School of Post Graduate Studies
Addis Ababa Institute of Technology

EVALUATION OF HYDRAULIC PARAMETERS IN OLD AKAKI WELL FIELDS

BY YOSEF AREGAW

Thesis Submitted to Addis Ababa Institute of Technology, School of Post graduate Studies in partial fulfilment of the requirements for the Degree of Master of Science in Civil Engineering (Hydraulic Engineering).

Thesis Advisor
DR.AGIZEW NIGUSSIE
Addis Ababa, Ethiopia

March 2018

ADDIS ABABA UNIVERSITY

INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

HYDRAULIC ENGINEERING STREAM

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Certification

The undersigned certify that he has read the thesis entitled: evaluation of hydraulic parameters in old Akaki well fields and hereby recommend for acceptance by the Addis Ababa University in partial fulfilment of the requirements for the degree of Master of Science.

DR.AGIZEW NIGUSSIE

(Advisor)

Declaration and Copyright

I hereby declare to the Senate of Addis Ababa University that this thesis is entirely original work and all other materials are duly acknowledged. This work has not been submitted for academic degree award at any University.

Declaration

ABSTRACT

The primary objective of this study is analysis and evaluation of pumping test data to determine the aquifer hydraulic property of the Old Akaki bore holes by using Thies curve matching method; Cooper Jacob and Thies recovery method on excel sheet and aquifer test software. The proposed ground-water sources are from two main well-fields, Old Akaki and North Fanta, located at the suburb of Addis Ababa city. Old Akaki well field is located at about 22km South of Addis Ababa and East of Akaki Town. The abstracted water from Old Akaki well-field is able to serve various condominium sites in Kilinto & Koye Feche. In addition_ it serves other areas along the way & nearby the condominium sites in Akaki Sub City with additional supplies from North Fanta Well field.

The transmissivity values obtained in this research has great variation from the study of WWDSE which accounts for 97 to 2000%. Among the eight wells analysed four wells have overestimated transmissivity, two wells underestimated and for two wells final result has not been obtained because of poor fitting of the Thies curve. The overestimated Transmissivity envisions good aquifer with better yield than the capacity of the aquifer. The underestimated Transmissivity values found to have lower yield than their discharging capacity.

The well efficiencies were also computed for the expected yield (as suggested in the well completion report). The results clearly show that majority of the wells (five wells out of the eight tested wells) were found to work below the recommended operational efficiency. A well is considered acceptable if it works above 65% efficiency. Within tested wells only one well works in recommended efficiency range. Such a result clearly shows that the seven wells have already failed during design phase as they are expected to yield the values recommended in their well completion report. Such huge yield expectation from the wells will create a larger draw down in the well that the pump inside the well will no longer be sustainable. Therefore, in this evaluation it is recommended to conduct multiple well tests to determine the actual hydraulic parameters of the aquifer in order to obtain the safe yield of the wells which is intended to prolong the productivity of the aquifer and to delay excessive loss of saturated thickness.

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Finally the last but not the least thanks to all dear my friends and my wife for deep Supporting and sharing ideas during my thesis preparation.

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List of Abbreviations

AAIT	Addis Abeba Institution of Technology
AAWSA	Addis Abeba Water Supply & Sewerage Authority
B	Saturated aquifer thickness
DD	Drawdown
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GPS	Global Positioning System
K	Hydraulic Conductivity
L/s	Litter per second
OWWDSE	Oromia Water Works Design & Supervision Enterprises
P_P	Partial penetration
Q	Average Pumping Rate
S	Storativity
S_a	Observed Drawdown
SC	Corrected Drawdown
T	Transmissivity
WWDSE	Water Works Design and Supervision Enterprises

Table of Contents

1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Groundwater constitutes one portion of the earth's water circulatory system known as the hydrologic cycle. Water bearing formations of the earth's crust act as conduits for transmission and as reservoir for storage of water. Practically all groundwater originates as surface water. Principal source of natural recharge include precipitation, stream flow, lakes and reservoir. Other contribution for groundwater recharge are artificial recharge occur from execs irrigation, seepage from canal water. Groundwater is the sub-surface water that occurs beneath the water table in soils and geologic formations that are fully saturated (Freeze and Cherry, 1979). It is one of the most valuable natural resources, which supports human health, economic development, and ecological diversity. Because of its several inherent qualities (e.g., consistent temperature, widespread and continuous availability, excellent natural quality, limited vulnerability, low development cost, drought reliability), it has become an important and dependable source of water supplies in all climatic regions including both urban and rural areas of developed and developing countries (Todd, 2005). Of the 37 Mkm3 of freshwater estimated to be present on the earth, about 22% exist as groundwater, which constitutes about 97% of all liquid freshwater potentially available for human use (Foster, 1998). Groundwater resource management of an aquifer system involves developing a quantitative understanding of the flow processes that operate within the aquifer. Three main futures must be considered: how water enters the aquifer system how water passes through the aquifer system and how water leaves the aquifer system. Groundwater regime forecasting involves a study of modifications to the flow processes due to changes in any of these futures induced by natural and/or manmade processes.

So far, in Ethiopia, groundwater is mainly utilized for the water supply purposes. It takes care at present of 70% of rural water supply and plays a major role in several of the largest cities (Addis Ababa, Dire Dawa, Mekelle, Bushoftu, and Harari) and a number of medium-sized towns. As capital of Ethiopian, Addis Ababa has seen greater expansions and urbanization than other major city in the country. Based on the estimated population The Addis Ababa City Administration Council with the help of Addis Ababa Water Supply & Sewerage Authority (AAWSSA) has so far executed some 13 major water supply projects. These are Kebena Mini-Dam, Kechene Mini-Dam, Series of Springs Development, Entoto Water Treatment Plant, Gafarsa-I Dam, Gafarsa-II

Dam, Gafarsa-III Dam, Water-I (Legedadi Dam & Water Treatment Plant), Water-IIA (Legedadi Water Treatment Expansion & Rehabilitation of the Existing Legedadi & Gafarsa Water Treatment Plants), Water-IIB (Replacement of the Existing Legedadi Transmission & Major Lines as well as Construction of Service Water Reservoirs), Wells & Springs Development-Emergency, Akaki Town Water Supply and Dire Dam-Emergency Projects and Legedadi Deep well developments. Currently, the total coverage of safe water accessible to the residents of Addis Ababa City Administration has reached around 94%. The current total potable water production of the city is reached to some 650,000 m3 per day.

The study area of this research is Akaki well field, situated south of Addis Ababa. It covers a total area of 103 sq. kilometers. Akaki well field is not an independent and isolated aquifer it is part of Ada'a-Becho groundwater system. It is within a wide groundwater basin that covers parts of the southern Abay and Upper Awash surface water basins (WWDSE, 2008). Therefore the groundwater recharge and movement into and out of the aquifers of Akaki well field is seen in the context of the wider groundwater basin.

The Akaki river basin is a primary source of water for much of the population of the southern part of Addis Ababa. Municipal- well pumping from Akaki well field has contributed to the water level decline and, in some areas, declining well yields. Concern related to the rate of water level decline and the longevity of the usefulness of the aquifer have prompted investigation with the goal of prolonging productivity of the aquifer for beneficial use. A recent report on ground water availability shows decline of water levels in wells in these areas as the rate of withdrawal of water from wells in the area has increased.

Most of the previous studies have been concerned more with resource development to meet users' need and alleviate the current water supply problem with low attention to the understanding of hydraulic characteristics of the area which is essential for efficient Sustainable management of the groundwater resources. However, safe groundwater abstraction and proper study of the aquifer is crucial for sustainability of the resource.

1.2 Statement of the problem

Decline of water level caused by heavily withdrawal of water from Akaki well field and ongoing projects of constructing additional new wells have caused the need to do this research with the aim of evaluating the exaggerated pumping test results to understanding the hydraulic characteristics of the aquifer which is intended to prolong the productivity of the aquifer and to delay excessive loss of saturated thickness.

The design of Old Akaki well field project by considering the existing prevailing critical potable water supply shortage within the command area as the results of the ongoing condominium housing development project. The project intends to supply from nine deep wells of old Akaki Well field which can provide 54,000m3/day. But during this time it is not giving the expected amount of water from the boreholes and the inadequate amount of water from the boreholes causes' shortage of water for the community. The cause of this reduction of water from the boreholes may be the incorrect evaluation of hydraulic parameters of the well field.

1.3 Objective of the research

1.3.1 General objective

The primary objective of this study is analysis and evaluation of pumping test data to determine the aquifer hydraulic property of the old Akaki bore holes.

1.3.2 Specific objective

- To Evaluate the existing well data interpretation
- To Estimate and compare the hydraulic parameters on the basis of standard interpretation technique.
- To understand the physical meaning behind under estimation or over estimation of hydraulic parameters.
- To recommend appropriate mitigation measure.

2. LITERATURE REVIEW

2.1 Ground water

Ground water is an important source of water supply throughout the world. Its use in irrigation, industry, municipalities and Municipals water supply demand continues to increase. There is a tendency to think of ground water as being the primary water source in arid regions and of surface water is in humid regions.

Hydrologic budget, water budget, or water balance is a measurement of continuity of the flow of water, which holds true for any time interval and applies to any size area ranging from local scale areas to regional scale areas.

The hydrologists usually should consider an open system for which quantification of the hydrologic cycle for that system becomes a mass balance equation which the change of storage of water (ds/dt) with respect to time within that system is equal to the inputs (I) to the system minus out (O) from the system. Ground water system hydrologic budget:

$$I + G_i - G_o - Q_g - E_g - T_g = \Delta S_g \text{..................Eq.1}$$

Where: Gi = ground water flow into the system, Go = ground water flow out of the system, Δ**Sg** = change in ground water storage, Eg = the evaporation. (Davidkeith TODD, groundwater hydrology). Aquifer well pumping test method is a widely adopted method to determine the aquifer parameters in groundwater hydrology. The detailed description about determining aquifer properties from pumping test data can be found in many groundwater hydrology text books. Equilibrium equation known as thiem's equation can be used to determine the hydraulic conductivity or the Transmissivity of confined aquifer from the fully penetrating well pumping test. Equilibrium equation also can be developed for the unconfined aquifer with Dupuit assumptions. However, equilibrium equations are valid only for steady flow conditions. Under this condition, the aquifer is in equilibrium in regard to flow to the well being pumped. The aquifer may take several days to reach the equilibrium condition for any constant pumping rate. (Delleur Jw, 1999)

"Water is vital for mankind and regions with easy availability of water have always been the most prosperous. Water was one of the most prized national resources in the olden times and occupied a prominent position amongst the pagan gods.

Tremendous quantities of water are stored in the earth's crust. According to Nace (1960) the total volume stored under land areas may be around 80 million km3, half of which may be at depths less than 800 m. This is about 35 times the quantity of fresh water available on the surface of the earth and is about one third of the volume stored as ice in Polar Regions and the mountain ranges.

Surface water is generally easy and economical to harness, but its availability varies with the seasons, and its use for irrigation frequently brings in its wake problems like water logging. Groundwater, on the other hand, is obtainable all the year round, and its use in conjunction with surface water holds the subsoil water level within reasonable limits. Groundwater reservoir can be used to store water in times of surplus availability. It yields clear water at almost constant temperature that is preferred as compared to surface water for municipal water supply, air conditioning and many industries." (Garg,1998).

2.2 Ground-water movement and topography

It is desirable, wherever possible, to determine the position of the water table and the direction of ground-water movement. To do so, it is necessary to determine the altitude, or the height above a datum plane, of the water level in wells. However, in most areas, general but very valuable conclusions about the direction of ground-water movement can be derived from observations of land-surface topography. Gravity is the dominant driving force in ground-water movement. Under natural conditions, ground water moves "downhill" until, in the course of its movement, it reaches the land surface at a spring or through a seep along the side or bottom of a stream channel or an estuary. Thus, ground water in the shallowest part of the saturated zone moves from inter-stream areas toward streams or the coast. If we ignore minor surface irregularities, we find that the slope of the land surface is also toward streams or the coast. The depth to the water table is greater along the divide between streams than it is beneath the flood plain. In effect, the water table usually is a subdued replica of the land surface. (Ralph c. heath, 1987)

In areas where ground water is used for domestic and other needs requiring good-quality water, septic tanks, sanitary landfills, waste ponds, and other waste-disposal sites should not be located uphill from supply wells.

The potentiometric surface of confined aquifers, like the water table, also slopes from recharge areas to discharge areas. Shallow confined aquifers, which are relatively common along the

Atlantic Coastal Plain, share both recharge and discharge areas with the surficial unconfined aquifers. This sharing may not be the case with the deeper confined aquifers. The principal recharge areas for these are probably in their outcrop areas near the western border of the Coastal Plain, and their discharge areas are probably near the heads of the estuaries along the major streams. Thus, movement of water through these aquifers is in a general west to east direction, where it has not been modified by withdrawals. (Ralph c. heath, 1987)

In the western part of the conterminous United States, and especially in the alluvial basins region, conditions are more variable than those described above. In this area, streams flowing from mountain ranges onto alluvial plains lose water to the alluvial deposits; thus, ground water in the upper part of the saturated zone flows down the valleys and at an angle away from the streams.

Ground water is normally hidden from view; as a consequence, many people have difficulty visualizing its occurrence and movement. This difficulty adversely affects their ability to understand and to deal effectively with groundwater- related problems. This problem can be partly solved through the use of flow nets, which are one of the most effective means yet devised for illustrating conditions in groundwater systems. (Ralph c. heath, 1987)

2.3 Aquifer, aquitard, and aquiclude

An aquifer is defined as a saturated permeable geological unit that is permeable enough to yield economic quantities of water to wells. The most common aquifers are unconsolidated sand and gravels, but permeable sedimentary rocks such as sandstone and limestone, and heavily fractured or weathered volcanic and crystalline rocks can also be classified as aquifers.

An aquitard is a geological unit that is permeable enough to transmit water in significant quantities when viewed over large areas and long periods, but its permeability is not sufficient to justify production wells being placed in it. Clays, loams and shale’s are typical aquitards.

An aquiclude is an impermeable geological unit that does not transmit water at all. Dense un-fractured igneous or metamorphic rocks are typical aquicludes. In nature, truly impermeable geological units seldom occur; all of them leak to some extent, and must therefore be classified as aquitards. In practice, however, geological units can be classified as aquicludes when their permeability is several orders of magnitude lower than that of an overlying or underlying aquifer.

The reader will note that the above definitions are relative ones; they are purposely imprecise with respect to permeability. (Todd, 2005)

2.4 Aquifer types

There are three main types of aquifer: confined, unconfined, and leaky.

2.4.1 Confined aquifer

A confined aquifer is bounded above and below by an aquiclude. In a confined aquifer, the pressure of the water is usually higher than that of the atmosphere, so that if a well taps the aquifer, the water in it stands above the top of the aquifer, or even above the ground surface. We then speak of a free-flowing or artesian well.

2.4.2 Unconfined aquifer

An unconfined aquifer, also known as a water table aquifer, is bounded below by an aquiclude, but is not restricted by any confining layer above it. Its upper boundary is the water table, which is free to rise and fall. Water in a well penetrating an unconfined aquifer is at atmospheric pressure and does not rise above the water table.

2.4.3 Leaky aquifer

A leaky aquifer, also known as a semi-confined aquifer, is an aquifer that's upper and lower boundaries are aquitards, or one boundary is an aquitard and the other is an aquiclude. Water is free to move through the aquitards, either upward or downward. If a leaky aquifer is in hydrological equilibrium, the water level in a well tapping it may coincide with the water table. The water level may also stand above or below the water table, depending on the recharge and discharge conditions.

In deep sedimentary basins, an interbedded system of permeable and less permeable layers that form a multi-layered aquifer system is very common. But such an aquifer system is more a succession of leaky aquifers, separated by aquitards, rather than a main aquifer type.

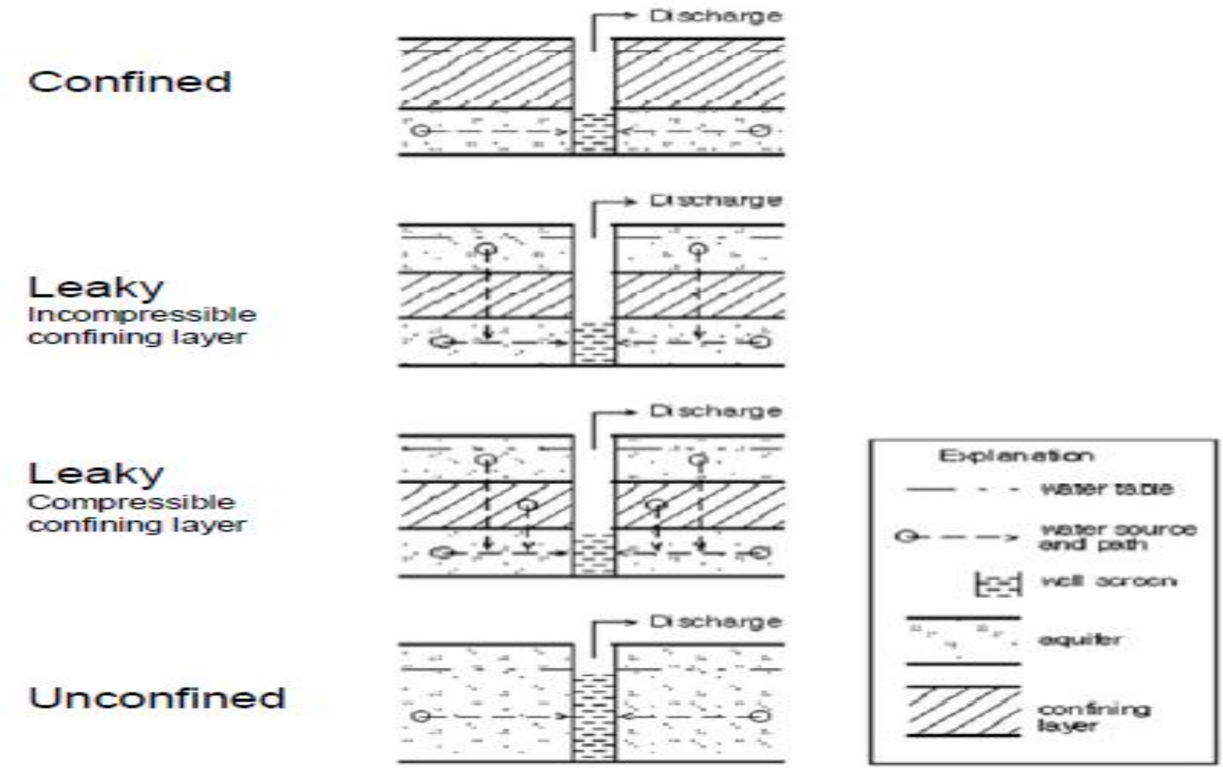

Figure 1:-types of aquifer

2.5 Bounded aquifers

Another common assumption in well hydraulics is that the pumped aquifer is horizontal and of infinite extent. But, viewed on a regional scale, some aquifers slope, and none of them extend to infinity because complex geological processes cause inter-fingering of layers and pinch outs of both aquifers and aquitards. At some places, aquifers and aquitards are cut by deeply incised channels, estuaries, or the ocean. In other words, aquifers and aquitards are laterally bounded in one way or another.

The interpretation of pumping tests conducted in the vicinity of such boundaries requires special techniques, which we shall be discussing. (G.P. Kruseman, 1994)

2.6 Anisotropy and heterogeneity

Most well hydraulics equations are based on the assumption that aquifers and aquitards are homogeneous and isotropic. This means that the hydraulic conductivity is the same throughout the geological formation and is the same in all directions. The individual particles of a geological formation, however, are seldom spherical so that, when deposited under water, they tend to settle on their flat sides. Such a formation can still be homogeneous, but its hydraulic conductivity in horizontal direction, K, will be significantly greater than its hydraulic conductivity in vertical direction, K. This phenomenon is called anisotropy.

The lithology of most geological formations tends to vary significantly, both horizontally and vertically. Consequently, geological formations are seldom homogeneous.

Heterogeneity occurs not only in the way shown in the figure: individual layers may pinch out; their grain size may vary in horizontal direction; they may contain lenses of other grain sizes; or they may be discontinuous by faulting or scour-and-fill structures. In horizontally-stratified alluvial formations, the K,/K, ratios range from 2 to 10, but values as high as 100 can occur, especially where clay layers are present.

Anisotropy is a common property of fractured rocks .The hydraulic conductivity in the direction of the main fractures is usually significantly greater than that normal to those fractures.

If the principal directions of anisotropy are known, one can transform an anisotropic system into an isotropic system by changing the coordinates. In the new coordinate system, the basic well-flow equation is again isotropic and the common equations can be used. (G.P. Kruseman, 1970)

2.7 Properties of Aquifers

2.7.1 Porosity

At the time they are formed some rocks contain void spaces while others are solid. Those rocks occurring near the surface of the earth are not totally solid. The physical and chemical weathering processes there continually decompose and disaggregate rock, thus creating voids, Slight movements of rock masses near the surface can cause rocks to crack or fracture. This also results in openings between rocks.

Sediments are assemblages of individual grains that were deposited by water, wind, ice, or gravity. There are opening called pore spaces between the sediment grains, so that sediments are not solid. The cracks, voids, and pore spaces in earth materials are of great importance to the study of hydrogeology. Ground water and soil moisture occur in the voids in otherwise solid earth materials. (Fetter, 2001)

The porosity of earth materials is the percentage of the rock or soil that is void of material. It is defined mathematically by the equation

$$n = \frac{100Vv}{v}$$ ………………………………Eq2

Where:

n= is the porosity (percentage)

V_v= is the volume of void space in a unit volume of earth material.

V=is the unit volume of earth material, including both voids and solids.

2.7.2 Specific Yield

Specific yield (S_y) is the ratio of volume of water that drains from a saturated rock owing to the attraction of gravity to the total volume of the rock (Meinzer 1923b)

Water molecules cling to surfaces because of surface tension of the water if gravity exerts a stress on a film of water surrounding a mineral grain, some of the film will pull away and drip downward. The remaining film will be thinner, with a greater surface tension so that, eventually, the stress of gravity will be exactly balanced by the surface tension. **Pendular water** is the moisture clinging to the soil particles because of surface tension. At the moisture content of the specific yield, gravity drainage will cease.

If two samples are equivalent with regard to porosity, but the average grain size of one is much smaller than the other, then the surface area of the finer sample will be larger. In addition, water will be primarily retained in the smaller pores. As a result, more water can be held as pendular by the finer grains.

The **specific retention (S_r)** of a rock or soil is the ratio of the volume of water a rock can retain against gravity drainage to the total volume of the rock (Meinzer 1923b). Since the specific yield represents the volume of water that a rock will yield by gravity drainage, with specific retention the remainder, the sum of the two is equal to porosity. (Fetter, 2001):

$$n = S_y + S_r$$ ………………………..Eq3

Where:

n = Porosity

Sy = Specific yield

Sr = Specific retention

The specific retention increases with decreasing grain size. So that a clay may have a porosity of 50% with a specific retention of 48% .

2.7.3 Hydraulic Conductivity

Earth materials near the surface generally contain some void space and thus exhibit porosity .Moreover, in most cases these void are interconnected to some degree. Water contained in the voids is capable of moving from one void to another, thus circulating through the soil, sediment, and rock. It is the ability of a rock to transmit water that, together with its ability to hold water, constitutes the most significant hydrologic properties. There are some rocks that exhibit porosity but lack interconnected void (e.g. vesicular basalt). These rocks cannot convey water from one void to another. Some sediments and rocks have porosity, but the pores are so small that water flows through the rock with difficulty. Clay and shale are examples. (Fetter, 2001)

Darcy's Experiment

Darcy found experimentally that discharge, Q, is proportional to the difference in the height of the water, h (hydraulic head), between the ends and inversely proportional to the flow length, L.

$$Q \alpha\ h_A - h_B \ \text{and}\ Q \alpha - 1/L$$

The flow is also obviously proportional to the cross-sectional area of the pipe, A. when combined with proportionality constant, K, the result is the expression known as Darcy's law:

$$Q = -KA\left(\frac{h_A - h_B}{L}\right) \text{ ....Eq4}$$

$$Q = -KA\left(\frac{dh}{dl}\right) \text{ ....Eq5}$$

Where: dh/dI is known as the hydraulic gradient. The quantity dh represents the change in head between two points that are very close together, and dl is the small distance between these points. The negative sign indicates that flow is in the direction of decreasing hydraulic head. The use of the negative sign necessitates careful determination of the sign of the gradient. If the value of h_2 at point X_2 is greater than h_1 at point X_1 then flow is from point X_2 to X_1. If $h_1 > h_2$, then flow is from X_1 to X_2.

We can rewrite the above Equation as

$$q = -K\frac{dh}{dl} \text{..........................Eq6}$$

Where q =Q/A. the factor q is called the specific discharge and has the dimensions of length/time (L/T). It is also sometimes called the Darcian velocity. it is not a true velocity as the cross-sectional area, A, is partially blocked with soil material.

We can also rearrange the above Equation to demonstrate that the coefficient K has the dimensions of L/T. this coefficient has been termed the hydraulic conductivity. In other works, it may be referred to as the coefficient of permeability. (Fetter, 2001):

$$K = \frac{-Q}{A(dh/dl)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Eq7}$$

Where:

K = Hydraulic Conductivity

A = Cross section area

$\frac{dh}{dl}$= Hydraulic Gradient

2.7.4 Transmissivity

A useful concept in many studies is aquifer transmissivity, which is a measure of the amount of water that can be transmitted horizontally through a unit width by the full saturated thickness of the aquifer under a hydraulic gradient of 1.

The transmissivity is the product of the hydraulic conductivity and the saturated thickness of the aquifer.

T=Bk………………………..Eq8

Where:

T is transmissivity (L_2/T)

b is saturated thickness of the aquifer(L)

K is hydraulic conductivity (L/T)

Aquifer transmissivity is a concept that assumes flow through the aquifer to be horizontal. In some cases, this assumption is valid; in others, it is not. (Fetter, 2001)

2.7.5 Storativity

When the head in a saturated aquifer or confining unit changes, water will be either stored or expelled. The **storage coefficient**, or **Storativity (S)**, is the volume of water that a permeable unit will absorb or expel from storage per unit surface area per unit change in head. It is dimensionless quantity.

In the saturated zone, the head creates pressure, affecting the arrangement of mineral grains and the density of the water in the voids. If the pressure increases, the mineral skeleton will expand; if it drops, the mineral skeleton will contract. This is known as elasticity. Likewise, water will contract with an increase in pressure and expand if the pressure drops. When the head in a confining bed declines, the aquifer skeleton compresses, which reduces the effective porosity and expels water. Additional water is released as the pore water expands to due to lower pressure.

The Storativity of a saturated aquifer is a function of its thickness. Storativity is a dimensionless quantity, as it involves a volume of water per volume of aquifer. Its values in confined aquifers range from 0.00005 to 0.005.

The **specific storage (Ss)** is the amount of water per unit volume of a saturated formation that is stored or expelled from storage owing to compressibility of the mineral skeleton and the pore water per unit change in head. This is also called the elastic storage coefficient. The concept can be applied to both aquifers and confining unit. The specific storage is given by the following expression (Jacob 1940, 1950; Cooper 1966).

$$S_s = \mathbf{r}_w \mathbf{g}(\mathbf{a} + \mathbf{n}\mathbf{b}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq9}$$

Where:

r is the density of water

g is the acceleration of gravity

a the compressibility of the aquifer skeleton

n is the porosity

b the compressibility of the water.

Specific storage has dimensions of1/L. The value of specific storage is very small, generally 3.048E-5 m^{-1} or less.

In a confined aquifer, the head may decline—yet the potentiometric surface remains above the unit. Although water is released from storage, the aquifer remains saturated. The Storativity (S) of a confined aquifer is the product of the specific storage (Ss) and the aquifer thickness (b)

$$S = b\,Ss \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq10}$$

Since specific storage has dimensions of 1/L and the aquifer thickness has dimensions of L, Storativity is dimensionless. All the water released is accounted for by the compressibility of the mineral skeleton and the pore water. The water comes from the entire thickness of the aquifer. The value of the Storativity of confined aquifer is on the order of 0.005 or less.

In an unconfined unit the level of saturation rises from the pore spaces. This storage or release is due to the **specific yield (Sy)** of unit. Water is also stored or expelled depending on the specific storage of the unit for an unconfined; the Storativity is found by the formula.

$$S = S_y + b\,S_s \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Eq11}$$

Where: b is the saturated thickness of the aquifer.

The value of Sy is several orders of magnitude greater then b Ss for an unconfined aquifer, and the Storativity is usually taken to be equal to the specific yield. For a fine-grained unit, the specific yield may be very small, approaching the same order of magnitude as b Ss. Storativity of unconfined aquifers ranges from 0.02 to 0.3. (Fetter, 2001)

2.8 Pumping tests

The principle of a pumping test is that if we pump water from a well and measure the discharge of the well and the drawdown in the well and in piezometers at known distances from the well, we can substitute these measurements into an appropriate well-flow equation and can calculate the hydraulic characteristics of the aquifer.

The five objectives of the purpose of test pumping water wells are:

(1) To confirm the yield, efficiency and performance of the well.

(2) To investigate water quality.

(3) To assess whether the abstraction can be sustained in terms of yield (and quality).

(4) To identify potential environmental impacts.

(5) To characterize the aquifer properties (such as transmissivity, hydraulic conductivity and storage).

The first and foremost objective of test pumping is to confirm that the well is performing as expected. Questions to be answered may include:

- ✓ Does the well provide the required yield?
- ✓ How does drawdown vary with pumping rate?
- ✓ What is the drawdown for the optimal yield and the peak yield?
- ✓ is the well abstracting efficiently or are there large well losses resulting ultimately in excessive pumping costs?
- ✓ Have any yield stimulation techniques been effective?

- ✓ Has the yield deteriorated over time due to clogging (chemical incrustation, biofouling) of well screen, gravel pack or aquifer formation? (Lewis Clark, 2006)

2.8.1 Duration of a Pumping Test

The question of how long a pumping test should last is difficult to answer because the period of pumping depends on the type of aquifer and the degree of accuracy desired in establishing its physical properties.

Economizing on the pumping period is not recommended because the costs of running the pump a few extra hours are low compared with the total costs of the test. Moreover, better and more reliable data are obtained if pumping continues until the cone of depression has stabilized and does not seem to be expanding further as pumping continues. At the beginning of the test, the cone develops quickly because the pumped water is initially derived from the aquifer storage immediately around the well. But, as pumping continues, the cone expands and deepens more slowly because, with each additional meter of horizontal expansion, a larger volume of stored water becomes available. This may often lead inexperienced observers to conclude that the cone has stabilized, or in other words that steady state has been reached. Inaccurate measurements of the drawdowns in the piezometers — drawdowns that are becoming additionally smaller and smaller as pumping continues — can also lead to this wrong conclusion. In reality, the depression cone will continue to expand until the recharge of the aquifer, if any, equals the discharge.

The unsteady-state flow, also known as non-equilibrium flow, is time dependent, i.e., the water level as observed in piezometers changes with time. During a pumping test, the unsteady-state flow condition occurs from the moment pumping starts until the steady state is reached. Theoretically, in an infinite, horizontal, completely confined aquifer of constant thickness which is pumped at a constant rate, there will always be an unsteady state, because the aquifer is not recharged by an outside source. In practice, well flow is considered to be in unsteady state as long as the changes in the water level in the piezometers are measurable, or as long as the hydraulic gradient changes in a measurable way.

The steady-state flow, also known as equilibrium flow, is independent of time, i.e., the water level, as observed in piezometers, does not change with time. It occurs, for instance, when there is equilibrium between the discharge of a pumped well and the recharge of the pumped aquifer by an outside source. Such outside sources may be recharge from surface water of nearby rivers, canals, or lakes, or recharge from groundwater of an unconfined aquifer with constant water table overlying an aquitard which covers a pumped leaky aquifer. Because real steady-state conditions seldom occur, it is said in practice that a steady-state condition is reached when the changes in the water level as observed in piezometers are negligibly small, or when the hydraulic gradient has become constant.

To establish whether unsteady or steady-state conditions prevail, the changes in head during the pumping test should be plotted. Figure 2 shows possible shapes of time-drawdown plots and their interpretations.

In some wells, a steady state occurs a few hours after the start of pumping; in others, it does not occur until after a few days or weeks, whereas in yet other wells it never occurs, even though pumping continues for years. Kruseman and de Ridder (1990) suggest that, under average conditions, steady-state flow is generally reached in leaky aquifers after 15 to 20 hours of pumping, and in a confined aquifer, after 24 hours. In an unconfined aquifer, the cone of depression expands more slowly, so a longer period of pumping is required, say, three days. Kruseman et.al. (2000)

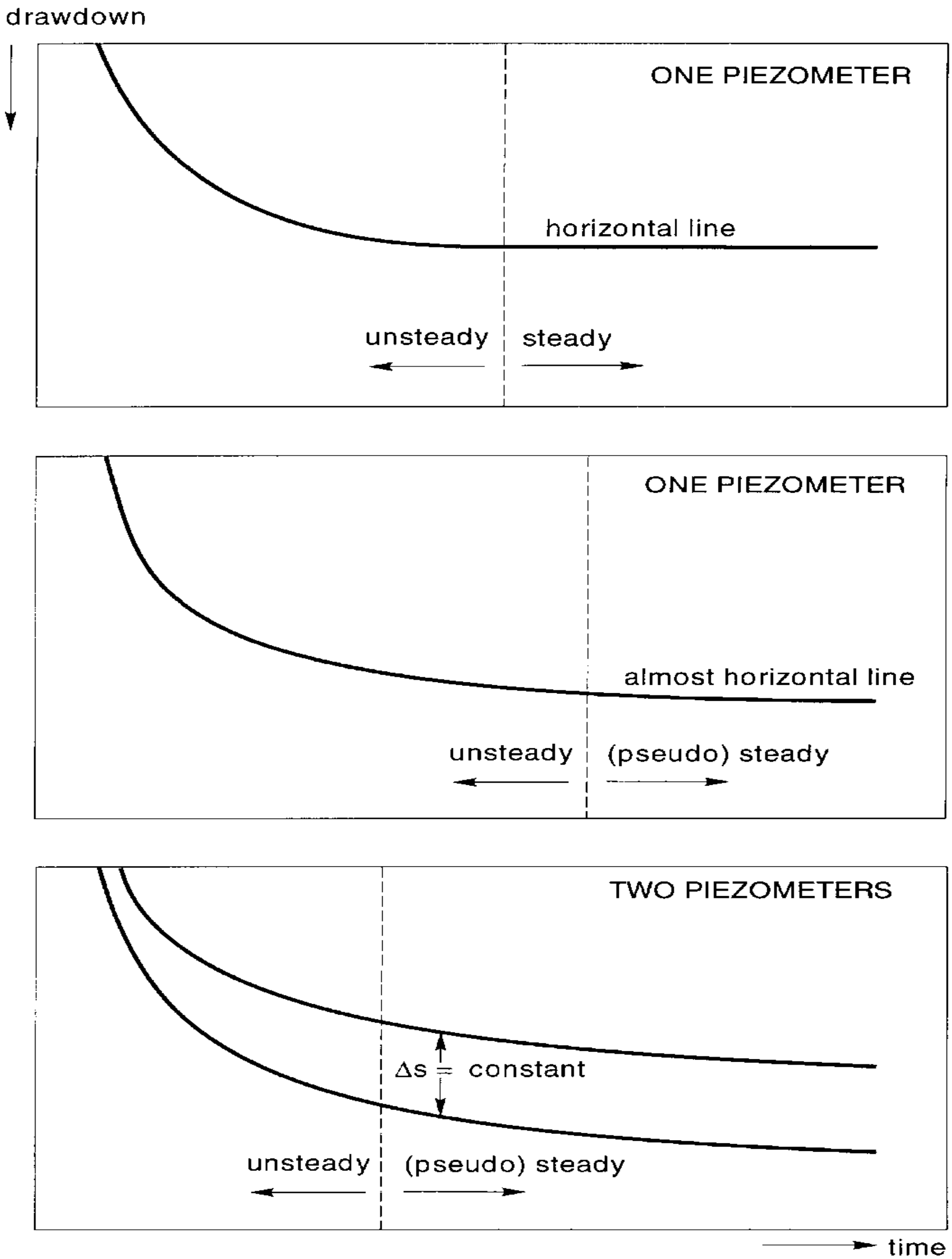

Figure 2:-Time-drawdown plots showing the changes in drawdown during an aquifer test and their interpretations.

2.8.2 Penetrating wells

Corrections may also be required to account for partially penetrating pumping wells. In these circumstances flow in the vicinity of the pumped well will be higher than a fully penetrating well and can result in additional head loss. This effect decreases with increasing distance from the pumping well, and no corrections are required at distances greater than 1.5 to 2 times the saturated thickness of the aquifer.

2.8.3 Single well tests

Single well tests are more common than aquifer tests using monitoring wells due to the obvious advantage that only one well is needed. However, in practice, only Transmissivity can be estimated, due to the high sensitivity of the (effective) well radius. Some of the disadvantages of single well tests are:

- Well construction (e.g. partial penetration) can lead to an underestimation of aquifer Transmissivity.
- Storativity cannot be reliably determined; and
- Single well test analyses typically make no allowance for leakage, or other recharge/no-flow boundaries.

2.8.4 Multiple Well Pumping Tests

A multiple well test is implemented by pumping a well continuously and measuring water level changes in both the pumped and observation wells during pumping or subsequent recovery. Properly designed and conducted multiple well tests can be used to define the overall hydro geologic regime of the area being investigated, including T, S and/or specific yield of a zone. They also can help design municipal well fields, predict rates of ground water flow, determine interconnectivity between saturated zones, and design a remediation system.

Two basic types are constant discharge and variable discharge. The former is performed by pumping at a constant rate for the duration of the test, while the latter is distinguished by changes in rate. Measurements obtained from the pumping well generally are less desirable for calculating hydraulic properties because of the irregularities induced from the operation of the pump and well bore storage. Obtaining data from observation well(s) allows for characterization of the pumped zone over a larger area. (Delleur –jw 1999)

General assumption of multiple well tests

The aquifer is infinite in a real extent.

- The aquifer is homogeneous, isotropic, and of uniform thickness over the area influenced by the test.
- Prior to pumping, the piezo metric surface is horizontal, or nearly so, over the area to be influenced by the test.
- The well penetrates the entire thickness of the aquifer and, thus, receives water by horizontal flow.
- The water removed from storage in the aquifer is discharged instantaneously with decline of head.
- Non-linear well losses are negligible

2.9 Constant rate test

The constant-rate test is the most common type of pumping test performed, and its concept is very simple: the borehole is pumped at a constant rate for an extended period (from several hours to several days or even weeks) while the water levels and pumping rates are monitored. If the most value is to be gained from constant-rate tests, water levels should be monitored in an observation borehole as well as in the pumping borehole (or better still, several observation boreholes at different distances from the pumping borehole). Data from constant-rate tests can be analysed to derive the Transmissivity of the aquifer. The storage coefficient of the aquifer can be calculated only if data from observation boreholes are available. (Delleur –jw 1999)

2.9.1 Method of solving cooper- Jacob method

The method of analysis presented here is called the Jacob (sometimes referred to as the Cooper-Jacob) *straight-line method*, which is based on a simplification of the Thies method. The procedure for analysing cooper- Jacob method is as follows:

1.Prepare a graph on semi-log graph paper, with water levels on the (linear) y-axis, in meters below datum, and time on the (logarithmic) x-axis (time since the start of pumping, in minutes). See Figure 3 Note that drawdowns can be plotted on the y-axis instead of water levels, if preferred – this does not affect the analysis.

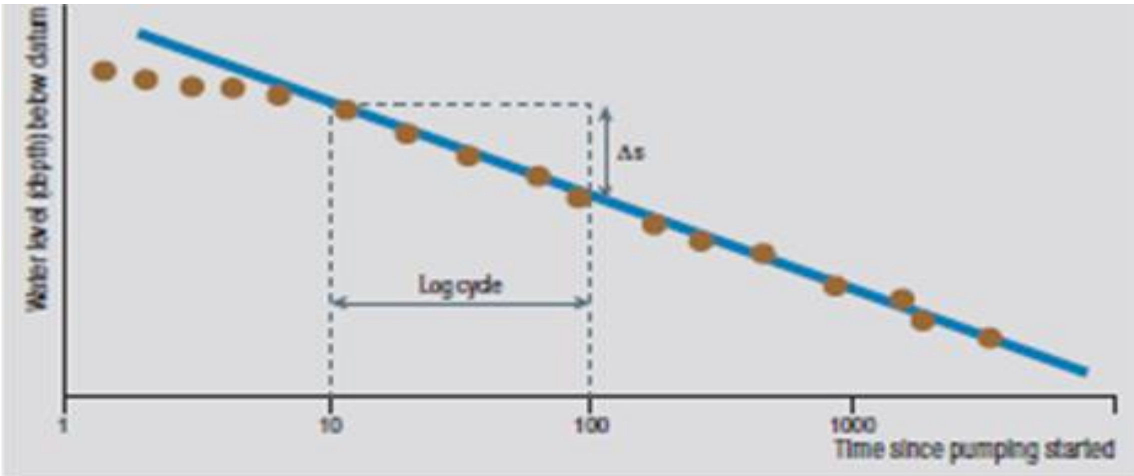

Figure 3:- constant rate pump analysis by cooper Jacob method

2. Plot the water levels against time for the duration of the test. The data should plot roughly as a straight line. Draw a best-fit line through the data, ignoring the early data and concentrating on middle to late data.

3. From this line, measure a parameter known as Δs, which is the difference in water levels (in meters) over one log cycle

4. Calculate the average pumping rate for the duration of the test, Q, in m3/day.

5. Insert the values of Q and Δs into the formula below to calculate the Transmissivity T. make sure that the correct units have been used, in which case the units of T will be m2/day. (David Keith Todd, 1959)

2.9.2 Recovery test

The recovery test is not strictly a pumping test, because it involves monitoring the recovery of the water level after the pump has been switched off. We have already come across it in the final stages of the procedures for undertaking step tests and constant-rate tests. It has been given a chapter to itself because recovery data are not always given the attention they deserve. Recovery tests are valuable for several reasons:

- They provide a useful check on the aquifer characteristics derived from pumping tests, for very little extra effort – just extending the monitoring period after the pump has been switched off.
- The start of the test is relatively ‘clean.’ In practice, the start of a constant-rate test, for example, rarely achieves a clean jump from no pumping to the chosen pumping rate.

Switching a pump off is usually much easier than starting a pump and the jump from a constant pumping rate to no pumping can be achieved fairly cleanly.

- Similarly, recovery smoothest out small changes in the pumping rate that occurred during the pumping phase, and there is no problem with well losses from turbulent flow. This results in more reliable estimates of aquifer properties when the recovery data are analyzed.
- The water levels in the borehole are easier to measure accurately in the absence of turbulence caused by the pumping (especially in the early stages of the test, when water levels are changing quickly). Some people find that it is easier to take readings quickly with a dipper when the water level is rising than when it is falling.
- Recovery tests represent a good option for testing operational boreholes that have already been pumping at a constant rate for extended periods. In these cases, the recovery test can be performed when the pumps are first switched off, followed by a constant discharge test when the pumps are switched back on again.

In theory, the recovery curve should be a mirror image of the drawdown curve, as long as it is measured from the extension to the drawdown curve. This is illustrated in Figure 4 , which also introduces the concept of residual drawdown (s'), the difference between the original water level before the start of pumping and the water level measured at a time (t') after the pump was switched off. (David Keith Todd, 1959)

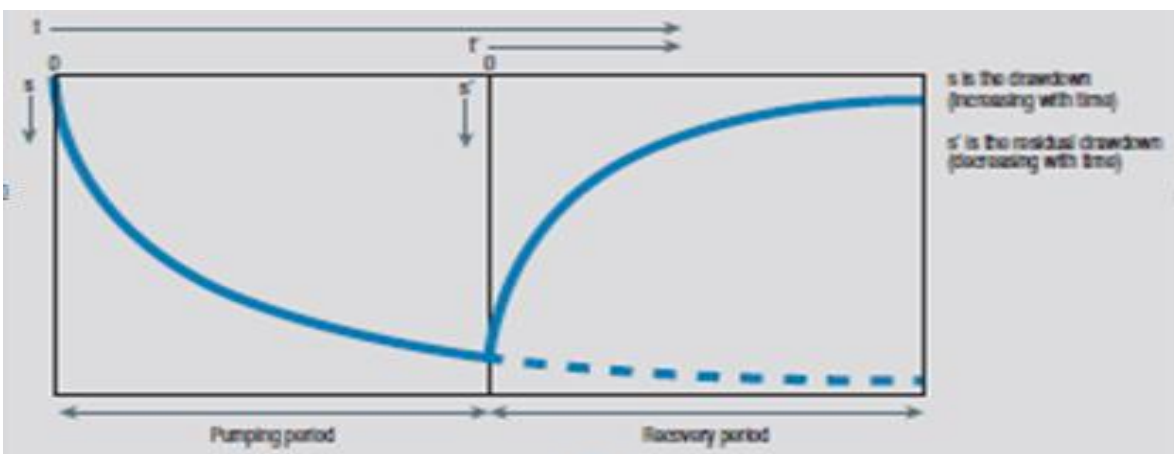

Figure 4:-recovery test.

Methods of analysis for recovery tests are supposed to be used only if the pumping was at a constant rate during the pumping phase, with the water level at or approaching equilibrium.

Recovery data following an extended constant-rate test are therefore preferable (as opposed to after a step test). As before, a simple analytical method will be presented here; the reader is referred to the reading list for more complex methods. The procedure for analysing recovery data is as follows:

1. Take all the water levels measured during the recovery phase (in meters below datum) and convert them to residual draw downs (s') by subtracting the original rest-water level measured just before the start of the pumping phase.
2. The time elapsed since the start of the recovery phase (in minutes) is denoted by t'. For all the residual draw downs, calculate t, which is the time elapsed since the very start of the pumping phase of the test
3. For all these pairs of times divide t by t'.

4. Prepare a graph on semi-log graph paper, with residual drawdown s' on the (linear) y-axis, in meters, and t/t' on the (logarithmic) x-axis.

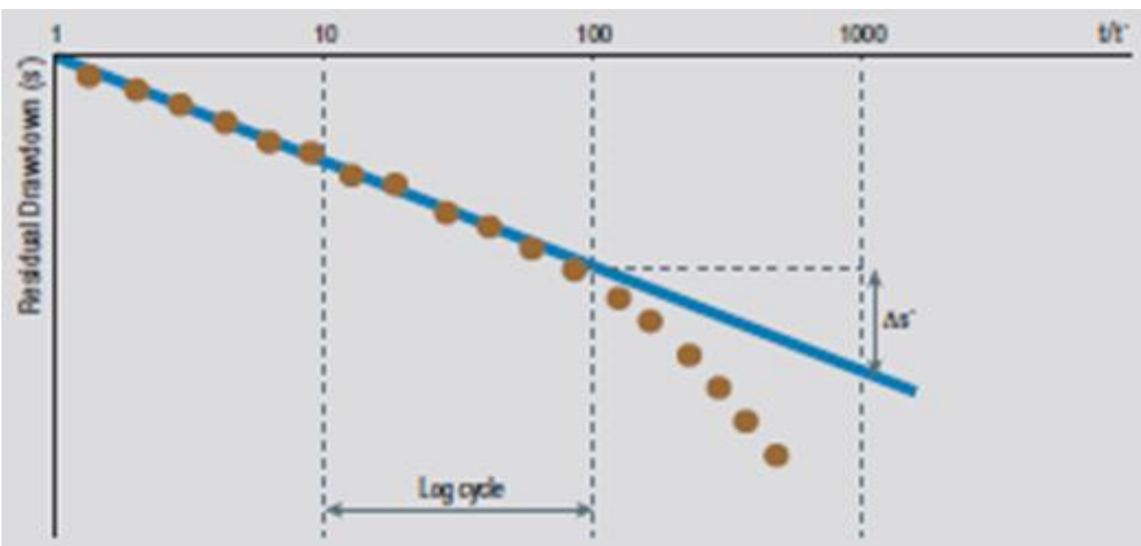

Figure 5:- recovery test analysis.

2.9.3 Step-Drawdown Test

Step-drawdown tests are tests at different pumping rates (Q) designed to determine well efficiency. Normally pumping at each successively greater rate Q1 < Q2 < Q3 < Q4 < Q5 takes place for 1-2 hours (Dt) and for 5 to 8 steps. The entire test usually takes place in one day. Equal pumping times (Dt) simplifies the analysis. At the end of each step, the pumping rate (Q) and drawdown (s) is recorded.

Step-drawdown tests are analysed by plotting the reciprocal of specific capacity (s/Q) against the pumping rate (Q). The intercept of the graph at Q=0 is B = W(u)/4□T and the slope is the well loss coefficient, C. B can also be obtained independently from a Thies or Cooper-Jacob analysis of a pump test.

2.9.4 Methods of solving Thies equation

Though Thies equation is widely recognized, solving it is a challenging task. Methods have been proposed by Thies, Cooper and Jacob and Chow to solve Thies equation. Out of these, Thies method involves curve matching. The other two are approximate methods.

2.9.4.1 Thies method

Theis method is one of the widely applied methods in groundwater hydrology to Determine S and T, However, this method requires curve matching of a type-curve and time draw down data from a pumping well test. Typically, this is done using a type-curve (W (u) Vs1/u) plotted on a logarithmic graph paper and the drawdown(s) data curve plotted on another transparent logarithmic graph paper (s Vs. r2/t) with the same scale, and superimposing and sliding the transparent one over the other to get the best possible match while keeping the coordinate axes of two plots parallel. Obviously this is a tedious approach. Based on the coordinates of a matching point from both plots (W (u), u, s, and r2/t) in the matched position, the values of S and T can be determined using Theis non equilibrium equation.

Procedure for the EXCEL type-curve-matching is described in this section. Systematic instructions to perform type-curves matching follow. The pump test data used is of a confined aquifer and is taken from the textbook by Todd. It should be noted that some of the EXCEL features may slightly differ for other versions of it. (David Keith Todd, 1959)

2.9.4.1.1 Enter data and create plots

Tabulate the well function data (W (u) and u) in EXCEL spread sheet. This needs to be done only once for the given type-curve. Appropriate well function need to be used other type of aquifers.

