Technical Report

ATLANTIS & SIMONSTOWN WELLFIELDS

OUTCOMES OF REHABILITATION AND REGENERATION PROJECTS 1999-2001 & 2014-2016 OF POTABLE WATER SUPPLY BOREHOLES FOR IMPLEMENTATION

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Table of Contents

Table of Figures

Executive Summary

CMC staff assisting with installation for testing before treatment, Atlantis, 2002.

Introduction

City of Cape Town (CoCT) Contract no. 18S/2013/14 required regeneration of forty (40) boreholes in the Witzands, Silwerstroom wellfields at Atlantis; and Brooklands at Simonstown. The objective to cost-effectively restore to optimum yields production of boreholes in operation adversely affected by clogging due to biofouling, would apply the same approach as done with treatment in 2002, previous application of the techniques having effectively achieved the objective (More Water, Atlantis Report, 2002). Boreholes treated are of varied construction, infrastructure, and management/maintenance protocols. The contractor would work in close liaison with CoCT staff facilitating skills transfer over the duration of the programme, as done during the 2002 project. CoCT staff would assist with the installation and removal of pump testing equipment. CoCT provided the test pumping equipment, water tanker and initially the hoisting unit. Project start was 15 September 2014 and ended 30 November 2016. Work performed excluded a 6-month Post-rehabilitation/regeneration Management Programme phase (referred as 'PRMP' in the tendered technical proposal). This phase intended to both maintain operational productivity, and develop a systematic operational strategy for implementation to manage the investment long-term through capacity building of CoCT staff.

Methodology

The treatment methodology covered a CCTV camera log with pre-testing timed pump tests, during which water samples were taken for analysis. Application of the Blended Chemical Heat Treatment (BCHT) patented process followed to break down and remove the biomass clogging the screens and surrounding aquifer. Hereafter followed a pump-to-waste series, to safely dispose of all effluents arising from the treatments via the tanker into the settling pond at the Atlantis Treatment Works. Once water quality tested close to original chemistry, a post-treatment pump test was performed establishing improvement if any, in addition to post-treatment camera logging being performed, to satisfy quality control requirements. CCTV material serves for future comparative reference. Water samples referred to earlier are purpose-specific microbiological tests known as BART™ test kit, again prescribed for application in the technical proposal for this programme included in all previous proposals but not yet introduced as part of a monitoring regime. BARTs were conducted solely on one (1) borehole in Simonstown (Brooklands no. 2) with operational constraints at ATW hindering comprehensive application during this programme.

Outcomes

BCHT process results indicate effective treatment was achieved within budget. As anticipated, borehole construction again significantly constrained success rate. Table 1 below summarises overall results achieved, with detailed data logs enclosed in Annexure A of the document. For this programme based on their post-test results, boreholes achieving improved performance were allocated a rating of either Good or Uncertain, and were given an Optimum Pumping Rate as a recommended yield for continuous production. Where no improvement was achieved a rating of Compromised is given.

Only three (3) of the total 40 selected for treatment were found to be compromised beyond repair, being recommended for de-commissioning. Improved yield (specific capacity/SD) was achieved in twenty-nine (29) boreholes, though in total thirty-seven (37) were allocated a rating Good or Uncertain. Of the 37 viable boreholes, five (5) primary production boreholes in the Witzands wellfield listed 1-5 in Table 1, after Return to Service (RTS) following treatment in the early stages of the project, retesting indicated in a short space of time concerning signs of decline by later stages of the project. A repeated course of treatment was applied to restore best possible performance to within acceptable levels, with reapplication results further exceeding the initial yield improvement achieved from the first course of treatment.

All 37 boreholes may be Returned to Service and reintroduced into continuous production on condition that management recommendations for abstraction adhere strictly to the recommended yields. An overall 67.5% success rate for this programme, compares favourably with a 73% improvement achieved during the 1999-2002 programme (Less, 2002), accounting for 3 boreholes' deterioration beyond the possibility for rehabilitation.

Looking Ahead

The proposed PRMP as a short-term process for maintaining the minimum 80% of productive boreholes in operation, planned to extend the success-rate achieved during the latest renewal project long-term; and was envisaged to result in a systematic operational strategy being developed and refined in the field. Circumstances having prevented the Contractor being able to roll out the 6-month PRMP resulted in the opportunity for skills transfer and capacity building of CoCT staff being lost. To mitigate the limited take-up of staff training as offered in the technical proposal, a Technical Report was considered the next alternative serving to combine the lessons learned from the original rehabilitation project concluded in 2002 with outcomes of this most recent project. As a theoretical operational strategy, the results obtained with CoCT's most recent investment (Contract no. 18S/2013/14) could be preserved as far as possible with implementation of the Recommended Monitoring Programme, as suggested in 2002.

The provision of a Technical Report however cannot replace the imperative need for and benefit to be gained from training and capacity building that would have CoCT staff exercising proficient site-specific skills and competencies relative to proper wellfield management long-term. The PRMP contained in the tendered technical proposal submitted to CoCT were to be implemented as a training intervention, may well form the basis for development of a recognised SAQA qualification.

**Reliability rating describes the level of performance anticipated from a borehole based on the most recent post-treatment test results, working at the continuous pumping rate recommended.*

***Good:** expected performance sustainable for at least 4 years, with no further intervention aside from monitoring being required.*

***Uncertain:** needs an additional jetting treatment within 4 years to sustain output.*

***Compromised**: implies non-performance and deterioration beyond revival. Decommission.*

Table 1 Summary of Results for production boreholes treated

Borehole ID	Post-treatment improvement/decline (%)	Continuous Pumping rate recommended (l/s)	*Reliability rating
	WITZANDS		
1. W34001*	26	15	Good
2. W34025*	26	7	Good
3. W34024*	14	7	Good
4. W34022*	48	7	Good
5. W34023*	76	7	Good
6. W34005	9.5	7	Uncertain
7. G30965	71	7	Uncertain
8. G30973	36	7	Uncertain
9. W34032	1.5	7	Uncertain
10. W34020	4.5	7	Uncertain
11. W34029	40.6	7	Good
12. W34012	34	7	Good
13. G33103	-10	5	Uncertain
14. W34031	1	7	Uncertain
15. W34009	-90	5	Uncertain
16. W34011	23	0	Compromised
17. W34019	-8.7	5	Uncertain
18. W34028	0	5	Uncertain
19. W34013	-36	2	Uncertain
20. G33107*	175	5	Uncertain
21. W34014*	71	7	Good
22. G30972	-11	5	Uncertain
23. W34030	39	7	Good
24. W34010	-1	7	Uncertain
25. G33104*	109	7	Good
26. G30966	8	5	Uncertain
	SILWERSTROOM		
27. W34018	14	4	Good
28. G32956	2	4	Uncertain
29. W34016	-2	2	Uncertain
30. G32959	12	4	Uncertain
31. G32955	15	2	Uncertain
32. W34034	6	0	Compromised
33. G30865	10	4	Uncertain
34. G32952	1	4	Uncertain
35. W34015	6	4	Uncertain
36. G32954	20.8	4	Uncertain
37. W34017	-2	0	Compromised
38. W34033	4	4	Uncertain
39. G30991	0	4	Uncertain
	BROOKLANDS		
40. No. 2	-26	2	Uncertain

(For complete record of results, refer to Appendix A, Pg. 38)

Scientific Foundation

Background

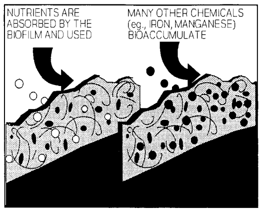


Figure 1

Biofilms (shown sectioned) will absorb and utilise nutrients (left, open circles) but may simply bioaccumulate other chemicals (right, black circles) such as iron during the lifetime

There are several stages commonly occurring during the process of biofouling in a water well, influenced by several major factors including the *water quality* and *production rate*, the *nature* and *porosity* of the media around the well, the *design* and *construction* of the well and extent of routine monitoring for preventative maintenance in operation.

Naturally occurring (intrinsic or 'inside') and introduced (extrinsic or 'outside') microorganisms can be expected to be present within the environment affected by the borehole installation. The intrinsic flora will have arisen from the groundwater, the unsaturated media above the water table, and from the soil. The extrinsic microorganisms are those likely to have been introduced during the use of drilling equipment, waters, personnel activity, muds, and various chemicals required for the construction during development of a well. These microorganisms will compete for the available surfaces onto which they attach, most desirable surfaces include those which are charged, occur at the *redox front, where turbulence is being generated in the water, and relative nutrient supply available (e.g. organic deposits, higher concentrations of dissolved/suspended organic carbon, or phosphate-rich zones). Microorganisms once attached to a favoured surface will begin reproducing, and growing outwards to form a *biofilm or plug. Plugging occurs both near-side, being inside the casing or screen and/or far-side, extending up to as much as 50 meters beyond the casing into the aquifer formation. As the various microbial biofilms form, they will interact and consortia (community) biofilms form, within which many strains (anywhere from 5–50+) are cooperating within a common biofilm. Referring to the CCTV footage obtained, a biofilm or plugging is visible on the casing interior and screen, as a sessile ('fluffy') growth, being near-side plugging.

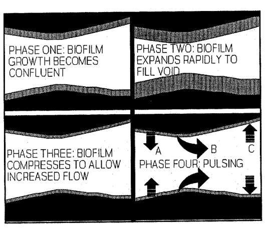


Figure 2

First four phases of biofilm growth (shaded) in porous media (back, upper, and lower edge). Phase four has three events: expansion (A), sloughing (B) and stabilisation (C).

The three principal elements associated with *biofouling or plugging events are C - carbon (organic), N - nitrogen (organic and inorganic) and P - phosphorus (inorganic and organic). The ratio of these three elements is crucial to the generation of a biomass and hence, a possible *biofouling or plugging event. Total organic carbon, inorganic and organic nitrogen (nitrate, nitrite, ammonium, and proteins, respectively) and inorganic phosphates (phosphate and polyphosphates) are the most common sources of the three elements in a biofilm. The optimal ratio to allow for growth is a C: N: P (carbon: nitrogen: phosphorus) ratio of 100: 1:0.25. All three elements must be in forms available to the microorganisms to be included in the ratio. While the carbon *ratio* may fluctuate quite considerably without effect, the nitrogen (N): phosphorus (P) ratio *shifts the activities* of the microorganisms in the biofouling.

The optimal N: P ratio is usually between 4 and 8:1. If the ratio is >8:1, the deficiency in the amount of available phosphorus restricts the extent of biofouling. If, on the other hand, the ratio

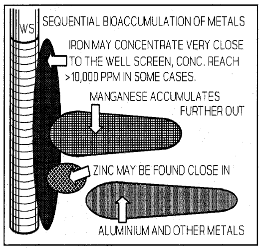


Figure 3

Diagrammatic presentation of the regions within the biological interface beyond the well-screen (WS) where various metallic compounds are bioaccumulated in a sequential manner

is < 1:1, nitrogen being deficient, the microorganisms able to use molecular nitrogen (N2, dinitrogen) may become dominant in the biofilm. As this is an energy-expensive process to obtain nitrogen, the rate of biofouling will also reduce. In the field, a diminishing availability of phosphorus is observed to be the limiting nutrient that stagnates growth and activity.

Significant reasons the use of nutrient concentrations or Nutrient Loadings in the water are not yet practical to use as a method of predicting the extent of or potential for biofouling:

1. The water sampled is often ‘product water’ in which much of the nutrients and elements would already have been removed or given off by the down-hole biological activity.
2. It is difficult to determine which substances and elements available bear a nutritional value for the microorganisms for growth and biological activities, and which do not (*recalcitrant).

Nutrient Loadings in a borehole water sample may not reflect true levels of elements as:

- In particularly, carbon and phosphorus accumulate in the biomass;
- Erratic sloughing (or ‘shedding’) of the matured plug causes sudden surges in the carbon, phosphorus, and nitrogen;
- Localised denitrification may cause reduced nitrogen levels (under anaerobic conditions);
- Nitrate levels may be exaggerated under aerobic conditions by seasonal rainfall, soil content or geological situations.

An example of the above, Witzands rest water levels in retreated boreholes measured between 1–7 metres higher than the previous rehab programme in 1999 e.g. rest water level below collar in W34005 measured 0.65m (01/2015) vs 7.04m (03/1999). Being the result of the above average rainfall during 2012, 2013 and 2014, Nature Conservation personnel at Koeberg indicated that between 30 and 35 previously unknown pans (vlei’s) had been discovered in the nature reserve by the end of December 2014, only some still had water as late as July 2015. This “flooding” creates some challenges to the functional operation of the boreholes. Commonly such waters would be saturated with oxygen carrying with it oxidative conditions on entry into a borehole bringing along with it a microbiological burden associated with the soils, any solid or liquid masses picked up at the surface that could have significant impact potential for the borehole. This would include a combination of stress on the natural biomass active within the aquifer and boreholes (basically with the redox front being pushed away from the borehole by the oxygen rich waters) and the indigenous microorganisms being carried within the “flood” waters interacting downhole with the natural biomass. There would normally not be competition and instability within the boreholes until the levels recede again and the redox front re-establishes.

It is therefore presently more efficient to determine the status of a biofouling event itself in terms of its location, mass, volume, and composition, rather than attempt prediction of the likelihood of an event occurring. Either way, one requires direct determination the form and extent the biological challenge poses to the integrity of the borehole system.

Total Organic Carbon (TOC)

A prime source for growth of heterotrophic microorganisms (organisms/bacteria obtaining both carbon for growth and energy from complex organic compounds *e.g.* humic acid exuded by plants), TOC in the water may be lowered as it passes through the plug formations throughout the well. In laboratory *mesocosms, more than 85% of the TOC accumulated within biofilms (and, therefore, is removed from the water) that will generally, keep TOC levels low. When destabilization and massive sloughing from the plug formations occur, values will be elevated by as much as an order of magnitude. These elevations may fluctuate with the degree of sloughing that is occurring, along with any re-suspension of any matter or other material that may have settled in the borehole system. TOC in the product water cannot by itself, be used to diagnose a biofouling event. Usually TOC reflects the occurrence of such an event after there have been other, and often more obvious, symptoms primarily a reduction in yield despite rest water levels being stable along with a change in water colour.

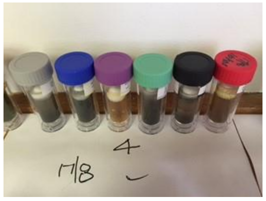
Total Nitrogen (TN)

The form in which Total Nitrogen occurs in the water, very often not estimated in borehole water beyond nitrate levels that form a hygiene-risk to infants when concentration exceeds 10 ppm, can be used to project the form of biological action that is occurring in addition to the different ratios being able to indicate the status of the biological systems in the upstream biological interfaces

Total Phosphorus (TP)

It was explained earlier that the availability of phosphorus influences the level of microbial growth activity, as phosphorus is such a desirable (and storable) nutrient. Phosphorus in biological systems is like a car's battery, it provides an energy storage system in the form of ADP – Adenosine diphosphate and ATP – Adenosine triphosphate, which drives the biological systems. ATP is most important, it performs much the same function that money plays in the economy. Just as people need to earn as much money as they can, biological systems need as much phosphorous as they can get. To microorganisms, it's an essential and sought-after element that gets 'stockpiled' by biological systems and will not be as readily released and thus available in the water in its soluble form. Within a cell, phosphorus may occur as orthophosphate (the currency), polyphosphate (the reserve) and metabolic phosphorus (the energy driver). In water, phosphorus is normally found in four states:

- SIP - Soluble Inorganic Phosphorus
- PIP - Particulate Inorganic Phosphorus
- POP - Particulate Organic Phosphorus
- SOP - Soluble Organic Phosphorus



BARTs KITS - test reaction at 5 days' post-sample, Brooklands, 2014

Together these form total phosphorus (TP) and ratios of these fractions of the different states of phosphorus can be used to diagnose some biofouling problems.

Analyses of product waters revealing low levels of phosphorus, the natural conclusion is that phosphorus must, be a limiting nutrient for growth being stored up by the biomass (the collective of all the different microorganisms forming the plug) as polyphosphates, and is very often concentrated at the *redox fringe. One can therefore estimate plugging potential, by determining the mass balance for phosphorus within a likely zone of plugging.

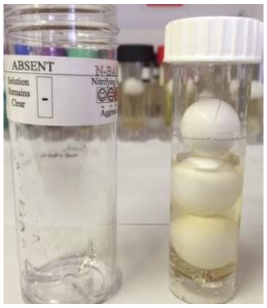
Iron

As the plug continues to mature, the sloughing events become more frequent with secondary symptoms becoming more apparent. There is a phased effect occurring (refer to Figure 2 above), initially being an erratic rise in the amount of soluble iron in the water, colouring the water a yellow to orange hue. To start with, there wouldn't be a significant increase in *turbidity and much of the iron may be retained within small *bio-colloidal particles which do not influence the turbidity much. With repeat sampling over a period of a few days, samples may begin to show significant differences between each other, since the plug is in a stable to unstable cycle. Variability in the total iron recorded may reflect the stability in the plug formation (i.e. the degree of surface sloughing occurring).

As sloughing events accelerate with maturation of the formation, a degenerative increase in *turbidity with larger particles, and high Total Suspended Solids (TSS) will often be measured with higher total iron content, leading to significant (>15%) reduction in production capacity of the borehole from the plugging. In addition, significant precipitation of all the loose particles in a quiescent (resting) borehole water column will lead further to the build-up of a sediment which may re-suspend as the borehole becomes active. This has been observed at Atlantis, particularly with boreholes that have not been pumped on a continuous basis. Early flow from an infested borehole will be very high in iron and particulate material, and should be diverted to waste to avoid seriously challenging the downstream systems and processes.

Redox Potential / Oxidation Reduction Potential (ORP)

The biological (and relatable plugging) activity will focus at the redox front as the water moves from a *reductive (breakdown of organic compounds occurring without oxygen being available) to an *oxidative (breakdown of organic compounds occurring where oxygen is available) state. Product water is commonly sampled from the oxidative side of the redox front and may, therefore, not be very useful in determining the position of the front itself. However, if there is a low redox value i.e. oxidation potential (e.g. +50 to 0.00 millivolts) then the site of biofouling is probably closer to the sampling site. A negative value implying a reduction potential (-0.00 to -200 millivolts) may indicate that the major biofouling could be occurring downstream from the sampling point.



BART™ sample tubes, referred to as a BART, is the most effective way to identify specific microbes responsible for biofouling and clogging.

Temperature

Within a borehole actively undergoing a biofouling, one can anticipate a temperature gradient to be created by the microbial activity. Studies measured minor gradients being created focussed at the sites where plugging concentrated. The temperatures ranged broadly, between 6 and 40^0 C, providing a varied temperate condition favourable to an equally varied spectrum of microbes.

Microbiological

The irony of searching for microbiological agents in product water is that one is likely to find low (anomalous) presence of microbes compared to the true amount of activity occurring, since biological activity, as observed, will be concentrated at the plug formation and other sites related to the redox front where sessile (fixed) microbes growing within the fouled zone/s dominating activities. Anomalous presence of microbes in water sample, together with an absence of coliform bacteria, have led to an underestimation of the role microorganisms play in the fouling process.

BART™ test – What's that?

Learning the rate of biofouling becomes especially important after a borehole regeneration programme such as the programme concluded in 2015, to efficiently test, monitor and track any changes. A ground-breaking opportunity exists to research, evaluate, and compare results from the three wellfields, that over time enhances longer term planning and management by incorporating world-class processes.

Some test methods require that microbes be removed from water samples taken to put them in contact with a growth medium (also known as a culture medium), such as agar, for the microbes to grow, using whatever water is bound up within the growth medium itself. This unnatural environment may inhibit the growth of certain microbes, making it easy for them to go undetected.

BART™ test is the patented Biological Activity Reaction Test. A BART™ test simplifies the test process by design with the system encouraging microbes to grow inside the BART sample, that simulates a natural habitat i.e. the environment from which they were sampled. The location of growth gives an early indication of the type of microbes involved. In the form of a field test kit consisting of a set of different sample tubes (each referred to as a 'BART'), biological activity is detected by looking for the changes and reactions occurring over time within a sample of product water taken from a borehole during a pump test.

Seven BARTs™ that are recommended for application at Atlantis contain different culture media as selective tests identifying and monitoring for seven specific kinds of bacteria impacting the wellfield:

- IRB – Iron reducing bacteria
- SRB – Sulphate reducing bacteria
- Slym – Slime forming bacteria
- HAB – Heterotrophic aerobic bacteria
- APB – Acid producing bacteria
- N – Nitrifying bacteria
- DN – Denitrifying bacteria

Reactions to look for are colour changes, generation of gasses, and precipitation. Simulated conditions helpful to Atlantis, Silwerstroom and Simonstown testing are created by two devices, the first (1) is a floating ball called an FID (floating interceding device) that restricts the entry of oxygen into the sample below. The second (2) device is the use of crystallized deposits of selective medium attached to the floor of the BART, that will slowly begin to dissolve when the sample is taken.

At the first device, oxygen enters around the floating ball to allow oxygen requiring (aerobic) microbes to grow. They will use all the oxygen diffusing down so that the sample further down becomes devoid of oxygen. This volume underneath becomes suitable for the growth of microbes that do not require oxygen (anaerobic). Activity in the base of the BART™ test would tend to suggest anaerobic organisms while activity at the top around the ball is more likely to be aerobic. Thus, the single BART™ provides environments which are aerobic (oxidative) and anaerobic (reductive).

The tube simulates a reduction-oxidation gradient with a transitional zone (redox front) in the middle. Microbes prefer to function at different sites on the redox gradient and so can be seen being active and reacting within that zone. First signs of this is often development of a cloud of 'fuzzy' growth and diffuse (float, floating) growth floating in the watery medium. Activity may often centre along the diffusion front (flat, floating growth), with those microbes likely to be able to grow under aerobic and anaerobic conditions (facultative anaerobes).

The second device ensures even sensitive microbes that would normally fail to grow on any agar media are better able to adapt and grow within a BART™ test if the crystallized medium is suitable for their growth. As the medium dissolves, a series of chemical diffusion fronts become established and move slowly up the BART™ tube. This slows upwards progression which can take approximately two days, gives the microbes in the sample time to adapt to the increasing concentration of nutrients and, if suitable, begin to become active.

Critical built-in control features ensure significant test quality and reliability, as firstly, performing BART tests avoids that samples are diluted, or are in contact with any other external contributing source or substance. Secondly, the sample becomes adjusted to a variety of different habitats by the nature of the BART™ kit by the different culture media and nutrients inside a BART, simulating a range of environments for different communities of microbes to become active and, hence, be detected. Thirdly, the microbes that become active and/or react with the selective conditions created within the BART™, belong to different groups of bacteria. In other words, certain bacteria thrive with certain nutrients and in certain conditions, and will grow better in one tube than in another. Activities and reactions that occur relate to growth events, such as the formation of clouds, slimes, and gels, mimicking what biofouling would be seen down-hole, giving clues to how the microbes are interacting.

BART testing is the most reliable early warning system for monitoring the onset or rate of biofouling/plugging in the area within and around a borehole (down-hole) that makes sampling convenient to perform in the field during a pump test without compromising results.

To learn more from the test kit manual one can visit http://www.dbi.ca/BARTs/

Methodology for Atlantis & Simonstown

Table 2 Anticipated outcome of rehabilitation relative to Capacity Loss

**Production Capacity Decline rating factors the severity of production capacity percentage loss due to plugging on a scale level 1-5, 1 being least severe and 5 being most severe.*

An empirical rather than qualitative rating scale applied in this instance, can be developed using BART™ data

Capacity Loss %	*PCD Rating	Anticipated outcome of effective rehabilitation treatment
0–5%	1	Well suffering minor degree of plugging. Returning the well to its original SC expected from an effective treatment.
5.1–20%	2	Well is becoming increasingly plugged. Effective treatment is still likely to return the well to its original SC.
20.1–40%	3	Well lost SC significantly. Effective treatment will require radical rehabilitation techniques to return well to its original SC.
40.1–80%	4	Well suffering significant decline and loss of production capacity. Reduced potential for rehabilitation to its original SC. Effective treatment expected to return production only a fraction of the way to full recovery using radical rehabilitation techniques (conservative estimate 10-30% improvement).
80.1–100 %	5	Significant/all production capacity lost due to plugging. Radical treatment expects to achieve small if any improvement to original SC (conservative estimate 5-15% improvement).

*(Dr Roy Cullimore, 2014, using a *PCD rating scale)*

Research studies conducted, and summarised above, by Dr Roy Cullimore (Droycon Bioconcepts, Canada, 2014) evidenced that a borehole presenting declining yield of more than 40% will seldom be successfully restored to a usable yield, even more unlikely in cases of poor construction. It is commonplace to lose a borehole and production capacity where water appears to be produced by the well at a reasonable rate (beyond pumping recommendation), with reasonable water quality, without maintenance being done. However, replacement costs are considerably more expensive, and more frequently spent on prematurely failed/failing boreholes, than rehabilitation or maintenance costs, drilling new holes being a tempting solution to regaining lost production. Replacing a well is only possible where geology or availability of land owned by the water utility allows.

Borehole rehabilitation/regeneration should be planned, and budgeted for to intervene as soon as decline limits are reached e.g. 25 % decline year on year, as the boreholes respond better when rehabilitation is initiated sooner rather than later. In practice in USA and Canada, production managers set parameters of maximum 25% decline limits for regeneration intervention adhering strictly to recommended pumping rates. Power consumption for production and regeneration processes beyond this point otherwise, becomes too expensive and therefore unsustainable in practice longer term. Careful monitoring of parameters set, inclusive of BARTS™, measures interim management and production requirements for the wellfields to function effectively within budgets and planned programmes. Projections using information obtained supports decisions about how soon, where and what construction type is best suited for the long term, and must be made with regeneration in mind.

This learning was applied using a sliding scale or Production Capacity Decline rating, according to lost production capacity, relative to rehabilitation results taken from Atlantis, Silwerstroom and Simonstown to highlight severity of capacity loss measured pre-treatment treatment and rehabilitation results obtained post-treatment. The rating scale is *qualitative* as BART test data is unavailable to apply a quantitative rating. Limiting factors to successful regeneration is not only the extent and duration of mismanagement but also construction, as mentioned earlier.

Capacity Loss and Construction considerations

Borehole construction across the Witzands and Silwerstroom wellfields are with only a few exceptions, PVC casing of varying wall thicknesses and PVC screens with slot sizes varying from 0.5mm to 3mm.

Thirteen (13) have a double layer of bidim wrapping (non-woven polyester geotextile), twenty (20) having PVC casing with 0.5mm openings in the screened area have no bidim wrapping per construction records, only six (6) have stainless steel wedge wire screens, 2 have PVC casing and the remaining four (4) are steel casing. These 4 are at risk of collapse due to corrosion possibly within 2 to 5 years, as has been observed with 10 to 12 similar holes drilled in the late 70's and early 80's. The bidim and small slot sizes make penetrating the formation behind the screen very difficult, where the densest biofouling occurs.

Most of these boreholes were subject to a regeneration programme previously. Bio-fouled boreholes unlike hydro-jacked (hydro-fracked) will not indefinitely respond positively to regeneration treatments, without proper management or maintenance. Furthermore, for the scheme to support healthy production long-term, *planned* replacement boreholes should be constructed using the results obtained from regeneration treatment programmes and monitoring processes ideally using PVC casing with wedge wire screens, no less than 100m away from the existing borehole as the first measure to avoid rapid plugging/clogging of any new hole.

Phased Rehabilitation and Return to Service activities

Factors contributing to the production loss from the boreholes treated point to extended overproduction and chronic mismanagement. Varied construction across the wellfields treated, merely adds to complications that affect treatment efficacy and the need for ongoing care and maintenance measures. Longer-term planning would only be possible with the correct and timely information that requires commitment and implementation of routine wellfield management. In addition, to implement wellfield management certain infrastructure needs to be made available e.g. temperature control facilities for BARTs testing, raw water balancing storage capacity improvements and softening plant return-to-service.

Witzands Wellfield at Atlantis

Of 26 boreholes regenerated in 2002, only 10 are presently in use for production purposes (<40 %). Of the 10, four boreholes (34022-34025) have been favoured for use on an intermittent basis, the pumping regime stopping when the Atlantis service reservoirs are full. This according to SCADA staff, is due to the lack of sufficient raw water balancing storage at the plant which has storage capacity of 250 000 litres presently, insufficient by far for the normal demands of approximately 15M litres/day in winter and approximately 24M litres/day in summer. The softening treatment plant having been out of commission for almost five years perpetuates the inconsistent pumping rates, exceeding at between 22 and 44% higher than what is a sustainable recommended rate at 7 litres/second.

Pumps in use are mostly of the 15kW bronze variety, incorrect for the recommended yield that smaller pumps with either 5.5kW or 7.5kW motors accommodate. Overproduction rates noted were 10, 9, 12, and 12.5 l/ s respectively, without orifice plates that help restrict yield within recommended rates being used. Smaller orifice plates should have been installed to maintain the recommended yields.

In addition, it was noted that presently pipeline supply from the Melkbos supply enjoys distinct preference as opposed to strongly favouring the use of more borehole water than pipeline supply for blending with the water from the Melkbos line. However, without adequate production and operation management of the wellfields, it would be impossible to maintain a sustainable equilibrium of borehole and pipeline supply.

Operating only a few boreholes at the high abstraction rates presently observed will lead to much shorter cycles of 5 years if not less, between rehabilitation. Five boreholes (34022-34025 & 34001) were retreated only 22 months after the first BCHT process was applied. Pre-test CCTV camera logs showed well advanced plugging of the screens demonstrating the effects of an irregular operating schedule.

Balancing storage and urgently addressing the softening treatment plant for return to service is desperately required to eradicate the start /stop pumping habit, in favour of an efficient continuous operation, as best practice. A raw water storage capacity of at least 2 to 3 days' production to optimise borehole and transfer pumping would be adequate allowing for efficient wellfield operation at lower abstraction rates 24 hours/day that reduces the rate at which plugging/clogging occurs. This extends the time between rehabilitation cycles and manages production power consumption, incorporating more efficient operation inclusive of the softening plant.

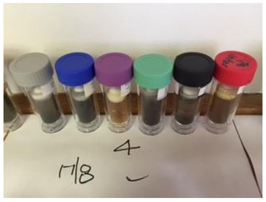


Photo 1: BARTs KITS - test reaction at 5 days' post-sample, Brooklands, 2014

The blend ratio decision-making staff would benefit greatly from training with Scientific Services (or someone with the chemistry knowledge and expertise) to fine-tune the blending function. A ratio between 60/40 or ideally 50/50 blend ratio of borehole to pipeline supply water would be recommended.

Silwerstroom Wellfield

A total of 13 boreholes were treated of which 6 showed no improvement at all. For this wellfield, borehole construction is the primary impairment to successful rehabilitation despite radical techniques being applied. Adding to its unique set of problems ito construction short-comings, the risk factor posed by continuous vandalism disrupting supply in addition to panels being subject to repeated sabotage was observed to be an escalating problem. During October 2016 alone 1.5 kilometres of overhead powerline had been stolen affecting the only two (2) producing boreholes at the time.

Intermittent production as emphasised repeatedly, exacerbates the clogging potential and increases the risk of unsuccessful rehabilitation and exponential decline beyond repair. Regeneration applied to poorly constructed wells makes it unlikely that any improvement in production can be achieved. Monitoring of the boreholes in production for this wellfield would assist with planning measures in the interim that should include consideration of new boreholes being constructed using PVC and, stainless steel screens (as prescribed earlier).

Brooklands at Simonstown

Of 2 boreholes situated at Brooklands only one rated 2 l/s was treated as access to the other is inaccessible, despite plans being agreed to over two years ago, for construction of an access road. Data obtained from the consultants overseeing the original drilling project in 1995, indicating yield of 2 l/s for the one inside the perimeter that received treatment and 8 l/s for the one outside that is inaccessible. Both are drilled into the TMG formation and are uncased or open hole completion.

Camera logs show they are very rough (rugose) with wide open fractures containing loose rock material. They are also not vertical which caused numerous problems with collapsing sidewall during the treatment process which nearly led to the loss of the hole. Although the hole was successfully cleaned yield improvement could not be achieved, though the recovery rate showed an improvement as consolation. It would be advisable to case both holes to prevent collapse that would also risk losing pump equipment as well.

Staff at Brooklands exuded enthusiasm and cooperation having arranged at arrival on site temperature controlled facilities for the BART testing to be performed. The staff took initiative with the sampling programme, once shown what the procedures were, to do testing over the 48 hours that followed. They set an exemplary benchmark for counterpart sites' staff to follow. Results of the BART testing shows that HAB (heterotrophic aerobic bacteria), moderate APB (acid producing bacteria), SLYM (slime), low SRB (sulphate reducing bacteria) and aggressive

IRB (iron related bacteria) are dominant within the biomass. This corresponds with the build-up found on and within the riser pipe and pump. Interestingly, similar results have previously been observed during a rehabilitation programme at the Little Karoo boreholes for the DWS (Dept. Water Affairs) during the mid-90's, boreholes were also in the TMG formations.

Overall Monitoring Programme

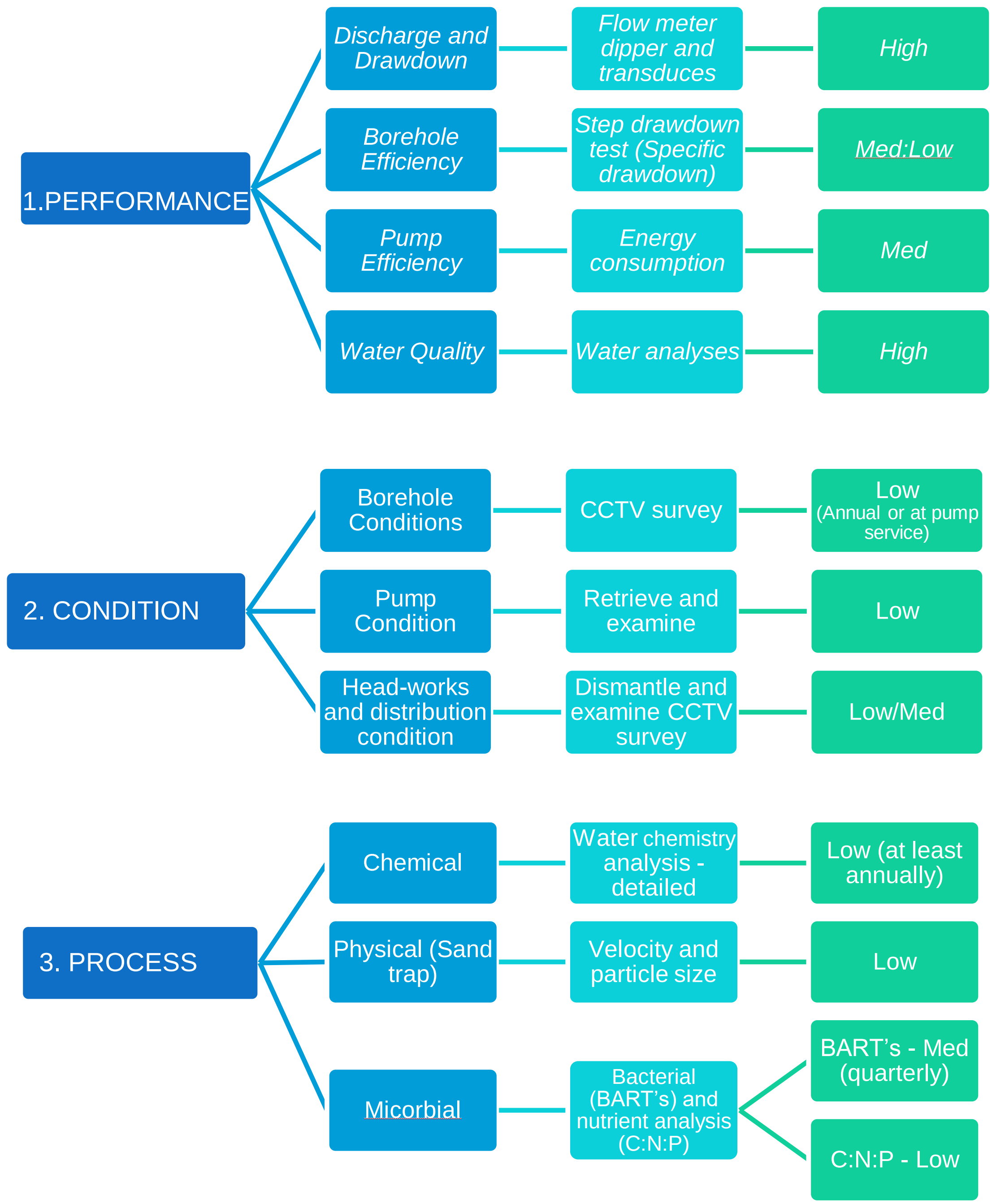
Figure 5 Recommended Monitoring Programme (Modified from CIRIA Report 137)

PRIORITY

1. Essential
2. Strongly recommended
3. Recommended

FREQUENCY

HIGH: Weekly-monthly
MED: Monthly-6 month
LOW: 6 mnth-1yr



Comments concerning Recommended Monitoring Programme

Some additional comment is necessary regarding the parameters set out in Figure 5 above and the list of constituents given in the Appendix B.

