Wallerawang Power Station – Ash Dam

Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan - Stage 1

Prepared for Generator Property Management

March 2026

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E220618 RP7

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26 March 2026

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1 Introduction

1.1 Background

The Sawyers Swamp Creek realignment concept was described in the Environmental Impact Statement (EIS) for Stage 2 of the Kerosene Vale Dry Ash Repository (KVAR) (PB 2008a). The EIS was approved by the Minister of Planning in 2008 (SSD Approval 07-0005, the 'Approval'). The stated purpose of the Sawyers Swamp Creek realignment was to allow for the construction of a new KVAR toe berm to stabilise the ash dam's embankment. Neither the KVAR toe berm nor the Sawyers Swamp Creek realignment were ever constructed despite Stage 2A of the KVAR being constructed.

Generator Property Management (GPM) commenced ownership and responsibility for the site in September 2020, taking over from EnergyAustralia NSW Pty Ltd. GPM's initial focus has been to manage the ongoing regulatory and contractual obligations for the site. The longer-term objective is to plan for and then undertake the safe closure of the ash dams and repositories and then appropriately remediate the balance of the site for permanent closure.

The site includes:

- The Kerosene Vale Dry Ash Repository (KVAR) and underlying former Kerosene Vale Ash Dam (KVAD)
- Sawyers Swamp Creek Ash Dam (SSCAD)
- Lidsdale Cut and adjacent asbestos landfills
- Demolition landfill south of the SSCAD.

The site location and layout are displayed in Figure 1.1.

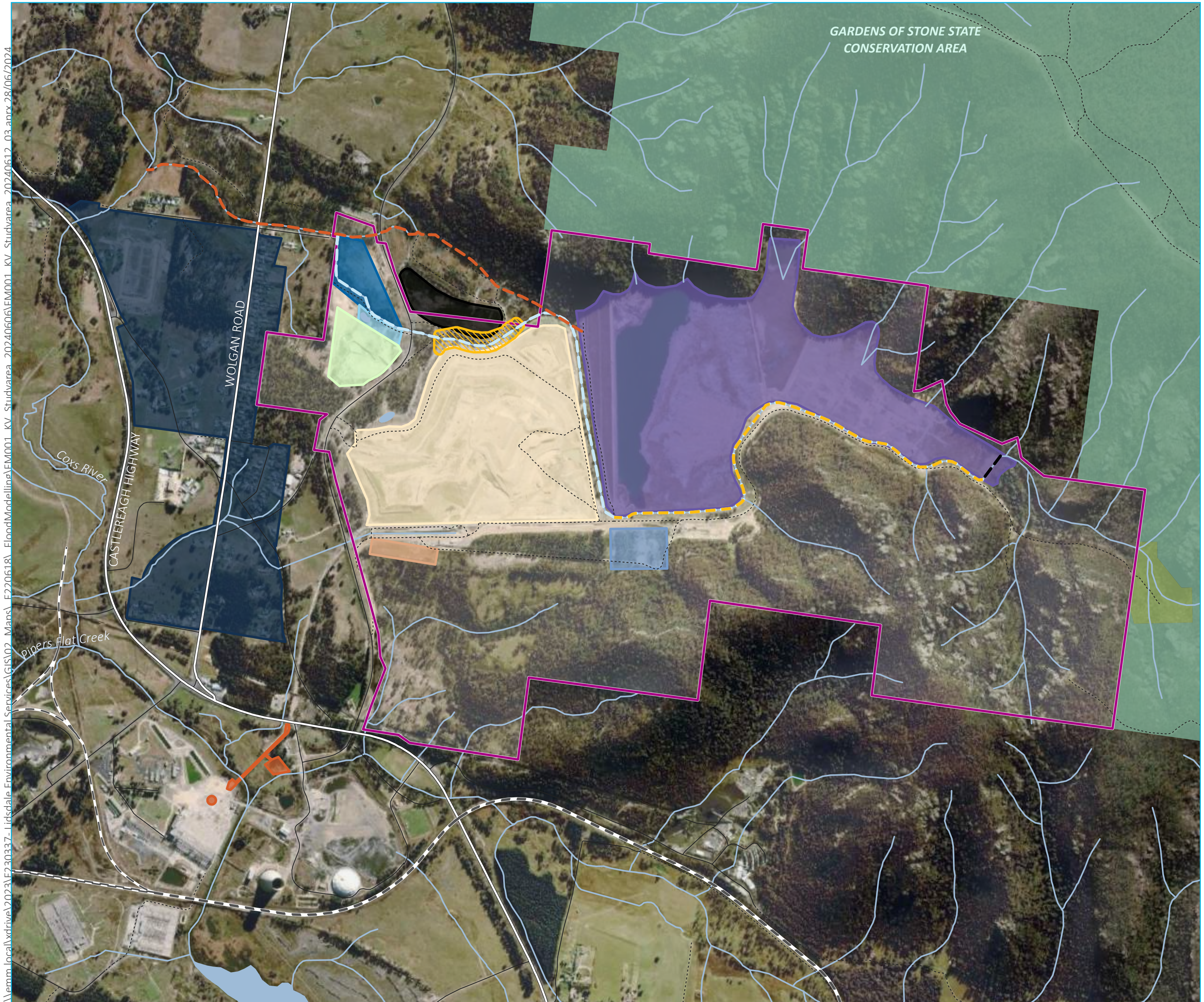
Geotechnical investigations completed by WSP that were commissioned by GPM have identified that KVAR and the underlying KVAD are unstable. Improved subsurface drainage from KVAD and a new KVAR stability berm/buttress have been proposed by WSP to address this issue. Sawyers Swamp Creek needs to be locally realigned to enable these works. The approval conditions also require Sawyers Swamp Creek to be rehabilitated in the long term.

A draft Rehabilitation Plan was developed in 2008 (PB 2008b) as part of the EIS Stage 2 of KVAR. Due to the need to implement stability measures for the KVAR and KVAD in the short term and a re-evaluation of the long-term creek realignment options as part of the site's rehabilitation activities, the staging of rehabilitation works on Sawyers Swamp Creek is required.

1.2 Purpose

This Progressive Rehabilitation Plan (the plan) has been developed to:

- describe the short-term realignment works, and outline the approach for determining the required long-term realignment works required for Sawyers Swamp Creek
- outline a framework for addressing the relevant conditions of approval
- provide assessment outcomes for the works proposed for Sawyers Swamp Creek, including ancillary studies to address potential environmental and operational risks
- provide a monitoring and management approach for surface water quality and instream ecology.



KEY

- Study area
- Stage 1 Sawyers Swamp Creek alignment
- Clean water diversion drain
- Diversion dam
- Downstream diversion (Sawyers Swamp Creek)
- Historical creek alignment

Site feature

- 2018 proposed asbestos disposal area
- Demolition landfill south of SSCAD
- Kerosene Vale ash repository
- Lidsdale cut
- Lidsdale cut northern landfill
- Lidsdale cut southern landfill
- Nearest sensitive (residential) receiver
- Sawyers Swamp Creek ash dam
- Southern EPL site
- Kerosene Vale coal stockpile area

Existing environment

- Rail line
- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- Named waterbody
- NPWS reserve

INSET KEY

- Major road

Site location and layout

Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan- Stage 1
Figure 1.1

EMM creating opportunities

Source: EMM (2024); GPM (2024); ABS (2021); DCSSS (2023); ESRI (2024)

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GDA2020 MGA Zone 56

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1.3 Progressive rehabilitation strategy

To achieve the rehabilitation objectives, a progressive strategy of a short- (Stage 1) and long-term (Stage 2) realignment of the creek has been developed:

- **Stage 1 – Short-term realigned creek:** a realignment of the existing Sawyers Swamp Creek diversion is required to construct a stability buttress on the KVAR ash repository. This realignment is expected to be a short-term measure due to constraints associated with the land adjacent to the current creek alignment limiting the ability for the creek to convey greater volumes or to provide any appreciable aquatic habitat.

- **Stage 2 - Long-term realigned creek:** As part of rehabilitation of the GPM Lidsdale site (including KVAR and SSCAD), realignment of Sawyers Swamp Creek is required to manage high flows and to improve aquatic habitat values of the creek. A number of options are available for this realignment that consider the rehabilitation activities and the ownership of the adjoining properties. Studies are being undertaken to evaluate the constraints with these options. Once the preferred creek alignment option has been determined, a revised version (Stage 2) of this plan will be completed that describes the long-term creek realignment.

Figure 1.2 presents a flow chart of the staged approach for the rehabilitation plan.

A review of how the conditions of consent are to be addressed progressively in this plan is provided in Section 2.1.

This plan will cover the required Stage 1 works, with Stage 2 currently under development and pending the outcomes of a range of investigations. Stage 2 will be issued for review and approval following completion of construction of Stage 1.

1.4 Relationship to other plans

This plan should be reviewed in conjunction with the Construction Environmental Management Plan (CEMP) and Operational Environmental Management Plan (OEMP). The plan has been prepared considering input from a range of associated studies, which are provided in the reference section.

1.5 Consultation

Consultation on this plan has occurred with the NSW Department of Primary Industries and Regional Development (NSW DPIRD, previously Department of Primary Industries Fisheries, Fisheries NSW) and Department of Planning, Housing and Infrastructure (DPHI). Consultation evidence and responses to information requests is provided in Appendix A.

1.6 Plan structure

The plan comprises the following sections:

Section 1 - describes the background for the preparation of the plan, the purpose, and key associated documents.

Section 2 - a summary of the associated environment legislation and regulatory requirements for the plan.

Section 3 - describes the existing environment, site features and baseline monitoring outcomes.

Section 4 - outlines the rehabilitation objectives and performance criteria.

Section 5 and 6 - provide the details on the Stage 1 realignment works and outlines the details and approaches under consideration for the Stage 2 realignment.

Section 7 – outlines the compliance tracking program.

Section 8 - outlines the monitoring program, management and response plan for the realignment and rehabilitation works.

Section 9 - describes the associated reporting requirements for the realignment and rehabilitation works.

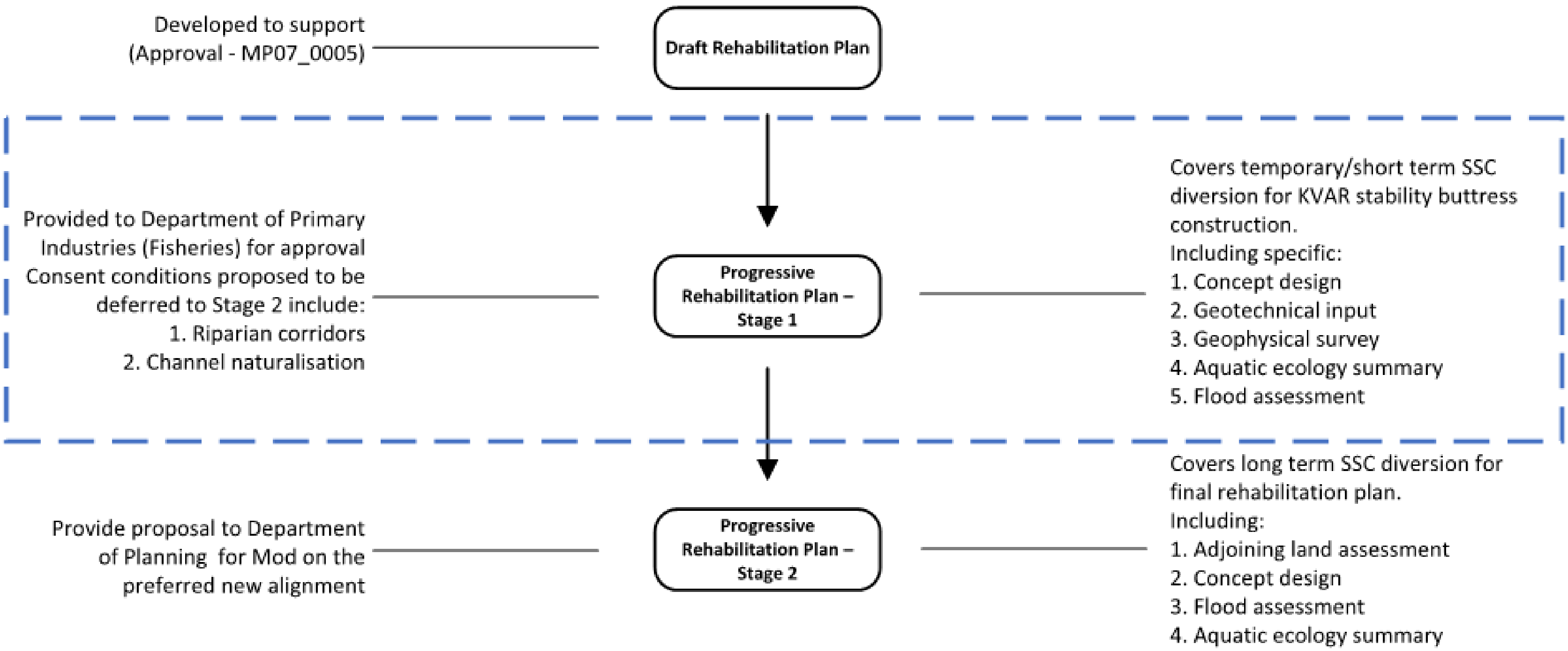


Figure 1.2 Staged approach to the rehabilitation plan

2 Regulatory requirements

2.1 Development consent conditions

The Kerosene Vale Stage 2 Ash Repository works were approved under the *Environmental Planning and Assessment Act 1979* (EP&A Act). The project is now considered a State Significant Development (SSD) following a transitional process of the approval.

The Kerosene Vale Stage 2 Ash Repository Approval (07_0005) has been subject to two modifications, with the last modification approved in October 2023.

This plan is a continuation of the draft Rehabilitation Management Plan prepared by Parsons Brinkerhoff (2008) for Delta Electricity, as part of the original environmental assessment documentation, and is now also required by Condition 2.26 of the consolidated consent.

Table 2.1 outlines the relevant conditions of consent in terms of both the original draft Rehabilitation Management Plan and the proposed revised elements, considered within this plan.

Table 2.1 Conditions of consent and revisions to the draft plan

Relevant conditions of consent	Draft Rehabilitation Management Plan (PB 2008) inclusions	Proposed amendments under staged approach	Where it is addressed in this report
1.1) The Applicant must carry out the project: a) in compliance with the conditions of this approval; b) in accordance with all written directions of the Secretary; c) generally in accordance with the EA; and d) generally in accordance with the project area.	Not covered	The project will be carried out in accordance with all the requirements of this condition.	This document
2.26) The Proponent shall prepare and submit to the Secretary for approval a Rehabilitation Plan addressing the restoration of the in-stream area (i.e. bed and bank) of Sawyers Swamp Creek and the associated riparian corridor at least two months prior to the realignment of the creek, unless otherwise agreed by the Secretary. The Plan shall be developed in consultation with, and to the satisfaction of, Fisheries NSW and shall include, but not necessarily be limited to:	Draft plan provided to support EIS. The concept provided is no longer feasible given changes to the stability berm/buttress and ash used as backfill within adjacent Kerosene A/B Open Cut.	Progressive plan prepared considering short- and long-term options for the restoration of Sawyers Swamp Creek.	This document and progressively updated with the rehabilitation of the site
a) the objectives and outcomes that would be sought through the implementation of the Plan;	Objectives proposed	Objectives improved following progression of rehabilitation expectations within industry	Section 4

Table 2.1 Conditions of consent and revisions to the draft plan

Relevant conditions of consent	Draft Rehabilitation Management Plan (PB 2008) inclusions	Proposed amendments under staged approach	Where it is addressed in this report
b) performance criteria for the realigned creek and associated riparian zone against which the impact of the project on the ecological health of Sawyers Swamp Creek will be assessed;	Detailed performance criteria not proposed or listed within consent	Performance criteria has been developed as part of this plan covering: • Stability (including geomorphology) • Water quality • Flow (hydrology/hydraulics) • Instream conditions (aquatic ecology, vegetation)/naturalisation • Riparian buffers • water licensing/regulation	Section 4
c) methodology used in developing the realignment planform;	Methodology detailed	Stage 1 realignment has been based on engineering requirements and optimised for the space available. Methodology proposed in draft plan to be adopted for Stage 2.	Section 5.1, Section 6
d) details of the final creek realignment including bank, meander, depth and slope characteristics (including pool-riffle sequences), flow and channel capacity characteristics, scour potential, and in-stream vegetation;	Option specific to the draft rehabilitation plan to be replaced by new two stage realignment	Details on the design and hydraulic performance for Stage 1 has been provided. Stage 2 options are currently under investigation and pending further studies.	Section 5.1, Section 6, Appendix B Appendix C
e) timing of the creek realignment;	Schedule of works not provided and is no longer relevant	Schedule of works outlined for the Stage 1 realignment. The conceptual scheduling of the Stage 2 realignment will be provided however specific dates are not currently available due to ongoing studies and preferred option yet to be determined.	Section 5.5 and 5.6 Section 6.3
f) a description of the proposed riparian zone and restoration works along the entire length of the creek realignment, including details of plant species to be used in rehabilitation;	Description provided for the original concept proposed	To be revised for Stage 1 and Stage 2. Stage 1 will comprise of an engineered channel with limited opportunity for riparian vegetation. Stage 2 options are currently under investigation and pending further studies. Stage 2 options will be evaluated based on the potential for achieving this condition.	Section 5.4

Table 2.1 Conditions of consent and revisions to the draft plan

Relevant conditions of consent	Draft Rehabilitation Management Plan (PB 2008) inclusions	Proposed amendments under staged approach	Where it is addressed in this report
g) details of any proposed riparian and in-stream controls to be implemented in the reach upstream of the alignment to ensure the effectiveness of the proposed creek realignment and rehabilitation;	Controls included riffle and pool sections	Stage 1 will not include any specific instream controls besides channel armouring and erosion and sediment control. Stage 2 options are currently under investigation. Stage 2 will include instream controls as required dependent upon the final option adopted.	Section 5.4, Section 8.2
h) a description of the initial and ongoing weed control measures;	Weed management strategies discussed throughout	Stage 1 will be stabilised with grasses where possible with instream vegetation removed for the diverted section as part of channel armouring requirements. Weed management will be in accordance with the OEMP. Stage 2 options are currently under investigation. Stage 2 will detail the required weed control measures.	Section 5.4
i) the methodology and timing of post realignment monitoring of the hydrology and ecological health of the aquatic and riparian vegetation as required under conditions 3.6 and 3.7 of this approval, respectively;	Conceptual monitoring program provided	Specific monitoring program provided for both Stage 1 and 2. Stage 1 will have limited instream aquatic biodiversity outcomes and hence monitoring will be prioritised in Stage 2.	Section 8
j) mitigation measures to be implemented in the event of an identified decline in ecosystem health as a direct result of the realignment of the creek or construction or operation of the project, including a timetable for implementation;	Not covered	Response plan to be developed as part of Stage 1 and 2.	Section 8.1
k) program for ongoing maintenance of the realigned creek system and associated	Conceptual monitoring program provided	Monitoring program has been provided and will be specific to the requirements of each proposed stage.	Section 8
l) any compensatory measures to offset the impacts of the project on the aquatic habitat and local waterways, if and as required by Fisheries NSW and	Not covered		Currently not required for Stage 1 works
m) provisions for periodic reporting of monitoring results to Fisheries NSW.	Not covered		Section 9.3

Table 2.1 Conditions of consent and revisions to the draft plan

Relevant conditions of consent	Draft Rehabilitation Management Plan (PB 2008) inclusions	Proposed amendments under staged approach	Where it is addressed in this report
2.27) The rehabilitation and restoration of Sawyers Swamp Creek and associated riparian zone are to be consistent with the Works and Watercourse Design Guideline (DWE, April 2007) and Guidelines for Controlled Activities: Vegetation Management Plans (DWE, February 2008).	Standards adopted as part of the preparation of the plan	Standards adopted as part of the preparation of the plan will consider the current regulatory guidance of: • *Controlled activities – Guidelines for instream works on waterfront land* (DPEW 2022a) • *Controlled activities – Guidelines for vegetation management plans on waterfront land* (DPEW 2022b)	Section 2.6
2.28) A riparian zone consisting of local native plant species shall be established and maintained in and adjacent to Swayers Swamp Creek, for the entirety of the site and be a minimum width of 20 m on both sides of the creek. Seed and propagule sources are to be from local botanical provenance and same general habitat.	Riparian zone proposed however due to site constraints this would not have been successful	Stage 1 will be stabilised with grasses due to proximity to geotechnical stability berm with a limited riparian buffer zone. Stage 2 options are currently under investigation. Stage 2 options will be evaluated on their ability to achieve a riparian zone that achieves at least 40-m plus channel width	Section 5.4, Section 6
2.29) The riparian zone referred to under condition 2.28 of this approval shall be maintained for a period of at least five years after final planting.	Maintenance program was provided	Stage 1 will be maintained as an engineered drainage channel. Stage 2 will include a vegetation management plan, consistent with (DPEW 2022b), including maintenance for a period of at least 5 years	Section 5.4
3.6) Implementation of a hydrological monitoring program	Broad scope for monitoring requirements	Specific monitoring program provided for Stage 1.	Section 8.1.1
3.7) Implementation of an ecological monitoring program	Conceptual monitoring program provided	Specific monitoring program provided for Stage 1.	Section 8.1.2
4) COMPLIANCE MONITORING AND TRACKING 4.1) Prior to each of the events listed below, the Applicant shall certify in writing to the satisfaction of the Secretary that it has complied with all conditions of this approval applicable prior to that event: a) commencement of any construction works on the land subject of this approval; and b) commencement of operation of the project.	Not covered	Compliance monitoring and tracking will be consistent with the requirements outlined within the CEMP and OEMP	Section 7

Table 2.1 Conditions of consent and revisions to the draft plan

Relevant conditions of consent	Draft Rehabilitation Management Plan (PB 2008) inclusions	Proposed amendments under staged approach	Where it is addressed in this report
4.2) The Applicant shall develop and implement a Compliance Tracking Program for the project, prior to commencing operations, to track compliance with the requirements of this approval and shall include, but not necessarily limited to a), b), c), d), e), f), g) The Compliance Tracking Program shall be implemented prior to operation of the project with a copy submitted to the Secretary for approval within four weeks of commencement of the project, unless otherwise agreed by the Secretary.			Section 7, Section 8 and Section 9
4.3) Nothing in this approval restricts the Applicant from utilising any existing compliance tracking programs administrated by the Applicant to satisfy the requirements of condition 4.2. In doing so, the Applicant must demonstrate to the Secretary how these systems address the requirements and/or have been amended to comply with the requirements of the condition.			Section 7, Section 8 and Section 9
4.4) The Applicant shall meet the requirements of the Secretary in respect of the implementation of any measure necessary to ensure compliance with the conditions of this approval, and general consistency with the documents listed under condition 1.1 of this approval.			Section 7, Section 8 and Section 9

2.2 Protection of the Environment and Operations Act

The *Protection of the Environment and Operations Act 1997* (POEO Act) controls how activities should be undertaken in consideration of environmental protection on all aspects, including air, water, soil and noise pollution, as well as waste.

Section 120 of the POEO Act prohibits the pollution of waters and creates a duty to notify the relevant authority of pollution incidents. The realignment works will be managed to ensure pollution risks to soil, waterways and air quality are avoided or minimised.

Scheduled activities (under Schedule 1, clause 17 of the POEO Act) are required to obtain a licence to operate from the Environment Protection Authority (EPA). Whilst the site no longer has scheduled activities, it does have a licence. Environmental protection licence (EPL) 21185 regulates the operation of the Kerosene Vale Ash Repositories. The licence was issued in September 2020.

The licence includes water discharge locations, water quality and flow monitoring and reporting requirements.

2.3 Contaminated Land Management Act 1997

Contamination at the Site was notified to the EPA by GPM under Section 60 of the *Contaminated Land Management Act 1997* (CLM Act) on 10 March 2021. Following review of available information, EPA advised (on

27 June 2022), that the contamination is significant enough to warrant regulation under the CLM Act. Given this determination, the EPA has declared the land as significantly contaminated land under Section 11 of the CLM Act and therefore it is being regulated as such.

The CLM Act establishes a process for investigating and remediating land that the EPA considers to be contaminated significantly enough to require regulation.

In August 2022, EMM completed a preliminary site investigation (PSI) at the Site, to develop an understanding of potential contamination that could impact on the future land use at the Site.

GPM submitted a Voluntary Management Proposal (VMP) outlining the proposed investigation and remediation approach to the NSW EPA on 11 October 2023.

A detailed site investigation (DSI) is one of the required next stages in the regulatory process and is currently underway. The outcomes of the DSI will be considered when determining which of the Stage 2 realignment options will be adopted.

2.4 Water Management Act 2000

The NSW *Water Management Act 2000* (WM Act) regulates water take from surface and groundwater water sources. The WM Act provides for water sharing between different water users, including environmental, basic landholder rights (i.e. domestic and stock, native title and harvestable rights) and existing water access holders and provides security for rights holders.

The *Water Act 1912* (Water Act) is gradually being repealed and replaced by the WM Act as water sharing plans (WSPs) are developed for water sources across NSW, and as new regulations are made. However, some aspects of the Water Act are still operational across all of NSW, such as licences for monitoring bores (except where exempt).

The licensing provisions of the WM Act apply to the GPM Lidsdale site, however the realignment activities will not constitute water take from surface water sources.

2.4.1 Waterfront land

The WM Act also defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of the riverbanks, lake shore or estuary mean high water mark and defines that a river includes ‘a stream of water, whether perennial or intermittent, flowing in a natural channel, or in a natural channel artificially improved, or in an artificial channel which has changed the course of the stream.’

The realignment work covered by the plan includes watercourses that satisfy the above definition within the WM Act, as well as proposed works on waterfront land. Controlled activity approvals (CAAs) under Section 91 of the WM Act for certain activities in, on or under waterfront land, do not apply to State Significant Development (SSD). However relevant guidance for controlled activities has been considered in the development of this plan (refer to Section 2.6.2).

2.5 Water NSW Act 2014

The NSW *Water NSW Act 2014* defines the functions and objectives of WaterNSW, which is a State-owned corporation formed in 2015 from the merger of the Sydney Catchment Authority and State Water Corporation. WaterNSW is Australia’s largest bulk water supplier and NSW’s major supplier of raw water. The principal objectives of WaterNSW under the *Water NSW Act 2014* are:

- to capture, store and release water in an efficient, effective, safe and financially responsible manner

- to supply water in compliance with appropriate standards of quality
- to ensure that declared catchment areas and water management works in such areas are managed and protected so as to promote water quality, the protection of public health and public safety and the protection of the environment
- to provide for the planning, design, modelling and construction of water storages and other water management works
- to maintain and operate the works of WaterNSW efficiently and economically and in accordance with sound commercial principles.

This plan includes realignment activities of watercourses within the upper Coxs River catchment, which is part of the Sydney drinking water catchment. A key responsibility of WaterNSW is identifying and managing impacts on water quality in the declared catchment areas. In order to protect water quality, the Water NSW Regulation 2013 provides for regulatory powers to manage pollution activities that potentially impact water quality.

2.6 Relevant policies and guidelines

2.6.1 State Environmental Planning Policy (Biodiversity and Conservation) 2021

Chapter 8 of State Environmental Planning Policy (Biodiversity and Conservation) 2021 (the SEPP) is applicable as the activities covered by this plan as the site is within the Sydney drinking water catchment area. The policy aims to maintain healthy water catchments that will deliver high quality drinking water while permitting development. It provides that a consent authority must not grant consent to development under Part 4 of the EP&A Act on land within the Sydney drinking water catchment unless it is satisfied that it would have a neutral or beneficial effect (NorBE) on water quality. The aims of Chapter 8 of the SEPP are:

a) to provide for healthy water catchments that will deliver high quality water while permitting development that is compatible with that goal

b) to provide that a consent authority must not grant consent to a proposed development unless it is satisfied that the proposed development will have a neutral or beneficial effect on water quality

c) to support the maintenance or achievement of the water quality objectives for the Sydney drinking water catchment.

The existing project approval allows for the realignment of a section of Sawyers Swamp Creek, which feeds into the upper Coxs River catchment. The environmental assessment indicated that the water quality during construction would be adequately managed. This plan outlines how this will be achieved with the nominated staged realignment activities.

2.6.2 Guidelines for controlled activities on waterfront land

The NSW DCCEEW provides several guidelines in relation to works on waterfront land, as defined by the WM Act. These include:

- *Controlled activities – guidelines for riparian corridors on waterfront land* (DPE 2022a)
- *Controlled activities – guidelines for watercourse crossings on waterfront land* (DPE 2022b)
- *Controlled activities – guidelines for instream works on waterfront land* (DPE 2022c).

Whilst a CAA is not required for the realignment activities due to the approval having a SSD designation, relevant guidelines have been considered in the development of this plan. These guidelines are relevant to the identification and management of riparian corridors and associated vegetated riparian zones.

2.6.3 Guidelines relevant to fish passage and fish habitat conservation and management

NSW DPIRD provides a number of guidelines in relation to activities that may adversely impact on management of key fish habitat or more generally limit fish passage along watercourses. These include:

- *Policy and guidelines for fish habitat conservation and management – Update 2013* (DPI 2013)
- *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull& Witheridge 2003).

Whilst a permit under the NSW *Fisheries Management Act 1994* is not required for the works defined due to the developments SSD designation, relevant guidelines have been considered in the development of the plan. These guidelines are relevant to consideration of appropriate riparian buffer distances for the purpose of key fish habitat conservation, as well as best practise guidance on minimising impacts to fish passage and general aquatic wildlife as a result of existing and future watercourse crossings required on site.

2.6.4 Erosion and sediment control guidelines

Managing Urban Stormwater: Soils and Construction – Volume 1 (Landcom 2004), Volume 2 (DECC 2008), and *Best Practice Erosion and Sediment Control* (IECA 2008) provide guidance on best practice erosion and sediment control methods. Strategies and measures outlined in these guidelines have been considered in the recommendation of mitigation measures within this plan.

3 Existing conditions

3.1 Water management system

The water management system for the site is described using the following nomenclature and includes:

- **Sawyers Swamp Creek Ash Dam (SSCAD)** is an ash dam that was formed in the Sawyers Swamp Creek valley. The surface of the dam is divided into four sections (A, B, C and D) and has a total area of 82 ha. Each section is separated by earthen embankments. Section A comprises an open water body that is referred to as the SSCAD Pond and has areas of exposed ash. Sections B, C and D are referred to as the Upper Dam and consist areas of mostly exposed soil surfaces with some vegetative cover . A perched groundwater system exists within the placed ash (the perched SSCAD groundwater system).

  The SSCAD Pond is a large water body and is a central feature of the site's overall water management system. It receives contaminated water from the KVAR water management area. This assists in minimising incidental surface and groundwater discharges from the site. SSCAD Pond also receives runoff from direct rainfall, a clean water catchment and overflows from the SSCAD Upper Dam (Section B, C and D).

  During wet conditions, clean water runoff and groundwater inflows from the vegetated escarpments located to the north of SSCAD accumulate on the surface of Section B, C and D. Water quality testing has identified this water as being clean (as it has not infiltrated through the ash). Accordingly, this water is pumped from Section B into Sawyers Swamp Creek (pump rates are in the order 300 L/sec). This practice has been successful in preventing overflows of clean water from the Upper Dam into SSCAD Pond. It is noted that GPM are currently constructing gravity operated systems that will minimise the volume of clean water that accumulates on Sections B, C and D.

- **KVAR water management area** is located to the west (downgradient) of SSCAD. The KVAR is a dry ash compacted stockpile situated on top of the capped KVAD. KVAD is the Power Station's original ash dam and was established in an open cut mine void. A perched groundwater system exists within the KVAD (the perched KVAD groundwater system). The combined area is contained within a dedicated water management system. Surface water runoff and seepage from this area drains to several water storage areas. Captured water that is known to be contaminated is reticulated to Lidsdale Cut (located downgradient of KVAR) where it is pumped to SSCAD Pond. Stormwater that is not ash affected is managed in accordance with the methods described in Managing Urban Stormwater Soils and Construction: Volume 1 (Landcom 2004) and Volume 2E Mines and Quarries (DECC 2008).

- **Sawyers Swamp Creek Diversion** is a clean water system that extends from upstream of SSCAD to the original Sawyers Swamp Creek channel to the north-west of the site. This is further described in Section 3.2.

3.2 Sawyers Swamp Creek

3.2.1 Overview

Sawyers Swamp Creek (SSC) is a watercourse that flows through the site in a westerly direction and joins the Coxs River approximately 1 km to the west of the site. The creek was diverted from its original alignment early in the site's history due to mining and ash emplacement activities and was further adjusted when the SSCAD was constructed. The diverted creek (the Sawyers Swamp Creek Diversion) is a clean water system that conveys the natural streamflow from the creek's catchment. The system diverts clean water from upstream of SSCAD (the Diversion embankment) around SSCAD (via the clean water diversion channel) and around the KVAR water management area. The diversion joins what is thought to be the original Sawyers Swamp Creek to the north-west of the site.

The Sawyers Swamp Creek Diversion generally receives inflows from the following sources:

- clean water runoff from naturally vegetated catchments to the east and south of the site
- clean water runoff from naturally vegetated catchments to the north of SSCAD that are diverted into the clean water diversion channel via the gravity main diversion works completed in Section D of the SSCAD
- water pumped from the surface of Sections B and C of the SSCAD (wet conditions only)
- stormwater discharges from the KVAR water management area (wet conditions only)
- inflows from Dump Creek, which are minor compared to the streamflow in Sawyers Swamp Creek
- groundwater inflows, including potential inflows from the perched groundwater systems that are within the ash dams.

An overview of the existing water management system surrounding and interacting with Sawyers Swamp Creek is provided in Figure 3.1.

The creek has been observed to have a perennial streamflow, indicating that baseflows are maintained by groundwater inflows. This means that the water quality will vary based on the groundwater inflow contribution as a percentage of total streamflow and water quality during wet and dry conditions can be markedly different.

As described by in the Department's Assessment Report of the Kerosene Vale Stage 2 Ash Repository, the section of Sawyers Swamp Creek subject to realignment works is degraded and does not constitute a natural waterway (NSW DP 2008).

Sawyers Swamp Creek also receives flow from Dump Creek. Dump Creek is a first order watercourse that is located to the west of the site and is potentially fed by site-affected groundwater.

Sawyers Swamp Creek contributes to the Coxs River which is a major tributary to the Hawkesbury-Nepean system. The river flows generally in a southerly direction through parts of the Central Tablelands and Blue Mountains regions of NSW. It has a total catchment area of 1,450 km^2 and ultimately flows into the northern arm of Lake Burragorang (impounded by Warragamba Dam). Lake Burragorang is a major water supply dam for the Sydney metropolitan region and is managed by WaterNSW

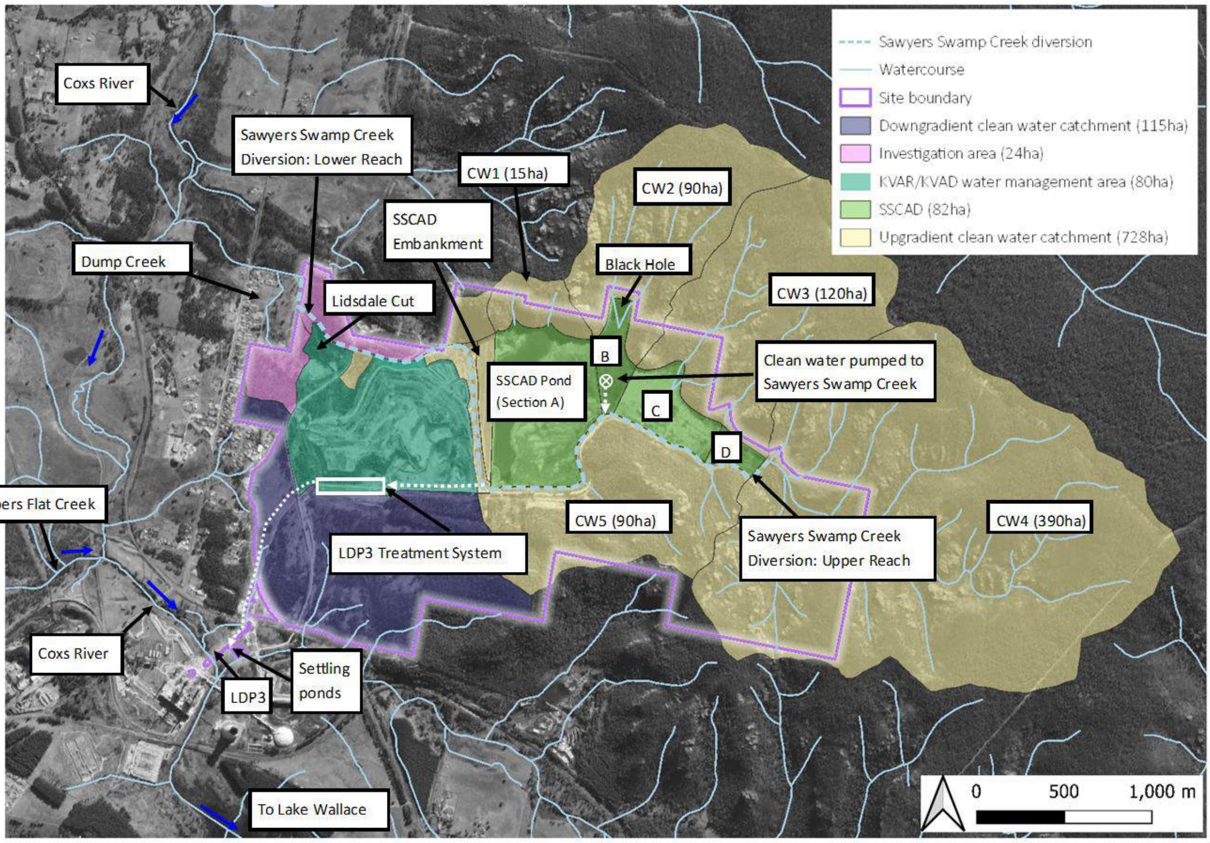


Figure 3.1 Water management overview

3.2.2 Sawyers Swamp Creek alignment

The Sawyers Swamp Creek alignment has been historically modified as part coal mining and ash repository activities. The lower portions of the creek were realigned as part of coal mining in the 1960s whereas, the upper sections were realigned later to allow construction of SSCAD (understood to be in the late 1970s).

This plan focuses on the realignment of the lower sections of the diverted Sawyers Swamp Creek (i.e. the section of watercourse downstream of the SSCAD spillway channel to the downstream boundary of the site).

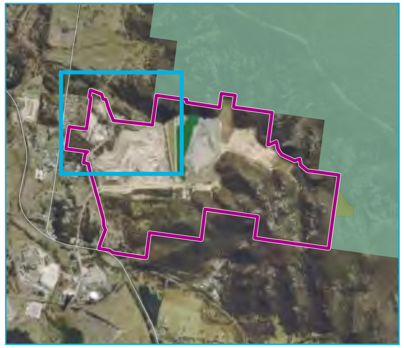
As described by PB (2008b), the existing diverted Sawyers Swamp Creek channel was constructed approximately 60 years ago, with no direct focus on stability or incorporating natural features, exhibiting incisional processes and erosion along the banks.

Prior to the diversion, the historical Sawyers Swamp Creek is believed to have been further north, on the other side of the Kerosene Vale Coal Stockpile, running perpendicular to the foothills of the Newnes Plateau, as shown in the current Hydro Line mapping under the Water Management (General) Regulation 2018 (refer to Figure 3.2). As supported by the flood modelling results (refer to Appendix C), flow does occur through the historical alignment. However, catchment-based flow is only in events where Sawyers Swamp Creek Diversion overtops and overland flow proceeds towards the alignment, vegetation growth along the historical flow path presents a significant hydraulic roughness and there is limited culvert capacity where the historical creek alignment intercepts the private haul road in the west.

River style mapping of the historical alignment of Sawyers Swamp Creek describes the length of watercourse downstream of the spillway channel as *Anthropogenic, bedrock margin-controlled,* reach relating to a *water storage*. No condition or recovery rating is described.

Further downstream on the creek, the river styles changes to a *laterally unconfined, continuous channel, low sinuosity, (channelised fill), gravel bed*. This lower section of creek was evaluated as in moderate condition with a low sinuosity. The evolution of the lower reaches, which can also be extrapolated to the upper reaches, is that the channels geomorphic evolution has occurred due to changes in the land uses (mining and ash emplacements) which has resulted in incisional processes occurring and general channelisation of the flow area. Based on the river style mapping adjacent it is expected that Sawyers Swamp Creek, prior to the change in land use, resembled a valley-fill river style.

As indicated by PB (2008b), the channelisation of sections of Sawyers Swamp Creek diversion, upstream of the private haul road, has no doubt occurred over time. However, the extent of the processes is now limited vertically by bedrock materials albeit friable shales, and horizontally through constructed embankment and stockpiles.



KEY

- Study area
- Historical creek alignment
- Downstream diversion (Sawyers Swamp Creek)

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line

Sawyers Swamp Creek alignments

Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan- Stage 1
Figure 3.2

EMM creating opportunities

Source: EMM (2024); GPM (2024); DCSSS (2024); GA (2009); MetroMap (2024)

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3.2.3 Existing instream condition

Sawyers Swamp Creek has a good coverage of instream vegetation however the channel banks are unstable throughout much of the watercourse section downstream of the spillway channel. Example areas of channel bank instabilities included adjacent to the existing KVAR embankment and Kerosene Vale stockpile area where the bank was exposed soil with a near vertical batter, suggesting erosion through capacity constraints; and the watercourse section adjacent to Lidsdale Cut where gully erosion is evident (refer to Figure 3.3).

Northern channel bank, adjacent to the KVAR and Kerosene Stockpile Area – in Stage 1 area

Eastern channel bank, adjacent to Lidsdale Cut – downstream of Stage 1

Figure 3.3 Examples of in-channel instabilities

WorleyParsons (2018) indicated that significant siltation exists along the Sawyers Swamp Creek below the end of the spillway channel to the private haul road. Worley Parsons considered it likely that increased sediment laden water from historical operations of mine dewatering and ash emplacement may have led to this siltation and has potentially decreased the capacity of the current alignment. This reduced capacity may encourage the overflow of water from the current channel to the north-west along the historical alignment. As part of previous hydraulic capacity assessments related to Sawyers Swamp Creek, WorleyParsons (2018) recommended that portions of the channel be desilted (via sucker truck or long reach excavator) to improve the flow conveyance.

3.2.4 Existing watercourse crossing and instream features

The watercourse crossing and instream features located on the diverted Sawyers Swamp Creek between the toe of the SSCAD spillway channel and the Cox River, and are relevant to the scope of realignment activities includes:

- **Instream reed bed** is an area of reeds located directly downstream of the spillway channel which acts as a stilling basin for flows from SSCAD and the upstream diverted Sawyers Swamp Creek catchment. This area also is where flow in specific events overtops northern end of the reed bed to head along the historical creek alignment. The reed bed is key in ameliorating high velocity flow from the SSCAD spillway channel. Changes to the vegetation within the reed bed would likely alter the hydraulic response of the system.

- **Access road culvert** is a crossing on the diverted Sawyers Swamp Creek located directly downstream of the Stage 1 works area including several circular concrete pipes.

- **Private haul road culvert** is a crossing on the diverted Sawyers Swamp Creek located downstream of the access road and includes a singular circular concrete pipe. At this location, flow area is constrained compared with upstream culvert crossings.

- **Flow monitoring weir** is a concrete v-notch plated flow monitoring station located on the diverted Sawyers Swamp Creek.

- **Maddox Lane culvert** is a crossing on the diverted Sawyers Swamp Creek, upstream of its confluence with the historical alignment, and includes several dilapidated corrugated steel circular pipes.

- **Wolgan Road culvert** is a crossing located on the historical alignment of Sawyers Swamp Creek consisting of several circular concrete pipes crossing Wolgan Road. The culvert location is also the monitoring location WX7 for surface water monitoring.

The instream features are important elements of the flood model provided in Appendix C and are potential connectivity barriers for instream ecology.

3.3 Catchment flow and surface water quality

3.3.1 Catchment flow

As outlined in Section 3.2.1, flow within the Sawyers Swamp Creek diversion comprises of natural rainfall runoff, pumped flows, and groundwater baseflow. A flow monitoring station has been established upstream of the confluence of the existing diverted creek section and the historical alignment however it is currently inactive. All current flow monitoring on site is based on observational monitoring.

The hydrologic and hydraulic function of the existing Sawyers Swamp Creek catchment, including the function of the SSCAD clean water diversion and SSCAD emergency spillway function, and the effect that these water management features have on clean water flows within Sawyers Swamp Creek diversion is further discussed within the flood study provided in Appendix C.

3.3.2 Surface water quality

The site has undertaken a site water quality characterisation assessment (EMM 2023b) based on the monitoring locations outlined as part of the monitoring program in Section 8.1.1 . Below is a summary of the outcomes from the assessment (refer to Figure 8.1 in Section 8 for surface water quality monitoring locations). It should be noted that the monitoring location SS5 is upstream of SSCAD in a headwater dam to the Sawyers Swamp Creek Diversion and is the upstream reference site currently adopted for the site, used to characterise ambient water quality in the Sawyers Swamp Creek catchment.

- Monitoring results upstream of SSCAD and downstream of the SSCAD spillway channel (monitoring location S6) show similar water quality results, indicating that water management activities on SSCAD does not typically degrade water quality in the Sawyers Swamp Creek Diversion.

- Elevated turbidity is generally evident within the Sawyers Swamp Creek diversion during and after rainfall events.

- For aluminium, cadmium, electrical conductivity and total nitrogen, the water quality in Sawyers Swamp Creek downstream of the site (WX7) was either below the default guideline values (DGVs) (ANZECC/ARMCANZ 2018) or lower than the ambient water quality range monitored at SS5. This indicates that there were no material impacts to the water quality (for these analytes) in Sawyers Swamp Creek.

- There was a trend of declining pH and increasing turbidity levels and concentrations of sulphate, total dissolved solids, cobalt, nickel and zinc between SS5 (upstream of SSCAD) and WX7 (downstream of the site), with most of the changes occurring in the lower reach of the Sawyers Swamp Creek diversion, between WX5 (adjacent to Lidsdale Cut) and WX7. The concentrations of cobalt and zinc were generally above default guideline values (DGVs) at WX7 in 2023. These results are consistent with historical trends during dry periods and indicate that there is some incidental discharge of ash affected water entering the lower portion of the Sawyers Swamp Creek Diversion. Dump Creek is one known source of potential poor surface water quality, however there is potential for groundwater sources from both the site and non-GPM owned land that adjoins the site.

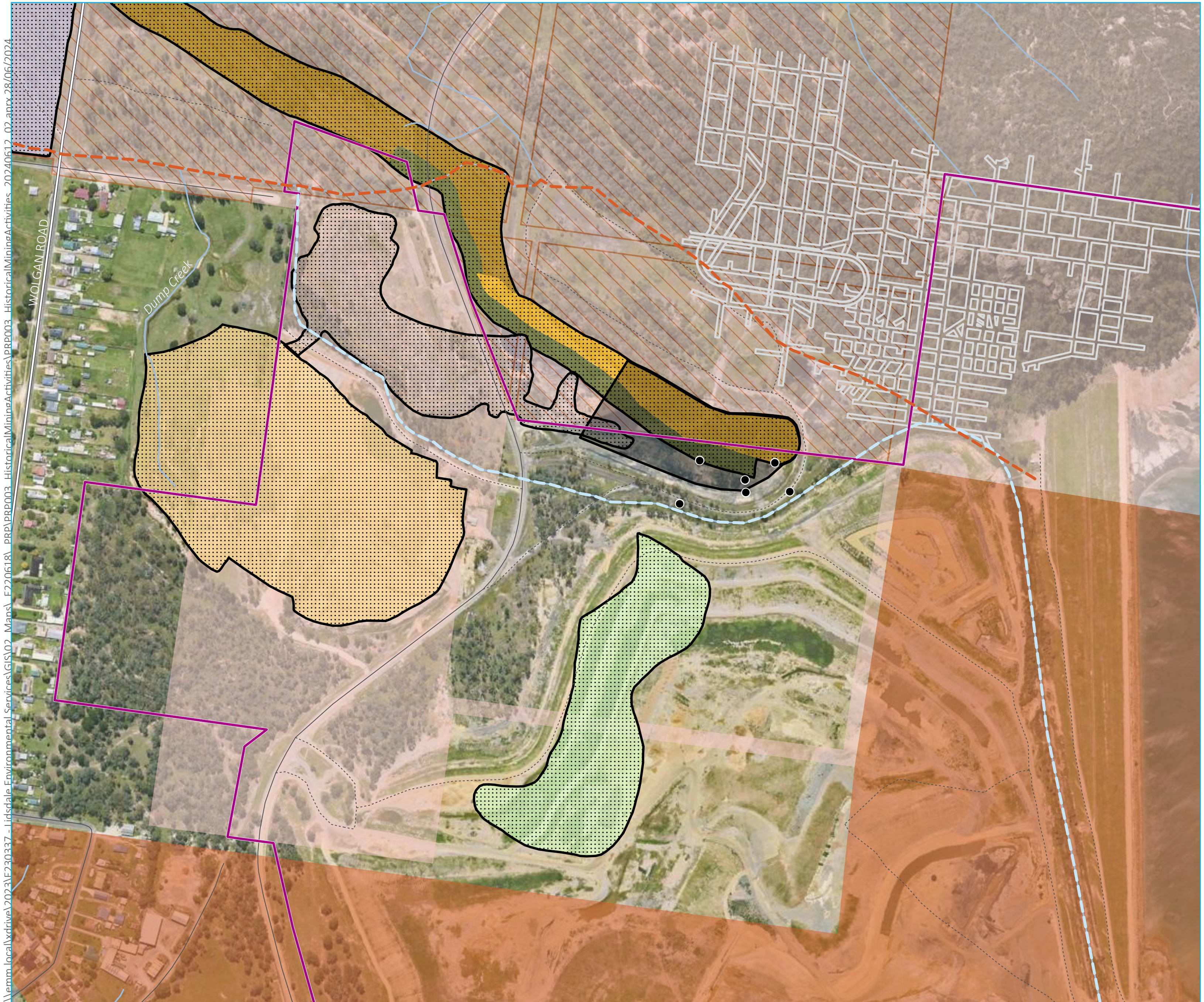
- Considering the contribution of inflows from Sawyers Swamp Creek to the Coxs River, these generally are beneficial for Coxs River water quality. The basis for this is that the concentrations (or values) of all analytes (except for pH) at Sawyers Swamp Creek (WX7) were either below DGVs and/or were similar to or lower than the upstream reference location on the Coxs River (site monitoring location WX12). The only exceptions were pH and turbidity.

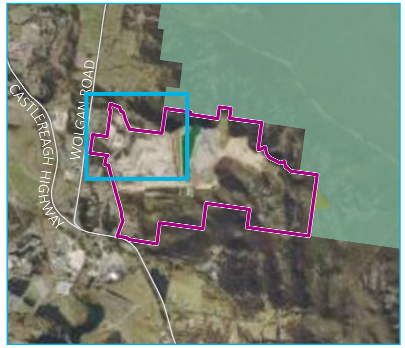
Monitoring and reporting of surface water quality are ongoing EPL 21185 requirements (refer to Section 9.1).

3.4 Mining activities

The area subject to this plan is underlain by coal. There are underground mining and surface exploration leases (notably for Stage 1, Mining Lease 1303, Consolidated Coal Lease 704 and Exploration Lease 6293) over the site, however there are no current proposals in place to mine these areas.

Historical open cut pits are located throughout the site. These areas are shown in Figure 3.4 with respect to the existing Sawyers Swamp Creek. Geotechnical test boreholes constructed to understand the uncertainty associated with the extent of the historical open cut pits, are further discussed in Appendix B.





KEY

- Study area
- Borehole
- Newcom first workings
- Historical creek alignment
- Downstream diversion (Sawyers Swamp Creek)
- Potential ash area
- Open cut mining area

Kerosene Vale OC RT167 workings

- Lithgow Seam Cut A
- Lithgow Seam Cut B
- Lithgow Seam Lidsdale Cut
- Lidsdale Seam Cut B
- Lidsdale Seam Cut C

Commonwealth OC No.4 RT 168 workings

- Lithgow Seam

Current mining title

- CCL 704
- EL 6293
- ML 1303

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line

INSET KEY

- Major road
- NPWS reserve
- State forest

Historical mining activities, extractive areas and titles

Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan - Stage 1
Figure 3.4

Source: EMM (2024); GPM (2024); Centennial Coal (2024); DCSSS (2024); GA (2009); MetroMap (2024)

3.5 Geotechnical stability requirements for KVAR

The KVAR (including the covered KVAD) has had a history of slope instabilities which occurred during ash emplacement and post closure of the Wallerawang Power Station (WSP 2022). Golders/WSP were engaged to develop a staged approach to implement stability related risk management controls at KVAR.

The KVAR Stage 2A earthworks buttress (northern toe stability buttress) was designed and is to be implemented to support the KVAR ash repository which modelling has confirmed a higher factor of safety can be achieved across a range of industry required earthquake modelling scenarios. The northern toe stability buttress interface with natural surface will increase by 13 m and therefore require the realignment of Sawyers Swamp Creek Diversion (refer to the typical section from modelling in Figure 3.5). WSP indicated as part of their design, the implementation of the northern toe stability buttress will:

- improve the factor of safety for batter stability under the safety evaluation and power-closure earthquake scenarios
- includes an external batter slope of 1V: 2.5H up to 919 to 920 mAHD, a bench, a further batter slope of 1V:3H up to 924 mAHD, and a further bench of approximately 22 m. The structure results in the KVAR toe extending out approximately 13 m, over the existing Sawyers Swamp Creek diversion.

The northern toe stability buttress extent is shown on Figure 3.6.

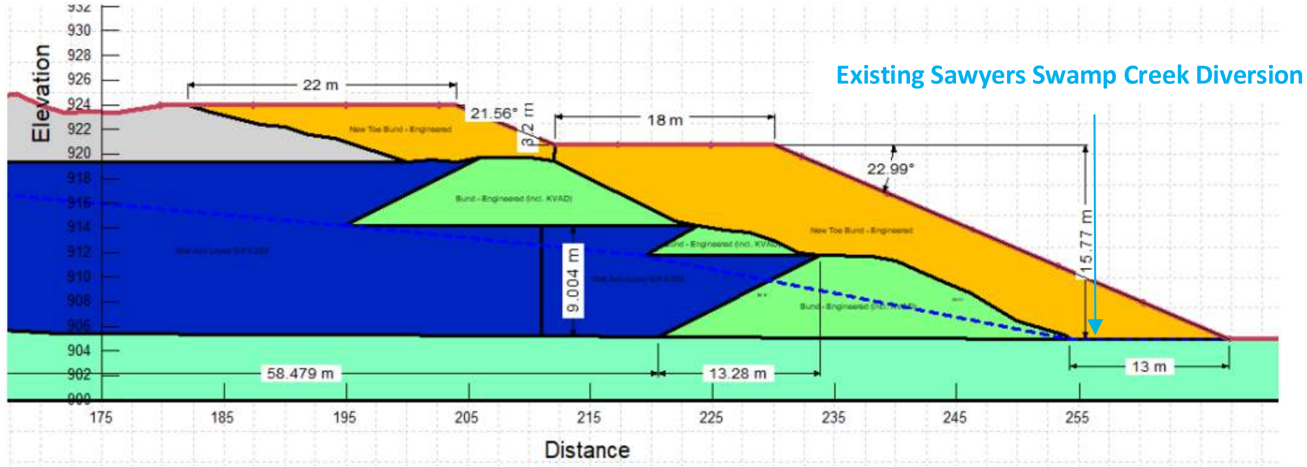
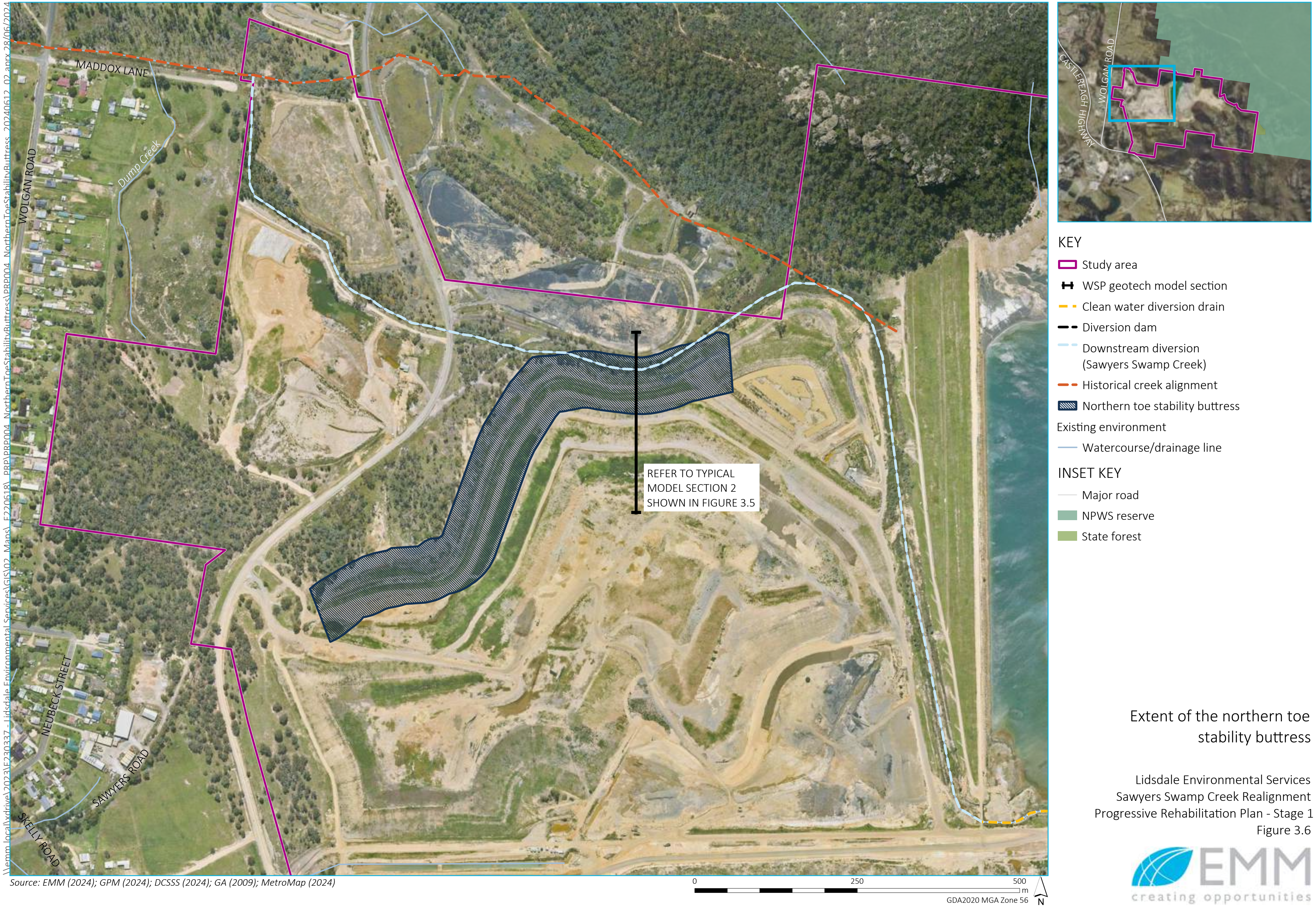


Figure 3.5 Geometry of northern toe stability buttress (model Section 2, after WSP 2022)

The design of final capping materials required for the toe buttress will be:

- resistant to erosion/non-dispersive
- be a low permeability and covered by a layer of supporting and sustaining vegetation (grasses preferred and shrubbery is to be avoided).

