NORTHERN STAR RESOURCES LTD

MEMORANDUM

Date: **27/08/2025**

To: **Duanne Ginger – Environmental Manager – CDO & Pilbara**

From: **Shawan Dogramaci, Hydrogeology Manager**

Additional Supporting Information

Groundwater Assessment – Hemi Gold Project

Purpose

Technical study '*Hemi Gold Project – Definitive Feasibility Study Conceptual and Numerical Groundwater Modelling – Operational Phase*' (Geowater, 2023) is a stand-alone technical study, with its discussions and conclusions drawn solely from the information available to Geowater at the time of writing. Its findings remain valid on that basis and should not be altered by subsequently incorporating data or interpretations beyond its original scope. This memorandum has been prepared to address any limitations in that report by providing a consolidated discussion of additional and more up-to-date understanding of the groundwater system and water balance across the Hemi Gold Project (Hemi, the Project). By presenting this information separately, the integrity of the Geowater report is preserved, while also ensuring that the latest insights into paleochannel delineation, river recharge, and model adequacy are clearly documented.

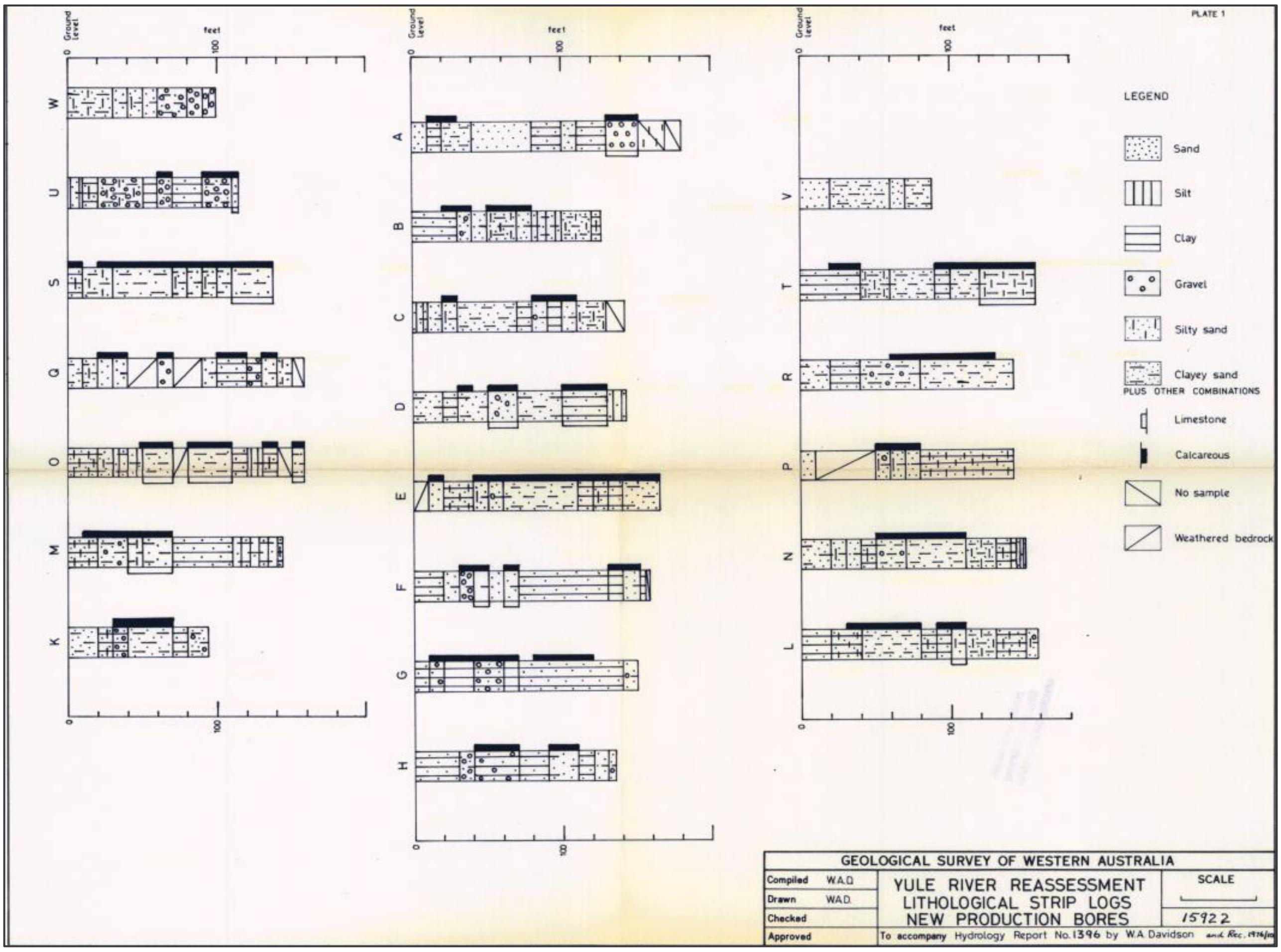
Delineation of the Paleochannel (Northwest Extent)

An extensive hydrogeological program has been undertaken for this greenfield site, incorporating 134 specific bores drilled through the alluvial aquifer and into the basement to a depth of 166 metres below ground level (mbgl) to inform development of the conceptual and numerical groundwater models. The extensive drilling program was supplemented by the data obtained from the drilling program that was conducted for the establishment of the Yule River borefield in 1976 (Davidson, 1976). The program included 22 drill holes examining the depth of the alluvium and underlying paleochannel aquifers.

