MODIMOLLE-MOOKGOPHONG Local Municipality

water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

VCS Denmark

South African – Danish Strategic Sector Cooperation
Project Support Facility

Borehole Optimization Project

Borehole optimization and strategic planning in Modimolle-Mookgophong Municipality

July 2022

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1. Introduction

The South African – Danish Strategic water sector program on water, Phase 2 has an opportunity through the Project Support Facility, PSF, to promote advisory services for developing capacity among partner authorities to develop finance ready solutions. This proposal is for optimization of the boreholes in Modimolle-Mookgophong Municipality.

The project has included a thorough testing of boreholes and wellfields to assess the present condition of the boreholes, the technical installations, especially the submersible pumps, and not the least the operating and management practices at the wellfields.

This important information can be used in regard to some immediate actions as well as a baseline for planning un future actions for groundwater abstraction. This is compiled in an Action Plan for the well fields in Modimolle-Mookgophong Municipality.

For future improvement of the groundwater abstraction monitoring procedures and automatization procedures is suggested. Procedures is balancing staff capacity, data requirements and actual hydrogeological situation.

In a broader perspective, an important objective for the project is to develop procedures for wellfield optimisation in a South African context as well as providing systems for monitoring and managing the wellfields in a sustainable manner regarding groundwater resources as well as technical installations.

2. Modimolle-Mookgophong Water Supply

The Modimolle-Mookgophong Local Municipality is a category B municipality situated within the Waterberg District in the Limpopo Province. The municipality's total population is 107,699 with a total of 28,977 households.

Insufficient provision of water from the bulk water supplier as well as the municipalities own sources and a water distribution loss of nearly 40% due to old and aging infrastructure and poor maintenance results in an unsatisfying situation where residents do not receive water for 24 hours a day.

The municipality as a Water Service Authority is responsible for ensuring access to water service – which happens through five water supply systems.

- Modimolle/Magalies
- Mabaleng (Alma)
- Mabatlane (Vaalwater)
- Mookgophong
- Roedtan

The Modimolle/Magalies and Mookgophong systems are surface water dependent augmented by boreholes. The Mabaleng, Mabatlane and Roedtan systems are completely dependent on boreholes.

Magalies provides services as a bulk water supplier to Modimole-Mookgophong. The municipality's own water sources are Donkerpoort Dam, Frikkie Geyser Dam and Boreholes (51).

An examination of the water provision in Modimolle / Mookgophong shows four critical areas:

- Insufficient availability of water resources
- A high loss of water in distribution system
- Insufficient revenue generation
- Lack of adequate planning of water services

All areas are interlinked. This project addresses groundwater resources, but to obtain a permanent improvement all areas need to be addressed.

3. Activities in project

The project group have consisted of Department of Water and Sanitation, DWS, Modimolle-Mookgophong Municipality, MMM, and VCS Denmark, VCS, referring to the PSF under the Danish Strategic Sector Cooperation. The fieldwork has been delayed by the Covid 19 disturbance with approximately one year.

Virtual meetings have been held in the group bi-weekly since beginning of 2021. In February 2021 DWS and MMM conducted a joint Site Inspection, /6/. Based on this, the process of developing ToR took place and finally in September 2021 the tendering took place. The date for tender submission was October 5th, 2021. A tender evaluation took place and VSA Leboa Consulting, (Leboa), received a signed appointment on 24 November 2021.

During the fieldwork and reporting from December 1st till end of March 2022, weekly online meetings were conducted, in which Leboa participated. VCS visited Modimolle from 23.02 till 03.03.2022.

The initial site visit identified 41 boreholes, but since February 2021 more boreholes had been established. They were in accordance with the ToR included in test program.

The reporting and findings were presented for all stakeholders at a Workshop in Modimolle, July 13th, 2022 and suggestions and comments from the participants have afterwards been included in the final report.

4. Borehole Investigations

Site visits to the in the ToR listed boreholes were conducted 1-8.12.2021. Leboa started fieldwork 07.12.2021 and finished the investigations the 03.03.2022 in accordance with the agreed workplan.

In total 46 boreholes were visited, 42 tests were conducted, and 40 tests were successfully completed. For the 4 boreholes not tested, 2 were not possible to test due to ongoing work, one provided safety issues for the team and one borehole turned out to be too shallow. This is summarised in table 5.1

Modimolle: 11 sites were assessed; at 10 sites a test could be completed. A new borehole from 2022 without any number was attempted tested, but was in such a bad state, as it had to be given up for test

System	No of BH	BH tested	BH disfunc.	Equip. Dis-func.	Working
Modimolle	11	10	0	9	2
Mookgophong	22	19	3	12	7
Mabatlane (Vaalwater)	9	7	0	(3)	6
Mabaleng (Alma)	2	2	0	1	1
Roedtan	2	2	0	1	1
Total	46	40	3	26	17

Table 5.1. Overview over boreholes tested in Modimolle-Mookgophong Municipality as per March 2022

Mookgophong: 22 sites were assessed; at 19 sites a test could be completed. BH-5 is a working borehole but could not be tested due to overhead power lines provided a safety risk for the test team. Bh-15 is too shallow to conduct a test. BH-20B, a new borehole, test was attempted, but the borehole is so poorly constructed, that it collapsed during test.

Vaalwater: 9 sites were assessed; at 7 sites a test could be completed. 2 boreholes were getting an overhaul in the form of equipment and housing and could therefore not be tested.
Alma and Roedtan are both supplied from 2 boreholes and on each location 2 tests were completed.

The investigation included:

- Assessment of equipment
- Collection of details on boreholes
- Conduction of stepwise pumping tests
- Collection of water samples
- Conduction of a hygienic assessment of borehole surroundings

Below a detailed list of onsite activities as given in the reporting from Leboa:

- Obtaining access to pump houses,
- Assess the current status of equipment –working or not and potential reasons if not operational,
- Dismantling of connection pipes,
- Removing installed equipment (riser pipes and submersible pump),
- Storing removed equipment on PVC sheets –not to be in contact with the ground,
- Note all details of pumps, motors, electrical installation and pipes,
- Note the details of the well –depth, water level, casing size, casing material, casing depth,
- Install test pump –attempt to install a pump sized according to the potential yield,
- Step testing of the borehole according to submitted procedures,
- Collect water sample during final stages of third step test,
- Measure the water level recovery,
- Remove the test pump,
- Reinstall existing equipment as agreed with Municipality –storage is problematic if not reinstalled,
- Ensure that the pump is working if it was in working order on arrival,
- Ensure the pump room etc. is locked again (Or protected as good as possible)
- Ensure the site is clean and left in a rather better condition as it was found in.

The pumping tests consisted of three step drawdown tests (1-hour, 1-hour and 2-hours) followed by a 1-hour water level recovery period. The yield of the first step should be approximately 50% of the estimated maximum yield, planned for the third step the estimation of the yield of the first step was determined based on the size of installed pump, measured yields of installed equipment and/or existing information on borehole capacity. However, available information was seldom accurate, because the available data on yields were recommended yields and not always reflecting the borehole's potential yields. This inaccuracy underlines the importance of conducting the present study.

Measurement of the water level was taken per minute of 1, 2, 3, 4, 5, 6, 8, 10, 15, 20, 25, 30, 40, 50, 60, 75, 90, 105, 120 intervals and flows were taken regularly during each step. The interpretation of the test results was done using the Flow Characteristic (FC) method as developed by the Institute for Groundwater Studies (RSA) to estimate a sustainable abstraction yield from the limited step test results but also to obtain values for transmissivity, specific capacity, and borehole efficiency.

Often borehole investigations include a longer constant discharge test, (8 hours up to several days), where the longer test can provide more precise information on aquifer characteristics. An activity mainly important for new boreholes, where operation data is not available. In the case for the boreholes in Modimolle-Mookgophong the aim has been to provide information for optimizing the existing wellfields.

The correct operation and utilization of boreholes depends on a realistic assessment of the borehole's production capacity and transfer this to the installation of the right equipment that reflects the hydrogeological conditions. It is important that the supply personnel understand the interdependence between the condition of the groundwater reservoir, the pump size, the pipe system, and the mode of operation in order to ensure a continued stable abstraction of groundwater.

5. Results of Borehole Investigations

Some general conclusions from the investigations are:

- With too few exceptions the general condition of the boreholes and the equipment are poor
- Borehole houses are unsystematic in design and do not provide proper protection against vandalism and theft. The present condition shows lack of maintenance
- The electrical installations are in a poor state. Old equipment, often dysfunctional, poor wiring and can result in dangerous situation for staff attending the installations
- Surroundings to the boreholes are often little maintained and do not demonstrate good hygienic conditions
- The submersible pumps, riser pipes and above-ground installations demonstrate in many cases a lack of consideration in design, such as too large submersible pumps, riser pipes of inferior material and length, above ground is in most boreholes found improper sealing of borehole and piping of inferior quality
- The boreholes often present a low-cost solution, with short casing in too small a diameter and some cases unacceptable craftsmanship from the driller. It seems as if proper design and supervision is missing
- The water quality in general is good, even elevated level of turbidity is found in 70% of the boreholes. However, this does not pose a health risk.

In the following some of the key findings is analyzed and recommendations for future operation and maintenance is given.

5.1. Abstraction capacity of boreholes

Borehole optimization is not only to improve the standard of the boreholes and their installations, but also to focus this effort on the most important boreholes, read the high yielding boreholes with no water quality problems.

For this purpose, the boreholes have been categorized es in three categories: A, B and C to enable MMM to prioritize their effort on rehabilitation and maintenance. The main criteria have simply been where do one get the most water for the money.

The frame for this assessment has been the recommended yield determined by the FC method and in some cases adjusted based on the development during the step-vise pumping test and the tendencies in the specific capacity development. The categorization is summarized and otherwise presented in annex 2.

Category A: recommended yield above 2 l/s
Category B: recommended yield above 0.5 l/s and below 2.0 l/s
Category C: recommended yield below 0.5 l/s

System	No of BH	BH tested	BH cat. A	BH cat. B	BH cat. C
Modimolle	11	10	4	4	2
Mookgophong	22	19	5	11	3
Mabatlane (Vaalwater)	9	7	2	5	0
Mabaleng (Alma)	2	2	1	0	1
Roedtan	2	2	0	2	0
Total	46	40	12	22	6

Table 5.2. Overview over boreholes categories in Modimolle-Mookgophong Municipality as per March 2022

Abstraction from a wellfield is not a stand-alone borehole exercise, simultaneous abstraction from nearby boreholes influences the capacity of all boreholes. Boreholes close to each other might not all be able to run with maximum yield. Therefore, the distance between boreholes should be taken into consideration when operating the borehole and in some cases also when prioritizing rehabilitation of the installations. Private boreholes, especially boreholes used for irrigation will also affect the capacity of the municipal boreholes.

In annex 1 the location of the boreholes is shown and more specifically distance between boreholes can be an issue for the following:

Modimolle:	Cat A: H24-0172 – H24-0213 ~ 80 m
	Cat B: H24-0174 – H24-0198 ~ 70 m
	Cat B: H24-0049 – H24-0198 ~120 m
Mookgophong:	Cat A: BH06 - Bh07A ~ 20 m
	Cat A: BH04 – Cat ? BH05 ~ 80 m *)
	Cat A: BH08A – Cat B: BH08B ~ 50 m
	Cat B: BH09A – BH09B ~ 25 m

*) BH05 could not be tested due to overhead power lines, but based on data from logbooks, it is assumed that BH05 is a category B borehole.

Vaalwater boreholes have a minimum of 250 meters between them. The impact from nearby abstraction is less significant.
Alma boreholes is spaced with 150 meters, primary abstraction H24-0067, where h24-0065 only will be a used as emergency borehole.
Roedtan are distanced with 1,200 meters and will have little to no impact between boreholes.

Many boreholes are open in the hard rock aquifer, which is common practice. But in several cases the casing is very short, and thereby gives a poor protection for contamination of the boreholes water with surface water. Further, the boreholes are less stable and there is an increased risk for collapse of the boreholes.

Before abandoning Cat C or any other borehole and sealing the borehole, it should be evaluated if the borehole will serve any purpose as a monitoring borehole. Will measuring the water level in such a borehole give any information about the sustainability of the abstraction from water supply boreholes?

5.2. Water quality
From all boreholes tested a sample was collected as late as possible during pumping, mostly during the third 2-hour step test. The samples were brought to Capricorn Veterinary Laboratory within three days and were analyzed as per SANS 241-2011/2015 regarding the physical, organoleptic and chemical parameters. The samples were not analyzed bacteriological.

Few boreholes were in compliance with the standard for all parameters, 2 in Modimolle and 3 in Vaalwater. However, in general the levels of minerals found is low. Overview of number of non-compliant boreholes is given in table 5.3.

The most common non-compliant parameter is turbidity, which is not surprising in open boreholes and with no further treatment on filters. Furthermore, there is a suspicion that not all boreholes are well made, especially with a very short casing leaving the borehole to be open in a less stable formation.

A high level of iron and manganese can cause higher turbidity, but in general levels of iron and manganese are low in all boreholes. The main problem about turbidity, is related to that an elevated level provides possibility for bacteria growth.

Nitrate comes from surface pollution and will move down towards the aquifer. The thickness of the overburden and the borehole construction can be determining the impact of nitrate.

Modimolle: In 7 boreholes turbidity is above 1.0 NTU, BH H24-0198 quite elevated at 38.5 NTU, it is the only borehole where the level is truly critical. The same borehole has the elevated level of color, which is not surprising, as both parameters are related to transparency.

Mookgophong: A high number, 13 boreholes, have an elevated level of turbidity. BH20A at an extremely high level. This properly due to bad craftsmanship from the driller, as it is assumed it is the same driller as the one who conducted the poorly made BH20B. Nitrate is very prominent in Mookgophong. Unfortunately, nitrate is mainly found in all the newer boreholes, especially the string from BH14-BH19. Again, poor borehole construction could be the cause. Lead is detected in 8 boreholes, everywhere at 0.02 mg/l, just above the guideline value of 0.01 mg/l.

Vaalwater: The boreholes have 4 cases of elevated turbidity and 1 with acidic water below guideline value. BH H24-0000 is the only other borehole nearby and here as well the is pH fairly low. It should be checked as it can be corrosive.

Alma: Both boreholes have a slightly elevated level of turbidity. Not critical.

Roedtan: Both boreholes have a slightly elevated level of turbidity. Not critical.

Borehole BH20A in Mookgophong cannot be used due to water quality but is already disqualified due to low abstraction capacity. Otherwise, there is no critical water quality problems.

System	No.BH Test	Turbidity	Colour	Lead	Nitrate	pH
Modimolle	10	7	1	-	1	-
Mookgophong	19	13	-	8	8	-
Mabatlane (Vaalwater)	7	4	-	-	-	1
Mabaleng (Alma)	2	2	-	-	-	-
Roedtan	2	2	-	-	-	-
Total	40	28	1	8	9	1

Table 5.3: Numbers of boreholes with a non-compliant water quality

For the boreholes with elevated nitrate content, the utility should be aware that they are not only boreholes supplying as the mixing with other boreholes reduce the level of nitrate in water distributed.

The suspicion of elevated level of nitrate is most likely related to bad borehole construction. Emphasis the need for better technical descriptions and supervision for future drilling activities.

5.3. Borehole installations

Different types of housing at the borehole are in many variations, 12 different variations were found.

Modimolle: Most boreholes are housed in a manhole either steel or in most cases concrete. Two boreholes on the golf course premises are totally unprotected. The manholes within steel and with steel lids are locked the concrete manholes are all closed with a heavy concrete lid but unlocked.

Mookgophong: All houses are in situ concrete houses. Three different closures were found, either no door at all and direct accessible, a steel door which in most cases are locked and concrete sliding door, which nowhere were lockable or in any degree being functionable.

Vaalwater: All houses are lockable and of solid material: In situ concrete, concrete slab houses or brick houses. Most doors are actually properly locked.

Roedtan: The older borehole is in a concrete manhole covered by a steel lid, not locked though, the other functional borehole in an open concrete unlocked house.

Alma: One borehole is fully open but fenced. The other in a concrete building with no roof and a door, which cannot be fenced.

Whatever house or manhole is chosen, it is mandatory that it can be locked properly, making theft more difficult. In Situ concrete houses are stable, but very unpractical for maintenance of borehole and pump. Often a hole in the roof is made, leaving the installations accessible for thieves despite a locked door. In the case of housings, the concrete slab seems to be the best to work with for maintenance purposes. Slabs can be removed by the maintenance crew.

The houses should of course be installed with a lockable door. In some cases, the steel doors were too thin and of a too inferior quality. Attempts have been made to use sliding concrete doors, nowhere with success. This solution is not recommended.

Manhole solution might be an option if the lid can be locked properly. This do though provide less protection of the electrical and mechanical installations.

To enable monitoring of the water level all boreholes shall be installed with guide tubes for dip meters. For monitoring of production capacity, a meter at each borehole is necessary. For collection of water samples, a tap on each borehole outlet is necessary.

Fencing provides a barrier towards theft and vandalism, but it has to be evaluated if it is enough and the costs reflects the gained.

Hygiene around the borehole could in several cases be improved. It is recommended that MMM develop standard guidelines for hygiene criteria around boreholes.

5.4. Submersible pumps

In Annex 9 information found on the submersible pumps is given, and an evaluation of their condition. This is summarized in table 5.4, where it is seen that the majority of the pumps are in a sufficient condition but not good. Further, there is very little consistency between the pump and the motor. There is an unusual high variety in how motors and pumps are combined. This could be due to replacement of one part when damaged, and here using available material, not always fully suitable for the remaining part. In annex 9 a quick choice of new pumps is made, and it is noticeable, how the motor size in almost all cases is much smaller than what is installed. In the annex Grundfos pumps is chosen, other quality brands can off course also be used.

System	Good	Sufficient	Poor	N/A
Modimolle	6	2	0	0
Mookgophong	1	10	1	4
Vaalwater	0	6	0	1
Alma	0	1	0	1
Roedtan	0	1	0	1
Total	7	20	1	7

Table 5.4. Condition of submersible pumps in Modimolle-Mookgophong Municipality as per March 2, 2022

A good match between pump and motor results in the best longtime operation as well as significantly lower electricity costs.

Good riser pipes are important for the operation. They need to have a size reflecting the yield as well as they need to be airtight, this is often a problem in the joints. For service it is preferable if they are fairly light and for small flows as in MMM, screw joints is the best to work with.

In MMM boreholes are found both HDPE, Steel and PVC pipes in 7 different dimensions. The best riser pipes are found in the Vaalwater boreholes, where Ashirvad uPVC Column Pipes are used. Those pipes are made specifically for being used as riser pipes and are easy to work with doing maintenance on the pumps and the riser pipes can be expected to be airtight.

There is no reason to have many variations of pipes. For future installations it is recommended using Ashirvad uPVC Column Pipes. For Cat A boreholes 65 mm length 3 m. For Cat B boreholes 50 mm length 3m.

5.5. Electrical installations

The correct electrical installation in the boreholes is important for high reliability of supply, as faults in the electrical installation can lead to breakdowns on the pump motor and dangerous work situations.

In principle all installations of this kind should qualify for an Electrical Certificate of Compliance (ECOC) that verifies an electrical installation is compliant on the date of inspection with all the legal requirements as stipulated in the Electrical Installations Occupational Health and Safety Act of South Africa. As it is not clear how MMM addresses this issue for other installations in the municipality, for the borehole survey a simple assessment has been conducted. And to be added it is certain that none of the existing BH installations will be able to obtain an electrical COC.

In the following, three levels of electrical installations for well stations are described.
It is advisable to expand future well stations as well as renovated well stations to the medium level, as this will increase security of supply due to increased protection of the pump motor against overload and overvoltage. It is also important to remove old electrical installations, as this can lead to dangerous work situations.

<u>Low level</u>
The electrical box is equipped with a main switch, circuit breaker and thermal relay.
This level corresponds to the level that most of the well stations in MMM are equipped with.

<u>Medium level</u>
The electrical box is equipped with a main switch, circuit breaker, thermal relay, surge arrester and Motorscope. A few installations have been carried out at medium level, but in many places the electrical installation needs to be cleaned up after previous installations. Figure 5.1 shows an example of an installation that lives up to the medium level, however the main switch is missing, which must be on the front cover of the electrical box.

High level
The electrical box is equipped with a main switch, circuit breaker, thermal relay, surge arrester, phase error relay, sine wave filter and frequency inverter.
This level is not advisable in MMM as it requires a control and monitoring system (SCADA system) to benefit from the frequency control.

In table 5.5 a summary of the condition and level of the electrical installation is given. Very few installations have a medium level and sufficient condition, none is in good condition. When upgrading the installations, it is recommended to develop a standard design for MMM boreholes and replace all installations.

System	Condition of Electrical instal.			Level of Electrical instal.			
	Sufficient	Poor	N/A	High	Medium	Low	N/A
Modimolle	6	2	3	0	0	4	7
Mookgophong	1	12	9	0	3	2	17
Vaalwater	-	7	2	0	2	4	3
Alma	2	-	0	0	2	0	0
Roedtan	-	1	1	0	0	1	1
Total	9	22	13	0	7	11	28

Table 5.5. Level and condition of electrical installations at boreholes categories in Modimolle-Mookgophong Municipality as per March 2, 2022

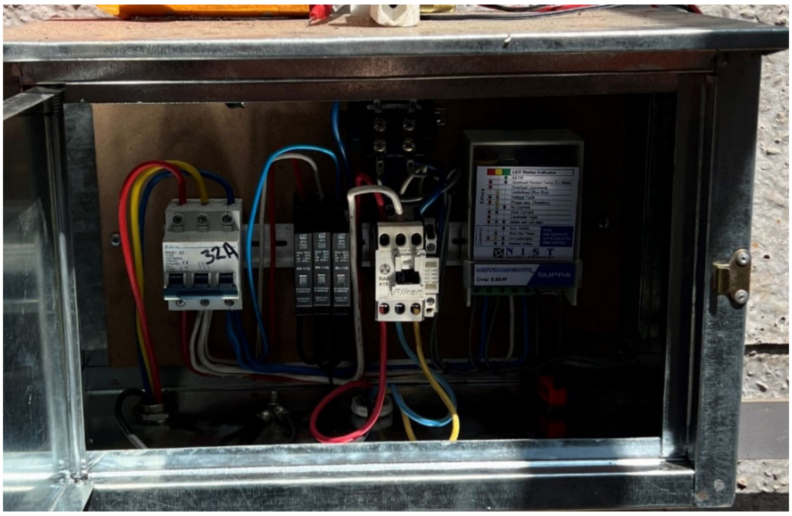


Figure 5.1: Example of medium level of electrical component, from borehole H24-0024 in Vaalwater

Figure 5.2 show an example of a good quality switchboard, with main switch and control buttons on the front of the electrical box for easy operation by operating personnel.

Figure 5.2: Example of medium level of electrical box, from bore-hole H24-0049 in Modimolle

<u>Operation of the electrical installation</u>

As power outages and lightning strikes occur, protection of the pump motor with surge ar-rester and Motorscope is very important for security of water supply, as power outages, lightning strikes and work on the public electricity grid can cause overvoltages which can damage the pump motor.

Motorscope also protects the pump motor from overload and phase faults and can provide some useful operating and fault data from the pump motor. Data extraction of operating and error data from Motorscope can be done using a laptop, Bluetooth (app on mobile phone) or an Optimizer, (a small device designed specifically for extracting data from a Mo-torscope), which can be easily learned by the operating staff.

