Georg -August -Universität Göttingen
M.Sc. Course Hydrogeology and Environmental Geosciences
M.HEG.05, TM 2: Hydrogeological Field Seminar

FIELD TRIP REPORT

HYDROGEOLOGICAL FIELD INVESTIGATION AT GZG SITE AND STEGEMÜHLLER WATERWORKS

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1. Introduction

On July 21st, 2015 and July 22nd, 2015 hydrogeological field trip was conducted on two sites in the city of Gottingen: on the first day at the geothermic site of North Campus of Georg-August-University(GZG), and on the second day at Stegemühle study site which is located Leine River valley in the South of Göttingen. The aim of this field trip is to understand the conventional investigation methods that are used to determine the composition of the subsurface and the hydraulic parameters of the aquifer such as hydraulic gradient, porosity, hydraulic conductivity, storativity etc. On the two days of period many tests were conducted such as water level reading, borehole camera investigation, gamma readings in the borehole, pumping test for drawdown and recovery along with chemical parameters of pH, oxygen saturation, temperature and electrical conductivity and the rate of pumping were also recorded, investigations such as electrical conductivity, water samples, and soil core samples was done using the Geoprobe and slug test.

2. Day 1-Geothermic site of North Campus of Georg-August-University(GZG)

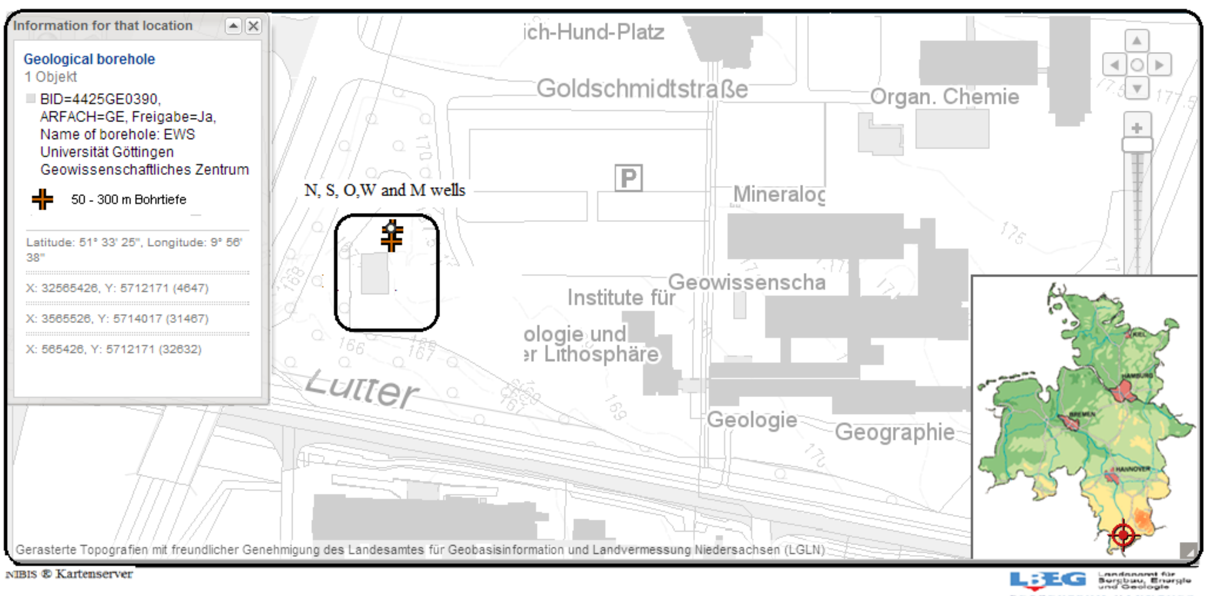

Figure 1:- Location of Geothermic site of North campus of Georg-August -University using NIBIS Kartenserver

In the geothermic site of North Campus of Georg-August-University(GZG), there were five slot arrangement of well named as North(N), South (S), East (0), Middle(M) and West(W) of the average depth of 80 meters as shown in appendix 1. These well were covered with steel pipe lid and circular concrete wall in order to prevent the contamination to enter the well. The two borehole Well M (East 32565427, North 5712168) used as pumping well and Well S (East 32565428, North 5712151) used as an observation well to conduct an experiment in our field trip. The weather was sunny and warm but there was an intense rain for about 10 minutes. There was a pond far away from east (O) well.

2.1. Geological situation

The geological situation at the GZG site comprised of Quaternary origin, which consists of beige siltstone, brown chalkstone and grey argillite which 12 meters' depth from the ground surface. Below quaternary, there was a Keuper, which consists of an alternative layer of siltstone, sandstone, and argillite. The sandstone layer acts as a confined aquifer. According to Henrik Werner bachelor thesis, geological structure of five wells (N, O, S, W, M) consisting of a number of different layers. It starts with silt clay around 24 meters thick on the top layer then sandy layer of 15 meters thick, silt of 2 meters, then clay of 10 meters, then again silty clay of 4 meters, silty sand of 4 meters, clay of 8 meters, sand of 5 meters and ends with clay 8 meters thick as shown appendix 2.

2.2. Water level Measurement

At GZG site, water level meter device is used to measure water level in the well from the top of the well cap. This water level meter measurement was applied to know the flow direction and hydraulic gradient. The ground water level was measured and found to be 4.05 meters' depth from the top of the well cap at well M and S well was 4.10 meters' depth using water level meter device. The aquifer thickness was to be 45.45 meters i.e., depth from the top layer of water to borehole bottom. This water level measurement was taken before pumping test was started.

2.3. Borehole Winch Camera and Gamma Ray Probe Application

Before performing the pumping test, it is necessary to check the construction plan and condition of pumping well and also to know whether the filter or screen are placed properly. Therefore, both Borehole Winch camera and Gamma Ray Probe was conducted at well M at the GZG test site. Appendix 3 Shows the lithography of Geological borehole at GZG site. The water level was measured the 4.05meters depth from well casing but it was set to reference point 0.

