Northern Star Resources Ltd

H1 Hydrogeological Investigation

Carosue Dam Operations - Kurnalpi Gold Project

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Carosue Dam Operations - Kurnalpi Gold Project

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EXECUTIVE SUMMARY

Northern Star Resources (NSR) plans to develop the Kurnalpi Gold Project as part of its Carosue Dam Operations. The Project will involve the excavation of two open-cut gold pits; the North & South Pit, over an estimated 20-month life of mine (LoM). While no mineral processing will be conducted on-site, the project will nonetheless require between 200,000 and 300,000 kL/year of water for camp facilities, together with dust suppression within the mine and on 21 km of haul road between the Project and the CDO Access Road. This water will be sourced opportunistically from mine dewatering activities in the Kurnalpi Pits supplemented by additional make-up water from bores in the fractured rock aquifer on-site.

NSR holds an existing groundwater license issued by the Department of Water and Environmental Regulation allowing the extraction of 20,000 kL/year from the Fractured Rock West – Fractured Rock aquifers in the Roe Subarea of the Goldfields Groundwater Management Area. To meet the project's water requirements, NSR seeks to increase the allocation limit under this license to 320,000 kL/year.

A numerical groundwater model has been developed to evaluate pit inflows and dewatering requirements over the 20-month LoM. The model was designed and calibrated in accordance with the *Australian Groundwater Modelling Guidelines* (Barnett et al., 2012) and incorporates a hydrogeological conceptual site model that defines aquifer geometry, hydrostratigraphy, recharge and discharge conditions, and hydraulic properties. Model calibration was achieved using existing groundwater data and inferred water level distributions, validating the adopted hydraulic parameters and conceptual framework.

Key findings of the groundwater modelling are:

- inflows during mining of the North Pit are expected to range from 1 to 3 L/s. Inflows at the South Pit are expected to be significantly lower, averaging around 0.5 L/s, as the South Pit will be dry mined for most of its operational period.
- discernible drawdown impacts (defined as more than 0.2 m of drawdown) are expected to be restricted to approximately 700 m from the edge of the North Pit and 50 m from the edge of the South Pit.
- Sensitivity and uncertainty analyses assessed the potential effects in the event that much higher-than-expected hydraulic conductivities are encountered in ultramafic and mafic formations. In this extreme case scenario (a four-fold increase in hydraulic conductivity), pit inflows would nearly double to 5 L/s, and drawdown extents could also approximately double compared with the expected case.

Even in the most conservative (extreme) case, the rate of groundwater influx to the pits would be sufficiently low that all dewatering could be undertaken from in-pit sumps, and discharge water could be consumed in dust suppression. Adopting the modelled extreme case drawdown as the benchmark, the implications for environmental and social impacts are as follows:

- The Project would have no material impact on Groundwater-Dependent Ecosystems (GDEs) because the existing water table beneath the pits is greater than 20 mBGL, which is beyond the reach of tree roots. The absence of registered GDEs in the area,

as confirmed by the Bureau of Meteorology's GDE Atlas and other datasets, supports this conclusion,

- The Project would have no material impact on Aboriginal Heritage values because there are no registered Aboriginal heritage sites within the Kurnalpi tenements or within the modelled drawdown extent, and
- The Project would have no material impact on other Groundwater Users because there are no other known groundwater users within the modelled drawdown extent. The only identified groundwater draw point within a 5 km radius of the pits is the historic Scottish Lass water supply shaft, located adjacent to the NE corner of the North Pit. This shaft was last used as the water supply for the old Kurnalpi Town but has not been used for more than a century and has long since collapsed.

In summary, Pennington Scott has found no evidence of serious or irreversible damage to environmental or social factors that would preclude DWER from approving NSR's application to increase the allocation under GWL 151848 (6) from 20,000 to 320,000 kL/year to support the Kurnalpi Gold Project.

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1. BACKGROUND

In 1894, alluvial gold was discovered on what are now mining tenements M28/7, M28/70, M28/92, M28/374, and M28/375 (**Figure 1.1**), located approximately 76 km northeast of Kalgoorlie and hereinafter referred to as "**the Site**". This discovery triggered a gold rush to the Site. The township of Kurnalpi was officially gazetted on the Site in 1895 and in its heyday, supported a population of 260 with essential infrastructure including: a police station, post - telegraph station, hospital boarding house, and two hotels (Dillon 2024). The groundwater quality within the fractured rock at the site is stratified, with a fresh to brackish quality lens overlying saline water at depth. Historically, the town's water supply is believed to have been opportunistic surface water harvesting from the Town Dam, supplemented with groundwater from the Scottish Lass water shaft. Five wood-fired condensers were needed to make the brackish groundwater drinkable. Shortly after the onset of World War I in 1914, the town of Kurnalpi had become a ghost town, and the Site has seen little mining activity over the past century.

Northern Star Resources Ltd (**NSR**) is now seeking to develop the **Kurnalpi Gold Project** as part of its Carosue Dam Operations (**CDO**). The Project will involve the excavation of two open-cut gold pits on the Site over an estimated 20-month life of mine (LoM). These include the North Pit to a depth of 93 mBGL, and the South Pit to 45 mBGL. About 1.0 million tonnes of run-of-mine (ROM) ore from the pits will be trucked 60 km via unsealed roads to the CDO carbon-in-leach (CIL) mineral processing facility over 18 months. Although no mineral processing, accommodation, or office facilities will be located on the Site, the Project will still require between 200,000 and 300,000 kL/year of water for dust suppression in the mine and on the haul roads. This water will be sourced opportunistically from mine dewatering activities, supplemented by make-up water from bores within the fractured rock aquifer on the Site.

NSR has an existing groundwater licence (**GWL**) issued by the Department of Water and Environmental Regulation (**DWER**) under Section 5C of the *Rights in Water and Irrigation Act 1914* to take 20,000 kL/year from the Fractured Rock West – Fractured Rock aquifers within the Roe Subarea of the Goldfields Groundwater Management Area. NSR now seeks to amend the allocation limit on GWL 151848 (6) from 20,000 to 320,000 kL/year. In accordance with Section 3.2 of DWER's *Operational Policy 5.12: Hydrogeological Reporting in the Water Licensing Process,* NSR is required to submit an H1 Desktop Hydrogeological Report to support its GWL amendment application. This requirement reflects the low volume of the GWL and the absence of nearby competing water users or registered Aboriginal heritage sites.

NSR has engaged Pennington Scott (groundwater consultants) to undertake the necessary hydrogeological investigations to support the GWL application. This report will also serve to support NSR's submission of a Notice of Intent (NOI) mining application to the Department of Mines, Industry Regulation and Safety (DMIRS) under the Mining Act (1978).

This document represents an H1 Desktop Hydrogeological Report prepared to support Northern Star Resources application for a groundwater licence to undertake dewatering and dust suppression operations at the Kurnalpi Gold Project.

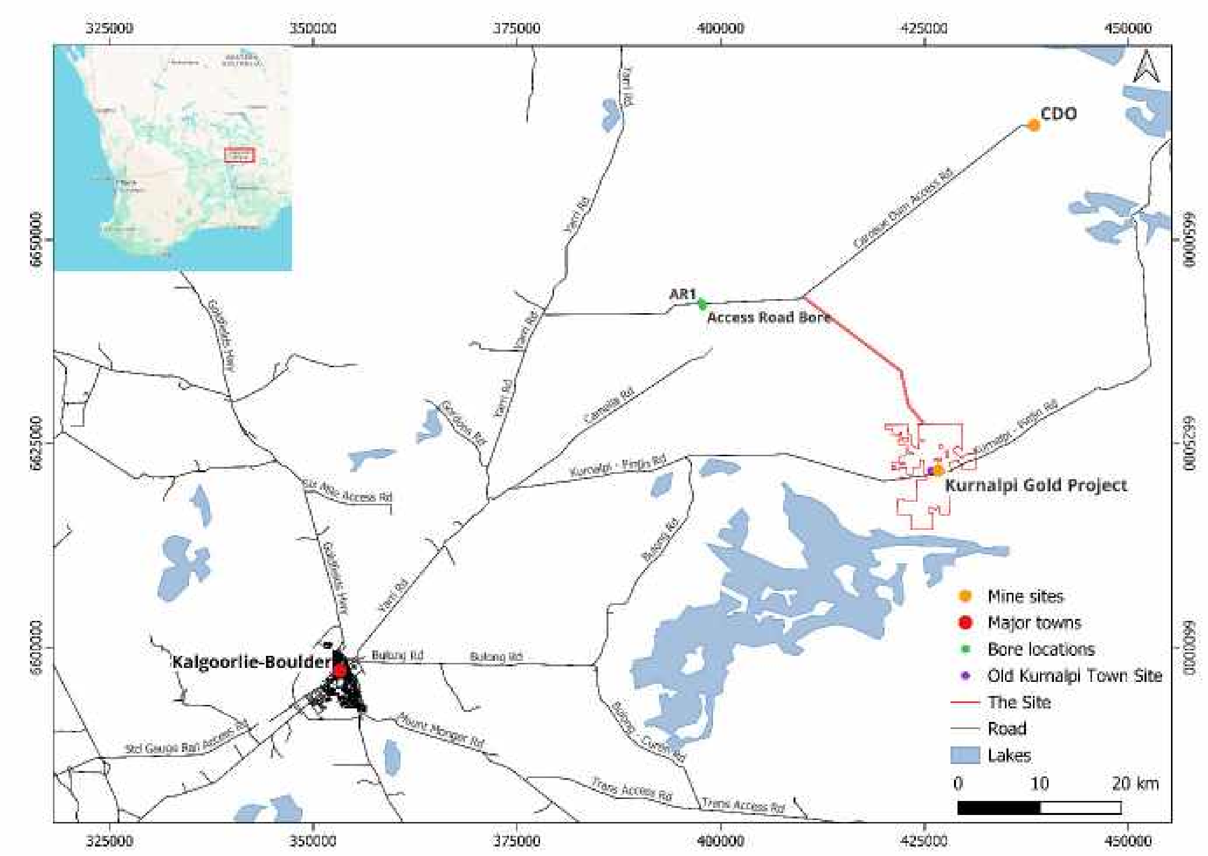

Figure 1-1 Location map of the Kurnalpi Gold Project.

1.2 Project Water demands

Figure 1-2 shows the projected water demand for the development of the Kurnapli Gold Project is primarily for dust suppression in the mine and along the 21 km of unsealed road between the Kurnalpi Gold Project and the intersection with the CDO Access Road (**Table 1-2**). Water consumption for dust suppression is anticipated to be consistent with other mine pits in the Goldfields. Similar sized mining operations use between 200,000 and 300,000 kL per year for dust suppression (Pennington Scott, 2017, 2021a), which should be sufficient to suppress the dust on the haul road, which (Mills ,2010).conservatively calculate at a rate of 100 kL/km/day.

While any mine water inflows to the Kurnapi pits would be used opportunistically for dust suppression, there is a possibility that both pits could be virtually dry and therefore an alternative borefield is required, capable of supplying the entire dust suppression demand if needed.

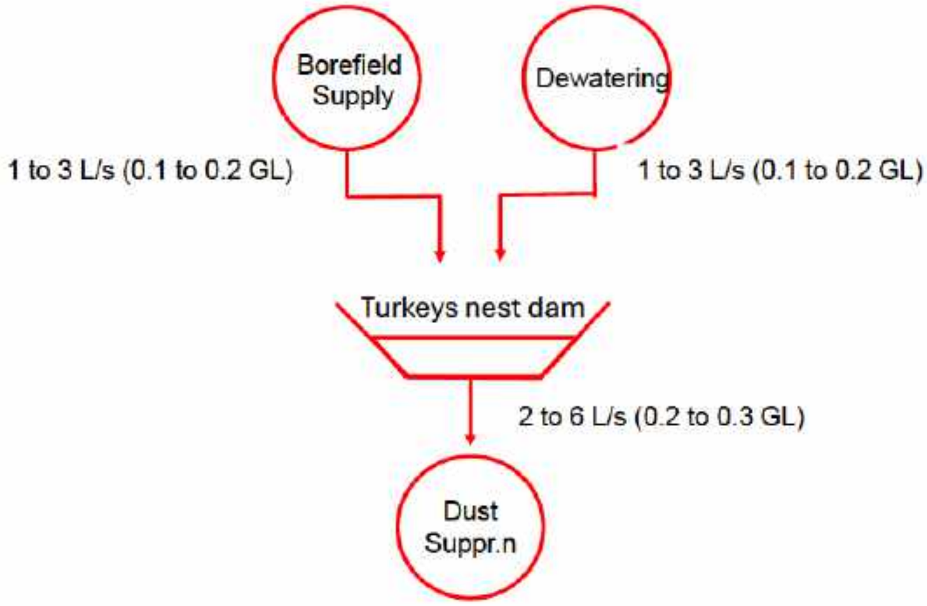

Figure 1-2: Flow diagram of water extraction and usage during the LoM

1.4 Existing CDO water licences

Table 1-1 summarises all groundwater licenses (GWLs) held by NSR for CDO under Section 5C of the *Rights in Water and Irrigation Act 1914*.

Reference to the table shows that CDO already holds a GWL to take 20,000 kL/year from the Fractured Rock West – Fractured Rock aquifers within the Roe Subarea of the Goldfields Groundwater Management Area for the purposes of dust suppression on the CDO Access Road, drawn from bore AR1.

NSR is now seeking to amend GWL 151848 (6) to include the following changes to facilitate the Kurnalpi Gold Project:

- Increase the allocation limit from 20,000 kL/year to 320,000 kL/year.
- Include additional mining tenements, including M28/7, M28/70, M28/92, M28/374, and M28/375 (and potentially others).
- Add mine dewatering as an approved water use.
- Include the proposed North and South Pits as approved draw points, plus any new make-up water bores on Site.

Table 1-1: Existing Groundwater Licences issued to NSR for CDO

GMA	Sub-area	Aquifer	GWL	Area	Projects	Volume (kL)	Expiry
Goldfields	Raeside	Combined Fractured Rock West - Fractured Rock	162879(8)	Mt Celia	Safari Pit Deep South Pit	2,000,000	31/01/2031
		Palaeochannel - Alluvium	175243(4)	Raeside	Raeside Bore	100,000	8/03/2026
	Rebecca	Combined - Fractured Rock West - Fractured Rock	206236(2)	Twin Peaks	Twin Peaks Exp	50,000	3/10/2032
			157428(6)	Carosue Dam	Karrari Pit Whirling Dervish Pit Luvironza TSF Lake Tana Monty's Pit Twin Peaks Pit Relief Hill	4,000,000	30/06/2024
			169295(5)	Edjudina	Enterprise Pit Margarets Pit Million Dollar Pit Porphyry Pit Wallbrook Pit	2,000,000	30/06/2024
		Palaeochannel	103538(7)	Carosue Dam	Southern Borefield	2,500,000	30/06/2024
	Roe	Combined - Fractured Rock West - Fractured Rock	151848(6)	Access Road	Access Road Bore	20,000	30/06/2024

1.5 Abbreviations and definitions used in this report

BOCO	Base of complete oxidation
BoM	Bureau of Meteorology (Federal)
CIL	Carbon in leach (gold processing technology)
CSM	Conceptual Site Model [with respect to the Australian Groundwater Modelling Guidelines]
DWER	Department of Water and Environmental Regulation (WA)
DEMIRS	Department of Energy, Mines, Industry Regulation and Safety (WA)
DPLH	Department of Planning, Lands and Heritage (WA)
GWL	groundwater licence
L/s	litres per second
LoM	Life of Mine
mAHD	metres above height datum
mBGL	metres below ground level
mg/L	milligrams per litre
Mtpa	million tonnes per annum
NSR	Northern Star Resources Limited
ROM	Run of mine ore
WIR	Water Information Report [with respect to the DWER bore database]

2. ECOLOGICAL SETTING

2.1 Climate

The project area experiences an arid climate, characterised by hot summers and cold winters. Climate data has been collected at the Kalgoorlie Boulder Airport Station (ID: 12038) since 1939, providing a reliable representation of the conditions on the Site

As shown in **Figure 2-1**, average monthly temperatures during the summer months can exceed 36°C, with typical ranges between 15°C and 32°C, while daily maximums often exceed 40°C. In contrast, winter temperatures generally range between 5°C and 17°C.

