Hydrogeological Characteristics of the Hmawbi Area

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Abstract

Hmawbi area approximately covers about 183.78 square miles. The major drainage is Hlaing river, along which the tidal action is noted in the western and southern parts of the area. In 2012, the population of study area was estimated by the Yangon City Development Committee (Y.C.D.C) to be 33,637. It is covered by alluvial soil and in some places lateritic soil. It is mainly composed of rocks ranging in age from Tertiary to Quaternary. The anticlinal structure is found in the Pegu Group. Groundwater occurs in many different geological formations. In Hmawbi area, water bearing geological formations are Alluvium and Irrawaddy Formation. The present study is based on well log data of 9 wells. Fence diagram shows that the groundwater flows towards the south-west direction. According to the grain size analysis of the aquifer sand samples from Irrawaddy Formation, the slotted size is 1.52mm. Hydraulic characteristics of the study area are determined by pumping out test and recovery test. Coefficient of transmissivity is found to be 128.51 m^2/d and 130.85 m^2/d respectively. According the semi-log plots of the theoretical time-drawdown, pumping out test well is confined aquifer.

Keywords: Hmawbi, groundwater, pumping out test, recovery test, aquifer

Introduction

Groundwater is an important source of water supply throughout the world. Its use in irrigation, industries, municipalities and rural homes continues to increase. The purpose of study is, to know the aquifer and hydraulics characteristics of Hmawbi area and to determine the optimum selection of gravel pack, screen and well design.

Location

The study area is situated at Latitude 17° 0′ 38″ to 17° 11′ 03″ and Longitude 95° 54′ 26″ to 96° 10′ 11″ in 85 O/16 and 94 C/4 of the Hmawbi Township, Yangon Region. It's coverage is about (183.78) square miles. It is accessible by Yangon-Pyay car road which passes through Mingalardone and Htaunkkyant. The location map shown in figure (1).

Geographic Condition

At the western part of Hmawbi area, Hlaing river flows across the study area from north to south. Tidal action is noted in the western and southern parts of the area, except the higher ground. Drainage pattern of the study area is predominantly of fine to medium dendritic pattern figure (2) . The average maximum temperature varies from 99° F to 102° F. The average rainfall range for Hmawbi is from 99.34 to 120. The mean monthly temperature around Yangon Region is fairly stable with annual average of about 30° C. The annual rainfall is about 550mm for Yangon Region. The graph of average monthly rainfall and temperature are shown in figures (3) and (4).

Methods of study

Basically, it began collecting literatures (such as papers, reports, thesis and other related data). Firstly, gathering information about household, population, well datas and general factors of the study area from the City Development Committee and other Departments. Secondly, systematic data collection was made for hydrogeological condition.

Thirdly, well's hydraulics characteristics are determined by pumping test and recovery test. Finally, collection of aquifer sand sample was made to assess the grain size distribution.