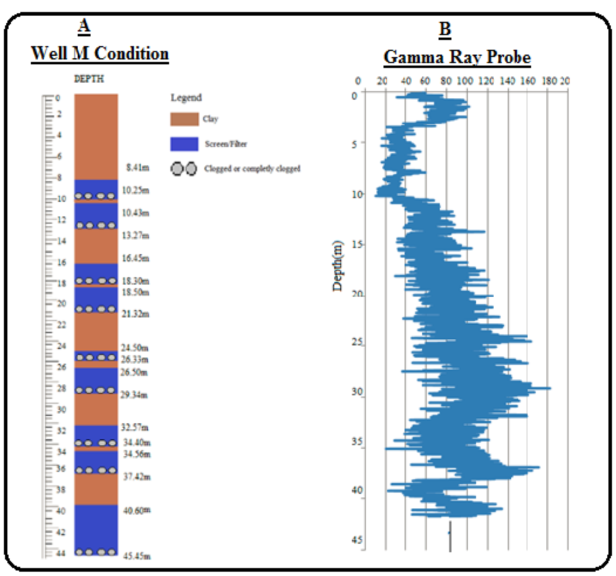

Figure 2: (A) Well condition using Borehole camera and (B) Gamma ray Probe

The Borehole camera was used in order to visualize interior part of the well, which contains LED light, rotating camera and screen. The camera was inserted at well M and monitored from the reference point 0 to 45.45 meters' depth of well casing. During the process, the condition of the well was studied and we found alternatively a layer of clay and screen or filter. Filter screen was completely clogged as shown in figure 2(A). The well M condition as shown in figure 2(A) and construction plan as seen in appendix 3 shows matches a little bit.

The Gamma Ray probe application is used to measure natural gamma radiation emitted by rock or sediment in the borehole. This application is used to characterize and differentiate between rocks. The energy emitted by these rocks are converted into the electric pulse and recorded in count per second (cps). MGX II digital logging system is used along with gamma probe that is introduced into well and monitors the graph. The clay pellet emits K-40 decay radiation seals the non-filtering region on wells. The probe monitors up to 41 meters' depth. As shown in figure 2(B), the higher gamma radiation(cps) shows present of clay or non-filter screen and lower gamma radiation (cps) shows present of filter or screen. From 25 to 28 meters' depth shows clay section where 29 to 32-meter depth is filtered section then from 33-meter depth is clay section and again 36-meter depth is filtered section.

2.4. Pumping Test

A pumping test is a field experiment in which a well is pumped at a controlled rate and water-level response (drawdown) is measured in observation wells and pumped well itself. The response data from pumping tests are used to estimate the hydraulic properties of aquifers such as hydraulic properties, specific yield, storativity, transmissivity and evaluate well performance. It is also used to determine direction of groundwater flow and identify aquifer boundaries.

In GZG site, well M was a pumping well and well S was an observation well. The water level was also measured and recorded automatically in the data logger using water meter and stopwatch. The data contained from data logger will provide drawdown data and recovery data that could fit the type of theis curve to determine whether the type of aquifer is confined, unconfined or leaky. The water level at well M was 4.05 meters and well S was 4.10 meters from the top of the well cap. The pumping test was performed for two hours (one-hour for pumping and one hour for recovery phase). But there was intense rainfall for 33 minutes, therefore test was restarted lasted was 44 minutes where drawdown was monitored and then later recovery was monitored after 45 minutes. The rate of pumping of well M was 32.1-32.2 liters/minute. Observation well S had recorded the pumping (i.e. drawdown) and recovery period using data logger. The aquifer thickness was 45.45 meters' depth (i.e. total length of the filter section of wells) as seen in figure 2. During pumping test, we also find out chemical parameter or properties of pumped water such pH, oxygen level (%), temperature(°C), electrical conductivity (µS/cm) and discharge rate(l/min).

