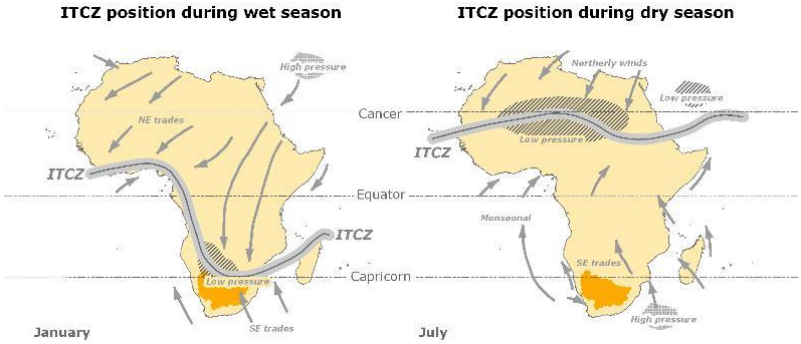
3.4 Meteorology and Hydrology

3.4.1 Meteorology

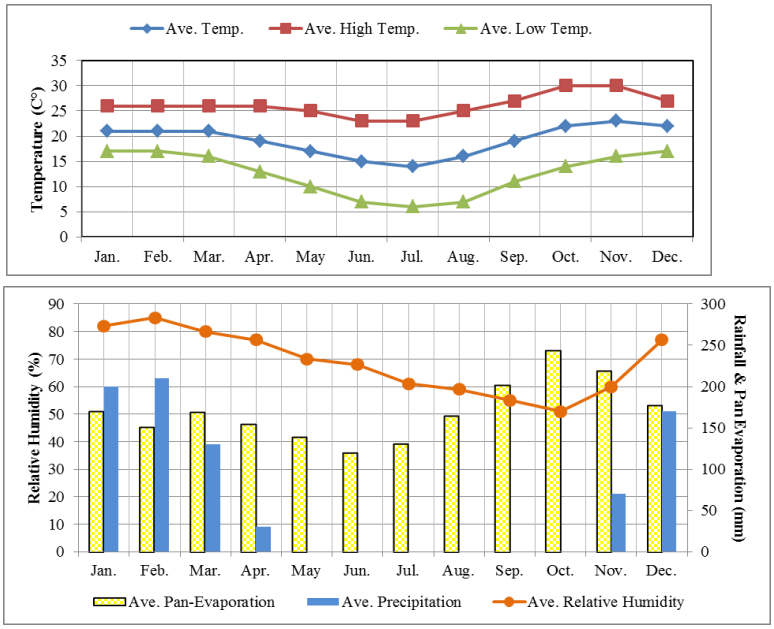
Climate conditions of Malawi are greatly influenced by the dominant wind shift caused by Inter-Tropical Convergence Zone (ITCZ), which oscillates north and south in seasons in the African continent as shown in **Figure 3.4.1**. The wet season occurs from November to April when the ITCZ moves southward bringing rainfall, and the dry season occurs from May to October when the ITCZ retreats northward.



Source: Orange-Senqu website (Ker et al. 1978)

Figure 3.4.1 ITCZ Variation across Africa throughout the Year

Due to the topographic diversity, spatial climate condition of Malawi has complex aspects depending on altitude and topography; however, the general tendency of yearly climate condition can be described by records of the Lilongwe Climate Station. Malawi also has two distinct seasons such as wet and dry seasons following the ITCZ moving state. The climate of Malawi is categorized as sub-tropical and divided into three weather variations such as warm-wet (November to April), cool-dry winter (May to August) and hot-dry seasons (September to October). The warm-wet season is recognized as the rainy season with about 95% of annual rainfall expected. The relative humidity in the rainy season is higher than that of the dry season, while the bar chart of pan-evaporation generally yields opposite reaction to the humidity as shown in **Figure 3.4.2**. As for the wind direction, lying northward of the sub-tropical high-pressure belt by ITCZ, the country is affected by south-easterly winds for about six months of the year in the dry season.



Source: weatherbase (http://www.weatherbase.com),
Graph made by Project Team

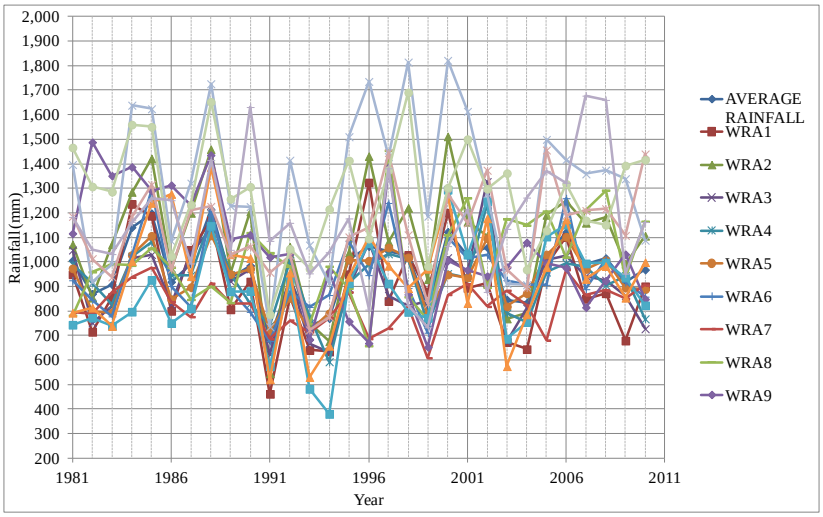
Figure 3.4.2 Average Climate Condition at Lilongwe

3.4.2 Hydrology

(1) Annual Rainfall

The annual average rainfall by WRA (Water Resources Area) in the whole country of Malawi estimated in the hydrological year determined by MoAIWD (from November to October) is presented in **Figure 3.4.3**.

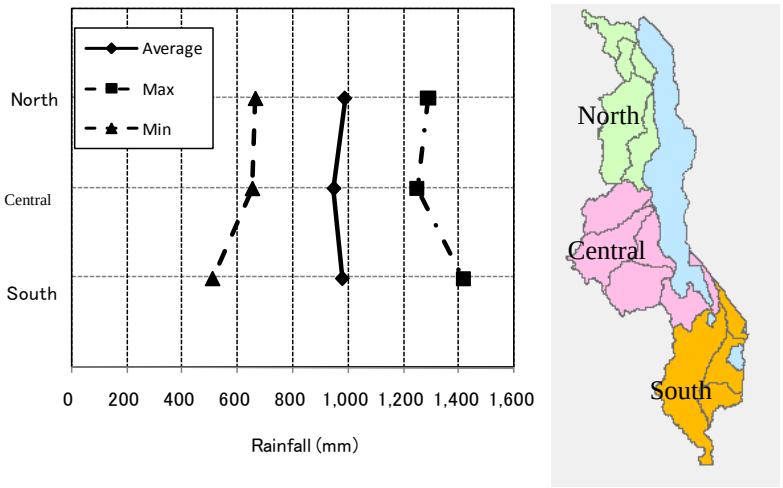
In whole Malawi, the average annual rainfall in the latest 3 decades is 971 mm which was calculated by the Tiesen Polygon Method in the Project and ranges between approx. 700 mm and 1,200 mm. The annual rainfalls for WRAs range from 400 mm to 1,800 mm depending on the topographic and climatic conditions.



Source: Project Team

Figure 3.4.3 Annual Rainfall 1981-2011 in Malawi

Annual rainfall characteristic by region is shown in **Figure 3.4.4**. The difference between maximum and minimum annual rainfall is about 600 mm in the northern and central regions; however, the southern region has a relatively large difference of 1,000 mm compared with that of other regions. Thus, it may be said that the variability of rainfall in the southern region is higher than the other regions.

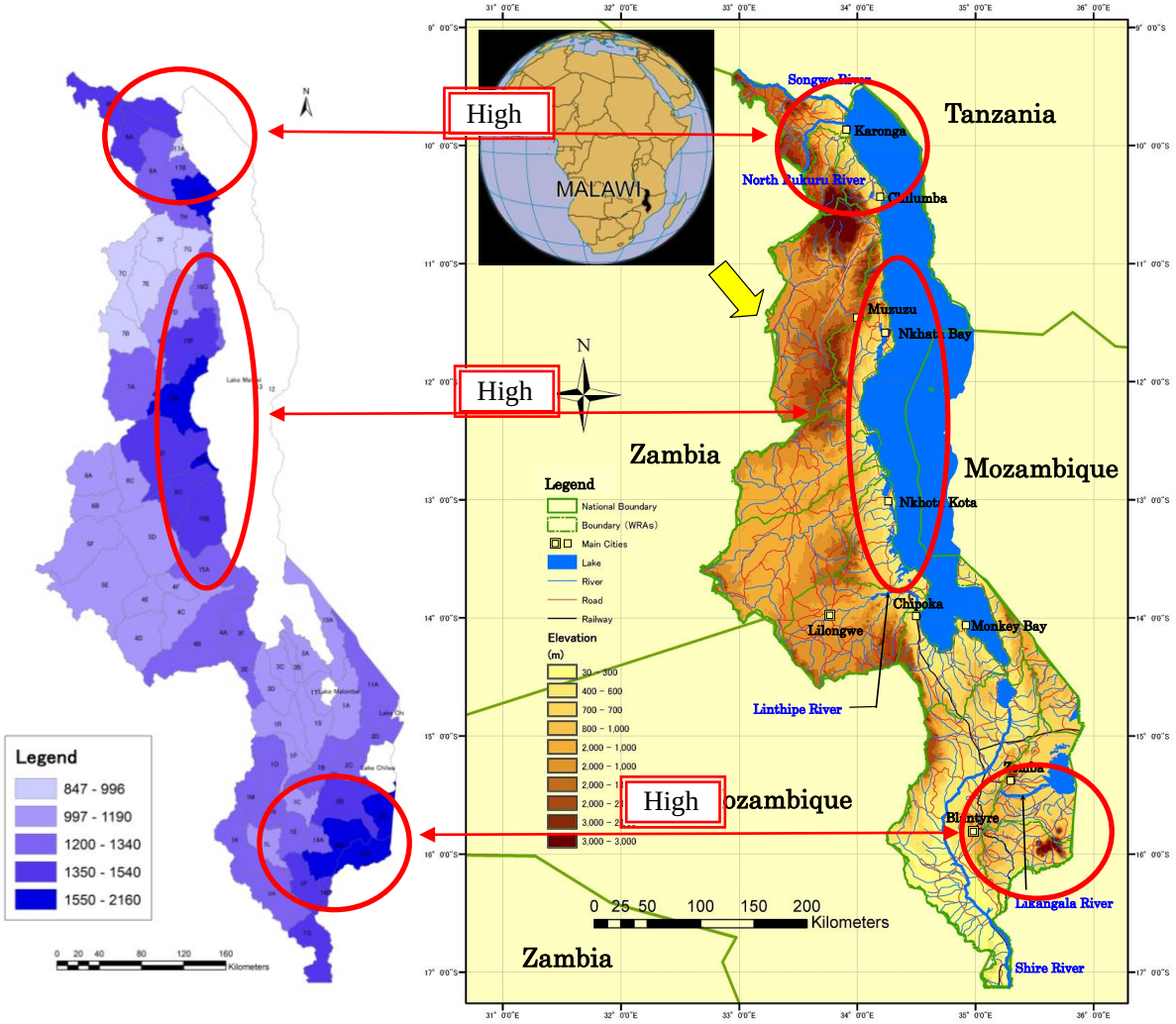


Source: Project Team

Figure 3.4.4 Annual Rainfall by Region

(2) Tendency of Maximum Annual Rainfall

Maximum year rainfalls by Water Resources Unit (WRU) are as calculated and illustrated in **Figure 3.4.5**. A relatively large amount of rainfall can be seen in the narrow area between Lake Malawi and the mountainous area as well as the southern mountainous area.



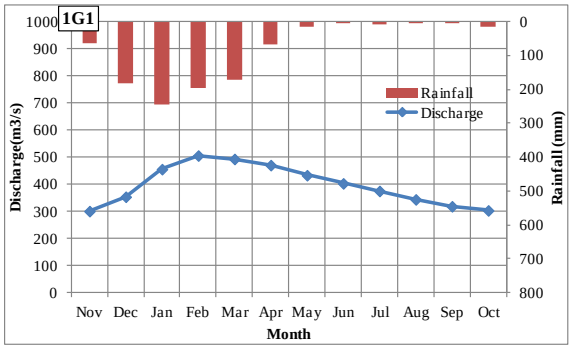
Source: Project Team

Figure 3.4.5 Comparison between Maximum Rainfall by WRU and Topographic Conditions

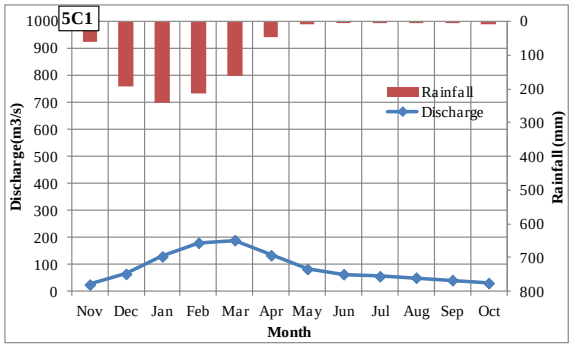
(3) Characteristics of Rainfall and Runoff

To confirm the characteristics of rainfall and runoff conditions, rainfall and discharge data were arranged as summarized in **Figure 3.4.6**. The data at 1G1 discharge station in the Shire River basin and 5C1 in the Bua River basin are shown as typical river discharges in which the water flows in the river course throughout the year.

As for 1G1 station, the large discharge continues until April after peak rainfall occurs in January. The river flow discharge keeps a large value even in the dry season compared with the other rivers in Malawi due to the outflow from the Lake Malawi. With regard to 5C1 station, the peak discharge occurs in March after peak rainfall occurs in January. In the dry season, the discharge decrease to less than half of the peak discharge in the rainy season while the rainfall depth is almost zero.



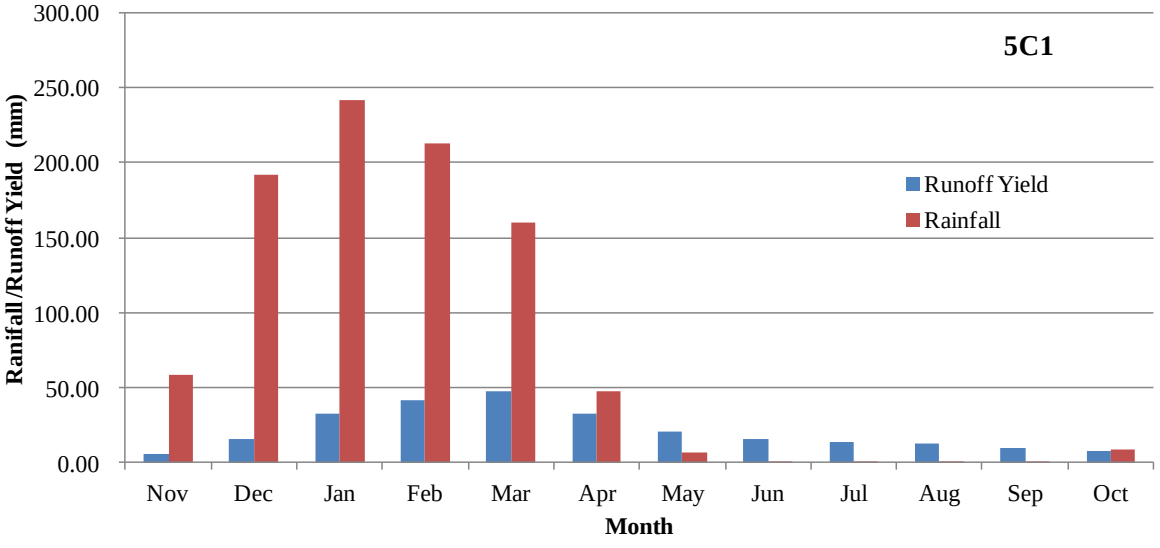
Source: Project Team



Source: Project Team

Figure 3.4.6 Rainfall and Runoff at 1G1 in Shire River and 5C1 in Bua River

Monthly runoff yield and rainfall depth of 5C1 station are shown in **Figure 3.4.7** as an example. The runoff yields are calculated dividing annual runoff by basin area. In the rainy season, runoff yield is about 20% of rainfall depth. In dry season, runoff yield become a little bit higher than rainfall depth because of base flow. The annual runoff ratios of rivers in Malawi fluctuate between 0.2 and 0.3 based on the collected rainfall and discharge data in the Project.



Source: Project Team

Figure 3.4.7 Monthly Runoff Yield and Rainfall (5C1)

3.4.3 Groundwater

(1) Boreholes

Rural water supply in Malawi had significantly depended on boreholes and dug wells. The first groundwater development started in the 1930's. Over 400 dug wells were constructed in Malawi between 1931 and 1939. After World War II, from 1947 to 1968, about 100 boreholes were constructed every year by mainly the Geological Survey Department. From 1969 to 1972, the construction rate increased to 500 boreholes every year in order to implement the large agriculture development programs. Since the late 1970's, the construction rate had declined to about 150 boreholes until the middle 1980's due to loss of water demand. Total borehole numbers had reached about 5,800 until 1985, thereupon all borehole records were unified to the specific form by the United Nations staff in NWRMP, 1986[4].

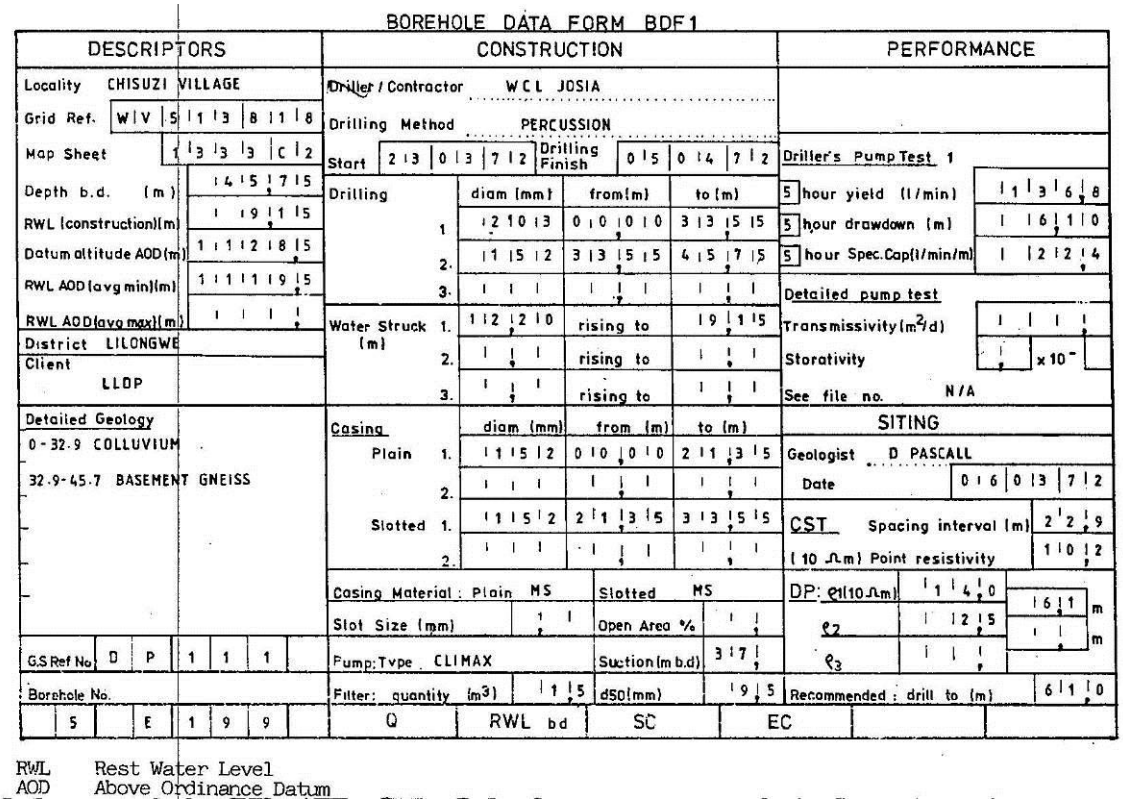
The only standardized borehole records in Malawi are the borehole data cards from the 1930's to 1985 designed by the Groundwater Project in NWRMP (see **Figure 3.4.8**). The location of boreholes can be referred on the Hydrogeological reconnaissance maps at a scale of 1:250,000 published at 1987, and the data cards allocate borehole numbers in chronological order of drilling each sub-catchment area of WRAs. For example, Borehole No. 1A001 means the first borehole constructed in sub-catchment area A of No. 1 WRA. The data cards give beneficial information for evaluating aquifers and thus producing potential as mentioned below.

<The front side of borehole data card>

- ✓ Borehole No.
- ✓ Locality (Note: Parts of the cards are mentioned district name)
- ✓ Grid Ref / Map Sheet No.
- ✓ Bottom depth of borehole
- ✓ R.W.L (Rest Water Level)
- ✓ Datum Altitude AOD (Above Ordinance Datum)
- ✓ R.W.L AOD (Altitude of groundwater table in rainy season or dry season)
- ✓ Client name
- ✓ Detailed geology
- ✓ Driller / Contractor
- ✓ Drilling Method
- ✓ Construction period (from start to finish)
- ✓ Construction records (Drilling diameters, depth of water struck, water level rising after the water struck, casing (plain/slotted) setting depth, specifications of the casing, pump type)
- ✓ Driller's recommended yield
- ✓ Driller's pumping test (Amount of yield, drawdown range, specific capacity in the fixed time)
- ✓ Detailed pump test (It is very rare to mention the results)
- ✓ CST (Core Sample Taker for electric logging)

<The back side of the borehole data card>

- ✓ Groundwater level at rehabilitation (There are 46 blanks to be filled with water level and the date)
- ✓ Results of water analysis (The items are; Ca, Mg, Na, K, Fe, HCO3, SO4, Cl, NO3, F, TDS, EC, pH, Temperature)
- ✓ Notes / Remarks



BOREHOLE DATA FORM BDF1

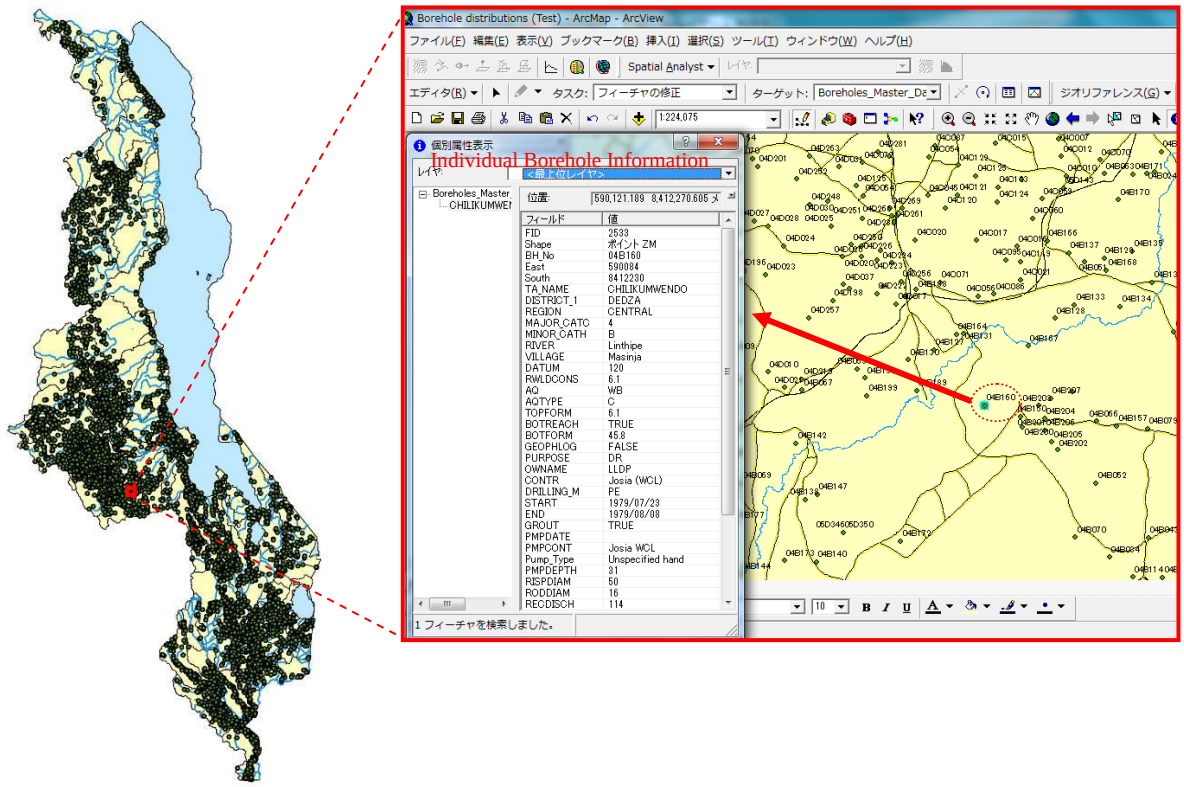
DESCRIPTORS	CONSTRUCTION	PERFORMANCE
Locality CHISUZI VILLAGE	Driller / Contractor WCL JOSIA	
Grid Ref. WV 511 38 118	Drilling Method PERCUSSION	
Map Sheet 1 33 33 C 2	Start 23 03 72 Drilling Finish 05 04 72	Driller's Pump Test 1
Depth b.d. (m) 145 175	Drilling: 1. diam (mm) 210 from (m) 000 to (m) 313 515; 2. 115 12 313 515 415 715; 3.	5 hour yield (l/min) 136 8
RWL (construction) (m) 19 115		5 hour drawdown (m) 16 10
Datum altitude AOD (m) 1112 85		5 hour Spec.Cap(l/min/m) 12 24
RWL AOD (avg min) (m) 1111 95		Detailed pump test
RWL AOD (avg max) (m)	Water Struck (m) 1. 12 20 rising to 19 115; 2. rising to; 3. rising to	Transmissivity (m^2/d)
District LILONGWE		Storativity x10⁻
Client LLDP		See file no. N/A
Detailed Geology: 0-32.9 COLLUVIUM; 32.9-45.7 BASEMENT GNEISS	Casing: Plain 1. diam (mm) 112 from (m) 000 to (m) 211 315; 2.; Slotted 1. 112 21 315 315 313 515 515; 2.	SITING: Geologist D PASCALL; Date 06 03 72
		CST Spacing interval (m) 229; (10 Ωm) Point resistivity 102
	Casing Material: Plain MS; Slotted MS	DP: ϱ1(10 Ωm) 140; ϱ2 125; ϱ3
	Slot Size (mm); Open Area %	161 m; m
G.S Ref No. D P 1 1 1	Pump: Type CLIMAX; Suction (m b.d) 317	
Borehole No.	Filter: quantity (m^3) 15; d50 (mm) 95	Recommended: drill to (m) 610
5 E 1 9 9	Q; RWL bd; SC; EC	

RWL Rest Water Level
AOD Above Ordinance Datum

Figure 3.4.8 Specimen of Existing Standardized Borehole Record in Malawi[4]

Hard copies of the borehole data cards have been created and stored in an exclusive shelf in the data collection room of the Groundwater Division belonging to MoAIWD. After the NWRMP project, the data cards were digitized by British Geological Society (BGS) staff during a groundwater data project. The data set were transferred to MoAIWD, but these were lost recently because the computer crushed. Fortunately, BGS has kept a soft copy of the data set, and the spread sheets are annexed to the reports on the Water Resources Investment Strategy [5] in NWDP II, 2010.

The Master Plan utilizes these digitized borehole information for groundwater analysis and in evaluating the groundwater potential of the whole Malawi, using Ground Information System (GIS) and numerical simulation software. The data set has been imported already into the GIS database by the Project Team as shown in **Figure 3.4.9** and **Table 3.4.1**.



Source: Project Team

Figure 3.4.9 Example of Visual Representation of Borehole Database on GIS

Table 3.4.1 Example of Borehole Database Spread Sheet on GIS

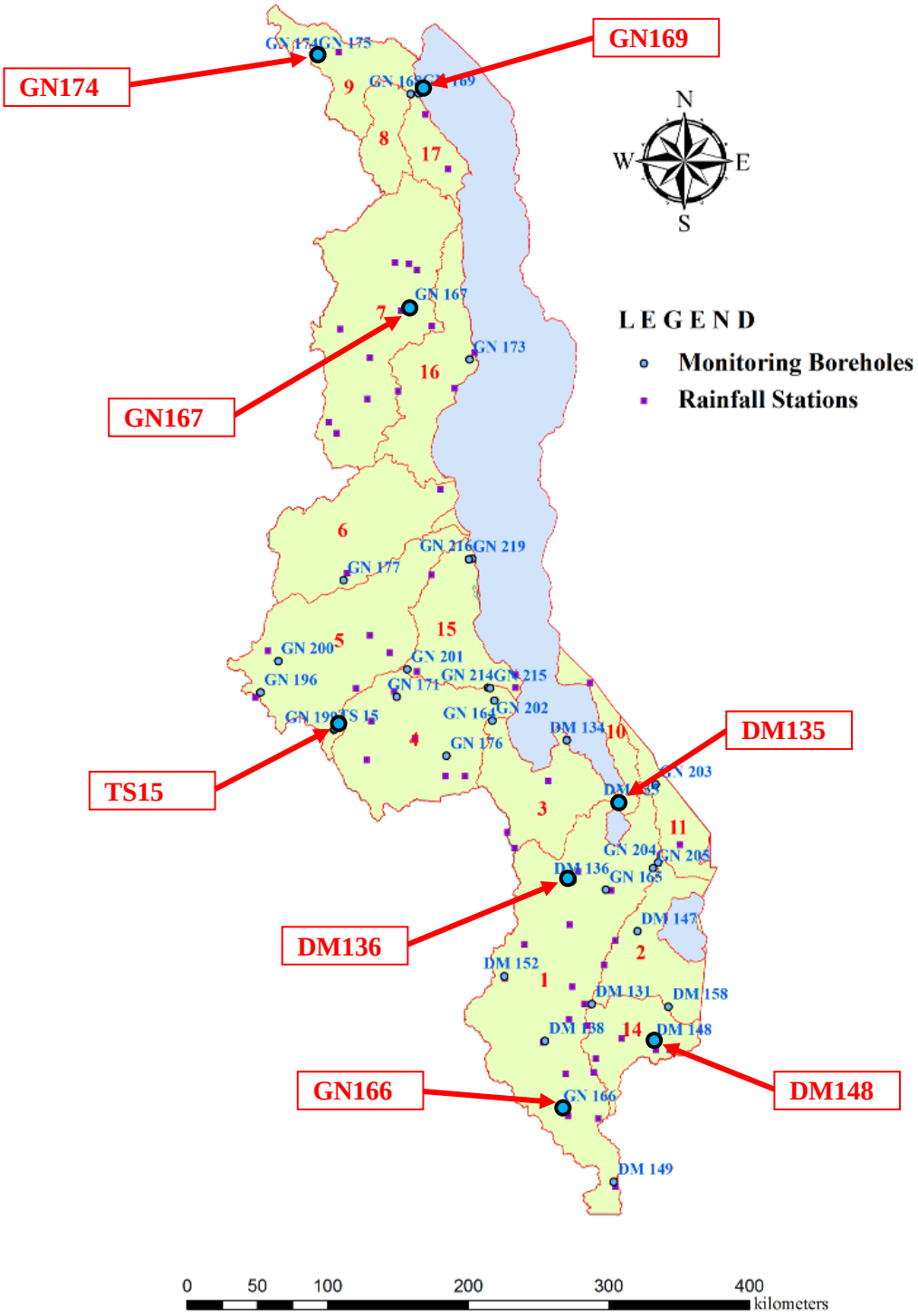
FID	Shape *	BH_No	East	South	TA_NAME	DISTRICT_1	REGION	MAJOR_CATC	MINOR_CATH	RIVER	VILLAGE	DATUM	RWLDOON	AQ	AQTYPE	TOPFORM	BOTREACH	BOTFORM
0	Point ZM	01 A001	77076	835445	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Nhala Trading Center	732	21.35	WB	S	7.6	TRUE	21.4
1	Point ZM	01 A002	76561	835226	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Mbonezhela	579	46.06	WB	O	7.6	TRUE	46.1
2	Point ZM	01 A003	77301	836518	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Nyanje	778	30.5	FB	O	3.1	TRUE	30.5
3	Point ZM	01 A004	76527	835406	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Ndenda	565	8.54	AL	O	8.2	TRUE	47.1
4	Point ZM	01 A005	74618	8321.71	SITOLA	MACHINGA	SOUTHER	1	B	Shire	Machinga	777	25.01	FB	S	25	TRUE	62.2
5	Point ZM	01 A006	76080	837384	CHIOWE	MANGOCHI	SOUTHER	1	A	Shire	Kambone	573	18.31	AL	O	18.3	TRUE	43.2
6	Point ZM	01 A007	76407	834942	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Mponda	563	85.4	AL	O	8.5	TRUE	39.7
7	Point ZM	01 A008	75142	836775	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Chikaluma	504	3.66	AL	O	3.7	TRUE	30.2
8	Point ZM	01 A009	75824	836448	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Mansembe	542	12.51	AL	O	12.5	TRUE	36.6
9	Point ZM	01 A010	75135	836813	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Mazaka	503	9.46	AL	O	9.5	TRUE	36.6
10	Point ZM	01 A011	75389	836809	CHIOWE	MANGOCHI	SOUTHER	1	A	Shire	Ndiuli	518	45.75	AL	O	7.6	TRUE	45.8
11	Point ZM	01 A012	76089	837279	CHIOWE	MANGOCHI	SOUTHER	1	A	Shire	Ndiuli	562	61	AL	-	0	TRUE	61
12	Point ZM	01 A013	75283	839286	CHIOWE	MANGOCHI	SOUTHER	10	A	S E Lakeshore	Mbuzu	506	14.03	AL	O	14	TRUE	40.1
13	Point ZM	01 A014	75422	839089	CHIOWE	MANGOCHI	SOUTHER	10	A	S E Lakeshore	Masi	518	32.64	AL	O	4.6	TRUE	32.6
14	Point ZM	01 A015	75449	839302	CHIOWE	MANGOCHI	SOUTHER	10	A	S E Lakeshore	Mtuwa	536	3.36	AL	O	3.7	TRUE	34.2
15	Point ZM	01 A016	75265	837893	CHIOWE	MANGOCHI	SOUTHER	1	A	Shire	Chiunda	509	9.75	AL	O	9.8	TRUE	35.4
16	Point ZM	01 A017	75992	835105	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Niambe	530	3.05	AL	O	3.1	TRUE	40.6
17	Point ZM	01 A018	74826	833474	LIWONDE	MACHINGA	SOUTH	1	B	Shire	Kamwendo (Sitola)	502	7.63	AL	O	7.6	TRUE	70.2
18	Point ZM	01 A019	75931	836107	LIWONDE GAME RESERVE	MACHINGA	SOUTHER	1	A	Shire	Nanjema	547	46.97	AL	O	46.9	TRUE	0
19	Point ZM	01 A020	76508	835860	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Mwikala	582	19.82	AL	O	19.8	TRUE	47.1
20	Point ZM	01 A021	75539	832250	CHIAMBA	MACHINGA	SOUTHER	1	B	Shire	Chirumbe	716	6.71	WB	S	6.7	TRUE	33.6
21	Point ZM	01 A022	75315	832193	SITOLA	MACHINGA	SOUTHER	1	B	Shire		731	0	WB	-	0	FALSE	0
22	Point ZM	01 A023	75384	832258	SITOLA	MACHINGA	SOUTHER	1	B	Shire		716	0	WB	-	0	FALSE	0
23	Point ZM	01 A024	74188	833924	LIWONDE GAME RESERVE	MACHINGA	SOUTHER	1	A	Shire	Liwonde Game Reserve	493	0.31	AL	S	0.3	TRUE	45.8
24	Point ZM	01 A025	76677	834142	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Nsanama H/Centre	548	43.31	WB	S	5.2	TRUE	43.3
25	Point ZM	01 A026	75753	835113	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Mbwezo	520	28.98	AL	O	29.1	TRUE	61
26	Point ZM	01 A027	75824	841186	JALASI	MANGOCHI	SOUTHER	1	A	Shire	Kwilembe	101	10.67	FB	S	10.7	TRUE	44.2
27	Point ZM	01 A028	76649	835367	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Namandenje	595	16.47	AL	S	16.7	TRUE	45.8
28	Point ZM	01 A029	76374	834430	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Chisuwi	564	15.25	AL	S	15.3	TRUE	45.8
29	Point ZM	01 A030	75591	833459	LIWONDE	MACHINGA	SOUTH	1	B	Shire	Nikasaula School	549	33.5	AL	O	3.4	TRUE	46.1
30	Point ZM	01 A031	76405	834673	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Mwekha	563	0	AL	-	0	FALSE	0
31	Point ZM	01 A032	74135	833856	LIWONDE GAME RESERVE	MACHINGA	SOUTHER	1	A	Shire	Liwonde Game Reserve	488	0	AL	-	0	TRUE	54.9
32	Point ZM	01 A033	74211	834042	LIWONDE GAME RESERVE	MACHINGA	SOUTHER	1	A	Shire		485	0	AL	-	0	FALSE	0
33	Point ZM	01 A034	75653	833486	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Nyama	555	6.1	WB	O	6.1	TRUE	37.5
34	Point ZM	01 A035	77306	837347		MANGOCHI	SOUTH	1	A	Shire	Mzinda	870	3.97	FB	O	3.9	TRUE	33.6
35	Point ZM	01 A036	76534	838128		MANGOCHI	SOUTH	1	A	Shire	Limbalire	837	8.54	WB	S	8.5	TRUE	33.6
36	Point ZM	01 A037	76333	838439		MANGOCHI	SOUTH	1	A	Shire	Niambe	869	8.54	WB	S	12.2	TRUE	47.1
37	Point ZM	01 A038	77111	835272	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Masaka Road Camp	716	9.31	AL	O	9.3	TRUE	41.4
38	Point ZM	01 A039	74427	833284	SITOLA	MACHINGA	SOUTHER	1	B	Shire	Chinguni School	489	9.4	AL	O	9.4	TRUE	63
39	Point ZM	01 A040	76703	834066	LIWONDE	MACHINGA	SOUTH	1	A	Shire	Msanama EP.A Centre	672	9.74	LB	O	9.7	TRUE	36.9
40	Point ZM	01 B001	72940	839944	MLUMBE	ZOMBA	SOUTHER	1	B	Shire	Balamania	594	0	WB	-	0	FALSE	0
41	Point ZM	01 B002	72234	839812	MLUMBE	ZOMBA	SOUTHER	1	B	Shire	Kalatika	518	0	AL	-	0	FALSE	0
42	Point ZM	01 B004	72760	839679	MLUMBE	ZOMBA	SOUTHER	1	B	Shire		498	0	AL	-	0	FALSE	0
43	Point ZM	01 B005	72321	839971	MLUMBE	ZOMBA	SOUTHER	1	B	Shire		500	0	AL	-	0	FALSE	0
44	Point ZM	01 B006	72256	8301.41	MLUMBE	ZOMBA	SOUTHER	1	B	Shire		531	0	AL	-	0	FALSE	0
45	Point ZM	01 B006	72711	839940	MLUMBE	ZOMBA	SOUTHER	1	B	Shire		0	0			0		0
46	Point ZM	01 B007	72249	830263	MLUMBE	ZOMBA	SOUTHER	1	B	Shire		490	0	AL	-	0	FALSE	0
47	Point ZM	01 B008	72487	829592	MLUMBE	ZOMBA	SOUTHER	1	B	Shire		483	0	AL	-	0	FALSE	0
48	Point ZM	01 B009	75439	830043	MLUMBE	ZOMBA	SOUTHER	1	B	Shire	Chingale Area	539	12.2	AL	S	12.2	TRUE	41.5
49	Point ZM	01 B010	72431	830649	MLUMBE	ZOMBA	SOUTHER	1	B	Shire	Chingale No 1	503	9.45	AL	O	9.5	TRUE	46.8
50	Point ZM	01 B011	72722	829789	MLUMBE	ZOMBA	SOUTHER	1	B	Shire	Masaulu	477	11.59	AL	O	11.6	TRUE	45.8
51	Point ZM	01 B012	72415	829751	MLUMBE	ZOMBA	SOUTHER	1	B	Shire	Sangala 2	549	26.54	AL	O	26.5	TRUE	176.1
52	Point ZM	01 B013	72290	8301.91	MLUMBE	ZOMBA	SOUTHER	1	B	Shire		518	0	AL	-	0	FALSE	0

Source: Project Team

(2) Groundwater Fluctuation

Within Malawi, there is very poor understanding of how groundwater behaves in response to climate patterns, increasing boreholes and changes in land use at present. Before 1986, a few groundwater monitoring at pilot districts were carried out, and many records of measured groundwater at borehole rehabilitations had been accumulated since 1970, thus slight findings for groundwater fluctuation of the whole of Malawi were brought by these data.

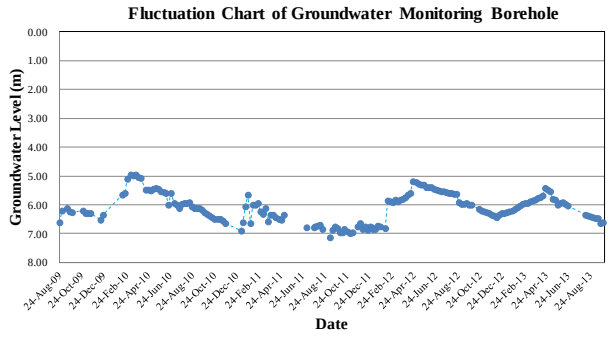
In 2009 to 2010, 35 monitoring wells (see **Figure 3.4.10**) were constructed in accordance with suggestions of the report of the Ministry of Water Development Strengthening of the Water Resources Board in 2003. Then continuous groundwater table measuring has been conducted by the local agency staff of MoAWID. Although the monitoring has been stopped at a part of the boreholes because of vandalism of boreholes or budget constraint in the local water office, monitoring data have been cumulated at several boreholes year by year. The groundwater fluctuations in each borehole, of which location is indicated as highlighted in **Figure 3.4.10**, are shown in **Figure 3.4.11** and **Figure 3.4.12**.

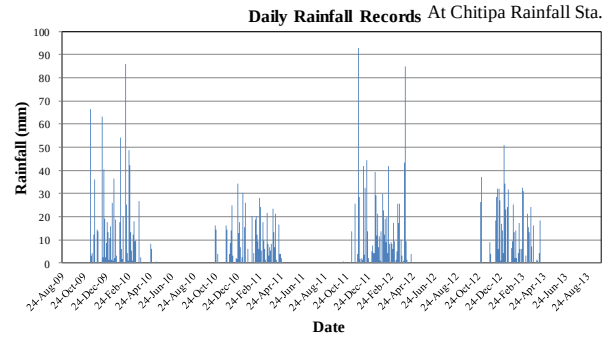


Source: Project Team

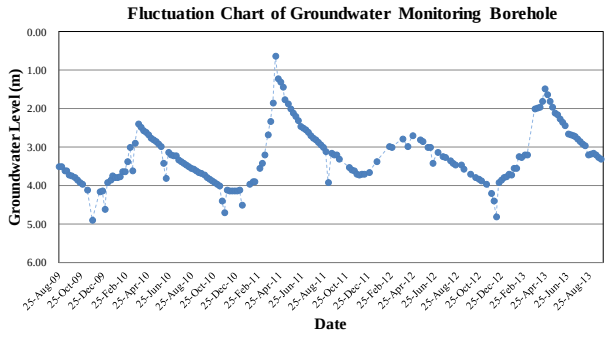
Figure 3.4.10 Location Map of Monitoring Wells

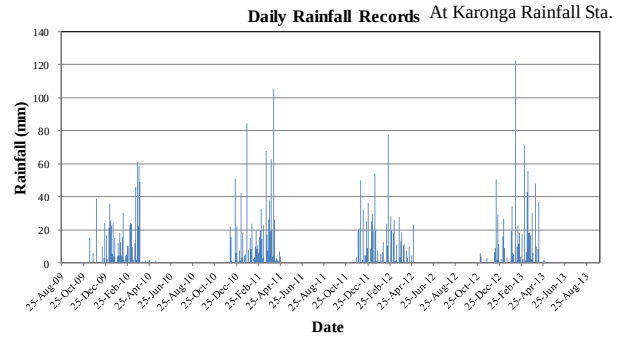
Chitipa Water Office (GN174) in WRA9



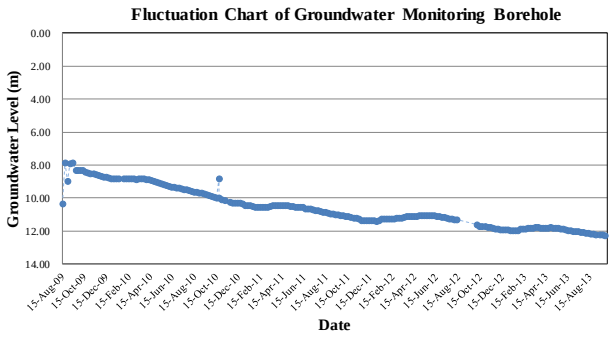


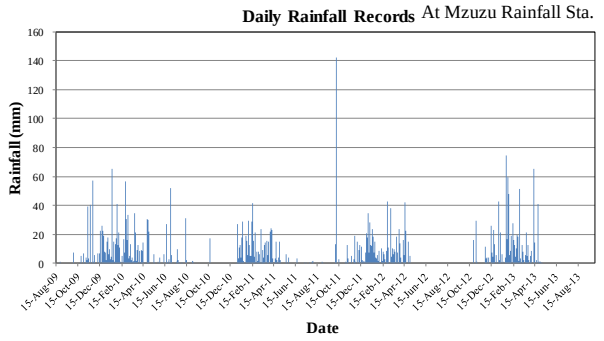
Karonga Water Office (GN169) in WRA17



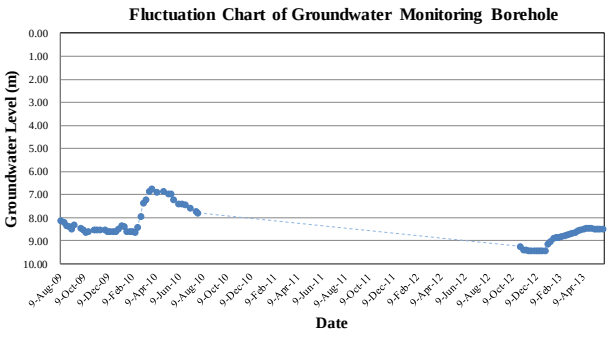


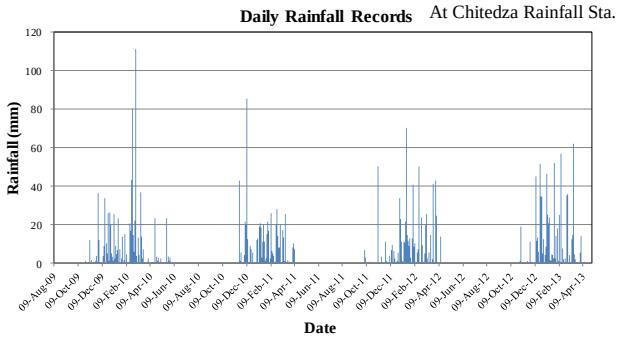
Endongolweni School (GN167) in WRA7





Chileka Water Office (TS15) in WRA5

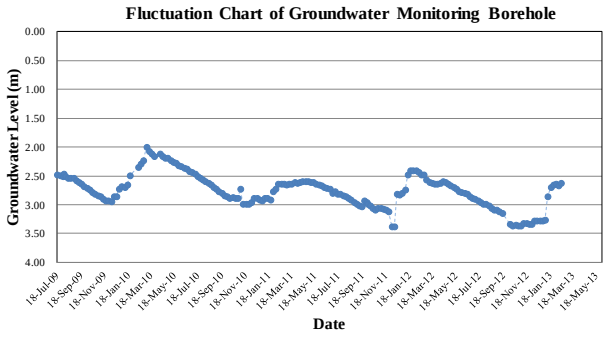


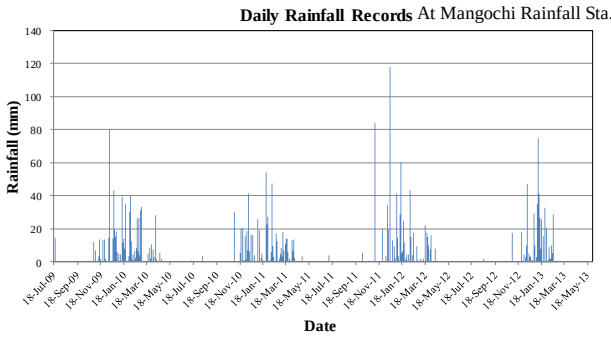


Source: Project Team

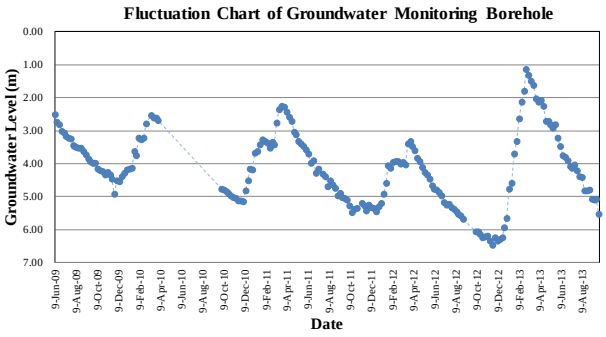
Figure 3.4.11 Chronological Changes of Groundwater Fluctuation in the North and Central Region

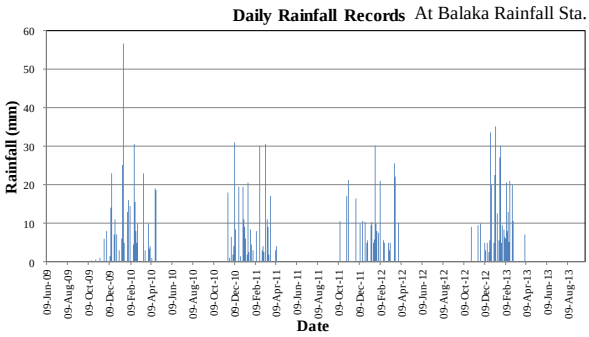
Mangochi Water Office (DM135) in WRA3



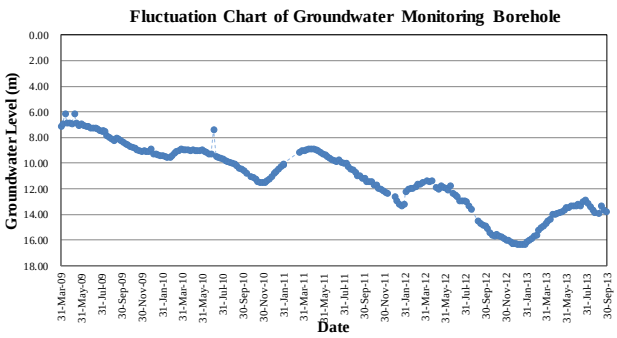


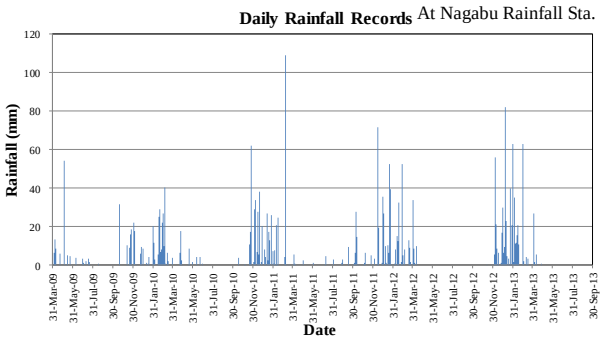
Balaka Water Office (DM136) in WRA1



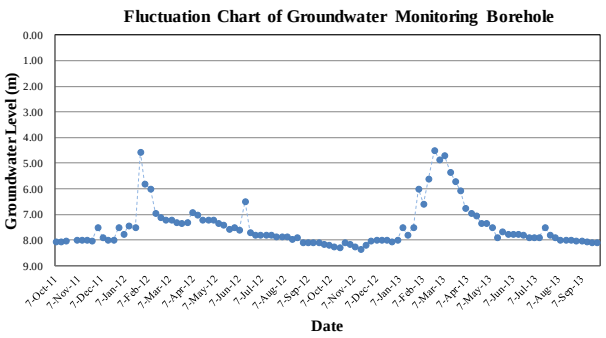


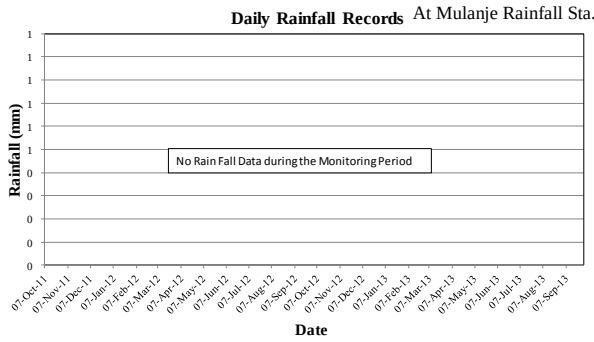
Ngabu Water Office (GN166) in WRA1





Mulanje Water Office (DM148) in WRA14





Source: Project Team

Figure 3.4.12 Chronological Changes of Groundwater Fluctuation in the South Region

(3) Tendency of Groundwater Dynamics

Groundwater fluctuation has a strong correspondence with precipitation intensity in the whole country of Malawi. Waterheads rise at the commencement of rainy season during November to December, and peak in March. In the dry season the waterheads gradually drop until the next rainy season, e.g., GN174 (Chitipa Water Office), GN169 (Karonga Water Office), DM136 (Balaka Water Office) and GN166 (Nagabu Water Office).