- Create the EXCEL plot of type-curve i.e., W (u) Vs. u in log-log scale. To create the plot, highlight the entire type-curve data set i.e. (u), u. Then, select the insert menu, and select the "Scatter" button and from the pull down menu select the "scatter with straight lines and markers" graph (to convert the X and Y axis to logarithmic scale, right click on the axes then select format axis, after that select the axis option and select the logarithmic scale base 10). Moreover, fix the major unit and minor unit values to 10; and assign fixed values for minimum and maximum values for both axes (i.e., for confined aquifer type-curve, vertical axis minimum 1×10-5, maximum 1×102; and horizontal axis minimum 1×10-15, maximum 1×101).
- Add the grid lines and axis titles for both axes.
- Format the chart area, gridline, data series, and axes for clear visualization

Plot the drawdown curve with the same size and scale as the type-curve. This can be performed by making a copy of the type-curve, and change the date series to drawdown data. However, both plots should have same number of log cycles in vertical and horizontal axis to preserve the same size and scale. (David Keith Todd, 1959)

2.9.4.1.2 Curve matching

In order to perform the curve matching, one of the plots should be transparent. In this demonstration, the transparency is set to 75% for the drawdown curve. Then, chart area of the drawdown curve need to be moved over the type-curve while keeping the coordinate axes of two plots parallel until get the best match.

2.9.4.1.3 Enlarge the plots

Though curve matching is obtained it is difficult to get the required parameters to calculate aquifer properties. The curve matching of drawdown curve was performed with entire type-curve but only a portion of the type-curve is required. It is difficult to determine which portion of the type-curve is required for curve matching. The curve matching is performed with entire type-curve to identify the matching portion. Then, matching portion is enlarged to obtain required parameters. It is necessary to keep the same number of log cycles for both axes to obtain the same size and scale for the plots. Once the required range of values are determined for curve matching, and to keep the same number of log cycle for both axis, the axis minimum and maximum values need to be assigned for axes. Thereafter, curve matching need to be performed again using enlarged plots to get the best matching. One the best matching is achieved, record from both plots the coordinates of any matching point i.e., u, W (u), s, and r2/t to determine the aquifer parameters using Theis equation. (David Keith Todd, 1959)

2.10 Variable-discharge tests and tests in well fields

Aquifers are sometimes pumped at variable discharge rates. This may be done deliberately, or it may be due to the characteristics of the pump. Sometimes, aquifers are pumped step-wise (i.e. at a certain discharge from to to t,, then at another discharge from t, to t2, and so on), or they may be pumped intermittently at different discharge rates. For confined aquifers that are pumped at variable discharge rates, Birsoy and Summers (1980).

It may happen that the discharge decreases with the decline of head in the well. If so, the sharpest decrease will occur soon after the start of pumping. For confined aquifers, the Aron-Scott and the Birsoy-Summers methods take this phenomenon into account. Although, strictly speaking, free-flowing wells are not pumped, the methods of analysis applied to them are very similar to those for pumped wells. Hantush's method for unsteady-state flow to a free-flowing well in a confined aquifer. Both methods are based on the condition that the decline of head in the well is constant and that the discharge decreases with time. The methods presented in the previous chapters are based on analytical solutions for the drawdown response in an aquifer that is pumped by a single well. If two or more wells pump the same aquifer, the drawdown will be influenced by the combined effects of these wells. The Cooper-Jacob method takes such effects into account.

The principle of superposition is used in some of the methods Used. According to this principle, two or more drawdown solutions, each for a given set of conditions for the aquifer and the well, can be summed algebraically to obtain a solution for the combined conditions.

2.10.1 Variable discharge

2.10.1.1 Confined aquifers, Birsoy-Summers's method

Birsoy and Summers (1980) present an analytical solution for the drawdown response in a confined aquifer that is pumped step-wise or intermittently at different discharge rates (Figure 6). Applying the principle of superposition to Jacob's approximation of the Theis equation

(Equation 12), they obtain the following expression for the drawdown in the aquifer at time t during the nth pumping period of intermittent pumping.

$$Sn = \frac{2.30Q_n}{4\pi KD} \log\{\frac{2.25KD}{r^2S} B_{t(n)}(t - t_n)\} \text{ ....Eq12}$$

Where:-

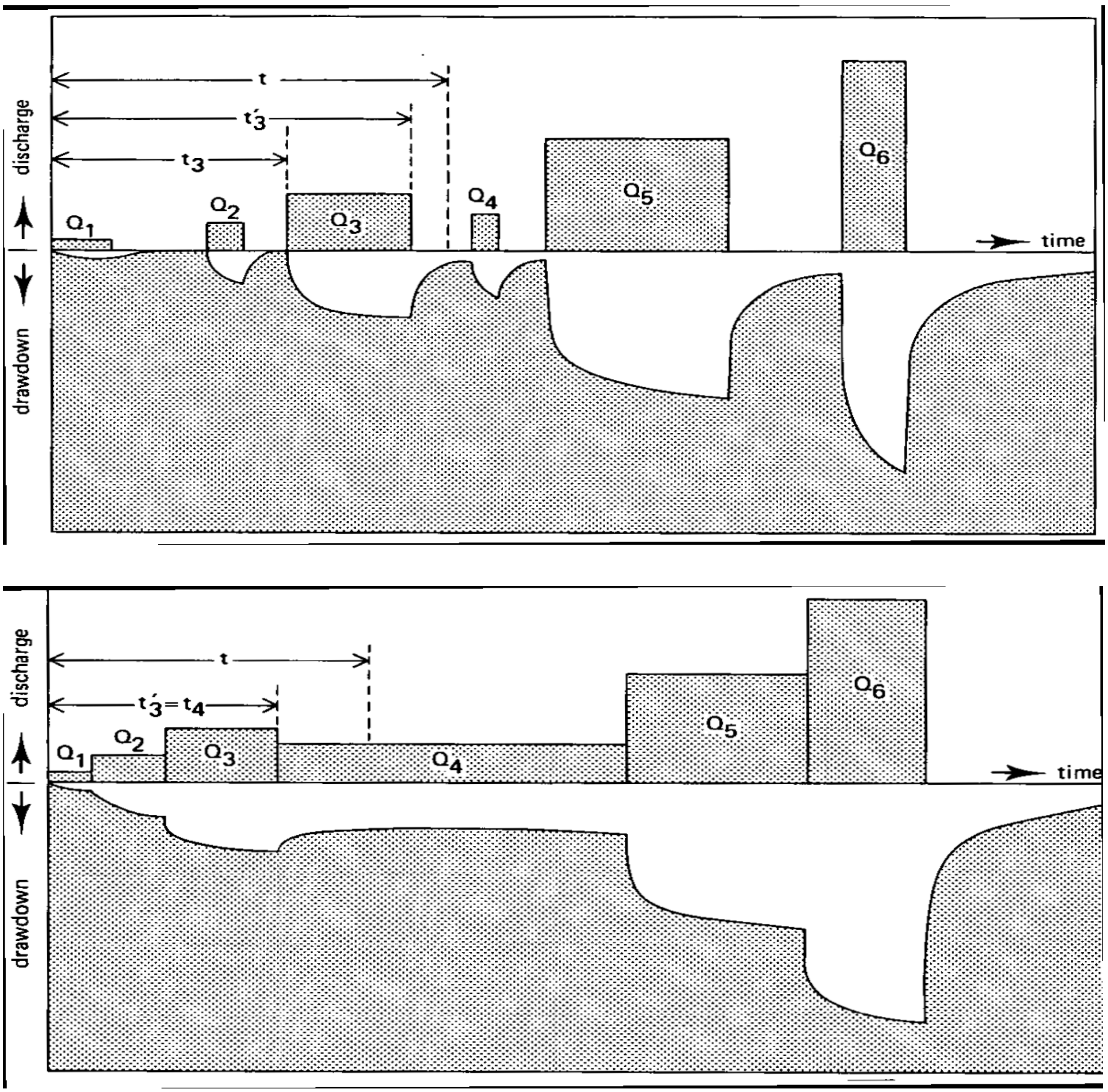

Figure **6:-** Step-wise and intermittently changing discharge rates and the resulting drawdown responses (after Birsoy and Summers 1980)

$$B_{t(n)} = \prod_{i=1}^{n-1} (\frac{t-t_i}{t-t'_i})^{Q_i/Q_n}$$

$$= (\frac{t-t_1}{t-t\prime_1})^{Q1/Qn} x (\frac{t-t_2}{t-t\prime_2})^{Q2/Qn} \text{x} \ldots \text{x} (\frac{t-t_{n-1}}{t-t\prime_{n-1}})^{Qn-1/Qn} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq13}$$

Where:-

t_i= time at which the i-th pumping period started

$t - t_i$ = time since the i-th pumping period started

t_i = time at which the i-th pumping period ended

$t - t'_i$ = time since the i-th pumping period ended

Qi = constant well discharge during the i-th pumping period

For step-wise or uninterrupted pumping, t' (i.l) = ti, and the 'adjusted time' {P, (,) (t-t,)}

Becomes

$$B_{t(n)}(t - t_n) = \prod_{i=1}^{n} (t - t_i)^{\Delta Q_i/Q_n}$$

$$= (t - t_1)^{\Delta Q_1/Q_n} x (t - t_2)^{\Delta Q_2/Q_n} x \ldots x (t - t_n)^{\Delta Q_n/Q_n} \ldots\ldots\ldots\ldots \text{Eq14}$$

Where: - **AQi** = **Qi** - **Qi.l** = discharge increment beginning at time ti.

If the intermittent pumping rate is constant (i.e. **Q** = **QI** = **Q2** = ... = **Qn),** the adjusted time becomes.

$$B_{t(n)}(t - t_n) = \frac{t_1}{t\prime_1} \frac{t_2}{t\prime_2} \ldots . \frac{t_{n-1}}{t\prime_{n-1}} t_n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq15}$$

Dividing both sides of Equation 12.1 by **Q,** gives an expression for the specific drawdown

$$\frac{S_n}{Q_n} = \frac{2.30}{4\pi KD} \log\{\frac{2.25KD}{r^2S} B_{t(n)}(t - t_n)\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq16}$$

The Birsoy-Summers method can be used if the following assumptions and conditions are satisfied:

- The assumptions listed with the exception of the aquifer is pumped step-wise or intermittently at a variable discharge rate fifth assumption, which is replaced by:

Or is intermittently pumped at a constant discharge rate.

The following conditions are added:

- The flow to the well is in an unsteady state;

- $\frac{r^2S}{4KD} x \frac{1}{B_{t(n)}(t-t_n)} < 0.01$

Procedure

- For a single piezometer, calculate the adjusted time Ptc, (t-tn) from Equations 13, 14, or 15 (whichever is applicable), using all the observed discharges and the appropriate values of time;

- On semi-log paper, plot the observed specific drawdown **sn/Q,** versus the corresponding values of Ptcn,(t-t,) (the adjusted time on the logarithmic scale), and draw a straight line through the plotted points;

- Determine the slope of the straight line, **A(s,/Q,),** which is the difference of **s,/Q,** per log cycle of adjusted time;

- Calculate KD from **A (sn/Qn)** = 2.3014nKD;

- Extend the straight line until it intersects the **sn/Qn** = O axis and determine the value of the interception point {Pt (n) (t-t,)),

- Knowing r, KD, and {Ptcn)(t-tn))oca, calculate **S** from

$$\boldsymbol{S = \frac{2.25KD}{r^2}\{B_{t(n)}(t-t_n)\}} \text{ ....} \textbf{Eq17}$$

Remarks

- The above Procedure can also be applied when the well discharge changes uninterruptedly with time. In that case, however, Q versus t for a single piezometer should be plotted on arithmetic paper. The time axis is then divided into appropriate equal time intervals t - ti and the average discharge Qi for each time interval is calculated;

- Calculating the adjusted time Pt(,,)(t-t;) by hand is a tedious process. Birsoy and Summers (1980) give a program for an HP-25 pocket calculator that computes Ptcn) for n < 4 for step-wise pumping.

2.11 Well-Performance Tests

The drawdown in a pumped well consists of two components: the aquifer losses and the well losses. A well-performance test is conducted to determine these losses. Aquifer losses are the head losses that occur in the aquifer where the flow is laminar.
They are time-dependent and vary linearly with the well discharge. In practice, the extra head loss induced, for instance, by partial penetration of a well is also included in the aquifer losses.

Well losses are divided into linear and non-linear head losses. Linear well losses are caused by damage to the aquifer during drilling and completion of the well. They comprise, for example, head losses due to compaction of the aquifer material during drilling, head losses due to plugging of the aquifer with drilling mud, which reduce the permeability near the bore hole; head losses in the gravel pack; and head losses in the screen. Amongst the non-linear well losses are the friction losses that occur inside the well screen and in the suction pipe where the flow is turbulent, and the head losses that occur in the zone adjacent to the well where the flow is usually also turbulent. All these well losses are responsible for the drawdown inside the wellbeing much greater than one would expect on theoretical grounds.

Petroleum engineering recognizes the concept of ‘skin effect’ to account for the head losses in the vicinity of a well. The theory behind this concept is that the aquifer is assumed to be homogeneous up to the wall of the bore hole, while all head losses are assumed to be concentrated in a thin, resistant ‘skin’ against the wall of the bore hole.(G.P Kruseman, 1970)

2.11.1 Well Efficiency

The relationship between drawdown and discharge can be expressed as the *specific capacity* of a well, *Q/SW*, which describes the productivity of both the aquifer and the well. The specific capacity is not a constant but decreases as pumping continues and also decreases with increasing *Q*. The well efficiency,E_w, is defined as the ratio of the aquifer head loss to the total head losses; it reads when expressed as a Percentage

$$E_w = \frac{BIQ}{BQ + CQ_p} * 100\%$$

The well efficiency according to the above Equation can be assessed when both the results of a step drawdown and those of an aquifer test are available. The former are needed for the values of *B*, *C*, and *P* and the latter for the value of *B*1.

In practice, only the results of a step-drawdown test are usually available. The substitution of the *B*, *C*, and *P* values into above Equation would overestimate the well efficiency, because *B* > *B*1. For these cases, Driscoll (1986) introduced another parameter, *Lp*, being the ratio of the laminar head loss to the total head losses; it reads when expressed as a percentage

$$L_P = \frac{BQ}{BQ+CQ_P} * 100\% \text{..Eq2}$$

3. RESEARCH METHODOLOGY

3.1 Description of the Study area

3.1.1 Location

The proposed ground water sources are from two main well fields, Old Akaki and North Fanta, located at the suburb of Addis Ababa city. Old Akaki well filed is located at about 22km South of Addis Ababa and East of Akaki Town. Five deep wells were already drilled in replacing the existing shallow wells with a total expected safe yield of 455l/s while four additional wells are also identified with collective expected yield of 400l/s. Similarly, North Fanta well field is located to North of Akaki well field around Koye area.

The abstracted water from old Akaki well field will able to serve various condominium sites in Kilinto and Koye feche condominium sites and other areas along the way & nearby the condominium sites in Akaki Sub City with additional supplies from North Fanta Well field. (OWWDSE, October 2014)

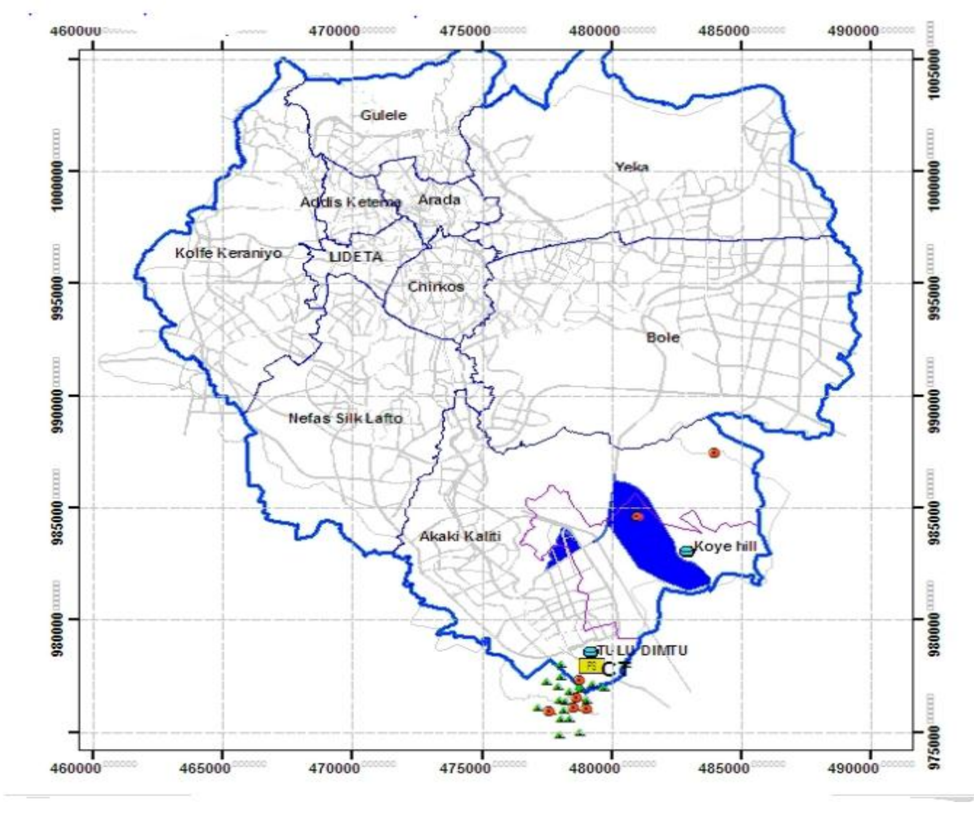

Figure 6:- Location map of the study area.

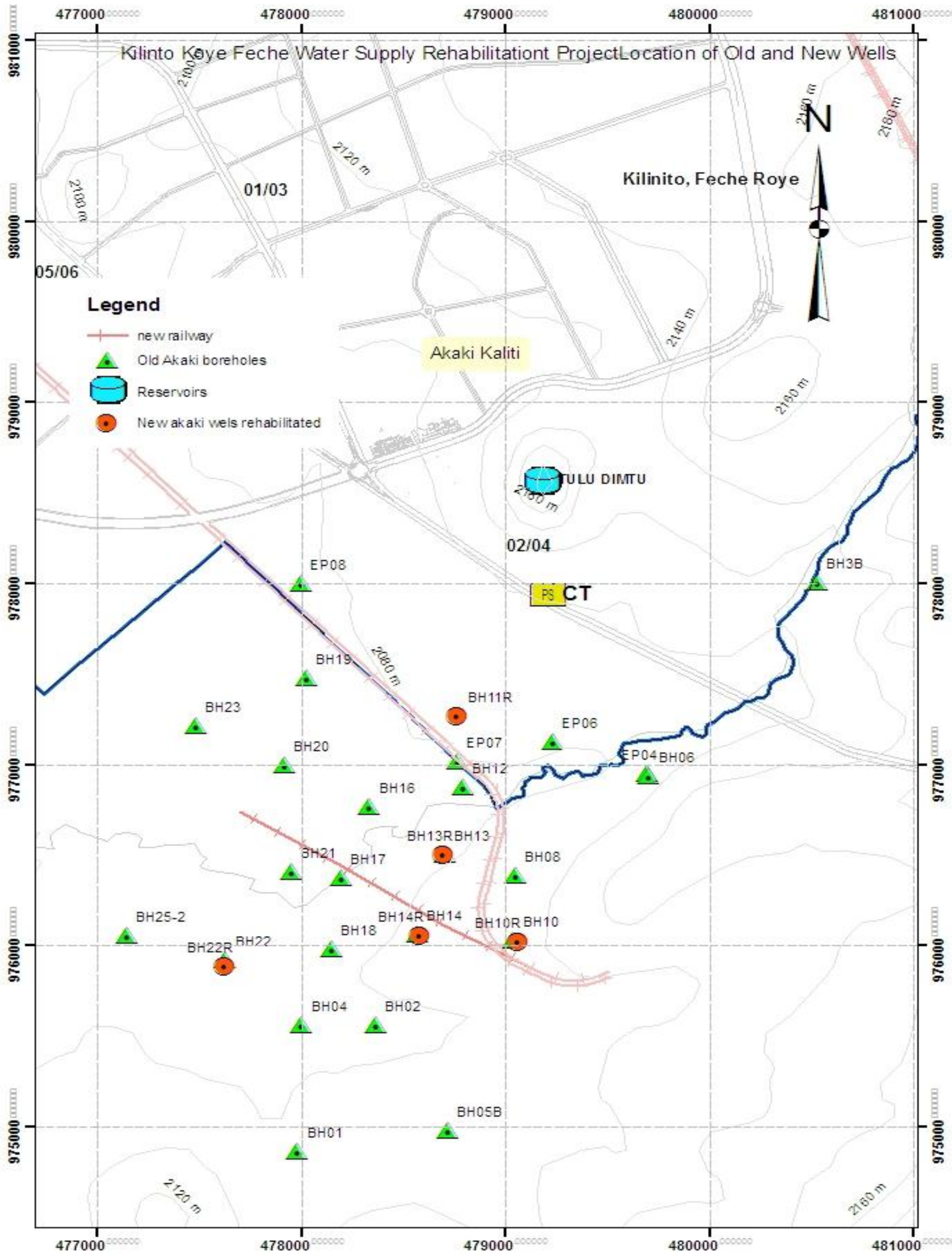

Figure 7:-Location Map of Existing and Drilled Deep Wells of Old Akaki Well field.

3.1.2 Climate

The climate of the Akaki catchment is characterized by two distinct seasonal weather patterns. The main wet season, locally known as Kiremt, extends from June to September .A minor rainy season, locally known as Belg, contributes moisture to the region from mid-February to mid-April (Daniel, 1977). The mean annual rainfall and temperatures are, respectively 153mm and 25 °C.

3.1.3 Population of the Project

The current command areas are predominantly used for condominium houses in addition to the nearby public institutions, private residential houses, factory, prison, etc. To estimate the population size it is essential to delineate the extent of the command area of the project beneficiaries in addition to Koye Feche, Kilinto and Tulu Dimetu Condominium Housing Project Sites. Based on the discussion with AAWSA project office it was found to be good to include all areas on the left side of Addis Ababa – Debre Ziet main road starting from Terunesh Dibaba Beijing Hospital up to Addis Ababa University (Ethiopian Water Resources Institution). These areas include all of the three condominium housing sites, cooperative houses currently under construction, existing public and residential areas located in a part of Woreda 1 & 2 of Akaki Kality Sub City. Accordingly, the population sizes of each the condominium housing sites were estimated based on the data obtained from Addis Ababa Housing Construction Project office where as other population size in the above stated command areas were obtained from Akaki Kality Sub City and detailed field survey, as indicated Table 1. The household size of the command area varies based on the data obtained from different sources. Addis Ababa Housing Construction Project Office considered a household size of 4.2 to estimate the population sizes expected to live in the ongoing Koye Feche and other condominium housing project sites. As most part of the command area is predominantly condominium housing site, it is vital to consider an average HH size of 4.2 for purpose of water supply system design for the command area. (OWWDSE, 2014)

Table3-1: Estimated Population of the Command Area

Item	Descriptions	Housing Unit	HH Size	Expected Populations
1	Koye - Feche Condominium Site	56,676	4.2	238,039
2	Kilinto Condominium Site	10,419	4.2	43,760
3	Tulu Dimetu Condominium Site	10,726	4.2	45,049
4	Existing Population in the Koye feche Area	10,000		10000
5	Cooperative Housing (780 coops with 24 members)	18,720	4.2	78,624
6	Other Residential areas to be included in the command area			
6.1	Woreda 1, Ketena 2	3,474	4.2	14,591
	Woreda 1, Ketena 3	5,000	4.2	21,000
	Woreda 1, Ketena 4	351	4.2	1,474
	Woreda 2, Ketena 6	800	4.2	3,360
Total Estimated Population				**455,897**

To forecast the future population, it was assumed that the population size remains the same in condominium and nearby cooperative houses based on the assumed household size and any growth in population is assumed to fill the empty spaces found in the current command area or move to other areas of the City. Therefore, the current unoccupied area will be assumed to be gradually filled during the design period as there is no recent future master plan of this particular area. The expected population in unoccupied areas is therefore estimated based on the proportion/ average area population taken from cooperative houses and Koye feche condominium housing site. It is believed that the unoccupied areas within the command areas will be assumed to be used either for any future condominium housing project site or leased residential and other commercial purposes. Therefore, the expected population sizes in new unoccupied area is assumed to be estimated based on the average area occupied by household in the Koye feche condominium and other existing / cooperative area which will be assumed to be gradually filled over the design period. However, the realistic growth rate or an observed number of inhabitants per plot in new areas is likely to be influenced by known socio-economic factors and government policies. (OWWDSE, 2014)

3.1.4 Topography Survey

Topographic survey are conducted for well filed collector pipes, on transmission main, reservoir sites and pumping station compound. Topographic drawings are prepared for the transmission main with appropriate scale which can show clearly pipe trench lines, obstructions, and permanent structures. Layout of the pumping station compound indicates the area requirement of infrastructures and arrangements of pump house, generator house, reservoirs, chemical house, and other structures constructed in the compound. Profile of pipelines is prepared from detail surveying of the pipe route. (OWWDSE, 2014)

3.1.4.1 Profile Survey

Detail profile surveys along the alignment of transmission main are carried out with additional cross sectional points are taken at locations where the transmission line crosses outer ring road and natural drainage. (OWWDSE, 2014)

3.2 Data Collection

A successful groundwater investigation depends on field data. However, to minimize additional fieldwork each groundwater study should start with the collection and analysis of the available information and documentation. This research primarily focuses on primary data collected from Federal Water Works Design and Supervision and Oromia Water Works Design and Supervision Enterprise while the pump test was conducted in Kilinto-Koye Feche well fields. Hence the primary pump test data like the step drawdown test data, constant pumping test data, recovery test data and the coordinate of each well were collected from Water works Design and Supervision Enterprise and Oromia Water Works Design and Supervision Enterprise.

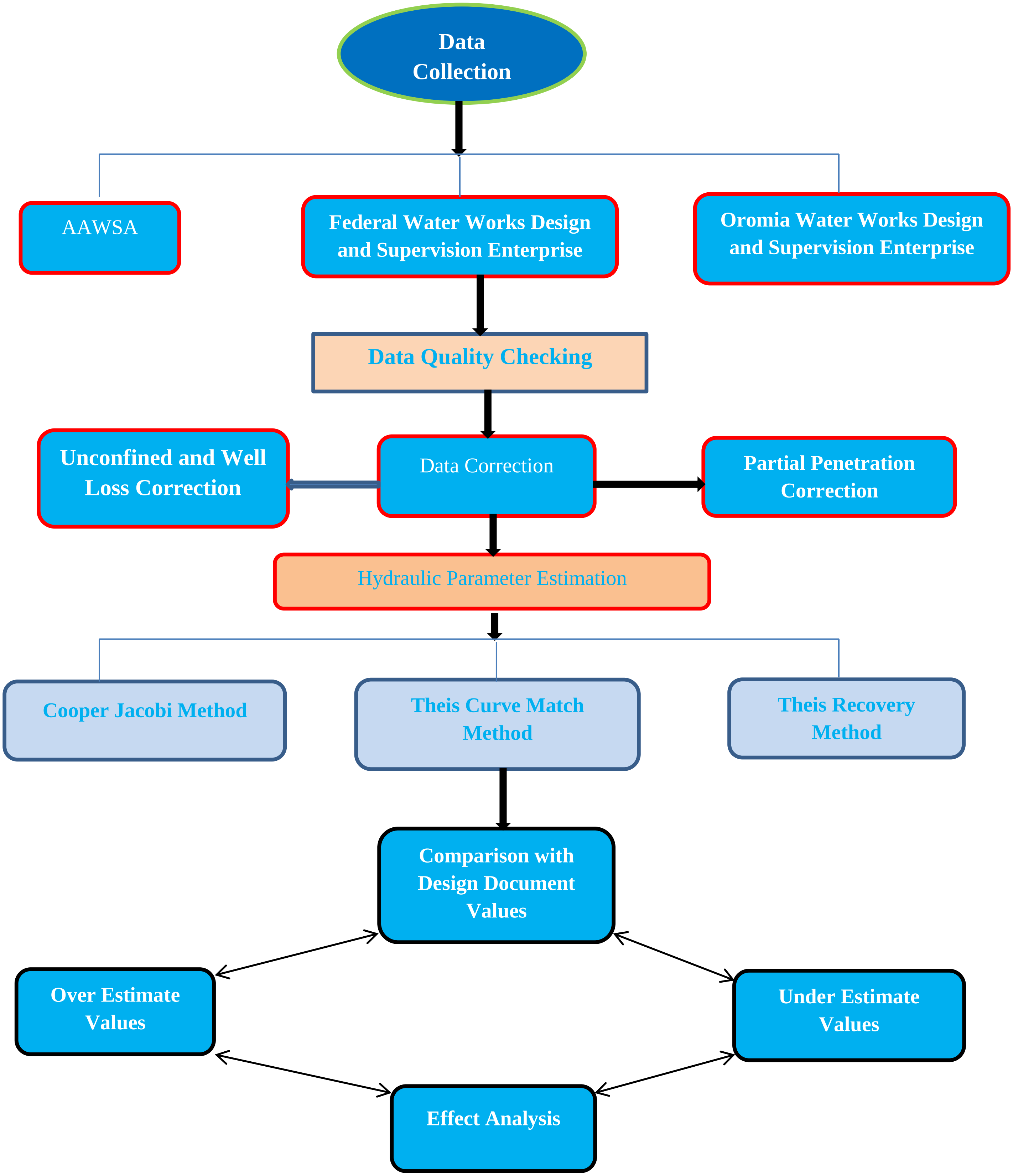

Figure 8:- Summary of research methodology.

3.3 Pre-field work

The research utilized both primary and secondary data in evaluating the research problem. The primary data collection includes measuring elevation & Locations of each well using GPS in order to verify (Check) what was measured by the contractors. And also a field visit was done in order to evaluate (to have a general over view of the area) the topography of the area, surface and ground water interaction and secondary data have been collected from different offices (Addis Ababa Water and Sewerage Authority, Federal Water Works Design and Supervision Enterprise and Oromia Water Works Design and Supervision Enterprise). Then, following the appraisal of the proposal all the reliable secondary data were arranged to prepare excel spread sheet, data quality checking and create excel spread sheet of each wells. After identifying the gaps to be filled and data that need field verification, field preparation was conducted that involved acquisition of equipment such as groundwater level measuring device or deep meter and GPS. Literature review related to evaluation of hydraulic parameter was also included in this stage.

3.4 Post-field work

In post field work to collect both primary and secondary essential data collection at field investigation and office work stage so as to achieve the objective of the study. The primary data gathering includes the works accomplished at the field investigation level. This task was carried out by collecting sites using GPS instrument to measure coordinates of the wells and to measure water level of the wells .The secondary data was collected from different sources. In this stage the following secondary data were gathered of validated and organized:- constant rate pumping test, step drawdown test, recover test, final drawdown, pumping duration, static water level, dynamic water level, well depth, design discharge. This duty covers the methods employed to achieve the subject matter as the citation of literature review on ground water books is substantially completed at the office work level. Physical characteristics of the aquifers, the necessary parameters such as the aquifer’s design discharge, transmissivity and storage coefficient are computed. Evaluate and analysis the pumping test data by using four common methods are included: -

- Theis’s Curve-Fitting Method,
- Cooper -Jacob method,
- Recovery method and

- Aquifer Test Model methods.

The data collected from different sectors was checked graphically by plotting time versus draw down on log-log scale and determining an R2 value greater than 0.5 indicates that the collected data is good data quality and R2 value below 0.5 shows that the collected data quality is poor.

A step draw-down test should have at least three steps that cover a wide range of flows, preferably matching or exceeding the proposed design flow. Step drawdown test data can be analysed with the Eden-Hazel (1973) method, which is based on the Jacob straight line method to give an estimate of transmissivity.

Step draw down test my data summarized by four stages. By this four step draw down data draw on excel spread sheet calculate the value of B and C values from trend line equation of the step draw down test graph. Using by B and C calculate all well efficiency vales. Minimum recommended well efficiency is 65%-80%. Below 65% well efficiency means used over discharge on the wells on the step draw down test and pumping test.

To identify the aquifer system of wells comparison of recorded draw down with various theoretical curves was made. The time draw down curve indicate the aquifer type where the wells are located could be and grouped in the following type

- Unconfined aquifer
  - BH1R, BH13R, BH22R, BH23R and BH26R.
- Confined aquifer
  - BH10R, BH11R and BH14R.

The above all unconfined aquifer change to confined aquifer by using the Jacob (1944) correction

Prior to analysis of drawdown data from an aquifer test it may be necessary to correct the data sets for external effects, or effects induced by the test. External effects include groundwater level changes due to barometric pressure variations, tidal fluctuations, and other recharge or discharge sources such as rainfall or river flow. Effects induced by the test may include the unintentional recharge of the aquifer from the in appropriate discharge of pumped water. To determine if corrections are required, trends in background water levels need to be analysed. For most analysis solutions, the aquifer is assumed to be of constant thickness. In an unconfined aquifer, this condition is not meet if the drawdown is large compared to the aquifers original saturated thickness. All method of analysis such as Theis Curve-Fitting Method, Cooper -Jacob method, recovery method is applied on the aquifer.

To achieve the objective used for calculating and analysing and evaluate my data for calculating hydraulic parameters by using the following four methods:-

- Theis (1935)
- Cooper-Jacob Time-Drawdown (1946)
- Theis Recovery (1935)
- Aquifer test software

Theis type curve classic analysis method is the basis for several other more complex analysis methods, described by Kruseman and de Ridder (1994). This method yields the following aquifer characteristics:

- Transmissivity [L2/T].
- Storativity (with an observation well).

Theis type curve overlapping method used to compute confined aquifer hydraulic parameters such as transmissivity, Storativity. Theis method used to time versus residual draw down data on log-log scale of all wells on excel spread sheet 2007.

However, this method requires curve matching of a type-curve and time drawdown data from a pumping well test. Typically, this is done using a type-curve (W (u) Vs. u) plotted on a logarithmic graph paper and the drawdown(s) data curve plotted on another transparent logarithmic graph paper (s Vs. r2/t) with the same scale, and superimposing and sliding the transparent one over the other to get the best possible match while keeping the coordinate axes of two plots parallel. Obviously this is a tedious approach.

Based on the coordinates of a matching point from both plots (W (u), u, s, and r2/t) in the matched position, the values of S and T can be determined using Theis equation.

The detailed descriptions about the manual type-curve matching can be found in many text books including Fetter1 and Todd and Mays.

Type curve match between Theis type curve and corrected field data curve on log-log spread sheet first tabulate the well function data (W (u) and u) in EXCEL spread sheet. This needs to be done only once for the given type-curve. The next step is tabulate the aquifer well pumping test data in EXCEL 2007 i.e., drawdown data with time, and creates a column r2/t; where r is the radial distance of the observation well from pumping well.

Plot the drawdown curve with the same size and scale as the type-curve. This can be performed by making a copy of the type-curve, and change the date series to drawdown data. However, both plots should have same number of log cycles in vertical and horizontal axis to preserve the same size and scale. In order to perform the curve matching, one of the plots should be transparent. In my log-log graph, the transparency is set to 75% for the drawdown curve The Cooper and Jacob method is based on the Theis formula, but uses a straight line approximation assuming that u (u=r2S/4Tt) is small. This method is described by Fetter (2001) and Kruseman and de Ridder (1994).

The Jacob method is a suitable method for verification of other analysis results by combining the final draw downs in one plot .The Jacob method yields the following aquifer characteristics:

- Transmissivity [L2/T].
- Storativity.

Cooper and Jacob method is used to time versus corrected drawdown data and draw the graphs on semi log form. First input time on X axis and residual draw down on Y axis .after draw the graph the X axis value changes to logarithm scale. Draw down data or Y axis values set on linear scale. After that draw the trend line and compute equation of the trend line. From the trend line calculate slope, intercept and change in draw down on one log scale. By using the above step calculate transmissivity and Storativity of the well by using cooper - Jacob formula and compare with preview design values.

Recovery test is more reliable than pumping taste data because recovery taste is not disturbing with pumping turbulence effect. When the pump is shut down after a pumping test, the water levels in the well and the piezometers will start to rise. This rise in water levels is known as residual drawdown, **s'.** It is expressed as the difference between the original water level before the start of pumping and the water level measured at a time t' after the cessation of pumping shows the change in water level with time during and after a pumping test. It is always good practice to measure the residual drawdowns during the recovery period. Recovery-test measurements allow the transmissivity of the aquifer to be calculated, thereby providing an independent check on the results of the pumping test, although costing very little in comparison with the pumping test. Residual drawdown data are more reliable than pumping test data because recovery occurs at a constant rate, whereas a constant discharge during pumping is often difficult to achieve in the field.

In recovery test first correct drawdown data by using (Kozeny; 1933) and well efficiency formulas. After correcting recovery taste data calculating t'/t and draw on semi log graph and draw trend line on semi log graph. On the trend line calculating slop of the line, intercept of the line and change of draw down on one log cycle. After analyzing the above data calculate transmissivity by Theis recovery formula. By recovery test data not calculating Storativity because the calculated Storativity values are out of real world Storativity values or very high Storativity values. After calculating transitivity values by using Theis recovery formula and comparing the pervious design values.

Aquifer test provides a flexible, user-friendly environment that will allow you to become more efficient in your aquifer testing projects. Data can be directly entered in Aquifer test via the keyboard, imported from a Microsoft Excel workbook file, or imported from any data logger file (in ASCII format). Test data can also be inserted from a Windows text editor, spreadsheet, or database by "cutting and pasting" through the clipboard.

Automatic type curve fitting to a data set can be performed for standard graphical solution methods in Aquifer test. However, you are encouraged to use your professional judgment to validate the graphical match based on your knowledge of the geologic and hydro geologic setting of the test. To easily refine the curve fit, you can manually fit the data to a type curve using the parameter controls.

Pumping tests, where water is pumped from a well and the change in water level is measured inside one or more observation wells (or, in some cases, inside the pumping well itself). You can present data in three different forms time versus water level, time versus discharge (applicable for variable rate pumping tests), and discharge versus water level (applicable for well performance analysis).

By aquifer test software to calculate all hydraulic parameters by Theis Curve-Fitting Method, Cooper -Jacob method, recovery methods. Aquifer test software is required the following data.

First fill all information on pumping test tool bar project name, date, site plane, time, unit and dimensions, aquifer type, aquifer thickness aquifer type, elevation, type of penetration etc.

The second step is fill discharge tool bar, insert the value of discharge, type of discharge such as constant or variable discharge and draw time versus discharge graph.

Third step is fill water level data such as static water level data, import time versus water level pumping test data.

Final step of aquifer test software is analyzing method in analyzing step compute all hydraulic parameters by Theis Curve-Fitting Method, Cooper -Jacob method, recovery methods and compare with design values.

3.5 Data Quality Checking

Data Quality Checking has been done both by preparing semi-log & log-log plots of drawdown versus time, after which comparison was made with theoretical curves. In addition detail inspection of the raw data was also made to see the trends of the drawdown for the presence of any unique values.

3.6 Data Analysis

Analysis of aquifer type (unconfined, confined or leaky aquifer) Aquifer may be classified as types confined or unconfined depending on the presence or absence of a water table, while leaky aquifer represent combination of the two types.

Data correction and analysis on partial penetration effect of the wells:-A well whose length of water entry is less than the aquifer it penetrates is known as partial penetrating wells. The Situation of partially penetrating wells in a confined aquifer. The flow patterns to such wells different from the radial horizontal flow assumed exist around fully penetrating wells.

Analysis pumping test data of the wells analysis by using Theis curve matching method on excel sheet and aquifer test software. Theis method is one of the widely applied methods in groundwater hydrology to Determine S and T, However, this method requires curve matching of a type-curve and time draw down data from a pumping well test. Plotted pumping test data's and type curve.

Detailed calculations: - leading to determinations of aquifer characteristics such as Transmissivity, Storativity, and specific yield by using Theis method.

Discussion on analysis and evaluation pumping test data of the wells:-to analyses and evaluation of pumping test data and analyse effect of error pumping test data on amount of Borehole yield, aquifer yield and basin yield, Long term yield capability of the borehole and amount of yield fluctuation of the well.

After collection of primary and secondary data-analyzing of the data estimated from well pumping test data using Theis curve match, Cooper-Jacob, Theis recovery method and aquifer test software computing Transmissivity, Storativity, specific yield and comparing the result with previous study.

4. RESULTS AND DISCUSSIONS

As the main goal of this paper is to see the interpretive techniques used in the determination of transmissivity and Storativity, the result and discussion part mostly contains the comparison between the corrected drawdown and uncorrected drawdown, comparison between manual curve fitting of Theis method and Aquifer Test software, comparison between results obtained by three method (Theis, Cooper-Jacob and a recovery method). Also here we will discuss the values obtained from the WWDSE and comparing them with the result determined in this paper.

In the study area all eight collecting wells are constant-rate single well test. constant-rate test is most common type of pumping test performed, and its concept is very simple the borehole is pumped at a constant rate for an extended period (most of the well pumped 3 day or 72 hour) while the water levels and pumping rates are monitored. If the most value is to be gained from constant-rate tests, water levels should be monitored in an observation borehole as well as in the pumping borehole. Data from constant-rate tests can be analysed to derive the transmissivity of the aquifer.

4.1 Evaluation of the Existing Well Data Interpretation

4.1.1 Well Information

Water well is an excavation or structure created in the ground digging driving boring or drilling to access ground water in underground aquifer. All collected well information of Old Akaki well fields such as northing, easting, elevation; Depth, Discharge and Average Transmissivity etc… are summarized in Table 2.

Well ID.	X(m)	Y(m)	Z(m)	Depth(m)	Q(l/s)	Tav(m2/d)	static water level(m)	dynamic water level(m)
BH1R	478074	975053	2089	520	126	2.55*10^3	83.67	136.6
BH10R	479001	976028	2097	551	150	1.97*10^3	95.33	100.71
BH11R	478782	977309	2088	545.92	150	3.05*10^3	82.34	88.36
BH13R	478695	976503	1874	550	55	9.48*10^1	76.6	137.7
BH14R	478583	976056		550.01	141	1.05*10^4	81.26	102.32
BH22R	77656	975932	2058	463.8	100	3.18*10^2	66.66	120.38
BH23R	477479	977222	2065	500	47.67	6.9*10^2	71.04	
BH26R	477246	975731	2077	500	90	3.59*10^2	72.8	130.56

Table 2:- Old Akaki well field information.

4.1.2 Data analysis

Old Akaki well field design document report not using pumping test data correction on all wells only use raw data for pumping test analysis. In this thesis all pumping test and recovery test data were corrected by using step draw down test data for well loss correction and by using Kozeny (1933) partial penetration formula. Kozeny formula is valid for L/b<0.5. Data quality checking for all wells by using best fit straight line regression values (R2).All of the wells with R2 above 0.5 summarized in the Table 3.

No.	Well ID.	Q(l/s)	B	C	R2	Efficiencies (%)
1	BH1R	126	0.0022	3*10^-7	0.9803	40.24
2	BH10R	150	0.001	1*10^-7	0.7938	43.55
3	BH11R	150	0.0001	2*10^-8	0.9185	27.57
4	BH13R	55	-0.0291	8*10^-6	0.8433	-326
5	BH14R	141	0.0003	1*10^-7	0.9977	19.75
6	BH22R	100	0.0244	-1E-06	0.9942	146.77
7	BH23R	47.67	-0.0262	1*10^-5	0.7162	-174.82
8	BH26R	90	0.0031	3*10^-7	0.9755	57.06

Table 3:- Summary of Old Akaki well fields efficiency.

For this thesis transmissivity value analysis by using average geometric mean of pumping test and recovery test results of Theis type curve much, cooper-Jacob and Theis recovery method. Geometric means normalize the range being average so that no range dominates the weight and a given percentage changes in any of the property the same effect on the range being. Arithmetic mean greatly influenced by outlier's value that is very much larger or smaller than other value.

4.1.2.1 Unconfined aquifer correction

All method of analysis such as Theis Curve-Fitting Method, Cooper -Jacob method, recovery method is applied on confined aquifer. All unconfined aquifer change to confined aquifer by using the Jacob (1944) correction.

$$S_C = S_a(1 - \frac{S_a}{2b})$$

4.1.2.2 Partial penetration correction

Out of eight well developed in Old Akaki wells need Kozeny correction factor to correct the measured drawdown for the head loss caused by partial penetration. The step drawdown test data are not included in the WWDSE report for well BH1R, BH13R, BH22R, BH23R and BH26R. In order to compute the hydraulic parameter the partial penetration correction is performed. By arranging the blind and screen for each of the five well the observed drawdown is adjusted the arithmetic and geometric mean values are obtained from the casing arrangement of blind and screen but for the correction of the drawdown we use the geometric mean as a Kozeny correction factor. List of the correction factor are shown in the table 4 below.

Well ID	Arithmetic mean	Geometric mean
BH1R	0.67	0.539
BH13R	0.67	0.568
BH22R	0.67	0.513
BH23R	0.67	0.568
BH26R	0.67	0.56

Table 4:- Kozeny correction factor for partial penetration of five well.

4.1.2.3 Step draw down test

Step-drawdown test is a single-well test in which the well is pumped at a low constant discharge rate until the drawdown within the well stabilizes. The pumping rate is then increased to a higher constant discharge rate and the well is pumped until the drawdown stabilizes once more. This process is repeated through at least three steps, which should all be of equal duration, say, a few hours each. The ratio of actual capacity of the well at the design yield to the maximum specific capacity possible calculated from hydraulic characteristics and well geometry is well efficiency. This is the same as the ratio of theoretical draw down to obtained design yield from a 100% efficient well to actual draw down measured in the well when producing at the design yield.

Collecting Step draw down test data summarized by five stages. From summarized step draw down test calculate efficiency of the well. Well is poor efficiency result high pump cost due to excessive drawdown. Old Akaki well should not be 65%-80%.efficency.Well efficiency values used for correcting aquifer loss and well loss calculation. According to step draw down test value summery of well efficiency listed on table 5.

Well Name	△Sw	Sw	Q(L/S)	Q(M3/D)	Sw/Q	B	C	R2	Efficiencies (%)
BH1R	38.7	38.71	100	8640	0.00448	0.0022	3*10^-7	0.9803	40.24
	6.62	45.3264	110	9504	0.00477				
	6.46	51.7845	120	10368	0.00499				
	2.7	54.4798	125	10800	0.00504				
BH10R	3.06	3.06	120	10368	0.0003	0.001	1*10^-7	0.7938	43.55
	0.33	3.39085	130	11232	0.0003				
	3.47	6.86415	140	12096	0.00057				
	0.36	7.22092	150	12960	0.00056				
BH11R	3.13	3.13	105	9072	0.00035	0.0001	2*10^-8	0.9185	27.57
	0.5	3.62963	120	10368	0.00035				
	1.13	4.76382	135	11664	0.00041				
	0.94	5.70535	152	13132.8	0.00043				
BH13R	37	36.97	50	4320	0.00856	-0.0291	8*10^-6	0.8433	-326
	-0.1	36.8742	55	4752	0.00776				
	31.2	68.073	60	5184	0.01313				
	36.8	104.893	65	5616	0.01868				
BH14R	13.1	13.14	110	9504	0.00138	0.0003	1*10^-7	0.9977	19.75
	2.27	15.41	120	10368	0.00149				
	2.2	17.612	130	11232	0.00157				
	2.63	20.2446	140	12096	0.00167				
BH22R	119	118.76	80	6912	0.01718	0.0244	-1E-06	0.9942	146.77
	7.07	125.827	90	7776	0.01618				
	5.54	131.371	100	8640	0.01521				
	6.37	137.746	110	9504	0.01449				
BH23R	12.1	12.08	31	2678.4	0.00451	-0.0262	1*10^-5	0.7162	-174.82
	4.91	16.9908	36	3110.4	0.00546				
	1.81	18.8052	40	3456	0.00544				
	55.5	74.335	46	3974.4	0.0187				
BH26R	38.8	38.71	100	8640	0.00448	0.0031	3*10^-7	0.9755	57.06
	4.75	43.464	110	9504	0.00457				
	5.97	49.4363	120	10368	0.00477				
	2.51	51.9436	125	10800	0.00481				

Table 5:-summery of Old Akaki well efficiency.

Each step draw down test is important to calculate well efficiency and correct draw down data that used to estimated hydraulic parameters in the base of standard interpretation techniques. All step draw down test data graphs are shown in APPENDIX – 1.

All shown in APPENDIX – 1 graphs are used to calculate well efficiency for the purpose of aquifer loss and well loss correction by using step draw down data.

4.2 Estimation and Comparison of Hydraulic Parameters on Standard Interpretation Techniques

4.2.1Transmissivity and Storativity result for Old Akaki wells

The object of this thesis is to find out the cause behind the well failure in Old Akaki wells and to evaluate the hydraulic parameter with the design document if the failure is at the beginning or due to day to day operation. The transmissivity and Storativity values both for observed and corrected drawdown are shown by the three methods using Excel 2013 and the result are computed with the documents of WWDSE. The percent of transmissivity increase and decrease for both corrected and observed drawdown are evaluated shown in the Table 12.

Most of the well developed in our city is single well test due to economic reason and has no observation well and it is difficult to calculate Storativity from single well test by using Theis recovery method. The Storativity of the 8 wells is also calculated by using the method Theis, Cooper-Jacob and all of the wells developed in Old Akaki well project don't have observation well. The value of Storativity by using Theis recovery method is not performed.

4.2.2 Transmissivity and Storativity values using Cooper-Jacob method

The first method of analysis presented here is called the Jacob (sometimes referred to as the Cooper-Jacob) straight-line method, which is based on a simplification of the Theis method. When a straight line was fitted to the data points, early time data were ignored because they tend to be affected by the volume of water stored in the borehole itself, and the points would probably not have fallen on the straight line. Because of the above reason used to calculate and analyze hydraulic parameter late time data. The method is apply for three of Old Akaki well in the semi-log plot of the drawdown vs. time the best fit line is done using Trend line tool which gives the equation of the line and R2 values From APPENDIX – 2 Figure 10(a) to figure 10(f) show the semi-log plots of the observed and corrected drawdown the correction is for well loss drawdown.

