Available at www.ijcasonline.com ISSN 2349 – 0594

International Journal of Modern Chemistry and Applied Science

International Journal of Modern Chemistry and Applied Science 2015, 2(4), 215-227

Characterization of aquifer system of different geological formations is based on pumping test data - a case of nekemte area, western Ethiopia.

Shayaq Ali*, Diriba Alemayehu Gurmu, and Geleta Geremew

Department of Earth Sciences, Wollega University, P.O Box 395, Nekemte, ETHIOPIA

……...........

Abstract: This research was conducted in Nekemte area which is bounded in 36° 30' to 36° 40' longitude and 9° 05' to 9° 10' latitude of western Ethiopia, for quantifying of the aquifer properties depending on the pumping test data as there is limited information on groundwater distribution. The study area was comprises different units like clay sediments, weathered and fractured basalt, and other quaternary sediments; and geological structures causes for different landforms and for primary and secondary permeability and porosity which are plays great role on the aquifer properties. For the achievement of the objectives the data of water bearing horizon, location depth of aquifer, analyze the draw down, discharge rate and pumping duration data, and characterize according to the given data were collected from geological field activities to fulfill the gaps in hydro geological field observation data recording and borehole depth to groundwater, and well completion reports. The discussed result indicates the type of aquifer is confined aquifer with confining layer clay from the top and weathered basalt from below and the pumping test data with maximum and minimum transmissivity of $T=9.8*10^{-4}m^2/s$ and $T=3.43*10^{-4}m^2/s$, respectively, and average transmissivity of $T=6.6*10^{-4}m^2/s$ was indicates the heterogeneity of the aquifer materials. From this the transmissivity and hydraulic conductivity vary laterally with in formations, and the property of aquifer it can be inferred that the specific capacity of aquifer is high, but its transmissivity is negligible since porosity is less interconnected.

Key Words: Groundwater, Aquifer, Pumping test, Transmissivity, Nekemte, Ethiopia.

…….

**corresponding author email: shayaqgeo*@yahoo.co.in

1. Introduction

1.1Background

This research was conducted in Nekemte area which is bounded in 36° 30' to 36° 40' longitude and 9° 05' to 9° 10' latitude (Fig.1) for the quantifying of the aquifer properties depending on the pumping test data. For the achievement of the objectives the data of water bearing horizon, location depth of aquifer, analyze the draw down, discharge rate and pumping duration data, and characterize according to the given data.

Groundwater is precious resource for life and growth and development of country. Hence, reliance on the groundwater has increased greatly. Accordingly, substantial increments in the groundwater withdrawals have occurred in almost every part of the country.

One of most fundamental condition for the growth and development of nation is certainly to fulfill its urgent water needs hence; along with this are demanded good scientific and technical capabilities for the assessment and substantial development of the country for water resource potential particularly the groundwater. To develop the existing groundwater potential in the country, the first attempt is to identify the main different surface and subsurface geological and hydro-geological environments of the study area and to characterize the aquifer systems of different geological formations.

When groundwater development consideration the highest problem to be encountered is lack of appropriate data to assess the viability of the aquifer, a common problem is scarcity of data relating to the variations in the value of the coefficient of storage and transmissivity. Knowledge relating to the position and nature of the aquifer may also be inadequate.

In order to carry out the test it is necessary to have some knowledge of the aquifer and in particular how the drawdown varies with the duration of pumping and distance from pumped well. In addition, it demands scientific and technical capabilities for its characterization, exploration and development. Too successfully perform the first attempt must be to identify the aquifer system with in different geological formation and to accurately characterize existing aquifer system.

1.2 Physiographic and Vegetation

The weathering and fractured degree of the geology, geomorphology, tectonics and climate of the regional setup have a great role on the groundwater occurrence. The variability of these factors in the area strongly influences the quantity and quality of the groundwater in different parts. The geology of the area and the surrounding provides usable groundwater and provides good transmission of rainfall to recharge aquifers, which produce springs and feed perennial rivers.

Accordingly, the study area comprises two major physiographical landforms. These are highlands and lowlands with different plateaus and basins.

The highest elevation ranges from 1500m to 3500m and the lowland part with elevation ranges from 1000m to 1500m. The total study area is highly vegetated and the type and amount of vegetation cover depends on the physiographic and climatic condition. It is mainly covered by grass, bushes, and large trees.