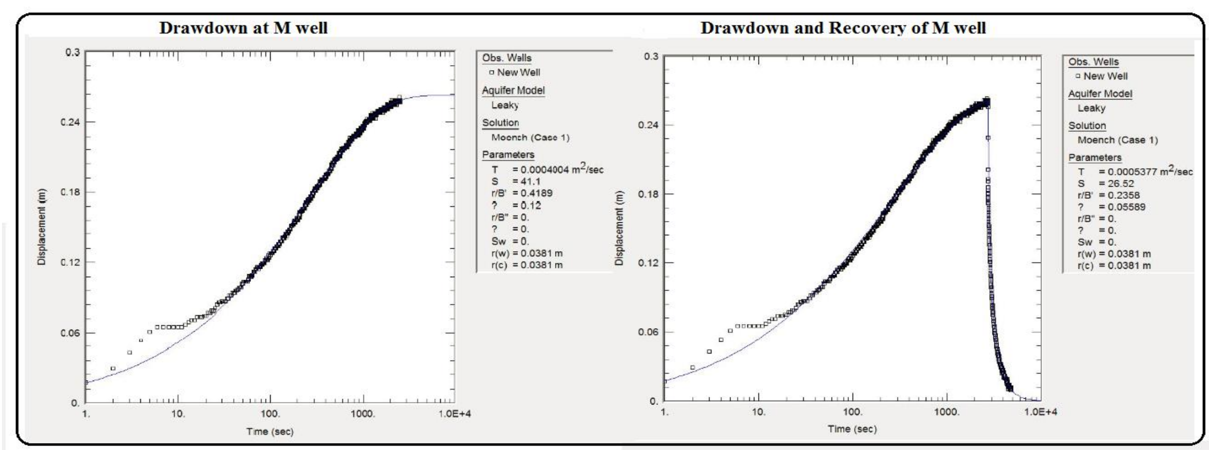

Figure 3: Drawdown and Recovery curve of well M using AQTESOLV

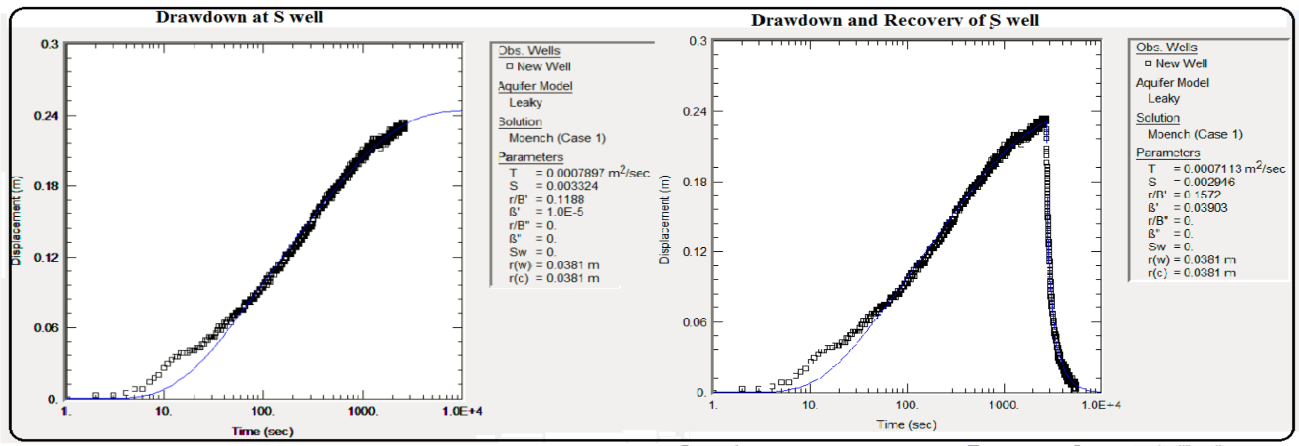

Figure 4: Drawdown and Recovery curve of well S using AQTESOLV

The distance between the well M and Well S was 3 meters. The data obtained from the data logger from both the pumping well and observation well was recorded. In pumping well M data, drawdown and recovery was separated. Drawdown and recovery curve was uploaded to the AQTESOLV software. Here the pumping well M, the drawdown and recovery was run by single test whereas for the observation well both the drawdown and recovery was run by multi well test. Figures 3 shows the drawdown and recovery curve from the pumping well M. Similarly, the same procedure was repeated for well S. For pumping well M, the drawdown was analyzed by using Moench Case 1- constant head boundary whose aquifer model is leaky. Before there was drawdown started there was an intense rain cause perched water table over leaky on upper layer. The maximum drawdown on pumping well M was 0.262 meter and where on observation well S is 0.231 meter. Transmissivity (T) value varies from 0.0007897m^2/s to 0.0004004 m^2/s it indicate aquifer is made of poor material such sand silt sandstone limestone or clay. Therefore, not suitable for drinking water supply. Storavity(S) of observation well S has value varies 0.003324 to 0.002916. Therefore, based AQTESOLV 2015 the storativity value of between 5E-3 to 5E-5 acts has a confined aquifer.

2.5. Chemical Properties of Pumped water

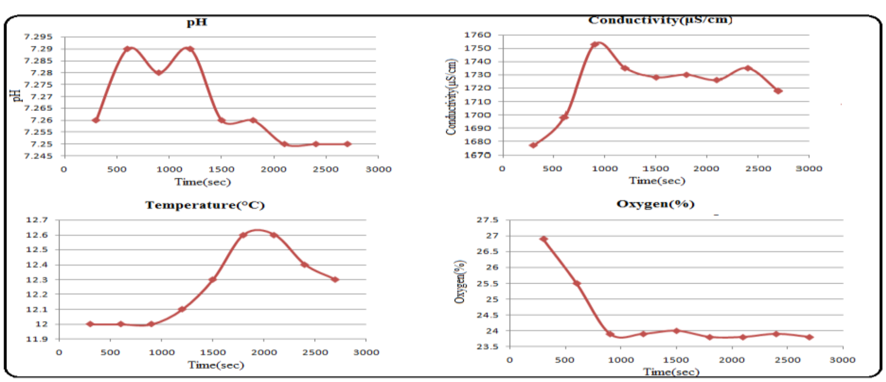

Figure 5: The Four chemical parameter or properties of pumped water

The Chemical Properties of Pumped water was measured using TetraCon probe and Multi 3430 digital sensor. The first data point shows water in the well and later data points shows water is in aquifer. The four of pumped water such as pH, oxygen saturation (%), temperature(°C), electrical conductivity (µS/cm) and discharge rate(l/min) was every 5 minutes till reaches the 45 minutes pumping period as shown in figure 5. The pH of pumped water fluctuates from 7.25 to 7.29 with time. The electrical conductivity increase suddenly due to intense rain for few seconds later decreases and reaches the constant value. The oxygen saturation decreases because water in contact with atmosphere is mixed with oxygen. The temperature increases through time due insulating effect of soil texture.

3. Day 2 - Stegemühller Waterworks in South of Göttingen

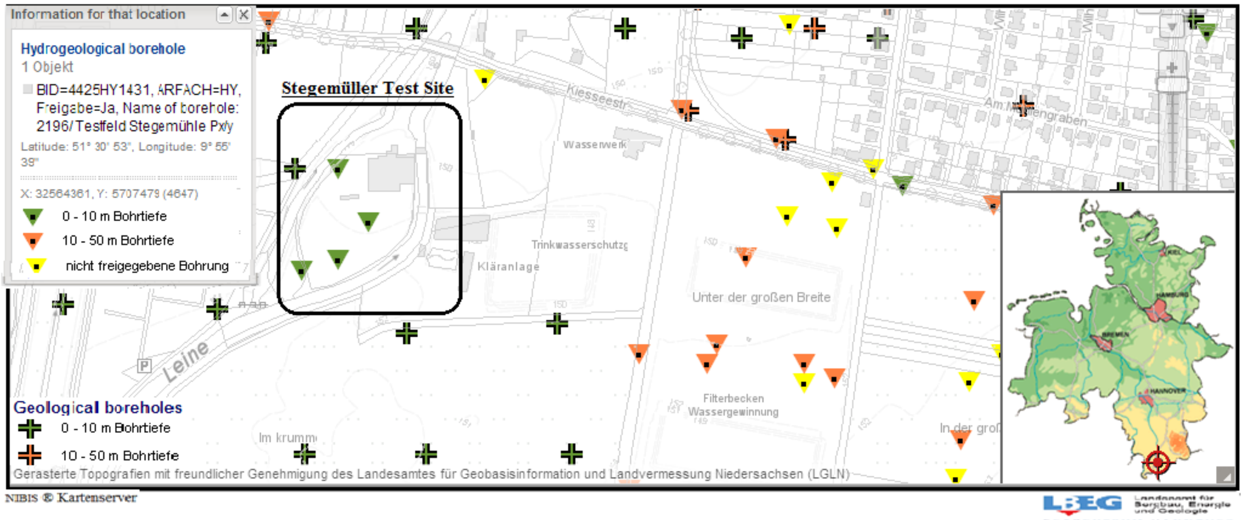

Figure 6: Location of Stegemühle waterworks using NIBIS Kartenserver

On the second day, the experiments were conducted at water protection area of Stegemühle waterworks, its located in Geismar / south of Gottingen city which is between Leine River and Muhlengraben channel as shown in figure 6. There are 20 different well located in this area with different casing diameter i.e. 1",2", 6" with single and multi-chamber well as shown in figure 7. In order to determine the hydraulic parameter of Stegemühle site we measured water level before and after pumping test, pumping test was conducted, soil core and water sample were taken using Geoprobe Machine even the electrical conductivity and rate of penetration was measured using Geoprobe Machine and Slug test.