Most items covered under PERFORMANCE and CONDITION can be carried out by the field maintenance crew at AWT Plant. Specific drawdown tests can also be done by the staff at Atlantis applying a variable speed drive in conjunction with one of the two (2) purpose-bought pumps used for testing during the rehabilitation work programme, taken into stock at ATW for future application.

As previously recommended, CoCT Water Department acquiring and operating a dedicated downhole camera system for CCTV surveys at AWT Plant would be a cost-effective solution, giving CoCT ultimate quality control over boreholes and pipelines. Alternatively, an outside contractor would be able to perform the service.

Responsibility for the ongoing water quality testing can remain with the staff at the works who presently collect samples for analysis on a weekly basis. Analyses ought to be done on the borehole water as well as the water entering the recharge ponds 7 and 12. Analysis should be inclusive of the following: alkalinity, hardness, conductivity, turbidity, colour, redox, dissolved oxygen, pH, Fe, and Mn. Refer to the Chemical Analyses for detailed chemical constituents.

These are to be measured in conjunction with the following BARTs, applying the required temperature control protocols: - IRB, SRB, SLYM, N (nitrifying), DN (denitrifying) HAB and APB's. The use and value of BART's tests have been covered in a previous report, refer Contract WS 2/99, also Scientific Foundation covering BART™ in more detail (Pg. 9).

The chemistry and any microbial analyses under PROCESS refers to a more detailed analysis and should be handled by CoCT - Scientific Services or an appropriate outside laboratory, such as Abbott Laboratories, for example.

The intended cooperative management of the regenerated boreholes for a period of 6 months abandoned by the conclusion of rehabilitation work, was to optimise the long-term production plan for the wellfield, with the above being set up for operation in that time. This aspect is yet to be addressed as at the writing of this report. Consideration may be given to picking up from where the project ended with a view to gaining renewed effort in this regard, pg. 24 covers a Post-Rehab/Regeneration Programme having been part of the tendered proposal.

Photo 2: Pumps from various boreholes, ATW, 2014

Photo 3: Pump from G30965, Witzands, 2014

Tender Requirements and Objectives

Pump Removal and Initial Sampling for Chemical Analysis

Parameters such as pH, temperature, conductivity, DO (dissolved oxygen) and ORP (oxidation-reduction potential) must continuously be monitored on site while testing and PTW (pump to waste) with the objectives that:

1. One avoids risk of reintroducing a poorer quality water into the system after treatment; and
2. Ensure the first two tanker volumes that might be detrimental to the sensitive local flora are safely disposed of into the waste water treatment pond.

The waste water chemistry reflects the typical short-term changes encountered during a BCHT process, with no detrimental effect on the lifetime operation of a borehole. The chemicals used in the regeneration process perform the function of disrupting the nuisance biomass clogging the aquifer especially within the immediate borehole surroundings (5 to 20+ metres). The results for numerous boreholes show high levels of various elements such as iron, aluminium etc. even after the treatment process. This is to be expected as much of the biomass which has extended out into the aquifer is being removed. Water samples were taken during the last step of both the pre-and post-tests at each borehole and during the pump to waste stage after treatment. CoCT Scientific Services and Abbott Laboratories analysed the samples to determine when reintroducing the treated borehole/s back into the system is safe, with the results also serving as the basis for determining any changes that occur over time. Refer to the Appendix B for all Laboratory results. Often the boreholes show very high levels (above standard limits) of various elements such as iron, aluminium, and manganese even after the treatment process. This is to be expected as much of the biomass which has extended out into aquifer is being successfully removed. With the holes being reintroduced into production chemistry measured regularly will track the decline in levels of the abovementioned nuisance elements to well within the SABS 241 specifications.

Included in the list of elements tested for, two previously never monitored namely, phenols and strontium, were included as precautionary observation of interest given that the Chevron pipeline cutting through the Witzands wellfield. Any leak in this pipeline would pollute the entire wellfield, the boreholes located at the back of the ATW plant would be the first affected. On that note, the phenol results are currently low enough to be of minor concern however the pipeline being more than 35 years old, a thorough survey of its condition would be prudent in avoiding catastrophe. Studies undertaken by Phillipe Négrel of BRGM, France, and others such as the USGS suggest the presence of strontium may be an indicator of deeper water, that was worth investigation at Atlantis in the domestic context.

The writer has long believed that the recharge of the aquifer is not only from the recharge ponds and dunes; but recharge contribution potentially comes also from the much deeper underlying granites and the presence of strontium would indicate as much. More scientific

Photo 4: 80mm riser pipe from W34012, Witzands, 2014

investigation would definitively confirm the theory, results thus far convincingly suggest however that any future boreholes being drilled could be drilled deeper into the granites which underlie the Atlantis area. Detailed geophysics would be vital for identifying or confirming potential target sites. Another aspect requiring possible further investigation would be monitoring Sulfur 35 (35S) levels as a tracer in the recharge ponds. Some observations made by Professor Clark et al. - Radio-Sulphur (35S) as an Intrinsic Tracer, 2010 may be validated to Atlantis' advantage.

Pre- and Post-treatment CCTV camera logging

Camera logging of boreholes before and after any treatment is vital, especially where biofouling is a problem since the severity of any clogging is confirmed. Logging before treatment is usually done some while after the pumping equipment removal, allowing for better visibility once suspended particles have settled. After treatment, logging serves to confirm how effectively the borehole and especially the screens have been rid of the clogging material. All boreholes treated will show clear screens on the CCTV logs. The video of any camera-logged borehole becomes a vital piece of data for future reference and should be properly stored. Reviewing the video logs, one will observe the following forms of biological growth in situ before treatment:

Photo 5: Pump from W34012, Witzands, 2014

- Well snow which are particles in almost a gel-like state;
- Slime-like globular structures;
- Nodule or tubercles;
- Encrustations;
- Loosely attached slime which easily detaches and floats through the water;
- Threads or sessile ('fuzzy');
- Ill-defined fragile clumps of slime that extends out into the water;
- Concretion arches that can extend right across the screen's diameter;
- Foreign matter and debris.

Observe the series of field images (Photos 2-5) that illustrate the downhole conditions throughout the Witzands and Silwerstroom wellfields.

Pre-treatment Pump Test & Microbial/Bacteriological Testing (BART test kit)

Efficiency testing of the boreholes before and after treatment was performed using two dedicated submersible pumps with 22 kW motors in conjunction with VSDs (variable speed drives), equipment provided by CoCT now in use on site at Atlantis. A series of calibration tests were performed at varied frequencies to establish the production capability of the pump relative to each borehole. These pumps were intended for future application in the management programme.

Pre- and post-testing in this manner determines the specific drawdown of the boreholes, results of which evaluate its performance, and indeed the success of the BCHT. CoCT staff repeating the tests at least bi-annually initially, and thereafter annually, is necessary for the proper management of the borehole/s and wellfield overall. Running tests using the identical equipment in the same sequence/procedure cost-effectively evaluates when the borehole will again need to be treated without requiring external contractors or prolonged disruption to the borehole.

Rest water levels in the Witzands wellfield are higher at present than at any time in the past and is attributable to higher than normal rainfall in 2012, 2013 and 2014 seasons. This water influx into the aquifer is both beneficial and detrimental, in that while more water is taken into storage available for extraction, the additional microorganisms, nutrients, and oxygen are used by the resident microbial communities leading to a higher rate of biofouling.

BART tests were not performed on any boreholes in Witzand and Silwerstroom wellfields. A single before and after sample was possible at Brooklands where before test showed aggressive microbial activity, and the after test indicating significant improvement in level of activity after treatment. BART tests would serve to rate borehole deterioration over time

No BART samples for analysis were possible for the Atlantis wellfields due to a temperature controlled facility never being provided in terms of the contract requirements, a crucial failure over the entire duration of the programme preventing the contractor being able to gather any essential data and intelligence with regards to microbiological aspects affecting the aquifer.

Conversely, the manager and staff at Brooklands set up the required facility within 30 minutes of the need being communicated upon arrival on site. A 48-hour sampling-protocol was followed with the staff at Brooklands participating enthusiastically, even for the duration of the night time sampling.

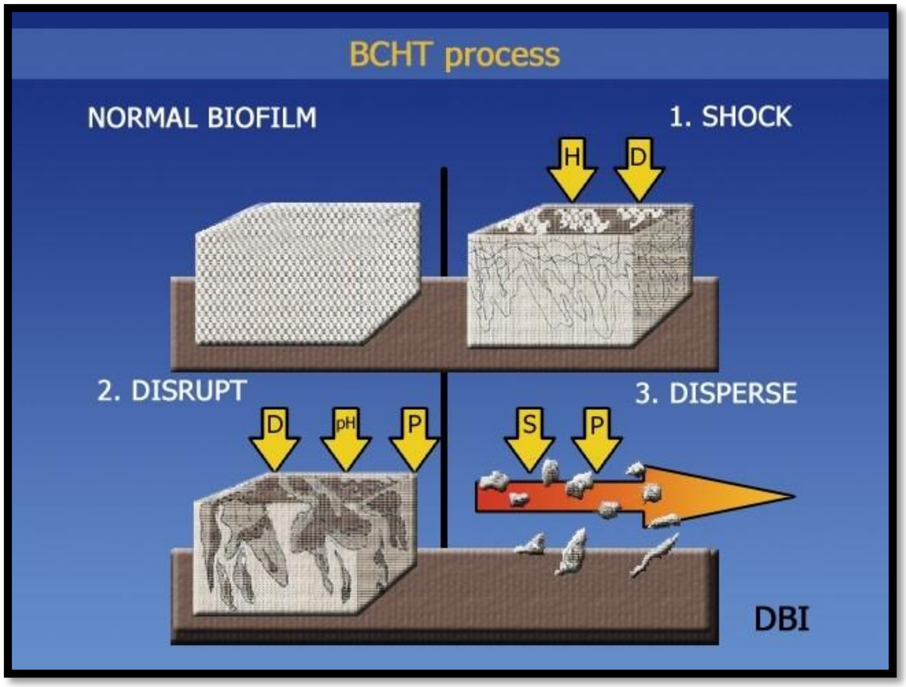
The exclusion of BART sampling as part of overall management effort is a crucial shortfall in the management of these wellfields that would provide critical information about the status or condition of the holes and efficacy of management protocols.

Refer to the **Appendix A** for all pump test data including pump depth, vari-speed settings, test results, **etc. No BART data is available.**

Figure 4 Blended Chemical Heat Treatment (BCHT) process

Figure 4

The patented Blended Chemical Heat Treatment (BCHT) proprietary process entails a shock, disrupt, and disperse phases involving the use of heat (H), pH manipulation, disinfectants (D), penetrants (P) and surging (S) to rehabilitate a bio fouled borehole through the three phases (Cullimore et al., 1999).



Shock phase

Designed to maximise the degree of trauma within the stratified biofilms forming the fouling phenomena, the initial shock phase is a triple-treatment approach with simultaneous application of heat, disinfectants, and surfactants. Terminal temperature, ranging between 65-95° Celsius, is applied within the lethal range for the treatment zone, dependent on the borehole's installation/construction ability to withstand the combined heat and chemical effects. The disinfectant should penetrate throughout the biofilm to cause, in conjunction with the thermal impact, the paralysis of most of the microorganisms. A surfactant is employed to increase the rate of diffusion of the disinfectant into the biofilm.

Disrupt phase

A pH shift initiates phase 2 in conjunction with application of a surfactant efficiently disturbing the traumatised biofilms generated by phase 1. Heat simultaneously being applied disrupts the biofilm structures into hydrolysing structures, destroying much of the incumbent microbial population.

Disperse phase

By this stage much of the biofilm structures within the treated zone are severely disrupted while any biofilms immediately outside of the zone are severely traumatised. Phase 3 is intended to disperse the residual materials still within the treatment zone, including the removal of these materials in a manner that precludes the possibility of re-entry or re-infestation. Without

An airlifting exercise effectively removes debris from the bottom of a borehole.

Properly sealing boreholes prevents foreign matter entering.

employing heat in this phase allowing the system to cool, a sequential surge-pump to waste process keeps treated material in suspension until pumped out until the water being pumped out exhibits no physical or chemical evidence of the treatment effects (e.g. low particulates, ambient temperature, turbidity, and pH, and "normal" chemical constituents). Recall that much of the bioaccumulated materials (e.g. iron and manganese salts) during this phase is dislodged. Borehole waste was disposed of by tanking into the waste pond at the treatment works until considered safe for pump to waste.

Airlifting

Each borehole was airlifted to clear as much debris from the bottom of the boreholes as possible. The camera logging showed that the boreholes especially those not properly sealed at the surface had all sorts of foreign material ranging e.g. cable ties, conduit piping of varying lengths, fire hose, frogs, snakes, grass, etc. lying on the bottom. The airlifting removed most if not all such material together with varying amounts of sand.

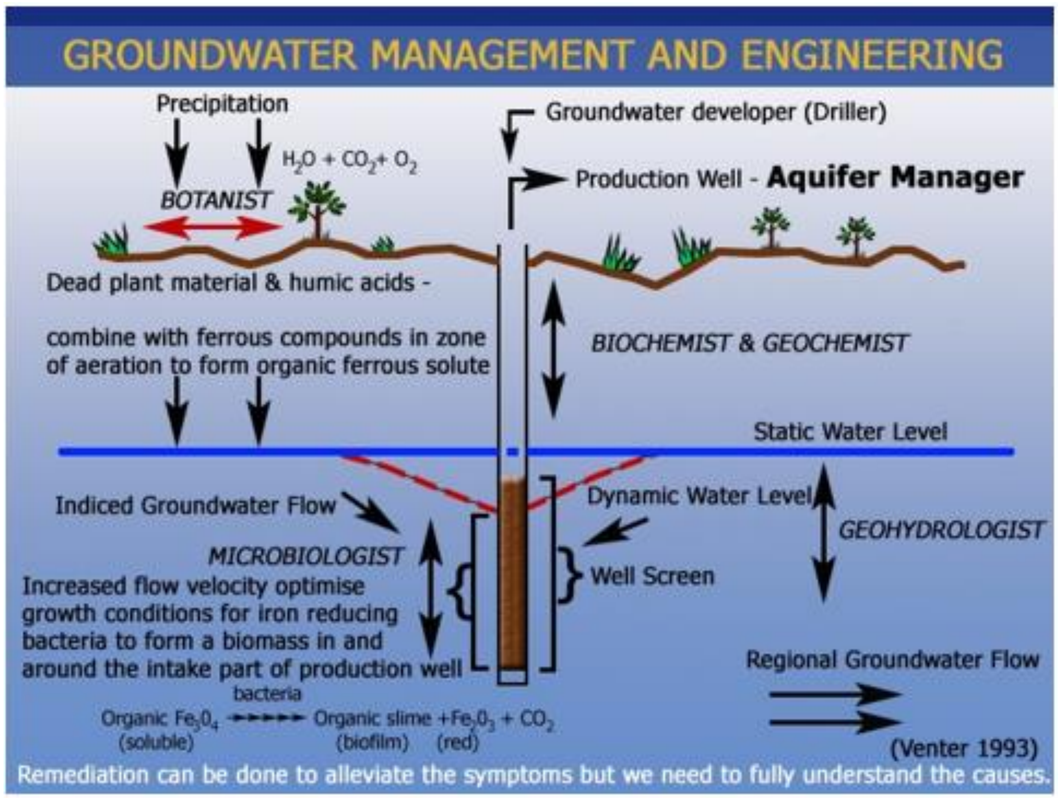
Properly sealing each borehole would eliminate the likelihood of foreign matter entering.

Post-Rehab/Regeneration Programme

Programme strategy & Groundwater Supply Management

Figure 5

The Groundwater Management and Engineering illustration above puts into perspective the benefits an integrated approach to managing the aquifers. (Venter, Less 1993)



Playing an integral role in an ***overall Groundwater Supply Management System*** that would include the Atlantis, Silwerstroom and Simonstown wellfields, crucial aspects of this system require:

- policy and planning;
- water resources and water quality monitoring;
- engineering;
- operations and control;
- treatment and distribution;
- finance and accounts.

Access to information and liaison with various role players benefits the overall functioning, the programme strategy should therefore include the following essential elements:

- Baseline ***information*** on the ***aquifer*** and each individual ***borehole*** is required to design and formulate a ***monitoring plan*** (the plan adjusted accordingly with changing conditions and performance);
- ***monitoring*** of the aquifer, boreholes, and their operation to ***acquire data;***
- data need to be ***processed*** and ***analysed*** to achieve a ***diagnosis;***
- the ***cause*** needs to be identified from the ***diagnosis*** to select a ***cure or prevention*** action;
- a ***cure*** may involve adjusted ***maintenance or rehabilitation;***
- the effects of any ***cure or prevention*** action need to be ***monitored;***
- ***diagnosis of the cause*** is used to select alternative operating schedules to prevent or reduce problem recurrence, within a problem-area or more broadly;
- ***diagnosis of the cause*** should be used in new borehole ***design and construction*** of to proactively avoid or reduce problems experienced.

Learning gained from the original rehabilitation project concluded in 2002 in view of the most recent project's outcomes, Success Factors that would aim to maintain productivity of the desired minimum 80 % of existing boreholes are described below. Intended for application and refinement during the PRMP that could not be exercised, a theoretical Operating Procedure for day to day implementation is recommended below.

Requirements for a best-practice Operating Procedure

1. Borehole identification & protection

- Proper identification and sealing of boreholes are necessary. Every borehole and monitored hole in use should be correctly and visibly marked including pertinent details i.e. depth and construction type of the borehole. DWAF project specs suggest either mounting the details on the electrical control panel or installing a 1.5m standard with 150x300mm yellow headboard at a safe working distance from the actual borehole (within 5m of the hole).
- All boreholes whether in use or not, including monitoring boreholes should be properly sealed to prevent unwanted matter like animals and birds from entering. Proper caps and seals must be installed. In the recent logging by PPS for CCT (June 2013), a snake can be seen at the bottom of G34020. On previous occasions, other boreholes were found to be infested with frogs and still others, dead birds had been found in them.

2. Routine pump testing & monitoring

- Retesting regularly, every 4 months during the first year after rehabilitation at the very least is necessary. This is to assess any changes to the borehole performance and to track chemistry and recurrence of biofouling/microbial activity. This information will be used to determine optimum wellfield abstraction. This means that the production boreholes will be tested three times in 12 months. The optimum wellfield abstraction would be adjusted accordingly.
- Any borehole in the production cycle should be pumped 24 hours/day. Weekly water level and quantity monitoring for all these production boreholes and any monitoring holes within proximity, will need to be done to establish actual borehole performance. This task can be

performed simultaneously by the responsible person who is collecting weekly water samples. Water level loggers are required for this, and can be moved from borehole to borehole as required.

- A scheme the size of Atlantis, acquisition its own camera equipment provides valuable capability to log both boreholes and pipelines. City of Cape Town (CoCT) staff can routinely inspect the boreholes or pipelines as is the norm abroad, or whenever problems are suspected. Also, any equipment potentially lost down-hole may be far easier and quicker to retrieve. Camera logs of boreholes and/or pipelines before and after any work is done for CoCT would become an effective quality control measure.

3. Routine water sampling

- During the retest programme all production boreholes tested will have samples taken for analyses that establishes the parameters recommended in the consolidated report. All tests can be done by CCT Scientific Services laboratory, for example, as a baseline value for monitoring of the biofouling potential of each individual borehole. This info could be very useful for tracking the effect of water coming from the recharge ponds which will have a direct effect on the rate of biofouling of some of the boreholes.
- These analyses are an early warning control measure for any potentially detrimental changes that might be occurring. Along with any retesting and sampling, a bacteriological testing programme using the BARTs (Bacteriological Activity Reaction Test system) should be implemented. This together with the performance testing will be needed to establish the biofouling rate for each individual borehole and subsequently indicate the overall fouling potential of the wellfield.
- The chemistry results of any testing done must be obtained from either Scientific Services or any other laboratory in use by CoCT and should be captured on the management programme database.
- The CSIR are monitoring observation boreholes throughout the Atlantis area. As per a 1996/97 Annual Report by the CSIR, a total of 264 points/boreholes are being monitored (152 monthly & 112 two-monthly). As part of any management programme, CSIR data is included. A number (10-20) of these observation and other monitored boreholes should be regularly sampled to identify potential problems resulting from possible pollution. This can be used to determine a risk profile for the aquifer.

4. Management for optimum yield

- A monitoring programme such as that shown in the consolidated More Water Report 2002, covers the performance, condition, and processes of individual boreholes. The information obtained will support the optimisation of not only borehole yields but also overall wellfield production.
- To fine-tune wellfield production, some understanding of the entire geohydrological status of Atlantis is important. Ideally, this could be possible in conjunction with the Council for Geoscience. This understandably may require separate instruction from CoCT.
- Where updated information from the testing and monitoring programme has been collected and critical review completed, the calculation of the Reserve Determination for submission to DWA for the necessary licensing application can be done.

- Development of a computer-based management database programme, customised to CoCT needs installed at ATW and CoCT-Head Office can be developed for control purposes. The programme requires a GIS base compatible with other CoCT programmes to make it a practical tool with which all levels of CoCT Management and staff can interact.

5. Training & Supervision

- This is likely to be the most challenging and time-consuming aspect of the programme to foster sustained interest in the wellbeing of the aquifer but is the single-most essential ingredient to long-term sustainability. In contrast to commitment staff displayed during the 2002 project, it posed the most significant threat to project failure throughout the most recent rehabilitation project. Staff not only need to acquire the necessary skills and competencies to perform the various tasks required for the healthy functioning of the wellfields but their contribution to the system's planned outcomes must be clearly defined for all parties to engage with their full commitment. Intentions were that all skills transfer and development training conducted during the PRMP would be monitored, and each assignment recorded as staff advanced with in-field work experience.
- Content within this report should hopefully provide some learning material to staff allocated to the specific tasks, inclusive of results obtained from each borehole to illustrate how each function in the technical regime adds to an overall picture.
- Training of engaged staff remaining a priority should cover aspects pertinent the Atlantis wellfields such as Aquifer characteristics (geology/geohydrology), Design, Construction & Operation of the boreholes, Monitoring & Diagnosis, Maintenance & Rehabilitation, and Economic and Practical benefits inclusive of Policy & Legislation that influence output.

6. Feasibility of Re-drilling boreholes

- A point is inevitably reached over the lifespan of a borehole that loss of production from cumulative deterioration results in eventual decommissioning, being the natural attrition requiring planned replacement in the cycle of wellfield management.
- Poor construction in some instances of existing boreholes shows unequivocally the constraints placed on production output and long-term maintenance and management that may be addressed.
- Knowledge about the status of the aquifers and the factors that influence them in addition to geological considerations, refurbishment of any boreholes or adding new ones where gaps in the abstraction coverage from the wellfield are apparent, can be addressed.
- Where re-drilling / refurbishing any existing boreholes or drilling of additional boreholes is considered viable and/or advisable, a detailed cost analyses can be done. CoCT can decide whether to proceed with such a drilling programme, or not.

7. Detection/Management in Respect of Biofouling

- As part of the overall prevention strategy (together with the BARTs), an investigation of the recharge ponds and their influence on the biofouling conditions is necessary, considering the anaerobic conditions found in a large portion of the Witzands wellfield. Cecil Less can engage Dr Roy Cullimore to help with certain aspects of the microbiological testing and analyses and potentially the groundwater chemistry.

- Certain inaccessible monitoring boreholes (8-10) covering the recharge ponds need to be made accessible to conduct pump tests/sampling tests. An understanding of how the various components of the system function and the true role of the recharge ponds in the Atlantis system together with the boreholes being monitored by the CSIR is an area not currently being investigated. The potential introduction into the aquifer of undesirable constituents potentially starts here and until it is known what the quality of water entering the aquifer and when this occurs, whether the recharge ponds are beneficial or not remains a question.

W34001 – Before and after treatment, ATW

Record of Results

Interpretation of the data results

Limitations of the existing production and maintenance

A boreholes' performance is governed by numerous factors primarily its construction relative to its location and the geology/geohydrology. In the case of the boreholes at Witzands and Silwerstroom (a primary aquifer setting), is highly variable since its inception in the 1970's. Construction ranges from mild steel casing with stainless steel wedge wire screens, mostly without bidim wrapping, to PVC casing and screens of varying thickness, slot configurations and size of openings (0.5mm, 0.8mm to 3mm). Many of the PVC cased holes have been wrapped with a double layer of bidim which detrimentally affects the performance of the borehole, and is unsuitable for application in boreholes. While overall results were favourable, boreholes with poor construction remain vulnerable to plugging events, particularly so with overproduction or continued mismanagement. All boreholes showed improvement with regeneration, plugging removed from screens.

Purpose of Step Tests

The boreholes are pumped at varied rates intermittently across the wellfield. The best method of evaluating efficiency with diverse constructions types is to perform step drawdown pump tests (aquifer tests), with as many steps as possible that conditions will allow. The data collected is then plotted as specific drawdown and/or specific capacity. In all cases with the recent regeneration programme, specific drawdown was measured primarily being the simplest test method to reproduce or retest using CoCT's available equipment, that being the pumps and variable speed drives applied throughout the regeneration programme. Once plotted, the performance or efficiency of the individual borehole can be observed diagrammatically.

Wherever possible, any historic test data obtainable should be included in plot charts to enable comparison of variation over time as these tests serve as a warning signal of the rate of biofouling plugging that is occurring. Each borehole has an optimum/'safe' pumping rate (abstraction rate) and pump inlet setting. The new pump inlet settings allow a higher velocity past the pump motor thus preventing the motor from overheating. This often happens when using orifice plates to control the flow rate.

Ongoing Testing and Monitoring

The optimum pumping rates for each hole has been determined by comparing the plotted data/curves over time, bearing in mind a high biofouling potential, e.g. a rate of 7 litres/second = ~605 m3/day (7x60 sec x 60 min x 24 hrs). The objective is to achieve as low and as constant a pumping rate as possible. One can plot this recommended rate/value on the base axis (Q Kl/day) of the relevant borehole graph to evaluate how conservative the yield is for the borehole. All recommended yields can be similarly viewed, collectively a total recommended production can be calculated for the wellfield. When the boreholes are retested, initially at 6-

monthly intervals for the first year after regeneration and thereafter annually, the data collected is plotted on the graph to measure whether any change has occurred since the last test performed. If any change is observed, one can determine the extent. If the change indicates a decline, the abstraction rate would need appropriate adjustment whereas little or no change, the initial rate can remain unchanged. Without the ongoing testing and monitoring, there is no way of tracking changes or knowing the extent of changes. The plant requires a team of staff who bring cooperation, commitment, and willingness to learn accountable to the CoCT in meeting its responsibilities to manage these wellfields effectively.

Controlled Pumping protocol

'Rule of thumb' or best practice being aimed for with a low pumping rate is to keep the rate within a laminar (streamlined) flow zone. In this way turbulence through the screen and pump intake is reduced to a minimum; the more turbulence within the borehole the faster the development of biofouling plugging. It is always better to pump the boreholes at lower rates 24/7 than pumping at higher rates intermittently, as this extends the life of the borehole at a much lower maintenance cost over its lifetime. In certain boreholes, those being used more than others, the specific capacity has also been plotted. The decline in performance and the beneficial effect of BCHT is clearly visible. Data recently collected shows evidence of a select number of boreholes having capacity to tolerate higher pump rates. *However,* these higher rates should be reserved for short periods only, such as during the summer seasonal months, when a higher pump rate is temporarily warranted.

Borehole construction, development, and the value of Geophysical logging

As previously mentioned in this report, construction in most cases is a problem particularly where regeneration/rehabilitation is concerned. The observation of the screen sections positioning relative to the actual production zones within a borehole has also been a matter of concern.

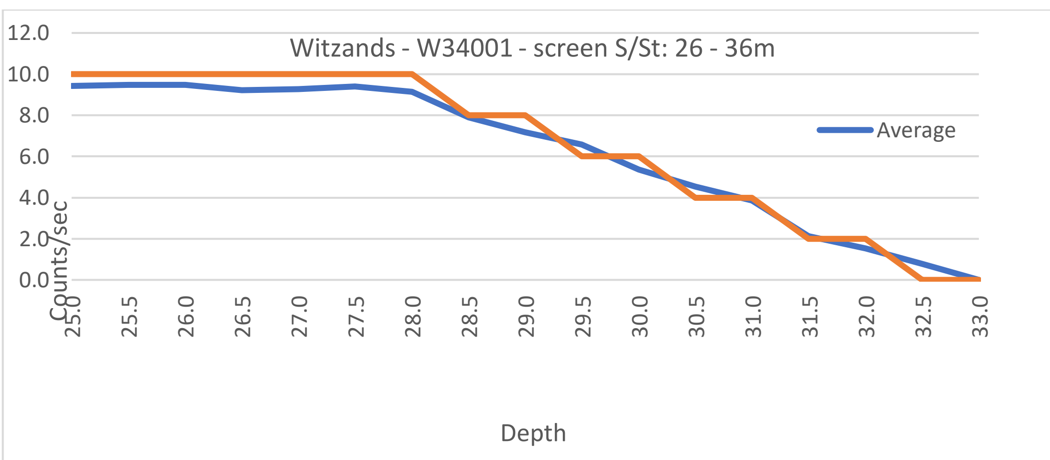
By way of resolving the question, 3 boreholes (W34001, W34012 at Witzands and G32954 at Silwerstroom) based on different constructions had geophysical logs. All logs are conducted from the bottom upwards and ends when the solid casing is reached. The techniques applied included downhole measurements with the following specialised probes:

- Magnetic susceptibility
- Full Wave Sonic
- Acoustic Tele Viewer
- Gamma
- Resistivity and
- Spinner or flowmeter

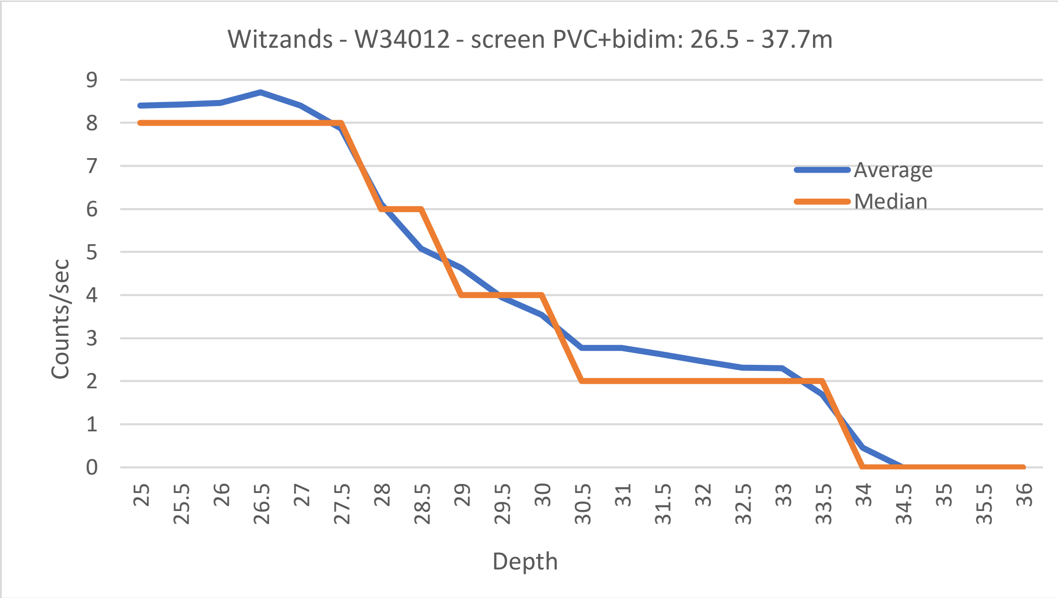
As there are insufficient lithology details or geological logs available, only the flowmeter results can be discussed as the information speaks directly to the ingress or flow through the screen into the borehole, which relates to the yield of the borehole. The results shown in the graphs below should be viewed together with the results obtained from the pump testing programme. (Appendix A)

Although a more sensitive Heat Pulse or Electromagnetic flowmeter would have been preferable, the resolution on the specific spinner flowmeter used was sufficient to get confirmation of what had been suspected. The resolution of the spinner necessitated a stepped approach to the measurements. The boreholes were logged in both static and dynamic states i.e. without being pumped and while being pumped. Every 0.5m the tool was stationary for a few minutes while the borehole was being continuously pumped at between 4-5l/s. The average and median readings have been plotted but it is the median which is the most interesting. In each case, they clearly show where the flow starts and where it ends.

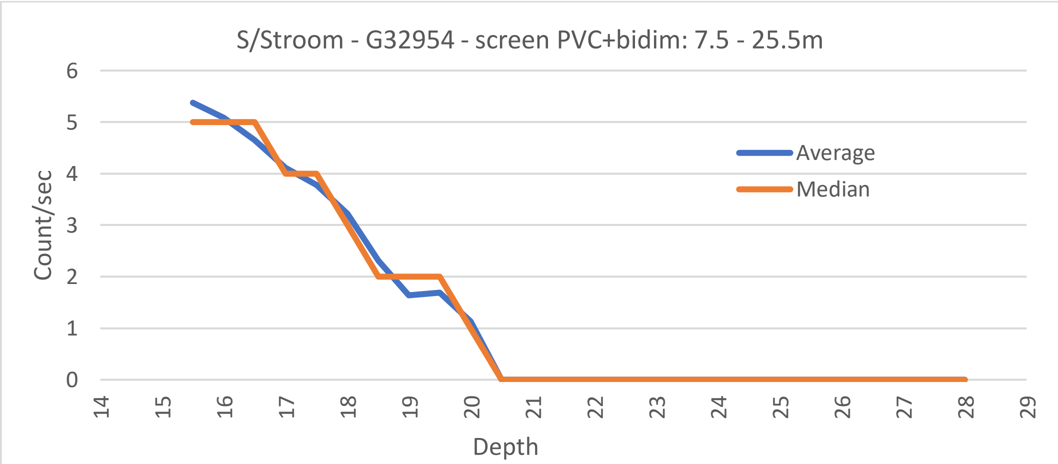
W34001 – this is the best constructed borehole in both Atlantis wellfields. It has 200mm OD PVC casing with a stainless wedge wire screen – 0.5mm opening. The screen is from 26 – 36m i.e. 10m in length. From the graph, it will be observed that flow starts at approximately 32.5m and stops at 28m or 4.5m which means that only 45% of the screened area is productive.