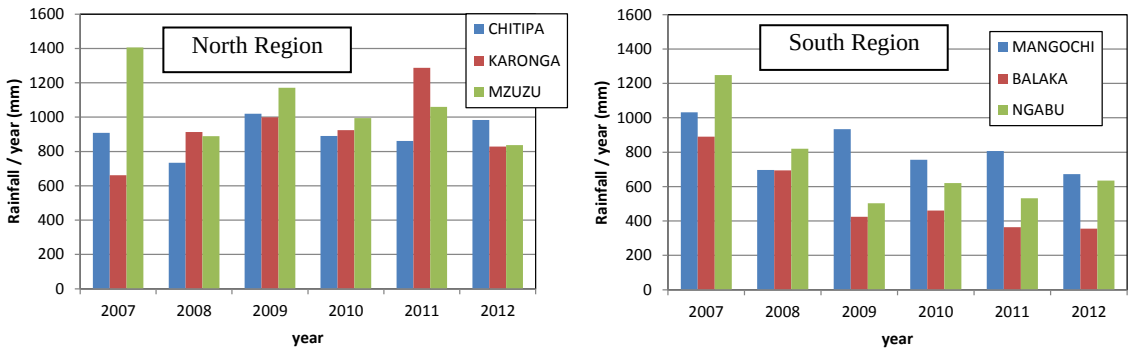
The gap of seasonal head between dry season and rainy season ranges from 2.0 to 3.0 meters in the highland area, and the top water table come after three or four months from the commencement of rainy season. This timing of the gap between precipitation and groundwater rise seems to reflect the rate of infiltration into unsaturated zone.

At the boreholes situated on the lakeshore plain such as DM135 (Mangochi Water Office), the fluctuation profiles are drawn as seasonal cycles but head differences which range approx. 1.0m are smaller than those of the boreholes in the highland area. Therefore, it seems that groundwater level in the lakeshore is influenced by inflow from Lake Malawi rather than rainfall.

In the south region, groundwater level in the watershed of Shire River in particular, has dropped repeating the periodic cycles since the monitoring began (i.e., DM136 and GN166 in **Figure 3.4.12**). According to the rainfall record of rainfall stations covering these monitoring wells, annual rainfall has decreased year by year and this is considered as the main reason why groundwater level in the watershed of Shire River has dropped together with the decrease of precipitation in the monitoring period, as shown in **Figure 3.4.13**. On the other hand, the bottom of groundwater level at GN174 and GN169 has decreased to almost the same level and this is attributed to the steady precipitation in the north region. This relationship between groundwater fluctuation and precipitation may enable the prediction of potential volume of groundwater using only the rainfall records.

The groundwater fluctuations at GN167 situated in Mzuzu indicate small water rises within 1m although the borehole locates on the highland area, and the groundwater table has dropped gradually since the monitoring began. It is thought that an impervious zone such as thick clay layer overlaying an aquifer may prevent precipitation from infiltrating into underground and the fluctuation may respond to other recharge areas located away from the monitoring well.

The tendencies of groundwater fluctuation at each WRA are summarized in **Table 3.4.2**.



Source: Project Team

Figure 3.4.13 Annual Rainfall from 2007 to 2011 in North and South Region

Table 3.4.2 Summary of Groundwater Fluctuations at WRAs

WRA	Exsiting MBH	Fluctuation Ranging	Descripitions
1	DM136: Balaka W/Office (◎) GN165: M'manga CDSS (○) DM131: Mzedi Damping Site (×) DM152: Mwanza Boma (○) DM138: Chikhwawa W/Office (▲) GN166: Nagabu W/Office (◎) DM149: Nsanje W/Office (◎) GN204: Ntaja W/Office (▲)	•Highest G.W.L: 2.24m (DM136) •Lowest G.W.L: 36.2m (DM138) •Range of periodic fluctuation :approx.3.0m	The fluctuations respond intensity of rainfall sensitively. Groundwater tended to gradually lower with seasonal cycle during 2009 to 2012 at DM136 and GN166. Because annual rainfall had decreased in the duration, it is considered that the groundwater dropping prones might be caused by decrease of precipitation.
2	DM147: Songani W/Office (○) DM158: Nasomba School (▲) GN205: Kawombe Dam (▲)	•Highest G.W.L: 3.04m (DM147) •Lowest G.W.L: 23.99 (GN205) •Range of periodic fluctuation :approx.2m	Seasonal groundwater change which corresponding to rainfall is recognized at DM147.
3	DM134: Monkey Bay PVT School (○) DM135: Mangochi W/Office (◎) GN164: Katelera School (×)	•Highest G.W.L: 1.92m (DM134) •Lowest G.W.L: 10.72 (GN164) •Range of periodic fluctuation :approx.1.0m	The monitoring boreholes are located in alluvial plain adjacent Lake Malawi, thus groundwater levels are usually shallow. These indicates periodic fluctuations corresponding to rainfall, but these ranges are within 1m. It is considered that recharge by inflow from the lake is prior to precipitation by rain.
4	GN171: Mlezi School (▲) GN176: Linthipe W/Office (▲) GN202: Mtongola Dam (▲) GN214: Kambwiri Sele W/Field (○) GN215: Kuti Plant (○)	•Highest G.W.L: 4.2m (GN202) •Lowest G.W.L: 15.3 (GN171) •Range of periodic fluctuation is unknown due to poorly collecting data.	Any monitorings in the area have been sparse at every holes, hence the gorundwater dynamics have been known so much.
5	GN196: Mchinji W/Office (◎) GN199: Kakuyo Dam (▲) TS15: Chileka W/Office (○) GN200: Lusa/Kalulu Dam (×)	•Highest G.W.L: 0.78m (GN199) •Lowest G.W.L: 8.63 (TS15) •Range of periodic fluctuation :approx.2m	Seasonal groundwater changes are recognized at GN196 and TS15, however relationship between the fluctuation and rainfall has been uncleared because the monitoring boreholes are far from rainfall stations over 20km.
6	GN177: Mwalawanyenje School (▲)	•Highest G.W.L: 2.1m (GN177) •Lowest G.W.L: 7.86 (GN177) •Range of periodic fluctuation is unknown due to poorly collecting data.	Monitoring borehole is just one points, and the monitoring has been sparse. Therefore the area lacks understanding of groundwater dynamics.
7	GN167: Endongolweri School (◎)	•Highest G.W.L: 7.85m (DM167) •Lowest G.W.L: 11.86(GN167) •Range of periodic fluctuation :within 1.0m	At GN167, the fluctuation range was relatively small in spite of high rainfall intensity. That is why in-situ precipitation may be prevented by impervious zone (i.e. thick clay layer) overlaid on aquifer. It seems that the groundwater may be derived from other recharge area.
8	GN168: Karonga W/Field (×)	Lack of current data due to be vandalized	Monitoring borehole is just one points, and the borehole was vandalized. Therefore the area lacks understanding of groundwater dynamics.
9	GN174: Chitipa W/Office (◎) GN175: Chitipa W/Field (△)	•Highest G.W.L: 4.94m (GN174) •Lowest G.W.L: 20.55 (GN175) •Range of periodic fluctuation :approx.2m	Seasonal groundwater change which corresponding to rainfall is recognized at GN174.
10	No monitoring boreholes	Groundwater fluctuation is unknown.	The area lacks understanding of groundwater dynamics.
11	GN203: Namwera W/Field (△)	•Highest G.W.L: 2.3m (GN203) •Lowest G.W.L: 10.03(GN203) •Range of periodic fluctuation : Not natural fuctuation	Monitoring borehole is just one point. The borehole obviously shows influence of pumping up, thus natural fluctuation have not known so much.
14	DM148: Mulanje W/Office (○)	•Highest G.W.L: 4.57m (DM148) •Lowest G.W.L: 8.35(GN148) •Range of periodic fluctuation :approx.1.0m	At DM148, groundwater rising in short term during rain season occured in early 2012. However the relationship between the fluctuation and rainfall was not known due to lack of rainfall records.
15	GN201: Chaliwa Dam (○) GN216: Nkhotakota W/Office (▲) GN219: Nkhotakota W/Field (▲)	•Highest G.W.L: 0.21m (DM201) •Lowest G.W.L: 2.42(GN201) •Range of periodic fluctuation :approx.2.0m	Seasonal groundwater change which corresponding to rainfall is recognized at GN201 located on scarpment area. GN216 and GN219 has very few data, so the groundwater fluctuation on lakeshore adjacent to Lake Malawi has been not known.
16	GN173: Msani School (▲)	•Highest G.W.L: 14.0m (DM173) •Lowest G.W.L: 15.3(DM173) •Range of periodic fluctuation :within 1.0m	A monitoring in the area has been sparse, but the fluctuation chart looks that no groundwater rising occurred during a rain season (from December 2009 to February 2010). Groundwater at GN173 may be stable due to preventing precipitation on surface.
17	GN169: Karonga W/Office (◎)	•Highest G.W.L: 0.93m (GN169) •Lowest G.W.L: 4.9m (GN169) •Range of periodic fluctuation :approx.3.0m	The fluctuations respond intensity of rainfall sensitively at GN169.

Notes; ◎: Almost completing weekly data since borehole instolled. ○: Continuously collecting data in annual at least. △: Data influenced by pumping up or other anthropogenic causes. ▲: Few data that not able to assess fluctuation. ×: Vandalized borehole. －: No collecting data.

Source: Project Team

3.4.4 Monitoring Condition

(1) Introduction

This section describes the present condition of observation and monitoring for surface water, groundwater and water quality/pollution control fields in Malawi based on the results of interview surveys, field surveys and literature surveys of past and ongoing study/project documents.

There are two recent important projects regarding the observation and monitoring for these fields. One of them is the Project on Strengthening of the Water Resources Board under the National Water Development Project I, which was carried out for about one year in 2002 to assess the capacity and effectiveness of water resources management mechanism including surface water network, groundwater network, water quality network, and MIS (Management Information System) and database. The other one, the Consultancy Services for Establishment of Water Resources Monitoring System under the National Water Development Program, was started in July 2010 and scheduled to be completed in 2013 to establish the network and MIS for groundwater, surface water, water quality monitoring system, and an administration system of water permits. These projects were carefully reviewed and referred for preparing this section.

(2) Conditions of Observation and Monitoring

1) Hydrological Observation

Hydrological observation of water level and discharge is managed by the Surface Water Division of the Department of Water Resources under MoAIWD. The present status of hydrological observation is as discussed below and summarized in Subsection 6.1.1.

(i) Condition of Hydrological Stations

More than 300 hydrological stations exist in Malawi and the number of operational stations historically has changed. According to the National Water Resources Master Plan (1986)[6], 173 stations were opened in 1986. Among them, 149 stations including 52 stations with daily chart automatic recorders were river gauging stations for water level and discharge observation, and the other 24 stations were gauging stations for water level observation. In addition, more than 100 stations had been closed as of 1986. The report of the Ministry of Water Development in 2003 regarding the Strengthening of the Water Resources Board[7], likewise stated that there were 194 open stations in 2002, of which 170 stations were river gauging stations for water level and discharge observation, and the remaining 24 stations were gauging stations for water level observation.

On the other hand, the Ministry of Agriculture, Irrigation and Water Development in 2011 stated in its report regarding the Consultancy Services for Establishment of Water Resources Monitoring System that 139 stations consisting of 136 MoAIWD stations and 3 Water Board stations are operational and 164 stations are closed[8]. **Table 3.4.3** gives a list of the presently operational stations whose locations were confirmed together with their physical condition. In the table, "Combined" under "Physical Conditions" means physical condition judged compositely by "accessibility" and "riverbed condition". In addition, **Figure 3.4.14** shows their location and physical condition ("Combined" physical condition), and **Table 3.4.4** summarizes the physical condition ("Combined" physical condition) by WRA.

Spatial distribution of the present operational stations is considered that the stations cover most of the sites to be reference points of WRAs and major rivers. Some sites not to be covered by the present operational stations can be dealt with by rehabilitating and reopening closed stations operated in past since Malawi historically had a very comprehensive network of stations.

The "Status by Past Study" in **Table 3.4.3** is the status assessed in consideration of the condition of (i) Bed and/or banks, (ii) Gauge plates, (iii) Hydraulic control, (iv) Benchmarks, (v) Vegetation, (vi) Siltation, (vii) High flow gauging (if necessary), (viii) Last gauging to check rating curve, and

(ix) Gauge reader, in the ongoing project entitled the "Establishment of Water Resources Monitoring System (MoWDI 2010-2013) (hereinafter referred to as "Past Study"). **Table 3.4.5** shows the summary of the above-mentioned status by WRA, and its distribution are shown in **Figure 3.4.15.** The assessment was done based on the results of field survey; therefore, the stations which have not been visited were not assessed.

The physical condition summarized in **Table 3.4.4,** and **Table 3.4.15** will be utilize in the Master Plan Study to confirm only the physical condition to decide the sustainable discharge station as a control point of water use planning.

Table 3.4.3 Present Operational Stations (2011)

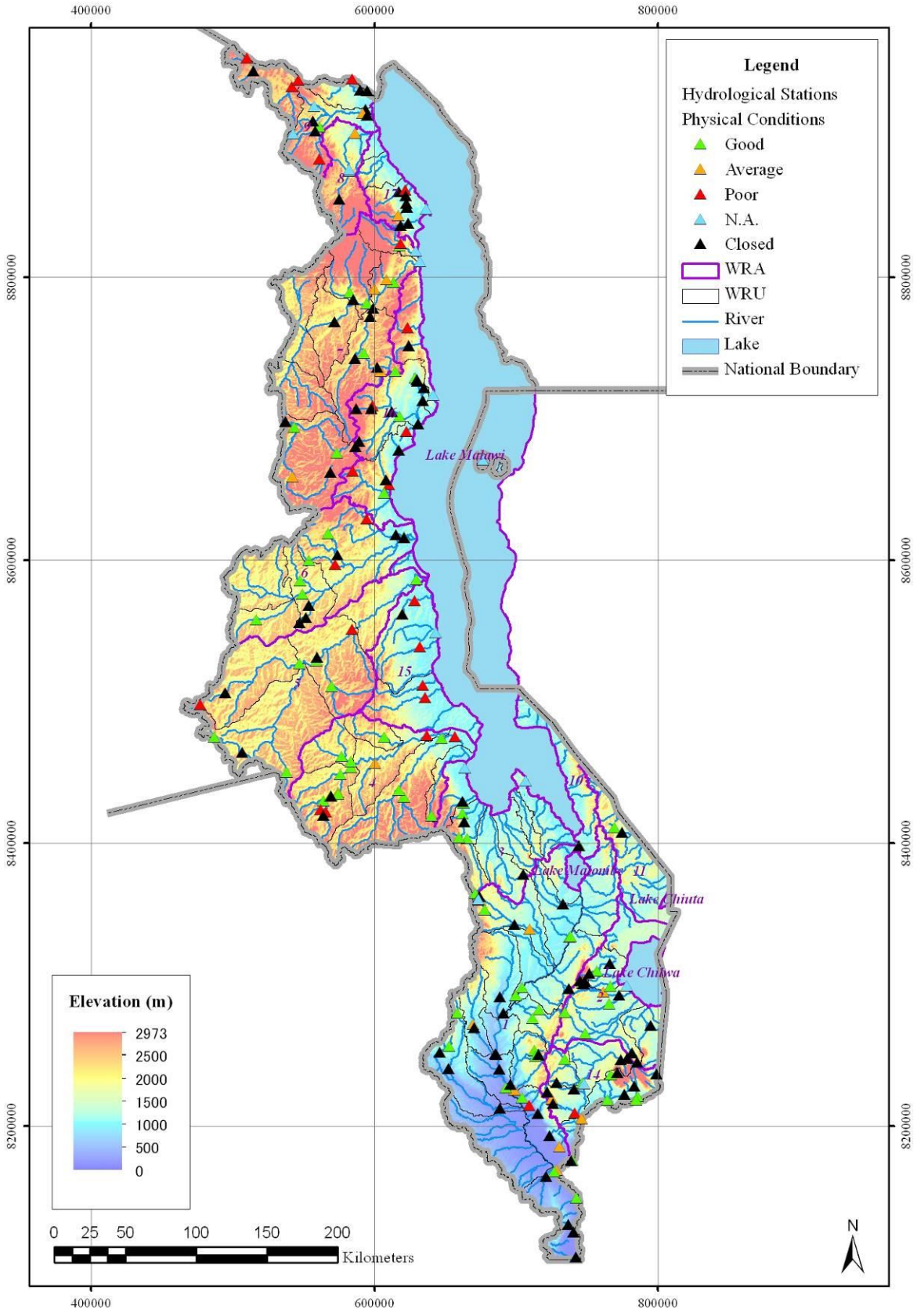
Code	Name (Region/Hydrometric District)	Coordinate		Physical Conditions			Status by Past Study[4]
		Latitude	Longitude	Accessi-bility	Riverbed Condition	*Combin-ed*	
	NORTHERN REGION						
	Karonga District (Chitipa Office)						
8A8	North Rukuru River at Uledi	S 10°10.0'	E 33°45.2'	Fair	N.A.	N.A.	N.A.
8A9	Mibanga River at Uledi	S 10°10.5'	E 33°44.9'	Fair	N.A.	N.A.	N.A.
9A13	Chambo River at Yotau Nyonbo	S 9°56.3'	E 33°23.3'	Good	N.A.	N.A.	N.A.
9A4	Lufira River at Chilanga	S 9°53.645'	E 33°33.590'	Good	Stable	Good	Average
9A5	Kalenje River at Chipwera	S 9°45.6'	E 33°31.5'	Fair	N.A.	N.A.	N.A.
9A9	Sekwa River at Wenga	S 10°05.8'	E 33°33.5'	Bad	Stable	Poor	N.A.
9B3	Kaseye River at Mwenebwiba	S 9°38.082'	E 33°22.795'	Fair	Fairly unstable	Poor	Poor
9B4	Songwe River at Ichinga	S 9°35.628'	E 33°25.388'	Fair	Fairly unstable	Poor	Average
9B6	Songwe River at Ipenza	S 9°27.094'	E 33°05.427'	Good	Unstable	Poor	Average
	Karonga District (Karonga Office)						
17C1	Lake Malawi at Chilumba	S 10°25.0'	E 34°14.9'	Good	N.A.	N.A.	N.A.
17C16	Wovwe River at Njalayankhunda	S 10°27.6'	E 34°04.2'	Fair	Fairly stable	Average	N.A.
17C17	Nyungwe River at Mcheka-cheka	S 10°17.5'	E 34°06.7'	Very bad	Fairly unstable	Poor	N.A.
7G18	South Rukuru River at Mlowe	S 10°45.1'	E 34°12.5'	Fair	N.A.	N.A.	N.A.
7H3	North Rumphi River at Chiweta	S 10°41.2'	E 34°10.9'	Fair	N.A.	N.A.	N.A.
8A5	North Rukuru River at Mwakimeme	S 9°56.0'	E 33°47.2'	Fair	Fairly stable	Average	N.A.
9A2	Lufira River at Ngerenge	S 9°48.4'	E 33°50.2'	Fair	Stable	Average	N.A.
9B7	Songwe River at Mwandenga (Hycos Station)	S 9°35.2'	E 33°46.0'	Fair	Fairly unstable	Poor	N.A.
	Rumphi District						
7F2	South Rumphi River at Rumphi	S 11°01.306'	E 33°51.960'	Good	Stable	Good	Good
7F3	Runyina River at Mjuma	S 10°57.226'	E 33°45.425'	Good	Stable	Good	Average
7G13	Luviri River at Ng'onga (Roadbridge)	S 10°55.846'	E 33°54.897'	Fair	Stable	Average	Average
7G14	South Rukuru River at Phwezi	S 10°53.220'	E 34°02.448'	Good	Stable	Good	Poor
7G19	Chivungulu River at Pwezi	S 10°53.168'	E 34°02.462'	Good	Stable	Good	Poor
7G3	Muhuju River at Muhuju	S 10°52.065'	E 33°59.769'	Fair	Stable	Average	Average
7H1	North Rumphi River at Phoka Court	S 10°39.160'	E 34°04.642'	Good	Stable	Good	Average
7H2	Kaziwiziwi River at Kaziwiziwi	S 10°38.297'	E 34°05.010'	Bad	Stable	Poor	Average
	Mzimba District (Mzuzu Office)						
13A1	Lake Malawi at Chisumulu Island	S 12°01.3'	E 34°37.4'	Good	N.A.	N.A.	N.A.
16E9	Luwawa River at Magwema (Mgwema)	S 12°05.7'	E 33°46.7'	Very bad	Stable	Poor	N.A.
16F5	Luchelemu (Lower) River at Mazamba (Road Bridge)	S 11°40.6'	E 33°54.3'	Bad	Stable	Poor	N.A.
16G2	Chiwisi River at Bula (Usisya Road Bridge)	S 11°10.4'	E 34°07.9'	Bad	Stable	Poor	N.A.

Code	Name (Region/Hydrometric District)	Coordinate		Physical Conditions			Status by Past Study[4]
		Latitude	Longitude	Accessi-bility	Riverbed Condition	*Combin-ed*	
7A12	South Rukuru River at Kamangadazi (Mungoni)	S 11°49.0'	E 33°23.9'	Good	Stable	Good	N.A.
7A3	South Rukuru River at Chimsewezo	S 12°07.830'	E 33°23.286'	Fair	Stable	Average	Good
7A4	Mzimba River at Muweru Bulukutu (Muweru Bukuluti)	S 11°58.812'	E 33°40.484'	Good	Stable	Good	Poor
7D16	Lunyangwa River at Mzuzu Water Works (Mzuzu WW Intake)	S 11°27.209'	E 34°03.154'	Good	Stable	Good	Average
7D17	Lusangazi River at Kamweko (Mzuzu-Malivneji Road Bridge)	S 11°27.263'	E 33°57.564'	Fair	Stable	Average	Good
7D8	Lunyangwa River at Zombwe (Ekwendeni - Mpherembe Bridge)	S 11°20.410'	E 33°50.877'	Good	Stable	Good	Average
	Nkhata Bay District (Mzuzu Office)						
16E13	Kawiya River at Chabizga (Thula Village)	S 11°50.352'	E 34°07.522'	Bad	Stable	Poor	Good
16F15	Luweya River at Mzenga	S 11°44.438'	E 34°04.868'	Good	Stable	Good	Good
16F6	Luwawa River at Kapalapata	S 11°29.740'	E 34°11.043'	Good	Stable	Good	Good
16G1	Lake Malawi at Nkhata Bay	S 11°36.474'	E 34°18.043'	Good	N.A.	N.A.	Good
	CENTRAL REGION						
	Kasungu District						
5D1	Bua River at Bua Drift	S 13°06.422'	E 33°46.792'	Bad	Stable	Poor	Poor
5D2B	Bua River at M1 Road bridge	S 13°18.484'	E 33°32.788'	Good	Stable	Good	Average
5D3	Mtiti River at Mtiti	S 13°28.208'	E 33°38.670'	Good	Stable	Good	Average
5F1	Rusa River at Kasela	S 13°19.509'	E 33°26.272'	Good	Stable	Good	Average
6C1	Dwangwa River at Khwengwere (Kwengwere)	S 12°52.977'	E 33°27.237'	Good	Stable	Good	Good
6C5	Mpasadzi River at M1 Road bridge	S 12°47.856'	E 33°26.443'	Good	Stable	Good	Average
6D1	Milenje River at M1 Road bridge	S 12°40.004'	E 33°29.809'	Good	Stable	Good	Good
6D11	Milenje River at Entandweni	S 12°41.532'	E 33°40.046'	Bad	Stable	Poor	Poor
6D5	Luwelezi River at Matundu	S 12°29.585'	E 33°37.278'	Good	Stable	Good	Average
6D7	Rupache River at Kamende	S 12°24.0'	E 33°52.3'	Very bad	Stable	Poor	N.A.
6B2	Lingadzi River at Kasungu National Park	S 13°02.703'	E 33°09.299'	Good	Stable	Good	Poor
	Nkhotakota District						
15A4	Chirua River at Mtambe	S 13°27.758'	E 34°14.389'	Good	Fairly unstable	Poor	Poor
15A8	Lingadzi River at Kaniche	S 13°32.5'	E 34°15.3'	Bad	Stable	Poor	N.A.
15B13	Kaombe River at Chanika	S 12°55.3'	E 34°11.1'	Bad	Stable	Poor	N.A.
15B14	Lifuliza River at Nyoni	S 13°13.0'	E 34°13.2'	Good	Fairly unstable	Poor	N.A.
15B6	Chia Lagoon River at Mtanga	S 13°07.572'	E 34°19.400'	Good	N.A.	N.A.	Poor
16E12	Mlowe River	S 12°10.7'	E 34°00.9'	Bad	Stable	Poor	N.A.
16E6	Dwambadzi River at Nthanda	S 12°14.127'	E 33°59.044'	Good	Stable	Good	Average
4B1	Linthipe River at Salima Rail bridge	S 13°47.4'	E 34°27.1'	Fair	Unstable	Poor	N.A.
4B9	Linthipe River at Malapa	S 13°48.1'	E 34°21.8'	Good	Stable	Good	N.A.
5C1	Bua River at S53 Road bridge	S 12°47.131'	E 34°11.733'	Good	Stable	Good	Average
6D10	Dwangwa River at S53 Road bridge (Downstream) (Dwasco)	S 12°30.820'	E 34°06.938'	Good	Stable	Good	Average
	Lilongwe District						
4A4	Makonda River at Eden Estate	S 14°17.9'	E 34°18.0'	Good	Stable	Good	N.A.
4B3	Linthipe River at Linthipe	S 14°10.793'	E 34°07.448'	Good	Stable	Good	Average
4B4	Diamphwe River	S 14°08.060'	E 34°05.290'	Good	Stable	Good	Good
4C11	Nanjiri River at Kadzizila (Kazizira)	S 13°57.714'	E 33°55.913'	Fair	Stable	Average	Poor
4C2	Lilongwe River at Nkwenembela	S 13°47.1'	E 34°16.1'	Bad	Stable	Poor	N.A.

Code	Name (Region/Hydrometric District)	Coordinate		Physical Conditions			Status by Past Study[4]
		Latitude	Longitude	Accessibility	Riverbed Condition	*Combined*	
4D21	Katete River at Kaweche	S 14°12.191'	E 33°35.754'	Good	Stable	Good	Poor
4D23	Kamuzu Dam at Malingunde	S 14°10.435'	E 33°38.494'	Good	Stable	Good	Good
4D24	Lilongwe River at Masula	S 14°09.104'	E 33°41.484'	Fair	Stable	Average	Average
4D25	Lilongwe River at Masula	S 14°09.806'	E 33°41.413'	Good	Stable	Good	Poor
4D27	Likuni River at Chigwirizano	S 14°02.087'	E 33°42.370'	Good	Stable	Good	Poor
4D28	Lilongwe River at Mamina	S 14°16.3'	E 33°36.5'	Very bad	Stable	Poor	N.A.
4D29	Chaulongwe River at Mamina .	S 14°15.5'	E 33°34.5'	Very bad	Stable	Poor	N.A.
4D4	Lilongwe River at Lilongwe Old Town	S 13°59.468'	E 33°46.363'	Good	Stable	Good	N.A.
4E1	Lingadzi River at M1Roadbridge	S 13°57.124'	E 33°46.463'	Good	Stable	Good	Poor
4E2	Lingadzi River at S11 Road bridge	S 13°55.071'	E 33°42.727'	Good	Stable	Good	Poor
4F6	Lumbadzi River at Simakumi	S 13°47.774'	E 33°59.329'	Good	Stable	Good	Poor
5E1	Namitete River at Namitete Town	S 14°01.257'	E 33°21.171'	Good	Stable	Good	Poor
5E6	Bua River at Mchinji	S 13°47.913'	E 32°52.803'	Good	Stable	Good	Average
5F3	Liwelezi River at Matuwamba	S 13°35.3'	E 32°47.4'	Very bad	Stable	Poor	N.A.
	Ntcheu District						
11A7	Masongola River at Namwera	S 14°21.745'	E 35°29.989'	Good	Stable	Good	Poor
1B1	Shire River at Liwonde	S 15°04.029'	E 35°12.848'	Good	Stable	Good	Good
1B7	Shire River at Liwonde	S 15°03.647'	E 35°13.208'	Good	Stable	Good	Good
1R18	Mpamadzi River at Gumbu	S 14°49.954'	E 34°37.350'	Fair	Stable	Average	Good
1R19	Mpira River at Gomeza	S 14°53.794'	E 34°39.224'	Good	Stable	Good	Good
1R22	Marko River at Water Supply Intake	S 14°49.761'	E 34°36.799'	N.A.	N.A.	N.A.	N.A.
1R3	Rivi-Rivi River at Balaka	S 15°01.070'	E 34°57.161'	Fair	Stable	Average	Poor
1T1	Shire River at Mangochi	S 14°28.749'	E 35°16.385'	Good	Stable	Good	Good
3A2	Lake Malawi at Monkey Bay	S 14°04.163'	E 34°55.031'	Good	N.A.	N.A.	Good
3E1	Nadzipokwe River at Mua Mission	S 14°16.828'	E 34°30.406'	Good	Stable	Good	Poor
3E3	Livulezi River at Khwekhwelele	S 14°26.530'	E 34°32.339'	Good	Stable	Good	Poor
3E5	Namikokwe River at Kampanikiza	S 14°26.051'	E 34°29.060'	Good	Stable	Good	Poor
3E7	Nkhande River at Thobola	S 14°47.581'	E 34°35.634'	Good	Stable	Good	Good
3F1	Lake Malawi at Chipoka	S 13°59.440'	E 34°31.141'	Good	N.A.	N.A.	Average
3F3	Nazipulu River at Ntakataka	S 14°12.860'	E 34°30.807'	Good	Stable	Good	Poor
	SOUTHERN REGION						
	Zomba Water Board						
ZWB1	Mulunguzi River at Falls	S 15°21.423'	E 35°18.352'	Good	Stable	Good	Good
ZWB2	Mulunguzi Dam	S 15°21.699'	E 35°18.850'	Good	N.A.	N.A.	Good
	Zomba District (Zomba Water Board)						
2B11	Mulunguzi River at Williams Falls	S 15°20.635'	E 35°18.037'	Bad	Stable	Poor	Good
2B21	Likangala River at Nkokanguwo	S 15°24.825'	E 35°26.314'	Fair	Stable	Average	Poor
2B22	Thondwe River at Jali	S 15°29.2'	E 35°28.7'	Good	Stable	Good	N.A.
2B33	Namadzi River at Matiti	S 15°40.9'	E 35°19.5'	Good	Stable	Good	N.A.
2B38	Mulunguzi River	S 15°21.415'	E 35°18.119'	Good	Stable	Good	Good
2B6	Namadzi River at Namadzi	S 15°32.761'	E 35°11.274'	Good	Stable	Good	Good
2C10	Lake Chilwa at Kachulu	S 15°22.335'	E 35°35.541'	Good	N.A.	N.A.	Poor
2C3	Domasi River at Domasi T.T.C. (Domasi College (Mie))	S 15°16.804'	E 35°23.849'	Good	Stable	Good	Poor
2C8	Naisi River at Mwandama	S 15°22.531'	E 35°29.142'	Good	Stable	Good	Good

Code	Name (Region/Hydrometric District)	Coordinate		Physical Conditions			Status by Past Study[4]
		Latitude	Longitude	Accessi-bility	Riverbed Condition	*Combin-ed*	
	Blantyre District						
14A3	Chisombezi River at Midima Road	S 15°50.8'	E 35°11.5'	Good	Stable	Good	N.A.
1C1	Lilongwe River at Lilongwe	S 15°31.833'	E 35°01.076'	Good	Stable	Good	Poor
1C9	Lunzu River at Whayo	S 15°35.304'	E 34°58.651'	Good	Stable	Good	Good
1E16	Chimwankhunda River	S 15°49.352'	E 35°01.238'	Good	Stable	Good	Poor
1E19	Mudi River at Sunnyside	S 15°47.508'	E 34°59.458'	Good	Stable	Good	Poor
1E4	Naperi River at Stella Maris School	S 15°49.670'	E 34°59.835'	Good	Stable	Good	Poor
1K2	Ng'ona River at Kalanga	S 15°46.3'	E 34°25.6'	Good	Stable	Good	N.A.
1K3	Mwanza River at Old Customs Road	S 15°33.318'	E 34°28.880'	Good	Stable	Good	Good
1M5	Nkulumadzi	S 15°37.585'	E 34°35.088'	Fair	Stable	Average	Good
1P2	Shire River at Matope	S 15°23.360'	E 34°54.425'	Good	Stable	Good	Poor
1P6	Shire River at Zalewa	S 15°26.572'	E 34°51.861'	Good	Stable	Good	Poor
	Thyolo District						
14A2	Luchenza River at Luchenza	S 15°59.931'	E 35°18.399'	Good	Stable	Good	Poor
14B2	Thuchila River at Chonde	S 16°00.095'	E 35°19.176'	Good	N.A.	N.A.	Poor
14B3	Nswadzi River at Chipungu	S 16°11.356'	E 35°15.714'	Bad	Stable	Poor	Average
14B8	Kwakwasi River at Mangunda (Kwakwasi)	S 16°02.085'	E 35°15.263'	Good	Fairly stable	Average	Average
14B9	Nsuwadzi River at Makwasa	S 16°06.121'	E 35°06.572'	Good	Fairly stable	Average	Poor
14C2	Ruo River at M1 Road bridge (Nsuwadzi) (Ruo)	S 16°04.778'	E 35°40.410'	Good	Stable	Good	Poor
14C5	Ruo River at Ruo Estate	S 16°05.980'	E 35°39.734'	Good	Stable	Good	Good
14C6	Likabula River at Likabula Forestry (Likabula Estate)	S 15°56.505'	E 35°29.752'	Good	Stable	Good	Poor
14C8	Lichenya River at Milonde	S 16°06.232'	E 35°28.536'	Good	Stable	Good	Poor
14D3	Ruo River at Sandama	S 16°13.401'	E 35°18.442'	Fair	Stable	Average	Average
	Ngabu District						
14D2	Ruo River at Sinoya (Sinoya North)	S 16°29.314'	E 35°14.914'	Good	Stable	Good	Good
1E1	Mwamphanzi River at Mpokonyola (Nsanje)	S 16°02.864'	E 34°51.748'	Good	Fairly stable	Average	Poor
1F1	Mapelera River at Mafumbi (Nyali)	S 16°05.766'	E 34°54.714'	Good	Stable	Good	Poor
1F2	Thangadzi East River at Gooke	S 16°24.258'	E 35°09.801'	Fair	Fairly stable	Average	Poor
1F20	Nkhate River at Irrig. Headworks	S 16°08.519'	E 34°57.432'	Fair	Unstable	Poor	Poor
1G1A	Shire River at Chiromo – left bank	S 16°33.217'	E 35°08.768'	Fair	Stable	Average	Poor
1G1B	Shire River at Chiromo – right bank channel	S 16°33.922'	E 35°07.656'	Good	Stable	Good	Poor
1G3	Shire River at Tengani	S 16°44.009'	E 35°16.779'	Good	Stable	Good	Poor
1L12	Shire River at Chikwawa	S 16°01.973'	E 34°48.171'	Good	Stable	Good	Good

Source: Project Team based on the information from MoIWD (2011) Consultancy Services for Establishment of Water Resources Monitoring System. Situation and Needs Assessment Report.



Source: Project Team

Figure 3.4.14 Location and Physical Condition of Hydrological Stations

Table 3.4.4 Summary of Physical Condition of Hydrological Stations

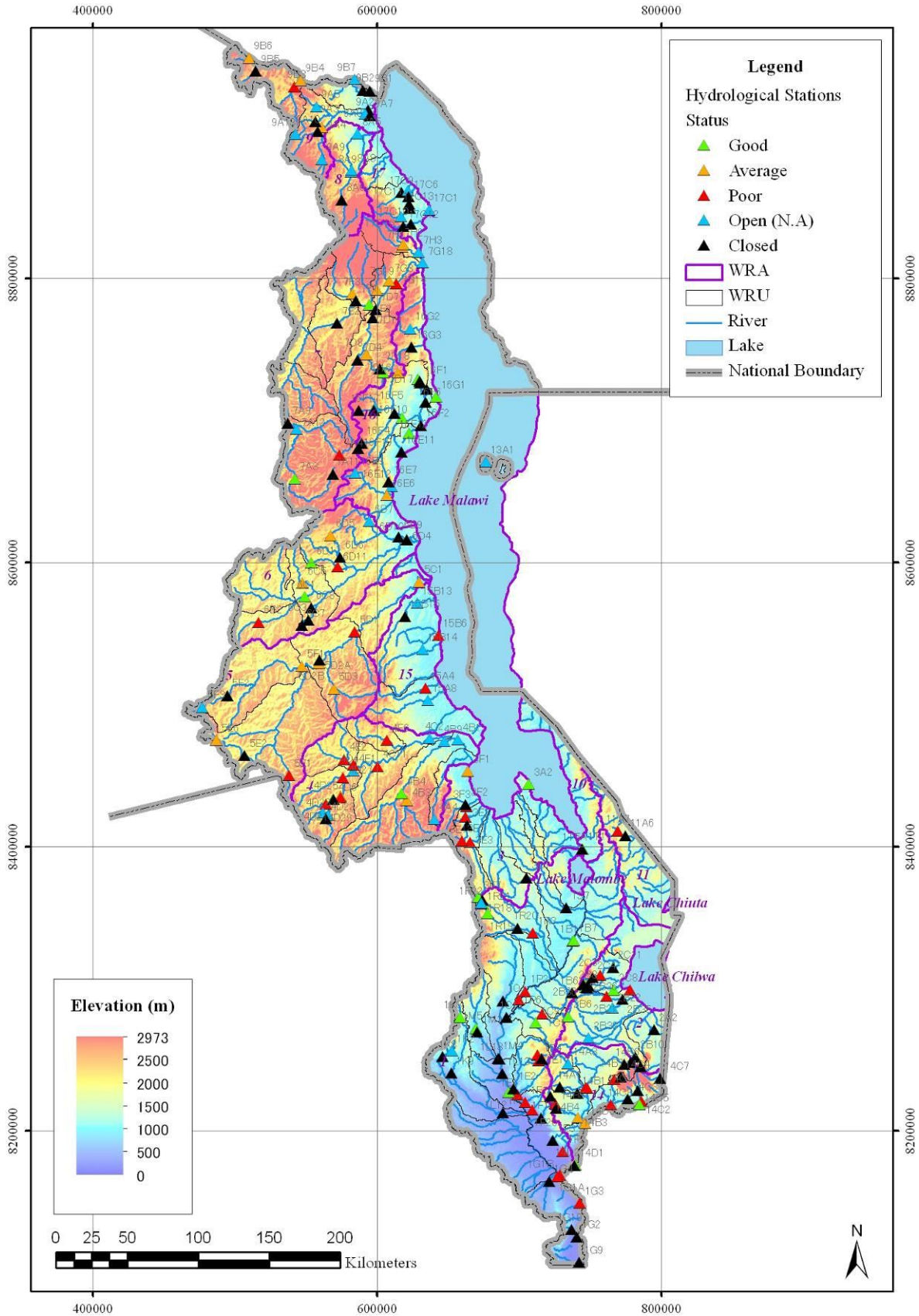
WRA		Open					Closed	Total: Open & Closed
No.	Name	Good	Average	Poor	N.A.	Total Open		
1	Shire	17	6	1	1	25	23	48
2	Lake Chilwa	7	1	1	2	11	9	20
3	South West Lakeshore	5	0	0	2	7	3	10
4	Linthipe	12	2	4	0	18	2	20
5	Bua	6	0	2	0	8	3	11
6	Dwangwa	6	0	2	0	8	6	14
7	South Rukuru/North Rumphi	9	4	1	2	16	8	24
8	North Rukuru	0	1	0	2	3	1	4
9	Songwe/Lufira	1	1	5	2	9	7	16
10	South East Lakeshore	0	0	0	0	0	0	0
11	Lake Chiuta	1	0	0	0	1	1	2
12	Likoma Island	0	0	0	0	0	0	0
13	Chizumulu Island	0	0	0	1	1	0	1
14	Ruo	7	3	1	1	12	11	23
15	Nkhota-kota Lakeshore	0	0	4	1	5	1	6
16	Nkhata-Bay Lakeshore	3	0	5	1	9	13	22
17	Karonga Lakeshore	0	1	1	1	3	6	9
	Total	**74**	**19**	**27**	**16**	**136**	**94**	**230**

Source: Project Team

Table 3.4.5 Summary of Status of Hydrological Stations Assessed by Past Study

WRA		Open					Closed	Total (Open & Closed)
		Visited			Not Visited (N.A.)	Total Open		
No.	Name	Good	Average	Poor				
1	Shire	9	0	14	2	25	23	48
2	Lake Chilwa	6	0	3	2	11	9	20
3	South West Lakeshore	2	1	4	0	7	3	10
4	Linthipe	2	2	7	7	18	2	20
5	Bua	0	5	2	1	8	3	11
6	Dwangwa	2	3	2	1	8	6	14
7	South Rukuru/North Rumphi	3	7	3	3	16	8	24
8	North Rukuru	0	0	0	3	3	1	4
9	Songwe/Lufira	0	3	1	5	9	7	16
10	South East Lakeshore	0	0	0	0	0	0	0
11	Lake Chiuta	0	0	1	0	1	1	2
12	Likoma Island	0	0	0	0	0	0	0
13	Chizumulu Island	0	0	0	1	1	0	1
14	Ruo	2	3	6	1	12	11	23
15	Nkhota-kota Lakeshore	0	0	2	3	5	1	6
16	Nkhata-Bay Lakeshore	4	1	0	4	9	13	22
17	Karonga Lakeshore	0	0	0	3	3	6	9
	Total	**30**	**25**	**45**	**36**	**136**	**94**	**230**

Source: Project Team



Source: Project Team based on the information from MoIWD (2011) Consultancy Services for Establishment of Water Resources Monitoring System. Situation and Needs Assessment Report. Prepared by aurecon, MoIWD, Malawi, 21-23pp

Figure 3.4.15 Location and Status of Hydrological Stations Assessed by Past Study

Automatic water level recorders with daily charts have operated in primary stations from the 1960's to the early 1990's. In 1979, about 40 automatic recorders were operational. However, some of them have been vandalized or damaged by floods during that period, then the others were closed in the early 1990's during the transition to democracy[9]. At present, the only automatic stations are the SADC-HYCOS (Southern African Development Community Hydrological Cycle Observing System) stations and those at the Mulunguzi Dam run by the Zomba Water Board.

One of the specific objectives of the SADC-HYCOS project was to establish a regional database to facilitate data exchange among the SADC National Hydrological Systems (NHSs). The database includes data acquired from the measuring station (DCP) network, and historical data and information provided by the NHSs[10]. The SADC-HYCOS project set up six stations during Phase I and a further four stations in Phase II as shown in **Table 3.4.6**. However, Phase II has not been completed due to funding issues and many of the Phase I stations need maintenance works.