Figure 7: Representation of 20 different well at Stegemühle site

The weather was sunny and warm on 22 July 2015.The well B3 was a pumping test and well PO/25 was an observation well.

3.1. Geology Situation

According to the field trip report, strata consists of five different layers, first layer is top soil, second layer is alluvial clay from Holocene (slit, fine, sandy and slight clayey), middle layer is fine sand, fourth layer is Leine gravel (gravel, sandy) and the last layer in bottom is middle Keuper (slit and clay stone). The soil texture varies 0 to 75 meters' distance as shown in appendix 5. The two channel or river (i.e. Leine River and Muhlengraben) has constant head boundary.

3.2. Direct Push Technology

Direct push technology is the tool that push the rod into the subsurface by hydraulic pressure. This method is used to collect the sample of ground water, soil and soil gas. It is also used to measure the electrical conductivity, hydraulic conductivity of a sample. Geoprobe 7730DT was one of the direct push machine used in the Stegemühle site, which consists of powerful GH2 hammer, controlling unit and Wenner probe with four electrodes in which the position, time and speed of each probe is one and half meter in length. At the tip of Wenner probe measure electrical conductivity and rate of penetration (ROP).

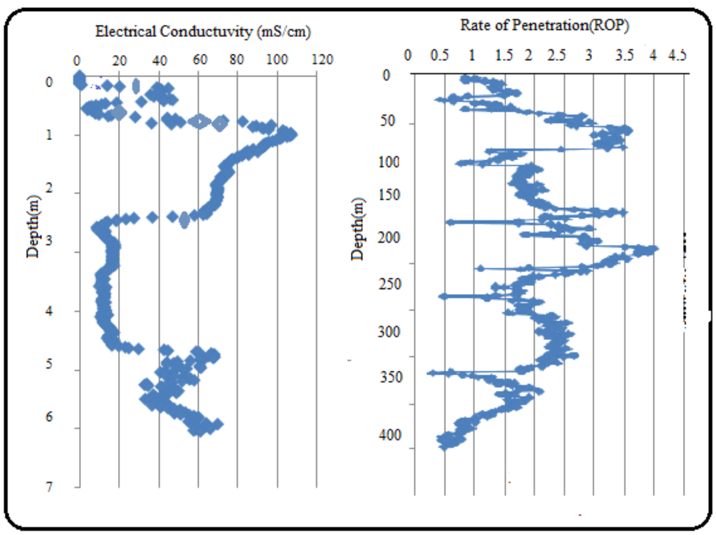

Figure 8: Electrical Conductivity (mS/cm) and Rate of penetration(ROP)

For electrical conductivity, the 5 steel rod each of 1.2-meter was hammered to 6-meter depth into the subsurface. According to figure 8, high conductivity is seen after 1-meter depth till 2.7 meters whereas low conductivity acts as aquiclude occurs after 2.7 to 4.7 meters' depth. Therefore, electrical conductivity, varies with soil grain size. Silt and clay exhibits higher electrical conductivity reading than sand and gravel.

The rate of penetration (ROP)depends upon what is type of material (hard or soft layer) of each depth how fast or slow it travel with time. For hard layer such as gravel material, it takes longer time to reach the subsurface, whereas for the soft layer like clay material, it takes lesser the time required to reach the subsurface to store water. For the soil sample The inner tube was placed at the depth of 2 meters, the tube length was 1.2 meter.

For Soil sample is extracted till 1.06-meter depth using direct push. This sampling gives composition of the soil, with particle size ranging from fine to coarse. Figure 9 show the composition of 0 to 0.32-meter is top soil with low conductivity, then 0.36-meter coarse gravel then 0.55-meter fine gravel material, 0.64-meter coal and 1.06-meter silt clay (fine material).

For water sample obtained using a submersible pump. water was brownish in color. The water sample contained gases. The water sample was later taken to laboratory for further experiments to know the geochemistry water sample. If water was clear, it could be used for drinking purposes.

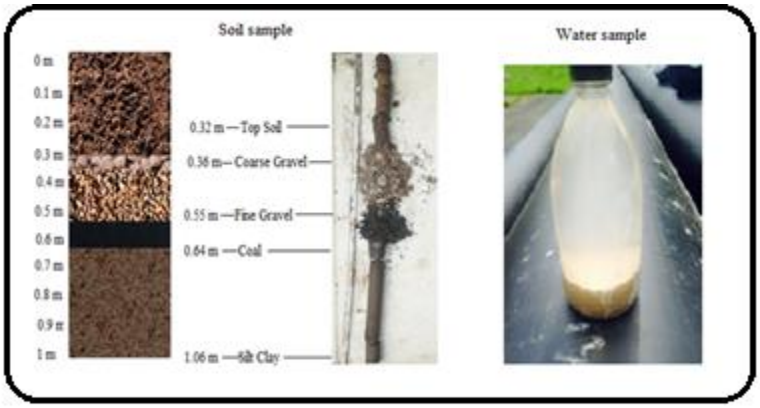

Figure 9: Soil sample and Water sample collected by using Direct Push Technology

3.3. Pumping Test

In Stegemühller site, well B3 (6-inch diameter) used has a pumping well and well P0/25 (1-inch diameter) used has an observation well. The same water level device was used on day 2, it was measured and recorded automatically in the data logger and stop watch. But large pump was used at this site. Here B3 well was a pumping well whose initial water level was 2.54m and P0/25 was observation well whose initial water level was 3.35meters. Aquifer thickness was measured to be 2.5meters and the pumping rate was measured to be 1.204 liter/sec. The distance between two wells was 14.25 meter. During pumping test, we also find out chemical parameter or properties of pumped water such pH, oxygen level (%), temperature(°C), electrical conductivity (µS/cm) and discharge rate(l/min). The pumping test started at 10.4am ended for 50 minutes whereas recovery phase started at 13: 45pm.was recorded for 60 minutes. In pumping well B3 data, drawdown and recovery curve was separated. Later it was uploaded to the AQTESOLV software. Figure 9 shows the drawdown and recovery curve of the pumping well B3 using AQTESOLV. Similarly, the same procedure was repeated for well S. For pumping well B3 and P0/25, the drawdown and recovery was analyzed by using Theis method whose aquifer model is confined. Figure 9 and figure 10 shows the drawdown and recovery curve of the pumping well B3 and P0/25 using AQTESOLV.

