CHAPTER 4 HYDROGEOLOGY

4.1 Collection of Existing Data

Existing data about hydrogeology managed by Directorate of Water Resources Management (DWRM) are Groundwater Database, Mapping Project data, and Groundwater Monitoring data. Others are the MIS database which is water supply facilities database managed by Directorate of Water Development, including the items of location, water source, functionality, and so on.

4.1.1 National Groundwater Database (NGWDB)

This database was established by DWRM with contracting to a local consultant in 2000. DWRM had been compiled database based on the "Borehole Completion Report" which is submitted by drilling company after completion of drilling. In 1990s, it was managed by database software on MS-DOS, and before 1990s, it was borehole ledger described on paper book. Now it was compiled by Microsoft Access database management software on the Windows base again. Figure 4-1 shows the initial display of the database. The database has been input the data based on the completion report submitted by drilling company every year. It is including the well specification, geological information, pumping test data, water quality test result, and so on. This database is very sophisticated.

Source: DWRM

Figure 4-1 Initial Display of National Groundwater Database

DWRM gave to the study team the data which are related to the Lake Kyoga Basin. In the obtained data, the number of data which described the registered well number is 11,880, the number of data which described the well construction information is 9,672, the number of data which described the hydrogeological information is 5,902, the number of data which described the pump information is 1,095, and the number of data which described the water quality is 2,293. However, the position data which is necessary for analysis have many mistakes. Some position data are input by Latitude-Longitude system, and others have UTM coordinates. Latitude-Longitude system were used in old data mainly. In this study, these data were used after correcting the position data to adequate position from referring to the location name, e.g. Sub-county name or parish name or village name.

Problem of this database is as follows:

1) Borehole positions have many mistakes,

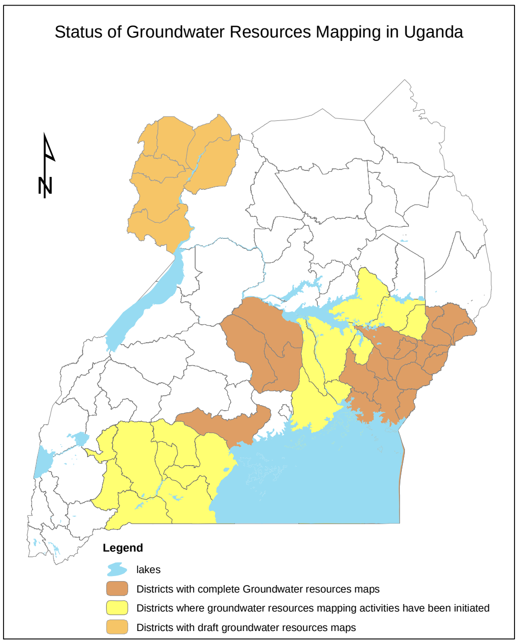
2) It is difficult to correct the administrative structure,

3) There are some duplicated data.

4.1.2 Groundwater Mapping Project

DANIDA has supported this project. This is compiling several maps for districts about groundwater development. Now, in 47 districts in total, mapping was completed or is going on .

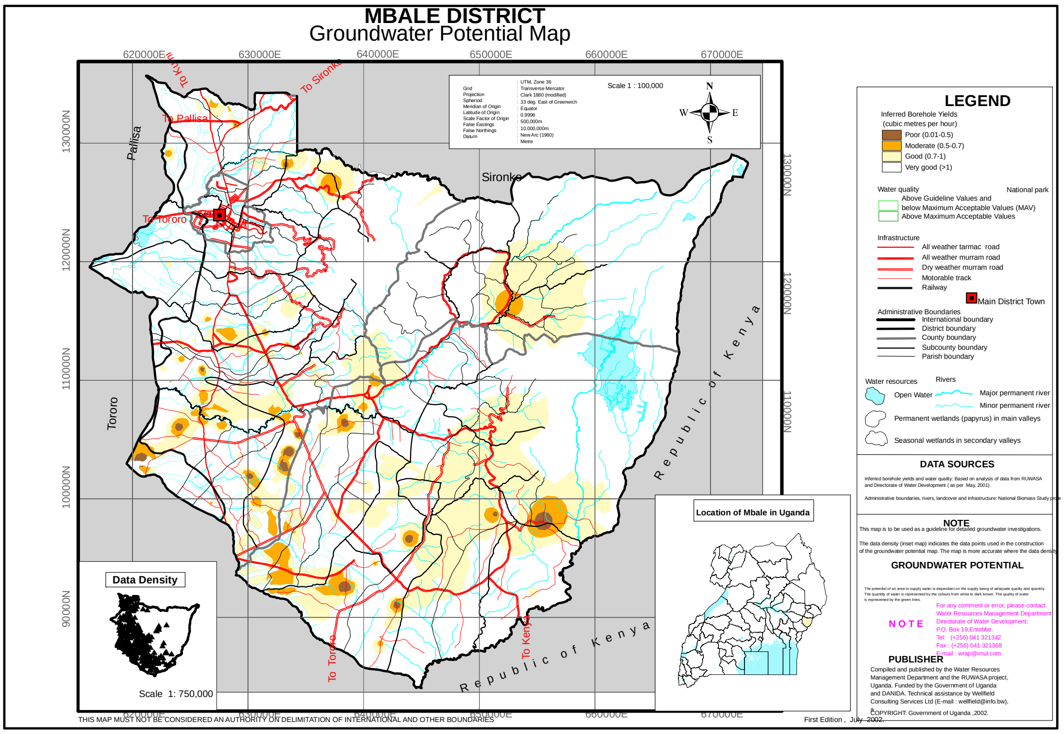
In addition to NGWDB data, re-measurement of the position of borehole which was unclear in NGWDB was conducted, and shallow well and spring data were collected from district office in this project. Final results are providing useful maps for administrators of each district.



