# REPORT - HYDROGEOLOGICAL ASSESSMENT INCORPORATING 48 HOUR PUMP TEST

**27782 HUME HIGHWAY, BOWNING, NSW,**
**LOT 172 DEPOSITED PLAN 649063**

| | |
|---|---|
| Prepared For: | **Barker Group** |
| Project Number: | **ENRS0978** |
| Date: | **December 2018** |

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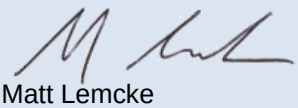
|  <br>Matt Lemcke<br>*Geologist & Environmental Consultant* |  <br>Rohan Last<br>*Hydrogeologist & Environmental Scientist* |
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# EXECUTIVE SUMMARY

Environment & Natural Resource Solutions (ENRS Pty Ltd) were commissioned as independent groundwater consultants to prepare a Hydrogeological Assessment (HA) incorporating the results of a 48 Hour Pump Test for a new production Bore at Lot 172 in DP 649063, street number 27782 Hume Highway, Bowning, NSW, 2582 (herein referred to as the Site).

ENRS understand this HA is required to document the groundwater supply at the Site in anticipation of development of a Highway Service Centre. The Centre will not be connected to the Yass Shire reticulation system. The proposal is to utilise groundwater at the Site to meet the design peak daily demand of approximately 20 Kilolitres per day.

Test drilling during the scope of work culminated in the construction and airlift testing of one (1) proposed production bore. The bore has intersected fractured and porous rock aquifers at depths between 48 and 115 metres with a cumulative yield up to 1.7 L/s demonstrated during air lifting. The bore was subject to a 48 hour drawdown and recovery pump test which reported a final drawdown level of 21.28 mbgl which is significantly shallower than the available limit at 108 metres.

This report documents the findings of a hydrogeological assessment incorporating aquifer testing (drillers airlift) in general accordance with requirements for water bores outlined by the *NSW Office of Water (NOW)* and consistent with the spirit and principles of the *NSW State Groundwater Policy Framework Document* (NSW Government 1997), the *NSW State Groundwater Quality Protection Policy* (NSW Government 1998) and the *NSW State Groundwater Dependent Ecosystems Policy* (NSW Government 2002).

The project objectives were to prepare a site specific hydrogeological assessment to document the hydrogeological setting and aquifer properties, and provide an assessment if the bore is capable of meeting the project water supply requirements supported by a 48 Hour Pump Test. Provide recommendations on bore yield, sustainable pumping regimes and assess potential impacts, if any, in context of the Site proposal.

A hydrogeological assessment was conducted for the site by undertaking the following scope of work:

- Pre-commencement groundwater target study - desktop review of available site data including; previous reports (if any); aerial photographs; geological and topographic maps; registered bore records;
- Review of the site proposal, water demand and operational requirements;
- Site inspection, check licensing requirements for distance setbacks and peg drilling targets;
- Prepare and lodge test bore drilling licences with NOW;
- Drill and construct test bore by licensed driller. Log cuttings and record details of aquifer intercepts. Conduct a minimum two (2) hour airlift to measure cumulative bore yield;
- 48 Hour drawdown and recovery Pump Test and data analysis;
- Collect representative water samples upon completion of pump testing and submit samples for NATA accredited laboratory analysis. Tabulate and compare the laboratory results against the Australian Drinking Water Guidelines (ADWG);

- Review the drilling and aquifer testing results. Identify any potential impacts from the proposed bore operations on existing bores, groundwater users (if any) and groundwater dependent ecosystems (GDEs), if any; and
- Compile the investigation results, prepare a Hydrogeological Assessment (HA) report including recommendations for bore licensing, groundwater management, and pumping regimes.

Based on the findings obtained during the scope of work the following conclusions and recommendations may be made:

- The subject bore was drilled and constructed by *Bungendore Water Bores* in April 2018. The bore was drilled to a depth of 120 m with 48 metres of solid surface casing and a 5 metre clay sanitary seal at the surface to prevent connection with any shallow soil water. The bore was completed with slotted PVC casing and gravel packed in general accordance with the *Minimum Construction Requirements for Water Bores in Australia* – 3rd *Edition* (2012). The bore sustained a drillers air lift yield of 1.7 L/s for three (3) hours during test drilling;
- The bore was subjected to a 48 hour (Bore 1) drawdown and recovery pumping test. The results indicate the subject bore is capable of sustaining an allocation of 24ML under the following pumping regime:
    - **Bore 1** - up to 1.15 L/s; 16 hr Pumping; 8 hrs Recovery; **24 ML** per year at 66 % duty. A higher pumping rate and operating duty may be realised supported by monitoring of pumping performance and recovery rates.
- The proposal is to convert the test bore to a production bore with a commercial, industrial and domestic groundwater access licence with an entitlement of 24 ML to facilitate the proposed development. The pumping yield of 1.15 L/s exceeds the estimated peak demand for the Site proposal of approximately 30,000 Litres per day (or up to 11 ML per year);
- Based on the capable yield the recommended pumping regime is considered low risk for groundwater impacts. Final drawdown in the bore was 21.28 mbgl which is significantly shallower than the available drawdown limit at a depth of 108 m below ground level at the top of the slotted casing and the primary aquifer zone. No registered water bores are present within a 1 km radius of the site and similarly no GDEs were identified at the Site area. Hence, it is assessed that under the proposed operating regime the bore will have no significant measurable impact on the groundwater environment and existing users in the area;
- NATA certificated laboratory results report water quality is generally within the criteria outlined by the ADWG (2016). Minor levels of iron and manganese are expected to reduce with long-term pumping as drilling sediment decrease, and any residual levels may be managed through primary treatment systems; and
- It is recommended that this report be submitted for final endorsement by the regulator.

# TABLE OF CONTENTS

# LIST OF TABLES, FIGURES & APPENDICES

## TABLES



## FIGURES



## APPENDICES

# 1.0 INTRODUCTION

Environment & Natural Resource Solutions (ENRS Pty Ltd) were commissioned as independent groundwater consultants to prepare a Hydrogeological Assessment (HA) incorporating the results of a 48 Hour Pump Test for a new production Bore at Lot 172 in DP 649063, street number 27782 Hume Highway, Bowning, NSW, 2582 (herein referred to as the Site).

ENRS understand this HA is required to document the groundwater supply at the Site in anticipation of development of a Highway Service Centre. The Centre will not be connected to the Yass Shire reticulation system. The proposal is to utilise groundwater at the Site to meet the design peak daily demand of approximately 20 Kilolitres per day.

Test drilling during the scope of work culminated in the construction and airlift testing of one (1) proposed production bore. The bore has intersected fractured and porous rock aquifers at depths between 48 and 115 metres with a cumulative yield up to 1.7 L/s demonstrated during air lifting. The bore was subject to a 48 hour drawdown and recovery pump test which reported a final drawdown level of 21.28 mbgl which significantly shallower than the available limit at 108 metres.

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## 1.1 OBJECTIVES

The project objectives were to prepare a site specific hydrogeological assessment to document the hydrogeological setting and aquifer properties, and provide an assessment if the bore is capable of meeting the project water supply requirements supported by a 48 Hour Pump Test. Provide recommendations on bore yield, sustainable pumping regimes and assess potential impacts, if any, in context of the Site proposal.

## 1.2 SCOPE OF WORK

A hydrogeological assessment was conducted for the site by undertaking the following scope of work:

- Pre-commencement groundwater target study - desktop review of available site data including; previous reports (if any); aerial photographs; geological and topographic maps; registered bore records;
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- Compile the investigation results, prepare a Hydrogeological Assessment (HA) report including recommendations for bore licensing, groundwater management, and pumping regimes.

# 2.0 SITE DESCRIPTION

## 2.1 LOCATION

The Site is located approximately two (2) kilometres west of the Township of Bowning in the Southern Tablelands of NSW. The site location is shown in **Figure 1**. The key features required to identify the Site are summarised in **Table 1**.

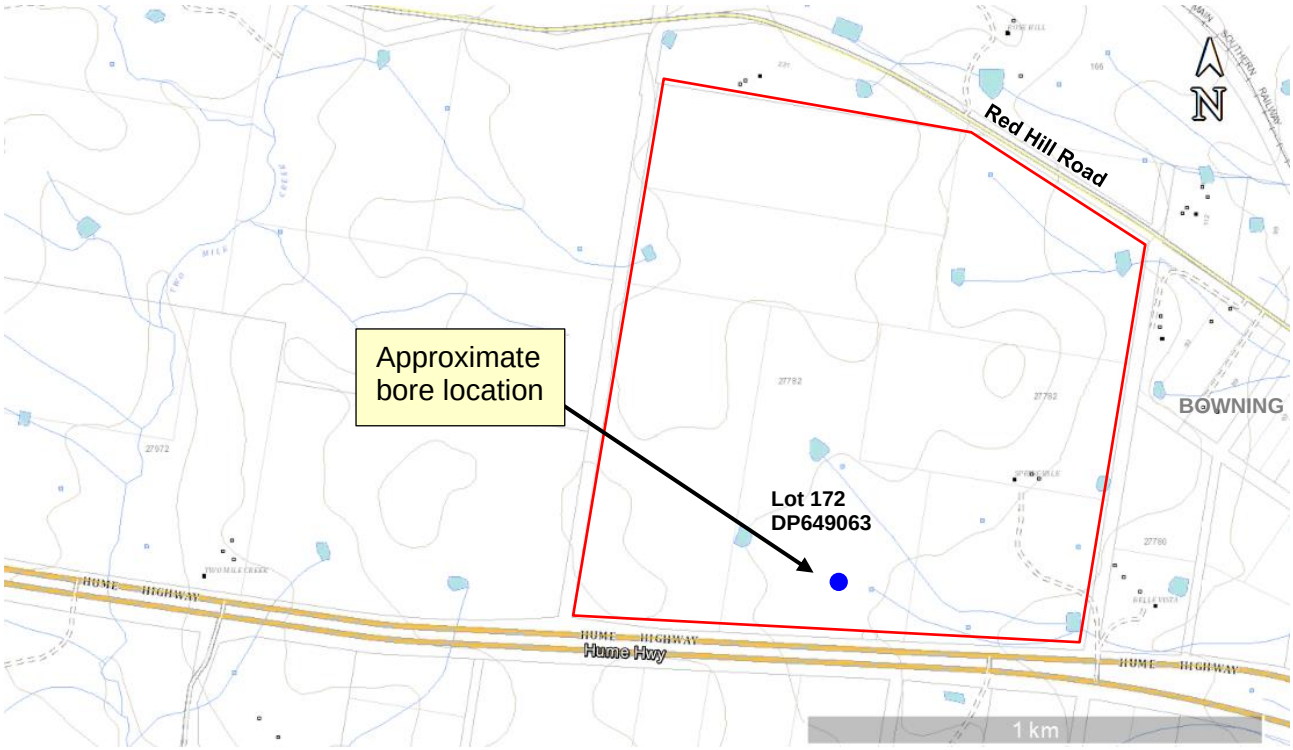
**Table 1: Site Identification**

| SITE | DESCRIPTION |
|---|---|
| **Street Address** | 27782 Hume Highway, Bowning, NSW, 2582 |
| **Lot / Deposited Plan** | 172 / 649063 |
| **Local Government Area** | Yass Valley |
| **Water Sharing Plan** | NSW Murray Darling Basin Fractured Rock |

## 2.2 TOPOGRAPHY

A review of the Yass (8628-2N) 1:25,000 topographic map sheet was conducted to assess the regional topography and identify potential groundwater controls including the location of structural lineaments, paleo-channels, recharge and discharge zones, and groundwater flow gradients. The Site is situated in a relatively flat and undulating area with a subtle regional gradient to the east as illustrated by drainage features mapped as blue lines on the topography sheet in **Figure 1**. The drainage features mapped within the Site are expected to be ephemeral.

**Figure 1: Site Location Map**



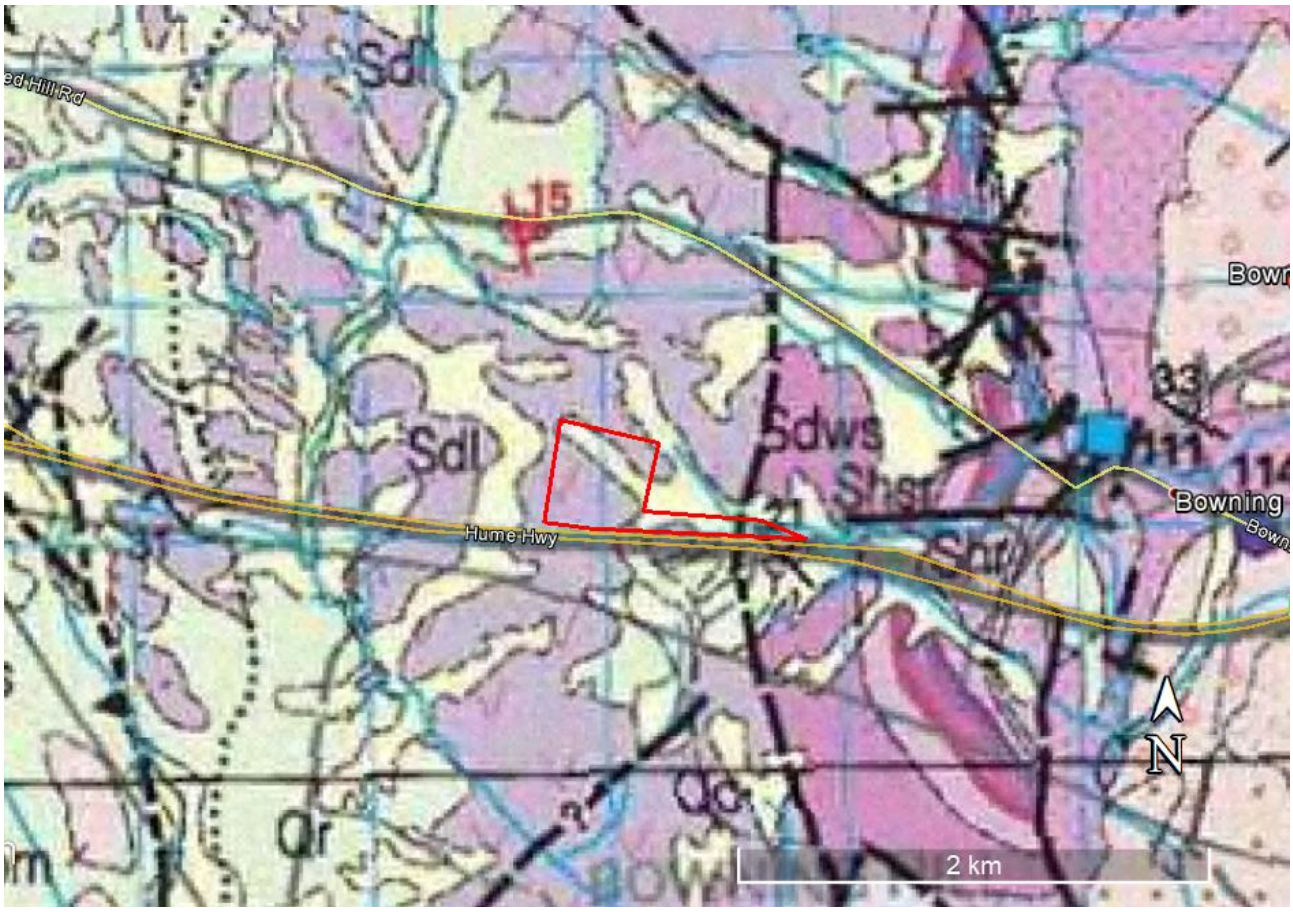

## 2.3 GEOLOGY

Review of the geological setting was conducted with reference to the Yass 1:100,000 geological series sheets. The site geology is provided in **Figure 2**. The assessment area is mapped as underlain by Laidlaw Volcanic (Sdl) with residual Quaternary deposits in lower lying areas through the central north and to the east. The mapped geology indicates there is a structural boundary in the far east of the site where the volcanics meet sedimentary deposits (Sdws-Mudstone). The stratigraphy is summarised in **Table 2** below:

**Table 2: Stratigraphic Formations**

| Period | Stratigraphy / Formation | Symbol | Lithology |
|---|---|---|---|
| Quaternary | Quaternary | Qa | Alluvial gravel, sand silt and clay. |
| Siluro-Devon | Laidlaw Volcanics | Sdl | Porphyritic rhyodacitic ignimbrite (extrusive volcanic) |
| Siluro-Devon | Brickies Creek Mudstone | Sdws | Light grey to beige aphanitic vitric tuff, light to grey siliceous mudstone |

**Figure 2: Geological Setting**




Source: NSW Government. Yass 1:100,000 Geological Series Sheet 8628.