W34012 – construction of this borehole is typical of many of the other boreholes in the wellfield. It has 250mm OD PVC casing with slotted screen sections of 3mm wide x 80mm long wrapped with 2 layers of bidim from 26.5m to 37.7m i.e. 11.2m in length. Graphically flow starts at approximately 34m and stops at 27.5m or 4.5m meaning only 58% of the screened area is productive. The rising main (pipes) were the most clogged of all the boreholes.



G32954 – the construction is 195mm OD class 6 PVC with a screened section from 7.5m to 25.5m i.e. 18m in length and comprising 3mm wide slots x 37 rows of 23 slots/6m length and wrapped with 2 layers of bidim. Graphically, flow begins at approximately 20.5m and stops at 16.5m or 4m meaning only 22.2% of its existing screened area is productive.



In all 3 cases, the length of the screened section was far longer than it needed to be as the inflow is not across the full screen length. This just means that in any future drilling programme the use of geophysical logging techniques will be vital for the proper placement of the screens which in turn will result in a considerable cost reduction in the overall cost of a borehole. A final consideration to flow meter log all the remaining boreholes would also be practical.

Outcomes of Rehabilitation work

The Future for Atlantis & Simonstown

Given that not all the contract requirements were met that would have contributed to a complete 6-months tried-and-tested maintenance protocol being extensively detailed in this report, CoCT is left with significant responsibility to sustainably manage the wellfield. Implementing the recommendations below without the critical skills transfer opportunity having been missed may pose some difficulty, however the willingness to assist CoCT in this regard remains firm. The best recommendations that could reasonably be made to safeguard the significant cost and efforts spent on the regeneration programme are the following ito a Risk Assessment below, relative to emphasis and urgency with which these shortcomings identified need be addressed:

Recommendation description	***Very high risk***	***High risk***	***Medium high risk***
A minimum of 18 - 20 new pumps between 4Kw, 7.5Kw and 11Kw, need to be acquired in the short-term as replacement of those incorrectly in use.		X	
Yields should be regularly checked, ensuring the appropriate size orifice plate is matched with recommended yield. Shorter length riser pipes would also be needed (e.g. 2, 1 and 0.5m).		X	
Level loggers must be installed to monitor production and water levels.		X	
SCADA staff require essential training to develop the knowledge on how best to achieve balance/match borehole with the Melkbos supply.			X
Implement immediate planning to address inadequate storage at ATW.	X		
Prioritise upgrade of softening plant	X		
Reconsider the staff roles and responsibilities at the ATW wellfield, any efforts to bring about optimal management and production may be at risk of failure otherwise.	X		
Replacing boreholes where necessary, designed with future rehabilitation in mind. If this groundwater scheme is to continue successfully into the longer term serious consideration should be given to the re-drilling of replacement boreholes. **The construction type of such boreholes will be critical.**	X		
Implementation of Overall Monitoring Programme Pg. 16	X		

Immediate cleaning of distribution/reticulation lines. Having cleaned the boreholes and not the distribution system would be remiss.	X		

Glossary of Terms

TERM	DEFINITION
BCHT	Blended Chemical Heat Treatment - the patented treatment process applied during a rehabilitation/regeneration programme for the purposes of restoring an optimum production yield
Rehabilitation	The sequential application of techniques within a process intended to bring about an improvement in conditions that have adversely affected borehole production within a scheme
Regeneration	Reapplication of rehabilitation techniques where signs of declining production yield are evident
Optimum yield	A production yield considered to be a safe level of abstraction to minimise adverse effects of over-production
Reliability rating - Good	Showed improvement above expectation. Expectation is borehole would sustain at least 4 years' production without intervention being required with application of the continuous pumping rate recommended
Reliability rating - Uncertain	Showed improvement, results obtained better than anticipated. Will require a jetting treatment within a maximum 4 years, where regularly in production
Reliability rating - Compromised	Showed significant decline since 1999-2002 treatment cycle. Conclude resource to be permanently out of commission. To be sealed and decommissioned for further use. No longer salvageable.
Recommended yield	The suggested abstraction rate in line with an optimum or safe level of abstraction determined by various factors measured during the rehabilitation process
Continuous Pumping rate	Pumping 24/7
Optimum abstraction rate	Continuous pumping rate recommended interpreted based on most the recent rehabilitation post-treatment data
Oxidation Reduction Potential	(ORP) Redox Potential
Redox Potential	See Oxidation Reduction Potential
Redox front	Depth at which oxygen availability begins to decrease from 'aerobic' (having oxygen available) to 'anaerobic' (little to no oxygen is available)
Redox fringe	'redox front'
Plug/plugging	Aka Biofilm/biofouling.
Sessile	(Of an organism) fixed in one place; attached directly by its base without a stalk or peduncle
Polyphosphate	Salts consisting of different phosphates to form structural units linked together by sharing oxygen atoms
Bioufouling	Or plugging
Biofilm	or plug
Step drawdown test	A single-well pumping sequence testing as a controlled measure of well performance and recovery.
Drawdown	The change in water level relative to background condition typically due to a pump test
Specific Capacity	A quantity at which a water well can produce per unit of drawdown normally obtained from a step drawdown test.

Specific Drawdown	Is drawdown within a well divided by the discharge rate of water from the well
Mesocosm	An enclosed and essentially self-sufficient (but not necessarily isolated) experimental environment or ecosystem that is on a larger scale than a laboratory microcosm
Heterotrophic (an heterotrophe)	An organism that cannot fix carbon from inorganic sources (like carbon dioxide) but uses organic carbon for growth
Bio-colloid	Interactions poly amino acids in aqueous solution with charged surfaces
Recalcitrant	Disorderly, disorganised, uncontrollable
Turbidity	Cloudiness caused by suspended or dissolved particles such as fine organic or inorganic matter, microscopic organisms, or algae in water, a key test of water quality

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Appendices

Appendix A – Rehabilitation results & Pump-test Data

Appendix B – Borehole Installation Data

Appendix C – Chemistry Data

Appendix A - Rehabilitation results

Production Boreholes Rehabilitated in the Witzands, Silwerstroom & Brooklands wellfields 2014-2016

Borehole ID	Drill date	Basic construction			Yield before treatment (l/s)	Post-treatment Improvement (%)	Continuous Pumping rate recommended (l/s)	*Reliability rating	Clogging potential based on construction and rehab results (Low / Med / High)	Recommended pump settings (Meters below collar)	Retest after rehab and long-term production
		Screen type / casing	Borehole bottom (m)	Screen top (m)							
1. W34001	1989	SSWW 0.5mm+7/16 gravel	40,0	27,0	15	26	15	Good	Medium	22.5	Sep-16
2. W34025	1994	PVCS 0.5mm+gravel	34,0	20,0	10	26	7	Good	Medium	19.5	Oct-16
3. W34024	1994	PVCS 0.5mm+gravel	37,3	24,0	10	14	7	Good	Medium	19.5	Oct-16
4. W34022	1994	PVCS 0.5mm+gravel	42,0	26,0	10	48	7	Good	Medium	22.5	Nov-16
5. W34023	1994	PVCS 0.5mm+gravel	39,0	24,0	10	76	7	Good	Medium	22.5	Nov-16
6. W34005	1989	SSWW 0.5mm+ 7/16 gravel	39,0	26,0	10	9.5	7	Uncertain	Medium/High	22.5	
7. G30965	1979	SSWW 0.75 + bidim + gravel	45,0	31,1	5	71	7	Uncertain	Medium/High	28.7	
8. G30973	1979	PVCS + bidim	40,0	***16.0	5	36	7	Uncertain	Medium/High	22.7	
9. W34032	1996	PVCS 0.5mm+ gravel	37,5	24,5	15	1.5	7	Uncertain	High	22.7	
10. W34020	1993	PVCS 0.8mm + gravel	36,0	24,4	10	4.5	7	Uncertain	High	22.7	
11. W34029	1996	PVCS 0.5mm+ gravel	43,0	28,0	10	40.6	7	Good	Medium	22.7	
12. W34012	1993	PVCS 3mm + bidim	40,5	26,5	10	34	7	Good	Medium	22.7	
13. G33103	1983	PVCS 3mm + bidim	41,0	***15.0	4	-10	5	Uncertain	High	22.7	
14. W34031	1993	PVCS 0.5mm+ gravel	40,5	25,5	10	1	7	Uncertain	High	22.7	
15. W34009	1993	PVCS 0.5mm +gravel	41,0	26,8	10	-90	5	Uncertain	Medium/High	22.5	
16. W34011	1993	PVCS 3mm + bidim	37,2	25,0	3	23	0	Compromised	High	19.7	
17. W34019	1993	PVCS 0.8mm + gravel	30,0	20,2	0	-8.7	5	Uncertain	High	19.7	
18. W34028	1996	PVCS 0.5mm + gravel	41,0	26,0	10	0	5	Uncertain	High	22.5	
19. W34013	1993	PVCS 3mm + bidim	39,0	26,8	3	-36	2	Uncertain	Medium	25.7	
20. G33107	1983	PVCS 3mm + bidim	46,0	***10.0	5	175	5	Uncertain	Medium/High	22.7	
21. W34014	1993	PVCS 0.5mm + gravel	36,0	23,3	10	71	7	Good	Medium/High	19.7	
22. G30972	1979	SSWW 0.75 + 7/16 gravel	46,0	26,2	5	-11	5	Uncertain	Medium	19.7	
23. W34030	1996	PVCS 0.5mm+ gravel	39,5	24,5	10	39	7	Good	Medium	22.7	
24. W34010	1993	PVCS 3mm + bidim	35,0	22,8	10	-1	7	Uncertain	High	19.7	
25. G33104	1983	PVCS 3mm + bidim	38,0	***12.0	5	109	7	Good	Medium	22.7	
26. G30966	1979	SSWW 0.75 + gravel	42,0	24,0	5	8	5	Uncertain	Medium	19.7	
27. W34018	1993	PVCS 0.5mm+gravel	19,0	***10.2	5	14	4	Good	Medium/High	16.7	
28. G32956	1983	PVCS 3mm+bidim+gravel	39,0	*** 12	5	2	4	Uncertain	High	19.7	
29. W34016	1993	PVCS 0.5mm+gravel	28,0	21,2	5	-2	2	Uncertain	High	19.5	
30. G32959	1983	PVCS 3mm+bidim+gravel	31,0	*** 11	5	12	4	Uncertain	Medium/High	19.7	
31. G32955	1983	PVCS 3mm+bidim+gravel	32,0	*** 12	5	15	2	Uncertain	High	19.7	
32. W34034	1996	PVCS 0.5mm+16/30gravel	35,0	23,0	5	6	0	Compromised	High	19.7	
33. G30865	1978	SSWW 0.75mm+ gravel	46,4	***23	5	10	4	Uncertain	Medium/High	22.4	
34. G32952	1983	PVCS 3mm+bidim+gravel	38,0	***12.3	5	1	4	Uncertain	High	22.4	
35. W34015	1993	PVCS 0.5mm+bidim+gravel	29,0	20,2	5	6	4	Uncertain	Medium/High	19.4	
36. G32954	1982	PVCS 3mm+ bidim + gravel	32,0	***8.7	5	20.8	4	Uncertain	Medium/High	19.7	
37. W34017	1993	PVCS 0.5mm+ gravel	27,0	***18.2	3	0	0	Compromised	High	16.4	
38. W34033	1996	PVCS 0.5mm+16/30gravel	35,0	23,0	2	0	4	Uncertain	High	19.7	
39. G30991	1979	PVCS 4mm+ bidim	45,3	***10.7	5	0	4	Uncertain	Medium/High	19.7	
40. Brooklands 2	1995	Open hole	110			-26	2	Uncertain	High	70.0	

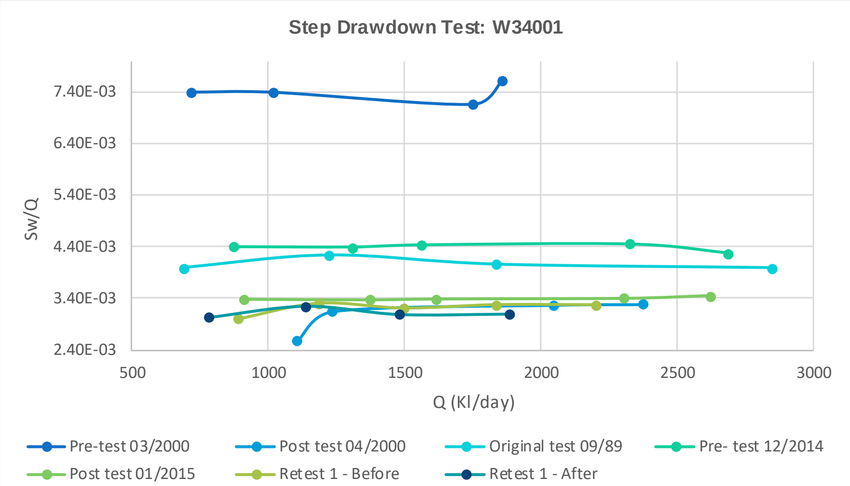
Appendix A - Rehabilitation results

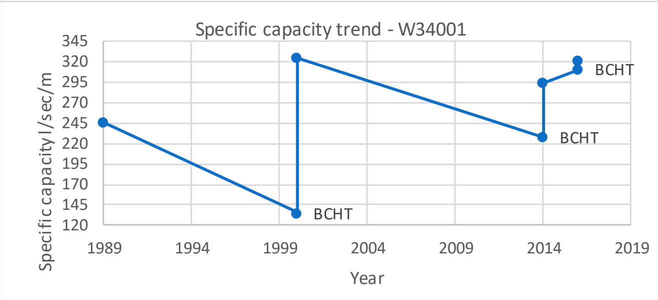
WITZANDS AQUIFER - BOREHOLE W34001

ORIGINAL TEST - CSIR Rest Waterlevel = 6.74 m.bgl (09/89) Pump inlet - 28.27m				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.0	691	2.760	3.99E-03
2	14.2	1227	5.207	4.24E-03
3	21.3	1840	7.470	4.06E-03
4	33.0	2851	11.375	3.99E-03
Average				4.07E-03
Decline(-) / Improve(+) Original				0

PRE-TEST Rest Waterlevel = 6.71 m.bgl (28/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.3	717	5.307	7.40E-03
2	11.8	1020	7.547	7.40E-03
3	20.3	1754	12.574	7.17E-03
4	21.5	1858	14.145	7.61E-03
Average				7.40E-03
Decline(-) / Improve(+) Original to Pre-Test				-82%

POST-TEST Rest Waterlevel = 6.74 m.bgl (01/04/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	12.8	1106	2.857	2.58E-03
2	14.3	1236	3.898	3.15E-03
3	23.7	2048	6.712	3.28E-03
4	27.5	2376	7.817	3.29E-03
Average				3.08E-03
Decline(-) / Improve(+) Pre- to Post-Test				58%





Date	SC l/s/m
1989	245.7
2000	135.1
2000	324.7
2014	227.8
2014	294.1
2016	310.6
2016	321.5

CCTV log review

Before						5	
After			2				

PRE-TEST Rest Waterlevel = 3.14m.bgl (5/11/14)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.11	873	3.84	4.40E-03
2	15.17	1311	5.76	4.39E-03
3	18.08	1562	6.93	4.44E-03
4	26.92	2326	10.36	4.45E-03
5	31.14	2690	11.49	4.27E-03
Average				4.39E-03
Decline(-) / Improve(+) Post '00 to Pre-Test '14				-42.5%

POST-TEST Rest Waterlevel = 3.11m.bgl (9/11/14)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.57	913	3.09	3.38E-03
2	15.92	1375	4.64	3.37E-03
3	18.75	1620	5.49	3.39E-03
4	26.69	2306	7.84	3.40E-03
5	30.39	2626	9.05	3.45E-03
Average				3.40E-03
Decline(-) / Improve(+) Pre- to Post-Test				22.6%

RETEST 1 - Before Rest Waterlevel = 4.17m.bgl (25/7/16)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.30	890	2.68	3.01E-03
2	13.74	1187	3.93	3.31E-03
3	17.33	1497	4.82	3.22E-03
4	21.28	1839	6.04	3.28E-03
5	25.48	2202	7.23	3.28E-03
Average				3.22E-03
Decline(-)/Improve(+) Pre- to Post-Test 2014				-5.3%

RETEST 1 - After Rest Waterlevel = 3.96m.bgl (30/9/16)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.04	781.1	2.37	3.03E-03
2	13.18	1138.8	3.69	3.24E-03
3	17.16	1482.6	4.58	3.09E-03
4	21.83	1886.1	5.84	3.10E-03
5				
Average				3.11E-03
Decline(-)/Improve(+) Pre- to Post-retest 2016				3.4%

COMMENTS

2000 improvement: 58%
Comment: Best constructed borehole in the wellfield
PVC with wedge wire screen.
2014 improvement: initial 22.6% + further 3.4% after retreating in 2016
Optimum Pumping Rate: 15l/s (2014)

Pre- & Post-Testing Details:
Pump Inlet Depth: **22.5m (11/2016)**

Vari-Speed Setting:
1. 26/20 Hz
2. 34/26 Hz
3. 42/30 Hz
4. 47/42 Hz

Construction:
PVC (200 mm) with stainless wedge wire Screen 26 - 36m, 200mm Houston, 20 slot with 0.5mm slots & *7/16 gravel pack.
*Did they mean 7/16" or 7 to 16 (1.19 - 2.38mm) on the Standard sieve series?

WITZANDS AQUIFER - BOREHOLE W34025

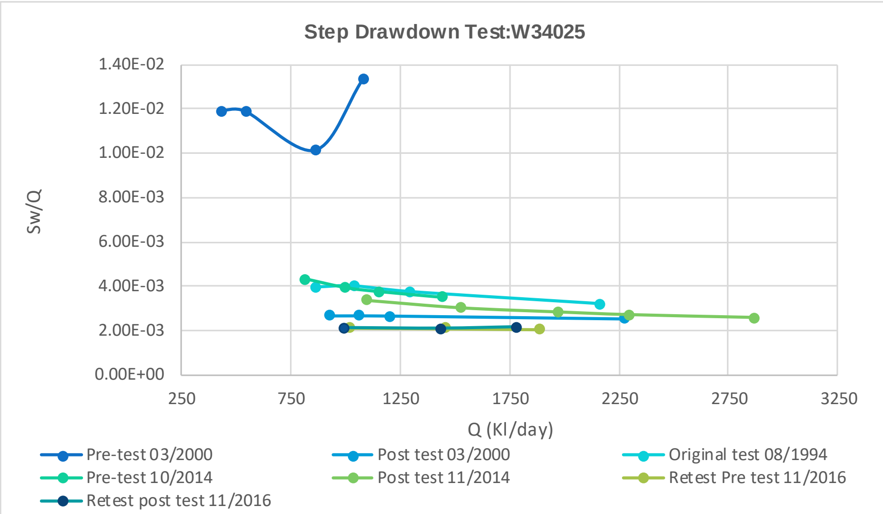
ORIGINAL TEST - CSIR Rest Waterlevel = 6.0 m.bgl (08/1994) Pump inlet - 19.5m				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.0	864	3.420	3.96E-03
2	12.0	1037	4.160	4.01E-03
3	15.0	1296	4.860	3.75E-03
4	25.0	2160	6.930	3.21E-03
Average				3.73E-03
Decline(-) / Improve(+) Original				0

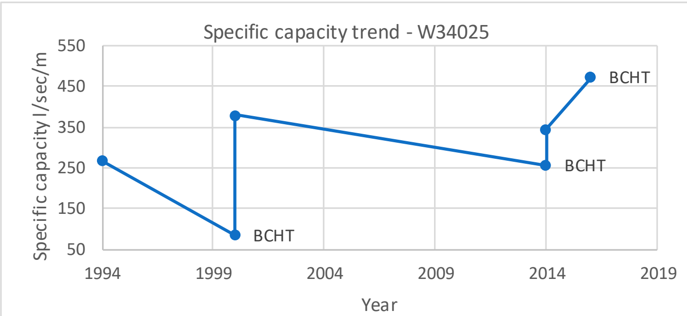
PRE-TEST Rest Waterlevel = 4.24 m.bgl (20/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.0	432	5.143	1.19E-02
2	6.3	544	6.47	1.19E-02
3	10.0	864	8.751	1.01E-02
4	12.5	1080	14.382	1.33E-02
Average				1.18E-02
Decline(-) / Improve(+) Pre to Original-Test				-216%

POST-TEST Rest Waterlevel = 4.26 m.bgl (23/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.7	924	2.459	2.66E-03
2	12.3	1063	2.833	2.67E-03
3	13.9	1201	3.190	2.66E-03
4	26.3	2272	5.720	2.52E-03
Average				2.63E-03
Decline(-) / Improve(+) Pre- to Post-Test				78%

PRE-TEST Rest Waterlevel = 1.16 m.bgl (03/10/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.45	816	3.53	4.33E-03
2	11.58	1000	3.94	3.94E-03
3	13.30	1149	4.33	3.77E-03
4	16.70	1443	5.07	3.51E-03
5				
Average				3.89E-03
Decline(-)/Improve(+) Pre-'14 to Post-Test 2000				-48%

POST-TEST Rest Waterlevel = 1.32 m.bgl (12/11/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	12.72	1099	3.72	3.38E-03
2	17.70	1529	4.62	3.02E-03
3	22.80	1970	5.56	2.82E-03
4	26.55	2294	6.17	2.69E-03
5(10min)	33.20	2868	7.32	2.55E-03
Average				2.89E-03
Decline(-)/Improve(+) Post-'14 to Pre-Test'14				26%





Date	SC l/s/m
1994	268.1
2000	84.7
2000	380.2
2014	257.1
2014	346
2016	473.9
2016	473.9

CCTV log review

Before: 4

After: 2

RETEST 1 - Before Rest Waterlevel = 2.75 m.bgl (8/11/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	11.77	1017	2.16	2.12E-03
2	16.86	1457	3.07	2.11E-03
3	21.83	1886	3.94	2.09E-03
Average				2.11E-03
Decline(-)/Improve(+) Pre- to Post-Test 2014				27%

RETEST 1 - After Rest Waterlevel = 2.68m.bgl (11/11/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	11.47	991	2.09	2.11E-03
2	16.61	1435	2.99	2.08E-03
3	20.61	1781	3.83	2.15E-03
4	25.66	2217	4.67	2.11E-03
Average				2.11E-03
Decline(-)/Improve(+) Pre- to Post-retest 2016				0%

COMMENTS

2000 improvement: 78%
2014 improvement: 26%
2016 Comment: Note improvement on 2014 treatment

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.5m (11/2016)**

Vari-Speed Setting 2000/2014:

1. 24/20 Hz
2. 26/28 Hz
3. 28/35 Hz
4. 45/40 Hz

Construction:

PVC (250mm x 10mm wall) - no bidim.
Actual screen section 19 - 29.8/30m *(records: 20-32m)*
Screen: 250mm x 10mm wall
Casing: 250mm x 10mm wall
0.5mm slots, 5% open area (assumed)

WITZANDS AQUIFER - BOREHOLE W34024

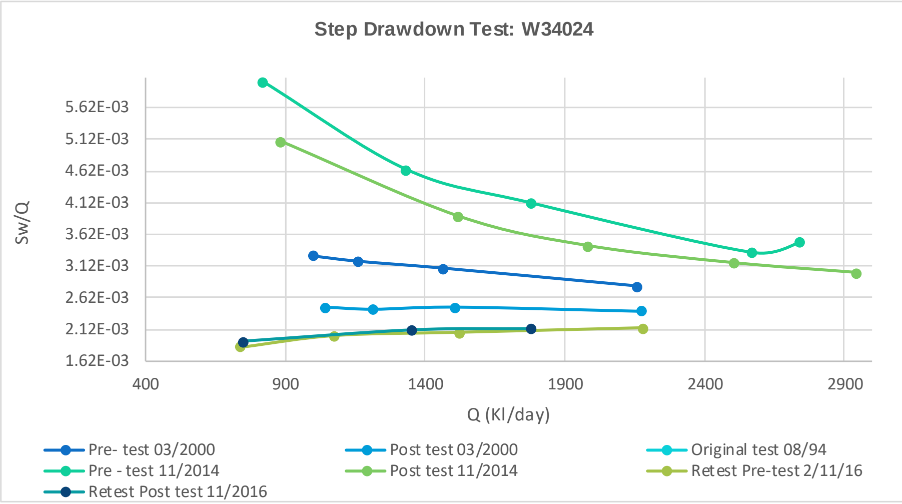
ORIGINAL TEST - CSIR Rest Waterlevel = 6.30 m.bgl (08/1994) Pump inlet: 23.5m				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.0	605	2.500	4.13E-03
2	10.0	864	3.170	3.67E-03
3	13.0	1123	4.200	3.74E-03
4	25.0	2160	8.430	3.90E-03
Average				3.86E-03
Decline(-) / Improve(+) Original				0

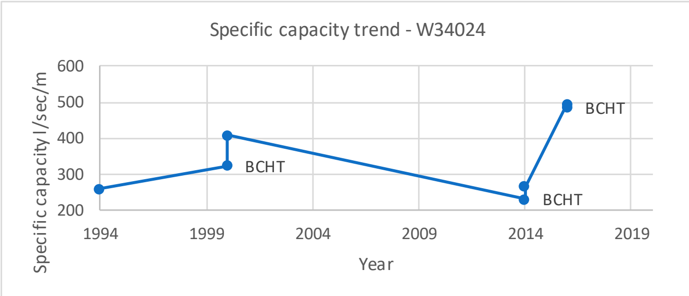
PRE-TEST Rest Waterlevel = 5.20 m.bgl (15/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	11.6	1002	3.295	3.29E-03
2	13.5	1166	3.733	3.20E-03
3	17.0	1469	4.538	3.09E-03
4	25.0	2160	6.045	2.80E-03
Average				3.09E-03
Decline(-) / Improve(+) Pre to Original-Test				20%

POST-TEST Rest Waterlevel = 5.21 m.bgl (17/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	12.1	1045	2.587	2.48E-03
2	14.1	1218	2.975	2.44E-03
3	17.5	1512	3.743	2.48E-03
4	25.2	2177	5.249	2.41E-03
Average				2.45E-03
Decline(-) / Improve(+) Pre- to Post-Test				21%

PRE-TEST Rest Waterlevel = 2.60 m.bgl (11/11/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.50	821	4.95	6.03E-03
2	15.44	1334	6.19	4.64E-03
3	20.61	1781	7.32	4.11E-03
4	29.77	2572	8.56	3.33E-03
5	31.76	2744	9.59	3.49E-03
Average				4.32E-03
Decline(-)/Improve(+) Pre '14 to Post-Test 2000				-76%

POST-TEST Rest Waterlevel = 2.68m.bgl (23/11/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.25	886	4.51	5.09E-03
2	17.61	1521	5.94	3.91E-03
3	22.96	1984	6.82	3.44E-03
4	29.03	2508	7.94	3.17E-03
5	34.13	2949	8.880	3.01E-03
Average				3.72E-03
Decline(-)/Improve(+) Pre '14 to Post-Test 2014				14%





Date	SC l/s/m
1994	259.1
2000	323.6
2000	408.2
2014	231.5
2014	266.9
2016	495
2016	485.4

CCTV log review

Before						5	
After			2				

Retest PRE-TEST Rest Waterlevel = 4.07 m.bgl (2/11/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.61	744	1.37	1.84E-03
2	12.50	1080	2.18	2.02E-03
3	17.69	1528	3.16	2.07E-03
4	25.25	2182	4.66	2.14E-03
Average				2.02E-03
Decline(-)/Improve(+) Re- '16 to Post-Test '14				46%

Retest POST-TEST Rest Waterlevel = 3.98m.bgl (7/11/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.69	751	1.45	1.93E-03
2	15.72	1358	2.88	2.12E-03
3	20.61	1781	3.81	2.14E-03
Average				2.06E-03
Decline(-)/Improve(+) Pre re-'16 to Post-retest '16				2%

COMMENTS

2000 improvement: 21%
2014 improvement: 14 %
2016 comment: Note improvement after 2014 treatment.

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.5m (11/2014)**

Vari-Speed Setting: 2000/2014

1. 28/20 Hz
2. 30/28 Hz
3. 34/34 Hz
4. 44/42 Hz
5. 0/50 Hz

Construction:

PVC (250mm x 10mm wall) - no bidim.
Actual Screen section at 23 - 34.7m (records 24-32m)
Screen: 250mm x 10mm wall
Casing: 250mm x 10mm wall
0.5mm slots, 5% open area (assumed)

WITZANDS AQUIFER - BOREHOLE W34022

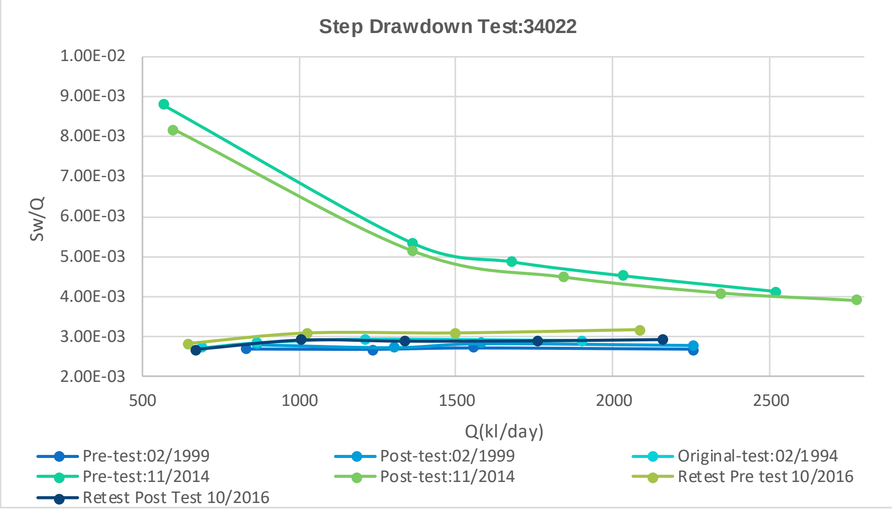
ORIGINAL TEST - CSIR Rest Waterlevel = ?? m.bgl (1994)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.0	691	1.890	2.73E-03
2	10.0	864	2.460	2.85E-03
3	14.0	1210	3.550	2.93E-03
4	22.0	1901	5.520	2.90E-03
Average				2.86E-03
Decline(-) / Improve(+) Original				0

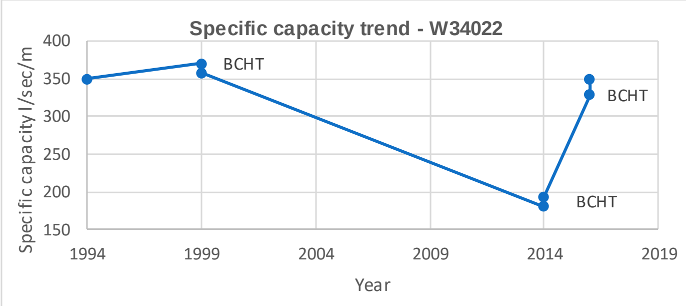
PRE-TEST Rest Waterlevel = 7.14 m.bgl (15/02/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.6	829	2.229	2.69E-03
2	14.3	1236	3.306	2.68E-03
3	18.0	1555	4.255	2.74E-03
4	26.1	2255	6.047	2.68E-03
Average				2.70E-03
Decline(-) / Improve(+) Pre to Original-Test				-5.6%

POST-TEST Rest Waterlevel = 7.10 m.bgl (19/02/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.0	864	2.428	2.81E-03
2	15.1	1305	3.553	2.72E-03
3	18.3	1581	4.498	2.84E-03
4	26.1	2255	6.293	2.79E-03
Average				2.79E-03
Decline(-) / Improve(+) Pre- to Post-Test				-4%

PRE-TEST Rest Waterlevel = 3.16 m.bgl (13/11/14)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.6	568	4.99	8.79E-03
2	15.75	1361	7.26	5.33E-03
3	19.4	1675	8.15	4.87E-03
4	22.5	2031	9.17	4.52E-03
5	29.1	2518	10.380	4.12E-03
Average				5.52E-03
Decline(-) / Improve(+) Pre-'14 to Post-test '99				-98%

POST-TEST Rest Waterlevel = 3.25m.bgl (28/11/14)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.94	600	4.9	8.17E-03
2	15.78	1363	7	5.14E-03
3	21.36	1845	8.28	4.49E-03
4	27.11	2342	9.59	4.09E-03
5	32.15	2778	10.850	3.91E-03
Average				5.16E-03
Decline(-)/Improve(+) Post-'14 to Pre-test '14				6.5%





Date	SC l/s/m
1994	349.7
1999	370.4
1999	358.4
2014	181.2
2014	193.8
2016	328.9
2016	348.4

CCTV log review

Before					4		
After			2				

Retest PRE-TEST Rest Waterlevel = 4.65 m.bgl (18/10/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.50	648	1.83	2.82E-03
2	11.86	1025	3.16	3.08E-03
3	17.33	1497	4.62	3.09E-03
4	24.14	2086	6.61	3.17E-03
Average				3.04E-03
Decline(-)/Improve(+) Pre-Re- to Post-Test '14				41%

Retest Post test Rest Waterlevel = 4.58m.bgl (21/10/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.75	670	1.79	2.67E-03
2	11.64	1006	2.94	2.92E-03
3	15.47	1337	3.87	2.90E-03
4	20.36	1759	5.11	2.90E-03
5	24.97	2157	6.340	2.94E-03
Average				2.87E-03
Decline(-)/Improve(+) Re- Post- to Pre retest '16				5.6%

COMMENTS

1999 decline: 4%
2014 improvement: 6.5%
2016 improvement: 5.6% Overall: 48%?
2016 comment: All tests show development improvements. This was confirmed during the airlifting procedure as evidenced by the type and quantity of material being removed.