Rainfall and evaporation data has been recorded over the past 87 years at the Kalgoorlie Boulder Airport Station. The most consistent rainfall occurs during the winter months, although storms and ex-tropical cyclones often bring significant rainfall events during the summer, particularly between February and March. Monthly average pan evaporation rates significantly exceed monthly rainfall averages. According to data from the Bureau of Meteorology (BoM), the annual average pan evaporation rate is approximately 2,000 mm/year, compared with a mean annual rainfall of about 265 mm/year.

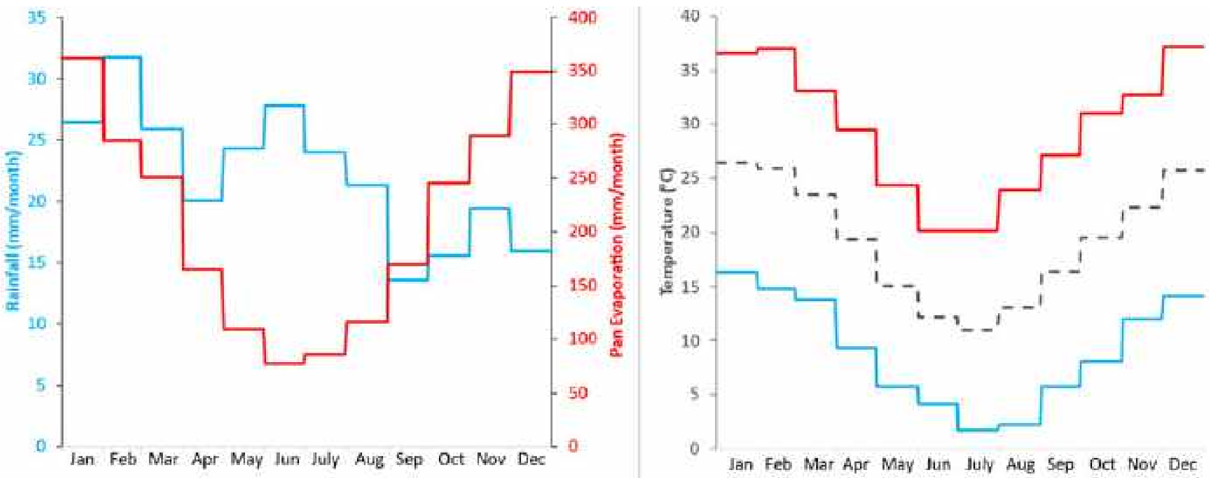

Figure 2-1: (a) Monthly Average Temperature (b) Monthly Average Rainfall & Evapotranspiration (Kalgoorlie Boulder Airport station ID:12038)

2.2 Physiography and Hydrology

The Kurnalpi Gold Project is situated north of Lake Yindarlgooda within the eastward draining Roe Palaeodrainage. The surface topography shown by **Figure 2-2** slopes southward from a catchment divide at around 460 metres above height datum (mAHD) almost 12 km north of the Site down to 321 mAHD at Lake Yindarlgooda 8 km to the south. A surface drainage is located 500 m to 1 km west of the Site, while the local surface falls away westward toward the drainage. The catchment area of this drainage referred to as Kurnalpi Creek (RPS, 2022) is 96.5 km^2. A minor tributary drainage line passes through the Site and extending 2 km above the Site, with a catchment area of about 3 km^2 above the pit areas.

2.3 Vegetation

The Kurnalpi Gold Project is within an area covered by the Barlee 20 vegetation association that retains more than 99% of its pre-European extent. It is dominated by low, open or sparse woodland of mulga (*acacia aneura sp.)*, eucalypts, Eremophila and associated species (Botanica, 2022).

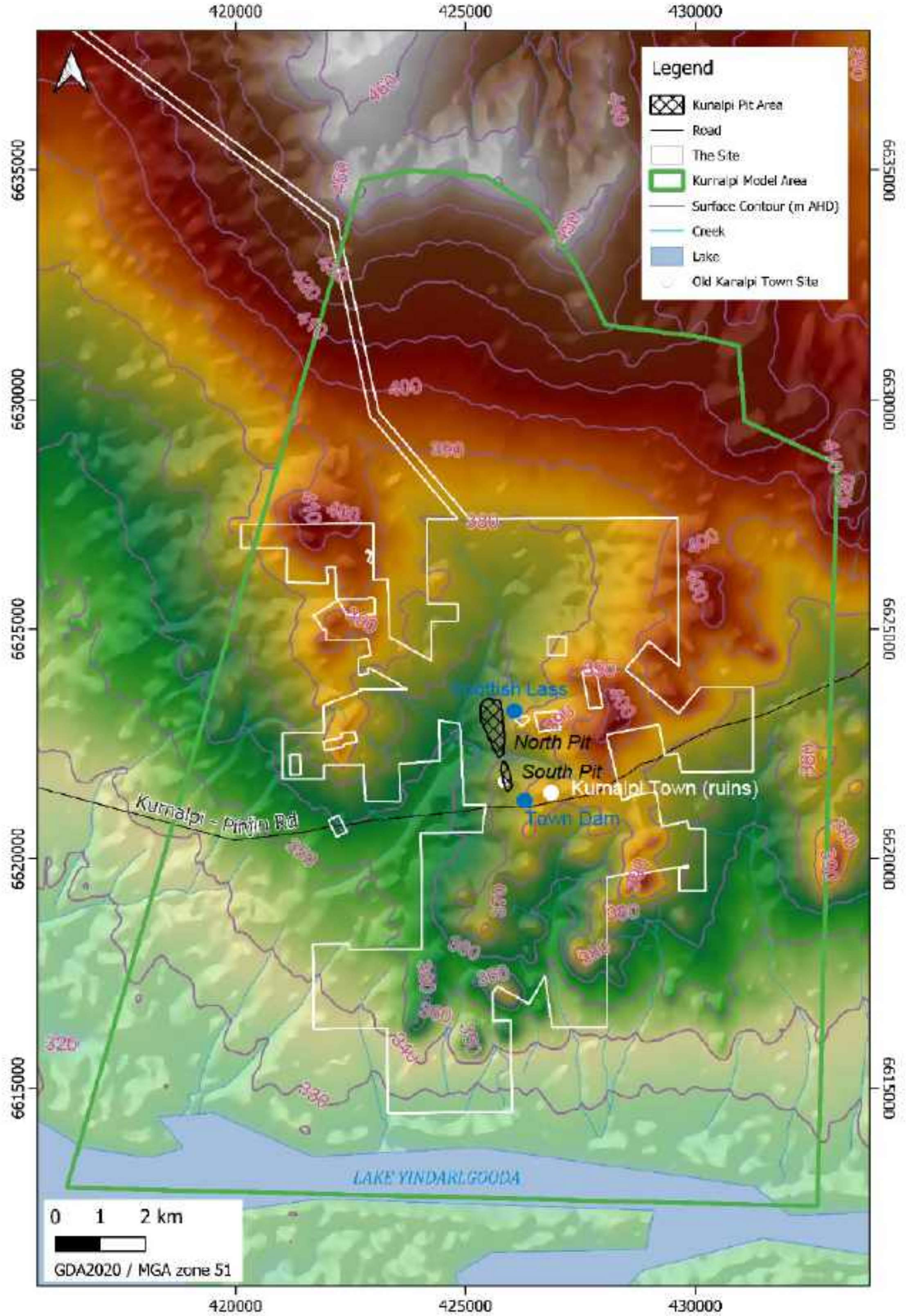

Figure 2-2 Physiography at Kurnalpi Gold Project (10 m contours).

3. HYDROGEOLOGY

This Section represents a defensible hydrogeological Conceptual Site Model (**CSM**) as defined by the Australian Groundwater Modelling Guidelines (Barnett *et. al.* 2012) and forms the foundation of the numerical groundwater modelling discussed in **Section 4** of this report.

3.1 Geology

The Kurnalpi Gold Project is located within the Eastern Goldfields Superterrane of the Yilgarn Craton, which consists of Mesoarchean to Neoarchean (3,200 to 2,500 ma) volcanic and sedimentary greenstone sequences, interspersed with granitoids. The bedrock geology of the area, shown in **Figure 3-1**, is primarily composed of mafic basalt, with interlayered mafic intrusions and ultramafic rock types (Swagger, 1994). The mafic rocks include altered (meta) basalts with lenses of dolerite and gabbro, while the ultramafic rocks are primarily komatiite and peridotite. In addition, the region contains metasedimentary siliciclastic pelitic schist, including slate and siltstone, as well as felsic schist. Granitoid plutons, which are ovoid to elongate in shape, disrupt the greenstone sequences, with large plutons located to the north of the project area, referred to as the Kurnalpi Batholith, and smaller ones to the east and west.

The Kurnalpi deposit itself is located within an ultramafic komatiite unit, approximately 150 m wide and trending north-south that is intruded by two sub-vertical mafic dolerite dykes trending roughly north-south. The primary gold mineralisation is associated with individual quartz veins that range from 0.1 m to 5 m thick (Snowden, 2012). Some fibrous material has been encountered with the ultramafic rocks during drilling.

Bedrock in the area has undergone low to high-grade metamorphism, with higher-grade zones surrounding granitic domes, resulting in the recrystallisation of rock minerals. Volcanic-sedimentary layers have been deformed by folding and faulting. A northwest-southeast trending anticline fold axis lies about 1.4 km west of the project area that is associated with the Kurnalpi Batholith to the north. The Avoca Fault is a significant fault located about 4.4 km west of the Kurnalpi deposit (Swagger, 1995) (**Figure 3-2**), while a north-northwest shear zone referred to as the Brilliant Shear zone passes through the dolerite intrusives at the deposit, and is a control for the gold mineralisation. This shear zone has also been referred to as the Town Dam Shear Corridor (Carrick Gold ref in Rockwater, 2021). There are no Proterozoic dykes near the Kurnalpi Project, although magnetic data suggests the presence of several smaller east – west and west-northwest to east-southeast trending dykes.

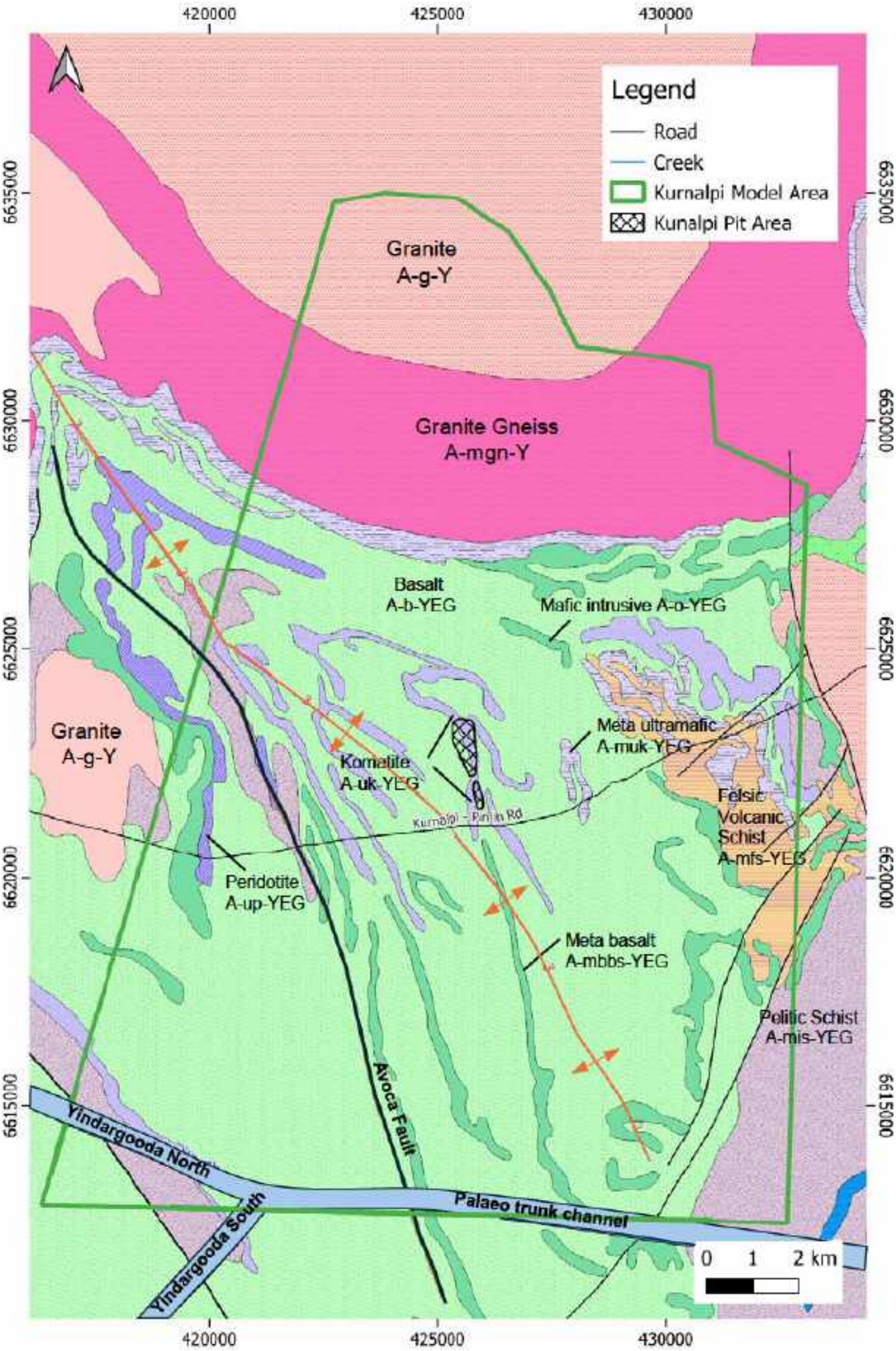

Figure 3-1 Bedrock geology (after GSWA 500k Interpreted Bedrock) and palaeochannel location

Figure 3-2 Interpreted surface exposure of the Avoca Fault in an ultramafic unit (after CSA Global, 2016).

A deep weathering profile over surface materials has developed through much of the Cenozoic era (65 Ma to present) with the breakdown of rock minerals and dissolution of elements, resulting in a sequence that typically progresses upward from fresh bedrock to material increasingly altered to clay (mostly kaolin) minerals and depletion of the more mobile elements. The weathered profile can be divided into several zones referred to in ascending order as saprock, saprolite, pallid zone (a clay-rich or sand-rich zone), mottled zone, which is typically capped with residual laterite (lateritic residuum) comprising a ferruginous duricrust and pisolitic gravel (Anand & Paine, 2002, Pennington Scott 2017), summarised by **Figure 3-3**. The Upper Saprolite refers to the zone immediately beneath the ferruginous hard cap including the pallid zone where the rock has undergone complete chemical decomposition into heavy textured clay minerals, with the transition into lower saprolite (the zone of joint oxidation) characterised by a change from heavy textured clay to soft, decomposed, friable rock 10 to 20 m thick. The base of Lower Saprolite is referred to as the base of complete oxidation (BOCO). The saprock is the zone of broken fresh rock between the lower saprolite and the hard fresh rock. Depth of weathering over bedrock varies considerably depending on rock type, mineralisation, deformation and topographical position. The average base of saprock depth ranges from approximately 37 m for ultramafic rocks to 64 m for Felsic rocks (including granite) (Anand & Paine, 2002).

Holocene to Eocene epoch (less than 56 Ma) deposits overlie the bedrock filling ancient drainage channels known as palaeochannels. South of the Site, beneath Lake Yindarlgooda, the Yindarlgooda South palaeochannel converges with the Yindarlgooda North palaeochannel, which flows from the west (Commander et al., 1992). The combined palaeochannel then flows eastward toward the Eucla Basin. **Figure 3-4** illustrates a representative profile of these palaeochannel deposits, which can be up to 120 m thick within the trunk channel. The deposits consist of fluvial sands and gravel from the Werillup Formation, filling the deepest and narrowest part of the palaeovalley. Overlying this is predominantly lacustrine clay of the Perkolilli Shale. At the top of the succession, there is typically a mixture of lacustrine, playa, alluvial, and colluvial deposits, collectively referred to as the Upper Deposits. Calcrete is commonly found in the central portion of the palaeodrainage. **Figure 3-1** shows the approximate location of the palaeochannel thalweg.