And figure 10(g) to figure 10(t) show the semi-log plots of the observed drawdown and corrected drawdown where the correction is done for the effects of partial penetration.

The result of the transmissivity and Storativity values for three wells using well efficiency to determine the drawdown loss in the well for both corrected and uncorrected drawdown shown in Table 6 and for the reaming five well using Kozeny correction factors to correct the drawdown are shown in Table 7.

Well index	Pumping rate (L/S)	Well efficiency %	Best fit Line for observed DD			Best fit Line for corrected DD			Transmissivity m2/day		Storativity	
			Slope	intercept	R-square	slope	intercept	R-square	Observed DD	Corrected DD	Observed DD	Corrected DD
BH10R	126	43.55	0.309	2.708	0.9413	0.1633	0.955	0.879	3335.46	6315.52	3.00E-03	1.05E-01
BH11R	150	27.57	0.115	5.082	0.9808	0.0316	1.401	0.981	9127.29	33072	2.67E-18	7.58E-18
BH14R	141	19.75	-2.2	22.9	0.6994	-0.435	4.522	0.694	-440.256	-2228.61	-8.44E+04	-4.26E+05

Table 6:-Transmissivity and Storativity values by cooper-Jacob method using efficiency correction factor.

Well index	Pumping rate (m3/day)	Radius of well in meters	Kozeny correction factor	Best fit Line for observed DD			Best fit Line for corrected DD			Transmissivity (m2/day)		Storativity	
				Slope	Intercept	R-square	Slope	Intercept	R-square	observed	corrected	observed	corrected
BH 1R	126	0.52	0.539	2.655	44.746	0.3687	0.257	49.97	0.115	326.233	7335.412	8.89E-08	6.25E-78
BH 13R	55	0.52	0.568	3.306	33.602	0.9244	2.955	32.63	0.9222	114.394	35.092	2.42E-05	7.43E-06
BH 22R	100	0.52	0.513	6.252	28.034	0.448	5.77	26.43	0.4251	98.9643	67.784	0.006426	4.40E-03
BH 23R	47.67	0.52	0.568	1.775	65.284	0.3423	1.526	60.3	0.3363	184.627	106.11	1.23E-16	7.06E-17
BH 26R	90	0.52	0.56	1.425	46.212	0.9375	0.813	26.37	0.9375	434.15	760.844	2.01E-14	3.52E-14

Table 7:- Transmissivity and Storativity values by cooper-Jacob method using Kozeny correction factor.

4.2.3 Transmissivity value using Theis curve much

Theis method is one of the widely applied methods in groundwater hydrology to determine S and T. However, this method requires curve matching of a type-curve and time drawdown data from a pumping well test. Typically, this is done using a type-curve [W (u) Vs. u] plotted on a logarithmic graph paper and the drawdown(s) data curve plotted on another transparent logarithmic graph paper [s Vs. r^2/t] with the same scale, and superimposing and sliding the transparent one over the other to get the best possible match while keeping the coordinate axes of two plots parallel.

$$T = \frac{Q}{4\,\pi \mathrm{T}} * W(u)$$

The plots of the overlap of the type curve and drawdown curve for all of the 8 well is shown in the figure below. The drawdown plots contain the correction for well loss using well efficiency in APPENDIX – 3 from figure 11(a) up to figure 11(d) and unconfined aquifer in figure 11(e) up to figure 11(l) partial penetration in addition unconfined aquifer correction.

The result of transmissivity values using the Theis curve much method is shown both for corrected and uncorrected drawdown in Table 8 and 9 by using a correction factor of efficiency and Kozeny correction factor.

Well index	Well efficiency (%)	Transmissivity m2/day		Storativity	
		Observed DD	Corrected DD	observed	corrected
BH10R	43.55	3738.77	5400.25	0.02596	0.0375
BH11R	27.57				
BH14R	19.75	418.321	2146.64	0.00291	0.01491

Table 8:- Transmissivity and Storativity by Theis method using efficiency correction factor.

Well index	Geometric mean	Transmissivity m2/day		Storativity	
		Observed DD	Corrected DD	observed	corrected
BH1R	0.539	159.67	216.491	0.00111	0.0015
BH13R	0.568	100.919	177.331	0.0007	0.00123
BH22R	0.513	152.055	51.9615	0.00106	0.00036
BH23R	0.568				
BH26R	0.56	178.12	228.216	0.00124	0.00159

Table 9:-Transmissivity and Storativity values by Theis method using Kozeny correction factor.

4.2.4Transmissivity Values Using Recovery Method

Using the time when pumping was stop (t'), the semi-log plot of the residual drawdown vs t/ t' was Plot for each of the well. Here also the use of best fit line was applied for the points in the plot of residual Drawdown vs t/ t'. Table 10 and Table 11 show the result for the transmissivity of both the corrected and uncorrected drawdown for the wells. From APPENDIX – 4 Figure 12(a) up to figure 12(f) are plots were the residual drawdown plots contain the correction to for well loss using well efficiency and correction for unconfined aquifer, where are figure from12(g) to 12(p)contains the drawdown plots where the effects of partial penetration is considered In addition to unconfined aquifer correction.

Storativity value by this method cannot be determined as in all case of the wells, single well test is conduct.

Well index	Pumping rate (m3/d)	Well efficiency (%)	Best fit Line for observed DD			Best fit Line for corrected DD			Transmissivity m2/day	
			slope	intercept	R-square	slope	intercept	R-square	Observed DD	Corrected DD
BH10R	126	43.55	-0.309	5.3887	0.9413	-0.135	2.3482	0.9407	-3337.6	-75279.1
BH11R	150	27.57	-0.114	6.04	0.9808	-0.032	1.6652	0.9808	-9167.3	-32658.6
BH14R	141	19.75	2.2023	4.4615	0.6944	0.4349	0.8811	0.6944	440.196	2229.12

Table 10:- Transmissivity values by Theis recovery method using efficiency correction factor.

Well index	Pumping rate(m3/ day)	Radius of well in meters	Kozeny correction factor	Best fit Line for observed DD			Best fit Line for corrected DD			Transmissivity (m2/day)	
				Slope	Intercept	R-square	Slope	Intercept	R-square	observed	corrected
BH1R	126	0.52	0.539	-0.641	55.224	0.1836	-0.069	51.069	0.0173	-1351.5	-27072
BH13R	55	0.52	0.568	-3.306	61.085	0.9244	-2.955	57.195	0.9222	-114.384	-35.079
BH22R	100	0.52	0.513	-2.152	55.67	0.3097	-1.974	51.909	0.2904	-402.56	-275.72
BH23R	47.67	0.52	0.568	-1.775	80.143	0.3423	-3.089	139.45	0.3423	-184.638	-106.1
BH26R	90	0.52	0.56	-1.425	58.143	0.9375	-0.813	33.177	0.9375	-434.242	-761.13

4.2.5 Summary of Result and Discussion

All above three method results such as cooper-Jacob method, Theis curve match method and Theis recovery results analysis by using geometric mean of Observed and corrected data Transmissivity values summarized for the purpose of comparison with Old Akaki design document values. All wells summarized transmissivity value of Old Akaki wells are listed in the table 12 below.

No.	well Id.	X	Y	Z	Method	WWDSE data	Geometric mean	corrected data	Geometric mean	Aqui-test 3.5 software	Geometric mean	% increase or decrease
1	BH 1R	478074	975053	2089	Theis overlap	159.6736	-288.53107	216.49	-6506.799	168	830	2255.14687
					Cooper-Jacob	326.2332		7335.412		522		
					Theis recovery	-1351.5		-27072.3		1800		
2	BH 10R	479001	976028	2097	Theis overlap	3738.77	1245.5433	5400.25	-21187.78	220	260	-1701.08708
					Cooper-Jacob	3335.46		6315.52		323		
					Theis recovery	-3337.6		-75279.1		237		
3	BH 11R	478782	977309	2088	Theis overlap		-13.336667		137.8	17.2	362.4	-1033.24169
					Cooper-Jacob	9127.29		33072		845		
					Theis recovery	-9167.3		-32658.6		225		
4	BH 13R	478695	976503	1874	Theis overlap	100.919	33.643	177.331	59.114667	9.18	43.22667	175.711639
					Cooper-Jacob	114.394		35.092		13.5		
					Theis recovery	-114.384		-35.079		107		
5	BH 14R	478583	976056	2050	Theis overlap	418.321	139.42033	2146.64	715.71667	200000	190833.3	513.351711
					Cooper-Jacob	-440.256		-2228.61		56500		
					Theis recovery	440.196		2229.12		316000		
6	BH 22R	77656	975932	2058	Theis overlap	152.055	-50.513567	51.9615	-51.9915	11.5	65.73333	-97.1573558
					Cooper-Jacob	98.9643		67.784		18.7		
					Theis recovery	-402.56		-275.72		167		
7	BH 23R	477479	977222	2065	Theis overlap		-0.0036667	44.51081	14.84027		0	-404734.636
					Cooper-Jacob	184.627		106.11				
					Theis recovery	-184.638		-106.1				
8	BH 26R	477246	975731	2077	Theis overlap	178.12	59.342667	228.2162	75.976733		0	128.124972
					Cooper-Jacob	434.15		760.844				
					Theis recovery	-434.242		-761.13				

Table12:- summery of hydraulic parameters by using the Theis curve much, cooper-Jacob, Theis recovery method and Aqui test 3.5 Software by using uncorrected draw down data and correct draw down data estimation.

Summary of hydraulic parameters by using Excel-spread sheet is calculated both for the Observed and corrected drawdown data estimation of Transmissivity are performed and the geometric mean result obtained by the three methods is compare with the result of WWDSE. The 8 well calculated transmissivity values are as shown in table 12. The results clearly show that there is clear variation from the one in the designed documents of WWDSE.

4.3 Summary results for over and Under Estimate Wells

The overestimated transmissivity envisions good aquifer with better yield than the capacity of the aquifer. By using above three methods calculating transmissivity value or geometric mean Greater than in the design document of average arithmetic or Observed calculated transmissivity is called over estimate.

The underestimated transmissivity values found to have lower yield than their discharging capacity. By using above three methods calculating transmissivity value or geometric mean less than in the design document of average arithmetic or Observed calculated transmissivity is called under estimate.

Summarize all calculated transmissivity values results dividing two groups depend on percentage of overestimate or percentage of underestimate. But two walls (BH11R and BH23R) not fiend final result because of by Thesis overlap method not fit the curve.

The first group is over estimate transmissivity value such as well BH1R, BH13R, BH14R and BH26R.

The second group is under estimate transmissivity value such as well ID BH10R and BH22R well.

4.3.1 Summary results for overestimate transmissivity

For Well BH1R using above the three methods calculating transmissivity by geometric mean is 6506.8 m2/day. In the design document of average arithmetic Observed calculated transmissivity is 288.53m2/day. This is due to use of average arithmetic Observed pumping test data and recovery test data. The difference in transmissivity values come from use of Observed average pumping test and recovery test data instead of corrected geometric mean value and magnitude of overestimate transmissivity is 2255 percent.

For Well BH13R using above the three method calculating transmissivity by geometric mean is 59.1m2/day and Observed data average geometric mean transmissivity is 33.6m2/day. From Kilinto and Koye Feche design document calculated average transmissivity value is 33.64m2/day and design document transmissivity over estimate by 175.7 percent. For this paper to compute hydraulic parameter of well ID BH13R using both pumping and recovery test data.

For Well ID BH14R average calculated transmissivity value by above three methods using geometric mean 715.7 m2/day and observed data transmissivity value is 139.42m2/day. Design document transitivity value is 10500 m2/day using Aqui test 3.5 software. From pumping test data using cooper Jacob method transmissivity is -2228.61m2/day and Theis type curve much method calculated transmissivity value 2146.64 m2/day and by using recovery data calculated transmissivity is 2229.12m2/day. Average calculated geometric is 715.7m2/day. Compare calculated value and design document value, design document value high as compared with estimated value by using above three methods.

For Well ID BH26R average calculated transmissivity value by above three methods using geometric mean 75.97m2/day. Project design document to select average Observed pumping and recovery data for computing average transmissivity is 59.34 m2/day and 72 percent over estimate transmissivity.

4.3.2 Summary results for underestimated transmissivity

Well ID BH10R calculating Corrected data transmissivity by geometric mean is 21187.7m2/day and observed data transmissivity by geometric mean is 1245.54m2/day. Design document value is under estimate because to select uncorrected pumping test and recovery test data for computing transmissivity. For this thesis used to compute both corrected pumping and recovery data to compute hydraulic parameters and analyse by geometric mean of the transmissivity value and magnitude of percentage underestimate by 1701 percent.

Well ID BH22R calculating Corrected data transmissivity by geometric mean is 51.99m2/day and observed data transmissivity by geometric mean is 50.51m2/day. Magnitude of percentage underestimate transmissivity value is 97 percent.

4.4 Demand and Supply Analysis

4.4.1 Design Period and Planning Horizon

The design horizon is 20 years divided in to two stages. Stage I will cater for demands up to 2025 and Stage II up to 2035. It is the expectation of this study that the system will be fully operational in year 2015.

(i) Water Demand Projection

The water demand of the beneficiaries is also estimated based on the recent development plan of the area for each of the demand categories. For the housing development project site (condominium houses) water demand can be calculated based on the estimated number of housing unit or population size using a per capita water consumption, 110l/c/d for stage I and 170l/c/d for stage II. Similarly, other residential water demand (other than condominium houses) within the project area is also calculated using the agreed per capita water demand with the AAWSA and based on socioeconomic survey and study for each demand category (house or yard connections). Generally, the adopted per capita water consumption for yard connection are 70l/c/d for stage I and 110l/c/d for stage II whereas for house connection 110l/c/d for stage I and 170l/c/d for stage II is considered for designs.

Additional public water demands such as institution, commercial, school and small industries will be also calculated explicitly or which can be estimated as 15% to 25% of domestic water demand. However, large industries are expected to have their own water supply system. On top of calculated water demand an average of unaccounted for water of 20% for stage I and stage II shall be added.

(ii) Demand Variations & Peak Hourly - Demand Curve

The average day demand is taken to be the sum of the demands of domestic and non-domestic including unaccounted for water. The average water demand represents the daily demand averaged over the year.

The daily water demand changes with the season and days of the week. The ratio of the maximum daily consumption to the mean daily consumption is called the maximum day factor and usually varies between 1.0 and 1.3. According to the Addis Ababa Water Supply Project – Stage IIIA a maximum day demand of 1.1 is adopted for the City of Addis Ababa.

The peak hour demand is the highest demand of any one hour over the day. Such an event is likely to happen during morning hours when most people use water for bathing, washing, utensils and cooking. Moreover, it could also occur at the end of the day when people need water for the same purpose after working hours. The peak hour water demand is greatly influenced by the size of the city, mode of service used and social activity pattern. The ratio of the peak hour demand to the maximum day demand is called peak hour factor. According to the Addis Ababa Water Supply Project – Stage IIIA), the hourly water usage varies according to the following pattern

- Low usage 23.00 – 05:00 Hours
- High Morning 05:00 – 11:00 Hours
- Moderate 11:00 – 18:00 Hours
- High Evening 18:00 – 23:00 Hours

The following hourly water consumption pattern can be adopted from pervious designs coupled with Addis Ababa Water Supply Project – Stage IIIA as shown in the following Fig 9.

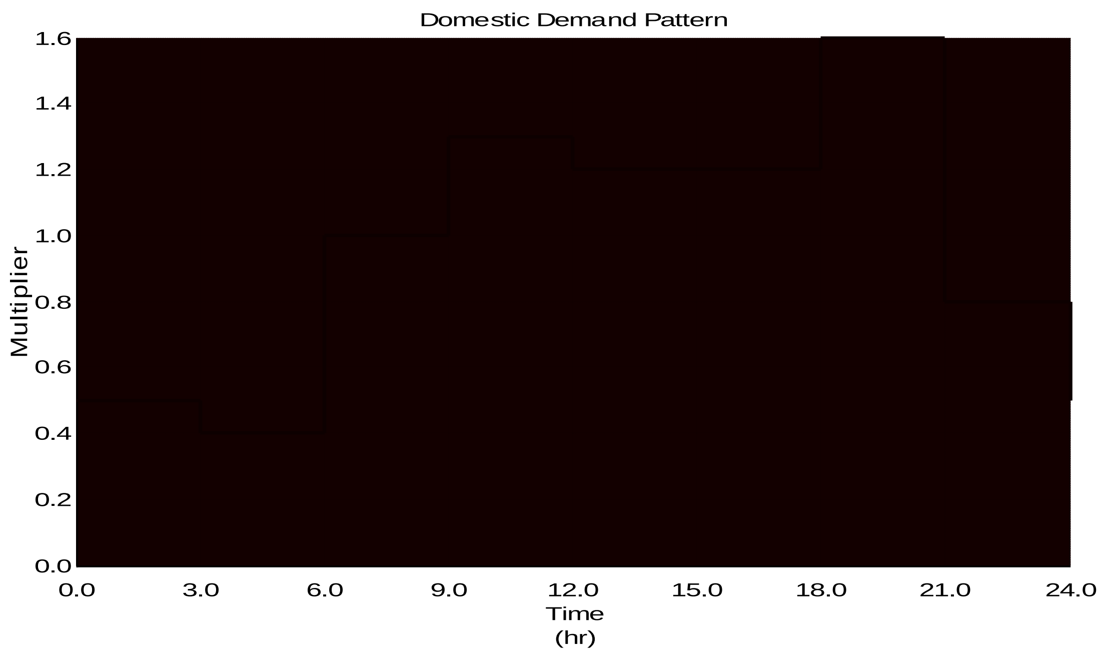

Figure 9:-: Recommended Domestic Water Demand usage pattern

4.4.2 Water Demand Calculations

Estimating water demands depends on the size of the population to be served, their standard of living and activities, the cost of water supplied, the availability of wastewater service and the purpose of demand. It varies according to the requirement of the domestic population, institutional, industrial and social establishments, etc. In addition to these, demand allowances need to be included for leakage, wastage, and operational requirements such as flushing of mains.

(i) Domestic Water Demand

Domestic water demand is the amount of water needed for drinking, food preparation, washing, cleaning, bathing and other miscellaneous domestic purposes. The amount of water used for domestic purposes greatly depends on the lifestyle, living standard, and climate, mode of service and affordability of the users.

The main purposes of each of the current condominium housing development projects within the command area are for residential purpose except few shops for commercial proposes and few public institutions and therefore the majority of water demand is domestic demand. Similarly, most of the other areas apart from condominium houses are also mostly residential purpose.

The following Table 13 shows the indoor human water requirement for different use of activities including leakage assuming there is adequate water supply coverage.

S/N	Activities	% Consumption
1	WC	26.7
2	Cloth Washing	21.7
3	Bath & Shower	18.6
4	Kitchen	17.1
5	Leakage	13.7
6	Others	2.2
	Total	**100**

Figure13: Composition of per-capita water demand for different purposes.

Sources: Addis Ababa Water Supply Project -Stage IIIA

(ii) Non-Domestic Water Demand

The major non domestic water users identified within the command area includes:- Addis Ababa Science and Technology University, Addis Ababa University (Water Resources) & UNISA, Kilinto Prison, Heineken Beer, Terunesh Dibaba Beijing Hospital and public and private institutions such as

Primary Schools (4), KG schools (31), Secondary School (1), Health Center (1) and Government offices (16).

From our detailed inventory, the water consumptions of the above identified non domestic water users is not greater than 6,000m^3/day which means very minimal as compared to the domestic water demand. Therefore, taking in to account the future growth of non-domestic water users such as expansion of Addis Ababa Science and Technology University and others there is a need to estimate non domestic demand as a reasonable estimate of 20% domestic demand. However, Kilinto industrial zone will be assumed to have their own water supply system as these will require more water.

(iii) Fire Fighting Demand

Choice of supplying the water demand for firefighting by the water supply service is a question of economic consideration. The annual volume required for firefighting purpose is small. However, during periods of need, the demand may be exceedingly large and in many cases govern the design of distribution, storage and pumping requirements. In most cases the firefighting water requirements is considered to be met by stopping supply to consumers and directing it for this purpose. Normally, this demand is taken care of by increasing the volume of storage tanks by 10%.

(iv) Non-Revenue Water

This mainly include the water losses within a particular water distribution systems of the command area and other such as illegal connections, overflow from storage tanks (if any), improper metering and water losses due to operational requirement such as washout. The amount is expressed as percentage of total domestic water demand covered from the water supply system. Usually the percentage of water losses depends on the age and condition of existing pipe network and complexity of the system. Even if this percentage is higher within the overall Addis Ababa water distribution network at present, but it will be minimum for smaller part of the network in the current command area.

In addition, for the new scheme losses will be minimal at the beginning of the design period and will increase gradually with time in the expected service life of the new system unless intermediate leakage detection & subsequent remedial work is carried out. Hence, on average about 20% non-revenue water is considered for modelling purpose.

(v) **Summary of Water Demand and Supply**

The total water demand used for this project site is summarized in Table 14.

Item	Descriptions	2015	2020	2025	2030	2035
1	Koye - Feche Condominium Site	26,184	29,755	33,325	36,896	40,467
2	Kilinto Condominium Site	4,814	5,470	6,126	6,783	7,439
3	Tulu Dimitu Condominium Site	4,955	5,631	6,307	6,983	7,658
4	Cooperative Housing	8,649	9,828	11,007	12,187	13,366
5	New Areas Within Kilinto - Koye feche area + Existing	700	2,996	6,710	11,144	16,297
6	Existing Residential areas (in Woreda 1&2) in the command area	2,830	3,234	3,638	4,043	4,447
	Total Domestic Water Demand	**48,132**	**56,914**	**67,115**	**78,035**	**89,674**
	Non Domestic Water Demand	9,626	11,383	13,423	15,607	17,935
	Non-Revenue Water	11,552	13,659	16,108	18,728	21,522
	Total Demand	**69,310**	**81,956**	**96,645**	**112,370**	**129,130**

Figure 14:-Water Demand of the Command Area

Step drawdown tests are usually lids us to assess well/aquifer-loss performance and for guidance in decide on optimum pumping rate for a later constant-rate pumping test. Since raw step drawdown data was available for eight well in the old Akaki Deep Well project, the well efficiency of these wells have been determined and comparison of was done with the result collected from WWDSE.

The drawdown in a pumped well consists of two components: the aquifer losses and the well losses. By using the well efficiency the drawdown was corrected for all wells which resulted much reduced value drawdown in both of the wells. Well efficiency range in the hydrogeologist's society is defined to be within the range of 65% to 85%.

S/N	BH Code	BH Coordinates			OWWDSE Estimated Q(l/s)	Hydrogeologist's society Recommanded efficiency(%)	B	C	Corrected Q(l/s)
		X	Y	Z					
1	BH1R	478074	975053	2089	126	65.35	0.0022	3.00E-07	45
2	BH10R	479001	976028	2097	150	65.12	0.001	1.00E+07	155
3	BH11R	478782	977309	2088	150		0.0001	2.00E+08	30
4	BH13R	478695	976503	1874	55	67	-0.0291	8.00E-06	105
5	BH14R	478583	976056	2078	141	65	0.0003	1.00E+07	20
6	BH22R	77656	975932	2058	100	68	0.0244	1.00E+06	130
7	BH23R	477479	977222	2065	47.67	65	-0.262	0.0332	47.67
8	BH26R	477246	975731	2077	90	65	0.0031	3.00E-07	65

Table 15:-Summery Results of OWWDSE Estimated discharge and based on hydrogeologist's society Recommend efficiency calculate discharge value.

Shown in the above table 15 summery results of OWWDSE Estimated discharge and based on hydrogeologist's society Recommend efficiency calculate discharge values. Assume the pump works daily 20 hr/ day total daily production estimated discharge from OWWDSE is 61,896.24m3/day, but corrected daily production discharge is 43,032.24m3/day. These show that daily 18,864m3/day amount of shortage within the command area. The effect of this shortage most of the condominium housing area and other supplying area not properly distribute and also it couldn't be serve the design command area.

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Single-well aquifer tests provide data in many situations in which aquifer pumping-test data from multiple wells would be a luxury for the ground-water analyst. The primary factor limiting the performance of multi-well aquifer tests is cost, particularly in areas with large depth to water (Belcher et al, 2001). Single well test is rapid and economical calculation of K, and T of the zone of interest at a single location. Single well tests also can determine response criteria for observation wells in multiple well pumping tests. Properly designed and conducted multiple well tests can be used to define the overall hydro geologic regime of the area being investigated, including T, S and/or specific yield of a zone.

From data quality point of view single well pumping test does not give accurate data and realistic Storativity value during pumping test analysis. Multiple well pumping test give better quality data than single well pumping test data and result in realistic hydraulic parameters estimation on large area.

The ground-water analyst faces many problems and challenges where hydraulic testing is limited to an isolated well. These problems include well-known and quantifiable effects such as borehole head loss during pumping, as well as much more difficult to quantify factors such as lateral and vertical anisotropy. Many effects could only be quantified with reasonable accuracy using multiple observation wells or flow logs (Hanson and Nishikawa, 1996).

Based on the outcomes of the analysis of eight of the Old Akaki-deep well the following conclusions are reached.

The transmissivity values obtained in this research has great variation from the study of WWDSE which accounts for 97 to more than 2000%. Among the eight wells analysed four wells have overestimated transmissivity, two wells underestimated and for two wells final result has not been obtained because of poor fitting of the Thies curve. The overestimated Transmissivity envisions good aquifer with better yield than the capacity of the aquifer. The underestimated Transmissivity values found to have lower yield than their discharging capacity.

Performing a step drawdown test, a test that lasts short period compared to other test, usually 8 to 10 hours, must be a done for all wells. As it's from this test that well yields are set, in doing this test, it assists in the determination the efficiency of wells. Well efficiency in turn tells us whether the construction of the well is done perfectly or not. For some well in the Old Akaki deep well major emphasis was not given to the well efficiency as it was mostly focused on getting a high well yield with no consideration on the well efficiency. Knowing a well has a low well efficiency and ignoring this low well efficiency is depraved way of developing any given well systems.

The well efficiencies were also computed for the expected yield (as suggested in the well completion report). The results clearly show that majority of the wells (five wells out of the eight tested wells) were found to work below the recommended operational efficiency. A well is considered acceptable if it works above 65% efficiency. Within tested wells only one well works in recommended efficiency range. Such a result clearly shows that the seven wells have already failed during design phase as they are expected to yield the values recommended in their well completion report. Such huge yield expectation from the wells will create a larger draw down in the well that the pump inside the well will no longer be sustainable.

The observed drawdown is expected to be worked out while the well efficiency is very low or the effects of partial penetration is high thus the actual aquifer parameters will result in unrealistic values. However, when major stress is given to the well drawdown loss by considering either the well efficiency or partial penetration the observed drawdown will have a lessor drawdown than originally thought. This corrected drawdown in turn can be used for describing the true nature of the aquifer.

5.2 Recommendation

Due to economic reason most of the groundwater developed in the city follows a single well test system. Such approach has a very serious drawback in aquifer property determination. Such approach, besides drawback in standard analysis and result interpretation challenges, has resulted in inappropriate well yield and transmissivity estimation in this study. Thus, for such huge projects that delivers water for 455,897 peoples, use of multiple well test method is recommended.

Determination of well efficiency should be give foremost importance when development of a well in any given well fields. As this will indicates if the well should be abandoned if it has a very low efficiency or it will specify if the well discharge should be decreased in order to prolong the wells life expectancy. In addition to this, highly efficient wells are less costly to operate because they require less power to operate the pump. Also As most well yield are set for a given well field based on the wells that are within the same well vicinity, mostly without conducting step drawdown test, it will also remove this unscientifically way of setting well yields.

Using the raw observed drawdown data without considering well efficiency or effects of partial penetration for the determination of transmissivity and Storativity is still being applied in the hydrogeological society's all over Ethiopia. As this was of interpretative techniques have lead wells most wells to dry up swiftly due to the fact they are being over pumped and also due to this interpretative techniques in some cases the full potential of the well are not being used.

During the development of groundwater attention has to be given for the well yield and the hydraulic characteristic estimations. Result interpretation and complying with the standard well pumping test approaches shall be strictly followed.

Finally I recommend to serve the command area properly needs additional wells or sources require 18,864m3/day amount of water for the command area.

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APPENDIX – 1:- Step draw down test data result

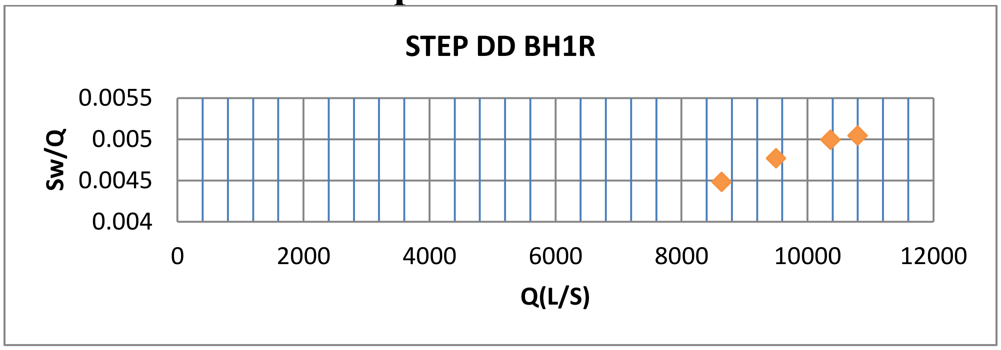


Figure 9(a):- step draw down test graph of well ID BH1R.

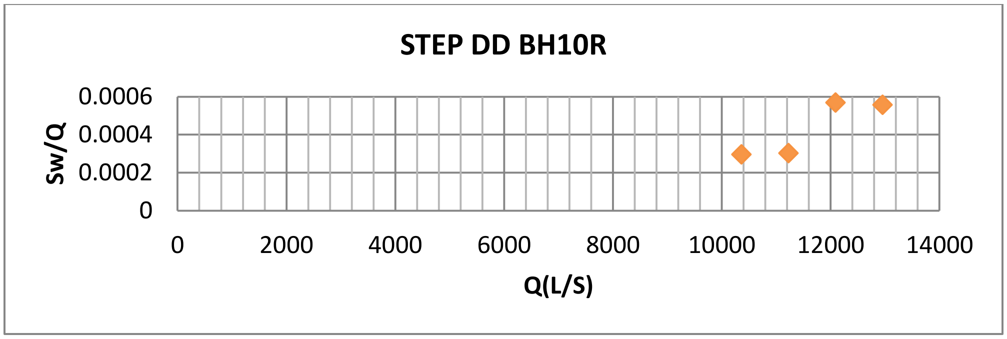


Figure 9(b):- step draw down test graph of well ID BH10R.

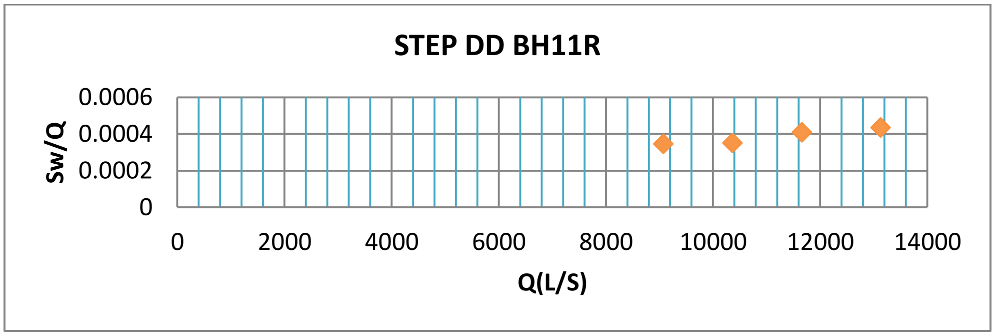


Figure 9(c):- step draw down test graph of well ID BH11R

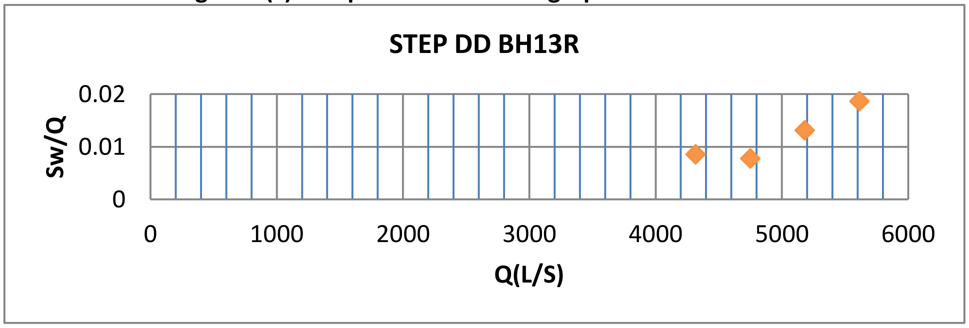


Figure 9 (d) :-step draw down test graph of well ID BH13R

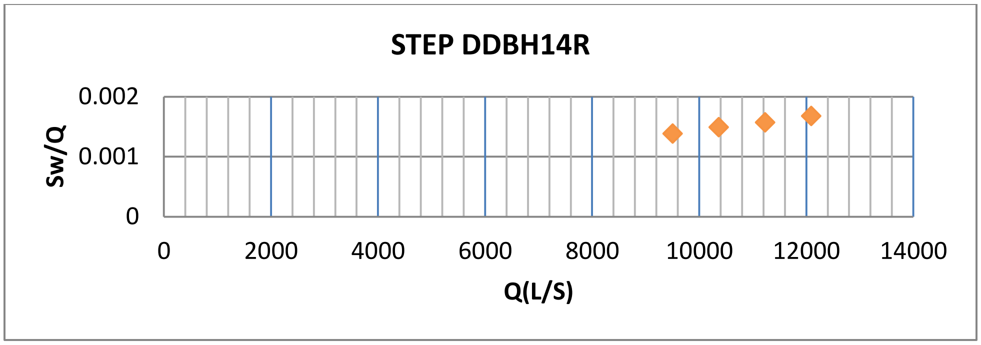


Figure 9(e) :-step draw down test graph of well ID BH14R.

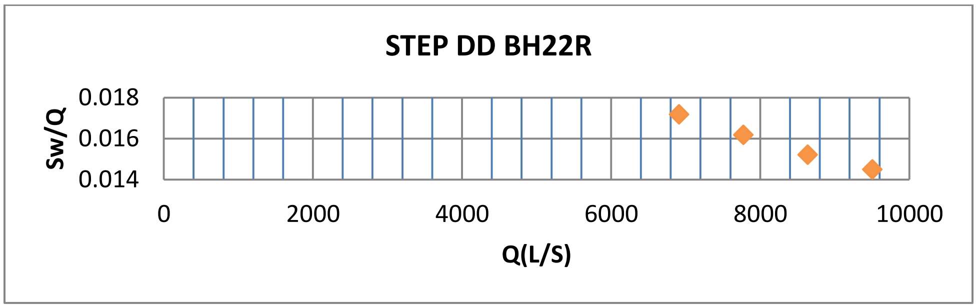


Figure 9(f):- step draw down test graph of well ID BH22R.

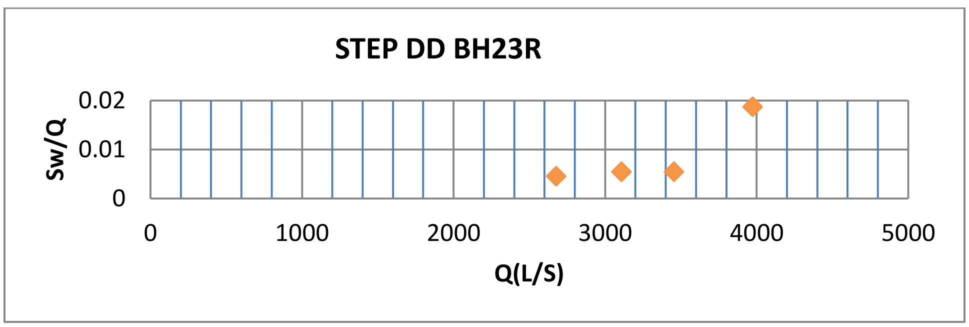


Figure 9(g):- step draw down test graph of well ID BH23R.

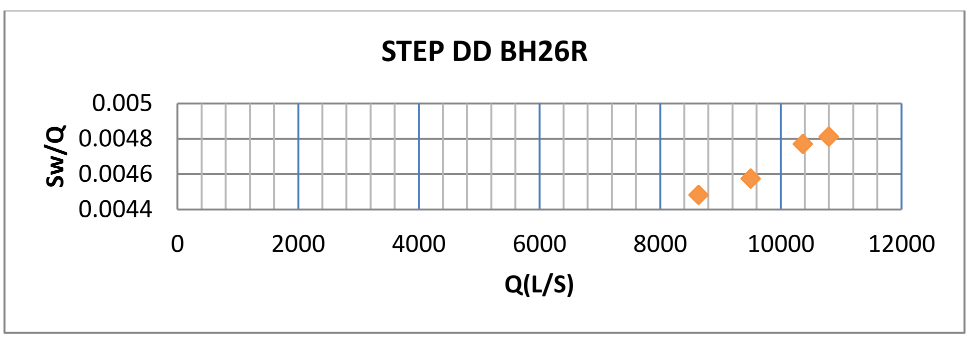


Figure 9(h):- step draw down test graph of well ID BH26R.

APPENDIX – 2:- Summery results for Co-oper Jacobe Methods

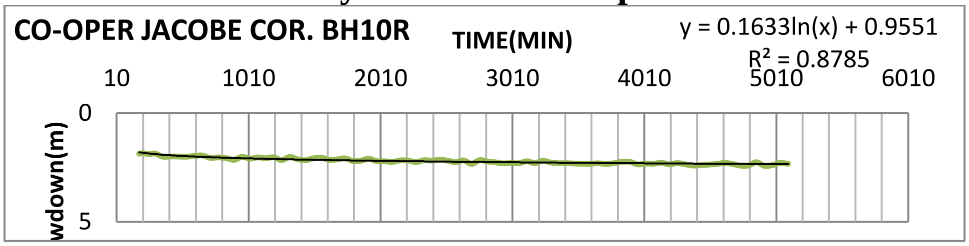


Figure 10(a):- Time versus drawdown cooper-Jacob corrected graph of well BH10R.

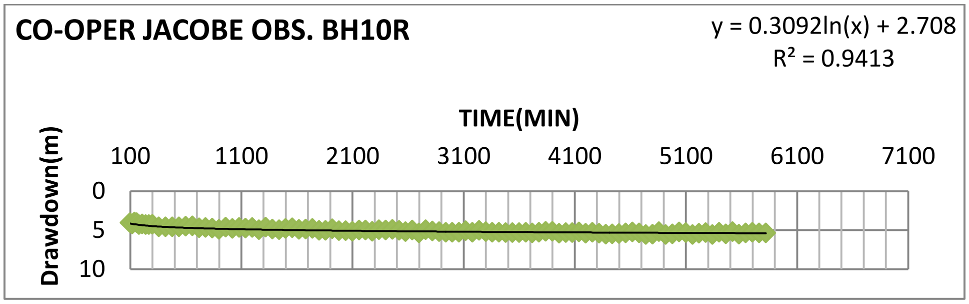


Figure 10(b):- Time versus drawdown cooper-Jacob observed graph of well BH10R.

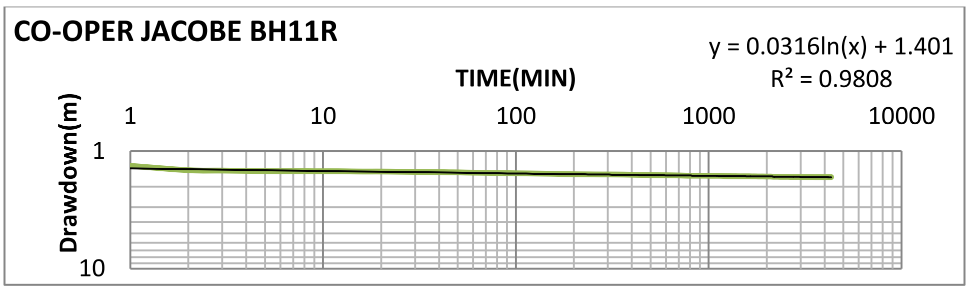


Figure 10(c):- Time versus drawdown cooper-Jacob corrected graph of well BH11R.

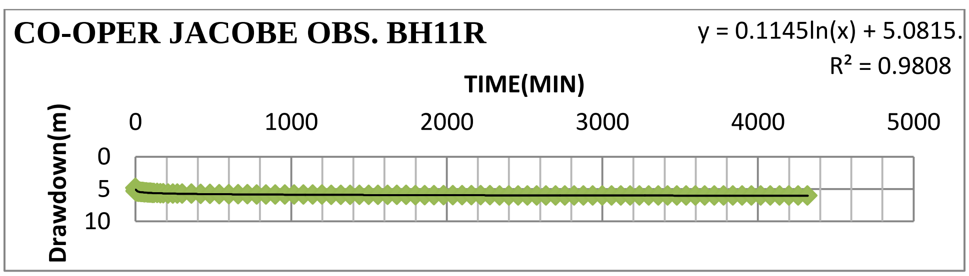


Figure 10(d):- Time versus drawdown cooper-Jacob observed graph of well BH11R.

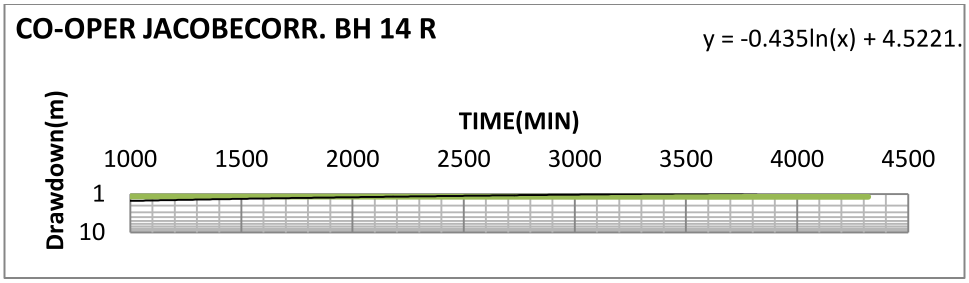


Figure 10(e):- Time versus drawdown cooper-Jacob corrected graph of well BH14R.

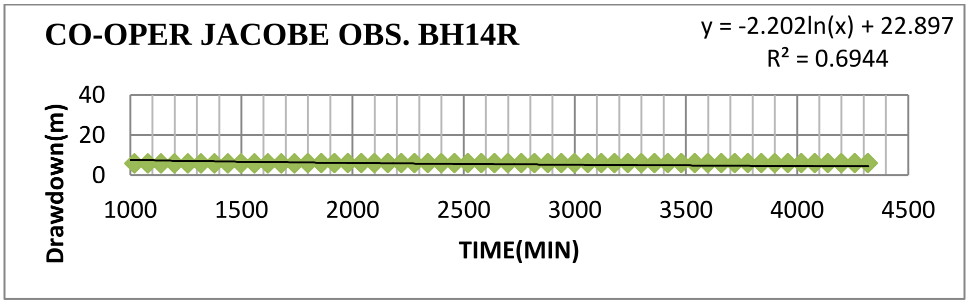


Figure 10(f):- Time versus drawdown cooper-Jacob observed graph of well BH14R.

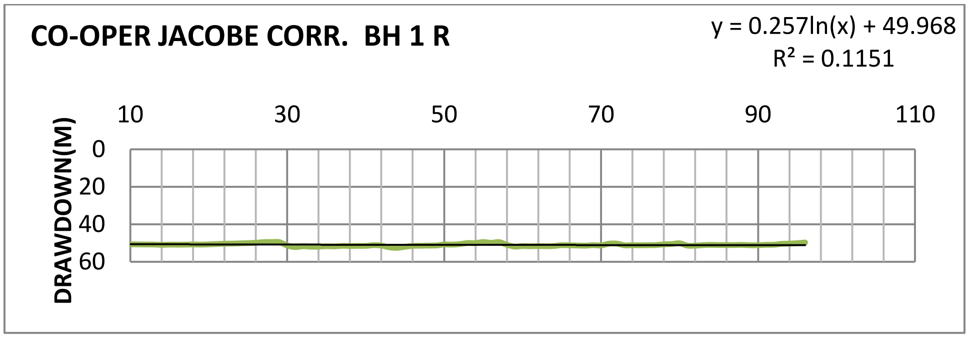


Figure 10(g):- Time versus drawdown cooper-Jacob corrected graph of well BH1R.

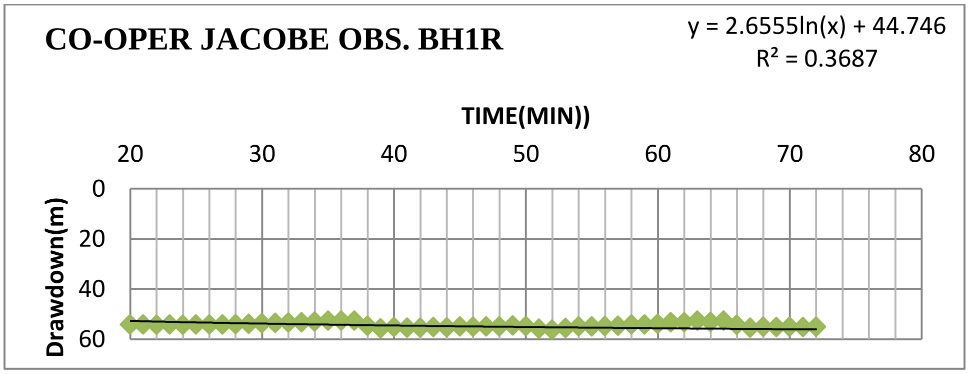


Figure 10(h):- Time versus drawdown cooper-Jacob observed graph of well BH1R.

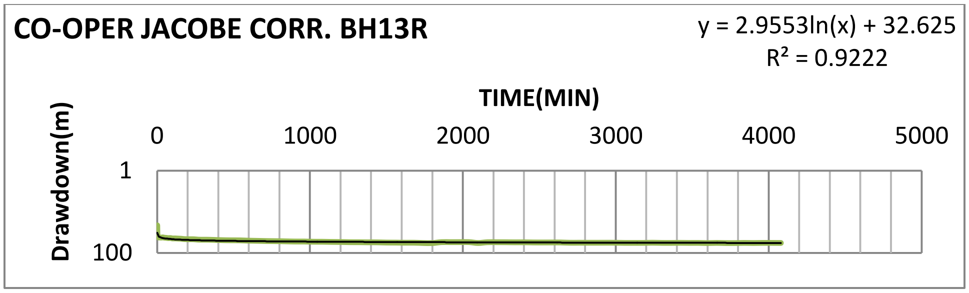


Figure 10(I):- Time versus drawdown cooper-Jacob corrected graph of well BH13R.

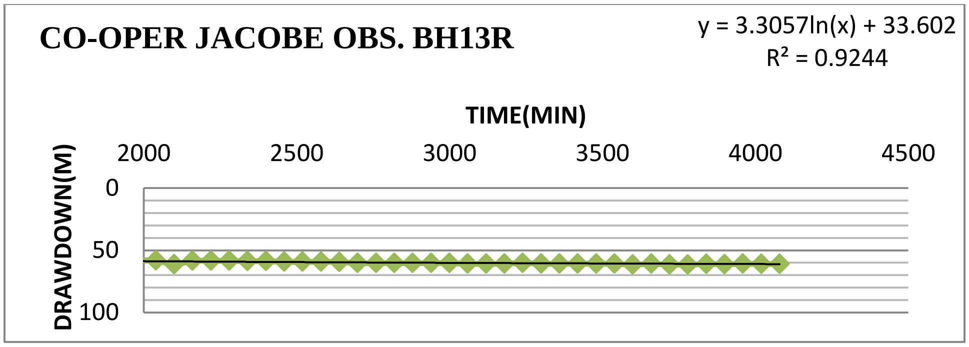


Figure 10(j):- Time versus drawdown cooper-Jacob observed graph of well BH13R.

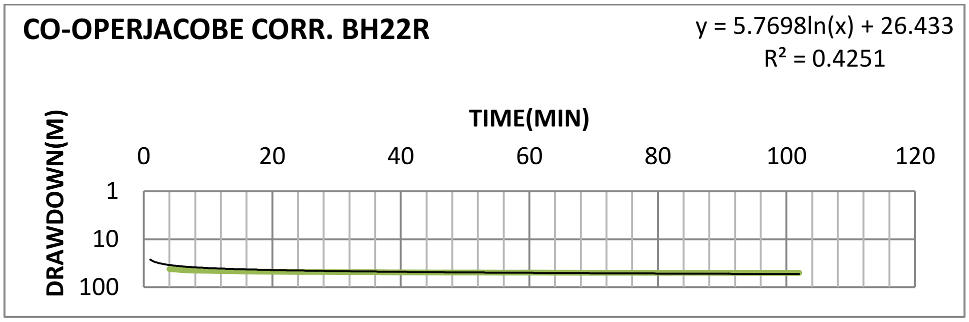


Figure 10(k):- Time versus drawdown cooper-Jacob corrected graph of well BH22R.

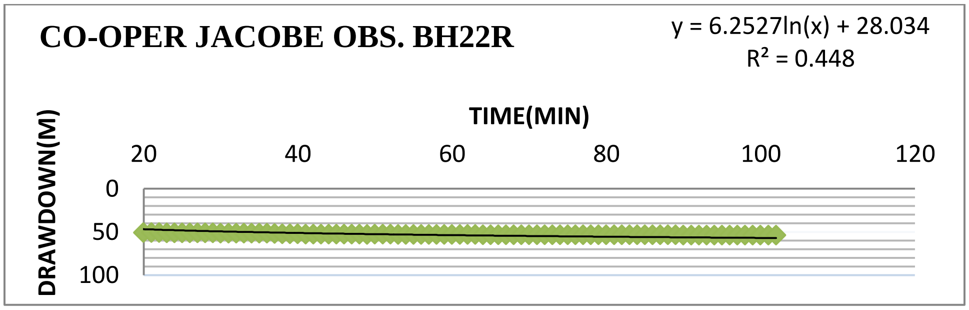


Figure 10(l):- Time versus drawdown cooper-Jacob observed graph of well BH22R.