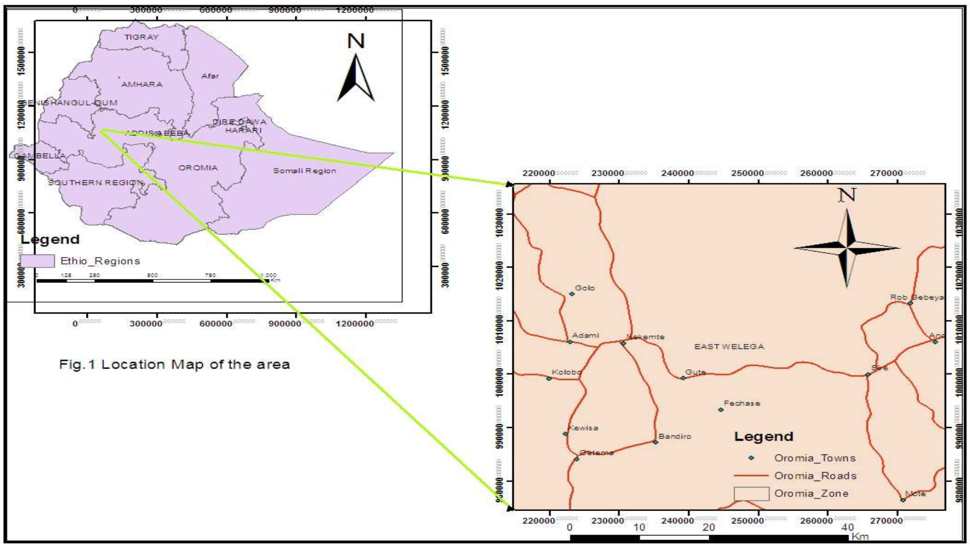

Fig.1 Location Map of the area

1.3. Climate and Drainage pattern

The main rainy seasons in this region are from June to August and dry season between October to January. The weather is cold during the rainy season in the highland. According to the annual rainfall mapping of the study area gets annual rainfall ranging from 1500mm to 2200mm. Study area is characterized by subtropical (Weina-Dega) climatic zone and 15-20^{0}c mean annual temperature [1].

There are so many tributaries flowing from upside to the low lands.

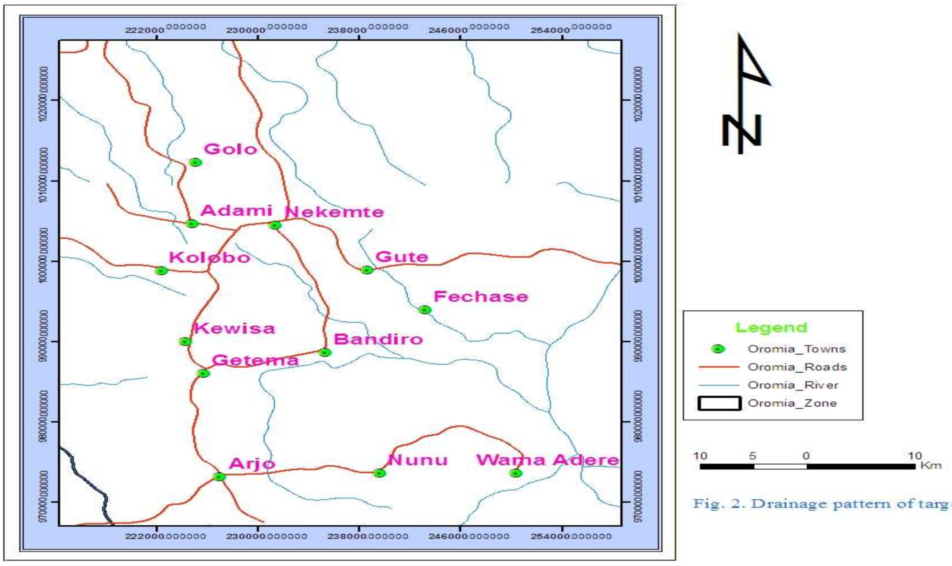

Fig. 2. Drainage pattern of target area

They are following a dendritic pattern. Most of the streams were drained from the center of the area to the surrounding lowlands (Fig.2).

2. Geology of the area

The area is composed of alluvium deposit (mainly composed of the clay soil) at the most top part and volcanic rocks particularly massive basalt, and weathered and fractured basalt. The clay seems developed from the insitu weathering of the underlying basalt. At many sites it has reddish to black color and variable thickness. The most abundant and dominant volcanic rock unit which composed of mostly basalt is fine grained, black to grayish in color and strongly subjected to weathering and varies degree of fracturing [2].

The occurrence of groundwater was directly related with geological formations, geological structures, topographic variations, vegetations and climatic conditions in this report [3-6]. So in this section the details of rock units and geological structures are discussed. These exposures were discussed based on their degree of weathering and fractures, colors, compositions, textures and grain size, related landforms and their typical locations, including related primary and secondary geological structures (columnar joints, faults, and fractures) with their alignments.

Quaternary Sediments

These units were exposed throughout the area as alluvial sediments and lacustrine deposits. At the west and central part of the area was dominated by weathered and fractured basalt as bedrock, the sediments from this unit is fine grained and very important for large size vegetations and multi agricultural products. In this part the sediments are dark gray color and slightly reddish at some plateaus, as they exposed from mafic weathered and fractured basalt. From the quarry site, road cut and river cut the quaternary deposits ranges from 1m – 50m in thickness [6].

Weathered and Fractured Basalt

This unit was covered the dominant part of the area with different degree of weathered and fractured density and distributions as discussed from drilled wells. The central, western and some other parts of the area were exposed by this unit. It is dark in color when fresh sampled and with pink yellowish weathered color. Compositionally, it is pyroxene, olivine, quartz and some fragments with different color. It is fine to medium grained and slightly distributed and interconnected vesicular textures. As it is observed and described from river cut, quarry site, hillside and drilled wells it comprises thick exposures ranging from 20m to 1000m.

This unit exposed with different landforms and it causes for the existence of springs through fractures and contacts between different rock units and landforms. In this annually high rainfall causes the development of weathering and alterations which the main reasons for the existence of secondary porosity and permeability. In addition to serving as aquifer this out crop is very important as raw material for road constructions.

The study area was deformed and characterized by different landforms which are exposed with different trends and elevations. Following the general trend of the deformation which is northwest direction locally there are various structures with different orientations and other volcanic landforms. The dominant geological structures exposed in the area are joints, fault and fractures and other volcanic structures such as; volcanic dome, columnar joints, volcanic ridge, and etc.