## 2.4 HYDROGEOLOGY

The Site is located within the Murray-Darling basin fractured groundwater system. Based on the site geology, groundwater resources in the area are expected to be associated with two (2) primary forms of aquifer systems:

- *Shallow unconfined* systems hosted in unconsolidated alluvium and colluvium deposits, generally less than 10 m in depth with low to moderate yields, and variably salinity. These shallow systems are strongly controlled by rainfall recharge and are not considered a reliable source of long-term water supply. Flow regimes are expected to mimic the topographic gradient pending any structural or geological barriers; and
- *Deep fractured rock* and dual porosity aquifers hosted by the underlying rock sequences. Typically deeper than 40 m with variable yields and water quality controlled by geological faults, fractures, and joints from local and district faulting. Enhanced hydraulic conductivity is largely dependent on the scale and density of primary (void space between sediments grains) and secondary (fractures) porosity.

A review of *NOW* registered bore records was conducted prior to drilling to develop a conceptual model of regional groundwater conditions, including aquifer depths, yields, and water quality. The

search did not identify any registered bores within a one (1) kilometre radius of the site (**Figure 3**) which is expected to be well beyond the maximum radius of any potential drawdown due to the low proposed pumping rate at the Site. The bore search area was expanded to include bores within a 5 km radius of the Site to assess groundwater conditions in other bores within the area. A summary of the available hydrogeological records is summarised below in **Table 3**.

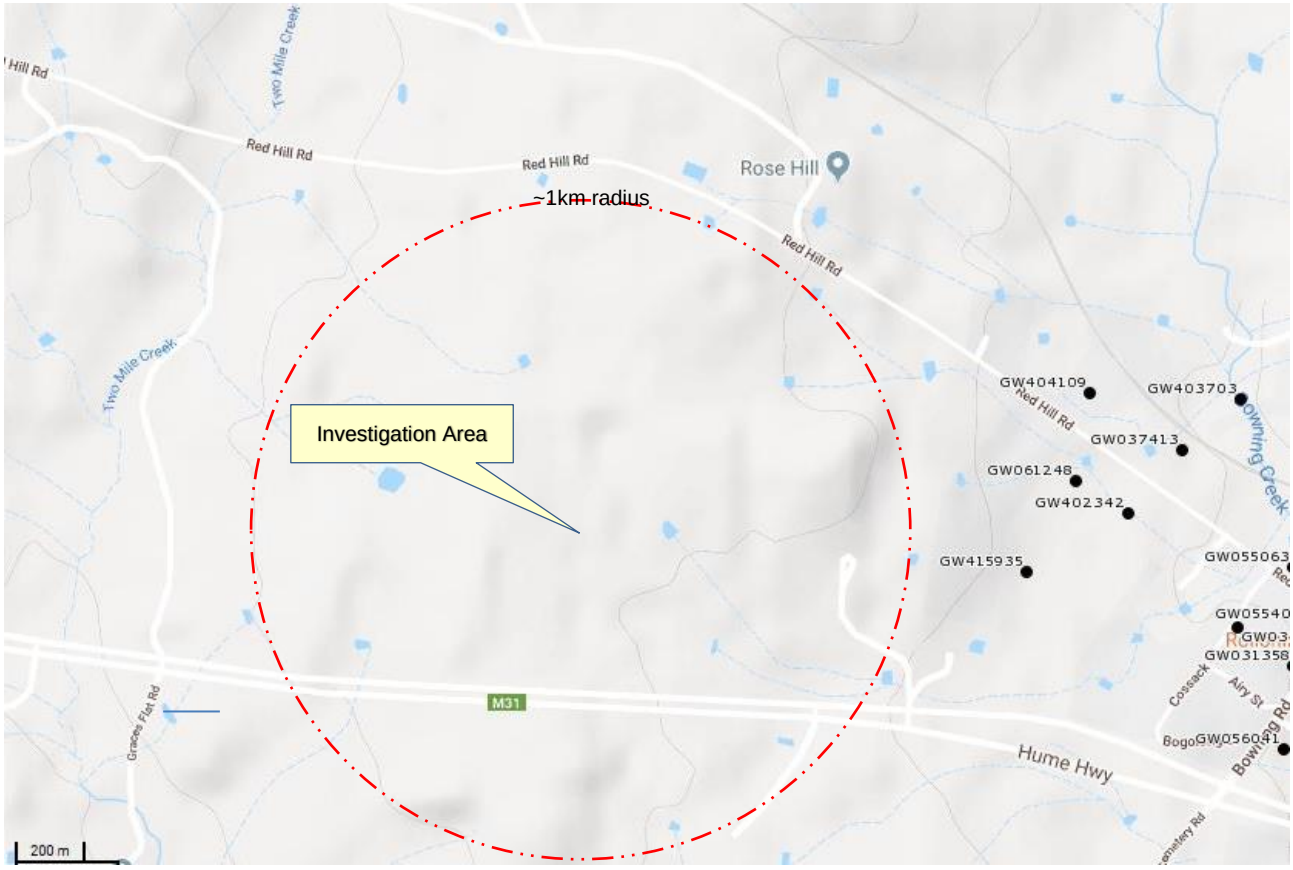
- Bore depths in the area ranged between 19.5 to 90 metres,;
- Yields ranged from 0.18-0.95 L/s;
- Standing Water Levels ranged from 3-14m below ground level (mbgl) and
- Host units are listed as both volcanic and igneous rocks.

**Table 3: Registered Bores within 5 km of the Site**

| Bore ID | Lat. | Long. | Bore Depth (m) | Yield L/s | SWL (mbgl) | Aquifer | Geology | Drilled Date | Use |
|---|---|---|---|---|---|---|---|---|---|
| GW416182 | - | - | 54 | 0.18 | 11 | 18-20, 46-48 | 0-36 shale, 36-54 volcanics | 18/03/2013 | S&D |
| GW061248 | -34.7652 | 148.8065 | 41.1 | 0.2 | 3 | 16.7-18.2 | Shale | 1/05/1985 | N/A |
| GW014383 | -34.7557 | 148.7695 | 25 | 0.51 | 13.4 | 15-25 | Granite | 1/01/1958 | S&D |
| GW020967 | -34.7334 | 148.8087 | 37.3 | 0.59 | - | 26-37 | Porphyry | 1/08/1953 | N/A |
| GW016395 | -34.7093 | 148.8093 | 19.5 | 0.63 | 4 | 14.6-19.5 | Porphyry | 1/07/1957 | S&D |
| GW031388 | -34.7512 | 148.7606 | 27.4 | 0.95 | - | 18-18.3 | Shale | 1/01/1967 | Unknown |
| GW409412 | -34.7505 | 148.7663 | 250 | 2.13 | 20 | 22-39, 96-99 | 0-60 shale 60-250 granite | 15/01/2010 | N/A |
| GW045239 | -34.7546 | 148.7737 | 34.1 | - | 14 | 29-34 | Shale | 1/04/1976 | Monitoring |
| GW415395 | - | - | 90 | - | - | - | - | 4/07/1905 | Domestic |

Note: S&D = Stock and Domestic

**Figure 3: Registered bore locations (Water NSW online database)**




# 3.0 TEST DRILLING

## 3.1 TEST BORE LICENCE

Prior to commencement ENRS submitted applications for test drilling and borehole construction with NOW. A Test Bore Licence was issued by NOW under Section 115 of the Water Act 1912. A summary of the test bore license is provided in **Table 4** below:

**Table 4: Test Bore Licence Summary**

| Licence | Purpose | Lot/DP | Issued | Valid | Number of Bores |
|---|---|---|---|---|---|
| 40BL192710 | Test Bore | 263//753596<br>128//753596<br>18//246891<br>172//649063<br>107//753596<br>16//246891<br>262//753596 | 20/3/2018 | Perpetuity | 8x Test Bores |

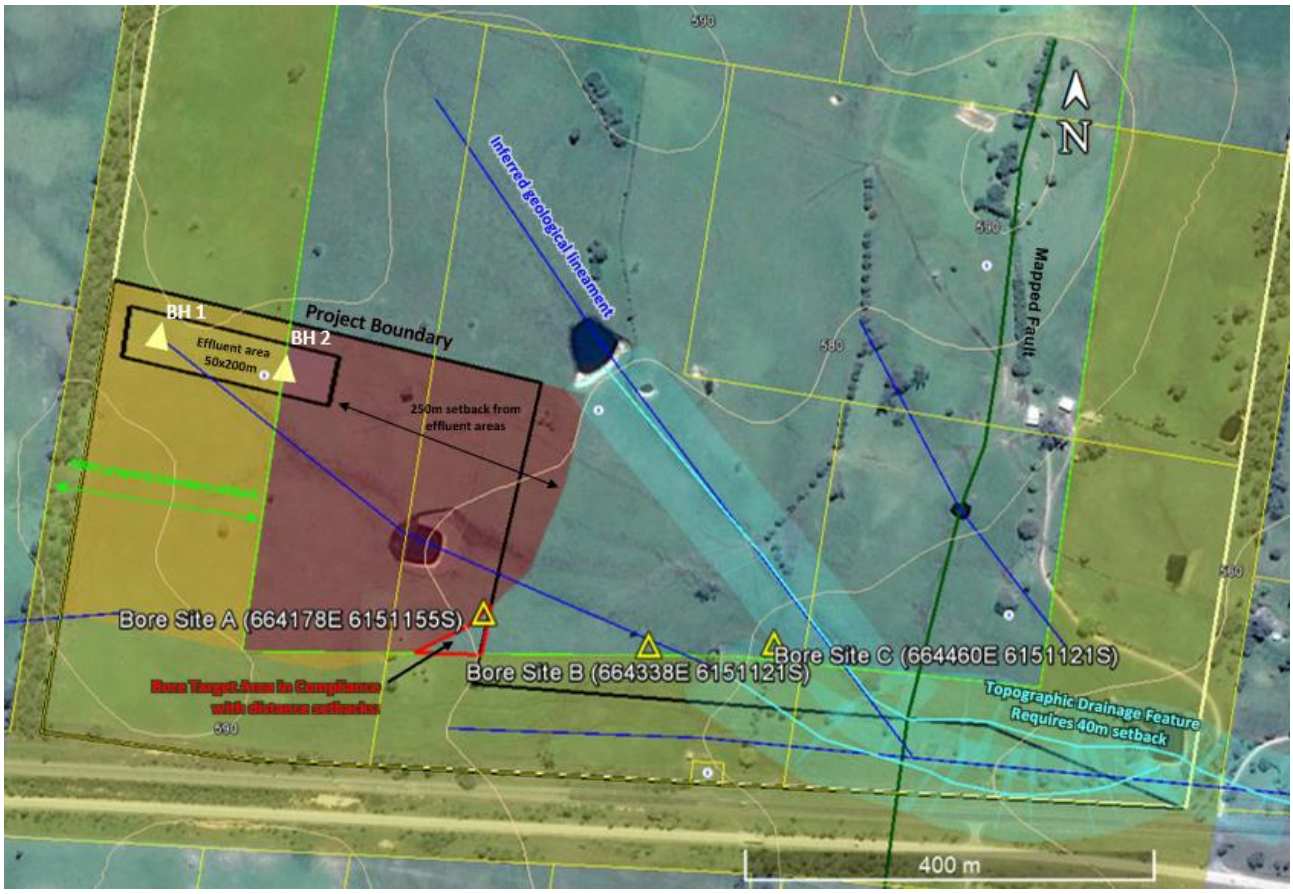
## 3.2 SELECTION OF DRILLING TARGETS

Drilling targets were selected following a desktop review of the hydrogeological setting with consideration of the following:

- Test bore licence terms and conditions;
- Land tenure and property boundary;
- Proximity to geological lineaments and potential groundwater controls;
    - 40 m from high bank (blue line on topographic maps);
    - 400 m from another WAL bore (irrigation/commercial pumping bore);
    - 200 m from a Basic Landholder Right (BLR/stock & domestic) bore;
    - 200 m from property boundary (or letter of non-objection from neighbouring landowners);
    - 500 m from Town Water Supply (TWS) Bores;
    - 400 m from NOW government monitoring bores; and
    - 250 m from effluent disposal area (or up/across gradient supported by Hydro Assessment).
- The distribution of alluvial deposits where additional surface casing is required to stabilise the borehole during drilling;
- Suitable distances between boreholes to minimise potential pumping interference;
- Suitable distance setback from potential sources of contamination including any dangerous goods storage and effluent disposal areas; and
- Drilling rig access, and proximity to services, namely power and existing reticulation pipelines;

Three (3) test bore targets were identified as Sites A, B, and C. The primary area of interest was positioned adjacent potential geological lineaments inferred from site topography. The location of test bore targets is shown in **Figure 4**.

**Figure 4: Test Bore Targets**




## 3.3 AIRLIFT TEST RESULTS

The bore was subject to minimum three (3) hour airlift test at completion of drilling. The flow rate during air lifting was recorded by the driller and documented on the Form A construction log.

***Bore 1 (Site A) was airlift tested for three (3) hours at an average rate of 1.7 L/s***. The bore sustained a constant flow throughout the duration of the airlift and no significant variation in water quality (pH and EC) was observed.

## 3.4 DRILLING RESULTS

Test drilling encountered two (2) metres of shallow soil and clay overlying volcanics. As sufficient flow was intercepted during the first test bore to warrant construction no further bores were drilled. A summary of the drilling results is provided below in **Table 5**:

**Table 5:Test Bore Drilling Results**

| Site | E (MGA) | N (MGA) | Depth | Result | Status |
|---|---|---|---|---|---|
| TB1 | 664195 | 6151138 | 120m | 50-52m 0.21 L/s<br>112-115m 1.47 L/s | Site 'A' constructed as Pumping Bore 1 |

# 4.0 BORE CONSTRUCTION

Drilling and borehole construction was conducted by *Bungendore Water Bores* during April 2018 in accordance with the minimum construction requirements for water bores in Australia (3rd ed. 2012). Details of the bore construction are documented in the 'Form A' reports contained in **Appendix A** with a summary provided in **Table 6** below.

- The bore was constructed with 48 metres of ***rigid surface casing*** sealed with expanding clay to prevent connection with surface water and shallow aquifers; and
- The bore casing extends above the surface and ***fitted with a sealed cap*** to prevent ingress from any flood water or surface water.

**Table 6: Bore Construction Summary**

| | |
|---|---|
| **Bore ID** | Production Bore 1 (TB1) |
| **Easting (MGA 56)** | 664195 |
| **Northing (MGA)** | 6151138 |
| **Drilled Depth (m)** | 120 |
| **Final Depth (m)** | 120 |
| **SWL (metres below ground level - mbgl)** | 0.5 mbgl (10/4/2018) |
| **Casing (150mm Cl 9)** | 0-120 m |
| **Slots (150mm Cl 9)** | 48-54 m<br>108-120 m |
| **Clay Seal** | 0-5.0 m |
| **Gravel pack (4-6mm)** | 5.0-120m |
| **TDS Lab** | 392 mg/L |
| **EC Lab** | 602 µS/cm |
| **pH Lab** | 8.17 pH |

# 5.0 AQUIFER TESTING

## 5.1 PUMP TEST METHODOLOGY

Pumping test design and methodology was developed and conducted in accordance with the Australian Standard for Test Pumping of Water Wells (AS 2368-1990). The pumping rate, duration and depth setting was selected following detailed review of the hydrogeological conditions including depth of target aquifers, aquifer type, available drawdown, and bore construction. Testing was conducted using a submersible pump. Water level data was collected in the pumping bore both manually and automatically with a submersible water level data logger programmed to record water levels at 10 minute intervals.

