Australasian Groundwater & Environmental Consultants

24 March 2023

Cadia Valley Operations
Cadia Holdings Pty Limited
1460 Cadia Road Orange
NSW 2800

Attention: Geoffrey Newcombe – Environmental approvals manager
via email: geoffrey.newcombe@newcrest.com.au

Dear Geoffrey,

Cadia Groundwater Review to Support Gateway Application

1 Introduction and Scope

Cadia Holdings Pty Limited (CHPL) operates the Cadia Valley Operations (CVO) located south-west of Orange in New South Wales. CHPL is planning to reinforce the embankment of the Southern Tailings Storage Facility (STSF) with an embankment raise which will result in the facility footprint extending outside the existing mining lease. Soil assessments have indicated that Biophysical Strategic Agricultural Land (BSAL) is present within the footprint of the proposed modified TSF embankment, which triggers a Gateway application, prior to lodging an application to modify the project approval (Mod 15).

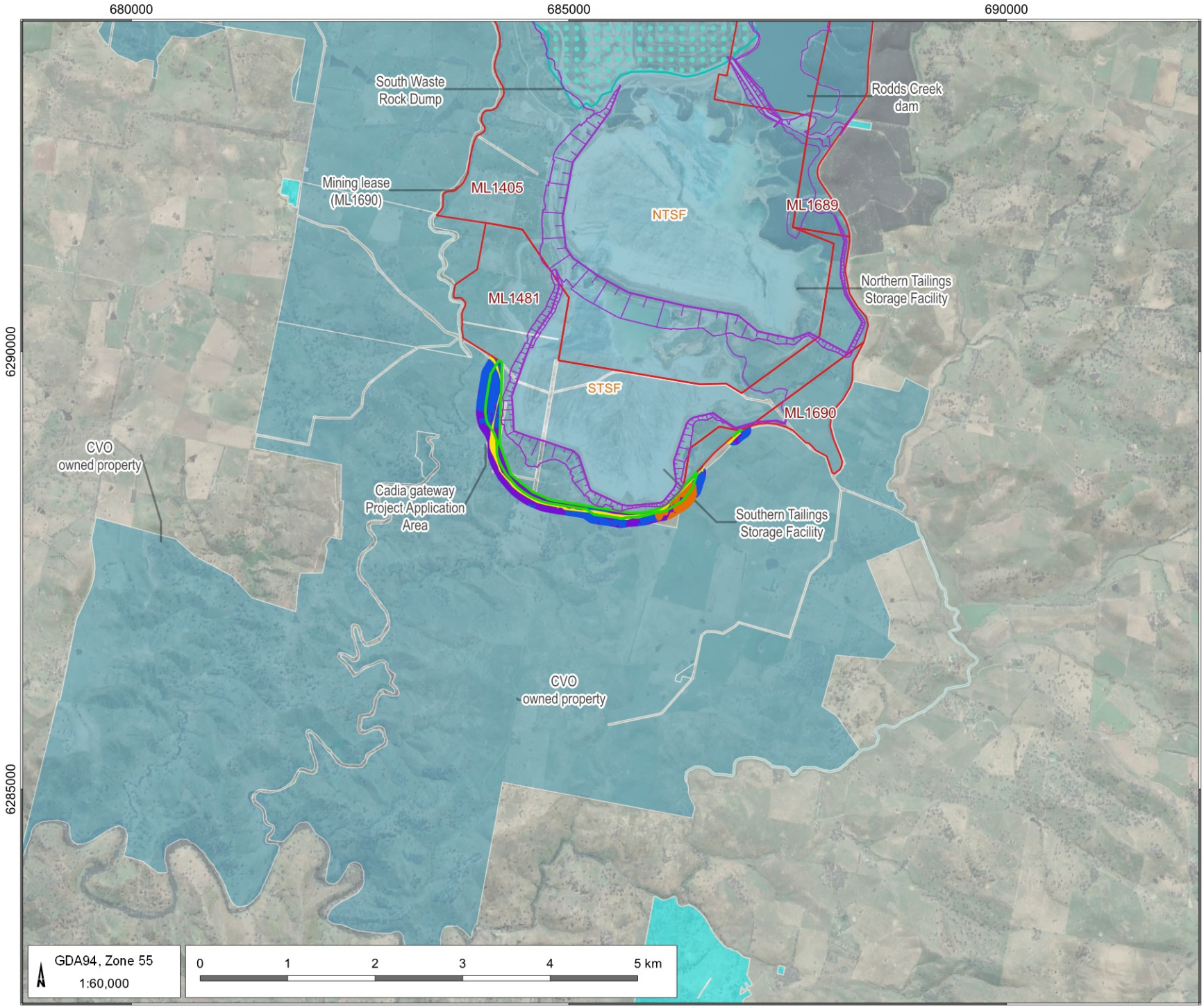
The Gateway process is established through Part 4AA of the *State Environmental Planning Policy (Resources and Energy) 2021* (the Mining SEPP). The Gateway process is an upfront, rigorous and independent assessment of the potential impacts of a project on agricultural land and water resources (including BSAL) before a development application can be lodged.

For proposals on BSAL, the supporting Gateway application must address the following criteria with respect to groundwater resources as listed in the Mining SEPP:

Clause 2.31:

> *(4) The relevant criteria are as follows:*
>
> > *(a) in relation to biophysical strategic agricultural land – that the proposed development will not significantly reduce the agricultural productivity of any biophysical strategic agricultural land, based on a consideration of the following:*
> >
> > > *(iv) any impacts on highly productive groundwater (within the meaning of the Aquifer Interference Policy[1]).*

This letter provides a groundwater review of the CVO and the proposed modification of the TSF embankment in support of the application for Gateway Certification. The CVO Gateway Project Application Area is shown on Figure 1.1 showing areas where the proposed embankment works would extend outside the mining lease. CHPL own properties outside mining lease ML 1481 on the south, west and south-eastern side of the STSF which includes the Gateway Project Application Area.



LEGEND

- Drainage
- TSF outline - MOD14
- Rodds Creek dam
- South Waste Rock Dump
- Mining leases
- CVO owned property
- Crown Land
- Cadia gateway Project Application Area

BSAL Soil Types

- Road Disturbance
- Verified BSAL
- Verified Non-BSAL
- Verified Non-BSAL (Slope or < 20Ha Contiguous)

Satellite image : Google

Cadia Gateway Application (CAD5004.001)

Cadia gateway Project Application Area

DATE
24/03/2023

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FIGURE No:
1.1

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2 Highly Productive Groundwater

2.1 Hydrogeology Context

The Gateway Project Application Area is primarily comprised of sedimentary turbidites and volcanic/volcaniclastic units, which are Ordovician and Silurian in age overlain by younger Tertiary aged basalt flows, and more recent Quaternary alluvium along drainage lines (Figure 2.1). The dominant regional structure consists of a series of roughly north striking faults and splays. These faults were caused by several tectonic events that occurred between the Ordovician and the Carboniferous Periods, with deformation generally driven by east-west crustal shortening (Washburn, 2008).

The alluvium generally comprises clays, sands and some gravels deposited by meandering fluvial systems that are generally well incised. Alluvial deposits are generally less than 5 metres (m) thick along the creeks in the Cadia region. Creeks are commonly incised into the bedrock with alluvium largely absent. The thickness of alluvium is known to be greater along the Belubula River south of the CVO.

