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2014 HYDROGEOLOGY DRILLING PROGRAM, OLD TAILINGS DAM AREA, RUM JUNGLE

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1 INTRODUCTION

1.1 GENERAL

The former Rum Jungle Mine Site is located 105 km by road south of Darwin in the headwaters of the East Branch of the Finnis River. Rum Jungle was one of Australia’s first major uranium mines and produced approximately 3,500 tonnes of uranium and 20,000 tonnes of copper concentrate between 1954 and 1971 (Davy, 1975).

As part of the Rum Jungle Rehabilitation Project, a Waste Storage Facility (WSF) has been proposed in the vicinity of the Old Tailings Dam area. The new WSF will likely contain waste rock from the Main Waste Rock Dump (WRD) and Dyson’s WRD, as well as contaminated material collected from around the site.

The current report details the field work completed from October 1st to November 11th, 2014 at the Rum Jungle Mine Site as well as the subsequent interpretation of field data. Robertson GeoConsultants Inc. (RGC) completed this program in support of the Rum Jungle Rehabilitation Project. This report is a deliverable under Contract No. D14-0114.

1.2 FIELD PROGRAM OBJECTIVES

The objective of the 2014 hydrogeological drilling program was to characterize the hydrogeological and hydrochemical conditions within and around the proposed footprint of a WSF (status 2014) in the Old Tailings Dam area of the Rum Jungle Mine Site.

Of particular interest were:

- Soil and bedrock types underlying and surrounding the proposed WSF footprint.
- Soil and bedrock thickness and spatial continuity.
- Hydraulic conductivity of the underlying soils and bedrock.
- Vertical and horizontal groundwater flow directions.
- Groundwater quality.

The results of the field program have been detailed herein.

1.3 SCOPE OF WORK

The scope of work of the 2014 drilling program consisted of the following tasks:
- Drilling & monitoring bore installation.
- Monitoring bore development.
- Hydraulic testing (slug testing).
- Groundwater quality survey.
- Groundwater level survey.
- Analysis & reporting

Drilling, bore installation and development were conducted by Geo Drilling Ltd. under the supervision of an RGC hydrogeologist, Genevieve Parent, P.Eng.. RGC staff also completed slug tests and the appropriate analysis. Groundwater sampling and a site-wide groundwater level survey were completed by the DME's Environmental Monitoring Unit (EMU) in late November/early December 2014.

Subsequently, the newly-completed 2014 series of bores were incorporated into the routine monitoring program for the Rum Jungle mine site, which includes bi-weekly surveys of groundwater levels and semi-annual water quality sampling (planned for March 2015).

RGC characterized sub-surface conditions near and within a preliminary footprint area of a waste storage facility (WSF) that was selected during a previous phase of the Rum Jungle Rehabilitation Project (see Figure 1-1). This footprint was located north of the Main Open Pit within the Old Tailings Dam area. Monitoring bore locations were selected in order to characterize conditions within this footprint and in adjacent areas upgradient and downgradient.

After completion of the 2014 drilling program, an alternate site was selected as the preferred location for this WSF. The new footprint is located further upgradient (northeast) of the original footprint (Figure 1-1). Some of the wells installed in 2014 lie near the perimeter and downgradient of this new footprint but the program was not designed specifically to reflect this revised location.
2 FIELD METHODS & RESULTS

2.1 DRILLING & MONITORING BORE INSTALLATIONS

Drilling was conducted at fourteen locations from October 6th to 31st, 2014 (see Figure 2-1). Twenty boreholes were drilled at these locations with monitoring bores installed at eighteen locations (as two of the bores were abandoned and backfilled).

2.1.1 Drilling and Lithology

Bores were first drilled (totally or partially) using a direct circulation (DC) air-rotary drill rig with down-hole percussion hammer (see Photo A1, Appendix A). Eight of the bore required casing advance with Tubex in order to advance past collapsing formation materials (see Photo A2).

During drilling, cuttings were sampled at 1 m intervals and logged by the supervising hydrogeologist. Drill cuttings in unconsolidated overburden material were logged using the United Soil Classification System (USCS), which involved first establishing the relative proportions of clay, silts, sands, gravels and/or cobbles, and then describing color, moisture, texture/consistency, angularity and lithology. In addition to the above, drill cuttings in bedrock were logged, where possible, for degree of weathering, alteration, fracture density and presence of karst features (in Coomalie Dolostone).

The soil and rock profile encountered generally comprised the following lithology, from the youngest to the oldest:

- **Unconsolidated material/soil**
  - Fill material, from laterite, tailings (at a few locations in the OTD area) or waste rock (on the hill side); silt to gravel; encountered throughout the study area; about 2 m thick.
  - Laterite, developed by intensive and long-lasting weathering of the underlying bedrock into an iron-rich oxidized pelloids profile; clayed silt to silty gravel; encountered throughout the study area; up to 7 m thick.
  - Saprolite, decomposed and chemically weathered (less than laterite) bedrock; clay and silt rich; contains trace structure and texture that were present in the original rock; up to 8 m thick.

- **Bedrock (Mount Partridge Group)**
  - Geolsec Formation, sedimentary deposit of hematite-quartz breccia (HQB); mainly quartz clasts in an amorphous hematite matrix; encountered on the hill side (southwest of the Old Tailings Dam area).
  - White’s Formation, sedimentary carbonaceous shale to metamorphosed schist with tremolite, graphite and pyrite; mainly poorly consolidated and friable; present in upland areas northwest of the Old Tailings Dam area.
Coomalie Dolostone, sedimentary carbonate rock, karstic in places, comprising mainly dolomite, magnetite and calcite; can be in a saccharoidal or crystalline form to a more hematized and silicified or even brecciated form closer to the thrust fault zones; encountered throughout and around the Old Tailings Dam area.

Shallower zones of the Mount Partridge Group are often weathered in situ to laterite and saprolite. These zones generally extend to 10 m below ground surface (m bgs) or remain as relatively competent, yet variably-weathered, bedrock. Weathered bedrock typically occurs from 10 to 20 m bgs, becoming more competent below 45 m bgs.

As drilling progressed, groundwater inflows at various depths were measured. These inflows generally occurred every 5 to 6 m or when a change in lithology was observed. When water was encountered, an airlift test within the drill rods was usually conducted. The groundwater collected was tested in the field for physical parameters using a PCSTestr35 handheld probe that measured pH, electrical conductivity (EC), total dissolved solids (TDS), and water temperature.

Lithology, a preliminary air lift yield, and field water quality data are provided in the monitoring bore logs (see Appendix B).

### 2.1.2 Monitoring Bore Installation

At ten locations, monitoring bores were completed as nested installations with two distinct piezometer pipes installed in a single bore with screens at different depths. The result is a shallow and deep monitoring bore at a single location. The piezometer screens are hydraulically isolated from one another via a bentonite seal (see Photo A3). At four locations clustered monitoring bores were installed, i.e. two separate holes a few meters apart (see Photo A4). These clustered monitoring bores are MB14-03/MB14-04, MB14-09/MB14-10, and MB14-16/MB14-15S/D,

26 (of 28) monitoring bores were completed using 50 mm diameter (2") Class 18 u-PVC pipe. Two monitoring bores (MB14-09 and MB14-10) were completed using 80 mm (3.15") diameter Class 12 u-PVC pipe. Each monitoring bore featured a machine-slotted screen with a slot size of 0.5 mm (0.020") and a perforated end-cap. The shallow screens were wrapped in continuous filter fabric ("geosock") to prevent fines entering the screen (see Photo A5). 

Typical monitoring bore installation materials and annulus space backfill for clustered and nested monitoring bores are illustrated in Figure 2-2. A monitoring bore installation summary is provided in Table 2-1 and the detailed installation for each monitoring bore is shown on the bore logs presented in Appendix B.
2.1.3 Surface Completion/Earth Work

Monitoring bores were completed at surface in the following manner (see Photo A3 and A4):

- Placement of a protective steel casing with lockable lid extending at least 1 m below ground surface and approximately 0.8 m above ground surface.
- Preparation of a leveled, free draining concrete slab around the collar of the monitoring bore a minimum of 400 mm in diameter and 150 mm thickness.

The name of each monitoring bore was written on the inside and outside of each protective steel casing and/or on the PVC stickup. By convention, the shallow monitoring bore at a nested location was cut a few centimeters above the deep monitoring bore. Each of the new monitoring bores was then professionally surveyed for coordinates (easting and northing) and elevations (top of PVC casing) on November 17th, 2014.

2.1.4 Monitoring Bore Development

The deeper monitoring bores were developed by airlifting, which was performed by Geo Drilling under the supervision of RGC using an external Atlas Copco air compressor set between 50 and 100 PSI (see Photo A6). The shallow monitoring bores that were not dry at the time were developed using a bailer by removing a minimum of six bore volumes or until dry.

During development, flow rate, pH, EC, and TDS were measured at regular time intervals. Monitoring bore development was conducted using the method of parameter stabilization whereby bailing was continued until pH, EC, and TDS values measured at intervals vary less than 10% over three consecutive readings. The pH, EC and TDS measurements recorded at the end of development for each monitoring bore are presented on Table 2-2.

2.2 Groundwater Level Survey

EMU completed a site-wide groundwater level survey on November 24th, 2014. Conditions at the site were dry and typical of the end of the dry season (or ‘build up’). Depth to water (DTW) from the top of the PVC casing was measured using a manual water level meter. These measurements were converted to geodetic groundwater levels using the top-of-casing (TOC) elevations established on November 17, 2014. The DTW, TOC and groundwater elevations are presented in Table 2-3.

Geodetic groundwater levels at the newly-installed monitoring bores and nineteen existing monitoring bores were used to assess groundwater flow and infer the prevailing direction of groundwater flow within the Old Tailings Dam area (see Figure 3-6). Water elevations in the Main and Intermediate Open Pits were incorporated in the flow field assessment.
2.3 HYDRAULIC TESTING

2.3.1 Data Acquisition

To assess hydraulic conductivity (K), each of the new monitoring bores containing sufficient water (i.e. more than 0.3 m of groundwater from the bottom of the monitoring bore) was slug tested using rising head (RH) and/or falling head (FH) tests. The following equipment was used for slug testing (see Photo A7):

- A 1.85 m long PVC slug with a 0.04 m diameter filled with sand and a theoretical displacement of 1.18 m in a 50 mm bore and a 0.46 m displacement in an 80 mm bore.
- A 0.92 m long clear sink-fast bailer with a 0.04 m diameter and a theoretical displacement of 0.59 and 0.23 m in a 50 mm bore and 80 mm bore, respectively.

Groundwater level recovery was monitored using a Solinst Levelogger installed at the bottom of the screen or 4 to 8 m below the static water level. Recording intervals from 0.125 to 3 seconds were selected depending on the initial recovery response. The (static) groundwater levels were manually measured immediately prior to commencement of the test and occasionally during recovery using a Solinst water level tape.

2.3.2 Data Analysis

RGC analyzed slug test data with the AQTESOLV Pro commercial software. The data were analyzed in most cases using the Bouwer and Rice (1976) method. This solution is applicable to confined and unconfined aquifer conditions. In the case of under-damped responses (oscillatory water-level response sometimes observed in aquifers with high hydraulic conductivity), the Butler (1998) method was used (see Appendix C).

The general assumptions for the slug testing solutions are as follows:

- Aquifer has infinite areal extent.
- Aquifer is homogeneous and of uniform thickness.
- Test monitoring bore is fully or partially penetrating (partially penetrating only for ’Butler’).
- Aquifer is unconfined or confined (confined only for ’Butler’).
- Flow is quasi-steady state, i.e. storage is negligible.
- Displacement of water is instantaneous

Although the total depth of the Coomalie Dolostone formation is not known, it is present to at least 60.7 m bgs at monitoring bore PMB-9D and 62.5 m bgs at monitoring bore PMB-13. For calculation purposes, a nominal depth of 40 m bgs was assigned to the Coomalie Dolostone.
2.3.3 Hydraulic Conductivity Values

The results of the slug testing are shown on Table 2-4. In assessing the hydraulic conductivities of each lithological unit, slug tests that demonstrated poor recovery, had inadequate initial displacement or were affected by significant fractures or voids, were discarded. The remaining slug tests provided a range of hydraulic conductivity values for each lithological unit as follows:

- Laterite/overburden/fill (n = 5):  $1 \times 10^{-5}$ to $8 \times 10^{-6}$ m/s
- Saprolite (n=4):  $7 \times 10^{-7}$ to $3 \times 10^{-6}$ m/s
- Coomalie Dolostone (n = 10):  $2 \times 10^{-6}$ to $7 \times 10^{-5}$ m/s
- Geolsec Formation (n = 3):  $8 \times 10^{-9}$ to $4 \times 10^{-7}$ m/s
- White's Formation (n = 1):  $8 \times 10^{-7}$ m/s

The slug testing results for the saprolite indicated K values ranging less than one order of magnitude while the k values for the Coomalie Dolostone and Geolsec units varied between one and two orders of magnitude. The variations in values are typical of natural formations and are generally due to varying degrees of weathering and/or fracturing.

2.4 Groundwater Quality Survey

2.4.1 Groundwater Sampling & Analysis

EMU collected initial groundwater quality samples from each of the new monitoring bores from December 1 to December 4, 2014. Samples were handled according to EMU’s internal quality assurance and quality control procedures and then analyzed for pH, EC, alkalinity, major cations (Ca, Mg, Na, K), major anions (SO₄, Cl), and dissolved metals.