3. Hydrogeology

The main features important for groundwater occurrence in crystalline rocks are weathered zones (regolith) and fractured zones. The weathered layer, also called regolith, developed on intact volcanic and sedimentary rocks is an important source of groundwater, for the rural and urban water supply in studied area. Even though, the studied area has thick and weathered layers, due to topographic influence most of them are not potential site for groundwater. However, in some places there is a good and perennial source of recharge (from rivers) even a thin layer of 2-10m thickness are a good source of water supply.

In volcanic rocks fractures, vesicles and interflow sediments are main features for groundwater occurrence. From these structures fractures are dominant one in volcanic terrain for groundwater in studied area. Normally the alluvium as well as the volcanic rock units lacks primary porosity which limit the capacity to preserve groundwater. As a result, both rock units have low permeability which inhibits movement of groundwater. Thus, these units are hydrogeological insignificant. However, the basalt which lacks primary porosity has high secondary porosity due to intense weathering and fracturing. So, it is a good aquifer in the area. The vesicular basalt has high primary and secondary porosity and hence high permeability for groundwater movement and reserve. It has high groundwater potential [7-8].

Springs are an important source of hydrologic information. They occur because hydraulic head in the aquifer system intersects the land surface. By paying attention to their distribution, flow characteristics, and water qualities, much valuable information can be derived without drilling a single well.

Impervious Rock Springs (fracture springs) are recorded in the area from gentle slope of Nekemte highland. They are found in massive basalt which is highly fractured and jointed, the water movement through fractures and springs from where these fractures intersect the land surface at low elevations. Due to the differences in mineralogy, texture and structure of volcanic rocks water bearing potential also varies. Groundwater circulation and storage in the volcanic rocks depend on the type of porosity and permeability formed during and after the rock formation. All rock structures possessing a primary porosity may not have necessarily permeability; i.e. without the original interconnection, the primary porosity may not give rise to the primary permeability, but the letter connection, by means of weathering or fracturing may results a secondary permeability.

4. Literature review

Aquifer is a body of rock that contains sufficient saturated permeable materials to conduct groundwater and to yield significant quantities of water to wells and springs [7]. Aquifer is a porous permeably, water bearing geological body of rock, generally it is material restricted to capable of yielding an appreciable amount of water [9]. Aquifer characteristics are property that determine the nature of the aquifer parameters on the basis of their property such as: hydraulic conductivity, transmissivity, specific capacity and storability [10].The analysis of the pumping test data is made using Jacob-time - drawdown graphic method by which aquifer properties are calculated.

5. Materials and Methods

The methods that were followed for the research that was conducted are:

The analysis of pumping test data has been made using Theis time – drawdown graphic method by which aquifer properties has been calculated. With the well pump test data and data of hydro geological field observation, it is possible to identify the type of aquifer system, interpret and analyzed the aquifer system of a given geological formation.

Pre-field work –which is reviewing previous works is geological and hydro geological reports and maps, well completion reports and well pump test data and aquifer curve types.

Field work activity –is to fulfill the gaps which include hydro geological field observation data recording, borehole depth to groundwater and major structure identification like effect of surface geological processes and tectonics activity. In addition to the above mentioned data, the following information's are also gathered during desk study from different government, and private companies and remaining data are collected during field work arranged for this study.

Lab-work activity –organizing a comprehensive well pump test data's yet interpreting and analyzing pump test data's and classify the bore hole technical data based on aquifer productivity with respect to borehole's depth has been done.

6. Result and Discussions

6.1 Aquifer data

6.1.1 Provisional and constant yield test

Prior to conducting constant yield test, provisional test was conducted for a period of 30 minutes using slowly increased discharge rates to avoid rash flow and blockage of screen. Well pumping was commenced with a discharge rates and their respective draw dawns were recorded to select suitable discharge rate and pump position for the constant yield test.

The static water level was recorded to be 9.75 mt top of surface casing. A submersible pump was installed at depth of 51.0 meter. Constant yield test was conducted to determine the well safe yield for long pumping period and aquifer property. Based on the result obtained from the provisional test, discharge rate of 4.75l/sec was selected and pump position remained the same.

Constant yield test was carried out for a period of 720 minutes and dynamic water level was recorded to be 14.35 mt with a drawdown of 4.6mt. Data to be provided by this pumping test and draw dawn measurements are:

Constant rate test	**Recovery data**
Transmissivity	Transmissivity
Specific capacity	Specific capacity

Recovery test was also carried out for a period of 180 minutes after pumping shout down. The data's recorded are given below.

Well characteristics

- ✓ Total drilled depth 58.0m
- ✓ Water striking point 12.0m
- ✓ Static water level 9.75m
- ✓ Testing pump position 51.0 m
- ✓ Testing discharge 4.75 l/sec
- ✓ Dynamic water level Drawdown 14.35m
- ✓ Drawdown 4.6m

Table 1: Constant yield test reading

Time	Elapsed time (min)	Water level(m)	Draw dawn (m)	Remark
01.30.00am	0	9.75	0.00	Pump start
	1	11.09	1.34	Q=4.75lt/sec
	2	11.14	1.39	
	3	11.22	1.47	
	4	11.27	1.52	
	5	11.31	1.56	
	6	11.35	1.60	

