3-2-5 Core Boring

3-2-5-1 Outline

The investigation area is topographically and geologically classified into two areas: the Thanlyin-Kyauktan ridge underlain by Tertiary (mainly Neogene) layers and the eastern plain covered with Quaternary Alluvium layers (called "the hill" and "the plain" respectively in this report). To grasp the representative geological sequence and layer condition in each area, core boring was carried out at each single point. Table 3-2-5-1 and Figure 3-2-1-1 (presented above) show the location and outline of the points.

The drill depth was first planned as 300 m at the D-2 point in the hill and 350 m at the D-4 in the plain. However, due to the limited ability of the contractor, the drilling finished at 272 m and 248 m respectively. The standard diameter of drilling was 66 mm.

The obtained core samples were used mainly for hydrogeological purpose to infer aquifer horizons. However, in such an area where an outcrop is rare, they are also very useful for geological study (stratigraphy and sedimentology). Therefore they were handed over to an academic sector in Myanmar for further study with them.

Table 3-2-5-1 Outline of Core Boring Locations

Name	Plann-ed Depth (m)	Drill-ed Depth (m)	Ground Elevat-Ion (m)	Coordinates (WGS84)		Location	Topography / Surface Geology
D-2	300	272	18.0	N 16° 41' 13.0"	E 96° 18' 28.9"	In Thilawa SEZ Supporting Committee compound, Thanlyin Township	Hill / Tertiary Pegu Group
D-4	350	248	3.6	N 16° 44' 50.5"	E 96° 26' 04.4"	On Payagon-Thongwa Road between Kan Myint and Thaik Tu Gan settlements, Thongwa Township	Plain / Quaternary Alluvium

3-2-5-2 Work Progress of Core Boring

The core drilling investigation was commenced at the D-2 site on 9 November and at the D-4 site on 25 November 2012, respectively. The D-2 hole was drilled to the depth of 272 m. The D-4 hole was drilled to the depth of 248 m. Both holes could not be drilled to the planned depth of 300 m and 350 m because drill rods and the core barrel were jamming many times due to collapsing strata, such as unconsolidated sand and clay. Drilling work therefore was forced to be interrupted. The work progress of the core drilling is shown in Figure 3-2-5-1.

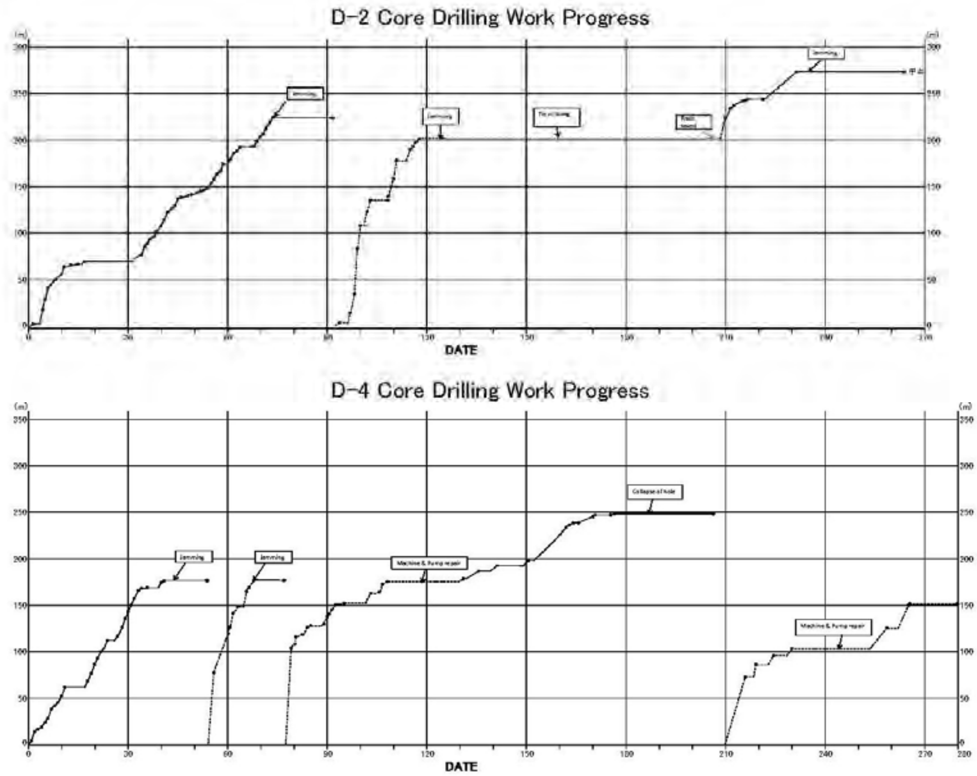


Figure 3-2-5-1 Core Drilling Work Progress

The drilling period planned was far exceeded because both holes were re-drilled 2-4 times due to jamming. The reasons were that the drilling machines and mud pumps employed to do the work were very old with more than 20 years of use, so they frequently broke down. Then the procurement for spare parts took a long time due to having to have been imported from outside of Myanmar.

In addition, drillers in Myanmar had little experience with the very deep core drilling work, and their drilling technique was also unskilled. This led to drilling accidents like the jamming of rod and the ground subsidence by collapse of the hole wall.

As most of the working period was spent in recovery after drilling accidents or in machine repair, the actual operation rate during the work period was only about 25 percent, as shown in Table 3-2-5-2. The drilling accidents include the jamming of rod and the ground subsidence due to collapse of the hole-wall

Table 3-2-5-2 Operation Rate of Core Drilling Work

Hole	Work Period	Actual drilling	Operation	Machinery Repair & Jamming
D-2	264 days	70 days	26.5%	194 days
D-4	279 days	71 days	25.4%	208 days

When the very deep core drilling work is carried out in Myanmar the next time, it is recommended that the work is executed under the guidance of experienced Japanese drillers with new drilling machines and mud pumps procured from Japan.

3-2-5-3 Boring Results

(1) D-2 (on Hill)

The detailed boring log and quality core photographs are attached in the "Supporting Data". Figure 3-2-5-2 to Figure 3-2-5-4 show an outline of facies (lithology) of layers and inferred aquifer horizons judged from the core sample condition.

1) Facies (Lithology)

<u>All</u>

The layers consist of alternation of semi-consolidated fine- to medium-grained sandstone and mudstone. Mudstone is generally more consolidated than sandstone. Sandstone dominates as a whole. Layers dip with 15 to 25 degrees.

A sandstone layer is usually a few ten centimeters to a few meters thick, but, in places, makes fine alternation with a mudstone layer with millimeter to centimeter units. Thick sandstone is generally massive, but is striped with dense black mica fragments in portions. Fine-grained sandstone is well consolidated. Sandstone containing medium-grained sand is generally not sorted well. The hardness varies from a slightly scrapable one with nail to easily crushable with the fingers (the latter described as “soft” in Figure 3-2-5-2 to Figure 3-2-5-4). Rip-up clasts and granules are contained in portions.

Mudstone partly looks massive, but mainly consists of fine alternation of clay and silt layers or silt and very-fine-grained sand layers with a few millimeters of lamination. The lamination is mostly crossed. Below 238.5m from the ground, it is very hard and partly looks like the shale.

<u>By interval</u>

0 ~ 43.55 m	Mudstone dominates. The present weathering zone extends down to 4.8 m (Figure 3-2-5-8). Brown spots and ferruginous concretions contained. Sandstone is moderately weathered, brownish with oxidized iron, and soft.
43.5 ~ 95.1 m	Sandstone dominates; mainly medium-grained, moderately weathered, brownish with oxidized iron, and soft (Figure 3-2-5-9).
95.1 ~ 100.6 m	Fine alternation of silt and fine-grained sandstone; hard (Figure 3-2-5-10)
100.6 ~ 176.2 m	Hard sandstone dominates. 131~148 m: Joint surface brownish with oxidized iron. Partly soft (Figure 3-2-5-11)
176.2 ~ 184.9 m	Mudstone (Fine alternation of clay and silt)
184.9 ~ 238.5 m	Sandstone dominates; soft, crushable with fingers in a considerable length of interval (Figure 3-2-5-12)
238.5 ~ 272.0 m	Hard mudstone dominates. Sandstone is hard, but a little contains soft portion, crushable with finger (Figure 3-2-5-13 and Figure 3-2-5-14)

Stratigraphy

According to existing reports, the Pegu Group of Oligocene(?) to Miocene age is distributed around the drilling point. Win Naing et al. (1991) (see Table 3-1-4-1) describes the lithology as "Alternation of shale and sandstone with ferruginous stripes. Sandstone is fine- to medium-grained." This description almost meets the core sample lithology, though sandstone dominates and ferruginous stripes develop only within 95.1 m from the ground in the core.

Note: It is considered that the ferruginous stripes were made when the groundwater table was fluctuating in the horizon. At present, such oxidization to the deep near 100 m below ground is impossible to occur. It might have occurred in the Glacier Age when the sea level lowered more than 100m maximum and the groundwater base level went down and up.

2) Possible Aquifer Horizons

Based mainly on the consolidation degree of sandstone, it is inferred that the aquifer lies in the intervals indicated with red line shown in Figure 3-2-5-2 to Figure 3-2-5-4.

(2) D-4 (in Plain)

The detailed boring log and quality core photographs are attached in the "Supporting Data". Figure 3-2-5-5 to Figure 3-2-5-7 show an outline of facies (lithology) of layers and inferred aquifer horizons judged from the core sample condition.

1) Facies (Lithology)

All

An unconformity is found at 82 m from the ground. Above it, there lie unconsolidated soil, clay and sand, and, below it, weakly-consolidated mudstone (silt and clay) and slightly- to weakly-consolidated sandstone (called "sandrock" in Myanmar). Sand and sandstone are not sorted well and mainly medium- to coarse-grained. Silt, clay and mudstone mainly consist of laminated fine alternation of clay and silt, or, silt and very fine sand with a few millimeter of unit layer. The layers lie almost horizontally.

By interval

0 ~ 12.3 m	Mainly fine alternation of silt and very fine sand; unconsolidated (Figure 3-2-5-15)
12.3 ~ 28.0 m	Mainly light brown fine sand; unconsolidated.
28.0 ~ 68.1 m	Mainly fine alternation of clay and silt; unconsolidated.
68.1 ~ 82.0 m	Poorly sorted fine- to coarse-grained sand; gravel less than 20 mm contained in the lower part; unconsolidated.
82.0 ~ 92.9 m	Organic mudstone of old soil and dark gray mudstone with brown spots of old weathered zone; weakly consolidated (Figure 3-2-5-16)
92.9 ~ 100.0 m	Fine alternation of clay and silt; weakly consolidated.

100.0 ~ 142.7 m	Mainly poorly sorted medium-grained sandstone; coarse-grained sand and granule contained partly; slightly consolidated.
142.7 ~ 173.0 m	Fine alternation of clay and silt; weakly consolidated (Figure 3-2-5-17)
173.0 ~ 248.0 m	Alternation of medium- to coarse-grained sandstone and mudstone (fine alternation of silt and very fine sand) (Figure 3-2-5-19); slightly to weakly consolidated; trace fossil at 201.4 m (Figure 3-2-5-18)

Stratigraphy

The layer above the unconformity is unconsolidated and classified as Quaternary formation. The layer below the unconformity should be considered to be Irrawaddy Formation of Pliocene (to Pleistocene ?) age, because it is slightly to weakly consolidated and lies almost horizontally.

2) Possible Aquifer Horizons

Sandstone could be an aquifer excepting the fine-grained parts, if it has sufficient thickness, because it is unconsolidated or weakly consolidated. The aquifer possibly lies in the intervals indicated with a red line shown in Figure 3-2-5-5 to Figure 3-2-5-7.

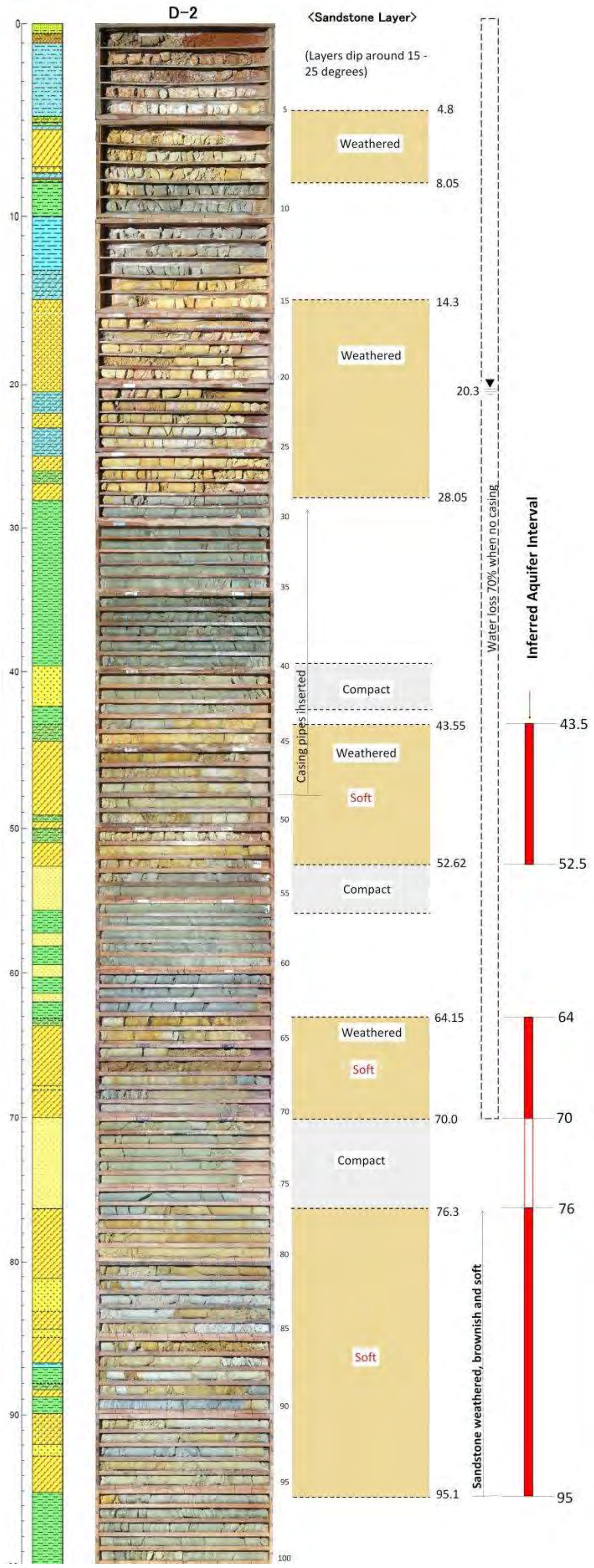


Figure 3-2-5-2 Photo and Facies Outline of D-2 Core Sample (1/3)

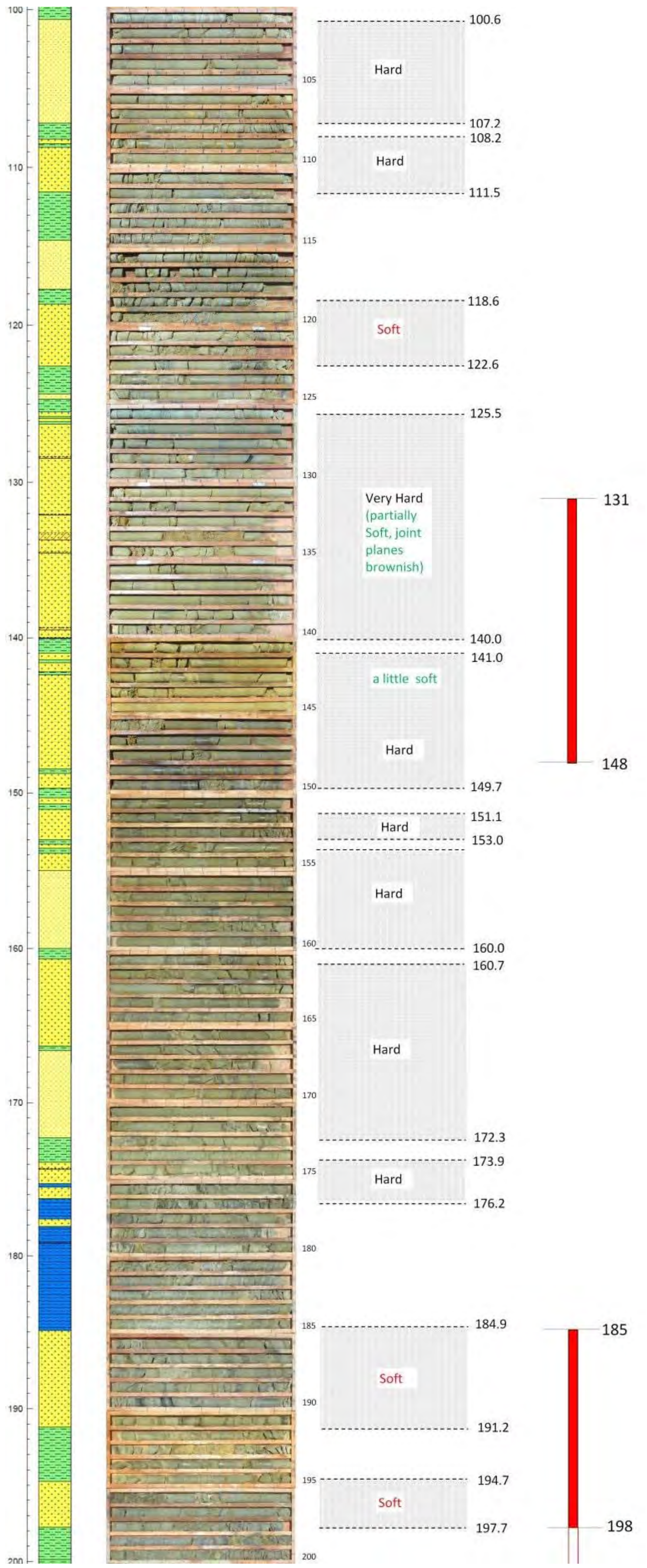


Figure 3-2-5-3 Photo and Facies Outline of D-2 Core Sample (2/3)

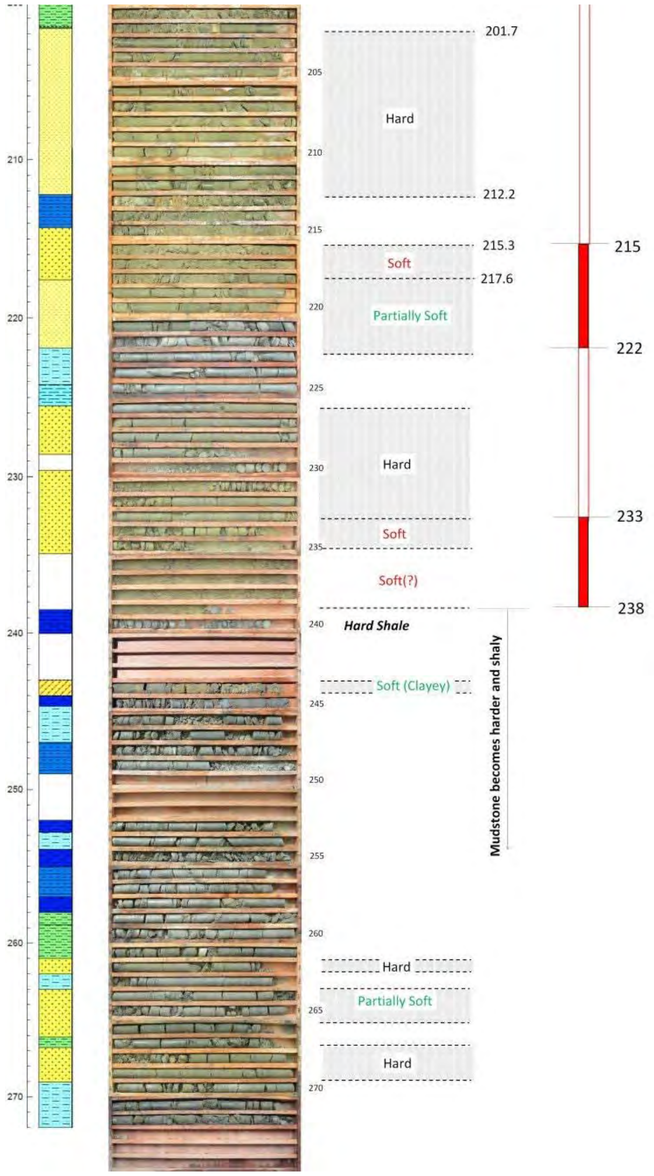


Figure 3-2-5-4 hoto and Facies Outline of D-2 Core Sample (3/3)

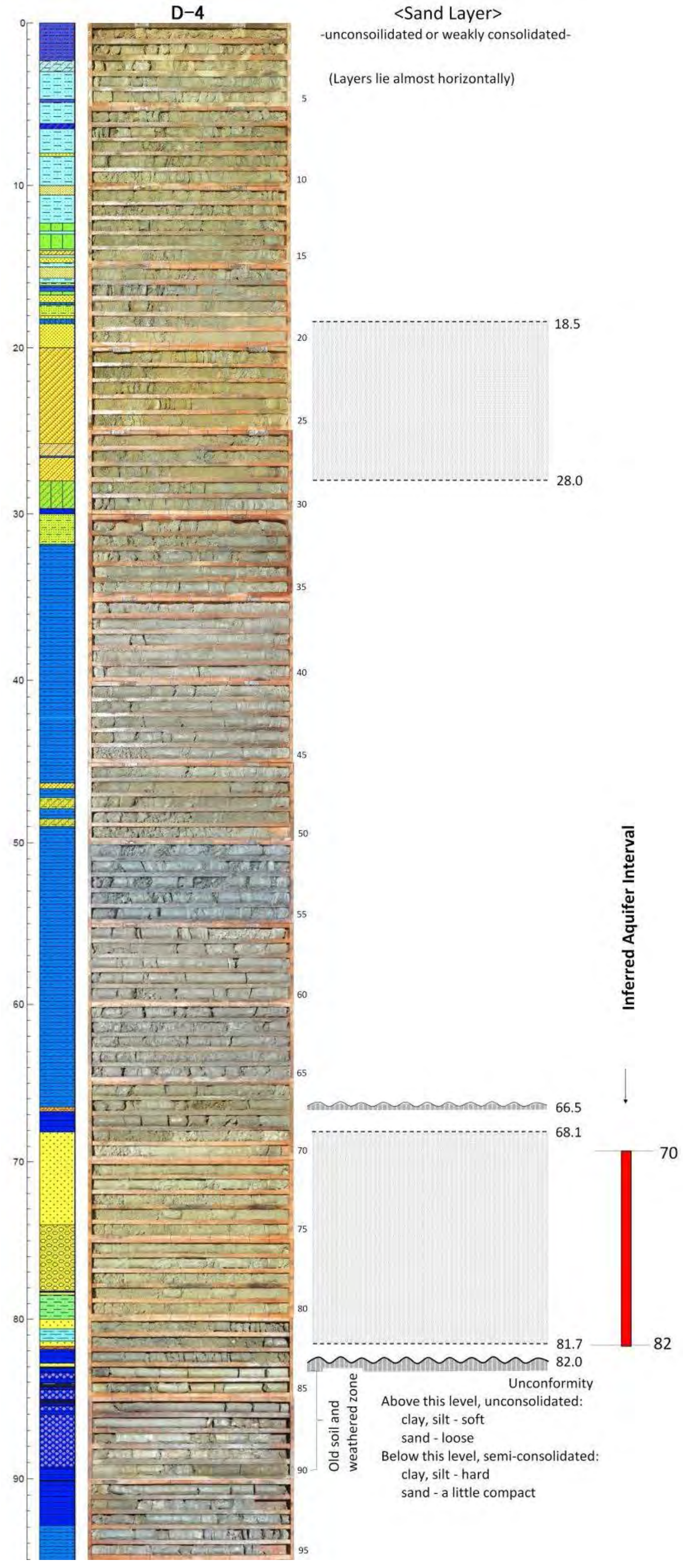


Figure 3-2-5-5 Photo and Facies Outline of D-4 Core Sample (1/3)

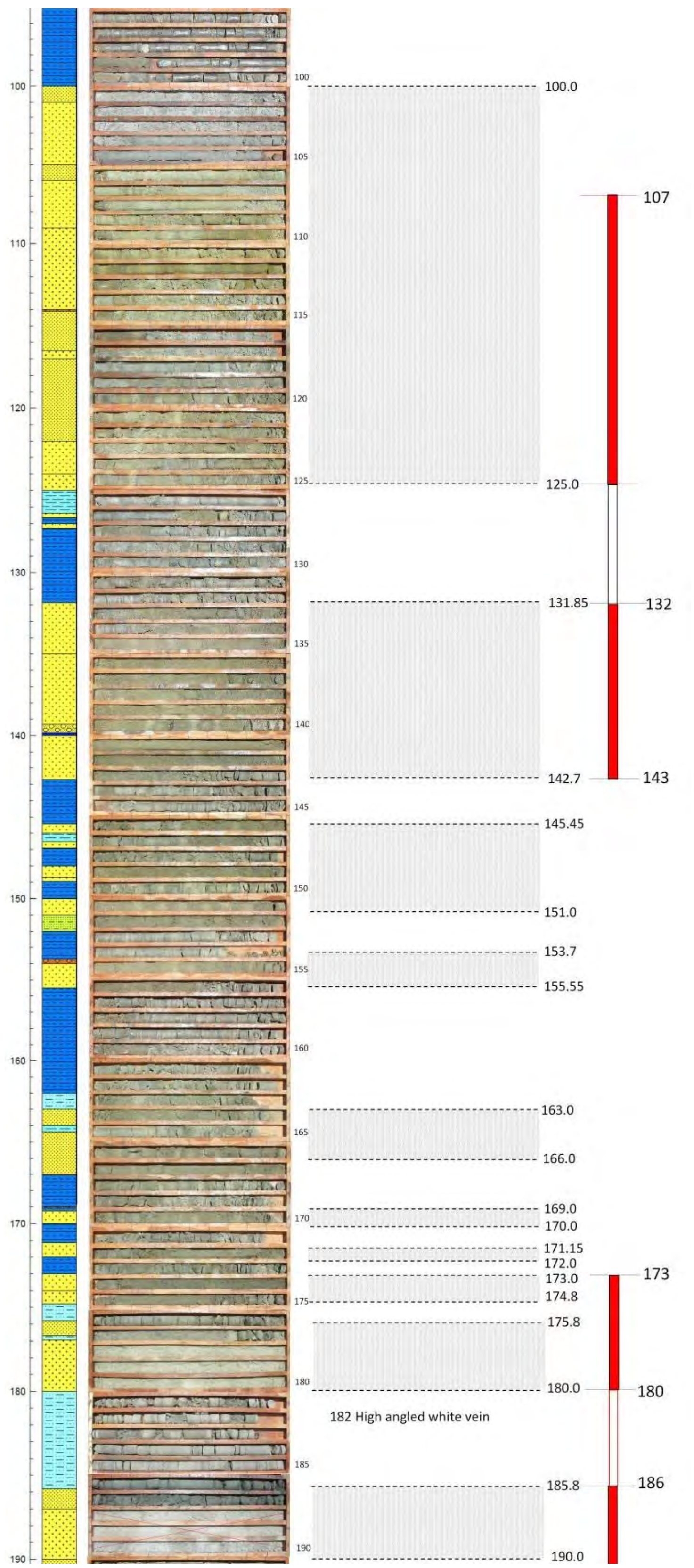


Figure 3-2-5-6 Photo and Facies Outline of D-4 Core Sample (2/3)

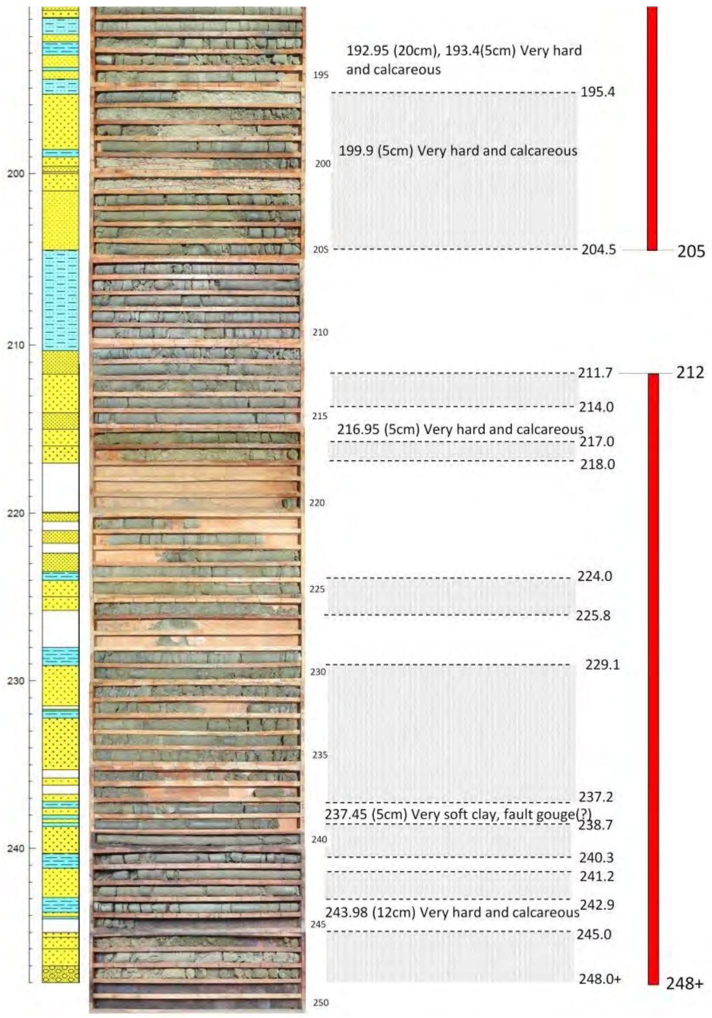


Figure 3-2-5-7 Photo and Facies Outline of D-4 Core Sample (3/3)

Figure 3-2-5-8 D-2 Surface - Lateritic Soil and Weathered Zone

Figure 3-2-5-9 D-2 86.5 ~ 89.5 m - Ferruginous Brown-colored Weathered Zone

Figure 3-2-5-10 D-2 95.5 ~ 96.5 m - Semi-consolidated Fine Alternation of Silt and Very Fine Sand

Figure 3-2-5-11 D-2 131.5 ~134.5 m-Hard Sandstone and Brownish Weakly Consolidated Sandstone

Figure 3-2-5-12 D-2 186.0 ~ 189.5 m - Weakly Consolidated Sandstone (Crushable with Fingers)

Figure 3-2-5-13 D-2 249.4 ~ 249.55 m - Fine Alternation of Clay and Silt; Almost Horizontally Bedded

Figure 3-2-5-14 D-2 255.5 ~ 256.5 m - Fine Alternation of Silt and Very Fine Sand; Dipping Approx. 15°

Figure 3-2-5-15 D-4 9.3 ~ 9.5 m - Fine Alternation of Silt and Very Fine Sand
(Disturbed by Drilling Torque)

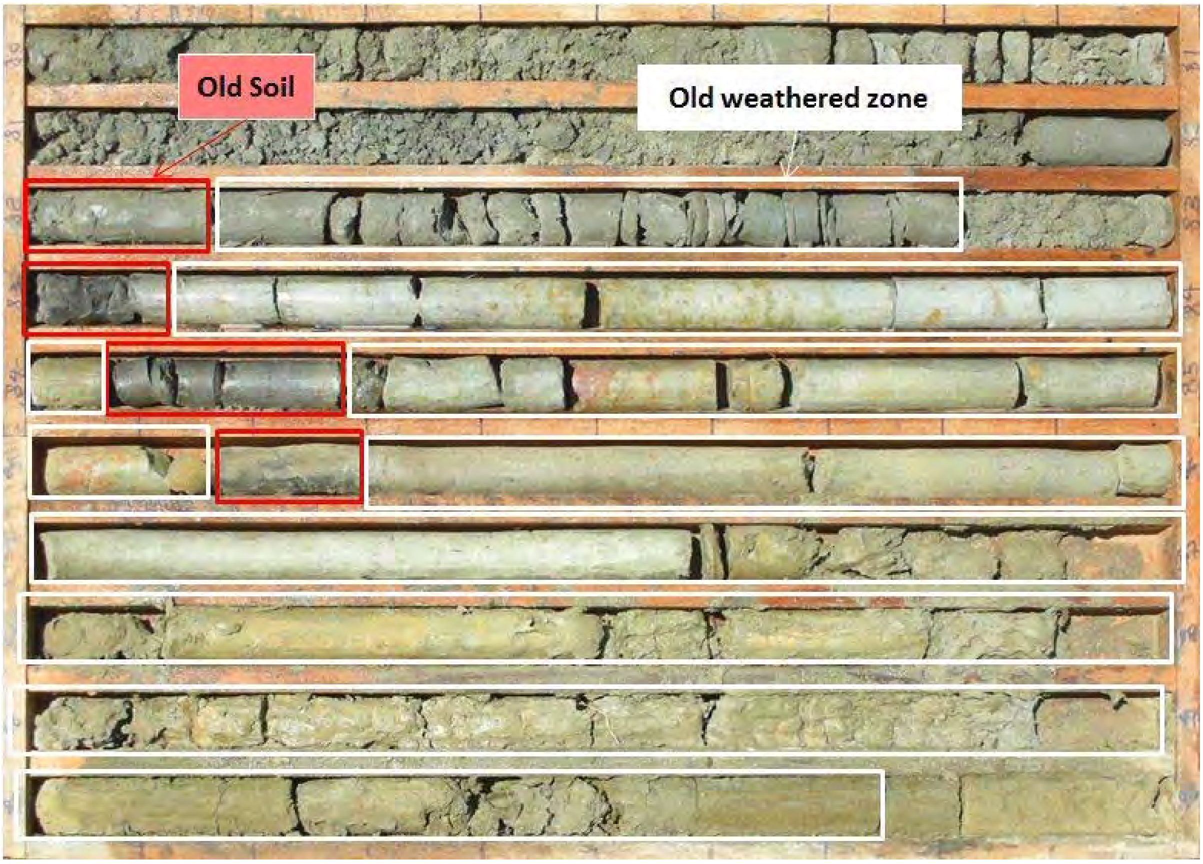


Figure 3-2-5-16 D-4 around 83 m - Old Soil and Old Weathered Zone

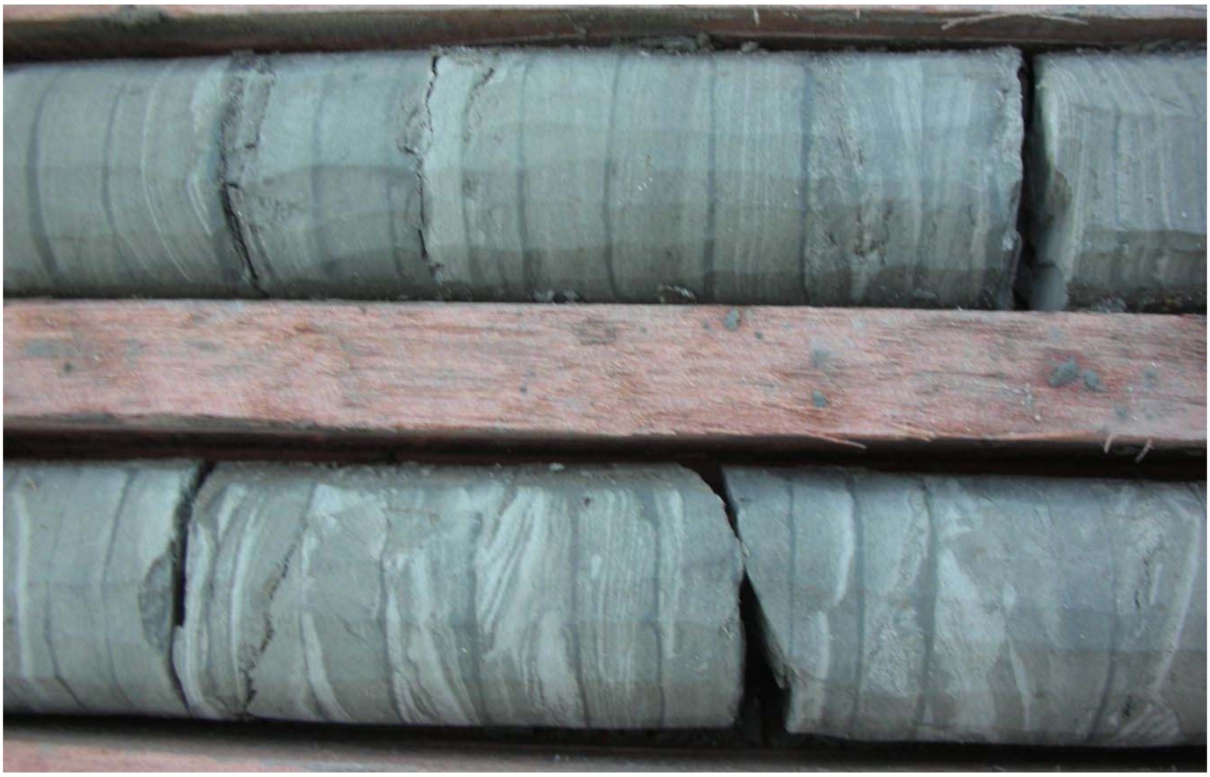


Figure 3-2-5-17 D-4 152.5 ~ 153.5 m - Fine Alternation of Clay and Silt (Weakly Consolidated)

Figure 3-2-5-18 D-4 201.4 m - Trace Fossil

Figure 3-2-5-19 D-4 223.5 ~ 224.5 m - Alternation of Silt and Very Fine Sand, and Slightly Consolidated Sandstone

3-2-6 Test Well

3-2-6-1 Outline

To grasp the aquifer distribution and hydraulic ability in the investigation area, test wells were installed at three sites in the Tertiary hill and at two sites in the Quaternary plain. In each site, two (2) to four (4) test wells with different depths were installed, because there are a few aquifers as shown in Figure 3-2-6-1.

Figure 3-2-1-1 (presented above) shows the location of the test wells and Table 3-2-6-1 shows their attributes. At the D-4 site, three test wells were planned. However among them, the deepest D-4-3 well could not be completed, because of the difficulty beyond the contractor's ability to hold the drill hole against the wall collapsing.

The diameter of the casing and screen is 6 inches. The material of the screen is PVC for a well shallower than 150 m and steel (GI) for a well deeper than 150m. The screen type is slit for the former, and wound wire for the latter.

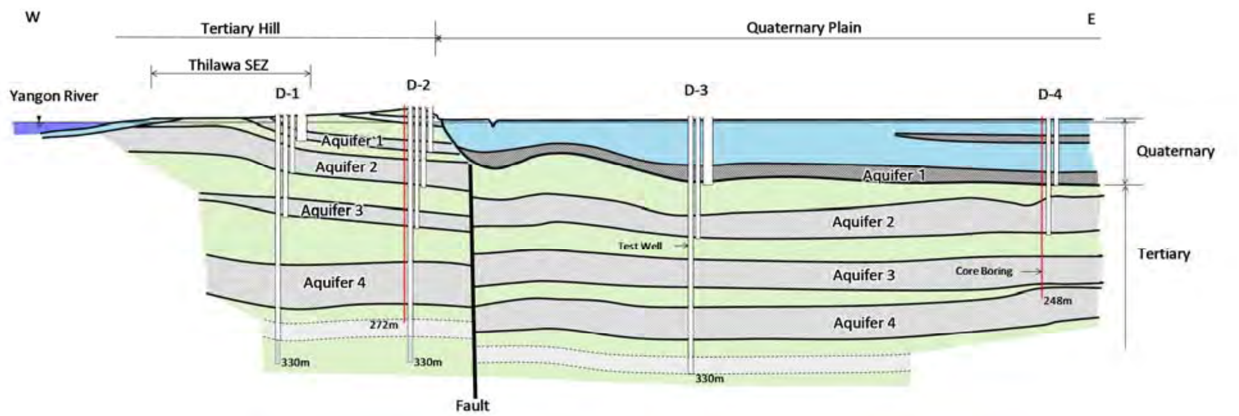


Figure 3-2-6-1 Schematic Profile of Test Well Allocation

Table 3-2-6-1 List and Attributes of Test Well

Site	Well No.	GPS POSITION (WGS84)		Actual Drilled Depth (GL-m)	Casing Installation Depth (GL-m)	Screen Position (m)	Total Screen Length (m)	Elevation (m)			Target Aquifer No.
		Latitude	Longitude					Top of Casing	Concrete Basement	Ground	
D-1	D-1-0	N 16º 40' 23.3"	E 96º 16' 59.9"	52	52	36.7-48.0	11.30	6.767	6.015	5.249	1
	D-1-1	N 16º 40' 23.5"	E 96º 17' 00.2"	85	85	66.1-83.0	16.95	6.759	6.010	5.265	2
	D-1-2	N 16º 40' 23.4"	E 96º 16' 59.6"	150.0	140.0	109.8-138.0	28.25	6.784	5.979	5.264	3
	D-1-3	N 16º 40' 23.3"	E 96º 16' 59.8"	330	285	187.0-199.0, 211.0-232.0 256.0-283.0	60.00	6.779	6.015	5.294	4
D-2	D-2-0	N 16º 41' 12.5"	E 96º 18' 27.5"	56	56	31.4-37.1 48.4-54.0	11.30	19.551	18.754	17.871	1
	D-2-1	N 16º 41' 12.2"	E 96º 18' 28.6"	97	97	66.8-95.0	28.25	19.459	18.608	17.654	2
	D-2-2	N 16º 41' 12.7"	E 96º 18' 28.3"	150	150	125.4-148.0	20.70	19.748	18.914	18.058	3
	D-2-3	N 16º 41' 11.7"	E 96º 18' 29.2"	330	303	196.0-217.0 223.0-225.0 241.0-250.0 268.0-277.0 283.0-301.0	69.00	19.019	18.147	17.414	4
D-3	D-3-1	N 16º 43' 01.7"	E 96º 21' 10.6"	80	79	60.4-77.3	16.95	5.436	4.633	3.833	1
	D-3-2	N 16º 43' 01.6"	E 96º 21' 10.0"	180	151	112.1-123.4 132.1-137.7 143.4-149.0	22.60	5.278	4.491	3.764	2
	D-3-3	N 16º 43' 01.6"	E 96º 21' 09.5"	330	330	244.0-274.0 298.0-328.0	60.00	5.298	4.584	3.751	4
D-4	D-4-1	N 16º 44' 50.6"	E 96º 26' 06.4"	85	85	66.1-83.0	16.95	5.125	4.290	3.667	1
	D-4-2	N 16º 44' 50.7"	E 96º 26' 06.4"	146	146	110.1-132.7 138.4-144.0	28.25	5.169	4.373	3.542	2
	D-4-3	N 16º 44' 50.6"	E 96º 26' 05.9"	(330)	Unable to complete						
D-5	D-5-1	N 16º 46' 08.8"	E 96º 14' 49.7"	65	65	46.1-63.0	16.95	25.848	25.114	24.238	1
	D-5-2	N 16º 46' 08.8"	E 96º 14' 49.2"	100	100	81.1-98.0	16.95	24.854	24.080	23.299	2
	D-5-3	N 16º 46' 08.8"	E 96º 14' 49.5"	350	240	180.0-240.0	60.00	25.502	24.736	23.929	3,4

3-2-6-2 Investigation Results

(1) Well Log

The well logs of all test wells are attached in the ”Supporting Data”. Figure 3-2-6-2 shows an example. The log contains facies of layers by observation of slime, logging results, drilling time and well structure. Based on the results of the test well investigation and core boring, a correlation of aquifers was carried out and aquifer profiles were created. Those results are presented in “3-2 Aquifer Distribution and Its Nature”.

