Appendix A

Lot/DP at the site

Plan	Lot Number	Ownership
DP222274	2	FREEHOLD
DP222274	3	FREEHOLD
DP229690	2	FREEHOLD
DP222274	1	FREEHOLD
DP1033183	2	FREEHOLD
DP1141049	7317	CROWN
DP1033184	2	FREEHOLD
DP714087	1	FREEHOLD
DP542415	1	FREEHOLD
DP754870	127	CROWN
DP754870	188	CROWN
DP754870	133	CROWN
DP754870	50	CROWN
DP754870	62	CROWN
DP754870	166	CROWN
DP754870	185	CROWN
DP754870	202	CROWN
DP754870	123	CROWN
DP754870	180	CROWN
DP754870	184	CROWN
DP754870	56	CROWN
DP754870	137	CROWN
DP754870	170	CROWN
DP754870	186	CROWN
DP754870	111	CROWN
DP754870	155	CROWN
DP754870	168	CROWN
DP754870	187	CROWN
DP754870	177	CROWN
DP754870	315	CROWN
DP754870	57	CROWN
DP754870	124	CROWN
DP754870	132	CROWN
DP754870	140	CROWN
DP754870	167	CROWN
DP754870	178	CROWN
DP754870	126	CROWN
DP754870	171	CROWN
DP754870	179	CROWN
DP754870	55	CROWN

Plan	Lot Number	Ownership
DP754870	128	CROWN
DP754870	136	CROWN
DP754870	131	CROWN
DP754870	139	CROWN
DP754870	172	CROWN
DP754870	125	CROWN
DP754870	129	CROWN
DP754870	49	CROWN
DP754870	58	CROWN
DP754870	138	CROWN
DP754870	161	CROWN
DP754870	173	CROWN
DP754870	64	CROWN
DP369062	1	FREEHOLD
DP572636	1	FREEHOLD
DP189797	1	FREEHOLD
DP1103495	1	FREEHOLD
DP1141226	7301	CROWN
DP1141226	7300	CROWN
DP1141179	7314	CROWN
DP1141179	7313	CROWN
DP1141179	7312	CROWN
DP172630	C	CROWN-MINISTER FOR PUBLIC WORKS administered by CROWN LANDS
DP754870	134	CROWN
DP1217100	4425	NSW GOVERNMENT held by TfNSW
DP754870	169	CROWN
DP754870	135	CROWN
DP754870	165	CROWN
DP754870	316	CROWN
DP754870	61	CROWN
DP754870	130	CROWN
DP229690	1	FREEHOLD
DP572636	2	FREEHOLD
DP754870	319	FREEHOLD held by MOGO LOCAL ABORIGINAL LAND COUNCIL

Appendix B

Lake George Mine, Captains Flat Detailed Design Report

Lake George Mine Remediation

Detailed Design Report

Department of Regional NSW (Legacy Mines Program)

March 2022

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Author	C Nivison-Smith
Project manager	Stuart Winchester
Client name	Department of Regional NSW (Legacy Mines Program)
Project name	Lake George Mine Remediation REF
Document title	Lake George Mine Remediation | Detailed Design Report
Revision version	Rev 4
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Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	4	C. Nivison-Smith	S. Winchester		S. Winchester		25/03/22
S4	3	C. Nivison-Smith	S. Winchester		S. Winchester		14/03/22
S4	2	C. Nivison-Smith	S. Winchester		S. Winchester		28/04/21
S4	1	C. Nivison-Smith	S. Winchester		S. Winchester		13/11/20

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1. Introduction

1.1 Background and purpose

1.1.1 Background

The Legacy Mines Program (LMP) within the NSW Department of Regional NSW (Mining, Exploration & Geoscience) commissioned GHD Pty Ltd (GHD) to provide a Capping and Revegetation Design (and Water Treatment Options Study) for the Lake George Mine at Captains Flat, NSW (the site) (Tender_2103). This document is the Detailed Design Report for the Capping and Revegetation Design component of the commission. The Water Treatment Options Study was issued as a separate report (GHD 2019).

The context of this report within the scope of progressing the knowledge and remedial work at Captains Flat is provided in Section 2.

1.1.2 Purpose

The purpose of this report is to describe the basis of the detailed design to neutralise surface material, cap and revegetate unvegetated areas across key locations on the northern portion of the site.

The works would be undertaken across several key site domains, predominantly in the northern portion of Lake George Mine. These areas are:

– North Mine Ridge/Elliot's
– Old Mill
– Mill Area (west of the Central Mine Area)
– Central Mine Area
– Creeks Area
– Rail Loading Area and Captains Flat Railway Precinct
– Minor areas of eroded capping on the Northern and Southern Dumps.

In addition, mine waste from the following sources are proposed for relocation to a containment cell that would be located on the Northern Dumps. These include:

– A sulfidic waste stockpile located on the junction of Miners Road and the Council wastewater treatment plant access road
– A slag pile located on the western side of Jerangle Road in Forster's Gully, adjacent to the northern end of the Southern Dumps.
– TfNSW lead contamination from around the Captains Flat Railway Precinct
– Crown Land / QPRC within the Captains Flat township. That is, The Captains Flat Lead Management Taskforce is currently undertaking an assessment of the Captains Flat township with the aim to prepare abatement plans for the higher risk public spaces. One option being investigated is moving up to 20,000 tonnes of contaminated soil from these Crown Land / QPRC-owned abatement areas into the containment cell on the Northern Dumps. Note that approval under the NSW Planning and Assessment Act 1979 for the abatement area remediation would be undertaken as a separate approval to this REF.

The above site domains are identified in the drawings contained in Appendix A, and Figure 1.1 (with the exception of the Lead Abatement Areas).

Nomenclature for site domains at the site remain entirely consistent with GHD (2018). For clarity, where past domain nomenclature varies from that reported herein, such as the URS (2004a) Old Mill Area and Unvegetated Area North Dump, it has been included on Figure 1.1 for ease of reference.

1.2 Scope of work

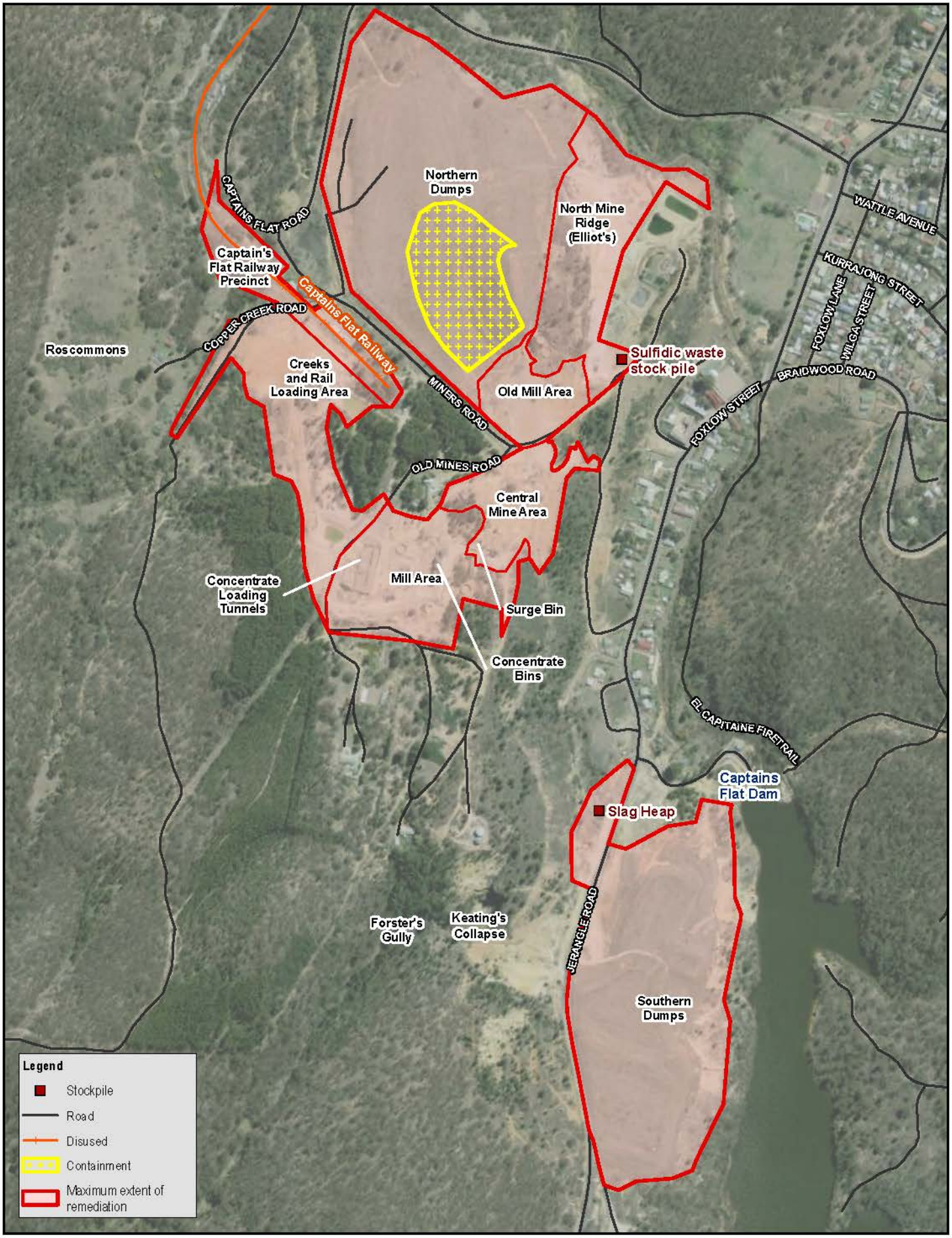
The scope of work included herein is:

- Review of remedial context, including consideration of local projects and other prospects for material sources
- Development of detailed design, including:
  - Identification of design basis, including relevant regulatory guidance
  - Development of capping options (including preliminary material specifications) with consideration to available local materials, borrow sources and regulatory guidance
  - 3D modelling of the final landform to estimate bulk earthworks and capping material quantities
  - Development of preliminary surface water management measures
  - Provision of order of magnitude capping costs to facilitate capping options selection
- Development of design documentation, including:
  - Detailed design drawings
  - Technical specification
  - Bill of quantities
  - Safety in design risk register.

1.3 Guideline documents

GHD has taken guidance from the following leading practice industry documents when undertaking detailed design of the AMD affected areas on site:

- AMIRA (2002). ARD Test Handbook. Project P387A *Prediction and kinetic control of acid mine drainage*
- Commonwealth Government – Department of Foreign Affairs and Trade (2016a). *Leading Practice Sustainable Development Program for the Mining Industry: Preventing Acid and Metalliferous Drainage*. Canberra
- Commonwealth Government – Department of Foreign Affairs and Trade (2016b). *Leading Practice Sustainable Development Program for the Mining Industry: Mine Rehabilitation.* Canberra
- Commonwealth Government – Department of Foreign Affairs and Trade (2016c). *Leading Practice Sustainable Development Program for the Mining Industry: Mine Closure*. Canberra
- ICMM (2019). *Integrated Mine Closure: Good Practice Guide*. Second edition. London, UK
- INAP (The International Network for Acid Prevention) (2009). Global Acid Rock Drainage Guide. Available at www.gardguide.com
- NEPC (2013). *National Environment Protection (Assessment of Site Contamination) Measure (NEPM),* National Environment Protection Council (NEPC).



Paper Size ISO A4

0 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA1994
Grid: GDA1994 MGA Zone 55

N

GHD

Department of Regional NSW
Lake George Mine Remediation

Key site domains and features including the maximum spatial extent of remediation

Project No. 12551771
Revision No. A
Date 14/03/2022

FIGURE 1.1

Data source: General topography - Sixmaps via SSNSW © Department of Customer Service 2020. Created by: eibbertson

2. Remedial context

2.1 Mining and site remediation history

As background, there were three key phases of mining at Captains Flat as described by Dobos and Associates (2002) that are summarised below.

2.1.1 Phase 1 – 1882 to 1899

The first mining operations starting in 1882 to mine for gold. In 1887, the Vanderbilt Mine was opened on the eastern side of Captains Flat. Open heap roasting of ore began in 1890, releasing sulfur into the atmosphere and killing most of the surrounding vegetation.

Pyritic smelting replaced the wood and coal fuels as the mining company attempted to boost metal production. The principal commodity was copper, with northern and southern workings having been developed. New stacks, flues and furnaces were built at the southern end of town between the Molonglo River and Jerangle Road. The mine produced silver, gold, and copper. However, high lead and zinc levels meant that copper yields could not be improved. In 1899, Lake George mine stopped smelting copper and attempted to extract gold by cyanidation. However, this attempt failed, and the mine shut down, with mine equipment subsequently dismantled.

The main environmental consequences from the first phase of mining were reported as:

– Smelting impacts: Increased production of ore caused extraction of deeper sulfidic ores causing stack emissions to become progressively more abundant and more sulfurous. When pyritic smelting was introduced, sulfur dioxide emissions increased substantially leading to acid rain and acidic runoff. Runoff was likely to include particulate lead, zinc, and copper that would have been deposited on the hillside from stack emissions
– Surface water impacts
– Groundwater impacts
– Vegetation and ecological impacts
– Human Health impacts.

2.1.2 Phase 2 – 1937 to 1962

The second phase of mining occurred from 1937 to 1962, with large-scale mining operations being employed. This included bringing electricity and a railway into the mine, with a dam constructed across the Molonglo River. Sulfide concentrate was recovered using froth flotation and transported to market via the railway. Much of the second phase of mining comprised sulfide ores containing pyrite, in addition to pyrite ore that was used to produce pyrite concentrate for the subsequent production of sulfuric acid (Glasson and Paine 1965).

Mining wastes were initially stored in the area known as the Northern Dumps, which was compromised in 1939 due to a breach in the wall of Dump 6A (in the area now known as the Northern Dumps) – with tailings and slimes entering the Molonglo River. Following this, tailings were disposed of to the Southern Dumps, which on 3 July 1942 collapsed sending approximately 30,000 m^3 of tailings into the water reservoir (Dobos and Associates 2002).

After the Southern Dumps failure, disposal of mine and process wastes reverted again to the Northern Dumps area. There were no recorded tailings impoundment failures after this, although a major flood in 1954 mixed, and further dispersed, the contaminated river bed sediments already in the Molonglo River, impacting the river for approximately 55 km downstream to Queanbeyan (Dobos and Associates 2002).

Key contaminant sources from the second phase of mining included:

– Tailings breaches contaminating the Molonglo River
– Seepage from adits / underground workings
– Seepage from dams
– Spillage and runoff from the Mill and Rail Loading areas.

2.1.3 Phase 3 – 1962 to 1976

Mining came to an end on 9 March 1962, principally due to the lack of economic grade ore, despite attempts to delineate additional reserves. In 1963, the Lake George Mining Company unsuccessfully attempted to reduce the contaminant flow to the Molonglo River from erosion and leaching of the mine waste dumps, by spraying the surfaces with some 70 m^3 of tar. The Lake George Mining Company surrendered its leases later that year.

2.1.4 Post-mining remedial work and studies

Since 1976, a succession of remediation work and environmental studies completed to close knowledge gaps to inform further remedial works has systematically improved the environmental legacy on site. This arguably commenced with the NSW Department of Public Works funded tailings dump remediation and Forster's Creek diversion in 1976 at a cost of $ 2.3 million (Brooks 1980).

Hogg (1990) found that the aims of the initial remedial work had been achieved, with a significant improvement in downstream water quality, though limited improvement in biological diversity. Hogg (1990) also noted that some further improvement might be achieved by treating surface runoff sources, especially in the Copper Creek catchment, in addition to managing major contaminant point sources such as the Main Adit Spring.

The then Derelict Mines Program commissioned Dobos and Associates (2002) to carry out an environmental and human health risk assessment and prepare a remedial action plan (RAP) for the site. Dobos and Associates' (2002) review of various sources of metalliferous discharge to the Molonglo River and tributaries was broadly consistent with the previous post dump-capping assessments (e.g. Hogg 1990). The work indicated that although there were many contaminant sources on site, the largest long-term source (88% of zinc and 99% of lead loading) was the Main Adit Spring that discharges directly into the Molonglo River. Secondary contaminant sources included wet weather runoff from the un-vegetated areas around the mine, and the Rail Loading and Mill areas that discharge to Copper Creek, Forsters Creek, and the Molonglo River.

Dobos and Associates (2002) provided broad recommendations on remediation of exposed contaminated soils as well as reducing hazards from various site structures, including shafts, loading tunnels and cliff faces. The report also included a summary of water treatment options to treat water from the Main Adit Spring that was used to inform GHD (2019).

Following on from Dobos and Associates (2002), URS (2004a) completed a detailed environmental site assessment (ESA) - including a heritage assessment, and remedial action plan (RAP) to assess and manage human health risks at the site. With respect to the risk of mineral waste on site generating acid and metalliferous drainage, URS (2004a) found that the Old Mill and Northern Dumps areas, plus waste ore material, were high risk. The Creek area, the Loading area, the Thick Fill Embankment, and North Face of Old Mill areas were of moderate risk, while the areas revegetated with pine trees were low risk.

The URS (2004a) RAP recommended the following works (followed by revegetation), to reduce the risk of direct exposure and runoff:

– High Risk Areas: Remove the contaminated material from the Old Mill area to a disposal area on the unvegetated area of the Northern Dump and encapsulate with clay, and ameliorate the newly exposed Old Mill areas *in situ* with lime and gypsum to neutralise and reduce dispersion;
– Moderate Risk Areas: Ameliorate *in situ* as per high risk areas; and
– Low Risk Areas: No action, as any lime or gypsum application would damage existing vegetation cover.

URS (2004a) also provided general capping and amelioration details, along with remedial cost estimates.

Since the URS (2004a) RAP, various site works have been undertaken by the LMP, including:

– Capping of slag on the uphill (east) side of the Jerangle Road, immediately south of Captains Flat
– Construction and periodic cleaning out of sediment dams above the Rail Loading area
– Cleaning out the V-notch weir at the Main Adit Spring
– Re-profiling and ameliorating the area above the Rail Loading area
– Additional fencing and sealing of some shafts
– Rehabilitating the northern face of the Southern Dump where previous remedial works had eroded

– Weather-proofing the sulfidic ore in the ore bins in the historic ore processing area
– Installing additional diversion drains to reduce runoff over contaminated areas, primarily in the Creek and Rail Loading areas in the Copper Creek catchment.

The LMP commissioned GHD in 2017/18 to undertake a review of all previous reports and works undertaken, in a bid to move forward in addressing the high priority site contamination issues. GHD's (2018) top five recommended remedial works for the site were:

1. The main adit spring – improve water quality to the Molonglo River by:
    a. Capturing and treating outflow to reduce metal, sulfate and acidity loads entering the Molonglo River (refer GHD 2019)
    b. Seal areas of air ingress to underground workings to reduce further sulfide oxidisation and consequent contaminated outflow (i.e. consider use of inert gas technology)

    Note that GHD (2019) added the concept of exploring the feasibility of paste backfilling the underground mine voids to minimise acid and metalliferous drainage at source as a longer-term option.
2. Remediate exposed and un-vegetated mine waste at the Mill area, Elliot's / Northern mine ridge and Old Mill, Central Mine, and Rail Loading and Creeks Areas to reduce the risk of contaminated dust generation, erosion, and contaminated runoff
3. Re-profile, cap and vegetate the Keating's Collapse / adjacent smelter slag areas
4. Ongoing monitoring of the Molonglo River coupled with appropriate education to downstream water users
5. Repairs to the remedial capping on the Northern and Southern Dumps and dump drainage.

Cumulatively, items 1 and 2 above were reported to contribute around 90 % of known, off-site dissolved contaminant contribution at Captains Flat. Consequently, it is logical that they remain the focus of current and future contamination investigation and remedial works.

The content of this report, therefore, seeks to progress the work of Dobos and Associates (2002) and URS (2004a) by providing detailed capping design of the bare areas in both the Copper Creek and Molonglo River catchments; capturing areas outlined in item 2, above. As noted above, water quality issues outlined in dot point 1, above, are the focus of a separate report (GHD 2019).

2.2 Regulatory environment

URS (2004b) assessed the impacts of the proposed remediation strategy reported by URS (2004a) in a Review of Environmental Factors (REF) report. Since that time, Council areas have changed, and the REF would require updating. For example, the site is now located in the Queanbeyan-Palerang Regional Council Area, and works would be subject to the *Palerang Local Environment Plan 2014* and the *Queanbeyan Local Environment Plan 2012*.

Lesryk Environmental Consultants (2012) completed a REF for revegetation and drainage works in the Copper Creek Catchment that concluded the proposed works would provide significant long-term environmental and social benefits.

The above notwithstanding, it is recommended that an updated, project specific REF be completed to assess the potential environmental impacts of the proposed works if progressed from detailed design to construction.

Applicable State Environmental Planning Policies (SEPP) for consideration in an updated REF include:

– SEPP (Resilience and Hazards) 2021
– SEPP (Transport and Infrastructure) 2021
– SEPP (Planning Systems) 2021
– SEPP (Resources and Energy) 2021.

Applicable NSW statutes for consideration in an updated REF include:

– *Environmental Planning and Assessment Act 1979*
– *Water Management Act 2000*
– *Heritage Act 1977*

– *Biosecurity Act 2015*
– *Biodiversity Conservation Act 2016*
– *Fisheries Management Act 1994*
– *National Parks and Wildlife Act 1974*
– *Crown Lands Management Act 2016.*

Note that the *Captains Flat (Abatement of Pollution) Agreement Act 1975* was repealed on 10 December 2015 and is therefore redundant in an updated REF.

An updated assessment of approval the applicability of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* should also be considered within the context of an updated REF.

3. Design basis and development

3.1 Objective and extent of capping and revegetation works

The objective of the capping and revegetation works is to remediate bare, un-vegetated areas on site to reduce the risk of airborne dust, erosion and contaminated runoff generated from the continued oxidation of sulfidic mineral waste. Ultimately, the capped area should sustain native vegetation and preserve mining heritage.

Key tasks include:

1. Neutralising *in situ* surface soils / mineral waste on exposed areas, or relocating material where required
2. Capping exposed areas
3. Vegetating (or re-vegetating) capped areas
4. Containing and re-directing surface water flow across the remediated areas.

The extent of neutralising *in situ* surface soils, capping, and revegetation works includes remediation works in the following areas (refer to Figure 1.1):

– North Mine ridge / Elliot's
– Old Mill
– Mill Area (west of the Central Mine Area)
– Central Mine Area
– Creeks Area
– Rail Loading Area
– Minor areas or eroded capping on the Northern and Southern Dumps
– Captains Flat Railway Precinct.

Work will include fencing as well as localised capping around permanent historic ore processing structures that remain on site.

3.2 Site survey and area

Airborne LiDAR survey (dated March 2018) was used as the basis for the existing site surface. Based upon the airborne LiDAR survey and available site aerial photography, the area that requires capping is estimated to be approximately 123,000 m^2 (or around 12.3 ha.).

3.3 Remedial options

3.3.1 Overview

Based on GHD's assessment and in consultation with the LMP, the most applicable remedial options identified were:

1. *In situ* lime neutralisation overlain with a 300 mm thick low permeability, natural soil barrier with high clay content, itself overlain with a 300 mm thick (subsoil (200 mm)/growing media or topsoil (100 mm)) layer. (Note that URS 2004a had recommended a 500 mm thick compacted clay cap, with a 200 mm thick protection/moisture retention layer and a 100 mm overlying topsoil layer).
2. *In situ* lime neutralisation overlain with a 300 mm thick (subsoil (200 mm)/growing media or topsoil (100 mm)) layer.
3. *In situ* lime neutralisation overlain with a 300 mm thick rock mulch layer comprising a hard rock drainage aggregate with high lime content inherent therein or blended throughout.

4. An engineered solution for steeper slopes – refer below.
5. Relocating *in situ* surface soils / mineral waste to an on site containment cell and applying a cap as per Options 1 – 4 above (i.e. on-site encapsulation).

Each of the proposed options is considered suitable to meet the design objectives of the works when considering the specific variables within each domain proposed for remediation. The main remedial strategy is to exclude oxygen from the mineral waste to minimise sulfide oxidation and the generation of acid and metalliferous drainage. The application of either clay (Option 1), or a select fill natural subsoil (Option 2) assumes a clay component to each, whereby oxygen diffusion into underlying sulfidic mineral wastes would be significantly reduced. This would reduce the rate of sulfide oxidation that would, in turn, be balanced by available neutralising capacity over time from the lime amendment, thereby managing oxidation products and significantly reducing environmental risk over time. Under Option 1, where no physical relocation of the sulfidic mineral waste is proposed, *in situ* liming before the addition of a clay cap would assist in managing the actual and retained acidity present in secondary minerals formed from previously oxidised sulfides. If the sulfidic material was physically removed, there would be no need to lime the remediated excavation area, subject to successful site validation.

Where a lower risk area has been lime amended *in situ*, it would negate the need for a clay cap. Rather, a subsoil and topsoil would be added, with subsequent re-vegetation (i.e. Option 2 above).

The addition of a cover material including a vegetated growing media would also aid in reducing infiltration into the sulfidic waste, further reducing oxygen ingress. Evapotranspiration from the vegetation would assist this process on what would effectively become quasi-store-release covers over the *in situ*, lime-amended mineral waste. The remediation strategy addresses the key risks of acid and metalliferous runoff and windborne dust generation from oxidising mineral waste on site.

No specific drainage layers were considered as a requirement for the capping works based on the remedial options identified, with current drainage considered adequate to be tied into.

3.3.2 Steeper areas

GHD reviewed the site survey provided and identified that only limited areas would require regrading to allow capping installation, in turn limiting additional volumes of contaminated material movement required during rehabilitation.

Based on the survey review, some site areas proposed for rehabilitation contain slopes exceeding 1V:3H, whereby installation of Options 1-3 above may not be feasible. Therefore, an alternative such as re-profiling the areas to a shallower slope (max. 1V:2H) followed by implementing either Option 3 or an alternate capping and revegetation system (Option 4) is required. This has been determined as feasible based on the information reviewed and the 3 D modelling undertaken.

A slope analysis identified two potential areas where re-profiling was required. These are:

– The south-eastern extent of the Central Mine Area; and
– The eastern extent of the Old Mill Area.

Option 4 capping includes:

a. Surface neutralisation by lime amendment (where practical and as required based on the geochemistry of the surface material)
b. A geosynthetic cellular confinement system (Presto Geoweb or similar)
c. Application of growth media and vegetation (where practical), or hydro-mulching as an alternate solution.

3D modelling was undertaken to estimate the regrading volumes required in these areas and this is captured in the drawings (refer Appendix A) and bill of quantities (refer Appendix C).

3.3.3 On site encapsulation

In locations where it is not preferred or feasible to cap material *in situ*, designated material may be excavated and relocated to a location that can be feasibly neutralised, capped and revegetated (Option 5).

URS (2004a) identified designated material of approximately 40,000 m^3 from what they referred to as the 'Old Mill Area' and relocation to the Northern Dumps area where it would be encapsulated and revegetated. The Old Mill Area (URS 2004a) includes areas of GHD's (2018) Mill and Central Mine Areas (refer to Figure 1.1).

URS (2004a) identified a 1.265 ha area called the 'Unvegetated Area North Dump' as a second high-risk area containing around 7,500 m^3 of sulfidic material. URS (2004a) suggested the high-risk material from their Old Mill Area (i.e. GHD's Mill Area) could be encapsulated within this already degraded, unvegetated area. The URS (2004a) Unvegetated Area North Dump area is known as the 'Old Mill Area' in GHD (2018) (refer to Figure 1.1). Initial concept surfaces developed by URS (2004a), indicated that there is adequate space to encapsulate the higher-risk material from the Old Mill Area (URS 2004a) within the Northern Dumps. Emplaced material would need to be capped once placed, most likely with a low permeability layer, like Option 1. This has been allowed for as part of the detailed design, however given the quantity of material to be relocated, the footprint for the relocated material needed to expand across other areas of the Northern Dumps.

It is noted based upon previous work by URS (2004a) and site visits conducted by GHD, that infrastructure within the processing area is generally in poor condition and/or unsafe. Therefore, earthworks, and in particular excavation works, in proximity to existing infrastructure should consider potential structural and geotechnical stability issues as well as long-term safety hazards to on-site workers and future site users prior to being undertaken. This requirement has been captured in the detailed design documentation for use during the construction phase.

3.4 Benefits and constraints of identified options

Table 3.1 provides a summary of the benefits and constraints of each option provided.

Table 3.1 Benefits and constraints

Options	Benefits	Constraints
Option 1: *In situ* lime neutralisation with a 300 mm (min.) thick low permeability, natural soil barrier with high clay content, itself overlain with a 300 mm thick (subsoil (200 mm)/growing media or topsoil (100 mm)) layer[1]	– A natural soil barrier with a high clay content would provide an additional benefit of reducing infiltration and oxygen ingress to underlying sulfidic mineral waste. – Naturally occurring material, which may provide longer-term solution.	– Material is not readily available at the site; considerable cost may be involved in transporting the material to site. – Requires suitable moisture conditioning prior to placement. – Sensitive to drying and desiccation if overlying cover is not suitably maintained. – Difficult termination around existing structures and key-in to existing surface water management infrastructure. – Potentially prone to erosion. – Increased capping depth requirement for the higher-risk areas on site, increasing cost relative to alternative solutions.
Option 2: *In situ* lime neutralisation with a 300 mm thick (subsoil (200 mm)/growing media or topsoil (100 mm)) layer	– Material may be available from local borrow sources. – Requires minimal soil conditioning prior to placement. – Greater potential to mimic surrounding soil chemistry and therefore ecological assemblages.	– Difficult termination around existing structures and key-in to existing surface water management infrastructure. – Potentially prone to erosion.