Table 3.4.6 Condition of SADC-HYCOS Stations

District	Station Number	Station Description	SADC-HYCOS Phase	Date of Installation	Recorder Type
Northern Region					
Karonga	9B7	Songwe at Mwandenga	I	6 November 1999	DCP
Karonga	8A5	North Rukuru at Mwakimeme	II	Not fully installed	DCP
Karonga	17C1	Lake Malawi at Chilumba	I	11 November 1999	DCP
Mzimba (Nkhata Bay)	16G1	Lake Malawi at Nkhata Bay	I	12 November 1999	DCP
Central Region					
Ntcheu	3A2	Lake Malawi at Monkey Bay	I	15 November 1999	DCP
Ntcheu	1B1	Shire at Liwonde	I	28 September 1998	DCP
South Region					
Thyolo	14D3	Ruo at Sandama	I	1 October 1998	DCP
Ngabu	1G3	Shire at Tengani	II	Not fully installed	DCP

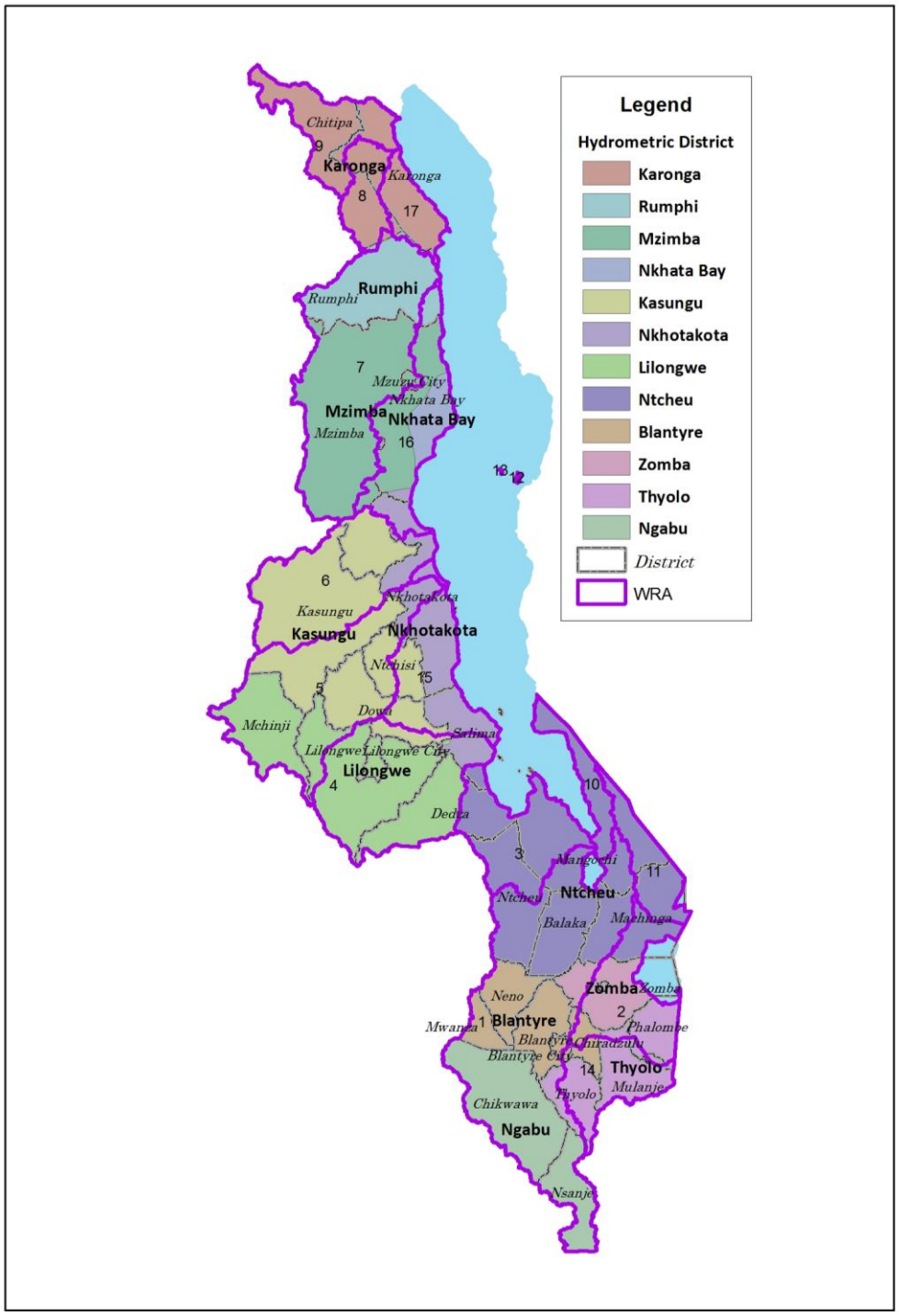
DCP: Data collection platform (to broadcast observed data via Meteosat satellite), DL: Data logger
Source: MoIWD (2011); Consultancy Services for Establishment of Water Resources Monitoring System. Design of Water Resources Monitoring System. Prepared by Aurecon, MoWDI, Malawi, 44pp

(ii) Observation and Data Recording Method, Data Management System and Maintenance of Observation Equipment

a) Observation Management System

From the hydrological management viewpoints such as clarification of area of responsibility for operation and maintenance of gauging stations, country is divided into three regions (Northern, Central and Southern) and into 12 hydrometric districts within those regions. The hydrometric districts do not necessarily overlap with the governmental districts and mostly include several governmental districts. The hydrometric districts are divided along catchment boundaries and district boundaries where appropriate as shown in **Figure 3.4.16.** Each hydrometric district is managed by the corresponding responsible district water office. The hydrometric districts and responsible district water offices are summarized in **Table 3.4.7**. Hydrological staff are assigned to only these 12 district water offices among 28 offices. The role of the district water office regarding hydrological observation is (i) maintenance of gauging stations, (ii) maintenance of access routes to the stations, (iii) discharge measurement (routine measurement of flows and measurement of high flow), and (iv) payment of and

communication with gauge readers (data collection from gauge readers). Each responsible district water office manages about 10 stations from eight stations of Rumphi and Chitipa to 19 of Lilongwe.



Source: Project Team

Figure 3.4.16 Hydrometric Districts

Table 3.4.7 Hydrometric District and Responsible District Water Office

Region	Hydrometric District	Responsible District Water Office
Southern	Blantyre	Blantyre
	Zomba	Zomba
	Thyolo	Thyolo
	Ngabu	Ngabu
Central	Ntcheu	Ntcheu
	Lilongwe	Lilongwe
	Nkhotakhota	Nkhotakhota
	Kasungu	Kasungu
Northern	Karonga	Karonga, Chitipa
	Rumphi	Rumphi
	Mzimba	Mzuzu
	Nkhata Bay	

Source: Project Team

Ideally, each district water office that hydrological positions/posts are assigned is desired to have two hydrologists and a hydrological team of five staff members of two assistant hydrological officers, one hydrological assistant and two gauging assistants. However, only two offices have just one hydrologist and most offices have two or three staff members of the hydrological team as shown in **Table 3.4.8**. Some offices have just one staff member, therefore, they can carry out only simple task such as data collection from the gauge readers although two or three staff members may be able to conduct low flow discharge measurement and basic maintenance of gauging stations.

Table 3.4.8 Staff Status on Hydrological Services in District Water Office that Hydrological Positions/Posts are assigned

District Water Office	Principal Hydrologist	Hydrologist	Senior Assistant Hydrological Officer	Assistant Hydrological Officer	Hydrological Assistant	Head Gauging Assistant	Gauging Assistant
Southern Region							
Blantyre	Vacant	Vacant	Vacant	1	2	Vacant	1(Senior)
Zomba	Vacant	Vacant	Vacant	1	Vacant	Vacant	1
Thyolo	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	1(Senior)
Ngabu	Vacant	Vacant	Vacant	1	2	Vacant	Vacant
Central Region							
Ntcheu	Vacant	1(Senior)	1	1	1	Vacant	Vacant
Lilongwe	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	1
Nkhotakhota	Vacant	1(Senior)	Vacant	1	Vacant	Vacant	1(Senior)
Kasungu	Vacant	Vacant	Vacant	1	1	Vacant	1
Northern Region							
Karonga,	Vacant	Vacant	1	Vacant	1	Vacant	1
Chitipa	Vacant	Vacant	Vacant	Vacant	1	Vacant	1
Rumphi	Vacant	Vacant	Vacant	Vacant	1	Vacant	1
Mzuzu	Vacant	Vacant	Vacant	1	1	1	Vacant

Source: Project Team

b) Observation Management System

Gauge readers have been assigned in operational stations to perform daily observation and data recording. Frequency of water level observation is twice a day (basically 8:00 AM and 4:00 PM) and data recording is in triplicate hardcopy format.

Collection and consolidation of observation records are carried out in the following way:

- The District Officer collects the records from gauge readers basically on a monthly basis. However, this is sometimes discouraged by logistical problems of unavailability of staff, vehicles or fuel.
- One copy of the record is filed at the District Office, a second copy is sent to the Regional Office, and the third copy is sent to the MoAIWD head office in Lilongwe. It takes about two to three months for the data to reach the head office.
- Collected recorded sheets are then input in the hydrological database of HYDSTRA in the head office.

Maintenance conditions are as follows:

- Gauge reader carries out simple maintenance of the gauge like clearance of the site. In case of some serious rehabilitation/replacement such as washing away by flood, it is done by district staff.

However, remuneration to gauge readers is not enough to ensure their commitment. Many stations are not being properly maintained and many gauges are now not even being read because of low remuneration to gauge reader, which is 150 kwacha (less than 1USD) per month. In addition, maintenance by district staff is also constrained by unavailability of staff, vehicles or fuel. As a result, about 70 stations are estimated to need reinstallation or replacement of gauge plates among 136 present operational stations managed by MoAIWD.

c) Data Accumulation and Management System

The Surface Water Division had used the hydrometric database of HYDATA software for the accumulation of hydrological data until the recent year, and then started to migrate the data from HYDATA to HYDSTRA as part of the SADC-HYCOS initiative. Data migration has almost finished, and assistance activities including training in HYDSTRA are being carried out in the ongoing project, the Establishment of Water Resources Monitoring System (MoWDI 2010-2013)

HYDATA Data

Daily data of water level and discharge were collected from the HYDATA database of Surface Water Division of MoAIWD. **Table 3.4.9** and **Table 3.4.10** show the periods of actual available data of water level and discharge, respectively. The years indicated by gray color in these tables means there are some data in the years even though data may not fulfill all the year. Although the data collected periods are various, total 185 stations' water level data and 144 stations' discharge data have been collected. Distribution of water level gauging stations and available period of water level and discharge data are shown in **Figure 3.4.17** and **Figure 3.4.18**, respectively.

HYDSTRA Data

Daily discharge data was collected from the HYDSTRA database of the Surface Water Division of MoAIWD. **Table 3.4.11** shows the periods of actual available data of daily discharge even though some years have a lot of missing data. Totally, 137 stations' data has been collected. Distribution of water level gauging stations and available period of daily discharge are shown in **Figure 3.4.19**.

Table 3.4.9 Data Availability of Daily Water Level (HYDATA Database) (1/2)

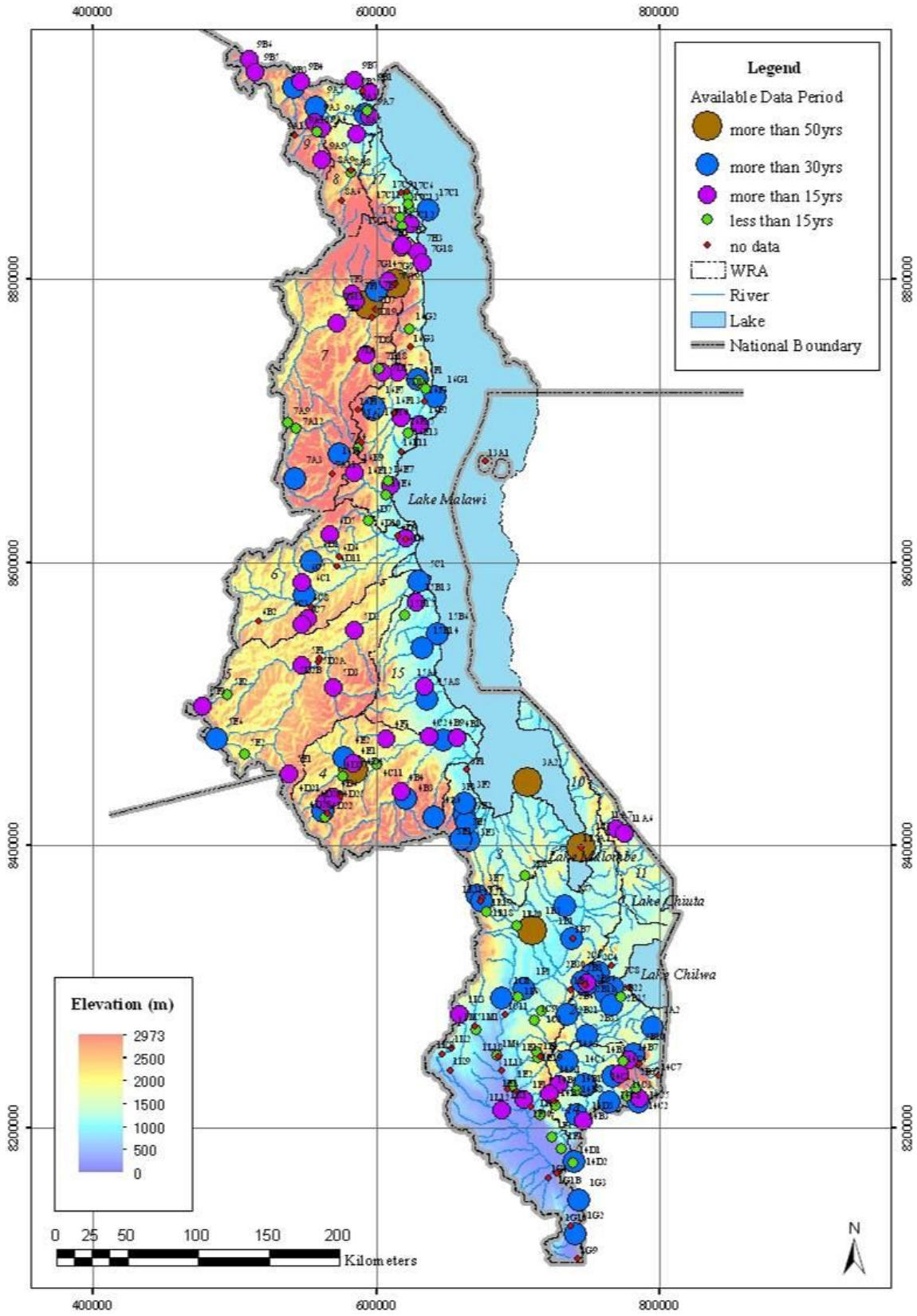
Code	Station Name	No. of Year
1B1	Shire at Liwonde	31
1C1	Lirangwe at Lirangwe	14
1C9	Lunzu at Whayo	4
1E2	Likhubula at Namira	11
1E4	Naperi at Stella Maris School	12
1E19	Mudi at Sunnyside	6
1F1	Mapelera at Mafumbi	21
1F2	Thangadzi East at Gooke	12
1F3	Mlore at Masenjere	10
1F17	Livunzu at Malata	11
1G1	Shire at Chiromo	40
1G2	Shire at Nsanje	41
1G3	Shire at Tengani	34
1I1	Mwanza at Tomali	25
1K1	Mwanza at Tomali	28
1K3	Mwanza at Mwanza Old Customs	27
1M1	Mkurumadzi at Mlongola	15
1M4	Mkurumadzi at Majete Camp	2
1O1	Lisungwe at Moffat	32
1P2	Shire at Matope	46
1P6	Shire at Zalewa	12
1R3	Rivi-Rivi at Balaka	53
1R18	Mpamadzi at Gumbu	37
1R19	Mpira at Gomeza	11
1R20	Rivi-Rivi at Manjawira	7
1S2	Shire at Mvera Point-Malombe Out	32
1S7	Nkasi at Kalembo	37
1T1	Shire at Mangochi	52
2A2	Sombani at Phaloni Hill	32
2B6	Namadzi at Namadzi	49
2B8	Mulunguzi at Zomba Plateau	44
2B10	Phalombe at Phalombe	44
2B11	Mulunguzi at William Falls	45
2B21	Likangala at Nkokanguwo	44
2B22	Thondwe at Jali	40
2B30	Mulunguzi West at No 6 Raingauge	31
2B33	Namadzi at Matiti	37
2B35	Likangala at Irrigation Scheme	6
2B36	Chagwa at Chagwa Dam Outfall	17
2C3	Domasi at Domasi T.T.C.	42
2C4	Domasi By-Pass at Za-Ll Road	35
2C8	Naisi at Mwandama	46
3A2	Lake Malawi at Monkey-Bay	57
3D1	Mtemankhokwe at Nkuchila	6
3E1	Nadzipokwe at Mua Mission	49
3E2	Namikokwe at Mua-Livulezi F.R.	45
3E3	Livulezi at Khwekhwelele	48
3E5	Namikokwe at Kamparikiza	41
3E7	Nkhande at Thobola	47
3F2	Nakaingwa at Songwe	31
3F3	Nadzipulu at Mtakataka	46
4A4	Makanda at Eden Estate	36
4B1	Linthipe at Salima Railbridge	19
4B3	Linthipe at Linthipe	38
4B4	Diamphwe at Chilowa New Bridge	27
4B5	Diamphwe at Chinthakwa 1 VGE	6
4B9	Linthipe at Malapa	37
4B10	Diamphwe at Chilowa New Bridge	16
4C2	Lilongwe at Nkwenembela	16
4C10	Nanjiri at Chingira	6
4C11	Nanjiri at Kadzizila	14
4D4	Lilongwe at Lilongwe Old Town	54
4D6	Lilongwe at Malingunde	22
4D21	Katete at Kaweche	29
4D22	Lilongwe at Dzimbili	14
4D23	Kamuzu Dam at Malingunde	30
4D27	Likuni at Chigwirizano	14
4D29	Chaulongwe at Mamina	36
4E1	Lingadzi at M1 Roadbridge	18
4E2	Lingadzi at S11 Roadbridge	35
4F6	Lumbadzi at Simakumi	26
5C1	Bua at S53 Roadbridge	34
5D1	Bua at Bua Drift	19
5D2	Bua at Old Bua Bridge	33
5D3	Mtiti at Mtiti	22
5E1	Namitete at Namitete Town	28
5E2	Bua at Tembwe	7
5E6	Bua at Mchinji	36
5F1	Rusa at Kasela	19
5F2	Liwelezi at Mkanda	2
5F3	Liwelezi at Matuwamba	18
6C1	Dwangwa at Khwengwere	47
6C3	Chitete at S54 Roadbridge	25
6C5	Mpasadzi at M1 Roadbridge	28
6C7	Chitete Dam Water Works	25
6D1	Mlenje at M1 Roadbridge	35
6D5	Luwelezi at Matundu	29
6D7	Rupache at Kamende	13
6D10	Dwangwa at S53 Roadbridge (D/S)	16
7A3	South Rukuru at Chimsewezo	49
7A4	Mzimba at Muweru Bulukutu	42
7A9	South Rukuru at Kamteteka	15
7A12	South Rukuru at Kamangadazi	12

Source: Project Team

Table 3.4.9 Data Availability of Daily Water Level (HYDATA Database) (2/2)

Code	Station Name	No. of Year
7D8	Lunyangwa at Zombwe	29
7D16	Lunyangwa at Mzuzu Water Works	24
7D17	Lusangazi at Kamweko	16
7D18	Lunyangwa at Mopho Jere	7
7E2	South Rukuru at Kazuni Bridge	18
7F1	Runyina at Chikwawa	29
7F2	South Rumphi at Rumphi	51
7F3	Runyina at Mjuma	30
7G3	Muhuju at Muhuju	28
7G13	Luviri at Ng'onga	32
7G14	South Rukuru at Phwezi	51
7G18	South Rukuru at Mlowe	16
7H1	North Rumphi at Phoka Court	30
7H2	Kaziwiziwi at Kaziwiziwi	16
7H3	North Rumphi at Chiweta	22
8A5	North Rukuru at Mwakimeme	29
8A9	Mibanga at Uledi	10
9A2	Lufira at Ngerenge	49
9A3	Chambo at Chiwona	29
9A4	Lufira at Chilanga	24
9A5	Kalenje at Chipwera	38
9A7	Lufira at Mwakasangila	19
9A8	Lufira Canal at Ngerenge Scheme	15
9A9	Sekwa at Wenga	23
9A10	Mbalizi at Chilanga	10
9B1	Songwe at Mwangulukulu	18
9B3	Kaseye at Mwenebwiba	34
9B4	Songwe at Ichinga	22
9B5	Hanga at David Kameme	22
9B6	Songwe at Ipenza	28
9B7	Songwe at Mwandenga	25
9D1	Songwe at Mwenitende (Norplan)	2
9D2	Songwe at Mpunguti (Norplan)	1
9D3	Songwe at Mwamburi (Norplan)	2
9D5	Kiwira at Mbeya Road Bridge (Norplan)	1
9D6	Songwe at Mapwa (Norplan)	1
9D7	Kiwira at Mbako (Norplan)	2
11A6	Lusangwisi at Nambande Estate	18
11A7	Masongola at Namwera	22
14A1	Namadzi at Henderson Estate	28
14A2	Luchenza at Luchenza	31
14A3	Chisombezi at Midima Road	33
14B1	Kwakwasi at M1 Roadbridge	7
14B2	Thuchila at Chonde	32
14B3	Nswadzi at Chipungu	33
14B4	Nswadzi at Naming'Omba	23
14B5	Nswadzi at Magombe Estate	10
14B6	Thuchila at Kambenje	14
14B7	Likulezi at Daudi	28
14B8	Kwakwasi at Mangunda	14
14C1	Lujeri at Lujeri Estate Weir	11
14C2	Ruo at M1 Roadbridge (Nsuwadzi)	23
14C3	Lichenya at Mini Mini Estate	11
14C4	Chapaluka at Chambe Plateau	21
14C5	Ruo at Ruo Estate	39
14C6	Likabula at Likabula Forestry	33
14C8	Lichenya at Mlonde	43
14D1	Ruo at Sinoya South	12
14D2	Ruo at Sinoya	35
14D3	Ruo at Sandama	23
15A4	Chirua at Mtambe	24
15A8	Lingadzi at Kaniche	39
15B6	Chia Lagoon at Mtanga	36
15B13	Kaombe at Chanika	24
15B14	Lifuliza at Nyoni	34
15B15	Kaombe at M1 Roadbridge	2
16E6	Dwambadzi at Nthanda	14
16E7	Mlowe at Katawa	15
16E9	Luwawa at Magwema	24
16E12	Mlowe at Katawa	21
16E13	Kawiya at Chabizga	15
16F1	Limphasa at Timbiri	15
16F2	Luweya at Zayuka	20
16F5	Luchelemu (Lower) at Mazamba	39
16F6	Luwawa at Kapalapata	36
16F10	Luchelemu at Mazamba Estate	40
16F15	Luweya at Mzenga	17
16F18	Lonjozwa at Kanyoli (Mazamba)	8
16F19	Kalungulo Ta Chikangawa	7
16F20	Limphasa at Kango Village	7
16F21	Kalwe at Chigha Chang'Ombe	8
16G1	Lake Malawi at Nkhata-Bay	42
16G2	Chiwisi at Bula	4
17C1	Lake Malawi at Chilumba	43
17C6	Wovwe at Kapiyira	14
17C10	Hara at Nthipa	16
17C11	Wovwe Intake at Wovwe Scheme	5
17C12	Hara Intake Canal at Hara	8
17C13	Wovwe New Canal at Wovwe	12
17C14	Mantchewe at Mantchewe Falls	11
17C15	Nyungwe at Mcheka-Cheka	11
17C16	Wovwe at Njalayankhunda	5

Source: Project Team



Source: Project Team

Figure 3.4.17 Distribution and Availability of Water Level Data (HYDATA) in 1940's to 2010's

Table 3.4.10 Data Availability of Daily Discharge (HYDATA Database) (1/2)

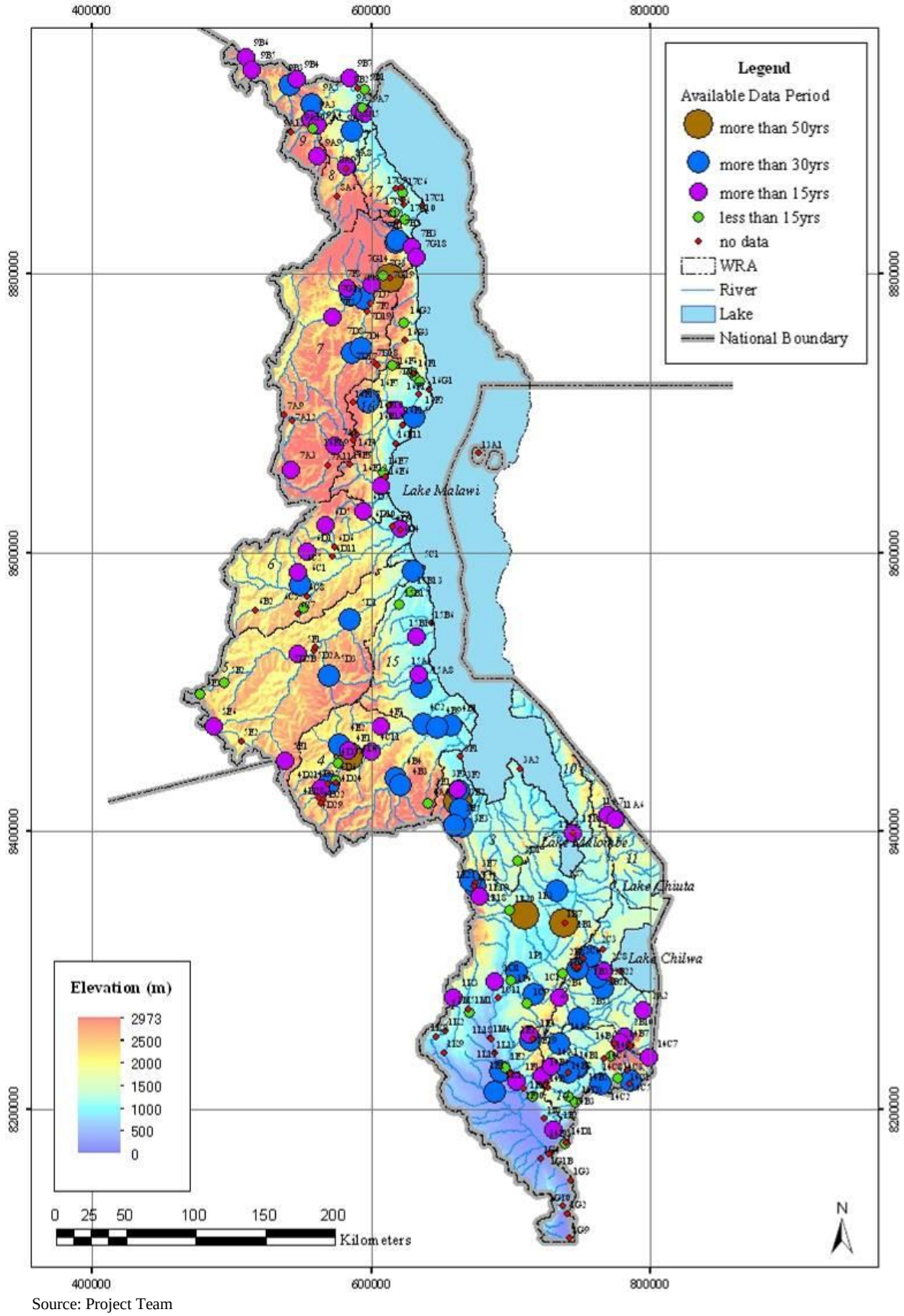
Code	Station Name	No. of Year
1B1	SHIRE AT LIWONDE	63
1B6	KALOTI AT CHANGALUME CEMENT	13
1C1	LIRANGWE AT LIRANGWE	43
1C9	LUNZU AT WHAYO	4
1E2	LIKHUBULA AT NAMIRA	7
1E4	NAPERI AT STELLA MARIS SCHOOL	32
1E19	MUDI AT SUNNYSIDE	27
1F1	MAPELERA AT MAFUMBI	20
1F2	THANGADZI EAST AT GOOKE	25
1F17	LIVUNZU AT MALATA	9
1G1	SHIRE AT CHIROMO	57
1K1	MWANZA AT TOMALI	42
1K2	NG'ONA AT KALANGA	0
1K3	MWANZA AT MWANZA OLD CUSTOMS	17
1K8	NG'ONA AT GAGA	0
1L12	SHIRE AT CHIKWAWA	33
1M1	MKURUMADZI AT MLONGOLA	15
1O1	LISUNGWE AT MOFFAT	16
1P2	SHIRE AT MATOPE	45
1P6	SHIRE AT ZALEWA	11
1R3	RIVI-RIVI AT BALAKA	53
1R18	MPAMADZI AT GUMBU	45
1R19	MPIRA AT GOMEZA	28
1R20	RIVI-RIVI AT MANJAWIRA	7
1S7	NKASI AT KALEMBO	37
1T1	SHIRE AT MANGOCHI	30
2A2	SOMBANI AT PHALONI HILL	28
2B1	LAKE CHILWA AT NGANGALA	0
2B6	NAMADZI AT NAMADZI	21
2B8	MULUNGUZI AT ZOMBA PLATEAU	43
2B9	LIKANGALA AT LAMBULIRA	17
2B10	PHALOMBE AT PHALOMBE	30
2B11	MULUNGUZI AT WILLIAM FALLS	13
2B21	LIKANGALA AT NKOKANGUWO	39
2B22	THONDWE AT JALI	45
2B23	MULUNGUZI AT UPPER DAMBO	0
2B33	NAMADZI AT MATITI	41
2C1	DOMASI AT ZOMBA-LIWONDE ROAD	12
2C3	DOMASI AT DOMASI T.T.C.	43
2C8	NAISI AT MWANDAMA	26
3D1	MTEMANKHOKWE at NKUCHILA	6
3E1	NADZIPOKWE AT MUA MISSION	58
3E2	NAMIKOKWE AT MUA-LIVULEZI F.R.	46
3E3	LIVULEZI AT KHWEKHWELELE	49
3E5	NAMIKOKWE AT KAMPANIKIZA	40
3E7	NKHANDE AT THOBOLA	44
3F2	NAKAINGWA AT SONGWE	29
3F3	NADZIPULU AT MTAKATAKA	46
4A4	MAKANDA AT EDEN ESTATE	15
4B1	LINTHIPE AT SALIMA RAILBRIDGE	46
4B3	LINTHIPE AT LINTHIPE	35
4B4	DIAMPHWE AT CHILOWA NEW BRIDGE	37
4B5	DIAMPHWE AT CHINTHAKWA 1VGE	0
4B9	LINTHIPE AT MALAPA	37
4B10	DIAMPHWE AT CHILOWA NEW BRIDGE	0
4C2	LILONGWE AT NKWENEMBELA	44
4C11	NANJIRI AT KADZIZILA	25
4D4	LILONGWE AT LILONGWE OLD TOWN	56
4D6	LILONGWE AT MALINGUNDE	33
4D21	KATETE AT KAWECHE	23
4D24	LILONGWE AT MASULA	11
4D27	LIKUNI AT CHIGWIRIZANO	6
4D28	LILONGWE AT MAMINA	0
4D29	CHAULONGWE AT MAMINA	0
4E1	LINGADZI AT M1 ROADBRIDGE	25
4E2	LINGADZI AT S11 ROADBRIDGE	42
4F6	LUMBADZI AT SIMAKUMI	24
5C1	BUA AT S53 ROADBRIDGE	49
5C8	KAMUZU ACA D AT MTUNTHAMA	0
5D1	BUA AT BUA DRIFT	35
5D2	BUA AT OLD BUA BRIDGE	46
5D3	MTITI AT MTITI	45
5E1	NAMITETE AT NAMITETE TOWN	28
5E6	BUA AT MCHINJI	23
5F1	RUSA AT KASELA	30
5F2	LIWELEZI AT MKANDA	5
5F3	LIWELEZI AT MATUWAMBA	11
6C1	DWANGWA AT KHWENGWERE	50
6C3	CHITETE AT S54 ROADBRIDGE	15
6C5	MPASADZI AT M1 ROADBRIDGE	18
6D1	MILENJE AT M1 ROADBRIDGE	24
6D5	LUWELEZI AT MATUNDU	25
6D7	RUPACHE AT KAMENDE	17
6D10	DWANGWA AT S53 ROADBRIDGE (D/S)	25

Source: Project Team

Table 3.4.10 Data Availability of Daily Discharge (HYDATA Database) (2/2)

Code	Station Name	No. of Year
7A3	SOUTH RUKURU AT CHIMSEWEZO	30
7A4	MZIMBA AT MUWERU BULUKUTU	24
7A11	SOUTH RUKURU AT MAPANJIRA	0
7A12	SOUTH RUKURU AT KAMANGADAZI	0
7D4	KASITU AT EDUNDU	43
7D7	KASITU AT NJAKWA	0
7D8	LUNYANGWA AT ZOMBWE	42
7D16	LUNYANGWA AT MZUZU WATER WORKS	14
7E2	SOUTH RUKURU AT KAZUNI BRIDGE	18
7F1	RUNYINA AT CHIKWAWA	44
7F2	SOUTH RUMPHI AT RUMPHI	50
7F3	RUNYINA AT MJUMA	20
7G3	MUHUJU AT MUHUJU	9
7G13	LUVIRI AT NG'ONGA	21
7G14	SOUTH RUKURU AT PHWEZI	51
7G18	SOUTH RUKURU AT MLOWE	25
7H1	NORTH RUMPHI AT PHOKA COURT	44
7H2	KAZIWIZIWI AT KAZIWIZIWI	42
7H3	NORTH RUMPHI AT CHIWETA	30
8A2	NORTH RUKURU AT MWANKENJA	5
8A5	NORTH RUKURU AT MWAKIMEME	40
8A6	RUKULU AT MWENESALALA	0
8A8	NORTH RUKURU AT ULEDI	16
9A2	LUFIRA AT NGERENGE	30
9A3	CHAMBO AT CHIWONA	20
9A4	LUFIRA AT CHILANGA	18
9A5	KALENJE AT CHIPWERA	38
9A7	LUFIRA AT MWAKASANGILA	19
9A8	LUFIRA CANAL AT NGERENGE SCHEME	14
9A9	SEKWA AT WENGA	18
9A10	MBALIZI AT CHILANGA	10
9B1	SONGWE AT MWANGULUKULU	4
9B3	KASEYE AT MWENEBWIBA	38
9B4	SONGWE AT ICHINGA	21
9B5	HANGA AT DAVID KAMEME	19
9B6	SONGWE AT IPENZA	28
9B7	SONGWE AT MWANDENGA	25
9D1	SONGWE AT MWENITENDE (NORPLAN)	0
9D2	SONGWE AT MPUNGUTI (NORPLAN)	0
9D3	SONGWE AT MWAMBURI (NORPLAN)	0
9D5	KIWIRA AT MBEYA ROAD BRIDGE (NORPLAN)	0
9D6	SONGWE AT MAPWA (NORPLAN)	0
9D7	KIWIRA AT MBAKO (NORPLAN)	0
11A6	LUSANGWISI AT NAMBANDE ESTATE	21
11A7	MASONGOLA AT NAMWERA	22
14A1	NAMADZI AT HENDERSON ESTATE	20
14A2	LUCHENZA AT LUCHENZA	44
14A3	CHISOMBEZI AT MIDIMA ROAD	39
14B1	KWAKWASI AT M1 ROADBRIDGE	36
14B2	THUCHILA AT CHONDE	45
14B3	NSWADZI AT CHIPUNGU	1
14B4	NSWADZI AT NAMING'OMBA	22
14B7	LIKULEZI AT DAUDI	18
14C2	RUO AT M1 ROADBRIDGE (NSUWADZI)	50
14C3	LICHENYA AT MINI MINI ESTATE	9
14C4	CHAPALUKA AT CHAMBE PLATEAU	6
14C6	LIKABULA AT LIKABULA FORESTRY	0
14C7	MULOZA AT MLELEMBA DRIFT	20
14C8	LICHENYA AT MILONDE	35
14D1	RUO AT SINOYA SOUTH	11
14D3	RUO AT SANDAMA	11
15A4	CHIRUA AT MTAMBE	18
15A8	LINGADZI AT KANICHE	48
15B13	KAOMBE AT CHANIKA	11
15B14	LIFULIZA AT NYONI	29
15B15	KAOMBE AT M1 ROADBRIDGE	3
16E6	DWAMBADZI AT NTHANDA	29
16E7	MLOWE AT KATAWA	2
16E12	MLOWE AT KATAWA	0
16F1	LIMPHASA AT TIMBIRI	12
16F2	LUWEYA AT ZAYUKA	43
16F4	CHIKANGAWA AT VIPHYA	0
16F5	LUCHELEMU (LOWER) AT MAZAMBA	47
16F6	LUWAWA AT KAPALAPATA	6
16F10	LUCHELEMU AT MAZAMBA ESTATE	36
16F15	LUWEYA AT MZENGA	22
16F20	LIMPHASA AT KANGO VILLAGE	0
16F21	KALWE AT CHIGHA CHANG'OMBE	8
16G2	CHIWISI AT BULA	3
17C6	WOVWE AT KAPIYIRA	14
17C10	HARA AT NTHIPA	15
17C15	NYUNGWE AT MCHEKA-CHEKA	4
17C16	WOVWE AT NJALAYANKHUNDA	5

Source: Project Team



Source: Project Team

Figure 3.4.18 Distribution and Availability of Discharge Data (HYDATA) in 1940's to 2010's

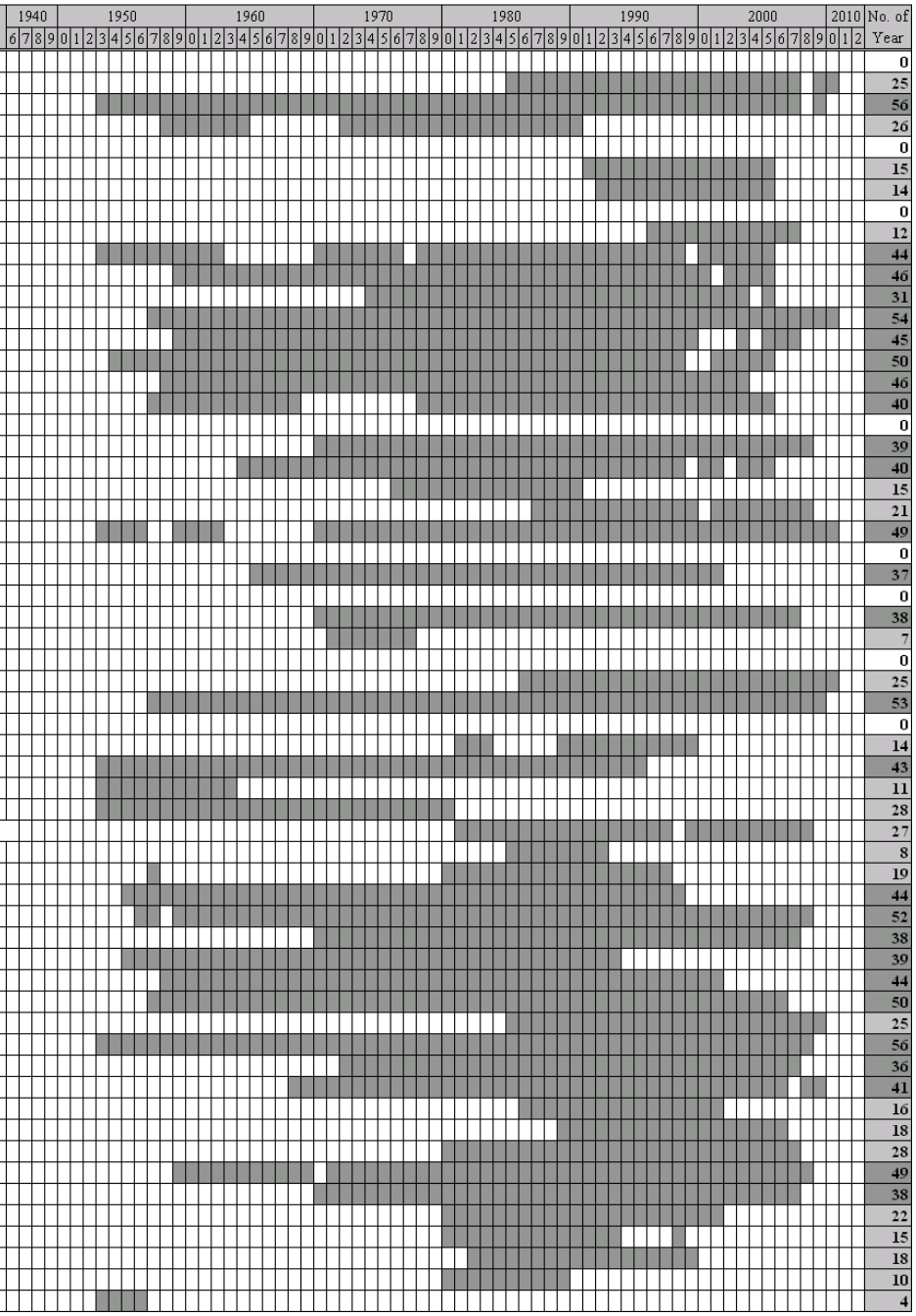
Table 3.4.11 Data Availability of Daily Discharge (HYDSTRA Database) (1/3)

Code	Station Name	1940	1950	1960	1970	1980	1990	2000	2010	No. of Year
		6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2	
1B1	SHIRE AT LIWONDE									63
1C1	LIRANGWE AT LIRANGWE									55
1C9	LUNZU AT WHAYO									0
1E1	MWAMPHANZI AT MPOKONYOLA									52
1E2	LIKHUBULA AT NAMIRA									18
1E4	NAPERI AT STELLA MARIS SCHOOL									0
1E17	NANKHUNDA AT ZINGWANGWA									8
1E19	MUDI AT SUNNYSIDE									25
1F1	MAPELERA AT MAFUMBI									24
1F2	THANGADZI EAST AT GOOKE									39
1F3	MILORE AT MASENJERE									0
1F17	LIVUNZU AT MALATA									19
1F20	NKHATE AT IRRIG. HEADWORKS									3
1G1	SHIRE AT CHIROMO									57
1G2	SHIRE AT NSANJE									0
1G3	SHIRE AT TENGANI									0
1G4	THANGADZI WEST AT NYANTHANA									0
1K1	MWANZA AT TOMALI									46
1K3	MWANZA AT MWANZA OLD CUSTOMS									36
1L12	SHIRE AT CHIKWAWA									33
1M1	MKURUMADZI AT MLONGOLA									25
1M4	MKURUMADZI AT MAJETE CAMP									2
1O1	LISUNGWE AT MOFFAT									20
1P2	SHIRE AT MATOPE									53
1P6	SHIRE AT ZALEWA									14
1R3	RIVI-RIVI AT BALAKA									53
1R18	MPAMADZI AT GUMBU									46
1R19	MPIRA AT GOMEZA									32
1R20	RIVI-RIVI AT MANJAWIRA									7
1S2	SHIRE AT MVERA POINT-MALOMBE OUT									0
1S7	NKASI AT KALEMBO									37
2A2	SOMBANI AT PHALONI HILL									0
2B1	LAKE CHILWA AT NGANGALA									0
2B6	NAMADZI AT NAMADZI									58
2B8	MULUNGUZI AT ZOMBA PLATEAU									50
2B10	PHALOMBE AT PHALOMBE									44
2B21	LIKANGALA AT NKOKANGUWO									44
2B22	THONDWE AT JALI									51
2B30	MULUNGUZI WEST AT NO 6 RAINGAUGE									0
2B33	NAMADZI AT MATITI									49
2B35	LIKANGALA AT IRRIGATION SCHEME									0
2C3	DOMASI AT DOMASI T.T.C.									53
2C4	DOMASI BY-PASS AT ZA-LL ROAD									35
2C8	NAISI AT MWANDAMA									46
2C10	LAKE CHILWA AT KACHULU									0
3D1	MTEMANKHOKWE at NKUCHILA									6
3E1	NADZIPOKWE AT MUA MISSION									58
3E2	NAMIKOKWE AT MUA-LIVULEZI F.R.									47
3E3	LIVULEZI AT KHWEKHWELELE									52
3E5	NAMIKOKWE AT KAMPANIKIZA									44
3E7	NKHANDE AT THOBOLA									47
3F2	NAKAINGWA AT SONGWE									31
3F3	NADZIPULU AT MTAKATAKA									46
4A4	MAKANDA AT EDEN ESTATE									0
4B3	LINTHIPE AT LINTHIPE									51
4B4	DIAMPHWE AT CHILOWA NEW BRIDGE									54
4B9	LINTHIPE AT MALAPA									37
4B10	DIAMPHWE AT CHILOWA NEW BRIDGE									0
4C2	LILONGWE AT NKWENEMBELA									46

Source: Project Team

Table 3.4.11 Data Availability of Daily Discharge (HYDSTRA Database) (2/3)

Code	Station Name	No. of Year
4C10	NANJIRI AT CHINGIRA	0
4C11	NANJIRI AT KADZIZILA	25
4D4	LILONGWE AT LILONGWE OLD TOWN	56
4D6	LILONGWE AT MALINGUNDE	26
4D23	KAMUZU DAM AT MALINGUNDE	0
4D24	LILONGWE AT MASULA	15
4D27	LIKUNI AT CHIGWIRIZANO	14
4D28	LILONGWE AT MAMINA	0
4D29	CHAULONGWE AT MAMINA	12
4E1	LINGADZI AT M1 ROADBRIDGE	44
4E2	LINGADZI AT S11 ROADBRIDGE	46
4F6	LUMBADZI AT SIMAKUMI	31
5C1	BUA AT S53 ROADBRIDGE	54
5D1	BUA AT BUA DRIFT	45
5D2	BUA AT OLD BUA BRIDGE	50
5D3	MTITI AT MTITI	46
5E1	NAMITETE AT NAMITETE TOWN	40
5E2	BUA AT TEMBWE	0
5E6	BUA AT MCHINJI	39
5F1	RUSA AT KASELA	40
5F2	LIWELEZI AT MKANDA	15
5F3	LIWELEZI AT MATUWAMBA	21
6C1	DWANGWA AT KHWENGWERE	49
6C3	CHITETE AT S54 ROADBRIDGE	0
6C5	MPASADZI AT M1 ROADBRIDGE	37
6C7	CHITETE DAM WATER WORKS	0
6D1	MILENJE AT M1 ROADBRIDGE	38
6D4	DWANGWA AT S53 ROADBRIDGE	7
6D5	LUWELEZI AT MATUNDU	0
6D10	DWANGWA AT S53 ROADBRIDGE (D/S)	25
7A4	MZIMBA AT MUWERU BULUKUTU	53
7A9	SOUTH RUKURU AT KAMTETEKA	0
7A11	SOUTH RUKURU AT MAPANJIRA	14
7D4	KASITU AT EDUNDU	43
7D5	LUNYANGWA AT MZUZU	11
7D8	LUNYANGWA AT ZOMBWE	28
7D16	LUNYANGWA AT MZUZU WATER WORKS	27
7D18	LUNYANGWA AT MOPHO JERE	8
7E2	SOUTH RUKURU AT KAZUNI BRIDGE	19
7F1	RUNYINA AT CHIKWAWA	44
7F2	SOUTH RUMPHI AT RUMPHI	52
7F3	RUNYINA AT MJUMA	38
7G3	MUHUJU AT MUHUJU	39
7G13	LUVIRI AT NG'ONGA	44
7G14	SOUTH RUKURU AT PHWEZI	50
7G18	SOUTH RUKURU AT MLOWE	25
7H2	KAZIWIZIWI AT KAZIWIZIWI	56
7H3	NORTH RUMPHI AT CHIWETA	36
8A5	NORTH RUKURU AT MWAKIMEME	41
8A8	NORTH RUKURU AT ULEDI	16
8A9	MIBANGA AT ULEDI	18
9A2	LUFIRA AT NGERENGE	28
9A3	CHAMBO AT CHIWONA	49
9A5	KALENJE AT CHIPWERA	38
9A7	LUFIRA AT MWAKASANGILA	22
9A8	LUFIRA CANAL AT NGERENGE SCHEME	15
9A9	SEKWA AT WENGA	18
9A10	MBALIZI AT CHILANGA	10
9B1	SONGWE AT MWANGULUKULU	4