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.5m (2014)**

Vari-Speed Setting:

1. 28/20 Hz
2. 32/28 Hz
3. 36/35 Hz
4. 45/38 Hz
5. 0/45 Hz

Construction:

PVC no with bidim.
Screen depth:26 - 38m
Casing 250mm x 10 mm wall
Screen: 250mm x 10mm wall
0.5mm slots, 5% open area (assumed)

WITZANDS AQUIFER - BOREHOLE W34023

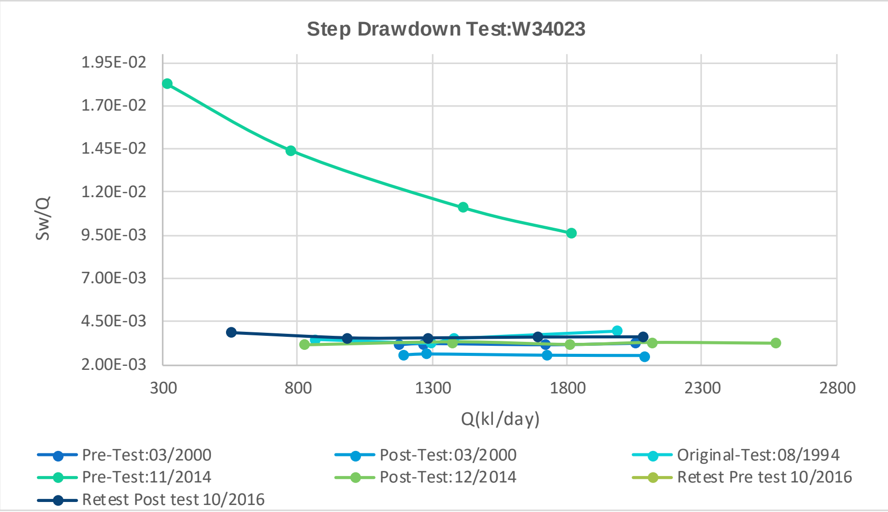
ORIGINAL TEST - CSIR Rest Waterlevel = 6.4m.bgl (08/1994) Pump inlet:23.5m				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.0	864	3.000	3.47E-03
2	15.0	1296	4.210	3.25E-03
3	16.0	1382	4.850	3.51E-03
4	23.0	1987	7.880	3.97E-03
Average				3.55E-03
Decline(-) / Improve(+) Original				0

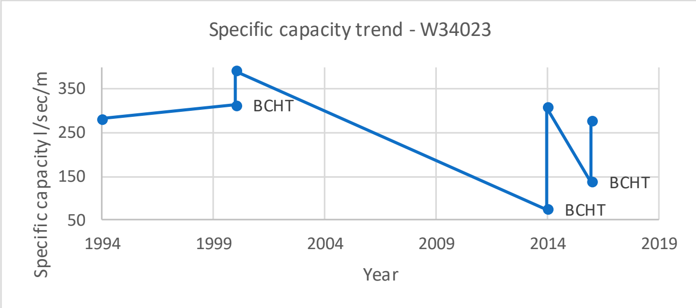
PRE-TEST Rest Waterlevel = 4.85 m.bgl (24/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	13.6	1175	3.718	3.16E-03
2	14.7	1270	4.111	3.24E-03
3	19.9	1719	5.436	3.16E-03
4	23.8	2056	6.694	3.26E-03
Average				3.20E-03
Decline(-) / Improve(+) Pre to Original-Test				10%

POST-TEST Rest Waterlevel = 4.81 m.bgl (28/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	13.8	1192	3.043	2.55E-03
2	14.8	1279	3.358	2.63E-03
3	20.0	1728	4.381	2.54E-03
4	24.2	2091	5.261	2.52E-03
Average				2.56E-03
Decline(-) / Improve(+) Pre- to Post-Test				20%

PRE-TEST Rest Waterlevel = 2.75 m.bgl (14/11/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.64	314	5.74	1.83E-02
2	8.97	775	11.18	1.44E-02
3	16.36	1413	15.71	1.11E-02
4	21.03	1817	17.5	9.63E-03
Average				1.34E-02
Decline(-)/Improve(+) Pre '14 to Post-Test '00				-81%

POST-TEST Rest Waterlevel = 2.57m.bgl (5/12/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.56	826	2.63	3.18E-03
2	15.94	1377	4.58	3.33E-03
3	20.96	1811	5.8	3.20E-03
4	24.50	2117	6.98	3.30E-03
5	29.83	2577	8.400	3.26E-03
Average				3.25E-03
Decline(-)/Improve(+) Pre 2014 to Post-Test '14				76%





Date	SC l/s/m
1994	281.7
2000	312.5
2000	390.6
2014	74.6
2014	307.7
2016	137.6
2016	275.5

CCTV log review

Before					5	
After				3		

Retest PRE-TEST Rest Waterlevel = 4.23 m.bgl (24/10/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.19	535	3.9	7.29E-03
2	9.36	809	5.94	7.35E-03
3	13.92	1203	8.63	7.18E-03
Average				7.27E-03
Decline(-)/Improve(+) Pre re-'16 to Post-Test'14				-55%

Retest POST-TEST Rest Waterlevel = 4.02m.bgl (27/10/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.40	553	2.14	3.87E-03
2	11.42	987	3.5	3.55E-03
3	14.86	1284	4.55	3.54E-03
4	19.61	1694	6.09	3.59E-03
5	24.08	2081	7.510	3.61E-03
Average				3.63E-03
Decline(-)/Improve(+) Post re-'16 to Pre retest'16				50%

COMMENTS

2000 improvement: 28%
2014 improvement: 76%
2016 comment: Note decline in yield between 2014 and 2016 treatments.

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:
Pump Inlet Depth: 19.**5m (2014)**

Vari-Speed Setting:
1. 28/20 Hz
2. 30/28 Hz
3. 36/34 Hz
4. 42/40 Hz

Construction:
PVC (250mm) no with bidim.
Screen depth:24 - 36m
Screen: 250mm x 10 mm wall
Caasing: 250mm x 10mm wall
0.5mm slots, 5% open area (assumed)

WITZANDS AQUIFER - BOREHOLE W34005

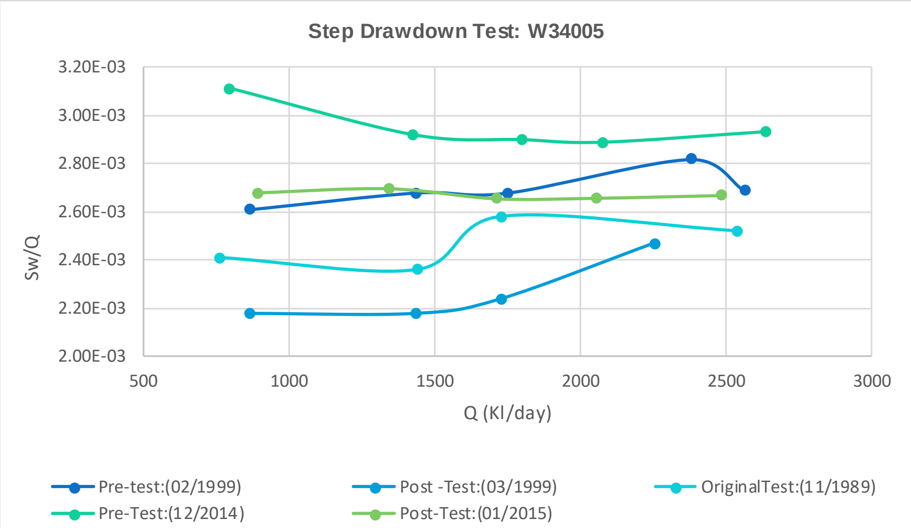
ORIGINAL TEST - CSIR Rest Waterlevel = ?? m.bgl (11/1989?)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.8	760	1.83	2.41E-03
2	16.7	1440	3.40	2.36E-03
3	20.0	1728	4.45	2.58E-03
4	29.4	2540	6.40	2.52E-03
Average				2.47E-03
Decline(-) / Improve(+) Original				0

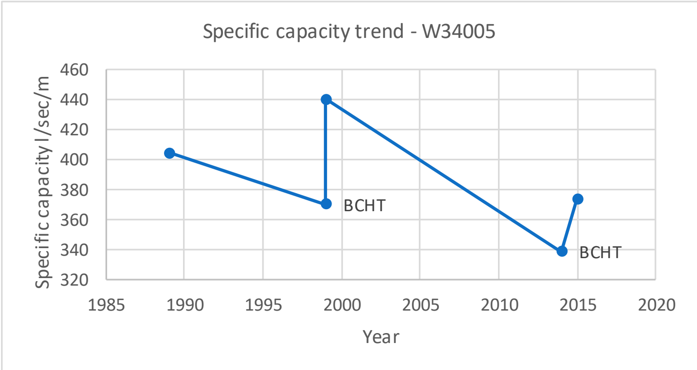
PRE-TEST Rest Waterlevel = 6.98 m.bgl (23/02/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.0	864	2.552	2.61E-03
2	16.6	1434	3.844	2.68E-03
3	20.3	1754	4.708	2.68E-03
4	27.6	2385	6.725	2.82E-03
5	29.7	2566	6.905	2.69E-03
Average				2.70E-03
Decline(-) / Improve(+) Original to Pre-Test				-9%

POST-TEST Rest Waterlevel = 7.04 m.bgl (02/03/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.0	864	1.882	2.18E-03
2	16.6	1434	3.125	2.18E-03
3	20.0	1728	3.871	2.24E-03
4	26.1	2255	5.582	2.47E-03
Average				2.27E-03
Decline(-) / Improve(+) Pre- to Post-Test				16%

PRE-TEST Rest Waterlevel = 0.63m.bgl (8/12/14)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.23	797	2.48	3.11E-03
2	16.53	1428	4.17	2.92E-03
3	20.83	1800	5.22	2.90E-03
4	24.08	2080	6.01	2.89E-03
5	30.55	2639	7.74	2.93E-03
Average				2.95E-03
Decline(-) / Improve(+) Pre- 2014 to Post-test '99				-23%

POST-TEST Rest Waterlevel = 0.65 m.bgl (8/01/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.33	892	2.39	2.68E-03
2	15.55	1343	3.62	2.70E-03
3	19.83	1713	4.55	2.66E-03
4	23.77	2054	5.46	2.66E-03
5	28.80	2488	6.64	2.67E-03
Average				2.67E-03
Decline(-) / Improve(+) Pre- to Post-Test 2015				9.5%





Date	SC l/s/m
1989	404.9
1999	370.4
1999	440.5
2014	339
2015	374.5

COMMENTS

1999 improvement: 16%
2015 improvement: 9.5%

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: 27.8m (03/1999)& **22.5m (11/2014)**

Vari-Speed Setting:

1. 28/20 Hz
2. 34/26 Hz
3. 38/30Hz
4. 49/42 Hz
5. 50/47 Hz

Construction:

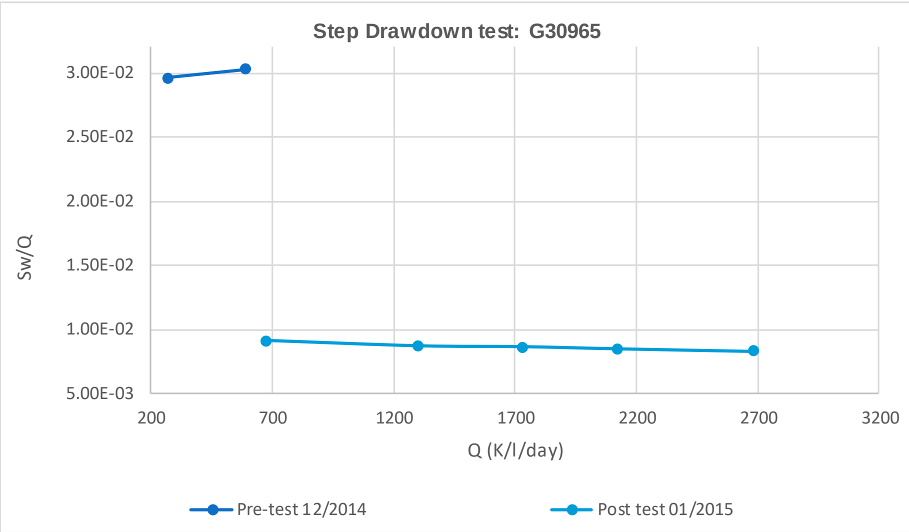
PVC (200 mm) with stainless wedge wire
Screen 26 - 36m, 200mm Houston, 20 slot with 0.5mm slots & *7/16 gravel pack
* did they mean 7/16" or 7 to 16 (1.19 - 2.38mm) on the Standard sieve series

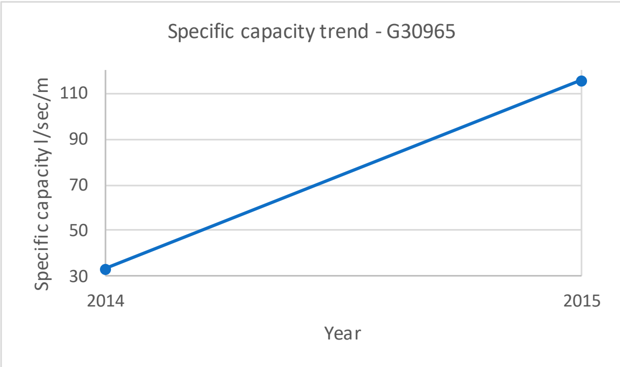
CCTV log review

Before						5	
After			2				

WITZANDS AQUIFER - BOREHOLE G30965

ORIGINAL TEST - DWAF-No data Available Rest Waterlevel = ?? m.bgl (Drilled 12/79)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original				
PRE-TEST Rest Waterlevel = 2.41 m.bgl (11/12/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.11	269	7.97	2.96E-02
2	6.79	587	17.78	3.03E-02
Average				3.00E-02
Decline(-) / Improve(+) Original to Pre-Test				3.03%
POST-TEST Rest Waterlevel = 2.54 m.bgl (11/01/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.77	671	6.13	9.14E-03
2	15.03	1298	11.33	8.73E-03
3	20.00	1728	14.96	8.66E-03
4	24.58	2124	18.04	8.49E-03
5	31.08	2685	22.27	8.29E-03
Average				8.66E-03
Decline(-) / Improve(+) Pre- to Post-Test				71%





Date	SC l/s/m
2014	33.3
2015	115.4

COMMENTS

2001 improvement: 0

2015 improvement: 71%

Optimum Pumping Rate: 7 L/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **28.7m (2015)**

Vari-Speed Setting: 2015

1. 20 Hz
2. 28 Hz
3. 34 Hz
4. 40 Hz
5. 48 Hz

Construction detail:

Mild steel casing - 304 mm ID, with stainless wedge wire screen (Johnson) - 150 mm ID with 2 layers

U34 bidim??

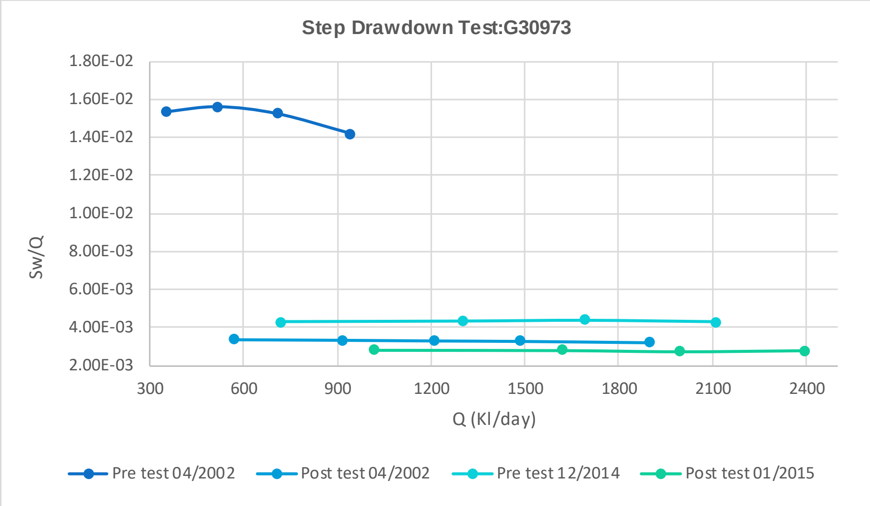
Screen ~31 - 37m

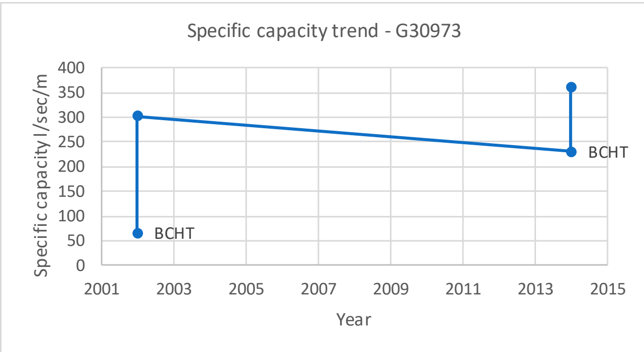
CCTV log review

Before						5	
After				3			

WITZANDS AQUIFER - BOREHOLE G30973

ORIGINAL TEST - DWAF-No Data Available Rest Waterlevel = ~5.5m.bgl (1979)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original to Post-Test				
PRE-TEST Rest Waterlevel = 3.70m.bgl (02/04/2002)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.1	354	5.439	1.54E-02
2	6.0	518	8.096	1.56E-02
3	8.2	708	10.795	1.52E-02
4	10.9	942	13.35	1.42E-02
Average				1.51E-02
Decline(-) / Improve(+) Original to Pre-Test				0%
POST-TEST Rest Waterlevel = 4.0m.bgl (14/04/2002)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.6	570	1.928	3.38E-03
2	10.6	916	3.068	3.35E-03
3	14.0	1210	4.006	3.31E-03
4	17.2	1486	4.882	3.29E-03
5	22.0	1901	6.099	3.21E-03
Average				3.31E-03
Decline(-) / Improve(+) Pre- to Post-Test				78%
PRE-TEST Rest Waterlevel = 2.58m.bgl (10/12/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.30	717	3.08	4.30E-03
2	15.05	1300	5.65	4.35E-03
3	19.58	1692	7.47	4.41E-03
4	24.44	2112	9.06	4.29E-03
Average				4.34E-03
Decline(-) / Improve(+) Post 2002 to Pre-Test 2015				-31%
POST-TEST Rest Waterlevel = 2.72m.bgl (15/01/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	11.80	1019	2.870	2.82E-03
2	18.75	1620	4.54	2.80E-03
3	23.11	1997	5.5	2.75E-03
4	27.72	2395	6.7	2.80E-03
5(15mins)	34.83	3009	8.2	2.73E-03
Average				2.78E-03
Decline(-) / Improve(+) Pre- to Post-Test 2015				36%





Date	SC l/s/m
1979	0
2002	66.2
2002	302.1
2014	230.4
2014	359.7

COMMENTS

2015 improvement: 36%

This borehole was previuosly unused from January 1997 to rehab in 2002 due to decline in yield.

Optimum Pumping Rate: 7 L/s (2002)

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (2014) ?**

Vari-Speed Setting: 2002 / 2015

1. 20/22 Hz
2. 26/28 Hz
3. 30/34 Hz
4. 34/40 Hz
5. 40/48 Hz

Construction:

PVC with 2 layers U34 bidim.

Boode screen 200mm class 6 PVC: 15.9m - 21.9m

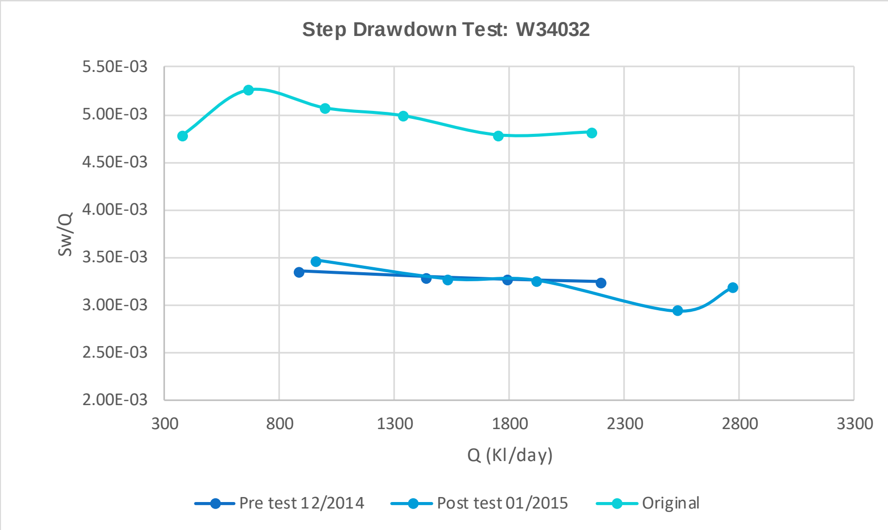
Boode screen 175mm class 12 PVC: 21.9m - 36.5m

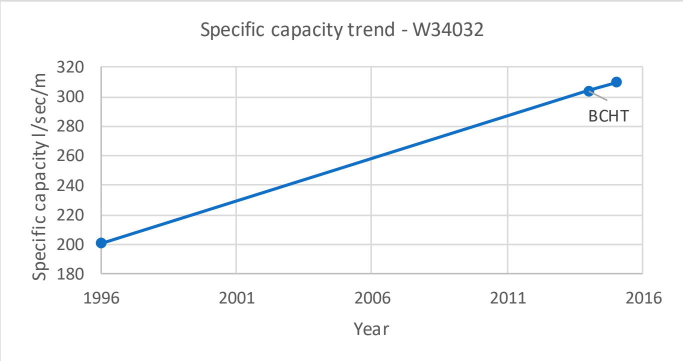
CCTV log review

Before						5	
After				3			

WITZANDS AQUIFER - BOREHOLE W34032

ORIGINAL TEST - CSIR Rest Waterlevel = 1.83m.bgl (11/11/1996)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.4	380	1.82	4.79E-03
2	7.7	665	3.50	5.26E-03
3	11.6	1002	5.08	5.07E-03
4	15.5	1339	6.68	4.99E-03
5	20.3	1754	8.39	4.78E-03
6	25.0	2160	10.40	4.81E-03
Average				4.98E-03
Decline(-) / Improve(+) Original				0
PRE-TEST Rest Waterlevel = 1.87 m.bgl (17/12/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.22	883	2.96	3.35E-03
2	16.66	1439	4.74	3.29E-03
3	20.72	1795	5.86	3.26E-03
4	25.50	2203	7.14	3.24E-03
Average				3.29E-03
Decline(-) / Improve(+) Original to Pre-Test				-34%
POST-TEST Rest Waterlevel = 1.90m.bgl (18/01/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	11.14	962	3.34	3.47E-03
2	17.75	1534	5.03	3.28E-03
3	22.25	1922	6.27	3.26E-03
4	29.33	2534	7.46	2.94E-03
5	32.14	2777	8.87	3.19E-03
Average				3.23E-03
Decline(-) / Improve(+) Pre- to Post-Test				1.5%





Date	SC l/s/m
1996	200.8
2014	303.9
2015	309.6

COMMENTS

2014 improvement: 1.5%

Optimum Pumping Rate: 7 L/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (03/2015)**

Vari-Speed Setting: 2002/2015

1. 22/20 Hz
2. 26/28 Hz
3. 30/34 Hz
4. 36/40 Hz
5. 44/0 Hz

Construction detail:

PVC (250mm class 9 & class 12) - no bidim

0.5mm slots, 5% open area

Screen: 25.5m - 37.5m

Grade 16/30 (1.19mm to 595 micron) gravel pack, 400mm diameter filled from 14-37m.

CCTV log review

Before					4		
After				3			

WITZANDS AQUIFER - BOREHOLE W34020

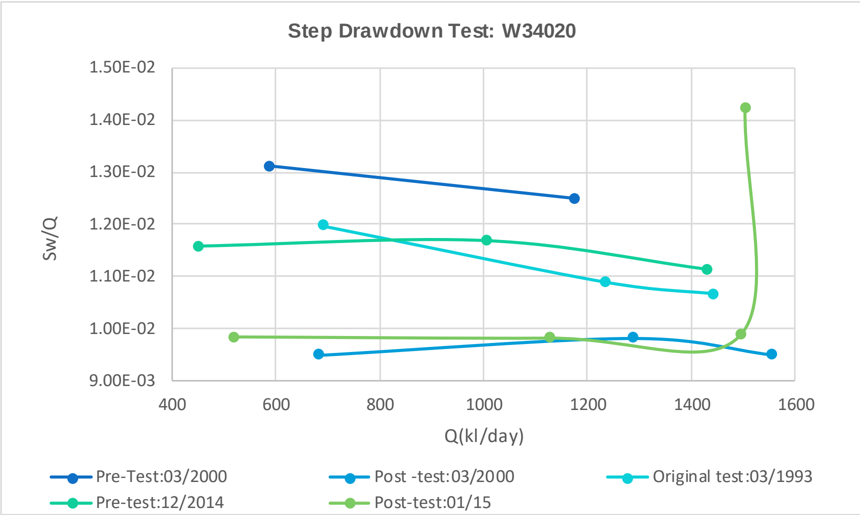
ORIGINAL TEST - CSIR Rest Waterlevel = 9.200 m.bgl (03/93)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.0	691	8.281	1.20E-02
2	14.3	1236	13.459	1.09E-02
3	16.7	1443	15.391	1.07E-02
Average				1.12E-02
Decline(-) / Improve(+) Original				0

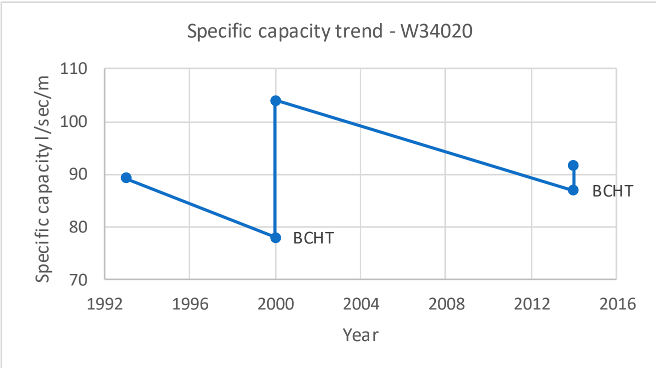
PRE-TEST Rest Waterlevel = 6.09 m.bgl (09/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.8	588	7.709	1.31E-02
2	13.6	1175	14.682	1.25E-02
Average				1.28E-02
Decline(-) / Improve(+) Original to Pre-Test				-15%

POST-TEST Rest Waterlevel = 6.14 m.bgl (14/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.9	683	6.488	9.50E-03
2	14.9	1287	12.639	9.82E-03
3	18.0	1555	14.786	9.51E-03
Average				9.61E-03
Decline(-) / Improve(+) Pre- to Post-Test				25%

PRE-TEST Rest Waterlevel = 2.63m.bgl (19/12/14)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.22	451	5.22	1.16E-02
2	11.64	1006	11.75	1.17E-02
3	16.55	1430	15.92	1.11E-02
4				
Average				1.15E-02
Decline(-) / Improve(+) Pre 2014 to Post-test 2000				-19.6%

POST-TEST Rest Waterlevel =2.79 m.bgl (22/01/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.00	518	5.10	9.85E-03
2	13.05	1127	11.07	9.82E-03
3	17.33	1497	14.82	9.90E-03
4	17.41	1504	21.38	1.42E-02
Average				1.09E-02
Decline(-) / Improve(+) Pre- to Post-Test 2014/15				4.5%





Date	SC l/s/m
1993	89.3
2000	78.1
2000	104
2014	87
2014	91.7

COMMENTS

2000 improvement: 25%
2014/15 improvement: 4.5%

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (2015)**

Vari-Speed Setting:

1. 28/20 Hz
2. 38/28 Hz
3. 42/34 Hz

Construction:

PVC (250 mm x 10mm wall) - no bidim
Screen depth: ~24 - 32m
Screen 0.8mm x 43mm slots size, 8 slots /row

CCTV log review

Before					4		
After				3			

WITZANDS AQUIFER - BOREHOLE W34029

ORIGINAL TEST - CSIR
Rest Waterlevel = 9.61 m.bgl (11/1996) Pump inlet - 27m

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.8	242	1.742	7.20E-03
2	8.6	743	5.462	7.35E-03
3	16.4	1417	9.666	6.82E-03
4	18.0	1555	11.192	7.20E-03
5	24.0	2074	14.180	6.84E-03
Average				7.08E-03
Decline(-) / Improve(+) Original				0

PRE-TEST
Rest Waterlevel = 4.93 m.bgl (12/04/2000)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.3	372	3.033	8.15E-03
2	7.4	639	5.31	8.31E-03
3	13.1	1132	9.001	7.95E-03
4	17.8	1538	11.774	7.66E-03
5	22.9	1979	15.445	7.80E-03
Average				7.97E-03
Decline(-) / Improve(+) Pre to Original-Test				-13%

POST-TEST
Rest Waterlevel = 4.98 m.bgl (14/04/2000)

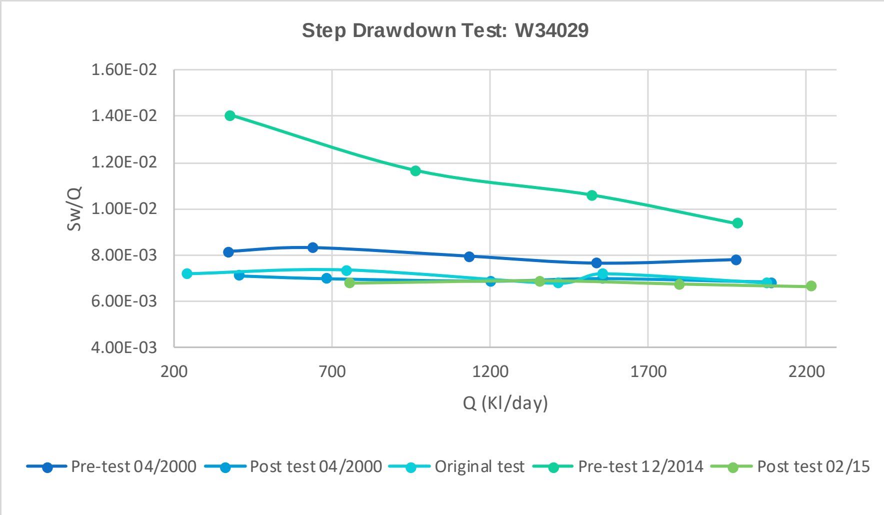
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.7	406	2.899	7.14E-03
2	7.9	683	4.781	7.00E-03
3	13.9	1201	8.259	6.88E-03
4	18.0	1555	10.893	7.01E-03
5	24.2	2091	14.283	6.83E-03
Average				6.97E-03
Decline(-) / Improve(+) Pre- to Post-Test				14%

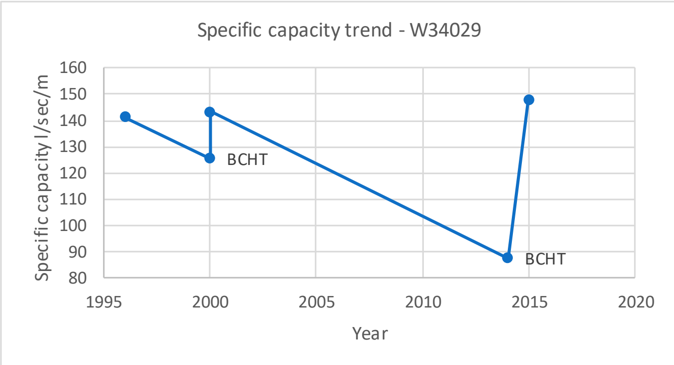
PRE-TEST
Rest Waterlevel = 1.66 m.bgl (15/12/2014)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.36	377	5.29	1.40E-02
2	11.16	964	11.24	1.17E-02
3	17.61	1521	16.13	1.06E-02
4	22.97	1985	18.59	9.37E-03
Average				1.14E-02
Decline(-)0/Improve(+) Pre- '15 to Post-Test '00				-39%

POST-TEST
Rest Waterlevel = 1.94m.bgl (27/02/2015)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.75	756	5.13	6.79E-03
2	15.69	1356	9.33	6.88E-03
3	20.81	1798	12.14	6.75E-03
4	25.66	2217	14.74	6.65E-03
Average				6.77E-03
Decline(-)/Improve(+) Post-'15 to Pre test '15				40.6%





Date	SC l/s/m
1996	141.2
2000	125.5
2000	143.5
2014	87.7
2015	147.7

COMMENTS

2000 improvement: 13%
2015 improvement: 41%

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (02/2015)**

Vari-Speed Setting 2000/2015:

1. 22/20 Hz
2. 26/28 Hz
3. 34/34 Hz
4. 40/40 Hz
5. 48 Hz

Construction:

PVC (250mm class 9 & class 12) - no bidim
0.5mm slots, 5% open area, horizontal slots
Screen: 26m - 38m
Grade 16/30 (1.19mm to 595 micron) gravel pack, 400mm diameter filled from 18 - 43m

CCTV log review

Before						5	
After			2				

WITZANDS AQUIFER - BOREHOLE W34012

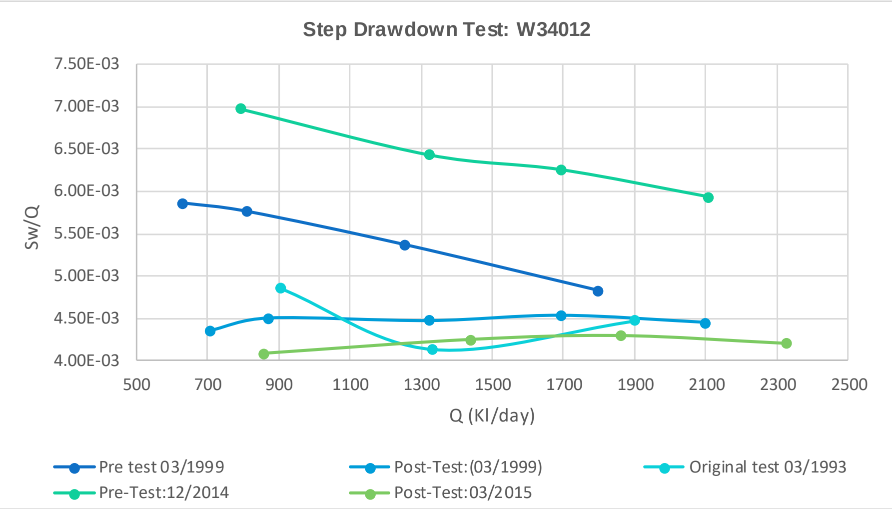
ORIGINAL TEST - CSIR Rest Waterlevel = ?? m.bgl (??) (1993)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.5	907	4.4	4.85E-03
2	15.4	1330	5.5	4.14E-03
3	22	1901	8.5	4.47E-03
Average				4.49E-03
Decline(-) / Improve(+) Original				0

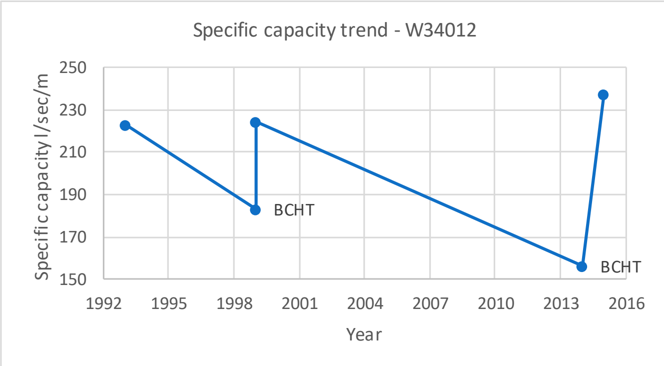
PRE-TEST Rest Waterlevel = 9.54 m.bgl (15/03/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.3	631	3.684	5.86E-03
2	9.4	812	4.672	5.76E-03
3	14.5	1253	6.741	5.37E-03
4	20.8	1797	8.667	4.83E-03
Average				5.46E-03
Decline(-) / Improve(+) Original to Pre-Test				-22%

POST-TEST Rest Waterlevel = 9.06 m.bgl (19/03/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.2	708	3.084	4.36E-03
2	10.1	873	3.918	4.50E-03
3	15.3	1322	5.894	4.47E-03
4	19.6	1693	7.673	4.53E-03
5	24.3	2100	9.325	4.45E-03
Average				4.46E-03
Decline(-) / Improve(+) Pre- to Post-Test				18%

PRE-TEST Rest Waterlevel = 2.54 m.bgl (12/12/14)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.2	795	5.54	6.97E-03
2	15.3	1322	8.5	6.43E-03
3	19.6	1693	10.59	6.26E-03
4	24.4	2108	12.51	5.93E-03
Average				6.40E-03
Decline(-)/Improve(+) Pre- '15 to Post-Test 1999				-43%