## 5.2 PUMP TEST RESULTS

A summary of the drawdown and recovery test results is provided in **Table 7**. Drawdown and recovery data was tabulated and plotted to produce aquifer response curves. The drawdown and recovery curves (refer to **Appendix B**) demonstrate high quality aquifer response data to support graphical analysis of aquifer properties.

No monitoring bores were constructed at the site during this assessment. Monitoring was conducted in the pumping bore. Aquifer response data was analysed in Aqtesolv software applying Cooper-Jacob and Theis straight line methods. Transmissivity (T) values for late drawdown data report values between 3.99 $m^2$/day and 5.92 $m^2$/day. Whilst the recovery data reports T values between 6.75 $m^2$/day and 7.46 $m^2$/day. From these reported values the Median T is 6.335 $m^2$/day.

The drilling and aquifer test results indicate the subject bore is capable of sustaining discharge rates of 1.5 L/s supported by equipping the bore with cut out transducers to prevent drawdown below the available limit at 108 mbgl. Based on the test results it is recommended to operate the bore under the following pumping regime:

- **Bore 1** - up to 1.5 L/s; 10 hrs Pumping; 14 hrs Recovery; 20 Mega Litres (ML) per year at 50 % pumping duty. A higher pumping rate and duty may be realised supported by monitoring of pumping performance and recovery rates.

**Table 7: Summary of Drawdown and Recovery Test Results**

| Bore ID | Bore 1 |
|---|---|
| Test Date | 3 / 12 / 2018 |
| Drawdown Test Duration (hrs) | 2 Day (48 Hours) |
| Recovery Test Duration (hrs) | 1 Day (26 Hours) |
| Pump Test Flow Rate (Litres per second) | 1.15 L/s |
| Static Water Level (SWL) (mbgl) | 2.5 (pump test) |
| Aquifers m-m~L/s (reported by driller) | 50-52 m ~0.21 L/s<br>112-115 m ~1.47 L/s |
| Indicative Yield (driller L/s) | 1.7 L/s sustained during 3 hour airlift |
| Available Drawdown | 108 mbgl to top of the slotted casing at the primary aquifer zone. |
| Final Drawdown during testing | 21.28 mbgl (18.78 mbSWL) |
| Transmissivity ($m^2$/day) | ~6.335 $m^2$/day |
| Recommended discharge rate (L/s) | ~1.15 L/s (or Up to 1.5 L/s) |
| Recommended pump setting (mbgl) | Max depth 108m with shroud |
| Recommended pumping schedule (hrs on – hrs off) | 16hr On – 8hr Off |
| Pump Duty % | 66 % |
| Capable Annual Yield (ML) | 24 ML per year |

Bore 1 was pump tested for 48 hours at a rate of 1.15 L/s with a maximum drawdown to 21.28 mbgl (or 18.78 mbSWL). The drawdown curve indicates a relatively steady drawdown rate with no significant barrier or boundary effects. The driller's aquifer intercepts and pump test results indicate the available drawdown is to a depth of 108 mbgl to the top of the slotted casing at the primary

aquifer zone. Initial water level recovery at completion of pumping is noted to be rapid becoming gradual. The bore recovered rapidly to within 20 cm of the initial SWL after 24 hours of ceasing to pump. Groundwater yields are supported by the intersection of dual porosity regional scale aquifers supported by an extensive recharge area.

The drilling and aquifer test results indicate the subject bore is capable of sustaining discharge rates greater than 1.15 L/s. It is recommended to operate the bore under the following pumping regime:

- **Bore 1 – pumping at 1.15L/s; 16 hours on followed by 8 hours recovery; 24 ML per year at 66 % duty.**

## 5.3 CAPABLE YIELD

Groundwater investigations comprised drilling of one (1) test bore culminating in the construction of one (1) production bore. The bore has intersected deep fractured rock aquifers supported by an extensive recharge area and no competing registered groundwater users. Based on the drillers airlift results the bore has a **capable yield of 24 ML** per annum operating at 66 per cent duty. The pumping yield of 1.15 L/s exceeds the estimated peak daily demand for the Site of approximately 30,000 Litres per day (or up to 11 ML per year).

It should be noted that the indicated groundwater extraction regimes are based on the aquifer response during a 48 hour period of testing and simulation stress. Groundwater extraction should be supported by appropriate groundwater management practices including regular water level monitoring. Bore performance may alter as a result of structural and chemical changes within the bore or due to variations in aquifer recharge, namely extended droughts or reductions in recharge from rainfall. It is recommended that groundwater bores be pumped on a cyclic pump duty such as (16 hours on and 8 hours off) to provide for sufficient water level recovery between pumping cycles and ensure the long-term sustainability of the groundwater resources. The Bore should also be equipped with cut-out probes to prevent dewatering below the primary aquifer.

# 6.0 WATER QUALITY

Water samples were collected after 48 hour pumping and submitted to a NATA accredited laboratory for analysis. The reader is referred to **Appendix C** for copies of Laboratory Certificates of Analysis (COA). The following section summarises the key water quality results. In general, the results report concentrations of key analytes within the criteria set by the Australian Drinking Water Guidelines (2016). Minor levels of iron and manganese are expected to decrease during long term pumping as residual sediments from drilling reduce. These minerals may also be managed through primary treatment and storage:

## 6.1 POTENTIAL HYDROGEN

pH is a measure of hydrogen activity. pH determines the balance between positive hydrogen ions (H+) and negative hydroxyl ions (OH-) and provides a test of water acidity (low pH) or alkalinity (high pH). Most natural freshwaters have a pH in the range 6.5 to 8.0. ***pH in the bore was reported at 7.57 (B1***) which is within the Australian Drinking Water (ADWG;2011) guideline of 6.5-8.5 pH.

## 6.2 SALINITY

Salinity reported as TDS is within the ADWG aesthetic criteria which is suitable for the proposed use (industrial, commercial and domestic). The ADWG note that typical values for TDS in regional water supplies can be up to 1,000 mg/L or higher due to groundwater characteristics. A summary of the salinity guidelines for palatability is provided in **Table 8**.

**Table 8: Water Salinity Criteria**

| Bore ID | TDS Criteria (ADWG;2016) | Palatability |
|---|---|---|
| | 0 – 600<br>600 – 900<br>900 – 1200<br>>1200 | Good<br>Fair<br>Poor<br>Unacceptable |
| Bore 1 | 404 mg/L (600 uS/cm) | Good |

## 6.3 METALS AND METALLOIDS

Water samples were analysed for a suite of sixteen (16) selected heavy metals and metalloids including:

- Aluminium (Al);
- Arsenic (As);
- Boron (B);
- Barium (Ba);
- Cadmium (Cd);
- Calcium (Ca);
- Total Chromium (T.Cr.)
- Copper (Cu);
- Iron (Fe);
- Lead (Pb);
- Magnesium (Mg);
- Manganese (Mn);
- Mercury (Hg);
- Nickel (Ni);
- Silver (Ag); and
- Zinc (Zn).

Analysis for Heavy Metals and Metalloids generally reported concentrations below the limits stipulated in the Australian Drinking Water Guidelines (ADWG 2016). These results are considered satisfactory. Minor concentrations of total Iron were detected with 0.33 mg/L which is slightly above the aesthetic criteria of 0.3 mg/L. Similar levels of manganese were reported with 0.591 mg/L. Table 10.6 of the ADWG (2016) documents that Manganese occurs naturally in water and is higher in oxygen-depleted water (e.g. groundwater at bottom of deep storages). Section 8.3.5 of the ADWG (2016) outlines treatment options for iron and manganese by oxidation, through chlorination which enables ready removal by coagulation, flocculation and filtration. The reported concentrations of iron and manganese are not expected to limit site operations and may be managed by treatment and filtration.

# 7.0 IMPACT ASSESSMENT

## 7.1 DISTANCE DRAWDOWN

A search of the *NOW* groundwater database did not identify any licensed water bores within one (1) kilometre of the assessment site which indicates there is no existing users in proximity to the site.

Given the significant distance from registered bores and minor drawdown in the bore after continuous pumping for 48 hours it is assessed that there is a low risk for distance drawdown impacts on existing groundwater users in the area. No further impact assessment or calculations are considered necessary.

## 7.2 GROUNDWATER DEPENDENT ECOSYSTEMS (GDE)

Review of the property and surrounding landuse indicates that the site is located within the Bowning Creek sub catchment area. It was identified that there is potential for shallow colluvium aquifers to interact with intermittent streams recorded on the topographic map sheet. An online search of the Bureau of Meteorology (BOM) GDE atlas was conducted to identify any potential sensitive ecosystems within 5 km of the Bore. Information held in the GDE atlas includes:

- The supplied ecosystem type;
- The GDE potential, which is a measure of the assessed dependence potential of the ecosystem on groundwater resources; and
- The Inflow Dependent Ecosystem (IDE) likelihood, which is a measure of the likelihood of the landscape accessing water in addition to rainfall.

A summary of identified potential ecosystems within 5km of the bore is presented below in **Table 9**.

**Table 9: Identified Potential GDEs**

| Distance from Bore Site | Supplied Ecosystem Type | GDE Potential |
|---|---|---|
| 600m | Northern slopes dry grass woodland | Low potential |
| 3km | Western slopes herb/grass woodland | Moderate potential |
| 4km to Bowning Creek riparian area | Western slopes herb/grass woodland | Moderate potential |

Further review of the Site's hydrogeological setting including walkover and aerial imagery did not identify any GDE's at the Site. Furthermore, given the borehole has been constructed with solid casing to 48 metres and at least a five (5) metre clay sanitary seal to prevent inflow of shallow soil water, this assessment considers the bore to be adequately constructed so as not to be in direct hydraulic connection with any overlying shallow aquifer. Hence, the proposed pumping from the deep fractured rock aquifers is not assessed to present any measurable impact on Groundwater Dependent Ecosystems (GDE's) in connection with the colluvial systems.

# 8.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings obtained during the scope of work the following conclusions and recommendations may be made:

- The subject bore was drilled and constructed by *Bungendore Water Bores* in April 2018. The bore was drilled to a depth of 120 m with 48 metres of solid surface casing and a 5 metre clay sanitary seal at the surface to prevent connection with any shallow soil water. The bore was completed with slotted PVC casing and gravel packed in general accordance with the *Minimum Construction Requirements for Water Bores in Australia* – 3rd *Edition* (2012). The bore sustained a drillers air lift yield of 1.7 L/s for three (3) hours during test drilling;
- The bore was subjected to a 48 hour (Bore 1) drawdown and recovery pumping test. The results indicate the subject bore is capable of sustaining an allocation of 24ML under the following pumping regime:
    - **Bore 1** - up to 1.15 L/s; 16 hr Pumping; 8 hrs Recovery; **24 ML** per year at 66 % duty. A higher pumping rate and operating duty may be realised supported by monitoring of pumping performance and recovery rates.
- The proposal is to convert the test bore to a production bore with a commercial, industrial and domestic groundwater access licence with an entitlement of 24 ML to facilitate the proposed development. The pumping yield of 1.15 L/s exceeds the estimated peak demand for the Site proposal of approximately 30,000 Litres per day (or up to 11 ML per year);
- Based on the capable yield the recommended pumping regime is considered low risk for groundwater impacts. Final drawdown in the bore was 21.28 mbgl which is significantly shallower than the available drawdown limit at a depth of 108 m below ground level at the top of the slotted casing and the primary aquifer zone. No registered water bores are present within a 1 km radius of the site and similarly no GDEs were identified at the Site area. Hence, it is assessed that under the proposed operating regime the bore will have no significant measurable impact on the groundwater environment and existing users in the area;
- NATA certificated laboratory results report water quality is generally within the criteria outlined by the ADWG (2016). Minor levels of iron and manganese are expected to reduce with long-term pumping as drilling sediment decrease, and any residual levels may be managed through primary treatment systems; and
- It is recommended that this report be submitted for final endorsement by the regulator.

# 9.0 REFERENCES

Cooper H.H. and Jacob C.E. 1946. A Generalised Graphical Method for Evaluating Constants and Summarising Field History. Trans. Amer. Geophys. Union. Vol. 27, pp.526

Australian Government National Water Commission (2012). Minimum Construction Requirements for Water Bores in Australia (third Edition).

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Murray-Darling Basin Commission 1997, Murray-Darling Basin Groundwater Quality Sampling Guidelines, Technical Report No. 3, MDBC Groundwater Working Group, Commonwealth of Australia.

Standards Australia 1998a, AS/NZS 5667.1:1998 Water quality sampling guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples

Standards Australia, New South Wales. 1998b, AS/NZS 5667.11:1998 Water Quality Sampling Guidance on Sampling of Groundwaters, Standards Australia, New South Wales.

# 10.0 REFERENCES

**Air-lift yield**: a yield obtained using compressed air (via a compressor normally coupled to a drilling rig) to lift water flowing into a well to the surface, to enable measurement of its flow.

**Alluvium:** Sediment (gravel, sand, silt, clay) transported by water (i.e. deposits in a stream channel or floodplain).

**Anisotropy:** The condition of a porous medium where the permeability is different in different directions.

**Aquiclude:** A low-permeability unit that forms either the upper or lower boundary of a groundwater flow system.

**Aquifer:** Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable able to transmit quantities of water to wells and springs. An aquifer may be porous rock, unconsolidated gravel, fractured rock, or cavernous limestone.

**Aquitard:** A low-permeability unit than can store ground water and also transmit it slowly from one aquifer to another.

**Beneficial Use**: general categorization of groundwater uses based on water quality and the presence or absence of contaminants. Beneficial use is the equivalent to the environmental value of water.

**Bore:** A deep hole of small diameter bored into the aquifer, through which water equilibrates and may rise under hydrostatic pressure.

**Colluvium:** Sediment (gravel, sand, silt, clay) transported by gravity (i.e. deposits at the base of a slope).

**Cone of Depression:** The depression in the water table around a well or excavation defining the area of influence of the well. Also known as cone of influence.

**Confined Aquifer:** an aquifer that is overlain by a confining bed. The confining bed has a significantly lower hydraulic conductivity than the aquifer.

**Drawdown:** A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of ground water from wells or excavations.

**Dual porosity aquifer**: upon pumping releases water from both intergranular pores and fractures

**Environmental flow:** A water regime provided within a river, wetland or estuary to improve or maintain ecosystems and their benefits where there are competing water uses and where flows are regulated.

**Groundwater Dependant Ecosystems (GDE)**: GDEs are ecosystems that use groundwater as part of survival, and can potentially include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps. The groundwater dependence of ecosystems will range from complete reliance to those that partially rely on groundwater, such as during droughts.

**Groundwater recharge:** Inflow of water to an aquifer from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge.

**Hanging swamps:** ancient freshwater wetlands often rich in biodiversity. The soil structure is fragile generally with low fertility and a loose structure that is highly susceptible to erosion and fire. Hanging Swamps rarely show surface water, but large amounts of water are often held in

the soil beneath the surface, filtering through the swamp and flowing into the downstream creek. The Hanging swamps in the Hawkesbury-Nepean catchment have been identified as an Endangered Ecological Community under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

**Hydraulic Conductivity** The ease with which a fluid will flow through a porous medium. It is a function of the pore size and fluid properties of viscosity and density.

**Hydraulic gradient**: The hydraulic gradient is a vector gradient between two or more hydraulic head measurements over the length of the flow path. The distribution of hydraulic head through an aquifer determines where groundwater will flow.

