Winu Gold and Copper Project

Infiltration Pond Study

Rio Tinto

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Disclaimer

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PROJECT 311012-01817: Winu Gold and Copper Project - Infiltration Pond Study

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Executive summary

An Order of Magnitude (OoM) infiltration pond study was completed to assess the feasibility of an infiltration pond system for management of excess mine dewater at the Winu mine site over the life of mine. Several potential locations were assessed in relation to proposed mine infrastructure and sensitive environmental/heritage areas, and an area (Site 07) located approximately 2 km south-east of the mine pit was identified as the preferred (Figure 0-1).

A review of the available geological data provided by Rio Tinto suggests the lithology comprises the following:

- **Surficial Sands:** high hydraulic conductivity and approximately 10 to 15 m thick in the selected area, underlain by
- **Silcrete:** low hydraulic conductivity and approximately 14 to 26 m thick, underlain by
- **Sandstone:** moderate hydraulic conductivity and at least 30 m thick

One dimensional (1D) vertical infiltration modelling was completed using Hydrus and an assumed peak excess water inflow rate of 11ML/day. The results, based on literature parameter values, suggested that the Silcrete layer is likely to act as a practically impermeable barrier to vertical infiltration of water, impacting on the effectiveness of the infiltration pond and resulting in unfeasible and unpracticable pond areas.

Options such as blasting of and/or drilling holes through the Silcrete layer were explored and tested in the 1D model but while found to provide some improvement to performance and some reduction in pond size, in most cases still resulted in unfeasible and unpracticable pond areas. There are also significant uncertainties associated with the effectiveness of blasting, and the drilling of large numbers of holes required to increase connectivity through Silcrete would be costly.

3D numerical modelling was then completed using MODFLOW-USG to effectively simulate the likely performance of the infiltration from the pond into the surficial Sand layer and the extent of mounding and lateral spread of groundwater (Pond Option).

It was also agreed that an alternative option of excavating out the Silcrete layer as part of quarrying activities and using the void to discharge and infiltrate water predominantly into the underlying sandstone aquifer should also be tested using the numerical model (Quarry Infiltration Option).

To accommodate both options, the preferred site for the infiltration pond / quarry options was moved approximately 1 km south-east from Site 07 to a proposed stockpile area, shown in Figure 0-1. The current stockpile design will be updated to accommodate the infiltration pond / quarry. The results of numerical modelling are summarised below for the Infiltration Pond and the Quarry Infiltration Options.

Infiltration Pond Option

For the infiltration pond to be effective 3D numerical groundwater modelling suggests that the following conditions would need to be satisfied:

- Excess water inflow rates are consistent with and do not exceed, the estimated excess mine dewater rates,

- Two ponds (Pond 1 and 2) are adopted at the locations shown in Figure 0-2 and with the following minimum dimensions:
  - **Pond 1**: 100 m effective base width comprising two cells each 50 m width to facilitate maintenance and cleanout regimes; 500 m effective base length; average depth of ponds of around 1.5 m with 1m operating water depth; and perimeter and central embankments.
  - **Pond 2:** Same as Pond 1, but with a 200 m effective base width comprising two cells each 50 m width to facilitate maintenance and cleanout regimes.

  Figure 0-3 and Figure 0-4 provide approximate dimensions of Pond 1 and 2. These are indicative only.
- The thickness of the surficial Sand layer would need to be at least 11 to 12 m and ideally 15 to 16 m at the ponds and extending at least 2.5 km from the ponds, and
- The hydraulic conductivity of the Sand should be at least 5 m/day, to prevent overtopping. If a single overtopping event is considered acceptable by Rio Tinto, then a hydraulic conductivity of 2 m/day may be acceptable.

In addition:

- If the conditions outlined are confirmed, then modelling suggests that there would be less than 1 L/s of groundwater ingress into the mine pit void over the simulation period and therefore have negligible impact on mining,
- The total indicative estimated disturbance area for both ponds is approximately 200,000 m^2 allowing for perimeter and central embankments (assuming flat base no cut/fill), and
- The Infiltration Pond Option is a potentially viable option and should be explored further but is associated with numerous uncertainties associated with the hydraulic conductivity and consistent thickness of the Sand unit, which have a significant influence on effectiveness and feasibility. Geotechnical and hydrogeological investigations, hydraulic and material testing is needed to confirm the hydraulic conductivity and thickness of the Sand unit at the pond locations and across an area extending at least 2.5 km from the ponds, to confirm effectiveness and feasibility of the infiltration pond option (Pond 1 and 2). Blasting of and/or drilling holes through the Silcrete layer may improve the performance of infiltration ponds, however this would be costly to implement.

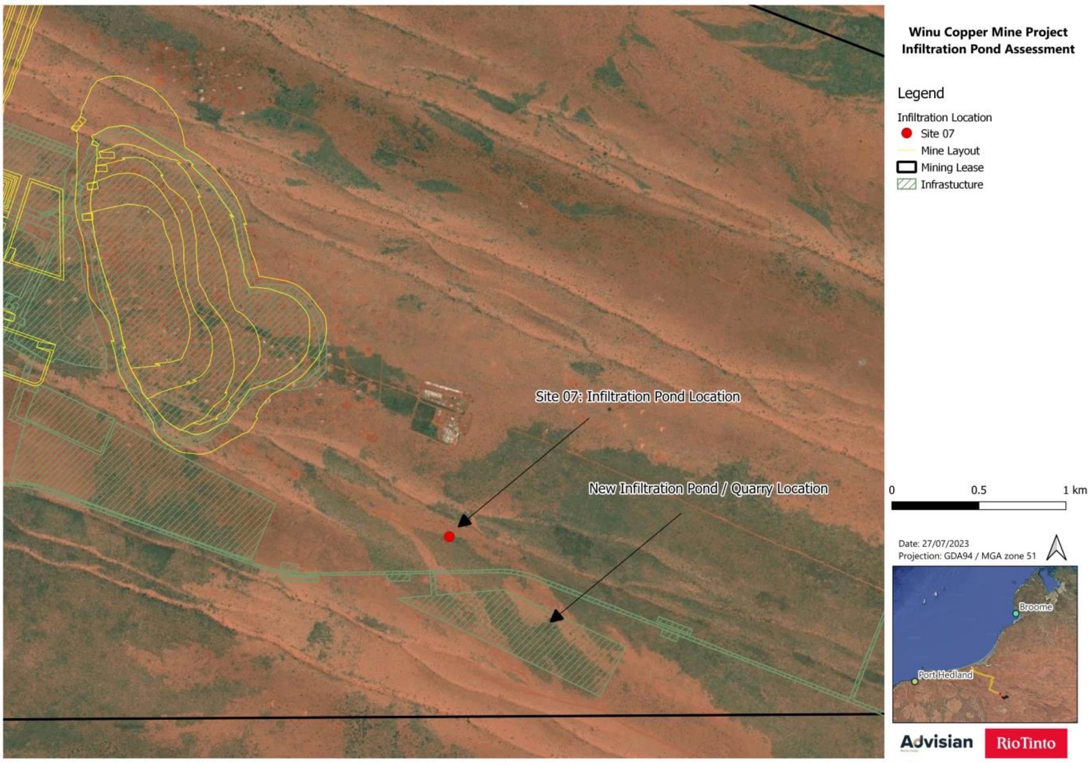

Figure 0-1. Original Site 07 and new location for Infiltration Pond and Quarry Infiltration Options

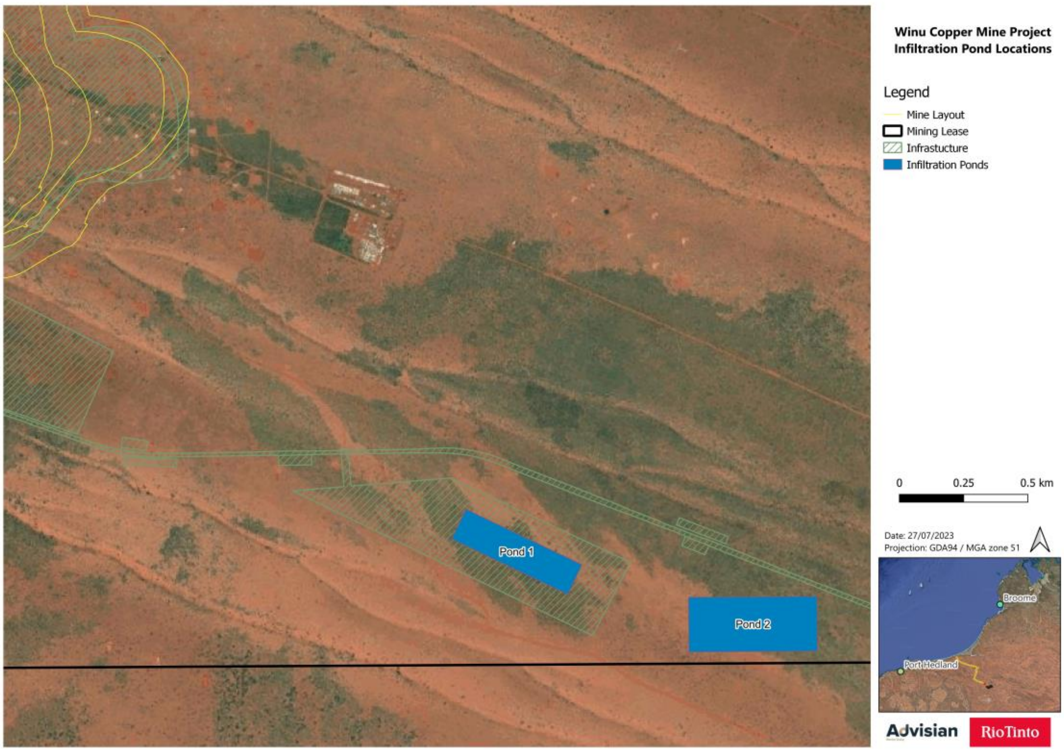

Figure 0-2. Locations and layouts of infiltration Ponds 1 and 2, in relation to proposed mine infrastructure layouts and mining lease boundary

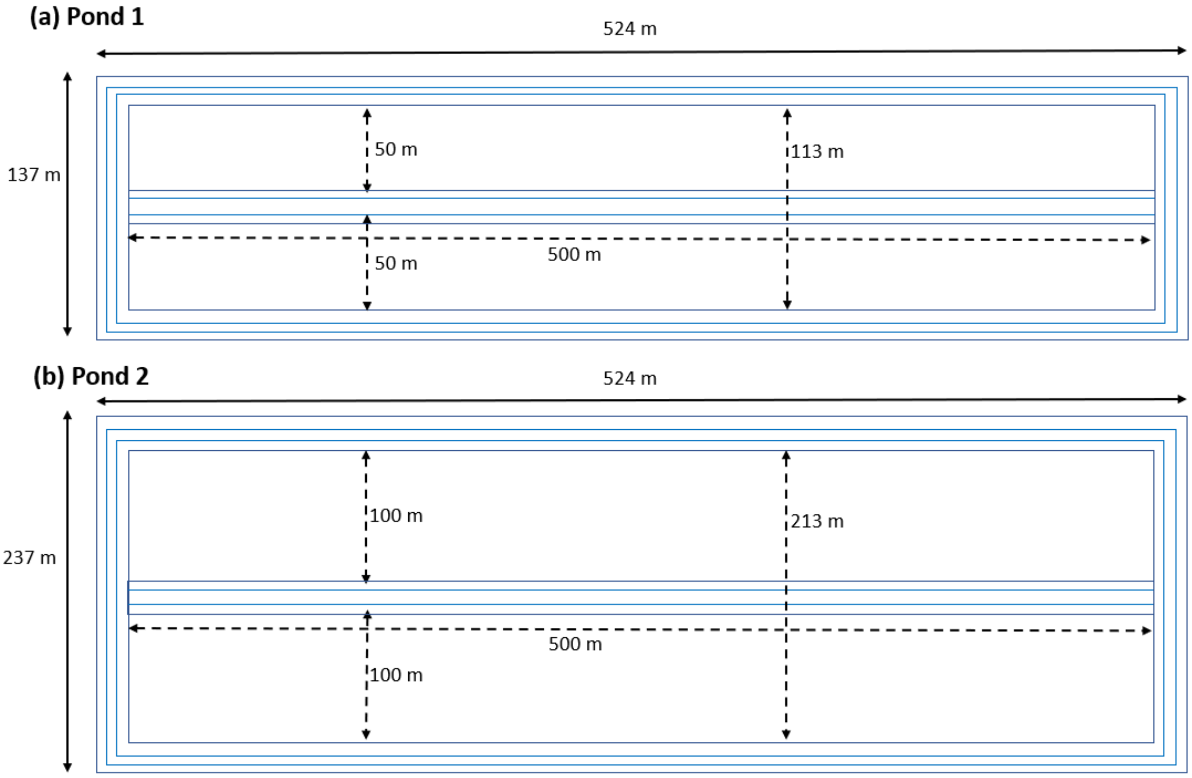

Figure 0-3. Schematics showing approximate dimensions of (a) Pond 1 and (b) Pond 2 (not to scale)

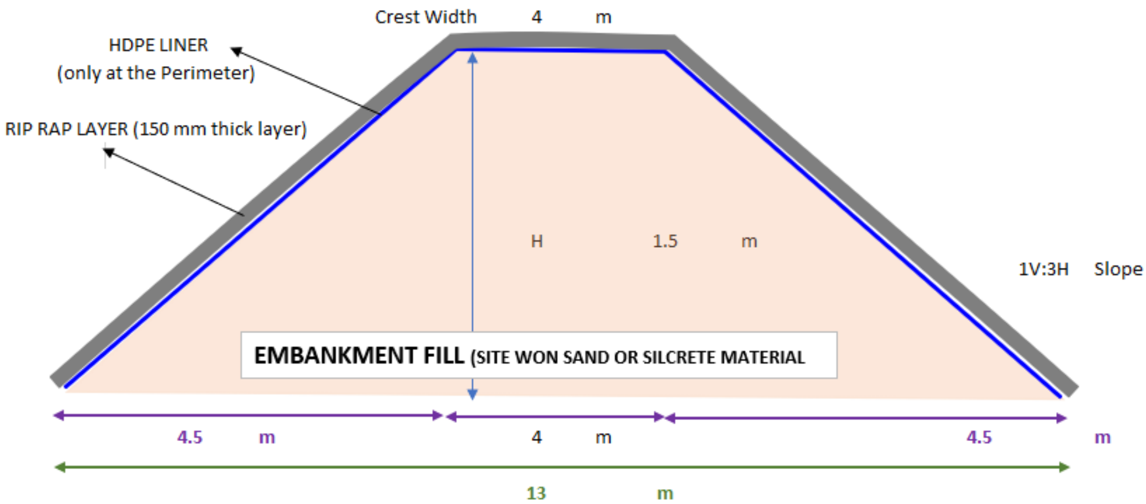

Figure 0-4. Embankment with HDPE liner and protection rip rap layer (not to scale)

Quarry Infiltration Option

The results and available data suggest that the Quarry Infiltration Option is likely to be more effective at infiltrating excess mine water than the Infiltration Pond Option, with the following benefits:

- It effectively infiltrates the water down into the Sandstone layer,
- It does not result in groundwater mounding within the upper Sand layer (above the Silcrete), and therefore does not present a risk of establishment of groundwater dependent ecosystems (GDEs) at the surface,
- The estimated peak inflow rates to the mine pit, attributable to infiltration, are between 11 and 33 L/s and the mean inflows are between 7 and 14 L/s, which are manageable and should not impact on operations,
- The quarry provides additional contingency, in the form of high storage capacity and ability to infiltrate water laterally into the upper Sand unit if required, which can manage risks associated with excess water flow rate and hydraulic conductivity uncertainties. This is important as there has been limited and, in some cases, no hydrogeological testing completed on the Sand, Silcrete and Sandstone units so the parameter values adopted for modelling are indicative, and
- The quarry has a smaller approximate disturbance area of 153,600 m^2 when including the cut slopes and setbacks,
- Provides the opportunity to use the excavated Silcrete material to source construction material for use on site. Geotechnical investigations and designs are required to confirm suitability of this material for use, and
- The quarry could potentially be backfilled with mine waste or potentially inert tailings for mine closure.

Flood risk

The results of 1% AEP event modelling with the two ponds in place (Pond 1 and 2) suggest there is likely to be only minor ponding to depths of no more than 0.7 m adjacent to Pond 1 (western pond) in the 1% AEP event. The depth of ponding around Pond 2 (eastern pond) is less than 0.25 m.

Previous 1% AEP event modelling by Advisian (2023b) in the mine area suggests that 0.7 m and 0.25 m of ponded water are expected to completely infiltrate within approximately 70 hours (< 3 days) and 24 hours (1 day), respectively. Therefore, given the limited depth and extent of 1% AEP flooding and rapid infiltration rates, the risk posed floodwater is considered very low.

The results are expected to be similar if the Quarry Infiltration Option is selected, assuming bunds are constructed for safety but to also direct floodwater around the quarry.

Impact assessment

Comparison of impacts suggests that the Quarry Infiltration Option has least potential impact on environmental and heritage values at Winu, when compared with the Infiltration Pond Option:

- The Infiltration Pond Option presents a potential risk of prolonged periods with near surface groundwater and establishment of groundwater dependent ecosystems (GDE’s) at the surface.

The Quarry Infiltration Option infiltrates the water down into the Sandstone layer. It does not result in groundwater mounding within the upper Sand layer (above the Silcrete), and therefore does not present a risk of establishment of groundwater dependent vegetation at the surface,

- The estimated ground disturbance area for the Infiltration Pond Option is also approximately 50,000 m^2 greater than the Quarry Infiltration Option.

The Quarry Infiltration Option is likely to produce higher rates of groundwater inflow to the mine pit. However, the estimated incremental peak inflow rates to the mine pit are between 11 and 33 L/s and the mean inflows are between 7 and 14 L/s over the life of mine, which are manageable and should not impact on mining operations.

As both options will result in the formation of a temporary surface water body appropriate flora and fauna management measures will be required, during operations. At mine closure the infiltration ponds and quarry can be backfilled and rehabilitated to natural surface.

Concept designs, quantities and cost estimates

Conceptual infiltration pond designs (Pond 1 and 2) were developed in 12D civil design package and concept drawings produced and provided in Appendix F.

Indicative OoM quantity and CAPEX cost estimates were then developed for the two infiltration pond designs using unit earthworks rates from the Remote Borefield Pipeline Study (Advisian, 2023b) and unit rates provided by liner suppliers. Different combinations of locally sourced construction material and imported material, as well as combinations of HDPE and concrete canvas liners for the central and perimeter embankments were considered. The results suggest that the following design option is preferred for both ponds due to lowest estimated cost and was adopted for development of the design drawings:

- **Design Option 1A:** Source the embankment (Sand) fill material locally + 2.5mm HDPE liner + imported rip rap rock protection.

The estimated CAPEX cost estimates for this option are presented for Pond 1 and Pond 2 in Table 0-1.

Table 0-1. Indicative CAPEX cost estimates for Pond 1 and 2

Item	Cost Estimate $AUD (excl GST)	
	Pond 1	Pond 2
Cut	$180,000	$406,880
Fill *	$139,120	$276,220
Central Fill ^	$63,750	$63,750
Volume rip rap	$491,250	$517,500
HDPE liner	$209,950	$221,496
Total	**$1,084,070**	**$1,485,846**

** Perimeter embankment fill*
^ Central embankment fill

A concept design was also developed for the quarry option using 12D civil design software and used to develop indicative quantities and cost estimates presented in Table 0-2.

Table 0-2. Quarry option: indicative excavation quantities and cost estimates

Lithology / Layer	In-Situ Volume (m^3)	Cost Estimate ($ AUD)
Sand	1,072,702	$ 5,492,234
Regolith (Silcrete/Ferricrete)	1,787,859	$ 13,845,184
Sandstone	98,189	$ 760,372
Total	**2,958,750**	**$ 20,097,790**

Recommendations

To further assess and confirm the feasibility of an infiltration system for management of excess mine dewater at the Winu mine site, the following recommendations are made:

- Explore both the Infiltration Pond (Ponds 1 and 2) and Quarry Options in more detail using the results of geotechnical and hydrogeological investigations, hydraulic and material testing. The testing should be used to confirm:
    - The hydraulic conductivities and thickness of the Sand, Silcrete and Sandstone layers at the proposed infiltration ponds and quarry locations and surrounding areas, and
    - The suitability of the Sand and Silcrete materials for use as construction material on site if required.
- **Infiltration Pond Option:** The infiltration pond is a potentially viable option and should be explored further but is associated with numerous uncertainties associated with the hydraulic conductivity and thickness of the Sand unit, which have a significant influence on effectiveness and feasibility. The results of geotechnical and hydrogeological investigations, hydraulic and material testing should be used to confirm the hydraulic conductivity and thickness of the Sand unit at the pond locations and across an area extending at least 2.5 km from the ponds. The results should be used to update the numerical groundwater model then use the model to confirm effectiveness and feasibility of the Infiltration Pond Option (Pond 1 and 2). Blasting of and/or drilling holes through the Silcrete layer may improve the performance of infiltration ponds and could also be considered, however would be costly to implement, and
- **Quarry Infiltration Option:** Use the results of geotechnical and hydrogeological investigations, hydraulic and material testing to confirm the hydraulic conductivities and thickness of the Sand, Silcrete and Sandstone layers at the proposed quarry location. The results should then be used to update the numerical groundwater model then use it to confirm effectiveness and feasibility of the Quarry Infiltration Option. The results should also be used to develop a quarry design.

The numerical modelling should also assess the effect of infrequent, high intensity rainfall events on infiltration pond / quarry performance and risk of mounding.

The results should be used to select the preferred option and develop more detailed 12D civil designs, quantity estimates and CAPEX cost estimates.

Acronyms and abbreviations

Acronym/abbreviation	Definition
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
DEM	Digital Elevation Model
DRN	Drain package available in MODFLOW-USG software
EVT	Evapotranspiration package available in MODFLOW-USG software
HDPE	High Density Polyethylene
Kv	Horizontal hydraulic conductivity
Kh	Vertical hydraulic conductivity
LAK	Lake package available in MODFLOW-USG software
LiDAR	Light Detection and Ranging
ML	Megalitres
mbgl	Meters below ground level
OoM	Order of Magnitude
1D	One dimensional
2D	Two dimensional
3D	Three dimensional

1 Introduction

1.1 Background

The Winu Copper and Gold Project is focused on a deposit discovered in 2017 by Rio Tinto, with exploration activities beginning in 2018 and continuing through 2022. A series of technical studies, including those related to water, were completed between 2019 and 2022 to support mine planning, Project development and regulatory approvals. Advisian joined the project in June 2022 to deliver hydrology and hydrogeological studies.

Recent water balance modelling by Advisian (2023) over the life of mine, identified periods of excess mine dewater. Managed Aquifer Recharge (MAR) using a borefield has been explored by Rio Tinto, however Rio Tinto would also like to explore the option of using an infiltration pond system at a single location, to manage the predicted excess water.

Advisian was engaged by Rio Tinto to assess the feasibility of an infiltration pond system for management of excess mine dewater at the Winu mine site.

1.2 Project objective

The objective of the study is to assess the feasibility of an infiltration pond system for management of excess mine dewater at the Winu mine site. Develop a conceptual infiltration pond design in 12D civil design package, concept layout drawing, material quantities and OoM CAPEX cost estimates.

1.3 Scope of work

This Scope of Works includes the following:

- Use existing water balance results to confirm volumes/rates of excess water to be managed by the infiltration pond system,
- In consultation with Rio Tinto, determine the preferred location for the infiltration pond system,
- Advisian onsite hydrogeologist to visit the pond site to take up to four soil samples from the proposed pond location for laboratory (PSD) testing and to collect relevant site data,
- One-dimensional (1D) Infiltration modelling:
    - Use existing hydrogeological/geological data to conceptualise the study area and select appropriate parameter ranges based on site data, relevant Project reports, and published literature,
    - Develop a 1D vertical infiltration model for the pond location using the conceptual hydrogeological model and use to estimate vertical infiltration rates assuming peak excess water disposal rates. The results will be used to evaluate whether there is potential for formation of perched groundwater and/or surface-groundwater interactions,
    - Use model to test sensitivity of pond size to variations in model input parameters,

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    - Select in consultation with Rio Tinto, a pond size to be adopted for concept design and deliverables based on previous experience and similar inflow rates, and
    - Develop a water balance model for the pond and use the estimated infiltration rate, evaporation rate and excess dewater inflows to simulate pond storage over time and assess pond's ability to store and infiltrate water over the life of mine.

- Surface water flood modelling – use the 2D hydraulic model developed for the Winu water supply pipeline study to simulate the risk posed by external floodwaters in the 1% AEP flood event and make any necessary recommendations for the pond design,
- Review of surplus water quality data and blending in relation to the water balance to determine if there is a potential for fouling / scaling of the pond floor which would inhibit infiltration and require regular maintenance for clean out,
- Determine the required pond availability which in turn dictates how many individual cells are required in the pond system to facilitate maintenance and cleanout regimes,
- Review what existing aquatic vegetation is in the area and what its likely growth rate is when provided with a continuous water source. This will also inform the likely maintenance regimes and number of pond cells,
- Determine a suitable construction methodology based on the likely soil types at each site i.e. soils that are compactable require the ponds to be long and narrow so they can be dug from the edges without machinery running over compacting the floor which will negate infiltration while less compactable soils can take any shape and be constructed using dozers or scrapers,
- Develop a typical pond footprint using LIDAR data taking into consideration the construction methodology, topography, drainage paths and required maintenance access,
- Complete a geotechnical desktop assessment of the pond location and construction materials,
- Develop conceptual pond design in 12D civil design package, concept layout drawing, material quantities and OoM CAPEX cost estimates. The design drawing deliverable will be limited to:
    - 1 x General Arrangement (GA) drawing showing overall site layout/plan
- The OoM cost estimate will be based on the indicative cost from similar projects undertaken by Advisian,
- The 12D design files (DWG/DGN) and images (JPG) and will be provided to Rio Tinto to so 3D visualisations of the design can be generated to support stakeholder consultation, and
- Document all deliverables and design assumptions/findings in a concept design report.

1.4 Sources of information

Table 1-1 lists the sources of information (relied upon information) used in this study.

Table 1-1. Sources of information

Data type and description	Source(s)	Date Supplied
LiDAR topographic survey data File: 1m_DEM_RT_MERGE_EPSG28351.tiff	RTIO	17/06/2022
Mining Lease Boudary File: Winu_Proposed_MiningLease_GCSGDA94.zip	RTIO	18/07/2023
Mine layout layout File: Mine_Layout_20230717.dxf	RTIO	18/07/2023
Particle Size Distribution (PSD) data (Appendix A)	Advisian / ALS	05/04/2023
Geology Data: Borehole logs & non-graphical (text) borehole log lithologies provided in Appendix B. Rio Tinto Geology Database and Leapfrog model outputs	RTIO	2023
Winu 2D TUFLOW model (flood model)	Advisian (2023b)	30th March 2023
Winu mine water balance model outputs	Advisian (2023a)	20th April 2023

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2 Excess water estimates

A mine water balance model provided by Rio Tinto, was updated by Advisian based on the latest mine plan and estimated dewatering rates and simulations ran over the life of mine. The results of water balance modelling are presented in the Water Balance and Dewatering Update 2023 memorandum report (Advisian, 2023a).

The results were used to develop monthly and daily estimates of excess mine dewater (in ML/month and ML/day) that will need to be disposed via infiltration at Winu, which are plotted in Figure 2-1 and Figure 2-2 respectively. These estimates have been adopted as basis of this infiltration study.

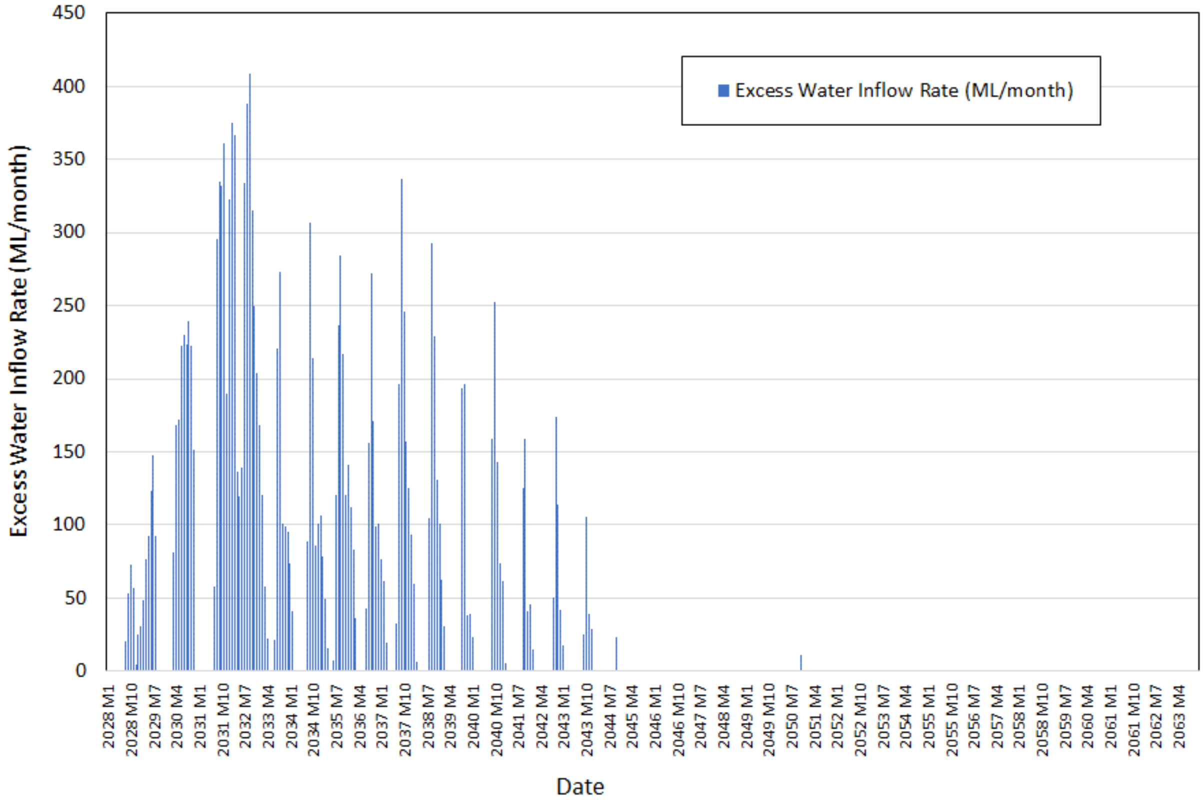

Figure 2-1. Monthly excess water inflow rate to infiltration pond (ML/month)

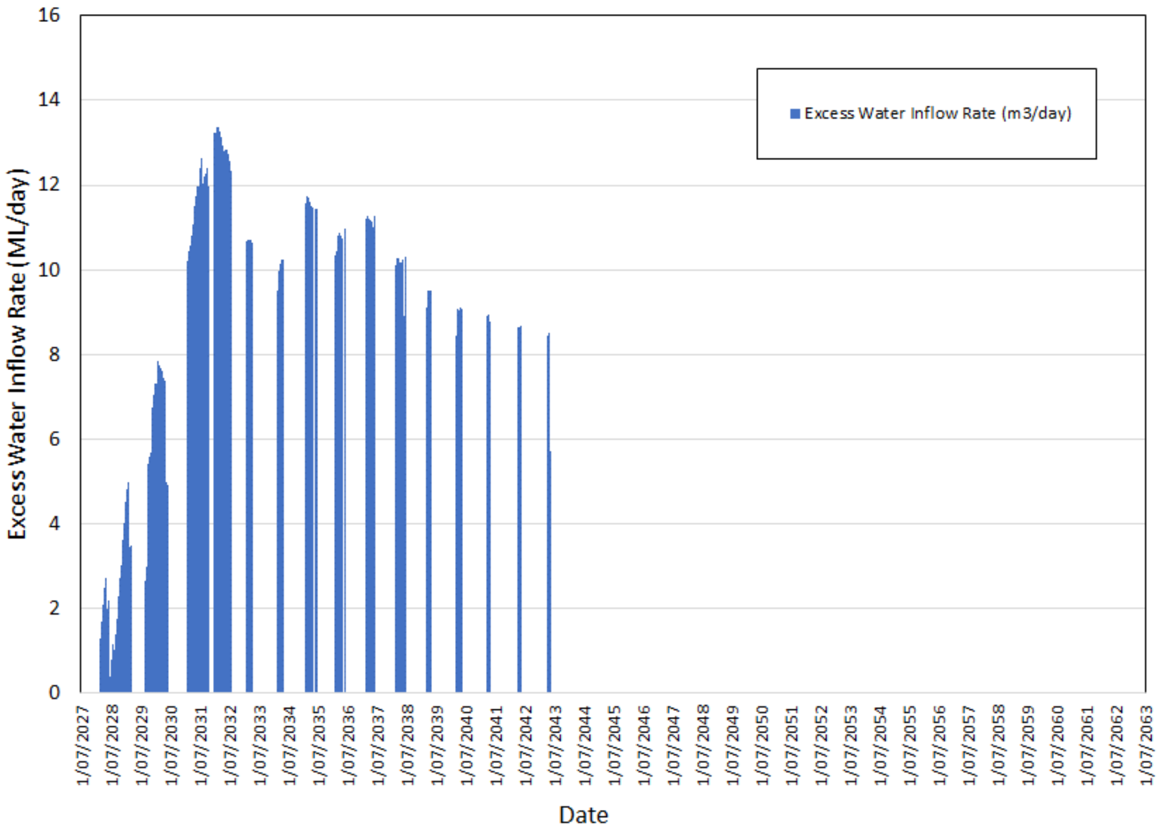

Figure 2-2. Daily excess water inflow rate to infiltration pond (ML/day)

3 Basis of design

The infiltration pond is to be designed to effectively storge and infiltrate excess water over the life of mine, while minimising the risk of:

- Overtopping of the infiltration pond due to storage capacity exceedance,
- Recirculation of infiltrated water into the mine pit, as this would impact on operations, or
- Forming a surface expression of groundwater or near surface groundwater table, as this could lead to adverse environmental and/or heritage impacts.

The infiltration pond design criteria are listed below:

- The excess water inflow rates to be managed by the infiltration system are presented in Section 2,
- The design should provide 0.5 m of freeboard from the operating water level in the pond and the crest of perimeter embankments,
- The pond should be protected from external floodwaters in the 1% Annual Exceedance Probability (AEP) event,
- The pond design should consider the potential for fouling / scaling of the pond floor and vegetation growth, and include provision for routine maintenance without impacting on pond performance, and
- The pond should not impact on sensitive environmental and heritage areas, such as the dune systems.

4 Pond site selection

The mine area is characterised by longitudinal aeolian sand dunes separated by interdunal corridors, which have cultural and environmental values (Advisian, 2023b). Therefore, infiltration ponds should be designed and located to avoid impacts to dunes and associated cultural and environmental values.

Advisian previously used the results of preliminary water balance and surplus water discharge modelling at Winu (Advisian, 2022) to estimate surplus water rates, volume and timing over the life of mine and to estimate the depth and extent of inundation resulting from surplus water discharge at a number of alternative locations shown in Figure 4-1. The results are presented in the Preliminary Surplus Water Discharge Modelling Memorandum Report (Advisian, 2022a).

Each of the seven locations were considered at the commencement of this infiltration pond study, and assessed based on proximity to existing infrastructure, distance from pits and proximity/potential impact to dunes. Site 07 was selected in consultation with Rio Tinto as the preferred location for the infiltration pond study.

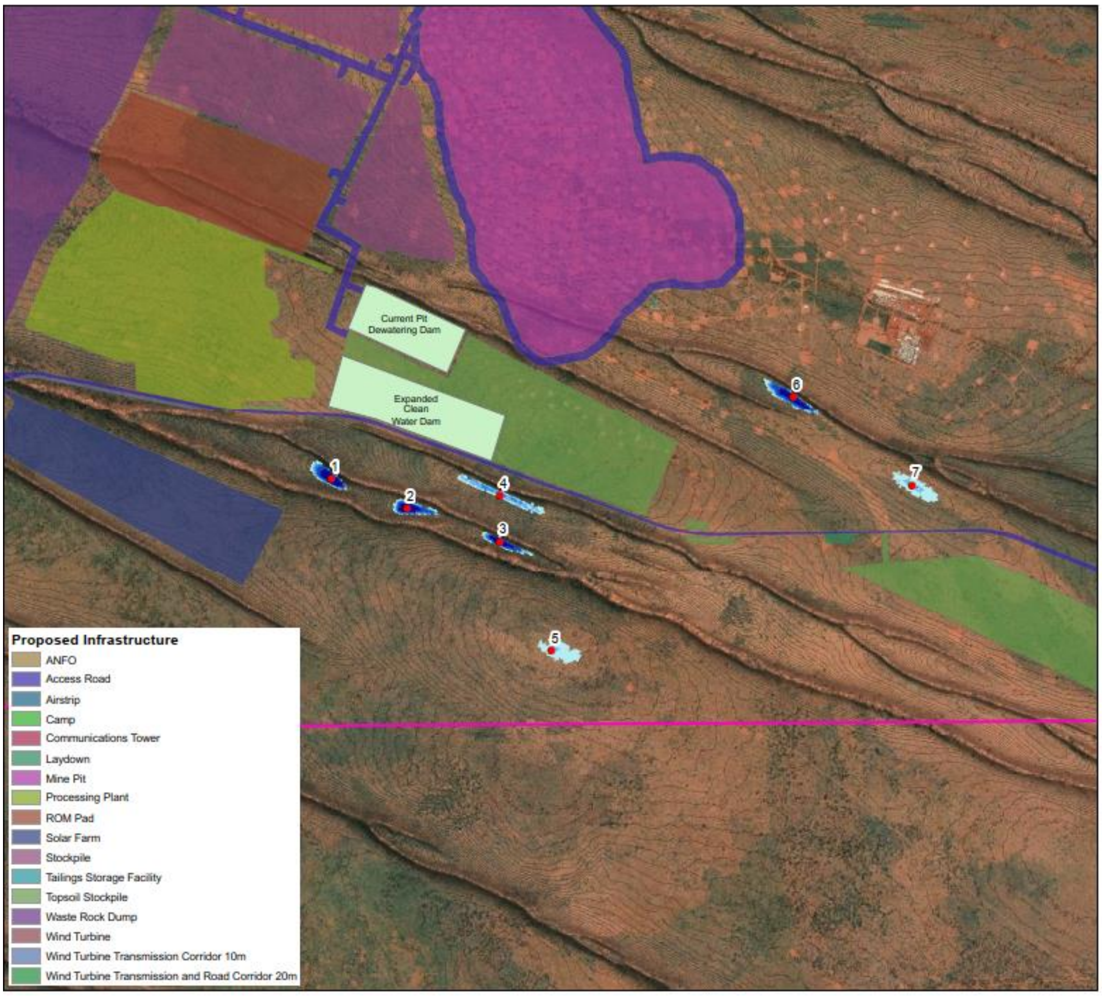

Figure 4-1. Seven locations assessed in the Preliminary Surplus Water Discharge Modelling Study (Advisian, 2022a).

5 Field testing

The infiltration potential of surficial Sands was assessed using the results of the following field tests:

- Particle Size Distribution (PSD) testing of samples of Sand collected on site, and estimation of hydraulic conductivity using the following methods:
  - Alyamani and Sen (1993), Hazen (1893), Chapuis et al. (2005), Beyer (1964), Kozeny-Carman (1956), and Harleman et al. (1963)
- Field infiltration trial on site, where dewater from a bore test pumping trial was pumped into a turkey's nest and surface water levels monitored and recorded then the results used to estimate the rate of infiltration and hydraulic conductivity.

The results, described below, were used to inform the selection of infiltration modelling parameters in Section 6.2.2.2.

5.1 PSD analysis

Samples of surficial Sands were collected from two locations near the preferred infiltration pond Site 7, as shown in Figure 5-1. Samples were sent to ALS Laboratories for PSD analysis. The complete lab results are presented in Appendix A.

A range of methods are available to estimate the hydraulic conductivity (K) of Sand. The equations presented in Table 5-1 were used along with the PSD mass-median-diameter values (i.e., d_{10}, d_{50}, etc.) in Table 5-2 to estimate the hydraulic conductivity (K).

The resulting hydraulic conductivities for each sample were uniform, however "WINU Point Pad 1_Sample03" was generally found to have a 30% higher hydraulic conductivity. Between the various equations, the average hydraulic conductivity ranged from 1.20 to 9.35 m/d, with an average of 4.89 m/d.

The resulting hydraulic conductivity estimates are presented in Table 5-3.

Table 5-1. Equations used to calculate hydraulic conductivity from PSD data (after Rosas et al. (2014))

Reference	Equation	Variables
Alyamani and Sen (1993)	$K\left[\frac{m}{d}\right] = \beta[I_o + 0.025(d_{50} - d_{10})]^2$	β – 1300 I_0 – Intercept of the line formed by d_{50} and d_{10} with the grain size axis (in mm)
Hazen (1893)	$K\left[\frac{cm}{s}\right] = \beta C d_{10}^2$	β – 1 C – Hazen coefficient, where 100<C<150. Taken to be 125
Chapuis et al. (2005)	$K\left[\frac{cm}{s}\right] = \beta\left(\frac{d_{10}^2 e^3}{1+e}\right)^{0.7825}$	β – 2.4622 e – void ratio, ($\frac{n}{1-n}$), where n is effective porosity. Assumed to be 0.3
Beyer (1964)	$K\left[\frac{m}{s}\right] = \beta \frac{g}{v} \log \frac{500}{C} d_{10}^2$	β – 0.0006 g – Gravitational acceleration, 9.81 m/s^2

Reference	Equation	Variables
		v – Fluid kinematic viscosity at 35°C, 7.24E-07 m^2/s C – Coefficient of uniformity (d_{60}/d_{10})
Kozeny-Carman (1956)	$K\left[\frac{m}{s}\right]=\beta\frac{\rho g}{\mu}\frac{n^3}{(1-n)^2}d_{10}^2$	β – 1/180 g – Gravitational acceleration, 9.81 m/s^2 ρ/μ – Fluid viscosity divided by fluid density, i.e. the reciprocal of fluid kinematic viscosity, v, at 35°C, (1381025 m^{-2}/s) n – Effective porosity, assumed to be 0.25
Harleman et al. (1963)	$K\left[\frac{m}{s}\right]=\frac{\rho g}{\mu}d_{10}^2$	g – Gravitational acceleration, 9.81 m/s^2 ρ/μ – Fluid viscosity divided by fluid density, i.e. the reciprocal of fluid kinematic viscosity, v, at 35°C, (1381025 m^{-2}/s)

Table 5-2. Mass-median-diameter values derived from PSD testing

Parameter	WINU Point 7_Sample01	WINU Point 7_Sample02	WINU Point Pad 1_Sample03	WINU Point Pad 1_Sample04
d_{10} (mm)	0.08	0.075	0.09	0.08
d_{50} (mm)	0.28	0.25	0.425	0.3
d_{60} (mm)	0.39	0.35	0.48	0.38
d_{50}-d_{10} Intercept, I_0 (mm)	0.053	0.052	0.055	0.053
d_{60}/d_{10}	4.88	4.67	5.33	4.75

Table 5-3. Hydraulic conductivity estimates derived using PSD data and the equations listed in Table 5-1

Equation	Hydraulic conductivity, K (m/d)				
	WINU Point 7_Sample01	WINU Point 7_Sample02	WINU Point Pad 1_Sample03	WINU Point Pad 1_Sample04	Average across the samples
Alyamani and Sen (1993)	4.37	4.13	5.22	4.45	**4.54**
Hazen (1893)	6.91	6.08	8.75	6.91	**7.16**
Chapuis et al. (2005)	1.97	1.78	2.37	1.97	**2.02**
Beyer (1964)	9.05	8.03	11.23	9.10	**9.35**
Kozeny-Carman (1956)	1.16	1.02	1.46	1.16	**1.20**
Harleman et al. (1963)	4.90	4.31	6.20	4.90	**5.08**
				Total average:	**4.89**

Figure 5-1. Sand sampling locations for PSD analysis

5.2 Infiltration trial

An infiltration trial was completed on site by pumping water from a bore test pumping trial into an infiltration test site shown in Figure 5-2. The test site was constructed as a 1.5 m deep, 12m x 16m sump, surrounded by 0.5 m high bund constructed from the excavated sand material. A v-notch weir was installed in the bund to record the flow rate of water leaving the sump. The sump was constructed within a cleared drill pad which had a dimension of 30 m by 30 m and the pad was surrounded by 1 m high bund.