POST-TEST Rest Waterlevel = 2.81 m.bgl (06/03/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.92	857	3.5	4.08E-03
2	16.66	1439	6.11	4.25E-03
3	21.55	1862	7.99	4.29E-03
4	26.92	2326	9.77	4.20E-03
Average				4.21E-03
Decline(-) / Improve(+) Original to Post-Test				34%





Date	SC l/s/m
1993	222.7
1999	183.1
1999	224.2
2014	156.2
2015	237.5

COMMENTS

1999 improvement: 18%
2015 improvement: 34%

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (03/2015)**

Vari-Speed Setting: 1999 & 2015

1. 28/20 Hz
2. 30/28 Hz
3. 35/34 Hz
4. 40/40 Hz
5. 45/48* Hz

*2015 crash @ 1 min

Construction:

PVC with bidim.
250mm PVC 10mm wall
Screen ~26.5 - 37.7m with 3mm x 80mm slots, 5 slots to row
U34 bidim - 2 layers

CCTV log review

Before					4		
After			2				

WITZANDS AQUIFER - BOREHOLE G33103

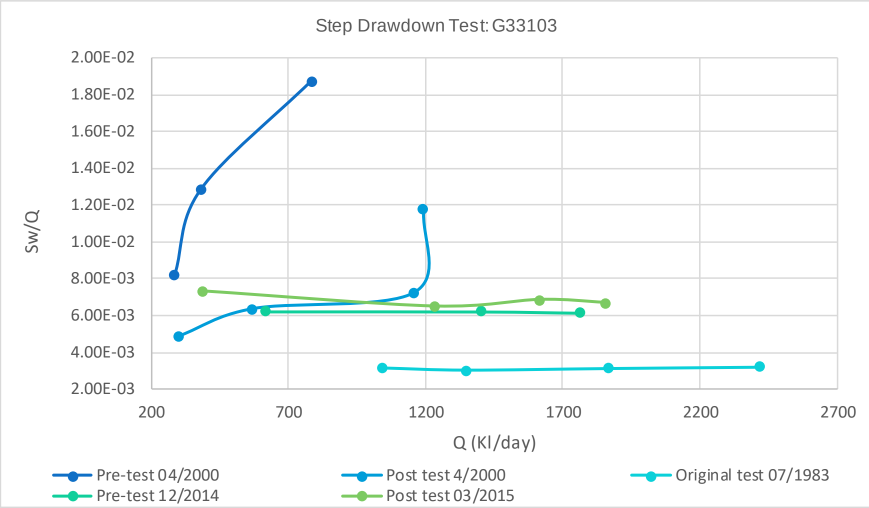
ORIGINAL TEST - DWAF Rest Waterlevel =7. 450m.bg(07/1983)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	12.1	1045	3.307	3.16E-03
2	15.6	1348.0	4.049	3.00E-03
3	21.6	1866	5.82	3.12E-03
4	28.0	2419	7.785	3.22E-03
Average				3.13E-03
Decline(-) / Improve(+) Original				0

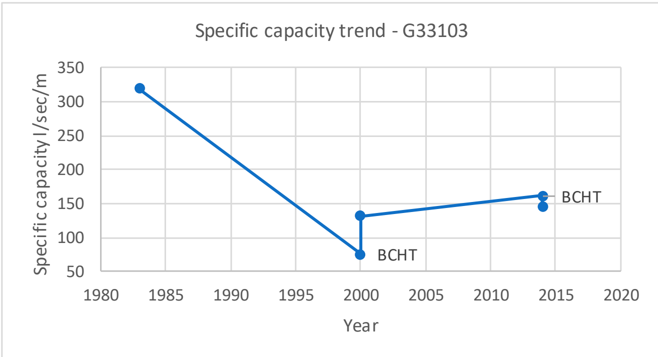
PRE-TEST Rest Waterlevel = 8.800 m.bgl (17/04/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.3	285	2.348	8.24E-03
2	4.4	380	4.879	1.28E-02
3	9.1	786	14.714	1.87E-02
Average				1.33E-02
Decline(-) / Improve(+) Pre to Original-Test				-324%

POST-TEST Rest Waterlevel = 8.830m.bgl (19/04/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.5	302	1.472	4.87E-03
2	6.6	570	3.624	6.36E-03
3	13.4	1158	8.39	7.25E-03
4	13.8	1192	14.092	1.18E-02
Average				7.57E-03
Decline(-) / Improve(+) Pre- to Post-Test				43%

PRE-TEST Rest Waterlevel = 5.5 m.bgl (22/12/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.2	619	3.85	6.22E-03
2	16.22	1401	8.71	6.22E-03
3	14.4	1764	10.9	6.18E-03
4				
Average				6.21E-03
Decline(-) / Improve(+) Pre 2014 to Post-Test 2000				18%

POST-TEST Rest Waterlevel = 5.97m.bgl (13/03/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.47	386	2.82	7.31E-03
2	14.28	1234	8.02	6.50E-03
3	18.72	1617	11.08	6.85E-03
4	21.50	1858	12.43	6.69E-03
Average				6.84E-03
Decline(-) / Improve(+) Post-Test to Pre -test 2015				-10%





Date	SC l/s/m
1983	319.4
2000	75.2
2000	132.1
2014	161
2014	146.2

COMMENTS

2000 improvement: 43%

Comment: The bidim w rap is the limiting factor in increasing the production of this borehole. It w ould be a good candidate for reconstruction or be used as an injection w ell for the vyredox process experiment.

2015 decline: -10%

Optimum Pumping Rate: 5 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (03/2015)?**

Vari-Speed Setting: 2000/2015

1. 22/20 Hz
2. 26/28 Hz
3. 34/34 Hz
4. 40/40 Hz

Construction:

PVC (195mm) -w ith bidim.

U34 bidim w rap -2 layers

Screen 15m - 39m - 3mm x 100mm slots, 23 row s x 46 slots

CCTV log review

Before					4		
After					4		

WITZANDS AQUIFER - BOREHOLE W34031

ORIGINAL TEST - CSIR
Rest Waterlevel = 1.83m.bgl (11/11/1996)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.6	311	1.640	5.27E-03
2	8.6	743	5.350	7.20E-03
3	16.1	1391	9.420	6.77E-03
4	20.0	1728	11.550	6.68E-03
5	24.2	2091	14.390	6.88E-03
Average				6.88E-03
Decline(-) / Improve(+) Original				0

PRE-TEST
Rest Waterlevel = 4.55m.bgl (22/04/2002)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.0	518	2.659	5.13E-03
2	9.2	795	4.145	5.21E-03
3	12.4	1071	5.581	5.21E-03
4	17.1	1477	7.785	5.27E-03
5	23.0	1987	10.398	5.23E-03
Average				5.21E-03
Decline(-) / Improve(+) Original to Pre-Test				-32%

POST-TEST
Rest Waterlevel = 4.64m.bgl (26/04/2002)

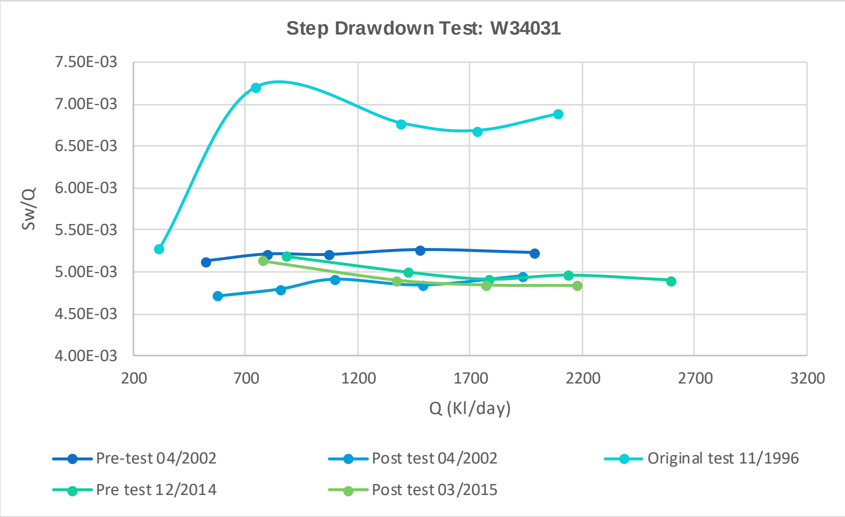
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.6	570	2.688	4.71E-03
2	9.9	855	4.104	4.80E-03
3	12.7	1097	5.392	4.91E-03
4	17.2	1486	7.201	4.85E-03
5	22.4	1935	9.591	4.96E-03
Average				4.85E-03
Decline(-) / Improve(+) Pre- to Post-Test				7%

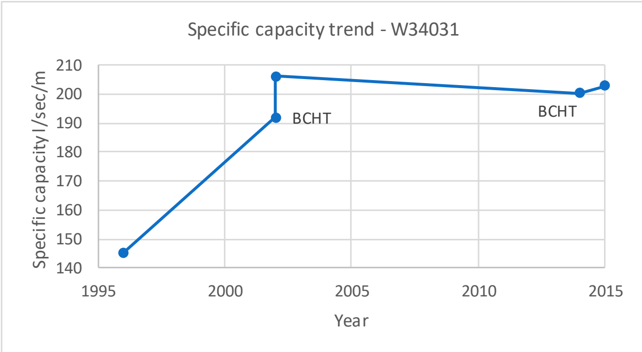
PRE-TEST
Rest Waterlevel = 2.59m.bgl (23/12/2014)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.22	883	4.58	5.19E-03
2	16.50	1426	7.120	4.99E-03
3	20.66	1785	8.76	4.91E-03
4	24.75	2138	10.6	4.96E-03
5	30.03	2595	12.71	4.90E-03
Average				4.99E-03
Decline(-) / Improve(+) Pre-Test 2015 to Post test 2002				-28%

POST-TEST
Rest Waterlevel = 3.21m.bgl (19/03/2015)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.97	775	3.98	5.14E-03
2	15.83	1368	6.71	4.90E-03
3	20.50	1771	8.58	4.84E-03
4	25.16	2174	10.52	4.84E-03
Average				4.93E-03
Decline(-) / Improve(+) Post-Test 2015 to Pre test 2014				1%





Date	SC l/s/m
1996	145.3
2002	191.9
2002	206.2
2014	200.4
2015	202.8

COMMENTS

2002 improvement: 7%
2015 improvement: 1%

Optimum Pumping Rate: 7 L/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (03/2015)?**

Vari-Speed Setting: 2002/2015

1. 22/20 Hz
2. 26/28 Hz
3. 30/34 Hz
4. 36/40 Hz
5. 44 Hz

Construction detail:

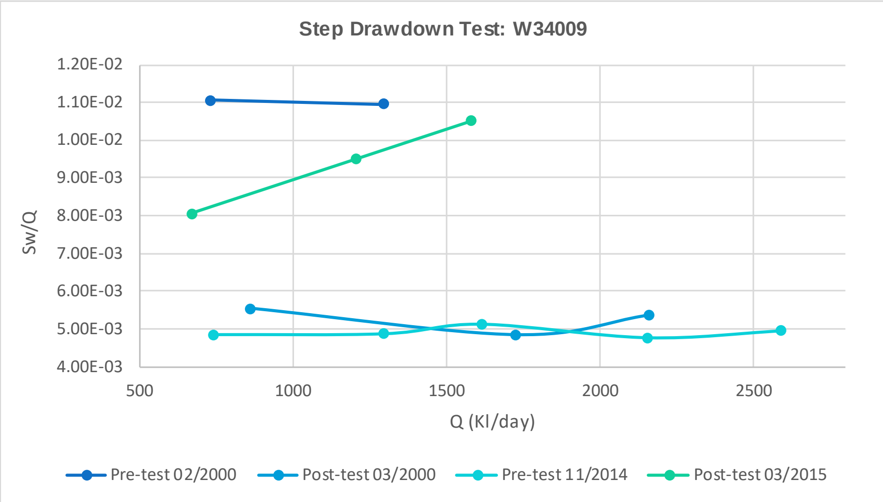
PVC (250mm class 9 & class 12) - no bidim
0.5mm slots, 5% open area
Screen: 25.5m - 37.5m
Grade 16/30 (1.19mm to 595 micron) gravel pack, 400mm diameter filled from 15-40m.

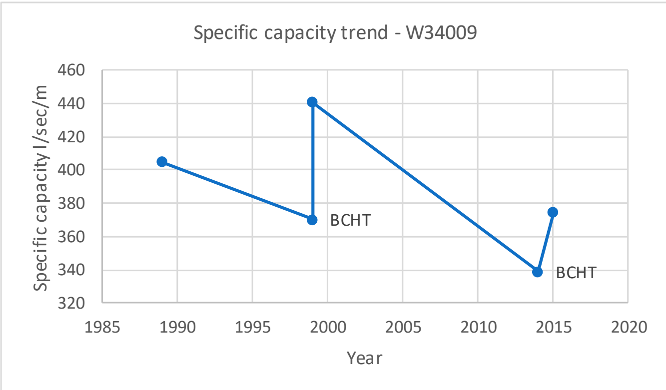
CCTV log review

Before					4		
After				3			

WITZANDS AQUIFER - BOREHOLE W34009

ORIGINAL TEST - CSIR - No data available Rest Waterlevel = m.bg Pump inlet (no data)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original				
PRE-TEST Rest Waterlevel = 6.480 m.bgl (28/02/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.5	734	8.12	1.11E-02
2	15.0	1296	14.21	1.10E-02
Average				1.10E-02
Decline(-) / Improve(+) Pre to Original-Test				0%
POST-TEST Rest Waterlevel = 6.280 m.bgl (02/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.0	864	4.784	5.54E-03
2	20.0	1728	8.385	4.85E-03
3	25.0	2160	11.573	5.36E-03
Average				5.25E-03
Decline(-) / Improve(+) Pre- to Post-Test				52%
PRE-TEST Rest Waterlevel = 2.65 m.bgl (17/11/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	8.6	741	3.60	4.86E-03
2	15.03	1299	6.34	4.88E-03
3	18.7	1617	8.28	5.12E-03
4	24.9	2155	10.30	4.78E-03
5	30.0	2592	12.84	4.95E-03
Average				4.92E-03
Decline(-)/Improve(+) Pre- '14 to Post-Test '00				-6%
POST-TEST Rest Waterlevel = 3.21m.bgl (21/03/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.77	671	5.41	8.06E-03
2	13.97	1207	11.47	9.50E-03
3	18.31	1582	16.63	1.05E-02
Average				9.36E-03
Decline(-) / Improve(+) Original to Post-Test				-90%





Date	SC l/s/m
1989	404.9
1999	370.4
1999	440.5
2014	339
2015	374.5

COMMENTS

2000 improvement: 52%
2015 improvement/decline: -90% (possible retest)
2016 comment: It was planned to have the staff retest this hole with smaller pump as part of their training but this never materialised. Power supply problems still prevail due to the fire in January 2016.

Optimum Pumping Rate: 5 l/s

Pre- & Post-Testing Details:
Pump Inlet Depth: **22.5m (03/2015)**

Vari-Speed Setting:
1. 30/20 Hz
2. 38/28 Hz
3. 45/34 Hz

Construction:
PVC (250mm) -no bidim.
Screen 25.5 - 36m, 250mm class 12 PVC with 250mm slots of 0.5mm(?)
Camera shows different configuration.
7/16 gravel pack

CCTV log review

Before						5	
After					4		

WITZANDS AQUIFER - BOREHOLE W34011

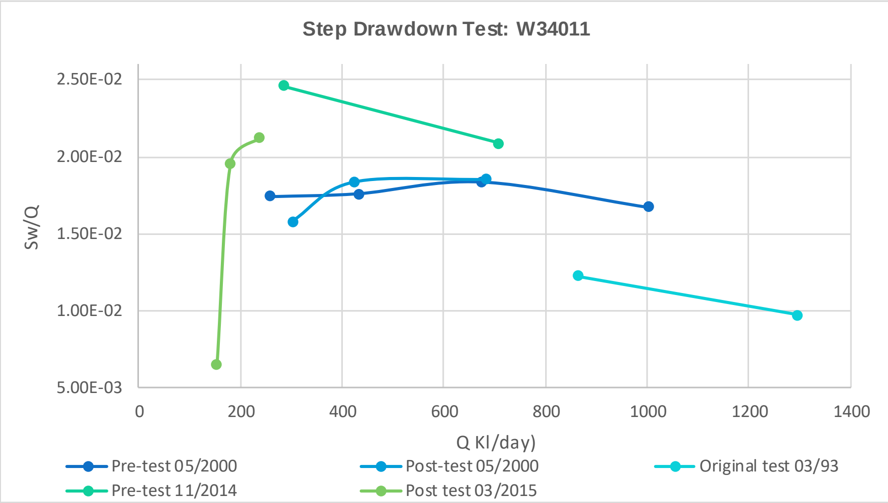
ORIGINAL TEST - CSIR Rest Waterlevel =10.600 m.bg(03/93) Pump inlet - 28.89m				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10	864	10.600	1.23E-02
2	15.0	1296.0	12.607	9.73E-03
Average				1.10E-02
Decline(-) / Improve(+) Original				0

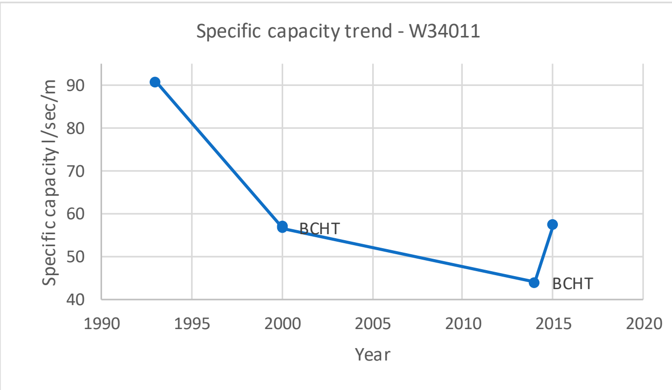
PRE-TEST Rest Waterlevel = 5.370 m.bgl (01/05/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.0	259	4.513	1.74E-02
2	5.0	432	7.608	1.76E-02
3	7.8	674	12.369	1.84E-02
4	11.6	1002	16.783	1.67E-02
Average				1.75E-02
Decline(-) / Improve(+) Pre to Original-Test				-59%

POST-TEST Rest Waterlevel = 5.450 m.bgl (04/05/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.5	302	4.765	1.58E-02
2	4.9	423	7.779	1.84E-02
3	7.9	683	12.685	1.86E-02
Average				1.76E-02
Decline(-) / Improve(+) Pre- to Post-Test				0%

PRE-TEST Rest Waterlevel = 2.65 m.bgl (17/11/2014)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.3	285	7.01	2.46E-02
2	8.19	708	14.78	2.09E-02
Average				2.27E-02
Decline(-) / Improve(+) Original to Post-Test				-28%

POST-TEST Rest Waterlevel = 3.21m.bgl (21/03/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	1.77	153	1.00	6.54E-03
2	2.08	180	3.53	1.96E-02
3	2.76	238	5.05	2.12E-02
4(46min)	3.48	301	6.66	2.21E-02
Average				1.74E-02
Decline(-) / Improve(+) Original to Post-Test				23%





Date	SC l/s/m
1993	90.9
2000	57.1
2000	56.8
2014	44
2015	57.47

COMMENTS

2000 improvement: 0%
2015 improvement: 23%
2015 comment: It would not be worth using this hole in future. Construction is a problem and as a result it is highly inefficient

Optimum Pumping Rate: Not worth equipping & using

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (03/2015)**

Vari-Speed Setting: 2000 & 2015

1. 22/20 Hz
2. 26/28 Hz
3. 32/34 Hz
4. 38/40 Hz

Construction:

PVC (200mm) -with bidim.
250mm PVC 10mm wall
Screen ~23 - 34m with 3mm x 80mm slots, 5 slots to row
U34 bidim - 2 layers

CCTV log review

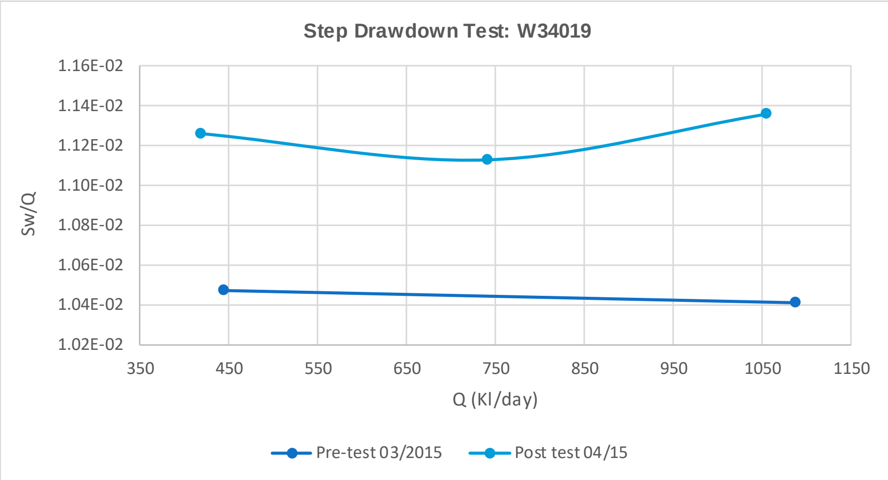
Before						5	
After						Compromised	

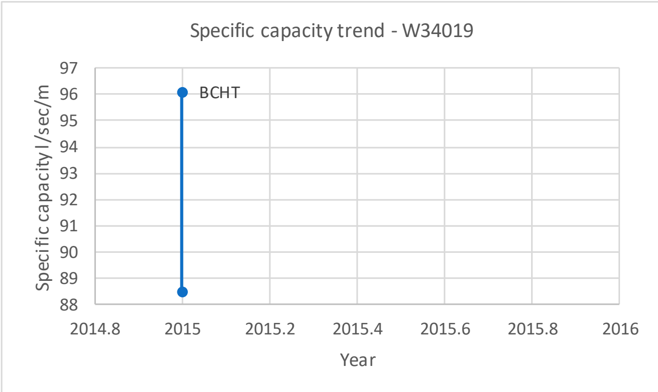
WITZANDS AQUIFER - BOREHOLE W34019

ORIGINAL TEST - CSIR - No data available Rest Waterlevel = ??m.bg(??) (no data)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original				

PRE-TEST Rest Waterlevel = 5.21 m.bgl (27/03/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.14	444	4.65	1.05E-02
2	12.61	1089	11.34	1.04E-02
Average				1.04E-02
Decline(-) / Improve(+) Pre to Original-Test				0%

POST-TEST Rest Waterlevel = 5.28 m.bgl (13/04/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.9	419	4.72	1.13E-02
2	8.6	741	8.25	1.11E-02
3	12.2	1056	12.00	1.14E-02
Average				1.13E-02
Decline(-) / Improve(+) Pre- to Post-Test				-8.7%





Date	SC l/s/m
2015	96.1
2015	88.5

COMMENTS

2015 decline: -8.7 %

2015 comment - This hole has been out of commission since Decmber 1994 ???? Reason unknow n

Optimum Pumping Rate: 5 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (03/2015)**

Vari-Speed Setting:

1. 20 Hz
2. 25 Hz
3. 28 Hz

Construction:

PVC (250mm x 10mm w all) - No bidim????

Screen: 0.8mm x 43mm slot size, 8 slots/row

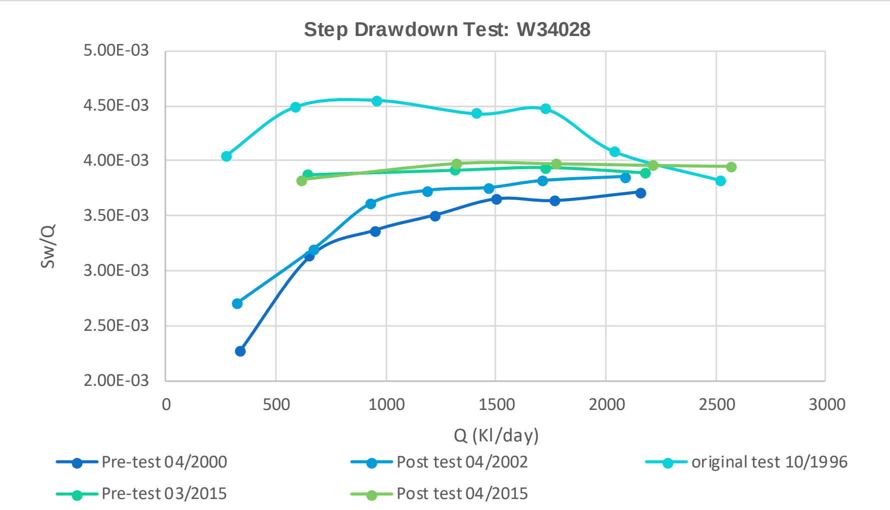
Screen ~20 - 26m

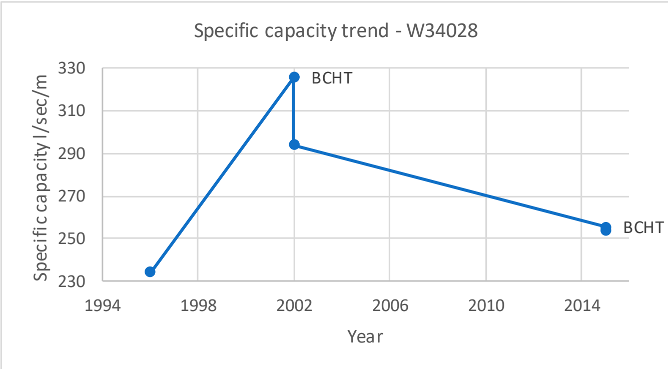
CCTV log review

Before					Decomissioned		
After					4		

WITZANDS AQUIFER - BOREHOLE W34028

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
ORIGINAL TEST - CSIR				
Rest Waterlevel = 12.1m.bgl (28/10/1996)				
1	3.2	276	1.120	4.05E-03
2	6.8	588	2.640	4.49E-03
3	11.1	959	4.370	4.56E-03
4	16.4	1417	6.280	4.43E-03
5	20.0	1728	7.730	4.47E-03
6	23.6	2039	8.330	4.09E-03
7	29.2	2523	9.640	3.82E-03
Average				4.27E-03
Decline(-) / Improve(+) Original				0
PRE-TEST				
Rest Waterlevel = 6.31m.bgl (03/04/2002)				
1	3.9	337	0.767	2.28E-03
2	7.6	657	2.059	3.14E-03
3	11.0	950	3.204	3.37E-03
4	14.2	1227	4.307	3.51E-03
5	17.4	1503	5.495	3.66E-03
6	20.5	1771	6.445	3.64E-03
7	25.0	2160	8.033	3.72E-03
Average				3.07E-03
Decline(-) / Improve(+) Original to Pre-Test				28%
POST-TEST				
Rest Waterlevel = 6.17m.bgl (18/04/2002)				
1	3.8	328	0.890	2.71E-03
2	7.8	674	2.159	3.20E-03
3	10.8	933	3.374	3.62E-03
4	13.8	1192	4.449	3.73E-03
5	17.0	1469	5.517	3.76E-03
6	19.8	1711	6.535	3.82E-03
7	24.2	2091	8.066	3.86E-03
Average				3.40E-03
Decline(-) / Improve(+) Pre- to Post-Test				-11%
PRE-TEST				
Rest Waterlevel = 4.59m.bgl (23/03/2015)				
1	7.50	648	2.51	3.87E-03
2	15.22	1315	5.150	3.92E-03
3	19.97	1725	6.8	3.94E-03
4	25.25	2182	8.49	3.89E-03
Average				3.91E-03
Decline(-)/Improve(+) Pre-'15 to Post-test 2002				-15%
POST-TEST				
Rest Waterlevel = 4.78m.bgl (16/04/2015)				
1	7.14	619	2.370	3.83E-03
2	15.28	1320	5.25	3.98E-03
3	20.53	1774	7.05	3.97E-03
4	25.64	2215	8.77	3.96E-03
5	29.77	2572	10.16	3.95E-03
Average				3.94E-03
Decline(-)/Improve(+) Post-'15 to Pre-Test 2015				0.76%





Date	SC l/s/m
1996	234.2
2002	325.7
2002	294.1
2015	255.7
2015	253.8

COMMENTS

2002 decline: -11%

2015 improvement: 1%

Optimum Pumping Rate: 5 L/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.5m (04/2015)**

Vari-Speed Setting: 2002/2015

1. 20/20 Hz
2. 24/28 Hz
3. 28/34 Hz
4. 32/40 Hz
5. 36/45 Hz
6. 40 Hz
7. 46 Hz

Construction detail:

PVC (250mm class 9 & class 12) - no bidim ?

0.5mm slots, 5% open area

Screen: 26m - 38m

Grade 16/30 (1.19mm to 595 micron) gravel pack

filled from 15 - 41m.

CCTV log review

Before						5	
After				3			

WITZANDS AQUIFER - BOREHOLE W34013

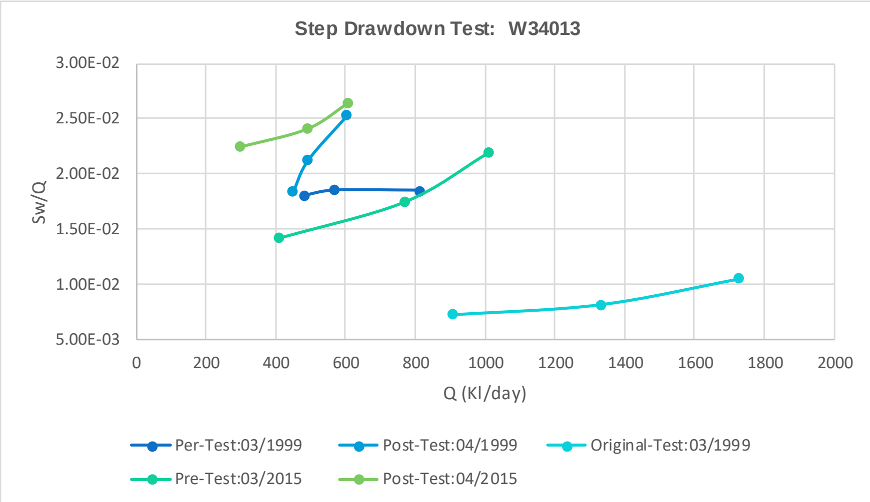
ORIGINAL TEST - CSIR Rest Waterlevel = ?? m.bgl (??) (1993)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.5	907	6.600	7.28E-03
2	15.4	1331	10.900	8.19E-03
3	20.0	1728	18.200	1.05E-02
Average				8.67E-03
Decline(-) / Improve(+) Original				0

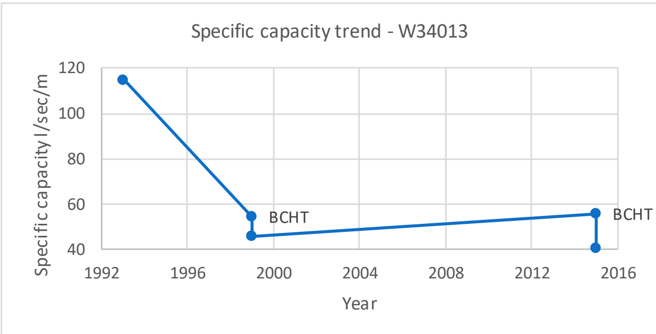
PRE-TEST Rest Waterlevel = 9.18 m.bgl (28/03/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.6	484	8.727	1.80E-02
2	6.6	570	10.556	1.85E-02
3	9.4	812	15.024	1.85E-02
Average				1.83E-02
Decline(-) / Improve(+) Pre to Original-Test				53%

POST-TEST Rest Waterlevel = 8.92 m.bgl (01/04/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.2	449	8.257	1.84E-02
2	5.7	492	10.474	2.13E-02
3	7.0	605	15.312	2.53E-02
Average				2.17E-02
Decline(-) / Improve(+) Pre- to Post-Test				-18%

PRE-TEST Rest Waterlevel =2.60 m.bgl(24/03/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.72	408	5.80	1.42E-02
2	8.94	772	13.53	1.75E-02
3	11.69	1010	22.15	2.19E-02
Average				1.79E-02
Decline(-) / Improve(+) Pre 2015to Post-test 1999				-18%

POST-TEST Rest Waterlevel = 2.48 m.bgl (20/04/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.43	296	6.65	2.2466E-02
2	5.67	490	11.8	2.4082E-02
3	7.01	606	15.97	2.6353E-02
Average				2.43E-02
Decline(-) / Improve(+) Pre- to Post-Test 2015				-36%





Date	SC l/s/m
1993	115
1999	54.6
1999	46.1
2015	55.9
2015	41.1

COMMENTS

1999 decline: -18%
2015 decline: -36%

2015 comment - This hole should be reconstructed

Optimum Pumping Rate: 2 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **25.7m (04/2015)**

Vari-Speed Setting:

1. 28/20 Hz
2. 30/25 Hz
3. 35/28 Hz

Construction:

PVC with bidim.
250mm PVC 10mm wall
Screen ~27 - 38m with 3mm x 80mm slots, 5 slots to row
U34 bidim - 2 layers??

CCTV log review

Before					4		
After					4		

WITZANDS AQUIFER - BOREHOLE G33107

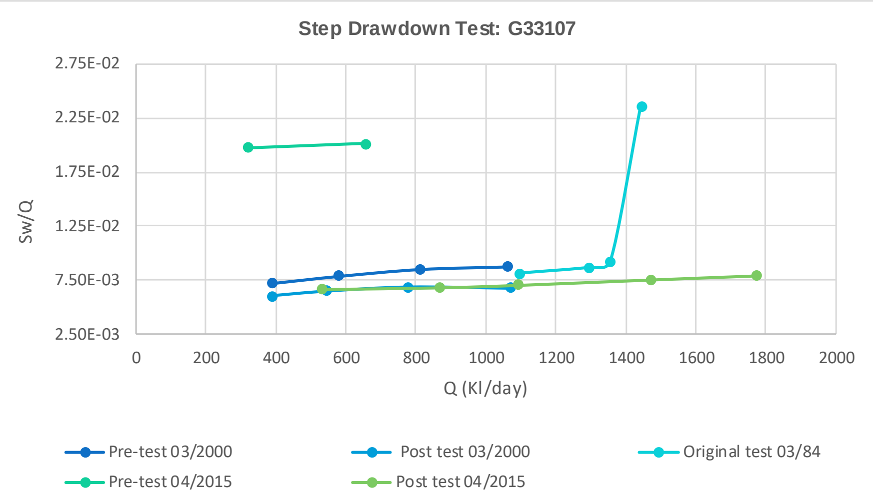
ORIGINAL TEST - DWAF Rest Waterlevel = 5.21m.bgl (01/03/1984)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	12.7	1097	8.908	8.12E-03
2	15.0	1296	11.213	8.65E-03
3	15.7	1356	12.512	9.23E-03
4	16.7	1443	34.029	2.36E-02
Average				1.24E-02
Decline(-) / Improve(+) Original				0

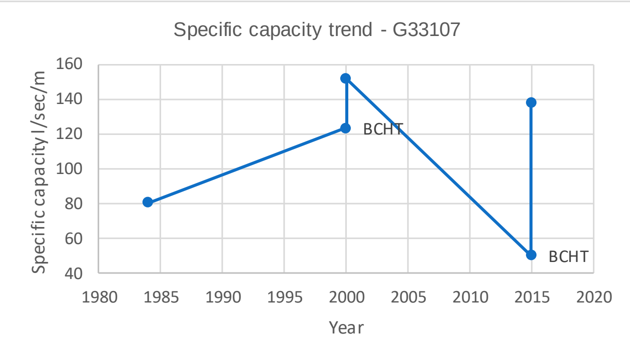
PRE-TEST Rest Waterlevel = 6.43 m.bgl (03/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.5	389	2.827	7.27E-03
2	6.7	579	4.574	7.90E-03
3	9.4	812	6.915	8.52E-03
4	12.3	1063	9.299	8.75E-03
Average				8.11E-03
Decline(-) / Improve(+) Pre to Original-Test				35%

POST-TEST Rest Waterlevel = 6.43 m.bgl (08/03/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.5	389	2.369	6.09E-03
2	6.3	544	3.549	6.52E-03
3	9.0	778	5.385	6.92E-03
4	12.4	1071	7.288	6.80E-03
Average				6.59E-03
Decline(-) / Improve(+) Pre- to Post-Test				19%

PRE-TEST Rest Waterlevel = 4.14 m.bgl (21/04/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.72	321	6.34	1.98E-02
2	7.57	654	13.15	2.01E-02
Average				1.99E-02
Decline(-) / Improve(+) Pre 2015 to Post-Test 2000				-201%

POST-TEST Rest Waterlevel = 4.14 m.bgl (24/04/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.14	530	3.55	6.70E-03
2	10.03	867	5.94	6.85E-03
3	12.63	1091	7.72	7.08E-03
4	17.00	1469	11.12	7.57E-03
5	20.50	1771	14.07	7.94E-03
Average				7.23E-03
Decline(-) / Improve(+) Original to Post-Test				175%





Date	SC l/s/m
1984	80.6
2000	123.3
2000	151.7
2015	50.3
2015	138.3

COMMENTS

2000 improvement: 19%

Comment: The pre- and post tests indicate an average improvement of 19% in the specific draw dow n of the borehole. Note the original pumptest data and the effect of the bidim. Also a candidate for reconstruction or as an injection w ell for the vyredox process.