**Hydrogeology:** The branch of geology that deals with the occurrence, distribution, and effect of groundwater.

**Igneous intrusions:** Igneous intrusions are rocks which form when magma cools and solidifies before it reaches the earth's surface. Three common types of intrusion are sills, dykes, and batholiths.

**Infiltration:** The flow of water downward from the land surface into and through the upper soil layers.

**Losing Stream** A stream in which the water surface is lower than the adjacent water table, thus causing water to flow from the groundwater system into the stream.

**Packer test:** An aquifer test performed in an open borehole; the segment of the borehole to be tested is sealed off from the rest of the borehole by inflating seals, called packers, both above and below the segment.

**Perched aquifer:** A region in the unsaturated zone where the soil or rock may be locally saturated because it overlies a low-permeability unit.

**Permeability** The property of a porous medium to transmit water. It is a function of pore diameter.

**Piezometer:** A non-pumping well, generally of small diameter, that is used to measure the elevation of the water-table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.

**Porosity**: ratio of pore spaces and voids to that of solid aquifer matrix.

**Potentiometric surface:** a pressure head surface commonly, but sometimes incorrectly referred to as the water table. The movement of groundwater is largely driven by elevation (pressure head). Aka as piezometric head – a piezometer being a special bore that monitors pressure head.

**Primary Porosity** The porosity characteristic of a rock or soil when first formed.

**Pumping Test:** A test made by pumping a well for a period of time and observing the response/change in hydraulic head in the aquifer.

**Secondary Porosity** The porosity that is added to a rock or soil after formation; it can include faults, fissures, fractures, etc.

**Semi-Confined Aquifer** An aquifer overlain or underlain by a semi-permeable aquitard which will allow limited flow of water to pass through.

**Slug Test:** A test made by the instantaneous addition, or removal, of a known volume of water to or from a well. The subsequent well recovery is measured.

**Specific yield**: effective or drainable porosity – a measure of the ratio of groundwater that may be extracted from an aquifer relative to the solid matrix.

**Spring**: a location where groundwater naturally emerges from the earth's subsurface in a seep or defined flow. Occurs when the water table is higher than the ground surface. Pressure head forces the water out of the land at a weak point which creates the spring. The existence of a spring requires that below the subsurface, the infiltrating water encounters a low-permeability zone and is unable to continue to percolate downward as fast as it is supplied at the surface. As a result, the water spreads laterally until it intersects the land surface where erosion has lowered the topography to the water's level (e.g., on the side of a gully, hill or valley). For many people, springs are the most obvious and interesting evidence of groundwater.

**Standing Water Level**: Depth to groundwater (m) below a datum point or reference point, usually from the top of casing or natural surface.

**Storativity:** The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer, per unit change in head.

**Sustainable yield**: volume of groundwater that may be abstracted from an aquifer without detrimentally affecting existing supplies or flows / fluxes to the environment including groundwater dependent environments. The estimation of sustainable yield takes into account rainfall amount, recharge as a proportion of rainfall and environmental water requirements (environmental flows to creeks as 'baseflow' and groundwater dependent ecosystems).

**Transmissivity:** A measure of the rate at which water moves through an aquifer of unit width under a unit hydraulic gradient.

**Unconfined Aquifer:** An aquifer in which there are no confining beds between the saturated zone and the surface. There will be a water-table in an unconfined aquifer.

**Unsaturated zone:** The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone. Also called zone of aeration and vadose zone.

**Water budget:** An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or a drainage basin.

# LIMITATIONS

This report and the associated services performed by ENRS are in accordance with the scope of services set out in the contract between ENRS and the Client. The scope of services was defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to Site.

ENRS derived the data in this report primarily from visual inspections, and, limited sample collection and analysis made on the dates indicated. In preparing this report, ENRS has relied upon, and presumed accurate, certain information provided by government authorities, the Client and others identified herein. The report has been prepared on the basis that while ENRS believes all the information in it is deemed reliable and accurate at the time of preparing the report, it does not warrant its accuracy or completeness and to the full extent allowed by law excludes liability in contract, tort or otherwise, for any loss or damage sustained by the Client arising from or in connection with the supply or use of the whole or any part of the information in the report through any cause whatsoever.

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It is the responsibility of the Client to accept if the Client so chooses any recommendations contained within and implement them in an appropriate, suitable and timely manner.

# Appendix A

# Form A Drillers Logs

27782 Hume Hwy Bowning Supply Bore

NSW DEPARTMENT OF WATER & ENERGY

Natural Resource Products

# FORM A
# PARTICULARS OF COMPLETED WORK

| | | | |
|---|---|---|---|
| Driller's Licence No: | 1623 | Work Licence No: | 40 B L 40BL192710 |
| Class of Licence: | 4 | Name of Licensee: | Wayne Lawrence |
| Driller's Name: | Danny Hill | Intended Use: | Domestic Supply |
| Assistant Driller: | Gerry Hill | Completion Date: | Apr-18 |
| Contractor: | Bungendore Water Bores | | |

| | | | |
|---|---|---|---|
| New bore | X | Replacement bore | |
| Deepened | | Enlarged | |
| Reconditioned | | Other (specify) | |

Final Depth 120.0 m

## DRILLING DETAILS

| From (m) | To (m) | Hole Diameter (mm) | Drilling Method Code |
|---|---|---|---|
| 0 | 120 | 200 | 5 |
| | | | |
| | | | |

## WATER BEARING ZONES

| From (m) | To (m) | Thickness (m) | S W L (m) 0.5 | Estimated Yield (L/s) Individual Aquifer | Estimated Yield (L/s) Cumulative | Test method Code | D D L at end of test (m) | Duration Hrs | Duration min | Salinity (Conductivity or TDS) Cond. (µS/cm) | Salinity (Conductivity or TDS) TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 52 | 2 | 0.5 | 0.21 | 0.21 | 1 | | | | | |
| 112 | 115 | 3 | | 1.26 | 1.47 | 1 | | | | 602 | |
| | | | | | | | | | | | |

## CASING / LINER DETAILS

| Material Code | OD (mm) | Wall Thickness (mm) | From (m) | To (m) | Method Fixing Code |
|---|---|---|---|---|---|
| 5 | 150 | | 0 | 120 | 1 |
| | | | | | |
| | | | | | |
| | | | | | |

Casing support method Code 2

Type of casing bottom Code 2

Centralisers installed No [ ] Yes [ ] (indicate on sketch)

Sump installed No [X] Yes [ ] From m To m

Pressure cemented No [X] Yes [ ] From m To m

Casing Protector cemented in place No [ ] Yes [ ]

## WATER ENTRY DESIGN

| General: Material Code | OD (mm) | Wall Thickness (mm) | From (m) | To (m) | Opening type Code | Fixing Code | Screen Aperture (mm) | Slot Details Length (mm) | Slot Details Width (mm) | Slot Details Alignment Code |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 150 | | 48 | 54 | 5 | 1 | | | | V |
| 5 | 150 | | 108 | 120 | 5 | 1 | | | | V |
| | | | | | | | | | | |
| | | | | | | | | | | |

## GRAVEL PACK

| Type | | Grade | | Grain size (mm) From | Grain size (mm) To | Depth (m) From | Depth (m) To | Quantity Litres or $m^3$ | |
|---|---|---|---|---|---|---|---|---|---|
| Rounded | X | Graded | X | 4 | 6 | 5 | 120 | | |
| Crushed | | Ungraded | | | | | | | |
| Bentonite/Grout seal | No [ ] | Yes | [X] | | | 0 | 5 | | |

Method of placement of Gravel Pack Code 1

For D W E use only: G W

 27782 Hume Hwy Bowning Supply Bore

**NSW DEPARTMENT OF WATER & ENERGY**

**Natural Resource Products**

**FORM A .....**
**PARTICULARS OF COMPLETED WORK**

**Work Licence No:** 4 0 B L 40BL192710

## BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud No [X] Yes [ ] Name:

| | | | | | | |
|---|---|---|---|---|---|---|
| Method | Bailing/Surging [ ] | Jetting | Airlifting [X] | Backwashing [ ] | Pumping [ ] | Other: |
| Duration | hrs | hrs | 3 hrs | hrs | hrs | hrs |

## DISINFECTION ON COMPLETION 9

| Chemical/s used | Quantity applied (litres) | Method of application |
|---|---|---|
| | | |

## PUMPING TESTS ON COMPLETION 10

| Test type | | Date | Pump intake depth (m) | Initial Water Level (SWL) (m) | Pumping rate (L/s) | Water Level at end of pumping (DDL) (m) | Duration of Test (hrs) | Recovery: Water level (m) | Recovery: Time taken (hrs) | Recovery: Time taken (mins) |
|---|---|---|---|---|---|---|---|---|---|---|
| Multi stage (stepped drawdown) | Stage 1 | | | | | | | | | |
| | Stage 2 | | | | | | | | | |
| | Stage 3 | | | | | | | | | |
| | Stage 4 | | | | | | | | | |
| Single stage (constant rate) | | | | | | | | | | |

Height of measuring point above ground level _____ Test Method **Code** [ ] See Code Table 4

## WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: _____ metres Is work partly backfilled: No [x] Yes [ ]

Is work abandoned: No [x] Yes [ ] Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work No [ ] Yes [ ] From _____ m To _____ m

| Sealing / fill type Code | From depth (m) | To depth (m) | Sealing / fill type Code | From depth (m) | To depth (m) |
|---|---|---|---|---|---|
| | | | | | |

Site chosen by: Hydrogeologist [X] Geologist [ ] Driller [ ] Diviner [ ] Client [ ] Other _____ 12

Lot No **16** DP No **246891** 13

**Work Location Co ordinates** Easting **664195** Northing **6151138** Zone **55H**

**GPS:** No [ ] Yes [x] >> AMG/AGD [ ] or MGA/GDA [X] (See explanation)

Please mark the work site with "X" on the DWE CLID map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

## Signatures:

**Driller:** *Danny Hill (on behalf of applican* **Licensee:** W K Lawrence

**Date:** *9/05/2018* **Date:** *9/05/2018*

 27782 Hume Hwy Bowning Supply Bore

**NSW DEPARTMENT OF WATER & ENERGY**

**Natural Resource Products**

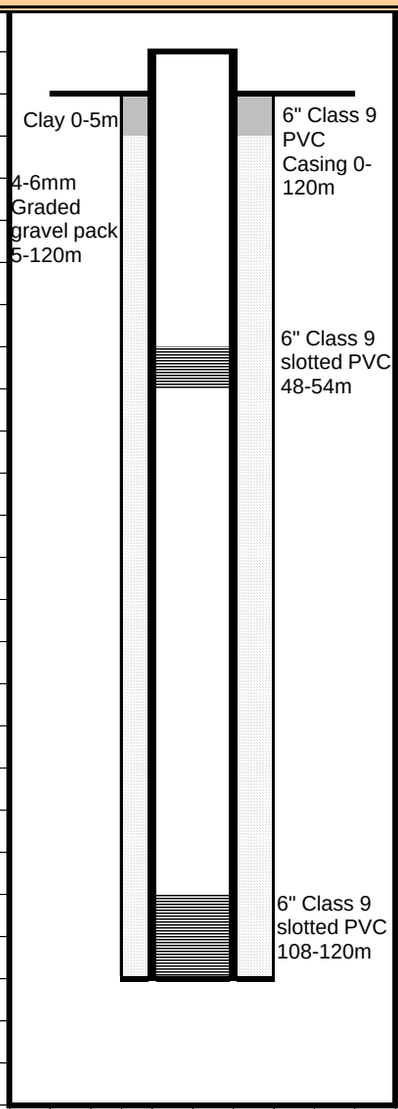
**FORM A** ……..
**PARTICULARS OF COMPLETED WORK**

**Work Licence No:** 4 0 B L 40BL192710

## DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

| Depth From (m) | Depth To (m) | Description |
|---|---|---|
| 0 | 2 | Soil, brow clay |
| 2 | 33 | Light brown volcanics |
| 33 | 56 | Grey brown volcanics |
| 56 | 120 | Black fractured volcanics |
| 30 | | |
| 35 | | |
| 40 | | |
| 45 | | |
| 50 | | |
| 55 | | |
| 60 | | |
| 65 | | |
| 70 | | |
| 75 | | |
| 80 | | |
| 85 | | |
| 90 | | |
| 95 | | |
| 100 | | |
| 105 | | |
| 110 | | |
| 115 | | |
| 120 | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**WORK CONSTRUCTION SKETCH**




## WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug ☐ Back hoe ☐ Dragline ☐ Dozer ☐ Other ……

| Depth (m) | Length (m) | Width (m) | Diameter (m) | Lining material | Dimentions of liner (m) | From Depth (m) | To Depth (m) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |

## Please attach copies of the following if available — 17

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Geologist log | No | X | Yes | ☐ | Laboratory analysis of water Sample | No | ☐ | Yes | X | Pumping test(s) | No | X | Yes | ☐ |
| Geophysical log | No | X | Yes | ☐ | Sieve analysis of aquifer material | No | X | Yes | ☐ | Installed Pump details | No | X | Yes | ☐ |

Bowning Bore 1 – During Pump Test

664195E 6151138N

- The bore is constructed with 48 metres of ***rigid surface casing*** sealed with expanding clay to prevent connection with surface water and shallow aquifers; and
- The bore casing extends above the surface and is finished with a monument pad and ***fitted with a sealed cap*** to prevent ingress from any flood water or surface water.


Bore Location
Work Licence No: 40
BL: 40BL192710
Lot 172
DP 649063
Google Earth
Imagery © Department Finance, Services and Innovation 2016
Data © Department Finance, Services and Innovation 2016
N
700 m

# Appendix B

# Pump Test Results

**TABLE 1**

## DRAWDOWN ANALYSIS DATA

## SINGLE RATE PUMP TEST

| | | | |
|---|---|---|---|
| ***Test date :*** | 3/12/2018 | **PROJECT :** | Bowning |
| ***Start time :*** | 12:00 PM | **CLIENT :** | - |
| ***Pump Off:*** | 5/12/2018 12:30 PM | **BORE No #** | Pumping Bore #1 |
| ***Casing I.D.:*** | 150 mm | **Tested by:** | GoulProd |
| ***Pump type/mod:*** | - | **Av.Pump Rate (L/sec):** | 1.15L/s |
| ***Pump O.D.:*** | - | **SWL (mbtoc):** | 2.50 |
| ***Pump Intake m:*** | 100m | **Ref. Point (m):** | 0.00 |

| *Real time* | *Hours* | *Time minutes T* | *Drawdown metres S1* | *Depth to water metres below ground level mbgl* | *Discharge Rate L/sec Q* | *Time to fill 200L Secs* | *Comments / Observations* |
|---|---|---|---|---|---|---|---|
| 12:00 PM | | **0** | 0.00 | 2.50 | - | - | **= SWL** |
| | | **10** | 8.35 | 10.85 | - | - | |
| | | **20** | 9.15 | 11.65 | - | - | Note: Data recorded at |
| | | **30** | 9.25 | 11.75 | 20.00 | 10.0 | 10 minute intervals |
| | | **40** | 10.33 | 12.83 | - | - | on Diver Logger |
| | | **50** | 10.13 | 12.63 | - | - | |
| 1:00 PM | **1** | **60** | 9.99 | 12.49 | 20.00 | 10.0 | |
| | | **70** | 11.50 | 14.00 | - | - | |
| | | **80** | 12.12 | 14.62 | - | - | |
| | | **90** | 12.60 | 15.10 | 17.39 | 11.5 | |
| 2:00 PM | **2** | **120** | 12.72 | 15.22 | 13.99 | 14.3 | |
| | | **130** | 12.80 | 15.30 | 10.00 | 20.0 | |
| | | **150** | 13.00 | 15.50 | - | - | |
| 3:00 PM | **3** | **180** | 13.27 | 15.77 | - | - | |
| | | **210** | 13.41 | 15.91 | - | - | |
| 4:00 PM | **4** | **240** | 13.66 | 16.16 | - | - | |
| | | **270** | 13.82 | 16.32 | - | - | |
| 5:00 PM | **5** | **300** | 13.31 | 15.81 | - | - | |
| | | **330** | 13.38 | 15.88 | - | - | |
| 6:00 PM | **6** | **360** | 13.45 | 15.95 | - | - | |
| | **7** | **420** | 15.12 | 17.62 | 10.00 | 20.0 | |
| | **8** | **480** | 15.13 | 17.63 | - | - | |
| 9:00 PM | **9** | **540** | 14.64 | 17.14 | - | - | |
| | **10** | **600** | 14.72 | 17.22 | 9.09 | 22.0 | |
| | **11** | **660** | 14.77 | 17.27 | - | - | |
| | **11** | **670** | 15.53 | 18.03 | - | - | |
| 12:00 AM | **12** | **720** | 15.91 | 18.41 | - | - | |
| | **14** | **840** | 16.06 | 18.56 | - | - | |
| | **16** | **960** | 16.14 | 18.64 | - | - | |
| 6:00 AM | **18** | **1080** | 16.34 | 18.84 | - | - | |
| 8:00 AM | **20** | **1200** | 16.52 | 19.02 | 8.40 | 23.8 | |
| | **20.2** | **1210** | 16.56 | 19.06 | 10.00 | 20.0 | |
| | **20.3** | **1220** | 16.56 | 19.06 | 10.00 | 20.0 | |
| 12:00 PM | **24** | **1440** | 17.14 | 19.64 | - | - | |
| | **28** | **1680** | 18.77 | 21.27 | - | - | |
| | **32** | **1920** | 18.18 | 20.68 | - | - | |
| | **36** | **2160** | 18.37 | 20.87 | - | - | |
| | **40** | **2390** | 18.65 | 21.15 | - | - | |
| | **44** | **2640** | 18.54 | 21.04 | - | - | |
| 12:00 PM | **48** | **2880** | 18.78 | 21.28 | - | - | |