2.4.2 Groundwater Quality

The laboratory results of the groundwater quality analyses are presented in Table 2-5. Field measurements of temperature, pH, EC, turbidity, dissolved oxygen (DO) and redox potential (Eh) are also shown in Table 2-5.
3 DISCUSSION

3.1 HYDROSTRATIGRAPHY

The delineation of the groundwater flow system requires evaluation of the hydrostratigraphic controls, such as topography, lithology and the structural geology of the study area. Cross-sections A-A’ to E-E’ illustrate the discussion below (see Figures 3-1 to 3-5).

3.1.1 Topography

The topography in the Old Tailings Dam area is mainly flat with a gentle slope towards the East Branch of the Finniss River. This area is bordered by higher elevation features to the west and north of the study area.

On the southwest portion, there is a 30 m high hill with a 6% slope towards the Main Open Pit and the Old Tailings Dam area. Topography on the northwest portion shows a 1% slope towards the Old Tailings Dam area. The area north of the Old Tailings Dam area has a 5% slope.

Because the Old Tailings Dam area is lower in elevation, groundwater naturally flows towards it from the surrounding upland area. Additionally, the Old Tailings Dam area lies in the lower reach of the catchment area of the East Branch of the Finniss River so it typically floods during the wet season.

3.1.2 Lithological controls

The lithology of the Old Tailings Dam area is a determinant in the direction and velocity of groundwater flow. Hydrogeological studies to date indicate the following with regard to lithology:

- The fill soils and laterite that comprise the shallow soil unit are expected to be of relatively high K. During the November 2014 water level survey, the shallow unit was dry and therefore hydraulic testing could not be conducted. One slug test conducted previously at PMB-8S, screened in laterite overlying Geolsec rock to the east of the Old Tailings Dam area, indicated a K value of 5x10^{-5} m/s. As can be seen in Figures 3-1 to 3-5, the fill soils and laterites, though absent or very thin in areas, are generally present throughout the Old Tailings Dam area.

- The saprolite soils underlying the shallow fill and laterite soils have significantly lower hydraulic conductivity than the shallow soils and the underlying weathered Coomalie Dolostone. Although not shown on Figures 3-1 to 3-5, the saprolite is present throughout the Old Tailings Dam area.

- The Coomalie Dolostone is characterized by slight to extreme chemical weathering (dolomite dissolution) that imparts higher K values than that of the surrounding lithology. The weathering can potentially produce karstic features (voids) in the Old Tailings Dam area that, if hydraulically connected, could act as areas of preferred flow or preferential recharge.
- The Geolsec Formation is much less permeable than Coomalie Dolostone with hydraulic conductivities generally two orders of magnitude lower. Groundwater flow in this unit appears to be driven primarily by topography and the occasional fracture.
- The White’s Formation was encountered at some locations in the northwest upland area near a contact zone with the Coomalie Dolostone. It has hydraulic conductivities similar to that of the Geolsec Formation and are, as well, significantly lower than the Coomalie Dolostone.

The degree of weathering of bedrock appears to considerably affect groundwater flow across the site; the top portion of this profile (i.e. saprolite unit to highly weathered bedrock) extends generally between 4 and 20 m bgs and contains high portions of fine material that reduces k values or the connectivity of the fractures.

The underlying bedrock portion (weathered to slightly weathered/fresh highly fractured bedrock) from 20 and 45 m bgs appears to bear more groundwater and to be more inter-connected than the overlying zone. Fresh, un-weathered bedrock underneath (> 45 m bgs) is expected to be less fractured and hence characterized by lower secondary permeability. However, it should be noted that monitoring bores installed in the central mining area in earlier investigations and screened at depths greater than 50 mbgs, relatively high K values ($10^{-5}$ m/s) were calculated from slug testing.

### 3.1.3 Hydrostratigraphic Units

Based on RGC’s understanding of the above controls and conceptual model of the study area, four different hydrostatigraphic units were identified:

- Shallow soil unit (fill and laterite), potentially acting as local unconfined aquifers in the wet season.
- Saprolite to highly weathered (HW) bedrock with higher clay content (lower permeability semi-confining aquitard).
- Moderately to slightly weathered (MW-SW) to fresh, fractured bedrock aquifers:
  - Geolsec Formation (less permeable, less fractured)
  - White’s Formation (moderately permeable and fractured)
  - Coomalie Dolostone (highly permeable and a potentially karstic environment)

### 3.1.4 Structural controls

There are several faults cutting across the study area with a SW-NE to N-S trend (see Figure 3-6). Some of these faults are connected to the flooded open pits and may potentially affect the direction of groundwater flow. The low grade metamorphism associated with the fault zones could also be affecting the hydraulic properties and groundwater flow (potentially acting as a flow barrier or as a preferred flow path).
3.1.5 Karst Features

During the drilling investigation, cavities were encountered in the Coomalie Dolostone at monitoring bores MB14-07 (8 to 12 m bgs), MB14-11A (23-26 m bgs) and MB14-12A (>19 m bgs). During drilling at these locations, yields of greater than 3 L/s were encountered. Due to flowing mud from the cavities at bores MB14-11A and -12A, attempts to install monitoring bore PVC and screens were abandoned. A similar cavity was encountered during the drilling investigation of 2010 at monitoring bore MB10-14 with yields of approximately 50 L/s.

The cavities encountered may be related to faults, however, the potential exists that the cavities represent karst formations. Like faults, karst formations can affect groundwater flow direction and velocity, the structural integrity of facilities, and the chemical quality of groundwater discharging to receiving creeks.

With regard to groundwater flow within the Old Tailings Dam area, preferential pathways can exist or form depending on the interconnectivity of karst voids, both horizontally and vertically. Where high interconnectivity of voids exists, relatively high flows to discharge areas (creeks) can occur. Karst voids in the saprolite can also induce flows of nominally perched, shallow groundwater to the deeper, confined aquifer in the underlying Coomalie Dolostone. Preferential pathways due to karst formations can therefore induce rapid migration of tailings impacted groundwater.

Typically, the Coomalie Dolostone tends to buffer the acidity of groundwater with the concomitant effect of dropping some metals such as copper out of solution. In a karst void, less buffering of acidity is available due to reduced dolomite particle surface area, and hence, relatively higher metals concentrations. In a system of well-connected karst voids, impacted groundwater from the WSF would reach discharge areas with relatively high acidity and metals concentrations than it otherwise would flowing through non-karst Coomalie Dolostone.

Although it is possible that the voids encountered during drilling in 2010 and 2014 were related to faults, there is a potential that the voids represent karst formations. Further investigation of this is warranted due to the potential complications outlined above.

3.2 Groundwater Flow Field

The Old Tailings Dam area is dominated by confined weathered and fractured bedrock aquifer systems and shallow, localized (seasonal), unconfined aquifers. Generally, the direction of groundwater flow within the study area is from higher elevation areas to the west towards the East Branch of the Finniss River (See Figure 3-6) to the east of the Old Tailings Dam area.
3.2.1 Recharge and Discharge Areas

The shallow, seasonal aquifer in the Old Tailings Dam area is recharged in the wet season directly by infiltration of rainfall. The deep, semi-confined bedrock aquifer is recharged during the wet season, in part, by seepage through the saprolite from the shallow groundwater. During the dry season, and in part during the wet season, the deep aquifer is recharged by lateral flow from mounded groundwater in the upland areas to the east.

The East Branch of the Finniss River is inferred to be a major groundwater discharge zone for the OTD area (see Figure 3-6). Old Tailings Creek is also a potential discharge zone. The flooded open pits may represent groundwater discharge or recharge zones depending on the seasonal flow field. During the dry season, the flooded open pits recharge the surrounding bedrock aquifer, while during the wet season groundwater in the surrounding aquifer system discharges into the flooded pits.

3.2.2 Hydraulic Gradients

As described previously, the less permeable lithologies create steeper horizontal hydraulic gradients (ih) and the more permeable units flatter gradients. This is apparent from the steeper hydraulic gradients in the Geolsec Formation compared to the hydraulic gradients in the Coomalie Dolostone (see Figure 3-6). These gradients are also influenced by topography.

The 2014 monitoring bores were installed as ‘nested’ or ‘clustered’ pairs to allow groundwater level monitoring in both the shallow ‘seasonal’ aquifer and the deep, confined aquifer that underlies the saprolite. This allows vertical hydraulic gradients across the saprolite to be estimated and enables an assessment of the connectivity between the aquifers. Additionally, these monitoring bores will provide a comparison of the responses of the shallow and deep aquifers to recharge during the wet season.

Each of the new monitoring bore pairs installed in 2014 indicates a downward hydraulic gradient (where a vertical gradient exists). Monitoring bores MB14-02S/D are an exception, as a brief upward gradient occurs during the early part of the wet season (Figure 3-6). A downward gradient is then established by mid-January.

3.2.3 Volumetric Flow Rate

Groundwater movement in the hydrostratigraphic units follows Darcy's law and hence can be estimated using the ‘equivalent porous medium’ approach, i.e. the use of effective (or 'bulk') hydraulic properties to approximate conditions in the aquifer. Based on this assumption and the K values for different hydrostratigraphic units, the volumetric flow of groundwater discharged to the Old Tailings Dam area is expected to be between 300 to 1200 m$^3$ per day. The upper end of the range is comparable to the volumetric flow simulated by the numerical model for this area (1300 m$^3$/d) (see RGC, 2012).
3.2.4 Seasonal Variations

The bi-weekly groundwater elevations measured from late November 2014 (dry season) to early March 2015 (wet season) at five monitoring bore pairs are shown on Figure 3-7. The monitoring bore pairs have been selected roughly along a line from the highest elevation (MB14-15D/S) to the lowest elevation (MB14-18 and MB14-19).

The figure demonstrates the difference in change of groundwater elevation from dry season to wet season at different elevations. The largest increase in groundwater elevation occurs at the highest elevation with a maximum change of approximately 8 m (MB14-15S/D). The minimum change occurs at monitoring bore pairs MB14-18 and MB14-19 at approximately 2.9 m. The bi-weekly groundwater elevation measurements indicate that the rise in groundwater elevations observed at the monitoring bores shown on Figure 3-7 are typical for all monitoring bores in the Old Tailings Dam area.

Of note is the lag in the water table rise observed at monitoring bores MB14-15 Deep and Shallow compared to the monitoring bores at lower elevations. The lag is likely due to the significantly lower hydraulic conductivities at monitoring bores MB14-15 Shallow and Deep screened in Geolsec (2x10^{-7} m/s and 2x10^{-8} m/s, respectively) compared to the other three well pairs screened in Coomalie Dolostone (greater than 5x10^{-6} m/s).

The groundwater elevation changes shown on Figure 3-7 reflect the rapid rise from dry season to wet season that has been observed at previously-installed monitoring bores since 2010. Figure 3-8 shows all the available groundwater elevation monitoring data to date for monitoring bores MB10-18 and MB10-19. The dry season of 2014 is the driest recorded at the site which is reflected in the lowest groundwater elevations.

3.3 Groundwater Quality

The select laboratory results and field measurements of groundwater quality are presented on Figures 3-9a, 3-9b and 3-9c. Field measurements from the time of sample collection of pH and electrical conductivity (EC), as well as the laboratory analytical results for sulphate (SO_4), magnesium (Mg), copper (Cu), cobalt (Co), nickel (Ni), zinc (Zn), aluminum (Al), iron (Fe), and manganese (Mn) are presented in groups on the drawings. All metals analytical results represent dissolved concentrations. Only the dry season results are presented as the wet season groundwater quality results have not been received to date. Groundwater samples were not collected from some shallow monitoring bores where groundwater levels were too low at the time of sampling.

Key findings from the initial round of groundwater quality sampling are summarized here:

- Deeper groundwater within the footprint of the new WSF generally contains less than 200 mg/L SO_4 and low concentrations of dissolved metals (see Figure 3-9). These concentrations
suggest limited impacts to groundwater in the deep bedrock aquifer by residual tailings in this area\(^1\) or no impact at all (at MB14-01S).

- Immediately north and east of the WSF footprint, groundwater appears to be impacted to a similar degree as groundwater within the footprint
- \(\text{SO}_4\) concentrations are also elevated further east at monitoring bores MB14-06D, MB14-014D and MB14-15D.
- To the immediate southeast of the footprint, high concentrations of \(\text{SO}_4\) and metals are present at monitoring bore MB14-20D.

The most likely source of (slightly) elevated \(\text{SO}_4\) and metals concentrations to the west of the Old Tailings Dam footprint is the historic (acidic) seepage from the Main Open Pit (which was flooded with acidic water prior to reclamation works in the 1980s). This may demonstrate the limits of the buffering potential of the Coomalie Dolostone and possibly the effect of karstic features on groundwater quality in the area west of the Old Tailings Dam footprint. The most likely source of the high \(\text{SO}_4\) and metals concentrations at monitoring bore MB14-20D is the historic waste rock that was placed on the hillside to the east of the OTD area (confirmed during test pitting in this area). The historic waste rock may also be the source of the elevated \(\text{SO}_4\) concentrations at monitoring bore MB14-15D. There are no obvious sources of the elevated \(\text{SO}_4\) concentrations at monitoring bores MB14-06D and -14D.

Wet season groundwater quality results will provide more information regarding the seasonal, shallow aquifer.