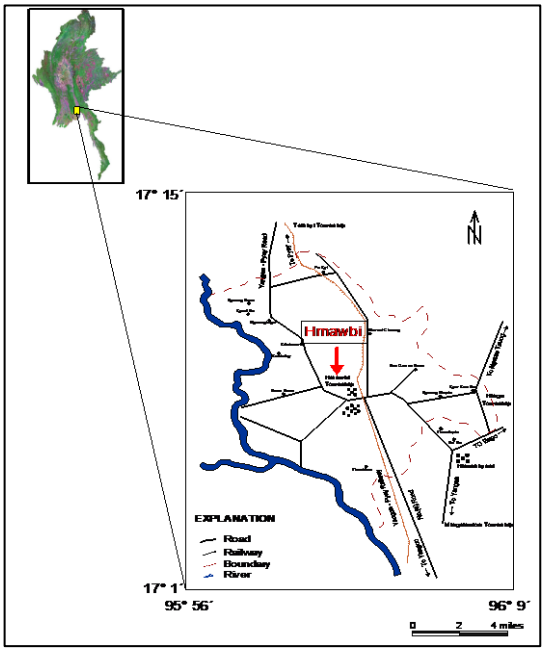

Figure (1). Location map of the study area

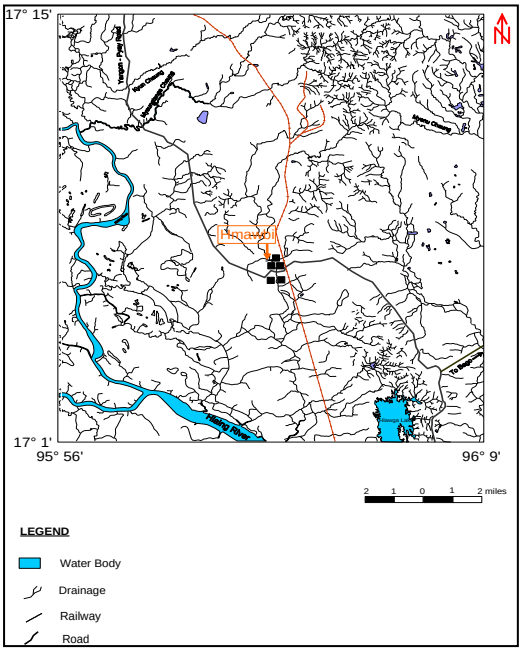

Figure (2). Drainage Map of the Study Area

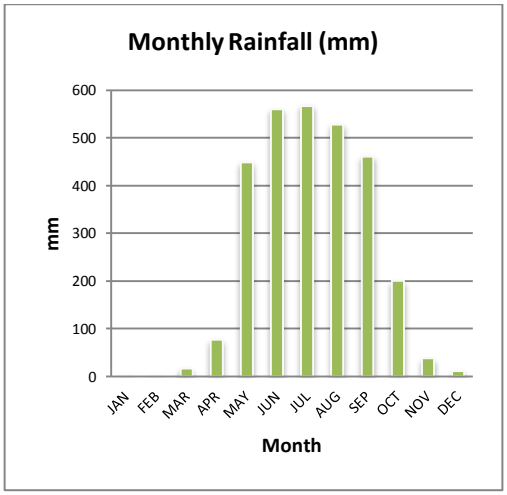

Figure (3) Monthly Mean Rainfall of Year 1999-2008 (from Kabaaye Hydrology Kabaaye Hydrology and Meteorology Station)

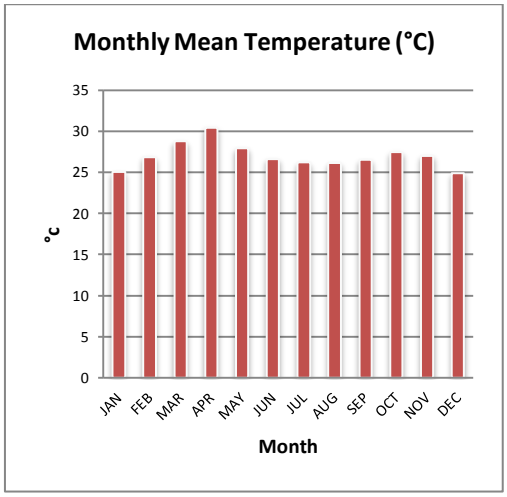

Figure (4) Monthly Mean Temperature of Year 1999-2008 (from Hydrology and Meteorology Station)

Regional Geologic Setting

Yangon region is generally covered by Quaternary and Tertiary sediments. The study area is covered by alluvial soil in the plain and the lateritic soil on the elevated part of the valley between the plain and rolling hills. The sedimentary rocks of sandstone, shale and mudstone belonging to Irrawaddian Formation and Upper Pegu Group occupy the hilly

region. Within the study area the oldest layer is the Pegu Group of Miocene age consisting mainly of Hlawga shale, Thadugan sandstone and Besapet alternation at the south-western part of the study area. On top of it the Irrawaddy Formation (Pliocene) was deposited, north-south trending at the eastern part of the study area. Recent Alluvium sediments are widely distributed in the study area. Geological map of the study area is shown in figure (5). In the study area, folding of Peguan rocks are seen at the south east of the area. The regional structural trend is nearly N-S trending. The anticlinal structure occurs in the Pegu Group of the study area.