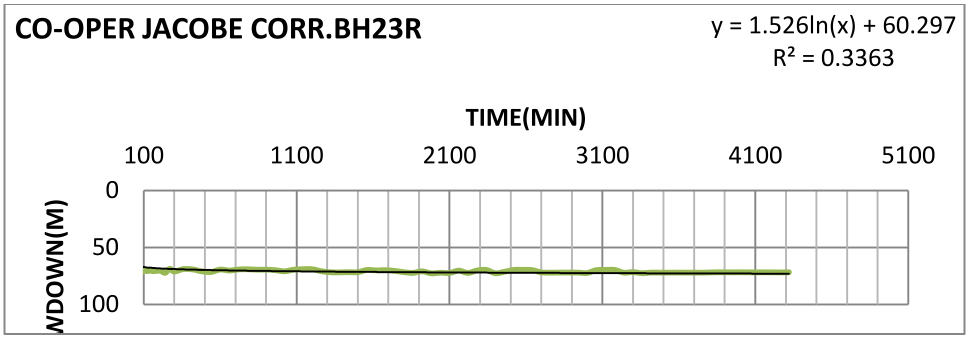


Figure 10(m):- Time versus drawdown cooper-Jacob corrected graph of well BH23R.

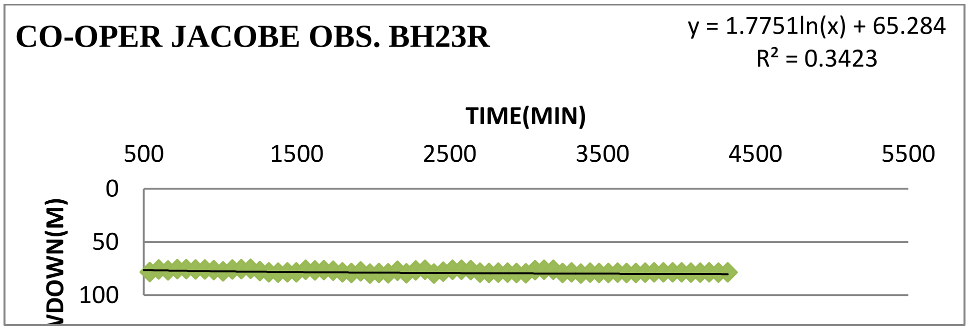


Figure 10(n):- Time versus drawdown cooper-Jacob observed graph of well BH23R.

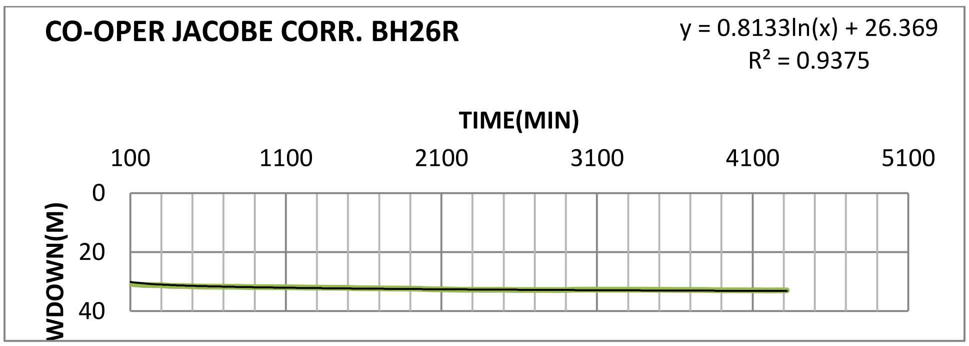


Figure 10(s):- Time versus drawdown cooper-Jacob corrected graph of well BH26R.

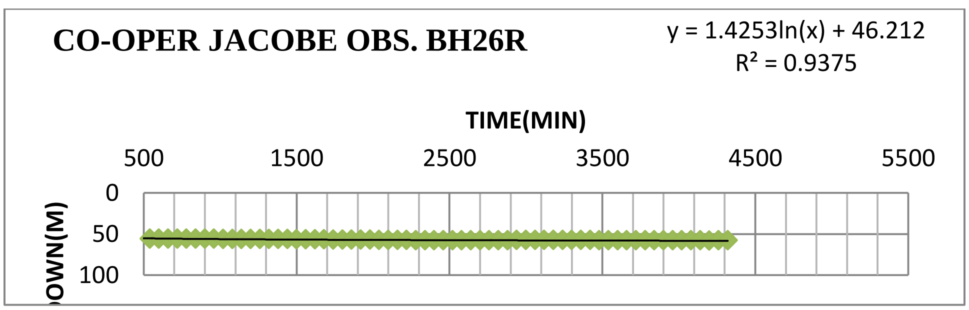


Figure 10:-(t) Time versus drawdown cooper-Jacob observed graph of well BH26R.

APPENDIX – 3:- Summery results for Thise curve Method

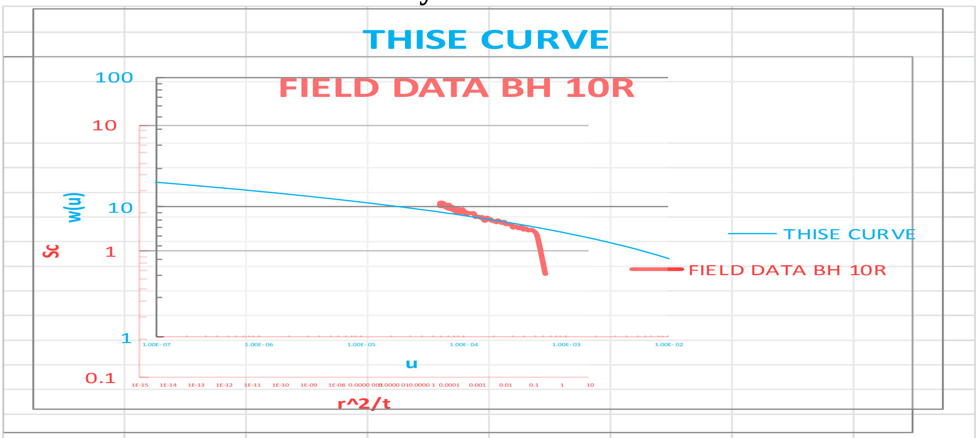


Figure 11(a):- Time versus drawdown Theis curve much method graph corrected of well BH10R.

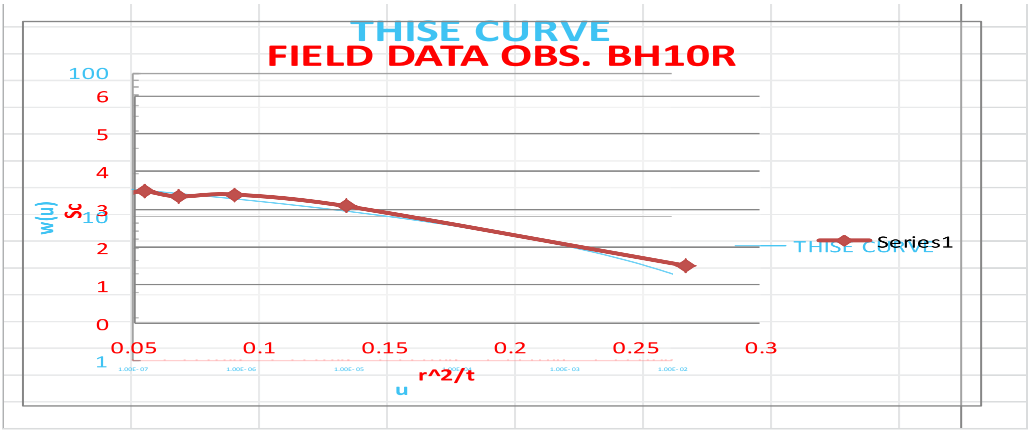


Figure 11 (b) Time versus drawdown Theis curve much method graph of observed well BH11R

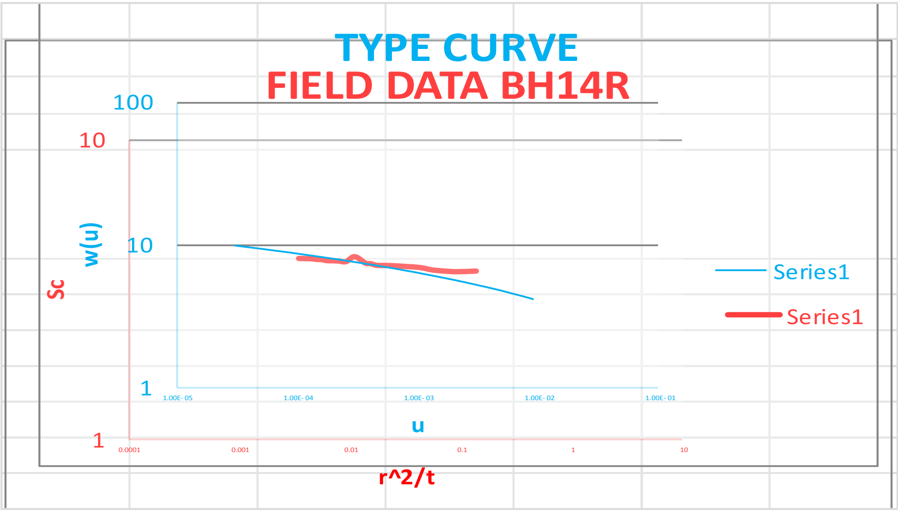


Figure 11(c):- Time versus drawdown Theis curve much method graph corrected of well BH14R.

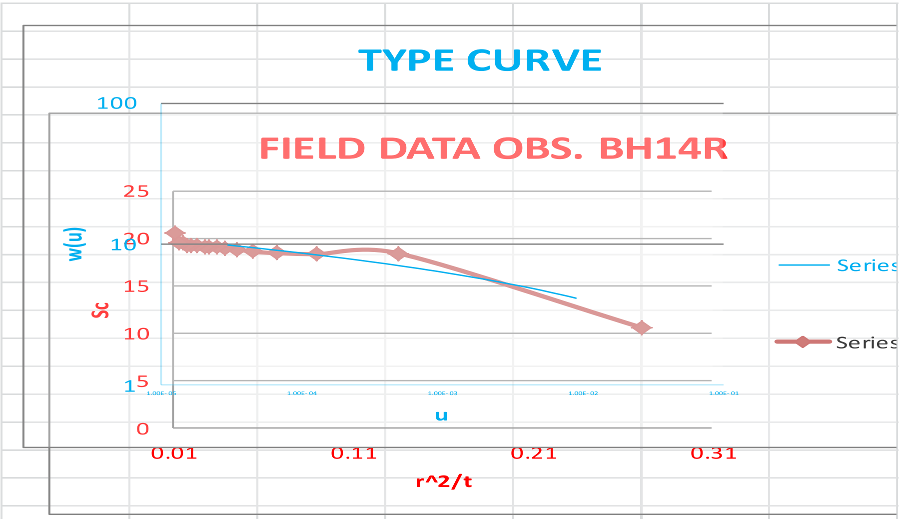


Figure 11(d):- Time versus drawdown Theis curve much method graph of observed well BH14R.

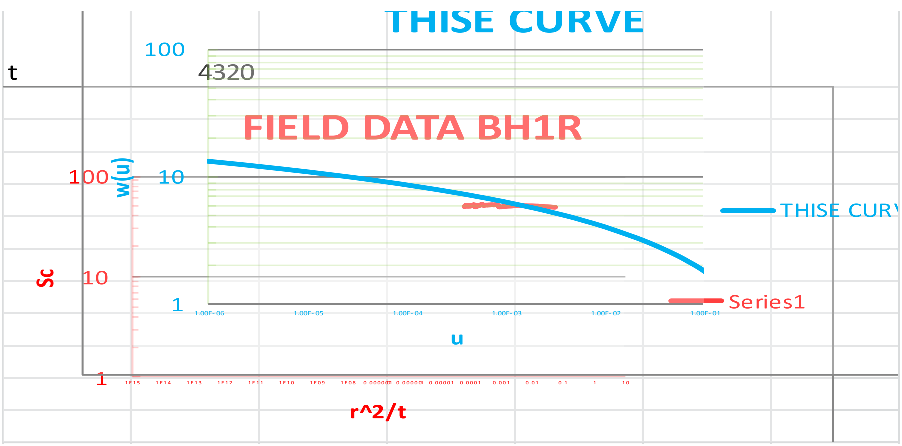


Figure 11(e):- Time versus drawdown Theis curve much method graph corrected of well BH1R.

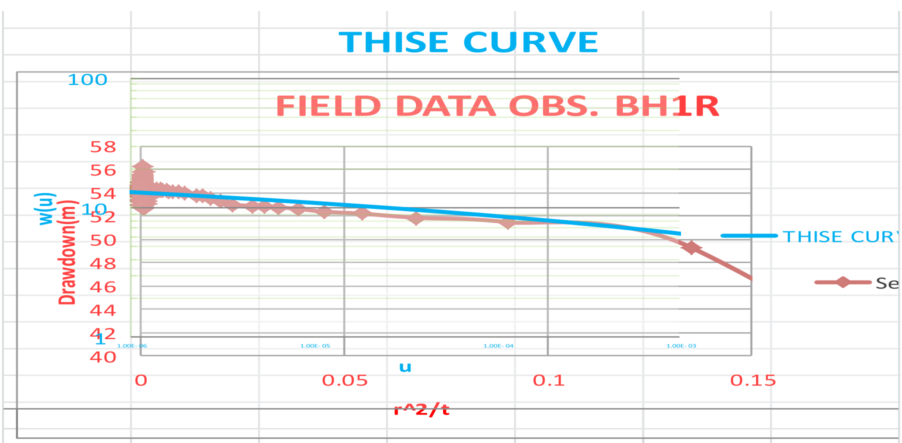


Figure 11(f):- Time versus drawdown Theis curve much method graph of observed well BH1R.

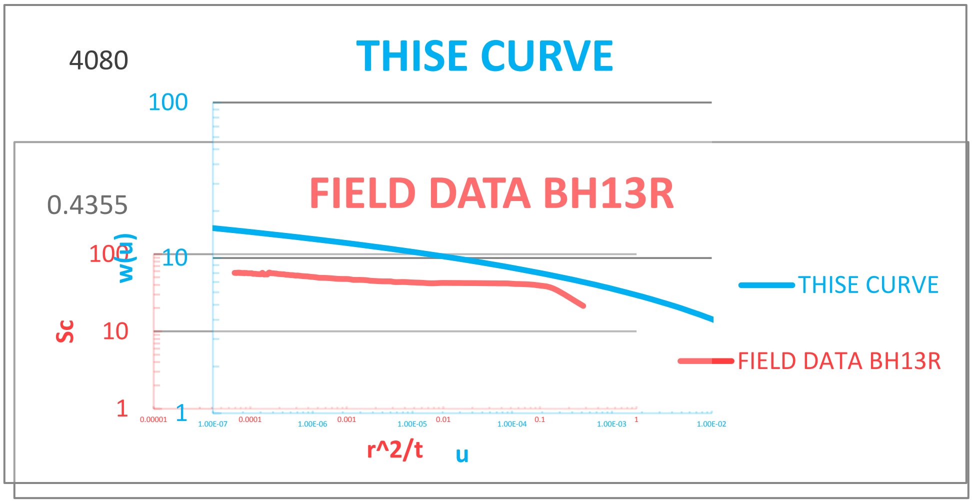


Figure 11(g):- Time versus drawdown Theis curve much method graph corrected of well BH13R.

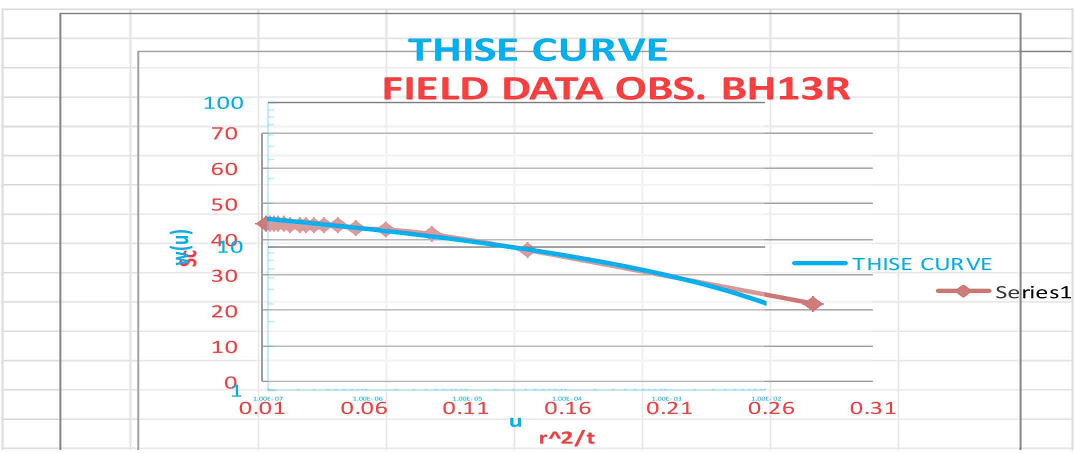


Figure 11 (h) Time versus drawdown Theis curve much method graph of observed well BH13R

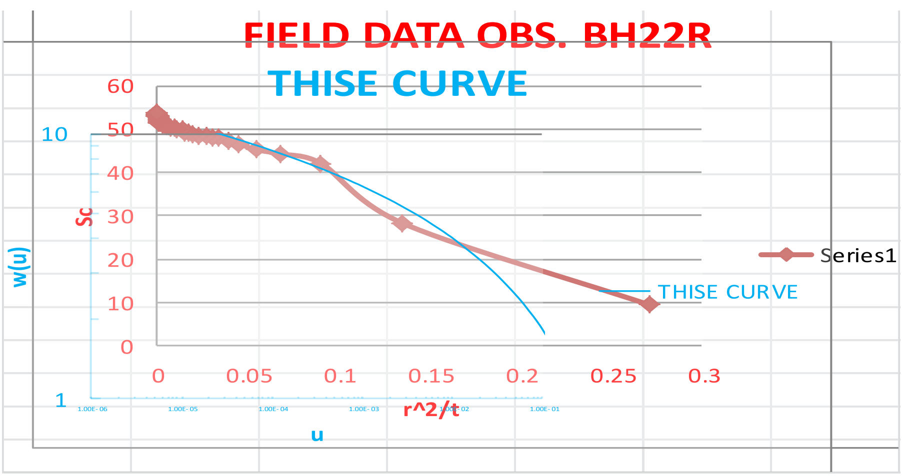


Figure 11(l):- Time versus drawdown Theis curve much method graph of observed well BH22R.

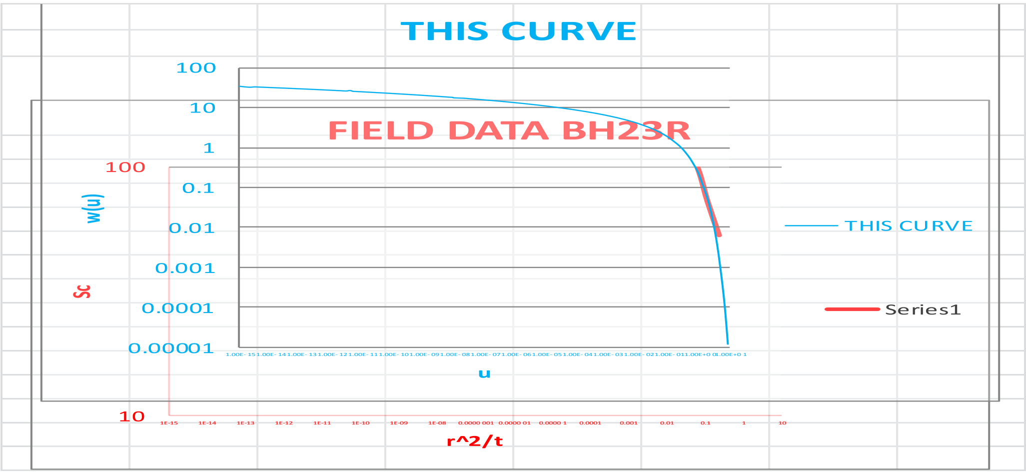


Figure 11(j):- Time versus drawdown Theis curve much method graph corrected of well BH23R.

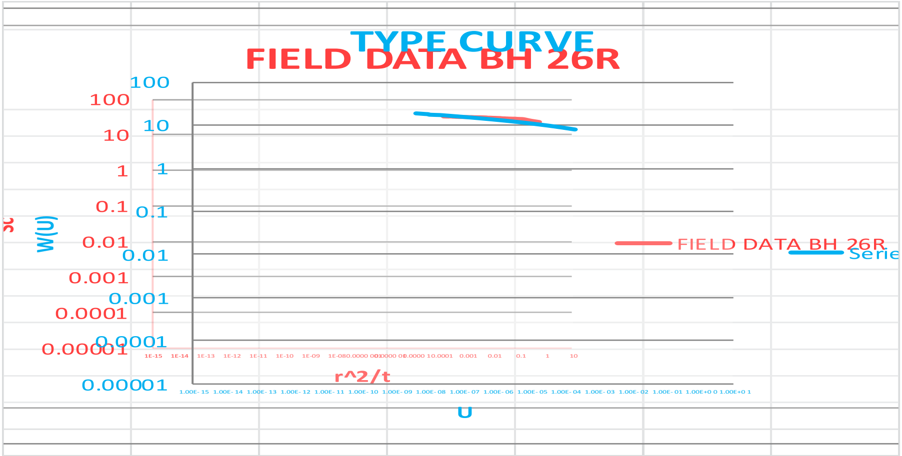


Figure 11(k):- Time versus drawdown Theis curve much method graph corrected of well BH26R.

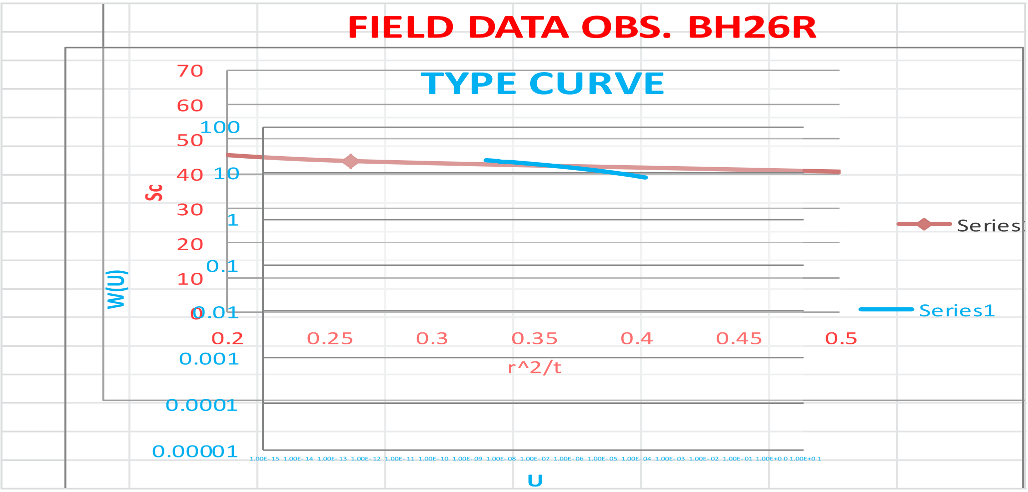


Figure 11(l):- Time versus drawdown Theis curve much method graph of observed well BH26R.

APPENDIX – 4:- Summery Results for Recovery Method

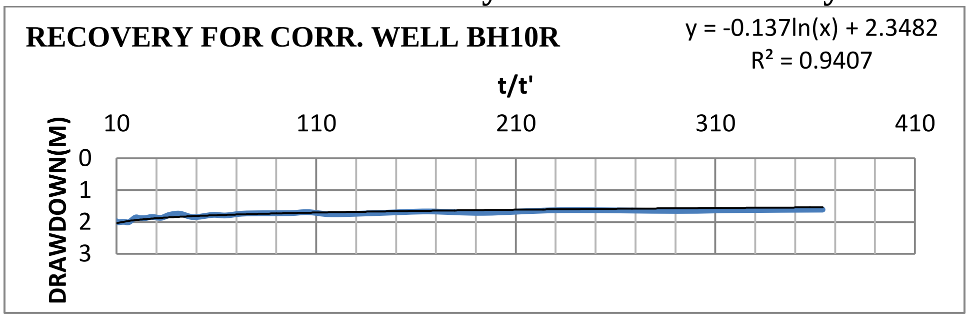


Figure 12(a):- Theis recovery graph for observed well BH10R.

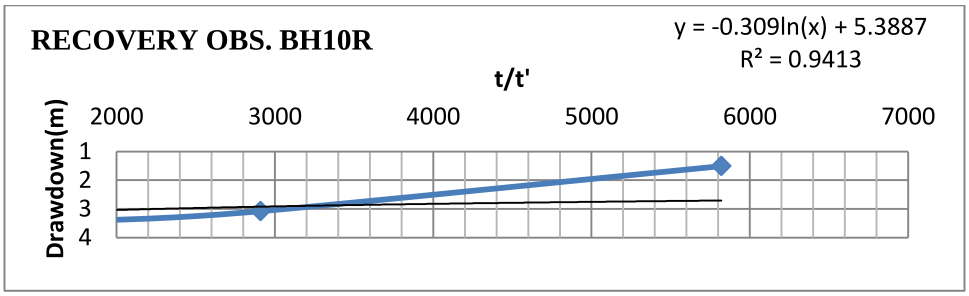


Figure 12(b):- Theis recovery graph for observed well BH10R.

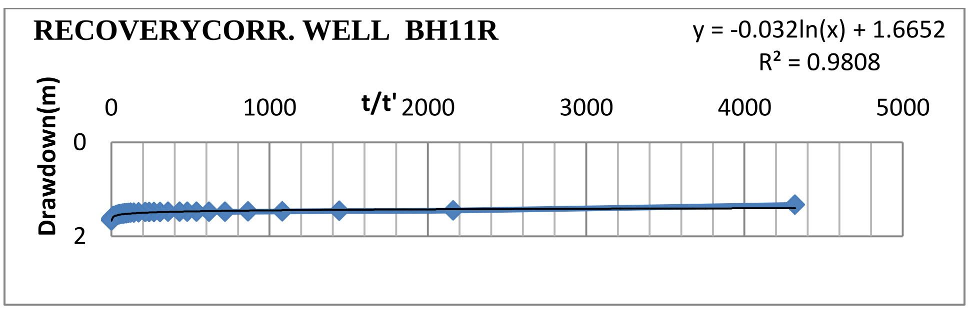


Figure 12(c):- Theis recovery graph for corrected well BH11R.

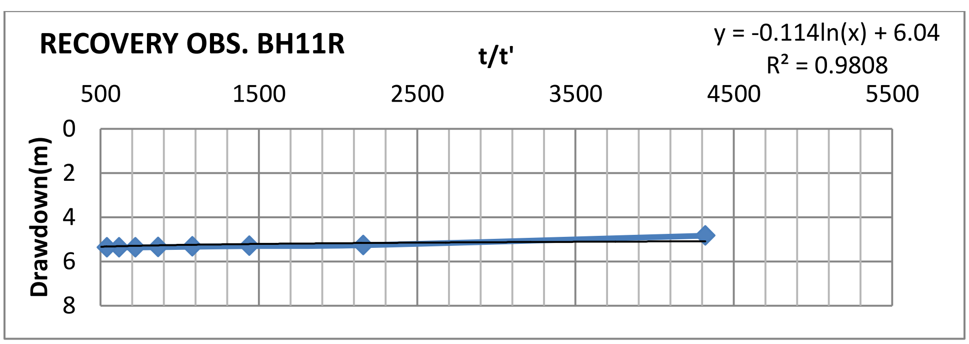


Figure 12(d):- Theis recovery graph for Observed well BH11R.

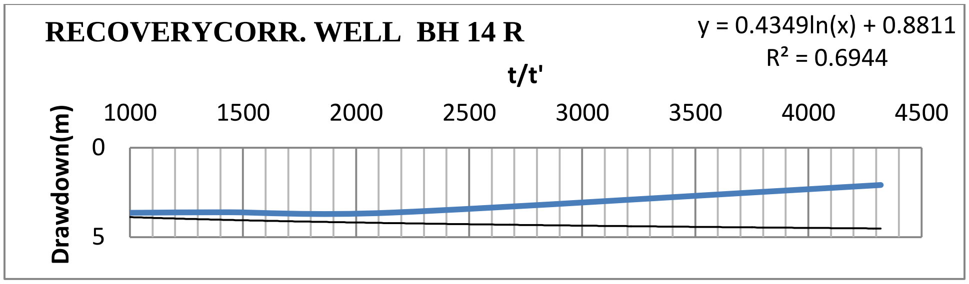


Figure 12(e):- Theis recovery graph for corrected well BH14R.

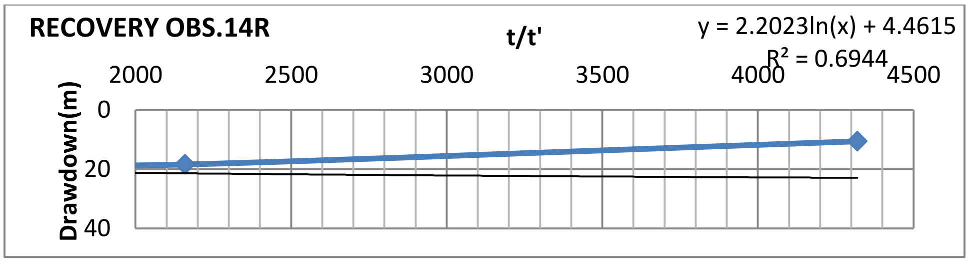


Figure 12(f):- Theis recovery graph for observed well BH14R.

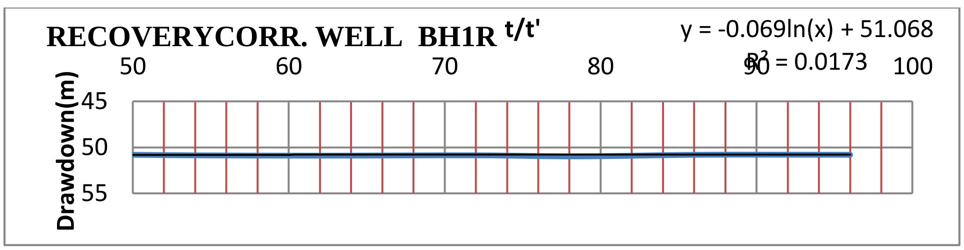


Figure 12(g):- Theis recovery graph for corrected well BH1R.

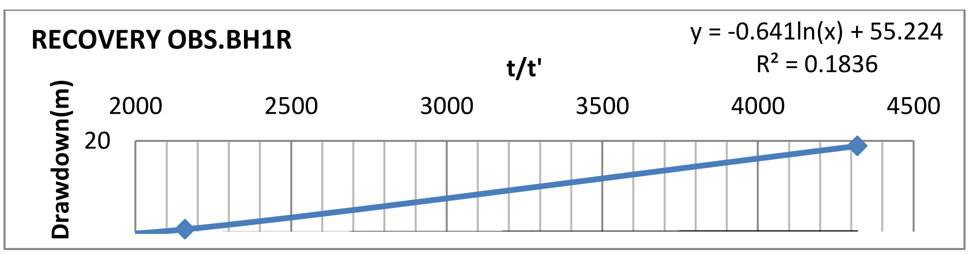


Figure 12(h):- Theis recovery graph for observed well BH1R.

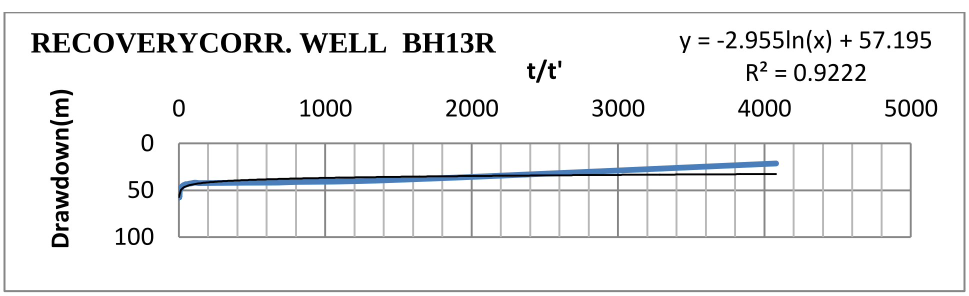


Figure 12(i):- Theis recovery graph for corrected well BH13R.

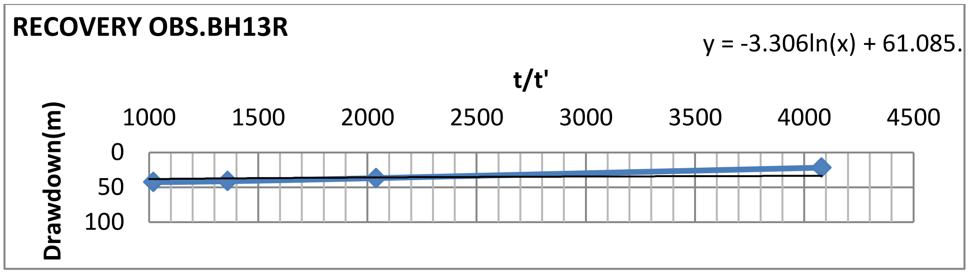


Figure 12(j):- Theis recovery graph for observed well BH13R.

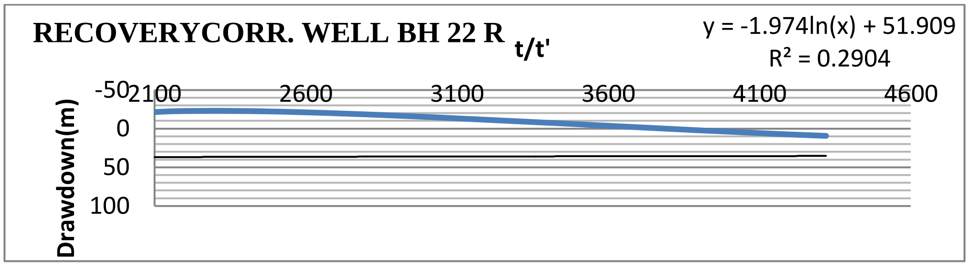


Figure 12(k):- Theis recovery graph for corrected well BH22R.

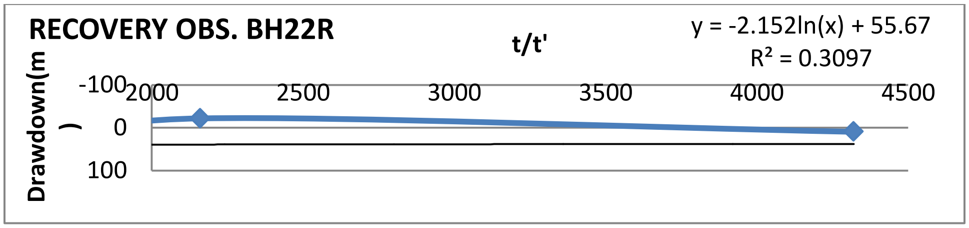


Figure 12(l):- Theis recovery graph for observed well BH22R.

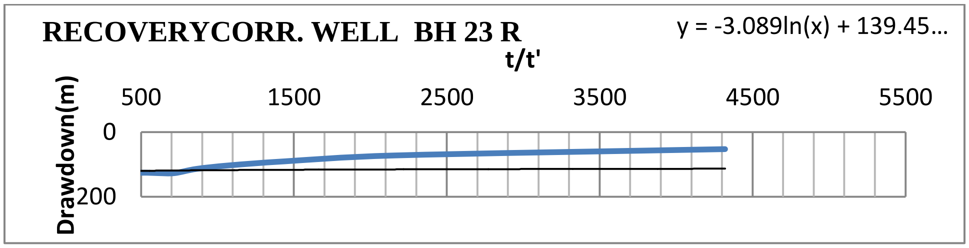


Figure 12(m):- Theis recovery graph for corrected well BH23R.

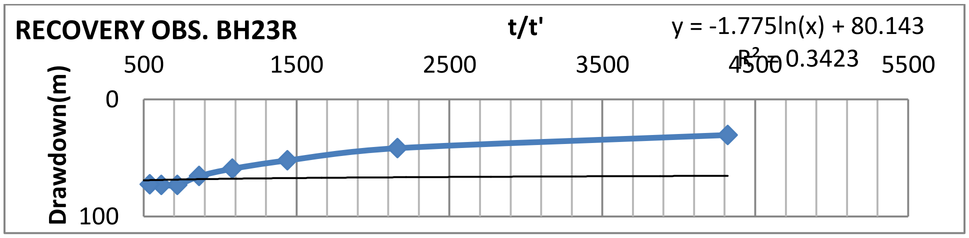


Figure 12(n):- Theis recovery graph for observed well BH23R.

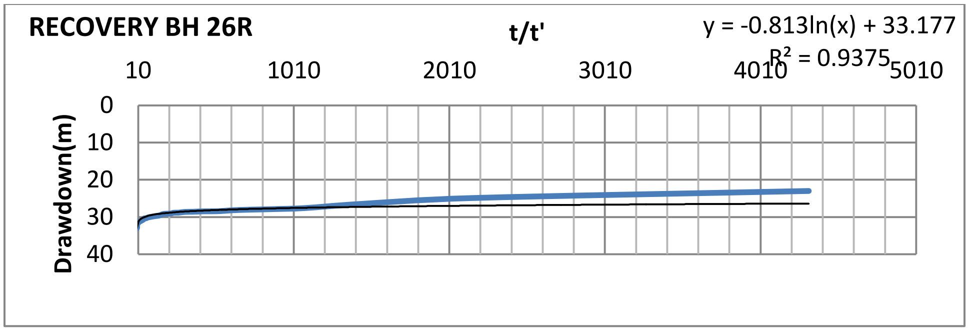


Figure 12(o):- Theis recovery graph for corrected well BH26R.

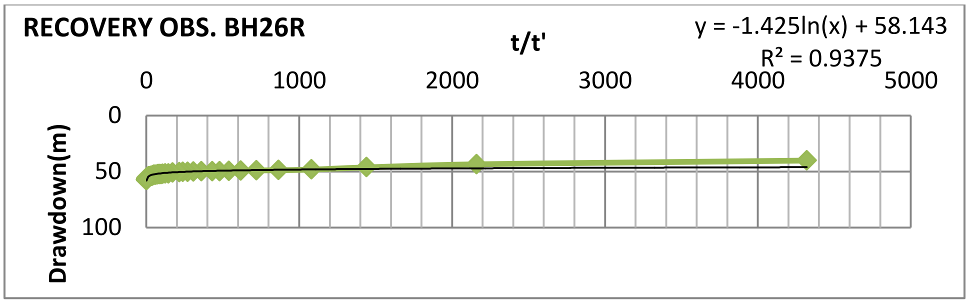
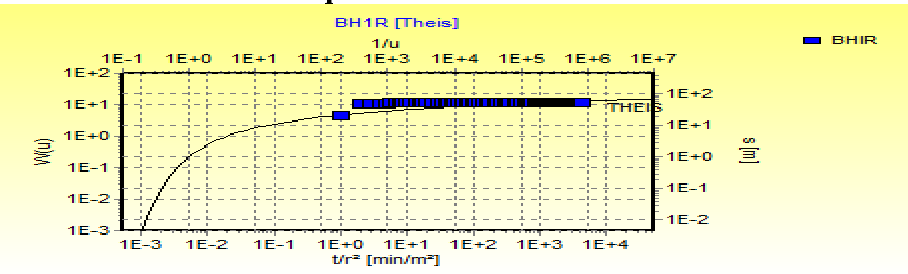


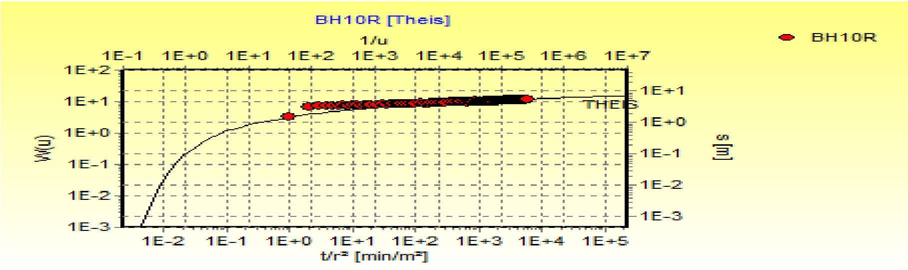
Figure 12(p):- Theis recovery graph for observed well BH26R

APPENDIX – 5:-Aquifers Test 3.5 software Automatic Curve Fitting results



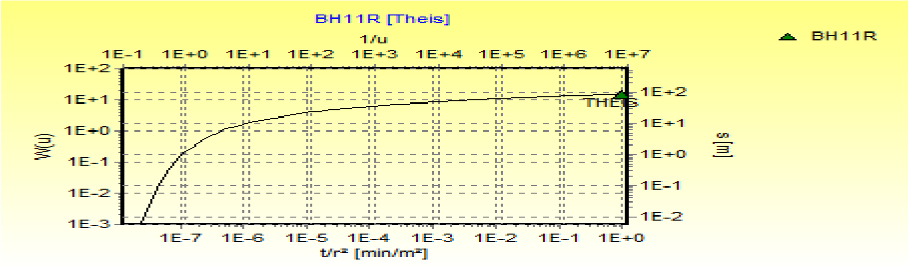
Transmissivity: 1.68E+2 m²/d
Conductivity: 3.18E+0 m/d
Storativity: 2.45E-3

Figure 13(a):- Theis's time versus drawdown Curve-Fitting Method graph well ID BH1R



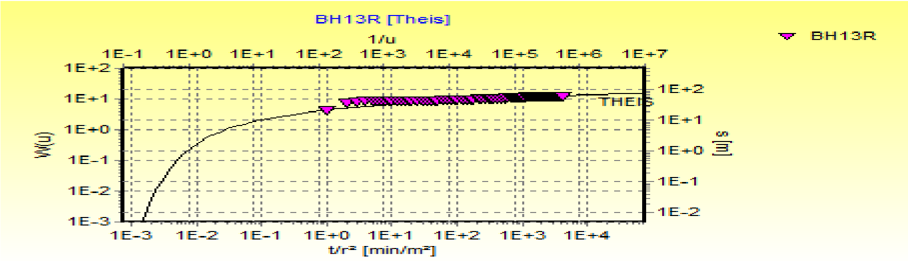
Transmissivity: 2.20E+2 m²/d
Conductivity: 4.09E+1 m/d
Storativity: 1.40E-2

Figure 13(b):- Theis's time versus drawdown Curve-Fitting Method graph well ID BH10R



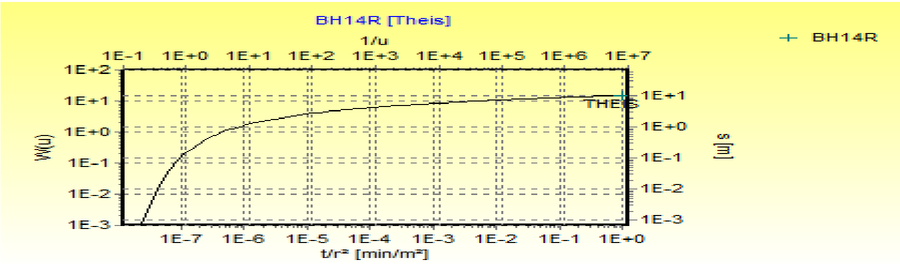
Transmissivity: 1.72E+1 m²/d
Conductivity: 2.86E+0 m/d
Storativity: 5.75E-9

Figure 13(c):- Theis's time versus drawdown Curve-Fitting Method graph well ID BH11R



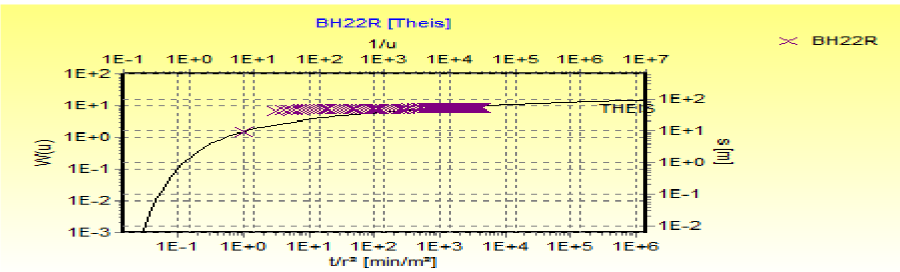
Transmissivity: 9.18E+0 m²/d
Conductivity: 1.50E-1 m/d
Storativity: 1.93E-4

Figure 13(d):- Theis's time versus drawdown Curve-Fitting Method graph well ID BH13R



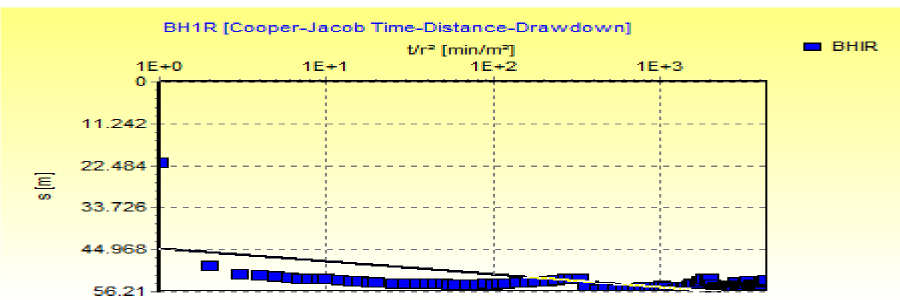
Transmissivity: 2.00E+5 m²/d
Conductivity: 9.46E+3 m/d
Storativity: 6.67E-5

Figure 13(e):- Theis's time versus drawdown Curve-Fitting Method graph well ID BH14R



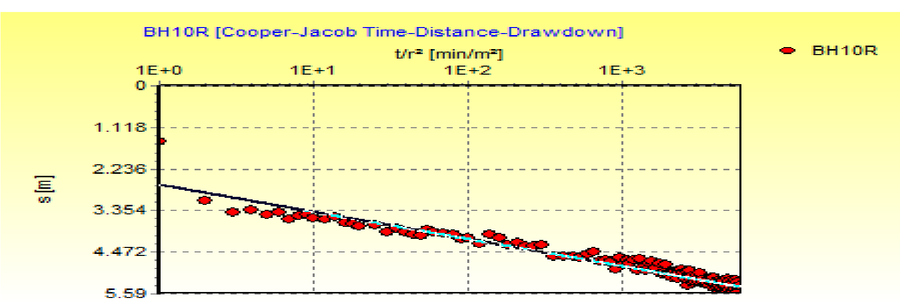
Transmissivity: 1.15E+1 m²/d
Conductivity: 2.14E-1 m/d
Storativity: 4.62E-3

Figure 13(f):- Theis's time versus drawdown Curve-Fitting Method graph well ID BH22R



Transmissivity: 5.22E+2 m²/d
Conductivity: 9.87E+0 m/d
Storativity: 8.95E-14

Figure 14(a):- Cooper and Jacob Drawdown versus Time Graph of well ID BH1R



Transmissivity: 3.23E+2 m²/d
Conductivity: 6.01E+1 m/d
Storativity: 1.26E-4

Figure 14(b):- Cooper and Jacob Drawdown versus Time Graph of well ID BH10R

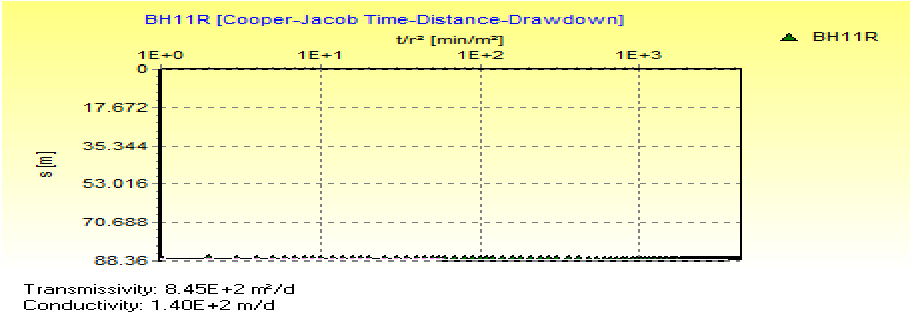


Figure 14(c):- Cooper and Jacob Drawdown versus Time Graph of well ID BH11R

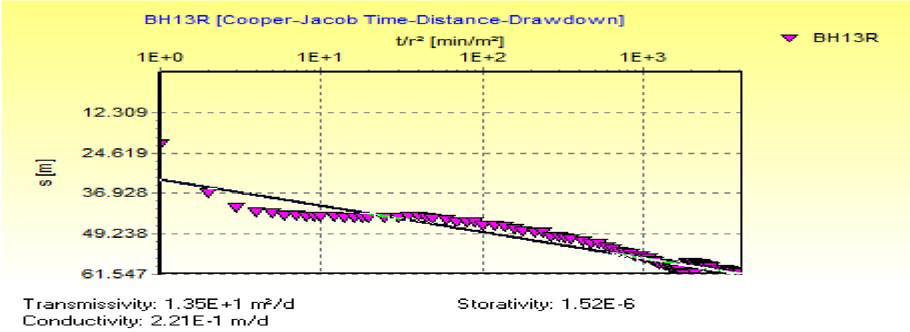


Figure 14(d):- Cooper and Jacob Drawdown versus Time Graph of well ID BH13R

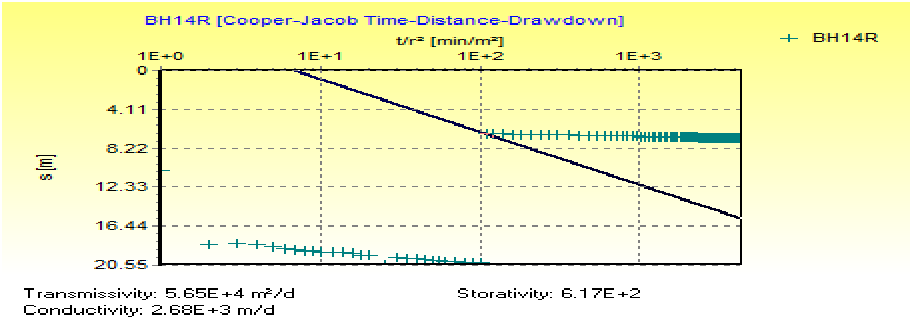


Figure 14(e):-Cooper and Jacob Drawdown versus Time Graph of well ID BH14R

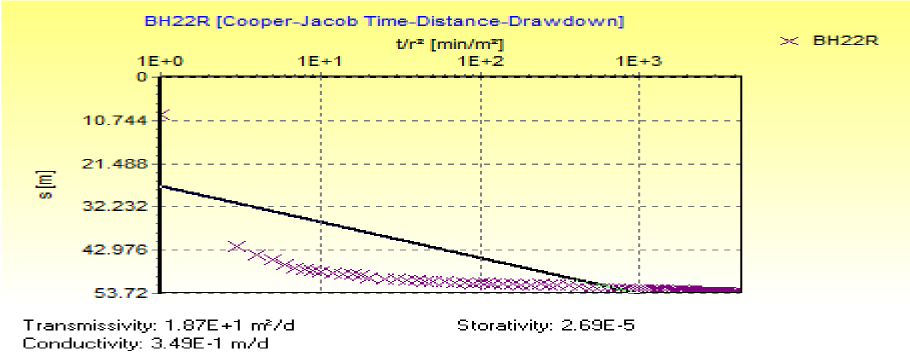


Figure 14(f):- Cooper and Jacob Drawdown versus Time Graph of well ID BH22R

APPENDIX-6:- Partial Penetration Correction Summery

partial penetration correction 0Fwell ID BH1R										
from(m)	to(m)	length(m) (B)	blinded length(m)(l)	screen length(m) (L)	2l/r	L/B	[7COS(3. 1L/2B)]	SQRT(R/2L)		F
0	126.19	126.19	126.19	-						
126.19	131.99	5.8	-	5.8	91.34	0.044	6.983348	0.10463	0.7307	0.0761
131.99	143.6	11.61	11.6		0					
143.6	166.79	23.19		23.19	365.2	0.667	3.504129	0.05233	0.1834	0.7888
166.79	178.33	11.54	11.54		0					
178.33	195.72	17.39		17.39	273.9	0.601	4.107365	0.06043	0.2482	0.7503
195.72	201.53	5.81	5.8		0					
201.53	230.53	29		29	456.7	0.833	1.81622	0.04679	0.085	0.9042
230.53	247.87	17.34	17.34							
247.87	249.14	1.27		1.27	20	0.068	6.959861	0.22361	1.5563	0.1744
249.14	266.63	17.49	17.49		0					
266.63	277.66	11.03		11.03	173.7	0.387	5.748776	0.07588	0.4362	0.5554
277.66	289.29	11.63	11.63		0					
289.29	294.79	5.5		5.5	86.61	0.321	6.129313	0.10745	0.6586	0.5325
294.79	306.4	11.61	11.61		0					
306.4	322.9	16.5		16.5	259.8	0.587	4.232058	0.06204	0.2625	0.7411
322.9	334.48	11.58	11.58							
334.48	356.48	22		22	346.5	0.655	3.612199	0.05372	0.1941	0.7823
356.48	368.05	11.57	11.57		0					
368.05	379.05	11		11	173.2	0.487	5.048828	0.07598	0.3836	0.6743
379.05	390.68	11.63	11.63		0					
390.68	407.2	16.52		16.52	260.2	0.587	4.23314	0.062	0.2624	0.7409
407.2	424.76	17.56	17.56		0					
424.76	441.26	16.5		16.5	259.8	0.484	5.071104	0.06204	0.3146	0.6368
441.26	464.63	23.37	24.57							