Options	Benefits	Constraints
Option 3: *In situ* lime neutralisation with a 300 mm minimum overlying rock mulch	– Material may be available from local borrow sources. – Simple capping termination required around existing structures in the Mill Area. – Rock mulch with high lime content can assist with neutralising acidity from emplaced mineral waste.	– May require existing surface to be stabilised prior to placement of rock mulch. – Unable to grow much vegetation in rock mulch. – May require ongoing maintenance during significant rain events to repair eroded material.
Option 4: *In situ* lime neutralisation with a combination cap for steep areas	– Allows stabilisation and revegetation of steep areas.	– Additional cost would be required for engineered materials and hydro-mulching. – More prone to erosion and may require additional maintenance following significant rain events.
Option 5: Excavate and relocate material to Northern Dumps for on-site encapsulation with make good of excavated areas	– Removes higher risk sulfidic material from the Mill Area (GHD 2018). – Source area may not subsequently require Option 1 capping. – Removes and manages the key contaminant source, thereby preventing sulfide oxidation, rather than managing ongoing sulfidic mineral waste oxidation products.	– Excavation and earthworks in proximity to unsafe infrastructure poses short term safety hazards due to exposes physical hazards (during construction) and potentially, long term safety hazards due to structural integrity (post-construction). – Geotechnical stability (slope constraint) of emplaced and capping materials.

Note: 1. Alternative use of geosynthetic clay liner in lieu of high clay content soil may be considered during construction.

3.5 Surface neutralisation

Large areas of the Captains Flat site have historically been, and remain, devoid of vegetation due to the presence of low-grade sulfidic ore and mineral waste, providing a growing environment too hostile for many plant species. In order to facilitate site remediation and rehabilitation, stoichiometric liming rates based on historic geochemical data have been developed (Table 3.2). Domain nomenclature reported in Table 3.2 is consistent with that used by GHD (2018).

The liming rates provided in Table 3.2 have been developed considering the maximum potential acidity value as determined using the mean total sulfur value for each mine domain using geochemical data from URS (2004a) and GHD (2018); totalling 166 data points across eight mine domains. The data is not normally distributed, with mean values generally greater than medians. The calculations, and therefore lime volumes, are subsequently conservative. The liming rates also assume:

– A 300 mm tilling depth for *in situ* neutralisation of mineral waste (i.e. acid neutralisation based on maximum potential acidity from total sulfur concentrations within the top 300 mm of material). This is a conservative assessment method whereby 100 % of the theoretical net acid generation potential of the mineral waste is considered for lime demand.
– No acid neutralising capacity is present in the mineral waste (using URS 2004a geochemical results).
– A 90 % lime purity.
– The lime is fine-grained or powdered lime.
– An average of 2.0 t/m^3 soil/mineral waste bulk density and a fine lime density of 1.78 t/m^3.
– For *in situ* liming for capping Options 2, a two times lime (neutralising capacity) to maximum potential acidity ratio has been used (AMIRA 2002).
– Areas containing infrastructure that will remain have been excluded from liming calculations.

Note that the liming calculations described herein relate only to the neutralisation of acidity risk from oxidising sulfides. It does not consider the need for gypsum amendment to manage soil sodicity and manage dispersion potential as required. The latter was reported by URS (2004a) and should be provided to the Contractor for information during construction.

Table 3.2 Estimated liming requirements (after GHD 2018)

Location	Approx. extent of clearing and grubbing (ha)	Total lime (tonnes)
North Mine Ridge, Elliot's	2.71	194
Old Mill	1.7	451
Mill area – *in situ*	3.46	0[A]
Central Mine Area	1.81	365
Creeks and Rail Loading Areas	4.92	610
Minor area or eroded capping on the Northern and Southern Dumps	2.4	8
Containment Cell (comprising material from Mill Area, Captains Flat Railway Precinct, Central Mine Area, Old Mill, two site stockpiles and Lead Abatement Areas in Captains Flat)	NA	6,803[B]

[A]: Subject to successful geochemical validation as per details in the *Construction Quality Control Plan.*

[B]: Approximately 9,071 tonnes of an alternate lime amendment is proposed for use in lieu of lime subject to the approval of a Resource Recovery Order and Exemption being issued under the NSW *Protection of the Environment Waste Regulation 2014*.

Note that it may not be feasible for all areas to have lime tilled into the soil surface due to the presence of natural rock outcrops and/or steep slopes. In such instances, the lime application rate would be reviewed, with the lime being applied surfically and/or blended into the imported subsoil as determined for each specific area requiring remediation. For the purposes of estimating lime volumes for application by tilling into the *in-situ* material, a tilling depth of 300 mm has been assumed herein. This remains consistent with URS (2004a).

3.6 Availability of borrow materials

Chesnut (1974) undertook an assessment of local sources of large volumes of potential capping and neutralising materials. Chesnut's (1974) brief was to locate up to approximately 500,000 tonnes of remedial construction material (an order of magnitude more than required based on the current design). The assessment identified various sources within 35 km, except for suitable loams for the upper growth media.

Clays were identified at several sites along Captains Flat Road, with the best resources noted in deeply weathered granite approximately 7 km south of Captains Flat and shales near Foxlow, around 13 km north of Captains Flat. The optimum source of large volumes of hard rock for armouring was massive acid porphyritic rock at a site located 21 km south of Captains Flat, on Wild Cattle Flat Road, near Wild Cattle Flat.

Previously worked limestone lenses, suitable for adjusting the pH of the growth medium and surface materials, were identified at two locations adjacent to Captains Flat Road at Koomooloo, approximately 5 km from Captains Flat. These sites were thought to be the original source of limestone used in the smelting process at the Lake George Mine.

In summary, Chesnut (1974) noted that most construction materials for site remediation are available *in situ* within 35 km of Captains Flat with the exception of suitable soil or loam for top dressing (i.e. a growing medium), and suggested that a manufactured soil may be the optimum choice. It was suggested that by using highly weathered rock materials such as granite, then adding limestone overburden and blending with organic materials such as domestic garbage, saw dust, wood pulp/chips etc. and adding mineral fertilizers, a satisfactory vegetation supporting medium could be created.

A geotechnical appendix was included within Dobos and Associates (2002) that discussed capping requirements for the eastern slag area at the southern end of the mine. The appendix noted that (then) Department of Land and Water Conservation officers were not aware of any clay borrow in the area, nor was any identified during the site inspection. It was judged that weathered rock exposed in the road cutting would not have sufficient clay content to provide low permeability cover material. Similarly, a quarry to the northwest showed rock that would be expected to break down to relatively pervious silty gravel. The report concluded that 'in summary, no resource of material suitable for capping the slag was found during the site inspection'.

URS (2004a) provided a cost estimate for capping materials including clay, soil, and topsoil. They assumed the material would be sourced from Bungendore; the location from where the NSW Soil Conservation Service borrowed material for rehabilitation of the South waste dump at Captains Flat. Bungendore is around 60 km from site.

GHD (2018) undertook borrow material sampling and analysis to the south of Keating's Collapse on the eastern flank of the ridge that continues along the strike of the mine. GHD (2018) identified some clayey soils and highly weathered schist (Sites XRF138-152 and SS17 and SS18). The potential borrow area is, however, located in a naturally forested area, whereby any borrow would create visual impact and itself require remediation as it would become an erosion risk.

GHD (2018) undertook hand held x-ray fluorescence (XRF) and laboratory analysis on soil samples from the potential borrow area, and upon receipt of results, determined that the material was unlikely to be dispersive, though had low potential to adsorb nutrients. The soils also contained low nitrogen and phosphorous levels. GHD (2018) concluded that the soils would make good general cover material as a growth medium, though may require some fertiliser addition to promote vegetation growth subject to metal contaminant concentrations.

Whilst not reported in GHD (2018), it was estimated that approximately 38,000 m^3 of potential borrow material may be available on site immediately south of Keating's Collapse, assuming a depth of around one metre. However, considering the slope, presence of native vegetation, the aspect (i.e. facing Jerangle Road) and subsequent rehabilitation requirements, it is recommended that the potential borrow material be left *in situ,* with capping material sourced from off site.

Given the reconnaissance work of Chesnut (1974), it is highly likely that additional geotechnical drilling will be required to source appropriate material once final volumetric requirements by material type are known.

There also remains the possibility of innovative full or partial solutions through opportunistically sourcing cut material from road upgrades and/or other civil works being undertaken in the Canberra/Queanbeyan region at the time of implementing remedial works on site. Additionally, other organic residual products could be used to manufacturing a growing media such as municipal solid waste compost from Veolia Woodlawn (subject to approvals under the NSW *Protection of the Environment Waste Regulation 2014*) and/or biosolids from the Sydney and/or Canberra markets as deemed permissible statutorily and acceptable by local residents. It is highly recommended that the use of such organic residuals be canvassed with key stakeholders and the community prior to implementation.

Additional locations and costs for commercially available remedial material supplies have been considered as part of the cost estimation for the works. These include rates and products available from Holcim Quarries, Bungendore, Divalls in Marulan, HiQuality in Windellama and/or Bungendore Landscape Supplies.

3.7 Revegetation

Each domain slated for remediation would be re-vegetated (or vegetated if currently bare), following neutralisation and capping, with the exception of the central portion of the Central Mine Area, around one-third of the Mill Area and other select areas, which would be remediated using rock mulch (i.e. Capping Option 3). The rock mulch remedial option was agreed upon through stakeholder consultation to retain the industrial feel of the high point in the Central Mine Area as well as being more appropriate on steeper grades.

The primary objective of site revegetation is to establish a self-sustaining vegetation community that will maintain site stability and reduce erosion risk from both wind and water. A secondary consideration is acceptable visual amenity whereby an acceptable balance is struck between reduced erosion risk, dust suppression and maintaining the mining heritage character of the site.

The long-term objective is that the site would naturally revegetate with native species present in the vicinity such as native grasses, herbs and shrub species found in the grassy woodlands and dry sclerophyll forests of surrounding areas (e.g. Yanununbeyan State Conservation Area, approximately 5 km the west of Captains Flat). Species may include silver wattle (*Acacia dealbata*), green wattle (*Acacia mearnsii*), bitter pea (*Daviesia mimisoides*), dogwood (*Cassinia sp*.), bush pea (*Pultenaea procumbens*), tussock grass (*Poa labillardierer*) and redanther wallaby grass (*Joycea pallida*).

To ensure initial site stabilisation following neutralisation and capping (and reduce erosion and weed colonisation risk), a sterile 'nurse' crop of pioneer species, including non-native grasses, should also be utilised. These species may include Japanese millet, oats, couch, tall fescue, and perennial rye grass. As the native vegetation develops, these pioneer species consisting of non-native grasses will decrease or disappear altogether. Monitoring of the vegetation re-establishment will occur in accordance with a Revegetation Plan and will be supplemented if required. Where required, temporary erosion control and protection measures (for example: Class 1 or Class 2 erosion control blankets, mats or hydroseeded grass species) may be required during the vegetation establishment phase.

Note that no consideration of gypsum amendment has been considered herein to ameliorate sodic subsoils on site prior to remediation and revegetation. This concept is described and quantified in URS (2004a) and should be considered within the overall holistic remedial strategy for the site and will be included in the detailed design phase.

3.8 Water management

Runoff from the Central Mine and Old Mill Areas is predominantly uncontrolled through informal flow paths/channels. As part of the capping and revegetation works, a series of toe-drains would be constructed as required to maintain the existing drainage system. As part of the works, existing flow paths will be connected into and formalised as required to provide long-term integrity to the drainage system.

Surface water is managed through the Mill and Rail Loading Areas via a network of engineered drainage lines and on-site sediment storage ponds. The proposed works will interface with the existing surface water system, with new drains and subsoil drainage established to manage surface water from the regraded areas. A toe drain will be constructed at the northern extent of the Rail Loading Area and the northern and eastern extents of the Central Mine Area to intercept runoff and provide controlled discharge to the nearby river or drainage system.

It is noted that the culvert under the access road on the eastern side of the Central Mine Area may require upgrading to maintain functionality. It is assumed that existing surface water management infrastructure (drains, dams, etc.) other than those mentioned above, have been appropriately designed and do not need modification on the basis that the catchments remain unchanged. Rather, runoff should decrease following the proposed works given the increased volume of soil and vegetated areas, thereby increasing infiltration into the soil profile.

Cap termination and works in proximity to and within Copper Creek and Forsters Creek waterways will be finalised during construction once the extent of works is confirmed on-site, in accordance with environmental and planning approvals.

3.9 Existing infrastructure

Historic infrastructure within the Mill Area will require additional works prior to capping and revegetation to ensure safety, amenity, and longevity. As part of the capping and revegetation works in the Mill Area, the tunnels should be filled, sealed, or fenced to minimise long-term safety risks. Existing structures in the Mill Area should be fenced as required to minimise public access to the structures. URS (2004a) detailed the specific safety works that should precede site remedial works outlined herein. As some of the planned capping works will impact on the fencing location and alignment in the Old Mill Area, and the land ownership of that area has recently changed, fencing will occur at an appropriate time in consultation with the new landowner.

GHD also notes that the existing ore bins in the Mill Area have been rehabilitated *in situ* to minimise rainfall contact and subsequent leaching. Should the remediation of the existing ore bins prove unsuccessful from a contaminated drainage perspective, the material within the ore bins may also be encapsulated in the Old Mill Area. Ongoing physical monitoring of the remediated ore bins should be undertaken to determine rehabilitation success over time.

It is further noted that excavation and works in proximity to existing infrastructure may influence options assessments because of potential safety hazards. Earthworks or machinery may destabilise structures and slopes with potential safety considerations for both short and long timeframes. This requirement has been captured in the detailed design documentation for implementation as part of the construction phase.

3.10 Design limitations

The following limitations have been identified with our proposed design works:

– It is assumed that suitably sized existing surface water management measures are present, and the surface water measures we design will be able to be keyed into these existing measures.
– Liming assumptions as outlined in Section 3.5.

3.11 Design recommendations

Summary information compiled from three key historic studies (Dobos and Associates 2002, URS 2004a and GHD 2018) at Captains Flat are shown in Table 3.3. Note that for alignment, naming conventions from Dobos and Associates 2002 and URS 2004a have been adjusted to integrate with that of GHD (2018).

For context, Dobos and Associates (2002) undertook a benchmark study that recognised the primary (Mill area) and secondary contaminant risk area (Rail loading area) on site, and recommended additional investigative works that were subsequently completed by URS (2004a). The findings of URS (2004a) were aligned with those of Dobos and Associates (2002) and provided additional detail on the level and location of contamination and offered costed remedial solutions. GHD (2018) undertook infill sampling and analysis work across the areas investigated by URS (2004a) to fine-tune the remedial solutions.

This report provides the additional remedial design detail not scoped in GHD (2018), and therefore, consistently builds on the work of Dobos and Associates 2002, URS 2004a and GHD 2018.

Table 3.3 Design recommendations summary

Location (cf. GHD 2018)	Contamination risk			Preferred remedial solution		
	Dobos (2000)	URS (2004a)	GHD (2018)	Dobos (2000)	URS (2004a)	GHD (2018)
North Mine ridge, Elliot's	-	High	Ranked 2 of 6[1]	-	(1) Excavate and remove; import clean fill/topsoil (2) Clay encapsulate in situ	Neutralise surface material, cap and revegetate to prevent generation of contaminated dust, erosion and runoff, and direct exposure to site visitors (as detailed in URS 2004a)
Old Mill	-			-		
Mill area (west of the Central Mine Area)[1]	Primary			Remove material, lime, and import clean fill/topsoil		
Central Mine area	-	Moderate (north), Low (south)		-	Ameliorate *in situ* and import topsoil - excavate and remove; import clean fill/topsoil (north - as required) Do nothing or ameliorate in situ (south)	
Creeks area	-	Moderate		-	Ameliorate *in situ* and import topsoil	
Rail Loading area	Secondary			*In situ* liming		
Minor area or eroded capping on the Northern and Southern Dumps	-	-	Ranked 5 of 6	-	-	Repair Southern Dump perimeter drainage. Repair capping and revegetate. Repair fencing.

Note: 1. Addressing dissolved contaminant loads from the Main Adit Spring ranked highest.

Based upon the summary above, all five capping options provided herein have merit and can meet the design objectives on specific areas, commensurate with their contamination risk and unique domain characteristics.

Table 3.4 provides a summary of the recommended remedial solution by site domain. Note that the recommended remedial solutions are based on technical efficacy, not cost. It also incorporates feedback from various stakeholders such as the current land owner.

Table 3.4 Recommended remedial solution by site domain

Site domain	Remediation option to be used
North Mine Ridge/Elliot's	Option 2 Option 3 and/or 4 for steeper areas – extra overs to be encapsulated in containment cell
Old Mill	Option 2 Option 3 and/or for steeper areas – extra overs to be encapsulated in containment cell. Option 3 around heritage structure and drainage pipe steep areas
Mill Area	Option 5 followed by Option 2, with around 35% Option 3
Central Mine Area	Option 2 around the periphery and Option 3 in the central portion Option 4 for steeper areas – extra overs to be encapsulated in containment cell
Creeks Area	Option 2
Rail Loading Area	Option 2
Captains Flat Railway Precinct	Option 5 followed by Option 2
Minor areas of eroded capping in the Northern and Southern Dumps Northern Dumps Encapsulation Cell	Option 1, with Options 3 and 4 along Jerangle Road Option 1
Smaller stockpiles to be relocated	Option 5 followed by one of Options 1 to 4 inclusive as deemed appropriate and as assessed in the REF once the material has been removal (Note that this excludes in channel stabilisation works in Copper Creek and for the Slag Heap capping/stabilisation in Forsters Creek as it has not been assessed in the REF. i.e., material removal in channel in Forsters Creek is acceptable from top of bank, however, no channel stabilisation works have been assessed).

4. Design documentation

GHD has developed detailed design documentation based on the design basis outlined above, suitable for tendering and construction. These include:

– Detailed Design Drawings (refer Appendix A)
– Technical Specification (refer Appendix B)
– Bill of Quantities (refer Appendix C)
– Safety in Design Risk Register (refer Appendix D).

The design documentation is based around the recommended remedial solutions outlined in Table 3.4, however it also maintains flexibility for the other potential options available to be implemented if required.

5. Limitations

Note: As of 1 July 2019, the NSW Department of Planning and Environment became known as the NSW Department of Planning, Industry and Environment. In 2020, the LMP was moved from Department of Planning, Industry and Environment into the Department of Regional NSW. This commission was completed under a tender issued by the NSW Department of Planning and Environment. Under instruction from the LMP, the Client has been changed to the NSW Department of Regional NSW.

This report has been prepared by GHD for the NSW Department of Regional NSW and may only be used and relied on by the NSW Department of Regional NSW for the purpose agreed between GHD and the NSW Department of Regional NSW as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than the NSW Department of Regional NSW arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring after the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described throughout this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by the NSW Department of Regional NSW and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

6. References

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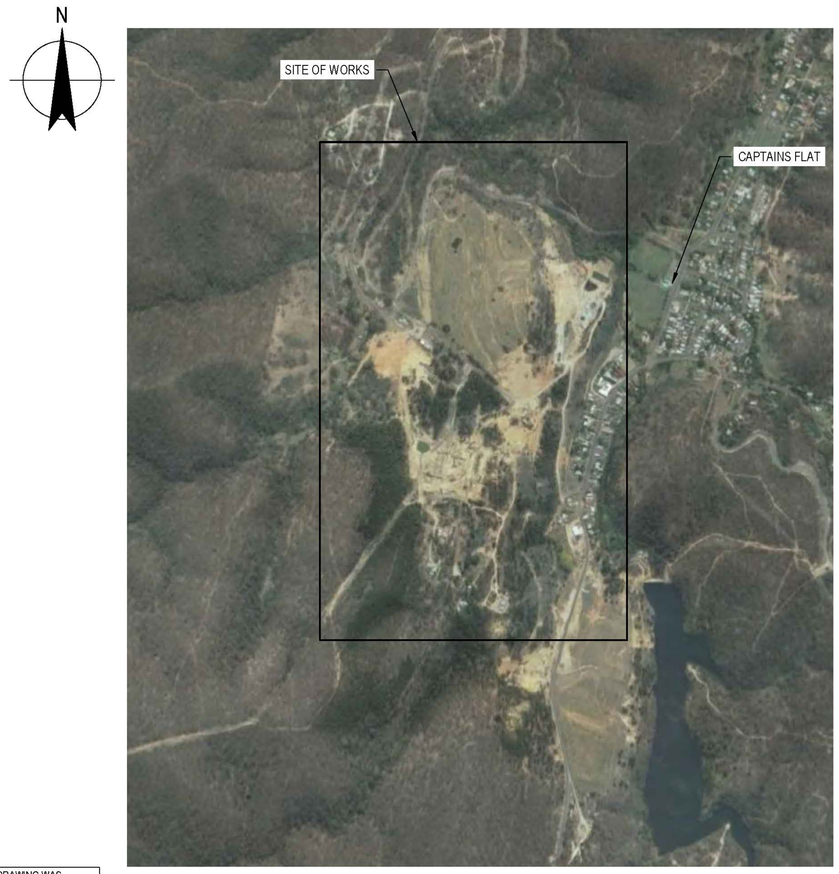
Appendix A

Detailed Design Drawings

DEPARTMENT OF REGIONAL NSW
LAKE GEORGE MINE, CAPTAINS FLAT
CAPPING AND REVEGETATION WORKS
12551771



LOCALITY PLAN
SCALE NTS

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DRAWING LIST

DRG No.	DRAWING TITLE
12551771-C001	COVER SHEET, LOCALITY PLAN AND DRAWING LIST
12551771-C002	EXISTING SITE LAYOUT
12551771-C003	GENERAL ARRANGEMENT
12551771-C004	TYPICAL SECTIONS AND DETAILS

DRAWINGS SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATION. WHERE THE DRAWINGS & THE SPECIFICATION DO NOT AGREE, THE CONTRACTOR SHALL SEEK CLARIFICATION FROM THE CLIENT'S REPRESENTATIVE.

FOR CONSTRUCTION

Rev	Description	Checked	Approved	Date
1	UPDATED FORMAT			08.03.22
0	FOR CONSTRUCTION			29.10.20

Author	L. POSADAS	**Drafting Check**	A. MACLEAN*
Designer	C. N-SMITH	**Design Check**	S. WINCHESTER*

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Project No. 12551771

Client: DEPARTMENT OF REGIONAL NSW

Project: LAKE GEORGE MINE, CAPTAINS FLAT

Status: FOR CONSTRUCTION — Status Code: S4

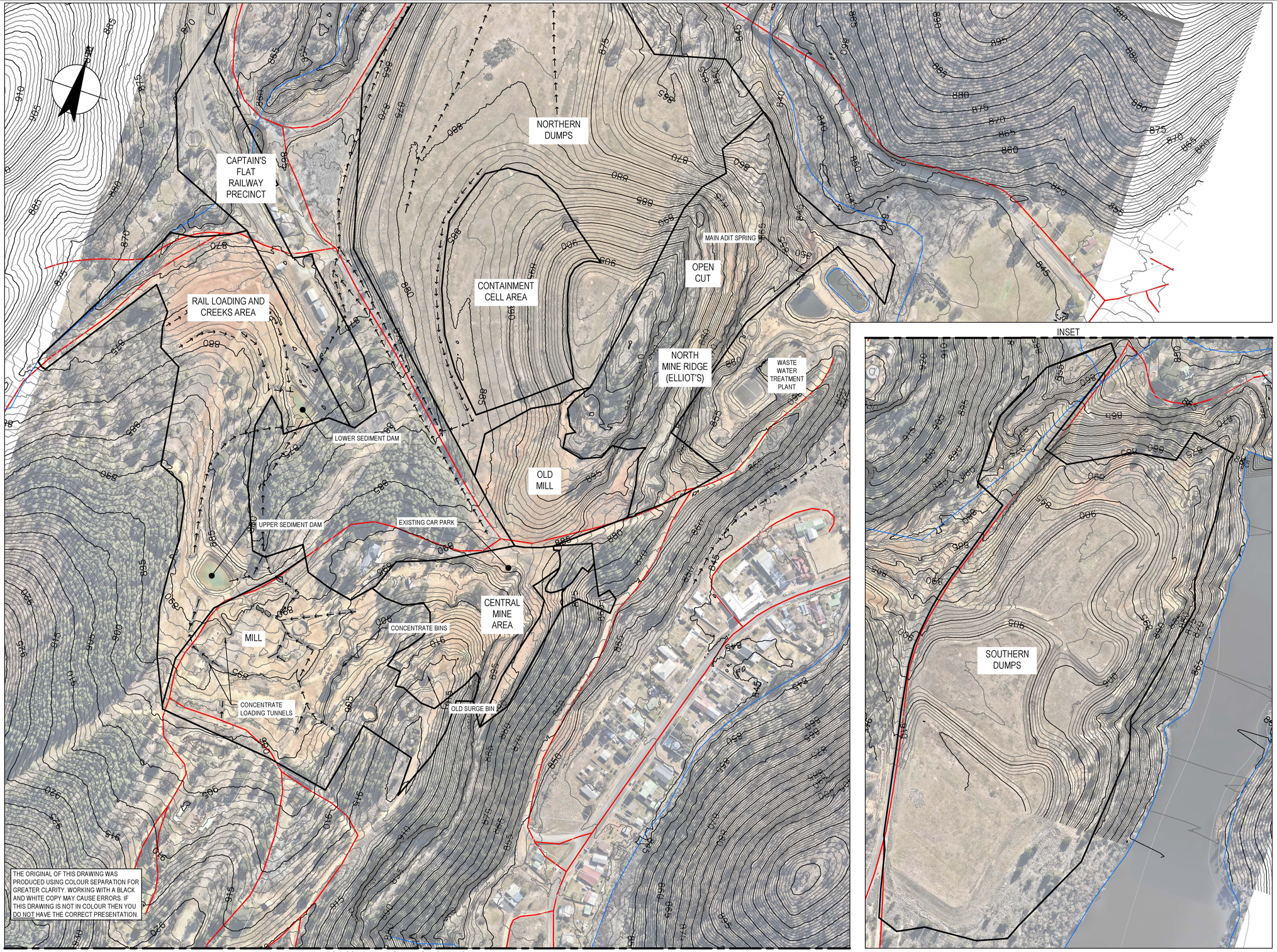
Drawing Title: CAPPING AND REVEGETATION WORKS
COVER SHEET, LOCALITY PLAN AND DRAWING LIST

Size: A1

Drawing No.: 12551771-C001

Rev: 1

Plot Date: 8 March 2022 - 7:49 AM Plotted by: Riken Joshua Lopez File Name: \\ghdnet\ghd\PH\Cebu\Projects\21\27816\CADD\Drawings\12551771\Drawings\12551771-C001.DWG



INSET

LEGEND

- EXISTING SURFACE
- HYDROLINES
- EXISTING FLOW PATH
- REHABILITATION AND CAPPING EXTENTS (REFER NOTES 2 AND 3)

NOTES:

1. EXISTING SURFACE CONTOURS BASED ON NSW GOVERNMENT LIDAR DATA DATED MARCH 2018
2. ALL AREAS AND LOCATIONS ARE APPROXIMATE
3. EXTENT OF REHABILITATION AND CAPPING AREAS AREA TO BE CONFIRMED BY CLIENT'S REPRESENTATIVE AS PART OF CLEARING AND GRUBBING
4. SET DOWN AND CONTRACTOR AREA TO BE CONFIRMED BY CLIENT'S REPRESENTATIVE
5. CONTRACTOR TO CONFIRM LOCATION OF EXISTING SERVICES WITH THE CLIENT'S REPRESENTATIVE PRIOR TO INITIATION OF THE WORKS
6. CONTRACTOR TO CONFIRM LOCATION OF SURVEY BENCHMARKS WITH THE CLIENT'S REPRESENTATIVE PRIOR TO INITIATION OF THE WORKS
7. CONTRACTOR TO NOTIFY CLIENT'S REPRESENTATIVE FOR APPROVAL PRIOR TO REMOVAL OF ANY TREES OR LARGE PLANTS
8. NO EXISTING STRUCTURES SHALL BE DAMAGED OR REMOVED WITHOUT WRITTEN CONSENT FROM THE CLIENT'S REPRESENTATIVE

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FOR CONSTRUCTION

Rev	Description	Checked	Approved	Date
2	UPDATED BOUNDARY			10.03.22
1	UPDATED FORMAT AND BOUNDARIES			08.03.22
0	FOR CONSTRUCTION			29.10.20

Author L POSADAS Drafting Check A. MACLEAN*
Designer C. N-SMITH Design Check S. WINCHESTER*

0 20 40 60 80 100m
SCALE 1:2000 AT ORIGINAL SIZE

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Project No. 12551771

Client DEPARTMENT OF REGIONAL NSW
Project LAKE GEORGE MINE, CAPTAINS FLAT
Status FOR CONSTRUCTION Status Code S4

Drawing Title CAPPING AND REVEGETATION WORKS
EXISTING SITE LAYOUT

Size A1
Drawing No. 12551771-C002
Rev 2

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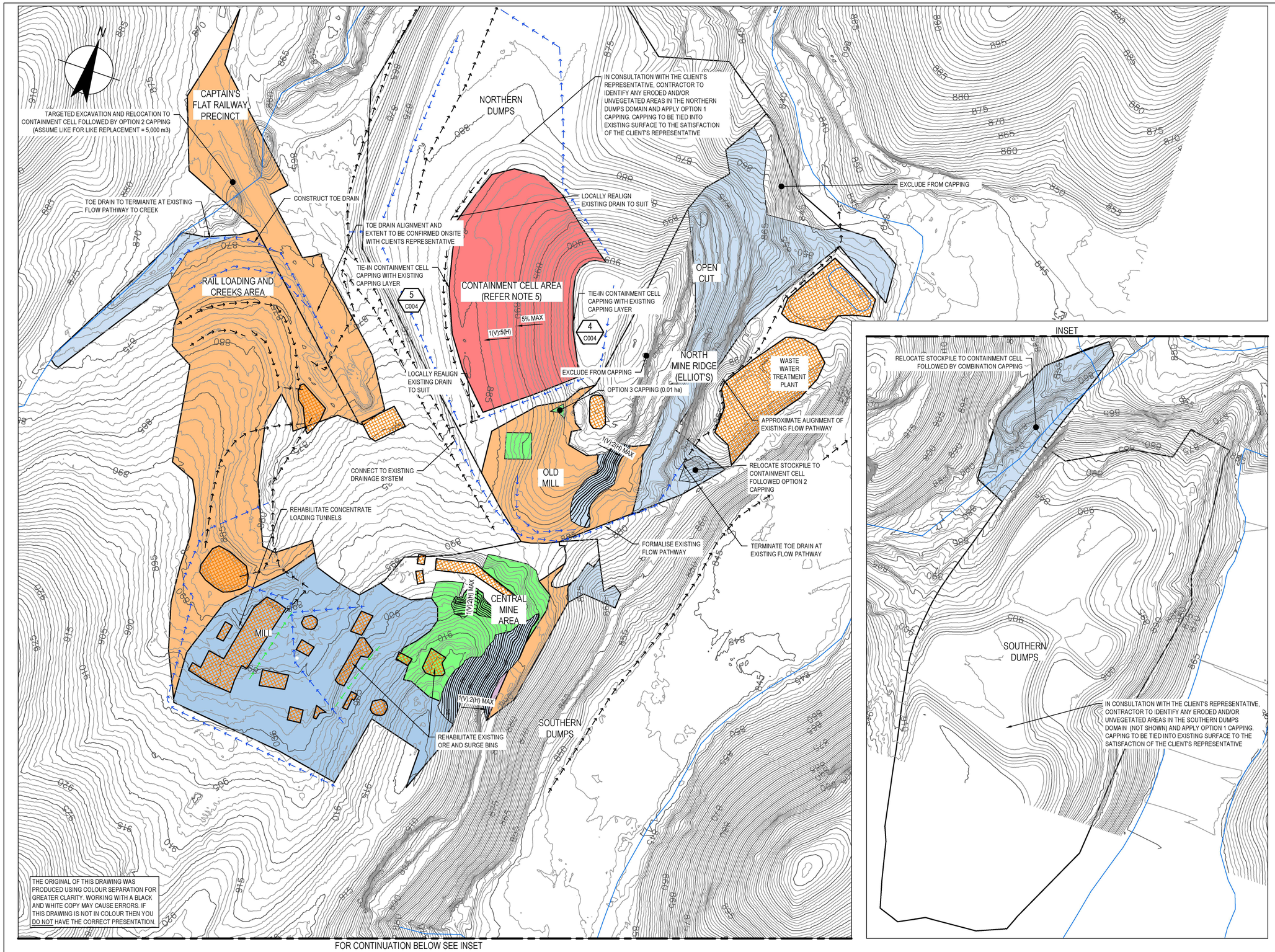

LEGEND

- EXISTING SURFACE
- HYDROLINES
- EXISTING FLOW PATH
- PROPOSED FLOW PATH
- PROPOSED SUBSOIL DRAIN
- REHABILITATION AND CAPPING EXTENTS (APPROX.)
- EXISTING INFRASTRUCTURE (APPROX.)
- OPTION 1 CAPPING
- OPTION 2 CAPPING
- OPTION 3 CAPPING
- OPTION 4 CAPPING
- COMBINATION CAPPING (AS DIRECTED BY SUPERINTENDENT)

NOTES:

1. REFER NOTES ON DRG C002.
2. CONTRACTOR TO ARRANGE FOR A SUITABLY QUALIFIED STRUCTURAL AND/OR GEOTECHNICAL ENGINEER TO INSPECT ALL EXISTING STRUCTURES IN THE PROPOSED CAPPING AREAS TO CONFIRM CAPPING EXTENT, OFFSET, TERMINATION AND TIE-IN ADJACENT TO THESE STRUCTURES.
3. ALL DRAINAGE TO BE CONSTRUCTED WITH MINIMUM 1% LONGITUDINAL FALL.
4. ALL DRAINAGE ALIGNMENTS ARE CONSIDERED INDICATIVE AND SHOULD BE SET-OUT AND CONFIRMED ON-SITE WITH CLIENT'S REPRESENTATIVE TO ACHIEVE MINIMUM SLOPE REQUIREMENTS.
5. MAXIMUM CONTAINMENT CELL AREA SHOWN, FINAL EXTENT TO BE CONFIRMED WITH CLIENT'S REPRESENTATIVE BASED ON ACTUAL MATERIAL RELOCATION QUANTITIES.