	7	11.40	1.65	
	8	11.45	1.70	
	9	11.50	1.75	
	10	11.52	1.77	
	12	11.54	1.79	
	14	11.56	1.81	
	16	11.58	1.83	
	18	11.60	1.85	
	20	11.62	1.87	
	25	11.65	1.90	
	30	11.70	1.95	
	35	11.70	2.01	
	40	11.76	2.04	
	45	11.79	2.09	
	50	11.84	2.16	
	55	11.91	2.23	
02.30pm	60	11.98	2.36	
	70	12.11	2.43	
	80	12.18	2.51	
	90	1262	2.64	
	100	12.39	2.73	
03.30	120	12.48	2.80	Clean water
	140	12.55	2.89	
	160	12.62	2.90	
04.30	180	12.72	3.10	
	200	12.85	3.33	
	240	13.08	3.48	
05.30	260	13.23	3.70	
06.30	300	13.45	3.84	
7.3o	360	13.59	3.94	
8.30	420	13.69	4.07	
9.30	480	13.82	4.20	
10.30	510	13.95	4.37	
11.30	600	14.12	4.50	Pump test
0.30	660	14.25	4.60	Sample collect

Source: E/Wollega water, mineral and energy office [11-12]

Time versus drawdown plot from constant rate

The collected borehole pump test data's with time and drawdown data's are plotted in semi-log to select proper pump test data analysis methods.

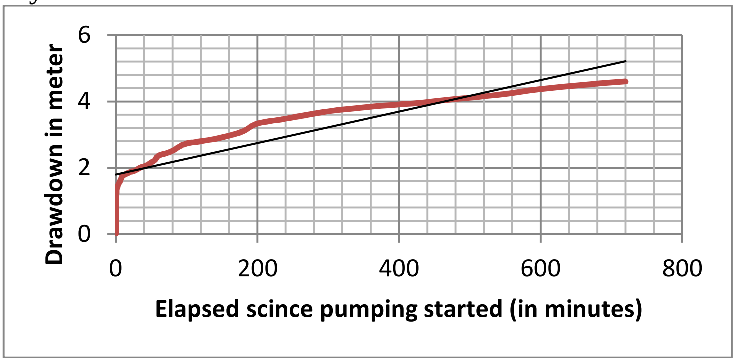

Fig.3. Time vs. Drawdown plot curve

Table 2: Recovery test (From constant yield test)

Time	Elapsed time since pumping started(min)	Elapsed time science pumping stopped t'(min)	Depth to water level(m)	Residual draw dawn(m)	(t/t')
1:30	1440	0	14.35	4.60	1441
	1441	1	11.95	2.20	721
	1442	2	11.77	2.02	481
	1443	3	11.70	1.95	361
	1444	4	11.65	1.90	289
	1445	5	11.54	1.79	241

	1446	6	11.46	1.71	206.71
	1447	7	11.40	1.65	181
	1448	8	11.35	1.60	161
	1449	9	11.29	1.54	145
1:40	1450	10	11.23	1.48	121
	1454	12	11.11	1.41	103
	1456	14	11.10	1.35	86
	1458	16	11.06	1.31	103.86
	1460	18	11.03	1.28	91.00
	1465	20	11.00	1.25	81.00
	1470	25	10.98	1.23	73.0058.6
02:00:00am	1475	30	10.96	1.21	48.00
	1480	35	10.94	1.19	42.14
	1485	40	10.91	1.16	37
	1490	45	10.89	1.14	33
	1495	50	10.86	1.11	29.18
	1500	55	10.82	1.07	27.18
02:30pm	1500	60	10.78	1.03	25.00
	1510	70	10.75	1.00	21.57
	1520	80	10.68	0.93	19
	1530	90	10.62	0.87	17
	1540	100	10.57	0.82	15.4
03:30	1560	120	10.51	0.76	13
4:30	1620	180	10.46	0.71	9

Source: E/Wollega Water, mineral and energy office [11-12]

Residual drawdown versus time plot from recovery test

In this method we assume that, after pump has been shutdown, the well continues to be pumped at the same discharge as before and an imaginary recharge equal to the discharge is injected in to the well (Fig.3 & 4). The recharge and discharge thus cancel each other, resulting in an idle well as is required for the recovery period. The recovery method is widely used for the analyses of recovery test.

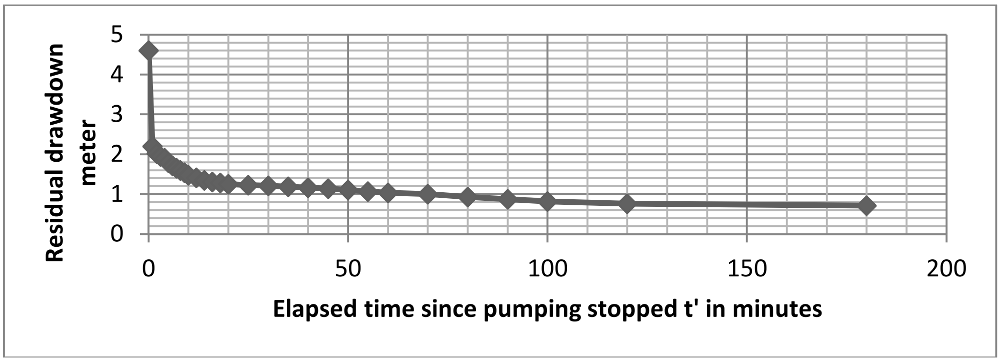

Fig.4. Residual drawdown versus time (min) curve

6.1.2 Determination of transmissivity of the aquifer from constant and recovery test

Constant rate pumping tests and recovery tests were used primarily to determine transmissivity of the aquifer. The pumping times are varying between 10 and 72 hours. Single pumping well test data's can be analyzed using standard the analysis method.