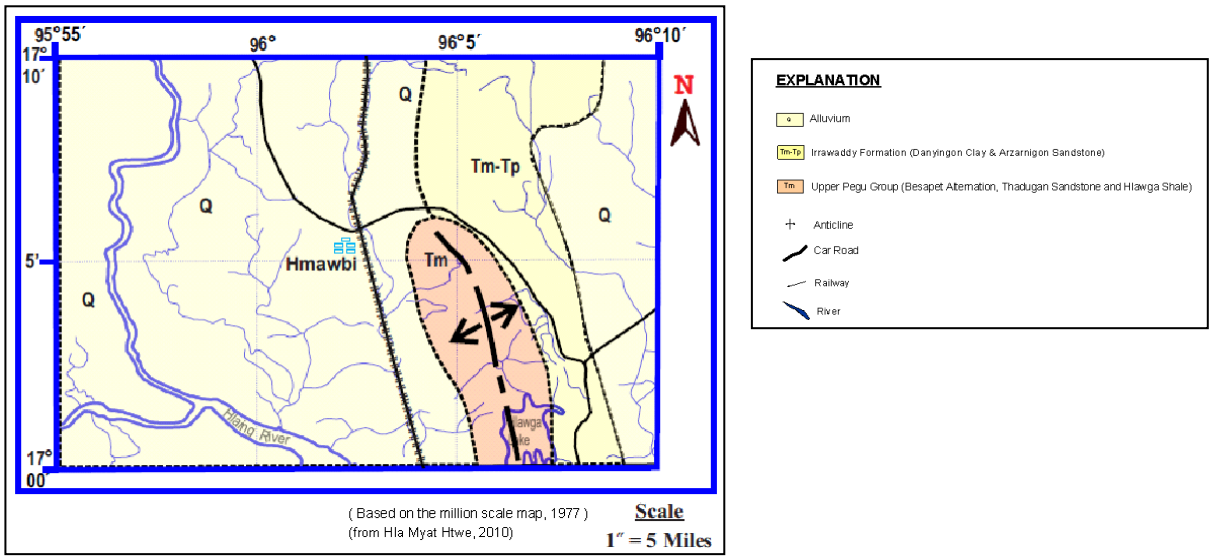

Figure (5). Geological Map of the Study Area

Hydrogeological Characteristics of the Study Area

Data of 1156 hung-dug wells and 874 tube wells were recorded for Hmawbi, although no reliable data is available for the existing producing wells of the present time. Therefore, the present study is based on well log data of 9 tube wells. Most of these wells are private wells, serving a single family or a small group of families. Groundwater from the shallow aquifer near the Hlaing river in the Hmawbi is mostly used for domestic purpose and irrigation of agricultural plots or animal breeding.

Groundwater occurs in many different geological formations. In Hmawbi area, water bearing geological formations are Alluvium and Irrawaddy Formation. The Irrawaddium deposits have moderate to high transmissivities. Well location map of the study area shown in figure (6) and water table contour map shows in figure (7).

Groundwater in Alluvium Units

Alluvium is found in the west and east of the study area. Alluvium is mainly composed of fine to medium-grained sand of yellow and gray coloured, bluish gray, silt and clays. Thickness of this unit may vary about 50 feet.

Groundwater in Irrawaddy Formation

The Irrawaddy Formation covers the eastern part of the Hmawbi near Htaunkkyant Junction. It consists of blue and grey clays and sand rock. In the Myawaddy Television well, the depth of water bearing horizon is ranging from 420 to 460 ft. The yield of aquifer about 800 gph for 2″ well. Thickness of the Irrawaddy Formation is about 1000 feet.

Fence Diagram

Fence diagram is shown in figure (8). From Fence diagram of well No. 4, 5, 7, and 9 in the Alluvium, it was evident that the sand and clay of alluvium are gently dipping towards the south-west direction.