Water levels in the sump were recorded using a pressure logger, and the flow rates recorded using the v-notch weir. The trial showed water levels in the sump steadily increasing before the bunding at the v-notch weir was breached, allowing water to flow around the v-notch and out into the adjacent drill pad area. As the drill pad area was bunded, the breached water was contained and continued to fill up within the drill pad. Once the pad had filled up, discharge into the sump and pad was ceased and water levels monitored using the pressure logger to record the rate of recession.

This recession data, presented in Figure 5-3, was considered effectively a falling head test, and the data used to estimate the infiltration rate and saturated hydraulic conductivity. The resulting hydraulic conductivity measured across the full infiltration period was 1.57 m/d, however the data was also assessed across three smaller time windows which showed distinct changes in gradient, resulting in hydraulic conductivity ranges varying between 1.09 to 1.94 m/d. The result of the recession analysis for each assessment window is provided in Table 5-4. The assessment windows shown in Figure 5-3.

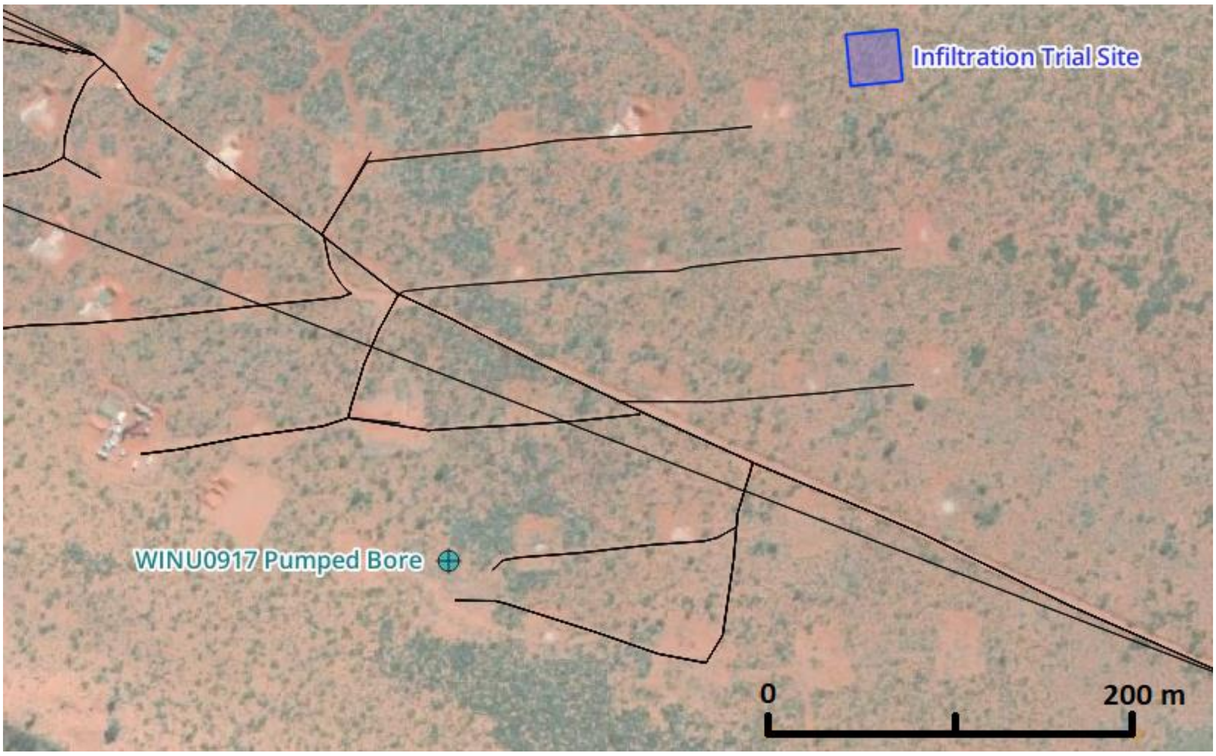

Figure 5-2. Test pumping bore and infiltration test (sump) location

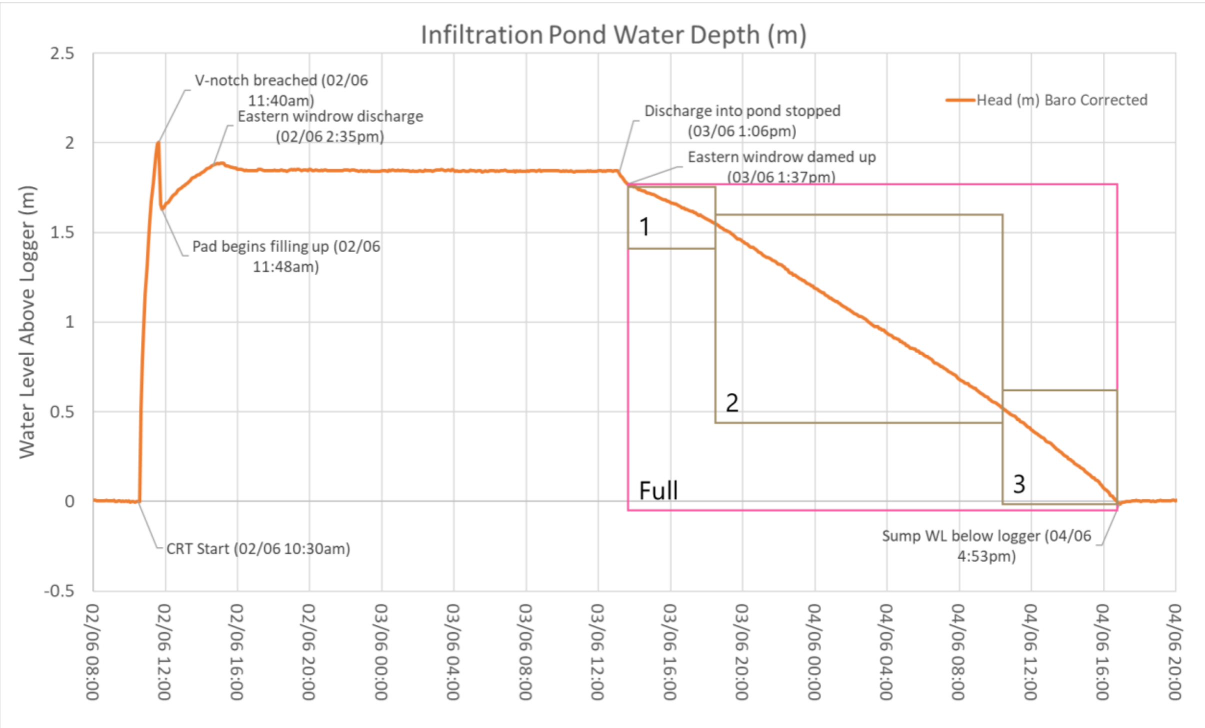

Figure 5-3. Water level data from the infiltration trial on site and recession assessment windows

Table 5-4 Hydraulic conductivities estimated from the infiltration trial

Assessment window	Water level decrease (m)	Duration (days)	Infiltration rate (m/d)
Full	1.78	1.14	1.57
1	0.22	0.20	1.09
2	0.99	0.64	1.55
3	0.57	0.30	1.94

6 One dimensional (1D) infiltration modelling

6.1 Objectives

The objectives of one-dimensional (1D) infiltration modelling was to simulate vertical infiltration from a pond, using a simplified and conservative approach to determine whether excess water is likely to infiltrate to the underlying aquifer, with high degree of confidence, without posing a risk of:

- Recirculation of water into the mine, as this would impact on operations, or
- Forming a surface expression of groundwater or near surface groundwater table, as this could lead to adverse environmental and/or heritage impacts.

If the results suggest there is sufficient vertical infiltration, then the pond concept is considered feasible, and the pond can then be sized without the need for more complex/detailed numerical modelling and assessments.

If the results suggests that the water is unlikely to infiltrate or there is low confidence in ability to vertically infiltrate, then:

- Alternative infiltration methodologies should be considered,
- Alternative pond locations should be considered, and/or
- A more detailed 3D numerical assessment methodology should be considered.

6.2 Methodology

6.2.1 Model selection

The infiltration modelling adopted the Hydrus-1D software Version 4.17.0140 (Šimůnek et al, 2013). This software package simulates water, heat and solute movement in one-dimensional variably saturated media.

The 1D modelling approach adopted in this study estimates the vertical infiltration rate as a vertical flux, per square meter. This is then used to estimate the equivalent pond area assuming the excess water inflow rates presented in Section 2.

6.2.2 Model set up

6.2.2.1 Model layers

Geological logs obtained from drilling investigations on site were used to characterise the lithology at the proposed infiltration pond location (Site 07). Figure 6-1 shows the borehole locations in proximity to infiltration pond Site 07, with the corresponding borehole logs provided in Appendix B. Rio Tinto also provided a spreadsheet with non-graphical (text) borehole log lithologies for boreholes. Figure 6-2 shows the non-graphical (text) borehole locations in proximity to infiltration pond Site 07, and a table summarizing the corresponding lithologies provided in Appendix B.

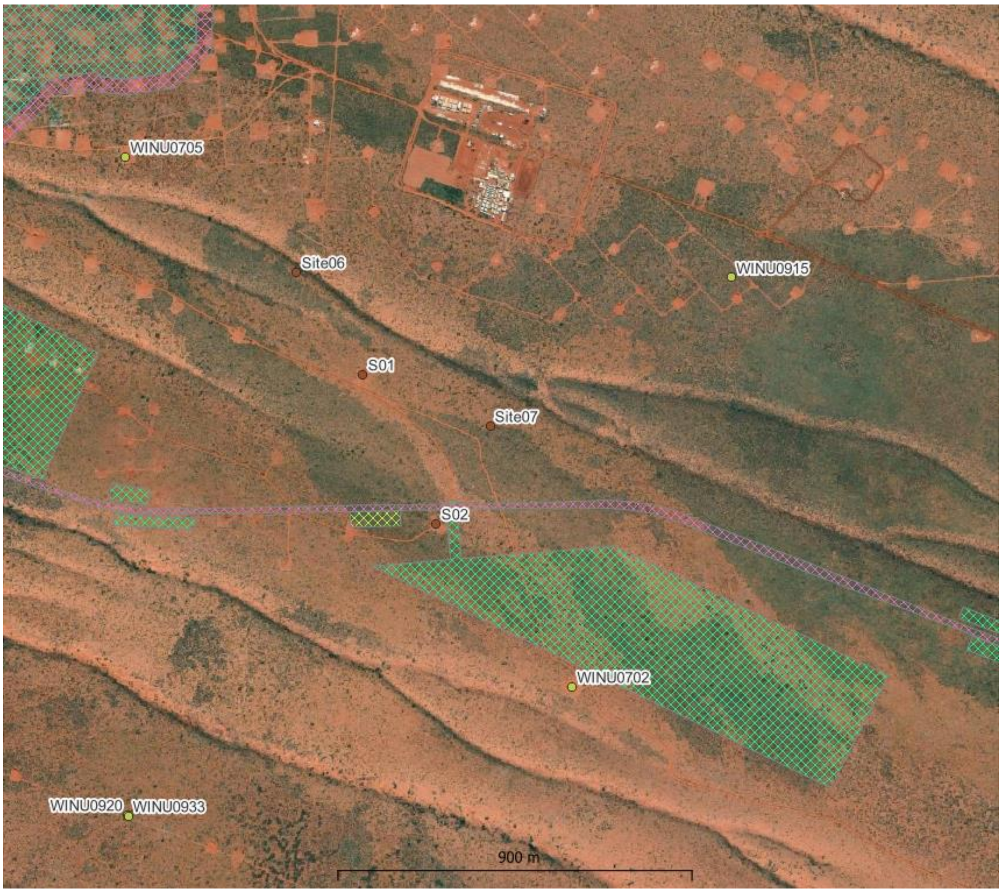

Figure 6-1. Locations of graphical bore logs relative to the proposed infiltration pond Site 07

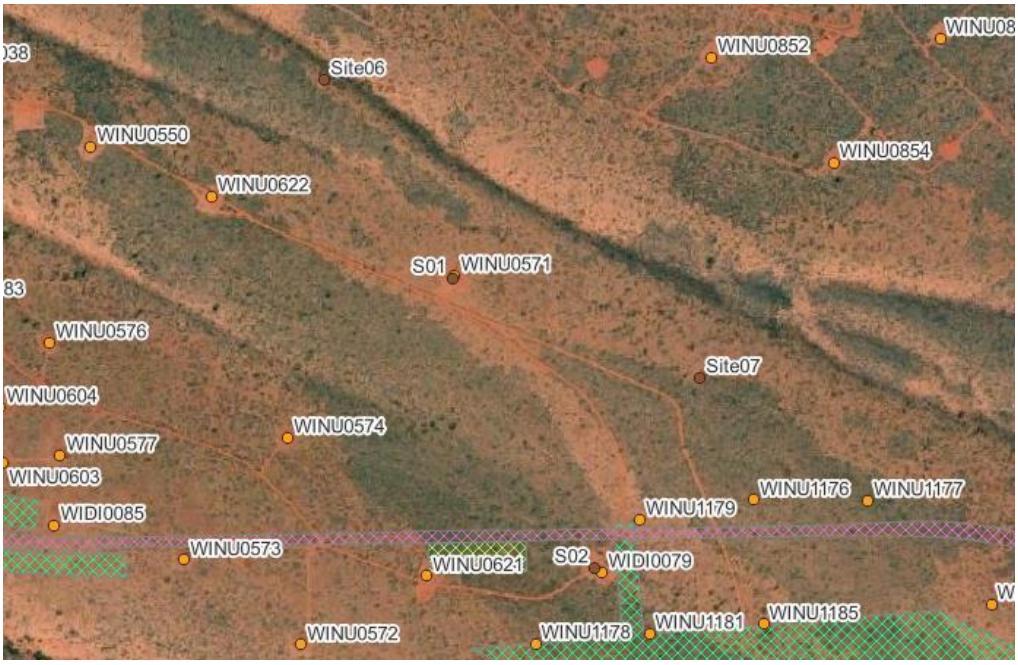

Figure 6-2. Locations of non-graphical (text) borehole logs in vicinity of proposed infiltration pond Site 07

This data was used to develop lithological layers for 1D modelling at the proposed infiltration pond Site 07.

O'Kane (2020) characterised the Sand and Sandstone lithologies as follows:

- **Sand:** comprising 10-30% clays and silts with the majority or the remainder sand size.
- **Sandstone:** comprising 5-20% clay/silt and up to 30% gravels and cobbles.

O'Kane (2020) provided no description for Silcrete, however borehole logs suggest the Silcrete comprises cemented silica and ferric sands and therefore likely to be of low conductivity.

The lithology for Site 07 is summarised in Table 6-1. As the thickness of each layer varies and the Silcrete layer is likely to control the rate of vertical infiltration, two alternative profiles were adopted for modelling to test the model sensitivity to variations in layer thickness. Table 6-2 presents the lithological layers and modelled layer thicknesses for each profile. The two adopted profiles have the Silcrete layer thickness varying from 26m to 15m.

Table 6-1. Lithology at proposed infiltration pond Site 07

Layer	Top (mbgl)	Bottom (mbgl)
Sand	0	4 - 10
Silcrete (includes ferricrete)	4 - 10	25 - 30
Sandstone	25 - 30	50

Table 6-2. Alternative profiles adopted for 1D infiltration modelling at Site 07

Layer	Profile 1		Profile 2	
	Top (mbgl)	Bottom (mbgl)	Top (mbgl)	Bottom (mbgl)
Sand	0	4	0	10
Silcrete (includes ferricrete)	4	30	10	25
Sandstone	30	50	25	50

6.2.2.2 Model parameters

The following parameters are required for each layer to run Hydrus-1D software:

- Vertical saturated hydraulic conductivity (K_s) in m/day
- Saturated water content (θ_s), expressed as a fraction
- Residual water content (θ_r), expressed as a fraction
- Empirical coefficients:
    - Alpha (α), in m^{-1}
    - *n,* dimensionless coefficient

Hydraulic conductivity values were based on published values and field data where available (Table 6-3). Conservatively low values were adopted for modelling infiltration in the Sandstone to assess whether lower hydraulic conductivities have the potential to govern vertical infiltration, when compared with the infiltration rates through the Silcrete layer.

The remaining model parameters for each layer were initially based on the Hydrus-1D User Manual (Šimůnek et al., 2013) parameter values associated with indicative United States Department of Agriculture (USDA) soil classifications (Rawls et al., 1982) provided in Table 6-4. Minor adjustments were made to model parameters within acceptable ranges to remove model instabilities, with the adopted parameters presented in Table 6-4.

Table 6-3. Saturated vertical hydraulic conductivity (Kv) parameter sources and adopted values (m/day)

Reference	Sand Layer	Silcrete Layer	Sandstone Layer
O'Kane (2020)	1	-	1
Golder (2020), refer Appendix C	8 to 16 Average = 10	-	-
Golder (2022), refer Appendix D	-	-	0.4 to 0.8
Tellus (2021)	0.1	0.004	-
Roach et al. (2010)	-	-	0.75
Leech et al. (1979)	-	-	1.85
Rojas et al. (2018)	-	-	10 to 0.1
PSD analysis	1.2 to 9.4 Average = 4.9	-	-
Infiltration trial	1.1 to 1.9 Average = 1.6	-	-
Parameter values / ranges adopted for 1D modelling	**0.1 to 10 m/day** (10 to 1000 cm/day)	**0.004 m/day** (0.43 cm/day)	**0.01 to 0.2 m/day** (1 to 20 cm/day)

Table 6-4. Model layers, equivalent USDA soil classifications and adopted 1D infiltration model parameters

Layer	Indicative USDA soil classification	θ_s	θ_r	α	n
Sand	Loamy Sand	0.25	0.05	0.12	10.00
Silcrete (includes ferricrete)	Silty Loam	0.10	0.04	0.10	4.32
Sandstone	Loamy Sand	0.20	0.05	0.14	5.00

6.2.2.3 Discretisation and run times

The model was discretised into 5cm intervals (1,000 intervals, over a 50m model depth). This allowed a suitable number of cells to be applied for the model to resolve the physical processes in the unsaturated zone.

The models were run for a period of 5 years (1,830 days).

6.2.2.4 Boundary conditions

Modelling adopted a head (water depth) of 1 m at the surface to simulate the pond and allowed a free drainage at the bottom of the model.

6.2.2.5 Peak excess water inflow

A peak rate of 11ML/day was calculated as the average daily rate over the peak 6-month period over the duration of the water balance (occurring in 2023, refer to Section 2).

6.3 Model results

6.3.1 Selected pond location (Site 07)

The Hydrus-1D model output the following data:

- Head of water within each layer over time, and
- Water flux within each layer over time.

As there is uncertainty associated with the hydraulic conductivities of the three layers and thickness of the Silcrete layer, sensitivity analysis modelling was completed, testing different combinations of conductivity and Silcrete thickness. The results of modelling are presented in Table 6-5 with the following methodology used to determine the feasibility of the infiltration pond for each scenario:

- Calculate the pond area (Ha) needed to dispose of the peak excess water disposal rate (11 ML/day) assuming the vertical flux / infiltration rate estimated by the model for the Silcrete layer, and
- Assess the feasibility of constructing / operating the estimated pond size.

The model scenario “Reported Values” is considered the base case and adopts the hydraulic conductivity values reported by Tellus (2021) in Table 6-3. The other model scenarios test variations of parameter values over the adopted ranges presented in Table 6-3. The determining factor/parameter for infiltration is shaded in light blue for each scenario in Table 6-5.

These results in Table 6-5 show the determining factor for infiltration is the hydraulic conductivity of the Silcrete layer in most instances. The vertical flux is directly proportional to the order of magnitude change to the Silcrete conductivity even when other parameters are changed. The only exception to this is when the Sandstone conductivity is decreased below that of the Silcrete then it becomes determining factor of the infiltration rate. The conductivity of the regolith Sand is shown to have minimal impact on the rate of infiltration or the time to saturation.

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Changing the thickness of the Silcrete layer was shown to have an impact on infiltration rates, with the thinner Silcrete layer resulting in a 45% increase in the rate of infiltration for the same model parameters. The time to saturation for the 50 m profile is also reduced for the majority of scenarios tested, due to the decreased thickness of the Silcrete, apart from the two model scenarios where Silcrete conductivity is elevated relative to Sandstone. In which case the increased modelled thickness of the Sandstone increases the time to saturation.

Figure 6-3 compares the infiltration pond areas associated with different combinations of Silcrete and Sandstone hydraulic conductivities and Silcrete layer thicknesses. The results in Figure 6-3 and Table 6-5 show that for almost all scenarios, the pond size needed to infiltrate 11 ML/day of excess dewater is greater than 100 Ha, which would be impracticable and cost prohibitive. The few scenarios which resulted in potentially feasible pond areas (i.e. ~10 Ha or less) are associated with less likely hydraulic conductivity values and combinations.

The results therefore suggest that the excess water is unlikely to vertically infiltrate through the Silcrete at a sufficient rate needed to prevent mounding of groundwater. The following options should therefore be explored (in order) to further assess feasibility of the infiltration pond concept:

1. Potential to move the infiltration pond to a location where no Silcrete layer is present,
2. Explore options to increase the vertical conductivity of the Silcrete later, and
3. Complete more detailed 3D numerical modelling to simulate mounding of groundwater above the Silcrete layer and the lateral spread of water through the Sand layer.

*Table 6-5. Hydrus-1D modelling results and pond areas needed to infiltrate 11ML/day **

Model Scenario	Silcrete thickness (m)	Silcrete Ks (cm/day)	Regolith Sand Ks (cm/day)	Sandstone (cm/day)	Time for saturation (days)	Flux (cm/day)	Area (ha)
Reported values (base case)	26	0.43	1,000	20	465	0.52	213.2
Regolith sand $x10^{-2}$		0.43	10	20	472	0.51	214.8
Sandstone $x20^{-1}$		0.43	1,000	1	717	0.52	213.2
Silcrete $x10^{1}$		4.32	1,000	20	65	5.15	21.4
Silcrete $x10^{1}$, Regolith Sand $x10^{-2}$, Sandstone x0.25		4.32	10	5	90	4.83	22.8
Silcrete $x10^{1}$, Regolith Sand $x10^{-2}$, Sandstone $x20^{-1}$		4.32	10	1	138	1	110.0
Silcrete $x10^{2}$		43.20	1,000	20	35	12.6	8.7
Reported values	15	0.43	1,000	20	306	0.75	146.5
Regolith sand $x10^{-2}$		0.43	10	20	330	0.73	150.5
Sandstone $x20^{-1}$		0.43	1,000	1	537	0.75	146.5

Model Scenario	Silcrete thickness (m)	Silcrete Ks (cm/day)	Regolith Sand Ks (cm/day)	Sandstone (cm/day)	Time for saturation (days)	Flux (cm/day)	Area (ha)
Silcrete x10[1]		4.32	1,000	20	48	7.51	14.6
Silcrete x10[1], Regolith Sand x10[-2], Sandstone x0.25		4.32	10	5	153	5.64	18.9
Silcrete x10[1], Regolith Sand x10[-2], Sandstone x20[-1]		4.32	10	1	149	1.00	110.0
Silcrete x10[2]		43.2	1,000	20	51	11.00	10.0

** Cells highlighted in light blue show the hydraulic conductivities governing the vertical infiltration rate*

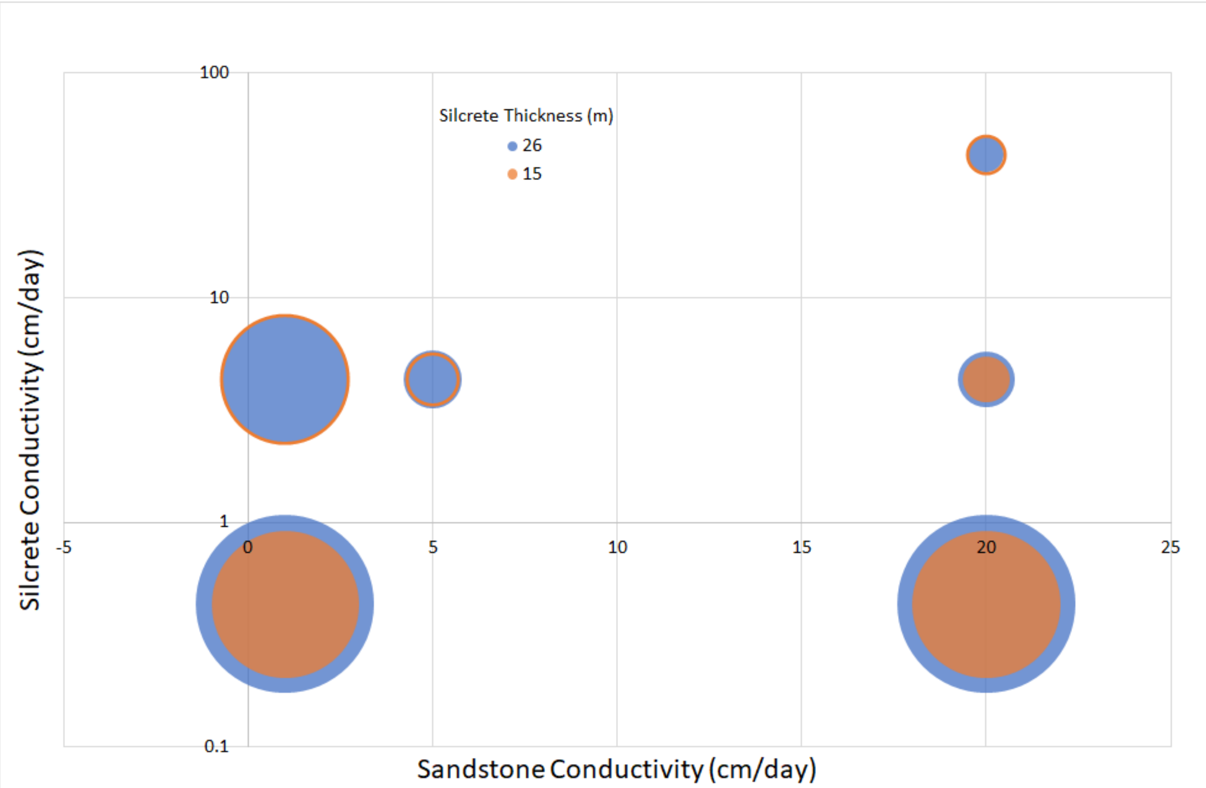


Figure 6-3. Infiltration pond areas and associated Silcrete and Sandstone hydraulic conductivities, and Silcrete layer thickness

6.3.2 Alternative pond locations

Advisian liaised with Rio Tinto's mine planning team to try and identify alternative locations where the Silcrete layer is not present. A Leapfrog model developed by Rio Tinto was used to interrogate geological data across the site, with the results presented in Appendix D.

The results suggest there are unlikely to be any locations around the mine site where Silcrete layer is not present and therefore the preferred Site 07 should be adopted. No 1D modelling of alternative sites was completed.

6.3.3 Increasing hydraulic conductivity of the Silcrete Layer

The following two potential methods were explored to increase the vertical hydraulic conductivity of the Silcrete layer at Site 07:

Method 1: Blasting the Silcrete, and

Method 2: Drill holes through Silcrete and backfill with gravel pack.

The results of each scenario are summarised below.

6.3.3.1 Method 1: Blasting the Silcrete

The results of 1D infiltration modelling presented in Table 6-5 were used to assess the feasibility of blasting the Silcrete layer to increase vertical hydraulic conductivity. The reported hydraulic conductivity of Silcrete (Tellus, 2021) presented in Table 6-3, was increased by factors of 10x and 100x to represent the potential impact blasting may have on the vertical conductivity of Silcrete, estimated vertical flux and resulting size of infiltration pond required to infiltrate at a constant rate of 11 ML/day (127 L/s).

Sensitivity analysis was also performed to test model (pond) sensitivity to changes in (a) Silcrete thickness and (b) Sandstone and Sand hydraulic conductivities. The results suggest that practical pond sizes may be achieved but only under certain and limited number of scenarios. Most scenarios resulted in unfeasible pond sizes.

There is uncertainty associated with (a) the hydraulic conductivity that could be achieved by blasting, and (b) whether the blasted Silcrete layer could clog with time, thus reducing hydraulic conductivity. These uncertainties make this method less favorable/feasible.

6.3.3.2 Method 2: Drill holes through Silcrete and backfill with gravel pack

This scenario would involve drilling numerous holes through the Silcrete layer and backfilling with gravel pack to increase the effective hydraulic conductivity of a given pond area.

The equivalent hydraulic conductivity of an area perforated by drill holes and backfilled with gravel will depend on:

- the spacing used between holes,
- the drill hole radius,
- the conductivity of the gravel back fill, and
- the conductivity of the low conductivity Silcrete layer.

To account for these factors, the following equation was used, where Xm^2 is the area of the grid spacing used between holes:

$$Kequivalent = \frac{\pi r^2 \times \text{Kgravel} + \text{Ksilcrete}(\text{X}m^2 - \pi r^2)}{\text{X}m^2}$$

The surplus water rate of 11 ML/day was then divided by this new K*equivalent* to calculate the area required to manage the input of the surplus water. This area is then divided by the drill hole spacing area to determine the number of wells needed and shown to be sensitive to minor changes in the hydraulic conductivity of the gravel and the well diameter.

The results of 1D infiltration modelling assuming different drill hole spacings are provided in Table 6-6. These results are based on an assumed hydraulic conductivity of Silcrete of 0.43 cm/day. These estimates are indicative only but suitable for assessing feasibility of the method. The calculations do not factor in any limitations associated with flow from the gravel filled holes into the underlying Sandstone.

Figure 6-4 presents the number of bores and required pond areas for a range of drill hole spacings.

The results suggest that an unrealistic number of drill holes would be required and for most scenarios, resulted in impracticable and cost prohibitive pond sizes. Therefore, this method of increasing conductivity was not explored further.

Table 6-6. Number of backfilled drillholes and pond area required to infiltrate 11ML/day

Drill hole spacing	Drill hole area (m^2)	Kgravel (cm/day)	Well diameter (inch)	Kequivalent (cm/day)	No. of wells required	Land required (ha)
2x2m	4	1,000	16	32.8	8,372	3.4
3x3m	9			14.8	8,237	7.4
5x5m	25			5.6	7,831	19.6
10x10m	100			0.6	6,363	63.6
20x20m	400			0.8	3,637	145.5
50x50m	2500			0.5	909	227.3
2x2m	4	1,000	22	61.7	4,456	1.8
3x3m	9			27.7	4,417	4.0
5x5m	25			10.2	4,298	10.7
10x10m	100			0.7	3,815	38.2
20x20m	400			1.0	2,632	105.3
50x50m	2500			0.5	830	207.5
2x2m	4	1,500	16	49.1	5,605	2.2
3x3m	9			22.0	5,544	5.0
5x5m	25			8.2	5,358	13.4
10x10m	100			2.4	4,627	46.3

Drill hole spacing	Drill hole area (m^2)	Kgravel (cm/day)	Well diameter (inch)	Kequivalent (cm/day)	No. of wells required	Land required (ha)
20x20m	400			9.2	2,995	119.8
50x50m	2500			0.5	863	215.8

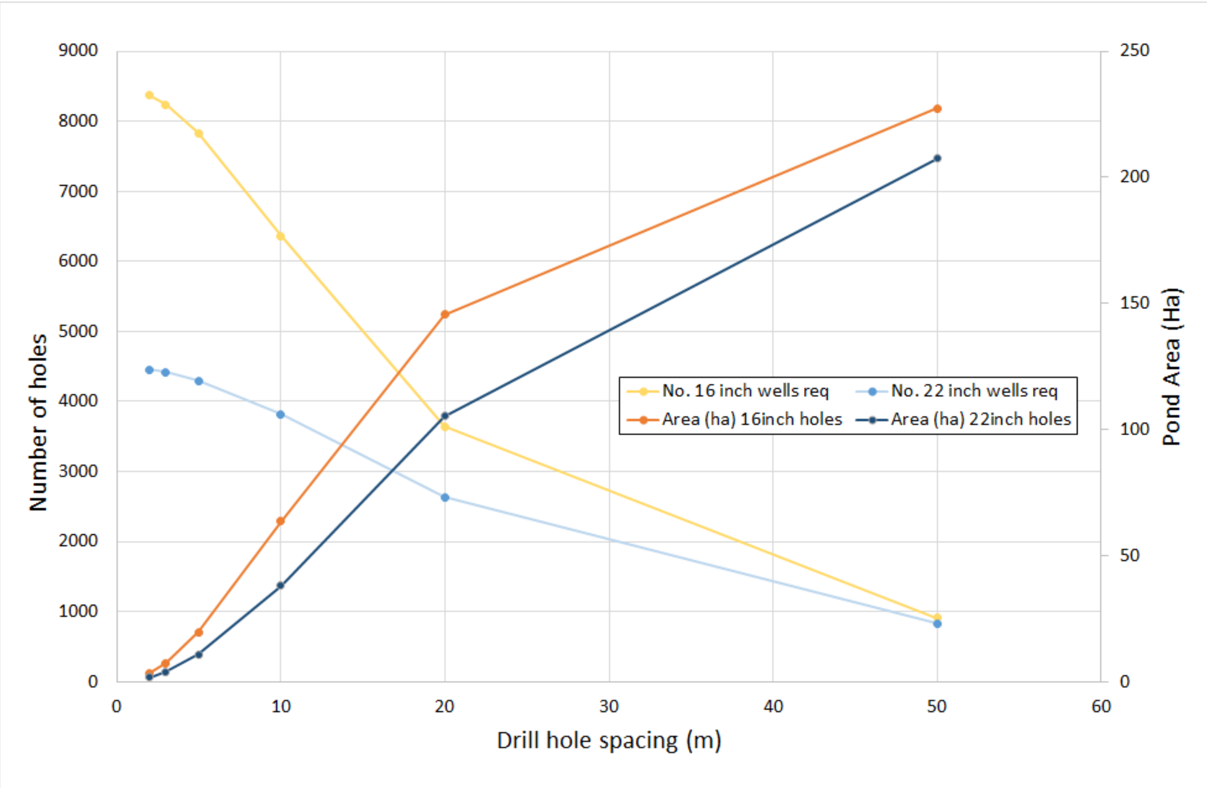


Figure 6-4. Number of bores and required pond area for given drill hole spacings

6.4 Conclusions

The results of 1D infiltration modelling suggest that the excess water is unlikely to vertically infiltrate through the Silcrete at a sufficient rate to prevent mounding of groundwater. The following alternative options were explored:

- Move the pond to a location where Silcrete is not present, and
- Options to increase vertical hydraulic conductivity of the Silcrete layer.

The available geological and hydrogeological records suggest that the Silcrete layer is likely to be present everywhere across the site and the modelling shows that the options available to increase vertical hydraulic conductivity of the Silcrete layer are unlikely to increase conductivity sufficiently to allow free flowing vertical infiltration using a 1D infiltration model.

These results were discussed with Rio Tinto and concluded that more detailed 3D numerical modelling of the infiltration pond option (Infiltration Pond Option) was required to simulate mounding of groundwater above the Silcrete layer and the lateral spread of water through the Sand layer.

It was also concluded that an alternative option of excavating out the Silcrete layer as part of quarrying activities and using the void to discharge and infiltrate water should also be explored (Quarry Infiltration Option).

7 Assessment of infiltration pond and quarry options

The following two options were assessed in detail using a numerical groundwater model, to assess the feasibility of using infiltration for managing excess mine dewater at the Winu mine site:

- **Infiltration Pond Option:** constructed at ground surface and infiltrating into the surficial Sands. Infiltrated water spreads within the Sand layer, laterally across the top of the Silcrete layer, and
- **Quarry Infiltration Option:** an approximate 30m deep excavation, removing the Sand and Silcrete layer as part of quarrying activities and using the void to discharge and infiltrate water, primarily into the Sandstone layer.

7.1 Concept design

7.1.1 Infiltration pond option

7.1.1.1 Initial sizing

A pond size was initially adopted for the assessment, based on previous experience and similar inflow rates. The selection of pond dimensions also considered site constraints.

In summary:

- At the current preferred site for the infiltration pond at (Site 07), the width of the pond is constrained by the sand dunes. The length of the pond is unconstrained (within practical limits),
- Features of previous infiltration pond designs recently developed by Advisian for other projects are described below:
    - o Ponds were located on highly permeable soil/ground conditions with thick unsaturated zones,
    - o Adopted long and narrow infiltration ponds configured with several cells per set (500 m long with each cell approximately 20 to 50 m wide), which can infiltrate up to 10 ML/day,
    - o Average depth of ponds of around 1.5 m with 1.0 m operating water depth.
- Adopting a narrow construction allows the placement of excavated material between each pond so that it does not have to be transported out of the area hence a very efficient layout. It also minimizes earth moving traffic on the pond floor which reduces floor compaction (which can limit infiltration).

The following pond design was adopted for numerical modelling and feasibility assessment:

- 100 m effective pond width between dunes (to not impact on dunes) comprising two cells each 50 m width to facilitate maintenance and cleanout regimes,
- 500 m effective pond length, and

- 1.5 m high embankments with 1m operating water depth, assuming peak discharge rate of 11 ML/day.

7.1.1.2 Water balance calculations

A basic spreadsheet water balance model was developed using the pond dimensions, evaporation rate, estimated infiltration rates (Section 6) and the inflow rates over the life of mine (Section 2). A summary of the model inputs is provided in Table 7-1.

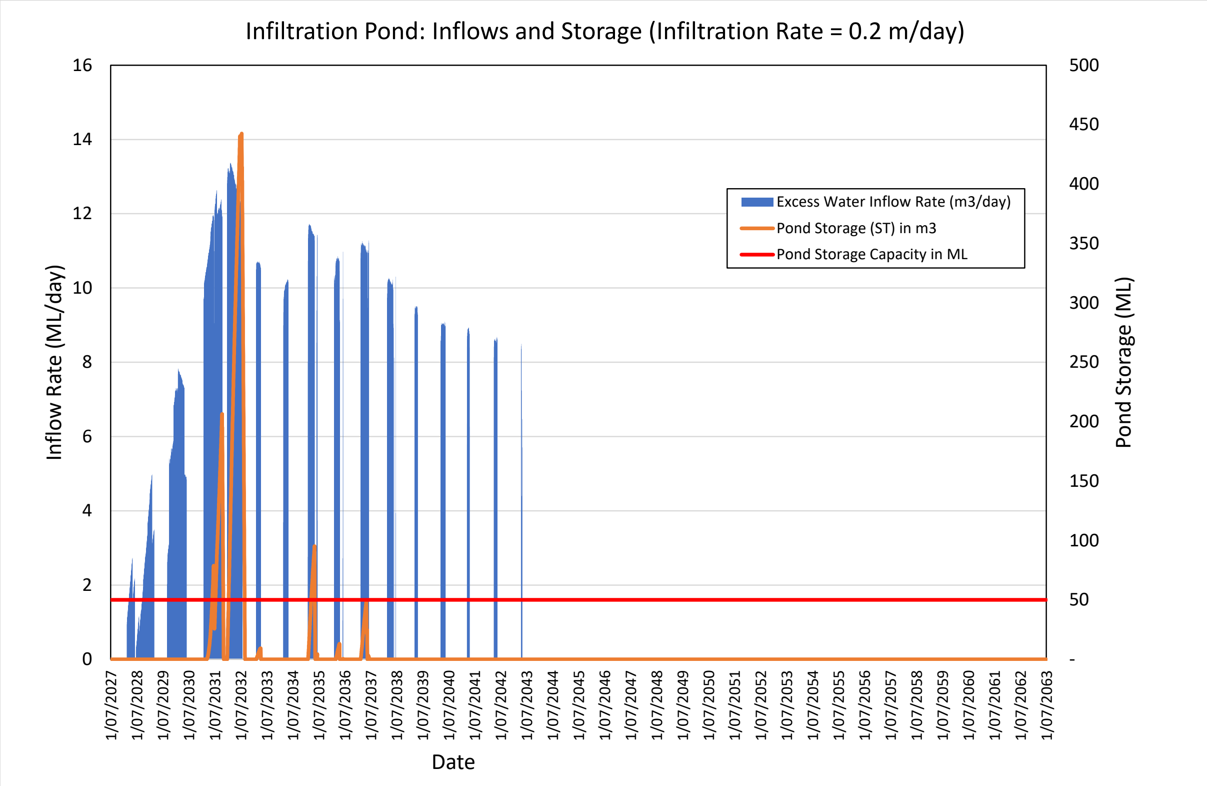
Monthly and daily inflow timeseries (Section 2) were simulated using the water balance model, and infiltration rates varied between 5 and 20 m/day based on typical ranges for Sand. The results showed that all excess water is infiltrated when adopting infiltration rates of between 5 and 20 m/day.

However, as the 1D infiltration modelling indicated that vertical infiltration will be limited by the Silcrete layer, the water balance modelling was tested at progressively lower infiltration rates from 1 m/day to 0.1 m/day, to see what effect this has on pond performance. The model results presented in Figure 7-1, suggest that the performance of the pond reduces when the vertical infiltration rates reduce to around 0.2 m/day, impacting on the ponds ability to store and infiltrate water during peak inflow periods.

As the hydraulic conductivity of the Silcrete layer is expected to be less than 0.2 m/day (Table 6-3), the feasibility of the infiltration pond will be dependent on the thickness and hydraulic conductivity of the surficial Sand layer, determining the rate and extent at which infiltrated water will spread laterally away from the pond and extent of mounding.