There is no apparent palaeotributary channel associated with the tributary drainage channel west of the deposit, where alluvial and colluvial deposits overlie a weathered bedrock profile.

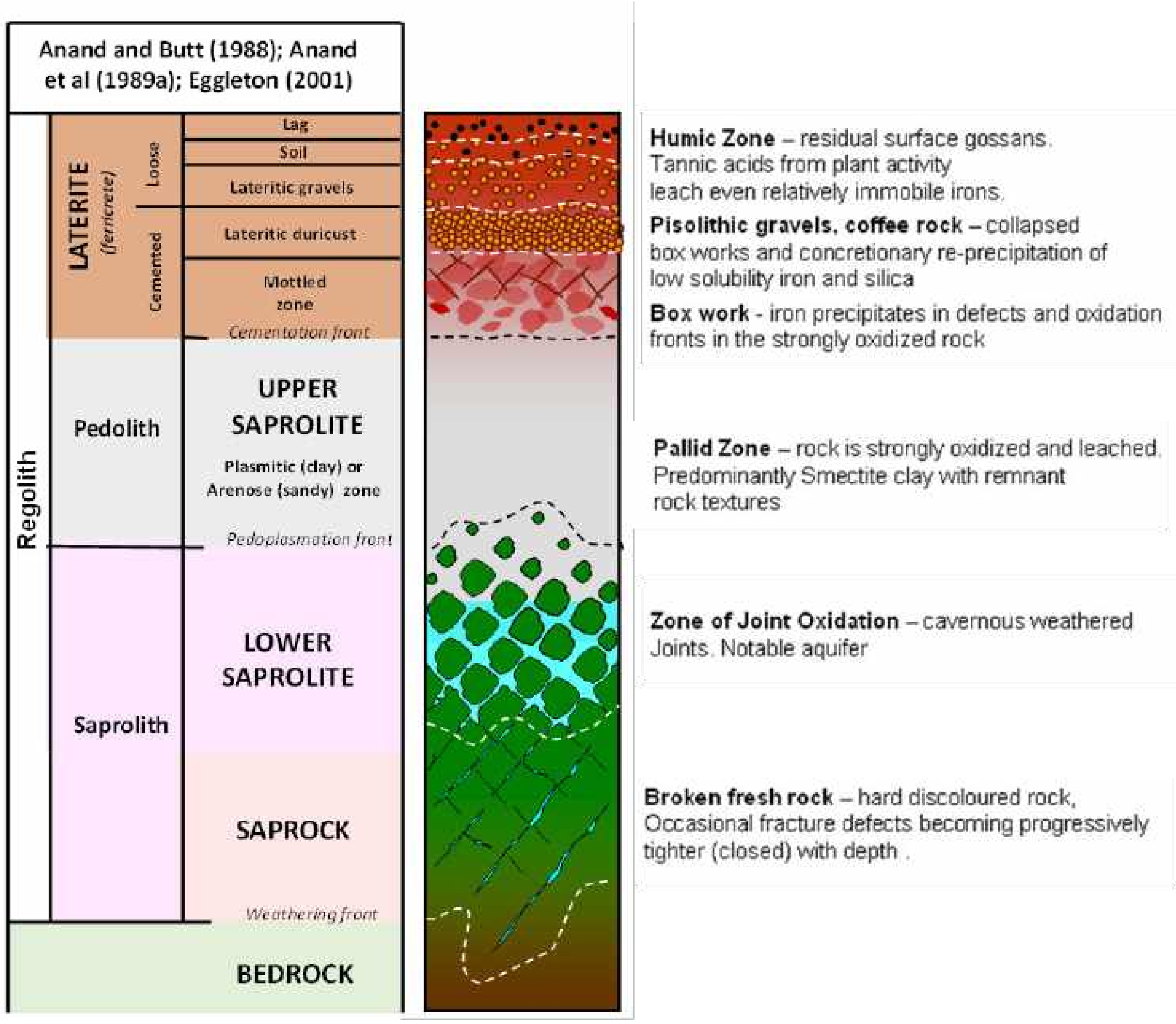

Figure 3-3 Typical saprolite profile (modified from Anand et al 1989, *Pennington Scott 2017*)

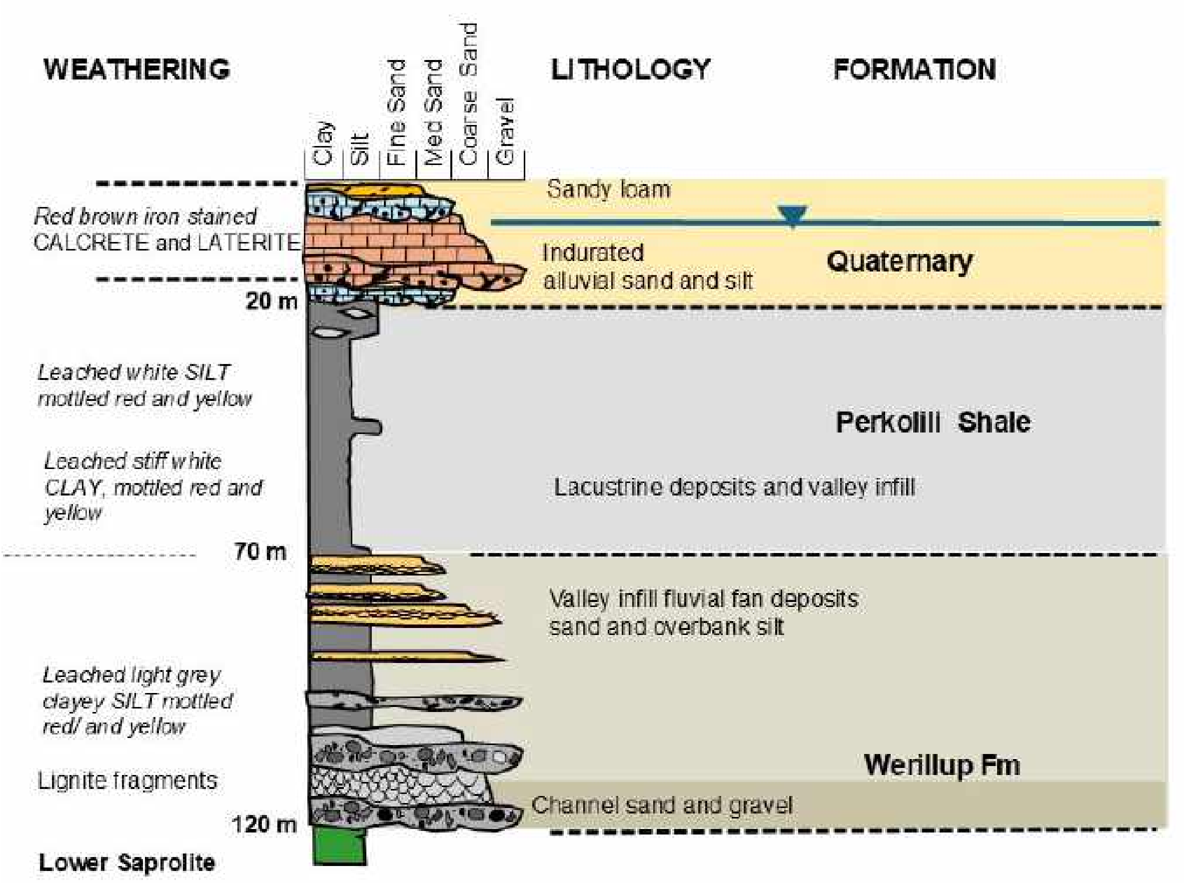

Figure 3-4 Representative graphic profile of typical palaeovalley deposits (from Pennington Scott 2024)

3.2 Groundwater Occurrence

Crystalline Archaean rocks are essentially impermeable, with virtually non-existent primary porosity or permeability. Groundwater in these rocks is primarily associated with secondary porosity in structural features such as joints, faults, and shears. Secondary permeability is further enhanced by the saprolite weathering profile. The most important aquifer units on the Site are the lower Saprolite and Saprock layers, where the thickest saturated sections are typically located in the lower topographic areas around the surface drainage and toward Lake Yindarlgooda.

The Yindarlgooda palaeochannel consists of three main hydrogeological units:

- Low to moderately permeable Upper Deposits,
- Low permeability aquitard unit of the Perkolilli Shale,
- Permeable sands of the Werillup Formation at the base of the palaeochannel.

The sands of the Werillup Formation form a highly productive aquifer, usually 20 to 40 m thick, at the base of the Yindarlgooda Palaeochannel, approximately 8.5 km south of the proposed Kurnalpi pits. This aquifer is confined by the overlying Perkolilli Shale. The upper deposits, consisting of sands, silts, and calcrete, form an unconfined surficial aquifer at the top of the palaeochannel profile. This aquifer may have a saturated thickness ranging from several metres to around 20 m.

3.3 Water levels

Although there are several pastoral wells recorded by the DWER Water Information Report (**WIR**) around the Site, none have any water level data. The depth to water table on the Site was measured from angled resource drillholes in October 2021 by Rockwater (2021), with corrected vertical depths ranging from 32.6 to 40 mBGL, being equivalent to water elevations of between 331.3 to 341 mAHD (based on the digital terrain elevation model developed from the Shuttle Radar Topography Mission - SRTM). The water table depth beneath salt lakes is typically within a couple of mBGL and therefore would be approximately 320 mAHD at Lake Yindarlgooda.

Figure 3-5 presents the interpreted water table elevation over the Kurnalpi region, which is based on the levels recorded around the proposed pits and for Lake Yindarlgooda, extrapolated for the catchment area using typical trends. The water table rises northward to around 400 mAHD about the catchment divide north of the project where the depth to water may reach about 50 mBGL.

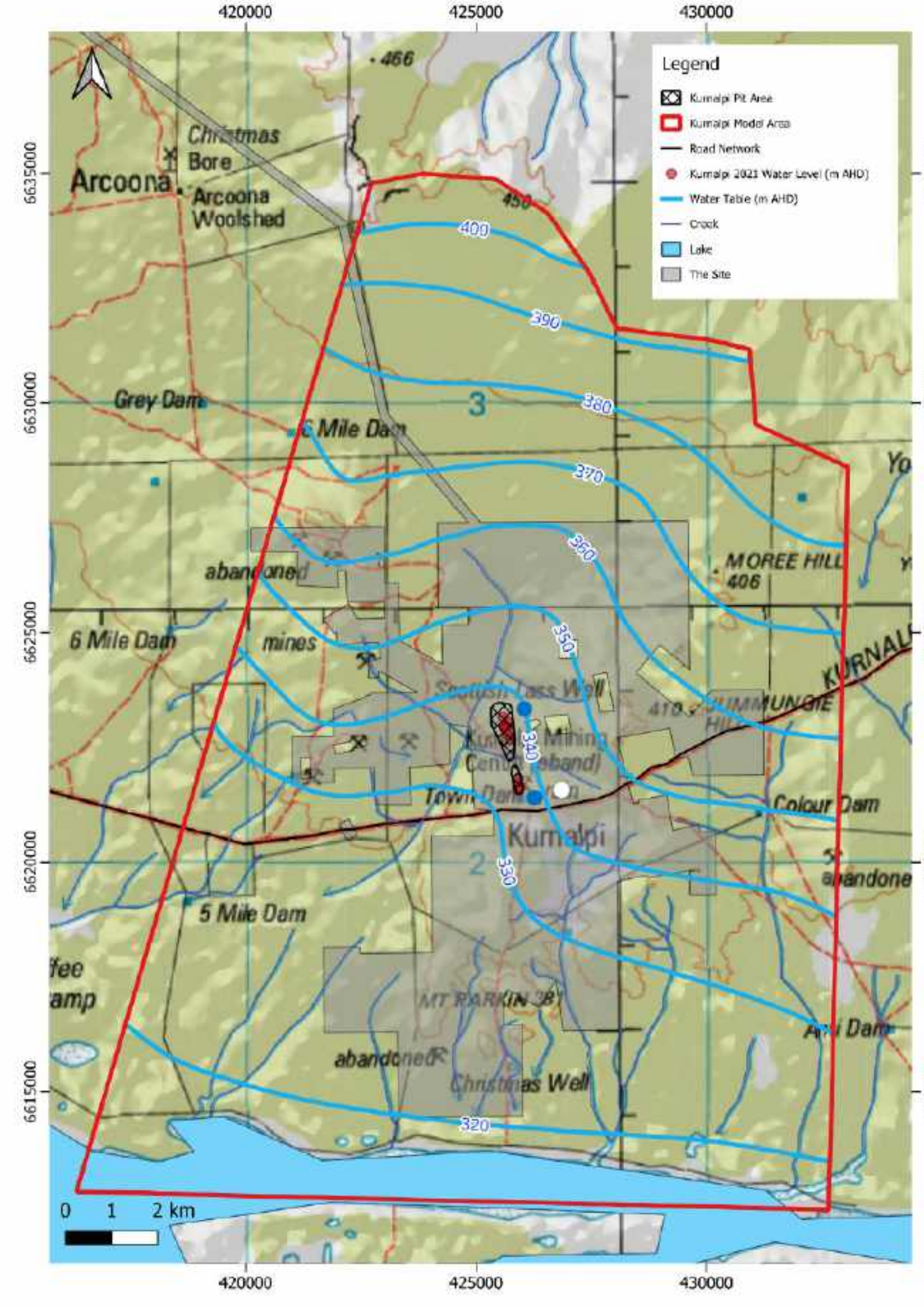

Figure 3-5 Interpreted water table in the Kurnalpi Gold Project area.

3.4 Hydraulic parameters

Permeability of the weathered profile and fractured bedrock is highly variable, depending on the clay content and degree of fracturing, but is dominantly very low to moderately permeability. The lower saprolite to saprock zone is typically the most permeable layer, while the upper saprolite can have a hydraulic conductivity up to an order of magnitude lower than the underlying lower saprolite, potentially acting as an aquitard. Unfractured bedrock has virtually non-existent permeability. Hydraulic conductivity values of bedrock types and its weathered profile similar to those on the Site have been determined using pumping and packer tests from various locations over the Yilgarn Craton and elsewhere in Western Australia (Pennington Scott 2012, 2019). A summary is provided by **Table 3-1**.

Bedrock on the Site is mainly composed of mafic and ultramafic rock types, which have low permeability. However, mafic rocks and the associated weathered profile tend to have the highest permeability of the bedrock types. Testing of gabbro saprolite – saprock at Windimurra was found to have an average permeability of 0.4 m/day, while an average of 3.4 m/day found in a Mid-West site may be higher than typical (Pennington Scott 2009). The permeability of ultramafic rocks is highly variable.

Permeability testing around the proposed pit area conducted by Rockwater (2021) used falling-head slug tests in open, angled resource drill-holes using a 20-litre slug of water. Results indicated very low values of hydraulic conductivity, ranging from less than 0.01 to 0.05 m/day. The highest values were mostly associated with mafic dolerite, while the lowest were from ultramafic rocks. This suggests that the permeability of lower saprolite – saprock derived from mafic bedrock is one or two orders of magnitude higher than that from ultramafic rocks. However, as the drill holes were undeveloped, the slug tests are likely to significantly underestimate aquifer permeability due to clogging and bore skin effects. Additionally, more permeable zones, such as those often found at contact zones like between dolerite and ultramafic rock units, could exist. Mineralisation associated with a northerly oriented Brilliant Shear zone in the ultramafic is also potentially a more permeable zone. Therefore, the permeability of ultramafic rocks on the Site may be significantly greater than implied by the slug tests and these values should be considered as lower bounds for permeability.

A significant degree of anisotropy is likely within the saprock due to structural features on the Site, including the anticline axis west of the proposed Kurnalpi pits and the Brilliant Shear Zone. Permeability is expected to be greater in the approximately N-NW – S-SE orientation.