2014 improvement: 175%

Comment: When this hole is pumped at too high a rate the draw dow n is to a point below 14m w here w ater starts cascading into the hole w hich in turn affects the level probes resulting in an erratic pumping cycle. Reconstruction is imperative if this hole is to be properly utilised.

Optimum Pumping Rate: 5 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: 22.7m (04/2015)

Vari-Speed Setting: 2000/2015

1. 21/20 Hz
2. 24/25 Hz
3. 28/28 Hz
4. 32/34 Hz
5. 0/40 Hz

Construction:

PVC (195mm) - w ith bidim.

Screen 8.9 - 33m class 6 & 12

3mm x 100mm slots - 23 row s x 46 slots/6m

U34 bidim - 2 layers

CCTV log review

Before						5	
After				3			

WITZANDS AQUIFER - BOREHOLE W34014

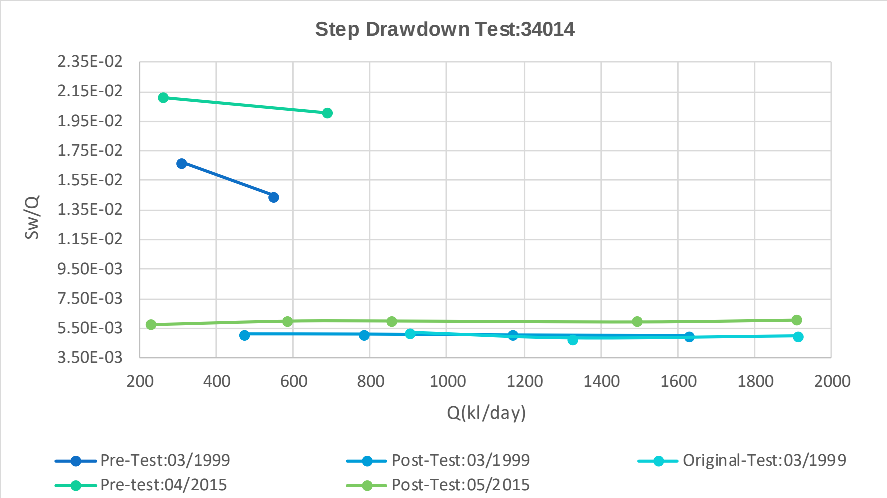
ORIGINAL TEST - CSIR Rest Waterlevel = ?? m.bgl (??) 1993??				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.5	907	4.700	5.18E-03
2	15.4	1331	6.400	4.81E-03
3	22.2	1918	9.500	4.95E-03
Average				4.98E-03
Decline(-) / Improve(+) Original				0

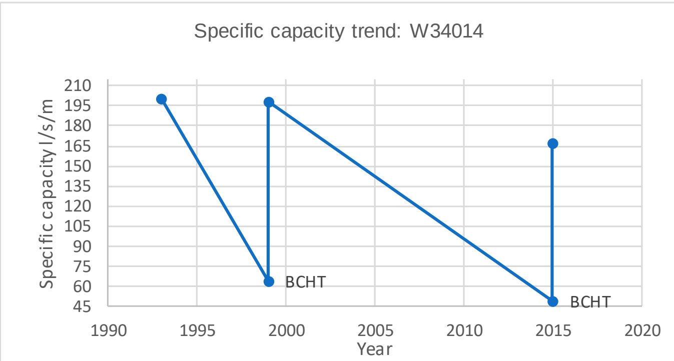
PRE-TEST Rest Waterlevel = 10.78 m.bgl (23/03/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.6	311	5.194	1.67E-02
2	6.4	553	7.972	1.44E-02
Average				1.56E-02
Decline(-) / Improve(+) Pre to Original-Test				68%

POST-TEST Rest Waterlevel = 12.00 m.bgl (26/03/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.5	475	2.436	5.13E-03
2	9.1	786	4.019	5.11E-03
3	13.6	1175	5.910	5.03E-03
4	18.9	1633	8.143	4.99E-03
Average				5.06E-03
Decline(-) / Improve(+) Pre- to Post-Test				67%

PRE-TEST Rest Waterlevel = 6.82m.bgl (28/04/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.06	264	5.58	2.11E-02
2	8	691	13.88	2.01E-02
Average				2.06E-02
Decline(-) / Improve(+) Pre 2015 to Post-test '99				-75%

POST-TEST Rest Waterlevel = 7.85 m.bgl (8/05/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.7	230	1.33	5.78E-03
2	6.8	588	3.55	6.04E-03
3	9.9	857	5.18	6.04E-03
4	17.3	1496	8.94	5.98E-03
5	22.1	1913	11.69	6.11E-03
Average				5.99E-03
Decline(-) / Improve(+) Pre- to Post-Test 2015				71%





Date	SC l/s/m
1993	200
1999	64
1999	198
2015	49
2015	167

COMMENTS

1999 improvement: 67%
2015 improvement: 71%

1999 comment - borehole was well developed.

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (05/15)**

Vari-Speed Setting:

1. 28/20 Hz
2. 32/25 Hz
3. 37/28 Hz
4. 40/34 Hz

Construction:

PVC - No bidim
250mm PVC 10mm wall
Screen ~23 - 34.5m with 0.5mm x 55mm slots, 7 slots to row

CCTV log review

Before						5	
After			2				

WITZANDS AQUIFER - BOREHOLE G30972

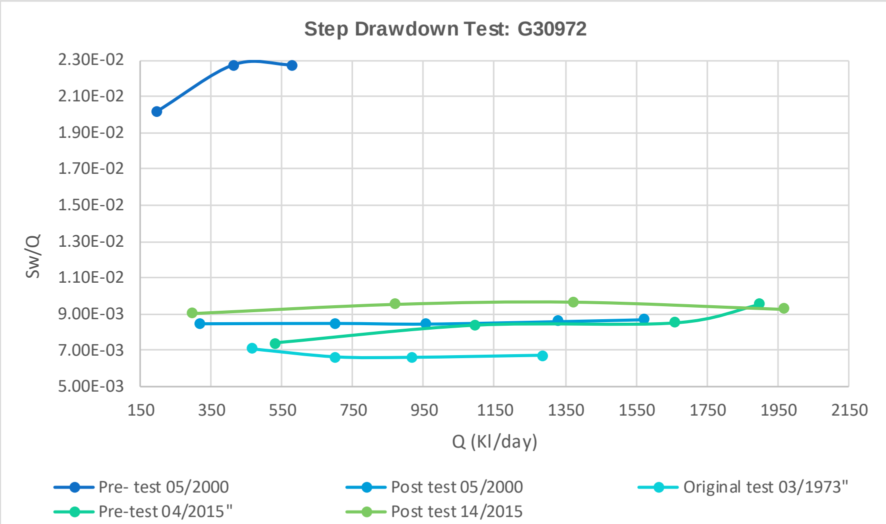
ORIGINAL TEST - DWAF Rest Waterlevel = 4.710 m.bgl (09/03/1979)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.4	467	3.309	7.09E-03
2	8.1	700	4.6	6.64E-03
3	10.6	916	6.054	6.61E-03
4	14.9	1287	8.659	6.73E-03
Average				6.77E-03
Decline(-) / Improve(+) Original				0

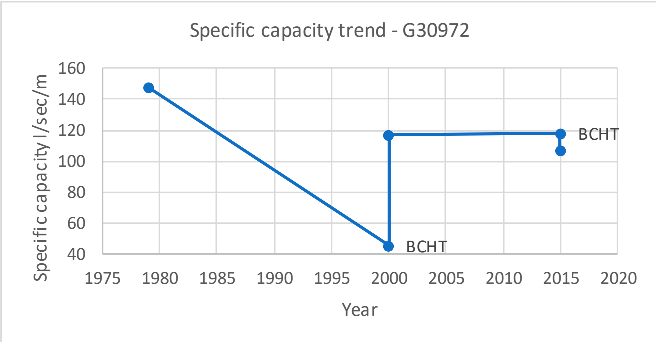
PRE-TEST Rest Waterlevel = 7.440 m.bgl (18/05/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.3	199	4.019	2.02E-02
2	4.8	415	9.438	2.27E-02
3	6.7	579	13.162	2.27E-02
Average				2.19E-02
Decline(-) / Improve(+) Original to Pre-Test				-224%

POST-TEST Rest Waterlevel = 7.330 m.bgl (23/05/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.7	320	2.719	8.50E-03
2	8.1	700	5.960	8.51E-03
3	11.1	959	8.133	8.48E-03
4	15.4	1331	11.452	8.60E-03
5	18.2	1572	13.674	8.70E-03
Average				8.56E-03
Decline(-) / Improve(+) Pre- to Post-Test				61%

PRE-TEST Rest Waterlevel =6.04m.bgl (29/04/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.14	530	3.92	7.40E-03
2	12.69	1096	9.2	8.39E-03
3	19.22	1661	14.16	8.52E-03
4(15min)	22.00	1901	18.19	9.57E-03
Average				8.47E-03
Decline(-) / Improve(+) Pre to Original-Test				-1%

POST-TEST Rest Waterlevel = 5.97 m.bgl (14/05/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.43	296	2.68	9.0541E-03
2	10.06	869	8.3	9.5512E-03
3	15.91	1375	13.3	9.6727E-03
4	22.8	1967	18.260	9.2832E-03
Average				9.39E-03
Decline(-) / Improve(+) Pre- to Post-Test				-11%





Date	SC l/s/m
1979	147.7
2000	45.7
2000	116.8
2015	118.1
2015	106.4

COMMENTS

2000 improvement: 61%
2015 improvement: -11%
This borehole responded well in 2000 having declined some 224% from its original. It may still be wise to reconstruct this borehole to extend its life even futher. The Pre- and Post-tests of 2000 indicate an average improvement of 61% in the specific drawdown of the well. Unfortunately the 2015 treatment did not yield the same result.

Optimum Pumping Rate: 5 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: 22.7m (05/2015)

Vari-Speed Setting: 2000 / 2015

1. 24/20 Hz
2. 30/28 Hz
3. 34/34 Hz
4. 40/40 Hz
5. 44/- Hz

Construction:

Mild steel casing - 203mm ID, with stainless wedge wire screen (johnson) - 152mm ID.
Screen ~26 - 29m & 30 - 33.7m
Size 0.75mm with 7/16 gravel pack

CCTV log review

Before						5	
After						5	

WITZANDS AQUIFER - BOREHOLE W34030

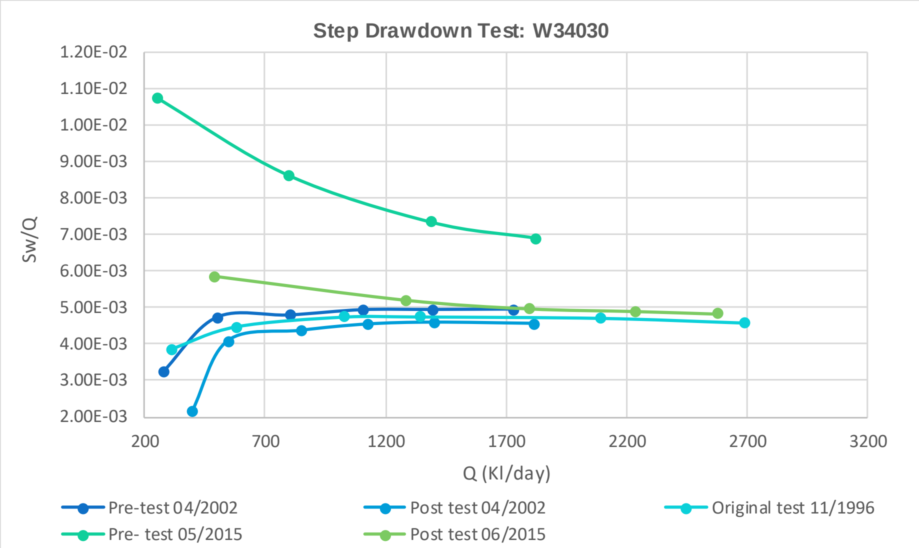
ORIGINAL TEST - CSIR Rest Waterlevel = 10.29m.bgl (05/11/1996)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.6	311	1.200	3.86E-03
2	6.7	579	2.590	4.47E-03
3	11.9	1028	4.880	4.75E-03
4	15.5	1339	6.360	4.75E-03
5	24.2	2091	9.850	4.71E-03
6	31.1	2687	12.310	4.58E-03
Average				4.52E-03
Decline(-) / Improve(+) Original				0

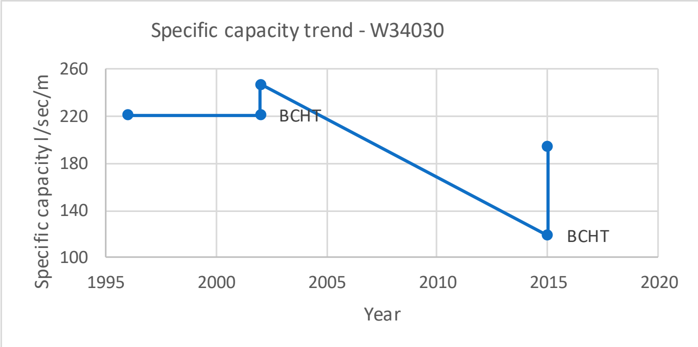
PRE-TEST Rest Waterlevel = 7.33m.bgl (01/04/2002)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.2	276	0.895	3.24E-03
2	5.8	501	2.365	4.72E-03
3	9.3	804	3.845	4.79E-03
4	12.8	1106	5.449	4.93E-03
5	16.1	1391	6.862	4.93E-03
6	20.0	1728	8.541	4.94E-03
Average				4.52E-03
Decline(-) / Improve(+) Original to Pre-Test				0%

POST-TEST Rest Waterlevel = 7.15m.bgl (11/04/2002)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.6	397	0.859	2.16E-03
2	6.3	544	2.220	4.08E-03
3	9.8	847	3.692	4.36E-03
4	13.0	1123	5.091	4.53E-03
5	16.2	1400	6.414	4.58E-03
6	21.0	1814	8.255	4.55E-03
Average				4.04E-03
Decline(-) / Improve(+) Pre- to Post-Test				11%

PRE-TEST Rest Waterlevel = 6.59m.bgl (20/05/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.89	250	2.69	1.08E-02
2	9.18	793	6.850	8.64E-03
3	16.07	1388	10.19	7.34E-03
4	21.10	1823	12.58	6.90E-03
Average				8.41E-03
Decline(-) / Improve(+) Pre-'15 to Post test '02				-52%

POST-TEST Rest Waterlevel = 6.54m.bgl (19/06/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.60	484	2.83	5.85E-03
2	14.83	1281	6.66	5.20E-03
3	20.75	1793	8.90	4.96E-03
4	25.86	2234	10.93	4.89E-03
5	29.81	2575	12.42	4.82E-03
Average				5.15E-03
Decline(-)/Improve(+) Post- '15 to Pre test '15				39%





Date	SC l/s/m
1996	221.2
2002	221.2
2002	247.5
2015	118.9
2015	194.2

COMMENTS

2002 improvement: 11%
2015: This hole showed 39% improvement

Optimum Pumping Rate: 7 L/S

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (06/2015)**

Vari-Speed Setting 2002/2015:

1. 21/20 Hz
2. 24/28 Hz
3. 28/30 Hz
4. 32/40 Hz
5. 36/45 Hz
6. 42/0 Hz

Construction detail:

PVC (250mm class 9 & class 12) - no bidim
0.5mm slots, 5% open area
Screen: 24.5m - 36.5m
Grade 16/30 (1.19mm to 595 micron) gravel pack, 400mm diameter filled FROM 14-40M

CCTV log review

Before						5	
After				3			

WITZANDS AQUIFER - BOREHOLE W34010

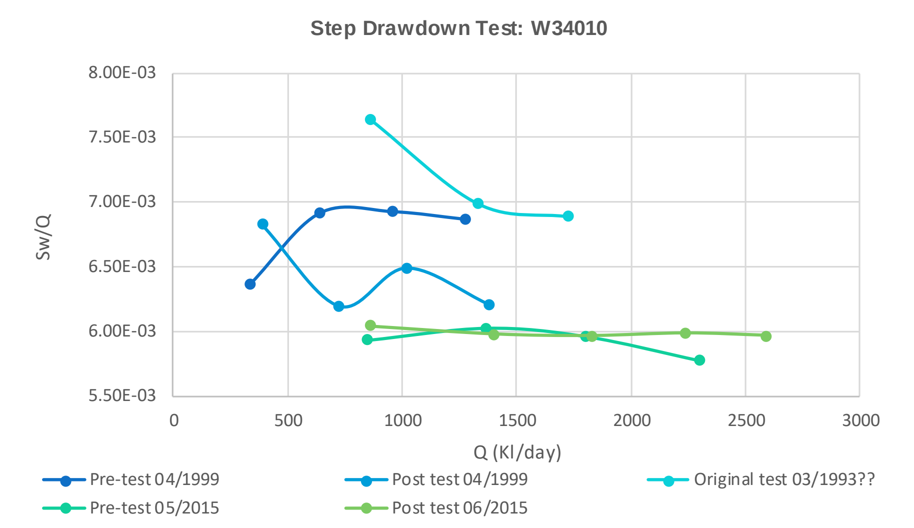
ORIGINAL TEST - CSIR Rest Waterlevel = ? m.bgl (no data)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	10.0	864	6.60	7.64E-03
2	15.4	1331	9.30	6.99E-03
3	20.0	1728	11.90	6.89E-03
Average				7.17E-03
Decline(-) / Improve(+) Original				0

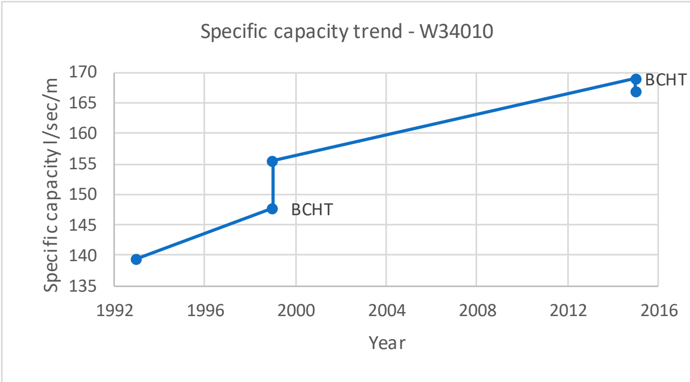
PRE-TEST Rest Waterlevel = 6.83 m.bgl (05/04/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.9	337	2.168	6.37E-03
2	7.4	639	4.438	6.92E-03
3	11.1	959	6.651	6.93E-03
4	14.8	1279	8.756	6.87E-03
Average				6.77E-03
Decline(-) / Improve(+) Original to Pre-Test				-5.6%

POST-TEST Rest Waterlevel = 6.80 m.bgl (09/04/99)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.5	389	2.644	6.83E-03
2	8.4	726	4.471	6.19E-03
3	11.8	1020	6.616	6.49E-03
4	16.0	1382	8.572	6.20E-03
Average				6.43E-03
Decline(-) / Improve(+) Pre- to Post-Test				5%

PRE-TEST Rest Waterlevel = 1.18 m.bgl /(21/05/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.8	848	5.03	5.93E-03
2	15.8	1368	8.24	6.02E-03
3	20.9	1804	10.75	5.96E-03
4	26.7	2303	13.3	5.78E-03
Average				5.92E-03
Decline(-)/Improve(+) Pre- '15 to Post-test 1999				8%

POST-TEST Rest Waterlevel = 1.86.bgl (20/06/15)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	9.9	859	5.19	6.04E-03
2	16.3	1404	8.39	5.98E-03
3	21.2	1828	10.90	5.96E-03
4	25.9	2239	13.40	5.98E-03
	30.0	2592	15.46	5.96E-03
Average				5.99E-03
Decline(-) / Improve(+) Pre- to Post-Test 2015				-1%





Date	SC l/s/m
1993	139.4
1999	147.7
1999	155.5
2015	168.9
2015	166.9

COMMENTS

1999 improvement: 5%
2015 improvement/decline: -1% (?)

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (05/2015)**

Vari-Speed Setting:1999/2015

1. 28/20 Hz
2. 30/28 Hz
3. 35/34 Hz
4. 40/40 Hz
5. 45/45 Hz

Construction:

PVC (250mm) - with bidim.
250mm PVC 10mm wall
Screen ~23 - 34m with 3mm x 80mm slots, 5 slots to row
U34 bidim - 2 layers

CCTV log review

Before					4		
After				3			

Appendix A - Rehabilitation results

WITZANDS AQUIFER - BOREHOLE G33104

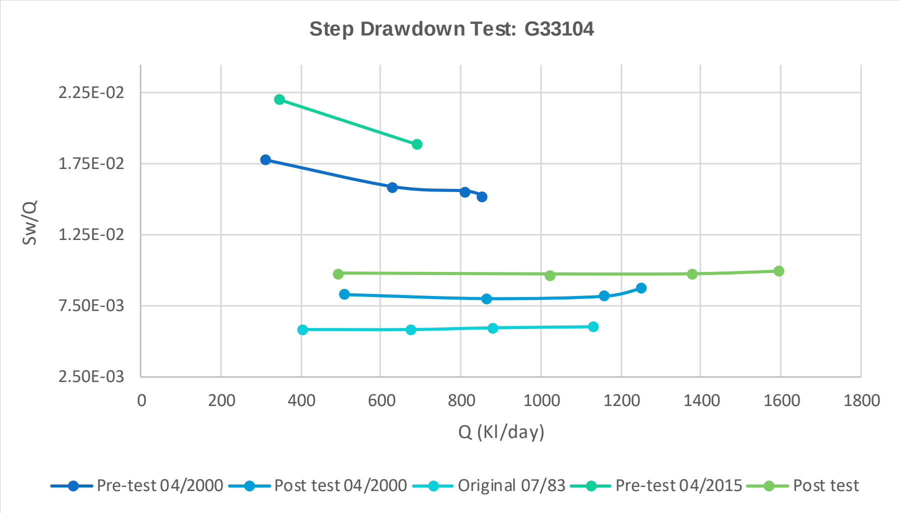
ORIGINAL TEST Rest Waterlevel = 3.140m.bgl (07/1983) Pump inlet - 37m				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.7	406	2.360	5.81E-03
2	7.8	674	3.919	5.81E-03
3	10.2	881	5.241	5.95E-03
4	13.1	1132	6.828	6.03E-03
Average				5.90E-03
Decline(-) / Improve(+) Original				0

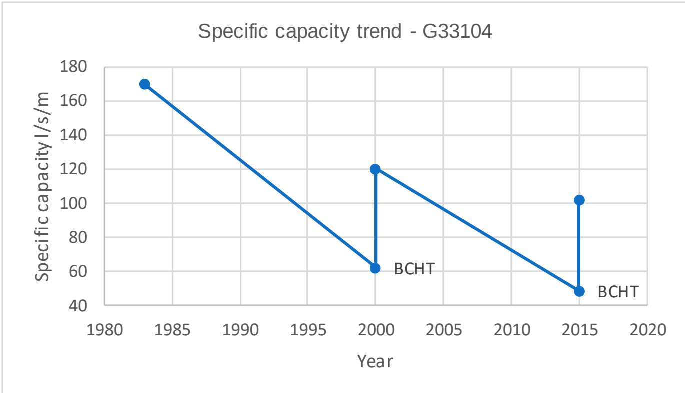
PRE-TEST Rest Waterlevel = 5.020 m.bgl (25/04/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.6	311	5.539	1.78E-02
2	7.3	631	10.025	1.59E-02
3	9.4	812	12.658	1.56E-02
4	9.9	855	13.057	1.53E-02
Average				1.61E-02
Decline(-) / Improve(+) Pre to Original-Test				-173%

POST-TEST Rest Waterlevel = 6.43 m.bgl (28/04/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.9	510	4.248	8.33E-03
2	10.0	864	6.954	8.05E-03
3	13.4	1158	9.514	8.22E-03
4	14.5	1253	11.007	8.78E-03
Average				8.34E-03
Decline(-) / Improve(+) Pre- to Post-Test				48%

PRE-TEST Rest Waterlevel = 1.55 m.bgl (30/04/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.01	346	7.63	2.21E-02
2	8.00	691	13.06	1.89E-02
Average				2.05E-02
Decline(-) / Improve(+) Pre 2015 to Post-Test 2000				-146%

POST-TEST Rest Waterlevel =1.75 m.bgl (22/06/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.72	494	4.84	9.80E-03
2	11.83	1022	9.94	9.73E-03
3	15.97	1380	13.44	9.74E-03
4	18.50	1598	15.92	9.96E-03
Average				9.81E-03
Decline(-) / Improve(+) Pre to Post-Test 2015				109%





Date	SC l/s/m
1983	169.5
2000	62.1
2000	119.9
2015	48.8
2015	101.9

COMMENTS

2000 improvement: 48%
2014 improvement: 109%

Optimum Pumping Rate: 7 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **22.7m (06/2015)**

Vari-Speed Setting: 2000/2015

1. 24/20 Hz
2. 30/28 Hz
3. 36/34 Hz
4. 42/40* Hz

**crashed after 20min*

Construction:

PVC (195mm) - with bidim.
Screen 12 - 34m class 6 & 12
3mm x 100mm slots - 23 rows x 46 slots/6m
U34 bidim - 2 layers

CCTV log review

Before						5	
After				3			

WITZAND AQUIFER - BOREHOLE G30966

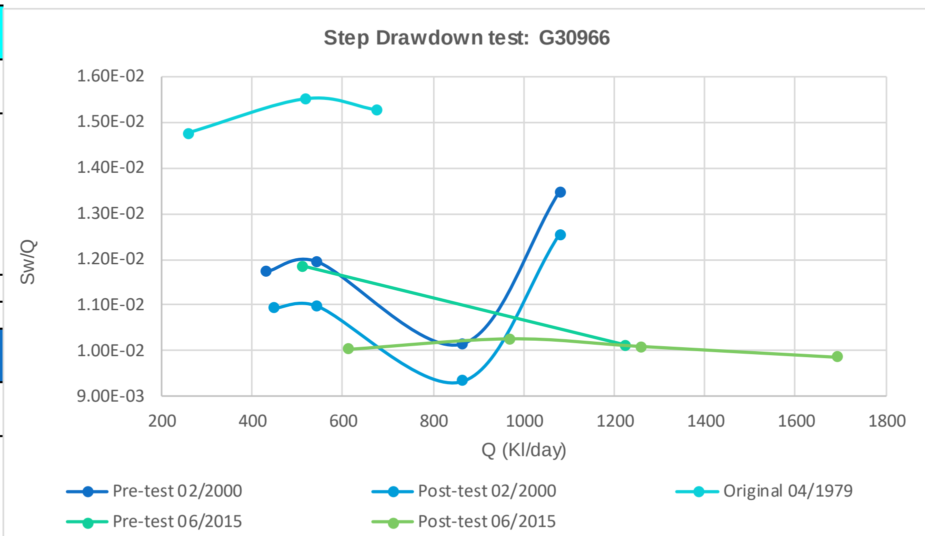
ORIGINAL TEST - DWAF Rest Waterlevel = 5.750 (03/04/79) Pump Inlet – 21.8 m				
Step No:	Q (l/s)	Q (m^3/Day)	Sw (m)	Sw/Q
1	3	259	3.824	1.48E-02
2	6	518	8.041	1.55E-02
3	7.8	674	10.298	1.53E-02
Average				1.52E-02
Decline(-) / Improve(+) Original				0

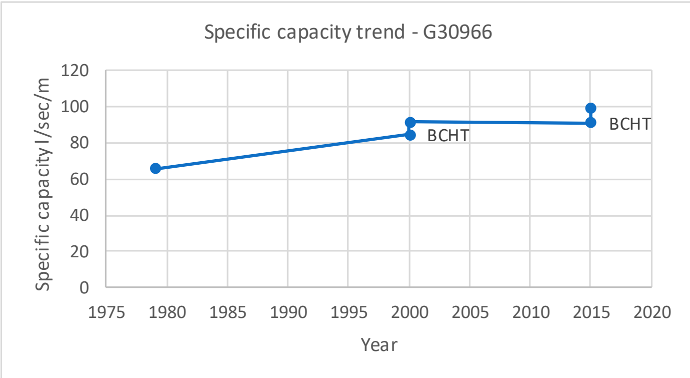
PRE-TEST Rest Waterlevel = 3.700 m.bgl (22/02/2000)				
Step No:	Q (l/s)	Q (m^3/Day)	Sw (m)	Sw/Q
1	5.0	432	5.07	1.17E-02
2	6.3	544	6.5	1.19E-02
3	10.0	864	8.78	1.02E-02
4	12.5	1080	14.56	1.35E-02
Average				1.18E-02
Decline(-) / Improve(+) Original to Pre Test				-22%

POST-TEST Rest Waterlevel = 3.750 m.bgl (26/02/2000)				
Step No:	Q (l/s)	Q (m^3/Day)	Sw (m)	Sw/Q
1	5.2	449	4.91	1.094E-02
2	6.3	544	5.97	1.097E-02
3	10	864	8.07	9.340E-03
4	12.5	1080	13.55	1.255E-02
Average				1.09E-02
Decline(-) / Improve(+) Pre to Post Test				8%

PRE-TEST Rest Waterlevel = 2.59 m.bgl (23/06/2015)				
Step No:	Q (l/s)	Q (m^3/Day)	Sw (m)	Sw/Q
1	5.92	511	6.06	1.19E-02
2	14.16	1223	12.38	1.01E-02
3				
Average				1.10E-02
Decline(-) / Improve(+) Original to Pre Test				-27.6%

POST-TEST Rest Waterlevel = 2.55 m.bgl (27/06/2015)				
Step No:	Q (l/s)	Q (m^3/Day)	Sw (m)	Sw/Q
1	7.08	612	6.14	1.00E-02
2	11.22	969	9.94	1.03E-02
3	14.58	1260	12.72	1.01E-02
4	19.61	1694	16.71	9.86E-03
Average				1.01E-02
Decline(-) / Improve(+) Pre to Post Test				8%





Date	SC l/s/m
1979	65.8
2000	84.7
2000	91.7
2015	90.9
2015	99

COMMENTS

2000 improvement: 8%
2015 improvement: 8.5%

2015 comment -
The lower 9m of the borehole has been lost due to corrosion/collapse at screen/casing join (the screened length has declined from 6 to 4m).