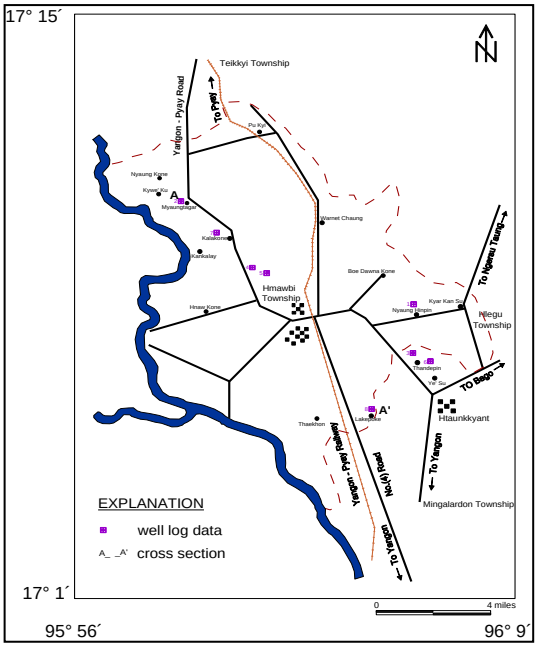

Figure (6). Well Location Map of the Study Area

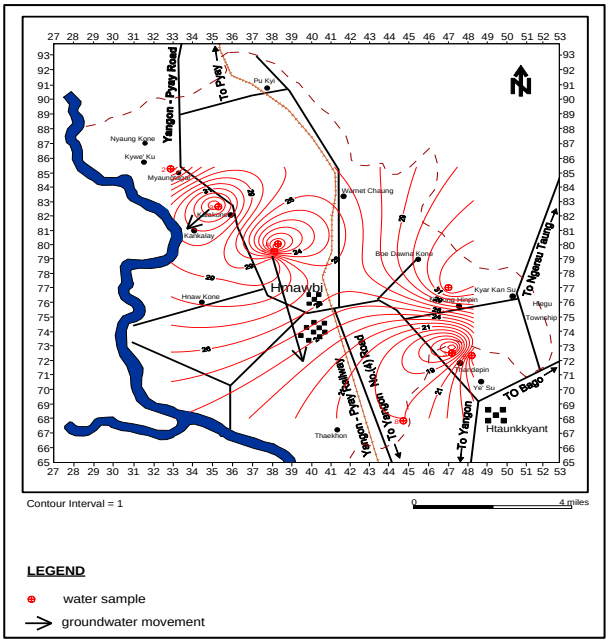

Figure (7). Watertable Contour Map

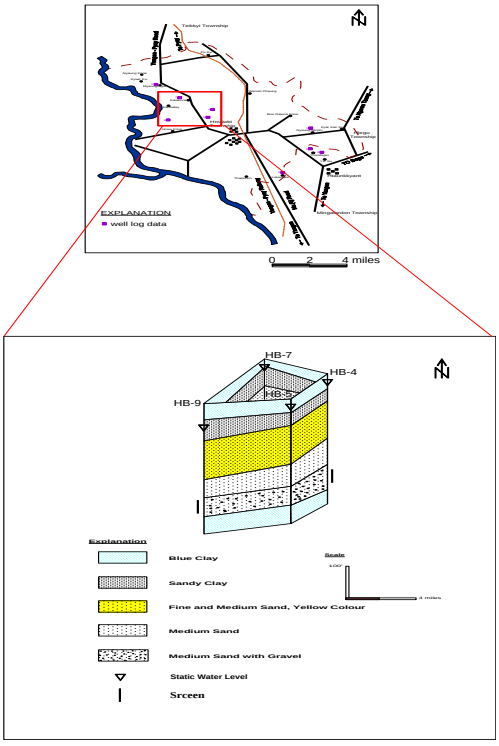

Figure (8). Fence Diagram the south-western part of the Study Area

Gravel Pack Design

Grain size analysis is essential and important to suggest and prepare for construction of proper well design. Aquifer sand samples were collected from the Staff Compound of the Paper Factory, Thandaepin Village, Hmawbi Area (Figs. 9 & 10). This sample was analysed to calculate the grain size distribution for gravel packing design and screen opening at Applied Geology Department Soil Laboratory. With a gravel pack, larger slot sizes can be selected for the screen. Grain size analysis shown in table (1).

Results are plotted on a grain size distribution graph as shown in figure (11). Grain size analysis of the aquifer sand samples show that the slotted size is 1.52mm. It must be equal to the Hazen's effective size (D_{10}). Water well screen opening 1.52mm is the best for production well using proper gravel packing materials. It is mainly composed of medium to coarse-grained sand.