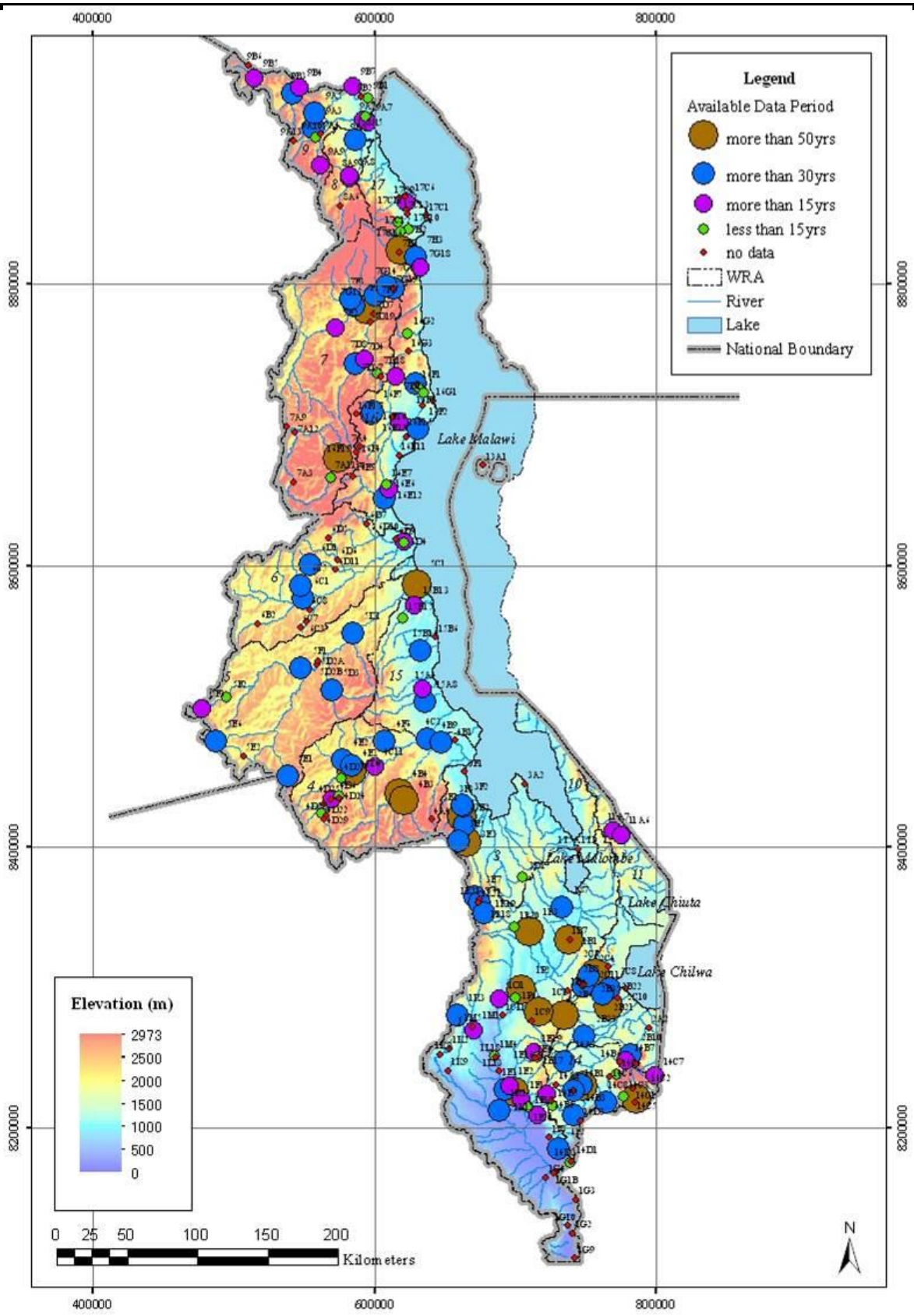


Source: Project Team

Table 3.4.11 Data Availability of Daily Discharge (HYDSTRA Database) (3/3)

Code	Station Name	1940	1950	1960	1970	1980	1990	2000	2010	No. of Year
		6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2	
9B3	KASEYE AT MWENEBWIBA									38
9B4	SONGWE AT ICHINGA									21
9B5	HANGA AT DAVID KAMEME									25
9B7	SONGWE AT MWANDENGA									25
9D1	SONGWE AT MWENITENDE (NORPLAN)									0
9D2	SONGWE AT MPUNGUTI (NORPLAN)									0
9D3	SONGWE AT MWAMBURI (NORPLAN)									0
11A6	LUSANGWISI AT NAMBANDE ESTATE									21
11A7	MASONGOLA AT NAMWERA									22
14A2	LUCHENZA AT LUCHENZA									47
14A3	CHISOMBEZI AT MIDIMA ROAD									39
14B1	KWAKWASI AT M1 ROADBRIDGE									36
14B2	THUCHILA AT CHONDE									51
14B3	NSWADZI AT CHIPUNGU									49
14B4	NSWADZI AT NAMING'OMBA									23
14B5	NSWADZI AT MAGOMBE ESTATE									10
14B6	THUCHILA AT KAMBENJE									0
14B7	LIKULEZI AT DAUDI									28
14C1	LUJERI AT LUJERI ESTATE WEIR									0
14C2	RUO AT M1 ROADBRIDGE (NSUWADZI)									55
14C3	LICHENYA AT MINI MINI ESTATE									11
14C4	CHAPALUKA AT CHAMBE PLATEAU									6
14C5	RUO AT RUO ESTATE									0
14C6	LIKABULA AT LIKABULA FORESTRY									0
14C7	MULOZA AT MLELEMBA DRIFT									28
14C8	LICHENYA AT MILONDE									43
14D1	RUO AT SINOYA SOUTH									12
14D3	RUO AT SANDAMA									0
15A4	CHIRUA AT MTAMBE									24
15A8	LINGADZI AT KANICHE									46
15B6	CHIA LAGOON AT MTANGA									0
15B13	KAOMBE AT CHANIKA									24
15B14	LIFULIZA AT NYONI									34
15B15	KAOMBE AT M1 ROADBRIDGE									1
16E6	DWAMBADZI AT NTHANDA									37
16E7	MLOWE AT KATAWA									15
16E12	MLOWE AT KATAWA									21
16E13	KAWIYA AT CHABIZGA									0
16F1	LIMPHASA AT TIMBIRI									15
16F2	LUWEYA AT ZAYUKA									43
16F5	LUCHELEMU (LOWER) AT MAZAMBA									39
16F6	LUWAWA AT KAPALAPATA									37
16F10	LUCHELEMU AT MAZAMBA ESTATE									40
16F13	LIMPHASA AT LIMPHASA SCHEME									0
16F15	LUWEYA AT MZENGA									22
16F19	KALUNGULO TA CHIKANGAWA									0
16F20	LIMPHASA AT KANGO VILLAGE									0
16F21	KALWE AT CHIGHA CHANG'OMBE									8
16G1	LAKE MALAWI AT NKHATA-BAY									0
16G2	CHIWISI AT BULA									4
17C1	LAKE MALAWI AT CHILUMBA									0
17C6	WOVWE AT KAPIYIRA									24
17C10	HARA AT NTHIPA									15
17C11	WOVWE INTAKE AT WOVWE SCHEME									0
17C12	HARA INTAKE CANAL AT HARA									8
17C13	WOVWE NEW CANAL AT WOVWE									0
17C14	MANTCHEWE AT MANTCHEWE FALLS									0
17C15	NYUNGWE AT MCHEKA-CHEKA									11
17C16	WOVWE AT NJALAYANKHUNDA									5

Source: Project Team



Source: Project Team

Figure 3.4.19 Distribution and Availability of Discharge Data (HYDSTRA) in 1940s-2010s

(iii) Discharge Measurement

a) Discharge Measurement

Discharge measurement has been and is being carried out by staff of the district water offices of MoAIWD using several types of propeller current meters. Discharge measurement in high flow has been carried out using propeller current meters from bridge or using cableway not using float since float measurement has not been common in MoAIWD.

Flood camping (where teams went out in the field during the wet season months to measure discharge at high flows) were conducted every season in the 1980's, but no flood camping has been done since the early 1990's. Then, at present certain districts still undertake discharge measurement fairly regularly several times a year, but in some districts no measurement has been undertaken in many years. Frequency of discharge measurement in each station is summarized in **Table 3.4.11**, which was prepared from the data of HYDATA. In the table, columns with gray or black color indicate the year when discharge measurement was carried out less than 10 times per year or more than 10 times, respectively. Numbers in the columns denote frequency of discharge measurement. Discharge measurement has been recorded only at several stations in WRA-1, 3, 4, 5, 7 and 9 since the late 2000's although a lot of measurements were implemented in every WRA in the 1980's and early 1990's.

In addition, regarding the equipment in the district offices, in general, the conditions of survey equipment are fairly good but the flow meters are fairly bad[9].

Table 3.4.12 Status of Implementation of Discharge Measurement (1/4)

Code	Station Name	Frequency of Discharge Measurement																																									Number of Years by Annual Frequency of Discharge Measurement			No. of Rating Curves	
		1970										1980										1990										2000										2010							
		0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	0< <10 /year	10≦ /year	0< /year	1900s	2000s
1B1	SHIRE AT LIWONDE																				2	27	12	11		16	2	5	5	5			1		1		1		5						9	4	13	1	1
1B6	KALOTI AT CHANGALUME CEMENT																																												0	0	0	0	0
1C1	LIRANGWE AT LIRANGWE									5	18	20	7	4	9	8	8	6	10	11	8	10	9	9	4	8	2	8	7	7	6	8	7	4											20	5	25	1	1
1C9	LUNZU AT WHAYO													6	10	9	4	8	10	11	9	10	5	8	4	6	3	8	5	4	6	8	6	4											17	4	21	1	0
1C11	SHIRE AT TEDZANI																																												0	0	0	0	0
1E1	MWAMPHANZI AT MPOKONYOLA												3	9	9	7	6	11	11	12	11	12	10	10	9	7	4	6	5	7	1	4	3	1	1										16	7	23	6	1
1E2	LIKHUBULA AT NAMIRA											19	23	10	6		6	10	10	11	7	10	9	10	8	7	3	6	5	6	1	1													12	8	20	8	0
1E4	NAPERI AT STELLA MARIS SCHOOL													8	10	7	6	10	8			6	6	7	2	6	3	3	1	3				1											14	2	16	0	0
1E17	NANKHUNDA AT ZINGWANGWA																		1	1		5	1	2	1	6	4	6	1	2															11	0	11	2	0
1E19	MUDI AT SUNNYSIDE												7	5	3	6	6	9	9	11	13	10	5	8	3	5	6	5	2	3				1											16	3	19	1	1
1F1	MAPELERA AT MAFUMBI										11	4		7	9	7	10	11	10	12	11	11	12	10	10	8	4	7	6	7	3	5	4												12	10	22	6	1
1F2	THANGADZI EAST AT GOOKE										11	21	22	10	9	26	8	18	14	16	10	12	12	10	7	6	3	6	2	5	2	5	3												11	12	23	4	1
1F3	MILORE AT MASENJERE																																												0	0	0	0	0
1F17	LIVUNZU AT MALATA												4	9	9	7	9	9	10	12	11	12	11	10	9	5	3	7	4																11	6	17	8	0
1F20	NKHATE AT IRRIG. HEADWORKS												2	11	9	8	9	9	10	12	11	12	13	10	9	8	5	5	5	5	3	5	4												14	7	21	0	0
1G1	SHIRE AT CHIROMO										4	34	6	8	12	5	8	8	10	9	7	30	12	1	3	4	1	2		3															14	5	19	2	1
1G4	THANGADZI WEST AT NYANTHANA																																												0	0	0	0	0
1G10	NYAMADZERE AT MCHACHA REST HOUSE																																												0	0	0	0	0
1K1	MWANZA AT TOMALI													6	1		8	7	6	10	7	9	7	2	5																				10	1	11	1	0
1K2	NG'ONA AT KALANGA												9	4	1	5	9	7	9	9	6	10	9	5	8	9	2	6	5	7	5	8	5	1											21	1	22	7	1
1K3	MWANZA AT MWANZA OLD CUSTOMS										11	17	9	8	9	10	9	11	12	8	11	11	11	13	8	10	6	9	6	6	6	7	7	4											14	10	24	3	2
1K8	NG'ONA AT GAGA												8	9	1	5	7	6	8	11	6	11	7	6	7	8	3	9	2																15	2	17	3	0
1K9	MWANZA AT JASICHINDOKO																																												0	0	0	0	0
1L12	SHIRE AT CHIKWAWA								2	7	20	25	22	4	7	7	8	11	11	11	11	25	15	3	4	7	4	2	1	4															13	9	22	1	1
1L13	SHIRE AT MAGANGA SOUTH																																												0	0	0	0	0
1M1	MKURUMADZI AT MLONGOLA											3	10	8	10	10	7	9	12	10	10	15	11	11	8	8	3	8	6	5	5		5	3											13	9	22	8	1
1M4	MKURUMADZI AT MAJETE CAMP											2	20	10	9	6	6	7	15	16	6	9	9	10	6	7	3	5	1	5		3	2												16	5	21	2	1
1O1	LISUNGWE AT MOFFAT											2	22	3	7	10	5	17	17	11	11	10	7	11	9	7	4	6	6	6	6	6	6	2											15	8	23	0	0
1P2	SHIRE AT MATOPE									3	81	3						4	11	4	5	11	4	1		4	1																		9	3	12	1	1
1P6	SHIRE AT ZALEWA																		1	8	10	18	10	4	4	6	1																		6	3	9	1	1
1R3	RIVI-RIVI AT BALAKA												8	9	8	8	10	22	12	10	10	11	8	8	8	6	2	5	4	1		2													13	6	19	1	1
1R18	MPAMADZI AT GUMBU															1	4	9	12	10	9	12	12	4	6			6	5	2		3		1											11	4	15	1	1
1R19	MPIRA AT GOMEZA												2	10	9	11	11	11	13	10	9	11	12	11	8	5	6	5	6	1		3		1											11	9	20	6	1
1R20	RIVI-RIVI AT MANJAWIRA												10	20	9	8	10	6	11																										3	4	7	1	0
1S2	SHIRE AT MVERA POINT-MALOMBE OUT																																												0	0	0	0	0
1S7	NKASI AT KALEMBO											13	3	14		5	5	7	10	8	9	13	19	5	7	7	3	3	3	2															13	5	18	6	1
1T1	SHIRE AT MANGOCHI														3	3	12	5	12	8	12	12	7				2	8	3			1													9	4	13	1	1
2A2	SOMBANI AT PHALONI HILL																																												0	0	0	0	0
2B6	NAMADZI AT NAMADZI											15	13	12	10	7	8	8	12	8	12	10	11	10	9	9	5	6	5	5	5	7	7	6											14	9	23	4	1
2B8	MULUNGUZI AT ZOMBA PLATEAU									1	8	7									11	14	8	13	12	15	4	8	4	3															18	5	23	3	0
2B10	PHALOMBE AT PHALOMBE																	2	9	12	11	10	8	11	9	10	5	6	5																7	5	12	3	0
2B11	MULUNGUZI AT WILLIAM FALLS																				10	12	6	10	9	6	2	7	4	5	6	7	5	2											11	3	14	3	1
2B21	LIKANGALA AT NKOKANGUWO													8	9	9	8	6	11	10	9	7	10	9	6	7	4	7	3	5	4	7	5	4											18	3	21	6	1
2B22	THONDWE AT JALI													6	9	9	10	7	13	10	11	11	11	8	9	2				2	5	5	5	4											12	6	18	1	1
2B23	MULUNGUZI AT UPPER DAMBO																				8	9	7	10	8	1	1																		6	1	7	1	1
2B30	MULUNGUZI WEST AT NO 6 RAINGAUGE										2	3													1	5																			4	0	4	0	0
2B33	NAMADZI AT MATITI										5			2	9	38	6	8	10	11	11	8	7	9	3	6	3	7	4	3	1	6	5	3											18	4	22	5	2
2B35	LIKANGALA AT IRRIGATION SCHEME																																												0	0	0	0	0
2B36	CHAGWA AT CHAGWA DAM OUTFALL																																												0	0	0	0	0
2C3	DOMASI AT DOMASI T.T.C.								4	65	13	15								10	9	5	5	11	6	8	2	7	6	5	5	6	5	4											14	5	19	3	1
2C4	DOMASI BY-PASS AT ZA-LL ROAD																				8	5	7	10	7	9	4	7	5																8	1	9	5	0
2C8	NAISI AT MWANDAMA																						1			2	4	5	6	3	6	3	4	3											10	0	10	2	1
2C11	DOMASI AT MPHETA RICE SCHEME																																												0	0	0	0	0
3A2	LAKE MALAWI AT MONKEY-BAY																																												0	0	0	0	0

(light grey): Discharge measurement was conducted from once to 10 times per year

(dark): Discharge measurement was conducted more than 10 times per year

Source: Project Team

Table 3.4.12 Status of Implementation of Discharge Measurement (2/4)

Code	Station Name	Frequency of Discharge Measurement (1970 0 1 2 3 4 5 6 7 8 9 | 1980 0 1 2 3 4 5 6 7 8 9 | 1990 0 1 2 3 4 5 6 7 8 9 | 2000 0 1 2 3 4 5 6 7 8 9 | 2010 0 1 2)	Number of Years by Annual Frequency of Discharge Measurement: 0< <10 /year	10≦ /year	0< /year	No. of Rating Curves: 1900s	2000s
3D1	MTEMANKHOKWE at NKUCHILA	1990: 4 4 5 4 1 | 2000: 1	5	0	5	1	1
3E1	NADZIPOKWE AT MUA MISSION	1980: 4 10 10 12 9 13 11 12 9 11 | 1990: 10 12 10 8 5 2 5 5 1 | 2000: 4 1 | 2010: 2 1	13	10	23	1	1
3E2	NAMIKOKWE AT MUA-LIVULEZI F.R.	1980: 15 10 5 9 8 8 6 13 9 9 | 1990: 10 12 10 8 7 3 4 1 | 2000: 4	13	6	19	1	1
3E3	LIVULEZI AT KHWEKHWELELE	1980: 5 15 5 9 5 8 5 7 8 8 | 1990: 7 12 8 5 7 3 4 3 2 | 2000: 2	18	2	20	6	1
3E5	NAMIKOKWE AT KAMPANIKIZA	1980: 1	1	0	1	6	1
3E7	NKHANDE AT THOBOLA	1980: 5 3 1 2 3 10 10 10 12 | 1990: 7 2 7 7 5 6 6 2 | 2000: 2 1	15	4	19	2	1
3F2	NAKAINGWA AT SONGWE	1980: 2 10 11	1	2	3	1	0
3F3	NADZIPULU AT MTAKATAKA	1980: 6 13 4 6 8 7 3 9 9 8 | 1990: 9 11 9 8 7 4 5 1 | 2000: 3	17	2	19	1	1
4A4	MAKANDA AT EDEN ESTATE	1980: 4 2 1 | 1990: 4 10 10 7 3 7 5 3 | 2000: 4 2	11	2	13	2	1
4B1	LINTHIPE AT SALIMA RAILBRIDGE	1980: 2 8 10 7 5 3 1 7 | 1990: 11 12 11 9 7 5 7 8 5 1 | 2000: 4	15	4	19	5	1
4B3	LINTHIPE AT LINTHIPE	1980: 2 10 6 8 13 14 12 8 11 | 1990: 12 11 9 8 6 6 6 4 | 2000: 3 2 3	14	7	21	3	1
4B4	DIAMPHWE AT CHILOWA NEW BRIDGE	1980: 6 3 9 3 3 11 10 20 | 1990: 15 17 9 9 6 6 8 7 1	12	5	17	1	1
4B5	DIAMPHWE AT CHINTHAKWA 1 VGE	2000: 3 13 11 3 14	2	3	5	0	0
4B9	LINTHIPE AT MALAPA	1970: 15 106 1 | 1980: 12 12 9 6 | 2000: 1	4	4	8	2	1
4B10	DIAMPHWE AT CHILOWA NEW BRIDGE		0	0	0	0	0
4C2	LILONGWE AT NKWENEMBELA	1970: 1 | 1980: 7 13 6 13 6 8 19 10 7 6 | 1990: 6 7 11 9 7 4 5 5 1 | 2010: 1	16	5	21	2	1
4C10	NANJIRI AT CHINGIRA		0	0	0	0	0
4C11	NANJIRI AT KADZIZILA	1980: 4 9 8 9 10 | 1990: 12 11 10 8 2 2 5 3 2 | 2000: 3 2 1 2 2 1	16	4	20	3	1
4D4	LILONGWE AT LILONGWE OLD TOWN	1980: 15 9 6 7 6 4 2 9 7 | 1990: 10 11 12 6 8 2 6 5 5 1	15	4	19	1	1
4D6	LILONGWE AT MALINGUNDE	1980: 6 12 8 8 8 11 10 7	5	3	8	1	1
4D21	KATETE AT KAWECHE	1980: 1 10 6 6 9 9 7 2 8 | 1990: 11 10 8 8 7 6 9 5 1	15	3	18	4	0
4D22	LILONGWE AT DZIMBILI		0	0	0	0	0
4D24	LILONGWE AT MASULA	1990: 8 4 1 | 2000: 1 1 2 1	7	0	7	2	1
4D27	LIKUNI AT CHIGWIRIZANO	1990: 1 9 9 7 5 5 2 1 | 2000: 1 1 1	11	0	11	4	0
4D28	LILONGWE AT MAMINA		0	0	0	0	0
4D29	CHAULONGWE AT MAMINA	1990: 3 3 1 | 2000: 2 1 2 1	7	0	7	1	1
4E1	LINGADZI AT M1 ROADBRIDGE	1980: 16 8 5 6 11 7 12 10 10 | 1990: 11 10 7 8 4 2 8 3 1 | 2000: 1 1 4	14	7	21	1	1
4E2	LINGADZI AT S11 ROADBRIDGE	1980: 2 8 8 8 11 8 8 6 11 | 1990: 12 9 7 5 4 8 6 1 | 2000: 3 1 1 1	18	3	21	4	0
4F6	LUMBADZI AT SIMAKUMI	1970: 1 | 1980: 12 20 17 11 11 6 13 11 13 12 12 | 1990: 11 12 10 9 7 7 8 5 1 | 2000: 5 5 3 2 1	13	13	26	1	1
5C1	BUA AT S53 ROADBRIDGE	1980: 17 7 11 8 8 8 4 4 | 1990: 1 12 12 9 7 4 8 1 | 2000: 3 1 1	15	4	19	1	1
5C8	KAMUZU ACA D AT MTUNTHAMA	1980: 5 | 1990: 7 3 8 4 1	6	0	6	0	0
5D1	BUA AT BUA DRIFT	1980: 1 6 6 5 2 4 23 9 19 8 | 1990: 11 11 9 8 7 1 4 2 1 | 2000: 1	16	4	20	1	1
5D2	BUA AT OLD BUA BRIDGE	1980: 2 19 10 9 7 6 4 13 7 5 8 | 1990: 12 11 9 8 7 2 3	13	5	18	1	1
5D2_01	BUA AT OLD BUA BRIDGE - 5D2(A)	1980: 2 10 9 7 6 4 19 7 1	7	2	9	1	1
5D2_02	BUA AT M1 ROAD BRIDGE - 5D2(B)	1980: 4 9 11 9 9	4	1	5	1	0
5D3	MTITI AT MTITI	1980: 2 19 11 8 11 12 9 10 14 | 1990: 12 8 4 8 5 2 4 6 3 1 | 2000: 1 1	14	7	21	5	1
5E1	NAMITETE AT NAMITETE TOWN	1970: 8 | 1980: 11 20 17 14 9 8 12 11 13 13 13 | 1990: 8 12 10 9 7 4 6 6 2 | 2000: 3 1 3 1 1 1 2 1 | 2010: 1	19	11	30	9	1
5E2	BUA AT TEMBWE		0	0	0	0	0
5E6	BUA AT MCHINJI	1980: 3 12 13 10 10 12 10 10 11 9 | 1990: 12 11 7 8 7 7 10 5 2 | 2000: 3 2 4 1 1 1 1 1	16	11	27	1	1
5F1	RUSA AT KASELA	1980: 2 3 10 5 3 4 8 12 23 6 9 | 1990: 11 10 9 8 5 2 4 3 1 | 2000: 1	16	5	21	10	1
5F2	LIWELEZI AT MKANDA	1980: 5 20 26 10 8 12 9 9 10 12 10	4	7	11	1	1
5F3	LIWELEZI AT MATUWAMBA	1980: 4 10 11 12 11 11 9 7 5 8 6 1 | 1990: 1 | 2000: 3 1 1 1	12	5	17	1	1
6C1	DWANGWA AT KHWENGWERE	1980: 6 5 5 6 14 15 6 8 9 10 11 8 3 2 6 2 | 2000: 1	13	4	17	2	1
6C3	CHITETE AT S54 ROADBRIDGE	1980: 1	1	0	1	0	0
6C5	MPASADZI AT M1 ROADBRIDGE	1980: 4 3 10 7 5 8 23 9 18 8 12 10 9 9 6 4 6 4	13	5	18	4	0
6D1	MILENJE AT M1 ROADBRIDGE	1980: 2 8 9 6 4 6 10 8 5 10 12 6	9	3	12	4	1
6D4	DWANGWA AT S53 ROADBRIDGE		0	0	0	0	0
6D5	LUWELEZI AT MATUNDU	1980: 2 12 11 8 9 12 12 12 11 19 18 9 9 9	6	8	14	1	0
6D6	LUWELEZI AT CHIWEYU		0	0	0	0	0
6D7	RUPACHE AT KAMENDE	1980: 5 5 2 7 9 11 10 9 10 11 9 9 8 5 6 4	12	4	16	2	1
6D9	RUPACHE AT CHIKANJE		0	0	0	0	0
6D10	DWANGWA AT S53 ROADBRIDGE (D/S)	1980: 7 12 1 5 8 4 3 7 11 12 13 10 7 7 5 1 | 2000: 4	12	5	17	1	1
7A3	SOUTH RUKURU AT CHIMSEWEZO	1980: 2 9 12 12 8 12 12 6 10 9 4 5 2 2 3 | 2000: 6 6 1	13	5	18	2	1
7A4	MZIMBA AT MUWERU BULUKUTU	1980: 2 53 11 10 11 14 15 10 10 12 12 12 12 7 1 3 | 2000: 6 5 3	7	12	19	4	1

: Discharge measurement was conducted from once to 10 times per year

: Discharge measurement was conducted more than 10 times per year

Source: Project Team

Table 3.4.12 Status of Implementation of Discharge Measurement (3/4)

Code	Station Name	Frequency of Discharge Measurement																																						Number of Years by Annual Frequency of Discharge Measurement			No. of Rating Curves	
		1970										1980										1990										2000										2010					
		0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	0< <10 /year	10≦ /year	0< /year	1900s	2000s
7A9	SOUTH RUKURU AT KAMTETEKA																																												0	0	0	0	0
7A11	SOUTH RUKURU AT MAPANJIRA																				4	12	11	11	10	7				1	3	1	6	3												7	4	11	3	1
7A12	SOUTH RUKURU AT KAMANGADAZI																				2	5	6	6	11	7																			5	1	6	1	1
7D4	KASITU AT EDUNDU						2	4	4	8	4	12	8	8	8	8	8	7	8	6	9	9	8	11	9	7																			18	2	20	5	0
7D7	KASITU AT NJAKWA														2	61	12	11	12	12	13	3																							2	6	8	1	0
7D8	LUNYANGWA AT ZOMBWE															2	10	8	12	12	9	12	12	12	12	7	7	5	6	2	3	5	6	2											12	7	19	3	1
7D16	LUNYANGWA AT MZUZU WATER WORKS												2	18	18	4			1							2	5	6	8	3															8	2	10	2	1
7D17	LUSANGAZI AT KAMWEKO																	6	11	8	8	12	10	12	8	9	5	4	6	3	5	6	6	1											13	4	17	3	1
7D18	LUNYANGWA AT MOPHO JERE																	7	11	9	8	1																							4	1	5	2	1
7E2	SOUTH RUKURU AT KAZUNI BRIDGE											3	15	10	10	12	12	11	10	25	12	7	8	6	11	2																			5	10	15	3	1
7F1	RUNYINA AT CHIKWAWA													2		10	6	8	11	12	12	10	6	5	7	3																			7	5	12	1	0
7F2	SOUTH RUMPHI AT RUMPHI												2	1			7	8	10	12	10	8	6	8	11	6	1	3	2	1		5	3											14	4	18	1	1
7F3	RUNYINA AT MJUMA											4	14	10	12	12	11	36	11	12	12	5	5	9	12	3			1	1	3	6	5											10	10	20	1	1
7G3	MUHUJU AT MUHUJU													2	12	13	12	12	12	12	12	12	12	12	12	10	9	7	4	2	3	7	6											8	12	20	3	1
7G13	LUVIRI AT NG'ONGA												2	12	13	13	13	13	12	12	12	12	11	12	12	10	9	7	4	2	2	8	8	1										9	13	22	1	1
7G14	SOUTH RUKURU AT PHWEZI													2	6	4	2		2		5	20	51	11	6								1											9	3	12	1	1
7G18	SOUTH RUKURU AT MLOWE																2	6				13	24	10	11	8	2	2	3	3	1	2	1												10	4	14	2	1
7H1	NORTH RUMPHI AT PHOKA COURT	1	2						1	8		4	9	10	6	9	3		1	3			9	12	12	7		2	1	1	1	5	4						1					20	3	23	1	1
7H2	KAZIWIZIWI AT KAZIWIZIWI											4	13	32	39	13	12	11	12	12	12	12	12	12	11	8	3	6	3	1		6	6											8	13	21	1	1
7H3	NORTH RUMPHI AT CHIWETA			1	5	9	15	21	15	12	5	9	9	11	21	12	12	36	10	27	10	7	12	12	12	8	3	2	3	2	1	3	3											15	15	30	1	1
8A5	NORTH RUKURU AT MWAKIMEME											2	12	11	10	6	10	30	11	11	9	9	12	12	12	8	6	2	4		1	2	1											11	10	21	1	1
8A6	RUKULU AT MWENESALALA																																											0	0	0	0	0
8A8	NORTH RUKURU AT ULEDI																	1	12	10	11	11	8	9	9	11	7		4	2	2	2	3	4	2										12	5	17	2	1
8A9	MIBANGA AT ULEDI																				2	8	8	9	11	6																			5	1	6	1	0
9A2	LUFIRA AT NGERENGE												3	4	7	7	8	7	4	3		3	1	3	7	5	3	3	4	1	1	1	3											20	0	20	1	1
9A3	CHAMBO AT CHIWONA																2	12	12	10	10	10	32	11	11	10	2		3	1	1	3	3	3										8	9	17	1	1
9A4	LUFIRA AT CHILANGA													1	6	7	9	11	13	12	12	10	10	11	8	7	2	2	4															9	7	16	2	0
9A5	KALENJE AT CHIPWERA									2	11	23	14	12	11	11	9	12	11	13	12	11	13	12	11	8	7	3	2		1	4	3	1										10	14	24	1	1
9A7	LUFIRA AT MWAKASANGILA															2	11	11	10	9	8	7	3		4	5	7	3	3															10	3	13	8	1
9A8	LUFIRA CANAL AT NGERENGE SCHEME										5	3											11	8	10	7	7		3															6	2	8	1	0
9A9	SEKWA AT WENGA											8	1	1	10	10	8	12	12	12	12	12	12	12	10	9	5	6	3	2	2	3	1											12	10	22	7	1
9A10	MBALIZI AT CHILANGA													2	8	8	6	12	12	14	11																							4	4	8	4	0
9B1	SONGWE AT MWANGULUKULU																																											0	0	0	0	0
9B2	KYUNGU AT NDENGELA																																											0	0	0	0	0
9B3	KASEYE AT MWENEBWIBA		6	7	6	9	8	11	13	13	10	9	4	11	9	8	8	12	12	11	12	10	8	11	10	9	2	2	3	1	2	5	3	1										20	12	32	1	1
9B4	SONGWE AT ICHINGA												1	3	4	5	2	4	5	5	6	6	5	4	6	2			2	4	1	3	1											19	0	19	2	1
9B5	HANGA AT DAVID KAMEME												1	10	20	13	9	15	29	13	9	34	7	7	10	5	2	2	1	1	2	1	1	1										14	8	22	7	1
9B6	SONGWE AT IPENZA												5	6	6	5	2	6	5	7	7	8	8	9	8	4	3	2	2	2	1	2												20	0	20	5	1
9B7	SONGWE AT MWANDENGA																4	6	2	3	2	4	5	18	12	9	5	2	4	2	1	3	2		2	7	2	1						19	2	21	1	1
9D1	SONGWE AT MWENITENDE (NORPLAN)																																											0	0	0	0	0
9D2	SONGWE AT MPUNGUTI (NORPLAN)																																											0	0	0	0	0
9D3	SONGWE AT MWAMBURI (NORPLAN)																																											0	0	0	0	0
9D5	KIWIRA AT MBEYA ROAD BRIDGE (NORPLAN)																																											0	0	0	0	0
9D6	SONGWE AT MAPWA (NORPLAN)																																											0	0	0	0	0
9D7	KIWIRA AT MBAKO (NORPLAN)																																											0	0	0	0	0
11A6	LUSANGWISI AT NAMBANDE ESTATE																	9	10	10	9	12	11	8	7	5	3	5	4	2		2													10	4	14	1	1
11A7	MASONGOLA AT NAMWERA								6	9	12	41	10	4	6	8	9	10	12	11	12	12	11	10	7	7	4	6	4	2		3												13	10	23	1	1
14A1	NAMADZI AT HENDERSON ESTATE															1	12	11	8	10	8	9	7	8	9	8	2	5	5	2	2	6													14	3	17	1	1
14A2	LUCHENZA AT LUCHENZA															2	9	11	10	17	10	9	8																						4	4	8	3	1
14A3	CHISOMBEZI AT MIDIMA ROAD															2	9	11	11	33	12	10	7	7	4	6	5	6	3	2	1	2		1											13	5	18	1	1
14B1	KWAKWASI AT M1 ROADBRIDGE												8	11	11	9	13	8																										3	3	6	2	1
14B2	THUCHILA AT CHONDE														1	10	10	8	9	12	4	19	11	10	9	8	4	3	3			2												10	6	16	9	0
14B3	NSWADZI AT CHIPUNGU														12	9	5	9	6	7	2	7	6	11	10	1																		9	3	12	5	1
14B4	NSWADZI AT NAMING'OMBA											3	7	11	9	22	11	10	10	10	6	5	7																						6	6	12	1	1

: Discharge measurement was conducted from once to 10 times per year

: Discharge measurement was conducted more than 10 times per year

Source: Project Team

Table 3.4.12 Status of Implementation of Discharge Measurement (4/4)

Code	Station Name	Frequency of Discharge Measurement																																											Number of Years by Annual Frequency of Discharge Measurement			No. of Rating Curves	
		1970										1980										1990										2000										2010							
		0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	0< <10 /year	10≦ /year	0< /year	1900s	2000s
14B5	NSWADZI AT MAGOMBE ESTATE												2	9		7	9	6	9	4																									7	0	7	3	1
14B6	THUCHILA AT KAMBENJE																																												0	0	0	0	0
14B7	LIKULEZI AT DAUDI										2	12	10	14	6	8	8	8	4	7	7	8	8																						10	3	13	4	1
14B8	KWAKWASI AT MANGUNDA																8	15	10	6	6	4																							4	2	6	3	1
14C1	LUJERI AT LUJERI ESTATE WEIR																																												0	0	0	0	0
14C2	RUO AT M1 ROADBRIDGE (NSUWADZI)																4	15		7	6	2	9	10	7	8	2	4	4	3	2	2													13	2	15	1	1
14C3	LICHENYA AT MINI MINI ESTATE													2	10	7	10	11	12	11	7																								3	5	8	2	1
14C4	CHAPALUKA AT CHAMBE PLATEAU																																												0	0	0	0	0
14C5	RUO AT RUO ESTATE																																												0	0	0	0	0
14C6	LIKABULA AT LIKABULA FORESTRY																					3	9	11	3																				3	1	4	0	0
14C7	MULOZA AT MLELEMBA DRIFT													2	10	8	8	6	7	10	6	11	9	11	8	8	5	4	3	2		5													14	4	18	1	1
14C8	LICHENYA AT MILONDE												5	7	8	5	7	7	6	11	6	13	11	8	6	8	3	3	1	3	1	2													17	3	20	1	1
14D1	RUO AT SINOYA SOUTH										5	8	11	2	4	6	1	2	6				1	1	1																				11	1	12	3	1
14D2	RUO AT SINOYA																						1	1																					2	0	2	0	0
14D3	RUO AT SANDAMA																																												0	0	0	0	0
15A4	CHIRUA AT MTAMBE												3	10	11	11	11	11	12	10	11	12	12	11	9	9	4	8	8	3	1	5		1											10	11	21	8	1
15A8	LINGADZI AT KANICHE												2	18	10	10	11	11	12	10	8	9		4	10	9	4	7	8	4		2		1		1									12	8	20	1	1
15B6	CHIA LAGOON AT MTANGA																																												0	0	0	0	0
15B13	KAOMBE AT CHANIKA															1	9	8	10	9	7	9																							6	1	7	5	1
15B14	LIFULIZA AT NYONI													2	10	10	11	10	10	8	4	11	12	11	10	7	3	6	8	4		6			2										10	9	19	1	1
15B15	KAOMBE AT M1 ROADBRIDGE															2	2				6	9																							4	0	4	1	1
16E6	DWAMBADZI AT NTHANDA											3	14	13	12	11	12	11	9	11	9	12	8	12	8	8	8	9	9	5	1	3													12	9	21	3	1
16E7	MLOWE AT KATAWA											3	14	11	12	11	13	11	10	11	5																								2	8	10	3	0
16E9	LUWAWA AT MAGWEMA														2	10	11	11	12	8	7	11	4																						4	5	9	0	0
16E10	KAWIYA RIVER AT CHABIZGA																																												0	0	0	0	0
16E11	MAZEMBE AT CHITUNGULO																				1	9																							2	0	2	0	0
16E12	MLOWE AT KATAWA																				2	9																							2	0	2	1	1
16E13	KAWIYA AT CHABIZGA																																												0	0	0	0	0
16F1	LIMPHASA AT TIMBIRI												2	12	12	12	12	8	11	12	9	11	3																						4	7	11	1	1
16F2	LUWEYA AT ZAYUKA												2	10	9	10	17	10	10	12	9	12	9	8	10	2																			6	8	14	1	0
16F4	CHIKANGAWA AT VIPHYA																		10	7	6	8																							3	1	4	1	0
16F5	LUCHELEMU (LOWER) AT MAZAMBA														28	10	11	10	12	9	6	12	11	12	10	8	5	5	1	1	1	4	4	1											11	9	20	1	1
16F6	LUWAWA AT KAPALAPATA																1	11	10	12	10	9	7	11	12	10	6	3	5	4	3	7	5	2											11	7	18	2	1
16F10	LUCHELEMU AT MAZAMBA ESTATE												2	12	26	10	10	8	12	9	8	11	4																						5	6	11	4	1
16F12	LUWEYA AT TEMBWE																																												0	0	0	0	0
16F13	LIMPHASA AT LIMPHASA SCHEME												4	6	8	15	8	6	8	8	6	10	3																						9	2	11	1	0
16F14	KAVUZI AT KAVUZI COMPOUND																	2	23	9	1	8	1																						5	1	6	0	0
16F15	LUWEYA AT MZENGA																			18	11	15	16	8	11	5	5	5	5	2	4	7	3												9	5	14	1	1
16F18	LONJOZWA AT KANYOLI (MAZAMBA)																							9	3																				2	0	2	1	0
16F19	KALUNGULO TA CHIKANGAWA																						1	13	4																				2	1	3	0	0
16F20	LIMPHASA AT KANGO VILLAGE																																												0	0	0	0	0
16F21	KALWE AT CHIGHA CHANG'OMBE																									4	2	13	5	2	1	5	2												7	1	8	1	0
16G2	CHIWISI AT BULA															9	10	4	12	12	9	11	3																						4	4	8	2	0
16G3	RUVUO AT KAMPEYA VILLAGE																5	7	13	10	9	8																							4	2	6	0	0
17C1	LAKE MALAWI AT CHILUMBA																																												0	0	0	0	0
17C6	WOVWE AT KAPIYIRA											2	18	9	12	9	9	9	8	7	10	6	11	12	10	6	4																		10	6	16	8	1
17C9	NYUNGWE AT NYUNGWE DIP TANK						10	14	18	15	15	17	5	10	14	9	12	13	9	12	2																								4	11	15	4	1
17C10	HARA AT NTHIPA						3	13	20	7			4	6	48	12	11	12	12	12	10																								4	9	13	3	0
17C11	WOVWE INTAKE AT WOVWE SCHEME												2	7	11	10	10	10	10	10	10	9	3																						4	7	11	0	0
17C12	HARA INTAKE CANAL AT HARA																7	9	9	9	11	9	5																						6	1	7	1	1
17C13	WOVWE NEW CANAL AT WOVWE																	4	11	11	11	11	3																						2	4	6	0	0
17C14	MANTCHEWE AT MANTCHEWE FALLS																		10	12	12	8																							1	3	4	0	0
17C15	NYUNGWE AT MCHEKA-CHEKA																					1	10	9	9	6	6	2	1	1	1	1													10	1	11	5	0
17C16	WOVWE AT NJALAYANKHUNDA																					2	11	17	9	9	7	3	3	3	1	3	2												10	2	12	1	1

(light grey): Discharge measurement was conducted from once to 10 times per year
(dark): Discharge measurement was conducted more than 10 times per year

Source: Project Team

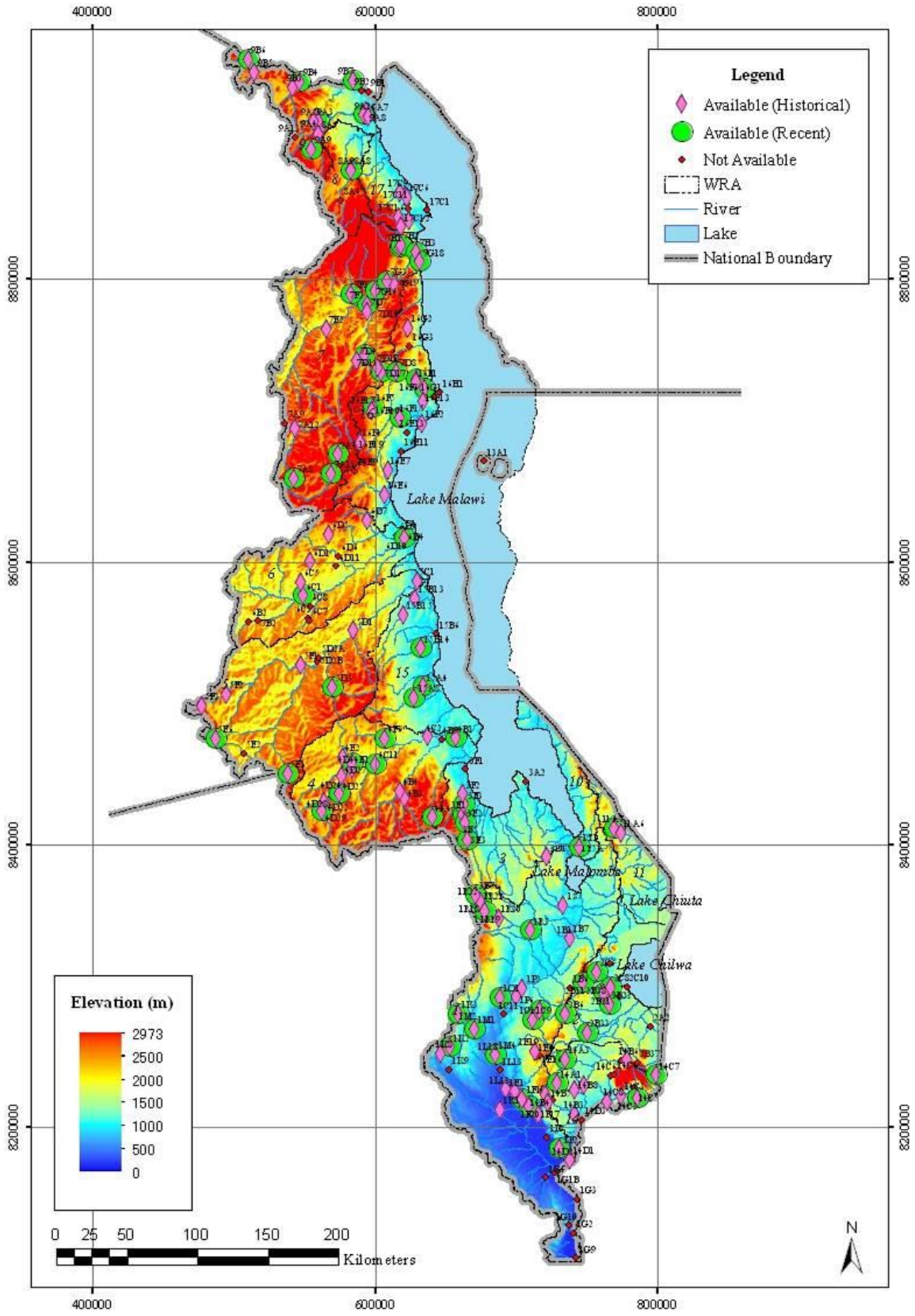
b) Development of Rating Curve

Rating curves have been and are being developed by staff members of MoAIWD. Number of developed rating curves in the 1900's and 2000's is indicated in the right column of **Table 3.4.12**, and the status of preparation of the rating curves of each station and its distribution are shown in **Figure 3.4.20**.

Number of the stations with rating curves developed in the 1900's is 157 among 174 stations where discharge measurement data were recorded. The stations with rating curves developed in the 2000's or the stations that have rating curves available in 2000's are 123 stations, and all of them have rating curves developed in the 1900's. Focusing on the situation since 2000, ratio of the stations that have available rating curves in the 2000's is comparatively low in WRA-6, 8, 16 and 17.

Since frequency of discharge measurement are drastically decreasing after late 2000s as revealed by the record of discharge measurement, it can be said that updating of rating curves as well as confirmation of advisability of existing rating curves has been hardly carried out in recent years. In addition, some existing rating curves are not proper to use in high flow because discharge measurement in high flow has not been adequately conducted since late 1990's. Each rating curve has applicable maximum water level determined based on observed water level in discharge measurement for developing the rating curve. Comparing the applicable maximum water levels with average observed high water levels (average of annual 10% water level) for rating curves available in 2000's, the applicable maximum water levels are lower than the observed high water levels in approximately 20% of the rating curves. Further, some existing rating curves are not able to apply in low flow since those applicable minimum water levels are not adequate compared with the observed low water level.

Accurate rating curves are crucial to obtain accurate discharge values from water level data, therefore, more frequent discharge measurement including measurement in high flow should be continuously carried out and accurate rating curves should be properly developed.



Source: Project Team

Figure 3.4.20 Status of Preparation of Rating Curves

(iv) Issues in Hydrological Observation

Major issues in hydrological observation are as follows:

- Improvement and/or rehabilitation of existing hydrological stations and installation of new stations are not implemented mainly due to shortage of fund although the condition of the stations has deteriorated due to vandalism, stolen equipment and flood damage.
- Remuneration to gauge readers is not enough to ensure their commitment. Many stations are not being properly maintained and many gauges are now not even being read because of low remuneration to gauge readers, which is 150 kwacha (less than 1USD) per month.
- Manual records by gauge readers often contain errors and/or have lengthy periods of missing data. One of the reasons is that gauge readers are undertrained.
- It takes about two to three months for the observed data to reach the head office due to transportation and budgetary problems.
- The running expense budgets, transportation and equipment for district staff to maintain and monitor hydrological stations as well as to collect data are insufficient, which prevent them from performing their duties effectively. Number of staff in each district office is also inadequate.
- Accessibility to hydrological stations is limited during high flows/rainy season.
- Discharge measurement is rarely carried out and rating curves are not updated.
- Hydrological observation system from daily observation at site to data input and accumulation to database is considered to be adequately established; however, it can be said that the major issue is that such system is not properly operated mainly due to financial constraints and shortage of human resources.