Based on testing of materials currently on-site, the design has determined that it is unlikely that the appropriate final capping materials will be available locally for construction. This is due to the erosion characteristics of the material present of site and therefore the import of appropriate material being required.



Source: EMM (2024); GPM (2024); DCSSS (2024); GA (2009); MetroMap (2024)

Extent of the northern toe stability buttress

Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan - Stage 1
Figure 3.6

EMM
creating opportunities

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3.6 Other infrastructure

Infrastructure within the site that is relevant and interacts with the activities covered by the plan includes:

- **Private haul road** is located to the west of SSCAD, KVAR and the Kerosene Vale Coal Stockpile Area. The road is a raised embankment orientated north–south and creates an impediment to the floodplain for the Sawyers Swamp Creek as it drains from east to west. From the flood modelling (refer to Appendix C) it was determined that existing culverts that cross the haul road are currently not effective at conveying catchment flows, generated by storms of an infrequent exceedance probability. Flood depths behind the road embankment are predicted to be greatest along the historical Sawyers Swamp Creek alignment between the 10% and 5% AEP event before overtopping is predicted to occur in events including and exceeding 5% AEP.

  The culvert crossing the haul road on the current Sawyers Swamp diversion alignment is undersized compared with the upstream culvert structure and therefore flow is constrained at this point and is predicted to bypass the culvert and overtop the road in more frequent storm events.

- **Centennial LDP003 Pollution Control Dam** is located west of the private haul and is positioned on the historical alignment of Sawyers Swamp Creek. It is unclear how the historical alignment of Sawyers Swamp creek proceeds through this area. The dam is part of the Centennial's current water management system of the Kerosene Coal Stockpile Area and receives runoff from the coal stockpile pad.

3.7 Surface water receptors

3.7.1 Flooding

A number of residential properties along Wolgan Road are adjacent to the lower reaches Sawyers Swamp Creek. Lithgow City Council does not have an existing regional floodplain risk management plan applicable for this part of the local government area. Flood model predictions prepared by EMM (refer to Appendix C) as part of this plan have indicated that these properties have the potential to be subjected to overland flooding in some modelled events.

3.7.2 Aquatic ecology and instream habitat

PB (2008b) and The Ecology Lab Pty Ltd (2007) indicated that within sections of Sawyers Swamp Creek instream habitat and degraded (when compared with adjacent reference catchments) conditions do exist, consisting of pollution-tolerant macroinvertebrates. The connectivity of sections of habitat along the existing Sawyers Swamp Creek diversion varies considering the existing infrastructure present on site. It is expected that as part of this plan, aquatic ecology and instream habitat is focused on improvement and restoration of areas from the outlet of the SSCAD spillway channel to the site boundary.

4 Rehabilitation objectives and performance criteria

4.1 Overview

The site is working towards complete rehabilitation of the site to establish a safe, stable and non-polluting landform. The rehabilitation objectives for Sawyers Swamp Creek have been established as broad goals. A number of objectives were proposed by the Draft Rehabilitation Plan (PB 2008b) which have been carried over into this plan, however these have been supplemented with additional objectives based on more recent rehabilitation guideline and regulatory expectations. This plan also provides performance criteria, which has been based on the recent *Guideline: Rehabilitation objectives and rehabilitation completion criteria* (NSW RR 2023). These guidelines are typically tailored towards mining activities but are also relevant to this site due to its past land use activities.

4.2 Rehabilitation objectives and performance criteria

Based on government guidelines, industry references and other consent conditions, the rehabilitation objectives and performance criteria that have been adopted for this plan are provided in Table 4.1.

The objectives and criteria nominated will be reviewed and refined in consultation with the relevant government and non-government stakeholders. The refinement of the criteria will also consider the outcomes of monitoring data and site investigation studies.

Table 4.1 Creek rehabilitation objectives and criteria

Rehabilitation objective category	Rehabilitation objective of Draft Rehabilitation Plan (PB 2008b)	Revised objective	Performance criteria	Monitoring	Relevance to Stage 1	Relevance to Stage 2	Basis for objective / performance criteria
Stability	*Ensure the geomorphic stability of Sawyers Swamp Creek and the long term stability of the proposed channel realignment*	The final landform is stable for the long-term and does not present a risk of environmental harm downstream/downslope of the site or a safety risk to the public/stock/native fauna. Where appropriate, the final landform incorporates geomorphic design principles.	Surface water management structures (e.g. spillways, drop structures, creek diversions) have been constructed in accordance with hydrological design. Minimal erosion that would not require moderate to significant ongoing management and maintenance works.	Visual monitoring considering: 1. no areas of active gully erosion 2. no evidence of tunnel erosion 3. no evidence of active scour likely to compromise surface water management structure 4. indicators that surface water management structure are functioning as designed	Will be achieved (no geomorphic design incorporated into the channel design)	Will be achieved	Guideline: Rehabilitation objectives and rehabilitation completion criteria (NSW RR 2023)
Water quality	*N/A*	Runoff water quality from site meets the requirements of the Approval and EPL and does not present a risk of environmental harm.	Water quality discharged from rehabilitated operation meet specifications in Environment Protection Licence and or ANZECC guidelines for specific environment.	Water quality monitoring reports. Achievement of criteria may need to be evaluated over a number of years (e.g. 5+ years).	Will be achieved	Will be achieved	

Table 4.1 Creek rehabilitation objectives and criteria

Rehabilitation objective category	Rehabilitation objective of Draft Rehabilitation Plan (PB 2008b)	Revised objective	Performance criteria	Monitoring	Relevance to Stage 1	Relevance to Stage 2	Basis for objective / performance criteria
Flow (hydrology / hydraulics)	*Maintain the existing hydrological flow regime within the catchment*	Achieve the NSW controlled activities and instream works guidelines No adverse flooding impacts to receptors Maintain, as far as practical, the natural hydrological regimes by accommodating site hydrological conditions. Modifications to watercourses should be based on roughness coefficients that represent the 'natural' state including fully structured mature riparian vegetation No changes to the gradient of the bed, except to address existing bed and bank degradation Not increasing velocities by constricting flows	Maintain the existing hydrological flow regime within the catchment	Independent hydrological assessment report and ongoing aquatic instream condition monitoring	No adverse flooding impacts predicted No riparian vegetation proposed Velocities are predicted to increase however planned to be mitigated through channel armouring	Will be achieved	NSW Controlled activities instream works guidelines

Table 4.1 Creek rehabilitation objectives and criteria

Rehabilitation objective category	Rehabilitation objective of Draft Rehabilitation Plan (PB 2008b)	Revised objective	Performance criteria	Monitoring	Relevance to Stage 1	Relevance to Stage 2	Basis for objective / performance criteria
Instream conditions - aquatic ecology, vegetation, naturalisation	*Develop a naturalised channel creating additional aquatic and riparian habitat along with other local and regional ecological benefits*	As per PB (2008b) develop a naturalised channel creating additional aquatic and riparian habitat along with other local and regional ecological benefits by: 1. Maintaining or improving channel stability. 2. Maintaining or improving instream vegetation 3. Protect and enhance water flow, water quality, stream ecology and existing riparian vegetation	Improved conditions, based on assessment of aquatic instream condition in accordance with Australian River Assessment System (AUSRIVAS).	Independent aquatic instream condition assessment report.	Vegetation will be removed for approximately 300 m of channel. Channel stability will be improved Remaining objectives to be addressed in Stage 2	Will be achieved	PB (2008b) Typical conditions of consent and Guideline: Rehabilitation objectives and rehabilitation completion criteria (NSW RR 2023)

Table 4.1 Creek rehabilitation objectives and criteria

Rehabilitation objective category	Rehabilitation objective of Draft Rehabilitation Plan (PB 2008b)	Revised objective	Performance criteria	Monitoring	Relevance to Stage 1	Relevance to Stage 2	Basis for objective / performance criteria
Riparian buffer	*Provide buffer to assist in future protection and rehabilitation of Sawyers Swamp Creek's potential ecological value*	As per PB (2008b) provide a buffer to assist in future protection and rehabilitation of Sawyers Swamp Creek's potential ecological value and: 1. Revegetation is sustainable for the long-term, and only requires maintenance that is consistent with the intended final land use	Topsoil or (a suitable soil substitute) has been applied to rehabilitation areas in a manner that is suitable for the final land use. Native vegetation areas contain flora species assemblages characteristic of species found within the region and will provide fauna habitat value in the future. Monitoring demonstrates that trees are healthy and growing. Monitoring demonstrates that vegetation and/or leaf litter cover is adequate to minimise soil erosion. Weeds do not comprise a significant proportion of species in any stratum.	Vegetation monitoring	Objectives to be addressed in Stage 2	Will be achieved	PB (2008b) Guideline: Rehabilitation objectives and rehabilitation completion criteria (NSW RR 2023)
Water licensing / regulation	*N/A*	Structures that take or divert water are appropriately licensed (e.g. under the *Water Management Act 2000*) and where required ensure sufficient licence shares are held in the water source(s) to account for water take.	Water approvals / licences are granted by relevant NSW Government Agency.	Independent water licensing report.	Will be achieved	Will be achieved	Guideline: Rehabilitation objectives and rehabilitation completion criteria (NSW RR 2023)

5 Stage 1 – Short-term realignment

5.1 Realignment

5.1.1 Approved concept

The original approved realignment concept (refer to Figure 5.1) for the realignment of Sawyers Swamp Creek was limited to approximately 380 m of channel local to KVAR and was one defined set of works. The approved concept consisted of a typical trapezoidal open channel with a depth of 0.65 m and 7.5 m wide (width defined by top of bank). The intention of this concept was to vary the cross-section using pool and riffle sequences, with the alignment including a number of meanders to promote the reach length.

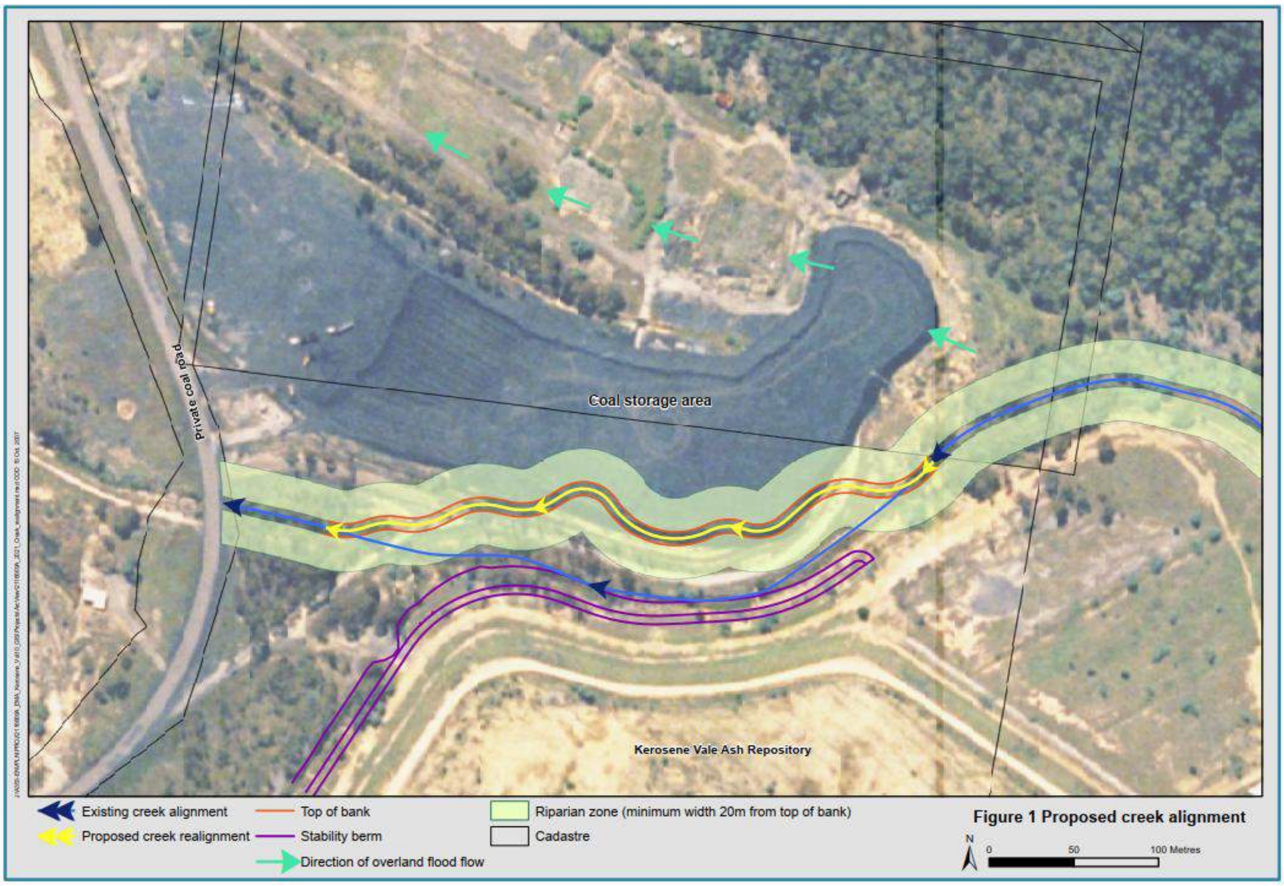


Figure 5.1 Approved Sawyers Swamp creek realignment concept (PB 2008b)

A review of the approved Sawyers Swamp creek realignment concept was undertaken by EMM (2022a). The review concluded that the approved concept was not suitable based on the reasons provided in Table 5.1.

Table 5.1 Key constraints

Area - Design constraint	Justification	Comments
Backfilled open cut voids - The former Kerosene Vale A&B Open Cut is in proximity to the realigned Sawyers Swamp Creek channel. The open cut has been backfilled with a variety of materials including ash.	There are several risks that need to be considered when proposing to reinstate a creek over a backfilled open cut void. These include but are not limited to: • Potential for leakage or seepage processes between the underlying backfill material and the creek . This could create water quality impacts to downstream groundwater and surface water systems by displacing contaminated groundwater and /or water contact with any ash or chitter that may have been used to backfill the void. • Potential for settlement and bank slumping if underlying material consolidates once water is introduced. • Potential for bed and bank scour if backfilled material has low scour resistance and is exposed to creek flows. • Ideally these risks are managed in design by avoiding or at least minimising contact with backfilled material. Where contact in unavoidable, engineering solutions such as removal of backfilled material to a certain depth and replacement with suitable materials can be used to mitigate risks.	The Sawyers Swamp Creek Draft Rehabilitation Plan (PB 2008b) did not identify the former Kerosene Vale A&B Open Cut as a constraint. Parts of the channel are located within the former open cut extent.
Potential for contaminated / unnatural material along proposed alignment – excavation depths vary between 1 to 5 m. There is potential for contaminated and unnatural material to occur along the proposed creek alignment.	The presence of contaminated or unnatural materials (i.e. coal chitter and ash) within the creek realignment corridor will need to be understood so that it can be considered in the design. It is likely that any contaminated or unnatural material would need to be removed to a certain depth and replaced with suitable materials for creek construction. Certain alternative creek alignments may minimise or avoid the need to excavate contaminated or unnatural materials.	The Sawyers Swamp Creek Draft Rehabilitation Plan (PB 2008b) did not note any potential constraints associated with contaminated or unnatural materials.

Area - Design constraint	Justification	Comments
Potential for flood impacts	The existing Sawyers Swamp Creek channel was assessed (PB 2008b) to have a limited capacity (4.3 m^3/s) with excess flow described as spilling from the channel and flowing through the former coal stockpile area. Some of these flood waters may flow through and scour the asbestos disposal area that is located to the west of the coal stockpile area. This design channel capacity (4.3 m^3/s) is minor compared to: • the capacity of the Sawyers Swamp Creek diversion channel (around SSCAD) – estimated to be 20 m^3/s in Worley Parsons (2014); and • the 1% AEP peak flow at the SSCAD spillway - estimated to be 71 m^3/s in Worley Parsons (2014). These comparisons indicate there is potential for significant flows through the coal stockpile area to occur. A channel design that limits capacity would increase the frequency and magnitude of flooding in the former coal stockpile area, resulting in a flood impact.	The assumed existing channel capacity that was applied to the EIS concept may be unreliable and should be reviewed.
Spatial constraint	In the Sawyers Swamp Creek Draft Rehabilitation Plan (PB 2008b), the riparian zone was designed to be a minimum of 20 metres from either side of the top of the bank of the channel which was defined as the area that contains the 2 year Average Recurrence Interval (ARI) flow. However, in accordance with the *Controlled activities – Guidelines for riparian corridors on waterfront land* (DPE, 2022), the riparian zone is measured from the top of the highest bank on each side of the watercourse. In the Draft Rehabilitation Plan (PB 2008b) design, the highest bank is at the 100 year ARI flood level on the north side, and further than the 100 year ARI flood level on the south side. As such the total riparian corridor should be much larger than what was designed. There is no physical space for this increase in width.	The top of bank definition used in the Sawyers Swamp Creek Draft Rehabilitation Plan (PB 2008b) is not consistent with the *Controlled activities – Guidelines for riparian corridors on waterfront land* (DPE 2022). When following the top of bank definition in accordance with the guidelines the riparian corridor width increases beyond the space available within the GPM property.

Based on the EMM review completed, the EIS concept is not suitable on the basis that:

- the concept does not include specific measures to mitigate risks associated with the backfilled open cut void, the material potentially stored within it, and the contamination risks of surface water interactions
- the adopted design flow is not representative of current or future site conditions
- the proposed riparian corridor is not consistent with the guidelines for riparian corridors on waterfront land.

The approved concept requires an alternative strategy to facilitate the construction of the required northern toe stability buttress of KVAR, but also a concept that does not require excavation of areas that have significant engineering and environmental constraints.

5.1.2 Stage 1 revised concept

The Stage 1 realignment is to be implemented as first part of the alternative rehabilitation strategy to the approved concept. The objective of Stage 1 is to realign the Sawyers Swamp Creek diversion to allow for the construction of the northern toe stability buttress.

Stage 1 will not address the requirements of the conditions of consent with respect to the permanent realignment and rehabilitation of Sawyers Swamp Creek and hence a Stage 2 concept is also required, which is further outlined in Section 6.

The Stage 1 realignment is shown in Figure 5.2.

i Design elements

The basis of design and design dimensions for the Stage 1 realignment is outlined in Appendix B. The design considers the outcomes of geotechnical and geophysical investigations in the diversion area.

The layout and shape of the Stage 1 realignment has minimal considerations for geomorphic features. Given the objective of the works is to provide sufficient space for construction of the northern toe stability buttress, the shape adopted for the realignment includes a trapezoidal channel that mimics the existing flow area and an alignment of the shortest distance, whilst also avoiding the mapped historical open cut pits located within Kerosene Vale Coal Stockpile area. Inlet and outlet interfaces for the realignment section were configured to avoid sharp angles, and to mitigate significant changes in the flow hydraulics.

As part of Stage 1 realignment works, there are no changes upstream or downstream within the Sawyers Swamp Creek diversion.

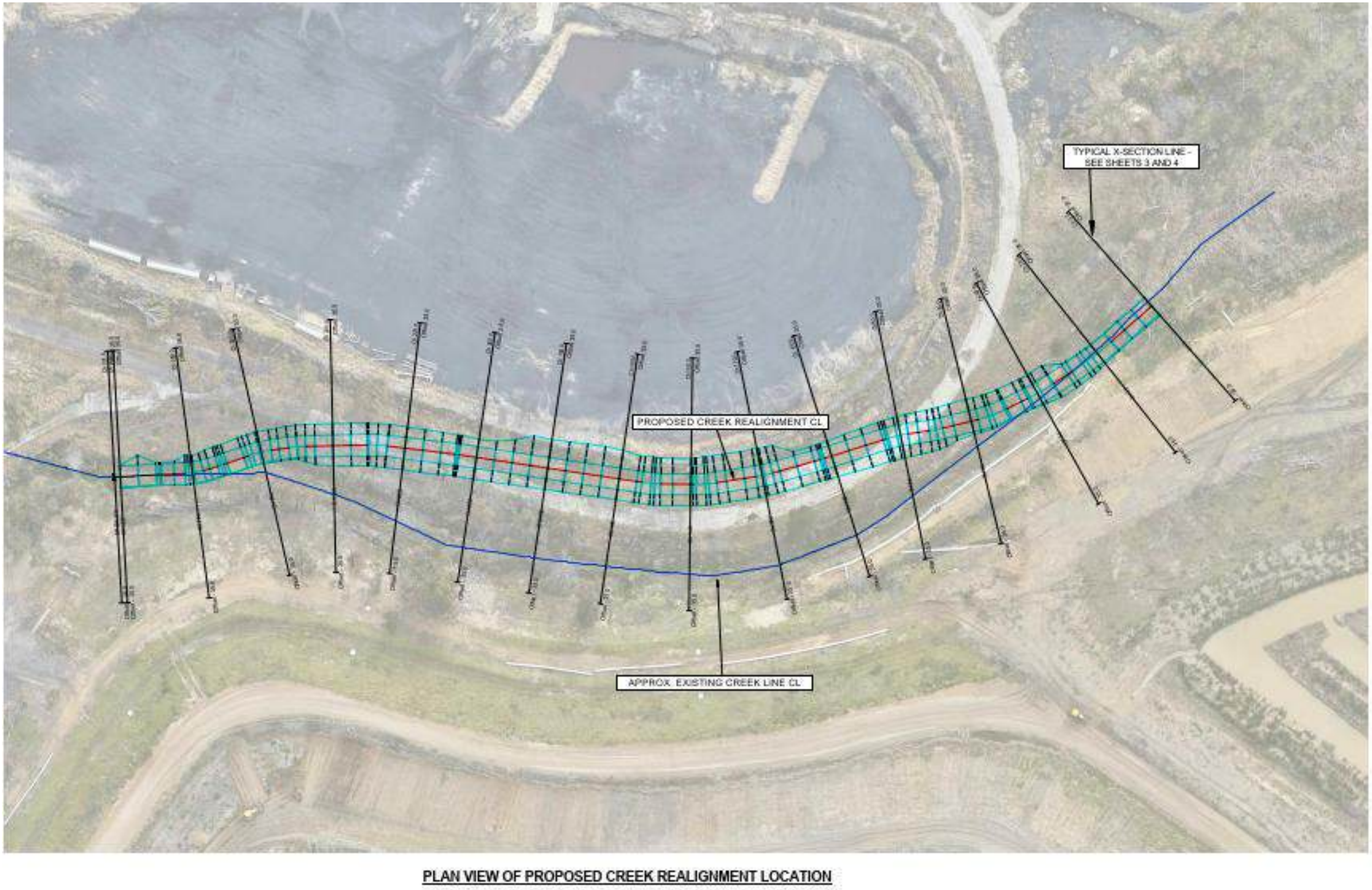


Figure 5.2 Stage 1 realignment (Monteath & Powys 2023)

5.2 Hydraulic function

To assess the hydraulic performance of the existing conditions and Stage 1 realignment, a two-dimensional flood model was developed (refer to Appendix C).

As part of the Department of Planning's (DP 2008) Assessment Report prepared on the original EIS, indicated concerns on the potential impacts both upstream and downstream of the section of proposed realignment, including potential changes to creek geomorphology and flow regimes. Considering these concerns the evaluation of the hydraulic performance of the Stage 1 realignment is outlined in the following sections.

5.2.1 Channel capacity

The Stage 1 realigned channel capacity is similar to the current alignment of Sawyers Swamp Creek diversion with a capacity of 5 m^3/s. For flow rates predicted above 5 m^3/s, flow breaks out towards the historical Sawyers Swamp Creek alignment. The flood model predictions indicated a channel capacity result that was similar for both the existing and design scenarios.

5.2.2 Changes to flow regime

The variance in flow within the channel was predicted to occur in events including and less than a 20% AEP. The predicted flow conveyance through the Stage 1 realigned diversion will be similar to the existing scenarios (typically within a range of 1%). In larger events than this, the in-channel flow rates and the effect of the break out into the historical creek alignment negates the potential hydraulic changes introduced by the Stage 1 realigned diversion, with less than 5 m^3/s change in flow predicted in the Stage 1 diversion channel between the 20% AEP and the 1% AEP event.

Table 5.2 summarises the design channel and breakout flow rates for a range of events.

Table 5.2 Model flow rates

Event	Design flow within Stage 1 Realigned Sawyers Swamp Creek (m^3/s)[1]	Breakout flow to historical Sawyers Swamp Creek (m^3/s)[1]	Proportion of flow breakout
4 EY[2]	0.4	0	0%
63.2% AEP	5.5	0.6	10%
20% AEP	14.0	35.1	72%
10% AEP	14.9	40.6	73%
5% AEP	15.3	42.8	74%
2% AEP	15.9	46.0	74%
1% AEP	17.1	52.0	75%
PMF	51.6	246.9	83%

1. Rounded to 1 decimal place

5.2.3 Potential for scour

The available flow area in the design channel will be less than that available in the existing conditions. This is due to refinements in the surface following smoothing and interfaces with the northern toe stability buttress surface (provided by WSP as part of final landform scope of works). The design surface considered by the flood model is therefore likely to produce a conservative outcome compared to the concept design information provided in

Appendix B. It is expected that as part of detailed design of the channel, further refinement of the cross-sectional area will be achieved including flattening the northern side batters and increases to the channel base width to achieve a flow area that is closer to the existing Sawyers Swamp Creek channel subject to the Stage 1 realignment.

The flood model has predicted that Stage 1 realignment of the creek diversion will result in an increase in velocity along with bed shear consistently along the realignment extent. This consistent nature of elevated change is likely due to the straightening of the channel which previously had a gentle curve.

Based on the predicted average flow velocities for a range of design flow events, placed rock channel lining is proposed as part of Stage 1 works. Table 5.3 presents the predicted average flow velocities and bed shear stresses over the length of the Stage 1 channel realignment.

Table 5.3 Model velocity and bed shear results

Event	Average channel velocity (m/s)	Permissible velocity for materials (m/s)[1]	Average bed shear stress (N/m^2)	Permissible bed shear stress[1]
63.2% AEP	1.9	• Long native grasses – 1.8 m/s • Cobbles to rocks (d_{50}=150 mm) -1.8 m/s • Riprap (d_{50} = 300 mm) – 2.8 m/s	35.7	• Long native grasses – 81.4 N/m^2 • Cobbles to rocks (d_{50}=150 mm) -96 N/m^2 • Riprap (d_{50} = 300 mm) – 218 N/m^2
20% AEP	2.4		51.2	
1% AEP	2.5		53.7	

1. Permissible channel velocity and bed shear stress derived from Fischenich (2001)

The rock placement within the channel realignment will be further provided as part of detailed design. Guidelines (Rutherfurd et al 2000) indicate that rock protection may only require the lower two-thirds of the bank providing an opportunity for revegetation through either grasses or reeds. Protection of the northern toe stability buttress from erosional processes is essential for the duration of operation for Stage 1. A response plan based on the monitoring program is provided in Section 8.

5.2.4 Interception of groundwater

A number of perched groundwater systems exist within the site, with water quality typically representative of groundwater that has been in contact with ash and generally low in pH. From drilling undertaken as part of the groundwater monitoring bore installations around site, groundwater within the vicinity of Stage 1 is expected at a depth of 11 mbgl. It is unknown how this result might vary with climate. However, it is unlikely that the Stage 1 realignment works will intercept the local groundwater table. This does not exclude the potential presence of perched systems being intercepted during construction.

5.3 Instream ecology

The Ecology Lab (2007) undertook an assessment of the potential impacts of the approved concept creek realignment as part of the EIS. Outcomes from this assessment that are still relevant include:

- **Potential impacts due to straightening and/or shortening of the creek:** It is expected that due to a straighter and shorter creek length that the potential for scour and erosion of water increases and the duration of water in the creek decreases. To mitigate this, the section of channel realignment for Stage 1 will be armoured with placed rock.

- **Construction impacts**: Major earthworks will be required for construction of both the Stage 1 realignment and the northern toe stability buttress with potential mobilisation of sediment into downstream reaches of the Sawyers Swamp Creek Diversion. The Ecology Lab, as part of their assessment of the approved concept, outlined the potential impacts of construction to include a loss of instream aquatic habitat and degraded water quality of the clean water system. These potential impacts are also expected to be relevant as part of the Stage 1 realignment, specifically the loss of habitat through the creek realignment. This impact cannot be mitigated as part of Stage 1 but will remain a focus as part of Stage 2 realignment works (refer to Section 6). Construction impacts will be subject to requirements of the existing site OEMP and CEMP and will require site specific erosion and sediment controls and specific construction staging (further discussed in Section 5.5). Unmitigated elevated turbidity and suspended sediment have the potential to impact on decreased growth and increased mortality of fish and aquatic macroinvertebrates, reduction of productivity in aquatic macrophytes, increased nutrient levels increasing the potential for algal growth and blooms, and sediment may also contain other bound contaminates occurring on the site (The Ecology Lab 2007).

A monitoring program for aquatic ecology as part of this plan is outlined in Section 8.1.2.

5.4 Riparian corridor and vegetation

The Stage 1 realignment works will not provide sufficient space for riparian corridors to be established. The left overbank area will be limited due to the construction of the northern toe stability buttress and the right overbank area will be located within the Kerosene Vale Coal Stockpile Area and may require perimeter access and fencing. The coal stockpile area is currently part of Centennial's Angus Place Colliery operations.

As part of Stage 1 realignment works, existing vegetation within approximately 300 m of the Sawyers Swamp Creek diversion will be lost. This extent of vegetation is unlikely to be replaced as part of the realignment works.

Vegetation mapping of the site indicate that KVAR and the Kerosene Vale Coal Stockpile Area is mapped as 'not native vegetation'. The nearest adjacent plant communities (DPE 2022) upstream of Stage 1 include the Newnes Plateau Peppermint-Ash Tall Forest (PCT 3687) and Southern Tableland Creekflat Swamp Woodland (PCT 3385), and downstream, the Central Tableland Granites Grassy Box Woodland (PCT 3367). The upstream of the Stage 1 disturbance works area (including a 20 m buffer) are likely to intercept parts of PCT 3367 and 3385.

Specific plant species that should be considered in the Stage 1 realignment if required are outlined in Table 5.4 based on Benson and Keith (1990). Care should be taken in revegetation activities of the bank where the stability buttress is located due its structural function and design specification to avoid shrubs.

Table 5.4 Plant species for Stage 1 revegetation activities

Species Name	Common Name	Application
Carex appressa	Tall sedge	Instream/bank
Poa labillardierei	Tussock grass	Instream/bank
Juncus usitatus	Common rush	Instream/bank
Imperata cylindrica	Cogon grass	Instream/bank

Outside of areas of placed rock, where vegetation is used in Stage 1, ongoing vegetation maintenance activities will consider:

- removal of Blackberry infestations and control of major noxious and environmental weed species listed in the OEMP
- plantings to include a representative mix of macrophyte and groundcover species, that aims to maximise diversity

- revegetation works should be timed to occur during early spring in order to avoid mortality of juvenile plants due to winter frosts
- arrest/minimise further erosion for existing sites through use of soft engineering approaches (coir logs, rolled erosion control products, targeted revegetation) and where more significant, use placed rock underlaid with an appropriate specified geotextile
- weed control works to be planned and resourced such that best-practice maintenance methods can be applied at all times.

A vegetation management plan will be developed as part of the Stage 2 scope of works. Stage 1 landscape and revegetation will be managed in accordance with the site OEMP.

5.5 Construction considerations

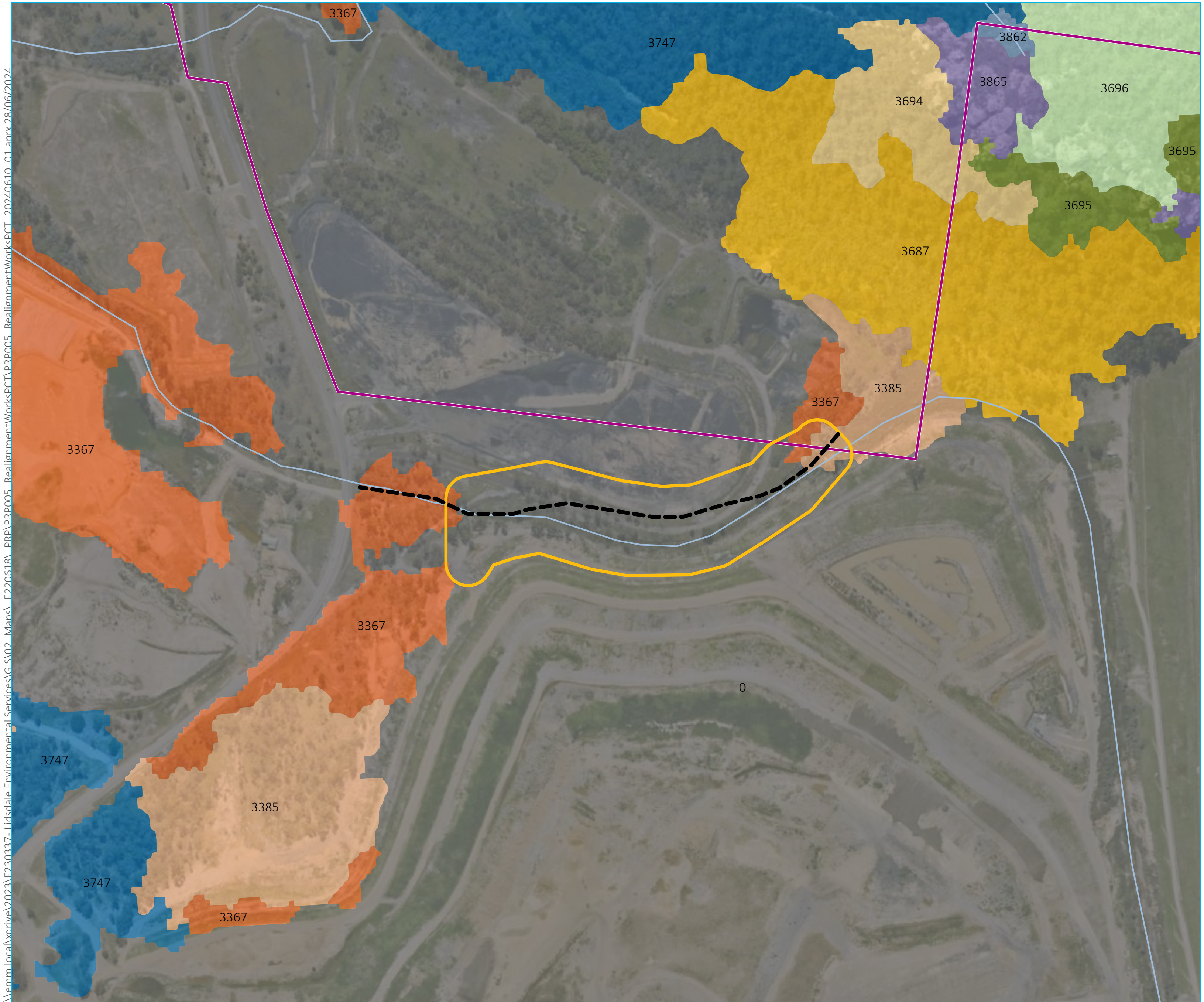
Construction staging will be prepared as part of detailed design. Key staging assumptions to be adopted include:

- Erosion and sediment controls will be installed prior to any construction or earthworks and will be undertaken in accordance with the CEMP and OEMP.
- Fences will be removed and replaced at the completion of construction, in consultation with potentially affected stakeholders.
- Where appropriate topsoil exists in the disturbance area, this will be stripped and stockpiled and reused as part of revegetation of disturbed areas.
- Where ash material is encountered through ground excavations during construction these locations will be recorded and reported to GPM to advise on further management.
- Areas of existing pavement and/or hardstand will be removed and the material disposed of. The reinstatement of access roads post construction will be confirmed with the operators of KVAR and/or the Kerosene Vale Coal Stockpile area.
- Construction equipment will utilise existing access routes, where possible, and avoid unnecessary in-channel vegetation clearance.
- Construction of the realigned channel will occur in isolation from the current Sawyers Swamp Creek diversion such that the inlet connection works will be completed last.
- Stockpiles of cut material will be stored within the Kerosene Vale Coal Stockpile area, available for material classification and potential reuse as part of the construction of the KVAR northern toe stability buttress.

Stage 1 construction is planned to commence in the 2026-2027 financial year.

5.6 Operational life

Stage 1 will remain in operation for at least 5 years from the completion of construction. It is not expected that any further changes to the alignment of Sawyers Swamp Creek will be permissible during this period. The minimum operational timeframe for Stage 1 has been proposed as the site will be required to modify the current approval and complete site closure plan studies before any construction of further realignment construction works can commence. This will not however limit studies and works for the approval of Stage 2 from being undertaken. Further details on the timeframes for Stage 2 are outlined in Section 6.3.



Source: EMM (2024); GPM (2024); DCSSS (2024); GA (2009); MetroMap (2024)

KEY

- Study area
- Short term Sawyers Swamp Creek alignment
- Stage 1 Sawyers Swamp Creek alignment

Existing environment

- Watercourse/drainage line
- Non-native vegetation

Plant community type

- 3367 | Central Tableland Granites Grassy Box Woodland
- 3385 | Southern Tableland Creekflat Swamp Woodland
- 3687 | Newnes Plateau Peppermint-Ash Tall Forest
- 3694 | Upper Blue Mountains Ridgetop Woodland
- 3695 | Western Blue Mountains Peppermint Sheltered Forest
- 3696 | Western Blue Mountains Rocky Scribbly Gum Woodland
- 3747 | Southern Tableland Western Hills Scribbly Gum Forest
- 3862 | Newnes Plateau Rockplate Heath
- 3865 | Western Blue Mountains Pagoda Scrub

INSET KEY

- Major road
- NPWS reserve
- State forest

Stage 1 realignment works area and regional plant community mapping

Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan- Stage 1
Figure 5.3

EMM
creating opportunities

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6 Stage 2 – Long-term realignment

The staged realignment strategy has been developed to satisfy short-term and long-term creek realignment requirements for the site.

As outlined in Section 4, the Stage 2 realignment works will provide the long-term creek realignment that will aim to meet all rehabilitation objectives and consent conditions. The realignment option will need to provide a robust ecological outcome such as improving and reinstating riparian habitat, improve fish passage and habitat connectivity, and improve and/or maintain water quality from the upper catchment into Coxs River.

6.1 Options under consideration

The options presented within this section and shown in Figure 6.1 are being considered as part of the Stage 2 realignment works. These options are under current assessment and are not finalised. Additional options may be identified as more site investigations are undertaken and completed. The Stage 2 options have been developed based on existing studies, and the objectives of Rutherfurd *et al* (2000) of restoration, rehabilitation or remediation of watercourses.

These objectives are defined as follows:

- The aim of **restoration** is reinstating the natural range of water quality, sediment load, flow regime, channel geometry and stability, riparian cover, and instream biodiversity.
- Where restoration is not possible, **rehabilitation** involves improving the most important aspects of the stream environment. While the rehabilitated stream may only resemble the pre-European condition, it is nevertheless an improvement on the degraded stream, and often a valuable environment in its own right.
- Where even rehabilitation is not possible because of irretrievable changes to the stream and where inputs from the catchment would not support a restored or rehabilitated condition, the suitable treatment is **remediation** (Bradshaw 1996). The aim of remediation is to improve the ecological condition of the stream, but the endpoint of that improvement will not necessarily resemble the original state of the stream.

An assessment method was developed using the above objectives and additional principles for rehabilitating streams from Rutherfurd *et al* (2000). This method has been used to assess the rehabilitation options and provides an indication of likelihood of success and benefit. For the purposes of this assessment, the principles have been adapted as a scaled measure (out of 5) for each factor, as described in Table 6.1.

Table 6.1 Option assessment matrix

Factor	Description from Rutherfurd *et al* (2000)	Application for this options assessment
Stream Condition	Condition of a stream by what lives in it. If the stream contains close to the pre-European population and diversity of organisms, then is it likely to be in fair condition.	What is the current condition, can it be improved? Numeric Scale: 5 = Full alignment to 1 = Not met
Damage	Direct changes to streams, combined with changes to catchments and water quality, have simplified the physical and hydrological character of Australian streams. These impacts have interrupted the life cycles of many species such that they have the potential to become locally extinct or stressed. As a result, the biological communities in streams have also become simpler, such that they are now dominated by relatively few animals and plants. Often the remaining plants are exotic (not native) species.	Are the changes undertaken on site reversible; can they be remediated? Numeric Scale: 5 = Full alignment to 1 = Not met

Factor	Description from Rutherfurd *et al* (2000)	Application for this options assessment
Recovery	Damage to stream systems may be permanent (e.g. extinction of species), essentially permanent on human time scales (e.g. taking hundreds of years to recover), or resilient systems may recover within years. If you understand the natural process of recovery, then you may be able to work with that recovery to more quickly rehabilitate a stream	Can suitable enhancements in riparian cover and stream structure be achieved? Numeric Scale: 5 = Full alignment to 1 = Not met
Rehabilitation	Rehabilitation is an effort to artificially return the fundamental elements of the original (pre-European) stream, either by direct intervention, or by hastening the recovery process. Rehabilitation usually involves managing the physical and chemical conditions in the stream.	Can water quality be maintained and is there adequate space to incorporate riparian cover and stream structure to mimic natural conditions? Numeric Scale: 5 = Full alignment to 1 = Not met
Copy/mimic	Often, we want to rehabilitate a stream, but we do not know enough about the complexities of the natural stream ecosystems to know where to begin. When in doubt about what to do to rehabilitate your stream, either copy the original form and conditions, or find a reach in good condition, that has the physical or biological characteristics you want and copy that reach.	Can the stream be returned to what a representative good condition stream looks like for the region? Numeric Scale: 5 = Full alignment to 1 = Not met
Preventions	It is easy quick and cheap to damage natural streams. It is hard, slow, and expensive to return them to their original state. Usually, we are not capable of returning anything approaching the subtlety and complexity of the natural system. For this reason, the highest priority for stream rehabilitators is to avoid further damage to streams, especially streams that remain in good condition	Can the stream be protected from future damage and exposure? Numeric Scale: 5 = Full alignment to 1 = Not met
	Total scores	**Up to 35 points = equivalent to full naturalisation**

Further details on the assessment undertaken is provided as part of the consultation activities completed on this which is provided in Appendix A.

6.1.1 Option 1: Do Nothing

Following Stage 1, the Sawyers Swamp Creek alignment will remain unchanged with restoration works undertaken where possible to enhance instream aquatic and geomorphic conditions, stabilisation of creek banks, and revegetation of a riparian corridor. Refer to Figure 6.1.

This option would enable the construction of the KVAR buttress, while also allowing for the development and modification of the Sawyers Swamp Creek channel to bypass around the KVAR buttress. However, this option does not include the complete realignment of Sawyers Swamp Creek and is unlikely to meet the conditions required to enable the long-term rehabilitation objectives.

Constraints and risks associated with Option 1 include:

- The full riparian buffer requirements (Condition 2.28 of the Development Consent) are unlikely to be met given the adjacent land uses.
- There is a risk inundation upstream of the Private Haul Road.
- The highly spatially constrained downstream environment is unlikely to provide good channel structure.
- Due to the downstream proximity of the KVAR and underlying KVAD, there is potential for an increased long-term exposure to contamination risk.

- Proximity to construction activities is expected to limit the ability to progress channel realignment rehabilitation.

Opportunities and advantages associated with Option 1 include:

- minimises additional rehabilitation effort required and further disturbance to other areas
- maintains the greatest consistency with the initial realignment design

This option is spatially limited and would require compromising on ecological, water quality and general stream health values of the future realigned watercourse. Increased diligence and proactive management will be necessary to protect the realigned watercourse from future construction, remediation and rehabilitation works on site. When reviewing this option using the assessment process described in Table 6.1, this option scores 12 out of 35 assessment points and is therefore not likely to provide positive environmental outcomes or condition compliance.

6.1.2 Option 2: Divert onto historical alignment

Following Stage 1, the creek alignment will be modified from the base of the SSCAD spillway channel to divert all flow to the north-west. This option prioritises rehabilitation through diverting flows of the upper catchment to the historical Sawyers Swamp Creek alignment (refer to Figure 6.1).

Constraints and risks associated with Option 2 include:

- a risk of significant inundation upstream of the Private Haul Road
- a high risk of conflicts occurring through the design process due to existing and historical mine land usage, with the potential for voids and presence of underground access portals
- the entire riparian buffer requirements (Condition 2.28 of the development consent) are unlikely to be satisfied given the adjacent land uses and additional rehabilitation requirements for the mining areas
- realignment has potential contamination risk (instream and overbank) through existing stockpiles of coal and other materials.
- A planning approval modification is required.

Opportunities and advantages associated with Option 2 include:

- traces of a remnant open channel, albeit discontinuous, are present along the historical alignment
- option minimises disturbance elsewhere on site by containing rehabilitation within the historical alignment.

This option is spatially constrained and may not fully achieve the ecological, water quality, and overall stream health objectives required for successful rehabilitation of the creek. Due to the unknown geotechnical and contamination constraints, a schedule of works for this option are difficult to determine. The long-term viability and the likely extended program of this option, as well as the low score (16 out of 35 assessment points) determined using the assessment process described in Table 6.1, means that this option is unlikely to provide good environmental outcomes or be able to achieve all of the conditions of consent.

6.1.3 Option 3: Divert away from the west and redirect to the south

Following Stage 1, civil works will be undertaken to construct a connection from the outlet of the SSCAD clean water diversion channel to the unnamed tributaries of the Coxs River, draining catchment runoff to the south, via a culvert crossing the Castlereagh Highway (refer to Figure 6.1).

This option has been developed following careful review of Option 2 and focuses on the protection of water quality and removes the risk of contamination and disturbance from the surrounding activities. The best way to achieve this is to move the catchment runoff away from areas potentially requiring current or future rehabilitation works. Diverting the flow from Sawyers Swamp Creek to the south would utilise existing established vegetation and an existing channel formation. The Option 3 alignment would enable a diversion of catchment runoff away from potential areas of future earthworks and unconfirmed areas of contamination.

Constraints and risks associated with Option 3 include:

- A number of investigations on the feasibility of Option 3 are yet to be undertaken
- Reduced flow contribution to a section of Coxs River and part of Sawyers Swamp Creek (although not eliminating all flow)
- Infrastructure upgrades to culverts on Castlereagh Highway
- A planning approval modification is required.

Opportunities and advantages associated with Option 3 include:

- Allows diversion of upper catchment runoff from Sawyers Swamp Creek, allowing for a longer section of the creek channel to be naturalised.
- Moves channel away from unconfirmed contamination risks below SSCAD and adjacent to KVAR and Kerosene Vale Coal Stockpile Area.
- Moves channel away from active construction on site.
- Potentially mitigate downstream flooding severity.
- SSCAD spillway flows will remain contributing to the current Sawyers Swamp Creek alignment creating a dedicated overflow path that is infrequently activated allowing for engineered stabilisation.
- Improvements can be achieved in a more predictable time frame.
- Riparian corridor buffer condition of 40 m width is achievable.

This option offers the greatest protection for surface water quality and safeguards against future disturbance. It is not spatially constrained as rehabilitation works will be undertaken on land with sufficient space to implement habitat structures such as meandering channels, pools, riffles, and runs. When reviewing this option using the assessment process described in Table 6.1, this option produced the highest assessment score of 28 out of 35 assessment points, and is likely to provide positive environmental outcomes and condition compliance.

6.2 Current works

The site is currently undertaking a DSI to understand the contamination present on parcels of land. Furthermore, associated and related due diligence studies are also being completed in adjoining lands to understand whether land acquisition or purchase may be possible to assist in the wider rehabilitation objectives of the site but also related to the future management and treatment of water, including Sawyers Swamp Creek.

There are currently clear risks and opportunities associated with each option. These will form the basis of consultation with the relevant government agencies whilst the necessary investigations and studies are progressed.

Stage 2 options, depending on their configuration and works required, may require modification to the existing development consent (approval 07_0005).

6.3 Schedule of works

Stage 2 realignment options are under internal assessment by GPM as part rehabilitation and landform design tasks. The preferred realignment option will be submitted as part of the **Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan - Stage 2**, within 2 years of the construction being completed on Stage 1 (currently scheduled for 2029-2030 financial year).

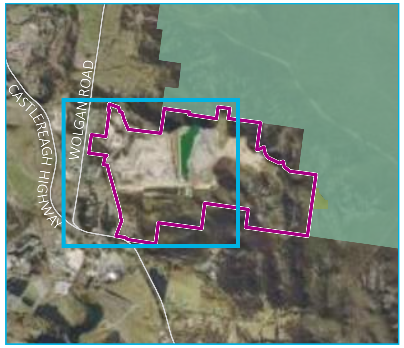
The Stage 2 options are all significantly different to the approved concept and therefore a modification to the planning approval will be required which will affect the implementation and construction schedule for the realignment works. As part of the modification process several investigations and assessments will be required.

Investigations and assessments include:

- Flood/water studies into the impact of the preferred Stage 2 option, both for catchments directly downstream to the new alignment as well as catchments downstream of the original realignment. This will include investigating the implications of diverting majority of the flow from the upper SSC catchment away from the historic lower SSC catchment. This investigation has commenced and is currently ongoing.
- Relocation of existing services that may conflict with the preferred option
- Geotechnical conditions of the in-situ materials of the preferred option
- Ecological assessments to ensure the preferred option protects and maintains ecological value of the water from the upper catchment
- Contamination studies investigating the potential contamination risk of the preferred option

Timeframe to complete Stage 2 works will also be influenced by ongoing construction and rehabilitation activities associated with closure. Condition 2.31 of the planning approval requires that '*Earthworks not associated with the realignment of Sawyers Swamp Creek shall not be undertaken within 50 m of the creek where reasonable and feasible.*'. To comply with this condition, rehabilitation earthworks will need to be staged appropriately. Rehabilitation and landform reshaping works are currently underway. Condition 2.31 will be complied with where reasonable and feasible in the context of the sites overall closure activities. Where works are required to be undertaken with 50 m of Sawyers Swamp Creek, these will be subject to the environmental controls outlined within the CEMP and OEMP.

Once all necessary approvals have been achieved for Stage 2, construction works for the realignment are expected to be completed in 1 to 2 years. Financial approval requirements for the works have the potential to increase commencement of various stages by up to 12 months.



KEY

Study area

Options

Option 1 - Do nothing

Option 2 - Historical alignment

Option 3 - Diversion to the south

Existing environment

Major road

Minor road

Watercourse/drainage line

INSET KEY

Major road

NPWS reserve

State forest

Stage 2 - realignment options under consideration

Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan - Stage 1
Figure 6.1

Source: EMM (2024); GPM (2024); DCSSS (2024); GA (2009); MetroMap (2024)

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EMM creating opportunities

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7 Compliance tracking program

GPM has developed and implemented a Compliance Tracking Program for the project, in accordance with the Condition 4.2, to track compliance with the requirements of this approval and as detailed in Table 7.1. Reporting against the Compliance Tracking Program is conducted on a yearly basis as part of the Annual Environment Management Report (AEMR). The AEMR is provided to the Secretary for approval and demonstrates how GPM has satisfied its approval conditions for the relevant financial year.

Table 7.1 Compliance tracking program

Condition number	Requirement	Where addressed
4.2 (a)	Provisions for periodic review of the compliance status of the project against the requirements of this approval and the Statement of Commitments detailed in the document referred to in condition 1.1c) of this approval	Section 8.2 Inspections Section 9.3 Reporting
4.2 (b)	Provisions for periodic reporting of the compliance status to the Secretary	Section 9.3 Reporting
4.2 (c)	A program for independent environmental auditing in accordance with the Independent Audit Post Approval Requirements (NSW Government 2020)	Independent audit process outlined within the OEMP
4.2 (d)	Procedures for rectifying any non-compliance identified during environmental auditing or review of compliance	Section 9.2.1 Non-compliance management
4.2 (e)	Mechanisms for recording incidents and actions taken in response to those incidents	Section 9.2 Environmental incident and Non-compliance management
4.2 (f)	Provisions for reporting incidents to the Secretary during construction and operation	Section 9.2 Environmental incident and Non-compliance management
4.2 (g)	Provisions for ensuring all employees, contractors and sub-contractors are aware of, and comply with, the conditions of this approval relevant to their respective activities.	Environmental awareness training is covered within the OEMP

The conditions of approval states that any existing compliance tracking program already administrated by GPM can be used to satisfy the approval requirements. The Compliance Tracking Program currently used for this project relates solely to this site and fully satisfies all requirements of Planning Approval 07_0005.

8 Monitoring, management and response requirements

8.1 Monitoring and response plan

The monitoring program has considered the recommended monitoring requirements provided as part of the rehabilitation objectives and performance criteria outlined in Section 4.2.

A summary of the monitoring and response plan for rehabilitation of Sawyers Swamp Creek diversion is provided in the following sections.

8.1.1 Surface flow and quality monitoring

The surface water monitoring program that currently occurs on site as part of the EPL requirements is described in Table 8.1 and outlined in Table 8.2.

Table 8.1 Surface water monitoring locations

Site ID	Description	Monitoring objective
SS5	Upstream of SSCAD– Located on the historical alignment of Sawyers Swamp Creek	Surface water quality - SS5 is located upstream of SSCAD and is therefore not potentially impacted by the site's water management system. Water quality data from SS5 can be used to identify changes in Swayer Swamp Creek water quality within the site (i.e. by comparison with downstream samples)
S6	Downstream of SSCAD, SSCAD embankment and the eastern part of KVAR water management area – Located on the Sawyers Swamp Creek Diversion	Surface water quality - To identify changes in water quality in the upper reach of the Sawyers Swamp Creek Diversion, which flows to the south of SSCAD
S5	Downstream of SSCAD, SSCAD embankment and the eastern part of KVAR water management area – Located on the Sawyers Swamp Creek Diversion	Surface water quality - To identify changes in water quality in the Sawyers Swamp Creek Diversion reach that flows between the SSCAD embankment and the eastern portion of the KVAR/KVAD water management area. This reach may receive seepage from SSCAD and the eastern portion of KVAD.
WX5	Downstream of SSCAD, SSCAD embankment and KVAR water management area, adjacent to Lidsdale Cut – Located on the Sawyers Swamp Creek Diversion	Surface water quality - To identify changes in water quality in the lower reach of the Sawyers Swamp Creek Diversion, which flows past the northern portion of the KVAR/KVAD water management area. This reach of the creek may receive seepage from western and northern portions of KVAD.
Inactive flow monitoring site[1]	Downstream of SSCAD, SSCAD embankment, KVAR water management area, and Lidsdale Cut– Located on the Sawyers Swamp Creek Diversion	Surface water flow - To understand the baseflow contribution and flow frequency of Sawyers Swamp Creek Diversion
WX7	Downstream of the site – Located on the historical alignment of Sawyers Swamp Creek	Surface water quality - To characterise the water quality in Sawyers Swamp Creek downstream of the site.

1. Timing on the commissioning the flow monitoring site is to be confirmed.

Table 8.2 Surface water monitoring plan

Category	Analytes	Frequency	Sampling and analysis method
Streamflow conditions	Visual inspection and recorded clean water diversion pumping only (until downstream monitoring station is commissioned)	Monthly[1]	Note and photograph streamflow or water storage conditions at the time of sampling
Physio-chemical parameters	pH, turbidity, electrical conductivity, dissolved oxygen, redox		Analysis is to be undertaken using a calibrated water quality meter OR by a NATA-certified laboratory.
	Total suspended solids (TSS) Total dissolved solids (TDS) Total hardness (as CaCO3) Total alkalinity (as $CaCO_3$) Ammonia as N, oxides of nitrogen as N (NOx), total kjeldahl nitrogen (TKN) as N and total nitrogen as N Total phosphorus as P Filterable reactive phosphate as P		Analysis is to be undertaken by a NATA-certified laboratory.
Anions	Chloride, fluoride, sulfate		Analysis is to be undertaken by a NATA- certified laboratory.
Cations	Sodium, potassium, calcium, magnesium		Analysis is to be undertaken by a NATA- certified laboratory.
Metals and Metalloids (dissolved)	aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), boron (B), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), silver (Ag), strontium (Sr), vanadium (V) and zinc (Zn)		Samples for dissolved metals analysis are to be filtered using a 0.45 µm filter. Analysis is to be undertaken by a NATA-certified laboratory.

1. In the first 12 months following completion of creek realignment works, additional physio-chemical only monitoring rounds will be undertaken following wet weather (generating at or near bank full flow) events, refer to Table 8.3.

The surface water monitoring program outlined in Table 8.2 is undertaken as part of requirements of the EPL and OEMP. The program addresses the requirements for the rehabilitation of Sawyers Swamp Creek.

i Trigger and response plan

To support the surface water monitoring program, a trigger and response plan has been developed and is provided in Table 8.3.