Granitic bedrock of the Kurnalpi Batholith is located in the upper portion of the catchment above the proposed North Pit. Test pumping of successful bores drilled into the lower saprolite over granites elsewhere in the Yilgarn yielded hydraulic conductivity values averaging 1 m/day (Pennington Scott, 2009), while George (1992) reported an average hydraulic conductivity of 0.57 m/day for granitic lower saprolite across several wheatbelt sites. However, most drill holes into granite fail to yield significant water and are abandoned as "dusters" (i.e., producing less than 0.5 L/s on airlift). Consequently, the bulk permeability of granite is likely much lower than the reported pump test values, which is likely to be between 0.2 and 0.4 m/day. George (1992) also determined that the clayey upper saprolite had an average hydraulic conductivity of 0.07 m/day and was an effective aquitard in the wheatbelt.

The Yindarlgooda Palaeochannel, although too distant to directly affect dewatering in the proposed Kurnalpi Pits, nonetheless provides an area of constant head.

The total permeability or transmissivity of the profile through the catchment is dependent on the combined permeability of the saturated portion. The greatest thickness of saturated weathered profile is typically about the lower slopes of the drainage channels, and therefore these areas are likely to be the most transmissive to groundwater, depending on the rock type. Beneath the upper ridges the weathered profile can be unsaturated, where groundwater is restricted to fractures and joints within fresh bedrock and is normally of very low permeability.

Table 3-1 Summary of hydraulic conductivity values derived from pumping and packer tests over weathered profile zones for various rock types.

Rock Type	Aquifer Unit	Location	Hydraulic conductivity m/day	Reference
Granite	Lower Saprolite	Mid West – Cunningham's site	0.3 – 2.8	Pennington Scott, 2009
		Mid West – Lochada site	0.1 – 1.3	Pennington Scott, 2009
Mafic	Lower Saprolite	Gruyere (diorite/andesite)	0.28 – 0.43	Pennington Scott, 2017
		Mid West – Moorbec's site	0.6 – 6.9	Pennington Scott, 2009
		Windimurra (gabbro)	0.3 – 0.4	Pennington Scott, 2019
		Koolyanobbing	1.1 - 1.3	Rockwater 2011b
	Saprock	Windimurra (gabbro)	0.05	Pennington Scott, 2019
		Gruyere (diorite/andesite)	<0.04	Pennington Scott, 2017

3.5 Groundwater quality

Water samples collected by Rockwater (2021) from open resource drill-holes show considerable variability in water salinity across the Site, ranging from around 3,300 mg/L to 11,500 mg/L and averaging 6,600 mg/L Total Dissolved Solids (**TDS**) determined from the water electrical conductivity. This is within the brackish water classification (ANZECC 2017). A laboratory analysis of a water sample from a water bore at the site showed a water salinity of 8,100 mg/L TDS, with a high sulphate content of 1,100 mg/L and nitrate of 84 mg/L.

Several pastoral wells in the lower portion of the catchment show fresh to brackish water quality (WIR data) of 1,110 to 4,018 mg/L TDS (9 Hackets Well, 6 Cables Well and Christmas Well), while groundwater will be highly saline beneath Lake Yindarlgooda. Groundwater in the Werillup Formation palaeochannel aquifer will be hypersaline (>35,000 mg/L TDS), possibly exceeding 100,000 mg/L TDS.

Water pH values measured from the Site were slightly alkaline, with a field range of 7.1 to 8.0 (Rockwater, 2021).

4. NUMERICAL AQUIFER SIMULATION

The use of computer-based numerical models as an aid in groundwater investigations provides a powerful tool for addressing the spatial and temporal variability of aquifer characteristics and their excitation-response behaviour (e.g., groundwater levels, responses to pumping, aquifer yield, estimation of fluxes, etc.).

Distributed groundwater numerical models represent the latest advancements in quantitative hydrogeology. When properly developed, these models enable the detailed investigation of aquifer responses to various natural and human-induced stresses, such as recharge, pumping, and mine dewatering. They also facilitate sensitivity and uncertainty analyses, which are crucial for identifying the dominant drivers and parameters governing groundwater dynamics within an aquifer system. Numerical modelling employs a system of equations grounded in the principles of continuity and Darcy's Law, allowing the simulation of groundwater flow regimes in porous media and aquifer systems.

This modelling study was undertaken to explore the pit inflows, and dewatering rates over the projected 20 month LoM. The objectives of the groundwater modelling are to:

- Assess the aquifer's potential and its capacity to supply the required yield for mining operations;
- Estimate the dewatering requirements throughout the LoM; and
- Evaluate the extent of LoM drawdown impacts.

The development and structure of the numerical groundwater model in this study adhere to the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). This approach includes:

- ***Development of a comprehensive and defensible Conceptual Site Model (CSM):*** The CSM, detailed in **Section 3** of this report, and encompasses descriptions of aquifer geometry, the classification and extent of hydro-stratigraphic units, recharge and discharge patterns, aquifer hydraulic properties, and a conceptual understanding of the aquifer's working mechanisms.
- ***Design of the numerical model in alignment with the CSM:*** The numerical model is carefully constructed to reflect the conceptual understanding of the aquifer system.
- ***Model calibration:*** Calibration is performed against steady-state and transient stresses to ensure the model accurately represents observed conditions.
- ***Predictive simulation:*** The model is used to address the objectives of the study, primarily focusing on the spatial and temporal variations in groundwater levels, the cone of drawdown, and the dewatering rates under the provided mining plan, thereby supporting decision-making for mining operations.
- *Qualitative* ***uncertainty analysis***: Sensitivity & Uncertainty analysis evaluates the influence of key parameters on model outcomes, while limitations analysis highlights potential uncertainties in predictions.

4.1 Model selection

Modelling methodologies and relevant guidelines (Barnet et al, 2012, Anderson, 2015) recommend justifying the selection of a numerical code based primarily on the modelling objectives, aquifer characteristics, and the functionality and performance features of the computer code (Van Der Heijde, 1996).

Examples of performance and functionality criteria include the ability of the code to simulate steep gradients at hydraulic or natural geological boundaries (e.g., pumping wells), the desaturation and re-saturation of model cells or elements, the capacity to simulate various parameters and state variables (such as groundwater levels, fluxes, pressure, and quality), flexibility in handling time-varying aquifer properties and boundary conditions, and support for data assimilation and processing through programming interfaces, among others

Based on the review and analysis of site-specific conditions, available data and modelling objectives, the numerical code selected for the development of the Kurnalpi aquifer system was the latest version of the Finite - Element DHI-WASY code **FEFLOW**.

4.2 Model domain and mesh design

The finite element method implemented by FEFLOW requires discretisation of the modelled area into a mesh of triangular elements defined by a series of node locations. Solutions are obtained for potentiometric head at each nodal point within the model domain and is interpolated within the entire area of each model element by interpolation functions based on Galerkin method.

The model mesh was created using a mesh generator based on the Advancing Front method (https://www.aquaveo.com/software) which, except for polygon topologies, honours the presence of linear, point, and area features such as rivers, faults and pumping locations and pit boundaries. This methodology produces a finite-element mesh of smooth, mostly equilateral and Delaunay triangles, minimising numerical errors and improving model stability and runtimes. In terms of mesh quality, the final model mesh that was created in this project contains triangles that are mostly equilateral with minimal violations of Delaunay criterion.

The model domain covers the Kurnalpi aquifer system over an area of 273 square kilometres, which has been discretised into a finite element mesh consisting of 21,145 elements and 10,690 nodes per model layer/slice, totalling 85,590 elements and 53,450 nodes over the four model layers (**Figure 4-1**).

The mesh is enhanced by way of increased nodal density within the pit areas. A multi-layered modelling approach has been adopted to accommodate stratigraphic complexity in the hydrogeological model. The size of the mesh elements ranges from as low as about 10 m within the pits, increasing gradually to about 250 m towards the periphery of the model domain. A refined element size of about 40 m was selected at the proposed borehole locations, and of about 100 m over the fault zone in the west.

The model domain is discretised vertically into four model layers representing the Upper Saprolite (layer 1) and Lower Saprolite or Saprock (layer 2), the fractured-weathered Bedrock (layer 3) and the Fresh Bedrock (layer 4). The north part of the model is dominated by the Granite while the southern part is covered by Paleochannel sediments. **Figure 4-2** shows a 3-

Dimensional view of the model domain while the layer structure along Section 1 is shown in **Figure 4-3.**

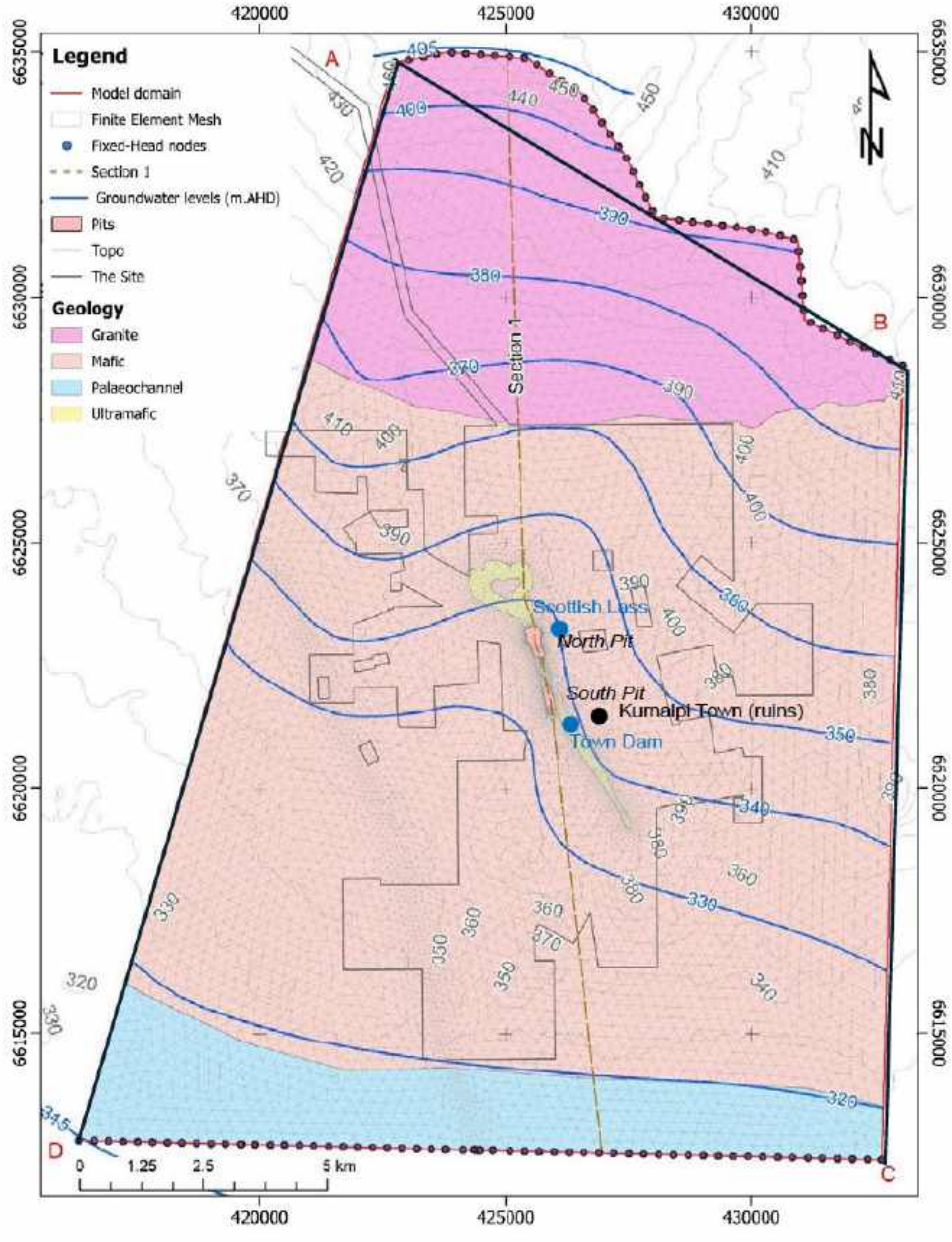

Figure 4-1 Mesh design and boundary conditions of the model

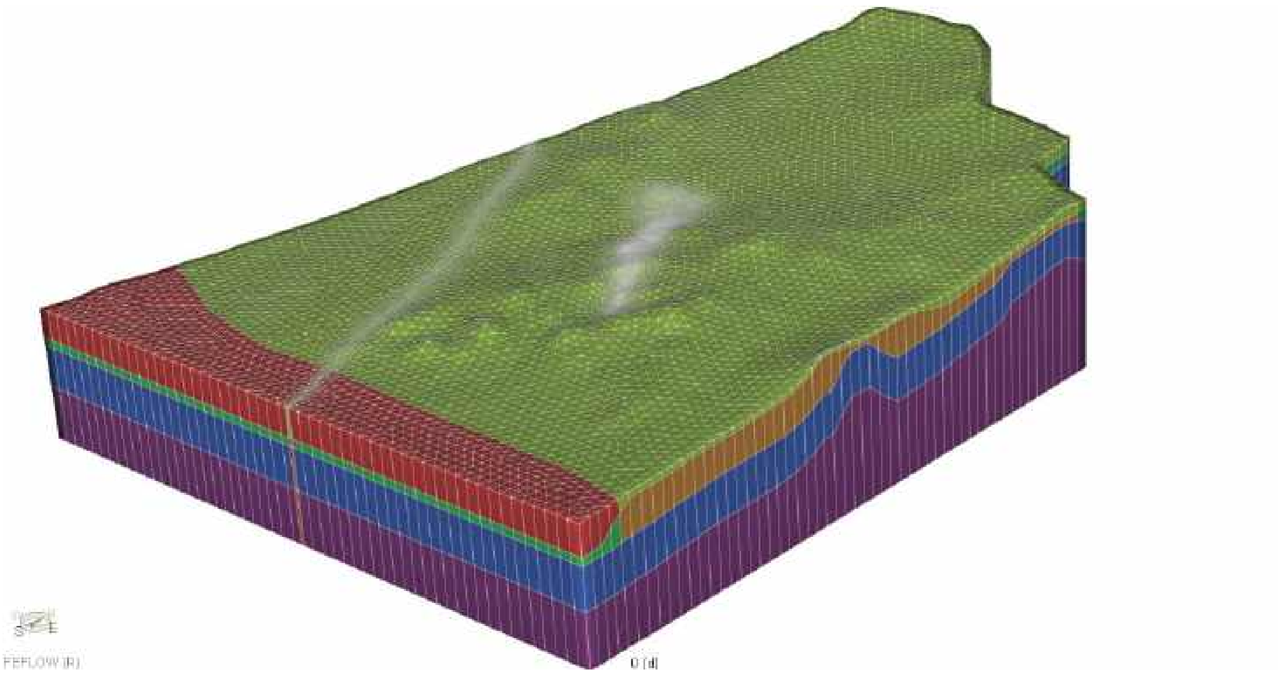

Figure 4-2 3D view of the model domain

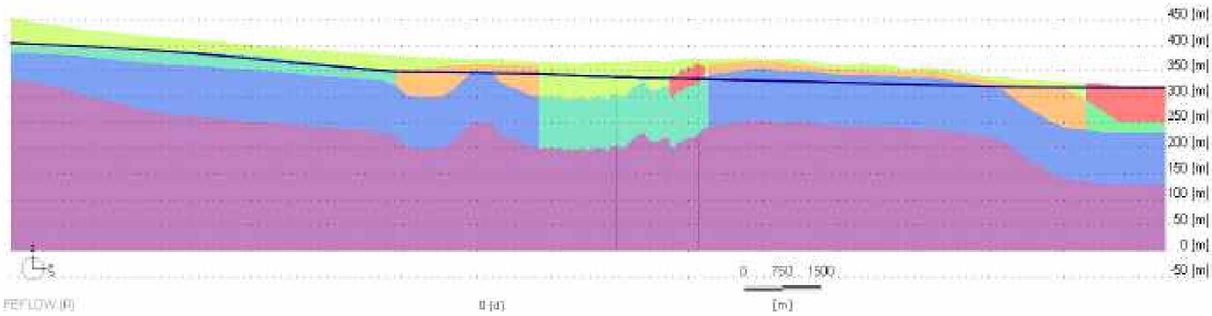

Figure 4-3 Structure of model layers along Section 1

During the mesh design, efforts were made to accurately represent the boundaries of the individual geological formations, particularly the bands of mafic and ultramafic formations, which, due to their differing hydraulic properties, could affect the calculated flow rates and their sensitivity analysis. A major fracture zone in the southwest (the Avoca Fault) was also delineated. However, due to its significant distance from the pit and its orientation, it is not expected to have any impact on pit inflows or drawdowns.