The Tertiary basalt originated from numerous extrusive episodes from Mount Canobolas and surrounding volcanic vents, covering an area of about 530 square kilometres (km^2). The nature of the basalt varies from relatively massive to vesicular (scoriaceous). The Tertiary basalt thickness is dependent on the topography of the underlying land surface, with the basalt being thickest along paleochannels (can be up to 150 m thick). In parts there are thin paleo-alluvial and lacustrine sediments and residual soils thought to be of Tertiary age that underlay the basalts within the paleochannels. These sediments and residual soils are comprised of clay, sandy / clayey gravels and gravelly clays (GHD, 2019).

The Silurian sediments predominantly comprise siltstones, sandstones and minor limestone. The Ordovician units in the region comprise the Forest Reef Volcanics that conformably overlie the Weemalla Formation. The Forest Reef Volcanics are dominated by volcaniclastic lithologies, which comprise lithic conglomerates, breccias, sandstones, and lesser siliceous siltstone. The Weemalla Formation comprises turbidite sediments that consist of fine grained and thinly laminated, carbonaceous to volcanic siltstones, with minor arenaceous volcanic beds, including pillow basalts.

These geological units can be grouped into the following hydrostratigraphic units based on their ability to store and transmit groundwater:

- **Quaternary alluvium** - forms minor saturated porous systems that are limited to major drainage lines, although of limited extent, thin, and of variable permeability;
- **Tertiary basalt flows** - variable permeability unit that forms fractured aquifer systems or aquitards;
- **Silurian sediments** - generally fine grained and forms low permeability aquitards, except in zones of fracturing where permeability (and storage) is enhanced; and
- **Ordovician volcanics and intrusives** - rock matrix has inherently low permeability and forms competent aquitards, except in zones of fracturing where permeability is enhanced.

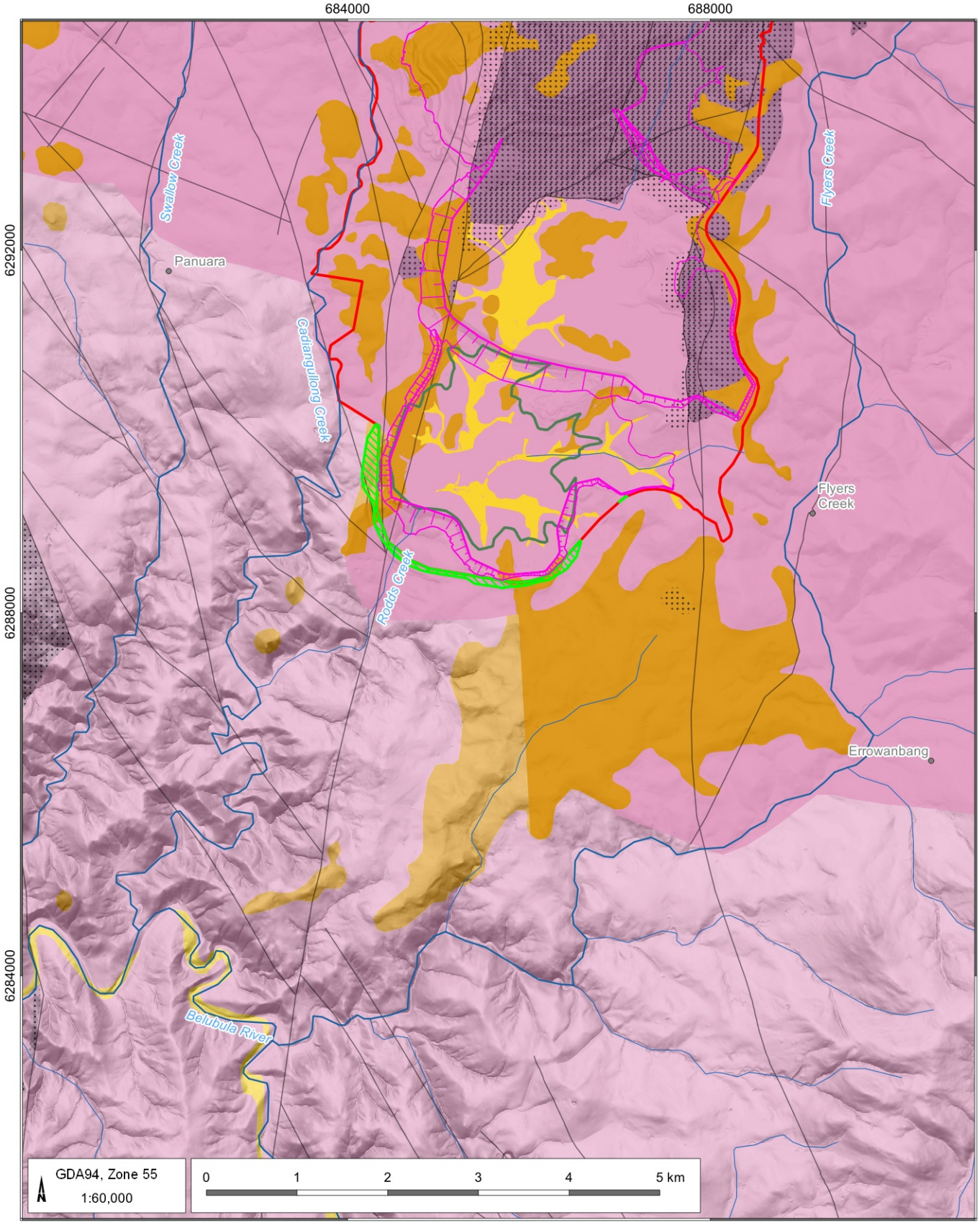
The main aquifers in the vicinity of the CVO are within fractured systems of the Tertiary basalt and structural zones in the underlying Silurian and Ordovician rocks. The extent of the fractured aquifer system is highly uncertain and is dependent on the connectivity of fracture networks, as well as the occurrence of chemical precipitates or clay infill restricting groundwater flow. The transmission of groundwater within these fractured systems may be enhanced in the weathered zone and restricted at depth, due to a combination of rock mass loading (which reduces fracture apertures) and an absence of weathering.

The Quaternary alluvium in the CVO area is thin (typically less than 5 m thick along creeks) and generally occurs above the water table. Alluvium along creeks may be temporarily saturated in places where there is baseflow from weathered rock, especially during wetter periods. There are some locations along drainage lines where permanent baseflow contributions from adjacent units report to the alluvial sediments, for example, parts of Flyers Creek. The saturated thickness of these alluvial systems is very thin, and typically they are not very laterally extensive. Anecdotal evidence suggests most of the Quaternary alluvium consists of silty/clayey sediments of low permeability. Therefore, the alluvium along creeks form only minor aquifers. The nearest alluvial system of significance is most likely the Belubula River, which, at its nearest point, is approximately three kilometres (km) south of the Gateway Project Application Area. The Quaternary alluvium is not known to form a significant groundwater resource locally.

Perched groundwater systems may form at the interface between weathered fractured units (including Silurian/Ordovician rocks and Tertiary basalt), overlying low permeability fresh massive rock. These systems will drain downslope and emanate as surface seepage typically within creek lines or topographic breaks of slope.

The water table is generally a subdued reflection of the topography with groundwater flows to the south-southwest (AGE, 2021a). The water table in the Gateway Project Application Area and to the south is between 5 m to 20 m below surface, with shallower levels occurring along drainage, and deeper levels occurring in topographically elevated areas.

Groundwater within the alluvium is typically fresh and slightly acidic. Groundwater within the Tertiary basalt is mainly fresh, although in places can be slightly saline and typically slightly acidic. Groundwater in the Ordovician volcanics / intrusives and Silurian sediments range from fresh to slightly saline and slightly acidic to alkaline.