2) Meteorological Observation

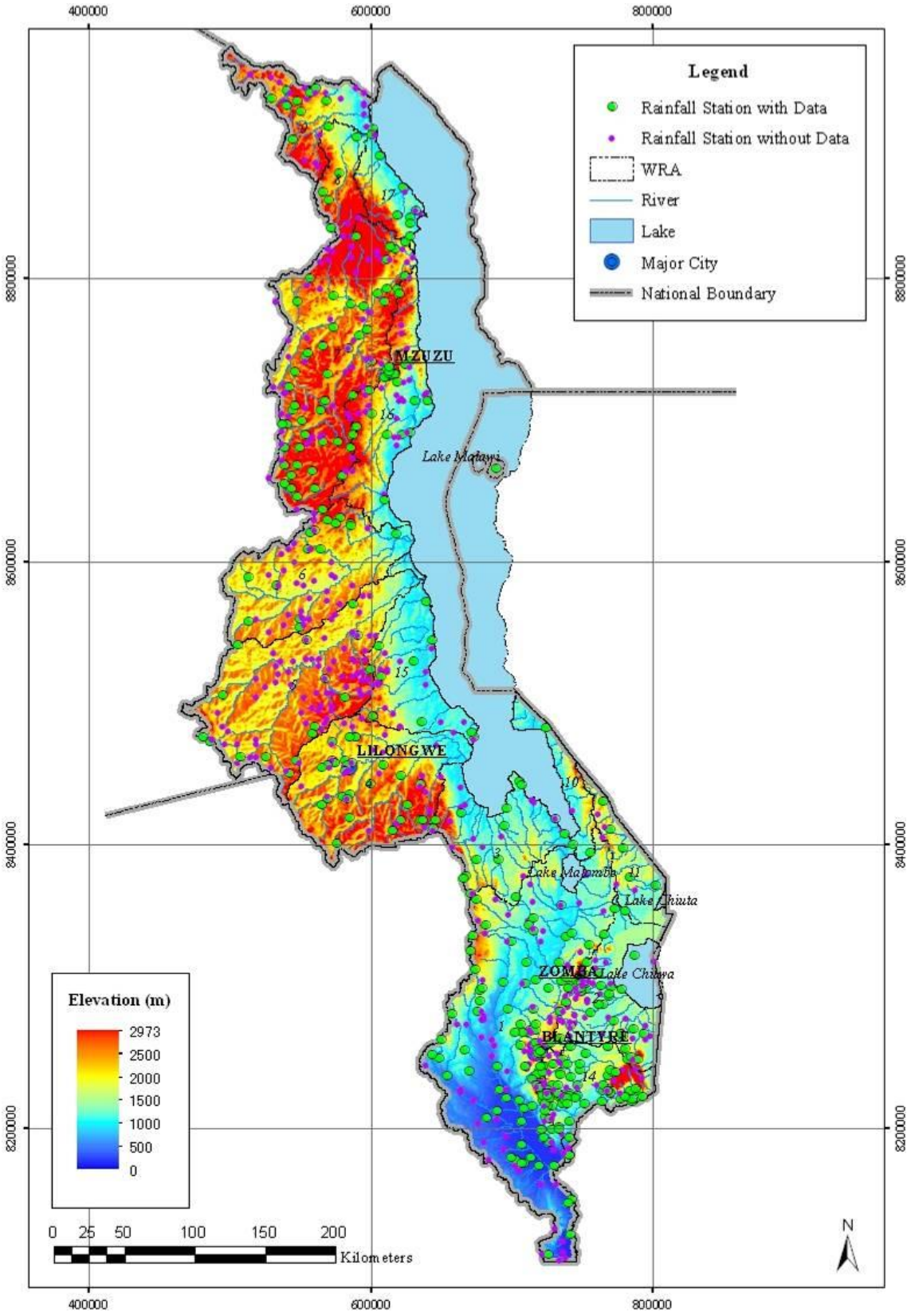
Meteorological observation is managed by the Department of Climate Change and Meteorological Services under MoNREE (Ministry of Natural Resources, Energy and Environment). Present conditions of meteorological observation are summarized below.

(i) Condition of Rainfall Gauging Stations

There have been about 800 rainfall stations in the 1980's, but there are only between 100 and 200 operational rainfall stations at present in Malawi (MoWDI 2011).

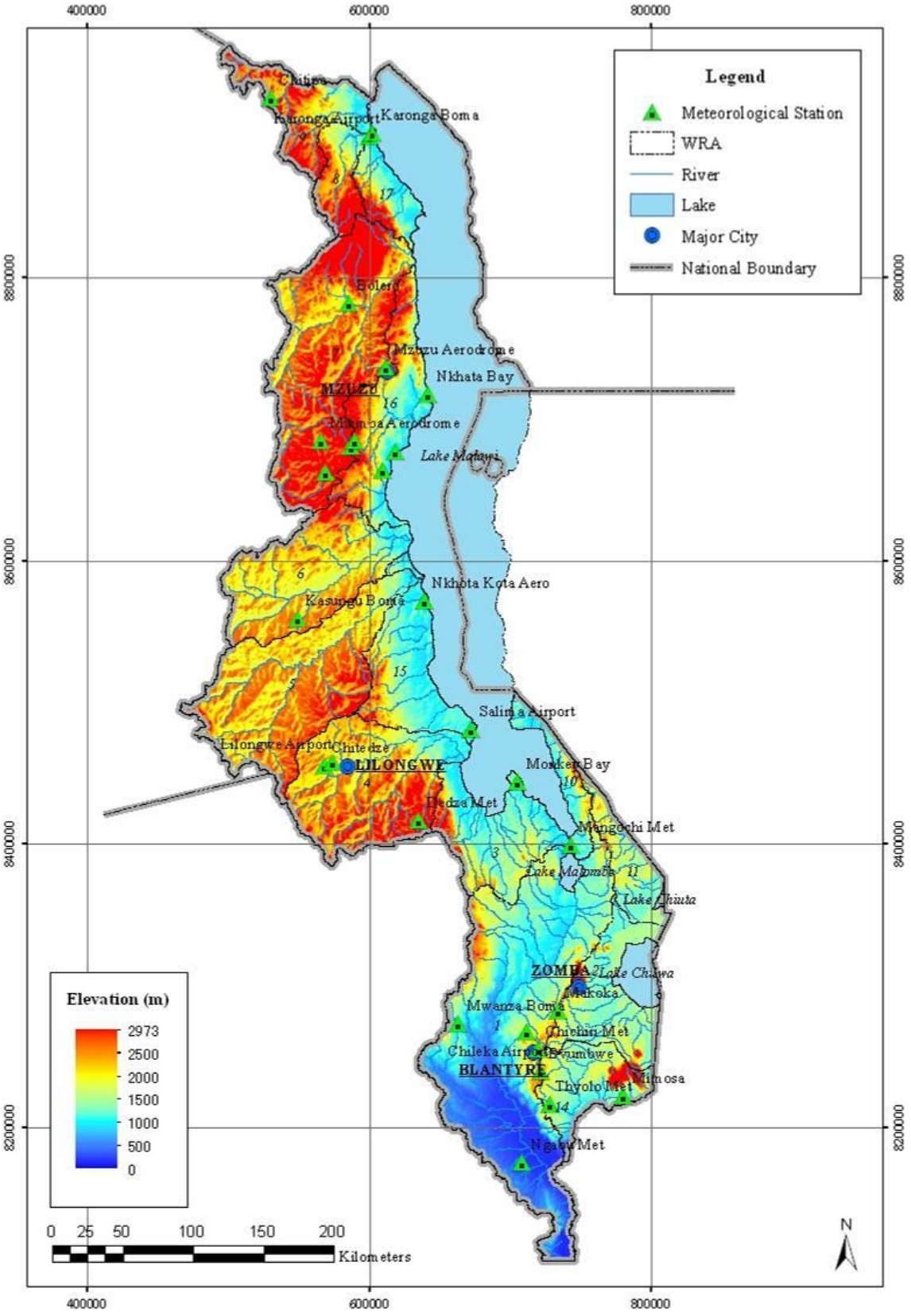
Evaporation, and other climatic data, is recorded at full meteorological stations. The Department of Climate Change and Meteorological Services manages 23 full meteorological stations. There are some other institutions that have their own meteorology stations and data are sent to the Department of Climate Change and Meteorology Services.

Locations of rainfall stations and meteorological station are shown in **Figure 3.4.21** and **Figure 3.4.22**, respectively.



Source: Project Team

Figure 3.4.21 Location Map of Rainfall Gauging Stations



Source: Project Team

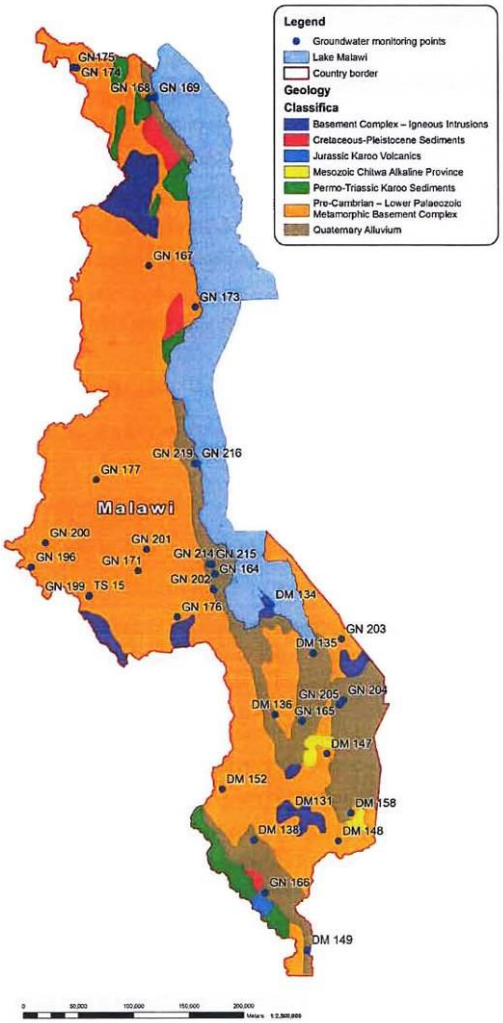
Figure 3.4.22 Location Map of Meteorological Stations

3) Groundwater Monitoring

Groundwater monitoring is managed by the Groundwater Division of the Department of Water Resources under MoAIWD (Ministry of Agriculture, Irrigation and Water Development). Present conditions of groundwater monitoring are summarized below.

(i) General Condition of Groundwater Monitoring Wells

Thirty-five (35) monitoring wells were constructed during 2009-2010 in Malawi. However, as of December 2012, groundwater level was being monitored at only 18 boreholes due to several troubles. In the report of the Ministry of Water Development (2003) Strengthening of the Water Resources Board in 2003, the monitoring of boreholes in 18 sites were proposed. According to the interview survey, detailed investigation has been done based on the proposal, and then finally the present 35 monitoring wells were constructed. Several monitoring wells were considered to be necessary to grasp artificial influences in some specific locations. For example, there are three monitoring wells in Salima district, which are located near a dam, a production well for irrigation, and a production well for water supply, respectively. Locations of monitoring wells are shown in **Figure 3.4.23** and the present situations are tabulated in **Table 3.4.13**.



Source: MoWDI (2011) Consultancy Services for Establishment of Water Resources Monitoring System. Situation and Needs Assessment Report. Prepared by aurecon, MoWDI, Malawi, pp69

Figure 3.4.23 Location Map of Monitoring Wells for Groundwater in Malawi[12]

Table 3.4.13 Summary of Present Situation of Monitoring Wells

MBH ID.	District	Location	Coordinate (UTM)		Availability of Monitoring	Term of Monitoring	Remarks
			Easting	Southing			
DM 131	Blantyre	Mzedi Dumping Site	8254317	724823	Vandalized	Unknown	
DM 134	Mangochi	Monkey Bay PVT School	8441914	707025	Available	3-Aug-2009 to End of Sep-2013 (Ongoing)	had suspended during Apr-2010 to Apr-2012
DM 135	Mangochi	Mangochi W/Office	8397702	744587	Available	18-July-2009 to End of Feb-2013 (Ongoing)	
DM 136	Balaka	Balaka W/Office	8341853	710733	Available	6-Jun-2009 to End of Sep-2013 (Ongoing)	
DM 138	Chikhwawa	Chikhwawa W/office	8228042	691579	Available	10-May-2010 to End of Feb-2013 (Ongoing)	had suspended during Feb-2011 to Sep-2012
DM 147	Zomba	Songani W/Office	8306148	757269	Available	5-Mar-2010 to End of Sep-2013 (Ongoing)	had suspended during Feb-2011 to Nov-2012
DM 148	Mulanje	Mulanje W/Office	8227032	767928	Available	7-Oct-2011 to End of Sep-2013 (Ongoing)	
DM 149	Nsanje	Nsanje W/Office	8128015	740438	Available	8-Mar-2010 to End of Aug-2013 (Ongoing)	
DM 152	Mwanza	Mwanza Prison	8274199	662532	Available	5-Oct-2012 to End of Sep-2013 (Ongoing)	
DM 158	Phalombe	Nasomba School	8252442	779287	Available	7-Aug-2013 to End of Nov-2013 (Ongoing)	
GN 164	Salima	Katelera School	8470188	655554	Vandalized	18-Feb-2009 to 6-Feb-2010 (12 monthes)	
GN 165	Balaka	M'manga CDSS	8335777	734813	Available	2-Feb-2009 to End of Dec-2013 (Ongoing)	had suspended during Nov-2010 to Feb-2012
GN 166	Chikhwawa	Ngabu W/Office	8180063	701901	Available	31-Mar-2009 to End of Sep-2013 (Ongoing)	
GN 167	Mzimba	Endongolweni School	8749938	596102	Available	15-Aug-2009 to End of Sep-2013 (Ongoing)	
GN 168	Karonga	Karonga Well Field	8901394	596013	Vandalized	25-Aug-2009 to 13-Jan-2010 (5 monthes)	
GN 169	Karonga	Karonga W/Office	8901744	601681	Available	25-Aug-2009 to End of Sep-2013 (Ongoing)	
GN 171	Lilongwe	Mlezi School	8472734	586173	Available	3-Aug-2009 to End of Sep-2013 (Ongoing)	had suspended during Feb-2010 to Oct-2012
GN 173	NkhataBay	Msani School	8712640	637876	Available	10-Oct-2009 to End of May-2013 (Ongoing)	had suspended during Feb-2010 to Oct-2012
GN 174	Chitipa	Chitipa W/Office	8928212	530732	Available	17-Aug-2009 to End of Sep-2013 (Ongoing)	
GN 175	Chitipa	Chitipa Well Field	8928710	527832	Vandalized	17-Aug-2009 to 6-Jan-2011 (17 monthes)	
GN 176	Dedza	Linthipe W/Office	8430908	621378	Available	19-Nov-2012 to End of Jan-2013 (Ongoing)	had suspended until Nov-2012
GN 177	Kasungu	Mwalawanyenje School	8555724	548248	Available	13-Nov-2009 to End of Dec-2013 (Ongoing)	had suspended during Mar-2010 to Oct-2012
GN 196	Mchinji	Mchinji W/Office	8476026	489197	Available	12-Oct-2009 to End of May-2013 (Ongoing)	
GN 199	Lilongwe	Kakuyu Dam	8449354	541369	Available	5-Oct-2009 to End of May-2013 (Ongoing)	had suspended during Jul-2010 to Oct-2012
GN 200	Mchinji	Lusa/Kalulu Dam	8498220	501897	Vandalized	Not started	
GN 201	Dowa	Chaliwa Dam	8492364	593614	Available	23-Oct-2009 to End of Dec-2013 (Ongoing)	had suspended during Oct-2011 to Oct-2012
GN 202	Salima	Mtongola Dam	8455926	654015	Available	17-Oct-2009 to End of Sep-2013 (Ongoing)	had suspended during Feb-2010 to Oct-2012
GN 203	Mangochi	Namwera Well Field	8410528	770245	Available	11-Nov-2009 to End of Sep-2013 (Ongoing)	had suspended during May-2010 to Jan-2012
GN 204	Machinga	Ntaja W/Office	8355077	772050	Available	14-Nov-2009 to End of Sep-2013 (Ongoing)	had suspended during May-2010 to Sept-2012
GN 205	Machinga	Kawombe Dam	8351059	768384	Available	14-Oct-2011 to End of Mar-2013 (Ongoing)	
GN 214	Salima	Kambwiri Sele W/Field	8479332	651015	Available	6-Oct-2012 to End of Sep-2013 (Ongoing)	had suspended until Oct-2012
GN 215	Salima	Kuti Plant	8478894	652511	Available	6-Oct-2012 to End of Aug-2013 (Ongoing)	installed automatic recorder but it did not worked
GN 216	Nkhotakota	Nkhotakota W/Office	8571052	639640	Available	23-Nov2012 to End of Aug-2013 (Ongoing)	unknown until Nov-2012
GN 219	Nkhotakota	Nkhotakota Well Field	8570550	637466	Available	5-Oct2012 to End of Sep-2013 (Ongoing)	unknown until Oct-2012
TS 15	Lilongwe	Chileka W/Office	8450216	541757	Available	8-Aug-2009 to End of May-2013 (Ongoing)	had suspended during Jul-2010 to Oct-2012
Available Monitoring Boreholes : 30							
Existing Monitoring Data							
• Ongoing monitoring : 30							
• Stopped monitoring on the way but data existing : 3							
• No data collection since boreholes were set : 2							

Source: Project Team

(ii) Condition of Groundwater Monitoring

Groundwater levels were measured in boreholes at the time of construction, and had been irregularly recorded at borehole rehabilitations from 1971 to the early 1980's. These enormous records were noted on the borehole data cards in NWRMP. Between the 1990's and the 2000's, data of groundwater levels had not been accumulated due to non-recording of data into the cards. After that, the project of "Strengthening of the Water Resources Board National" [11] in NWDP I indicated the significance of continuous monitoring of groundwater, and thus a total of 35 monitoring wells were established in the whole country of Malawi between 2009 and 2010 (the location map is in **Figure 3.4.23)**.

The groundwater monitoring has been conducted by the local agency staff of MoWID named Water Monitoring Assistants (WMAs), basically once every week. The collected records of each monitoring well are sent to the central office of the Groundwater Division by phone, text messages and e-mail. The central officer inputs the records into EXCEL spread sheets in chronological order, and draw graphs of the water table fluctuation changes over time.

Although the boreholes for only monitoring were established with much effort, the monitoring in 2012 was carried out at only 18 boreholes out of the established 35 boreholes owing to several troubles. The current situation of the groundwater monitoring was verified in the project of "The Establishment of a Management Information System (MIS)" in detail. The troubles and issues on monitoring wells were mentioned as the follows:

1) Five (5) of the 35 monitoring wells were not available due to vandalism such as filling with stones. DM131 (Mzedi dumping site), GN164 (Katelera school), GN168 (Karonga well field), GN175 (Chitipa well field) and GN200 (Lusa/Kalulu Dam) come under the unavailable boreholes. Hence the available monitoring wells are 30 boreholes. There are 28 monitoring wells which are not protected with a locking steel lid aside from the vandalized boreholes, thus these were exposed also to vandalism (see **Figure 3.4.24**).

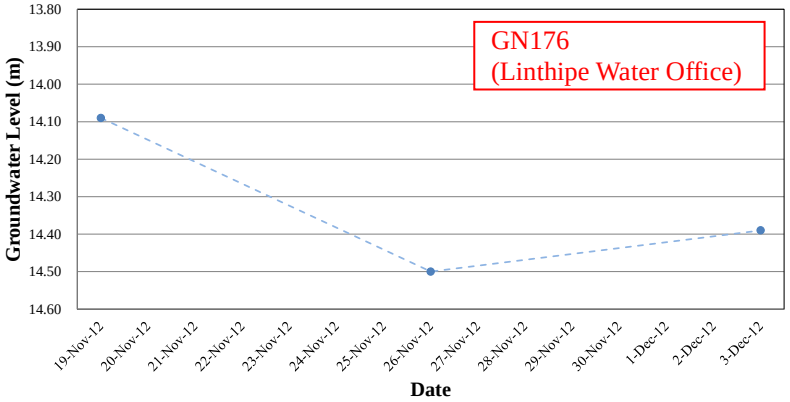
↑A specimen of the monitoring well protected with a locking steel lid. Large parts of the boreholes are not protected as well as the photograph.

↑A specimen of the vandalized monitoring well. On the survey in 2011, the vandalized boreholes were four, but two among them have been repaired after then.

Figure 3.4.24 Current Situation of Groundwater Monitoring Wells [12]

2) At 2 out of the 35 monitoring wells, no data has been collected since they were constructed. Fourteen (14) out of the wells in which data exist at present show sparse data as shown in **Figure 3.4.23**. Only 8 boreholes have been measured almost continuously since monitoring began. According to the interview with staff of the Groundwater Division, the reasons why monitoring assistants seldom go to the measuring site were because the boreholes are situated very far from the local water office, lack of fuel for mobilization, or health problems of monitoring assistants. Only two monitoring wells (GN 166 and GN 173) are

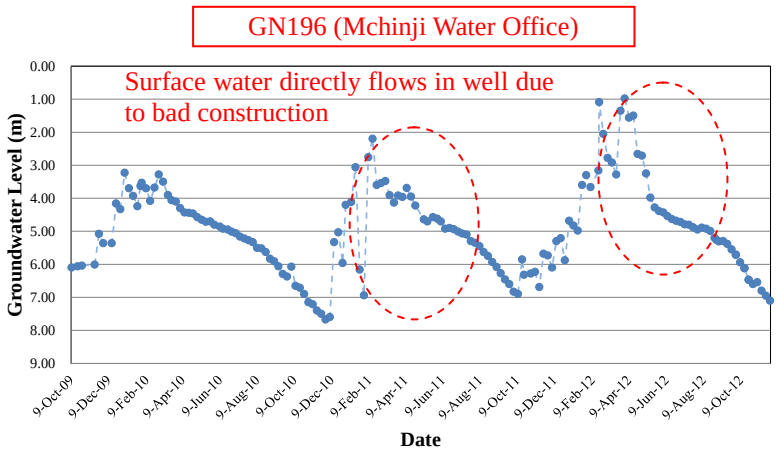
located near the rain gauge station, and an automatic rain recorder is installed adjacent to GN166.



Very few data (just 3 points) so that tendency of fluctuation cannot be interpreted.
Source: Project Team

Figure 3.4.25 Example of Sparse Data on Groundwater Level

3) There is no well construction log including detailed geology, construction records, pumping test, etc.
4) Several wells which have produced turbid water because the gravel packing and cement grouting to the inner wall of well were not adequate in the construction. These wells with uncoated inner wall should be relocated because true groundwater levels are suspected not to be reflected in-situ due to the clogging of aquifer with clayey materials. A well at GN196 (Mchinji Water Office) indicates that the water table suddenly rose in response to rainfall as shown in **Figure 3.4.26,** and it is doubted that seepage from the surface will directly flow into the well along the space in the wall.

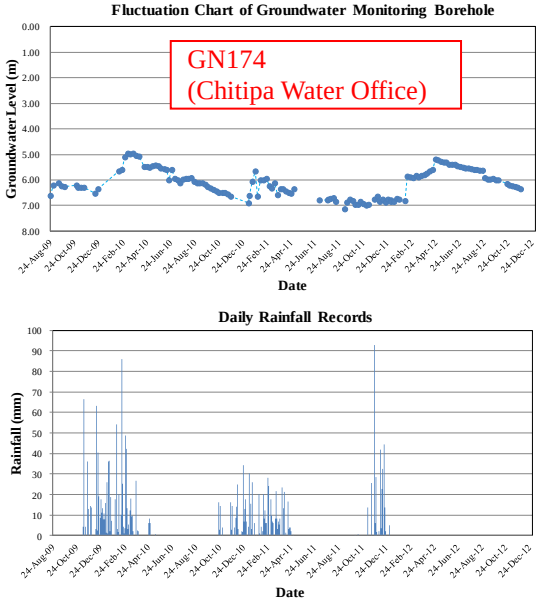


Source: Project Team

Figure 3.4.26 Example of Influence of Bad Construction on Water Fluctuation in Well

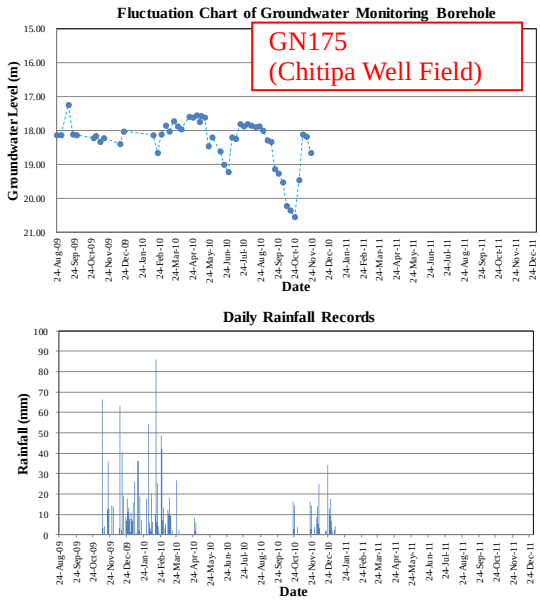
5) Several monitoring wells are located very far from rainfall stations (over 20 km). However, measurement of groundwater table is required to confirm the relationship with rainfall; thus it is desirable that a rainfall station is set adjacent to the monitoring well or within 2 km.
6) All 30 operational monitoring wells are now equipped with data loggers for automatic recording since 2013.
7) There are six locations where two wells are located near each other. These paired wells correspond to the couples of GN-174 and GN-175, GN-168 and GN-169, GN-216 and GN-219, GN-214 and GN-215, GN-199 and TS-15, and GN-204 and GN-205. The reason for pairing is to enable the MoAIWD staff to monitor groundwater fluctuation based on

both natural condition and artificial influence such as pumping up for water supply or irrigation. According to the monitoring records, both the natural and artificial fluctuations are recognized as shown in **Figure 3.4.27** and **Figure 3.4.28**. However, the intervals of monitoring do not correspond to the timing of pumping, and the amount of pumping has not been considered. Hence the monitoring wells adjacent to the pumping facilities are useless to evaluate the true fluctuation of groundwater level in the localities. If the assessment of artificial influence on groundwater must be conducted, it is necessary to set automatic recorders in the influenced boreholes and groundwater monitoring should be carried out in shorter intervals corresponding to the timing of pumping. Furthermore, the fluctuation of groundwater level at monitoring wells should be compared with the amount of drawdown at pumping facilities.



Source: Project Team

Figure 3.4.27 Example of Natural Fluctuation of Groundwater Level



The groundwater table varied in the dry season (during April to October in 2010).
It was thought that the influence of artificial pumping came accidentally.
Source: Project Team

Figure 3.4.28 Fluctuation of Groundwater Artificially Influenced by Pumping Up

(iii) Monitoring and Data Recording Method and Data Management System

Groundwater leveling is conducted by the water monitoring assistants of the district staff basically on a weekly basis, mostly on Saturdays. Measured groundwater level is sent by SMS to the Head Office of the Groundwater Division in Lilongwe. Then, the data is input into EXCEL worksheets. After September 2013, automatic monitoring recommended by the project of MIS has been ongoing at the available wells. WISH software is available for hydrological data management, but it requires annual renewal of license.

4) Water Quality Monitoring

Water quality monitoring is managed by the Water Quality Service Division of the Department of Water Resources of MoAIWD. Present conditions of water quality monitoring are summarized below.

(i) Implementation of Water Quality Monitoring

a) Laboratory

The Water Quality Service Division has jurisdiction over the Central Water Laboratory, South Water Laboratory and North Water Laboratory which are the only water research laboratories of the government. The Central Water Laboratory which is the most advanced in Malawi was established in 1973, and dedicated to conduct simultaneous water quality monitoring in Malawi since the early 1980's. It has enough equipment to analyze most of the chemical and biological constituents of drinking water and effluent defined by the Malawi Bureau of Standards and equipment to analyze and collect samples in situ (i.e., EC/TDS/pH meter, etc.). Recently, a modern instrument for pesticide analysis, the Gas Chromatography (GC), was installed in the laboratory by grant aid; however, it has never been operated due to lack of trained personnel for operation and maintenance, as well as consumables for the GC.

The South Water Laboratory was established in Blantyre in 1993. The laboratory is very small and has less equipment for analysis than the Central Water Laboratory, and lack of computer to be used exclusively to store analysis data. The laboratory cannot analyze heavy metal constituents such as Copper, Lead, Zinc and Manganese.

The North Water Laboratory was established in Mzuzu in 1993 but was assimilated into the Northern Region Water Board along with the remaining equipment in mid-1998. The laboratory only has portable analysis kits for in-situ use but has no instrument nor reagents for analyzing conventional parameters. Researchers assigned to the Water Quality Service Division do not always reside in the laboratory. The laboratory is only a tentative base for monitoring in the Northern region.

As mentioned above, the Water Quality Service Division has three laboratories but the actually operational laboratory for monitoring is only the Central Water Laboratory because of poor equipment, shortage of staff and budgetary constraint for mobilization at the other laboratories. Apart from monitoring activities, the Central Water Laboratory offer commercial services to private clients and other government agencies. It supports the financial source for the monitoring and analyzing activities of the Water Quality Service Division in spite of little proportion of such activities.

b) Condition of Water Quality Monitoring Points

There are 195 water quality monitoring points in Malawi which are classified in three categories: surface water, pollution control (it means outlet of effluent source) and groundwater. There had been about 300 monitoring points before 2003. In the project called as Strengthening of the Water Resources Board (MoWDI, 2003), a reduced number of the identified water quality monitoring points was proposed to the Ministry considering the capacity of the Water

Quality Division and the regional laboratories. After detailed review of the list by the Division, monitoring points that were almost the same as the present ones were determined.

Many water quality monitoring points were selected from hydrological stations, and all groundwater points were selected from monitoring wells constructed after 2009. The exact coordinates of each sampling point are not available due to the lack of GPS instruments except the monitoring points selected from hydrological stations and monitoring wells while approximate locations were determined using 1:250,000 maps.

The list of the monitoring points with corresponding hydrological stations and groundwater monitoring wells is given in **Table 3.4.14** to **Table 3.4.18**

Table 3.4.14 List of Water Quality Monitoring Points (1/5)

No.	Region	District	Station	Type[1]	Corresponding Gauging Station/Borehole ID
1	Central	Lilongwe	Katete River at Gauging Station, Malingunde	SW	4D21
2	Central	Lilongwe	Lilongwe River, Upstream Kamuzu Dam	SW	4D23
3	Central	Lilongwe	Lilongwe River/Likuni Rivers at the confluence (Chigwirizano Area)	SW	4D27
4	Central	Lilongwe	Lilongwe River at Gauging Station (Kamuzu Procession Road Bridge)	SW / Pollution	4D4
5	Central	Lilongwe	Lilongwe Downstream of Lingadzi confluence at Gauging Station (Road Bridge to August House)	SW	4C2
6	Central	Lilongwe	Lingadzi River at Buli Road Bridge	SW	4E2
7	Central	Lilongwe	Lingadzi River at Gauging Station (Area 18 M1 Road Bridge)	SW	4E1
8	Central	Lilongwe	Diampwe at Gauging Station (Blantyre/Lilongwe M-1 Road Bridge)	SW	4B4
9	Central	Lilongwe	Lumbadzi River downstream Lilongwe/Kasungu Road Bridge (Lumbadzi Trading Centre)	SW	
10	Central	Lilongwe	Lilongwe River at Gauging Station, Mkwezalamba	SW	4D6
11	Central	Lilongwe	Lumbadzi River upstream Lilongwe/Salima Road bridge	SW	4F6
12	Central	Mchinji	Namitete River (Lilongwe/Mchinji Road Bridge)	SW	5E1
13	Central	Mchinji	Bua River Gauging station (Foot Path to customs Deport)	SW	5E6
14	Central	Mchinji	Liwelezi River at Gauging Station (Mkanda Area)	SW	5F2
15	Central	Kasungu	Bua River at Gauging Station (Lilongwe/Kasungu M-1Road Bridge)	SW	5D2
16	Central	Kasungu	Dwangwa River at Gauging Station (Kasungu/Mzimba M-1 Road Bridge)	SW	6C1
17	Central	Ntchisi	Koambe River at Water Supply Intake	SW	15B15
18	Central	Nkhotakota	Chia Lagoon at Gauging Station (Salima/Nkhotakota M-1Road Bridge)	SW	15B6
19	Central	Nkhotakota	Kaombe River at Gauging Station (Nkhotakota/Dwangwa Road Bridge)	SW	15B13
20	Central	Nkhotakota	Lake Malawi at Nkhotakota Boma.	SW	
21	Central	Nkhotakota	Bua River at Gauging Station (Nkhotakota/Dwangwa Road Bridge)	SW	5C1
22	Central	Nkhotakota	Dwangwa River at Gauging Station (Dwangwa/Nkhata Bay Road Bridge)	SW	6D10
23	Central	Nkhotakota	Dwambadzi River at Dwangwa/Nkhata Bay Lakeshore Road Bridge (Near Dwambadzi Trading Centre)	SW	16E6
24	Central	Salima	Chiluwa River at Gauging Station (Salima/KK Road Bridge)	SW	15A4
25	Central	Salima	Linthipe River at Gauging Station (Railways Bridge)	SW	4B1
26	Central	Salima	Lake Malawi at Livingstonia Beach Hotel	SW	
27	Central	Salima	Lake Malawi at Gauging Station (Chipoka Harbour)	SW	3F1
28	Central	Salima	Lifidzi River at Salima/Chipoka Lakeshore Road Bridge	SW	
29	Central	Dedza	Diamphwe River at Old Bridge (Lilongwe/Blantyre Road Bridge)	SW	
30	Central	Dedza	Linthipe River at Lilongwe/Blantyre M-1 Road Bridge (Near Dedza Boma)	SW	4B3
31	Central	Dedza	Linthipe III River at Gauging Station (Lilongwe/Blantyre M-1 Road Bridge)	SW	
32	Central	Dedza	Livulezi River at Balaka/Salima Road Bridge (Lakeshore Road)	SW	3E3
33	Central	Dedza	Nankokwe River at Lakeshore Road Bridge	SW	3F3

Note: 1Monitoring point type (SW = Surface water, GW = Groundwater, Pollution = Pollution control)

Source: Project Team

Table 3.4.15 List of Water Quality Monitoring Points (2/5)

No.	Region	District	Station	Type[1]	Corresponding Gauging Station/Borehole ID
34	Central	Dedza	Nadzipokwe River at Balaka/Salima Road Bridge (Lakeshore Road)	SW	3E1
35	Central	Ntcheu	Mpira River at Gauging Station	SW	1R23
36	Central	Ntcheu	Mpamadzi River at Water Supply Intake	SW	1R21
37	Central	Ntcheu	Mpamadzi River at Ntcheu Boma (Downstream Ntcheu Secondary School/Mpira Dam Road Bridge)	SW	1R18
38	Central	Ntcheu	Rivirizi River at Manjawira Road Bridge (Zalewa Road)	SW	1R3
39	Central	Mchinji	Bua River on Mchinji/ Lilongwe Road Bridge	SW	
40	Central	Mchinji	Rusa River on Mchinji/Kasungu Road Bridge	SW	5F1
41	Central	Kasungu	Bua River on Kasungu/Nkhotakota Road Bridge	SW	5D1
42	Central	Dowa	Mtiti River on Kasungu/Lilongwe Road Bridge	SW	
43	Central	Ntchisi	Mpherere River on the Mponela/Ntchisi Road Bridge	SW	
44	Central	Lilongwe	Chatuwa Stream before the confluence with Lingadzi River (Area 18)	Pollution	
45	Central	Lilongwe	Nankhaka Stream at the Road Bridge to Area 25	Pollution	
46	Central	Lilongwe	Nankhaka Stream at area 18/49 Road Bridge (Before the confluence with Lingadzi River)	Pollution	
47	Central	Lilongwe	Kamuzu Barracks Sewage Treatment Works Effluent	Pollution	
48	Central	Lilongwe	Kauma Sewage Treatment Works Effluent	Pollution	
49	Central	Lilongwe	Natural Resources College Sewage Treatment Works Effluent	Pollution	
50	Central	Lilongwe	Chipasula Secondary School Sewage Treatment Works Effluent	Pollution	
51	Central	Lilongwe	Kanengo Sewage Treatment Works Effluent	Pollution	
52	Central	Lilongwe	Lumbadzi Sewage Treatment Works Effluent	Pollution	
53	Central	Lilongwe	Lilongwe International Airport Sewage Treatment Works Effluent	Pollution	
54	Central	Lilongwe	Biwi Stream Upstream Chipasula Secondary School Road Bridge	Pollution	
55	Central	Lilongwe	Biwi Stream Downstream Chidzanja Road Bridge	Pollution	
56	Central	Lilongwe	Lilongwe River at Mchesi Location on Lilongwe/Central Hospital Road Bridge	Pollution	
57	Central	Lilongwe	Lilongwe River Downstream Kauma Sewage Treatment Works Effluent	Pollution	
58	Central	Lilongwe	Dumping site at Area 38 closer to Bunda Turn Off Road Bridge stream	Pollution	
59	Central	Nkhotakota	Dwasco Wastewaters, Dwangwa	Pollution	
60	Central	Nkhotakota	Ethcol Wastewaters, Dwangwa	Pollution	
61	Central	Dowa	Mvera Support Batallion Sewage Treatment Works Effluent	Pollution	
62	Central	Salima	Salima Hospital Sewage Treatment Works Effluent	Pollution	
63	Central	Lilongwe	Chileka at Kukuyu Dam	GW	GN199
64	Central	Lilongwe	Chileka at Water Office	GW	TS15
65	Central	Lilongwe	Lilongwe at Mlezi Primary School behind Valleys Chicks, Before Airport Turn-off	GW	GN171
66	Central	Mchinji	Mchinji at Lusa Dam	GW	GN200
67	Central	Mchinji	Mchinji at Water Office	GW	GN196
68	Central	Salima	Katelera Primary School at Salima/Chipoka, 10 km from Kamuzu Bridge	GW	GN164
69	Central	Salima	Salima at Mtongolo Dam, Eastern side of Lifidzi Trading Centre	GW	GN202
70	Central	Salima	Salima at Kabwiretsere Scheme, Closer to Well Field for Irrigation Scheme Boreholes	GW	GN214

Note: 1Monitoring point type (SW = Surface water, GW = Groundwater, Pollution = Pollution control)

Source: Project Team

Table 3.4.16 List of Water Quality Monitoring Points (3/5)

No.	Region	District	Station	Type[1]	Corresponding Gauging Station/Borehole ID
71	Central	Salima	Salima at Kuti Well Field	GW	GN215
72	Central	Dedza	Linthipe River I at Water Office	GW	GN176
73	Central	Dowa	Dowa at Chaliwa Dam	GW	GN201
74	Central	Kasungu	Kasungu at Mwalawanyenje Dam	GW	GN177
75	Central	Nkhotakota	Nkhotakota W/Office	GW	GN216
76	Central	Nkhotakota	Nkhotakota Well Field	GW	GN219
77	Northern	Karonga	Lake Malawi at Karonga Boma	SW	17A1
78	Northern	Karonga	North Rukuru River at Karonga/ Songwe M1 Road Bridge	SW	8A5
79	Northern	Karonga	Songwe River at the Bridge near Customs Office	SW	9B3
80	Northern	Karonga	Songwe River near Lake Malawi	SW	9B7
81	Northern	Karonga	Wowve River at Mzuzu/Karonga M1 Road Bridge	SW	17C6
82	Northern	Karonga	Lufilya River at Karonga/Songwe M1Road Bridge, Kapolo area	SW	9A7 (9A2)
83	Northern	Karonga	Lake Malawi at Chilumba Jetty	SW	17C1
84	Northern	Mzimba	Mzimba River at Mzimba/Mzuzu M1 Road Bridge	SW	7A4
85	Northern	Mzimba	South Rukuru River at Kasungu/Mzimba M1 Road Bridge	SW	7A11
86	Northern	Mzimba	Lunyangwa River at Mzuzu Water Supply Intake	SW	7D8
87	Northern	Mzimba	Lunyangwa River at Ekwendeni	SW	
88	Northern	Rumphi	South Rukulu at Lake Kazuni outlet	SW	
89	Northern	Rumphi	Kasitu River at Bwengu/Rumphi Boma Road Bridge	SW	
90	Northern	Rumphi	North Rumphi River at Mzimba/Karonga M1Road Bridge, Chiweta Area	SW	7H3
91	Northern	Rumphi	North Rumphi River at Rumphi Boma Water Supply Intake	SW	
92	Northern	Rumphi	South Rukuru at the Road Bridge	SW	7G14
93	Northern	Nkhata Bay	Luchelemu River at Nkhata Bay/Nkhotakota Road Bridge	SW	16F10
94	Northern	Nkhata Bay	Lake Malawi at Nkhata Bay Boma	SW	16A1
95	Northern	Nkhata Bay	Lweya River at Nkhata Bay/Chintheche Road Bridge	SW	16F15
96	Northern	Nkhata Bay	Lake Malawi at Chintheche Water Supply Intake	SW	
97	Northern	Nkhata Bay	Limphasa River at the Lakeshore Road Bridge	SW	
98	Northern	Chitipa	Songwe River at Gauging Station	SW	9B4
99	Northern	Chitipa	North Rukulu River upstream Kayerekere Uranium Mine	SW	
100	Northern	Likoma	Lake Malawi at Likoma Island	SW	12A1
101	Northern	Karonga	North Rukuru on Karonga/Chitipa Road Bridge	SW	
102	Northern	Mzimba	Lunyangwa River upstream Water treatment works	Pollution	
103	Northern	Mzimba	Lunyangwa River downstream water treatment works	Pollution	
104	Northern	Mzimba	Lunyangwa River downstream Moyale Barracks Sewage Treatment Works	Pollution	
105	Northern	Mzimba	General Hospital effluent, Mzuzu	Pollution	
106	Northern	Mzimba	Southern Bottlers (SOBO) effluent, Mzuzu	Pollution	
107	Northern	Mzimba	Raiply Factory effluent at Chikangawa	Pollution	
108	Northern	Mzimba	Mzimba Hospital Sewage Treatment Works effluent, Mzimba Boma	Pollution	
109	Northern	Mzimba	A stream at SS corner, Mzimba Boma	Pollution	
110	Northern	Mzimba	A stream near Chibuku Brewery Limited, upstream Chibuku outflow	Pollution	
111	Northern	Mzimba	A stream near Chibuku Brewery Limited, downstream Chibuku outflow	Pollution	
112	Northern	Mzimba	Mchengautuwa Landfill Site stream	Pollution	

Note: 1Monitoring point type (SW = Surface water, GW = Groundwater, Pollution = Pollution control)

Source: Project Team

Table 3.4.17 List of Water Quality Monitoring Points (4/5)

No.	Region	District	Station	Type[1]	Corresponding Gauging Station/Borehole ID
113	Northern	Nkhata Bay	Kakumbi stream at the road Bridge to Chikale Beach	Pollution	
114	Northern	Nkhata Bay	Vizala Rubber Factory effluent	Pollution	
115	Northern	Nkhata Bay	Chombe Tea Factory effluent	Pollution	
116	Northern	Chitipa	Chitipa at Water Office	GW	GN174
117	Northern	Chitipa	Chitipa at Well Field	GW	GN175
118	Northern	Karonga	Karonga at Water Office	GW	GN169
119	Northern	Karonga	Karonga at Well Field	GW	GN168
120	Northern	Nkhata-Bay	Nkhata-Bay at Msani Primary School	GW	GN173
121	Northern	Mzimba	Ekwendeni at Endiongoloweni Primary School	GW	GN167
122	Southern	Blantyre	Mudi River at Makata Road Bridge	SW	
123	Southern	Blantyre	Mudi River upstream confluence with Likhubula	SW	
124	Southern	Blantyre	Likhubula River upstream confluence with Shire River	SW	
125	Southern	Blantyre	Limbe River upstream Royale Chemicals	SW	
126	Southern	Blantyre	Limbe River downstream confluence with Limbe Main Sewage treatment works	SW	
127	Southern	Blantyre	Lunzu River at the M1 Road Bridge	SW	1C9
128	Southern	Blantyre	Lilangwe River at M1 Road Bridge	SW	1C1
129	Southern	Mangochi	Lake Malawi at Monkey Bay L.G.S	SW	3A2
130	Southern	Mangochi	Lake Malawi at Club Makokola Lodge	SW	
131	Southern	Mangochi	Lake Malawi at Nkopola Lodge	SW	
132	Southern	Mangochi	Shire River at R.G.S Road Bridge	SW	
133	Southern	Zomba	Lake Chiuta at Chisi Island	SW	
134	Southern	Zomba	Likangala River at Zomba Road Bridge	SW	2B21
135	Southern	Zomba	Likangala River at Kachulu inlet to Lake Malawi	SW	2C10
136	Southern	Zomba	Mulungudzi River upstream Mulungudzi Dam	SW	2B11
137	Southern	Zomba	Mulungudzi River at Zomba Road Bridge	SW	
138	Southern	Zomba	Domasi River at Zomba Road Bridge	SW	2C3
139	Southern	Machinga	Shire River at Mvera point	SW	
140	Southern	Machinga	Shire River Liwonde Railway Bridge	SW	1B1
141	Southern	Mwanza	Mwanza River at Thambani Road Bridge	SW	1K2
142	Southern	Mwanza	Lisungwi River at Mwanza Road Bridge	SW	1O1
143	Southern	Thyolo	Nsuwandzi River upstream water supply intake	SW	14B4
144	Southern	Thyolo	Kwakwasi River at Luchenza Road Bridge	SW	14B8
145	Southern	Mulanje	Likhubula River upstream water supply Intake	SW	14C6
146	Southern	Mulanje	Lichenya upstream water supply Intake	SW	14C8
147	Southern	Mulanje	Muloza River upstream water supply Intake	SW	14C7
148	Southern	Mulanje	Ruo River at Ruo Trading Centre Road Bridge	SW	14C2
149	Southern	Phalombe	Phalombe River upstream water supply Intake	SW	2B37
150	Southern	Phalombe	Phalombe River upstream confluence with Lake Chilwa	SW	
151	Southern	Phalombe	Sombani River upstream water supply Intake	SW	
152	Southern	Phalombe	Sombani River upstream confluence with Lake Chilwa	SW	2A2
153	Southern	Chikhwawa	Shire River at Cikhwawa Road Bridge	SW	1L12
154	Southern	Chikhwawa	Mwanza River at Bereu Road Bridge	SW	1K3
155	Southern	Nsanje	Shire River at Chilomo Railway/Road Bridge	SW	1G1
156	Southern	Nsanje	Shire River Marine Police Station	SW	
157	Southern	Nsanje	Ruo River at Chilomo upstream confluence with Shire River	SW	14D2
158	Southern	Chiradzulu	Namadzi River on Zomba/Blantyre Road Bridge	SW	
159	Southern	Mangochi	Lake Malombe at Marine Police office	SW	
160	Southern	Mangochi	Lusangwisi River at the Bridge	SW	
161	Southern	Mangochi	Masongola River at Namwera Trading Centre Road Bridge	SW/PoII. Con	
162	Southern	Mulanje	Thuchira River on Phalombe/Mulanje Road Bridge	SW	

Note: 1Monitoring point type (SW = Surface water, GW = Groundwater, Pollution = Pollution control)

Source: Project Team

Table 3.4.18 List of Water Quality Monitoring Points (5/5)

No.	Region	District	Station	Type[1]	Corresponding Gauging Station/Borehole ID
163	Southern	Mangochi	Lake Malawi at Cape McLear	SW	
164	Southern	Blantyre	Mudi River at upstream confluence with Blantyre Main Sewage Treatment Works	Pollution	
165	Southern	Blantyre	Mudi River at downstream confluence with Blantyre Main Sewage Treatment Works	Pollution	
166	Southern	Blantyre	Mlambala River downstream confluence with Zingwangwa Main Sewage Treatment Works	Pollution	
167	Southern	Blantyre	Mlambala River upstream confluence with Zingwangwa Main Sewage Treatment Works	Pollution	
168	Southern	Blantyre	Limbe River upstream confluence with Limbe Main Sewage Treatment Works	Pollution	
169	Southern	Blantyre	Limbe River downstream confluence with Limbe Main Sewage Treatment Works	Pollution	
170	Southern	Chikhwawa	SUCOMA Factory Wastewater, SUCOMA	Pollution	
171	Southern	Chikhwawa	PressCane Factory Wastewater, Chikhwawa Boma	Pollution	
172	Southern	Zomba	Likangala River upstream confluence with Municipality Sewage Treatment Works	Pollution	
173	Southern	Zomba	Likangala River downstream confluence with Municipality Sewage Treatment Works	Pollution	
174	Southern	Zomba	Domasi River upstream confluence with Teachers Training College (TTC) Sewage Treatment Works	Pollution	
175	Southern	Zomba	Domasi River downstream confluence with TTC Sewage Treatment Works	Pollution	
176	Southern	Zomba	Domasi River downstream confluence with Prison Sewage Treatment Works	Pollution	
177	Southern	Machinga	Liwonde Sewage Treatment Works Effluent	Pollution	
178	Southern	Zomba	CHANCO Sewerage Treatment Works Effluent	Pollution	
179	Southern	Blantyre	Namwiyo Stream on Chirimba Road Bridge	Pollution	
180	Southern	Blantyre	Naperi River on Blantyre/Chikwawa Road Bridge	Pollution	
181	Southern	Blantyre	Blantyre at the dumping site, Mzedi	GW	DM131
182	Southern	Zomba	Zomba at Songani	GW	DM147
183	Southern	Machinga	Machinga at Ntaja Water Office	GW	GN204
184	Southern	Machinga	Machinga at Kawombe Dam	GW	GN205
185	Southern	Mulanje	Mulanje at Water Office	GW	DM148
186	Southern	Chikhwawa	Chikhwawa at Ngabu	GW	GN166
187	Southern	Chikhwawa	Chikhwawa at the Boma	GW	DM138
188	Southern	Nsanje	Nsanje at Water Office	GW	DM149
189	Southern	Balaka	Balaka at Water Office	GW	DM136
190	Southern	Mangochi	Mangochi at Namwera Well Field, Closer to Southern Region Water Board Boreholes	GW	GN203
191	Southern	Mangochi	Mangochi at Water Office	GW	DM135
192	Southern	Mangochi	Mangochi at Monkey-Bay, before the Trading Centre on Lake Malawi Side	GW	DM134
193	Southern	Mwanza	Mwanza Boma	GW	DM152
194	Southern	Phalombe	Nasomba School	GW	DM158
195	Southern	Balaka	M'manga CDSS	GW	GN165

Note: 1Monitoring point type (SW = Surface water, GW = Groundwater, Pollution = Pollution control)

Source: Project Team

(ii) Data Management System for Groundwater

a) Monitoring and Analysis

The Malawi Bureau of Standards has defined the drinking water standard as MS214:2005 and the industry and sewage effluent standards as MS539:2002 and MS691:2005, but there is no environmental standard considering prevention of environmental destruction and protection of ecosystem in Malawi. It is significant to define thresholds to be observed on natural water and to monitor the impact of increasing load of human activities in future. The Water Quality Service Division has tentatively defined the monitoring parameters as tabulated in **Table 3.4.19**. In future, the constituents to be added and the adequate threshold of each constituent should be examined closely.