As drilling across Hemi has been limited to sites further away from the Yule River, the northwest extent of the alluvium aquifer and associated paleochannel has instead been mapped, and its thickness defined, in the context of the regional assessment undertaken by Davidson (1976). Bore logs from this aquifer assessment, shown in Figure 1, confirm that the lower alluvium in the northwest area of Hemi's model domain, where it approaches the Yule River, is ~50m.

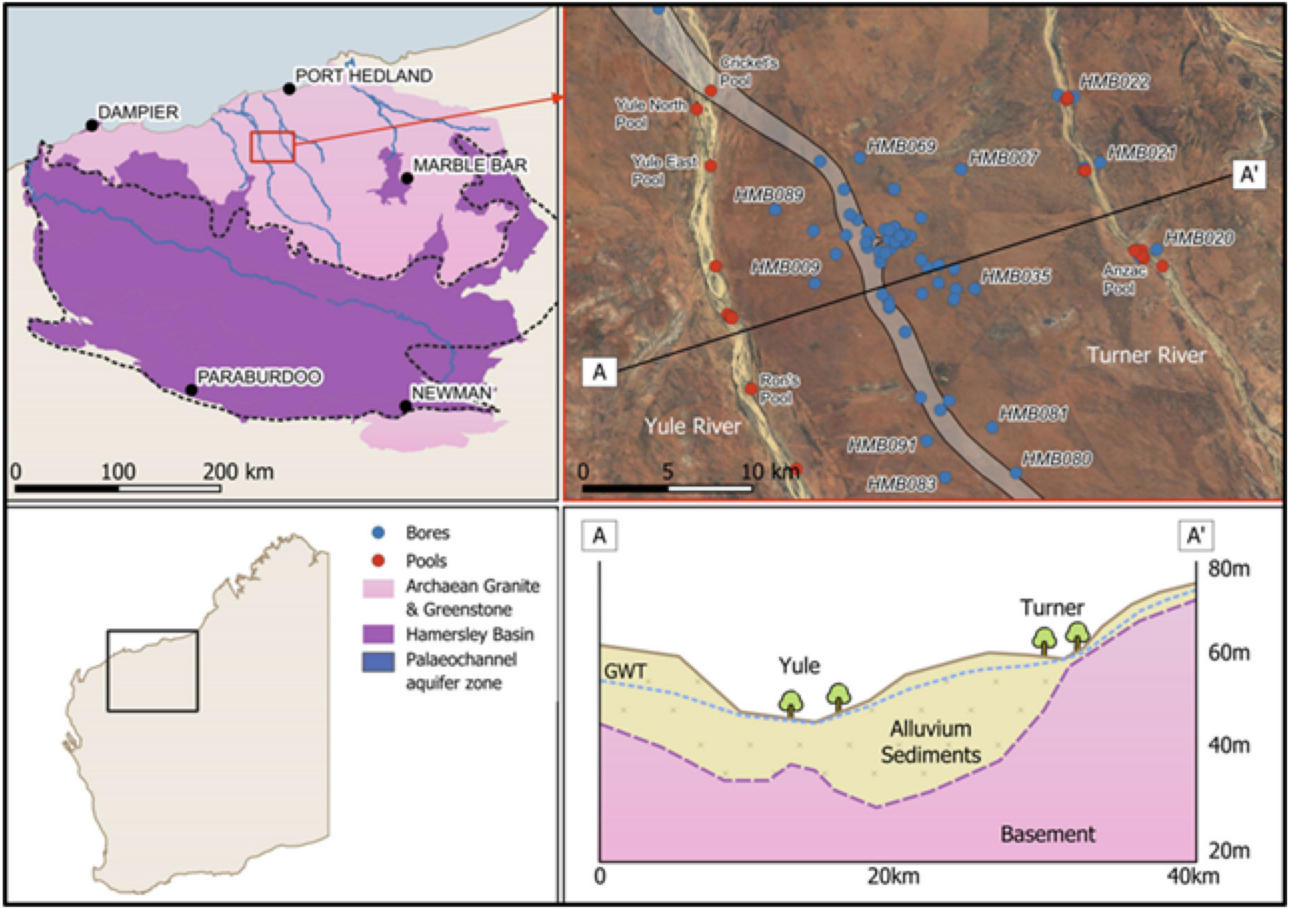
The depth of the paleochannel encountered in the Hemi drilling program (Geowater, 2023) is consistent with the maximum depth of the base of the paleochannel of ~50 mbgl encountered by the Davidson (1976) drilling program. This historical drilling data has proven to be of immense value in assisting current modelling efforts and is freely available for public application.

Figure 1: Bore logs - Yule River Assessment (Davidson, 1976)



A conceptual hydrogeological setting demonstrating the approximate aquifer thickness and groundwater level across a 40 km east-west section is provided in Figure 2. This conceptual setting of the site comprises a primary alluvial aquifer (with a maximum thickness of 50 m) that overlies the basement aquifer. The water table in the cross-section is below the base of the Yule and Turner Rivers and does not represent the water balance or groundwater flow.

The east-west transect shows a graphical representation that the thickness of the alluvium aquifer under the Turner River is minimal, which is supported by the geological map showing the bedrock high abuts the Turner River across the Hemi site (Figure 3). The deepest part of the alluvium aquifer occurs in the middle of the cross-section at a depth of up to ~50 mbgl. The width of the paleochannel aquifer in this location is ~1000m. The thickness of the alluvium further west decreases to ~25m deep obtained from a recent drilling program close to the Yule River.