Whenever possible, recovery data should be taken to verify the accuracy of pumping test data's often, the recovery data's will be more reliable because no pumping is required. Moreover, analysis of recovery data's have the advantage that the pumping discharge rate is constant and it can be considered equal to the mean rate of pumping discharge during pumping. Also, the recording of recovery data helps in assessing the response and extent of the aquifer concerned, that is, for an aquifer system which is to exploited for groundwater, the recovery levels must be adequate and yet recovery measurements should be recorded with the same frequents as those taken during the constant yield test portion of the aquifer and /or well.

Transmissivity from constant yield test

Transmissivity (T) =2.3Q/4∏ΔS, from drawdown Vs time plot

Q=4.75lt/sec

Δs =1m←Drawdown per log cycle

T=2.3(4.75l/s)/4(3.14)(1m)
=0.87l/s/m

Transmissivity from recovery test data

Transmissivity (T) =2.3Q/4∏Δs, Q=4.75l/s
Δs=0.7m

T’=2.394.75l/s)/4(3.14) (0.7m) =1.24 l/s/m

Transmissivity from both tests;

Tav=T+T’/2 =0.87+1.24/2 l/s/m =1.05l/s/m

Estimation of hydraulic conductivity (k) from recovery test

K =Tav/b , b –aquifer thickness (total screen length is considered)

=1.05l/s/m/15m =0.07l/s=$7*10^{-2}$l/s

Specific capacity

Specific capacity is a constant of proportionality defining the discharge rate to drawdown.

Specific capacity (s .c) =Q (l/s)/H, H-total drawdown

S .c =4.75 l/s/4.6m =1.03l/s/m

Table 3: Step draw down test Record sheet

Pumping 8 hr Recover 11.25hr		Static water level:6.92m	Depth of pump:68m		
Time	Time science pump start t	Water level measurement	Water level	Water level change	Discharge measurement
1:20pm	0	6.92	5.62		3.33
	1	7.92	6.62	1	“
	2	8.22	6.92		‘’
	3	8.44	7.14		‘’
	4	8.66	7.36		‘’
	5	8.84	7.57		‘’
	6	8.99	7.69		‘’
	7	9.14	7.84		‘’
	8	9.28	7.98		‘’
	9	9.41	8.11		‘’
	10	9.54	8.24		‘’
	12	9.75	8.45		‘’
	14	9.95	8.65		‘’
	16	10.18	8.88		‘’
	18	10.38	9.08		‘’
	20	10.58	9.28		‘’
	25	11	9.7		‘’
	30	11.41	10.11		‘’
	35	11.76	10.46		‘’
	40	12.08	10.78		‘’
	45	12.37	11.07		‘’
	50	12.66	11.36		‘’
	55	12.95	11.65		‘’
	60	13.24	11.94		‘’
	80	14.06	12.76		‘’
	100	14.88	13.58		‘’
	120	15.7	14.4		‘’
	121	16.68	15.38		4.88
	122	16.85	15.55		‘’
	123	17	15.7		‘’
	124	17.14	15.84		‘’
	125	17.25	15.95		“
	126	17.36	16.06		‘’
	127	17.46	16.16		‘’
	128	17.57	16.27		‘’
	129	17.68	16.38		‘’
	130	17.77	16.47		‘’
	132	17.95	16.65		‘’
	134	18.13	16.83		‘’
	136	18.28	16.98		‘’
	138	18.43	17.13		‘’
	140	18.56	17.26		‘’
	145	18.84	17.54		‘’
	150	19.13	17.83		‘’
	155	19.4	18.1		‘’

	160	19.65	18.35		‘’
	165	19.89	18.59		‘’
	170	20.1	18.8		‘’
	175	20.27	18.97		‘’
	180	20.46	19.16		‘’
	200	21.11	19.81		‘’
	220	21.66	20.36		‘’
	240	22.12	20.82		‘’
	241	22.25	20.95		5.5
	242	22.27	20.97		‘’
	243	22.3	21		‘’
	244	22.33	21.03		‘’
	245	22.36	21.06		‘’
	246	22.39	21.09		‘’
	247	22.42	21.12		‘’
	248	22.45	21.15		‘’
	249	22.48	21.18		‘’
	250	22.51	21.21		‘’
	252	22.57	21.27		‘’
	254	22.65	21.35		‘’
	256	22.7	21.4		‘’
	258	22.75	21.45		‘’
	260	22.81	21.51		‘’
	265	22.95	21.65		‘’
	270	23.08	21.78		‘’
	275	23.2	21.9		‘’
	280	23.31	22.01		‘’
	285	23.44	22.14		‘’
	290	23.56	22.25		‘’
	295	23.67	22.37		‘’
	300	23.79	22.49		‘’
	320	24.22	22.92		‘’
	340	24.55	23.25		‘’
	360	24.88	23.58		‘’
	361	24.96	23.66		5.94
	362	24.98	23.68		“
	363	25.01	23.71		“
	364	25.03	23.73		‘’
	365	25.07	23.75		“
	366	25.09	23.77		“
	367	25.11	23.79		“
	368	25.12	23.81		“
	370	25.14	23.82		“
	372	25.18	23.84		“
	374	25.22	23.88		“
	376	25.25	23.92		“
	378	25.28	23.95		“
	380	25.32	23.98		“
	385	25.41	24.02		“
	390	25.49	24.11		“
	395	25.6	24.19		“
	400	25.68	24.3		“
	405	25.76	24.38		“
	410	25.84	24.46		“
	415	25.92	24.54		“
	420	26.01	24.62		“
	440	26.32	24.71		“
	460	26.62	25.32		“
9:20 Pm	480	26.92	25.62		“