LEGEND

- Place name
- Drainage
- CVO interpreted regional fault traces
- TSF outline - MOD14
- Mining lease
- Cadia gateway Project Application Area
- Southern Tailings Storage Facility

Surface geology units

- Quaternary sediments
- Tertiary basalt with Tertiary sediments beneath basalt in places
- Silurian meta-sediments
- Ordovician volcanics
- volcaniclastic and turbidite sediments
- Geological units comprising sedimentary rocks

Note: Darker colours represent the extent of CVO geological mapping

Cadia Gateway Application (CAD5004.001)

Geological plan of Cadia gateway Project Application Area

AGE

DATE 11/10/2022

FIGURE No: **2.1**

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Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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2.2 Highly Productive Groundwater Criteria

A “highly productive” groundwater source is defined by the Aquifer Interference Policy (AIP) as a groundwater source declared in regulations, based on the following criteria:

- has a Total Dissolved Solids (TDS) concentration less than 1,500 milligrams per litre (mg/L); and
- contains water supply works that can yield water at a rate greater than 5 Litres per second (L/s).

Highly productive groundwater sources are further grouped by geological characteristics into alluvial, coastal sands, porous rock, and fractured rock.

The NSW Department of Primary Industries – Office of Water (now known as the Department of Industry - Lands and Water - DILW) produced a map of groundwater productivity across NSW in 2013, which shows areas classified as either highly or less productive. The DILW groundwater productivity map has been reproduced in Figure 2.2 for the Gateway Project Application Area and indicates the Orange basalt fractured rock source has been classified as highly productive. The Orange basalt groundwater source as shown in Figure 2.2 is more extensive than determined from finer scale mapping on government geology maps and CVO geological mapping as shown in Figure 2.1. In reality, there are areas in the Gateway Project Application Area that do not contain basalt, whereas the DILW groundwater productivity map provided in Figure 2.2 indicates it underlies the entire area.

The surrounding and underlying Ordovician and Silurian rocks do not satisfy either the water quality or flow rate criteria for highly productive aquifers and therefore are classified as ‘less productive groundwater sources’. There is no alluvium along streams in the Gateway Project Application Area classified as highly productive. The nearest highly productive alluvium is over 20 km from the Gateway Project Application Area on the Belubula River.

The Orange Basalt Groundwater Source is the most heavily utilised groundwater resource in the region and there are a large number of water supply bores with yields greater than 5 L/s. Figure 2.3 shows the location of registered bores and recorded yields for bores within 5 km around the Gateway Project Application Area. Details on the registered bores from the Water NSW online portal are summarised in Table 2.1. Whilst groundwater use is common within the wider region, there are no registered bores extracting water from the basalt within 5 km of the Gateway Project Application Area with yields > 5 L/s.

The Gateway Project Application Area is largely located on the Ordovician volcanics and intrusives of low permeability classified as low productivity (refer to Figure 2.1). The Orange Basalt occurs in two small areas to the south and west of the STSF gateway Project Application Area (note on Figure 2.1 the basalt already occurs in areas under the existing STSF).

DPI-Water (2012) states that productive sections of the basalt aquifer are associated with interconnected joints and fractures mostly developed during the cooling of the basalt flows, as well as secondary fractures developed during regional orogenic events. Locations of productive basalt aquifer zones are difficult to infer, as the distribution of cooling dependant primary fractures/joints is unknown.

A constraint on the long-term productivity of the basalt aquifer is the extent and connectivity of fractures zones, which may limit aquifer storage. As stated in the *Australian Natural Resource Atlas* (National Land and Water Resources Audit [NLWRA], 2001):

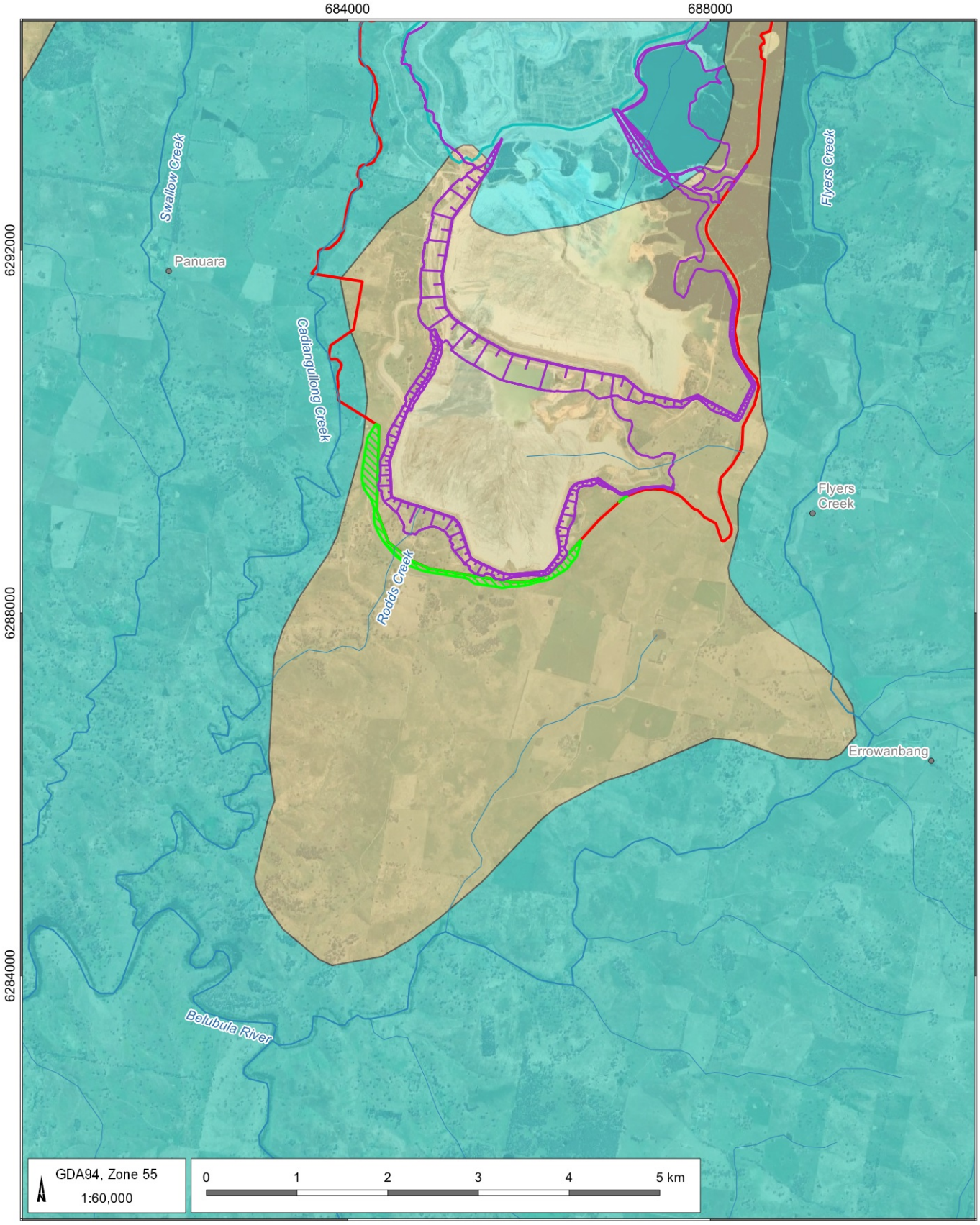
‘A major problem with this aquifer is a lack of continuity of fractures zones. A bore sunk into a well fractured and consequently highly permeable zone may appear to have a good supply, especially if not tested rigorously. On long term pumping, however, the yield might not be sustainable because the radius of influence extends beyond the fractured zone into the surrounding non-fractured area.’