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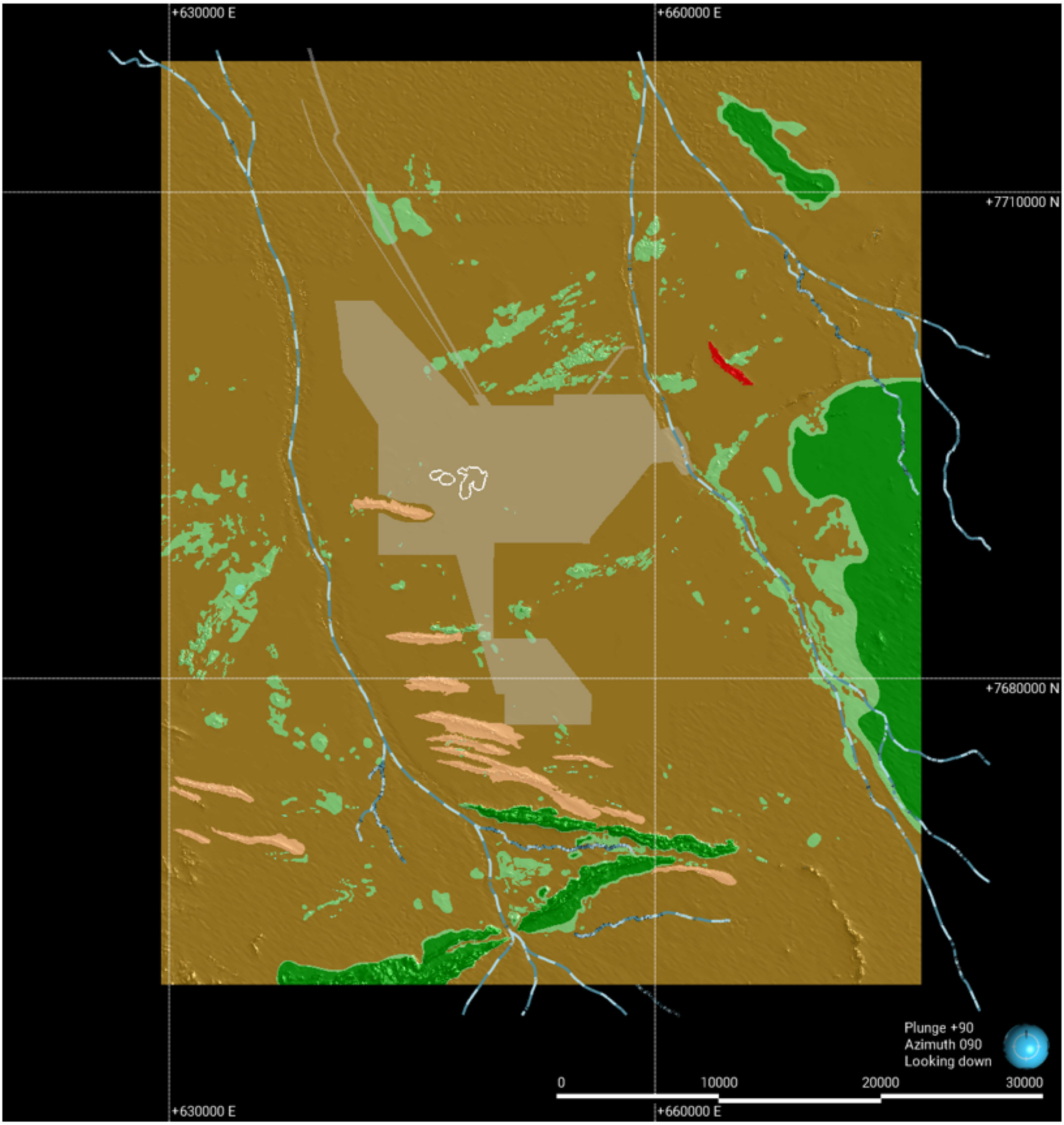
Created/Reviewed By: KM/EL

PROJECT						CLIENT
Hemi Gold Project - Hydrogeological Model East-West Cross-Section of the Hydrogeological Setting						NORTHERN STAR RESOURCES LIMITED
FIGURE No.	2	PROJECT No.	ADV-AU-00673	DATE	August 2025	



ALLUVIUM
SAPROLITE AND SAPROCK
AEOLIAN DUNES
PISOLITIC LIMONITE
FRACTURED BEDROCK
BEDROCK
MAJOR RIVER SYSTEMS

SLR

PROJECT	CLIENT
NAME **Hemi Gold Project - Hydrogeological Model**	NORTHERN STAR RESOURCES LIMITED
DRAWING **Geological Map Showing The Bedrock Abuts The Turner River**	

FIGURE No.	PROJECT No.	DATE
3	ADV-AU-00673	August 2025

Created/Reviewed By: KM/EL

The numerical model of the site is based on the conceptual model described, separating the upper alluvium aquifer from the lower alluvium/paleochannel aquifer. The hydraulic conductivity obtained from the pump testing program of the aquifers suggests a relatively higher hydraulic conductivity of the lower paleochannel aquifer compared with the upper alluvium aquifer. The pump testing of the bores drilled into the basement aquifer averaged 2.5 l/s and therefore, insufficient water to continue pump testing program. It has been concluded the basement rock is not considered a water-producing aquifer, and if seeps or flow occurred from the bedrock aquifer due to unknown fractures during mine operation, it will be dewatered using in-pit sump pumping. In development of the site water balance, a conservative production rate of 10 l/s was used in the event the future drilling program encounters fractures.