**TABLE 2**

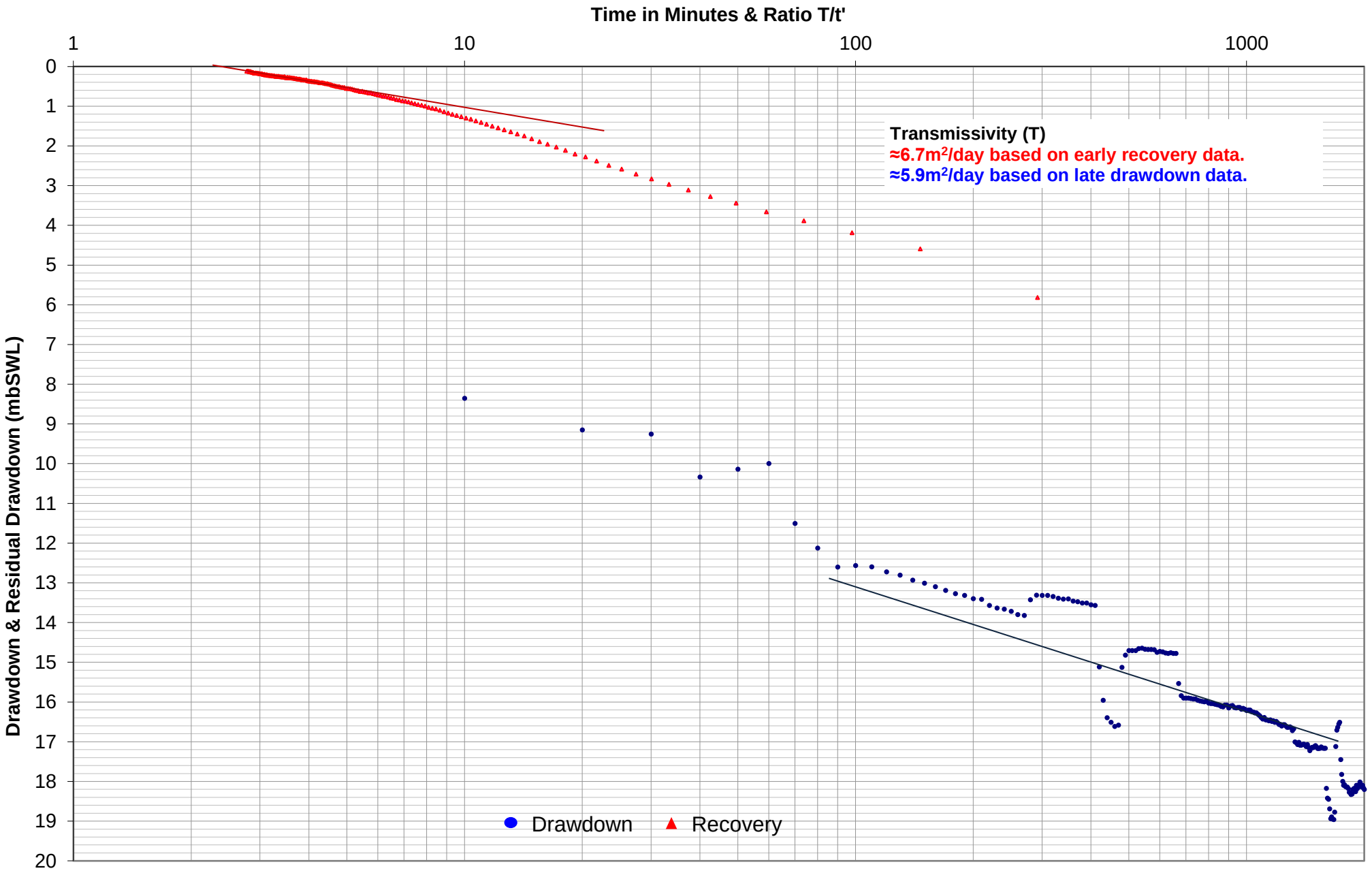
## RECOVERY ANALYSIS DATA

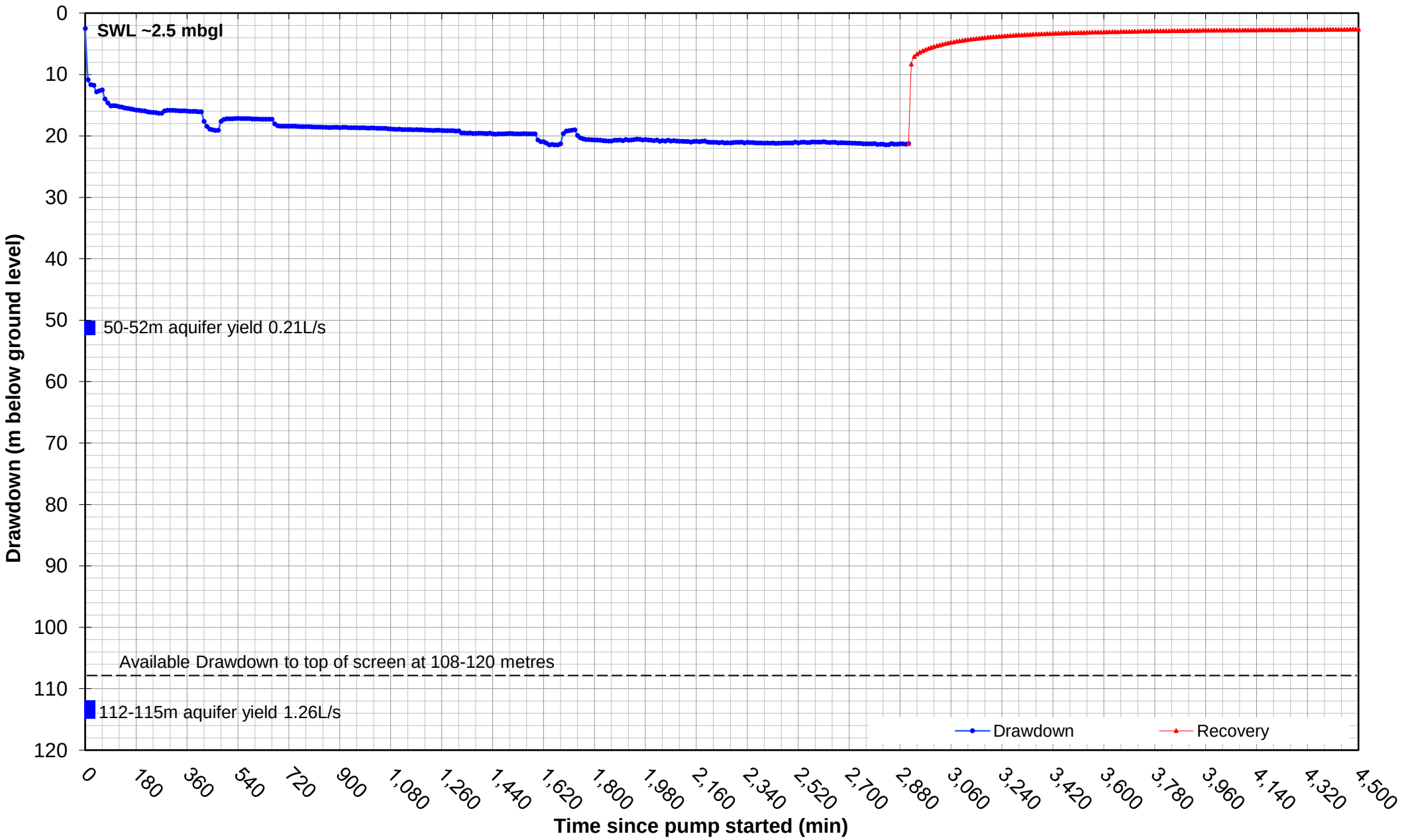
## SINGLE RATE PUMP TEST

| | | | |
|---|---|---|---|
| ***Test date :*** | 3/12/2018 | **PROJECT :** | Bowning |
| ***Start time :*** | 12:00 PM | **CLIENT :** | - |
| ***Pump Off:*** | 5/12/2018 12:30 PM | **BORE No #** | Pumping Bore #1 |
| ***Casing I.D.:*** | 150 mm | **Tested by:** | GoulProd |
| ***Pump type/mod:*** | - | **Av.Pump Rate (L/sec):** | 1.15L/s |
| ***Pump O.D.:*** | - | **SWL (mbtoc):** | 2.5 |
| ***Pump Intake m:*** | 100m | **Ref. Point (m):** | 0.00 |

| ***Real time*** | ***Minutes since pump Started*** **t** | ***Time since pump stopped*** ***Hrs*** | ***Minutes*** **t'** | ***Depth to water metres below ground level*** ***mbgl*** | ***Ratio t/t'*** | ***Residual Drawdown metres*** ***S'*** | ***Comments / Observations*** |
|---|---|---|---|---|---|---|---|
| 12:30 PM | 2910 | | **0.1** | 21.25 | 29101 | 18.75 | **= depth to water at** |
| | 2920 | | **10** | 8.31 | 292 | 5.81 | **instant pump stopped** |
| | 2930 | | **20** | 7.09 | 147 | 4.59 | |
| | 2940 | | **30** | 6.68 | 98.0 | 4.18 | |
| | 2950 | | **40** | 6.39 | 73.8 | 3.89 | |
| | 2960 | | **50** | 6.16 | 59.2 | 3.66 | |
| 1:30 PM | 2970 | **1** | **60** | 5.94 | 49.5 | 3.44 | |
| | 2980 | | **70** | 5.77 | 42.6 | 3.27 | |
| | 2990 | | **80** | 5.61 | 37.4 | 3.11 | |
| | 3000 | | **90** | 5.47 | 33.3 | 2.97 | |
| 2:30 PM | 3030 | **2** | **120** | 5.08 | 25.3 | 2.58 | |
| | 3060 | | **150** | 4.78 | 20.4 | 2.28 | |
| 3:30 PM | 3090 | **3** | **180** | 4.53 | 17.2 | 2.03 | |
| | 3120 | | **210** | 4.32 | 14.9 | 1.82 | |
| 4:30 PM | 3150 | **4** | **240** | 4.15 | 13.1 | 1.65 | |
| | 3180 | | **270** | 4.00 | 11.8 | 1.50 | |
| 5:30 PM | 3210 | **5** | **300** | 3.87 | 10.7 | 1.37 | |
| | 3240 | | **330** | 3.76 | 9.8 | 1.26 | |
| 6:30 PM | 3270 | **6** | **360** | 3.67 | 9.1 | 1.17 | |
| 7:30 PM | 3330 | **7** | **420** | 3.50 | 7.9 | 1.00 | |
| 8:30 PM | 3390 | **8** | **480** | 3.38 | 7.1 | 0.88 | |
| 9:30 PM | 3450 | **9** | **540** | 3.27 | 6.4 | 0.77 | |
| 10:30 PM | 3510 | **10** | **600** | 3.19 | 5.9 | 0.69 | |
| 11:30 PM | 3570 | **11** | **660** | 3.13 | 5.4 | 0.63 | |
| 12:30 AM | 3630 | **12** | **720** | 3.05 | 5.0 | 0.55 | |
| 2:30 AM | 3750 | **14** | **840** | 2.93 | 4.5 | 0.43 | |
| 4:30 AM | 3870 | **16** | **960** | 2.87 | 4.0 | 0.37 | |
| 6:30 AM | 3990 | **18** | **1080** | 2.81 | 3.7 | 0.31 | |
| 8:30 AM | 4110 | **20** | **1200** | 2.76 | 3.4 | 0.26 | |
| 12:30 PM | 4350 | **24** | **1440** | 2.68 | 3.0 | 0.18 | |
| 2:30 PM | 4470 | **26** | **1560** | 2.64 | 2.9 | 0.14 | |
| - | - | **-** | **-** | - | - | - | |
| - | - | **-** | **-** | - | - | - | |
| - | - | **-** | **-** | - | - | - | |
| - | - | **-** | **-** | - | - | - | |
| - | - | **-** | **-** | - | - | - | |
| - | - | **-** | **-** | - | - | - | |
| - | - | **-** | **-** | - | - | - | |
| - | - | **-** | **-** | - | - | - | |

## Drawdown & Recovery Curves - Bowning Bore 1 Pumping at 1.15 for 48 Hours




Time-Drawdown & Recovery - Bowning Bore 1 Pumping at 1.15 L/sec for 48 Hours
SWL ~2.5 mbgl
50-52m aquifer yield 0.21L/s
Available Drawdown to top of screen at 108-120 metres
112-115m aquifer yield 1.26L/s
Drawdown
Recovery
Drawdown (m below ground level)
Time since pump started (min)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
180
360
540
720
900
1,080
1,260
1,440
1,620
1,800
1,980
2,160
2,340
2,520
2,700
2,880
3,060
3,240
3,420
3,600
3,780
3,960
4,140
4,320
4,500

Data Set:
Date: 12/17/18
Time: 11:15:23

## PROJECT INFORMATION

Company: ENRS
Project: ENRS0978
Location: Bowning
Test Date: 3/12/2018
Test Well: Bore 1

## AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 1.

## PUMPING WELL DATA

No. of pumping wells: 1

### Pumping Well No. 1: Bore 1

X Location: 0. m
Y Location: 0. m

Casing Radius: 0.075 m
Well Radius: 0.11 m

Fully Penetrating Well

No. of pumping periods: 3

Pumping Period Data

| Time (min) | Rate (L/sec) | Time (min) | Rate (L/sec) |
|---|---|---|---|
| 1. | 1.15 | 2881. | 0. |
| 2880. | 1.15 | | |