Table 2.1 Details of registered landholder and exploratory bores within 5 km of the gateway Project Application Area

Registered bore No.	Easting MGA94	Northing MGA94	Status	Bore depth (m)	Screened geology	Yield (L/s)	Standing water level (m)	Water quality
GW052182	687448	6287687	stock & domestic	62	Basalt	0.04	17.8	fresh
GW704196	687821	6287814	stock & domestic	65	Basalt	1.8	20	na
GW055160	686524	6286595	stock & domestic	32	Basalt	0.51	14	hard
GW701757	686413	6286559	stock & domestic	Na	na	na	na	na
GW700401	686148	6286533	test exploration bore	40	Basalt	0.38	15	na
GW700402	685898	6286283	test exploration bore	40	Basalt	0.38	15	na
GW700403	686148	6286083	test exploration bore	53	Basalt	0.51	15	na
GW704197	680652	6286051	stock	179	Limestone	0.95	10	na
GW050192	680351	6290411	stock	25	Basalt	na	13.4	fresh
GW704741	681960	6291826	stock & domestic	49	Limestone (Basalt)	0.85 (0.13)	6	na
GW051764	690971	6287032	stock & domestic	40	Basalt	1.55	2.4	na
GW066469	690200	6291146	stock & domestic	52	na	0.33	13	na
GW701811	690760	6291276	stock & domestic	40	Granite	1	21	na
GW700024	690673	6292832	stock & domestic	37	Granite	0.97	na	good

Source: Information of works summary bore reports from Water NSW online portal.

Note: na = information not available.



LEGEND

- Place name
- Drainage
- TSF outline - MOD14
- Mining lease
- Cadia gateway Project Application Area
- South Waste Rock Dump

Groundwater productivity
(DPI – Office of Water, 2013)

Orange Basalt Groundwater Source
- Fractured rock - Highly productive

Lachlan Fold Belt MDB Groundwater Source
- Fractured rock - Less productive

Cadia Gateway Application (CAD5004.001)

Mapping of highly productive groundwater (DPI – Office of Water, 2013)

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FIGURE No: **2.2**

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Groundwater productivity © State Government of NSW and Department of Planning and Environment 2021.; Landing page:https://www.planningportal.nsw.gov.au/opendata/dataset/highly-productive-groundwater-in-nsw
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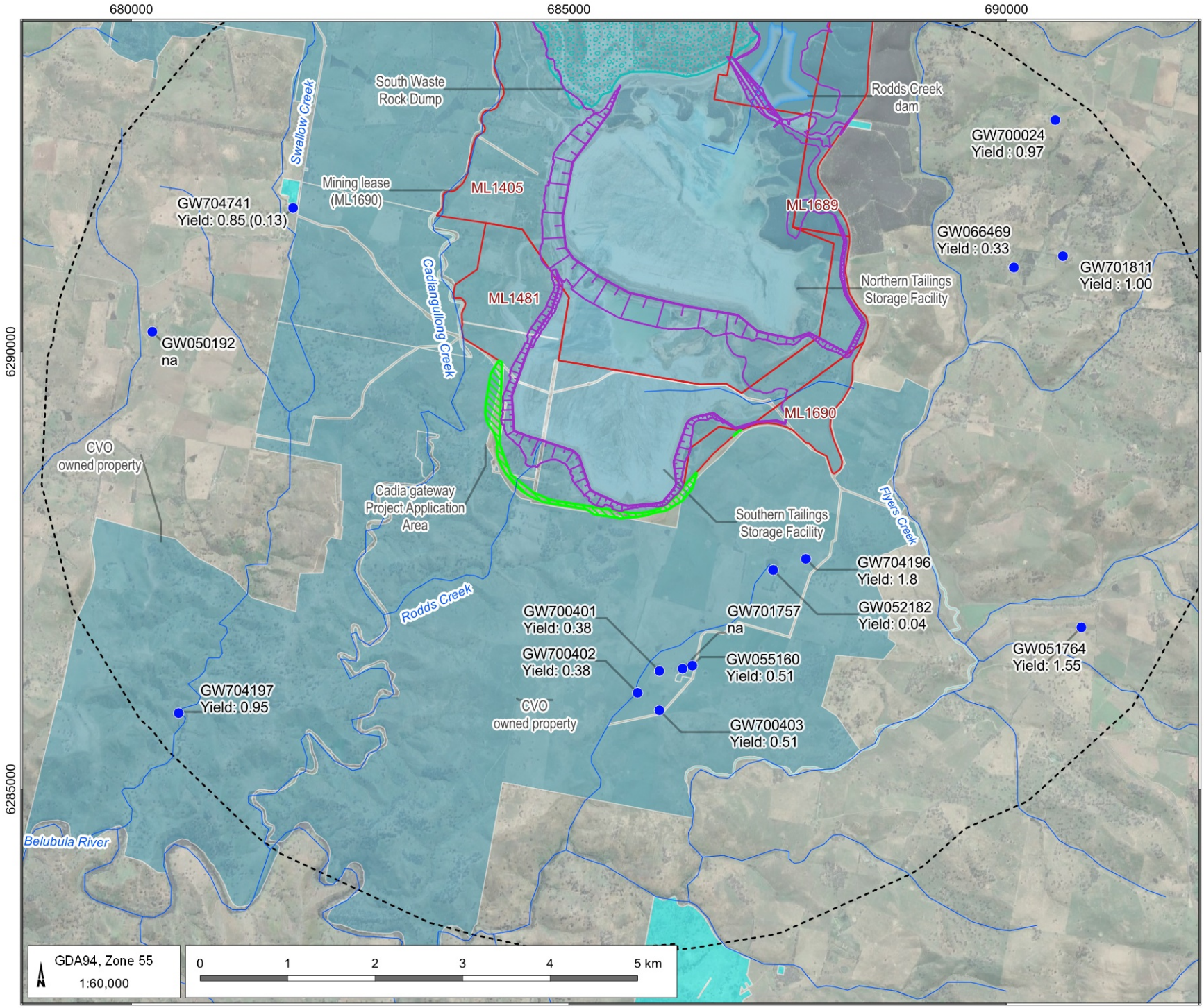

LEGEND

- Registered bores
  GW051764 : RN
  1.55 : Yield (L/s)
  na – no yield data available
- Drainage
- Gateway study area 5km radius
- TSF outline - MOD14
- Rodds Creek dam
- South Waste Rock Dump
- Mining leases
- CVO owned property
- Crown Land
- Cadia gateway Project Application Area

NOTE:
Bore yield provided from registered bore logs (NSW Water portal)

Satellite image : Google

Cadia Gateway Application (CAD5004.001)

Registered landholder bores and exploratory bores within 5 km of the gateway Project Application Area

DATE
11/10/2022

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FIGURE No:
2.3

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G:\Projects\CAD5004.001 Cadia Gateway Application\3_GIS\Workspaces\001_Deliverable1\02.03_CAD5004.001_Registered landholder bores and exploratory bores within 5 km of the gateway Project Application Area.qgs

Salinity is the key potential quality constraint to groundwater use and can be described by TDS concentrations. TDS concentrations are commonly classified on a scale ranging from fresh to extremely saline. The National Water Commission (2011) provide a useful set of categories for assessing salinity based on TDS concentrations as follows:

- Fresh water <500 mg/L;
- Brackish (slightly saline) 500 to 1,500 mg/L;
- Moderately saline 1,500 to 7,000 mg/L;
- Saline 7,000 to 15,000 mg/L;
- Highly saline 15,000 to 35,000 mg/L; and
- Brine >35,000 mg/L.

Salinity (TDS) of the Orange Basalt Groundwater Source from sampling in April 2021 of 14 CVO monitoring bores indicate the water is predominantly fresh to brackish with a TDS below 1,500 mg/L (refer to Table 2.2 and Figure 2.4).