Table 8.3 Surface water response plan

Trigger	Action required	Timing	Follow up actions
Water quality Concentration of physical parameters at downstream monitoring site is above DGVs Observations indicate increased turbidity in Sawyers Swamp Creek diversion	Identify if exceedance is naturally occurring or due to the realignment works by reviewing: 1. Upstream sample location data to determine if exceedance is naturally occurring 2. Baseline sampling data to determine if similar exceedances are known to occur Inspect the creek realignment to identify potential contaminate sources, and remove/mitigate these sources if possible	Remove/control identified contaminant sources, if possible, as soon as practicable. Immediate notification of EPA if an incident has occurred (refer to OEMP for incident reporting requirements)	If the source of exceedance is determined not to be associated with the realignment activities then no further action is required under this plan. If the source of exceedance is undetermined or identified as potentially due to the realignment activities, the exceedance is to be noted for consideration in future monitoring rounds and reported as part of annual performance reporting. If exceedances are ongoing (for 2 consecutive monitoring rounds), then advise EPA (refer to OEMP).
Water flow Water levels within the channel are near or at bankfull flow. Currently no trigger with gauge station not operational	Following completion of Stage 1, undertake a visual inspection of the Stage 1 alignment including 100 m upstream and downstream. Rectify issues identified instream due to high flow event. Undertake a round of physio-chemical parameter monitoring for all Sawyers Swamp Creek monitoring sites.	Monitoring to be completed within preferably 48 hours, or as soon as possible beyond this period. Immediate notification of EPA if an incident has occurred (refer to OEMP for incident reporting requirements)	Document outcomes of monitoring as part of annual performance reporting. If monitoring indicates concentrations above the EPL limits, advise EPA (refer to OEMP)

The trigger and response plan for surface water flow and quality monitoring aspects of this plan will be reviewed and revised as necessary following the site annual environmental reporting.

KEY

- Study area
- Surface water monitoring program
  - Flow monitoring (inactive)
  - Watercourse
- Existing environment
  - Rail line
  - Major road
  - Minor road
  - Watercourse/drainage line

Source: EMM (2024); GPM (2024); DCSSS (2024); GA (2009); MetroMap (2024)

Surface water monitoring program

Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan- Stage 1
Figure 7.1

EMM creating opportunities

8.1.2 Aquatic ecology monitoring

As per the assessment works provided by The Ecology Lab (2007) monitoring of instream aquatic ecology monitoring is to be undertaken on Sawyers Swamp Creek downstream of the realignment works. Given that the realignment works under Stage 1 are within the upper portion of the existing Sawyers Swamp Creek diversion and there is limited upstream area available, the monitoring program will be supported by two reference/control sites, namely Marrangaroo Creek (to the south) and Kangaroo Creek (to the north). The reference sites have been nominated given that they are within catchments draining to the Coxs River, they were considered by The Ecology Lab in baseline studies and are typical of the watercourses draining off the Newnes Plateau area.

The monitoring program is outlined in Table 8.4 and shown in Figure 8.2.

Monitoring is required to commence 12 months prior to construction capturing at least one round of autumn and spring sampling.

Table 8.4 Aquatic ecology/instream monitoring plan

Creek	Monitoring components	Frequency	Sampling and analysis method
Sawyers Swamp Creek Diversion	Reach length – 80 m Upstream monitoring location – SSC_US Downstream monitoring location – SSC_DS	• Pre-construction – 1x round (autumn and spring monitoring) • Post-construction – Biannually (autumn and spring monitoring rounds)	• Visual monitoring for instabilities • Sampling, sorting and identification of macroinvertebrates associated with pool edge habitat in accordance with the Australian Rivers Assessment System (AUSRIVAS) protocols • Assessment of the condition of the habitat • Measurement of DO, EC, pH, temperature and turbidity just below the surface of the water column and at depth (where sufficient water is available) • Collection of 1 representative surface water and sediment grab sample for water and sediment quality analysis
Kangaroo Creek	Reach length 1– 90 m Upstream monitoring location – KC1_US Downstream monitoring location – KC1_DS Reach length 2 – 90 m Upstream monitoring location – KC2_US Downstream monitoring location – KC2_DS		
Marrangaroo Creek	Reach length 1 – 130 m Upstream monitoring location – MC1_US Downstream monitoring location – MC1_DS Reach length 2 – 140 m Upstream monitoring location – MC2_US Downstream monitoring location – MC2_DS		

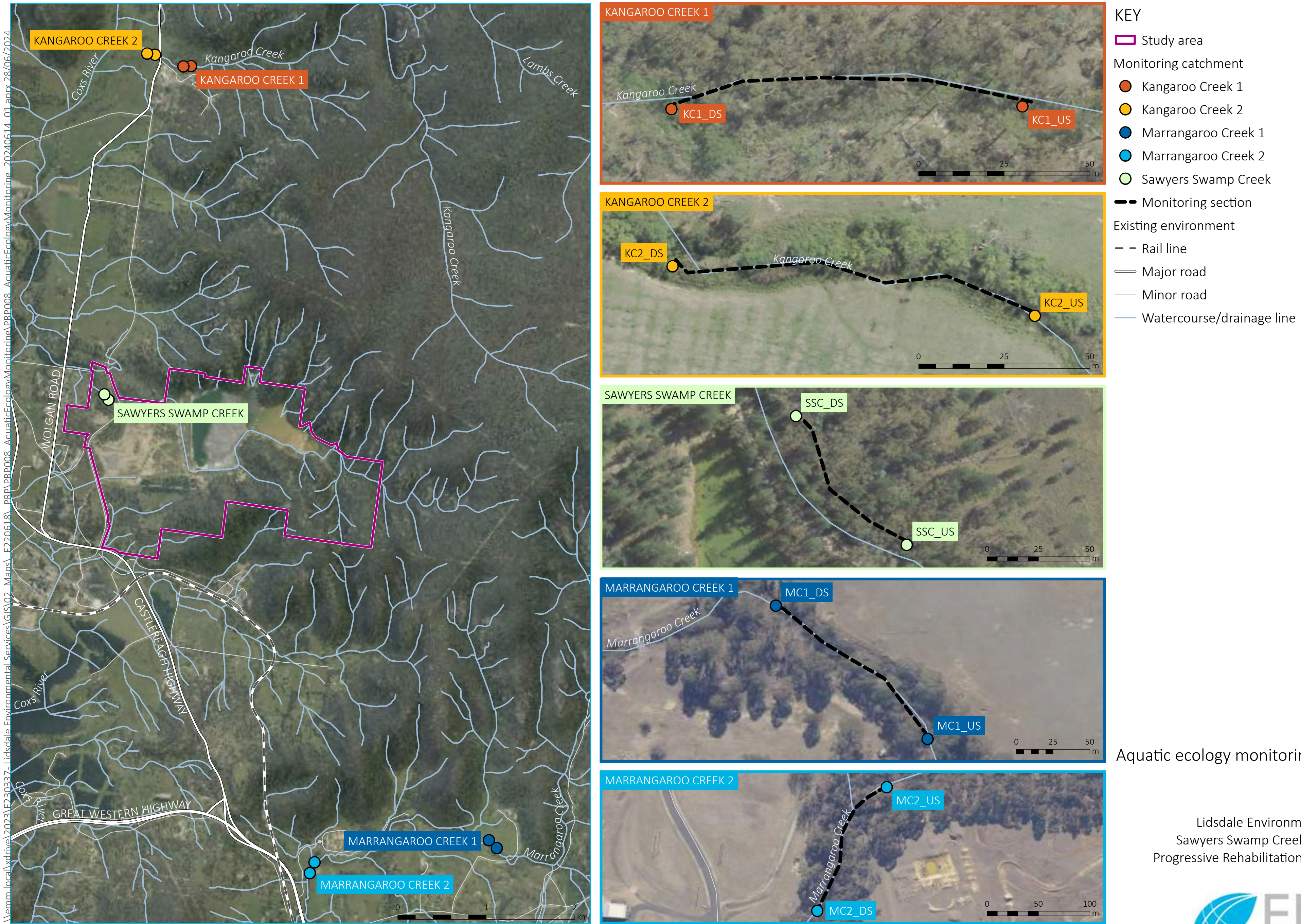
i Trigger and Response plan

To support the aquatic ecology/instream monitoring program, a trigger and response plan has been prepared and is provided in Table 8.5.

Table 8.5 Aquatic ecology/instream response plan

Trigger	Action required	Timing	Follow up actions
Incisional processes and instabilities Visual monitoring indicates new areas of instream erosion	Remediate instabilities in accordance with site erosion and sediment controls Investigate options to implement further velocity mitigation such as rock check dams or other energy dissipation structures	Implement controls as soon as practicable or immediately prior to incoming rainfall Immediate notification in accordance with OEMP incident reporting requirements	If the source of the issue is determined not to be associated with the realignment activities then no further action is required under this plan. If the cause as potentially due to the realignment activities, the issue is to be noted and reported as part of annual performance reporting.
Instream riparian vegetation Change in vegetation type and density not consistent with reference sites **Macroinvertebrate metrics** Change in seasonal results not consistent with outcomes with reference sites	Undertake a review of operational activities undertaken in the last 3 to 6 months that may have an influence on instream vegetation and macroinvertebrates. Review surface water quality data to understand whether there are any change or trends in specific parameters	Review to be undertaken within a month of receiving aquatic ecology monitoring results. Address the recommendations of the review, as soon as practicable. Immediate notification of DPHI if an incident has been found to occur (refer to OEMP for incident reporting requirements)	If the source of the issue is determined not to be associated with the realignment activities then no further action is required under this plan. If the cause as potentially due to the realignment activities, the issue is to be noted and reported as part of annual performance reporting.

The trigger and response plan for aquatic ecology/instream aspects of this plan will be reviewed and revised as necessary following the site annual environmental reporting.



Source: EMM (2024); GPM (2024); DCSSS (2024); GA (2009); MetroMap (2024)

GDA2020 MGA Zone 56 N

Aquatic ecology monitoring program

Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan- Stage 1
Figure 7.2

EMM creating opportunities

8.2 Management measures

8.2.1 Inspections

Site inspections of the water management system, including erosion and sediment controls are undertaken in accordance with the OEMP. These will continue and will include inspection of the realignment works for associated with Sawyers Swamp Creek, Stage 1 and the future Stage 2. Corrective maintenance will be undertaken as required to maintain the integrity and function of infrastructure.

8.2.2 Management measures

The management measure for the realignment works are summarised in Table 8.6.

Table 8.6 Management measures

Measure	Description	Implementation stage
Erosion and sediment control	Controls to be implemented in accordance with the OEMP and sub-plans.	Pre- and post-construction Operational
Stockpile management	Excavated materials requiring stockpile will utilise available space on the Kerosene Vale Coal Stockpile area following agreement with Centennial.	Pre- and post-construction
Scour protection in-channel	Nominated scour protection for the Stage 1 channel will be placed rock (d_{50} to be 150 mm to 300 mm) to be further specified as part of detailed design.	Operational
Revegetation in-channel	Revegetation will be undertaken opportunistically in association with Stage 1 works, including: • outside of the instream area but within 20 m of the channel bank • upstream and downstream of the realignment works • rehabilitating areas of disturbance associated with construction.	Post-construction Operational
Access road restoration	Existing access roads requiring removal as part of Stage 1 realignment works will be restored in a configuration agreed with the site operations team and/or other stakeholders (e.g. Centennial).	Post-construction
Property fences replacement	Existing fences requiring removal as part of Stage 1 realignment works will be restored in a configuration agreed with the site operations team and/or other stakeholders (e.g. Centennial).	Post-construction

9 Reporting requirements

9.1 Monitoring data

Surface water monitoring undertaken as part of the program outlined in Section 8.1.1 will be periodically provided as part of the existing reporting requirements to WaterNSW and NSW DPIRD required under consent conditions 3.5 and 3.6.

9.2 Environmental incident and non-compliance management

9.2.1 Non-compliance management

Non-compliances or potential non-compliances are situations or events that do not comply with the Conditions of Approval and other relevant environmental legislation, licenses, permits and approvals, but are not classified as incidents. Non-compliances or potential non-compliances may be identified in any of the following situations:

- as part of internal site inspections, supervision or monitoring of normal activities
- during external audits
- following significant verbal or written third party complaints.

All non-compliances will be recorded in the appropriate registers and stored electronically i.e. site inspection checklists, auditing reports, complaints register. Corrective actions will be recorded on the site inspection checklist. Notification and reporting of non-compliance matters to DPHI shall be undertaken in accordance with the conditions of approval. The non-compliance will be investigated and managed by the contract administrator until compliance is achieved.

9.2.2 Types of environmental incidents

Examples of environmental incidents include (but are not limited to):

- discharge of sediment or polluted water to Sawyers Swamp Creek or Cox's River
- collapse of ash steep slopes
- collapse of bunds, capping or surface water control measures
- exposure of suspected contaminated materials in areas outside known landfills and repositories
- significant dust or noise impacts on surrounding community
- spills of chemicals, fuel or oil.

9.2.3 Environmental incident response procedure

All site staff must communicate any environmental incident that occurs on the Lidsdale Ash Repository site (including near misses) to the Site Manager or Manager Environment and Regulatory. All staff shall follow direction of GPM to resolve the issue as soon as practicably possible. Environmental incidents that have caused or have the potential to cause a pollution event will be managed in accordance with the Site Pollution Incident Response Management Plan (PIRMP) and the Site Emergency Response Plan.

A list of the incident categories and appropriate actions is provided in Table 9.1.

Table 9.1 Incident categories

Incident type	Incident characteristics	Action required
Near-miss	A near- miss is when there is: • potential for but no actual pollution • general environmental hazards (such as hazardous substances not stored in secured locations) • handling mishaps with fuels, oil, lubricants and/or hazardous substances not resulting in spillage • loss of control of equipment not resulting in damage to vegetation or property • inefficient or lacking traffic and access controls that almost resulted in an incident.	Contractor staff must report incident to the Site Manager immediately. GPM must then be notified within 24 hours and be provided with an incident notification record. Contractor must advise suitable controls to be implemented in future situations to prevent recurrence.
Minor	A minor environmental incident has occurred when material has been spilled or released to the environment (land, air, water, people affected), causing no material pollution and no material harm to the environment. Its consequence/impact are measured as minor and includes some or all of the following aspects: • material easily contained and recovered • is confined to work site boundaries • involves minimal or minor interruption to work activities • complaints easily handled at the work site • has no external or regulatory involvement (community, Council, emergency services, media, other relevant authorities).	Contractor staff must report incident to the Site Manager immediately. GPM review incident against PIRMP and record an incident notification record. The Environment Representative will be notified of the incident. GPM to review incident and controls in place or to be implemented to prevent a recurrence.
Major	Any incident with actual or potential material impacts on the biophysical environment and/or off-site impacts on people and includes some or all of the following aspects: • actual or potential breach of environmental legislation or permit/licence/consent/ approval condition • actual or potential material environmental harm involves or has the potential to involve community, media or regulatory authorities.	Contractor staff must report incident to the Site Manager immediately. GPM review incident against PIRMP and record an incident notification record. The Environment Representative will be notified of the incident. GPM to review incident and controls in place or to be implemented to prevent a recurrence. Notifications under the PIRMP are to be undertaken and recorded. The POEO Act requires the occupier of premises, the employer or any person carrying out an activity which has caused a pollution incident to immediately notify each relevant authority when material harm to the environment is caused or threatened. EPA will be notified immediately of pollution incidents via the EPA Environment Line (telephone 131 555). DPHI will be notified as soon as reasonably possible after becoming aware of the incident in accordance with condition of approval 7.1 and Appendix 3 of the Planning Approval. DPHI notification and reporting requirements are outlined further below. GPM will provide incident report to the Secretary of the DPHI and EPA within 7 days of the incident occurring.

Incident type	Incident characteristics	Action required
Disaster	• National press coverage • regulatory investigation and significant penalties/fines incurred and potential or actual loss of licence • major community impacts (for example whole suburb) • major and long-term consequence on environment. Extensive clean-up required with external assistance.	Contractor staff must report incident to the Site Manager immediately. GPM review incident against PIRMP and record an incident notification record. The Environment Representative will be notified of the incident. GPM to review incident and controls in place or to be implemented to prevent a recurrence. EPA will be notified immediately of pollution incidents via the EPA Environment Line (telephone 131 555). Notifications under the PIRMP are to be undertaken and recorded GPM shall provide an incident report to the Secretary of DPHI and EPA within 7 days of the incident occurring. Work on site to cease during external incident investigation.

All near misses and incidents must be actioned, reported, and recorded. In the event of an environmental incident occurring that is above the 'near-miss' category and which cannot be managed by equipment on-site, the most senior person on site at the time of the incident must immediately obtain assistance from GPM.

GPM may engage and coordinate external service providers, such as the NSW State Emergency Services, to assist in the response.

The Manager Environment and Regulatory must be notified as soon as possible in order to address the cause or impact of the environmental incident and to ensure procedures are undertaken in accordance with the OEMP and GPM's existing emergency response system.

i DPHI incident notification and reporting requirements

Notification to DPHI must be in writing via the Major Projects website. In accordance with condition of approval 7.1, the notification must identify the project (including the Planning Approval number and the name of the project) and set out the location and nature of the incident. Subsequent notification and reporting requirements in accordance with Appendix 3 of the Planning Approval are listed below:

- A follow-up written incident notification must be submitted to the Secretary via the Major Projects website within seven days after the Applicant becomes aware of an incident. This follow-up notification is required even if the notification required under condition 7.1 was not given or, having given such notification, GPM subsequently forms the view that an incident has not occurred
- The written notification must contain the following details:
  - a) identify the project and application number;
  - b) provide details of the incident (date, time, location, a brief description of what occurred and why it is classified as an incident);
  - c) identify how the incident was detected;
  - d) identify when the Applicant became aware of the incident;
  - e) identify any actual or potential non-compliance with conditions of approval;
  - f) describe what immediate steps were taken in relation to the incident;
  - g) identify further action(s) that will be taken in relation to the incident; and

h) identify a project contact for further communication regarding the incident.

- Within 30 days of the date on which the incident occurred or as otherwise agreed to by the Secretary, GPM must provide the Secretary and any relevant public authorities (as determined by the Secretary) with a detailed report on the incident addressing all requirements below, and such further reports as may be requested. The Incident Report must include:

  i) a summary of the incident;

  j) outcomes of an incident investigation, including identification of the cause of the incident;

  k) details of the corrective and preventative actions that have been, or will be, implemented to address the incident and prevent recurrence; and

  l) details of any communication with other stakeholders regarding the incident.

9.2.4 Incident investigation

The Manager Environment and Regulatory must be involved in the investigative process as an independent observer with a collaborative effort made to ensure that the cause of the incident is identified in order to establish the most suitable methods for preventing recurrence.

All major and above incident reports will be provided to DPHI and the EPA establishing full details including causes and the mitigation measures implemented.

9.3 Annual performance reporting

9.3.1 Realignment works status

As part of the works undertaken to Sawyers Swamp Creek as part of Stage 1 realignment works, GPM will provide a status report on works completed and works forecast to be completion annual as part of Annual performance reporting (to be included within the AEMR) under Condition 7.3. As part of this reporting, the progress and revised schedule of works supporting the future Stage 2 works will be covered.

9.3.2 Surface water quality

An annual water quality review (AWQR) is prepared as part of the AEMR. The AWQR includes:

- a description of weather and streamflow conditions over the AEMR period (the period)
- a description of the water management system that was operated over the period
- all water quality data and analysis.

Water quality outcomes specifically relating to this plan will be included within this AWQR.

9.3.3 Aquatic ecology

A report of aquatic ecology monitoring undertaken annually will be prepared to be summarised within the AEMR. The report will include the results from the assessment work of the condition of instream aquatic flora and fauna for both Sawyers Swamp Creek diversion and reference sites. Monitoring and reporting will cease after five years of Stage 1 works being complete, pending the confirmation of timing on the Stage 2 implementation. Monitoring results will be shared with NSW DPIRD.

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Appendix A
Consultation evidence

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A.1 Consultation documents

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02 9493 9500
www.emmconsulting.com.au

26 October 2023

Department of Primary Industries - Fisheries
Department of Planning and Environment - Water

Re: Kerosene Vale, Sawyers Swamp Creek Realignment

The Wallerawang Power Station, located about 14 km north-west of Lithgow, operated between 1957 and 2014. Ash from the power station was deposited in ash repositories in the Kerosene Vale site (the Site) north of the power station site.

Ownership and responsibility for the Site was transferred from EnergyAustralia NSW Pty Ltd to Generator Property Management Pty Limited (GPM) in September 2020, who are rehabilitating the Site. GPM is established as a transaction company in accordance with the *Electricity Generator Assets (Authorised Transactions) Act 2012*, and was formed in 2016 to own former power station sites in Government ownership and undertake all things necessary to remediate these sites. GPM owns the Site, as well as the site of the former Munmorah Power Station.

EMM Consulting Pty Limited (EMM) is writing to you on behalf of GPM regarding realignment of part of Sawyers Swamp Creek (SSC) that flows through the Site, where it runs adjacent to the Kerosene Vale Ash Repository (KVAR) (the SSC realignment).

The SSC realignment adjacent to KVAR was approved in 2008 as part of (now) State significant development (SSD) Project Approval 07_0005, based on a conceptual realignment design presented in *Kerosene Vale Stage 2 Ash Repository Area Environmental Assessment* (Parsons Brinckerhoff 2008a). The approval conditions require (in part):

Sawyers Swamp Creek Realignment

> 2.26 The Proponent shall prepare and submit to the Secretary for approval a Rehabilitation Plan addressing the restoration of the in-stream area (i.e. bed and bank) of Sawyers Swamp Creek and the associated riparian corridor at least two months prior to the realignment of the creek, unless otherwise agreed by the Secretary. The Plan shall be developed in consultation with, and to the satisfaction of, Fisheries NSW…

Further details of the approval conditions as relevant to the SSC realignment are presented herein.

The SSC realignment has not yet been constructed, however GPM now intends to prepare the rehabilitation plan referred to in condition 2.26 above to allow the SSC realignment to be constructed for the purpose of facilitating other important Site rehabilitation works described herein.

The following attachments to this letter provide supporting information:

- Appendix A – presents an overview of the Site background, the approved SSC realignment concept, a review of the realignment concept and investigations proposed as part of a revision of the realignment design.
- Appendix B – contains several historic aerial images and photographs showing the changes to the Site and SSC since 1969.
- Appendix C – contains Project Approval 07_0005 including conditions relevant to the SSC realignment.

GPM and EMM are seeking to engage with Department of Primary Industries (DPI) – Fisheries and Department of Planning and Environment (DPE) – Water during the preparation of the rehabilitation plan.

Prior to the commencement of the full investigations and design program, it is proposed to meet with DPI-Fisheries and DPE-Water to:

- provide an overview of the Site and approvals as context for the realignment – the Site is complex so a site inspection is highly desirable
- present preliminary baseline conditions findings
- discuss the environmental outcomes that could be achieved
- review the proposed investigation and design program
- as part of ongoing engagement as part of plan preparation.

Accordingly, we seek an onsite meeting with DPI-Fisheries/DPE-Water. Please contact me via email below or on 0411 100 998 to arrange a suitable time or to discuss if you require any further information.

We look forward to working with you as part of the wider program to rehabilitate the Site.

Yours sincerely

Nick Bartho
Associate Director
nbartho@emmconsulting.com.au

Kerosene Vale
Sawyers Swamp Creek Realignment

20 November 2023

Agenda

Introductions

Overview of the site and approvals

Approved realignment – need, concept and constraints

Environmental outcomes

Assessment, investigation and design program

Ongoing engagement

Context

- The Wallerawang Power Station, operated between 1957 and 2014 – with ash deposited in the Kerosene Vale site
- Ownership and responsibility of site transferred to Generator Property Management Pty Limited (GPM) in September 2020
- GPM is established as a transaction company in accordance with the *Electricity Generator Assets (Authorised Transactions) Act 2012*
- Initial focus: managing ongoing regulatory and contractual obligations
- Long-term objective: safe closure of the ash repositories, and to remediate the Site for permanent closure

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Regulatory

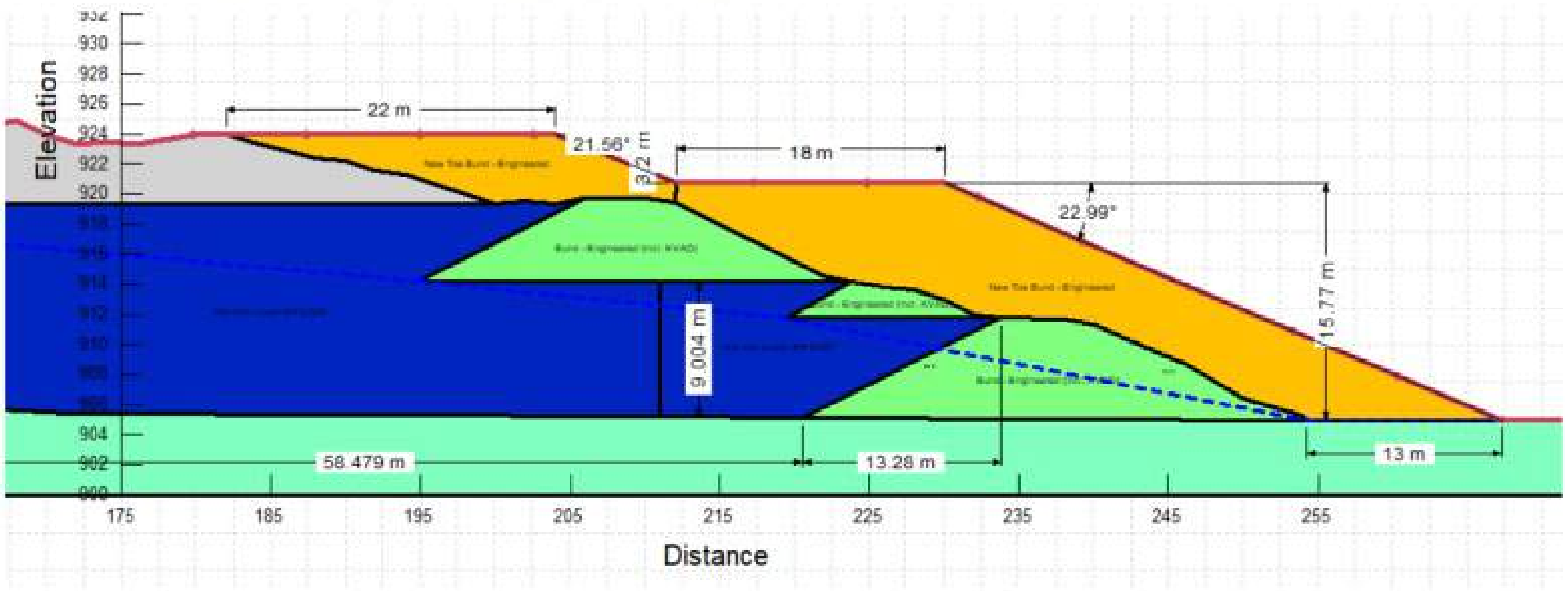
- Majority of site and activities approved under SSD Planning Approval 07_0005 (MOD2)
- Environment Protection Licence (EPL) 21185
- Lithgow City Council Development Consent DA016/19 for landfill, generally associated with power station decommissioning
- Site has been declared to be significantly contaminated land under section 11 of the *Contaminated Land Management Act 1997* (CLM Act) (Declaration Number 20211113, Area Number 3494).


Sawyers Swamp Creek Ash Dam (SSCAD)
Kerosene Vale Ash Repository (KVAR) which overlies the Kerosene Vale Ash Dam (KVAD)
Filled historical mine voids
Sawyers Swamp Creek (SSC) – original
Sawyers Swamp Creek (SSC) – diverted
Coxs River
Lidsdale
COXS RIVER

Need for realignment

- KVAR and the underlying KVAD require stabilisation – a perimeter stability buttress is the preferred option.
- The current alignment of SSC sits within the stability buttress toe – creek needs to be locally realigned to accommodate the buttress footprint and construction access.

Plate 2: Section 2 – Geometry of Stage 2A Toe Buttress



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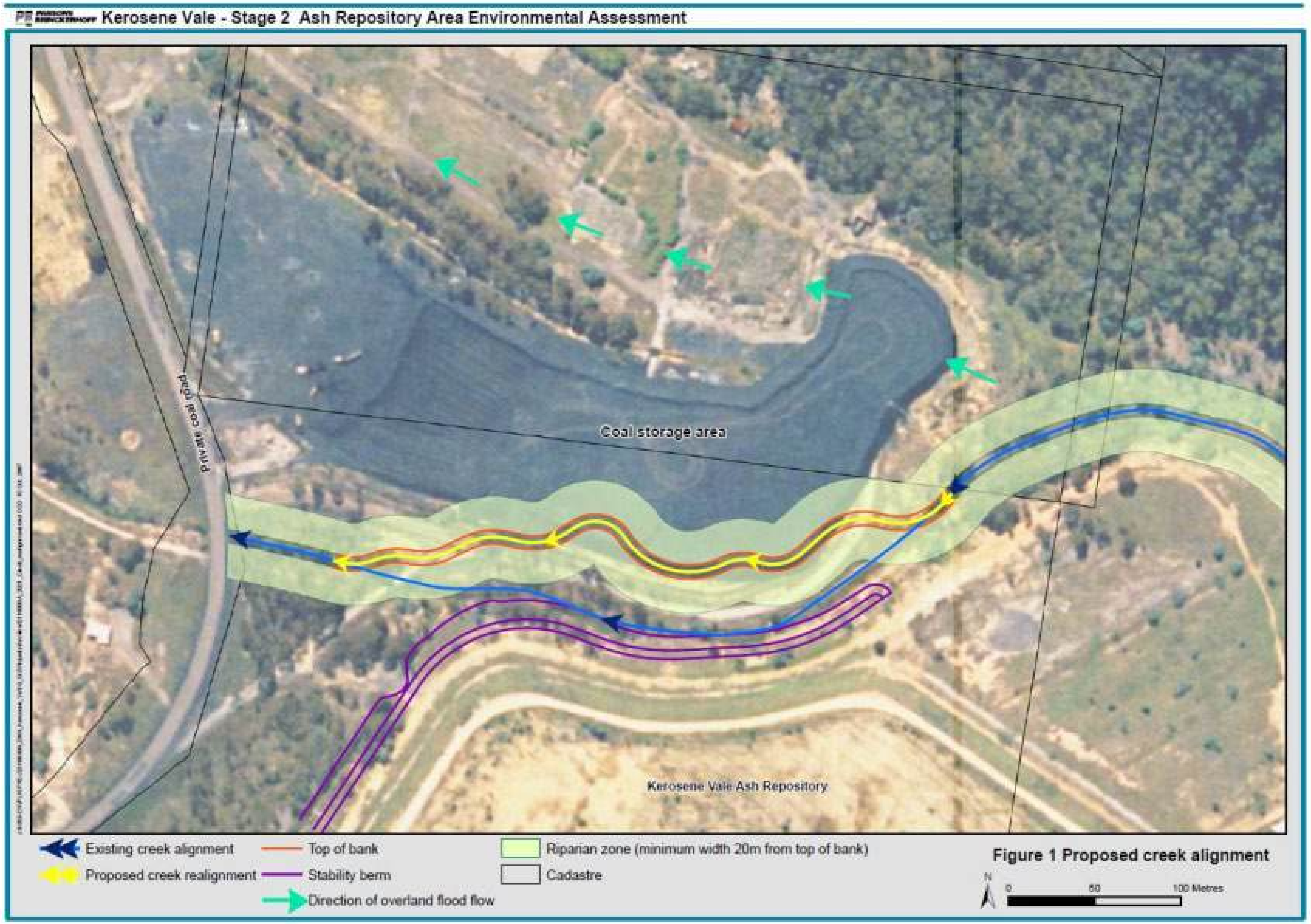
Approved realignment concept



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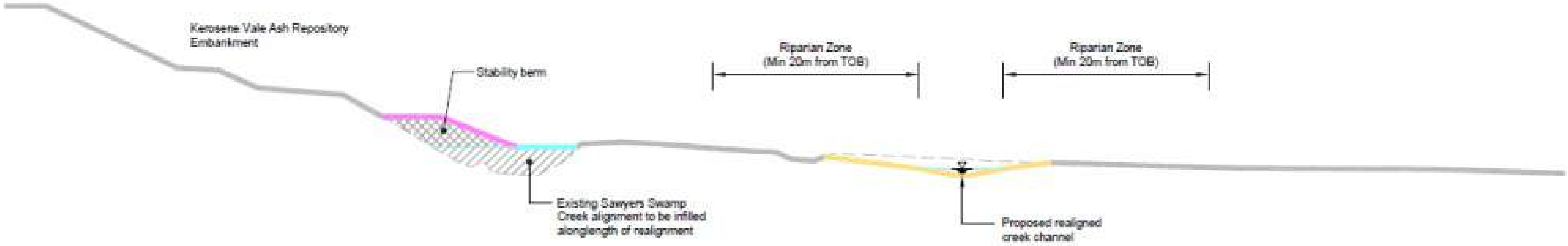
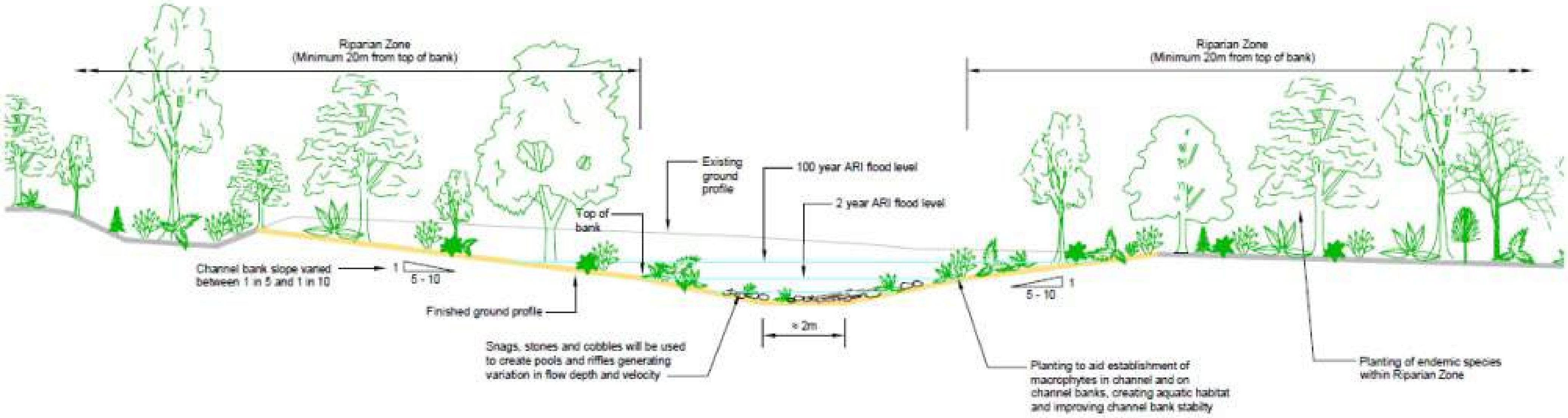
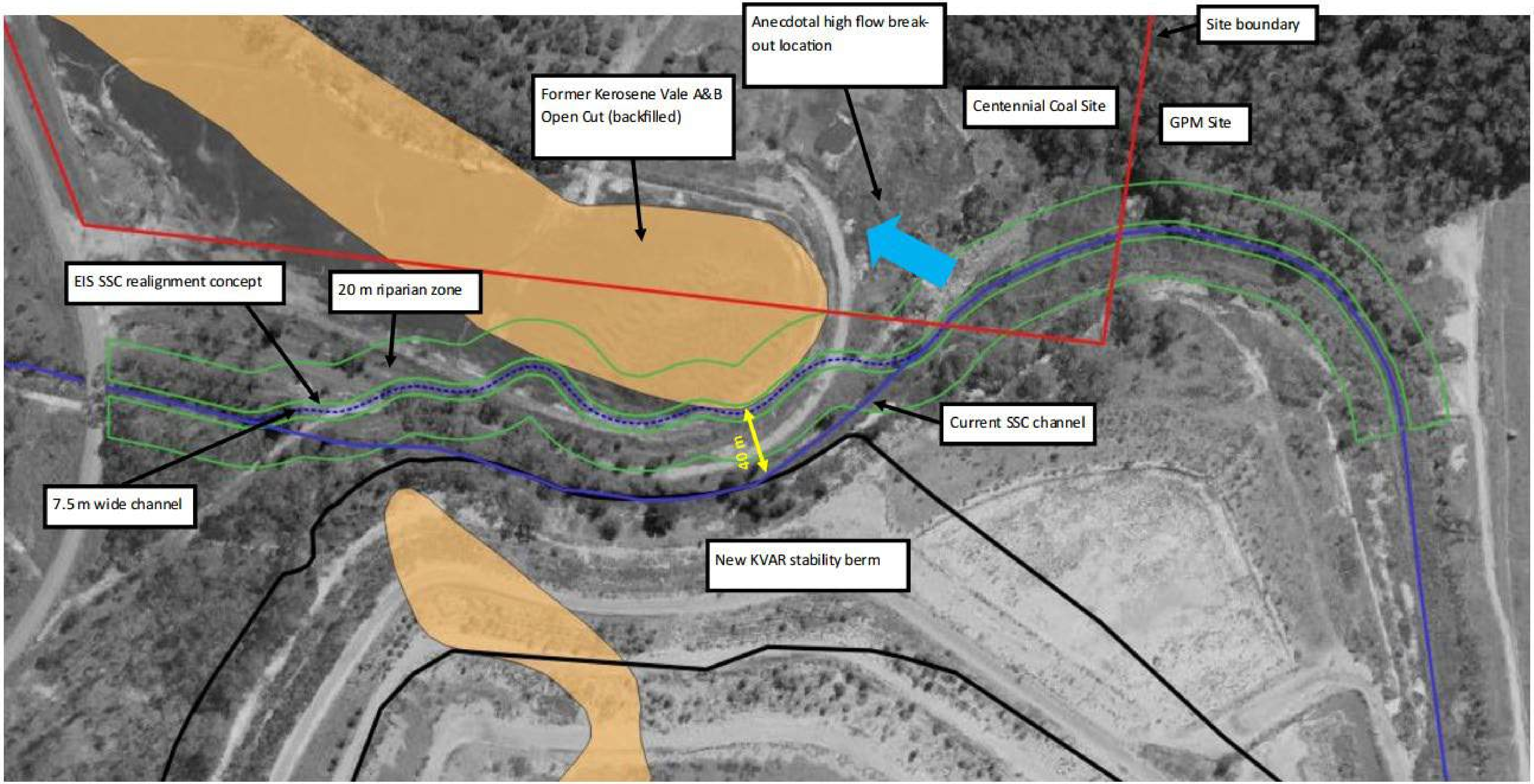
Approved realignment concept





Approved concept v known constraints



Key issues

- Approved realignment concept is for a ‘naturalised’ creek channel and riparian zone:
  - Kerosene Vale A&B open cut filled with ash – high scour and ash mobilisation risk
  - KVAR required buttress is larger than previously envisaged
  - previous conceptual realignment design (inc. 20 m riparian zones) is not achievable in the space available
  - hydrology that underpinned the approved concept was flawed and requires revision – flood flows are likely to be materially higher
  - long-term measures to protect the stability berm toe and adjacent backfilled open cut void from scouring not considered.
- Approved concept did not contemplate site closure in detail, rather based on assumption of ongoing operational site.

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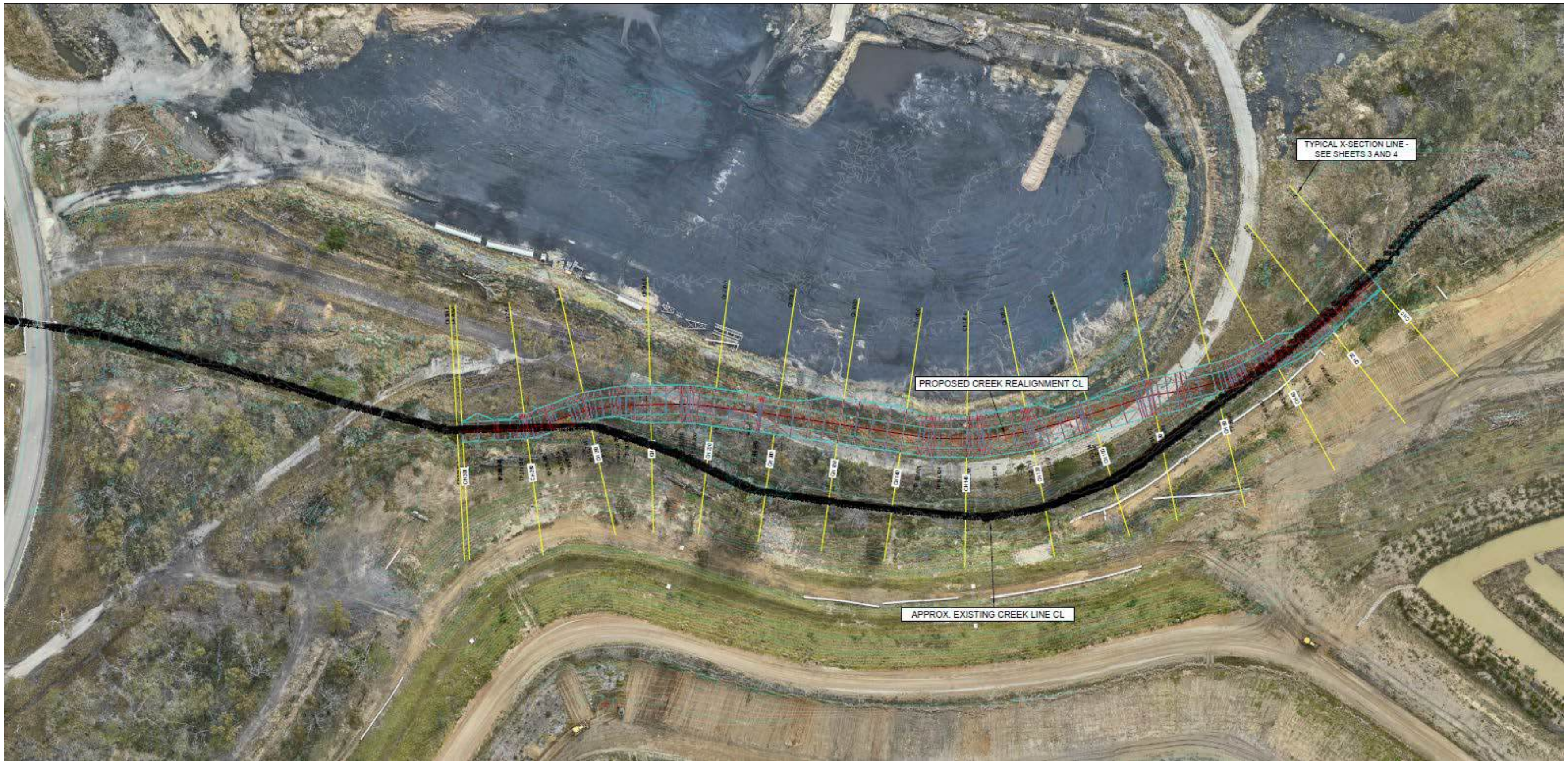
Concept

- Channel design to primarily consider water management and scour protection
- Move alignment of current channel but with similar design and consideration for higher capacity
- Minimal/no riparian zone
- Avoid disturbance of filled open cut



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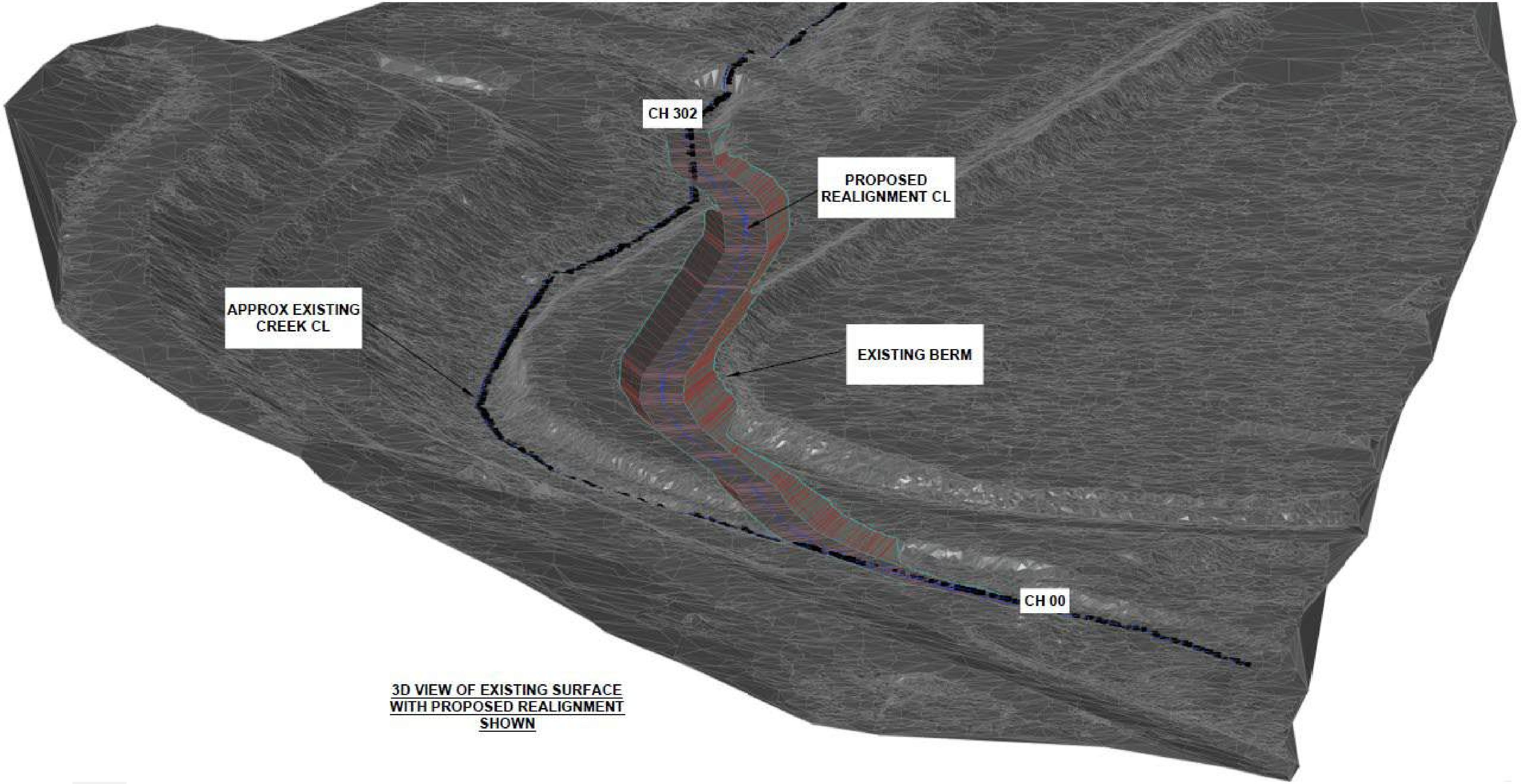
Concept



3D VIEW OF EXISTING SURFACE
WITH PROPOSED REALIGNMENT
SHOWN

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Kerosene Vale, Lidsdale NSW - Sawyers Swamp Creek Realignment

Date/time:	Monday, 20 November 2023, 01:00 pm to 02:00 pm	
Facilitator:	Nick Bartho, Associate Director	
Next meeting:	TBC	
Attendees:	Paul Glasson – Generator Property Management (GPM) [PG] John Pola (GPM) [JP] Phil Towler (EMM) [PT]	Rob Brownbill (DPE Water) [RB] David Ward (DPI Fisheries) [DW] Nick Bartho (EMM) [NB]
Apologies:	n/a	

Agenda

Item	Agenda Item	Presenter	Time
1	Introductions	All	1-2pm
	Overview of the site and approvals	EMM	
	Approved creek realignment	EMM	
	Constraints and key issues	EMM	
	Revised concept	EMM	
	Discussion/feedback	All	

Minutes and actions

PT and NB presented slides providing context, approved realignment, issues and a revised conceptual alignment.

Discussion points (grouped thematically):

- Realignment location:
  - DW – is there an opportunity to put creek back to original alignment?
  - JP – yes in the longer term. Site owned by Centennial (not GPM) so access would need to be negotiated and timing on this may not be compatible with the short term requirement to stabilise KVAR. There are a number of mine adits on the Centennial site that would need to be closed before using the original alignment.
- Riparian zone:
  - DW – would like to see return to functioning riparian zone as far as possible.

- DW – larger trees in the riparian zone aim to provide canopy, shading, ecosystem, fall into creek to create snags/aquatic habitat, etc.

- KVAR embankment:
  - DW – what vegetation is proposed for the KVAR buttress?
  - JP – grass planned. Concerns that if tress are used, they may fall (eventually) creating holes in the buttress surface.
  - NB - perhaps could achieve a better outcome than grass, but need to avoid anything with roots that could penetrate into engineered structure. Small shrubs perhaps, grasses such as lomandra and the like. Will consider in more detail what is achievable.
  - DW – agreed potential room for compromise on buttress side given design requirement, using smaller plants if practical.
- Northern side (filled Kerosene Vale A/B open cut):
  - NB – hard to resolve a new riparian zone on northern side as there is no long-term plan yet for the filled Kerosene Vale A/B open cut and coal stockpile area. Preference would be to not implement a riparian zone here in the short term.
- Regulatory:
  - RB – question whether there are any regulatory constraints.
  - PT – a conceptual realignment is approved but a rehabilitation plan describing the realignment needs to be prepared to the satisfaction of Fisheries in accordance with Project Approval (07_0005) Condition 2.26.
  - PT – preference to progress based on current consent but can seek a modification if required.
  - RB – have GPM engaged with DPE?
  - PT – not on the realignment at this stage. Preference is to find a solution (or solutions) with Fisheries before taking to DPE.
- SSCAD:
  - Creek currently runs in concrete channel on south side of SSCAD – channel has no ecological value.
  - Options for SSCAD being considered, including location of creek.
  - The stretch of creek running along the base of SSCAD dam (about 40 m fall over 850 m) will not be realigned.
- Conceptual design:
  - DW – existing policy (Policy and guidelines for fish habitat conservation and management) is starting point, would like to see a response to this.
  - DW - present qualities of existing creek sections (including assessment of aquatic habitat value).

- DW – consider stream order and corresponding DPI riparian zone requirements.
- DW – open to merits-based position, present against current guidance and policy (e.g. stream order, description of condition, classify, etc.) – what can be achieved?
- PT – we will look further at existing aquatic habitat values.
- NB – could we consider a short-term fix (e.g. realignment with no/lower habitat value) and long-term solution (an alignment providing achievable habitat value) could be considered.
- DW – yes, a staged approach could be considered.

• Consultation:
  - RB – don't believe need to be involved at this stage, happy to leave it with DPI-F. Will check with team).
  - RB - requested summary of notes/actions.
  - GPM/EMM – to continue to engage with Fisheries.

Action Item	Owner	Due date
1. EMM to prepare brief meeting minutes to capture summary of discussion points and circulate	EMM	ASAP
2. EMM to provide presentation to DW and RB	EMM	ASAP
3. EMM to work with GPM to further develop the conceptual design and then brief DPI Fisheries on progress	EMM	Jan/Feb 2024

Sawyers Swamp Creek Realignment

Aquatic Ecology rehabilitation options assessment

Prepared for Generator Property Management Pty Ltd

July 2024

Sawyers Swamp Creek Realignment

Aquatic Ecology rehabilitation options assessment

Generator Property Management Pty Ltd

E220618 RP11

July 2024

Version	Date	Prepared by	Reviewed by	Comments
1	14 June 2024	Andrea McPherson	Lachlan Hammersley	Draft
2	11 July 2024	Andrea McPherson	Lachlan Hammersley	Final

Approved by

Andrea McPherson
Associate Ecologist
11 July 2024

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1 Introduction

1.1 Project background

The Site comprises an area of approximately 528 hectares (ha) on Skelly Road, Lidsdale, NSW. The Site has been used for a range of purposes including ash placement from the Wallerawang Power Station that operated between 1957 to 2014. Prior the 1957, the site was used for open cut coal mining and some of the voids were subsequently used as landfills.

Key features of the Site relevant to this assessment include:

- the Kerosene Vale Dry Ash Repository (KVAR) and underlying former Kerosene Vale Ash Dam (KVAD)
- Sawyers Swamp Creek Ash Dam (SSCAD) which spills via a spillway to Sawyers Swamp Creek (SSC)
- the SSC diversion channel, which reduces inflows to SSCAD from upstream catchment areas
- the former Kerosene Vale A&B Open Cut, which has been backfilled. Following backfilling, this area has been used to stockpile coal.

These key elements are shown on Figure 1.1.

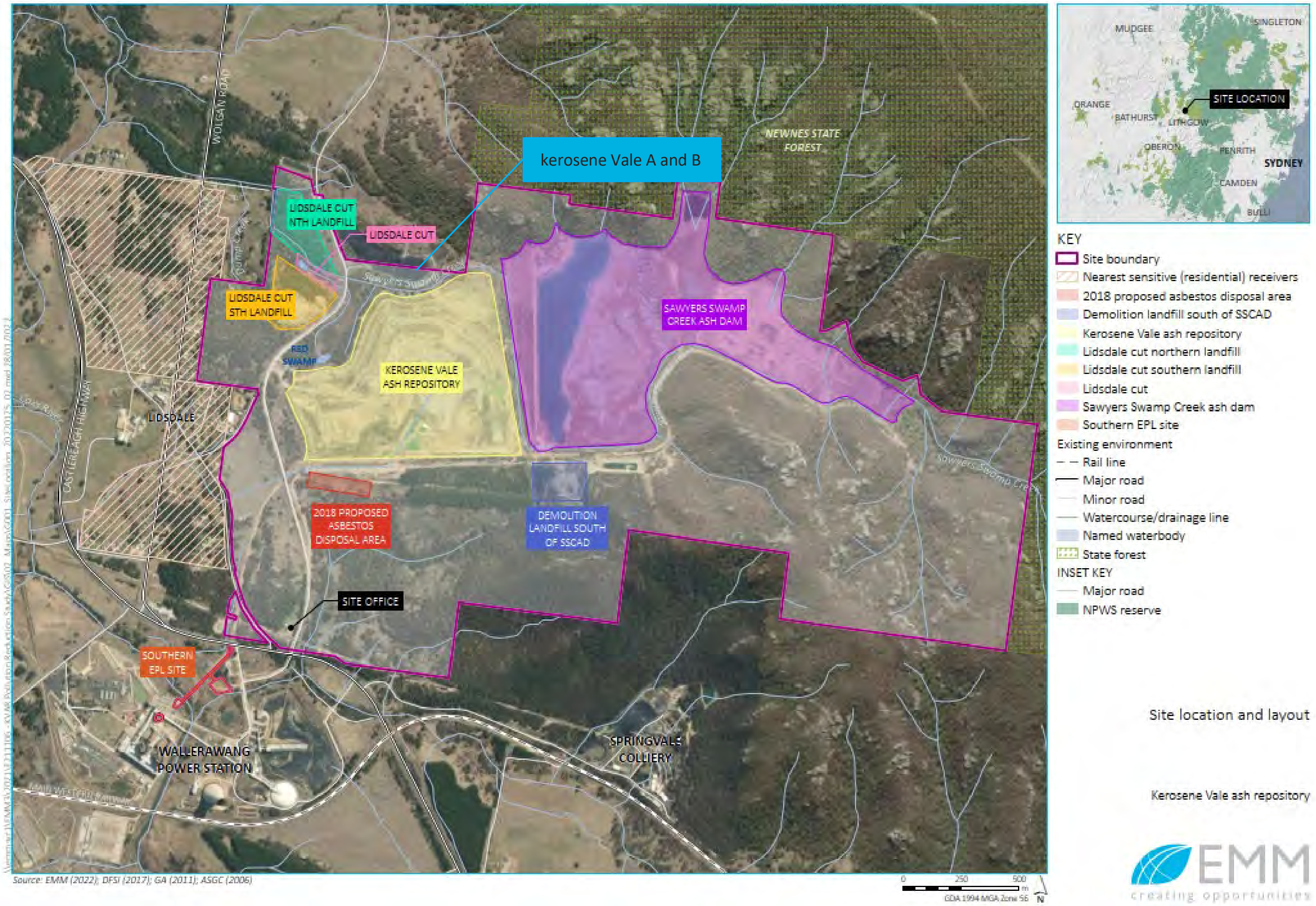


Figure 1.1 Site layout

Geotechnical investigations commissioned by Generator Property Management Pty Ltd (GPM) have identified that KVAR and the underlying KVAD is unstable. Improved subsurface drainage from KVAD and a new KVAR stability berm are proposed to address this issue. SSC needs to be locally realigned to enable these works to proceed.

The Site closure and rehabilitation plan will also involve the closure of the SSCAD, which currently provides significant flood storage in the catchment. Closure of SSCAD will therefore increase the upstream contributing catchment to SSC, have an impact on downstream flood dynamics. The SSC realignment should consider these changes to ensure compatibility with future site conditions.

Consent conditions need to be met or a modification application is needed to change conditions. The Project Approval MP07_0005 (refer to Annexure A) includes the following conditions regarding the creek diversion:

> 2.27 The rehabilitation and restoration of Sawyers Swamp Creek and associated riparian zone are to be consistent with the Works and Watercourse Design Guideline (DWE, April 2007) and Guidelines for Controlled Activities: Vegetation Management Plans (DWE, February 2008).
>
> 2.28 A riparian zone consisting of local native plant species shall be established and maintained in and adjacent to Swayers Swamp Creek, for the entirety of the site and be a minimum width of 20 m on both sides of the creek.

The creek design will aim to meet these conditions. However, if it is not possible to develop a reasonable and feasible design that meets them, a modification application may be required.

1.2 Proposed changes

The proposed works will include the reinforcement of the KVAR with a berm and or buttress that needs to be secure to protect against flood risk damage. The addition of the structural buttress will require the realignment of SSC along the base of this structure as the buttress will extend into the current creek channel (Figure 1.2).

The current creek alignment of SSC flows along the based of the KVAR area and west eventually connecting to Coxs River. This existing channel is heavily modified and constrained within its channel with little natural meandering. Once the channel moves past the KVAR there is an improvement in habitat availability but it is still modified with a small weir structure, culverts and the historical realignments.