### 3.4 IMPLICATIONS FOR DESIGN OF NEW WASTE ROCK STORAGE FACILITY

The results of the 2014 hydrogeological investigation have the following implications for the design of a new waste rock storage facility (WSF) in the Old Tailings Dam area:

1) **The WSF Foundation:**
   - The footprint of the proposed WSF can be expected to have seasonal groundwater less than 1 m below the current ground surface. The resulting saturated conditions may reduce the strength of the foundation soils. The shallow groundwater may also rise into the basal layer of waste rock and the shallow drains of the WSF in significant quantities.
   - The WSF design may require a double drainage system including an underdrain to divert shallow, clean groundwater and an internal liner/collection system to collect waste rock seepage.

\(^1\) RGC had not received wet season groundwater quality data at the time of writing.
2) **Natural Attenuation:**
- The bedrock aquifer underlying the proposed WSF could provide significant dilution potential for impacted seepage. An estimated 300 to 1200 m³/day of groundwater, or 3 to 12 times the target net percolation rate, flows under the footprint of the proposed WSF. However, due to preferential flow pathways in the shallow laterite, as well as pathways potentially caused by karstic features, complete mixing of waste rock seepage in the aquifer water may not occur. This could significantly reduce the effectiveness of dilution of impacted seepage from the WSF.
- The Coomalie Dolostone has buffering capacity to reduce the acidity of impacted seepage from the WSF which in turn may reduce concentrations of some metals, particularly copper. The buffering potential may be lost, however, due to coating of the Dolostone over time and reduced surface area in fractured bedrock and karstic features. Seepage flowing preferentially through the shallow, low buffering capacity laterites would also not benefit from the buffering potential of the Dolostone.

3) **Seepage Control:**
- The currently proposed WSF location requires control of two potential seepage pathways including lateral flow in the shallow laterite to Old Tailings Creek during the wet season and vertical seepage into the underlying, potentially karstic bedrock, eventually flowing towards the East Finnis River (sacred site).
- Impacted seepage in the laterite could be intercepted with a shallow ditch. However, a shallow ditch would likely collect significant volumes of clean, shallow groundwater during the wet season, increasing seepage treatment requirements.
- Seepage collection in the deeper Coomalie Dolostone aquifer may prove difficult due to the potential of karstic features which would provide preferential pathways for impacted seepage. Karstic features are difficult to detect and have the potential to form over time.
- A basal liner underlying the WSF with an internal collection system would provide the best control of waste rock seepage.
4 KEY FINDINGS & RECOMMENDATIONS

4.1 KEY FINDINGS

The hydrogeological field investigation of the proposed location for a new WSF (status 2014) consisted of the installation of 28 monitoring bores at 14 locations.

Twenty one monitoring bores were slug tested to determine $K$ and groundwater samples were collected from the 16 monitoring bores that contained water in November and December. Dry and wet season groundwater elevations have been measured on a bi-weekly basis since November 24, 2014 at all new monitoring bores. Key findings from the 2014 hydrogeological investigation are summarized as follows:

- The lithology of the Old Tailings Dam area generally consists of fill and laterite soils overlying a semi-confining saprolite unit which is in turn underlain by a weathered Coomalie Dolostone bedrock layer.
- Faults and/or karst voids were encountered at locations to the south-east, south and west of the OTD area.
- $K$ values estimated from the results of slug testing varied from $8 \times 10^{-9}$ m/s to $2.8 \times 10^{-3}$ m/s. In general, the saprolite unit has a lower hydraulic conductivity than the overlying surficial fill and laterite soils and the underlying weathered Coomalie Dolostone. The White’s Formation and Geolsec Formation have significantly lower hydraulic conductivity than the weathered Coomalie Dolostone.
- Groundwater generally flows from east to west from the higher elevations east of the Old Tailings Dam area to the East Branch of the Finniss River to the west. Groundwater discharge to Old Tailings Creek immediately north of the Old Tailings Dam area is also likely.
- From the dry season to the wet season, groundwater elevations rise rapidly by approximately 3 m to 8 m to near-ground surface in some areas with the greatest rise occurring in the elevated areas to the west of the Old Tailings Dam area.
- Base flow from the higher elevations through the Coomalie Dolostone occurs year-round while flow in the shallow fill and laterite soils occurs during the wet season.
- Vertical hydraulic gradients, when present, are typically downward from the shallow fill and laterite soils to the deeper Coomalie Dolostone. They are more prevalent in the higher elevations to the east of the Old Tailings Dam area.
- Hydraulic gradients in the Old Tailings Dam area are much flatter than in the higher elevations to the east and north of the Old Tailings Dam area. This is due to topography, hydraulic conductivity differences and possibly preferential recharge.
• Although there is evidence of residual groundwater impacts from the historical waste rock stored on the hillside to the east of the OTD area, impacts from the historical tailings within the Old Tailings Dam area were not observed.

4.2 RECOMMENDATIONS

To better understand the vertical gradients in the Old Tailings Dam area, RGC recommended that the following monitoring bores be equipped with ‘vented’ pressure transducers/data loggers:

- MB14-02S (laterite in center of WSF)
- MB14-02D (fractured BR in center of WSF)
- MB14-17S (laterite/saprolite on hill side)
- MB14-17D (fractured BR on hill side)
- MB14-20S (laterite/saprolite at toe of hill side)
- MB14-20D (fractured BR at toe of hill side)

These loggers would record groundwater levels (head pressure) throughout the upcoming wet season. This groundwater level monitoring would assist in the assessment of (i) development of perched conditions on the hill side and (ii) the extent of potential flooding of groundwater to surface (upward hydraulic gradients) in the Old Tailings Dam area, in particular in shallow laterite soils.

Furthermore, to evaluate the head pressure generated by the upward gradients, it would be useful to install a pressure gauge which can be installed on any of the 50 mm or 80 mm monitoring bores which develop/have the potential to develop artesian pressures during the wet season (e.g. as observed at MB10-18 and MB10-19, possibly MB14-03 and MB14-04). Such a gauge should be mounted when the monitoring bore is observed to “overflow” to read the total pressure.
5 CLOSURE

Robertson GeoConsultants Inc. is pleased to submit this report entitled Phase 5: 2014 Hydrogeological Drilling Program at Rum Jungle, NT.

This report was prepared by Robertson GeoConsultants Inc. for the use of the NT Department of Mines and Energy and prior consent by the Department should be given before the contents of this report are considered by any third party.

We trust that the information provided in this report meets your requirements at this time. Should you have any questions or if we can be of further assistance, please do not hesitate to contact the undersigned.

Respectfully submitted,

ROBERTSON GEOCONSULTANTS INC.

Prepared by:

[Signature]

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Senior Hydrogeologist

Reviewed by:

[Signature]  [Signature]

Dr. Paul Ferguson  Dr. Christoph Wels, M.Sc., P.Geo.
Senior Geochemist  Principal Hydrogeologist
6 REFERENCES


TABLES
## Table 2-1: Bore Details

<table>
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<tr>
<th>Bore ID</th>
<th>Coordinates GDA94 MGA zone 52L</th>
<th>Location</th>
<th>Total Depth (mbgs)</th>
<th>Bedrock Depth (mbgs)</th>
<th>Residual Distance (m)</th>
<th>Stick up Height (m)</th>
<th>TOC Elevation (m AHD)</th>
<th>Screened Top (mbgs)</th>
<th>Screened Bottom (mbgs)</th>
<th>PVC (Blank and screens)</th>
<th>Screen Aperture (mm)</th>
<th>Lithology Screened</th>
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Notes:
- TOC: top of casing
- DTW: depth to water
- SWL: static water level
- mAHD: metre Australian Height Datum
- mbgs: metre below ground surface

**Nested**

- Nested wells

**Shallow**

- Shallow/overburden well (clustered with MB14-15 s/d)

**Deep**

- Deep well (clustered with MB14-14)
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<th>EC (uS/cm)</th>
<th>TDS (ppm)</th>
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**Notes:**
- **TOC:** top of casing
- **DTW:** depth to water
- **SWL:** static water level
- **mAHD:** metre Australian Height Datum
- **mbgs:** metre below ground surface
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<th>Time</th>
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<th>Test Type (FH/RH)</th>
<th>Analytical Method</th>
<th>K (Calculated)</th>
<th>K (Best Engineering Judgement)</th>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Dry</td>
</tr>
<tr>
<td>MB14-13S</td>
<td>Fill/Laterite/Saprolite/Extremely Weathered Coomalie Dolostone</td>
<td>Unconfined</td>
<td>25-Mar-15</td>
<td>10:25:49 AM</td>
<td>Injection RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>3.5E-06</td>
<td>3.5E-06</td>
<td>3.5E-06</td>
<td>Drawdown recorded manually with water level</td>
</tr>
<tr>
<td>MB14-13D</td>
<td>Weathered Coomalie</td>
<td>Confined</td>
<td>4-Nov-14</td>
<td>2:21:32 PM</td>
<td>Slug FH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>4.7E-05</td>
<td>4.7E-05</td>
<td>4.7E-05</td>
<td>Rising head test failed due to slug tangling</td>
</tr>
<tr>
<td>MB14-14S</td>
<td>Laterite/Extremely</td>
<td>Unconfined</td>
<td>7-Nov-14</td>
<td>11:25:12 AM</td>
<td>Slug RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>3.1E-03</td>
<td>3.1E-03</td>
<td>3.1E-03</td>
<td>20 litres/35s, recovery stops at ~68%, slope change</td>
</tr>
<tr>
<td>MB14-14D</td>
<td>Weathered Coomalie</td>
<td>Confined</td>
<td>5-Nov-14</td>
<td>5:28:23 PM</td>
<td>Slug RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>8.3E-07</td>
<td>8.3E-07</td>
<td>8.3E-07</td>
<td>No falling head test</td>
</tr>
<tr>
<td>MB14-15S</td>
<td>Highly Weathered Gooloo Formation</td>
<td>Unconfined</td>
<td>7-Nov-14</td>
<td>5:24:23 PM</td>
<td>Slug RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>3.9E-07</td>
<td>3.9E-07</td>
<td>3.9E-07</td>
<td>No falling head test</td>
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<td>Fresh Gooloo Formation</td>
<td>Unconfined</td>
<td>5-Nov-14</td>
<td>12:59:23 PM</td>
<td>Slug RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>2.3E-08</td>
<td>2.3E-08</td>
<td>2.3E-08</td>
<td>No falling head test</td>
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<td>MB14-16C</td>
<td>Laterite Fill</td>
<td>Unconfined</td>
<td>24-Mar-15</td>
<td>4:42:45 PM</td>
<td>Injection RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>3.8E-06</td>
<td>3.8E-06</td>
<td>3.8E-06</td>
<td>20 litres/35s, recovery stops at ~68%, slope change</td>
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<td>MB14-17S</td>
<td>Fill/Laterite/Highly Weathered Gooloo</td>
<td>Unconfined</td>
<td>23-Mar-15</td>
<td>7:53:42 PM</td>
<td>Injection RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>3.8E-06</td>
<td>3.8E-06</td>
<td>3.8E-06</td>
<td>40 Litres/94s,</td>
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<td>Slightly Weathered Gooloo Formation</td>
<td>Unconfined</td>
<td>6-Nov-14</td>
<td>9:22:29 AM</td>
<td>Slug RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>8.7E-09</td>
<td>8.7E-09</td>
<td>8.7E-09</td>
<td>No falling head test</td>
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<td>MB14-18D</td>
<td>Weathered Coomalie Dolostone</td>
<td>Confined</td>
<td>7-Nov-14</td>
<td>2:37:21 PM</td>
<td>Slug FH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>8.6E-05</td>
<td>8.6E-05</td>
<td>8.6E-05</td>
<td>Falling head test was disturbed</td>
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<td>MB14-19S</td>
<td>Slightly Weathered Coomalie Dolostone</td>
<td>Unconfined</td>
<td>7-Nov-14</td>
<td>10:23:36 AM</td>
<td>Slug RH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>1.1E-05</td>
<td>1.1E-05</td>
<td>1.1E-05</td>
<td>35 Litres/82s, abrupt slowing of recovery at ~50s. As above with l, H reduced to only depth of laterite.</td>
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<td>MB14-20S</td>
<td>Laterite/Saprolite</td>
<td>Unconfined</td>
<td>25-Mar-15</td>
<td>8:46:47 AM</td>
<td>Injection FH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>2.0E-05</td>
<td>2.0E-05</td>
<td>2.0E-05</td>
<td>As above with L reduced to Laterite only;</td>
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<td>MB14-20D</td>
<td>Slightly Weathered Coomalie Dolostone</td>
<td>Confined</td>
<td>8-Nov-14</td>
<td>9:27:53 AM</td>
<td>Slug FH</td>
<td>Bouwer and Rice (Unconfined)</td>
<td>7.6E-07</td>
<td>7.6E-07</td>
<td>7.6E-07</td>
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<td>SAMPLE ID</td>
<td>DESCRIPTION/LOCATION</td>
<td>DATE</td>
<td>Alkalinity mg/L</td>
<td>Ca mg/L</td>
<td>Mg mg/L</td>
<td>Na mg/L</td>
<td>K mg/L</td>
<td>SO4 mg/L</td>
<td>Cl mg/L</td>
<td>Al_f µg/L</td>
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<td>MB14-01D</td>
<td>MB1401 Deep old tailings dam area</td>
<td>1-Dec-14</td>
<td>128</td>
<td>43.4</td>
<td>43.9</td>
<td>5.3</td>
<td>0.5</td>
<td>133</td>
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<td>1-Dec-14</td>
<td>128</td>
<td>56.8</td>
<td>46.1</td>
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<td>MB1402 Deep old tailings dam area</td>
<td>1-Dec-14</td>
<td>98</td>
<td>36</td>
<td>42.3</td>
<td>5.7</td>
<td>0.4</td>
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<td>MB14-03</td>
<td>MB1403 northern edge of old tailings dam area</td>
<td>2-Dec-14</td>
<td>192</td>
<td>34.7</td>
<td>39.9</td>
<td>10</td>
<td>1.6</td>
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<td>MB14-04</td>
<td>MB1404 northern edge of old tailings dam area</td>
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<td>306</td>
<td>51.5</td>
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<td>110.67</td>
<td>34.7</td>
<td>38.1</td>
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<td>MB14-06D</td>
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<td>4-Dec-14</td>
<td>86</td>
<td>27.8</td>
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<td>43.7</td>
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<td>3-Dec-14</td>
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<td>63.9</td>
<td>51.5</td>
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<td>MB1408 Deep old tailings dam area</td>
<td>3-Dec-14</td>
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<td>82.7</td>
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<td>11.2</td>
<td>1.1</td>
<td>237</td>
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<td>8</td>
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<td>MB1409 western edge of old tailings dam area</td>
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<td>88.2</td>
<td>65.9</td>
<td>10</td>
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<td>74.3</td>
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<td>34.8</td>
<td>20.5</td>
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<td>75.2</td>
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<td>MB1414 Deep near borrow area 5</td>
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<td>168</td>
<td>121</td>
<td>32.1</td>
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<td>786</td>
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<td>75.9</td>
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<td>4-Dec-14</td>
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<td>MB14-18</td>
<td>MB1418 western edge of old tailings dam area</td>
<td>4-Dec-14</td>
<td>246</td>
<td>38.4</td>
<td>45.5</td>
<td>3.4</td>
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<td>18.7</td>
<td>5</td>
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<td>248</td>
<td>92.2</td>
<td>101</td>
<td>23.5</td>
<td>1.8</td>
<td>376</td>
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<td>MB14-20D</td>
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<td>3-Dec-14</td>
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<td>177</td>
<td>199</td>
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<td>3.3</td>
<td>1360</td>
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<td>3-Dec-14</td>
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</table>