In the event of overvoltage's on the public electricity grid, the surge arrester will switch off and a manual action must subsequently be performed, which includes replacing the tripped module, but this can easily be done by instructed operating personnel, See figure 5.3

Figure 5.3: *Optimizer, Motorscope and Surge arrester*

5.6. Wellfield Network

A wellfield network will normally be designed as a branch system in contrast to the ring connected systems being used on the distribution network. Alternatively, it can be decided to establish single pipeline systems per borehole. This is to some extent the case in Mookgophong.

A branch system is the optimal manner to design a wellfield network as the total pipe length normally will be the least in such a system. Further, as several boreholes will be pumping into the network the likelihood that at least one pump will be active causes that the time in which the network is not pressurized is less. Having the wellfield pipes under pressure reduces the risk for contamination of the pipes by intrusion of water from surrounding soil.

When several boreholes are pumping to the same network there is risk for if not pumps are active to pump from one borehole to another. Preventing this requires functional no return valves.

Another risk is if the submersible pumps are not correctly sized. In situation where several pumps are operating, a pump can have too little head, and will therefore be suppressed by larger pumps installed in other boreholes on the same network. This will cause less water production and higher energy costs.

Single string well pipes seem to be very common. Such a system requires more length of pipes but is simple to operate. However, when the pump is stopped, there is a high likelihood that the pipe will be with no pressure, allowing air to enter the pipes causing higher friction loss, (higher energy costs), when in operation again.

For all pipe systems, it is important that their location is documented by drawings or better by survey and digitalization. In MMM there is no digitalization at all.

Location and standards of valves are uncertain. Valves needs to be registered, and it should be controlled that they all are fully opened. Often a valve on a network system is found to be "hanging" or not fully opened. This causes an extra unnecessary loss of energy for the pumps.

The quality of the present network is fairly uncertain. The network location should be registered and digitalized. It should be tested if any water loss occurs in the pipe system.

6. Action Plan

The boreholes have been reviewed and tested with a focus on providing a basis for decision-making to provide an improved abstraction routine, this both in quantity as well as consistency. Some activities are more long term, while others are mandatory to address soon:

- Develop a strategy for preventing theft and vandalism
- On site activities implementing the strategy
- Improvement of all electrical installations as described in section 5.5

An Action Plan has been prepared, which describes: A short horizon of 1 year and a 5-year financial plan which is not more precisely timed. The Action Plan is enclosed in Annex 11. A draft version was prepared and further developed during a Workshop on July 13th, 2022. All relevant stakeholders participated in the workshop.

A summary of the investment is presented in Table 6.1.

Town	2022/23, ZAR	2023-/27, ZAR
General	340,000	0
Modimolle	720,000	1,330,000
Mookgophong	1,875,000	7,045,000
Vaalwater	900,000	875,000
Alma	205,000	195,000
Roedtan	360,000	1,390,000
Total	4,400,000	10,835,000

Table 6.1: Action Plan Summary of Investments

7. Operation and Maintenance

MMM is obliged to put much more emphasis on the O&M activities. This in general for the entire utility, here is addressed what is needed for the boreholes. They will have to develop a maintenance plan, addressing O&M issues.

The ongoing O&M shall as a minimum include:

- Periodically Inspection, measure water level, and read flowmeters
- Drain Surface Water Away
- Secure Sanitary Seal and maintain surroundings
- Annual Water Quality Testing at boreholes
- Better electrical installations give opportunities to monitor by using Motorscope Systems
- Repair and replace broken items within maximum 3 days
- Maintain Records digitally

One of the main issues are the vandalism. Therefore, a proper strategy against theft and vandalism needs to be developed and implemented.

To be able to conduct fast repairs, it is recommended to establish a small spare part stock/warehouse. To enable to run a functional warehouse requires to a large extent standardized solutions, as already mentioned several times through the report.

The stock could also include parts for other functions of water services such as the distribution network, pumping stations and water treatment plants.

The wellfield section in a warehouse could include: One or two common submersible pumps, Riser pipes, minimum 60 meter of 50 and 65 mm, Dip meter guide tubes, Replacements for all electrical installations, locks for borehole houses, cables of all used types, flowmeters, bandage for pipelines, lengths of pipes, small stuff as relevant tools, batteries for dip meters and Motorscopes, wirestraps etc.

It is estimated that the cost establishing such a borehole warehouse will be 4-500.000 ZAR. This do only include material costs as mentioned above.

Below a rough first estimate of what an O&M Plan can include and the cost of this.

To conduct annual O&M it is assumed having a replacement of 10 % of boreholes installations per year. This means approximately for installations of 4 boreholes, this totals to 800.000 ZAR/year.

Boreholes last normally longer than installations, here it assumed with a lifetime of 20 years, annual borehole replacement costs are 1,200,000 ZAR.

Further normal maintenance of borehole houses, approximately 200,000 ZAR.

Annual water quality test at each borehole, approximately 200,000 ZAR.

Monitoring of groundwater level is mainly heavy on manpower, but requires some expenses to maintain monitoring boreholes, per year approximately 100,000 ZAR.

Total annual O&M cost excluding manpower and electricity:

Installation replacement:	800,000 ZAR
Borehole replacement:	1,200,000 ZAR
Borehole house maintenance:	200,000 ZAR
Water quality Tests:	200,000 ZAR
Monitoring Groundwater level:	100,000 ZAR
Total annual O&M cost:	2,500,000 ZAR

WRC are in the process of developing a new guideline: "Guidance for Management of a Groundwater Scheme", final version is expected end of 2022. MMM should look into this and adapt.

The enforcement O&M and Monitoring requires new qualifications. MMM is he process of hiring a Water Quality expert and should consider the need of staff with electrical and mechanical experience allocated specifically to the water services.

A process should be started in organizing monitoring data digitally setting up databases or just spreadsheets.

8. Recommendations

There are differences among the five location for municipal borehole abstraction, but the general condition of the wellfields is poor. There are several recommendations on all aspects for improving the service of the groundwater supply.

The overarching recommendation is that the municipality should try to harmonize their installations, as this will facilitate the O&M on the wellfields. Further, the municipality should take the front seat and have much more strict requirements and specifications for consultants and contractors working on the municipal assets. It is required to develop ToR for refurbishment. This should include ToR for Siting of Boreholes, ToR for drilling of boreholes, ToR for electrical installations. It is important to use only Certified Drillers, as well as Consulting Engineers with a good record.

The boreholes
The boreholes are to a very large extent low yielding, this due to difficult aquifer conditions, but also due to in several cases very bad craftsmanship from the drillers as well as poor advice from consultants in location of boreholes. In most cases the existing boreholes cannot be improved, therefore it is important for MMM to focus their investments and efforts on the better boreholes, this attempted described by the categorising of the boreholes.

The installations
The submersible pumps do not always reflect the borehole capacity and in most cases the motors are too large. This results in a bad pump economy and a risk of lowering the groundwater table down to the submersible pump.

For future installations it is recommended for riser pipes to use Ashirvad uPVC Column Pipes. For Cat A boreholes 65 mm length 3 m. For Cat B boreholes 50 mm length 3m.

The electrical installations in general are in a very poor condition. It is recommended that all borehole installations get upgraded so they are in compliance with ECOC requirements. In this report three levels of electrical installations are described. MMM should aim for a medium level, not requiring any remote control through SCADA systems.

The present housings solutions are inadequate. Several shortcomings are found in the present especially in preventing theft and vandalism. It is recommended that MMM adopt a standard solution and do <u>not</u> leave it for contractors to decide on details, for example as important a functional door. And it should be considered to establish fencing around boreholes.

The current wellfield network should be inspected.

Planning
It should be known and clearly flagged what are the sustainable yield form each borehole and it should be hold up against the readings of abstraction.

MMM shall own all production boreholes. As it is now a few boreholes are privately owned an MMM pays for the water abstracted. This is not feasible, neither economically nor from an O&M perspective. The municipality should take over the borehole or establish of their own.

Operation and Maintenance
WRC are in the process of developing a new guideline: "Guidance for Management of a Groundwater Scheme", final version is expected August 2022.

MMM should look into this and adapt. This requires development an O&M plan including of precise job descriptions and most likely some restructuring of the present department.

Monitoring
Develop a proper monitoring plan, look into the coming "Guidance Document for Management of a Groundwater Scheme: O&M Protocol and Governance Structures", /8/, to be published by WRC in the end of August 2022.

The boreholes need to be supervised more closely and the data collected should be compiled and used. Therefore, data should be registered digitally.

The staff need some training in being able to take on their new responsibilities. MMM needs to allocate manpower to organise and digitalise the collected monitoring data.

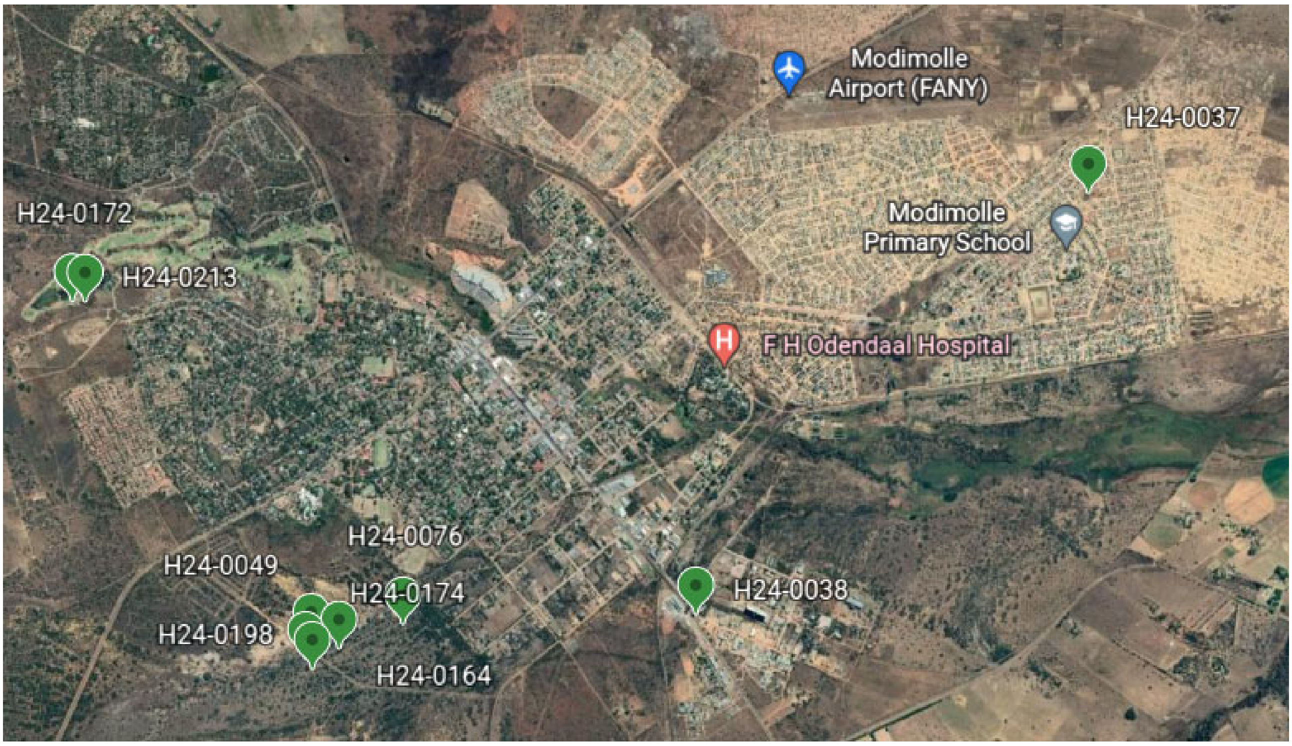
Staff Capacity at utility
Without having performed any institutional analysis, it is obvious that the utility is lacking staff with a mechanical and electrical engineering background. The water services constitute approximately 140 staff members. Such numbers require a middle management, team leader segment with s stronger mandate than at present.

9. References

1. Borehole investigations in Modimolle-Mookgophong Municipality for Borehole Optimisation Project, Roedtan Town, VSA Leboa Consulting Ltd, February 2022.
2. Borehole investigations in Modimolle-Mookgophong Municipality for Borehole Optimisation Project, Modimolle Town, VSA Leboa Consulting Ltd, February 2022.
3. Borehole investigations in Modimolle-Mookgophong Municipality for Borehole Optimisation Project, Vaalwater Town, VSA Leboa Consulting Ltd, March 2022.
4. Borehole investigations in Modimolle-Mookgophong Municipality for Borehole Optimisation Project, Alma Town, VSA Leboa Consulting Ltd, March 2022
5. Borehole investigations in Modimolle-Mookgophong Municipality for Borehole Optimisation Project, Mookgophong Town, VSA Leboa Consulting Ltd, March 2022
6. Modimolle-Mookgophong Borehole Optimization Study – Site Inspection report, DWS, February 2021
7. Manual on pumping test analysis in fractures rock aquifers, DWS, March 2003
8. Draft document for Guidance Document for Management of a Groundwater Scheme: O&M Protocol and Governance Structures, WRC, June 2022

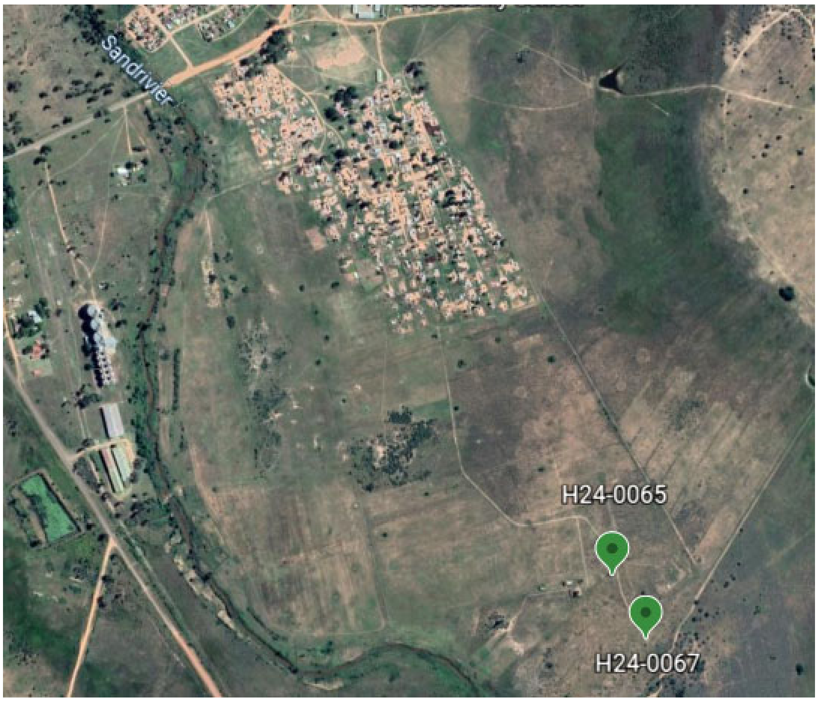
Appendix 1

Modimolle

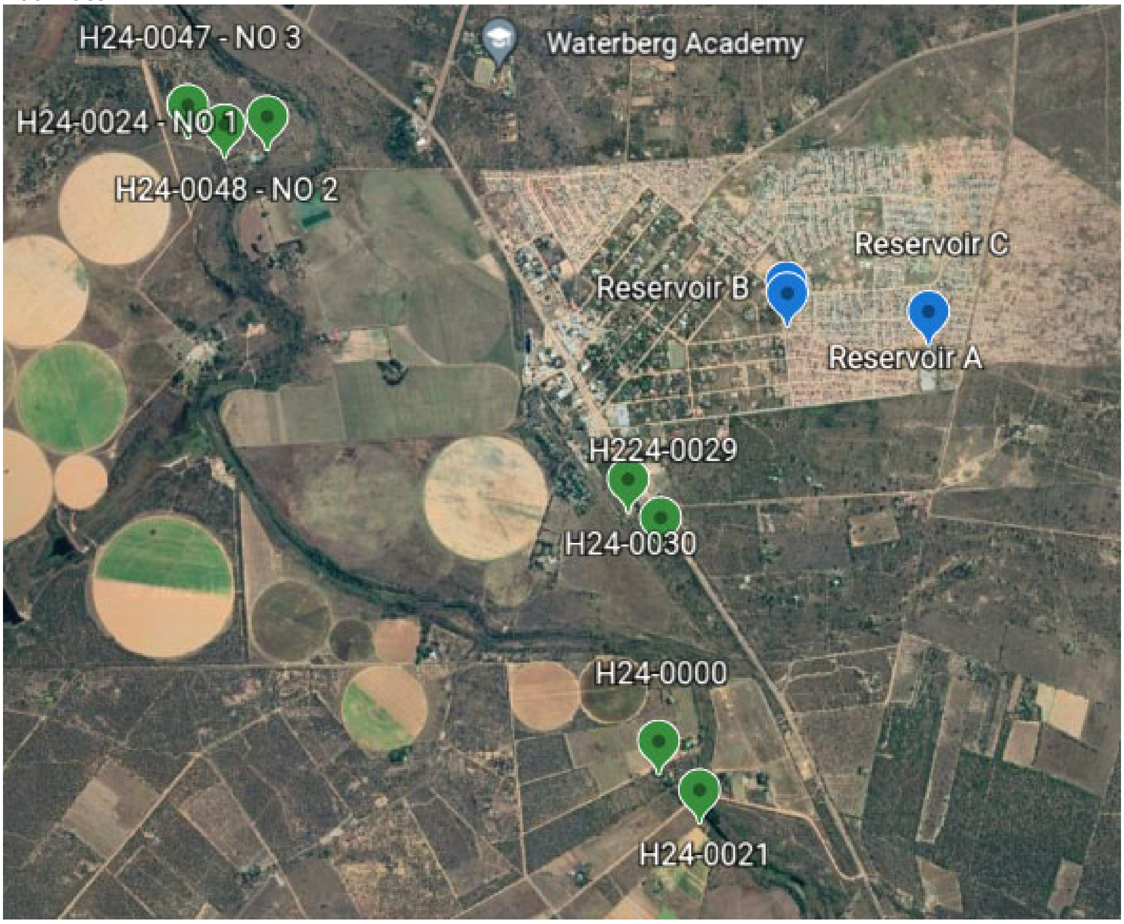


Roedtan

Alma

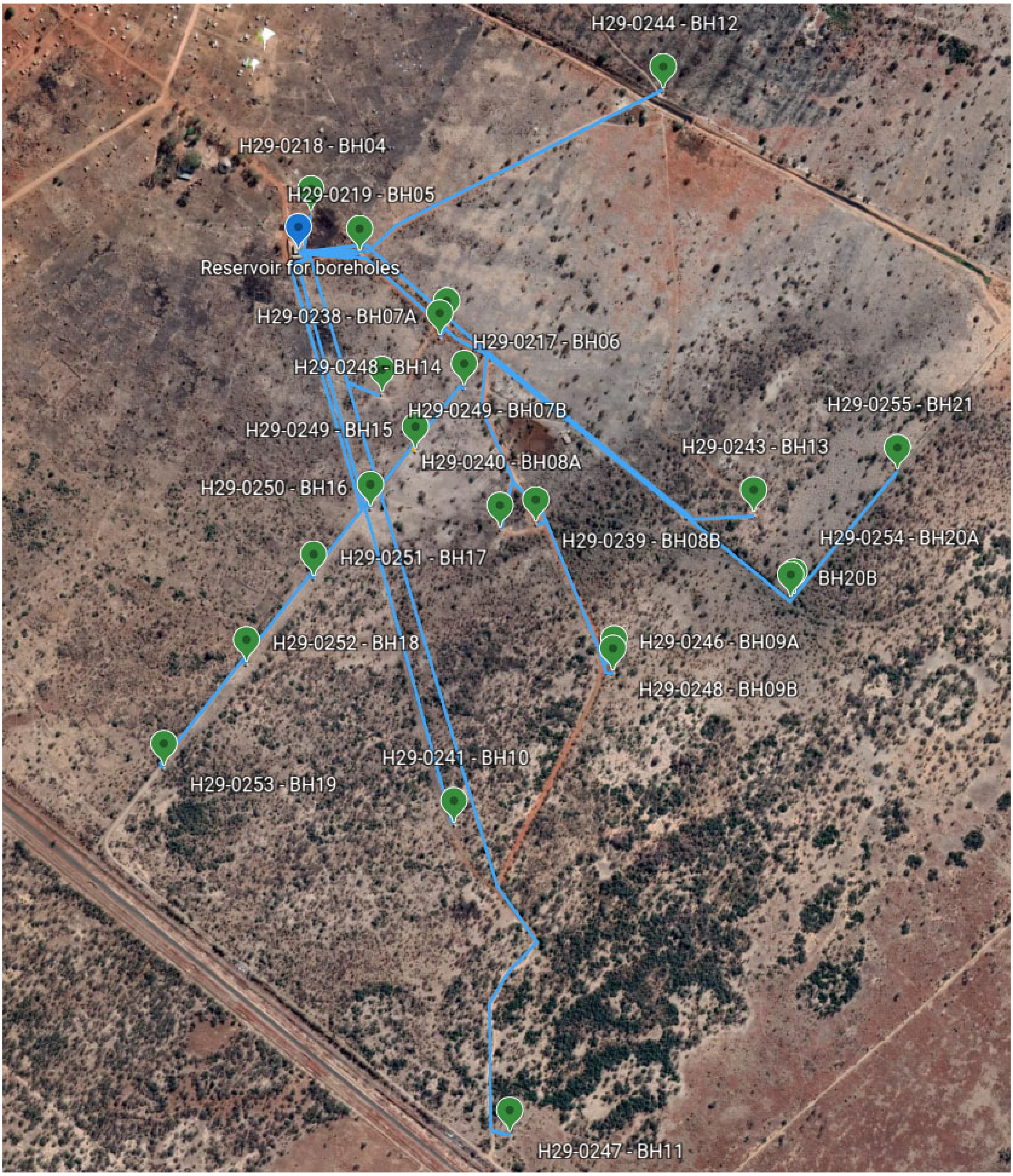


Vaalwater



Mookgophong

Appendix 1


H29-0244 - BH12
H29-0218 - BH04
H29-0219 - BH05
Reservoir for boreholes
H29-0238 - BH07A
H29-0217 - BH06
H29-0248 - BH14
H29-0249 - BH07B
H29-0249 - BH15
H29-0240 - BH08A
H29-0255 - BH21
H29-0243 - BH13
H29-0250 - BH16
H29-0239 - BH08B
H29-0254 - BH20A
H29-0251 - BH17
BH20B
H29-0252 - BH18
H29-0246 - BH09A
H29-0248 - BH09B
H29-0241 - BH10
H29-0253 - BH19
H29-0247 - BH11