464.63	486.63	22		22	346.5	0.472	5.161347	0.05372	0.2773	0.6034
486.63	492.45	5.82	5.8		0					
492.45	497.95	5.5		5.5	86.61	0.487	5.05375	0.10745	0.543	0.751
497.95	515.36	17.41	17.41		0					
									F GEO MEAN	0.5392
									F ART MEAN	0.67

partial penetration correction 0F well ID BH13R										
from(m)	to(m)	length (m) (B)	blinded length(m)	screen length(m) (L)	2l/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)		F
0.8	133.8	134.6	134.6							
133.8	145.4	11.6		11.6	182.68	0.07934	6.946	0.0739874	0.5139	0.1201178
145.4	157.1	11.7	11.7		0					
157.1	162.9	5.8		5.8	91.339	0.33143	6.074	0.104634	0.6355	0.5420511
162.9	180.6	17.7	17.7		0					
180.6	209.6	29		29	456.69	0.62099	3.928	0.0467938	0.1838	0.7351398
209.6	222.15	12.55	12.55		0					
222.15	228.8	6.65		6.65	104.72	0.34635	5.99	0.0977183	0.5854	0.5490977
228.8	240.4	11.6		11.6	182.68	1	0.006	0.0739874	0.0004	1.0004124
240.4	252.2	11.8	11.8		0					
252.2	258	5.8		5.8	91.339	0.32955	6.084	0.104634	0.6366	0.5393251
258	275.2	17.2	17.7		0					
275.2	298.9	23.7		23.2	365.35	0.56724	4.403	0.052317	0.2303	0.697896
298.9	310.7	11.8	11.8		0					
310.7	322.3	11.6		11.6	182.68	0.49573	4.985	0.0739874	0.3688	0.6785567
322.3	357.6	35.3	35.3		0					
357.6	375	17.4		17.4	274.02	0.33017	6.08	0.0604105	0.3673	0.4514491

375	380.9	5.9	5.9		0					
380.9	386.7	5.8		5.8	91.339	0.49573	4.985	0.104634	0.5216	0.7542875
386.7	398.5	11.8	11.8		0					
398.5	404.3	5.8		5.8	91.339	0.32955	6.084	0.104634	0.6366	0.5393251
404.3	421.8	17.5	17.5		0					
421.8	433.4	11.6		11.6	182.68	0.39863	5.673	0.0739874	0.4198	0.5659493
433.4	445.2	11.8	11.8		0					
445.2	451	5.8		5.8	91.339	0.32955	6.084	0.104634	0.6366	0.5393251
451	462.8	11.8	11.8		0					
462.8	468.6	5.8		5.8	91.339	0.32955	6.084	0.104634	0.6366	0.5393251
468.6	480.4	11.8	11.8		0					
480.4	497.8	17.4		17.4	274.02	0.59589	4.154	0.0604105	0.2509	0.7454133
497.8	503.7	5.9	5.9		0					
503.7	515.4	11.7		11.7	184.25	0.66477	3.521	0.0736706	0.2594	0.8372217
515.4	527.1	11.7	11.7		0					
527.1	532.9	5.8		5.8	91.339	0.33143	6.074	0.104634	0.6355	0.5420511
532.9	545	12.1	12.1		0					
									F GEO MEAN	0.5689937
									F ART MEAN	0.67

partial penetration correction 0Fwell ID BH22R										
from(m)	to(m)	length(m) (B)	blinded length(m)	screen length(m) (L)	2l/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)		F
-1	115.52	114.52	114.52							
115.52	127.15	11.63		11.63	183.15	0.09219	6.926803	0.0739	0.512	0.13938
127.15	138.93	11.78	11.78		0					
138.93	156.34	17.41		17.41	274.17	0.59644	4.148804	0.0604	0.251	0.74588

156.34	173.98	17.64	1764		0					
173.98	185.62	11.64		11.64	183.31	0.00656	6.999629	0.0739	0.517	0.00994
185.62	191.51	5.89	5.89		0					
191.51	208.94	17.43		17.43	274.49	0.74743	2.708741	0.0604	0.163	0.86963
208.94	220.7	11.76	11.76		0					
220.7	232.33	11.63		11.63	183.15	0.49722	1	1	1	1
232.33	238.2	5.87		5.87	92.441	1	0.005574	0.104	6E-04	1.00058
238.2	239.74	1.54	1.54		0					
239.74	251.52	11.78		11.78	185.51	0.88438	1.269132	0.0734	0.093	0.96679
251.52	257.32	5.8	5.8		0					
257.32	275.04	17.72		17.72	279.06	0.7534	2.648081	0.0599	0.159	0.87283
275.04	286.67	11.63	11.63		0					
286.67	292.57	5.9		5.9	92.913	0.33657	6.045274	0.1037	0.627	0.54765
292.57	298.38	5.81	5.81		0					
298.38	304.29	5.91		5.91	93.071	0.50427	4.918467	0.1037	0.51	0.76135
304.29	315.91	11.62	11.62		0					
315.91	321.82	5.91		5.91	93.071	0.33714	6.042111	0.1037	0.626	0.54828
321.82	333.47	11.65	11.65		0					
333.47	345.27	11.8		11.8	185.83	0.5032	4.926811	0.0734	0.361	0.68506
345.27	362.69	17.42	17.42		0					
362.69	386.29	23.6		23.6	371.65	0.57533	4.333334	0.0519	0.225	0.70465
386.29	409.53	23.24	23.24		0					
409.53	421.32	11.79		11.79	185.67	0.33657	6.045259	0.0734	0.444	0.48589
421.32	432.94	11.62	11.62		0					
432.94	444.74	11.8		11.8	185.83	0.50384	4.921776	0.0734	0.361	0.68576
444.74	450.54	5.8	5.8		0					
450.54	462.38	11.84		11.84	186.46	0.6712	3.459979	0.0732	0.253	0.84128
									F GEO MEAN	0.51365

	F ART MEAN	0.67

partial penetration correction 0Fwell ID BH23R										
from(m)	to(m)	length (m) (B)	blinded length(m)	screen length(m) (L)	2l/r	L/B	[7COS(3.1L/2B)]	SQRT (R/2L)		F
0.8	133.8	134.6	134.6							
133.8	145.4	11.6		11.6	183	0.079	6.946	0.074	0.5139	0.1201178
145.4	157.1	11.7	11.7		0					
157.1	162.9	5.8		5.8	91.3	0.331	6.074	0.1046	0.6355	0.5420511
162.9	180.6	17.7	17.7		0					
180.6	209.6	29		29	457	0.621	3.928	0.0468	0.1838	0.7351398
209.6	222.15	12.55	12.55		0					
222.2	228.8	6.65		6.65	105	0.346	5.99	0.0977	0.5854	0.5490977
228.8	240.4	11.6		11.6	183	1	0.006	0.074	0.0004	1.0004124
240.4	252.2	11.8	11.8		0					
252.2	258	5.8		5.8	91.3	0.33	6.084	0.1046	0.6366	0.5393251
258	275.2	17.2	17.7		0					
275.2	298.9	23.7		23.2	365	0.567	4.403	0.0523	0.2303	0.697896
298.9	310.7	11.8	11.8		0					
310.7	322.3	11.6		11.6	183	0.496	4.985	0.074	0.3688	0.6785567
322.3	357.6	35.3	35.3		0					
357.6	375	17.4		17.4	274	0.33	6.08	0.0604	0.3673	0.4514491
375	380.9	5.9	5.9		0					
380.9	386.7	5.8		5.8	91.3	0.496	4.985	0.1046	0.5216	0.7542875
386.7	398.5	11.8	11.8		0					
398.5	404.3	5.8		5.8	91.3	0.33	6.084	0.1046	0.6366	0.5393251
404.3	421.8	17.5	17.5		0					

421.8	433.4	11.6		11.6	183	0.399	5.673	0.074	0.4198	0.5659493
433.4	445.2	11.8	11.8		0					
445.2	451	5.8		5.8	91.3	0.33	6.084	0.1046	0.6366	0.5393251
451	462.8	11.8	11.8		0					
462.8	468.6	5.8		5.8	91.3	0.33	6.084	0.1046	0.6366	0.5393251
468.6	480.4	11.8	11.8		0					
480.4	497.8	17.4		17.4	274	0.596	4.154	0.0604	0.2509	0.7454133
497.8	503.7	5.9	5.9		0					
503.7	515.4	11.7		11.7	184	0.665	3.521	0.0737	0.2594	0.8372217
515.4	527.1	11.7	11.7		0					
527.1	532.9	5.8		5.8	91.3	0.331	6.074	0.1046	0.6355	0.5420511
532.9	545	12.1	12.1		0					
									F GEO MEAN	0.5689937
									F ART MEAN	0.67

partial penetration correction 0f well ID BH26R

from(m)	length(m) (B)	blinded length(m)	screen length(m) (L)	2l/r	L/B	[7COS(3.1L/2B)]	SQRT(R/2L)		F
-0.48	120.9	121.9							
121.38	17.41		17.41	274.17	0.13	6.866	0.06	0.415	0.176842
138.79	17.35	17.35		0					
156.14	11.6		11.6	182.68	0.4	5.66	0.074	0.419	0.568487
167.74	11.63	11.63		0					
179.37	17.42		17.42	274.33	0.6	4.12	0.06	0.249	0.748829
196.79	5.77	5.77		0					
202.56	17.43		17.43	274.49	0.75	2.67	0.06	0.161	0.872347
219.99	17.39	17.39		0					

237.38	5.8		5.8	91.339	0.25	6.467	0.105	0.677	0.419354
243.18	7.18	7.18		0					
250.36	11.57	11.57		0					
261.93	11.02		11.02	173.54	0.49	5.045	0.076	0.383	0.67466
272.95	17.49	17.49		0					
290.44	16.5		16.5	259.84	0.49	5.064	0.062	0.314	0.637924
306.94	23.31	23.31		0					
330.25	16.5		16.5	259.84	0.41	5.57	0.062	0.346	0.557673
346.75	29.08	29.08		0					
375.83	16.51		16.51	260	0.36	5.899	0.062	0.366	0.494621
392.34	17.43	17.43		0					
409.77	16.51		16.51	260	0.49	5.056	0.062	0.314	0.638973
426.28	5.83	5.83		0					
432.11	16.5		16.5	259.84	0.74	2.795	0.062	0.173	0.867026
448.61	17.33	17.33		0					
465.94	11		11	173.23	0.39	5.739	0.076	0.436	0.557591
476.94	11.63	11.63		0					
488.57	5.5		5.5	86.614	0.32	6.129	0.107	0.659	0.532531
494.07	5.93	5.93		0					
								F GEO MEAN	0.560416
								F ART MEAN	0.67

APPENDIX-7:- Summery of Step Drawdown Test Result

Employer /Client : AAWSSA				**Pump Position** : 210 m				
Well ID : BH10R				**Discharge Measuring device** : 90 V - notch				
Date of Pumping :15/10/2013				**SWL** : 95.35 m				
Step Drawdown Test Data								
Time (T) Since pumping started	**Step 1**	**Step 2**		**Step 3**		**Step 4**		
	Q =120 l/s	**Q =130 l/s**		**Q = 140 l/s**		**Q =1 50l/s**		
	Draw down (m)	**T=T+120**	**Draw down (m)**	**T=T+120**	**Draw down (m)**	**T=T+120**	**Draw down (m)**	
0	0	60	3.06	120	3.44	180	3.78	
1	1.61	61	3.23	121	3.68	181	3.95	
2	2.61	62	3.28	122	3.7	182	3.99	
3	2.7	63	3.32	123	3.71	183	4.02	
4	2.72	64	3.34	124	3.71	184	4.04	
5	2.74	65	3.35	125	3.72	185	4.04	
6	2.75	66	3.36	126	3.72	186	4.04	
7	2.77	67	3.36	127	3.73	187	4.04	
8	2.79	68	3.36	128	3.73	188	4.05	
9	2.8	69	3.37	129	3.73	189	4.05	
10	2.82	70	3.37	130	3.73	190	4.05	
12	2.88	72	3.37	132	3.74	192	4.07	
14	2.92	74	3.38	134	3.74	194	4.08	
16	2.95	76	3.38	136	3.74	196	4.08	
18	2.98	78	3.38	138	3.75	198	4.08	
20	2.99	80	3.39	140	3.76	200	4.1	
25	3	85	3.4	145	3.76	205	4.12	
30	3.02	90	3.42	150	3.77	210	4.14	
35	3.04	95	3.43	155	3.77	215	4.15	
40	3.05	100	3.43	160	3.77	220	4.15	
50	3.05	110	3.43	170	3.78	230	4.15	
60	3.06	120	3.44	180	3.78	240	4.16	
61	3.06386207	121	3.43931034	181	3.781448	241	4.15931	
62	3.06252504	122	3.43899957	182	3.782211	242	4.159	
63	3.06278238	123	3.43987562	183	3.782745	243	4.159876	
64	3.06488494	124	3.44142706	184	3.782114	244	4.161427	
65	3.06541795	125	3.44094833	185	3.783361	245	4.160948	
66	3.06553597	126	3.44182323	186	3.783495	246	4.161823	
67	3.06682648	127	3.44263077	187	3.78374	247	4.162631	
68	3.06771131	128	3.44311294	188	3.784102	248	4.163113	

69	3.06819372	129	3.44350473	189	3.784669	249	4.163505
70	3.06905515	130	3.44432475	190	3.78484	250	4.164325
72	3.07082676	132	3.44543009	192	3.785617	252	4.16543
74	3.07230057	134	3.44653791	194	3.786383	254	4.166538
76	3.07389723	136	3.44773247	196	3.787107	256	4.167732
78	3.07556611	138	3.44892516	198	3.787807	258	4.168925
80	3.07715688	140	3.45004104	200	3.788578	260	4.170041
85	3.0811161	145	3.45295745	205	3.790403	265	4.172957
90	3.08515101	150	3.45587565	210	3.792229	270	4.175876
95	3.08915103	155	3.45877285	215	3.794066	275	4.178773
100	3.09313899	160	3.46167418	220	3.795905	280	4.181674
110	3.10114246	170	3.46749691	230	3.799563	290	4.187497
120	3.10915394	180	3.4733075	240	3.803231	300	4.193307

Employer /Client : AAWSSA	**Pump Position** : 182.88 m
Well ID : BH11R	**Discharge Measuring device** : 90 V - notch
Date of Pumping :26/11/2013	**SWL** : 82.34 m

Step Drawdown Test Data

Time (T) Since pumping started	Step 1	Step 2		Step 3		Step 4	
	Q =105 l/s	Q =120 l/s		Q = 135 l/s		Q =1 52l/s	
	Draw down (m)	T=T+120	Draw down (m)	T=T+120	Draw down (m)	T=T+120	Draw down (m)
0	0	120	3.13	240	3.83	360	5.01
1	1.98	121	3.48	241	4.23	361	5.43
2	2.52	122	3.59	242	4.26	362	5.64
3	2.6	123	3.6	243	4.32	363	5.67
4	2.65	124	3.61	244	4.37	364	5.68
5	2.66	125	3.61	245	4.42	365	5.69
6	2.67	126	3.61	246	4.47	366	5.69
7	2.68	127	3.62	247	4.51	367	5.7
8	2.69	128	3.62	248	4.54	368	5.7
9	2.7	129	3.62	249	4.57	369	5.72
10	2.71	130	3.63	250	4.6	370	5.72
12	2.73	132	3.63	252	4.64	372	5.73
14	2.75	134	3.63	254	4.67	374	5.73
16	2.76	136	3.63	256	4.7	376	5.74
18	2.77	138	3.64	258	4.72	378	5.75
20	2.78	140	3.65	260	4.73	380	5.76
25	2.81	145	3.68	265	4.77	385	5.79
30	2.84	150	3.69	270	4.8	390	5.81

35	2.86	155	3.69	275	4.82	395	5.83
40	2.88	160	3.71	280	4.84	400	5.86
45	2.9	165	3.72	285	4.85	405	5.87
50	2.93	170	3.74	290	4.87	410	5.89
55	2.94	175	3.76	295	4.9	415	5.9
60	2.95	180	3.78	300	4.93	420	5.91
70	2.97	190	3.79	310	4.94	430	5.93
80	2.99	200	3.81	320	4.96	440	5.95
90	3.1	210	3.82	330	4.97	450	5.98
100	3.11	220	3.82	340	4.98	460	6.01
110	3.12	230	3.83	360	5	470	6.02
120	3.13	240	3.83	360	5.01	480	6.02
121	3.153	241	3.8325	361	5.005672	481	6.0338
122	3.141913734	242	3.832296	362	5.007069	482	6.032078
123	3.144390981	243	3.833145	363	5.008458	483	6.030746
124	3.147454193	244	3.832579	364	5.009429	484	6.031635
125	3.151241592	245	3.833845	365	5.008619	485	6.035716
126	3.148207193	246	3.833765	366	5.010326	486	6.033812
127	3.152472797	247	3.834218	367	5.010783	487	6.035329
128	3.15382834	248	3.83451	368	5.011186	488	6.03685
129	3.154834673	249	3.835053	369	5.011772	489	6.037682
130	3.155959112	250	3.835226	370	5.012687	490	6.037968
132	3.160206709	252	3.836058	372	5.013636	492	6.040595
134	3.162707346	254	3.836778	374	5.014877	494	6.042407
136	3.16594002	256	3.837522	376	5.016123	496	6.044252
138	3.169270217	258	3.838233	378	5.017308	498	6.046285
140	3.172523337	260	3.839006	380	5.018445	500	6.048389
145	3.180167784	265	3.840828	385	5.0215	505	6.053145
150	3.188237896	270	3.842673	390	5.024485	510	6.058099
155	3.196121023	275	3.844515	395	5.027473	515	6.063033
160	3.203981245	280	3.84636	400	5.030477	520	6.067921
165	3.211866973	285	3.848194	405	5.033488	525	6.072803
170	3.219817502	290	3.85004	410	5.036475	530	6.077742
175	3.227676477	295	3.85188	415	5.039478	535	6.082636
180	3.235576794	300	3.853721	420	5.04248	540	6.087535
190	3.251384039	310	3.857403	430	5.048478	550	6.097352
200	3.267182121	320	3.861087	440	5.054474	560	6.107169
210	3.282969445	330	3.864768	450	5.060476	570	6.116975
220	3.298774456	340	3.86845	460	5.066474	580	6.12679
230	3.31457159	360	3.875815	470	5.072472	590	6.136604
240	3.330366561	360	3.875815	480	5.078471	600	6.146415

Employer /Client : AAWSSA				**Pump Position** : 188.2 m			
Well ID : BH14R				**Discharge Measuring device** : 90 V - notch			
Date of Pumping :31/12/2013				**SWL** : 81.27 m			
Step Drawdown Test Data							
Time (T) Since pumping started	**Step 1**	**Step 2**		**Step 3**		**Step 4**	
	Q =110 l/s	**Q =120 l/s**		**Q = 130 l/s**		**Q =140l/s**	
	Draw down (m)	**T=T+120**	**Draw down (m)**	**T=T+120**	**Draw down (m)**	**T=T+120**	**Draw down (m)**
0	0	120	13.14	240	15.53	360	17.86
1	4.256	121	15.06	241	17.12	361	19.81
2	10.27	122	15.08	242	17.55	362	20.23
3	11.95	123	15.12	243	17.59	363	20.27
4	12.08	124	15.14	244	17.61	364	20.29
5	12.12	125	15.15	245	17.63	365	20.3
6	12.21	126	15.16	246	17.65	366	20.31
7	12.29	127	15.21	247	17.66	367	20.32
8	12.43	128	15.22	248	17.67	368	20.34
9	12.48	129	15.23	249	17.69	369	20.36
10	12.52	130	15.24	250	17.71	370	20.37
12	12.54	132	15.27	252	17.74	372	20.39
14	12.55	134	15.28	254	17.75	374	20.41
16	12.58	136	15.29	256	17.76	376	20.43
18	12.03	138	15.31	258	17.77	378	20.45
20	12.68	140	15.33	260	17.78	380	20.46
25	12.75	145	15.34	265	17.79	385	20.48
30	12.81	150	15.36	270	17.79	390	20.49
35	12.88	155	15.38	275	17.8	395	20.49
40	12.91	160	15.41	280	17.8	400	20.5
45	12.93	165	15.42	285	17.8	405	20.5
50	12.97	170	15.42	290	17.81	410	20.51
55	12.98	175	15.43	295	17.81	415	20.51
60	13.08	180	15.43	300	17.81	420	20.52
70	13.09	190	15.46	310	17.82	430	20.53
80	13.1	200	15.48	320	17.83	440	20.54
90	13.11	210	15.5	330	17.84	450	20.55
100	13.12	220	15.51	340	17.85	460	20.55
110	13.13	230	15.52	350	17.86	470	20.55
120	13.14	240	15.53	360	17.86	480	20.56
121	13.141	241	15.5332	361	17.8648	481	20.5584
122	13.142	242	15.53299	362	17.8649	482	20.5581

123	13.143	243	15.53414	363	17.86492	483	20.55922
124	13.144	244	15.53535	364	17.8647	484	20.56064
125	13.145	245	15.53662	365	17.86672	485	20.5599
126	13.146	246	15.53722	366	17.8663	486	20.56092
127	13.147	247	15.53855	367	17.86689	487	20.56166
128	13.148	248	15.53958	368	17.86757	488	20.56201
129	13.149	249	15.54058	369	17.86821	489	20.56238
130	13.15	250	15.5416	370	17.86841	490	20.56319
132	13.152	252	15.54382	372	17.86969	492	20.56413
134	13.154	254	15.54587	374	17.87074	494	20.56513
136	13.156	256	15.54799	376	17.87177	496	20.56622
138	13.158	258	15.55013	378	17.87283	498	20.56729
140	13.16	260	15.55225	380	17.87397	500	20.56829
145	13.165	265	15.55752	385	17.87659	505	20.57093
150	13.17	270	15.56282	390	17.87927	510	20.57356
155	13.175	275	15.56811	395	17.88195	515	20.57617
160	13.18	280	15.5734	400	17.88461	520	20.57878
165	13.185	285	15.57869	405	17.88727	525	20.58141
170	13.19	290	15.58398	410	17.88995	530	20.58403
175	13.195	295	15.58927	415	17.89262	535	20.58665
180	13.2	300	15.59456	420	17.89529	540	20.58927
190	13.21	310	15.60514	430	17.90063	550	20.59451
200	13.22	320	15.61572	440	17.90597	560	20.59975
210	13.23	330	15.6263	450	17.91131	570	20.60499
220	13.24	340	15.63688	460	17.91665	580	20.61023
230	13.25	350	15.64746	470	17.92199	590	20.61547
240	13.26	360	15.65804	480	17.92732	600	20.62071

APPENDIX 8:- SUMMERY OF CONSTANT PUMPING TEST RESULT

Employer /Client :AAWSA	**Discharge Rate** :126 l/s
Well ID :BH1R	**Pump Position** :203 m
Date of Pumping :12-16/06/2015	**SWL** :83.67 m
Reference :0 m	

CONSTANT DISCHARGE RATE TEST

Time since pumping started	BH1R Water Level (m)	Observed DD	unconfined DD	Corrected DD
0	83.67	0	0	0
1	105.4	21.73	21.18890393	11.42081922
2	132.92	49.25	46.47049538	25.04759701
3	135.12	51.45	48.4166279	26.09656244
4	135.51	51.84	48.76046662	26.28189151
5	135.86	52.19	49.06874304	26.4480525
6	136.02	52.35	49.20957589	26.52396141
7	136.27	52.6	49.42950977	26.64250577
8	136.4	52.73	49.54381878	26.70411832
9	136.51	52.84	49.64051154	26.75623572
10	136.52	52.85	49.64930041	26.76097292
12	136.65	52.98	49.76353494	26.82254533
14	136.99	53.32	50.06211904	26.98348216
16	137.16	53.49	50.21131174	27.06389703
18	137.44	53.77	50.4568965	27.19626721
20	137.44	53.77	50.4568965	27.19626721
25	137.63	53.96	50.62344097	27.28603468
30	137.71	54.04	50.69354021	27.32381817
35	137.71	54.04	50.69354021	27.32381817
40	137.77	54.1	50.74610501	27.3521506

45	137.82	54.15	50.78990271	27.37575756
50	137.82	54.15	50.78990271	27.37575756
55	138.02	54.35	50.96503621	27.47015452
60	137.89	54.22	50.85120986	27.40880212
70	137.93	54.26	50.88623748	27.427682
80	137.89	54.22	50.85120986	27.40880212
90	137.8	54.13	50.77238432	27.36631515
100	137.88	54.21	50.84245239	27.40408184
110	137.74	54.07	50.71982364	27.33798494
120	137.54	53.87	50.5445618	27.24351881
140	137.35	53.68	50.37797814	27.15373022
160	137.28	53.61	50.31658435	27.12063897
180	137.13	53.46	50.18498843	27.04970876
210	136.97	53.3	50.0445626	26.97401924
240	136.76	53.09	49.86016467	26.87462876
270	136.37	52.7	49.51744322	26.6899019
300	136.32	52.65	49.47347936	26.66620538
330	136.38	52.71	49.5262353	26.69464083
360	138.42	54.75	51.31502819	27.65880019
420	139.4	55.73	52.17095879	28.12014679
480	138.9	55.23	51.73453453	27.88491411
540	139.17	55.5	51.97027479	28.01197811
600	139.14	55.47	51.94408968	27.99786434
660	138.83	55.16	51.67338941	27.85195689
720	138.96	55.29	51.78693569	27.91315834
780	138.63	54.96	51.49862719	27.75776005
840	138.73	55.06	51.58601976	27.80486465
900	138.66	54.99	51.52484736	27.77189273

960	138.67	55	51.53358696	27.77660337
1020	138.23	54.56	51.14882772	27.56921814
1080	138.48	54.81	51.36749536	27.68708
1140	139.51	55.84	52.26689524	28.17185653
1200	139.88	56.21	52.58938705	28.34567962
1260	139.23	55.56	52.02263883	28.04020233
1320	138.63	54.96	51.49862719	27.75776005
1380	138.59	54.92	51.46366374	27.73891476
1440	138.47	54.8	51.3587514	27.68236701
1500	138.42	54.75	51.31502819	27.65880019
1560	137.83	54.16	50.79866156	27.38047858
1620	137.9	54.23	50.85996711	27.41352227
1680	137.58	53.91	50.5796215	27.26241599
1740	136.94	53.27	50.01822623	26.95982394
1800	136.94	53.27	50.01822623	26.95982394
1860	136.33	52.66	49.48227259	26.67094493
1920	136.79	53.12	49.88651342	26.88883073
1980	136.35	52.68	49.49985836	26.68042366
2040	137.98	54.31	50.93001685	27.45127908
2100	139.1	55.43	51.90917299	27.97904424
2160	138.77	55.1	51.62097037	27.82370303
2220	138.88	55.21	51.71706564	27.87549838
2280	138.75	55.08	51.60349552	27.81428408
2340	138.85	55.18	51.69086059	27.86137386
2400	138.72	55.05	51.57728153	27.80015474
2460	138.22	54.55	51.14007804	27.56450206
2520	138.35	54.68	51.25380606	27.62580147
2580	138.43	54.76	51.32377329	27.6635138

2640	138.54	54.87	51.41995428	27.71535536
2700	138.23	54.56	51.14882772	27.56921814
2760	138.41	54.74	51.30628286	27.65408646
2820	137.33	53.66	50.3604382	27.14427619
2880	137.29	53.62	50.32535558	27.12536666
2940	138.32	54.65	51.22756457	27.6116573
3000	138.25	54.58	51.1663264	27.57864993
3060	138.29	54.62	51.20132102	27.59751203
3120	138.23	54.56	51.14882772	27.56921814
3180	138.18	54.51	51.10507701	27.54563651
3240	137.74	54.07	50.71982364	27.33798494
3300	137.54	53.87	50.5445618	27.24351881
3360	137.07	53.4	50.13233562	27.0213289
3420	138.5	54.83	51.38498258	27.69650561
3480	138.53	54.86	51.4112117	27.7106431
3540	138.18	54.51	51.10507701	27.54563651
3600	138.06	54.39	51.00005191	27.48902798
3660	138.13	54.46	51.06132056	27.52205178
3720	138.15	54.48	51.07882383	27.53148604
3780	138.16	54.49	51.08757512	27.53620299
3840	138.06	54.39	51.00005191	27.48902798
3900	138.28	54.61	51.19257271	27.59279669
3960	138.26	54.59	51.1750754	27.58336564
4020	138.02	54.35	50.96503621	27.47015452
4080	137.98	54.31	50.93001685	27.45127908
4140	137.43	53.76	50.44812871	27.19154137
4200	137.28	53.61	50.31658435	27.12063897
4260	136.97	53.3	50.0445626	26.97401924

4320	136.6	52.93	49.71960317	26.79886611

Employer /Client :AAWSSA **Well ID** :BH10R **Date of Pumping** :16/-19/10/13 **Reference** :0 m	**Discharge Rate** :150 l/s **Pump Position** :210 m **SWL** :95.33 m

CONSTANT DISCHARGE RATE TEST

Time since pumping started	BH10 R Water Level (m)	**Observed DD**	**Corrected DD**
0	95.33	0	0
1	96.84	1.51	0.657605
2	98.41	3.08	1.34134
3	98.72	3.39	1.476345
4	98.67	3.34	1.45457
5	98.81	3.48	1.51554
6	98.72	3.39	1.476345
7	98.93	3.6	1.5678
8	98.82	3.49	1.519895
9	98.81	3.48	1.51554
10	98.89	3.56	1.55038
12	98.93	3.6	1.5678
14	98.85	3.52	1.53296
16	99.03	3.7	1.61135
18	99.06	3.73	1.624415
20	99.12	3.79	1.650545
25	99.07	3.74	1.62877
30	99.26	3.93	1.711515
35	99.16	3.83	1.667965

40	99.25	3.92	1.70716
45	99.33	4	1.742
50	99.36	4.03	1.755065
55	99.21	3.88	1.68974
60	99.28	3.95	1.720225
70	99.29	3.96	1.72458
80	99.32	3.99	1.737645
90	99.45	4.12	1.79426
100	99.41	4.08	1.77684
120	99.57	4.24	1.84652
140	99.32	3.99	1.737645
160	99.41	4.08	1.77684
180	99.62	4.29	1.868295
210	99.56	4.23	1.842165
240	99.64	4.31	1.877005
270	99.64	4.31	1.877005
300	99.6	4.27	1.859585
360	99.93	4.6	2.0033
420	99.91	4.58	1.99459
480	99.92	4.59	1.998945
540	99.94	4.61	2.007655
600	99.85	4.52	1.96846
660	99.81	4.48	1.95104
720	100.06	4.73	2.059915
780	100.01	4.68	2.03814
840	100.09	4.76	2.07298
900	100.27	4.94	2.15137
960	99.95	4.62	2.01201

1020	100.14	4.81	2.094755
1080	100.01	4.68	2.03814
1140	100.1	4.77	2.077335
1200	100	4.67	2.033785
1260	100.3	4.97	2.164435
1320	99.97	4.64	2.02072
1380	100.2	4.87	2.120885
1440	100.31	4.98	2.16879
1500	100.11	4.78	2.08169
1560	100.04	4.71	2.051205
1620	100.27	4.94	2.15137
1680	100.22	4.89	2.129595
1740	100.11	4.78	2.08169
1800	100.39	5.06	2.20363
1860	100.36	5.03	2.190565
1920	100.15	4.82	2.09911
1980	100.4	5.07	2.207985
2040	100.42	5.09	2.216695
2100	100.49	5.16	2.24718
2160	100.33	5	2.1775
2220	100.34	5.01	2.181855
2280	100.51	5.18	2.25589
2340	100.31	4.98	2.16879
2400	100.35	5.02	2.18621
2460	100.26	4.93	2.147015
2520	100.36	5.03	2.190565
2580	100.52	5.19	2.260245
2640	100.32	4.99	2.173145

2700	100.7	5.37	2.338635
2760	100.3	4.97	2.164435
2820	100.44	5.11	2.225405
2880	100.53	5.2	2.2646
2940	100.64	5.31	2.312505
3000	100.61	5.28	2.29944
3060	100.62	5.29	2.303795
3120	100.42	5.09	2.216695
3180	100.62	5.29	2.303795
3240	100.37	5.04	2.19492
3300	100.55	5.22	2.27331
3360	100.62	5.29	2.303795
3420	100.62	5.29	2.303795
3480	100.66	5.33	2.321215
3540	100.68	5.35	2.329925
3600	100.68	5.35	2.329925
3660	100.63	5.3	2.30815
3720	100.7	5.37	2.338635
3780	100.62	5.29	2.303795
3840	100.48	5.15	2.242825
3900	100.48	5.15	2.242825
3960	100.75	5.42	2.36041
4020	100.66	5.33	2.321215
4080	100.68	5.35	2.329925
4140	100.57	5.24	2.28202
4200	100.75	5.42	2.36041
4260	100.61	5.28	2.29944
4320	100.74	5.41	2.356055

4380	100.87	5.54	2.41267
4440	100.83	5.5	2.39525
4500	100.77	5.44	2.36912
4560	100.7	5.37	2.338635
4620	100.59	5.26	2.29073
4680	100.71	5.38	2.34299
4740	100.89	5.56	2.42138
4800	100.86	5.53	2.408315
4860	100.52	5.19	2.260245
4920	100.9	5.57	2.425735
4980	100.83	5.5	2.39525
5040	100.59	5.26	2.29073
5100	100.68	5.35	2.329925
5160	100.92	5.59	2.434445
5220	100.75	5.42	2.36041
5280	100.67	5.34	2.32557
5340	100.89	5.56	2.42138
5400	100.64	5.31	2.312505
5460	100.81	5.48	2.38654
5520	100.53	5.2	2.2646
5580	100.88	5.55	2.417025
5640	100.7	5.37	2.338635
5700	100.61	5.28	2.29944
5760	100.69	5.36	2.33428
5820	100.71	5.38	2.34299

Employer /Client :AAWSSA	**Discharge Rate** :152 l/s
Well ID:BH11R	**Pump Position** :182.88 m

Date of Pumping :27/-30/11/13 **Reference** :0 m		SWL :82.34 m	
CONSTANT DISCHARGE RATE TEST			
Time since pumping started	**Water Level (m)**	**Observed DD**	**Corrected DD**
0	82.34	0	0
1	87.17	4.83	1.331631
2	87.6	5.26	1.450182
3	87.64	5.3	1.46121
4	87.67	5.33	1.469481
5	87.69	5.35	1.474995
6	87.7	5.36	1.477752
7	87.7	5.36	1.477752
8	87.7	5.36	1.477752
9	87.71	5.37	1.480509
10	87.71	5.37	1.480509
12	87.71	5.37	1.480509
14	87.73	5.39	1.486023
16	87.74	5.4	1.48878
18	87.74	5.4	1.48878
20	87.74	5.4	1.48878
25	87.76	5.42	1.494294
30	87.78	5.44	1.499808
35	87.79	5.45	1.502565
40	87.8	5.46	1.505322
45	87.82	5.48	1.510836
50	87.83	5.49	1.513593
55	87.85	5.51	1.519107

60	87.86	5.52	1.521864
70	87.88	5.54	1.527378
80	87.9	5.56	1.532892
90	87.91	5.57	1.535649
100	87.93	5.59	1.541163
110	87.94	5.6	1.54392
120	87.95	5.61	1.546677
140	87.97	5.63	1.552191
160	87.99	5.65	1.557705
180	88.02	5.68	1.565976
210	88.04	5.7	1.57149
240	88.05	5.71	1.574247
270	88.06	5.72	1.577004
300	88.06	5.72	1.577004
360	88.07	5.73	1.579761
420	88.1	5.76	1.588032
480	88.12	5.78	1.593546
540	88.14	5.8	1.59906
600	88.15	5.81	1.601817
660	88.16	5.82	1.604574
720	88.18	5.84	1.610088
780	88.2	5.86	1.615602
840	88.2	5.86	1.615602
900	88.2	5.86	1.615602
960	88.2	5.86	1.615602
1020	88.21	5.87	1.618359
1080	88.21	5.87	1.618359
1140	88.21	5.87	1.618359
1200	88.23	5.89	1.623873

1260	88.25	5.91	1.629387
1320	88.26	5.92	1.632144
1380	88.26	5.92	1.632144
1440	88.27	5.93	1.634901
1500	88.27	5.93	1.634901
1560	88.27	5.93	1.634901
1620	88.27	5.93	1.634901
1680	88.28	5.94	1.637658
1740	88.28	5.94	1.637658
1800	88.29	5.95	1.640415
1860	88.29	5.95	1.640415
1920	88.29	5.95	1.640415
1980	88.3	5.96	1.643172
2040	88.3	5.96	1.643172
2100	88.3	5.96	1.643172
2160	88.32	5.98	1.648686
2220	88.32	5.98	1.648686
2280	88.32	5.98	1.648686
2340	88.33	5.99	1.651443
2400	88.33	5.99	1.651443
2460	88.33	5.99	1.651443
2520	88.33	5.99	1.651443
2580	88.33	5.99	1.651443
2640	88.34	6	1.6542
2700	88.34	6	1.6542
2760	88.34	6	1.6542
2820	88.34	6	1.6542
2880	88.34	6	1.6542
2940	88.34	6	1.6542

3000	88.35	6.01	1.656957
3060	88.35	6.01	1.656957
3120	88.35	6.01	1.656957
3180	88.35	6.01	1.656957
3240	88.35	6.01	1.656957
3300	88.35	6.01	1.656957
3360	88.35	6.01	1.656957
3420	88.35	6.01	1.656957
3480	88.35	6.01	1.656957
3540	88.36	6.02	1.659714
3600	88.36	6.02	1.659714
3660	88.36	6.02	1.659714
3720	88.36	6.02	1.659714
3780	88.36	6.02	1.659714
3840	88.36	6.02	1.659714
3900	88.36	6.02	1.659714
3960	88.36	6.02	1.659714
4020	88.36	6.02	1.659714
4080	88.36	6.02	1.659714
4140	88.36	6.02	1.659714
4200	88.36	6.02	1.659714
4260	88.36	6.02	1.659714
4320	88.36	6.02	1.659714

Employer /Client : AAWSSA **Well ID** : BH13R **Date of Pumping** :15-17/0/2013	Discharge Rate : 55 l/s Pump Position : 175 m SWL :76.6 m
Constant Discharge Rate Test	

Time since pumping started	Water level at BH 13R	Observed DD	Unconfined DD	Corrected DD
0	76.606	0	0	0
1	98.44	21.84	21.3362129	12.11896894
2	113.49	36.89	35.4526615	20.13711173
3	117.95	41.35	39.5441038	22.46105097
4	119.31	42.71	40.7833586	23.16494767
5	119.6	43	41.047106	23.31475623
6	120.33	43.73	41.7102356	23.69141384
7	120.4	43.8	41.7737643	23.7274981
8	120.48	43.88	41.8463557	23.76873005
9	120.51	43.91	41.873574	23.78419005
10	120.61	44.01	41.964288	23.8357156
12	120.72	44.12	42.064049	23.89237984
14	120.79	44.19	42.12752	23.92843134
16	120.81	44.21	42.1456526	23.93873069
18	120.86	44.26	42.1909806	23.96447696
20	120.92	44.32	42.2453671	23.99536853
25	120.96	44.36	42.2816206	24.01596051
30	120.98	44.38	42.2997461	24.02625578
35	120.56	43.96	41.9189337	23.80995433
40	120.65	44.05	42.0005677	23.85632245
45	121.09	44.49	42.3994211	24.08287119
50	121.42	44.82	42.6982928	24.2526303
60	121.75	45.15	42.9969344	24.42225875
70	122.34	45.74	43.5302962	24.72520822
80	122.29	45.69	43.4851245	24.69955073
90	122.34	45.74	43.5302962	24.72520822

100	123.26	46.66	44.3605116	25.1967706
120	123.28	46.68	44.3785399	25.20701068
140	123.77	47.17	44.8199695	25.45774266
160	124.25	47.65	45.2518985	25.70307835
180	125.18	48.58	46.087376	26.17762957
210	125.49	48.89	46.3654625	26.3355827
240	125.56	48.96	46.4282281	26.37123358
270	126.77	50.17	47.5115411	26.98655534
300	126.9	50.3	47.6277461	27.05255978
330	126.99	50.39	47.7081748	27.09824329
360	127.33	50.73	48.0118622	27.27073771
420	128.21	51.61	48.7967426	27.7165498
480	128.7	52.1	49.2330693	27.96438335
540	128.87	52.27	49.3843294	28.05029911
600	129.9	53.3	50.2994825	28.57010604
660	130.45	53.85	50.7872386	28.84715152
720	131.19	54.59	51.4424841	29.21933094
780	131.5	54.9	51.716635	29.37504867
840	132	55.4	52.1583861	29.62596333
900	132.7	56.1	52.7759506	29.97673992
960	132.66	56.06	52.7406891	29.95671138
1020	133.4	56.8	53.3924799	30.3269286
1080	133.47	56.87	53.4540759	30.36191513
1140	134.05	57.45	53.9640447	30.65157738
1200	134.26	57.66	54.1485133	30.75635556
1260	134.97	58.37	54.7715031	31.11021374
1320	135.04	58.44	54.8328669	31.14506841
1380	135.37	58.77	55.1220143	31.3093041
1440	135.52	58.92	55.2533688	31.38391349

1500	136.28	59.68	55.9181681	31.76151951
1560	136.44	59.84	56.0579704	31.8409272
1620	136.89	60.29	56.4508744	32.06409667
1680	136.82	60.22	56.3897841	32.02939738
1740	137.87	61.27	57.3050519	32.54926946
1800	138.11	61.51	57.5139289	32.66791163
1860	134.84	58.24	54.6575142	31.04546804
1920	134.87	58.27	54.6838225	31.06041115
1980	134.76	58.16	54.5873494	31.00561445
2040	134.77	58.17	54.5961207	31.01059657
2100	137.78	61.18	57.2266916	32.50476082
2160	135.12	58.52	54.9029844	31.18489512
2220	135.07	58.47	54.8591625	31.16000433
2280	135.18	58.58	54.9555636	31.21476011
2340	135.42	58.82	55.1658044	31.3341769
2400	135.36	58.76	55.1132556	31.30432918
2460	135.87	59.27	55.559678	31.55789709
2520	135.96	59.36	55.6384014	31.60261197
2580	135.89	59.29	55.5771735	31.56783457
2640	135.99	59.39	55.6646387	31.61751477
2700	136.96	60.36	56.5119544	32.09879008
2760	136.86	60.26	56.4246941	32.04922626
2820	136.93	60.33	56.4857785	32.0839222
2880	136.94	60.34	56.494504	32.08887828
2940	136.88	60.28	56.4421479	32.05913999
3000	136.94	60.34	56.494504	32.08887828
3060	137.45	60.85	56.9392242	32.34147936
3120	137.44	60.84	56.9305095	32.3365294
3180	137.39	60.79	56.8869327	32.31177779

3240	136.858	60.258	56.4229487	32.04823487
3300	137.414	60.814	56.9078502	32.32365893
3360	137.491	60.891	56.9749524	32.36177296
3420	137.282	60.682	56.7927888	32.25830406
3480	137.494	60.894	56.9775665	32.36325777
3540	137.462	60.862	56.9496816	32.34741916
3600	138.147	61.547	57.54612	32.68619615
3660	137.47	60.87	56.956653	32.35137893
3720	138.132	61.532	57.5330699	32.6787837
3780	138.077	61.477	57.4852155	32.65160243
3840	137.571	60.971	57.0446556	32.4013644
3900	137.922	61.322	57.3503189	32.57498112
3960	137.486	60.886	56.9705955	32.35929823
4020	137.57	60.97	57.0437844	32.40086956
4080	137.706	61.106	57.1622492	32.46815756

Employer /Client :AAWSSA

Well ID :BH14R

Date of Pumping :01/-04/01/14

Reference :0 m

Discharge Rate :141 l/s

Pump Position :188.2 m

SWL :81.26 m

CONSTANT DISCHARGE RATE TEST

Time since pumping started	Water Level at BH 14R (m)	Observed DD	Corrected DD
0	81.26	0	0
1	91.84	10.58	2.08955
2	99.65	18.39	3.632025
3	99.56	18.3	3.61425
4	99.67	18.41	3.635975

5	99.82	18.56	3.6656
6	100.08	18.82	3.71695
7	100.22	18.96	3.7446
8	100.28	19.02	3.75645
9	100.33	19.07	3.766325
10	100.38	19.12	3.7762
12	100.45	19.19	3.790025
14	100.46	19.2	3.792
16	100.49	19.23	3.797925
18	100.73	19.47	3.845325
20	100.81	19.55	3.861125
25	101.81	20.55	4.058625
30	101.04	19.78	3.90655
35	101.13	19.87	3.924325
40	101.17	19.91	3.932225
45	101.19	19.93	3.936175
50	101.35	20.09	3.967775
55	101.37	20.11	3.971725
60	101.47	20.21	3.991475
70	101.51	20.25	3.999375
80	101.53	20.27	4.003325
90	101.56	20.3	4.00925
100	101.58	20.32	4.0132
110	87.94	5.6	1.106
120	87.95	5.61	1.107975
140	87.97	5.63	1.111925
160	87.99	5.65	1.115875
180	88.02	5.68	1.1218

210	88.04	5.7	1.12575
240	88.05	5.71	1.127725
270	88.06	5.72	1.1297
300	88.06	5.72	1.1297
360	88.07	5.73	1.131675
420	88.1	5.76	1.1376
480	88.12	5.78	1.14155
540	88.14	5.8	1.1455
600	88.15	5.81	1.147475
660	88.16	5.82	1.14945
720	88.18	5.84	1.1534
780	88.2	5.86	1.15735
840	88.2	5.86	1.15735
900	88.2	5.86	1.15735
960	88.2	5.86	1.15735
1020	88.21	5.87	1.159325
1080	88.21	5.87	1.159325
1140	88.21	5.87	1.159325
1200	88.23	5.89	1.163275
1260	88.25	5.91	1.167225
1320	88.26	5.92	1.1692
1380	88.26	5.92	1.1692
1440	88.27	5.93	1.171175
1500	88.27	5.93	1.171175
1560	88.27	5.93	1.171175
1620	88.27	5.93	1.171175
1680	88.28	5.94	1.17315
1740	88.28	5.94	1.17315

1800	88.29	5.95	1.175125
1860	88.29	5.95	1.175125
1920	88.29	5.95	1.175125
1980	88.3	5.96	1.1771
2040	88.3	5.96	1.1771
2100	88.3	5.96	1.1771
2160	88.32	5.98	1.18105
2220	88.32	5.98	1.18105
2280	88.32	5.98	1.18105
2340	88.33	5.99	1.183025
2400	88.33	5.99	1.183025
2460	88.33	5.99	1.183025
2520	88.33	5.99	1.183025
2580	88.33	5.99	1.183025
2640	88.34	6	1.185
2700	88.34	6	1.185
2760	88.34	6	1.185
2820	88.34	6	1.185
2880	88.34	6	1.185
2940	88.34	6	1.185
3000	88.35	6.01	1.186975
3060	88.35	6.01	1.186975
3120	88.35	6.01	1.186975
3180	88.35	6.01	1.186975
3240	88.35	6.01	1.186975
3300	88.35	6.01	1.186975
3360	88.35	6.01	1.186975
3420	88.35	6.01	1.186975