Furthermore, the Davidson (1976) report suggests that an abstraction rate of 21,000 m^3/d (7.6 GL/a), equivalent to the estimated groundwater throughflow, could be safely maintained for one year after river flow, without further recharge, provided that pumping was spread over the entire area. The yield of 7.6 GL per annum from the Yule River bore field has been sustained since 1976 due to the primary source of the abstraction is recharge from annual flooding events that can be up to 1,800GL/a. The total surface flow over 40 years calculated upgradient of the Yule River bore field is 9,391 GL/a with average flow of approximately 240 GL/a.

Role of River Recharge

The Yule and Turner Rivers play a critical role in the recharge and discharge dynamics of the aquifer system surrounding the Hemi Gold Project. Their interaction with the groundwater system was considered in both the operational and closure phases of the groundwater model.

In the '*Hemi Gold Project – Definitive Feasibility Study Conceptual and Numerical Groundwater Modelling – Operational Phase*' (Geowater, 2023), the rivers were initially simulated as simple gaining streams. This was achieved by assigning drain cells at the basal elevations of the riverbeds along the reaches intersecting the model domain. Under this approach, direct stream recharge was not explicitly modelled; instead, average recharge estimates derived from rainfall infiltration were applied within river channels to approximate groundwater inflows.

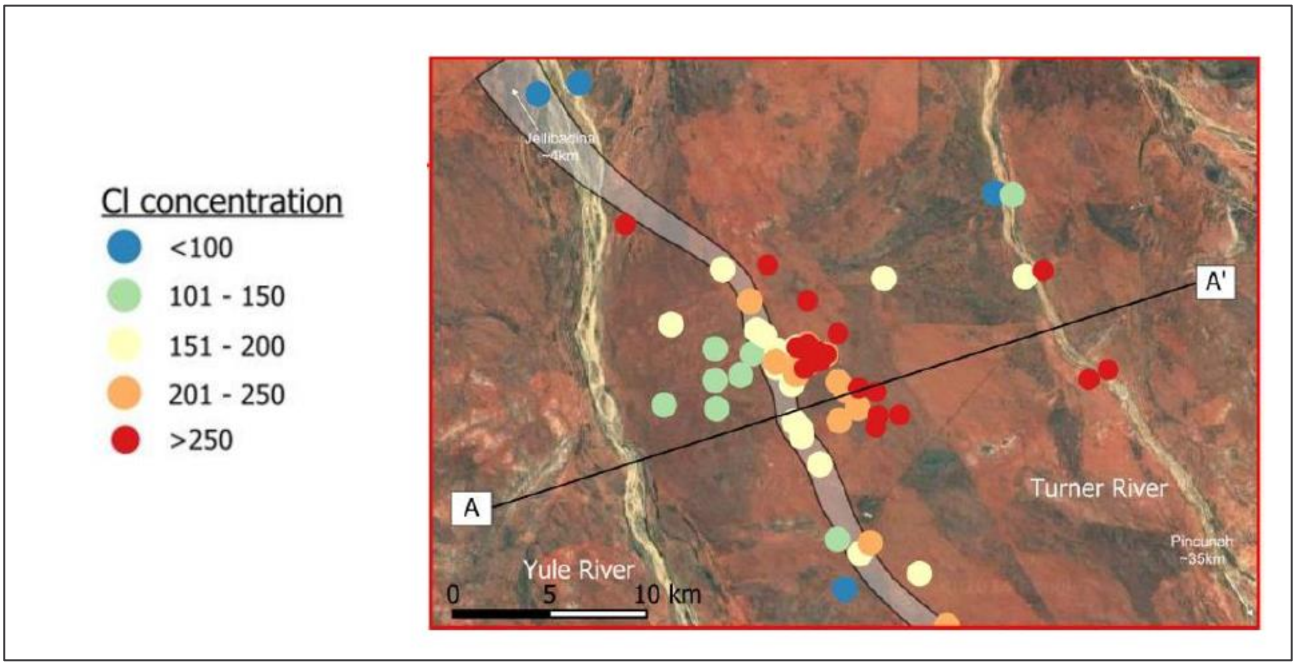
While this conservative approximation was sufficient for the operational phase, given the distance between predicted cones of drawdown and the rivers, it was recognised that this method underestimates recharge during episodic high-flow events. These events, which can result in flows of hundreds of gigalitres, represent a significant recharge source that cannot be adequately captured by using rainfall averages alone.

To address this, the closure phase groundwater model was revised to incorporate 40 years of gauged streamflow data for a steady-state condition:

- Yule River: Mean annual flow of approximately 240 GL/a (1984–2024) with a maximum annual flow of ~1,820 GL in 2000 (Jelliabidina gauging station).
- Turner River: Mean annual flow of approximately 28 GL/a with maximum 1096 GL/a at the Pincunah gauging station.
- Climatic record: Both rivers flowed to the ocean in 80% of years, with an average duration of ~42 days per year.

This dataset demonstrates the magnitude and reliability of river recharge contributions to the aquifer system. Importantly, when the projected mine dewatering volumes are compared to the long-term recharge from river flows, the dewatering represents a relatively small fraction of the aquifer's overall water balance. An extensive study was carried out to calculate recharge into the model domain using four different methods being chloride mass balance, water table fluctuation, stable isotope of water molecule and groundwater dating method using CFC's and Tritium. The recharge ranges from 0.3 to 15 mm/a averaging across the four methods of 5 mm/a. Assuming the model domain of 35x35 km^2, the total diffuse recharge is therefore ~ 6.1 GL/a. Additional recharge occurs to the aquifer during annual flood events, and it could be higher than the diffuse recharge along the 40 km stretch across the model domain. This is evident by lowest chloride (Cl) concentration measured in two bores adjacent to the Yule River (Figure 4). The Cl concentration measured in these bores were 24 and 32 mg/L whereas most of the Cl concentration at Hemi site is > 200 mg/L.