Table 2.2 Salinity results from monitoring bores screened in the Orange Basalt

Salinity category	No of bores	TDS range of results (mg/L)
> 1500 mg/L	2	1880 - 3340
< 1500 mg/L	12	48 - 1430

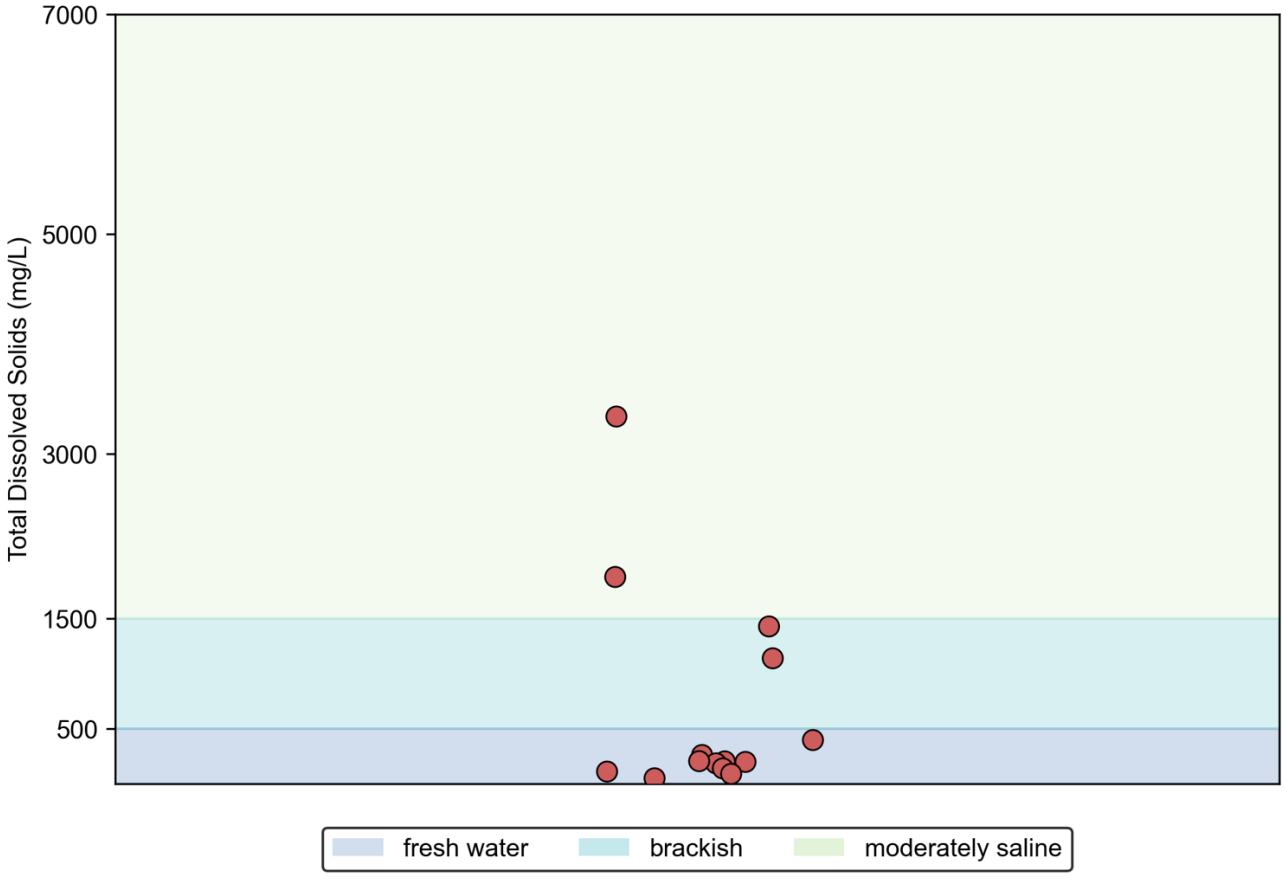


Figure 2.4 Salinity data from 14 monitoring bores screened in Orange Basalt presented within the National Water Commission (2011) Total Dissolved Solids category system

2.3 Potential Impact Mechanisms

The proposed modification of the southern and western embankment of the STSF would not have an influence on groundwater take, and therefore would not affect water access licensing. The main concern would be potential seepage from the TSF into the underlying bedrock and creeks. The TSF embankment would be designed with a very low permeability core to minimise seepage through the wall. The existing CVO TSFs have the following design elements to control seepage into foundations and through embankments:

- clay blanket seal of Rodds Creek beneath the TSFs, although only partially sealed beneath the STSF;
- underdrainage system beneath the TSFs that assist the control of seepage into the underlying foundation soil/rock and for consolidation of the tailings; and
- a low permeability clay core zone within the embankment to retard seepage through the embankment wall.

Direct seepage from the existing TSFs is currently conceptualised and modelled to be a relatively small flux, with predictions from the recent AGE (2021) numerical model providing an average of 0.4 ML/day and 0.2 ML/day from the NTSF and STSF, respectively. These predictions are also consistent with the findings of other seepage investigations (KCB, 2019; GHD, 2018). As the Modification would not change amount or height of tailings stored or the general embankment construction methodology, these estimates would not be expected to materially change.

According to GHD (2018), conceptually the seepage from the existing TSFs is most likely to remain within the Quaternary alluvial soils and shallow weathered rock. In this scenario water would move laterally within the shallow strata rather than infiltrate vertically into the low permeability basement rock. Therefore, any seepage to the surface is likely to be localised and occur at shallow depths, rather than migrate within the deeper groundwater system at large distances from the TSFs.

The TSF decant water is characterised as sodium/potassium-sulfate type water while background groundwater is generally more calcium-magnesium and bicarbonate dominant (GHD, 2018). Both groundwater and TSF decant water is of low salinity. Increasing sulfate concentrations have historically been used as an indicator for seepage contributions in groundwater near the TSFs. While these trends have been observed in several monitoring bores that are at a lower hydraulic gradient relative to the TSFs, it is difficult to confidently attribute these increases to seepage due to variability in sulphate concentration in groundwater as some areas are naturally elevated. The TSF decant water also has similarities with native groundwater in respect of low salinity and low concentrations of dissolved metals. A review of water quality results suggest that there is minimal appreciable risk of environmental harm to aquifer sources (AGE, 2021b). The current identified areas of potential seepage downgradient from the STSF have pump back systems in place to transfer seepage back to the STSF.

The proposed raise of the STSF embankment associated with the Modification would continue to apply to the approved centreline/downstream lift design methodology and is not expected to result in a notable change in seepage water quality.

The mass loading of the TSF embankment will lead to some degree of compaction (varies between consolidated/unconsolidated rock types) and reduced porosity in the immediate vicinity. This in turn will cause a slight groundwater level rise due to reduced storage, and this effect is more notable in unconsolidated sediments. Based on existing groundwater rise on the periphery of the TSF attributed to loading effects, the spatial extent away from the TSF for this loading effect to occur is within 200 m. Any localised groundwater level increase due to the overburden loading compaction effect, however, diminishes the distance from the TSF increases.

2.4 Assessment Against Gateway Criteria

The "Guideline for Gateway Applicants" (2013) provides specific matters of concern which need to be addressed to assess the project against the criteria specified in 'Table 1 – Minimal Impact Considerations for Aquifer Interference Activities' in the Aquifer Interference Policy. These matters of concern are addressed below:

- ***Estimates of all quantities of water that are likely to be taken from any water source on an annual basis during and following cessation of the activity.***

The modification of the TSF footprint outside the mining lease will not result in additional water being taken from the groundwater regime during operations or post closure.