Table 7-1. Infiltration pond water balance inputs

Model parameter	Value
Pond width	100 m
Pond length	500 m
Pond area	50,000 m^2
Water depth (in pond)	1 m
Max pond depth capacity	1.5 m
Infiltration rate (range)	5 – 20 m/day 150 – 600 m/month
Max operating pond storage capacity	50,000 m^3 50 ML
Evaporation (BoM, 2023)	3.6 m/yr/m^2 0.3 m/month/m^2 0.01 m/day/m^2



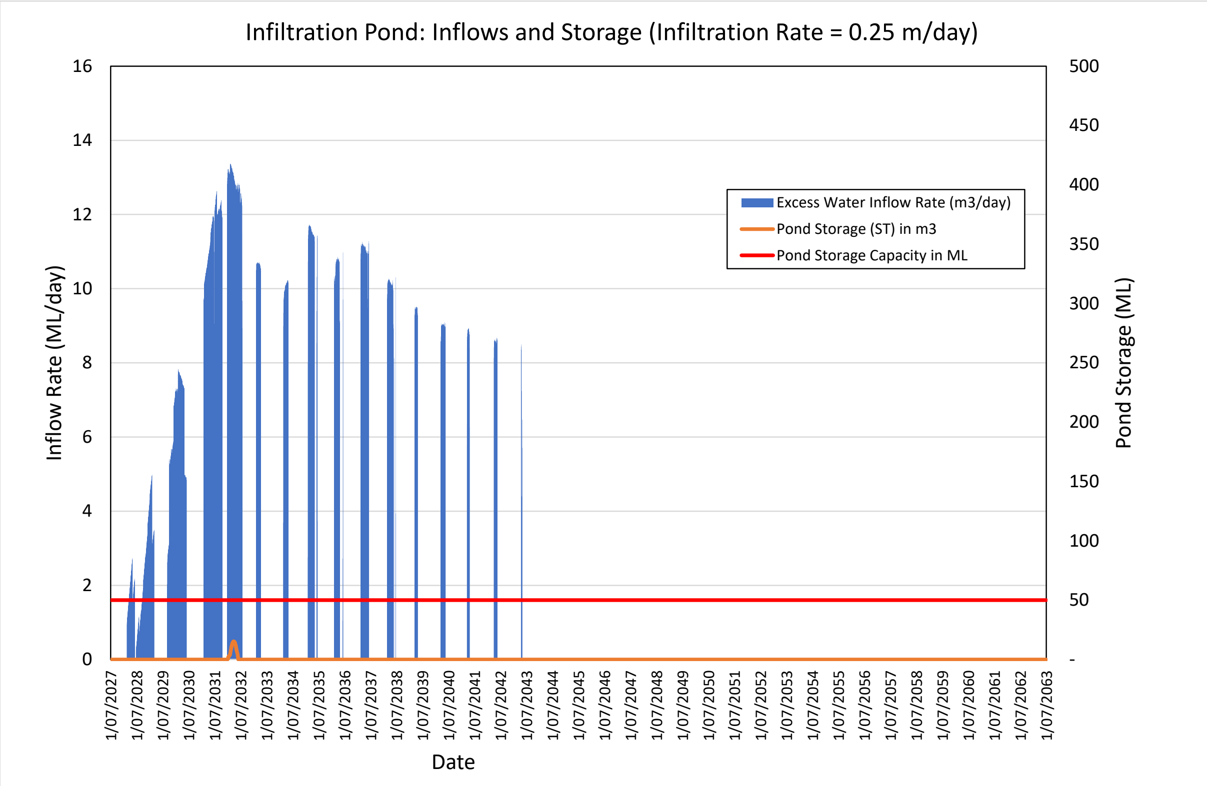


Figure 7-1. Infiltration pond inflows and storage, assuming infiltration rates of 0.2 m/day (top) and 0.25 m/day (bottom)

7.1.1.3 Pond maintenance

Available water quality data was analyzed to assess the following in relation to likely maintenance of the pond:

- Determine if there is a potential for fouling / scaling of the pond floor which would inhibit infiltration and require regular maintenance for clean out, and
- Review what existing aquatic vegetation is in the area and what its likely growth rate is when provided with a continuous water source.

Five water quality results for bores WINU0076 and WINU0080 (years 2019 to 2022) were averaged to provide an indication as to the likely water quality that would report to the infiltration pond. The following observations were made from the results:

- The water is expected to be slightly alkaline with a pH of 7.8 and moderately saline (approx. 2,500 μS/cm),
- Reported suspended solids (TSS) are quite high for a groundwater source, at 26 mg/L. The water will appear cloudy and it is expected that particulate will settle once stagnant,
- Iron content is elevated and it is expected that the iron will oxidise rapidly at the given pH once the water comes into contact with oxygen. It is suspected that the oxidised iron (and other metals) is causing the elevated suspended solids value described in the point above,
- The averaged Total Organic Carbon (TOC) is greater than 1 mg/L which is unusual for a groundwater source but it was highly variable between bores and samples. Suspect that this is due to contamination or from drilling muds etc,
- The Chemical Oxygen Demand (COD) is high at 15 mg/l but it is expected that this is due to the oxidation of iron and other metals in the water,
- Aluminium, cobalt, copper, manganese and nickel are all within typical ranges although all are likely to precipitate as oxides / hydroxides under these water conditions, and
- A slightly negative LSI indicates that the water will be mildly corrosive to unprotected carbon steel.

In general terms the water can be considered as good quality. The primary concern with the indicated water quality with respect to discharge to an infiltration pond is the suspended solids value. If the surplus water is to be pumped directly from the dewatering bores to the infiltration pond at a peak inflow of 11 ML/d, the amount of solids that would be expected to settle in the pond would be approximately 290 kg/d. If over the life of the operation this level of inflow occurred for 1000 days, the total solids deposition would be in the order of 290 tonne which equates to 5.8 kg/m^2 of material over the pond floor. In reality, the deposition will not be spread evenly over the pond floor but would instead concentrate in the vicinity of the inlet pipe. It would be necessary to have multiple pond inlets that could be operated independently to more evenly spread the solids and also it would be expected that the pond would need to be cleaned every few years at least adjacent the inlet pipes.

The proposed configuration of the dewatering / surplus water system includes a water storage located between the bores and the infiltration ponds. The nature of the suspended solids is expected to be such that they will settle quickly in this intermediate storage and that the surplus water carried over into the infiltration pond will have a low TSS value. It is expected that the infiltration pond will be able to operate over its life without being cleaned from solids accumulation.

The other cause of pond maintenance and cleaning is from aquatic vegetation. Infiltration ponds in the Pilbara's iron ore region are prone to very rapid vegetation growth due to seed transport from birdlife and other wildlife. It is not unusual for the ponds to be cleaned every two to three years to control this growth. To assess if the Winu infiltration pond would be subject to the same level of vegetation growth, the Winu Mine Pit Lake Preliminary Environmental Risk Assessment by Mine Lakes Consulting, 2021 was used as guidance. The Pit Lake Assessment concludes that there will be several migratory bird species attracted to the artificial water bodies that the project will create. Although the distance that plant material has to be transported is significantly greater than that in the iron ore regions, it should be assumed that the expected birdlife will initiate plant growth in the infiltration pond. For this reason it is recommended to divide the infiltration pond into at least two cells such that one can be taken off line for periodic cleaning.

Ramps should be included in the pond designs to provide access for cleaning and maintenance, with entry and exit ramps included at opposite ends of each cell to allow vehicles to drive through the cells and out the other side. The concept designs presented for this OoM study (Section 8) do not include the ramps, however they should be included in future phases of design.

The proposed infiltration pond configuration is two 50 m x 500 m pond cells (per pond) which can be operated in parallel or individually. During period of high inflow both cells would operate and then during low inflow events one cell could be taken offline for cleaning.

7.1.1.4 Pond embankment construction

The conceptualisation presented in Section 6.2.2.1, suggests the subsurface conditions at the proposed Site 07 pond location comprise an approximate 10 m thick surficial Silty Sand layer, underlain by an approximate 15 to 26 m thick Silcrete layer. The Silcrete is underlain by Sandstone.

Winu Soil Characterization Report by Landloch (2020) characterises the shallow Silty Sand materials as loamy, dry, and loose. Silty Sand is highly permeable, and it can be used as an embankment construction material if constructed with a liner to protect from water seepage.

In-situ Silcrete materials have low permeability, and once it is excavated, it they will be broken down to boulders and angular fragments (duricrusts). These materials are suitable for the embankment construction; however, the embankments must be lined to avoid lateral seepage. A further geotechnical investigation is required to assess the suitability of Silcrete material for the pond construction.

Considering the weather conditions of the site, it is recommended to provide the liner across the perimeter of the embankments to protect from the heavy wind and the storm events.

Advisian recommends consideration of the following two liners options for the pond embankment design:

- high-density polyethylene (HDPE), and
- concrete canvas materials.

Both options have pros and cons which are discussed below.

Liner Option 1: HDPE

HDPE liners are a relative cheaper material to import and flexible to construct. It is relatively light in weight, and the protection layer such as rip rap is required to cover the liner. A conceptual design for Liner Option 1 is depicted in Figure 7-2.

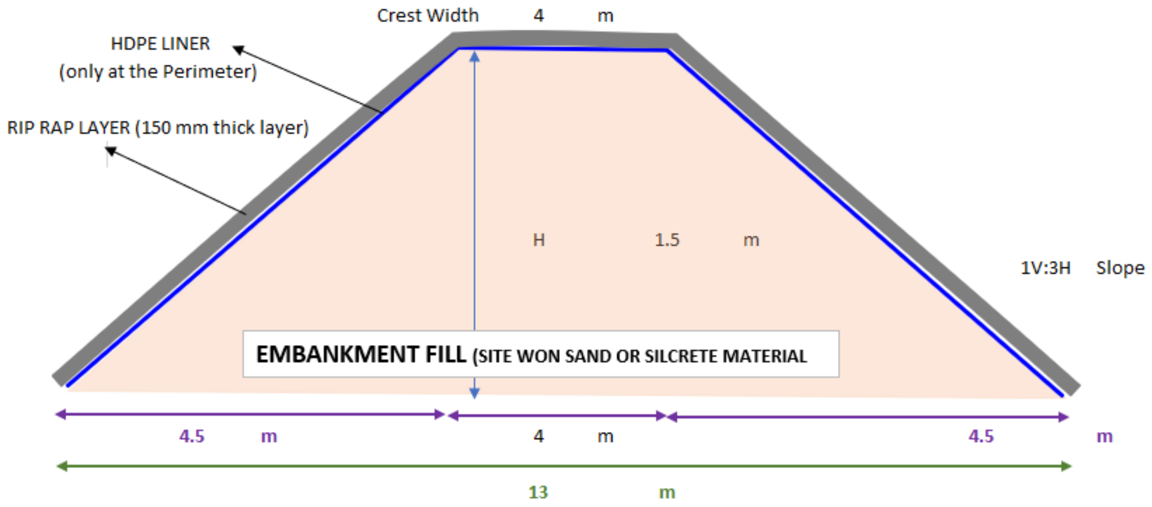


Figure 7-2. Liner Option 1 – Embankment cover with HDPE liner and protection rip rap layer (not to scale)

Liner Option 2: Concrete Canvas

Concrete canvas is significantly more expensive option however the installation is simpler and will have less maintenance over the life of the asset. Due to concrete canvas self-weight, there is no requirement for a rip rap protection layer. A conceptual design for Liner Option 2 is depicted in Figure 7-3.

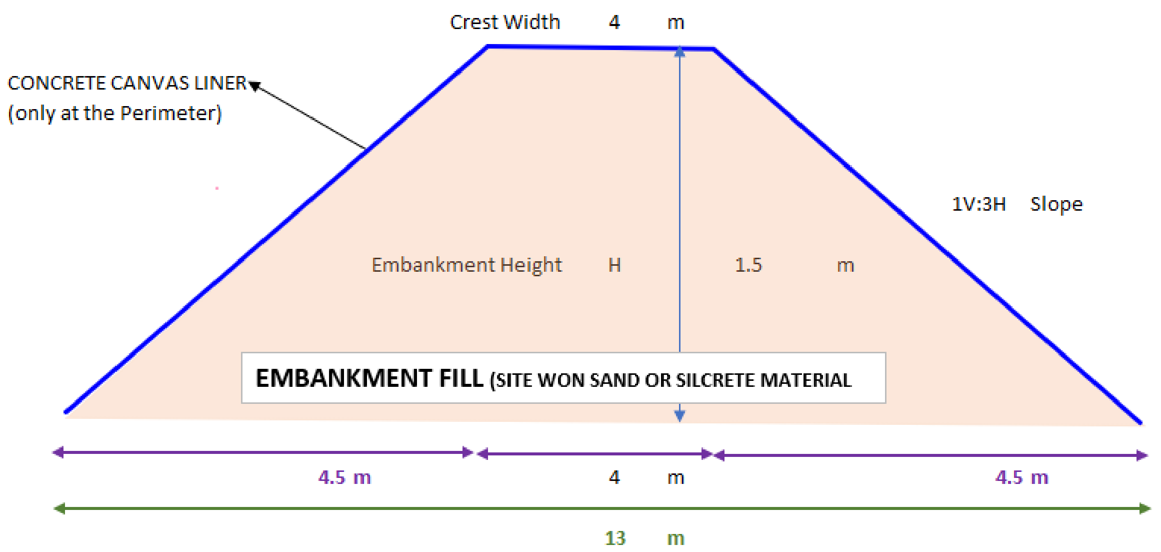


Figure 7-3. Liner Option 2 – Embankment covered with concrete canvas layer (not to scale)

A detailed geotechnical assessment of available construction material is required to characterise the available materials and confirm suitability of adopted materials for pond embankment construction, and associated costs. The adopted construction material and design specifications should be consistent with Winu Preliminary Study Earthworks and Site Preparation Engineering Specification Document (Rio Tinto, 2020).

7.1.2 Quarry infiltration option

7.1.2.1 Initial sizing

The quarry was assumed to have the same effective base area as the infiltration pond (100m x 500m) to allow a like for like comparison. The quarry will be excavated down to the estimated top of Sandstone layer, with the Silcrete material sourced for construction materials. The top of Sandstone is estimated to be 30 mbgl (Table 6-1).

To determine the total extent of the quarry excavation, allowance is made to accommodate cut slopes, estimated using the bench face angles (BFA), bench heights and widths provided by Rio Tinto mine planning for pit design and presented in Table 7-2 (Rio Tinto, 2023). Assuming the lithology in Table 6-1 and pit design parameters in Table 7-2, a indicative cut slope geometry was developed for the quarry and presented in Figure 7-4. The results suggest that an allowance of 50m should be made to accommodate the cut slopes at the quarry. A nominal allowance of an additional 20m should also be made to accommodate a safety bund with 10m setback and to provide some access around the quarry. This results in a total estimated disturbance footprint area of 240m x 640m for the quarry.

Table 7-2. Bench face angles (BFA), bench heights and widths provided by Rio Tinto mine planning (Rio Tinto, 2023)

Geotechnical Unit / Layer	BFA (°)	Bench Height (m)	Bench Width (m)
Sand	37°	30	10.5
Regolith (Silcrete)	55°	10	7.5
Sandstone	80°	10	8.0

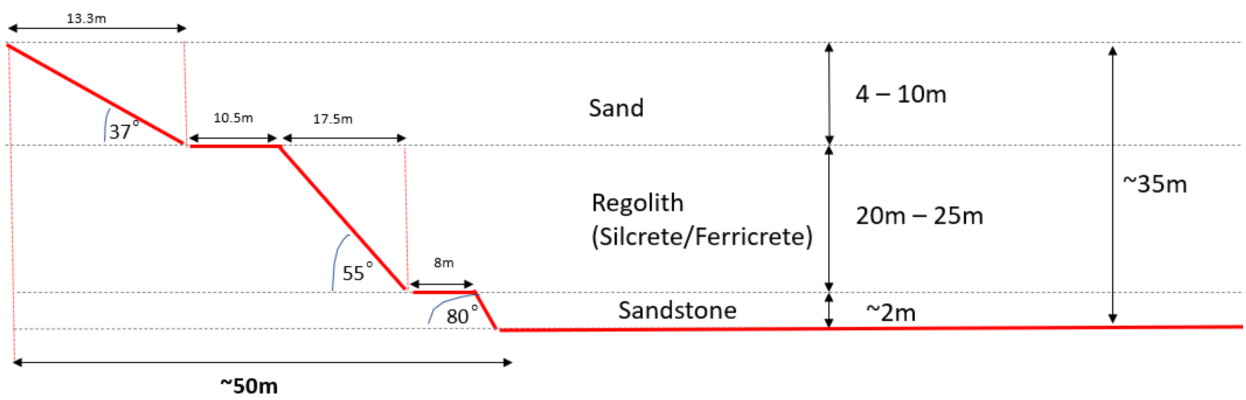


Figure 7-4. Assumed cut slope geometry for quarry excavation

7.1.2.2 Water balance calculations

A basic spreadsheet water balance model was developed using the quarry base dimensions, evaporation rate, estimated infiltration rates (Section 6) and the inflow rates over the life of mine (Section 2). A summary of the model inputs is provided in Table 7-3.

Monthly and daily inflow timeseries (Section 2) were simulated using the water balance model, and infiltration rates varied between 0.5 and 5 m/day based on typical ranges for Sandstone. The results showed that all excess water is infiltrated when adopting infiltration rates of between 0.5 and 5 m/day.

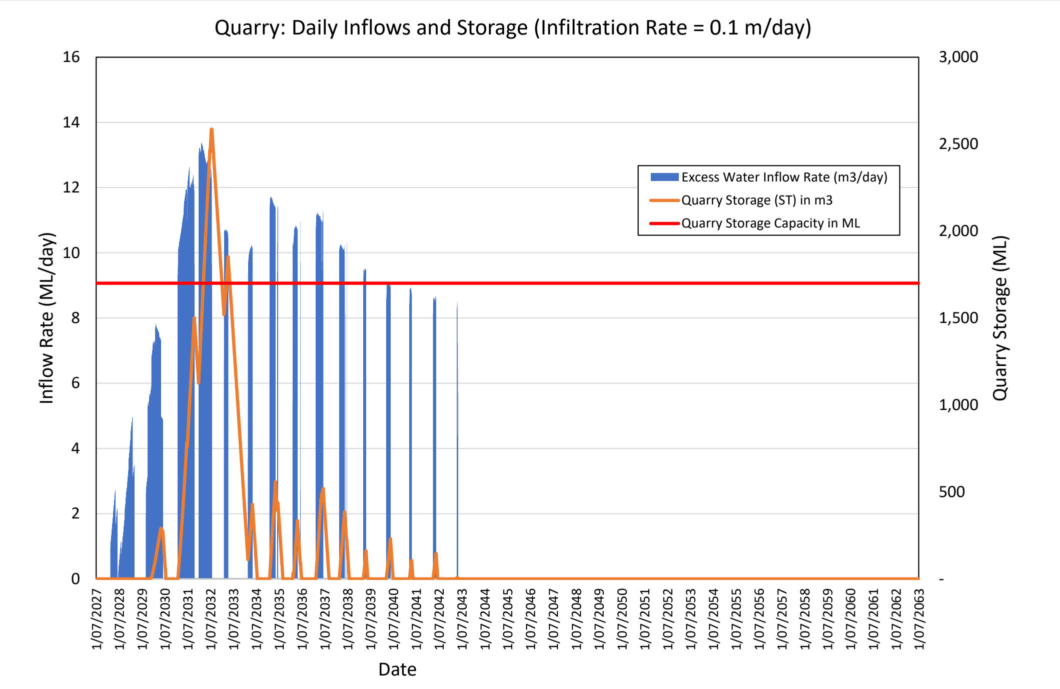
To test sensitivity to reductions in hydraulic conductivity of Sandstone over time, infiltration rates were progressively reduced from 0.5 to 0.1 m/day. The model results presented Figure 7-5, suggest that the performance of the quarry infiltration reduces when the infiltration rates reduce to around 0.1 m/day, impacting its ability infiltrate water during peak inflow periods. However, the water balance model does not consider the available storage and lateral infiltration that would occur into the upper Sand layer when water levels in the quarry rise above the Silcrete layer, which would help maintain water levels below natural ground level during peak inflow periods.

The results suggest that even with infiltration capacities reduced by a factor of 5 to 50 times the natural range, water levels in the quarry are likely to rise, but can be maintained by infiltration of water laterally into the upper Sand layer during peak periods.

Table 7-3. Quarry water balance inputs

Model parameter	Value
Quarry width at base	100 m
Quarry length at base	500 m
Pond area at base	50,000 m^2
Water depth	Can vary up to ~34 m
Max pond depth capacity	35 m
Infiltration rate (range)	0.5 to 5 m/day 15 – 150 m/month
Max operating pond storage capacity	1,700,000 m^3 1,700 ML
Evaporation (BoM, 2023)	3.6 m/yr/m^2 0.3 m/month/m^2 0.01 m/day/m^2

** Maximum storage capacity assumes vertical walls*



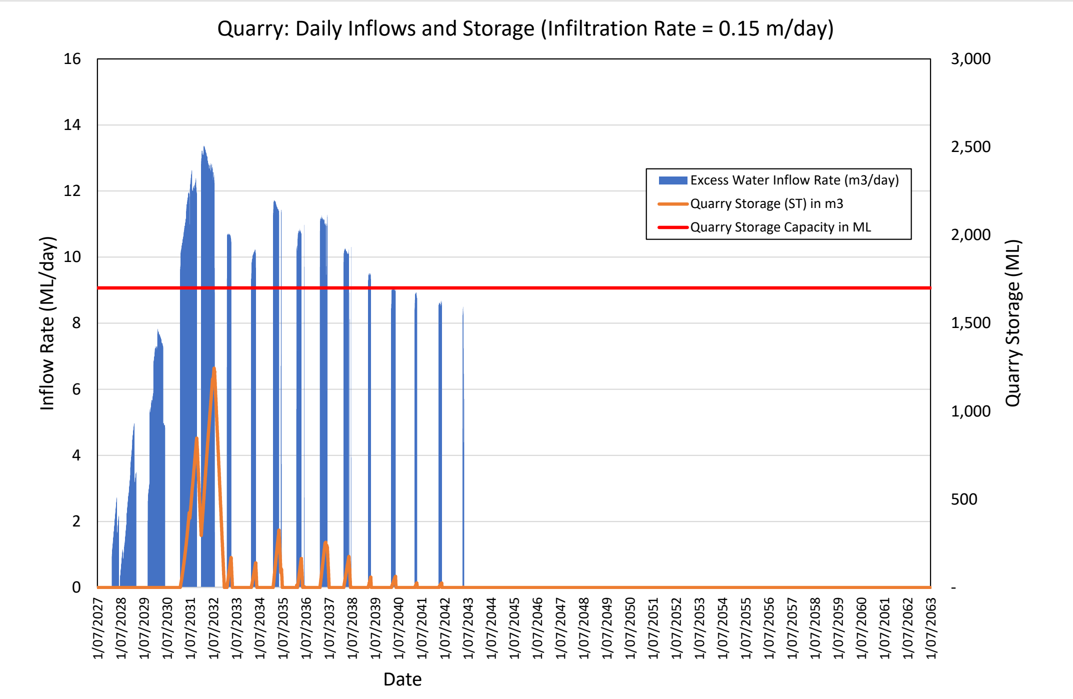


Figure 7-5. Quarry inflows and storage, assuming infiltration rates of 0.1 m/day (top) and 0.15 m/day (bottom)

7.1.2.3 Quarry maintenance

The results of water quality analysis described in Section 7.1.1.3, suggest that the risk of fouling / scaling of the quarry floor or accumulation of aquatic vegetation is low. Although quarry design is out of scope for this study, it is anticipated that it may be feasible to include an internal embankment along the base of the quarry if required to create two cells which would allow for routine maintenance during low excess water in flow periods.

7.1.2.4 Quarry construction

It is assumed that the quarry design will be developed using results from intrusive geotechnical investigations and laboratory testing and constructed by Rio Tinto operations. Perimeter bunding is required for safety and to prevent ingress of surface water from surrounding areas.

7.2 Relocation of infiltration pond and quarry options

The estimated initial pond and quarry areas, topographic survey data, aerial imagery, mine infrastructure layouts and mining lease boundaries were used to assess the feasibility of locating the pond and/or quarry options at Site 07. The results presented to Rio Tinto on the 20th June 2023 showed that the quarry would impact on the dunes and that the pond would potentially constrain existing infrastructure. Nearby alternative sites were explored with Rio Tinto to identify a location which provided sufficient area needed to accommodate both options without impacting on the dunes and providing additional contingency area if required. It was agreed that the infiltration pond / quarry site should be relocated approximately 1 km south-east to a proposed stockpile area, shown in Figure 7-6. The stockpile design will be updated to accommodate the infiltration pond / quarry.

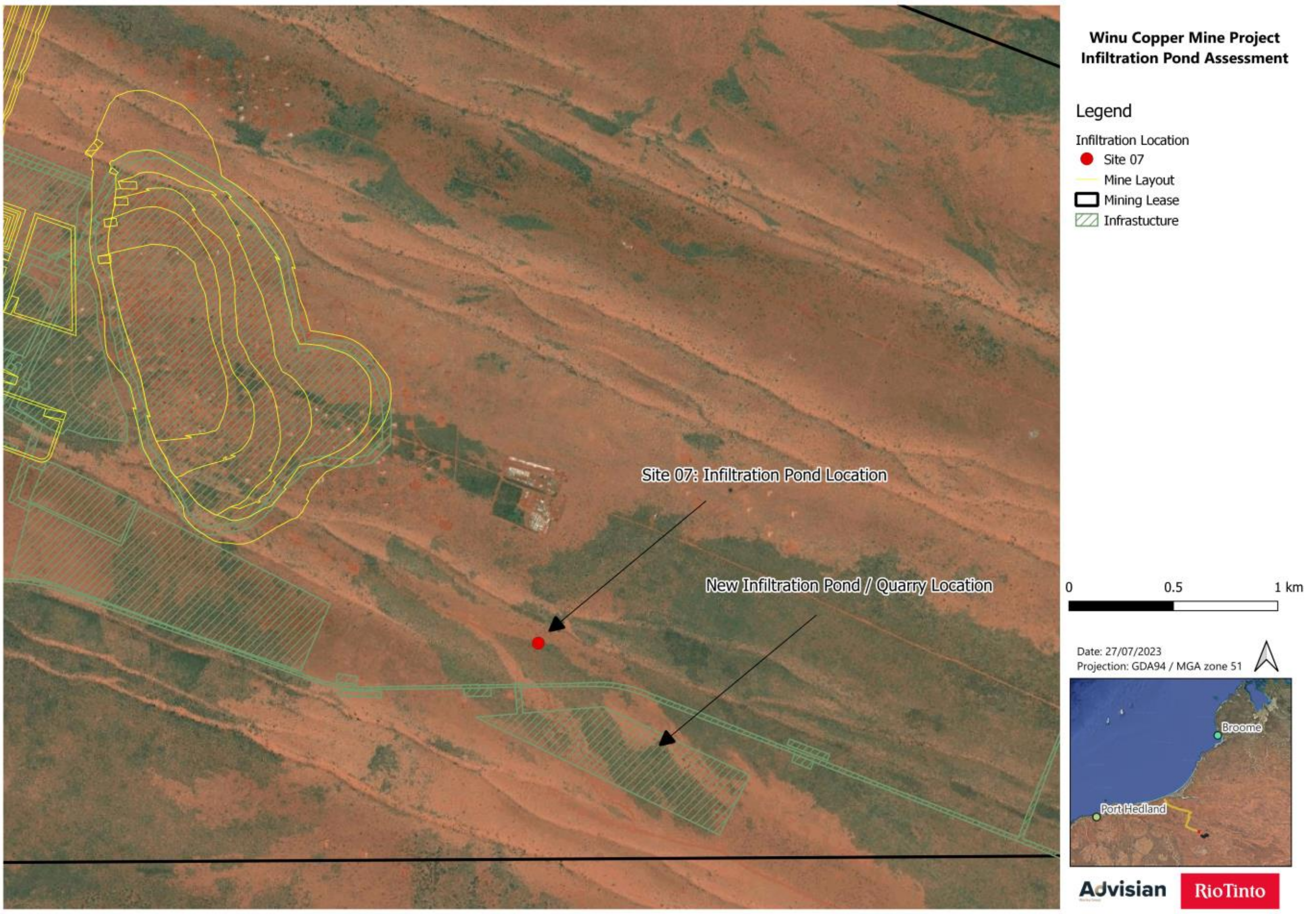


Figure 7-6. Original Site 07 and new location for Infiltration Pond and Quarry Infiltration Options

7.3 Numerical modelling

7.3.1 Objectives

The objectives of the numerical modelling are to take the initial concept pond and quarry designs described in Section 7.1.1.1 and 7.1.2.1, simulate infiltration of monthly excess water estimates over the life of mine (Section 2) and use the results to determine whether:

- There is overtopping of the infiltration pond / quarry due to storage capacity exceedance which would also indicate surface expression of groundwater due to mounding, and
- There is recirculation of infiltrated water in the mine pit and associated inflow rates.

7.3.2 Infiltration pond option

7.3.2.1 Model set up

A numerical groundwater model was developed in MODFLOW-USG by Advisian as part of the Winu Dewatering Strategy and Groundwater Supply Update (Advisian, 2022b). This previous model included a single top layer lumping the surficial Sand and the underlying Sandstone into a single layer, which is largely unsaturated and did not consider the Silcrete as that near surface unit does not influence the mine dewatering estimates. The following amendments were made to the numerical groundwater model to allow it to be used to simulate infiltration and assess the feasibility of the pond option.

Model Layers

The model was converted to a 2-layer model, with the two layers described below:

- **Layer 1 (Pond):** Top of later set to existing ground surface. Base of layer set to 1.5 m below existing ground surface. This layer contains the infiltration pond and assumes Sand properties for the purpose of modelling,
- **Layer 2 (Sand):** The top of this layer was defined by the topographic survey (LiDAR) data and the top of the Silcrete layer as follows:
    - o The initial silcrete layer was created by Rio Tinto using their geological database and Leapfrog (Rio Tinto Layer) and presented to Advisian for use on the 20th of April 2023 (Appendix E). This layer had some interpolation issues such as holes and other irregularities based on direct snapping techniques to logged geology data. The interpolation of these logs vary across site and data for interpolation is not consistent. The layer provided did not cover the entire area of interest and to extend this layer for modelling purposes, a new layer was created with interpolation and extrapolation techniques. Key steps adopted to create this new Silcrete layer are described below:
        - ▪ To fill in the holes in the initial layer, interpolation techniques were applied. Interpolating data based one average depth of surrounding data points,
        - ▪ After interpolating the holes in the Silcrete layer, extrapolation was then employed to extend the layer's coverage beyond the known data area (groundwater model domain). Extrapolation outside the known data range was done using FEFLOW to create an interpolated depth of Silcrete using the

average depth of Silcrete from the first interpolated layer (+-10 m below ground surface). This layer is based on the patterns and trends observed in the existing data. However, does not allow for small scale irregularities in the Silcrete spatial extend and assumes that the deposition of Silcrete is flat, following the regional elevation dip.

- The adopted method assumes that Silcrete deposition is relatively flat and that the thickness of Sand above the Silcrete layer will increase with topography (i.e. thicker Sand when closer to dunes),
- At the proposed infiltration pond site, the adopted Sand layer is between 11 to 12 m thick, and this thickness is slightly larger in surrounding areas where the topographic elevation is higher,
- The base of the Sand layer was set to an impervious boundary,
- It is recommended that site specific testing and intrusive hydrogeological investigations are conducted at the proposed pond locations to confirm the thickness of Sand / depth to Silcrete.

Initial groundwater levels

Although the Sand layer is practically unsaturated, the numerical model required an initial water level in the Sand layer which was represented as having nominal saturation, of 0.1 to 0.5 m. A 1000-year pre-infiltration run is modelled to optimise distribution of initial water levels.

Infiltration pond

The infiltration pond was simulated using a Lake (LAK) package, with LAK base at 254 m AHD and the overtopping level at 255.5 m AHD based on preliminary pond designs. Disposal of excess water into the pond is simulated as Lake (LAK package) 'withdrawal' (with negative value denoting addition). Evaporation from the pond is set at rate of 0.01 m/day. Inflows to the pond (LAK package) were based on estimated monthly excess water inflow rates presented in Section 2.

Mining pit

The mining pit was modelled using the Drain (DRN) package, with head elevation consistent with the base of the Sand layer. This ensures that if the groundwater mound developed at the infiltration pond, extends to the pit, then the water would spill (flow) into the pit. The DRN package also provides an estimate of inflow rates / volumes to the pit.

Boundary conditions

There are no throughflow boundaries due to 'unsaturated' status of this model. Modelling checks were conducted with nominal General Head Boundaries (GHB) in the north and south set at 0.5 m above the base of the Sand Layer and these did not indicate any differences in predictive results.

Recharge

No recharge was implemented in the model, for consistency with the dewatering model.

Evapotranspiration

The Evapotranspiration (EVT) package was used to simulate evaporative effects in the model. The implemented evaporation rate was 0.01 m/d (Table 7-1), with extinction depth 0.5 m. This appears to be only active in the immediate vicinity of the infiltration pond on occasions where groundwater mounding reaches the ground surface.

Hydraulic conductivity and storage parameters

The hydraulic conductivity and storage parameter values presented in Table 7-4 were adopted for numerical modelling. These values were based the ranges presented in Table 6-3, typical storage parameter values for Sand (eg. Johnson, 1967).

Stress Periods

The model was set up to run at monthly stress periods.

Table 7-4. Hydraulic conductivity and storage parameter values adopted for numerical modelling of the Infiltration Pond Option

Parameter	Sand Layer
Vertical conductivity (Kv) in m/day	
Kv - Base case parameter	5
Kv - Parameter ranges	2 to 10
Horizontal conductivity (Kh) in m/day	
Kh – Base case parameter	5
Kh - Parameter ranges	2 to 10
Storage parameters	
Specific storage (Ss) (1/m)	$1x10^{-5}$
Specific yield (Sy) (dimensionless)	0.25

7.3.2.2 Model scenarios

The scenarios described in Table 7-5 were simulated using the numerical infiltration pond model. The scenarios were progressively developed in consultation with Rio Tinto, so the results of Scenario 1 informed the development of Scenario 2, and so on for Scenarios 3 and 4.

The results of Scenario 1 with the hydraulic conductivity (K) set to 5 m/day (described in Section 7.3.2.3) suggested that additional pond area was required to effectively infiltrate excess water. Rather than increase the size of the 100 m x 500 m pond (Pond 1) it was decided to create an additional 200 m x 500 m pond (Pond 2) located east of Pond 1 where the interpreted Sand layer thickness was larger. The locations and layouts for Ponds 1 and 2 are shown in Figure 7-7.

Table 7-5. Numerical modelling scenarios for the infiltration pond

Modelled Scenarios	Pond dimensions (m)	Sand layer thickness (m)	Proportion of discharge	K (Sand) m/day
Scenario 1	Pond 1: 100 x 500	Pond 1: 11-12	Pond 1: 100%	5
Scenario 2	Pond 1: 100 x 500	Pond 1: 11-12	Pond 1: 100%	10
Scenario 3	Pond 1: 100 x 500 Pond 2: 120 x 500	Pond 1: 11-12 Pond 2: 15-16	Pond 1: 50% Pond 2: 50%	5
Scenario 4	Pond 1: 100 x 500 Pond 2: 200 x 500	Pond 1: 11-12 Pond 2: 15-16	Pond 1: 33.3% Pond 2: 66.7%	2

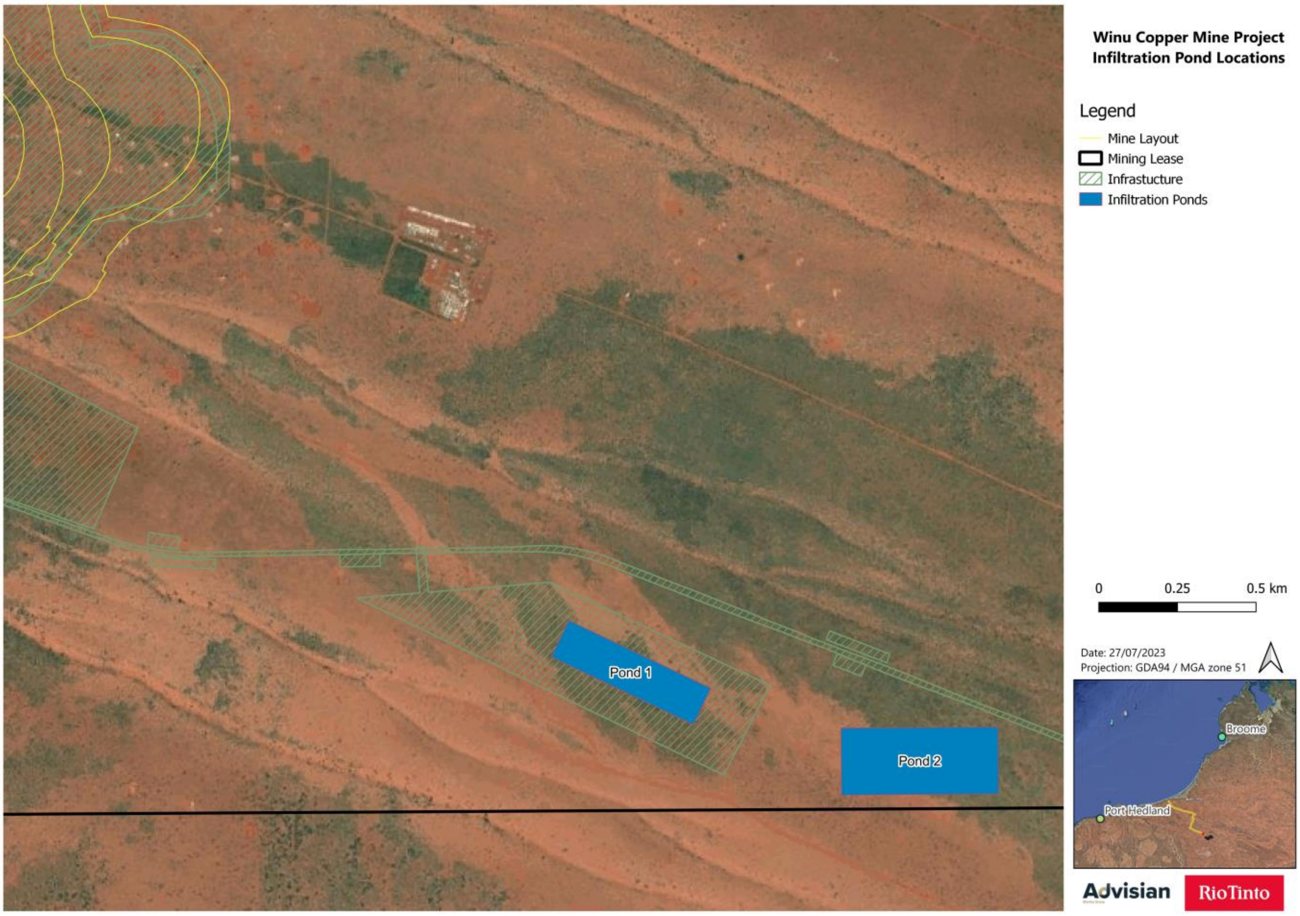


Figure 7-7. Locations and layouts of infiltration Ponds 1 and 2, in relation to proposed mine infrastructure layouts and mining lease boundary

7.3.2.3 Results

The results presented in Figure 7-8 suggest the following:

- **Scenario 1:** Pond 1 water storage capacity is exceeded, and the pond is overtopped several times over the excess water disposal period. This is due to the infiltration rate being limited by mounding beneath the pond and above the Silcrete layer due to the hydraulic conductivity (K = 5 m/day). Therefore, additional pond area is required to effectively infiltrate excess water into the Sand layer,
- **Scenarios 2 and 3:** water effectively infiltrates over the excess water disposal period:
    - Scenario 2 was successful due to the higher hydraulic conductivity adopted at Pond 1 (K = 10 m/day).
        - Scenario 3 was successful due to:
            - The increase in total pond area (Ponds 1 and 2), and
            - Larger thickness of Sand layer at Pond 2.
- **Scenario 4:** the combined Pond 1 and 2 water storage capacity is exceeded when the excess water disposal rate peaks in 2032. The reduction in infiltration capacity is due to the reduction in hydraulic conductivity of the Sand (K = 2 m/day). The excess water is effectively infiltrated throughout the remainder of the excess water disposal period, and

For all scenarios, inflow to the pit was less than 1 L/s over the simulation period.

The maximum extent of groundwater mounding above the Silcrete layer, across all scenarios was approximately 2.5 km from the pond as depicted in Figure 7-9.

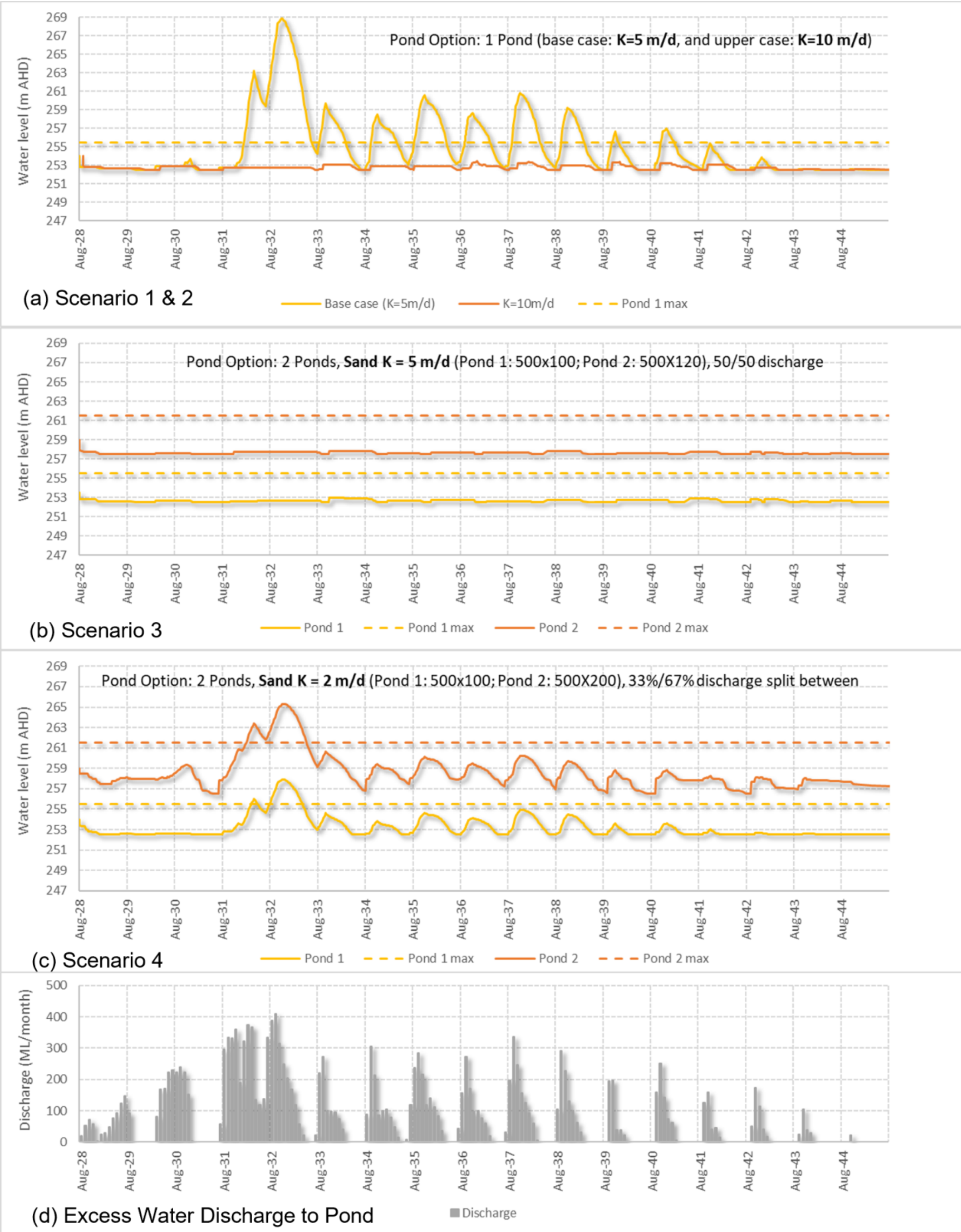


Figure 7-8. Plots showing the simulated water levels in the ponds for (a) Scenarios 1 & 2, (b) Scenario 3, (c) Scenario 4, and (d) Excess water discharge rate to the pond over the life of mine

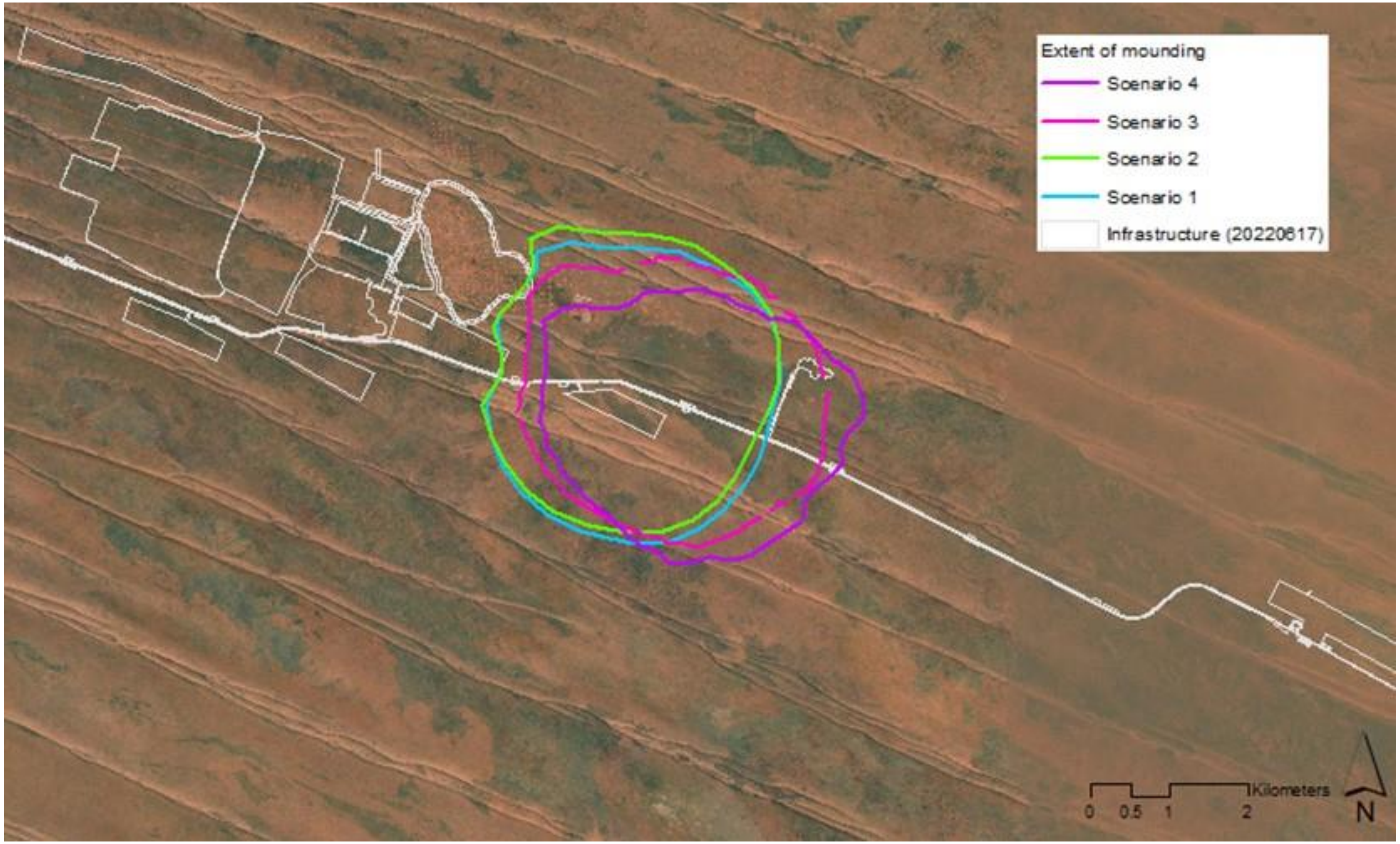


Figure 7-9. Infiltration pond option: extent of groundwater mounding (as defined by 1 m drawup contour) in surficial sands (above the silcrete) for each model scenario

7.3.3 Quarry infiltration option

7.3.3.1 Model set up

The top layer of the existing groundwater model (Advisian, 2022b) was amended as follows to enable simulation of the Quarry Infiltration Option.