Source: DWRM

Figure 4-2 Progress of Mapping Project

Several kinds of maps are provided as follows; 1) Groundwater potential map, 2) Hydrogeological characteristic map, 3) Groundwater Quality map, 4) Hydrochemical characteristic map, 5) Water sources location map, 6) Water coverage per parish map, 7) Water services area and population density map, 8) Population per parish and distance to water source map, and 9) Water supply technology option map. However, Since data management of DWRM is poor, all data is not available even in published paper maps or digital data, now.



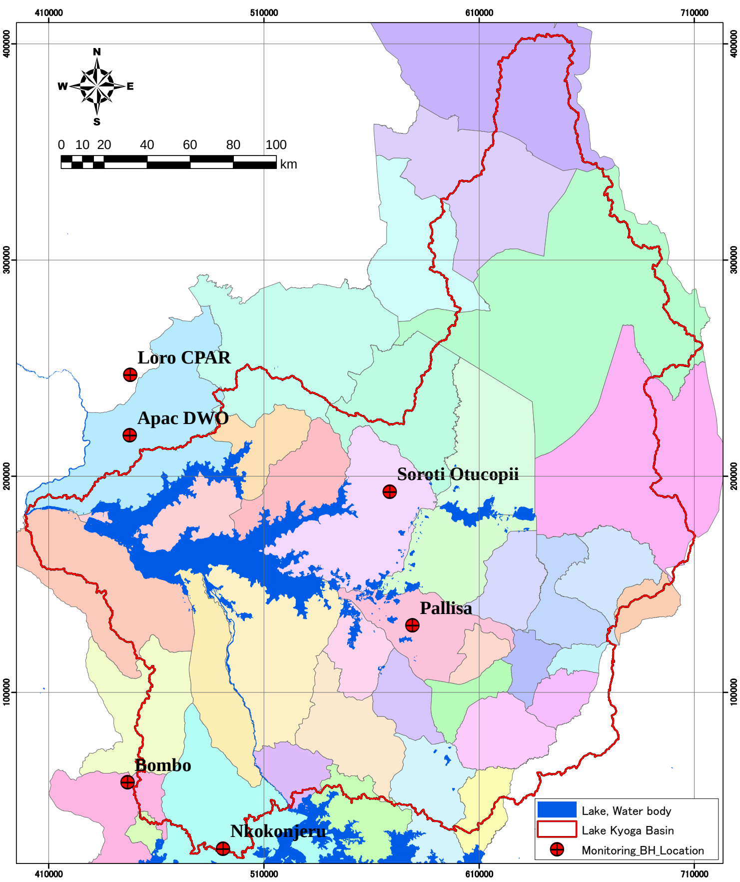
Source: DWRM

Figure 4-3 Example of Groundwater Potential Map on the Mapping Project

(former Mbale district, it was divided to Mbale, Bududa, and Manafwa district)