Source: E/Wollega Water, mineral and energy office [11-12]

Time Vs Drawdown curve

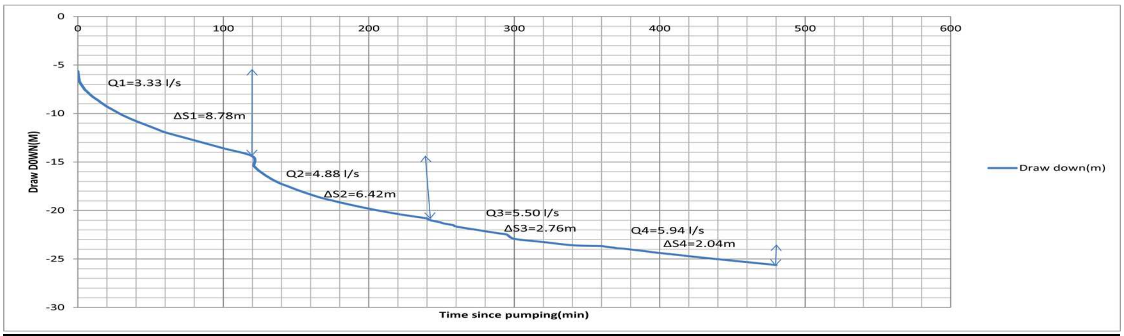

Fig.5. Time vs. drawdown

6.1.3 Determining performance of well from step drawdown tests

Step drawdown was conducted to determine the losses (aquifer and well) and the performance of well.

S_w=BQ (linear well loss) + CQ^2 (non-linear well loss)……………Jacob's equation, where B-is formation loss constant.

Table 4: Well loss data.

Step	Q(l/s)	ΔS(m)	S_w(m)	S_w/Q(m/l/s)	BQ	$CQ^2(l^2/s^2)$
1	3.33	8.78	8.78	2.63	5.7	3.1
2	4.88	6.42	15.20	3.11	8.3	6.67
3	5.50	2.76	17.96	3.26	9.35	8.47
4	5.94	2.04	20.00	3.36	10	9.8

Source: E/Wollega water, mineral and energy office[11-12]

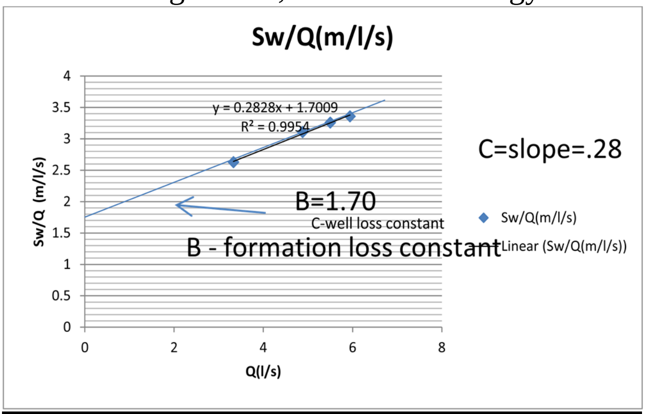

Fig.6. Sw/Q vs. Q curve

Table 5: Constant rate pumping test record

Pumping 36 hr Recovery 14 hr		Static water level 6.92m	Depth of pump 68m	
Time	Time science pump start t/	Water level measurement	Water level	Discharge measurement
9.05AM	0	9.98	8.68	5.50 l/sec
	1	13.41	12.11	‘’
	2	15.62	14.32	‘’
	3	15.96	14.66	‘’
	4	16.27	14.97	‘’
	5	16.52	15.22	‘’
	6	16.76	15.46	‘’
	7	16.97	15.67	‘’
	8	17.17	15.87	‘’
	9	17.34	16.04	‘’
	10	17.51	16.21	‘’
	12	17.82	16.52	‘’
	14	18.1	16.8	‘’
	16	18.36	17.02	‘’
	18	18.6	17.03	‘’
	20	18.81	17.51	‘’
	25	19.3	18	‘’

	30	19.7	18.4	‘’
	35	20.09	18.79	‘’
	40	20.44	19.14	‘’
	45	20.73	19.43	‘’
	50	21.02	19.72	‘’
	55	21.28	19.98	‘’
	60	21.52	20.22	‘’
	80	22.35	21.05	‘’
	100	23	21.2	‘’
	120	23.59	22.79	‘’
	140	24.17	22.84	‘’
	160	24.55	23.25	‘’
	180	24.91	23.61	‘’
	240	25.95	24.65	‘’
	300	26.97	25.67	‘’
	360	27.95	26.65	‘’
	420	28.9	27.6	‘’
	480	29.83	28.53	‘’
	540	30.76	29.46	‘’
	600	31.67	30.37	‘’
	660	32.56	31.26	‘’
	720	33.45	32.15	‘’
	780	34.34	33.04	‘’
	840	35.2	33.9	‘’
	900	36.04	34.74	‘’
	960	36.87	35.57	‘’
	1020	37.69	36.39	‘’
	1080	38.51	37.21	‘’
	1140	39.31	38.01	‘’
	1200	40.09	38.79	‘’
	1260	40.86	39.56	‘’
	1320	41.6	40.3	‘’
	1380	42.32	41.02	‘’
	1440	43.04	41.74	‘’
	1500	43.75	42.45	‘’
	1560	44.45	43.15	‘’
	1620	45.14	43.84	‘’
	1680	45.82	44.52	‘’
	1740	46.51	45.21	‘’
	1800	47.18	45.88	‘’
	1860	47.84	46.54	‘’
	1920	48.48	47.18	‘’
	1980	49.11	47.81	‘’
	2040	49.75	48.45	‘’
	2100	50.38	49.08	‘’
9.05PM	2160	51.02	49.72	'