FOR CONSTRUCTION

Rev	Description	Checked	Approved	Date
3	UPDATED DRAINAGE			10.03.22
2	UPDATED FORMAT AND BOUNDARIES			08.03.22
1	UPDATED DETAILS			13.11.20
0	FOR CONSTRUCTION			29.10.20

Author L POSADAS Drafting Check A. MACLEAN*
Designer C. N-SMITH Design Check S. WINCHESTER*

0 20 40 60 80 100m
SCALE 1:2000 AT ORIGINAL SIZE

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Project No. 12551771

Client DEPARTMENT OF REGIONAL NSW
Project LAKE GEORGE MINE, CAPTAINS FLAT
Status FOR CONSTRUCTION Status Code S4

Drawing Title CAPPING AND REVEGETATION WORKS GENERAL ARRANGEMENT

Size A1
Drawing No. 12551771-C003
Rev 3

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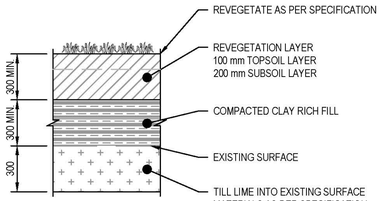
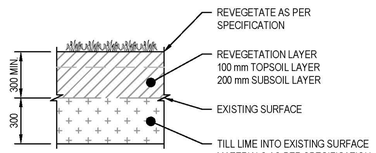


1 - DETAIL
SCALE 1 : 20

TYPICAL CAPPING PROFILE OPTION 1



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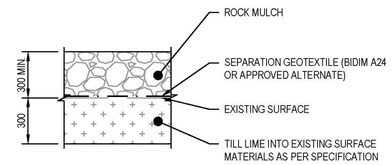
TYPICAL CAPPING PROFILE OPTION 2



3 - DETAIL
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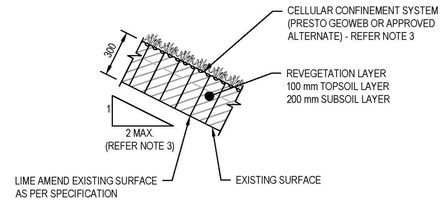
TYPICAL CAPPING PROFILE OPTION 3



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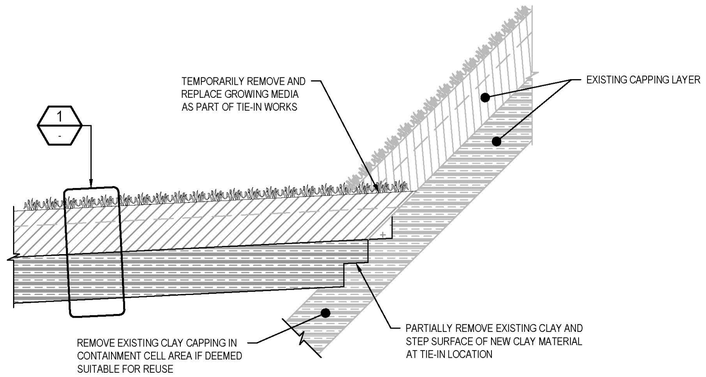
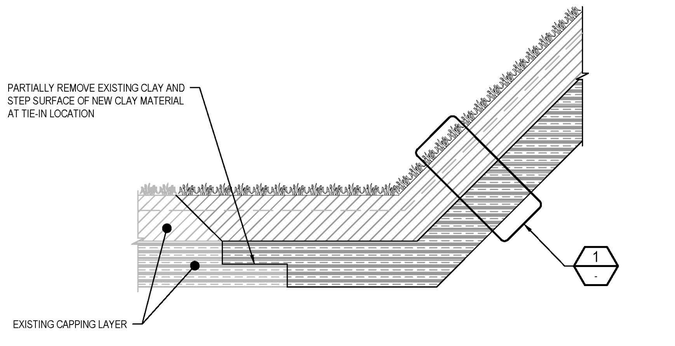
TYPICAL CAPPING PROFILE OPTION 4



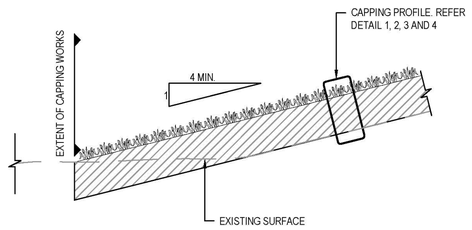
4 C003 - DETAIL
SCALE 1 : 20

TYPICAL TIE-IN WITH EXISTING CAPPING (BATTER) (REFER NOTE 4)



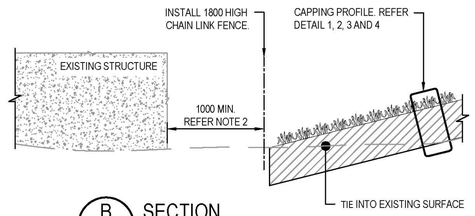
5 C003 - DETAIL
SCALE 1 : 20

TYPICAL TIE-IN WITH EXISTING CAPPING (BASE) (REFER NOTE 4)



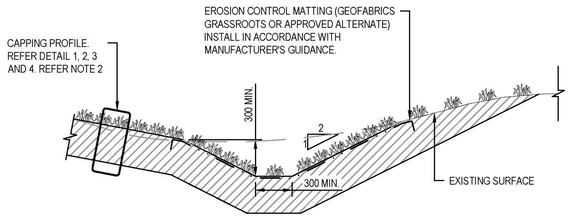
A - SECTION
SCALE 1 : 25

TYPICAL TIE-IN WITH EXISTING SURFACE (CAPPING TERMINATION)



B - SECTION
SCALE 1 : 25

TYPICAL CAPPING TERMINATION AT EXISTING STRUCTURE



C - SECTION
SCALE 1 : 25

TIE-IN WITH EXISTING SURFACE AND TYPICAL PERIMETER DRAIN

NOTES:

1. REFER NOTES ON DRG C002 AND C003.
2. CONTRACTOR TO ARRANGE FOR A SUITABLY QUALIFIED STRUCTURAL AND/OR GEOTECHNICAL ENGINEER TO INSPECT ALL EXISTING STRUCTURES IN THE PROPOSED CAPPING AREAS TO CONFIRM CAPPING EXTENT, OFFSET, TERMINATION AND TIE-IN ADJACENT TO THESE STRUCTURES.
3. FINAL GRADING AND INSTALLATION METHOD FOR CELLULAR CONFINEMENT SYSTEM TO BE CONFIRMED IN CONSULTATION WITH THE MANUFACTURER BASED ON REVEGETATION MATERIAL PROPERTIES.
4. FINAL TIE-IN DETAIL TO BE CONFIRMED FOLLOWING TEST PITTING BY CONTRACTOR IN CONTAINMENT CELL AREA, INCLUDING MINIMUM DEPTH OF EXISTING CAPPING MATERIAL TO BE RETAINED.

FOR CONSTRUCTION

Rev	Description	Checked	Approved	Date
1	UPDATED FORMAT			08.03.22
0	FOR CONSTRUCTION			29.10.20

Author L POSADAS Drafting Check A. MACLEAN*
Designer C. N-SMITH Design Check S. WINCHESTER*

0 200 400 600 800 1000mm
SCALE 1:20 AT ORIGINAL SIZE

0 250 500 750 1000 1250mm
SCALE 1:25 AT ORIGINAL SIZE

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Project No. 12551771

Client DEPARTMENT OF REGIONAL NSW
Project LAKE GEORGE MINE, CAPTAINS FLAT
Status FOR CONSTRUCTION Status Code S4

Drawing Title CAPPING AND REVEGETATION WORKS
TYPICAL SECTIONS AND DETAILS

Size A1
Drawing No. 12551771-C004
Rev 1

Plot Date: 8 March 2022 - 7:46 AM Plotted by: Riken Joshua Lopez File Name: \\ghdnet\ghd\PH\Cebu\Projects\21\27816\CADD\Drawings\12551771\Drawings\12551771-C004.dwg

Appendix B

Technical Specification

Lake George Mine Remediation

Technical Specification – Capping and Revegetation Works

Department of Regional NSW (Legacy Mines Program)

March 2022

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Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	2	N Griffiths	C Nivison-Smith		S Winchester		25/03/22
S4	1	N Griffiths	C Nivison-Smith		S Winchester		14/03/22
S4	0	N Griffiths	C Nivison-Smith		S Winchester		30/10/20

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Appendices

1. Introduction

1.1 General

This Specification contains the technical requirements for materials and procedures to be used for the construction of capping and revegetation works (the Works) across key locations on the northern portion of Lake George Mine (the site) and must be read in conjunction with the other Contract Documents.

Where the Specification and any other Contract Documents do not agree, the Contractor shall seek clarification from the Client's Representative.

1.2 Definitions

The Definitions described in the Contract Documents apply to this document. The following additional terms used in this Specification shall have the meanings ascribed to them below unless the context otherwise requires:

- 'Client's Representative' – As defined in the Conditions of Contract
- 'Contract' – The agreement between the Principal and Contractor
- 'Contract Drawings' – The construction drawings which form part of the Contract Documents
- 'Contract Documents' – The documents which form the Contract
- 'Contractor' – The person bound to execute the work under the Contract
- 'Contractor's Independent Testing Firm' – Independent testing firm(s) engaged by the Contractor to conduct construction quality control (CQC) testing
- 'ENM' – Excavated natural material. As defined in the NSW EPA excavated natural material exemption 2014 (http://www.epa.nsw.gov.au/resources/waste/rre14-excavated-natural-material.pdf)
- 'Specification' – This document
- 'Principal' – As defined in the Conditions of Contract
- 'VENM' – Virgin excavated natural material. As defined in Schedule 1 of the *Protection of the Environment Operations Act 1997*
- 'Work under the Contract' – The work which the Contractor is or may be required to execute under the Contract and includes variations, remedial work, constructional plant, and temporary works
- 'Works' – The whole of the work to be executed in accordance with the Contract, including variations provided for by the Contract, which by the Contract is to be handed over to the Principal
- 'Works Area' – As shown on the Contract Drawings.

1.3 Materials

The Contractor shall be responsible for the sourcing, delivery, storage, preparation, handling, and installation of all materials, except as modified in individual sections of this Specification.

Material and installation specifications are included in the individual sections of this Specification for each material type.

1.4 Sequencing and scheduling

The Contractor shall be responsible for sequencing the installation of all materials, including surveys, testing and field trials.

In general, installation sequencing shall proceed from higher elevations to lower elevations to prevent precipitation runoff from flowing into and/or below installed products.

Individual components shall not be covered with the subsequent component until the underlying component has been accepted by the Client's Representative.

1.5 Works program

The Contractor shall prepare a program for the Works. The program shall encompass all phases of the Works. The Contractor shall submit a draft of the program to the Client's Representative for review and approval at least 10 days prior to construction. The Contractor shall not undertake any works on the site until approval for such is given by the Client's Representative. The program shall include regular progress meetings with the Client's Representative.

1.6 Submittals

Submittals for each material are included in the individual chapters of this Specification.

The following pre-qualification submittals are required to be submitted by the Contractor at least 10 working days prior to construction for approval by the Client's Representative.

1.6.1 Pre-qualification of the Contractor's Independent Testing Firm

Prior to construction, the Contractor shall provide a listing of qualifications for the proposed Contractor's Independent Testing Firms(s) and its key personnel who shall perform the work described in this Specification. The Contractor's Independent Testing Firms(s) shall be National Association Testing Authorities (NATA) accredited and proof of accreditation shall be maintained throughout the duration of the Works.

A listing of testing apparatus and testing standards typically performed by the testing firm shall be provided along with a letter stating that the testing firm is independent and has no financial interest in the Contractor, the Geosynthetic Installer (as applicable) or any of the manufacturers/suppliers that are providing materials for the Works.

1.6.2 Works program

Refer to Section 1.9.

1.7 Construction quality control testing

All construction quality control (CQC) testing shall be arranged by the Contractor and shall be carried out by appropriately qualified personnel. The cost of CQC testing shall be borne by the Contractor. Unless noted otherwise, copies of all test results shall be sent to the Client's Representative as soon as available but in any event within two days of becoming available. The minimum testing frequencies shall be as nominated within this Specification.

The Contractor shall prepare and implement a construction quality control (CQC) plan for the Works, and the plan shall address all quality considerations identified or outlined in this Specification. The CQC plan shall incorporate, as necessary, field testing and verification, manufacturer's certifications, and quality control testing at the manufacturing plant, to demonstrate that all Works comply with this Specification. The CQC plan shall also demonstrate how construction will occur and the methods by which the materials will be supplied, placed, and tested to ensure compliance with this Specification.

Works shall not commence until the CQC plan has been approved by the Client's Representative.

The Contractor shall submit a draft of the CQC plan to the Client's Representative for review at least 10 days prior to construction. The Contractor shall prepare a final Construction Quality Control Plan after receiving advice from the Client's Representative. The Contractor shall not undertake any work on the site until approval for such is given by the Client's Representative.

The CQC plan is to include details on geochemical / environmental validation methods for lime blending rates, lime alternative blending rates and certification testing of imported materials including sub- and topsoil. The CQC plan is to provide detail regarding site validation of excavated areas including the sulfidic mineral waste stockpile, the slag heap, the Mill Area, the Captains Flat Railway Precinct and other areas where contaminated material is being removed from a domain to the containment cell located on the Northern Dumps.

The Principal may, at its discretion, audit the Contractor's implementation of the CQC plan. The Contractor shall co-operate with all such auditing.

At any stage throughout the Works, the Client's Representative may arrange for independent testing and/or surveying to be carried out. If that testing reveals that any works are found to be not compliant with the requirements of this Specification and the Contract Drawings, the Contractor shall undertake rectification of the non-compliant items and conduct re-testing in accordance with this Specification. All costs of undertaking such rectification work and re-testing shall be borne by the Contractor.

1.8 Construction quality assurance

The Principal may engage an independent organisation, the Construction Quality Assurance (CQA) Engineer, to provide CQA services under contract to the Principal, to verify that the Works are undertaken in a manner that meets the requirements of the Contract Documents. This may include independent CQA monitoring, observation, review, and documentation on behalf of the Principal.

The Contractor shall cooperate fully with the Client's Representative and all representatives of the CQA Engineer during any CQA works and shall ensure, at all times, safe access to the Works for the purpose of monitoring, observation, and CQA implementation.

1.9 Work method statements

Prior to the commencement of each type of work, the Contractor shall submit to the Client's Representative work method statements that detail how the work is to be carried out and the plant and equipment proposed.

The Contractor shall submit such work method statements to the Client's Representative at least 5 days prior to undertaking any work addressed by the work method statement.

The Client's Representative may reject the submitted work method statement if, in the opinion of the Client's Representative, the statement does not comply with the Specification or any other Contract Documents provided to the Contractor prior to or during construction.

Where a work method statement is rejected, the Contractor shall revise and resubmit the statement. No work addressed by the work method statement shall be undertaken by the Contractor until the work method statement is approved by the Client's Representative.

Acceptance by the Client's Representative of a proposed work method statement in no way reduces the Contractor's liability to achieve the requirements described in this Specification.

Appendix A contains a schedule of activities for which the Contractor shall produce work method statements.

1.10 Survey requirements

Prior to commencing construction, the Contractor shall establish a survey grid over the Works footprint. The survey grid shall be maximum 10 metre spacing over the works, as well as any locations at which there is a change or break in grade and set out points identified on the Contract Drawings. The elevation of excavated surfaces and placed materials shall be recorded at these grid locations.

Survey data shall be provided to the Client's Representative in graphical and tabular formats. All survey shall be to MGA and levels shall be based on Australian Height Datum (AHD).

Table 1.1 contains a schedule of survey requirements for the Works.

Table 1.1 Survey requirements

Component	Survey requirements
Bulk earthworks	Following completion of clearing and grubbing works, survey the elevation of the completed layer at all grid locations and at any changes in grade.
Revegetation layer (subsoil and topsoil)	Following completion of the subsoil layer, survey the elevation of the completed layer at all grid points and at any changes in grade. Following completion of the topsoil layer, survey the elevation of the completed layer at all grid locations and at any changes in grade. A conformance survey shall also be provided (with consideration to the surveyed elevations of the underlying surface) showing conforming layer thickness within the allowable tolerances.
Surface water and subsoil drains	Following completion of the surface water and subsoil drains, survey the levels and alignments of drain invert and crest levels at maximum 10 m spacing and at any significant changes in grade.

1.11 Witness and hold points

The following information applies to witness and hold points for the Works:

– A hold point is a defined position in the Works beyond which work shall not proceed without mandatory verification and acceptance by the Client's Representative.
– A witness point is a nominated position in the Works where the option of attendance may be exercised by the Client's Representative, after notification of the requirement.
– It shall be the Contractor's responsibility to ensure that all obligations are fulfilled in regard to the witness and hold points within the Contract.
– The Contractor shall give the Client's Representative a minimum two days' notice prior to the required inspection.
– Where the witness or hold point relates to the condition of a surface or installed material, the Contractor shall verify that the completed surface has achieved full conformance with the Contract Documents.
– Witness or hold points may be released for part of the Works Area only, as defined by the Client's Representative, so that the Works can be completed in a sequenced manner. The Client's Representative's approval of the completed items is required prior to the release of each witness or hold point.

Table 1.2 contains a list of activities to which witness and hold points apply.

Table 1.2 Witness and hold points

Item	Description	Witness	Hold
1	**General**		
	Provision of required pre-construction submittals, including general work method statements, management plans and details of proposed testing firm(s)		✓
	Provision of test pitting results for containment cell		✓
2	**Bulk earthworks**		
	Prior to placement of fill material, provision of submittals identified in Section 2.3.1		✓
	Test pitting	✓	
	Subgrade inspection following bulk earthworks		✓
	Surface inspection of completed clay rich fill layer		✓
	Following completion of bulk earthworks, provision of submittals identified in Section 2.3.2		✓
3	**Drainage**		
	Prior to delivery of materials, provision of submittals identified in Section 3.3.1		✓
	Prior to construction of the drainage features, provision of submittals identified in Section 3.3.2		✓
	Inspection of finished features		✓

Item	Description	Witness	Hold
	Following completion of the drainage features, provision of submittals identified in Section 3.3.3		✓
4	**Revegetation layer**		
	Prior to delivery of materials to site, provision of submittals identified in Section 4.3.1		✓
	Prior to placement of subsoil and topsoil, provision of submittals identified in Section 4.3.2		✓
	Prior to revegetation, provision of submittals identified 4.3.3		✓

1.12 Works as Executed Drawings

The Contractor shall provide one (1) set of Works as Executed Drawings, which shall include all corrections and as-constructed information done in a professional draftsman-like manner. All Works as Executed Drawings shall be certified by a Registered Surveyor.

The following Works as Executed Drawings shall be prepared as a minimum:

– Surface contours following clearing and grubbing
– Finished installed contours of the clay rich fill layer
– Finished installed contours of the revegetation layer
– The installed alignments, levels and grades of surface water drains, channels, and culverts.

All Works as Executed Drawings shall include test locations, showing as a minimum the approximate location, identification number, date sampled, and type of testing completed.

1.13 Erosion and sediment control

1.13.1 General

The Contractor shall provide all temporary erosion and sediment controls necessary to protect the areas immediately adjacent to the Works Area from negative impacts.

The removal of temporary erosion and sediment control works shall be the responsibility of the Contractor. The extent of removal of the temporary works shall be confirmed by the Contractor with the Client's Representative before the end of the Contract. Materials used for the temporary erosion and sediment control works shall be removed from the Works Area or otherwise disposed of by the Contractor to the satisfaction of the Client's Representative. Maintenance of permanent control measures entrusted into the care and control of the Contractor by the Contract up until the Date of Practical Completion shall be the responsibility of the Contractor.

1.13.2 Control Plan

It is the Contractor's responsibility to prepare and implement their own erosion and sediment control plan (ESCP) for the Works with consideration to this Specification and the Contract Drawings. The Contractor shall prepare this plan with reference to:

– Landcom (2004) *Managing Urban Stormwater: Soils and Construction – Volume 1* (4th Ed.); informally known as the "Blue Book"
– Department of Environment & Climate Change (2008) *Managing Urban Stormwater: Soils and Construction – Volume 2A, Installation of services*
– Department of Environment & Climate Change (2008) *Managing Urban Stormwater: Soils and Construction – Volume 2B, Waste landfills*
– Department of Environment & Climate Change (2008) *Managing Urban Stormwater: Soils and construction – Volume 2C, Unsealed roads*
– Department of Environment & Climate Change (2008) *Managing Urban Stormwater: Soils and construction – Volume 2D, Main road construction*

– Department of Environment & Climate Change (2008) *Managing Urban Stormwater: Soils and Construction – Volume 2E, Mines and quarries*

The plan shall identify all erosion and sediment control measures the Contractor shall implement during the Works (including staging). The plan shall be submitted to the Client's Representative for review and approval prior to commencing any of the Works (submission of the plan forms a hold point for the Works).

1.13.3 Vegetation establishment

It is noted that erosion and sediment control measures for the Works are crucial following placement of the topsoil layer and prior to vegetation establishment, to prevent any significant erosion of the topsoil layer. The Contractor shall be responsible for establishing suitable controls for managing erosion and sediment control during this period, including inspection of non-vegetated or partially vegetated areas following rain events. The Contractor shall consider relevant guidance provided in the Blue Book when developing and implementing these control measures.

Any erosion of the final landform areas identified following rainfall shall be remediated by the Contractor to the satisfaction of the Client's Representative.

1.14 Site investigation data

The Principal has previously conducted investigations of site conditions. Copies of the investigations have been provided for information only and represent the best available information at the time. The Contractor shall be responsible for any assumptions made based on the data provided.

2. Earthworks

2.1 General

This section contains the technical requirements for earthworks.

The Client's Representative may reject any earthworks that do not meet or exceed the requirements of this section.

Any earthworks rejected by the Client's Representative shall be remediated at the expense of the Contractor.

2.2 Standards

2.2.1 Australian standards

Relevant Australian standards are as follows:

– 1152 Specification for test sieves
– 1289 Methods of testing soils for engineering purposes
– 1289.2.1.1 Determination of the moisture content of a soil - oven drying method
– 1289.3.1.1 Soil classification tests - Calculation of the plasticity index of a soil
– 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving
– 1289.3.6.3 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of fine analysis using a hydrometer
– 1289.3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil
– 1289.5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using standard compactive effort
– 1289.5.6.1 Soil compaction and density tests - Compaction control test - Density index method for a cohesionless material
– 1289.5.7.1 Soil compaction and density tests - Compaction control test - Hilf density ratio and Hilf moisture variation (rapid method)
– 1289.5.8.1 Soil compaction and density tests - Determination of field density and field moisture content of a soil using a nuclear surface moisture density gauge
– 1289.6.7.2 Determination of the permeability of a soil - Falling head method for a remoulded specimen
– 1289.6.7.3 Determination of the permeability of a soil - Constant head method using a flexible wall permeameter
– 1726 Geotechnical site investigations
– 2868 Classification of machinery for earthmoving, construction, surface mining and agricultural purposes
– 3798 Guidelines on earthworks for commercial and residential developments
– 4419 Soil for landscaping and garden use.

2.3 Submittals

2.3.1 Prior to placement of fill material

The Contractor shall submit the following to the Client's Representative for review and approval prior to placement of each type of fill material (per material source):

– Fill material source
– Certification that the fill material is virgin excavated natural material (VENM) or excavated natural material (ENM)

– Pre-qualification test results/reports demonstrating that the fill material complies with the material property requirements of this Specification
– Estimated quantity of material which is represented by the pre-qualification test results/reports
– Survey of the underlying surface in accordance with Section 1.10
– Work method statement(s) for the placement of the fill material, including testing and repair procedures (refer Appendix A).

2.3.2 Following completion of earthworks

The Contractor shall submit the following to the Client's Representative for review and approval following completion of earthworks (per layer and/or segment):

– As-built survey of the completed surface/s showing conforming layer thickness within the allowable tolerances
– CQC testing results/reports showing compliance with the requirements of this Specification
– Defect and repairs log, showing details of all defects identified and any repairs completed.

2.4 Materials

2.4.1 Unsuitable material

Fill material shall not contain any of the following:

– Materials contaminated through past site usage which may contain toxic substances or soluble compounds harmful to water supply or agriculture
– Materials containing substances that can be dissolved or leached out in the presence of moisture, or which undergo volume change or loss of strength when disturbed and exposed to moisture
– Asbestos or materials containing asbestos
– Silts or materials that have the deleterious engineering properties of silt
– Materials containing fire ant infestation/s
– Fill that contains wood, metal, plastic, boulders, or other deleterious material
– Actual or potential acid sulphate soils (ASS)
– High plasticity clays
– Material susceptible to combustion.

2.4.2 Unclassified fill

Unclassified fill material shall:

– Be selectively sourced material from excavation works. Imported material shall not be used unless approved by the Client's Representative. Imported material shall be classed as clean fill
– Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Client's Representative
– Be well graded in accordance with AS 1726
– Comply with the acceptance criteria specified in Table 2.1.

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 2.1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

Table 2.1 Acceptance criteria – unclassified fill

Properties	Test method	Acceptance criteria	Minimum test frequency
Particle size distribution: – Passing 150 mm	AS 114.11, 12, 13 or AS 1289.3.6.1, 3.6.3	100%	Greater of: 1 per 5,000 m^3 of material or 3 per source
California Bearing Ratio (CBR)	AS 1289.5.7.1	>3	Greater of: 1 per 5,000 m^3 of material or 3 per source

2.4.3 Select fill

Select fill material shall:

– Be selectively sourced material from on-site or imported from an approved source. Imported material shall be classed as VENM or ENM
– Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Client's Representative
– Be well graded in accordance with AS 1726
– Comply with the acceptance criteria specified in Table 2.2.