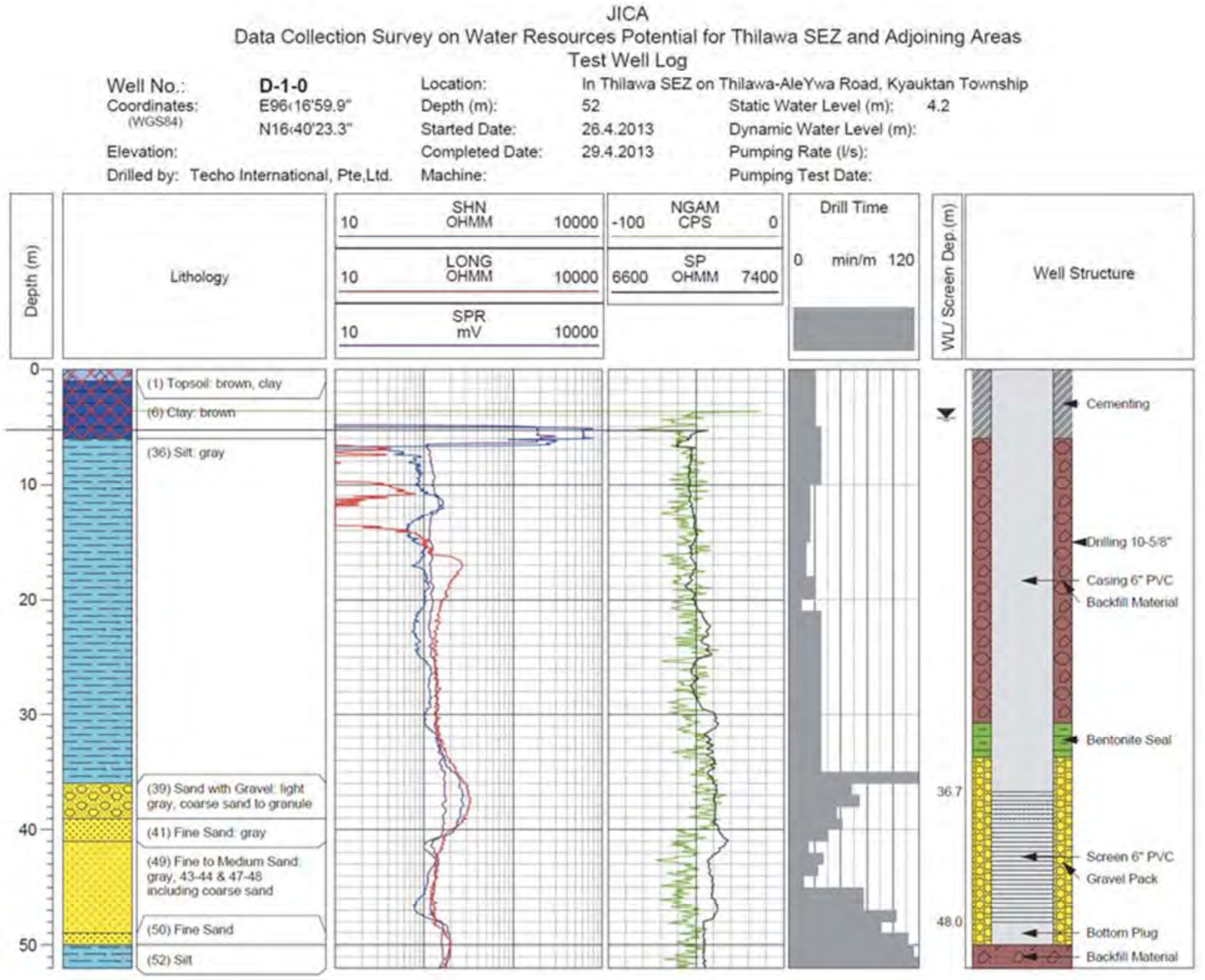


Figure 3-2-6-2 Example of Well Log

(2) Pumping Test

After completion of the well, a pumping test was carried out to grasp well capacity and hydraulic ability of the aquifer around the well. The test constitutes three sub-tests: preliminary, step drawdown (5 steps down and up) and constant discharge (48 hours in principle) tests. (See the files in the attached CD for the detail of the pumping test results)

1) Step Drawdown Test

The test was carried out with five (5) down-steps and four (4) up-steps, totaling 9steps. Each step was held for 100 minutes. Table 3-2-6-2 shows a summary of the test. The pumping rate for the constant discharge test was determined based on this result.

At D-2-0, D-2-2 and D-5-1, the step drawdown test was not carried out, because the well yield was small. At D-2-1 and D-5-2, the test was done with three steps, because drawdown was large compared with discharge. At D-1-1, the fifth step was skipped, because the dynamic level almost reached the pump installation level at the fourth step. At D-1-3, the fifth step was cancelled, because of the limit of pump capacity.

2) Constant Discharge Test

Table 3-2-6-3 shows a summary of the constant discharge test. The duration of pumping was basically 48 hours. At D-2-0, D-2-2 and D-5-2, the pumping ended before 48 hours passed, because the drawdown was large, even though the discharge was the smallest one measurable with the triangular weir.

At the D-3 and D-4 sites in the plain and at D-1 at the western base of the hill, the applied discharge was 400 to 900 m^3/day. The average permeability calculated is 9×10^{-4} to 3×10^{-2} cm/s.

At test wells shallower than 150m at D-2 and D-5 sites which are located on the hill ridge, the applied discharge was 20 to 70 m^3/day. The average permeability calculated is 3×10^{-5} to 5×10^{-4} cm/s.

There is more than ten times difference between them. However it is notable that, at D-5-2, much leakage of mud water occurred in drilling and many bags of bentonite were injected into the aquifer. The original permeability around the well must be larger.

3) Water Quality Test

Water quality analysis was carried out with samples taken in the constant discharge test. The analysis was entrusted to laboratories in Myanmar and Thailand. The results are presented later in “2-8 Water Quality Test of Test Well”.

Water in D-3-1, D-4-1 and D-4-2 is a little saline. Generally, water contains much iron and zinc.

Table 3-2-6-2 Summary of Step Drawdown Test of Test Wells

Site	Test Well No.	Screen Position	S.W.L.	Step-1		Step-2		Step-3		Step-4		Step-5		Step-4		Step-3		Step-2		Step-1	
		(m)	(GL-m)	Q1 (L/min)	D.W.L. (GL-m)	Q2 (L/min)	D.W.L. (GL-m)	Q3 (L/min)	D.W.L. (GL-m)	Q4 (L/min)	D.W.L. (GL-m)	Q5 (L/min)	D.W.L. (GL-m)	Q4 (L/min)	D.W.L. (GL-m)	Q3 (L/min)	D.W.L. (GL-m)	Q2 (L/min)	D.W.L. (GL-m)	Q1 (L/min)	D.W.L. (GL-m)
D-1	D-1-0	36.7-48.0	3.70	74	4.325	152	4.908	266	6.05	420	7.89	596	9.55	420	7.881	266	6.389	152	5.124	74	4.40
	D-1-1	66.1-83.0	8.65	74	14.23	152	19.42	266	26	377	32.83					266	27.16	152	21.12	74	16.47
	D-1-2	109.8-138.0	3.90	74	8.85	152	10.44	266	14.07	420	17.17	523	21.66	420	21.3	266	19.64				
	D-1-3	187.0-199.0 211.0-232.0 256-283	5.00	74	6.09	152	6.85	266	8.43	420	10.99					266	9.51	152	8.22	74	7.91
D-2	D-2-0	31.4-37.1 48.4-54.0	6.83	Test not conducted because of small discharge																	
	D-2-1	66.8-95.00	7.96	27	29.39	36	36.68	47	44.58									36	40.05	27	32.81
	D-2-2	125.4-148.0	10.08	Test not conducted because of small discharge																	
	D-2-3	196.0-217.0 223.0-225.0 241.0-250.0 268.0-277.0 283.0-301.0	12.96	27	19.81	74	27.18	152	36.34									74	28.90	27	20.88
D-3	D-3-1	60.4-77.3	1.60	78	2.93	152	3.91	266	5.56	420	7.61	618	10.58	420	8.62	266	6.49	152	4.98	78	3.79
	D-3-2	112.1-123.4 132.1-137.7 143.4-149.0	1.85	74	6.145	152	8.962	266	13.845	420	19.387	564	25.56	420	22.13	266	17.845	152	12.778	74	8.9
	D-3-3	244-274 298-328	1.40	74	2.95	152	4.64	266	7.13	338	8.79	420	10.14	338	9.45	266	8.12	152	5.48	74	3.65
D-4	D-4-1	66.1-83.0	2.09	74	2.55	152	3.33	266	4.25	420	5.39	618	7.22	420	6.16	266	4.99	152	3.82	74	2.69
	D-4-2	110.1-132.7 138.4-144.0	1.35	74	1.81	152	2.53	266	3.1	420	3.8	618	4.95	420	4.38	266	3.66	152	2.96	74	2.24
D-5	D-5-1	46.1-63.0	17.00	Test not conducted because of small discharge																	
	D-5-2	81.1-98.0	28.01	27.0	34.05	47	36.95	90	43.52									47	40.3	27	35.69
	D-5-3	180.0-240.0	35.96	27.0	38.70	74	42.18	109	43.62									74	42.7	27	40.15

Table 3-2-6-3 Summary of Constant Discharge Test of Test Wells

Site	Test Well No.	Screen Position	Total Screen Length L	S.W.L	Discharge Q		Pumping Duration	D.W.L	Draw-dowm s	Trans-missivity T	Perme-ability k	Srativity S	Specific Capacity Sc		T/Sc	Target Aquifer No.
		(m)	(m)	(GL-m)	(L/min)	(m^3/day)	(hr)	(GL-m)	(m)	(m^2/sec)	(cm/sec)		(m^3/sec/m)	(m^3/day/m)		
D-1	D-1-0	36.7-48.0	11.30	3.70	596	858	48	9.65	5.95	5.4E-03	3.4E-02	4.8E-13	1.7E-03	144	3.2	1
	D-1-1	66.1-83.0	16.95	8.65	378	544	48	36.79	28.14	2.3E-04	1.4E-03	2.1E-04	2.2E-04	19	1.0	2
	D-1-2	109.8-138.0	28.25	3.90	266	383	48	27.96	24.06	4.3E-04	1.6E-03	7.9E-03	1.8E-04	16	2.3	3
	D-1-3	187.0-199.0 211.0-232.0 256-283	60.00	5.41	465	670	48	20.7	15.29	5.4E-04	9.0E-04	-	5.1E-04	44	1.1	4
D-2	D-2-0	31.4-37.1 48.4-54.0	11.30	6.83	13	19	2.3	26.02	19.19	1.1E-05	9.6E-05	7.7E-02	1.1E-05	1	1.0	1
	D-2-1	66.8-95.00	28.25	7.96	27	39	48	34.54	26.58	2.4E-05	8.4E-05	2.6E-05	1.7E-05	1	1.4	2
	D-2-2	125.4-148.0	20.70	10.08	20	29	0.4	49.80	39.72	6.0E-06	2.6E-05	1.2E-01	8.4E-06	1	0.7	3
	D-2-3	196.0-217.0 223.0-225.0 241.0-250.0 268.0-277.0 283.0-301.0	69.00	12.96	153	220	48	44.24	31.28	8.8E-05	1.3E-04	8.3E-03	8.1E-05	7	1.1	4
D-3	D-3-1	60.4-77.3	16.95	1.60	564	812	48	12.45	10.85	9.7E-04	5.8E-03	3.5E-02	8.7E-04	75	1.1	1
	D-3-2	112.1-123.4 132.1-137.7 143.4-149.0	22.60	1.85	266	383	48	18.90	17.05	3.1E-04	1.4E-03	1.9E-02	2.6E-04	22	1.2	2
	D-3-3	244-274 298-328	60.00	1.40	564	812	48	11.74	10.34	1.3E-03	2.2E-03	1.3E-03	9.1E-04	79	1.5	4
D-4	D-4-1	66.1-83.0	16.95	2.09	564	812	48	7.59	5.50	3.8E-03	2.2E-02	1.6E-07	1.7E-03	148	2.2	1
	D-4-2	110.1-132.7 138.4-144.0	28.25	1.35	618	890	48	5.65	4.30	6.5E-03	2.3E-02	2.3E-09	2.4E-03	207	2.7	2
D-5	D-5-1	46.1-63.0	16.95	17.00	13	19	26	36.90	19.90	7.3E-06	4.3E-05	7.4E-02	1.1E-05	1	0.7	1
	D-5-2	81.1-98.0	16.95	28.01	47	68	48	43.09	15.08	7.8E-05	4.6E-04	3.0E-04	5.2E-05	4	1.5	2
	D-5-3	180.0-240.0	60.00	35.96	109	157	48	48.51	12.55	7.1E-05	1.2E-04	2.0E-02	1.4.E-04	13	0.5	3,4

3-2-6-3 Test Well by another JICA Team

(1) Outline

In parallel to the present survey, another JICA team which makes preliminary design of infrastructure for SEZ installed test wells and carried out tests. Their locations, appearance on the ground and attributes are shown in Figure 3-2-6-3, Figure 3-2-6-4 and Table 3-2-6-4 respectively. The “TW” well is a preliminary test well. It was drilled with a water jet, and a simple one-hour pumping test was carried out with airlift discharging. The “PW” well could be converted to a production well. A 72-hour pumping test was carried out with it. A water quality test was conducted for all wells.

(2) Investigation Results

The well logs are attached in the ”Supporting Data”. Table 3-2-6-5 shows a summary of the pumping test. The hydraulic parameters obtained are similar to the results at D-1 showing the same order values.

The results of the water quality test are presented in “2-8 Water Quality Test of Test Wells”. Saline water was found in all wells located to the west of TW7.

Figure 3-2-6-3 Location of Test Wells by another JICA Team

Table 3-2-6-4 List and Attributes of Test Wells by another JICA Team

Kind of Well	Dia-meter	Name of Well	Drilled Depth (m)	Screen Position (m)	Coordinated (WGS84)		Elevation (m)		
					Latitude	Longitude	Top of Casing	Concrete Basement	Ground Elevation
Test Well	1.5"	TW3	198.1	36.6~42.7	N16° 40' 49.68”	E96° 15' 47.04”	7.569	7.094	7.032
		TW4	198.1	45.7~54.9	N16° 40' 26.16”	E96° 15' 54.12”	6.105	5.86	5.748
		TW5	204.2	88.4~97.6	N16° 40' 46.80”	E96° 16' 46.26”	7.152	6.946	6.788
		TW6	198.1	48.7~54.9 70.1~76.2	N16° 40' 34.14”	E96° 16' 11.16”	9.519	9.315	9.163
		TW7	195.1	79.2~85.3	N16° 40' 19.26”	E96° 16' 41.28”	5.681	5.298	5.082
		TW8	198.1	48.8~54.9	N16° 40' 04.14”	E96° 16' 19.20”	6.097	5.984	5.776
		TW9	198.1	73.1~79.2	N16° 40' 28.68”	E96° 17' 15.06”	4.881	4.6	4.35
		TW10	198.1	149.0 ~155.1	N16° 40' 12.36”	E96° 17' 18.66”	5.129	4.854	4.492
Production Well	10"	PW1	91.4	32.9~49.4 50.0~55.5 61.0~66.4	N16° 40' 16.32”	E96° 16' 42.12”	5.493	5.392	5.092
		PW2	91.4	36.0~52,4 57.9~68.9	N16° 40' 11.28”	E96° 17' 18.84”	5.114	4.692	4.341
		PW3	91.4	27.4~32.9 33.5~66.4	N16° 39' 56.70”	E96° 16' 57.12”	5.679	5.371	5.058
		PW4	91.4	51.8~85.7	N16° 40' 34.20”	E96° 16' 11.46”	9.853	9.692	9.331

Source: Nippon Koei (2013); Elavation surveyed by the present JICA survey team.

TW well

PW well

Figure 3-2-6-4 Appearance of Test Wells by another JICA Team

Table 3-2-6-5 Summary of Pumping Test of Test Wells by another JICA Team

Test Well No.	Dia-meter	Screen Position	Total Screen Length L	S.W.L	Discharge Q		Pumping Duration	D.W.L	Draw-dowm s	Trans-missivity T	Perme-ability k	Specific Capacity Sc		T/Sc	Pumping Method
	(mm)	(m)	(m)	(GL-m)	(L/min)	(m^3/day)	(hr)	(GL-m)	(m)	(m^2/sec)	(cm/sec)	(m^3/sec/m)	(m^3/day/m)		
TW3		36.6~42.7	6.1	6.63	82	117	1	7.33	0.70	2.3.E-03	3.7.E-02	1.9.E-04	16	12.2	
TW4		45.7~54.9	9.1	5.72	136	196	1	6.10	0.38	8.3.E-03	1.4.E-01	3.7.E-04	32	22.3	
TW5		88.4~97.6	9.1				1								
TW6		48.7~54.9 70.1~76.2	12.2	8.63	90	130	1	9.30	0.67	2.9.E-03	1.2.E-02	1.6.E-04	14	17.7	
TW7	38.1	79.2~85.3	6.1	4.63	90	130	1	5.75	1.12	4.7.E-03	7.6.E-02	2.6.E-04	23	17.8	Airlift
TW8		48.8~54.9	6.1	5.36	122	176	1	5.73	0.37	4.9.E-03	8.0.E-02	3.6.E-04	31	13.8	
TW9		73.1~79.2	6.1				1								
TW10		149.0 ~155.1	6.1	Flowing			1								
PW1		32.9~49.4 50.0~55.5 61.0~66.4	27.4	4.26	454	653	72	8.99	4.73	2.0E-03	7.1E-03	8.4.E-04	73	2.3	
PW2	254	36.0~52,4 57.9~68.9	27.4	-0.61	454	653	72	32.06	32.67	2.9E-04	1.0E-03	2.4.E-04	20	1.2	Sub-mergible Pump
PW3		27.4~32.9 33.5~66.4	38.4	4.33	454	653	72	10.34	6.01	1.5E-03	4.0E-03	7.3.E-04	63	2.1	
PW4		51.8~85.7	32.9	8.70	454	653	72	43.81	35.11	2.6E-04	7.9E-04	1.7.E-04	15	1.5	

Source: Nippon Koei (2013)

3-2-7 Water Quality Survey of Existing Wells

3-2-7-1 Outline

100 wells each for the shallow and deep wells were selected based on the results of the well inventory survey to grasp spatial water quality condition of groundwater. The locations are shown in Figure 3-2-7-1. A water quality survey was carried out each once during the dry and wet seasons, targeting the following in-situ measurement items:

Measurement Items

Odor, Taste, Turbidity, Color, pH, EC and Temperature

3-2-7-2 Results

Table 3-2-7-1 and Table 3-2-7-2 show the results of water quality measurement for the shallow wells. Table 3-2-7-3 and Table 3-2-7-4 show those for the deep wells. Because many wells were not used in the wet season, the figures of areal distribution of water quality are presented here mainly for the dry season.

(1) Electric Conductivity (EC)

As already described in “2-2-4 Water Quality”, in the groundwater in the area, chloride and sodium ions occupy a large proportion among the main anions, so that chloride ion concentration and electric conductivity (EC) have a good relationship and it is presumed that approx. 750 μS/cm of EC correspond to 200 mg/l of chloride concentration beyond which people possibly feel water is salty.

As shown in Figure 3-2-7-2 and Figure 3-2-7-3, EC rarely exceeds this value for both shallow and deep wells on the hill, but it exceeds this at many wells in the plain. The depth of the deep wells in the plain ranges from 120 m to 180 m, as shown in Figure 3-2-7-1

(2) pH

As shown in Figure 3-2-7-4, the measured pH values show that water is mostly acidic in the shallow wells on the hill, neutral at the shallow wells on the plain and deep wells on the hill, and basic at the deep wells on the plain.

(3) Turbidity

As shown in Figure 3-2-7-5, there is no characteristic of turbidity distribution. Turbidity must be mainly related to the finishing quality of the well.

(4) Color

As shown in Figure 3-2-7-6, the color index shows mostly a small value at the shallow wells in the hill, but shows a large value at the shallow wells on the plain and the deep wells. High content of humic material and/or iron ion may be a main factor for the high color index.

(5) Taste

As shown in Figure 3-2-7-7, salty water was found at the wells on the plain and to the south of the hill.

(6) Odor

As shown in Figure 3-2-7-8, rust-smelling water was found at the wells on and near the hill, and a rotten smell was detected at the wells on the plain and the shallow wells to the south of the hill.

(7) Temperature

There is no characteristic of spatial distribution of water temperature.

Table 3-2-7-1 In-situ Water Quality Measurement Results of Existing Wells – Shallow Well (1)

No	WPT_ID	Township	Village_Group_Name	Latitude	Lobgitude	Address_of_Owner	First Survey (Dry Seasn)								Second Survey (Wet Seasn)								Year Installed	Kind of Well	Diameter (meter)	Depth (meter)	Screen Positions (meter)
							date	Odour	Taste	Turbidity (KTU)	Color Index	PH	EC (µs)	Temperature (deg C)	Date	Odour	Taste	Turbidity (KTU)	Color Index	PH	EC (µs)	Temperature (deg C)					
1	KA - 2-11	Khayan	Pauk Taw Village,Aye Ywa Group	16.825892	96.405481	Public Well, Pauk Taw Village, Aye Village Group	12.12.12	_	_	11.6	20.3	8.10	503	30.0	1.9.13	Well broken							2010	tube well	0.05	14.63	13.1
2	KA - 2-13	Khayan	Pauk Taw Village,Aye Ywa Group	16.825300	96.404136	Daw Kaing, Pauk Taw Village, Aye Ywa Village Group	12.12.12	–	–	11.2	22.5	8.04	482	30.1	1.9.13	Silty smell	Salty	13.4	29.0	7.83	504	28.3	2007	tube well	0.05	15.24	13.1
3	KA - 3-58	Khayan	Kyaung Kan Gyi Kwin,Hla Bi Lu Village Group	16.863836	96.462547	U Yin Htwe, Kyaung Kan Gyi Kwin,Hla Bi Lu Village Group	6.12.12	Rottem smell	–	12.0	42.5	7.41	458	27.1	1.9.13	Silty smell	Light	14.0	30.5	7.36	996	26.9	2009	tube well	0.05	13.72	11.6
4	KA - 7-214	Khayan	Kyon Tu Village	16.894200	96.510475	U Min Min Htwe,Chauktesu Village,Kyone Tu Village Group	3.12.12	–	–	0.0	12.0	8.07	1,290	30.2	–	Pump broken							2009	tube well	0.05	18.29	13.1
5	KA - 15-601	Khayan	Ka Mar Ka Lote Village,Swe Ka Tawt Village Group	16.834319	96.424417	U Win Aung,Ka Mar Ka Lote Village, Swe Ka Tawt Village Group	11.12.12	–	–	5.4	12.0	7.84	1,778	28.5	1.9.13	Silty smell	–	11.5	33.0	7.76	1451	27.5	2003	tube well	0.05	12.19	10.1
6	KYA - 5-744	Kyauktan	Kan Pyaung Village	16.684722	96.414261	Kan Pyaung(village)	10.11.12	–	–	1.9	19.0	7.24	8,250	29.0	5.7.13	-	Salty	>20	>50	6.15	5000	27.3		tube well	0.05	21.34	20.4
7	KYA - 9-1723	Kyauktan	Nyaung Waing Group	16.674489	96.303261	U Tin Oo, Shan Su	6.11.12	–	Light	0.0	0.5	6.95	189	32.0	29.6.13	well smell	-	1.6	1.0	5.80	181	27.6		tube well	0.05	18.29	13.7
8	KYA - 9-1725	Kyauktan	Nyaung Waing Group	16.674975	96.302139	U Kyaw Sein Win, Shan Su	6.11.12	–	–	5.9	>50.0	7.70	212	26.4	29.6.13	–	–	3.7	29.5	8.26	224	26.7		tube well	0.05	30.48	24.4
9	KYA - 12-1885	Kyauktan	Par Da Gyi Village	16.656417	96.324167	U Mon Tae ,Kun Chan Su,Pa Da Gyi Village	27.10.12	–	–	0.1	0.0	5.89	31	28.3	29.6.13	–	–	0.7	0.0	5.78	32	26.9	2002	tube well	0.05	21.03	18.9
10	KYA - 14-2200	Kyauktan	Shwe pyauk Village	16.656747	96.298989	U Myint Aung ,Shwe Pyauk,A Dwet Taw ,Shwe Pyauk Village	25.10.12	Rottem smell	Light	0.9	4.5	8.39	656	28.1	30.6.13	well smell	Light	3.4	19.5	6.35	183	27.6	2011	tube well	0.05	30.48	24.4
11	KYA - 20-2555	Kyauktan	Urban(Shwe Kone)	16.639783	96.328392	U Nyan Lin ,N0 (1063),Wai Lu Won KaungStreet , Shwe Kone	16.10.12	Rottem smell	–	0.9	8.5	5.68	423	35.7	5.7.13	-	-	3.0	19.5	5.45	441	27.3	2005	dug well	0.91	9.14	0.0
12	KYA - 20-2629	Kyauktan	Sin Kan Ward	16.641075	96.324500	Daw Mya San,No (222)) , Aye Say Ti (2) Street,Shwe Kone Ward	16.10.12	–	–	0.0	0.0	5.57	125	29.6	29.6.13	–	–	1.3	11.5	9.30	79	27.1	2003	tube well	0.05	16.76	15.9
13	KYA - 20-2793	Kyauktan	Middle Ward	16.650972	96.327278	Daw Kyaw Sein ,No (46), Min Street ,Middle, Shwe Kone Ward	15.10.12	–	Light	0.6	14.0	6.57	782	28.6	3.7.13	-	-	1.2	0.0	6.50	8	28.3	1977	tube well	0.1	9.14	7.0
14	KYA - 21-3147	Kyauktan	Urban, Aye Mya Thida Ward	16.653639	96.290667	U Mg Soe, No(47),Aye Mya Thida street	20.10.12	Rottem smell	Light	20.0	40.0	7.31	613	28.0	30.6.13	-	-	0.9	10.5	7.11	591	28.6	1997	tube well	0.03	27.43	22.9
15	KYA - 21-3149	Kyauktan	Urban, Aye Mya Thida Ward	16.654611	96.290944	UThein Wai, No(31), Aye Mya Thida Street	20.10.12	Rottem smell	–	0.0	6.0	6.91	573	27.7	30.6.13	-	-	2.7	29.0	7.17	550	28.2	2008	tube well	0.04	18.29	15.2
16	KYA - 21-3203	Kyauktan	Urban, Thida Myine Ward	16.630417	96.303083	U Myint Lwin, No ( ),Kayat, Thida Myine Street	22.10.12	Rottem smell	Salty	1.6	22.5	7.54	1,921	27.5	3.7.13	well smell	Light	2.3	7.0	6.63	1434	28.3	2000	tube well	0.04	10.67	6.1
17	KYA - 21-3268	Kyauktan	Urban, Swe Pyi Tharyar Ward	16.645778	96.291528	Daw Kyine,Tapyar Kune, Shwe Phi Tharyar Street, Old Village	24.10.12	Rottem smell	Salty	10.5	21.0	6.80	476	28.1	5.7.13	Silty smell	Light	>20	>50	6.21	419	26.6	2011	tube well	0.05	16.76	12.2
18	KYA - 21-3309	Kyauktan	Urban, Swe Pyi Tharyar Ward	16.642319	96.293608	U Aye Thaung, Shwe Pyi Tharyar(3)Street	23.10.12	Rottem smell	Salty	1.0	14.0	7.48	581	27.8	3.7.13	well smell	Light	20.0	15.0	6.35	377	27.8	2012	tube well	0.05	15.24	10.1
19	THA - 1-3693	Thanlyin	Ah Lun Soke Village	16.734567	96.260475	U Htay Aung, No( ) Aye Myit-tar	7.12.12	–	–	0.3	1.0	7.20	394	29.3	22.7.13	–	–	3.5	8.0	7.85	583	29.7	2012	tube well	0.05	24.39	18.9
20	THA - 1-3728	Thanlyin	Ah Lun Soke Village	16.734133	96.254683	U Saw Lwin, No( ), Aye Myit-tar Street	7.12.12	–	–	1.1	11.0	6.99	195	29.6	22.7.13	–	–	6.1	>50	7.08	264	30.0	2000	tube well	0.05	25.92	22.0
21	THA - 1-3778	Thanlyin	Ah Lun Soke Village	16.735650	96.255653	U Mg One, No(1811),Aye Myit-tar	8.12.12	–	–	0.7	1.5	8.03	321	29.5	22.7.13	–	Salty	0.2	1.5	7.63	555	30.1	2004	tube well	0.05	30.48	25.3
22	THA - 5-3846	Thanlyin	Bo Gyoke(major general) Village	16.756642	96.240517	U San Thein, No(1/94)	19.12.12	–	–	3.9	10.0	5.63	295	27.9	19.7.13	–	–	14.8	26.5	4.80	348	29.1	1980	dug well	1.22	11.58	
23	THA - 5-3889	Thanlyin	Bo Gyoke(major general) Village	16.755628	96.241889	U Khin Maung Lat, No(2/86), Bo Gyoke Village	19.12.12	–	–	6.0	16.0	6.53	60	28.5	17.7.13	–	–	8.4	40.5	6.55	84	27.9	1995	tube well	0.05	28.96	25.0
24	THA - 5-4038	Thanlyin	Bo Gyoke(major general) Village	16.755469	96.241967	U Khin Maung Myint, No(2/87), Bo Gyoke Village	19.12.12	–	–	8.3	13.5	7.23	71	28.1	17.7.13	–	–	13.0	12.0	6.29	88	28.2	1962	tube well	0.05	30.48	25.3
25	THA - 5-4243	Thanlyin	Bo Gyoke(major general) Village	16.746292	96.239853	U Tin New, Navy Street	22.12.12	–	–	3.4	7.0	6.36	84	28.6	19.7.13	–	–	17.7	10.0	5.60	113	28.5	2011	tube well	0.05	28.96	25.0
26	THA - 5-4296	Thanlyin	Bo Gyoke(major general) Village	16.747561	96.245339	U Zaw Min Naung, region(12)	22.12.12	–	–	0.0	1.0	7.32	354	28.8	18.8.13	–	–	0.5	2.0	7.00	280	29.0	2010	tube well	0.05	23.96	22.0
27	THA - 5-4459	Thanlyin	Bo Gyoke(major general) Village	16.766353	96.244369	U Zaw Win, No(14/37), Bo Gyoke Village	24.12.12	–	–	1.7	0.0	5.64	79	31.6	19.7.13	–	–	0.0	0.0	5.35	112	28.7	2008	tube well	0.05	27.44	22.0
28	THA - 5-4469	Thanlyin	Bo Gyoke(major general) Village	16.766425	96.244867	U Tin Shwe, No(14/77), Bo Gyoke Village	24.12.12	–	–	0.2	0.0	6.12	114	28.8	–	Well broken							2002	tube well	0.05	24.39	18.9
29	THA - 5-4493	Thanlyin	Bo Gyoke(major general) Village	16.751950	96.244942	Daw Ohin Shan, No(14/130), Bo Gyoke Village	24.12.12	–	–	4.5	>50.0	7.13	206	29.7	19.7.13	–	–	4.3	>50.0	6.89	285	28.4	2010	tube well	0.05	30.49	25.0
30	THA - 5-4509	Thanlyin	Bo Gyoke(major general) Village	16.748986	96.245606	U Kyaw Swar Lwin, No(14/237), Bo Gyoke Village	25.12.12	–	–	7.4	18.5	7.18	311	28.1	19.7.13	Silty smell	–	>20.0	>50.0	7.05	413	28.2	2000	tube well	0.05	26.91	20.4
31	THA - 5-4521	Thanlyin	Bo Gyoke(major general) Village	16.749297	96.246947	U Than Myint, No(14/318), Bo Gyoke Village	25.12.12	–	–	15.3	28.5	7.17	345	30.5	19.7.13	Rust smell	–	>20.0	13.0	6.82	1122	28.4	1994	tube well	0.05	27.44	21.7
32	THA - 7-4693	Thanlyin	Ka Larr Tan Village	16.889283	96.344414	U Tun Nyunt, Ka Larr Tan Village, Day Set Group	27.11.12	–	–	18.5	36.5	7.88	478	28.6	20.7.13	-	-	2.4	10.5	7.29	607	29.3	1992	tube well	0.05	10.67	10.1
33	THA - 7-4705	Thanlyin	Ka Larr Tan Village	16.886719	96.344894	Ka Larr Phayar Kyaung, Ka Larr Tan Village, Day Set Group	14.12.12	–	–	16.4	24.0	7.80	315	28.7	21.7.13	Well broken							1982	tube well	0.05	13.72	13.4
34	THA - 7-4714	Thanlyin	U Yin Village	16.884706	96.350517	U Kyaw Htay, U Yin Village, Day Set Group	14.12.12	–	–	19.5	>50.0	7.98	730	29.6	21.7.13	–	Salty	2.0	30.0	7.48	932	29.2	2010	tube well	0.05	13.72	13.1
35	THA - 8-4764	Thanlyin	Padonesan Village, Payargone Group	16.745906	96.273164	Than Than Maw,No(69),The Street	13.10.12	–	–	3.6	18.0	5.75	120	26.8	20.7.13	–	–	5.2	12.5	5.32	247	28.2	1972	dug well	1.22	9.15	0.0
36	THA - 8-4840	Thanlyin	The Phyu Chaung Village, Payargone Group	16.742286	96.275764	U Tin Htun,No(99),	14.10.12	–	–	0.0	0.0	5.29	26	27.4	20.7.13	–	–	0.0	0.0	5.67	28	28.9	2002	tube well	0.05	27.44	24.7
37	THA - 8-4874	Thanlyin	Net Sin Gone Village, Payargone Group	16.739411	96.278586	U Win Zaw,No(4),Net Sin Kone Street	15.10.12	–	–	1.2	10.0	5.38	68	27.5	20.7.13	–	–	0.0	0.0	5.25	52	28.8	2007	dug well	0.92	3.35	0.0
38	THA - 8-4910	Thanlyin	The Phyu Chaung Village, Payargone Group	16.739486	96.273322	U Htay Myint,No(-)	16.10.12	–	–	1.0	0.0	5.70	131	31.5	20.7.13	–	–	0.0	0.0	5.93	378	28.6	2008	dug well	0.92	4.57	0.0
39	THA - 8-4959	Thanlyin	Net Sin Gone Village, Payargone Group	16.738108	96.279075	Daw Mya Mya Thwe,No(-)	16.10.12	–	–	6.5	19.0	5.83	76	26.0	20.7.13	–	–	8.4	14.5	7.80	94	28.8		dug well	1.52	7.62	0.0
40	THA - 8-5040	Thanlyin	Kanyinpin Village, Payargone Group	16.735261	96.280783	U Hla Myint,No(38),Maharsiyeikthar Street	18.10.12	–	–	0.5	0.0	4.60	118	29.8	20.7.13	–	–	0.0	0.0	4.63	122	29.3	2002	dug well	1.22	12.20	0.0
41	THA - 8-5089	Thanlyin	Phayar kone Village	16.748281	96.282258	U Kyar Su ,2101/ Kanyinpyin	10.8.12	–	–	1.9	3.5	4.65	126	32.0	20.7.13	–	–	5.8	10.0	4.21	194	29.0	1977	dug well	1.83	9.15	0.0
42	THA - 8-5220	Thanlyin	Phayar kone Village	16.725483	96.286103	Ma Hta War Ba Li,singapol street Myo pya new block	10.8.12	–	–	0.5	3.0	6.31	73	29.0	20.7.13	–	–	0.0	0.0	4.73	28	28.8	2000	dug well	1.22	9.15	0.0
43	THA - 8-5238	Thanlyin	Phayar kone Village	16.727583	96.287889	U San Win,779/ 5 qtr,Tawa new block	10.8.12	–	–	0.0	0.2	5.56	44	28.9	20.8.13	–	–	1.0	0.0	6.20	40	28.9	1992	tube well	0.04	18.29	6.1
44	THA - 8-5268	Thanlyin	Phayar kone Village	16.728264	96.285400	Daw Hla Myint,665,Myopya new block,Payar Kone	10.8.12	–	–	0.9	2.5	4.65	90	28.2	20.8.13	–	–	2.0	3.0	6.00	109	27.8	2002	dug well	1.22	4.57	0.0
45	THA - 8-5491	Thanlyin	Myoepya Kwet Thit Village	16.723422	96.288658	Capatain Mya Thin (retired), No(65589), Phayar Kyaung Street, Kon Chan Kone Kwet Thit , Phayarkone	24.10.12	–	–	1.8	3.0	5.10	33	27.8	20.8.13	–	–	1.0	4.0	6.50	40	29.0	1952	dug well	1.83	8.23	0.0
46	THA - 8-5507	Thanlyin	Urban (Kun Chan Kone) Village	16.720128	96.284006	U Moe Khaing,Kun Chan KoneYwa,Phayar Kone	27.12.12	–	–	2.5	8.5	5.95	212	31.8	20.8.13	–	–	8.0	3.0	6.00	195	29.1	2008	tube well	0.05	28.96	25.3
47	THA - 8-5528	Thanlyin	Urban (Kun Chan Kone) Village	16.722181	96.279647	U Khaing Win,Kun Chan KoneYwa,Phayar Kone	27.12.12	–	–	3.9	22.5	5.90	86	27.6	20.8.13	–	–	3.4	22.5	6.20	120	28.2	2005	dug well	1.22	9.14	0.0
48	THA - 14-5760	Thanlyin	Aye Thitsar Quarter, Kyaung Kone Seik Gyi Village	16.728403	96.258506	U Pyaw, No(790), Aye Thitsar	8.12.12	–	–	8.8	36.5	5.74	111	27.2	–	–	–	8.8	36.5	5.74	111	27.2	2000	dug well	1.07	3.66	0.0
49	THA - 14-5789	Thanlyin	Aye Thitsar Quarter, Kyaung Kone Seik Gyi Village	16.729642	96.258475	U Hla Shwe, No(780), Aye Thitsar	8.12.12	–	–	3.1	8.0	7.20	288	28.4	–	–	–	3.1	8.0	7.20	288	28.4	2008	tube well	0.05	38.5	25.3
50	THA - 15-5870	Thanlyin	La Har Yat Village	16.878136	96.329231	U Kyaw Myint, La Har Yat Village	15.12.12	–	–	5.2	>50.0	6.67	1,081	32.0	28.7.13	–	–	7.7	16.5	7.34	179	27.8	2010	tube well	0.05	16.8	13.7

Table 3-2-7-2 In-situ Water Quality Measurement Results of Existing Wells – Shallow Well (2)