4.3 Boundary conditions

Based on the interpreted geometry, and the principal direction of the regional groundwater flow, from the upgradient boundary on northwest to the downgradient model boundary on the southeast along the trunk of the palaeovalley, boundaries (AB), (CD) were set constant head (i.e. 1st – Type or Dirichlet) boundaries with fixed water levels of 353 and 346 respectively, following the interpreted groundwater levels. No flow boundaries were used elsewhere.

The model was initially designed in fully saturated mode, by setting the top layer as water table layer and the lowers below as convertible, i.e. from confined to unconfined depending on the dynamic state of the groundwater levels at transient simulations.

4.4 Model Calibration

Given the limited availability of groundwater measurements and the absence of historical data, the model was calibrated and validated using the inferred distribution of groundwater level contours described in the CSM.

The steady state calibration target was set to achieve groundwater levels and flow directions similar to the inferred water levels from the CSM shown in Figure *3-5*.

The hydraulic properties adopted in the model are summarised in **Table 4-1.** These values are based on values from the hydrogeological CSM, which were further refined during the model calibration process. An initial recharge rate of 0.1 mm/year was applied uniformly across the main model area to represent minimal recharge conditions. Although higher recharge rates may occur during wetter years, sensitivity analyses indicated that recharge contributions are negligible, effectively representing a worst-case scenario.

The modelled groundwater levels in **Figure 4-4** show similar patterns to the inferred water levels, while the calculated value at the pits is approximately 337.5 mAHD, which is also in good agreement with the water levels in the CSM.

Table 4-1 Expected Case model hydraulic properties

Model Layer	**Geological Unit**	**Kh** m/d	**Kz** m/d	**Sy** [ ]	**Ss** 1/m
1. Upper Saprolite	Granite	0.05	0.05	0.01	1.00E-05
	Mafic (pits)	0.05	0.05	0.01	1.00E-05
	Mafic	0.05	0.05	0.01	1.00E-05
	Ultramafic	0.05	0.05	0.01	1.00E-05
	Palaeochannel	0.5	0.5	0.01	1.00E-05
2. Lower Saprolite	Granite	0.005	0.005	0.05	1.00E-05
	Mafic (pits)	0.5	0.5	0.05	1.00E-05
	Mafic	0.2	0.2	0.05	1.00E-05
	Ultramafic	0.05	0.05	0.05	1.00E-05
	Palaeochannel	0.01	0.01	0.05	1.00E-05
3. Saprock	Granite	0.001	0.001	0.01	5.00E-06
	Mafic (pits)	0.001	0.001	0.01	5.00E-06
	Mafic	0.001	0.001	0.01	5.00E-06
	Ultramafic	0.001	0.001	0.01	5.00E-06
	Palaeochannel	0.001	0.001	0.01	5.00E-06
4. Bedrock - fresh	Granite	0.001	0.001	0.001	1.00E-06
	Mafic (pits)	0.001	0.001	0.001	1.00E-06
	Mafic	0.001	0.001	0.001	1.00E-06
	Ultramafic	0.001	0.001	0.001	1.00E-06
	Palaeochannel	0.001	0.001	0.001	1.00E-06

The adopted hydraulic properties and the calculated groundwater levels align well with the available data and the assumptions made in the CSM, making the model reliable for use in predictive scenarios, as discussed earlier in the model objectives section.

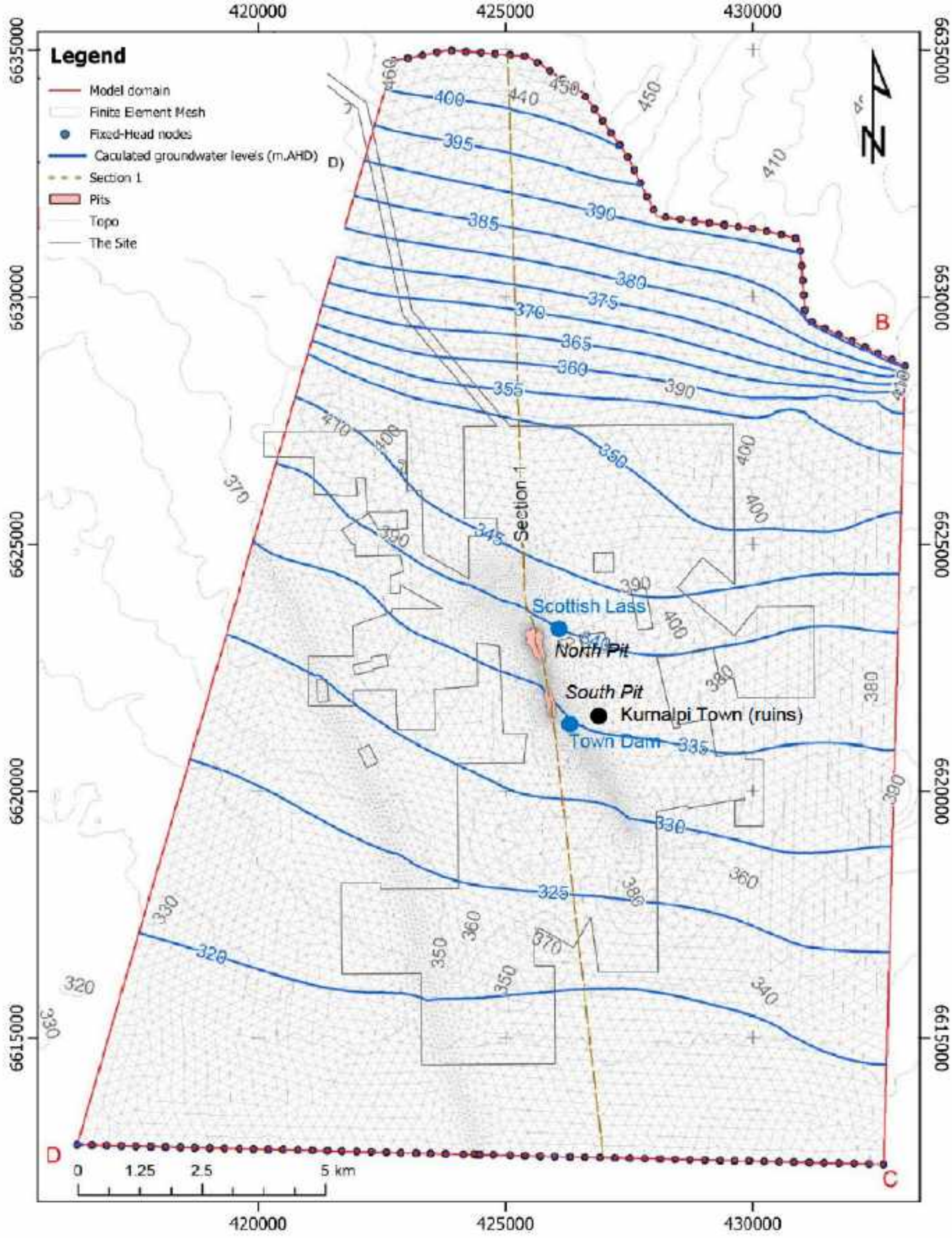

Figure 4-4 Calculated groundwater levels at Steady-state calibration

4.5 Predictive simulations – pit inflows and drawdowns

The estimation of open pit inflows and aquifer drawdowns using numerical modelling is typically conducted by assigning target dewatering levels at each stage of mining. These target levels are set over the designated pit area for each mining stage using a fixed-head boundary condition (also known as a First-Type or Dirichlet boundary condition). This boundary condition drives water movement from the surrounding aquifer toward specified nodes near the pit to achieve and maintain the desired water level in the pit sump, which is lower than the surrounding aquifer levels. The accumulated water is then removed from the model to effectively simulate the dewatering process.

An alternative approach involves the use of unstructured meshes, where portions of the model domain are sequentially deactivated to simulate the formation of open pit voids. However, in both approaches, the changing pit geometry is not implemented in its entirety, which can limit the accuracy of the results.

To more accurately represent the quarterly changes in pit geometries and the corresponding boundary conditions for this project, the scripting interface of the FEFLOW modelling engine was employed. FEFLOW provides a robust scripting interface, available in Python or C++, which offers numerous functions for programmatically assigning and modifying model features. This scripting capability allows for greater flexibility in adjusting boundary conditions, modifying mesh geometry at selected time steps, and precisely implementing the progression of mining activities.

While FEFLOW's Graphical User Interface (GUI) supports only static finite element meshes with fixed geometry, the scripting interface enables advanced features such as moving mesh nodes and collapsing elements to reflect the evolving pit geometry over time. This approach more realistically represents the excavation process, the removed rock mass, and the associated dewatering dynamics. For each mining stage (updated quarterly), an appropriate seepage face boundary condition is programmatically assigned. This constrained First-Type boundary condition activates only when water levels at pit nodes exceed the projected pit elevation, ensuring water inflows into the pit are accurately collected and removed from the model.

Using this scripting functionality, an in-house adaptive mesh deformation and dynamic boundary condition technique was developed. This technique allows for efficient simulation of changing pit geometries across different mining scenarios and time intervals. Pit inflow rates at each time step, as well as cumulative inflow rates for each pit, are recorded and analysed in detail in the subsequent section. This approach enables a more detailed calculation of changing water levels and the dynamics of the three-dimensional flow field around the pit and the aquifer, providing a more realistic representation of the mining process.

Thus, the LoM is 20 months, which includes 17 months for the North and South pits and additional three months for the expansion of the Southern pit referred to as the 'South pit proposal' (**Figure 4-5**).

Figure 4-6 illustrates characteristic profiles at selected time intervals, showing the progression of pit geometry and groundwater levels along Section 1 during the simulation. The bottom portion of the profile (highlighted in magenta) represents the fresh bedrock formation, while the upper third (shaded in greenish colours) consists of Saprock and the overlying overburden formations.

Calculated groundwater levels and final drawdown at the end of simulation (month 20) are shown in **Figure 4-7** and **Figure 4-8** respectively. **Figure 4-9** through **Figure 4-11** show modelled pit inflows.

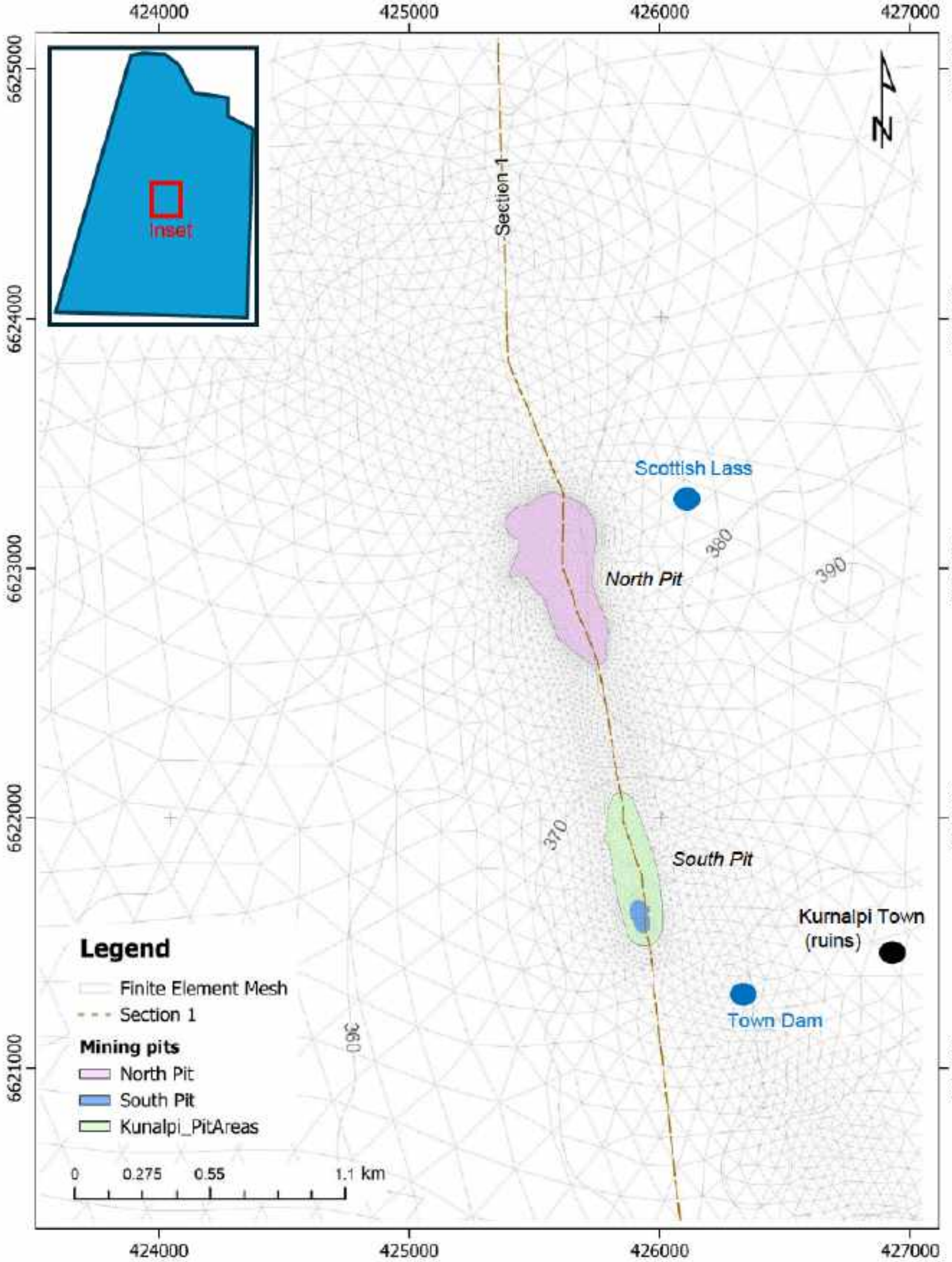

Figure 4-5 Pit boundaries, and mesh design in the vicinity of the pits.