3480	88.35	6.01	1.186975
3540	88.36	6.02	1.18895
3600	88.36	6.02	1.18895
3660	88.36	6.02	1.18895
3720	88.36	6.02	1.18895
3780	88.36	6.02	1.18895
3840	88.36	6.02	1.18895
3900	88.36	6.02	1.18895
3960	88.36	6.02	1.18895
4020	88.36	6.02	1.18895
4080	88.36	6.02	1.18895
4140	88.36	6.02	1.18895
4200	88.36	6.02	1.18895
4260	88.36	6.02	1.18895
4320	88.36	6.02	1.18895

Employer /Client :AAWSA **Well ID** :BH22R **Date of Pumping** :30/08/2013 Reference :0 m	**Discharge Rate** :90 l/s **Pump Position** :172m SWL :66.6m			
CONSTANT DISCHARGE RATE TEST				
Time since pumping started	**BH1R Water Level (m)**	**Observed DD**	**Unconfined DD**	**Corrected DD**
0	66.66	0	0	0
1	76.09	9.49	9.3762245	4.8100032
2	44.82	-21.78	-22.37928	-11.48057
3	108.65	42.05	39.81618	20.4257
4	110.86	44.26	41.785206	21.435811

5	111.86	45.26	42.672113	21.890794
6	113.19	46.59	43.847785	22.493913
7	114	47.4	44.561605	22.860103
8	114.46	47.86	44.966246	23.067684
9	114.64	48.04	45.124439	23.148837
10	114.88	48.28	45.335235	23.256975
12	115.18	48.58	45.598525	23.392043
14	115.51	48.91	45.887882	23.540483
16	115.66	49.06	46.019316	23.607909
18	115.78	49.18	46.124423	23.661829
20	116.51	49.91	46.763039	23.989439
25	116.7	50.1	46.929034	24.074594
30	116.88	50.28	47.086207	24.155224
35	117.1	50.5	47.278197	24.253715
40	117.2	50.6	47.365425	24.298463
45	117.36	50.76	47.504937	24.370033
50	117.37	50.77	47.513654	24.374505
60	117.5	50.9	47.626957	24.432629
70	117.7	51.1	47.801185	24.522008
80	117.75	51.15	47.844726	24.544345
90	117.88	51.28	47.957904	24.602405
100	117.7	51.1	47.801185	24.522008
110	117.8	51.2	47.888261	24.566678
120	117.9	51.3	47.975312	24.611335
140	117.9	51.3	47.975312	24.611335
160	118.01	51.41	48.071039	24.660443
180	118.19	51.59	48.227617	24.740767
210	118.14	51.54	48.184131	24.718459

240	118.1	51.5	48.149338	24.70061
270	118.25	51.65	48.279791	24.767533
300	118.23	51.63	48.262401	24.758612
360	118.37	51.77	48.384113	24.82105
420	118.67	52.07	48.644758	24.954761
480	119.08	52.48	49.000604	25.13731
540	119.05	52.45	48.974581	25.12396
600	119.08	52.48	49.000604	25.13731
660	119.2	52.6	49.104674	25.190698
720	119.19	52.59	49.096003	25.18625
780	119.35	52.75	49.234711	25.257407
840	119.32	52.72	49.208708	25.244067
900	119.46	52.86	49.330034	25.306308
960	119.44	52.84	49.312705	25.297418
1020	119.47	52.87	49.338699	25.310752
1080	119.48	52.88	49.347363	25.315197
1140	119.49	52.89	49.356026	25.319642
1200	119.47	52.87	49.338699	25.310752
1260	119.43	52.83	49.30404	25.292973
1320	119.46	52.86	49.330034	25.306308
1380	119.57	52.97	49.425328	25.355193
1440	119.59	52.99	49.44265	25.36408
1500	119.7	53.1	49.537907	25.412947
1560	119.8	53.2	49.624478	25.457357
1620	119.66	53.06	49.503272	25.395179
1680	119.73	53.13	49.563881	25.426271
1740	119.69	53.09	49.529249	25.408505
1800	119.54	52.94	49.399342	25.341862

1860	119.66	53.06	49.503272	25.395179
1920	119.67	53.07	49.511931	25.399621
1980	119.79	53.19	49.615822	25.452917
2040	119.92	53.32	49.72833	25.510633
2100	119.89	53.29	49.70237	25.497316
2160	119.88	53.28	49.693717	25.492877
2220	119.96	53.36	49.762939	25.528388
2280	119.99	53.39	49.788893	25.541702
2340	120.01	53.41	49.806195	25.550578
2400	120.06	53.46	49.849444	25.572765
2460	120.07	53.47	49.858093	25.577202
2520	120.07	53.47	49.858093	25.577202
2580	120.04	53.44	49.832145	25.56389
2640	120.04	53.44	49.832145	25.56389
2700	120.03	53.43	49.823495	25.559453
2760	120.04	53.44	49.832145	25.56389
2820	120.09	53.49	49.875391	25.586075
2880	120.21	53.61	49.979154	25.639306
2940	120.19	53.59	49.961863	25.630436
3000	120.2	53.6	49.970509	25.634871
3060	120.13	53.53	49.909983	25.603821
3120	120.18	53.58	49.953217	25.626
3180	120.03	53.43	49.823495	25.559453
3240	120.05	53.45	49.840795	25.568328
3300	120.09	53.49	49.875391	25.586075
3360	120.16	53.56	49.935924	25.617129
3420	120.04	53.44	49.832145	25.56389
3480	120.18	53.58	49.953217	25.626

3540	120.18	53.58	49.953217	25.626
3600	120.25	53.65	50.013734	25.657046
3660	120.33	53.73	50.082882	25.692518
3720	120.26	53.66	50.022379	25.66148
3780	120.26	53.66	50.022379	25.66148
3840	120.32	53.72	50.074239	25.688085
3900	120.24	53.64	50.00509	25.652611
3960	120.33	53.73	50.082882	25.692518
4020	120.34	53.74	50.091524	25.696952
4080	120.32	53.72	50.074239	25.688085
4140	120.28	53.68	50.039666	25.670349
4200	120.32	53.72	50.074239	25.688085
4260	120.27	53.67	50.031023	25.665915
4320	120.38	53.78	50.126091	25.714685

Employer /Client:AAWSA **Well ID** :BH23R **Date of Pumping** :1-4/12/2015 Reference :0 m	**Discharge Rate** :47.67 l/s **Pump Position** :180m SWL :71.06 m

CONSTANT DISCHARGE RATE TEST

Time since pumping started	BH23R Water Level (m)	Observed DD	Unconfined DD	Corrected DD
0	71.06	0	0	0
1	101.47	30.41	29.38005379	16.68787055
2	112.72	41.66	39.72705172	22.56496538
3	123.22	52.16	49.12990065	27.90578357
4	130.34	59.28	55.36620484	31.44800435
5	136.63	65.57	60.78158184	34.52393848

6	144.16	73.1	67.14863679	38.1404257
7	144.2	73.14	67.18212189	38.15944523
8	143.51	72.45	66.60400443	37.83107452
9	143.88	72.82	66.91414131	38.00723226
10	145.66	74.6	68.40188889	38.85227289
12	146.43	75.37	69.04327828	39.21658206
14	147.92	76.86	70.28065799	39.91941374
16	148.18	77.12	70.49606985	40.04176768
18	148.55	77.49	70.80235789	40.21573928
20	149	77.94	71.17445939	40.42709294
25	150.51	79.45	72.41977046	41.13442962
30	149.9	78.84	71.91730922	40.84903164
35	149.87	78.81	71.89257662	40.83498352
40	148.85	77.79	71.05047568	40.35667018
45	148.26	77.2	70.56232013	40.07939783
50	149.08	78.02	71.24056355	40.4646401
55	149	77.94	71.17445939	40.42709294
60	148.77	77.71	70.98433053	40.31909974
70	148.86	77.8	71.05874282	40.36136592
80	149.33	78.27	71.44704716	40.58192278
90	149.37	78.31	71.48007161	40.60068068
100	146.64	75.58	69.21797345	39.31580892
120	148.57	77.51	70.81890531	40.22513822
140	148.03	76.97	70.37181216	39.97118931
160	148.6	77.54	70.84372477	40.23923567
180	148.35	77.29	70.63683465	40.12172208
210	148.25	77.19	70.55403963	40.07469451
240	150.42	79.36	72.34568896	41.09235133

270	146.12	75.06	68.7852154	39.07000235
300	148.97	77.91	71.14966666	40.41301066
360	146.4	75.34	69.01831381	39.20240224
420	146.77	75.71	69.32606885	39.37720711
480	148.8	77.74	71.00913663	40.33318961
540	149.5	78.44	71.58737649	40.66162984
600	146.92	75.86	69.45074754	39.4480246
660	147.92	76.86	70.28065799	39.91941374
720	146.81	75.75	69.3593214	39.39609456
780	146.6	75.54	69.18470575	39.29691287
840	147.05	75.99	69.55876186	39.50937674
900	147	75.94	69.51722235	39.48578229
960	147.55	76.49	69.97385074	39.74514722
1020	148.74	77.68	70.95952243	40.30500874
1080	147.1	76.04	69.60029581	39.53296802
1140	146.55	75.49	69.14311612	39.27328996
1200	146.5	75.44	69.10152092	39.24966388
1260	148.6	77.54	70.84372477	40.23923567
1320	149.78	78.72	71.81836682	40.79283235
1380	149.89	78.83	71.90906524	40.84434906
1440	149.68	78.62	71.73589032	40.7459857
1500	149.7	78.64	71.7523874	40.75535604
1560	147.3	76.24	69.76637591	39.62730152
1620	147.8	76.74	70.18118635	39.86291385
1680	147.56	76.5	69.98214683	39.7498594
1740	148.3	77.24	70.59543993	40.09820988
1800	149.65	78.59	71.71114303	40.73192924
1860	150.43	79.37	72.35392113	41.0970272

1920	148.8	77.74	71.00913663	40.33318961
1980	150.91	79.85	72.74880329	41.32132027
2040	150.29	79.23	72.23865049	41.03155348
2100	150.55	79.49	72.45268978	41.1531278
2160	148.05	76.99	70.38838275	39.9806014
2220	150.47	79.41	72.38684757	41.11572942
2280	147.88	76.82	70.24750434	39.90058247
2340	147.3	76.24	69.76637591	39.62730152
2400	150.85	79.79	72.69947109	41.29329958
2460	149.22	78.16	71.35621152	40.53032814
2520	147.3	76.24	69.76637591	39.62730152
2580	147.18	76.12	69.66673854	39.57070749
2640	147.46	76.4	69.89917584	39.70273188
2700	149.85	78.79	71.87608712	40.82561748
2760	150.2	79.14	72.16452488	40.98945013
2820	150.1	79.04	72.08214193	40.94265662
2880	150.08	79.02	72.06566267	40.9332964
2940	150.18	79.12	72.14805007	40.98009244
3000	150.58	79.52	72.47737693	41.1671501
3060	147.55	76.49	69.97385074	39.74514722
3120	147.26	76.2	69.73316702	39.60843886
3180	147.28	76.22	69.74977191	39.61787044
3240	150.2	79.14	72.16452488	40.98945013
3300	149.63	78.57	71.69464372	40.72255763
3360	150.74	79.68	72.60900789	41.24191648
3420	150.1	79.04	72.08214193	40.94265662
3480	150.18	79.12	72.14805007	40.98009244
3540	150.16	79.1	72.13157438	40.97073425

3600	150.12	79.06	72.09862031	40.95201633
3660	150.17	79.11	72.13981234	40.97541341
3720	150.2	79.14	72.16452488	40.98945013
3780	150.11	79.05	72.09038123	40.94733654
3840	149.79	78.73	71.82661324	40.79751632
3900	149.82	78.76	71.85135118	40.81156747
3960	149.83	78.77	71.85959672	40.81625094
4020	149.77	78.71	71.81012017	40.78814826
4080	149.89	78.83	71.90906524	40.84434906
4140	149.84	78.78	71.86784203	40.82093427
4200	149.82	78.76	71.85135118	40.81156747
4260	149.93	78.87	71.9420398	40.86307861
4320	149.76	78.7	71.8018733	40.78346404

Employer /Client :AAWSA	**Discharge Rate** :90 l/s
Well ID :BH26R	**Pump Position** :240 m
Date of Pumping :23/07/2015	SWL :72.8m
Reference :0 m	

CONSTANT DISCHARGE RATE TEST

Time since pumping started	BH26R Water Level (m)	Observed DD	Corrected DD
1	113.1	40.3	22.99518
2	116.42	43.62	24.889572
3	119.2	46.4	26.47584
4	121.15	48.35	27.58851
5	121.66	48.86	27.879516
6	121.91	49.11	28.022166
7	122.17	49.37	28.170522

8	122.57	49.77	28.398762
9	122.67	49.87	28.455822
10	122.68	49.88	28.461528
12	122.89	50.09	28.581354
14	122.95	50.15	28.61559
16	123.31	50.51	28.821006
18	123.34	50.54	28.838124
20	123.73	50.93	29.060658
25	123.92	51.12	29.169072
30	124.67	51.87	29.597022
35	124.89	52.09	29.722554
40	125.06	52.26	29.819556
45	125.24	52.44	29.922264
50	125.35	52.55	29.98503
55	125.49	52.69	30.064914
60	125.58	52.78	30.116268
70	125.93	53.13	30.315978
80	125.97	53.17	30.338802
90	126.02	53.22	30.367332
100	126.55	53.75	30.66975
110	126.75	53.95	30.78387
120	126.87	54.07	30.852342
140	127.06	54.26	30.960756
160	127.15	54.35	31.01211
180	127.37	54.57	31.137642
210	127.38	54.58	31.143348
240	127.48	54.68	31.200408
270	127.5	54.7	31.21182

300	127.51	54.71	31.217526
360	127.94	55.14	31.462884
420	127.97	55.17	31.480002
480	128.09	55.29	31.548474
540	128.28	55.48	31.656888
600	128.34	55.54	31.691124
660	128.38	55.58	31.713948
720	128.4	55.6	31.72536
780	128.43	55.63	31.742478
840	128.58	55.78	31.828068
900	128.62	55.82	31.850892
960	128.64	55.84	31.862304
1020	128.67	55.87	31.879422
1080	128.71	55.91	31.902246
1140	128.75	55.95	31.92507
1200	128.82	56.02	31.965012
1260	128.94	56.14	32.033484
1320	128.96	56.16	32.044896
1380	129.01	56.21	32.073426
1440	129.03	56.23	32.084838
1500	129.08	56.28	32.113368
1560	129.28	56.48	32.227488
1620	129.34	56.54	32.261724
1680	129.36	56.56	32.273136
1740	129.45	56.65	32.32449
1800	129.48	56.68	32.341608
1860	129.5	56.7	32.35302
1920	129.55	56.75	32.38155

1980	129.73	56.93	32.484258
2040	129.93	57.13	32.598378
2100	129.96	57.16	32.615496
2160	130.07	57.27	32.678262
2220	130.19	57.39	32.746734
2280	130.22	57.42	32.763852
2340	130.23	57.43	32.769558
2400	130.28	57.48	32.798088
2460	130.25	57.45	32.78097
2520	130.26	57.46	32.786676
2580	130.35	57.55	32.83803
2640	130.35	57.55	32.83803
2700	130.35	57.55	32.83803
2760	130.35	57.55	32.83803
2820	130.36	57.56	32.843736
2880	130.4	57.6	32.86656
2940	130.2	57.4	32.75244
3000	130.17	57.37	32.735322
3060	130.14	57.34	32.718204
3120	130.18	57.38	32.741028
3180	130.18	57.38	32.741028
3240	130.18	57.38	32.741028
3300	130.18	57.38	32.741028
3360	130.18	57.38	32.741028
3420	130.18	57.38	32.741028
3480	130.24	57.44	32.775264
3540	130.26	57.46	32.786676
3600	130.31	57.51	32.815206

3660	130.31	57.51	32.815206
3720	130.32	57.52	32.820912
3780	130.32	57.52	32.820912
3840	130.44	57.64	32.889384
3900	130.52	57.72	32.935032
3960	130.52	57.72	32.935032
4020	130.52	57.72	32.935032
4080	130.54	57.74	32.946444
4140	130.54	57.74	32.946444
4200	130.62	57.82	32.992092
4260	130.56	57.76	32.957856
4320	130.56	57.76	32.957856

APPENDIX-9:- SUMMERY OF THIES TEST RESULT

Employer /Client :AAWSA	**Discharge Rate** :126 l/s
Well ID :BH1R	**Pump Position** :203 m
Date of Pumping :12-16/06/2015	**SWL** :83.67 m
Reference :0 m	

Constant Discharge Rate Test

Time since pumping started	BH1R Water Level (m)	Observed DD	Unconfined DD	Corrected DD	r^2/t	U	W(U)	U	W(U)
						1.00E-15	34	8.00E-04	6.55
0	83.67	0	0	0	0	2.00E-15	32.3	9.00E-04	6.44
1	105.4	21.73	21.188904	11.420819	0.2704	3.00E-15	32.9	1.00E-03	6.33
2	132.92	49.25	46.470495	25.047597	0.1352	4.00E-15	32.6	2.00E-03	5.64
3	135.12	51.45	48.416628	26.096562	0.0901	5.00E-15	32.4	3.00E-03	5.23
4	135.51	51.84	48.760467	26.281892	0.0676	6.00E-15	32.2	4.00E-03	4.95
5	135.86	52.19	49.068743	26.448052	0.0541	7.00E-15	32	5.00E-03	4.73
6	136.02	52.35	49.209576	26.523961	0.0451	8.00E-15	31.9	6.00E-03	4.54
7	136.27	52.6	49.42951	26.642506	0.0386	9.00E-15	31.8	7.00E-03	4.39
8	136.4	52.73	49.543819	26.704118	0.0338	1.00E-14	31.7	8.00E-03	4.26
9	136.51	52.84	49.640512	26.756236	0.03	2.00E-14	31	9.00E-03	4.14
10	136.52	52.85	49.6493	26.760973	0.027	3.00E-14	30.6	1.00E-02	4.04
12	136.65	52.98	49.763535	26.822545	0.0225	4.00E-14	30.3	2.00E-02	3.35
14	136.99	53.32	50.062119	26.983482	0.0193	5.00E-14	30.1	3.00E-02	2.96
16	137.16	53.49	50.211312	27.063897	0.0169	6.00E-14	29.9	4.00E-02	2.68
18	137.44	53.77	50.456897	27.196267	0.015	7.00E-14	29.7	5.00E-02	2.47
20	137.44	53.77	50.456897	27.196267	0.0135	8.00E-14	29.6	6.00E-02	2.3
25	137.63	53.96	50.623441	27.286035	0.0108	9.00E-14	29.5	7.00E-02	2.15
30	137.71	54.04	50.69354	27.323818	0.009	1.00E-13	29.4	8.00E-02	2.03
35	137.71	54.04	50.69354	27.323818	0.0077	2.00E-13	28.7	9.00E-02	1.92
40	137.77	54.1	50.746105	27.352151	0.0068	3.00E-13	28.3	1.00E-01	1.82

45	137.82	54.15	50.789903	27.375758	0.006	4.00E-13	28	2.00E-01	1.22
50	137.82	54.15	50.789903	27.375758	0.0054	5.00E-13	27.8	3.00E-01	0.91
55	138.02	54.35	50.965036	27.470155	0.0049	6.00E-13	27.6	4.00E-01	0.7
60	137.89	54.22	50.85121	27.408802	0.0045	7.00E-13	27.4	5.00E-01	0.56
70	137.93	54.26	50.886237	27.427682	0.0039	8.00E-13	27.3	6.00E-01	0.45
80	137.89	54.22	50.85121	27.408802	0.0034	9.00E-13	27.2	7.00E-01	0.37
90	137.8	54.13	50.772384	27.366315	0.003	1.00E-12	27.1	8.00E-01	0.31
100	137.88	54.21	50.842452	27.404082	0.0027	2.00E-12	26.4	9.00E-01	0.26
110	137.74	54.07	50.719824	27.337985	0.0025	3.00E-12	26	1.00E+00	0.22
120	137.54	53.87	50.544562	27.243519	0.0023	4.00E-12	26.7	2.00E+00	0.05
140	137.35	53.68	50.377978	27.15373	0.0019	5.00E-12	25.4	3.00E+00	0.01
160	137.28	53.61	50.316584	27.120639	0.0017	6.00E-12	25.3	4.00E+00	0
180	137.13	53.46	50.184988	27.049709	0.0015	7.00E-12	25.1	5.00E+00	0
210	136.97	53.3	50.044563	26.974019	0.0013	8.00E-12	25	6.00E+00	0
240	136.76	53.09	49.860165	26.874629	0.0011	9.00E-12	24.9	7.00E+00	0
270	136.37	52.7	49.517443	26.689902	0.001	1.00E-11	24.8	8.00E+00	0
300	136.32	52.65	49.473479	26.666205	0.0009	2.00E-11	24.1	9.00E+00	0
330	136.38	52.71	49.526235	26.694641	0.0008	3.00E-11	23.7		
360	138.42	54.75	51.315028	27.6588	0.0008	4.00E-11	23.4		
420	139.4	55.73	52.170959	28.120147	0.0006	5.00E-11	23.1		
480	138.9	55.23	51.734535	27.884914	0.0006	6.00E-11	23		
540	139.17	55.5	51.970275	28.011978	0.0005	7.00E-11	22.8		
600	139.14	55.47	51.94409	27.997864	0.0005	8.00E-11	22.7		
660	138.83	55.16	51.673389	27.851957	0.0004	9.00E-11	22.6		
720	138.96	55.29	51.786936	27.913158	0.0004	1.00E-10	22.5		
780	138.63	54.96	51.498627	27.75776	0.0003	2.00E-10	21.8		
840	138.73	55.06	51.58602	27.804865	0.0003	3.00E-10	21.4		
900	138.66	54.99	51.524847	27.771893	0.0003	4.00E-10	21.1		

960	138.67	55	51.533587	27.776603	0.0003	5.00E-10	20.8
1020	138.23	54.56	51.148828	27.569218	0.0003	6.00E-10	20.7
1080	138.48	54.81	51.367495	27.68708	0.0003	7.00E-10	20.5
1140	139.51	55.84	52.266895	28.171857	0.0002	8.00E-10	20.4
1200	139.88	56.21	52.589387	28.34568	0.0002	9.00E-10	20.3
1260	139.23	55.56	52.022639	28.040202	0.0002	1.00E-09	20.2
1320	138.63	54.96	51.498627	27.75776	0.0002	2.00E-09	19.5
1380	138.59	54.92	51.463664	27.738915	0.0002	3.00E-09	19.1
1440	138.47	54.8	51.358751	27.682367	0.0002	4.00E-09	18.8
1500	138.42	54.75	51.315028	27.6588	0.0002	5.00E-09	18.5
1560	137.83	54.16	50.798662	27.380479	0.0002	6.00E-09	18.4
1620	137.9	54.23	50.859967	27.413522	0.0002	7.00E-09	18.2
1680	137.58	53.91	50.579622	27.262416	0.0002	8.00E-09	18.1
1740	136.94	53.27	50.018226	26.959824	0.0002	9.00E-09	18
1800	136.94	53.27	50.018226	26.959824	0.0002	1.00E-08	17.5
1860	136.33	52.66	49.482273	26.670945	0.0001	2.00E-08	17.2
1920	136.79	53.12	49.886513	26.888831	0.0001	3.00E-08	16.7
1980	136.35	52.68	49.499858	26.680424	0.0001	4.00E-08	16.5
2040	137.98	54.31	50.930017	27.451279	0.0001	5.00E-08	16.2
2100	139.1	55.43	51.909173	27.979044	0.0001	6.00E-08	16.1
2160	138.77	55.1	51.62097	27.823703	0.0001	7.00E-08	15.9
2220	138.88	55.21	51.717066	27.875498	0.0001	8.00E-08	15.8
2280	138.75	55.08	51.603496	27.814284	0.0001	9.00E-08	15.7
2340	138.85	55.18	51.690861	27.861374	0.0001	1.00E-07	15.5
2400	138.72	55.05	51.577282	27.800155	0.0001	2.00E-07	14.9
2460	138.22	54.55	51.140078	27.564502	0.0001	3.00E-07	14.4
2520	138.35	54.68	51.253806	27.625801	0.0001	4.00E-07	14.2
2580	138.43	54.76	51.323773	27.663514	0.0001	5.00E-07	13.9

2640	138.54	54.87	51.419954	27.715355	0.0001	6.00E-07	13.8
2700	138.23	54.56	51.148828	27.569218	0.0001	7.00E-07	13.6
2760	138.41	54.74	51.306283	27.654086	1E-04	8.00E-07	13.5
2820	137.33	53.66	50.360438	27.144276	1E-04	9.00E-07	13.3
2880	137.29	53.62	50.325356	27.125367	9E-05	1.00E-06	13.2
2940	138.32	54.65	51.227565	27.611657	9E-05	2.00E-06	12.6
3000	138.25	54.58	51.166326	27.57865	9E-05	3.00E-06	12.1
3060	138.29	54.62	51.201321	27.597512	9E-05	4.00E-06	11.9
3120	138.23	54.56	51.148828	27.569218	9E-05	5.00E-06	11.6
3180	138.18	54.51	51.105077	27.545637	9E-05	6.00E-06	11.5
3240	137.74	54.07	50.719824	27.337985	8E-05	7.00E-06	11.3
3300	137.54	53.87	50.544562	27.243519	8E-05	8.00E-06	11.2
3360	137.07	53.4	50.132336	27.021329	8E-05	9.00E-06	11
3420	138.5	54.83	51.384983	27.696506	8E-05	1.00E-05	10.9
3480	138.53	54.86	51.411212	27.710643	8E-05	2.00E-05	10.2
3540	138.18	54.51	51.105077	27.545637	8E-05	3.00E-05	9.84
3600	138.06	54.39	51.000052	27.489028	8E-05	4.00E-05	9.55
3660	138.13	54.46	51.061321	27.522052	7E-05	5.00E-05	9.33
3720	138.15	54.48	51.078824	27.531486	7E-05	6.00E-05	9.14
3780	138.16	54.49	51.087575	27.536203	7E-05	7.00E-05	8.99
3840	138.06	54.39	51.000052	27.489028	7E-05	8.00E-05	8.86
3900	138.28	54.61	51.192573	27.592797	7E-05	9.00E-05	8.74
3960	138.26	54.59	51.175075	27.583366	7E-05	1.00E-04	8.63
4020	138.02	54.35	50.965036	27.470155	7E-05	2.00E-04	7.94
4080	137.98	54.31	50.930017	27.451279	7E-05	3.00E-04	7.53
4140	137.43	53.76	50.448129	27.191541	7E-05	4.00E-04	7.25
4200	137.28	53.61	50.316584	27.120639	6E-05	5.00E-04	7.02
4260	136.97	53.3	50.044563	26.974019	6E-05	6.00E-04	6.84

4320	136.6	52.93	49.719603	26.798866	6E-05	7.00E-04	6.69	

Employer /Client :AAWSSA **Well ID** :BH10R **Date of Pumping** :16/-19/10/13 **Reference** :0 m	**Discharge Rate** :150 l/s **Pump Position** :210 m **SWL** :95.33 m

Constant Discharge Rate Test

Time since pumping started	BH10 R Water Level (m)	Observed DD	Corrected DD	r^2/t	U	W(U)
					1.00E-15	33.96
0	95.33	0	0	0	2.00E-15	32.27
1	96.84	1.51	0.657605	0.2704	3.00E-15	32.86
2	98.41	3.08	1.34134	0.1352	4.00E-15	32.58
3	98.72	3.39	1.476345	0.090133	5.00E-15	32.35
4	98.67	3.34	1.45457	0.0676	6.00E-15	32.17
5	98.81	3.48	1.51554	0.05408	7.00E-15	32.02
6	98.72	3.39	1.476345	0.045067	8.00E-15	31.88
7	98.93	3.6	1.5678	0.038629	9.00E-15	31.76
8	98.82	3.49	1.519895	0.0338	1.00E-14	31.66
9	98.81	3.48	1.51554	0.030044	2.00E-14	30.97
10	98.89	3.56	1.55038	0.02704	3.00E-14	30.56
12	98.93	3.6	1.5678	0.022533	4.00E-14	30.27
14	98.85	3.52	1.53296	0.019314	5.00E-14	30.05
16	99.03	3.7	1.61135	0.0169	6.00E-14	29.87
18	99.06	3.73	1.624415	0.015022	7.00E-14	29.71
20	99.12	3.79	1.650545	0.01352	8.00E-14	29.58
25	99.07	3.74	1.62877	0.010816	9.00E-14	29.46
30	99.26	3.93	1.711515	0.009013	1.00E-13	29.36
35	99.16	3.83	1.667965	0.007726	2.00E-13	28.66

40	99.25	3.92	1.70716	0.00676	3.00E-13	28.26
45	99.33	4	1.742	0.006009	4.00E-13	27.97
50	99.36	4.03	1.755065	0.005408	5.00E-13	27.75
55	99.21	3.88	1.68974	0.004916	6.00E-13	27.56
60	99.28	3.95	1.720225	0.004507	7.00E-13	27.41
70	99.29	3.96	1.72458	0.003863	8.00E-13	27.28
80	99.32	3.99	1.737645	0.00338	9.00E-13	27.16
90	99.45	4.12	1.79426	0.003004	1.00E-12	27.05
100	99.41	4.08	1.77684	0.002704	2.00E-12	26.36
120	99.57	4.24	1.84652	0.002253	3.00E-12	25.96
140	99.32	3.99	1.737645	0.001931	4.00E-12	26.67
160	99.41	4.08	1.77684	0.00169	5.00E-12	25.44
180	99.62	4.29	1.868295	0.001502	6.00E-12	25.26
210	99.56	4.23	1.842165	0.001288	7.00E-12	25.11
240	99.64	4.31	1.877005	0.001127	8.00E-12	24.97
270	99.64	4.31	1.877005	0.001001	9.00E-12	24.86
300	99.6	4.27	1.859585	0.000901	1.00E-11	24.75
360	99.93	4.6	2.0033	0.000751	2.00E-11	24.06
420	99.91	4.58	1.99459	0.000644	3.00E-11	23.65
480	99.92	4.59	1.998945	0.000563	4.00E-11	23.36
540	99.94	4.61	2.007655	0.000501	5.00E-11	23.14
600	99.85	4.52	1.96846	0.000451	6.00E-11	22.96
660	99.81	4.48	1.95104	0.00041	7.00E-11	22.81
720	100.06	4.73	2.059915	0.000376	8.00E-11	22.67
780	100.01	4.68	2.03814	0.000347	9.00E-11	22.55
840	100.09	4.76	2.07298	0.000322	1.00E-10	22.45
900	100.27	4.94	2.15137	0.0003	2.00E-10	21.76
960	99.95	4.62	2.01201	0.000282	3.00E-10	21.35

1020	100.14	4.81	2.094755	0.000265	4.00E-10	21.06
1080	100.01	4.68	2.03814	0.00025	5.00E-10	20.84
1140	100.1	4.77	2.077335	0.000237	6.00E-10	20.66
1200	100	4.67	2.033785	0.000225	7.00E-10	20.5
1260	100.3	4.97	2.164435	0.000215	8.00E-10	20.37
1320	99.97	4.64	2.02072	0.000205	9.00E-10	20.25
1380	100.2	4.87	2.120885	0.000196	1.00E-09	20.15
1440	100.31	4.98	2.16879	0.000188	2.00E-09	19.45
1500	100.11	4.78	2.08169	0.00018	3.00E-09	19.05
1560	100.04	4.71	2.051205	0.000173	4.00E-09	18.76
1620	100.27	4.94	2.15137	0.000167	5.00E-09	18.54
1680	100.22	4.89	2.129595	0.000161	6.00E-09	18.35
1740	100.11	4.78	2.08169	0.000155	7.00E-09	18.2
1800	100.39	5.06	2.20363	0.00015	8.00E-09	18.07
1860	100.36	5.03	2.190565	0.000145	9.00E-09	17.95
1920	100.15	4.82	2.09911	0.000141	1.00E-08	17.48
1980	100.4	5.07	2.207985	0.000137	2.00E-08	17.15
2040	100.42	5.09	2.216695	0.000133	3.00E-08	16.74
2100	100.49	5.16	2.24718	0.000129	4.00E-08	16.46
2160	100.33	5	2.1775	0.000125	5.00E-08	16.23
2220	100.34	5.01	2.181855	0.000122	6.00E-08	16.05
2280	100.51	5.18	2.25589	0.000119	7.00E-08	15.9
2340	100.31	4.98	2.16879	0.000116	8.00E-08	15.76
2400	100.35	5.02	2.18621	0.000113	9.00E-08	15.65
2460	100.26	4.93	2.147015	0.00011	1.00E-07	15.54
2520	100.36	5.03	2.190565	0.000107	2.00E-07	14.85
2580	100.52	5.19	2.260245	0.000105	3.00E-07	14.44
2640	100.32	4.99	2.173145	0.000102	4.00E-07	14.15

2700	100.7	5.37	2.338635	0.0001	5.00E-07	13.93
2760	100.3	4.97	2.164435	9.8E-05	6.00E-07	13.75
2820	100.44	5.11	2.225405	9.59E-05	7.00E-07	13.6
2880	100.53	5.2	2.2646	9.39E-05	8.00E-07	13.46
2940	100.64	5.31	2.312505	9.2E-05	9.00E-07	13.34
3000	100.61	5.28	2.29944	9.01E-05	1.00E-06	13.24
3060	100.62	5.29	2.303795	8.84E-05	2.00E-06	12.55
3120	100.42	5.09	2.216695	8.67E-05	3.00E-06	12.14
3180	100.62	5.29	2.303795	8.5E-05	4.00E-06	11.85
3240	100.37	5.04	2.19492	8.35E-05	5.00E-06	11.63
3300	100.55	5.22	2.27331	8.19E-05	6.00E-06	11.45
3360	100.62	5.29	2.303795	8.05E-05	7.00E-06	11.29
3420	100.62	5.29	2.303795	7.91E-05	8.00E-06	11.16
3480	100.66	5.33	2.321215	7.77E-05	9.00E-06	11.04
3540	100.68	5.35	2.329925	7.64E-05	1.00E-05	10.94
3600	100.68	5.35	2.329925	7.51E-05	2.00E-05	10.24
3660	100.63	5.3	2.30815	7.39E-05	3.00E-05	9.84
3720	100.7	5.37	2.338635	7.27E-05	4.00E-05	9.55
3780	100.62	5.29	2.303795	7.15E-05	5.00E-05	9.33
3840	100.48	5.15	2.242825	7.04E-05	6.00E-05	9.14
3900	100.48	5.15	2.242825	6.93E-05	7.00E-05	8.99
3960	100.75	5.42	2.36041	6.83E-05	8.00E-05	8.86
4020	100.66	5.33	2.321215	6.73E-05	9.00E-05	8.74
4080	100.68	5.35	2.329925	6.63E-05	1.00E-04	8.63
4140	100.57	5.24	2.28202	6.53E-05	2.00E-04	7.94
4200	100.75	5.42	2.36041	6.44E-05	3.00E-04	7.53
4260	100.61	5.28	2.29944	6.35E-05	4.00E-04	7.25
4320	100.74	5.41	2.356055	6.26E-05	5.00E-04	7.02

4380	100.87	5.54	2.41267	6.17E-05	6.00E-04	6.84
4440	100.83	5.5	2.39525	6.09E-05	7.00E-04	6.69
4500	100.77	5.44	2.36912	6.01E-05	8.00E-04	6.55
4560	100.7	5.37	2.338635	5.93E-05	9.00E-04	6.44
4620	100.59	5.26	2.29073	5.85E-05	1.00E-03	6.33
4680	100.71	5.38	2.34299	5.78E-05	2.00E-03	5.64
4740	100.89	5.56	2.42138	5.7E-05	3.00E-03	5.23
4800	100.86	5.53	2.408315	5.63E-05	4.00E-03	4.95
4860	100.52	5.19	2.260245	5.56E-05	5.00E-03	4.73
4920	100.9	5.57	2.425735	5.5E-05	6.00E-03	4.54
4980	100.83	5.5	2.39525	5.43E-05	7.00E-03	4.39
5040	100.59	5.26	2.29073	5.37E-05	8.00E-03	4.26
5100	100.68	5.35	2.329925	5.3E-05	9.00E-03	4.14
5160	100.92	5.59	2.434445	5.24E-05	1.00E-02	4.04
5220	100.75	5.42	2.36041	5.18E-05	2.00E-02	3.35
5280	100.67	5.34	2.32557	5.12E-05	3.00E-02	2.96
5340	100.89	5.56	2.42138	5.06E-05	4.00E-02	2.68
5400	100.64	5.31	2.312505	5.01E-05	5.00E-02	2.47
5460	100.81	5.48	2.38654	4.95E-05	6.00E-02	2.3
5520	100.53	5.2	2.2646	4.9E-05	7.00E-02	2.15
5580	100.88	5.55	2.417025	4.85E-05	8.00E-02	2.03
5640	100.7	5.37	2.338635	4.79E-05	9.00E-02	1.92
5700	100.61	5.28	2.29944	4.74E-05	1.00E-01	1.82
5760	100.69	5.36	2.33428	4.69E-05	2.00E-01	1.22
5820	100.71	5.38	2.34299	4.65E-05	3.00E-01	0.91
					4.00E-01	0.7
					5.00E-01	0.56
					6.00E-01	0.45

7.00E-01	0.37
8.00E-01	0.31
9.00E-01	0.26
1.00E+00	0.219
2.00E+00	0.049
3.00E+00	0.013
4.00E+00	0.0038
5.00E+00	0.0011
6.00E+00	0.00036
7.00E+00	0.00012
8.00E+00	0.000038
9.00E+00	0.000012

Employer /Client :AAWSSA	**Discharge Rate** :152 l/s
Well ID :BH11R	**Pump Position** :182.88 m
Date of Pumping :27/-30/11/13	**SWL** :82.34 m
Reference :0 m	

Constant Discharge Rate Test								
Time since pumping started	**Water Level (m)**	**Observed DD**	**Corrected DD**	**r^2/t**	**U**	**W(U)**	**U**	**W(U)**
					1.00E-15	33.96	7.00E-04	6.69
0	82.34	0	0	0	2.00E-15	32.27	8.00E-04	6.55
1	87.17	4.83	1.331631	0.2704	3.00E-15	32.86	9.00E-04	6.44
2	87.6	5.26	1.450182	0.1352	4.00E-15	32.58	1.00E-03	6.33
3	87.64	5.3	1.46121	0.090133	5.00E-15	32.35	2.00E-03	5.64
4	87.67	5.33	1.469481	0.0676	6.00E-15	32.17	3.00E-03	5.23
5	87.69	5.35	1.474995	0.05408	7.00E-15	32.02	4.00E-03	4.95
6	87.7	5.36	1.477752	0.045067	8.00E-15	31.88	5.00E-03	4.73
7	87.7	5.36	1.477752	0.038629	9.00E-15	31.76	6.00E-03	4.54

8	87.7	5.36	1.477752	0.0338	1.00E-14	31.66	7.00E-03	4.39
9	87.71	5.37	1.480509	0.030044	2.00E-14	30.97	8.00E-03	4.26
10	87.71	5.37	1.480509	0.02704	3.00E-14	30.56	9.00E-03	4.14
12	87.71	5.37	1.480509	0.022533	4.00E-14	30.27	1.00E-02	4.04
14	87.73	5.39	1.486023	0.019314	5.00E-14	30.05	2.00E-02	3.35
16	87.74	5.4	1.48878	0.0169	6.00E-14	29.87	3.00E-02	2.96
18	87.74	5.4	1.48878	0.015022	7.00E-14	29.71	4.00E-02	2.68
20	87.74	5.4	1.48878	0.01352	8.00E-14	29.58	5.00E-02	2.47
25	87.76	5.42	1.494294	0.010816	9.00E-14	29.46	6.00E-02	2.3
30	87.78	5.44	1.499808	0.009013	1.00E-13	29.36	7.00E-02	2.15
35	87.79	5.45	1.502565	0.007726	2.00E-13	28.66	8.00E-02	2.03
40	87.8	5.46	1.505322	0.00676	3.00E-13	28.26	9.00E-02	1.92
45	87.82	5.48	1.510836	0.006009	4.00E-13	27.97	1.00E-01	1.82
50	87.83	5.49	1.513593	0.005408	5.00E-13	27.75	2.00E-01	1.22
55	87.85	5.51	1.519107	0.004916	6.00E-13	27.56	3.00E-01	0.91
60	87.86	5.52	1.521864	0.004507	7.00E-13	27.41	4.00E-01	0.7
70	87.88	5.54	1.527378	0.003863	8.00E-13	27.28	5.00E-01	0.56
80	87.9	5.56	1.532892	0.00338	9.00E-13	27.16	6.00E-01	0.45
90	87.91	5.57	1.535649	0.003004	1.00E-12	27.05	7.00E-01	0.37
100	87.93	5.59	1.541163	0.002704	2.00E-12	26.36	8.00E-01	0.31
110	87.94	5.6	1.54392	0.002458	3.00E-12	25.96	9.00E-01	0.26
120	87.95	5.61	1.546677	0.002253	4.00E-12	26.67	1.00E+0 0	0.219
140	87.97	5.63	1.552191	0.001931	5.00E-12	25.44	2.00E+0 0	0.049
160	87.99	5.65	1.557705	0.00169	6.00E-12	25.26	3.00E+0 0	0.013
180	88.02	5.68	1.565976	0.001502	7.00E-12	25.11	4.00E+0 0	0.0038
210	88.04	5.7	1.57149	0.001288	8.00E-12	24.97	5.00E+0	0.0011

							0	
240	88.05	5.71	1.574247	0.001127	9.00E-12	24.86	6.00E+00	0.00036
270	88.06	5.72	1.577004	0.001001	1.00E-11	24.75	7.00E+00	0.00012
300	88.06	5.72	1.577004	0.000901	2.00E-11	24.06	8.00E+00	0.000038
360	88.07	5.73	1.579761	0.000751	3.00E-11	23.65	9.00E+00	0.000012
420	88.1	5.76	1.588032	0.000644	4.00E-11	23.36		
480	88.12	5.78	1.593546	0.000563	5.00E-11	23.14		
540	88.14	5.8	1.59906	0.000501	6.00E-11	22.96		
600	88.15	5.81	1.601817	0.000451	7.00E-11	22.81		
660	88.16	5.82	1.604574	0.00041	8.00E-11	22.67		
720	88.18	5.84	1.610088	0.000376	9.00E-11	22.55		
780	88.2	5.86	1.615602	0.000347	1.00E-10	22.45		
840	88.2	5.86	1.615602	0.000322	2.00E-10	21.76		
900	88.2	5.86	1.615602	0.0003	3.00E-10	21.35		
960	88.2	5.86	1.615602	0.000282	4.00E-10	21.06		
1020	88.21	5.87	1.618359	0.000265	5.00E-10	20.84		
1080	88.21	5.87	1.618359	0.00025	6.00E-10	20.66		
1140	88.21	5.87	1.618359	0.000237	7.00E-10	20.5		
1200	88.23	5.89	1.623873	0.000225	8.00E-10	20.37		
1260	88.25	5.91	1.629387	0.000215	9.00E-10	20.25		
1320	88.26	5.92	1.632144	0.000205	1.00E-09	20.15		
1380	88.26	5.92	1.632144	0.000196	2.00E-09	19.45		
1440	88.27	5.93	1.634901	0.000188	3.00E-09	19.05		
1500	88.27	5.93	1.634901	0.00018	4.00E-09	18.76		
1560	88.27	5.93	1.634901	0.000173	5.00E-09	18.54		
1620	88.27	5.93	1.634901	0.000167	6.00E-09	18.35		

1680	88.28	5.94	1.637658	0.000161	7.00E-09	18.2
1740	88.28	5.94	1.637658	0.000155	8.00E-09	18.07
1800	88.29	5.95	1.640415	0.00015	9.00E-09	17.95
1860	88.29	5.95	1.640415	0.000145	1.00E-08	17.48
1920	88.29	5.95	1.640415	0.000141	2.00E-08	17.15
1980	88.3	5.96	1.643172	0.000137	3.00E-08	16.74
2040	88.3	5.96	1.643172	0.000133	4.00E-08	16.46
2100	88.3	5.96	1.643172	0.000129	5.00E-08	16.23
2160	88.32	5.98	1.648686	0.000125	6.00E-08	16.05
2220	88.32	5.98	1.648686	0.000122	7.00E-08	15.9
2280	88.32	5.98	1.648686	0.000119	8.00E-08	15.76
2340	88.33	5.99	1.651443	0.000116	9.00E-08	15.65
2400	88.33	5.99	1.651443	0.000113	1.00E-07	15.54
2460	88.33	5.99	1.651443	0.00011	2.00E-07	14.85
2520	88.33	5.99	1.651443	0.000107	3.00E-07	14.44
2580	88.33	5.99	1.651443	0.000105	4.00E-07	14.15
2640	88.34	6	1.6542	0.000102	5.00E-07	13.93
2700	88.34	6	1.6542	0.0001	6.00E-07	13.75
2760	88.34	6	1.6542	9.8E-05	7.00E-07	13.6
2820	88.34	6	1.6542	9.59E-05	8.00E-07	13.46
2880	88.34	6	1.6542	9.39E-05	9.00E-07	13.34
2940	88.34	6	1.6542	9.2E-05	1.00E-06	13.24
3000	88.35	6.01	1.656957	9.01E-05	2.00E-06	12.55
3060	88.35	6.01	1.656957	8.84E-05	3.00E-06	12.14
3120	88.35	6.01	1.656957	8.67E-05	4.00E-06	11.85
3180	88.35	6.01	1.656957	8.5E-05	5.00E-06	11.63
3240	88.35	6.01	1.656957	8.35E-05	6.00E-06	11.45
3300	88.35	6.01	1.656957	8.19E-05	7.00E-06	11.29

3360	88.35	6.01	1.656957	8.05E-05	8.00E-06	11.16	
3420	88.35	6.01	1.656957	7.91E-05	9.00E-06	11.04	
3480	88.35	6.01	1.656957	7.77E-05	1.00E-05	10.94	
3540	88.36	6.02	1.659714	7.64E-05	2.00E-05	10.24	
3600	88.36	6.02	1.659714	7.51E-05	3.00E-05	9.84	
3660	88.36	6.02	1.659714	2.08E-05	4.00E-05	9.55	
3720	88.36	6.02	1.659714	2.04E-05	5.00E-05	9.33	
3780	88.36	6.02	1.659714	2.01E-05	6.00E-05	9.14	
3840	88.36	6.02	1.659714	1.98E-05	7.00E-05	8.99	
3900	88.36	6.02	1.659714	1.95E-05	8.00E-05	8.86	
3960	88.36	6.02	1.659714	1.92E-05	9.00E-05	8.74	
4020	88.36	6.02	1.659714	1.89E-05	1.00E-04	8.63	
4080	88.36	6.02	1.659714	1.86E-05	2.00E-04	7.94	
4140	88.36	6.02	1.659714	1.84E-05	3.00E-04	7.53	
4200	88.36	6.02	1.659714	1.81E-05	4.00E-04	7.25	
4260	88.36	6.02	1.659714	1.78E-05	5.00E-04	7.02	
4320	88.36	6.02	1.659714	1.76E-05	6.00E-04	6.84	

Employer /Client : AAWSSA	**Discharge Rate** : 55 l/s
Well ID : BH13R	**Pump Position** : 175 m
Date of Pumping :15- 17/0/2013	**SWL** :76.6 m

Constant Discharge Rate Test

Time since pumping started	Water level at BH 13R	Observed DD	Unconfined DD	Corrected DD	r^2/t	U	W(U)	U	W(U)
0	76.606	0	0	0		1.00E-15	33.96	1.00E-04	8.63
1	98.44	21.84	21.33621293	12.1189689	0.281	2.00E-15	32.27	2.00E-04	7.94
2	113.49	36.89	35.45266149	20.1371117	0.14	3.00E-15	32.86	3.00E-04	7.53

3	117.95	41.35	39.54410382	22.461051	0.094	4.00E-15	32.58	4.00E-04	7.25
4	119.31	42.71	40.78335858	23.1649477	0.07	5.00E-15	32.35	5.00E-04	7.02
5	119.6	43	41.04710604	23.3147562	0.056	6.00E-15	32.17	6.00E-04	6.84
6	120.33	43.73	41.71023564	23.6914138	0.047	7.00E-15	32.02	7.00E-04	6.69
7	120.4	43.8	41.77376426	23.7274981	0.04	8.00E-15	31.88	8.00E-04	6.55
8	120.48	43.88	41.84635572	23.7687301	0.035	9.00E-15	31.76	9.00E-04	6.44
9	120.51	43.91	41.87357404	23.7841901	0.031	1.00E-14	31.66	1.00E-03	6.33
10	120.61	44.01	41.96428802	23.8357156	0.028	2.00E-14	30.97	2.00E-03	5.64
12	120.72	44.12	42.06404901	23.8923798	0.023	3.00E-14	30.56	3.00E-03	5.23
14	120.79	44.19	42.12751996	23.9284313	0.02	4.00E-14	30.27	4.00E-03	4.95
16	120.81	44.21	42.14565262	23.9387307	0.018	5.00E-14	30.05	5.00E-03	4.73
18	120.86	44.26	42.19098057	23.964477	0.016	6.00E-14	29.87	6.00E-03	4.54
20	120.92	44.32	42.24536713	23.9953685	0.014	7.00E-14	29.71	7.00E-03	4.39
25	120.96	44.36	42.28162062	24.0159605	0.011	8.00E-14	29.58	8.00E-03	4.26
30	120.98	44.38	42.29974609	24.0262558	0.009	9.00E-14	29.46	9.00E-03	4.14
35	120.56	43.96	41.91893367	23.8099543	0.008	1.00E-13	29.36	1.00E-02	4.04
40	120.65	44.05	42.0005677	23.8563225	0.007	2.00E-13	28.66	2.00E-02	3.35
45	121.09	44.49	42.3994211	24.0828712	0.006	3.00E-13	28.26	3.00E-02	2.96
50	121.42	44.82	42.69829278	24.2526303	0.006	4.00E-13	27.97	4.00E-02	2.68
60	121.75	45.15	42.99693441	24.4222587	0.005	5.00E-13	27.75	5.00E-02	2.47
70	122.34	45.74	43.53029616	24.7252082	0.004	6.00E-13	27.56	6.00E-02	2.3
80	122.29	45.69	43.48512452	24.6995507	0.004	7.00E-13	27.41	7.00E-02	2.15
90	122.34	45.74	43.53029616	24.7252082	0.003	8.00E-13	27.28	8.00E-02	2.03
100	123.26	46.66	44.36051162	25.1967706	0.003	9.00E-13	27.16	9.00E-02	1.92
120	123.28	46.68	44.37853992	25.2070107	0.002	1.00E-12	27.05	1.00E-01	1.82
140	123.77	47.17	44.81996948	25.4577427	0.002	2.00E-12	26.36	2.00E-01	1.22
160	124.25	47.65	45.2518985	25.7030783	0.002	3.00E-12	25.96	3.00E-01	0.91
180	125.18	48.58	46.087376	26.1776296	0.002	4.00E-12	26.67	4.00E-01	0.7