No	WPT_ID	Township	Village_Group_Name	Latitude	Lobgitude	Address_of_Owner	First Survey (Dry Seasn)								Second Survey (Wet Seasn)								Year Installed	Kind of Well	Diameter (meter)	Depth (meter)	Screen Positions (meter)
							date	Odour	Taste	Turbidity (KTU)	Color Index	PH	EC (µs)	Temperature (deg C)	Date	Odour	Taste	Turbidity (KTU)	Color Index	PH	EC (µs)	Temperature (deg C)					
51	THA - 15-5875	Thanlyin	La Har Yat Village	16.874247	96.325400	U Tin Myint, La Har Yat Village	15.12.12	–	Salty	19.0	0.0	7.19	5,400	31.3	28.7.13	–	-	>20	0.0	7.48	59	27.7	2012	tube well	0.05	16.8	13.7
52	THA - 15-5882	Thanlyin	Thar Yar Kone Village	16.871539	96.322569	Monastery Well, Thar Yar Kone Village	15.12.12	–	–	19.8	>50.0	8.50	828	30.9	–	Silty smell	Salty	3.1	30.0	7.76	1448	30.9	1992	tube well	0.05	21.3	14.6
53	THA - 16-5920	Thanlyin	Kyeik Inn Village	16.719764	96.292525	U Myint Thu,Kyeik Inn, Let Yet San	24.10.12	–	–	0.8	2.5	5.12	79	28.1	–	Not found							2010	dug well	1.22	3.7	0.0
54	THA - 16-6058	Thanlyin	Htan Pin Ceit Village	16.709008	96.298569	U Win Kyaw Moe,Htan Pin Ceit,Let Yet San	26.10.12	–	–	1.6	5.5	5.50	79	28.5	18.7.13	–	Light	0.0	2.0	4.80	211	28.3	2002	dug well	0.91	4.6	0.0
55	THA - 16-06287	Thanlyin	A Lae Ywa Village	16.690361	96.309631	U Han Sein,ALaeYwa ,Let Yet San	1.10.12	–	–	1.2	3.5	4.87	71	30.3	18.7.13	–	–	6.4	27.0	4.43	75	28.8	1990	dug well	1.52	5.2	0.0
56	THA - 16-6522	Thanlyin	Lat Yat San Village	16.702086	96.291267	U Kyaw San,Lat Yat San	24.12.12	–	–	6.0	6.5	6.23	136	28.7	–	Not found							1982	dug well	2.44	7.6	0.0
57	THA - 21-6779	Thanlyin	Nyaungthonepin Village	16.746222	96.269736	U Myint Hlaing, No(81), Hnin Zi Street	12.10.12	–	–	18.0	5.5	5.33	36	28.3	–	–	–	18.0	5.5	5.33	36	28.3	2002	tube well	0.05	27.4	18.9
58	THA - 21-6880	Thanlyin	Nyaungthonepin Village	16.762131	96.262092	U Than Shwe, No(1204), Shwe Myittar Street	18.10.12	–	–	13.2	40.0	6.27	545	28.0	20.8.13	–	–	10.0	5.0	6.50	50	18.0	2011	dug well	0.91	4.6	0.0
59	THA - 27-7053	Thanlyin	Urban(Staff Compound) Ward	16.754469	96.263725	U Win Tin,No(64), Paunt Phyo Yae (4) Street	9.10.12	–	–	18.6	13.5	5.03	90	28.0	20.8.13	–	–	20.0	15.0	6.30	100	29.0	2006	dug well	1.22	8.5	0.0
60	THA - 27-7132	Thanlyin	Urban(Staff Compound) Ward	16.755714	96.262086	U Sein Aung,No(D/4),Thit Taw (3) Street	10.10.12	–	–	0.0	0.0	7.26	173	30.0	13.7.13	–	–	0	0.0	6.0	201	30	2009	dug well	1.22	8.5	0.0
61	THA - 27-7368	Thanlyin	Urban(Staff Compound) Ward	16.760717	96.261047	Daw Htay Kyi,No(72), Da Ma Yaung Chi Kyaung Street	12.10.12	–	–	0.0	4.0	5.18	62	26.9	20.8.13	–	–	2.0	5.0	6.00	80	28.0	1992	dug well	0.92	3.7	0.0
62	THA - 27-7806	Thanlyin	Urban(Staff Compound) Ward	16.761725	96.259492	Daw Myint Myint San,No(26), Shwe War (3) Street	15.10.12	–	–	0.5	3.0	5.87	50	28.1	20.8.13	–	–	1.0	3.0	6.50	70	29.0	2006	tube well	0.05	27.4	25.0
63	THA - 27-7819	Thanlyin	Urban(Staff Compound) Ward	16.762217	96.258750	Shwe War (2) Street, U Tin Tun	15.10.12	–	–	3.6	8.0	5.35	108	28.3	13.7.13	–	–	1.7	1.5	5.33	69	30.1		dug well	1.52	6.1	0.0
64	THA - 27-8218	Thanlyin	Urban(Oake Pho Su Ward)	16.767453	96.256775	Daw Loe, No(4), Baw Ga Street	18.10.12	–	–	0.0	0.0	7.15	118	28.5	20.8.13	–	–	0.0	0.0	7.10	130	28.0	2009	dug well	0.91	24.4	0.0
65	THA - 27-8548	Thanlyin	Urban(Oake Pho Su Ward)	16.770075	96.254714	U Thein Phae Myint, No(32),Waik Zar (2) Street	22.10.12	–	–	0.0	0.0	6.29	45	27.1	13.7.13	–	–	0.0	1.0	5.63	47	30.4	2011	tube well	0.05	27.4	21.7
66	THA - 27-8653	Thanlyin	Urban(Oake Pho Su Ward)	16.771222	96.254583	U Sein Nyunt ,no(10/a),Swe Taw Pin Street	23.10.12	–	–	0.2	5.5	4.58	384	29.3	13.7.13	well smell	–	1.7	1.5	4.50	372	30.9	2000	dug well	1.52	9.1	0.0
67	THA - 27-8879	Thanlyin	Urban (Tauk Taw Twin) Ward	16.776403	96.251481	U Kyaw Min Tun,no(11),Phayar Ni Street	25.10.12	–	–	0.0	0.0	5.76	58	27.5	13.7.13	–	–	0.0	2.8	4.85	64	35.2	2002	tube well	0.05	30.5	24.4
68	THA - 27-8968	Thanlyin	Urban (TaukTaw Twin) Ward	16.774444	96.253000	Daw Sein Yi ,no(61),TaukTaw Twin Street	25.10.12	–	–	0.0	1.0	5.66	131	32.9	20.8.13	–	–	1.0	2.0	6.50	140	28.9	1996	dug well	0.91	9.1	0.0
69	THA - 27-9364	Thanlyin	Urban, Eastern Of Old Town Ward	16.780792	96.248061	Daw San San Oo, No(32/Ka), U Bo Thein Street	1.11.12	–	–	0.0	4.0	6.03	158	28.0	14.7.13	–	–	1.5	5.5	5.10	226	30.2	1972	dug well	1.07	9.1	0.0
70	THA - 27-9627	Thanlyin	Urban, Middle Of Old Town Ward, (Aung Thukha)	16.777528	96.246028	U Aye Than, No(21), Kan Kaw Street	2.11.12	–	–	0.0	0.0	5.67	153	27.7	14.7.13	–	–	3.8	0.0	5.11	183	29.6	1992	tube well	0.05	30.5	27.7
71	THA - 27-9785	Thanlyin	Urban, Middle Of Old Town Ward	16.745261	96.244847	U Phone Myint, No(O/162), Bo Aye Cho Street	26.11.12	–	–	0.0	0.0	5.36	166	35.0	18.8.13	–	–	4.0	10.0	6.30	150	35.0	1997	dug well	0.98	9.1	0.0
72	THA - 27-10248	Thanlyin	Urban(Myothit(Middle) Ward)	16.765361	96.247333	Daw Khin Myint Than, No.(8), Min Tan Street	7.11.12	–	–	0.3	4.5	6.45	387	31.2	15.7.13	–	–	2.7	12.5	5.99	435	31.1	1962	dug well	1.22	9.1	0.0
73	THA - 27-10389	Thanlyin	Urban	16.764472	96.247000	U Chit Chaung,20/Patain tan st.,Myothit(mid) qtr.	11.12.12	–	–	5.4	15.5	6.11	471	28.9	15.7.13	–	–	7.6	>50.0	7.15	465	30.9	1932	dug well	1.22	9.2	0.0
74	THA - 27-10439	Thanlyin	Urban	16.769181	96.246094	U Min Wai,1/Sartie st.,Darrkar Ward	11.12.12	–	–	0.0	0.0	7.80	185	26.9	–	Not found							1982	tube well	0.05	27.4	22.0
75	THA - 27-10485	Thanlyin	Urban	16.772478	96.244781	U Khin Mg Gyi, 46/ThantZin st.,Darrkar Ward	11.12.12	–	–	0.0	0.0	6.34	251	26.4	15.7.13	–	–	2.7	10.5	5.65	395	31.6	2007	dug well	0.91	4.9	0.0
76	THA - 27-10803	Thanlyin	Myot Ma Myauk Ward	16.766700	96.243492	Sayargyi U Yin,No(27-B),Myot Ma Street	12.11.12	–	–	0.0	0.0	6.70	752	26.7	15.7.13	–	–	0.9	1.0	5.91	455	30.4	1973	dug well	1.82	9.2	0.0
77	THA - 27-10899	Thanlyin	Urban (Myoe Ma North) Ward	16.766233	96.243850	U Tin Myint,no(11),Kaung Si Street	13.11.12	–	–	0.0	0.0	5.34	242	28.2	14.7.13	–	–	0.0	0.0	5.42	351	29.9	2009	dug well	1.21	6.7	0.0
78	THA - 27-11045	Thanlyin	Urban (Myoe Ma South) Ward	16.763694	96.245083	U Myint Thein,no(1), Thu Kha Street	14.11.12	–	–	0.0	3.0	6.84	956	27.2	15.7.13	Rust smell	Salty	1.4	12.5	6.53	788	30.4	1993	dug well	1.52	9.2	0.0
79	THA - 27-11273	Thanlyin	Kwet Thit (2),Myot Ma Taung Ward	16.760167	96.240806	U Aung Myat Kyaw, No(-),Nilar Street	16.11.12	–	–	9.5	>50.0	6.60	342	32.7	25.7.13	–	–	9.0	>50.0	6.70	365	30.7	2000	tube well	0.05	24.4	19.2
80	THA - 27-11340	Thanlyin	Myot Ma Taung Ward	16.762533	96.241639	U Zaw Min,No(33),Chan Myae Street (nearest)	16.11.12	–	–	0.0	0.0	6.97	654	28.5	15.7.13	–	–	1.5	10.0	7.20	434	30.7	2006	tube well	0.03	27.4	22.0
81	THA - 27-11360	Thanlyin	Myot Ma Taung Ward	16.760869	96.242142	U Aye Tun,No(4-B),Thida Yaemyaung Street (nearest)	16.11.12	–	–	60.0	>50.0	6.13	374	28.1	15.7.13	–	–	10.0	5.0	6.03	838	30.9	2005	tube well	0.03	25.9	20.4
82	THA - 27-11821	Thanlyin	Urban (Htan Pin Kone) Ward	16.758528	96.245861	U Khin Zaw ,no(27),(2) Street	19.11.12	–	–	0.0	0.0	4.88	386	27.7	15.7.13	–	–	5.9	15.5	5.70	482	31.0	1976	dug well	1.21	7.9	0.0
83	THA - 27-12906	Thanlyin	Urban, Aung Chan Thar (3) Ward	16.746794	96.261017	Ma Thin Thin Lin ,No(Wa/115), Bo Saw Aung Street	26.11.12	–	–	0.4	11.0	6.53	75	29.4	16.7.13	–	–	0.0	0.0	4.38	107	26.7	1989	dug well	1.22	8.5	0.0
84	THA - 27-13018	Thanlyin	Urban, Aung Chan Thar Ward	16.746250	96.260944	U Ohn Maung, No(Wa/101), Bo Taik Choun Street	26.11.12	Rottem smell	–	2.2	29.0	5.70	111	28.1	16.7.13	–	–	2.8	12.5	5.00	108	32.0	1992	dug well	0.91	6.1	0.0
85	THA - 27-13051	Thanlyin	Urban, Aung Chan Thar Ward	16.744250	96.260806	U Nyunt Shwe, No(Wa/4), School Street	26.11.12	–	–	4.3	22.0	6.60	84	28.4	18.8.13	–	–	5.0	15.0	6.80	968	32.0	2008	tube well	0.04	27.4	22.0
86	THA - 27-13061	Thanlyin	Urban, Aung Chan Thar (Extension) \	16.739292	96.258644	U Aye Lwin, No(C/42), Six Street	27.11.12	–	–	0.0	0.0	7.66	371	29.9	18.8.13	–	–	3.0	4.0	7.20	40	29.9	2010	tube well	0.05	29.0	26.5
87	THA - 27-13071	Thanlyin	Urban, Aung Chan Thar (4) Ward	16.740875	96.258461	U Chan Perann, No(28/35), Thazin (6) Street	27.11.12	–	–	1.8	>50.0	7.64	280	29.1	18.8.13	–	–	1.8	>50.0	7.50	320	30.0	2010	tube well	0.05	27.4	25.0
88	THA - 27-13087	Thanlyin	Urban, Aung Chan Thar (Extension) (	16.736769	96.256744	Daw May Hla Shwe, Rose(10) Street, Aye Thar Yar Qu	27.11.12	–	–	0.0	0.0	7.74	342	31.1	18.8.13	–	–	0.0	0.0	7.80	300	30.0	2004	tube well	0.05	24.4	21.7
89	THA - 27-13097	Thanlyin	Urban, Aung Chan Thar (4) Ward	16.738900	96.256889	U Kyaw Oo, No(33), Taw Win(10) Street	27.11.12	–	–	0.0	13.0	7.81	374	34.9	18.8.13	–	–	0.0	13.0	7.80	310	31.0	2007	tube well	0.05	27.4	25.0
90	THA - 27-13161	Thanlyin	Urban, Aung Chan Thar Ward	16.742122	96.255556	Daw Ohn Kyin, No(Kha/359), Moe Code Kyaung Stree	29.11.12	–	–	4.9	3.0	5.79	768	29.2	16.7.13	Silty smell	–	2.0	9.0	5.80	738	30.9	2001	tube well	0.04	27.4	22.3
91	THA - 27-13442	Thanlyin	Urban (Aung ChanThar) (2) Ward	16.745350	96.253547	U Nay Soe ,no(379/b),Bo Myint Aung Street	2.12.12	–	–	0.0	7.0	6.30	124	31.4	16.7.13	Silty smell	–	8.7	14.5	5.96	188	30.7	2004	tube well	0.05	24.4	22.0
92	THA - 27-13581	Thanlyin	Urban (Aung ChanThar) Ward	16.742194	96.252625	Daw Thaung Sein,Ta Khin Phoe Hla Kyi Street	3.12.12	–	–	0.0	0.0	5.82	199	28.8	18.8.13	–	–	4.5	30.0	6.30	168	27.0	2002	tube well	0.03	27.4	22.3
93	THA - 27-13694	Thanlyin	Urban (Aung ChanThar) (1) Ward	16.747433	96.247208	U Win Khin,No(20),Thi Yi Zay Yar Street	4.12.12	–	–	0.0	0.0	6.69	189	29.5	18.8.13	–	–	3.0	0.0	7.10	150	29.5	2012	tube well	0.05	18.3	15.9
94	THA - 27-14067	Thanlyin	Urban (Aung Chan Thar) Ward	16.734822	96.261214	Paw Taw Mu KyaungTite,Myat Ya Ta Nar Street	6.12.12	–	–	3.2	>50.0	6.63	87	29.8	17.7.13	–	–	4.8	0.0	7.40	489	36.1	2009	tube well	0.05	21.3	18.9
95	THA - 27-14155	Thanlyin	Urban (Aung Chan Thar) Ward	16.740547	96.259047	U Nyunt Swe,No(62/b),Aye Thar Yar (5) Street	6.12.12	–	–	14.1	>50.0	7.19	268	32.6	16.7.13	Silty smell	Light	3.0	5.0	6.58	268	32.6	2008	tube well	0.03	27.4	22.3
96	THA - 27-14175	Thanlyin	Urban (Aung Chan Thar) Ward	16.740908	96.259378	U Aung Than,No(71/a),Ta Zin (4) Street	6.12.12	–	–	2.3	41.5	6.88	257	28.1	16.7.13	–	–	2.3	14.0	6.44	275	31.0	2007	tube well	0.03	27.4	22.3
97	THA - 27-14316	Thanlyin	Urban (Aung Chan Thar) Ward	16.742503	96.262183	Daw YinYin Nu,No(4),Developoment Street,Myat Ya	7.12.12	–	–	5.9	49.0	7.10	103	28.9	17.7.13	–	–	2.3	2.0	5.11	194	31.6	2006	tube well	0.05	27.4	25.0
98	Tho - 15-14562	Thonegwa	Tha Khut Kone Village	16.802092	96.484603	U Chin Hun (Le Tal), Tha Khut Kone Village	21.11.12	–	Salty	1.6	14.5	8.48	1,689	26.4	18.8.13	–	-	4.6	25.0	7.42	792	27.8	2002	tube well	0.05	15.2	13.7
99	Tho - 15-14573	Thonegwa	Tha Khut Kone Village	16.807131	96.481361	U Aung Phyo (Le Tal), Tha Khut Kone Village	22.11.12	–	Light	2.0	14.5	7.58	3,580	27.6	18.8.13	well smell	-	3.4	27.0	7.65	696	27.9	2010	tube well	0.05	10.7	9.2
100	Tho - 15-14598	Thonegwa	Tha Khut Kone Village	16.827806	96.481003	U Win Shwe (Lel Tal), Tha Khut Kone Village	23.11.12	–	Salty	1.7	14.6	8.10	3,480	27.5	18.8.13	-	-	4.6	25.0	7.42	792	27.8	1997	tube well	0.05	10.7	9.2

Table 3-2-7-3 In-situ Water Quality Measurement Results of Existing Wells – Deep Well (1)

No	WPT_ID	Township	Village_Group_Name	Latitude	Lobgitude	Address_of_Owner	First Survey (Dry Seasn)								Second Survey (Wet Seasn)								Year Installed	Kind of Well	Diameter (meter)	Depth (meter)	Screen Positions (meter)
							date	Odour	Taste	Turbidity (KTU)	Color Index	PH	EC (μs)	Temperature (deg C)	Date	Odour	Taste	Turbidity (KTU)	Color Index	PH	EC (μs)	Temperature (deg C)					
1	KA - 1-3	Khayan	A Lel Ywar	16.877947	96.395631	Monastery Well, A Lel Ywar Village Group	10.12.12	-	-	0.0	2.5	7.74	616	25.6	10.8.13	-	-	7.6	6.0	7.47	551	28.5	1912	tube well	0.05	158.5	153.4
2	KA - 2-23	Khayan	Myauk Aye Village, Aye Ywa Group	16.857386	96.405961	Monastery, Myauk Aye Village, Aye Ywa Village Group	12.12.12	-	-	0.0	0.0	8.28	788	30.5	29.8.13	-	-	2.1	4.5	7.41	908	30.2	2011	tube well	0.05	158.5	152.4
3	KA - 3-45	Khayan	A Lal Wun Kone Village,Hla Bi Lu Village Group	16.880878	96.473783	Monastery Well, A Lal Wun Kone Village,Hla Bi Lu Village Group	6.12.12	-	-	0.0	11.5	8.02	115	30.4	1.9.13	-	light	7.7	>50	7.95	1,167	26.4	2010	tube well	0.05	146.3	141.5
4	KA - 4-66	Khayan	Ye Mon Village,Ka Mar Ka Lu Village Group	16.915681	96.538772	Ye Mon Monastery, Ka Mar Ka Lu Village Group	10.11.12	-	-	0.0	0.0	8.19	441	29.1	26.8.13	Silty smell	-	10.3	34.5	6.78	115	28.8	1972	tube well	0.05	152.4	147.9
5	KA - 5-136	Khayan	Ka Mar Chaik Village	16.894694	96.432756	Monastery,Ka Mar Chaik Village (nearest)	8.12.12	-	-	1.0	13.5	8.87	2,650	30.8	29.8.13	green smell	light	9.5	>50.0	7.50	2,660	27.6	2005	tube well	0.05	146.3	142.1
6	KA - 6-153	Khayan	Ka Ma Mat Village	16.955089	96.483178	U Myint Sein, Ka Mar Mat Village	14.11.12	Rotten smell	-	0.0	13.5	8.34	793	30.2	27.8.13	Locked the house,not install the machine& not use in rainy season							2010	tube well	0.05	167.7	162.5
7	KA - 7-217	Khayan	Kyon Tu Village	16.865936	96.516661	Primary School Public Well, Kyone Tu Village (nearest)	3.12.12	-	-	0.0	12.0	8.07	129	30.2	27.8.13	Silty smell	-	1.7	32.0	7.78	1,294	25.6	2003	tube well	0.05	143.3	138.4
8	KA - 8-231	Khayan	Kyone Kyone Kya	16.939692	96.493347	Public Well,DawTin Street,Kyone Kyone Kya Village	4.11.12	-	-	1.2	19.5	8.06	1,470	31.6	28.8.13	not use in rainy season, not install the machine							2010	tube well	0.05	164.6	159.5
9	KA - 9-424	Khayan	Ka Mar Sein Village,Kyu Taw Village Group	16.909864	96.436806	Public Well, Ka Mar Sein Village,Kyu Taw Village Group	7.12.12	Silt smell	-	11.7	19.0	8.04	543	32.7	30.8.13	Silty smell	-	3.7	39.5	7.65	530	34.1	2005	tube well	0.05	158.5	153.7
10	KA - 10-445	Khayan	Ma Gyi Kan Village	16.823756	96.458900	Primary School, Ma Gyi Kan Village (South)	16.12.12	-	-	0.0	0.0	8.36	597	28.0	20.8.13	well smell	light	4.9	34.0	7.62	579	28.1	2011	tube well	0.05	152.4	147.3
11	KA - 11-491	Khayan	Maung Ma Village	16.937703	96.425461	Public Well, Maung Ma Village	19.11.12	Rotten smell	Salty	13.5	38.0	7.24	2,840	30.0	1.9.13	Not use in rainy season because of the bad water ,breaking down the machine							2000	tube well	0.05	164.6	160.1
12	KA - 12-527	Khayan	Oak Hpo Village	16.936981	96.470489	Public Well,(Northern) Oak Hpo Village	17.11.12	Rotten smell	Salty	0.0	1.0	7.65	2,880	31.2	26.8.13	-	salty	1.7	4.5	8.04	4,200	27.9	2004	tube well	0.05	131.1	123.5
13	KA - 13-554	Khayan	Aye Village,Pauk Pin Village Group	16.952439	96.426125	Public Well, Aye Ywa,Pauk Pin VillageGroup	21.11.12	Rotten smell	Light	0.0	27.0	7.46	1,090	28.9	30.8.13	Silty smell	-	7.7	>50.0	7.41	997	34.5	2005	tube well	0.05	167.7	163.1
14	KA - 14-571	Khayan	Pein Kan Village	16.876814	96.450508	U Tin Htut, Peinn Kan Village (nearest)	11.12.12	Rotten smell	-	0.9	>50.0	7.60	1,986	26.7	29.8.13	Silty smell	-	2.3	>50.0	7.23	1,922	26.5	2003	tube well	0.05	122.0	116.5
15	KA - 16-612	Khayan	Latpadan Village,Ta Man Gyi Village Group	16.874272	96.554444	Public Well, Latpadan Village(West),Ta Man Gyi Village Group	1.12.12	-	Salty	1.9	7.5	7.76	6,990	28.7	31.8.13	-	salty	9.2	44.5	7.66	7,790	26.6	2011	tube well	0.05	158.5	153.4
16	KA - 17-635	Khayan	Yoe Gyi Village	16.840692	96.481439	Monastery Well, Yoe Gyi Village(South)	4.12.12	-	-	0.0	18.0	8.15	917	28.3	20.8.13	well smell	light	0.0	17.0	7.59	879	28.1	2004	tube well	0.05	128.1	123.5
17	KYA - 1-656	Kyauktan	Ah Se Village	16.596231	96.462639	U Aye Kyo,Ah Se Village(West)	16.11.12	Rotten smell	Light	2.0	21.0	7.50	2,260	24.4	16.8.13	-	-	0.6	4.0	8.20	259	29.7	2004	tube well	0.05	73.2	67.1
18	KYA - 5-874	Kyauktan	Kan Pyaung Village	16.706275	96.398200	U Khin Maung Lwin,Kan Pyaung Village	23.12.12	Rotten smell	Salty	4.3	44.5	7.36	642	31.4	13.7.13	Cannot absorp the well water							2005	tube well	0.05	109.7	103.6
19	KYA - 6-1014	Kyauktan	Kyan Pin Village	16.623403	96.394486	Ba Hoot Pon Nya Monestry,Kyan Pin(Village)	23.11.12	-	-	9.9	18.0	9.46	368	27.1	14.7.13	-	-	4.9	2.5	9.23	138	28.3	2001	tube well	0.05	128.0	115.9
20	KYA - 7-1031	Kyauktan	Kyar Kan Village	16.676389	96.353333	Public use well,Kyar Kan(Village)	11.11.12	-	-	1.6	3.4	8.00	406	27.6	13.7.13	-	-	9.2	12.0	7.48	457	29.0		tube well	0.05	121.9	113.4
21	KYA - 8-1208	Kyauktan	Kyon Kan Village	16.651389	96.423722	Basic Education High School,Kyon Kan(Village)	9.11.12	Rotten smell	-	20.0	50.0	6.76	3,660	27.8	13.7.13	Not use in rainy season								tube well	0.05	128.0	115.9
22	KYA - 9-1720	Kyauktan	Nyaung Waing Group	16.668236	96.308572	U Mya Win, Shan Su	5.11.12	-	-	0.6	10.0	7.98	489	28.2	-	-	-	0.6	7.0	7.03	448	27.5	2010	tube well	0.05	85.3	76.2
23	KYA - 9-1782	Kyauktan	Nyaung Waing Group	16.680206	96.319222	U Win Yu War, No(), Myain Thar Yar (1) Ward	2.11.12	-	-	0.0	0.0	6.15	31	27.8	-	well smell	-	0.0	0.0	5.55	22	27.4	2010	tube well	0.05	67.1	54.9
24	KYA - 11-1859	Kyauktan	Pan Taw Village	16.620944	96.375611	Kyoun Ka Lay Monestry,Kyoun Ka Lay(Village)	24.11.12	-	-	0.3	1.5	8.70	418	30.7	14.7.13	-	-	1.0	0.0	8.55	467	28.8		tube well	0.05	207.3	201.8
25	KYA - 12-1907	Kyauktan	Par Da Gyi Village	16.658656	96.323922	U Than Htut , Kun Chan Su,Pa Da Gyi Village	27.10.12	Rust smell	-	0.2	3.0	6.78	106	27.9	29.6.13	-	-	1.0	7.5	6.31	99	27.3	2005	tube well	0.05	97.5	88.4
26	KYA - 13-2029	Kyauktan	Pi la khat Village	16.652750	96.367861	ku lar pi lat kat(Tample)	10.12.12	-	-	2.3	1.0	8.47	401	31.1	4.7.13	-	-	0.0	0.0	7.58	402	29.9		tube well	0.05	115.8	109.7
27	KYA - 14-2104	Kyauktan	Shwe pyauk Village	16.659306	96.303056	U Kyi Htay , No (198) ,Shwe Pyauk Village	25.10.12	Silt smell	Light	2.8	17.0	8.16	401	27.5	30.6.13	-	-	1.6	8.5	7.17	233	26.8	1992	tube well	0.05	85.3	82.3
28	KYA - 14-2232	Kyauktan	Shwe pyauk Village	16.656175	96.317628	Daw San Yi,Shwe Pyauk Village	26.10.12	-	-	6.7	50.0	7.63	397	26.3	30.6.13	-	-	0.8	0.0	6.30	83	28.4	2005	tube well	0.03	91.5	82.3
29	KYA - 14-2272	Kyauktan	Shwe pyauk Village	16.658369	96.315894	Myat Saw Nyi Naung, Bone Kyi Kyaung, Aung Thar Ce,Shwe pyauk Village	26.10.12	Silt smell	–	0.0	8.5	8.10	601	27.7	29.6.13	-	-	2.3	46.5	6.83	496	27.9	2008	tube well	0.07	61.0	46.3
30	KYA - 15-2298	Kyauktan	Sin Ma Kaw Village	16.641944	96.498947	Public use pond, Sin Ma Kaw (Village)	25.11.12	-	-	0.0	0.5	8.60	931	28.3	16.8.13	-	-	1.0	1.0	8.47	780	30.4		tube well	0.05	140.2	120.0
31	KYA - 16-2307	Kyauktan	Tar Pat Village	16.662500	96.496781	Public use Well,Zi Phyu Pin(Village)	25.11.12	Rotten smell	Salty	0.9	33.5	7.97	5,380	28.8	14.8.13	Silty smell	salty	0.2	4.5	7.75	5,710	29.9		tube well	0.05	128.0	115.9
32	KYA - 18-2340	Kyauktan	Thaung Gyi Village	16.636944	96.366139	Basic Education High School, Thaung Gyi (Village)	13.11.12	-	-	-	-	-	-	-	15.7.13	In summer not getting the water, not installed the instrument								tube well	0.05	97.5	91.4
33	KYA - 20-2464	Kyauktan	Urban(Shwe Kone)	16.641444	96.329819	U Myint Aye, No(871), Aung Thu Ka Street	13.10.12	-	-	6.4	18.0	7.65	211	28.6	4.7.13	-	-	2.0	19.0	6.65	206	28.1	2004	tube well	0.05	106.7	91.8
34	KYA - 20-2622	Kyauktan	Sin Kan Ward	16.641467	96.324897	U Htin Lin , Aye Say Ti (2) Street,Shwe Kone Ward	16.10.12	-	-	0.6	27.5	7.10	138	28.0	29.6.13	-	-	1.9	32.5	6.30	139	27.7	1984	tube well	0.05	122.0	115.9
35	KYA - 20-2785	Kyauktan	East Ward	16.651056	96.328250	U Soe Myint ,No (68), Lam Ma Taw ,East, Shwe Kone Ward	16.10.12	-	-	0.0	1.0	6.42	138	28.1	3.7.13	well smell	-	0.6	1.5	5.98	158	28.6	1983	tube well	0.05	79.3	73.2
36	KYA - 21-2919	Kyauktan	Urban, San Gyine Mi (3) Ward	16.638861	96.320500	Dr. Hla Shwe, No(284), Zayyar (5) Street	9.10.12	-	-	14.9	23.5	8.42	819	28.4	13.7.13	The owner of the house was transferred								tube well	0.05	64.0	61.6
37	KYA - 21-3109	Kyauktan	Urban, Middle Ward	16.634389	96.326500	U Kyaw Win, No(88), Lut Lat Yee Street	14.10.12	Rust smell	Little sour	5.6	50.0	7.10	137	29.8	3.7.13	-	light	20.0	20.0	6.29	139	29.3	2011	tube well	0.04	82.3	79.3
38	KYA - 21-3155	Kyauktan	Urban, Aye Mya Thida Ward	16.654083	96.291639	U Ko Lin, No( ), Aye Mya Thida Street	20.10.12	Rust smell	Light	2.4	42.0	8.13	304	29.4	30.6.13	roast	-	1.8	40.5	7.05	325	28.7		tube well	0.04	61.0	54.9
39	KYA - 21-3197	Kyauktan	Urban, Thida Myine Ward	16.631056	96.302417	U Than Sein, No (36), Kayat,Thida Myine Street	22.10.12	-	-	0.0	0.0	8.65	1,125	28.1	3.7.13	-	-	2.1	2.5	7.60	995	28.5		tube well	0.04	128.0	122.0
40	KYA - 21-3314	Kyauktan	Urban, Swe Pyi Tharyar Ward	16.641911	96.294006	Singapore-Myanmar, Shwe Pyi Tharyar(2)Street	22.10.12	Rotten smell	Light	3.3	23.0	7.62	2,020	30.3	5.7.13	well smell	light	15.2	>50.0	6.77	1,396	26.6	1998	tube well	0.05	61.0	55.5
41	KYA - 21-3382	Kyauktan	Urban, West Ward	16.633208	96.322381	Public Well, West Ward	17.12.12	-	-	1.6	8.0	7.30	198	29.9	3.7.13	-	-	1.3	6.5	7.65	224	28.8		tube well	0.05	146.3	134.1
42	KYA - 22-3395	Kyauktan	Wea Gyi Village	16.621111	96.447222	Monestry,Kying pout(village),Wea Gyi Village Group	9.11.12	Rotten smell	-	0.0	0.0	8.12	663	31.2	15.7.13	-	-	2.0	3.0	9.06	290	27.8		tube well	0.05	146.3	137.2
43	KYA - 23-3467	Kyauktan	Yae Kyaw Village	16.700972	96.339639	Vi Da Ma Theint Di(Tample),Yae Kyaw Village	7.11.12	-	-	0.0	8.0	7.80	681	32.8	6.7.13	-	-	0.0	3.0	5.87	140	28.5		tube well	0.05	67.1	57.9
44	KYA - 24-3667	Kyauktan	Ywar Thit Gyi Village	16.621667	96.420747	Min Gar lar Myanmar,Ywa Thit Gyi(Village)	23.11.12	Rotten smell	Salty	13.4	>50.0	8.82	4,000	31.1	15.7.13	-	-	0.0	3.0	7.88	3,090	29.3		tube well	0.05	122.0	109.8
45	THA - 1-3679	Thanlyin	Ah Lun Soke Village	16.734711	96.259689	U Aung Twe Naung, No(338), Aye Myit-tar	7.12.12	-	-	0.7	2.5	8.26	371	28.2	22.7.13	-	-	2.6	1.0	7.81	30	30.2	2011	tube well	0.05	76.2	70.4
46	THA - 1-3780	Thanlyin	Ah Lun Soke Village	16.735336	96.256181	U Aung Htay,No(1770)	8.12.12	-	-	0.7	6.0	7.80	382	32.6	22.7.13	-	-	9.6	19.0	6.87	94	30.3	2002	tube well	0.05	67.1	61.6
47	THA - 2-3792	Thanlyin	Ba Yat Village	16.762964	96.309656	School, Ba Yat Village	11.12.12	Rust smell	-	1.4	3.0	6.83	462	29.5	11.8.13	-	-	>20.0	>50.0	6.82	5,830	28.2	2007	tube well	0.05	91.5	86.3
48	THA - 3-3798	Thanlyin	Pagan Taung Village	16.855214	96.377022	Dammikaryarma Monastery, Southern Monastery, (nearest)	17.12.12	-	-	1.6	20.5	7.44	845	31.4	10.8.13	-	-	2.3	12.0	7.17	3,370	28.6	2009	tube well	0.05	115.9	110.7
49	THA - 4-3824	Thanlyin	Baw Tha Byay Kan Village	16.785428	96.337472	Western Monastery, Baw Tha Byay Kan Village	12.12.12	-	-	0.8	3.5	8.50	353	28.9	19.7.13	-	-	0.0	2.0	8.41	408	30.2	2006	tube well	0.05	170.7	165.6
50	THA - 5-3865	Thanlyin	Bo Gyoke(major general) Village	16.756036	96.241311	Daw Hla Hla Myint, No(1/133), Bo Gyoke Village	19.12.12	-	-	3.1	11.5	7.79	410	28.6	17.7.13	-	-	0.0	0.0	5.76	95	28.8	2012	tube well	0.05	76.2	70.1

Table 3-2-7-4 In-situ Water Quality Measurement Results of Existing Wells – Deep Well (2)

No	WPT_ID	Township	Village_Group_Name	Latitude	Lobgitude	Address_of_Owner	First Survey (Dry Seasn)								Second Survey (Wet Seasn)								Year Installed	Kind of Well	Diameter (meter)	Depth (meter)	Screen Positions (meter)
							date	Odour	Taste	Turbidity (KTU)	Color Index	PH	EC (μs)	Temperature (deg C)	Date	Odour	Taste	Turbidity (KTU)	Color Index	PH	EC (μs)	Temperature (deg C)					
51	THA - 5-3955	Thanlyin	Bo Gyoke(major general) Village	16.753278	96.238603	Primary School, Area (11), Bo Gyoke Village	19.12.12	-	-	1.3	4.5	8.76	87	29.4	19.7.13	-	-	5.5	39.5	7.80	160	28.6	2000	tube well	0.05	73.2	61.9
52	THA - 5-4086	Thanlyin	Bo Gyoke(major general) Village	16.757336	96.236528	Da Mar Yone Well, Area (7), Bo Gyoke Village	20.12.12	-	-	22.5	10.1	6.33	448	29.6	17.7.13	-	-	12.4	17.5	6.14	761	23.0	2008	tube well	0.05	85.4	79.9
53	THA - 5-4127	Thanlyin	Bo Gyoke(major general) Village	16.757792	96.236550	U Ohn Myint, No(6/57)	20.12.12	-	-	2.9	38.5	6.47	292	29.3	17.7.13	fish smell	-	20.0	29.0	6.42	560	28.5	2012	tube well	0.05	82.3	76.8
54	THA - 5-4192	Thanlyin	Bo Gyoke(major general) Village	16.755608	96.237350	U Khin Mg Myint, No(8/35)	21.12.12	-	-	23.0	18.0	7.00	256	28.8	17.7.13	-	-	9.4	22.5	6.67	356	28.6	1992	tube well	0.05	64.0	58.8
55	THA - 5-4668	Thanlyin	Bo Gyoke(major general) Village	16.754764	96.244986	Nay La Company, Bo Gyoke Village	28.12.12	-	-	18.0	5.0	6.45	98	29.2	19.7.13	-	-	0.0	0.0	5.88	115	29.8	2012	tube well	0.05	91.5	86.3
56	THA - 6-4676	Thanlyin	Chaung Sauk Village	16.717472	96.358750	Da Ma Wae Thu Di Kyaung Taike	7.11.12	-	-	5.1	26.0	7.80	1,299	29.9	7.7.13	-	light	2.7	4.5	7.50	782	28.4	2009	tube well	0.05	109.7	107.3
57	THA - 7-4692	Thanlyin	Day Sat Village	16.906036	96.346786	Hospital, Day Set Group	27.11.12	-	Salty	0.1	3.5	8.18	1,032	30.1	20.7.13	-	-	0.5	3.5	7.35	1,734	29.3	2011	tube well	0.05	176.8	171.0
58	THA - 8-4726	Thanlyin	Padonesan Village, Payargone Group	16.747592	96.271003	U Sein Han,No(20),The Street	13.10.12	-	-	0.2	0.5	5.12	57	28.2	20.7.13	-	-	0.0	0.0	4.73	28	28.8	2011	tube well	0.05	36.6	31.1
59	THA - 8-4954	Thanlyin	Net Sin Gone Village, Payargone Group	16.737953	96.277183	Aung Si Taw Da Ma Thike Tup Oo Kyaung,No(-)	16.10.12	-	-	7.4	>50.0	6.54	146	29.1	21.7.13	-	-	7.4	4.1	6.80	220	29.0	2011	tube well	0.05	109.8	98.2
60	THA - 8-5116	Thanlyin	Phayar kone Village	16.737281	96.284797	Eastern University / Kanyinpyin	10.8.12	-	-	1.2	1.5	6.10	91	29.0	21.7.13	-	-	0.0	0.0	5.88	126	30.1	2006	tube well	0.15	73.2	62.2
61	THA - 8-5451	Thanlyin	Myoepya Kwet Thit Village	16.730125	96.274431	Daw Shwe Thein, No(), Warkyaung Street, Phayarkone	23.10.12	-	-	1.9	0.0	6.30	49	28.7	21.7.13	-	-	0.2	1.0	6.53	57	28.3	1992	tube well	0.05	91.5	86.0
62	THA - 9-5658	Thanlyin	Hpa Ku (East) Village	16.925542	96.373811	Monastery Well, Hpa Ku A Shae Group	23.11.12	Rotten smell	-	12.2	>50.0	7.39	1,001	29.3	30.7.13	well smell	-	2.0	26.5	7.54	599	27.7	2011	tube well	0.05	176.8	171.0
63	THA - 11-5691	Thanlyin	Pyi Taw Thar Village	16.848039	96.342178	monastery, Pyi Taw Thar Village	14.12.12	-	-	-	-	-	-	-	Not used in rainy season								2010	tube well	0.51	161.6	150.6
64	THA - 12-5707	Thanlyin	Kayin Seik Village	16.783997	96.288436	U Hla Myo Kyaw, Kayin Seik Village	12.12.12	-	-	0.0	2.0	8.14	334	30.7	19.7.13	-	light	0.5	1.0	7.63	405	29.4	2012	tube well	0.05	158.5	153.7
65	THA - 13-5720	Thanlyin	Ka La Well Village	16.816172	96.291528	Kwet Thit Prosperity Office, Ka La Well Village	10.12.12	-	-	7.2	40.0	7.76	740	28.0	22.7.13	-	-	0.7	0.5	7.56	350	31.4	2006	tube well	0.05	109.8	104.6
66	THA - 14-5802	Thanlyin	Aye Thitsar Quarter, Kyaung Kone Seik Gyi Village	16.728864	96.261606	U Aye Min, No(881), Aye Thitsar	8.12.12	-	-	2.4	16.0	6.80	136	29.8	21.7.13	rust smell	-	0.0	7.0	6.49	222	29.6	2011	tube well	0.05	64.0	58.8
67	THA - 14-5853	Thanlyin	Aye Thitsar Quarter, Kyaung Kone Seik Gyi Village	16.730147	96.262389	U Soe Myint, No(901/902), Development Road, (neare	8.12.12	-	-	0.6	5.5	6.73	117	29.6	21.7.13	-	-	6.6	15.0	6.03	118	30.3	2000	tube well	0.05	103.7	98.2
68	THA - 15-5869	Thanlyin	La Har Yat Village	16.878464	96.329856	Mingalar Myanmar, La Har Yat Village	15.12.12	-	-	0.9	9.0	8.07	935	32.3	28.7.13	-	-	1.1	3.5	8.19	695	28.1	2010	tube well	0.05	152.4	147.6
69	THA - 16-6015	Thanlyin	Pyinhaung Kyaung Village	16.714608	96.291756	U Zaw Win Aung,Thanlyin Kyauktan Street ,Pyinhaung Kyaung Ywa	26.10.12	-	-	13.5	4.0	6.75	89	28.7	18.7.13	-	light	17.9	3.0	6.20	95	28.4	2006	tube well	0.05	91.5	86.0
70	THA - 16-6030	Thanlyin	Pyinhaung Kyaung Village	16.708075	96.297211	U Zaw Lin,Bu Ya (5)Suu, Zaw Ti Ca Street,Pyinhaung Kyaung	26.10.12	-	-	3.4	>50.0	7.56	132	27.8	Not used in rainy season								2008	tube well	0.05	97.6	92.1
71	THA - 16-6203	Thanlyin	Hta Ma Lone Village	16.703706	96.300689	U Tin Htay,Thanlyin Kyauktan Street ,Hta Ma Lone,Let Yet San	28.10.12	Rust smell	-	11.8	>50.0	6.77	130	28.3	Not used in rainy season								2003	tube well	0.05	61.0	54.9
72	THA - 19-6638	Thanlyin	Nga Pa Kyae Village	16.788683	96.276292	U Saw Maung, Nga Pa Village	8.12.12	-	-	0.0	0.0	6.62	490	29.1	Not used in rainy season								2004	tube well	0.05	85.4	80.2
73	THA - 20-6647	Thanlyin	Nyaung Lay Pin Village	16.821592	96.319753	Mingalar Myanmar Well, Nyaung Lay Pin Village	15.12.12	-	-	0.5	9.5	8.17	497	29.1	Not used in rainy season								2010	tube well	0.05	143.3	137.8
74	THA - 21-6652	Thanlyin	Nyaungthonepin Village	16.750386	96.264769	No.(1),B.E.P.S,Daw Thida Aung	10.8.12	-	-	1.3	4.5	8.76	87	29.4	14.7.13	-	-	0.0	0.0	6.92	69	32.0	2001	tube well	0.05	97.5	95.1
75	THA - 21-6905	Thanlyin	Nyaungthonepin Village	16.762969	96.260628	Daw Khin May, No(1418), The Street	19.10.12	-	-	0.6	1.0	6.73	99	31.9	20.8.13	-	-	1.0	2.0	6.50	100	29.0	2005	tube well	0.05	67.1	61.6
76	THA - 22-6916	Thanlyin	Say Lone Gyi Village	16.712278	96.327028	Say Lone Gyi Kyaung Taike	7.11.12	-	-	0.1	0.0	8.61	327	30.9	7.7.13	-	light	3.4	21.0	8.48	183	28.4		tube well	0.05	82.3	76.2
77	THA - 23-6926	Thanlyin	Sit Pin Kwin Village	16.759908	96.313264	Monastery, Sit Pin Kwin Village	11.12.12	Rust smell	-	40.0	>50.0	7.31	4,444	25.9	Not used in rainy season								2010	tube well	0.05	91.5	86.3
78	THA - 24-6941	Thanlyin	Tha Nat Pin Vilage	16.783975	96.288461	U Thaung Hun, Tha Nat Pin Vilage	9.12.12	-	-	40.0	>50.0	7.76	650	25.3	25.7.13	Not used in rainy season							2001	tube well	0.05	79.3	71.0
79	THA - 25-6958	Thanlyin	Tha Pyae Kone Village	16.871294	96.367858	Monastery, Tha Pyae Kone Village , (nearest)	12.12.12	-	-	4.6	18.0	9.20	976	28.4	No one there								2009	tube well	0.51	146.3	140.5
80	THA - 26-6967	Thanlyin	Thu Htay Kwinn Village	16.766944	96.348136	Western Monastery, Thu Htay Kwinn Village	11.12.12	-	Light	1.5	7.5	7.44	917	28.7	19.7.13	-	light	0.6	3.5	7.14	2,110	29.1	2012	tube well	0.05	182.9	177.7
81	THA - 27-7168	Thanlyin	Urban(Staff Compound) Ward	16.756506	96.260764	U Yan Myint Chi,No(48/52),Co-operative University Road	11.10.12	-	-	1.4	3.0	6.11	37	29.1	13.7.13	-	-	1.1	0.0	5.56	41	29.9	1992	tube well	0.05	76.2	61.6
82	THA - 27-7256	Thanlyin	Urban(Staff Compound) Ward	16.753397	96.260667	U SinThaw Win,Thit Taw Street	12.10.12	-	-	0.0	0.0	6.39	114	29.2	22.7.13	-	-	0.0	0.0	5.73	133	29.0	2002	tube well	0.05	103.7	55.3
83	THA - 27-7748	Thanlyin	Urban(Staff Compound) Ward	16.746967	96.266547	U Ohin Khaing,No(32), Zaw Ti Ka Street	12.10.12	-	-	0.0	31.5	7.24	97	30.6	13.7.13	-	-	0.0	0.0	6.50	115	30.9	2001	tube well	0.05	67.1	46.6
84	THA - 27-8753	Thanlyin	Urban (Tauk Taw Twin) Ward	16.769933	96.251581	U Han Thein,no(16),Nant Ta Kone(2) Street	24.10.12	-	-	1.0	0.5	7.06	46	28.0	13.7.13	-	-	0.0	2.5	6.16	53	32.0	2000	tube well	0.05	68.6	62.5
85	THA - 27-9261	Thanlyin	Urban (Myoe Haung East) Ward	16.778144	96.252572	U Kyaw Win,TaukTaw Twin Street	28.10.12	-	-	0.0	0.0	6.21	77	30.9	13.7.13	-	-	3.1	22.0	5.97	72	31.7	2012	tube well	0.05	61.0	55.5
86	THA - 27-10314	Thanlyin	Urban	16.769300	96.244897	U Mg Kyaw,14/Post office st.,Darrkar qt.	11.12.12	Rust smell	-	0.0	>50.0	7.28	202	28.4	14.7.13	Silty smell	-	20.0	21.0	6.40	315	29.0	2012	tube well	0.05	109.8	104.3
87	THA - 27-10890	Thanlyin	Urban (Myoe Ma North) Ward	16.766992	96.245956	U Myo Khin,no(4),Kaung Si Street	13.11.12	-	-	0.0	32.0	7.43	158	31.4	14.7.13	-	-	0.0	3.5	6.73	225	30.9	1997	tube well	0.05	67.1	62.2
88	THA - 27-11236	Thanlyin	Myot Ma Taung Ward	16.761944	96.242139	U Zaw Myint,No(134), Nyain Chan Street	16.11.12	-	-	0.0	7.0	7.71	368	30.2	15.7.13	-	salty	1.8	6.5	6.61	512	30.0	2008	tube well	0.05	91.5	82.6
89	THA - 27-12331	Thanlyin	Urban (Bago Su) Ward	16.756861	96.233472	U Shu Shae ,no(15), Thar Du Street	22.11.12	-	-	0.7	>50.0	7.26	170	29.3	15.7.13	-	-	1.6	1.0	5.73	188	31.7	1997	tube well	0.05	85.4	49.7
90	THA - 28-14439	Thanlyin	Win Khani Village	16.951419	96.367797	Phone Gyi Kyaung Yae Twin,Ale Win Khani	26.11.12	Rotten smell	-	4.3	16.5	7.58	2,730	28.2	30.7.13	well smell	salty	4.0	25.5	7.14	1,732	27.1	2010	tube well	0.05	176.8	171.6
91	THA - 29-14452	Thanlyin	Yone Tha Pyay Kan Village	16.833278	96.344986	U Phoe Si, Yone Tha Pyay Kan Village	13.12.12	-	-	1.8	15.0	8.94	536	29.2	12.8.13	-	-	2.3	2.5	8.70	364	28.5	2002	tube well	0.05	146.3	141.5
92	Tho - 4-14474	Thonegwa	Kan Myint Vilage	16.747244	96.411133	Kan Myint (Monastery)	16.11.12	-	-	0.0	9.0	8.33	553	31.4	16.7.13	-	-	0.0	4.0	7.92	604	30.3	2002	tube well	0.05	152.4	146.3
93	Tho - 8-14496	Thonegwa	Min Village	16.678950	96.493644	Middle School (Well)	25.11.12	-	Light	0.9	3.0	8.28	1,426	30.7	13.8.13	-	-	12.6	16.0	8.60	197	30.5	2006	tube well	0.08	152.4	137.2
94	Tho - 10-14506	Thonegwa	Nyaung Ni Village	16.791022	96.463142	High School, Nyaung Ni Village	18.11.12	-	Light	0.0	4.5	8.43	1,615	28.3	15.8.13	-	-	1.1	7.5	7.92	1,405	28.8	2004	tube well	0.07	157.0	137.2
95	Tho - 11-14511	Thonegwa	Pale Village	16.763808	96.403747	Pale (High School)	16.11.12	-	-	0.1	3.0	8.52	1,077	30.3	16.7.13	-	-	1.3	1.0	7.53	1,126	29.9	1982	tube well	0.05	152.4	146.3
96	Tho - 12-14528	Thonegwa	Pyin Ma Kan Village	16.700961	96.429100	High School, Pyin Ma Kan Village	17.11.12	-	-	0.0	0.0	8.38	430	28.8	16.7.13	-	light	0.8	1.0	7.86	463	29.6	2004	tube well	0.08	152.4	146.3
97	Tho - 16-14599	Thonegwa	Thaik Tu Kan Village	16.747131	96.458114	Middle School, Theik Tu Kan Village	17.11.12	Rotten smell	Salty	1.1	9.0	8.89	1,663	23.8	25.7.13	-	light	2.1	31.0	8.30	122	29.4	2002	tube well	0.1	176.8	170.7
98	Tho - 17-14610	Thonegwa	West Thaongwa Village	16.759981	96.491364	well near Eait Sar Tha Ya Pagoda	17.11.12	-	Light	0.0	6.0	8.47	3,050	26.5	12.8.13	well smell	light	0.6	7.5	8.29	3,210	28.3	2008	tube well	0.05	146.3	140.2
99	Tho - 20-14681	Thonegwa	Ye Nwet Villge	16.724500	96.486550	Public Well, Ye Nwet Villge	17.11.12	Rotten smell	Salty	>20.0	>50.0	7.55	6,330	29.4	12.8.13	well smell	salty	6.3	16.5	7.71	1,199	28.3	2004	tube well	0.05	152.4	140.2
100	Tho - 21-14686	Thonegwa	Ywar Thit Villge	16.788197	96.493408	U Aung Nyein, Ywar Thit Villge (nearest)	23.11.12	-	Light	0.9	40.5	8.27	1,766	28.5	18.8.13	-	salty	3.6	24.8	7.80	718	27.9	2010	tube well	0.05	103.7	100.6