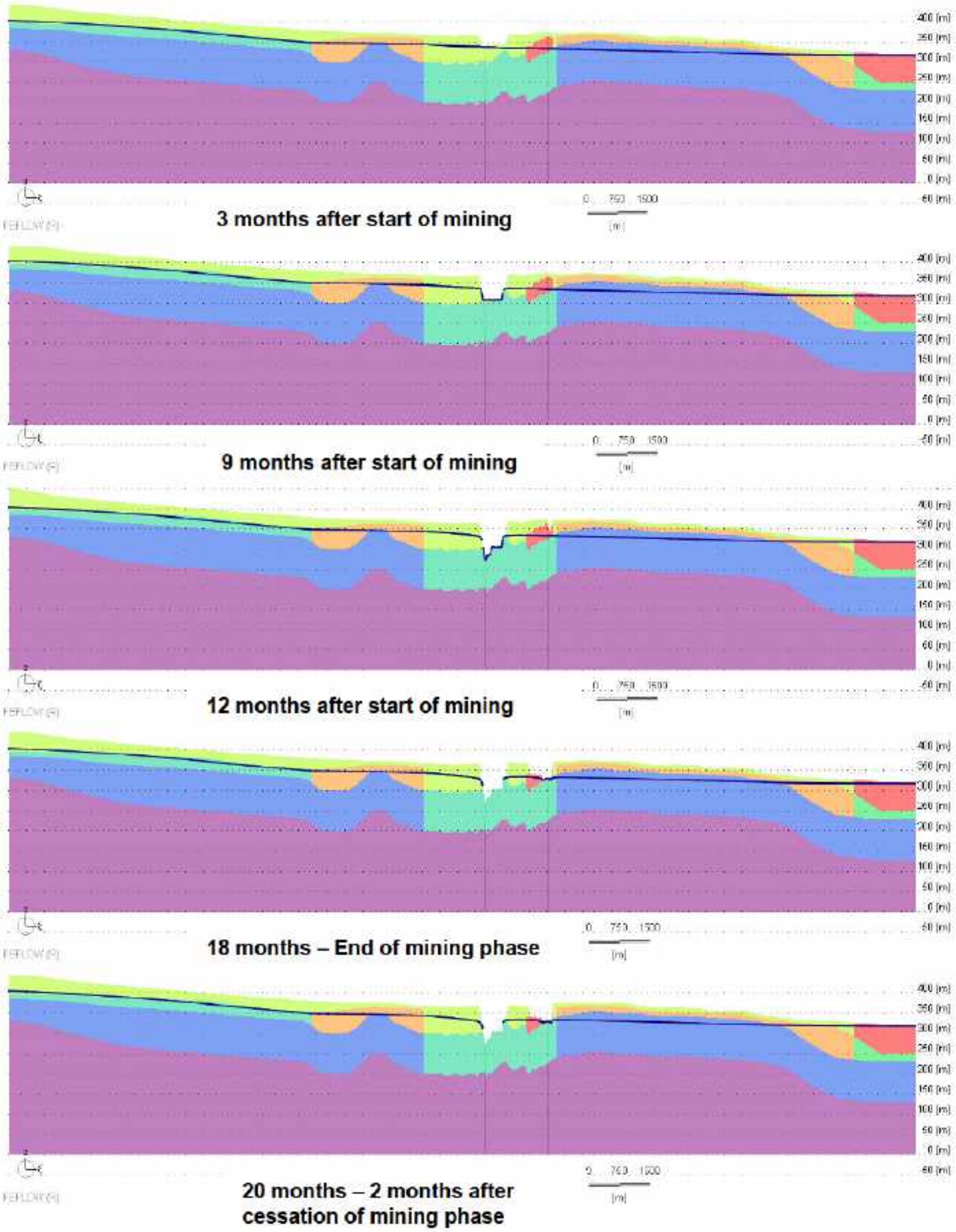

Figure 4-6 Water level profiles and changing pit geometries along Section 1 during the model run, at selected time intervals (vertical scale 10x).

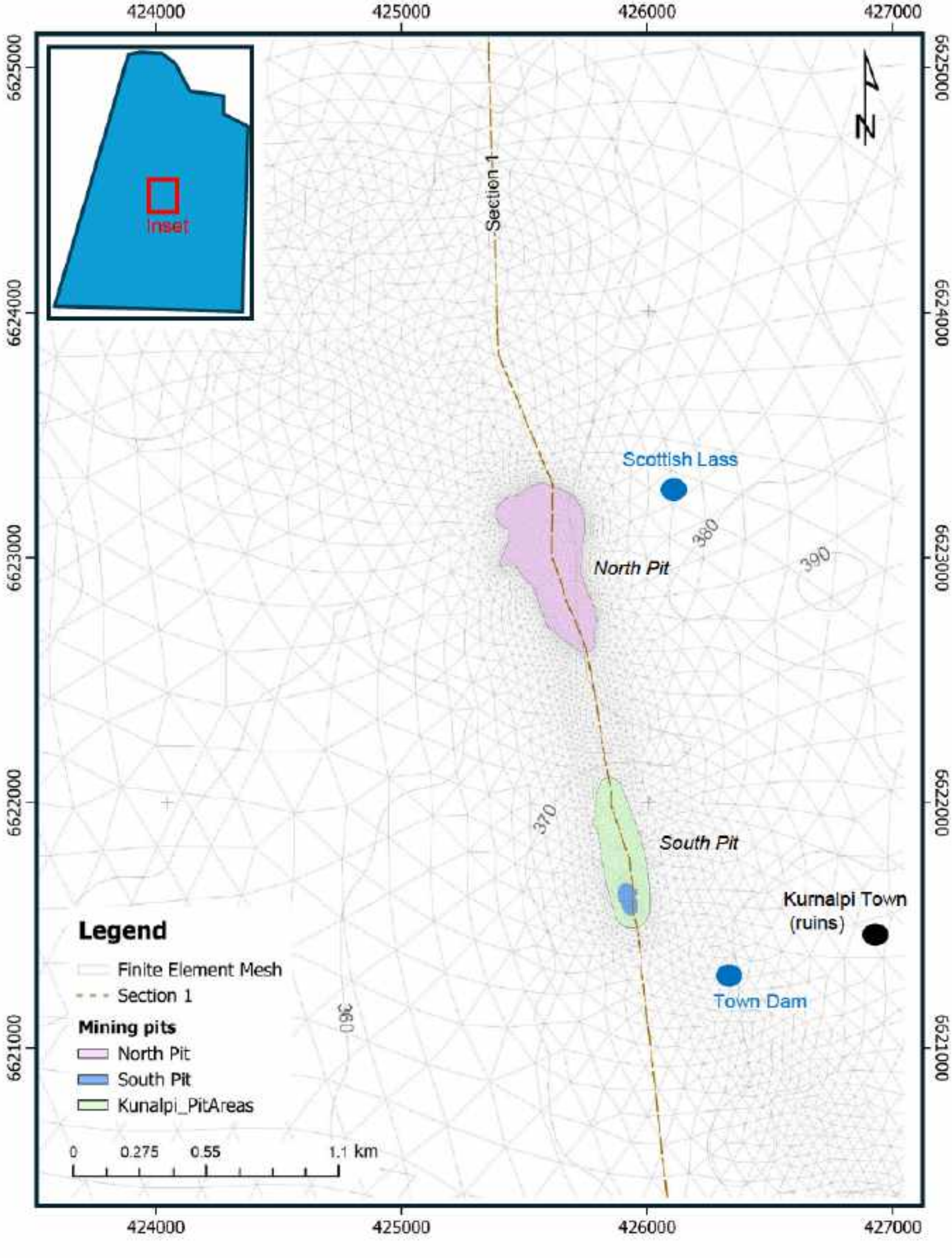

Figure 4-7 Calculated groundwater levels at the end of mining

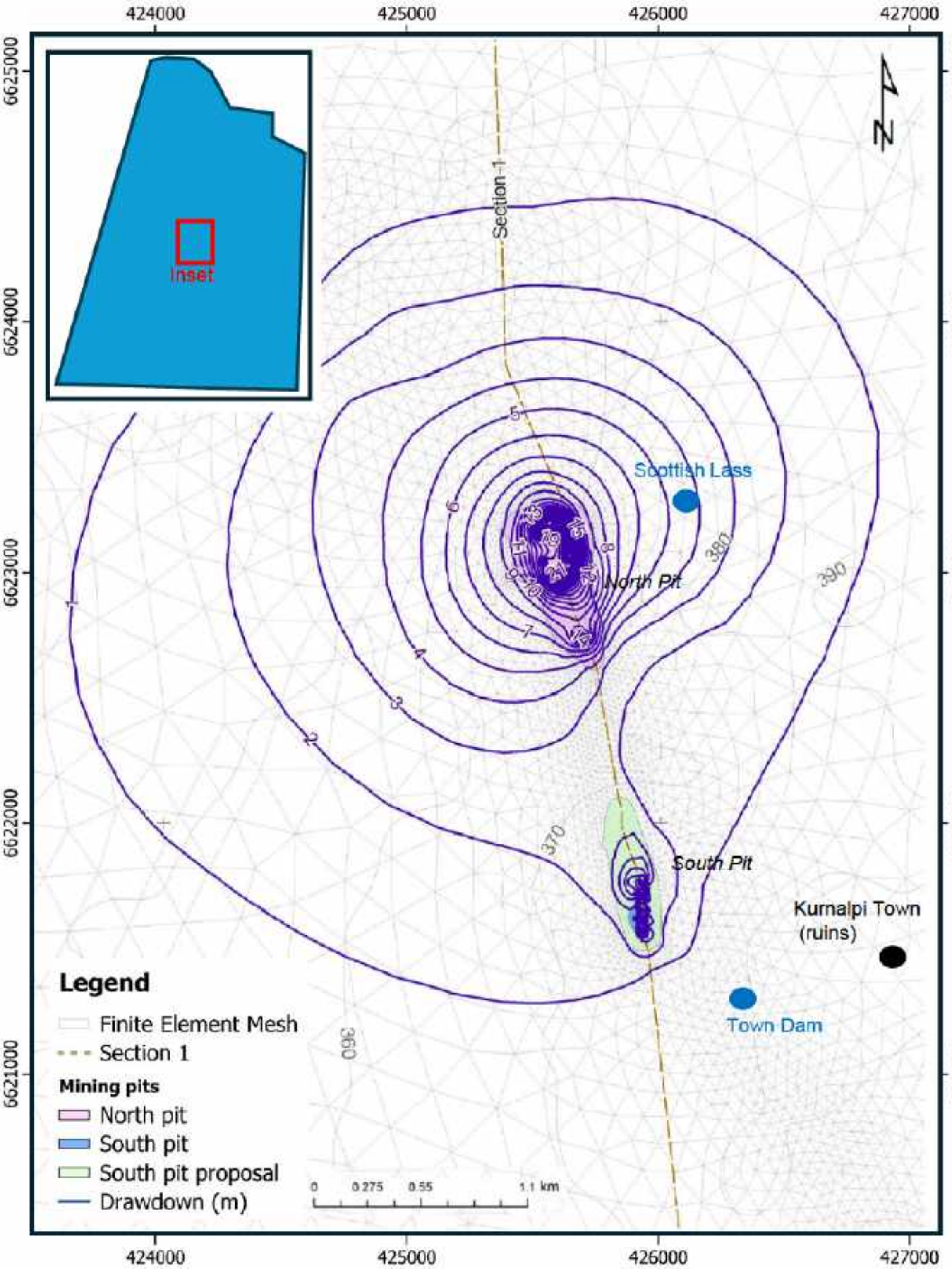

Figure 4-8 Calculated drawdowns at the end of mining

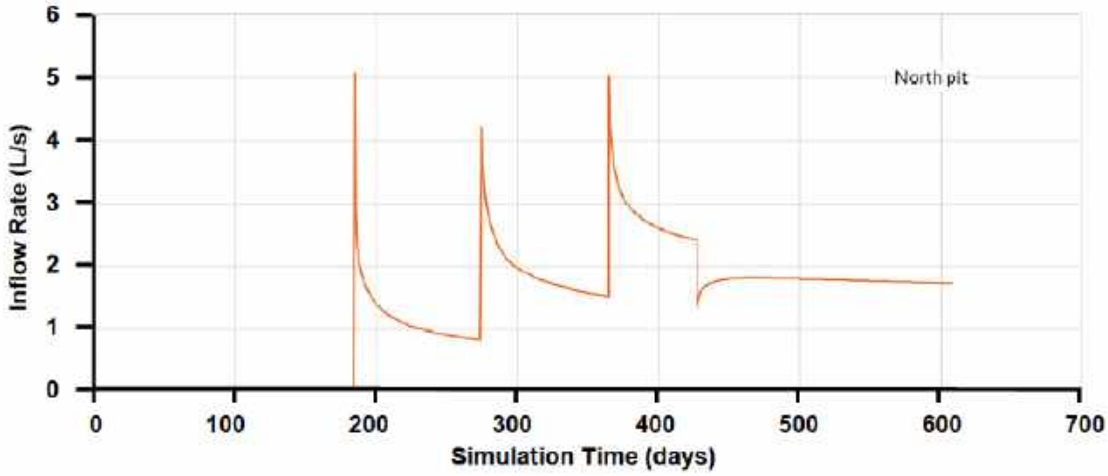

Figure 4-9 Calculated pit inflows at the North pit

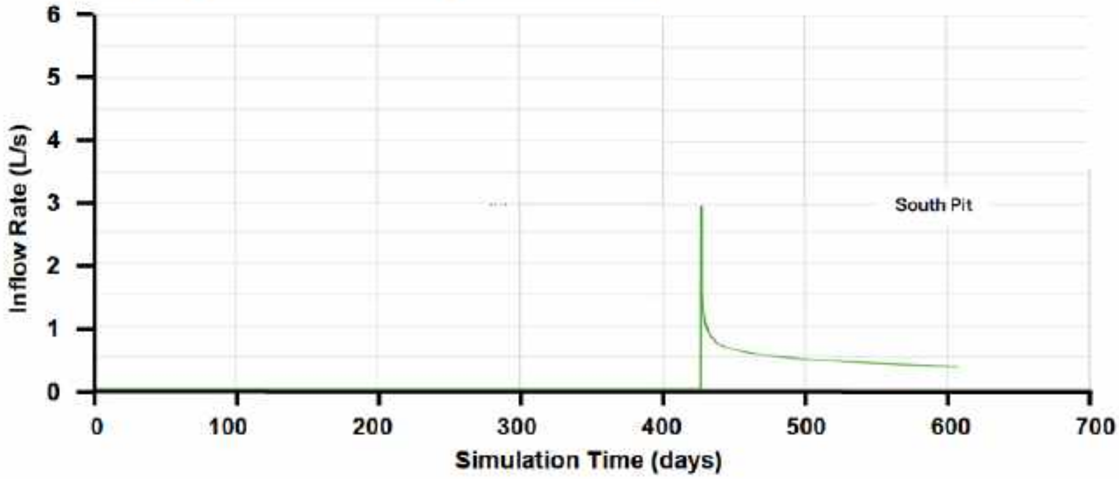

Figure 4-10 Calculated pit inflows at the South pit

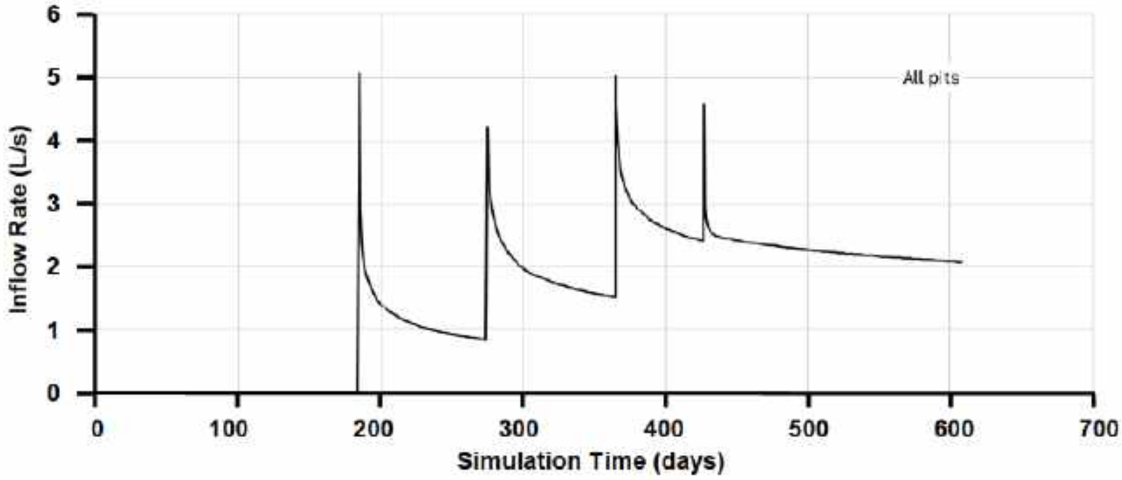

Figure 4-11 Calculated total pit inflows at both pits

4.6 Sensitivity & uncertainty analysis on pit inflows

Geological data indicate that the host formations in the pit area are primarily mafic and ultramafic units. The ultramafic unit forms a north-south band intersecting the pits, potentially representing a more permeable fractured zone associated with higher uncertainty. To assess the sensitivity of pit inflow predictions, a sensitivity and uncertainty analysis was conducted under four different hydraulic conductivity scenarios:

1. **Expected (Base) Permeability Case**: Hydraulic conductivity values for the mafic and ultramafic units were derived from the CSM and refined through model calibration process.
2. **High Permeability Mafic Case**: in this simulation the hydraulic conductivity values for the mafic unit have been increased by a factor of four relative to the expected case, while all other parameters remained unchanged.
3. **High Permeability Ultramafic Case**: in this simulation the hydraulic conductivity values for the ultramafic unit have been increased by a factor of four relative to the expected case, with all other parameters kept consistent with the base case.
4. **Extreme Case Scenario**: in this simulation the hydraulic conductivity values for both the mafic and ultramafic units have been increased by a factor of four relative to the expected case, while all other parameters remained unchanged.