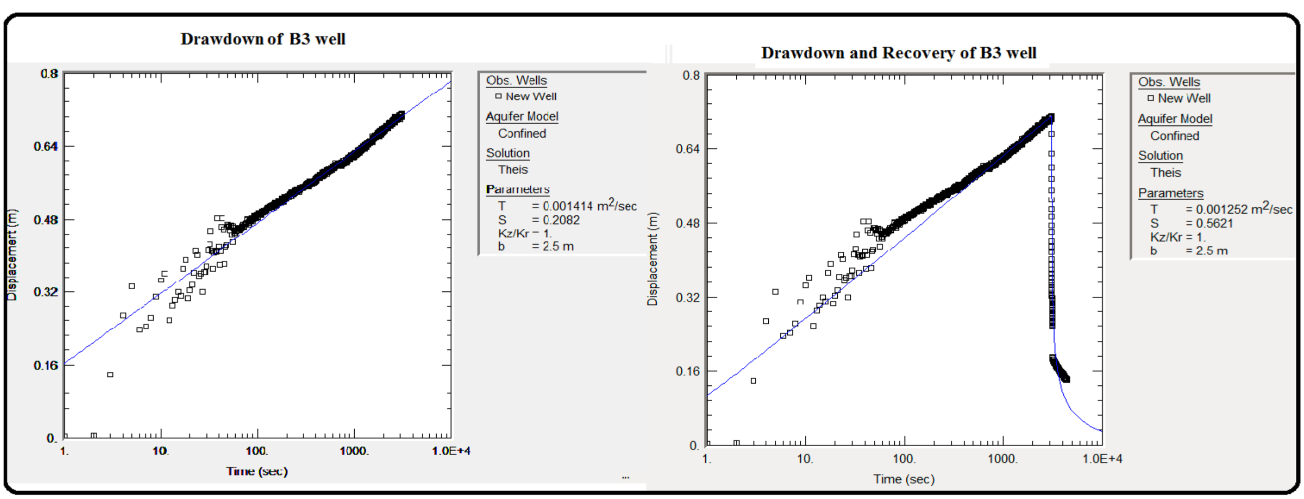

Figure 10: The drawdown and recovery curve of the pumping well B3 using AQTESOLV.

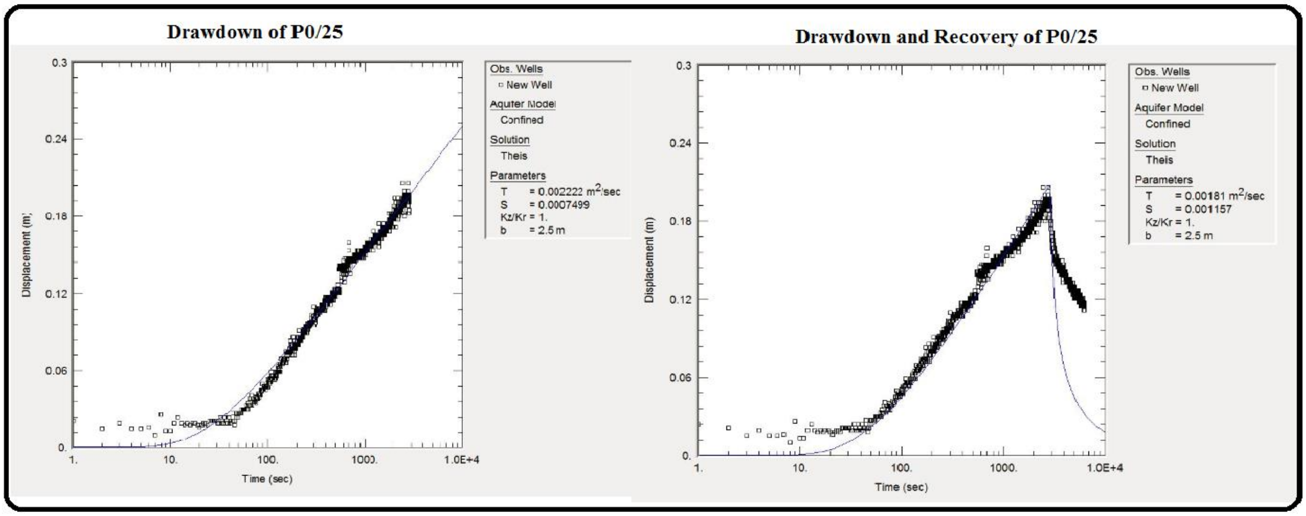

Figure 11: The drawdown and recovery curve of the observation well P0/25 using AQTESOLV.

The maximum drawdown on pumping well M was 0.262 meter and where on observation well S is 0.231 meter. Transmissivity(T) value varies from $0.0022m^2/s$ to $0.0081m^2/s$ that means that Higher transmissivities the aquifer made up gravels or coarse sands and matches with the geological situation as shown in appendix 5. Due higher hydraulic conductivity it can be suitable for drinking water supply. Storativity(S) of observation well S has value varies 0.001157 to 0.000749. Therefore, based AQTESOLV 2015 the storativity value of between 5E-3 to 5E-5 acts has a confined aquifer.

3.4. Chemical parameter

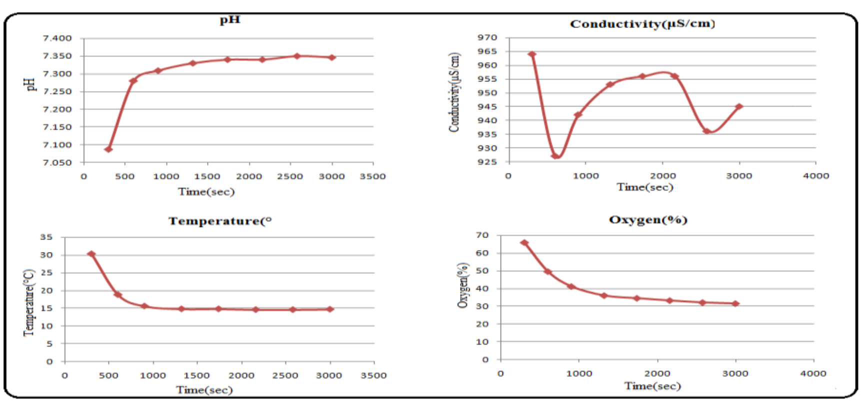

Figure 12: The four chemical parameter or properties of pumped water

The Chemical Properties of Pumped water measured using TetraCon probe and Multi 3430 digital sensor. The four of pumped water such as pH, oxygen level (%), temperature(°C), electrical conductivity (µS/cm) and discharge rate(l/min) was every 5 minutes till reaches the 60 minutes pumping period.