0.01 Concentration less than indicated detection limit
- Data not available
Italicized TDS values calculated from EC
Suspect data
Z:\Files\Projects\183000 RumJungle\183005 Phase 5\RGC Reports\2014 Hydrogeo Field Result Report\Tables\Table S GW data November all Wells 2014.xls
Sheet Table 2-5
FIGURES
Figure 2-2: Typical Monitoring Bore Installation Diagram

Annulus Space:
- Drill cuttings
- Bentonite chips (3/8”)
- Slow-release 1/4” bentonite pellet plug
- Washed bulked medium sand (1 mm) filter pack (around shallow screen)
- Washed, bagged coarse sand (2-3 mm) filter sand pack (around deep screen)

Bore Material:
- 50mm diameter PVC blank Class 18 or 80mm diameter PVC Blank Class 12
- 50mm diameter PVC screen Class 18 or 80mm diameter PVC screen Class 12 (aperture 0.5mm)
Groundwater Level Contours and Flow Direction

Rum Jungle Mine Site

Scale: 1:500

Groundwater Level Contours
Flow Direction

Legend:
- Drainage
- Flow
- Groundwater Level Contour
- Fault
- Fault Line
- Lithology
- Contoured
- Uncontoured
- Sandstone Formation
- Carbonate Formation
- Granite formation
- Gravelly horizon
- Shale
- Sandstone
- Metasedimentary Complex
- White's Formation

Client: Macraes Territory Environment
Project No: 183065
Report: RSC 183065
Client: Rum Jungle Mine Site, NT, Australia
Drawn: L.R.
Last Update: Apr 08, 2015

Figure: 3-6

Projection: GDA 1994 MGA Zone 52 (m)
Figure 3-7: Groundwater Elevation Changes With Season
Figure 3-8: Typical Groundwater Elevation Changes 2010 to 2015
Appendix A. Photographs
Appendix A: Photographs

Photograph 1: Open hole RC drilling

Photograph 2: Tubex RC drilling
Appendix A: Photographs

Photograph 3: Nested bore (MB14-02 s/d)

Photograph 4: Clustered bores (MB14-03 (d) and MB14-04 (d))
Appendix A: Photographs

Photograph 5: Screen, PVC (50 mm Class 18) and ‘geosock’

Photograph 6: Bore development using an external air compressor (Atlas Copco)
Photograph 7: Slug testing instruments and set up
Appendix B. Borehole Logs
### Ground Description

**GM** (Fill cover - lateritic like), silty GRAVEL-SAND with clay matrix, yellowish red (5YR 5/6), moist, subrounded, well sorted (G: 35% S: 45% F: 20%), some iron rich minerals.

*Sand & gravel mainly dolomite, trace slate, quartz and limestone.*

**SM** (Saprolite), silty SAND to sandy SILT with gravel, trace clay (G: 15%, S: 65%, F: 20%), pale brown (2.5Y 8/3), dry, rounded, well sorted, some gravel fizz to HCl when scratched

*Root channels + oxidation (possibly laterite up to ~1.5m)*

**ML** (Dolomite boulder), sandy SILT (rock flour), trace gravel chips,
light pink to pale red (7.5R 8/2 to 7/3), dry to moist from 8m,
subrounded, poorly sorted, highly weathered dolomite.

*Trace oxidation minerals.*

**Extremely weathered COOMALIE DOLOSTONE**, clayey silt with sand, trace gravel, very pale brown (10YR 7/3 to 8/3), wet, extremely weathered (dolomite altered to whiteish & yellowish silty clay), soft, extremely low strength.

*Trace oxidation minerals.*

**Highly weathered COOMALIE DOLOSTONE**, gravel & sand size chips of dolomite, trace quartz, and/or silicious dolomite (marble?) in a clayey silt matrix with some relic clasts (altered to clay minerals crush under thumb but show dolomite texture & very low strength), pinkish grey to reddish yellow (7.5YR 7/2, 7/4 & 7/6) + yellow staining (alteration), wet, highly weathered.

- Decreasing clay from 16m-19m.
Weathered COOMALIE DOLOSTONE, sand sized chips + trace silt & trace gravel chips, dolomite & quartz or silicious (mainly quartz from 19-20m) - poorly cemented sandstone like material, wet, subrounded to subangular, weathered, white (10YR 8/1) light grey (10R 7/1) pale red (10R 7/2), trace yellow & white staining.

*Extremely weathered pocket from 21-22.5m (chips are mainly altered to clay in silty clay matrix."

Slightly weathered COOMALIE DOLOSTONE, sand & gravel sized chips, mainly dolomite, trace quartz, subangular to angular, very fine platy shaped, wet, slightly weathered & possibly densely fractured, friable, light pink (7.5R 8/3) & weak red to pale red (5R 4/3 to 7/3) - bleached-like pink + trace white, trace yellow alteration.

* Pocket of highly weathered & increased alteration to clay from 27-28m. - brownish yellow (10YR 6/6).
**Shallow Well (S):**
- Depth: 6.91 m
- Elevation: 57.32 m AHD
- Date: 11/24/2014
- Material:
  - (ML) [Fill cover - lateritic like] clayey SILT, trace gravel & sand (G:10% S: 10% F: 80%), moist, rounded, non elastic, red (2.5YR 4/6), iron rich peloids & black minerals. Some peloids are magnetic.

**Deep Well (D):**
- Depth: 6.98 m
- Elevation: 57.25 m AHD
- Date: 11/24/2014
- Material:
  - [Laterite], clayey SILT, with gravel & iron rich peloids (G: 25% S: 10% F: 65%), moist to wet, rounded, non elastic, dark red (2.5YR 3/6), extremely weathered/detrital.*Contains iron rich minerals, trace magnetic peloids, trace quartz, trace vuggy textured black, red & yellow chips (hematite with limonite alteration?). *Root channels & oxidation.

**Notes:**
- Tubex to 30 mbgs.

**Ground Water Levels:**
- Northing: 8563962
- Easting: 717757
- Shallow Well: 6.91 m TOC / Elev 57.32 m AHD; 11/24/2014
- Deep Well: 6.98 m TOC / Elev 57.25 m AHD; 11/24/2014

**STICKUP HEIGHT (m):**
- Shallow Well (S): 0.74
- Deep Well (D): 0.72

**Additional Information:**
- Ground Elevation: 64.23 m
- Casing Top Elev: (m)
- Casing Type: Steel
- Well Diagram

**客户的** DME
**项目编号** 183005
**项目完成时间** 10/9/14
**钻孔图** Air Rotary (Tubex)
**备注**
- Tubex to 30 mbgs.
- Interval with less clay and relic clasts from 12-14m & 18-19m.
[Extremely weathered COOMALIE DOLOSTONE], sand & gravel size chips of hematized and silicified magnesite in a limonitic silty elastic clay matrix, wet, subrounded to subangular, vuggy, yellowish brown (10YR 5/8), extremely weathered.

* Less clay between 19-20m & 23-24m.

[Weathered COOMALIE DOLOSTONE], gravel, with sand size chips of hematized and silicified magnesite, hematite and quartz, wet, rounded to angular, very vuggy (scoria-like), from dark grayish brown (10YR 3/2) to red (2.5YR 4/6).

- hematite (vuggy or dense pelloids).
- quartz or silicified dolomite? -- grey and weathered.

*The pebbles show: high porosity & thin hard white veins (quartz).
- vuggy and recrystalized small dolostone flakes in a weak limonite cement matrix (brecciated).
- highly weathered in some intervals (voids and alteration of the silification).

Bottom of hole at 31.00 m.
(Continued Next Page)
[Weathered COOMALIE DOLOSTONE], sand & gravel size chips with silt, calcite, wet, subangular, well sorted, white (7.5YR 8.5/1), weathered, highly reactive to HCl.

Bottom of hole at 23.00 m.
Shallow bore next to MB14-03.

**LOGGED BY** Genevieve Parent

**DATE STARTED**

**COMPLETED** 10/14/14

**DRILLING CONTRACTOR** Geo Drilling

**DRILLING METHOD** Air Rotary (open hole)

**GROUND WATER LEVELS:**

**SHALLOW WELL (S)** 5.99 mTOC / Elev 57.37 mAHD

**DEEP WELL (D)**

**STICKUP HEIGHT (m):**

**(S):** 0.75

**(D):**

**NOTES**
## Ground Water Levels:

- **Shallow Well (S)**
  - **Depth:** 7.93 m
  - **Elevation:** 60.47 m AHD
  - **Date:** 11/24/2014

- **Deep Well (D)**
  - **Depth:** 10.83 m
  - **Elevation:** 57.57 m AHD
  - **Date:** 11/24/2014

## Notes

- **Tubex to 27.7 m bgs.**

## Material Description

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<th>U.S.C.S.</th>
<th>Graphic Log</th>
<th>Material Description</th>
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<td>2.00</td>
<td>SM</td>
<td></td>
<td>(SM) [Fill], silty SAND, trace gravel (G: 10% S: 50% F: 40%), dry, rounded, poorly sorted (fine), reddish brown to red (2.5 YR 4/4 to 4/8).</td>
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<td>4.00</td>
<td>GM</td>
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<td>(GM) [Laterite], silty GRAVEL &amp; SAND (G: 40% S: 34% F: 25%), dry, sounded to subangular, well sorted, chert and iron rich mineral, magnetic pelloids, red (2.5Y 4/6)</td>
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<tr>
<td>6.00</td>
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<td></td>
<td>(ML) [Saprolite], clayey SILT with sand &amp; gravel, moist, rounded, 6-8m &amp; 9-11m [light greenish grey and light red (gley1 8/SG_1 &amp; 2.5YR 6/6)] and yellow oxidation minerals. 8-9m [light greenish grey &amp; weak red (gley1 7/10GY &amp; 5R 4/3)], amorphous and waxy. *aside from 8-9m the rest is mainly greenish grey &amp; light red relic clasts (plastic clayey silt) in a clayey matrix. *extremely weathered with high oxidation &amp; staining.</td>
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<tr>
<td>11.00</td>
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<td>[Highly weathered GEOLSEC FORMATION], coarse sand to small gravel size chips in a silty matrix, moist, rounded to subangular, brown (7.5YR 4/4). *Sand &amp; gravel chips are quartz &amp; iron rich/oxidized minerals &amp; charcoal slate, pink minerals (K feldspar, hematite, hematized and silicified magnesite), highly weathered.</td>
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</tbody>
</table>

### Graphical Log

- **Elevation (m AHD):**
  - 66.40
  - 62.40
  - 57.40

- **Yield (L/s):**
  - EC (uS/cm): 200, 400, 600, 800
  - pH: 2, 4, 6, 8

### Well Diagram

- Steel protective casing
- Cuttings
- Bentonite Pellets
- Filter Pack
- Screen & geo sock (50mm PVC screen class 18 aperture 0.5mm)
- Bentonite Chips
- PVC Blank (50mm PVC class 18)
[Very highly weathered TRANSITION ZONE], coarse sand size chips, trace gravel, with relic clasts in a clayey silt matrix, wet, rounded to subrounded, light greenish grey (gley1 8/10Y), trace of white, black, red mineral & light green grey clayey silt clasts, friable, waxy, trace yellow alteration & staining. Very highly weathered.
(Could be a transition zone between Geolsec Formation & Coomalie Dolostone, it has elements from HQB + green and purple rock chips (chlorite, serpentine, dravite?)