Table 3.4.19 Basic Analyzed Parameters for Water Quality Monitoring

Category	Parameters
Water Quality (Surface Water)	pH, Electrical conductivity, Total dissolved solids, Carbonate, Bicarbonate, Chloride, Sulphate, Nitrate, Fluoride, Sodium, Potassium, Calcium, Magnesium, Iron, Manganese, Silica, Turbidity, Suspended solids, Hardness (CaCO3), Alkalinity (CaCO3 and Phosphate, if necessary); 20-21 parameters in total
Pollution Control	pH, Electrical conductivity, Suspended solids COD, BOD, DO (and Phosphate, if necessary); 7-8 parameters in total
Groundwater	pH, Electrical conductivity, Total dissolved solids, Carbonate, Bicarbonate, Chloride, Sulphate, Nitrate, Fluoride, Sodium, Potassium, Calcium, Magnesium, Iron, Manganese, Silica, Turbidity, Suspended solids, Hardness (CaCO3), Alkalinity (CaCO3 and Phosphate, if necessary), (and Faecal coliforms and Faecal streptococci, for drinking water) (20 (23) parameters in total)

Source: Project Team

As recent monitoring activities, one pilot district in each region, i.e., Karonga in the Northern region, Nitcheu in the Central region and Chikwawa in the Southern region, has been selected and monitoring was done in the M&E Project with AfDB funds. All the monitoring points in each district were monitored twice a year during the project period from 2011 to 2013.

b) Data Management

There are no computers to store analysis data in the North and South Water laboratories. The analyzed results are entered first into the field or laboratory logbooks of the laboratories. Separate logbooks for bacteriological records and chemical records are used. Only the Central Regional Laboratory enters analyzed results into the computerized database called Dbase III as a further step of data processing. Dbase III which run on a DOS machine has been used since the mid-1980's. The database can allow the recording of just 18 parameters (pH, Electrical Conductivity, Total Dissolved Solid, Carbonate, Bicarbonate, Chloride, Sulphate, Nitrate, Fluoride, Sodium, Potassium, Calcium, Magnesium, Iron, Manganese, Silica, Turbidity, Suspended solids) as shown in **Table 3.4.20**. It cannot hold any bacteriological parameter, effluent parameters such as DO, BOD and COD, heavy metals, or specialized chemical parameters such as pesticides, oily liquids, radioactive intensity, etc. The database provides limited information such as sample type, sample number, location name, river name, testing data, and analyzed sampling point results. There are no coordinate and grid references, so that sample locations were never identified on maps.

Dbase III is planned to be replaced by MS Access database and all analysis results are recommended to be transferred and stored in the HYDSTRA system in the ongoing project known as Establishment of Water Resources Monitoring System (MoWDI 2010-2013).

Table 3.4.20 Example Sheet of Analysis Data Stored in Dbase III

IDENTITY	LABNO	LOCATION	STYPE	RIVER	DATETEST	PH	EC	TDS	CO3	HCO3	CL	SO4	NO3	F	NA	K	CA	MG	FE	MN	SIO2	NTU	SS
BH	11	Chimpangu, T/A Malil	NBH		27/01/10	7	4150	2205	0	480	15	1258	1	1	156	27	457	51	1	0	13	1	0
Mwanden	1	T/A Mwakaboko, KA	RIV	Songwe	05/01/10	7	43	28	0	14	2	4	0	0	1	1	3	2	0	0	17	300	3968
	2					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RIVER	61	BAMBALA UPSTR PHWEKK			22/02/10	8	172	95	5	78	5	3	0	1	11	4	12	6	0	0	31	2	3
RIVER	62	BAMBALA MIDDLE KK			22/02/10	7	57	29	0	20	5	4	0	1	3	0	6	1	1	0	18	4	10
RIVER	63	BAMBALA MOUTH KK			22/02/10	7	142	80	0	71	5	8	0	1	6	1	14	5	1	0	19	100	58
RIVER	64	LUWI UPSTR NTHANJEKK			22/02/10	7	85	48	0	30	5	7	0	1	2	0	10	3	0	0	18	40	41
RIVER	65	LUWI MIDDLE NTHANJE			22/02/10	7	77	43	0	28	7	4	0	1	3	0	9	2	0	0	20	20	44
LAGOON	66	LUWI MOUTH KK			22/02/10	0	126	64	0	72	3	1	0	1	8	0	11	5	1	0	0	0	0
RIVER	67	LIKOWA UPSTR KANAMA			22/01/10	0	119	70	0	57	5	4	0	0	5	0	11	5	0	0	0	0	0
RIVER	68	LIKOWA MIDDLE KK			22/02/10	0	182	91	10	65	6	6	0	1	8	1	14	8	0	0	0	0	0
RIVER	69	LIKOWA MOUTH KK			22/02/10	7	157	80	0	65	7	13	0	0	9	0	14	5	0	0	13	260	270
RIVER	70	LIFULIZA UPSTR EAMKK			22/02/10	7	101	68	0	24	10	11	0	0	7	2	7	2	0	0	27	60	62
RIVER	71	LIFULIZA MIDCHIT EDZI			22/02/10	7	106	60	0	42	5	9	0	0	5	1	9	4	1	0	20	280	2738
RIVER	72	LIFULIZA AT CHIA MOU			22/02/10	7	148	78	0	61	5	15	0	0	7	0	13	6	1	0	19	320	400
RIVER	73	LIUDZI UPSTR AT MBAW			22/02/10	8	285	143	10	117	5	17	0	0	11	3	30	8	1	0	20	140	146
RIVER	74	LIUDZI MID AT MACHIP		ISA	22/02/10	8	161	80	10	55	3	9	0	0	6	0	13	7	1	0	24	340	400
RIVER	75	LIUDZIB4 CONF WITH L		IFULIZA	22/02/10	8	157	80	10	50	3	9	0	0	6	1	13	7	1	0	22	420	400
RIVER	76	MCHOLI AT MALIKHIT CH		U	22/02/10	8	329	160	24	80	5	31	0	1	15	3	27	10	0	0	26	20	22
RIVER	77	KASANGADZI-MWANSAMBO		TC	22/02/10	8	306	154	14	60	30	16	0	0	13	4	25	9	1	0	24	180	200
RIVER	78	KATETE AT KASAKULASS			22/02/10	7	154	98	0	47	7	23	0	0	7	1	13	6	1	0	29	140	148
RIVER	79	KAVUMA AT CHIT SULOVG			22/02/10	7	100	50	0	42	3	9	0	0	3	0	10	4	1	0	17	210	2110
RIVER	80	CHAFUMBI AT CONFU WI		TH LIFULIZ	22/02/10	7	123	72	0	45	3	16	0	0	6	0	11	5	0	0	23	100	1200
LAGOON	81	CHIA AT THE BRIDGE			22/02/10	8	167	85	10	46	7	10	0	0	9	4	12	5	0	0	16	260	244
LAGOON	82	CHIA AT CENTRE			22/02/10	7	152	83	0	67	5	10	0	0	9	5	11	6	1	0	19	480	520
RIVER	1	SONGWE UPSTR MWAKABO		KA	07/01/10	7	43	28	0	14	2	4	0	0	1	1	3	2	0	0	15	300	3800
RIVER	2	SONGWE AT MWANDENGA		KU	07/01/10	7	45	32	0	17	3	4	0	0	2	1	5	1	0	0	18	305	3300
BH.3	3	MWANDENGA VG MWAKABO	NBH	KA	07/01/10	7	1696	780	38	528	162	22	0	0	130	42	125	22	1	0	10	2	3
BH 2	4	NRA HOUSE SE01/01 KA	NBH		70/11/0	7	340	172	0	108	20	40	0	0	18	2	30	11	1	0	9	2	2
TAP	5	NRA HOUSE			07/01/10	7	271	146	0	84	12	36	1	1	11	1	22	11	1	0	18	2	3
BH	6	MUHALAUNDA MZIKUBOLA	NBH	MZ	07/01/10	6	170	85	0	59	18	3	0	1	9	4	12	6	0	0	19	7	6
BH	7	KAMIZA SCHOOL MZIKUB	NBH	MZ	7 /01/10	7	171	86	0	62	16	6	0	0	12	4	11	6	0	0	14	14	12
RIVER	23	RIVRIVI AT ZALEWARD			04/02/10	8	243	115	16	84	10	1	0	1	14	1	20	8	1	0	11	240	395
RIVER	24	MPAMADZI AT MATSIMBE		NU	04/02/10	8	238	113	17	82	9	1	0	1	12	3	21	7	0	0	13	20	18
RIVER	25	MPAMADZI AT RD BRIDG		MPIRA	04/02/10	8	170	90	0	92	5	0	0	1	9	2	16	6	0	0	13	260	350
RIVER	58	RIVRIVI AT ZALEWARD			04/02/10	8	254	120	20	82	9	1	0	1	12	4	22	8	0	0	13	180	249
RIVER	59	MPAMADZI BELOW WS IN		TAKE NU	04/02/10	8	328	156	18	125	15	0	0	0	11	3	33	11	0	0	9	120	103
RIVER	60	MPAMADZI AT BR TOMPI		RA	04/02/10	8	134	69	0	75	5	1	0	1	7	2	11	6	0	0	9	580	719
RIVER	8	LUMBADZI AT M1 RD BR			12/01/10	8	374	190	14	83	7	62	0	0	20	3	32	10	0	0	11	1	1
RIVER	9	MTOFU AT MGULULA DA			12/01/10	8	616	310	18	219	9	59	0	1	41	4	59	11	0	0	11	12	10
RIVER	10	LUMBADZI AT CHIMOTO		VG	12/01/10	8	445	224	14	141	7	53	0	0	24	4	43	9	0	0	11	30	24
BH	11	CHIMPHANGU VG CHINSA	NBH	PO LL	12/02/10	7	4156	2205	0	480	15	1258	1	1	156	27	457	51	1	0	13	1	0
BH 1	12	SNO.3,4,5			12/02/10	7	33	17	0	2	6	5	0	0	2	0	2	1	0	0	10	220	2217
BH NO.1	13	SNO. 4&5	NBH		22/01/10	7	30	15	0	9	3	2	0	0	2	1	2	1	0	0	10	300	3864
BHNO.1	14	SAMPLE NO.5	NBH		22/01/10	7	12	6	0	10	0	1	0	0	0	0	0	0	4	0	10	210	2354
BHNO.4	15	SNO.2 0.60-10.645M	NBH		22/01/10	7	9	5	0	5	0	0	0	0	0	0	1	0	0	0	10	170	1240
BHNO.2	16	AT 4.50-4.95M	NBH		22/01/10	7	18	9	0	8	1	1	0	0	1	0	1	0	1	0	10	130	1192
BHNO.3	17	SNO.2 1.50-1.95M	NBH		22/01/10	7	39	20	0	7	8	1	0	0	3	1	2	1	1	0	10	180	2600
BHNO.3	18	SNO.5 AT 8.80-10.50M	NBH		22/01/10	7	18	9	0	9	1	0	0	0	1	0	2	1	0	0	10	240	2442
BHNO.4	19	SAMPLE 1 AT 0.0-.605	NBH	M	22/01/10	7	55	27	0	14	9	1	0	0	3	1	4	2	0	0	10	270	2788
BHNO.4	20	SAM.3 AT 3.45-5.87M	NBH		22/01/10	7	10	5	0	6	1	1	0	0	1	0	1	0	1	0	10	180	2000
TP2 AT	21	SAM.2 AT 2.00M LL	SOBO		22/01/10	7	24	12	0	5	2	3	0	0	1	0	3	1	0	0	10	180	2090
4	22	SAM.2 AT 1.00M LL	SOBO		22/01/10	7	20	10	0	8	2	0	0	0	1	0	2	0	0	0	10	130	1290
RIVER	83	AT BRIDGE,NU		MPIRA	06/03/10	8	182	91	2	75	7	10	0	1	15	2	16	3	0	-9	19	194	95
DAM	84	INTAKE,GOMEZA VGE,NU		MPIRA DA	06/03/10	9	180	90	5	73	7	4	0	1	12	2	14	6	0	-9	16	18	12
FILTER	85	DAM PLANT,GOMEZA,NU		RF INLET	06/03/10	8	183	92	5	71	7	7	0	1	10	1	15	5	0	-9	10	17	8
FILTER	86	DAM PLANT,GOMEZA,NU		SSF OUTL	06/03/10	8	178	89	5	69	9	4	0	1	10	1	14	5	0	-9	19	2	1
FILTER	87	GOLONG'OZI PLANT,NU		SSF OUTL	06/03/10	8	168	84	5	65	7	5	0	1	11	1	15	3	0	-9	16	9	3
FILTER	88	MAIN PLANT,MALASWA		RF INLET	06/03/10	8	180	90	5	68	7	5	0	1	13	2	14	5	0	-9	14	24	10
FILTER	89	MAIN PLANT,MALASWA		SSF6 OUT	06/03/10	8	186	93	2	73	12	5	0	1	11	2	16	5	0	-9	14	1	0
TANK	90	MAIN PLANT,MALASWA		T2 TANK	06/03/10	8	179	90	5	75	3	5	0	1	10	1	17	5	0	-9	14	13	5

Source: Water Quality Service Division of MoAIWD

(iii) Issues of Water Quality Monitoring

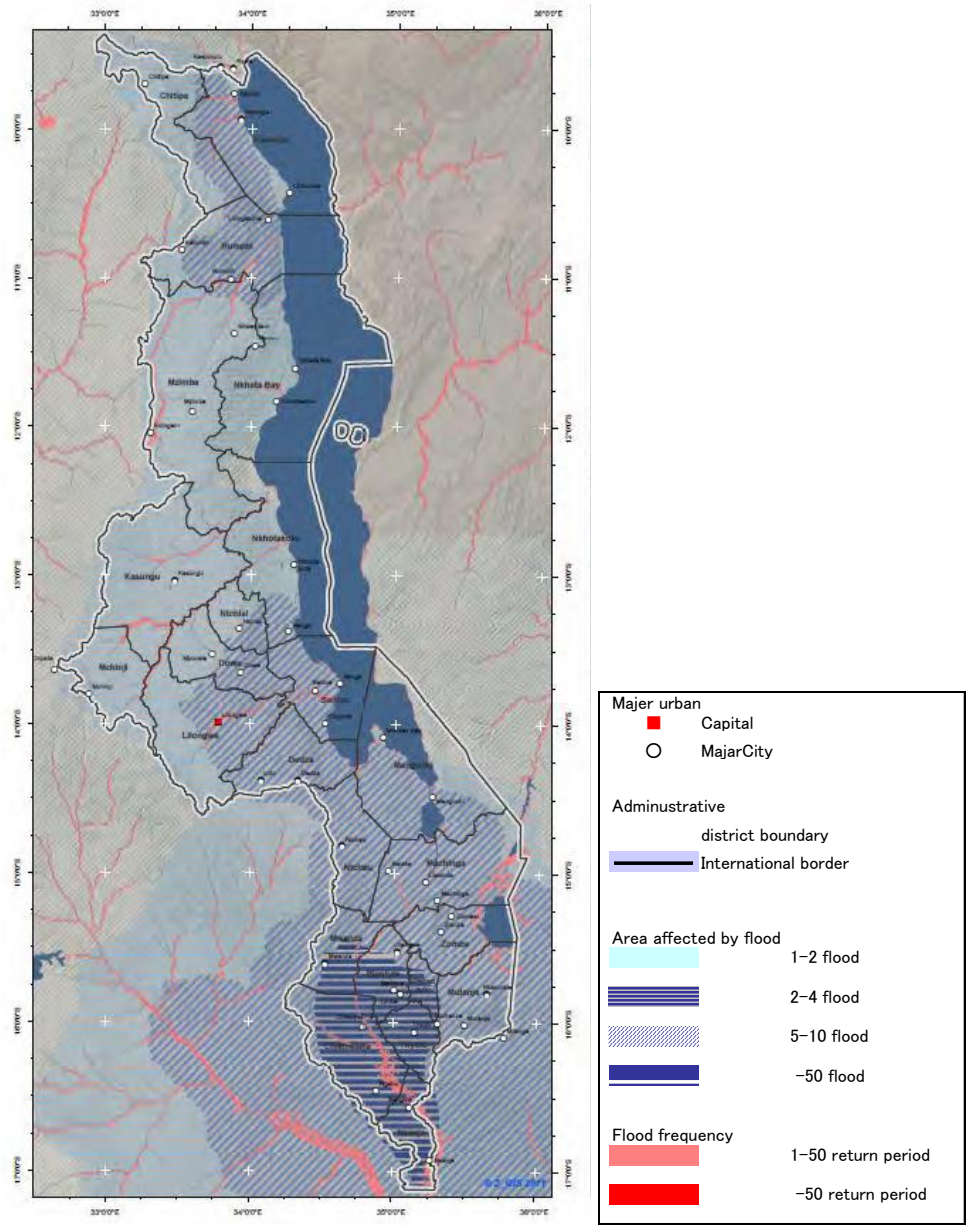
Major issues of water quality monitoring are listed as follows:

- Numbering system of monitoring points and registration system are not established.
- The exact coordinates of each sampling point are not fully determined.
- Modern computerized data management system including database are not developed.
- The running budget for the laboratory was insufficient for the maintenance and repair of equipment as well as purchase of reagents needed for the analyses.
- Sampling and analyzing activities cannot be carried out regularly due to budget, transport, and staffing constraints.

3.5 Flood Conditions

3.5.1 General Flood Conditions

Several flood events had affected Malawi in 1985 to 2010. Based on the past studies and records, it is obvious that more than ten flood events in these 25 years have affected, particularly, the southern region. In the area, the Shire River flows southward from the Malawi Lake to the national boundary through the wide flood plain which has suffered from gradual floods caused by seasonal rising of the water level of the Shire River. The Northern Region also had been severely affected by floods. Particularly, there is a high frequency of flood in the Songwe River. In addition, several districts in the Central Region and the Northern Region have also been affected by floods. The recent flooding condition is illustrated in **Figure 3.5.1**.



Source: Linthipe and Lingadzi River System Study Central Region River Basin, Malawi Final Report

Figure 3.5.1 Flood Inundation Area in Malawi

3.5.2 Flooding Condition of Remarkable Flood Areas

The Project Team had conducted field surveys to grasp the flooding condition in the remarkable flood areas. The results of the survey are summarized below.

(1) Flooding by Shire River

According to the interview with government officials, in the junction of Shire and Ruo River, flood occurred every year due to backwater effect. Serious floods occurred in 1989, 1997, 2005 and 2012 in the area and, especially in the flood in 2012, the levee near Osyana Village in TA Mlolo was breached causing serious flood damage.

(2) Flooding by Songwe River

The Songwe River is located in the boarder of Malawi and Tanzania. The river is divided into middle part and lower part. The lower part is flood plain and many rice fields are cultivated. The middle part of the river often changes its course during the flood.

The river hydraulics is dominated by a number of flood events, each lasting a few days in the rainy season from January to May. Flashfloods from the tributaries converge in the lower reaches of the Songwe River and make the flow even more variable. Finally, the water level of Lake Malawi significantly influences the flooding in the most downstream part of the floodplain.

Figure 3.5.2 Songwe River (Middle Stream)

(3) Flooding by North Rukuru River

The North Rukuru River basin is one of the areas vulnerable to flood in Malawi. Floods often occur due to levee breach in the North Rukuru River. According to a government official, there is a huge flood in every 2 years. Floods may occur due to direct runoff of heavy rainfall as observed during the flood on April 5, 2011 when 104 mm of rainfall was recorded. In the North Rukuru River, the embankment became weak due to the earthquake in 2009. This is one of the main issues of flood protection in the North Rukuru River.

Figure 3.5.3 Flood Inundation Area in Malawi

(4) Flooding by Lakes in Malawi

The areas mainly flooded around Lake Malawi are Mangochi, Karonga, Salima and Makanji. There is a flood plain around Lake Chilwa and some NGOs are supporting the residents in the flooding area.

3.5.3 Past Flood Events

Flooding situations in the Shire, Ruo, Songwe, North Rukuru and Lifidzi river areas are as described below.

(1) Shire and Ruo Rivers

Large floods in the Shire and Ruo areas occurred in 1997 and 2012. The situation of each flood is as explained below.

1) Flood in 2012

Past flood events in the Shire and Ruo river areas were clarified through interview with the residents and government officials. The flood in 2012 caused the most serious damage to the surrounding villages. According to the interview with residents of Mlolo, the following facts were confirmed:

- Flood Depth was about 1 m.
- Velocity was much faster during the flood and it makes difficult to evacuate.
- The flood in 2012 is the largest since 1993.
- Residents in the upper stream alert the flood to the residents in the lower stream by using instruments such as drum.
- During the flood, residents in Mozambique came to Mlolo by boat to help in the evacuation.
- The flood started from the breeched levee in Osyana and finally reached the James villages.

Figure 3.5.4 Flood Mark near the Ruo River

2) Flood in 1997

In March 1997, floodwaters overflowed into Elephant Marsh located upstream of Kamuzu Truss Bridge on the southern bank of the Shire River. This breach was caused by the backflow of the Shire River from the confluence of the Shire and Ruo rivers, thereby causing the embankment of the railway and the S151 road at Chiromo to be washed away. A new river channel was formed by the flood and called the New Shire River, which flows parallel to the original Shire River. The effects of the wash away of embankment still remained as of May 1997.

(2) Songwe River

1) Recent Flood in the Songwe River

According to the government officials, the area most affected by flood is North Karonga and there are large floods in every 2 years such as the floods in 2011 and 2009 when the water depths reached 6.4 m and 8.1 m respectively.

Figure 3.5.5 Flood Mark (Village near the Songwe River)

2) Details of Flood in 2011

Through the interview in Mwandenga (GVH: Mwababwe), the condition of the Songwe flood in 2011 was confirmed as follows:

- More than 1,000 households were affected.
- Inundation depth was about 1 m.
- The early warning system was not working properly; therefore, flood information was obtained from the neighboring residents.
- Water logged for 1 day and there were also problems about Malaria after the flood.
- River courses have changed in this flood and this affected agriculture.
- There was no gender problem during the flood.
- There was no collaboration between Tanzania and Malawi during the flood due to the small scale of flood. If the flood scale was large, there might be some collaboration or support from each other.

(3) North Rukuru River

1) 2011 Flood

In April 2011, heavy rain caused massive flooding in Karonga District of Malawi. Due to the intense rainfall, the dikes constructed to prevent floods from North Rukuru River and the Songwe River collapsed resulting in the extensive flooding around the District Assembly of Karonga including the main market, offices and residential houses. Most of the houses collapsed and fields were washed out. An area stretching to nearly 60 km was submerged. The flood affected areas of Mwakaboko, Kilipula, Wansambo, Mwirang'ombe and Kyungu. At the end of April 2011, a total of 105 villages were affected with 541 houses completely washed away and a total of 27,995 people affected.

One of the main reasons of the 2011 flood was the embankment which became weak after the earthquake in 2009 because only a few maintenance were done.

Figure 3.5.6 Flood Mark near the North Rukuku River

The interview with residents and government officials confirmed the following facts:

- During the flood, UNICEF provided medicine and WFD provided food to the refugees.
- There were mobile EWS but some residents started to evacuate only after they saw the water, which means that the EWS was not functioning properly.
- Water was logged for 2 or 3 days.
- The flood seriously affected agriculture and food security.

- There is a conflict between the residents outside of the embankment and those inside of embankment, because residents outside of the embankment are always protected from flood.
- There was a school evacuation drill after the flood.

2) 1997 Flood

In 1997, the flood from the North Rukuru River inflicted damage to 6 villages in T.A. Wasambo and Karonga in Karonga District, 98 households had their cassava gardens washed away, 13 households had their houses damaged, and 58 people had their corn and rice gardens washed away.

(4) Lifidzi River

On March 17, 2011 heavy rains caused the Lifidzi River to overflow, leading to the evacuation of about 136 households (of which 96 were female headed) to the evacuation center at Naliomba Primary School in Salima District, Central Malawi. The flood destroyed seven homesteads and affected 182 gardens (450 ha) planted mainly with corm and rice.

3.5.4 Condition of Countermeasures

The condition of countermeasures are as described below.

(1) Shire River Basin

In the upper stream of Shire River, people conduct Early Warning System by using instruments such as drums. After the flood in March 2012, the government decided to remove residents from the Osyana village to the upper hill.

(2) Songwe River

The farmers expressed their wish to have the floods controlled. They indicated their willingness to participate in the flood control work despite the consequences associated with flood control work either through provision of the necessary voluntary labor as well as other forms of participation. North Rukuru River

There are natural dikes along the North Rukuru River but they were washed away by floods. The embankment was constructed about 40 years ago and it is becoming older. The embankment was also damaged by the earthquake in 2009 increasing the vulnerability to floods.

(3) Countermeasures for Whole Country

1) New Construction Guidance

The government is considering the formulation of construction guidelines to tackle with disasters. Construction regulations will be included and it is expected that flood damage will be reduced. One of the countermeasures concern the construction of stilt houses.

2) Civil Protection Committee

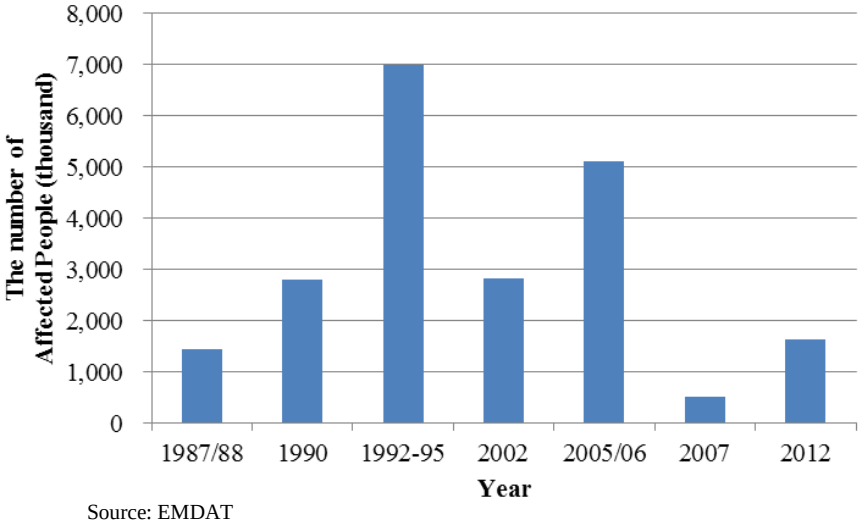
The Civil Protection Committee is to be established for the mitigation of flood damage. There are three levels of the committee; namely, the Village level, Area level and Central level committees. All information about disasters are to be gathered and transmitted to the Department of Disaster Management Affairs (DoDMA).

3.5.5 Droughts

(1) General Condition of Drought

Malawian people suffered from serious drought disasters over the last few decades. According to EM-DAT, the droughts occurred six times between 1987 and 2007 as shown in **Figure 3.5.7** and **Table**

3.5.1 with about 21 million people affected. Furthermore, the Center for Research on the Epidemiology of Disasters (CRED) reported that the number of people affected by droughts since 1965 was almost 20 million while floods have only affected close to 2 million people over the same period.



Source: EMDAT

Figure 3.5.7 Number of People Affected by Droughts

Table 3.5.1 Representative Droughts between 1987 and 2012

Start (Month/Year)	Location	Fatality	Total Affected People
08/2012	Balaka, Blantyre, Chikhaw, etc.	nil	1,630,007
10/2007	Karonga, Mzimba (North), etc.	nil	520,000
10/2005	Southern and central region	nil	5,100,000
02/2002	Balaka, Nlantyre, Chikwawa, etc.	500	2,829,435
04/1992	Dedza, Dowa, Mzimba, Nkho, etc.	nil	7,000,000
02/1990	N.A.	nil	2,800,000
1987	South	nil	1,429,267
Total			21,308,709

Source: EMDAT

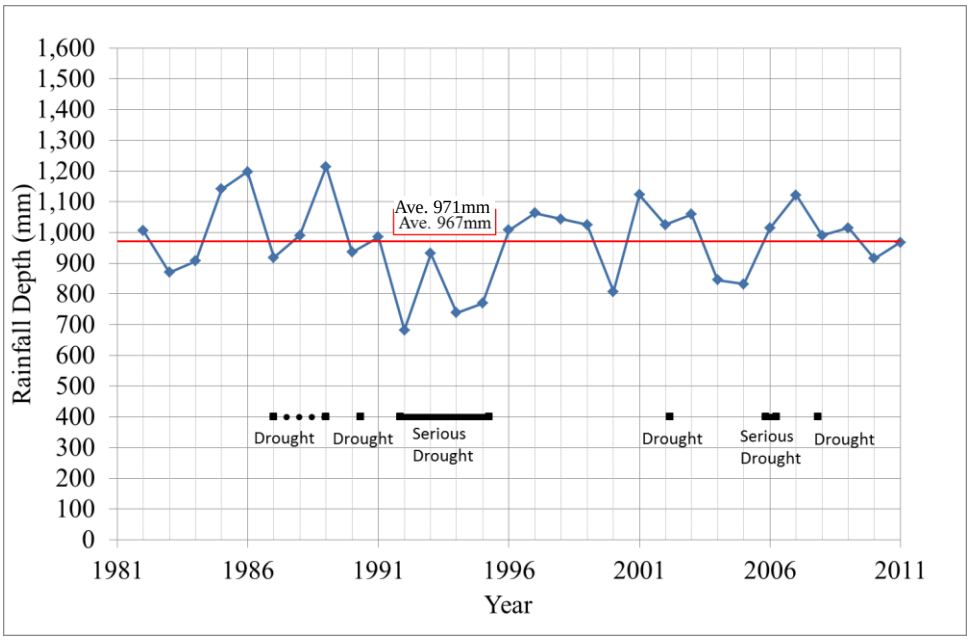
In addition to the information mentioned above, drought information was collected from past reports and announcements issued from the WB and UNDP as shown below although the information were not recorded and summarized in MoAIWD.

- Malawi's drought of January and February 2005 rendered a terrible blow to the country, and the corn harvest had dropped 30 percent from the previous year resulting in the worst season in 10 years (The World Bank).
- Over the last ten years the Shire Valley has experienced some of the worst droughts (1991/92).
- The most vulnerable areas to floods are the lakeshore plains and lower Shire valley; whereas, droughts affect all parts of Malawi. Severe droughts occurred in 1915, 1948, 1992 and 1995 (NAPA).
- During the droughts in the 1991/92 crop season, hydroelectric power (HEP) generation was reduced from 240 megawatts (MW) down to 80 MW.
- The worst scenario occurred between 1915 and 1937 when there was no water outflow from the lake due to lowered lake level, so that during this period the Shire River stopped flowing.
- Lake Chirwa dried up completely in 1995 which may have occurred as a result of the successive droughts in 1991/92 and 1993/94 rainfall season, which resulted in the total loss of fish stocks of the Lake in 2005.
- The 1979/80 drought resulted in the death and migration of most animals from the game reserve of Nyala in Lengwe National Park in Chikwawa.

- During the drought of 1995, some 5,550 ha (or 36%) of Chongoni Forest were destroyed by forest fires caused by human activities such as hunting resulting in smoke haze and pollution.

(2) Drought and Rainfall

Figure 3.5.8 shows annual rainfall depths and occurrences of drought, which indicate that serious droughts happened in the periods after annual rainfall became lower than average.



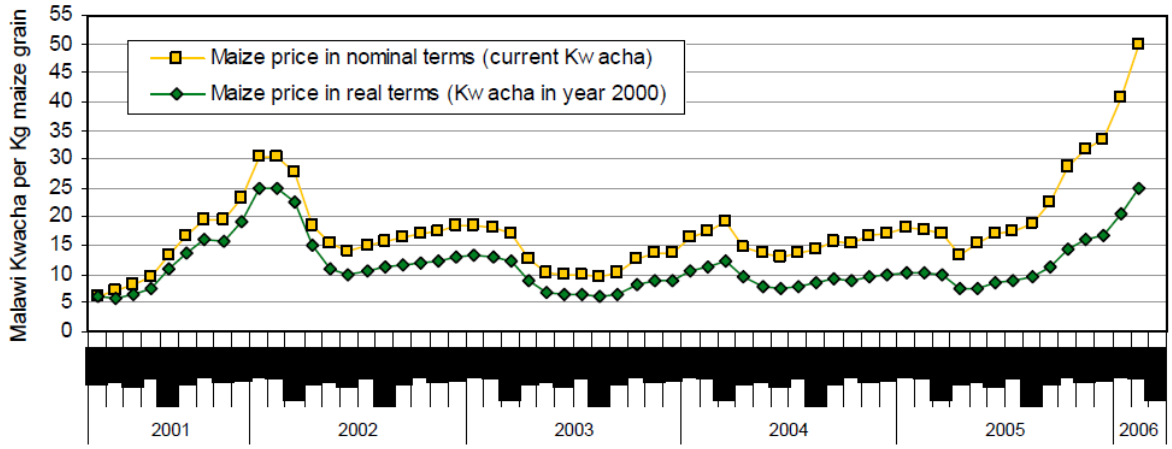
Source: Project Team

Figure 3.5.8 Annual Rainfall Depths and Occurrences of Drought

(3) Influence to Economic Condition

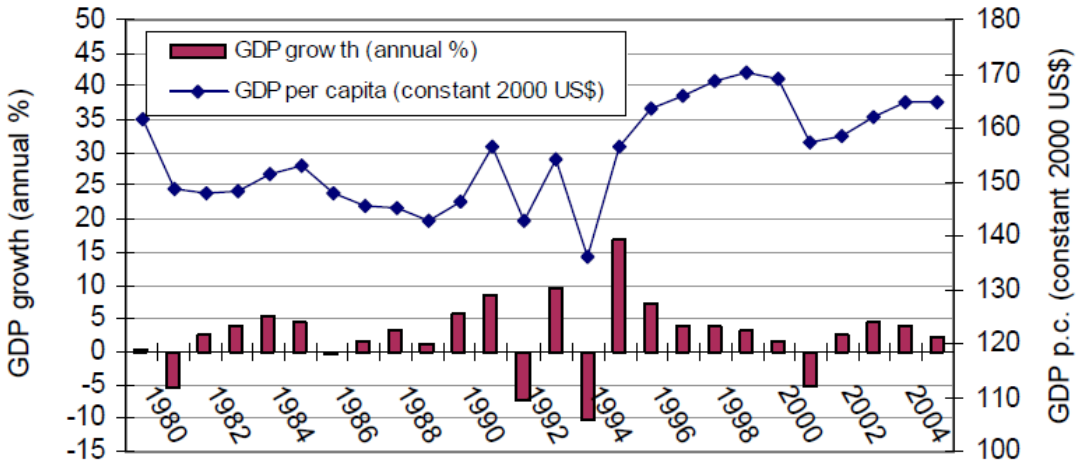
The severe droughts such as the 2001/2002 and 2005/2006 greatly affected not only the agricultural sector but also the GDP. According to "Malawi Poverty and Vulnerability Assessment (WB, 2006)", the enormous inter-annual volatility of prices can be seen between drought years although in normal years, the price variation is substantial (see **Figure 3.5.9**). Practically, the price of corn in August 2005 had risen to about 125 percent higher in February 2006.

As mentioned in Section 2.7, the agricultural sector accounts for 41 percent of the GDP and consists mainly of smallholder farmers. Therefore, the serious drought clearly affected the GDP annual growth rate and volatility of GDP per capita as shown in **Figure 3.5.10**.



Source: Malawi Poverty and Vulnerability Assessment (WB, 2006)

Figure 3.5.9 Monthly Average Maize Price in Nominal and Real Terms



Source: Malawi Poverty and Vulnerability Assessment (WB, 2006)

Figure 3.5.10 GDP Growth and Changes in GDP per Capita

3.6 Ecosystem

Ecosystem is a functional unit of nature where living resources and the residents are in constant relationship. It includes plants, animals, soil, water and people. The ecosystem is sustainable when the elements live in balance. The ecosystem generally has a biodiversity which means that a variety of organisms and species live in it.

3.6.1 Terrestrial Flora and Fauna

Malawi has a wide diversity of terrestrial habitats which accommodate a huge diversity of terrestrial plants and animals.

(1) Plants

According to the National Herbarium and Botanical Gardens, Malawi has about 5,500 to 6,000 flowering plants estimated on the bases of herbarium species. However, a number of species had undergone taxonomic revision; consequently, the exact number of flowering plants is unknown. Likewise, the number of non-flowering plants (Bryophytes and Pteridophytes) has not been updated with new studies, but it has been estimated that the number of Bryophytes could be 250 species.

On the other hand, 261 are considered threatened, vulnerable, rare or endangered out of the estimated 5,000 plant species or over; however, only 11 plant species have legal protection. Recent studies indicate that a large number of plant species are vulnerable since their populations are declining due to over-exploitation and habitat degradation[12].

Other studies were implemented in 1997 to know the plant species that can be found in Malawi by district whose results are summarized in the table below.

Table 3.6.1 Distribution of Plant Species in Malawi

District	Dicots	Monocots	Gymnosperms	Pteridophytes	Bryophytes	Lichens
Chitipa	1123	267	2	52	2	1
Karonga	680	267	2	7	0	0
Rumphi	1367	453	4	7	0	0
Mzimba	1481	538	3	62	4	5
Nkata Bay	1216	326	1	59	2	0
Kasungu	501	124	0	2	0	0
Nkhotakota	371	75	0	14	0	0
Ntchisi	354	44	0	25	0	0
Mchinji	180	41	0	6	0	0
Dowa	260	69	0	5	0	0
Lilongwe	807	169	0	27	0	0
Salima	496	72	1	2	3	0
Dedza	1372	329	15	35	22	0
Ntcheu	585	103	0	11	0	0
Mangochi	923	180	0	11	0	0
Machinga	835	161	1	27	5	2
Zomba	1704	578	12	102	102	35
Mwanza	224	8	0	9	0	0
Blantyre	1121	290	14	44	35	16
Chiradzulu	327	5	0	19	0	0
Mulanje	1540	364	4	122	42	1
Chikwawa	360	52	0	5	0	0
Thyolo	398	134	3	42	0	0
Nsanje	434	61	0	12	0	0

Source: Plant Diversity Task Force Study. NHBG, 1997 (Unpublished)

(2) Animals (Mammals)

About 192 mammal species were recorded, from which 125 are small mammals such as bats and rodents. According to the International Union for Conservation of Nature (IUCN), there are 8 mammals under threat as shown in the table below being the black rhinoceros which is critically endangered[13].

Table 3.6.2 List of Mammal Species under Threat

Scientific Name	English Name	Locations
Diceros bicornis	Black rhino	Liwonde N.P., Majete
Hippopotamus amphibius	Hippopotamus	Elephant Marsh (lower Shire River), the south-west arm of Lake Malawi, Upper Shire River and Lake Malombe in Liwonde National Park
Loxodonta Africana	African elephant	Nyika NP, Thuma FR, Namizimu FR, Kasungu NP, Vwaza, Liwonde, Nkhotakota
Lycon pictus	African wild dog	Vwaza, Kasungu, Nkhota Kota, Mwavi
Rhynchocyon cirnei	Checkered elephant shrew	Widespread in forests
Panthera leo	Lion	Liwonde, Kasungu, Vwaza, NkhotaKota
Paraxerus palliates	Red squirrel	Mulanje, Liwonde, Viphya Ntchisi, lower shire
Lutra amculicollis	Spotted necked otter	Shire river, L. Chilwa, Nkhotakota

Source: IUCN, 2010.

(3) Birds

The number of species of birds recorded in Malawi reaches 648 which were not updated recently. Current data on conservation status of birds is lacking; therefore, only nine species continue to be listed on the IUCN Red Data List (2010)[14].

(4) Habitat for Terrestrial Biodiversity

While customary land areas are rich in biodiversity, most of the terrestrial biodiversity in Malawi occur as wildlife, mainly in national parks, wildlife reserves and forest reserves covering an area of about 1,995,246 ha. According to the Department of Parks and Wildlife, there are five national parks, four wildlife reserves and three nature sanctuaries in the country that serve as home to many animals. Their characteristic features are as presented in the table below.

Table3.6.3 Biodiversity in National Parks, Wildlife Reserves and Nature Sanctuaries

Nº	Name	Description
National Parks: total		
1	Nyika National Park	Located in the northern part of Malawi and covers a total area of 3,134 km^2. The type of vegetation consists of mountain grassland on plateau and miombo woodland on the lower escarpments. Some of the animals that can be found tare zebra, roan antelope, eland, bushbuck, reedbuck, elephant, etc. Poaching is the major threat followed by fires.
2	Kasungu National Park	Located in the central part of Malawi and covers a total area of 2,316 km^2. The type of vegetation consists of miombo woodlands. Some of the animals that can be found are elephant, buffalo, hartebeest, puku, kudu, hippo, etc. Poaching is the major threat.
3	Lengwe National Park	Located in the southern part of Malawi and covers a total area of 887 km^2. Dominant type of vegetation is thicket and thicket savanna. Some of the animals that can be found are impala, warthog, kudu, buffalo, bushbuck, duickers, grysbok, bush pig, suni, etc. Poaching is the major threat.
4	Liwonde National Park	Located in the south eastern part of Malawi and covers a total area of 538 km^2. Dominant type of vegetation is mopane woodland deciduous forest, thicket. Some of the animals that can be found are elephant, impala, sable, warthog, bushbuck, kudu, buffalo, eland, zebra, hartebeest, roan, black rhino, etc. Poaching is the major threat.
5	Lake Malawi National Park	Located in the south eastern part of Malawi and covers a total area of 94 km^2. The type of vegetation consists of miombo woodlands on the escarpments. Some of the animals that can be found are elephant, buffalo, roan, antelope hartebeest, puku, kudu, hippo, etc. Poaching is the major threat.
Wildlife Reserve		
1	Nkhotakota Wildlife Reserve	Located in the central part of Malawi and covers a total area of 1,802 km^2. The type of vegetation consists of miombo woodlands. Some of the animals that can be found are elephant, buffalo, roan, antelope hartebeest, puku, kudu, hippo, etc. Poaching is the major threat.
2	Vwaza Marsh Wildlife Reserve	Located in the northern part of Malawi and covers a total area of 970 km^2. The type of vegetation consists of marsh grassland and miombo woodlands. Some of the animals that can be found are elephant, buffalo, roan antelope, hartebeest, puku, kudu, hippo, etc. Poaching is the major threat.
3	Majete	Area of 691 km^2 (to be confirmed)
4	Mwabvi Wildlife Reserve	Located in the southern part of Malawi and covers a total area of 340 km^2. The types of vegetation consist of Mopane woodland and riparian thicket. Some of the animals that can be found are nyala, suni, sable, etc. Poaching is the major threat.
Nature Sanctuary		
1	Mzuzu Nature Sanctuary	Located in the northern part of Malawi. The type of vegetation consists of tropical rainforest. No records exist on the kind of animals that can be found at the site.
2	Lilongwe Nature Sanctuary	Located in the central part of Malawi, Lilongwe City. The type of vegetation consists of mixed woodland. No records exist on the kind of animals that can be found at the site.
3	Michiru Nature Sanctuary	Located in the southern part of Malawi, Blantyre City. Dominant type of vegetation consists of miombo. No records exist on the kind of animals that can be found at the site. Poaching is the major threat

Remarks: all these protected areas, are important bird areas and are home to a number of species of birds of different extents.
Source: Department of Parks and Wildlife, 2012.

The total forest cover in Malawi is estimated to be declining at the rate of 1.0 to 2.8% annually due to deforestation for firewood, settlement and agricultural expansion.[14]

The JICA Project Team during its field observation in the northern region had noted the presence of artificial forest which is currently under exploitation by communities and enterprises for timber production. This artificial forest plantation named also as Viphia Forest is located in the southern part of Mzuzu City with an area of 560 km^2. An audit report on this forest had mentioned its deterioration since more trees have been harvested than planted, and it has been ravaged by fires.[15]

Generally, forest reserves are proposed for biodiversity conservation, forest production, protection of water supply, erosion control, etc. As for protection of water supply, it is very important to mention here

the license issued to the Northern Region Water Board by the Department of Forestry to manage and maintain catchment and produce potable water in Kaning'ina Forest Reserve. A copy of the License is given in **Annex 3.6.1-1**. These types of licenses must be promoted specially in degraded water catchment zones in order to secure sustainable water resources management.

3.6.2 Aquatic Flora and Fauna

Malawi has three major types of aquatic ecosystems: lakes and small water bodies (e.g. lagoons), rivers, and wetlands, e.g., marshes and swamps.[16]

Among the lakes, the Lake Malawi is considered as very important renewable water resource in Malawi. Other lakes include Lake Chilwa (without outlet), Lake Malombe (formed from Shire River below its outlet from Lake Malawi), Lake Chiuta (shared with Mozambique), and Lake Kazuni. Among the small water bodies exist the Chia and Chiwondo lagoons. The Shire River is the largest river in the country and the only outlet of Lake Malawi. All other major rivers and streams drain into Lake Malawi or the Shire River[17].

Many river basins in the country are under severe pressure due to deforestation, unsustainable agriculture, settlements, mining, industry, commerce, tourism and climate change. These activities have influenced changes in water quality especially due to sediment loads, industrial wastes, chemicals from agricultural lands, and the proliferation of aquatic vegetation. As for sediment loads, large concentration of sand in the river beds can be found in central Karonga, the Nkhotakota lakeshore, the Shire valley and in rivers that flow towards Lake Chilwa[18].