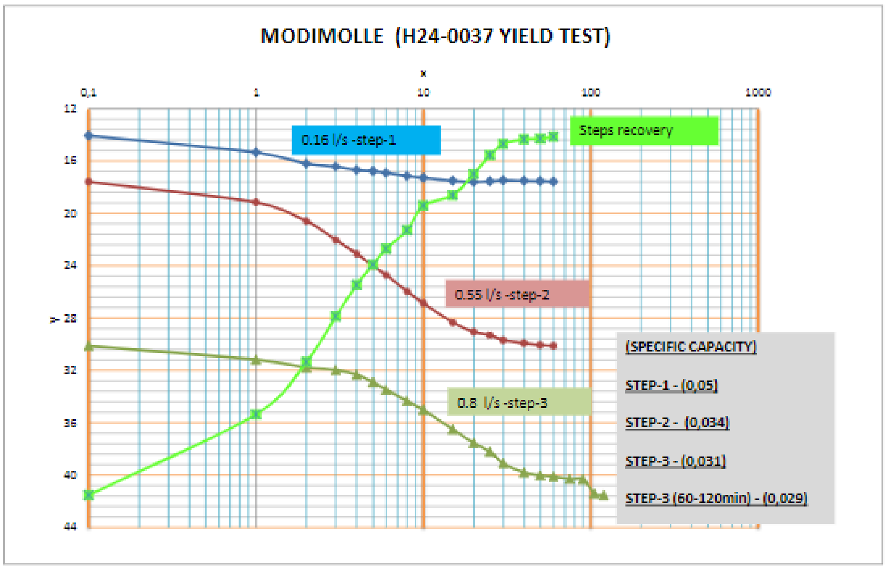
Appendix 2

Borehole Capacity Assessment

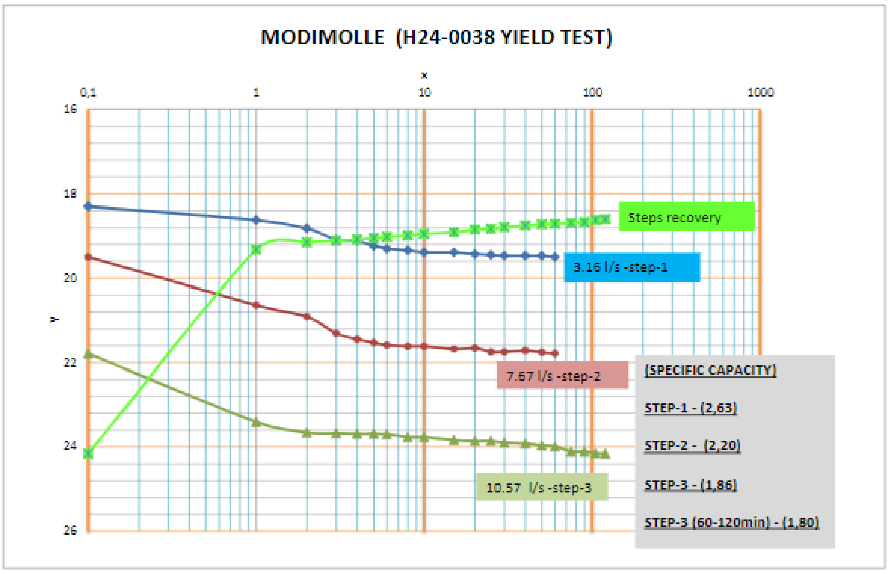
TOWN	DWS SITE ID	BOREHOLE NUMBER	BH Depth	START WATER LEVEL	Max DD, m	Pump Suction	MAX YIELD	RECOVERY OUTSTANDING (1-HOUR) - m	SPECIFIC CAPACITY, L/S/M	CALC. T VALUE	REC PUMP SETTING	REC YIELD (L/S)	BH Category
Modimolle	2429CBV0001	H24-0037	70.2	14.06	27.47	NO	0.80	0.08	0.03	1.5	60	0	C
Modimolle	2428CBV0018	H24-0038	87	18.30	5.84	NO	10.60	0.41	1.95	45.0	60	5	A
Modimolle	2428CBV0019	H24-0049	49.9	14.11	22.83	YES	3.80	0.14	0.17	14.0	36	1.2	B
Modimolle	2428CBV0020	H24-0076	58.5	14.31	13.57	NO	10.25	1.42	0.84	50.0	39	3	A
Modimolle	2428CBV0021	H24-0164	37.75	14.30	17.35	NO	5.80	0.83	0.35	13.0	30	1.5	B
Modimolle		H24-0172	65.5	17.61	5.20	NO	10.14	0.35	2.09	70.0	54	3.5	A
Modimolle	2428CBV0024	H24-0174	92.7	14.31	18.55	NO	5.15	0.27	0.28	16.0	60	2	B
Modimolle	2428CBV0025	H24-0198	44.6	14.45	20.55	YES	3.59	0.24	0.18	8.0	36	1	B
Modimolle	2428CBV0013	H24-0213	91.6	18.79	4.48	NO	10.27	-0.14	2.22	70.0	60	4	A
Modimolle	No Number 1		Could not verify equipment / borehole yield because the pump is stuck inside the borehole										
Modimolle	No number 5		125.4	11.79	56.45	YES	2.03	2.20	0.04	1.5	60	0	C
Mookgophong	2428DAV0011	BH04	48.25	16.76	10.78	NO	8.04	0.12	0.75	120.0	36	2.5	A
Mookgophong	2428DAV0012	BH05	Not tested, overhead powerlines										
Mookgophong	2428DAV0013	BH06	60.41	18.87	10.73	NO	7.07	0.14	0.67	60.0	36	3	A
Mookgophong	2428DAV0014	BH07A	38.27	18.41	8.89	NO	7.55	0.08	0.86	120.0	36	2.5	A
Mookgophong	2428DAV0030	BH07B	169.4	18.69	58.11	YES	4.6	0.01	0.08	9.0	60	1.3	B
Mookgophong	2428DAV0016	BH08A	171.5	18.9	25.12	NO	8.24	0.07	0.33	60.0	66	3	A
Mookgophong		BH08B (New)	75.7	19.9	0.53	NO	1.74	0.14	4.46	160.0	48	1.5	B
Mookgophong	2428DAV0015	BH08B (Old)	31.9	19.29		0	0	Not tested					
Mookgophong	2428DAV0027	BH09A	149.8	18.18	16.98	NO	4.68	0.05	0.28	60.0	54	2	B
Mookgophong	2428DAV0029	BH09B	162.8	17.97	61.76	YES	5.72	0.07	0.09	5.0	48	1.3	B
Mookgophong		BH10	220	18.04	57.51	YES	3.19	0.04	0.06	4.0	60	1	B
Mookgophong	2428DAV0028	BH11	74.1	17.6	44.40	YES	1.15	0.69	0.03	0.5	42	0.2	C
Mookgophong		BH12	49.11	15.1	4.83	NO	3.28	0.1	0.69	30.0	36	1	B
Mookgophong		BH13	57.59	17.46	10.84	NO	4.97	0.19	0.47	80.0	48	2.5	A
Mookgophong		BH14	75.1	17.37	3.94	NO	3.35	0.01	0.85	120.0	54	2	B
Mookgophong		BH15	23.9	18.34		0	0	Not tested, too shallow					
Mookgophong		BH16	100.1	18.18	5.00	NO	3.39	0.68	0.78	120.0	36	2	B
Mookgophong		BH17	80.1	18.74	6.27	NO	2.05	0.01	0.33	30.0	36	1.1	B
Mookgophong		BH18	98.8	17.85	62.02	YES	5.57	0.09	0.09	7.0	36	1	B
Mookgophong		BH19	80.4	18.76	55.11	YES	1.19	0.02	0.02	4.0	36	0.3	C
Mookgophong		BH20A	46.2	17.23	26.67	YES	2.26	-0.03	0.08	18.0	42	1	C
Mookgophong		BH20B	90.9	16.47		0	0	Not tested					
Mookgophong		BH21	90.35	16.98	60.35	YES	2.66	0.1	0.04	4.0	60	1.1	B
Vaalwater	2428ACV0001	H24-0000	44.5	8.38	6.41	NO	6.31	0.54	1.07	60.0	30	2,2	A
Vaalwater	2428ACV0002	H24-0001											
Vaalwater		H24-0001B											
Vaalwater		H24-0021	73.38	3.73	4.61	NO	6.11	0.12	1.36	100.0	36	3.5	A
Vaalwater	2428ACV0008	H24-0024	110.72	25.81	28.93	NO	3.87	0.48	0.14	11.0	60	1	B
Vaalwater	2428ACV0011	H24-0029	63.55	37.15	14.60	YES	4.8	0.03	0.33	40.0	54	1.1	B
Vaalwater	2428ACV0006	H24-0030	>87,15	36.98	38.26	YES	3.8	-1.23	0.10	8.0	66	1.1	B
Vaalwater	2428ACV0081	H24-0047	96	42.96	37.00	NO	3.98	3.75	0.12	6.0	84	1	B
Vaalwater	2428ACV0082	H24-0048	172.05	33.15	21.73	NO	4.48	2.1	0.23	10.0	72	1.2	B
Alma	2428ACV0105	H24-0065	204	9.46	55.21	YES	2.02	1.33	0.037	2.0	66	0.5	C
Alma	2428ACV0091	H24-0067	156.6	9.65	12.96	NO	10.18	1.84	0.915	60.0	60	4	A
Roedtan		H29-0405	179.5	86.59	44.23	YES	3.07	3.31	0.075	6.0	66	1.1	B
Roedtan		BH2	147.9	13.14	14.96	NO	5.42	0.37	0.371	30.0	60	1.4	B

Pumping Tests Modimolle

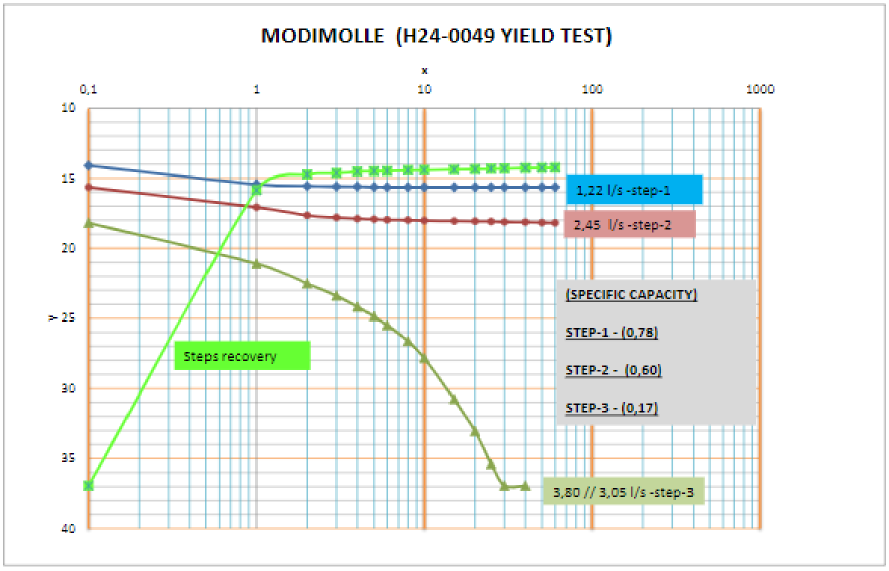
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	14,06	17,59	30,12	41,53
1	15,34	19,15	31,18	35,37
2	16,2	20,59	31,78	31,35
3	16,43	22,03	31,97	27,87
4	16,68	23,09	32,32	25,47
5	16,77	24,01	32,9	23,92
6	16,91	24,72	33,48	22,7
8	17,15	25,97	34,34	21,29
10	17,28	26,86	35,02	19,41
15	17,51	28,34	36,51	18,62
20	17,6	29,06	37,54	16,99
25	17,55	29,31	38,22	15,55
30	17,48	29,69	39,1	14,69
40	17,51	29,92	39,8	14,34
50	17,54	30,06	40,02	14,29
60	17,59	30,12	40,11	14,14
75			40,29	
90			40,32	
105			41,41	
120			41,53	



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,3	19,5	21,79	24,16
1	18,62	20,64	23,41	19,32
2	18,82	20,91	23,66	19,15
3	19,09	21,31	23,68	19,11
4	19,11	21,45	23,69	19,08
5	19,24	21,53	23,69	19,05
6	19,3	21,59	23,7	19,02
8	19,34	21,62	23,77	18,99
10	19,39	21,62	23,77	18,95
15	19,39	21,68	23,84	18,91
20	19,43	21,66	23,86	18,85
25	19,45	21,75	23,86	18,83
30	19,47	21,75	23,9	18,79
40	19,47	21,72	23,92	18,75
50	19,47	21,76	23,97	18,72
60	19,5	21,79	23,99	18,71
75			24,11	18,69
90			24,11	18,67
105			24,15	18,62
120			24,16	18,6

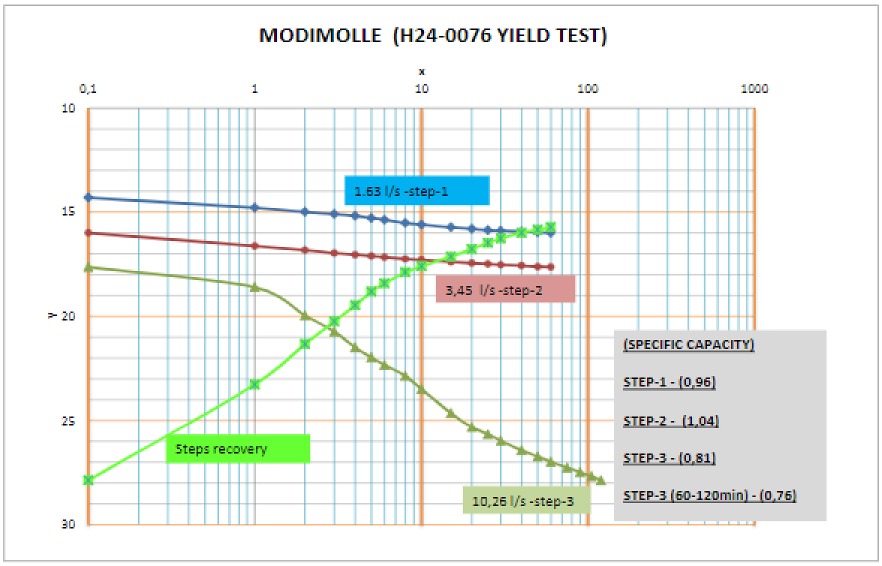


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	14,11	15,65	18,2	36,94
1	15,45	17,08	21,09	15,86
2	15,57	17,66	22,52	14,74
3	15,6	17,81	23,39	14,64
4	15,61	17,9	24,18	14,53
5	15,64	17,93	24,86	14,5
6	15,65	17,98	25,5	14,48
8	15,65	18	26,63	14,44
10	15,65	18,03	27,84	14,42
15	15,65	18,07	30,77	14,38
20	15,65	18,08	33,05	14,36
25	15,65	18,1	35,4	14,33
30	15,65	18,13	36,94	14,31
40	15,65	18,15	36,94	14,28
50	15,65	18,18		14,26
60	15,65	18,2		14,25
75				
90				
105				
120				

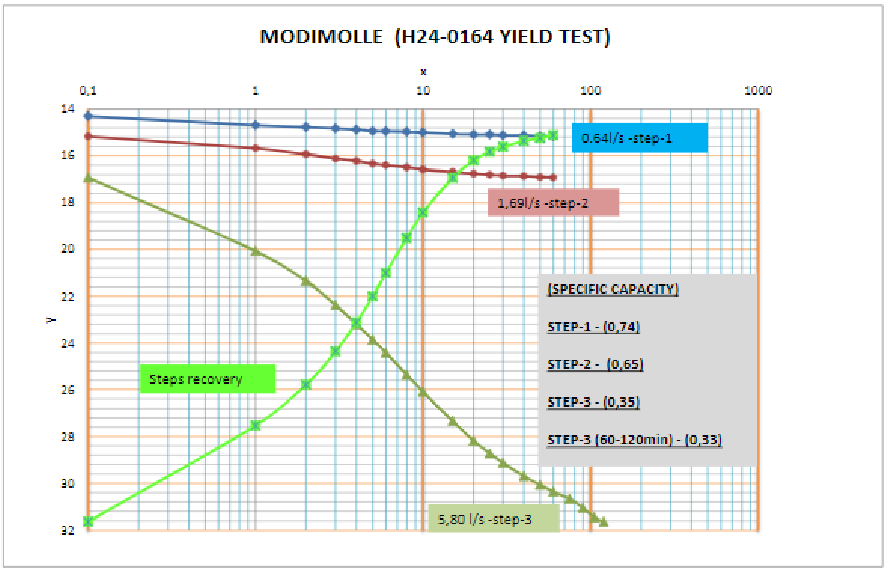


Appendix 3

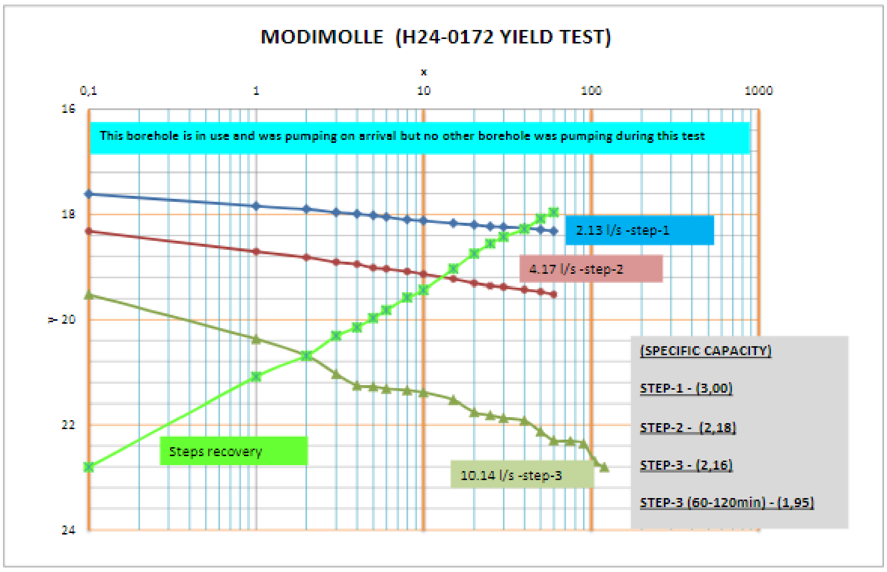
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	14,31	16	17,64	27,88
1	14,8	16,63	18,6	23,27
2	15	16,83	19,96	21,33
3	15,1	16,97	20,73	20,25
4	15,19	17,05	21,49	19,47
5	15,29	17,11	21,97	18,82
6	15,38	17,17	22,33	18,42
8	15,53	17,25	22,85	17,89
10	15,61	17,3	23,49	17,6
15	15,73	17,39	24,64	17,14
20	15,81	17,45	25,32	16,78
25	15,88	17,49	25,67	16,48
30	15,9	17,53	25,98	16,27
40	15,94	17,57	26,44	16
50	15,97	17,62	26,74	15,85
60	16	17,64	26,99	15,73
75			27,27	
90			27,49	
105			27,69	
120			27,88	



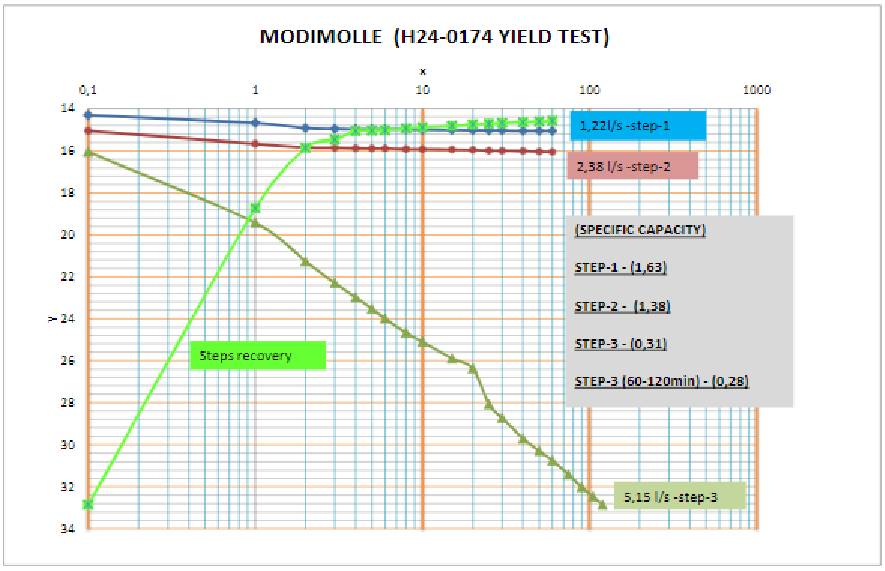
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	14,3	15,17	16,92	31,65
1	14,69	15,68	20,07	27,53
2	14,77	15,94	21,35	25,8
3	14,83	16,12	22,38	24,36
4	14,88	16,22	23,2	23,12
5	14,94	16,34	23,86	22
6	14,95	16,4	24,42	21,02
8	14,97	16,49	25,37	19,52
10	15	16,58	26,09	18,42
15	15,06	16,69	27,33	16,93
20	15,09	16,76	28,18	16,2
25	15,09	16,8	28,72	15,83
30	15,12	16,84	29,13	15,62
40	15,13	16,86	29,7	15,37
50	15,16	16,9	30,07	15,25
60	15,17	16,92	30,37	15,12
75			30,67	
90			31,06	
105			31,46	
120			31,65	



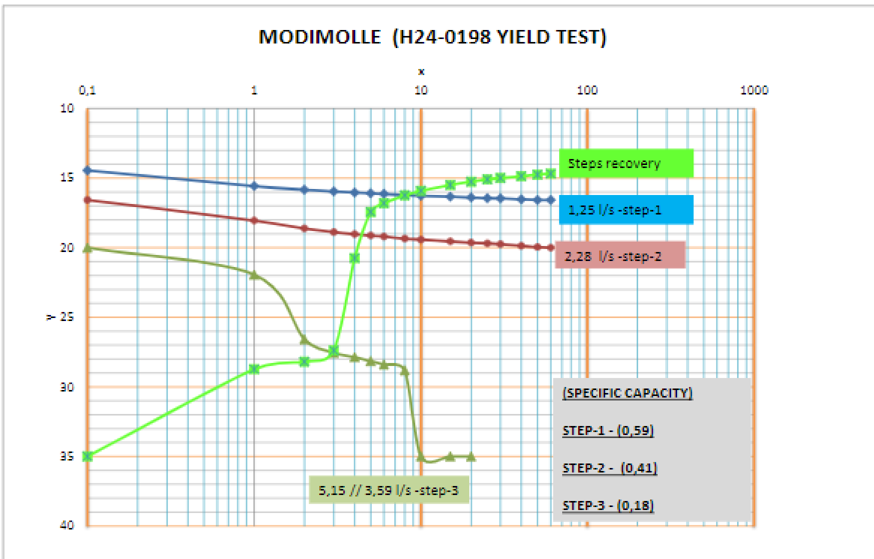
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	17,61	18,32	19,52	22,81
1	17,84	18,71	20,37	21,09
2	17,9	18,82	20,69	20,69
3	17,96	18,91	21,04	20,31
4	17,99	18,95	21,26	20,15
5	18,02	19,02	21,28	19,97
6	18,05	19,04	21,32	19,82
8	18,1	19,09	21,35	19,58
10	18,12	19,14	21,39	19,44
15	18,17	19,23	21,53	19,04
20	18,2	19,31	21,76	18,75
25	18,23	19,36	21,82	18,56
30	18,24	19,38	21,87	18,43
40	18,26	19,43	21,92	18,28
50	18,29	19,47	22,13	18,08
60	18,32	19,52	22,3	17,96
75			22,31	
90			22,36	
105			22,7	
120			22,81	