Figure (9). Photograph shows manual water jetting with mud circulation drilling method

Figure (10). Photograph shows manual saw slotted screen type

Table (1). Grain Size Distribution Analysis of Aquifer Sand
Location : Paper Factory, Thandaepin Village, Hmawbi
Well Casing : 6″ tube well
Total Drill Depth : 340 feet
Aquifer Thickness : 240 – 260 feet

Sieve No.	Sieve Opening, mm	Wt of Sieve, g	Wt of Sieve & Soil, g	Wt of Soil Retained, g	Percent Retained	Commulated Percent Retained	Percent Finer
4	4.75	58.8	59.4	0.6	0.14	0.14	99.86
10	2	58.8	62.1	3.3	0.75	0.89	99.11
20	0.85	58.8	220.8	162	36.80	37.69	62.31
40	0.425	58.8	247.6	188.8	42.89	80.58	19.42
100	0.15	58.8	138.7	79.9	18.15	98.73	1.27
200	0.075	58.8	61.8	3	0.68	99.41	0.59
pan		58.8	61.4	2.6	0.59	100.00	0.00
				440.2			

From Graph : Hazen's effective size D10= 1.52
: Hazen's Uniformity Coefficient Cu = D60/D10 = 3.3/1.52 = 2.17
: Coefficient of Concavity Cc = $D30^2/D10 \times D60$ = 1.34

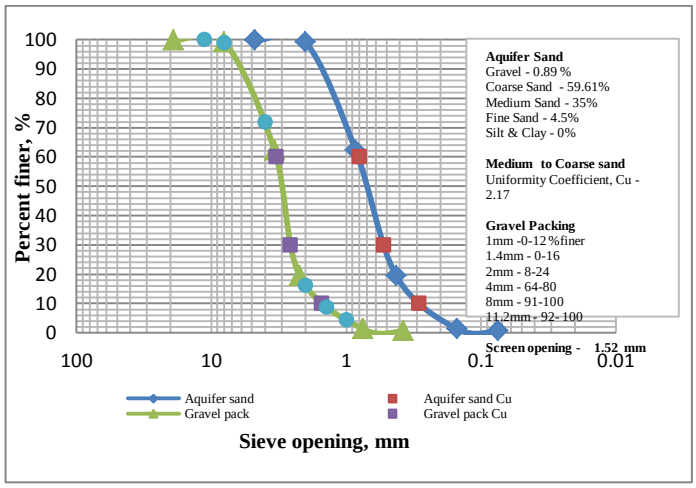

Figure (11). Grain Size Distribution Graph of Aquifer Sand and Proposed Gravel Pack Design Depth 340 ft, 8" Tube well, Paper Factory, Thandaepin Village, Hmawbi

Hydraulic Characteristics of the Study Area

Pumping Out Test

In the study area, (9) wells log data were collected. Among them, pumping-out test was made at 8″Ø production well of Alpine Purified Drinking Water Factory, Thandaepin Village, Hmawbi Area. Well water was pumped out by submersible pump. The constant discharge pumping test was performed for three hours with the pumping rates of (393) m^3/d (Fig. 12). The water level was measured at the top of the well using electric water level indicator. Discharge rate was measured by container method (Fig. 13). Time drawdown data during pumping test is shown in table (2).

Figure (12). Photograph showing pumping-out test at Alpine Purified Drinking Water Factory

Figure (13). Measurement of the discharge rate at Alpine Purified Drinking Water Factory

Drawdown data are plotted on the semi-log paper. On the semi-log plots, most of the points fall on a straight line. Semi-log plots is shown in figure (14) and the well log of pump well is shown in figure (15). The straight line drawdown different per log-cycle (Δs) were measured and the hydraulic properties were calculated using the Jacob straight line method as follows:

$$\text{Coefficient of Transmissivity, KD} = \frac{2.3\,Q}{4\pi\Delta s}$$

$$= \frac{2.3 \times 393}{4 \times 3.14 \times 0.56}$$

$$= 128.51\ m^2/d$$

Where; KD = T = Transmissivity, m^2/d

Q = Discharge rate, m^3/d

Δs = Drawdown difference per log-cycle, m

Table (2) Time Drawdown Data During The Pumping Test at Alpine Purified Drinking Water Factory, Hmawbi Area