## OBSERVATION WELL DATA

No. of observation wells: 1

### Observation Well No. 1: Bore 1

X Location: 0. m
Y Location: 0. m

Radial distance from Bore 1: 0. m

Fully Penetrating Well

No. of Observations: 455

Observation Data

| Time (min) | Displacement (m) | Time (min) | Displacement (m) |
|---|---|---|---|
| 10. | 8.35 | 2290. | 18.56 |
| 20. | 9.145 | 2300. | 18.53 |
| 30. | 9.253 | 2310. | 18.52 |
| 40. | 10.33 | 2320. | 18.51 |
| 50. | 10.13 | 2330. | 18.64 |
| 60. | 9.991 | 2340. | 18.54 |
| 70. | 11.5 | 2350. | 18.57 |
| 80. | 12.12 | 2360. | 18.57 |
| 90. | 12.6 | 2370. | 18.63 |
| 100. | 12.56 | 2380. | 18.62 |
| 110. | 12.59 | 2390. | 18.65 |
| 120. | 12.72 | 2400. | 18.68 |

| Time (min) | Displacement (m) | Time (min) | Displacement (m) |
|---|---|---|---|
| 130. | 12.8 | 2410. | 18.64 |
| 140. | 12.93 | 2420. | 18.66 |
| 150. | 13. | 2430. | 18.63 |
| 160. | 13.09 | 2440. | 18.69 |
| 170. | 13.19 | 2450. | 18.66 |
| 180. | 13.27 | 2460. | 18.67 |
| 190. | 13.31 | 2470. | 18.62 |
| 200. | 13.4 | 2480. | 18.64 |
| 210. | 13.41 | 2490. | 18.62 |
| 220. | 13.56 | 2500. | 18.63 |
| 230. | 13.63 | 2510. | 18.49 |
| 240. | 13.66 | 2520. | 18.63 |
| 250. | 13.71 | 2530. | 18.54 |
| 260. | 13.8 | 2540. | 18.51 |
| 270. | 13.82 | 2550. | 18.56 |
| 280. | 13.42 | 2560. | 18.56 |
| 290. | 13.31 | 2570. | 18.48 |
| 300. | 13.31 | 2580. | 18.5 |
| 310. | 13.31 | 2590. | 18.5 |
| 320. | 13.34 | 2600. | 18.51 |
| 330. | 13.38 | 2610. | 18.44 |
| 340. | 13.41 | 2620. | 18.55 |
| 350. | 13.4 | 2630. | 18.58 |
| 360. | 13.45 | 2640. | 18.54 |
| 370. | 13.47 | 2650. | 18.55 |
| 380. | 13.5 | 2660. | 18.62 |
| 390. | 13.5 | 2670. | 18.6 |
| 400. | 13.55 | 2680. | 18.61 |
| 410. | 13.56 | 2690. | 18.65 |
| 420. | 15.12 | 2700. | 18.63 |
| 430. | 15.95 | 2710. | 18.68 |
| 440. | 16.39 | 2720. | 18.67 |
| 450. | 16.51 | 2730. | 18.7 |
| 460. | 16.61 | 2740. | 18.71 |
| 470. | 16.58 | 2750. | 18.78 |
| 480. | 15.13 | 2760. | 18.78 |
| 490. | 14.82 | 2770. | 18.78 |
| 500. | 14.7 | 2780. | 18.78 |
| 510. | 14.7 | 2790. | 18.73 |
| 520. | 14.7 | 2800. | 18.87 |
| 530. | 14.65 | 2810. | 18.83 |
| 540. | 14.64 | 2820. | 18.86 |
| 550. | 14.67 | 2830. | 18.95 |
| 560. | 14.67 | 2840. | 18.9 |
| 570. | 14.67 | 2850. | 18.75 |
| 580. | 14.68 | 2860. | 18.85 |
| 590. | 14.75 | 2870. | 18.85 |
| 600. | 14.72 | 2880. | 18.78 |
| 610. | 14.74 | 2890. | 18.78 |
| 620. | 14.76 | 2900. | 18.84 |
| 630. | 14.77 | 2910. | 18.75 |
| 640. | 14.76 | 2920. | 5.813 |
| 650. | 14.77 | 2930. | 4.591 |
| 660. | 14.77 | 2940. | 4.183 |
| 670. | 15.53 | 2950. | 3.885 |
| 680. | 15.84 | 2960. | 3.656 |
| 690. | 15.9 | 2970. | 3.441 |
| 700. | 15.9 | 2980. | 3.272 |
| 710. | 15.9 | 2990. | 3.107 |
| 720. | 15.91 | 3000. | 2.968 |
| 730. | 15.92 | 3010. | 2.832 |
| 740. | 15.92 | 3020. | 2.706 |
| 750. | 15.95 | 3030. | 2.584 |
| 760. | 15.97 | 3040. | 2.491 |
| 770. | 15.98 | 3050. | 2.377 |
| 780. | 15.99 | 3060. | 2.276 |

| Time (min) | Displacement (m) | Time (min) | Displacement (m) |
|---|---|---|---|
| 790. | 15.98 | 3070. | 2.201 |
| 800. | 16.02 | 3080. | 2.111 |
| 810. | 16.03 | 3090. | 2.029 |
| 820. | 16.03 | 3100. | 1.957 |
| 830. | 16.05 | 3110. | 1.893 |
| 840. | 16.06 | 3120. | 1.821 |
| 850. | 16.08 | 3130. | 1.749 |
| 860. | 16.1 | 3140. | 1.699 |
| 870. | 16.11 | 3150. | 1.646 |
| 880. | 16.08 | 3160. | 1.595 |
| 890. | 16.07 | 3170. | 1.545 |
| 900. | 16.15 | 3180. | 1.502 |
| 910. | 16.09 | 3190. | 1.452 |
| 920. | 16.09 | 3200. | 1.409 |
| 930. | 16.14 | 3210. | 1.37 |
| 940. | 16.15 | 3220. | 1.327 |
| 950. | 16.14 | 3230. | 1.298 |
| 960. | 16.14 | 3240. | 1.262 |
| 970. | 16.18 | 3250. | 1.233 |
| 980. | 16.16 | 3260. | 1.205 |
| 990. | 16.18 | 3270. | 1.173 |
| 1000. | 16.21 | 3280. | 1.14 |
| 1010. | 16.2 | 3290. | 1.101 |
| 1020. | 16.2 | 3300. | 1.069 |
| 1030. | 16.24 | 3310. | 1.051 |
| 1040. | 16.25 | 3320. | 1.029 |
| 1050. | 16.27 | 3330. | 0.9969 |
| 1060. | 16.27 | 3340. | 0.9754 |
| 1070. | 16.31 | 3350. | 0.9575 |
| 1080. | 16.34 | 3360. | 0.936 |
| 1090. | 16.38 | 3370. | 0.9145 |
| 1100. | 16.42 | 3380. | 0.893 |
| 1110. | 16.38 | 3390. | 0.8751 |
| 1120. | 16.44 | 3400. | 0.8644 |
| 1130. | 16.44 | 3410. | 0.8429 |
| 1140. | 16.47 | 3420. | 0.8321 |
| 1150. | 16.44 | 3430. | 0.8034 |
| 1160. | 16.48 | 3440. | 0.7927 |
| 1170. | 16.47 | 3450. | 0.7712 |
| 1180. | 16.51 | 3460. | 0.7569 |
| 1190. | 16.49 | 3470. | 0.7497 |
| 1200. | 16.52 | 3480. | 0.7282 |
| 1210. | 16.56 | 3490. | 0.7174 |
| 1220. | 16.56 | 3500. | 0.6995 |
| 1230. | 16.6 | 3510. | 0.6852 |
| 1240. | 16.57 | 3520. | 0.6673 |
| 1250. | 16.57 | 3530. | 0.6673 |
| 1260. | 16.6 | 3540. | 0.6494 |
| 1270. | 16.63 | 3550. | 0.6386 |
| 1280. | 16.63 | 3560. | 0.6243 |
| 1290. | 16.62 | 3570. | 0.6279 |
| 1300. | 16.64 | 3580. | 0.6064 |
| 1310. | 16.71 | 3590. | 0.6028 |
| 1320. | 16.67 | 3600. | 0.5849 |
| 1330. | 17. | 3610. | 0.5669 |
| 1340. | 17.02 | 3620. | 0.5562 |
| 1350. | 17.06 | 3630. | 0.5526 |
| 1360. | 17.01 | 3640. | 0.5526 |
| 1370. | 17.08 | 3650. | 0.5311 |
| 1380. | 17.08 | 3660. | 0.5239 |
| 1390. | 17.06 | 3670. | 0.5204 |
| 1400. | 17.05 | 3680. | 0.5024 |
| 1410. | 17.08 | 3690. | 0.5024 |
| 1420. | 17.11 | 3700. | 0.4917 |
| 1430. | 17.06 | 3710. | 0.4809 |
| 1440. | 17.14 | 3720. | 0.4702 |

| Time (min) | Displacement (m) | Time (min) | Displacement (m) |
|---|---|---|---|
| 1450. | 17.22 | 3730. | 0.4523 |
| 1460. | 17.17 | 3740. | 0.4415 |
| 1470. | 17.14 | 3750. | 0.4308 |
| 1480. | 17.14 | 3760. | 0.4308 |
| 1490. | 17.11 | 3770. | 0.42 |
| 1500. | 17.09 | 3780. | 0.4093 |
| 1510. | 17.13 | 3790. | 0.4093 |
| 1520. | 17.17 | 3800. | 0.4093 |
| 1530. | 17.17 | 3810. | 0.3985 |
| 1540. | 17.16 | 3820. | 0.3878 |
| 1550. | 17.13 | 3830. | 0.3878 |
| 1560. | 17.15 | 3840. | 0.377 |
| 1570. | 17.16 | 3850. | 0.3806 |
| 1580. | 17.16 | 3860. | 0.3699 |
| 1590. | 17.16 | 3870. | 0.3699 |
| 1600. | 18.17 | 3880. | 0.3663 |
| 1610. | 18.42 | 3890. | 0.3591 |
| 1620. | 18.44 | 3900. | 0.3376 |
| 1630. | 18.68 | 3910. | 0.3448 |
| 1640. | 18.93 | 3920. | 0.3376 |
| 1650. | 18.89 | 3930. | 0.3376 |
| 1660. | 18.94 | 3940. | 0.3269 |
| 1670. | 18.95 | 3950. | 0.3161 |
| 1680. | 18.77 | 3960. | 0.3161 |
| 1690. | 17.11 | 3970. | 0.3161 |
| 1700. | 16.7 | 3980. | 0.3054 |
| 1710. | 16.63 | 3990. | 0.3054 |
| 1720. | 16.55 | 4000. | 0.2946 |
| 1730. | 16.51 | 4010. | 0.2946 |
| 1740. | 17.44 | 4020. | 0.2874 |
| 1750. | 17.82 | 4030. | 0.2874 |
| 1760. | 17.99 | 4040. | 0.2767 |
| 1770. | 18.09 | 4050. | 0.2839 |
| 1780. | 18.08 | 4060. | 0.2731 |
| 1790. | 18.13 | 4070. | 0.2839 |
| 1800. | 18.14 | 4080. | 0.2767 |
| 1810. | 18.14 | 4090. | 0.2552 |
| 1820. | 18.18 | 4100. | 0.2659 |
| 1830. | 18.27 | 4110. | 0.2624 |
| 1840. | 18.28 | 4120. | 0.2624 |
| 1850. | 18.32 | 4130. | 0.2552 |
| 1860. | 18.31 | 4140. | 0.2552 |
| 1870. | 18.2 | 4150. | 0.2444 |
| 1880. | 18.18 | 4160. | 0.248 |
| 1890. | 18.17 | 4170. | 0.2444 |
| 1900. | 18.25 | 4180. | 0.248 |
| 1910. | 18.09 | 4190. | 0.2373 |
| 1920. | 18.18 | 4200. | 0.2337 |
| 1930. | 18.14 | 4210. | 0.2373 |
| 1940. | 18.08 | 4220. | 0.2265 |
| 1950. | 18.01 | 4230. | 0.2265 |
| 1960. | 18.06 | 4240. | 0.2265 |
| 1970. | 18.14 | 4250. | 0.2229 |
| 1980. | 18.09 | 4260. | 0.2229 |
| 1990. | 18.16 | 4270. | 0.2229 |
| 2000. | 18.2 | 4280. | 0.205 |
| 2010. | 18.26 | 4290. | 0.2122 |
| 2020. | 18.17 | 4300. | 0.2122 |
| 2030. | 18.36 | 4310. | 0.1943 |
| 2040. | 18.27 | 4320. | 0.2014 |
| 2050. | 18.32 | 4330. | 0.1943 |
| 2060. | 18.18 | 4340. | 0.1835 |
| 2070. | 18.34 | 4350. | 0.1835 |
| 2080. | 18.26 | 4360. | 0.1835 |
| 2090. | 18.34 | 4370. | 0.1799 |
| 2100. | 18.36 | 4380. | 0.1728 |

| Time (min) | Displacement (m) | Time (min) | Displacement (m) |
|---|---|---|---|
| 2110. | 18.35 | 4390. | 0.1728 |
| 2120. | 18.38 | 4400. | 0.1656 |
| 2130. | 18.39 | 4410. | 0.1656 |
| 2140. | 18.5 | 4420. | 0.162 |
| 2150. | 18.39 | 4430. | 0.1656 |
| 2160. | 18.37 | 4440. | 0.1656 |
| 2170. | 18.43 | 4450. | 0.1549 |
| 2180. | 18.37 | 4460. | 0.1513 |
| 2190. | 18.34 | 4470. | 0.1441 |
| 2200. | 18.51 | 4480. | 0.1405 |
| 2210. | 18.53 | 4490. | 0.1334 |
| 2220. | 18.54 | 4500. | 0.1226 |
| 2230. | 18.54 | 4510. | 0.1298 |
| 2240. | 18.61 | 4520. | 0.1226 |
| 2250. | 18.54 | 4530. | 0.119 |
| 2260. | 18.62 | 4540. | 0.119 |
| 2270. | 18.61 | 4550. | 0.119 |
| 2280. | 18.65 | | |

## SOLUTION

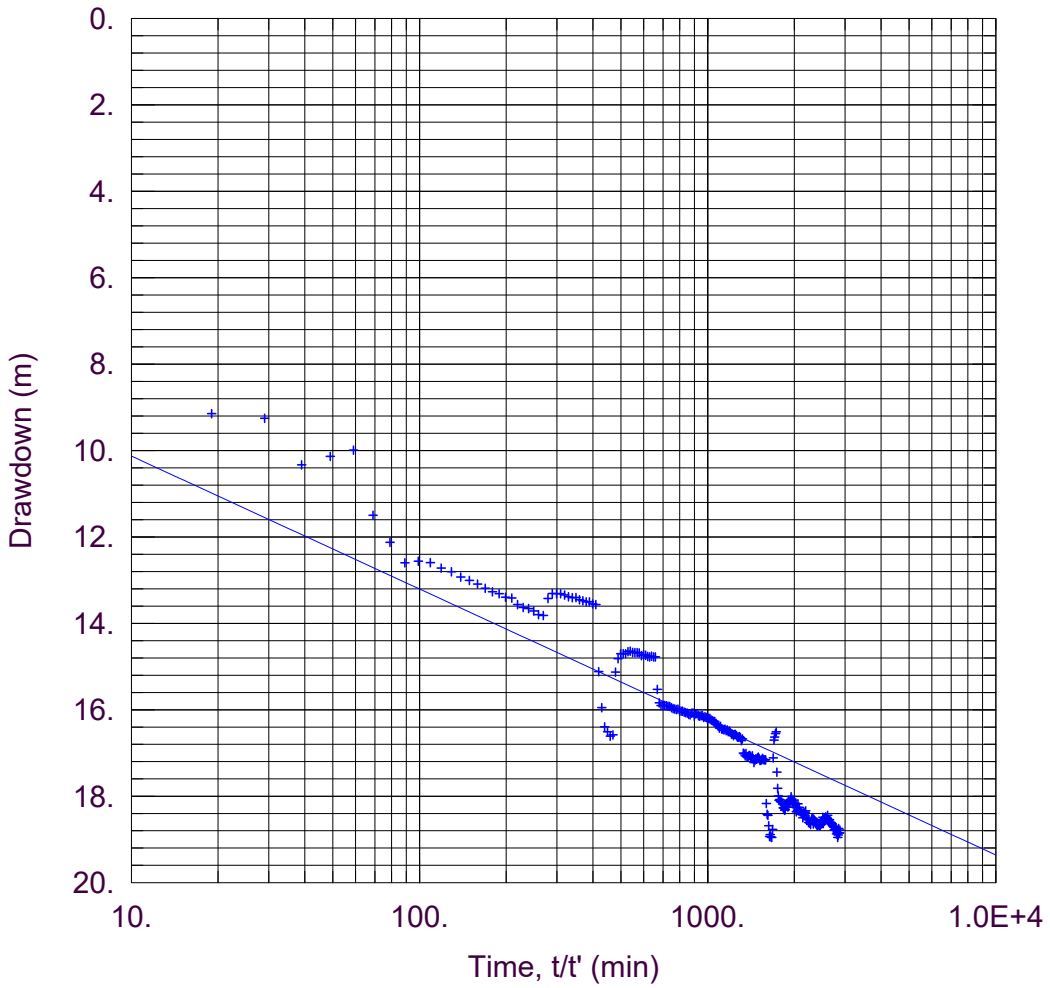
Pumping Test
Aquifer Model: Confined
Solution Method: Cooper-Jacob

## VISUAL ESTIMATION RESULTS

### Estimated Parameters

| Parameter | Estimate | |
|---|---|---|
| T | 6.07 | $m^2$/day |
| S | 0.002893 | |

K = T/b = 2.023 m/day (0.002342 cm/sec)
Ss = S/b = 0.0009642 1/m




## WELL TEST ANALYSIS

Data Set:
Date: 12/17/18 Time: 11:27:18

## PROJECT INFORMATION

Company: ENRS
Project: ENRS0978
Location: Bowning
Test Well: Bore 1
Test Date: 3/12/2018

## AQUIFER DATA

Saturated Thickness: 3. m Anisotropy Ratio (Kz/Kr): 1.