- ***A strategy for obtaining appropriate water licence/s for maximum predicted annual take.***

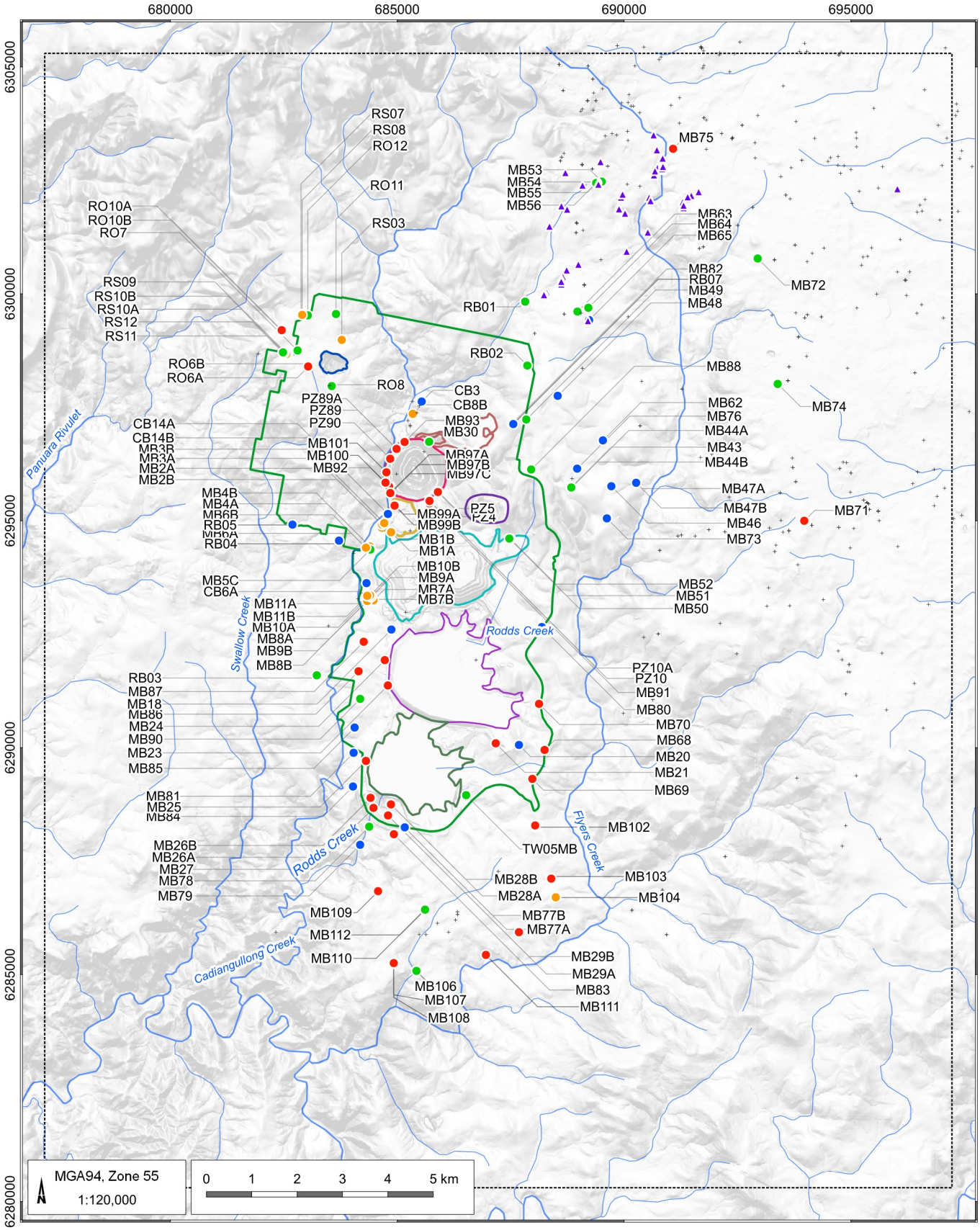
There is no water take from the modification of the TSF embankment outside the mining lease and consequentially there is no requirement to amend existing water licenses.

- ***Establishment of baseline groundwater conditions including groundwater depth, quality and flow based on sampling of all existing bores in the area, any existing monitoring bores and any new monitoring bores that may be required under an authorisation issued under the Mining Act 1992 or the Petroleum (Onshore) Act 1991.***

A network of baseline monitoring bores has been installed within the alluvium, Tertiary basalts, Ordovician and Silurian basement rocks for the existing Cadia operations. The monitoring bore network extends to the south of the mining lease as shown on Figure 2.5. The CVO monitoring bore network has been operating for over 25 years and has been continuously expanded over time in response to additional mining infrastructure and local site investigations. Currently there are approximately 150 groundwater bores active within and surrounding CVO. There are a number of bores that have been decommissioned or abandoned due to mine site operations or bore blockages as shown on Figure 2.5. The most recent review of the data from the monitoring network was completed for the 2020-2021 financial year by AGE (2021b).

Routine groundwater levels and quality monitoring data has been collected from the network according to the site water management plan with monitoring frequencies generally monthly to quarterly. Information on groundwater levels and quality is provided above in Section 2.1 and 2.2. A groundwater contour level plan based on water level measurements in monitoring bores is provided in Figure 2.6 and indicates groundwater flow is generally towards the south-southwest.

With the proposed modification of the embankment there will be some monitoring bores decommissioned in the footprint of the expansion footprint and new bores installed outside the proposed embankment extension. These new monitoring bores are currently in a planning stage. They will be integrated into the water management plan with monitoring at similar frequencies as existing monitoring bores in the area.



LEGEND

- Drainage
- Cadia Hill Pit
- Cadia East subsidence zone
- Ridgeway cave mine subsidence zone
- Rodds Creek dam
- Mining lease
- Model boundary
- North Waste Rock Dump
- Ore Processing Facilities
- South Waste Rock Dump
- Northern Tailings Storage Facility
- Southern Tailings Storage Facility

- Private landholder bores
- Springs
- Ordovician Volcanics
- Silurian Sediments
- Soil/Clay
- Tertiary Basalt

NOTE:
Cadia geological units assigned to monitoring bores is from the CVO Environmental database

Cadia Gateway Application (CAD5004.001)