Optimum Pumping rate: 5 l/s

Pre- & Post-Testing Details:
Pump Inlet Depth: 19.7m (06/2015)

Vari-Speed Setting: 2000 & 2015
1. 21/20 Hz
2. 23/25 Hz
3. 27/28 Hz
4. 38/34 Hz

Construction:
Steel (203mm) with St/steel screen(150mm)
Screen ~23.3 - 27.8 m size 0.75mm (bottom hole 2015 at 27.85m)

CCTV log review

Before 5
After 3

SILVERSTROOM AQUIFER - BOREHOLE W34018

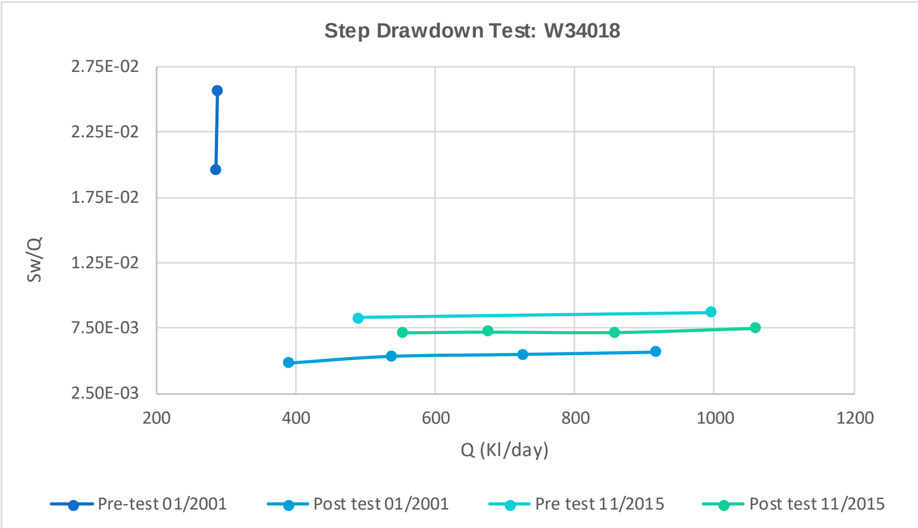
ORIGINAL TEST - CSIR - No Data Available Rest Waterlevel =?? m.bgl				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1				
2				
3				
4				
5				
Average				
Decline(-) / Improve(+) Original				

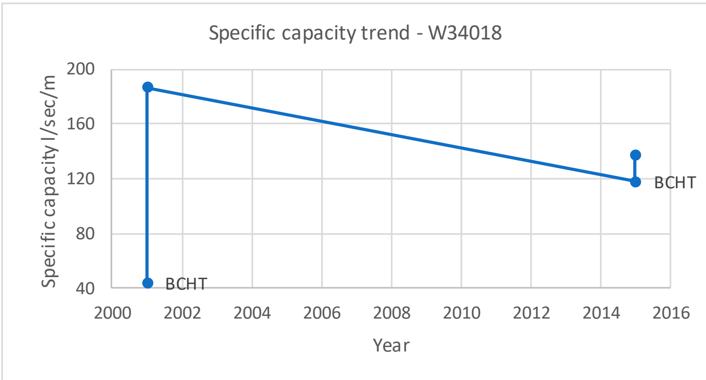
PRE-TEST Rest Waterlevel = 5.20 m.bgl (22/01/01)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.3	285	5.613	1.97E-02
2	3.3	288	7.397	2.57E-02
Average				2.27E-02
Decline(-) / Improve(+) Original to Pre-Test				0%

POST-TEST Rest Waterlevel = 5.37 m.bgl (26/01/01)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.5	389	1.874	4.82E-03
2	6.2	536	2.875	5.37E-03
3	8.4	726	4.011	5.53E-03
4	10.6	916	5.229	5.71E-03
Average				5.36E-03
Decline(-) / Improve(+) Pre- to Post-Test				76%

PRE-TEST Rest Waterlevel = 4.36m.bgl (9/11/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.65	488	4.04	8.28E-03
2	11.51	994	8.65	8.70E-03
Average				8.49E-03
Decline(-)/Improve(+) Pre '15 to Post-test 2001				-58%

POST-TEST Rest Waterlevel = 4.39m.bgl (13/11/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.4	553	3.98	7.20E-03
2	7.8	675	4.90	7.26E-03
3	9.9	857	6.19	7.22E-03
4	12.3	1058	7.96	7.52E-03
5	13.5	1166	9.36	
Average				7.30E-03
Decline(-) / Improve(+) Pre- to Post-Test				14%





Date	SC l/s/m
2001	44.1
2001	186.6
2015	117.8
2015	137

COMMENTS

2001 Improvement: 75%
2015 improvement: 14%

Optimum Pumping Rate: 4 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **16.7m (11/2015)**

Vari-Speed Setting: 2001/2015

1. 20 Hz
2. 22 Hz
3. 25 Hz
4. 28 Hz

Construction:

PVC (250 mm) - no bidim (?)
250mm PVC 10mm wall
Screen ~11.5 - 19m with 0.8mm x 43mm slots, 8 slots to row

CCTV log review

Before						5	
After				3			

SILVERSTROOM AQUIFER - BOREHOLE G32956

ORIGINAL TEST - DWAF
Rest Waterlevel =10.615 m.bgl (20/04/1983)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.8	242	3.501	1.45E-02
2	4.8	415	4.418	1.06E-02
3	6.4	553	4.902	8.86E-03
4	8.6	743	5.634	7.58E-03
5	11.1	959	6.569	6.85E-03
Average				9.68E-03
Decline(-) / Improve(+) Original				0

PRE-TEST
Rest Waterlevel = 11.60 m.bgl (08/05/2000)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	1.4	121	0.165	1.36E-03
2	5.0	432	1.600	3.70E-03
3	11.0	950	3.797	4.00E-03
4	15.4	1331	5.481	4.12E-03
5	16.8	1452	6.308	4.34E-03
Average				3.51E-03
Decline(-) / Improve(+) Original to Pre-Test				64%

POST-TEST
Rest Waterlevel = 11.67 m.bgl (11/05/2000)

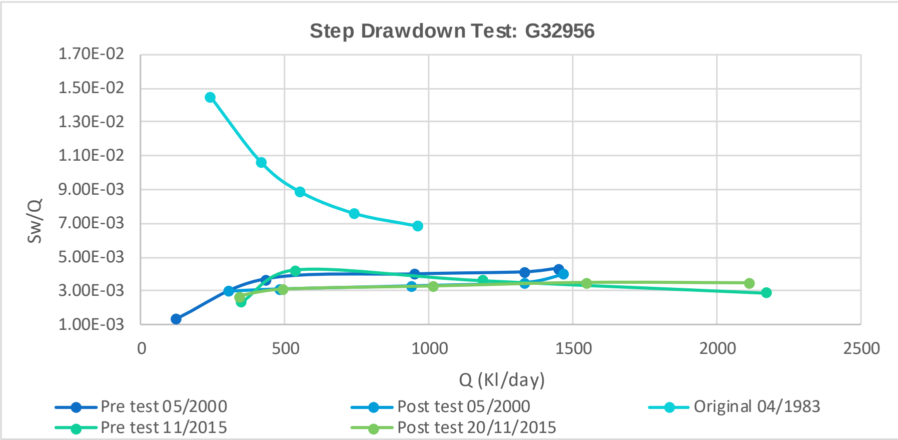
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.5	302	0.907	3.00E-03
2	5.6	484	1.518	3.14E-03
3	10.9	942	3.128	3.32E-03
4	15.4	1331	4.681	3.52E-03
5	17.0	1469	5.903	4.02E-03
Average				3.40E-03
Decline(-) / Improve(+) Pre- to Post-Test				**3%**

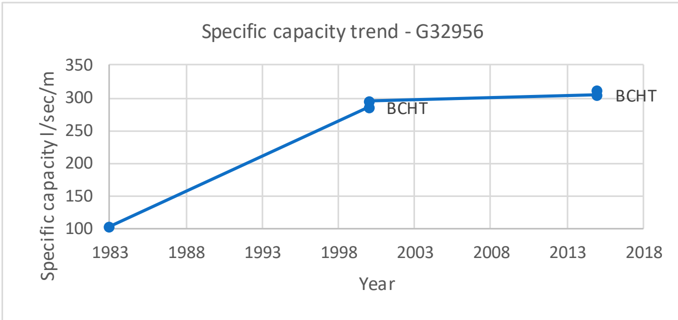
PRE-TEST
Rest Waterlevel = 10.94m.bgl (16/11/2015)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.03	348	0.83	2.39E-03
2	6.19	535	2.28	4.26E-03
3	13.7	1185	4.30	3.63E-03
4	25.2	2175	6.30	2.90E-03
Average				3.29E-03
Decline(-) / Improve(+) Pre 2015 to Post-Test 2000				-3%

POST-TEST
Rest Waterlevel = 10.92m.bgl (20/11/2015)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.93	340	0.91	2.68E-03
2	5.71	493	1.53	3.10E-03
3	11.77	1017	3.36	3.30E-03
4	17.94	1550	5.47	3.53E-03
5	24.44	2112	7.40	3.50E-03
Average				3.22E-03
Decline(-) / Improve(+) Pre- to Post-Test 2015				2%





Date	SC l/s/m
1983	103.3
2000	284.9
2000	294.1
2015	303.9
2015	310.6

COMMENTS

2001 Improvement: 3%

Comment: The original DWAF step-draw down test data shows the effect of incorrect construction. The rehabilitation has at the least provided another usable borehole in this wellfield.

The pre- & post-tests indicate no real improvement in the specific draw down of the well. It would be a good candidate for reconstruction.

2015 improvement: 2%

Optimum Pumping Rate: 4 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (11/2015)**

Vari-Speed Setting: 2000/2015

1. 22/20 Hz
2. 26/22 Hz
3. 32/28 Hz
4. 38/34 Hz
5. 44/45 Hz

Construction:

PVC (195 mm) -with bidim

195mm PVC class 6 PVC

Screen ~12 - 36m class 12, with 3mm slots, 37 rows of 23 slots/6m

CCTV log review

Before						5	
After					4		

SILVERSTROOM AQUIFER - BOREHOLE W34016

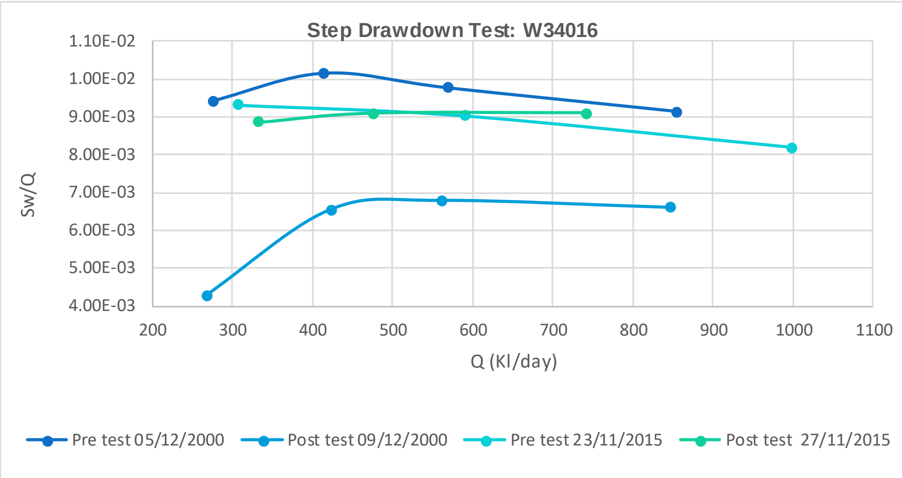
ORIGINAL TEST - CSIR - No Data Available Rest Waterlevel =?? m.bgl				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original				

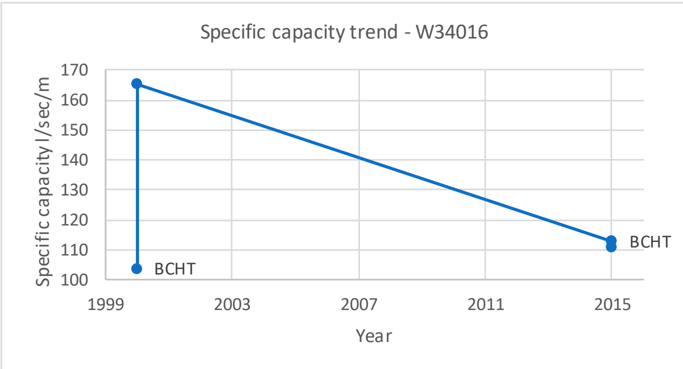
PRE-TEST Rest Waterlevel = 12.08 m.bgl (05/12/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.2	276	2.60	9.42E-03
2	4.8	415	4.22	1.02E-02
3	6.6	570	5.57	9.77E-03
4	9.9	855	7.81	9.13E-03
Average				9.62E-03
Decline(-) / Improve(+) Original to Pre-Test				0%

POST-TEST Rest Waterlevel = 12.86 m.bgl (09/12/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.1	268	1.15	4.28E-03
2	4.9	423	2.77	6.54E-03
3	6.5	562	3.81	6.78E-03
4	9.8	847	5.59	6.60E-03
Average				6.05E-03
Decline(-) / Improve(+) Pre- to Post-Test				37%

PRE-TEST Rest Waterlevel = 12.02m.bgl (23/11/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.55	307	2.86	9.33E-03
2	6.83	590	5.33	9.03E-03
3	11.6	998	8.170	8.19E-03
Average				8.85E-03
Decline(-) / Improve(+) Pre 2015 to Post-test 2000				-46%

POST-TEST Rest Waterlevel = 12.01m.bgl (27/11/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.85	333	2.95	8.87E-03
2	5.51	476	4.33	9.10E-03
3	8.58	741	6.75	9.11E-03
Average				9.02E-03
Decline(-) / Improve(+) Pre- to Post-Test				-2%





Date	SC l/s/m
2000	104
2000	165.3
2015	113
2015	110.9

COMMENTS

2000 Improvement: 37%
2015 Decline: -2%

Optimum Pumping Rate: 2 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.5m (11/2015)**

Vari-Speed Setting: 2001/2015

1. 25 Hz
2. 28 Hz
3. 30 Hz
4. 34 Hz

Construction:

PVC (250 mm) - no bidim (??)
250mm PVC 10mm wall
Screen ~21 - 27m with 0.8mm x 43mm slots, 8 slots to row

CCTV log review

Before					4		
After					4		

SILVERSTROOM AQUIFER - BOREHOLE G32959

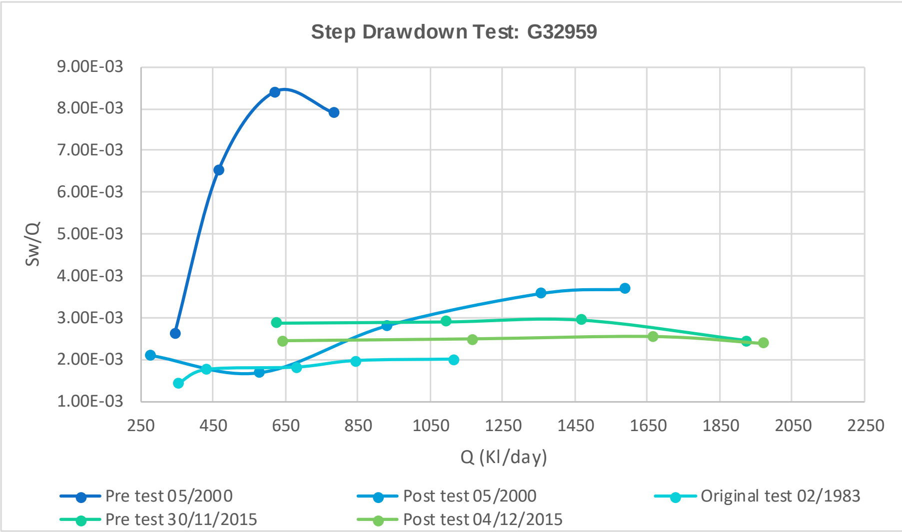
ORIGINAL TEST - DWAF Rest Waterlevel =11.43 m.bgl (02/1983)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.1	354	0.503	1.42E-03
2	5.0	432	0.760	1.76E-03
3	7.9	683	1.240	1.82E-03
4	9.8	847	1.667	1.97E-03
5	12.9	1115	2.231	2.00E-03
Average				1.79E-03
Decline(-) / Improve(+) Original				0

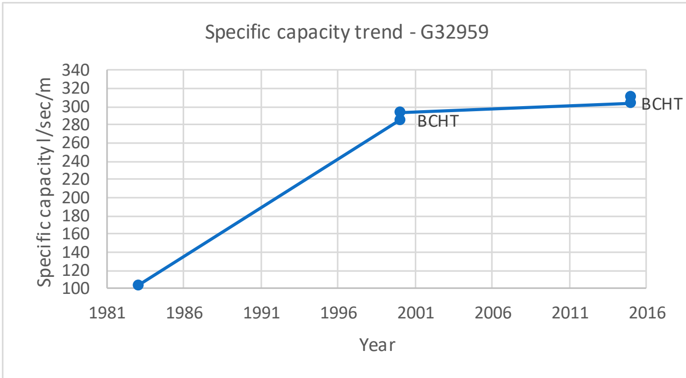
PRE-TEST Rest Waterlevel = 12.48 m.bgl (12/05/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.0	346	0.905	2.62E-03
2	5.4	467	3.051	6.53E-03
3	7.2	622	5.232	8.41E-03
4	9.1	786	6.203	7.89E-03
Average				6.36E-03
Decline(-) / Improve(+) Original to Pre-Test				-255%

POST-TEST Rest Waterlevel = 12.53 m.bgl (17/05/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.2	276	0.582	2.11E-03
2	6.7	579	0.978	1.69E-03
3	10.8	933	2.631	2.82E-03
4	15.7	1356	4.865	3.59E-03
5	18.4	1590	5.871	3.69E-03
Average				2.78E-03
Decline(-) / Improve(+) Pre- to Post-Test				56%

PRE-TEST Rest Waterlevel = 11.43m.bgl (30/11/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.22	624	1.80	2.89E-03
2	12.66	1094	3.19	2.92E-03
3	17.0	1469	4.35	2.96E-03
4	22.3	1922	4.72	2.46E-03
Average				2.80E-03
Decline(-) / Improve(+) Pre 2015 to Post-Test 2000				0%

POST-TEST Rest Waterlevel = 11.45m.bgl (04/12/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	7.46	645	1.58	2.45E-03
2	13.51	1167	2.91	2.49E-03
3	19.28	1666	4.24	2.55E-03
4	22.83	1973	4.71	2.39E-03
5				
Average				2.47E-03
Decline(-) / Improve(+) Pre- to Post-Test 2015				12%





Date	SC l/s/m
1983	103.3
2000	284.9
2000	294.1
2015	303.9
2015	310.6

COMMENTS

2001 Improvement: 56%

Comment: This is also a bidim wrapped construction but in comparison to G32956 it apprears to have been reasonably well developed after being drilled. The Pre- and Post-test indicated an average improvement of 56 % in specific drawdown of the well. Still another usable borehole for this wellfield.

2015 improvement: 12%

Optimum Pumping Rate: 4 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (11/2015)**

Vari-Speed Setting: 2000/2015

1. 24/24 Hz
2. 26/28 Hz
3. 32/34 Hz
4. 38/38 Hz
5. 44/- Hz

Construction:

PVC (195 mm) - with bidim. 195mm PVC class 6 PVC

Screen ~10.4 - 27.5m class 12, with 3mm slots, 37 rows of 23 slots/6m

CCTV log review

Before					4		
After					4		

SILVERSTROOM AQUIFER - BOREHOLE G32955

ORIGINAL TEST - DWAF -No Data Available
Rest Waterlevel =?? m.bgl (03/1983) Pump rate 15 L/s

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1				
2				
3				
4				
5				
Average				
Decline(-) / Improve(+) Original				

PRE-TEST
Rest Waterlevel = 13.82 m.bgl (18/12/2000)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.9	251	0.918	3.66E-03
2	4.4	380	2.625	6.91E-03
3	5.6	484	3.775	7.80E-03
4	6.7	579	4.909	8.48E-03
Average				6.71E-03
Decline(-) / Improve(+) Original to Pre-Test				

POST-TEST
Rest Waterlevel = 13.85 m.bgl (03/01/2001)

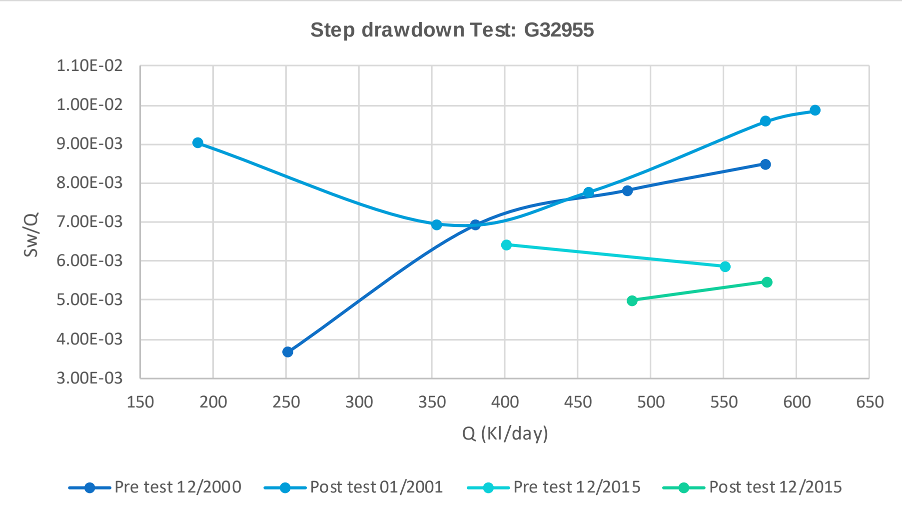
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.2	190	1.713	9.02E-03
2	4.1	354	2.455	6.94E-03
3	5.3	458	3.551	7.75E-03
4	6.7	579	5.538	9.56E-03
5	7.1	613	6.037	9.85E-03
Average				8.62E-03
Decline(-) / Improve(+) Pre- to Post-Test				-28%

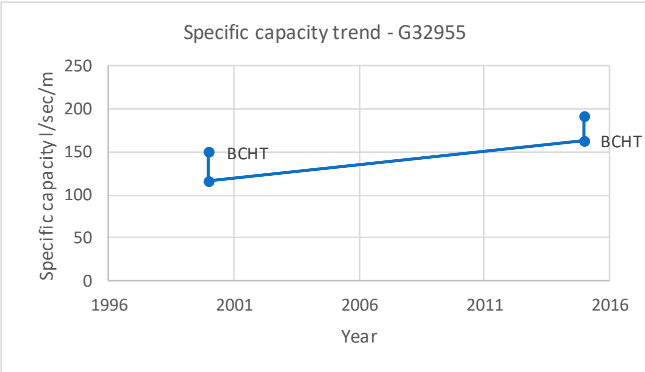
PRE-TEST
Rest Waterlevel = 12.91m.bgl (08/12/2015)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.64	401	2.57	6.41E-03
2	6.38	551	3.23	5.86E-03
Average				6.14E-03
Decline(-) / Improve(+) Pre 2015 to Post-Test 2001				28%

POST-TEST
Rest Waterlevel = 12.97m.bgl (11/12/2015)

Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.64	487	2.43	4.99E-03
2	6.71	580	3.17	5.47E-03
Average				5.23E-03
Decline(-) / Improve(+) Pre- to Post-Test 2015				15%





Date	SC l/s/m
1983	
2000	149
2000	116
2015	162.9
2015	191

COMMENTS

2001 decline: -28%
2015 improvement: 15 %

Optimum Pumping Rate: 2 l/s (12/2015)

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (04/12/2015)**

Vari-Speed Setting: 2000/2015

1. 22/24 Hz
2. 26/26 Hz
3. 32/- Hz
4. 38/- Hz
5. 44/- Hz

Construction:

PVC (195 mm) -with bidim
195mm PVC class 6 PVC
Screen ~12 - 30m class 12, with 3mm slots, 37 rows of 23 slots/6m

CCTV log review

Before						5	
After				3			

SILWESTROOM AQUIFER - BOREHOLE W34034

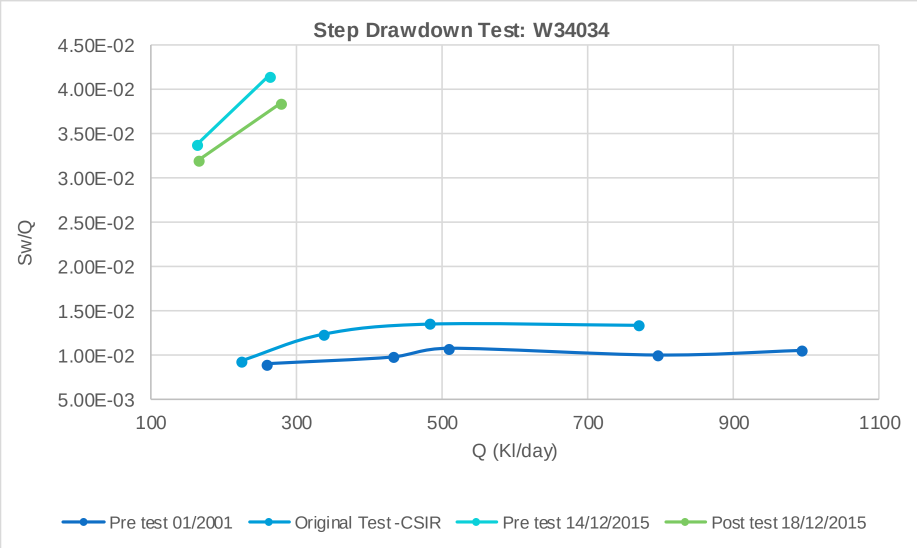
ORIGINAL TEST - CSIR				
Rest Waterlevel = 12.12m.bgl (Date 1995/6) Pump inlet 24m				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.6	225	2.121	9.43E-03
2	3.9	337	4.183	1.24E-02
3	5.6	484	6.565	1.36E-02
4	8.9	769	10.322	1.34E-02
5				
Average				1.22E-02
Decline(-) / Improve(+) Original				

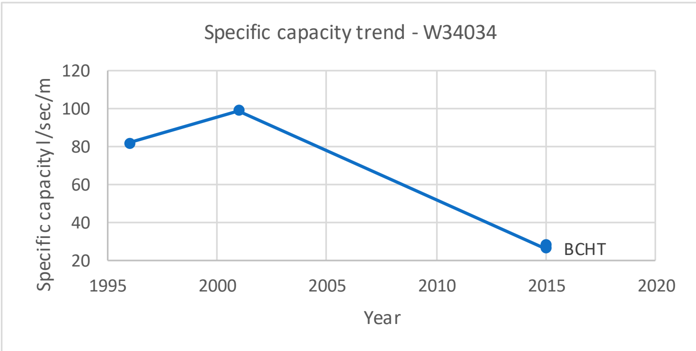
PRE-TEST				
Rest Waterlevel = 10.90m.bgl (04/01/2001)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.0	259	2.352	9.08E-03
2	5.0	432	4.240	9.81E-03
3	5.9	510	5.501	1.08E-02
4	9.2	795	7.984	1.00E-02
5	11.5	994	10.488	1.06E-02
Average				1.01E-02
Decline(-) / Improve(+) Original to Pre-Test				17%

POST-TEST				
Rest Waterlevel = ??m.bgl				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Pre- to Post-Test				

PRE-TEST				
Rest Waterlevel = 10.22 m.bgl (14/12/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	1.88	162	5.48	3.37E-02
2	3.04	263	10.910	4.15E-02
Average				3.76E-02
Decline(-)/Improve(+) Pre-'15 to Pre Test '01				-275%

POST-TEST				
Rest Waterlevel = 10.27m.bgl (18/12/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	1.925	166	5.33	3.20E-02
2	3.230	279	10.74	3.85E-02
Average				3.53E-02
Decline(-)/Improve(+) Post-'15 to Pre Test '15				6%





Date	SC l/s/m
1996	82
2001	99
2015	26.6
2015	28.3

COMMENTS

2001 improvement: Retest of hole only

2015 improvement: 6%?

Optimum Pumping Rate: Not worth equipping & using

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (12/2015)**

Vari-Speed Setting 2001/2015:

1. 22/22 Hz
2. 24/24 Hz
3. 28 Hz
4. 32 Hz
5. 36 Hz
6. 42 Hz

Construction detail:

PVC (250mm class 9 & class 12) - no bidim (?)

0.5mm slots, 5% open area

Screen: 21.5m - 30.4m

Grade 16/30 (1.19mm to 595 micron) gravel pack, 400mm diameter filled from 13-15m.

CCTV log review

Before						5	
After						**Decomission**	

SILVERSTROOM AQUIFER - BOREHOLE G30865

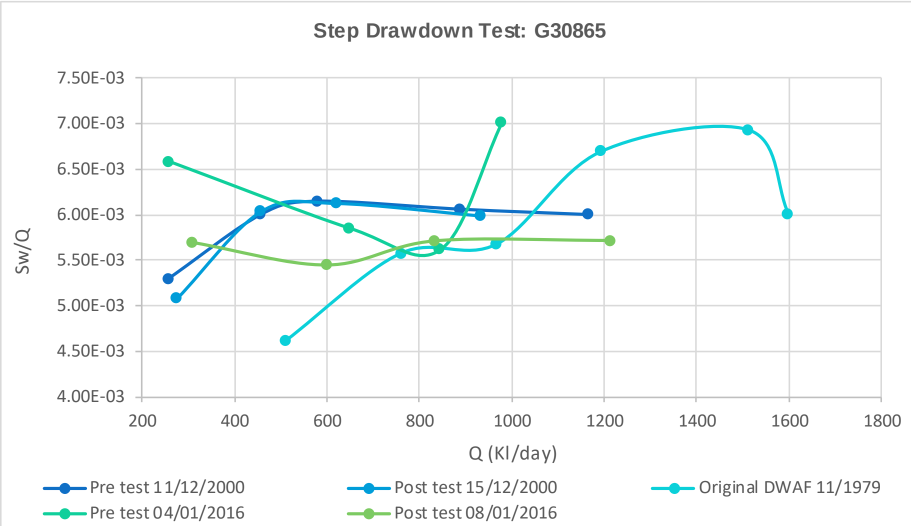
ORIGINAL TEST - DWAF				
Rest Waterlevel = ? m.bgl @pump rate = 12.51 l/s (11/1979)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.9	510	2.352	4.61E-03
2	8.8	760	4.240	5.58E-03
3	11.2	968	5.501	5.68E-03
4	13.8	1192	7.984	6.70E-03
5	17.5	1512	10.488	6.94E-03
6	18.5	1598	9.606	6.01E-03
Average				5.92E-03
Decline(-) / Improve(+) Original				0

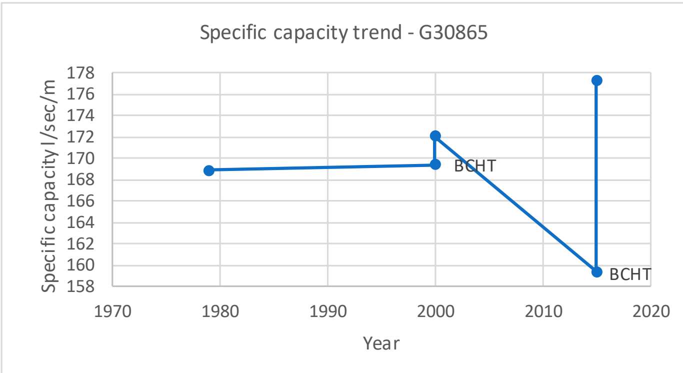
PRE-TEST				
Rest Waterlevel = 13.45 m.bgl (11/12/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.0	259	1.372	5.30E-03
2	5.3	458	2.751	6.01E-03
3	6.7	579	3.562	6.15E-03
4	10.3	890	5.396	6.06E-03
5	13.5	1166	7.000	6.00E-03
Average				5.90E-03
Decline(-) / Improve(+) Original to Pre-Test				0%

POST-TEST				
Rest Waterlevel = 13.46 m.bgl (15/12/2000)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.2	276	1.402	5.08E-03
2	5.3	458	2.767	6.04E-03
3	7.2	622	3.812	6.13E-03
4	10.8	933	5.589	5.99E-03
Average				5.81E-03
Decline(-) / Improve(+) Pre- to Post-Test				2%

PRE-TEST				
Rest Waterlevel = 12.36m.bgl (04/01/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.99	258	1.70	6.59E-03
2	7.51	649	3.80	5.86E-03
3	9.8	845	4.75	5.62E-03
4	11.3	978	6.86	7.01E-03
Average				6.27E-03
Decline(-) / Improve(+) Pre to Original-Test				-8%

POST-TEST				
Rest Waterlevel = 10.92m.bgl (20/01/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.58	309	1.76	5.69E-03
2	6.94	600	3.27	5.45E-03
3	9.65	834	4.76	5.71E-03
4	14.04	1213	6.93	5.71E-03
Average				5.64E-03
Decline(-) / Improve(+) Pre- to Post-Test				10%





Date	SC l/s/m
1979	168.9
2000	169.4
2000	172.1
2015	159.4
2015	177.3

COMMENTS

2001 Improvement: 0
2015 improvement: 10%

Optimum Pumping Rate: 4 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: 22.4m (01/2015)

Vari-Speed Setting: 2000/2015

1. 22/22 Hz
2. 26/25 Hz
3. 32/28 Hz
4. 38/32 Hz
5. 44/nil Hz

Construction:

Mild steel casing - 203mm ID, with stainless wedge wire screen (Johnson) - 152mm ID.
Screen ~23 - 27.2m
Size 0.75mm with 7/16 gravel pack

CCTV log review

Before						5	
After				3			

SILVERSTROOM AQUIFER - BOREHOLE G32952

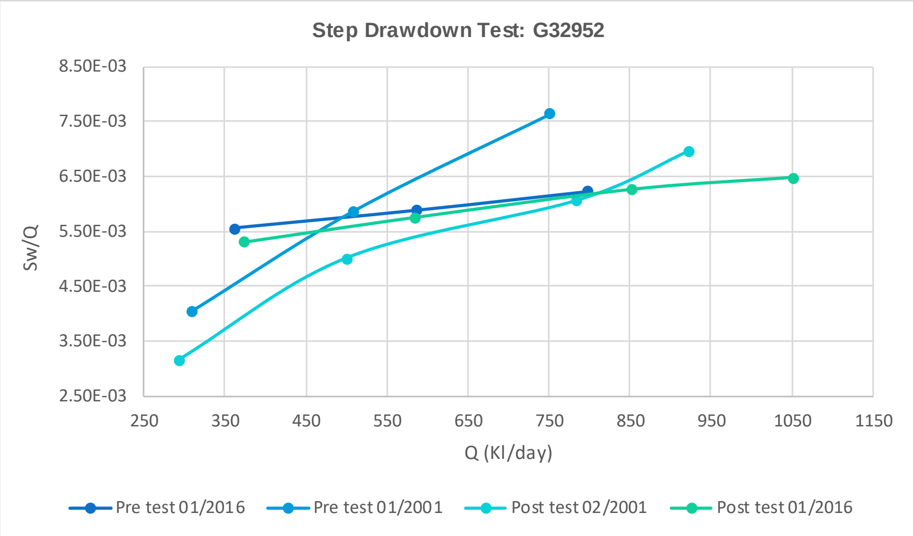
ORIGINAL TEST - DWAF -No Data Available Rest Waterlevel =? m.bgl Pump rate = 18 L/s (01/1983)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original				

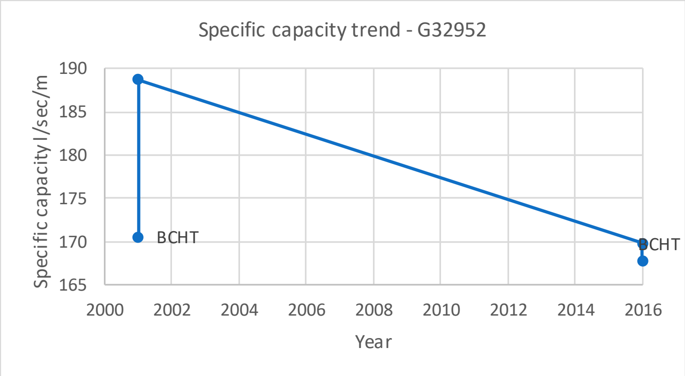
PRE-TEST Rest Waterlevel = 12.25 m.bgl (29/01/2001)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.6	311	1.261	4.05E-03
2	5.9	510	3.000	5.88E-03
3	8.7	752	5.755	7.65E-03
Average				5.86E-03
Decline(-) / Improve(+) Original to Pre-Test				0%

POST-TEST Rest Waterlevel = 12.28 m.bgl (01/02/2001)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.4	294	0.929	3.16E-03
2	5.8	501	2.511	5.01E-03
3	9.1	786	4.767	6.06E-03
4	10.7	924	6.437	6.97E-03
Average				5.30E-03
Decline(-) / Improve(+) Pre- to Post-Test				9.6%

PRE-TEST Rest Waterlevel = 11.30m.bgl (11/01/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.19	362	2.01	5.55E-03
2	6.81	588	3.46	5.88E-03
3	9.3	799	4.98	6.23E-03
Average				5.89E-03
Decline(-) / Improve(+) Post 2001 to Pre 2016				-11%

POST-TEST Rest Waterlevel = 10.92m.bgl (20/11/2015)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.33	374	1.99	5.32E-03
2	6.77	585	3.37	5.76E-03
3	9.88	854	5.35	6.26E-03
4	12.19	1053	6.82	6.48E-03
Average				5.96E-03
Decline(-) / Improve(+) Pre- to Post-Test 2016				1%





Date	SC l/s/m
1983	
2001	170.6
2001	188.7
2016	169.8
2016	167.8

COMMENTS

2001 improvement: 9.6%
2015 improvement: 1%

Optimum Pumping Rate: 4 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: 22.4m (01/2016)

Vari-Speed Setting: 2000/2015

1. 22/22 Hz
2. 26/25 Hz
3. 32/28 Hz
4. 38/32 Hz
5. 44/- Hz

Construction:

PVC (195 mm) -with bidim
195mm PVC class 6 PVC
Screen ~11.7 - 27.8m class 12, with 3mm slots, 37 rows of 23 slots/6m