Model Layers

- The model layers were adjusted as follows:
    - **Layer 1:** Sand Layer with top set to ground surface,
    - **Layer 2:** Silcrete Layer, which has low permeability and assumed to be 14 m thick, and
    - **Layer 3:** Sandstone layer, which is partly saturated and assumed to be at least 30 m thick.
- The quarry was conceptualised as an area of 500 m x 100 m and as a pit placed on the top of the Sandstone with the Sand and Silcrete material removed, and
- In the quarry area, the top elevation of the grid cells in Layer 1 (Sand) were set to the top elevation of sandstone (approximate base of quarry), which is approximately 227 m AHD. The top elevations of model Layers 2 (Silcrete) and 3 (Sandstone) for those grid cells are specified to be 226 and 225 m AHD, respectively. Therefore, model Layers 1 and 2 are only 1 m thick for the grid cells representing the quarry.

Hydraulic parameters

In the quarry area, the grid cells in model Layers 1 and 2 were specified to have the same hydraulic properties as Sandstone, so the Sand and Silcrete is absent in the quarry area and the base of the quarry is sitting on the top of Sandstone.

Quarry infiltration

The Lake (LAK) package in MODFLOW-USG was used to simulate the infiltration and evaporation processes in the quarry with excess water discharge. Inflows to the pond (LAK package) were based on estimated monthly excess water inflow rates presented in Section 2. Evaporation from water in the quarry was assumed to be 0.01 m/d (Table 7-3). The initial lake stage is specified to be 227 m AHD. Lake conductance was set to 100 m^2/day.

Mining pit

The DRN package in MODFLOW was used to simulate the open pit. DRN stage was specified to be the bottom elevation of sandstone, which is the bottom of the groundwater model.

Initial groundwater levels

Before the infiltration to the quarry was implemented in the model, initial groundwater conditions were derived with an open pit but without the LAK package. These were used for infiltration model(s), to subsequently estimate the water levels in the quarry and groundwater inflows to the open pit as a result of infiltration to the quarry.

Stress Periods

The groundwater model has a total of 140 stress periods, with the first stress period representing the quasi steady-state conditions and other stress periods representing the transient periods with varying infiltration rates to the quarry. Most of the stress periods have monthly durations when there is infiltration to the quarry, while other stress periods have durations of more than one month when there is no infiltration to the quarry.

7.3.3.2 Model scenarios

Four model scenarios were simulated assuming different combinations of hydraulic conductivity values of the Sand and Sandstone aquifers to assess the impacts of hydraulic properties on the estimated water levels in the quarry. Hydraulic conductivity of Silcrete is specified to be isotropic and 0.004 m/day for all scenarios.

The hydraulic parameter values presented in Table 7-6 were adopted for numerical modelling. The storage parameters adopted for all model scenarios are presented in Table 7-7.

Table 7-6. Hydraulic conductivity values adopted for numerical modelling of quarry infiltration scenarios

Modelled Scenarios	Sand Layer	Silcrete Layer	Sandstone Layer
Vertical Hydraulic conductivity (Kv) in m/day			
Case 1	5	0.004	1
Case 2	5	0.004	0.5
Case 3	5	0.004	5
Case 4	20	0.004	0.5
Horizontal Hydraulic conductivity (Kh) in m/day			
Case 1	5	0.004	2
Case 2	5	0.004	1
Case 3	5	0.004	10
Case 4	20	0.004	1

Table 7-7. Storage parameter values adopted for numerical modelling of quarry infiltration scenarios

Storage parameter	Sand Layer	Silcrete Layer	Sandstone Layer
Specific storage (Ss) (1/m)	$1x10^{-5}$	$1x10^{-6}$	$1x10^{-5}$
Specific yield (Sy) (dimensionless)	0.25	0.01	0.0325

7.3.3.3 Results

Simulated water levels in the quarry for the four simulated cases are shown in Figure 7-10 and the results summarised as follows:

- For all cases, the water is successfully infiltrated and maximum water levels in the quarry do not exceed the original ground surface elevation in the quarry area (approx. 255.5 m AHD) so there is no overtopping,
- Case 1 has peak surface water levels in the quarry <10 mbgl and no lateral infiltration of water into the upper Sand unit,
- Cases 2 and 4 have resulted in relatively higher maximum water levels in the quarry due to the lower adopted hydraulic conductivity of Sandstone layer. Further rise in water levels is mitigated by the lateral infiltration of water into the upper Sand unit,
- Case 3 has lower maximum water levels in the quarry due to the higher adopted hydraulic conductivity of the Sandstone layer. There is no lateral infiltration of water into the upper Sand unit, and
- The hydraulic conductivity of the Sandstone layer has a direct effect on ingress of infiltrated quarry water to the mining pit. Higher permeabilities of this unit leads to higher rates of inflow. The groundwater inflow rates to the mine pit are presented in Figure 7-11 for the four modelled scenarios. The peak and mean inflow rates are summarised in Table 7-8, with peak inflows ranging from 11 to 33 L/s and mean inflows ranging from 7 to 14 L/s across all scenarios.

The extent of groundwater mounding in the Sandstone layer is shown in Figure 7-12 (expressed as the extent of 1 m drawup contour at the end of the prediction period). Note the following:

- The drawup for Case 3 is not shown in Figure 7-12 because the mounding is minor and less than 1m. This is due to the relatively higher hydraulic conductivity value in the Sandstone layer for that scenario, and
- The extent of the drawup in the Sandstone layer is larger than in the Sand layer for the infiltration pond option due to the difference in specific yield values.

Table 7-8. Numerical modelling results for range of quarry scenarios

Scenario	Water successfully infiltrated without overtopping?	Lateral infiltration of water into upper Sand unit?	Peak and mean rates of groundwater inflow to the mine pit due to quarry infiltration (L/s)
Case 1	✓	✗	Peak: 15 Mean: 10
Case 2	✓	✓	Peak: 11 Mean: 7
Case 3	✓	✗	Peak: 33 Mean: 14
Case 4	✓	✓	Peak: 11 Mean: 7

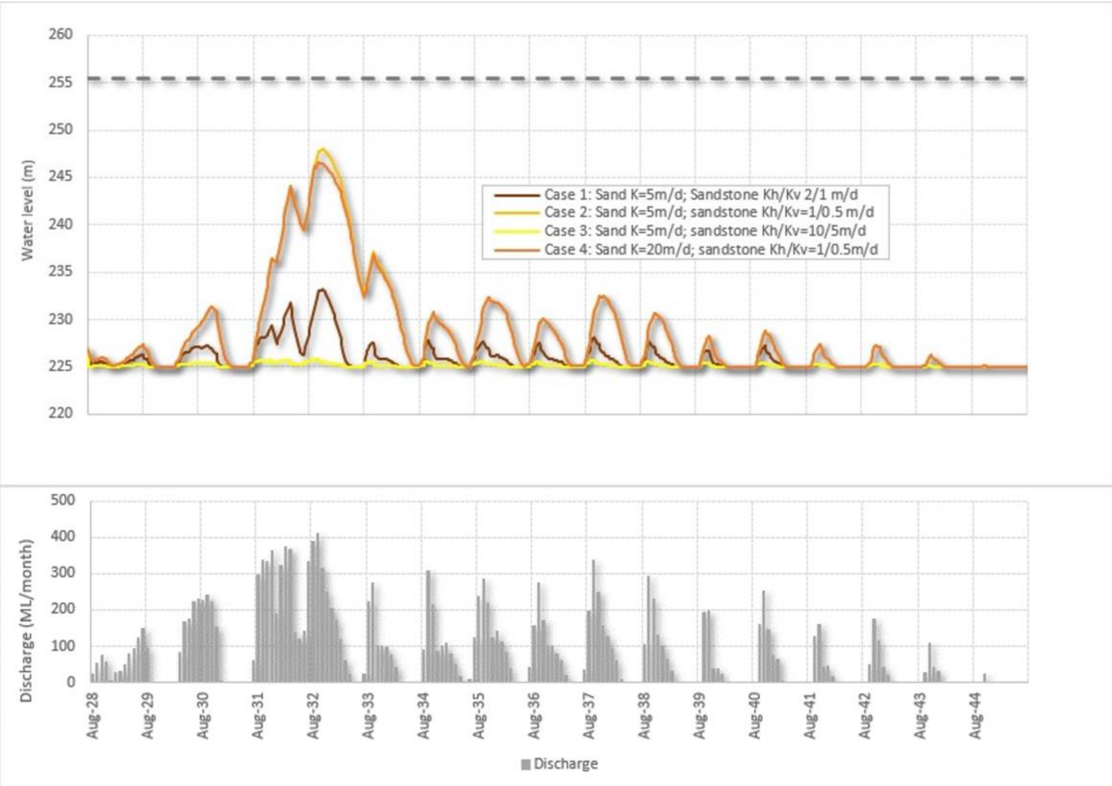


Figure 7-10. Predicted water levels in the quarry for the four simulated scenarios (Cases 1 to 4)

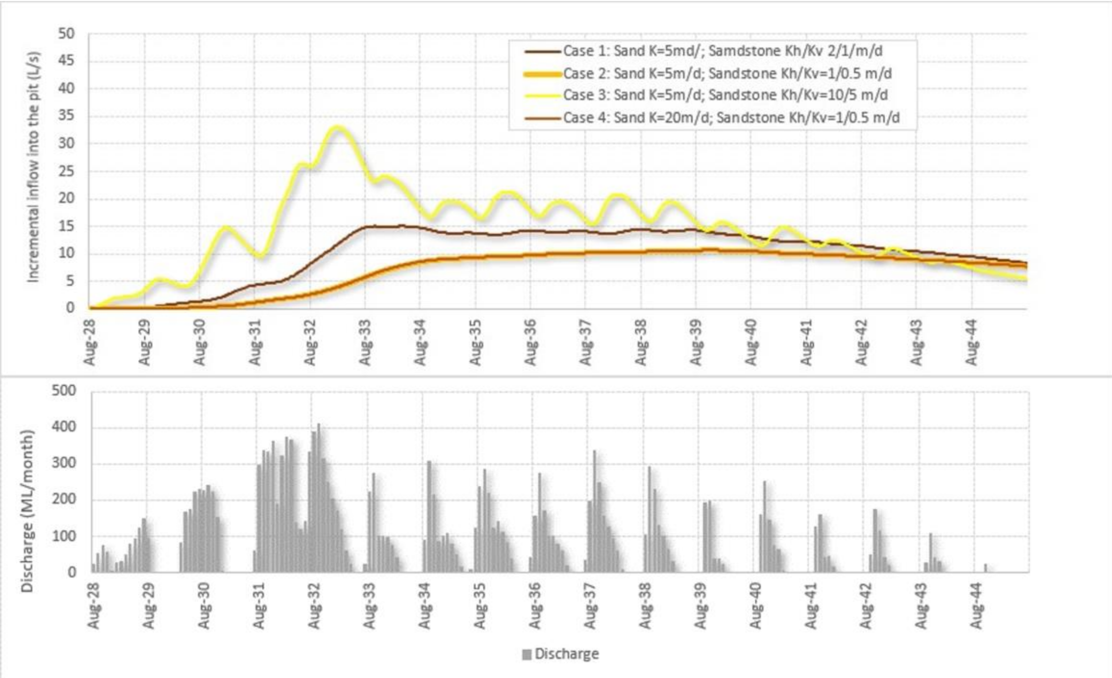


Figure 7-11. Predicted incremental groundwater inflow rates to the mine pit for the four simulated scenarios due to infiltration of excess water in the quarry (Cases 1 to 4)

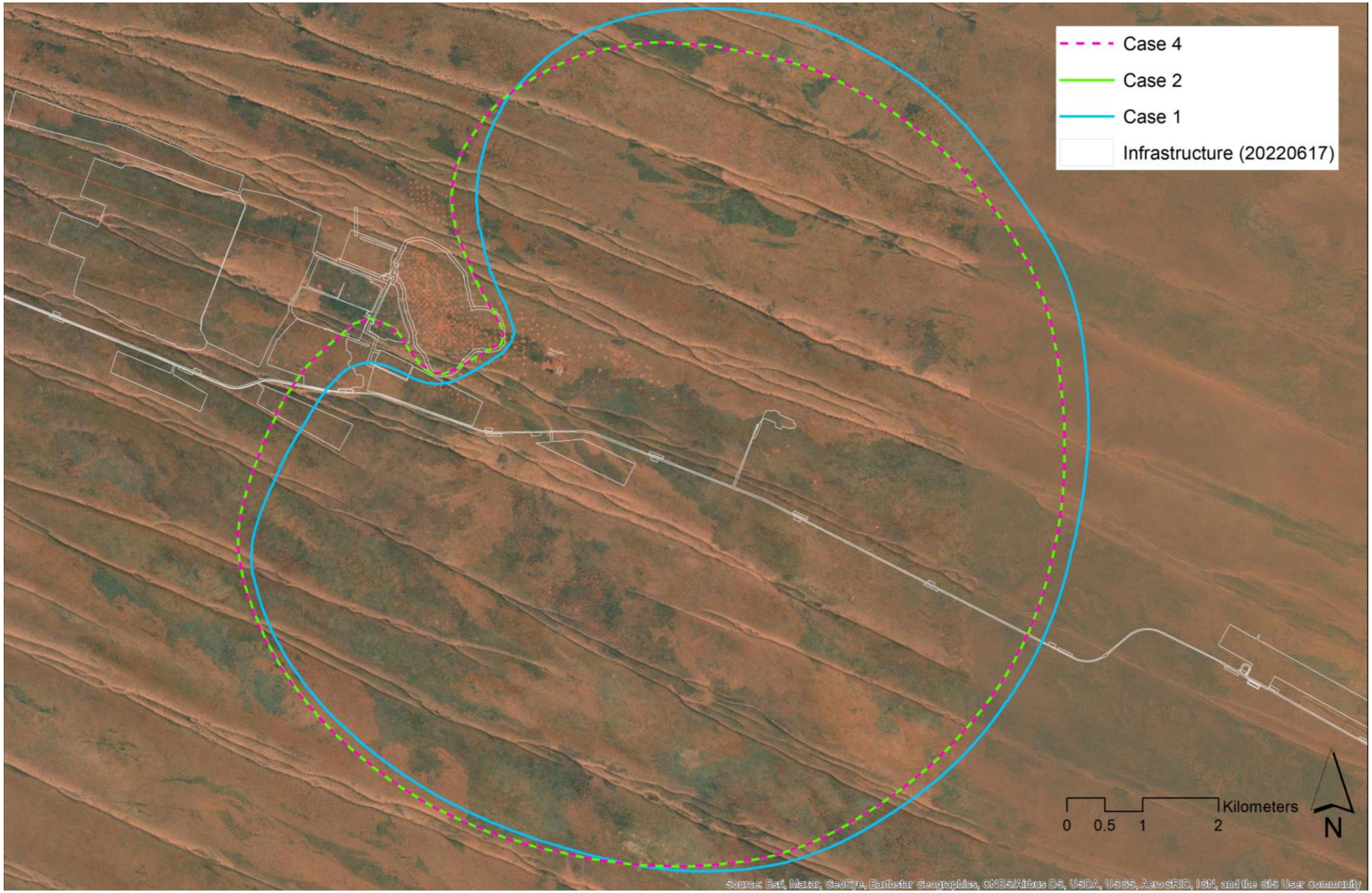


Figure 7-12. Quarry infiltration option: extent of groundwater mounding (portrayed as the extent of 1 m drawup contour) in the Sandstone layer for each model case. Note: drawup for Case 3 is not shown because the mounding is minor and less than 1m.

7.4 Summary of results

The results of infiltration modelling (with all included assumptions) suggest the following in relation to the feasibility of using infiltration for managing excess mine dewater at the Winu mine site.

7.4.1 Infiltration pond option

- The Infiltration Pond Option is only effective under certain conditions, with several of the model scenarios predicting overtopping of the pond on numerous occasions over the life of mine, due to the infiltration being limited by the hydraulic conductivity and thickness of the Sand unit,
- A single pond option (Pond 1) would only be effective when the hydraulic conductivity of Sand is at least 10 m/day and the Sand unit is at least 11 to 12 m thick. Comparison with recent field testing and lab testing, as well as literature values for Sand (Table 6-3) suggest that 10 m/day is at the higher end of the potential range of conductivity values, and it is likely that the conductivity could be lower in some areas. In addition, the available geological data suggests there is some uncertainty associated with the thickness of the Sand unit and the thickness is likely to be less than 11 to 12 m in places. Therefore, it is recommended that two infiltration ponds (Ponds 1 and 2) are considered at the locations shown in Figure 7-7,
- The results of modelling two ponds (Ponds 1 and 2), suggest that it may be feasible to infiltrate excess water if the hydraulic conductivity of Sand is 5 m/day. However, if the hydraulic conductivity reduces to 2 m/day, then modelling suggests the combined pond storage capacity is exceeded when the excess water disposal rate peaks in 2032, resulting in overtopping. Comparison with recent field testing and lab testing, as well as literature values for Sand (Table 6-3) suggest that hydraulic conductivity values of 2 m/day are possible across the site. This, along with the potential for encountering lower Sand thickness, poses a risk to the feasibility of the infiltration pond option,
- The maximum extent of groundwater mounding estimated across all scenarios was approximately 2.5 km from the pond assuming a Sand thickness of 11 to 12 m,
- For the infiltration pond to be effective, all of the following conditions would need to be satisfied:
    - Excess water inflow rates are consistent with or do not exceed, the rates presented in Section 2,
    - Two ponds (Pond 1 and 2) are adopted at the locations shown in Figure 7-7 and with the following minimum dimensions:
        - Pond 1: 100m x 500m x 1.5m, and
        - Pond 2: 200m x 500m x 1.5m.
    - The thickness of the Sand layer would need to be at least 11 to 12 m and ideally 15 to 16 m at the ponds and extending at least 2.5 km from the ponds, and

- The hydraulic conductivity of the Sand should be at least 5 m/day, to prevent overtopping. If a single overtopping event is considered acceptable by Rio Tinto, then a hydraulic conductivity of 2 m/day may be acceptable.

- If the conditions outlined are confirmed, then modelling suggests that there would be less than 1 L/s of groundwater ingress into the mine pit void over the simulation period and therefore have negligible impact on mining,
- The available geological and hydrogeological data suggests that the there is considerable variability and uncertainty associated with the hydraulic conductivity of Sand and thickness of the Sand unit at and around the pond locations, therefore the feasibility of the infiltration pond option remains uncertain,
- The total indicative estimated disturbance area for both ponds is approximately 200,000 m^2 allowing for perimeter and central embankments (assuming flat base no cut / fill), as discussed in Section 8 and depicted in Figure 8-1, and
- Intrusive geotechnical and hydrogeological investigations, hydraulic and material testing is recommended to confirm the hydraulic conductivity and thickness of the Sand unit at the pond locations and across an area extending at least 2.5 km from the ponds.

7.4.2 Quarry infiltration option

- The Quarry Infiltration Option, covering an area of 500m x 100m, is effective at infiltrating the excess mine water into the underlying Sandstone layer over the life of mine across all scenarios tested, with the discharged water contained and infiltrated within the quarry without overtopping,
- The quarry has significant storage capacity and provides the ability to infiltrate water laterally into the upper Sand unit if required. When low hydraulic conductivity values are adopted for the Sandstone unit (Kh = 1 m/day, Kv = 0.5 m/day) vertical infiltration is reduced resulting in higher water levels, however the rise in water levels is limited by the lateral infiltration of water into the upper Sand unit,
- The estimated peak inflow rates from infiltration to the mine pit are between 11 and 33 L/s which are manageable,
- Therefore, the Quarry Infiltration Option provides additional contingency, in the form of high storage capacity and ability to infiltrate water laterally into the upper Sand unit, which can manage risks associated with excess water flow rate and hydraulic conductivity uncertainties. This is important as there has been limited and, in some cases, no hydrogeological testing completed on the Sand, Silcrete and Sandstone units so the parameter values adopted for modelling are indicative, and
- Other benefits of the Quarry Infiltration Option include:
  - A smaller approximate disturbance area of 153,600 m^2 when including the cut slopes and setbacks (Section 7.1.2.1), and

- Opportunity to use the excavated Silcrete material to source construction material for use on site. Geotechnical investigations and designs are required to confirm suitability of this material for use.

7.4.3 Comparison of options

The results and available suggest that the Quarry Infiltration Option is likely to be more effective at infiltrating excess mine water than the Infiltration Pond Option, with the following benefits:

- It effectively infiltrates the water down into the Sandstone layer,
- It does not result in groundwater mounding within the upper Sand layer (above the Silcrete), and therefore does not present a risk of establishment of groundwater dependent ecosystems (GDE's) at the surface,
- The estimated peak inflow rates to the mine pit attributable to excess water infiltration are between 11 and 33 L/s and the mean inflows are between 7 and 14 L/s, which are manageable and should not impact on operations,
- The quarry provides additional contingency, in the form of high storage capacity and ability to infiltrate water laterally into the upper Sand unit if required, which can manage risks associated with excess water flow rate and hydraulic conductivity uncertainties. This is important as there has been limited and, in some cases, no hydrogeological testing completed on the Sand, Silcrete and Sandstone units so the parameter values adopted for modelling are indicative, and
- The quarry has a smaller approximate disturbance area of 153,600 m^2 when including the cut slopes and setbacks (Section 7.1.2.1), and
- Provides the opportunity to use the excavated Silcrete material to source construction material for use on site. Geotechnical investigations are required to confirm suitability of this material for use, and
- The quarry could potentially be backfilled with mine waste or potentially inert tailings for mine closure.

Infiltration ponds are a potentially viable option and should be explored further but is associated with numerous uncertainties associated with the hydraulic conductivity and thickness of the Sand unit, which have a significant influence on effectiveness and feasibility. Geotechnical and hydrogeological investigations, hydraulic and material testing is needed to confirm the hydraulic conductivity and thickness of the Sand unit at the pond locations and across an area extending at least 2.5 km from the ponds, to confirm effectiveness and feasibility of the Infiltration Pond Option (Pond 1 and 2). Blasting of and/or drilling holes through the Silcrete layer may improve the performance of infiltration ponds, however this would be costly to implement.

Concept designs have been developed for the two infiltration ponds (Ponds 1 and 2) shown in Figure 7-7 and are presented in Section 8.

The scope of work did not include design of the Quarry Infiltration Option, so it is recommended that geotechnical investigations are completed, and civil designs developed for the quarry.

8 Conceptual infiltration pond design

8.1 Civil designs

Conceptual infiltration pond designs (Pond 1 and 2) were developed in 12D civil design package and concept drawings produced and provided in Appendix F. The two ponds proposed are described below and depicted in Figure 8-1:

- **Pond 1:** comprises of two cells each has an effective infiltration area at the base of 50 X 500 m, and
- **Pond 2:** comprises of two cells each has an effective infiltration area at the base of 100 X 500 m.

Ponds are designed to have a flat base. Each pond is divided into two equal-sized cells lengthwise by the central embankment, which is 1.5 m high with 1:3 batter slope and a 4 m wide crest, resulting in a 13 m width at the base. The current design and positioning of the ponds is based on balancing the cut a fill as much as practical.

The perimeter embankments of each pond are 1.5m high with a 1:3 batter slope and a 3 m wide crest, resulting in a 12 m wide base. From the outer edge of the perimeter, a 1:3 cut/fill batter will be extended to interface with the natural surface, so the base width of the perimeter embankments will vary. In some locations, where the pond is in cut, there will be no perimeter embankments. To ensure easy maintenance, access ramps will be incorporated to allow for entering the pond for cleaning.

Both ponds will be provided with either a HDPE liner and ballast or concrete canvas, applied to the batters and across the crest of the perimeter and central embankments, as depicted in Figure 7-2 and Figure 7-3. The liner acts as a protective barrier, preventing seepage and leakage, thus ensuring the containment and efficiency of the infiltration process. In addition, the liner will protect the embankments from wind and rainfall erosion during extreme weather events often associated with cyclonic activity from November to April.

The flat bases of the ponds will remain unlined to facilitate infiltration.

A safety barrier or a fence shall be considered to restrict unauthorized access and 1.5m high earth bunding would also be required in areas where the pond is in cut, to divert floodwater around the ponds. The access ramps will be designed with an appropriate gradient to facilitate safe passage for maintenance personnel and equipment.

The cost of each liner option was assessed in Section 0 and the recommended liner option adopted for concept design was the HDPE liner. The HDPE liner has been included in the drawings presented in Appendix F along with some preliminary specifications.

As discussed in Section 7.1.1.3, it will be necessary to have multiple pond inlets that could be operated independently to evenly spread the suspended solids more evenly around the pond cells. The next stage of the design needs to consider the design of inflow pips and valving stations, the valve station shall be designed to allow the isolation of any of the 4 cells individually to facilitation cleaning and maintenance operations.

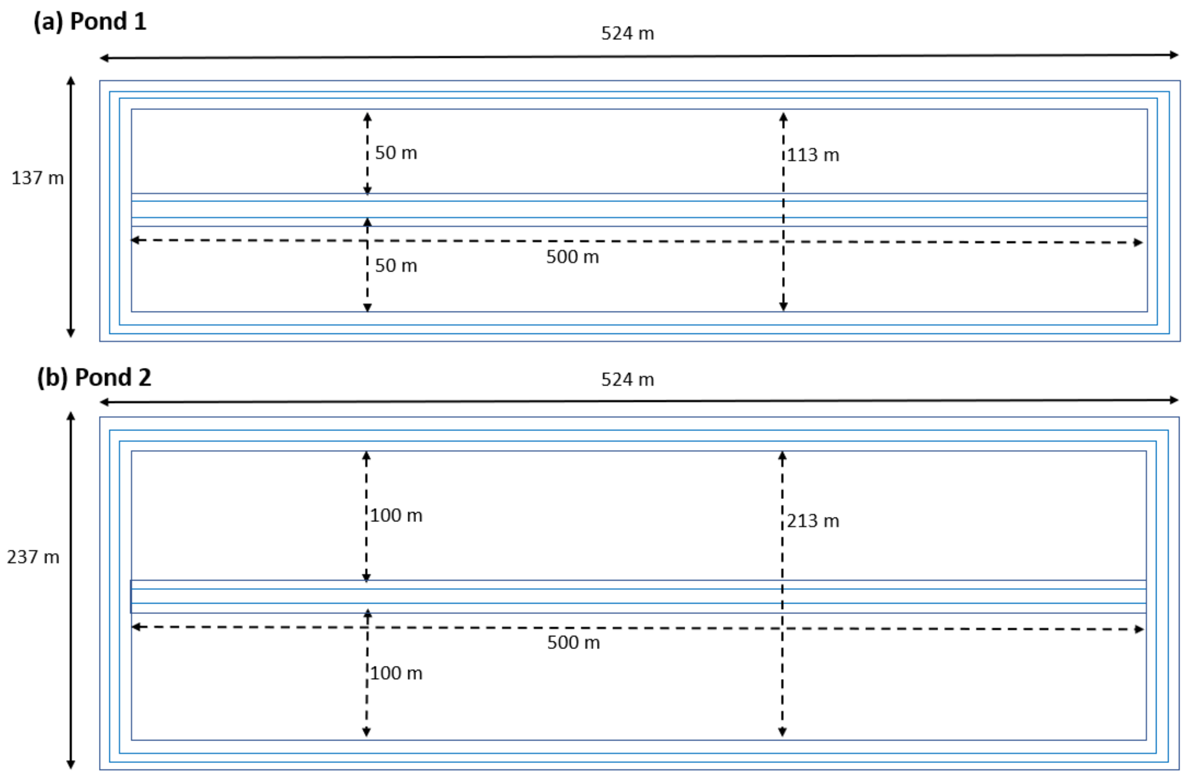


Figure 8-1. Schematics showing approximate dimensions of (a) Pond 1 and (b) Pond 2 (not to scale)

8.2 CAPEX estimates

Indicative OoM CAPEX cost estimates were developed for the two infiltration pond designs presented in Section 8.1, based on 12D civil design quantity estimates and unit earthworks rates from the Remote Borefield Pipeline Study (Advisian, 2023b) and unit rates provided by liner suppliers (Appendix G).

The geotechnical assessment of available construction materials in Section 7.1.1.4 suggests that locally sourced Sand or Silcrete material has the potential to be suitable for pond embankment construction. This would need to be confirmed by a detailed geotechnical assessment to characterise the materials and confirm suitability for construction.

Indicative quantities and cost estimates were calculated assuming different combinations of locally sourced construction material and imported material, as well as combinations of HDPE and concrete canvas liners. The locally sources material is assumed to be Sand due to its availability on site. This resulted in the following four alternative design options:

- **Design Option 1A:** Source the embankment fill material locally + 2.5mm HDPE liner + imported rip rap rock protection,
- **Design Option 1B:** Import the embankment fill material from nearby quarries + 2.5mm HDPE liner + imported rip rap rock protection,
- **Design Option 2A:** Source the embankment fill material locally + concrete canvas liner, and

- **Design Option 2B:** Import the embankment fill material from nearby quarries + concrete canvas liner.

The estimated quantities and cost estimates for each option are presented for Pond 1 and Pond 2 in Table 8-1 and Table 8-2 respectively. The following exclusions are associated with the cost estimates:

- Project management overheads not included,
- No contingency allowed, and
- No processing of site material is allowed.

The results suggest that Design Option 1A is preferred for both ponds due to lowest estimated cost and was adopted for development of the design drawings presented in Appendix F and associated preliminary specifications.

Table 8-1. Pond 1: comparison of Infiltration Pond Option quantities and indicative CAPEX cost estimates

Item	Quantity	Unit	Unit Rates ($AUD / m^3)		Cost Estimate $AUD (excl GST)			
			Local Source	Imported	Option 1A	Option 1B	Option 2A	Option 2B
Cut	18,000	m^3	$10	$200	$180,000	$3,600,000	$180,000	$3,600,000
Fill *	13,912	m^3	$10	$200	$139,120	$2,782,400	$139,120	$2,782,400
Central Fill ^	6,375	m^3	$10	$200	$63,750	$1,275,000	$63,750	$1,275,000
Volume rip rap	2,456	m^3	-	$200	$491,250	$491,250	-	-
HDPE liner	20,995	m^2	-	$10	$209,950	$209,950	-	-
Concrete canvas	20,995	m^2	-	$65	-	-	$1,364,675	$1,364,675
				Total	**$1,084,070**	**$8,358,600**	**$1,747,545**	**$9,022,075**

** Perimeter embankment fill*
^ Central embankment fill

Table 8-2. Pond 2: comparison of Infiltration Pond Option quantities and CAPEX cost estimates

Item	Quantity	Unit	Unit Rates ($AUD / m^3)		Cost Estimate $AUD (excl GST)			
			Local Source	Imported	Option 1A	Option 1B	Option 2A	Option 2B
Cut	40,688	m^3	$10	$200	$406,880	$8,137,600	$406,880	$8,137,600
Fill *	27,622	m^3	$10	$200	$276,220	$5,524,400	$276,220	$5,524,400
Central Fill ^	6,375	m^3	$10	$200	$63,750	$1,275,000	$63,750	$1,275,000
Volume rip rap	2,588	m^3	-	$200	$517,500	$517,500	-	-
HDPE liner	22,150	m^2	-	$10	$221,496	$221,496	-	-
Concrete canvas	22,150	m^2	-	$65	-	-	$1,439,724	$1,439,724
				Total	**$1,485,846**	**$15,675,996**	**$2,186,574**	**$16,376,724**

** Perimeter embankment fill*
^ Central embankment fill

9 Conceptual quarry design

An indicative concept design was developed for the quarry option using 12D civil design software (Figure 9-1), and quantities and cost estimates developed. The results are presented in Table 9-1. The following assumptions are associated with the results:

- Quarry base area of 100m x 500m,
- No allowance in the design/quantities for haul road access,
- Quarry located at the same location as Infiltration Pond #1,
- Batter widths and slopes based on email correspondence from Rio Tinto (2023), with pit slope parameters provided in Table 9-2,
- Adopted the indicative cross section shown in Figure 9-2 and associated lithology:
    - Sand layer (10m thick),
    - Silcrete layer (25m thick), and
    - Sandstone (2m thick).
- Cost of total material movement: $3.20/tonne (provided by RTIO).

The preparation of design drawings was not in scope for the study, so were not developed.

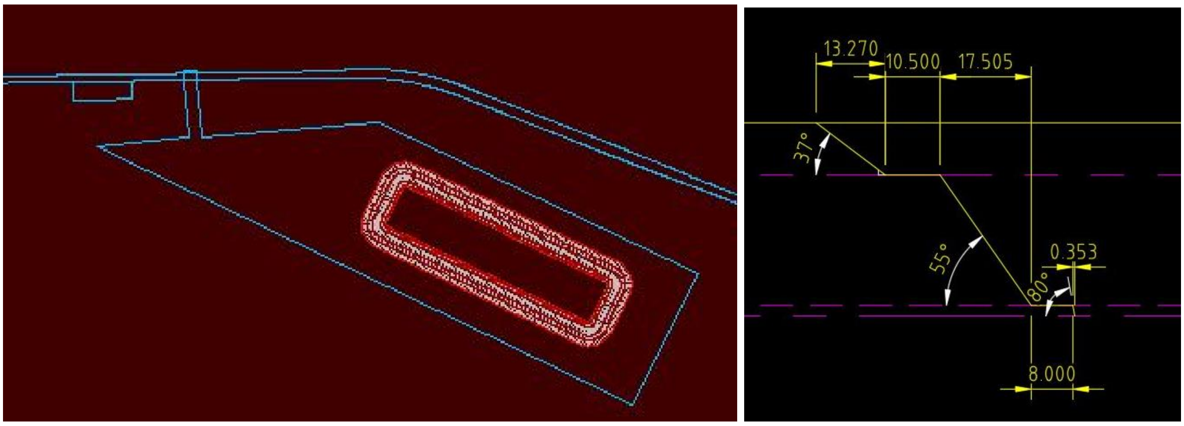


Figure 9-1. Concept quarry design layout (shown in red) and cut/wall section

Table 9-1. Quarry option: indicative excavation quantities and cost estimates

Lithology / Layer	In-Situ Volume (m^3)	Conversion Factor (tonnes/m^3) *	In-Situ Weight (tonnes)	Unit Rate ($/tonne)	Cost Estimate ($ AUD)
Sand	1,072,702	1.60	1,716,323	$ 3.20	$ 5,492,234
Regolith (Silcrete/Ferricrete)	1,787,859	2.42	4,326,620	$ 3.20	$ 13,845,184
Sandstone	98,189	2.42	237,616	$ 3.20	$ 760,372
Total	**2,958,750**	**-**	**6,280,559**	**-**	**$ 20,097,790**

** Source: Australasian Institute of Mining and Metallurgy (1995).*

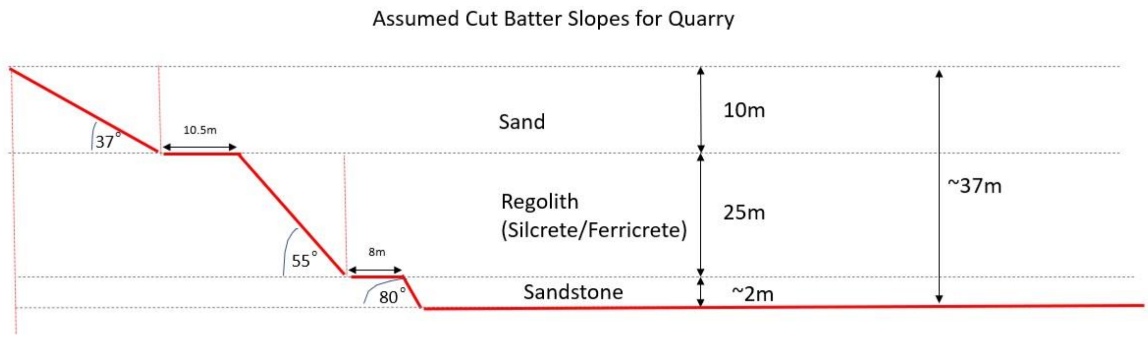


Figure 9-2. Indicative cross section assumed for concept quarry design, quantities and cost estimates

Table 9-2. Pit wall parameters (Rio Tinto, 2023)

Geotechnical Unit	Wall	Stage	IRA (degrees)	BFA (degrees)	Height (m)	Min Berm Width (m)
Sand	All	All stages	31	37	30	10.5
Regolith	All		35	55	10	7.5
Sandstone	West		46	80	10	8
	East, North & South Walls		48	80	10	7

** Source: Australasian Institute of Mining and Metallurgy (1995).*

10 Flood risk assessment

The 2D TUFLOW hydraulic model developed for the Winu water supply pipeline study (Advisian 2023b) was updated to include the proposed infiltration pond designs, and the 1% Annual Exceedance Probability (AEP) event simulated to assess risk posed by external floodwaters. Additional bunding (1.5 m high) was included in the model in areas where the pond was in cut where required to prevent ingress of surface water. The locations where additional bunding is required are shown in Figure 10-1, along with the peak 1% AEP flood depths predicted by the TUFLOW model.

The results show there is only minor ponding to depths of no more than 0.7 m adjacent to Pond 1 (western pond) in the 1% AEP event. The depth of ponding around Pond 2 (eastern pond) is less than 0.25 m. Previous 1% AEP event modelling by Advisian (2023b) in the mine area suggests that 0.7 m and 0.25 m of ponded water are expected to completely infiltrate within approximately 70 hours (< 3 days) and 24 hours (1 day), respectively. Therefore, given the limited depth and extent of 1% AEP flooding and rapid infiltration rates, the risk posed floodwater is considered very low.

The results are expected to be similar if the Quarry Infiltration Option is selected, assuming bunds are constructed for safety but to also direct floodwater around the quarry.

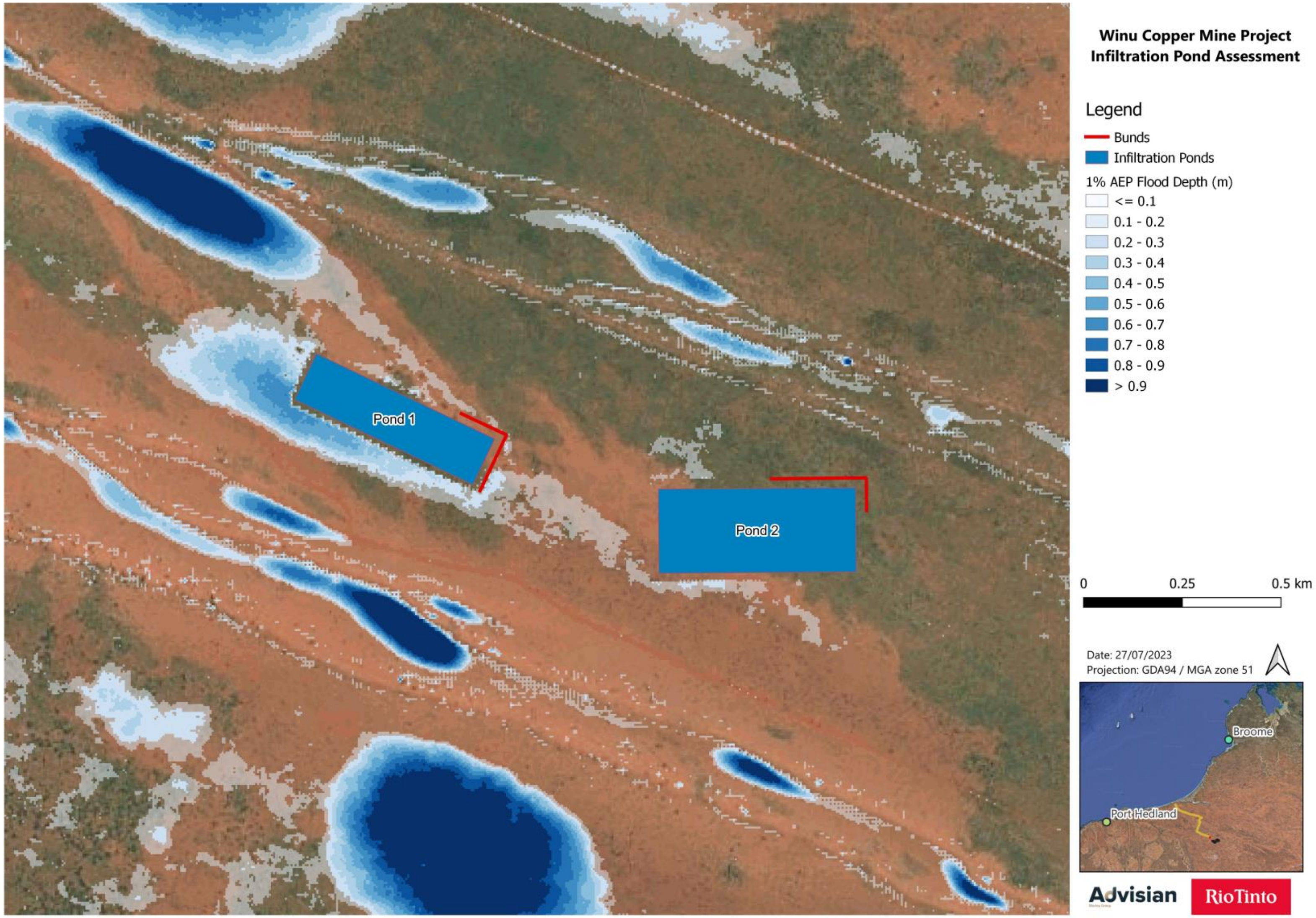


Figure 10-1. 1% AEP peak flood depth map with the proposed infiltration ponds in place

11 Impact assessment

The results of numerical modelling have been used to assess the potential risks posed by the Infiltration Pond and Quarry Infiltration Options, on mining operations and environmental and heritage values at Winu.