Source: E/Wollega water, mineral and energy office [11-12]

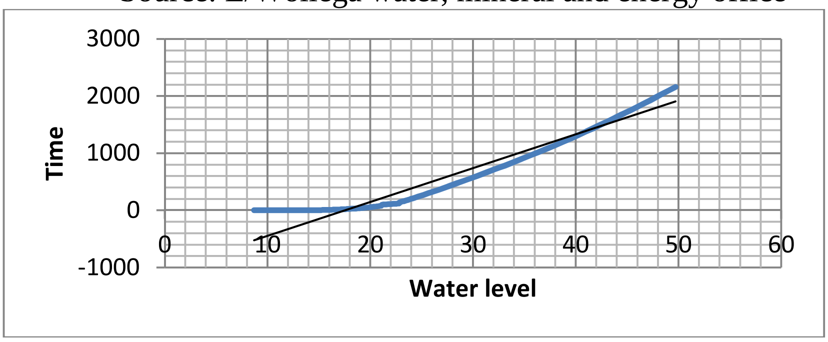

Fig.7. Water level versus time curve

From this figure transmissivity can be calculated as follows: Transmissivity (T)=2.3Q/4∏ΔS, Where Q=5.50l/s ΔS=2.0m

$T=2.3*5.50*10^{-3}m3/sec/4*3.14*2.0m$

$T=5.03*10^{-4}m^2/sec$………………………………….. (a)

Table 7: Recovery measurement data record

Pumping 36 hr Recovery 14 hr		Static water level 6.92m	Depth of pump 68m
Time	Time science pump start t/min/	Water level measurement	Water level
9.05pm	2160	51.02	49.72
	2161	42.48	41.18
	2162	35.32	34.02
	2163	28.69	27.39
	2164	26.85	25.55
	2165	26.65	23.35
	2166	26.6	25.3
	2167	26.57	25.27
	2168	26.54	25.24
	2169	26.51	25.21
	2170	26.48	25.18
	2172	26.44	25.14
	2174	26.37	25.07
	2176	26.3	25
	2178	26.25	24.95
	2180	26.21	24.91
	2185	26.05	24.75
	2190	25.96	24.66
	2195	25.82	24.52
	2200	25.7	24.4
	2205	25.57	24.27
	2210	25.46	24.16
	2215	25.34	24.04
	2220	25.24	23.94
	2240	24.81	23.51
	2260	24.43	23.13
	2280	24.01	22.71
	2300	23.6	22.3
	2320	23.2	21.9
	2340	23.8	21.5
	2400	21.79	20.40
	2460	20.99	19.69
	2520	20.22	18.92
	2580	19.6	18.3
	2640	18.98	17.68
	2700	18.36	17.06
	2760	17.78	16.48
	2820	17.28	15.98
	2880	16.79	15.49
	2940	16.33	15.03
11.05am	3000	16.9	14.6

Source: E/Wollega water, mineral and energy office[11-12]

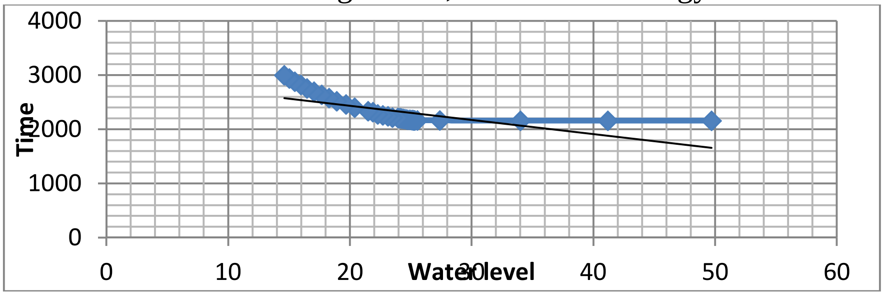

Fig.8. Time versus water level curve

Transmissivity from this recovery data can be calculated as follows:

$T^{|}=2.3Q^{|}/4\prod\Delta S^{|}$, Where $Q^{|}$=Preceeding discharge

ΔS=Residual drawdown per log cycle=2.6m

$T^{|}=2.3*5.50*10^{-3}m^2/sec/4*3.14*2.6m$

$T^{|}=3.8*10^{-4}m^2/sec$……………………………………………………..(b)

- **Average transmissivity(Tav)=**$T+T^{|}/2=5.03*10^{-4}m^2/sec+3.8*10^{-4}m^2/sec/2$

Tav$=4.4*10^{-4}m^2/s$………………………………(c)

- **Hydraulic conductivity(k)=**Tav/b(aquifer thickness)$=4.4*10^{-4}m^2/sec/29.6m$

K$=1.48*10^{-5}m/s$………………………………………(d)

- **Specific capacity(sp.c**)=Q(l/s)/H(total drawdown)=5.50l/s/41.04m

=0.13l/s/m………………… (e)

6.2 Aquifer characterization

The hydrogeological and hydrodynamic system that can be defined by the following quantifiable characteristics [7].Its dimension (geometry) and boundary condition that give rise to its volume and its hydrodynamic, hydro-chemical and hydro-biological behavior respectively characterizing water storage and transmission, geochemical interaction, and biological purification of aquifer.