[Weathered COOMALIE DOLOSTONE], gravel & sand size chips (mainly green & red, trace white & black) in a clayey silt matrix, weak red or light greenish grey. (2.5YR 4/2 or gley1 7/5G-1), wet, subrounded to angular, well sorted.
*Less silt & clay alteration (&relic clasts) from 22m.
*Mainly greenish chips & matrix from 22-25m, trace red chips which fizz slightly to HCl when scratched (could be dravite tourmaline or chlorite or serpentine?).
*From 25-27m mainly reddish dolostone chips with small quartz & black veins (trace greenish & yellow waxy chips). Possibly highly fractured from 26-27m & less weathered.

Bottom of hole at 27.60 m.
<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>U.S.C.S.</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
<th>Elevation (m AHD)</th>
<th>Yield (L/s)</th>
<th>EC (uS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>ML</td>
<td>1.00</td>
<td>(ML) [Fill], SILT, trace sand (G: 0% S: 10% F: 90%), dry, rounded, low plasticity, poorly sorted, reddish yellow (7.5YR 7/8).</td>
<td>71.71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>GP</td>
<td>2.00</td>
<td>(GP) [Laterite], silty GRAVEL with sand (G: 50% S: 20% F: 30%), dry, rounded to subangular, poorly sorted, iron rich material, oxidation pelloids (some magnetic), yellowish red (5YR 4/6).</td>
<td>70.71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.00</td>
<td></td>
<td></td>
<td>[Extremely weathered SILTSTONE], silt (rock flour), trace clay &amp; trace fine sand, dry to moist, low plasticity, highly cohesive when compacted, varying between light grey &amp; pale brown (2.5Y 7/1 to 7/4).</td>
<td>61.71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.00</td>
<td></td>
<td></td>
<td>[Extremely weathered SHALE], similar to above but dark bluish-grey (gley 2 4/1), trace white and red sand chips.</td>
<td>56.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Possibly White's Formation.
**Weathered COOMALIE DOLOSTONE**, sand & gravel size chips with silt & trace relic clasts of mainly calcite, wet at 17m, subrounded to subangular, platy, weathered, white (5Y 8/1), discoloration, trace alteration (yellow) & oxidation (red) minerals.

*The bigger chips show either bulk white calcite crystal (with cleavage), or light bluish grey calcite (limestone-like) or light greenish white calcite breccia (calcite flakes in a weak calcite cement).

**Slightly weathered COOMALIE DOLOSTONE**, gravel (21-23m) to sand & gravel (23-24) size chips of platy subangular limestone (high in calcite), slightly weathered, light bluish grey (gley2 8/SPB), trace rounded and highly weathered red chips, some chips show lamination, friable & discoloured.

Bottom of hole at 24.00 m.
### Material Description

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>U.S.C.S.</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>ML</td>
<td>(ML) [Fill cover/tailings], sandy SILT, trace gravel, trace clay (G: 10% S: 30% F: 60%), moist to dry, poorly sorted, rounded, ~10cm of dark reddish grey tailings (2.5YR 4/1) &amp; the rest (above &amp; below) is fill cover dark red (2.5 YR 3/6).</td>
</tr>
<tr>
<td>2.00</td>
<td>ML</td>
<td>(ML) [Saprolite], clayey SILT, trace sand, trace gravel, moist, moderately plastic, mainly relic clasts (bluish white) in a silty matrix, trace red &amp; yellow wet from 6.5m, organics &amp; root channels, dark yellowish brown (10YR 4/6).</td>
</tr>
<tr>
<td>7.00</td>
<td>GM</td>
<td>(GM) [Laterite], silty GRAVEL &amp; SAND pelloids, trace clay (G: 35% S: 35% F: 30%), moist, rounded, poorly sorted (small gravel &amp; coarse sand in a silty matrix), iron rich minerals, oxidation, rootlets.</td>
</tr>
<tr>
<td>8.00</td>
<td>GM</td>
<td>[Slightly weathered COOMALIE DOLOSTONE], sand &amp; gravel size chips of dolostone, trace relic clasts (yellow &amp; bluish), trace silt, slightly weathered, yellowish staining, discoloration, cavity. 7-10m: pale red (7.5R 7/2, 7-10mbgs).</td>
</tr>
<tr>
<td>12.00</td>
<td>ML</td>
<td>10-12m: reddish brown (5YR 5/4).</td>
</tr>
</tbody>
</table>

**Ground Water Levels:**
- **Northing:** 8563917
- **Easting:** 717332
- **Ground Elevation:** 62.46 m
- **Casing Top Elev:**
  - **Quick set cement**
  - **Steel protective casing to 4m bgs**
  - **Open Hole, PVC blank (50mm PVC class 18)**
  - **Bentonite Chips**
  - **Screen (50mm PVC screen class 18 aperture 0.5mm)**
  - **Slough**

**Notes:** Cavity encountered. No filter pack.
(Continued Next Page)
[Slightly weathered COOMALIE DOLOSTONE], gravel size chips with sand & silt (size particles) of dolostone, wet, platy, subangular, trace yellow alteration, trace red oxidized, mineral, pale red (10R 6/2), slightly weathered, discoloration.

Possibly fractured slightly but no water strike & dry.

(continued)

Weathered/fractured COOMALIE DOLOSTONE], sand & gravel size chips of dolostone & oxidation & alteration minerals, quartz, trace black minerals (tremolite?), subrounded to subangular, some platy chips. The pebbles are oxidized and/or eroded.

Fractured from 20.0-21.5 & no yield flushed the hole a few lines to install & then water strike occurred.

Fracture was initially mud & no yield, flushed the hole a few times to install & then water strike occurred.

Rock hard again at 24m EOH

Bottom of hole at 24.00 m.
Tubex to 16 mgs, shallow bore is MB14-10.

*Could be low energy fluvial sediments or fill, next to a stream.

(GM) [Laterite], silty GRAVEL with sand, (G: 45% S: 25% F: 30%) dry, rounded, well sorted, gravel becoming more silty clasts (relic clasts) at 2-3m, iron rich oxidized minerals, pelloids, trace rootlets & organics, trace yellow alteration, reddish brown (2.5YR 4/4).

(ML) [Saprolite], SILT, trace sand, trace dolomite, gravel, trace clay (mainly relic clasts), dry to moist (~5m), subrounded to subangular, from very pale brown to light grey (10YR 7/4 to 7/2).

[Highly weathered COOMALIE DOLOSTONE], gravel & sand size chips of dolostone in a silty matrix, moist, subrounded to subangular, highly weathered & altered & discolored trace relic clasts (yellow or pinkish), brown stained chips (10YR 5/3).

[Weathered COOMALIE DOLOSTONE], gravel & sand size chips of dolostone (slight HCl reaction) in a dark greyish brown silty matrix, wet, subrounded to angular, weathered & discoloured & stained, no more relic clasts, trace yellow alteration, reddish grey (2.5YR 5/1).

*Possible fracture from 8-9m.

[Slightly weathered COOMALIE DOLOSTONE], sand with gravel size chips of dolostone, wet, subangular to angular, some chips are platy, slightly weathered & fractured, discoloration, yellow alteration, stained slightly (brown & grey), trace vuggy black scoria-like 11-12m, light reddish grey (2.5YR 7/1) to pinkish grey (7.5YR 7/2).
1.00  (ML) [Alluvium/fluvial (or fill?)], sandy SILT, trace gravel, dry, poorly sorted, rounded, non-plastic, cohesive when compressed b/w fingers, yellow (10YR 7/8).

GM  (GM) [Laterite], silty GRAVEL with sand, dry, rounded, well sorted, gravel chips becoming less fresh & more silty relic clasts at 2-3m, iron rich oxidized mineral, pelloids, trace yellow alteration reddish brown (2.5YR 4/4).

3.00  (ML) [Saprolite], SILT, trace sand, trace dolomite gravel, trace clay (mainly relic clasts), dry to moist (~5m), subrounded to subangular, from very pale brown to light grey (10YR 7/4 to 7/2).

5.20  Bottom of hole at 5.20 m.
**Very highly weathered COOMALIE DOLOSTONE (or saprolite),** coarse sand & small gravel size chips of waxy relic clasts (low strength), purple, blue or white, scratchable, no reaction to HCl, in a plastic clayey silt matrix, rounded to subrounded, from pale red to reddish grey (7.5R 6/3 to 6/1), dry to moist. 

*Mainly clayey silt from 10-13.5m.
*Purple & blue relic clasts from 9-10m.

**[Extremely weathered COOMALIE DOLOSTONE],** gravel size chips of relic clasts, red (10R 4/6), rounded, coated by & in a reddish grey clayey silt matrix (5YR 4/2), trace quartzite, chert, silicified dolostone or marble (whitish) dry to moist, extremely weathered.

**[Highly weathered COOMALIE DOLOSTONE],** silty clay matrix (elastic) with trace sand & gravel size chips of quartz (weathered or relic), moist to wet, subrounded to subangular, frothy texture, stained & oxidized, mainly silicified rock, highly to very highly weathered dark reddish grey (5YR 4/2) to weak red (5YR 4/3). 

*Mainly matrix from 17m - Matrix is possibly hematite alteration.

*Could be highly weathered Geolsec Formation.
[Weathered COOMALIE DOLOSTONE], coarse sand size chips with gravel size shiny blue, grey & matte white minerals, (light bluish grey (gley2 7/10B)) in a clayey silt matrix (yellowish brown (10YR 5/4)), trace yellow alteration mineral & matte red chips, weathered, wet, subrounded to angular, no reaction to HCl, can be scratched slightly, some silicification, some platy trace lamination (schist-like or tremolite-like), low grade metamorphism. *Possibly dravite tourmaline with quartz veinlets (or crystalized/partly silicified chlorite or massive tremolite).

(continued)

[Karstic cavity/mud/clay pocket], no chip return, lots of water, dark brown mud (7.5YR 3/3)

[Weathered COOMALIE DOLOSTONE], gravel & sand size chips of light blue/grey & beige stained frothy texture (pumice-like), trace yellow alteration & red clay, weathered, wet, subrounded to subangular, reddish yellow (5YR 6/6), No reaction to HCl (chert-like), low grade metamorphism.

*Possibly dravite tourmaline with quartz veinlets (or chlorite or massive tremolite).

[Slightly weathered COOMALIE DOLOSTONE], sand & gravel size chips of blue & white (quartz) mineral, shiny, platy, slightly weathered, no HCl reaction, discoloured, trace matte red minerals (hematization), stained, light bluish grey (gley2 7/10B).

*Bluish shiny mineral could be dravite (tourmaline), this would indicate a low grade metamorphism contact zone or fault zone.

Bottom of hole at 29.00 m.
<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>U.S.C.S.</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
<th>Elevation (m AHD)</th>
<th>Yield (L/s)</th>
<th>EC (uS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>SM</td>
<td></td>
<td>(SM) [Fill (lateritic)], silty SAND, (G: 5% S: 60% F: 40%), dry, rounded, well sorted, iron-rich mineral (red &amp; black), oxidized trace olive green &amp; yellow minerals. Dark red (2.5YR 3/6).</td>
<td>66.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SM</td>
<td></td>
<td>(SM) [Laterite], silty SAND with gravel (G: 30% S: 40% F: 30%), dry, round to subrounded, well sorted (silt to small gravel), pellets of iron-rich &amp; oxidized minerals, trace beige chert gravel, dark red (2.5YR 3/6).</td>
<td>61.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-9</td>
<td></td>
<td></td>
<td>[Very highly weathered COOMALIE DOLOSTONE], gravel &amp; sand size chips of waxy to powdery relic clasts in a silty matrix, dry to moist, rounded to subrounded, well sorted, very highly weathered, replacement minerals, yellow &amp; brown alteration, many colours 6-7m: white (7.5R 8/1). *No particular arrangement of minerals in clasts (disorganised).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>7-9m: light greenish grey (gley1 8/5GY) &amp; pale red (10R 7/3) &amp; white (10R 8/1).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-13</td>
<td></td>
<td></td>
<td>9-10m: reddish grey (10R 5/1).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>10-13m: similar to 7-9m.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10-13m: similar to 7-9m. *(continued)*

13-14m: pale yellow (2.5Y 8/2).

14-16m: similar to 7-9m.

16-19m: weak red (10R 4/4) & dark red (10R 3/6) - trace white and yellow powdered silt & trace quartzite clasts (this could be Coomalie Dolostone).

Bottom of hole at 19.00 m.
1.00

(GM) [Fill (lateritic)], silty GRAVEL, with sand (G: 50% S: 25%, 25%), dry, rounded, well sorted, black & red oxidized minerals in a yellowing silty matrix (limonite-like), yellowish brown (10YR 5/6).

2.00

(GM) [Lateritic], GRAVEL & SAND with silt (G: 40% S: 40% F: 20%), dry, rounded, well sorted iron-rich minerals, pelloids, dark yellowish brown (10YR 4/6) to dark greyish brown (10YR 4/2).

*Relic clasts from 2.5-3m (medium strength).

3.00

(ML) [Saprolite], clayed SILT, with sand, trace gravel size white or yellow relic clasts (low strength), pale brown (2.5Y 8/2), cohesive when compressed b/w fingers, medium plasticity.

4.00

[Extremely weathered COOMALIE DOLOSTONE], clayed silt matrix with gravel size relic clasts (red, white or yellow) rounded, in a very dark greyish brown matrix (10YR 3/2), low plasticity, cohesive, moist to wet at 9m, extremely weathered.
[Weathered COOMALIE DOLOSTONE], sand & gravel size chips, with silt (greyish brown) matrix, wet, subangular, schistosity (fine), trace vuggy chips, trace red relic clast (friable), metallic/sparkly.
*Graphitic & pyritic schist, trace hematite.
Dark bluish grey (gley2 4/1), highly weathered to weathered, friable, alteration mineral & trace oxidation & hematization - no reaction to HCl.
* Mainly foliated.