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 2.2 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

Table 2.2 Acceptance criteria – select fill

Property	Test method	Acceptance criteria	Minimum test frequency
Particle size distribution: – Passing 19 mm – Passing 0.075 mm	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	 100% > 25%	Greater of: 1 per 5,000 m^3 of material or 3 per source
Atterberg limits: – Plasticity index – Liquid limit	AS 1289.3.1.1, 3.2.1 & 3.3.1	 8 – 35 ≤ 50	Greater of: 1 per 5,000 m^3 of material or 3 per source
California Bearing Ratio (CBR)	AS 1289.5.7.1	≥ 5	Greater of: 1 per 5,000 m^3 of material or 3 per source
Emerson class	AS 1289.3.8.1	> 3	Greater of: 1 per 5,000 m^3 of material or 3 per source
% Organic content	AS 1289.4.1.1 or Walkley Black method	< 2%	1 per source
pH	AS 1289.4.3.1 or USEPA 9045 (1:5 solution)	4.5 – 8.5	1 per source

2.4.4 Rock mulch

Rock mulch material shall:

– Be selectively sourced material from on-site or imported from an approved source. Imported material shall be classed as VENM or ENM
– Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Client's Representative
– Comprise non-acid forming, clean, sound, and durable rock of nominal 25-150 mm in size, with less than 15% fines content.

2.4.5 Clay rich fill

Clay rich fill material shall:

– Be selectively sourced material from on-site or imported from an approved source. Imported material shall be classed as VENM or ENM
– Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Client's Representative
– Be well graded in accordance with AS 1726
– Comply with the acceptance criteria specified in Table 2.3.

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 2.3 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Client's Representative, a sample of the material shall be provided (per source) and the Client's Representative may undertake an inspection of the material source. The Contractor shall cooperate fully with the Client's Representative to allow this inspection to occur.

Table 2.3 Acceptance criteria – clay rich material

Property	Test method	Acceptance criteria	Minimum test frequency
Saturated hydraulic conductivity – (triaxial)	AS 1289.6.7.3[1]	≤ 10^{-8} m/s	Greater of: 1 per 10,000 m^3 of material or 3 per source
Standard compaction	AS 1289.5.1.1	N/A	Greater of: 1 per 5,000 m^3 of material or 3 per source
Moisture content	AS 1289.2.1.1	N/A	Greater of: 1 per 5,000 m^3 of material or 3 per source
Atterberg limits: – - Plasticity index – - Liquid limit	AS 1289.3.1.1, 3.2.1 & 3.3.1	 ≥ 10 ≤ 50	Greater of: 1 per 5,000 m^3 of material or 3 per source
Particle size distribution: – Passing 50 mm – Passing 19 mm – Passing 0.075 mm – Passing 0.002 mm	AS 1141.11,12,13 or AS 1289.3.6.1, 3.6.3	 100% > 70% > 30% > 15%	Greater of: 1 per 5,000 m^3 of material or 3 per source
Emerson class	AS 1289.3.8.1	> 3	Greater of: 1 per 5,000 m^3 of material or 3 per source
% Organic content	AS 1289.4.1.1 or Walkley Black method	< 2%	Greater of: 1 per 10,000 m^3 of material or 3 per source
pH	AS 1289.4.3.1 or USEPA 9045 (1:5 solution)	5.5 - 7.5	Greater of: 1 per 10,000 m^3 of material or 3 per source
Cation exchange capacity	Rayment & Lyons 2011 15A1	> 10 m Eq/100 mL	Greater of: 1 per 10,000 m^3 of material or 3 per source

[1] Tests to be completed at Optimum Moisture Content, 95% standard Dry Density, effective stress of 30 kPa and applied pressure of 10 kPa.

2.5 Equipment

All earthworks shall be undertaken using conventional earthmoving equipment and methods typical to this type of project. Equipment shall be industry standard and operated in accordance with the equipment manufacturer's instructions.

Blasting is not permitted.

2.6 Quantities

The Contractor shall monitor all earthworks and shall be responsible for verifying the quantities of cut and fill available for constructing the Works.

Quantities of cut and fill provided in the Contract Documents are provided for bidding purposes only and do not account for shrinkage and swell or excess material.

The Contractor shall be responsible for any assumptions made in relation to the nature, hardness, and types of materials to be encountered in excavations and the bulking and compaction characteristics of materials.

2.7 Extent of disturbed areas

The Contractor shall confine machinery operations within the Works Area as shown on the Contract Drawings.

All disturbed, compacted, or spoiled ground outside of the designated Works Area shall be cultivated and sown with an approved grass mix. The Contractor shall ensure that this operation is programmed to enable germination of seed prior to the Date of Practical Completion.

2.8 Lines and levels

All earthworks shall be to the lines and levels shown in the Contract Drawings.

Earthworks shall be trimmed to line and level by machine and/or hand as necessary to produce profiles to the tolerances required.

2.9 Clearing and grubbing

The Contractor shall undertake all clearing and grubbing necessary to execute the Works including all vegetation, both living and dead, all minor man-made structures (such as fences and livestock yards), all rubbish and other materials which, in the opinion of the Client's Representative, are unsuitable for use in the Works, the chipping of the crowns of trees and the branches of shrubs, and the grubbing of trees and stumps from the Works Area. Clearing and grubbing shall also include the disposal of all materials that have been cleared and grubbed. All natural landscape features, including natural rock outcrops, natural vegetation, soil, and watercourses are to remain undisturbed except where affected by the Works.

Cleared vegetation material shall be retained on site (chipped/reused). If required, vegetation for disposal shall be disposed of by the Contractor at a facility approved by the Client's Representative.

During clearing and grubbing works, the Contractor may ascertain material which can be utilised as topsoil for the outlined in this Specification. Subject to approval by the Client's Representative, the Contractor may stockpile this material for use as topsoil. Stockpiling of topsoil shall be undertaken in accordance with Section 2.17.

2.10 Excavation

Excavation shall consist of all excavation required to complete the Works unless separately designated.

Material that is unsuitable for use shall be excavated and disposed by the Contractor as directed by the Client's Representative.

If excavated material is unsatisfactory for its specified use because of high moisture content, the Contractor may be directed by the Client's Representative to either process the material to reduce the moisture content or to remove the material and replace it with suitable material.

Excavation slopes shall be finished in conformance with the lines and grades shown on the Contract Drawings or as re-determined by the Client's Representative on the basis of site inspection and investigation during the works. All debris and loose material shall be removed.

The tops of excavation slopes and the end of excavations shall be rounded where shown on the Contract Drawings.

If the Contractor excavates beyond the slope line and the tolerance applicable, the Contractor shall request, and the Client's Representative may authorise a minor change in the general slope of the surface. This shall not be regarded as a redetermination of the final grades and levels. If the Contractor's request is denied, the Contractor shall submit details of the material and/or methods proposed to restore the specified slope and stability of the surface for approval.

2.11 Filling

Filling includes all operations associated with the preparation of the Works on which fill material is to be placed and the placing and compacting of approved fill material to the alignment, grading and dimensions shown on the Contract Drawings, including any pre-treatment such as breaking down, blending or drying out material containing excess moisture.

All fill shall be placed, spread, mixed, watered and compacted in accordance with the Specification.

The ground surface prepared to receive fill shall be firm and unyielding. This shall be determined by undertaking compaction testing and roll testing.

Prior to filling, the ground surface shall be scarified, disked, or bladed until it is uniform and free from uneven features which may prevent uniform compaction. The scarified ground surface shall then be brought to appropriate moisture content, mixed as required and compacted. If the scarified zone is greater than 300 mm in depth, the excess shall be removed and placed in compacted lifts not greater than 200 mm compacted thickness.

Unless otherwise specified, fill material shall be placed in thin lifts with a maximum compacted lift thickness of 200 mm. Each lift shall be spread evenly and thoroughly mixed to obtain a near uniform condition in each lift. In areas of excess lift thickness, regrading of the surface to the maximum lift thickness shall be completed prior to construction of additional lifts.

Handling and spreading of all fill material shall produce a gradation of the materials when compacted in the fill material to comply with this Specification.

All fill materials shall be placed in such a manner that the distribution and gradation of the materials throughout will be such that the fill will be free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material within the zone.

Where work is interrupted by rain, fill operations shall not be resumed until observations and field tests by the Contractor indicate that the moisture content and density of the in-place fill materials and/or materials intended for placement are within the limits identified in this Specification. This requirement does not preclude the Contractor from disking or aerating excessively wet areas to enhance drying.

2.12 Contaminated material

The Contractor shall excavate designated contaminated materials to achieve the final lines and levels as shown on the Contract Drawings.

All excavated contaminated material shall be transported as a priority to a nominated location as directed by Client's Representative. All excavated contaminated materials will be immediately relocated to the nominated locations.

Stockpiling of contaminated materials is prohibited.

All exposed contaminated materials or contaminated materials used as fill are to be covered with a minimum of 150 mm of suitable fill material by the end of each working day. This includes contaminated materials relocated to locations nominated by the Client's Representative. A suitable alternative approach may be used for covering subject to approval by the Client's Representative.

2.13 Lime amendment

The Contractor shall stabilise the existing surface to a depth of 300 mm using commercial grade agricultural lime (referred to in the REF as 'lower-risk' lime from a water quality impact perspective), unless otherwise approved by the Client's Representative. Prior to delivery of the lime to site, the Contractor shall provide material and source data for the proposed material, to the satisfaction of the Client's Representative.

The Contractor, in consultation with the Client's Representative, shall identify any areas where stabilisation is not feasible due to the presence of natural rock outcrops, steep slopes or similar. In such instances, the lime application rate shall be reviewed by the Client's Representative, with the lime being applied surfically and/or be blended into the overlying material.

Estimated lime quantities are provided in Table 2.4 and shall be finalised as part of the bulk earthworks.

Table 2.4 Estimated liming requirements

Location	Approx. extent of clearing and grubbing (ha)	Total lime (tonnes)
North Mine Ridge, Elliot's	2.71	194
Old Mill	1.7	451
Mill area – *in situ*	3.46	0[A]
Central Mine Area	1.81	365
Creeks and Rail Loading Areas	4.92	610
Minor area or eroded capping on the Northern and Southern Dumps	2.4	8
Containment Cell (comprising material from Mill Area, Railway Station Precinct, Central Mine Area, Old Mill, two site stockpiles and Lead Abatement Areas in Captains Flat)	NA	6,803[B]

[A]: Subject to successful geochemical validation as per details in the *Construction Quality Control Plan.*
[B]: Approximately 9,071 tonnes of an alternate lime amendment is proposed for use in lieu of lime subject to the approval of a Resource Recovery Order and Exemption being issued under the NSW *Protection of the Environment Waste Regulation 2014*.

2.14 Compaction

All fill, with the exception of clay rich fill, shall be compacted at a moisture content of -2 to +2% of optimum moisture content (OMC) in accordance with Table 2.5. Clay rich fill shall be compacted at a moisture content of 0 to +3% of OMC in accordance with Table 2.5.

Table 2.5 Minimum relative compaction

Application	Minimum relative compaction (%)	
	Minimum density ratio (cohesive soils)	Minimum density index (cohesionless soils)
Unclassified fill / select fill	95 std	-
Clay rich fill	95 std	-
Subsoil material	Refer Section 3	-

2.15 Construction quality control testing

Unless stated otherwise, the Contractor shall undertake CQC testing of all fill in accordance with Table 2.6 (general filling works) and Table 2.7 (trench filling works) as a minimum. Sampling locations for testing shall be agreed with the Client's Representative.

The Client's Representative may request additional tests at any time, where in the opinion of the Client's Representative, a deficiency is suspected.

The Client's Representative shall direct the extent of work rejected due to non-conforming CQC test results based on the area represented by the non-conforming test results (with respect to test locations and frequencies). Following a thorough re-working of a non-conforming area, retesting shall be performed by the Contractor to evaluate whether the re-worked area meets the requirements of the Specification. The Contractor shall undertake all necessary remedial work, including retesting, to reinstate the work to the requirements of the Specification. Further details are provided in Section 2.18.

CQC testing for all earthworks shall be carried out by the Contractor's Independent Testing Firm who shall supply reports identifying the material type, the Specification requirements, and associated results.

The Contractor shall maintain a register of in-situ test results, which shall record the following details:

– Test number
– Description of the fill material
– Location/Grids or co-ordinates of the tests
– Lift tested
– Density ratio
– Moisture content
– Method of testing in accordance with AS 1289.

Where tests do not conform to the Specification requirements, retests shall be undertaken, and these shall be clearly identified in the register.

Table 2.6 Construction quality control testing – earthworks (general)

Property	Test method	Minimum test frequency
Moisture content	AS 1289.5.1.1 or AS 1289.5.7.1	Greater of: 1 per layer per 2,500 m^2 or 1 per 500 m^3 or 3 per lift
Dry density	AS 1289.5.8.1 AS 1289.5.1.1 or AS 1289.5.7.1	Greater of: 1 per layer per 2,500 m^2 or 1 per 500 m^3 or 3 per lift

Table 2.7 Construction quality testing – earthworks (trenches)

Property	Test method	Minimum test frequency
Moisture content	AS 1289.5.1.1 or AS 1289.5.7.1	1 per 2 layers per 120 linear metres
Dry density	AS 1289.5.8.1 AS 1289.5.1.1 or AS 1289.5.7.1	1 per 2 layers per 120 linear metres

2.16 Tolerances

Unless specified otherwise, tolerances shall meet the acceptance criteria in Table 2.8.

The Contractor may excavate and re-compact the existing material if necessary, to assist in achieving this tolerance.

Notwithstanding these allowable tolerances, the Contractor shall be responsible for meeting grading requirements across the surfaces of earthworks materials as shown on the Contract Drawings.

Plus (+) refers to the following:

– Elevation: Plus (+) is higher than design
– Layer thickness: Plus (+) is thicker than design
– Depth: Plus (+) is deeper than design
– Width: Plus (+) is wider than design.

Minus (-) refers to the following:

– Elevation: Minus (-) is lower than design
– Layer thickness: Minus (-) is thinner than design
– Depth: Minus (-) is shallower than design
– Width: Minus (-) is narrower than design.

Table 2.8 Tolerances

Element	Measurement	Acceptance criteria
General excavation	Elevation	±100 mm
Embankments/bunds	Elevation	+100, -0 mm
All trenches	Depth Width	+100, -0 mm +100, -0 mm
Revegetation layer	Layer thickness	+100, -0 mm

2.17 Stockpiles

The Contractor shall be responsible for managing stockpiles of fill materials for the Works until the Date of Practical Completion. It is the Contractor's responsibility to prevent the fill material stockpiles to become contaminated with unsuitable material (refer Section 2.4.1) or by other methods (such as fines contamination) which may result in the fill material no longer meeting the relevant acceptance criteria in this Specification. The Client's Representative may organise independent inspections and/or testing of the fill material stockpiles to verify conformance with these requirements. In the opinion of the Client's Representative, if remediation of any contaminated fill materials is not viable then the fill shall be rejected by the Client's Representative and removed from the site at the expense of the Contractor.

All stockpiles shall be located so that drainage from the stockpile flows into the site. Where a stockpile cannot be located such that drainage flows into the site, the stockpile shall have a drainage swale placed on the uphill side of the stockpile to divert surface water from the stockpile area and sediment traps at its base to capture sediment running off the stockpile. These drainage measures shall be constructed as per the Blue Book. Stockpile management shall be considered as part of the ESCP submitted for the Works.

In addition, all stockpiles shall:

– Have maximum slopes not exceeding 1(V):2(H)
– Have rounded shoulders and base of batters to minimise wind and water erosion
– Not be located in areas above any existing drainage infrastructure
– Be surrounded by filter fence.

2.18 Defects and repairs

Compacted fill material with non-conforming CQC test results shall be remediated as Table 2.9. This includes non-conformances resulting from independent testing commissioned by the Client's Representative.

Material with non-conforming CQC test results after remedial work has been implemented (i.e. tested for a second time) shall be removed and replaced.

The Contractor shall submit to the Client's Representative for review a log containing details of any defects identified and repairs carried out.

Table 2.9 Remedial actions for compacted fill

Category	Density ratio result	Density index result	Moisture result	Remedial action[2]
A	Non-conforming by less than 1%	Non-conforming by less than 3%	Conforming	Re-compact (maximum of three passes)
B	Non-conforming by 1% or more	Non-conforming by less than 5%	Conforming, but not more than 1.0% wet of OMC	Rip, re-water, re-compact and re-test
C	Non-conforming by 1% or more	N/A	Pass, but 1.0% or more wet of OMC	Rip, re-compact and re-test
D	Conforming	N/A	Non-conforming	Rip, re-water, re-compact and re-test
E	Non-conforming	Non-conforming by more than 5%	Non-conforming	Remove fill, replace, compact and re-test

2.19 Acceptance

The Contractor shall retain ownership and responsibility for the earthwork activities until final acceptance of earthworks by the Principal.

The earthworks shall be accepted by the Principal when all the following conditions are met:

– The Client's Representative has received, reviewed, and accepted the required as-built surveys of the completed earthworks showing conformance with the Contract Drawings within the allowable tolerances.
– Required submittals are provided by the Contractor to the Client's Representative and approved.
– CQC test results have been received and show compliance with the requirements of this Specification.
– Details of all defects identified, and repairs performed have been submitted to the Client's Representative and approved.
– The Client's Representative has inspected and approved the finished surfaces.

[2] Should the Client's Representative deem the depth of insufficiently compacted material to be greater than can be effectively compacted from the surface, material shall be removed to a depth at which compaction is satisfactory and replaced and compacted in layers

3. Drainage

3.1 General

This section contains the technical requirements for drainage elements including open drainage channels and underground culverts.

All drainage provided is to maintain the cross-sectional flow areas, slopes and lining types indicated in the Contract Drawings to allow for the design flow conveyance and resistance to scour. All drainage is to be constructed to the tolerances as specified in Section 2.16.

3.2 Standards

3.2.1 Australian standards

In addition to Section 2, relevant Australian standards are as follows:

– AS3500 – Plumbing and Drainage
– AS1141 – Methods for Sampling and Testing Aggregates
– Australian Rainfall and Runoff A Guide to Flood Estimation.

3.3 Submittals

3.3.1 Prior to delivery of materials

The Contractor shall submit the following to the Client's Representative for review and approval prior to delivery of drainage materials to site (per material per source):

– Material source.

3.3.2 Prior to construction of drainage features

The Contractor shall submit the following to the Client's Representative for review and approval prior to construction of surface water drainage measures at the site:

– Survey of the underlying surface in accordance with Section 1.10.

3.3.3 Following completion of drainage features

The Contractor shall submit the following to the Client's Representative for review and approval following completion of the drainage features:

– As-built survey of the completed surface/s showing conformance within the allowable tolerances.

3.4 Materials and installation

3.4.1 Erosion control matting

Erosion control matting is to be provided in locations as specified in Contract Drawings. The erosion control matting shall consist of a needle punched, open weave scrim, permanent erosion control mat, made from UV stabilised fibres (Geofabrics Grassroots or approved alternate).

Erosion control matting to be installed in accordance with manufacturer's guidelines including matting installation guide available from the supplier.

3.5 Maintenance

The Contractor shall be responsible for monitoring and maintaining the drainage network for a period of 12 months, with relation to revegetation of channels, scour and the condition of the network after significant rainfall events. A maintenance program shall be undertaken by the Contractor and shall be submitted to the Client's Representative for approval.

Vegetation shall be established as soon as is practicable and shall be timed to correlate to periods of generally low rainfall as far as is practicable.

3.6 Defects and repairs

All repairs shall be undertaken in accordance with the approved work method statement. All repairs shall be verified by the Client's Representative. An inspection of all drainage lines is to be undertaken after all major storm events. The inspection shall include observation for any signs of overflow from the system and any resulting damage. The Contractor shall be responsible for undertaking any repairs required to the satisfaction of the Client's Representative.

Whilst the proposed works reduce the risk of erosion as far as is practicable, erosion still may occur if intense rainfall is experienced before revegetation is complete. During the revegetation stage inspection of the drainage network shall be undertaken after each rainfall event. The Contractor shall be responsible for undertaking any repairs required to the satisfaction of the Client's Representative.

3.7 Acceptance

The Contractor shall retain all ownership and responsibility for the drainage features until final acceptance of all work under this Contract by the Principal.

The drainage features shall be accepted by the Principal when all the following conditions are met:

- Required submittals are provided by the Contractor to the Client's Representative and approved.
- The Contractor has submitted the required as-built surveys of the completed drainage features showing conformance with the Contract Drawings within the allowable tolerances, and this has been approved by the Client's Representative.
- Details of all defects identified, and repairs performed have been provided by the Contractor to the Client's Representative and approved.
- The Client's Representative has inspected and approved the finished surface.

4. Revegetation layer

4.1 General

This section contains the technical requirements for the revegetation layer. The relevant requirements for the revegetation layer in Section 2 shall be considered alongside guidance provided in this section.

The Client's Representative may reject any component of the revegetation layer that do not meet or exceed the requirements of this section.

Any component of the revegetation layer rejected by the Client's Representative shall be remediated at the expense of the Contractor.

4.2 Standards

4.2.1 Australian standards

Relevant Australian standards are as follows:

– 1289 Methods of Testing Soils for Engineering Purposes
– 4419 Soils for Landscaping and Garden Use.

4.3 Submittals

4.3.1 Prior to delivery of materials to site

The Contractor shall submit the following to the Client's Representative for review and approval prior to delivery of materials to site (per material per source):

– Material source
– Certification that the material is VENM or ENM
– Pre-qualification test results/reports demonstrating that the proposed material complies with the material property requirements of this section of the Specification (refer Section 4.4)
– Estimated quantity of material which is represented by the pre-qualification test results/reports
– Certification of the proposed vegetation showing the species, variety, and weight.

4.3.2 Prior to placement of subsoil and topsoil

The Contractor shall submit the following to the Client's Representative for review and approval prior to placement of the subsoil and topsoil materials:

– Survey of the underlying surface in accordance with Section 1.10
– Work method statement for placement of the revegetation layer, including testing and repair procedures.

4.3.3 Prior to seeding and sowing

The Contractor shall submit the following to the Client's Representative for review and approval following placement of seal bearing layer:

– Proposed seed mix
– As-built survey of the completed soil layers showing conforming layer thickness within the allowable tolerances
– CQC testing results/reports for the completed soil layers showing compliance with the requirements of this Specification

– Defect and repairs log for the soil layers, showing details of all defects identified and any repairs completed
– Statement from the supplier/s showing conformance of the seed mixes with the requirements of the Technical Specification.

4.4 Material

4.4.1 Subsoil

Subsoil material shall:

– Be selectively sourced material from on-site or imported from an approved source. Imported material shall be classed as VENM or ENM
– Not contain any unsuitable materials identified in Section 2.4.1 unless approved by the Client's Representative
– Be well graded in accordance with AS 1726
– Comply with the acceptance criteria specified in Table 4.1.

Subsoil shall be a low organic matter material that is well balanced chemically and is not saline, sodic, excessively acidic, calcium deficient or dispersive. The subsoil material is intended to provide improved rooting depth and reduce the likelihood of water logging.

The Contractor shall supply pre-qualification testing results in accordance with the testing frequencies identified in Table 4.1 showing that the proposed material meets the requirements of this table. Samples taken shall be representative of the whole material source and shall be evenly distributed across the material source.

If required by the Client's Representative, a sample of the material shall be provided (per source) and the Client's Representative may undertake an inspection of the material source.

Table 4.1 Acceptance criteria – subsoil

Property	Test method	Acceptance criteria	Minimum testing frequency
Particle size distribution: - Passing 37.5 mm - Passing 13.2 mm - Passing 2.36 mm - Passing 0.075 mm - Passing 0.002 mm	AS1141.11,12,13 or AS1289.3.6.1, 3.6.3	 100% 95 – 100% 80 – 100% 20 – 50% 10 – 30%	Greater of: 1 per 5,000 m^3 of material or 3 per source
Atterberg limits: - Plasticity index - Liquid limit	AS1289.3.1.1, 3.2.1 & 3.3.1	 8 – 35 < 50	Greater of: 1 per 5,000 m^3 of material or 3 per source
Emerson class	AS1289.3.8.1	> 4	Greater of: 1 per 5,000 m^3 of material or 3 per source
% Organic content	AS 1289.4.1.1 or Walkley Black method	2-3%	Greater of: 1 per 10,000 m^3 of material
pH	AS 1289.4.3.1 or USEPA 9045 (1:5 solution)	5.5 – 6.8	Greater of: 1 per 10,000 m^3 of material

4.4.2 Topsoil

Topsoil shall be a 'natural soil or soil blend' in accordance with Table 1 of AS 4419. The Contractor shall provide certified pre-qualification test results from a NATA Accredited Laboratory to show the proposed material meets these requirements.

If required by the Client's Representative, a sample of the material shall be provided (per source) and the Client's Representative may undertake an inspection of the material source.

4.4.3 Seed mix

The Contractor shall submit their proposed seed mix to the Client's Representative for approval prior to use, based on the guidance below.

The long-term objective is that the site would naturally revegetate with native species present in the vicinity such as native grasses, herbs and shrub species found in the grassy woodlands and dry sclerophyll forests of surrounding areas (e.g. similar to the Yanununbeyan State Conservation Area located approximately five kilometres west of Captains Flat). Species shall include silver wattle (*Acacia dealbata*), green wattle (*Acacia mearnsii*), bitter pea (*Daviesia mimisoides*), dogwood (*Cassinia sp*.), bush pea (*Pultenaea procumbens*), tussock grass (*Poa labillardierer*) and redanther wallaby grass (*Joycea pallida*).

To ensure initial site stabilisation following neutralisation and capping (and reduce erosion and weed colonisation risk), a sterile 'nurse' crop of pioneer species, including non-native grasses, shall also be utilised. These species shall include Japanese millet, oats, couch, tall fescue, and perennial rye grass. As the native vegetation develops, these pioneer species consisting of non-native grasses shall decrease or disappear altogether.

4.5 Surface preparation

Prior to placement of the revegetation layer, the receiving surface shall be cleared of any debris and/or foreign material.

The receiving surface shall be surveyed as per the requirements of Section 1.10.

Placement of the revegetation layer shall not proceed until the receiving surface has been approved by the Client's Representative.

4.6 Installation

4.6.1 Subsoil

The Contractor shall prepare a work method statement for placement of the subsoil layer outlining the placement methodology and proposed construction plant to be used (refer Appendix A).

The subsoil shall be placed in thin lifts with a maximum compacted layer thickness of 200 mm, in accordance with lift thickness, compaction and moisture content requirements identified in Section 2.14. Each layer shall be spread evenly and thoroughly mixed to obtain a near uniform condition in each layer. In areas of excess lift thickness, regrading of the surface to the maximum lift thickness will be completed prior to construction of additional lifts.

4.6.2 Topsoil

The Contractor shall prepare a work method statement for placement of the topsoil layer outlining the placement methodology and proposed construction plant to be used (refer Appendix A). The work method statement and construction methodology for the topsoil layer shall be developed in accordance with the guidance provided below:

- The Contractor shall cover trucks transporting the topsoil material to prevent loss of material during transport. The Contractor shall ensure trucks do not allow loss of material through tailgates or other parts of the truck body.
- Topsoil shall be spread evenly in one layer over the designated areas and compacted lightly and uniformly so that the finished surface is smooth and free of stones or other lumps, weeds, rubbish and other deleterious material brought to the surface. Excessive compaction shall be avoided.
- Once placed, the topsoil surface shall be thoroughly watered. Regular watering shall be conducted by the Contractor to minimise establishment time for the vegetation and mitigate any erosion risks. Watering shall continue to be conducted until the vegetation has been established to the satisfaction of the Client's Representative.
- The equipment used for placing and spreading of materials shall be suitable for the purpose. Low pressure tyred vehicles shall be used. Graders and other high-pressure tyred vehicles equipment shall not be used.

The Contractor shall vary the routes of vehicles and other plant passing over completed areas of each soil profile layer to avoid areas of excess compaction.

– Where topsoil is placed on batters with grades of 1(V):5(H) or greater, topsoil shall be placed from the bottom of the batter upwards and perpendicular to the contour lines.

4.7 Seeding and sowing

Revegetation shall be completed in accordance with the supplier's requirements, guidance from the erosion control matting manufacturer on installation sequencing, and the following guidance (as a minimum):

– Grass seed shall be sown in accordance with the supplier's requirements and/or achieve a minimum 70% cover per square meter (whichever is greater).
– Seeding outside of the specified areas shall be prevented.
– After sowing the topsoil surface shall be lightly raked to cover the surface and the area watered immediately.
– Watering shall continue throughout the establishment period in accordance with the supplier's requirements.
– This area shall be protected from pedestrians or animals until the grass has established, and from vehicles or heavy plant at all times.

The Contractor shall submit to the Client's Representative their proposed vegetation mix based on a list of local species provided in the design documentation, and this mix shall be finalised in consultation with the Client's Representative prior to use. Alternative revegetation approaches may be implemented at the discretion of the Client's Representative in consultation with the Designer.

Where required, the Contractor shall be responsible for installing temporary erosion control and protection measures (such as Class 1 or Class 2 erosion control blankets, mats or hydroseeded grass species) during the vegetation establishment phase.

4.8 Maintenance

The Contractor shall be responsible for maintaining the revegetation for a maintenance period of 12 months. A maintenance program shall be undertaken by the Contractor to assist vegetation establishment. This shall include activities such as watering, herbicide spraying and general maintenance.

The Contractor shall submit their proposed maintenance program for the revegetation to the Client's Representative for approval prior to seeding.

4.9 Defects and repairs

Any areas of placed revegetation layer that do not conform to the required compaction and moisture content testing criteria shall be repaired by the Contractor to the satisfaction of the Client's Representative.

The Contractor shall submit to the Client's Representative for review details of any defects identified and repairs carried out.

4.10 Acceptance

The Contractor shall retain ownership and responsibility for the revegetation layer until final acceptance of all work under this Contract by the Principal.

The topsoil layer shall be accepted by the Principal when all the following conditions are met:

– Required lines, levels and thickness of the topsoil layer has been achieved within the allowable tolerances as confirmed by survey data
– Required submittals are provided by the Contractor to the Client's Representative and approved
– CQC test results have been received and show compliance with the requirements of this Specification
– Revegetation requirements of the topsoil layer have been met

– Details of all defects identified, and repairs performed have been submitted to the Client's Representative and approved
– The Client's Representative has inspected and approved the finished surface.