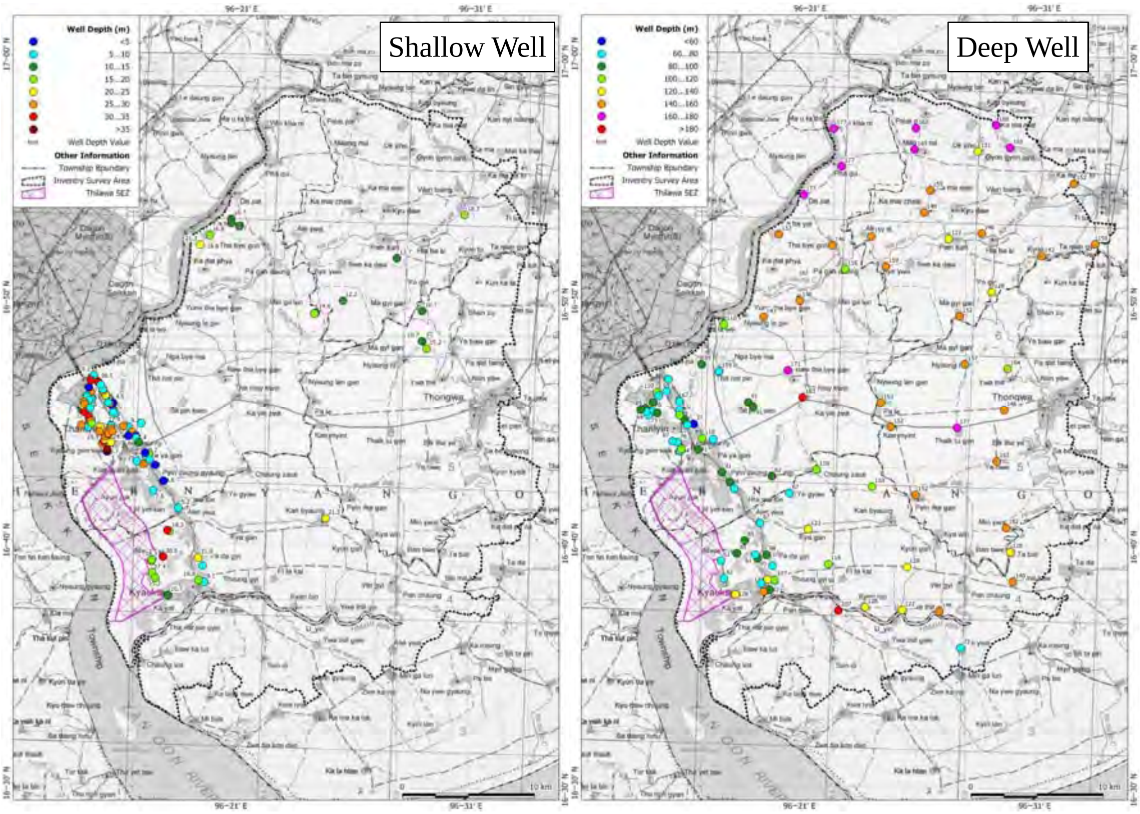


Figure 3-2-7-1 Location and Depth of Existing Wells for Water Quality Survey

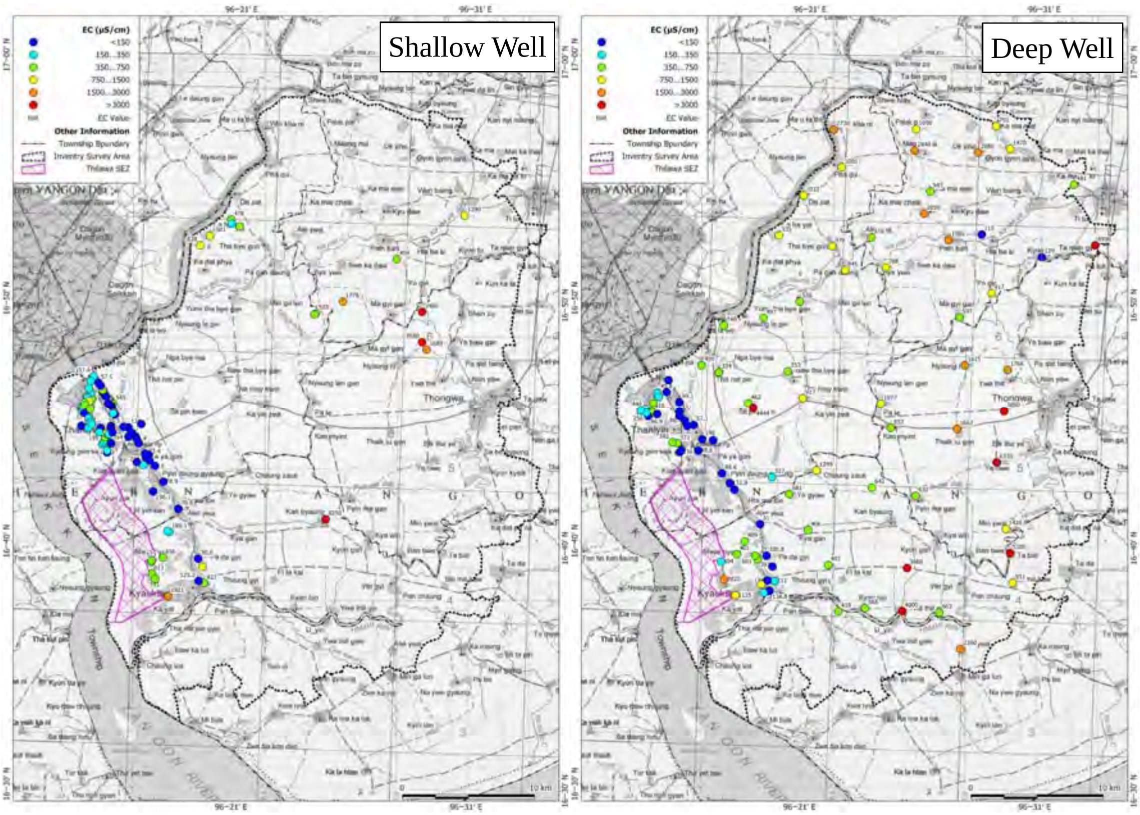
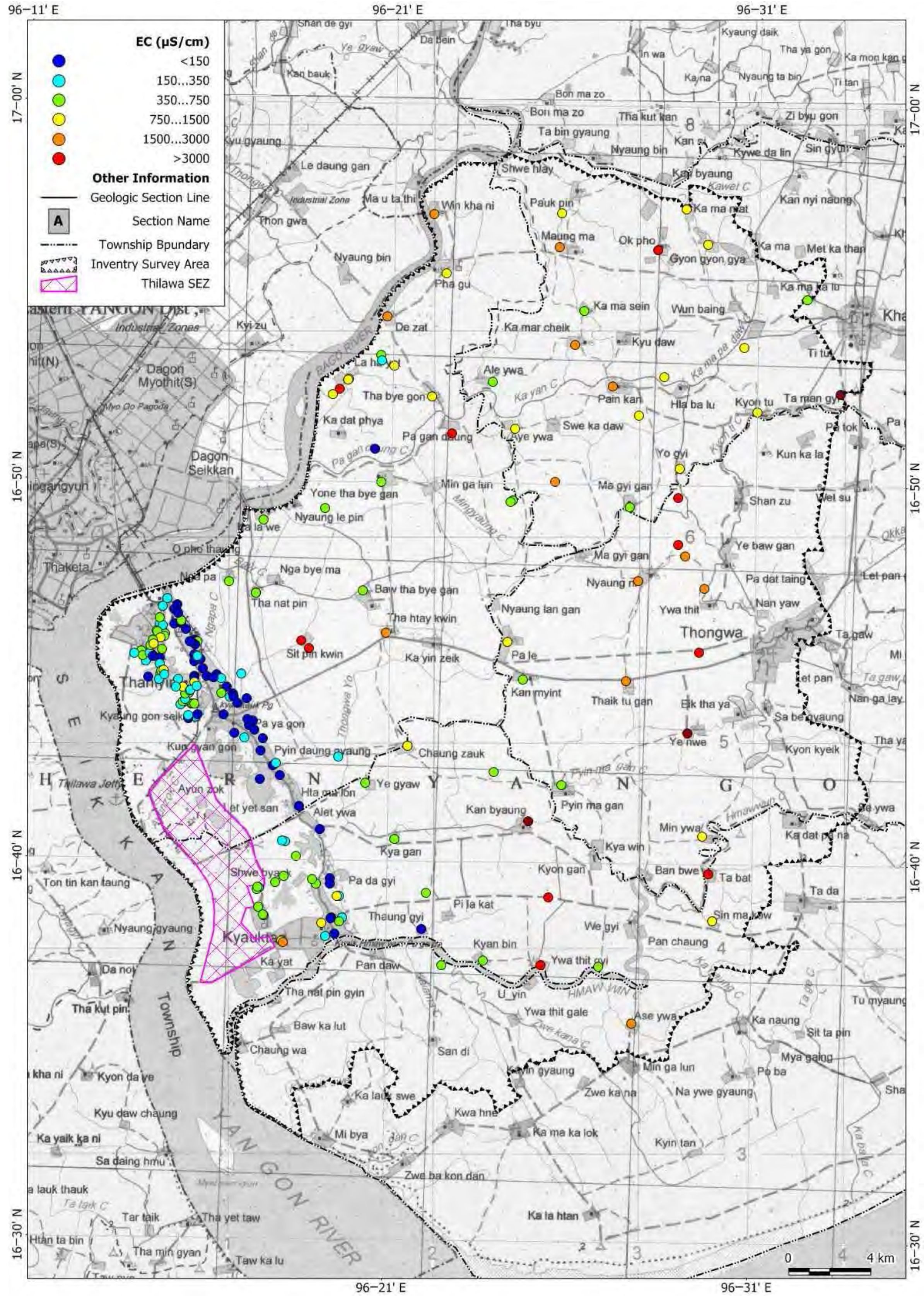


Figure 3-2-7-2 Distribution of Electric Conductivity (EC) of Existing-Well Water (Dry Season, 2013)



Note: A higher EC value in the dry and wet season adopted for plot.

Figure 3-2-7-3 Distribution of Electric Conductivity (EC) of Existing-Well Water (Both Seasons, 2013)

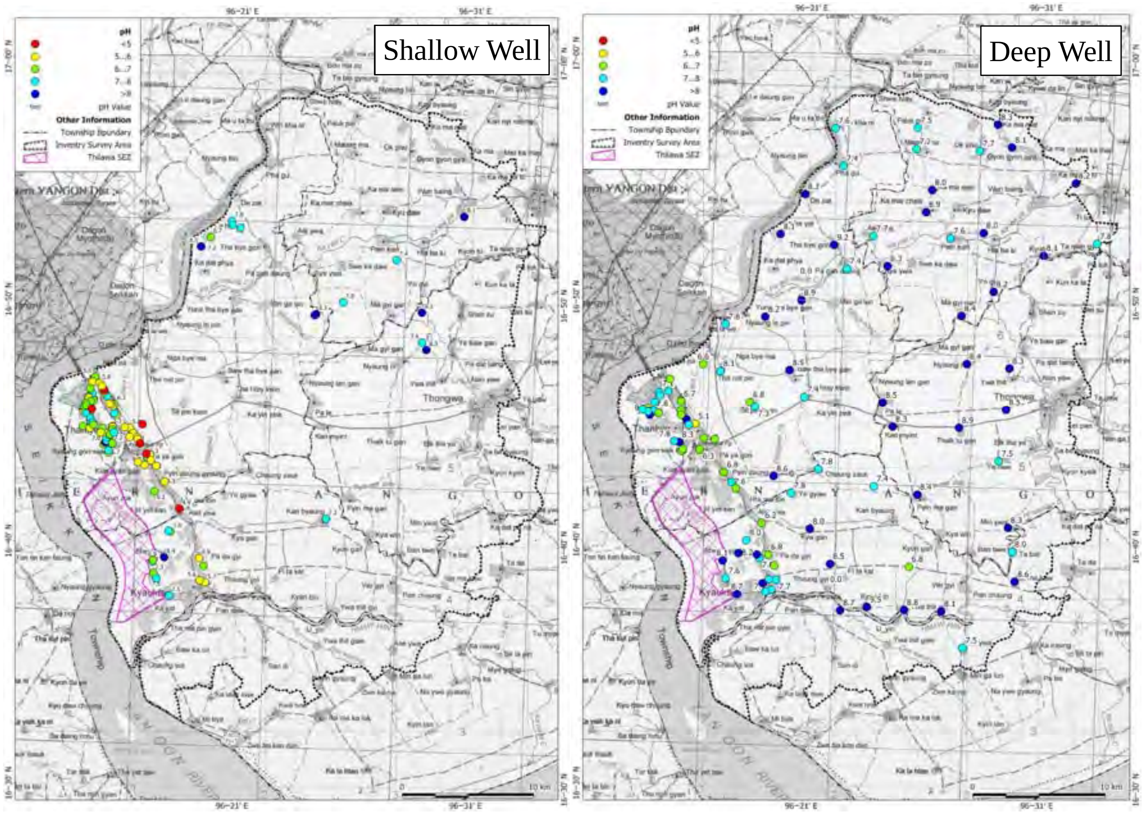


Figure 3-2-7-4 Distribution of pH of Existing-Well Water (Dry Season, 2013)

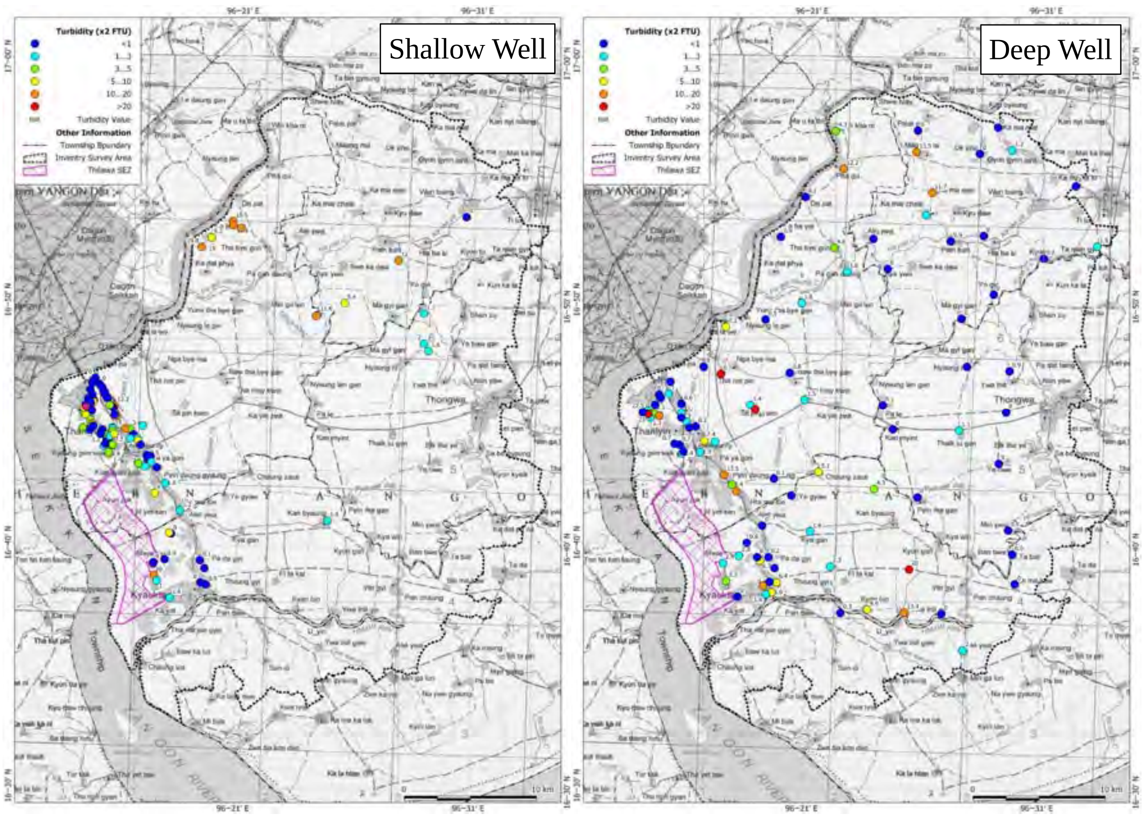


Figure 3-2-7-5 Distribution of Turbidity of Existing-Well Water (Dry Season, 2013)

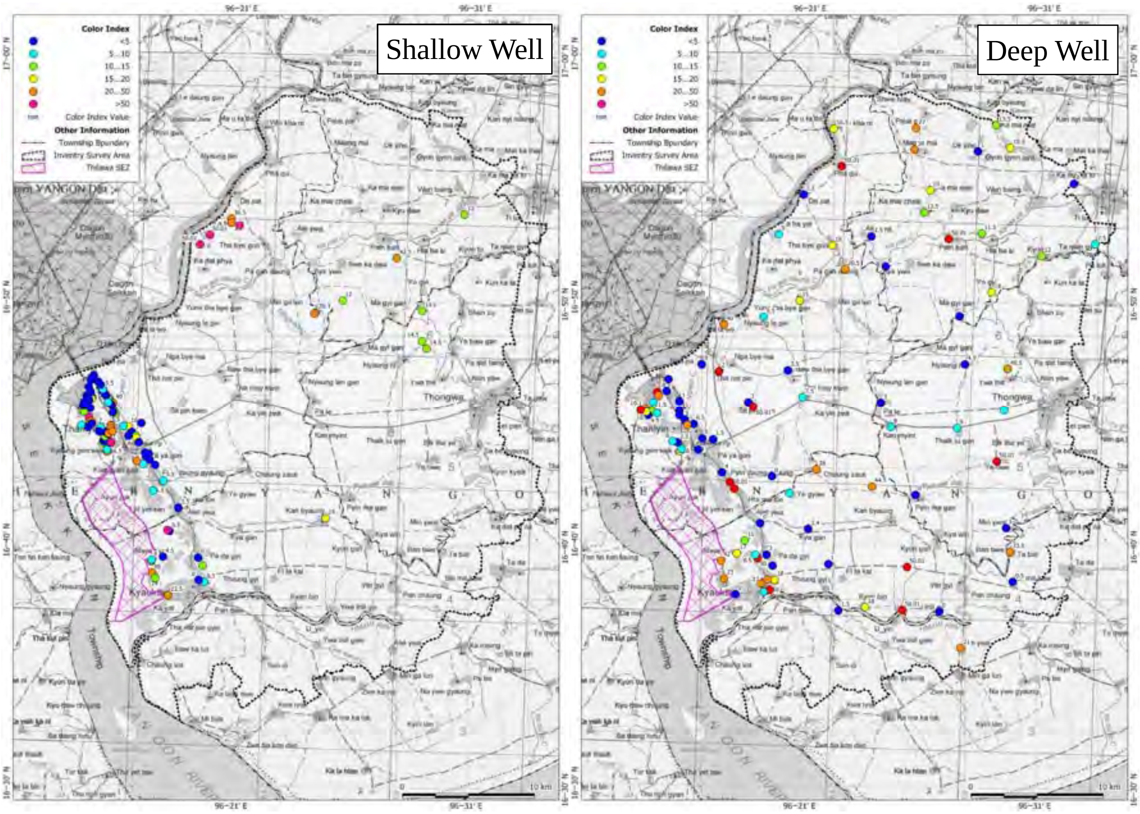


Figure 3-2-7-6 Distribution of Color Index of Existing-Well Water (Dry Season, 2013)

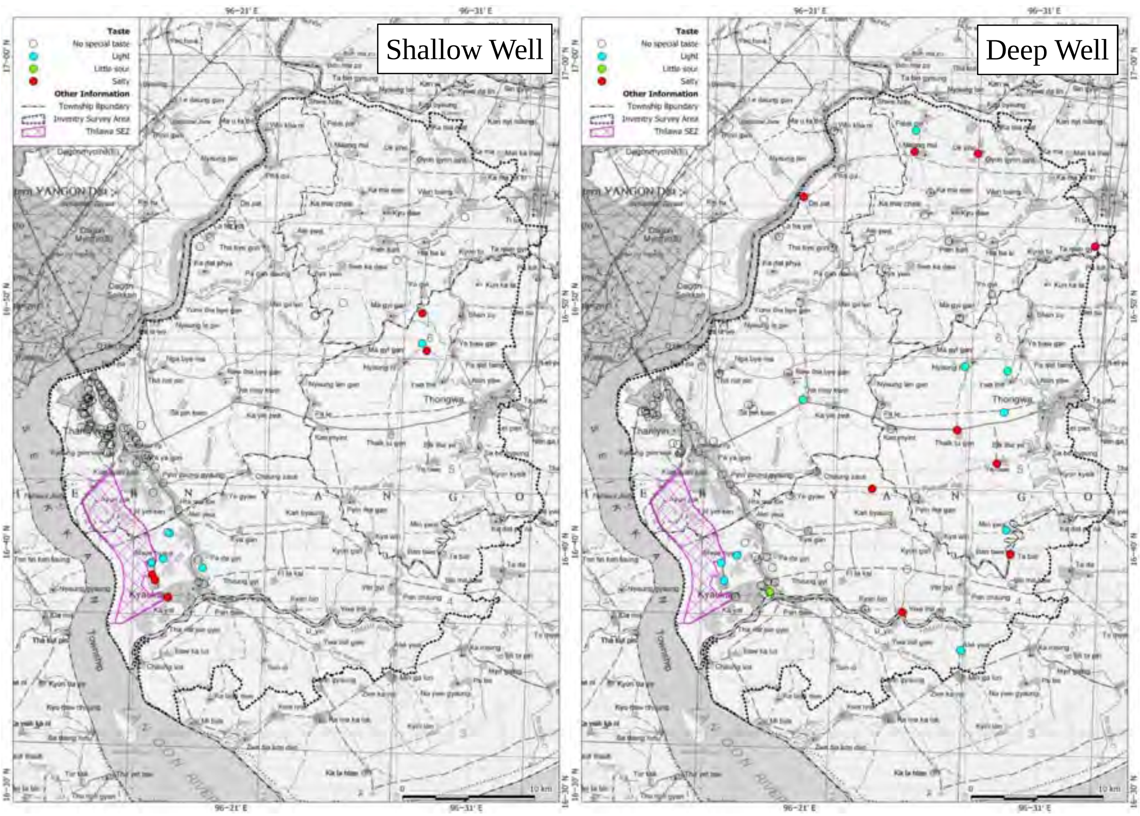


Figure 3-2-7-7 Distribution of Taste of Existing-Well Water (Dry Season, 2013)

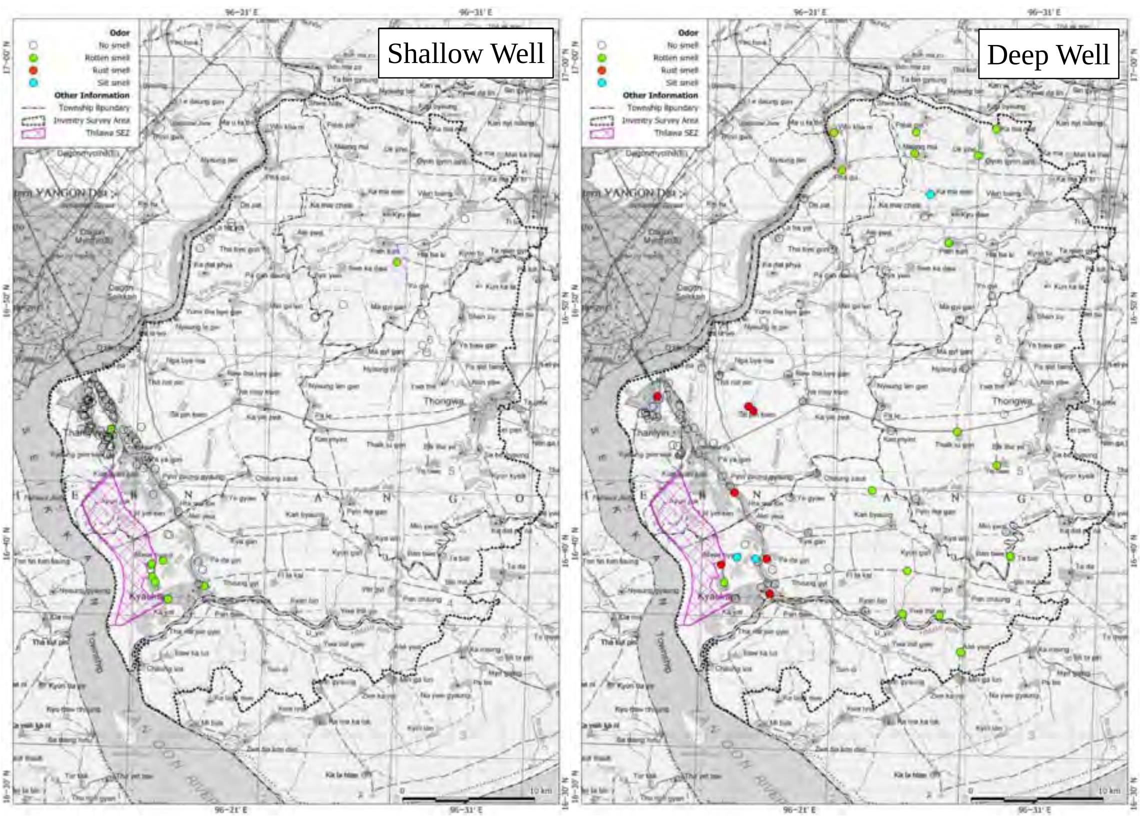


Figure 3-2-7-8 Distribution of Odor of Existing-Well Water (Dry Season, 2013)

3-2-8 Water Quality Test of Test Well

3-2-8-1 Outline

The following water quality tests were carried out on the test wells:

1) Analysis of samples taken in the pumping test
   (Analyzed in laboratories in Myanmar and Thailand)
2) Monthly analysis of samples taken with a tube sampler
   (Analyzed with instruments brought by the JICA team in Myanmar and in laboratory in Japan)
3) Isotopic Analysis of samples taken with submergible pump
   (In-situ measurement and analysis in IAEA laboratory)
4) Water quality test of test wells in SEZ by another JICA team

3-2-8-2 Water Quality Analysis of Samples Collected in Pumping Test

The contractor of test well work carried out sampling in the pumping test at every test well, and sent the sample to laboratories in Myanmar and Thailand for water quality analysis. The results are shown in Table 3-2-8-1.

Table 3-2-8-1 Results of Water Quality Analysis of Samples Taken in Pumping Test of Test Well

Item	Uniit / Well No. (Depth)	D-1-0 (52m)	D-1-1 (85m)	D-1-2 (150m)	D-1-3 (330m)	D-2-0 (56m)	D-2-1 (97m)	D-2-2 (150m)	D-2-3 (330m)	D-3-1 (80m)	D-3-2 (180m)	D-3-3 (330m)	D-4-1 (85m)	D-4-2 (146m)	D-5-1 (65m)	D-5-2 (100m)	D-5-3 (350m)	WHO Drinking Water Guideline Version 4, 2012 (or other guidelines)
pH		7.6	7.5	8.6	8.2	6.3	6.0	6.5	6.8	7.1	8.0	8.3	8.8	7.8	6.2	6.5	8.1	(6.5-8.5)*1
EC	μS/cm	283	351	234	262	54	44	210	291	3210	221	205	2750	1259	55	80	418	
Taste		Iron	Iron	Slightly iron	Slightly iron	Normal	Normal	Normal	Iron	Salty	Sulfuric	Iron	Sulfuric & salty	Salty	Iron	Iron	Iron	
Odor		Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Sulfuric	Normal	Sulfuric	Normal	Normal	Normal	Normal	
Color	TCU	90	60	nil	25	nil	nil	485	15	20	nil	nil	110	60	nil	30	5	(15TCU)*1
Turbidity	NTU	688	490	3	118	8	8	120	46	42	3	2	450	128	4	80	22	(5NTU)*4
Temperature	℃	-	29.7	31.1	33.5	28.4	28.7	30.0	31.8	29.7	31.5	36.7	30.5	32.3	29.8	30.0	-	
E. coli	MPN/100ml	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	
Total	MPN/100ml	>16	>16	9.2	>16	>16	>16	>16	>16	>16	2.2	>16	>16	>16	>16	>16	>16	
Fluoride	mg/l	0.08	0.06	0.02	0.06	0.02	0.02	0.02	0.06	0.06	0.06	0.04	0.04	0.04	0.06	0.05	0.09	1.5 mg/L
Ammonia	mg/l	0.19	0.12	nil	0.1	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	
Nitrate	mg/l	0.51	0.87	nil	0..59	0.12	nil	nil	0.11	0.03	nil	nil	nil	nil	0.09	nil	0.13	50 mg/L
Nitrite	mg/l	nil	nil	0.02	nil	0.002	0.003	0.004	nil	0.2	0.003	0.001	0.002	0.18	0.003	0.002	nil	3 mg/L
Hardness	mg/l as $CaCO_3$	154	222	118	108	28	18	52	104	700	14	58	900	1240	30	38	86	
Calcium	mg/l	32	34	32	30	6	10	18	24	56	6	14	80	36	6	10	26	
Iron	mg/l	>10	6	0.35	10	0.2	0.8	5	2.5	0.7	0.3	0.8	6	16	0.4	4	0.8	(0.3 mg/L)*1
Manganese	mg/l	0.02	0.02	nil	0.01	nil	nil	0.05	0.12	0.02	nil	nil	0.04	0.03	nil	0.02	0.05	(0.05 mg/L)*1
Chloride	mg/l	32	77	7	12	5	6	6	4	1700	4	4	1450	570	8	7	8	(250 mg/L)*1
Sulfate	mg/l	27	28	16	20	15	12	22	12	128	18	25	92	188	8	22	28	
Bicarbonate	mg/l	230	224	236	250	48	40	104	146	175	218	200	172	208	44	68	212	
Potassium	mg/l	7	6	4	4	5	5	3	4.16	17	3	5	25	8	5	5	4	
Sodium	mg/l	62	48	52	72	8	7	20	34	255	96	65	735	398	6	14	62	(200 mg/L)*2
Arsenic	mg/l	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	0.01 mg/L
Copper	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2mg/L
Lead	mg/l	nil	nil	0	nil	0	0	0	nil	nil	nil	nil	nil	nil	nil	nil	nil	0.01 mg/L
Zinc	mg/l	0	0.2	1.0	0.9	6.2	24.6	5.4	3.0	4.7	19.4	25.2	23.8	1.4	1.3	1.0	1.0	(1 or 5 mg/L)*3
Chromium	mg/l	0.07	0.03	0.01	0.03	0.01	0.02	0.04	0.02	0.02	0.01	0.02	0.03	0.06	0.01	0.02	0.02	0.05mg/L
Cadmium	mg/l	nil	nil	nil	nil	nil	0.02	nil	nil	nil	nil	nil	nil	nil	nil	nil	nd	0.003mg/L

3-2-8-3 Monthly Water Quality Analysis of Samples taken with a Tube Sampler

Water quality analysis was carried out monthly with instruments brought from Japan and in a laboratory in Japan. Table 3-2-8-2 shows items and methods for the analysis. A sample is collected with a tube sampler at the screen position of the well. Results are shown in Table 3-2-8-3 to Table 3-2-8-7.