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| Bore 1 | 0 | 0 |

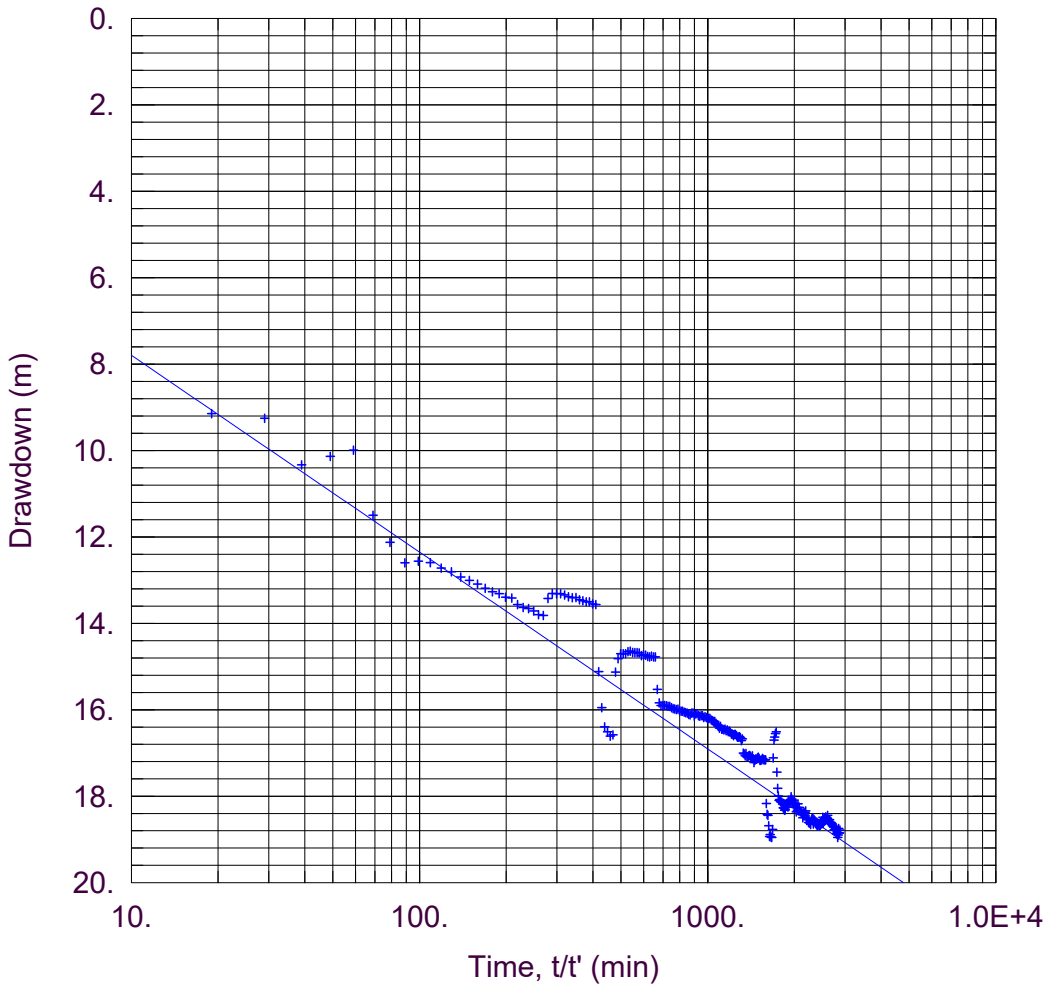
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| + Bore 1 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Jacob

T = 5.916 $m^2$/day S = 0.003901




## WELL TEST ANALYSIS

Data Set:
Date: 12/17/18 Time: 11:31:44

## PROJECT INFORMATION

Company: ENRS
Project: ENRS0978
Location: Bowning
Test Well: Bore 1
Test Date: 3/12/2018

## AQUIFER DATA

Saturated Thickness: 3. m Anisotropy Ratio (Kz/Kr): 1.

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| Bore 1 | 0 | 0 |

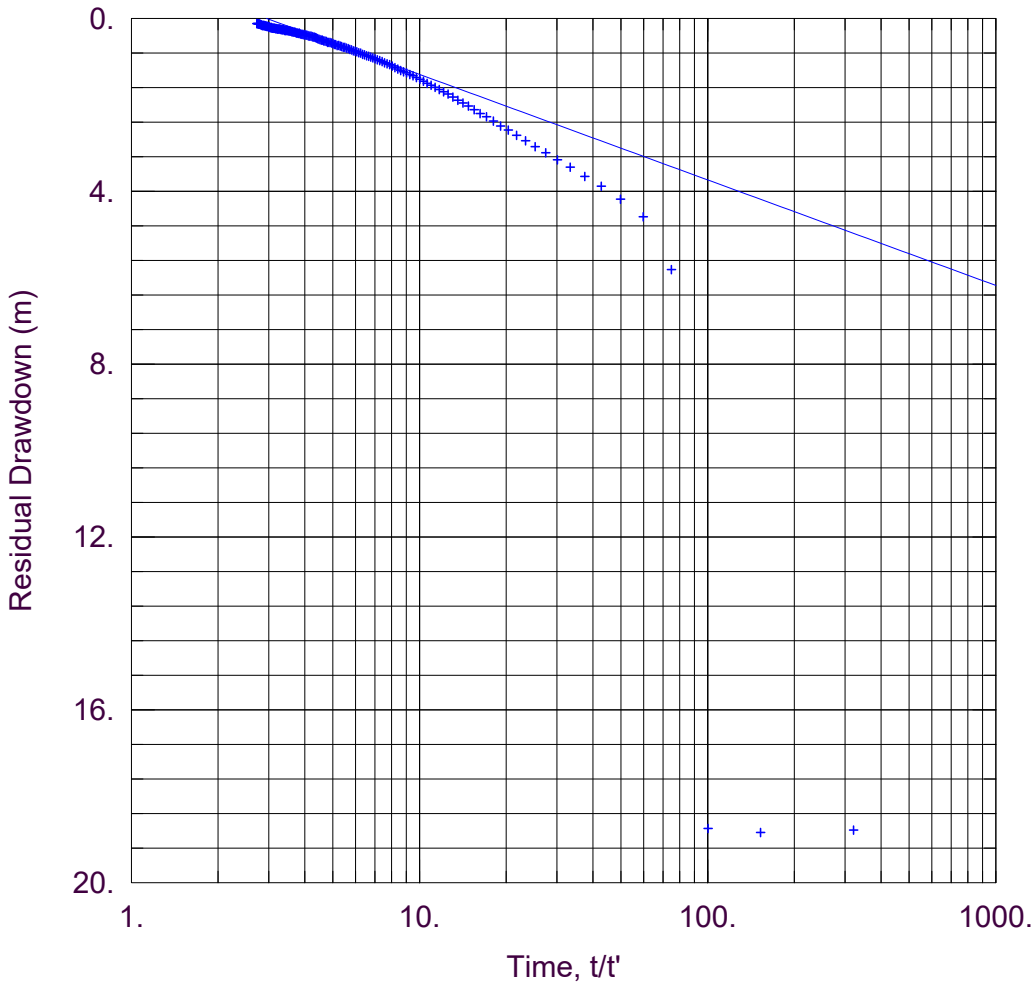
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| + Bore 1 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Jacob

T = 3.998 $m^2$/day S = 0.1




## WELL TEST ANALYSIS

Data Set: D:\...\bowning.aqt
Date: 12/18/18 Time: 14:26:00

## PROJECT INFORMATION

Company: ENRS
Project: ENRS0978
Location: Bowning
Test Well: Bore 1
Test Date: 3/12/2018

## AQUIFER DATA

Saturated Thickness: 3. m Anisotropy Ratio (Kz/Kr): 1.

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| Bore 1 | 0 | 0 |

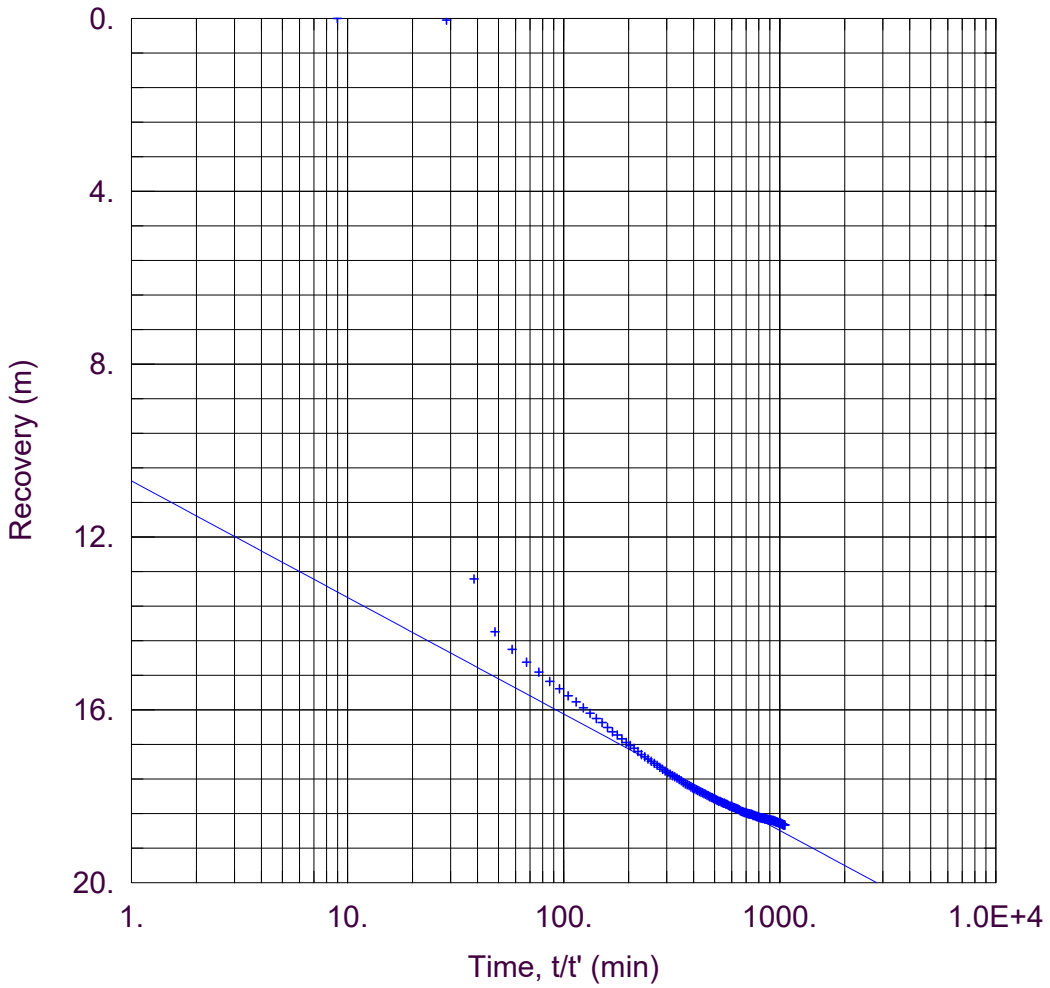
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| + Bore 1 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 7.458 $m^2$/day S/S' = 2.946




## WELL TEST ANALYSIS

Data Set:
Date: 12/17/18 Time: 11:37:52

## PROJECT INFORMATION

Company: ENRS
Project: ENRS0978
Location: Bowning
Test Well: Bore 1
Test Date: 3/12/2018

## AQUIFER DATA

Saturated Thickness: 3. m Anisotropy Ratio (Kz/Kr): 1.

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| Bore 1 | 0 | 0 |

Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| + Bore 1 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Jacob

T = 6.752 $m^2$/day S = 9.347E-5

# Appendix C

# NATA Laboratory Certificates of Analysis (CoA)

ENRS

Environment & Natural Resource Solutions

# Chain of Custody

ALS

SYDNEY 277-289 Woodpark Road Smithfield NSW 2164
Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

NOWRA 4/13 Geary Place North Nowra NSW 2541
Ph: 02 4422 2063 E: nowra@alsglobal.com

WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CLIENT:** | ENRS P/L | **TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics) | ☒ Standard TAT (List due date): | | | | | | | **FOR LABORATORY USE ONLY (Circle)** | | | |
| **OFFICE:** | 108 Jerry Bailey Rd Shoalhaven Heads | | ☐ Non Standard or urgent TAT (List due date): | | | | | | | Custody Seal Intact? | Yes | No | N/A |
| **PROJECT:** | ENRS0978- Bowning | **ALS QUOTE NO.:** | | **COC SEQUENCE NUMBER (Circle)** | | | | | | Free ice / frozen ice bricks present upon receipt? | Yes | No | N/A |
| **ORDER / PURCHASE NUMBER:** | ENRS0978 | **COUNTRY OF ORIGIN:** | Aus | COC: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Random Sample Temperature on Receipt: | °C |
| **PROJECT MANAGER:** | Rohan Last (ENRS) | **CONTACT PH:** | 0401 518 443 | OF: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Other comment: | |

| | | | | | |
|---|---|---|---|---|---|
| **SAMPLER:** | AB | **SAMPLER MOBILE:** | - | **RELINQUISHED BY:** | **RECEIVED BY:** Anete |
| **COC Emailed to ALS? ( Yes / No )** | | **EDD FORMAT (or default):** | | | |
| **Email Reports to** (will default to PM if no other addresses are listed): | | lab@enrs.com.au | | DATE/TIME:.....7/12/2018 | DATE/TIME: 7/12/18 |
| **Email Invoice to** (will default to PM if no other addresses are listed): | | accounts@enrs.com.au | | | |

**COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:**

| **RELINQUISHED BY:** | **RECEIVED BY:** |
|---|---|
| DATE/TIME: | DATE/TIME: |

| ALS USE ONLY | SAMPLE DETAILS (MATRIX: Solid(S) Water(W)) | | | CONTAINER INFORMATION | | ANALYSIS REQUIRED Including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required). | | | | | | | | Additional Information |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LAB ID | SAMPLE ID | DATE / TIME | MATRIX | TYPE & PRESERVATIVE (refer to codes below) | | DW3 | | | | | | | | Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc. |
| | Bowning Bore 1 | 6/12/2018 | Water | multiple bottles | | 1 | | | | | | | | Not Filtered |
| | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | |
| | | | | TOTAL | | 1 | 0 | | | | | | 0 | |

Environmental Division
Wollongong
Work Order Reference
EW1805133

Telephone : 02 42253125

***Water Container Codes:*** P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

| | 17/12/2018 | Sample | ID 1 | | | Bowning Bore 1 |
|---|---|---|---|---|---|---|
| | | | Project# | | | ENRS0978- Bowning |
| | Results | | Date Sampled | | | 7/12/2018 |
| | | | Order # | | | EW1805133001 |
| **Analyte** | **CAS #** | **Units** | **LOR** | **Health** | **Aesthetic** | Results |
| | | | | | | |
| **EA005P: pH by PC Titrator** | | | | | | |
| pH Value | | pH Unit | 0.01 | - | 6.5-8.5 | 7.57 |
| **EA010P: Conductivity by PC Titrator** | | | | | | |
| Electrical Conductivity @ 25°C | | µS/cm | 1 | - | - | 600 |
| **EA015: Total Dissolved Solids dried at 180 ± 5 °C** | | | | | | |
| Total Dissolved Solids @180°C | | mg/L | 10 | - | 600 | 404 |
| **EA041: Colour (True)** | | | | | | |
| Colour (True) | | PCU | 1 | - | 15 | <1 |
| pH Colour | | pH Unit | 0.01 | - | - | 7.49 |
| **EA045: Turbidity** | | | | | | |
| Turbidity | | NTU | 0.1 | - | 5 | 2 |
| **EA065: Total Hardness as CaCO3** | | | | | | |
| Total Hardness as CaCO3 | | mg/L | 1 | - | - | 246 |
| **ED037P: Alkalinity by PC Titrator** | | | | | | |
| Bicarbonate Alkalinity as CaCO3 | 71-52-3 | mg/L | 1 | - | - | 194 |
| Carbonate Alkalinity as CaCO3 | 3812-32-6 | mg/L | 1 | - | - | <1 |
| Hydroxide Alkalinity as CaCO3 | DMO-210-001 | mg/L | 1 | - | - | <1 |
| Total Alkalinity as CaCO3 | | mg/L | 1 | - | - | 194 |
| **ED041G: Sulfate (Turbidimetric) as SO4 2- by DA** | | | | | | |
| Sulfate as SO4 - Turbidimetric | 14808-79-8 | mg/L | 1 | - | 250 | 31 |
| **ED045G: Chloride by Discrete Analyser** | | | | | | |
| Chloride | 16887-00-6 | mg/L | 1 | - | 250 | 28 |
| **ED093F: Dissolved Major Cations** | | | | | | |
| Calcium | 7440-70-2 | mg/L | 1 | - | - | 82 |
| Magnesium | 7439-95-4 | mg/L | 1 | - | - | 10 |
| Potassium | 7/09/7440 | mg/L | 1 | - | - | 3 |
| Sodium | 7440-23-5 | mg/L | 1 | - | 180 | 27 |
| **EG020T: Total Metals by ICP-MS** | | | | | | |
| Aluminium | 7429-90-5 | mg/L | 0.01 | - | 0.2 | 0.02 |
| Antimony | 7440-36-0 | mg/L | 0.001 | 0.003 | - | <0.001 |
| Arsenic | 7440-38-2 | mg/L | 0.001 | 0.01 | - | 0.008 |
| Barium | 7440-39-3 | mg/L | 0.001 | 2 | - | 0.004 |
| Boron | 7440-42-8 | mg/L | 0.05 | 4 | - | <0.05 |
| Cadmium | 7440-43-9 | mg/L | 0.0001 | 0.002 | - | <0.0001 |
| Chromium | 7440-47-3 | mg/L | 0.001 | 0.05 | - | <0.001 |
| Copper | 7440-50-8 | mg/L | 0.001 | 2 | 1 | <0.001 |
| Iron | 7439-89-6 | mg/L | 0.05 | - | 0.3 | 0.33 |
| Lead | 7439-92-1 | mg/L | 0.001 | 0.01 | - | <0.001 |
| Manganese | 7439-96-5 | mg/L | 0.001 | 0.5 | 0.1 | 0.591 |
| Molybdenum | 7439-98-7 | mg/L | 0.001 | 0.05 | - | <0.001 |
| Nickel | 7440-02-0 | mg/L | 0.001 | 0.02 | - | <0.001 |
| Selenium | 7782-49-2 | mg/L | 0.01 | 0.01 | - | <0.01 |
| Silver | 7440-22-4 | mg/L | 0.001 | 0.1 | - | <0.001 |
| Zinc | 7440-66-6 | mg/L | 0.005 | - | 3 | <0.005 |
| **EG035T: Total Recoverable Mercury by FIMS** | | | | | | |
| Mercury | 7439-97-6 | mg/L | 0.0001 | 0.001 | - | <0.0001 |
| **EK025G: Free cyanide by Discrete Analyser** | | | | | | |
| Total Cyanide | 57-12-5 | mg/L | 0.004 | 0.08 | - | <0.004 |
| **EK040P: Fluoride by PC Titrator** | | | | | | |
| Fluoride | 16984-48-8 | mg/L | 0.1 | 1.5 | - | 0.6 |
| **EK055G: Ammonia as N by Discrete Analyser** | | | | | | |
| Ammonia as N | 7664-41-7 | mg/L | 0.01 | - | 0.5 | 0.01 |
| **EK057G: Nitrite as N by Discrete Analyser** | | | | | | |
| Nitrite as N | 14797-65-0 | mg/L | 0.01 | 3 | - | <0.01 |
| **EK058G: Nitrate as N by Discrete Analyser** | | | | | | |
| Nitrate as N | 14797-55-8 | mg/L | 0.01 | 50 | - | 1.2 |
| **EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser** | | | | | | |
| Nitrite + Nitrate as N | | mg/L | 0.01 | - | - | 1.2 |
| **EK085M: Sulfide as S2-** | | | | | | |
| Sulfide as S2- | 18496-25-8 | mg/L | 0.1 | - | - | <0.1 |
| **EN055: Ionic Balance** | | | | | | |
| Ionic Balance | | % | 0.01 | - | - | 7.45 |
| Total Anions | | meq/L | 0.01 | - | - | 5.31 |
| Total Cations | | meq/L | 0.01 | - | - | 6.17 |

ALS Environmental

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Work Order** | : **EW1805133** | Page | : 1 of 4 |
| Client | : **ENVIRONMENT & NATURAL RESOURCE SOLUTIONS** | Laboratory | : Environmental Division NSW South Coast |
| Contact | : Mr Rohan Last | Contact | : Aneta Prosaroski |
| Address | : 25 River Rd<br>Shoalhaven Heads 2535 | Address | : 1/19 Ralph Black Dr, North Wollongong 2500<br>4/13 Geary Pl, North Nowra 2541<br>Australia NSW Australia |
| Telephone | : ---- | Telephone | : +61 2 4225 3125 |
| Project | : ENRS0978- Bowning | Date Samples Received | : 07-Dec-2018 13:28 |
| Order number | : ENRS0978 | Date Analysis Commenced | : 07-Dec-2018 |
| C-O-C number | : ---- | Issue Date | : 17-Dec-2018 09:01 |
| Sampler | : ---- | | |
| Site | : ---- | | |
| Quote number | : EN/222 | | |
| No. of samples received | : 1 | | |
| No. of samples analysed | : 1 | | |

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

**Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.**

## *Signatories*

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

| *Signatories* | *Position* | *Accreditation Category* |
|---|---|---|
| Ankit Joshi | Inorganic Chemist | Sydney Inorganics, Smithfield, NSW |
| Celine Conceicao | Senior Spectroscopist | Sydney Inorganics, Smithfield, NSW |

## General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Ionic Balance out of acceptable limits due to analytes not quantified in this report.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

## Analytical Results

| Sub-Matrix: WATER (Matrix: WATER) | | | Client sample ID | Bowning Bore 1 | ---- | ---- | ---- | ---- |
|---|---|---|---|---|---|---|---|---|
| | | | Client sampling date / time | 07-Dec-2018 00:00 | ---- | ---- | ---- | ---- |
| Compound | CAS Number | LOR | Unit | EW1805133-001 | -------- | -------- | -------- | -------- |
| | | | | Result | ---- | ---- | ---- | ---- |
| **EA005P: pH by PC Titrator** | | | | | | | | |
| pH Value | ---- | 0.01 | pH Unit | **7.57** | ---- | ---- | ---- | ---- |
| **EA010P: Conductivity by PC Titrator** | | | | | | | | |
| Electrical Conductivity @ 25°C | ---- | 1 | µS/cm | **600** | ---- | ---- | ---- | ---- |
| **EA015: Total Dissolved Solids dried at 180 ± 5 °C** | | | | | | | | |
| Total Dissolved Solids @180°C | ---- | 10 | mg/L | **404** | ---- | ---- | ---- | ---- |
| **EA041: Colour (True)** | | | | | | | | |
| Colour (True) | ---- | 1 | PCU | <1 | ---- | ---- | ---- | ---- |
| pH Colour | ---- | 0.01 | pH Unit | **7.49** | ---- | ---- | ---- | ---- |
| **EA045: Turbidity** | | | | | | | | |
| Turbidity | ---- | 0.1 | NTU | **2.0** | ---- | ---- | ---- | ---- |
| **EA065: Total Hardness as CaCO3** | | | | | | | | |
| Total Hardness as CaCO3 | ---- | 1 | mg/L | **246** | ---- | ---- | ---- | ---- |
| **ED037P: Alkalinity by PC Titrator** | | | | | | | | |
| Hydroxide Alkalinity as CaCO3 | DMO-210-001 | 1 | mg/L | <1 | ---- | ---- | ---- | ---- |
| Carbonate Alkalinity as CaCO3 | 3812-32-6 | 1 | mg/L | <1 | ---- | ---- | ---- | ---- |
| Bicarbonate Alkalinity as CaCO3 | 71-52-3 | 1 | mg/L | **194** | ---- | ---- | ---- | ---- |
| Total Alkalinity as CaCO3 | ---- | 1 | mg/L | **194** | ---- | ---- | ---- | ---- |
| **ED041G: Sulfate (Turbidimetric) as SO4 2- by DA** | | | | | | | | |
| Sulfate as SO4 - Turbidimetric | 14808-79-8 | 1 | mg/L | **31** | ---- | ---- | ---- | ---- |
| **ED045G: Chloride by Discrete Analyser** | | | | | | | | |
| Chloride | 16887-00-6 | 1 | mg/L | **28** | ---- | ---- | ---- | ---- |
| **ED093F: Dissolved Major Cations** | | | | | | | | |
| Calcium | 7440-70-2 | 1 | mg/L | **82** | ---- | ---- | ---- | ---- |
| Magnesium | 7439-95-4 | 1 | mg/L | **10** | ---- | ---- | ---- | ---- |
| Sodium | 7440-23-5 | 1 | mg/L | **27** | ---- | ---- | ---- | ---- |
| Potassium | 7440-09-7 | 1 | mg/L | **3** | ---- | ---- | ---- | ---- |
| **EG020T: Total Metals by ICP-MS** | | | | | | | | |
| Aluminium | 7429-90-5 | 0.01 | mg/L | **0.02** | ---- | ---- | ---- | ---- |
| Silver | 7440-22-4 | 0.001 | mg/L | <0.001 | ---- | ---- | ---- | ---- |
| Arsenic | 7440-38-2 | 0.001 | mg/L | **0.008** | ---- | ---- | ---- | ---- |
| Boron | 7440-42-8 | 0.05 | mg/L | <0.05 | ---- | ---- | ---- | ---- |
| Barium | 7440-39-3 | 0.001 | mg/L | **0.004** | ---- | ---- | ---- | ---- |
| Cadmium | 7440-43-9 | 0.0001 | mg/L | <0.0001 | ---- | ---- | ---- | ---- |

## Analytical Results

| Sub-Matrix: WATER (Matrix: WATER) | | | | Client sample ID | Bowning Bore 1 | ---- | ---- | ---- | ---- |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Client sampling date / time | 07-Dec-2018 00:00 | ---- | ---- | ---- | ---- |
| Compound | CAS Number | LOR | Unit | | EW1805133-001 | -------- | -------- | -------- | -------- |
| | | | | | Result | ---- | ---- | ---- | ---- |
| **EG020T: Total Metals by ICP-MS - Continued** | | | | | | | | | |
| Chromium | 7440-47-3 | 0.001 | mg/L | | <0.001 | ---- | ---- | ---- | ---- |
| Copper | 7440-50-8 | 0.001 | mg/L | | <0.001 | ---- | ---- | ---- | ---- |
| Manganese | 7439-96-5 | 0.001 | mg/L | | **0.591** | ---- | ---- | ---- | ---- |
| Molybdenum | 7439-98-7 | 0.001 | mg/L | | <0.001 | ---- | ---- | ---- | ---- |
| Nickel | 7440-02-0 | 0.001 | mg/L | | <0.001 | ---- | ---- | ---- | ---- |
| Lead | 7439-92-1 | 0.001 | mg/L | | <0.001 | ---- | ---- | ---- | ---- |
| Antimony | 7440-36-0 | 0.001 | mg/L | | <0.001 | ---- | ---- | ---- | ---- |
| Selenium | 7782-49-2 | 0.01 | mg/L | | <0.01 | ---- | ---- | ---- | ---- |
| Zinc | 7440-66-6 | 0.005 | mg/L | | <0.005 | ---- | ---- | ---- | ---- |
| Iron | 7439-89-6 | 0.05 | mg/L | | **0.33** | ---- | ---- | ---- | ---- |
| **EG035T: Total Recoverable Mercury by FIMS** | | | | | | | | | |
| Mercury | 7439-97-6 | 0.0001 | mg/L | | <0.0001 | ---- | ---- | ---- | ---- |
| **EK025G: Free cyanide by Discrete Analyser** | | | | | | | | | |
| Total Cyanide | 57-12-5 | 0.004 | mg/L | | <0.004 | ---- | ---- | ---- | ---- |
| **EK040P: Fluoride by PC Titrator** | | | | | | | | | |
| Fluoride | 16984-48-8 | 0.1 | mg/L | | **0.6** | ---- | ---- | ---- | ---- |
| **EK055G: Ammonia as N by Discrete Analyser** | | | | | | | | | |
| Ammonia as N | 7664-41-7 | 0.01 | mg/L | | **0.01** | ---- | ---- | ---- | ---- |
| **EK057G: Nitrite as N by Discrete Analyser** | | | | | | | | | |
| Nitrite as N | 14797-65-0 | 0.01 | mg/L | | <0.01 | ---- | ---- | ---- | ---- |
| **EK058G: Nitrate as N by Discrete Analyser** | | | | | | | | | |
| Nitrate as N | 14797-55-8 | 0.01 | mg/L | | **1.20** | ---- | ---- | ---- | ---- |
| **EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser** | | | | | | | | | |
| Nitrite + Nitrate as N | ---- | 0.01 | mg/L | | **1.20** | ---- | ---- | ---- | ---- |
| **EK085M: Sulfide as S2-** | | | | | | | | | |
| Sulfide as S2- | 18496-25-8 | 0.1 | mg/L | | <0.1 | ---- | ---- | ---- | ---- |
| **EN055: Ionic Balance** | | | | | | | | | |
| Total Anions | ---- | 0.01 | meq/L | | **5.31** | ---- | ---- | ---- | ---- |
| Total Cations | ---- | 0.01 | meq/L | | **6.17** | ---- | ---- | ---- | ---- |
| Ionic Balance | ---- | 0.01 | % | | **7.45** | ---- | ---- | ---- | ---- |