Comparison of impacts suggests that the Quarry Infiltration Option has least potential impact on environmental and heritage values at Winu, when compared with the Infiltration Pond Option:

- The Infiltration Pond Option presents a potential risk of prolonged periods with near surface groundwater and establishment of groundwater dependent ecosystems (GDEs) at the surface. The Quarry Infiltration Option infiltrates the water down into the Sandstone layer. It does not result in groundwater mounding within the upper Sand layer (above the Silcrete), and therefore does not present a risk of establishment of groundwater dependent vegetation at the surface,
- The estimated ground disturbance area for the Infiltration Pond Option is also approximately 50,000 m^2 greater than the Quarry Infiltration Option.

The Quarry Infiltration Option likely to produce higher rates of groundwater inflow to the mine pit. However, the estimated peak inflow rates to the mine pit attributable to infiltration are between 11 and 33 L/s and the mean inflows are between 7 and 14 L/s over the life of mine, which are manageable and should not impact on mining operations.

Both the Infiltration Pond and Quarry Infiltration Options can be constructed without directly impacting on the dunes.

As both options will result in the formation of a temporary surface water body appropriate flora and fauna management measures will be required, during operations. At mine closure the infiltration ponds and quarry can be backfilled and rehabilitated to natural surface.

12 Conclusions

An Order of Magnitude (OoM) infiltration pond study was completed to assess the feasibility of an infiltration pond system for management of excess mine dewater at the Winu mine site over the life of mine. Several potential locations were assessed in relation to proposed mine infrastructure and sensitive environmental/heritage areas, and an area (Site 07) located approximately 2 km south-east of the mine pit was identified as the preferred.

A review of the available geological data provided by Rio Tinto suggests the lithology comprises the following:

- **Surficial Sands:** high hydraulic conductivity and approximately 10 to 15 m thick in the selected area, underlain by
- **Silcrete:** low hydraulic conductivity and approximately 14 to 26 m thick, underlain by
- **Sandstone:** moderate hydraulic conductivity and at least 30 m thick

One dimensional (1D) vertical infiltration modelling was completed using Hydrus and an assumed peak excess water inflow rate of 11ML/day. The results, based on literature parameter values, suggested that the Silcrete layer is likely to act as a practically impermeable barrier to vertical infiltration of water, impacting on the effectiveness of the infiltration pond and resulting in unfeasible and unpracticable pond areas.

Options such as blasting of and/or drilling holes through the Silcrete layer were explored and tested in the 1D model but while found to provide some improvement to performance and some reduction in pond size, in most cases still resulted in unfeasible and unpracticable pond areas. There are also significant uncertainties associated with the effectiveness of blasting, and the drilling of large numbers of holes required to increase connectivity through Silcrete would be costly.

3D numerical modelling was then completed using MODFLOW-USG to effectively simulate the likely performance of the infiltration from the pond into the surficial Sand layer and the extent of mounding and lateral spread of groundwater (Pond Option).

It was also agreed that an alternative option of excavating out the Silcrete layer as part of quarrying activities and using the void to discharge and infiltrate water predominantly into the underlying sandstone aquifer should also be tested using the numerical model (Quarry Infiltration Option).

To accommodate both options, the preferred site for the infiltration pond / quarry options was moved approximately 1 km south-east from Site 07 to a proposed stockpile area, shown in Figure 7-6. The current stockpile design will be updated to accommodate the infiltration pond / quarry.

The results of numerical modelling are summarised below for the Infiltration Pond and the Quarry Infiltration Options.

Infiltration Pond Option

For the infiltration pond to be effective 3D numerical groundwater modelling suggests that the following conditions would need to be satisfied:

- Excess water inflow rates are consistent with or do not exceed, the rates presented in Section 2,
- Two ponds (Pond 1 and 2) are adopted at the locations shown in Figure 7-7 and with the following minimum dimensions:
  - **Pond 1**: 100 m effective base width comprising two cells each 50 m width to facilitate maintenance and cleanout regimes; 500 m effective base length; average depth of ponds of around 1.5 m with 1 m operating water depth; and perimeter and central embankments.
  - **Pond 2:** Same as Pond 1, but with a 200 m effective base width comprising two cells each 50 m width to facilitate maintenance and cleanout regimes.
- The thickness of the surficial Sand layer would need to be at least 11 to 12 m and ideally 15 to 16 m at the ponds and extending at least 2.5 km from the ponds, and
- The hydraulic conductivity of the Sand should be at least 5 m/day, to prevent overtopping. If a single overtopping event is considered acceptable by Rio Tinto, then a hydraulic conductivity of 2 m/day may be acceptable.

In addition:

- If the conditions outlined are confirmed, then modelling suggests that there would be less than 1 L/s of groundwater ingress into the mine pit void over the simulation period and therefore have negligible impact on mining,
- The total indicative estimated disturbance area for both ponds is approximately 200,000 m^2 allowing for perimeter and central embankments (assuming flat base no cut / fill), as discussed in Section 8 and depicted in Figure 8-1, and
- Infiltration ponds are a potentially viable option and should be explored further but is associated with numerous uncertainties associated with the hydraulic conductivity and thickness of the Sand unit, which have a significant influence on effectiveness and feasibility. Geotechnical and hydrogeological investigations, hydraulic and material testing is needed to confirm the hydraulic conductivity and thickness of the Sand unit at the pond locations and across an area extending at least 2.5 km from the ponds, to confirm effectiveness and feasibility of the Infiltration Pond Option (Pond 1 and 2). Blasting of and/or drilling holes through the Silcrete layer may improve the performance of infiltration ponds, however this would be costly to implement.

Quarry Infiltration Option

The results and available suggest that the Quarry Infiltration Option is likely to be more effective at infiltrating excess mine water than the Infiltration Pond Option, with the following benefits:

- It effectively infiltrates the water down into the Sandstone layer,
- It does not result in groundwater mounding within the upper Sand layer (above the Silcrete), and therefore does not present a risk of establishment of groundwater dependent ecosystems (GDEs) at the surface,

- The estimated peak inflow rates to the mine pit, attributable to infiltration, are between 11 and 33 L/s and the mean inflows are between 7 and 14 L/s, which are manageable and should not impact on operations,
- The quarry provides additional contingency, in the form of high storage capacity and ability to infiltrate water laterally into the upper Sand unit if required, which can manage risks associated with excess water flow rate and hydraulic conductivity uncertainties. This is important as there has been limited and, in some cases, no hydrogeological testing completed on the Sand, Silcrete and Sandstone units so the parameter values adopted for modelling are indicative, and
- The quarry has a smaller approximate disturbance area of 153,600 m^2 when including the cut slopes and setbacks,
- Provides the opportunity to use the excavated Silcrete material to source construction material for use on site. Geotechnical investigations and designs are required to confirm suitability of this material for use, and
- The quarry could potentially be backfilled with mine waste or potentially inert tailings for mine closure.

Flood risk

The results of 1% AEP event modelling with the two ponds in place (Pond 1 and 2) suggest there is likely to be only minor ponding to depths of no more than 0.7 m adjacent to Pond 1 (western pond) in the 1% AEP event. The depth of ponding around Pond 2 (eastern pond) is less than 0.25 m.

Previous 1% AEP event modelling by Advisian (2023b) in the mine area suggests that 0.7 m and 0.25 m of ponded water are expected to completely infiltrate within approximately 70 hours (< 3 days) and 24 hours (1 day), respectively. Therefore, given the limited depth and extent of 1% AEP flooding and rapid infiltration rates, the risk posed floodwater is considered very low.

The results are expected to be similar if the Quarry Infiltration Option is selected, assuming bunds are constructed for safety but to also direct floodwater around the quarry.

Impact assessment

Comparison of impacts suggests that the Quarry Infiltration Option has least potential impact on environmental and heritage values at Winu, when compared with the Infiltration Pond Option:

- The Infiltration Pond Option presents a potential risk of prolonged periods with near surface groundwater and establishment of groundwater dependent ecosystems (GDE's) at the surface. The Quarry Infiltration Option infiltrates the water down into the Sandstone layer. It does not result in groundwater mounding within the upper Sand layer (above the Silcrete), and therefore does not present a risk of establishment of groundwater dependent vegetation at the surface,
- The estimated ground disturbance area for the Infiltration Pond Option is also approximately 50,000 m^2 greater than the Quarry Infiltration Option.

The Quarry Infiltration Option is likely to produce higher rates of groundwater inflow to the mine pit. However, the estimated incremental peak inflow rates to the mine pit are between 11 and 33 L/s and the mean inflows are between 7 and 14 L/s over the life of mine, which are manageable and should not impact on mining operations.

As both options will result in the formation of a temporary surface water body appropriate flora and fauna management measures will be required, during operations. At mine closure the infiltration ponds and quarry can be backfilled and rehabilitated to natural surface.

Concept designs, quantities and cost estimates

Conceptual infiltration pond designs (Pond 1 and 2) were developed in 12D civil design package and concept drawings produced and provided in Appendix F.

Indicative OoM quantity and CAPEX cost estimates were then developed for the two infiltration pond designs using unit earthworks rates from the Remote Borefield Pipeline Study (Advisian, 2023b) and unit rates provided by HDPE liner suppliers (Appendix G). Different combinations of locally sourced construction material and imported material, as well as combinations of HDPE and concrete canvas liners for the central and perimeter embankments were considered. The results suggest that the following design option is preferred for both ponds due to lowest estimated cost and was adopted for development of the design drawings:

- **Design Option 1A:** Source the embankment (Sand) fill material locally + 2.5mm HDPE liner + imported rip rap rock protection.

The estimated CAPEX cost estimates for this option are presented for Pond 1 and Pond 2 in Table 12-1.

A concept design was also developed for the quarry option using 12D civil design software and used to develop indicative quantities and cost estimates presented in Table 12-2. The preparation of design drawings was out of scope for the study, so no drawings were developed.

Table 12-1. Indicative CAPEX cost estimates for Pond 1 and 2

Item	Cost Estimate $AUD (excl GST)	
	Pond 1	Pond 2
Cut	$180,000	$406,880
Fill *	$139,120	$276,220
Central Fill ^	$63,750	$63,750
Volume rip rap	$491,250	$517,500
HDPE liner	$209,950	$221,496
Total	**$1,084,070**	**$1,485,846**

** Perimeter embankment fill*
^ Central embankment fill

Table 12-2. Quarry option: indicative excavation quantities and cost estimates

Lithology / Layer	In-Situ Volume (m^3)	Cost Estimate ($ AUD)
Sand	1,072,702	$ 5,492,234
Regolith (Silcrete/Ferricrete)	1,787,859	$ 13,845,184
Sandstone	98,189	$ 760,372
Total	**2,958,750**	**$ 20,097,790**

13 Recommendations

To further assess and confirm the feasibility of an infiltration system for management of excess mine dewater at the Winu mine site, the following recommendations are made:

- Explore both the Infiltration Pond (Ponds 1 and 2) and Quarry Infiltration Options in more detail using the results of geotechnical and hydrogeological investigations, hydraulic and material testing. The testing should be used to confirm:
    - The hydraulic conductivities and thickness of the Sand, Silcrete and Sandstone layers at the proposed infiltration ponds and quarry locations and surrounding areas, and
    - The suitability of the Sand and Silcrete materials for use as construction material on site if required.
- **Infiltration Pond Option:** Infiltration ponds are a potentially viable option and should be explored further but is associated with numerous uncertainties associated with the hydraulic conductivity and thickness of the Sand unit, which have a significant influence on effectiveness and feasibility. The results of geotechnical and hydrogeological investigations, hydraulic and material testing should be used to confirm the hydraulic conductivity and thickness of the Sand unit at the pond locations and across an area extending at least 2.5 km from the ponds. The results should be used to update the numerical groundwater model then use the model to confirm effectiveness and feasibility of the Infiltration Pond Option (Pond 1 and 2). Blasting of and/or drilling holes through the Silcrete layer may improve the performance of infiltration ponds and could also be considered, however would be costly to implement, and
- **Quarry Infiltration Option:** Use the results of geotechnical and hydrogeological investigations, hydraulic and material testing to confirm the hydraulic conductivities and thickness of the Sand, Silcrete and Sandstone layers at the proposed quarry location. The results should then be used to update the numerical groundwater model then use it to confirm effectiveness and feasibility of the Quarry Infiltration Option. The results should also be used to develop a quarry design.

The numerical modelling should also assess the effect of infrequent, high intensity rainfall events on infiltration pond / quarry performance and risk of mounding.

The results should be used to select the preferred option and develop more detailed 12D civil designs, quantity estimates and CAPEX cost estimates.

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Appendix A
Particle Size Distribution Test Results

Certificate of Analysis

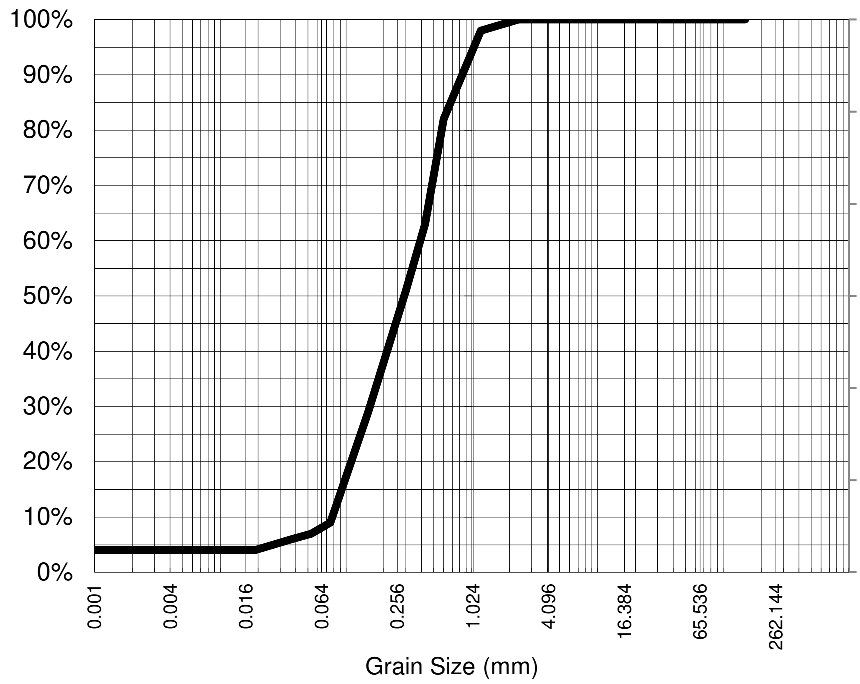
ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	GERHARD JACOBS	**DATE REPORTED:**	5-Apr-2023
COMPANY:	ADVISIAN PTY LTD	**DATE RECEIVED:**	24-Mar-2023
ADDRESS:	Level 14 240 St George Terrace Perth Wa, Australia	**REPORT NO:**	EP2303843-001 / PSD
PROJECT:	Winu Soil Sampling	**SAMPLE ID:**	WINU Point 7_Sample01

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	82%
0.425	63%
0.300	51%
0.150	29%
0.075	9%
Particle Size (microns)	
37	6%
26	5%
19	4%
13	4%
10	4%
7	4%
5	4%
3	4%
1	4%

Median Particle Size (mm)*	0.293

Analysis Notes

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: AS1289.3.6.3 states that hydrometer analysis is not applicable for samples containing <10% fines (<75um). Results should be assessed accordingly

Analysed: 3-Apr-23

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.61

NATA Accreditation: 825 Site: Newcastle
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WORLD RECOGNISED ACCREDITATION

Vincent Emerton-Bell
Laboratory Analyst
Authorised Signatory

Certificate of Analysis

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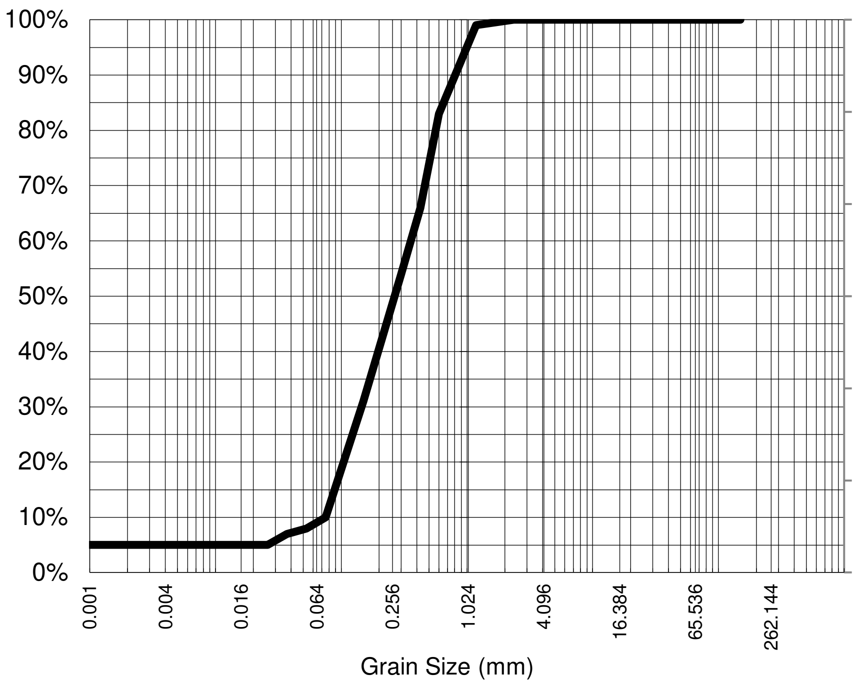
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	GERHARD JACOBS	**DATE REPORTED:**	5-Apr-2023
COMPANY:	ADVISIAN PTY LTD	**DATE RECEIVED:**	24-Mar-2023
ADDRESS:	Level 14 240 St George Terrace Perth Wa, Australia	**REPORT NO:**	EP2303843-002 / PSD
PROJECT:	Winu Soil Sampling	**SAMPLE ID:**	WINU Point 7_Sample02

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	83%
0.425	66%
0.300	54%
0.150	31%
0.075	10%
Particle Size (microns)	
37	7%
26	5%
19	5%
13	5%
10	5%
7	5%
5	5%
3	5%
1	5%

Median Particle Size (mm)*	0.274

Analysis Notes

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 3-Apr-23

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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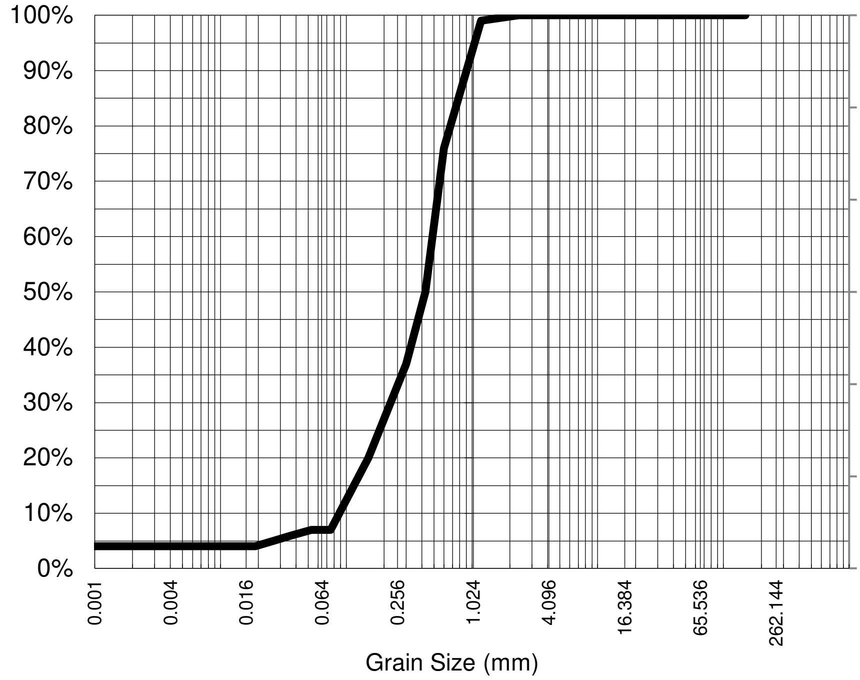
ALS Environmental

Newcastle, NSW

CLIENT:	GERHARD JACOBS	**DATE REPORTED:**	5-Apr-2023
COMPANY:	ADVISIAN PTY LTD	**DATE RECEIVED:**	24-Mar-2023
ADDRESS:	Level 14 240 St George Terrace Perth Wa, Australia	**REPORT NO:**	EP2303843-003 / PSD
PROJECT:	Winu Soil Sampling	**SAMPLE ID:**	WINU Point Pad 1_Sample03

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	76%
0.425	50%
0.300	37%
0.150	20%
0.075	7%
Particle Size (microns)	
37	6%
26	5%
19	4%
13	4%
10	4%
7	4%
5	4%
3	4%
1	4%

Median Particle Size (mm)*	0.425

Analysis Notes

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: AS1289.3.6.3 states that hydrometer analysis is not applicable for samples containing <10% fines (<75um). Results should be assessed accordingly

Analysed: 3-Apr-23

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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Vincent Emerton-Bell
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Certificate of Analysis

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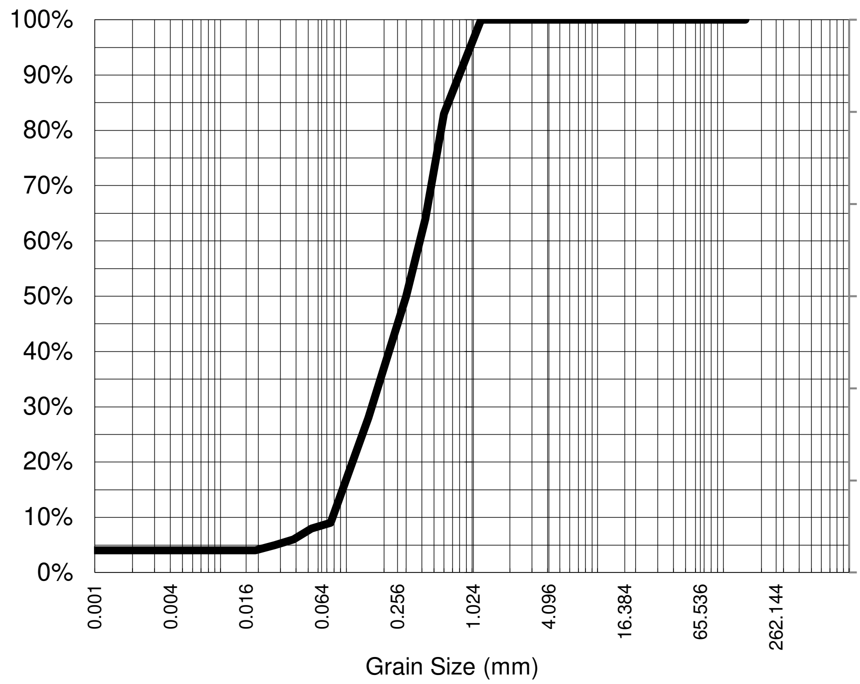
ALS Environmental

Newcastle, NSW

CLIENT:	GERHARD JACOBS	**DATE REPORTED:**	5-Apr-2023
COMPANY:	ADVISIAN PTY LTD	**DATE RECEIVED:**	24-Mar-2023
ADDRESS:	Level 14 240 St George Terrace Perth Wa, Australia	**REPORT NO:**	EP2303843-004 / PSD
PROJECT:	Winu Soil Sampling	**SAMPLE ID:**	WINU Point Pad 1_Sample04

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	83%
0.425	64%
0.300	50%
0.150	28%
0.075	9%
Particle Size (microns)	
38	6%
27	5%
19	4%
13	4%
10	4%
7	4%
5	4%
3	4%
1	4%

Median Particle Size (mm)*	0.300

Analysis Notes

Samples analysed as received.

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: AS1289.3.6.3 states that hydrometer analysis is not applicable for samples containing <10% fines (<75um). Results should be assessed accordingly

Analysed: 3-Apr-23

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: SAND, FINES

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.59

NATA Accreditation: 825 Site: Newcastle
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WORLD RECOGNISED ACCREDITATION

Vincent Emerton-Bell
Laboratory Analyst
Authorised Signatory

CERTIFICATE OF ANALYSIS

Work Order	: **EP2303843**	Page	: 1 of 3
Client	: **ADVISIAN PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: GERHARD JACOBS	Contact	: Genevieve De Souza
Address	: LEVEL 14 240 ST GEORGE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: ----	Telephone	: +61-8-9406 1301
Project	: Winu Soil Sampling	Date Samples Received	: 24-Mar-2023 13:00
Order number	: Gerhard Jacobs to pay via credit cad	Date Analysis Commenced	: 05-Apr-2023
C-O-C number	: ----	Issue Date	: 05-Apr-2023 12:54
Sampler	: GERHARD JACOBS		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 4		
No. of samples analysed	: 4		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Vincent Emerton-Bell	Laboratory Technician	Newcastle - Inorganics, Mayfield West, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

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

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

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

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

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

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

- PSD conducted by ALS Newcastle, NATA accreditation no. 825, site no 1656.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	WINU Point 7_Sample01	WINU Point 7_Sample02	WINU Point Pad 1_Sample03	WINU Point Pad 1_Sample04	----
			Sampling date / time	22-Mar-2023 00:00	22-Mar-2023 00:00	22-Mar-2023 00:00	22-Mar-2023 00:00	----
Compound	CAS Number	LOR	Unit	EP2303843-001	EP2303843-002	EP2303843-003	EP2303843-004	--------
				Result	Result	Result	Result	----
EA150: Particle Sizing								
+75µm	----	1	%	91	90	93	91	----
+150µm	----	1	%	71	69	80	72	----
+300µm	----	1	%	49	46	63	50	----
+425µm	----	1	%	37	34	50	36	----
+600µm	----	1	%	18	18	24	17	----
+1180µm	----	1	%	2	1	<1	<1	----
+2.36mm	----	1	%	<1	<1	<1	<1	----
+4.75mm	----	1	%	<1	<1	<1	<1	----
+9.5mm	----	1	%	<1	<1	<1	<1	----
+19.0mm	----	1	%	<1	<1	<1	<1	----
+37.5mm	----	1	%	<1	<1	<1	<1	----
+75.0mm	----	1	%	<1	<1	<1	<1	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	4	5	4	4	----
Silt (2-60 µm)	----	1	%	3	4	3	5	----
Sand (0.06-2.00 mm)	----	1	%	93	91	93	91	----
Gravel (>2mm)	----	1	%	<1	<1	<1	<1	----
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.61	2.60	2.60	2.59	----

Inter-Laboratory Testing

Analysis conducted by ALS Newcastle, NATA accreditation no. 825, site no. 1656 (Chemistry) 9854 (Biology).

(SOIL) EA150: Soil Classification based on Particle Size

(SOIL) EA150: Particle Sizing

(SOIL) EA152: Soil Particle Density

Appendix B
Geological Logs: Site 07

PRELIMINARY REPORT OF BOREHOLE: WINU0915

GOLDER
MEMBER OF WSP

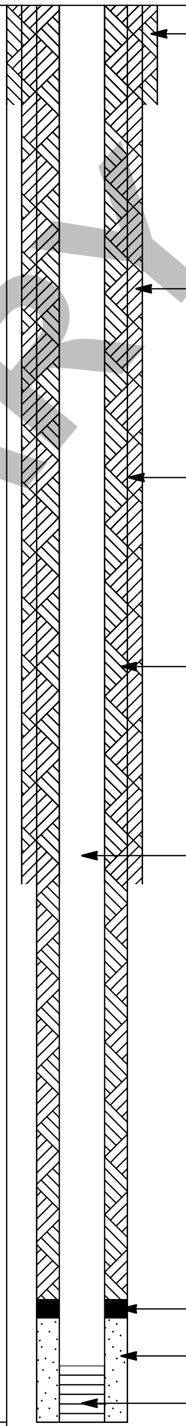
SHEET: 1 OF 1

CLIENT: Rio Tino Winu	COORDS: 371445.0 m E 7706696.0 m N MGA94 51	DRILL RIG: Versadrill Advantage V2000NG	
PROJECT: Winu Project	SURFACE RL: 248.00 m DATUM: AHD	CONTRACTOR: Acquadrill	
LOCATION: East Pilbara	INCLINATION: -90°	LOGGED: BR	DATE: 3/3/22
JOB NO: 20136763	HOLE DIA: 248/375/559 mm HOLE DEPTH: 150.00 m	CHECKED: BR	DATE: 22/6/22

Drilling | **Sampling** | **Field Material Description and Instrumentation**

METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)
RMF		0	248.00				SAND fine to coarse grained, red, poorly to well graded, sub-rounded	
RMF			8.00 240.00 239.00				SILT red, poorly graded	
			13.00 235.00				fine to coarse grained, orange, yellow, well graded. sub-rounded	
			17.00 231.00				SILCRETE fine to coarse grained, pale yellow, orange grey, 5-30% sandstone and quartz granules, moderately graded, subangular	
		20	20.00 228.00				SANDSTONE fine grained, grey, angular, poorly graded, trace quartz	
							moderately graded, 10-30% quartz, trace siltstone	
			30.00 218.00				subangular, intervals of very fine loose sand	
			38.00				very fine grained, 10% of chips weathered to red/brown, subrounded-subangular	
	10/04/22, 44.21 mbtoc (stickup TBC)	40	40.00 208.00				MUDSTONE purple, grey, oxidised, subangular to angular, increasing clay content with depth	
			58.00 190.00				purple, yellow, high plasticity clay in recovery	
		60	63.00 185.00				dark grey, reduced, trace quartz, trace metasediment chips	
			74.00 174.00				METASEDIMENTS yellow, grey, leached cap, highly oxidised, subangular to angular, poorly graded	
		80	84.00 164.00				grey, highly oxidised	1.5
RAB		100	101.00 147.00				brown grey, large quartz chips (10%)	2
			106.00 142.00	104.00 m pH = 9.51, EC = 763 uS/cm, T = 37.9°C			trace quartz chips (<1%)	2 2
		120	119.00 129.00	116.00 m pH = 8.84, EC = 614 uS/cm, T = 40.6°C 122.00 m pH = 9.24, EC = 644 uS/cm, T = 40.3°C			dark grey, weakly oxidised, highly oxidised along fractures, slightly weathered	2 2 2
		140	135.00 113.00	134.00 m pH = 8.64, EC = 591 uS/cm, T = 38.6°C 140.00 m pH = 8.67, EC = 553 uS/cm, T = 37.2°C			brown grey, highly oxidised	2 3 4
			150.00 98.00	150.00 m pH = 8.58, EC = 574 uS/cm, T = 33.8°C			END OF BOREHOLE @ 150.00 m TARGET DEPTH STANDPIPE INSTALLED Development Water Quality: pH = 8.26, EC = 531 uS/cm, T = 28.2°C	
		160						

CONSTRUCTION



PRELIMINARY

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

GAP gINT FN. F05
RL3

GOLDER
MEMBER OF WSP

REPORT OF BOREHOLE: WINU0705

SHEET: 1 OF 1

CLIENT: Rio Tino Winu	COORDS: 369905.46 m E 7707002.86 m N MGA94 51	DRILL RIG: Versadrill Advantage V2000NG	
PROJECT: Winu Final Study: 2020 Hydro Investigation	SURFACE RL: 248.86 m DATUM: AHD	CONTRACTOR: Acquadrill	
LOCATION: Winu, East Pilbara	INCLINATION: -90°	LOGGED: GJ	DATE: 14/10/20
JOB NO: 20136763	HOLE DIA: 203/375/508 mm HOLE DEPTH: 200.00 m	CHECKED: RI	DATE: 11/12/20

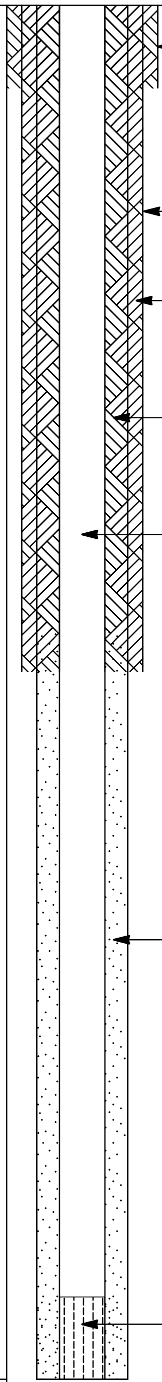
Drilling | **Sampling** | **Field Material Description and Instrumentation**

METHOD: RMF (0–98 m), RAB (98–200 m)

WATER: 52.12 mbgl , 16/10/20

DEPTH / RL	SAMPLE OR FIELD TEST	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)
0.00 / 248.86		SILTY SAND medium to coarse grained, red, loose, aeolian sand, with some root matter, highly weathered	
4.00		coarse grained, loose, trace lithic fragments, moist, 20% silt (cohesive)	
8.00 / 240.86		FERRICRETE fine grained, red, gravels of moderately cemented sandstone, with some fine-medium grained sand, moist, dense, highly weathered	
19.00 / 229.86		SILTY SAND fine grained, orange, with some coarse grained sand, 15% clay, loose, highly weathered	
24.00 / 224.86		SANDSTONE coarse grained, tan, orange iron staining on quartz grains, moist, loose, moderately weathered	
39.00 / 209.86		SAND medium grained, tan, orange staining on sand grains, loose, moderately weathered	
50.00		MUDSTONE white, medium plasticity, wet, soft, slightly weathered	
54.00 / 194.86		NO SAMPLE lost circulation	
57.00 / 191.86		MUDSTONE white, medium plasticity, wet, soft, moderately weathered	
61.00 / 187.86		yellow, sandy lens within the mudstone, with some coarse grained angular sand grains, minor clay (10%), silt (10%), medium dense, moist	
73.00 / 175.86		white/purple, hematitic clay, low-medium plasticity, moist	
81.00 / 167.86		orange, geothitic mudstone, high plasticity	
88.00 / 160.86		grey, high plasticity, reduced mudstones	
		orange brown, clay with fine sand, 35% sand becoming sand dominant with depth (diamictite?), soft	
95.00 / 153.86		METASEDIMENT/MUDSTONE fine grained, grey brown, highly oxidised, highly weathered	
103.00 / 145.86	104.00 m pH = 7.86, EC = 1784 uS/cm, T = 30.9°C	METASEDIMENT grey, geothitic, fractured zone with large chips with oxidised staining, highly weathered to fresh	5
109.00 / 139.86		some oxidiation on chips	6
114.00 / 134.86	116.00 m pH = 9.09, EC = 2006 uS/cm, T = 31.1°C	quartz veins <5%, oxidised staining on chips between 142-144, 157-160 and 177-179	7
			7
	134.00 m pH = 8.76, EC = 2385 uS/cm, T = 30.6°C		8
			8
	146.00 m pH = 8.66, EC = 2771 uS/cm, T = 30.5°C		10
			10
	158.00 m pH = 7.49, EC = 2914 uS/cm, T = 30.3°C		10
			10
	170.00 m pH = 7.96, EC = 3010 uS/cm, T = 30.4°C		11
			11
	182.00 m pH = 8.19, EC = 3009 uS/cm, T = 30.2°C		12
			12
	194.00 m pH = 8.39, EC = 3150 uS/cm, T = 30°C		12
200.00 / 48.86	200.00 m pH = 8.31, EC = 3179 uS/cm, T = 30.8°C	END OF BOREHOLE @ 200.00 m TARGET DEPTH STANDPIPE INSTALLED Development Water Quality: pH = 7.53, EC = 7966 uS/cm, T = 30.8°C	12

CONSTRUCTION



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GOLDER
MEMBER OF WSP

PRELIMINARY REPORT OF BOREHOLE: WINU0920

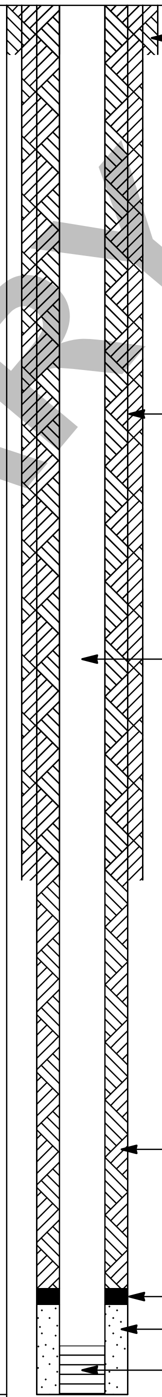
CLIENT: Rio Tino Winu	COORDS: 369909.0 m E 7705330.0 m N MGA94 51	DRILL RIG: Versadrill Advantage V2000NG
PROJECT: Winu Project	SURFACE RL: 261.00 m DATUM: AHD	CONTRACTOR: Acquadrill
LOCATION: East Pilbara	INCLINATION: -90°	LOGGED: EJ DATE: 15/5/22
JOB NO: 20136763	HOLE DIA: 241/375/559 mm HOLE DEPTH: 170.00 m	CHECKED: BR DATE: 22/6/22

Drilling | **Sampling** | **Field Material Description and Instrumentation**

METHOD	DEPTH RL	SAMPLE OR FIELD TEST	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)
RMF	0.00 / 261.00		SAND red, fine to coarse grained, well graded, subrounded to rounded	
RMF	4.00 / 257.00		SILCRETE moderately graded, angular to subangular, 2-5mm silcrete and minor sandstone chips, white with mottled orange/red, pink silt from 22-25m	
RMF	25.00 / 236.00		SANDSTONE purple, well graded, medium to coarse grained, subrounded to rounded, 2-4mm sandstone/quartz grains, minor silcrete chips observed	
RMF	35.00 / 226.00		generally white/clear, increasing yellow goethitic staining from 61-66m	
RMF	66.00 / 195.00		CLAY mottled purple/yellow/red, very little to no inclusions/chips	
RMF	76.00 / 185.00		red/brown, progressively becoming more reduced (grey)	
RMF	83.00 / 178.00		grey, reduced	
RAB	106.00 / 155.00		METASEDIMENTS dark grey, angular, slightly weathered, minor pyrite visible (2%)	
RAB	109.00 / 152.00		fresh, well graded chip size distribution	
RAB	123.00 / 138.00		fracture noted (driller comment)	
RAB	126.00 / 135.00		minor quartz observed, fracture noted (driller comment)	
RAB	136.00 / 125.00		fracture noted (driller comment)	
RAB	145.00 / 116.00	144.00 m pH = 8.55, EC = 630 uS/cm, T = 26.3°C	fracture noted (driller comment)	4
RAB	152.00 / 109.00		fracture noted (driller comment)	
	170.00 / 91.00		END OF BOREHOLE @ 170.00 m TARGET DEPTH STANDPIPE INSTALLED Development Water Quality: pH = 8.56, EC = 584 uS/cm, T = 24.2°C	6

WATER: 11/06/22, 138.37 mbtoc (stickup TBC)

CONSTRUCTION



- 0 - 6m: 16" steel surface casing, tremie grouted GP cement / bentonite mix (1.44 SG)
- 0 - 107m: 10" NB steel casing + float shoe, pressure grouted GP cement / bentonite mix (1.44 SG)
- 0 - 164m: 100mm blank PVC casing, threaded
- 0 - 157m: Tremie grouted GP cement / bentonite mix (1.42 SG)
- 157 - 159m: Bentonite seal
- 159 - 170m: Graded gravel pack (3.2 - 6.4mm)
- 164 - 170m: 100mm slotted PVC casing (1mm aperture), threaded, with end cap

PRELIMINARY

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

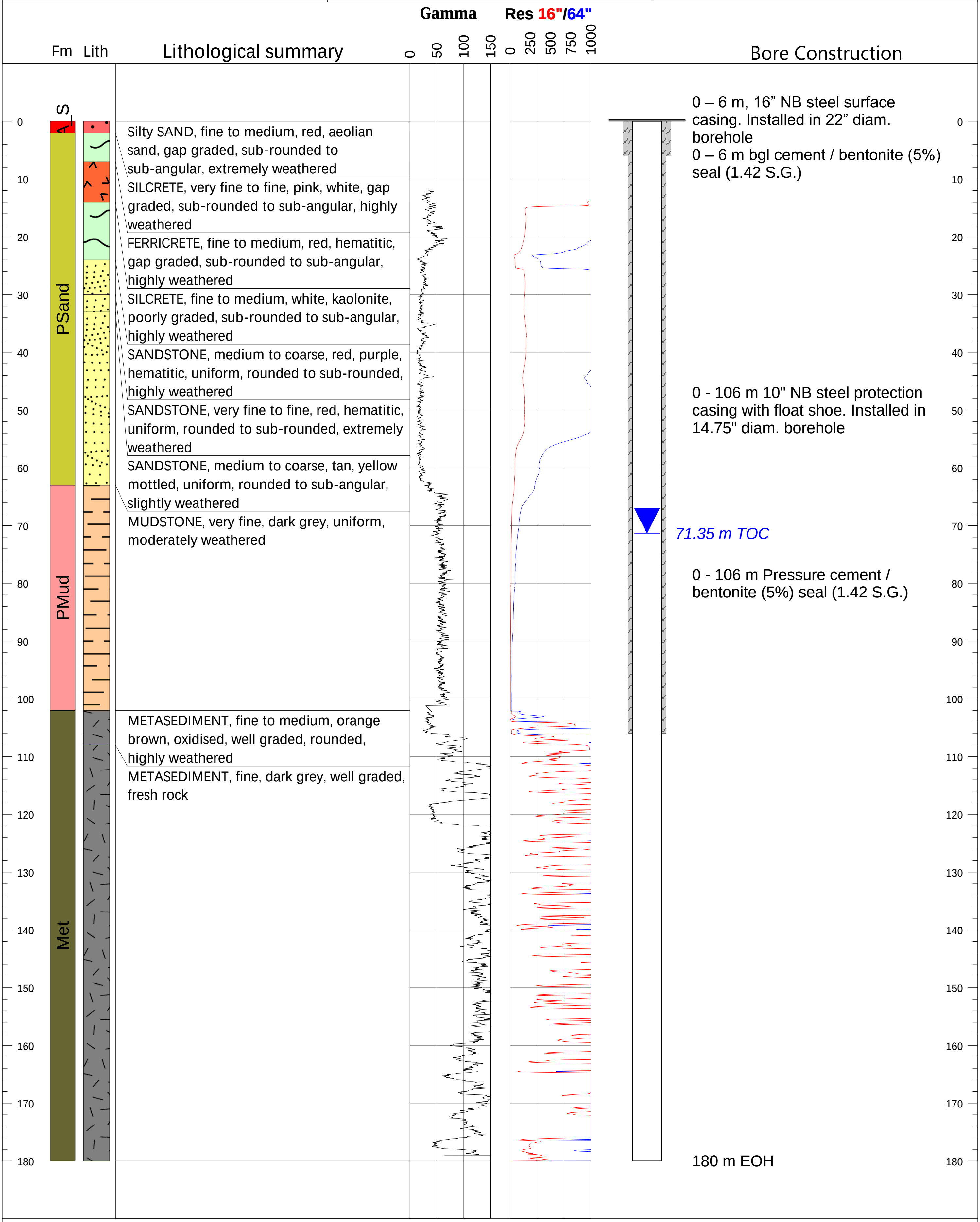
GAP gINT FN. F05
RL3

WINU0933 - Composite Bore Log

Project: Winu Hydrogeological Investigation Program
Client: Rio Tinto
CRS: GDA94 MGA51
Coordinates: 369912 mE / 7705327 mN
Elevation: 250 m AHD (RL = TOC)