Table 3-2-8-2 Item and Method of Monthly Water Quality Analysis of Test Wells

Item			Method	Measurement/Analysis Place	Sampling
Classifi-cation	No.	Name			
Physical	1	Odor	By nose	In-situ	-
	2	Taste	By tongue		
	3	Turbidity	Degital tubidity & color meter		
	4	Color index	〃		
	5	pH	Potable pH meter		
	6	EC	Portable EC meter		
	7	Temperature	Portable EC meter		
Micro-bial	8	Total Coliforms 1	Test Paper, 24 hours incubation	In labo.	100 ml sterlile bottle
	8	Total Coliforms 2	EC Plate, 24 hours incubation		
	9	E. coli	EC Plate, 48 hours incubation		
Chemical	10	Fluoride	Degital pack test kit and meter	In labo.	500 ml bottle
	11	Nitrate	〃		
	12	Nitrite	〃		
	13	Anmonia	〃		
	14	Iron	〃		
	15	Manganese	Pack test kit（High accraccy type)		
	16	Hardness	Degital pack test kit and meter		
	17	Chloride	〃		
	18	Sulfate	〃		
	19	Potassium	Portable potassium electrode		
	20	Sodium	Portable sodium electrode		
	21	Bicarbonate	Bicarbonate titration kit		
	22 ~ 27	Heavy metals（Arsenic,copper, lead, zinc,chromium, cadmium）	Authorized laboratory equipment	In Japan	500 ml bottle

Table 3-2-8-3 Result of Monthly Water Quality Analysis of D-1 Site Wells

Measure./ Analysis Place	No.	Items: Name	Unit \ Date (Well No. D-1-0)	30/01/2013	20/02/2013	18/03/2013	06/04/2013	03/06/2013	13/08/2013	17/09/2013	15/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor						-	-	-	-	-	-	-	-	-	-	-	
	2	Taste						Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	not tested	not tested	not tested	not tested	
	3	Turbidity	PTU					> 20	13.4	10.9	3	1.8	14	2.7	0.8	15	2	0	
	4	Color index						25	27.5	7	2.5	2.5	10	5.5	6	6	6	0	
	5	pH						7.32	7.5	7.94	7.3	7.44	7.17	7.53	6.71	7.58	6.89	7.9	(6.5 -8.5 recommened)
	6	EC	μS					454	768	477	540	565	569	551	585	583	590	536	(Maybe salty if over 750)
	7	Temperature	℃					29.0	32.0	29.0	30.7	31.5	29.9	29.3	31.7	32.0	32.8	29.9	
In labo. with incubator	8	Total Coliforms 1	CFU/ml					0	0	40	0	38	0	0	0	0	0	13	by Test Paper
	8	Total Coliforms 2	CFU/ml					0	0	0	0	0	0	0	1	0	18	6	by EC Plate
	9	E. coli	CFU/ml					0	0	0	0	0	0	0	0	0	0	6	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l					<0.4	0.72	<0.4	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l					< 0.02	>1	<0.02	<0.02	>1	0.496	>1	0.037	0.393	0.03	0.03	3 mg/l
	12	Nitrate (NO_3^-)	mg/l					< 1.0	1.1	1.8	0.121	< 1	< 1	< 1	< 1	< 1	< 1	< 1	50 mg/l
	13	Anmonium (NH_4^+)	mg/l					1.88	0.43	<0.2	0.5	0.44	1.02	1.3	0.58	1.92	1.94	1.46	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l					< 0.2	<0.2	<0.2	<0.2	<0.2	0.51	<0.2	0.2	0.24	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l					0.2	0.2	0.2	0.05	0.2	0.35	0.5	0.5	0.2	0.2	0.5	(<0.4mg recommened)
	16	Total Hardness	mg/l					90.0	>100	>100	102.0	>100	101.0	>100	90.0	78.0	86.0	89.0	
	17	Chloride (Cl^-)	mg/l					17.8	58	35	48	25.3	18.8	24	35	24	28	29	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l					< 20	49	<10	<10	<10	10	16	42	<10	12	<10	
	19	Potassium (K^+)	mg/l					3.1	4.9	5	6.3	5.2	5.5	7	5.1	4.1	5.5	9	
	20	Sodium (Na^+)	mg/l					14.1	33.0	10.5	19.9	20.0	20.0	22.0	29.0	35.0	44.0	30.0	
	21	Bicarbonate (HCO_3^-)	mg/l					153	218	196	153	196	218	218	196	174	218	218	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l					**0.002**	**0.001**	<0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l					<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l					0.003	<0.001	**0.004**	<0.001	**0.011**	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l					**0.02**	<0.01	**0.08**	**0.04**	**0.11**	<0.01	**0.01**	**0.01**	**0.02**	<0.01	**0.06**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l					<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	No.	Items: Name	Unit \ Date (Well No. D-1-1)	30/01/2013	20/02/2013	18/03/2013	06/04/2013	03/06/2013	13/08/2013	17/09/2013	15/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor					-	-	-	-	-	-	-	-	-	-	-	-	
	2	Taste					Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	not tested	not tested	not tested	not tested	
	3	Turbidity	PTU				158	5	4	7.7	5	4.7	3.9	1.3	4.9	7.3	5	0	
	4	Color index					22.5	8.5	50	47	5.5	36	26	14.5	9	6.5	10	0	
	5	pH					6.94	7.72	7.6	8.1	7.57	7.73	8.01	7.66	7.72	7.76	7.59	7.95	(6.5 -8.5 recommened)
	6	EC	μS				386	480	820	450	511	524	505	467	475	478	425	444	(Maybe salty if over 750)
	7	Temperature	℃				30	27.6	26.8	29.2	30.5	31.0	29.9	29.3	31.0	31.2	32.6	29.9	
In labo. with incubator	8	Total Coliforms 1	CFU/ml				0	80	6	0	0	2	1	0	0	0	0	24	by Test Paper
	8	Total Coliforms 2	CFU/ml				0	43	3	0	0	0	0	0	0	0	0	48	by EC Plate
	9	E. coli	CFU/ml				0	0	0	0	0	0	0	0	0	0	0	0	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l				< 0.4	< 0.4	0.86	<0.4	0.49	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l				< 0.02	0.105	<0.02	0.063	0.035	< 0.02	0.194	0.203	0.175	0.025	<0.02	<0.02	3 mg/l
	12	Nitrate (NO_3^-)	mg/l				< 1	< 1.0	2.7	<1	0.63	< 1	< 1	< 1	< 1	< 1	< 1	< 1	50 mg/l
	13	Anmonium (NH_4^+)	mg/l				3.02	0.5	1.2	0.72	0.56	0.84	0.76	1.11	0.68	2.54	0.89	2.04	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l				< 0.2	0.58	<0.2	<0.2	<0.2	<0.2	0.53	<0.2	0.24	<0.2	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l				0.1	0.1	0.2	0.2	<0.02	0.075	0.1	0.2	0.05	0.1	0.1	0.05	(<0.4mg recommened)
	16	Total Hardness	mg/l				73	> 100	77	>100	>100	>100	>100	>100	>100	69.0	85.0	97.0	
	17	Chloride (Cl^-)	mg/l				36.1	16.8	72	25	35	23.2	12.3	9.9	9	5.7	5.7	8.5	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l				< 10	< 20	17	29	12	<10	20	15	<10	<10	19	<10	
	19	Potassium (K^+)	mg/l				5.9	77	4.4	3.5	5.2	14	4.4	6.2	3.7	4.8	5.1	5.5	
	20	Sodium (Na^+)	mg/l				14	9.2	17.1	7.9	16.3	14.8	17.9	18.7	20.0	26.0	26.0	18.1	
	21	Bicarbonate (HCO_3^-)	mg/l				196	196	174	196	218	196	196	218	196	196	196	218	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l				**0.015**	**0.002**	**0.003**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**	**0.001**	**0.001**	0.01 mg/l
	23	Copper (Cu)	mg/l				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l				<0.001	<0.001	**0.012**	**0.004**	<0.001	**0.007**	**0.005**	**0.003**	**0.003**	<0.001	<0.001	**0.001**	0.01 mg/l
	25	Zinc (Zn)	mg/l				**1.6**	<0.01	**0.66**	**0.56**	**0.35**	**0.65**	**1.1**	**1.1**	**0.93**	**0.73**	**0.71**	**0.56**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l				<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l				<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	No.	Items: Name	Unit \ Date (Well No. D-1-2)	30/01/2013	20/02/2013	18/03/2013	06/04/2013	03/06/2013	13/08/2013	17/09/2013	15/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU	0	7.4	4.2	0.9	4.5	30	5.2	12.8	8.1	7	325	1.3	2.8	2	0	
	4	Color index		0	7.5	5.5	4.0	9.5	21	17	14.5	12	>50	34.5	17	29	17	0	
	5	pH		7.68	8.14	8.05	7.68	7.56	7.6	7.5	7.16	7.23	7.35	7.8	7.7	7.66	7.9	8.05	(6.5 -8.5 recommened)
	6	EC	μS	456	506	374	354	476	634	358	370	387	332	276	388	478	398	426	(Maybe salty if over 750)
	7	Temperature	℃	30.1	30.1	32.8	30.0	29.0	27.2	29.8	31.7	32.5	30.1	29.2	32.4	31.5	33.2	29.9	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	1	0	28	0	5	1	0	0	72	21	34	0	0	0	190	by Test Paper
	8	Total Coliforms 2	CFU/ml	0	96	5	0	0	4	1	0	10	0	1	7	0	20	468	by EC Plate
	9	E. coli	CFU/ml	1	0	0	7	0	0	0	0	0	1	0	3	0	0	0	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	<0.4	1.02	0.54	< 0.4	1.08	<0.4	0.48	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	0.02	0.053	< 0.02	< 0.02	0.035	<0.02	<0.02	<0.02	0.021	0.156	<0.02	0.035	0.07	<0.02	<0.02	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.4	<1	<0.2	<1	<1	4.1	<1	<1	<1	<1	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	0.33	0.94	0.51	1.77	1.25	0.23	<0.2	0.4	0.34	0.19	1.39	0.78	2.31	1.43	0.86	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	0.2	<0.2	> 5 (?)	< 0.2	< 0.2	<0.2	<0.2	<0.2	<0.2	0.33	<0.2	<0.2	<0.2	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	0.3	0.05	0.2	< 0.02	0.02	0.1	0.2	0.1	0.2	0.035	<0.02	0.1	0.2	0.05	0.02	(<0.4mg recommened)
	16	Total Hardness	mg/l	92	73	< 20	> 100	90	104.0	102.0	>100	101.0	98.0	75.0	>100	71.0	66.0	88.0	
	17	Chloride (Cl^-)	mg/l	27	31.5	12.1	< 2	15.8	26	14.2	18	6.3	<2	8.9	7.2	6.1	4.7	3.7	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	<10	<10	> 100	< 10	< 20	26	44	16	< 10	44	<10	49	23	<10	<10	
	19	Potassium (K^+)	mg/l	3.9	2.2	5.9	2.9	3.8	1.78	2.4	4.6	3.1	2.3	2.3	2.1	2.6	3.5	8.7	
	20	Sodium (Na^+)	mg/l	45	20	17.1	17.7	12.5	18.7	10.4	15.1	15.8	15.1	34.0	24.0	23.0	41.0	32.0	
	21	Bicarbonate (HCO_3^-)	mg/l	174	218	109	240	153	153	174	131	153	131	109	131	109	218	218	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	**0.003**	**0.003**	**0.002**	**0.003**	**0.002**	**0.002**	<0.001	**0.002**	**0.002**	**0.001**	**0.003**	**0.003**	**0.002**	**0.001**	**0.002**	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	**0.006**	**0.004**	<0.001	**0.043**	**0.008**	**0.012**	**0.003**	**0.001**	<0.001	**0.001**	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.01**	**0.01**	**0.002**	**0.004**	**0.02**	**0.06**	**0.03**	**0.04**	**0.11**	**0.04**	**0.06**	**0.02**	<0.01	<0.01	**0.02**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	No.	Items: Name	Unit \ Date (Well No. D-1-3)	30/01/2013	20/02/2013	18/03/2013	06/04/2013	03/06/2013	13/08/2013	17/09/2013	15/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor							-	-	-	-	-	-	-	-	-	-	
	2	Taste							Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU						0	105	2.6	1.9	340	500	13.5	20	14	225	
	4	Color index							0	24	1.5	0	31.5	0	10	11.5	18	38.5	
	5	pH							9.0	8.95	8.64	9.04	9.18	9.21	9.18	9.25	9.15	9.39	(6.5 -8.5 recommened)
	6	EC	μS						686	375	428	437	464	426	413	416	420	462	(Maybe salty if over 750)
	7	Temperature	℃						26	29.9	30.3	31.7	30.1	29.5	31.9	32.8	32.0	30.1	
In labo. with incubator	8	Total Coliforms 1	CFU/ml						1	4	0	0	4	38	0	0	1	4	by Test Paper
	8	Total Coliforms 2	CFU/ml						0	0	0	1	0	28	1	0	46	8	by EC Plate
	9	E. coli	CFU/ml						0	0	0	0	0	28	0	0	0	5	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l						<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l						0.02	0.023	1.01	<0.02	0.161	<0.02	<0.02	<0.02	<0.02	<0.02	3 mg/l
	12	Nitrate (NO_3^-)	mg/l						1.5	1	<0.2	<1	<1	<1	<1	<1	<1	<1	50 mg/l
	13	Anmonium (NH_4^+)	mg/l						0.28	0.68	0.7	<0.2	0.34	0.83	<0.2	0.95	0.71	<0.2	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l						0.42	<0.2	<0.2	<0.2	0.39	<0.2	<0.2	<0.2	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l						<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	(<0.4mg recommened)
	16	Total Hardness	mg/l						31	53.0	>100	67.0	26.0	45.0	42.0	33.0	35.0	31.0	
	17	Chloride (Cl^-)	mg/l						6.4	85	9.5	<2	<2	3.8	5.9	4.3	4.8	5	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l						<10	<10	28	< 10	41	< 10	< 10	11	<10	<10	
	19	Potassium (K^+)	mg/l						1.78	1.92	3.5	2.9	1.56	2.7	1.57	2	2.2	3.1	
	20	Sodium (Na^+)	mg/l						37	16.8	29.0	35.0	54.0	52.0	46.0	82.0	83.0	41.0	
	21	Bicarbonate (HCO_3^-)	mg/l						196	196	196	174	174	196	153	174	218	196	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l						**0.004**	**0.002**	<0.001	<0.001	**0.011**	**0.023**	<0.001	<0.001	**0.002**	**0.001**	0.01 mg/l
	23	Copper (Cu)	mg/l						<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l						<0.001	**0.003**	<0.001	**0.005**	**0.008**	**0.025**	<0.001	<0.001	**0.001**	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l						<0.01	**2.6**	**0.24**	**1.4**	**5.1**	**1.7**	**0.08**	**0.22**	**7.7**	**3.5**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l						<0.005	<0.005	<0.005	<0.005	**0.011**	**0.025**	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l						<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Table 3-2-8-4 Result of Monthly Water Quality Analysis of D-2 Site Wells

Measure./ Analysis Place	Items		Well No.	D-2-0											Remarks/WHO Guideline Value
	No.	Name	Unit \ Date	18/07/2013	14/08/2013	17/09/2013	17/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not tested	Not tested	Not tested	Not tested	Not tested	not tested	not tested	not tested	not tested	not tested	not tested	
	3	Turbidity	PTU	16.6	2.2	4.7	2.3	3.4	3.6	4	0	1	0	150	
	4	Color index		4	2.5	0.5	2	0	3.5	2.5	0	0	0	6.5	
	5	pH		5.89	6.0	6.33	5.96	5.74	5.75	5.4	5.6	5.92	5.5	5.71	(6.5 -8.5 recommened)
	6	EC	µS	124	113	76.8	66.8	75	60.2	54.2	57.8	61.7	58	58.8	(Maybe salty if over 750)
	7	Temperature	℃	30.6	32.1	29.7	27.7	29.4	29.4	29.1	30.2	33.8	32.8	28.7	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	16	0	75	59	114	10	70	Nil	Nil	124	49	by Test Paper
	8	Total Coliforms 2	CFU/ml	5	0	555	510	223	15	187	5	Nil	231	13	by EC Plate
	9	E. coli	CFU/ml	5	0	0	0	0	7	165	Nil	Nil	6	12	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	<1	<1	<0.2	<1	<1	<1	<1	2.3	<1	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	0.25	<0.2	0.33	0.39	1.04	1.67	0.32	0.22	2.02	1.27	<0.2	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	0.33	<0.2	<0.2	<0.2	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	0.2	<0.02	0.2	0.2	0.5 (?)	0.02	0.5	0.05	0.2	<0.02	0.02	(<0.4mg recommened)
	16	Total Hardness	mg/l	34.0	39.0	>100	32.0	28.0	20.0	<20	<20	<20	21.0	23.0	
	17	Chloride (Cl^-)	mg/l	6.8	5.4	6.8	6.4	<2	<2	3.5	5.1	4.2	3.6	4.9	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	<10	34	48	20	<10	28	<10	11	<10	<10	26	
	19	Potassium (K^+)	mg/l	3.8	3.9	5.4	4.3	4.3	4.4	5.3	3.3	5.2	4.7	5.4	
	20	Sodium (Na^+)	mg/l	2.2	2.1	0.8	5.2	4.7	5.3	6.0	6.6	8.0	7.6	7.8	
	21	Bicarbonate (HCO_3^-)	mg/l	65	44	87	44	44	22	22	22	44	22	44	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	**0.012**	**0.011**	**0.001**	**0.002**	**0.010**	**0.001**	**0.001**	**0.013**	**0.024**	**0.003**	**0.008**	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.1**	**0.04**	**0.05**	**0.08**	**0.08**	**0.05**	**0.04**	**0.08**	**0.21**	**0.05**	**0.04**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	**0.006**	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	Items		Well No.	D-2-1											Remarks/WHO Guideline Value
	No.	Name	Unit \ Date	18/07/2013	14/08/2013	17/09/2013	17/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not tested	Not tested	Not tested	Not tested	Not tested	not tested	not tested	not tested	not tested	not tested	not tested	
	3	Turbidity	PTU	5.1	1.3	16.6	13.7	2.2	4.5	3.1	90	3	14	0	
	4	Color index		4	5	13	6.5	0.5	3.5	1.5	9	0	8	0	
	5	pH		5.68	5.5	6.58	6.12	5.94	5.72	5.68	5.76	6	5.78	5.79	(6.5 -8.5 recommened)
	6	EC	µS	95	135	72.2	100.1	96.9	77.8	75.7	75.9	75.7	75.9	72.7	(Maybe salty if over 750)
	7	Temperature	℃	30.9	31.6	28.9	27.6	29.1	29.7	28.7	30.0	34.8	32.1	28.7	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	1	25	41	48	34	129	62	8	0	Nil	223	by Test Paper
	8	Total Coliforms 2	CFU/ml	1	6	53	9	35	133	159	24	0	6	8	by EC Plate
	9	E. coli	CFU/ml	0	0	0	0	17	8	154	20	0	Nil	4	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	1.2	<1	<0.2	<1	<1	<1	<1	<1	<1	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	1.4	0.32	0.48	0.7	0.46	0.25	<0.2	1.65	3.78	2.13	<0.2	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	0.05	0.02	<0.02	0.02	0.05	0.02	0.1	0.05	0.05	0.02	0.02	(<0.4mg recommened)
	16	Total Hardness	mg/l	20	39.0	44.0	>100	27.0	<20	<20	<20	<20	<20	32.0	
	17	Chloride (Cl^-)	mg/l	8.2	5.3	6.3	9.7	<2	<2	4.9	4.5	3.9	4.1	4.6	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	29	9	23	9	<10	14	<10	<10	<10	12	16	
	19	Potassium (K^+)	mg/l	4.1	15.6	2.6	6.1	5.2	4.9	6.3	3.6	4.1	5.1	7.9	
	20	Sodium (Na^+)	mg/l	1.74	2.6	1.4	5.9	4.8	6.6	8.7	5.7	7.9	7.5	5.7	
	21	Bicarbonate (HCO_3^-)	mg/l	65	44	65	44	44	44	44	22	44	22	44	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	<0.001	**0.007**	**0.029**	**0.014**	**0.036**	**0.006**	**0.006**	**0.005**	**0.002**	**0.006**	**0.005**	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.2**	**0.12**	**0.1**	**0.17**	**0.14**	**0.07**	**0.04**	**0.03**	**0.08**	**0.41**	**0.03**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	**0.008**	<0.005	<0.005	**0.006**	**0.008**	**0.008**	**0.009**	<0.005	**0.007**	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	Items		Well No.	D-2-2											Remarks/WHO Guideline Value
	No.	Name	Unit \ Date	18/07/2013	14/08/2013	17/09/2013	17/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	
	3	Turbidity	PTU	>50	190	7.9	4.1	2.5	195	5.2	0.2	70	85	0	
	4	Color index		0	50	>50	3.5	5	15	27	3.5	>50	>50	6.5	
	5	pH		6.36	6.3	6.87	6.51	6.41	6.4	6.44	6.5	6.58	6.5	6.51	(6.5 -8.5 recommened)
	6	EC	µS	298	314	206	249	257	213	232	232	226	240	219	(Maybe salty if over 750)
	7	Temperature	℃	30.9	31.0	28.8	27.7	29.3	29.7	29.1	30.4	35.1	33.1	28.7	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	4	1	7	0	106	10	56	7	9	68	122	by Test Paper
	8	Total Coliforms 2	CFU/ml	7	0	7	0	49	5	71	11	17	2	141	by EC Plate
	9	E. coli	CFU/ml	4	0	0	0	0	0	11	Nil	0	Nil	33	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	<0.4	<1	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	<0.02	0.047	<0.02	<0.02	<0.02	0.043	<0.02	<0.02	<0.02	<0.02	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	<1	<1	<0.2	<1	<1	<1	<1	<1	<1	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	0.24	0.43	<0.2	0.68	<0.4	<0.2	0.85	0.43	<0.2	0.84	<0.2	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	<0.2	<0.2	<0.2	0.24	0.48	<0.2	<0.2	<0.2	0.71	3.81	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	0.2	0.2	1.0 (?)	<0.02	0.035	0.5(?)	1.0(?)	1.0(?)	<0.02	1.0(?)	0.05	(<0.4mg recommened)
	16	Total Hardness	mg/l	51	60.0	74.0	49.0	66.0	67.0	47.0	56.0	39.0	46.0	54.0	
	17	Chloride (Cl^-)	mg/l	7.2	5.8	2.1	8.1	<2	10.4	6.3	4.5	3.7	4.1	4.5	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	24	12	17	<10	<10	<10	37	20	<10	<10	<10	
	19	Potassium (K^+)	mg/l	4.1	2.7	2	3.3	3	2.9	3.6	2.2	10.9	2.9	3.7	
	20	Sodium (Na^+)	mg/l	4	4.1	2.7	9.2	10.2	12.7	14.1	10.2	14.1	14.4	8.3	
	21	Bicarbonate (HCO_3^-)	mg/l	87.2	44	87	109	87	65	87	109	87	87	87	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	**0.003**	**0.002**	<0.001	**0.002**	**0.003**	**0.002**	**0.002**	**0.002**	**0.002**	**0.001**	**0.002**	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	**0.002**	**0.003**	**0.001**	<0.001	**0.009**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.25**	**0.16**	**0.18**	**0.16**	**0.24**	**0.02**	**0.14**	**0.05**	**0.01**	<0.01	**0.03**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	Items		Well No.	D-2-3											Remarks/WHO Guideline Value
	No.	Name	Unit \ Date	18/07/2013	14/08/2013	17/09/2013	17/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	
In-situ	1	Odor					-	-	-	-	-	-	-	-	
	2	Taste					Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	
	3	Turbidity	PTU				18.8	6.6	>500	3.9	230	280	100	8.9	
	4	Color index					31	25.5	26	6.5	0	0	14	>50	
	5	pH					7.32	7.41	6.76	8.57	6.31	6.56	6.5	6.82	(6.5 -8.5 recommened)
	6	EC	µS				400	396	235	296	239	217	280	247	(Maybe salty if over 750)
	7	Temperature	℃				27.8	29.1	29.6	29..2	30.5	35.2	31.0	28.8	
In labo. with incubator	8	Total Coliforms 1	CFU/ml				0	0	73	18	3	1	Nil	101	by Test Paper
	8	Total Coliforms 2	CFU/ml				0	0	288	381	140	67	52	382	by EC Plate
	9	E. coli	CFU/ml				0	0	18	20	Nil	3	Nil	8	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l				0.56	<0.4	<0.4	<0.4	0.72	<0.4	<0.4	0.59	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l				<0.02	0.024	0.029	<0.02	<0.02	<0.02	<0.02	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l				<0.2	<1	<1	<1	<1	<1	<1	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l				0.39	<0.2	0.81	0.22	<0.2	0.3	1.08	<0.2	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l				<0.2	<0.2	<0.2	<0.2	0.5	0.47	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l				0.1	0.1	0.5(?)	0.05	0.5(?)	0.05	0.05	0.5(?)	(<0.4mg recommened)
	16	Total Hardness	mg/l				<20	<20	30.0	64.0	<20	<20	52.0	<20	
	17	Chloride (Cl^-)	mg/l				8.1	<2	<2	3.9	4.3	3.8	3.9	5.1	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l				51	<10	<10	<10	21	<10	11	<10	
	19	Potassium (K^+)	mg/l				4.3	3.8	2.8	4.3	2.1	2.7	3.5	3.9	
	20	Sodium (Na^+)	mg/l				16.2	20	13.1	17.4	12.6	5.0	22.0	11.6	
	21	Bicarbonate (HCO_3^-)	mg/l				196	153	87	109	87	87	109	131	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l				<0.001	<0.001	**0.003**	<0.001	**0.001**	**0.001**	<0.001	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l				<0.001	**0.004**	**0.005**	<0.001	**0.001**	**0.002**	<0.001	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l				**5.9**	**9.7**	**13**	**1.2**	**6.3**	**5.5**	**7.5**	**15**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l				<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l				<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Table 3-2-8-5 Result of Monthly Water Quality Analysis of D-3 Site Wells

Measure./ Analysis Place	No.	Name	Un \ Date	10/07/2013	14/08/2013	18/09/2013	18/10/2013	15/11/2013	12/12/2013	14/01/2014	20/02/2014	18/03/2014	21/04/2014	23/05/2014	Remarks/WHO Guideline Value
		Items	Well No.	D-3-1											
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU	8.6	3	4.8	6	3.4	5.2	2	10.6	13.5	2.3	0	
	4	Color index		35.5	44.6	29	29	1	25.5	17	24	21.5	16	11	
	5	pH		6.63	5.8	7.5	7.44	7.23	7.63	7.3	7.15	7.21	7.44	7.52	(6.5 -8.5 recommened)
	6	EC	μS/cm	1024	1654	2090	2420	2160	2270	1886	2360	1918	1565	1694	(Maybe salty if over 750)
	7	Temperature	℃	28.5	32.0	26.9	29.2	32.9	33.8	30.5	32.2	34.5	34.5	30.2	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	40	20	1	2	0	0	0	11	0	Nil	32	by Test Paper
	8	Total Coliforms 2	CFU/ml	47	0	4	0	47	1	2	1	5	Nil	28	by EC Plate
	9	E. coli	CFU/ml	0	0	0	2	1	0	0	Nil	1	Nil	Nil	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	<0.4	0.67	<0.4	<0.4	<0.4	<0.4	0.57	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	0.116	>1	>1	>1	0.081	0.488	0.376	<0.02	<0.027	<0.02	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	2.2	0.33	<0.2	<1	<1	<1	<1	<1	1.6	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	0.84	<0.2	0.7	2.58	2.95	0.19	2.36	3.11	2.34	2.49	2.55	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	0.48	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	0.2	0.5 (?)	1.0 (?)	1.0 (?)	0.75 (?)	<0.02	1.0(?)	1.0(?)	0.5(?)	1.0(?)	0.5(?)	(<0.4mg recommened)
	16	Total Hardness	mg/l	80	>100	>100	>20	>100	>100	>100	>100	56.0	>100	>100	
	17	Chloride (Cl^-)	mg/l	300	410	660	610	383	9.1(?)	420	480	330	250	330	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	<10	21	<10	24	<10	28	55	33	<10	<10	<10	
	19	Potassium (K^+)	mg/l	25	14.5	12.6	21	17	18.1	20	12.7	16.2	15.6	17.4	
	20	Sodium (Na^+)	mg/l	0.5	69.0	78.0	103.0	129.0	159.0	110.0	143.0	22.0	110.0	73.0	
	21	Bicarbonate (HCO_3^-)	mg/l	109	109	109	153	131	153	131	131	131	131	153	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	**0.002**	<0.001	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	**0.015**	**0.003**	<0.001	<0.001	**0.026**	**0.003**	**0.002**	**0.003**	<0.001	<0.001	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.45**	**0.04**	**0.02**	**0.03**	**0.14**	**0.03**	**0.04**	**0.03**	<0.01	<0.01	**0.01**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	No.	Name	Un \ Date	10/07/2013	14/08/2013	18/09/2013	18/10/2013	15/11/2013	12/12/2013	14/01/2014	20/02/2014	18/03/2014	21/04/2014	23/05/2014	Remarks/WHO Guideline Value
		Items	Well No.	D-3-2											
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU	9.3	1.6	170	5.2	2.5	>20	1.4	0	1.6	0	0	
	4	Color index		9.0	4.5	26	5.5	0	12.5	1	1.5	1.5	2	0	
	5	pH		7.40	7.9	8.47	7.93	7.94	8.54	7.97	7.89	7.92	8.3	8.01	(6.5 -8.5 recommened)
	6	EC	μS/cm	484	525	434	433	459	457	439	471	463	448	454	(Maybe salty if over 750)
	7	Temperature	℃	29.8	32.4	26.7	28.8	32.0	33.3	30.2	32.2	35.9	35.1	30.9	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	100	1	1	3	0	0	5	20	0	3	2	by Test Paper
	8	Total Coliforms 2	CFU/ml	14	0	10	10	3	89	6	54	8	Nil	89	by EC Plate
	9	E. coli	CFU/ml	0	0	0	0	1	0	0	0	0	Nil	Nil	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	0.5	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.028	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	1.7	<1	<0.2	<1	<1	<1	<1	<1	2.4	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	<0.2	<0.2	<0.2	0.35	0.4	3.02	<0.2	1.15	0.3	<0.2	0.6	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	0.32	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.23	0.21	0.41	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	<0.02	<0.02	<0.02	0.02	0.02	<0.02	0.02	0.05	<0.02	<0.02	0.02	(<0.4mg recommened)
	16	Total Hardness	mg/l	22	<20	<20	>20	24.0	<20	28.0	23.0	27.0	63.0	30.0	
	17	Chloride (Cl^-)	mg/l	8.3	14.8	6.4	10	5	6.8	5	17.4	8.9	6.9	10.9	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	<10	<10	<10	12	<10	11	42	<10	<10	<10	<10	
	19	Potassium (K^+)	mg/l	29	3.4	2.3	3.8	3.4	3.4	4.6	2	3	4.5	5.8	
	20	Sodium (Na^+)	mg/l	0.7	36.0	30.0	57.0	63.0	79.0	77.0	25.0	23.0	73.0	57.0	
	21	Bicarbonate (HCO_3^-)	mg/l	196	174	196	174	174	218	174	174	174	174	240	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	0.007	**0.006**	**0.006**	**0.005**	**0.005**	**0.006**	**0.005**	**0.005**	**0.006**	**0.006**	**0.005**	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	<0.001	**0.003**	**0.001**	**0.002**	**0.011**	**0.001**	**0.004**	**0.006**	**0.002**	<0.001	**0.004**	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.04**	**0.1**	**0.08**	**0.18**	**0.4**	**0.04**	**0.16**	**0.17**	**0.06**	**0.01**	**0.1**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	No.	Name	Un \ Date	10/07/2013	14/08/2013	18/09/2013	18/10/2013	15/11/2013	12/12/2013	14/01/2014	20/02/2014	18/03/2014	21/04/2014	23/05/2014	Remarks/WHO Guideline Value
		Items	Well No.	D-3-3											
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU	>50	190	4.2	7.3	160	6.2	1.4	230	45	>500	2	
	4	Color index		>50	0	1.5	8	12.5	6	1	29.5	11.5	0	0	
	5	pH		7.71	9.3	9.3	9.26	9.83	10.09	9.88	9.53	9.43	9.84	8.29	(6.5 -8.5 recommened)
	6	EC	μS/cm	407	429	378	349	338	349	322	337	335	327	327	(Maybe salty if over 750)
	7	Temperature	℃	28.5	32.4	26.7	28.7	33.1	34.7	30.2	33.2	35.4	34.7	30.5	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	50	15	0	4	0	4	8	55	0	4	38	by Test Paper
	8	Total Coliforms 2	CFU/ml	1	3	7	69	0	4	21	3	54	114	73	by EC Plate
	9	E. coli	CFU/ml	0	0	0	0	0	0	0	0	0	Nil	Nil	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.2	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	<0.02	0.022	0.024	<0.02	<0.02	0.032	<0.02	<0.02	<0.02	0.058	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	<10	<1	<0.2	<1	<1	<1	<1	<1	<1	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	<0.2	<0.2	<0.2	0.29	<0.2	<0.2	<0.2	<0.2	<0.2	0.23	<0.2	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	0.37	0.43	0.35	<0.2	0.24	<0.2	<0.2	0.26	<0.2	0.49	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	(<0.4mg recommened)
	16	Total Hardness	mg/l	68	56.0	61.0	45.0	26.0	58.0	32.0	<20	49.0	20.0	27.0	
	17	Chloride (Cl^-)	mg/l	7.8	6.4	6.1	25	<2	6.2	2.9	4.2	4.2	5.5	7.3	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	<10	<10	9	59	23	26	27	<10	<10	<10	<10	
	19	Potassium (K^+)	mg/l	27	4.4	3	4.8	4.3	4.3	6.9	3.1	4.1	4.7	5.3	
	20	Sodium (Na^+)	mg/l	0.8	26.0	24.0	38.0	45.0	65.0	41.0	21.0	14.4	63.0	49.0	
	21	Bicarbonate (HCO_3^-)	mg/l	174.4	153	196	153	131	131	131	131	131	131	131	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	<0.001	**0.003**	<0.001	<0.001	**0.002**	**0.001**	**0.001**	**0.002**	**0.001**	**0.003**	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	<0.001	**0.005**	**0.001**	<0.001	**0.011**	**0.004**	**0.003**	**0.004**	**0.002**	**0.002**	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.68**	**0.19**	**0.74**	**0.31**	**2.8**	**2.0**	**3.0**	**2.3**	**1.6**	**7.3**	**0.6**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	<0.005	<0.005	**0.008**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Table 3-2-8-6 Result of Monthly Water Quality Analysis of D-4 Site Wells

Measure./ Analysis Place	Items No.	Items Name	Well No. Unit \ Date	D-4-1 18/07/2013	14/08/2013	18/09/2013	17/10/2013	15/11/2013	12/12/2013	14/01/2014	20/02/2014	18/03/2014	21/04/2014	23/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not tested	Not tested	Not tested	Not tested	Not tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU	4.8	65	4.9	14.7	5	150	2.8	1.2	150	2.4	0	
	4	Color index		15.5	>50	16.5	7	8.5	>50	4	11.5	35	4	6	
	5	pH		6.86	6.6	7.15	6.93	6.93	7.04	6.89	7.01	6.96	7.06	6.9	(6.5 -8.5 recommened)
	6	EC	μS/cm	4170	4180	4290	4540	4660	4890	4680	4650	4050	3250	4350	(Maybe salty if over 750)
	7	Temperature	℃	30.0	30.6	28.3	28.3	30.8	33.0	27.8	30.2	32.7	30.4	29.8	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	23	4	10	0	0	3	4	Nil	1	Nil	45	by Test Paper
	8	Total Coliforms 2	CFU/ml	13	0	70	0	0	32	7	95	Nil	2	506	by EC Plate
	9	E. coli	CFU/ml	10	0	9	0	0	Nil	7	1	Nil	Nil	Nil	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	0.52	0.62	<0.4	<0.4	<0.4	<0.4	0.58	<0.4	0.63	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	<0.02	0.073	0.035	0.029	0.065	0.325	0.038	<0.02	<0.02	0.052	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	<1	<1	<0.2	<1	<1	1.8	<1	<1	<1	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	4.02	>5	>5	>5	>5	>5	>5	>5	>5	>5	>5	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.51	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	0.05	0.02	0.1	0.2	<0.02	0.1	0.1	0.1	0.02	<0.02	0.05	(<0.4mg recommened)
	16	Total Hardness	mg/l	90	>100	>100	>20	>100	>100	>100	32.0	>100	102.0	>100	
	17	Chloride (Cl^-)	mg/l	1380	2400	2240	2400	8.3(?)	16.5(?)	1560	1470	1430	1410	1470	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	<10	13	<10	<10	<10	<10	21	<10	<10	62	26	
	19	Potassium (K^+)	mg/l	23	30	18.5	31	25	28	36	21	24	33	32	
	20	Sodium (Na^+)	mg/l	185	260	200.0	270	350	320.0	320.0	0.2(g/l)	177.0	0.52(g/l)	0.29g/l)	
	21	Bicarbonate (HCO_3^-)	mg/l	153	109	153	131	153	174	131	153	131	153	153	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	<0.001	**0.002**	<0.001	0.002	**0.002**	<0.001	<0.001	**0.002**	**0.004**	**0.003**	**0.002**	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	<0.001	**0.001**	<0.001	<0.001	**0.003**	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.65**	**0.42**	**0.08**	**0.07**	**0.15**	**0.02**	**0.07**	**0.04**	<0.01	**0.01**	**0.02**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	Items No.	Items Name	Well No. Unit \ Date	D-4-2 18/07/2013	14/08/2013	18/09/2013	17/10/2013	15/11/2013	12/12/2013	14/01/2014	20/02/2014	18/03/2014	21/04/2014	23/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not tested	Not tested	Not tested	Not tested	Not tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU	0	20	4.6	4.9	2.3	7.6	4.2	0.2	3	10.6	1	
	4	Color index		0.0	16.5	2.5	4.5	3.5	13.5	3.5	6	4	8	6	
	5	pH		7.44	7.6	7.98	7.74	7.87	8.06	7.71	7.65	7.82	7.73	7.65	(6.5 -8.5 recommened)
	6	EC	μS/cm	2160	2140	2340	2660	2560	5540	4750	3280	2780	3150	3130	(Maybe salty if over 750)
	7	Temperature	℃	30.0	31.0	28.8	27.3	31.2	32.8	29.4	30.6	33.0	32.8	30.1	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	0	15	3	0	0	0	10	22	Nil	3	Nil	by Test Paper
	8	Total Coliforms 2	CFU/ml	0	0	14	0	0	2	23	1	10	2	4	by EC Plate
	9	E. coli	CFU/ml	0	0	0	0	0	0	0	0	Nil	2	Nil	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	<0.4	<0.4	0.62	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	0.686	>1	>1	>1	>1	>1	>1	<0.02	0.281	0.055	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	<1	<0.2	<0.2	<1	<1	<1	<1	<1	<1	-	50 mg/l
	13	Anmonium (NH_4^+)	mg/l	4	<0.2	<0.2	1.76	1.22	>5	4.42	2.28	2.1	4.16	2.8	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.05	<0.02	0.05	0.05	(<0.4mg recommened)
	16	Total Hardness	mg/l	<100	>100	>100	>20	>100	>100	>100	>100	>100	>100	90.0	
	17	Chloride (Cl^-)	mg/l	640	840	>40	1040	37.3(?)	13.4(?)	1360	860	720	960	940	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	<10	<10	21	16	<10	11	26	19	16	28	17	
	19	Potassium (K^+)	mg/l	5.6	6.7	4.9	11.3	6.4	20	24	20	7.9	13.5	12.5	
	20	Sodium (Na^+)	mg/l	90	80	148	199	220	450	380	166	67	0.41(g/l)	0.25(g/l)	
	21	Bicarbonate (HCO_3^-)	mg/l	153	109	153	153	131	218	174	196	174	196	196	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	**0.003**	**0.003**	**0.002**	**0.003**	**0.003**	**0.002**	**0.002**	**0.002**	**0.003**	**0.003**	**0.004**	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	< 0.001	<0.001	<0.001	<0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l	**0.14**	**0.06**	**0.02**	**0.02**	**0.06**	**0.02**	**0.05**	**0.02**	<0.01	<0.01	**0.01**	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	< 0.005	<0.005	<0.005	<0.005	<0.005	**0.24**	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Table 3-2-8-7 Result of Monthly Water Quality Analysis of D-5 Site Wells

Measure./ Analysis Place	No.	Name	Unit \ Date	D-5-1 18/03/2013	04/06/2013	18/07/2013	14/08/2013	17/09/2013	17/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor					-	-	-	-	-	-	-	-	-	-	
	2	Taste					Not tested	Not tested	Not tested	Not tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU				250	1.1	3.4	0.2	8.6	7	5.8	3.1	6	2.7	
	4	Color index					28	1.5	3.5	0	1	3	2	0.5	3	0	
	5	pH					5.7	6.09	5.92	5.57	5.59	5.83	5.97	5.93	5.9	5.97	(6.5 -8.5 recommened)
	6	EC	µS/cm				161	96.8	123.4	115.5	100.7	101	103.6	104	110	112.9	(Maybe salty if over 750)
	7	Temperature	℃				24.2	29.5	26.6	33.3	29.7	28.5	31.9	32.4	31.0	28.4	
In labo. with incubator	8	Total Coliforms 1	CFU/ml				8	5	0	0	100	0	0	0	Nil	101	by Test Paper
	8	Total Coliforms 2	CFU/ml				0	0	0	0	119	12	123	24	28	261	by EC Plate
	9	E. coli	CFU/ml				0	0	0	0	0	1	0	0	Nil	28	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l				0.44	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l				<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l				<1	<1	<0.2	<1	<1	2.8	3.1	3.1	2.2	-	50 mg/l
	13	Ammonium (NH_4^+)	mg/l				<0.2	<0.2	<0.2	0.25	<0.2	<0.2	0.29	<0.2	0.46	<0.2	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l				<0.02	0.05	<0.02	0.1	<0.02	0.05	0.05	0.02	0.05	0.1	(<0.4mg recommened)
	16	Total Hardness	mg/l				34.0	28.0	80.0	37.0	24.0	32.0	22.0	<20	36.0	28.0	
	17	Chloride (Cl^-)	mg/l				9	5.8	11	4	11.3	7.5	15.3	10.9	14	6.4	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l				<10	10	<10	<10	<10	<10	<10	<10	<10	21	
	19	Potassium (K^+)	mg/l				3.7	2.8	4.9	3.8	3.5	5.1	2.8	3.4	3.9	3.9	
	20	Sodium (Na^+)	mg/l				5.0	8.1	10.4	8.1	12.3	10.3	4.8	2.4	6.3	24.0	
	21	Bicarbonate (HCO_3^-)	mg/l				87	65	44	44	44	44	44	44	44	44	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l				<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l				< 0.2	< 0.2	< 0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l				0.004	0.006	<0.001	0.017	0.001	0.013	0.001	0.002	0.009	0.005	0.01 mg/l
	25	Zinc (Zn)	mg/l				0.10	0.05	0.23	0.11	0.03	0.08	0.02	0.04	0.03	2.1	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l				<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l				<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	No.	Name	Unit \ Date	D-5-2 18/03/2013	04/06/2013	18/07/2013	14/08/2013	17/09/2013	17/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor		-	-	-	-	-	-	-	-	-	-	-	-	-	
	2	Taste		Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU	5.2	4.8	0	4.5	1.2	2	0.2	1.7	3.4	0.5	110	2	0	
	4	Color index		0	12	0	0	0	4	0	0.5	1	2.5	38	13	0	
	5	pH		6.25	6.84	5.07	4.2	6	5.89	5.93	6.03	6.15	6.26	6.26	6.25	6.17	(6.5 -8.5 recommened)
	6	EC	µS/cm	126	223	133	136	135	169.1	206	187.6	168.3	172.7	135.7	178	130.6	(Maybe salty if over 750)
	7	Temperature	℃	30.0	28.8	29.6	32.7	28.9	26.8	32.3	29.4	28.4	31.8	33.3	31.8	28.8	
In labo. with incubator	8	Total Coliforms 1	CFU/ml	0	15	40	15	62	27	0	Nil	Nil	0	11	Nil	22	by Test Paper
	8	Total Coliforms 2	CFU/ml	0	40	1	1	3	2	0	Nil	1	141	60	5	22	by EC Plate
	9	E. coli	CFU/ml	0	45	1	1	0	0	0	Nil	Nil	0	6	Nil	Nil	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l	0.81	1.05	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l	<0.02	<0.02	<0.02	0.033	<0.02	<0.02	<0.02	<0.02	0.024	<0.02	0.02	<0.02	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l	<1	<1	0.42	22.6	15.7	4.42	15.7	10.2	<1	1.3	<1	<1	-	50 mg/l
	13	Ammonium (NH_4^+)	mg/l	0.4	0.24	0.28	<0.2	<0.2	0.64	0.27	<0.2	0.28	0.25	0.55	0.21	0.28	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l	2.2	>5.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.24	0.29	0.52	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l	0.1	0.15	0.05	0.02	<0.02	0.1	0.1	0.1	<0.02	0.02	0.05	<0.02	0.05	(<0.4mg recommened)
	16	Total Hardness	mg/l	<20	<20	<20	20.0	22.0	48.0	55.0	51.0	58.0	44.0	20.0	20.0	44.0	
	17	Chloride (Cl^-)	mg/l	10.6	2.0	18.4	16.5	14.5	36	10.4	16	11.2	6.1	6.4	6.8	5.7	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l	<10	<10	29	33	27	<10	<10	10	<10	<10	45	38	<10	
	19	Potassium (K^+)	mg/l	3.2	2.9	2.0	0.76	0.91	1.34	1.69	2.5	5.2	2.7	3.2	4.3	4.2	
	20	Sodium (Na^+)	mg/l	5.0	10.5	3.7	4.5	5.3	6.1	7.6	9.1	8.1	5.7	3.7	9.0	13.9	
	21	Bicarbonate (HCO_3^-)	mg/l	65	87.2	65	22	65	44	65	65	65	65	44	44	65	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l	0.003	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l	<0.2	<0.2	< 0.2	< 0.2	< 0.2	< 0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l	<0.001	<0.001	0.023	0.041	0.034	0.001	0.021	0.023	0.024	0.044	0.012	0.003	0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l	0.03	0.14	0.44	0.05	0.09	0.09	0.16	1.5	0.13	0.08	0.09	0.02	0.06	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

Measure./ Analysis Place	No.	Name	Unit \ Date	D-5-3 18/03/2013	04/06/2013	18/07/2013	14/08/2013	17/09/2013	17/10/2013	14/11/2013	11/12/2013	14/01/2014	17/02/2014	17/03/2014	22/04/2014	20/05/2014	Remarks/WHO Guideline Value
In-situ	1	Odor							-	-	-	-	-	-	-	-	
	2	Taste							Not tested	Not tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	
	3	Turbidity	PTU						20	3.8	300	500	>500	19.8	18	7.4	
	4	Color index							14	3.5	31.5	0	0	7.5	0	1.5	
	5	pH							7.66	7.98	8.62	8.96	9.01	9.1	9.02	9.69	(6.5 -8.5 recommened)
	6	EC	µS/cm						402	427	419	384	390	374	402	340	(Maybe salty if over 750)
	7	Temperature	℃						26.8	32	29.6	29.1	31.8	33.0	31.2	29.3	
In labo. with incubator	8	Total Coliforms 1	CFU/ml						0	1	1	Nil	5	2	Nil	68	by Test Paper
	8	Total Coliforms 2	CFU/ml						0	8	61	2	118	24	719	336	by EC Plate
	9	E. coli	CFU/ml						0	0	Nil	Nil	0	0	Nil	14	by EC Plate
In labo.	10	Fluoride (F^-)	mg/l						<0.4	<0.4	0.87	<0.4	<0.4	0.99	<0.4	<0.4	1.5 mg/l
	11	Nitrite (NO_2^-)	mg/l						<0.02	<0.02	<0.02	<0.02	<0.02	0.024	<0.02	-	3 mg/l
	12	Nitrate (NO_3^-)	mg/l						<0.2	<1	<1	<1	<1	<1	<1	-	50 mg/l
	13	Ammonium (NH_4^+)	mg/l						<0.2	0.21	<0.2	<0.2	<0.2	<0.2	<0.2	0.37	
	14	Iron (Fe^{2+}, Fe^{3+})	mg/l						<0.2	<0.2	0.27	<0.2	<0.2	0.37	<0.2	<0.2	(<0.3mg recommened)
	15	Manganese (Mn)	mg/l						0.05	0.02	0.05	0.02	<0.02	<0.02	<0.02	<0.02	(<0.4mg recommened)
	16	Total Hardness	mg/l						<20	66	66.0	60.0	54.0	29.0	37.0	28.0	
	17	Chloride (Cl^-)	mg/l						15.2	2.4	5.1	8.7	7.9	6.8	7.1	8.1	(Maybe salty if over 200)
	18	Sulfate (SO_4^{2-})	mg/l						<10	11	12	<10	<10	<10	29	<10	
	19	Potassium (K^+)	mg/l						5	3.7	4.1	5.9	3.1	4	4.7	4.4	
	20	Sodium (Na^+)	mg/l						27	38	31.0	19.4	21.0	11.5	49.0	52.0	
	21	Bicarbonate (HCO_3^-)	mg/l						152.6	174.4	174	196	131	174	196	131	(Resolution 21.8 mg/l)
In Japan	22	Arsenic (As)	mg/l						<0.001	<0.001	<0.001	0.002	0.002	<0.001	<0.001	<0.001	0.01 mg/l
	23	Copper (Cu)	mg/l						< 0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2 mg/l
	24	Lead (Pb)	mg/l						0.001	0.006	0.012	0.018	0.018	0.005	<0.001	<0.001	0.01 mg/l
	25	Zinc (Zn)	mg/l						5.2	2.6	2.6	3.9	4.1	1.8	1.0	0.14	(<3 mg/l better)
	26	Total Chromium (Cr)	mg/l						<0.005	<0.005	0.007	0.006	0.009	<0.005	<0.005	<0.005	0.05 mg/l
	27	Cadmium (Cd)	mg/l						<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.003 mg/l

3-2-8-4 Isotopic Analysis

To estimate the creation age of groundwater and the environment in which water was entrapped in an aquifer and to analyze the groundwater recharge mechanism, water samples for the isotope analysis were collected from the test wells and analyzed by the IAEA laboratory.