Figure 4.12 illustrates the variation in pit inflows over the LoM under the different hydraulic conductivity scenarios. In the expected case, pit inflows over the LoM range between 1 to 3 L/s.

Changing the permeability of the mafic unit alone has minimal impact on pit inflows. However, a fourfold increase in the permeability of the ultramafic unit significantly increases inflows. In the extreme case scenario, where the permeability of both the mafic and ultramafic units are increased by a factor of four, pit inflows nearly double, ranging from 2 to 5 L/s compared to the expected case.

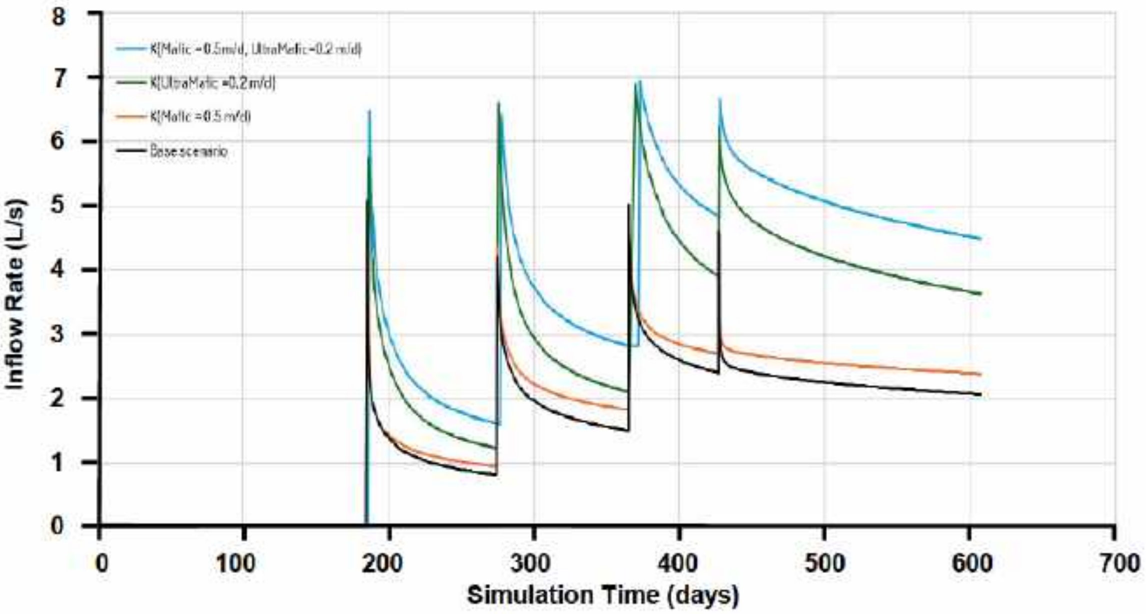

Figure 4-12 Sensitivity- uncertainty analysis of the pit inflows to the variation of mafic and ultramafic hydraulic conductivities.

4.7 Sensitivity & uncertainty analysis on drawdown impacts

Numerical modelling results indicate that discernible drawdown impacts (defined as more than 0.2 m of drawdown) from the Expected Case would be limited to approximately 700 m from the edge of the North Pit and no more than 50 m from the edge of the South Pit, as illustrated by the black line in **Figure 4.13**.

Sensitivity and uncertainty analyses were conducted to evaluate the potential effects of higher-than-expected hydraulic conductivities in ultramafic and mafic formations on the magnitude and extent of drawdown impacts. Key findings include:

- Increasing the hydraulic conductivity of the mafic unit alone has minimal impact on the geometry or magnitude of the drawdown. The only notable change is a broadening of the drawdown extent by approximately 200 m further to the west of the North Pit, as shown by the blue line in Figure 4.13.
- Increasing the hydraulic conductivity of the ultramafic unit alone by a factor of four significantly extends the drawdown. The drawdown extent increases by approximately 400 m to the east and west of the North Pit and up to 1,000 m to the north, as illustrated by the red line in Figure 4.13.
- The greatest impact occurs in the extreme case scenario, where the hydraulic conductivities of both the ultramafic and mafic units are increased by a factor of four. In this case the drawdown around the North Pit extends up to 1,700 m further westward and up to 1,100 m further north and east compared to the expected case. This scenario is represented by the green line in Figure 4.13.

The increased permeability of both the mafic and ultramafic units has minimal impact on the drawdown around the South Pit, as this pit remains unsaturated during the first 12 months of mining.

To adopt a conservative approach, the extreme case drawdown impacts will be used in **Section 6** to assess potential cumulative impacts of the Kurnalpi Gold Project on social and environmental values.

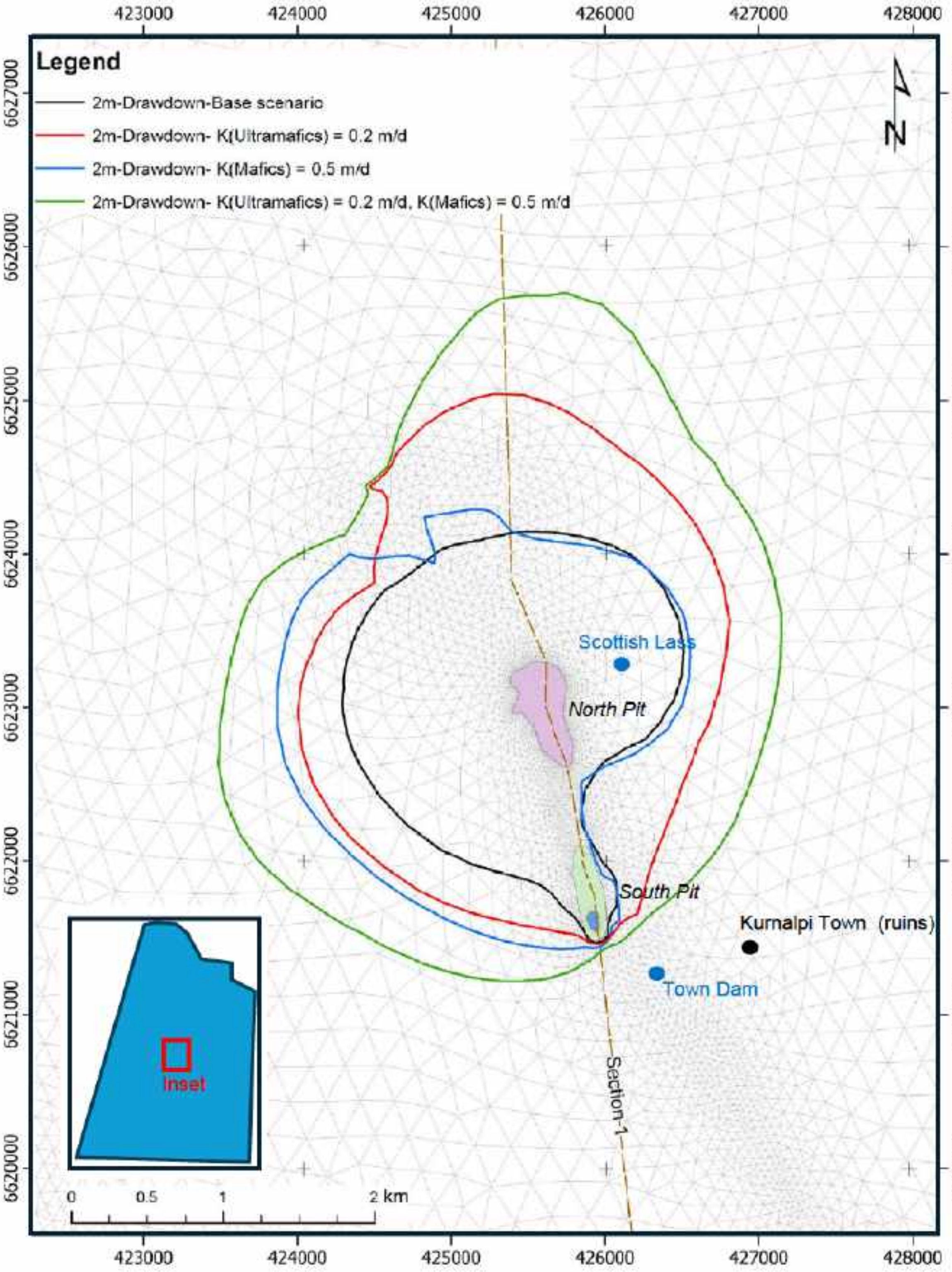

Figure 4-13 Sensitivity- uncertainty analysis of the cone of drawdown to the variation of mafic and ultramafic hydraulic conductivities

5. MINE WATER MANAGEMENT

The Kurnalpi Gold Project will involve the development of the North and South pits, haul roads, and waste rock dumps over a 20-month LoM. The water related management issues arising from the Project include:

- exclusion of external catchment floodwaters around both pits;
- management of groundwater influx to the mine;
- management of stormwater generation within each pit;

These are discussed further below.

5.1 Storm water management

In February 2014, a once-in-150-year storm event brought 130 mm of rainfall over 14 hours, resulting in approximately 4,700 ML of upstream catchment runoff overtopping a flood exclusion bund above Regis Resources' Duketon gold project in Laverton, Western Australia. This event caused the Garden Well and Rosemount open-cut pits to become inundated to a depth of 40 m, suspending operations for several months (Kalgoorlie Miner, 2014). A subsequent review by DEMIRS revealed that the pits were constructed across a natural drainage line, and the flood risk should have been both evident and mitigated through a comprehensive surface water management plan.

Figure 3-1 shows the location of the proposed Kurnalpi pits on the STRM digital elevation model. The pits and associated waste rock dumps are positioned to the east of Kurnalpi Creek. A small tributary, with a catchment area of approximately 278 hectares cuts through the southern side of the North Pit.

The south side of the North Pit intersects a small tributary creek with an upslope catchment area of 278 hectares. Without intervention, this creek has the potential to generate approximately 550 ML of stormwater impounded against the North Pit exclusion bund following a 1% Annual Exceedance Probability (AEP) 72-hour storm (i.e., a 100-year storm event). To mitigate this risk, a surface water assessment by RPS (2022) recommended a minor diversion drain be excavated around the southern edge of the North Pit exclusion bund.

The base of the drain should be survey-levelled to ensure it free drains between points A and B on Figure 3-1. With a peak flow of 0.81 m^3/s from a 1% AEP storm, a channel width of only one metre would be more than adequate. For optimal functionality and safety, the diversion drain should be aligned no closer than 50 m from the pit's edge. Exclusion bund walls should also maintain a minimum distance of 20 m from both the pit edge and the diversion drain, as shown in the cross-section in **Figure 5-2**.

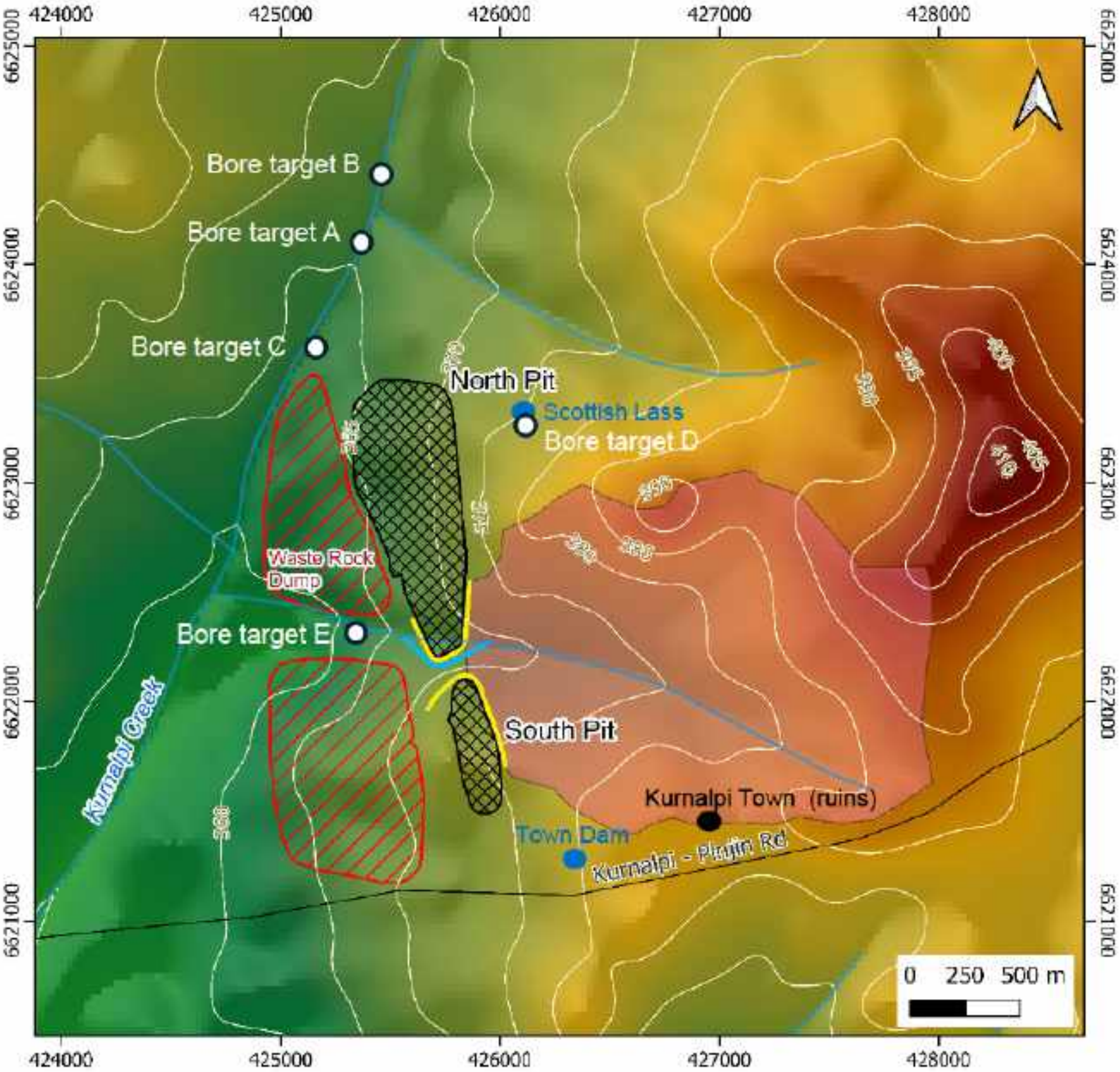

Figure 5-1 Local physiography about the Kurnalpi Gold Project area.