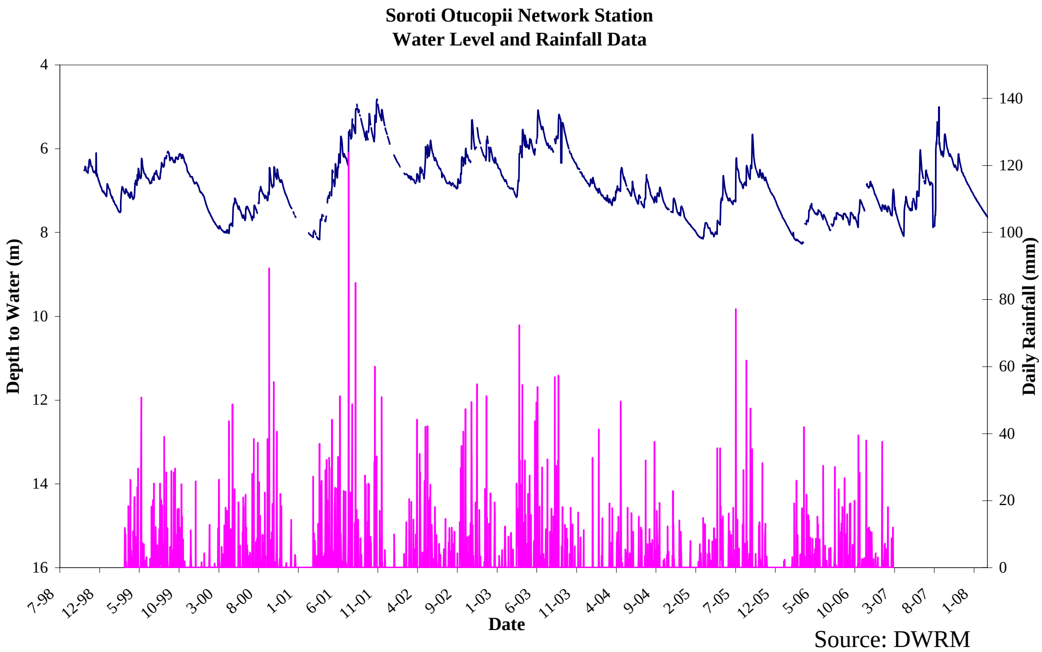
4.1.3 Groundwater Monitoring

DWRM is monitoring the groundwater levels by using the monitoring wells in Uganda. Although 32 monitoring wells were constructed in whole Uganda. Now functioning monitoring wells are only 11 locations, because some boreholes have been already demolished, or some facilities are not functioning yet. Three wells of 11 monitoring wells are in Lake Kyoga Basin; they are at Soroti, Pallisa, and Nkokonjeru. Figure 7-4 shows the location of monitoring wells in and around Lake Kyoga Basin. Figure 4-5 shows the relationship between groundwater level and rainfall, as an example of the monitoring data. According to this data, it is recognized that water level is rising after rainfall. The time lag can be estimated approximately 0.5 to 1 month.



Source: DWRM

Figure 4-4 Location of Groundwater Monitoring Station



Source: DWRM

Figure 4-5 Relationship between Groundwater Level and Rainfall

4.1.4 Borehole Completion Report

Borehole Completion Report is submitted from drilling contractors 4 times a year. The data of NGWDB is based the reports. However, boreholes which were conducted the pumping test are not very much. The reports which were conducted pumping test properly were selected from whole reports. This purpose was to grasp the hydrogeological condition conducted by pumping test analysis ourselves, because these reports have no analysis result of pumping test. The number of report collected was 204, after exception of the data which the location was not clear and pumping test data was not good, the number of analyzable data was 158. Figure 4-6 shows the location of borehole which the pumping test data was analyzed.

Most of the data are conducted constant rate pumping test and recovery test, however, step drawdown test data were very few. Most of pumping period of constant rate pumping test was 3 hours (180 minutes), few are 24 hours (1,440 minutes). However, there are some data which changed pumping rate in the period of constant rate test.

Step number of step drawdown test is 3 to 5 times.