Figure 4: Cl concentration measured in bores across the model domain.



In practice, this means that natural recharge from episodic flood events will significantly buffer and mitigate the drawdown effects associated with dewatering and therefore protecting potentially groundwater-fed pools along the Yule River. The revised closure-phase model now includes the MODFLOW Stream (STR) package, to simulate streams and route flow instantaneously to downstream streams, which enhances the model's adaptability and relevance. This improves the model's relevance for predicting post-closure water balance and strengthens its capacity to represent long-term aquifer recovery.

The steady-state condition shows that the groundwater flow mimics the topography with a gradient of 0.001 from southwest to northeast. The transient recharge from the Yule River only occurs during flow periods, resulting in a higher water level under the river relative to the adjacent groundwater. Following the recession of the flow, the water table under the river declines due to evapotranspiration. The steady-state regional water table, based on recharge over the last 100 years, is unable to capture this seasonal transient process.

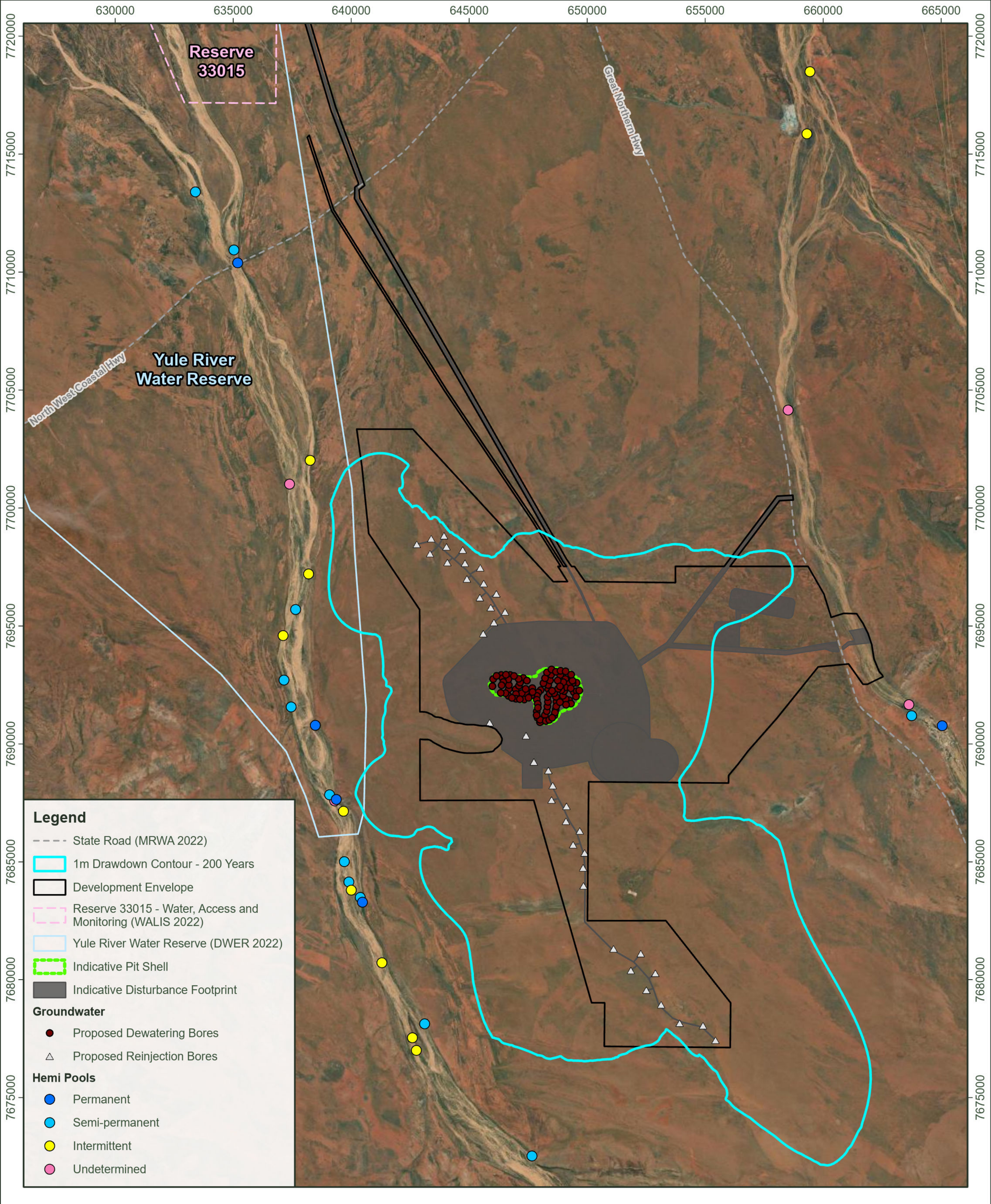
Adequacy of the Groundwater Model and Calibration

The adequacy of the groundwater model is underpinned by its domain, calibration, sensitivity testing, and monitoring framework.

- Model domain and scope: The model domain spans approximately 35 × 35 km^2, incorporating both the Yule and Turner Rivers as well as the Yule River reserve. This ensures that regional-scale groundwater interactions, including those with the paleochannel, are incorporated into the assessment.