[Weathered COOMALIE DOLOSTONE], gravel & sand size chips, trace silt, wet, subangular, some schistosity but not all the chips, trace black vuggy chips, slight reaction to HCl when scratched, metallic grey (graphite) & red (magnesite/dolomite), weathered, reddish grey (5R 5/1).

[Slightly weathered COOMALIE DOLOSTONE], gravel & sand size chips with silt of dolostone with trace graphite schist, sparkly, subangular to angular, wet, no schistosity, trace oxidation, trace alteration, trace vuggy chips, trace foliation, fine quartz veins, no staining, almost fresh rock (hard rock) but slightly weathered, weak red (5R 5/2).

Bottom of hole at 19.00 m.
1.00
(ML) [Fill (lateritic)], gravelly SILT with sand (G: 35% S: 20% F: 45%), dry, rounded to subangular, non plastic, iron-rich minerals and chert, dark red (2.5YR 3/6).

2.00
(GM) [Laterite], silty GRAVEL with sand (G: 45% S: 20% F: 35%), dry, rounded to subangular, poorly sorted, iron-rich minerals, chert, trace oxidized pelloids, trace rootlets, yellowish red (5YR 5/6).

[Saprolite], SILT with trace gravel & sand (decreasing gravel & sand from 5 to 7m - poorly consolidated siltstone-like), dry, subrounded to subangular, trace altered chert-like gravel and sand, reddish yellow (7.5YR 6/6).

[Very highly weathered WHITE’S FORMATION], gravel size, small white talc-like relic clasts in a clayey silt matrix (red matrix (2.5YR 5/6) from 7-8m, then white (same as clast colour) (5Y 8/1) from 8-12m), moist, subrounded, trace fine foliation in some clasts (especially 7-8m), very highly weathered, friable, low plasticity, low strength clasts. *No reaction to HCl (no fresh clasts).
*Possibly White's Formation (altered to talc, white silicate or kaolinite) but could also be carbonates (Coomalie Dolostone).

[Highly weathered WHITE’S FORMATION], gravel size clasts (mainly relic clasts, trace intact ones) in a clayey silt matrix, moist, subrounded, apparent foliation (schistosity) on most relic & fresh clasts, trace metamorphism (small scale folding & shearing), trace oxidation, yellow alteration, staining, highly weathered.
*Tremolite & graphite schist, trace quartz veinlets, light bluish grey (gley2 7/5PB)
- 16-17m: mainly silt
- 17-18m: clasts (relict) looking more like 8-11m (white, less foliation)

DEPTH  | U.S.C.S. | MATERIAL DESCRIPTION | Elevation (m AHD) | Yield (L/s) | EC (uS/cm) | pH | WELL DIAGRAM
--- | --- | --- | --- | --- | --- | --- | ---
1.00 | ML  | (ML) [Fill (lateritic)], gravelly SILT with sand (G: 35% S: 20% F: 45%), dry, rounded to subangular, non plastic, iron-rich minerals and chert, dark red (2.5YR 3/6). | 76.43 | | | | -Steel protective casing
2.00 | GM  | (GM) [Laterite], silty GRAVEL with sand (G: 45% S: 20% F: 35%), dry, rounded to subangular, poorly sorted, iron-rich minerals, chert, trace oxidized pelloids, trace rootlets, yellowish red (5YR 5/6). | 75.43 | | | | -Bentonite Pellets
| | | | | | | *Filter Pack
| | | | | | | -PVC blank (50mm PVC class 18)
| 7.00 | | | | | | -Screen & geo sock (50mm PVC screen class 18 aperture 0.5mm)
| 12.00 | | | | | | -Bentonite Pellets
| 18.00 | | | | | | -Bentonite Chips
| | | | | | | -Cuttings

(Continued Next Page)
<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>U.S.C.S. GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
<th>Elevation (m AHD)</th>
<th>Yield (L/s)</th>
<th>EC (uS/cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
<td>[Very highly weathered WHITE'S FORMATION], silt (poorly consolidated schist), trace coarse sand to small gravel or friable schist (graphite, biotite &amp; possibly tremolite), moist, trace oxidation &amp; alteration minerals, very highly weathered, dark bluish grey (gley2 4/10B), subangular</td>
<td>54.43</td>
<td>0.1</td>
<td>400</td>
<td>2.5</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>[Weathered WHITE'S FORMATION], gravel size chips of relic &amp; fresh clasts in a silty matrix, harder to drill but still friable, fractured, weathered tremolite, sericite/muscovite, graphite schist, trace quartz (veins), alteration &amp; oxidation minerals, wet, greenish grey matrix &amp; clasts (gley 2 6/5BG) with light greenish grey relic clasts (possibly sericite alteration) (gley 1 8/10Y). *Trace calcite in some clasts.</td>
<td>51.43</td>
<td>0.2</td>
<td>600</td>
<td>2.4</td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>[Slightly weathered WHITE'S FORMATION], silty matrix with gravel size chips (relic &amp; fresh clasts) of graphite &amp; sericite/muscovite schist, trace chlorite &amp; oxidation, trace quartz, hard to drill but friable, wet, subangular, very dark bluish grey (gley2 3/10B), slightly weathered.</td>
<td>46.43</td>
<td>0.3</td>
<td>800</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Bottom of hole at 31.00 m.
### MATERIAL DESCRIPTION

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>GRAPHIC LOG</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td>ML</td>
<td>(ML) [Fill/disturbed], sandy SILT with gravel (G: 20% S: 30% F: 50%), dry, subrounded to subangular, well sorted, low plasticity, low cohesion, mainly chert, trace hard black (slate?) &amp; red (hematite?), light reddish brown (2.5YR 6/4).</td>
</tr>
</tbody>
</table>
| 7.00      | SM          | (SM) [Laterite/overburden], silty SAND & GRAVEL (G: 35% S: 40% F: 25%), dry, rounded to subangular, chert (or silicified rock), trace hematite (oxidized), trace slate, trace iron rich pelloids (magnetic).
*Possible weathered boulders. 2-4m: light red (2.5YR 6/6) |
| 10.00     |            | [Weathered GEOLSEC FORMATION], silty gravel with sand size chips, clay, dry, subrounded to subangular, silicified rocks or quartz & hematite, highly weathered, trace magnetic minerals, stained, discoloured, frothy texture, becoming more relic clast from 9-10m, highly weathered, weak red (7.5R 5/3 to 4/3).  
*Hematite and quartz breccia.  
*Hard to drill through (crumbly & loose). |
| 13.50     |            | [Highly weathered GEOLSEC FORMATION], clayey silt with gravel & sand size chips, plastic, cohesive, moist to wet (from 12m), subrounded, very highly weathered or fractured or altered to clay minerals, chips are quartz (or silicified hematite) in a hematite clayey silt matrix, weak red (5R 4/4). |
| 15        |             | [Fresh GEOLSEC FORMATION], gravel and sand size chips (quartz, silicified hematite, hematite, grey schist, trace greenish chips (37-42m) in a weak red hematite silt matrix (cement), subrounded to angular, wet, mostly fresh, very little fractures & hard to drill - could be slightly weathered), trace chips show schistosity, some are platy, some are frothy.  
*Low yielding & small fractures only, different tones of weak red (7.5R 4/2 to 4/4) |

**WELL DIAGRAM**

- Steel protective casing
- Cuttings
- PVC blank (50mm PVC class 18)
- Bentonite Chips
- Bentonite Pellets
- Screen (50mm PVC screen class 18 aperture 0.5mm)
- Bentonite Chips
- Bentonite Pellets
- Bentonite Pellets
- Bentonite Pellets
- Bentonite Pellets

**GROUND WATER LEVELS:**

- **SHALLOW WELL (S):** 9.68 mTOC / Elev 74.32 mAHD ; 11/24/2014
- **DEEP WELL (D):** 10.75 mTOC / Elev 73.25 mAHD ; 11/24/2014

**STICKUP HEIGHT (m):**

- (S): 0.77
- (D): 0.74
42.00

[Fresh GEOLSEC FORMATION], gravel and sand size chips (quartz, silicified hematite, hematite, grey schist, trace greenish chips (37-42m) in a weak red hematite silt matrix (cement), subrounded to angular, wet, mostly fresh, very little fractures & hard to drill - could be slightly weathered), trace chips show schistosity, some are platy, some are frothy.

*Low yielding & small fractures only, different tones of weak red (7.5R 4/2 to 4/4) (continued)

Bottom of hole at 42.00 m.
(ML) Laterite/overburden, sandy SILT, gravel, trace clay, dry, rounded to subrounded, poorly sorted, soft to drill (compared to MB14-15). The gravel is quartz or silicified rock & iron-rich pelloids, reddish yellow (5YR 6/6), (G: 15% S: 35% F: 50%).

(ML) 5-7m: similar but less rounded (subangular), very little pelloids (~1%), yellow (2.5Y 8/6).

*Note: Gets harder to drill & crumbly (boulder or highly weathered bedrock from 7m (as MB14-15). Stop drilling to ensure well is in the overburden only.

Bottom of hole at 7.00 m.
### Shallow Well (S)

**Depth (m):** 2

**Material Description:**

- **SM** (Fill/overburden), silty SAND to sandy SILT with gravel, subrounded to angular, dry, well sorted (except 2-3m (silt) & 5-6m (silty gravel with sand)), chert, schist, slate, quartz.
  - 0-1m: red (2.5YR 4/8)
  - 1-2m: bluish grey (gley2 5/5B)

**Elevation (m AHD):** 75.48

### Deep Well (D)

**Depth (m):** 16.03

**Material Description:**

- **ML** (Laterite), silty SAND to sandy SILT with gravel, subrounded to angular, dry, well sorted (except 2-3m (silt) & 5-6m (silty gravel with sand)), chert, schist, slate, quartz, reddish yellow (5YR 6/6).

**Elevation (m AHD):** 70.48

### Notes

- Easy to drill, crumbly
- Harder to drill than 7-10m
- Less quartz between 13-14m

---

### Graphical Log

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>U.S.C.S. Log</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>SM</td>
<td>(SM) [Fill/overburden], silty SAND to sandy SILT with gravel, subrounded to angular, dry, well sorted (except 2-3m (silt) &amp; 5-6m (silty gravel with sand)), chert, schist, slate, quartz. 0-1m: red (2.5YR 4/8) 1-2m: bluish grey (gley2 5/5B)</td>
</tr>
<tr>
<td>4</td>
<td>ML</td>
<td>(ML) [Laterite], silty SAND to sandy SILT with gravel, subrounded to angular, dry, well sorted (except 2-3m (silt) &amp; 5-6m (silty gravel with sand)), chert, schist, slate, quartz, reddish yellow (5YR 6/6).</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>[Highly weathered GEOLSEC FORMATION], sandy silty trace with gravel size chips, dry, rounded to subangular, poorly consolidated quartz &amp; silicified chips in a hematite silt clay, highly weathered, discoloured, altered, stained, frothy, light red (2.5YR 6/6). Easy to drill, crumbly</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>[Weathered GEOLSEC FORMATION], sand &amp; gravel size chips of mainly quartz &amp; hematite &amp; trace black minerals (slate?) in a silty, friable but consolidated hematite matrix, weathered, stained, discoloured, frothy, subrounded to subangular, weak red (10R 5/3). Harder to drill than 7-10m less quartz between 13-14m</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
[Slightly weathered GEOLSEC FORMATION], gravel with sand chips of quartz & hematite (cemented or silicified) & trace black mineral (slate?) in a clayey silt hematite matrix, moist to wet around small & low yielding fractures (20-21m, 23m, 27m, 29m), rounded to angular chips (more rounded in the fractured intervals), trace staining & alteration minerals (yellow or brown), trace oxidation around fractured intervals & some chips are frothy.

"Hard to drill, drilling rate not constant & seems more weathered than fresher zone encountered at MB14-15, weak red (5R 5/3 (more quartz) and 4/3 (less quartz)).

Bottom of hole at 29.00 m.
ML  

(ML) Saprolitic overburden, clayed SILT relic clasts, trace sand, (G: 5% S: 15% F: 80%), trace pelloids of iron rich minerals (magnetic), moist, low plasticity, cohesive, sparkly, very pale brown (10YR 7/4), rootlets.

ML  

(ML) Saprolite, clayed SILT (no relic clasts), trace sand, (G: 1% S: 15% F: 84%), sparkly silt grains (pyrite or tremolite-like), low plasticity, cohesive when compressed between fingers, moist, rootlets, light yellowish brown (10YR 6/4).

[Very highly weathered COOMALIE DOLOSTONE], trace gravel & sand size chips of carbonate & trace pelloids, quartz, green & black silicate minerals in a pale brown matrix of clayed silt, very highly weathered, altered to relic clasts, oxidized, frothy, wet, subrounded to subangular.  
*Could be a cavity from 9-10m, took a lot of bentonite to backfill.  
*More chips in matrix 7-8m.
[Weathered COOMALIE DOLOSTONE], sand size chips, trace gravel in a poorly cemented silt matrix, carbonate rock (calcite cement with calcite, limestone, sericite/muscovite & tremolite schists, dolomite or magnetite and pyrite silt, quartz veins), sparkly, weathered, trace alteration minerals (yellow & brown & white). No clear fractures but constant flow of water ~1-1.2 L/s from 11m, pale yellow/white (2.5Y 8/2).