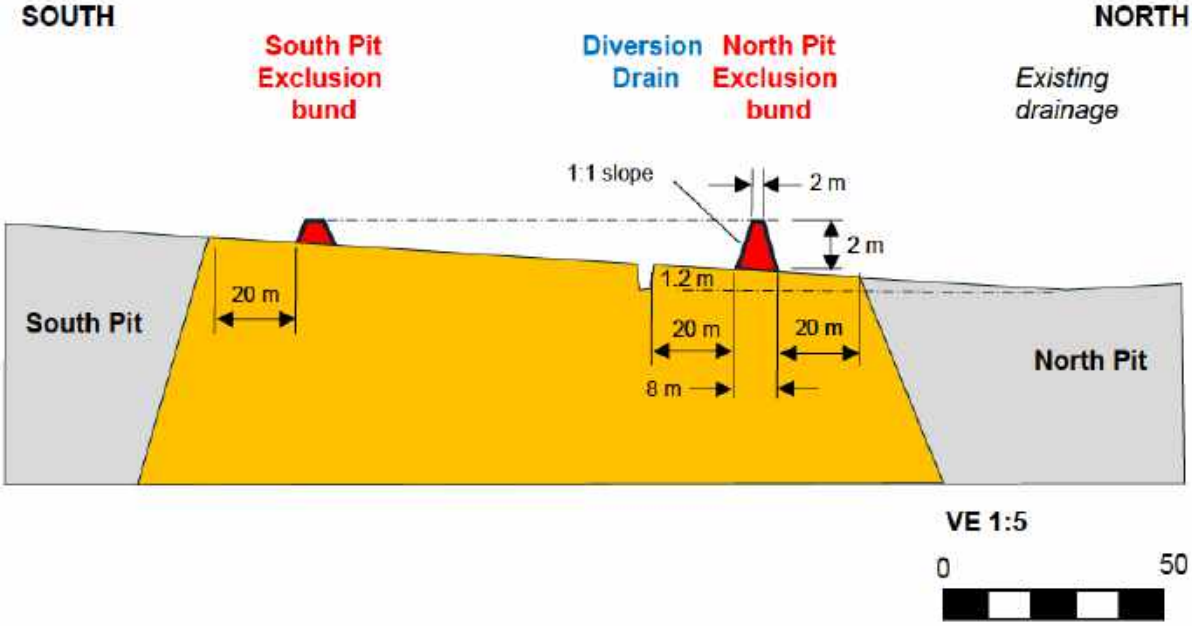

Figure 5-2 **Cross section through proposed stormwater infrastructure (looking west).**

5.2 Groundwater influx management

The proposed Kurnalpi pits will be mined to a final depth of 93 m at the North Pit and 45 m at the South Pit, progressing through the saprolite and saprock profile described in **Section 3.1**. With the static water level approximately 30 mBGL, the saturated depth of mining at the North Pit will primarily occur within the competent lower saprolite and saprock layers. In contrast, mining at the South Pit will mostly involve the upper saprolite. The North Pit will extend approximately 63 m below the water table, whereas the South Pit will penetrate only 15 m below it.

Predictive simulations indicate that pit inflows at the North Pit will typically range between 1 and 3 L/s, but could potentially reach up to 5 L/s in an unlikely extreme case. Inflows at the South Pit are expected to be lower, averaging around 0.5 L/s, as the South Pit will dry mined for most of its operational period.

These inflows are low enough that Pennington Scott recommends dewatering be undertaken using in-pit sumps. Water discharged from dewatering activities can be used opportunistically for dust suppression in the mine and on mine haul roads.

Most of the excavation will occur within competent saprock, minimising the risk of wall stability issues. However, if saturated lower saprolite is encountered in the pit walls, horizontal seepage wells are recommended to manage groundwater. These wells should be drilled 20 to 30 m into the pit wall at an upward angle with a minimum slope of 5% to allow free drainage of groundwater into the pit. Spacing between seepage wells should be maintained at 30 m intervals.

5.3 Makeup water supply and pit dewatering bore development

The project requires approximately 6.3 L/s of water for dust suppression in the Kurnalpi Pits and along the 25 km haul road between the Kurnalpi Gold Project and the intersection with the CDO Access Road. Although mine dewatering wiould be used opportunistically to meet this demand, the anticipated dewatering rates are expected to be less than half of the required volume, and they will only peak towards the end of the LoM.

- **Make-up water bores:** Pennington Scott recommends that two production water bores be constructed in the fractured rock aquifer at least 400 m from the edge of the proposed Kurnalpi pits to provide make-up water for the Project.
- **Dewatering monitor bores:** NSR is also required to construct three monitor bores around the pit in line with its Groundwater Operating Strategy (NSR 2024), being two primary dewatering monitor bores and one alternative monitor bore.

Bores in fractured greenstone rocks typically yield between 0.1 and 3 L/s, whereas ideally the water supply bores would produce at least 1 L/s. Given the uncertain yields when targeting in mafic/ultramafic saprolite aquifers, Pennington Scott recommends engaging an RC (Reverse Circulation) or RAB (Rotary Air Blast) drilling contractor holding a Class 1 water well license from the Australian Drilling Industry Association (ADIA) to drill and construct five (5) six-inch diameter water bores at the locations shown in Figure 5.1 and summarised in **Table 5.1**. All bores will be constructed in accordance with the Minimum Construction Guidelines for Water Bores in Australia, Version 4 (NUDLC 2020). After completion, the two most productive bores will be selected as the make-up water supply bores, while the remaining bores will serve as monitor wells per GWOS-V11.

All bores would be constructed under the supervision of a Pennington Scott hydrogeologist, following these protocols: A nominal 200 mm (6") diameter pilot hole will be drilled at each site to a minimum depth of 70 mBGL and a maximum of 90 mBGL, or to a depth 6 m into competent saprock, whichever occurs first. Upon completion of the pilot hole, the hole will be cased with 150 mm ID uPVC PN12 machine-slotted liners extending to full depth, with 30 m of blank casing at the surface. The annulus will then be backfilled with 3.2 to 6.4 mm gravel to a depth of 5 mBGL, followed by a cement grout seal extending to the surface to ensure compliance with construction standards. Finally, the completed bore will be developed with air for a minimum of 30 minutes or until the discharge is deemed sand-free, in accordance with the minimum construction requirements.

Table 5-1 Proposed bore targets

Drill Target	Easting (m)	Northing (m)	Target depth (mBGL)
A	425,383	6,624,035	70 to 90
B	425,455	6,624,408	70 to 90
C	425,997	6,623,282	70 to 90
D	425,161	6,623,590	70 to 90
E	425,409	6,622,298	70 to 90

6. IMPACTS ASSESSMENT

The Kurnalpi Project requires 300,000 kL/year of water for dust suppression, inclusive of 50% contingency above the anticipated average demand of 6.3 L/s. While dewatering from the North and South pits could potentially supply much of this volume, the timing and magnitude of dewatering are uncertain. Consequently, additional make-up bores are necessary to ensure a reliable water supply. The North Pit is planned for excavation down to 275 mAHD, approximately 65 m below the water table, whereas the South Pit will be shallower, with mining extending to 330 mAHD, less than 15 m below the water table.

To ensure a conservative evaluation, the extreme case drawdown impacts outlined in **Section 4** have been adopted in this Section to assess the potential cumulative impacts of the Kurnalpi Gold Project on social and environmental values.

The key environmental and social factors that may be affected by pit-induced drawdown include:

- Groundwater-dependent ecosystems
- Groundwater abstraction by other water users
- Aboriginal heritage sites with water-related significance

Each of these potential impacts is discussed in greater detail in the following sections.

6.1 Groundwater Dependent Ecosystems

Groundwater-dependent ecosystems (GDEs) are biological communities that rely on groundwater, or its surface expressions, either opportunistically or as their primary water source.

The natural water table depth ranges between approximately 24 and 40 mBGL in the vicinity of the proposed Kurnalpi pits, making groundwater dependence by vegetation highly unlikely. Only deep-rooted tree species are capable of accessing groundwater at depths greater than 10 mBGL, and vegetation dependence becomes negligible at depths exceeding 20 mBGL (Cook and Aemus, 2018).

Based on a review of the Department of Biodiversity, Conservation and Attractions (DBCA) datasets 36 and 38, there are no known terrestrial GDEs within the potential drawdown impact zone around the proposed Kurnalpi pits. Furthermore, the Bureau of Meteorology's (BoM) Groundwater Dependent Ecosystems Atlas classifies the Kurnalpi project area as having a low to moderate potential for GDEs.

Given the already deep water table in the area of potential drawdown impact, the Project poses no threat to terrestrial GDEs (**Figure 6.1**)

6.3 Other Water Users

Drawdown around the Kurnalpi pits has the potential to detrimentally impact other surrounding groundwater users. Reference to DWER's WIN bore database has identified a single registered third-party bore within 3 km of the pit, being Scottish Lass Well located just 200 m east of North Pit (**Figure 6-1**). Scottish Lass is an unusable well that drew water from a collapsed shaft, but is now abandoned (Rockwater, 2021).

Pennington Scott therefore concludes that the Project poses no risk to other groundwater users.

6.4 Aboriginal Heritage Sites

Mining activities has the potential to impact water sensitive Aboriginal heritage values.

Based on the Aboriginal Heritage Inquiry System (AHIS) through the Department of Planning, Lands and Heritage (DPLH), the only registered heritage site near the Kurnalpi project is to the south covering Lake Yindarlgooda (Place Id 30602) (**Figure 6-1**). This is a mythological type of site that lies well beyond the impact area of the project. There are no further sites lodged within 10 km of the project.

Given that the site has little water sensitivity and lies well outside the zone of potential drawdown impacts, Pennington Scott concludes that the Project poses no risk to aboriginal heritage values.

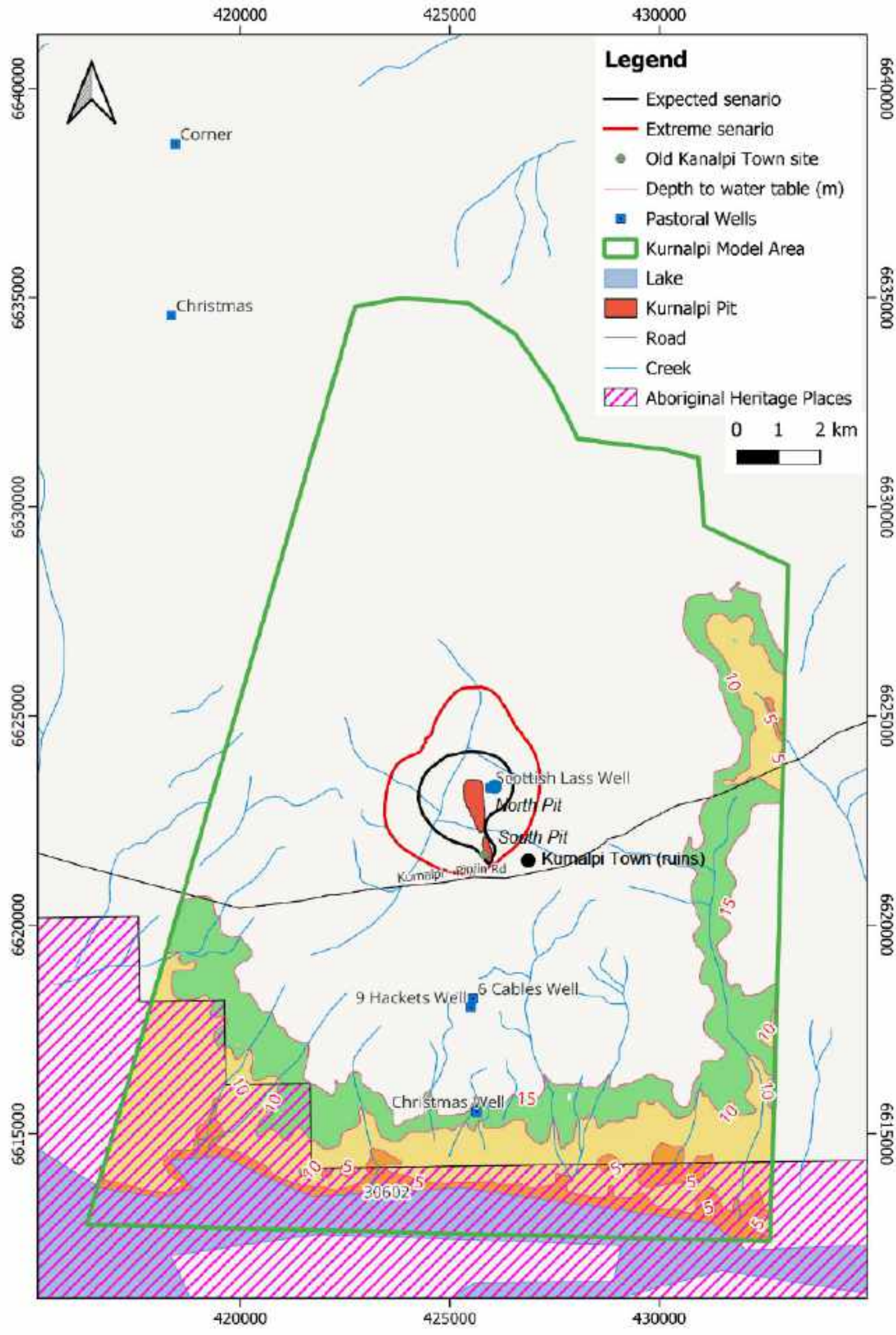

Figure 6-1: Environmental and Social Impact Assessment

7. CONCLUSIONS

Northern Star Resources (NSR) plans to develop the Kurnalpi Gold Project as part of its Carosue Dam Operations. The Project will involve the excavation of two open-cut gold pits; the North & South Pit, over an estimated 20-month life of mine (LoM). While no mineral processing will be conducted on-site, the project will nonetheless require between 200,000 and 300,000 kL/year of water for camp facilities, together with dust suppression within the mine and on 21 km of haul road between the Project and the CDO Access Road. This water will be sourced opportunistically from mine dewatering activities in the Kurnalpi Pits supplemented by additional make-up water from bores in the fractured rock aquifer on-site.

NSR holds an existing groundwater license issued by the Department of Water and Environmental Regulation allowing the extraction of 20,000 kL/year from the Fractured Rock West – Fractured Rock aquifers in the Roe Subarea of the Goldfields Groundwater Management Area. To meet the project's water requirements, NSR seeks to increase the allocation limit under this license to 320,000 kL/year.

A numerical groundwater model has been developed to evaluate pit inflows and dewatering requirements over the 20-month LoM. The model was designed and calibrated in accordance with the *Australian Groundwater Modelling Guidelines* (Barnett et al., 2012) and incorporates a hydrogeological conceptual site model that defines aquifer geometry, hydrostratigraphy, recharge and discharge conditions, and hydraulic properties. Model calibration was achieved using existing groundwater data and inferred water level distributions, validating the adopted hydraulic parameters and conceptual framework.

Key findings of the groundwater modelling are:

- inflows during mining of the North Pit are expected to range from 1 to 3 L/s. Inflows at the South Pit are expected to be significantly lower, averaging around 0.5 L/s, as the South Pit will be dry mined for most of its operational period.
- discernible drawdown impacts (defined as more than 0.2 m of drawdown) are expected to be restricted to approximately 700 m from the edge of the North Pit and 50 m from the edge of the South Pit.
- Sensitivity and uncertainty analyses assessed the potential effects in the event that much higher-than-expected hydraulic conductivities are encountered in ultramafic and mafic formations. In this extreme case scenario (a four-fold increase in hydraulic conductivity), pit inflows would nearly double to 5 L/s, and drawdown extents could also approximately double compared with the expected case.

Even in the most conservative (extreme) case, the rate of groundwater influx to the pits would be sufficiently low that all dewatering could be undertaken from in-pit sumps, and discharge water could be consumed in dust suppression. Adopting the modelled extreme case drawdown as the benchmark, the implications for environmental and social impacts are as follows:

- The Project would have no material impact on Groundwater-Dependent Ecosystems (GDEs) because the existing water table beneath the pits is greater than 20 mBGL, which is beyond the reach of tree roots. The absence of registered GDEs in the area, as confirmed by the Bureau of Meteorology's GDE Atlas and other datasets, supports this conclusion,

- The Project would have no material impact on Aboriginal Heritage values because there are no registered Aboriginal heritage sites within the Kurnalpi tenements or within the modelled drawdown extent, and
- The Project would have no material impact on other Groundwater Users because there are no other known groundwater users within the modelled drawdown extent. The only identified groundwater draw point within a 5 km radius of the pits is the historic Scottish Lass water supply shaft, located adjacent to the NE corner of the North Pit. This shaft was last used as the water supply for the old Kurnalpi Town but has not been used for more than a century and has long since collapsed.

In summary, Pennington Scott has found no evidence of serious or irreversible damage to environmental or social factors that would preclude DWER from approving NSR's application to increase the allocation under GWL 151848 (6) from 20,000 to 320,000 kL/year to support the Kurnalpi Gold Project.

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