CVO monitoring bore network

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DATE 21/03/2023

FIGURE No: **2.5**

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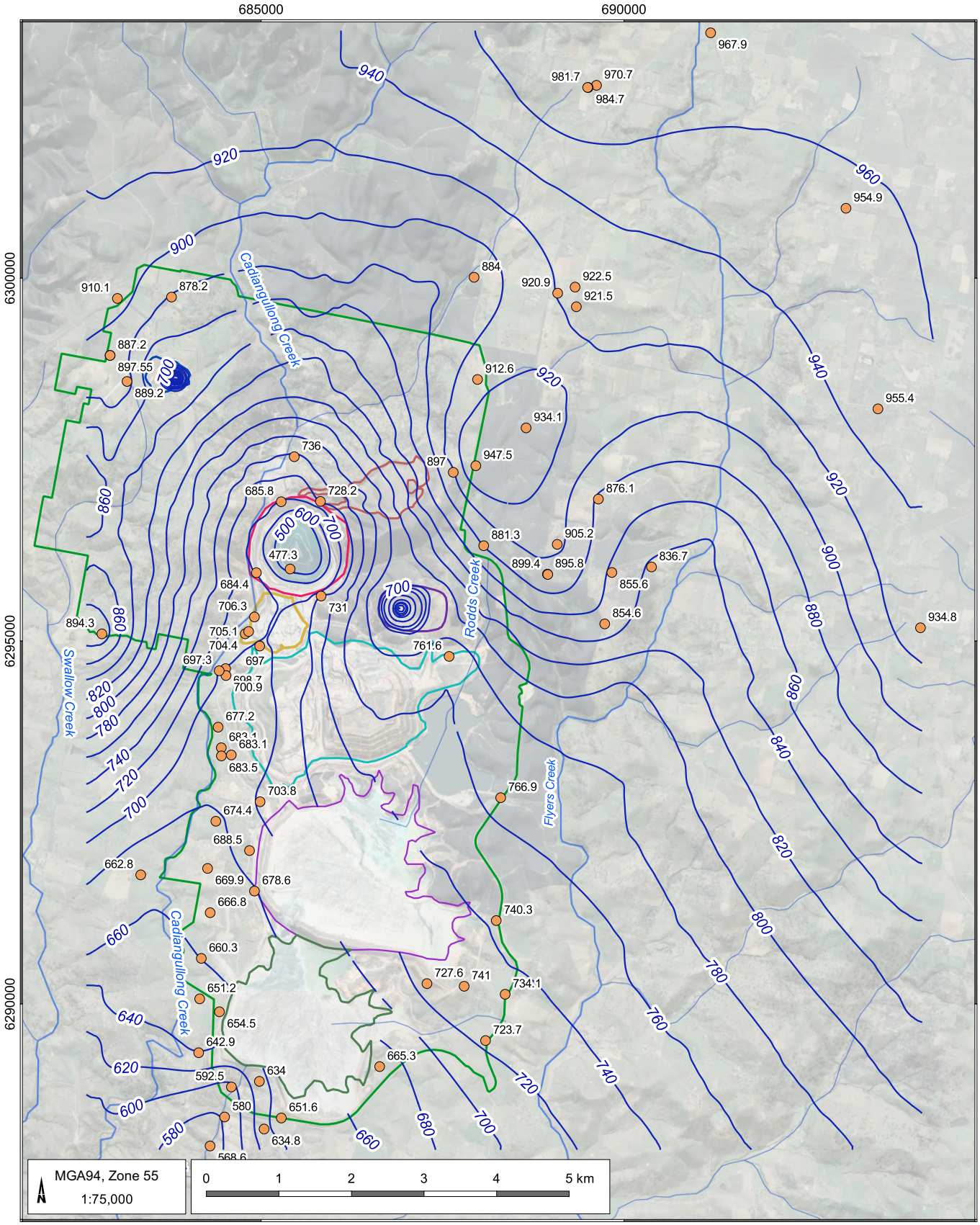

LEGEND

- Drainage
- Cadia Hill Pit
- Cadia East subsidence zone
- Ridgeway cave mine subsidence zone
- Mining lease
- Rodds Creek dam
- Ore Processing Facilities
- North Waste Rock Dump
- South Waste Rock Dump
- Northern Tailings Storage Facility
- Southern Tailings Storage Facility
- Cadia monitoring bores
- Groundwater level contours (mAHD)

Cadia Gateway Application (CAD5004.001)

Interpreted water table elevation and contours (June 2020)

AGE

DATE 12/07/2022

FIGURE No: **2.6**

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- ***A strategy for complying with any water access rules applying to relevant categories of water access licences, as specified in relevant water sharing plans.***

The modification of the TSF footprint outside the mining lease will not result in water being taken from the groundwater regime during operations or post closure.

CVO mining activities take water directly from the NSW Murray-Darling Fractured Rock Groundwater Sources water sharing plan. Under this water sharing plan CVO will directly take water from the Lachlan Fold Belt (MDB) Groundwater Source, and indirectly through induced flow from the Orange Basalt Groundwater Source.

A numerical groundwater flow model (AGE, 2021a) has been developed for the local region and this has been used to determine water take from groundwater sources in the region for the CVO operations to comply with water accessing licencing and water sharing plans. This model would be updated with the change in the TSF footprint during the next regular update, subject to receiving approval of the Project. There is expected to be minimal, if any change to water access licensing for the proposed modification of the embankment footprint outside the CVO mining lease as there would not be groundwater take.

- ***Estimates of potential water level, quality and pressure drawdown impacts on nearby water users who are exercising their right to take water under a basic landholder right.***

The nearest landholder bores to the Gateway Project Application Area are at a distance of 1.5 km to the south (GW704196 and GW052182) as shown in Figure 2.3 and are screened within the Orange Basalt. There will be no water level changes on landholder bores from the proposed STSF embankment modification as there is no groundwater take and the landholder bores are outside the approximate 200 m influence of the zone where loading/compaction may induce water level rises. Although landholder bores are in several cases located hydraulically downgradient from the TSF, it is anticipated that there would be no changes in water quality for these bores from the Project's activities due to:

  - design of embankment with anticipated very low rate of seepage;
  - dilution of water quality over the distance of 1.5 km or more to nearest landholder bores when considering the make up of decant water is low in salinity and metals are not noticeably elevated; and
  - most historic seepage occurs at shallow depths at the interface of soil/weathered materials and low permeability fresh bedrock and emanates in low areas, such as drainage lines, where it is recaptured and recycled back into the CVO operations. (refer to Section 2.3 for more information).

- ***Estimates of potential water level, quality and pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources.***

There are no licensed water users in 5 km of the proposed Gateway Project Application Area who have connected groundwater and surface water sources.

- ***Estimates of potential water level, quality and pressure drawdown impacts on groundwater dependent ecosystems.***

Groundwater dependant ecosystems (GDEs) rely on shallow groundwater for water uptake and typically are associated with streams or low wetland depressions. GDE's also occur along streams which intersect the water table and receive groundwater baseflow; and also, in vicinity of springs which occur on structure discontinuities or at the contact of permeable formations overlying impermeable formations.

According to the Bureau of Meteorology (BoM), (2019) GDE Atlas, mapped high potential aquatic and terrestrial GDE's occur along creeks near the Gateway Project Application Area and are shown on Figure 2.7. High potential aquatic GDEs are mapped in Flyers Creek and its tributaries to the east of CVO, and in some tributaries of the Belubula River to the south of mining operations. High potential terrestrial GDEs that comprise River Oak and River Red Gum trees occur in small areas adjacent to Flyers Creek (to the east and southeast of the STSF), adjacent to Cadiangullong Creek (downstream of the NTSF), and along the Belubula River. These high potential terrestrial GDE's are consistent with the High Ecological Value Aquatic Ecosystems (HEVAE) framework (The Commonwealth Scientific and Industrial Research Organisation [CSIRO], 2019), which in turn constitute high priority GDEs under 2020 updates to the Water Sharing Plan (WSP) for the NSW Murray Darling Basin Fractured Rock Groundwater Sources.

Mapped springs do not occur within 5 km of the Gateway Project Application Area. Springs occur in the upper headwaters of Cadia Creek (flows into Cadiangullong Creek) and Flyers Creeks as discharge from the Tertiary basalt, Tertiary paleochannel sediments, or fractured Silurian sediments, and are 10 km or more from the Gateway Project Application Area.

There is likely to be groundwater contributions as baseflow to creeks within 5 kms of the Gateway Project Application Area which may be ephemeral and dependant on high rainfall recharge events (e.g. Flyers Creek and Cadiangullong Creek). These baseflow events may temporarily support ecosystems.

There is anticipated to be no changes in water levels from the proposed TSF embankment modification on GDEs in the area as there is no groundwater take associated with the proposed activities. Along Cadiangullong Creek, the mapped high potential terrestrial GDEs are within 200 m of the proposed embankment footprint on the western side of the STSF. However, these terrestrial GDEs are not expected to be adversely affected by any localised groundwater level rise due to the influence of overburden compaction which occurs adjacent to the TSF. The potential of changes in water quality from seepage influencing GDE health is considered to be negligible based on:

- design of embankment raise with anticipated very low rate of seepage;
- dilution of water quality over the distance travelled from the embankment to the creek; and
- the make up of decant water is low in salinity and metals are low in concentrations.