Pumped Well:	8″ tube well	Static Water Level:	20.59 ft
Drilled Depth:	340 ft	Top of Casing:	0.4 m
Screen Depth:	280 - 320 ft	Pumping Start:	10 : 30 am
Discharge Rate:	393 m^3/d	Pumping Stopped:	1 : 30 pm
		Date:	28/1/2013

Time Since Pump Started, t (min)	Depth to water level (m)	Static Water Level (m)	Drawdown, s (m)
0	20.19	20.19	0
1	32.09	20.19	11.9
2	39.08	20.19	18.89
3	42.14	20.19	21.95
4	43.76	20.19	23.57
5	44.45	20.19	24.26
6	44.82	20.19	24.63
7	45.03	20.19	24.84
10	45.17	20.19	24.98
15	45.6	20.19	25.41
20	45.59	20.19	25.4
25	45.51	20.19	25.32
30	45.5	20.19	25.31
35	45.42	20.19	25.23
40	45.59	20.19	25.4
45	45.52	20.19	25.33
50	45.63	20.19	25.44
55	45.36	20.19	25.17
60	45.53	20.19	25.34
70	45.76	20.19	25.57
85	45.61	20.19	25.42
100	45.71	20.19	25.52
120	45.75	20.19	25.56
140	45.32	20.19	25.13
160	45.72	20.19	25.53
180	45.89	20.19	25.7

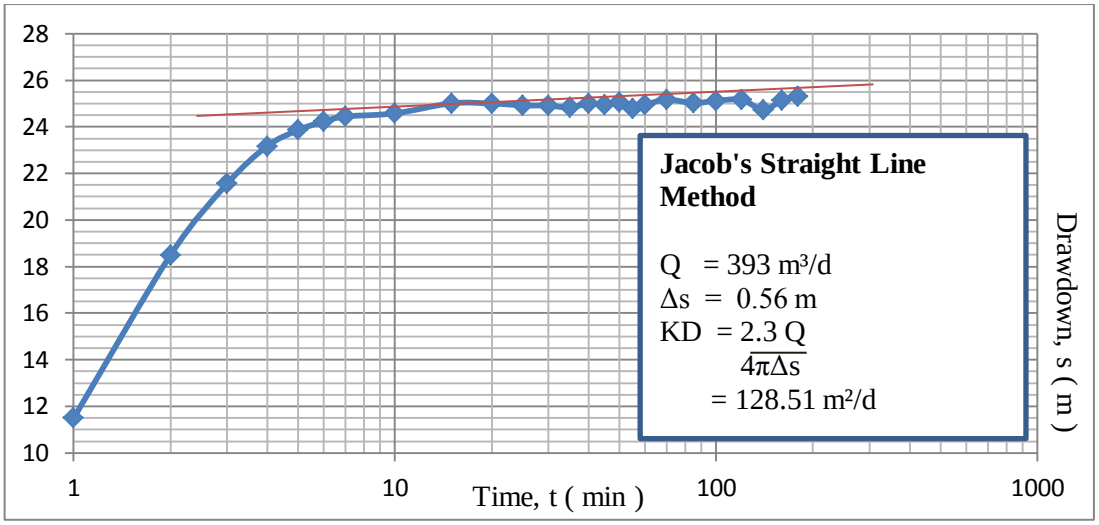

Figure (14). Constant Discharge Pumping Test, 8″ Production Well at Alpine Purified Drinking Water Factory, Thandaepin Village, Hmawbi Area