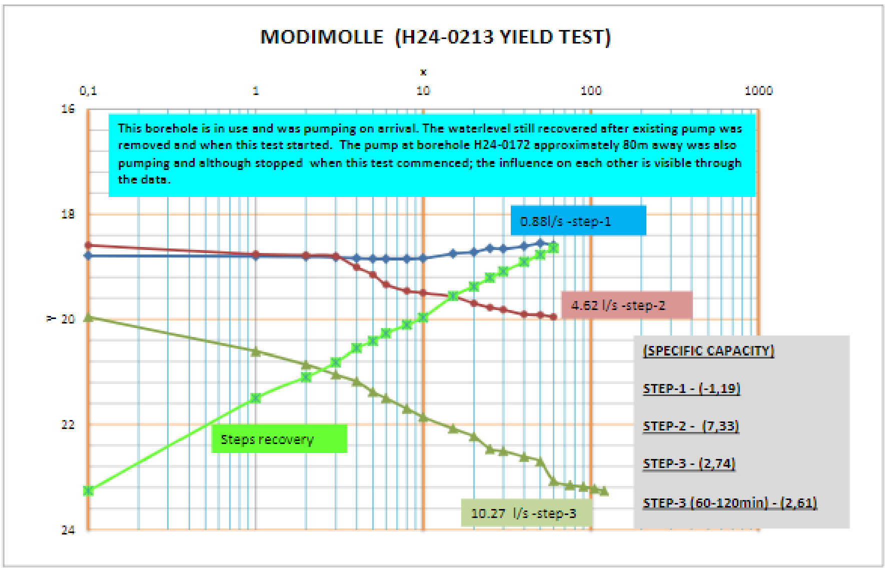
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	14,31	15,06	16,04	32,86
1	14,68	15,67	19,42	18,73
2	14,93	15,83	21,26	15,85
3	14,97	15,85	22,3	15,47
4	14,98	15,87	22,98	15,07
5	14,98	15,88	23,53	15,05
6	14,98	15,88	23,99	15,03
8	14,99	15,91	24,68	14,95
10	15	15,92	25,1	14,89
15	15,02	15,93	25,9	14,82
20	15,03	15,95	26,37	14,75
25	15,04	15,98	28,08	14,72
30	15,04	15,99	28,74	14,69
40	15,06	16	29,7	14,65
50	15,06	16,03	30,29	14,61
60	15,06	16,04	30,75	14,58
75			31,42	
90			32,02	
105			32,47	
120			32,86	



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	14,45	16,57	20	35
1	15,58	18,05	21,94	28,73
2	15,84	18,62	26,59	28,2
3	15,96	18,88	27,56	27,39
4	16,04	19,03	27,87	20,76
5	16,1	19,13	28,16	17,44
6	16,14	19,2	28,4	16,81
8	16,22	19,35	28,82	16,24
10	16,27	19,42	35	15,92
15	16,34	19,55	35	15,5
20	16,4	19,64	35	15,26
25	16,45	19,69		15,1
30	16,46	19,75		15
40	16,53	19,87		14,87
50	16,57	19,96		14,75
60	16,57	20		14,69
75				
90				
105				
120				

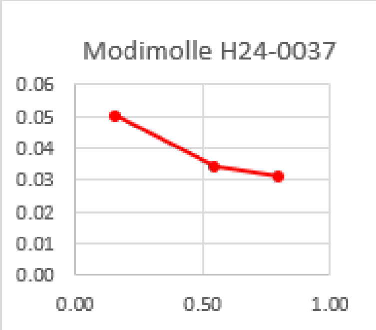


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,79	18,59	19,96	23,27
1	18,8	18,76	20,61	21,5
2	18,81	18,78	20,86	21,1
3	18,82	18,8	21,05	20,82
4	18,84	19,01	21,18	20,55
5	18,85	19,15	21,38	20,42
6	18,85	19,34	21,5	20,27
8	18,85	19,46	21,7	20,11
10	18,84	19,5	21,86	19,97
15	18,75	19,57	22,08	19,56
20	18,72	19,7	22,23	19,38
25	18,65	19,78	22,47	19,21
30	18,66	19,82	22,51	19,09
40	18,61	19,91	22,62	18,91
50	18,55	19,92	22,71	18,77
60	18,59	19,96	23,08	18,65
75			23,16	
90			23,19	
105			23,23	
120			23,27	

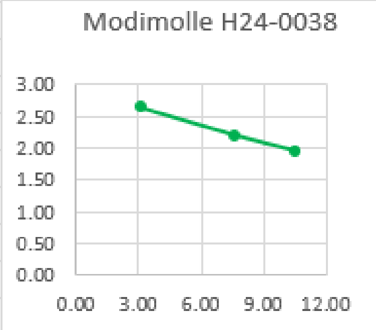


Appendix 3

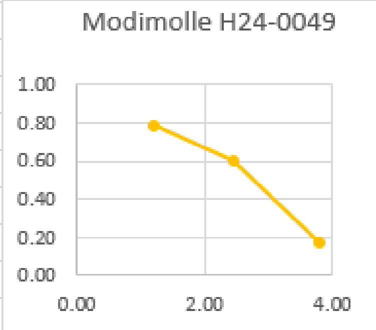
H24-0037		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.16	0.05	
0.55	0.03	
0.80	0.03	27.47



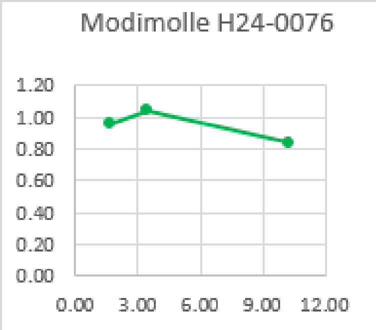
H24-0038		
Yield l/s	Spec cap, L/s/m	Max DD, m
3.16	2.63	
7.67	2.20	
10.57	1.95	5.84



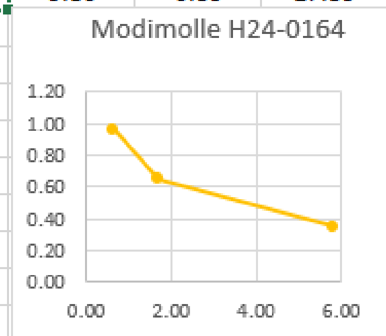
H24-0049		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.22	0.78	
2.45	0.60	
3.80	0.17	22.83



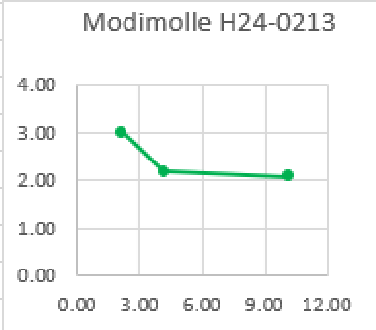
H24-0076		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.63	0.96	
3.45	1.04	
10.26	0.84	13.57



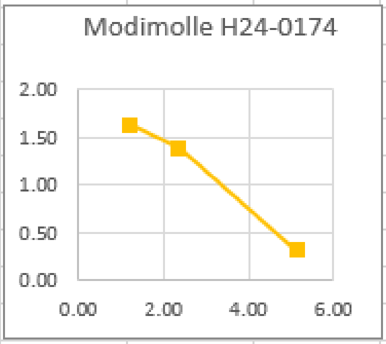
H24-0164		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.64	0.96	
1.69	0.65	
5.80	0.35	17.35



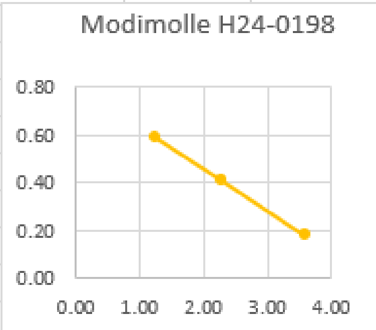
H24-0172		
Yield l/s	Spec cap, L/s/m	Max DD, m
2.13	3.00	
4.17	2.18	
10.14	2.09	5.20



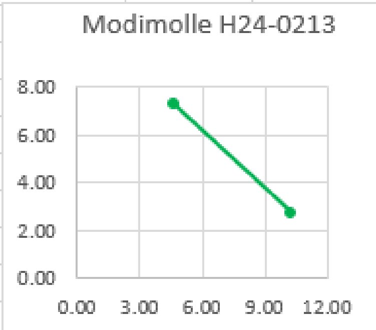
H24-0174		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.22	1.63	
2.38	1.38	
5.15	0.31	18.55



H24-0198		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.25	0.59	
2.28	0.41	
3.59	0.18	20.55

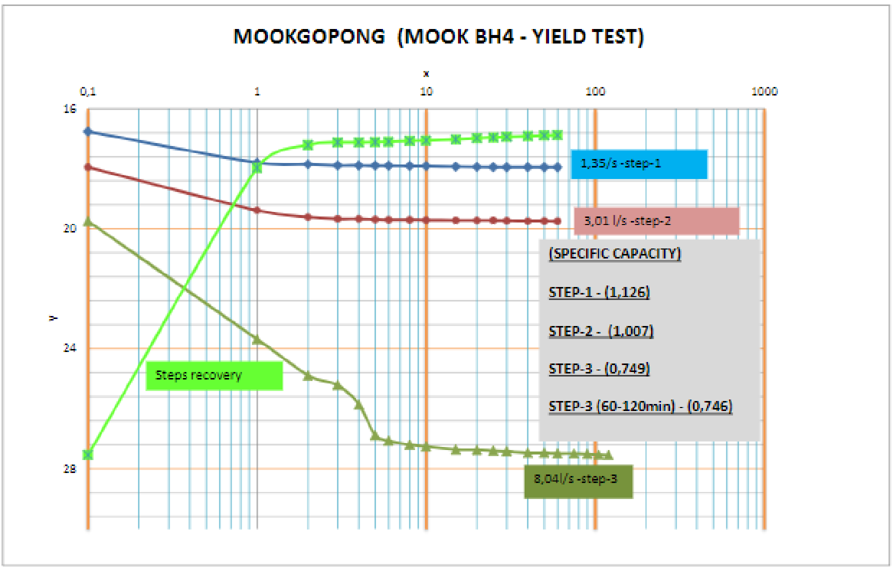


H24-0213		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.88		
4.62	7.33	
10.27	2.74	4.48

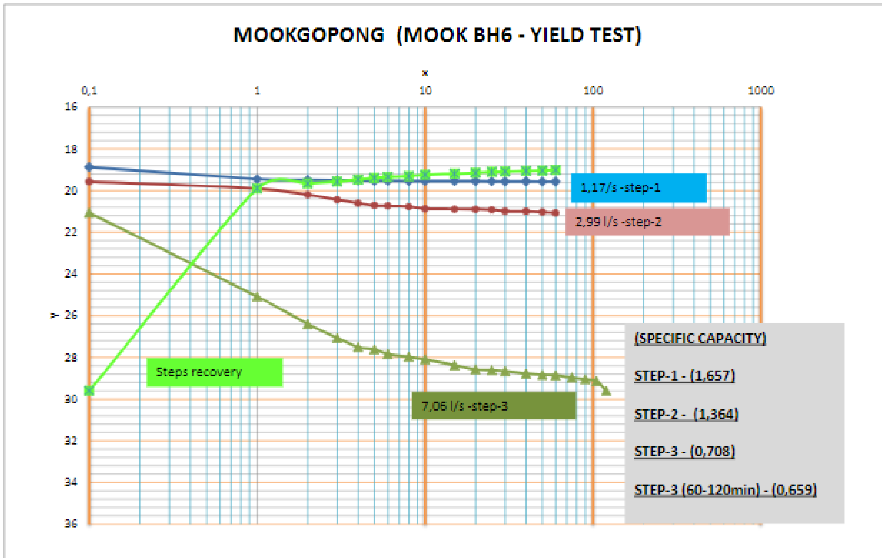


Pumping Tests Mookgophong

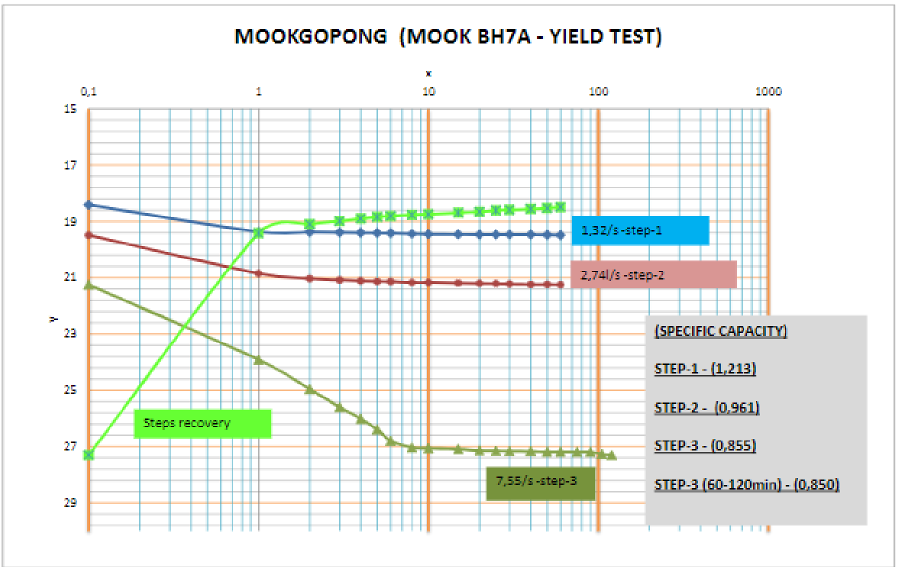
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	16,76	17,95	19,75	27,54
1	17,8	19,39	23,68	17,97
2	17,85	19,61	24,89	17,21
3	17,89	19,67	25,21	17,12
4	17,89	19,67	25,86	17,12
5	17,9	19,69	26,89	17,11
6	17,9	19,7	27,07	17,1
8	17,91	19,7	27,2	17,07
10	17,91	19,71	27,26	17,06
15	17,93	19,72	27,36	17,02
20	17,94	19,72	27,37	16,98
25	17,95	19,72	27,4	16,96
30	17,95	19,73	27,42	16,94
40	17,95	19,74	27,47	16,91
50	17,95	19,74	27,47	16,89
60	17,95	19,75	27,49	16,88
75			27,49	
90			27,51	
105			27,53	
120			27,54	



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,87	19,57	21,07	29,6
1	19,45	19,9	25,08	19,9
2	19,49	20,2	26,4	19,66
3	19,51	20,44	27,07	19,57
4	19,52	20,6	27,51	19,47
5	19,53	20,71	27,62	19,39
6	19,53	20,73	27,84	19,35
8	19,54	20,77	27,98	19,31
10	19,54	20,87	28,1	19,24
15	19,55	20,89	28,38	19,19
20	19,55	20,9	28,58	19,15
25	19,56	20,92	28,61	19,1
30	19,56	20,99	28,66	19,09
40	19,56	21	28,78	19,06
50	19,57	21,03	28,83	19,04
60	19,57	21,07	28,86	19,01
75			28,97	
90			29,05	
105			29,14	
120			29,6	

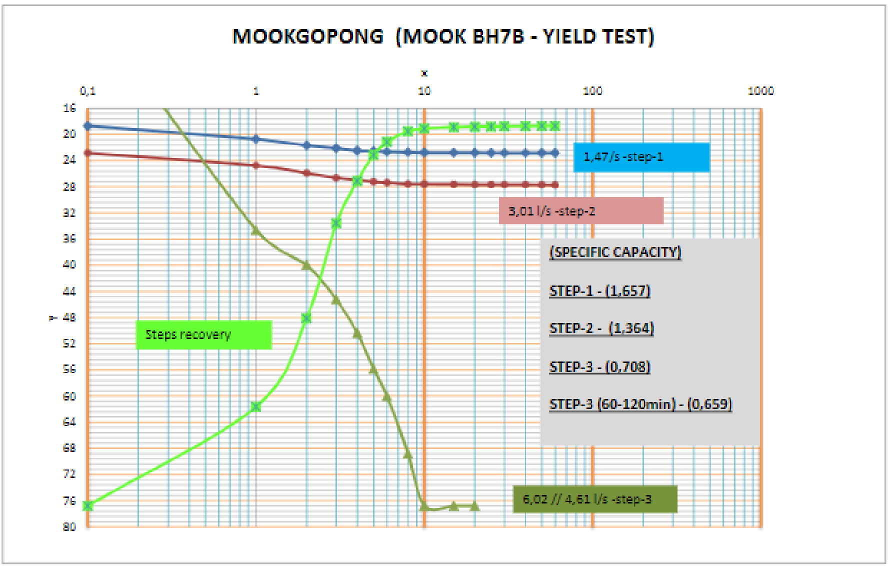


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,41	19,49	21,25	27,3
1	19,37	20,85	23,91	19,42
2	19,38	21,03	24,96	19,1
3	19,39	21,08	25,6	18,99
4	19,4	21,11	26,02	18,9
5	19,41	21,13	26,4	18,84
6	19,42	21,14	26,8	18,81
8	19,44	21,17	27,03	18,77
10	19,45	21,17	27,06	18,75
15	19,46	21,19	27,09	18,69
20	19,47	21,2	27,14	18,66
25	19,47	21,21	27,15	18,61
30	19,47	21,22	27,16	18,59
40	19,47	21,24	27,17	18,56
50	19,48	21,24	27,19	18,53
60	19,49	21,25	27,19	18,49
75			27,19	
90			27,19	
105			27,27	
120			27,3	

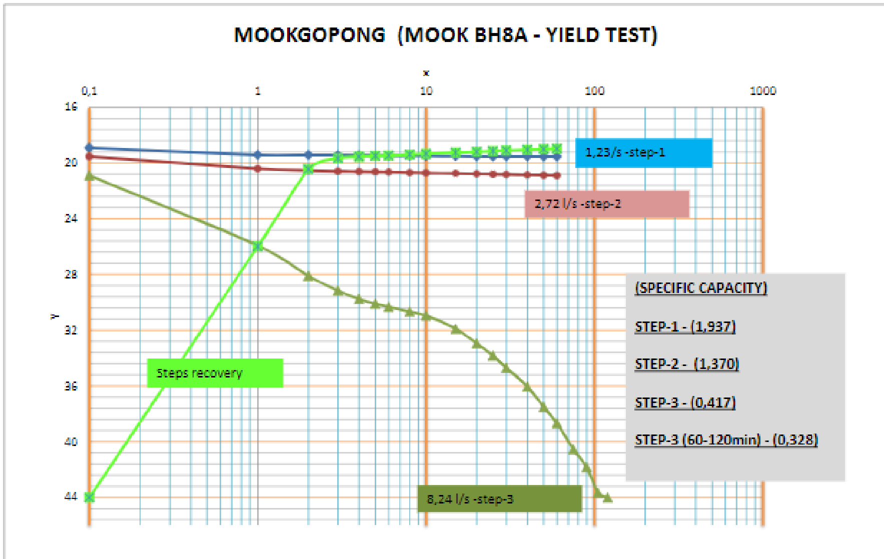


Appendix 4

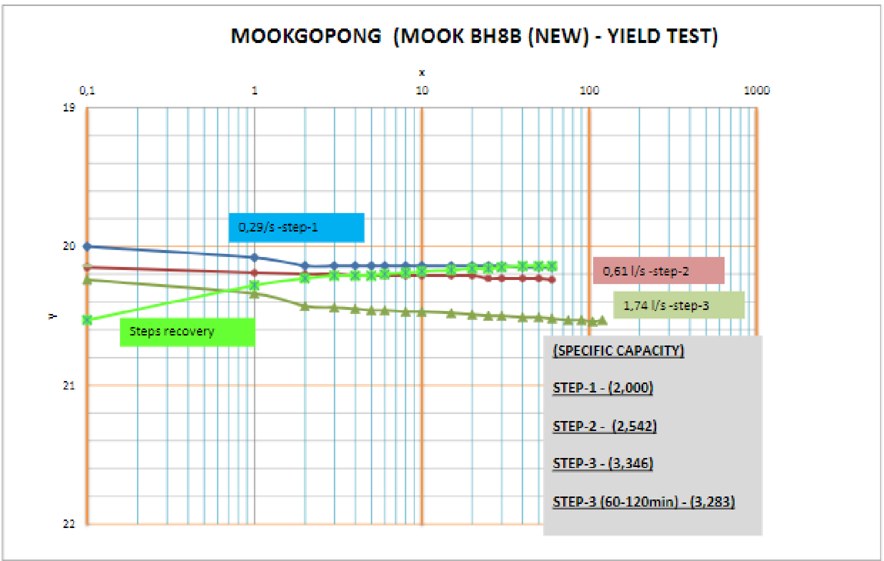
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,69	22,84	27.7	76,8
1	20,71	24,74	34,61	61,64
2	21,67	25,91	39,93	48,12
3	22,1	26,63	45,22	33,56
4	22,46	26,97	50,34	27,11
5	22,53	27,22	55,82	23,14
6	22,63	27,36	59,99	21,15
8	22,71	27,57	68,77	19,53
10	22,77	27,58	76,8	19,09
15	22,79	27,62	76,8	18,88
20	22,8	27,65	76,8	18,8
25	22,81	27,65		18,78
30	22,82	27,67		18,75
40	22,82	27,67		18,71
50	22,84	27,69		18,69
60	22,84	27,7		18,68
75				
90				
105				
120				



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,9	19,53	20,9	44,02
1	19,42	20,4	25,92	26
2	19,42	20,53	28,11	20,45
3	19,44	20,59	29,17	19,66
4	19,45	20,61	29,77	19,54
5	19,46	20,63	30,11	19,49
6	19,48	20,65	30,33	19,46
8	19,48	20,69	30,67	19,4
10	19,49	20,71	30,95	19,34
15	19,51	20,75	31,9	19,25
20	19,53	20,78	32,95	19,19
25	19,53	20,8	33,84	19,14
30	19,53	20,83	34,71	19,1
40	19,53	20,86	36,06	19,05
50	19,53	20,88	37,52	19
60	19,53	20,9	38,7	18,97
75			40,55	
90			41,84	
105			43,67	
120			44,02	

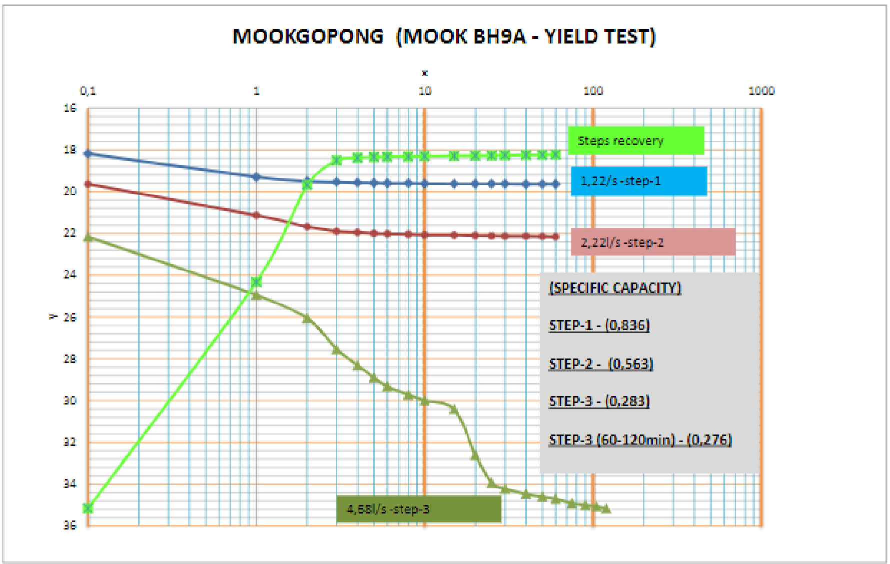


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	20	20,15	20,24	20,53
1	20,08	20,19	20,34	20,28
2	20,14	20,2	20,43	20,23
3	20,14	20,2	20,44	20,21
4	20,14	20,21	20,45	20,21
5	20,14	20,21	20,46	20,21
6	20,14	20,21	20,46	20,2
8	20,14	20,21	20,47	20,19
10	20,14	20,21	20,47	20,18
15	20,14	20,21	20,48	20,17
20	20,14	20,21	20,49	20,16
25	20,14	20,23	20,5	20,16
30	20,14	20,23	20,5	20,15
40	20,15	20,23	20,51	20,14
50	20,15	20,23	20,51	20,14
60	20,15	20,24	20,52	20,14
75			20,53	
90			20,53	
105			20,54	
120			20,53	