The first data point shows water in the well and latter points shows water is in aquifer as shown in figure12. The pH of pumped water increases from 7.08 to 7.34 with time. The electrical conductivity in the well water increases whereas water in aquifer decreases and reaches the constant value. The oxygen saturation decreases during pumping because water in contact with atmosphere is mixed with oxygen. The temperature in well water increases later when water in aquifer it decreases through time. At latter point, the electrical conductivity decreases due influence of nearby river or channel at pumped well.

3.5. Water level measurement before and after pumping

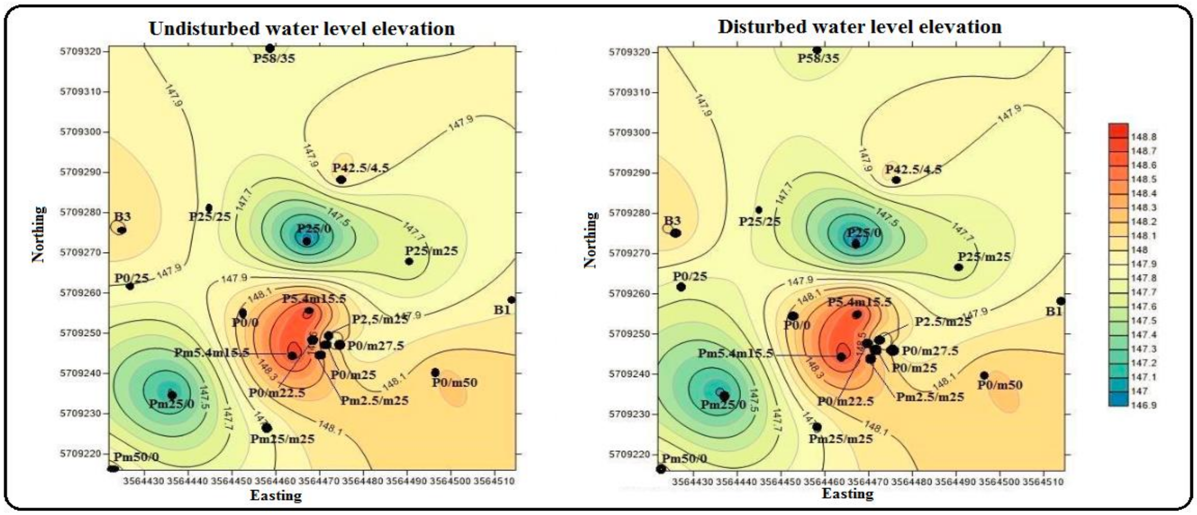

Figure 13 The counter map of undisturbed (before pumping) and disturbed (after pumping) using the SURFER software

At Stegemühle site, ground water level before and after pumping of every well is noted, and use for making the ground water contour maps with help of SURFER version 13 software and also by hand method. It used to estimate the groundwater flow. The coordinate system used here was Gauss Kringing method. In contour map, x-axis is easting whereas y-axis is northing (given in the field trip notes) and z-axis is the ground water elevation of each well. This elevation of each well is calculated by subtracting given measured elevation (given in field notes) with ground water measured before and after pumping of every well in the site. Figure 13 shows the counter map of undisturbed (before pumping) and disturbed (after pumping) produced by the SURFER software and appendix 6 show as the counter map of undisturbed and disturbed groundwater flow generated by hand method. The strongest influence was seen between well B3 and P0/25. The distance between two wells 14.25 meter and their drawdown was 0.14 meter. The least influence was seen from pumping well B3 and P58/35, which far away from B3 well and their drawdown was 0.01 meter. This shows that aquifer material has greater influence on distance. The counter map generated by hand method does not give proper water level since its influence with nearby river (constant head boundaries).

4. Slug test at Stegemühle site

Slug test was conducted in order to determine the hydraulic conductivity of aquifer at small scale compared to that of pumping test. Slug test is done using a pneumatic method with double or multilevel packer system in order to avoid the fluctuation of reading from the response signal. This pneumatic approach involves pressuring the air column in the sealed well by injecting compressed air using bicycle pump in the double packer system. At the sealed part of the well there is increased pressure of air column, due to which there is depression in the water level and hence because of this water comes out of the well screen. The change in water level and the change in pressure of the air column is recorded with small diameter pressure transducers (PDCR 35/D-8070) connected to a data logger (Campbell Scientific® CR

1000 or CR3000). The head data during a test can be monitored simultaneously and saved on a field laptop. Here the pressurized air act as the slug. The KGS method were applied using the slug test data by using AQTESOLV software. Slug test was done in Stegemühle site in well P0/m25.The three slug test experiment was conducted at varying depth within the confined aquifer. The one slug test reading was done at depth 25cm from the bottom and other slug test reading was done at depth of 50 cm upper.

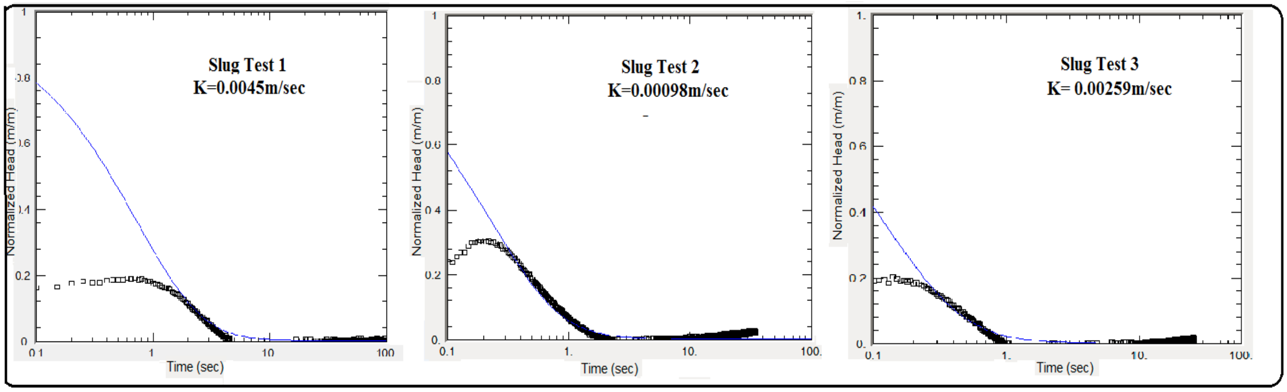

Figure 14: The Three slug test using AQTESOLV

As shown in the figure 14, the slug test 1 has high hydraulic conductivity (K=0.00 45m/sec) it means that sample is main section of aquifer or aquitard, so it a middle slug test. Slug test 2 has lowest hydraulic conductivity (K=0.00098m/sec) that mean sample is in or near to aquifer or near confining layer constant head boundary so it top slug test (higher confining layer). The slug test 3 has considerably lower hydraulic conductivity that slug test 1 there for its lower confining layer. The advantages of slug test are the low costs, the relative simplicity of the method, the short duration (at least in high permeability media), and the consideration that no water needs to be handled, which is very beneficial at sites of suspected groundwater contamination than pumping test. Slug Test is done in single well whereas pumping test is done on multi well.