Appendix A

Schedule of Work Method Statements

Component	Work method statement requirements
General	The Contractor shall prepare the following general work method statement for review approval by the Client's Representative with consideration to the following: – Scheduling – Site access and traffic control – Survey control – Traffic management – Environmental management – Surface water management – Erosion and sediment control.
Earthworks	The Contractor shall prepare an earthwork work method statement for review approval by the Client's Representative with consideration to the following: – Scheduling – Removal of vegetation – Test pitting – Excavation of earthworks – Processing of earthworks – Filling of earthworks materials – Supply and quality control – Stabilisation – Stockpile management and control measures – Method of moisture conditioning, material placement and compaction for earthworks material – Earthworks material layer thickness control and survey – Trimming and final surface preparation – Defects and repairs – Quality control testing.
Drainage	The Contractor shall prepare a drainage work method statement for review approval by the Client's Representative with consideration to the following: – Scheduling – Supply and quality control – Method of material placement – Surface preparation – Material layer thickness control and survey – Trimming and final surface preparations – Defects and repairs – Quality control testing.
Revegetation layer	The Contractor shall prepare a revegetation layer work method statement for review approval by the Client's Representative with consideration to the following: – Scheduling – Supply and quality control – Method of material placement – Surface preparation – Material layer thickness control and survey – Trimming and final surface preparations – Defects and repairs – Quality control testing.

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Appendix B

Bill of Quantities

Bill of Quantities

Client: Department of Regional NSW
Project: Lake George Mine Cap and Water Treatment Design
Subject: Bill of Quantities

Project Number: 2127816
Prepared by: N. Griffiths
Checked by: C Nivison-Smith

Revision:
Date of issue: 23-Mar-22

ID	Description	Quantity	Unit	Rate	Amount	Reference and notes
1	**General**					
1.01	Mobilisation	1	Item			
1.02	Preparation of construction program, management plans, WHS plans, method statements, ITPs, construction management, site meetings, approvals, etc.	1	Item			
1.03	Stormwater and sediment and erosion control measures, including development and implementation of a erosion and sediment control plan	1	Item			
1.04	Structural inspections and monitoring	1	item			
1.05	Survey	1	Item			
1.06	Vegetation maintenance	1	item			
2	**North Mine ridge, Elliot's area**					
2.01	Clearing and grubbing	27,100	m2			Refer labelled capping area in sketch
2.02	Bulk earthworks					
2.02a	Cut and relocate stockpile to containment cell area	2,710	m3			PROVISIONAL ESTIMATE (average of 1 m excavation across 10% of the area). Contaminated materials, as directed by the Client's Representative
2.02b	Excavate stockpile and relocate to containment cell area	360	m3			Northern stockpile. Contaminated materials, as directed by the Client's Representative
2.03	Lime amendment					
2.03a	Supply lime amendment	194	t			PROVISIONAL ESTIMATE
2.03b	Spread and till lime to amend subgrade surface	27,100	m2			
2.04	Capping Profile - Type 2					50% of capping area
2.04a	Supply and install 200 mm thick subsoil layer	2,710	m3			
2.04b	Supply and install 100 mm thick topsoil layer	1,355	m3			
2.04c	Revegetate as per Technical Specification	13,550	m2			
2.05	Capping Profile - Type 3					50% of capping area
2.05a	Supply and install separation geotextile	13,550	m2			
2.04b	Supply and install rock mulch	4,065	m3			
3	**Mill area**					
3.01	Clearing and grubbing	34,600	m2			Refer labelled capping area in sketch. Excluding existing structures
3.02	Earthworks					
3.02a	Cut and relocate to containment cell area	34,600	m3			PROVISIONAL ESTIMATE (assume 1 m depth across area). Contaminated materials, as directed by the Client's Representative
3.03	Capping Profile - Type 2					Excluding existing structures, 65% of capping area
3.03a	Supply and install 200 mm thick subsoil layer	4,498	m3			
3.03b	Supply and install 100 mm thick topsoil layer	2,249	m3			
3.03c	Revegetate as per Technical Specification	22,490	m2			

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ID	Description	Quantity	Unit	Rate	Amount	Reference and notes
2.05	Capping Profile - Type 3					Excluding existing structures, 35% of capping area
2.05a	Supply and install separation geotextile	12,110	m2			
2.04b	Supply and install rock mulch	3,633	m3			
4	**Old Mill area**					
4.01	Clearing and grubbing	17,000	m2			Refer labelled capping area in sketch
4.02	Earthworks					
4.02a	Cut to fill in oversteepened area	100	m3			Contaminated materials, as directed by the Client's Representative
4.02b	Cut and relocate to containment cell area	2,900	m3			Contaminated materials, as directed by the Client's Representative
4.03	Lime amendment					
4.03a	Supply lime amendment	451	t			PROVISIONAL ESTIMATE
4.03b	Spread and till lime to amend subgrade surface	17,000	m2			
4.04	Capping Profile - Type 2					
4.04a	Supply and install 200 mm thick subsoil layer	2,820	m3			
4.04b	Supply and install 100 mm thick topsoil layer	1,410	m3			
4.04c	Revegetate as per Technical Specification	14,100	m2			
4.05	Capping Profile - Type 3					
4.05a	Supply and install separation geotextile	2,400	m2			
4.05b	Supply and install rock mulch	720	m3			
4.06	Capping Profile - Type 4					
4.06a	Supply and install 200 mm thick subsoil layer	100	m3			
4/06b	Supply and install 100 mm thick topsoil layer	50	m3			
4.06c	Supply and install cellular confinement system	500	m2			
4.06d	Revegetate as per Technical Specification	500	m2			
5	**Central Mine area**					
5.01	Clearing and grubbing	18,100	m2			Refer labelled capping areas in sketch (five combined areas)
5.02	Earthworks					
5.02a	Cut to fill in oversteepened area	1,500	m3			Contaminated materials, as directed by the Client's Representative
5.02b	Cut and relocate to containment cell area	6,700	m3			Contaminated materials, as directed by the Client's Representative
5.03	Lime amendment					
5.03a	Supply lime amendment	365	t			PROVISIONAL ESTIMATE
5.03b	Spread and till lime to amend subgrade surface	18,100	m2			
5.04	Capping Profile - Type 2					Refer labelled capping areas in sketch (two combined areas, noting portion of mixed capping area)
5.04a	Supply and install 200 mm thick subsoil layer	820	m3			
5.04b	Supply and install 100 mm thick topsoil layer	410	m3			

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ID	Description	Quantity	Unit	Rate	Amount	Reference and notes
5.04c	Revegetate as per Technical Specification	4,100	m2			
5.05	Capping Profile - Type 3					Refer labelled capping areas in sketch (three combined areas, noting portion of mixed capping area)
5.05a	Supply and install separation geotextile	13,200	m2			
5.05b	Supply and install rock mulch	3,960	m3			
5.06	Capping Profile - Type 4					Refer labelled capping area in sketch
5.06a	Supply and install 200 mm thick subsoil layer	160	m3			
5.06b	Supply and install 100 mm thick topsoil layer	80	m3			
5.06c	Supply and install cellular confinement system	800	m2			
5.06d	Revegetate as per Technical Specification	800	m2			
6	**Creeks and Rail Loading area**					
6.01	Clearing and grubbing	49,200	m2			Refer labelled capping areas in sketch (two combined areas)
6.02	Lime amendment					
6.02a	Supply lime amendment	610	t			PROVISIONAL ESTIMATE
6.02b	Spread and till lime to amend subgrade surface	49,200	m2			
6.03	Capping Profile - Type 2					Refer labelled capping area in sketch
6.03a	Supply and install 200 mm thick subsoil layer	9,390	m3			
6.03b	Supply and install 100 mm thick topsoil layer	4,695	m3			
6.03c	Revegetate as per Technical Specification	46,950	m2			
6.04	Capping Profile - Type 3					Refer labelled capping area in sketch
6.04a	Supply and install separation geotextile	2,250	m2			
6.04b	Supply and install rock mulch	675	m3			
7	**Captain's Flat Railway Precinct**					
7.01	Clearing and grubbing	10,000	m2			Refer labelled capping area in sketch, assume 2x excavation volume (0.5 m excavation)
7.02	Earthworks					
7.02a	Cut and relocate to containment cell area	5,000	m3			PROVISIONAL ESTIMATE, provided by others. Contaminated materials, as directed by the Client's Representative
7.03	Capping Profile - Type 2					Based on estimated capping area (see above)
7.03a	Supply and install 400 mm thick subsoil layer	4,000	m3			Fill to grade with 0.5 m excavation
7.03b	Supply and install 100 mm thick topsoil layer	1,000	m3			Fill to grade with 0.5 m excavation
7.03c	Revegetate as per Technical Specification	10,000	m2			
8	**Minor area or eroded capping on the Northern and Southern Dumps**					
8.01	Clearing and grubbing	20,400	m2			PROVISIONAL ESTIMATE. Refer labelled capping area in sketch. 5% of total dumps area plus southern stockpile (excluding containment cell area)
8.02	Earthworks					

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Revision:
Date of issue: 23-Mar-22

ID	Description	Quantity	Unit	Rate	Amount	Reference and notes
8.02a	Excavate stockpile and relocate to containment cell area	1,200	m3			Southern stockpile. Contaminated materials, as directed by the Client's Representative
8.03	Lime amendment					
8.03a	Supply lime amendment	8	t			PROVISIONAL ESTIMATE
8.03b	Spread and till lime to amend subgrade surface	20,400	m2			
8.04	Capping Profile - Type 1					5% of total dumps area
8.04a	Supply and install 300 mm thick clay rich fill	3,450	m3			
8.04b	Supply and install 200 mm thick subsoil layer	2,300	m3			
8.04c	Supply and install 100 mm thick topsoil layer	1,150	m3			
8.04d	Revegetate as per Technical Specification	11,500	m2			
8.05	Capping Profile - Type 2					50% of southern stockpile
8.05a	Supply and install 200 mm thick subsoil layer	890	m3			
8.05b	Supply and install 100 mm thick topsoil layer	445	m3			
8.05c	Revegetate as per Technical Specification	4,450	m2			
8.06	Capping Profile - Type 3					50% of southern stockpile
8.06a	Supply and install separation geotextile	4,450	m2			
8.06b	Supply and install rock mulch	1,335	m3			
9	**Containment cell**					
9.01	Clearing and grubbing	28,700	m2			Based on possible maximum area
9.02	Strip existing capping material and stockpile for reuse, reuse for capping	17,220	m3			PROVISIONAL ESTIMATE
9.03	Alternate alkaline amendment					
9.03a	Supply alternate alkaline amendment	9,071	t			PROVISIONAL ESTIMATE
9.03b	Incorporate alternate alkaline amendment through contaminated material prior to placement	58,470	m3			Including additional material from CF lead abatement areas (estimate provided by others)
10	**Surface water management**					
10.01	Install toe drains	870	m			Refer DRG C004
10.02	Rebuild and re-establish drains in Mill area	720	m			PROVISIONAL ESTIMATE
10.03	Install subsoil drains	150	m			PROVISIONAL ESTIMATE
10.04	Supply and install fibre rolls for erosion protection (open cut component in North Mine ridge, Elliot's area)	100	m			PROVISIONAL ESTIMATE

Notes:

1 Based on surface contours accessed from NSW Government LIDAR data dated March 2018
2 Excludes bulking and wastage
3 For tendering purposes only

Appendix C

Safety in Design Risk Register

HSE040 Safety in Design Risk Assessment

Notes: *Designs with significant quantities of dangerous goods may require detailed risk assessments under Dangerous Goods or Major Hazard legislation
* Most industrial processes will require an industry specific assessment, e.g. HAZOP and/or Quantitative Risk Assessment for facilities that have chemical or high-pressure processes under Dangerous Goods or Major Hazard legislation.

Design Life Cycle:	Investigation and Design	Setup, Construction and Commissioning	Operation	Maintenance	Disposal		Date:	30/10/2020	Revision No:	0
Job Name:	Captains Flat Capping and Revegetation Works		Job No:	21-27816	Client	Department of Planning, Industry and Environment	Design:	Capping and Revegetation Works		
People involved in Risk Assessment:	N Griffiths, C Nivison-Smith, S Winchester									

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	L	RR	Potential Control Measures (Consider Hierarchy of Control Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	L	RR	Comments
Investigation and Design															
101a	Investigation and Design	Exposure of site workers to existing contaminated materials during construction works	Physical injury and illness due to uncontrolled exposure, including inhaling or coming into contact with the contaminated sediment	Existing cover and capping layers (partial)	C	3	Moderate	- Minimise relocation of mineral waste during earthworks design - Include provisions in the construction documentation for Contractor to prepare work method statements for contaminated material relocation	Designer	During design phase	Control measures included in Design Documentation	B	3	Low	
101b	Investigation and Design	Exposure of site workers to existing contaminated materials during construction works	Physical injury and illness due to uncontrolled exposure, including inhaling or coming into contact with the mineral waste	Existing cover and capping layers (partial)	C	3	Moderate	- Include provisions in the construction documentation for Contractor to prepare safety plans and environmental management plans with regards to contaminated material exposure, relocation and filling - Provide results of previous investigations	Principal	During design phase	To be addressed by Principal	B	3	Low	
102a	Investigation and Design	Risks to off-site receptors associated with relocating contaminated materials	Physical injury and illness due to uncontrolled exposure, including inhaling or coming into contact with the contaminated material	Existing cover and capping layers (partial)	C	3	Moderate	- Minimise relocation of mineral waste during earthworks design - Include provisions in the construction documentation for Contractor to prepare work method statements for contaminated material relocation	Designer	During design phase	Control measures included in Design Documentation	B	3	Low	
102b	Investigation and Design	Risks to off-site receptors associated with relocating contaminated materials	Physical injury and illness due to uncontrolled exposure, including inhaling or coming into contact with the contaminated material	Existing cover and capping layers (partial)	C	3	Moderate	- Include provisions in the construction documentation for Contractor to prepare safety plans and environmental management plans with regards to contaminated material exposure, relocation and filling - Provide results of previous investigations	Principal	During design phase	To be addressed by Principal	B	3	Low	

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	L	RR	Potential Control Measures (Consider Hierarchy of Control Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	L	RR	Comments
103	Investigation and Design	Uncontrolled release of site contaminants during the Works (including contaminated waters, sediment laden water, dust)	- Contamination to local water sources resulting in injury, illness or death of wildlife or damage to environment - Dust causing disamenity and discomfort to off-site residents and fauna	Some sediment contained below existing water body	D	3	Significant	- Include provisions in the construction documentation for Contractor to prepare safety plans and environmental management plans with regards to the mitigating release of site contaminants, including monitoring requirements - Provide results of previous investigations	Principal	During design phase	To be addressed by Principal	C	2	Low	
104	Investigation and Design	Landform slopes become unstable resulting in slumping and/or landslides, causing injury to on-site workers	- Physical injury to on-site workers due to being struck or buried by soil - Release of contaminats due to cap failure from slumping	None	D	3	Significant	- Regrading of oversteepened areas designed at a grade of (1(V):2(H) max) to mitigate slope instability - Cellular confinement systems included in design to reduce stability risk	Designer	During design phase	Control measures included in Design Documentation	C	2	Low	
Setup, Construction and Commissioning															
201	Setup, Construction and Commissioning	Exposure of site workers to existing contaminated materials during construction works	Physical injury and illness due to uncontrolled exposure, including inhaling or coming into contact with the contaminated sediment	Existing cover and capping layers (partial)	C	3	Moderate	- Develop and implement appropriate work health and safety plan, environmental management plan and work method statements to address safety measures for managing exposure, excavation and relocation of contaminated materials	Contractor	Prior to and during construction works	Required by Specification and other Contract Documents	B	3	Low	
202	Setup, Construction and Commissioning	Risks to off-site receptors associated with relocating contaminated materials	Physical injury and illness due to uncontrolled exposure, including inhaling or coming into contact with the contaminated sediment	Existing cover and capping layers (partial)	C	3	Moderate	- Develop and implement appropriate work health and safety plan, environmental management plan and work method statements to address safety measures for managing exposure, excavation and relocation of contaminated materials - Environmental monitoring during the construction works as required	Contractor	Prior to and during construction works	Required by Specification and other Contract Documents	B	3	Low	
205	Investigation and Design	Uncontrolled release of site contaminants during the Works (including contaminated waters, sediment laden water, dust)	- Contamination to local water sources resulting in injury, illness or death of wildlife or damage to environment - Dust causing disamenity and discomfort to off-site residents and fauna	Existing cover and capping layers (partial)	D	3	Significant	- Develop and implement appropriate work health and safety plan, environmental management plan and work method statements to address safety measures with regards to the mitigating release of site contaminants, including monitoring requirements - Environmental monitoring during the construction works as required	Contractor	Prior to and during construction works	Required by Specification and other Contract Documents	C	2	Low	
207	Setup, Construction and Commissioning	Vehicle accident due to passing on-site traffic/earthmoving equipment	Injury/death from collision	Fencing/restricted access to site	E	3	Extreme	- Develop and implement appropriate work health and safety plan and work method statements to address safety measures for managing earthworks/traffic movements during the construction works	Contractor	Prior to and during construction works	Required by Specification and other Contract Documents	C	2	Low	
Maintenance															

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	L	RR	Potential Control Measures (Consider Hierarchy of Control Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	L	RR	Comments
303	Maintenance	Vegetation dieback and/or erosion of placed topsoil materials, resulting in exposure of mineral waste in revegetated areas	- Physical injury and illness due to uncontrolled exposure (including inhaling or coming into contact with the waste) - Contamination to local water sources resulting in injury, illness or death of wildlife or damage to environment	Existing cover and capping layers (partial)	C	3	Moderate	- Develop and implement plan to regularly inspect and maintain on-site vegetation - Develop and implement plan to regularly inspect and repair any damage caused by erosion to the topsoil layer	Principal	After construction works as required	To be addressed by Principal	C	2	Low	

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Appendix C

Transport and Infrastructure SEPP consultation requirements

Council related infrastructure or services

The existing SEPPs have been consolidated into 11 policies from 1 March 2022. The original *State Environmental Planning Policy (Infrastructure) 2007* has now been consolidated into the *State Environmental Planning Policy (Transport and Infrastructure) 2021*.

TISEPP section	Yes	No
Section 2.10, council related infrastructure or services – consultation with council		
Will the work:		
Potentially have a substantial impact on stormwater management services provided by council?		X
Be likely to generate traffic that will strain the capacity of the road system in the LGA?		X
Involve connection to, and have a substantial impact on, the capacity of a council owned sewerage system?		X
Involve connection to, and use of a substantial volume of water from a council owned water supply system?		X
Involve installation of a temporary structure on, or enclosing, a public space under council's control that will cause a disruption to pedestrian or vehicular traffic that is not minor or inconsequential?		X
Involve excavation of the surface of, or a footpath adjacent to, a road for which the council is the roads authority that is not minor or inconsequential?	Yes	
Section 2.11, local heritage – consultation with council		
Is the work likely to affect the heritage significance of a local heritage item, or of a heritage conservation area (not also a State heritage item) more than a minor or inconsequential amount?	X	
Section 2.12, flood liable land – consultation with council		
Will the work be located on flood liable land (that is land that is susceptible to flooding by the probable maximum flood event) and will they alter flood patterns other than to a minor extent?		X
Section 2.13, flood liable land – consultation with State Emergency Services		
Will the work be located on flood liable land (ie. land that is susceptible to flooding by the probable maximum flood event) and undertaken under a relevant provision*, but not the carrying out of minor alterations or additions to, or the demolition of, a building, emergency works or routine maintenance? * (e) Div.14 (Public admin buildings), (g) Div. 16 (Research/ monitoring stations), (i) Div. 20 (Stormwater systems)?		X
Section 2.14, development with impacts on certain land within the coastal zone– council consultation		
Is the work on land mapped as coastal vulnerability area and inconsistent with a certified coastal management program?		X
Section 2.15, consultation with public authorities other than councils		
Will the proposal be located on land adjacent to land reserved under the *National Parks and Wildlife Act 1974* or to land acquired under Part 11 of that Act*? If so, consult with DPIE (NPWS).*		X
Will the proposal be located on land in Zone E1 National Parks and Nature Reserves or in a land use zone that is equivalent to that zone? *If so, consult with DPIE (NPWS)*		X
Will the proposal be adjacent to an aquatic reserve or a marine park declared under *Marine Estate Management Act 2014? If so, consult with the Department of Industry.*		X
Will the proposal be in the foreshore area within the meaning of the *Sydney Harbour Foreshore Authority Act 1998? If so, consult with Sydney Harbour Foreshore Authority*		X
Will the proposal comprise a fixed or floating structure in or over navigable waters? If so, consult *TfNSW*		X
Will the proposal be located on land in a mine subsidence district within the meaning of the *Coal Mine Subsidence Compensation Act 2017*? *If so, consult with Subsidence Advisory NSW.*		X
Will the proposal involve clearing of native vegetation on land that is not subject land (ie non-certified land)? *If so, notify DPIE at least 21 days prior to work commencing. (Requirement under s3.24 Chapter 3 Sydney Region Growth Centres - of the SEPP (Precincts – Central River City) 2021.*		X

Note: Flood liable land means land that is susceptible to flooding by the probable maximum flood event, identified in accordance with the principles set out in the manual entitled *Floodplain Development Manual: the management of flood liable land* published by the New South Wales Government.

Appendix D

Consideration of clause 171(2) factors and matters of national environmental significance

Clause 171(2) Checklist

Factor	Impact
(a) Any environmental impact on a community? The majority of nearby receivers are located nearby Captains Flat township. Impacts may occur due to construction generating noise, vibration, dust and traffic. However, these impacts are likely to be limited, would be temporary in nature and would be mitigated with the implementation of mitigation measures. The proposal would reduce the amount of contaminants which are discharged into the surrounding environment including downstream areas. This would benefit these communities as water quality in downstream watercourses would be improved. The proposal would also improve the public health and safety of Captains Flat.	Short-term negative Long-term positive
(b) Any transformation of a locality? The proposal is not considered to transform the locality as Lake George Mine would generally remain as they currently stand. Any works are considered to improve Lake George Mine.	Nil
(c) Any environmental impact on the ecosystem of the locality? The proposal would result in the removal or modification of vegetation which consists largely of exotic grassland. Small areas of native vegetation such as Box Gum Woodland and Broad-leaved Peppermint Mountain Gum Forest may also be impacted. Overall, the proposal would result in the removal of about 0.04 hectares of Box Gum Woodland. This removal would not result in a significant impact to threatened ecological community. Where possible vegetation removal would be minimised. Following the remediation works rehabilitation through revegetation with native species would occur, thereby improving biodiversity upon completion of the proposal. Impacts on ecosystems are discussed further in section 6.2.	Short-term negative
(d) Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality? During the construction phase (i.e. remediation works) there would be some visual impacts associated with the remediation works, plant and equipment and the establishment of work areas. Overall, the proposal would result in the removal of small areas of Box Gum Woodland and Broad-leaved Peppermint Mountain Gum Forest. Overall, about 0.04 hectares of Box Gum Woodland would be removed. This removal would not result in a significant impact to this community. Following the remediation works, visual impacts are not considered substantial as views to, from and within the proposal site would not vary substantially from the existing situation. However, rehabilitation of the site would occur following the works, including revegetation. There would be some positive impacts from the revegetation and planting in currently cleared areas.	Short-term negative Long-term positive
(e) Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations? The proposal would result in impacts within the site which contain non-Aboriginal heritage items of local significance as discussed in section 6.4.3. These locally significant sites would be maintained as much as possible. Overall, the proposal is not considered to substantially impact upon the heritage significance of Lake George Mine (refer to the Heritage Assessment in Appendix O).	Short-term negative
(f) Any impact on the habitat of protected animals (within the meaning of the *Biodiversity Conservation Act 2016*)? The proposal is unlikely to impact any protected animals. However, cave roosting microbats may roost within derelict mine structures proposed for removal. Seasonal surveys will be used to determine any presence of roosting habitat for microbat species in derelict mine structures, with additional mitigation measures to be incorporated if present.	Nil

Factor	Impact
(g) Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air?	
The proposal is considered unlikely to endanger any species of flora or fauna due to the minimal amount of vegetation to be removed and the presence of large areas of additional habitat present in the locality and immediately adjacent to the proposal site.	Nil
Threatened cave roosting microbats may roost within derelict mine structures proposed for removal. However, none were confirmed as roosting during the site surveys. The potential roosting habitat that would be removed in the loading tunnel and concentrate bins would comprise a small proportion of the habitat available in the locality.	
Seasonal surveys will be used to determine any presence of roosting habitat for microbat species in derelict mine structures, with additional mitigation measures to be incorporated if present.	
(h) Any long-term effects on the environment?	
The proposal would not result in any adverse effects on the environment in the long-term. However, the proposal would result in an improvement in the Lake George Mine environment and the water quality of the site's run off.	Long-term positive
(i) Any degradation of the quality of the environment?	
Areas of the existing proposal site are heavily degraded as a result of past mining and processing activities. During the remediation works the quality of the environment would be temporarily reduced due to the potential for erosion and sedimentation. Such impacts would be mitigated through the implementation of appropriate mitigation measures specified herein.	Short term negative
The proposal would, however, improve the quality of the environment through the removal and containment of contaminated material at Lake George Mine.	Long-term positive
(j) Any risk to the safety of the environment?	
The proposal would involve the disturbance of contaminated material which could potentially result in health impacts to workers and the surrounding community. The remediation works would, however, be undertaken in line with the RAP (refer to URS, 2004) and would seek to minimise any impacts to public health.	Short-term negative
Following the remediation works, the proposal site is considered to be safer due to the removal of contaminants at Lake George Mine which currently pose a health risk to nearby residents and users of Molonglo River water.	Long-term positive
(k) Any reduction in the range of beneficial uses of the environment?	
The proposal would not impact on the use of the land. Indeed, the proposal would improve land use at the site. The proposal would make the area safer for use by tourists.	Nil
(l) Any pollution of the environment?	
The proposal would potentially result in air, noise and water pollution during construction; however, these impacts are considered minimal due to the isolated nature of works, short term impacts at any one location and the implementation of mitigation measures.	Short-term negative
During operation (i.e. post remediation), pollution is considered to be minimal and similar to the operation of the existing transmission line.	Nil
(m) Any environmental problems associated with the disposal of waste?	
Overall, the proposal seeks to more effectively manage contaminated waste to ensure off-site impacts are minimised.	Short-term negative.
Domestic waste excavated from the Lake George mine would be disposed of at an appropriately licenced landfill.	Long-term positive
Sewage waste from construction ablution facilities would be managed through a licenced contractor.	
(n) Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply?	
All resources required would not be in short supply and would be readily available.	Nil
(o) Any cumulative environmental effects with other existing or likely future activities?	
No existing or future activities are expected to occur in conjunction with the proposal and would therefore not result in cumulative environmental or social impacts.	Nil

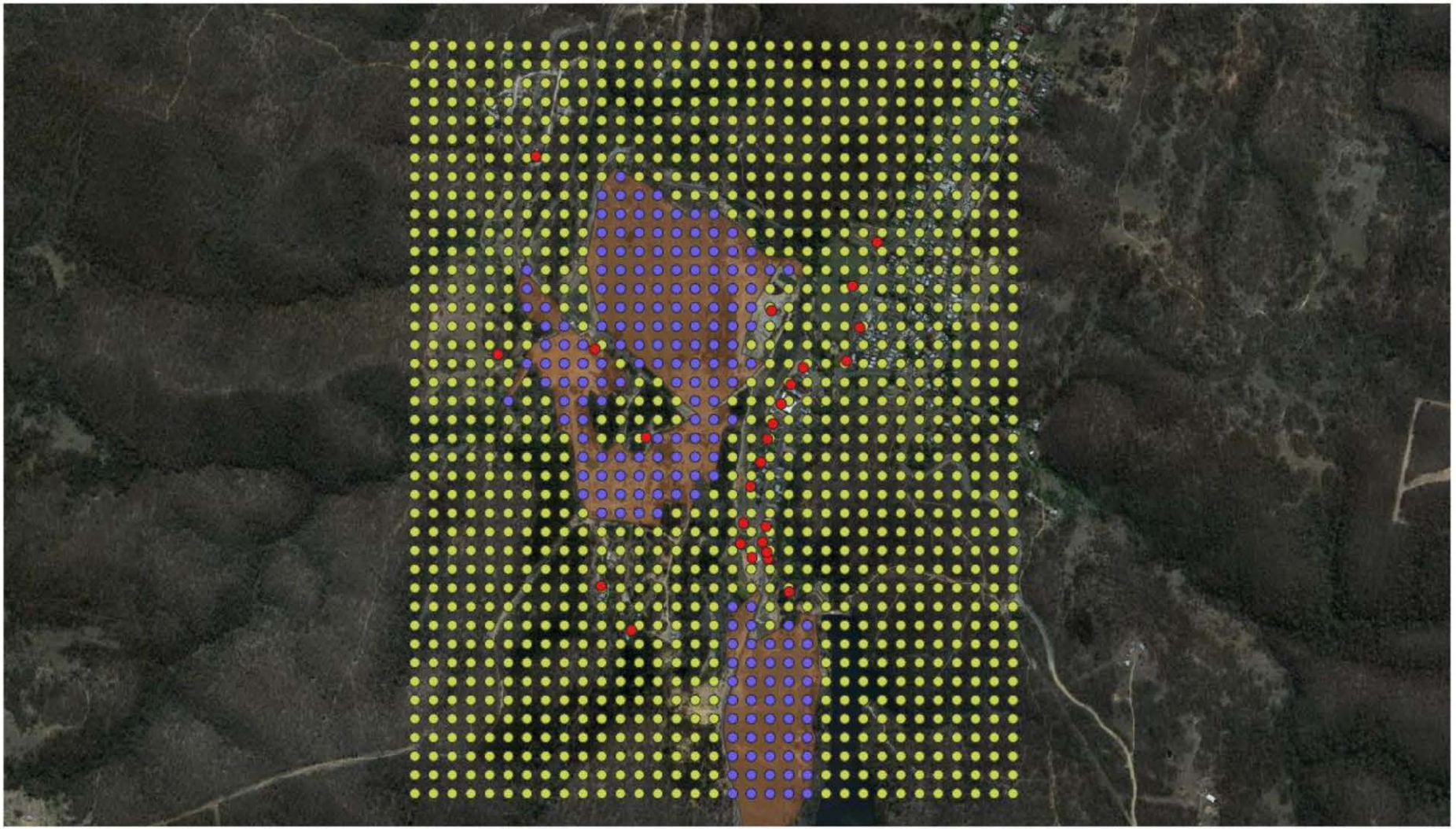
Factor	Impact
(p) Any impact on coastal processes and coastal hazards, including those under projected climate change conditions? This is not applicable as the proposal is not located within a coastal area.	Nil
(q) Any applicable local strategic planning statements, regional strategic plans or district strategic plans made under the EP&A Act, Division 3.1	No
(r) Any other relevant environmental factors?	No

Matters of National Environmental Significance

Factor	Impact
1. Any impact on a World Heritage property? There would be no World Heritage properties impacted by the proposal.	Nil
2. Any impact on a National Heritage place? There would be no negative impact to a National Heritage Places by the proposal.	Nil
3. Any impact on a wetland of international importance? There would be no impact to wetlands of international importance (Ramsar wetlands) by the proposal.	Nil
4. Any impact on a listed threatened species or communities? There would be no negative impacts on listed threatened species and communities listed under the EPBC Act.	Nil
5. Any impact on listed migratory species? The proposal would not result in any impacts to migratory species which could potentially use the proposal site. Alternative habitat is readily available in the areas surrounding the proposal site.	Nil
6. Any impact on a Commonwealth marine area? There would be no impact to Commonwealth marine areas by the proposal.	Nil
7. Any impact on the Great Barrier Reef Marine Park? There would be no impact to the Great Barrier Marine Park by the proposal	Nil
8. Does the proposal involve a nuclear action (including uranium mining)? The proposal does not involve a nuclear action (including uranium mining).	Nil
9. Any impact (direct or indirect) on Commonwealth land? The proposal would not impact Commonwealth land.	Nil
10. Does the proposal involve a coal seam gas development or large coal mining development which would impact upon a water resource? The proposal does not involve a coal seam gas or large coal mine development.	Nil

Appendix E

Air quality figures



Legend

Sampling grid classification
- Off-site
- On-site
- Receptor

Site Boundary

Paper Size ISO A4

0 100 200 300 400 m

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 55

N

GHD

Department of Regional NSW
Lake George Mine Remediation

Air quality assessment receptor sampling gird

Project No. 12551771
Revision No. 0
Date. 14/03/2022

FIGURE E.1

Document Path: C:\Users\nspurrett\Desktop\Air Quality\2021-12551771-Lake George Mine Remediation REF\QGIS\12551771-QGIS.qgz
Print Date: 14/03/2022

Data Source:Google Earth Imagery 2021.
Created By: nspurrett

Appendix F

Water impact assessment

Lake George Mine Remediation

Water Impact Assessment

Department of Regional NSW (Legacy Mines Program)

March 2022

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File name	https://projectsportal.ghd.com/sites/pp15_03/lakegeorgemineremedi/ProjectDocs/Technical Reports/6-C FLat-Appx-F-Water Impact Assessment_Rev B_LMP comments_TD_RT.docx
Author	Thomas Darley
Project manager	Karen Yale
Client name	Department of Regional NSW (Legacy Mines Program)
Project name	Lake George Mine Remediation REF
Document title	Lake George Mine Remediation | Water Impact Assessment
Revision version	Rev 1
Project number	12551771

Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	Rev 0	T Darley K Karunaratne	R Towner S Winchester		S Winchester		25/3/2022
S4	Rev 1	T Darley K Karunaratne	R Towner S Winchester		S Winchester		30/3/2022

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1. Introduction

1.1 Overview

1.1.1 Department of Regional NSW and the proposal

The Department of Regional NSW is a central agency within the NSW Government, which covers a range of regional issues, including the state's mineral and mining resources. The Department of Regional NSW hosts the Legacy Mines Program (LMP), which delivers works to reduce the risk from legacy mine sites which are commonly historic and abandoned, where no person or company is responsible for the rehabilitation.