Construction start date: 19/09/2022
Construction end date: 11/10/2022
Inclination: -90°
Depth drilled: 180 m BGL

Final airlift yield: 0.01 L/s
EC: µS/cm
pH:
Temp: °C
Static Water Level: 71.35 m bgl



Additional notes:

Advisian
Worley Group

REPORT OF BOREHOLE: WINU0702

GOLDER MEMBER OF WSP

SHEET: 1 OF 1

CLIENT: Rio Tino Winu	COORDS: 371041.556 m E 7705656.827 m N MGA94 51	DRILL RIG: Versadrill Advantage V2000NG	
PROJECT: Winu Final Study: 2020 Hydro Investigation	SURFACE RL: 255.46 m DATUM: AHD	CONTRACTOR: Acquadrill	
LOCATION: Winu, East Pilbara	INCLINATION: -90°	LOGGED: AC	DATE: 8/7/20
JOB NO: 20136763	HOLE DIA: 165/304/381 mm HOLE DEPTH: 154.00 m	CHECKED: RI	DATE: 22/9/20

METHOD	WATER	DEPTH (metres)	DEPTH / RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION
RMF		0	255.46				SILTY SAND fine to medium grained, poorly graded, sub-angular, red, aeolian sand		0 - 5.7m: 12 3/4" Schedule 10 steel casing. Tremie grouted GP cement /bentonite to surface
			5.00 / 250.46				SILCRETE red/brown, pisolites and ferruginous clasts, angular, highly weathered		
			9.00 / 246.46				SANDSTONE coarse grained, poorly cemented, white, minor gravels, minor orange straining, silcrete cement		
			14.00 / 241.46 / 240.46				highly weathered / 100% chips iron oxide stained		
		20	21.00 / 234.46				moderately weathered (50% oxidised chips)		
			232.46				20% white clay with gravels of sandstone		0 - 55m: 8" Schedule 40 steel
			38.00 / 39.00 / 216.46				hard 1m band well cemented sandstone gravels		
	45.85 mbgl , 18/08/20	40					SAND white, coarse grained, subrounded - subangular, loose poorly sorted sand, trace clay, orange staining on chips, similar to beach sand, gravels of sandstone throughout		0 - 55m: Pressure grouted GP cement / bentonite (SG 1.42)
			53.00 / 202.46				CLAY high plasticity, brown/red, massive, trace fine grained sand, high strength clay		
		60	61.00 / 194.46				gravels of low plasticity clay (30%), white		0 - 128m: Tremie grouted GP cement / 5% bentonite
			193.46				red/brown, high plasticity, sticky, 10% fine grained sand lenses throughout		
		80	77.00 / 178.46				yellow/brown, organic, 20% fine grained sand, trace angular metasediment chips		0 - 142m: 50mm ND Schedule 80 blank steel
		100							
		120	126.00 / 129.46				CLAY/METASEDIMENT brown, highly weathered, predominantly clay with 10-40% highly weathered metasediment chips		125 - 128m: Bentonite seal
									128m - 152.8m: 1.6 - 3.2mm gravel pack
		140	140.00 / 115.46				METASEDIMENT slightly to moderately weathered, brown, orange geothite staining on fractures, angular, fine grained, trace quartzite and sandstone chips		140.8 - 152.8m: 50mm ND Schedule 80 slotted steel. Welded steel end cap on base
			149.00 / 106.46				slightly weathered, decrease in drilling rate		152.8 - 154m: Fallback
		160	154.00 / 101.46				END OF BOREHOLE @ 154.00 m TARGET DEPTH STANDPIPE INSTALLED Drilling with mud - no downhole water samples/yields collected Development Water Quality: pH = 8.69, EC = 2591 uS/cm, T = 30.7°C		

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GAP gINT FN. F05 RL3

Table A-1. Non-graphical (text) borehole lithologies near proposed infiltration pond Site 07

Location	Top (mbgl)	Bottom (mbgl)	Category	% Lithology	Lithology	Modifier1	Modifier2
Winu0571	0	8	Regolith	100	Sand	Aeolian	
	8	10	Sedimentary	70	Sand	Aeolian	Oxidised
				30	Ferricrete	Hematitic	
	10	16	Sedimentary	90	Ferricrete	Hematitic	
				10	Sandstone	Hematitic	
	16	22	Sedimentary	70	Sandstone	Goethitic	
				30	Ferricrete	Hematitic	
	22	26	Sedimentary	80	Silcrete	Hematitic	
				20	Sandstone		
	26	31	Sedimentary	90	Silcrete	Hematitic	Goethitic
				10	Sandstone		
	31	39	Sedimentary	60	Silcrete	Hematitic	
				40	Sandstone		
	39	40	Sedimentary	60	Sandstone	Hematitic	
				40	Silcrete		
Winu0622	0	10	Sedimentary	100	Sand		
	10	22	Sedimentary	100	Silcrete	Kaolinised	
	22	30	Sedimentary	50	Silcrete		
				50	Ferricrete	Hematitic	Oxidised
	30	52	Sedimentary	100	Sandstone		
	52	55	Sedimentary	100	Claystone	Oxidised	Hematitic
	55	84	Sedimentary	100	Claystone	Oxidised	
Winu1176	0	10	Sedimentary	100	Sand	Hematitic	Aeolian
	10	22	Sedimentary	100	Sand	Hematitic	Silicified
	22	26	Sedimentary	100	Sand	Clayey	Silicified
	26	44	Sedimentary	60	Sandstone		
				40	Sand	Clayey	Silicified
	44	46	Sedimentary	100	Conglomerate		
	46	48	Sedimentary	100	Sandstone	Silicified	Silicified
	48	50	Sedimentary	100	Gritstone	Clayey	
	50	72	Sedimentary	100	Claystone	Hematitic	
Winu1177	0	12	Sedimentary	100	Sand	Aeolian	Hematitic
	12	40	Sedimentary	70	Sandstone	Hematitic	Clayey
				30	Sand	Silicified	Hematitic
	40	48	Sedimentary	100	Sandstone	Clayey	
	48	66	Sedimentary	100	Claystone	Hematitic	
	66	76	Sedimentary	100	Claystone		
Winu1180	0	6	Regolith	100	Sand	Aeolian	
	6	10	Sedimentary	60	Ferricrete	Hematitic	
				40	Silcrete	Hematitic	
	10	32	Sedimentary	90	Silcrete	Hematitic	Goethitic
				10	Sandstone	Hematitic	
	32	48	Sedimentary	90	Sandstone		
				10	Silcrete	Hematitic	

Location	Top (mbgl)	Bottom (mbgl)	Category	% Lithology	Lithology	Modifier1	Modifier2
	48	64	Sedimentary	90	Claystone	Hematitic	Goethitic
				10	Sandstone	Goethitic	
Winu1182	0	4	Regolith	100	Sand	Aeolian	
	4	14	Sedimentary	90	Ferricrete	Goethitic	Silicified
				10	Silcrete	Silicified	Goethitic
	14	34	Sedimentary	70	Silcrete	Silicified	
				30	Ferricrete	Silicified	Goethitic
	34	38	Sedimentary	70	Sandstone		
				30	Ferricrete	Silicified	Hematitic
	38	46	Sedimentary	100	Sandstone	Kaolinised	
	46	48	Sedimentary	80	Sandstone	Hematitic	Kaolinised
				10	Conglomerate		
				10	Diamictite	Pebbles	Hematitic
Winu1183	0	8	Regolith	100	Sand	Aeolian	
	8	14	Regolith	100	Ferricrete	Hematitic	Goethitic
	14	26	Regolith	70	Silcrete	Kaolinised	
				30	Gritstone		
	26	36	Sedimentary	60	Gritstone		
				40	Silcrete	Kaolinised	
	36	44	Sedimentary	60	Sandstone	Hematitic	
				40	Silcrete	Hematitic	Kaolinised
	44	48	Sedimentary	65	Silcrete	Kaolinised	Hematitic
				30	Claystone	Kaolinised	Goethitic
				5	Conglomerate		
Winu1184	0	4	Regolith	100	Sand	Aeolian	
	4	10	Sedimentary	90	Ferricrete	Hematitic	
				10	Sand		
	10	32	Sedimentary	100	Silcrete	Silicified	
	32	48	Sedimentary	100	Sandstone	Hematitic	Kaolinised
	48	52	Sedimentary	100	Claystone	Kaolinised	Goethitic
Winu1185	0	6	Regolith	100	Sand	Aeolian	
	6	12	Regolith	75	Sand	Aeolian	
				25	Ferricrete	Silicified	
	12	20	Sedimentary	75	Ferricrete	Hematitic	Silicified
				25	Sand	Aeolian	
	20	38	Sedimentary	100	Silcrete	Silicified	Kaolinised
	38	46	Sedimentary	100	Sandstone	Kaolinised	
	46	50	Sedimentary	50	Conglomerate	Kaolinised	
				50	Sandstone	Kaolinised	
	50	52	Sedimentary	100	Silcrete	Kaolinised	
	52	68	Sedimentary	100	Claystone	Hematitic	Goethitic
	68	104	Sedimentary	100	Claystone		

Appendix C
Golder (2020) Infiltration Test Data: Surficial Sands

Infiltration testing was carried out by Golder (2020) at 13 sites shown in Figure C-1, including the mine area, mine infrastructure and access tracks. The testing was conducted using a double ring infiltrometer, with an outer ring 12 inches diameter and inner ring 6 inches diameter. Between 1 and 3 tests were performed at each site. The closest sites to the proposed infiltration basin are sites 12 and 13.

The observations from the infiltration testing included time (minutes) and volume added plus cumulative volume for each observation. Results included infiltration calculated per observation gap and adjusted for the area of the inner part of the infiltrometer. To smooth the results additional analysis looking at the difference in cumulative volume over 2 and 5 observations was calculated (see Figures C-2 to C-4). This showed that the use of 5 observations for averaging resulted in a smoother infiltration rate and was therefore used to estimate infiltration rates.

The results presented in Table C-1 below, suggest infiltration rates for Sand, ranging between 8 and 16 m/day, with an approximate average of ~12 m/day.

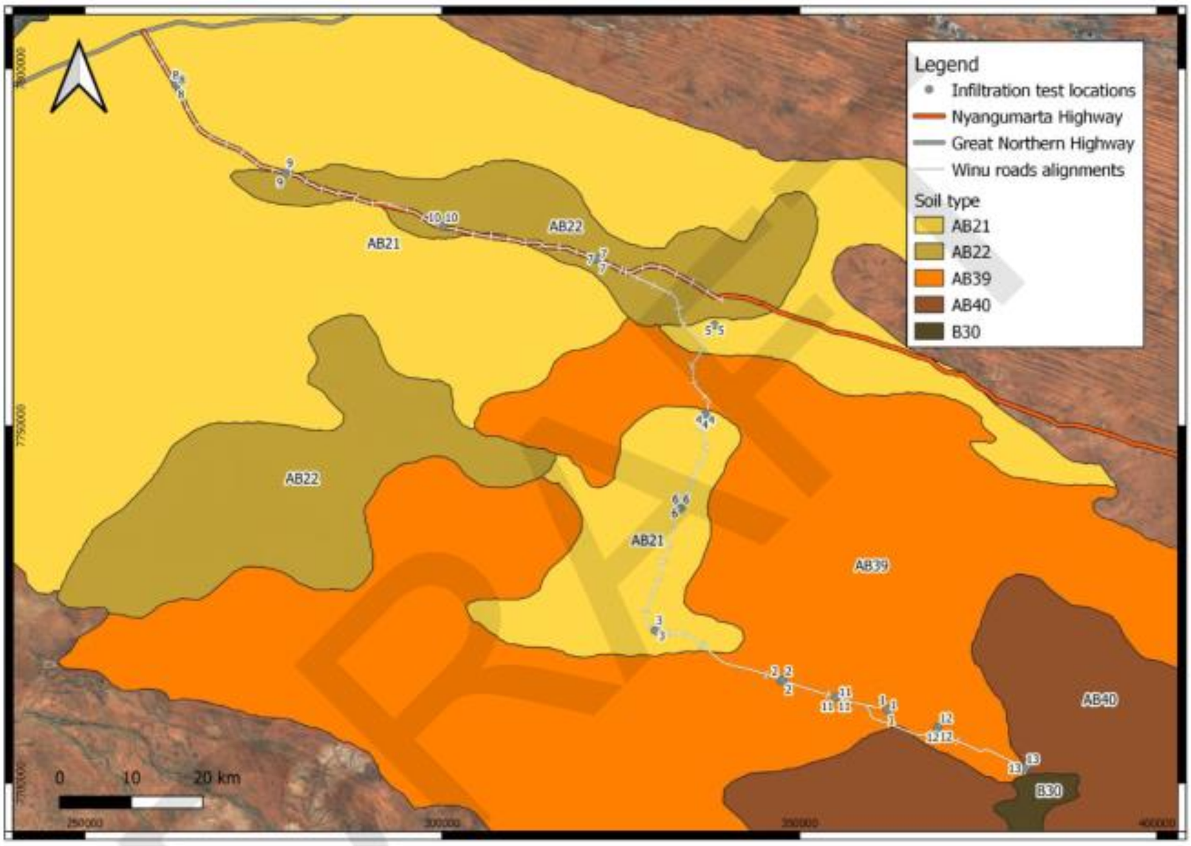


Figure C-1. Locations of infiltration testing (Figure 3, Golder 2020)

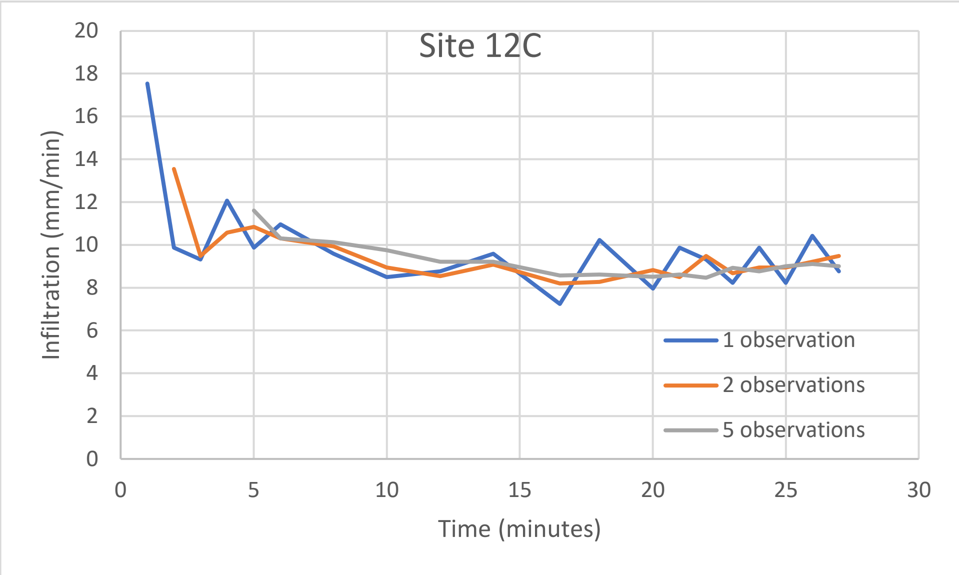


Figure C-2. Site 12C infiltration rate for different averaging periods over number of observations

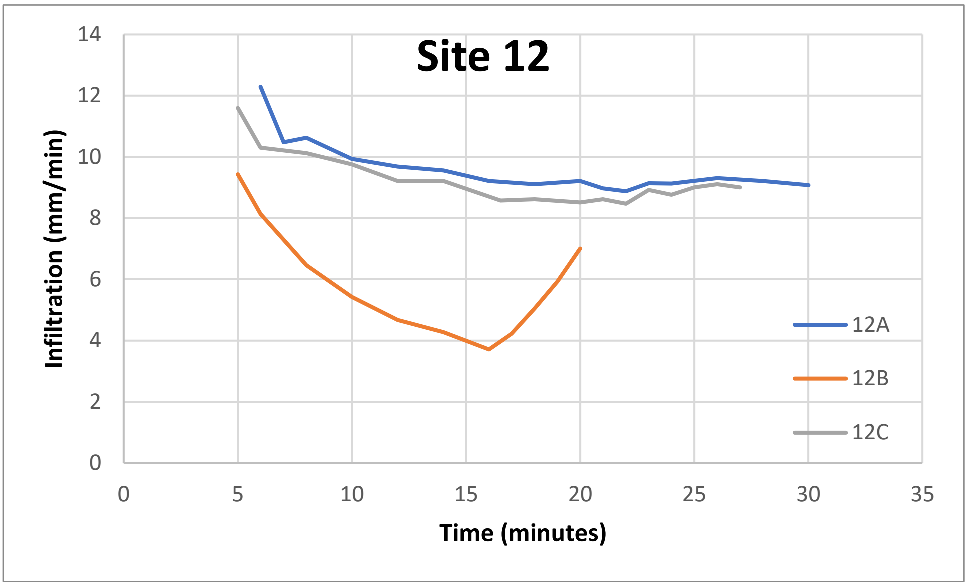


Figure C-3. Infiltration results Site 12 (5 observation difference)

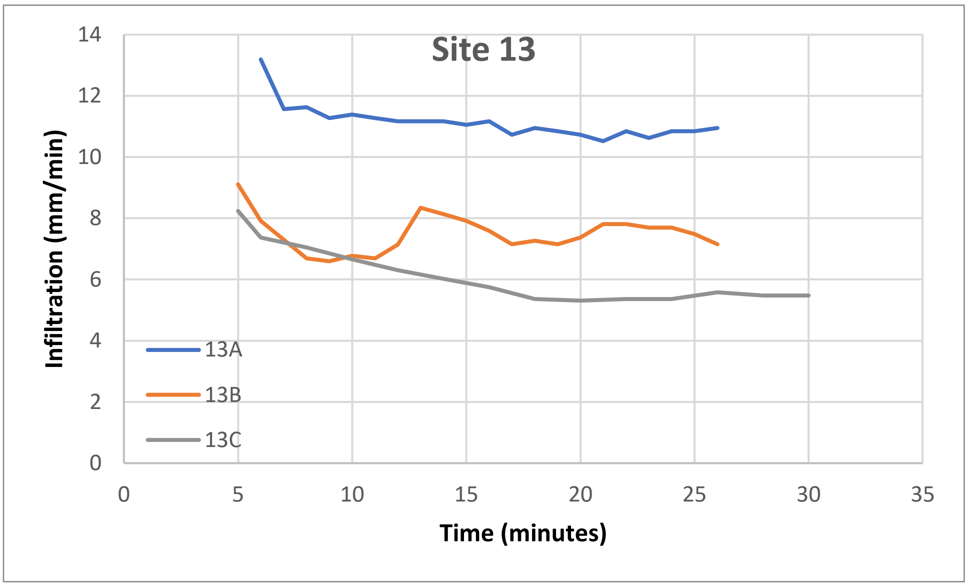


Figure C-4. Infiltration results Site 13 (5 observation difference)

Table C-1. Infiltration test results at Sites 12 and 13, using 5-observation averaging

Site	Date	Soil Type	Soil Notes (Golder, 2020)	Obs.	Last Time (min)	Inf (mm/min) Avg	Min	Max	Range
12A	23/03/2020	AB39	Sand	21	30	9.17	9.08	9.30	0.23
12B	23/03/2020	AB39	Sand	16	20	5.18	3.71	7.00	3.29
12C	23/03/2020	AB39	Sand	21	27	8.96	8.76	9.11	0.34
13A	23/03/2020	AB40	Clay	26	26	10.82	10.62	10.95	0.33
13B	23/03/2020	AB40	Clay	26	26	7.57	7.15	7.80	0.65
13C	23/03/2020	AB40	Clay	19	30	5.45	5.37	5.58	0.22

Appendix D
Golder (2022) Slug Test Data for Sandstone and Drilling Data Analysis

Advisian reviewed the Golder (2022) report and drilling database, to evaluate the conductivity (Kh and Kv) values for the Sandstone at the proposed infiltration pond or quarry site (Site 07). The findings are summarised below.

Slug Testing Data

Data was presented from slug testing on site, with the results suggesting Kh values of between 0.8 and 1.9 m/day (extract from Golder (2022) report provided in Table D-1).

Table D-1. Slug Test (rising-head) Hydraulic Conductivity Estimates for Unconfined Sandstone (Golder, 2022)

Bore ID	Test Date	Aquifer	Screen Interval (mbgl)	Estimated K Range (m/day)	Solution
WIDI0020	April 2021	Unconfined sandstone	42-66	1.1-1.3	Cooper – Jacob (unconfined)
WIDI0020	October 2019	Unconfined sandstone	42-66	0.8-1.3	Unconfined Bouwer & Rice and Hvorslev
WINU0214	October 2019	Unconfined sandstone	41.34-53.34	1.2-1.3	Unconfined Bouwer & Rice and Hvorslev
WINU0216	October 2019	Unconfined sandstone	41.2-53.2	1.3-1.9	Unconfined Bouwer & Rice and Hvorslev
WIDI0016	April 2021	Metasediments and unconfined sandstone	56.5-80	1.3	Cooper – Jacob CRT and Recovery

The Rio Tinto drilling database was investigated to identify available core / chip tray data for the boreholes associated with these slug tests. The bores associated with the slug tests appeared to be before the images (of cores/chip trays) were collected, as no photos were available for these boreholes. The lithological logs developed by Golder (2022) for each of the bores are provided below, which were reviewed. Advisian also searched the drilling database for boreholes near the slug testing sites and core/chip tray photographs are available.

In summary (refer to photos below):

- WINU0839 (Close to WIDI0020, 350m east): Chip tray photos suggests similar lithology to slug test location WIDI0020. Silcrete present up to 38mbgl. Very course homogenous sandstone encountered between 38 – 62mbgl (Table 11 below suggests K = 0.8 – 1.3 m/d),

- WINU0381 (Close to WINU0216 and WINU 0214, 20m away): Core photos suggest similar lithology to the slug test location. Silcrete present up to 37mbgl. Coarse banded sandstone encountered from 37 mbgl. (Table 11 below suggests K = 1.3 – 1.9 m/d), and

- Sandstone appears coarse, homogeneous and consistent between the holes, suggesting Kh would be close to Kv at these locations.

Site 07: Infiltration Pond Location

Chip tray photos from two locations (WINU1176 & WINU1177) near the proposed infiltration pond Site 07 suggest (refer to photos below):

- Silcrete encountered from depths of 12 to 26 mbgl and 10 to 20 mbgl respectively,
- Average Silcrete thickness in the area is approximately 10-14 m,

- Sandstone layer encountered from depths of +-26 mbgl. The sandstone from 26 mbgl to 44mbgl is weathered with a higher fraction of fines (orange colour). Therefore, we should assume a lower Kv for this Sandstone when compared with the Kh values estimated from the slug tests (suggest applying Kv = 0.5*Kh).

The closest diamond core hole to the infiltration pond location is WINU0038, 1 km west. The core photos suggest:

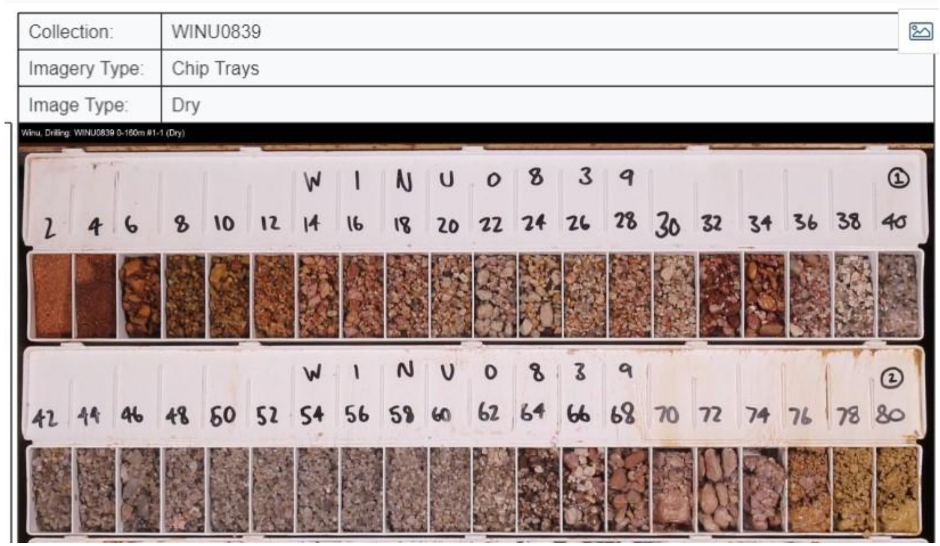
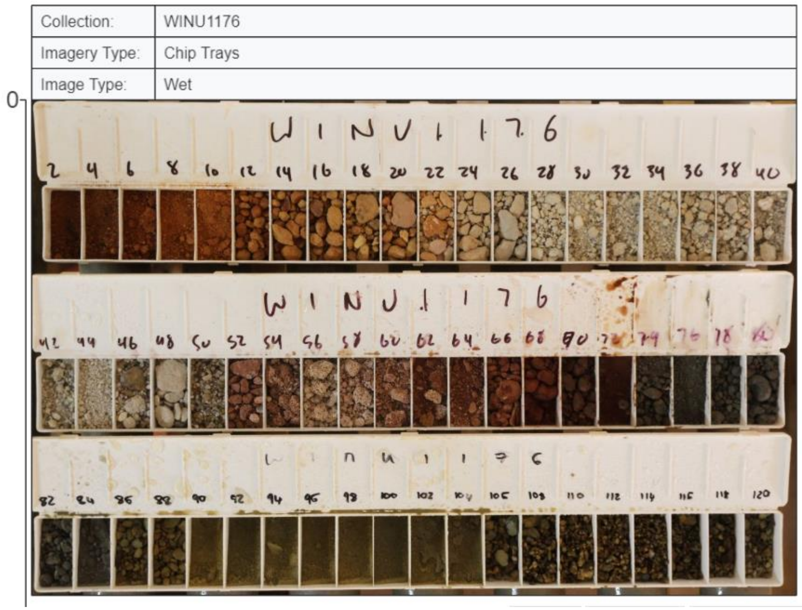
- Silcrete layer appears present to depths of up to 28.5 mbgl, with a weathered sandstone unit underneath,
- The weathered sandstone from 28.5mbgl to ~48.5 mbgl is consistent with the descriptions above for WINU1176 & WINU1177, suggesting Kv lower than Kh for the top ~20 m of weathered sandstone, and
- Below approx. ~50 mbgl, the sandstone appears coarser and more consistent with the sandstone encountered in the other slug test holes. Therefore, the sandstone may become more homogeneous and Kv becomes closer to Kh with depth.

Winu Numerical Model

The parameters from the Winu numerical groundwater model were assessed (refer to figure below):

- Kv and Kh were similar in the model (Kv was slightly lower than Kh), based on PEST calibration, although the sandstone was unsaturated in the numerical model,
- The selection of K values for modelling did not consider the more detailed analysis of Sandstone K above (as it was unsaturated), and
- Therefore, for the infiltration study we recommend testing Kv<Kh for sandstone in the numerical model (suggest applying Kv = 0.5*Kh).

Extracts from Winu Drilling Database

	Areas tested (Slug Test Locations)	**Chip Comparison – Boreholes Close to Site 7 Infiltration Pond Location**
Close to WIDI0020 (350m east), similar lithology Silcrete present up to 38m 38 – 62 Very course homogenous sandstone (K = 0.8 – 1.3m/d)		

	Areas tested (Slug Test Locations)	Chip Comparison – Boreholes Close to Site 7 Infiltration Pond Location
Close to WINU0216 and WINU 0214 (20m), Similar Lithology Silcrete up to 37m Coarse banded sandstone, typical for Winu area (K = 1.3 – 1.9)		

Advisian
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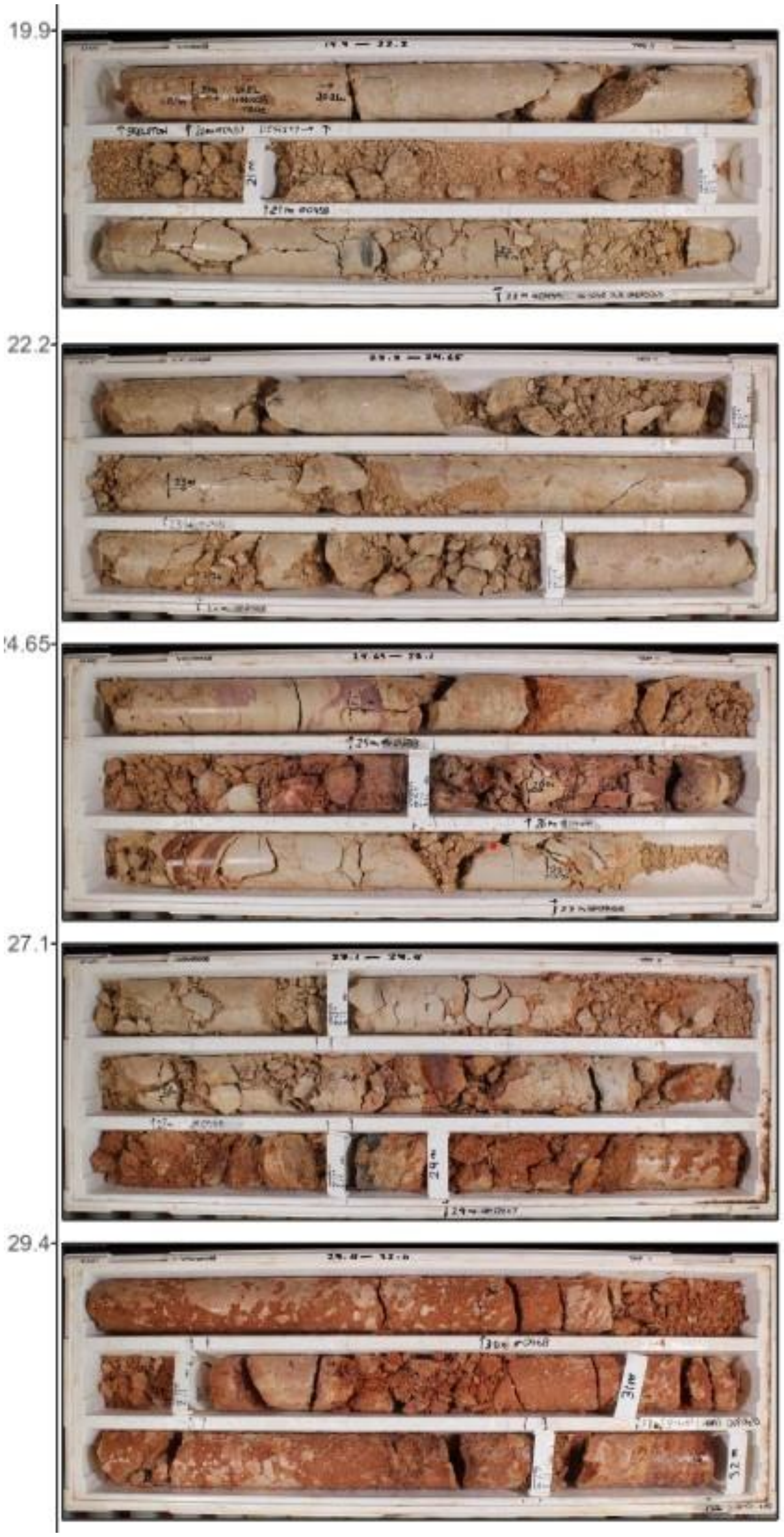
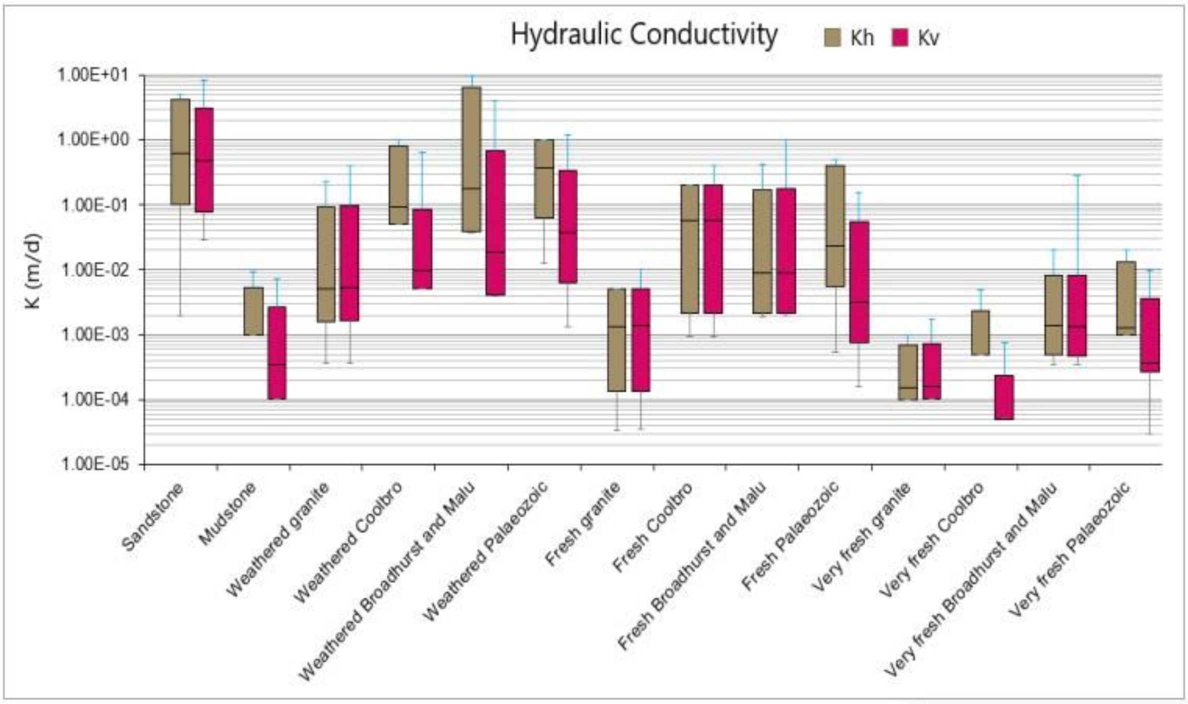
<u>**Core Photo for WINU0038 (1 km from Site 07)**</u>



Conductivities adopted in Numerical Model developed for Winu (no silcrete layer present in model)

The sandstone of interest was unsaturated in the model.



REPORT OF BOREHOLE: WINU0214

GOLDER

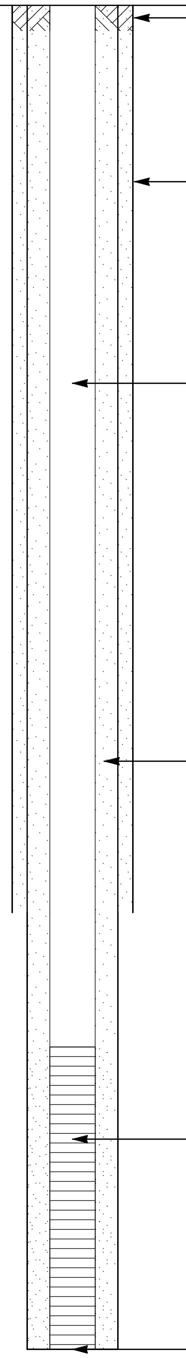
SHEET: 1 OF 1

CLIENT: Rio Tinto Exploration	COORDS: 368914.525 m E 7707907.198 m N MGA94 51 K	DRILL RIG: Ranger 4	
PROJECT: WINU Water Studies	SURFACE RL: 246.213 m DATUM: AHD	CONTRACTOR: Ranger Drilling	
LOCATION: East Pilbara - WINU	INCLINATION: -90°	LOGGED: PC	DATE: 20-7-19
JOB NO: 19117831	HOLE DIA: 140 mm HOLE DEPTH: 53.40 m	CHECKED: AP	DATE: 4-10-19

Drilling | **Sampling** | **Field Material Description and Instrumentation**

METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)
RC		0	246.21				SAND Red, uncemented, fine to coarse aeolian sands	
		10	11.00 235.21				Yellow, uncemented fine to coarse sands	
			16.00 230.21				SANDSTONE Cemeneted yellow coarse sandstone	
		20	20.00 226.21				Yellow-white coarse sandstones. Medium to high quartz content	
			25.00 221.21				Yellow-red coarse sandstones	
		30	30.00 216.21				White-pink coarse sandstones	
			38.00 208.21				White coarse sandstones. High quartz content	
		40						
	50.63 mbgl , 22-09-19	50						
			53.40 192.81				END OF BOREHOLE @ 53.40 m TARGET DEPTH STANDPIPE INSTALLED	
		60						

CONSTRUCTION



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GAP gINT FN. F05
RL3

GAP 8_16.8 LIB.GLB Log GAP WELL WINU-PTH1-L-PCALAFA1 - REV0.GPJ <<DrawingFile>> 09-01-2020 15:33 8.30.002 Datgel Tools

GOLDER

REPORT OF BOREHOLE: WINU0216

SHEET: 1 OF 1

CLIENT: Rio Tinto Exploration	COORDS: 368871.055 m E 7707872.409 m N MGA94 51 K	DRILL RIG: Ranger 4	
PROJECT: WINU Water Studies	SURFACE RL: 246.491 m DATUM: AHD	CONTRACTOR: Ranger Drilling	
LOCATION: East Pilbara - WINU	INCLINATION: -90°	LOGGED: PC	DATE: 20-7-19
JOB NO: 19117831	HOLE DIA: 140/190 mm HOLE DEPTH: 53.20 m	CHECKED: AP	DATE: 3-10-19

Drilling | **Sampling** | **Field Material Description and Instrumentation**

METHOD	WATER	DEPTH (metres)	DEPTH / RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)
RC		0	246.49				SAND Red orange aeolian sands	
		10	11.00 / 235.49				Yellow-orange coarse quartz sands	
			17.00 / 229.49				Yellow quartz-silcrete; coarse sand to fine gravel	
		20	20.00 / 226.49				SANDSTONE White coarse quartz silcretic sands, unconsolidated-semiconsolidated	
		30	33.00 / 213.49				White coarse quartz silcretic sandstones, consolidated	
		40	40.00 / 206.49				White coarse quartz silcretic sandstones, friable, white silty matrix	
	51.055 mbgl , 22-09-19	50	53.20 / 193.29				END OF BOREHOLE @ 53.20 m TARGET DEPTH STANDPIPE INSTALLED	
		60						
		70						

CONSTRUCTION

- 0 - 1m: Cement Plug
- 0m - 28m: 150mm collar casing. Annulus between collar casing and hole wall cemented
- 0m - 41.2m: 50mm blank class 18 PVC
- 1m - 53.2m: 1.2 - 3.4mm gravel pack
- 41.2m - 53.2m: 50mm slotted class 18 PVC, 1mm aperture
- PVC End cap

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GOLDER

REPORT OF BOREHOLE: WIDI0020

SHEET: 1 OF 1

CLIENT: Rio Tinto Exploration	COORDS: 367880.025 m E 7708358.243 m N MGA94 51 K	DRILL RIG: HYD07	
PROJECT: WINU Water Studies	SURFACE RL: 252.704 m DATUM: AHD	CONTRACTOR: Easternwell	
LOCATION: East Pilbara - WINU	INCLINATION: -90°	LOGGED: IC	DATE: 28-5-19
JOB NO: 19117831	HOLE DIA: 244 mm HOLE DEPTH: 142.00 m	CHECKED: AP	DATE: 4-10-19

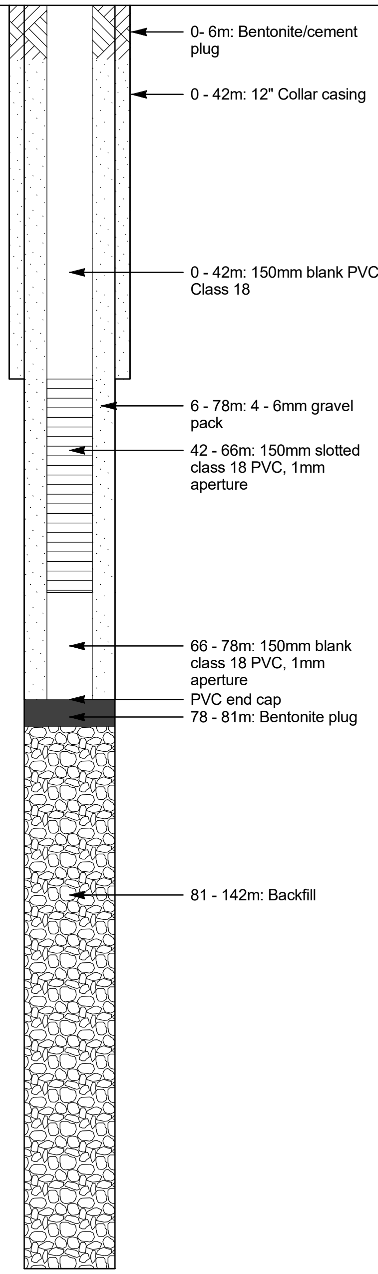
Drilling | Sampling | Field Material Description and Instrumentation

METHOD: RAB

WATER: 61.61 mbgl , 30-05-19

DEPTH	RL	SOIL/ROCK MATERIAL DESCRIPTION
0.00	252.70	AEOLIAN SANDS
8.00	244.70	SANDSTONE Patchy siliceous. Becoming cemented with depth
20.00	232.70	Common patchy silicification, common kaolinite on grains
37.00		Slight colour change, common traces of kaolinite on grains
40.00	212.70	Drilling with mud rotary. Formation change, increasing grainsize
52.00	200.70	Interval of medium to fine gravel at 56m BGL, common kaolinite on grains
58.00	194.70	Increased kaolinite on grains with depth
62.00		Slight light orange at 62m BGL. Slight content of limonite. Possible water-induced alteration.
64.00	188.70	Clayey, occasionally purple/red. Silicified. Shattered quartz vein
69.00		Fine sandstone interbedded with shale, purple
71.00	181.70	MUDSTONE Cavings
82.00	170.70	More cohesive cuttings, less dispersive, becoming dark purple/black with depth
90.00	162.70	Change in colour. Massive, amorphous, possible palaeo-watertable interface
121.00	131.70	Increasing hardness
130.00	122.70	Moderately hard in part, 10% cuttings platy at 132m below ground level
137.00	115.70	Clay returns to being amorphous
142.00	110.70	END OF BOREHOLE @ 142.00 m TARGET DEPTH STANDPIPE INSTALLED Golder supervision only for casing installation. Drilling and design not under Golder's supervision

CONSTRUCTION



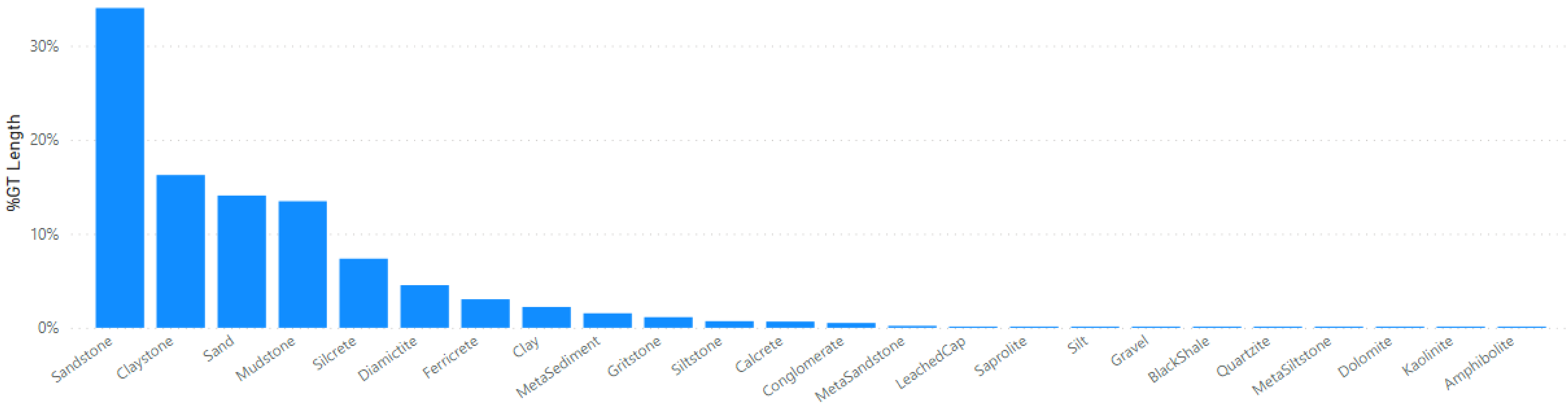
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Appendix E
Rio Tinto Silcrete Analysis

Data Review for identified the silcrete/ferricrete Spatial distribution- Continuity

- Drillhole geological units logged in the cover (slide 2)
- Drillhole charts: In which geochronological unit (s) is located the package silcrete/ferricrete? (slides 3 and 4).
- The downhole geophysics data is not suitable for cover depth <35 m (slide 5 to 7). Only Gamma data is used for lithology discrimination.
- Assumptions for interpolate the surface and some drillhole example (slide 9 to 11).
- Main Observations and recommendations (slide 12).