5. Conclusion

The main criteria for conducting experiment at north campus and Stegemühle site is to check which location has good aquifer or groundwater, so that it can be used for drinking water supply. At GZG site, borehole camera was done to check whether well construction same as planned before during construction of well and gamma ray logging was done, in order to distinguish where clay and gravel particle are present. The high reading of gamma ray(cps) was emitted due to presence of clay whereas low gamma ray(cps) was emitted due to the presence of gravel. During pumping test where transmissivities is very low due to presence of poor aquifer material such sand silt sandstone limestone or clay. Therefore, not suitable for drinking water supply. The storativity value of between 5E-3 to 5E-5 acts has a confined aquifer. The pH, electrical conductivity, and temperature increases based on sediment material whereas oxygen saturation decreases when water is in contact with atmosphere.

At Stegemühle site, Direct push technology method was conducted to measure the electrical conductivity, hydraulic conductivity of a sample and also used collect the ground water and soil sample. The electrical conductivity varies with soil grain size. Silt and clay exhibits higher electrical conductivity reading than sand and gravel. Soil sample was measured to 1.06 meter with varying grain size, where as water sample obtained was brownish in color. If the water was kept for longer time could be clear and suitable for drinking purpose. During the pumping test, transmissivities (T) obtained was higher could fit for coarse sand and gravel aquifer and it matches with geological situation as shown in appendix 5 and even the storativity value was between 5E-3 to 5E-5, it acts has a confined aquifer. The pH increases where electrical conductivity, and temperature and oxygen saturation decreases, electrical conductivity is lower than north campus due to presence of two channels on either side. Stegemühle site, has good aquifer or groundwater that can be used for drinking purpose due to high hydraulic conductivity (K) and low electrical conductivity. The Slug test is done at different depths within a well giving a higher resolution view of hydraulic conductivity within one well. Slug test is low cost, less time consuming and done in single well as compared with pumping test. purpose. Good quality drinking water should be free from disease-causing organisms, harmful chemical substances and radioactive matter and must taste good. It would better to conduct water quality test, biological and geochemistry experiment at GZG site and Stegemühle site to know quality of water whether it can be used for drinking purposes. At GZG site it would better to conduct the direct push technology to know how does groundwater and soil sample looks like.

6. Acknowlegment

I would like to thank Prof. Dr.- Ing. habil. Thomas Ptak, gave me better understanding about Hydrogeological Field Trip Study. I would like to thanks Rui hu and Stefen Fischer for assistance with equipment settings and data collection.

7. Declaration

I (Swathi Mohandas Surekha, matriculation number 21407887) hereby declare that this report is a presentation of my original work. No contributions of others are involved, no parts are copied from other reports or other sources. I am aware that the reports are equivalent to an examination, and that any attempt to defraud will lead to serious consequences such as removal from the registry of students.

Signature: Swathi MS **Date:** 30.06.2016

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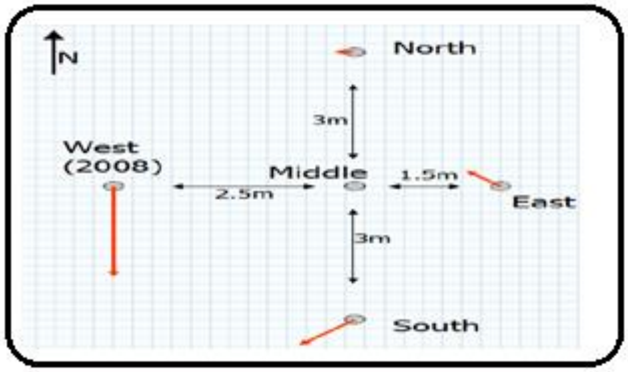
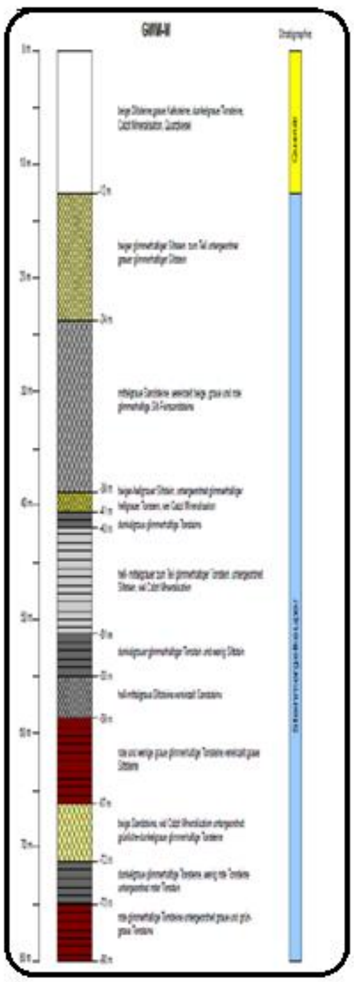
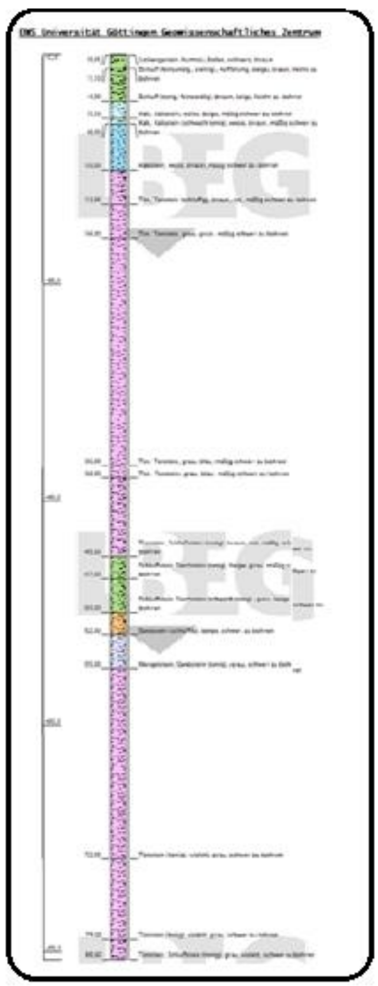
9.Appendix