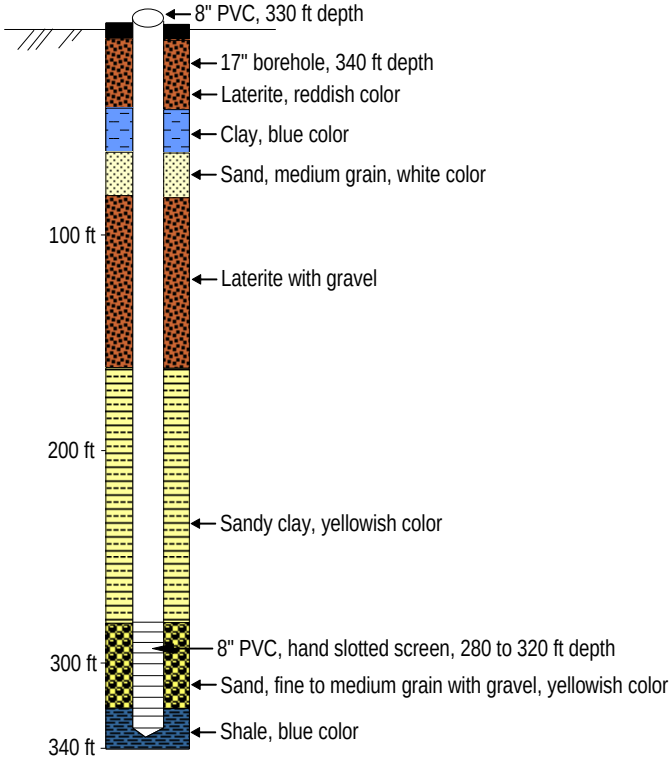

Figure (15). Well Log of the Alpine Purified Drinking Water Factory, Thandaepin Village, Hmawbi

Recovery Test

Transmissivity of the aquifer were calculated by using Theiss's recovery method. Residual drawdown data are more reliable than pumping test data. From residual drawdown versus the ratio of time plot on the semi-log graph, the residual drawdown difference Δs′ per log cycle of t/t′ is determined.

In Hmawbi area, 8″Ø production well of Alpine Purified Drinking Water Factory is used for the recovery test after finishing the constant discharge test. Calculated transmissivity is shown in table (3) and plotted graph is shown in figure (16).

Theiss's recovery method is widely used for analysis of recovery test. This method is described as follow:

$$\text{Transmissivity} = KD = \frac{2.30\,Q}{4\pi\Delta s'}$$

$$= \frac{2.3 \times 393}{4 \times 3.14 \times 0.55}$$

$$= 130.85\ m^2/d$$

Where, $\Delta s'$ = residual drawdown, m

KD = Transmissivity, m^2/d

Q = Discharge rate, m^3/d

Aquifer Categories

Aquifer fall into two board categories: unconsolidated aquifers and consolidated fractured aquifers. Within both categories, the aquifers may be confined, unconfined, or leaky. According the semi-log plots of the theoretical time-drawdown, pumping out test well in Alpine Purified Drinking Water Factory is confined aquifer.

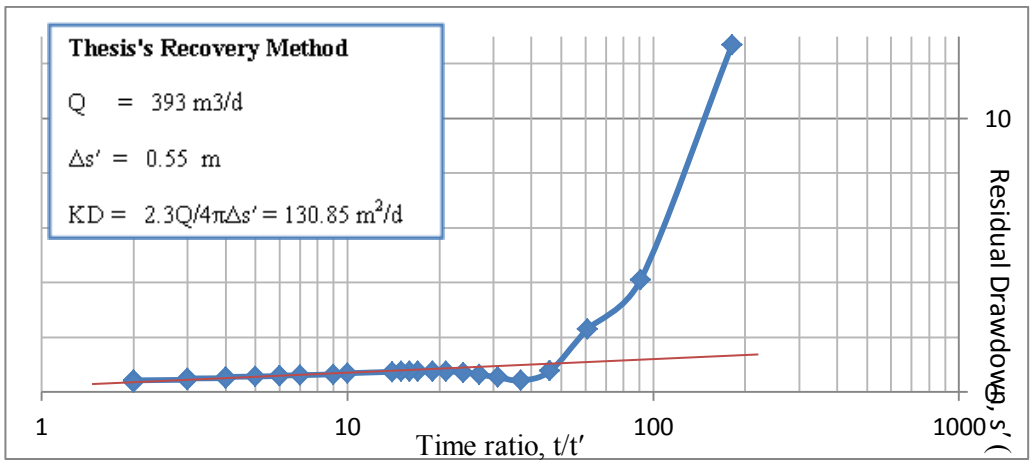

Figure (16). Recovery Test, 8″ Production Well at Alpine Purified Drinking Water Factory, Thandaepin Village, Hmawbi Area