The proposed realignment to shift the current channel around the base of the buttress will divert the channel to the north (Figure 1.2). This shift will present a few issues as the channel will be at the base of the structural buttress and restricted by the adjacent Kerosene Vale A and B open cut area to the immediate north (Figure 1.3). Because of the location it significantly restricts incorporating natural features that would meet the rehabilitation requirements for the project.

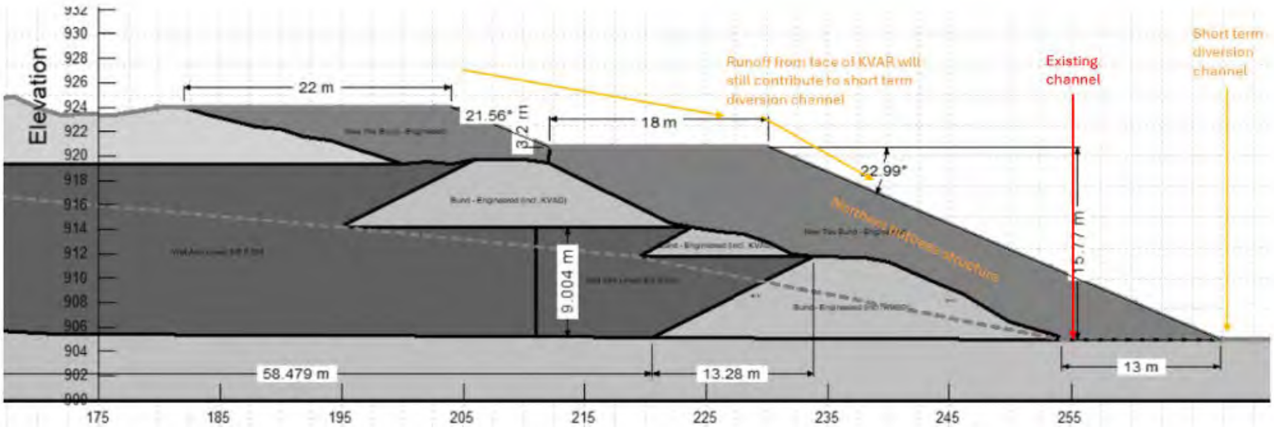


Figure 1.2 Cross section and geometry of the northern buttress in relation to the creek channel

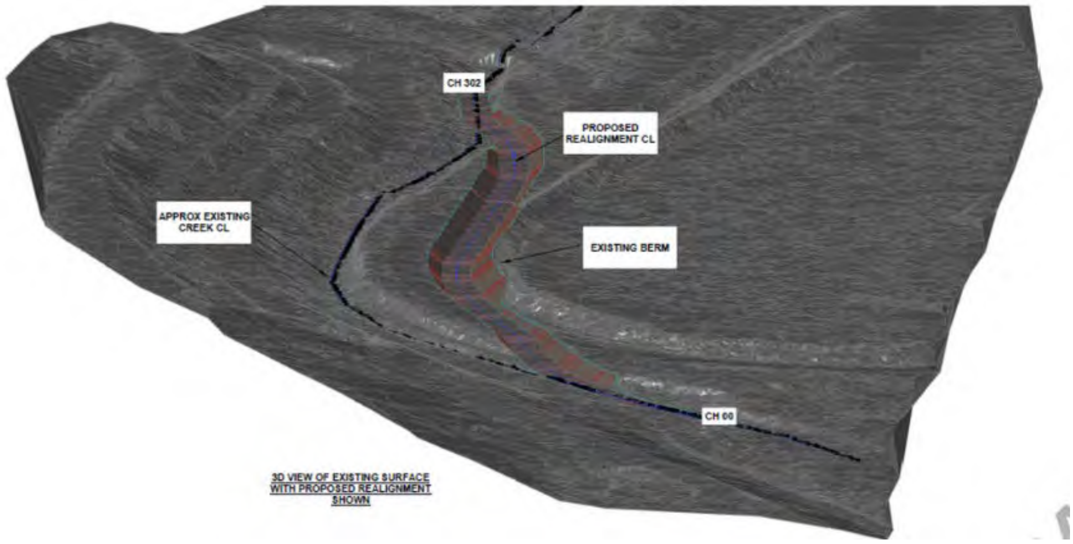


Figure 1.3 Proposed design of the KVAR bypass channel

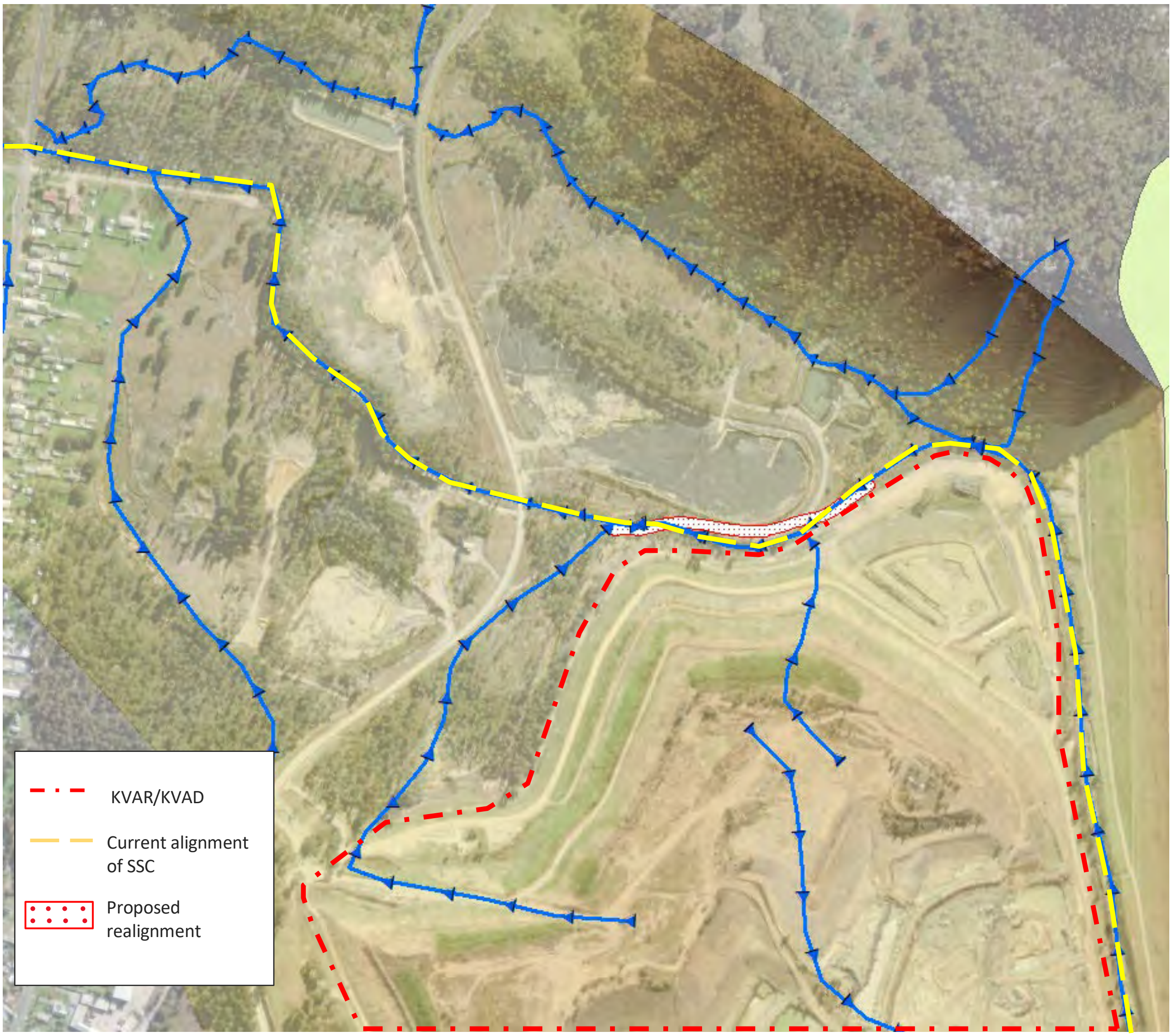


Figure 1.4 Current drainage channels across the site

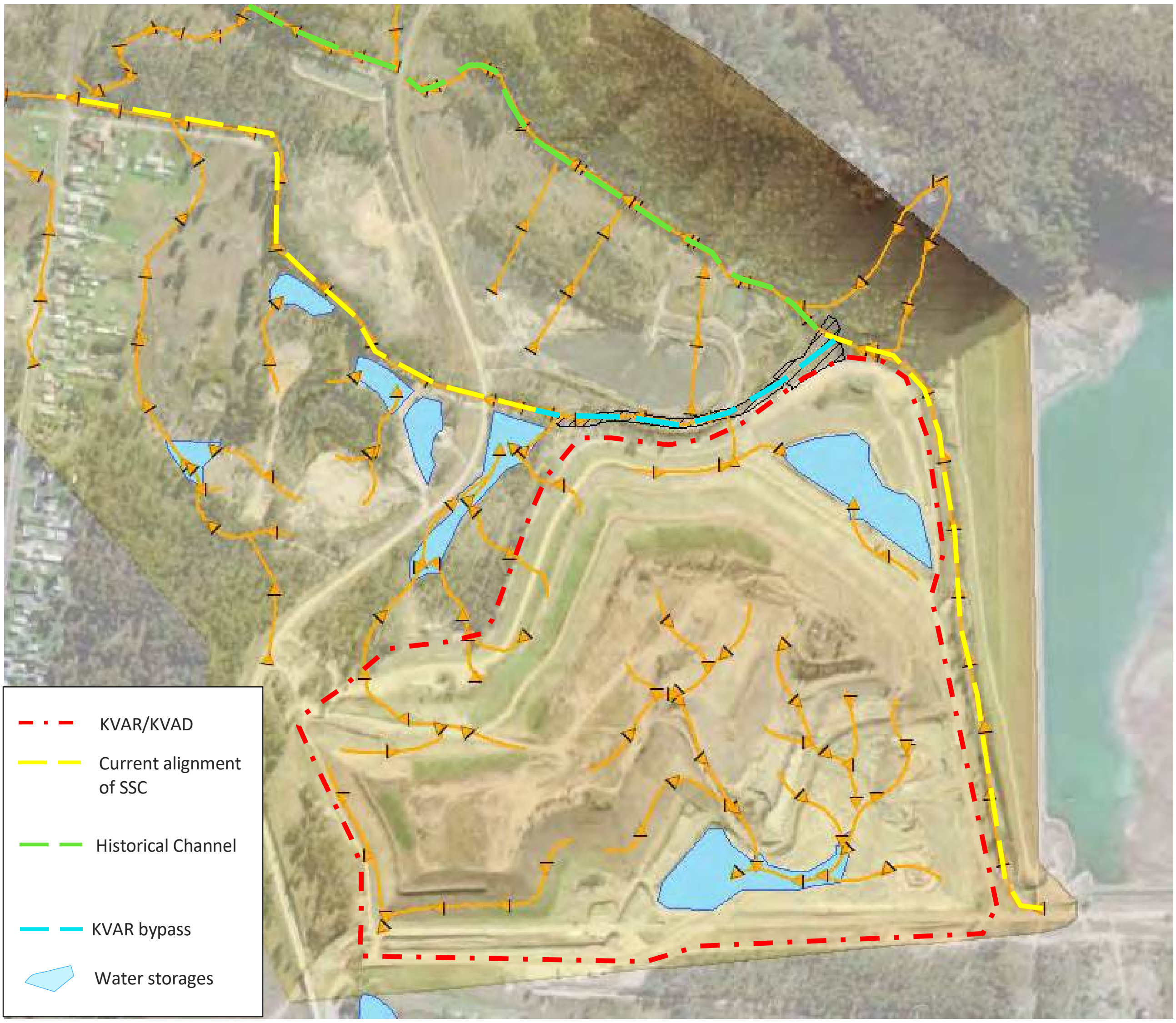


Figure 1.5 Modelled drainage channels across the site, once northern buttress is completed

1.3 Purpose of report

The purpose of this report is to review and present options that would provide the project with long term options to meet the consent conditions while providing suitable conveyance of catchment runoff, and protection of the structures required for the KVAR remediation works.

This report will consider the project history and current environmental setting to provide context to three broad options that have been identified internally based on the current state of the design requirements in conjunction with GPM for consideration:

- Option 1 – Construct permanent channel realignment of SSC that lies between KVAR and Kerosene Vale A/B open cut that provides no/minimal environmental value. This is preferred by GPM, but is considered unlikely to be acceptable to NSW Department of Primary Industries (DPI) Fisheries.
- Option 2 - Construct full realignment of SSC to the north through the historic channel that likely provides higher ecological value (e.g. along the abandoned creek line that sits currently within Centennial land to the north of the site).

- Option 3 - Construct permanent remediation channel away from the current realignment SSC on the south side of the property to protect and maintain ecological value of the water from the upper catchment.

Further options and recommendations may be identified and will be considered to assist GPM with a path forward.

1.4 Desktop assessment

Information regarding the surrounding catchment area, including condition, climate and sensitive receptors will be reviewed. Databases applicable to the subject matter will be searched for added context to the site constrains and conditions these databases include, but not limited to:

- Protected Matters Search tool (*Environmental Protection of Biodiversity and Conservation Act 1999* (EPBC Act))
- BioNet, Department of Environment and Heritage
- SEED Map, NSW Government
- NSW Spatial Data Portal, Fisheries NSW
- Bureau of Meteorology (BOM).

1.5 Background review

The proposed options will consider the designs completed to date, the site topography, previous aquatic ecology assessments existing constraints to fish passage, project conditions for the closure, and reviewing the best outcome for the project and the aquatic environment. Each section of SSC will be reviewed for current constraints and existing conditions.

This will provide three options for the project to consider. These options will be based on objectives that will be formulated through the project requirements and potential outcomes.

1.6 Site inspection

A site inspection was undertaken on the 16 April 2024 by Andrea McPherson an Aquatic Ecologist with over 14 years' experience. The site inspection included visual inspection of:

- habitat availability
- general condition
- water quality influences
- existing barriers that would impede fish movement
- site constraints.

Photographs and GPS tracks and points were collected. The inspection outcome confirmed the limitations of the options and identify the major restrictions to the potential of rehabilitation efforts not only in the lower sections of SSC but also in the upper sections of SSC.

1.6.1 Sections of Sawyer Swamp Creek

For clarity the regions of SSC have been broken down into sections to be clear about what is being discussed, consistent wording and for the review of attributes for each option. Table 1.1 includes a description of each section (Figure 1.6). Images of the various section are provided in Annexure B.

Table 1.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	Location	Stream order
Upper Sawyer Swamp Creek	Head waters of SSC inclusive of all tributaries upstream of the Ash Dam that are controlled and diverted.	Range from 1st to 4th
SSCAD Clean Water Diversion Channel	Bunded shaped channel, some sections are piped other section are open.	4th
SSCAD cross diversions	No defined channels, drainage is either 1. currently bunded and gravity fed via pipe across to the current clean water diversion channel, or 2. overland flow into the exposed SSCAD, being collect for treatment.	Conceptually 1st to 3rd
Spillway	The spillway connects the top of the SSCAD, where it received overflow of the SSCAD, and connects to the SSCAD Clean Water Diversion Channel.	4th
Current SSC	From the spillway flowing west along the KVAR.	4th
Historical Channel	The assumed historical channel alignment of SSC, currently runs through the adjacent property (Centennial) and is not within the bounds of the GPM site.	Mapped as 4th, but disconnected, currently operating as a 2nd
KVAR bypass	The short-term diversion section of SSC.	4th
Lower SSC	Downstream of the haul road and downstream of the property boundary, connects to the Coxs River upstream of the Maddox Lane crossing.	4th
Southern Channel (Golf course)	Channel flow along the 'golf course' of the GPM site and flows out of the property to the south and connects to Coxs River after crossing below the Castlereagh Highway.	Mapped as a 2nd, however all drainages in this region are not consisting with the mapping possibly could be a 3rd
Coxs River	All site watercourses connect to the Coxs River.	5th and 6th

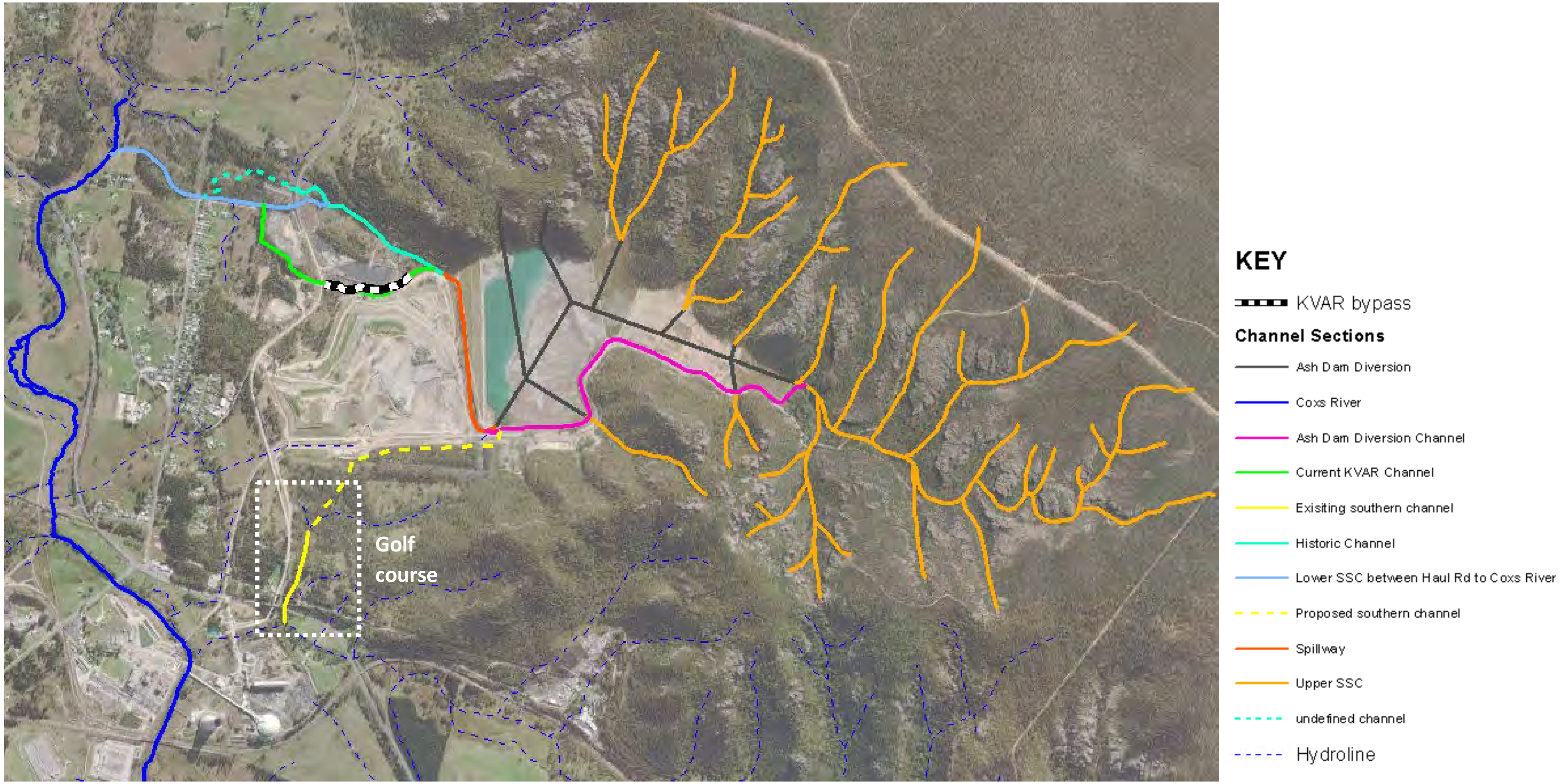


Figure 1.6 SSC sections and related tributaries

1.6.2 Options

Proposed options will be identified and compared based on a number of characteristics and features available for each option. The area of the site in review is broadly defined as downstream of the SSCAD spillway channel (described as the lower SSC).

i Limitations

- Cost implications are not considered as part of this study.
- The future land tenure for some options is currently unknown.
- Detailed site contamination investigation is underway for a number of cadastral parcels within the GPM site.
- Additional studies will need to be undertaken to understand the feasibility of each of these options.

1.7 Objectives

The realignment objectives have been developed based on the requirements of the project, that is what is needed to progress shorter term critical outcomes compared with the long-term rehabilitation requirements of the conditions of consent. The realignment objectives are outlined below:

1. **Short term objectives: It is assumed that consent conditions are focused on the longer-term rehabilitation outcomes:**
   a) Allow construction of the KVAR buttress.
2. **Long term objectives: Combination of addressing consent condition requirement but also providing robust ecological outcomes:**
   a) Improve and reinstate riparian habitat (20-metre (m) buffer).
   b) Improve habitat and fish passage connectivity.
   c) Improve and or maintain water quality from upper catchment.

1.8 Creek Rehabilitation approach

Rehabilitation methods generally applied through the Rutherfurd, *et al* (2000) A *Rehabilitation Manual for Australian a Streams (Volume 1 and 2).* There are three main approaches to stream rehabilitation (paraphrased from section 1, Rutherfurd et al 2000):

- **Restoration:** An ideal restoration would be reinstating the natural range of water quality, natural sediments and flow regimen, natural channel geometry and stability, riparian cover, and instream biodiversity.
- **Rehabilitation:** Although restoration may be impossible, this does not leave a degraded stream without hope. By improving the most important aspects of the stream environment, you may create a stream that, although only resembling the pre-European condition, is nevertheless an improvement on the degraded stream, and often a valuable environment in its own right.

- **Remediation:** In some cases, even rehabilitation is not possible because of irretrievable changes to the stream. In such a situation, we can say that the original state is no longer an appropriate aim for the stream, because inputs from the catchment would not support such a condition. In this situation, the suitable treatment is remediation (Bradshaw 1996). The aim of remediation is to improve the ecological condition of the stream, but the endpoint of that improvement will not necessarily resemble the original state of the stream.

The manual further discusses the principles for rehabilitating streams. This is particularly useful as a way of measuring the options reviewed in this assessment as it provides an indication of likelihood of success and benefit. For the purposes of this assessment, the principles have been adapted as a scaled measure (out of 5) for each factor, as described in Table 1.2.

Table 1.2 Option considerations

Factor	Rutherfurd *et al* (2000) description	Application for this options assessment
Condition	Condition of a stream by what lives in it. If the stream contains close to the pre-European population and diversity of organisms, then is it likely to be in fair condition.	What is the current condition, can it be improved? Yes -5, No -1
Damage	Direct changes to streams, combined with changes to catchments and water quality, have simplified the physical and hydrological character of Australian streams. These impacts have interrupted the life cycles of many species so that they can become locally extinct, or stressed. As a result, the biological communities in streams have also become simpler, such that they are now dominated by relatively few animals and plants. Often the remaining plants are exotic (not native) species.	Are the changes undertaken on site, reversible can they be remediated? Yes -5, No -1
Recovery	Damage to stream systems may be permanent (e.g. extinction of species), essentially permanent on human time scales (e.g. taking hundreds of years to recover), or resilient systems may recover within years. If you understand the natural process of recovery, then you may be able to work with that recovery to more quickly rehabilitate a stream	Can suitable enhancements in riparian cover and stream structure be achieved? Yes -5, No -1
Rehabilitation	Rehabilitation is an effort to artificially return the fundamental elements of the original (pre-European) stream, either by direct intervention, or by hastening the recovery process. Rehabilitation usually involves managing the physical and chemical conditions in the stream.	Can water quality be maintained and is there adequate space to incorporate riparian cover and stream structure to mimic natural conditions? Yes -5, No -1
Copy	Often, we want to rehabilitate a stream but we do not know enough about the complexities of the natural stream ecosystems to know where to begin. When in doubt about what to do to rehabilitate your stream, either copy the original form and conditions, or find a reach in good condition, that has the physical or biological characteristics you want, and copy that reach	Can the stream be returned to what a representative good condition stream looks like for the region? Yes -5, No -1

Table 1.2 Option considerations

Factor	Rutherfurd *et al* (2000) description	Application for this options assessment
Preventions	It is easy quick and cheap to damage natural streams. It is hard, slow, and expensive to return them to their original state. Usually, we are not capable of returning anything approaching the subtlety and complexity of the natural system. For this reason, the highest priority for stream rehabilitators is to avoid further damage to streams, especially streams that remain in good condition	Can the stream be protected from future damage and exposure? Yes -5, No -1
	Total scores	**Up to 35 points = equivalent to full naturalisation**

2 Current conditions and aquatic values on site

SSC has a legacy of historical modifications, it is currently estimated around 67% of the current channel has been modified from its natural state. The most available habitat of reasonable quality is currently limited to the upper section of SSC above the Ash Dam and within the lower section before the creek connects to the Coxs River. The wider catchment of the Coxs River (Hawkesbury-Nepean Catchment) is considered to be in poor condition according to the River Condition Index. This rating includes:

- Water Quality Sub Index: *Moderate*
- Catchment Disturbance Sub Index: *Good*
- Riparian Vegetation Condition Sub Index: *Moderate*
- River Biodiversity Condition Sub Index: *Very Poor*
- River Styles Geomorphic Condition Sub Index: *Moderate*
- Hydrologic Stress Condition Sub Index: *Very Good*

River condition which is broadly based on the fish community status and the area or length of watercourse reaches within a sub catchment area. Of the relative index this was the lowest value suggesting the condition of the fish community in this region is poor and or very poor (Figure 2.1). This outcome is likely contributed to the historical clearing, modification and resource extraction in the region.

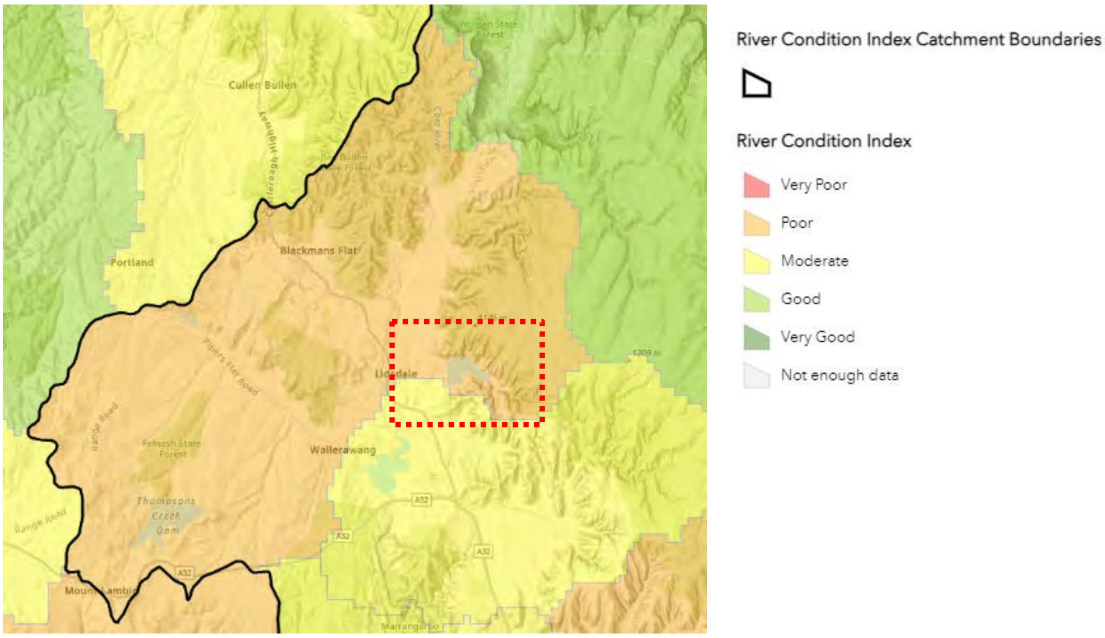


Figure 2.1 River Condition Index mapping (SEED Portal, accessed 24/03/2024)

The downstream end of SSC has also been identified for medium priority river management, with a moderate recovery potential. This is limited to the lower downstream section only (Figure 2.2). This is consistent with the requirements for rehabilitation (outlined in the conditions consent) of the lower section of the creek, and the requirement for Fisheries NSW support for approval.

Figure 2.2 Aquatic condition and proity mapping (Fisheries Spatial Data Portal, Accessed 03 May 2024)

2.1 Current habitat and condition

2.1.1 Habitat

Habitat availability across the SSC is highly restrictive and limited to the upper sections of the creek, before the ash dam clean water diversion. There is marginal habitat value downstream of the spillway but this slightly improves once the creek is off the GPM site, as the riparian cover increases and limited presence of in stream structures/crossings.

Table 2.1 Habitat availability of SSC

Section	Channel structure	Level of modification Level of disturbance and contamination risk	Macroinvertebrate indices	Water quality
Upper Sawyer Swamp Creek	Upper SSC is less defined appears to form shallow channels across a wide valley. The valley is heavily vegetated further downstream before the ash dam that channel becomes more defined. Then connects to a wetland/pool before an overflow pipe connects to the Ash Dam Diversion channel	Some modification in the presence of track crossings, disturbance is low limited to access tracks. Low – upstream of ash dam waste, riparian habitat in tacked.	Sampled only 2020-2022: • Range of richness: 10-21 • Range of EPT richness: 1-5 • Range of SIGNAL score: 3.36-5.5. Limited survey effort.	Water quality collected at head waters dam SS5. Generally, below or within normal range of the project DVG*, with the exception of turbidity, cobalt, sometimes zinc and EC. Suspect likely linked to naturel conditions. No groundwater bores near head waters.
SSCAD clean water Diversion Channel	From a long pipe section from the top of the ash dam, the pipe opens to an open hard packed and concreted channel. Which is highly is constrained.	High disturbance. With only isolated vegetation located along edge of channel banks, not providing habitat. High contamination risk– sediment transport form ash dam.	N/A	Site S6. Generally, within/below DGV with the exception of Aluminium, cobalt, zinc.
SSCAD diversions	These bunded tributaries are gravity fed to the Ash Dam diversion channel. There are piped through the Ash dam. To remove surface water from the dam, reduce ash exposure and connect downstream.	Highly modified – enclosed.	N/A	N/A
Spillway	Some habitats available, very limited to in channel for macroinvertebrates – slope likely a barrier for fish passage. Beginning of spillway – wide concreate lined connection between the Ash Dam diversion.	Highly modified and channel is constrained. Moderate disturbance. Exposed to very high flow velocities during flow periods, would likely strip vegetation and habitat from channel. Some meandering through sediments. High contamination risk– sediment transport form ash dam.	N/A	Site 25. Similar to site S5 with above DGV levels of cobalt.

Table 2.1 Habitat availability of SSC

Section	Channel structure	Level of modification Level of disturbance and contamination risk	Macroinvertebrate indices	Water quality
Current Sawyer Swamp Creek	Channel is modified with some sections with habitat, instream vegetation and bed sediments. Most of the channel is cleared with little to no vegetation and little structure.	Highly to moderately disturbed. Sections considered more moderate in disturbance have been cleared previously after fires in the region and have poor inconsistent riparian cover.	Sampled 2017-2022: • Range of richness: 7-19 • Range of EPT richness: 0-5 • Range of SIGNAL score: 2.28-5.07.	WX5 – generally increasing downstream from SS5, There was a significant increase in most analytes Showed an increase in most parameters, where just further downstream at WX7 concentrations dropped off pH normalized but was still outside the DGB range.
Historical channel	Short channel leading from pool at the end of spill way, channel ends at a void. Channel reappears about 300 m downstream and is a very small poorly defined channel.	Most native vegetation is present along the right back (looking downstream), left bank is cleared and hard scrapped with tracks and gravel.	N/A	N/A
Lower SSC	Channel in tack, highly channelised before connecting with the Coxs River. Some riparian buffer, little instream vegetation exposed bed and bank sediments.	Channel is restricted but becomes more natural as it approached the Coxs River.	N/A	N/A
Southern channel (Golf course)	Previously efforts to formalise and destabilise the channel.	Currently some modification, appears some effort to rehabilitate the creek has been undertaken.	N/A	N/A
Coxs River	The river in this section runs through open pastoral land with a very limited riparian cover and then flows through the Wallerawang power station before connecting with Lake Wallace.	Historical clearing and channelising present.	N/A	Does exceeded several DVG trigger values. Symptomatic of surrounding land usage and historical modifications.

* DVG- Default value guidelines as per the ANZEC water quality guidelines

2.1.2 Condition

Aquatic monitoring has been undertaken periodically more recently collected from 2017 to 2022. Available date included macroinvertebrate sampling that recorded Richness, SIGNAL Score, and EPT richness. Macroinvertebrate indices were calculated using Chessman (2003).

The Chessman (2003) quadrant method compares Signal 2 scores to the family richness, where each quadrant provides an indication of the condition of the site (Figure 2.3).

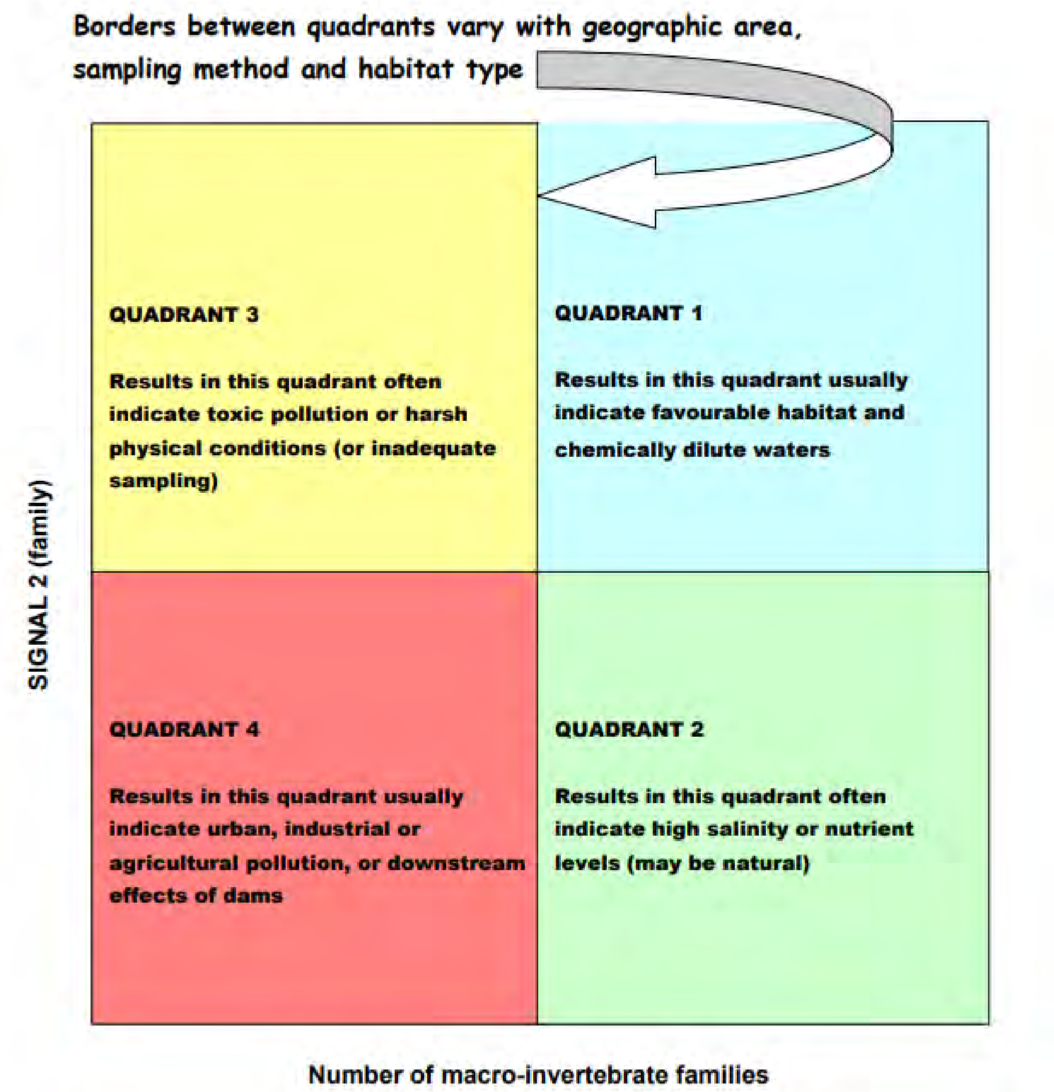


Figure 2.3 Chessman (2003) macroinvertebrate indices quadrants

Based on the aquatic monitoring information provided from the more recent studies two locations have been recently surveyed over the 2017 to 2022 period. An upstream site (SSCup) upstream of the Ash dam sampled between 2020 and 2022 and one site downstream (DP9dn) sampled between 2017 and 2018 (Figure 2.4). With only two locations available there is only limited understanding of the condition across SSC. When plotted, the majority of the downstream sites fell in Quadrant 3, where most of the upstream samples fell within the Quadrant 1, with the exception of two results that were surveyed after the fires in 2019 (Mt Gospers Fire) that had moved through the wider region and had impacted on the forests around Kerosene Vale (Figure 2.4). Overall, the downstream site indicates a range of poor water conditions and disturbance.

Pervious studies were under taken in 2006, their results summarised that SSC was degraded , with poor what quality and a relatively dapauperte faunal assemsbilage. Of the macroinvertebrate taxa present were of pollutant tolelrat species. However the survey only focused on the lower SSC and the Coxs River and refence sites.

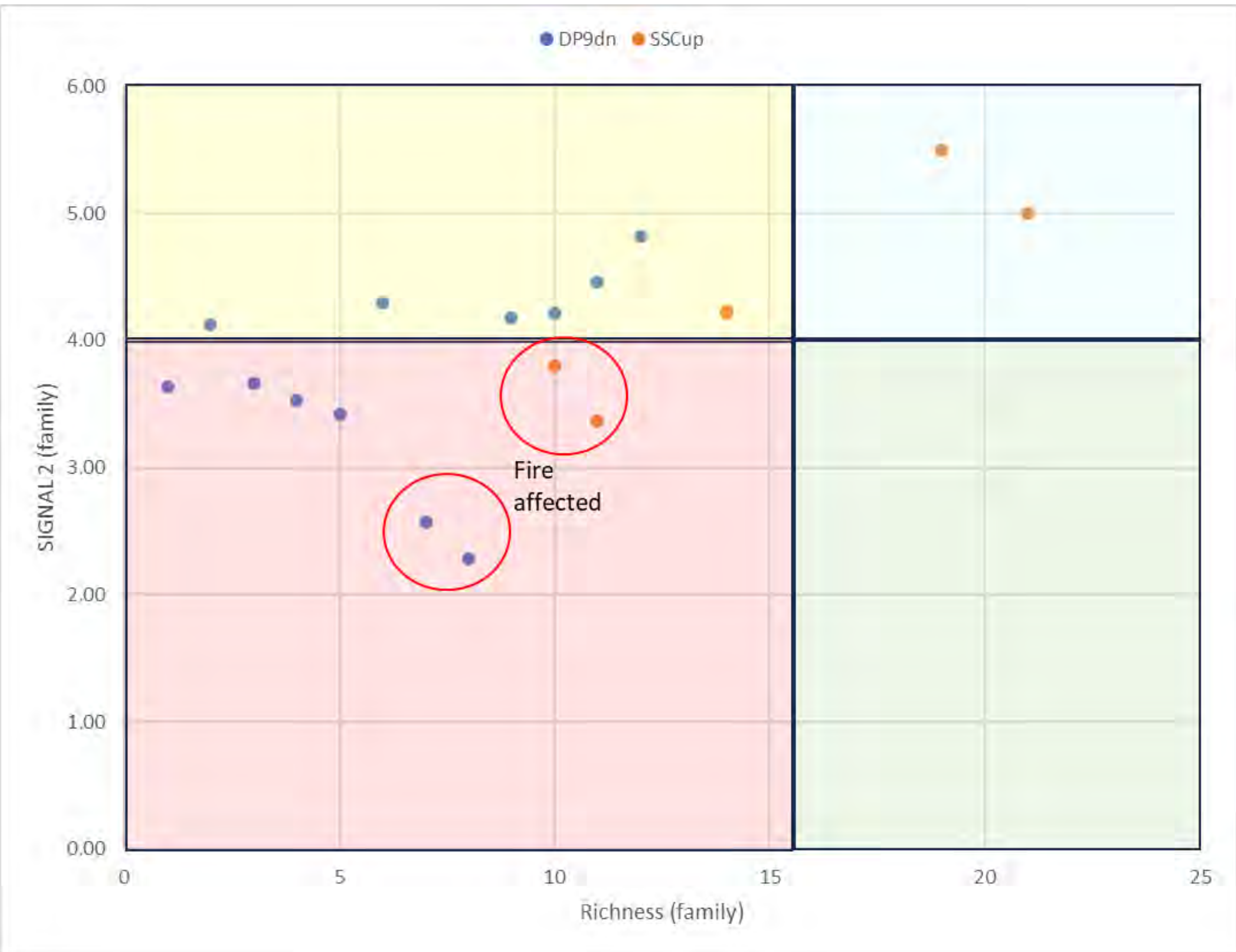


Figure 2.4 Macroinvertebrate indices plotted from the Kerosene Vale property

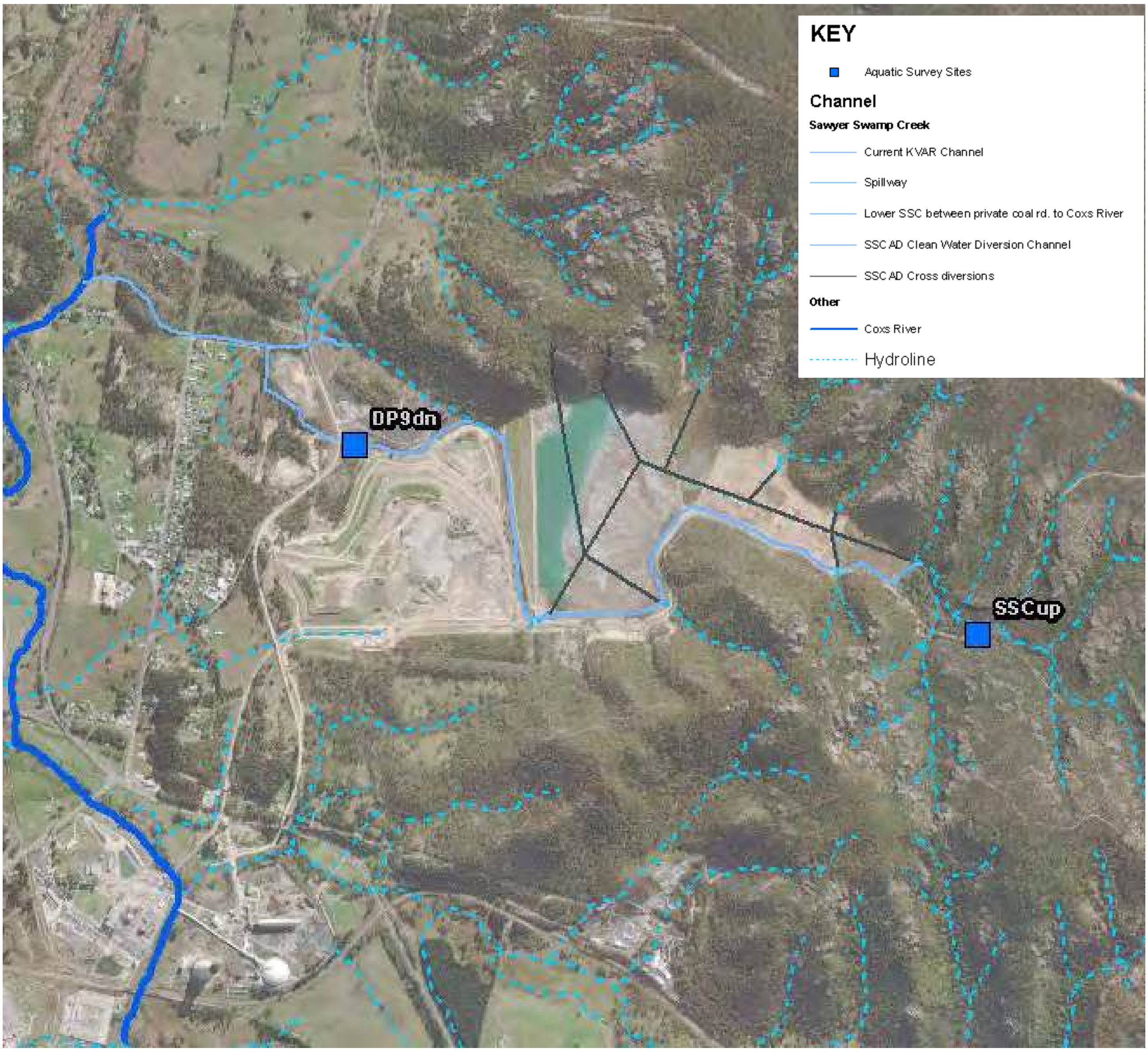


Figure 2.5 Recent aquatic ecology sites

2.2 Supporting studies

In September 2023, EMM completed *Kerosene Vale Ash Repositories and Surrounds Surface Water Characterisation Report: EPL Condition* E1.2, which discussed in detail the water management sections of the site and how water was conveyed from the upper catchment to the Coxs River (for monitoring site locations see Figure 2.6).

The outcome of this study confirmed:

- the current pumping and bypassing of clean surface water from the upper catchment area is proving effective in maintain water quality
- likely groundwater seepage occurring from the SSCAD, KVAD and KVAR and indicated that seepage is the primary source ash affected water

- there was a trend of declining pH and increasing turbidity levels and concentrations of sulphate, total dissolved solids, cobalt, nickel and zinc between SS5 (upstream of SSCAD) and WX7 (downstream of the site), with most of the changes occurring in the lower reach of the SSC Diversion, between WX5 (adjacent to Lidsdale Cut) and WX7
- Dump Creek which flows into SSC downstream of the KVAR is a first order stream and dose not flow outside of wet weather, this creek line is a source of reduced water quality
- inflows from SSC were generally beneficial for Coxs River water quality.

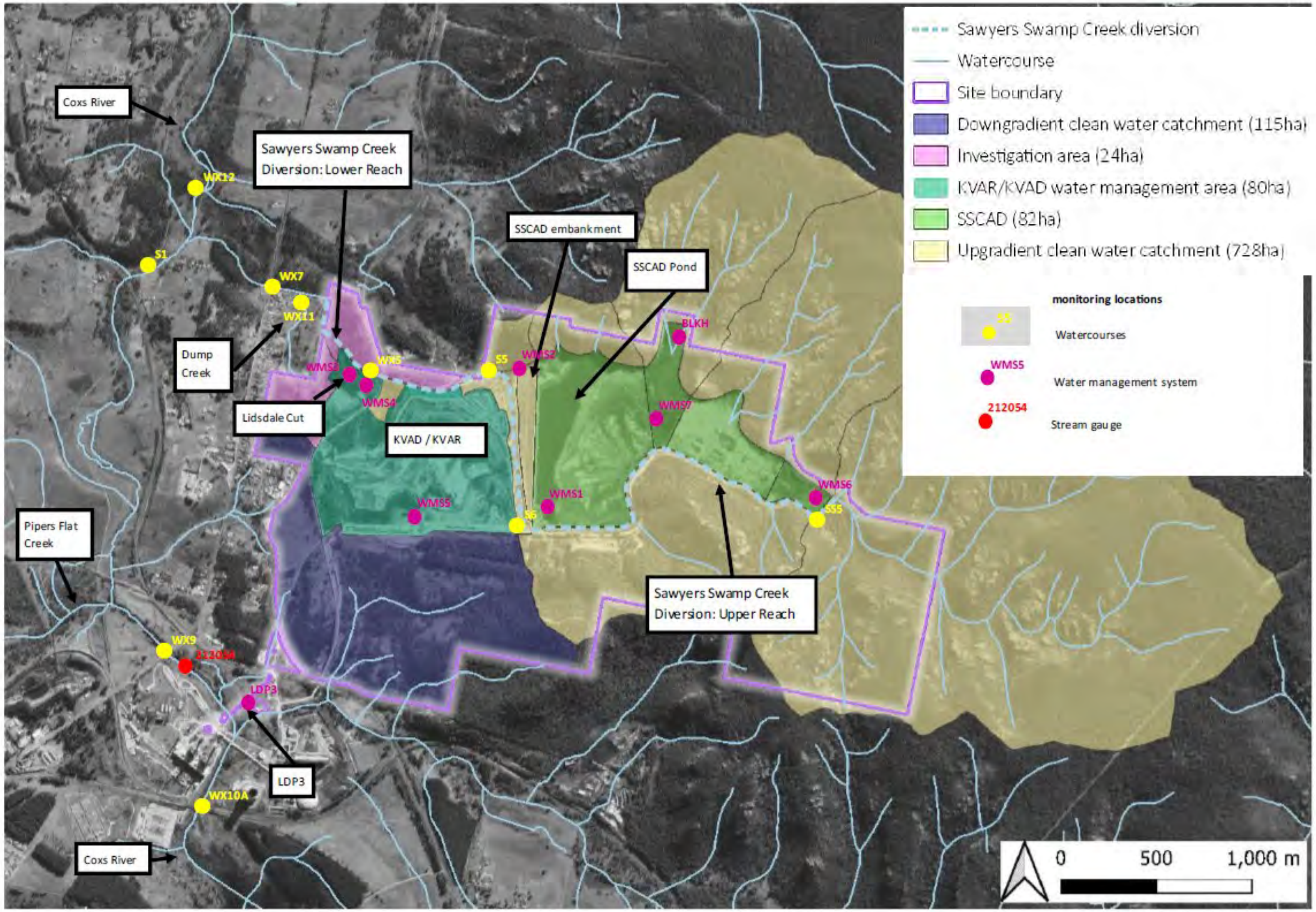


Figure 2.6 Surface water monitoring locations

3 Proposed options

After careful consideration and review of the background, historic information and completing the site visit, three options have been identified. Essentially the options put forward consider the various versions of the Rutherfurd approach, restore, rehabilitate, and remediate. Each option is reviewed for positive and negative outcomes and the likelihood of being effectively implemented.

3.1 Option 1: Maintain current channel arrangement.

Option 1 would allow for the development and progress of the reinforcement and modify SSC channel to bypass around KVAR buttress, which meets the short-term requirements (Figure 3.1). However, this option does not include the complete realignment of SSC and is unlikely to meet the conditions required to meet the long-term objectives.

As such this is likely to not be an accepted outcome due to:

- the full riparian buffer requirements are unlikely to be met given the adjacent land uses
- may risk significant inundation upstream of the Private Haul Road
- the highly spatially constrained downstream environment is unlikely to implement good channel structure
- long term exposure to contamination risk
- construction activities that are likely to continue within 50 m of the realigned watercourse.

Although this is not a preferred option it must remain an option as there is potential that the other preferred options may be determined later to not be feasible. While there are still a number of opportunities to improve overall habitat along the alignment of SSC there will be a number of limitations to how improvements can be incorporated.

When reviewing the Rutherfurd *et al* (2003) approach this would be a restoration approach, however based on the assessment outcomes it is not likely to provide good environmental outcomes or condition compliance (Table 3.1), scoring 12 out of 35 assessment points.

Table 3.1 Option 1 assessment

Condition	Damage	Recovery	Rehabilitation	Copy	Preventions
What is the current condition, can it be improved?	Are the changes undertaken on site, reversible can they be remediated?	Can suitable enhancements in riparian cover and stream structure be achieved?	Can water quality be maintained and is there adequate space to incorporate riparian cover and stream structure to mimic natural conditions?	Can the stream be returned to what a representative good condition stream looks like for the region?	Can the stream be protected from future damage and exposure?
3	2	2	2	1	3
Improvements can be made but they are limited	Possibly however we do not understand the full limitation of the region of the property	Likely limited and not ideal	Seepage issues identified in the downstream section of SSC	Too many constraints	Precautions can be taken but its likely additional work maybe needed near the channels to help control for seepage
				Total	**12**

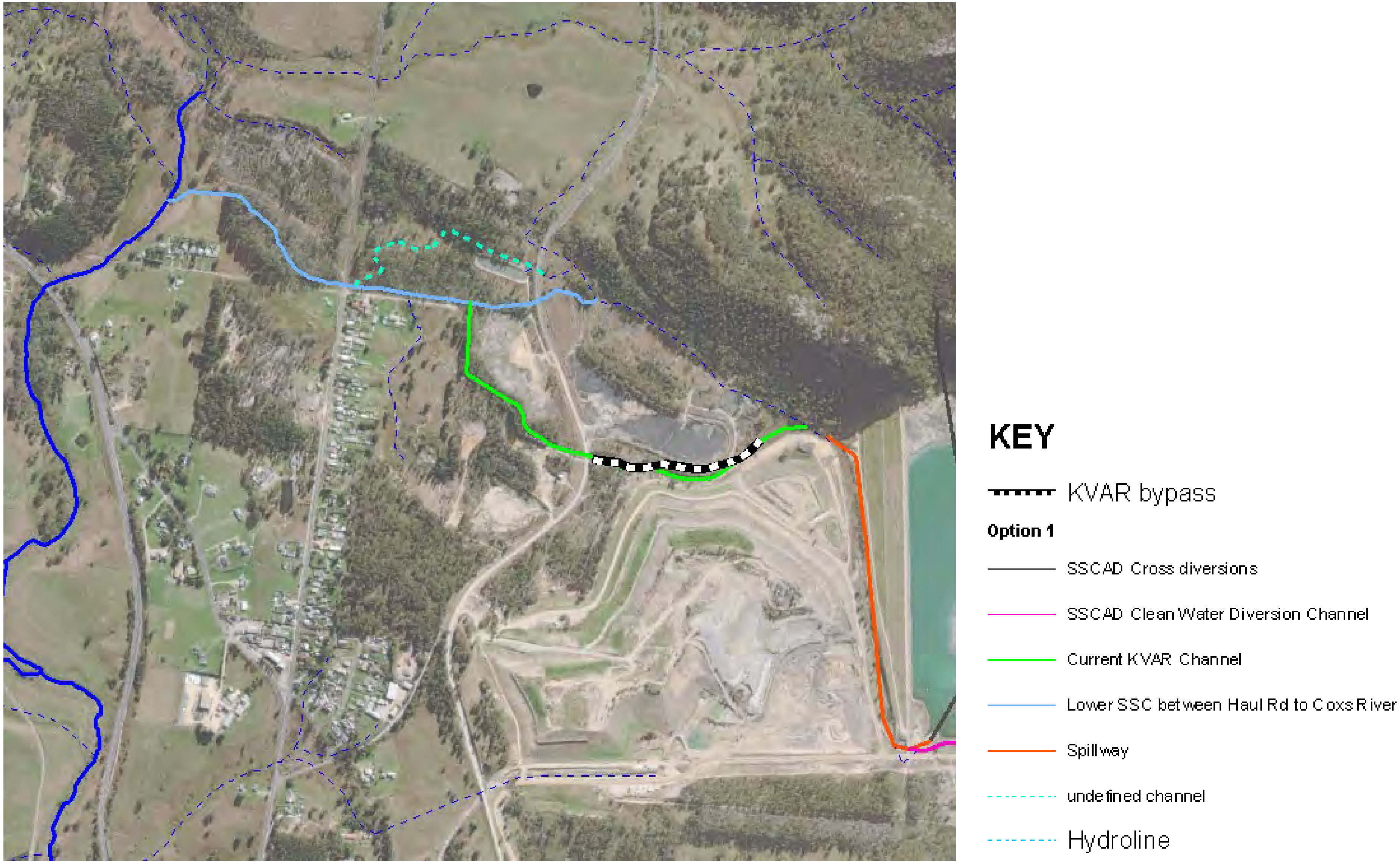


Figure 3.1 Option 1: Maintain current channel arrangement

3.2 Option 2: Divert SSC onto historical alignment

Option 2 prioritises rehabilitation through using the historical SSC alignment. The option includes the development of the KVAR bypass achieving the short-term objectives then to meet the long-term objectives the channel realignment would connect and divert flows of the upper catchment flows to the historical channel. The option would start at the end of the spillway and flow would be directed to the north-west of the site (Figure 3.2).

Risks associated with this option are as follows:

- May be a risk of significant inundation upstream of the Private Haul Road without changes to downstream culverts.
- There is a high risk of not being feasible given the existing and historical mine land usage with:
  - potential for voids and presence of underground access portals
  - unconfirmed contamination risks within area.
- Full riparian buffers are unlikely to be met due to existing site constraints – it is likely the site rehabilitation (mine sealing, infrastructure demolition, bulk earthworks) in this area would likely limit the ability for large trees and dense vegetation to be planted for some time.
- Realignment will have contamination risk (instream and overbank) and the proximity of construction for the overall site rehabilitation activities underway at the site are expected to continue limiting the ability to progress channel realignment rehabilitation.

Advantages of this option include:

- traces of a remnant open channel, albeit discontinuous, are present along the historical alignment.

The long-term viability and the likely extended program of this option coming to fortition, is unlikely to provide protection for water quality, provide habitat, eliminate proximity to construction. Currently, the schedule of works for this option are difficult to determine and therefore unknown.

When reviewing the positive and negative aspects of this option the assessment scoring based on the Rutherfurd *et al* (2003) method suggest a number of unknowns exist and the option has a potential to produce poorer environmental benefits only scoring 16 out of 35 assessment points (Figure 3.2).