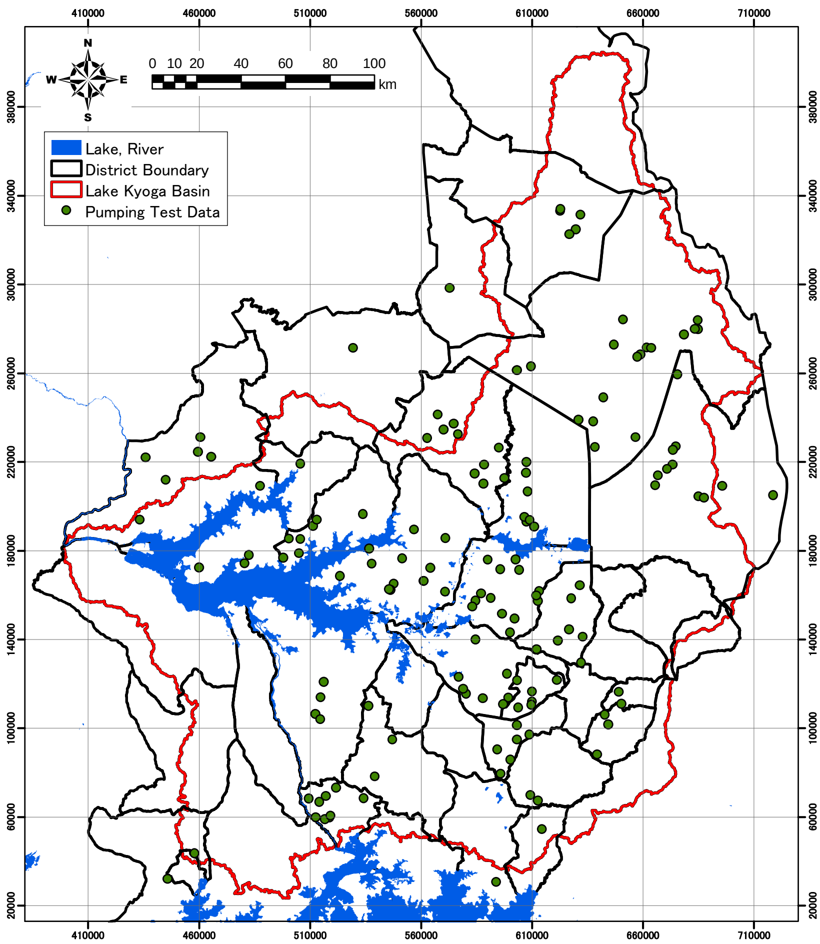


Figure 4-6 Location of Boreholes Analyzed Pumping Test

4.2 Hydrogeological Analysis

Data from NGWDB were used for hydrogeological analysis mainly. Since the data have many mistake on the position data, correction of position data was necessary. First, unification of position data was necessary, because both of Latitude - Longitude system and UTM system are used as position data in the database. The numbers of data for each coordinate system are shown below.

UTM coordinate system: 4,736

Latitude – Longitude system: 2,564

UTM system would be used in this study, because the number of UTM is more than Latitude – Longitude system, UTM is used for managing data in NGWDB now, and latest data is input by UTM. Then after checking of coordination data, mistaken data which are wrong ordering and mixing up east and North are corrected. Finally, the numbers of data which were used for analysis are shown below.

Drilling Depth data: 4,709

Static Water Level Data: 4,094

Pumping Test Data: 4,416

Depth to Bedrock: 3,834

Water quality (TDS) data: 1,530

Table 4-1 shows the summarized table of drilling depth, static water level, well yield, and depth to bedrock. Additionally, Table 4-2 is summarized by districts.

Table 4-1 Drilling Depth, Static Water Level, Well Yield and Depth to Bedrock in Each Geological Unit

	Formation Name	Symbol	Drilling Depth		Static Water Level		Well Yield		Depth to Bedrock	
			Data No.	Average (m)	Data No.	Average (m)	Data No.	Average (m3/h)	Data No.	Average (m)
1	Quaternary	P1 2	190	66.1	166	16.2	178	1.9	151	26
2	Alkali volcanics	T	49	64.6	47	15.9	46	2.3	32	28
3	Carbonatite	TC	17	58.7	16	19.4	15	2.2	11	35
4	Karoo System	KR	5	78.9	3	16.0	3	4.6	5	28
5	Aswa Shear Zone	CM	53	64.9	51	8.0	53	2.5	50	26
6	Karasuk serise	KS	15	78.8	15	29.4	14	1.7	7	11
7	Kyoga Series	B-K	65	69.4	58	20.9	62	4.0	50	39
8	Granite	G	75	55.2	71	12.6	72	1.9	57	31
9	Buganda-Toro System	B-T	338	69.9	238	19.5	302	1.8	284	35
10	Nyanzian System	NZ	98	55.1	86	13.7	92	2.5	69	32
11	Aruan Series	A	77	85.2	64	23.3	71	2.0	62	24
12	Watian Series	W	75	71.4	63	21.7	66	2.7	49	34
13	Gneiss-Granulite Complex	GC	3551	62.5	3127	13.9	3345	1.9	2946	28
14	Granitoid	GZ	101	56.1	89	15.3	97	2.0	61	28
			4709	63.5	4094	14.7	4416	2.0	3834	29

Table 4-2 Drilling Depth, Static Water Level, Well Yield and Water Quality (TDS) by District