Drillhole Data: Logged units in Lith 1

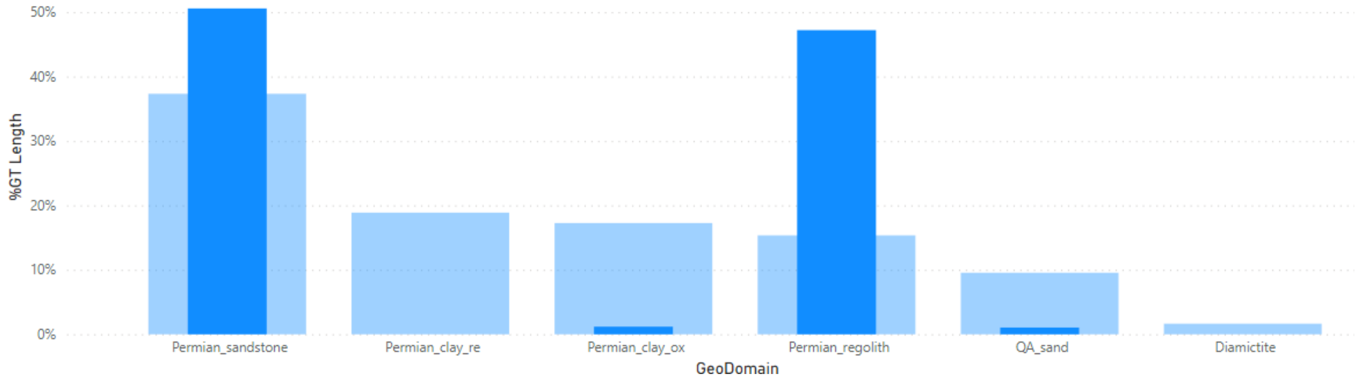


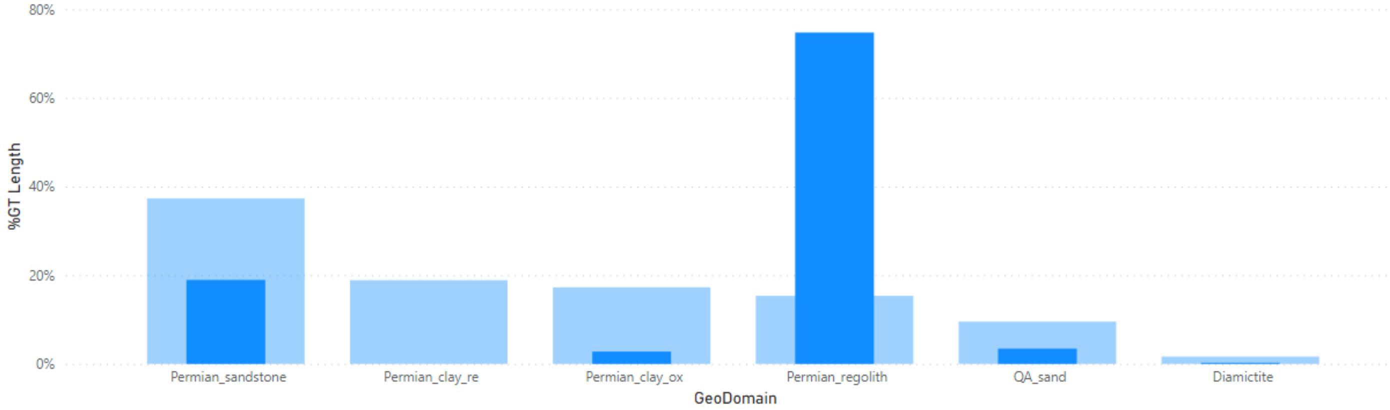
1. The predominat lithology logged in WINU cover is sandstone

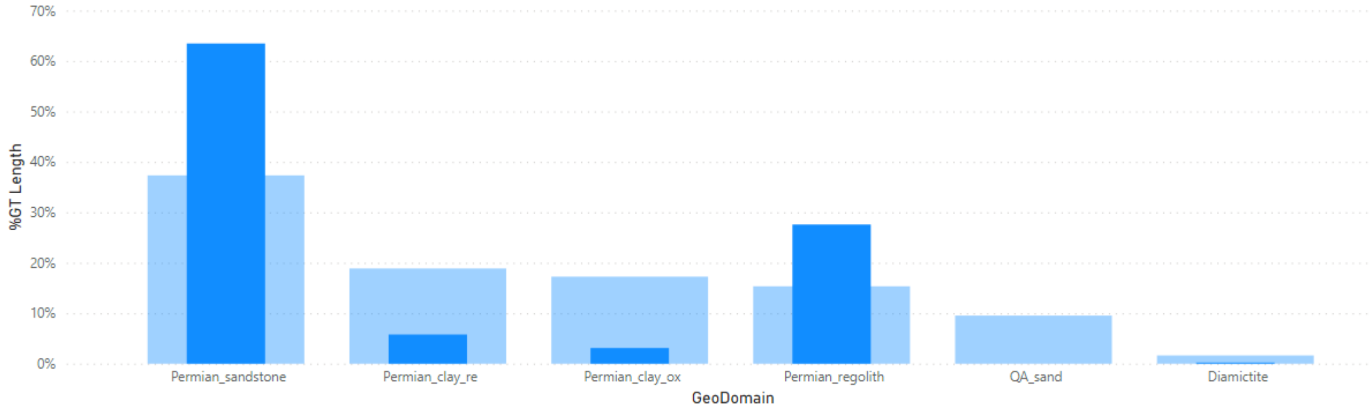
2. Silcrete, ferricrete and calcrete represents <15% of total data

Drillhole Data

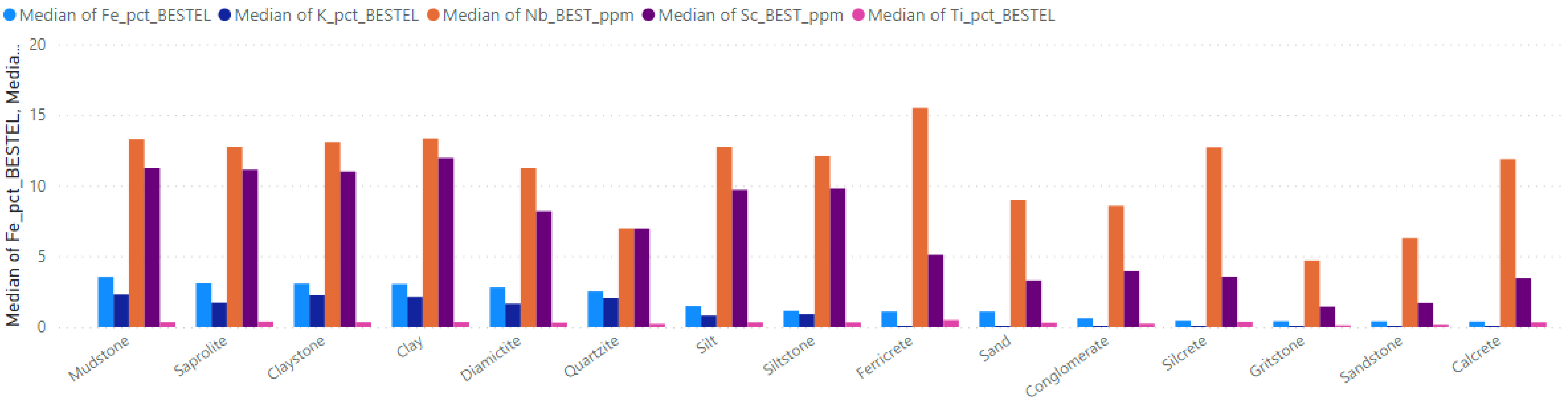
Silcrete	Mainly recognized in Permian Regolith and Permian Sandstone
Ferricrete	Mainly recognized in Permian Regolith and a reduce proportion in Permian Sandstone
Calcrete	Mainly recognized in Permian Sandstone and a reduce proportion in Permian Regolith



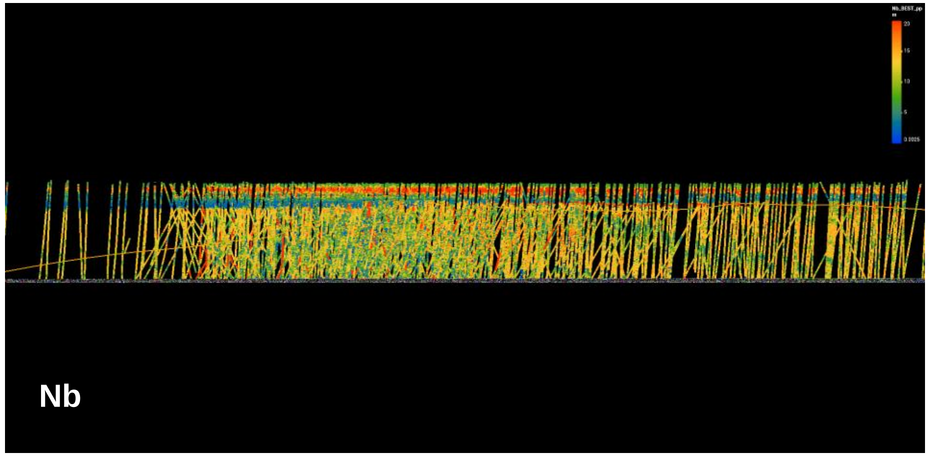


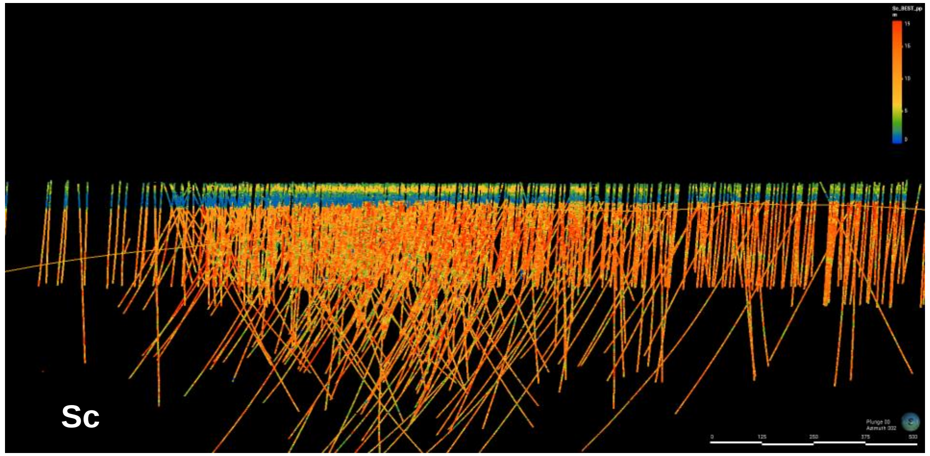


Drillhole Data: Logged units in Lith 1 and Assays



1. Nb and Sc can be used to differentiate the different lithology





Full Waveform Sonic (FWS)

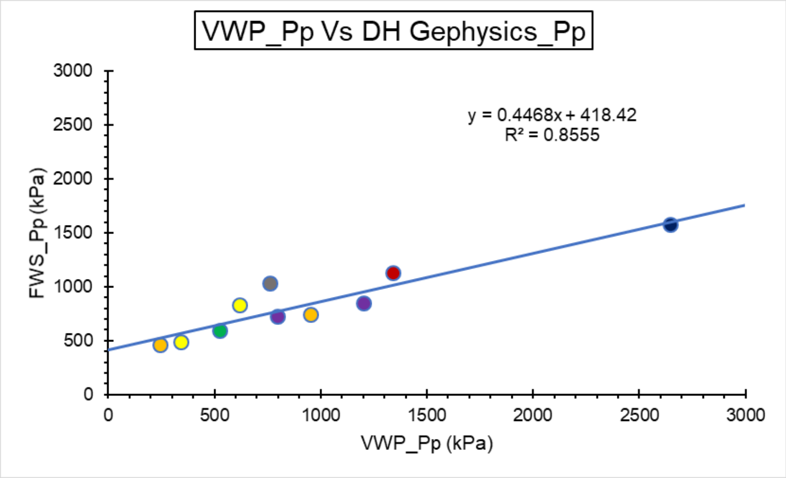
- Full wave sonic (FWS) detects P and S waves velocities.
- FWS tool is used extensively in the groundwater, mining, and geotechnical industries.

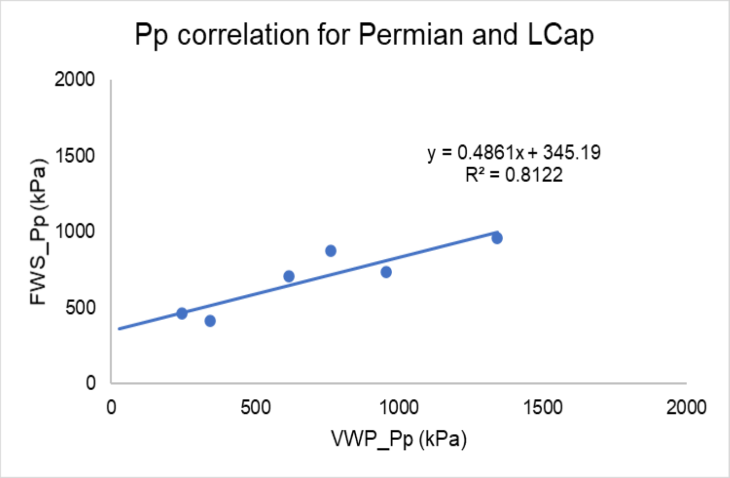
Applications of FWS:

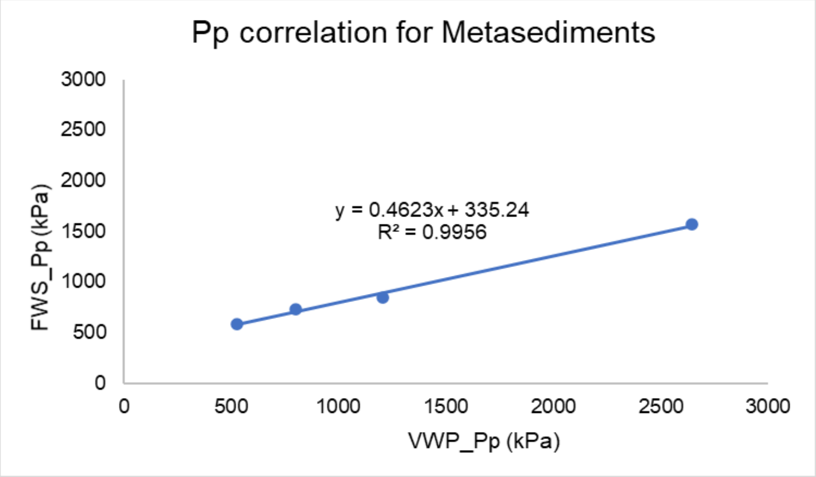
- Pore Pressure
- Uniaxial Compressive Strength
- Brittleness Index
- Young's Modulus
- Poisson's Ratio

Limitations of FWS based Pp:

- **Cannot work for <35m sediments**.
- Error margin for:
  - ❑ Permian and Leached Cap = ±10%
  - ❑ Metasediments = ±5%





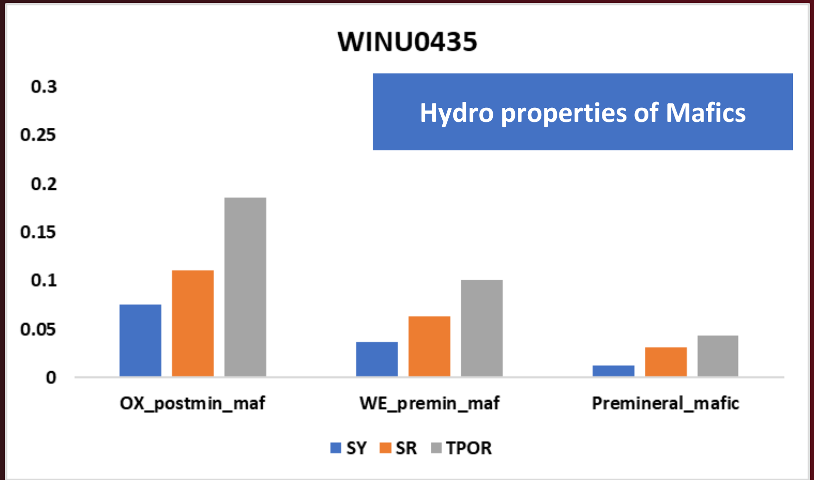


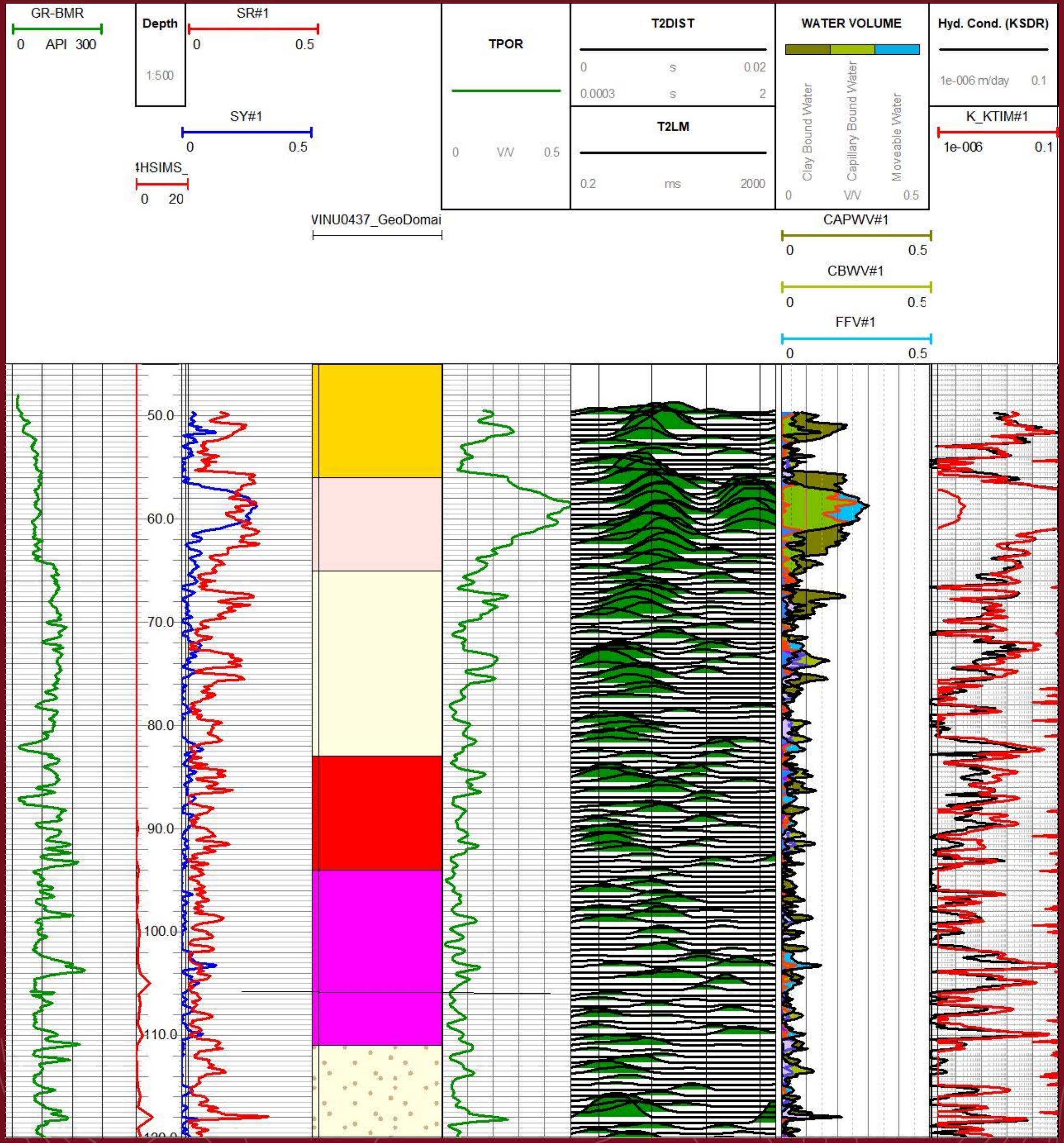
Borehole Magnetic Resonance (BMR)

- Borehole magnetic resonance (BMR) works according to interactions between hydrogen nuclei and applied electromagnetic fields.

Applications of BMR:

- Bound water (clay or capillary)
- Free water in pores.
- Total porosity
- Hydraulic conductivity
- Moisture content





Hydro Form with Calculated Fields: Low confidence in shallow cover

	HOLEID	PROJECTCODE	DEPTHSTEP	RUN	PRIORITY	DEPTH	DT_Log_GD_D	DTn_GD_D	GeoDomain_GD_D	P_Hydro_GD_D	PP_Calc_GD_D
76	WINU0342	WINU	0.1	1	1	71.7	167.02010488	204.91054261	Permian_clay_ox	702.66	572.72966729
77	WINU0342	WINU	0.1	1	1	71.8	167.98756627	204.89052386	Permian_clay_ox	703.64	576.90696917
78	WINU0342	WINU	0.1	1	1	71.9	168.53559817	204.87050788	Permian_clay_ox	704.62	579.65177326
79	WINU0342	WINU	0.1	1	1	72	168.61111572	204.85049466	Permian_clay_ox	705.6	580.77479114
80	WINU0342	WINU	0.1	1	1	72.1	169.60753218	204.83048421	Permian_clay_ox	706.58	585.07546153
81	WINU0342	WINU	0.1	1	1	72.2	170.37070161	204.81047652	Permian_clay_ox	707.56	588.58069995
82	WINU0342	WINU	0.1	1	1	72.3	171.00826428	204.7904716	Permian_clay_ox	708.54	591.6593415
83	WINU0342	WINU	0.1	1	1	72.4	172.29002154	204.77046944	Permian_clay_ox	709.52	596.97678292
84	WINU0342	WINU	0.1	1	1	72.5	173.24186224	204.75047004	Permian_clay_ox	710.5	601.16268889
85	WINU0342	WINU	0.1	1	1	72.6	173.55061323	204.7304734	Permian_clay_ox	711.48	603.12364961
86	WINU0342	WINU	0.1	1	1	72.7	173.55061323	204.71047953	Permian_clay_ox	712.46	604.01338607
87	WINU0342	WINU	0.1	1	1	72.8	173.55061323	204.69048842	Permian_clay_ox	713.44	604.90328819
88	WINU0342	WINU	0.1	1	1	72.9	173.55061323	204.67050007	Permian_clay_ox	714.42	605.79335598
89	WINU0342	WINU	0.1	1	1	73	173.88030326	204.65051448	Permian_clay_ox	715.4	607.83609203
90	WINU0342	WINU	0.1	1	1	73.1	173.88030326	204.63053166	Permian_clay_ox	716.38	608.72818266
91	WINU0342	WINU	0.1	1	1	73.2	172.95775927	204.61055159	Permian_clay_ox	717.36	606.38602077
92	WINU0342	WINU	0.1	1	1	73.3	172.55337096	204.59057428	Permian_clay_ox	718.34	605.85385681
93	WINU0342	WINU	0.1	1	1	73.4	172.00514661	204.57059974	Permian_clay_ox	719.32	604.81194374
94	WINU0342	WINU	0.1	1	1	73.5	172.25983656	204.55062795	Permian_clay_ox	720.3	606.59193039
95	WINU0342	WINU	0.1	1	1	73.6	172.30463097	204.53065892	Permian_clay_ox	721.28	607.63449783
96	WINU0342	WINU	0.1	1	1	73.7	172.21506543	204.51069265	Permian_clay_ox	722.26	608.20317775
97	WINU0342	WINU	0.1	1	1	73.8	171.24749983	204.49072914	Permian_clay_ox	723.24	605.66580352
98	WINU0342	WINU	0.1	1	1	73.9	170.48505459	204.47076839	Permian_clay_ox	724.22	603.84517165
99	WINU0342	WINU	0.1	1	1	74	169.53300554	204.45081039	Permian_clay_ox	725.2	601.34433011
100	WINU0342	WINU	0.1	1	1	74.1	168.89514426	204.43085516	Permian_clay_ox	726.18	599.94992326
101	WINU0342	WINU	0.1	1	1	74.2	168.56542418	204.41090267	Permian_clay_ox	727.16	599.64528429
102	WINU0342	WINU	0.1	1	1	74.3	168.56542418	204.39095295	Permian_clay_ox	728.14	600.51203926
103	WINU0342	WINU	0.1	1	1	74.4	168.939142	204.37100598	Permian_clay_ox	729.12	602.71224201
104	WINU0342	WINU	0.1	1	1	74.5	169.69723964	204.35106177	Permian_clay_ox	730.1	606.28975249
105	WINU0342	WINU	0.1	1	1	74.6	171.29273186	204.33112031	Permian_clay_ox	731.08	612.8713542
106	WINU0342	WINU	0.1	1	1	74.7	171.55690139	204.3111816	Permian_clay_ox	732.06	614.69932409
107	WINU0342	WINU	0.1	1	1	74.8	171.55690139	204.29124565	Permian_clay_ox	733.04	615.58228105
108	WINU0342	WINU	0.1	1	1	74.9	172.29002154	204.27131246	Permian_clay_ox	734.02	619.09976534
109	WINU0342	WINU	0.1	1	1	75	173.80494842	204.25138202	Permian_clay_ox	735	625.43829975
110	WINU0342	WINU	0.1	1	1	75.1	173.96962381	204.23145433	Permian_clay_ox	735.98	626.92675891
111	WINU0342	WINU	0.1	1	1	75.2	174.29891578	204.21152939	Permian_clay_ox	736.96	629.01115012
112	WINU0342	WINU	0.1	1	1	75.3	174.29891578	204.19160721	Permian_clay_ox	737.94	629.90905291
113	WINU0342	WINU	0.1	1	1	75.4	174.20925687	204.17168778	Permian_clay_ox	738.92	630.48263686
114	WINU0342	WINU	0.1	1	1	75.5	173.2871689	204.1517711	Permian_clay_ox	739.9	628.03852046
115	WINU0342	WINU	0.1	1	1	75.6	172.37966508	204.13185717	Permian_clay_ox	740.88	625.6379971
116	WINU0342	WINU	0.1	1	1	75.7	171.6544834	204.111946	Permian_clay_ox	741.86	623.8909459
117	WINU0342	WINU	0.1	1	1	75.8	170.68840965	204.09203757	Permian_clay_ox	742.84	621.25979894
118	WINU0342	WINU	0.1	1	1	75.9	171.58201091	204.0721319	Permian_clay_ox	743.82	625.3971582
119	WINU0342	WINU	0.1	1	1	76	171.58201091	204.05222897	Permian_clay_ox	744.8	626.28221397
120	WINU0342	WINU	0.1	1	1	76.1	170.56614754	204.03232879	Permian_clay_ox	745.78	623.45424506
121	WINU0342	WINU	0.1	1	1	76.2	169.67173418	204.01243137	Permian_clay_ox	746.76	621.06050778
122	WINU0342	WINU	0.1	1	1	76.3	168.53373439	203.99253669	Permian_clay_ox	747.74	617.76482905
123	WINU0342	WINU	0.1	1	1	76.4	166.62384448	203.97264476	Permian_clay_ox	748.72	611.62419593
124	WINU0342	WINU	0.1	1	1	76.5	167.39618745	203.95275558	Permian_clay_ox	749.7	615.32349185
125	WINU0342	WINU	0.1	1	1	76.6	167.51762837	203.93286914	Permian_clay_ox	750.68	616.63494363
126	WINU0342	WINU	0.1	1	1	76.7	166.62384448	203.91298545	Permian_clay_ox	751.66	614.20550862
127	WINU0342	WINU	0.1	1	1	76.8	165.48578875	203.89310451	Permian_clay_ox	752.64	610.86530777
128	WINU0342	WINU	0.1	1	1	76.9	163.4544226	203.87322632	Permian_clay_ox	753.62	604.21137284

P_Hydro_GD_D : Hydrostatic Pressure = water density * gravity*Depth

1*9.8*{DEPTH}

***

DT_Log_GD_D : Same as DTC but in msec/feet = 304800/Velocity_Pwave_m_sec

304800/{Velocity_Pwave_m_sec}

***

DTn_GD_D : Normalized DT ms/feet = DTm+(DTml-DTm)exp(-cZ)

```
case
when {GeoDomain_GD_D} = 'Metasediment' then 50+(150-50)*power(cast(10 as float), -0.0006*{DEPTH})
else 60+(220-60)*power(cast(10 as float), -0.0006*{DEPTH})
END
```

***

PP_Calc_GD_D : Calculated Pore Pressure (The ratio method)= P_hyd (DTlog/DTn)

{P_Hydro_GD_D}*({DT_Log_GD_D}/{DTn_GD_D})

Assumptions for interpolate the surface

The silcrete rocks is distributed a shallow depth <50 m

Data supporting: drillhole logging and geochemistry

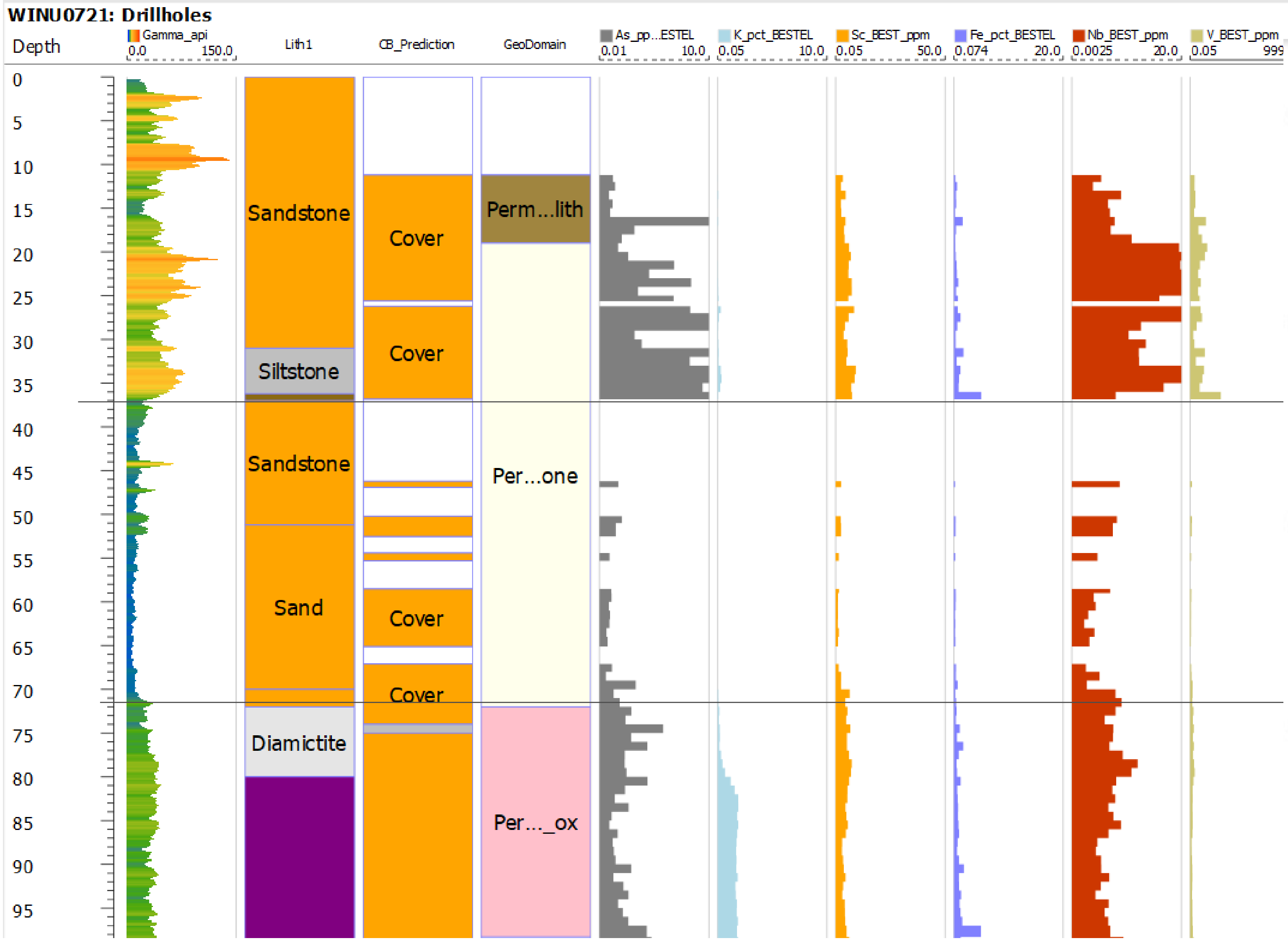
Is unknown the variability and distribution (lateral and vertical) of low permeability units

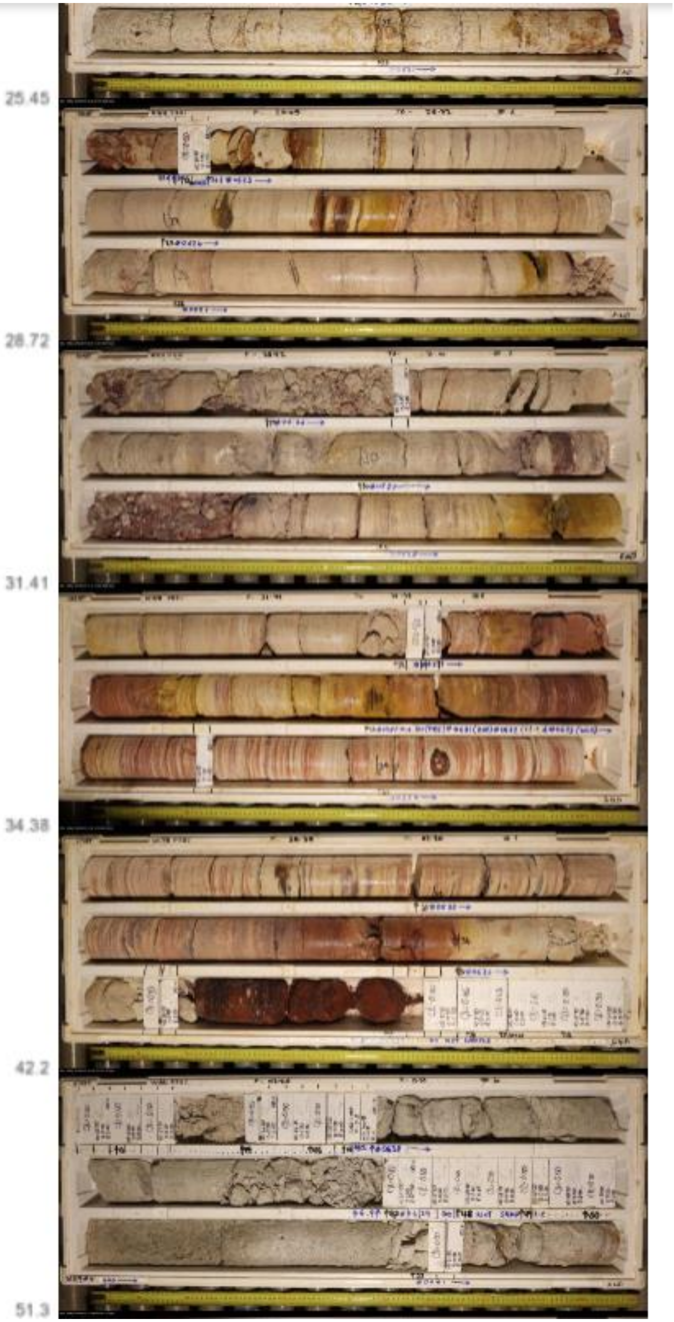
Some drillhole data suggest vertical variability e.g. WINU0721

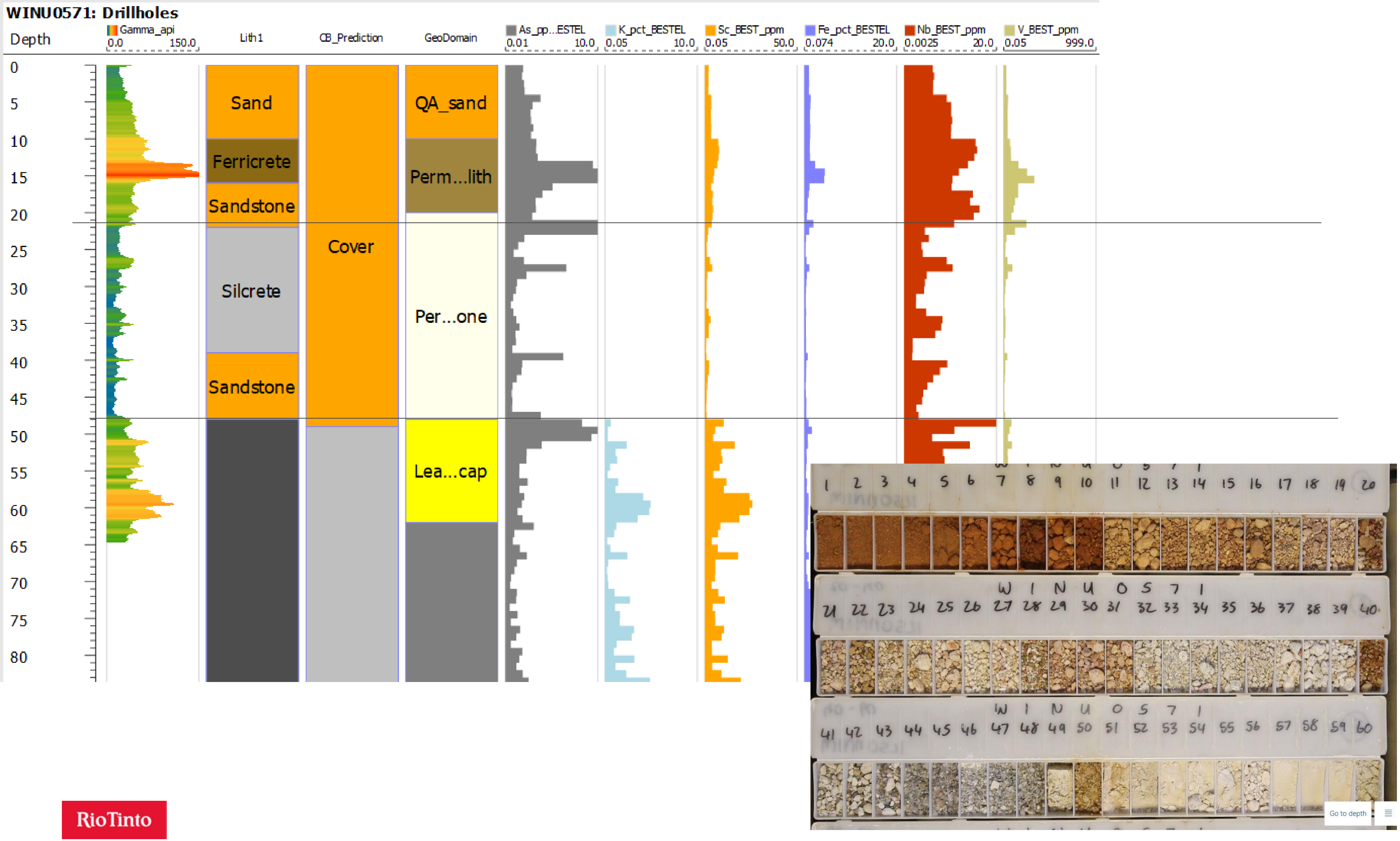
Some drillhole that had been identified silcrete just have ferricrete e.g. WINU0521