Table 3.2 Option 2 assessment

Condition	Damage	Recovery	Rehabilitation	copy	Preventions
What is the current condition, can it be improved?	Are the changes undertaken on site, reversible can they be remediated?	Can suitable enhancements in riparian cover and stream structure be achieved?	Can water quality be maintained and is there adequate space to incorporate riparian cover and stream structure to mimic natural conditions?	Can the stream be returned to what a representative good condition stream looks like for the region?	Can the stream be protected from future damage and exposure?
3	2	3	4	3	3
Improvements can be made but they may be impacted to historical mining activities	Possibly however we do not understand the full limitation of the property	Likely limited	Likely if suitable improvements can be made	A number of unknown constraints	Precautions can be taken but its likely additional work may be needed near the channels to help control for seepage or other contamination works
				Total	**16**

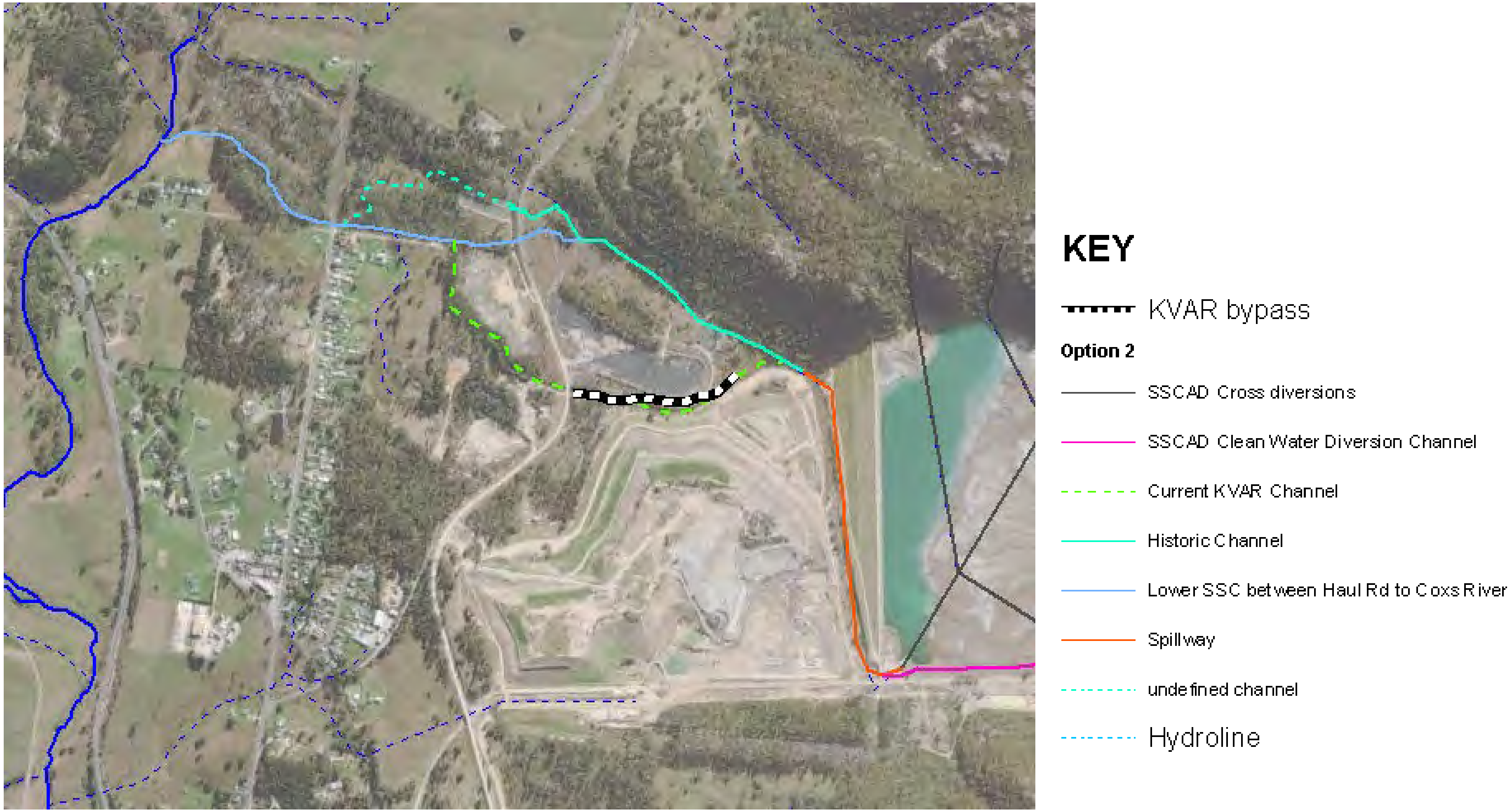


Figure 3.2 Option 2: Divert SSC onto historical alignment

3.3 Option 3: Divert upstream section of SSC to the south

Option 3 has been developed following careful review of Option 2. Identifying the risks in associated with that option, it became clear that an additional remediation option needed to be considered. Reflecting on the objectives (Section 1.7), water quality has the greater influence on the overall catchment condition. Where riparian habitat plays a more localised role through habitat availability.

Option 3 focuses on the protection of water quality and removing the risk of contamination and disturbance form the surrounding activities. To do this the best approach is to move the catchment runoff away from areas potentially requiring current or future rehabilitation works.

Therefore Option 3 is a diversion of SSC from the SSCAD clean water diversion channel across a site access road and connected with the southern tributary that runs through the 'golf course' and off site connecting with the Springvale Creek (*unofficially named* but is associated with discharges from the Springvale Mine) (Figure 3.3). Diverting the flow from SSC to the south would utilise existing established vegetation, an existing channel and provide an alignment that would divert flow away from areas of existing and potential future bulk earthworks and unconfirmed contamination.

This option has the potential to allow for the construction of the short term KVAR bypass, but also prioritise the longer-term channel realignment, that is compliant with the conditions of consent, forward in the program. Likely outcomes of Option 3 include the following:

- Allows diversion of upper catchment runoff from SSC, allowing for a longer section of the creek channel to be naturalised.
- Moves channel away from unconfirmed contamination risks below SSCAD and adjacent to KVAR and Kerosene Vale Coal Stockpile Area.
- Potentially aid in reducing flood prone lands through rebalancing catchment contribution.
- SSCAD spillway flows will remain contributing to the current SSC alignment creating a prioritised overflow path.
- Improvements can be achieved in a potentially shorter time frame.
- Riparian corridor buffer condition of 40 m width is more achievable.

Some identified risks include:

- a number of investigations on the feasibility of Option 3 are yet to be undertaken
- movement of the contributing catchment of most of the SSC approximately 3 km downstream. This option will not eliminate catchment flows to the current SSC all together
- a modification of conditions may be required given the significant difference in concept.

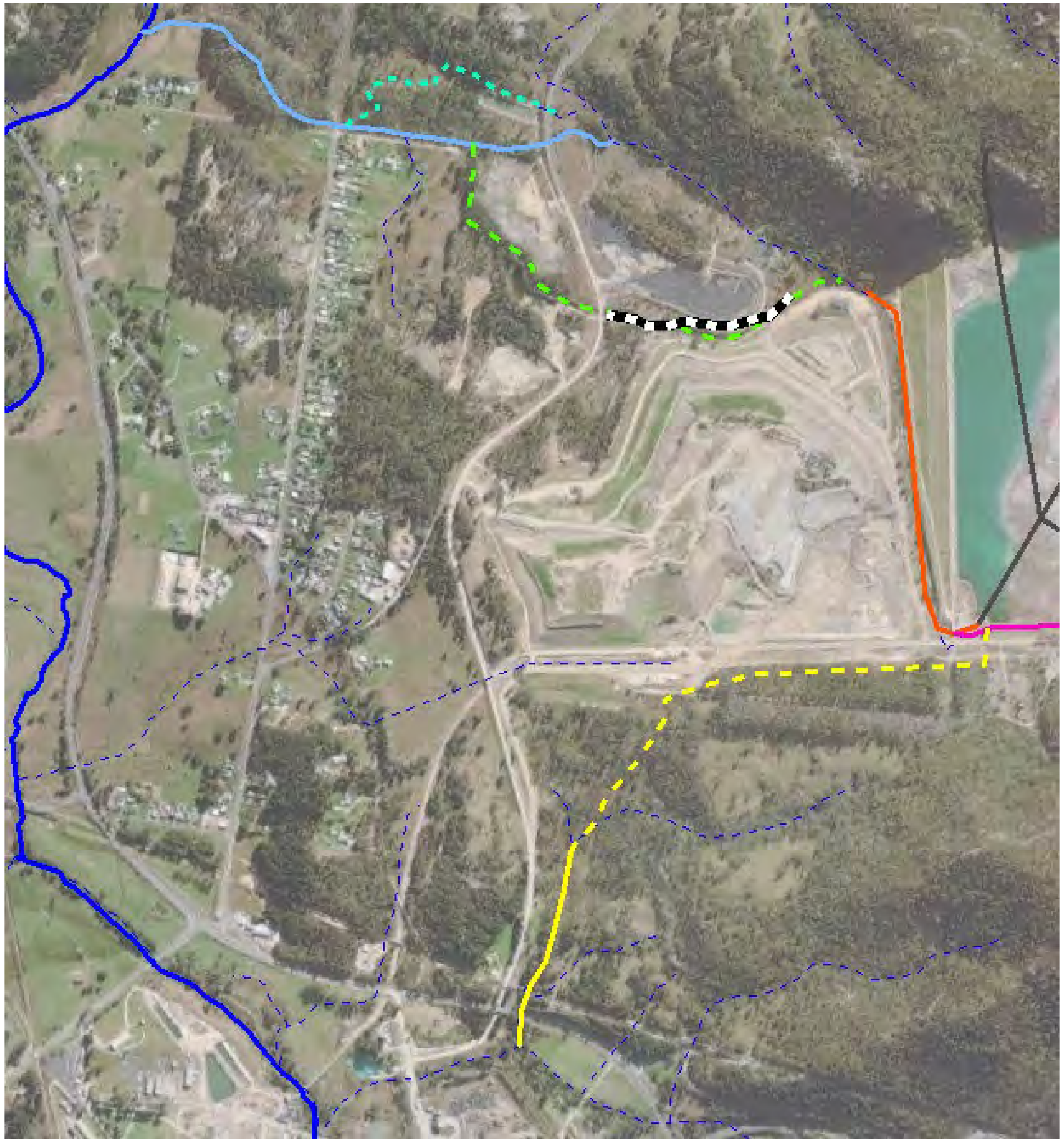
Option 3 requires several additional studies to confirm risks and feasibility. However, even if the southern tributary only receives the frequent to very frequent flow events and high flow events are diverted down the spillway channel towards the current SSC, it has the potential to protect water quality contamination and disturbance activities. SSC will still receive water from high flow events helping to sustain what ecological processes are remaining. The lower SSC will still convey water from and around the KVAR.

Option 3 may also prove to be beneficial to the project activities helping to the remove flow of water through the northern side of the property while future rehabilitation works is carried out. The 'golf course' also provides adequate space to implement adequate channel habitat structural of meandering channel pools riffles and runs.

Reviewing the Rutherfurd et al (2003) assessment this option produced the highest assessment score (see Table 3.3). This option has works on GPM owned land and offers the greatest protection for surface water quality and protection from future disturbance.

Table 3.3 Option 3 assessment

Condition	Damage	Recovery	Rehabilitation	copy	Preventions
What is the current condition, can it be improved?	Are the changes undertaken on site, reversible can they be remediated?	Can suitable enhancements in riparian cover and stream structure be achieved?	Can water quality be maintained and is there adequate space to incorporate riparian cover and stream structure to mimic natural conditions?	Can the stream be returned to what a representative good condition stream looks like for the region?	Can the stream be protected from future damage and exposure?
4	4	5	5	5	5
Yes – condition will be changed. Smaller stream order	Little damage present	Yes, space and existing vegetation	Yes – moved away from active construction	Yes, space and existing vegetation	Yes – moved away from active construction
				Total	**28**



KEY

KVAR bypass

Option 3

SSCAD Cross diversions

Coxs River

SSCAD Clean Water Diversion Channel

Current KVAR Channel

Exisiting southern channel

Lower SSC between Haul Rd to Coxs River

Proposed southern channel

Spillway

Upper SSC

undefined channel

Hydroline

Figure 3.3 Option 3: Divert upstream section of SSC to the south

4 Additional restoration works

When considering the wider property and the current stream connectivity across the site and within the SSC sub catchment area there is one aspect that can be improved throughout the site and benefit the wider rehabilitation plans. Improving connectivity through upgrading existing culverts to be more fish passage friendly structures will improve channel connectivity in the lower SSC. Across the wider catchment area there are numerous culvert structures that would reduce and or impeded movement of fish and or more mobile aquatic species (Table 4.1). Figure 4.1 shows the location, spread and level of impediment. Culverts and other instream structures have been assessed and ranked based on their location in relation to the site and the level of impediment of passage:

- Moderate – overall ok connectivity likely passable
- Low – requires suitable flow events, and would likely be difficult to pass
- Poor – very challenging to pass due to elevations and flow conditions
- Barrier – fully impeding the movement of aquatic species.

The spillway channel from SSCAD is considered a full barrier, while some of the in-channel structure may be passable at lower flow events there is little habitat and there is no connection to habitat for refuge from the top of the spillway moving upstream. Also, the upstream section including the spillway and ash diversion channel have not been further considered in how connectivity could be improved as they are part of a much larger rehabilitation plan being developed for the ash repository.

While improving instream habitat connectivity is not considered in the approval conditions, this outcome would benefit the overall rehabilitation plan, and it is likely to be a fundamental objective of Fisheries NSW. It is an action that can be applied to all options considered in Section 3. Not all culverts are within the project site and there may be limitations to changing culverts; however, it may be possible to improve the access to and from some of the structures with minimal works. There may be some additional benefits to the broader stakeholders (i.e. Centennial) through improving hydraulic conveyance of some structures on the Private Haul Road and reduce the currently predicted flood impediments. The information provided covers much of the site, whilst the connectivity assessment is not complete, it does inform the potential changes that could be made across the majority of the site.

Additionally, the rehabilitation design should wherever possible look to planting suitable riparian habitat and appropriately revegetate areas to provide a site wide improvement. All works undertaken should be completed in accordance with the *Policy and guidelines for fish habitat conservation and management (Update 2013)*, (NSW DPI 2013). The rehabilitation plan as it currently stands will need to be updated with the preferred option once further feasibility studies have been completed. Future works should be done in accordance with the condition recommended resources (updated version provided):

- *Controlled activities – guidelines for riparian corridors on waterfront land*, NSW Department of Planning and Environment, Fact sheet
- *Controlled activities – guidelines for watercourse crossings on waterfront land*, NSW Department of Planning and Environment, Fact sheet
- *Controlled activities – guidelines for instream works on waterfront land*, NSW Department of Planning and Environment, Fact sheet
- *Controlled activities – Guidelines for vegetation management plans on waterfront land*, NSW Department of Planning and Environment, Fact sheet

- additionally recommended guidelines including:
  - Technical Guidelines for Waterway Management, Department of Sustainability and Environment (DSE), Victoria
  - Waterway and Channel Rehabilitation Guidelines, Ipswich City Council.

Table 4.1 Selection of existing culvert crossings

Culvert (Figure 4.1)	Description	image
C5	Pipe culverts at the boundary of the GPM site near the eastern end of Maddox Lane.	
C2	Pipe culvert under the haul road connecting SSC. The downstream invert of the culvert has a step down that would be challenging to pass due to velocities and elevation.	

Table 4.1 Selection of existing culvert crossings

Culvert (Figure 4.1)	Description	image
C10 and S8	Downstream of the golf course, C10 is actually a moderate connection, invert of the culvert is at bed level; however, just before the culvert there is a gabion wall (S8) that is a significant barrier to aquatic species moving upstream.	
C4	Small culvert that impedes flow under the Private Haul Road from historical SSC alignment.	

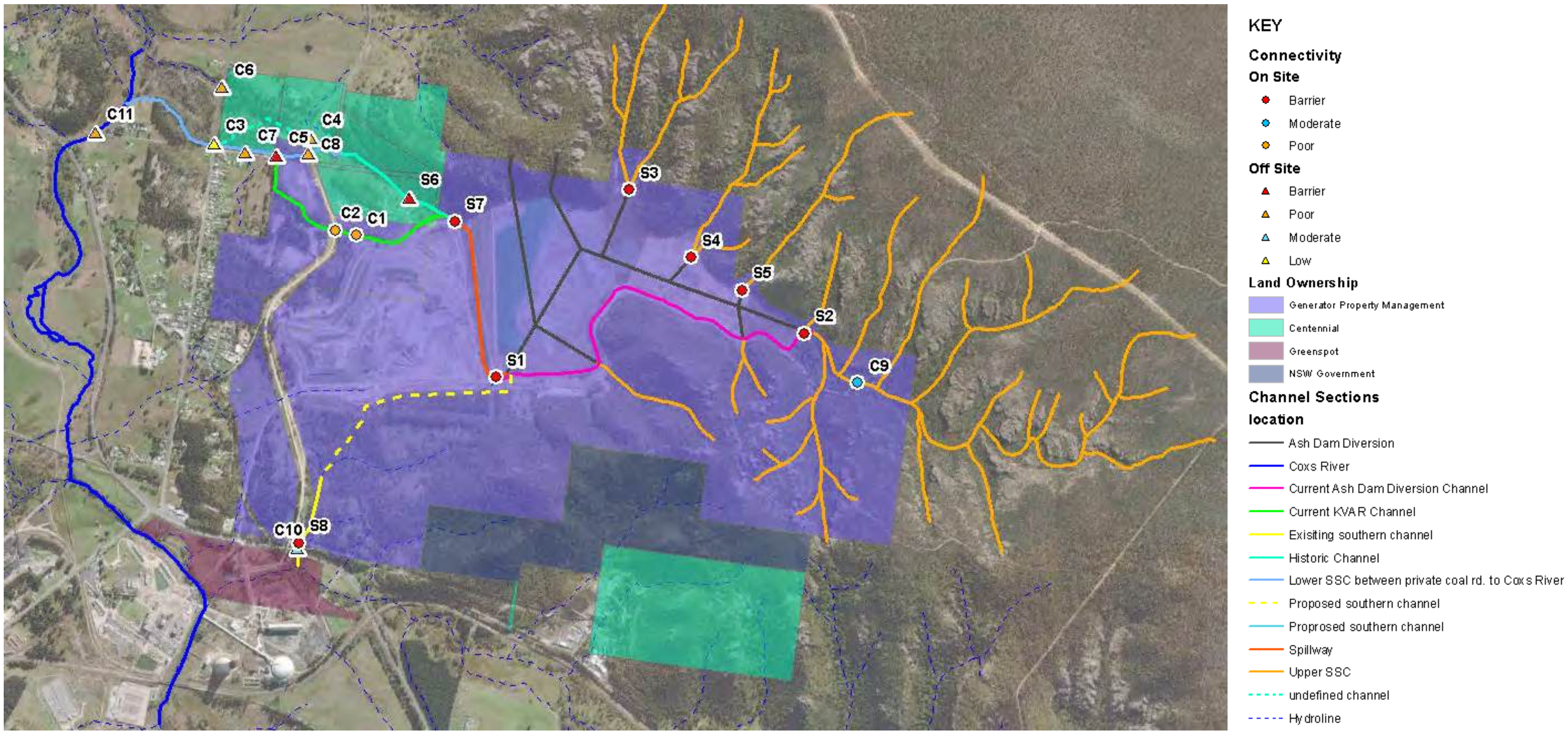


Figure 4.1 **Culvert and structure connectivity assessment**

5 Discussion

The project involving SSC realignment is an ever-evolving challenge, where it less driven by what can be achieved but more by what has been already occurred on site. Much of which only becomes apparent when areas are investigated. Overall, the wider site is highly modified and disturbed and there may be opportunities to improve the current condition, but it comes back to what is realistically achievable.

The review of the options prepared in Section 3 has considered if SSC Creek can be restored, rehabilitated and/or remediated. Out of the options, Option 3 has potential to provide for the short-term requirements of the bypass channel, but also compress the required time frames for the long-term objectives. This would include diversion of the upstream section of SSC to the south which has the potential in maximising the ecological outcome on site and minimising future disturbance and contamination risk into the future.

The main outcomes of Option 3 would be:

- establishing and improving riparian habitat and aquatic habitat within the GPM site
- maintaining protection for the water quality from the upper SSC catchment.

The additional improvements to habitat connectivity though improving the existing culvert structures on and surrounding the site would see wider catchment benefits to instream habitat in the long term.

However, with any of the options additional studies will need to confirm feasibility. As this site is so constrained there is potential that the preferred outcomes discussed in this report cannot be achieved.

References

Chessman B, (2003), *SIGNAL 2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers*, Monitoring River Heath Initiative Technical, Report no 31, Commonwealth of Australia, Canberra.

Department of Sustainability and Environment (2007), *Technical Guidelines for Waterway Management*, Department of Sustainability and Environment, Victoria.

DPEW (2022a), *Controlled activities – guidelines for riparian corridors on waterfront land*, NSW Department of Planning and Environment, Fact sheet INT22/173814 dated May 2022

DPEW (2022b), *Controlled activities – guidelines for watercourse crossings on waterfront land*, NSW Department of Planning and Environment, Fact sheet INT22/159001 dated May 2022

DPEW (2022c), *Controlled activities – guidelines for instream works on waterfront land*, NSW Department of Planning and Environment, Fact sheet INT22/159006 dated May 2022

DPEW (2022d), *Controlled activities – Guidelines for vegetation management plans on waterfront land*, NSW Department of Planning and Environment, Fact sheet INT22/159010 dated May 2022

Markwell, K., Breen, P. (2010) *Waterway Channel Rehabilitation Guidelines*, Final V3, Ipswich City Council

Rutherfurd, et al (2000) *A Rehabilitation Manual for Australian a Streams (Volume 1 and 2).* Land and Water Resources Research and Cooperative Research Centre Development Corporation Canberra, and Cooperative Research Centre Development Corporation for Catchment Hydrology, Monash University

Department of Primary industries (DPI) (2013) *Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management* (2013 update). NSW Department of Primary Industries

Annexure A
Approval condition requirements

creating opportunities

A.1 Summary approval conditions

Table A.1 Specific environmental conditions

Number	Conditions	Sub conditions
2.26	The Applicant shall prepare and submit to the Secretary for approval a Rehabilitation Plan addressing the restoration of the in-stream area (i.e. bed and bank) of SSC and the associated riparian corridor at least two months prior to the realignment of the creek, unless otherwise agreed by the Secretary. The Plan shall be developed in consultation with, and to the satisfaction of, Fisheries NSW and shall include, but not necessarily be limited to:	a) the objectives and outcomes that would be sought through the implementation of the Plan
		b) performance criteria for the realigned creek and associated riparian zone against which the impact of the project on the ecological health of Sawyers Swamp Creek will be assessed
		c) methodology used in developing the realignment planform
		d) details of the final creek realignment including bank, meander, depth and slope characteristics (including pool-riffle sequences), flow and channel capacity characteristics, scour potential, and in-stream vegetation
		e) timing of the creek realignment
		f) a description of the proposed riparian zone and restoration works along the entire length of the creek realignment, including details of plant species to be used in rehabilitation
		g) details of any proposed riparian and in-stream controls to be implemented in the reach upstream of the alignment to ensure the effectiveness of the proposed creek realignment and rehabilitation
		h) a description of the initial and ongoing weed control measures
		i) the methodology and timing of post realignment monitoring of the hydrology and ecological health of the aquatic and riparian vegetation as required under conditions 3.6 and 3.7 of this approval, respectively
		j) mitigation measures to be implemented in the event of an identified decline in ecosystem health as a direct result of the realignment of the creek or construction or operation of the project, including a timetable for implementation
		k) program for ongoing maintenance of the realigned creek system and associated riparian zone
		l) any compensatory measures to offset the impacts of the project on the aquatic habitat and local waterways, if and as required by Fisheries NSW;
		m) provisions for periodic reporting of monitoring results to Fisheries NSW;
		n) the Applicant shall not commence any construction work that would result in the disturbance of SSC until the Rehabilitation Plan has been approved by the Secretary.

Table A.1 Specific environmental conditions

Number	Conditions	Sub conditions
2.27	The rehabilitation and restoration of SSC and associated riparian zone are to be consistent with the Works and Watercourse Design Guideline (DWE, April 2007) and Guidelines for Controlled Activities: Vegetation Management Plans (DWE, February 2008).	
2.28	A riparian zone consisting of local native plant species shall be established and maintained in and adjacent to SSC, for the entirety of the site and be a minimum width of 20 m on both sides of the creek. Seed and propagule sources are to be from local botanical provenance and same general habitat.	
2.29	The riparian zone referred to under condition 2.28 of this approval shall be maintained for a period of at least five years after final planting.	
3.6	The Applicant is to implement a Hydrological Monitoring Program to assess and quantify the impacts and effectiveness of the realigned section of SSC in consultation with and to the satisfaction of Fisheries NSW. Monitoring is to be undertaken for a period of five (5) years upon completion of the creek realignment and is to include scour and erosion monitoring. The program must include sampling before and after the realignment works and include a sampling site downstream of the realigned section of creek. In the first 12 months following completion of the realignment, monitoring is to be undertaken at least every three (3) months upon completion of the creek realignment and after any wet weather/bankful flow event. The monitoring program shall form part of the Rehabilitation Plan for the project as referred to in condition 2.26 of this approval.	
3.7	The Applicant shall prepare an Ecological Monitoring Program, in consultation with, and to the satisfaction of, Fisheries NSW, to monitor and quantify the impacts of the realignment of SSC on the ecology and ecosystems of the creek and the associated riparian environment. The Program shall include, but not necessarily be limited to:	a) a sampling, data collection and assessment regime to establish baseline ecological health and for ongoing monitoring of ecological health of the in-stream environment during construction and throughout the life of the project;
		b) at least one in-stream sampling period prior to the realignment of SSC and at least two (2) sampling periods following the realignment of SSC; and
		c) an assessment regime for monitoring the ecological health of the riparian environment for a period of at least five (5) years after final planting.

The following points, in regard to the potential options and realignment preferences, were identified in the meeting held with EMM, GPM and Fisheries NSW on 20 November 2023.

Table A.2 Additional considerations from consultation

Area	Expectation
Conceptual design	Refer to existing policy (Policy and guidelines for fish habitat conservation and management) as a starting point, would like to see a response to this.
	Need to consider present qualities of existing creek sections (including assessment of aquatic habitat value).
	Consider stream order and corresponding DPI riparian zone requirements.
Conceptual design	Open to merits-based position, present against current guidance and policy (e.g. stream order, description of condition, classify, etc.). What can be achieved?
	A staged approach could be considered.

Table A.2 Additional considerations from consultation

Area	Expectation
Riparian zone	Would like to see return to functioning riparian zone as far as possible.
	Larger trees in the riparian zone aim to provide canopy, shading, ecosystem, fall into creek to create snags/aquatic habitat, etc.
	Concerns of having trees along buttress and risk of falling and or compromising buttress structure, grass was planned for the embankment vegetation however investigation to consider smaller shrub and or larger grasses, i.e. Lomandra to be considered.
	Would like to see return to functioning riparian zone as far as possible.

Annexure B
Image library

EMM
creating opportunities

B.1 Creek sections

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Upper Sawyer Swamp Creek	
SSCAD Channel Image: Clean water bund before SSCAD	

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Image: Concrete lined, little to no vegetation	
Image: Top of spillway end of SSCAD channel	

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Ash Dam Diversions Image: Bund at far end, with a gravity fed pip connecting to the SSCAD channel	
Image: Clean water bund drains thorough gravity fed pipe to SSCAD channel	

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Spillway Image: Top of spillway. Some potential for species to move up the spillway but once to the top of the spill multiple jumps in height and no instream structure just concreted channel	
Image: Spillway channel, semi naturalised, small meanders, present some vegetation in channel, bed is a combination of bedrock and hard pack substrate	

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Image: Current Sawyer Swamp Creek	
Image: Downstream of KVAR	

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Image: Just upstream of the haul road/downstream of KVAR	
Image: Downstream of haul road	

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Historic Channel Image: Upstream of void, channel downstream of spillway	
Image: Downstream of mine voids and access tunnels	

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Lower SSC Image: Culverts at the end of the GPM site	
Southern Channel (Golf course) Image: Looking downstream	

Table B.1 Sections of Sawyer Swamp Creek and nearby watercourses

Section	
Coxs River Image: Downstream of SSC conjunction at Maddox Lane crossing	
Image: Downstream of crossing	

From: David Ward <david.ward@dpi.nsw.gov.au>
Sent: Thursday, 20 June 2024 2:54 PM
To: Andrea McPherson
Cc: Lachlan Hammersley; Phil Towler
Subject: RE: Kerosene Vale Aquatic Options discussion

Follow Up Flag: Follow up
Flag Status: Flagged

Hi Andrea,

Thank you for providing this report. I wasn't aware of the Rutherford scoring system but it appears useful for evaluating the various options and highlights that option 3 may appears to be the best choice. I was a little surprised however that you state that the land tenure for option 3 is unknown, as it appears to in the title of GPM, or have I misinterpreted the term?

Your report also highlights the additional restoration works that can be achieved within the lower SSC, particularly in relation to culvert structures which are impeding fish passage and could be modified, etc to allow for improved fish passage within the site. Such restoration works aligns with sub condition *l) any compensatory measures to offset the impacts of the project on the aquatic habitat and local waterways, if and as required by Fisheries NSW.* Looking at the number of barriers downstream of Options 1 & 2, particularly those that are off site, and the presence of only C10 & S8 downstream of Option 3 obstructing fish passage to the Coxs River, I tend to think that this weighs heavily in favour of Option 3.

Whichever option is chosen will need to include feasible solutions for restoring fish passage.

Cheers
David

David Ward
Fisheries Manager Murray Darling
Freshwater Environment
Department of Regional NSW
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NSW GOVERNMENT Department of Regional NSW

From: Andrea McPherson <amcpherson@emmconsulting.com.au>
Sent: Wednesday, 19 June 2024 9:23 AM
To: David Ward <david.ward@dpi.nsw.gov.au>
Cc: Lachlan Hammersley <lhammersley@emmconsulting.com.au>; Phil Towler <ptowler@emmconsulting.com.au>
Subject: FW: Kerosene Vale Aquatic Options discussion

Hi David,
I hope you are well.

I have attached the Aquatic Ecology Options Assessment for your review.

I am happy to receive feedback, suggestions and or recommendations.
Also I am happy to organise a follow up discussion on teams.

Just so you know I am on leave from the 24th June, returning 3rd of July.
If you have any urgent questions in that time, please feel free to reach out to Lachlan Hamersly he is well across the project and can likely answer any questions you have.

Regards,
Andrea

Andrea McPherson
Associate Aquatic Ecology, Ecology & Heritage

[redacted]

www.emmconsulting.com.au
Note: My work days are Tuesday, Wednesday, Thursday and Friday

From: Andrea McPherson
Sent: Thursday, May 30, 2024 4:47 PM
To: David Ward <david.ward@dpi.nsw.gov.au>
Cc: Lachlan Hammersley <lhammersley@emmconsulting.com.au>; Phil Towler <ptowler@emmconsulting.com.au>; David Bone <dbone@emmconsulting.com.au>
Subject: Kerosene Vale Aquatic Options discussion

Hi David,
Many thanks again for your time today.

Please see the slides attached – I added a few more images and text for context

As discussed in-principle you agree that the option to divert 'normal flows' from the upper Sawyer Swamp Creek to the south (yellow line) is a likely viable option, as it would likely provided the greater ecological and water quality benefit to the wider catchment then the historic alignment given the site constraints and contamination risks, but for final approval for the realignment the Aquatic Ecology Options Assessment needs to be reviewed and should contain adequate:

- Justification of the preferred option
- Principles of how the southern channel would convey water (that will be later developed in the Progressive Rehabilitation Plan)
- Considerations for additional works needed i.e. where sediment basis are required, they are to be excluded from the channel. Essentially protections for the realignment going forward

In addition, you agree that the additional consideration to upgrade the poorly connected culverts and or connections to and from those culverts across the entire site (where feasible) would support the wider habitat connectivity of Sawyers Swamp Creek and related tributaries.

Also for transparency: the plan going forward *(I have spoken with the wider team to make sure these fits with the general approach and aligns with the schematic in the attached slides*):

Stage 1:

The sticking point is getting the KVAR bypass approved (this is the focus of Stage 1)

- I will send on the options assessment soon and we need support on whether the preferred option is acceptable and essentially the OK from fisheries to progress the bypass construction.

- About mid/late June the team/ GPM will be submitting a Progressive Rehabilitation Plan for the KVAR bypass and longer-term strategy to Fisheries and Planning (there is a condition that requires this approval) for comment and review. As part of this submission we will include consultation gathered to date (i.e. correspondence on the options assessment if the justification is approved/accepted) plus any further correspondence provided on the document following review.

- Once the consultation is complete and the document is effectively approved – construction can commence on the bypass and the stability buttress can be completed.

Stage 2:

- We will then move into Stage 2 which will link to further assessment to confirm viability of the preferred longer-term option – and have a better understanding of what that will look like.

- We will complete an updated Progressive Rehabilitation Plan that will contain more information and details on what the realigned flow path will look like and how it will meet the current conditions and rehab objectives and consent conditions.

With Thanks

Andrea

Andrea McPherson BSc, GradCertResMeth, MSc

Associate Aquatic Ecology, Technical Lead

EMM

creating opportunities

[redacted]

LI   Connect on LinkedIn

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BRISBANE | Yuggera/Turrbal Country, Level 1, 87 Wickham Terrace, Spring Hill QLD 4000

Note: My work days are Tuesday, Wednesday, Thursday and Friday

Lachlan Hammersley

From:	David Ward <david.ward@dpird.nsw.gov.au>
Sent:	Wednesday, 25 March 2026 1:20 PM
To:	Lachlan Hammersley
Cc:	Phil Towler; Andrea McPherson
Subject:	RE: Generator Property Management Pty Limited - Wallerawang Power Station Ash Dam - Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan
Follow Up Flag:	Follow up
Flag Status:	Flagged

Some people who received this message don't often get email from david.ward@dpird.nsw.gov.au. Learn why this is important

Hi Lachlan,

Thank you for your correspondence. It has been a while since I last reviewed this report so had to get reacquainted with it.

I have reviewed the *Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan - Stage 1* and support the proposed progressive rehab strategy in the report for Stage 1 realignment of Sawyers Swamp Creek, including Table 4.1 which outlines objectives and criteria and chapter 5 On-ground works, riparian reveg and operational life of Stage 1.

Cheers
David

David Ward
Fisheries Manager, Aquatic Ecosystem Assessment
Freshwater Fisheries and Threatened Species | Fisheries and Forestry
Department of Primary Industries
and Regional Development

[redacted] E david.ward@diprd.nsw.gov.au

nsw.gov.au/dpird

4 Marsden Park Road CALALA NSW 2340

Department of Primary Industries
and Regional Development

We stand on Country that always was and always will be Aboriginal land. We acknowledge the Traditional Custodians of the land and waters, and we show our respect for Elders past, present and emerging. We are committed to providing places in which Aboriginal people are included socially, culturally and economically through thoughtful and collaborative approaches to our work.

From: Lachlan Hammersley <lhammersley@emmconsulting.com.au>
Sent: Wednesday, 18 March 2026 2:35 PM
To: David Ward <david.ward@dpird.nsw.gov.au>
Cc: Phil Towler <ptowler@emmconsulting.com.au>; Andrea McPherson <amcpherson@emmconsulting.com.au>
Subject: Generator Property Management Pty Limited - Wallerawang Power Station Ash Dam - Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan

Hi David,

We last communicated in June 2024 regarding consultation requirements on the development of *Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan - Stage 1* for GPM. Please see attached email advice provided at the time regarding conversations had with Andrea McPherson.

DPHI are still yet to approve the plan and we have received an RFI (table below) for more specific consultation feedback from NSW Department of Primary Industries and Regional Development (Fisheries) on the creek realignment plan. We believe that Fisheries supported the plan but maybe that was in conversation only.

Sawyers Swamp Realignment	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**
Condition 2.26			
2.26) The Proponent shall prepare and submit to the Secretary for approval a Rehabilitation Plan addressing the restoration of the in-stream area (i.e. bed and bank) of Sawyers Swamp Creek and the associated riparian corridor at least two months prior to the realignment of the creek, unless otherwise agreed by the Secretary. The Plan shall be developed in consultation with, and to the satisfaction of, Fisheries NSW and shall include, but not necessarily be limited to:	Partial	Fisheries NSW was consulted but it is not clear that it has been developed to their satisfaction.?	Provide evidence that Fisheries NSW are satisfied with the progressive rehabilitation strategy (ie Stage 1 and 2) including the objectives, performance criteria and the proposed timing.

Are you able to provide any further feedback on the plan from Fisheries such that we can progress approval with DPHI ? More specifically is Fisheries supportive of Stage 1 of the plan? I appreciate the timeframe between review and follow up questions has been significant.

I have provided a sharedrive link below for v3 of the report issued to DPHI. A consultation and doc history is provided:
[redacted]

Currently we are responding to minor DPHI requests to cover various conditions within the consent and provide shorter completion timeframe for stage 1 and 2. None of these change the proposed works or assessment specific to matters of aquatic/fish movements or habitats.

Please call me if you would like to discuss further.

Thanks

Lachlan Hammersley BEng (Env)
Senior Associate Water Resources Engineer
Team Manager Surface Water and Land

[redacted]
LI Connect on LinkedIn
emmconsulting.com.au

NEWCASTLE | Awabakal Country, Level 3, 175 Scott Street, Newcastle NSW 2300

A.2 Consultation register

Table A.1 Consultation comment register and responses

Date	Department	Engagement description
26 October 2023	Department of Primary Industries and Regional Development, Department of Planning and Environment – Water group	Pre-consultation letter
20 November 2023	Department of Primary Industries and Regional Development, Department of Planning and Environment – Water group	Virtual project introduction meeting
30 May 2024	Department of Primary Industries and Regional Development	Stage 1 and Stage 2 options consultation
20 Jun 2024	Department of Primary Industries and Regional Development	Stage 2 options assessment and consideration for aquatic ecology outcomes
July 2024	Department of Primary Industries and Regional Development	Issue for consultation the Progressive Rehabilitation Plan covering Stage 1
30 April 2025	Department of Planning, Housing and Infrastructure	Request for information issued
18 February 2026	Department of Planning, Housing and Infrastructure	Request for information issued

A.3 Consultation comments

Table A.2 Consultation comment register and responses

Date	Department	Comment	Response
20/6/2024	Department of Primary Industries and Regional Development	Confirm land tenure	Future land tenure for some options are currently unknown but the works proposed under Option 3 are primarily located within existing GPM property.
30/4/2025	Department of Planning, Housing and Infrastructure	Provide more evidence/justification in the revised Rehabilitation Plan for why the approved alignment is not viable.	Further justification has been provided in Section 5.1.1
		Provide relevant geotechnical reports including but not limited to: • Fender Geophysics 2024, Processing and Interpretation Report, Project Number 24014, prepared for EMM, May 2024, Sydney • Macquarie Geotech 2024, KVAR Creek Realignment – Geotechnical Investigation, Geotechnical Investigation Report, Job No: G23994, submitted to Generator Property Management (GPM)	Reports provided as Appendix D and Appendix E

Table A.2 Consultation comment register and responses

Date	Department	Comment	Response
		While an options analysis is provided in the Aquatic Ecology Rehabilitation Options Assessment (EMM, July 2024), please develop the options and constraints for Stage 2 further and include the results in the Rehabilitation Plan.	Further detail has been provided in Section 6
		Further, given the length of time that has elapsed from the approval of the original concept design (2008), the Department is requesting a shorter, more defined schedule of time for rehabilitation. Please review and revise the timeframe for determining Stage 2, noting it is not clear what the drivers for the stated timeframes are: • Section 5.6 states that Stage 1 will be in operation for at least 5 years from the completion of construction. • Section 6.3 states that Stage 2 options will be confirmed 2 to 3 years from the completion of Stage 1.	The following is noted in response to DPHI's comments on the length of rehabilitation timing: • the site ownership has transitioned from EnergyAustralia to GPM (NSW Treasury). • the site has been identified as a contaminated site. • rehabilitation of the site is constrained by the availability of appropriate material to complete rehabilitation of landforms. • existing approvals for the site have constrained existing and future planned works and modifications are required • priority remedial works for the site have focused on Dam safety requirements and water quality management. Further detail has been provided in response to the request for clarification in Section 5.6 and Section 6.3. Key drives to the nominated timeframes required for rehabilitation works, specifically for Stage 2, is : • completion of the contaminated site investigation and remedial action plans • completion of a consent modification.
18/2/2026	Department of Planning, Housing and Infrastructure	Refer to review table provided for requested information and responses.	

Department of Planning, Housing and Infrastructure

Our ref: MP07_0005-PA-13

Stephen Saladine
Managing Director
Generator Property Management Pty Limited
Via the Major Projects Portal
22/04/2025

Subject: Wallerawang Power Station - Ash Dam Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan Stage 1 - Request for Information

Dear Mr Saladine,

Reference is made to your post approval matter, MP07_0005-PA-13, Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan Stage 1, submitted as required by Schedule 2, Condition 2.26 of MP07_0005 as modified (the consent) to the NSW Department of Planning, Housing and Infrastructure (the Department).

The Department has reviewed the Sawyers Swamp Creek Realignment Progressive Rehabilitation Plan - Stage 1 (Rehabilitation Plan) and considers more information is required to satisfy the conditions of consent.

Please submit a revised Rehabilitation Plan addressing the below points by Friday 30 May 2025 (or as otherwise agreed by the Planning Secretary):

- provide more evidence/justification in the revised Rehabilitation Plan for why the approved alignment is not viable.
- provide relevant geotechnical reports including but not limited to:
  - Fender Geophysics 2024, Processing and Interpretation Report, Project Number 24014, prepared for EMM, May 2024, Sydney.
  - Macquarie Geotech 2024, KVAR Creek Realignment – Geotechnical Investigation, Geotechnical Investigation Report, Job No: G23994, submitted to Generator Property Management (GPM).
- while an options analysis is provided in the Aquatic Ecology Rehabilitation Options Assessment (EMM, July 2024), please develop the options and constraints for Stage 2 further and include the results in the Rehabilitation Plan.
- further, given the length of time that has elapsed from the approval of the original concept design (2008), the Department is requesting a shorter, more defined schedule of time for

rehabilitation. Please review and revise the timeframe for determining Stage 2, noting it is not clear what the drivers for the stated timeframes are:

- Section 5.6 states that Stage 1 will be in operation for at least 5 years from the completion of construction.
- Section 6.3 states that Stage 2 options will be confirmed 2 to 3 years from the completion of Stage 1.

Should you wish to discuss the matter further, please contact Katie Weekes on (02) 4927 3223 or via email at katie.weekes@dpie.nsw.gov.au

Yours sincerely

Stephen O'Donoghue
Director
Resource Assessments

As nominee of the Planning Secretary

Wallerawang Ash Dam Area (MP07_0005) Post Approval Review

Document: Sawyers Creek Realignment Progressive Rehabilitation Plan – Stage 1
Revision: Rev 3 dated June 2025
Reviewed: KH 11 December 2025
Response provided: LH 26 March 2026

Terms of Approval	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
Condition 1.1				
The Applicant must carry out the project: a) in compliance with the conditions of this approval; b) in accordance with all written directions of the Secretary; c) generally in accordance with the EA; and d) generally in accordance with the project area.	Partial		Include a commitment that the project will be carried out in accordance with all the requirements of this condition.	**Addressed**
Sawyers Swamp Realignment	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
Condition 2.26				
2.26) The Proponent shall prepare and submit to the Secretary for approval a Rehabilitation Plan addressing the restoration of the in-stream area (i.e. bed and bank) of Sawyers Swamp Creek and the associated riparian corridor at least two months prior to the realignment of the creek, unless otherwise agreed by the Secretary. The Plan shall be developed in consultation with, and to the satisfaction of, Fisheries NSW and shall include, but not necessarily be limited to:	Partial	Fisheries NSW was consulted but it is not clear that it has been developed to their satisfaction.?	Provide evidence that Fisheries NSW are satisfied with the progressive rehabilitation strategy (ie Stage 1 and 2) including the objectives, performance criteria and the proposed timing.	**Additional consultation evidence achieved in March 2026 and provided in Appendix A**
a) the objectives and outcomes that would be sought through the implementation of the Plan;	No	The overall objectives and performance criteria are outlined in Section 4. The 3 options presented in Aquatic Ecology Options report include: • Maintain current channel arrangement • Divert onto historical alignment • Divert upstream to the south However, the choice of the 2 stages and adequate justification for the works is not provided.	Provide stronger justification for staging the rehabilitation in 2 key stages. It is not clear why the final realignment may take up to 7 to 8 years to determine. How does the proposed modification fit in with this plan? Is the modification required to deliver Stage 2?	**The site is currently working through site remediation strategies.** **Condensed the dates for Stage 2 to run concurrently with Stage 1** **Mod 3 does not include Stage 2 an additional modification will be necessary once the**

		How does this strategy fit in with the modification and will help reduce proposed timeframes.		**closure strategy has been confirmed.** **Closure strategy under development.**
b) performance criteria for the realigned creek and associated riparian zone against which the impact of the project on the ecological health of Sawyers Swamp Creek will be assessed;	Will not be satisfied until stage 2	Performance criteria are addressed in in Section 4. Stage 1 will not achieve the performance objectives.		**NA**
c) methodology used in developing the realignment planform;	Will not be satisfied until stage 2	The methodology for the proposed Stage 1 works is outlined in Section 5.1 and 6. It is assumed the detailed design and methodology will be completed for the next stage to ensure objectives are met.		**NA**
d) details of the final creek realignment including bank, meander, depth and slope characteristics (including pool-riffle sequences), flow and channel capacity characteristics, scour potential, and in-stream vegetation;	Will not be satisfied until stage 2	Addressed in Section 5.1 and 6 for Stage 1. It is assumed the detailed design and methodology will be completed for the next stage to ensure objectives are met.		**NA**
e) timing of the creek realignment;	No	The timeframes are addressed in Section 5.5 and 5.6. It is suggested that the preferred Stage 2 work will not be confirmed until 2 to 3 years from the completion of Stage 1. Section 5.6 says Stage 1 will remain operational for at least 5 years from the completion of construction. This means that the preferred Stage 2 work will not be confirmed for at 7 or 8 years and then will need to be constructed.	Review the timeframes with a view to reducing the time in particular to defining the long term Stage 2 work and demonstration that the final wor	**Further clarification on the timeframes has been provided**
f) a description of the proposed riparian zone and restoration works along the entire length of the creek realignment, including details of plant species to be used in rehabilitation;	Will not be satisfied until stage 2	It is assumed the detailed design and methodology will be completed for the next stage to ensure objectives are met.		**NA**
g) details of any proposed riparian and in-stream controls to be implemented in the reach upstream of the alignment to ensure the	Will not be satisfied until stage 2	Addressed in Section 5.4 and 7.2		**NA**

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effectiveness of the proposed creek realignment and rehabilitation;				
h) a description of the initial and ongoing weed control measures	Yes	Addressed in Section **Error! Reference source not found.**		**NA**
i) the methodology and timing of post realignment monitoring of the hydrology and ecological health of the aquatic and riparian vegetation as required under conditions 3.6 and 3.7 of this approval, respectively;	Will not be satisfied until stage 2	Addressed in Section 7		**NA**
k) program for ongoing maintenance of the realigned creek system and associated riparian zone	Will not be satisfied until stage 2	Addressed in Section 7		**NA**
l) any compensatory measures to offset the impacts of the project on the aquatic habitat and local waterways, if and as required by Fisheries NSW and	No	Not mentioned in Table 2.1	Include condition and address appropriately in the plan	**Addressed**
m) provisions for periodic reporting of monitoring results to Fisheries NSW.	No	Not mentioned in Table 2.1	Include condition and address appropriately in the plan	**Addressed**
2.27) The rehabilitation and restoration of Sawyers Swamp Creek and associated riparian zone are to be consistent with the Works and Watercourse Design Guideline (DWE, April 2007) and Guidelines for Controlled Activities: Vegetation Management Plans (DWE, February 2008).	Will not be satisfied until stage 2	Partially addressed in Section 2.6		**NA**
2.28) A riparian zone consisting of local native plant species shall be established and maintained in and adjacent to Swayers Swamp Creek, for the entirety of the site and be a minimum width of 20 m on both sides of the creek. Seed and propagule sources are to be from local botanical provenance and same general habitat.	Will not be satisfied until stage 2	Addressed in Section 5.4 and 6. It is not clear that the 20 metre buffer can be established in the short term due to close proximity of the boundary.		**NA**
2.29) The riparian zone referred to under condition 2.28 of this approval shall be maintained for a period of at least five years after final planting.	Will not be satisfied until stage 2	Partially addressed in Section 5.4		**NA**

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Condition 3.6				
3.6) The Applicant is to implement a **Hydrological Monitoring Program** to assess and quantify the impacts and effectiveness of the realigned section of Sawyers Swamp Creek in consultation with and to the satisfaction of Fisheries NSW. Monitoring is to be undertaken for a period of five (5) years upon completion of the creek realignment and is to include scour and erosion monitoring. The program must include sampling before and after the realignment works and include a sampling site downstream of the realigned section of creek. In the first 12 months following completion of the realignment, monitoring is to be undertaken at least every three (3) months upon completion of the creek realignment and after any wet weather/bankful flow event.	Yes	Addressed in Section 7.1.1 for stage 1.		**NA**
3.7) The Applicant shall prepare an **Ecological Monitoring Program**, in consultation with, and to the satisfaction of, Fisheries NSW, to monitor and quantify the impacts of the realignment of Sawyers Swamp Creek on the ecology and ecosystems of the creek and the associated riparian environment. The Program shall include, but not necessarily be limited to: a) a sampling, data collection and assessment regime to establish baseline ecological health and for ongoing monitoring of ecological health of the in-stream environment during construction and throughout the life of the project; b) at least one in-stream sampling period prior to the realignment of Sawyers Swamp Creek and at least two (2) sampling periods following the realignment of Sawyers Swamp Creek; and c) an assessment regime for monitoring the ecological health of the riparian environment for a period of at least five (5) years after final planting.	Yes	Aquatic ecology monitoring is outlined in Section 7.1.2 for Stage 1.		**NA**

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The monitoring program shall form part of the Rehabilitation Plan for the project as referred to in condition 2.26 of this approval.				
Condition 3.8	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
The applicant shall prepare an Air Quality Monitoring Program, in consultation with, and to the satisfaction of the EPA. The Program shall include, but not necessarily be limited to, monitoring for dust at the monitoring sites identified in the document referred to under condition 1.1 of this approval. The air quality monitoring program shall be ongoing for the life of the project, including final rehabilitation and stabilisation of the site. The monitoring program shall form part of the Air Quality Management Plan referred to in condition 6.5d) of this approval.	Addressed in AQMP	Covered by AQMP (post approval task 28)		**NA**
Condition 2.31	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
Earthworks not associated with the realignment of Sawyers Swamp Creek shall not be undertaken within 50 m of the creek where reasonable and feasible.	Partial	Section 6.3 refers to earthworks not associated with the realignment of the creek.	Include commitment that Condition 2.31 will be complied with for any earthworks not associated with the realignment of Sawyers Swam Creek.	**Further clarification words added.** **It should be noted that the development boundary is currently not consistent with all activities on site and subject to Modification 3**
Compliance Monitoring and Tracking				
Condition 4.1	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
Prior to each of the events listed below, the Applicant shall certify in writing to the satisfaction of the Secretary that it has complied	No	Table 2.6 refers to Section 2.10.6 to address this requirement however this has not been included in the referenced section.	Update the plan to address the requirements of CoA 4.1 (specifically part a)) and include reference to where this condition has been addressed.	**Section added to Table 2.1.**

with all conditions of this approval applicable prior to that event: a) a) commencement of any construction works on the land subject of this approval; and b) commencement of operation of the project.				
Condition 4.2	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
The Applicant shall develop and implement a Compliance Tracking Program for the project, prior to commencing operations, to track compliance with the requirements of this approval and shall include, but not necessarily limited to: a) provisions for periodic review of the compliance status of the project against the requirements of this approval and the Statement of Commitments detailed in the document referred to in condition 1.1c) of this approval; b) provisions for periodic reporting of the compliance status to the Secretary; c) a program for independent environmental auditing in accordance with the Independent Audit Post Approval Requirements (NSW Government 2020); d) procedures for rectifying any non-compliance identified during environmental auditing or review of compliance; e) mechanisms for recording incidents and actions taken in response to those incidents; f) provisions for reporting incidents to the Secretary during construction and operation; g) and provisions for ensuring all employees, contractors and sub-contractors are aware of, and comply with, the conditions of this approval relevant to their respective activities.	No	Provide details on the Compliance Tracking Program.	Update the plan to include reference to the timing and approval requirement associated with CoA 4.2.	**Reference added to overarching plans CEMP/OEMP required. Section to added**

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The Compliance Tracking Program shall be implemented prior to operation of the project with a copy submitted to the Secretary for approval within four weeks of commencement of the project, unless otherwise agreed by the Secretary.				
Condition 6.6	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
Within three months of: *a) the submission of an incident report under condition 7.1;* *b) the submission of an Annual Review under condition 7.3;* *c) the submission of an Independent Environmental Audit under condition 4.2); or* *d) the modification of the conditions of this approval (unless the conditions require otherwise),* *the Applicant must review and, if necessary, revise the studies, strategies or plans required under the conditions of approval to the satisfaction of the Secretary. Where this review leads to revisions in any such document, then within 4 weeks of the review Non-Compliance Notification the revised document must be submitted to the Secretary for approval, unless otherwise agreed with the Secretary. Note: This is to ensure the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the development.*	Partial	Incident reporting is discussed generally in Section 7 under reporting requirements. The details required to be provided during an incident notification (as outlined by CoA 7.1) have not been outlined.	Update the plan to include all of the incident notification requirements stipulated by CoA 7.1.	**Addressed**
Condition 7.1	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
The Secretary must be notified in writing via the Major Projects website immediately after the Applicant becomes aware of an incident. The notification must identify the development	Partial	Incident reporting is discussed generally in Section 7 under reporting requirements.	Update the plan to include all incident notification requirements stipulated by CoA 7.1.	**Addressed**

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(including the application number and the name of the development if it has one) and set out the location and nature of the incident. Subsequent notification requirements must be given, and reports submitted in accordance with the requirements set out in Appendix 3.		The details required to be provided during an incident notification (as outlined by CoA 7.1) have not been outlined.		
Condition 7.2	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
The Secretary must be notified in writing via the Major Projects website within seven days after the Applicant becomes aware of any non-compliance. A non-compliance notification must identify the development and the application number for it, set out the condition of approval that the development is non-compliant with, the way in which it does not comply and the reasons for the non-compliance (if known) and what actions have been, or will be, undertaken to address the non-compliance. Note: A non-compliance which has been notified as an incident does not need to also be notified as a non-compliance.	No	Non-compliances are not detailed.	Update the plan to include all of the non-compliance notification requirements stipulated by CoA 7.2.	**Incident response Section added**
Condition 7.3	**Sufficient (Yes/No/Partial)**	**Document reference and comment**	**Action Required**	**Company Response**
The Applicant shall, throughout the life of the project, prepare and submit for the approval of the Secretary, an Annual Environmental Management Report (AEMR). The AEMR shall review the performance of the project against the Operation Environmental Management Plan (refer to condition 6.4 of this approval) and the conditions of this approval. The AEMR shall include, but not necessarily be limited to: *a) details of compliance with the conditions of this approval;* *b) a copy of the Complaints Register (refer to condition 5.4 of this approval) for the preceding twelve-month period (exclusive of personal details), and details of how*	Yes	AEMR reporting requirements addressed in Section 8		**NA**

these complaints were addressed and resolved; c) *identification of any circumstances in which the environmental impacts and performance of the project during the year have not been generally consistent with the environmental impacts and performance predicted in the documents listed under condition 1.1 of this approval, with details of additional mitigation measures applied to the project to address recurrence of these circumstances;* d) *results of all environmental monitoring required under conditions 3.3 to 3.8 of this approval, including interpretations and discussion by a suitably qualified person;* e) *a list of all occasions in the preceding twelve-month period when environmental goals/objectives/impact assessment criteria for the project have not been achieved, indicating the reason for failure to meet the criteria and the action taken to prevent recurrence of that type of failure.* *The Applicant shall submit a copy of the AEMR to the Secretary every year, with the first AEMR to be submitted no later than twelve months after the commencement of operation of the project. The Secretary may require the Applicant to address certain matters in relation to the environmental performance of the project in response to review of the Annual Environmental Report. Any action required to be undertaken shall be completed within such period as the Secretary may require. The Applicant shall make copies of each AEMR available for public inspection on request.*				

General Comments	**Action Required**	**Company Response**

Appendix B

Stage 1 revised concept design summary

creating opportunities

B.1 Basis for design

The Stage 1 creek realignment was required in order to facilitate the building of the KVAR stability buttress. The basis for the design of the Stage 1 creek realignment are summarised in Table B.1.

Table B.1 Stage 1 basis for design

Element	Adopted criteria	Basis
Available flow area	Maintain a comparative cross sectional flow area in the revised channel alignment compared to the existing creek Average flow area required: 32 m^2	Maintain existing flow conveyance through the realigned section of creek
Channel in situ material	Locate channel flow area within residual parent material	Minimise opportunity for contamination and site instabilities.
Longitudinal grade and channel length	Minimise changes to total channel length Current channel length approximately 320 m	Controlled activity guidelines
Depth	Optimised to be within residual parent material	Maintain depth to replicate existing channel. Limited by longitudinal gradient.
Channel base width		Maximise width to mitigate elevated flow velocity
Channel side slope		Unmitigated batter slope largely within soil should be as low gradient as possible Geotechnical stable

B.1.1 Geotechnical design considerations

Macquarie Geotechnical (2019) undertook an assessment of the in-situ material along the proposed alignment of Stage 1. The assessment characterised material along the alignment as comprising of a thin cover of fill material overlying residual soils grading into rock. Testing was undertaken to 10 mbgl.

Key outcomes from the Macquarie Geotechnical assessment includes:

- Dispersion potential of the material is relatively low with an Emerson class value of 5 to 6.
- Permeability of the material was estimated at $2x10^{-10}$ m/s indicating a semi-permeable in situ material.
- Due to the presence of high weathered rock at depth, the construction of the channel should be achievable by using conventional earth moving plant that is currently available on site. However, in-situ rock material is unlikely suitable in channel armouring or in use as scour protection.
- Batters should be no steeper than 1V to 2H to avoid ongoing risks with slumping or failure in the long-term. This risk increases in situations of concentrated flow.
- Material used to backfill the diverted section of creek will require signoff by a suitably qualified and experienced geotechnical engineer and include:
  - Where practicable the stripped, prepared ground should be benched to allow the fill material to key into the natural ground and provide level platforms for compaction.