(1) Water Sample and Analysis Item

In principle, sampling was carried out at each well with the following containers which are prepared by IAEA:

a)	Copper Tube	2 pieces; for helium gas analysis (age determination for a long range)
b)	1000ml Plastic Bottle	1 piece; for tritium analysis (age determination for a short range)
c)	500ml Plastic Bottle	1 piece; for the stable hydrogen and oxygen isotope analysis (estimation of environment in which water was entrapped)
d)	50ml Amber Glass Bottle	3 pieces; for CFC (chlorofluorocarbon) analysis (age determination for a short range)

Note: C^{14} analysis might be carried out also with 1000 ml plastic bottle sample.

(2) Sampling Method

Sampling was carried out with submergible pump after discharging water of a volume at least more than a whole capacity of the well casing pipe.

a) Copper Tube

Figure 3-2-8-1 shows a schematic figure of pipe system for helium gas sampling. Figure 3-2-8-2 shows the real pipe system and sampling scenes.

Because helium gas can easily move through plastic and glass, the water sample is collected into a copper tube. The sample water must be able to flow through the pipe under some water pressure to prevent water from degassing and mixing with the present air. Both sides of the tube are crushed well in order to be sealed under such a flowing condition. Hoses connected to both ends of the pipe must be transparent to confirm no bubble is in the sample water. A clamp to close the pipe is mounted on an aluminum rack with a copper tube. This set was provided by IAEA with the transparent hoses and a clamp handle. The diameter of the copper tube is small, so that diameter of the water-supplying pipe must be reduced step by step.

b) Amber Glass Bottle

Sample water for CFC analysis must be collected not to mix with the present air. After submerging the bottle in the sample water and letting the air in the bottle out, the bottle was rinsed well in water with the flowing sample water from the hose, and then capped also in water to close. The cap is lined inside with aluminum film.

c) Plastic Bottle

No special care is required for sampling for tritium and stable isotopic analysis. Sample water was collected from the pipe end after rinsing the bottle well with the same water.

(3) Sampling Work and Physical Water Quality Measured in Sampling

Table 3-2-8-9 shows a list of sampling wells and samples. Table 3-2-8-8 shows attributes of sampling wells and EC, pH and temperature of sample water measured in sampling.

At many wells, the water was rusty. A sulfuric smell and taste like hot springs are found at D-3-2 and D-4-1. The water was salty at D-3-1 and D-4-2. The water temperature is generally higher at a deeper well. It was 34 to 37 ℃ at a very deep well like D-3-3 and D-1-3. The pH level was low at shallower wells on the hill.

(4) Analysis Results

a)Hydrogen-Oxygen Stable Isotope

Figure 3-2-8-3 shows the result of the stable hydrogen and oxygen isotope analysis.

All sets of the values of both elements are plotted near the Global Meteoric Line and the difference among the values is small. This means that the rain water which turned to the groundwater was created in a similar environment on temperature and altitude, and spent a time in a similar history of storage and movement underground after the creation. However, the following difference is found:

Waters of the D-1, D-2 and D-5 sites located on the hill show a similar isotope ratio except D-1-3. The water of the deepest aquifer at D-1-3 shows a slightly less value. Waters of the D-3 and D-4 sites located in the plain show a slightly less isotope ratio than those in the hill and are near to the value at D-1-3.

b)Noble Gas Isotope

Table 3-2-8-10 shows the noble gas analysis result and calculated values like age of water based on it. Hereafter it is explained following the draft report prepared by Dr. T. Matsumoto, IAEA.

<u>Tritium Age</u>

The amount of Helium 3 created by the collapse of Tritium gives a groundwater age for relatively short storage in aquifer less than 50 to 100 years. As shown in Table 3-2-8-10, the age was obtained only for the D-2-1 and D-5-2 samples. It is 40 years (±7) and 36 years (±15) respectively. The age of the other samples are estimated to be more than 50 years.

<u>Helium 4 Age</u>

Even if the age exceeds 100 years, it can be estimated by using the phenomenon that the long life nuclei, U (Uranium) and Th (Thorium) in the earth crust collapse to Helium 4 and it is added to groundwater as time. This method allows estimation of age even over a million year. The decrease of

$^{3}He/^{4}He$ ratio as increase of Helium 4 shown in Figure 3-2-8-4 proves that the Helium 4 was added in groundwater as time. As shown in Figure 3-2-8-5, the isotope ratios locate along the mixture curve of the air and the continental crust components. Figure 3-2-8-7 shows the estimated Helium 4 ages on an aquifer profile. These ages are reliable on relative oldness, but for the accurate absolute value, a cross calibration like with krypton 81 is required.

The calculated Helium 4 ages of the D-2-1 and D-5-2 samples show a few ten years of young age like the Tritium age. The other samples show a few hundred to a few thousand years of old age. Especially the D-4-1 and D-4-2 sample show very old ages, 8671 years and 21785 years respectively.

The D-2-1 and D-5-2 wells are located on the hill ridge and the sampled aquifer is the main target of groundwater use. There are many wells around and much groundwater is being extracted. Furthermore, a large seasonal groundwater level fluctuation responding to rainfall is confirmed. These facts suggest that the seepage velocity in the area is relatively large and the water is circulating relatively fast. Therefore the above-said relatively shorter storage in aquifer meets the hydrogeological condition.

The other sampled wells are located in the eastern plain (the elevation less than 4 m) or the western lowland. The area is covered with a thick clayey layer. In addition, groundwater use and the seasonal fluctuation of groundwater level are small. These facts imply that the seepage velocity in the area is relatively small and the water is circulating relatively slowly. Generally it is inferred that the water circulation through a deeper aquifer takes a longer time, because the water must go across more impervious layers between aquifers. Therefor the obtained large ages and the larger value as going deeper match well the hydrogeological condition. However the following two points are a little off the line.

- At the D1 site, the deeper located D-1-3 water shows a younger age than the shallower located D-1-3 one. Concerning the hydrogen and oxygen isotope ratios, as explained above, only the D-1-3 water shows a little different value among D1, D2 and D5 sites, which is near to the value of D3 and D4 sites. The deep portion at the D1 site may be in a different environment.
- The D-4-1 and D-4-2 waters show very old ages, though their aquifer depths are not so large. The natural “gas shows” on the ground surface are reported around the D4 site as shown in Figure 3-2-8-6. The upward move and mixing of the gas possibly increased the concentration of ^{4}He and give an apparent older age.

<u>Paleo-Temperature of Groundwater Recharge Area</u>

The paleo-temperature of the groundwater recharge area can be estimated from the dissolved amount of all noble gases because it depends on the temperature. As shown in Table 3-2-8-10, the estimated paleo-temperature is 16.1℃ ~ 23.6℃, which is smaller than the present average temperature 27℃. The gas dissolution rate is also related to the barometric pressure, which is correlated to the altitude. To obtain the precise temperature, a carful estimation with further analysis data is required considering the geologic history in the area as well.

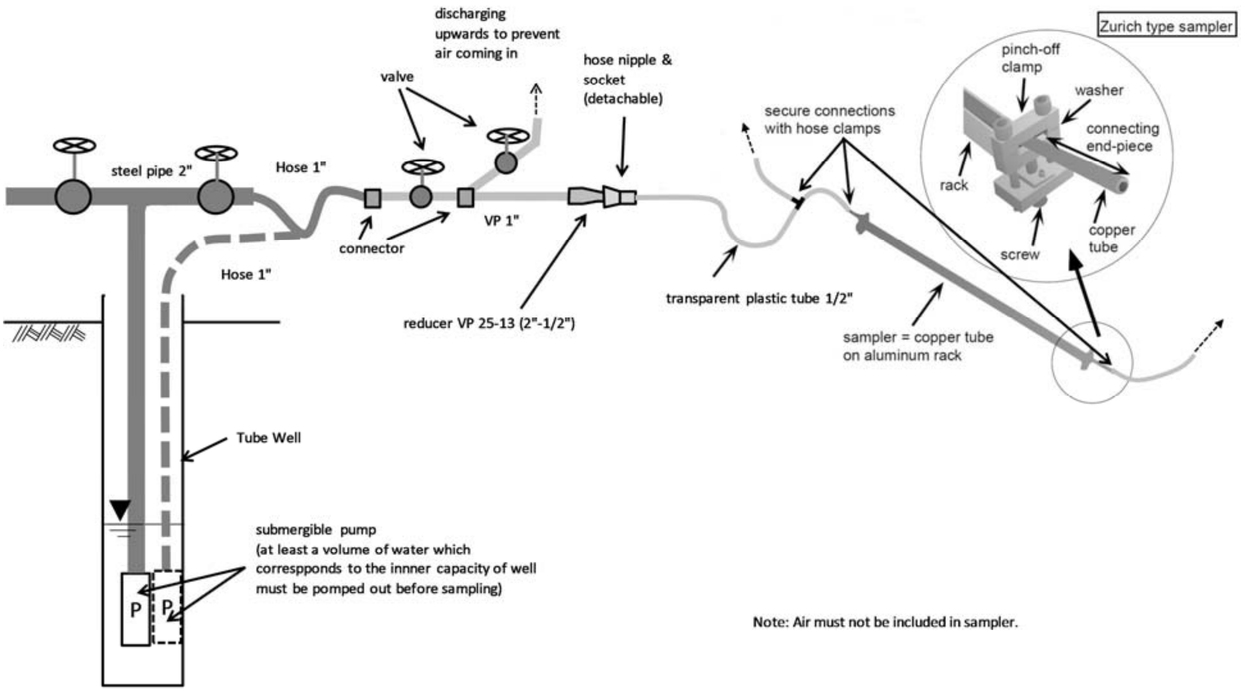


Figure 3-2-8-1 Schematic Figure of Pipe System for Helium Gas Sampling

Table 3-2-8-8 Attributes of Sampling Well and Physical Water Quality Measured In-situ

COUNTRY AND PROJECT CODE: Myanmar, Data Collection Survey on Water Resources Potential for Thilawa Special Ecomonic Zone and Adjoining Area by JICA **DATE:** 25/07/2013

INSTITUTE: Japan International Cooperation Agency (JICA) Survey Team for the Project **Responsible Officer:** Shigeru Sugiyama

No.	Sample Code (local name)	Aquifer name	Samp. depth (a)	Coordinates		Altitude (m)	Field data			Remarks
				Latitude N/S DDMMSS.DD	Longitude W/E DDDMMSS.DD		Cond µS/cm	Temp. °C	pH units	
1	D-1-1	Ridge-S-1	66.1-83.0	N 16 40 23.5	E 96 17 00.2	5	660	29.7	7.2	Iron taste. A little turbide,
2	D-1-2	Ridge-S-2	109.8-138.0	N 16 40 23.4	E 96 16 59.6	5	430	31.1	7.6	Slight iron taste. Measured in rain; hose cooled.
3	D-1-3	Ridge-S-3	187.0-199.0 211.0-232.0	N 16 40 23.3	E 96 16 59.8	5	540	33.5	7.8	A little iron taste
4	D-2-0	Ridge-S-0	31.4-37.1 48.4-54.0	N 16 41 12.5	E 96 18 27.5	20	96	28.4	5.7	
5	D-2-1	Ridge-S-1	66.8-95.00	N 16 41 12.2	E 96 18 28.6	20	75	28.7	5.7	
6	D-2-2	Ridge-S-2	125.4-148.0	N 16 41 12.7	E 96 18 28.3	20	210	30.0	6.4	Turbidity increased at final
7	D-3-1	Plain-1	60.4-77.3	N 16 43 01.7	E 96 21 10.6	4	2100	29.7	7.0	Salty taste
8	D-3-2	Plain-2	112.1-123.4 132.1-137.7 143.4-149.0	N 16 43 01.6	E 96 21 10.0	4	440	31.5	7.7	Sulfuric smell and taste
9	D-3-3	Plain-4	244-274 298-328	N 16 43 01.6	E 96 21 09.5	4	390	36.7	7.9	Iron taste
10	D-4-1	Plain-1	66.1-83.0	N 16 44 50.6	E 96 26 06.4	4	4600	30.5	6.6	Sulfuric smell and taste. Many micro bubbles appeared on the inside tube surface which was not coming by flow.
11	D-4-2	Plain-2	110.1-132.7 138.4-144.0	N 16 44 50.7	E 96 26 06.4	4	2100	32.3	7.7	Salty taste, with a little brownish color. Many micro bubbles appeared on the tube which was not coming by flow.
12	D-5-1	Ridge-N-1	46.1-63.0	N 16 46 08.8	E 96 14 49.7	25	109	29.8	5.9	Iron taste
13	D-5-2	Ridge-N-2	81.1-86.0	N 16 46 08.8	E 96 14 49.2	25	157	30.0	5.9	Iron taste

Note: Presumed recharge area -the area around wells where sampling was done. Mean annual temperature - 27.4℃ at Yangon.
(a) For samples collected from aquifers, lakes and reservoirs, the sampling depth field (spec. depth, range of depths or screen ranges) should always be filled in.
(b) If possible taken with a GPS, otherwise from a 1:50,000 topographic map.
If relevant, please provide a short description of the lithologies of the aquifers in the study area.
Lithological units:

IAEA Water Resources Programme

Figure 3-2-8-2 Sampling Scene

Table 3-2-8-9 List of Samples for Isotopic Analysis

LIST OF SAMPLES FOR ISOTOPE OR CHEMICAL ANALYSIS

COUNTRY AND PROJECT CODE: Myanmar, Data Collection Survey on Water Resources Potential for Thilawa Special Economic Zone and Adjoining Area **DATE:** 25/07/2013

INSTITUTE: JICA (Japan International Cooperation Agency) Survey Team **Responsible Officer:** Shigeru Sugiyama

No.	Sample Code (local) (a)	Sampling date YY/MM/DD	Type (b)	Bottle Type and Volume	No. of bottles shipped	Other information	Target analysis: He (Noble Gas)	Tritium	Stable Isotopes	CFC
1	D-1-1	24/07/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
2	D-1-2	26/06/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
3	D-1-3	24/07/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	0					
				500ml Plastic	1				Y	
				50ml Amber Glass	0					
4	D-2-0	24/06/2013	GWB	Copper Tube	0					
				1000ml Plastic	1			Y		
				500ml Plastic	0					
				50ml Amber Glass	3					Y
5	D-2-1	26/06/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
6	D-2-2	24/06/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
7	D-3-1	22/06/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
8	D-3-2	22/06/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
9	D-3-3	22/06/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	0					
				500ml Plastic	1				Y	
				50ml Amber Glass	0					
10	D-4-1	24/06/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
11	D-4-2	01/07/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
12	D-5-1	01/07/2013	GWB	Copper Tube	0					
				1000ml Plastic	1			Y		
				500ml Plastic	0					
				50ml Amber Glass	3					Y
13	D-5-2	01/07/2013	GWB	Copper Tube	2		Y			
				1000ml Plastic	1			Y		
				500ml Plastic	1				Y	
				50ml Amber Glass	3					Y
Total				Copper Tube	22	(+empty 2)	(total 24)			
				1000ml Plastic	11	(+empty 1)	(total 12)			
				500ml Plastic	11	(+empty 1)	(total 12)			
				50ml Amber Glass	33	(+empty 3)	(total 36)			

(a) It is essential that the codes placed on the labels coincide with the sample codes listed in this Table.
(b) GWB-groundwater (borehole); GWD-groundwater (dug, shallow well); GWS-spring; SLA-lake ; SRE-reservoir; SRI-river; SPR-precipitation

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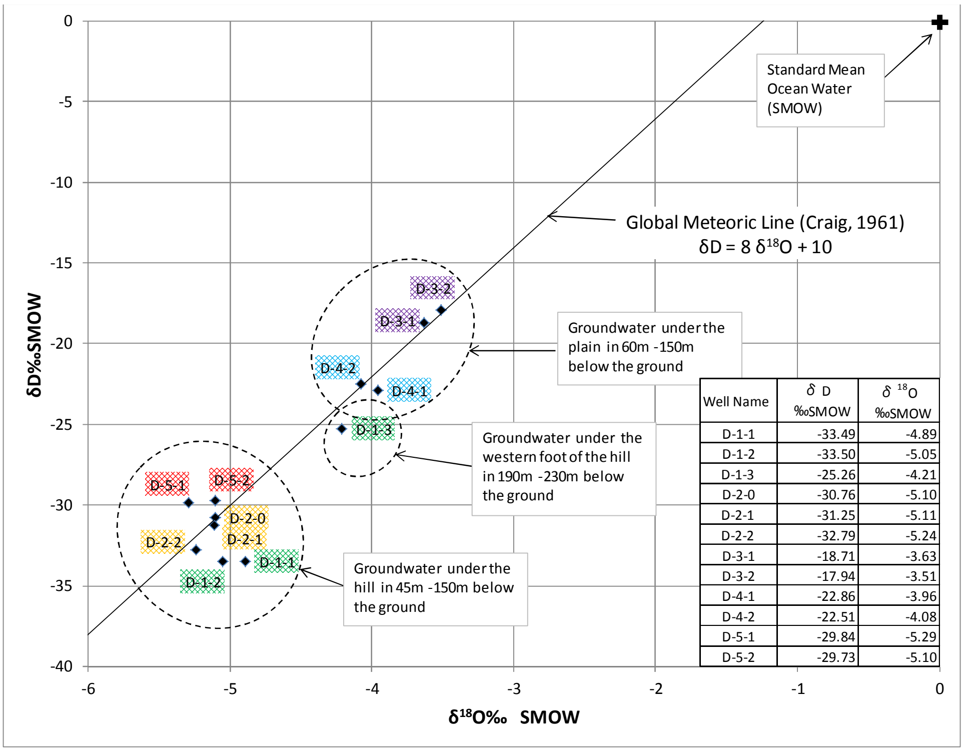


Figure 3-2-8-3 Result of Stable Isotope Analysis – Hydrogen and Oxygen

Table 3-2-8-10 Noble Gas Analysis Result and Values Calculated by Model

Sample ID	He (cm3STP/g)	±	Ne (cm3STP/g)	±	Ar (cm3STP/g)	±	Kr (cm3STP/g)	±	Xe (cm3STP/g)	±
D-1-1 (JICA-MYAN)	1.99E-07	2.72E-09	2.82E-07	3.03E-09	4.30E-04	6.66E-06	8.37E-08	2.71E-09	1.11E-08	5.18E-10
D-1-3 (JICA-MYAN)	1.21E-07	1.65E-09	3.00E-07	3.15E-09	4.87E-04	7.54E-06	9.10E-08	2.93E-09	1.16E-08	5.29E-10
D-2-1 (JICA-MYAN)	6.74E-08	9.01E-10	2.61E-07	2.87E-09	3.73E-04	5.55E-06	7.54E-08	1.83E-09	1.02E-08	5.15E-10
D-3-1 (JICA-MYAN)	9.58E-08	1.19E-09	2.71E-07	2.99E-09	4.31E-04	6.41E-06	8.85E-08	2.16E-09	1.18E-08	5.92E-10
D-3-2 (JICA-MYAN)	1.11E-07	1.36E-09	2.79E-07	3.06E-09	4.35E-04	6.51E-06	8.71E-08	2.14E-09	1.08E-08	5.54E-10
D-3-3 (JICA-MYAN)	4.18E-07	6.98E-09	1.23E-06	1.30E-08	9.62E-04	1.52E-05	1.35E-07	4.35E-09	1.50E-08	6.77E-10
D-4-1 (JICA-MYAN)	4.31E-07	6.42E-09	1.49E-07	1.55E-09	2.72E-04	4.20E-06	6.32E-08	1.55E-09	8.89E-09	3.61E-10
D-4-2 (JICA-MYAN)	1.05E-06	1.89E-08	2.41E-07	2.53E-09	3.81E-04	5.88E-06	7.78E-08	2.54E-09	1.13E-08	5.24E-10
D-5-2 (JICA-MYAN)	6.80E-08	8.49E-10	2.64E-07	2.90E-09	3.81E-04	5.67E-06	7.60E-08	1.85E-09	9.78E-09	5.02E-10

Sample ID	Tritium (TU)	±	3He/4He	±	NGT	T-3He age (years)	±	Crustal 4He ($) (cm3STP/g)	4He age (years) (#)
D-1-1 (JICA-MYAN)	b.d		5.40E-07	2.79E-09	20.9			1.28E-07	2846
D-1-3 (JICA-MYAN)	b.d		8.75E-07	6.21E-09				4.54E-08	1008
D-2-1 (JICA-MYAN)	0.3	0.1	1.41E-06	9.26E-09	20.3	41	6	1.70E-09	38
D-3-1 (JICA-MYAN)	b.d		8.98E-07	3.94E-09	17.5			2.88E-08	639
D-3-2 (JICA-MYAN)	b.d		8.35E-07	3.86E-09	21.2			4.16E-08	924
D-3-3 (JICA-MYAN)	b.d		1.29E-06	8.24E-09				9.96E-08	2212
D-4-1 (JICA-MYAN)	b.d		2.08E-07	2.10E-09				3.90E-07	8671
D-4-2 (JICA-MYAN)	b.d		1.45E-07	2.24E-09	16.1			9.81E-07	21785
D-5-2 (JICA-MYAN)	0.2	0.1	1.37E-06	9.23E-09	23.6	36	15	1.78E-09	39

NGT : Equilibrium temperature (Centigrade) between the air and the recharge water inferred by the noble gas. The blank shows low reliability of the data to approximate with the model.

（$） Crustal ^{4}He: The sample gas was a mixture of gases of three origins (continental crust, mantle and air) and each component amount can be calculated. This value shows the value from the continent crust.

（#） To obtain a precise ^{4}He age, various factors like the geology of the sampling area, configuration of the sampling well etc. are required as well as a reasonable estimation of the addition rate of helium to the groundwater. The additional rate of ^{4}He was assumed to be the same as the one estimated from the T-^{3}He analysis with two samples. If the other sample waters are in the same groundwater system as them, the relative age(older or younger) is reliable, but the absolute value needs cross calibration like with krypton 81 for accuracy.

(Translated by JICA survey team)

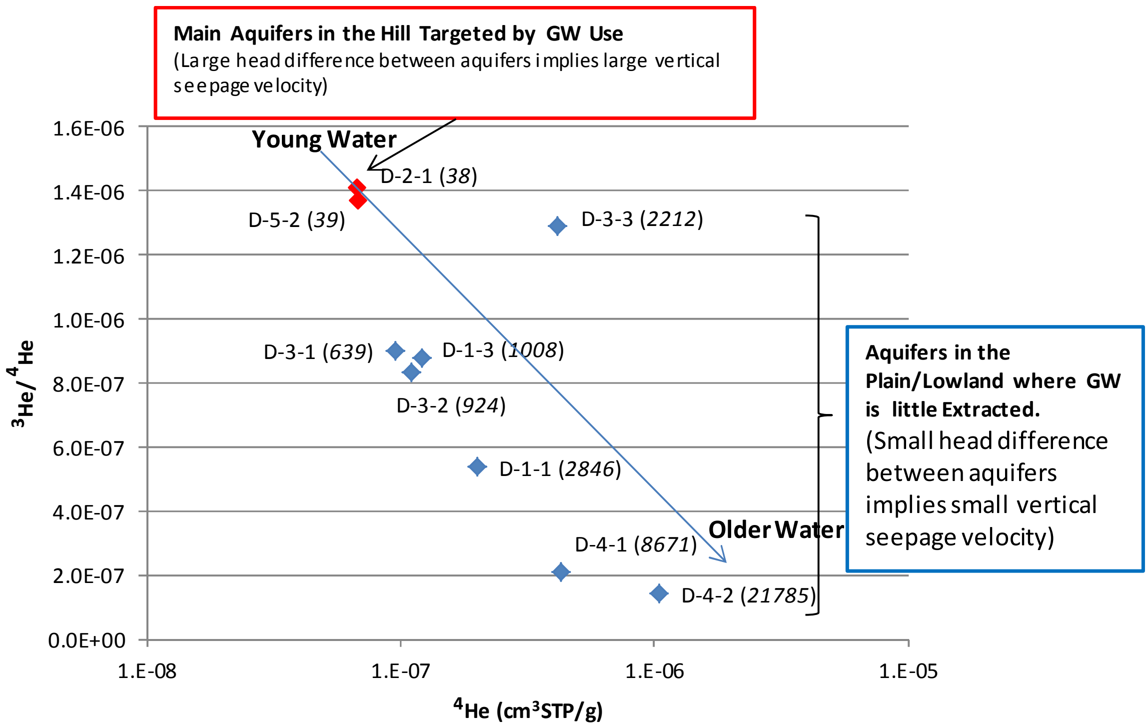
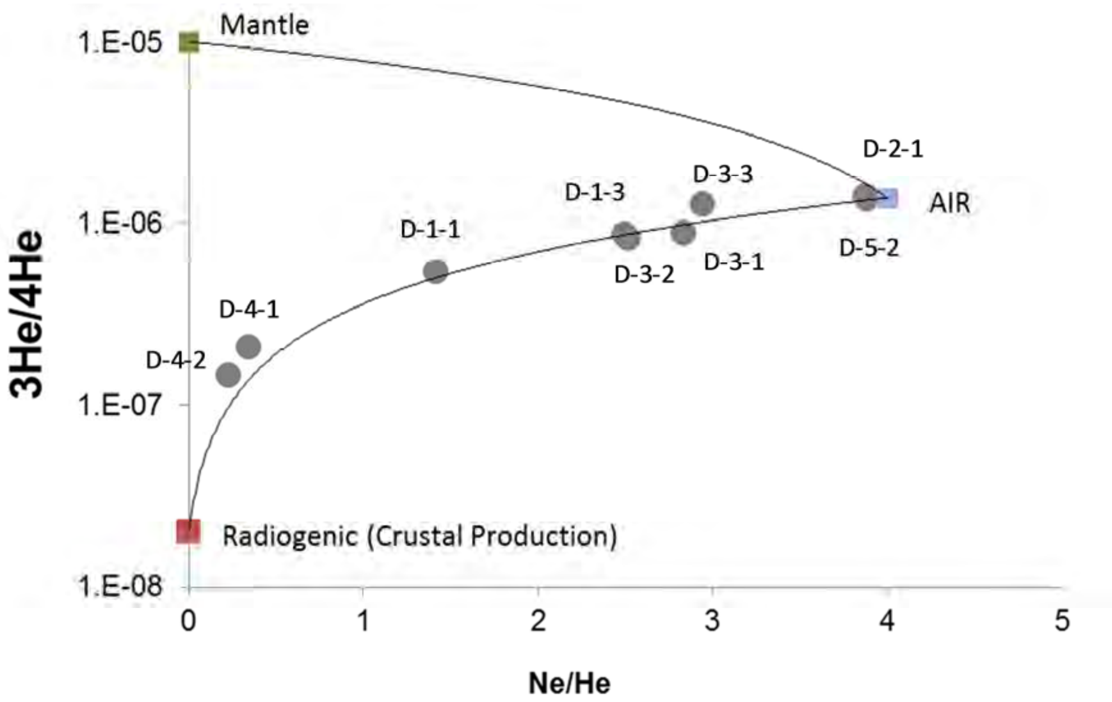
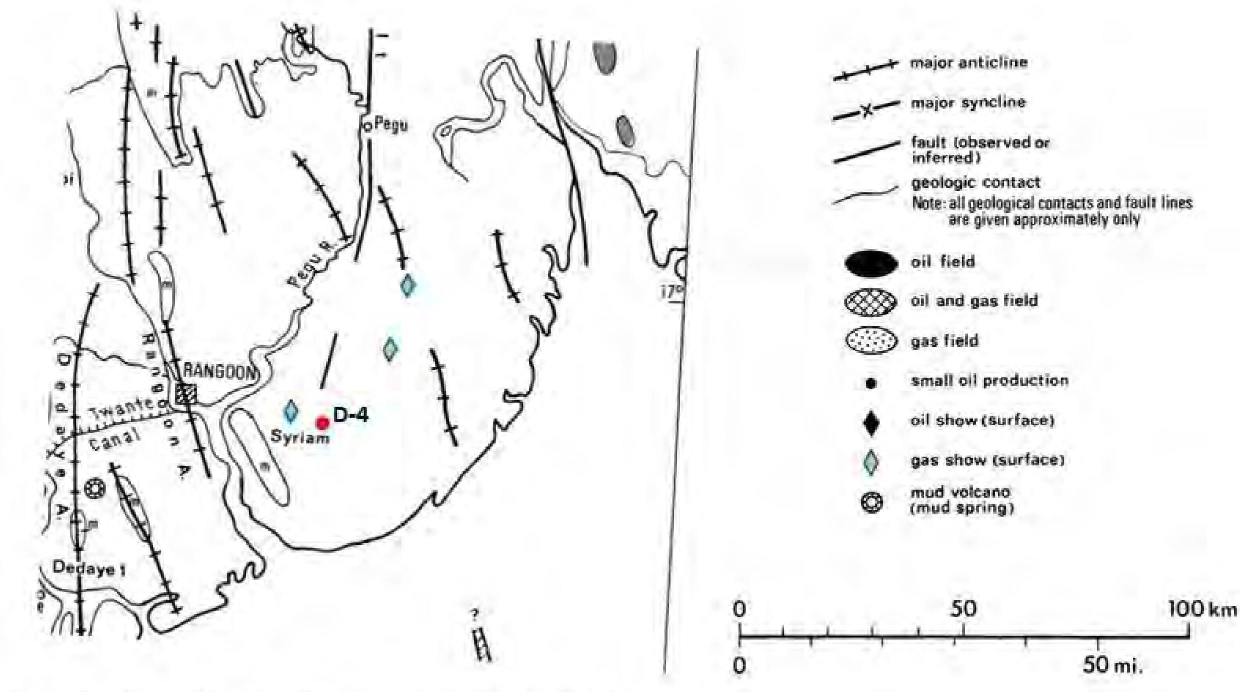


Figure 3-2-8-4 Relationship between Helium 4 and Isotopes



Source: T. Matsumoto (2014, unpublished), IATA ; Sampled well names added.

Figure 3-2-8-5 Relationship between Helium Isotopes and Ne/He



Source: Beder (1983) Geology of Burma; excerpted and retouched.

Figure 3-2-8-6 Natural Gas Show around D-4 Site

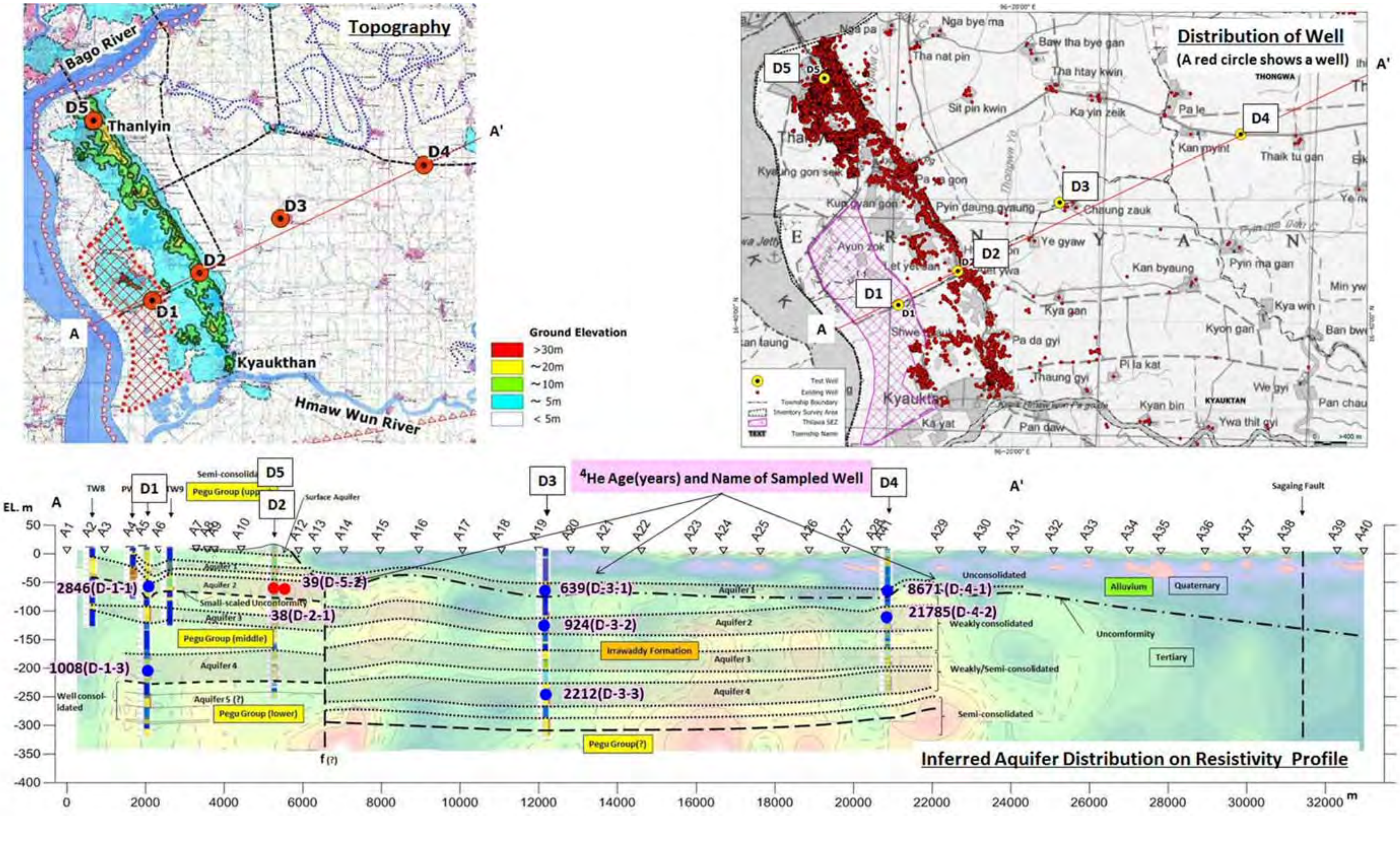


Figure 3-2-8-7 Helium-4 Age Distribution on Aquifer Profile

3-2-8-5 Water Quality Test of Test Wells in SEZ by another JICA Team

In parallel to the present survey, another JICA team, which makes preliminary design of infrastructure for SEZ, installed test wells and carried out a water quality test. Table 3-2-8-11 shows the test results. The well location is shown with the EC value in Figure 3-2-8-8. The aquifer lying shallower than 100 m in the eastern and central parts of SEZ has an EC beyond 1,400 μS/cm. It must be a little salinized. The result also shows that iron concentration is high at many wells.

Table 3-2-8-11 Water Quality Test Results of Test Well in SEZ by another JICA Team

Kind of Well			Test Well (1.5" dia.)									Production Well (10" dia.)						Remarks
Name of Well			TW-3	TW4	TW5	TW6	TW7	TW8	TW9	TW9	TW10	PW1		PW2	PW3	PW4		
Screen Depth		m	36.6 ~42.7	45.7 ~54.9	73.2 ~97.6	70.1 -76.2	79.3 ~85.4	48.8 ~54.9	73.2 ~79.3	91.5 ~97.6	149.0 152.4	32.9 ~66.4		36.0 ~68.9	27.4 ~66.4	51.8 ~85.7		
Sampling Date			17.10.12	22.10.12	22.10.12	19.20.12	12.10.12	14.10.12	12.10.12	12.10.12	12.10.12	3.12.12	6.12.12	12.12.12	17.12.12	19.12.12	20.12.12	
1	Appearance		Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	
2	Water Temperature	℃	30.6	30.5	30.4	30.4	31.2	31.4	29.4	30	29.6	28.6	28.9	26.8	30.5	27.9	27.1	
3	Total Dissolved Solid	mg/l	805	2110	212	994	710	765	175	180	169	848	710	86.1	330	710	994	Palatable if <600mg/l (WHO)
4	Electrical Conductivity	µs/cm	1678	1420	254	2000	1420	1420	363	365	350	1420	1420	169.3	662	1420	1420	Maybe salty if >750
5	pH		7.12	6.62	7.92	7.87	7.97	7.97	7.95	7.9	7.95	7.45	7.58	6.48	7.24	7.74	7.78	
6	Magnesium (Mg)	mg/l	ND	ND	60	90	ND	70	ND	ND	55	75	55	46	80	80	90	
7	Alkalinity ($CaCo_3$)	mg/l	135	ND	70	65	170	55	255	200	75	165	185	ND	105	45	25	
8	Sulphate (SO_4)	mg/l	ND	ND	19	24	22	32	30	15	ND	91	104	ND	ND	19	15	
9	Iron (Fe)	mg/l	0.80	4.50	1.10	ND	ND	ND	1.05	0.80	ND	ND	0.09	0.40	ND	ND	ND	No taste and no staining if <0.3mg/l (WHO)
10	Potassium (K)	mg/l	4.1	ND	10	7.3	4.5	8.8	5.8	4.6	5.0	5.0	5.3	3.2	4.2	4.8	5.3	

Source: Nippon Koei (2013) The Preparatory Study for Infrastructure Development in Thilawa SEZ, Final Report

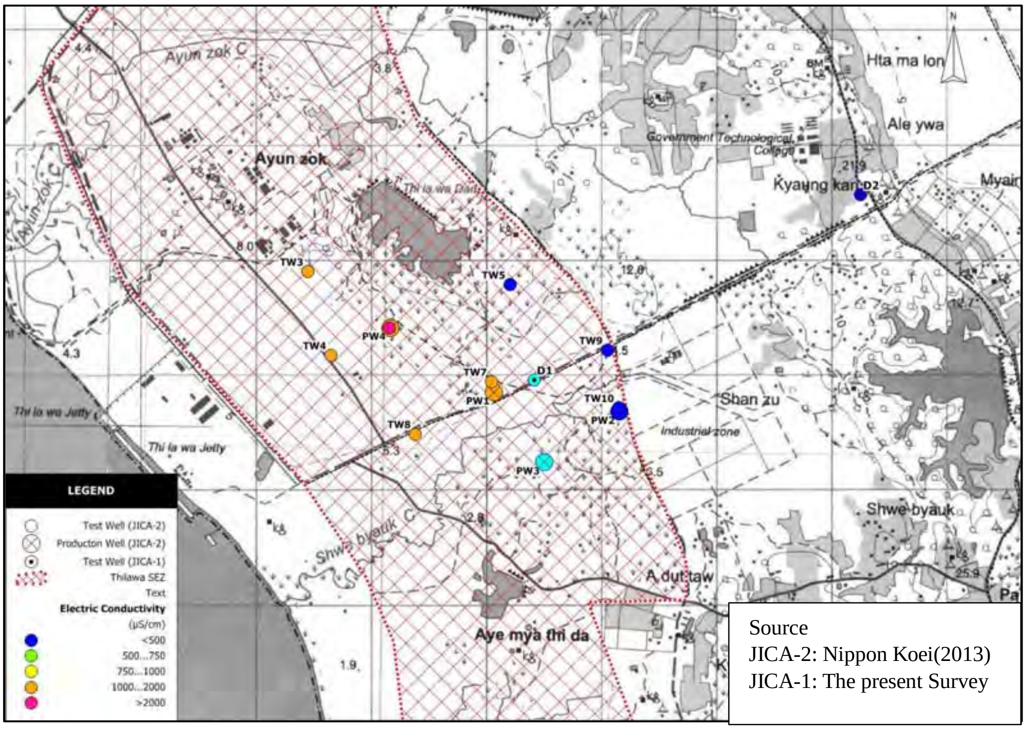


Figure 3-2-8-8 Location and EC of Test Well in SEZ by another JICA Team

3-2-9 Groundwater Level Monitoring

3-2-9-1 Observation Well and Observation Period

Groundwater level represents a result of water budget. Therefore, the groundwater level is very important data to estimate the groundwater recharge and water extraction condition in the investigation area. In the present survey, an automatic water level meter is installed into every test well (see Figure 3-2-9-1), and the water level was monitored approximately for one year. The level meter has an accuracy of one centimeter and is equipped with a vent pipe to cancel the atmospheric pressure effect. Table 3-2-9-1 shows attributes and observation starting day of the wells. Due to the delay of well completion, the observation started mostly in July or August of 2013 and in October to November for D-2-3 and D-5-3. The delay of start for D-5-3 is due to the low water level which forced re-ordering of the sensor with a longer cable.

The monitoring work was carried out by the JICA survey team until Aug. 7th, 2014.

3-2-9-2 Results of Observation

Figure 3-2-9-2 and Figure 3-2-9-3 show the groundwater level fluctuation in elevation at all the observation wells and at those in the plain/lowland respectively. Figure 3-2-9-4 and Figure 3-2-9-5 show the fluctuation in depth from the ground. Figure 3-2-9-6 to Figure 3-2-9-10 show the fine fluctuation at every site. Table 3-2-9-2 shows the daily rainfall in Yangon in 2013, which are plotted in the fluctuation figures. The annual rainfall sums about 2,800 mm, which is almost the average during the recent 30 years.

Hereunder, the characteristics of groundwater head distribution and fluctuation found in the graphs are described:

(1) Observation Wells on the Hill

1) D-2 Site

This site is located in the compound of the Thilawa SEZ Supporting Committee which lies on the Tertiary hill ridge. The ground elevation is EL. 17.4 m ~ EL. 18.1 m. Four observation wells named D-2-0 ~ D-2-3 are installed. The screen depth from the ground is 31 ~ 54 m, 67 ~ 95 m, 125~ 148 m and 196~301 m respectively.

The observed groundwater head ranges mostly EL. 3 m～EL 15 m and is lower at a deeper well. The difference of head between two wells is 1m, 4m and 3m from the shallower set.