No.	District	Drilling Depth		Static Water Level		Well Yield		TDS	
		Sample Number	Average (m)	Sample Number	Average (m)	Sample Number	Average (m^3/h)	Sample Number	Average (mg/L)
1	ABIM	49	67.43	38	18.92	47	2.86	15	255.5
2	AMOLATAR	46	76.58	37	29.39	42	2.52	4	456.0
3	AMURIA	103	66.11	98	9.47	98	2.12	39	201.9
4	APAC	221	76.50	201	18.92	211	2.26	66	507.3
5	BUDAKA	136	61.54	121	9.61	120	1.51	35	268.3
6	BUDUDA	3	43.30	3	17.33	3	1.60	1	185.0
7	BUGIRI	89	56.26	82	14.20	79	2.28	22	471.3
8	BUKEDEA	67	78.05	63	10.97	67	2.44	16	444.8
9	BUSIA	121	54.50	110	12.13	118	2.16	35	313.4
10	BUTALEJA	46	66.15	27	6.60	41	1.27	5	256.8
11	DOKOLO	42	70.64	40	8.18	41	2.12	17	476.5
12	IGANGA	306	55.43	272	13.64	282	2.63	51	225.8
13	JINJA	171	54.52	157	17.10	160	2.07	24	241.7
14	KAABONG	48	79.85	42	30.85	39	1.54	25	495.0
15	KABERAMAIDO	70	58.10	68	11.86	67	2.13	27	397.5
16	KALIRO	149	52.88	146	12.79	147	2.44	47	536.4
17	KAMULI	274	60.12	266	17.50	264	1.73	66	376.5
18	KAPCHORWA	13	92.44	13	28.48	13	1.81	1	451.0
19	KATAKWI	85	69.97	80	12.19	79	1.64	32	273.8
20	KAYUNGA	243	66.27	224	20.44	235	1.28	26	202.3
21	KOTIDO	32	80.17	20	28.92	32	2.48	14	308.9
22	KUMI	145	80.42	139	9.15	145	1.58	23	243.2
23	LIRA	195	70.96	190	8.86	190	2.10	93	186.5
24	LUWERO	335	64.01	182	17.28	318	1.69	78	195.6
25	MANAFWA	74	62.21	74	14.81	72	1.48	21	238.1
27	MBALE	95	64.10	87	11.22	93	1.86	10	254.3
28	MOROTO	50	77.77	47	25.77	47	2.81	15	483.7
29	MUKONO	111	63.69	102	17.97	107	2.20	22	117.2
30	NAKAPIRIPIRITI	49	83.23	45	19.32	41	2.22	20	463.2
31	NAKASONGOLA	120	70.94	85	31.05	111	1.23	47	465.2
32	NAMUTUMBA	154	52.53	146	9.82	148	1.73	55	243.9
33	PALLISA	330	57.29	307	9.90	307	1.80	73	382.7
34	SIRONKO	51	58.86	46	11.39	49	1.93	12	402.4
35	SOROTI	112	55.74	110	8.87	105	2.93	51	277.9
36	TORORO	149	56.60	122	7.55	137	1.81	46	268.1
37	WAKISO	246	66.89	185	19.54	198	2.09	5	120.8

4.2.1 Drilling Depth Distribution

The Drilling depth distribution map of existing boreholes is shown in Figure 4-7. Although each borehole has different condition, this distribution seems to indicate the actual depth of the aquifer which was needed to secure particular amount of water.

Average depth of drilling is 64m. It is tend to show that the depth is relatively shallow in the central and southern part of the Basin. On the other hand, the drilling depth is deeper in Karamoja area in the north-eastern part of Lake Kyoga Basin, Apac district, Nakasongola district, and Kumi district around the Lake Kyoga, and Kapchorwa district in the northern part of Mt. Elgon.

Drilling depth is a parameter for estimation of the cost of the well construction.