*Sloughy and not hard to drill but requires the hammer.

*Possible cavity from 10-11m as it takes a lot of filter pack to backfill this 1m (same for 9-10m with bentonite).
### Shallow Well (S)

- **Depth**: 2 m
- **Material Description**: (ML) [Saprolitic overburden], clayed SILT relic clasts, trace sand, (G: 5% S: 15% F: 80%), trace pelloids of iron rich minerals (magnetic), moist, low plasticity, cohesive, sparkly, very pale brown (10YR 7/4), rootlets.

- **Depth**: 3.00 m
- **Material Description**: (ML) [Saprolite], clayed SILT (no relic clasts), trace sand, (G: 1% S: 15% F: 84%), sparkly silt grains (pyrite or tremolite-like), low plasticity, cohesive when compressed between fingers, moist, rootlets, light yellowish brown (10YR 6/4).

- **Depth**: 6.20 m
- **Material Description**: Bottom of hole at 6.20 m.

### Deep Well (D)

- **Shallow bore next to MB14-18.**
GW (GW) [Fill (lateritic)], SAND & GRAVEL with silt (G: 40% S: 40% F: 20%), dry, rounded to subangular, trace pelloids, well graded from silt to small gravel, mainly chert & iron-rich minerals, yellowish red (5YR 4/6).

GM (GM) [Laterite], silty GRAVEL & SAND of chert, iron-rich minerals (pelloids), quartz & trace relic clasts, dry, rounded to subangular, well graded from silt to pebble size, from dark red to dark reddish brown (2.5YR 3/3 to 5YR 3/4).

SM (SM) [Saprolite], SAND & GRAVEL relic clasts in a silty matrix, trace quartz interval from 9-10m, dry, frothy, powdery & friable, alteration minerals, various colours. 6-7m: dark reddish brown (2.5YR 3/3).

7-11m: very pale brown, (10YR 8/3).

11-13m: white (7.5R 8/1).
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Material Description</th>
<th>Yield (L/s)</th>
<th>EC (uS/cm)</th>
<th>pH</th>
<th>WELL DIAGRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.00</td>
<td>[Very highly weathered COOMALIE DOLOSTONE], relic clasts of clayey silt, gravel size chips of hematized and silicified magnesite, moist, very highly weathered, alteration minerals, the clasts are rounded &amp; coated in a clayed silty matrix, reddish brown (2.5YR 4/4).</td>
<td>1.00</td>
<td>200</td>
<td>7.0</td>
<td>-</td>
</tr>
<tr>
<td>17.00</td>
<td>[Highly weathered COOMALIE DOLOSTONE], sand &amp; gravel size clasts (fresh &amp; relic) in a clayed silty matrix, wet, rounded to subangular, highly weathered (easy to drill), frothy, staining, some chips are vuggy &amp; altered, some fresh quartz, reddish brown (5YR 4/4). *Hematized magnesite.</td>
<td>2.00</td>
<td>400</td>
<td>7.0</td>
<td>-</td>
</tr>
<tr>
<td>20.00</td>
<td>[Slightly weathered COOMALIE DOLOSTONE], sand &amp; gravel chips (fresh) of quartz &amp; blue &amp; purple minerals (dravite?) or hematized and silicified magnesite, crystalline dolostone, wet, subangular to angular, platy, slightly weathered (hard to drill), trace alteration (yellow &amp; red), staining, discoloured, some frothy, white (white N8 to white 7.5YR8/1). *Same as MB14-11(A) below 19m, quartz &amp; blue &amp; purple low grade metamorphism.</td>
<td>3.00</td>
<td>600</td>
<td>7.0</td>
<td>-</td>
</tr>
</tbody>
</table>

Bottom of hole at 28.00 m.
Appendix C. Slug Test Analyses
### PROJECT INFORMATION

- **Company:** RGC  
- **Client:** DME  
- **Project:** 183005  
- **Location:** Rum Jungle  
- **Test Date:** 4 November 2014

### AQUIFER DATA

- **Saturated Thickness:** 2.26 m  
- **Anisotropy Ratio (Kz/Kr):** 1.

### WELL DATA (MB14-01s)

- **Initial Displacement:** -0.016 m  
- **Static Water Column Height:** 1.76 m  
- **Total Well Penetration Depth:** 4.5 m  
- **Screen Length:** 4.5 m  
- **Casing Radius:** 0.025 m  
- **Well Radius:** 0.075 m  
- **Gravel Pack Porosity:** 0.3

### SOLUTION

- **Aquifer Model:** Unconfined  
- **Solution Method:** Bouwer-Rice  
- **K:** 9.159E-7 m/sec  
- **y0:** -0.01318 m
SLUG OUT (RH)

Data Set: Z:\..\MB14-01d(RH)_a.aqt
Date: 03/26/15
Time: 13:22:25

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 3 November 2014

AQUIFER DATA

Saturated Thickness: 31. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-01d)

Initial Displacement: -0.8047 m
Total Well Penetration Depth: 22.8 m
Casing Radius: 0.025 m
Static Water Column Height: 27.08 m
Screen Length: 6. m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 6.737E-5 m/sec
y0 = -1.156 m
Project Information

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 3 November 2014

Aquifer Data

Saturated Thickness: 5.4 m
Anisotropy Ratio (Kz/Kr): 1.

Well Data (MB14-02s)

Initial Displacement: -0.4946 m
Total Well Penetration Depth: 6. m
Casing Radius: 0.025 m
Static Water Column Height: 1.4 m
Screen Length: 6. m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

Solution

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 3.57E-6 m/sec
y0 = -0.6094 m
SLUG IN (FH)

Data Set: Z:\...\MB14-02d(FH)_a.aqt
Date: 03/26/15
Time: 13:23:40

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 3 November 2014

AQUIFER DATA

Saturated Thickness: 28. m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MB14-02d)

Initial Displacement: 0.7094 m
Total Well Penetration Depth: 22.44 m
Casing Radius: 0.025 m
Static Water Column Height: 22.4 m
Screen Length: 6. m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Butler
K = 0.0003438 m/sec
Le = 18.7 m
SLUG OUT (RH)

Data Set: Z:\...\MB14-02d(RH)_a.aqt
Date: 03/26/15
Time: 13:23:56

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 3 November 2014

AQUIFER DATA

Saturated Thickness: 28. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-02d)

Initial Displacement: -0.3517 m
Total Well Penetration Depth: 22.44 m
Casing Radius: 0.025 m
Static Water Column Height: 22.4 m
Screen Length: 6. m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
K = 0.001134 m/sec
Solution Method: Butler
Le = 18.39 m
**PROJECT INFORMATION**

Company: RGC  
Client: DME  
Project: 183005  
Location: Rum Jungle  
Test Date: 5 November 2014

**AQUIFER DATA**

Saturated Thickness: 30. m  
Anisotropy Ratio (Kz/Kr): 1.

**WELL DATA (MB14-03)**

Initial Displacement: 1.77 m  
Total Well Penetration Depth: 12.8 m  
Casing Radius: 0.025 m  
Static Water Column Height: 30. m  
Screen Length: 5. m  
Well Radius: 0.075 m  
Gravel Pack Porosity: 0.3

**SOLUTION**

Aquifer Model: Confined  
Solution Method: Bouwer-Rice  
\[ K = 2.117E-5 \text{ m/sec} \]  
\[ y_0 = 0.8752 \text{ m} \]
SLUG OUT (RH)

Data Set: Z:\...\MB14-03(RH)_a.aqt
Date: 03/26/15
Time: 13:24:59

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 5 November 2014

AQUIFER DATA

Saturated Thickness: 30. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-03)

Initial Displacement: -1.02 m
Total Well Penetration Depth: 12.8 m
Casing Radius: 0.025 m
Static Water Column Height: 17.14 m
Screen Length: 5. m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 1.379E-5 m/sec
y0 = -0.964 m
### Project Information

**Company:** RGC  
**Client:** DME  
**Project:** 183005  
**Location:** Rum Jungle  
**Test Date:** 5 November 2014

### Aquifer Data

- **Saturated Thickness:** 4.3 m  
- **Anisotropy Ratio (Kz/Kr):** 1.

### Well Data (MB14-04)

- **Initial Displacement:** -0.3712 m  
- **Total Well Penetration Depth:** 6.0 m  
- **Casing Radius:** 0.025 m  
- **Static Water Column Height:** 2.6 m  
- **Screen Length:** 6.0 m  
- **Well Radius:** 0.073 m  
- **Gravel Pack Porosity:** 0.3

### Solution

- **Aquifer Model:** Unconfined  
- **Solution Method:** Bouwer-Rice  
- **K:** $7.185 \times 10^{-7}$ m/sec  
- **y0:** -0.1645 m
WELL TEST ANALYSIS

Data Set: C:\...\MB14-05s_2015.aqt
Date: 03/30/15
Time: 15:01:50

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Run Jungle Mine Site
Test Date: Mar 25 2015

AQUIFER DATA

Saturated Thickness: 7.86 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-05S)

Initial Displacement: 3.07 m
Total Well Penetration Depth: 6. m
Casing Radius: 0.025 m
Static Water Column Height: 4.86 m
Screen Length: 6. m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 2.912E-7 m/sec
y0 = 1.148 m
### WELL TEST ANALYSIS

Data Set: C:\...\MB14-05s_6m.aqt  
Date: 03/30/15  
Time: 15:01:25

### PROJECT INFORMATION

Company: RGC  
Client: DME  
Project: 183005  
Location: Run Jungle Mine Site  
Test Date: Mar 25 2015

### AQUIFER DATA

- Saturated Thickness: 2.86 m  
- Anisotropy Ratio (Kz/Kr): 1.

### WELL DATA (MB14-05S)

- Initial Displacement: 3.07 m  
- Total Well Penetration Depth: 4. m  
- Casing Radius: 0.025 m  
- Static Water Column Height: 2.86 m  
- Screen Length: 4. m  
- Well Radius: 0.075 m  
- Gravel Pack Porosity: 0.3

### SOLUTION

- Aquifer Model: Unconfined  
- Solution Method: Bouwer-Rice  
- \( K = 5.714E-7 \) m/sec  
- \( y_0 = 1.142 \) m
**SLUG IN (FH)**

Data Set: Z:\…\MB14-05d(FH)_a.aqt  
Date: 03/26/15  
Time: 13:27:35

**PROJECT INFORMATION**

- Company: RGC  
- Client: DME  
- Project: 183005  
- Location: Rum Jungle  
- Test Date: 5 November 2014

**AQUIFER DATA**

- Saturated Thickness: 17.08 m  
- Anisotropy Ratio (Kz/Kr): 1

**WELL DATA (MB14-05d)**

- Initial Displacement: 0.7243 m  
- Total Well Penetration Depth: 17.08 m  
- Casing Radius: 0.025 m  
- Static Water Column Height: 17.08 m  
- Screen Length: 6 m  
- Well Radius: 0.075 m  
- Gravel Pack Porosity: 0.3

**SOLUTION**

- Aquifer Model: Confined  
- Solution Method: Bouwer-Rice  
- $K = 1.3E-5$ m/sec  
- $y_0 = 0.28$ m
**Data Set:** Z:\...\MB14-05d(RH)_a.aqt  
**Date:** 03/26/15  
**Time:** 13:27:50

---

**PROJECT INFORMATION**

- **Company:** RGC  
- **Client:** DME  
- **Project:** 183005  
- **Location:** Rum Jungle  
- **Test Date:** 5 November 2014

---

**AQUIFER DATA**

- **Saturated Thickness:** 20 m  
- **Anisotropy Ratio (Kz/Kr):** 1

---

**WELL DATA (MB14-05d)**

- **Initial Displacement:** -0.46 m  
- **Total Well Penetration Depth:** 7.6 m  
- **Casing Radius:** 0.025 m  
- **Static Water Column Height:** 17.08 m  
- **Screen Length:** 6 m  
- **Well Radius:** 0.075 m  
- **Gravel Pack Porosity:** 0.3

---

**SOLUTION**

- **Aquifer Model:** Confined  
- **Solution Method:** Bouwer-Rice  
- **K:** $8.978 \times 10^{-6}$ m/sec  
- **y0:** -0.2395 m
WELL TEST ANALYSIS

Data Set: C:\...\MB14-06s.aqt
Date: 03/30/15  Time: 15:03:17

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Run Jungle Mine Site
Test Date: Mar 24 2015

AQUIFER DATA

Saturated Thickness: 7.86 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-06S)

Initial Displacement: 2.05 m
Total Well Penetration Depth: 6. m
Casing Radius: 0.025 m
Static Water Column Height: 4.86 m
Screen Length: 6. m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 7.169E-6 m/sec
Solution Method: Bouwer-Rice
y0 = 1.876 m
SLUG IN (FH)

Data Set: Z:\..\MB14-06d(FH)_a.aqt
Date: 03/26/15
Time: 13:28:37

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 11 November 2014

AQUIFER DATA

Saturated Thickness: 29. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-06d)

Initial Displacement: 1.848 m
Total Well Penetration Depth: 15.48 m
Casing Radius: 0.025 m
Static Water Column Height: 15.48 m
Screen Length: 6. m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 2.444E-6 m/sec
y0 = 1.102 m
SLUG OUT (RH)

Data Set: Z:\..\MB14-06d(RH)_a.aqt
Date: 03/26/15
Time: 13:28:49

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 11 November 2014

AQUIFER DATA

Saturated Thickness: 29. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-06d)