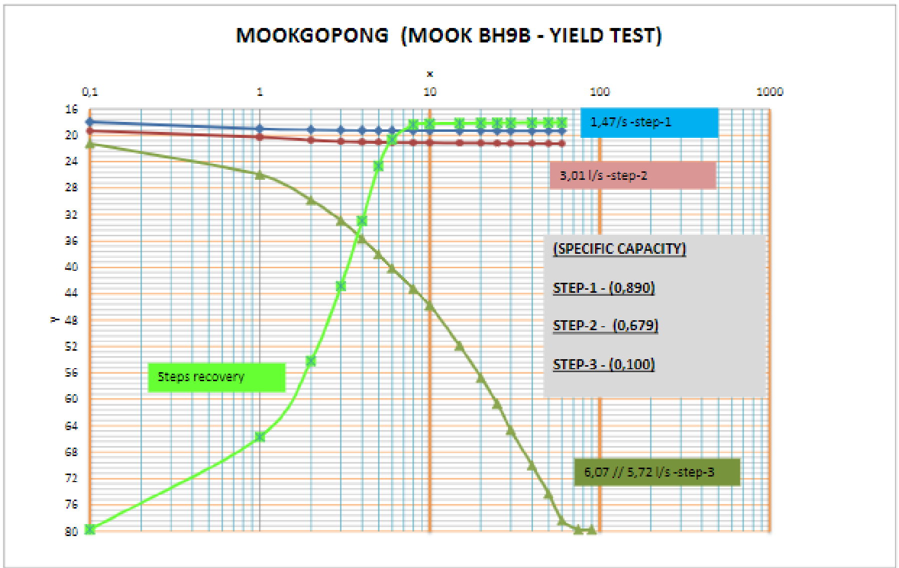


Appendix 4

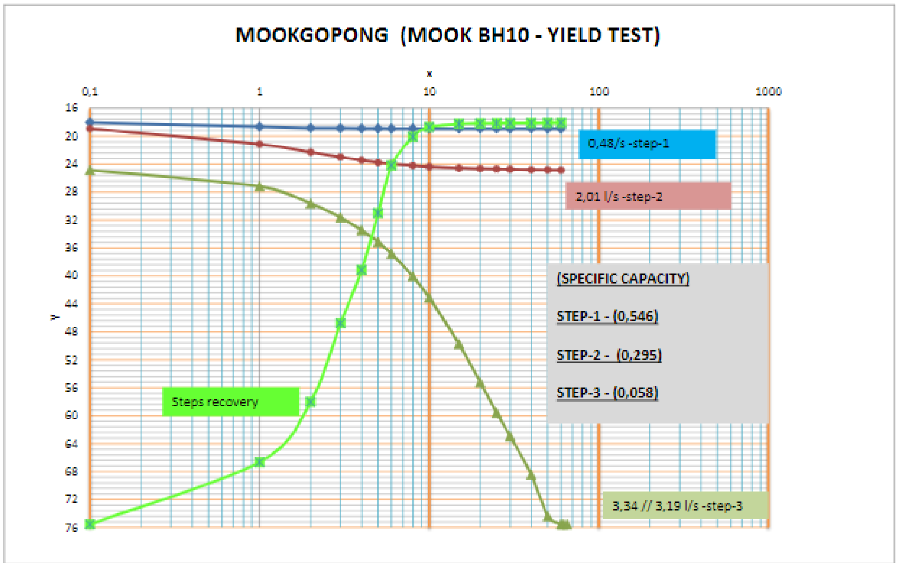
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,18	19,64	22,16	35,16
1	19,3	21,13	24,95	24,33
2	19,5	21,68	26,05	19,68
3	19,54	21,9	27,55	18,51
4	19,57	21,95	28,32	18,38
5	19,58	22	28,9	18,34
6	19,6	22,02	29,33	18,33
8	19,6	22,04	29,72	18,32
10	19,62	22,07	30	18,31
15	19,63	22,08	30,41	18,29
20	19,63	22,1	32,61	18,28
25	19,63	22,11	33,94	18,27
30	19,63	22,13	34,22	18,26
40	19,64	22,13	34,47	18,25
50	19,64	22,14	34,6	18,24
60	19,64	22,16	34,71	18,23
75			34,92	
90			35	
105			35,07	
120			35,16	



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	17,97	19,33	21,24	79,73
1	19,02	20,27	25,95	65,73
2	19,15	20,72	29,8	54,19
3	19,22	20,91	32,89	42,83
4	19,25	20,99	35,7	32,97
5	19,28	21,03	38,03	24,63
6	19,28	21,06	40,16	20,64
8	19,28	21,09	43,24	18,39
10	19,28	21,11	45,78	18,23
15	19,3	21,15	51,88	18,17
20	19,31	21,16	56,7	18,13
25	19,32	21,22	60,68	18,11
30	19,32	21,22	64,65	18,1
40	19,33	21,23	70	18,07
50	19,33	21,24	74,31	18,06
60	19,33	21,24	78,34	18,04
75			79,73	
90			79,73	
105				
120				

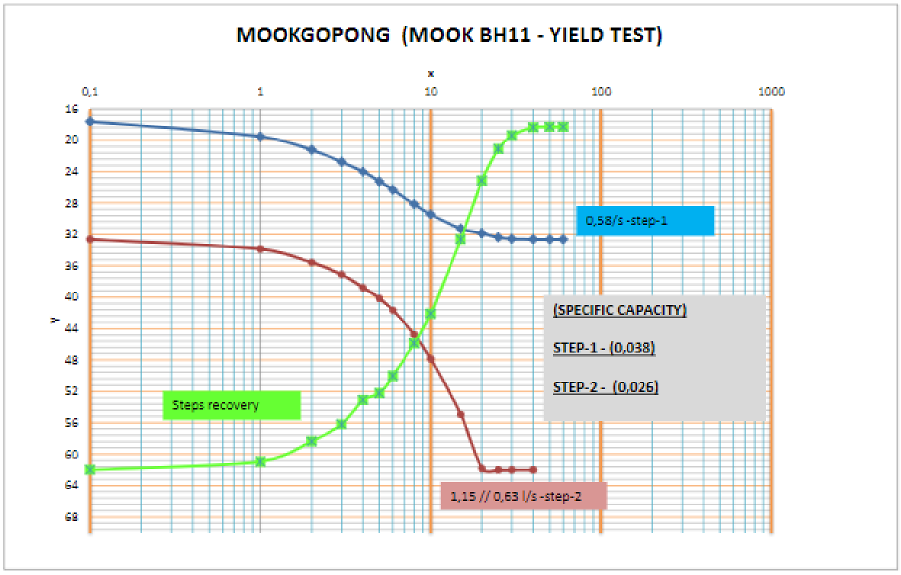


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,04	18,92	24,85	75,55
1	18,65	21,14	27,18	66,66
2	18,83	22,28	29,63	58,03
3	18,86	22,98	31,64	46,77
4	18,89	23,43	33,46	39,15
5	18,91	23,75	35,15	31
6	18,92	23,96	36,84	24,16
8	18,92	24,19	40,04	20,09
10	18,92	24,37	43,13	18,72
15	18,92	24,56	49,77	18,25
20	18,92	24,64	55,23	18,18
25	18,92	24,7	59,6	18,15
30	18,92	24,73	62,96	18,13
40	18,92	24,79	68,45	18,11
50	18,92	24,82	74,38	18,09
60	18,92	24,85	75,55	18,08
62			75,55	
65			75,55	
105				
120				

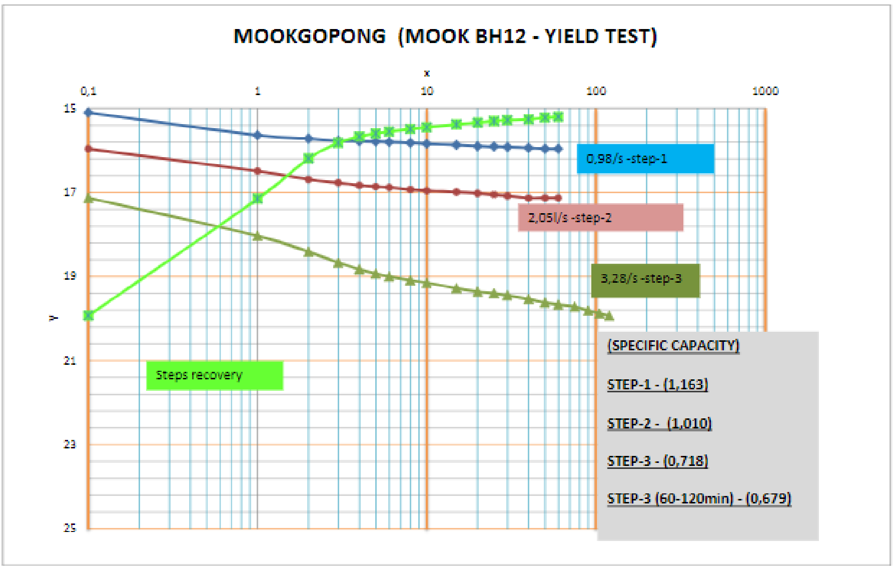


Appendix 4

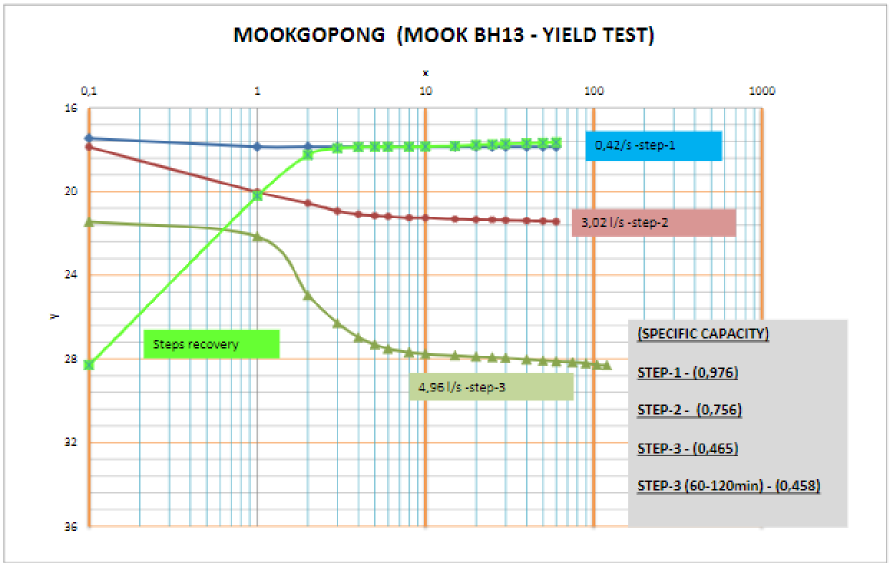
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	17,6	32,63		62
1	19,55	33,86		60,97
2	21,21	35,57		58,37
3	22,77	37,13		56,22
4	24,02	38,8		53,08
5	25,26	40,13		52,22
6	26,32	41,67		50,04
8	28,14	44,72		45,87
10	29,46	47,86		42,11
15	31,27	54,94		32,62
20	31,87	61,81		25,16
25	32,37	62		21,09
30	32,56	62		19,41
40	32,63	62		18,38
50	32,63			18,3
60	32,63			18,29
75				
90				
105				
120				



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	15,1	15,96	17,13	19,93
1	15,64	16,49	18,03	17,15
2	15,72	16,69	18,41	16,19
3	15,77	16,77	18,67	15,82
4	15,78	16,83	18,83	15,67
5	15,79	16,86	18,93	15,6
6	15,8	16,88	19	15,55
8	15,82	16,93	19,09	15,49
10	15,84	16,96	19,15	15,45
15	15,87	16,99	19,28	15,38
20	15,9	17,02	19,36	15,34
25	15,91	17,05	19,4	15,3
30	15,92	17,08	19,45	15,28
40	15,94	17,13	19,54	15,26
50	15,96	17,13	19,62	15,22
60	15,96	17,13	19,67	15,2
75			19,72	
90			19,81	
105			19,88	
120			19,93	

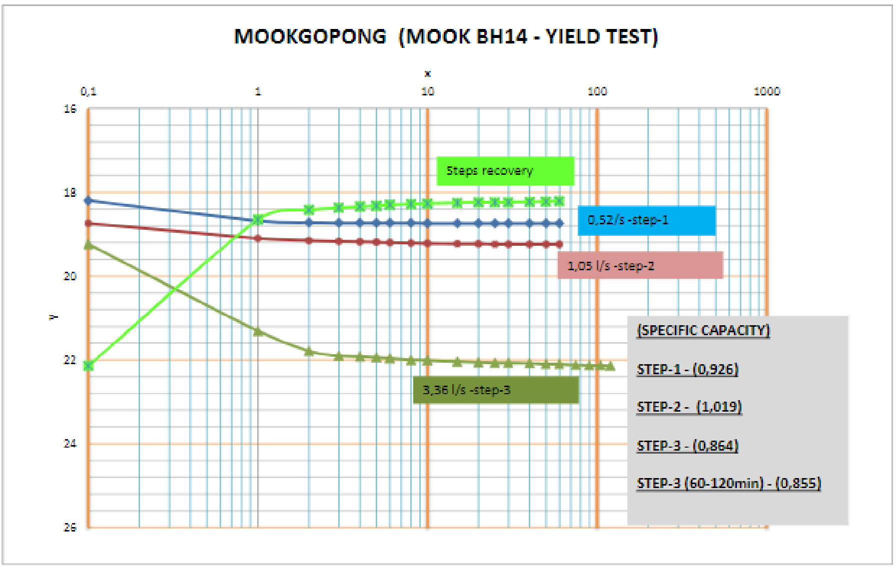


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	17,46	17,87	21,44	28,3
1	17,86	20,03	22,15	20,21
2	17,86	20,56	24,96	18,25
3	17,86	20,94	26,29	17,94
4	17,86	21,09	26,97	17,88
5	17,86	21,15	27,32	17,87
6	17,86	21,19	27,52	17,87
8	17,86	21,26	27,69	17,87
10	17,86	21,26	27,77	17,85
15	17,86	21,32	27,84	17,82
20	17,86	21,34	27,9	17,77
25	17,86	21,35	27,93	17,74
30	17,86	21,37	27,95	17,72
40	17,86	21,4	28,03	17,69
50	17,87	21,41	28,08	17,67
60	17,87	21,44	28,12	17,65
75			28,16	
90			28,21	
105			28,28	
120			28,3	

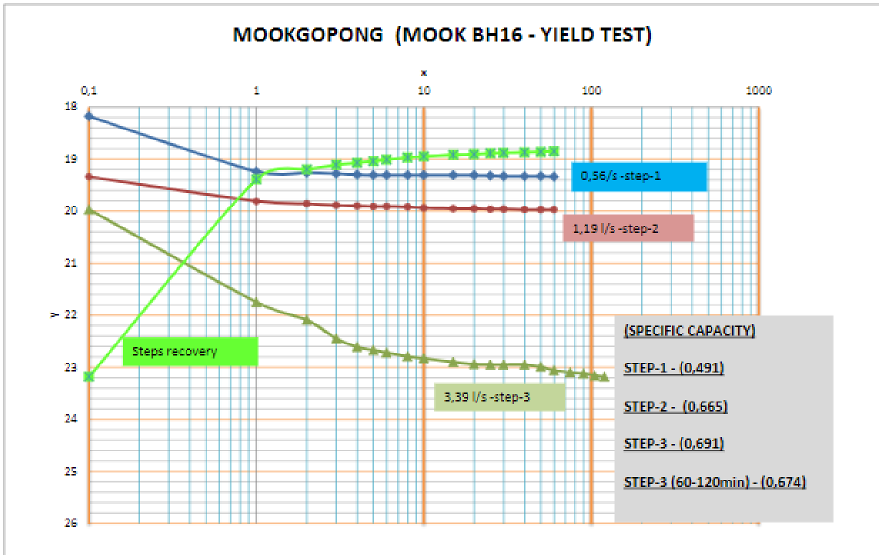


Appendix 4

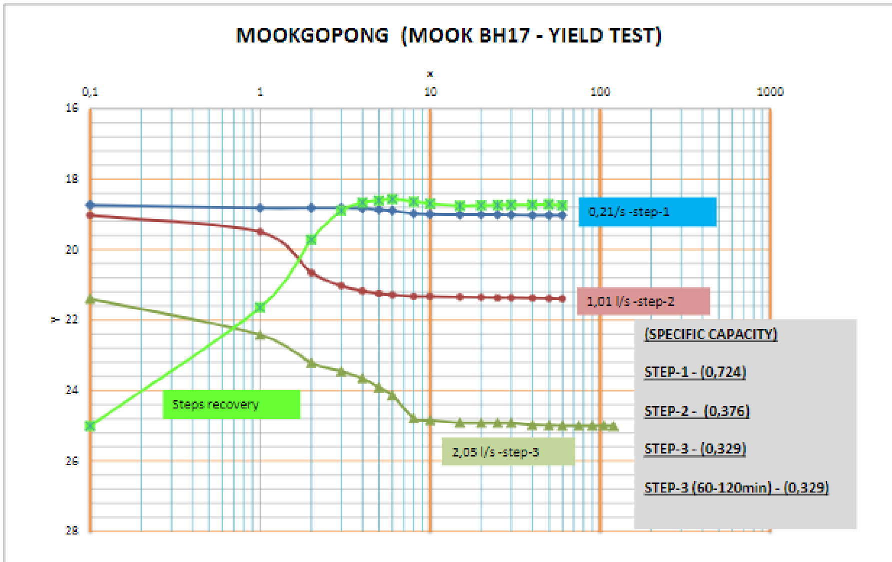
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,2	18,74	19,24	22,14
1	18,68	19,1	21,31	18,65
2	18,72	19,15	21,79	18,42
3	18,73	19,17	21,9	18,37
4	18,73	19,18	21,92	18,34
5	18,73	19,19	21,94	18,32
6	18,73	19,2	21,96	18,3
8	18,73	19,21	22	18,28
10	18,74	19,22	22,01	18,27
15	18,74	19,23	22,04	18,25
20	18,74	19,23	22,06	18,24
25	18,74	19,24	22,07	18,24
30	18,74	19,24	22,07	18,24
40	18,74	19,24	22,08	18,23
50	18,74	19,24	22,1	18,22
60	18,74	19,24	22,1	18,21
75			22,12	
90			22,13	
105			22,13	
120			22,14	



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,18	19,34	19,97	23,18
1	19,24	19,81	21,75	19,39
2	19,26	19,86	22,09	19,2
3	19,28	19,89	22,45	19,11
4	19,3	19,9	22,61	19,07
5	19,31	19,91	22,67	19,04
6	19,31	19,91	22,72	19,01
8	19,31	19,92	22,79	18,97
10	19,31	19,94	22,83	18,95
15	19,31	19,95	22,9	18,92
20	19,31	19,95	22,94	18,91
25	19,32	19,96	22,95	18,89
30	19,33	19,96	22,95	18,88
40	19,33	19,97	22,95	18,87
50	19,33	19,97	22,99	18,86
60	19,34	19,97	23,06	18,85
75			23,1	
90			23,12	
105			23,16	
120			23,18	

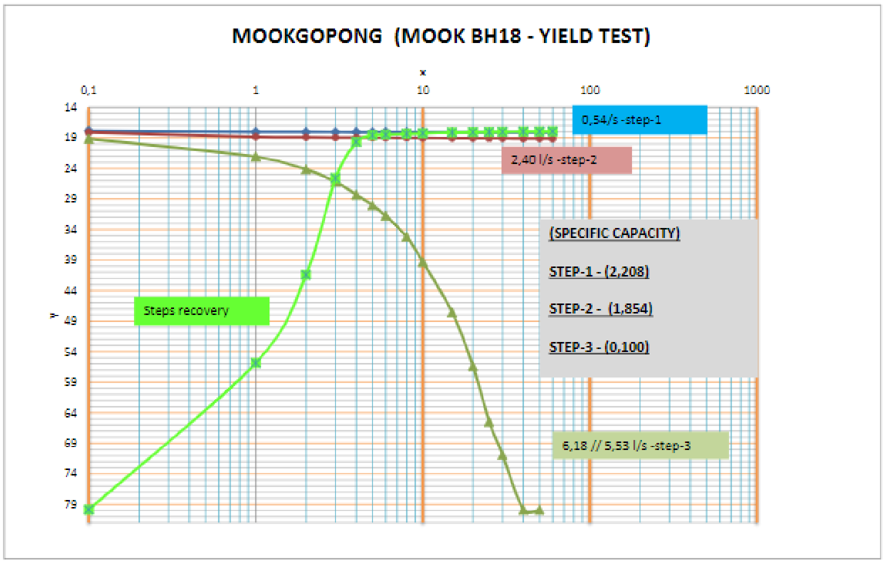


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,74	19,03	21,4	25,01
1	18,82	19,5	22,42	21,65
2	18,82	20,66	23,22	19,72
3	18,82	21,03	23,46	18,9
4	18,83	21,18	23,66	18,67
5	18,87	21,25	23,92	18,61
6	18,9	21,29	24,14	18,57
8	18,98	21,33	24,79	18,64
10	19	21,33	24,85	18,7
15	19,01	21,35	24,92	18,76
20	19,01	21,36	24,92	18,75
25	19,01	21,37	24,92	18,74
30	19,02	21,37	24,92	18,73
40	19,03	21,38	24,98	18,73
50	19,03	21,39	24,99	18,72
60	19,03	21,4	25	18,75
75			25	
90			25	
105			25	
120			25,01	

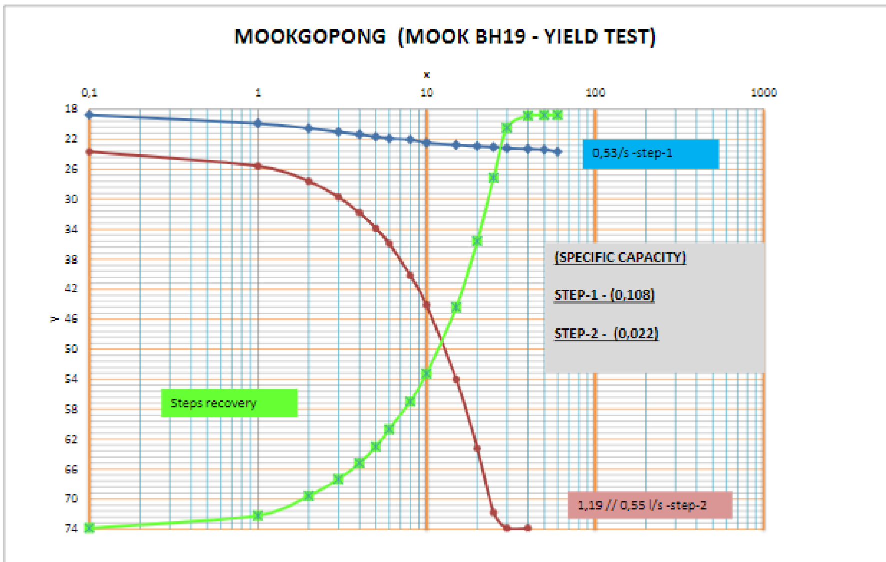


Appendix 4

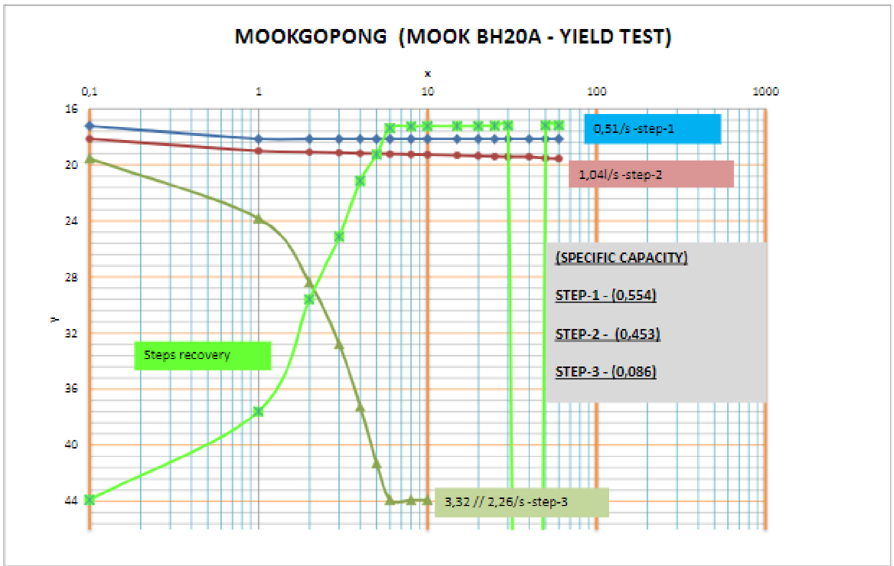
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	17,85	18,09	19,15	79,87
1	18,04	18,83	22,07	55,87
2	18,04	18,91	24,13	41,44
3	18,05	18,95	26,18	25,61
4	18,06	18,97	28,34	19,67
5	18,06	18,98	30,02	18,59
6	18,06	18,99	31,77	18,47
8	18,07	19,02	35,19	18,35
10	18,07	19,03	39,32	18,24
15	18,07	19,06	47,6	18,13
20	18,08	19,08	56,38	18,08
25	18,08	19,1	65,47	18,05
30	18,08	19,11	70,88	18,02
40	18,08	19,13	79,89	17,98
50	18,09	19,14	79,87	17,96
60	18,09	19,15		17,94
75				
90				
105				
120				