CCTV log review

Before						5	
After				3			

SILVERSTROOM AQUIFER - BOREHOLE W34015

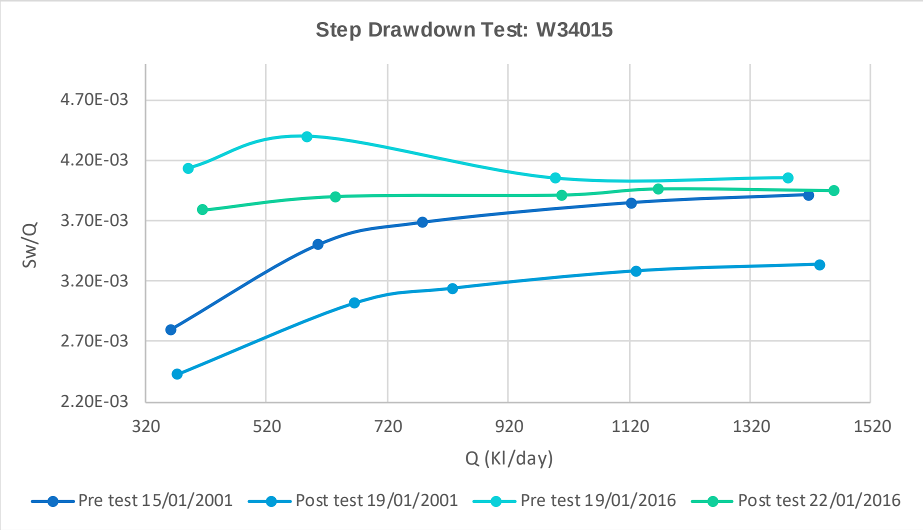
ORIGINAL TEST - CSIR - No Data Available Rest Waterlevel =?? m.bgl				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original				

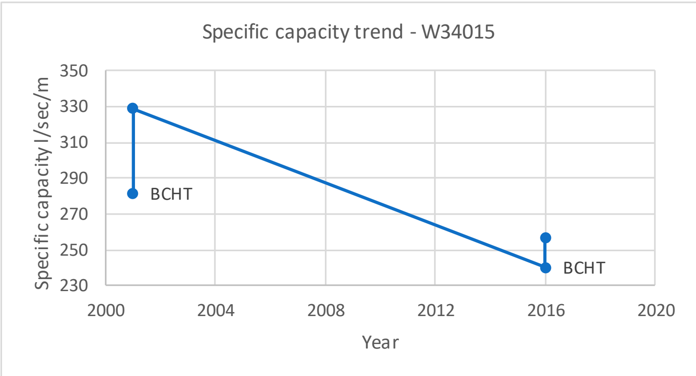
PRE-TEST Rest Waterlevel = 11.82 m.bgl (15/01/2001)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.2	363	1.017	2.80E-03
2	7.0	605	2.118	3.50E-03
3	9.0	778	2.869	3.69E-03
4	13.0	1123	4.325	3.85E-03
5	16.4	1417	5.552	3.92E-03
Average				3.55E-03
Decline(-) / Improve(+) Original to Pre-Test				0%

POST-TEST Rest Waterlevel = 11.94 m.bgl (19/01/2001)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.3	372	0.904	2.43E-03
2	7.7	665	2.007	3.02E-03
3	9.6	829	2.606	3.14E-03
4	13.1	1132	3.720	3.29E-03
5	16.6	1434	4.791	3.34E-03
Average				3.04E-03
Decline(-) / Improve(+) Pre- to Post-Test				14%

PRE-TEST Rest Waterlevel = 11.08m.bgl (19/01/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.53	391	1.62	4.14E-03
2	6.79	587	2.58	4.40E-03
3	11.56	999	4.05	4.05E-03
4	16.00	1382	5.61	4.06E-03
Average				4.16E-03
Decline(-)/Improve(+) Pre to Post -test 2001				-36%

POST-TEST Rest Waterlevel = 11.10m.bgl (01/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.79	414	1.57	3.79E-03
2	7.33	633	2.47	3.90E-03
3	11.68	1009	3.95	3.91E-03
4	13.5	1168	4.63	3.96E-03
5	16.9	1458	5.76	3.95E-03
Average				3.90E-03
Improve(+) Pre- to Post-Test				6%





Date	SC l/s/m
2001	281.7
2001	328.9
2016	240.4
2016	256.4

COMMENTS

2000 Improvement: 14%
2015 improvement: 6%

2015 comment: The contruction of this hole has seriously affected its yield, also not used for many years

Optimum Pumping Rate: 4 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.4m (19/01/2016)**

Vari-Speed Setting: 2001/2015

1. 25 Hz
2. 28 Hz
3. 30 Hz
4. 34 Hz
5. 38 Hz

Construction:

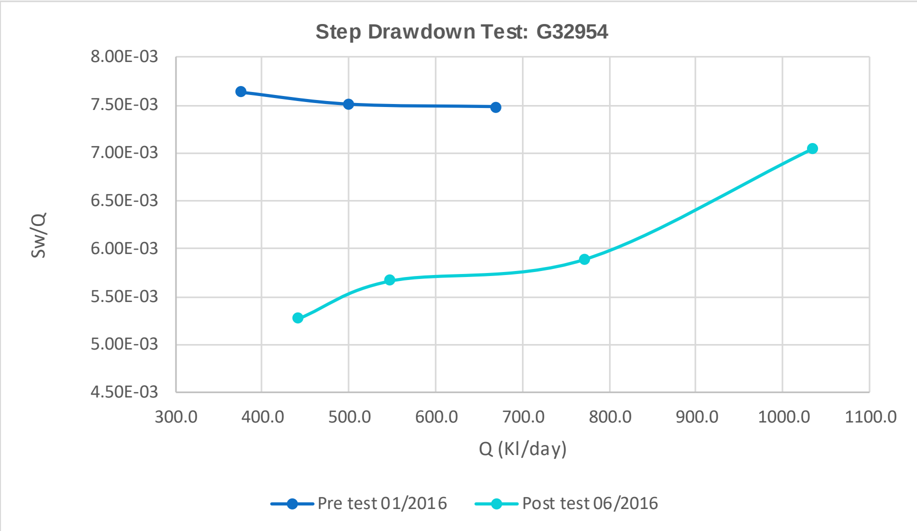
PVC (250 mm) - with bidim
250mm PVC 10mm wall
Screen ~20 - 26m with 0.8mm x 43mm slots, 8 slots to row

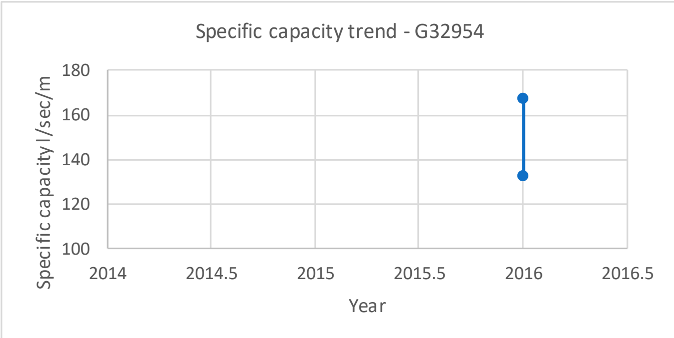
CCTV log review

Before					4		
After				3			

SILVERSTROOM AQUIFER - BOREHOLE G32954

ORIGINAL TEST - DWAF -No Data Available Rest Waterlevel =??? m.bgl Pump rate = 19 L/s(12/1982)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original				
PRE-TEST Rest Waterlevel = 11.80 m.bgl (25/06/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.35	375.8	2.87	7.64E-03
2	5.78	499.4	3.75	7.51E-03
3	7.75	669.6	5.01	7.48E-03
Average				7.54E-03
Decline(-) / Improve(+) Original to Pre-Test				0%
POST-TEST Rest Waterlevel = 11.76 m.bgl (28/06/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	5.11	441.5	2.33	5.28E-03
2	6.33	546.9	3.10	5.67E-03
3	8.92	770.7	4.54	5.89E-03
4	11.97	1034.2	7.28	7.04E-03
Average				5.97E-03
Decline(-) / Improve(+) Pre- to Post-Test				20.8%





Date	SC l/s/m
2016	132.6
2016	167.5

COMMENTS

2016 improvement: 21%

Optimum Pumping Rate: 4 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (06/2016)**

Vari-Speed Setting: 2016

1. 23 Hz
2. 25 Hz
3. 28 Hz
4. 32 Hz

Construction:

PVC (195 mm) - with bidim

195mm PVC class 6 PVC

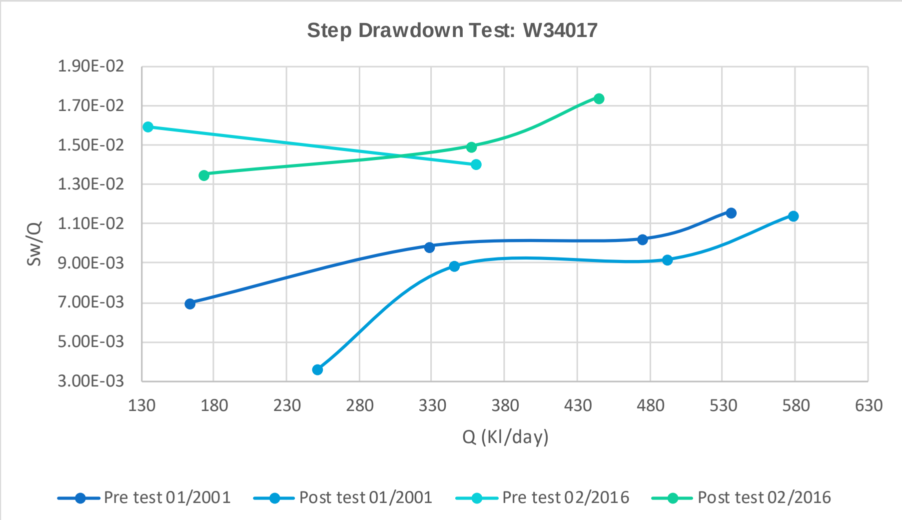
Screen 7.5 - 25.5m class 12, with 3mm slots, 37 rows of 23 slots/6m

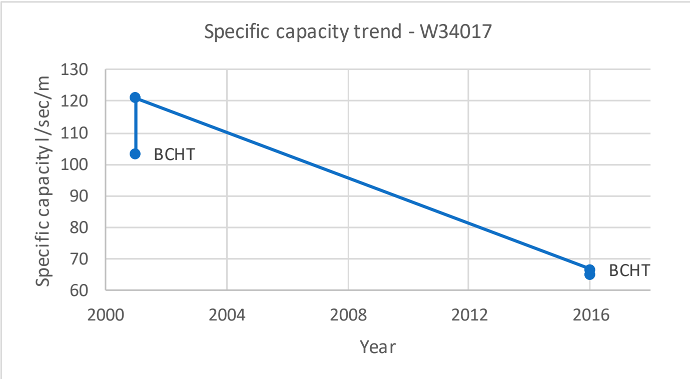
CCTV log review

Before						5	
After				3			

SILVERSTROOM AQUIFER - BOREHOLE W34017

ORIGINAL TEST - CSIR - No Data Available Rest Waterlevel =?? m.bgl				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1				
2				
3				
4				
5				
Average				
Decline(-) / Improve(+) Original				
PRE-TEST Rest Waterlevel = 12.85 m.bgl (08/01/01)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	1.9	164	1.143	6.97E-03
2	3.8	328	3.233	9.86E-03
3	5.5	475	4.856	1.02E-02
4	6.2	536	6.227	1.16E-02
Average				9.67E-03
Decline(-) / Improve(+) Original to Pre-Test				
POST-TEST Rest Waterlevel = 12.96m.bgl (12/01/01)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.9	251	0.904	3.60E-03
2	4.0	346	3.060	8.84E-03
3	5.7	492	4.515	9.18E-03
4	6.7	579	6.622	1.14E-02
Average				8.26E-03
Decline(-) / Improve(+) Pre- to Post-Test				15%
PRE-TEST Rest Waterlevel = 12.15m.bgl (17/02/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	1.56	135	2.15	1.59E-02
2	4.17	360	5.06	1.40E-02
Average				1.50E-02
Decline(-) / Improve(+) Pre 2016 to Post-test 2000				-45%
POST-TEST Rest Waterlevel = 12.4m.bgl (23/02/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.00	173	2.34	1.35E-02
2	4.14	357	5.34	1.50E-02
3	5.15	445	7.76	1.74E-02
Average				1.53E-02
Decline(-) / Improve(+) Pre- to Post-Test				-2%





Date	SC l/s/m
2001	103.4
2001	121.1
2016	66.7
2016	65.3

COMMENTS

2001 Improvement: 15%
2016 decline: -2%

2016 comment: This hole has been abused.

Optimum Pumping Rate: Not worth equipping & using

Pre- & Post-Testing Details:

Pump Inlet Depth: **16.4m (02/2016)**

Vari-Speed Setting: 2001/2016

1. 25/22 Hz
2. 28/25 Hz
3. 30/28 Hz
4. 34/0 Hz

Construction:

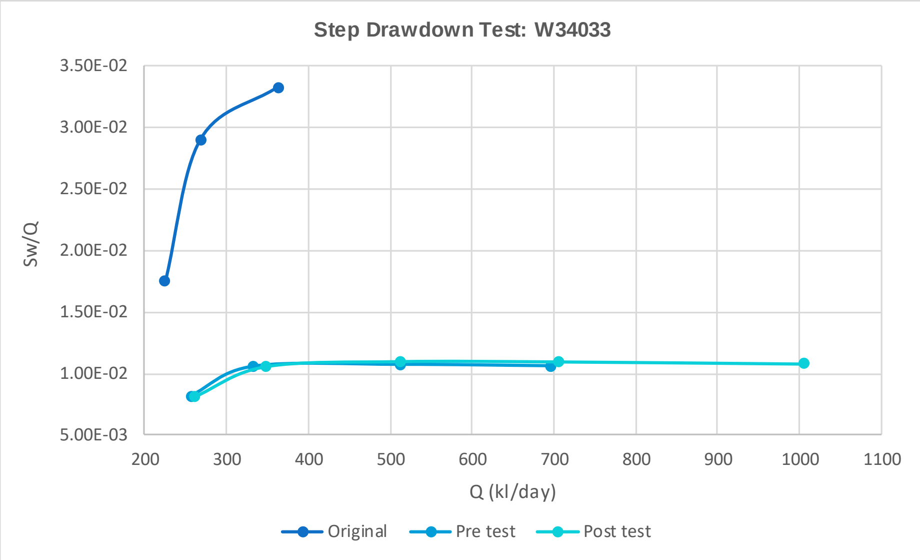
PVC (250 mm) -no bidim ??
250mm PVC 10mm w all
Screen 18 - 24m w ith 0.8mm x 43mm slots, 8 slots to row

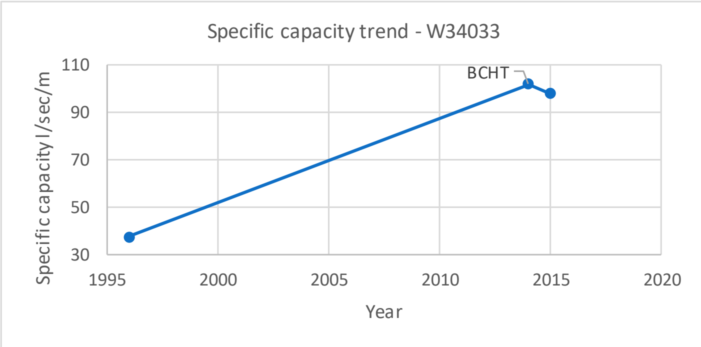
CCTV log review

Before						5	
After						Compromised	

SILVERSTROOM AQUIFER - BOREHOLE W34033

ORIGINAL TEST - CSIR Rest Waterlevel =??? m.bgl Pump rate = 3 L/s(21/11/1996)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.6	225	3.93	1.75E-02
2	3.1	268	7.78	2.90E-02
3	4.2	363	12.07	3.33E-02
Average				2.66E+02
Decline(-) / Improve(+) Original				0
PRE-TEST Rest Waterlevel = 10.28 m.bgl (01/07/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.97	256.6	2.10	8.18E-03
2	3.86	333.5	3.52	1.06E-02
3	5.93	512.4	5.48	1.07E-02
4	8.06	696.4	7.37	1.06E-02
Average				9.81E-03
Decline(-) / Improve(+) Original to Pre-Test				-63%
POST-TEST Rest Waterlevel = 10.09 m.bgl (07/07/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	3.02	260.9	2.11	8.09E-03
2	4.03	348.2	3.68	1.06E-02
3	5.92	511.5	5.62	1.10E-02
4	8.16	705.0	7.73	1.10E-02
5	11.65	1006.6	10.86	1.08E-02
Average				1.02E-02
Decline(-) / Improve(+) Pre- to Post-Test				4%





Date	SC l/s/m
1996	37.6
2014	101.9
2015	98

COMMENTS

2016 improvement: 4%

2016 comment: Highly questionable if this is in fact W34033.

Optimum Pumping Rate: 4 l/s (07/2016)

Pre- & Post-Testing Details:

Pump Inlet Depth: **19.7m (07/2016)**

Vari-Speed Setting: 2016

1. 20 Hz
2. 22 Hz
3. 25 Hz
4. 28 Hz
5. 32 Hz

Construction:

PVC (250 mm OD) class 9 - no bidim?

Screen class 12: 23 - 32m with 0.5mm slots, 5% open area

Annulus: 400mm diameter filled from 13 - 35m with 16/30gravel pack

CCTV log review

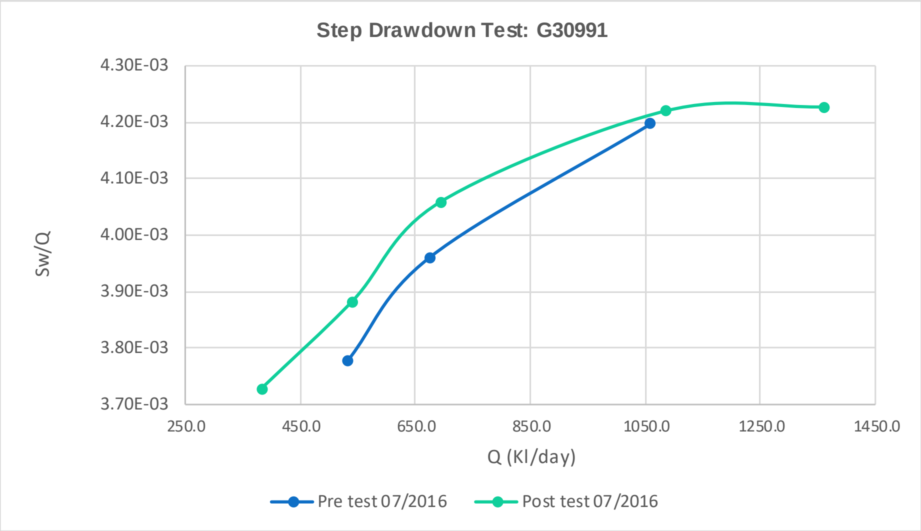
Before					4		
After					4		

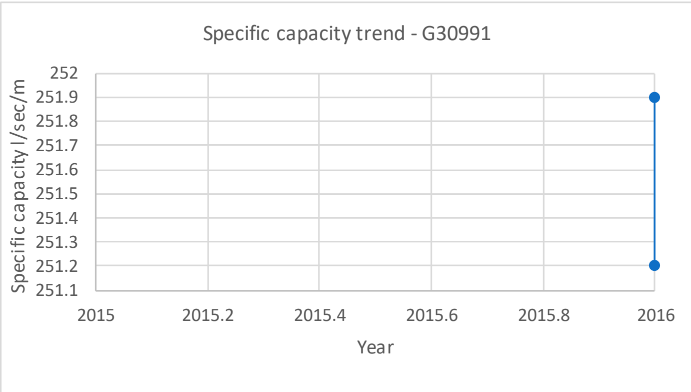
SILVERSTROOM AQUIFER - BOREHOLE G30991

ORIGINAL TEST - DWAF -No Data Available Rest Waterlevel =??? m.bgl Pump rate = 12.5 L/s(11/1979)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
Average				
Decline(-) / Improve(+) Original				

PRE-TEST Rest Waterlevel = 12.0m.bgl (08/07/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	6.16	532.2	2.01	3.78E-03
2	7.83	676.5	2.68	3.96E-03
3	12.27	1060.1	4.45	4.20E-03
Average				3.98E-03
Decline(-) / Improve(+) Original to Pre-Test				0%

POST-TEST Rest Waterlevel = 12.07 m.bgl (14/07/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	4.44	383.6	1.43	3.73E-03
2	6.3	540.9	2.10	3.88E-03
3	8.0	694.7	2.82	4.06E-03
4	12.6	1085.2	4.58	4.22E-03
5	15.8	1362.5	5.76	4.23E-03
Average				3.97E-03
Decline(-) / Improve(+) Pre- to Post-Test				0%





Date	SC l/s/m
2016	251.2
2016	251.9

COMMENT

2016 improvement: 0

Optimum Pumping Rate: 4 l/s

Pre- & Post-Testing Details:

Pump Inlet Depth: 19.7m (07/2016)

Vari-Speed Setting: 2000/2015

1. 22 Hz
2. 24 Hz
3. 26 Hz
4. 30 Hz
5. 33 Hz

Construction:

PVC (200mm OD) -with bidim

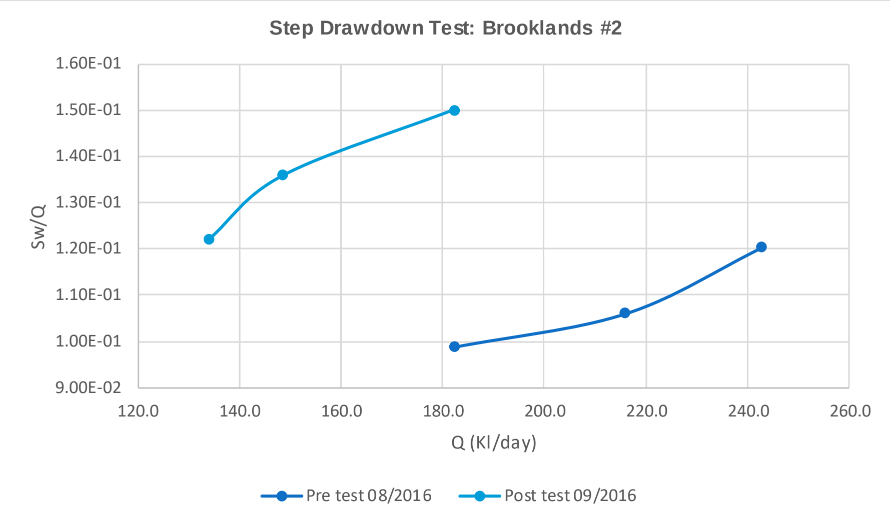
Screen 180mm 10.6 - 28.4m with 4mm x 57mm slots

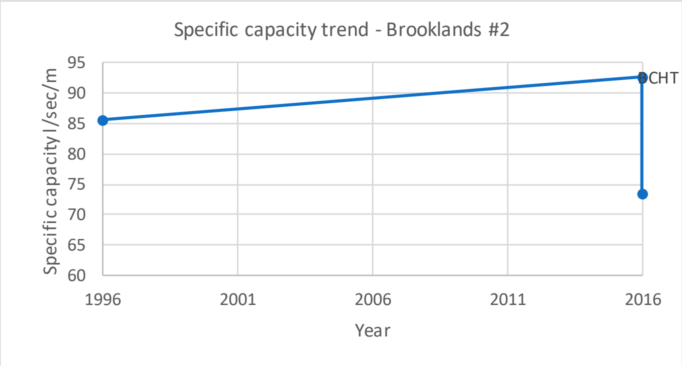
CCTV log review

Before					4		
After				4			

Brooklands (Simonstown no.2)

ORIGINAL TEST - PD Toens & Partners Rest Waterlevel = 5.19 m.bgl (6/1996)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	0.59	50.98	3.29	6.45E-02
2	1.02	88.128	5.99	6.80E-02
3	1.90	164.16	15.26	9.30E-02
4	2.49	215.136	26.65	1.24E-01
5	3.16	273.024	39.54	1.45E-01
6	4.28	369.792	77.24	2.09E-01
Average				1.17E-01
Decline(-) / Improve(+) Original				0
PRE-TEST Rest Waterlevel = 12.25 m.bgl (21/08/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	2.11	182.3	18.01	9.88E-02
2	2.50	216.0	22.90	1.06E-01
3	2.81	242.8	29.21	1.20E-01
Average				1.08E-01
Decline(-) / Improve(+) Original to Pre-Test				7.6%
POST-TEST Rest Waterlevel = 12.28 m.bgl (19/09/2016)				
Step No:	Q (l/s)	Q (m³/Day)	Sw (m)	Sw/Q
1	1.55	133.9	16.33	1.22E-01
2	1.72	148.6	20.19	1.36E-01
3	2.11	182.3	27.35	1.50E-01
Average				1.36E-01
Decline(-) / Improve(+) Pre- to Post-Test				-26%





Date	SC l/s/m
1996	85.5
2016	92.6
2016	73.5

COMMENTS

2016 decline: -26%
2016 comment: Although there is no improvement in yield this hole has been cleaned & would more than likely benefit from being hydrojacked (fracced) to increase the yield.
This borehole is uncased, during treatment there were sidewall collapses resulting in equipment getting stuck.
Fortunately all equipment was recovered but it would be wise to have this hole cased if it is to be used longterm.

Optimum Pumping Rate: maintain 2 l/s constant

Pre- & Post-Testing Details:

Pump Inlet Depth: 70m normally but at 45m during rehab programme due to problems downhole.

Vari-Speed Setting: 08/2016

1. 22 Hz
2. 25 Hz
3. 28 Hz

Construction:

Open hole beyond approximately 6m of steel casing - ~165mm OD.
Depth ~109m when initially camera logged. Unable to reach this depth with post logging due to unstable open fractures/sidewall.

CCTV log review, with BART™ data

Before						5	
After				3			

BART before shows very aggressive populations, within 48hrs of sampling.
BART after showing far less aggressive populations, possibly 4-5 days after sampling.

Appendix B – Borehole installation data

Note: screens marked ***** are within the drawdown zone and prone to redox changes because of aeration, which can lead to rapid biofouling and care must be taken not to over-pump them

				All depths measured down from top of concrete wellhead							?=orignl	Original construction details		Pump details suitable for duty				
Borehole ID	Date drilled	Proposed set yield	Orifice plate size	Bhole bottom	Screen top	Pump inlet	Com'n probe	CUT-OUT probe	LOW level alarm	ON level probe	Static WL recorded	Borehole Internal Diam	Screen Type	Flow Q	Head H	Makers model	Stages	Motor rating
		litres/sec	mm	m	m	m	m	m	m	m	m	mm		m3/h	m	Franklin/other		kW
				Spacing to lower		1.5	1.0	0.5	0.5	2.0	>=2.0							
Witzands																		
G30965	1979	7	25				**Out of commission**											
G30966	1979	5	20	42.0	24.0	**22.5**	**21.5**	**21.0**	**20.5**	**18.5**	? 5.8	203/150	SSWW 0.75mm+gravel					
G30969	1979						**Out of commission**											
G30971	1980						**Out of commission**											
G30972	1979	5	20	46.0	26.2	**24.7**	**23.7**	**23.2**	**22.7**	**20.7**	7.33	304/150	SSWW 0.75mm+gravel					
G30973	1979	7	25	40.0	*****16.0	**17.5**	**16.5**	**16.0**	**15.5**	**13.5**	? 4.2	200/175	PVCS 2.0mm+bidim+gravel					
G30975	1979						**Out of commission**											
G30978	1979						**Out of commission**											
G30981	1979						**Out of commission**											
G33091	1983						**Out of commission**											
G33092	1983						**Out of commission**											
G33095	1983						**Out of commission**											
G33103	1983	5	20	41.0	*****15.0	**16.5**	**15.5**	**15.0**	**14.5**	**12.5**	8.83	195	PVCS 3.0mm+bidim+gravel					
G33104	1983	7	25	38.0	*****12.0	**13.5**	**12.5**	**12.0**	**11.5**	**9.5**	5.07	195	PVCS 3.0mm+bidim+gravel					
G33106	1983						**Out of commission**											
G33107	1983	5	20	46.0	*****10.0	**12.5**	**11.5**	**11.0**	**10.5**	**8.5**	6.43	195	PVCS 3.0mm+bidim+gravel					
W34001	1989	15	40	40.0	27.0	**25.5**	**24.5**	**24.0**	**23.5**	**21.5**	6.74	200/200	SSWW 0.5mm+gravel					
W34002	1989						**Out of commission**											
W34003	1989						**Out of commission**											
W34004	1989						**Out of commission**											
W34005	1989	7	25	39.0	26.0	**24.5**	**23.5**	**23.0**	**22.5**	**20.5**	? 5.1	200/200	SSWW 0.5mm+gravel					
W34006	1989						**Borehole collapsed-Out of commission**											
W34007	1989						**Out of commission**											
W34008	1989						**Out of commission**											
W34009	1993	7	25	41.0	26.8	**25.3**	**24.3**	**23.8**	**23.3**	**21.3**	6.28	250	PVCS 0.5??mm+gravel					
W34010	1993	7	25	35.0	22.8	**21.3**	**20.3**	**19.8**	**19.3**	**17.3**	? 9.2	250	PVCS 3.0mm+bidim+gravel					
W34011	1993			37.2	25.0		**Not worth equipping - Out of commission**					250	PVCS 3.0mm+bidim+gravel					
W34012	1993	7	25	40.5	26.5	**25.0**	**24.0**	**23.5**	**23.0**	**21.0**	? 8.6	250	PVCS 3.0mm+bidim+gravel					
W34013	1993	2	15	39.0	26.8	**25.3**	**24.3**	**23.8**	**23.3**	**21.3**	? 8.8	250	PVCS 3.0mm+bidim+gravel					
W34014	1993	7	25	36.0	23.3	**21.8**	**20.8**	**20.3**	**19.8**	**17.8**	? 11.0	250	PVCS 0.5mm+bidim+gravel					
W34019	1993	5	20	30.0	20.2	**18.7**	**17.7**	**17.2**	**16.7**	**14.7**	? 13.6	250	PVCS 0.8mm+bidim?+gravel					
W34020	1993	7	25	36.0	24.4	**22.9**	**21.9**	**21.4**	**20.9**	**18.9**	6.14	250	PVCS 0.8mm+bidim?+gravel					
W34021	1994						**Out of commission**											
W34022	1994	7	25	42.0	26.0	**22.5**	**21.5**	**21.0**	**20.5**	**18.5**	? 6.4	250	PVCS 0.5/0.8mm ? +gravel					
W34023	1994	7	25	39.0	24.0	**22.5**	**21.5**	**21.0**	**20.5**	**18.5**	4.81	250	PVCS 0.5/0.8mm ? +gravel					
W34024	1994	7	25	37.3	24.0	**19.5**	**18.5**	**18.0**	**17.5**	**15.5**	5.21	250	PVCS 0.5/0.8mm ? +gravel					
W34025	1994	7	25	34.0	20.0	**18.5**	**17.5**	**17.0**	**16.5**	**14.5**	4.26	250	PVCS 0.5/0.8mm ? +gravel					
W34028	1996	5	20	41.0	26.0	**24.5**	**23.5**	**23.0**	**22.5**	**20.5**	? 12.1	250	PVCS 0.5 + gravel					
W34029	1996	7	25	43.0	28.0	**26.5**	**25.5**	**25.0**	**24.5**	**22.5**	4.98	250	PVCS 0.5 + gravel					
W34030	1996	7	25	39.5	24.5	**23.0**	**22.0**	**21.5**	**21.0**	**19.0**	1? 10.2	250	PVCS 0.5 + gravel					

Note: screens marked ***** are within the drawdown zone and prone to redox changes brecause of aeration, which can lead to rapid biofouling and care must be taken not to over-pump them

				All depths measured down from top of concrete wellhead							?=orignl	Original construction details		Pump details suitable for duty				
Borehole ID	Date drilled	Proposed set yield	Orifice plate size	Bhole bottom	Screen top	Pump inlet	Com'n probe	CUT-OUT probe	LOW level alarm	ON level probe	Static WL recorded	Borehole Internal Diam	Screen Type	Flow Q	Head H	Makers model	Stages	Motor rating
		litres/sec	mm	m	m	m	m	m	m	m	m	mm		m3/h	m	Super D		kW
				Spacing to lower		1.5	1.0	0.5	0.5	2.0	>=2.0							
W34031	1996	7	25	40.5	25.5	**24.0**	**23.0**	**22.5**	**22.0**	**20.0**	? 10.8	250	PVCS 0.5 + gravel					
W34032	1996	7	25	37.5	24.5	**23.0**	**22.0**	**21.5**	**21.0**	**19.0**	? 9.8	250	PVCS 0.5 + gravel					
TOTAL YIELD		**166**	l/s	597.6	m3/h													
Silverstroom																		
G29757	1977	3	17	43.0	*****15.5	**15.0**	**14.0**	**13.5**	**13.0**	**11.0**	? 8.7	1000	slotted steel-Massarenti					
G29794	1978						**Out of commission**											
G30865	1978	4	18	46.4	*****23	**22.4**	**21.4**	**20.9**	**20.4**	**18.4**	? 18.6	152	SSWW 0.75mm + gravel					
G30991	1979	4	18	45.3	*****10.7	**17.5**	**16.5**	**16.0**	**15.5**	**13.5**	? 11.3	180	PVCS 4.0mm + Bidim					
G30999	1979						**Out of commission**											
G32952	1983	4	18	38.0	*****12.3	**17.5**	**16.5**	**16.0**	**15.5**	**13.5**	? 11.3	195	PVCS 3.0mm+bidim					
G32954	1982	4	18	32.0	*****8.7	**17.5**	**16.5**	**16.0**	**15.5**	**13.5**	? 11.1	195	PVCS 3.0mm+bidim					
G32955	1983	2	15	32.0	***** 12	**17.5**	**16.5**	**16.0**	**15.5**	**13.5**	? 13.0	195	PVCS 3.0mm+bidim					
G32956	1983	4	18	39.0	***** 12	**17.5**	**16.5**	**16.0**	**15.5**	**13.5**	11.67	195	PVCS 3.0mm+bidim					
G32959	1983	4	18	31.0	***** 11	**17.5**	**16.5**	**16.0**	**15.5**	**13.5**	12.53	195	PVCS 3.0mm+bidim					
W34015	1993	4	18	29.0	20.2	**18.7**	**17.7**	**17.2**	**16.7**	**14.7**	? 10.8	250	PVCS 0.8mm+bidim?+gravel					
W34016	1993	2	15	28.0	21.2	**18.7**	**17.7**	**17.2**	**16.7**	**14.7**	? 12.6	250	PVCS 0.8mm+bidim?+gravel					
W34017	1993	0	0	27.0	*****18.2		**Not worth equipping**				? 13.2	250	PVCS 0.8mm+bidim?+gravel					
W34018	1993	4	18	19.0	*****10.2	**16.7**	**15.7**	**15.2**	**14.7**	**12.7**	? 5.3	250	PVCS 0.8mm+bidim?+gravel					
W34033	1996	4	18	35.0	23.0	**19.7**	**18.7**	**18.2**	**17.7**	**15.7**	? 11.6	250	PVCS 0.5mm + gravel					
W34034	1996			35.0	23.0		**Not worth equipping**				? 12.1	250	PVCS 0.5mm + gravel					
TOTAL		**43**	l/s	154.8	m3/h													

The pump positions are approximate and are based on the current piping lengths (3m) available and the average distance from pump inlet to outlet coupling.
Every endeavour should be made to acquire 1m and 2m lengths in order to correctly position the pumps which should if at all possible NEVER be set within the screen section.
The reason for setting the pump and motor above the screen is so that there will be sufficient flow over the motor to keep it cool.