- Following site stripping the exposed subgrade should be proof rolled.
- Site filling activities are to be undertaken in accordance with AS 3798-2007 and achieve a 95% standard maximum dry density, to be confirmed by geotechnical engineer, considering potential interactions with the northern stability buttress.

- There is no expected limitation on the capacity of the in-situ soil to support revegetation requirements.
- Further information on the geotechnical site investigations for the site, reference should be made to Macquarie Geotechnical (2024)

Confirmation of areas of where ash has been used as backfill was undertaken. It has been thought that areas of historical open cut mining within the site, when mining was completed, where purposed as unofficial repositories for ash. Considering this information, test boreholes were constructed around the survey boundaries of historical open cut mining areas. The borehole locations are shown in Figure B.1. Ash was found typically at 0.5mbgl in BH3, BH4 and BH5.

To further refine the expected extent of unofficial ash repositories geophysical investigations were undertaken using resistivity survey.

B.1.2 Geophysical survey design considerations

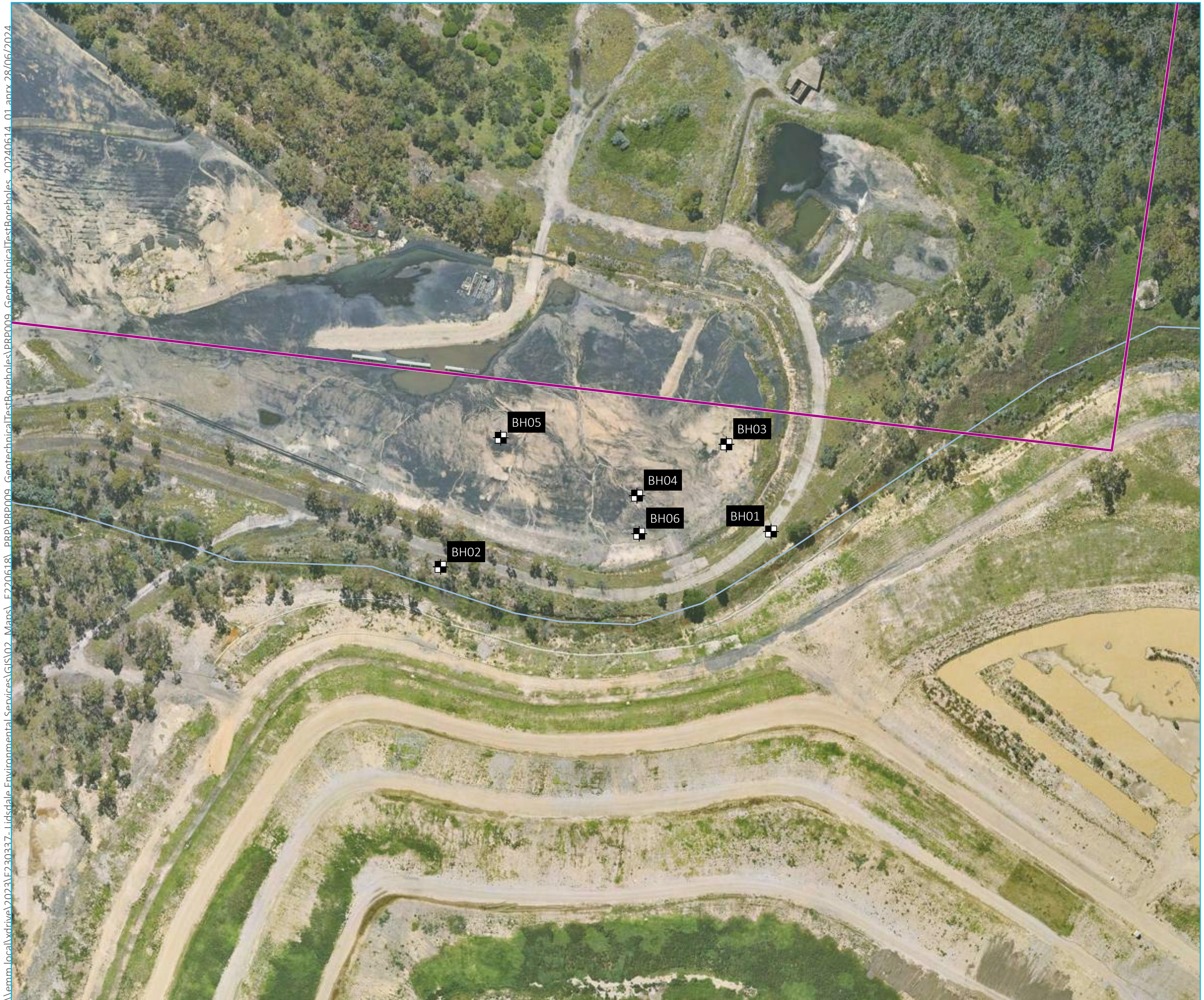
Fender Geophysics were engaged by EMM to undertake resistivity survey (consisting of approximately six transects) across the Kerosene Vale Coal Stockpile Pad westward to Lidsdale Cut and the GPM site boundary. The resistivity survey objective was to determine:

- The form and extent of historical open cut coal extraction pits
- Assess the fill material below ground and identify possible voids
- Consistency and type of backfill material
- Assess the subsurface rock and soil strata and identify potential connectivity between surface water sources and historical open coal extraction pits.

The location of survey transects and results of the geophysics investigation is provided on Figure B.2

The results of the survey indicated:

- Ash material (supported by supporting drilling information) was generally low conductivity and was identified in profiles as shallow lobes up to 20 m deep. Fill material, known to occur in other locations from drilling information, was determined to have a similar low conductivity to ash making it difficult to distinguish between, in the data collected.
- Higher resistivity data was collected in survey transects for bedrock consisting of coal, siltstone and sandstone geological layers.
- Large zones of groundwater saturated bedrock occurred in several of the profiles surveyed. These occur at depths greater than that expected to be intercepted by creek realignment activities.
- The existing Sawyers Swamp Creek diversion and the historical alignment were identified as placed within general higher conductive ground, indicative of a higher moisture content (with water present within creeks at the time of survey). The survey results were not able to conclude potential connectivity between groundwater and surface water systems in any of the survey profiles.



KEY

Study area

Geotechnical test borehole

Existing environment

Major road

Minor road

Watercourse/drainage line

INSET KEY

Major road

NPWS reserve

State forest

Source: *EMM (2024); GPM (2024); DCSSS (2024); GA (2009); MetroMap (2024)*

0 100 200 m

GDA2020 MGA Zone 56

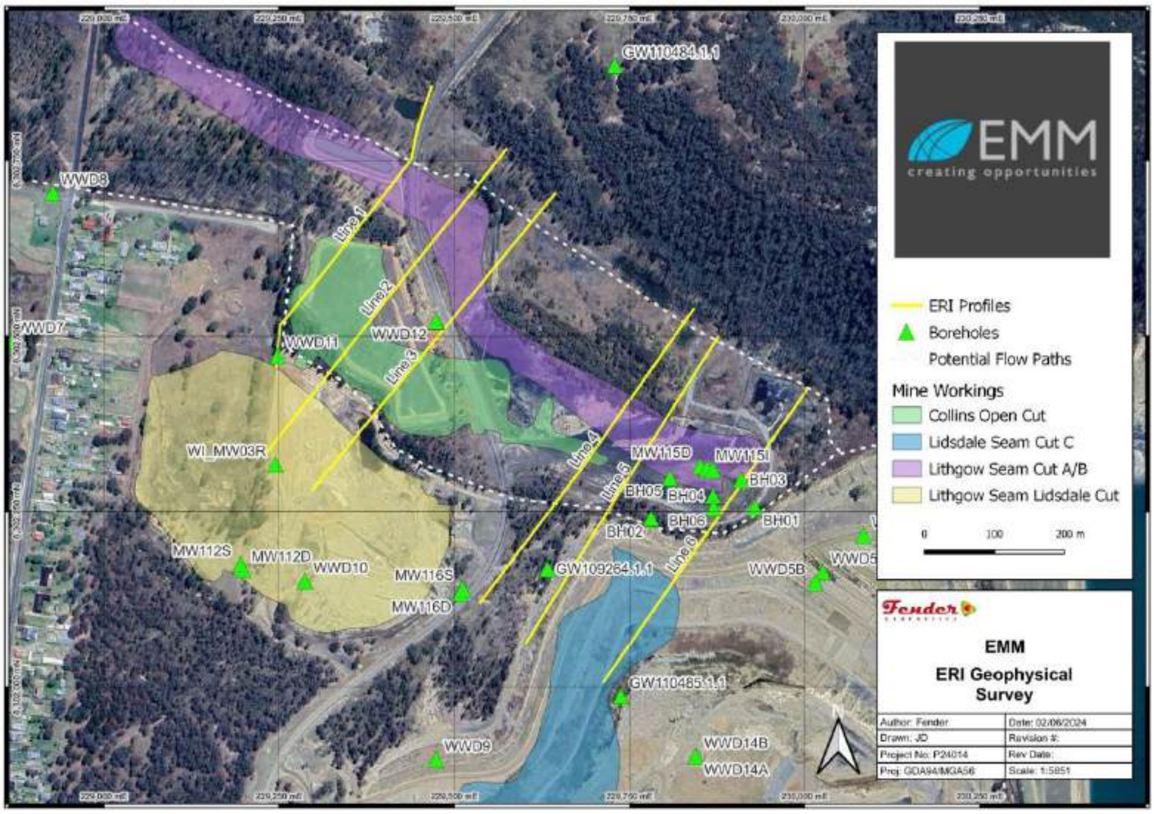
N

Geotechnical test boreholes

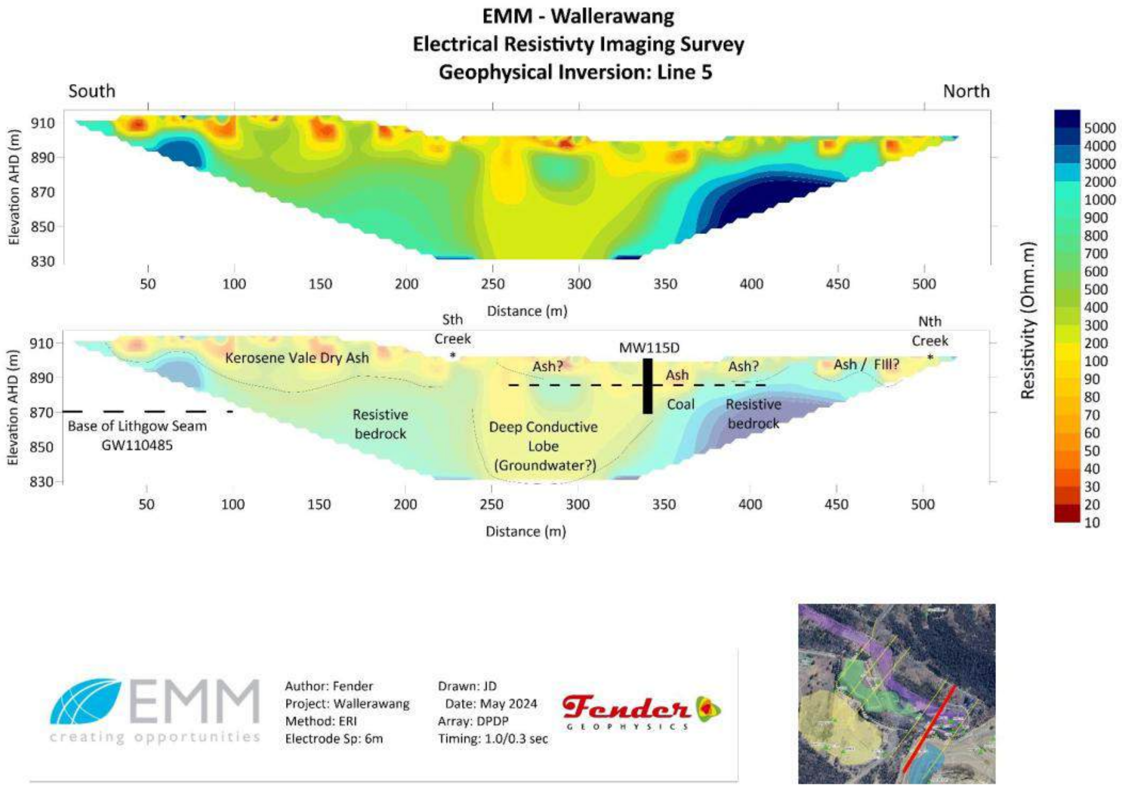
Lidsdale Environmental Services
Sawyers Swamp Creek Realignment
Progressive Rehabilitation Plan- Stage 1
Figure B.1

EMM creating opportunities

\\emm.local\xdrive\2023\E230337_Lidsdale Environmental Services\GIS\02_Maps_E220618_PRP\PRP009_GeotechnicalTestBoreholes\PRP009_GeotechnicalTestBoreholes_20240614_01.aprx 28/06/2024



Map of ERI geophysics survey area, ERI profiles, boreholes and historical mine workings



Transect at Line 5 results specific to Stage 1

Figure B.2 Geophysics survey (Fender Geophysics 2024)

B.2 Creek realignment dimensions

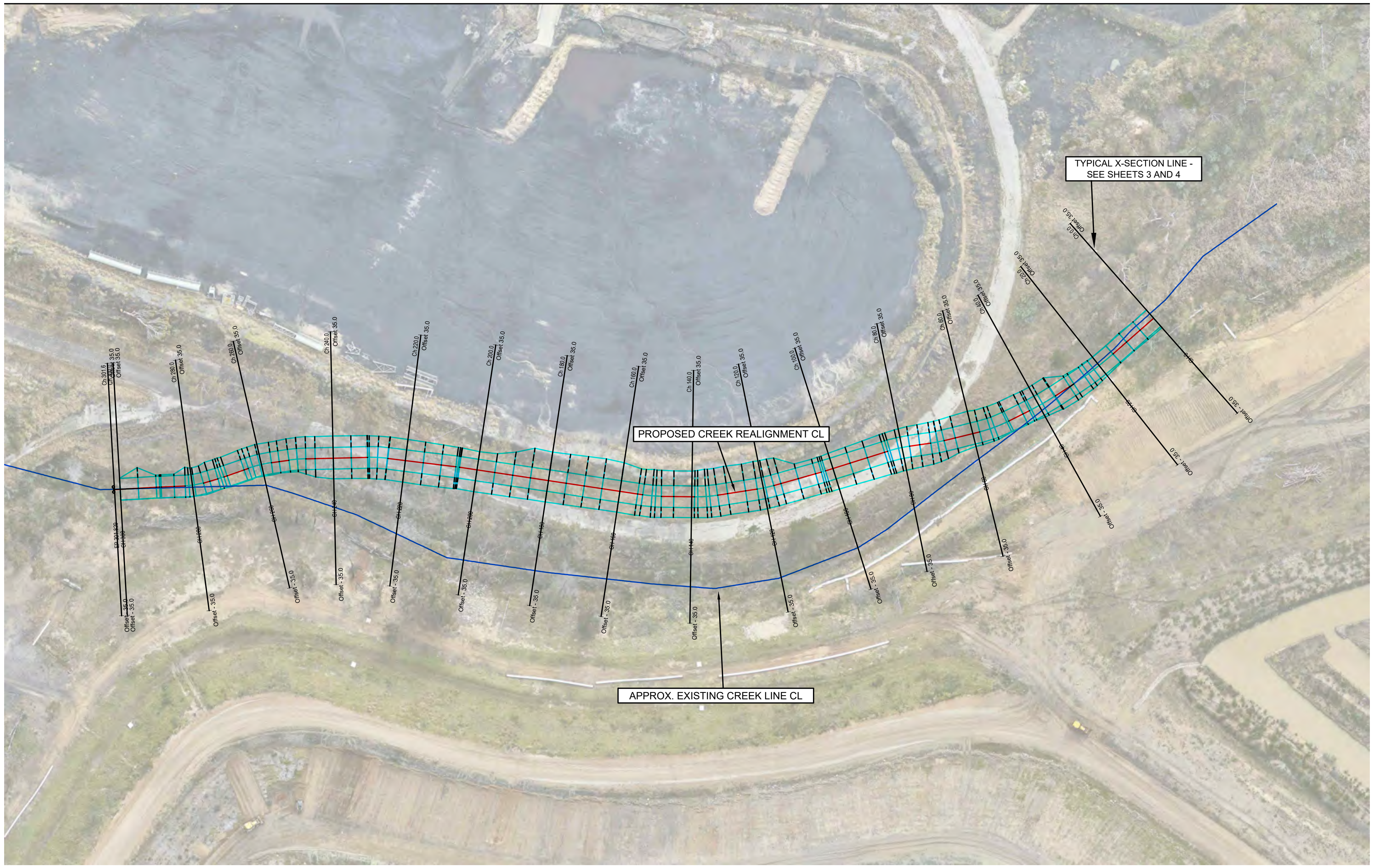
The dimensions of the Stage 1 creek alignment are summarised in Table B.2.

Table B.2 Stage 1 creek alignment concept sizing

Element	Size
Length of diversion works	302 m
Channel form	Trapezoidal shape
Longitudinal grade	1.2%
Channel base width	5-6 m
Channel top width	8 to 12.2 m
Channel depth	2 to 2.5 m
Channel side slope	1V in 1.2H based on area available (this should flatten where possible to 1V in 2H based on geotechnical advice)
Nominated scour protection	Placed rock – d_{50} 300 mm installed at 1.5x d_{50} underlaid by an appropriate geotextile and keyed into natural surface

B.3 Concept earthworks drawings

Monteath and Powys (2023) have prepared conceptual earthworks for Stage 1 including a perspective view, and channel cross sections against the existing survey. These plans have been prepared for the purposes of informing further detailed design and construction requirements as part of this management plan. The plans are provided in the following pages.



PLAN VIEW OF PROPOSED CREEK REALIGNMENT LOCATION

TABLE SHOWING SETOUT CO-ORDINATES FOR CENTRELINE OF PROPOSED CREEK REALIGNMENT :

Alignment Name: MC01

Description:

Chainage Range: Start: 0.000, End: 301.829

IP Chainage	Easting	Northing	Bearing	Distance
0.00	229990.28	6302288.00		
			228° 36' 05"	21.82
21.82	229973.91	6302273.57		
			236° 53' 13"	17.12
38.92	229959.57	6302264.22		
			243° 25' 08"	14.85
53.75	229946.29	6302257.57		
			256° 11' 14"	16.34
70.06	229930.42	6302253.67		
			261° 44' 09"	10.95
81.00	229919.59	6302252.10		
			252° 27' 32"	21.76
102.75	229898.84	6302245.54		
			254° 16' 11"	16.63
119.38	229882.84	6302241.03		
			261° 14' 37"	16.63
136.00	229866.40	6302238.50		
			270° 49' 53"	15.03
151.02	229851.37	6302238.72		
			278° 32' 38"	54.37
205.38	229797.60	6302246.80		
			277° 02' 34"	22.33
227.71	229775.44	6302249.53		
			268° 40' 14"	22.27
249.97	229753.18	6302249.02		
			261° 43' 47"	10.54
260.50	229742.75	6302247.50		
			250° 51' 00"	11.33
271.81	229732.05	6302243.78		
			253° 38' 14"	7.61
279.42	229724.74	6302241.64		
			267° 49' 34"	9.44
288.83	229715.31	6302241.28		
			266° 46' 28"	13.00
301.83	229702.34	6302240.55		

IMPORTANT NOTES:

1. ALL CREEK REALIGNMENT INFORMATION SHOWN IN THIS PLAN MUST BE CONFIRMED BY GPM PRIOR TO USE.
2. ALL EXISTING LEVELS SHOWN HAVE BEEN OBTAINED FROM LIDAR DATA AND HAVE NOT BE CONFIRMED BY ONSITE SURVEY. ESTIMATED ACCURACY OF LIDAR ON HARDSTAND SURFACES ± 0.2m
3. DATE OF LIDAR CAPTURE - 03/06/22
4. LIDAR IS A LINE OF SIGHT TOOL. ANY OBSTRUCTIONS (GRASSES, TREES ETC) OR STEEP EDGES WILL IMPACT ON THE ACCURACY OF THE DATA. .
5. CRITICAL LEVELS AND CRITICAL LOCATIONS (EG STRUCTURES) MUST BE VERIFIED BY FURTHER SURVEY PRIOR TO FINAL DESIGN.
6. THIS PLAN MUST REMAIN UNALTERED AS ISSUED BY MONTEATH & POWYS. ALTERING ANY PART OF THIS PLAN DESTROYS THE INTEGRITY OF THE PLAN. ANY REVISIONS REQUESTED MUST BE ISSUED BY MONTEATH & POWYS.
7. THESE NOTES ARE AN INTEGRAL PART OF THIS PLAN. REPRODUCTION OF THIS PLAN OR OF ANY PART OF THIS PLAN, WITHOUT THESE NOTES BEING INCLUDED IN FULL, WILL RENDER THE INFORMATION SHOWN ON SUCH REPRODUCTION INVALID AND NOT SUITABLE FOR USE.

SURVEY NOTES:

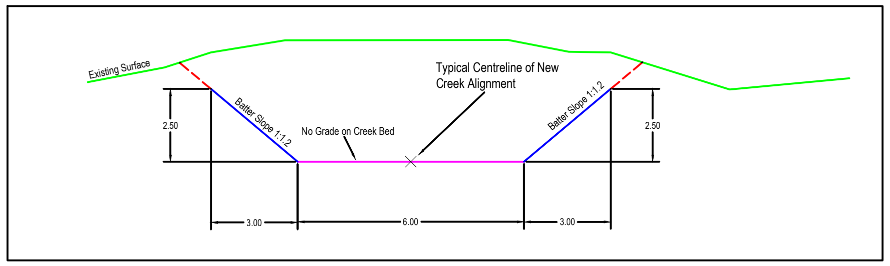
1. THIS DATA IS ON MAP GRID OF AUSTRALIA (MGA) CO-ORDINATES (GDA 94) ZONE 56.

   -THE ORIGIN OF CO-ORDINATES IS PM 72243
   E 228849.090 N 6301900.759
   -SOURCE OF CO-ORDINATES: SCIMS

2. ALL REDUCED LEVELS ARE ON AUSTRALIAN HEIGHT DATUM (A.H.D)

   -ORIGIN OF LEVELS PM 72243. RL906.163
   -SOURCE OF REDUCED LEVELS: SCIMS

3. MGA AND ISG CO-ORDINATE SYSTEMS ARE BASED ON A MATHEMATICAL EARTH MODEL AND SUBJECT TO VARIABLE SCALE FACTORS. DISTANCES CALCULATED FROM CO-ORDINATES MAY VARY SIGNIFICANTLY FROM GROUND MEASUREMENTS. IF FURTHER CLARIFICATION IS REQUIRED CONTACT MONTEATH AND POWYS.



TYPICAL CROSS SECTION OF PROPOSED CREEK WHEN IN CUT AREA

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Original Size: A3

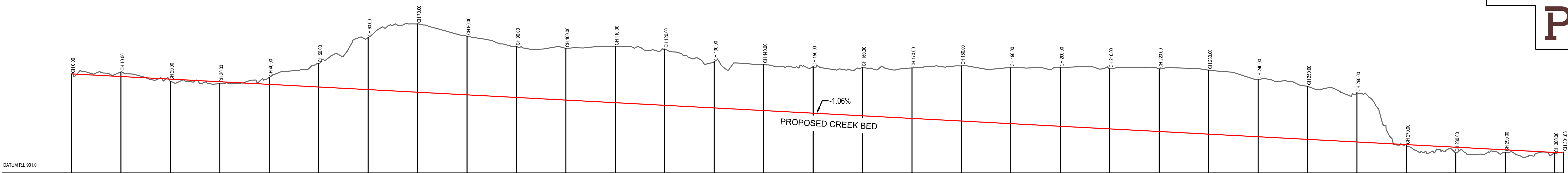
Client: GPM

Title: KVAR CREEK REALIGNMENT DESIGN
WALLERAWANG POWER STATION

CAD File: 200014K_01.DWG | Ref No: 200014 | Date: 18/10/2022

Sheet No. 1/4

Revision 1



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50.00	905.42	904.47
60.00	906.47	904.36
70.00	907.03	904.26
80.00	906.53	904.15
90.00	906.11	904.04
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220.00	905.20	902.66
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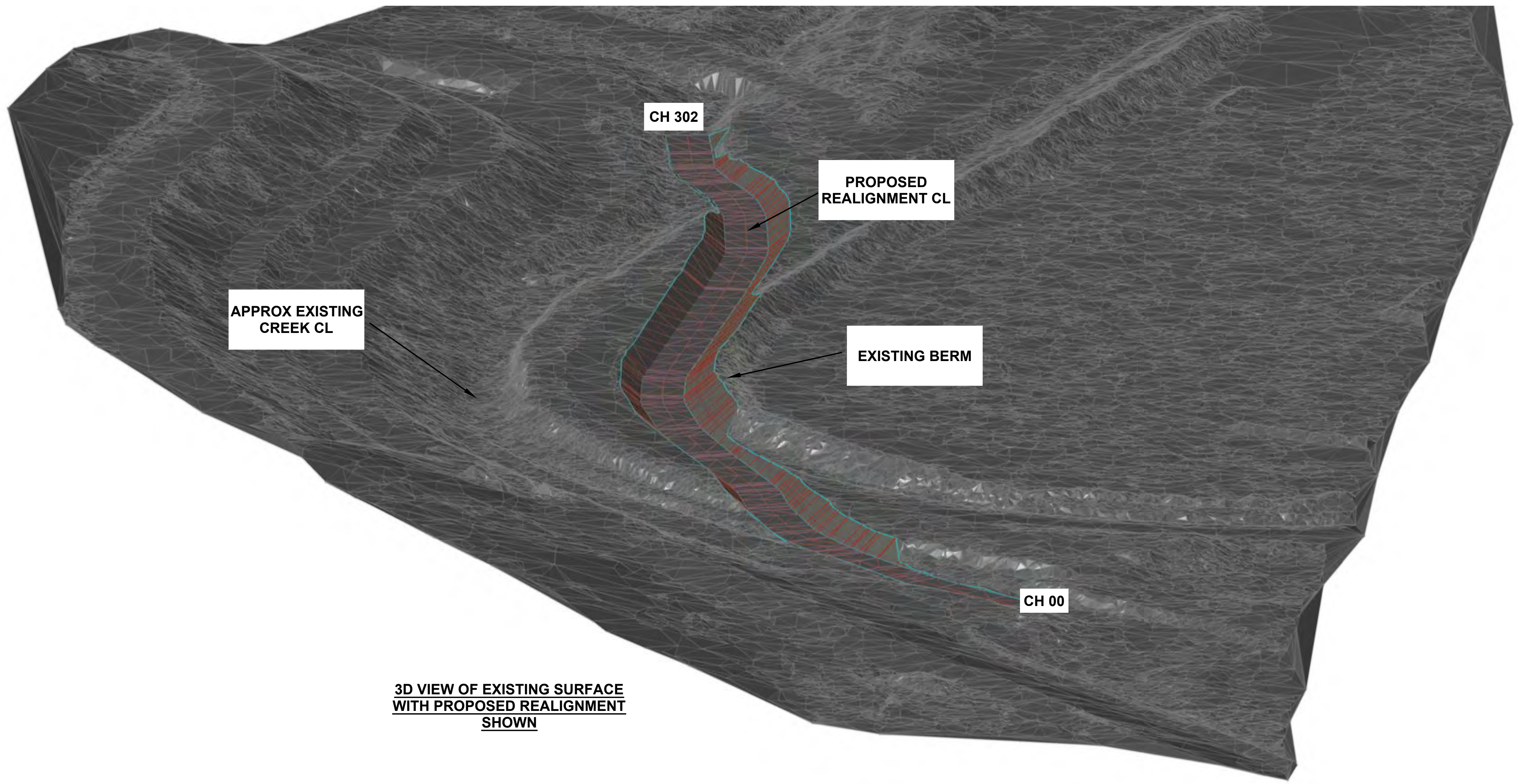
280.00	901.80	902.03
290.00	901.82	901.92
300.00	901.78	901.82
301.83	901.83	

LONGITUDINAL SECTION - MC01

LONGSECTION SHOWING EXISTING SURFACE LEVELS AND PROPOSED CREEK BED ALONG PROPOSED CREEK REALIGNMENT CENTRELINE



3D VIEW OF EXISTING SURFACE WITH PROPOSED REALIGNMENT SHOWN

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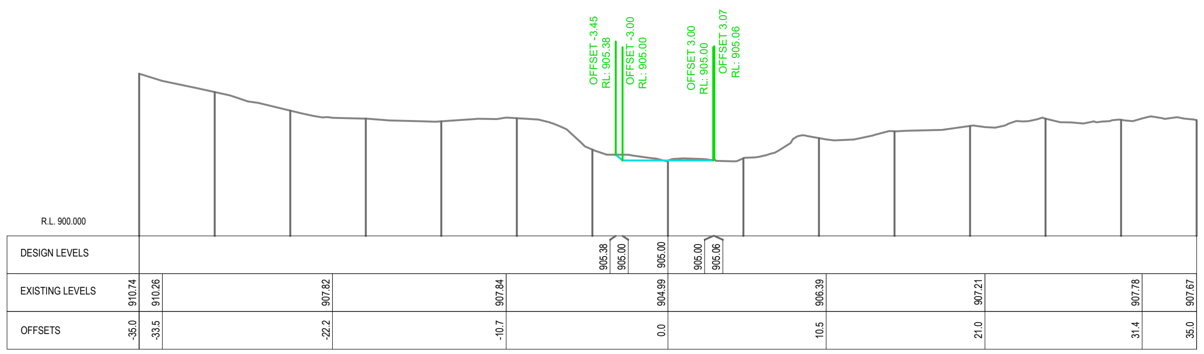
Ref No: 200014
Date: 18/10/2022

Sheet No. 2 / 4
Revision 1



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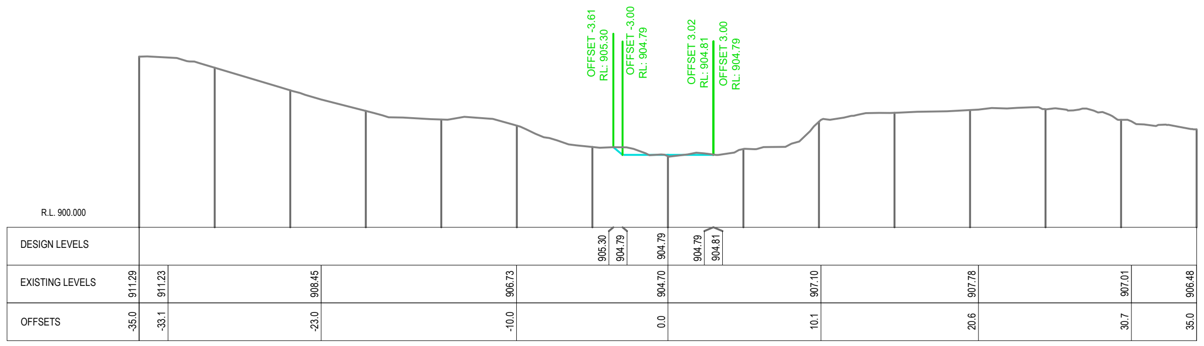

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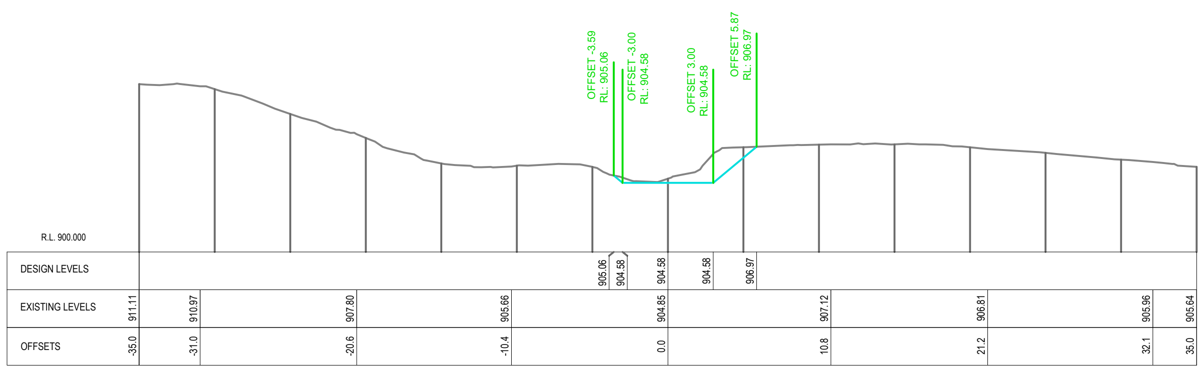

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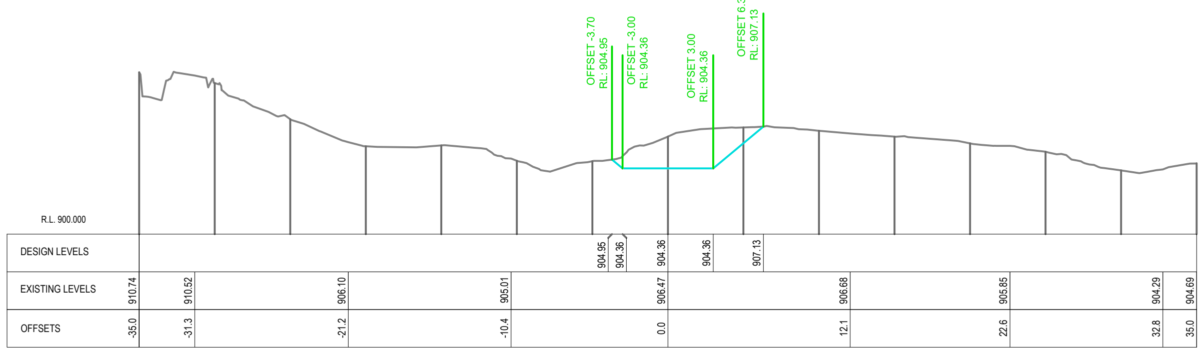

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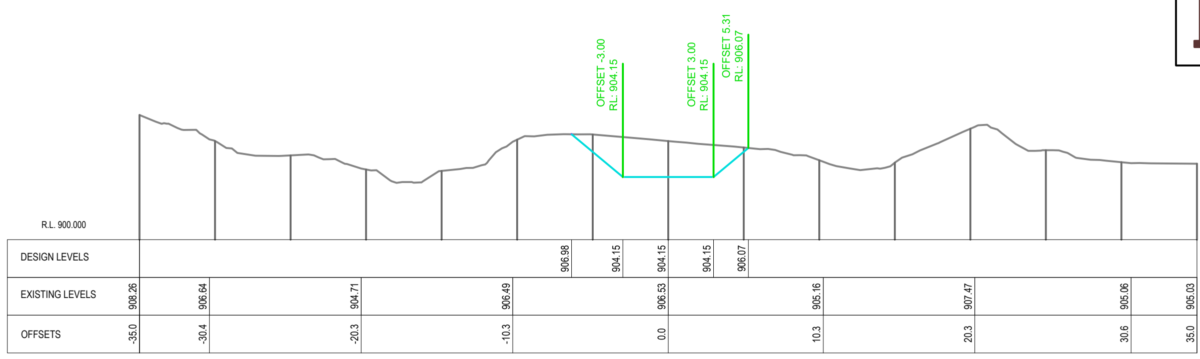

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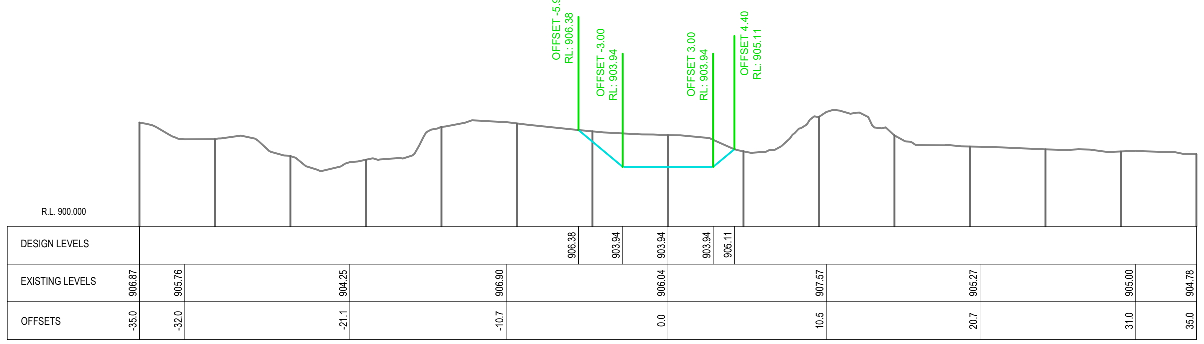

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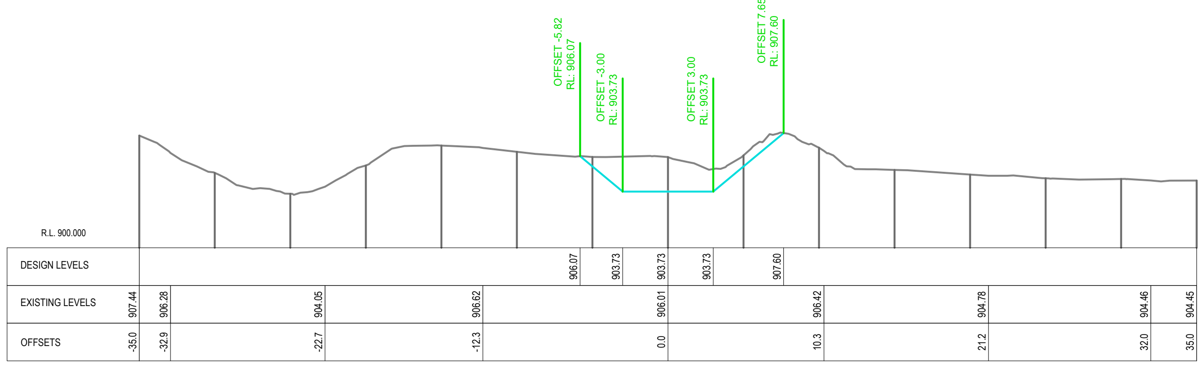

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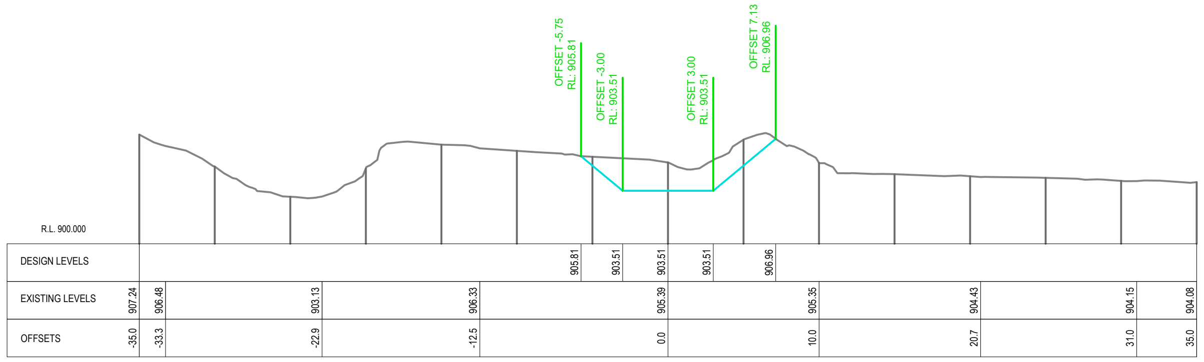

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CROSS SECTION VIEWS ALONG PROPOSED CREEK REALIGNMENT

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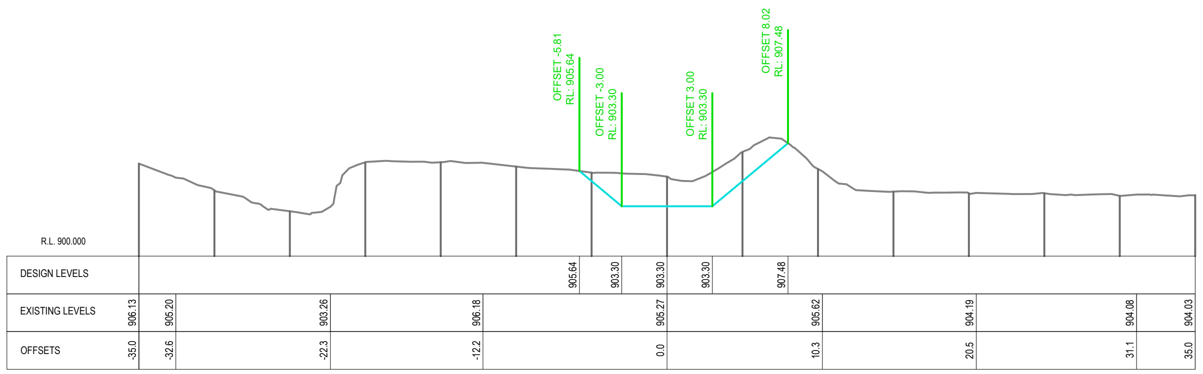

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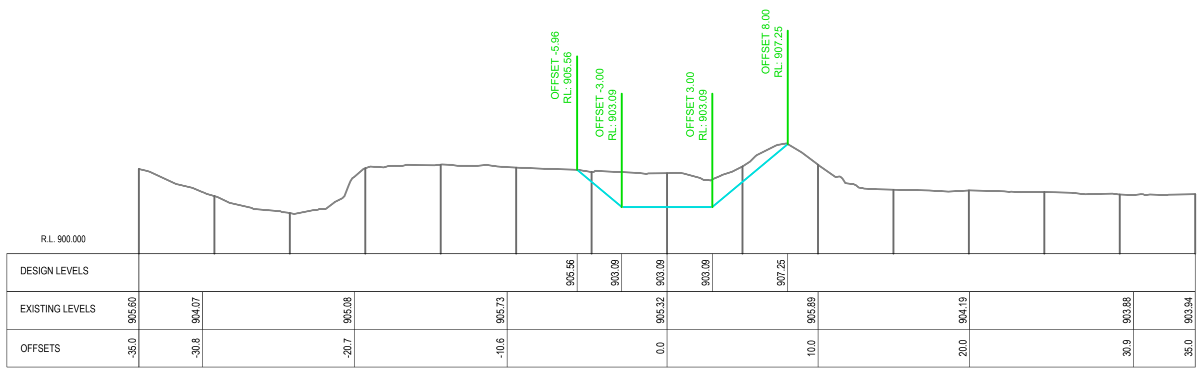

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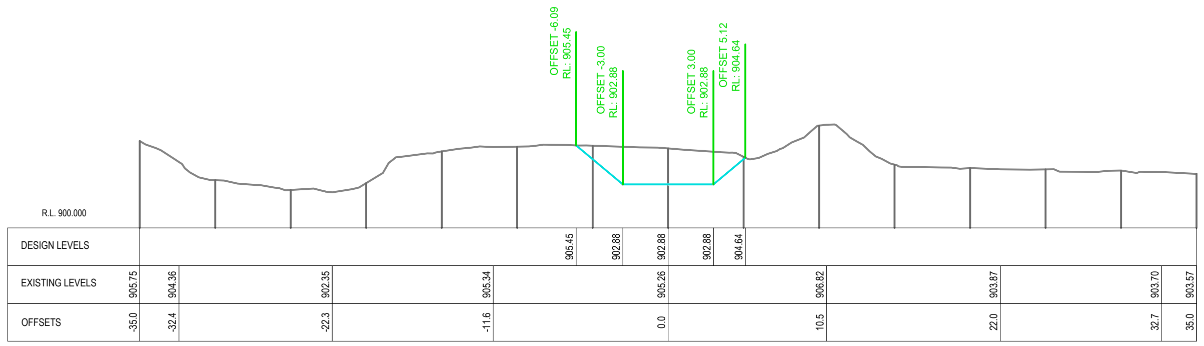

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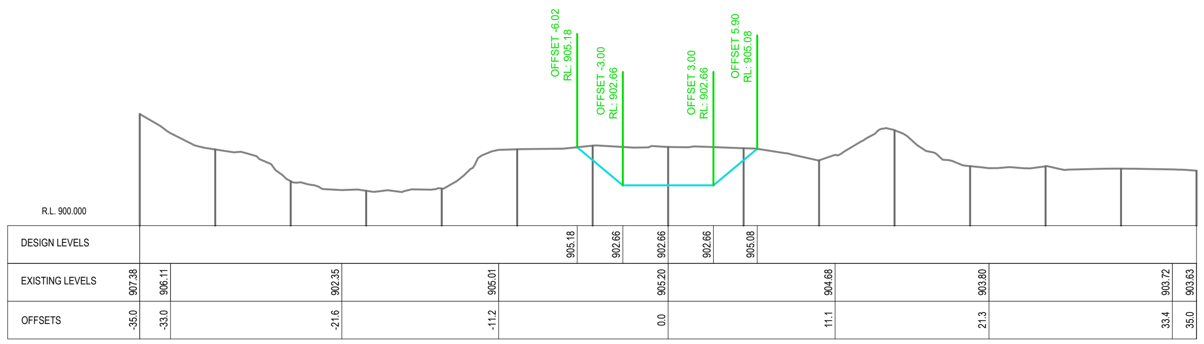

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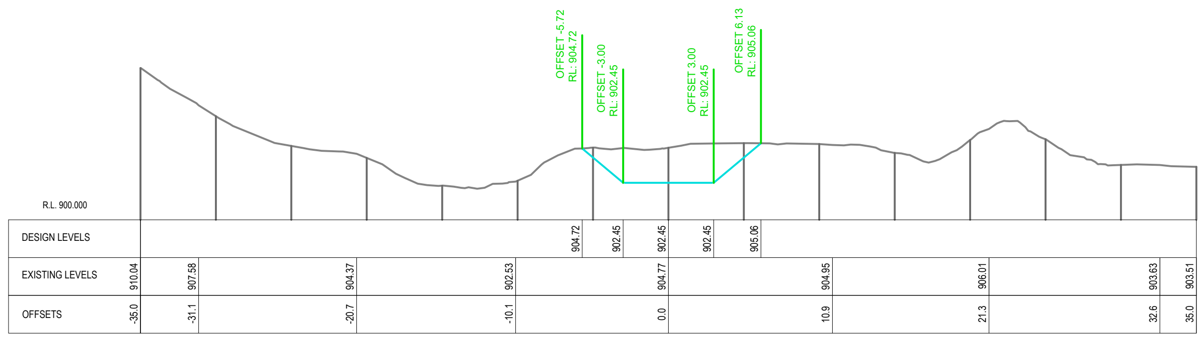

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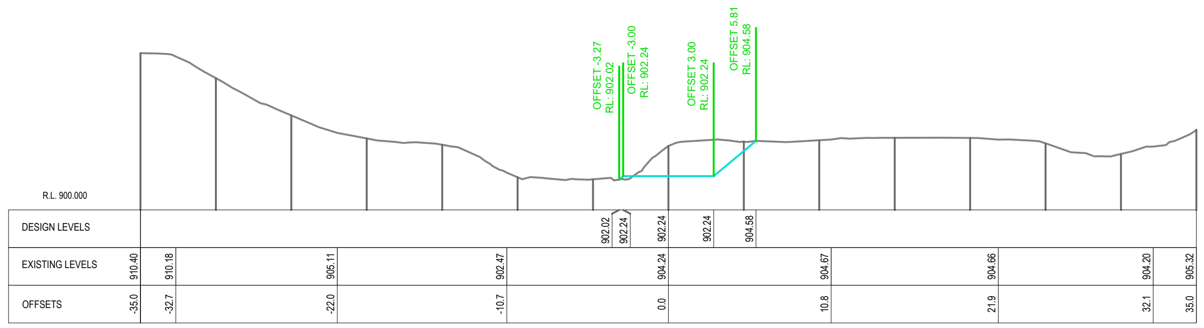

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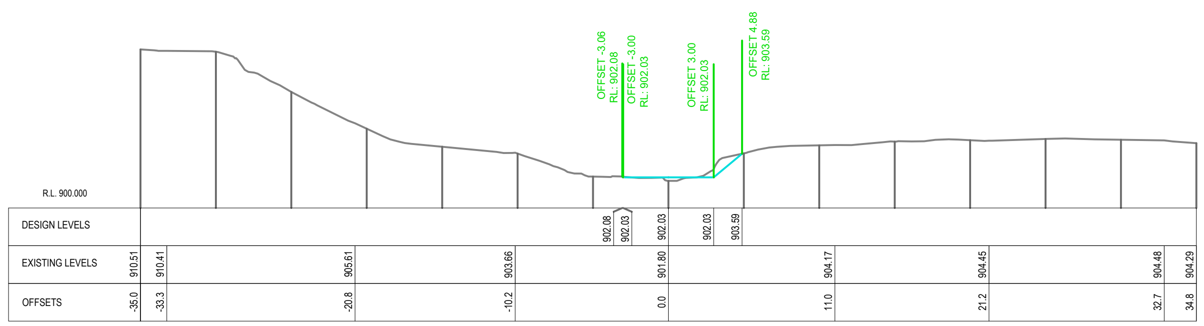

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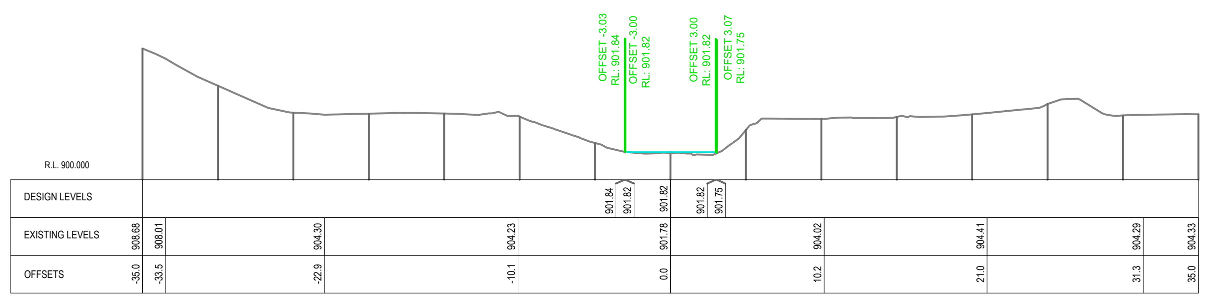

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Date: 18/10/2022

Sheet No. 4 / 4

Revision 1

B.4 Risk assessment

An evaluation of the Stage 1 realignment, and the potential impacts to water and water receptors has been completed. The risk assessment criteria are provided in Section B.4.1 and the risk evaluation is provided in Section B.4.2.

B.4.1 Criteria

The classification of likelihood for a risk is provided in Table B.3.

Table B.3 Likelihood criteria

Level	Occurrence	Frequency	Probability
A. Almost certain	Already happened or is expected to occur in most circumstanced.	Once per month or more.	90% or greater chance of occurrence.
B. Likely	May probably occur in most circumstances.	Oncer per year up to once per month.	66% up to 90% chance of occurrence.
C. Possible	Not unusual and might occur in the foreseeable future.	Once in 10 years up to once per year.	10% up to 33% of occurrence.
D. Unlikely	Could occur at some time but unlikely in the foreseeable future.	Once in 10 years up to once in 3 years.	10% up to 33% chance of occurrence.
E. Rare	Is expected to occur only in exceptional or extreme occurrences.	Less than once in 10 years.	Less than 10% chance of occurrence.

The classification of consequence, as defined within the categories of environment, legal and reputational are summarised in Table B.4.

Table B.4 Consequence criteria

Consequence (impact)	Environmental, legal and/or reputation impact
Insignificant	Environmental – Limited and localised, environmental consequence is limited to weeks. Legal – Low level compliance issue. Reputation – Potential to cause negligible level of impact.
Minor	Environmental – On-site release immediately contained by local personnel, short-term. Temporary environmental impact, environmental consequence is less than 12 months. Legal – Non-compliance, breaches in regulation. Reputation – Potential to cause a low level of impact.
Moderate	Environmental – On-site release contained with assistance from personnel not based at the works location. Medium term environmental impact, environmental consequence 1-2 years. Legal – Serious breach of regulations, prosecution/fine. Reputation – Potential to cause a medium level of impact.
Major	Environmental – Off-site release or pollution with a medium to long term environmental impact, environmental consequence 2-5 years. Legal – Major breach/major litigation. Reputation – Potential to cause a high level of impact.

Table B.4 Consequence criteria

Consequence (impact)	Environmental, legal and/or reputation impact
Critical	Environmental – Toxic pollution and off-site contamination, permanent or long-term environmental impact, environmental consequence >5 years. Legal – Major litigation, heavy fines, potential jail terms. Reputation – Potential to cause a severe level of impact.

The risk assessment matrix has been used to evaluate the potential risks of the project on water receptors and is outlined in Table B.5.

Table B.5 Risk assessment matrix

Consequence	Likelihood				
	Rare	Unlikely	Possible	Likely	Almost Certain
Insignificant	Low	Low	Low	Medium	Medium
Minor	Low	Low	Medium	Medium	High
Moderate	Low	Medium	Medium	High	High
Major	Medium	Medium	High	High	Extreme
Critical	Medium	High	High	Extreme	Extreme

Table B.6 Risk ranking

Risk ranking	Management required
Extreme	Immediate management action required
High	Priority management action warranted
Medium	Management action warranted
Low	Management action should be considered, particularly for low level impacts which nevertheless occur on a continual basis

B.4.2 Risk evaluation

The risks of potential impacts caused by the Stage 1 realignment are summarised in Table B.7. The risk evaluation assumes no additional controls (beyond those included as part of the current concept) are in place.

Table B.7 Assessment of potential project risks

Potential impact mechanism	Potential impact or event	Unmitigated risk evaluation			Mitigation	Residual risk evaluation			Residual risk comment
		Likelihood	Consequence	Rank		Likelihood	Consequence	Rank	
Inadequate channel capacity	Stage1 design template not sufficient to match existing conditions (depth or velocity change above acceptable threshold)	Possible	Minor	Med	• Flood modelling assessment	Unlikely	Minor	Low	• Design refinements as part detailed design to flatten bank batters and increase width if required
	Additional water entering channel than expected (additional catchment diversion, groundwater egress)	Possible	Insignificant	Low	• Catchment review of proposed final landform surface to confirm likely drainage pattern change	Unlikely	Insignificant	Low	
	Impacts to northern stability buttress from concentrated flow in Stage 1 channel	Possible	Moderate	Med	• Channel armouring to utilise placed rock • Flood modelling assessment	Unlikely	Moderate	Med	• Configure scour protection in consultation with buttress geotechnical engineer as part of detailed design
	Scour occurs in Stage 1 channel realignment	Likely	Minor	Med	• Channel armouring to utilise placed rock • Flood modelling assessment	Unlikely	Minor	Low	• Channel armouring to utilise placed rock
	Increased breakout/overbank flow	Possible	Minor	Med	• Flood modelling assessment	Possible	Minor	Med	• Include breakout area in general site inspections
Constructability issues	Channel construction is within unsuitable/contaminated materials including ash	Likely	Moderate	High	• Geotechnical investigation • Geophysics survey	Unlikely	Moderate	Med	• Further intrusive investigations to be undertaken if channel needs to increase width

Table B.7 Assessment of potential project risks

Potential impact mechanism	Potential impact or event	Unmitigated risk evaluation			Mitigation	Residual risk evaluation			Residual risk comment
		Likelihood	Consequence	Rank		Likelihood	Consequence	Rank	
Constructability issues	Area required for construction works is not sufficient	Possible	Moderate	Med	• Buffer of 20m off top of bank considered in disturbance zone • Consult with buttress geotechnical engineer to confirm construction requirements	Unlikely	Moderate	Med	• Detailed design to further confirm with buttress geotechnical engineer to confirm construction requirements
	Sources of rock not appropriate	Possible	Minor	Med	• Igneous rock required for channel armouring	Unlikely	Minor	Low	• If rock is not available investigate appropriate equivalent channel armouring products
Surface water quality: enhanced erosion and sediment processes during construction activities.	Increased turbidity or suspended solids in clean water system	Possible	Minor	Med	• Geotechnical in situ material characterisation • Erosion and sediment control • Scour protection • Surface water monitoring program and response plan	Unlikely	Minor	Low	• Surface water monitoring program and response plan

A safety in design risk assessment has not been undertaken on the concept design for Stage 1 and should be completed as part of detailed design.

Appendix C
Flood model report

Stage 1 - Sawyers Swamp Creek Realignment

Flood Model Report

Prepared for Generator Property Management

July 2024

Stage 1 - Sawyers Swamp Creek Realignment

Flood Model Report

Generator Property Management

E220618 RP7

July 2024

Version	Date	Prepared by	Approved by	Comments
V1	7 June 2024	Harrison Callen	Lachlan Hammersley	Draft
V2	12 July 2024	Harrison Callen	Lachlan Hammersley	Final

Approved by

Lachlan Hammersley
Associate Water Resources Engineer
12 July 2024

Level 3 175 Scott Street
Newcastle NSW 2300
ABN: 28 141 736 558

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Annexures

Tables

Figures

1 Introduction

1.1 Background and purpose

The environmental approval for the Kerosene Vale Stage 2 Ash Repository Area (MP07_0005) was granted in 2008. EMM as part of their existing engagement for environmental services provided a memorandum in July 2022 to Generator Property Management (GPM) which reviewed the proposed realignment of short reach of Sawyers Swamp Creek (SSC) which was approved under MP07_0005. The realignment is required to facilitate construction of a stabilising buttress on the northern side of the Kerosene Vale Ash Repository (KVAR), and is referred to herein as the 'Stage 1 realignment' as it is possible that further creek realignments will be required in future as part of ongoing site operations and rehabilitation. The location of the Stage 1 realignment within the existing site layout is shown in Figure 1.1.

Generally, the July 2022 review found that there were several issues with the approved Stage 1 realignment concept with a number of additional investigations recommended to address the identified issues. The additional investigations included:

- detailed topographic survey of SSC where it is proposed to be realigned
- review of the catchment hydrology and to confirm flow and flooding conditions in the vicinity of the Stage 1 realignment.