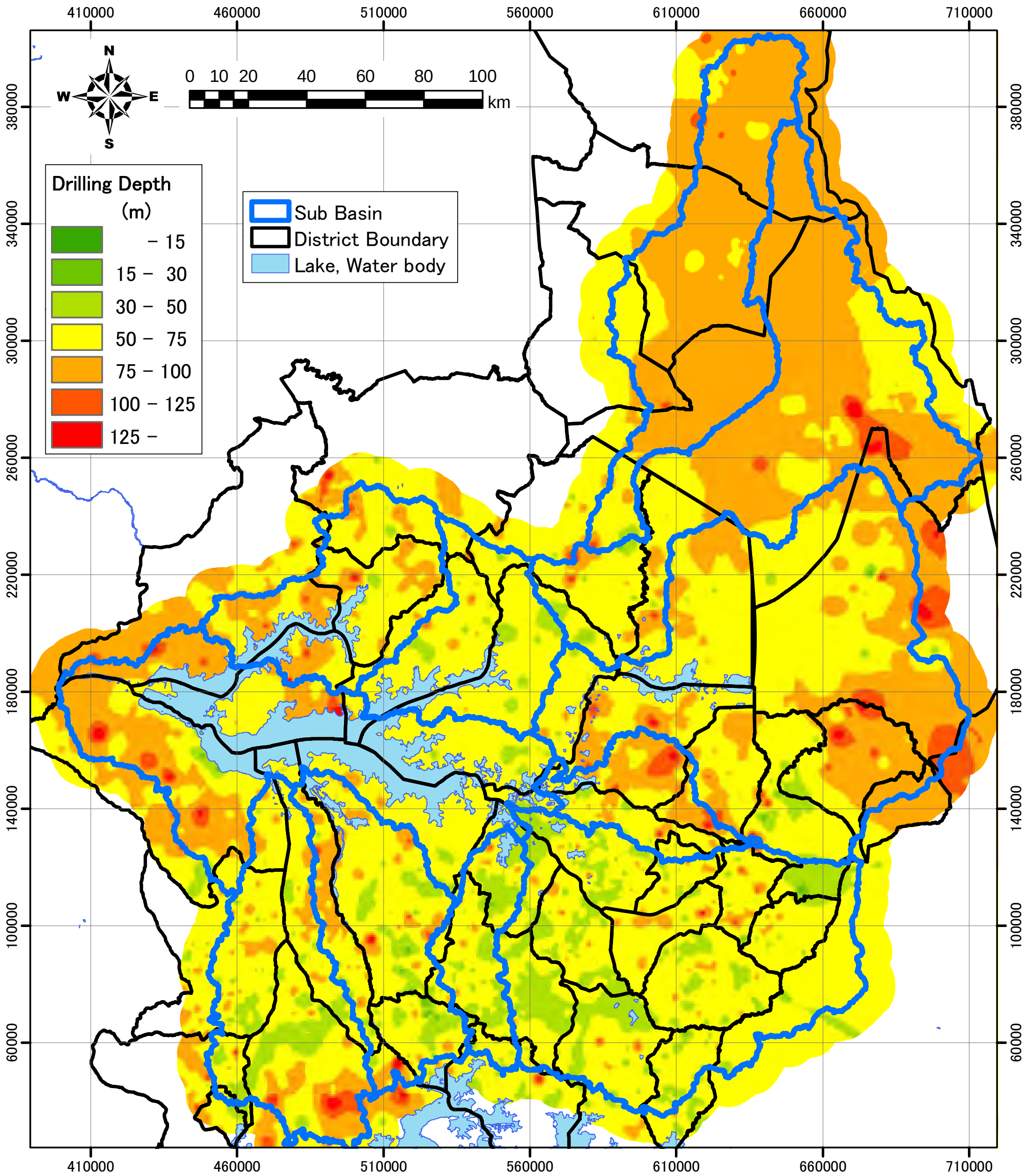


Figure4-7 Drilling Depth Distribution Map

4.2.2 Static Water Level Distribution

Static water level distribution of existing boreholes is shown in Figure 4-8.

I It is recognized that belt-like zone from north-northwest to south-southeast in the central part of Lake Kyoga Basin has shallow static water level. On the other hand, deep static water level zones are in Karamoja area in the north-eastern part of Lake Kyoga Basin, Apac district, Amolatar district, Nakasongola district, Kayunga district, and Kamuli district around the Lake Kyoga.

Static water level is the parameter to decide a capacity of pump.