One site, managed by the LMP, is the Captains Flat (Lake George) Mine, located approximately 50 kilometres south-east of Canberra. Mining operations (for silver, gold, and copper) in this mine area commenced in the early 1880s with several small operations amalgamating to form Lake George Mine. Mining for base metals continued until 1962, when the Lake George Mine officially closed. The site is heavily contaminated with metals (including lead, arsenic, copper, and zinc) and sulfur and has undergone a succession of remediation works since 1972.

In 2018, GHD prepared the *Lake George Captains Flat Mine Review: Assessment of Remediation Options,* which identified ongoing site contamination, and identified potential remediation options. To progress treatment of ongoing site contamination, GHD were tasked to prepare a soils treatment, capping and vegetation design in late 2018. The resultant *Lake George Mine, Captains Flat Detailed Design Report* was prepared by GHD in October 2020, and this proposal is to undertake the identified remediation works in this design package.

1.1.2 Approval and assessment requirements

Prior to commencing the proposal, an environmental assessment is required to identify potential environmental impacts of the development and how they may be mitigated. This environmental assessment process has been conducted in accordance with the EP&A Act and associated guidelines including the *ESG2: Guideline for preparing a Review of Environmental Factors (REF) for exploration activities subject to Part 5 of the Environmental Planning and Assessment Act 1979.*

This document, the Water Impact Assessment, forms a technical attachment to this REF, covering relevant water related impacts described in ESG2.

1.2 The proposal

1.2.1 Location

The Lake George Mine is located adjacent to, and directly west of the township of Captains Flat within the Southern Tablelands of NSW. It is about 50 kilometres south-east of Canberra and is adjacent to Captains Flat Road. The proposal site includes several areas within the Lake George Mine. (Refer to Figure 1.1).

1.2.2 Key features

Key features of the proposal are identified in *Lake George Mine, Captains Flat Detailed Design Report* (GHD, 2020) and are shown in Figure 1.1.

1.2.3 Project description

In 2017, the LMP commissioned a review of previous remediation works, and an additional site contamination delineation assessment, to establish the current situation at Lake George Mine. The purpose of the work was to formulate a way forward to reduce the environmental impacts from the Lake George Mine. The work was documented in *Lake George Captains Flat Mine Review: Assessment of Remediation Options* (GHD 2018).

To progress remedial work on the exposed, or partly vegetated contaminated soil in the Rail Loading and Mill Areas, and the exposed waste rock and mineralised *in situ* rock in the Central and Elliot's Mine Area, GHD were tasked to prepare a soil treatment, capping and vegetation design in late 2018. The resultant *Lake George Mine, Captains Flat Detailed Design Report* was the output (GHD 2020).

To allow approval for the proposed remediation works to proceed, a Review of Environmental Factors (REF) is required to be prepared under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) (NSW). This package involves the preparation of the Review of Environmental factors (REF) document as the statutory instrument that seeks approval to implement the remedial works as described in App B to the REF.

1.2.4 Proposed Remedial Measures

The proposed remediation works include those described in the *Lake George Mine, Captains Flat Detailed Design Report* (GHD 2020). The proposed remediation works include:

- Site preparatory early works
- Fencing permanent historic structures (including native fauna fencing where applicable to encourage revegetation and demarcate private property)
- Strategic structural works
- Remediation earthworks
- Augmentation of surface water drainage
- Revegetation.

The proposed remediation works would be undertaken across several key domains, predominantly in the northern portion of Lake George Mine. These include:

- North Mine Ridge/Elliot's
- Old Mill
- Mill Area (west of the Central Mine Area)
- Central Mine Area
- Creeks Area
- Rail Loading Area
- Minor areas of eroded capping in the Northern and Southern Dumps.

In addition, mine waste from the following sources are proposed for relocation to a containment cell that would be located on the Northern Dumps. These include:

- A sulfidic waste stockpile located on the junction of Miners Road and the Council wastewater treatment plant access road
- A slag heap located on the western side of Jerangle Road in Forster's Gully, adjacent to the northern end of the Southern Dumps.
- TfNSW lead contamination from around the Captains Flat Railway Precinct. TfNSW propose to remediate the Captains Flat Railway Precinct by removing approximately the surface 500 millimetres of contaminated topsoil for encapsulation in the containment cell on the Northern Dumps, before importing railway ballast, sub- and topsoil to site for backfilling. Prior to excavation of the contaminated surface soils, existing railway infrastructure including the railway line, signalling, gantry, signs, posts and fencing would be removed and temporarily stored on, or nearby the site. Once excavation and backfilling had been completed, the railway infrastructure would be replaced into its original location as far as reasonably practicable.
- Crown Land / QPRC land within the Captains Flat township. That is, the Captains Flat Lead Management Taskforce is currently undertaking an assessment of the Captains Flat township with the aim to prepare abatement plans for the higher risk public spaces. One option being investigated is moving up to a maximum 20,000 tonnes of contaminated soil from these Crown Land / QPRC-owned abatement areas into the containment cell on the Northern Dumps. These remediation works would be subject to a separate approval under the NSW Planning and Assessment Act 1979.

The purpose of the proposed remediation works is to reduce the risk of off-site migration of airborne dust and contaminated runoff generated from the continued oxidation of sulfidic mineral waste at Lake George Mine. The proposed remediation works are required to prevent serious environmental and human health risks to people accessing the site, to residents in the vicinity of the site, and in the town of Captains Flat, and to aquatic ecosystems and downstream users of the Molonglo River.

Further details regarding the proposal activities are covered in Section 4 of the REF.

1.3 Assessment requirements

This environmental assessment covers the remediation works, intended to improve environmental conditions at the Lake George Mine and reduce existing impacts to downstream environment. It is noted that significant water quality related impacts are already occurring from the site in its existing conditions. As such, these impacts are anticipated to continue through the construction phase and are best mitigated by the completion of the project itself.

As such, this assessment does not target the elimination of water quality risks during the construction of the project but rather focusses on assessment of:

– Potential construction phase impacts where water quality risks may be temporarily elevated such as through construction phase mobilisation of soils
– Ancillary water related impacts that may occur through the process of implementing the project e.g. adequate sourcing of water, impacts on flood conditions.

The proposed remediation works are subject to Part 5 of the *Environmental Planning and Assessment Act 1979* and require environment assessment in accordance with the Act as well as *ESG2: Guideline for preparing a Review of Environmental Factors (REF) for exploration activities subject to Part 5 of the Environmental Planning and Assessment Act 1979.* Specifically, Section 4.1.2 of ESG2, identifies potential water impacts that should be considered – and accordingly, this assessment considers the following potential impacts.

– Impacts arising from surface or groundwater use
– Impacts associated with water storage
– Impacts associated with changes to the hydrological network (waterbodies, runoff, riverine flows, etc.)
– Groundwater related impacts
– Impacts arising from hydraulic fracturing
– Changes to the flooding or tidal regime
– Changes to water quality.

1.4 Purpose of this report

This Water Impact Assessment, prepared by GHD, forms part of the environmental assessment for the proposed remediation woks at Lake George Mine. The purpose of this report is to describe the proposed remediation works, identify potential water related impacts to the existing environment, and identify potential monitoring and mitigation measures to reduce any likely impacts. This document, has been prepared with reference to *ESG2: Guideline for preparing a Review of Environmental Factors* (Department of Planning and Environment 2015), and should be read in conjunction with the REF.

1.5 Structure of this report

The structure of this report, outlines the water impact assessment process undertaken as a technical appendix to the main REF. The structure and content are summarised below:

– Section 1: Outlines the project overview, describes the proposal, and identifies relevant water-related assessment requirement as part of the REF.
– Section 2: Describes the existing environment of the proposal site, and context within the hydrological network.

– Section 3: Outlines the assessment methodology and describes the procedure to identify impacts and determine whether mitigations measures will be required, during both construction and post-remediation.
– Section 4: Provides an assessment of impacts to water, including any physical and pollution impacts, during both construction and post-remediation.
– Section 5: Summarises any impacts and mitigations measures; and provides a conclusion of the water impact assessment process undertaken.

1.6 Scope and limitations

This report has been prepared by GHD for Department of Regional NSW (Legacy Mines Program) and may only be used and relied on by Department of Regional NSW (Legacy Mines Program) for the purpose agreed between GHD and Department of Regional NSW (Legacy Mines Program) as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Department of Regional NSW (Legacy Mines Program) arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

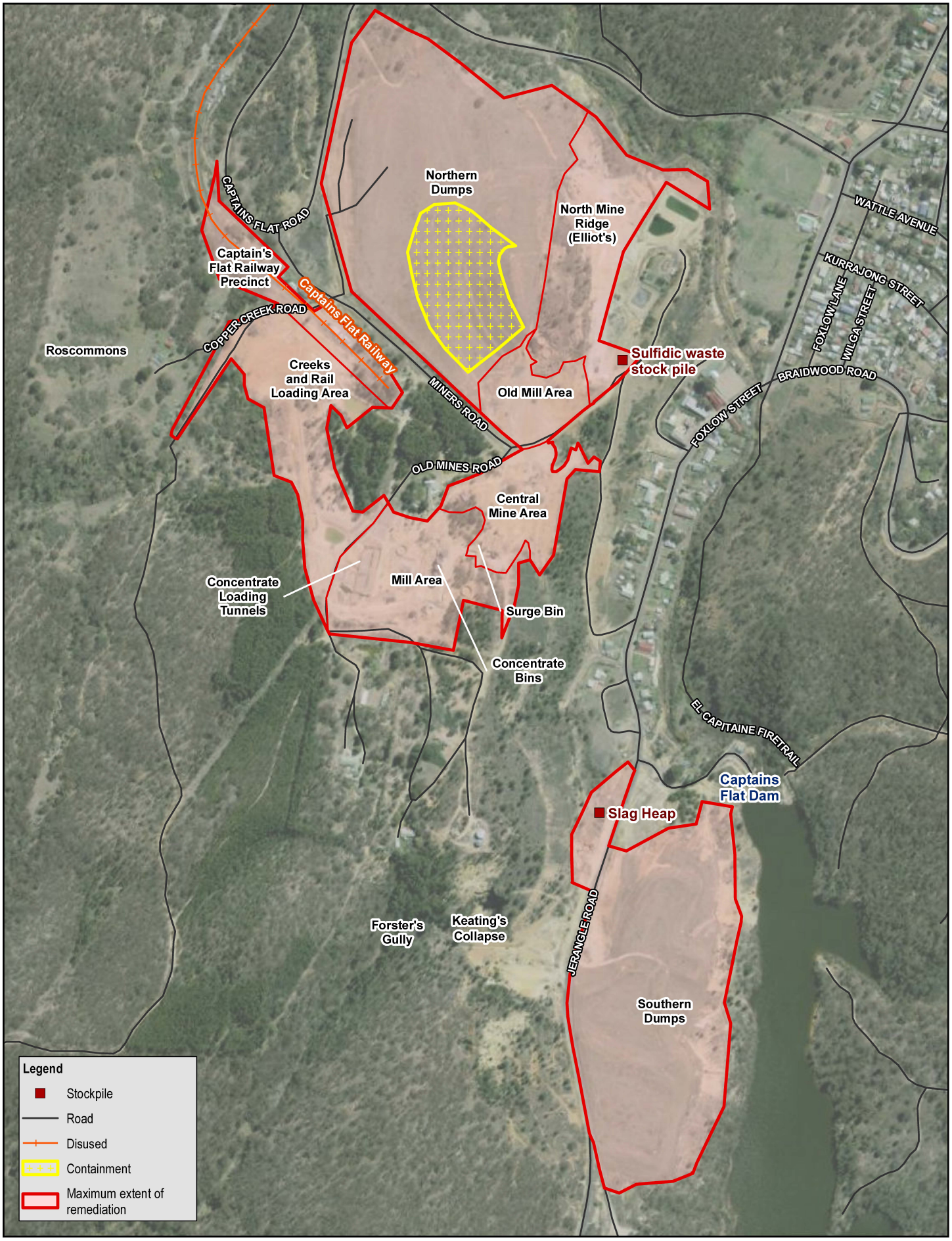
The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

GHD has prepared this report on the basis of information provided by Department of Regional NSW (Legacy Mines Program) and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.



Paper Size ISO A4

0 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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GHD

Department of Regional NSW
Lake George Mine Remediation

Key site domains and features including the maximum spatial extent of remediation

Project No. **12551771**
Revision No. **A**
Date **14/03/2022**

FIGURE 1.1

\\ghdnetghd\AU\Sydney\Projects\21\12551771\GIS\Maps\Deliverables\12551771_Z004_SiteLayout.mxd
Print date: 14 Mar 2022 - 17:06

Data source: General topography - Sixmaps via SSNSW © Department of Customer Service 2020. Created by: eibbertson

2. Existing environment

2.1 Climate

Captains Flat is located west of Canberra and has a cool temperate climate, which typically comprises of distinctive seasons, with hot dry summers, variable spring and autumn conditions and cold winters.

Based on data from the Captains Flat (Foxlow Street) weather station, average annual rainfall for the area, from January 1900 to December 2020, is approximately 777 mm. There is a consistent rainfall across the year with some increase in rainfall over late spring, summer, and early autumn.

Monthly and annual rainfall statistics are shown for the period 1900 to 2020 in Figure 2.1.

Table 2.1 Monthly rainfall, temperature, and evaporation

	J	F	M	A	M	J	J	A	S	O	N	D	Ann
Rain (mm)	74.1	63.7	70.8	56.3	55.8	61.6	62.9	57.3	65.0	71.9	72.4	65.4	777.4
Max temp (°C)	24.5	23.8	21.2	17.1	13.0	9.8	9.0	10.5	13.6	16.9	19.9	22.8	16.8
Min temp (°C)	10.8	10.8	8.8	5.3	2.1	0.0	-1.0	-0.2	2.0	4.6	7.1	9.2	4.9
Evap (mm)	182.0	137.5	115.8	69.4	41.2	26.1	31.6	51.3	81.0	112.6	137.6	171.1	1157.3

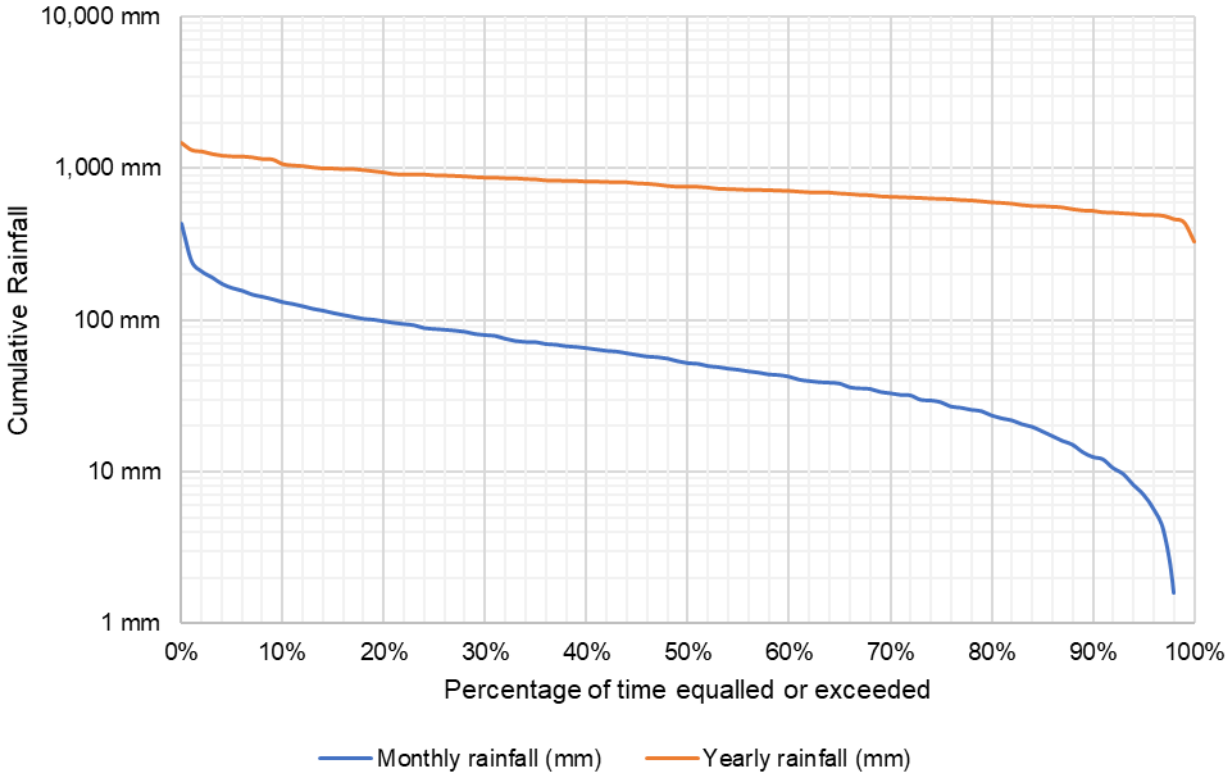

Figure 2.1 Cumulative annual and monthly rainfall statistics at Captain's Flat (1900-2020)

A wind rose of annual average 3 pm wind directions and strengths for Tuggeranong, the nearest station with adequate data, is presented in Figure 2.2, which shows that the prevailing wind is from the northwest at 10-30 km/h. This places the southern part of Captains Flat downwind of the Northern Tailings Dumps, Main (Elliot's) Mine Ridge and Central Mine Areas, for the dominant wind direction.

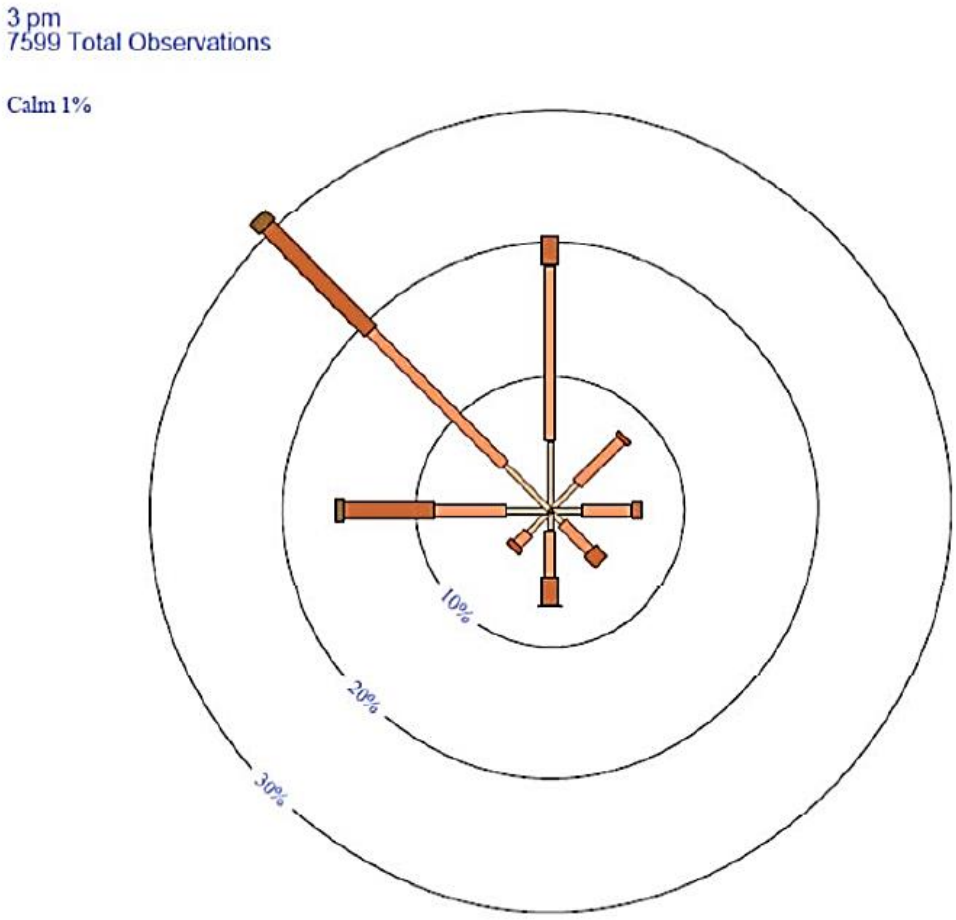

Figure 2.2 Wind rose – Annual 3 pm wind at Tuggeranong (BOM Station 070339)

2.2 Hydrology and land use

The remediation site is located in the headwaters of the Murrumbidgee catchment, immediately to the south and west of the Molonglo River and to the east of Copper Creek, a tributary of the Molonglo. The site is located downstream of the Captain's Flat town dam located on the Molonglo River as shown in Figure 2.3. The Molonglo is a perennial river which flows into Lake Burley Griffin in Canberra, ACT, before flowing into the Murrumbidgee River, west of Belconnen. Lake Burley Griffin, in Canberra, ACT, is a key hydrologic feature, acting as a sink for sediment conveyed by the Molonglo River (Caitcheon *et al*., 1988), which could include any sediment mobilised from the site. This feature is often used for recreational use and water sports, provided by Scrivener Dam which regulates depth and width.

The Molonglo River and its tributaries form "uncontrolled streams", within the Murrumbidgee Surface Water Resource Plan Area, of the Murray Darling Basin – and is subject to the Murrumbidgee Unregulated Rivers Water Sharing Plan (WSP) within the Molonglo Water Source. Land use around the Molonglo River is generally farming activities in upper reaches, prior to flowing into Lake Burley Griffin, which includes urban areas around Queanbeyan and Canberra. Relevant water quality and river flow objectives apply to these areas as shown in Figure 2.4.

The Captains Flat water supply dam is located just upstream of the site. The dam has a capacity of 820ML at full supply level and is operated by the Queanbeyan-Palerang Regional Council as the water supply source for Captains Flat.

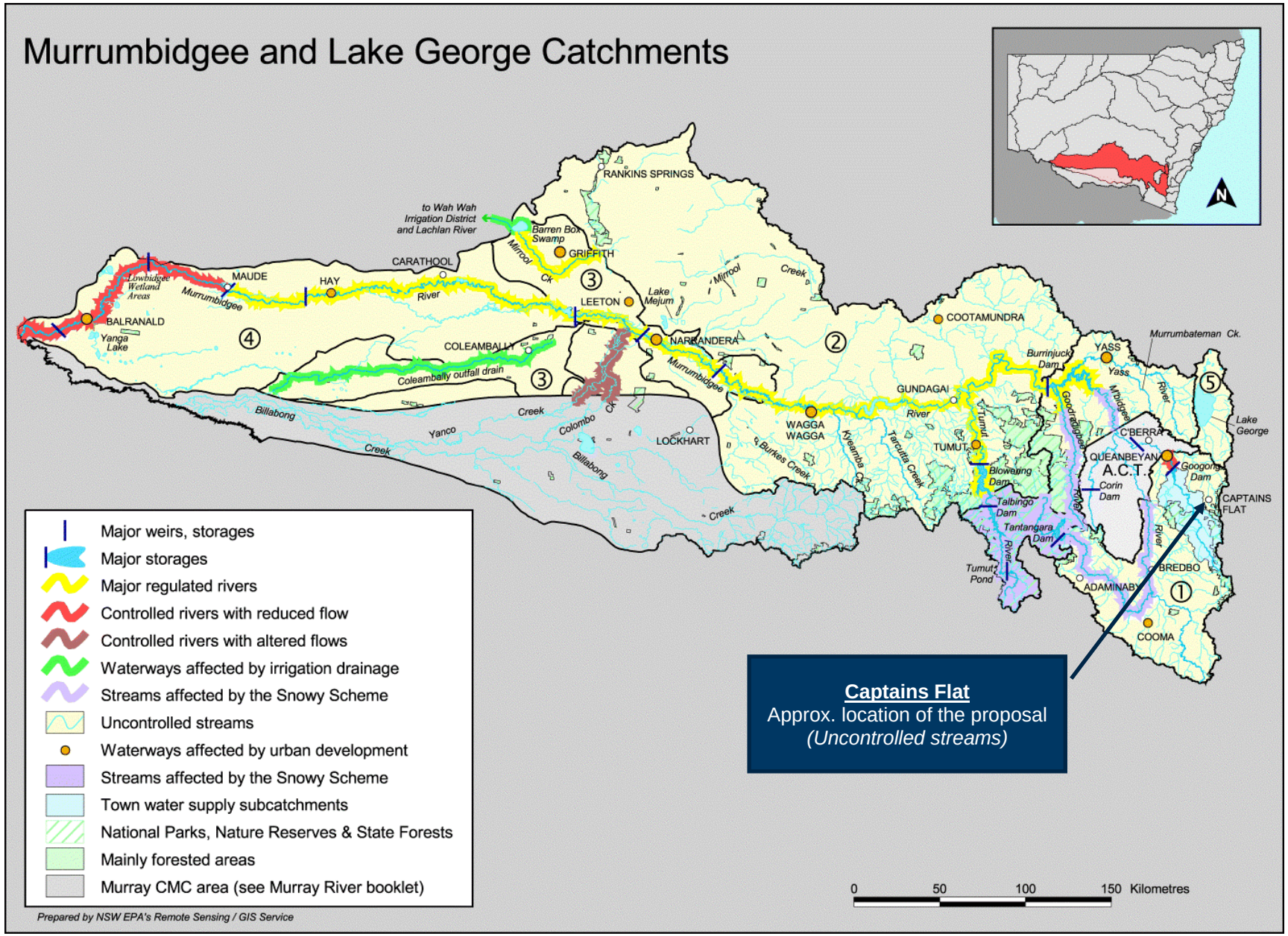

Figure 2.3 *Murrumbidgee and Lake George Catchments – Overview (NSW DPIE)*

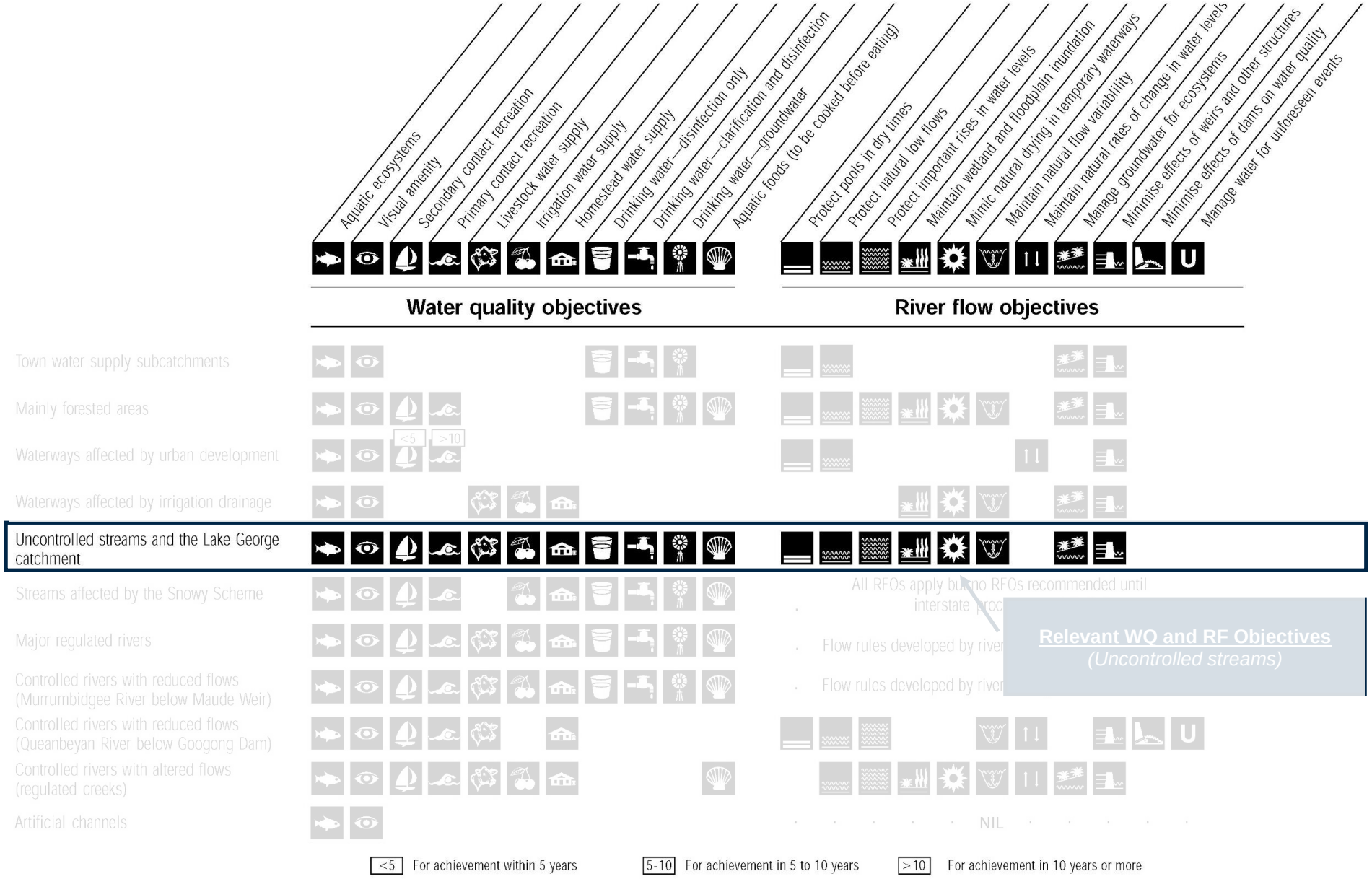

Figure 2.4 ***Murrumbidgee and Lake George Catchments – Water quality and River flow Objectives (NSW DPIE)***

2.3 Water quality and soils

The Molonglo River and Lake George Mine at Captains Flat, have been subject to previous water quality studies, including those undertaken by GHD. Previous studies have identified that adverse environmental impacts of legacy mining at the Lake George Mine are present within the Molonglo River System, with key contaminants being cadmium, copper, lead and zinc. Water quality objectives are prescribed for the catchment as shown in Figure 2.4.