210	125.49	48.89	46.36546251	26.3355827	0.001	5.00E-12	25.44	5.00E-01	0.56
240	125.56	48.96	46.42822814	26.3712336	0.001	6.00E-12	25.26	6.00E-01	0.45
270	126.77	50.17	47.51154109	26.9865553	0.001	7.00E-12	25.11	7.00E-01	0.37
300	126.9	50.3	47.62774609	27.0525598	9E-04	8.00E-12	24.97	8.00E-01	0.31
330	126.99	50.39	47.7081748	27.0982433	9E-04	9.00E-12	24.86	9.00E-01	0.26
360	127.33	50.73	48.01186217	27.2707377	8E-04	1.00E-11	24.75	1.00E+00	0.219
420	128.21	51.61	48.79674261	27.7165498	7E-04	2.00E-11	24.06	2.00E+00	0.049
480	128.7	52.1	49.23306929	27.9643834	6E-04	3.00E-11	23.65	3.00E+00	0.013
540	128.87	52.27	49.38432943	28.0502991	5E-04	4.00E-11	23.36	4.00E+00	0.004
600	129.9	53.3	50.29948247	28.570106	5E-04	5.00E-11	23.14	5.00E+00	0.001
660	130.45	53.85	50.78723859	28.8471515	4E-04	6.00E-11	22.96	6.00E+00	4E-04
720	131.19	54.59	51.44248405	29.2193309	4E-04	7.00E-11	22.81	7.00E+00	1E-04
780	131.5	54.9	51.71663498	29.3750487	4E-04	8.00E-11	22.67	8.00E+00	4E-05
840	132	55.4	52.15838614	29.6259633	3E-04	9.00E-11	22.55	9.00E+00	1E-05
900	132.7	56.1	52.77595057	29.9767399	3E-04	1.00E-10	22.45		
960	132.66	56.06	52.74068906	29.9567114	3E-04	2.00E-10	21.76		
1020	133.4	56.8	53.39247993	30.3269286	3E-04	3.00E-10	21.35		
1080	133.47	56.87	53.45407594	30.3619151	3E-04	4.00E-10	21.06		
1140	134.05	57.45	53.96404468	30.6515774	2E-04	5.00E-10	20.84		
1200	134.26	57.66	54.14851331	30.7563556	2E-04	6.00E-10	20.66		
1260	134.97	58.37	54.77150306	31.1102137	2E-04	7.00E-10	20.5		
1320	135.04	58.44	54.83286692	31.1450684	2E-04	8.00E-10	20.37		
1380	135.37	58.77	55.12201426	31.3093041	2E-04	9.00E-10	20.25		
1440	135.52	58.92	55.25336882	31.3839135	2E-04	1.00E-09	20.15		
1500	136.28	59.68	55.91816815	31.7615195	2E-04	2.00E-09	19.45		
1560	136.44	59.84	56.05797043	31.8409272	2E-04	3.00E-09	19.05		
1620	136.89	60.29	56.45087442	32.0640967	2E-04	4.00E-09	18.76		
1680	136.82	60.22	56.38978411	32.0293974	2E-04	5.00E-09	18.54		

1740	137.87	61.27	57.30505186	32.5492695	2E-04	6.00E-09	18.35
1800	138.11	61.51	57.51392892	32.6679116	2E-04	7.00E-09	18.2
1860	134.84	58.24	54.65751415	31.045468	2E-04	8.00E-09	18.07
1920	134.87	58.27	54.68382245	31.0604112	1E-04	9.00E-09	17.95
1980	134.76	58.16	54.58734939	31.0056145	1E-04	1.00E-08	17.48
2040	134.77	58.17	54.59612072	31.0105966	1E-04	2.00E-08	17.15
2100	137.78	61.18	57.22669159	32.5047608	1E-04	3.00E-08	16.74
2160	135.12	58.52	54.90298437	31.1848951	1E-04	4.00E-08	16.46
2220	135.07	58.47	54.85916255	31.1600043	1E-04	5.00E-08	16.23
2280	135.18	58.58	54.95556358	31.2147601	1E-04	6.00E-08	16.05
2340	135.42	58.82	55.16580439	31.3341769	1E-04	7.00E-08	15.9
2400	135.36	58.76	55.1132556	31.3043292	1E-04	8.00E-08	15.76
2460	135.87	59.27	55.55967797	31.5578971	1E-04	9.00E-08	15.65
2520	135.96	59.36	55.63840135	31.602612	1E-04	1.00E-07	15.54
2580	135.89	59.29	55.57717353	31.5678346	1E-04	2.00E-07	14.85
2640	135.99	59.39	55.66463868	31.6175148	1E-04	3.00E-07	14.44
2700	136.96	60.36	56.51195437	32.0987901	1E-04	4.00E-07	14.15
2760	136.86	60.26	56.42469413	32.0492263	1E-04	5.00E-07	13.93
2820	136.93	60.33	56.48577852	32.0839222	1E-04	6.00E-07	13.75
2880	136.94	60.34	56.49450401	32.0888783	1E-04	7.00E-07	13.6
2940	136.88	60.28	56.44214787	32.05914	1E-04	8.00E-07	13.46
3000	136.94	60.34	56.49450401	32.0888783	9E-05	9.00E-07	13.34
3060	137.45	60.85	56.93922423	32.3414794	9E-05	1.00E-06	13.24
3120	137.44	60.84	56.93050951	32.3365294	9E-05	2.00E-06	12.55
3180	137.39	60.79	56.88693272	32.3117778	9E-05	3.00E-06	12.14
3240	136.858	60.258	56.42294871	32.0482349	9E-05	4.00E-06	11.85
3300	137.414	60.814	56.90785024	32.3236589	9E-05	5.00E-06	11.63
3360	137.491	60.891	56.97495239	32.361773	8E-05	6.00E-06	11.45

3420	137.282	60.682	56.79278884	32.2583041	8E-05	7.00E-06	11.29
3480	137.494	60.894	56.9775665	32.3632578	8E-05	8.00E-06	11.16
3540	137.462	60.862	56.94968162	32.3474192	8E-05	9.00E-06	11.04
3600	138.147	61.547	57.54611997	32.6861961	8E-05	1.00E-05	10.94
3660	137.47	60.87	56.95665304	32.3513789	8E-05	2.00E-05	10.24
3720	138.132	61.532	57.53306989	32.6787837	8E-05	3.00E-05	9.84
3780	138.077	61.477	57.48521554	32.6516024	7E-05	4.00E-05	9.55
3840	137.571	60.971	57.04465564	32.4013644	7E-05	5.00E-05	9.33
3900	137.922	61.322	57.35031888	32.5749811	7E-05	6.00E-05	9.14
3960	137.486	60.886	56.97059548	32.3592982	7E-05	7.00E-05	8.99
4020	137.57	60.97	57.04378443	32.4008696	7E-05	8.00E-05	8.86
4080	137.706	61.106	57.16224922	32.4681576	7E-05	9.00E-05	8.74

Employer /Client :AAWSSA **Well ID** :BH14R **Date of Pumping** :01/-04/01/14 **Reference** :0 m	**Discharge Rate** :141 l/s **Pump Position** :188.2 m **SWL** :81.26 m

Constant Discharge Rate Test

Time since pumping started	Water Level at BH 14R (m)	Observed DD	Corrected DD	r^2/t	U	W(U)	U	W(U)
					1.00E-15	33.96	7.00E-04	6.69
0	81.26	0	0	0	2.00E-15	32.27	8.00E-04	6.55
1	91.84	10.58	2.08955	0.2704	3.00E-15	32.86	9.00E-04	6.44
2	99.65	18.39	3.632025	0.1352	4.00E-15	32.58	1.00E-03	6.33
3	99.56	18.3	3.61425	0.09013	5.00E-15	32.35	2.00E-03	5.64
4	99.67	18.41	3.635975	0.0676	6.00E-15	32.17	3.00E-03	5.23
5	99.82	18.56	3.6656	0.05408	7.00E-15	32.02	4.00E-03	4.95
6	100.08	18.82	3.71695	0.04507	8.00E-15	31.88	5.00E-03	4.73

7	100.22	18.96	3.7446	0.03863	9.00E-15	31.76	6.00E-03	4.54
8	100.28	19.02	3.75645	0.0338	1.00E-14	31.66	7.00E-03	4.39
9	100.33	19.07	3.766325	0.03004	2.00E-14	30.97	8.00E-03	4.26
10	100.38	19.12	3.7762	0.02704	3.00E-14	30.56	9.00E-03	4.14
12	100.45	19.19	3.790025	0.02253	4.00E-14	30.27	1.00E-02	4.04
14	100.46	19.2	3.792	0.01931	5.00E-14	30.05	2.00E-02	3.35
16	100.49	19.23	3.797925	0.0169	6.00E-14	29.87	3.00E-02	2.96
18	100.73	19.47	3.845325	0.01502	7.00E-14	29.71	4.00E-02	2.68
20	100.81	19.55	3.861125	0.01352	8.00E-14	29.58	5.00E-02	2.47
25	101.81	20.55	4.058625	0.01082	9.00E-14	29.46	6.00E-02	2.3
30	101.04	19.78	3.90655	0.00901	1.00E-13	29.36	7.00E-02	2.15
35	101.13	19.87	3.924325	0.00773	2.00E-13	28.66	8.00E-02	2.03
40	101.17	19.91	3.932225	0.00676	3.00E-13	28.26	9.00E-02	1.92
45	101.19	19.93	3.936175	0.00601	4.00E-13	27.97	1.00E-01	1.82
50	101.35	20.09	3.967775	0.00541	5.00E-13	27.75	2.00E-01	1.22
55	101.37	20.11	3.971725	0.00492	6.00E-13	27.56	3.00E-01	0.91
60	101.47	20.21	3.991475	0.00451	7.00E-13	27.41	4.00E-01	0.7
70	101.51	20.25	3.999375	0.00386	8.00E-13	27.28	5.00E-01	0.56
80	101.53	20.27	4.003325	0.00338	9.00E-13	27.16	6.00E-01	0.45
90	101.56	20.3	4.00925	0.003	1.00E-12	27.05	7.00E-01	0.37
100	101.58	20.32	4.0132	0.0027	2.00E-12	26.36	8.00E-01	0.31
110	87.94	5.6	1.106	0.00246	3.00E-12	25.96	9.00E-01	0.26
120	87.95	5.61	1.107975	0.00225	4.00E-12	26.67	1.00E+00	0.219
140	87.97	5.63	1.111925	0.00193	5.00E-12	25.44	2.00E+00	0.049
160	87.99	5.65	1.115875	0.00169	6.00E-12	25.26	3.00E+00	0.013
180	88.02	5.68	1.1218	0.0015	7.00E-12	25.11	4.00E+00	0.004
210	88.04	5.7	1.12575	0.00129	8.00E-12	24.97	5.00E+00	0.001
240	88.05	5.71	1.127725	0.00113	9.00E-12	24.86	6.00E+00	4E-04

270	88.06	5.72	1.1297	0.001	1.00E-11	24.75	7.00E+00	1E-04
300	88.06	5.72	1.1297	0.0009	2.00E-11	24.06	8.00E+00	4E-05
360	88.07	5.73	1.131675	0.00075	3.00E-11	23.65	9.00E+00	1E-05
420	88.1	5.76	1.1376	0.00064	4.00E-11	23.36		
480	88.12	5.78	1.14155	0.00056	5.00E-11	23.14		
540	88.14	5.8	1.1455	0.0005	6.00E-11	22.96		
600	88.15	5.81	1.147475	0.00045	7.00E-11	22.81		
660	88.16	5.82	1.14945	0.00041	8.00E-11	22.67		
720	88.18	5.84	1.1534	0.00038	9.00E-11	22.55		
780	88.2	5.86	1.15735	0.00035	1.00E-10	22.45		
840	88.2	5.86	1.15735	0.00032	2.00E-10	21.76		
900	88.2	5.86	1.15735	0.0003	3.00E-10	21.35		
960	88.2	5.86	1.15735	0.00028	4.00E-10	21.06		
1020	88.21	5.87	1.159325	0.00027	5.00E-10	20.84		
1080	88.21	5.87	1.159325	0.00025	6.00E-10	20.66		
1140	88.21	5.87	1.159325	0.00024	7.00E-10	20.5		
1200	88.23	5.89	1.163275	0.00023	8.00E-10	20.37		
1260	88.25	5.91	1.167225	0.00021	9.00E-10	20.25		
1320	88.26	5.92	1.1692	0.0002	1.00E-09	20.15		
1380	88.26	5.92	1.1692	0.0002	2.00E-09	19.45		
1440	88.27	5.93	1.171175	0.00019	3.00E-09	19.05		
1500	88.27	5.93	1.171175	0.00018	4.00E-09	18.76		
1560	88.27	5.93	1.171175	0.00017	5.00E-09	18.54		
1620	88.27	5.93	1.171175	0.00017	6.00E-09	18.35		
1680	88.28	5.94	1.17315	0.00016	7.00E-09	18.2		
1740	88.28	5.94	1.17315	0.00016	8.00E-09	18.07		
1800	88.29	5.95	1.175125	0.00015	9.00E-09	17.95		
1860	88.29	5.95	1.175125	0.00015	1.00E-08	17.48		

1920	88.29	5.95	1.175125	0.00014	2.00E-08	17.15
1980	88.3	5.96	1.1771	0.00014	3.00E-08	16.74
2040	88.3	5.96	1.1771	0.00013	4.00E-08	16.46
2100	88.3	5.96	1.1771	0.00013	5.00E-08	16.23
2160	88.32	5.98	1.18105	0.00013	6.00E-08	16.05
2220	88.32	5.98	1.18105	0.00012	7.00E-08	15.9
2280	88.32	5.98	1.18105	0.00012	8.00E-08	15.76
2340	88.33	5.99	1.183025	0.00012	9.00E-08	15.65
2400	88.33	5.99	1.183025	0.00011	1.00E-07	15.54
2460	88.33	5.99	1.183025	0.00011	2.00E-07	14.85
2520	88.33	5.99	1.183025	0.00011	3.00E-07	14.44
2580	88.33	5.99	1.183025	0.0001	4.00E-07	14.15
2640	88.34	6	1.185	0.0001	5.00E-07	13.93
2700	88.34	6	1.185	0.0001	6.00E-07	13.75
2760	88.34	6	1.185	9.8E-05	7.00E-07	13.6
2820	88.34	6	1.185	9.6E-05	8.00E-07	13.46
2880	88.34	6	1.185	9.4E-05	9.00E-07	13.34
2940	88.34	6	1.185	9.2E-05	1.00E-06	13.24
3000	88.35	6.01	1.186975	9E-05	2.00E-06	12.55
3060	88.35	6.01	1.186975	8.8E-05	3.00E-06	12.14
3120	88.35	6.01	1.186975	8.7E-05	4.00E-06	11.85
3180	88.35	6.01	1.186975	8.5E-05	5.00E-06	11.63
3240	88.35	6.01	1.186975	8.3E-05	6.00E-06	11.45
3300	88.35	6.01	1.186975	8.2E-05	7.00E-06	11.29
3360	88.35	6.01	1.186975	8E-05	8.00E-06	11.16
3420	88.35	6.01	1.186975	7.9E-05	9.00E-06	11.04
3480	88.35	6.01	1.186975	7.8E-05	1.00E-05	10.94
3540	88.36	6.02	1.18895	7.6E-05	2.00E-05	10.24

3600	88.36	6.02	1.18895	7.5E-05	3.00E-05	9.84	
3660	88.36	6.02	1.18895	7.4E-05	4.00E-05	9.55	
3720	88.36	6.02	1.18895	7.3E-05	5.00E-05	9.33	
3780	88.36	6.02	1.18895	7.2E-05	6.00E-05	9.14	
3840	88.36	6.02	1.18895	7E-05	7.00E-05	8.99	
3900	88.36	6.02	1.18895	6.9E-05	8.00E-05	8.86	
3960	88.36	6.02	1.18895	6.8E-05	9.00E-05	8.74	
4020	88.36	6.02	1.18895	6.7E-05	1.00E-04	8.63	
4080	88.36	6.02	1.18895	6.6E-05	2.00E-04	7.94	
4140	88.36	6.02	1.18895	6.5E-05	3.00E-04	7.53	
4200	88.36	6.02	1.18895	6.4E-05	4.00E-04	7.25	
4260	88.36	6.02	1.18895	6.3E-05	5.00E-04	7.02	
4320	88.36	6.02	1.18895	6.3E-05	6.00E-04	6.84	

Employer /Client :AAWSA	**Discharge Rate** :90 l/s
Well ID :BH22R	**Pump Position** :172m
Date of Pumping :30/08/2013	**SWL**:66.6m
Reference :0 m	

Constant Discharge Rate Test

Time since pumping started	BH1R Water Level (m)	Observed DD	Unconfined DD	Corrected DD	r^2/t	U	W(U)	U	W(U)
						1.00E-15	33.96	6.00E-04	6.84
0	66.66	0	0	0	0	2.00E-15	32.27	7.00E-04	6.69
1	76.09	9.49	9.37622454	4.8100032	0.2704	3.00E-15	32.86	8.00E-04	6.55
2	94.82	28.22	27.2139254	13.960744	0.1352	4.00E-15	32.58	9.00E-04	6.44
3	108.65	42.05	39.8161801	20.4257	0.090133	5.00E-15	32.35	1.00E-03	6.33
4	110.86	44.26	41.7852064	21.435811	0.0676	6.00E-15	32.17	2.00E-03	5.64
5	111.86	45.26	42.6721133	21.890794	0.05408	7.00E-15	32.02	3.00E-03	5.23

6	113.19	46.59	43.8477845	22.493913	0.045067	8.00E-15	31.88	4.00E-03	4.95
7	114	47.4	44.5616049	22.860103	0.038629	9.00E-15	31.76	5.00E-03	4.73
8	114.46	47.86	44.9662464	23.067684	0.0338	1.00E-14	31.66	6.00E-03	4.54
9	114.64	48.04	45.1244388	23.148837	0.030044	2.00E-14	30.97	7.00E-03	4.39
10	114.88	48.28	45.3352347	23.256975	0.02704	3.00E-14	30.56	8.00E-03	4.26
12	115.18	48.58	45.5985249	23.392043	0.022533	4.00E-14	30.27	9.00E-03	4.14
14	115.51	48.91	45.8878815	23.540483	0.019314	5.00E-14	30.05	1.00E-02	4.04
16	115.66	49.06	46.0193163	23.607909	0.0169	6.00E-14	29.87	2.00E-02	3.35
18	115.78	49.18	46.1244232	23.661829	0.015022	7.00E-14	29.71	3.00E-02	2.96
20	116.51	49.91	46.7630394	23.989439	0.01352	8.00E-14	29.58	4.00E-02	2.68
25	116.7	50.1	46.9290338	24.074594	0.010816	9.00E-14	29.46	5.00E-02	2.47
30	116.88	50.28	47.0862075	24.155224	0.009013	1.00E-13	29.36	6.00E-02	2.3
35	117.1	50.5	47.2781975	24.253715	0.007726	2.00E-13	28.66	7.00E-02	2.15
40	117.2	50.6	47.3654252	24.298463	0.00676	3.00E-13	28.26	8.00E-02	2.03
45	117.36	50.76	47.5049371	24.370033	0.006009	4.00E-13	27.97	9.00E-02	1.92
50	117.37	50.77	47.5136544	24.374505	0.005408	5.00E-13	27.75	1.00E-01	1.82
60	117.5	50.9	47.6269569	24.432629	0.004507	6.00E-13	27.56	2.00E-01	1.22
70	117.7	51.1	47.801185	24.522008	0.003863	7.00E-13	27.41	3.00E-01	0.91
80	117.75	51.15	47.8447262	24.544345	0.00338	8.00E-13	27.28	4.00E-01	0.7
90	117.88	51.28	47.9579039	24.602405	0.003004	9.00E-13	27.16	5.00E-01	0.56
100	117.7	51.1	47.801185	24.522008	0.002704	1.00E-12	27.05	6.00E-01	0.45
110	117.8	51.2	47.8882612	24.566678	0.002458	2.00E-12	26.36	7.00E-01	0.37
120	117.9	51.3	47.975312	24.611335	0.002253	3.00E-12	25.96	8.00E-01	0.31
140	117.9	51.3	47.975312	24.611335	0.001931	4.00E-12	26.67	9.00E-01	0.26
160	118.01	51.41	48.0710388	24.660443	0.00169	5.00E-12	25.44	1.00E+0 0	0.219
180	118.19	51.59	48.2276167	24.740767	0.001502	6.00E-12	25.26	2.00E+0 0	0.049
210	118.14	51.54	48.1841311	24.718459	0.001288	7.00E-12	25.11	3.00E+0	0.013

								0	
240	118.1	51.5	48.149338	24.70061	0.001127	8.00E-12	24.97	4.00E+00	0.0038
270	118.25	51.65	48.2797912	24.767533	0.001001	9.00E-12	24.86	5.00E+00	0.0011
300	118.23	51.63	48.2624007	24.758612	0.000901	1.00E-11	24.75	6.00E+00	0.0004
360	118.37	51.77	48.3841128	24.82105	0.000751	2.00E-11	24.06	7.00E+00	0.0001
420	118.67	52.07	48.6447576	24.954761	0.000644	3.00E-11	23.65	8.00E+00	4E-05
480	119.08	52.48	49.0006044	25.13731	0.000563	4.00E-11	23.36	9.00E+00	1E-05
540	119.05	52.45	48.9745812	25.12396	0.000501	5.00E-11	23.14		
600	119.08	52.48	49.0006044	25.13731	0.000451	6.00E-11	22.96		
660	119.2	52.6	49.1046743	25.190698	0.00041	7.00E-11	22.81		
720	119.19	52.59	49.0960032	25.18625	0.000376	8.00E-11	22.67		
780	119.35	52.75	49.2347106	25.257407	0.000347	9.00E-11	22.55		
840	119.32	52.72	49.2087079	25.244067	0.000322	1.00E-10	22.45		
900	119.46	52.86	49.3300344	25.306308	0.0003	2.00E-10	21.76		
960	119.44	52.84	49.312705	25.297418	0.000282	3.00E-10	21.35		
1020	119.47	52.87	49.3386986	25.310752	0.000265	4.00E-10	21.06		
1080	119.48	52.88	49.3473627	25.315197	0.00025	5.00E-10	20.84		
1140	119.49	52.89	49.3560265	25.319642	0.000237	6.00E-10	20.66		
1200	119.47	52.87	49.3386986	25.310752	0.000225	7.00E-10	20.5		
1260	119.43	52.83	49.30404	25.292973	0.000215	8.00E-10	20.37		
1320	119.46	52.86	49.3300344	25.306308	0.000205	9.00E-10	20.25		
1380	119.57	52.97	49.4253276	25.355193	0.000196	1.00E-09	20.15		
1440	119.59	52.99	49.4426503	25.36408	0.000188	2.00E-09	19.45		
1500	119.7	53.1	49.5379074	25.412947	0.00018	3.00E-09	19.05		
1560	119.8	53.2	49.6244782	25.457357	0.000173	4.00E-09	18.76		

1620	119.66	53.06	49.503272	25.395179	0.000167	5.00E-09	18.54
1680	119.73	53.13	49.5638813	25.426271	0.000161	6.00E-09	18.35
1740	119.69	53.09	49.529249	25.408505	0.000155	7.00E-09	18.2
1800	119.54	52.94	49.3993416	25.341862	0.00015	8.00E-09	18.07
1860	119.66	53.06	49.503272	25.395179	0.000145	9.00E-09	17.95
1920	119.67	53.07	49.5119312	25.399621	0.000141	1.00E-08	17.48
1980	119.79	53.19	49.6158223	25.452917	0.000137	2.00E-08	17.15
2040	119.92	53.32	49.7283299	25.510633	0.000133	3.00E-08	16.74
2100	119.89	53.29	49.7023704	25.497316	0.000129	4.00E-08	16.46
2160	119.88	53.28	49.6937167	25.492877	0.000125	5.00E-08	16.23
2220	119.96	53.36	49.762939	25.528388	0.000122	6.00E-08	16.05
2280	119.99	53.39	49.7888932	25.541702	0.000119	7.00E-08	15.9
2340	120.01	53.41	49.8061947	25.550578	0.000116	8.00E-08	15.76
2400	120.06	53.46	49.8494441	25.572765	0.000113	9.00E-08	15.65
2460	120.07	53.47	49.8580933	25.577202	0.00011	1.00E-07	15.54
2520	120.07	53.47	49.8580933	25.577202	0.000107	2.00E-07	14.85
2580	120.04	53.44	49.8321451	25.56389	0.000105	3.00E-07	14.44
2640	120.04	53.44	49.8321451	25.56389	0.000102	4.00E-07	14.15
2700	120.03	53.43	49.8234952	25.559453	0.0001	5.00E-07	13.93
2760	120.04	53.44	49.8321451	25.56389	9.8E-05	6.00E-07	13.75
2820	120.09	53.49	49.8753907	25.586075	9.59E-05	7.00E-07	13.6
2880	120.21	53.61	49.9791545	25.639306	9.39E-05	8.00E-07	13.46
2940	120.19	53.59	49.961863	25.630436	9.2E-05	9.00E-07	13.34
3000	120.2	53.6	49.9705089	25.634871	9.01E-05	1.00E-06	13.24
3060	120.13	53.53	49.9099827	25.603821	8.84E-05	2.00E-06	12.55
3120	120.18	53.58	49.9532169	25.626	8.67E-05	3.00E-06	12.14
3180	120.03	53.43	49.8234952	25.559453	8.5E-05	4.00E-06	11.85
3240	120.05	53.45	49.8407948	25.568328	8.35E-05	5.00E-06	11.63

3300	120.09	53.49	49.8753907	25.586075	8.19E-05	6.00E-06	11.45
3360	120.16	53.56	49.935924	25.617129	8.05E-05	7.00E-06	11.29
3420	120.04	53.44	49.8321451	25.56389	7.91E-05	8.00E-06	11.16
3480	120.18	53.58	49.9532169	25.626	7.77E-05	9.00E-06	11.04
3540	120.18	53.58	49.9532169	25.626	7.64E-05	1.00E-05	10.94
3600	120.25	53.65	50.0137343	25.657046	7.51E-05	2.00E-05	10.24
3660	120.33	53.73	50.0828818	25.692518	7.39E-05	3.00E-05	9.84
3720	120.26	53.66	50.0223786	25.66148	7.27E-05	4.00E-05	9.55
3780	120.26	53.66	50.0223786	25.66148	7.15E-05	5.00E-05	9.33
3840	120.32	53.72	50.0742392	25.688085	7.04E-05	6.00E-05	9.14
3900	120.24	53.64	50.0050897	25.652611	6.93E-05	7.00E-05	8.99
3960	120.33	53.73	50.0828818	25.692518	6.83E-05	8.00E-05	8.86
4020	120.34	53.74	50.0915241	25.696952	6.73E-05	9.00E-05	8.74
4080	120.32	53.72	50.0742392	25.688085	6.63E-05	1.00E-04	8.63
4140	120.28	53.68	50.0396665	25.670349	6.53E-05	2.00E-04	7.94
4200	120.32	53.72	50.0742392	25.688085	6.44E-05	3.00E-04	7.53
4260	120.27	53.67	50.0310227	25.665915	6.35E-05	4.00E-04	7.25
4320	120.38	53.78	50.1260908	25.714685	6.26E-05	5.00E-04	7.02

Employer /Client :AAWSA **Well ID** :BH23R **Date of Pumping** :1-4/12/2015 **Reference** :0 m	**Discharge Rate** :47.67 l/s **Pump Position** :180m **SWL** :71.06 m

Constant Discharge Rate Test

Time since pumping started	BH23R Water Level (m)	Observed DD	Corrected DD	r^2/t	U	W(U)	U	W(U)
					1.00E-15	33.96	6.00E-04	6.84
0	71.06	0	0	0	2.00E-15	32.27	7.00E-04	6.69
1	101.47	30.41	52.9134	0.2401	3.00E-15	32.86	8.00E-04	6.55

2	112.72	41.66	72.4884	0.12005	4.00E-15	32.58	9.00E-04	6.44
3	123.22	52.16	90.7584	0.08003	5.00E-15	32.35	1.00E-03	6.33
4	130.34	59.28	103.1472	0.06003	6.00E-15	32.17	2.00E-03	5.64
5	136.63	65.57	114.0918	0.04802	7.00E-15	32.02	3.00E-03	5.23
6	144.16	73.1	127.194	0.04002	8.00E-15	31.88	4.00E-03	4.95
7	144.2	73.14	127.2636	0.0343	9.00E-15	31.76	5.00E-03	4.73
8	143.51	72.45	126.063	0.03001	1.00E-14	31.66	6.00E-03	4.54
9	143.88	72.82	126.7068	0.02668	2.00E-14	30.97	7.00E-03	4.39
10	145.66	74.6	129.804	0.02401	3.00E-14	30.56	8.00E-03	4.26
12	146.43	75.37	131.1438	0.02001	4.00E-14	30.27	9.00E-03	4.14
14	147.92	76.86	133.7364	0.01715	5.00E-14	30.05	1.00E-02	4.04
16	148.18	77.12	134.1888	0.01501	6.00E-14	29.87	2.00E-02	3.35
18	148.55	77.49	134.8326	0.01334	7.00E-14	29.71	3.00E-02	2.96
20	149	77.94	135.6156	0.01201	8.00E-14	29.58	4.00E-02	2.68
25	150.51	79.45	138.243	0.0096	9.00E-14	29.46	5.00E-02	2.47
30	149.9	78.84	137.1816	0.008	1.00E-13	29.36	6.00E-02	2.3
35	149.87	78.81	137.1294	0.00686	2.00E-13	28.66	7.00E-02	2.15
40	148.85	77.79	135.3546	0.006	3.00E-13	28.26	8.00E-02	2.03
45	148.26	77.2	134.328	0.00534	4.00E-13	27.97	9.00E-02	1.92
50	149.08	78.02	135.7548	0.0048	5.00E-13	27.75	1.00E-01	1.82
55	149	77.94	135.6156	0.00437	6.00E-13	27.56	2.00E-01	1.22
60	148.77	77.71	135.2154	0.004	7.00E-13	27.41	3.00E-01	0.91
70	148.86	77.8	135.372	0.00343	8.00E-13	27.28	4.00E-01	0.7
80	149.33	78.27	136.1898	0.003	9.00E-13	27.16	5.00E-01	0.56
90	149.37	78.31	136.2594	0.00267	1.00E-12	27.05	6.00E-01	0.45
100	146.64	75.58	131.5092	0.0024	2.00E-12	26.36	7.00E-01	0.37
120	148.57	77.51	134.8674	0.002	3.00E-12	25.96	8.00E-01	0.31
140	148.03	76.97	133.9278	0.00172	4.00E-12	26.67	9.00E-01	0.26

160	148.6	77.54	134.9196	0.0015	5.00E-12	25.44	1.00E+00	0.219
180	148.35	77.29	134.4846	0.00133	6.00E-12	25.26	2.00E+00	0.049
210	148.25	77.19	134.3106	0.00114	7.00E-12	25.11	3.00E+00	0.013
240	150.42	79.36	138.0864	0.001	8.00E-12	24.97	4.00E+00	0.0038
270	146.12	75.06	130.6044	0.00089	9.00E-12	24.86	5.00E+00	0.0011
300	148.97	77.91	135.5634	0.0008	1.00E-11	24.75	6.00E+00	0.00036
360	146.4	75.34	131.0916	0.00067	2.00E-11	24.06	7.00E+00	0.00012
420	146.77	75.71	131.7354	0.00057	3.00E-11	23.65	8.00E+00	3.8E-05
480	148.8	77.74	135.2676	0.0005	4.00E-11	23.36	9.00E+00	1.2E-05
540	149.5	78.44	136.4856	0.00044	5.00E-11	23.14		
600	146.92	75.86	131.9964	0.0004	6.00E-11	22.96		
660	147.92	76.86	133.7364	0.00036	7.00E-11	22.81		
720	146.81	75.75	131.805	0.00033	8.00E-11	22.67		
780	146.6	75.54	131.4396	0.00031	9.00E-11	22.55		
840	147.05	75.99	132.2226	0.00029	1.00E-10	22.45		
900	147	75.94	132.1356	0.00027	2.00E-10	21.76		
960	147.55	76.49	133.0926	0.00025	3.00E-10	21.35		
1020	148.74	77.68	135.1632	0.00024	4.00E-10	21.06		
1080	147.1	76.04	132.3096	0.00022	5.00E-10	20.84		
1140	146.55	75.49	131.3526	0.00021	6.00E-10	20.66		
1200	146.5	75.44	131.2656	0.0002	7.00E-10	20.5		
1260	148.6	77.54	134.9196	0.00019	8.00E-10	20.37		
1320	149.78	78.72	136.9728	0.00018	9.00E-10	20.25		
1380	149.89	78.83	137.1642	0.00017	1.00E-09	20.15		
1440	149.68	78.62	136.7988	0.00017	2.00E-09	19.45		
1500	149.7	78.64	136.8336	0.00016	3.00E-09	19.05		
1560	147.3	76.24	132.6576	0.00015	4.00E-09	18.76		
1620	147.8	76.74	133.5276	0.00015	5.00E-09	18.54		

1680	147.56	76.5	133.11	0.00014	6.00E-09	18.35
1740	148.3	77.24	134.3976	0.00014	7.00E-09	18.2
1800	149.65	78.59	136.7466	0.00013	8.00E-09	18.07
1860	150.43	79.37	138.1038	0.00013	9.00E-09	17.95
1920	148.8	77.74	135.2676	0.00013	1.00E-08	17.48
1980	150.91	79.85	138.939	0.00012	2.00E-08	17.15
2040	150.29	79.23	137.8602	0.00012	3.00E-08	16.74
2100	150.55	79.49	138.3126	0.00011	4.00E-08	16.46
2160	148.05	76.99	133.9626	0.00011	5.00E-08	16.23
2220	150.47	79.41	138.1734	0.00011	6.00E-08	16.05
2280	147.88	76.82	133.6668	0.00011	7.00E-08	15.9
2340	147.3	76.24	132.6576	0.0001	8.00E-08	15.76
2400	150.85	79.79	138.8346	0.0001	9.00E-08	15.65
2460	149.22	78.16	135.9984	9.8E-05	1.00E-07	15.54
2520	147.3	76.24	132.6576	9.5E-05	2.00E-07	14.85
2580	147.18	76.12	132.4488	9.3E-05	3.00E-07	14.44
2640	147.46	76.4	132.936	9.1E-05	4.00E-07	14.15
2700	149.85	78.79	137.0946	8.9E-05	5.00E-07	13.93
2760	150.2	79.14	137.7036	8.7E-05	6.00E-07	13.75
2820	150.1	79.04	137.5296	8.5E-05	7.00E-07	13.6
2880	150.08	79.02	137.4948	8.3E-05	8.00E-07	13.46
2940	150.18	79.12	137.6688	8.2E-05	9.00E-07	13.34
3000	150.58	79.52	138.3648	8E-05	1.00E-06	13.24
3060	147.55	76.49	133.0926	7.8E-05	2.00E-06	12.55
3120	147.26	76.2	132.588	7.7E-05	3.00E-06	12.14
3180	147.28	76.22	132.6228	7.6E-05	4.00E-06	11.85
3240	150.2	79.14	137.7036	7.4E-05	5.00E-06	11.63
3300	149.63	78.57	136.7118	7.3E-05	6.00E-06	11.45

3360	150.74	79.68	138.6432	7.1E-05	7.00E-06	11.29	
3420	150.1	79.04	137.5296	7E-05	8.00E-06	11.16	
3480	150.18	79.12	137.6688	6.9E-05	9.00E-06	11.04	
3540	150.16	79.1	137.634	6.8E-05	1.00E-05	10.94	
3600	150.12	79.06	137.5644	6.7E-05	2.00E-05	10.24	
3660	150.17	79.11	137.6514	6.6E-05	3.00E-05	9.84	
3720	150.2	79.14	137.7036	6.5E-05	4.00E-05	9.55	
3780	150.11	79.05	137.547	6.4E-05	5.00E-05	9.33	
3840	149.79	78.73	136.9902	6.3E-05	6.00E-05	9.14	
3900	149.82	78.76	137.0424	6.2E-05	7.00E-05	8.99	
3960	149.83	78.77	137.0598	6.1E-05	8.00E-05	8.86	
4020	149.77	78.71	136.9554	6E-05	9.00E-05	8.74	
4080	149.89	78.83	137.1642	5.9E-05	1.00E-04	8.63	
4140	149.84	78.78	137.0772	5.8E-05	2.00E-04	7.94	
4200	149.82	78.76	137.0424	5.7E-05	3.00E-04	7.53	
4260	149.93	78.87	137.2338	5.6E-05	4.00E-04	7.25	
4320	149.76	78.7	136.938	5.6E-05	5.00E-04	7.02	

Employer /Client :AAWSA	**Discharge Rate** :90 l/s
Well ID :BH26R	**Pump Position** :240 m
Date of Pumping :23/07/2015	**SWL** :72.8m
Reference :0 m	

Constant Discharge Rate Test

Time since pumping started	BH26R Water Level (m)	Observed DD	Corrected DD	r^2/t	U	W(U)	U	W(U)
					1.00E-15	33.96	6.00E-04	6.84
1	113.1	40.3	22.99518	0.52	2.00E-15	32.27	7.00E-04	6.69
2	116.42	43.62	24.88957	0.26	3.00E-15	32.86	8.00E-04	6.55
3	119.2	46.4	26.47584	0.173333	4.00E-15	32.58	9.00E-04	6.44

4	121.15	48.35	27.58851	0.13	5.00E-15	32.35	1.00E-03	6.33
5	121.66	48.86	27.87952	0.104	6.00E-15	32.17	2.00E-03	5.64
6	121.91	49.11	28.02217	0.086667	7.00E-15	32.02	3.00E-03	5.23
7	122.17	49.37	28.17052	0.074286	8.00E-15	31.88	4.00E-03	4.95
8	122.57	49.77	28.39876	0.065	9.00E-15	31.76	5.00E-03	4.73
9	122.67	49.87	28.45582	0.057778	1.00E-14	31.66	6.00E-03	4.54
10	122.68	49.88	28.46153	0.052	2.00E-14	30.97	7.00E-03	4.39
12	122.89	50.09	28.58135	0.043333	3.00E-14	30.56	8.00E-03	4.26
14	122.95	50.15	28.61559	0.037143	4.00E-14	30.27	9.00E-03	4.14
16	123.31	50.51	28.82101	0.0325	5.00E-14	30.05	1.00E-02	4.04
18	123.34	50.54	28.83812	0.028889	6.00E-14	29.87	2.00E-02	3.35
20	123.73	50.93	29.06066	0.026	7.00E-14	29.71	3.00E-02	2.96
25	123.92	51.12	29.16907	0.0208	8.00E-14	29.58	4.00E-02	2.68
30	124.67	51.87	29.59702	0.017333	9.00E-14	29.46	5.00E-02	2.47
35	124.89	52.09	29.72255	0.014857	1.00E-13	29.36	6.00E-02	2.3
40	125.06	52.26	29.81956	0.013	2.00E-13	28.66	7.00E-02	2.15
45	125.24	52.44	29.92226	0.011556	3.00E-13	28.26	8.00E-02	2.03
50	125.35	52.55	29.98503	0.0104	4.00E-13	27.97	9.00E-02	1.92
55	125.49	52.69	30.06491	0.009455	5.00E-13	27.75	1.00E-01	1.82
60	125.58	52.78	30.11627	0.008667	6.00E-13	27.56	2.00E-01	1.22
70	125.93	53.13	30.31598	0.007429	7.00E-13	27.41	3.00E-01	0.91
80	125.97	53.17	30.3388	0.0065	8.00E-13	27.28	4.00E-01	0.7
90	126.02	53.22	30.36733	0.005778	9.00E-13	27.16	5.00E-01	0.56
100	126.55	53.75	30.66975	0.0052	1.00E-12	27.05	6.00E-01	0.45
110	126.75	53.95	30.78387	0.004727	2.00E-12	26.36	7.00E-01	0.37
120	126.87	54.07	30.85234	0.004333	3.00E-12	25.96	8.00E-01	0.31
140	127.06	54.26	30.96076	0.003714	4.00E-12	26.67	9.00E-01	0.26
160	127.15	54.35	31.01211	0.00325	5.00E-12	25.44	1.00E+00	0.219

180	127.37	54.57	31.13764	0.002889	6.00E-12	25.26	2.00E+00	0.049
210	127.38	54.58	31.14335	0.002476	7.00E-12	25.11	3.00E+00	0.013
240	127.48	54.68	31.20041	0.002167	8.00E-12	24.97	4.00E+00	0.0038
270	127.5	54.7	31.21182	0.001926	9.00E-12	24.86	5.00E+00	0.0011
300	127.51	54.71	31.21753	0.001733	1.00E-11	24.75	6.00E+00	0.00036
360	127.94	55.14	31.46288	0.001444	2.00E-11	24.06	7.00E+00	0.00012
420	127.97	55.17	31.48	0.001238	3.00E-11	23.65	8.00E+00	3.8E-05
480	128.09	55.29	31.54847	0.001083	4.00E-11	23.36	9.00E+00	1.2E-05
540	128.28	55.48	31.65689	0.000963	5.00E-11	23.14		
600	128.34	55.54	31.69112	0.000867	6.00E-11	22.96		
660	128.38	55.58	31.71395	0.000788	7.00E-11	22.81		
720	128.4	55.6	31.72536	0.000722	8.00E-11	22.67		
780	128.43	55.63	31.74248	0.000667	9.00E-11	22.55		
840	128.58	55.78	31.82807	0.000619	1.00E-10	22.45		
900	128.62	55.82	31.85089	0.000578	2.00E-10	21.76		
960	128.64	55.84	31.8623	0.000542	3.00E-10	21.35		
1020	128.67	55.87	31.87942	0.00051	4.00E-10	21.06		
1080	128.71	55.91	31.90225	0.000481	5.00E-10	20.84		
1140	128.75	55.95	31.92507	0.000456	6.00E-10	20.66		
1200	128.82	56.02	31.96501	0.000433	7.00E-10	20.5		
1260	128.94	56.14	32.03348	0.000413	8.00E-10	20.37		
1320	128.96	56.16	32.0449	0.000394	9.00E-10	20.25		
1380	129.01	56.21	32.07343	0.000377	1.00E-09	20.15		
1440	129.03	56.23	32.08484	0.000361	2.00E-09	19.45		
1500	129.08	56.28	32.11337	0.000347	3.00E-09	19.05		
1560	129.28	56.48	32.22749	0.000333	4.00E-09	18.76		
1620	129.34	56.54	32.26172	0.000321	5.00E-09	18.54		
1680	129.36	56.56	32.27314	0.00031	6.00E-09	18.35		

1740	129.45	56.65	32.32449	0.000299	7.00E-09	18.2
1800	129.48	56.68	32.34161	0.000289	8.00E-09	18.07
1860	129.5	56.7	32.35302	0.00028	9.00E-09	17.95
1920	129.55	56.75	32.38155	0.000271	1.00E-08	17.48
1980	129.73	56.93	32.48426	0.000263	2.00E-08	17.15
2040	129.93	57.13	32.59838	0.000255	3.00E-08	16.74
2100	129.96	57.16	32.6155	0.000248	4.00E-08	16.46
2160	130.07	57.27	32.67826	0.000241	5.00E-08	16.23
2220	130.19	57.39	32.74673	0.000234	6.00E-08	16.05
2280	130.22	57.42	32.76385	0.000228	7.00E-08	15.9
2340	130.23	57.43	32.76956	0.000222	8.00E-08	15.76
2400	130.28	57.48	32.79809	0.000217	9.00E-08	15.65
2460	130.25	57.45	32.78097	0.000211	1.00E-07	15.54
2520	130.26	57.46	32.78668	0.000206	2.00E-07	14.85
2580	130.35	57.55	32.83803	0.000202	3.00E-07	14.44
2640	130.35	57.55	32.83803	0.000197	4.00E-07	14.15
2700	130.35	57.55	32.83803	0.000193	5.00E-07	13.93
2760	130.35	57.55	32.83803	0.000188	6.00E-07	13.75
2820	130.36	57.56	32.84374	0.000184	7.00E-07	13.6
2880	130.4	57.6	32.86656	0.000181	8.00E-07	13.46
2940	130.2	57.4	32.75244	0.000177	9.00E-07	13.34
3000	130.17	57.37	32.73532	0.000173	1.00E-06	13.24
3060	130.14	57.34	32.7182	0.00017	2.00E-06	12.55
3120	130.18	57.38	32.74103	0.000167	3.00E-06	12.14
3180	130.18	57.38	32.74103	0.000164	4.00E-06	11.85
3240	130.18	57.38	32.74103	0.00016	5.00E-06	11.63
3300	130.18	57.38	32.74103	0.000158	6.00E-06	11.45
3360	130.18	57.38	32.74103	0.000155	7.00E-06	11.29

3420	130.18	57.38	32.74103	0.000152	8.00E-06	11.16	
3480	130.24	57.44	32.77526	0.000149	9.00E-06	11.04	
3540	130.26	57.46	32.78668	0.000147	1.00E-05	10.94	
3600	130.31	57.51	32.81521	0.000144	2.00E-05	10.24	
3660	130.31	57.51	32.81521	0.000142	3.00E-05	9.84	
3720	130.32	57.52	32.82091	0.00014	4.00E-05	9.55	
3780	130.32	57.52	32.82091	0.000138	5.00E-05	9.33	
3840	130.44	57.64	32.88938	0.000135	6.00E-05	9.14	
3900	130.52	57.72	32.93503	0.000133	7.00E-05	8.99	
3960	130.52	57.72	32.93503	0.000131	8.00E-05	8.86	
4020	130.52	57.72	32.93503	0.000129	9.00E-05	8.74	
4080	130.54	57.74	32.94644	0.000127	1.00E-04	8.63	
4140	130.54	57.74	32.94644	0.000126	2.00E-04	7.94	
4200	130.62	57.82	32.99209	0.000124	3.00E-04	7.53	
4260	130.56	57.76	32.95786	0.000122	4.00E-04	7.25	
4320	130.56	57.76	32.95786	0.00012	5.00E-04	7.02	

APPENDIX-10:-SUMMERY OF RECOVERY TEST RESULT

Employer /Client :AAWSA **Well ID** :BH1R **Date of Pumping** :12-16/06/2015 **Reference** :0 m	**Discharge Rate** :126 l/s **Pump Position** :203 m **SWL** :83.67 m

Recovery of Constant Rate Test

Time since pumping started	BH1R Water Level (m)	Observed DD	Unconfined DD	Corrected DD	t/t'
0	83.67	0	0	**0**	0
1	105.4	21.73	21.18890393	**11.42081922**	4320
2	132.92	49.25	46.47049538	**25.04759701**	2160
3	135.12	51.45	48.4166279	**26.09656244**	1440
4	135.51	51.84	48.76046662	**26.28189151**	1080
5	135.86	52.19	49.06874304	**26.4480525**	864
6	136.02	52.35	49.20957589	**26.52396141**	720
7	136.27	52.6	49.42950977	**26.64250577**	617.142857
8	136.4	52.73	49.54381878	**26.70411832**	540
9	136.51	52.84	49.64051154	**26.75623572**	480
10	136.52	52.85	49.64930041	**26.76097292**	432
12	136.65	52.98	49.76353494	**26.82254533**	360
14	136.99	53.32	50.06211904	**26.98348216**	308.571429
16	137.16	53.49	50.21131174	**27.06389703**	270
18	137.44	53.77	50.4568965	**27.19626721**	240
20	137.44	53.77	50.4568965	**27.19626721**	216
25	137.63	53.96	50.62344097	**27.28603468**	172.8
30	137.71	54.04	50.69354021	**27.32381817**	144
35	137.71	54.04	50.69354021	**27.32381817**	123.428571
40	137.77	54.1	50.74610501	**27.3521506**	108
45	137.82	54.15	50.78990271	**27.37575756**	96
50	137.82	54.15	50.78990271	**27.37575756**	86.4
55	138.02	54.35	50.96503621	**27.47015452**	78.5454545
60	137.89	54.22	50.85120986	**27.40880212**	72
70	137.93	54.26	50.88623748	**27.427682**	61.7142857
80	137.89	54.22	50.85120986	**27.40880212**	54
90	137.8	54.13	50.77238432	**27.36631515**	48
100	137.88	54.21	50.84245239	**27.40408184**	43.2
110	137.74	54.07	50.71982364	**27.33798494**	39.2727273
120	137.54	53.87	50.5445618	**27.24351881**	36
140	137.35	53.68	50.37797814	**27.15373022**	30.8571429
160	137.28	53.61	50.31658435	**27.12063897**	27
180	137.13	53.46	50.18498843	**27.04970876**	24
210	136.97	53.3	50.0445626	**26.97401924**	20.5714286
240	136.76	53.09	49.86016467	**26.87462876**	18