The head fluctuates responding cumulatively to rainfall and a shallower well has a larger short-time variation. The annual fluctuation is about 5 m at D-2-1 and D-2-2.

The pumping test carried out at D-2-3 in the middle September of 2013 affected the groundwater head largely at D-2-2 and slightly at D-2-1. After the pumping test, recovery of the head took about three months. This implies that the permeability of the aquifers and the aquitards between them is small. This corresponds to that the compactness of the layer increases below 95m from the ground according to the core boring result.

A drawdown during about a half day which is made by extraction of a nearby well is clearly found on the graph of D-2-1 (drawdown about 5 cm) and D-2-3 (ditto. 15 cm) as shown in Figure 3-2-9-7. The compound has a well in it, which has a screen faced to the same aquifer as D-2-1.

2) D-5 Site

This site is located on the ridge of the northern Tertiary hill near the hill end. The ground elevation is EL. 23.3 m ~ EL. 24.3 m. Three observation wells named D-5-1 ~ D-5-3 are installed. The screen depth from the ground is 46 ~ 63 m, 81 ~ 98 m, 180 ~ 240 m respectively. There are many well around because the site is in the central part of the Thanlyin Town.

The observed groundwater head ranges mostly EL. 12m～EL. -12m (minus 12m) and is lower at a deeper well. The difference of head between two wells is 10 m and 7 m from the shallower one. At D-5-2, the water level is kept below EL. 0 m through a year except during from August to October. At D-5-3, it is kept below EL.-10m (minus 10m) throughout a year. The aquifer for D-5-2 is one of the main aquifers in the area and such low water level probably induces the saline water intrusion into the aquifer. This is a serious problem and an appropriate countermeasure must be taken (Refer to “3-8-2 Monitoring and Aquifer Management in Thanlyin Town ”).

The head fluctuates responding cumulatively to the rainfall. The annual fluctuation amounts about 8m at D-5-1 and 10m at D-5-2.

At D-5-2, the daily fluctuation with 1 m~1.5 m in variation, which is made by wells around, is clearly found as shown in Figure 3-2-9-10. Such fluctuation is also found at D-5-1 (drawdown about 10 cm) and D-5-3 (ditto. 15 cm). At D-5-3, another fluctuation with two peaks in a day and about 6 cm in variation is found, which is probably made by the atmospheric tide (or the earth tide).

Around Nov. 20th, the water level changed down largely and then the level was depleting linearly. In the natural condition, the depletion curve of groundwater head is like exponential and such a linear type does not appear. The linear depletion must be made by the intensive extraction around the site.

(2) Observation Wells in the Plain

1) D-1 Site

This site is located in the central eastern part of the Thilawa SEZ. The ground elevation is EL. 5.3 m. Four observation wells named D-1-0 ~ D-1-3 are installed. The screen depth from the ground is 37 ~ 48 m, 66 ~ 83 m, 110 ~ 138 m, 187 ~ 283 m respectively. The site is located on lowland, but is underlain by the Tertiary layers.

The observed groundwater head ranges mostly EL. 1.0 m ～ EL. -2.2 m and is higher at the deeper well. The difference of head between two wells is 0.6 m, 0.1m and 0.2 m from the shallower one.

The head fluctuates responding rather sensitively to the rainfall, but the level increase is small. The annual fluctuation is about 0.8 m at D-1-0 and 0.5 m at the other wells.

After the pumping test which is carried out at D-1-1 and D-1-3 in the middle and late July of 2013, the water level at the three wells except D-1-0 increased gradually and it took about three months to recover to the normal level in the dry season. However, the level at D-1-0 reacts differently from them and shows a fluctuation similar to the shallower wells on the hill that the level is high in the rainy season and depletes exponentially in the dry season.

As shown in Figure 3-2-9-6, A daily fluctuation is found at every well with a variation about 1cm at D-1-0 and 3cm at other wells, which is provably made by the ocean or/and atmospheric tide. The long-span fluctuation with a half month cycle is also found, which must be made by the ocean tide. The short-time fluctuation by groundwater use around is not found.

2) D-3 Site

This site is located in the southwestern part of the plain. The ground elevation is EL. 3.8 m. Three observation wells named D-3-1 ~ D-3-3 are installed. The screen depth from the ground is 60 ~ 77m, 112 ~ 149 m and 244 ~ 278 m (298 ~ 328 m as well) respectively. The aquifer at 60 ~ 77 m is the basal sand layer (with gravel) of the unconsolidated Quaternary.

The observed groundwater head ranges mostly EL.1.8 m～EL.- 2.3 m and is higher at a deeper well. The difference of head between two wells is 0.2 m and 0.1 m from the shallower one.

The head fluctuates responding rather sensitively to rainfall, but the level increase is small. The annual fluctuation is about 0.2 m at every well.

The three level fluctuation curves look very similar as shown in Figure 3-2-9-8,

A daily fluctuation is found at every well with a variation about 1 cm at D-3-1, 1 ~ 2 cm at D-3-2 and 2 ~ 3 cm at D-3-3, which is probably made by the atmospheric tide. The short-time fluctuation by groundwater use around is not clear.

3) D-4 Site

This site is located in the central eastern part of the plain. The ground elevation is EL. 3.6 m. Two observation wells named D-4-1 and D-4-2 are installed. The screen depth from the ground is 66 ~ 83 m and 110 ~ 144 m respectively. The aquifer at 66 ~ 83 m is the basal sand layer (with gravel) of the unconsolidated Quaternary.

The observed groundwater head ranges mostly EL.1.9 m～EL.- 2.4 m and is lower at a deeper well. The difference of head between two wells is 0.2 ~ 0.3 m.

The head fluctuates responding rather sensitively to the rainfall, but the level increase is small. The annual fluctuation is about 0.4 m at every well.

A daily fluctuation is found at every well with 1cm of variation, which must be made by the atmospheric tide, because there are two peaks a day in the morning and evening and the peak time almost doesn’t move according to the high resolution measurement at D-4-1 as shown in Figure 3-2-9-9. The short-time fluctuation by groundwater use around is not clear.

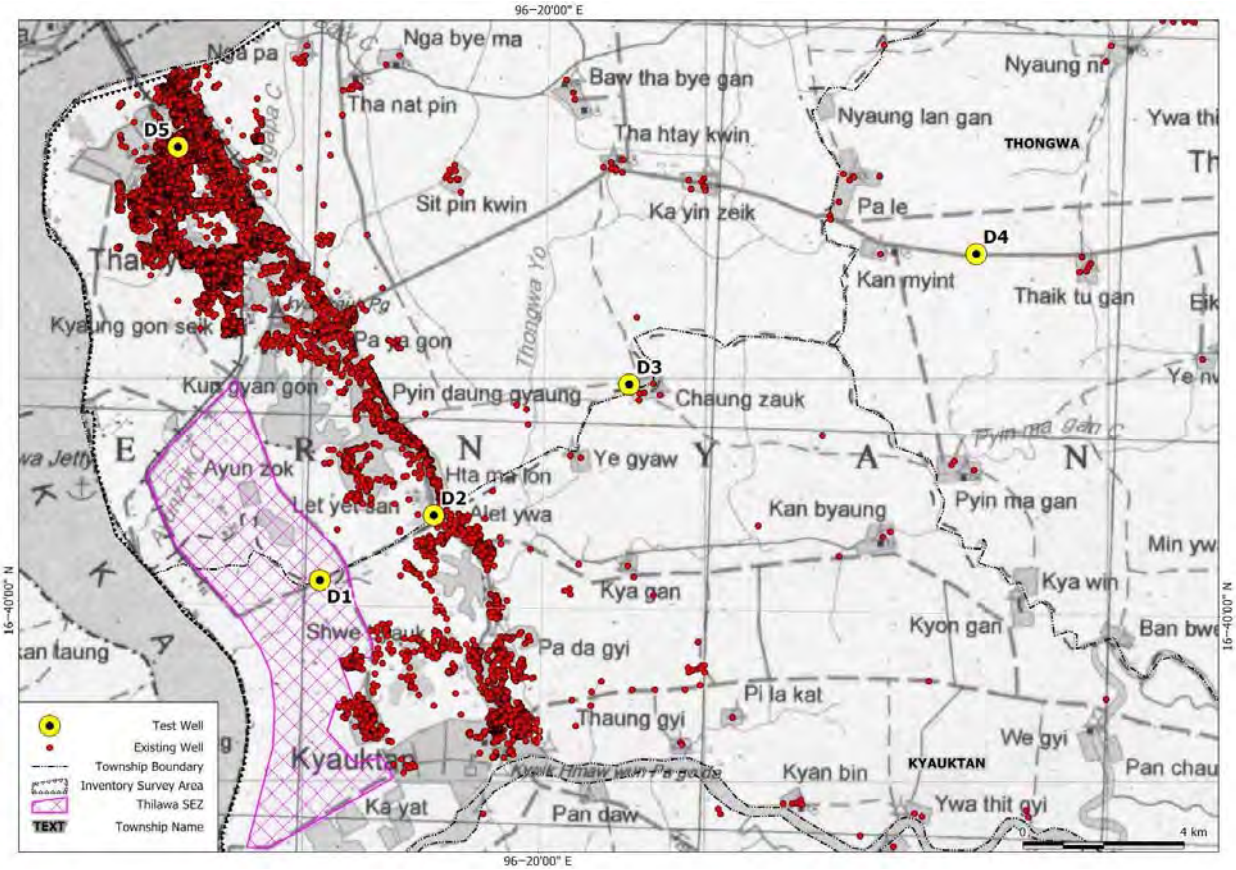


Figure 3-2-9-1 Location of Observation Wells and Existing Wells

Table 3-2-9-1 Specification of Observation Well

Name	Coordinates (WGS84)		Depth (m)	Screen Depth (m)	Elevation (m)			Water Level Observation Starting Day and Time		Serial No. of Water Level Data Logger	Measurable Range of Sensor (m)	Resolution of Water Level Measurement	Sensor Cable Length (m)	Sensor Depth from TOC (m)	Sensor Elevation (EL., m)	Remarks
	Latitude	Longitude			Head of Casing	Concrete Base	Ground									
D-1-0	N 16º 40' 23.3"	E 96º 16' 59.9"	52	36.7-48.0	6.767	6.015	5.249	14/08/2013	15:00	AQ120737	20	1 cm	30	20.50	-13.73	
D-1-1	N 16º 40' 23.5"	E 96º 17' 00.2"	85	66.1-83.0	6.759	6.010	5.265	14/08/2013	15:00	AQ120741	20	1 cm	30	21.07	-14.31	
D-1-2	N 16º 40' 23.4"	E 96º 16' 59.6"	150	109.8-138.0	6.784	5.979	5.264	14/08/2013	15:00	AQ120739	20	1 cm	30	21.31	-14.53	
D-1-3	N 16º 40' 23.3"	E 96º 16' 59.8"	330	187.0-199.0 211.0-232.0 256.0-283.0	6.779	6.015	5.294	14/08/2013	15:00	AQ120738	20	1 cm	30	20.90	-14.12	
D-2-0	N 16º 41' 12.5"	E 96º 18' 27.5"	56	31.4-37.1 48.4-54.0	19.551	18.754	17.871	18/07/2013	11:00	AQ130422	20	1 cm	30	21.36	-1.81	
D-2-1	N 16º 41' 12.2"	E 96º 18' 28.6"	97	66.8-95.0	19.459	18.608	17.654	18/07/2013	12:00	AQ120733	10	1 mm	30	15.20	4.26	
D-2-2	N 16º 41' 12.7"	E 96º 18' 28.3"	150	125.4-148.0	19.748	18.914	18.058	18/07/2013	10:00	AQ120713	20	1 cm	30	25.00	-5.25	
D-2-3	N 16º 41' 11.7"	E 96º 18' 29.2"	330	196.0-217.0 223.0-225.0 241.0-250.0 268.0-277.0 283.0-301.0	19.019	18.147	17.414	02/10/2013	14:00	AQ120715	20	1 cm	30	28.05	-9.03	
D-3-1	N 16º 43' 01.7"	E 96º 21' 10.6"	80	60.4-77.3	5.436	4.633	3.833	10/07/2013	12:00	AQ120718	20	1 cm	30	15.25	-9.81	Salty water
D-3-2	N 16º 43' 01.6"	E 96º 21' 10.0"	180	112.1-123.4 132.1-137.7 143.4-149.0	5.278	4.491	3.764	10/07/2013	11:00	AQ120720	20	1 cm	30	15.07	-9.79	
D-3-3	N 16º 43' 01.6"	E 96º 21' 09.5"	330	244.0-274.0 298.0-328.0	5.298	4.584	3.751	10/07/2013	11:00	AQ120712	20	1 cm	30	15.04	-9.74	
D-4-1	N 16º 44' 50.6"	E 96º 26' 06.4"	85	66.1-83.0	5.125	4.290	3.667	18/07/2013	14:00	AQ120731 (AQ130424 till 13/11/13)	10	1 mm	30	11.20 (18.22 till 28/01/14)	-6.07 (-13.09 till 28/01/14)	Salty water
D-4-2	N 16º 44' 50.7"	E 96º 26' 06.4"	146	110.1-132.7 138.4-144.0	5.169	4.373	3.542	18/07/2013	14:00	AQ120714	20	1 cm	30	20.27	-15.10	Salty water
D-5-1	N 16º 46' 08.8"	E 96º 14' 49.7"	65	46.1-63.0	25.848	25.114	24.238	13/08/2013	15:00	AQ120736	20	1 cm	30	30.28	-4.43	
D-5-2	N 16º 46' 08.8"	E 96º 14' 49.2"	100	81.1-98.0	24.854	24.080	23.299	18/07/2013	9:00	AQ130421	20	1 cm	40	37.53	-12.68	
D-5-3	N 16º 46' 08.8"	E 96º 14' 49.5"	350	180.0-240.0	25.502	24.736	23.929	22/11/2013	13:00	AQ120740	20	1 cm	50	47.47	-21.97	

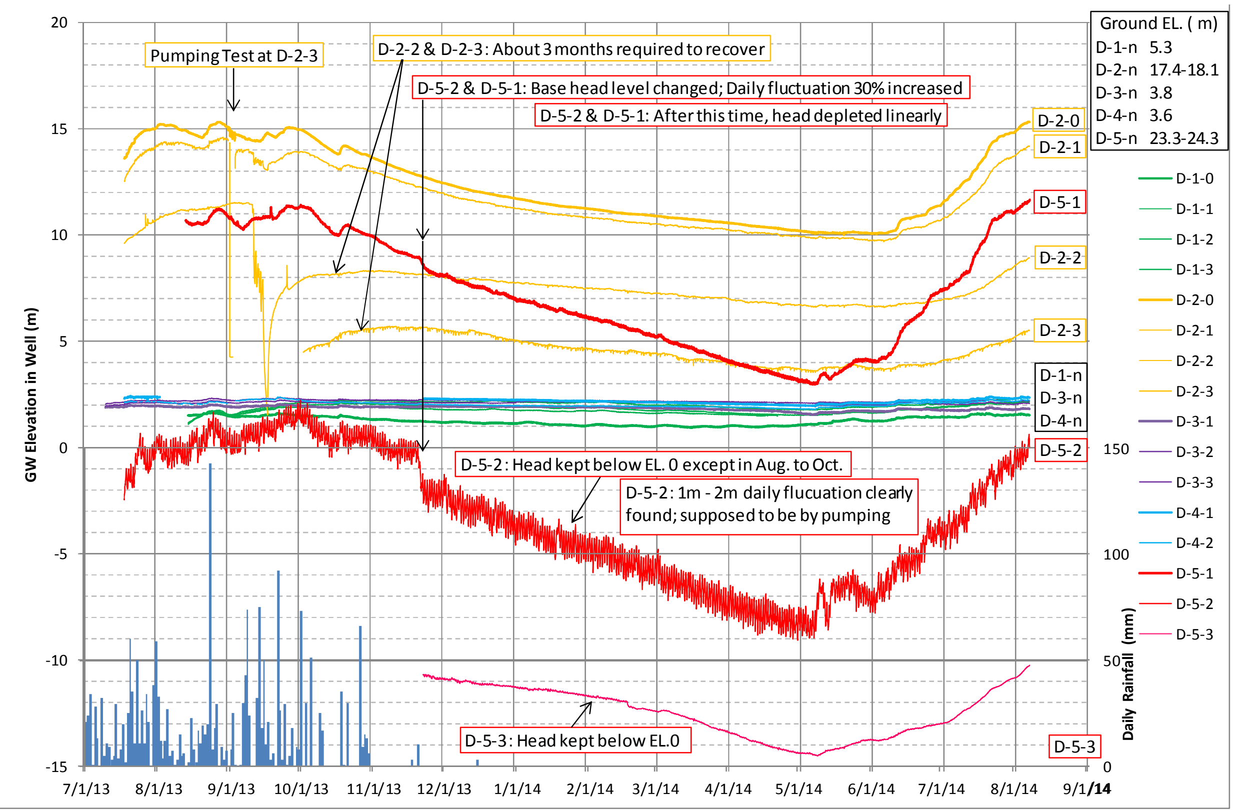


Figure 3-2-9-2 GW Level Fluctuation of Observation Well in Elevation – All Wells

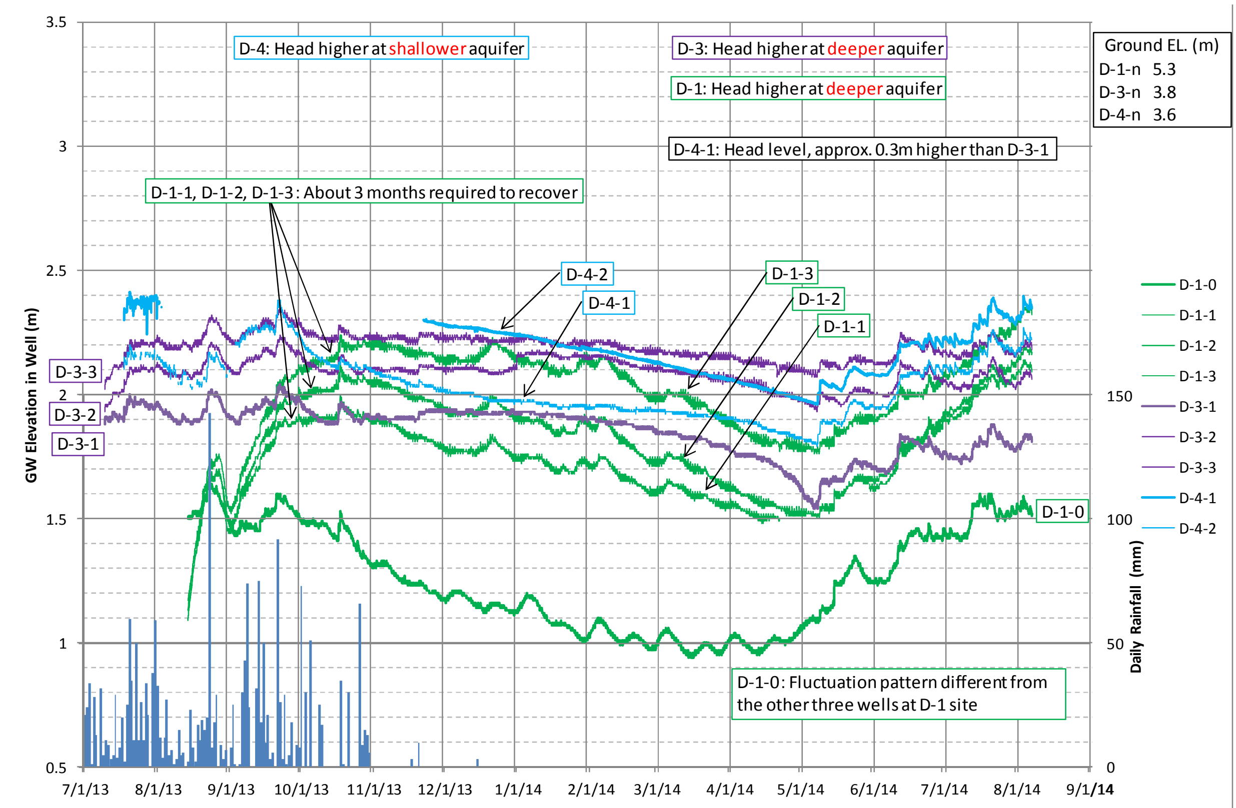


Figure 3-2-9-3 GW Level Fluctuation of Observation Well in Elevation –Wells in Plain/Lowland

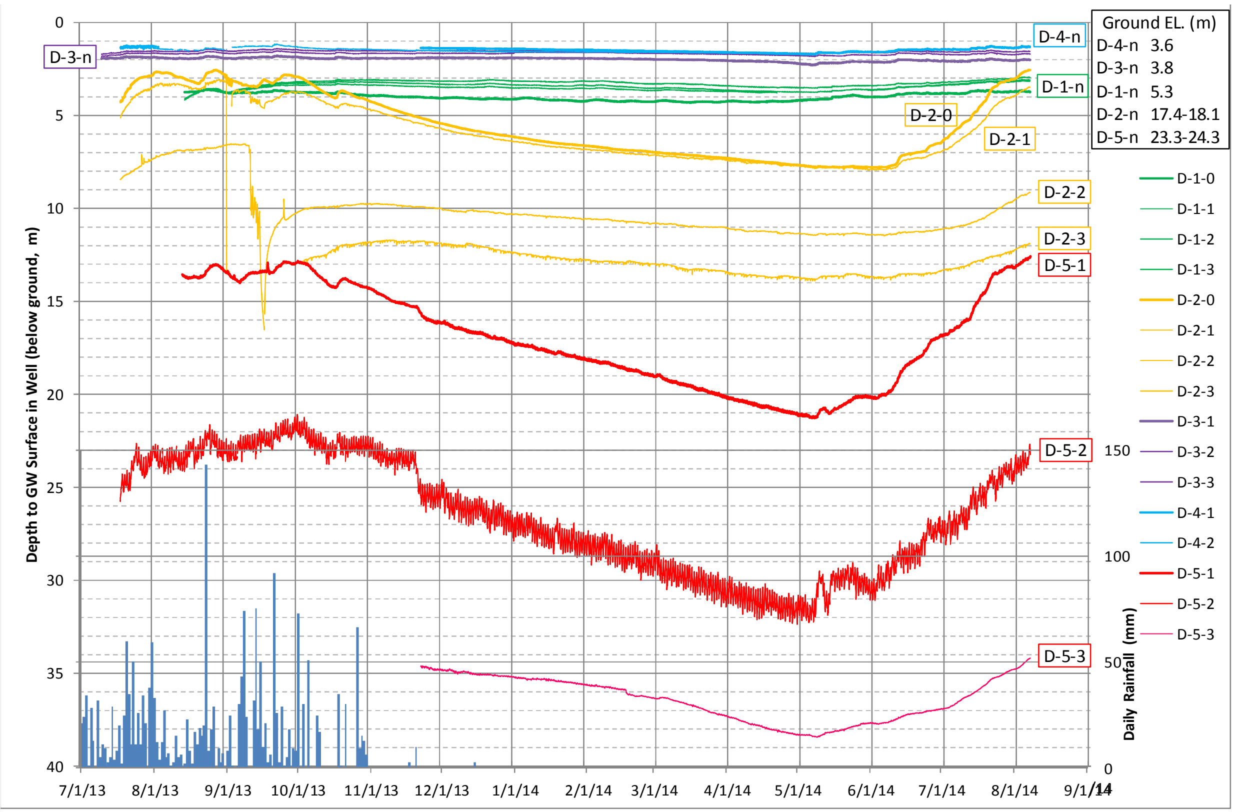


Figure 3-2-9-4 GW Level Fluctuation of Observation Well in Depth – All Wells

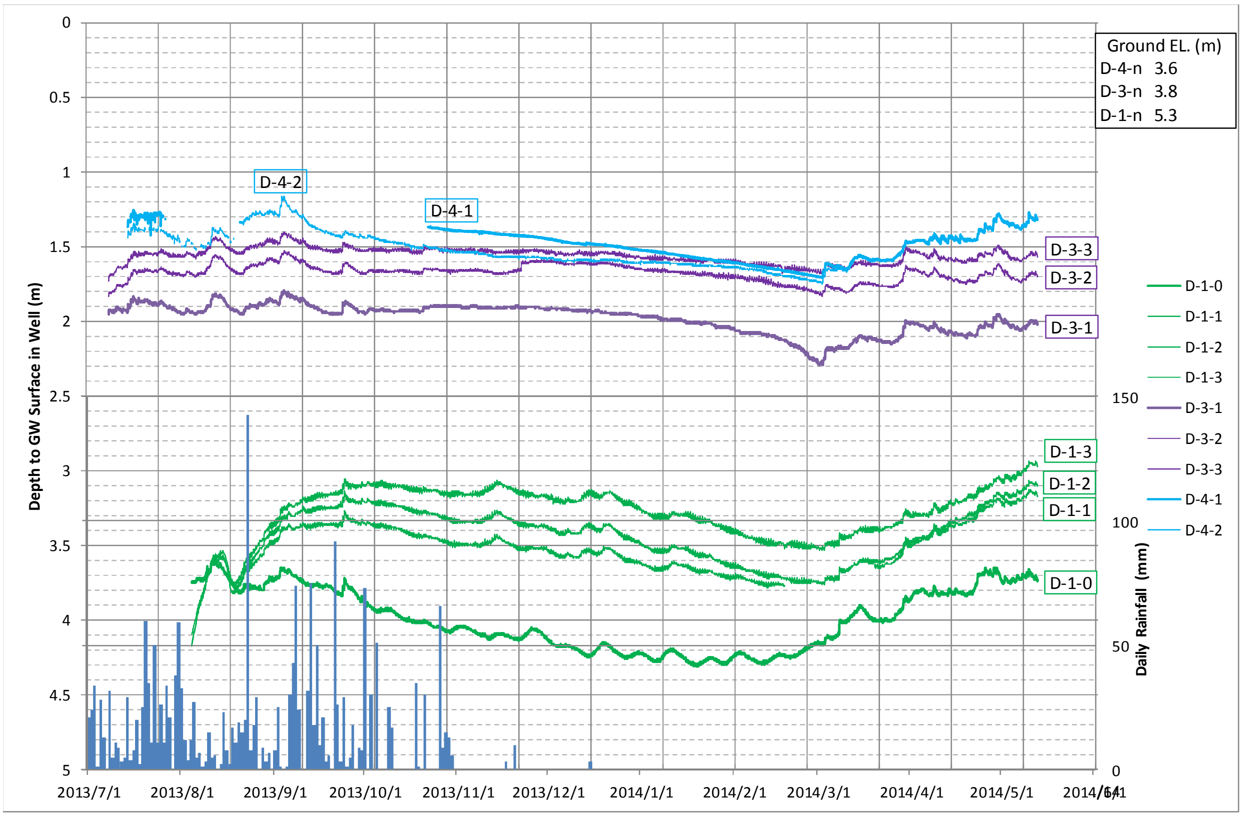


Figure 3-2-9-5 GW Level Fluctuation of Observation Well in Depth – Wells in Plain/Lowland

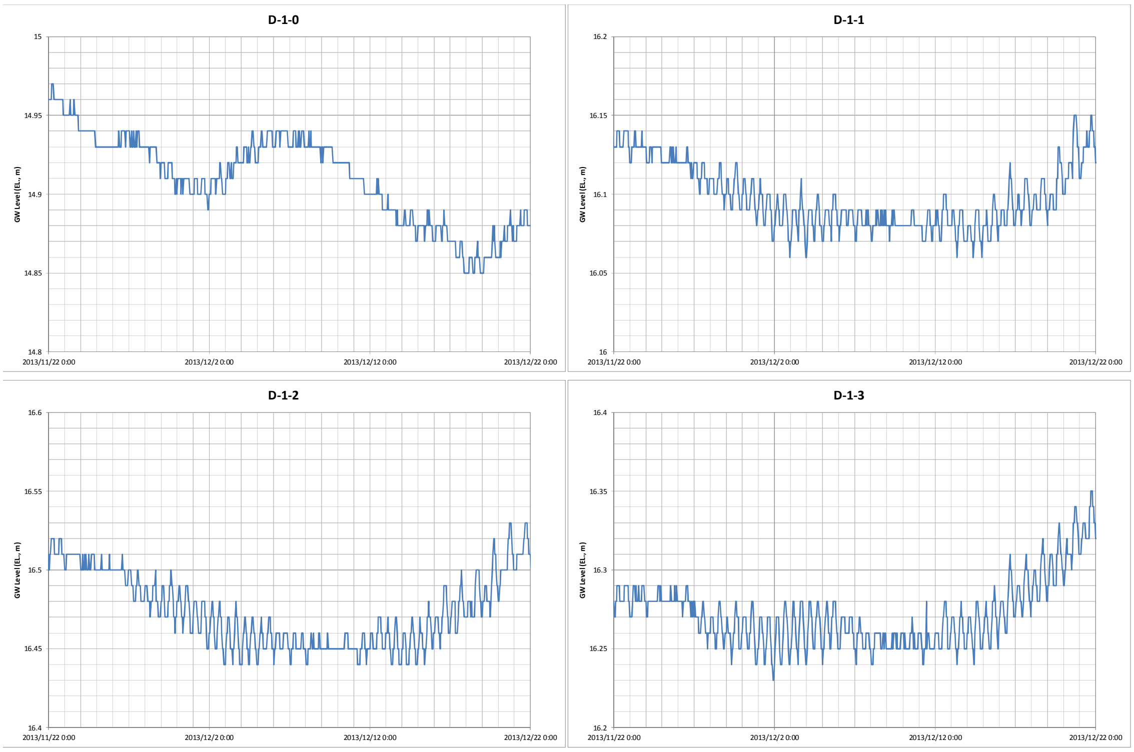


Figure 3-2-9-6 Fine Fluctuation of GW Level at D-1 Site Wells

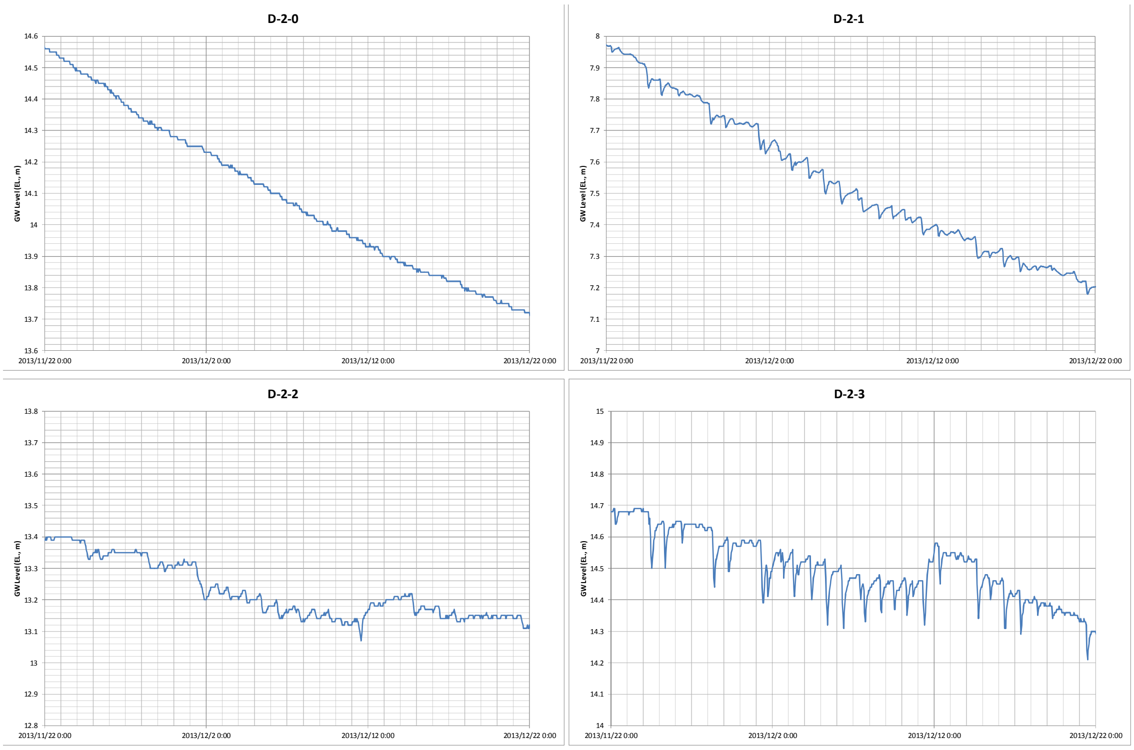


Figure 3-2-9-7 Fine Fluctuation of GW Level at D-2 Site Wells

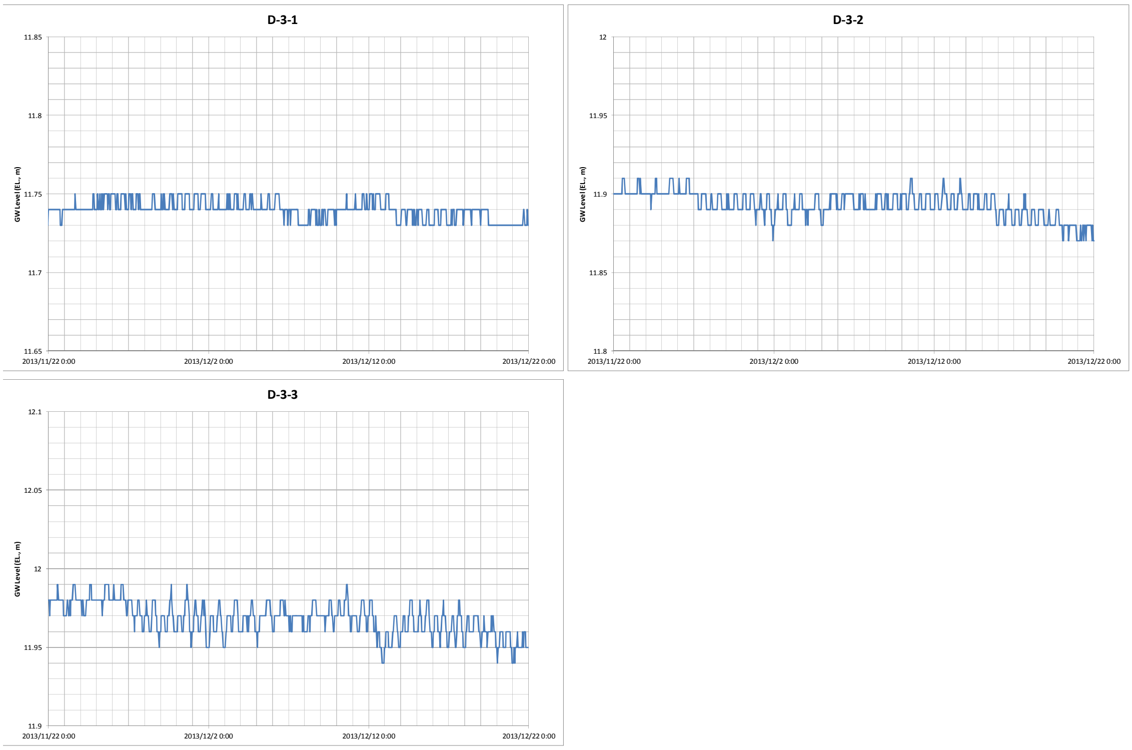


Figure 3-2-9-8 Fine Fluctuation of GW Level at D-3 Site Wells

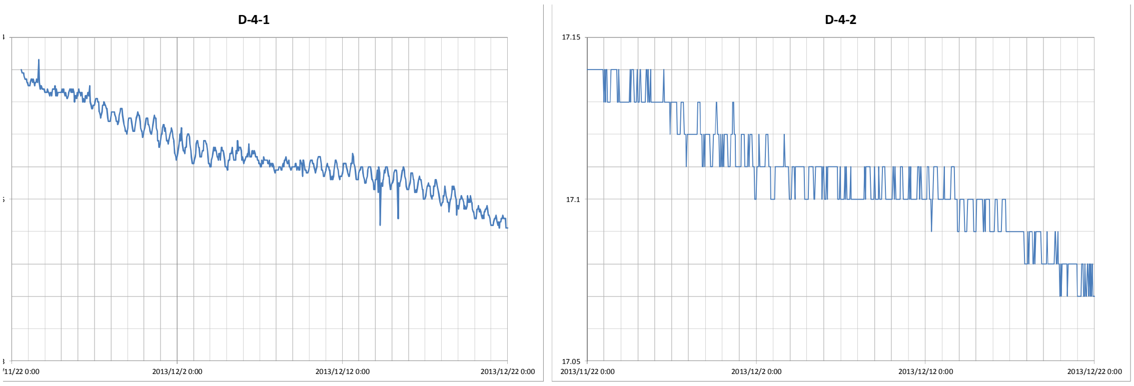


Figure 3-2-9-9 Fine Fluctuation of GW Level at D-4 Site Wells

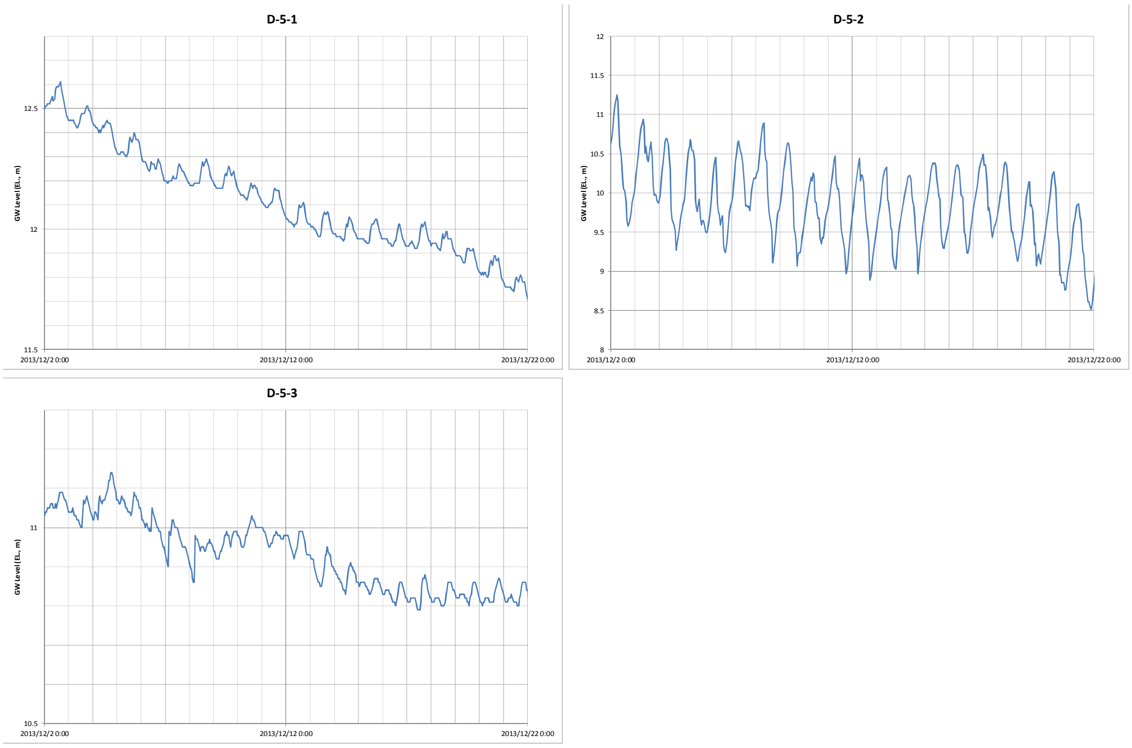


Figure 3-2-9-10 Fine Fluctuation of GW Level at D-5 Site Wells

Table 3-2-9-2 Daily Rainfall in 2013 in Yangon

Station:	Kaba-Aye (Yangon)									Year:	2013
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	16	21	33	8	73	0	0
2	0	0	0	0	0	0	24	12	25	0	0	0
3	0	0	0	0	0	9	34	4	1	30	0	0
4	0	0	0	0	0	31	1	12	0	0	0	0
5	0	0	0	0	0	74	28	27	1	51	0	0
6	0	0	0	0	0	14	13	5	30	0	0	0
7	0	0	0	0	0	24	0	7	43	0	0	0
8	0	0	0	0	1	21	32	1	74	0	0	0
9	0	0	0	0	0	13	5	3	24	25	0	0
10	0	0	0	0	2	19	11	15	0	17	0	0
11	0	0	0	0	0	20	9	5	0	0	0	0
12	0	0	0	0	0	47	3	6	32	0	0	0
13	0	0	0	0	0	7	5	0	75	0	0	0
14	0	0	0	0	0	46	29	2	18	0	0	0
15	0	0	0	0	0	11	4	23	50	0	0	3
16	0	0	0	0	4	23	8	8	10	0	0	0
17	0	0	0	0	21	0	20	2	21	0	3	0
18	0	0	0	0	0	0	2	17	3	35	0	0
19	0	0	0	0	0	21	25	11	6	1	0	0
20	0	0	0	0	0	2	60	19	0	0	10	0
21	0	0	0	0	0	12	35	15	92	30	0	0
22	0	0	0	0	25	2	11	20	26	0	0	0
23	0	0	0	0	12	3	50	143	3	0	0	0
24	0	0	0	0	17	18	11	8	29	0	0	0
25	0	0	0	0	5	38	26	18	1	0	0	0
26	0	0	0	0	1	17	11	29	5	66	0	0
27	0	0	0	0	2	12	34	0	18	9	0	0
28	0	0	0	0	2	20	21	9	0	15	0	0
29	0		0	0	7	33	0	3	9	13	0	0
30	0		0	0	21	3	38	7	8	6	0	0
31	6		0		5		59	0		0		0
Total	6	0	0	0	125	556	630	464	612	371	13	3
											Total	2780

3-2-10 Seasonal Groundwater Level Measuremnet at Dug Wells

To grasp the ground water level distribution and its seasonal change in the unconfined aquifer in the hill, the water level at dug wells was measured mostly in November, 2012 for all wells and at the end of April, 2014 for the selected 56 wells. Figure 3-2-10-2 and Figure 3-2-10-3 show the results. The depth to the groundwater table is small at the sides of the hill and large in the central part of the hill. The maximum depth at the end of April, 2014 was 11.65 m and it is dried up at some wells. The largest annual fluctuation was 6.1 m.

Figure 3-2-10-1 show the groundwater table contour map created based on the measurement in November, 2012. The groundwater is considered to flow from the ridge part of the hill to the both sides.