GHD assessed the Lake George mine in 2018 to identify sources of contamination at the site and review potential remediation options. The work was documented in *Lake George Captains Flat Mine Review: Assessment of Remediation Options* (GHD 2018). The assessment notes historic mining at the site has left a contamination legacy that continues off-site to the present day for up to 40 kilometres downstream of the site. As a result of past remediation works at the site, the most likely remaining areas of contamination comprise of:

– The Main Adit Spring, which contributes around 80 to 90 per cent of dissolved zinc loads and around 99 per cent of dissolved lead loads of into the Molonglo River during dry weather
– Exposed or only partly vegetated contaminated soils in the Rail Loading and Mill Areas (Copper Creek catchment)
– Exposed waste and mineralised rock in the Central and Elliot's Mine Areas (Molonglo River and Copper Creek catchments).

The conceptual site mode shown in Figure 2.5 highlights the key contamination pathways prevalent at the site.

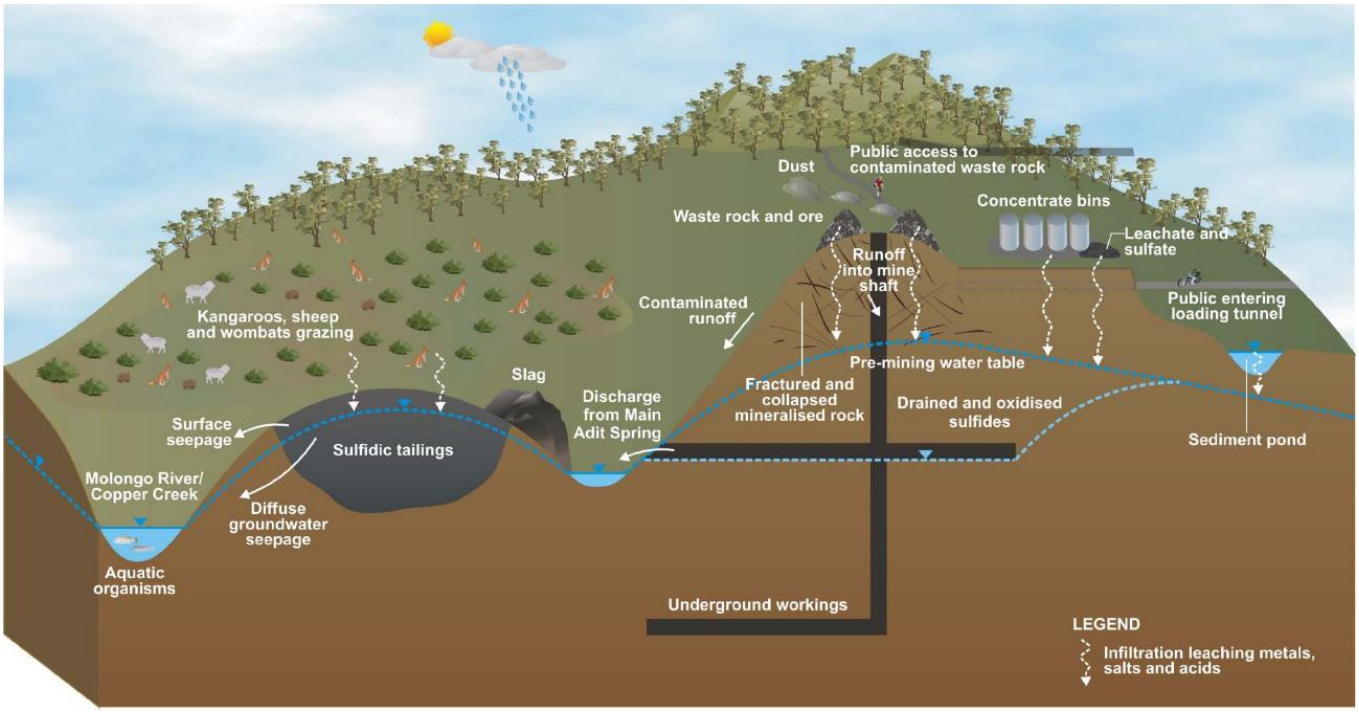

Figure 2.5 Conceptual site model for the site (GHD, 2018)

The previous options assessment (GHD, 2018) included characterisation of water quality in the context of the Lake George Mine. Water quality results have been included in Appendix B, and key outcomes of this investigation included:

– That historical mining activities at the site continue to negatively impact water quality.
– The Main Adit Spring contributes the majority of dissolved metal concentrations observed in the downstream environment. In particular, concentrations of zinc from the adit are orders of magnitude higher than in upstream Molonglo River reaches. As indicated in the conceptual site model, this is likely due to contact between seepage daylighting from the adit with contaminated material underground.

– There are also minor, low-volume seeps at the southern dumps (SW01 and SW07) that historically have exceeded guideline concentrations for selected analytes, however concentrations at the water supply dam (CF001-W) are orders of magnitude lower than at the point sources suggesting a high-level of mixing with the upstream catchment.
– The existing sedimentation dams at the Mill and Creeks Area (SW09 and SW10) have historically had relatively high concentrations of key analytes – identifying that a potential impact may be associated with the mobilisation of sediment and the contamination of runoff following contact with exposed waste materials. It is noted however, that these dams capture runoff only from the site and evapo-concentration may account for the high concentrations of key metal analytes. This may suggest a potential relatively lower risk to downstream water quality from the existing dams than other more concentrated sources such as the adit.
– Further downstream of Captains Flat (SW11, SW12 and SW13), up to 40 kilometres from the site, concentrations of arsenic, cadmium and lead are above the 95th percentile freshwater guideline value (ANZG, 2018), suggesting the existing downstream water quality impact may extend for at least 40 kilometres.

The GHD (2018) report recommended the two following key remedial actions be implemented at Lake George mine as a priority:

– Implement water treatment on discharge from the Main Adit Spring, while considering implementing inert gas technology to mitigate at source. Incremental water quality improvements over time from implementing the inert gas technology would reduce water treatment costs over time.
– Remediate the Mill Area, Old Mill Area, Central Mine, Elliot's / Northern Mine Area, Rail Loading Area and Creeks Area through A combination of excavation on-site encapsulation, surface neutralisation, backfilling, capping and revegetation. Additional works include upgrading fencing around mine infrastructure to deter human interaction.

This project, as described in Section 1.2, covers remediation of the Old Mill Area, Central Mine, Elliot's / Northern Mine Area, Rail Loading Area and Creeks Area. It also includes remedial works in the Captains Flat Railway Precinct. Through the proposed remedial strategies, it is aimed to isolate contaminated waste, soil, and rock from incident rainfall and surface water runoff through capping of exposed areas and thus reduce the mobilisation and conveyance of contaminants to downstream watercourses.

There is a separate work package assessing the feasibility of water treatment for the acid and metalliferous drainage emanating from the Main Adit Spring, which is not covered by this REF and would be subject to a future approval for implementation if found to be feasible.

2.4 Climate change

The South East and Tablelands snapshot (NSW OEH, 2014), includes the Captains Flat area and outlines projected changes to local climates for near future (2030) and far future (2070) compared to a baseline from 1900-2009. Climate change modelling suggests that:

– Maximum temperatures are projected to increase by 0.7 (near future) and 2.1 (far future) with similar observations for minimum temperatures. This may potentially increase evaporation and losses, reducing runoff. It may also lead to impacts to local vegetation. In addition, more hot days (temperature > 35°C) are anticipated.
– Changes in rainfall patterns may significantly affect the hydrological system. These changes are expected to be associated with an increase in extremes, comprising of potential more intense rainfall over short durations which may lead to more flooding, erosion, and sedimentation, and also extended periods of drought (coupled with higher temperatures). Seasonal rainfall is expected to decrease in spring and winter; and increase in summer and autumn.
– In addition, the Murray Darling Basin Authority and CSIRO have identified a range of potential climate change outcomes, with recent studies suggesting that decreases in streamflow by 20 to 30 per cent are the most likely outcomes, due to reduction in rainfall coupled with higher evapotranspiration (Zhang *et al*., 2020)

These potential changes to long-term climate are unlikely to significantly affect the proposed scope of works, including during the construction phase. As maintenance and monitoring of the site is performed into the future, potential climate trends should be considered as required.

3. Assessment methodology

The assessment methodology is presented in the sections below. As identified in Section 1.2 and Section 1.3, the assessment methodology presented notes the existing level of impacts to environment associated with the site's existing, or baseline, contamination. The approach intends to identify the incremental construction phase or ancillary impact associated with the works themselves, as well as identifying potential long-term benefits associated with the site's remediation.

3.1 Introduction

Identification of key issues was undertaken to determine potential impacts associated with the project. Key issues identified and presented in the following sections, include types of impacts associated with:

– The redirection of flow and changes in flow rates and volumes
– Changes to the area, volume, or flow of a waterbody
– Changes in runoff and stormwater discharges
– Changes to flood or tidal regimes or sea level rise
– The actual, or likely, pollution of waters.

3.2 Water sourcing

Following remediation, water will not need to be sourced for the site. During construction, water will be sourced externally (i.e. The Captains Flat town dam) or from the existing/temporary basins required to manage sedimentation. Any water sourced externally, for example water sourced from the Captains Flat town dam will be permissibly sourced in consultation with relevant authorities. The quantity of water necessary for the works to enable civil works and environmental controls (e.g. dust suppression) is anticipated to be relatively small (filling 0.11 megalitre tanks) compared to the nearby water storages (the Captains Flat town dam has a storage capacity of 820 megalitres)

Further, water sourced from existing basins will only be utilised for environmental outcomes such as dust control and vegetation establishment. No water will be injected or used to stimulate fractures as this activity is associated with onshore gas mining which is not an activity associated with the proposed works.

No significant impacts on existing water sources are anticipated for this project, and no further assessment was undertaken. Consultation with relevant authorities and dam operators will be undertaken and any take agreed prior to works commencing.

3.3 Storage

Storage of water at the site occurs within environmental basins, designed to manage sedimentation in accordance with the *Protection of the Environment Operations Act* (1997). These basins are minor in relation to the quantity of upstream catchment and streamflow in the riverine environment. During construction additional temporary basins may be required to capture runoff from disturbed areas in accordance with Managing Urban Stormwater (Landcom, 2004) (informally known as the 'Blue Book') and any environmental protection requirements specified by the NSW Environment Protection Authority or other relevant authority.

Water storage tanks are also anticipated to be utilised to enable civil works and environmental controls, should no appropriate water be able to be sourced from on-site dams. A water storage tank (of approximately 110kl) is proposed to be temporarily placed on-site and utilised where necessary.

No significant impacts on existing water sources are anticipated for this project, and no further assessment was undertaken.

3.4 Hydrology

Changes to natural water bodies, wetlands and runoff patterns are detailed in Table 3.1, along with commentary on the assessment methodology and outcomes. Potential hydrologic impacts are assessed against river flow objectives specified in Table 3.1.

Table 3.1 River flow objectives

Objective	Comments
Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows	No change to river flow objectives, as changes to runoff patterns are not anticipated to affect regional hydrology. Works proposed in proximity to Forsters Creek are to remove previously stockpiled material which has spilled over the natural surface. This work is to involve exposing the natural surface by removing historically emplaced material. To minimise disturbance mobile plant will not operate on the bank or within the waterway, and the works are anticipated to improve long-term management. Disturbance of the existing unnatural surface may pose a risk to water quality associated with sedimentation, however, is not anticipated to influence river flow objectives. No-instream works are to be undertaken within Copper Creek. In summary, works are on a minor scale compared to the downstream system overall such that measurable change to river flow objectives is not anticipated. Furthermore, works restore conditions closer to those of a natural state which is consistent with the objectives. On that basis, no significant impacts are anticipated with relation to these objectives, and no further assessment was undertaken.
Protect natural low flows	
Protect or restore a proportion of moderate flows ('freshes') and high flows	
Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems	
Mimic the natural frequency, duration, and seasonal nature of drying periods in naturally temporary waterways	
Maintain or mimic natural flow variability in all streams	
Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems	Refer Section 3.5.
Minimise the impact of instream structures	No instream structures are proposed, and works are not anticipated to interact with any instream structures. Accordingly, no significant impacts are anticipated for this project, and no further assessment was undertaken.

3.5 Groundwater

Groundwater passing through, or generated from, rainfall infiltrating into the existing surface, was reported in the *Assessment of Remediation Options* report (GHD, 2018) to ultimately flow to the Molonglo River north of Captains Flat. The proposal includes works to treat and cap portions of the existing surface to minimise risk from exposed mine wastes. In places, such as the containment cell on the Northern Dump, inclusion of a lower-permeability capping material may result in decreased volumes of water infiltrating the existing surface, however, any additional surface water runoff will report to the Molonglo River, minimising the risk of potential water quality impacts arising due to contact with underlying materials.

As both surface and groundwaters both report to the Molonglo River, no significant negative impacts on groundwater are anticipated for this project, and no further assessment was undertaken. It is also noted that this project is anticipated to result in positive benefits associated with groundwater by minimising infiltration into contaminated material that may report to the local groundwater system and ultimately into the Molonglo River, posing a potential risk to water quality.

3.6 Hydraulic fracturing

Hydraulic fracturing will not be used in the proposal. Accordingly, no impacts from hydraulic fracturing are applicable to this project, and no further assessment was undertaken.

3.7 Flooding

Major changes to the site's topography are not proposed for this project, and earthworks generally involve treating materials in-situ coupled with application of a lower permeability capping material. Where filling is proposed, for example in the northern dumps, these areas are located at much higher elevations than nearby river and flood pathways. This is shown in the *Captains Flat Floodplain Risk Management Study and Plan* (Cardno, 2015), which identifies the site is located well above the 1 in 100 AEP flood depth along the Molonglo River – refer Figure 3.1.

The site is also expected to be above flood levels along Copper Creek on the western boundary of the site, which has a significantly smaller catchment than the Molonglo River.

The works located within the Forsters Creek waterway alignment involve a net balance of cut over fill, and as such do not have potential to worsen flooding conditions.

Due to limited changes to site topography, and as filling is proposed above the flood levels, no significant impacts to flooding are anticipated for this project, and no further assessment was undertaken.

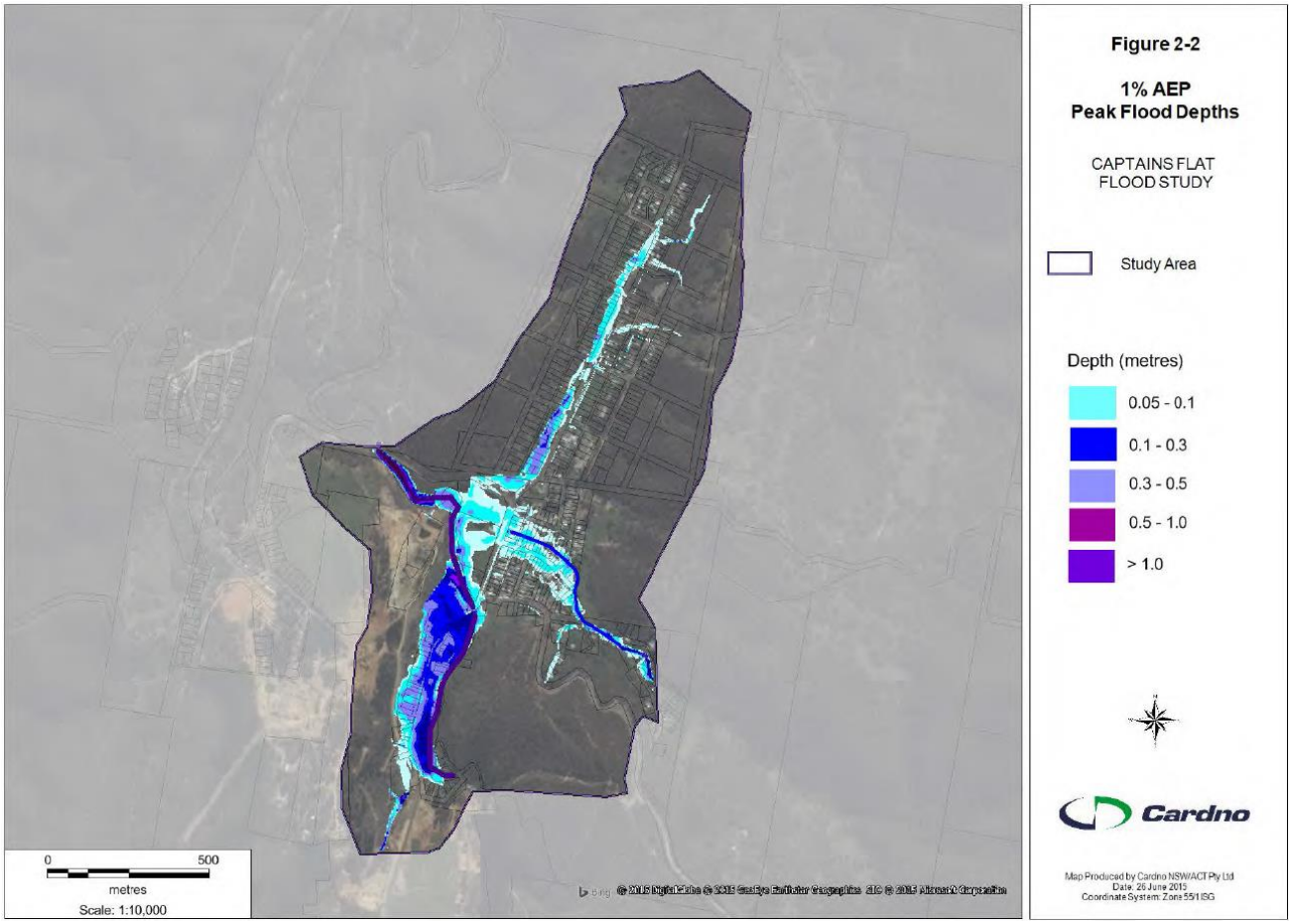

Figure 3.1 1 in 100 AEP flood depths (Cardno, 2015)

3.8 Water quality

The assessment methodology proposed has been developed with consideration of the current state of the site's contamination and existing impacts on downstream water quality. The approach intends to identify the incremental water quality impacts during construction, and qualifying potential long-term water quality benefits associated with the site's remediation. Potential impacts are associated with a potential worsening of water quality with respect to current conditions, for example: the assessment methodology has been developed with consideration that contaminated soils are currently exposed and will continue to be so during the construction works until they are treated, capped, and revegetated. Impacts to water quality are anticipated to continue during construction until the works are complete and should be mitigated accordingly to reduce impacts to a level of water quality equal to, or better than current conditions.

An objective of the proposed works is to neutralise and minimise the risk of contaminated runoff and potential sedimentation into the nearby Copper Creek and Molonglo River, which is anticipated to provide a long-term improvement to water quality downstream. However, during the works, there is a heightened risk of sedimentation due to mobile plant and soil treatment.

Water quality objectives (WQOs) apply to the catchment the site comprises as part of the Murrumbidgee and Lake George catchments shown in Figure 2.4. Nearby water resources are uncontrolled streams, which include various water quality (WQ) and river flow (RF – refer Section 2.2) objectives. To allow assessment of potential risks, risks to water quality involved the following methodology:

– Identifying existing water quality conditions and risks associated with the project
– Qualifying potential long-term changes to water quality
– Identifying additional risks during construction, including construction-phase surface water management measures which may need to be implemented to manage risk
– Identifying potential mitigation and management measures, including monitoring.

4. Impact assessment and mitigation

4.1 Introduction

Key issues identified in Section 3 are assessed in the following sections, including consideration of potential mitigation measures that may be employed to reduce the risk of potential impacts. It is noted that this project is intended to provide long-term environmental improvements, including on receiving surface and groundwaters, relative to existing conditions.

As identified in Section 1.2 and Section 1.3, the impact assessment presented below has been undertaken with consideration of the existing level of impact on the environment associated with the site. Accordingly, identification of impacts focuses on potential changes to the site which may result in incremental impacts above the existing level of contamination. Where mitigation measures are proposed, these are intended to manage a potential impact to a level equal to, or better than current conditions.

4.2 Water quality

4.2.1 Construction phase

4.2.1.1 Impact assessment

During the construction phase, there is an elevated risk associated with water quality associated with mobilisation of plant and earthworks. These risks include potential increase in mobilisation of sediment and/or waste rock as well as potential impacts associated with neutralising acidic mineral waste and soils. As described in Section 2.3, while the Main Adit (which is currently undergoing remediation design) is the main point source of contaminant into the Molonglo River, the surrounding areas as part of the proposed works do pose a risk, albeit lesser in magnitude.

Potential impacts associated with the works include the mobilisation of excess soil above existing rates into Copper Creek, Forsters Creek and the Molonglo River, resulting in water quality impacts associated with suspended sediment and/or leaching of contaminants of concern. This may result in additional sedimentation loads and potential higher concentrations of analytes of concern. It should be noted that even moderate changes to local runoff water quality associated with sedimentation loads are unlikely to pose a significantly higher risk to downstream water quality than other point sources on the site, such as the Main Adit which contributes a very high proportion of existing zinc and lead loads into the downstream environment. While the site is currently unvegetated and disturbed, mobilisation of mobile plant has the potential to increase risk of erosion and sedimentation above existing levels.

Impacts to water quality may also arise during the neutralisation of acidic mineral waste and soils using liming products. Over application of liming products has the risk to result in alkaline runoff, including other potential impacts associated with storing and handling this material.

These risks during construction are considered moderate, generally associated with short-term potential risks during the 12 months of construction. Ongoing monitoring and mitigation measures are detailed below and are anticipated to manage any additional risk during the construction phase to a suitable level.

Following establishment of vegetation, risks of worsening water quality outcomes are predicted to be minimal, and a long-term benefit is anticipated. Accordingly, as the site is progressively neutralised and vegetated through the construction phase, the risk will decrease.

4.2.1.2 Mitigation measures

To further reduce the risk of water quality impacts during construction to a level where impacts are negligible, various mitigation measures are proposed. These are focused on isolating potential pollution sources and managing potential pollution pathways. The measures are detailed in the following sections, including:

– Preparation of a Construction Environmental Management Plan
– Implementation of erosion and sedimentation controls
– Selection of suitable liming materials
– Ongoing monitoring of water quality throughout the works
– Implementation of a Trigger Action Response Plan (TARP).

Construction Environmental Management Plan

A Construction Environmental Management Plan (CEMP) will be prepared by the Contractor, including a Surface Water Management Plan based upon the detailed design to provide specific further guidance on the Contractor's proposed water management strategy. The Surface Water Management Plan should be developed in accordance with *Managing Urban Stormwater – Volume 1* (Landcom, 2004), and *Managing Urban Stormwater – Volume 2E, Mines and quarries* (DECC, 2008b), informally known as the 'Blue Book', this document, as well as any condition of consent and relevant agency requirements.

An example of a conceptual surface water management layout is shown in Appendix A. This would be confirmed and updated by the contractor in the Surface Water Management Plan. The Surface Water Management Plan should include detail such as:

– Sediment control devices such as silt fences installed on all drainage lines in the vicinity of the works
– All erosion and sediment control measures (discussed below), including installation of these measures prior to site disturbance
– Maintenance of erosion and sediment control devices through the construction and revegetation period
– Responsive monitoring following periods of excessive rainfall (resulting in observable runoff/sheet flow), including any maintenance (i.e. cleaning out)
– Period maintenance and operation of sedimentation basins, including clean-out requirements
– Managing of undisturbed areas outside of the site's proposed works footprint
– Details of traffic management and haul roads used to minimise disturbance where possible
– Staging of works, including the prioritisation of problem areas, ensuring that the area and duration of disturbance of each stage can be managed
– Stockpile management, including:
    - Protection of stockpiling during rainfall events
    - Placement of stockpiles on flat, level ground, away from drainage lines
    - Locating stockpiles outside of sensitive areas
    - Stabilisation or cover requirements of different stockpile types
– Progressive stabilisation of disturbed areas by vegetation, or other temporary requirements
– Post construction cleaning up of engineered controls and removal of any accumulated sediment
– Ongoing maintenance and monitoring post construction.

Erosion and Sedimentation Controls

To manage the erosion and sedimentation risk during the works, a system of engineered erosion and sedimentation controls. These controls should be implemented in accordance with the CEMP and the Surface Water Management Plan. Preliminary identification of potential controls is identified in Appendix A and summarised below.

Drainage network

A network of drainage features exists at the site and generally are to be replaced on a ‘like-by-like’ basis. It is recommended to maintain the drainage network where possible to convey sediment laden runoff to existing or proposed sedimentation basins for management.

Further, temporary clean water drains should also be established during the construction phase to collect surface water from undisturbed areas around and within the site to be conveyed to local watercourses.

Engineered controls

In areas where erosion and sediment generated by disturbed areas during construction are unable to be managed effectively through sedimentation basins (for example due to topographic constraints), it is suggested to employ additional engineered erosion controls in accordance with the Blue Book. This includes the application of erosion matting as well as sediment fencing along the boundaries of these areas. Steeper slopes may be shortened in these areas as required through the establishment of temporary mid-slope berms during construction. Bunds may also be implemented at specific locations through the site to divert clean runoff originating from outside the extent of works towards clean water drains and local watercourses.

Where these enhanced controls are implemented, an audit of the implementation of enhanced controls should occur at least fortnightly for these sensitive areas. The auditor should be a soil conservationist or an erosion control specialist.

Sediment basins

To manage risks for elevated mobilisation of sediment during the works, initial modelling using the design criteria shown in Table 4 indicates that potentially eleven sediment basins including the existing two basins at the site, with capacities as shown in Table 4.1 may be required to collect and treat surface water runoff from disturbed areas during the construction phase. The locations of these indicative basins are shown in Appendix A. In order to facilitate the collection of runoff at the site, additional temporary surface water drains may also be required.

The required storage capacity of the dams is to be determined in accordance with the Blue Book with the following design criteria and assumptions stated below in Table 4.2. The locations and catchment areas should be confirmed prior to construction during development of the Contractor's Surface Water Management Plan.