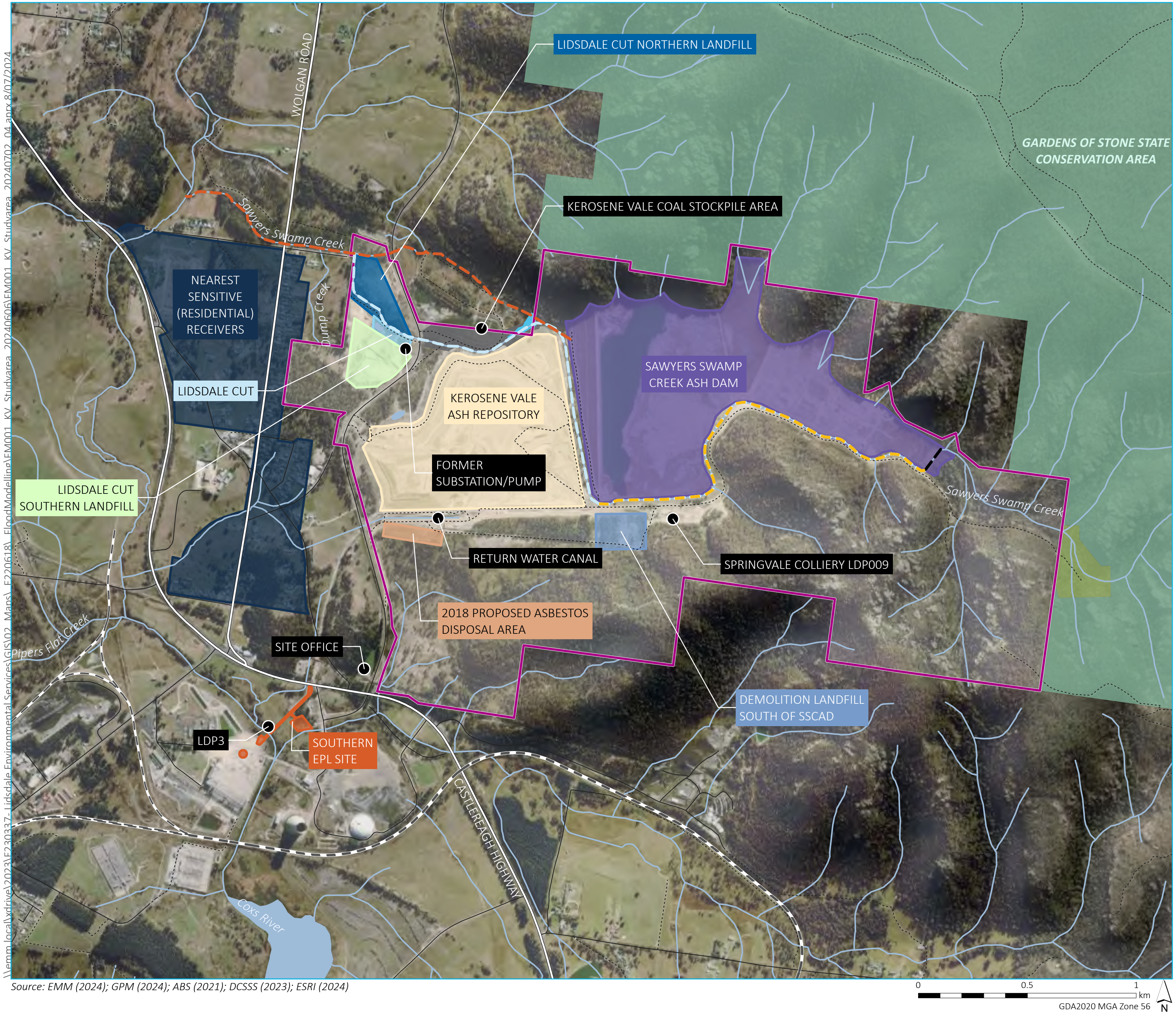
This report describes the methodology and outcomes of hydrologic and hydraulic modelling undertaken to address the above and provides a basis for future detailed design and construction of the Stage 1 SSC realignment. The report includes:

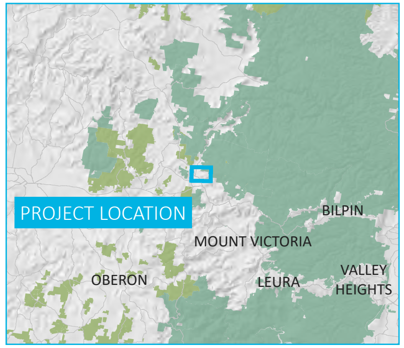
- a description of the assessment approach (Chapter 2)
- a description of the hydrologic modelling studies carried out to date and the modelling approach taken to define flood flows along SSC (Chapter 3)
- a description of the hydraulic modelling approach taken to assess flooding along the existing creek and proposed Stage 1 realignment (Chapter 4)
- hydraulic model results, including an assessment of the impacts of the Stage 1 realignment relative to the existing conditions and recommendations for next steps (Chapter 5)
- summary of the flood model report (Chapter 6).

1.2 Terminology

The following terms are used to describe site features hereafter and are shown on Figure 1.1:

- **Diversion dam –** the dam wall at the upstream (eastern) end of Sawyers Swamp Creek Ash Dam (SSCAD), that diverts water in the original alignment of Sawyers Swamp Creek into the upstream Sawyers Swamp Creek diversion.
- **Clean water SSC diversion drain –** this is the reach of the previously realigned Sawyers Swamp Creek channel that is adjacent to SSCAD from its upstream extent at the Diversion dam to the SSCAD spillway.
- **Historic SSC alignment –** this is the original (natural) creek alignment for Sawyers Swamp Creek before anthropogenic influence on flow pathways in the catchment.
- **Downstream Sawyers Swamp Creek diversion –** this is the reach of the previously realigned Sawyers Swamp Creek channel that is downstream of the SSCAD spillway to the confluence with the Coxs River which is south of the Historic SSC alignment.
- **Stage 1 SSC realignment –** this includes the Sawyers Swamp Creek realignment and KVAR Buttress concept designs in the area immediately north of KVAR. Generally interchangeable with the Downstream Sawyers Swamp Creek diversion in the sense that it is the conceptual design for the realignment of this creek section.
- **Kerosene Vale Coal Stockpile Area –** this includes the current day stockpile area immediately north of the Downstream Sawyers Swamp Creek diversion, which is situated on top of historical ash backfill.
- **Reed Bed –** in-stream feature along Sawyers Swamp Creek at the upstream end of the Stage 1 SSC realignment consisting of ponded water and riparian vegetation, namely reeds. This is a key hydraulic feature as well due to this being the location of the channel overflow/breakout towards the Historic SSC alignment.





KEY

- Study area
- Clean water diversion drain
- Diversion dam
- Downstream diversion (Sawyers Swamp Creek)
- Historical creek alignment
- Reed bed

Site feature

- Point of interest
- 2018 proposed asbestos disposal area
- Demolition landfill south of SSCAD
- Kerosene Vale ash repository
- Lidsdale cut
- Lidsdale cut northern landfill
- Lidsdale cut southern landfill
- Nearest sensitive (residential) receiver
- Sawyers Swamp Creek ash dam
- Southern EPL site
- Stage 1 SSC realignment area

Existing environment

- Rail line
- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- Named waterbody
- NPWS reserve
- State forest

INSET KEY

- Major road

Source: EMM (2024); GPM (2024); ABS (2021); DCSSS (2023); ESRI (2024)

Site location and layout

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure 1.1

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2 Assessment approach

2.1 Scope of works

This chapter describes the scope of work undertaken to assess flooding conditions along Sawyers Swamp Creek and potential risks and impacts as a result of the Stage 1 realignment. The scope of works is summarised below:

- Hydrologic and hydraulic modelling was undertaken by Aurecon and EMM, respectively, based on the procedures and design rainfall estimates in the latest version of Australian Rainfall and Runoff (ARR) (Ball et al, 2019).

- The hydraulic model was developed to cover an area both upstream and downstream of the Stage 1 SSC realignment. The model extends downstream to the confluence of SSC with the Coxs River whilst the upstream model boundary aligns with the existing SSCAD spillway.

- The hydraulic model simulates design flood events for flood frequencies ranging from including 4 exceedances per year (EY) up to and including the Probable Maximum Flood (PMF) event and is informed by hydrologic model results from corresponding events (Aurecon 2024).

- The hydraulic model is based on a digital elevation model (DEM) that is informed by site survey and Light Detection and Ranging (LiDAR) survey both from site specific datasets and publicly available data. The DEM developed for existing conditions has been used as a basis for the assessment of the Stage 1 SSC realignment.

- Assessment of Stage 1 SSC realignment concept and KVAR stabilising buttress concept to confirm the potential changes in flood behaviour.

2.2 Available data

The following data was available to inform the flood assessment:

- Stage 1 SSC realignment (Monteath and Powys (M&P) 2023) and KVAR buttress concept design data provided by WSP (2024), used to inform the Stage 1 developed case for hydraulic modelling (i.e. design scenario, note that this data is preliminary and has been considered to demonstrate proof of concept).

- Results of hydrologic modelling (Section 2.3) undertaken using XP-RAFTS software which included catchments upstream of SSCAD and the influence of SSCAD and associated diversions on downstream flows in SSC (Aurecon 2022 and 2024).

- Topographic survey data of elevations along the Stage 1 SSC realignment area and culvert data along SSC to inform existing flooding conditions (M&P 2023), captured between November and December 2023. This field survey was treated as highest priority when assigning hydraulic model elevations relative to the LiDAR data described below.

- LiDAR survey captured by M&P in June 2022 over KVAR and SSC downstream of SSCAD (refer Figure 1.1). The DEM derived from this LiDAR survey was treated as second priority when assigning hydraulic model elevations within the site and its immediate surrounds due to the recent capture date relative to the publicly available LiDAR data captured in 2011.

- NSW Department of Finance, Services and Innovation (DFSI) (2023) LiDAR survey captured in August 2011 and downloaded from the ELVIS data portal over the remaining areas of the sites surrounds such that topography within the hydraulic model domain can be fully represented. The DEM derived from this LiDAR survey was treated as third priority when assigning hydraulic model elevations within the site and its immediate surrounds due to changes that have happened within the site since 2011, however this dataset is still useful for areas not captured by higher priority surveys (such as areas downstream of KVAR and the Stage 1 SSC realignment).

- Field observations and photographs from site inspections undertaken between 2022 and 2024 by EMM site personnel.

2.3 Methodology

The assessment of flooding along SSC that is presented in this report is based on the following modelling tasks:

- Hydrologic modelling of the entire upstream catchment of SSC, down to the SSCAD spillway which is represented in an XP-RAFTS model that was originally developed by Aurecon (2022) and subsequently refined by Aurecon (2024). This is to inform flood flows from SSCAD overtopping along with contributions from the upstream SSC catchment via a diversion drain around SSCAD (refer Section 3).

- Additional hydrologic modelling of subcatchments downstream of the SSCAD spillway in the area of the Stage 1 realignment down to the confluence with the Coxs River using a refined XP-RAFTS model developed by EMM based on Aurecon (2022). This accounts for local runoff generation and contributions to SSC downstream of SSCAD (refer Section 3).

- Hydraulic modelling using TUFLOW software to determine the extent and depth of flooding and other flow characteristics throughout the model domain. This hydraulic modelling utilises inflow hydrographs from the XP-RAFTS models listed above (discussed further in Section 4).

Impact assessment of the proposed Stage 1 SSC realignment and related terrain modifications were assessed using the following scenarios (described further in Section 4.6):

- Hydraulic assessment of an existing case used to establish baseline flooding conditions.

- Hydraulic assessment of a developed case which was compared against the existing case to establish the hydraulic impact of proposed realignment and terrain modifications.

- Afflux mapping and result analysis for flows through SSC and associated floodplain.

3 Hydrologic model development

3.1 Overview

This chapter describes the development of the hydrologic models used to generate inflows to the TUFLOW hydraulic model.

3.2 Catchment contributing to SSCAD

3.2.1 Background

Catchment hydrology for the upstream catchment area that contributes to flows in the SSCAD spillway chute was previously investigated as part of the *Sawyers Swamp Creek Ash Dam – Dambreak Study and Consequence Assessment* (Aurecon 2022), and a hydrologic model developed using the XP-RAFTS software. This included consideration of design flood frequencies ranging from 5% AEP up to the PMF.

As part of the current flood assessment, updated XP-RAFTS model outputs were provided by Aurecon (2024) for events smaller in magnitude than the 5% AEP.

The XP-RAFTS model was developed to inform SSCAD dam safety studies, and therefore has a focus on relatively large and infrequent flood events. However, the model structure, parameters and key assumptions were reviewed by EMM and are considered broadly suitable for application to the Stage 1 SSC realignment. The XP-RAFTS model includes several key assumptions that will tend to maximise peak flood levels downstream of SSCAD. These include:

- The SSCAD water surface level was assumed to be full at the beginning of all design storm events.
- There is a fuse plug present in the SSCAD embankment and this is assumed to activate and erode per the design intent in all simulations.
- The clean water SSC diversion drain overtops into the adjacent SSCAD in events equal to or greater than the 5% AEP event.

It is noted these assumptions may not be suitable for all applications and so reliance on the XP-RAFTS model in its current form should be considered on a case by case basis.

The smaller magnitude events included as part of the updated results were the 10%, 20%, 50% and 63.2% AEP events as well as the 4 EY event (Aurecon 2024). These events were modelled with the same assumptions around initial water levels within SSCAD and fuse plug scenarios (i.e. eroded), however, the following modifications were made to the XP-RAFTS model for the smaller magnitude events:

- Storm losses have been applied consistently for events where FFA-reconciled loss values are not available with the 50% AEP losses being applied to the 63.2% AEP and 4EY events in the absence of event specific data.
- The fraction of flow diverted into SSCAD from the upstream diversion dam has been set to 0% reflecting the lack of overtopping in events smaller than the 5% AEP.

3.2.2 Results

Table 3.1 summarises the hydrologic model results for SSCAD for storm events from 4 EY through to the PMF. The key result of interest is the peak outflow in the spillway chute, which represents the upstream boundary to the TUFLOW hydraulic model (refer Section 4). Figure 3.1 presents the catchment plan considered as part of the modelling of SSC hydrology.

Table 3.1 Summary of hydrologic model results for SSCAD (Aurecon 2022 & Aurecon 2024)

AEP	SSCAD inflows	SSCAD outflows		Cell A Peak WSL (mAHD)	Critical duration (h)
	Peak inflow (m^3/s)[2]	Peak outflow - dam (m^3/s)	Peak outflow - spillway chute (m^3/s)[1]		
4 EY	1.1	0.37	0.37	942.22	9
63.2%	5.7	1.3	5.9	942.25	24
50%	5.7	1.6	7.4	942.26	24
20%	9.7	42	50	942.30	6
10%	18	45	56	942.31	3
5%	31	54	58	942.34	3
2%	38	58	63	942.38	3
1%	57	63	67	942.40	2
PMF	680	395	430	944.23	2

Notes: 1. The spillway chute flows include diversion channel contributions. Note the storm critical duration may be different to that producing the dam peak water level.

2. For the same event that produces the peak dam water level.

3.3 Catchment downstream of SSCAD

In order to account for local catchment runoff contributions to SSC downstream of SSCAD, a separate XP-RAFTS model was developed by EMM. Eight additional subcatchments were represented in the XP-RAFTS model for this purpose.

For each event magnitude modelled, a simplified approach to determining the critical duration was adopted whereby a single temporal pattern was applied during hydrologic and hydraulic modelling based on the critical durations determined by Aurecon (2022). It is noted that this critical duration was determined by Aurecon (2022) using the standard ARR 2019 ensemble approach. This simplified approach is a reasonable approximation in this case as the SSCAD spillway chute outflows are significantly larger than the downstream contributions into Sawyers Swamp Creek, for example, the largest downstream subcatchment has a local flow of approximately 4% of total SSCAD outflow for the 1% AEP, 2-hour event.

Hydrographs for each subcatchment were then applied to the hydraulic model (refer Section 4). The additional subcatchments and their relevance to the site are summarised in Table 3.2.

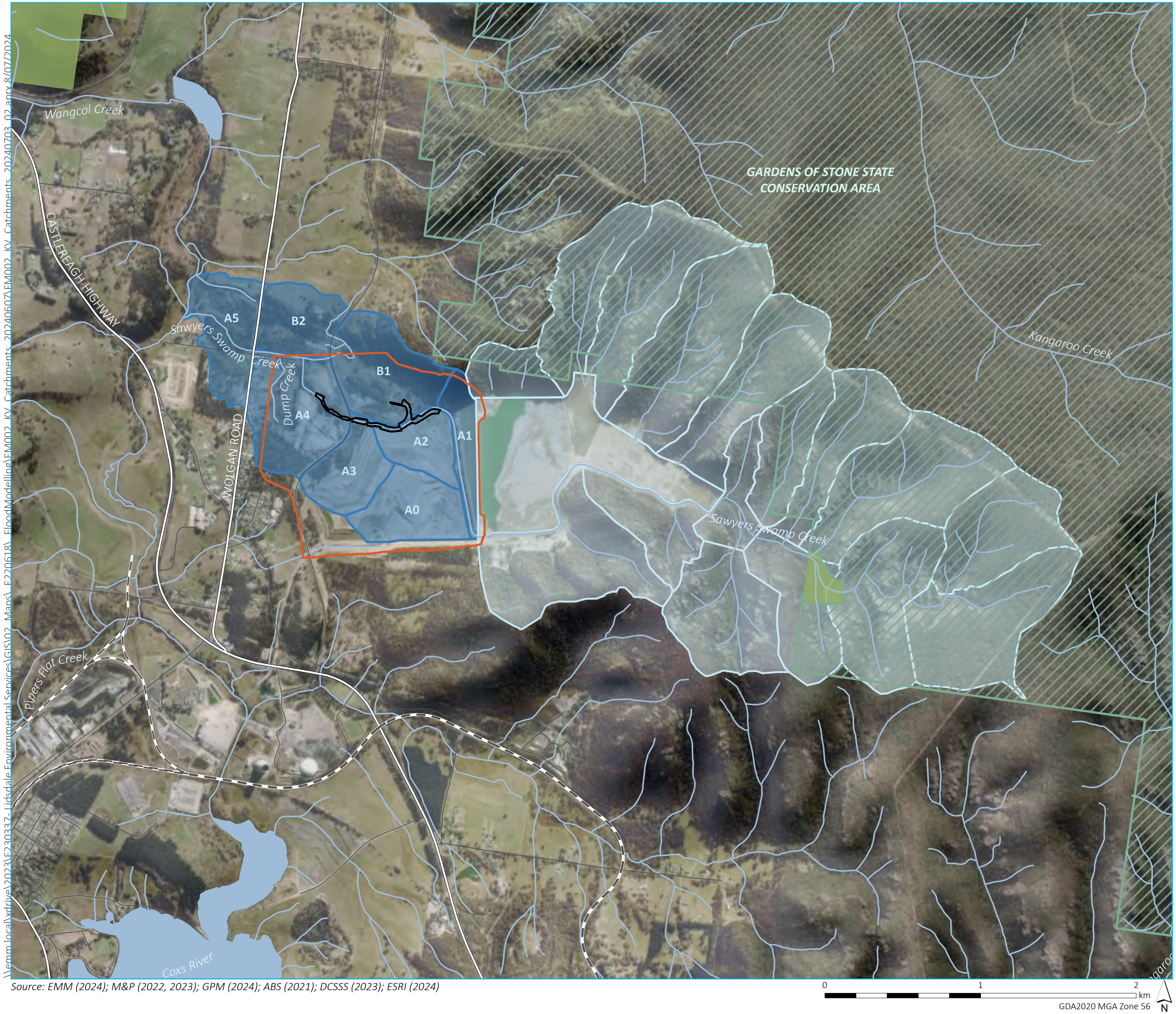
Table 3.2 Summary of additional subcatchments

Name	Area (ha)	Subcatchment description
A0	26.6	South of KVAR, due west of SSCAD spillway.
A1	14.5	Immediately downstream of SSCAD spillway chute, accepts overflows and diverted water, is the first subcatchment downstream of SSCAD.
A2	17.1	Extends from northern side of KVAR down to the Sawyers Swamp Creek alignment.
A3	21.8	Extends from the northwestern side of KVAR down to the Sawyers Swamp Creek alignment, includes Dump Creek.
A4	41.4	Includes populated areas of Lidsdale as well as western extent of the site.
A5	28.3	Final subcatchment in model, consists of mostly Sawyers Swamp Creek and terminates at confluence with the Coxs River.
B1	37.0	First overflow location from north of KVAR, include portion of the escarpment and terminates at the Haul Road.
B2	22.4	Downstream of B1 and the Haul Road, includes area between the haul road and Maddox Lane.

Table 3.3 below summarises the adopted parameter values for the XP-RAFTS model, adopted from Aurecon (2022).

Table 3.3 XP-RAFTS model parameters (Aurecon 2022)

Surface	Adopted values	Comments
Pervious Manning's n factor	• Vegetated areas - 0.07 • Water surface/ash dam – 0.0002	Consistent with Aurecon (2022)
Imperviousness	• Vegetated areas – 0% • Water surface/ash dam – 100%	Consistent with Aurecon (2022)
Vectored sloped	Catchment dependent, calculated based on 1 m LiDAR DEM	Consistent with Aurecon (2022), except where subcatchments have been added downstream of SSCAD (refer Figure 3.1)
Channel lag	Muskingum-Cunge method • X – 0.25 • K – Calculated based on assumed channel velocity and length	Consistent with Aurecon (2022)
Storage non-linearity coefficient	-0.285 (default)	Consistent with Aurecon (2022)
Storage global multiplier	1.0 (default)	Consistent with Aurecon (2022)



Source: EMM (2024); M&P (2022, 2023); GPM (2024); ABS (2021); DCSSS (2023); ESRI (2024)

KEY

- Downstream catchment
- Upstream catchment
- LiDAR survey extent- M&P 2022
- Hand survey extent- M&P 2023

Existing environment

- Rail line
- Major road
- Minor road
- Watercourse/drainage line
- Named waterbody
- State forest
- NPWS reserve

Sawyers Swamp Creek
catchments and available data

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure 3.1

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4 Hydraulic model development

4.1 Overview

This chapter describes the development of the TUFLOW hydraulic model. Model results are presented and discussed in Chapter 5.

4.2 Model domain, grid size and version

The hydraulic model was developed for a three kilometre (km) reach of SSC and floodplain between the SSCAD spillway chute and the confluence of SSC and the Coxs River. The model domain and key features are shown in Figure 4.1.

The modelled topography including SSC and its floodplain was represented entirely in two dimensions (2D) with the exception of existing hydraulic structures with a model grid size of 1 m, informed by the following topographic data presented in order of hierarchy (refer Section 2.2 for details on each source of data):

1. SSC proposed Stage 1 realignment and buttress concept design data (WSP 2024) (**Note:** relevant to the design scenario only, refer Section 4.6).

2. Topographic survey data (refer Annexure A, M&P 2023).

3. LiDAR survey data (M&P 2022).

4. LiDAR survey data (DFSI 2011).

TUFLOW Heavily Parallelised Compute (HPC), version 2023-03-AB was used with sub grid sampling implemented to provide a higher resolution of storage within the model.

4.3 Structures

4.3.1 Culverts

Existing culverts were modelled as embedded one-dimensional (1D) structures, accepting water from the 2D domain at the upstream end and distributing flows back into the 2D domain at the downstream end.

A total of six creek crossings were modelled as culvert structures, three of which included multiple cells. The details of these culverts such as invert levels and blockage factor (based on existing observed blockage characteristics) were informed by survey (refer Annexure A, M&P (2023)), site experience or desktop review where survey detail was not available. The locations of these culvert structures are shown in Figure 4.1 and a summary of the structure information is provided in Table 4.1.

Table 4.1 Summary of culvert structures

Name	Cell	Type	Blockage (%)	Diameter (m)	Source
Culvert 1	A	Circular	70	1.75	M&P (2023)
	B	Circular	0	1.75	M&P (2023)
	C	Circular	70	1.83	M&P (2023)
Culvert 2	A	Circular	5	1.75	M&P (2023)
Culvert 3	A	Circular	0	1.65	M&P (2023)
	B	Circular	0	1.65	M&P (2023)
	C	Circular	0	1.65	M&P (2023)
Culvert 4		Circular	50	1.75	M&P (2023)
Culvert 5	A	Circular	0	1.8	M&P (2023)
	B	Circular	0	1.9	M&P (2023)
Centennial		Circular	5	0.9	Site experience and desktop review

4.3.2 Weirs

Two weir structures have been incorporated into the TUFLOW hydraulic model through modifications to the 2D model domain using breaklines to represent the elevation of each weir crest. The modifications are described in Table 4.2.

Table 4.2 Summary of weir structures

Name	Type	Use	Weir crest (mAHD)	Width of breakline (m)[1]	Source
V-notch weir	V-notch	Flow gauging	892.90	1	M&P (2023), refer Annexure A
Lidsdale cut weir	Broad crested	Historic pump to Lidsdale Cut Open Cut Void	897.72	1	M&P (2023), refer Annexure A

1. Structure width has been modelled as a 1 m thick breakline in the TUFLOW model domain. Actual width of weir structures is <1 m but has been modelled as the minimum grid cell size in the absence of finer resolution.

4.4 Hydraulic roughness

The surface within SSC and on the floodplain is highly variable, with different creek reaches containing various types of vegetation cover and channel geometry (shape). For example, some reaches immediately downstream of the SSCAD spillway chute contain uniform channel sections with a base of bedrock whilst further downstream, the channel takes on a densely vegetated and non-uniform channel shape. Generally, the model domain can be conceptualised as a combination of the following land use types:

- **Vegetation** – ranging from minimal to densely vegetated.
- **Ash affected areas** – inclusive of ash piles and dams.
- **Built environment** – including dirt roads, paved roads (e.g. Haul Road) and houses/administration buildings.
- **Channel** – for Sawyers Swamp Creek variations in lining and shape are relevant to this project.

The following process for prescribing hydraulic roughness values (Manning's n) to the hydraulic model domain was carried out:

- Manning's n of 0.02 was globally applied to the model domain. Given the localised variability of the model domain, detailed variation in hydraulic roughness was then applied over the top of this global value.
- Manning's n values for various types of land use within the model domain was assigned based on the values presented in Table 4.3 (refer Figure 4.1).

The hydraulic roughness areas are shown as material layers along with other hydraulic model features in Figure 4.1.

Table 4.3 Adopted Manning's n values for the hydraulic model domain

Manning's n value	Land use
Vegetation	
0.02	Open Space Minimal Vegetation
0.045	Open Space Moderate Vegetation
0.07	Open Space Dense Vegetation
Ash affected areas	
0.002	Ash Dam
0.002	Ash stockpiles
Built environment	
0.025	Asphalt/Bitumen Road
0.035	Dirt Road
0.5	Buildings
0.2	Low Density Residential Land
Channel roughness	
0.001	Water surface
0.035	Vegetation lined channel, uniform and no real obstruction to flows
0.07	Waterways - changed, channel is more vegetated and likely more sluggish than assumes previously
0.018	Concrete Lined Channel
0.032	Gravel Lined Channel
0.04	Smoother channel, uniform channel some vegetation
0.045	Medium roughness channel, not quite uniform
0.05	Rough channel with only low flow blocked by vegetation, non uniform channel
0.08	Rough channel with non uniform shape and thick vegetation
0.1	Reed bed

Note: Manning's n of 0.02 was applied to all areas not assigned with a specific roughness as per Table 4.3

KEY

LiDAR survey extent- M&P 2022

Hand survey extent- M&P 2023

Hydraulic model layout

TUFLOW model domain

2D surface area inflow boundary

Reed bed

Material layer

Building

Channel

Roads

Stockpile

Water

Vegetation

Spillway chute inflow

Reporting point

Outflow boundary

Culvert location

Existing environment

Rail line

Major road

Watercourse/drainage line

NPWS reserve

Source: EMM (2024); M&P (2022, 2023); GPM (2024); ABS (2021); DCSSS (2023); ESRI (2024)

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Hydraulic model setup

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure 4.1

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4.5 Boundary conditions

Boundary conditions applied to the hydraulic model are outlined in Table 4.4 and presented in Figure 4.1.

Table 4.4 Model boundary conditions

Boundary condition	Type	Boundary assumptions
Spillway chute inflows.	Flow versus time boundary (QT)	Aurecon 2022 and 2024 hydrographs applied.
Catchment inflows.	Surface area inflow applied along local drainage line within each subcatchment (2D SA), informed by topography.	Flows from eight subcatchments downstream of SSCAD were distributed into the model domain with hydrographs exported from the XP-RAFTS model described in Section 3.3.
Downstream Sawyers Swamp Creek boundary (Coxs River).	Normal depth boundary (HQ).	Slope of 1%.
Downstream boundary along Historic Sawyers Swamp Creek alignment, north of current alignment.	Normal depth boundary (HQ).	Slope of 1%.

4.6 Model scenarios

The TUFLOW hydraulic model was run for the following scenarios:

- **Existing scenario** – the purpose of this model scenario is to represent existing site conditions, prior to the introduction of the Stage 1 SSC realignment and associated works. The existing scenario provides a baseline through which the hydraulic impacts of modifications to the topography can be assessed.

- **Design scenario** – the purpose of this model scenario is to represent the Stage 1 SSC realignment scenario, complete with conceptual KVAR buttress design input into the model domain topography. It should be noted that the modelling and impact assessment described in this report considers a concept prepared by M&P based on an equivalent channel arrangement to what is existing. The concept design is subject to further refinement as part of future detailed design and construction.

The following sections outline the specific topographic modifications that were made to represent the existing and design scenarios listed above.

4.6.1 Existing scenario modifications

The following topography modifications were made to the model domain:

- Incorporation of 2022 LiDAR survey from M&P, primarily due to the data being more recent than publicly available elevation data which represented KVAR poorly. This included Z shape adjustments to elevations that assisted with smoothing differences between datasets.

- Incorporation of the M&P (2023) ground survey, particularly in the SSC channel in the areas of the proposed realignment. In addition to enforcing elevations from the ground survey, a reeded area was 'cut' into the model domain to represent the ponded wetland area immediately north of the KVAR (refer Figure 4.2). Note that this area will be herein referred to as the Reed Bed. Modelling of this area is of particular importance due to the Reed Bed being a location of flow breakout when channel capacity is exceeded. At the boundary of datasets where there was a need to better merge elevations, Z shapes were used to adjust elevations except in cases such as the north of the Reed Bed where the elevations from the hand survey were strictly observed in preference to any other dataset.

- Breaklines representing top of bank, toe of bank and drainage line thalwegs (lowest point of channel section) were added where appropriate, particularly where ground survey was carried out and in areas where vegetation/landscape features inhibited LiDAR from surveying the true ground surface elevations. Note that site experience was used in these cases.
- Breaklines representing the crest height of the weirs described in Section 4.3.2, as well as topography modifications immediately upstream and downstream of culvert structures to ensure proper transfer of water and reduce model error.

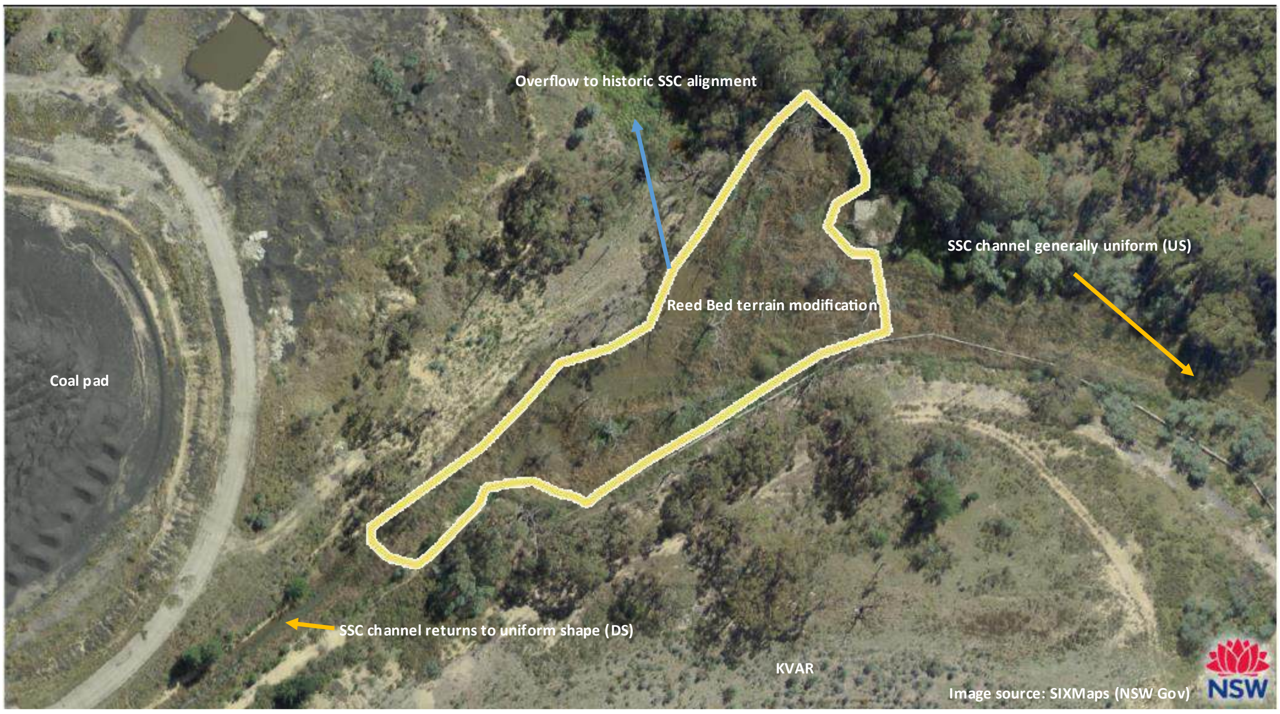

Figure 4.2 Reed Bed topography modifications to better represent area of channel breakout.

4.6.2 Design scenario modifications

In addition to the topography modifications listed above in Section 4.6.1, the following modifications were made to the design scenario.

- Incorporation of the WSP (2024) KVAR Buttress and M&P (2023) Stage 1 SSC realignment concept design. Effort was made to ensure a smooth transition between datasets, particularly in the channel. This included Z shape adjustments to elevations that assisted with smoothing differences between datasets. Refer Figure 4.3 for a complete representation of modifications.

4.7 Reporting points

To properly assess changes in the hydraulics of Sawyers Swamp Creek as a result of the Stage 1 SSC realignment works, two reporting locations have been included. These are shown in Figure 4.1 and are summarised below:

- **Reporting Point 1 (RP1)** – a plot output line feature (PO line) has been placed at the upstream end of the Stage 1 SSC realignment at the location where the proposed realignment begins to deviate from the current alignment. This provides an opportunity to assess differences in flows within Sawyers Swamp Creek at a similar location that is sufficiently downstream of the upstream end of the Stage 1 SS realignment.

- **Reporting Point 2 (RP2)** – a PO line has been placed at the high point along the northern (right) bank at the Reed Bed location. This provides an opportunity to assess differences in breakout flows to the Historic SSC alignment.

Source: EMM (2024); M&P (2022, 2024); GPM (2024); ABS (2021); DCSSS (2023); ESRI (2024)

KEY

- Point elevation data
- Breakline
- TUFLOW model domain
- LiDAR survey extent - M&P 2022
- Hand survey extent - M&P 2023
- Region modification
- Realignment and buttress design extent

Existing environment

- Rail line
- Major road
- Watercourse/drainage line
- NPWS reserve

Summary of topography modifications

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure 4.3

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5 Hydraulic model results

5.1 Overview

The hydraulic model described in Chapter 4 was applied to establish existing scenario and design scenario flood characteristics along SSC and its floodplain. Mapped flood model results for the 63.2%, 20%, 10%, 5%, 2%, 1% AEP and PMF events are included as annexures which are outlined below:

- Annexure B – Existing Scenario – Peak flood depth
- Annexure C – Design Scenario – Peak flood depth
- Annexure D – Existing Scenario – Peak flood velocity
- Annexure E – Design Scenario – Peak flood velocity
- Annexure F – Existing Scenario – Peak flood hazard
- Annexure G – Design Scenario – Peak flood hazard

Difference maps showing the change in flood behaviour under design scenario conditions are also provided as the following annexures:

- Annexure H – Flood afflux (relative difference)
- Annexure I – Flood afflux (was dry, now wet)

Relative difference was calculated as design flood depth (m) minus existing flood depth (m), that is, positive afflux indicates an increase in flood depth relative to the existing scenario.

Note that the 4 EY results have been included in selected tabulated results throughout this chapter but omitted from mapped results.

5.2 Potential impacts of Stage 1 SSC realignment

The potential impacts of the Stage 1 SSC realignment are described in the following sections, and primarily consists of two hydraulic changes:

- Changes to the flowrate (m^3/s) and flood depth (m) in SSC and adjacent floodplain areas relating to the change in hydraulic function due to earthwork and terrain modifications. This is referred to as relative difference in mapping presented in Annexure H.
- Changes to the location and extent of flooding due to realignment of the channel itself and placement of the KVAR buttress. For example, some areas that were previously dry during flood events will now be wet due to the location of the proposed works (similarly, some previously wet areas will now be dry). This is referred to as 'was wet, now dry' in mapping presented as part of Annexure I.

5.2.1 Discharge in Sawyers Swamp Creek

TUFLOW model results for all existing and design event magnitudes has been compared in Table 5.1, which shows relative difference in flowrates as a percent difference. It can be seen that the difference is within ±2% and demonstrates that the Stage 1 SSC realignment has a very minor impact on flow distributions.

Table 5.1 Comparison of Sawyers Swamp Creek flows at RP1

Event	Existing Scenario flow (m^3/s)	Design Scenario flow (m^3/s)	Difference (%)[1]
4 EY[2]	0.349	0.354	2%
63.2% AEP	5.49	5.53	1%
20% AEP	13.69	13.95	2%
10% AEP	14.69	14.91	1%
5% AEP	15.10	15.33	2%
2% AEP	15.70	15.89	1%
1% AEP	16.86	17.05	1%
PMF	50.45	51.55	2%

1. % difference calculated relative to Existing Scenario, i.e. a +1% difference represents a 1% increase in flow during the Design Scenario

2. The 4 EY event has not been included in flood mapping due to significant amount of floodwater not above depth cutoff of 100 mm

Table 5.2 Comparison of flows diverted to historic SSC alignment at RP2

Event	Existing Scenario flow (m^3/s)	Design Scenario flow (m^3/s)	Difference (%)[1]
4 EY[2]	0	0	0%
63.2% AEP	0.62	0.61	-1%
20% AEP	35.31	35.13	-1%
10% AEP	40.64	40.56	0%
5% AEP	42.77	42.82	0%
2% AEP	46.00	46.03	0%
1% AEP	51.74	51.98	0%
PMF	246.43	246.86	0%

1. % difference calculated relative to Existing Scenario, i.e. a +1% difference represents a 1% increase in flow during the Design Scenario

2. The 4 EY event has not been included in flood mapping due to significant amount of floodwater not above depth cutoff of 100 mm

5.2.2 Flood afflux

Flood afflux mapping is presented in Annexure H and Annexure I. It can be seen from these results that:

- Flood depth afflux in and around the Stage 1 SSC realignment works are generally demonstrated to not worsen flooding along the Stage 1 SSC realignment, with some changes in flood levels between upstream of the Haul Road culvert (i.e. reduction of up to approximately 0.5 m), with little to no afflux downstream of this for events up to and including the 1% AEP event (refer Annexure H). The PMF indicates more widespread changes to flood depth and extent but this is considered acceptable due to the extreme nature of this flood event and channel/floodplain capacity being exceeded (refer Annexure H).

- Areas that were previously dry that are now wet are almost exclusively related to the relocation of the channel alignment towards the coal pad area away from KVAR (i.e. the flow pathway has been moved north of its current location, refer Annexure I). This is with the exception of the PMF event, which has different KVAR elevations due to the proposed KVAR buttress concept design and therefore differing floodplain characteristics in these areas which means some areas are now dry that were previously wet under Existing scenario conditions (Annexure I).

5.3 Discussion

5.3.1 Capacity of existing channel and associated breakout

The breakout of the Sawyers Swamp Creek channel at the location of the Reed Bed occurs at approximately 5 m^3/s based on model results for both the existing and design scenarios (refer Figure 5.1 and Figure 5.2, respectively). This value is reasonably consistent with previous studies (refer Worley Parsons (2014) and Aurecon (2022)) and the similarities between Figure 5.1 and Figure 5.2 indicate no identifiable difference in channel capacity or overtopping volume for events up to and including the 1% AEP.

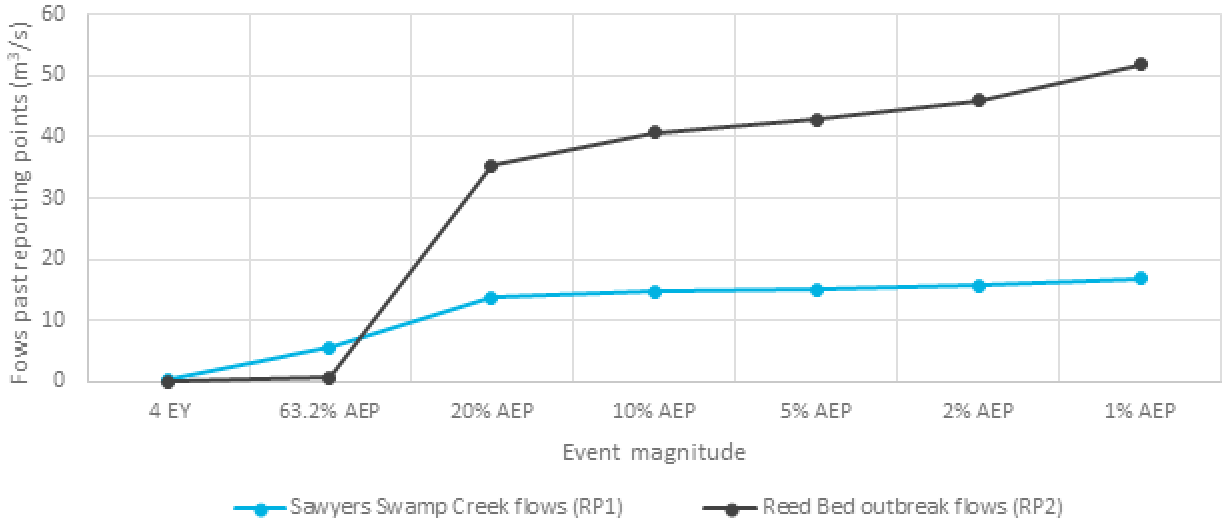

Figure 5.1 Simultaneous flows through current SSC alignment and towards the historic SSC alignment (Existing scenario)

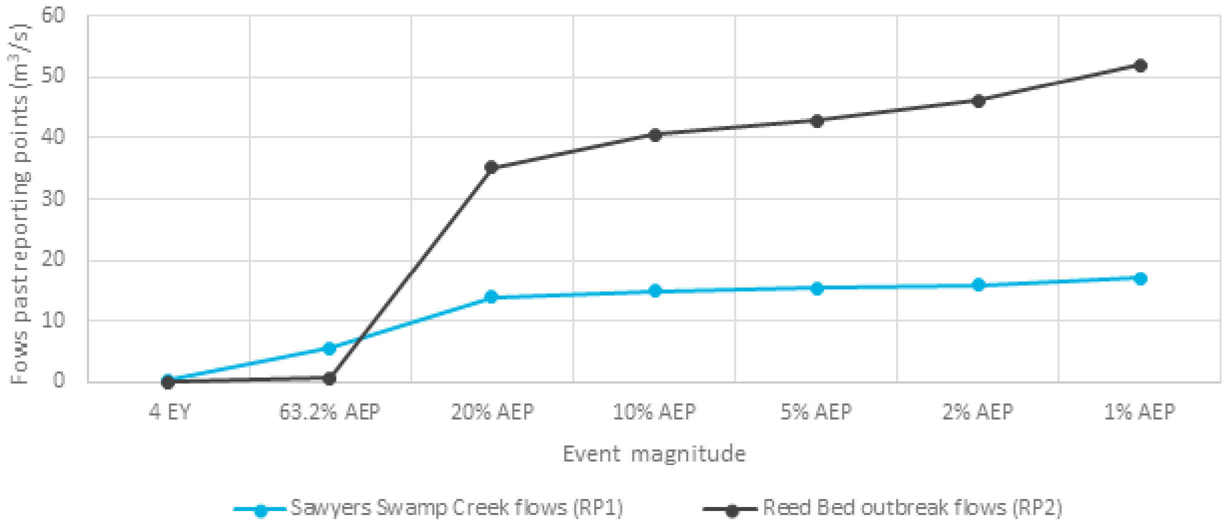

Figure 5.2 Simultaneous flows through current SSC and towards the historic SSC alignment (Design scenario)

5.3.2 Key flood risks

Risks associated with potential scouring of ash backfill beneath the current day Kerosene Vale Coal Stockpile area and potential scouring of the KVAR buttress wall is discussed in the main report of the Progressive Rehabilitation Plan (PRP). In terms of scour and velocity related risks for the Stage 1 SSC realignment, discussion on these flood risks will be limited to the proposed channel concept design only.

Flood mapping of peak flood velocity is included in Annexure D and Annexure E. The mapping shows generally that:

- Flood velocities through the Stage 1 SSC realignment in the Design scenarios are more consistent along the proposed realignment reach due to the uniformity of the conceptual design channel relative to the non-uniform and more naturalised channel geometry in the current alignment.

- Increases in flood velocity are minor for lower magnitude events (such as the 63.2% AEP, refer Table 5.3) with increases to velocity observed with larger magnitude events (such as the 20% AEP and above, refer Table 5.3).

Table 5.3 on the following page compares modelled flows at RP1 within the Stage 1 SSC realignment for Existing and Design scenarios across the 63.2%, 20% and 1% AEP events against maximum permissible velocities derived from industry standard sources. It can be seen that both the Existing and Design flows can be considered to be higher than permissible velocities associated with channel lining of grass media (refer Table 5.3).

Velocities that exceed the maximum permissible velocity conditions for vegetated linings, particularly the higher velocities (~10% increase) that result from the conceptual design of the Stage 1 SSC realignment, will likely need to be controlled by channel lining that include an element of engineering control such as placed rock or high performance bonded plastic fibres. Note that the high performance bonded plastic fibres example has been included as an indicative reference from Landcom (2004), and that other linings such as rock armouring, cellular confinement and other geotextile linings can be considered in place of this example. Additionally, geometry adjustments can be considered such as base width widening in the detailed design phase to reduce velocities within the channel.

Table 5.3 Maximum permissible velocities vs modelled flood velocity at RP1

Channel lining type	Maximum permissible velocity (m/s)	63.2% AEP – Peak flood velocity at RP1 (m/s)		20% AEP – Peak flood velocity at RP1 (m/s)		1% AEP – Peak flood velocity at RP1 (m/s)	
Reference values		Existing	Design	Existing	Design	Existing	Design
Bare soil	0.5[1]	1.51	1.46 (-3%)	1.79	1.94 (+8%)	1.85	2.02 (+9%)
Cobbles to rocks (d50=150 mm)	1.8[2]						
Riprap (d50 = 300 mm)	2.8[2]						
High performance bonded plastic fibres (vegetated)	5.0[3]						

1. Chow (1981)
2. Permissible channel velocity and bed shear stress derived from Fischenich (2001)
3. Table 5.2, page 524 of Landcom (2004), assuming inundation <24 hours and moderate soil erodibility.

5.3.3 Suitability of the Stage 1 SSC realignment concept design

The results presented in this section indicate that there are minor changes to the hydraulics (both flood depth and velocity) of SSC as a result of the introduction of Stage 1 SSC realignment, confirming proof of concept design for the proposed creek realignment and adjacent KVAR buttress works. Selection of suitable channel lining to cater for expected flow velocities will be required as part of the future detailed design. The result outcomes are provided on the basis that:

- Depth of flood flow through Sawyers Swamp Creek immediately north of KVAR at RP1 are kept relatively consistent relative to the Existing scenario, as demonstrated by a maximum difference of 2% increase (refer Table 5.1). Velocities are minor for low magnitude events with approximately 10% increase in flood velocity for larger magnitude events, with resultant flood velocities being manageable through channel lining options such as those included in Landcom (2004) (refer Table 5.3).

- Flows diverted from the Reed Bed towards the historic SSC alignment at RP2 are kept relatively consistent relative to the Existing scenario, as demonstrated by a maximum difference of 1% decrease during the Design scenario (refer Table 5.2). Furthermore, Figure 5.1 and Figure 5.2 indicate no identifiable change to direction of flow between the Stage 1 SSC realignment and the Reed Bed overtopping that enables flows towards the historic SSC alignment.

5.4 Recommendations

As part of the modelling exercise carried out as part of this report, the following recommendations were identified by EMM:

- Future design scenarios should include a single landform design from the SSCAD spillway to the Haul Road downstream of KVAR and the Stage 1 SSC realignment area such that ‘patching’ of different data sources and associated topographic modification is minimal.

- The model results and impact assessment presented in this report provide a proof of concept for the conceptual design of the Stage 1 SSC realignment and KVAR buttress, future modelling should increase the base width and look to reduce channel batter gradient (where possible within the space available) as part of the next stage of the project to minimise high velocity, bed shear stress and increase stability of the Stage 1 realignment.

- Designs that consider channel stability such as rock armouring or cellular confinement using mesh media (or multi-control stabilisation methods) should be favoured to further dissipate energy of water passing through the Stage 1 realignment.

5.5 Next steps

This report and associated flood model are considered to form the first iteration of the flooding assessment and should be updated as part of future detailed design. Some recommendations for updates in the next phase are:

- Flood estimation in and around the realignment should be based on detailed design rather than conceptual design.
- Elevations within the model domain should be based on topographic survey that covers the site in greater detail, that is, captures the entire model domain in a single survey. The 2024 LIDAR survey information was completed during the preparation of this assessment and hence was not able to be considered.
- The flooding assessment should be expanded to consider a wider spectrum of options in and around the site, that is, several design options instead of a singular option.

Potential residual risks to be further considered as part of future detailed design include:

- **Bank stability** – scouring of either the Kerosene Vale Coal Stockpile area bank or buttress design.
- **Velocities within channel** – need to be mitigated with channel design such as implementing controls to flow like rock armouring and cellular confinement (refer 5.3.2).

6 Summary

This report details the hydrologic model (Chapter 3) and hydraulic model (Chapter 4) that was used to consider flood impact for a conceptual design of the Stage 1 SSC realignment..

The hydraulic model results discussed in Chapter 5, which are included as mapped results in Annexure B through Annexure I, has established a baseline (existing) scenario and a design scenario for the Stage 1 SSC realignment. The results and analysis of flood afflux suggests only low and localised impact to peak flood depth and velocity around the realignment works that is limited to upstream of the culvert under the Haul Road (refer to Chapter 5).

7 References

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PB 2008, *Sawyers Swamp Creek Draft Rehabilitation Plan*, Parsons Brinckerhoff – prepared for GPM.

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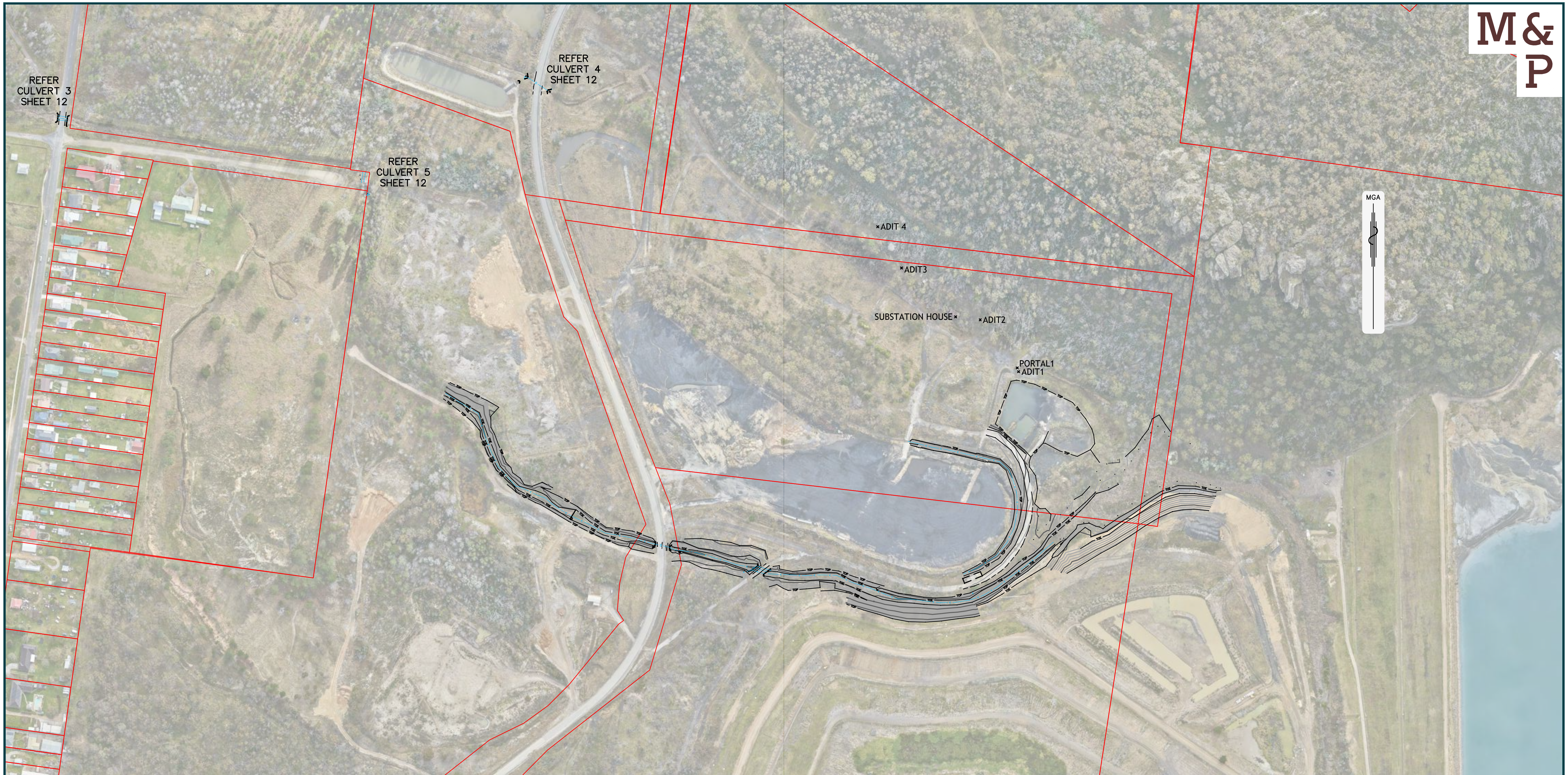
WSP 2024, *Buttress and Sawyers Swamp Creek Temporary Diversion Concept Design Drawing files* – prepared for GPM.

Annexure A

Survey information (M&P 2023)

EMM
creating opportunities



SURVEY INFORMATION

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   E 228806.895 N 6301710.749
   –SOURCE OF CO–ORDINATES: SCIMS
   –DATE 26/10/2023

2. ALL REDUCED LEVELS ARE ON AUSTRALIAN HEIGHT DATUM (A.H.D)

   –ORIGIN OF LEVELS SSM 92479. RL897.056
   –SOURCE OF REDUCED LEVELS: SCIMS
   –DATE OF REDUCED LEVELS 26/10/2023

3. CONTOUR INTERVAL IS 0.5m.

4. MGA AND ISG CO–ORDINATE SYSTEMS ARE BASED ON A MATHEMATICAL EARTH MODEL AND SUBJECT TO VARIABLE SCALE FACTORS. DISTANCES CALCULATED FROM CO–ORDINATES MAY VARY SIGNIFICANTLY FROM GROUND MEASUREMENTS. IF FURTHER CLARIFICATION IS REQUIRED CONTACT MONTEATH AND POWYS.