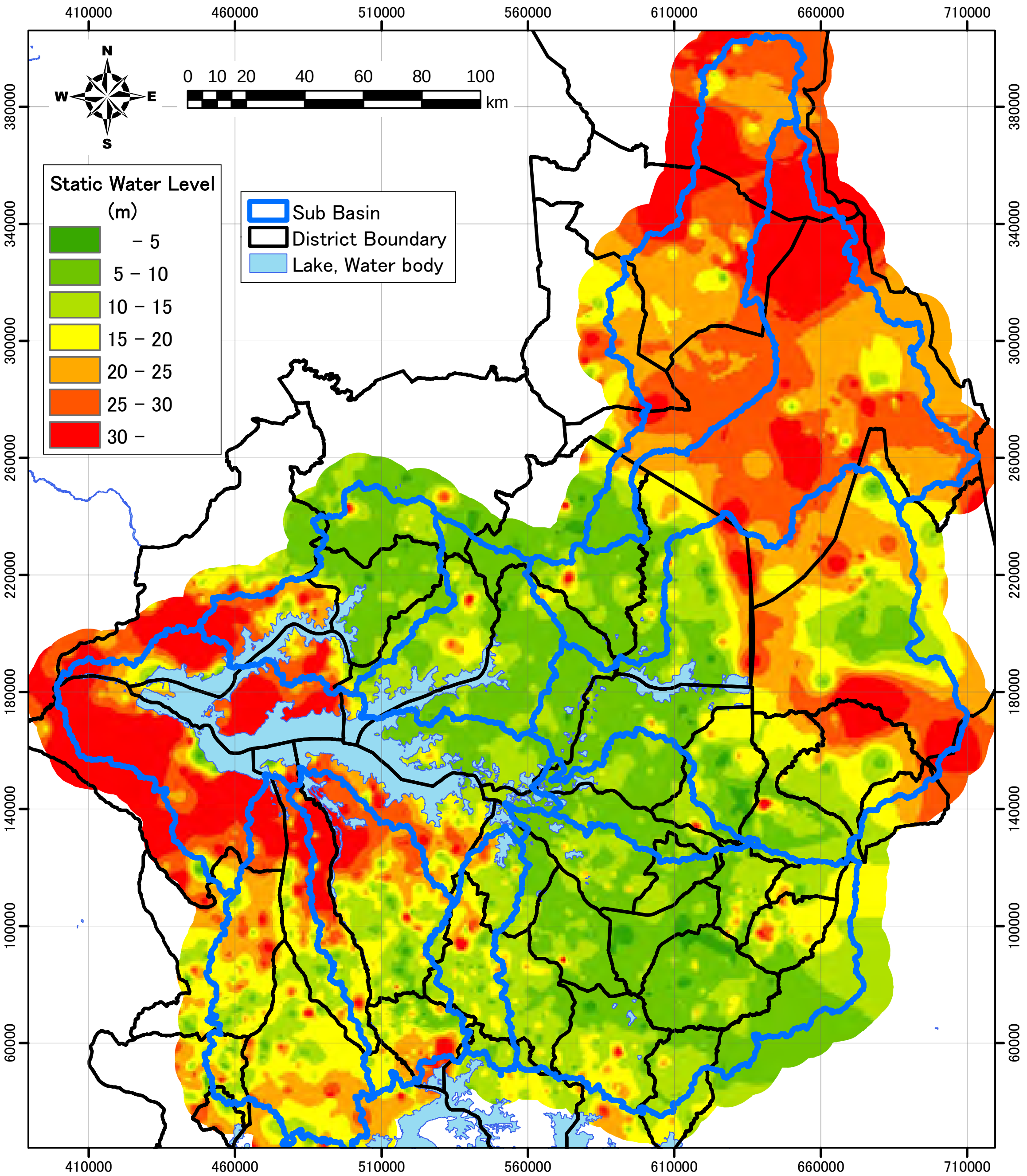


Figure4-8 Static Water Level Distribution Map

4.2.3 Well Yield Distribution

Distribution of the well yield of existing wells is shown in Figure 4-9. Constant pumping test results are used for this analysis as well yield data, because this parameter has relatively many data in NGWDB.

The areas which show large yield per well are in Karamoja area in the north-eastern part of Lake Kyoga Basin, and Soroti district, Amolatar district, Apac district, Dokolo district, and Kaberamaid district in the northern shore of Lake Kyoga. Southern area of Lake Kyoga has relatively low yield.

Well yield is the parameter to estimate groundwater potential and necessary number of wells at the target area.