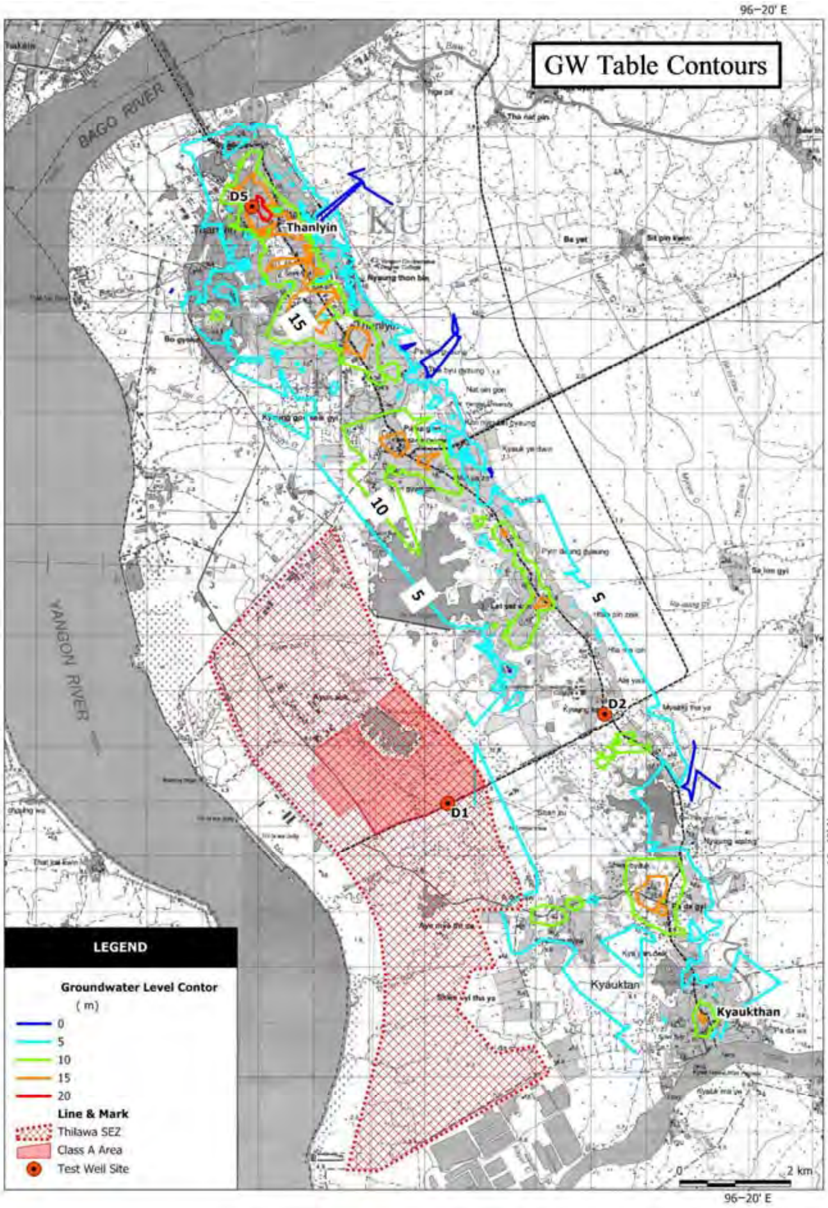


Figure 3-2-10-1 Groundwater Table Contours in Unconfined Aquifer in the Hill (Nov., 2012)

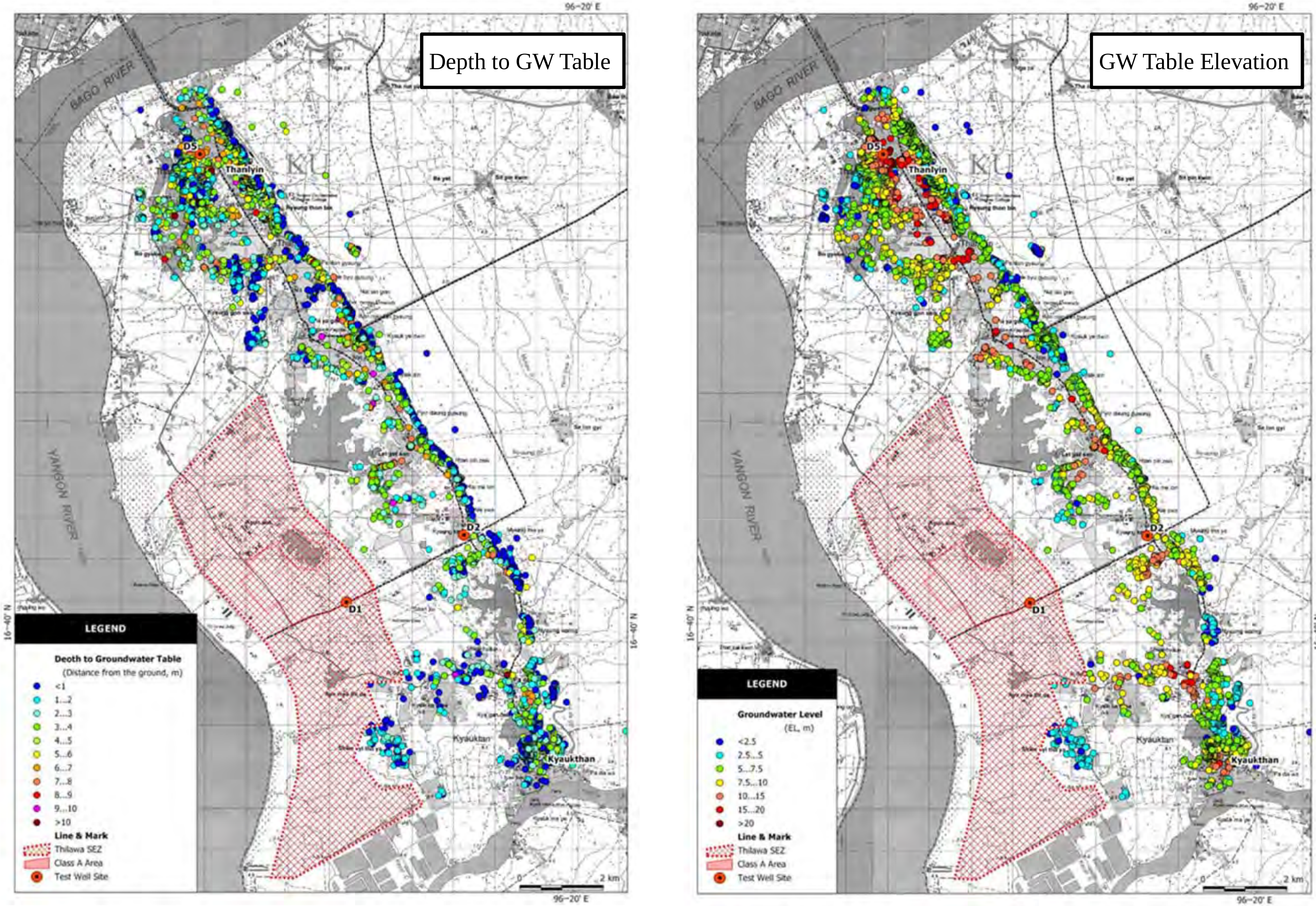


Figure 3-2-10-2 Groundwater Table Depth and Elevation in Dug Wells in Nov., 2012

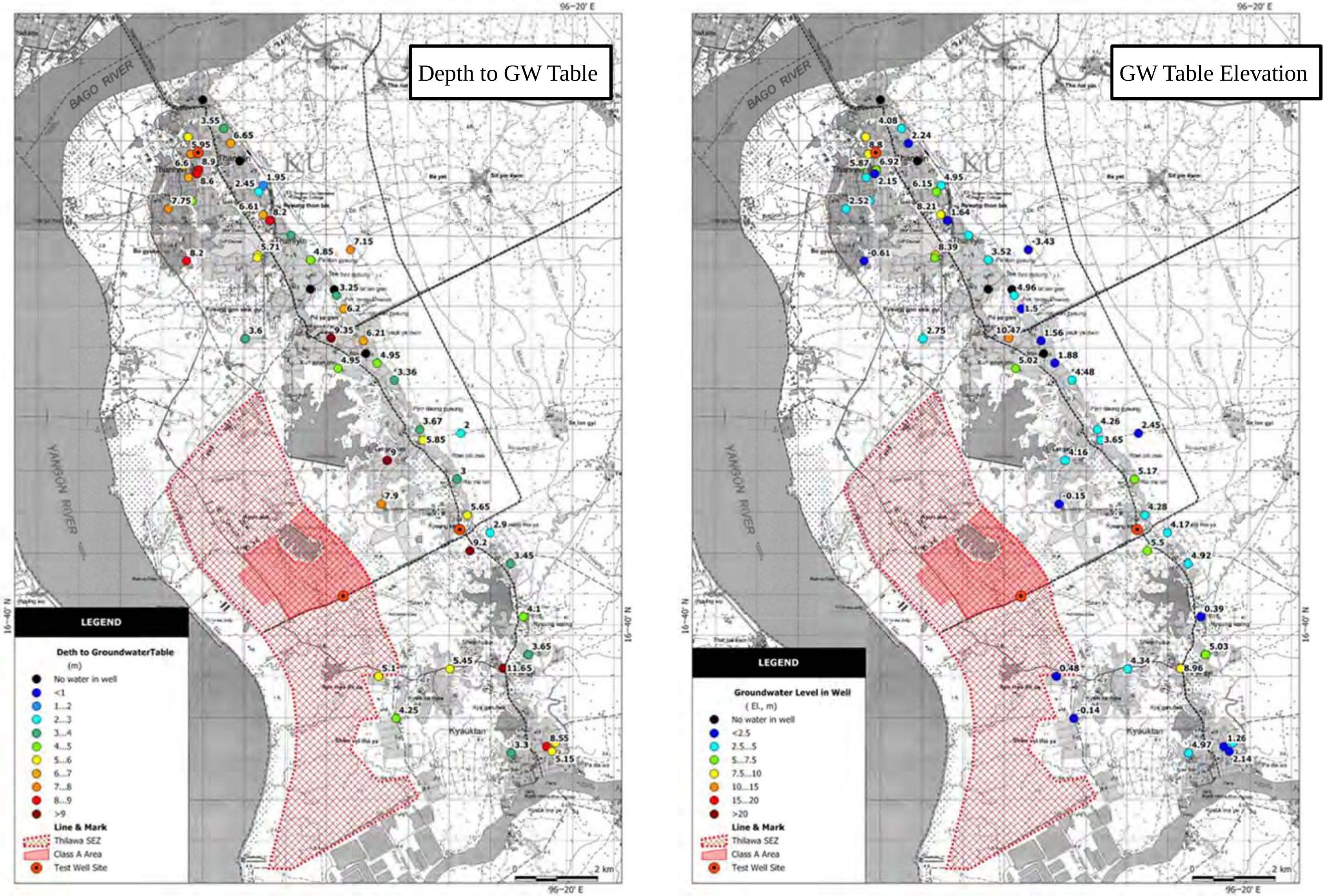


Figure 3-2-10-3 Groundwater Table Depth and Elevation in Dug Wells at the End of April. 2014

3-2-11 Creation of Landcover Map

A land cover map was created for the groundwater investigation area based on a satellite image to assist in the estimation of groundwater recharge and a load source of water quality. The SPOT image with a resolution 2.5m was used. The interpretation of the image pixel to a land cover classification was carried out first automatically by software. Then the interpretation was compared with the real condition in the field for typical land use and corrected manually with the comparing results.

The land cover map finally created is shown in Figure 3-2-11-1. Most of the area is covered with paddy fields. It is represented as five different classifications, which may reflect different water contents in the soil and different growing conditions of the grass. The unused developed area in and around SEZ is also included in those classifications. A part of the paddy fields still keeps water and is classified to water surface, because the image was taken in the early dry season (December and January). Classification "Artifact" means a building or paved road. "Forest" and "Bare land" are more found in and near the Thanlyin-Kyauktan Ridge.

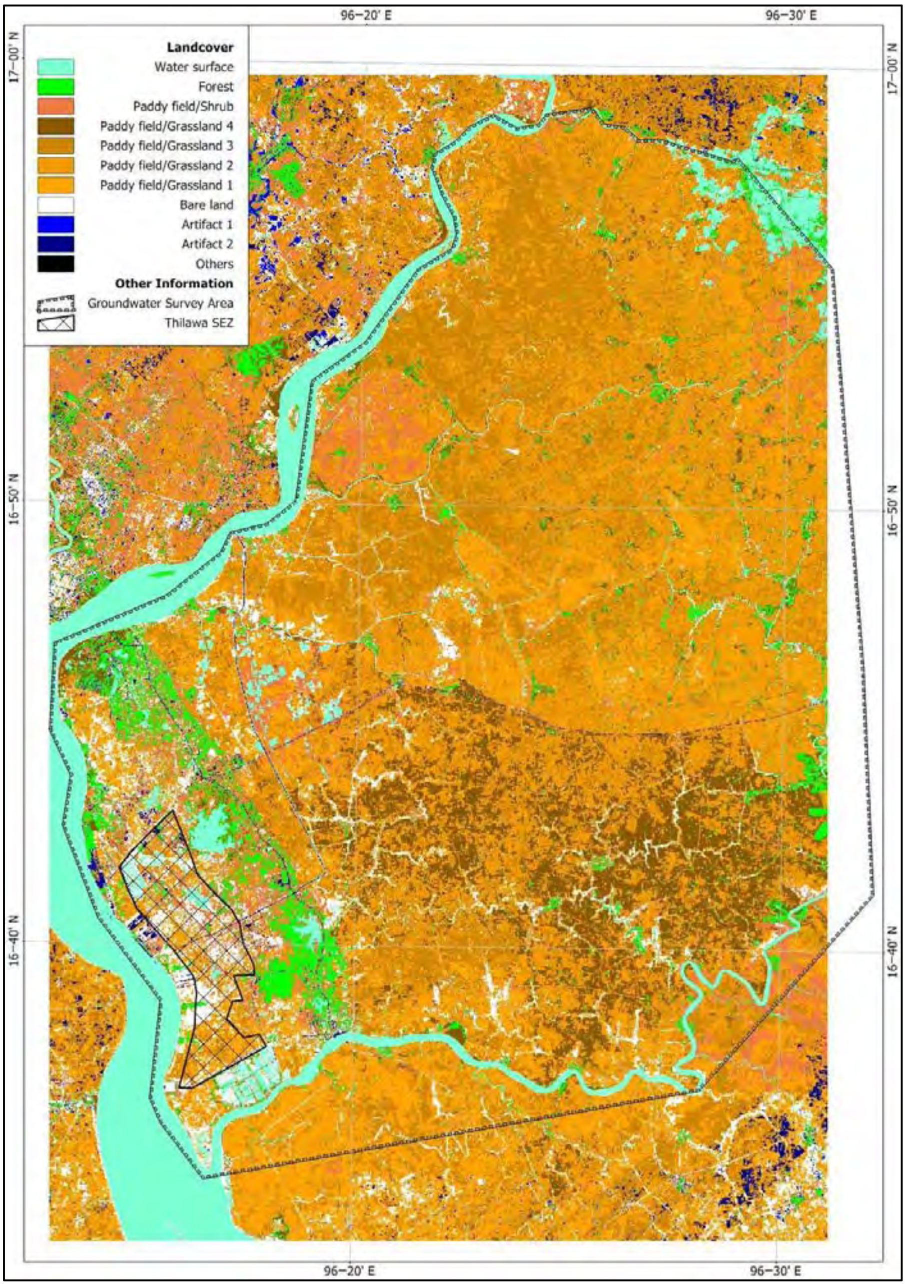


Figure 3-2-11-1 Land Cover Map of Groundwater Survey Area

3-2-12 Outcrop Reconnaissance

It is difficult to grasp the geological condition on the hill because outcropping is rare. However, land development work for projects made some new outcrops showing a few meter height of cut face. The outcrops were visited and observation of facies and measurement of dip and strike of layer were tried out. Though a considerable part of outcrop is strongly weathered (lateritized), and it was difficult to know the bedding condition, the measurement was completed at a few outcrops. In addition, the stratified condition could be well observed on the sidewall of some dug wells. Figure 3-2-12-1 to Figure 3-2-12-5 show the locations of such outcrops and their geological conditions.

(1) Outcrops in the Northern Part of the Hill near Kyaik Kauk Pagoda

In this area, the boundary between the Irrawaddy Formation and the Pegu Group is located. Here weathered sand layers with lateritic soil are widely found. Layers dip 22 degrees to the northwest at the outcrop of laminated mudstone along a waterway located to the north of the pagoda. (See Figure 3-2-12-1 and Figure 3-2-12-2)

(2) Outcrops in the Central Part of the Hill to the East of Thilawa

Mudstone dominates and sandstone only covers a partial area to the east of SEZ. The layer strikes along the ridge and dips almost horizontally in SEZ and within 15 to 20 degrees to the northeast in the area to the east of SEZ. (See Figure 3-2-12-3)

(3) Outcrop on the Southern Part of the Hill along Hmaw Wun River in Kyauktan

Mudstone with lamination and a laterite surface distribute. The strike of the layer is concordant to the ridge direction, and the dip is 30 to 60 degrees to the northeast. Along the riverside of the Hmaw Wun River in the plain a little to the east of Kyauktan town, a gently-dipping laminated mudstone is found. (See Figure 3-2-12-4 and Figure 3-2-12-5)

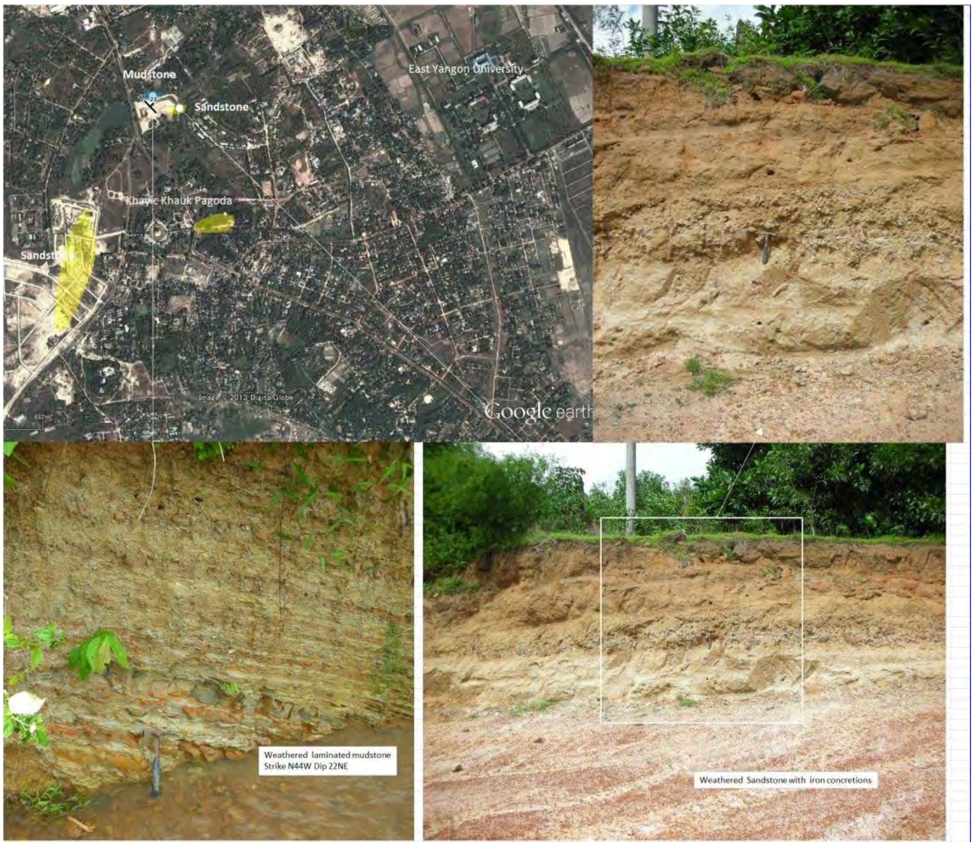


Figure 3-2-12-1 Outcrops in the Northern Part of the Hill near the Kyaik Kauk Pagoda (1)

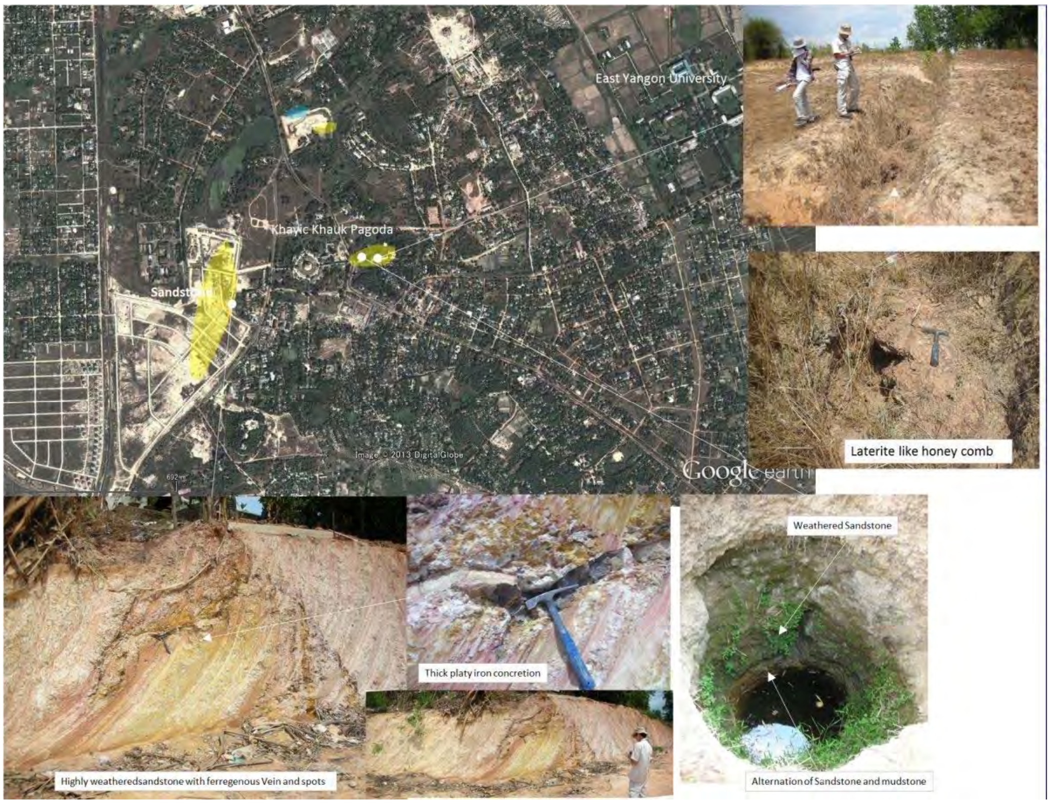


Figure 3-2-12-2 Outcrops in the Northern Part of the Hill near the Kyaik Kauk Pagoda (2)

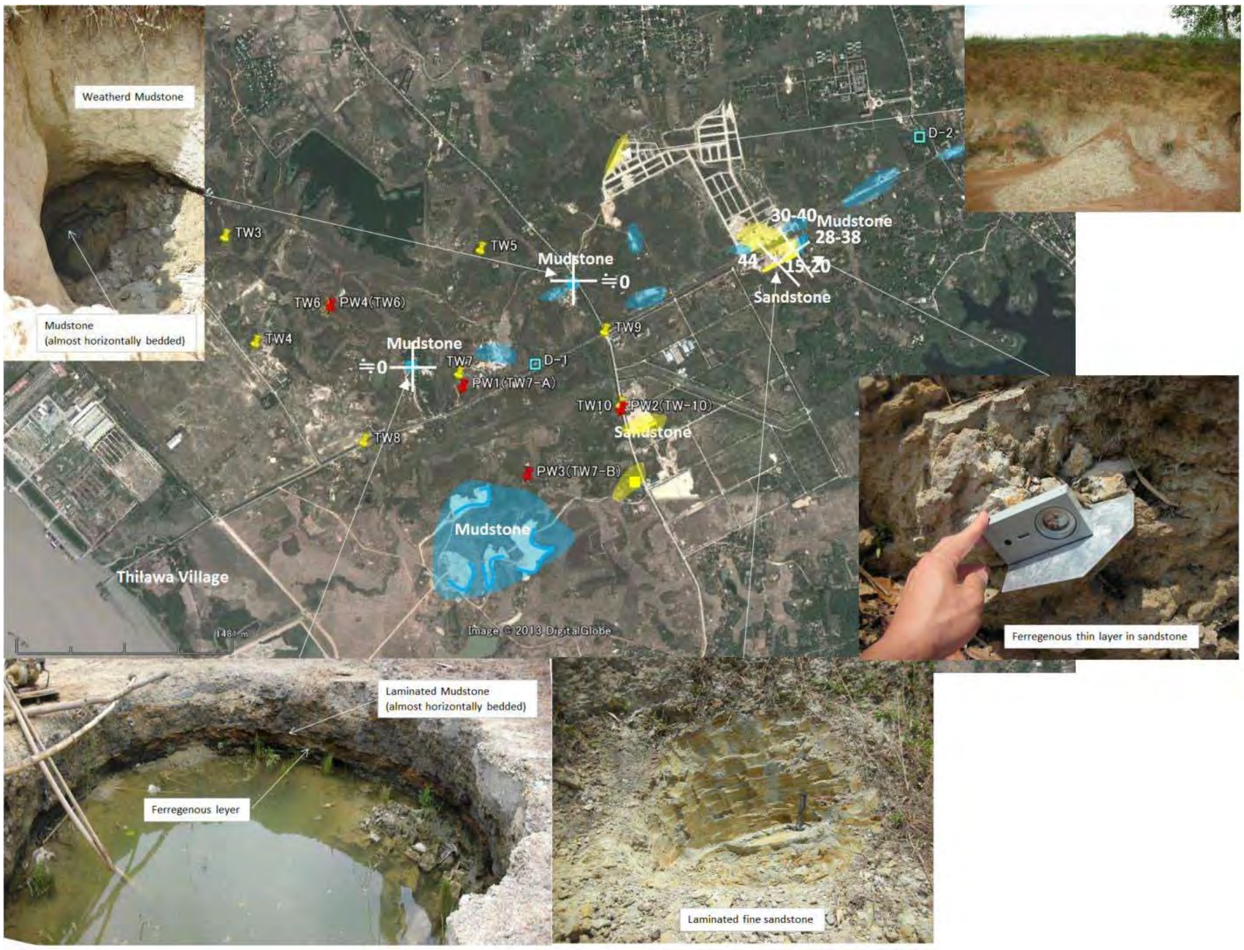


Figure 3-2-12-3 Outcrops in Central Part of the Hill to the East of Thilawa

Figure 3-2-12-4 Outcrop in Southern Part of the Hill along Hmaw Wun River in Kyauktan

Figure 3-2-12-5 Outcrop in the Plain along Hmaw Wun River to the East of Kyauktan Town

3-2-13 Pumping Test at Existing Wells

This pumping test was carried out to collect hydraulic parameters of the aquifer in the investigation area.

3-2-13-1 Location and Features of Test Wells

As described in “2-3 Well Inventory Survey”, first, the candidate wells for the pumping test, 20 shallow wells and 20 deep wells, were selected from the well inventory. Then, reconnaissance of them was carried out to confirm whether the test is really possible or not (water level and discharge rate are measureable or not). Finally the three wells shown in Figure 3-2-13-1 were selected for the test. The main features of the wells are shown in Table 3-2-13-1.

Among the three wells, KYA-20-2617 and THA-27-8653 are a kind of shallow well of dug type and THA-8-5116 is a kind of deep well of tube well type. The aquifer of the former ones is considered to be soft sandstone of Tertiary age and kept in unconfined condition. The aquifer of the latter is inferred to be an unconsolidated sand layer of Quaternary age and being in confined condition.

Hereunder in this report, the names of the wells used are abbreviated for simplicity as “KYA-20” for KYA-2617, “THA-27” for THA-27-8653 and “THA-8” for THA-8-5116 respectively.

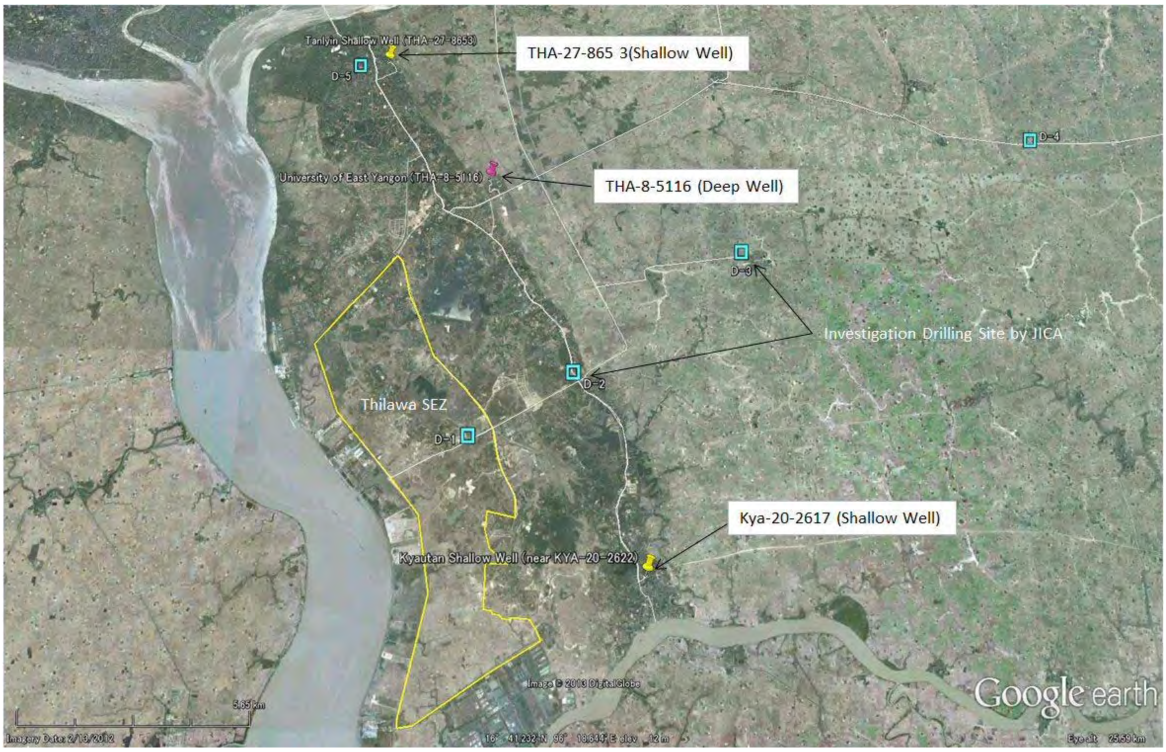


Figure 3-2-13-1 Location of Existing Wells for Pumping Test

Table 3-2-13-1 Main Features of Wells for Pumping Test

Township	Thanlyin		Thanlyin		Kyauktan
Owner	University of East Yangon		Private (U Sein Nyunt)		Monastery
Longitude	16.73728	16.73507	16.77122	16.77122	16.64256
Latitude	96.2848	96.28505	96.25458	96.25458	96.32532
Inventory Survey Well No.	**THA-8-5116**	-	**THA-27-8653**	-	**KYA-20-2617**
Tentative Well No.	No.4	No.2			No.1
Kind of Well	Deep well	Deep well	Shallow well	Shallow well	Shallow well
Type of Well	Tube well	Tube well	Dug well	Dug well	Dug well
Purpose of Water Use	Domestic, Drinking	Not used	Domestic, Drinking	Domestic, Drinking	Domestic, Drinking
Depth of Well	240'	180'	7.4 m	-	8.1 m
Depth of Screen	220' - 240' (67m-73m)				
Diameter of Well	6"	2"	1.1 m square	-	1.7m
Method to Take Water	submergible pump (3")	No pump	Suction pump and Bucket	-	Suction pump
Setting Depth of Pump or Mouth of Suction Pipe	140' (43m)	-	-	-	7.5 m
Suction Pipe Diameter	2"	-	1"	-	1"
Water Level Measurement	Possible	Possible	Possible	Possible	Possible
Static Water Level	8' ～9' (2.5m-3.0m)		5.85 m (2/4/13)	-	5.02 m (2/4/13)
Dynamic Water Level	40' ～45' (12m-14m)		Not dried up even after one day	-	Dried up after on hour pumping
Possibility of One Hour Pumping	Possible		Possible	-	30 min recommendable
Pumping/Observation Well	Pumping Well	Observation Well	Pumping Well	Observation Well (7.9m from THA-27-8653)	Pumping Well

3-2-13-2 Specification of Pumping Test

The pumping at the shallow well was carried out by a suction type of pump with about a 40 l/min discharge capacity which is almost the same as the one already equipped with the well (see Figure 3-2-13-3). The pumping at the deep well was done with a submergible pump originally equipped. The discharge was not controlled for simplicity of the test and not to damage the equipped pump. The pumping period was limited to one hour considering well use. The discharge rate by pump was measured by the cumulative flow meter (see Figure 3-2-13-2) and/or by bucket with stopwatch. The water level was measured by a pressure gauge type of automatic water level meter with a vent pipe as well as a manual water level meter (see Figure 3-2-13-4). At the wells THA-27 and THA-8, the water level of another nearby well was also measured.

Figure 3-2-13-3 Pump used at Shallow Well

Figure 3-2-13-2 Cumulative Flow Meter

Figure 3-2-13-4 Automatic Water Level Meter used for the Test

3-2-13-3 Measurement Result of Pumping Test

Measurement results of the pumping test at KYA-20, THA-27 and THA-8 are shown in Figure 3-2-13-5 to Figure 3-2-13-10. The water level change in the observation well at THA-8 and THA-27 was less than three centimeters.

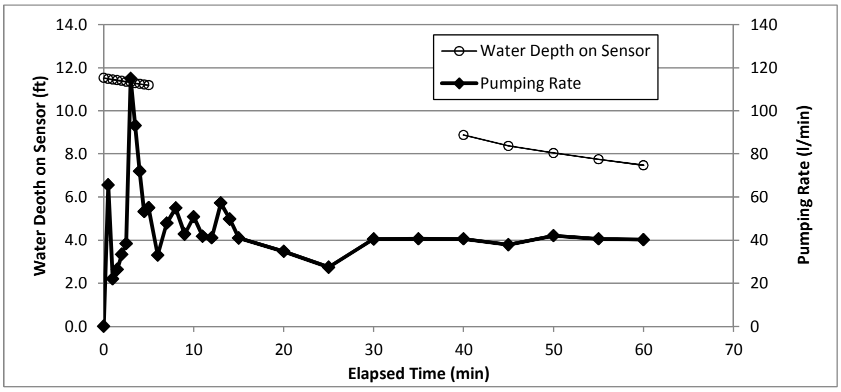


Figure 3-2-13-5 Water Level and Pumping Rate Change in Pumping at KYA-20

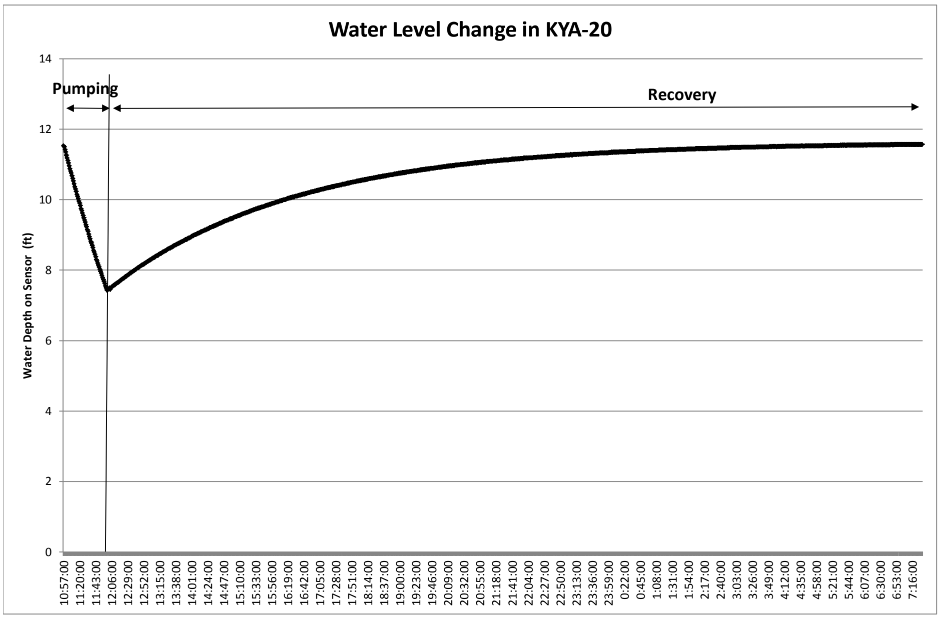


Figure 3-2-13-6 Water Level Change in Pumping and Recovery at KYA-2

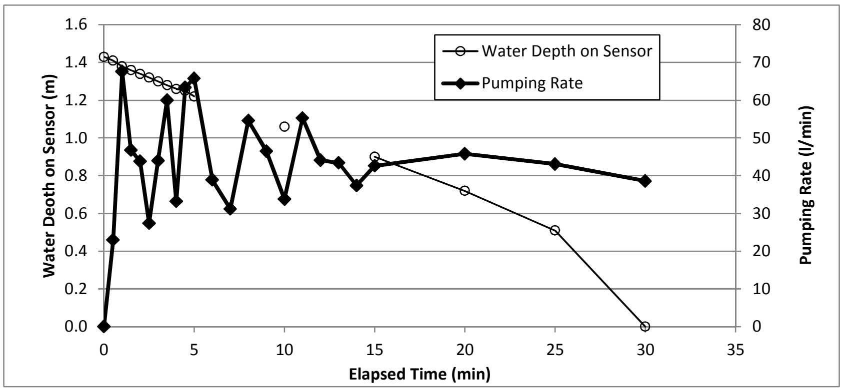


Figure 3-2-13-7 Water Level and Pumping Rate Change in Pumping at THA-27

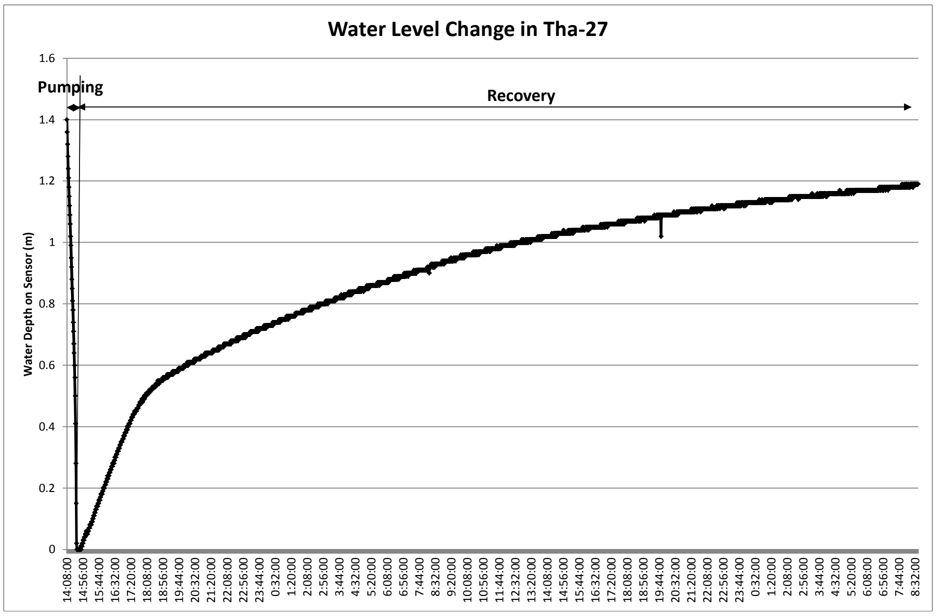


Figure 3-2-13-8 Water Level Change in Pumping and Recovery at THA-27

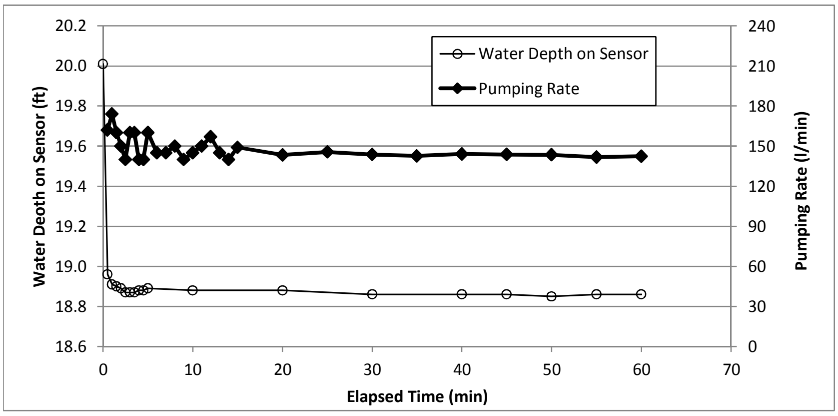


Figure 3-2-13-9 Water Level and Pumping Rate Change in Pumping at THA-8

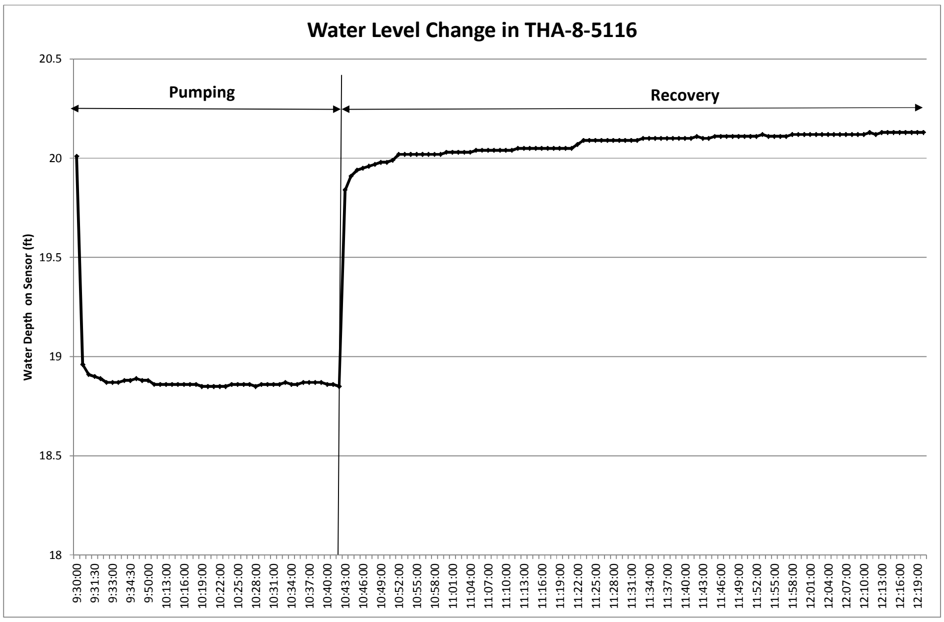


Figure 3-2-13-10 Water Level Change in Pumping and Recovery at THA-8

3-2-13-4 Analysis Result of Pumping Test

The hydraulic parameters of the aquifer of the pumping test wells are estimated as shown in Table 3-2-13-2. The analysis method is explained in the "Supporting Data" .

Table 3-2-13-2 Summary of Hydraulic Parameters of Aquifer at Pumping Test Wells

Well Name	Well Depth (m)	Type of Aquifer	Transmissivity (m^2/day)	Aquifer Thickness (m)	Permeability (cm/sec)	Storage Coefficient
KYA-20-2617	8.1	Unconfined	13	5 *1	3.0×10^{-3}	-
THA-27-8653	7.4	Unconfined	2～ 6	5 *1	$0.5\text{-}1.4\times10^{-3}$	-
THA-8-5116	73.2	Confined	340	6.1 *2	6.5×10^{-2}	Small

Note *1: Simply assumed
*2: Length of screen