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	18,76	23,68		73,87
1	19,9	25,57		72,22
2	20,56	27,61		69,57
3	21,02	29,71		67,36
4	21,38	31,8		65,19
5	21,68	33,89		63,02
6	21,91	35,91		60,68
8	22,06	40,17		56,99
10	22,48	44,11		53,26
15	22,78	54,03		44,39
20	22,93	63,23		35,6
25	23,06	71,8		27,14
30	23,2	73,87		20,48
40	23,3	73,87		18,87
50	23,4			18,79
60	23,68			18,78
75				
90				
105				
120				

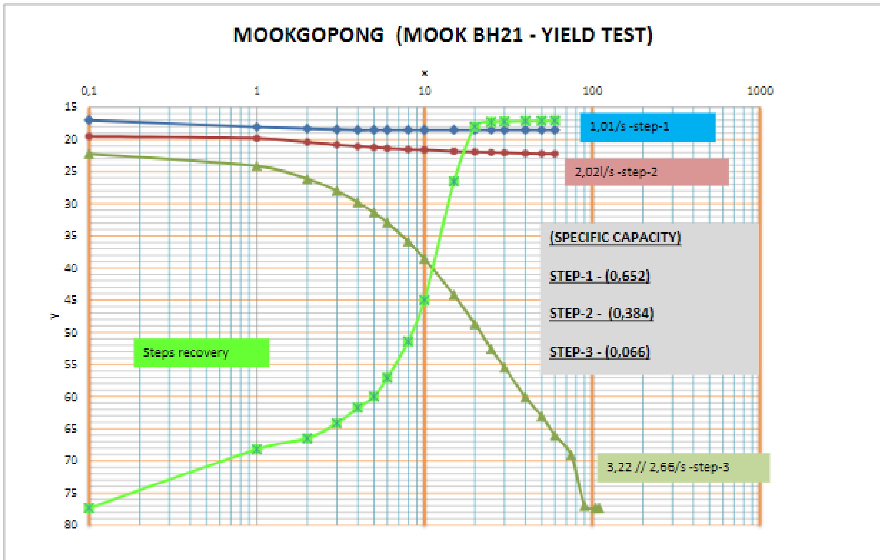


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	17,23	18,15	19,55	43,9
1	18,15	19	23,82	37,59
2	18,15	19,09	28,39	29,6
3	18,15	19,14	32,8	25,12
4	18,15	19,18	37,25	21,14
5	18,15	19,2	41,3	19,26
6	18,15	19,23	43,9	17,38
8	18,15	19,26	43,9	17,26
10	18,15	19,28	43,9	17,24
15	18,15	19,33		17,23
20	18,15	19,36		17,23
25	18,15	19,4		17,22
30	18,15	19,42		17,21
40	18,15	19,43		172
50	18,15	19,52		17,2
60	18,15	19,55		17,2
75				
90				
105				
120				



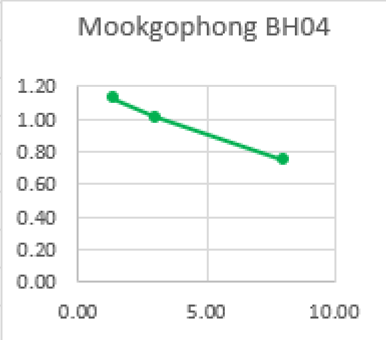
Appendix 4

	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	16,98	19,53	22,24	77,33
1	18,08	19,82	24,121	68,2
2	18,32	20,42	26,16	66,51
3	18,46	20,82	28	64,14
4	18,53	21,08	29,81	61,77
5	18,53	21,25	31,39	59,99
6	18,53	21,38	32,94	57,1
8	18,53	21,55	35,86	51,42
10	18,53	21,63	38,59	44,98
15	18,53	21,85	44,22	26,55
20	18,53	21,93	48,73	18
25	18,53	22	52,63	17,29
30	18,53	22,08	55,51	17,22
40	18,53	22,17	60,11	17,14
50	18,53	22,22	63,07	17,11
60	18,53	22,24	66,06	17,08
75			69,11	
90			77	
105			77,33	
110			77,33	

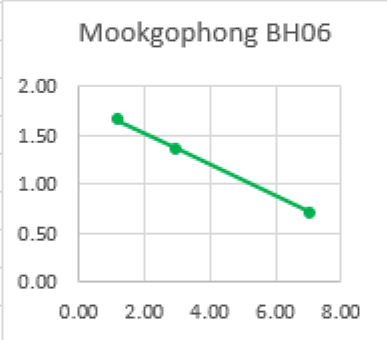


Appendix 4

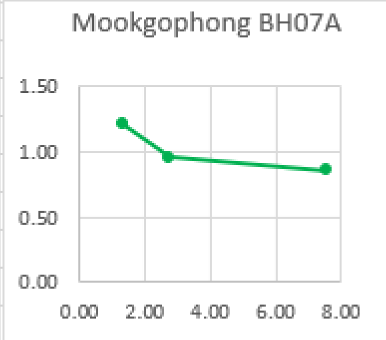
BH04		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.35	1.13	
3.00	1.01	
8.04	0.75	10.78



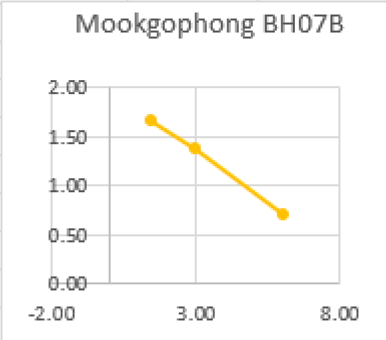
BH06		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.17	1.66	
2.99	1.36	
7.06	0.71	10.73



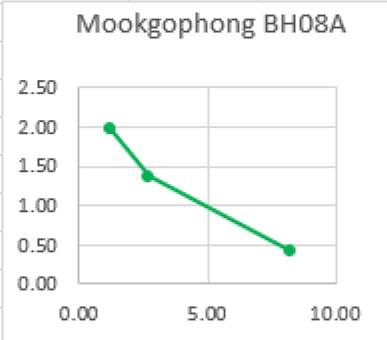
BH07A		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.32	1.21	
2.74	0.96	
7.55	0.86	8.89



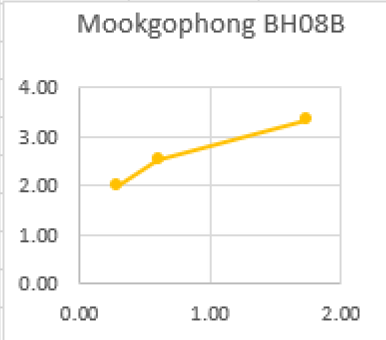
BH07B		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.47	1.66	
3.01	1.37	
6.02	0.71	58.11



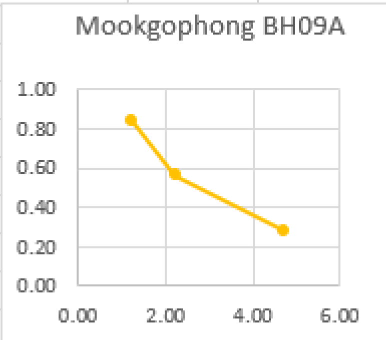
BH08A		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.23	1.97	
2.72	1.37	
8.24	0.42	25.12



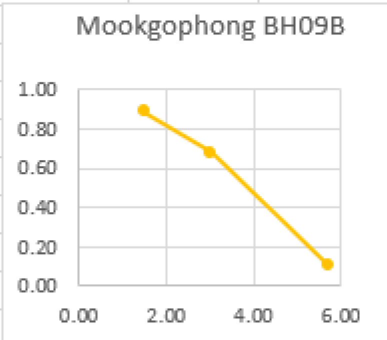
BH08B		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.29	2.00	
0.60	2.54	
1.74	3.35	0.53



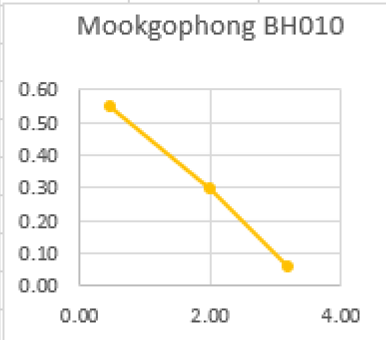
BH09A		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.22	0.84	
2.22	0.56	
4.68	0.28	16.98



BH09B		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.47	0.89	
3.01	0.68	
5.72	0.10	61.76

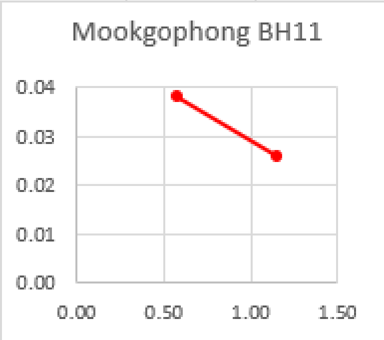


BH010		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.48	0.55	
2.01	0.30	
3.19	0.06	58.11

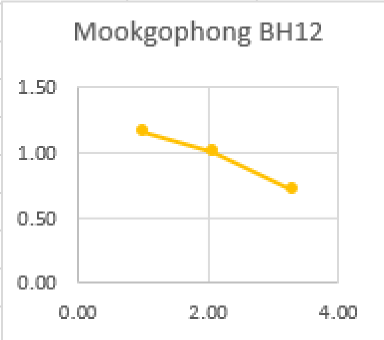


Appendix 4

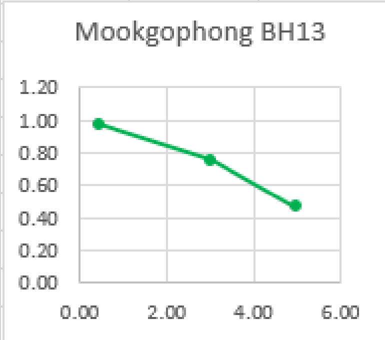
BH11		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.58	0.04	
1.15	0.03	
%	%	44.40



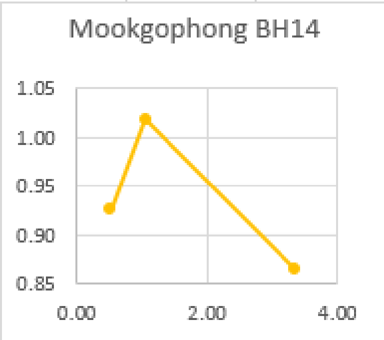
BH12		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.98	1.16	
2.05	1.01	
3.28	0.72	4.83



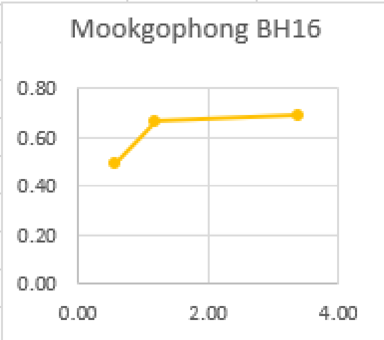
BH13		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.42	0.98	
3.02	0.76	
4.96	0.47	10.84



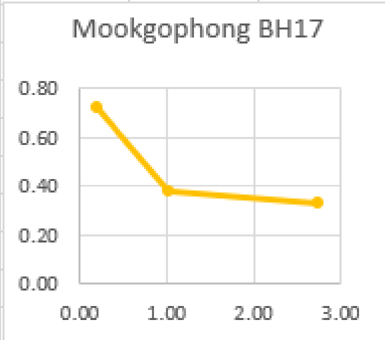
BH14		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.52	0.93	
1.05	1.02	
3.36	0.86	3.94



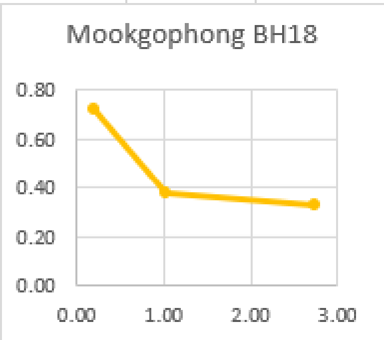
BH16		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.56	0.49	
1.19	0.67	
3.39	0.69	5.00



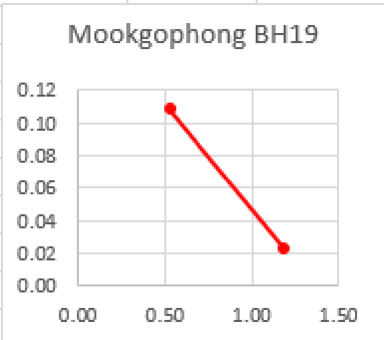
BH17		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.20	0.72	
1.01	0.38	
2.75	0.33	6.27



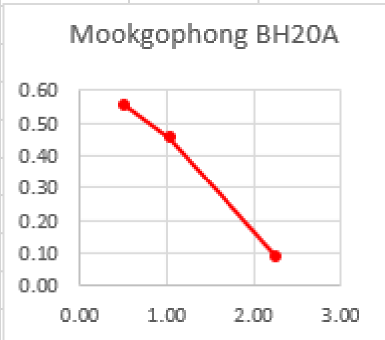
BH18		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.54	2.21	
2.40	1.85	
5.53	0.10	62.02



BH19		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.53	0.11	
1.19	0.02	
%	%	55.12

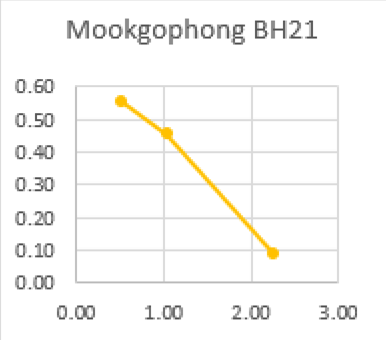


BH20A		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.51	0.55	
1.04	0.45	
2.26	0.09	26.67



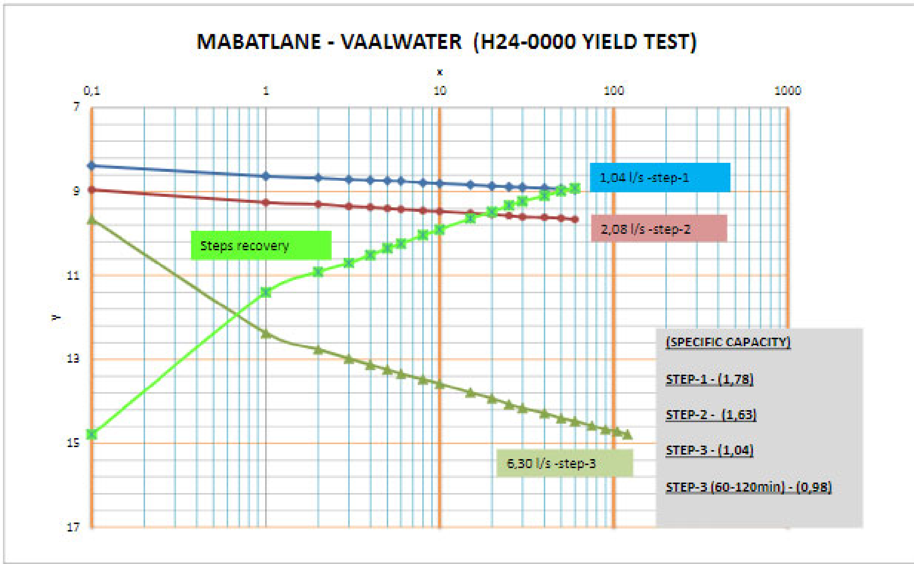
Appendix 4

BH21		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.01	0.65	
2.02	0.38	
2.66	0.07	60.35

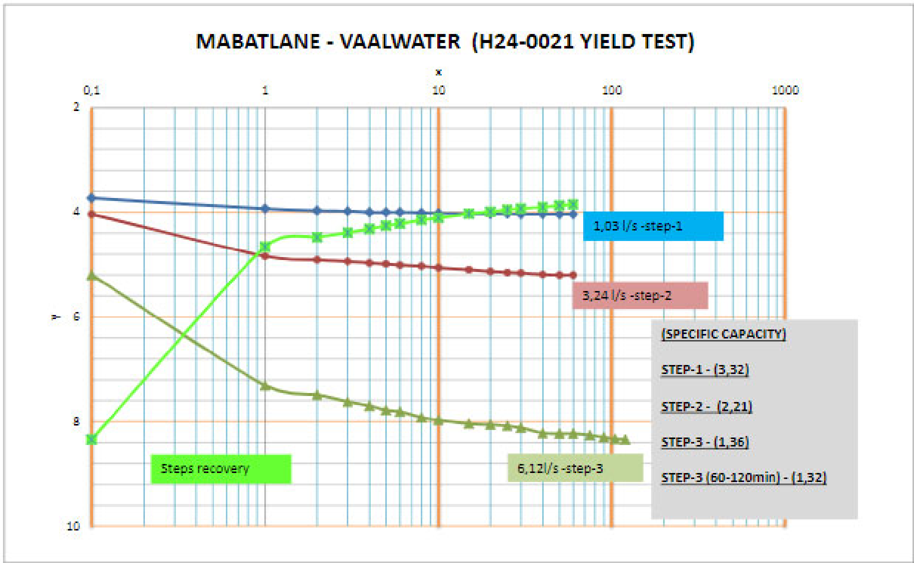


Pumping Tests Vaalwater

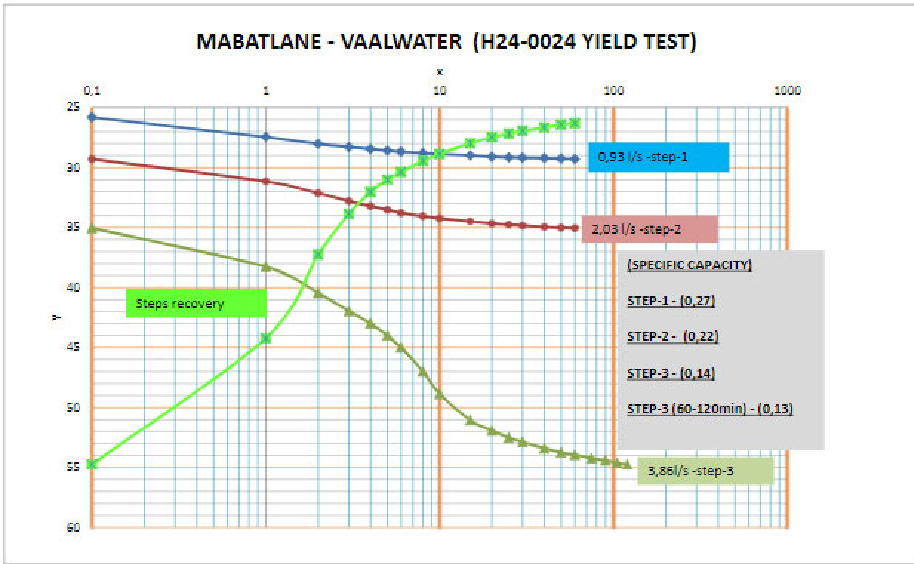
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	8,38	8,96	9,66	14,79
1	8,63	9,26	12,37	11,4
2	8,67	9,3	12,76	10,92
3	8,71	9,35	12,98	10,7
4	8,73	9,37	13,13	10,51
5	8,74	9,4	13,24	10,35
6	8,75	9,42	13,34	10,24
8	8,79	9,45	13,47	10,04
10	8,81	9,47	13,58	9,91
15	8,84	9,51	13,79	9,64
20	8,87	9,54	13,93	9,48
25	8,89	9,57	14,07	9,33
30	8,9	9,6	14,16	9,23
40	8,92	9,61	14,28	9,1
50	8,94	9,63	14,4	8,99
60	8,96	9,66	14,47	8,92
75			14,58	
90			14,67	
105			14,72	
120			14,79	



	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	3,73	4,04	5,2	8,34
1	3,93	4,84	7,31	4,66
2	3,97	4,91	7,49	4,48
3	3,98	4,94	7,62	4,39
4	4	4,97	7,7	4,32
5	4	4,99	7,78	4,26
6	4	5,01	7,81	4,22
8	4,01	5,03	7,92	4,15
10	4,02	5,06	7,97	4,11
15	4,03	5,1	8,04	4,03
20	4,03	5,13	8,06	3,99
25	4,03	5,15	8,08	3,95
30	4,04	5,16	8,12	3,93
40	4,04	5,19	8,22	3,9
50	4,04	5,2	8,23	3,87
60	4,04	5,2	8,23	3,85
75			8,26	
90			8,3	
105			8,33	
120			8,34	

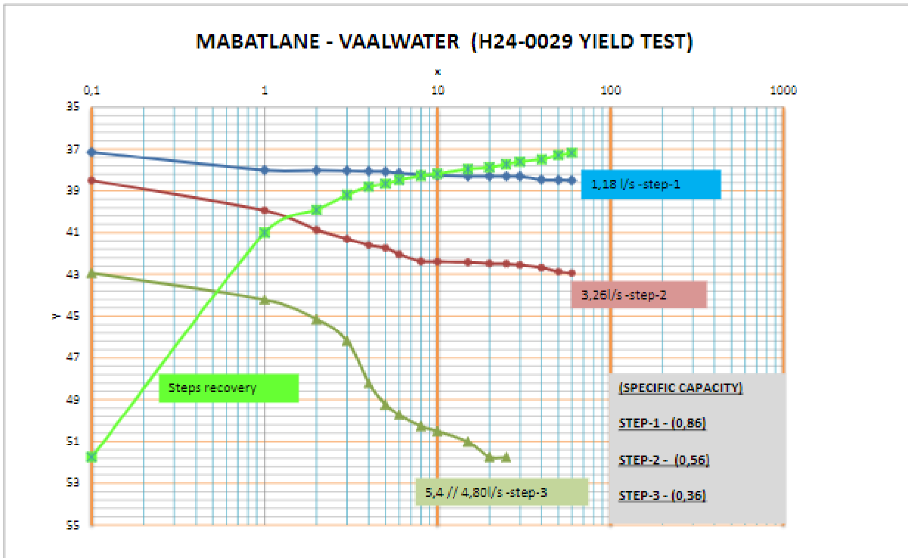


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	25,81	29,29	35,06	54,74
1	27,45	31,15	38,26	44,23
2	28,03	32,14	40,45	37,24
3	28,29	32,79	41,97	33,85
4	28,45	33,21	42,99	32,05
5	28,59	33,52	43,98	31
6	28,68	33,77	45,01	30,36
8	28,8	34,04	46,99	29,45
10	28,87	34,23	48,88	28,88
15	28,99	34,48	51,05	27,98
20	29,09	34,67	51,93	27,48
25	29,15	34,76	52,52	27,16
30	29,18	34,84	52,87	26,94
40	29,22	34,95	53,41	26,65
50	29,26	35,02	53,75	26,41
60	29,29	35,06	53,95	26,29
75			54,24	
90			54,4	
105			54,62	
120			54,74	