270	136.37	52.7	49.51744322	**26.6899019**	16
300	136.32	52.65	49.47347936	**26.66620538**	14.4
330	136.38	52.71	49.5262353	**26.69464083**	13.0909091
360	138.42	54.75	51.31502819	**27.65880019**	12
420	139.4	55.73	52.17095879	**28.12014679**	10.2857143
480	138.9	55.23	51.73453453	**27.88491411**	9
540	139.17	55.5	51.97027479	**28.01197811**	8
600	139.14	55.47	51.94408968	**27.99786434**	7.2
660	138.83	55.16	51.67338941	**27.85195689**	6.54545455
720	138.96	55.29	51.78693569	**27.91315834**	6
780	138.63	54.96	51.49862719	**27.75776005**	5.53846154
840	138.73	55.06	51.58601976	**27.80486465**	5.14285714
900	138.66	54.99	51.52484736	**27.77189273**	4.8
960	138.67	55	51.53358696	**27.77660337**	4.5
1020	138.23	54.56	51.14882772	**27.56921814**	4.23529412
1080	138.48	54.81	51.36749536	**27.68708**	4
1140	139.51	55.84	52.26689524	**28.17185653**	3.78947368
1200	139.88	56.21	52.58938705	**28.34567962**	3.6
1260	139.23	55.56	52.02263883	**28.04020233**	3.42857143
1320	138.63	54.96	51.49862719	**27.75776005**	3.27272727
1380	138.59	54.92	51.46366374	**27.73891476**	3.13043478
1440	138.47	54.8	51.3587514	**27.68236701**	3
1500	138.42	54.75	51.31502819	**27.65880019**	2.88
1560	137.83	54.16	50.79866156	**27.38047858**	2.76923077
1620	137.9	54.23	50.85996711	**27.41352227**	2.66666667
1680	137.58	53.91	50.5796215	**27.26241599**	2.57142857
1740	136.94	53.27	50.01822623	**26.95982394**	2.48275862
1800	136.94	53.27	50.01822623	**26.95982394**	2.4
1860	136.33	52.66	49.48227259	**26.67094493**	2.32258065
1920	136.79	53.12	49.88651342	**26.88883073**	2.25
1980	136.35	52.68	49.49985836	**26.68042366**	2.18181818
2040	137.98	54.31	50.93001685	**27.45127908**	2.11764706
2100	139.1	55.43	51.90917299	**27.97904424**	2.05714286
2160	138.77	55.1	51.62097037	**27.82370303**	2
2220	138.88	55.21	51.71706564	**27.87549838**	1.94594595
2280	138.75	55.08	51.60349552	**27.81428408**	1.89473684
2340	138.85	55.18	51.69086059	**27.86137386**	1.84615385
2400	138.72	55.05	51.57728153	**27.80015474**	1.8
2460	138.22	54.55	51.14007804	**27.56450206**	1.75609756
2520	138.35	54.68	51.25380606	**27.62580147**	1.71428571
2580	138.43	54.76	51.32377329	**27.6635138**	1.6744186

2640	138.54	54.87	51.41995428	**27.71535536**	1.63636364
2700	138.23	54.56	51.14882772	**27.56921814**	1.6
2760	138.41	54.74	51.30628286	**27.65408646**	1.56521739
2820	137.33	53.66	50.3604382	**27.14427619**	1.53191489
2880	137.29	53.62	50.32535558	**27.12536666**	1.5
2940	138.32	54.65	51.22756457	**27.6116573**	1.46938776
3000	138.25	54.58	51.1663264	**27.57864993**	1.44
3060	138.29	54.62	51.20132102	**27.59751203**	1.41176471
3120	138.23	54.56	51.14882772	**27.56921814**	1.38461538
3180	138.18	54.51	51.10507701	**27.54563651**	1.35849057
3240	137.74	54.07	50.71982364	**27.33798494**	1.33333333
3300	137.54	53.87	50.5445618	**27.24351881**	1.30909091
3360	137.07	53.4	50.13233562	**27.0213289**	1.28571429
3420	138.5	54.83	51.38498258	**27.69650561**	1.26315789
3480	138.53	54.86	51.4112117	**27.7106431**	1.24137931
3540	138.18	54.51	51.10507701	**27.54563651**	1.22033898
3600	138.06	54.39	51.00005191	**27.48902798**	1.2
3660	138.13	54.46	51.06132056	**27.52205178**	1.18032787
3720	138.15	54.48	51.07882383	**27.53148604**	1.16129032
3780	138.16	54.49	51.08757512	**27.53620299**	1.14285714
3840	138.06	54.39	51.00005191	**27.48902798**	1.125
3900	138.28	54.61	51.19257271	**27.59279669**	1.10769231
3960	138.26	54.59	51.1750754	**27.58336564**	1.09090909
4020	138.02	54.35	50.96503621	**27.47015452**	1.07462687
4080	137.98	54.31	50.93001685	**27.45127908**	1.05882353
4140	137.43	53.76	50.44812871	**27.19154137**	1.04347826
4200	137.28	53.61	50.31658435	**27.12063897**	1.02857143
4260	136.97	53.3	50.0445626	**26.97401924**	1.01408451
4320	136.6	52.93	49.71960317	**26.79886611**	1

Employer /Client :AAWSSA
Well ID :BH10R
Date of Pumping :16/-19/10/13
Reference :0 m

Discharge Rate :150 l/s
Pump Position :210 m
SWL :95.33 m

Recovery of Constant Rate Test

Time since pumping started	BH10 R Water Level (m)	Observed DD	Corrected DD	t/t'
0	95.33	0	**0**	0
1	96.84	1.51	**0.657605**	5820
2	98.41	3.08	**1.34134**	2910
3	98.72	3.39	**1.476345**	1940
4	98.67	3.34	**1.45457**	1455

5	98.81	3.48	**1.51554**	1164
6	98.72	3.39	**1.476345**	970
7	98.93	3.6	**1.5678**	831.4285714
8	98.82	3.49	**1.519895**	727.5
9	98.81	3.48	**1.51554**	646.6666667
10	98.89	3.56	**1.55038**	582
12	98.93	3.6	**1.5678**	485
14	98.85	3.52	**1.53296**	415.7142857
16	99.03	3.7	**1.61135**	363.75
18	99.06	3.73	**1.624415**	323.3333333
20	99.12	3.79	**1.650545**	291
25	99.07	3.74	**1.62877**	232.8
30	99.26	3.93	**1.711515**	194
35	99.16	3.83	**1.667965**	166.2857143
40	99.25	3.92	**1.70716**	145.5
45	99.33	4	**1.742**	129.3333333
50	99.36	4.03	**1.755065**	116.4
55	99.21	3.88	**1.68974**	105.8181818
60	99.28	3.95	**1.720225**	97
70	99.29	3.96	**1.72458**	83.14285714
80	99.32	3.99	**1.737645**	72.75
90	99.45	4.12	**1.79426**	64.66666667
100	99.41	4.08	**1.77684**	58.2
120	99.57	4.24	**1.84652**	48.5
140	99.32	3.99	**1.737645**	41.57142857
160	99.41	4.08	**1.77684**	36.375
180	99.62	4.29	**1.868295**	32.33333333
210	99.56	4.23	**1.842165**	27.71428571
240	99.64	4.31	**1.877005**	24.25
270	99.64	4.31	**1.877005**	21.55555556
300	99.6	4.27	**1.859585**	19.4
360	99.93	4.6	**2.0033**	16.16666667
420	99.91	4.58	**1.99459**	13.85714286
480	99.92	4.59	**1.998945**	12.125
540	99.94	4.61	**2.007655**	10.77777778
600	99.85	4.52	**1.96846**	9.7
660	99.81	4.48	**1.95104**	8.818181818
720	100.06	4.73	**2.059915**	8.083333333
780	100.01	4.68	**2.03814**	7.461538462
840	100.09	4.76	**2.07298**	6.928571429
900	100.27	4.94	**2.15137**	6.466666667

960	99.95	4.62	**2.01201**	6.0625
1020	100.14	4.81	**2.094755**	5.705882353
1080	100.01	4.68	**2.03814**	5.388888889
1140	100.1	4.77	**2.077335**	5.105263158
1200	100	4.67	**2.033785**	4.85
1260	100.3	4.97	**2.164435**	4.619047619
1320	99.97	4.64	**2.02072**	4.409090909
1380	100.2	4.87	**2.120885**	4.217391304
1440	100.31	4.98	**2.16879**	4.041666667
1500	100.11	4.78	**2.08169**	3.88
1560	100.04	4.71	**2.051205**	3.730769231
1620	100.27	4.94	**2.15137**	3.592592593
1680	100.22	4.89	**2.129595**	3.464285714
1740	100.11	4.78	**2.08169**	3.344827586
1800	100.39	5.06	**2.20363**	3.233333333
1860	100.36	5.03	**2.190565**	3.129032258
1920	100.15	4.82	**2.09911**	3.03125
1980	100.4	5.07	**2.207985**	2.939393939
2040	100.42	5.09	**2.216695**	2.852941176
2100	100.49	5.16	**2.24718**	2.771428571
2160	100.33	5	**2.1775**	2.694444444
2220	100.34	5.01	**2.181855**	2.621621622
2280	100.51	5.18	**2.25589**	2.552631579
2340	100.31	4.98	**2.16879**	2.487179487
2400	100.35	5.02	**2.18621**	2.425
2460	100.26	4.93	**2.147015**	2.365853659
2520	100.36	5.03	**2.190565**	2.30952381
2580	100.52	5.19	**2.260245**	2.255813953
2640	100.32	4.99	**2.173145**	2.204545455
2700	100.7	5.37	**2.338635**	2.155555556
2760	100.3	4.97	**2.164435**	2.108695652
2820	100.44	5.11	**2.225405**	2.063829787
2880	100.53	5.2	**2.2646**	2.020833333
2940	100.64	5.31	**2.312505**	1.979591837
3000	100.61	5.28	**2.29944**	1.94
3060	100.62	5.29	**2.303795**	1.901960784
3120	100.42	5.09	**2.216695**	1.865384615
3180	100.62	5.29	**2.303795**	1.830188679
3240	100.37	5.04	**2.19492**	1.796296296
3300	100.55	5.22	**2.27331**	1.763636364
3360	100.62	5.29	**2.303795**	1.732142857

3420	100.62	5.29	**2.303795**	1.701754386
3480	100.66	5.33	**2.321215**	1.672413793
3540	100.68	5.35	**2.329925**	1.644067797
3600	100.68	5.35	**2.329925**	1.616666667
3660	100.63	5.3	**2.30815**	1.590163934
3720	100.7	5.37	**2.338635**	1.564516129
3780	100.62	5.29	**2.303795**	1.53968254
3840	100.48	5.15	**2.242825**	1.515625
3900	100.48	5.15	**2.242825**	1.492307692
3960	100.75	5.42	**2.36041**	1.46969697
4020	100.66	5.33	**2.321215**	1.447761194
4080	100.68	5.35	**2.329925**	1.426470588
4140	100.57	5.24	**2.28202**	1.405797101
4200	100.75	5.42	**2.36041**	1.385714286
4260	100.61	5.28	**2.29944**	1.366197183
4320	100.74	5.41	**2.356055**	1.347222222
4380	100.87	5.54	**2.41267**	1.328767123
4440	100.83	5.5	**2.39525**	1.310810811
4500	100.77	5.44	**2.36912**	1.293333333
4560	100.7	5.37	**2.338635**	1.276315789
4620	100.59	5.26	**2.29073**	1.25974026
4680	100.71	5.38	**2.34299**	1.243589744
4740	100.89	5.56	**2.42138**	1.227848101
4800	100.86	5.53	**2.408315**	1.2125
4860	100.52	5.19	**2.260245**	1.197530864
4920	100.9	5.57	**2.425735**	1.182926829
4980	100.83	5.5	**2.39525**	1.168674699
5040	100.59	5.26	**2.29073**	1.154761905
5100	100.68	5.35	**2.329925**	1.141176471
5160	100.92	5.59	**2.434445**	1.127906977
5220	100.75	5.42	**2.36041**	1.114942529
5280	100.67	5.34	**2.32557**	1.102272727
5340	100.89	5.56	**2.42138**	1.08988764
5400	100.64	5.31	**2.312505**	1.077777778
5460	100.81	5.48	**2.38654**	1.065934066
5520	100.53	5.2	**2.2646**	1.054347826
5580	100.88	5.55	**2.417025**	1.043010753
5640	100.7	5.37	**2.338635**	1.031914894
5700	100.61	5.28	**2.29944**	1.021052632
5760	100.69	5.36	**2.33428**	1.010416667
5820	100.71	5.38	**2.34299**	1

Employer /Client :AAWSSA | **Discharge Rate** :152 l/s

Well ID :BH11R **Date of Pumping** :27/-30/11/13 **Reference** :0 m	**Pump Position** :182.88 m **SWL** :82.34 m

Recovery of Constant Rate Test				
Time since pumping started	**Water Level (m)**	**Observed DD**	**Corrected DD**	**t/t'**
0	82.34	0	**0**	0
1	87.17	4.83	**1.331631**	4320
2	87.6	5.26	**1.450182**	2160
3	87.64	5.3	**1.46121**	1440
4	87.67	5.33	**1.469481**	1080
5	87.69	5.35	**1.474995**	864
6	87.7	5.36	**1.477752**	720
7	87.7	5.36	**1.477752**	617.142857
8	87.7	5.36	**1.477752**	540
9	87.71	5.37	**1.480509**	480
10	87.71	5.37	**1.480509**	432
12	87.71	5.37	**1.480509**	360
14	87.73	5.39	**1.486023**	308.571428
16	87.74	5.4	**1.48878**	270
18	87.74	5.4	**1.48878**	240
20	87.74	5.4	**1.48878**	216
25	87.76	5.42	**1.494294**	172.8
30	87.78	5.44	**1.499808**	144
35	87.79	5.45	**1.502565**	123.428571
40	87.8	5.46	**1.505322**	108
45	87.82	5.48	**1.510836**	96
50	87.83	5.49	**1.513593**	86.4
55	87.85	5.51	**1.519107**	78.5454545
60	87.86	5.52	**1.521864**	72
70	87.88	5.54	**1.527378**	61.7142857
80	87.9	5.56	**1.532892**	54
90	87.91	5.57	**1.535649**	48
100	87.93	5.59	**1.541163**	43.2
110	87.94	5.6	**1.54392**	39.2727272
120	87.95	5.61	**1.546677**	36
140	87.97	5.63	**1.552191**	30.8571428
160	87.99	5.65	**1.557705**	27
180	88.02	5.68	**1.565976**	24
210	88.04	5.7	**1.57149**	20.57142857

240	88.05	5.71	**1.574247**	18
270	88.06	5.72	**1.577004**	16
300	88.06	5.72	**1.577004**	14.4
360	88.07	5.73	**1.579761**	12
420	88.1	5.76	**1.588032**	10.2857142
480	88.12	5.78	**1.593546**	9
540	88.14	5.8	**1.59906**	8
600	88.15	5.81	**1.601817**	7.2
660	88.16	5.82	**1.604574**	6.54545454
720	88.18	5.84	**1.610088**	6
780	88.2	5.86	**1.615602**	5.53846153
840	88.2	5.86	**1.615602**	5.14285714
900	88.2	5.86	**1.615602**	4.8
960	88.2	5.86	**1.615602**	4.5
1020	88.21	5.87	**1.618359**	4.23529411
1080	88.21	5.87	**1.618359**	4
1140	88.21	5.87	**1.618359**	3.78947368
1200	88.23	5.89	**1.623873**	3.6
1260	88.25	5.91	**1.629387**	3.42857142
1320	88.26	5.92	**1.632144**	3.27272727
1380	88.26	5.92	**1.632144**	3.13043478
1440	88.27	5.93	**1.634901**	3
1500	88.27	5.93	**1.634901**	2.88
1560	88.27	5.93	**1.634901**	2.76923076
1620	88.27	5.93	**1.634901**	2.66666666
1680	88.28	5.94	**1.637658**	2.57142857
1740	88.28	5.94	**1.637658**	2.48275862
1800	88.29	5.95	**1.640415**	2.4
1860	88.29	5.95	**1.640415**	2.32258064
1920	88.29	5.95	**1.640415**	2.25
1980	88.3	5.96	**1.643172**	2.18181818
2040	88.3	5.96	**1.643172**	2.11764705
2100	88.3	5.96	**1.643172**	2.05714285
2160	88.32	5.98	**1.648686**	2
2220	88.32	5.98	**1.648686**	1.945945946
2280	88.32	5.98	**1.648686**	1.89473684
2340	88.33	5.99	**1.651443**	1.84615384
2400	88.33	5.99	**1.651443**	1.8
2460	88.33	5.99	**1.651443**	1.75609756

2520	88.33	5.99	**1.651443**	1.71428571
2580	88.33	5.99	**1.651443**	1.67441860
2640	88.34	6	**1.6542**	1.636363636
2700	88.34	6	**1.6542**	1.6
2760	88.34	6	**1.6542**	1.565217391
2820	88.34	6	**1.6542**	1.531914894
2880	88.34	6	**1.6542**	1.5
2940	88.34	6	**1.6542**	1.469387755
3000	88.35	6.01	**1.656957**	1.44
3060	88.35	6.01	**1.656957**	1.411764706
3120	88.35	6.01	**1.656957**	1.384615385
3180	88.35	6.01	**1.656957**	1.358490566
3240	88.35	6.01	**1.656957**	1.333333333
3300	88.35	6.01	**1.656957**	1.309090909
3360	88.35	6.01	**1.656957**	1.285714286
3420	88.35	6.01	**1.656957**	1.263157895
3480	88.35	6.01	**1.656957**	1.24137931
3540	88.36	6.02	**1.659714**	1.220338983
3600	88.36	6.02	**1.659714**	1.2
3660	88.36	6.02	**1.659714**	1.180327869
3720	88.36	6.02	**1.659714**	1.161290323
3780	88.36	6.02	**1.659714**	1.142857143
3840	88.36	6.02	**1.659714**	1.125
3900	88.36	6.02	**1.659714**	1.107692308
3960	88.36	6.02	**1.659714**	1.090909091
4020	88.36	6.02	**1.659714**	1.074626866
4080	88.36	6.02	**1.659714**	1.058823529
4140	88.36	6.02	**1.659714**	1.043478261
4200	88.36	6.02	**1.659714**	1.028571429
4260	88.36	6.02	**1.659714**	1.014084507
4320	88.36	6.02	**1.659714**	1

Employer /Client : AAWSSA **Well ID** : BH13R **Date of Pumping** :15- 17/0/2013			**Discharge Rate** : 55 l/s **Pump Position** : 175 m **SWL** :76.6 m		
Recovery of Constant Rate Test					
Time since pumping started	**Water level at BH 13R**	**Observed DD**	**Unconfined DD**	**Corrected DD**	**t/t'**
0	76.606	0	0	**0**	
1	98.44	21.84	21.33621293	**12.11896894**	4080

2	113.49	36.89	35.45266149	**20.13711173**	2040
3	117.95	41.35	39.54410382	**22.46105097**	1360
4	119.31	42.71	40.78335858	**23.16494767**	1020
5	119.6	43	41.04710604	**23.31475623**	816
6	120.33	43.73	41.71023564	**23.69141384**	680
7	120.4	43.8	41.77376426	**23.7274981**	582.857143
8	120.48	43.88	41.84635572	**23.76873005**	510
9	120.51	43.91	41.87357404	**23.78419005**	453.333333
10	120.61	44.01	41.96428802	**23.8357156**	408
12	120.72	44.12	42.06404901	**23.89237984**	340
14	120.79	44.19	42.12751996	**23.92843134**	291.428571
16	120.81	44.21	42.14565262	**23.93873069**	255
18	120.86	44.26	42.19098057	**23.96447696**	226.666667
20	120.92	44.32	42.24536713	**23.99536853**	204
25	120.96	44.36	42.28162062	**24.01596051**	163.2
30	120.98	44.38	42.29974609	**24.02625578**	136
35	120.56	43.96	41.91893367	**23.80995433**	116.571429
40	120.65	44.05	42.0005677	**23.85632245**	102
45	121.09	44.49	42.3994211	**24.08287119**	90.6666667
50	121.42	44.82	42.69829278	**24.2526303**	81.6
60	121.75	45.15	42.99693441	**24.42225875**	68
70	122.34	45.74	43.53029616	**24.72520822**	58.2857143
80	122.29	45.69	43.48512452	**24.69955073**	51
90	122.34	45.74	43.53029616	**24.72520822**	45.3333333
100	123.26	46.66	44.36051162	**25.1967706**	40.8
120	123.28	46.68	44.37853992	**25.20701068**	34
140	123.77	47.17	44.81996948	**25.45774266**	29.1428571
160	124.25	47.65	45.2518985	**25.70307835**	25.5
180	125.18	48.58	46.087376	**26.17762957**	22.6666667
210	125.49	48.89	46.36546251	**26.3355827**	19.4285714
240	125.56	48.96	46.42822814	**26.37123358**	17
270	126.77	50.17	47.51154109	**26.98655534**	15.1111111
300	126.9	50.3	47.62774609	**27.05255978**	13.6
330	126.99	50.39	47.7081748	**27.09824329**	12.3636364
360	127.33	50.73	48.01186217	**27.27073771**	11.3333333
420	128.21	51.61	48.79674261	**27.7165498**	9.71428571
480	128.7	52.1	49.23306929	**27.96438335**	8.5
540	128.87	52.27	49.38432943	**28.05029911**	7.55555556
600	129.9	53.3	50.29948247	**28.57010604**	6.8
660	130.45	53.85	50.78723859	**28.84715152**	6.18181818
720	131.19	54.59	51.44248405	**29.21933094**	5.66666667

780	131.5	54.9	51.71663498	**29.37504867**	5.23076923
840	132	55.4	52.15838614	**29.62596333**	4.85714286
900	132.7	56.1	52.77595057	**29.97673992**	4.53333333
960	132.66	56.06	52.74068906	**29.95671138**	4.25
1020	133.4	56.8	53.39247993	**30.3269286**	4
1080	133.47	56.87	53.45407594	**30.36191513**	3.77777778
1140	134.05	57.45	53.96404468	**30.65157738**	3.57894737
1200	134.26	57.66	54.14851331	**30.75635556**	3.4
1260	134.97	58.37	54.77150306	**31.11021374**	3.23809524
1320	135.04	58.44	54.83286692	**31.14506841**	3.09090909
1380	135.37	58.77	55.12201426	**31.3093041**	2.95652174
1440	135.52	58.92	55.25336882	**31.38391349**	2.83333333
1500	136.28	59.68	55.91816815	**31.76151951**	2.72
1560	136.44	59.84	56.05797043	**31.8409272**	2.61538462
1620	136.89	60.29	56.45087442	**32.06409667**	2.51851852
1680	136.82	60.22	56.38978411	**32.02939738**	2.42857143
1740	137.87	61.27	57.30505186	**32.54926946**	2.34482759
1800	138.11	61.51	57.51392892	**32.66791163**	2.26666667
1860	134.84	58.24	54.65751415	**31.04546804**	2.19354839
1920	134.87	58.27	54.68382245	**31.06041115**	2.125
1980	134.76	58.16	54.58734939	**31.00561445**	2.06060606
2040	134.77	58.17	54.59612072	**31.01059657**	2
2100	137.78	61.18	57.22669159	**32.50476082**	1.94285714
2160	135.12	58.52	54.90298437	**31.18489512**	1.88888889
2220	135.07	58.47	54.85916255	**31.16000433**	1.83783784
2280	135.18	58.58	54.95556358	**31.21476011**	1.78947368
2340	135.42	58.82	55.16580439	**31.3341769**	1.74358974
2400	135.36	58.76	55.1132556	**31.30432918**	1.7
2460	135.87	59.27	55.55967797	**31.55789709**	1.65853659
2520	135.96	59.36	55.63840135	**31.60261197**	1.61904762
2580	135.89	59.29	55.57717353	**31.56783457**	1.58139535
2640	135.99	59.39	55.66463868	**31.61751477**	1.54545455
2700	136.96	60.36	56.51195437	**32.09879008**	1.51111111
2760	136.86	60.26	56.42469413	**32.04922626**	1.47826087
2820	136.93	60.33	56.48577852	**32.0839222**	1.44680851
2880	136.94	60.34	56.49450401	**32.08887828**	1.41666667
2940	136.88	60.28	56.44214787	**32.05913999**	1.3877551
3000	136.94	60.34	56.49450401	**32.08887828**	1.36
3060	137.45	60.85	56.93922423	**32.34147936**	1.33333333
3120	137.44	60.84	56.93050951	**32.3365294**	1.30769231
3180	137.39	60.79	56.88693272	**32.31177779**	1.28301887

3240	136.858	60.258	56.42294871	**32.04823487**	1.25925926
3300	137.414	60.814	56.90785024	**32.32365893**	1.23636364
3360	137.491	60.891	56.97495239	**32.36177296**	1.21428571
3420	137.282	60.682	56.79278884	**32.25830406**	1.19298246
3480	137.494	60.894	56.9775665	**32.36325777**	1.17241379
3540	137.462	60.862	56.94968162	**32.34741916**	1.15254237
3600	138.147	61.547	57.54611997	**32.68619615**	1.13333333
3660	137.47	60.87	56.95665304	**32.35137893**	1.1147541
3720	138.132	61.532	57.53306989	**32.6787837**	1.09677419
3780	138.077	61.477	57.48521554	**32.65160243**	1.07936508
3840	137.571	60.971	57.04465564	**32.4013644**	1.0625
3900	137.922	61.322	57.35031888	**32.57498112**	1.04615385
3960	137.486	60.886	56.97059548	**32.35929823**	1.03030303
4020	137.57	60.97	57.04378443	**32.40086956**	1.01492537
4080	137.706	61.106	57.16224922	**32.46815756**	1

Employer /Client :AAWSSA **Well ID** :BH14R **Date of Pumping** :01/-04/01/14 **Reference** :0 m			**Discharge Rate** :141 l/s **Pump Position** :188.2 m **SWL** :81.26 m	
Recovery of Constant Rate Test				
Time since pumping started	**Water Level at BH 14R (m)**	**Observed DD**	**Corrected DD**	**t/t'**
0	81.26	0	**0**	0
1	91.84	10.58	**2.08955**	4320
2	99.65	18.39	**3.632025**	2160
3	99.56	18.3	**3.61425**	1440
4	99.67	18.41	**3.635975**	1080
5	99.82	18.56	**3.6656**	864
6	100.08	18.82	**3.71695**	720
7	100.22	18.96	**3.7446**	617.142857
8	100.28	19.02	**3.75645**	540
9	100.33	19.07	**3.766325**	480
10	100.38	19.12	**3.7762**	432
12	100.45	19.19	**3.790025**	360
14	100.46	19.2	**3.792**	308.571429
16	100.49	19.23	**3.797925**	270
18	100.73	19.47	**3.845325**	240
20	100.81	19.55	**3.861125**	216
25	101.81	20.55	**4.058625**	172.8
30	101.04	19.78	**3.90655**	144
35	101.13	19.87	**3.924325**	123.428571

40	101.17	19.91	**3.932225**	108
45	101.19	19.93	**3.936175**	96
50	101.35	20.09	**3.967775**	86.4
55	101.37	20.11	**3.971725**	78.5454545
60	101.47	20.21	**3.991475**	72
70	101.51	20.25	**3.999375**	61.7142857
80	101.53	20.27	**4.003325**	54
90	101.56	20.3	**4.00925**	48
100	101.58	20.32	**4.0132**	43.2
110	87.94	5.6	**1.106**	39.2727273
120	87.95	5.61	**1.107975**	36
140	87.97	5.63	**1.111925**	30.8571429
160	87.99	5.65	**1.115875**	27
180	88.02	5.68	**1.1218**	24
210	88.04	5.7	**1.12575**	20.5714286
240	88.05	5.71	**1.127725**	18
270	88.06	5.72	**1.1297**	16
300	88.06	5.72	**1.1297**	14.4
360	88.07	5.73	**1.131675**	12
420	88.1	5.76	**1.1376**	10.2857143
480	88.12	5.78	**1.14155**	9
540	88.14	5.8	**1.1455**	8
600	88.15	5.81	**1.147475**	7.2
660	88.16	5.82	**1.14945**	6.54545455
720	88.18	5.84	**1.1534**	6
780	88.2	5.86	**1.15735**	5.53846154
840	88.2	5.86	**1.15735**	5.14285714
900	88.2	5.86	**1.15735**	4.8
960	88.2	5.86	**1.15735**	4.5
1020	88.21	5.87	**1.159325**	4.23529412
1080	88.21	5.87	**1.159325**	4
1140	88.21	5.87	**1.159325**	3.78947368
1200	88.23	5.89	**1.163275**	3.6
1260	88.25	5.91	**1.167225**	3.42857143
1320	88.26	5.92	**1.1692**	3.27272727
1380	88.26	5.92	**1.1692**	3.13043478
1440	88.27	5.93	**1.171175**	3
1500	88.27	5.93	**1.171175**	2.88
1560	88.27	5.93	**1.171175**	2.76923077
1620	88.27	5.93	**1.171175**	2.66666667
1680	88.28	5.94	**1.17315**	2.57142857
1740	88.28	5.94	**1.17315**	2.48275862

1800	88.29	5.95	**1.175125**	2.4
1860	88.29	5.95	**1.175125**	2.32258065
1920	88.29	5.95	**1.175125**	2.25
1980	88.3	5.96	**1.1771**	2.18181818
2040	88.3	5.96	**1.1771**	2.11764706
2100	88.3	5.96	**1.1771**	2.05714286
2160	88.32	5.98	**1.18105**	2
2220	88.32	5.98	**1.18105**	1.94594595
2280	88.32	5.98	**1.18105**	1.89473684
2340	88.33	5.99	**1.183025**	1.84615385
2400	88.33	5.99	**1.183025**	1.8
2460	88.33	5.99	**1.183025**	1.75609756
2520	88.33	5.99	**1.183025**	1.71428571
2580	88.33	5.99	**1.183025**	1.6744186
2640	88.34	6	**1.185**	1.63636364
2700	88.34	6	**1.185**	1.6
2760	88.34	6	**1.185**	1.56521739
2820	88.34	6	**1.185**	1.53191489
2880	88.34	6	**1.185**	1.5
2940	88.34	6	**1.185**	1.46938776
3000	88.35	6.01	**1.186975**	1.44
3060	88.35	6.01	**1.186975**	1.41176471
3120	88.35	6.01	**1.186975**	1.38461538
3180	88.35	6.01	**1.186975**	1.35849057
3240	88.35	6.01	**1.186975**	1.33333333
3300	88.35	6.01	**1.186975**	1.30909091
3360	88.35	6.01	**1.186975**	1.28571429
3420	88.35	6.01	**1.186975**	1.26315789
3480	88.35	6.01	**1.186975**	1.24137931
3540	88.36	6.02	**1.18895**	1.22033898
3600	88.36	6.02	**1.18895**	1.2
3660	88.36	6.02	**1.18895**	1.18032787
3720	88.36	6.02	**1.18895**	1.16129032
3780	88.36	6.02	**1.18895**	1.14285714
3840	88.36	6.02	**1.18895**	1.125
3900	88.36	6.02	**1.18895**	1.10769231
3960	88.36	6.02	**1.18895**	1.09090909
4020	88.36	6.02	**1.18895**	1.07462687
4080	88.36	6.02	**1.18895**	1.05882353
4140	88.36	6.02	**1.18895**	1.04347826
4200	88.36	6.02	**1.18895**	1.02857143
4260	88.36	6.02	**1.18895**	1.01408451
4320	88.36	6.02	**1.18895**	1

Employer /Client :AAWSA **Well ID** :BH22R **Date of Pumping** :30/08/2013 **Reference** :0 m			**Discharge Rate** :90 l/s **Pump Position** :172m **SWL** :66.6m		
Recovery of Constant Rate Test					
Time since pumping started	**BH1R Water Level (m)**	**Observed DD**	**Unconfined DD**	**Corrected DD**	**t/t'**
0	66.66	0	0	**0**	0
1	76.09	9.49	9.376224544	**4.810003191**	4320
2	44.82	-21.78	-22.37928293	**-11.48057215**	2160
3	108.65	42.05	39.81618007	**20.42570038**	1440
4	110.86	44.26	41.78520643	**21.4358109**	1080
5	111.86	45.26	42.6721133	**21.89079412**	864
6	113.19	46.59	43.8477845	**22.49391345**	720
7	114	47.4	44.56160493	**22.86010333**	617.14286
8	114.46	47.86	44.9662464	**23.0676844**	540
9	114.64	48.04	45.12443883	**23.14883712**	480
10	114.88	48.28	45.33523473	**23.25697541**	432
12	115.18	48.58	45.59852494	**23.39204329**	360
14	115.51	48.91	45.88788153	**23.54048322**	308.57143
16	115.66	49.06	46.01931629	**23.60790926**	270
18	115.78	49.18	46.12442316	**23.66182908**	240
20	116.51	49.91	46.76303944	**23.98943923**	216
25	116.7	50.1	46.92903381	**24.07459434**	172.8
30	116.88	50.28	47.08620749	**24.15522444**	144
35	117.1	50.5	47.27819748	**24.25371531**	123.42857
40	117.2	50.6	47.36542524	**24.29846315**	108
45	117.36	50.76	47.50493709	**24.37003273**	96
50	117.37	50.77	47.51365443	**24.37450472**	86.4
60	117.5	50.9	47.6269569	**24.43262889**	72
70	117.7	51.1	47.801185	**24.52200791**	61.714286
80	117.75	51.15	47.84472624	**24.54434456**	54
90	117.88	51.28	47.95790389	**24.60240469**	48
100	117.7	51.1	47.801185	**24.52200791**	43.2
110	117.8	51.2	47.88826116	**24.56667797**	39.272727
120	117.9	51.3	47.97531204	**24.61133508**	36
140	117.9	51.3	47.97531204	**24.61133508**	30.857143
160	118.01	51.41	48.07103883	**24.66044292**	27
180	118.19	51.59	48.22761673	**24.74076738**	24
210	118.14	51.54	48.18413108	**24.71845925**	20.571429
240	118.1	51.5	48.14933802	**24.7006104**	18
270	118.25	51.65	48.27979117	**24.76753287**	16
300	118.23	51.63	48.2624007	**24.75861156**	14.4

360	118.37	51.77	48.38411276	**24.82104985**	12
420	118.67	52.07	48.64475757	**24.95476063**	10.285714
480	119.08	52.48	49.00060438	**25.13731004**	9
540	119.05	52.45	48.97458121	**25.12396016**	8
600	119.08	52.48	49.00060438	**25.13731004**	7.2
660	119.2	52.6	49.10467431	**25.19069792**	6.5454545
720	119.19	52.59	49.09600321	**25.18624965**	6
780	119.35	52.75	49.23471057	**25.25740652**	5.5384615
840	119.32	52.72	49.20870787	**25.24406714**	5.1428571
900	119.46	52.86	49.33003436	**25.30630763**	4.8
960	119.44	52.84	49.31270504	**25.29741768**	4.5
1020	119.47	52.87	49.33869865	**25.31075241**	4.2352941
1080	119.48	52.88	49.34736268	**25.31519705**	4
1140	119.49	52.89	49.35602645	**25.31964157**	3.7894737
1200	119.47	52.87	49.33869865	**25.31075241**	3.6
1260	119.43	52.83	49.30404	**25.29297252**	3.4285714
1320	119.46	52.86	49.33003436	**25.30630763**	3.2727273
1380	119.57	52.97	49.42532758	**25.35519305**	3.1304348
1440	119.59	52.99	49.44265034	**25.36407962**	3
1500	119.7	53.1	49.53790742	**25.41294651**	2.88
1560	119.8	53.2	49.62447825	**25.45735734**	2.7692308
1620	119.66	53.06	49.50327202	**25.39517855**	2.6666667
1680	119.73	53.13	49.56388132	**25.42627112**	2.5714286
1740	119.69	53.09	49.52924895	**25.40850471**	2.4827586
1800	119.54	52.94	49.39934155	**25.34186222**	2.4
1860	119.66	53.06	49.50327202	**25.39517855**	2.3225806
1920	119.67	53.07	49.51193125	**25.39962073**	2.25
1980	119.79	53.19	49.6158223	**25.45291684**	2.1818182
2040	119.92	53.32	49.72832988	**25.51063323**	2.1176471
2100	119.89	53.29	49.70237038	**25.49731601**	2.0571429
2160	119.88	53.28	49.69371671	**25.49287667**	2
2220	119.96	53.36	49.76293901	**25.52838771**	1.9459459
2280	119.99	53.39	49.7888932	**25.54170221**	1.8947368
2340	120.01	53.41	49.80619473	**25.5505779**	1.8461538
2400	120.06	53.46	49.84944414	**25.57276484**	1.8
2460	120.07	53.47	49.85809326	**25.57720184**	1.7560976
2520	120.07	53.47	49.85809326	**25.57720184**	1.7142857
2580	120.04	53.44	49.83214513	**25.56389045**	1.6744186
2640	120.04	53.44	49.83214513	**25.56389045**	1.6363636
2700	120.03	53.43	49.82349525	**25.55945306**	1.6
2760	120.04	53.44	49.83214513	**25.56389045**	1.5652174
2820	120.09	53.49	49.87539075	**25.58607545**	1.5319149

2880	120.21	53.61	49.97915445	**25.63930624**	1.5
2940	120.19	53.59	49.96186303	**25.63043573**	1.4693878
3000	120.2	53.6	49.97050887	**25.63487105**	1.44
3060	120.13	53.53	49.90998269	**25.60382112**	1.4117647
3120	120.18	53.58	49.95321694	**25.62600029**	1.3846154
3180	120.03	53.43	49.82349525	**25.55945306**	1.3584906
3240	120.05	53.45	49.84079476	**25.56832771**	1.3333333
3300	120.09	53.49	49.87539075	**25.58607545**	1.3090909
3360	120.16	53.56	49.935924	**25.61712901**	1.2857143
3420	120.04	53.44	49.83214513	**25.56389045**	1.2631579
3480	120.18	53.58	49.95321694	**25.62600029**	1.2413793
3540	120.18	53.58	49.95321694	**25.62600029**	1.220339
3600	120.25	53.65	50.01373427	**25.65704568**	1.2
3660	120.33	53.73	50.08288178	**25.69251835**	1.1803279
3720	120.26	53.66	50.02237859	**25.66148022**	1.1612903
3780	120.26	53.66	50.02237859	**25.66148022**	1.1428571
3840	120.32	53.72	50.07423922	**25.68808472**	1.125
3900	120.24	53.64	50.0050897	**25.65261101**	1.1076923
3960	120.33	53.73	50.08288178	**25.69251835**	1.0909091
4020	120.34	53.74	50.09152408	**25.69695185**	1.0746269
4080	120.32	53.72	50.07423922	**25.68808472**	1.0588235
4140	120.28	53.68	50.03966648	**25.6703489**	1.0434783
4200	120.32	53.72	50.07423922	**25.68808472**	1.0285714
4260	120.27	53.67	50.03102266	**25.66591463**	1.0140845
4320	120.38	53.78	50.12609076	**25.71468456**	1

Employer /Client :AAWSA
Well ID :BH23R
Date of Pumping :1-4/12/2015
Reference :0 m

Discharge Rate :47.67 l/s
Pump Position :180m
SWL :71.06 m

Recovery of Constant Rate Test

Time since pumping started	BH23R Water Level (m)	Observed DD	Corrected DD	t/t'
0	71.06	0	**0**	0
1	101.47	30.41	**52.9134**	4320
2	112.72	41.66	**72.4884**	2160
3	123.22	52.16	**90.7584**	1440
4	130.34	59.28	**103.1472**	1080
5	136.63	65.57	**114.0918**	864
6	144.16	73.1	**127.194**	720
7	144.2	73.14	**127.2636**	617.142857
8	143.51	72.45	**126.063**	540

9	143.88	72.82	**126.7068**	480
10	145.66	74.6	**129.804**	432
12	146.43	75.37	**131.1438**	360
14	147.92	76.86	**133.7364**	308.571429
16	148.18	77.12	**134.1888**	270
18	148.55	77.49	**134.8326**	240
20	149	77.94	**135.6156**	216
25	150.51	79.45	**138.243**	172.8
30	149.9	78.84	**137.1816**	144
35	149.87	78.81	**137.1294**	123.428571
40	148.85	77.79	**135.3546**	108
45	148.26	77.2	**134.328**	96
50	149.08	78.02	**135.7548**	86.4
55	149	77.94	**135.6156**	78.5454545
60	148.77	77.71	**135.2154**	72
70	148.86	77.8	**135.372**	61.7142857
80	149.33	78.27	**136.1898**	54
90	149.37	78.31	**136.2594**	48
100	146.64	75.58	**131.5092**	43.2
120	148.57	77.51	**134.8674**	36
140	148.03	76.97	**133.9278**	30.8571429
160	148.6	77.54	**134.9196**	27
180	148.35	77.29	**134.4846**	24
210	148.25	77.19	**134.3106**	20.5714286
240	150.42	79.36	**138.0864**	18
270	146.12	75.06	**130.6044**	16
300	148.97	77.91	**135.5634**	14.4
360	146.4	75.34	**131.0916**	12
420	146.77	75.71	**131.7354**	10.2857143
480	148.8	77.74	**135.2676**	9
540	149.5	78.44	**136.4856**	8
600	146.92	75.86	**131.9964**	7.2
660	147.92	76.86	**133.7364**	6.54545455
720	146.81	75.75	**131.805**	6
780	146.6	75.54	**131.4396**	5.53846154
840	147.05	75.99	**132.2226**	5.14285714
900	147	75.94	**132.1356**	4.8
960	147.55	76.49	**133.0926**	4.5
1020	148.74	77.68	**135.1632**	4.23529412
1080	147.1	76.04	**132.3096**	4
1140	146.55	75.49	**131.3526**	3.78947368

1200	146.5	75.44	**131.2656**	3.6
1260	148.6	77.54	**134.9196**	3.42857143
1320	149.78	78.72	**136.9728**	3.27272727
1380	149.89	78.83	**137.1642**	3.13043478
1440	149.68	78.62	**136.7988**	3
1500	149.7	78.64	**136.8336**	2.88
1560	147.3	76.24	**132.6576**	2.76923077
1620	147.8	76.74	**133.5276**	2.66666667
1680	147.56	76.5	**133.11**	2.57142857
1740	148.3	77.24	**134.3976**	2.48275862
1800	149.65	78.59	**136.7466**	2.4
1860	150.43	79.37	**138.1038**	2.32258065
1920	148.8	77.74	**135.2676**	2.25
1980	150.91	79.85	**138.939**	2.18181818
2040	150.29	79.23	**137.8602**	2.11764706
2100	150.55	79.49	**138.3126**	2.05714286
2160	148.05	76.99	**133.9626**	2
2220	150.47	79.41	**138.1734**	1.94594595
2280	147.88	76.82	**133.6668**	1.89473684
2340	147.3	76.24	**132.6576**	1.84615385
2400	150.85	79.79	**138.8346**	1.8
2460	149.22	78.16	**135.9984**	1.75609756
2520	147.3	76.24	**132.6576**	1.71428571
2580	147.18	76.12	**132.4488**	1.6744186
2640	147.46	76.4	**132.936**	1.63636364
2700	149.85	78.79	**137.0946**	1.6
2760	150.2	79.14	**137.7036**	1.56521739
2820	150.1	79.04	**137.5296**	1.53191489
2880	150.08	79.02	**137.4948**	1.5
2940	150.18	79.12	**137.6688**	1.46938776
3000	150.58	79.52	**138.3648**	1.44
3060	147.55	76.49	**133.0926**	1.41176471
3120	147.26	76.2	**132.588**	1.38461538
3180	147.28	76.22	**132.6228**	1.35849057
3240	150.2	79.14	**137.7036**	1.33333333
3300	149.63	78.57	**136.7118**	1.30909091
3360	150.74	79.68	**138.6432**	1.28571429
3420	150.1	79.04	**137.5296**	1.26315789
3480	150.18	79.12	**137.6688**	1.24137931
3540	150.16	79.1	**137.634**	1.22033898
3600	150.12	79.06	**137.5644**	1.2

3660	150.17	79.11	**137.6514**	1.18032787
3720	150.2	79.14	**137.7036**	1.16129032
3780	150.11	79.05	**137.547**	1.14285714
3840	149.79	78.73	**136.9902**	1.125
3900	149.82	78.76	**137.0424**	1.10769231
3960	149.83	78.77	**137.0598**	1.09090909
4020	149.77	78.71	**136.9554**	1.07462687
4080	149.89	78.83	**137.1642**	1.05882353
4140	149.84	78.78	**137.0772**	1.04347826
4200	149.82	78.76	**137.0424**	1.02857143
4260	149.93	78.87	**137.2338**	1.01408451
4320	149.76	78.7	**136.938**	1

Employer /Client :AAWSA **Well ID** :BH26R **Date of Pumping** :23/07/2015 **Reference** :0 m	**Discharge Rate** :90 l/s **Pump Position** :240 m **SWL** :72.8m			
Recovery of Constant Rate Test				
Time since pumping started	**BH1R Water Level (m)**	**Observed DD**	**Corrected DD**	t/t'
1	113.1	40.3	**22.99518**	4320
2	116.42	43.62	**24.889572**	2160
3	119.2	46.4	**26.47584**	1440
4	121.15	48.35	**27.58851**	1080
5	121.66	48.86	**27.879516**	864
6	121.91	49.11	**28.022166**	720
7	122.17	49.37	**28.170522**	617.1429
8	122.57	49.77	**28.398762**	540
9	122.67	49.87	**28.455822**	480
10	122.68	49.88	**28.461528**	432
12	122.89	50.09	**28.581354**	360
14	122.95	50.15	**28.61559**	308.5714
16	123.31	50.51	**28.821006**	270
18	123.34	50.54	**28.838124**	240
20	123.73	50.93	**29.060658**	216
25	123.92	51.12	**29.169072**	172.8
30	124.67	51.87	**29.597022**	144
35	124.89	52.09	**29.722554**	123.4286
40	125.06	52.26	**29.819556**	108
45	125.24	52.44	**29.922264**	96
50	125.35	52.55	**29.98503**	86.4
55	125.49	52.69	**30.064914**	78.54545

60	125.58	52.78	**30.116268**	72
70	125.93	53.13	**30.315978**	61.71429
80	125.97	53.17	**30.338802**	54
90	126.02	53.22	**30.367332**	48
100	126.55	53.75	**30.66975**	43.2
110	126.75	53.95	**30.78387**	39.27273
120	126.87	54.07	**30.852342**	36
140	127.06	54.26	**30.960756**	30.85714
160	127.15	54.35	**31.01211**	27
180	127.37	54.57	**31.137642**	24
210	127.38	54.58	**31.143348**	20.57143
240	127.48	54.68	**31.200408**	18
270	127.5	54.7	**31.21182**	16
300	127.51	54.71	**31.217526**	14.4
360	127.94	55.14	**31.462884**	12
420	127.97	55.17	**31.480002**	10.28571
480	128.09	55.29	**31.548474**	9
540	128.28	55.48	**31.656888**	8
600	128.34	55.54	**31.691124**	7.2
660	128.38	55.58	**31.713948**	6.545455
720	128.4	55.6	**31.72536**	6
780	128.43	55.63	**31.742478**	5.538462
840	128.58	55.78	**31.828068**	5.142857
900	128.62	55.82	**31.850892**	4.8
960	128.64	55.84	**31.862304**	4.5
1020	128.67	55.87	**31.879422**	4.235294
1080	128.71	55.91	**31.902246**	4
1140	128.75	55.95	**31.92507**	3.789474
1200	128.82	56.02	**31.965012**	3.6
1260	128.94	56.14	**32.033484**	3.428571
1320	128.96	56.16	**32.044896**	3.272727
1380	129.01	56.21	**32.073426**	3.130435
1440	129.03	56.23	**32.084838**	3
1500	129.08	56.28	**32.113368**	2.88
1560	129.28	56.48	**32.227488**	2.769231
1620	129.34	56.54	**32.261724**	2.666667
1680	129.36	56.56	**32.273136**	2.571429
1740	129.45	56.65	**32.32449**	2.482759
1800	129.48	56.68	**32.341608**	2.4
1860	129.5	56.7	**32.35302**	2.322581
1920	129.55	56.75	**32.38155**	2.25
1980	129.73	56.93	**32.484258**	2.181818

2040	129.93	57.13	**32.598378**	2.117647
2100	129.96	57.16	**32.615496**	2.057143
2160	130.07	57.27	**32.678262**	2
2220	130.19	57.39	**32.746734**	1.945946
2280	130.22	57.42	**32.763852**	1.894737
2340	130.23	57.43	**32.769558**	1.846154
2400	130.28	57.48	**32.798088**	1.8
2460	130.25	57.45	**32.78097**	1.756098
2520	130.26	57.46	**32.786676**	1.714286
2580	130.35	57.55	**32.83803**	1.674419
2640	130.35	57.55	**32.83803**	1.636364
2700	130.35	57.55	**32.83803**	1.6
2760	130.35	57.55	**32.83803**	1.565217
2820	130.36	57.56	**32.843736**	1.531915
2880	130.4	57.6	**32.86656**	1.5
2940	130.2	57.4	**32.75244**	1.469388
3000	130.17	57.37	**32.735322**	1.44
3060	130.14	57.34	**32.718204**	1.411765
3120	130.18	57.38	**32.741028**	1.384615
3180	130.18	57.38	**32.741028**	1.358491
3240	130.18	57.38	**32.741028**	1.333333
3300	130.18	57.38	**32.741028**	1.309091
3360	130.18	57.38	**32.741028**	1.285714
3420	130.18	57.38	**32.741028**	1.263158
3480	130.24	57.44	**32.775264**	1.241379
3540	130.26	57.46	**32.786676**	1.220339
3600	130.31	57.51	**32.815206**	1.2
3660	130.31	57.51	**32.815206**	1.180328
3720	130.32	57.52	**32.820912**	1.16129
3780	130.32	57.52	**32.820912**	1.142857
3840	130.44	57.64	**32.889384**	1.125
3900	130.52	57.72	**32.935032**	1.107692
3960	130.52	57.72	**32.935032**	1.090909
4020	130.52	57.72	**32.935032**	1.074627
4080	130.54	57.74	**32.946444**	1.058824
4140	130.54	57.74	**32.946444**	1.043478
4200	130.62	57.82	**32.992092**	1.028571
4260	130.56	57.76	**32.957856**	1.014085
4320	130.56	57.76	**32.957856**	1