- Calibration: The steady state water level calibration was carried out using the 24-month logger data installed across the model domain.
- Sensitivity testing: Extensive sensitivity analyses were undertaken by systematically varying hydraulic parameters (e.g., hydraulic conductivity, specific yield, recharge). Even under worst-case parameter scenarios, the 200-year steady-state drawdown contour does not extend beneath the Yule or Turner Rivers or into the borefield area (as presented in Figure 5). This outcome provides reassurance that key environmental receptors, including pools and groundwater-dependent vegetation, will not be impacted by dewatering from the Project.
- Monitoring and adaptive management: An extensive network of monitoring bores has been installed (additional planned to be installed) to track the extent and progression of the cone of depression. This network will enable the collection of water level data to validate model predictions, refine parameters, and update management strategies, as required. This adaptive management framework further enhances the robustness of the model and ensures that any emerging risks can be addressed proactively.

These features demonstrate that the model is adequate for assessing potential groundwater impacts from the proposed action. It captures the key processes of aquifer characteristics, river recharge, and drawdown, and is supported by site-specific historical calibration data. The consistency between the conceptual and numerical models provides reassurance that the long-term transient groundwater drawdown contour will not impact the Yule River ecosystem. For further confidence, a program is proposed to monitor groundwater levels throughout the life of mine and update the groundwater model. A number of management actions are proposed in the event early response, trigger or threshold limits are reached.



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Scale: 1:200,000

0 1.25 2.5 5 km

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Projection: GDA2020 MGA Zone 50