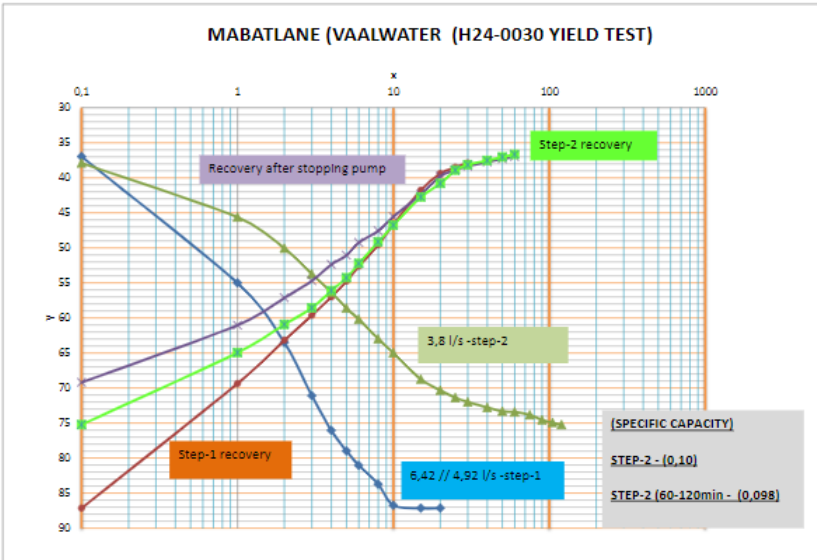


Appendix 5

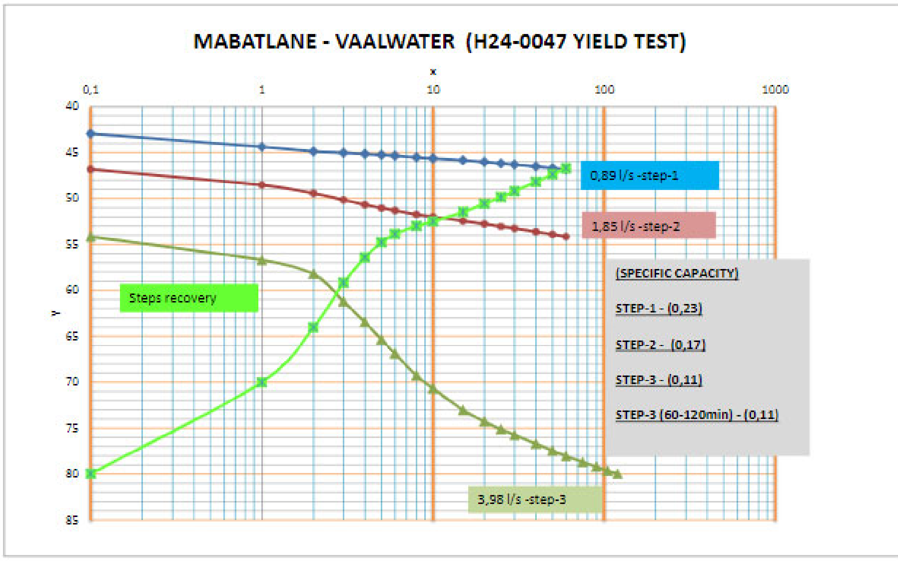
	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	37,15	38,5	42,94	51,75
1	38,01	39,94	44,21	41
2	38,02	40,87	45,15	39,91
3	38,04	41,3	46,18	39,2
4	38,06	41,6	48,21	38,8
5	38,08	41,74	49,24	38,66
6	38,15	42,04	49,72	38,47
8	38,22	42,37	50,27	38,27
10	38,26	42,39	50,51	38,18
15	38,29	42,42	51,02	37,96
20	38,29	42,47	51,75	37,88
25	38,3	42,49	51,75	37,73
30	38,3	42,54		37,61
40	38,46	42,67		37,49
50	38,47	42,87		37,29
60	38,5	42,94		37,18
75				
90				
105				
120				



	Step-1	step-1 Recovery	Step-2	Recovery after stop pumping-1	recovery after final step 2
Time	20	30	120	60	60
	36,98	87,15	37,9	69,21	75,24
1	55,01	69,37	45,62	61,04	64,96
2	63,52	63,2	50,07	57,14	60,95
3	71,11	59,62	53,74	54,71	58,58
4	76,07	57,04	56,35	52,38	56,11
5	78,98	54,77	58,61	51,08	54,27
6	81,04	52,63	60,2	49,25	52,24
8	83,74	49,57	63	47,57	49,15
10	86,75	46,62	65	45,56	46,77
15	87,15	41,78	68,75	42,37	42,75
20	87,15	39,4	70,34	39,79	40,83
25		38,51	71,38	38,9	38,93
30		37,9	72	38,34	38,16
40			72,78	37,77	37,54
50			73,33	37,31	37,05
60			73,42	36,98	36,67
75			73,85		
90			74,57		
105			74,93		
120			75,24		

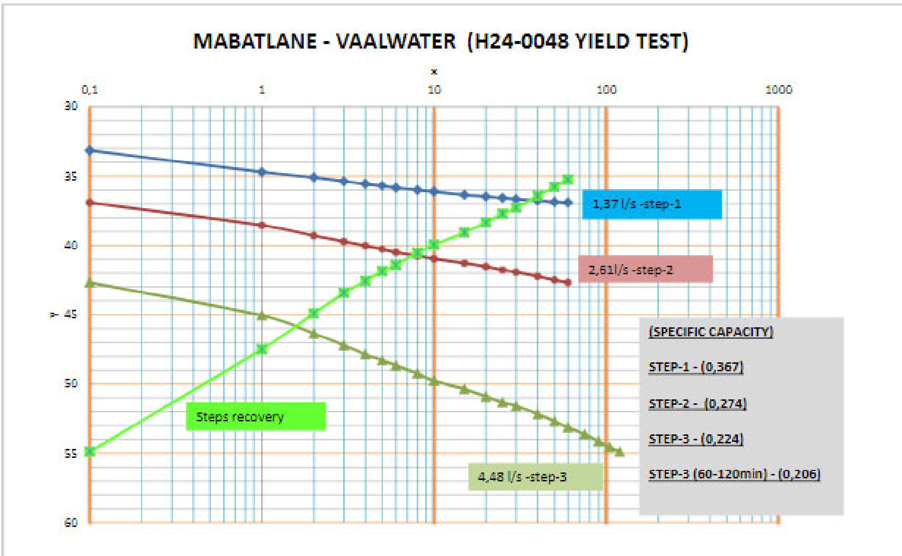


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	42,96	46,84	54,16	79,96
1	44,38	48,54	56,7	70,02
2	44,88	49,44	58,2	64,04
3	45,04	50,16	61,21	59,18
4	45,17	50,69	63,47	56,42
5	45,27	51,03	65,36	54,78
6	45,36	51,31	66,9	53,86
8	45,53	51,74	69,27	53,01
10	45,65	52	70,68	52,51
15	45,85	52,45	73,04	51,47
20	46,02	52,78	74,29	50,57
25	46,2	53,05	75,13	49,86
30	46,32	53,27	75,76	49,22
40	46,53	53,63	76,72	48,19
50	46,72	53,91	77,45	47,37
60	46,84	54,16	78,04	46,71
75			78,69	
90			79,21	
105			79,65	
120			79,96	



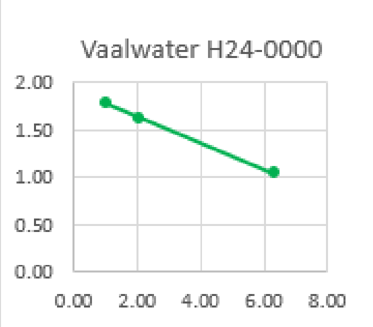
Appendix 5

	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	33,15	36,91	42,68	54,88
1	34,7	38,55	45,05	47,49
2	35,1	39,3	46,36	44,91
3	35,38	39,72	47,21	43,43
4	35,57	40,03	47,86	42,56
5	35,71	40,28	48,29	41,86
6	35,84	40,5	48,67	41,41
8	36	40,74	49,24	40,53
10	36,12	40,97	49,77	39,96
15	36,36	41,28	50,37	39,07
20	36,47	41,53	50,9	38,35
25	36,58	41,77	51,32	37,72
30	36,67	41,93	51,59	37,28
40	36,76	42,23	52,17	36,42
50	36,86	42,5	52,68	35,77
60	36,91	42,68	53,13	35,25
75			53,63	
90			54,13	
105			54,56	
120			54,88	

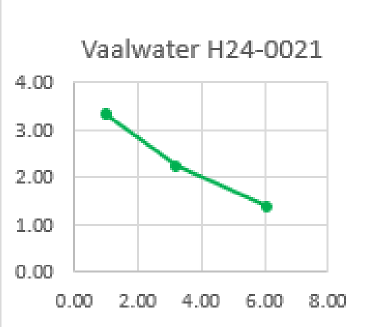


Appendix 5

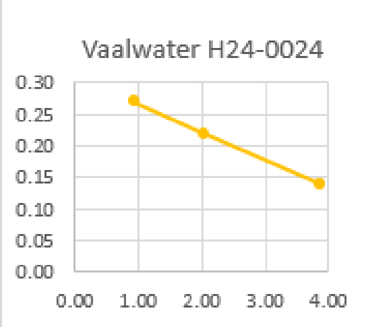
H24-0000		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.04	1.78	
2.08	1.63	
6.30	1.04	6.41



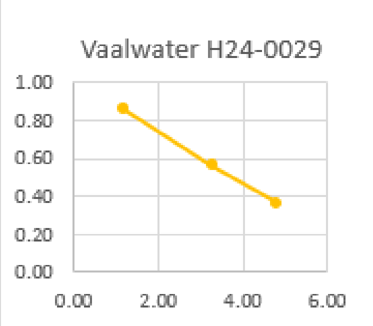
H24-0021		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.03	3.32	
3.24	2.22	
6.11	1.36	4.61



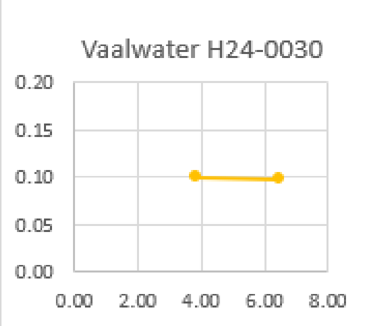
H24-0024		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.93	0.27	
2.03	0.22	
3.86	0.14	28.93



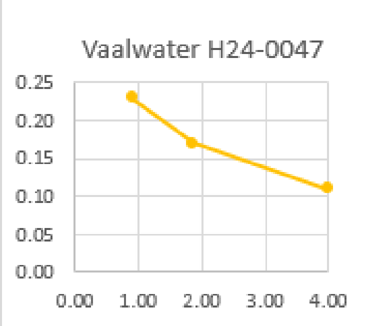
H24-0029		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.18	0.86	
3.26	0.56	
4.80	0.36	14.60



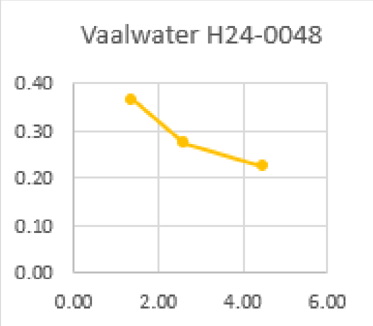
H24-0030		
Yield l/s	Spec cap, L/s/m	Max DD, m
3.80	0.10	
6.42	0.10	
		38.26



H24-0047		
Yield l/s	Spec cap, L/s/m	Max DD, m
0.89	0.23	
1.85	0.17	
3.98	0.11	37.00

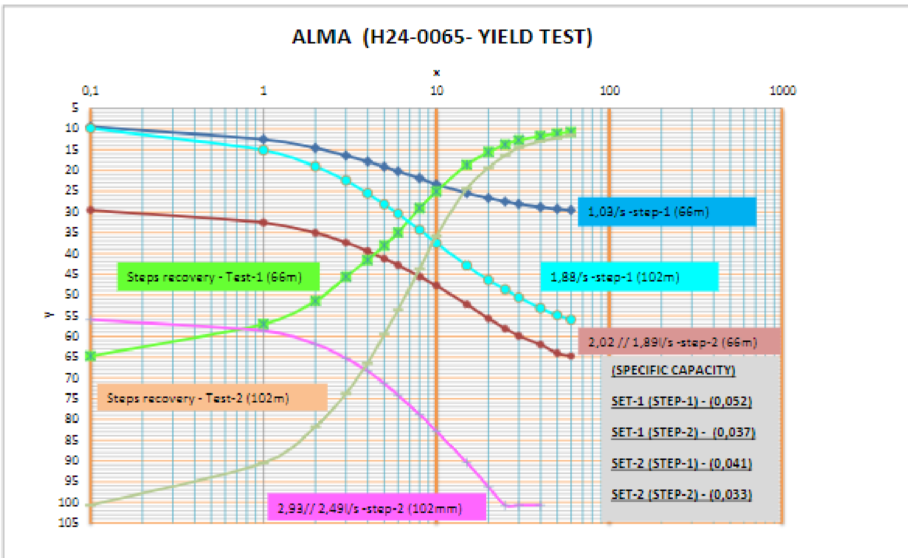


H24-0048		
Yield l/s	Spec cap, L/s/m	Max DD, m
1.37	0.37	
2.61	0.27	
4.48	0.22	21.73

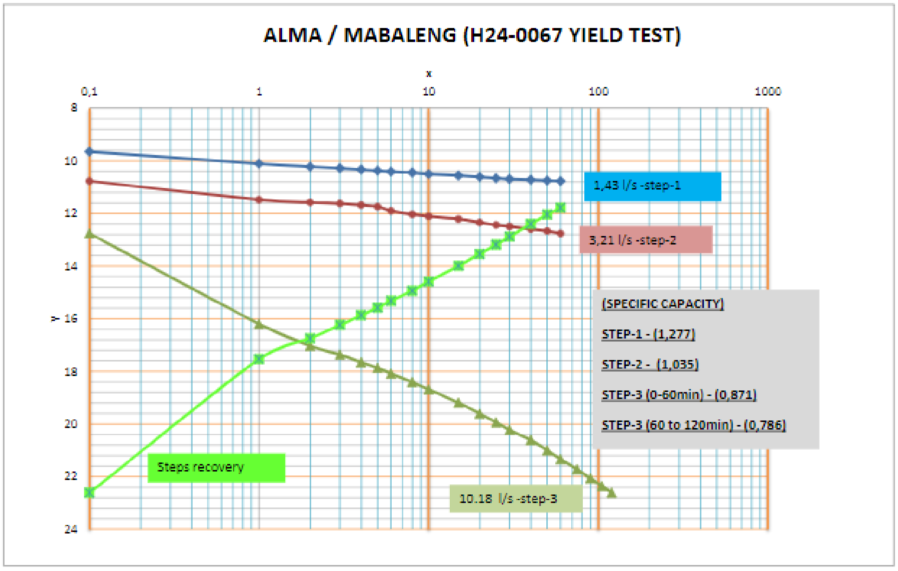


Pumping Tests Alma

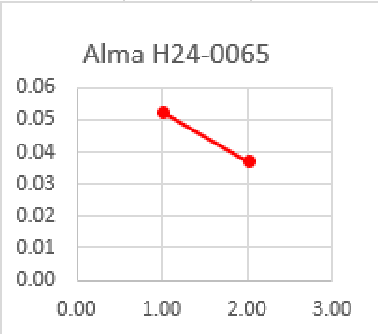
	FIRST TEST (1)			SECOND TEST (2)		
	Step-1	step-2	steps recovery	Step-1	Step-2	Steps recovery
Time	60	60	60	TEST	TEST	TEST
	9,46	29,57	64,75	9,85	55,99	100,74
1	12,51	32,58	57,08	15,11	58,63	90,54
2	14,61	35,06	51,48	19,07	61,84	81,77
3	16,43	37,39	45,62	22,47	65,3	73,78
4	17,87	39,44	41,61	25,54	68,37	66,47
5	19,13	41,29	38,12	28,16	71,35	59,51
6	20,26	42,84	34,97	30,45	74,17	53,61
8	21,87	45,57	29,14	34,33	78,81	43,77
10	23,37	47,75	25,08	37,51	82,84	35,78
15	25,44	52,29	18,69	42,94	90,42	24,37
20	26,65	55,71	15,59	46,44	96,29	19,38
25	27,54	58,15	13,77	48,65	100,74	16,37
30	28,13	59,9	12,69	50,63	100,74	14,51
40	28,9	61,97	11,79	53,22	100,74	13,01
50	29,33	64,05	11,17	54,91		12,15
60	29,57	64,75	10,79	55,99		11,48
75						
90						
105						
120						

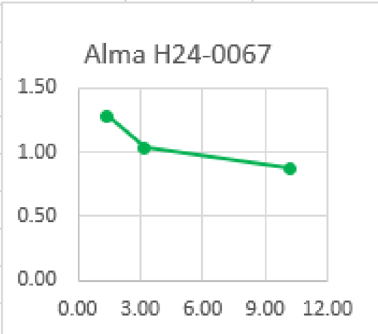


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	9,65	10,77	12,76	22,61
1	10,11	11,48	16,2	17,53
2	10,22	11,58	17,03	16,75
3	10,28	11,62	17,37	16,24
4	10,33	11,68	17,66	15,87
5	10,37	11,74	17,87	15,58
6	10,41	11,9	18,09	15,32
8	10,45	12,03	18,41	14,94
10	10,5	12,11	18,69	14,59
15	10,56	12,21	19,2	13,99
20	10,61	12,34	19,61	13,54
25	10,66	12,44	19,94	13,18
30	10,69	12,49	20,23	12,88
40	10,72	12,59	20,61	12,4
50	10,75	12,67	21,01	12,04
60	10,77	12,76	21,34	11,78
75			21,73	
90			22,07	
105			22,36	
120			22,61	



H24-0065			H24-0067		
Yield l/s	Spec cap,	Max DD,	Yield l/s	Spec cap,	Max DD,
1.03	0.05		1.43	1.28	
2.02	0.04		3.21	1.04	
%	%	55.21	10.18	0.87	12.96



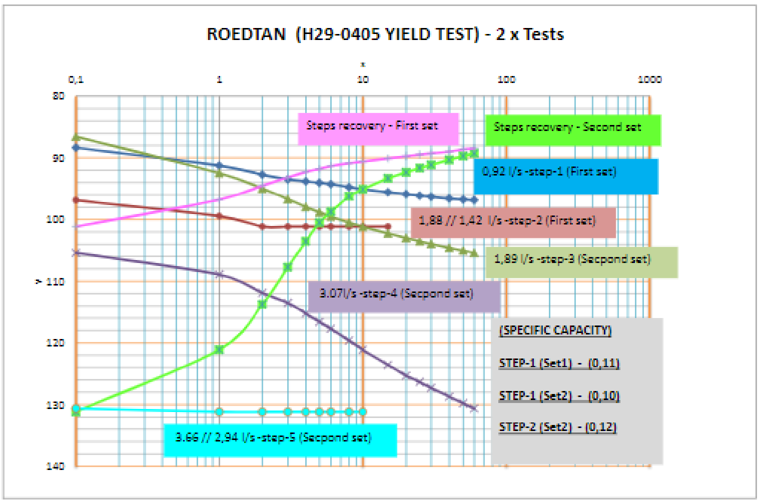


Pumping Tests Roedtan

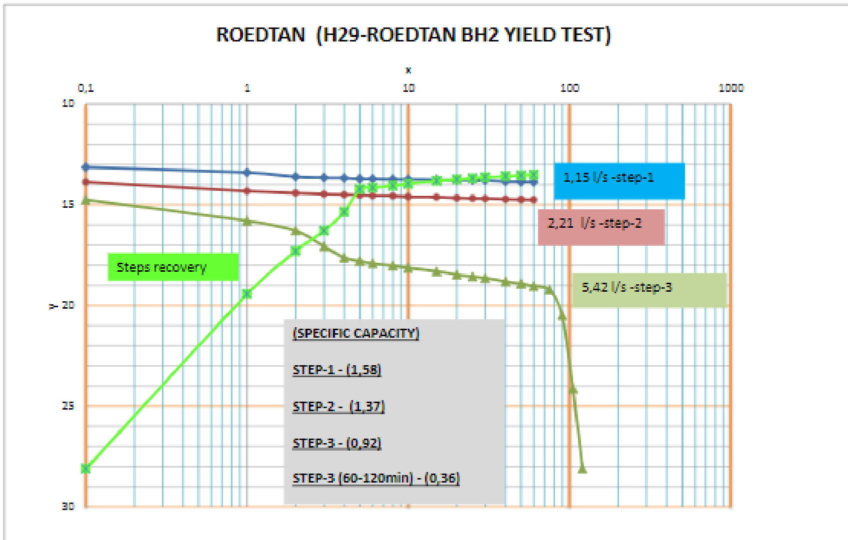
First set was done with pump setting at 102m

Second set was done with pump setting at 132m

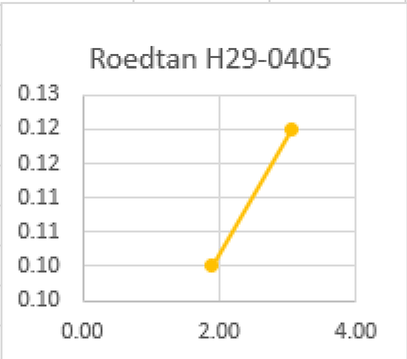
	First set	First set	Second set	Second set	Second set	First set	Second set
	Step-1	step-2	step-3	step-4	step-5	steps recovery	steps recovery
Time	60	60	60	60	60	60	60
	88,38	96,88	86,59	105,41	130,62	101,15	131,16
1	91,26	99,45	92,47	108,93	131,16	96,79	121,11
2	92,74	101,15	94,98	111,9	131,16	94,5	113,75
3	93,49	101,15	96,72	113,53	131,16	93,17	107,74
4	93,81	101,15	97,96	115,25	131,16	92,29	103,53
5	94,03	101,15	98,83	116,61	131,16	91,78	100,49
6	94,25	101,15	99,52	117,73	131,16	91,34	98,77
8	94,74	101,15	100,49	119,62	131,16	90,89	96,25
10	95,12	101,15	101,16	121,11	131,16	90,61	95,11
15	95,58	101,15	102,24	123,58		90,12	93,3
20	95,9		102,99	125,33		89,77	92,34
25	96,14		103,51	126,37		89,49	91,65
30	96,32		103,93	127,31		89,31	91,14
40	96,6		104,58	128,73		89,01	90,34
50	96,77		105,03	129,8		88,66	89,72
60	96,88		105,41	130,62		88,49	89,3
75							
90							
105							
120							