Table (3). Constant Discharge Recovery Test of Alpine Purified Drinking Water Factory, Thandaepin Village, Hmawbi

Pumped Well:	8″ tube well	Static Water Level:	20.59 ft	
Drilled Depth:	340 ft	Top of Casing:	0.4 m	Date:
Screen Depth:	280 - 320 ft	Pumping Start:	1 : 30 am	28/1/2013
Discharge Rate:	393 m³/d	Pumping Stopped:	4 : 30 pm	

Time since pump started, t (min)	Time since pump stopped, t' (min)	t/t'	Residual drawdown	s'
181	1	181	45.89	12.69
182	2	91	24.7	4.11
183	3	61	22.89	2.3
184	4	46	21.36	0.77
185	5	37	21.02	0.43
186	6	31	21.13	0.54
187	7	27	21.23	0.64
188	8	24	21.31	0.72
189	9	21	21.35	0.76
190	10	19	21.35	0.76
191	11	17	21.35	0.76
192	12	16	21.35	0.76
193	13	15	21.34	0.75
194	14	14	21.33	0.74
199	19	10	21.28	0.69
204	24	9	21.24	0.65
209	29	7	21.21	0.62
214	34	6	21.19	0.6
219	39	6	21.18	0.59
224	44	5	21.16	0.57
234	54	4	21.14	0.55
244	64	4	21.1	0.51
254	74	3	21.09	0.5
264	84	3	21.07	0.48
274	94	3	21.05	0.46
294	114	3	21.05	0.45
314	134	2	21.02	0.43
334	154	2	21.01	0.42
344	164	2	20.98	0.39
360	180	2	20.96	0.37

Conclusion

Hmawbi area is in the Yangon region covering about 17 miles in E-W direction and 14 miles in N-S direction. At the western part of Hmawbi area, Hlaing river flows across the study area in nearly north - south direction. Hmawbi Myoma Chaung, across the Myoma 3 and 4 Quarters, flows into Hlaing river. The tidal action is noted in the western and southern parts of the area along the Hlaing river. The average rainfall range for Hmawbi is from 99.34″ to 120″. The population of Hmawbi in 2012 is 33,637. The economy of Hmawbi heavily depends on its agricultural produce and industrial resource. Yangon region is generally covered by Quaternary and Tertiary sediments. Within the study area the oldest layer is the Pegu Group of Miocene age. On top of it the Irrawaddy Formation (Pliocene) overlies, trending N-S at the eastern part of the study area. Recent Alluvium sediments are

widely distributed in the study area. The anticlinal structure occurs in the Pegu Group. In Hmawbi area, water bearing geological formations are Alluvium units and Irrawaddy Formation. For the present study, 9 tube wells data in these formations were collected. Fence diagram of well No. 4 , 5, 7, and 9 in the Alluvium shows that the sand and clay of alluvium are gently dipping towards the south-west direction. So, groundwater flow towards the Hlaing river. According to the grain size analysis of the aquifer sand samples from Irrawaddy Formation, the Hazen's effective size (D_{10}) value is 1.52 mm. The slotted size must be equal to the Hazen's effective (D_{10}). The results of grain size analysis show that it is mainly composed of medium to coarse grained sand. Pumping-out test and recovery test were made at 8″ production well of Alpine Purified Drinking Water Factory, Thandaepin village, Hmawbi area. The constant discharge pumping test was performed for three hours with the pumping rates of (393) m^3/d. Hydraulic characteristics during the pumping out test shows that transmissivity (KD) is 128.51 m^2/d when discharge rate (Q) is 393 m^3/d and drawdown (Δs) is 0.56 m. Recovery analysis of Hmawbi area shows that transmissivity (KD) is 130.85 m^2/d when the discharge rate (Q) is 393 m^3/d and residual drawdown ($\Delta s'$) is 0.55 m. According the semi-log plots of the theorethical time-drawdown, pumping out test well is confined aquifer.

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