Prior to commencing the works, it is recommended that the existing sedimentation basins are cleaned out, maintained, and prepared for usage during the works as required to provide the required capacities to comply with the Blue Book. Sediment within the basins should be treated and/or encapsulated as directed by the Principal and the CQA Engineer/Designer. Dewatering and cleaning out of existing sedimentation basins should be undertaken with the following considerations:

– Pre-treatment of water (if applicable) to flocculate and/or precipitate suspended/dissolved material including metals and metalloids
– Application of treated water (if applicable) on the existing catchment. Water shall not be discharged directly into watercourses or other catchments unless:
    - All reasonable and feasible measures to reuse on site have been implemented beforehand; and
    - Releases arise out of operational practices consistent with ‘The Blue Book’ and any Environment Protection Licence applicable to the works.
– Enhanced erosion and sedimentation controls for cleaned-out sediment as required by the higher risk of mobilisation following rainfall, considering:
    - Temporary bunding of stockpiles to minimise run-on
    - Silt fencing on the downslope perimeter of material
    - Temporary covering of material using erosion control matting or geotextile
    - Blending of sediment with in-situ soils to reduce the moisture content
    - Alternate stabilisation techniques (i.e. binders, tackifiers).

Table 4.1 Indicative sediment basin sizes

Dam	Catchment Area (Ha)	Dam Capacity Required (ML)
Existing Upper Sediment Basin	4.6	1.0
Existing Lower Sediment Basin	5.0	1.0
Proposed Sediment Basin 1	1.0	0.2
Proposed Sediment Basin 2	1.0	0.2
Proposed Sediment Basin 3	4.1	0.9
Proposed Sediment Basin 4	1.2	0.3
Proposed Sediment Basin 5	0.4	0.1
Proposed Sediment Basin 6	0.7	0.1
Proposed Sediment Basin 7	0.4	0.1
Proposed Sediment Basin 8	0.2	0.1
Proposed Sediment Basin 9	4.2	0.9

Table 4.2 Sediment basin design criteria

Parameter	Value	Notes
Basin type	Type D/F	As per Blue Book
Design rainfall depth	25.8 mm	Capacity calculations based on a 5 day, 85th percentile rainfall depth as listed in Table 6.3a of the Blue Book for Queanbeyan (closest listed location). The design rainfall depth may be reduced in consultation with the principal to a shorter management time (e.g. 2 days) should existing dams to be used be under-sized, or if dewatering and management of these dams poses a higher risk to water quality.
Volumetric runoff coefficient	0.56	Based on hydrologic soil type D (disturbed area) for water storages
Sediment zone required	50% of settling zone	Conservatively adopted as per Blue Book recommendations

Enhanced control areas

It is noted that due to topography, some areas cannot be feasibly drained to a sediment basin. It is considered important that in these areas the increased sediment load discharged compared to existing conditions is managed as far as is reasonably practicable. Indicative calculations of yearly sediment generation for the areas requiring enhanced controls, range from approximately 100 - 150 cubic metres per year with limited controls, suggesting that the risk is generally low and that enhanced controls can be utilised to manage these areas. These areas comprise less than 1 hectare in area. Key mitigation measures include:

- Prioritising these works areas for early completion and promoting the rapid establishment of vegetation
- Managing slopes lengths such that slope lengths are:
  - For slopes <25 per cent (1V:4H): Slope lengths are to be a maximum of 10 metres
  - For slopes <50 per cent (1V:2H): Slope lengths are to be a maximum of 5 metres.
- Implementation of temporary erosion control matting on exposed surfaces
- The perimeter of all downgradient areas is to have sediment fencing installed, and drainage channels are to have controls installed perpendicular to concentrated flow directions at regular intervals.
- Work areas in proximity to natural waterways, including remediation of the slag heap near and in Forsters Creek, shall include removal of any existing waste material that may has spilled into the natural waterway over the site's history. Within these areas, mobile plant shall operate on the top of bank only and shall not enter the bed or the banks of water courses. These works shall include removal of surficial waste to expose the natural surface, no additional cut or emplacement of material shall be permitted.

Where remediation works are completed on existing watercourse batters to expose the natural surface, the surface should be made stable. Where instabilities of the natural surface occur, i.e. landslips, tension cracking, slumping, etc. guidance shall be sought from the designer on additional engineering controls – this may include vegetation and/or geosynthetics and/or rock armouring.

– Erosion and sedimentation controls in, and in proximity to watercourses should consider the suite of Guidelines for Controlled Activities on Waterfront Land provided by NSW Department of Planning and Environment.

Liming materials

Application of lime materials to neutralise existing mineral waste and soils can pose a water quality risk dependent on the type, and application method, of the liming agent.

Accordingly, a lower risk liming product (a calcium carbonate based agricultural lime) which is not anticipated to have any significant impact on water quality is recommended for use in areas not slated for clay capping. Non-calcium carbonate-based products, such as oxide or hydroxide-based products, should not be used in areas not slated for clay capping as they pose a potentially higher risk to water quality.

Water quality monitoring

Water quality monitoring should be implemented as a mitigation methodology to identify potential deficits in the site's environmental management during construction. The monitoring program should be undertaken at previous monitoring locations, including key upstream and downstream locations, using similar analytes to allow for comparison to historical observations. Recommended construction phase monitoring locations are shown in Appendix A, and include:

– SW01 (Upstream of Main Adit Spring on the Molonglo River)
– SW02 (Upstream of confluence between Molonglo River and Copper Creek)
– TARP-1 (Just downstream of the Main Adit Spring on Molonglo River)
– TARP-2 (On Copper Creek upstream of the Rail Loading Area)
– TARP-3 (On Copper Creek downstream of the Captains Flat Railway Precinct).

Key monitoring results to be assessed during construction with regards to the Trigger Action Response Plan (TARP) have been suggested below in Table 4.3.

Table 4.3 Suggested construction monitoring program

Analyte	Testing methodology	Frequency
pH	Probe, grab sample	Weekly, and Within 24 hours of an uncontrolled overflow of a sedimentation basin
Electrical conductivity	Probe, grab sample	
Total suspended solids (Refer note)	Grab sample (TSS), Probe (NTU)	
Total and Dissolved Metals	Grab sample	
Major Cations and Anions	Grab sample	Weekly during TARP Level 1
Nutrients and ammonia	Grab sample	

Note: The Contractor may use turbidity (NTU) in place of TSS to determine ongoing assessment of water quality, however the Contractor must first develop a statistical correlation which identifies the relationship between NTU and TSS for water quality in order to determine the NTU equivalent of 50 mg/L TSS.

Trigger Action Response Plan

A Trigger Action Response Plan (TARP) is proposed to identify trigger values and criteria and provide appropriate response actions if impacts during construction are identified through the monitoring program. The TARP is presented below in Table 4.4 and identifies the minimum responses to a range of triggers. Historical water quality observations shall be provided to the Contractor for the purpose of this TARP (refer App B to this report for data). It should be noted that the TARP should be referenced in the CEMP developed by the Contractor and may involve ongoing liaison with the Principal, as well as with the relevant CQA Engineer and/or Designer authority.

Table 4.4 Trigger Action Response Plan

Trigger Level	Indicator	Response
Trigger Level 1	At least one of the following triggers for two consecutive monitoring events: **pH:** the downstream monitoring point deviates by either more than one standard deviation from the rolling 12-month average of that suitable historic monitoring point, and is more than 1 pH unit lower than the upstream location **TSS:** The downstream monitoring point is greater by 50 mg/L than the upstream monitoring location and/or deviates by more than one standard deviation from the rolling 12-month average of a suitable historic monitoring point. **Metals:** A downstream monitoring point is higher by more than one standard deviation from the 12-month average of that suitable historic monitoring point.	All of the following: Review site housekeeping. Monitor the state of the works during the previous 7-day period, in particular review: – The state of stockpiled materials – Erosion and sedimentation control infrastructure – Signs of erosion and sedimentation – Any exposed waste rock or potential contaminated materials.
Trigger Level 2	At least one of the following triggers: **pH:** The downstream monitoring point deviates by either more than one standard deviation from the 12-month average of that suitable historic monitoring point and is more than 1 pH unit lower than the upstream location over four consecutive weeks. **TSS:** The downstream monitoring point is greater by 50 mg/L than the upstream monitoring location and/or deviates by more than one standard deviation from the rolling 12-month average of a suitable historic monitoring point over four consecutive weeks. **Metals:** A downstream monitoring point is higher by more than one standard deviation from the 12-month average of that suitable historic monitoring point over four consecutive weeks.	All of the following (in addition to Trigger Level 1 Reponses): – Undertake a review of the state of the site using a suitably qualified Construction Quality Assurance engineer, and/or the designer to identify a potential source/pathway attributable to the results – Conduct additional monitoring at the request of the CQA Engineer and/or the Designer.
Trigger Level 3	Both of the following triggers: – Trigger level 2 occurs for 2 consecutive weeks – A source/pathway cannot be identified following the review of the state of the site.	All of the following (in addition to Trigger Level 1 and Trigger Level 2 Responses): – Reconsideration of works staging in consultation with the CQA Engineer and the Principal. – Minimise the generation of additional disturbance areas until existing disturbed areas are remediated.

4.2.2 Post-remediation

4.2.2.1 Impact assessment

A key aspect of the proposal is to improve environmental outcomes by reducing risk associated with contaminated runoff and sediment loading from exposed contaminants and disturbed soils at the site. Previous investigations highlighted in *Lake George Captains Flat Mine Review: Assessment of Remediation Options (GHD 2018)* identified that two potential sources of contamination include:

– Exposed or only partly vegetated contaminated soils in the Rail Loading and Mill Areas (Copper Creek catchment)
– Exposed waste and mineralised rock in the Central and Elliot's Mine Area (Molonglo River and Copper Creek catchment).

Improvements to water quality and reduced mobilisation of soils is anticipated to occur through liming, importing sub and topsoils, capping in some instances and revegetating; all acting to stabilise the existing surface and isolate potentially contaminated materials from rainfall derived runoff or infiltration.

Contamination pathways associated with exposed material are anticipated to be significantly reduced, providing a post-remediation improvement in water quality. No significant negative impacts are anticipated.

4.2.2.2 Mitigation measures

Successful long-term water quality improvements anticipated by this project, are predominantly dependent on the successful construction and maintenance of the works program that includes capping and revegetation. To monitor and manage risk to water quality, the proposed mitigation measures are recommended:

– Continued monitoring of water quality, to identify any acute changes (anticipated benefits) arising from implementation of the works, as well as any long-term trends following remediation. This may identify ongoing maintenance necessary to maintain the capping system.
– Following remediation, conduct:
    - Monthly inspections of vegetation establishment, including monitoring and rectification of any deficiencies (or as required in accordance with the Technical Specification of the works) for a minimum of 12 months. In particular, monitoring should include identification of any erosion/riling, sedimentation (accumulation of eroded material), dying/dead vegetation, areas of instability (i.e. tension cracking), ponding of waters, and damage to the capping materials.
    - Quarterly visual stability inspections of Forsters Creek in proximity to the remediated slag heap. Where instabilities of the natural surface that was remediated is observed, i.e. landslips, tension cracking, slumping, etc. guidance shall be sought from the designer on additional engineering controls – this may include vegetation and/or geosynthetics and/or rock armouring.
    - Quarterly surface water quality monitoring at locations SW01 and SW02 (as shown in Appendix A) including monitoring of electrical conductivity, pH, total dissolved solids, total suspended solids, major cations and anions, total and dissolved metals and metalloids, ammonia and nutrients for a minimum of 24 months. Results are to be compared against upstream monitoring locations and background levels. Any discrepancies are to be reviewed with consideration to the state of the site with a suitably qualified consultant.

5. Conclusion

The project is expected to result in a significant improvement to water environments as the surface of the Lake George Mine is progressively remediated. Further, no significant further negative impacts are predicted as compared to the impacts already occurring. These conclusions are based on the following:

- Existing contamination sources and pathways from the site that pose an existing risk to downstream environments are remediated by application of in situ treatment, engineered capping, the importation of sub and topsoil and re-vegetation.
  - The existing risk of erosion and sedimentation is anticipated to be significantly reduced as the site is vegetated.
  - The exposure pathway of rainfall derived runoff and infiltration is anticipated to be significantly reduced as materials are isolated by the revegetation medium and the capping material.
- No changes to hydrology or river flows are anticipated, as existing surface water drainage network will be replaced with equivalent structures.
- There is no ongoing water source required, and water demand for construction is to be sourced externally from the Captains Flat town dam. Existing water storages will be unmodified.
- No impacts to flooding, either on-site or off-site are anticipated as the site is generally above existing flood levels and the topology of lower-lying areas is unchanged.
- During the construction phase, a Construction Environmental Management Plan would be prepared following approval of the proposal, in consultation with relevant agencies as required. In particular, the CEMP would include:
  - Implementation of sediment and erosion control devices with consideration to Managing Urban Stormwater, informally known as the 'Blue Book', including *Managing Urban Stormwater – Volume 1* (Landcom, 2004), *Managing Urban Stormwater – Volume 2* (DECC, 2008a) and *Managing Urban Stormwater – Volume 2E, Mines and quarries* (DECC, 2008b)
  - Utilising lower risk liming products in non clay capped domains, namely calcium carbonate based agricultural limes, rather than non-carbonate products such as oxide or hydroxide
  - Stockpiling of potential hazardous materials and emergency management procedures
  - Ongoing monitoring and maintenance during the works, in particular during establishment of vegetation
  - Management and inspection of natural waterways, including Forsters Creek and Copper Creek
  - Monitoring of water quality during the works, including consideration of the Trigger Action Response Plan which identifies trigger values and documents appropriate response actions.
- Following construction, continuation of the existing monitoring and maintenance at the site, as part of the site's post-remediation Environmental Management Plan.

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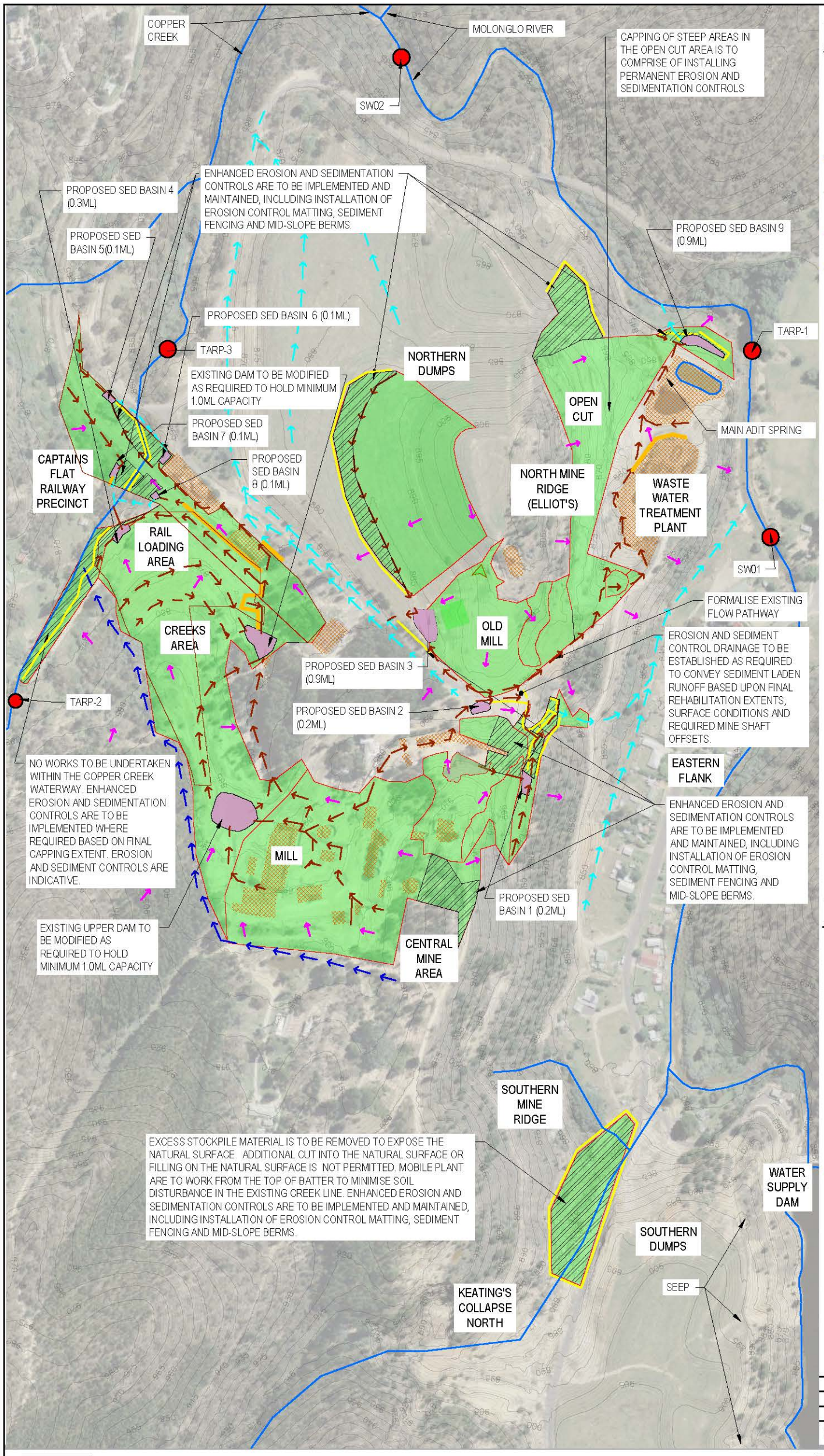
Appendix A

Conceptual surface water management plan



LEGEND

- SURFACE WATER FLOW DIRECTION
- HYDROLINES
- TEMPORARY SEDIMENT DRAIN
- EXISTING FLOW PATH
- TEMPORARY CLEAN WATER DRAIN
- REHABILITATION AND CAPPING EXTENTS (APPROX.)
- EXISTING INFRASTRUCTURE
- PROPOSED CAPPING AREAS
- TARP MONITORING LOCATIONS
- SEDIMENT BASINS
- SEDIMENT FENCING
- BUNDS
- AREAS REQUIRING ENHANCED SEDIMENT AND EROSION CONTROLS
- EXISTING 1m CONTOURS

NOTES:

1. EROSION AND SEDIMENT CONTROLS SHOWN ARE THE MINIMUM REQUIREMENTS. THE CONTRACTOR SHALL IMPLEMENT AN EROSION AND SEDIMENT CONTROL SYSTEM AS PART OF THE CONSTRUCTION MANAGEMENT PLAN IN ACCORDANCE WITH MANAGING URBAN STORMWATER - SOILS AND CONSTRUCTION MANUAL (DECC, 2004).
2. SEDIMENT BASINS TO BE DESIGNED TO PROVIDE FOR 85TH PERCENTILE 5 DAY RAINFALL CAPACITY IN ACCORDANCE WITH THE REQUIREMENTS OF MANAGING URBAN STORMWATER - SOILS AND CONSTRUCTION MANUAL (DECC, 2004)
3. DRAINAGE CHANNELS GENERALLY TO COMPRISE GRASSED SWALES LAID ON EROSION CONTROL MATTING AND UNDERLAIN BY TOPSOIL
4. ALL DRAINAGE TO BE CONSTRUCTED WITH MINIMUM 1% LONGITUDINAL FALL.
5. LOCATIONS OF EXISTING DRAINAGE AND CULVERTS ARE INDICATIVE ONLY AND TO BE CONFIRMED ONSITE
6. ALL CAPACITIES AND SIZINGS ARE INDICATIVE ONLY AND SUBJECT TO DESIGN.

Rev	Description	App'd	Date
B	CONCEPT PLAN		24.03.22
A	CONCEPT PLAN		22.09.21

GHD

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0 50 100 150m
SCALE 1:5000 AT ORIGINAL SIZE

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DEPARTMENT OF REGIONAL NSW
LAKE GEORGE MINE REMEDIATION REF

SURFACE WATER MANAGEMENT CONCEPT PLAN

Scale	Project no.	Status code
1:5000	12551771	S3

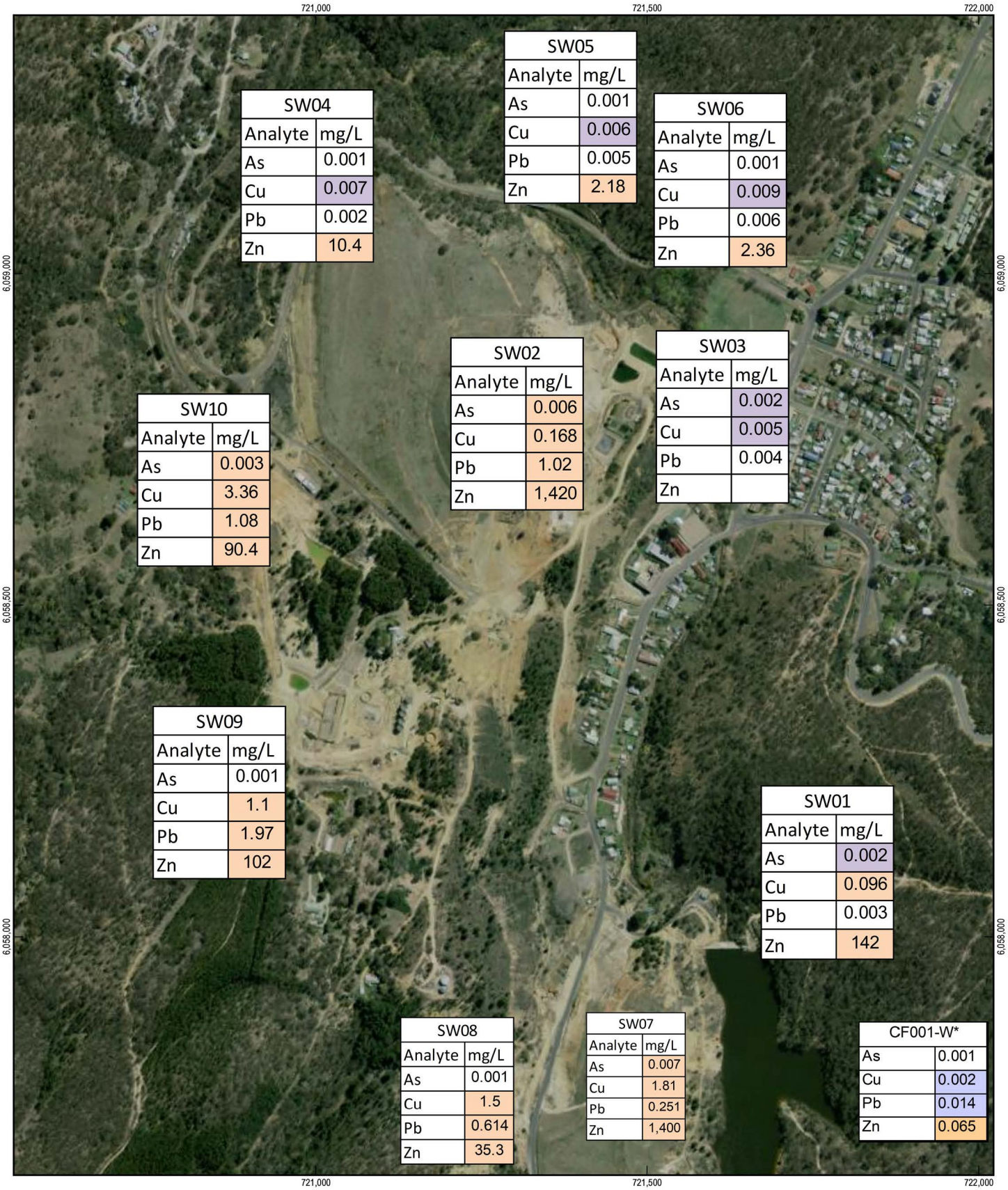
Sketch no. FIGURE A1

Rev no. B

Plot Date: 24 March 2022 - 12:48 PM Plotted by: Kavi Karunaratne Cad File No: \\ghdnet\ghd\AU\Sydney\Projects\21\12551771\Tech\SurfaceWater\CADD\21-27816-WIA_REF_Sketch_V4.dwg

Appendix B

Water quality results



SW04	
Analyte	mg/L
As	0.001
Cu	0.007
Pb	0.002
Zn	10.4

SW05	
Analyte	mg/L
As	0.001
Cu	0.006
Pb	0.005
Zn	2.18

SW06	
Analyte	mg/L
As	0.001
Cu	0.009
Pb	0.006
Zn	2.36

SW02	
Analyte	mg/L
As	0.006
Cu	0.168
Pb	1.02
Zn	1,420

SW03	
Analyte	mg/L
As	0.002
Cu	0.005
Pb	0.004
Zn	

SW10	
Analyte	mg/L
As	0.003
Cu	3.36
Pb	1.08
Zn	90.4

SW09	
Analyte	mg/L
As	0.001
Cu	1.1
Pb	1.97
Zn	102

SW01	
Analyte	mg/L
As	0.002
Cu	0.096
Pb	0.003
Zn	142

SW08	
Analyte	mg/L
As	0.001
Cu	1.5
Pb	0.614
Zn	35.3

SW07	
Analyte	mg/L
As	0.007
Cu	1.81
Pb	0.251
Zn	1,400

CF001-W*	
As	0.001
Cu	0.002
Pb	0.014
Zn	0.065

ANZECC 2000 FW80%	Exceedance
ANZECC 2000 FW95%	Exceedance

● Historical Surface Water Samples (after Brooks 1980)

Paper Size ISO A4

0 0.055 0.11 0.165 0.22

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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LAKE GEORGE MINE REMEDIATION
REF

SURFACE WATER RESULTS FAE80% & FAE95% SUMMARY (MINE AREA)

Project No. **12551771**
Revision No. **A**
Date **25/08/2021**

FIGURE B1

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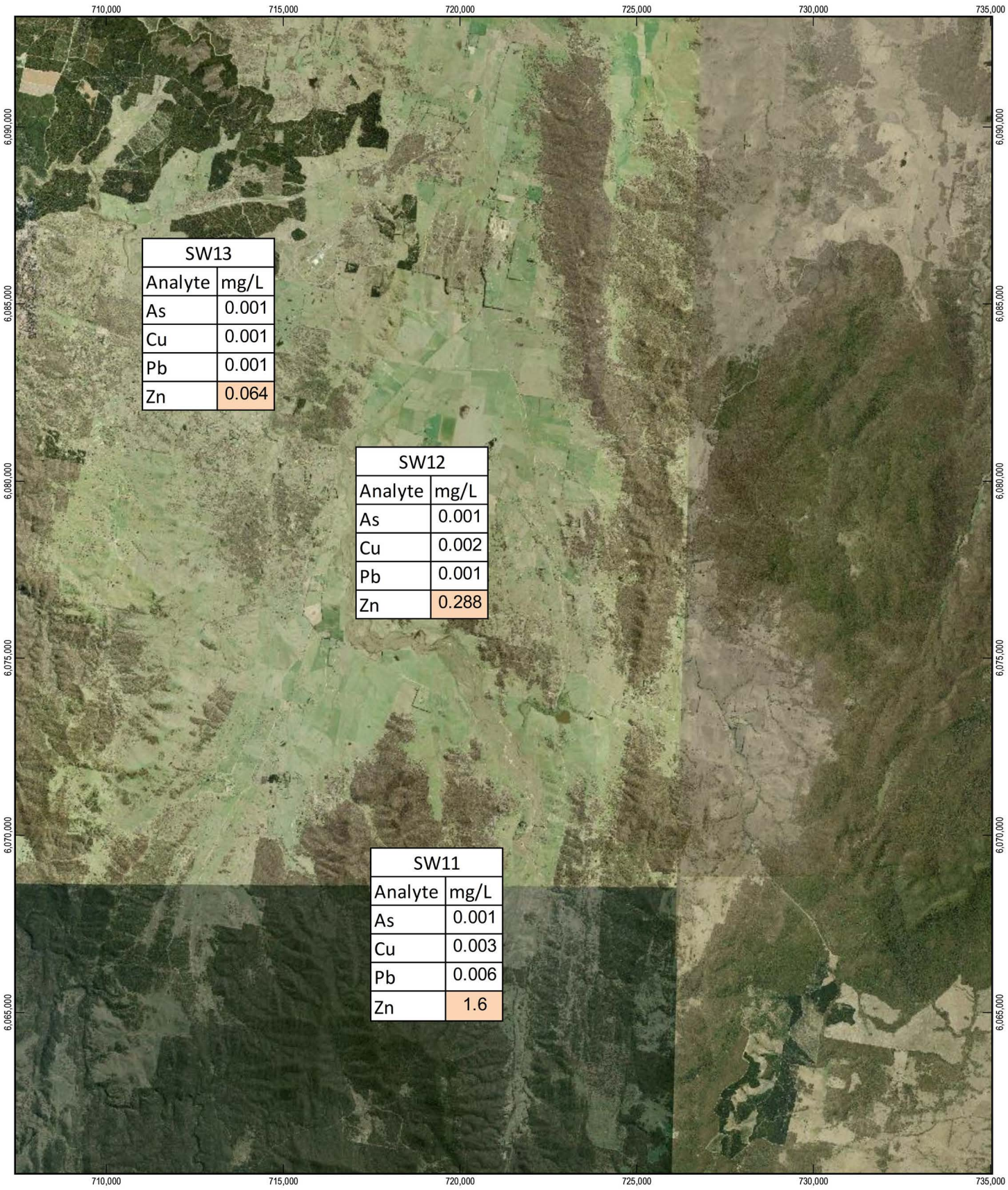
Print date: 25 Aug 2021 - 11:03



SW13	
Analyte	mg/L
As	0.001
Cu	0.001
Pb	0.001
Zn	0.064

SW12	
Analyte	mg/L
As	0.001
Cu	0.002
Pb	0.001
Zn	0.288

SW11	
Analyte	mg/L
As	0.001
Cu	0.003
Pb	0.006
Zn	1.6

ANZECC 2000 FW80%	Exceedance
ANZECC 2000 FW95%	Exceedance

● Historical Surface Water Samples (after Brooks 1980)

Paper Size ISO A4

0 1 2 3 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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DEPARTMENT OF REGIONAL NSW
LAKE GEORGE MINE REMEDIATION
REF

SURFACE WATER RESULTS FAE80% & FAE95% SUMMARY (MINE AREA)

Project No. **12551771**
Revision No. **A**
Date **25/08/2021**

FIGURE B2

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