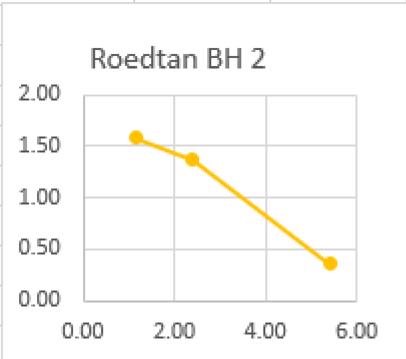


	Step-1	step-2	step-3	steps recovery
Time	60	60	120	60
	13,14	13,87	14,75	28,1
1	13,4	14,32	15,8	19,43
2	13,61	14,42	16,28	17,3
3	13,65	14,47	17,07	16,29
4	13,67	14,5	17,63	15,36
5	13,71	14,52	17,8	14,23
6	13,72	14,55	17,91	14,15
8	13,73	14,56	18,03	14,06
10	13,74	14,6	18,13	13,96
15	13,75	14,62	18,31	13,81
20	13,77	14,66	18,47	13,74
25	13,78	14,68	18,57	13,69
30	13,79	14,69	18,64	13,63
40	13,84	14,72	18,81	13,58
50	13,86	14,74	18,92	13,54
60	13,87	14,75	19,04	13,51
75			19,22	
90			20,49	
105			24,13	
120			28,1	



H29-0405			Roedtan-BH2		
Yield l/s	Spec cap, L/s/m	Max DD, m	Yield l/s	Spec cap, L/s/m	Max DD, m
1.89	0.10		1.15	1.58	
3.07	0.12		2.41	1.37	
%	%	55.21	5.42	0.36	14.96





Overview Electrical Installations

TOWN	BH NUMBER	MOTOR DETAILS Kw / Volts	BH STATUS	Condition, Electrical installation	Level, Electrical installation	Components installed (Electrical installation)
MODIMOLLE	H24-0037	CRI L4A 22N 2,2 / 230	NOT IN USE	Poor	NA	NA
MODIMOLLE	H24-0038	FRANKLIN 3,7 / 400	NOT IN USE	Poor	Low	NA
MODIMOLLE	H24-0049	FRANKLIN ? 2.2? / 400	NOT IN USE	Sufficient	NA	Main switch, Thermal relay, Motorscope.
MODIMOLLE	H24-0076	CRI W6A-93T / 9,3 / 400	NOT IN USE	Sufficient	NA	Main switch, Thermal relay, Motorscope.
MODIMOLLE	H24-0164	CRI L4A-22T 2,2 / 415	NOT IN USE	Sufficient	NA	Main switch, Thermal relay, Motorscope.
MODIMOLLE	H24-0172	CRI L4A-55T 5,5 / 415	WORKING	NA	NA	NA
MODIMOLLE	H24-0174	CRI L4A-37T 3,7 / 415	NOT IN USE	Sufficient	Low	Main switch, Thermal relay, Motorscope.
MODIMOLLE	H24-0198	CRI L4A-22T 2,2 / 415	NOT IN USE	Sufficient	Low	Main switch, Thermal relay, Motorscope.
MODIMOLLE	H24-0213	VANSAN 7,5 / 400	WORKING	NA	NA	NA
MODIMOLLE	lo Number 1		IN USE - NO TEST			
MODIMOLLE	lo number !	HURRICANE 3 / 380	NOT IN USE	Sufficient	Low	Main switch, Circuit breaker, Thermal relay, Motorscope.
VAALWATER	H24-0000	FRANKLIN 7.5 / 400	NOT IN USE	Poor	Low	Main switch, Circuit breaker, Thermal relay
VAALWATER	H24-0001		NOT IN USE			
VAALWATER	H24-0001B		NOT IN USE			
VAALWATER	H24-0021	WILO 61532400 - 19 7.5 / 380-460	WORKING	Poor	Medium	Main switch, Circuit breaker, Thermal relay, Motorscope, surge arrester .
VAALWATER	H24-0024	STAIRS / 2200032794-0548 / 7,5 / 380	WORKING	Poor	Medium	Main switch, Circuit breaker, Thermal relay, Motorscope, surge arrester .
VAALWATER	H24-0029	FRANKLIN 11 / 380-415	WORKING	Poor	NA	NA
VAALWATER	H24-0030	????? / 15 / 415	WORKING	Poor	Low	Main switch, Circuit breaker, Thermal relay, surge arrester .
VAALWATER	H24-0047	WORTEX 4R521	WORKING	Poor	Low	Main switch, Circuit breaker, Thermal relay, surge arrester .
VAALWATER	H24-0048	FRANKLIN 11 / 380-415	WORKING	Poor	Low	Main switch, Circuit breaker, Thermal relay, surge arrester .
ALMA	H24-0065	NONE	NOT IN USE	Sufficient	Medium	Main switch, Thermal relay, Motorscope.
ALMA	H24-0067	WILO 7,5 / 380	WORKING	Sufficient	Medium	Main switch, Thermal relay, Motorscope.
ROEDTAN	H29-0405	CRI 5.5kW / 415 V	WORKING	Poor	Low	Main switch, Thermal relay, Motorscope.
ROEDTAN	BH2	NONE	NOT IN USE	NA	NA	NA

Appendix 8

TOWN	BH NUMBER	MOTOR DETAILS	BH STATUS	Condition, Electrical	Level, Electrical	Components installed (Electrical installation)
Mookgophong	BH04	CRI L4A - 40T 4 / 415	WORKING	Poor	Medium	Main switch, Circuit breaker, Thermal relay, Motorscope,
Mookgophong	BH05		IN USE - NOT			
Mookgophong	BH06	WORTEX 4R517	NOT IN USE	NA	NA	NA
Mookgophong	BH07A	WORTEX 4R214	WORKING	Poor	Low	Main switch, Circuit breaker, Thermal relay, Overvoltage
Mookgophong	BH07B	WASA 4SD5500T	WORKING	Poor	NA	NA
Mookgophong	BH08A	FRANKLIN 236 614 9039	WORKING	Poor	Medium	Main switch, Circuit breaker, Thermal relay, Motorscope,
Mookgophong	H08B (New)		NOT IN USE	NA	NA	NA
Mookgophong	BH09A	WORTEX 4R316	NOT IN USE	Poor	NA	All the electrical components are stolen
Mookgophong	BH09B	WORTEX 4R519	NOT IN USE	Poor	NA	All the electrical components are stolen
Mookgophong	BH10	CRI L4A-22T / 2,2 / 380-415	WORKING	Poor	Low	Main switch, Circuit breaker, Thermal relay, surge arrester.
Mookgophong	BH11	NONE	NOT IN USE	NA	NA	All the electrical components are stolen
Mookgophong	BH12	NONE	NOT IN USE	NA	NA	NA
Mookgophong	BH13	COVERCO NBS4R 400T	NOT IN USE	Poor	NA	NA
Mookgophong	BH14	WORTEX 4R518 /	WORKING	Poor	Medium	Main switch, Circuit breaker, Thermal relay, Motorscope,
Mookgophong	BH15		NOT IN USE			
Mookgophong	BH16	VEGA 4SD 1100T /	NOT IN USE	Poor	NA	NA
Mookgophong	BH17	VEGA 4SD 1100T /	NOT IN USE	Sufficient	NA	Not working
Mookgophong	BH18	NONE	NOT IN USE	Poor	NA	All the wires are stolen
Mookgophong	BH19		NOT IN USE	Poor	NA	All the wires are stolen
Mookgophong	BH20A		NOT IN USE	NA	NA	The circuit breaker panel is used in 20B
Mookgophong	BH20B	PUMP USED FOR	NOT IN USE			
Mookgophong	BH21	WASA 4SD 4000T	NOT IN USE	NA	NA	The circuit breaker panel is stolen

Overview of submersible pumps

Town	Borehole No.	Pump Details Model / Head / Yield (l/s)	Motor Details Kw / Volts	Riser pipe	Existing Pump Setting	Pump Condition	Rec. Yield, l/s	Start water level	Calc . T Value, m2/d	Rec. Pump setting	Estimated Pump Head, m	Rec. Pumpe model or similar / Head (m) / Yield (l/s)	Rec. Motor Details kW / Volts
MODIMOLLE	H24-0038	NOT VISIBLE	FRANKLIN 3,7 / 400	HDPE PIPE (50mm)	52.8	Sufficient	5	18.30	45.0	60	62	Grundfos SP 17-9 / 65,23 / 5,13	5,5 / 400
MODIMOLLE	H24-0049	SPERONI ST6010 / 36 - 63m / 1,3	FRANKLIN ? 2.2? / 400	HDPE PIPE (50mm)	47.5	Good	1.2	14.11	14.0	36	57	Grundfos SP 7-12 / 65,48 / 1,28	1,5 / 400
MODIMOLLE	H24-0076	CRI S6S-60/05 / 37 / 16	CRI W6A-93T / 9,3 / 400	STEEL PIPES (80mm)	40.5	Good	3	14.31	50.0	39	49	Grundfos SP 11-11 / 49,81 / 3	2,2 / 400
MODIMOLLE	H24-0164	SALSUB SL 25-24 / 122-44 / 1 - 1.8	CRI L4A-22T 2,2 / 415	HDPE PIPE (50mm)	32.5	Good	1.5	14.30	13.0	30	65	Grundfos SP 9-11 / 68,25 / 1,53	2,2 / 400
MODIMOLLE	H24-0172	CRI S4P-10/28 / 112 / 2,7	CRI L4A-55T 5,5 / 415	HDPE PIPE (63mm)	50.5	Sufficient	3.5	17.61	70.0	54	49	Grundfos SP 14-11 / 49,78 / 3,52	3 / 400
MODIMOLLE	H24-0174	CRI S4P-14/16 / 53 / 3,8	CRI L4A-37T 3,7 / 415	HDPE PIPE (63mm)	50.5	Good	2	14.31	16.0	60	69	Grundfos SP 7-17 / 71,84 / 2	2,2 / 400
MODIMOLLE	H24-0198	CRI S4P-10/12 / 50 / 2,7	CRI L4A-22T 2,2 / 415	HDPE PIPE (50mm)	37.5	Good	1	14.45	8.0	36	68	Grundfos SP 5A-17 / 81,31 / 1,09	1,5 / 400
MODIMOLLE	H24-0213	VANSAN VSP SS06030 62m / 8	VANSAN 7,5 / 400	STEEL PIPES (80mm)	56	Good	4	18.79	70.0	60	50	Grundfos SP 14-13 / 51,69 / 4,06	3 / 400
MODIMOLLE	No Number 1			STEEL PIPES (80mm)									
MOOKGOPONG	BH04	WORTEX ST-6017 / 32-90 m / 4,2 - 1.6	CRI L4A - 40T 4 / 415	STEEL PIPES (80mm)	41	Sufficient	2.5	16.76	120.0	36	44	Grundfos SP 9-10 / 49,18 / 2,64	2,2 / 400
MOOKGOPONG	BH05												
MOOKGOPONG	BH06	NO PUMP	WORTEX 4R517 2,2 / 400	HDPE PIPE (40mm)	40.5	N/A	3	18.87	60.0	36	54	Grundfos SP 17-6 / 60,34 / 3,17	4 / 400
MOOKGOPONG	BH07A	VANSAN SVP 406/14 80m / 1,5 - 2,5	WORTEX 4R214 1,5 / 400	HDPE PIPE (50mm)	35	Sufficient	2.5	18.41	120.0	36	46	Grundfos SP 9-10 / 49,94 / 2,6	2,2 / 400
MOOKGOPONG	BH07B	WORTEX ST4013 / 90-180 m / 5,5 - 2,5	WASA 4SD5500T 5,5 / 380	HDPE PIPE (50mm)	86	Sufficient	1.3	18.69	9.0	60	73	Grundfos SP 5A-21 / 84,59 / 1,3	2,2 / 400
MOOKGOPONG	BH08A	SUPER D INFO NOT VISIBLE	FRANKLIN 236 614 9039 15 / 380-415	STEEL PIPES (80 & 100mm)	68	Sufficient	3	18.9	60.0	66	54	Grundfos SP 17-6 / 60,34 / 3,17	4 / 400
MOOKGOPONG	BH08B (New)			NONE		N/A	1.5	19.9	160.0	48	45	Grundfos SP 9-8 / 48,81 / 1,56	1,5 / 400
MOOKGOPONG	BH09A	SPERONI INFO NOT VISIBLE	WORTEX 4R316 2,2 / 400	HDPE PIPE (40mm)	44	Sufficient	2	18.18	60.0	54	48	Grundfos SP 7-12 / 50 / 2	1,5 / 400
MOOKGOPONG	BH09B	VEGA D3/62 / 93-420 / 1,3 - 3	WORTEX 4R519 7,5 / 400	HDPE PIPE (50mm)	76	Sufficient	1	17.97	5.0	48	80	Grundfos SP 5A-17 / 82,8 / 1	1,5 / 400
MOOKGOPONG	BH10	CRI S4P-4/22N / 128 / 1,1	CRI L4A-22T / 2,2 / 380-415	HDPE PIPE (50mm)	52	Sufficient	1	18.04	4.0	60	80	Grundfos SP 5A-17 / 82,8 / 1	1,5 / 400
MOOKGOPONG	BH12	NONE	NONE	NONE		N/A	1	15.1	30.0	36	45	Grundfos SP 7-8 / 46,14 / 1	1,1 / 400
MOOKGOPONG	BH13	WORTEX ST-6014 / 28-89 / 1,6 - 4,3	COVERCO NBS4R 400T 3 / 400	HDPE PIPES (50mm)	47	Poor	2.5	17.46	80.0	48	48	Grundfos SP 9-10 / 50,65 / 2,56	2,2 / 400
MOOKGOPONG	BH14	HURRICANE 4SD 12/19 28-75 / 3-4,5		HDPE PIPES (50mm)	74	Sufficient	2	17.37	120.0	54	44	Grundfos SP 9-8 / 45,66 / 2	1,5 / 400
MOOKGOPONG	BH16	HURRICANE 4SD 2/20 60-139 / 0,17 - 0,83	VEGA 4SD 1100T /1,1/ 380	(32mm)	94	Sufficient	2	18.18	120.0	36	44	Grundfos SP 9-8 / 45,66 / 2	1,5 / 400
MOOKGOPONG	BH17	HURRICANE 4SD 2/20 60-139 / 0,17 - 0,83	VEGA 4SD 1100T /1,1 / 380	HDPE PIPES (32mm)	76	Sufficient	1.1	18.74	30.0	36	50	Grundfos SP 9-8 / 50,28 / 1,1	1,5 / 400
MOOKGOPONG	BH18	NONE	NONE	NONE		N/A	1	17.85	7.0	36	71	Grundfos SP 5A-17 / 82,8 / 1	1,5 / 400
MOOKGOPONG	BH21	WASA 4SD10/22 / 30 - 134 /1 - 3,8	WASA 4SD 4000T 4 / 380	HDPE PIPES (50mm)	88	Good	1.1	16.98	4.0	60	90	Grundfos SP 7-17 / 96,26 / 1,13	2,2 / 400
Vaalwater	H24-0000	FRANKLIN SVM 150-45	FRANKLIN 7.5 / 400	PVC (65mm)	44.5	Sufficient	2,2	8.38	60.0	30	49	Grundfos SP 9-10 / 54,78 / 2,32	2,2 / 400
Vaalwater	H24-0001												
Vaalwater	H24-0001B												
Vaalwater	H24-0021	FRANKLIN SVM ??? / ???? / ????	WILO 61532400 - 19 7,5 / 380-460	PVC (65mm)	66	Sufficient	3.5	3.73	100.0	36	45	Grundfos SP 17-5 / 47,2 / 3,58	3 / 400
Vaalwater	H24-0024	FRANKLIN SVM 240 / 35 85-195 / 1,3 - 4,0	STAIRS / 2200032794-0548 / 7,5 / 380	PVC (40mm)	99	Sufficient	1	25.81	11.0	60	79	Grundfos SP 5A-17 / 82,8 / 1	1,5 / 400
Vaalwater	H24-0029	CRI S6S 22/14 / ???? / 7,5	FRANKLIN 11 / 380-415	PVC (65mm)	50	Sufficient	1.1	37.15	40.0	54	76	Grundfos SP 5A-17 / 79,15 / 1,12	1,5 / 400
Vaalwater	H24-0030	?????	????? / 15 / 415	PVC (65mm)	88	N/A	1.1	36.98	8.0	66	100	Grundfos SP 9-16 / 101 / 1,1	3 / 400
Vaalwater	H24-0047	FRANKLIN SVM 285 / 32 80 - 135 / 1,5 - 3,0	WORTEX 4R521 7,5 / 400	PVC (50mm)	95	Sufficient	1	42.96	6.0	84	110	Grundfos SP 7-23 / 130 / 1	3 / 400
Vaalwater	H24-0048	VANSAN VSP SS06030 / 76 - 110 / 5 - 8	FRANKLIN 11 / 380-415	PVC (65mm)	89	Sufficient	1.2	33.15	10.0	72	92	Grundfos SP 7-17 / 94,95 / 1,2	2,2 / 400
Alma	H24-0065	NONE	NONE			N/A	0.5	9.46	2.0	66	82	Grundfos SP 9-13 / 83,71 / 0,5	3 / 400
Alma	H24-0067	CRI S4P 8/43 / 194 / 2,2	WILO 7,5 / 380		101.5	Sufficient	4	9.65	60.0	60	49	Grundfos SP 14-13 / 51,35 / 4,01	3 / 400
Roedtan	H29-0405	VORTEX 4032 /80 - 180 m / 3,3 - 1.3l/s	CRI 5.5kW / 415 V	HDPE PIPES (50mm)	122	Sufficient	1.1	86.59	6.0	66	114	Grundfos SP 7-23 / 128,9 / 1,17	3 / 400
Roedtan	BH2	None	None			N/A	1.4	13.14	30.0	60	46	Grundfos SP 9-8 / 49,3 /1,45	1,5 / 400

Appendix 10

Mookgophong borehole yields

Mookgophong Boreholes, yield, m^3, as per logbook at pumpstation

Borehole no	20-jan-21	21-jan-21	16-aug-21	19-sep-21	30-sep-21	01-okt-21	02-okt-21	03-okt-21	04-okt-21	05-okt-21	08-okt-21	09-okt-21	10-dec-21	08-feb-22	09-feb-22	22-feb-22	23-feb-22	24-feb-22	25-feb-22	Avg. Operation
4	783,709	0	220	263	266	268	267	238	267	268	254	238	394	93	251	237	272	277	275	256
5	443,177	232	172	142	141	130	138	123	106	152	138	133	198	88	184	170	184	184	155	154
6	998,991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7a	234,738	174	148	159	169	170	72	72	45	185	169	109	155	126	157	156	183	183	167	144
7b	0	0	0	251	254	248	247	233	84	265	242	233	176	255	0	0	-23	0	39	226
8a	990,350	542	0	422	451	444	444	413	38	0	0	0	0	0	583	508	435	435	914	429
8b	732,423	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9a	201,569	85	177	256	271	125	267	243	211	273	261	256	0	0	0	0	0	0	0	234
9b	41,950	119	95	44	45	45	47	39	39	44	44	44	0	0	0	0	0	0	0	43
10	491,973	142	88	143	144	87	199	170	73	145	140	135	159	89	68	0	0	0	110	126
11	733,409	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	763,339	297	252	258	295	31	507	192	269	283	269	255	114	210	0	0	0	0	0	249
14	206,685	250	255	260	291	242	283	217	249	281	256	254	169	319	0	232	287	287	224	256
15	68,989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	45,684	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	58,802	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	63,975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	3,517	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	114	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	155	184	186	109	259	210	0	0	0	0	0	0	0	0	0	0	0	184
Total, m3/day		**1,841**	**1,674**	**2,406**	**2,514**	**1,899**	**2,730**	**2,150**	**1,381**	**1,896**	**1,773**	**1,657**	**1,365**	**1,182**	**1,243**	**1,303**	**1,338**	**1,366**	**1,884**	**2,301**
Total, m3/h		77	70	100	105	79	114	90	58	79	74	69	57	49	52	54	56	57	79	96
BH in operation	8	8	12	12	11	11	12	11	10	9	9	9	7	7	5	5	5	5	7	11

0: Borehole in operation, but yield can not be determined

XX: Borehole in operation, yield uncertain / not to be determined

Appendix 11

VCS Denmark

Actionplan for boreholes in Modimolle-Mookgophong Municipality

Prepared in July 2022

Pos. No	Unit	No.	Unit Price, ZAR	2022/23, ZAR	2023-/27, ZAR	Comments
	Total Costs			**4,400,000**	**10,835,000**	
0	**General**			**340,000**		
0.1	Standard tender documents for Siting of BH's	1	100,000	100,000		
0.2	Standard tender documents for Drilling of BH's	1	80,000	80,000		
0.3	Standard Electrical Specifications for BH's	1	60,000	60,000		
0.4	Training i Supervision of drilling of BH's	1	100,000	100,000		
1	**Modimolle**			**720,000**	**1,330,000**	
1.1	Vandalisme protection of BH	8	30,000	240,000		
1.2	Pump overhaul of Cat A BH	4	60,000	240,000		
	Pump overhaul of Cat B BH	4	60,000		240,000	
1.3	Electrical overhaul of Cat A BH	4	35,000	140,000		
	Electrical overhaul of Cat B BH	2	35,000		70,000	
1.4	Abandon Cat C BH	2	30,000		60,000	
1.5	Standard Pumphouses	8	70,000		560,000	
1.6	Pipeline Testing	1	100,000	100,000		
1.7	Pipeline upgrade	1	400,000		400,000	
2	**Mookgophong**			**1,875,000**	**7,045,000**	
2.1	Vandalisme protection of BH	8	30,000	240,000		
2.2	Pump overhaul of Cat A BH	5	60,000	300,000		
	Pump overhaul of Cat B BH	11	60,000		660,000	
2.3	Electrical overhaul of Cat A BH	11	35,000	385,000		
	Electrical overhaul of Cat B BH	5	35,000		175,000	
2.4	Abandon Cat C BH	3	30,000		90,000	
2.5	Standard Pumphouses	16	70,000		1,120,000	
2.6	Pipeline Testing	3	150,000	450,000		
2.7	Pipeline upgrade	1	600,000		600,000	
2.8	Siting of 4 new BH's	1	500,000	500,000		
2.9	Complete New BH incl. Installations	4	800,000		3,200,000	
2.10	Pipeline, 1km	4	300,000		1,200,000	
3	**Vaalwater**			**900,000**	**875,000**	
3.1	Vandalisme protection of BH	7	30,000	210,000		
3.2	Pump overhaul of Cat A BH	2	60,000	120,000		
3.3	Pump overhaul of Cat B BH	5	60,000		300,000	
3.4	Electrical overhaul of Cat A BH	2	35,000	70,000		
3.5	Electrical overhaul of Cat B BH	5	35,000		175,000	
3.6	Pipeline Testing	1	100,000	100,000		
3.7	Pipeline upgrade	1	400,000		400,000	
3.8	Purchase of private BH	1	400,000	400,000		
4	**Alma**			**205,000**	**195,000**	
4.1	Vandalisme protection of BH	2	30,000	60,000		
4.2	Pump overhaul of Cat A BH	1	60,000	60,000		
4.3	Pump overhaul of Cat C BH	1	60,000		60,000	
4.4	Electrical overhaul of Cat A BH	1	35,000	35,000		
4.5	Electrical overhaul of Cat C BH	1	35,000		35,000	
4.6	Pipeline Testing	1	50,000	50,000		
4.7	Pipeline upgrade	1	100,000		100,000	
3	**Roedtan**			**360,000**	**1,390,000**	
5.1	Vandalisme protection of BH	2	30,000	60,000		
5.2	Pump overhaul of Cat B BH	2	60,000		120,000	
5.3	Electrical overhaul of Cat B BH	2	35,000		70,000	
5.4	Pipeline Testing	1	50,000	50,000		
5.5	Pipeline upgrade	1	100,000		100,000	
5.6	Siting of 1 new BH	1	250,000	250,000		
5.7	Complete New BH incl. Installations	1	800,000		800,000	
5.8	Pipeline, 1km	1	300,000		300,000	