Initial Displacement: -1.26 m
Total Well Penetration Depth: 13. m
Casing Radius: 0.025 m
Static Water Column Height: 15.48 m
Screen Length: 6. m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
K = 2.121E-6 m/sec
Solution Method: Bouwer-Rice
y0 = -1.089 m
WELL TEST ANALYSIS

Data Set: C:\\MB14-08s.aqt
Date: 03/30/15
Time: 15:04:13

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Run Jungle Mine Site
Test Date: Mar 24 2015

AQUIFER DATA

Saturated Thickness: 4. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-08S)

Initial Displacement: 2.42 m
Total Well Penetration Depth: 3. m
Casing Radius: 0.025 m
Static Water Column Height: 3. m
Screen Length: 3. m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 3.647E-5 m/sec
y0 = 2.436 m
Data Set: Z:\..\MB14-08d(FH)_a.aqt
Date: 03/26/15  Time: 13:29:19

PROJECT INFORMATION
Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 11 November 2014

AQUIFER DATA
Saturated Thickness: 34.36 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-08d)
Initial Displacement: 1.627 m
Total Well Penetration Depth: 17.86 m
Casing Radius: 0.025 m
Static Water Column Height: 17.86 m
Screen Length: 6.0 m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 8.201E-6 m/sec
y0 = 0.94 m
SLUG OUT (RH)
Data Set: Z:\...\MB14-08d(RH)_a.aqt
Date: 03/26/15
Time: 13:29:30

PROJECT INFORMATION
Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 11 November 2014

AQUIFER DATA
Saturated Thickness: 34.36 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-08d)
Initial Displacement: -1.225 m
Total Well Penetration Depth: 17.86 m
Casing Radius: 0.025 m
Static Water Column Height: 17.86 m
Screen Length: 6. m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 7.654E-7 m/sec
y0 = -1.305 m
PROJECT INFORMATION
Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 7 November 2014

AQUIFER DATA
Saturated Thickness: 35 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MB14-09)
Initial Displacement: 0.1083 m
Total Well Penetration Depth: 11.29 m
Casing Radius: 0.04 m
Static Water Column Height: 11.29 m
Screen Length: 6 m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Confined
Solution Method: Butler
K = 0.001954 m/sec
Le = 6.891 m

SLUG IN (FH)
Data Set: Z:\...\MB14-09(FH)_a.aqt
Date: 03/26/15
Time: 13:29:57
SLUG OUT (RH)

Data Set: Z:\...\MB14-09(RH)_a.aqt
Date: 03/26/15
Time: 13:30:15

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 7 November 2014

AQUIFER DATA

Saturated Thickness: 35 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MB14-09)

Initial Displacement: -0.0583 m
Total Well Penetration Depth: 11.29 m
Casing Radius: 0.04 m
Static Water Column Height: 11.29 m
Screen Length: 6 m
Well Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Butler

K = 0.003067 m/sec
Le = 5.832 m
**PROJECT INFORMATION**

Company: RGC  
Client: DME  
Project: 183005  
Location: Rum Jungle  
Test Date: 7 November 2014

**AQUIFER DATA**

Saturated Thickness: 0.47 m  
Anisotropy Ratio (Kz/Kr): _1_

**WELL DATA (MB14-10)**

Initial Displacement: -0.12 m  
Total Well Penetration Depth: 5.2 m  
Casing Radius: 0.04 m  
Static Water Column Height: 0.47 m  
Screen Length: 5.2 m  
Well Radius: 0.075 m  
Gravel Pack Porosity: 0.3

**SOLUTION**

Aquifer Model: Unconfined  
$K = 3.5E-6$ m/sec  
Solution Method: Bouwer-Rice  
$y_0 = -0.08$ m
WELL TEST ANALYSIS

Data Set: C:\..\MB14-13s.aqt
Date: 03/30/15
Time: 15:04:44

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Run Jungle Mine Site
Test Date: Mar 24 2015

AQUIFER DATA

Saturated Thickness: 6.5 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MB14-13S)

Initial Displacement: 2.22 m
Total Well Penetration Depth: 6 m
Casing Radius: 0.025 m

Static Water Column Height: 6.25 m
Screen Length: 6 m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 3.211E-5 m/sec
y0 = 2.748 m
SLUG IN (FH)

Data Set: Z:\...\MB14-13d(FH)_a.aqt
Date: 03/26/15
Time: 13:31:19

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 4 November 2014

AQUIFER DATA

Saturated Thickness: 30.88 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-13d)

Initial Displacement: 0.3567 m
Total Well Penetration Depth: 8.88 m
Casing Radius: 0.025 m
Static Water Column Height: 8.88 m
Screen Length: 5. m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 4.742E-5 m/sec
y0 = 0.1892 m
**PROJECT INFORMATION**

Company: RGC  
Client: DME  
Project: 183005  
Location: Rum Jungle  
Test Date: 5 November 2014

**AQUIFER DATA**

Saturated Thickness: 21.96 m  
Anisotropy Ratio (Kz/Kr): 1

**WELL DATA (MB14-14d)**

Initial Displacement: -0.5392 m  
Static Water Column Height: 20.46 m  
Total Well Penetration Depth: 20.46 m  
Screen Length: 6 m  
Casing Radius: 0.025 m  
Well Radius: 0.075 m

**SOLUTION**

Aquifer Model: Confined  
Solution Method: Bouwer-Rice  
K = 8.321E-7 m/sec  
y0 = -0.3796 m
<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Normalized Head (m/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.</td>
<td>1.</td>
</tr>
<tr>
<td>1000.</td>
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<td>4000.</td>
<td>0.0001</td>
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<tr>
<td>5000.</td>
<td>0.00001</td>
</tr>
</tbody>
</table>

### BAILER (RH)

- **Data Set:** Z:\..\MB14-15s(RH)_a.aqt
- **Date:** 03/26/15
- **Time:** 13:48:27

### PROJECT INFORMATION

- **Company:** RGC
- **Client:** DME
- **Project:** 183005
- **Location:** Rum Jungle
- **Test Date:** 7 November 2014

### AQUIFER DATA

- Saturated Thickness: 4.13 m
- Anisotropy Ratio (Kz/Kr): 1.

### WELL DATA (MB14-15s)

- Initial Displacement: -0.5394 m
- Total Well Penetration Depth: 4.13 m
- Casing Radius: 0.025 m
- Static Water Column Height: 4.13 m
- Screen Length: 2.5 m
- Well Radius: 0.075 m
- Gravel Pack Porosity: 0.3

### SOLUTION

- Aquifer Model: Confined
- Solution Method: Bouwer-Rice
- $K = 3.933 \times 10^{-7}$ m/sec
- $y_0 = -0.3633$ m
**BAILER (RH)**

Data Set: Z:\...\MB14-15d(RH)_a.aqt  
Date: 03/26/15  
Time: 13:32:30

**PROJECT INFORMATION**

Company: RGC  
Client: DME  
Project: 183005  
Location: Rum Jungle  
Test Date: 5 November 2014

**AQUIFER DATA**

Saturated Thickness: 34.66 m  
Anisotropy Ratio (Kz/Kr): 1

**WELL DATA (MB14-15d)**

Initial Displacement: -0.5669 m  
Total Well Penetration Depth: 31.66 m  
Casing Radius: 0.025 m  
Static Water Column Height: 31.66 m  
Screen Length: 21. m  
Well Radius: 0.073 m  
Gravel Pack Porosity: 0.3

**SOLUTION**

Aquifer Model: Confined  
Solution Method: Bouwer-Rice  
\( K = 2.263 \times 10^{-8} \) m/sec  
\( y0 = -0.368 \) m
WELL TEST ANALYSIS

Data Set: C:\..\MB14-16.aqt
Date: 03/30/15

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Run Jungle Mine Site
Test Date: Mar 24 2015

AQUIFER DATA

Saturated Thickness: 3.18 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-16)

Initial Displacement: 4.39 m
Total Well Penetration Depth: 5. m
Casing Radius: 0.025 m
Static Water Column Height: 3.18 m
Screen Length: 5. m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.779E-6 m/sec
y0 = 3.167 m
WELL TEST ANALYSIS
Data Set: C:\..\MB14-17s.aqt
Date: 03/30/15          Time: 15:05:25

PROJECT INFORMATION
Company: RGC
Client: DME
Project: 183005
Location: Run Jungle Mine Site
Test Date: Mar 25 2015

AQUIFER DATA
Saturated Thickness: 2.46 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-17S)
Initial Displacement: 2.24 m
Total Well Penetration Depth: 5. m
Casing Radius: 0.025 m
Static Water Column Height: 2.46 m
Screen Length: 5. m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
K = 3.793E-6 m/sec
Solution Method: Bouwer-Rice
y0 = 1.313 m
**PROJECT INFORMATION**

Company: RGC  
Client: DME  
Project: 183005  
Location: Rum Jungle  
Test Date: 7 November 2014

**AQUIFER DATA**

Saturated Thickness: 33.5 m  
Anisotropy Ratio (Kz/Kr): 1.

**WELL DATA (MB14-18)**

Initial Displacement: 1.74 m  
Total Well Penetration Depth: 12.78 m  
Casing Radius: 0.025 m  
Static Water Column Height: 12.78 m  
Screen Length: 6. m  
Well Radius: 0.073 m  
Gravel Pack Porosity: 0.3

**SOLUTION**

Aquifer Model: Confined  
Solution Method: Bouwer-Rice  
\[ K = 7.953 \times 10^{-5} \text{ m/sec} \]  
\[ y_0 = 2.37 \text{ m} \]
## SLUG OUT (RH)

- **Data Set:** Z:\...\MB14-18(RH)_a.aqt
- **Date:** 03/26/15
- **Time:** 13:33:48

## PROJECT INFORMATION

- **Company:** RGC
- **Client:** DME
- **Project:** 183005
- **Location:** Rum Jungle
- **Test Date:** 7 November 2014

## AQUIFER DATA

- **Saturated Thickness:** 33.5 m
- **Anisotropy Ratio (Kz/Kr):** 1

## WELL DATA (MB14-18)

- **Initial Displacement:** -1.018 m
- **Total Well Penetration Depth:** 12.78 m
- **Casing Radius:** 0.025 m
- **Static Water Column Height:** 12.78 m
- **Screen Length:** 6 m
- **Well Radius:** 0.073 m
- **Gravel Pack Porosity:** 0.3

## SOLUTION

- **Aquifer Model:** Confined
- **Solution Method:** Bouwer-Rice
- **$K =$ 2.805E-5 m/sec**
- **$y_0 = -0.7075$ m**
Data Set: Z:\...\MB14-19(RH)_a.aqt
Date: 03/26/15
Time: 13:34:10

PROJECT INFORMATION
Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 7 November 2014

AQUIFER DATA
Saturated Thickness: 2.22 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-19)
Initial Displacement: -0.4307 m
Total Well Penetration Depth: 4.2 m
Casing Radius: 0.025 m
Static Water Column Height: 1.92 m
Screen Length: 4.2 m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Confined
K = 8.523E-6 m/sec
Solution Method: Bouwer-Rice
y0 = -0.1905 m
WELL TEST ANALYSIS

Data Set: C:\..\MB14-20s.aqt
Date: 03/30/15  Time: 15:06:24

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Run Jungle Mine Site
Test Date: Mar 25 2015

AQUIFER DATA

Saturated Thickness: 10.4 m  Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MB14-20S)

Initial Displacement: 3.24 m  Static Water Column Height: 5.4 m
Total Well Penetration Depth: 6 m  Screen Length: 6 m
Casing Radius: 0.025 m  Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined  Solution Method: Bouwer-Rice
K = 1.063E-5 m/sec  y0 = 2.596 m
WELL TEST ANALYSIS

Data Set: C:\\..\\MB14-20s_6m.aqt
Date: 03/30/15
Time: 15:06:45

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Run Jungle Mine Site
Test Date: Mar 25 2015

AQUIFER DATA

Saturated Thickness: 3.4 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MB14-20S)

Initial Displacement: 3.24 m
Total Well Penetration Depth: 4.0 m
Casing Radius: 0.025 m
Static Water Column Height: 3.4 m
Screen Length: 4.0 m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.98E-5 m/sec
y0 = 2.679 m
**PROJECT INFORMATION**

Company: RGC  
Client: DME  
Project: 183005  
Location: Rum Jungle  
Test Date: 8 November 2014

**AQUIFER DATA**

Saturated Thickness: 31.05 m  
Anisotropy Ratio (Kz/Kr): 1

**WELL DATA (MB14-20d)**

Initial Displacement: 1.546 m  
Total Well Penetration Depth: 18.05 m  
Casing Radius: 0.025 m  
Static Water Column Height: 18.05 m  
Screen Length: 6 m  
Well Radius: 0.073 m  
Gravel Pack Porosity: 0.3

**SOLUTION**

Aquifer Model: Confined  
Solution Method: Bouwer-Rice  
\[ K = 7.88 \times 10^{-7} \text{ m/sec} \]  
\[ y_0 = 1.077 \text{ m} \]
SLUG OUT (RH)

Data Set: Z:\..\MB14-20d(RH)_a.aqt
Date: 03/26/15
Time: 13:34:40

PROJECT INFORMATION

Company: RGC
Client: DME
Project: 183005
Location: Rum Jungle
Test Date: 8 November 2014

AQUIFER DATA

Saturated Thickness: 31.05 m
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MB14-20d)

Initial Displacement: -1.16 m
Total Well Penetration Depth: 18.05 m
Casing Radius: 0.025 m
Static Water Column Height: 18.05 m
Screen Length: 6 m
Well Radius: 0.073 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 7.288E-7 m/sec
y0 = -1.053 m