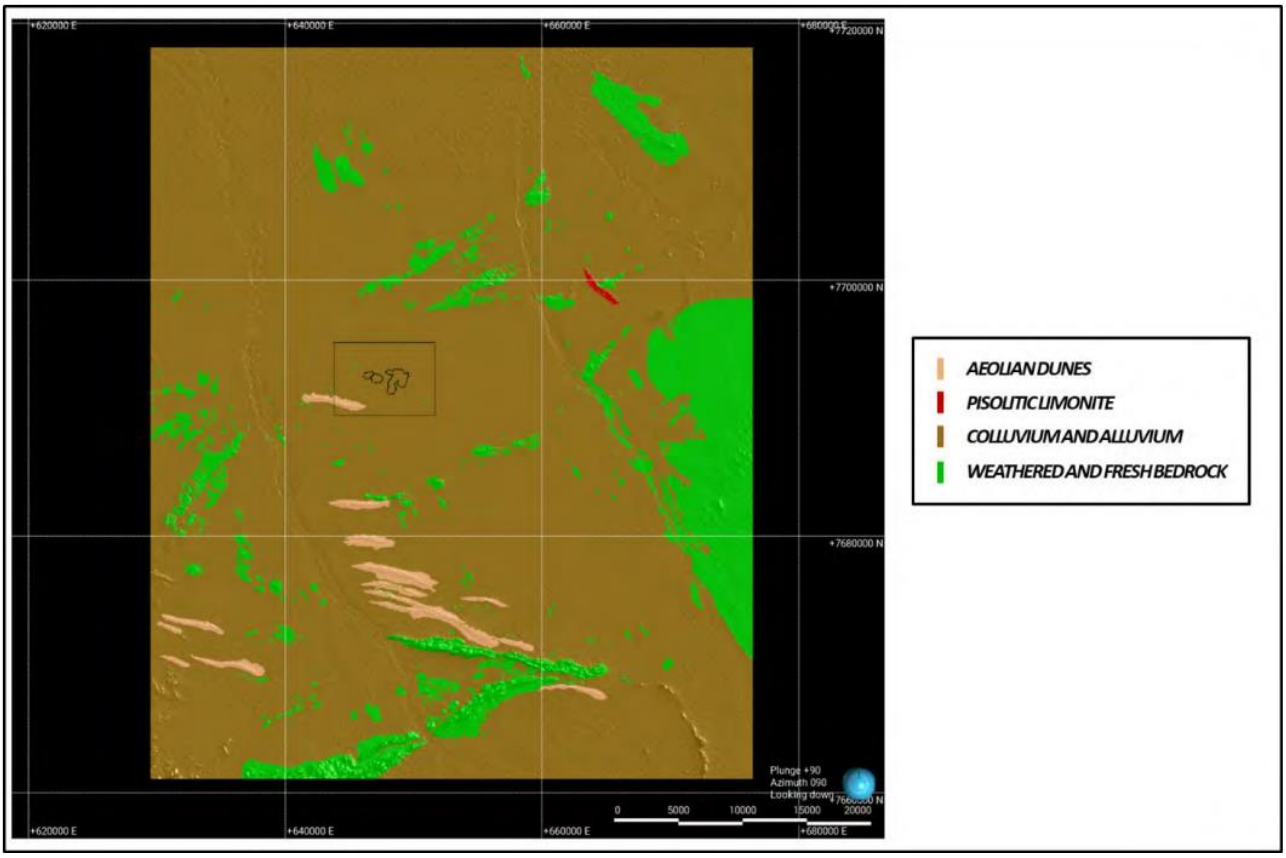
Created/Reviewed By: KM/EL

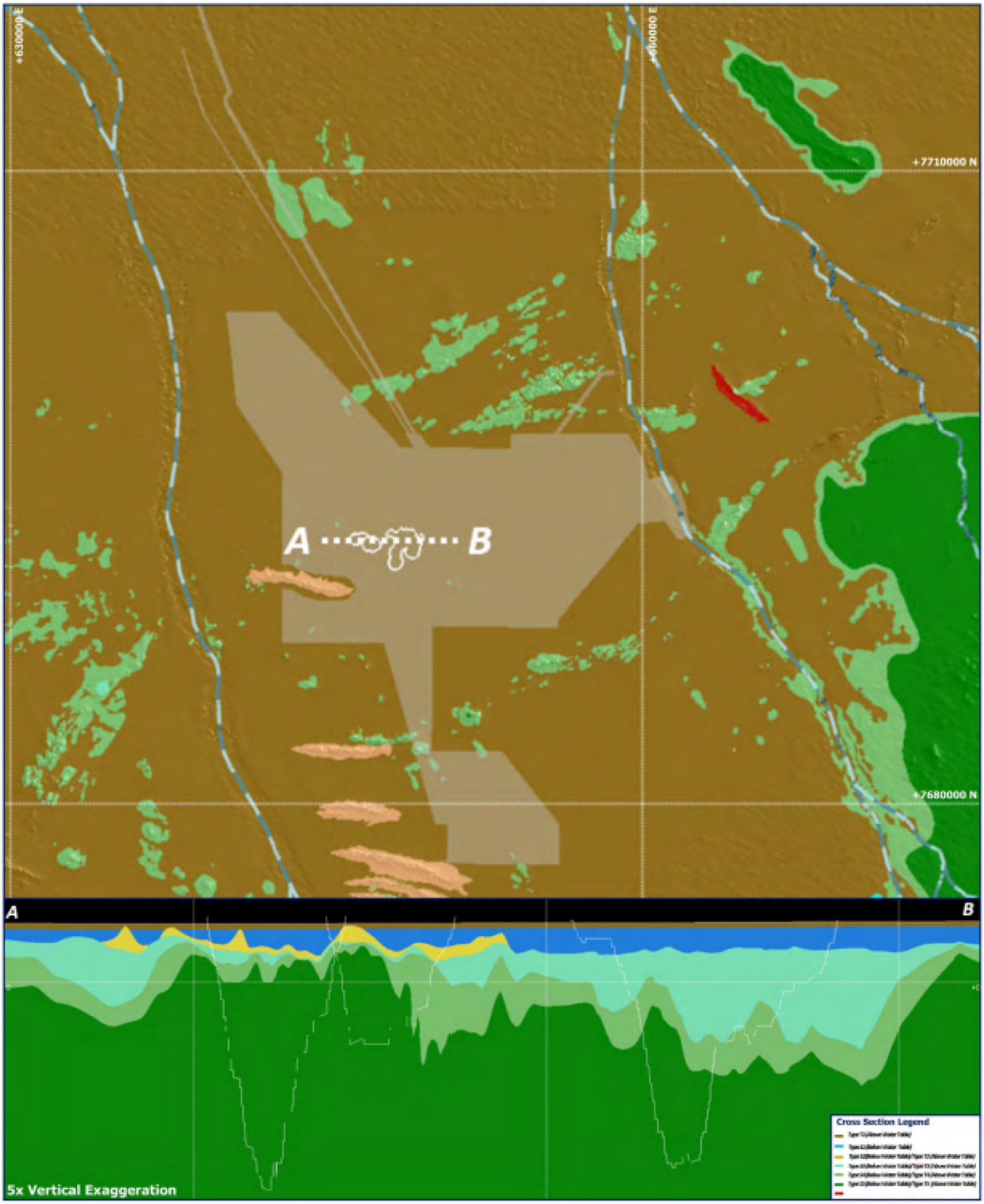
PROJECT			CLIENT
NAME **Hemi Gold Project - Hydrogeological Model**			NORTHERN STAR RESOURCES LIMITED
DRAWING **Post Closure Drawdown**			
FIGURE No. 5	PROJECT No. ADV-AU-00673	DATE August 2025	

Delineation of the Fractured Rock Aquifer Zone

As described in Geowater (2023), most of the groundwater in the Hemi hydrogeological model domain and its surroundings is contained within the alluvial aquifer zones. Beneath these alluvial deposits, groundwater is expected to be confined to fractured areas within igneous rock intrusions and along the contact zones where different rock types meet. These fractures may provide pathways for water movement however have limited storage capacity. Within the Hemi Regional Regolith Model (Figure 6 and Figure 7), the determination of potential groundwater occurrence beneath the alluvial aquifers was predominantly based on lithological information derived from downhole drill logging data and bore logs, diamond drill cores, hydrogeological information (inclusive of pump testing results), geophysical survey information, and structural information.

Figure 6: The extent of the Hemi Regional Regolith Model.





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PROJECT

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Hemi Gold Project - Hydrogeological Model

DRAWING

Cross and Long Section Of Geological Domains Of The Hemi Regional Regolith Model

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FIGURE No.	PROJECT No.	DATE
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Three main fractured rock geological domains were consistently shown in diamond drill core across the model area (Figure 8):

- Saprolite and Saprock - A compact clay dominant domain with lesser silt, sand and clasts of highly weathered rock. This domain contains minor volumes of voids or fractures that occur in association with shear zones and faults but also part of the natural development of the profile during a deep tropical weathering event.
- Joint Weathered Bedrock Basement - A weathered fractured bedrock (incipiently weathered rock) domain with minor clays/oxides on the joint surfaces. The joints increase in spacing as a result of the incipient weathering.
- Fresh Bedrock Basement – Fresh bedrock with no signs of incipient weathering of the rock mass. Generally low joint/fracture frequency spacing. Local areas of increased fracturing present where faults are present.