In this paper more emphasis is given to the hydrogeological investigation, particularly well data, in order to define the hydrodynamic or hydraulic parameters of aquifers in the study area. Based on the hydrogeological investigation as well as existing well log data, the main aquifers identified in the study area is fractured and weathered basalts.

In fractured aquifer system, we can recognize two systems: the fracture of high permeability and low storage capacity and matrix blocks of low permeability and high storage capacity .The flow towards the well in such a system is entirely through the fractures and in unsteady state. In this type of aquifers (consolidated aquifer) two fractures or joint system can be distinguished: a). a system with a large and wide joints and fractures with a high permeability and b). Another system with many small pores, fractures or joints have a low permeability but appreciable amount of storage.

During pumping test when recharging boundary is encountered on the time vs. drawdown graph, slope of the curve becomes flatter transmissivity calculated from the flatter slope will be higher than the true value. Extending of the flatter slope gives a value for to that is too low. Storage coefficient calculated from this figure (fig.5) will be lower than the correct value. When barrier boundary is encountered, on the time vs. Draw down curve, the slope of the curve becomes steeper transmissivity calculated from the steeper slope will lower than the true value. Extending line of the steeper slope will be lower a value for to initial time (t_o) that is too high. Storage coefficient calculated from this figure (fig.6) will be higher than the correct value. During analysis off constant yield test data's, standard is analysis method assumes that well bore storage effect is negligible. Ignoring well bore storage effect which occurred on the pumping well duration the test duration will result in low computed aquifer parameter values which again could result in high aquifer and well loss coefficient value.

The analysis of the step draw down tests clearly shows that, the wells have lower well efficiency and higher well loss coefficient values which is the effect of:

- Poor well design and development factors, (if C less than 0.5),
- Deterioration of functional well due to corrosion incrustation of the well screen (if C is between 0.5 and 4),
- Improper location of well site and etc.

Classification of aquifer potential based on transmissivity value and shows (Fig. 7 & 8) when transmissivity value greater than 500–potentiality is high, when transmissivity value falls between 50 and 500-the potentiality value is low, when then transmissivity value is between 0.5 to 5 potentiality is weak else the potentiality value of the geologic formation is negligible in the groundwater occurrence (Fig.8.). So, the potential value of transmissivity in the study area is negligible.

From step drawdown the value of well loss (C) is computed to be 0.28 shown in (fig 6). So, the well is categorized under poor well design and development.

7. Conclusion and Recommendations

7.1 Conclusion

- The following conclusion is made about aquifer property:
- The type of aquifer in the study area is confined aquifer with confining layer clay from the top and weathered basalt from below.
- Results of pumping test data shows that the maximum and minimum transmissivity

obtained is T=9.8*$10^{-4}m^2/s$ and T=3.43*$10^{-4}m^2/s$ and average transmissivity T=6.6*$10^{-4}m^2/s$. This indicates the heterogeneity of the aquifer materials.

- Transmissivity and hydraulic conductivity vary laterally with in formations.
- From the property of aquifer it can be inferred that the specific capacity of aquifer is high, but its transmissivity is negligible since porosity is less interconnected.

7.2 Recommendation

- Prevention maintenance should be carried out for the sustainability of well.
- Well design and development should be careful when it is to be constructed.
- Well site should be in proper location during exploration.
- Proper data must be taken when reading is to be made at a given time.

8. References

1. Alemayehu T, **(2006),** Ground water occurrence of Ethiopia M.Sc thesis,
2. Mengesha Tefera, Tadiwos Chernet and Workneh, Haro.. Explanation to geological map of Ethiopia. Scale 1: 2,000,000, 2nd edition. (1996)
3. Tesfaye, K., Koeberl, C. and Koller, F., J. Af. Earth Sci., **(2000).** 29,715-734.
4. Abreha G/Sillassie, **(2010)** Assessment on hydraulic properties of the Ethiopian tarmaber formation, unpublished M.sc thesis.
5. Gera, S. and Hailemariam, M., **(2000).** Geology of Nekemte area. Geological Survey of Ethiopia, memoir 14, 110p. G.S.E report
6. Kazmin, V. **1979.** Stratigraphy and correlation of volcanic rocks in Ethiopia. EIGS Ministry of Mines.
7. Lohman, (1972). Definition of aquifer.
8. Solomon and Mulugeta (H.M.2000) physiographic landforms of Nekemte area M.Sc thesis.
9. Kazmin, V.C., **(1973).** Geology of Ethiopia. Explanatory note to the geological map of Ethiopia, 1:2,000,000 scale. Ministry of Mines, Addis Ababa.
10. C.W.Fetter, Applied hydrogeology, (2001)4th edition, USA.
11. Water well drilling and pumping test project in East Wollega zone, ORS. April, **(2014)** Addis Ababa.
12. Pangaea drillers: well completion report at Gobu sayo in East Wollega zone, Addis Ababa, may **(2014).**