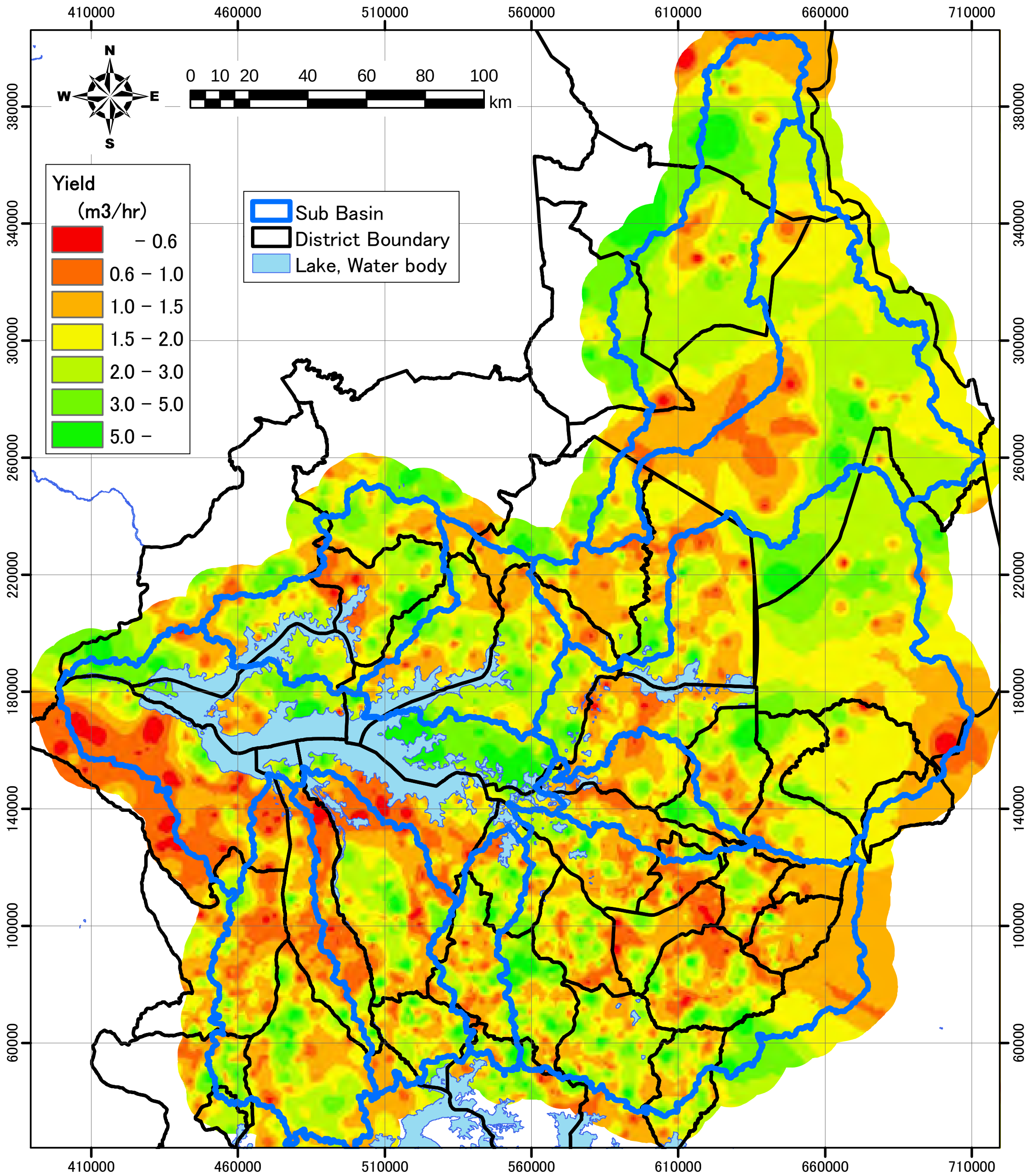


Figure4-9 WellYeild Disribution Map

4.2.4 Water Quality Distribution (TDS)

Distribution map of Total Dissolved Solid (TDS) is shown as water quality map in Figure 4-10. TDS is recognized as a good indicator to judge water quality comprehensively, for example salinity, iron content, and so on.

Surrounding to Lake Kyoga, especially, Apac district, amolatar district, and Kaliro district shows high value. It means the groundwater seems to be saline water.

Water quality is the parameter to judge the possibility of potable water and the necessity of water treatment facility.

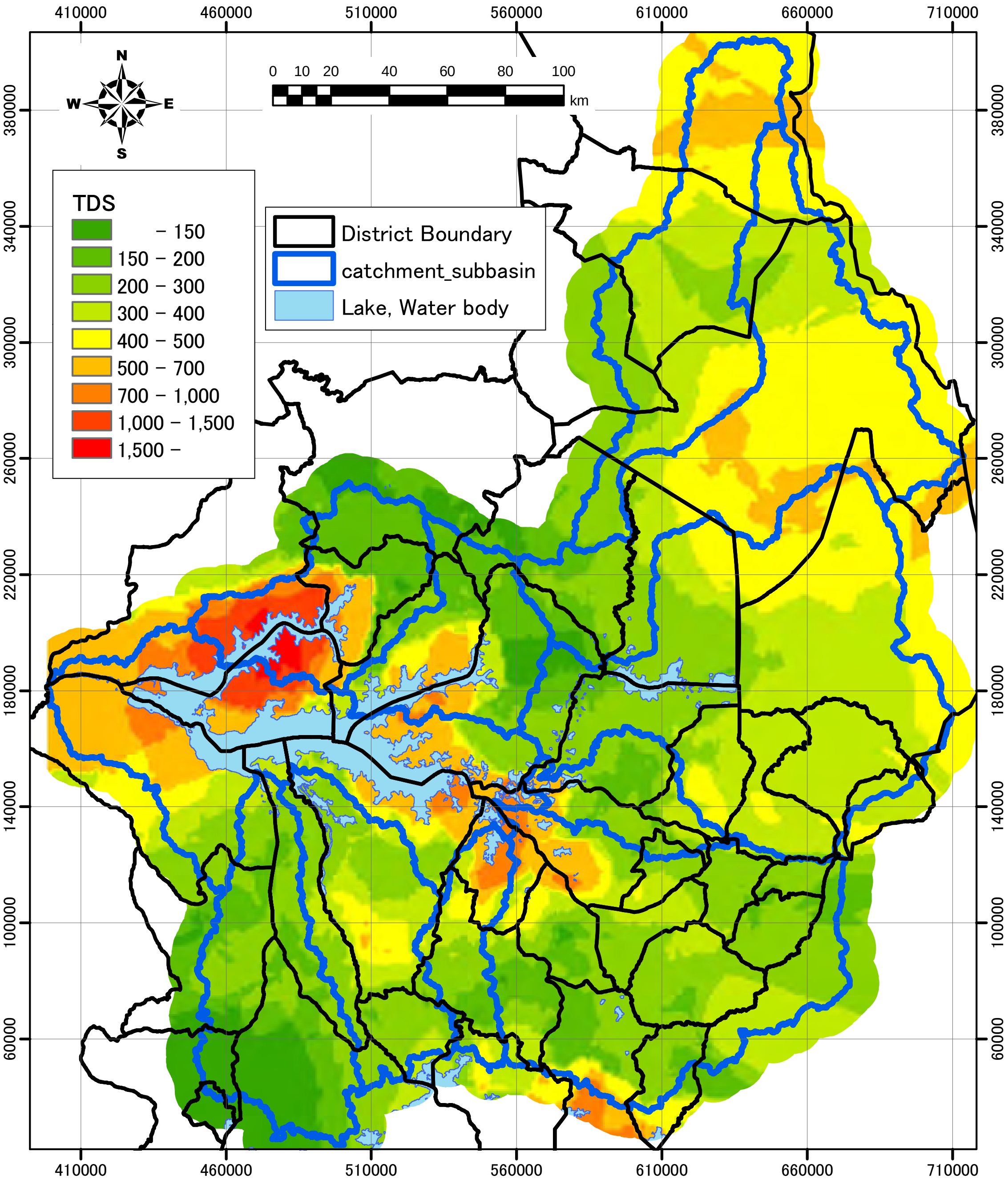


Figure4-10 Total Dissolved Solid Distribution Map