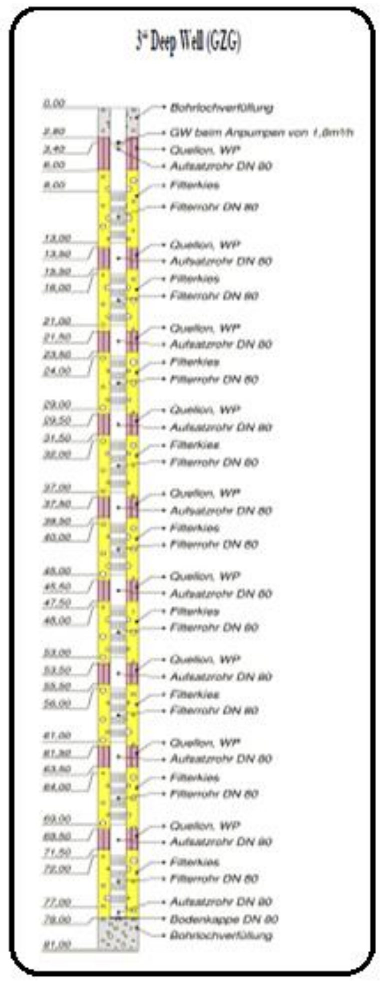
Appendix 1: The Five slot arrangement of wells at GZG Site



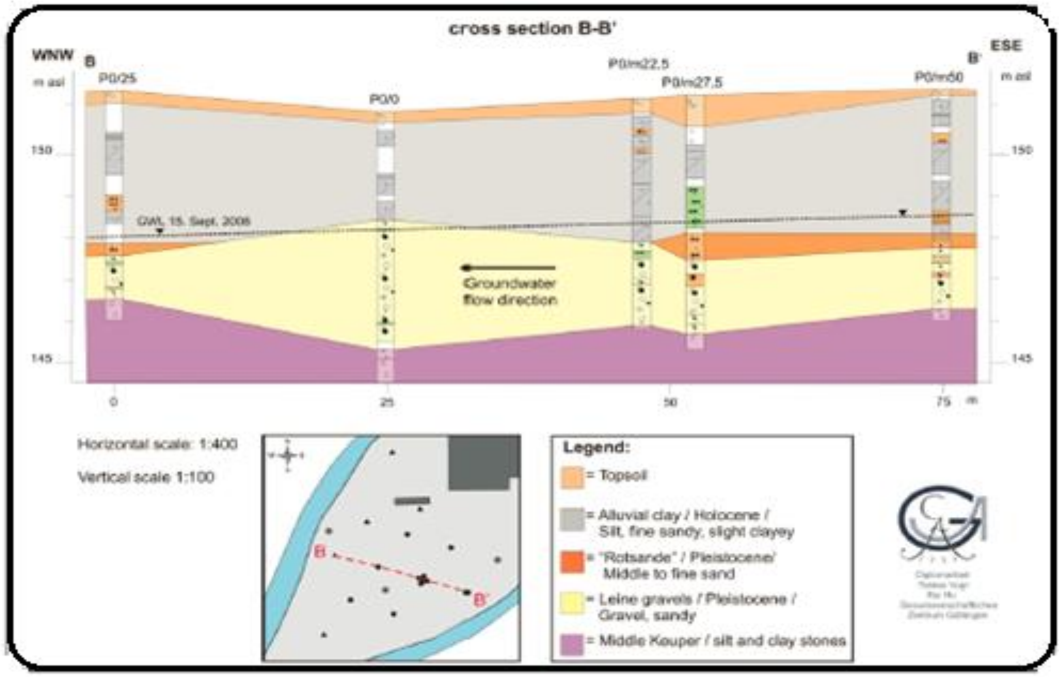
Appendix 2
Geology of Well M



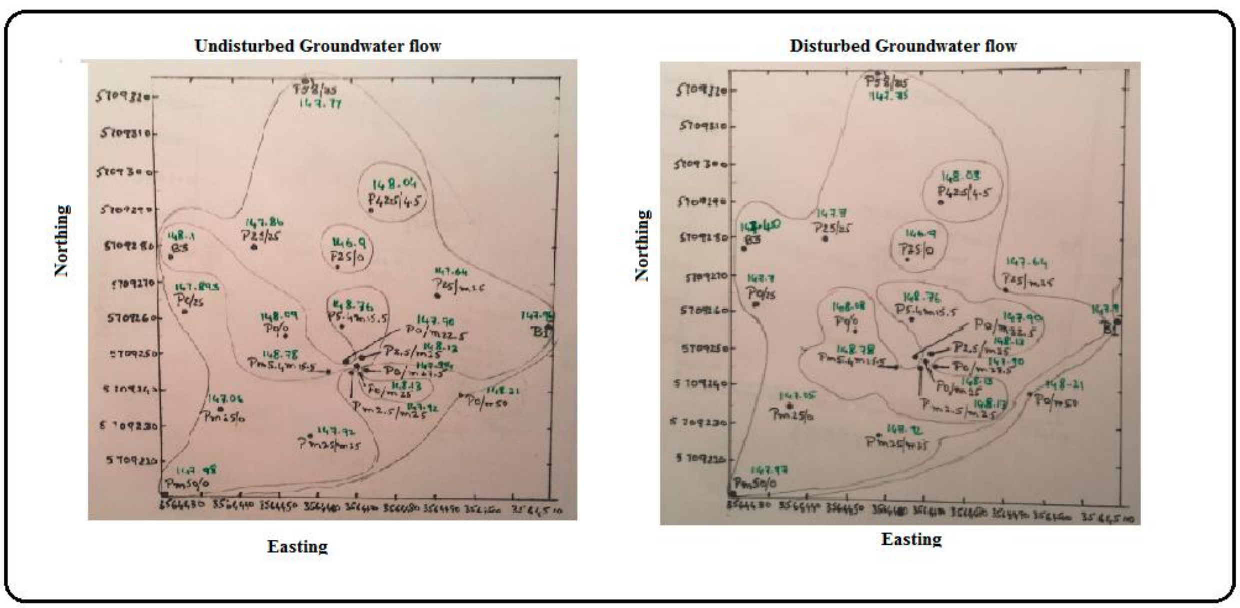
Appendix 3
Lithography of well (NIBIS Kartenserver)



Appendix 4
Construction plan of well



Appendix 5: Geology Situation of Stegemühle site



Appendix 6: The counter map of undisturbed and disturbed groundwater flow generated by hand method