About 20% of the country territory is covered by wetlands which provide a wide range of habitats for aquatic or semi-aquatic biodiversity. Three large marshes are of economic significance: the Elephant Marsh, Ndindi Marsh and Vwaza Marsh. The wetlands such as Lake Chilwa wetland and elephant marsh are bird sanctuary and destination for migratory birds. Wetlands are threatened and most of them have been modified by human activities[19].

On the other hand, all amphibians are associated with aquatic ecosystems in Malawi. About 11 amphibian species are threatened according to IUCN (2010). As for reptiles, 12 species are endemic to Malawi[20].

Malawi is one of the countries with rich fish diversity. It contributes about 14% of world freshwater fish and about 4% of world fishes. The total number of fish species that can be found in Malawi is estimated to be more than 1,000 species. Over 800 fish species have been described in Lake Malawi alone. About 9% of Lake Malawi fish species are endemic to Lake Malawi and 95% of these species are haplochromine cichlids, which are internationally recognized as an outstanding example of rapid speciation[21].

The International Union for Conservation of Nature (IUCN) in 2005, conducted a red list assessment of 423 Malawian fish species. The assessment showed that 65.72% of Malawian fishes were of least concern implying that they were quite abundant, 27.42% were vulnerable, 4.12% had no enough data for assessment, 2.36% were endangered while 0.47% were not evaluated. The endangered fish species were from the two most species diverse families of fishes in Malawi: Cichlidae and Cyprinidae as shown in the table below.

Table 3.6.4 List of Endangered Fish Species in Malawi

Nº	Scientific Name	Family Name	Local Name
1	*Labeo mesops*	Cyprinidae	Ntchila
2	*Lethrinops macracanthus*	Cichlidae	Mbaba
3	*Lethrinops micrentodon*	Cichlidae	Mbaba
4	*Lethrinops microdon*	Cichlidae	Mbaba
5	*Lethrinops stridae*	Cichlidae	Mbaba
6	*Opsaridium microlepis*	Cyprinidae	Mpatsa
7	*Oreochromis shiranus chilwae*	Cichlidae	Makumba
8	*Oreochromis (Nyasalapia) karongae*	Cichlidae	Chambo
9	*Oreochromis (Nyasalapia) lidole*	Cichlidae	Chambo
10	*Oreochromis (Nyasalapia) squamipinnis*	Cichlidae	Chambo

Source: International Union for Conservation of Nature, 2005

The ten species are probably endangered due to over exploitation by fishermen since they are commercially important species[22].

As for aquatic plants, from the point of view of water resources management, the water hyacinth (Eichhornia crassipes) is the most widespread and the most harmful among the plant invasive species in Malawi. Presently, water hyacinth is in most parts of Malawi, including the far north of the country. Water hyacinth covers the water surfaces interfering with the free flow of water and its dense mats reduce the amount of light that penetrates through it affecting the growth of plankton.

The major impact of water hyacinth in Malawi is related to its interference with the power generation at Nkula and Tedzani stations in lower Shire resulting in intermittent blackouts affecting the economy. It was estimated that ESCOM (Electricity Supply Commission of Malawi) spend about MK 3 million/month to mechanically remove the weeds[23].

3.6.3 Forestry

In Malawi, forestry resources form a principal part of natural resources and contribute significantly to the socioeconomic development of the country. They provide forest goods and services such as catchment conservation, employment, industrial poles, timber for construction, fruits, mushroom and grass for thatching houses, medicine and herbs among others[23]. Thus the forest is one of the indispensable resources in Malawi.

The following summarizes the historical changes of forest coverage and major issues on deforestation/degradation mechanism and necessary interventions.

(1) Historical Changes of Forest Coverage and Current Situation

There are two forest situation survey projects, the past and the presently ongoing project. In 1993, the World Bank supported project[24] conducted forest interpretation using the LANDSAT MSS (Multispectral Scanner) imagery taken in 1972/1973 and land use interpretation using the LANDSAT TM (Thematic Mapper) imagery taken in 1990/1991. Thus, historical changes of forest coverage could be clarified between the above two years, 1972/1973 and 1990/1991. Land use conditions over the entire Malawi, which was clarified by this WB study, is already presented in Chapter 2 as land use of natural conditions.

On the other hand, the Forest Resource Mapping Project[25] supported by Japan also has been conducting similar investigation on historical changes of forest coverage after the World Bank project, using LANDSAT TM and ALOS imagery. Thus after completion of this project, the historical changes of forest coverage and current situation could be made clear from 1990/1991 to date. After the completion of this project this coming October/November 2013, the JICA Project Team will be able to receive some satellite imagery from the Department of Forest and present the typical imagery in the report of the next stage.

Table 3.6.5 below summarizes the survey results by forest classification and region. Forest classifications as adopted in the table are as follows:

Fe: Evergreen forest; defined by the property of having green leaves throughout the whole year, even during dry season.

Fbh: Brachystegia forest in hilly areas; non-evergreen forest with brachystegia as main species in hilly areas.

Fbh: Brachystegia forest in flat areas; non-evergreen forest with brachystegia as main species in flat areas.

Fpe: Forest plantations of Eucalyptus; widely distributed all over Malawi.

Fpg: Forest plantations of Gmelina, found in Lilongwe district only.

Fpp: Forest plantations of Pine; widely spread all over the country, mainly on high altitudes.

Fpr: Forest plantations of Rubber; relatively new plantation species, found in Nkhatabay district only.

Fpt: Forest plantations of Tung; found in areas around Mzuzu only. The extent of Tung plantations has decreased during the last 20 years, the remaining ones often existing side by side with other tree plantations.

Fl: Logged forest; Logged areas are normally smaller than 100 ha and they were therefore not mapped. The large logged areas in Mangochi district were exceptions.

*Latest forest areas in 2010/2011 will be confirmed after submission of the survey results to the Department of Forest by the JICA Project Team in the end of August 2012. After that an evaluation shall be made for historical changes of forests in Malawi.

Regarding ownership pattern, forests are divided into three categories; namely, 1) public forest including forest reserve, national park and wildlife reserve; 2) customary forest including forests managed by traditional authority and village common forest; and 3) private forest. Forest area by ownership is summarized in the following table. Customary and private forest areas, however, are approximate values[26].

Table 3.6.5 Historical Forest Area Changes by Forest Classification and Region

Region	Northern Region			Central Region			Southern Region			The whole of Malawi		
Class/Year	1972/73	1990/91	2010/11	1972/73	1990/91	2010/11	1972/73	1990/91	2010/11	1972/73	1990/91	2010/11
Fe	593.6	572.1		73.2	67.7		213.0	186.3		879.9	826.2	
		(-21.5)			(-5.5)			(-26.7)			(-53.8)	
Fbh	10,605.8	7,954.8		6,418.0	4,313.1		6,972.2	4,590.7		23,996.1	16,858.5	
		(-2,651.0)			(-2,104.9)			(-2,381.5)			(-7,137.6)	
Fbf	3,876.2	1,843.4		8,393.9	2,728.2		6,862.8	2,759.5		19,133.0	7,331.1	
		(-2,032.9)			(-5,665.7)			(-4,103.3)			(-11,801.9)	
Fpe	0.8	5.6		0.8	111.2		44.7	123.6		46.3	240.4	
		(4.8)			(110.4)			(78.9)			(194.1)	
Fpg	0	0		6.1	7.2		0	0		6.1	7.2	
					(1.1)						(1.1)	
Fpp	335.8	811.5		31.9	146.5		48.2	114.9		415.9	1,072.9	
		(475.7)			(114.6)			(66.7)			(657.0)	
Fpr	0	26.7		0	0		0	0		0	26.7	
		(26.7)									(26.7)	
Fpt	37.9	17.1		0	0		0	0		37.9	17.1	
		(-20.8)									(-20.8)	
Fl	0	0		0	0		0	48.2		0	48.2	
								(48.2)			(48.2)	
Total Area	15,450.2	11,231.2		14,923.8	7,373.8		14,141.0	7,823.2		44,515.2	26,428.3	
		(-4,219.0)			(-7,550.0)			(-6,317.8)			(18,086.9)	

Source: 25 and 26 in the references, unit: km^2, Note: Figures in parentheses are changes of forest areas from the previous data.

Table 3.6.6 Forest Area by Ownership and Category

Ownership	Category	Area (km^2)	Remarks
Public	Forest Reserve (88 places)	9,184	Including 31 plantations of 9,000 km^2
	National Park (5 places) Game Reserve (4 places)	11,002	Entire park and reserve areas including another land use category
Customary		11,000	Including 2,565 village forest areas of 3,178 km^2
Private		2,750	
Total		33,936	

Source: 27 in the reference and Draft Summary Report on Malawi Forestry Sector

From the above table, although areas of the national park and game reserve sum up including entire designated extent, public and customary forests occupy almost all forest areas. Thus public and customary forests could be regarded as dominant forest categories in Malawi.

(2) Deforestation/Degradation Mechanism and Necessary Interventions

Comparing forest areas between 1972/73 and 1990/1991 in the World Bank study[26], the following facts could be clarified regarding deforestation and forest degradation:

- In 1972/73, forest area aggregated 44,515 km^2 being equivalent to 47% of the land area of 94,276 km^2, while it was reduced to 26,428 km^2 in 1990/91 of which reduction rate is about 41% for 18 years.

- In this period, the reduction rates by region are 27% in the northern region, 51% in the central region, and 45% in the southern region. Thus the deforestation/degradation proceeded in the central and southern regions due to their higher population density.
- Regarding deforestation/degradation process by the categorized forest types, it has been clearly proceeding particularly in the village forest areas in customary forest and in the forest reserve areas. It may occur mainly due to augmentation of agricultural land and logging for charcoal production and utilization of firewood [27].

Against these deforestation/degradation trends, the following measures were taken during the period of MGDS from 2006 to 2010[25]. In addition to these interventions, such deforestation/degradation of forest cover has accelerated soil erosion so that increase volume of sediment yields and transport has caused acceleration of riverbed aggradation and sediment deposition in the reservoirs. Against these adverse effects, some watershed management activities/projects have been conducted as presented in Section 4.3, Ongoing Activities and Projects, of this report.

- There has been an increase in the percentage of households with access to electricity from 4 in 2005 to 9 in 2010. As a result, there has been a decline in the proportion of population using solid fuels from 94.8% in 2005 to 78% in 2010.
- The sector concerning natural resources conducted the Environmental Management Plans of development projects and programs; increasing public awareness on environment and natural resources management; improved protection of river catchment areas, increased land area under industrial plantations from 1,609 ha in 2005 to 5,784 ha in 2010; and increased customary land area planted with trees from 77,810 ha in 2005 to 187,791 ha in 2010.

The MGDS II will continue the above improvement targeting increasing availability and access to energy in energy sector and increasing forest cover and incomes from forestry products and services in forestry sector for the period 2011-2016.

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PART I

Chapter 4. REVIEW OF EXISTING PLANS AND ACTIVITIES

CHAPTER 4. REVIEW OF EXISTING PLANS AND ACTIVITIES

4.1 National Water Resources Development and Management Context

4.1.1 National Development and Management Strategy Related to Water Resources

(1) National Development Overview

Since 1998 when Malawi Vision 2020 was launched, the Malawi Government had implemented two medium-term national development strategies: the Malawi Poverty Reduction Strategy (MPRS) and the Malawi Growth and Development Strategy (MGDS). The MGDS II, therefore, becomes the third national development strategy.

The following are brief summaries of these development policies:

1) Malawi Vision 2020 [1]

The Malawi Government developed the Malawi Vision 2020 and started implementing it in 1998. This policy framework sets out a long-term development perspective for Malawi and states that "by the year 2020 Malawi as a God fearing nation, will be secure, democratically mature, environmentally sustainable, self-reliant with equal opportunities for and active participation by all, having social services, vibrant cultural and religious values and a technologically driven middle income economy."

The Vision focuses water resources development and management on related areas which, together with their major strategic options, are as summarized below.

Development, Economic Infrastructure

Water Transport Development

- Dredging major rivers to make them passable
- Ratifying useful International Maritime Conventions

Promoting Efficient Electricity Supply and Distribution

- Taking preventive measures to avoid shortage of water by better conservation of catchment areas

Reducing Dependence on Fuelwood

- Developing commercial forests and encouraging the use of other forms of energy

Increasing Access to Water

- Increasing investment in water supply infrastructure
- Protecting catchment areas
- Encouraging harvesting of rainwater

Improving Sanitation Services

- Increasing investment in the construction of appropriate facilities and research
- Reducing waste generation
- Reviewing legislation governing disposal of waste including industrial hazardous waste
- Developing standard designs for sanitation disposal system of developers

Food Security and Nutrition

Irrigation Development

- Developing potential areas with best chance of success taking into account social factors, cost effectiveness and financial viability
- Developing irrigation schemes which are owned, operated and maintained by the farmers
- Developing various types of irrigation using pump and gravity-based systems that use both surface and groundwater sources
- Encouraging the development of irrigation both by groups of smallholders, individual smallholder farmers and estates, and encouraging private sector development of irrigated agriculture
- Encouraging farmers to use rain harvesting technics and encouraging construction of dams
- Encouraging indigenous irrigation methods

Improvement Disaster Management

- Putting in place a sound national disaster management plan
- Encouraging local initiatives for disaster preparedness

Natural Resources and Environmental Management

Controlling Land Degradation

- Reviewing land policy: undertaking land reform, and harmonizing sectoral policies to facilitate the implementation of a comprehensive soil conservation program
- Rehabilitating degraded land
- Intensifying afforestation and agro-forestry programs
- Preventing livestock overstocking
- Enforcing land conservation aspects of infrastructural project

Arresting Deforestation

- Developing consistent policies and laws to guide and enforce forest conservation
- Intensifying the rural electrification program and making electricity affordable
- Finding other forms of energy
- Enhancing the effectiveness of tree planting programs
- Promoting agroforestry, commercial forest ownership, and forestry industries
- Using sustainable methods of harvesting trees for fuel

Development Fisheries

- Declaring river mouths as protected areas
- Restocking the lakes
- Improving fish breeding using artificial methods

2) Malawi Poverty Reduction Strategy (MPRS) [2]

In May 2002, Government launched the MPRS which presented the first attempt to translate long-term vision into medium term focused action plans. The MPRS became the overarching medium term strategy of the Government for reducing poverty in the country. The goal of the MPRS was to achieve "sustainable poverty reduction through empowerment of the poor."

The MPRS was built around four strategic pillars; namely, sustainable pro-poor growth; human capital development; improvement of the quality of life of the most vulnerable; and good governance. The implementation period for the MPRS was three years ending in fiscal year 2004-2005.

The MPRS, however, did not state the interaction between poverty reduction and infrastructure improvement in detail, particularly, water resources development and management.

3) Malawi Growth and Development Strategy (MGDS) [3]

In the second half of 2005, the MPRS was reviewed to draw lessons from its implementation. The lessons were summarized and the findings informed the strategic direction of the MGDS. In the process of reviewing the previous MPRS, the Malawi Government launched the MGDS in 2007. It was designed as an overarching operational medium-term strategy for Malawi to attain the nation's Vision 2020 and the Millennium Development Goals (MDGs) for the period 2006-2011. The main aim of the MGDS was to create wealth through sustainable economic growth and infrastructure development as a means of achieving poverty reduction.

The MGDS had identified six priority areas that define the direction the country intends to take in the next five years to achieve economic growth and wealth creation. The government will concentrate its efforts on these key priority areas in the medium-term in order to achieve its overall policy objective of economic growth as a means of reducing poverty in the country. The six priority areas are: agriculture and food security; irrigation and water development; transport infrastructure development; energy generation and supply; integrated rural development; and prevention and management of nutrition disorders, HIV and AIDS.

The MGDS focuses water resources development and management on related areas which, together with their goals and key major strategic options, are summarized as follows:

Agriculture and Food Security

Agricultural Productivity

Long-Term Goal: To increase agriculture productivity

- Promoting soil and water conservation and farming techniques
- Promoting irrigation farming

Irrigation and Water Development

Long-Term Goal: To ensure that water resources are well protected and managed to meet agricultural, domestic and industrial demands

- Constructing and promoting small and medium scale irrigation schemes to enhance food crop production
- Constructing multi-purpose dams that apart from generating electricity will be used for irrigation, piped water supply, as well as promoting fish farming
- Improving sustainable access to water supply and sanitation in urban, peri-urban and rural areas by establishing water supply and sanitation systems using demand responsive and demand driven approaches
- Integrating rural water supply and participatory hygiene and sanitation transformation
- Empowering national authorities to manage water resources using integrated water resources management approaches
- Establishing good monitoring systems
- Improving the quality of surface and ground water and developing a system for pollution control
- Establishing contingency water supply reserves and sanitation backups

Transport Infrastructure Development

Water Transport

Long-Term Goal: To open up the linkage to the sea

- Developing an efficient and productive maritime transport system that meets national and regional requirements
- Dredging, opening up channels and acquiring badges or ships, which would navigate the Shire River through Zambezi and to the Indian ocean

Energy Generation and Supply

Long-Term Goal: To generate sufficient amount of energy to meet the economic and social demands

- Ensuring provision of reliable electrification to key mining, irrigation, business, tourism, and other economic activities
- Constructing mini hydropower stations along the Shire and other major rivers to supplement electricity supply in the three regions
- Expanding the Rural Electrification Programme (increase resources, promote development of micro hydropower stations and use of solar energy for off grid power supply) and use of both grid and off-grid options

4) Malawi Growth and Development Strategy II (MGDS II)

Annual reviews were conducted throughout the period of MGDS to draw lessons from its implementation. These lessons, among other things, informed the strategic direction of the MGDS II. After the similar process of MGDS formulation, the MGDS II was designed to attain the country's Vision 2020, overarching operational medium term strategy for Malawi for the next five years, 2011 to 2016.

MGDS II increases key priority areas from six to nine compared with MGDS, as presented in the table below.

Table 4.1.1 Comparison of Key Priority Areas of Both Strategies, MGDS and MGDS II

No.	Key Priority Areas of MGDS	Key Priority Areas of MGDS II
1	Agriculture and food security	Agriculture and food security
2	Irrigation and water development	Green Belt Irrigation and water development
3	Transport infrastructure development	Transport infrastructure and Nsanje World Inland Port
4	Energy generation and supply	Energy, industrial development, mining and tourism
5	Integrated rural development	Integrated rural development
6	Prevention and management of nutrition disorders, HIV and AIDS	Public health, sanitation, Malaria and HIV and AIDS management
7		Education, science and technology
8		Child development, youth development and empowerment
9		Climate change, natural resources and environmental management

Source: 3) and 4) in the References
Note: Appearance order follow the order in the MGDS.

In similar manner as the MGDS, **Table 4.1.2** summarizes the water related areas and their goals and key strategies stated in the MGDS II in comparison with MGDS.

As summarized in the table, MGDS II improves the new fields by adding projects for immediate implementation and elaborates the key strategies in comparison with the previous MGDS, as follows:

- The Green Belt Irrigation Project clearly stated as modified key priority area, namely, the "Green Belt Irrigation and Water Development."
- The Nsanje World Inland Port Project also stated as a modified key priority area, namely, the "Transport Infrastructure and Nsanje World Inland Port."
- "Climate Change, Natural Resources and Environmental Management" is newly added among the key priority areas as a burning issue.
- As easily understood in the table, various sub-areas and key strategies are elaborations from the ones of the previous MGDS.

Table 4.1.2 Comparison of Water-Related Key Priority Areas, Goals and Key Strategies between MGDS and MGDS II (1/3)

Item	Statement in MGDS	Statement in MGDS II
Key Priority Area	Agriculture and Food Security	Agriculture and Food Security
Sub-Area	Agricultural productivity	Agricultural productivity and diversification
Long-Term Goal	To increase agriculture productivity	To increase agriculture productivity and diversification
Key Strategies	Promoting soil and water conservation and farming techniques	Promoting soil and water conservation techniques
	Promoting irrigation farming	Promoting irrigation farming
Key Priority Area	Irrigation and Water Development	Greenbelt Irrigation and Water Development
Sub-Area	-	Greenbelt irrigation
Long-Term Goal	To ensure that water resources are well protected and managed to meet agricultural, domestic and industrial demands	To increase agricultural production and productivity through intensification of irrigation
Key Strategies	Constructing and promoting small and medium scale irrigation schemes to enhance food crop production	Promoting development of areas with irrigation potential
		Promoting rehabilitation of irrigation infrastructure
		Promoting research and use of appropriate technologies in irrigation
		Enhancing IEC on irrigation
		Enhancing technical and administrative capacities in irrigated agriculture

Source: 3 and 4 in the references

Table 4.1.2 Comparison of Water-Related Key Priority Areas, Goals and Key Strategies between MGDS and MGDS II (2/3)

Item	Statement in MGDS	Statement in MGDS II
Sub-Area	-	Water development
Long-Term Goal	-	To improve access to water through an integrated water management system
Key Strategies	Constructing multipurpose dams that, apart from generating electricity will be used for irrigation, piped water supply, as well as promoting fish farming	Promoting development of potential multi-purpose dam sites and groundwater resources
	Improving sustainable access to water supply and sanitation in urban, peri-urban and rural areas by establishing water supply and sanitation systems using demand responsive and demand driven approaches	Improving existing water infrastructure
		Increasing number of people connected to piped water supply systems in both urban and rural areas
		Enhancing information, education and communication
		Promoting private sector participation in the provision of water services
	Integrating rural water supply and participatory hygiene and sanitation transformation	Promoting the empowerment of local communities in water resources development and management
		Promoting equitable distribution of water points to rural areas through GPS mapping
	Expanding the Rural Electrification Programme (increase resources, promote development of micro hydropower stations and use of solar energy for off grid power supply) and use of both grid and off-grid options	Enhancing urban and rural electrification
Key Priority Area	-	Climate Change, Natural Resources and Environmental Management
Sub-Area	-	Climate change management
Long-Term Goal	-	To enhance resilience to climate change risks and impacts
Key Strategies	-	Improving weather and climate monitoring, prediction systems, and information and knowledge management systems
		Promoting dissemination of climate change information for early warning, preparedness and response
		Enhancing implementation of climate change mitigation and adaptation programmes

Source: 3 and 4 in the references

Table 4.1.2 Comparison of Water-Related Key Priority Areas, Goals and Key Strategies between MGDS and MGDS II (3/3)

Item	Statement in MGDS	Statement in MGDS II
Sub-Area	-	Natural resources and environmental management
Long-Term Goal	-	To ensure sustainable management and utilization of the environmental and natural resources
Key Strategies	-	Promoting development and implementation of Clean Development Mechanism (CDM), voluntary carbon markets and Reduced Emission from Deforestation and Degradation of Forest (REDD) projects

Source: 3 and 4 in the references

4.1.2 Development Achievement under the Strategies in the Recent Decade

The series of 5-year development strategies on the national level indicate that situations related to water resources development and management could be improved using the typical indicators described in the strategies. The indicators stated in the strategies, however, are inconsistent, particularly, those in the MPRS. The following table gives the comparison of indicators between the MGDS and the MGDS II. Based on the clarified indicators, the plan achievements and issues are as discussed below.

(1) General Indicators

GDP annual growth rate and income per capita have steadily increased as inflation has calmed down in these 5 years. Only the literacy rate has not improved faster than planned, although the poverty level also shows significant improvement.

(2) Forest Cover

The progress in forest cover is to be examined when the latest data are obtained.

Table 4.1.3 Baseline and Target Indicators in the MGDS and MGDS II

Indicators	MGDS 2006/2007 – 2010/2011		MGDS II 2011/2012 – 2016/2017	
	Baseline in 2005	Target for 2011	Baseline in 2010	Target for 2016
General				
Minimum annual growth rate of GDP	3.5%	6.0%	7.5%	7.3%
Inflation rate	16.9%	5.0%	6.3%	5.9%
Poverty headcount measured by consumption based on poverty line	52.4%	30.4%	39%	37%
Income per capita	170 USD	450 USD	380 USD	727 USD
Female literary rate	51%	85%	59%	89%
Youth literacy rate (age 15 to 24)	75%	95%	86%	95%
Natural Resources				
Proportion of land area covered by forest	27%	30%	35%	50%
Energy				
Access of electricity	7%	10%	9%	15%
Proportion of population using solid fuels	94%	85%	78%	
Water and Sanitation				
Percentage of population with access to safe portable water	66%	80%	81%	86%
Percentage of population with access to improved sanitation	(83%)	(95%)	46%	75%
Number of dams constructed	75	750		
Transportation				
Transport cost as a percentage of export/import	56%	12%		
Increase in passengers using water transport			9,935	630,000
Increase in cargo/tonnage using water transport			56,457 tons	160,600 tons
Irrigation				
Output from irrigation agriculture			482,555 tons	1,292,555 tons

Note: Figures in parentheses are based on basic type of sanitation.
Source: 3 and 4 in the References

(3) Energy

In proportion to the increase of electricity access rate, population using solid fuels has decreased. The access rate of electricity itself, however, is still very low. Regarding this issue, MGDS II states the following:

"This lack of reliable power is a key constraint to development in Malawi. The current installed capacity of 283 Megawatts is far much less than the estimated demand of 334 Megawatts. Unavailability of access to modern energy services contributes to low economic activity and productivity, lower quality of life and deters new investments across the country, in particular affecting key sectors of mining and manufacturing."

(4) Water and Sanitation

The water and sanitation sector made notable achievements including the promotion of Water and Sanitation Hygiene (WASH). The MGDS II also states as follows:

"In recent years, access to potable water has improved throughout the country. Statistics show that total water supply coverage has increased from 58% in 2004 to 76% in 2009. In 2008, water supply coverage in rural areas of Malawi was at 64%. Despite these achievements, there are considerable challenges facing the country in the water sector. These include relatively low access to potable water, aging infrastructure, inadequate maintenance capacity, theft and vandalism resulting in more than 30% non-functionality of the infrastructure."

(5) Water Transport

At present the Shire Zambezi waterway, as well as the Nsanje Port, is closed. There are enormous efforts to be made, including newly constructing various infrastructure connecting to the port, installation of international port facilities, waterway dredging and clean-up of thickly growing water hyacinth, and so on.

(6) Irrigation

The progress in irrigation could not be evaluated due to lack of related data in the strategy papers. As for the Greenbelt Irrigation project, it will utilize the available abundant water resources in Malawi and increase the irrigation area from 90,000 ha to 400,000 ha out of the potential 1 million ha.

4.2 Review of 1986 Master Plan

4.2.1 Water Supply

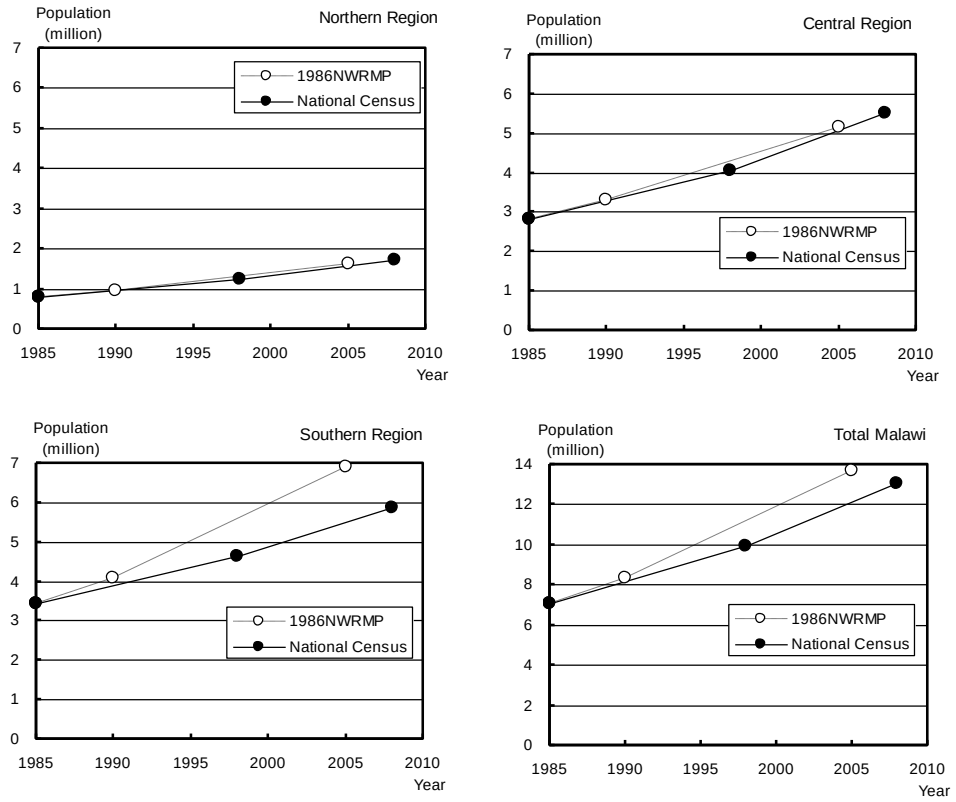
In general, water supply projects are governed by various parameters, particularly, future population projection. The Master Plan of 1986 (NWRMP 1986) proposed many water supply projects for both urban and rural areas. At the start, population changes projected in the NWRMP 1986 were examined together with the census results. Both figures in the northern and central regions fit well as presented in **Figure 4.2.1**, but the projected population in 2005 exceeds the population census data in 2008. As a result, population in the whole country of Malawi also shows a similar tendency.

Due to the difficulty in pursuing the implementation results of numerous water supply projects proposed in the NWRMP 1986, the progress of water supply situations was examined by referring to actual and proposed service coverage of accessing improved water. Malawi has a rapid population growth so that the service coverage will reduce in parallel with population growth and expansion of dwelling areas. **Table 4.2.1** enumerates the baseline data in 1985, planning projection in 2005, and actual recent data in 2010. In fact, population served by water supply in both urban and rural areas has been significantly increasing.

Figure 4.2.2 depicts the water supply system in 2010 in both urban and rural areas, and **Figure 4.2.3** presents a comparison of the water supply systems in 2004 and 2010. This figure shows that service coverage in 2004 is 58% so that it might fall lower than the 68% planned by the NWRMP 1986 for the year 2005. After 2004, however, this figure shows significant improvement up to 77% for 6 years.

Although these achievements of water supply places Malawi at a high position among the African countries in consideration of GDP per capita, the following issues should be solved in the next stage immediately:

- The very large amount of investment required for upgrading the water supply system in both cities of Lilongwe and Blantyre.
- The wide differences in access rates to improved water across districts in Malawi as pointed out by the World Bank[4]. A number of rural districts in the North have access rates of above 80%; whereas; some districts in the Center and the South have rates lower than 40%.



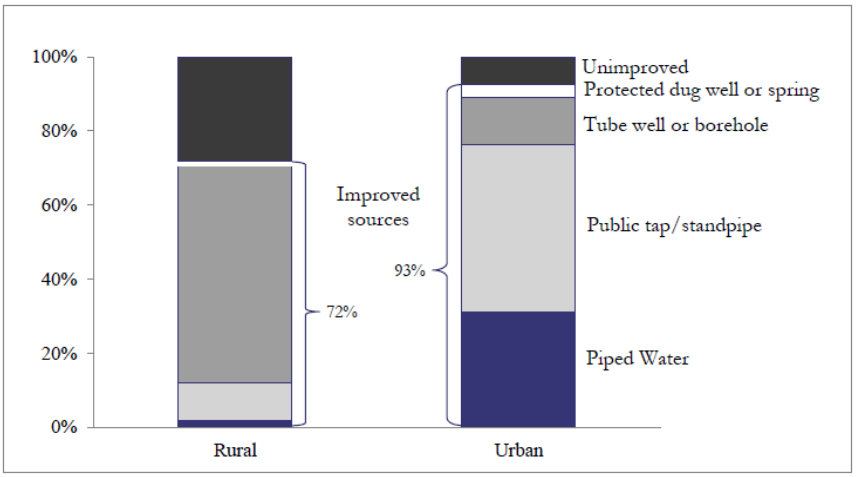
Source: NWRMP 1986 and National Census in 2008

Figure 4.2.1 Comparison between Populations Projected in NWRMP 1986 and the National Census in 2008

Table 4.2.1 Comparison between Water Supply planned in NWRMP 1986 and the Present Water Supply Situation

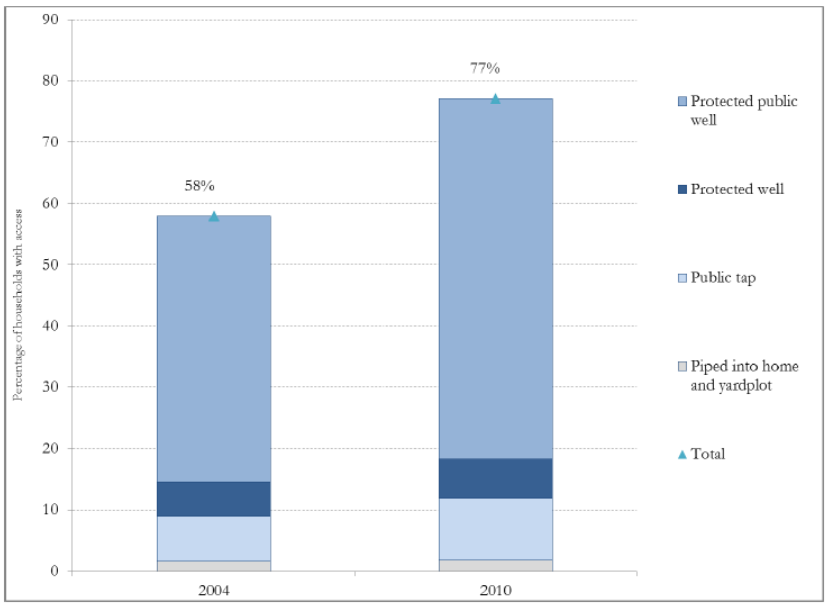
		Urban Areas	Rural Areas	Total
1985 Condition	Population	870,000	6,190,000	7,060,000
	Service Coverage	79%	33%	39%
2005 Target Planning	Population	3,590,000	10,070,000	13,660,000
	Service Coverage	65%	68%	67%
2010 Actual Condition	Population	2,232,000	11,716,000	13,948,000
	Service Coverage	93%	72%	75%

Source: 5 and 6 in the references



Data Source: Malawi Demographic and Health Survey 2010, National Statistical Office of Malawi, Government of Malawi.

Figure 4.2.2 Distribution of Household Source of Drinking Water in 2010 5



Source: Malawi Demographic and Health Survey, 2004 and 2010.

Figure 4.2.3 Access to Improved Water in Rural Areas 5

4.2.2 Hydropower Generation

(1) Summary of Hydropower Development in NWRMP 1986

1) Major Power Development

The NWRMP 1986 summarized hydropower development based mainly on the study conducted by Tippett, Abbett, McCarthy and Stratton Engineers (TAMS) for the Electricity Supply Corporation of Malawi, Ltd. (ESCOM) and the recommended Program of major power development is as shown in the following table. To compare with the demand forecast, the table also shows the forecasted demand in the base case.

Table 4.2.2 Program of Major Power Development Recommended in NWRMP 1986

Year	Name of Project (River Name)	Power or Units Proposed for Installation (MW)	Cumulative Generation (MW)	Firm Flow (m^3/s)	Demand Forecast in Base Case (MW)	Project Implementation
(1986)	(Existing capacity)	-	178	-		
1991	Kapichira (Shire)	3 x 25	253	136	151.3	Phase I in 2000 (2 x 32 MW)
1993	Kapichira (Shire)	1 x 25	278		192.1	Phase II is in progress
1995	Power from Mozambique	30	308	-	215.8	Not yet
1997	Low Fufu with dam at Rumphi or Henga valley (South Rukuru)	3 x 25	383	24	242.5	Not yet
2001	Ditto	1 x 25	408	24	288.8	Not yet

Source: Project Team based on NWRMP 1986

2) Small Hydropower Development for Northern Region not served by the National Power Grid

As for rural electrification, though it has not been discussed with national perspective in the NWRMP 1986, small hydropower development especially for Northern Region has been proposed.

The national power grid does not presently serve a large part of the Northern Region north of Rumphi Town. In view of the opening of the northern corridor route for road transport to Dar-es-Salaam Port in Tanzania, expected to develop faster is the Northern Region, especially the towns of Karonga, Chilumba and Chitipa, and comparatively cheap hydropower is necessary for such development. To supply electricity to these towns, recommended in NWRMP 1986 are the small hydropower schemes of North Rukuru (2MW) for Karonga and Chitipa towns and Wovwe (1.4 MW) for Chilumba town.

(2) Review of NWRMP 1986

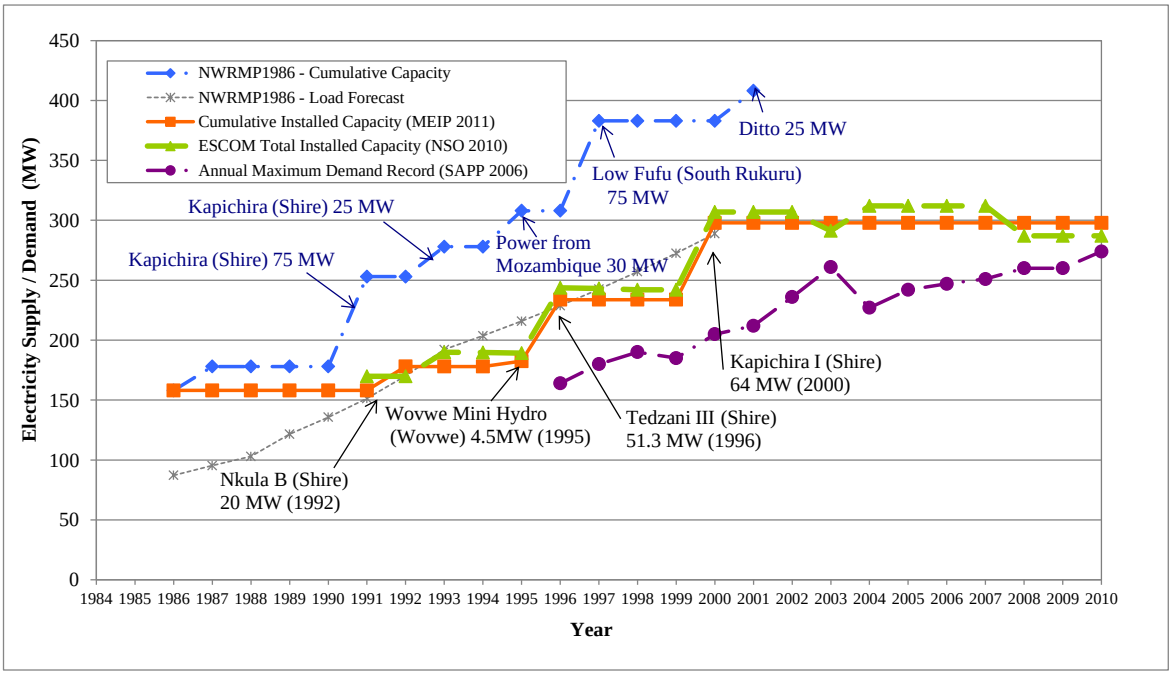
Hydropower installations after 1986 are the Nkula B (20MW in 1992), Wovwe (4.5MW in 1995), Tedzani III (51.2MW in 1996), and Kapichira I (64MW in 2000). Though electricity demand has not increased as forecasted in 1986, no hydropower plant has been installed as programmed in NWRMP 1986.

The following table and figure give a comparison between programs in NWRMP 1986 and the actual condition (installation of power plants and demand). The operation years and installed capacities are based on MEIP 2011 and electricity demand is based on values from the Annual Reports of the South African Power Pool (SAPP)

Table 4.2.3 Comparison between NWRMP1986 Programs and Actual Installation & Demand

	Hydropower Installation Program and Actual Installation							ESCOM Installed Capacity			Annual Maximum Damand Record (MW)
	Programs in NWRMP 1986				Actual Condition						
Year	Programs in NWRMP 1986	Installed Capacity (MW)	Cumulative Capacity (MW)	Load Forecast (MW)	Actual Condition (Information from MEIP)	Installed Capacity (MW)	Cumulative Installed Capacity (MW)	ESCOM (Total Installed Capacity)	ESCOM (Hydro)	ESCOM (Thermal)	
Source	(1)	(1)	(1)	(1)	(2)	(2)	(2)	(3)	(3)	(3)	(4)
1986	Nkula A : 3 x 8 MW (1966) Nkula B : 3 x 20 MW (1980) Nkula B : 1 x 20 MW (1986) Tedzani I : 2 x 10 MW (1973) Tedzani II : 2 x 10 MW (1977) + Blantyre gas turbine : 14 MW		158	87.2	Ditto		158	No Data	No Data	No Data	No Data
1987	Nkula B : 1 x 20 MW (being installed)	20	178	95.3			158				
1988			178	103.0			158				
1989			178	121.6			158				
1990			178	135.7			158				
1991	Kapichira (Shire) 3 x 25 MW	75	253	151.3			158	169.8	144.6	25.2	
1992			253	170.2	Nkula B (Shire) : 1 x 20 MW	20	178	169.8	144.6	25.2	
1993	Kapichira (Shire) 1 x 25 MW	25	278	192.1			178	189.8	164.6	25.2	
1994			278	203.6			178	189.7	164.6	25.1	
1995	Power from Mozambique 30 MW	30	308	215.8	Wovwe Mini Hydro(Wovwe) : 3 x 1.5 MW	4.5	182.5	189.2	164.6	24.6	
1996			308	228.8	Tedzani III (Shire): 2 x 25.65 MW	51.3	233.8	243.7	219.1	24.6	164
1997	Low Fufu fall at Rumphi or Henga valley 3 x 25	75	383	242.5			233.8	243.2	220.7	22.5	180
1998			383	257.1			233.8	242.1	220.7	21.4	190
1999			383	272.5			233.8	242.1	220.7	21.4	185
2000			383	288.8	Kapichira I (Shire): 2 x 32 MW	64	297.8	307.0	286.6	20.4	205
2001	Ditto 1 x 25	25	408				297.8	306.9	286.5	20.4	212
2002							297.8	306.9	286.5	20.4	236
2003							297.8	291.3	285.9	5.4	261
2004							297.8	312.0	285.9	26.1	227
2005							297.8	312.0	285.9	26.1	242
2006							297.8	312.0	285.9	26.1	247
2007							297.8	312.0	285.9	26.1	251
2008							297.8	287.0	285.9	1.1	260
2009							297.8	287.0	285.9	1.1	260
2010							297.8	287.0	285.9	1.1	274
2011							297.8	287.0	285.9	1.1	277

Source: Project Team based on (1) NWRMP 1986[6], (2) MEIP 2011[7], (3) Statistical Year Book 2011[8], (4) SAPP Annual Report[9,10]



Source: Project Team based on (1) NWRMP 1986, (2) MEIP 2011, (3) Statistical Year Book 2011, (4) SAPP Annual Report

Figure 4.2.4 Comparison between NWRMP1986 Programs and Actual Installation and Demand

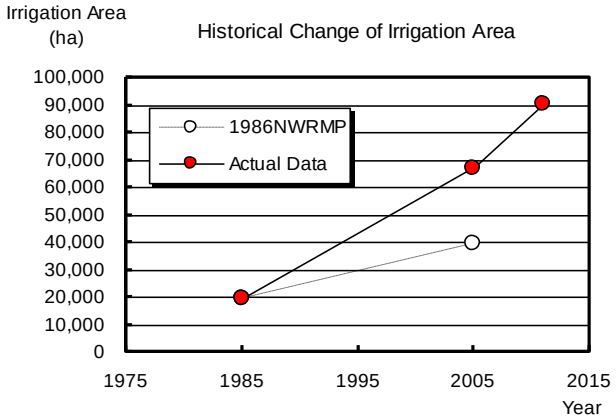
4.2.3 Irrigation

In the planning stage of the NWRMP 1986 in1985, two large-scale sugarcane estates extending to 16,000 ha were mainly irrigated. The 15 schemes of small-scale irrigation with a total area of 3,440 ha were under operation at that time and over 2 million ha of land was under cultivation almost entirely under rain-fed condition. Hence, only one percent of the total cultivated area was under irrigation in 1985 so that the consumptive use of water by irrigation was regarded as very little.

The NWRMP 1986 mainly proposed two kinds of projects located in the Lower Shire valley: the large scale gravity project and the pilot pumped irrigation scheme. Regarding the large irrigation project, soil conditions in the project area are suitable for irrigation. A gravity canal from Kapichira Falls to irrigate about 20,000 ha of new land and 9,000 ha of existing area of sugarcane estates was planned to be constructed in the master plan. As for the pilot pumped project, self-help irrigation schemes with an area of 100 ha was recommended for providing agricultural data/information to the major irrigation projects in the valley.

In 2011, two kinds of irrigation areas were found in Malawi: one is estate farming and the other one is the smallholders' irrigation area. These conditions have been described in Section 2.8, Water Utilization. The agricultural estates consist of 65 estates widely ranging from 2 ha to 22,000 ha, and they apply various irrigation methods: gravity-fed, dams, motorized pump, sprinkler, pivot sprinkler and drip watering. Their irrigated area is 48,382 ha in total. On the other hand, smallholders' irrigation schemes with an aggregate area of 42,181 ha are also widely distributed over the country, employing various watering methods like gravity-fed, motorized pump, treadle pump and water containers. As a result, the total irrigation area was 90,563 ha in 2011. The World Bank in its report indicated 67,000 ha as the actual irrigated area in 2005 [5].

The above-mentioned progress of irrigation projects in entire Malawi is depicted in the following figure. Although irrigation development has progressed more rapidly than planned by the NWRMP 1986, the irrigation area occupancy rate to the arable area of 3,994,000 ha is still 2.3% as in 2011.



Source: 5 and 6 in the reference and Project Team

Figure 4.2.5 Comparison between Irrigation Areas Projected in NWRMP 1986 and the Actual Achievement

4.2.4 Water Quality Conservation

The 1986 Master Plan report associated with water quality mainly evaluated the then current situations, made an inventory of problems under each analysis item, and recommended appropriate water quality standards. After then, the Malawi Bureau of Standards established a tentative standard for drinking water and issued the first revision in 2005, which is being enforced up to the present. The present standard defines more conservative thresholds than the standard recommended by NWRMP 1986 (see **Table 4.2.3**).

NWRMP 1986 indicated problems in drinking surface water, borehole, dug well and rural piped water by analysis item. Almost all of the problems were mostly related to the high concentration of minerals caused by natural factors (i.e., mineral liquates from basement rock), with some of them related to pollution caused by anthropogenic factors. For industrial development and population increase in future, the anthropogenic factors

have to be taken more into account rather than the natural factors on the contamination of surface water and groundwater environment.

Table 4.2.4 Comparison between the NWRMP 1986 Standard and the Present Standard of Water

Constituent	Unit	Proposed Standard by NWRMP1986	Present Standard (MS214:2005)	WHO Standard
Arsenic	mg/l	0.05	0.05	0.01
Cadmium	mg/l	0.01	0.005	0.003
Chromium	mg/l	0.05	0.01	0.05
Cyanide	mg/l	0.1	0.05	0.05
Fluoride	mg/l	3	1	1.5
Lead	mg/l	0.05	0.05	0.01
Nitrate as NO_3	mg/l	100	10	50
Selenium	mg/l	0.01	0.02	0.01
Aluminum	mg/l	5	0.3	0.2
Chloride	mg/l	750	200	250
Color	TCU	50	10	15
Copper	mg/l	1	1	2
Hardness as $CaCO_3$	mg/l	800	-	-
Iron	mg/l	3	0.2	1
Manganese	mg/l	0.5	0.1	0.5
pH	-	6 - 9.5	5 – 9.5	6.5 – 8.5
Sodium	mg/l	500	200	200
Total Dissolved Solid	mg/l	2,000	1,000	1,000
Sulphate	mg/l	800	400	400
Turbidity	NTU	25	1	5
Zinc	mg/l	10	5	15
Faecal Organisms	Number / 100 ml	Several thresholds defined treatment methods according to number of Faecal organisms.	0	0

Source:
(1) National Water Resource Master Plan (NWRMP), 1986, United Nations Development Programme (UNDP)
(2) MS214:2005 Drinking Water – Specification, Malawi Bureau of Standard
(3) Guidelines for Drinking-Water Quality, Fourth Edition, World Health Organization

4.3 Ongoing and Previous Activities and Projects

4.3.1 Hydrological Monitoring and Management Project

(1) Establishment of Water Resources Monitoring System

This study is being conducted as an African Development Fund Supported Component of the National Water Development Program (NWDP) and a part of the NWDP Water Resources Management Component which includes the assessment of water resources in the country, the establishment of water monitoring systems, and the establishment of a Management Information System (MIS) database structure.