Figure 8: Diamond Drill Core Examples of the Saprolite – Saprock, Fractured Bedrock and Bedrock Geological Domains.

Groundwater occurrence within these fractured rock zones is controlled by the frequency of joints and fractures and the aperture (width) of these features, which together define the void space available for water storage and aquifer capacity. Importantly, at Hemi, the degree of weathering strongly influences fracture development, with higher weathering intensity generally associated with greater void space.

To quantify the relative capacity of these domains to host water, joint/fracture data were compiled from Hemi diamond drill core geotechnical assessments. The analysis considered:

- Fracture frequency – the number of joints/fractures per metre of core.
- Fracture aperture – the average opening width of fractures.
- Void volume per cubic metre – calculated by integrating fracture frequency and aperture as a proxy for the amount of open space within the rock mass.
- Estimated void volume percent – the proportion of the geological domain's bulk volume that can reasonably be considered available for water storage and flow.

These values were then extrapolated across the total modelled volume of each geological domain to infer the total potential groundwater-bearing volume. An excerpt of the results of this analysis is provided in Table 1, highlighting a progressive reduction in permeability and water-bearing potential with depth due to lesser fracturing and weathering. These fractures also become tighter and less permeable with depth.

Table 1: Fracture analysis to estimate the available void volumes within the geological domains.

Geological Domain	No. Joints/Fractures (per m)	Joint/Fracture Aperture (m)	Estimated Void Volume (m^3)	Estimated Void Volume of Geological Domain (%)
Saprolite and Saprock	3.45	0.03	0.10	10.34%
Joint Weathered Bedrock	3.03	0.02	0.06	6.06%
Fresh Bedrock Basement	1.19	0.01	0.01	1.19%

The fracture analysis and estimated voids are consistent with the results of the pump testing program undertaken across the basement aquifers. Pumping of bores drilled into the fractured rock zones yielded low to insignificant rates, confirming limited hydraulic conductivity of these units. On this basis, the groundwater occurrence of the fractured rock and basement rock is restricted to discrete, low-yield fractures rather than continuous aquifer systems and expected to yield limited water volumes during operations.

Regardless, groundwater at the Project is subject to the water mitigation hierarchy as described in the Conservation Significant Species Management Plan (CSSMP). As all boreholes are drilled, developed, and pump tested, water quality sampling will determine the classification of the bore as a Type I or Type II producing bore. The proposed surplus water management strategy distinguishes two dewatering discharge stream types, primarily related to concentrations of arsenic and other trace metals:

- Type I contains <24 µg/ L of dissolved arsenic (As).
- Type II contains >24 µg/ L of dissolved arsenic (As).

The threshold of 24 µg/L of dissolved arsenic was defined based on the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) 2018 guidelines which safeguard 95% of aquatic species. Groundwater with naturally elevated concentrations of dissolved Arsenic (Type II) will be reinjected into the Reinjection Borefield South (RBS) and become available for re-abstraction after two to ten years, at which time it will be directed for use in the processing plant. Groundwater with naturally lower concentration of dissolved Arsenic (Type I) will be suitable for discharge to the Turner River, aquifer reinjection at both Reinjection Borefield North (RBN) and RBS and for camp and potable water supplies (once treated).

All water encountered via abstraction bores will be managed according to the above characterisation. Although likely to be of insignificant volume, any pit seeps or inflows from the bedrock domains due to unknown fractures during mining operations will be dewatered using in-pit sump pumping. All water collected via in-pit sumps regardless of its quality, will only be used in ore processing and will not be injected into the aquifer.

Conclusion

The Hemi regional regolith model is primarily focused on understanding the regional context and extent of the alluvium aquifer. The regolith model construction is derived from collating and interrogating multiple geoscientific datasets. These consist of geological logging of diamond drill core and percussion drill chips and spoils of over 20,000 drill holes for over 1.4 million metres of drilling (acquired over >30 years). The drill database is sourced from:

- De Grey drilling (includes all drill holes drilled for water purposes).
- Texas Gulf (public).
- Atlas Iron bores (public).
- DWER/Water Corporation bores (Davidson, 1976).
- Other publicly available drill holes.

The paleochannel has been reliably delineated from which consistently identify its base at ~50 mbgl depth. The northwest extent toward the Yule River is therefore well defined by both regional and project-scale datasets. Recharge from the Yule and Turner Rivers, particularly during major flood events, is orders of magnitude greater than projected dewatering from the Hemi Gold Project. As confirmed by the predicted steady-state 1 m drawdown contour, dewatering represents only a minor component of the aquifer balance and will not impact pools, riparian vegetation, or groundwater-dependent ecosystems of the Yule River.

In addition, the groundwater model has been calibrated to long-term Yule River borefield data, tested for sensitivity, and updated to include streamflow routing. Model predictions are conservative yet still show no drawdown extending to sensitive receptors (Yule or Tuner Rivers, inclusive of pools), with ongoing monitoring providing additional assurance.

Fractured rock aquifer zones are expected to yield minimal water, with pit inflows from saprolite, saprock, and fresh bedrock considered negligible compared to the volume derived from the alluvial aquifer. Any groundwater entering the mine voids during operations from fractures and bedrock seepage will be directed to the Hemi Processing Plant via in-pit sumps. The estimated water requirement for the processing plant operating at nameplate capacity is approximately 9 GL/annum.

Overall, the combined investigations demonstrate that the aquifer system is well understood, that river recharge buffers any potential dewatering impacts, and that modelling and mitigation measures ensure groundwater impacts to sensitive receptors will not occur.