The closest mapped high potential aquatic GDE's are over 2km to the east along Flyers Creek and are located cross gradient of the Gateway Project Application Area groundwater flow direction. Due to distance and the receptors not located hydraulically downgradient there is considered to be no potential impacts on groundwater quality and levels in the vicinity of Flyers Creek from the proposed activities.

The influence of the Project's activities on groundwater dependant ecosystems will be assessed further within Mod 15 following provision of detailed embankment design information, which is expected to confirm minor impacts.

- ***Estimates of potential for increased saline and contaminated water inflows to aquifers and highly connected river systems.***

The water quality of existing TSF decant water has similarities with native groundwater, that is, of low salinity, and has low concentrations of dissolved metals, although elevated in sulphate (AGE, 2021b). The Gateway Project Application Area is largely located on Ordovician bedrock of low groundwater productivity (refer to Figure 2.1). The Orange basalt groundwater source is intercepted by the Gateway Project Application Area in two small areas to the south and west of the TSF (note that the basalt already occurs under the existing STSF). The TSF embankment modification is unlikely to result in increased saline and contaminated water inflow into underlying aquifer systems due to the underlying rocks mainly being of poor permeability below the weathered zone (Ordovician volcaniclastics), and the presence of the pump back systems.

There are no highly connected groundwater – river/stream systems within 3.5 km of the Gateway Project Application Area. The closest waterway of significant alluvium thickness is the Belubula River located 3.5 km south of the Gateway Project Application Area.

- ***Estimates of the potential to cause or enhance hydraulic connection between aquifers.***

The emplacement of TSF embankment material would not enhance hydraulic connection between aquifer systems. Alternately, the TSF embankment may reduce hydraulic connection due to a decrease in porosity from mass loading in close vicinity to the embankment. There would be expected greater reduction of porosity in places where there is unconsolidated sediments/soils/weathered bedrock compared to where there is competent bedrock.

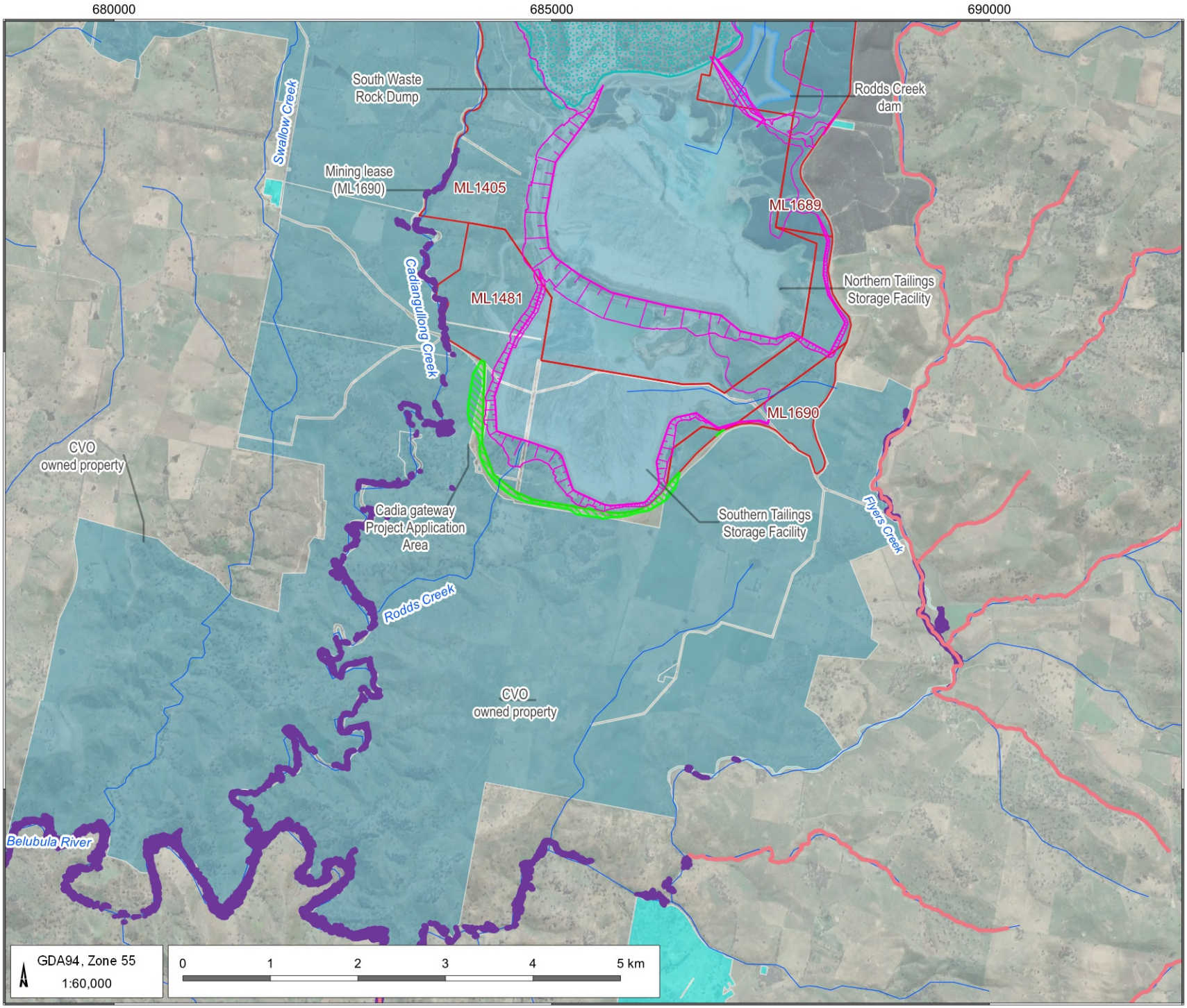
An assessment of the distance of mass loading influence of the proposed embankment modification on groundwater level rise will be undertaken in Mod 15. This will be in the form of a review of the existing mass loading influence on groundwater levels in the existing monitoring network adjacent to the TSF and applying to area adjacent to the proposed embankment modification .

- ***Estimates of the potential for river bank instability, or high wall instability or failure to occur.***

The proposed modification of the TSF embankment would occur in the vicinity of Rodds Creek, which is incised into the land surface on the southern section of the STSF embankment. At this location, the soil cover is thin with the bedrock outcropping and close to surface. Geotechnical investigations and underdrainage infrastructure will support the design of the emplacement of the embankment to ensure it is stable at this location. Design specifications of the embankment will be provided in Mod 15.

2.4.1 Conclusion

In conclusion, the predicted impacts from the proposed modification of the TSF embankment are considered to be less than Level 1 in Table 1 – Minimal Impact Considerations for Aquifer Interference Activities' within the Aquifer Interference Policy. This follows considering the effect that the reinforcement and extension of the southern TSF embankment will have on potential changes to productivity of aquifer sources, and potential impacts on sensitive receptors, groundwater levels/quality and nearby surface water bodies.



LEGEND

- Drainage
- TSF outline - MOD14
- Rodds Creek dam
- South Waste Rock Dump
- Mining leases
- CVO owned property
- Crown Land
- Cadia gateway Project Application Area
- High potential GDE (aquatic) - from national assessment
- High potential GDE (Terrestrial) - from regional studies

Satellite image : Google

Cadia Gateway Application (CAD5004.001)

Groundwater dependant ecosystems

DATE
11/10/2022

AGE

FIGURE No:
2.7

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Yours faithfully,

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