The overall objective of this study is to establish water monitoring systems and associated MIS for the Water Resources Board and the MoAIWD, particularly, the Water Resources Department which includes the three Divisions: Surface Water, Groundwater, and Water Quality/Pollution Control.

The specific study objectives are:

- To establish a network and MIS for groundwater, surface water, water quality monitoring system, and an administration system to track water use permit applications and to monitor compliance of water users.

- To assist in the stakeholder participation and involvement programme in water resources management.
- To assist in the strengthening of the MoAIWD with appropriate institutional management capacity building that will enable it to carry out its mandate, authority, responsibility, and duties.

The study period is about three years from the middle of 2010 to the middle of 2013 and divided into two overlapping phases.

The Phase 1 activities are as follows:

- To source relevant information, to initiate liaison, to finalize the scope of work and to prepare a detailed work program, work schedule and staffing schedule;
- To strengthen the MoAIWD with appropriate institutional capacity relating specifically to the technical components of the establishment of a water resource monitoring system;
- To assess the present situation and needs of water resource monitoring system and to design and rehabilitate the system; and
- To design, develop and populate the MIS.

The Phase 2 activities are as follows:

- To develop capacity building plans for the three divisions and one board: the Water Quality Division, the Groundwater Division, the Surface Water Division and the Water Resources Board; and
- To implement the capacity building plans.

The Project Study Team consists of 10 key professional staff including the Project Director, Team Leader, Hydrologist, Hydro-geologist, Water Chemist, MIS expert and others, and seven key support staff such as Water Quality Scientist, Hydrologist, Hydro-geologist, Institutional Specialist and GIS Specialist.

(2) Shire River Basin Management Program

As a part of the Shire River Basin Management Program (SRBMP) described in Subsection 4.3.4(2), the Government of Malawi has a plan to rehabilitate hydrological stations focusing on those located within the shire basin, particularly, those in Ntcheu, Blantyre, Thyolo and Ngabu Hydrometric districts. The expected project period is about one year. As of March 2013, the preparation stage for the Terms of Reference (TOR) and the bidding was ongoing. The project will include the following activities:

- Assessment of existing surface water resources monitoring network
- Re-design of the surface water resources monitoring network
- Procurement of modernized real time surface water resources monitoring equipment for the network
- Rehabilitation of existing structures and installation of modernized equipment for the optimized network
- Procurement of modernized ICT equipment for surface water resources monitoring
- Installation of modernized ICT equipment and software for surface water resources monitoring
- Training of staff on operation and maintenance of equipment
- Procurement and licensing of surface water resources modeling software
- Construction of database center

4.3.2 Water Quality Management Project

Water quality monitoring is managed by the Water Quality Division of the Department of Water Resources under MoAIWD. Approximately 200 water quality monitoring points are planned in the whole Malawi, which are classified into three categories: surface water points, pollution control points and groundwater points.

There had been about 300 monitoring points for water quality before 2003. A list of the past monitoring points has been prepared in the project named as the Strengthening of the Water Resources Board[1], and the reduction

of monitoring points was proposed considering the capacity of the Water Quality Division and the Regional Laboratories. After a detailed review of the list provided by the Division, monitoring points that were almost the same as the present ones were determined.

Water quality sampling and analysis are conducted by the staff of the regional water analysis laboratories of the Water Quality Division. There are three regional laboratories; namely, the Central Water Laboratory in Lilongwe, the Southern Water Laboratory in Blantyre and the Northern Water Laboratory in Mzuzu, which undertake sampling and analysis at the monitoring points in each region as shown in **Table 4.3.1**. Actually, however, there is no laboratory facility in the Northern Water Laboratory, and the analysis facilities in the Southern Water Laboratory have hardly operated due to budgetary and manpower constraints. Therefore, only the Central Water Laboratory has been in operation, and continuous monitoring is not being conducted well nowadays.

Table 4.3.1 Allocation of Water Quality Monitoring among Water Analysis Laboratories

Regional Laboratory	Surface water quality sampling points	Pollution sampling points	Groundwater sampling points	*Total*
Northern Region Water Laboratory	26	14	6	**46**
Central Region Water Laboratory	47	19	14	**80**
Sorthern Region Water Laboratory	42	17	15	**74**
Total	**115**	**50**	**35**	**200**

Source: Project Team

As for the ongoing monitoring activities, one pilot district in each region, i.e., Karonga in the Northern region, Nitcheu in Central and Chikwawa in Southern, has been selected and monitoring was done in the M&E Project with funds from AfDB. Monitoring was done twice a year in all of the monitoring points in each district during the project period from 2011 to 2013. **Table 4.3.2** gives a list of the monitoring points.

Table 4.3.2 Monitoring Points of Ongoing M&E Project in the Pilot Districts

A	**Nitcheu District in Central Region**	
1	Mpira River	At gauging station (1.R.3)
2	Mpira Dam	At water supply intake
3	Mpamadzi River	At water supply intake
4	Mpamadzi River	Downstream Ntcheu Secondary School/Mpira dam road bridge
5	Rivirivi River	At Manjawira M1 Road Bridge
6	Livulezi River	Khwekhwerere Road, At gauging station (3.E)
7	Nankokwe River	Lakeshore Road at the road bridge
8	Nazipokwe River	Lakeshore Road at the road bridge
9	Ntcheu Prison Effluent	Behind the fence
B	**Chikwawa District in Southern Region**	
1	Shire River	Upstream of Chikhwawa/Nsanje Road Bridge
2	Shire River	At gauging Station (1.G.1.B) in Ngabu
3	Mwanza River	Upstream of Chikhwawa/Nsanje Road Bridge
4	Katemalinga I village Borehole	In T/A Maseya, Chikhwawa district
5	Ngabu Groundwater Monitoring Well	In Ngabu, Chikhwawa district
6	Illovo Industrial Effluent	At Illovo final effluent discharge point in Nchalo
7	Illovo Industrial Effluent	From Illovo wastewater canal into Shire River at Ndirande vge
8	Illovo Industrial Effluent	From Illovo wastewater canal into Shire River at B. Compound
9	Presscane Industrial Effluent	At Presscane final effluent discharge point
10	Chikhwawa Groundwater Monitoring Well	At the Boma, Chikhwawa district
C	**Karonga District in Northern Region**	
1	North Rukulu River	At Karonga/Kapolo Road Bridge
2	North Rukulu River	At Mwankenja, Karonga/Chitipa Road Bridge
3	Lufira River	At Irrigation Intake Point
4	Songwe River	At Mwandenga gauging station 9.B.7
5	Mpata Hot Spring	Karonga/Chitipa Road before Mwankenja
6	Groundwater Monitoring Well	At Karonga Water Office
7	Wovwe River	At M1 Road Bridge
8	Wovwe River	At Fuliwa (ESCOM)
9	Coal Mine Water	At Mwansambo Coal Mine Tailings Dam
10	Coal Mine Water	At Nkhachira Coal Mining Site
11	Sere River	At Kayerekera
12	Hara River	At the Irrigation Scheme
13	Lake Malawi	At water supply intake, Karonga Boma
14	Lake Malawi	At Chilumba Jetty gauging station (17.C.1)

Source: MoAIWD

4.3.3 Water Supply and Sanitation Project

(1) National Water Development Program

The National Water Development Programme (NWDP) is a collection of water and sanitation development projects in the Ministry of Agriculture, Irrigation and Water Development.

The NWDP is an on-going national water development and management initiative that started with the National Water Development Project I in the late 1990's, up to 2004. Currently, there is a follow-up National Water Development Project II (NWDP II) that commenced in 2007 and runs up to 2015.

The main development objective of the NWDP is to increase access to sustainable water supply and sanitation services for people living in cities, towns, market centers, and rural areas and to improve water resources management at national level.

The NWDP is managed by the Ministry of Agriculture, Irrigation and Water Development through the Programme Management Unit (PMU), and is financed by the Government of Malawi with development partner assistance from the World Bank, the European Union, the European Investment Bank, the African Development Bank, Australian Aid, the African Catalytic Growth Fund, and the Government of the Netherlands. The total NWDP cost is estimated at USD354.53 million (MK57.4 billion).

The World Bank, NWDP II, has five main areas of focus, as follows:

(1) Urban water supply and sanitation (Blantyre and Lilongwe);
(2) Town and market center and rural piped water supply and sanitation (three regional water boards);
(3) Water resources management;
(4) Sector management and urban water sector reforms; and
(5) Rural water supply and sanitation.

The AfDB component is focused in the four districts of Lilongwe, Zomba, Machinga and Mulanje where a total of 2,588 new boreholes will be drilled, 1,508 old boreholes will be rehabilitated and 23 gravity fed systems will be rehabilitated. The AusAid is being channelled through the AfDB Component and will operate in the same four focus districts in 7 selected market centers (Nathenje, Nsalu, Kasiya, Nkando, Malosa, Ntaja and Ulongwe).

The WASH Component is focused in the fourteen districts of Chitipa, Karonga, Likoma, Nkhata Bay, Mzimba, Kasungu, Mchinji, Dowa, Lilongwe, Salima, Mangochi, Mwanza, Chiladzulu and Blantyre. The target of the WASH project is to construct 2,800 new boreholes and rehabilitate 1,050 existing boreholes in the 12 districts, and provision of hygiene and sanitation facilities in public places.

Table 4.3.3 National Water Development Program

ITEM	Cooperating Partner	Amount (US$ million)	Focus Districts/Areas	Target Outputs	Target Beneficiaries	Closing Date
1a	IDA	50.0	All five Water Boards, & Ministry	60,000 Water Points (IDA + ACGF)	1,000,000 (IDA + ACGF)	31st December 2012
	AGF(DFID)	25.0	7 Gravity schemes, and 3 focus districts (Dedza, Rumphi, Chikwawa)			30th June 2012
1b	IDA	120.0 additional	All five Water Boards, Ministry, focus on towns and market centres	160,000 Water Points	1,395,325	31st December 2015
2	EU/EIB	48.51	Lilongwe & Blantyre Water Boards, focus on low income areas	735 kiosks 50,000 new connections	1,131,000	31st December 2013
				80,000 VIP units	468,000	
3a	AfDB	14.0	Lilongwe, Machinga, Mulanje, Zomba, mainly in rural areas except for offices and houses.	2,588 New boreholes, 1,508 Repaired boreholes, 23 Gravity fed systems, 4 New offices & 12 New houses.		31st December 2013
3b	AusAid	14.0	Nathenje, Kasiya, Nsalu, Nsanama, Ntaja, Nkando, Malosa	Piped water systems in each centre and 151 sanitation facilities	78,000 Water 93,000 Sanitation	31st December 2013
4	UNICEF/ Netherlands	18.1	Chitipa, Likoma, Nkhata Bay, Mzimba, Kasungu, Mchinji, Dowa, Lilongwe, Salima, Mangochi, Mwanza, Blantyre	2,800 New boreholes 1050 Rehabilitated boreholes	577,500 water	31st December 2011
5	OECD/OPEC	10	Lilongwe, Blantyre, Kasungu, Zomba, Mangochi	Construction of water supply networks, after IDA designs.	Already captured under IDA	31st December 2012
6	GoM	20.7				
total		US$354.53		5,365,325		

Source: Project Team

(2) Second National Water Development Project by the World Bank

The development objective of the Second National Water Development Project of Malawi is to increase access to sustainable water supply and sanitation services for people living in cities, towns, market centers, and villages and improve water resources management at the national level. The project will also contribute to building sector capacity through improved monitoring, regulation, incentive structures, public private partnerships, and coordination among the sector stakeholders. The project has four components as presented below.

Component A: Urban Water Supply and Sanitation (Blantyre and Lilongwe)

(i) Priority investments for essential spare parts and materials to prevent water supply disruptions in Blantyre and urgent rehabilitation works in both cities;

(ii) Reaching the un-served areas, through piloting of water supply and sanitation services to low income areas in Blantyre, carrying out sanitation and hygiene promotion activities, expanding the water supply distribution network, and installing customer connections; and

(iii) Aqueduct planning in Lilongwe.

Component B: Town and Market Center and Rural Piped Water Supply and Sanitation (Three Regional Water Boards)

(i) Expansion of water supply facilities and improvements in operational efficiency in some of their largest, fastest-growing towns including Mzuzu, Kasungu, Mangochi, and Zomba, and other smaller towns;

(ii) Development of community-managed water supplies in market centers and rural piped systems; and

(iii) Training for the regional water boards, the staff of program implementation unit, district assemblies, and local communities.

Component C: Water Resources Management

(i) Development and support for the promulgation of enabling legislation for the National Water Policy of 2005;

(ii) Development of an integrated water resources investment strategy;

(iii) Design and independent environmental and social assessments for Lake Malawi level control;

(iv) Strengthening of institutional capacity for water resource management including the establishment of National Water Resources Authority; and

(v) Feasibility studies, designs, and environmental and social assessments for the development of future water sources.

Component D: Sector Management and Urban Water Sector Reforms

(i) Support to MoAIWD in the establishment of a management system for the sector investment program including investment planning, development partner coordination, accounting, procurement, monitoring and evaluation, safeguard tracking, and information technology and communications;

(ii) Development of a strategic sanitation plan for Lilongwe and Blantyre; and

(iii) Design and implementation of a sustainable reform plan for Blantyre and Lilongwe, including a regulatory framework, public awareness campaign, and institutional framework for a lease or similar contract with a private operator.

Component D is Sector Management and Urban Water Sector Reform which will consist of: ; and

Component Name Component Cost

Component A: Urban, Town and Market Center Water Supply 128.80

Component B: Sanitation and Hygiene 5.17

Component C: Water Resources Management 21.68

Component D: Sector Reform and Program Management 16.84

Component E: Rural Water Supply (IDA and ACGF-financed) 14.66

The following **Table 4.3.4 s**ummarizes the ongoing and previous water supply and sanitation projects in Malawi.

Table 4.3.4 Ongoing and Previous Water Supply and Sanitation Projects in Malawi

Item No.	Program/Schedule	Project Location	Sponsor/ Implementing Agency	Amount USD
< World Bank >				
1	Third Lilongwe Water Supply Project / Up to 1994	Lilongwe	World Bank/LWB	
National Water Development Project (NWDP) / 1995-2004			World Bank/Malawi	
National Water Development Project 2 (NWDPII) / 2007-2012			World Bank/Malawi	
2	Feasibility Studies and Preliminary Design for Lilongwe's New Water Sources / Up to 2010	Lilongwe and Surrounding Area	World Bank/LWB	
3	Feasibility Studies and Preliminary Design for Blantyre's New Raw Water Source and Other Purposes / Up to 2010	Blantyre and Surrounding Area	World Bank/BWB	
4	Sanitation & Hygiene Promotion under the National Water Development Program/2008-2012	Chitipa, Karonga, Rumphi, Dedza, Ntcheu, Balaka, Zomba, Chikhwawa	World Bank/MoAIWD	
5	Sanitation Planning/2012-2015	Balaka, Mwanza and Mulanje	World Bank/SRWB	
6	Sanitation Planning/2012-2015	Low Income Areas of Blantyre and Lilongwe	World Bank/ LWB-BWB	300,000
7	Development of Sanitation Act/ 2012-2015	Malawi	World Bank/MoAIWD	350,000
8	Transfer of responsibility for waterborne sanitation/ 2012-2015	Malawi	World Bank/MoAIWD	337,000
9	Communication campaign for Directorate of Sanitation & Hygiene/ 2012-2015	Malawi	World Bank/MoAIWD	20,000
10	Development and Refinement of Sanitation & Hygiene Messages and Public Relation/2012-2015	Low Income Areas of Blantyre and Lilongwe	World Bank/ LWB-BWB	200,000
11	Sanitation Marketing/2012-2015	Low Income Areas of Blantyre and Lilongwe	World Bank/LWB-BWB	600,000
12	School Sanitation and Hygiene/ 2012-2015	Dedza	World Bank/MoAIWD	1,000,000
< JICA >				
13	Basic Design Study Report on the Lilongwe Sewerage Project / 1994	Lilongwe	JICA/LCC	
14	Follow up Study on Sewerage / 2008	Lilongwe	JICA/LCC	
15	Study on Urban Development Master Plan for Lilongwe / Up to 2010	Lilongwe	JICA/LCC	
< Others >				
16	Sanitation and Hygiene Promotion in public institutions/ Up to 2013	Lilongwe, Machinga, Zomba, Mulanje	African Development Bank/MoAIWD	
17	Development of National 10 Year Sanitation and Hygiene Investment Plan and Strategy/ Up to 2012	Malawi	African Development Bank/MoAIWD	
18	Sanitation and Hygiene Promotion in Market Centers and surrounding institutions and communities (Up to 2013)	Lilongwe, Machinga, Zomba, Mulanje	AusAID	
19	Water, Sanitation and Hygiene Programme (WASH)	To be confirmed	UNICEF/MoAIWD	
20	Malawi Peri-Urban Water and Sanitation Project /2009-2014	Low Income Areas of Blantyre and Lilongwe	EU and EIB/ LWB-BWB-LCC-BCC	

Source: Ministry of Agriculture, Irrigation and Water Development
MoAIWD: Ministry of Agriculture, Irrigation and Water Development
SRWB: Southern Region Water Board, LWB: Lilongwe Water Board
BWB: Blantyre Water Board, AusAID: Australian Aid, LCC: Lilongwe City Council, BCC: Blantyre City Council

4.3.4 Watershed Management Projects

At present there are three ongoing projects focusing on watershed/forest management: 1) The European Union (EU) supported "Improved Forest Management for Sustainable Livelihoods"; 2) The World Bank (WB) supported "Shire River Basin Management Program Project"; and 3) The JICA supported "Project for Community Vitalization and Afforestation in Middle Shire". These projects could contribute as natural functions of forest for water fostering and prevention of soil erosion to a sound river and basin management.

(1) Improved Forest Management for Sustainable Livelihood

European countries led by the European Union (EU) have continuously supported the forest sector in Malawi since the late 1990's. The remarkable results are: the amendment of "Community Based Forest Management" in the National Forest Policy in 2003, the preparation of "Standards and Guidelines for Participatory Forestry" in 2005, and the preparation of "Guidelines for Co-Management of Forest Reserve" in 2008. These contributed particularly in the field of participatory forest management. [11]

The program "Improved Forest Management for Sustainable Livelihoods" promotes community involvement in forest management, both in forest reserves and on customary land. The program commenced in 2005 and will terminate in 2015 with EU contribution of 9 million euro. It formalizes local communities' access to, and control over forest resources. Since 2005, the program has ensured the following: [12]

- 12 forest reserves, as well as buffer zones around them, are jointly managed by the Government and local people who live in these areas;
- 23,858 ha of forest area are managed according to forest management plans, meaning that communities can make a living from forestry while sustaining forest resources;
- 10,500 ha of customary forest are set aside for regeneration, resulting in improved biodiversity and water availability and better soils; and
- 23 million trees have been planted on customary land.

(2) Shire River Basin Management Program

The overall program development objective of the Shire River Basin Management Program (SRBMP) is to increase sustainable social, economic and environmental benefits by effectively and collaboratively planning, developing and managing the Shire River Basin's natural resources. The SRBMP will last for 15 years. The Phase-I project – the Shire River Basin Management Program Project (SRBMP-I) – will establish coordinated intersectoral development planning and coordination mechanisms, undertake the most urgent water-related infrastructure investments, prepare additional infrastructure investments, and develop upscalable systems and methods to rehabilitate sub-catchments and protect existing natural forests, wetlands and biodiversity.

The SRBMP-1 would: (a) strengthen the institutional capacities and mechanisms for Shire Basin monitoring, planning, management and decision support systems; (b) invest in water-related infrastructure that sustainably improves water resources management and development; (c) reduce erosion in priority catchments and sedimentation and flooding downstream, while enhancing environmental services, agricultural productivity and improving livelihoods; (d) improve flood management in the Lower Shire and provide community level adaptation and mitigation support; and (e) protect and enhance ecological services in the Basin.[13]

The total cost of the project is US 132 million $, and the planned implementation period is 5.5 years from June 2012 to January 2018.

(3) The Project for Community Vitalization and Afforestation in Middle Shire

Since the local people living in the Middle Shire river basin have exploited the surrounding forest resources, customary forest areas have deteriorated to a great extent. It has resulted in the occurrence of serious soil erosion and a huge amount of siltation taking place in the Shire river channel, and therefore narrowed the capacity for hydropower generation and urban water supply.

To improve the vicious situations, JICA commenced a technical cooperation project for community vitalization and afforestation in Middle Shire in November 2007 which will continue until November 2012 for 5 years. The project aims at promoting productive activities with consideration for forest conservation and rehabilitation in the target villages, for which tree growing, soil erosion control and other productive activities should be promoted. Given the fact that considerable parts of the target areas of the forest have been turned into farmlands and a number of gullies have been developed in the farmlands, soil conservation should be prioritized in the project.

In order to achieve the objectives, the project is planned to achieve three outputs: (a) to transfer necessary knowledge and skills to the villagers; (b) to enhance the villager's capacity to access necessary sources for practicing the activities; and (c) to enhance capacity of the counterparts for supporting the villagers. The target villages are the 86 villages located in Kuntaja TA and Kapeni STA in Blantyre District in the Middle Shire. The total cost of the project is around 390 million JPY.[14]

4.3.5 Irrigation Development Project

There are many irrigation development projects/programs funded by the Malawi Government, development partners such as The World Bank, NGOs, etc.

(1) Smallholder's Project

1) Small Farms Irrigation Project (SFIP)

(i) Background

This project is implemented with loan funds from the Arab Bank for Economic Development in Africa (BADEA) of US$8 million and the Government of Malawi counterpart fund of USD2.04 million. The overall objective is to increase and improve family food security and incomes by enhancing the productivity of resource poor smallholder farmers. This objective is to be achieved through the optimum use of agricultural land, which otherwise lies idle during the dry season, through irrigation and developing a diversified irrigated agricultural project base for the improvement of beneficiary socio-economic status and the nation's agricultural industry.

SFIP intends to develop about 1,600 ha for two irrigation schemes at Lweya and Nkopola in Nkhata Bay and Mangochi Districts respectively. The Nkopola site covers an area of about 890 ha while the hintheche site covers an area of about 664 ha. The GOM contracted consultants and contractors to provide assistance in the delivery of services under the Irrigation Scheme Development and Farmer Support Service components.

(ii) Present Condition

Due to the poor performance of contractors, civil works have been delayed and some unfinished canals and drains were destroyed by erosion.

2) Malawi Irrigation Development Support Program (MIDSUP)

(i) Background

The Malawi Irrigation Development Support Program focuses on poverty reduction and sustainable irrigation development and management in order to ensure food security and improve the living standards of the people. These are to be achieved through the implementation of two projects, namely, the Capacity Building and Institutional Enhancement for Irrigation Development and Agricultural Productivity Improvement and Marketing. The main objective of the program is to increase productivity and income of rural households in the program area. This will be achieved through enhancing technical and institutional capacity at all levels for sustainable irrigation development and management, and the provision of dependable water supply for improved and intensified agricultural production. Specifically, the program aims at enhancing the administrative

and technical capacity in irrigation development; providing timely, reliable and dependable water supply for improved and intensified agricultural production; increasing smallholder farmers' food security and household incomes; and empowering the smallholder farmers to participate in sustainable irrigation development. The program is to be implemented over a period of 84 months with funding from the Government of Malawi and potential development partners.

The total estimated cost of the program is USD135 million. Currently, however, the program is funded solely by the Malawi Government.

(ii) Present Condition

The program targeted to develop 519 ha during 2010/11 as well as to rehabilitate the Hara Irrigation Scheme Headworks. A total of 459 ha were developed and rehabilitation of the Hara irrigation scheme headworks was completed. Some construction works are still in progress and the fund for the program should be disbursed timely to finish the work.

3) Other Projects

The DOI is also actively implementing the other projects coordinated by other ministries and development partners, as listed in **Table 4.3.5, Table 4.3.6** and **Table 4.3.7**.

Table 4.3.5 New Scheme Developed in 2010/11 (1/3)

ISD	District	Scheme name	Area		Technology	Beneficiaries			Fund/Donor	Remarks
			Potential	Developed		Male	Female	Total		
Shire Valley	Chikhwawa	Nanzolo B	48	48	Gravity	53	117	170	World Bank	
		Mazira	6	6	Gravity	22	13	35	World Bank	
		Namikhate	10	10	Gravity	21	79	100	World Bank	
		Namigoza	20	15	Gravity	45	105	150	World Bank	
		Chinkole	3	3	M/Pump	25	22	47	ORT	
		Chingetimani	3	2	T/Pump	15	11	26	ORT	
	Nsanje	Chambalo	50	18	R-M/Pump	53	32	85	Goal Mw	
		Kadansana	6	3	R-T/Pump	8	14	22	ORT	
		Nyang'ona	40	26.7	S/w-T/Pump	119	114	233	ORT	
		Njale	30	23.5	S/w-T/Pump	151	116	267	ORT	
		Ntolongo	20	11.8	C-T/Pump	35	15	50	CARD	
		Mkuyu (extension)	47	10.8	C-T/Pump	89	33	122	Goal Mw	
		Gooke	5	4.1	S/w-T/Pump	21	5	26	ORT	
		Chinyanje	40	29.5	C-T/Pump	99	118	217	ORT	
		Nyafika	20	4.2	C-T/Pump	29	14	43	WALA	
	Sub total		348	215.6		785	808	1593		
Blantyre	Mulanje	Namwera	10	45	Gravity	65	110	175	ORT	Const. in progress
		Kuzinja*	23.7	95	Gravity	135	230	365	MIDSUP	Setting out of weir and excavation of the intake completed
		Nakhonyo	5	14	Gravity	29	43	72	ORT	Weir const. completed
		Mbewa	15	58	Gravity	78	136	214	IGPWP-EU	Weir const. completed
		Mwana mvula	10	25	Gravity	57	82	139	IGPWP-EU	Weir const. completed
		Msamba Nyali*	10	26	Gravity	58	84	142	WVI	Topographic survey completed
	Neno	Ulande*	5	32	Gravity	30	62	92	ORT	Weir const. completed
		Nkulumadzi	2.4	4	M/Pump	10	14	24	ORT	Const. in progress
	Phalombe	Malema	6	33	Gravity	17	50	67	IRLADP - Miniscale	Const. in progress
		Khamula*	13	53	Gravity	12	65	77	IRLADP - Miniscale	Const. in progress
	Blantyre	Nkawinda*	10		Gravity			0	ORT/IFA	Const. of receiving chamber, installation of 66 m pipe line and excavation of 720 m canal completed.
		Dziwe*	1.2	4	M/Pump	7	11	18	Mai AISHA Trust	Scheme const. completed
		Chipala /Ndemanje	5	8	Gravity	32	40	72	IGPWP-EU	Weir const. completed
	Chiradzulu	Kanjedza*	3		Gravity			0	ORT	Weir const. completed
	Thyolo	Ulongo	18	16	Gravity	25	41	66	Govt (LDF)	Weir const. completed
		Khongono	50	35	Gravity	25	60	85	Govt (LDF & ORT)	Weir const. completed
	Mwanza	Chimulango	6	18	Gravity	34	52	86	Govt (LDF)	Weir const. and pipeline installation done.
		Nsato	5	12	M/Pump	33	45	78	ORT	Canal const. completed.
		Goshani	30	9	Gravity	18	27	45	Red Cross	Weir const. completed
	Sub total		228.3	487	665	1152	1817			
Kasungu	Kasungu	Rusa	60	10	M/Pump	60	23	83	LDF	
		Mikuyu	10	3.4	M/Pump	16	8	24	FICA - FAO	
		Kanyenda - Kasinjer	24	24	M/Pump	38	18	56	SCPMP	
	Ntchisi	Taona-Nyanja	5	3	Gravity	4	12	16	ORT	
	Dowa	Mthenthera	45	35	M/Pump	36	45	81	ORT	
		Kasangadzi	25	19	M/Pump	42	32	74	ORT	
		Madziabango	10	8.7	T/Pump	21	24	45	ORT	
		Tigwilanemanja	10	6	M/Pump	12	18	30	DAPP	
		Fumba	40	34	G-R-Div.	145	57	202	Care Malawi	
		Chakhusa	30	24	G-R-Div.	130	17	147	Care Malawi	
		Tsopa 1	50	35	G-R-Div.	120	95	215	Care Malawi	
		Tikolore	30	27	G-R-Div.	237	120	357	TLC	
		Tilime	50	31	G-R-Div.	178	56	234	TLC	
		Chibvala	16	15	G-R-Div.	75	15	90	TLC	
	Mchinji	Chibungo	10	8	T/Pump	16	18	34	ORT	
		Kasupe	7	5.6	M/Pump	21	15	36	ORT	
		Khamalathu	5	4	M/Pump	22	17	39	ORT	

Source: Project Team

Table 4.3.6 New Scheme Developed in 2010/11 (2/3)

ISD	District	Scheme name	Area		Technology	Beneficiaries			Fund/Donor	Remarks
			Potential	Developed		Male	Female	Total		
Kasungu	Mchinji	Nalitengere	4	2.2	M/Pump	7	18	25	ORT	
		Tayanjana	6	6	M/Pump	10	21	31	ORT	
	Sub total		437	300.9		1190	629	1819		
Karonga	Karonga	Tilyenge	10	2	M/Pump	13	10	23	ORT	
		Chiwondo	15	2	M/Pump	16	9	25	ORT	
		Usisya	20	4	M/Pump	12	18	30	ORT	
		Matema	12	5	M/Pump	9	14	23	ORT	
	Sub total		57	13		50	51	101		
Salima	Nkhotakota	Mgoza	2	0.9	Gravity	12	6	18	Government	
		Malanda 2	3	0.2	Gravity	2	2	4	Government	
		Kachere	2	0.8	Gravity	2	2	4	Government	
		Mndale	4.5	0.8	Gravity	6	2	8	Government	
		Msakanene	9	9	Gravity	32	19	51	Government	
		Ndolo	1	0.6	Gravity	6	2	8	Government	
		Msufu	1	0.2	Gravity	0	6	6	Government	
		Mneno	2.3	0.3	Gravity	3	3	6	Government	
		Nasongole	3	0.2	Gravity	5	1	6	Government	
		Chamawano	5	0.4	M/Pump	1	0	1	Individual	
		Maungu	4	2.4	M/Pump	1	0	1	Individual	
		Msolo	5	0.4	M/Pump	3	3	6	Government	
		Matsile	5	0.4	M/Pump	2	2	4	Government	
		Chipondelo	5	0.4	M/Pump	2	0	2	Government	
		Naphala	0.2	0.2	T/Pump	1	0	1	Government	
		Tikondane	0.8	0.8	T/Pump	4	4	8	Government	
		Chabango	1	1	T/Pump	6	4	10	Government	
		Kucherachera	0.8	0.8	T/Pump	12	6	18	Government	
		Msambaifa	0.8	0.8	T/Pump	14	6	20	Government	
		Tilimbike	0.7	0.7	T/Pump	12	8	20	Government	
		Ungwe	2	2	T/Pump	16	6	22	Government	
		Mtandila	1.2	1.2	T/Pump	11	4	15	Government	
		Zembeni	0.2	0.2	T/Pump	2	3	5	Government	
		Tepatepa 2	1.6	1.6	T/Pump	3	12	15	Government	
		Kazilira	0.8	0.8	T/Pump	10	1	11	Government	
		Chathamthumba	0.5	0.5	T/Pump	2	3	5	Government	
		Chinkhalamo	1.2	1.2	T/Pump	6	4	10	Government	
		Chivumu	0.8	0.8	T/Pump	7	3	10	Government	
		Chilasa	3	1.5	T/Pump	5	7	12	Government	
		Ng'ombeyayera	7	1.7	Gravity	7	9	16	Government	
	Sub total		74.4	32.8		195	128	323		
	Salima	Taomboledwa	5	5	M/Pump	28	43	71	Government	
		Kaziwamwini	5	5	M/Pump	7	5	12	Government	
		Tigwirizane	1	1	T/Pump	4	6	10	TLC	
		Taonekera	1	1	T/Pump	5	9	14	TLC	
		Mzathu	1	1	T/Pump	3	8	11	TLC	
		Gabe	1	1	M/Pump	6	10	16	Government	
		Katumba	15	15	M/Pump	22	39	61	Government	
		Suzi	1.5	1.5	Gravity	6	9	15	Government	
		Mgwirizano	2.5	2.5	Gravity	8	14	22	Government	
	Sub total		33	33		89	143	232		
	ISD total		107.4	65.8		284	271	555		
Mzuzu	Rumphi	Msongolo	20	20	Gravity	33	20	53	SCPMP	
		Chigumukire	34	34	M/Pump	20	18	38	SCPMP	
		Jambuko	64	64	M/Pump	64	23	87	SCPMP	
		Tiyese	17	17	Gravity	48	21	69	IRLADP	
		Tapukwa	27	27	Gravity	44	21	65	IRLADP	
		Zolokere	45	45	Gravity	74	43	117	IRLADP	
		Walutundu	39	39	Gravity	27	7	34	IRLADP	
		Tchetchetche	10	10	Gravity	26	14	40	IRLADP	
		Usowoya	40	40	Gravity	52	31	83	IRLADP	
		Mahomero	12	12	Gravity	41	32	73	IRLADP	
		Chayina	10	10	Gravity	25	23	48	IRLADP	
		Mphande	11	11	Gravity	52	21	73	IRLADP	

Source: Project Team

Table 4.3.7 New scheme developed in 2010/11 (3/3)

ISD	District	Scheme name	Area		Technology	Beneficiaries			Fund/Donor	Remarks
			Potential	Developed		Male	Female	Total		
Mzuzu	Rumphi	Bethani	33	33	Gravity	85	32	117	ORT	
		Kalonde	5	3	M/Pump	26	17	43	ORT	
		Chinkhazo	2.5	2.5	Gravity	18	7	25	ORT	
		Tiyese-Mphompha	5	5	Gravity	6	9	15	ORT	
		Umoza	1.5	1.5	Gravity	0	9	9	ORT	
	Sub total		383	379		676	374	1050		
Lilongwe	Lilongwe	Mbuto	15	9	Gravity	45	21	66		
		Mbala	7	4	Gravity	28	8	36		
		Katope	20	13	W/C,T/Pumps	40	27	67		
		Chisamba	11	8	W/C,T/Pumps	12	8	20		
		Chapata	14	10	W/C,T/Pumps	5	15	20		
		Mpheta	15	11	W/Cans	17	31	48		
		Tikondane	10	5	Gravity	5	21	26	ORT	
		Chingwenje	18	13	M/Pump	19	8	27		
		Kalimbira	10	7	Gravity	11	4	15		
		Kamamina	13	10	T/Pump	12	3	15		
	Dedza	Tiphunzire	25	16	Gravity	48	48	96		
		Mawe	27	19	Gravity	44	56	100		
		Chitengeza	23	17	Gravity	71	48	119		
		Windu	51	37	Gravity	167	139	306	ILAD	
		Zuze	19	14	Gravity	34	30	64	ORT	
		Mthetsanjala	35	26.3	Gravity	96	103	199	CADECOM	
	Ntcheu	Nazing'ombe	20	14	Gravity	16	29	45	MIDSUP	
		Namang'ung'u	19	15	Gravity	18	38	56	ORT	
		Bawi	18	15	Gravity	22	16	38	CU	
		Msipe	19	14	Gravity	10	39	49	ORT	
		Chisimbwi	23	17	T/Pump	23	46	69	SCPMP	
		Khomba	22	17	Gravity	29	64	93	ORT	
		ISD total	434	311.3	0	772	802	1574		
Machinga			-Data is not available-							
	Machinga ISD total		-	-	-	-	-	-	-	-
Overall Total new area developed			1,994.72	1,772.58		4,909	4,752	6,692		

Abbreviation: ORT=Other Recurrent Costs, CADECOM=Catholic Development Commission, CU=Concern Universal, CARD=Churches Action in Relief Development, DAPP=Development Aid from People Programe, FICA=Flemish International Cooperation Agency, Goal Mw=Goal Malawi, IFA=International Fertilizer Industory Association, IGPWP-EU=Income Generating Public Works Programe-European Union、IRLADP=Irrigation Rural Livelifood & Development Program, LDF=Local Development Fund, MIDSUP=Malawi Irrigation Development Support Programme, SCPMP =Smallholder Crop production & Marketing Project, TLC=Total Land Care, WALA=Wellness & Agriculture for Life Advancement, WVI=World Vision International

Source: Project Team

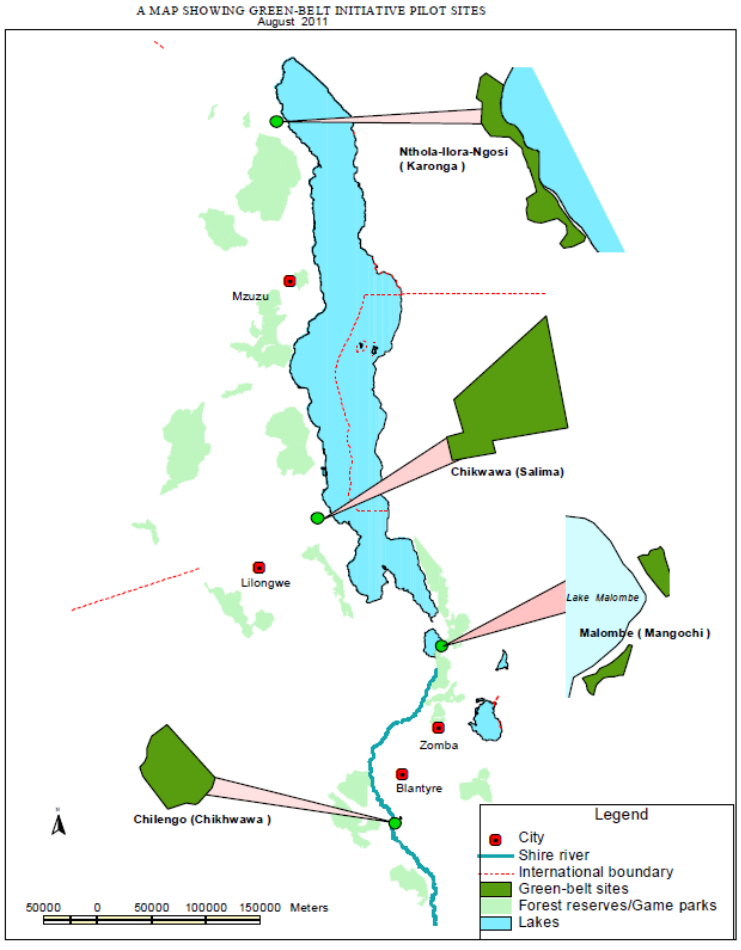
(2) Progress of GBI Project

The Office of the President and Cabinet (OPC) handles and coordinates the GBI project. The short term five-year target is 200,000 ha of irrigation area. Four sites were selected as pilot sites whose situation and location are as shown in **Table 4.3.8** and **Figure 4.3.1** respectively.

Table 4.3.8 Condition of Four (4) GBI Pilot Sites

District	Project Name	Area (ha)		Remarks
		Development	Potential	
Karonga	Nthola-Ilora-Ngosi	1,000	Large	Mainly paddy production
Salima	Chikwawa	530	6,290	Estate producing cashew nuts was procured for the project. The land is used for sugar cane and sugar factory. Medium scale irrigation of 1,500 ha and Core growers of 4,000 ha will be commenced within a few months. Mainly center pivot method is introduced for cultivation. Water source is Lake Malawi.
Mangochi	Malombe	500		Mainly paddy production. Water source is Lake Malombe.
Chikhwawa	Chilengo	240		Contractors built field office and nine months are required to complete the facility. Mainly maize production. Water source is Livunzu River, left tributary of the Shire River. Weir will be constructed to intake water.

Source: Project Team



Source: GBI-Strategic Plan Final Draft

Figure 4.3.1 Location of GBI Pilot Sites

(3) Large Scale Development Project

The Songwe River, which forms part of the physical boundary between the Republic of Malawi and the United Republic of Tanzania, has a length of 200 km and an approximate catchment area of 4,200 km^2. The Songwe River meanders considerably between the foothills to the Lake Malawi/Nyasa. This active meandering renders the river course an unstable boundary between the two countries. Much property is lost whenever the river changes course. Three multipurpose dam projects for flood mitigation, hydropower and irrigation have been proposed through the feasibility study and now under the detail design stage.

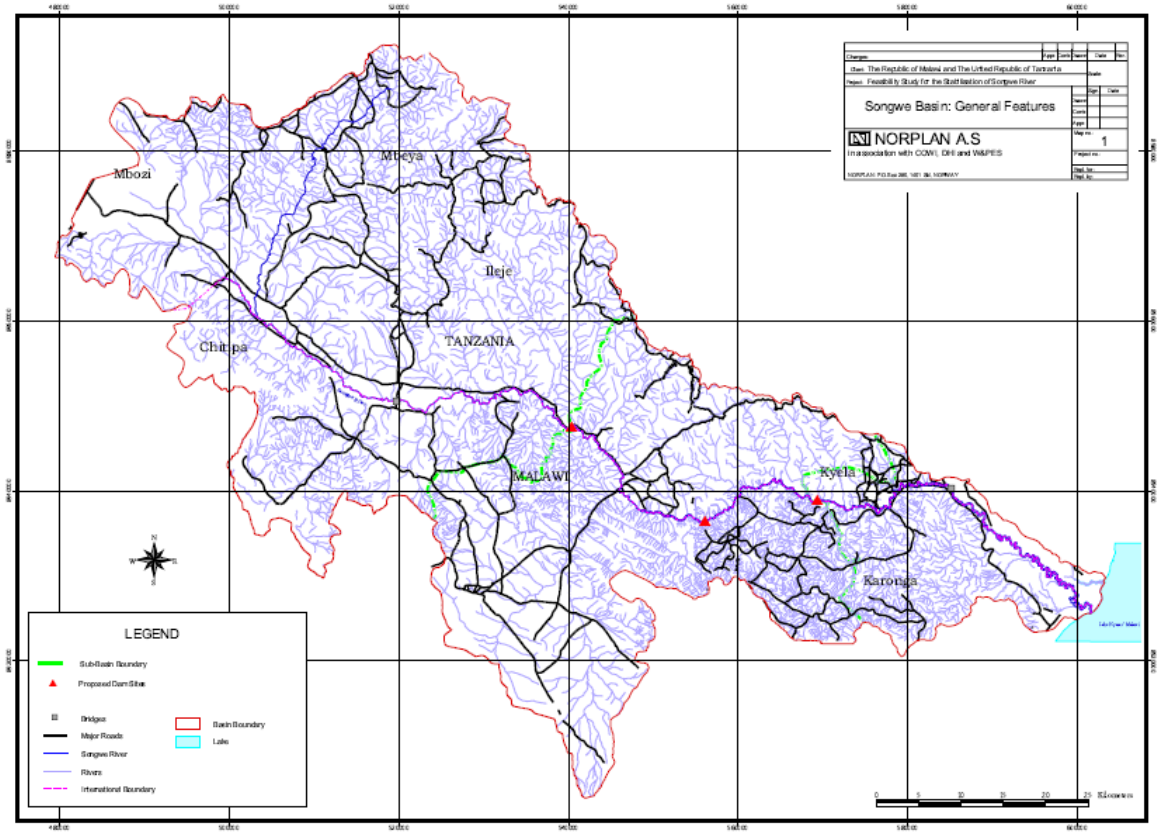


Figure 4.3.2 Location Map of Songe River Basin

1) Irrigation and Drainage Projects

(i) Condition of Rivers in Malawi and Tanzania

Tanzania: On the Tanzania side of the Songwe River, the western part of the plain does not flood. In this area, a single crop of rainy season rice is grown. The introduction of irrigation would permit the growing of two crops a year in this area and further east in areas which at present do flood. The elevation of the plain necessitates taking water from the tailrace of the Lower Dam power station, along a feeder canal some 19 km long. The feasibility study envisages an irrigation project on the Tanzania plain of more than 3,000 ha.

Malawi: On the Malawi floodplain the principal problem encountered by farmers is flooding both from the Songwe and, perhaps more importantly, from the Kyungu River and other streams flowing onto the floodplain from the Malawi hills. Since the Songwe levees are higher than the floodplain, there is no natural drainage from the floodplain to the Songwe so that all floodwaters flow down the floodplain to reach the Lake through a separate outlet.

2) Projects of Irrigation and Channels

(i) Project Outline

Drainage Channel: Although the construction of dams on the Songwe will reduce flooding from the Songwe, it is not technically viable to prevent the flooding from Kyungu and the other streams. It is, therefore, proposed that agriculture on the Malawi floodplain be improved by the construction of a drainage channel of about 14 km long from the western end of the floodplain to the Lake. The impact of this drainage scheme will be the reduction of depth and duration of flooding on about 1,400 ha of agricultural land and the drainage of about 530 ha of swamp that will become available as new agricultural land. Apart from the improvement to agriculture, the construction of the drain should improve the quality of life and the health of inhabitants of the floodplain.

Malawi Irrigation: Due to the difficulty of actually preventing the flooding of the flood plain, the construction of any major irrigation works on the Malawi floodplain is not proposed, since any infrastructure would be subject to frequent damage from the flooding.

Other Irrigation: A number of sites in the Songwe Basin were examined for their suitability for irrigation development. The only site where it appears that the construction of the dams on the Songwe would facilitate the development of irrigation is in the valley of the Kaseye River, near to Chitipa in Malawi. It is estimated that about 1,750 ha of this valley would be under the command of the Upper Dam. Although a 19 km long feeder canal would be required, the benefits of irrigation in this dry part of the basin could be considerable. It will be necessary to carry out a feasibility study for this project before the detailed design of the Upper Dam is carried out.

(ii) Irrigation Demand

Thus, for the irrigation demand from the Tanzanian side, 3,000 ha is set in the year 2020, and in Malawi, 1,750 ha is taken in the year 2035.

3) Shire River Basin Management Project (SRBMP)

(i) Project Outline

The development objective of the Adaptable Program Loan for the Shire River Basin Management Program Project is to develop the Shire River Basin planning framework to improve land and water management for ecosystem and livelihood benefits in target areas. There are three components to the project, to wit:

1) The first component of the project is Shire Basin planning. This component will finance development of a modern integrated Shire River Basin knowledge base and analytical tools, as well as well-planned structured stakeholder consultation processes, in order to facilitate investment planning and systems operation.

2) The second component of the project is catchment management. Its objective is the rehabilitation and management of sub-catchments and protected areas to reduce erosion and improve livelihoods.

3) The third component of the project is water related infrastructure. It aims at new investments to enable improvement in regulating the Shire flows and strengthening climate resilience.

The project development objective and the global environmental objective of the SRBMP (Phase-I) would be the Shire River Basin planning framework developed to improve land and water management for ecosystem and livelihood benefits in target areas.

The project would:

1) Strengthen the institutional capacities and mechanisms for Shire River Basin monitoring, planning, management and decision support systems;

2) Invest in water related infrastructure that sustainably improves water resources management and development;

3) Reduce erosion in priority catchments and sedimentation and flooding downstream, while enhancing environmental services, agricultural productivity and improving livelihoods;

4) Improve flood management in the Lower Shire River and provide community level adaptation and mitigation support; and

5) Protect and enhance ecological services in the Basin.

(ii) Irrigation Demand

The project has just started and irrigation demand is not yet clarified.

4) Lilongwe's New Water Source Project

The Government of Malawi (GoM) has received funds from the International Development Association (IDA) to finance the National Water Development Project II (NWDP II). This Project is aimed at improving infrastructure for water supply and sanitation, water resources development and management, and institutional development in the sector. A portion of the IDA funds is used to finance the Feasibility Study and Preliminary Design for New Water Sources for Lilongwe.

As the results of the Study, the four irrigation schemes shown in **Table 4.3.8** were proposed and the main characteristics of these irrigation schemes are in a way considered as compulsory compensation for flooding of agricultural lands by the reservoirs.

Table 4.3.9 Development of Irrigation Schemes Downstream the Dam Sites

	Flooded area (ha)	Loss of production (tons)	Irrigation scheme (ha)
Likuni	1060	650	135
Lilongwe 3	490	330	70
Diamphwe Upper	2140	1540	330
Diamphwe Lower	1330	970	260

Source: Feasibility Studies and Preliminary Design for Lolongwe's New Water Source

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