Some drillhole could have other sedimentary lith e.g. WINU0596

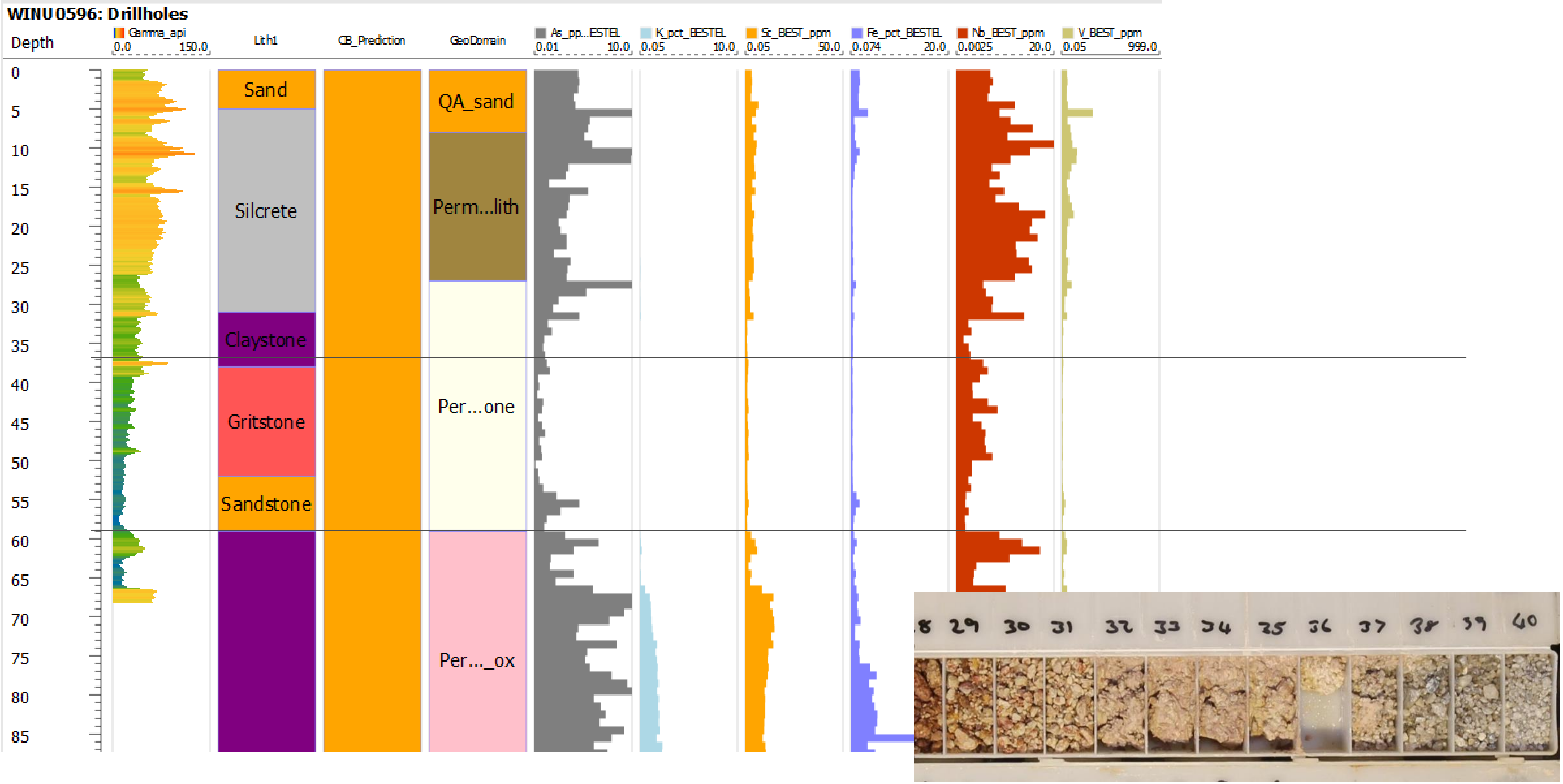
RioTinto


WINU0721: Drillholes
Depth
Gamma_api
0.0 150.0
Lith1
CB_Prediction
GeoDomain
As_pp...ESTEL
0.01 10.0
K_pct_BESTEL
0.05 10.0
Sc_BEST_ppm
0.05 50.0
Fe_pct_BESTEL
0.074 20.0
Nb_BEST_ppm
0.0025 20.0
V_BEST_ppm
0.05 999
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
Sandstone
Siltstone
Sandstone
Sand
Diamictite
Cover
Cover
Cover
Cover
Perm...lith
Per...one
Per..._ox


25.45
28.72
31.41
34.38
42.2
51.3


WINU0571: Drillholes
Depth
Gamma_api 0.0 150.0
Lith1
CB_Prediction
GeoDomain
As_pp...ESTEL 0.01 10.0
K_pct_BESTEL 0.05 10.0
Sc_BEST_ppm 0.05 50.0
Fe_pct_BESTEL 0.074 20.0
Nb_BEST_ppm 0.0025 20.0
V_BEST_ppm 0.05 999.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
Sand
Ferricrete
Sandstone
Silcrete
Sandstone
Cover
QA_sand
Perm...lith
Per...one
Lea...cap
WINU0571
Go to depth

RioTinto


WINU0596: Drillholes
Depth
Gamma_api 0.0 150.0
Lith1
CB_Prediction
GeoDomain
As_pp...ESTEL 0.01 10.0
K_pct_BESTEL 0.05 10.0
Sc_BEST_ppm 0.05 50.0
Fe_pct_BESTEL 0.074 20.0
Nb_BEST_ppm 0.0025 20.0
V_BEST_ppm 0.05 999.0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
Sand
Silcrete
Claystone
Gritstone
Sandstone
QA_sand
Perm...lith
Per...one
Per..._ox
29 30 31 32 33 34 35 36 37 38 39 40

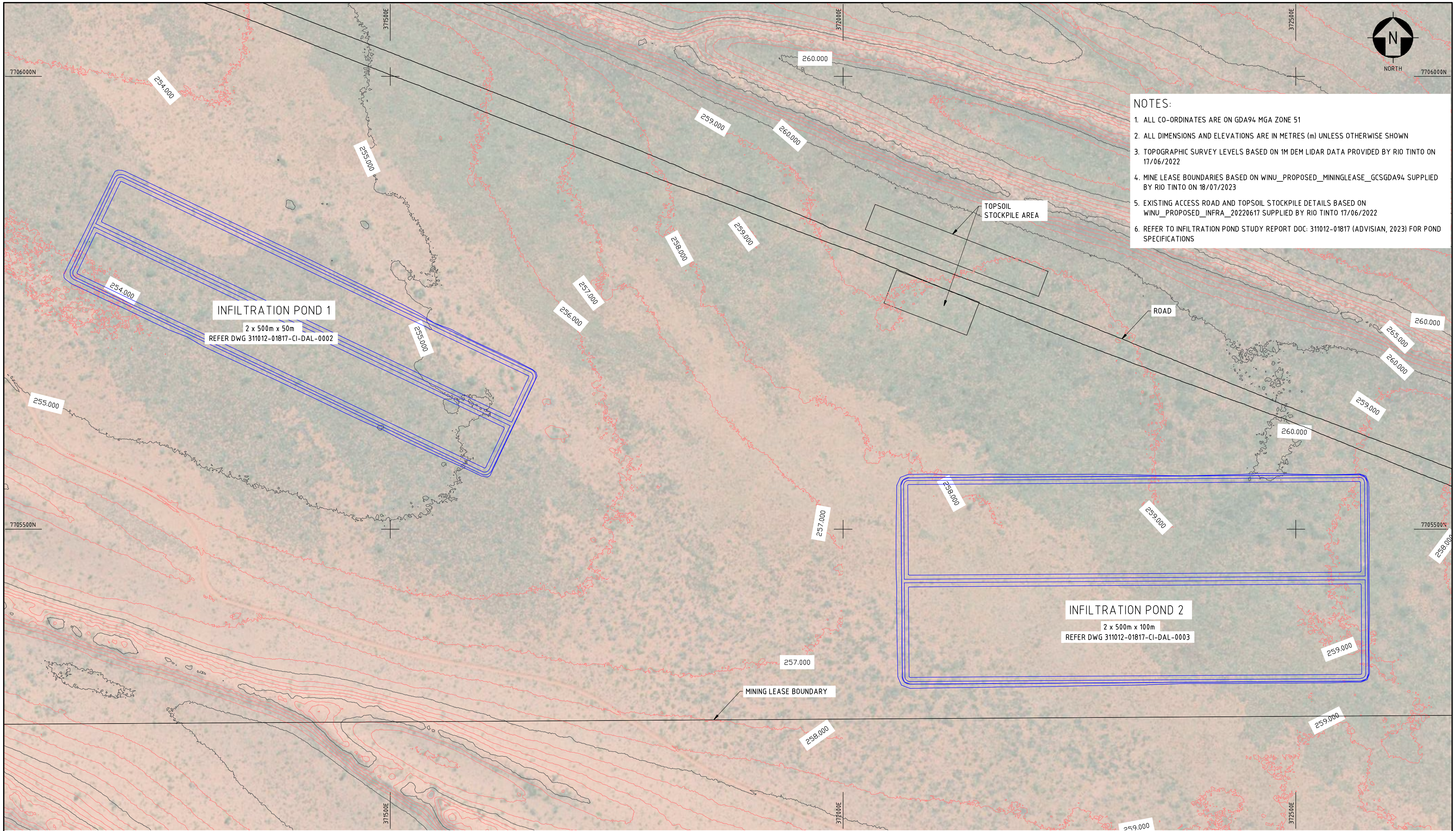
Main Observations and recommendations

- The drillhole logging indicates that the silcrete/ferricrete is not continuous in whole area, however uncertainty in the logging and logging/validation in the oldest holes the assessment of discontinuity should be questioned.

- The geochemistry suggest the silcrete/ferricrete could be continue in the whole area, then the continuity/discontinuity need to be validated.

- The drillhole data suggest that the silcrete/ferricrete package can have other sedimentary units as clays and mudstones. Then the continuity validation/rejection step should consider that the silcrete/ferricrete package is more heterogeneous in sedimentary units with low permeability as a common characteristic.

Appendix F
Concept Infiltration Pond Designs



NOTES:

1. ALL CO-ORDINATES ARE ON GDA94 MGA ZONE 51
2. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES (m) UNLESS OTHERWISE SHOWN
3. TOPOGRAPHIC SURVEY LEVELS BASED ON 1M DEM LIDAR DATA PROVIDED BY RIO TINTO ON 17/06/2022
4. MINE LEASE BOUNDARIES BASED ON WINU_PROPOSED_MININGLEASE_GCSGDA94 SUPPLIED BY RIO TINTO ON 18/07/2023
5. EXISTING ACCESS ROAD AND TOPSOIL STOCKPILE DETAILS BASED ON WINU_PROPOSED_INFRA_20220617 SUPPLIED BY RIO TINTO 17/06/2022
6. REFER TO INFILTRATION POND STUDY REPORT DOC: 311012-01817 (ADVISIAN, 2023) FOR POND SPECIFICATIONS

PLAN
SCALE 1:2000

40 0 40 80 120 160 200m
1:2000 (A1) 1:4000 (A3)

REV	DATE	REVISION DESCRIPTION	DRAWN	DRAFT CHK	DESIGNED	ENG CHK	APPR'D	CUSTOMER	REF DRAWING No	REFERENCE DRAWING TITLE
A	03/08/23	ISSUED FOR INFORMATION	MR	SJS	YA	AG	SA	-	-	-

A1 SHEET SCALE 1:2000

Worley

ADVISIAN PROJECT No. 311012-01817

ENGINEERING AND PERMIT STAMPS (As Required)

INFORMATION ONLY
NOT TO BE USED
FOR CONSTRUCTION

CUSTOMER
RioTinto

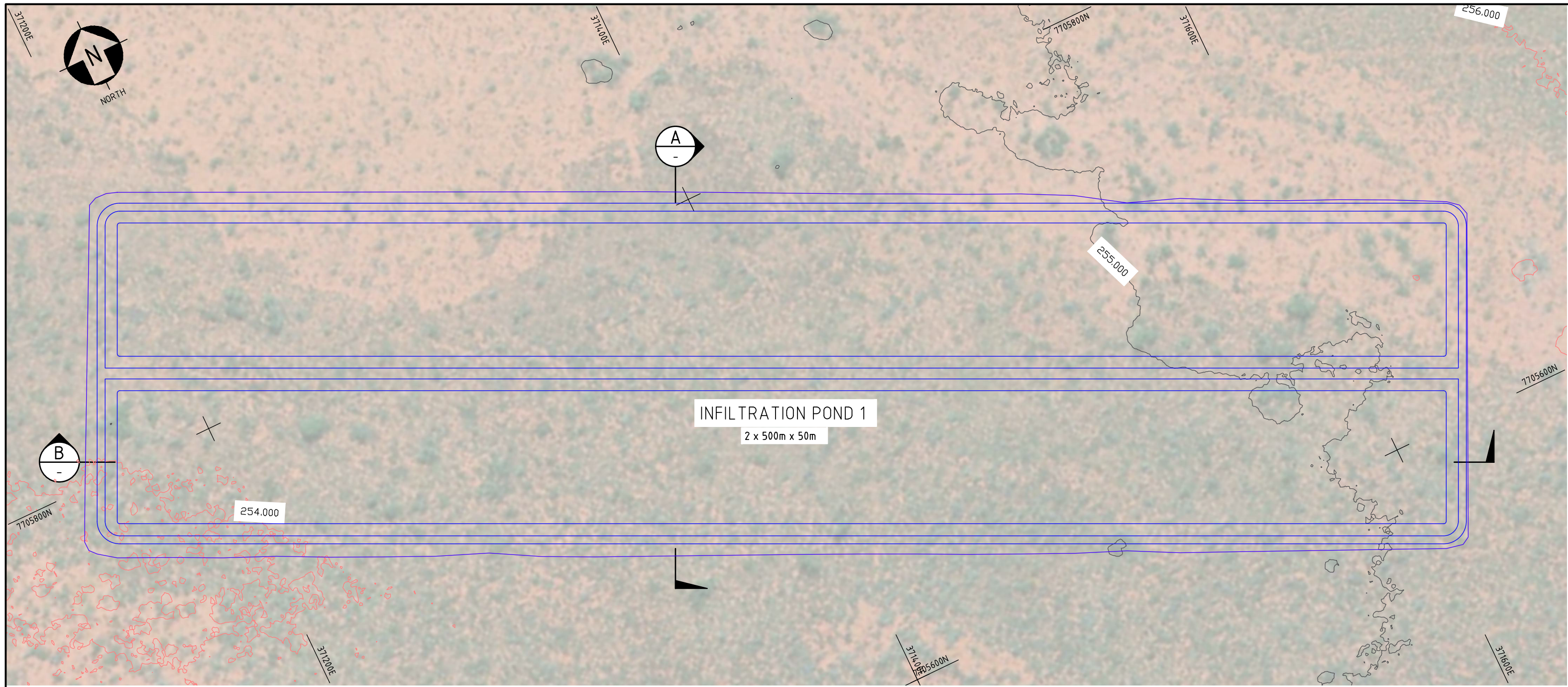
"This drawing is prepared solely for the use of the contractual customer of Advisian and Advisian assumes no liability to any other party for any representations contained in this drawing."

Advisian
Worley Group

WINU GOLD AND COPPER PROJECT
INFILTRATION POND OoM STUDY 2023
GENERAL ARRANGEMENT
INFILTRATION PONDS 1 AND 2

DRG No 311012-01817-CI-DAL-0001
REV A

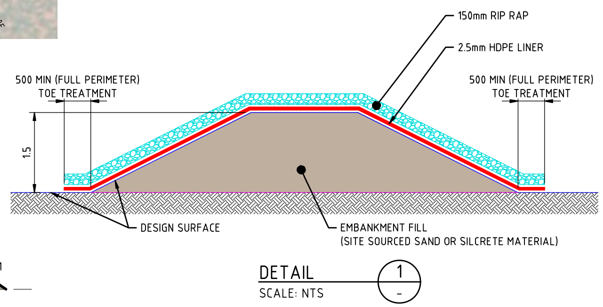
ADVISIAN_A1_REV0



PLAN
SCALE 1:1000

NOTES:

1. REFER DRG 311012-01817-CI-DAL-0001 FOR GENERAL NOTES
2. HDPE TEXTURED OR SMOOTH LINER - MINIMUM 2.5mm THICK. MANUFACTURING SPECIFICATIONS TO BE PROVIDED.
3. ADJACENT STRIPS AND LENGTHS OF GEOTEXTILE SHALL BE OVERLAPPED TO A MINIMUM OF 500mm. HDPE LINERS ARE TO BE WELDED TOGETHER WITH AN OVERLAPPING LENGTH OF 10 TO 15cm.
4. RIP-RAP SHALL CONSIST OF A COURSE OF HEAVY STONE PLACED ON BEDDING, LAID TO PROTECT BATTER SLOPES.
5. RIP-RAP SHALL BE HARD, DURABLE, ANGULAR ROCK HAVING A SPECIFIC GRAVITY WHEN DRY OF AT LEAST 2.5 AND FREE OF ALL FINES.
6. RIP RAP ROCK SIZE SHALL BE NOT LESS THAN 100mm AVERAGE DIMENSION NOR GREATER THAN 150mm AVERAGE DIMENSION. A FILTERED MEDIUM CUSHION LAYER SUCH AS SAND OR GRAVEL OR GEOFABRIC WRAPPED GRAVEL MIX IS REQUIRED BETWEEN THE HDPE LINER AND RIP RAP, WHICH WILL BE OPTIMISED DURING THE PRE-FEASIBILITY STUDY OF THE PROJECT.
7. GEOTEXTILES (GEOFABRIC) SHALL COMPLY WITH RELEVANT AS 3704, AS 3705, AND AS 3706.



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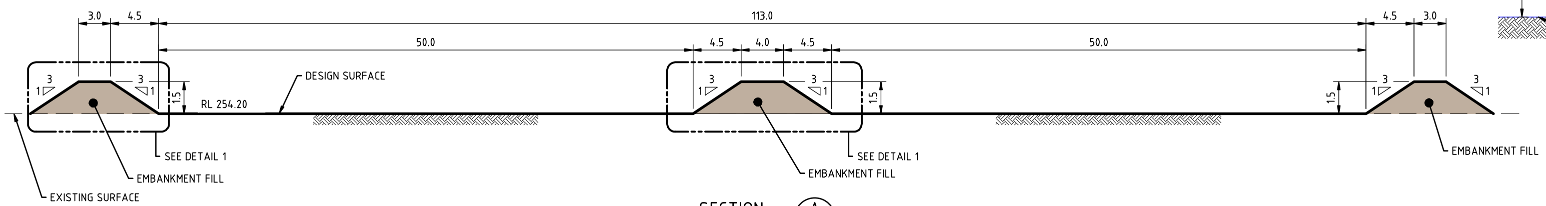
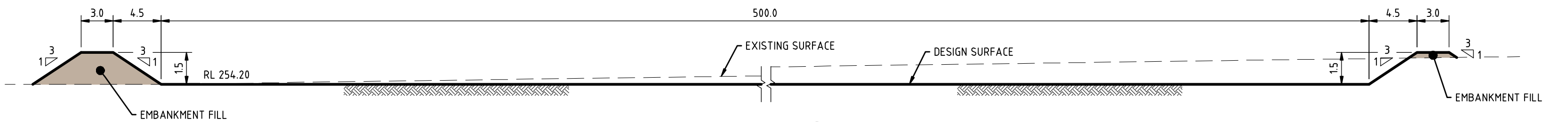
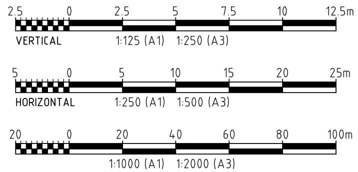


SECTION A
VERTICAL SCALE 1: 125
HORIZONTAL SCALE 1: 250



SECTION B
VERTICAL SCALE 1: 125
HORIZONTAL SCALE 1: 250



REV	DATE	REVISION DESCRIPTION	DRAWN	DRAFT CHK	DESIGNED	ENG CHK	APPR'D	CUSTOMER	REF DRAWING No	REFERENCE DRAWING TITLE
A	03/08/23	ISSUED FOR INFORMATION	MR	SJS	YA	AG	SA	-	-	-

A1 SHEET SCALE AS SHOWN

ADVISIAN PROJECT No. 311012-01817

ENGINEERING AND PERMIT STAMPS (As Required)

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CUSTOMER

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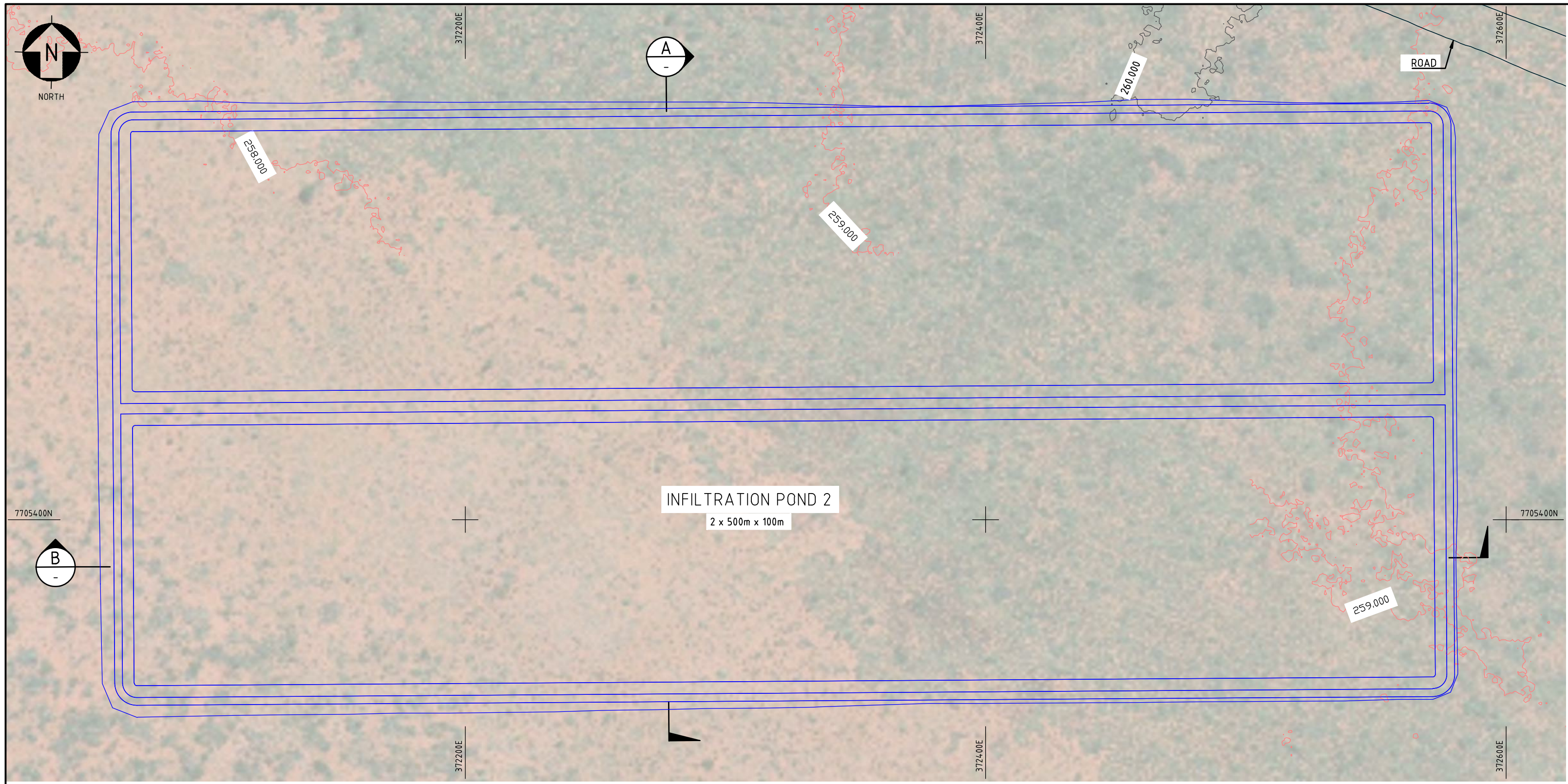
Advisian
Worley Group

WINU GOLD AND COPPER PROJECT
INFILTRATION POND OoM STUDY 2023
INFILTRATION POND 1

DRG No 311012-01817-CI-DAL-0002
REV A

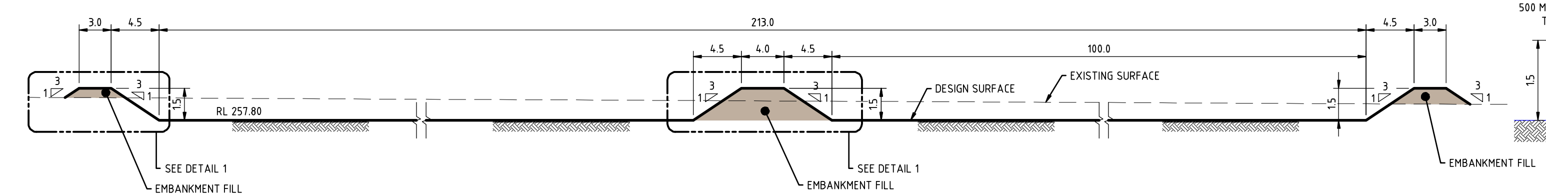
ADVISIAN_A1_REV0



PLAN
SCALE 1:1000

NOTES:

1. REFER DRG 311012-01817-CI-DAL-0001 FOR GENERAL NOTES
2. HDPE TEXTURED OR SMOOTH LINER - MINIMUM 2.5mm THICK. MANUFACTURING SPECIFICATIONS TO BE PROVIDED.
3. ADJACENT STRIPS AND LENGTHS OF GEOTEXTILE SHALL BE OVERLAPPED TO A MINIMUM OF 500mm. HDPE LINERS ARE TO BE WELDED TOGETHER WITH AN OVERLAPPING LENGTH OF 10 TO 15cm.
4. RIP-RAP SHALL CONSIST OF A COURSE OF HEAVY STONE PLACED ON BEDDING, LAID TO PROTECT BATTER SLOPES.
5. RIP-RAP SHALL BE HARD, DURABLE, ANGULAR ROCK HAVING A SPECIFIC GRAVITY WHEN DRY OF AT LEAST 2.5 AND FREE OF ALL FINES.
6. RIP RAP ROCK SIZE SHALL BE NOT LESS THAN 100mm AVERAGE DIMENSION NOR GREATER THAN 150mm AVERAGE DIMENSION. A FILTERED MEDIUM CUSHION LAYER SUCH AS SAND OR GRAVEL OR GEOFABRIC WRAPPED GRAVEL MIX IS REQUIRED BETWEEN THE HDPE LINER AND RIP RAP, WHICH WILL BE OPTIMISED DURING THE PRE-FEASIBILITY STUDY OF THE PROJECT.
7. GEOTEXTILES (GEOFABRIC) SHALL COMPLY WITH RELEVANT AS 3704, AS 3705, AND AS 3706.



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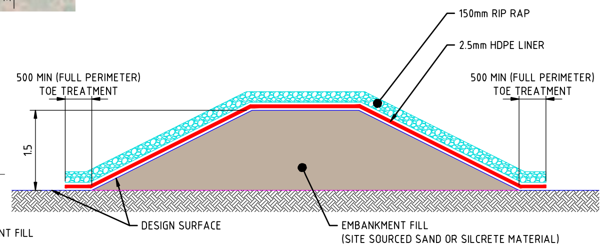
HORIZONTAL SCALE 1: 250



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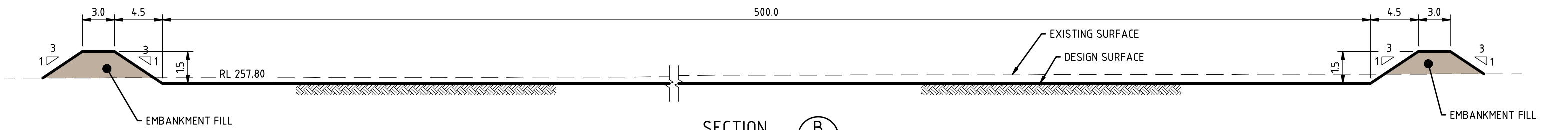

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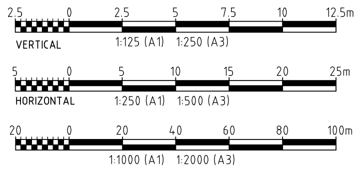

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A	03/08/23	ISSUED FOR INFORMATION	MR	SJS	YA	AG	SA	-	-	-

A1 SHEET SCALE AS SHOWN

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ADVISIAN PROJECT No.
311012-01817

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RioTinto

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Advisian
Worley Group

WINU GOLD AND COPPER PROJECT
INFILTRATION POND OoM STUDY 2023
INFILTRATION POND 2

DRG No 311012-01817-CI-DAL-0003
REV A

ADVISIAN_A1_REV0

Appendix G
Supplier Unit Rates for Liners

From: Jamie O'Brien <jamie@globalsynthetics.com.au>
Sent: Tuesday, 11 July 2023 3:48 PM
To: Arumugam, Yogeshwaran (Perth) <Yogeshwaran.Arumugam@advisian.com>
Cc: Peter Bayndrian <peter@globalsynthetics.com.au>; Peter Anderson <panderson@globalsynthetics.com.au>; Sean Hayes <sean@globalsynthetics.com.au>; Darrel Cheong <darrel@globalsynthetics.com.au>
Subject: RE: RFQ - Pilbara pond - Wall liner options [External Sender]

**** [EXTERNAL SENDER] Do not click links or open attachments unless you recognize the sender. ****

Hi Yogi,

Thanks for your patience here. Sorry took a little longer to get the GCCM pricing than I anticipated.

See below for budgetary pricing on all options ex-Welshpool, WA. Tiltex is our GCCM that we supply. It is also available in a 2.5m wide roll width. We also hire out a HDPE spreader system. Just allow $600+GST a week for hire if you want to add this to your costs. As a basic rule allow 12 rolls per semi-trailer.

	HDPE AND TILTEX 'BUDGETARY' PRICING			
Thickness	Type	Quantity required	Roll Size	m² rate
2.0mm	HDPE Smooth/Smooth	40,000m²	8x80m	$6.59
2.5mm	HDPE Smooth/Smooth	40,000m²	8x70	$8.20
3.0mm	HDPE Smooth/Smooth	40,000m²	7x50	$9.96
2.0mm	HDPE Smooth/Textured	40,000m²	8x80m	$6.92
2.5mm	HDPE Smooth/Textured	40,000m²	8x60m	$8.67
2.8mm	HDPE Smooth/Textured	40,000m²	8x55m	$9.70
2.0mm	HDPE Textured/Textured	40,000m²	8x70m	$7.23
2.5mm	HDPE Textured/Textured	40,000m²	8x50m	$9.07
3.0mm	HDPE Textured/Textured	40,000m²	7x40m	$10.98
7mm	7mm 40mpa Tiltex	40,000m²	5x20m	$44.26
10mm	10mm 40mpa Tiltex	40,000m²	5x20m	$65.02
12mm	12mm 40mpa Tiltex	40,000m²	5x20m	$74.53
Pricing ex Works Welshpool excluding GST				

Kind Regards,

Jamie O'Brien
Customer Service Consultant WA

P: 08 9459 4300

A :6 Riversdale Road, Welshpool WA 6106

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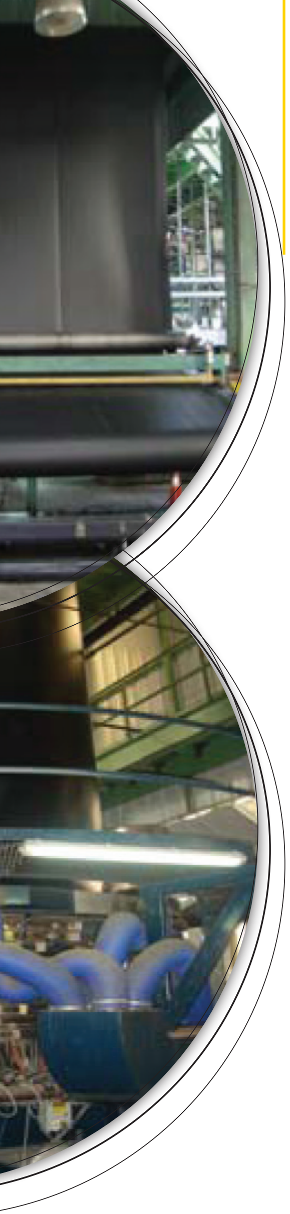

ProLiner® HDPE SMOOTH GEOMEMBRANE

DESCRIPTION

HDPE geomembranes have a generalised use as fundamental waterproofing materials of channels, dams & containment structures. HDPE is a non polar, semicrystalline thermoplastic material with good mechanical properties, high chemical stability & electrical insulation. ProLiner HDPE does not absorb humidity, is odourless & physically inert. ProLiner HDPE geomembranes are manufactured with resins which are specially formulated & certified.

HDPE smooth geomembranes have a minimum density of 0.94 g/cm³. HDPE smooth geomembranes have very low permeability, high stress resistance, high elongation at break and good chemical and UV resistance (2-3% carbon black) for the storage of liquids & solids.
All ProLiner HDPE geomembranes are manufactured to exceed the requirements of GRI GM13 standards.
Available in rolls of up to 170m long for 1mm thick product. All product is available in 8m width and roll length decreases with thickness increase.

PROPERTIES	UNIT	TEST METHOD*	STANDARD 1.00MM	STANDARD 1.50MM	STANDARD 2.00MM	STANDARD 2.50MM
Thickness Average	mm	ASTM D 5199	1.0	1.50	2.00	2.50
Thickness Min (-10%)	mm	ASTM D 5199	0.90	1.35	1.80	2.25
Density (min)	g/cm³	ASTM D 792	0.94	0.94	0.94	0.94
Tensile Properties:						
Yield Strength	kN/m	ASTM D 6693 (Type IV)	15	22	29	37
Break Strength	kN/m		30	45	58	75
Yield Elongation	%		13	13	13	13
Break Elongation	%		700	700	700	700
Tear Resistance	N	ASTM D 1004	125	191	254	317
Puncture Resistance	N	ASTM D 4833	360	528	704	880
Stress Crack Resistance	Hr	ASTM D 5397	600	600	600	600
Carbon Black Content	%	ASTM D 1603	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0
Carbon Black Dispersion	Cat	ASTM D 5596	1-2	1-2	1-2	1-2
Oxidative Induction Time (OIT)	min	ASTM D 3895	100	100	100	100
Oven Ageing at 85°C *Standard OIT* (90 days) or *High Pressure OIT* (90 days)	%	ASTM D5721 D3895	55 80	55 80	55 80	55 80
UV Resistance *High Pressure OIT* (1600 hours)	%	GM 11 ASTM D5885	50	50	50	50

DISTRIBUTORS OF :

Geotextiles
Geogrids
Dewatering Tubes
Subsoil Drainage
Wick Drains
Erosion Control
Gabions & Rock Mattresses
Industrial Fabrics
Lining Systems

v9._June15

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MELBOURNE P: (03) 9791 1772 F: (03) 9791 1776
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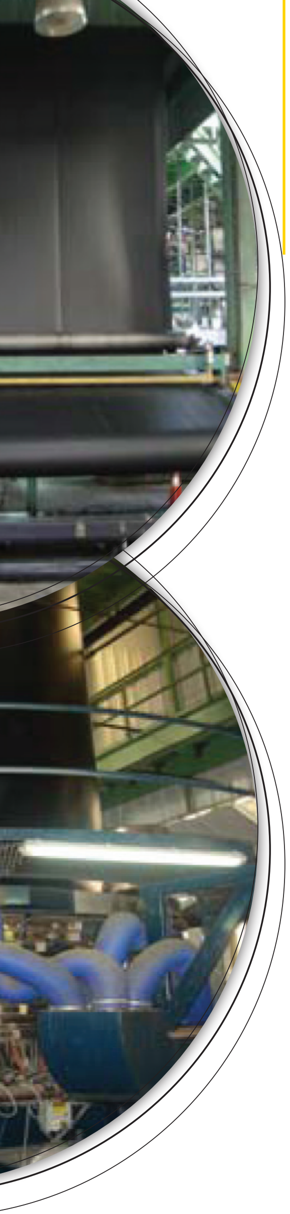
E: info@globalsynthetics.com.au | **www.globalsynthetics.com.au**



ProLiner® HDPE DOUBLE SIDED TEXTURED GEOMEMBRANE

DESCRIPTION

HDPE textured/textured geomembranes have a generalised use as high friction lining materials of channels, dams & containment structures. HDPE textured/textured geomembrane is a non polar, semicrystalline thermoplastic material with good mechanical properties, high chemical stability & electrical insulation. ProLiner HDPE textured/textured geomembrane does not absorb humidity, is odourless & physically inert. ProLiner HDPE textured/textured geomembranes are manufactured with resins which are specially formulated & certified.

HDPE textured/textured geomembranes have a minimum density of 0.94 g/cm³. HDPE textured/textured geomembranes have very low permeability, high stress resistance, high elongation at break and good chemical and UV resistance (2-3% carbon black) for the storage of liquids & solids. ProLiner HDPE textured/textured geomembranes offer improved frictional resistance of the liner on steep slopes as well as providing increased frictional resistance of cover materials above the liner.
All ProLiner HDPE geomembranes are manufactured to exceed the requirements of GRI GM13 standards.
Available in rolls of up to 125m long for 1mm thick product. All product is available in 8m width and roll length decreases with thickness increase.

PROPERTIES	UNIT	TEST METHOD*	STANDARD 1.00MM	STANDARD 1.50MM	STANDARD 2.00MM	STANDARD 2.50MM
Thickness Average	mm	ASTM D 5994	0.95	1.425	1.90	2.375
Thickness Minimum (-10%)	mm	ASTM D 5994	0.85	1.275	1.70	2.125
Asperity Height (min avg.)	mm	ASTM D 7466	0.4	0.4	0.4	0.4
Density (min)	g/cm³	ASTM D 792	0.94	0.94	0.94	0.94
Tensile Properties:						
Yield Strength	kN/m	ASTM D 6693 (Type IV)	15	22	29	37
Break Strength	kN/m		16	25	35	45
Yield Elongation	%		13	13	13	13
Break Elongation	%		350	350	350	350
Tear Resistance	N	ASTM D 1004	125	191	254	317
Puncture Resistance	N	ASTM D 4833	305	440	587	734
Stress Crack Resistance	Hr	ASTM D 5397	600	600	600	600
Carbon Black Content	%	ASTM D 1603	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0
Carbon Black Dispersion	Cat	ASTM D 5596	1-2	1-2	1-2	1-2
Oxidative Induction Time (OIT)	min	ASTM D 3895	100	100	100	100
Oven Ageing at 85°C *Standard OIT* (90 days) or *High Pressure OIT* (90 days)	%	ASTM D5721 ASTM D3895	55 80	55 80	55 80	55 80
UV Resistance *High Pressure OIT* (1600 hours)	%	GM 11 ASTM D5885	50	50	50	50

DISTRIBUTORS OF :

Geotextiles
Geogrids
Dewatering Tubes
Subsoil Drainage
Wick Drains
Erosion Control
Gabions & Rock Mattresses
Industrial Fabrics
Lining Systems

v7._June15

Global Synthetics
AUSTRALIAN COMPANY - GLOBAL EXPERTISE

ProLiner is manufactured to ISO9001, quality assurance procedure. Properties of ProLiner are minimum typical roll values unless otherwise noted. (GM) refers to the Geosynthetic Research Institute GRI-USA.

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F: (02) 9725 4304	F: (07) 3865 4444	F: (08) 9459 4311	F: (03) 9791 1776	F: (08) 8384 3886

E: info@globalsynthetics.com.au | **www.globalsynthetics.com.au**

ProLiner® HDPE SINGLE SIDED TEXTURED GEOMEMBRANE

DESCRIPTION

HDPE smooth/textured geomembranes have a generalised use as high friction lining materials of channels, dams & containment structures. HDPE smooth/textured geomembrane is a non polar, semicrystalline thermoplastic material with good mechanical properties, high chemical stability & electrical insulation. ProLiner HDPE smooth/textured geomembrane does not absorb humidity, is odourless & physically inert. ProLiner HDPE smooth/textured geomembranes are manufactured with resins which are specially formulated & certified.

HDPE smooth/textured geomembranes have a minimum density of 0.94 g/cm^3. HDPE smooth/textured geomembranes have very low permeability, high stress resistance, high elongation at break and good chemical and UV resistance (2-3% carbon black) for the storage of liquids & solids. ProLiner HDPE smooth/textured geomembranes offer improved frictional resistance of the liner on steep slopes. All ProLiner HDPE geomembranes are manufactured to exceed the requirements of GRI GM13 standards.
Available in rolls of up to 150m long for 1mm thick product. All product is available in 8m width and roll length decreases with thickness increase.

PROPERTIES	UNIT	TEST METHOD*	STANDARD 1.00MM	STANDARD 1.50MM	STANDARD 2.00MM	STANDARD 2.50MM
Thickness Average	mm	ASTM D 5994	0.95	1.425	1.90	2.375
Thickness Min (-10%)	mm	ASTM D 5994	0.85	1.275	1.70	2.125
Asperity Height (min avg.)	mm	ASTM D 7466	0.4	0.4	0.4	0.4
Density (min)	g/cm^3	ASTM D 792	0.94	0.94	0.94	0.94
Tensile Properties:						
Yield Strength	kN/m	ASTM D 6693 (Type IV)	15	22	29	37
Break Strength	kN/m		16	25	35	45
Yield Elongation	%		13	13	13	13
Break Elongation	%		400	400	400	400
Tear Resistance	N	ASTM D 1004	125	191	254	317
Puncture Resistance	N	ASTM D 4833	305	440	587	735
Stress Crack Resistance	Hr	ASTM D 5397	600	600	600	600
Carbon Black Content	%	ASTM D 1603	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0
Carbon Black Dispersion	Cat	ASTM D 5596	1-2	1-2	1-2	1-2
Oxidative Induction Time (OIT)	min	ASTM D 3895	100	100	100	100
Oven Ageing at 85°C *Standard OIT* (90 days) or *High Pressure OIT* (90 days)	%	ASTM D5721 ASTM D3895	55 80	55 80	55 80	55 80
UV Resistance *High Pressure OIT* (1600 hours)	%	GM 11 ASTM D5885	50	50	50	50

DISTRIBUTORS OF :

Geotextiles
Geogrids
Dewatering Tubes
Subsoil Drainage
Wick Drains
Erosion Control
Gabions & Rock Mattresses
Industrial Fabrics
Lining Systems

v8._June15

ProLiner is manufactured to ISO9001, quality assurance procedure. Properties of ProLiner are minimum typical roll values unless otherwise noted. (GM) refers to the Geosynthetic Research Institute GRI-USA.

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TECHNICAL DATA SHEET

TILTEX

Mechanically bonded composite, consisting of concrete-sand mix, embedded and fixed between two layers of geo-textile.

Properties of geotextile	**Test Method**	**Value**
Carrier Layer - PP Nonwoven Composite	EN ISO 9864	350 g/m^2
Cover Layer - PP Nonwoven	EN ISO 9864	200 g/m^2
Properties of concrete	**Test Method**	**Value**
Chemical composition	XRF	Sand-cement mix
Density	Typical	1,42 g/cm^3
Setting start	PN-EN 196-3	> 90 min
Properties of TILTEX(1)	**Test Method**	**Value**
Tensile Strength MD/CMD	EN ISO 10319	≥ 20,0 / 20,0 kN/m (±10%)
CBR Puncture Strength	EN ISO 12236	≥ 3,0 kN (±10 %)
Properties of TILTEX(2)	**Test Method**	**Value**
Compressive Strength	ASTM C 109-02	40 Mpa
Bending tests based	PN EN 12467:2016-08 5.4.3	6,0 MPa – Class 1
Water impermeability	PN EN 12467:2016-08 5.4.5-6	No drop of water
Durability against Freeze-thaw	PN EN 12467:2016-08 5.5.2	$R_L \geq 0,75$ Pass
Durability against Heat-rain	PN EN 12467:2016-08 5.5.3	$R_L \geq 0,75$ Pass
Durability against warm water	PN EN 12467:2016-08 5.5.4	$R_L \geq 0,75$ Pass
Durability against Soak-dry	PN EN 12467:2016-08 5.5.5	$R_L \geq 0,75$ Pass
Reaction to fire	PN EN 12467:2016-08 5.6	B-s1, d0*

Properties of TILTEX(1)	**TILTEX 7**	**TILTEX 9**	**TILTEX 10**	**TILTEX 12**
Mass per unit area of concrete EN 14196	7000 g/m^2 (±10%)	9000 g/m^2 (±10%)	10000 g/m^2 (±10%)	12000 g/m^2 (±10%)
Mass per unit area of TILTEX EN 14196	7550 g/m^2 (±10%)	9550 g/m^2 (±10%)	10550 g/m^2 (±10%)	12550 g/m^2 (±10%)
Thickness EN ISO 9863-1/-2	7,0 mm (±1mm)	9,0 mm (±1mm)	10,0 mm (±1mm)	12,0 mm (±1mm)

Standard Roll Dimensions	**Test Method**	**Value**
Width x Length	Typical	(5,0 x 20) m / (2,5 x 20) m
Quantity	Typical	100 m^2 / 50 m^2

(1) before hydration (2) after hydration *complies with EN 13501-1

These data are average values derived from standard tests and are subject to usual product variation. The right is reserved to make changes without notice at any time.

REV 11APR2018