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LINE TYPES

DRAIN PIPE
DISH DRAIN
EDGE OF CONCRETE
TOP OF BANK
TOE OF BANK
EDGE OF BITUMEN
EDGE OF GRAVEL

SYMBOLOGY

INVERT LEVEL

ADITS OR OTHER ENTRANCES

POINT	EASTING	NORTHING	LEVEL
ADIT 1	229938.917	6302452.429	904.06
PORTAL 1	229937.665	6302456.329	903.96
ADIT 2	229899.435	6302505.844	902.51
SUBSTATION HOUSE	229874.087	6302508.827	902.34
ADIT 3	229818.431	6302559.174	902.39
ADIT 4	229793.848	6302601.643	901.13

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REDUCTION RATIO – 1:4000 (A3)

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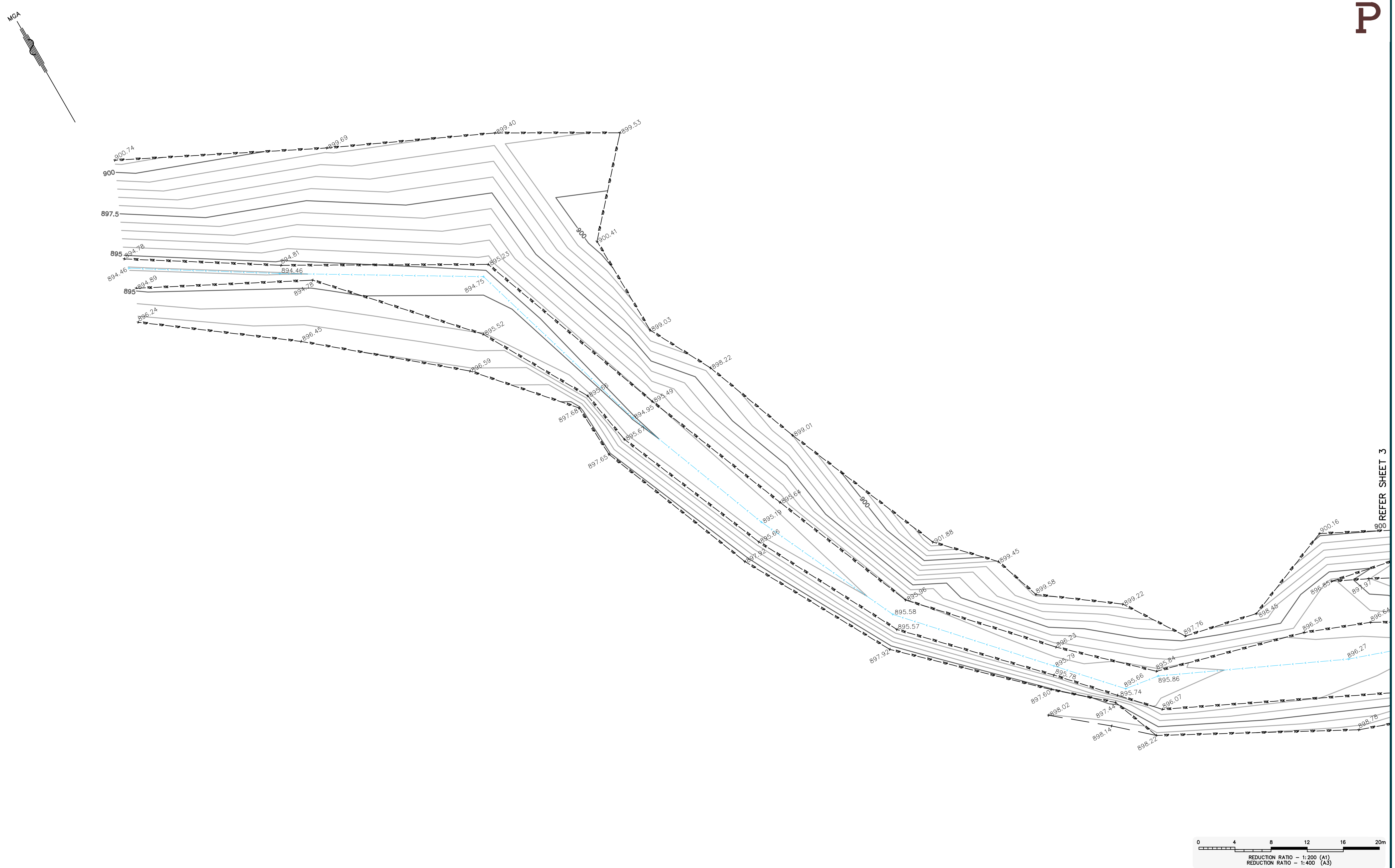

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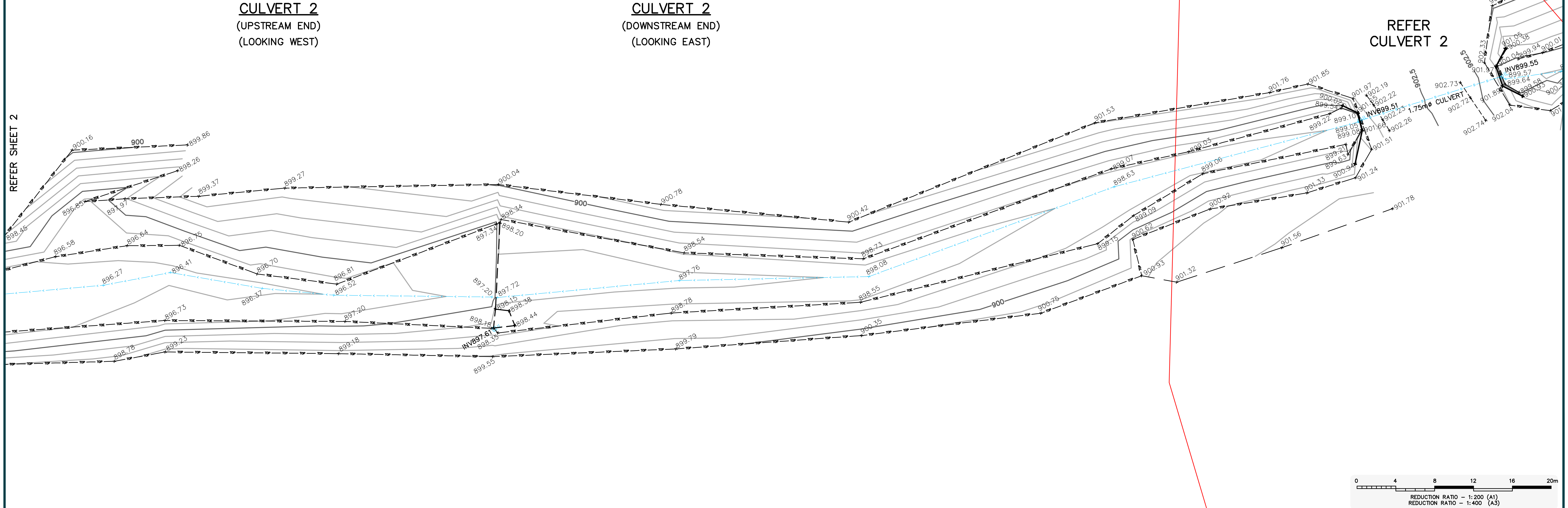

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(LOOKING WEST)

CULVERT 2
(DOWNSTREAM END)
(LOOKING EAST)

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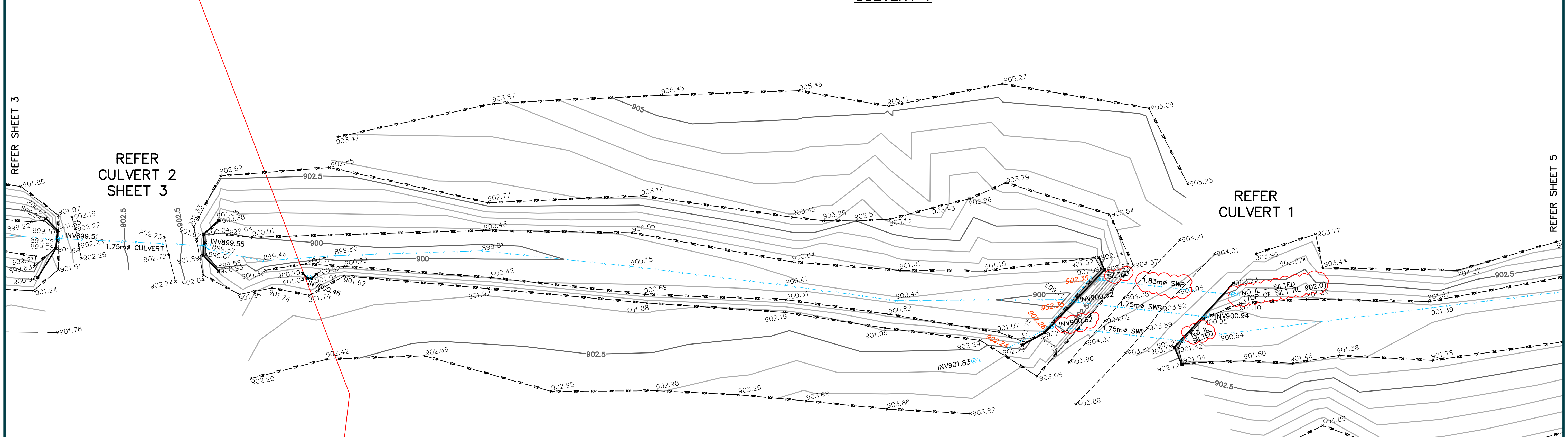

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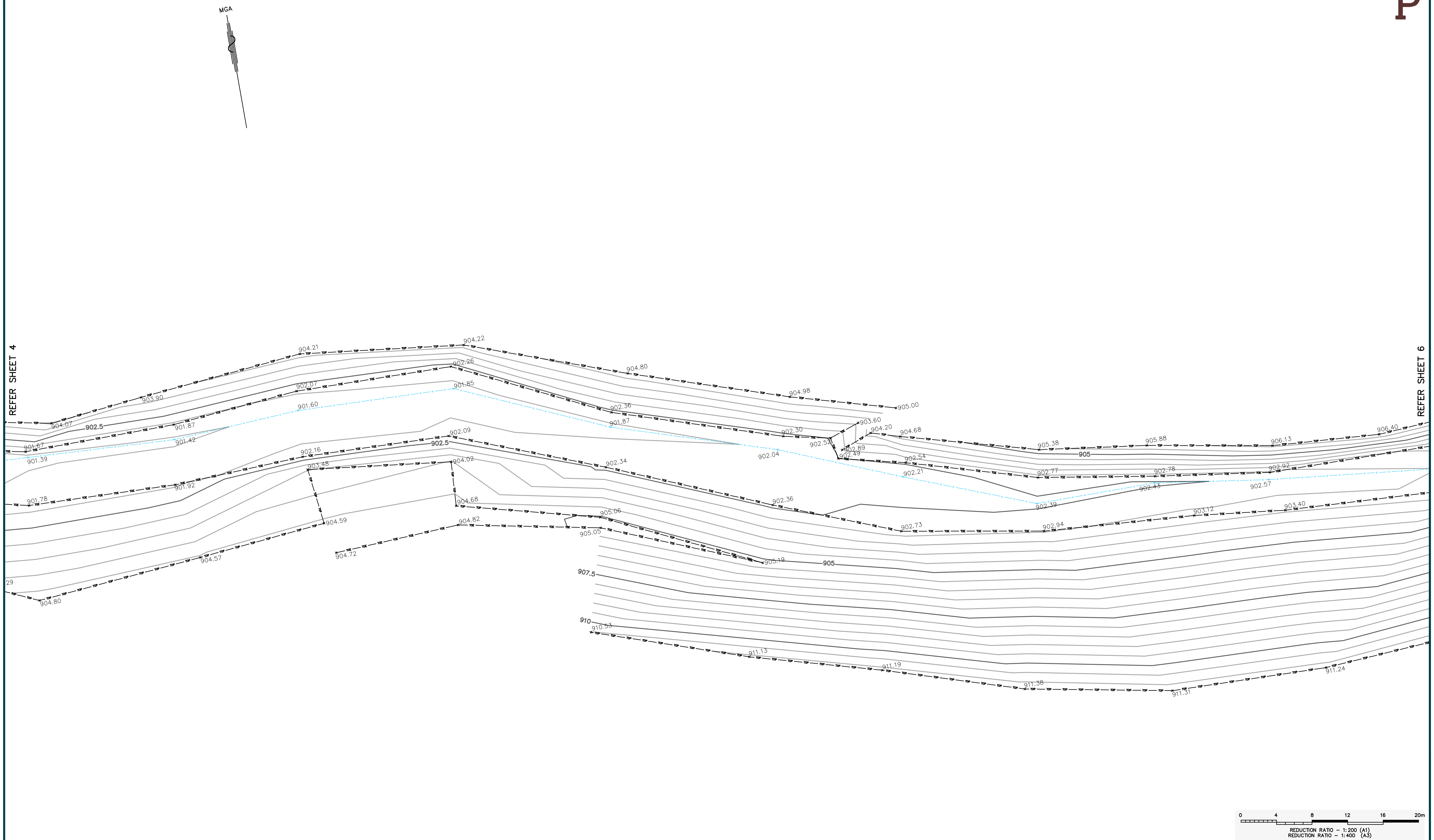

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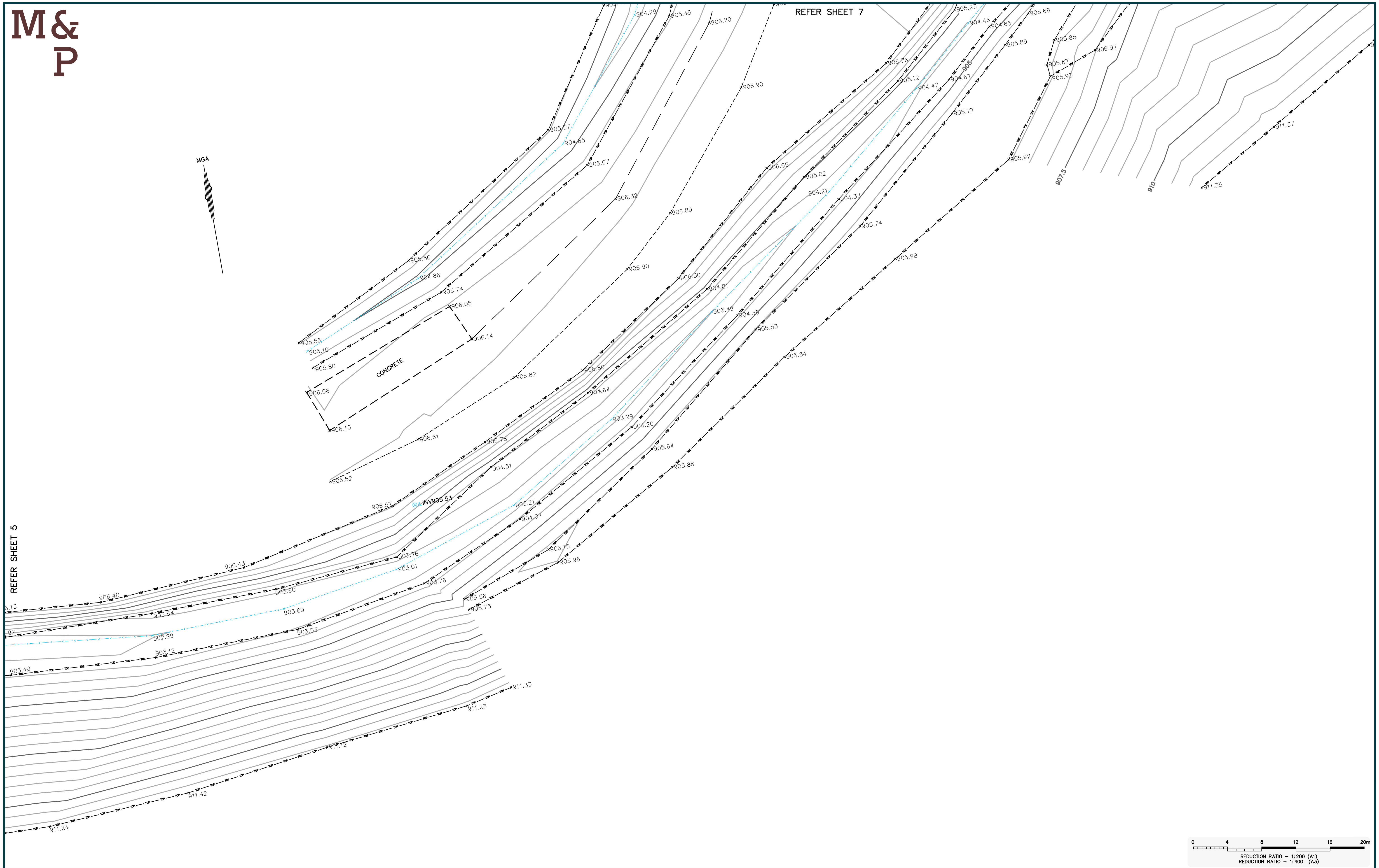

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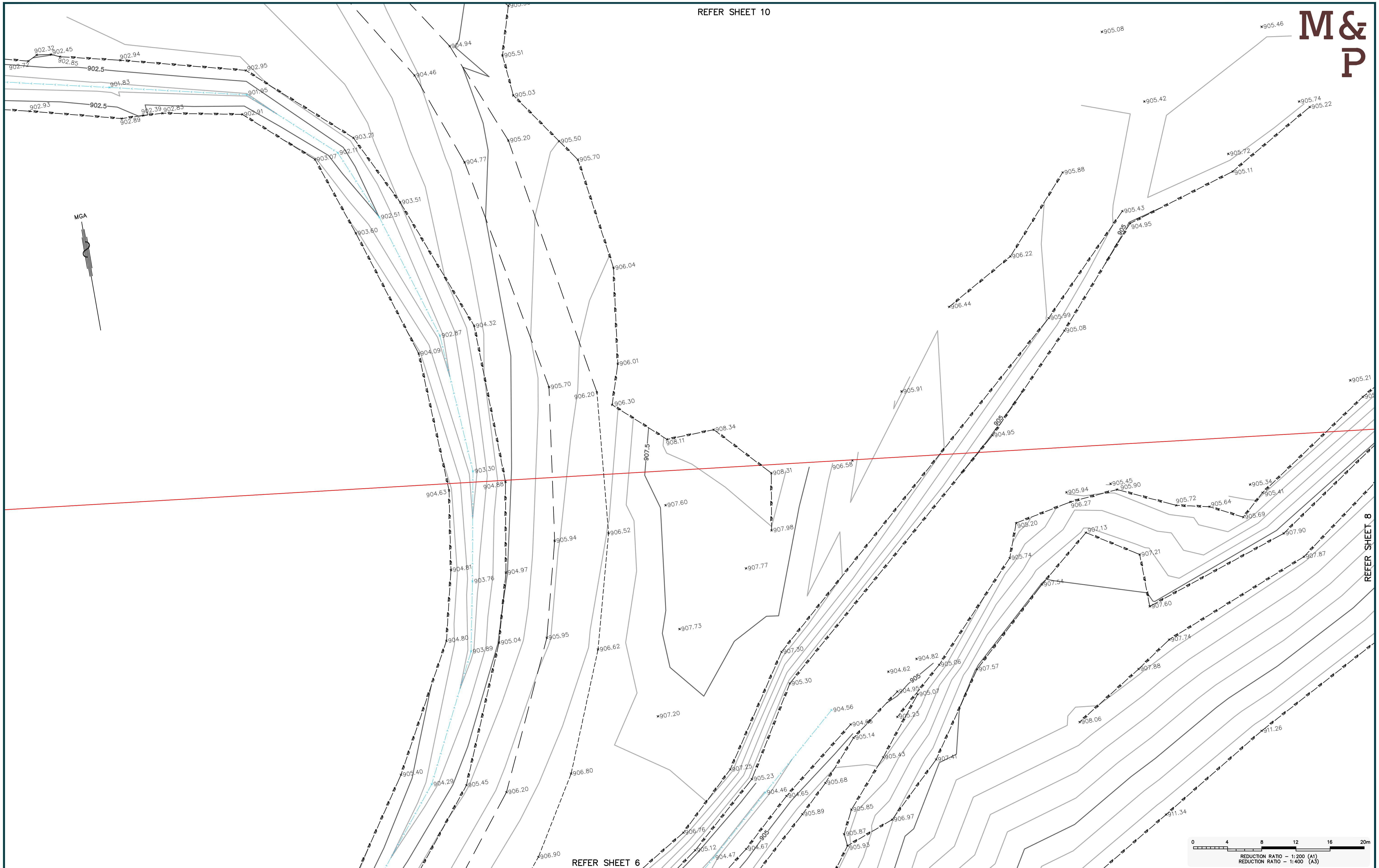

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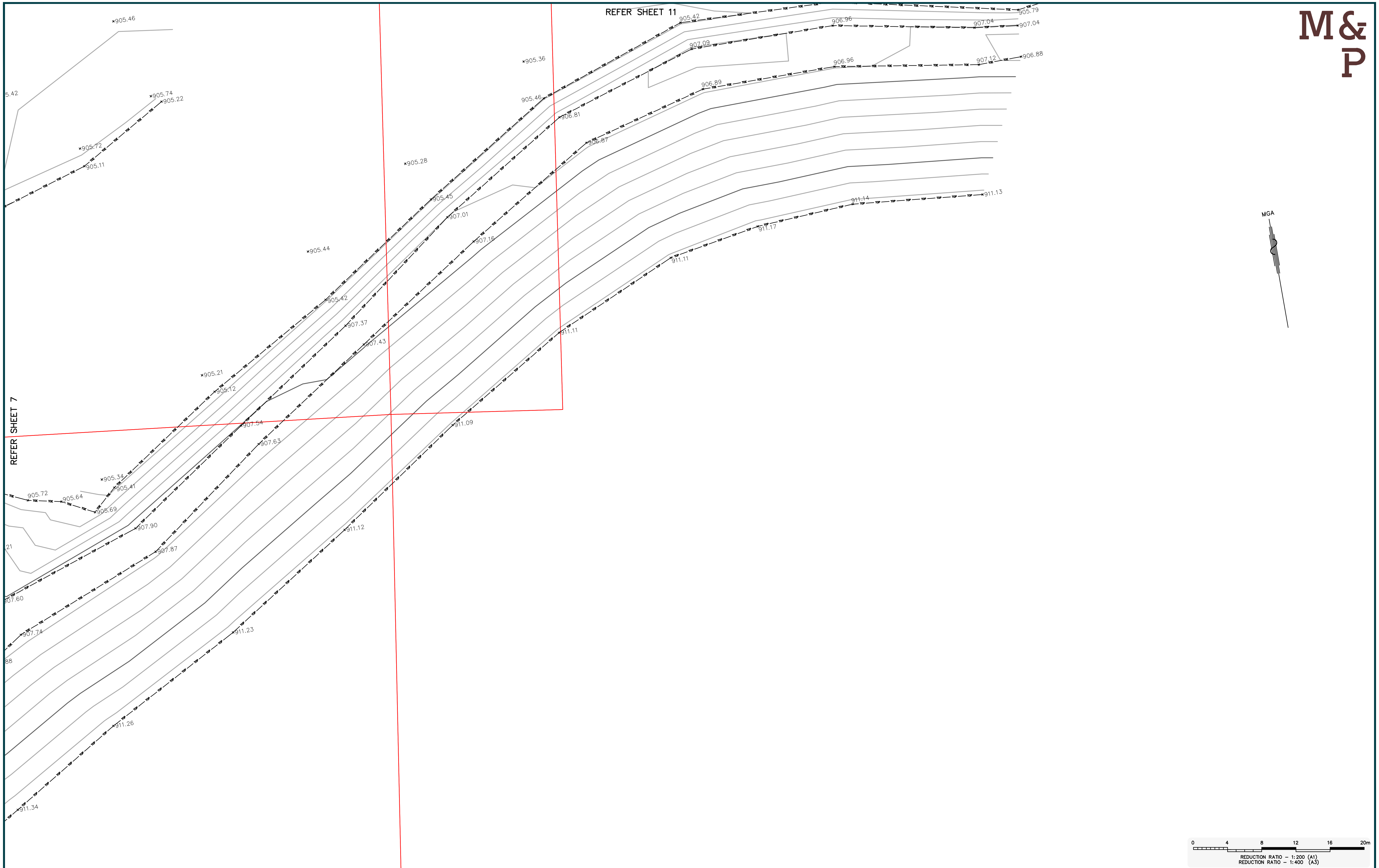

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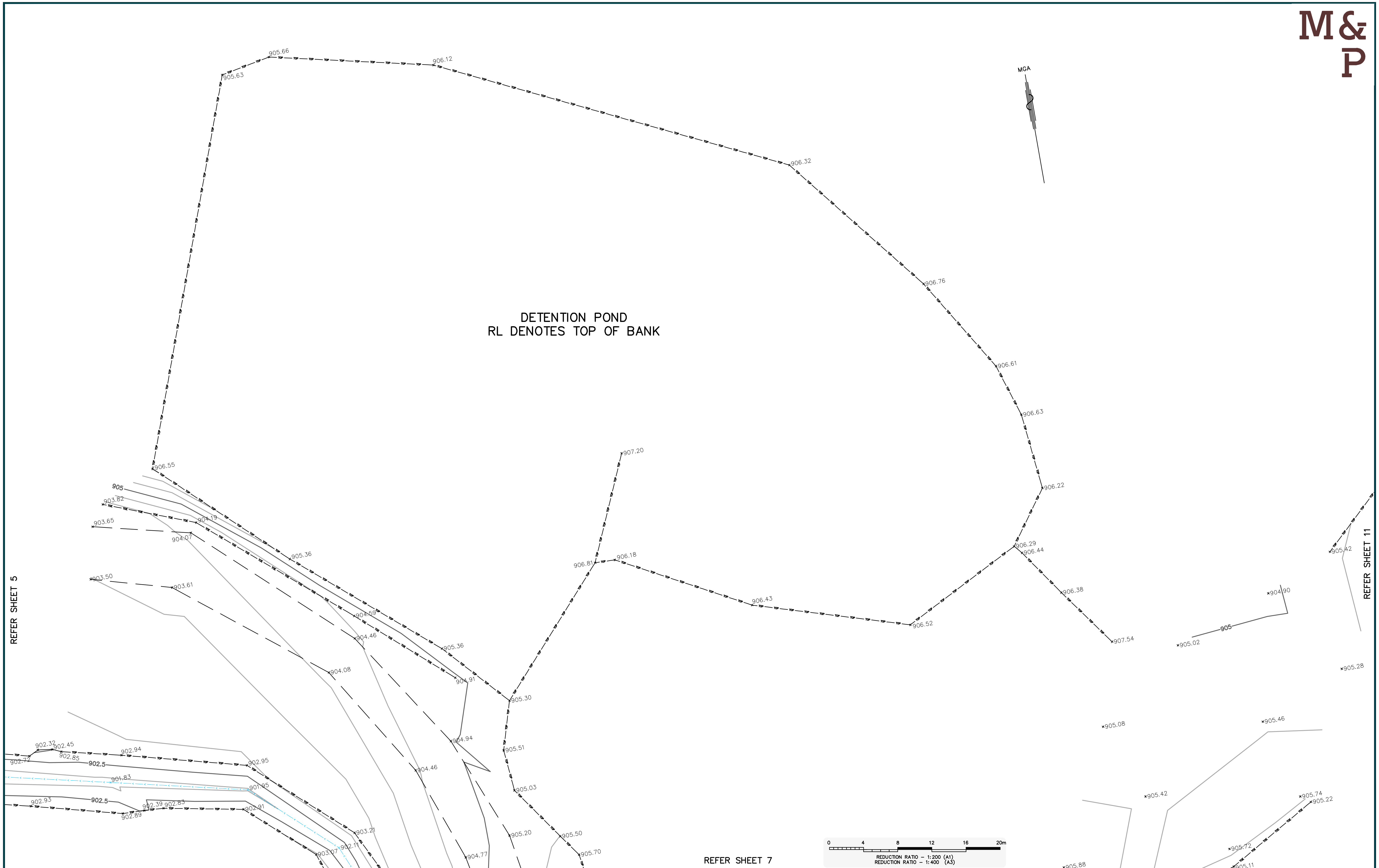
Sheet No. 9 / 12

Revision 2



REVISIONS					
No	REVISION	SVY	DFT	CHK	DATE
2	CULVERT 1 AND CULVERT 3 REVISED - SEE REVISION CLOUDS	JMS	MAK	BJW	23/12/23
1	ISSUE TO CLIENT	JMS	MAK	BJW	16/11/23

Monteath & Powys
PLANNING PROJECT MANAGEMENT SURVEYING 3D SPATIAL
monteathpowys.com.au
P (02) 4926 1388
NEWCASTLE SYDNEY GUNNEDAH MUSWELLBROOK

Surveyed	Drafted	Checked
JMS	MAK	BJW

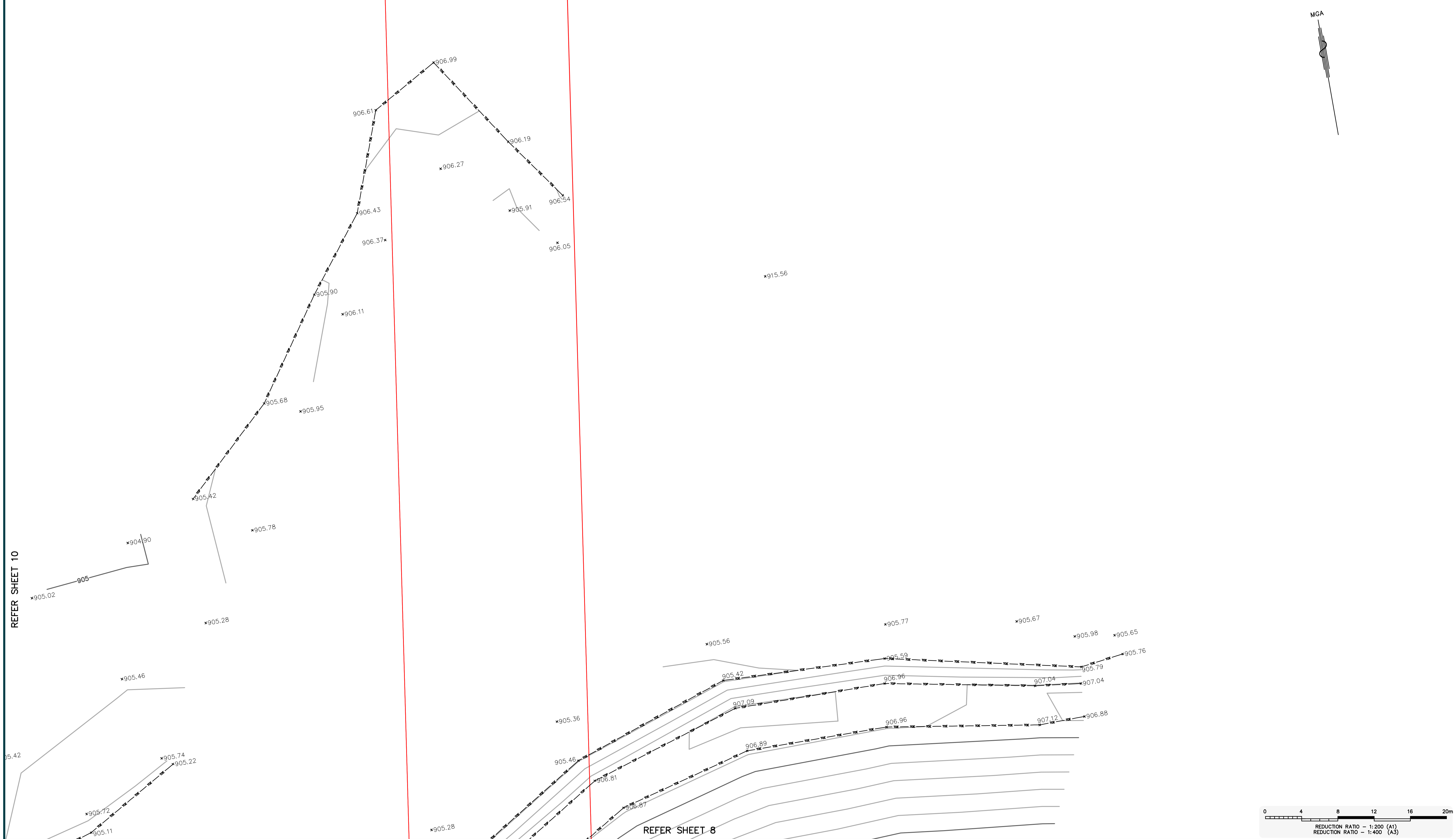
REGISTERED SURVEYOR
@A1 : 1:200
@A3 : 1:400
Original Size A1
DO NOT SCALE

Client: GPM

Title: DETAIL SURVEY OF CREEK & CULVERTS
WALLERAWANG POWER STATION
LIDSDALE

CAD File: 200014N_02 | Ref No: 20/0014 | Date: 13/11/2023

Sheet No. 10 / 12
Revision 2



No	REVISION	SVY	DFT	CHK	DATE
2	CULVERT 1 AND CULVERT 3 REVISED - SEE REVISION CLOUDS	JMS	MAK	BJW	23/12/23
1	ISSUE TO CLIENT	JMS	MAK	BJW	16/11/23

REVISIONS

Monteath & Powys

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NEWCASTLE SYDNEY GUNNEDAH MUSWELLBROOK

Surveyed	Drafted	Checked
JMS	MAK	BJW

REGISTERED SURVEYOR
@A1 : 1:200
@A3 : 1:400

Original Size: A1

DO NOT SCALE

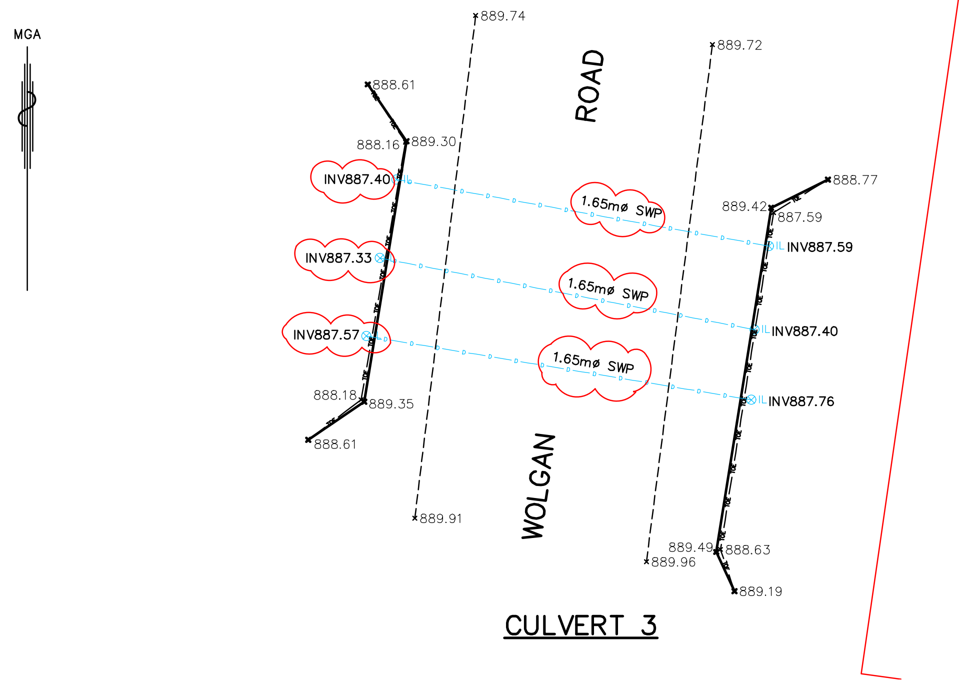
Client: GPM

Title: DETAIL SURVEY OF CREEK & CULVERTS
WALLERAWANG POWER STATION
LIDSDALE

CAD File: 200014N_02
Ref No: 20/0014
Date: 13/11/2023

Sheet No. 11/12

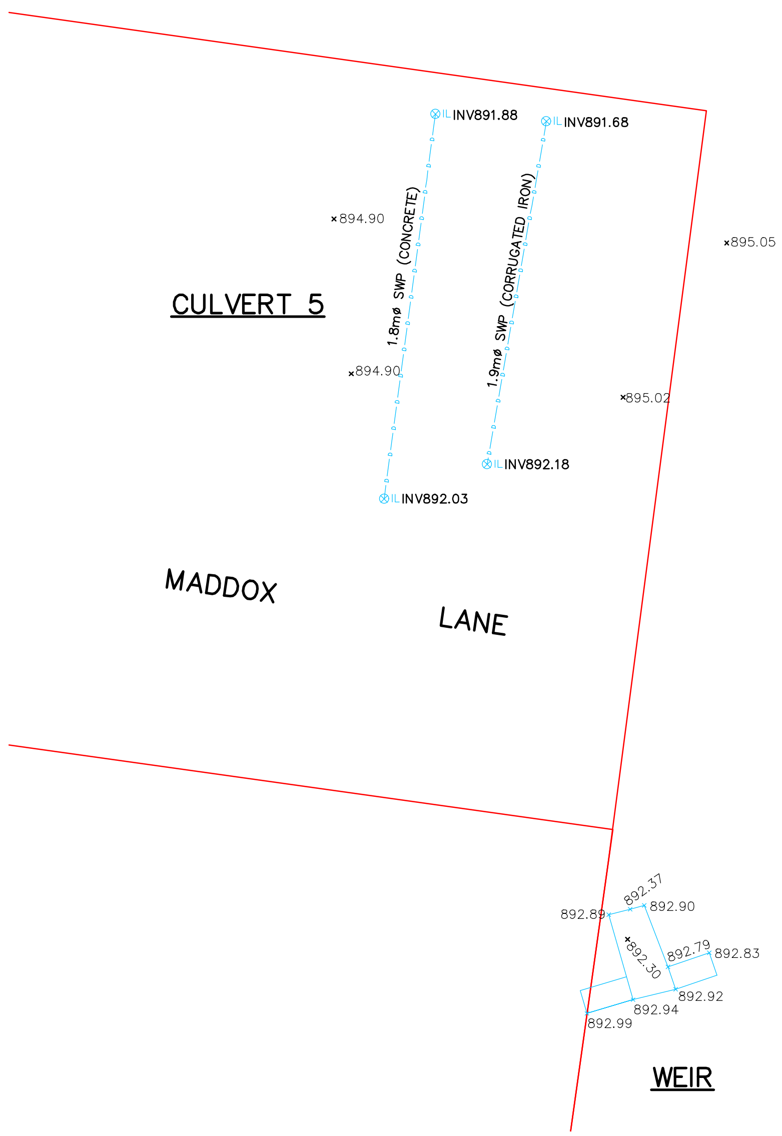
Revision 2



CULVERT 3

CULVERT 3
(DOWNSTREAM END)
(LOOKING EAST)

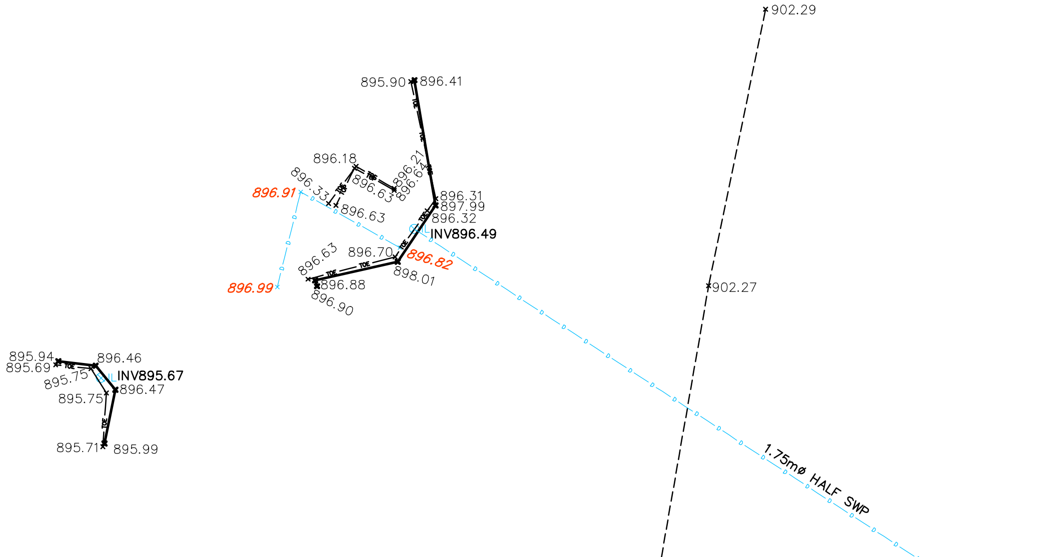
CULVERT 3
(UPSTREAM END)
(LOOKING WEST)

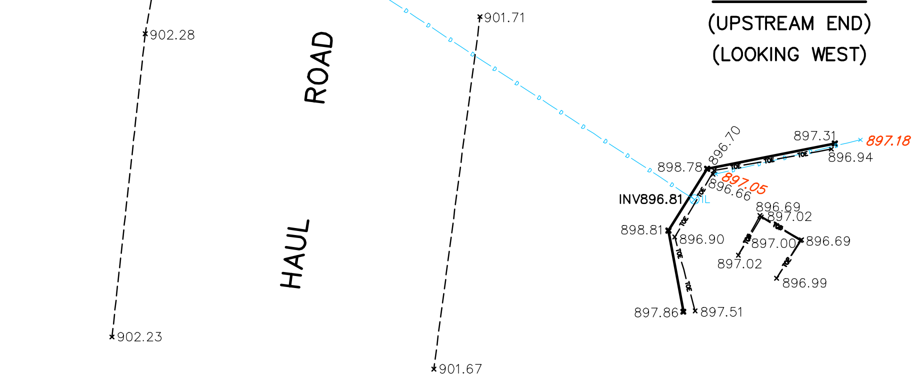


CULVERT 5

WEIR

NOTE
XXX.XX – HEIGHTS SHOWN IN RED ARE ON TOP OF THIS PIPE.





CULVERT 4
(UPSTREAM END)
(LOOKING WEST)

CULVERT 4
(DOWNSTREAM END)
(LOOKING EAST)

CULVERT 4

CULVERT 5
(UPSTREAM END)
(LOOKING NORTH)

CULVERT 5
(DOWNSTREAM END)
(LOOKING SOUTH)

WEIR
(0.7 WIDE x 0.31 DEEP)
(LOOKING SOUTH)

0 2 4 6 8 10m
REDUCTION RATIO – 1:100 (A1)
REDUCTION RATIO – 1:200 (A3)

REVISIONS

No	REVISION	SVY	DFT	CHK	DATE
2	CULVERT 1 AND CULVERT 3 REVISED - SEE REVISION CLOUDS	JMS	MAK	BJW	23/12/23
1	ISSUE TO CLIENT	JMS	MAK	BJW	16/11/23

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P (02) 4926 1388
NEWCASTLE SYDNEY GUNNEDAH MUSWELLBROOK

Surveyed	Drafted	Checked
JMS	MAK	BJW

REGISTERED SURVEYOR
@A1 : 1:100
@A3 : 1:200
Original Size A1
DO NOT SCALE

Client: GPM

Title: DETAIL SURVEY OF CREEK & CULVERTS
WALLERAWANG POWER STATION
LIDSDALE

CAD File: 200014N_02 | Ref No: 20/0014 | Date: 13/11/2023

Sheet No. 12 / 12
Revision 2

Annexure B

Existing Scenario - Peak flood depth

EMM creating opportunities

KEY

TUFLOW model domain

Maximum water depth (m)
- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment
- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY
- Major road
- Study area
- Realignment area

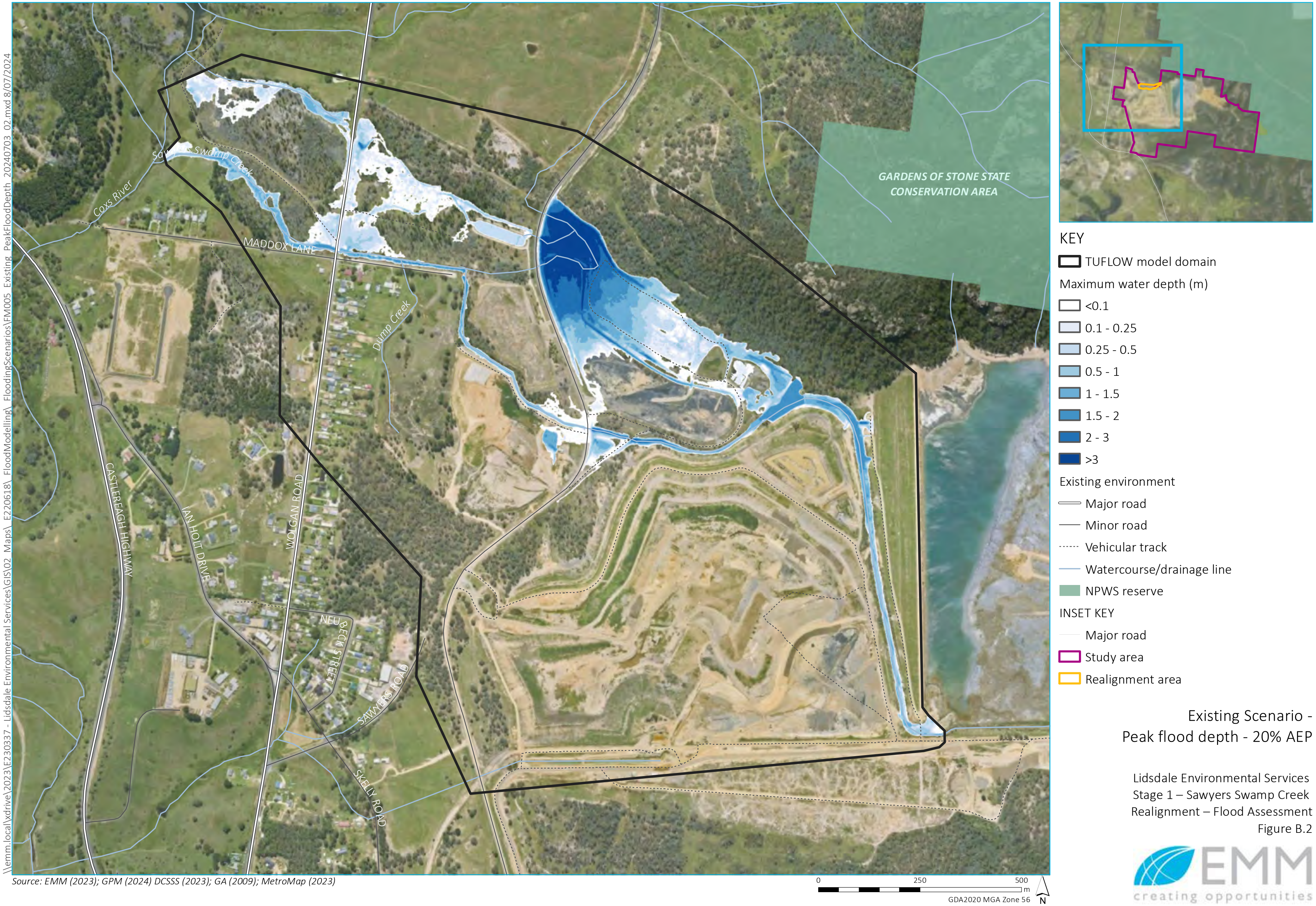
Existing Scenario -
Peak flood depth - 63.2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure B.1

EMM
creating opportunities

Source: EMM (2023); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2023)

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02 Maps\ E220618\ FloodModelling\ FloodingScenarios\FM005 Existing PeakFloodDepth 20240703 02.mxd 8/07/2024



Source: EMM (2023); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2023)

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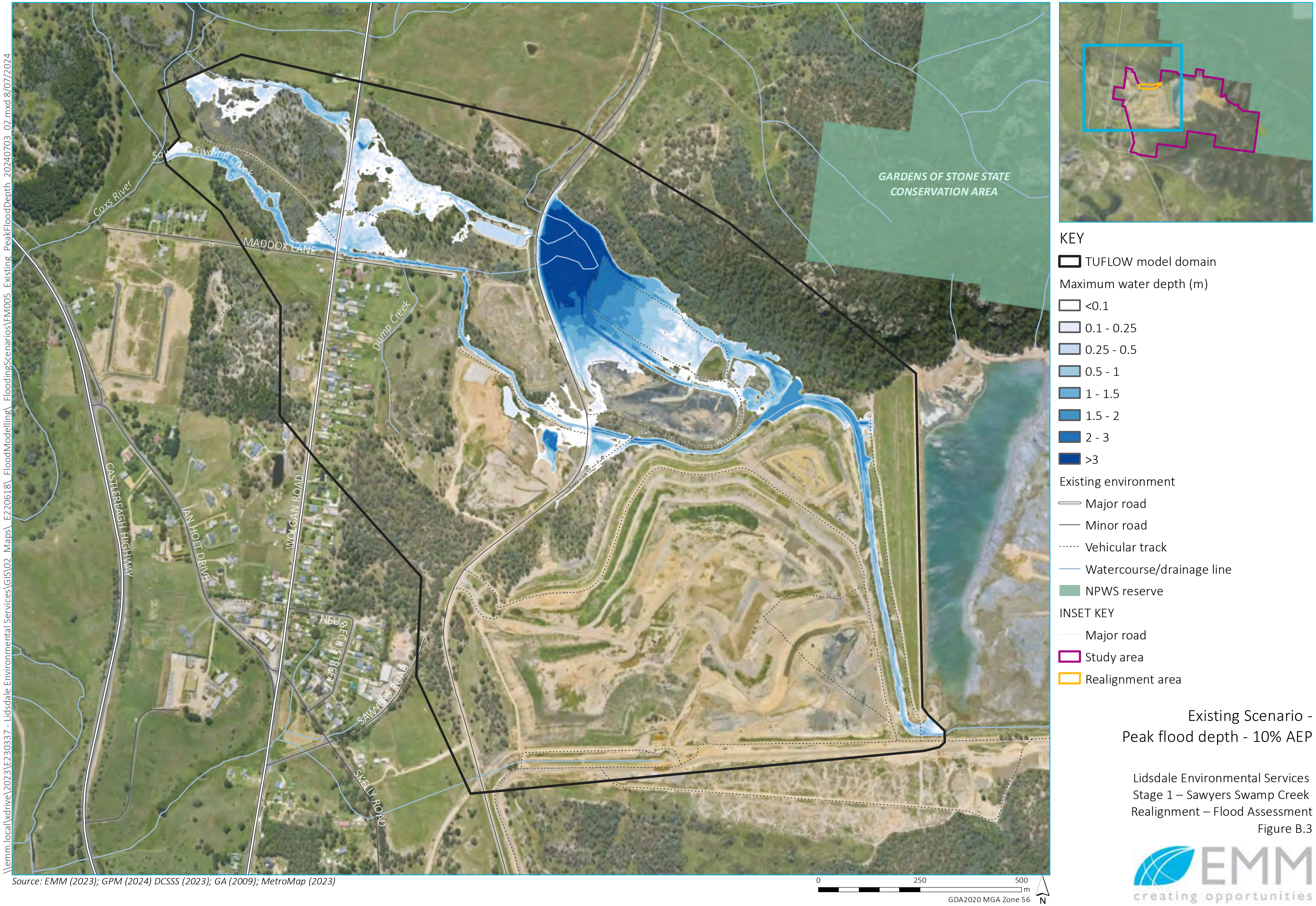
Existing Scenario -
Peak flood depth - 20% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure B.2

EMM
creating opportunities



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Source: EMM (2023); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2023)

KEY

TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario -
Peak flood depth - 10% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure B.3

EMM
creating opportunities

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KEY

TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Source: EMM (2023); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2023)

0 250 500 m

GDA2020 MGA Zone 56

N

Existing Scenario -
Peak flood depth - 5% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure B.4

EMM
creating opportunities

KEY

TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario -
Peak flood depth - 2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure B.5

Source: EMM (2023); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2023)

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KEY

TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario -
Peak flood depth - 1% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure B.6

EMM creating opportunities

Source: EMM (2023); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2023)

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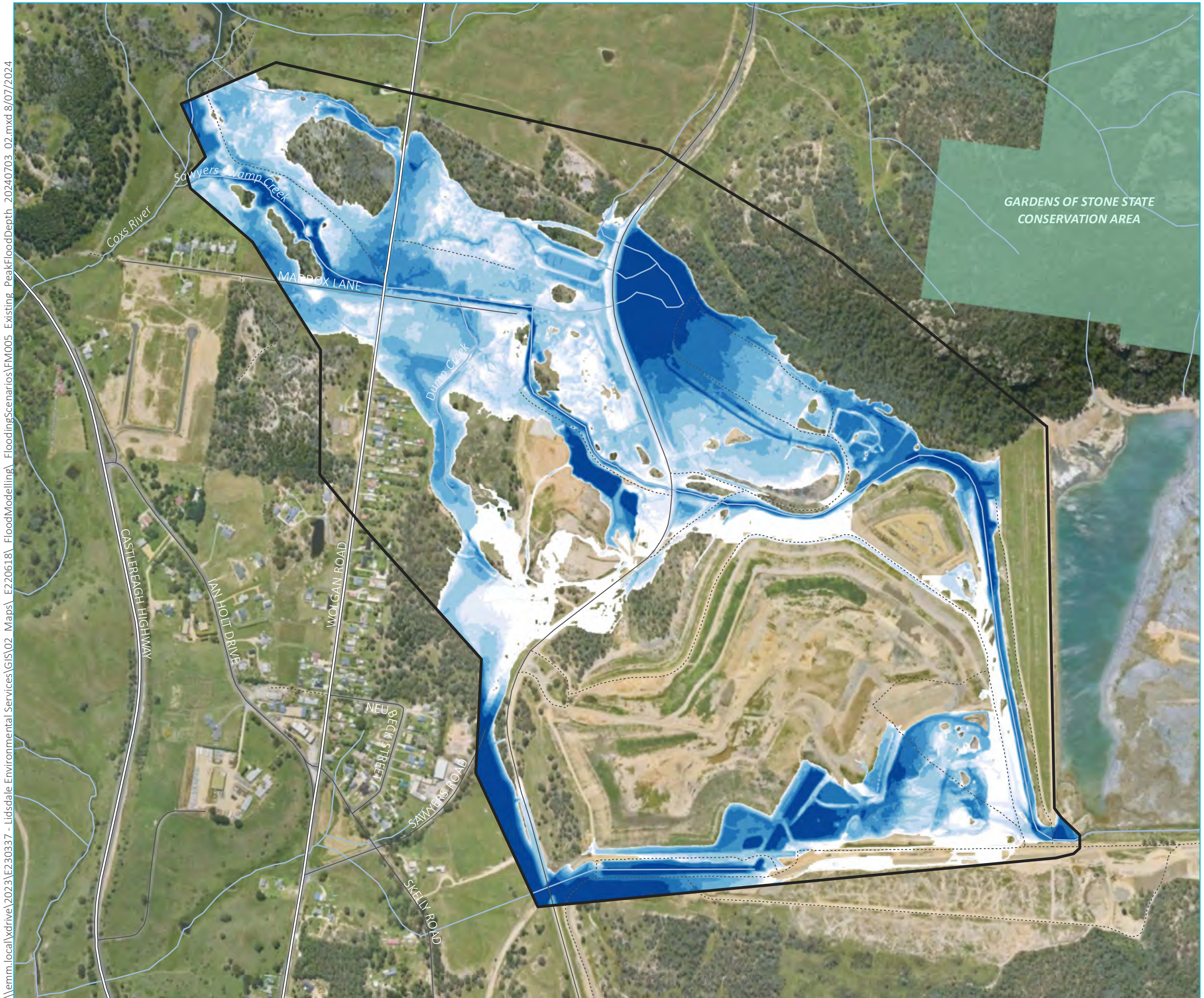

KEY

TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario -
Peak flood depth - PMF

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure B.7

Source: EMM (2023); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2023)

0 250 500 m
GDA2020 MGA Zone 56

N

EMM
creating opportunities

Annexure C

Design Scenario - Peak flood depth

EMM

creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood depth - 63.2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure C.1

EMM
creating opportunities

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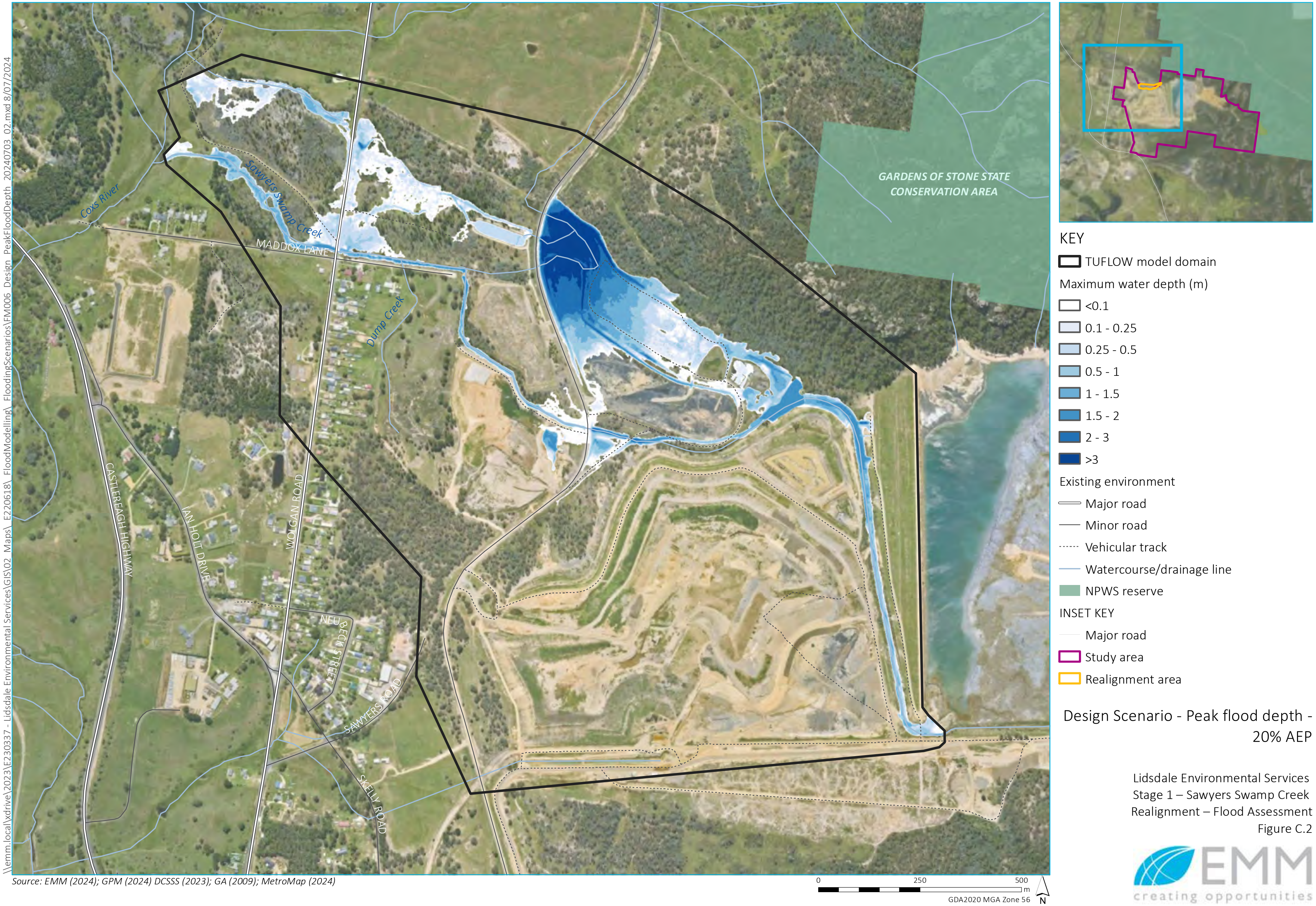

Design Scenario - Peak flood depth - 20% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure C.2

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m
GDA2020 MGA Zone 56
N

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM006_Design_PeakFloodDepth_20240703_02.mxd 8/07/2024

KEY

TUFLOW model domain

Maximum water depth (m)

<0.1

0.1 - 0.25

0.25 - 0.5

0.5 - 1

1 - 1.5

1.5 - 2

2 - 3

>3

Existing environment

Major road

Minor road

Vehicular track

Watercourse/drainage line

NPWS reserve

INSET KEY

Major road

Study area

Realignment area

Design Scenario - Peak flood depth - 10% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure C.3

creating opportunities

KEY

TUFLOW model domain

Maximum water depth (m)
- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment
- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY
- Major road
- Study area
- Realignment area

Design Scenario - Peak flood depth - 5% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure C.4

EMM
creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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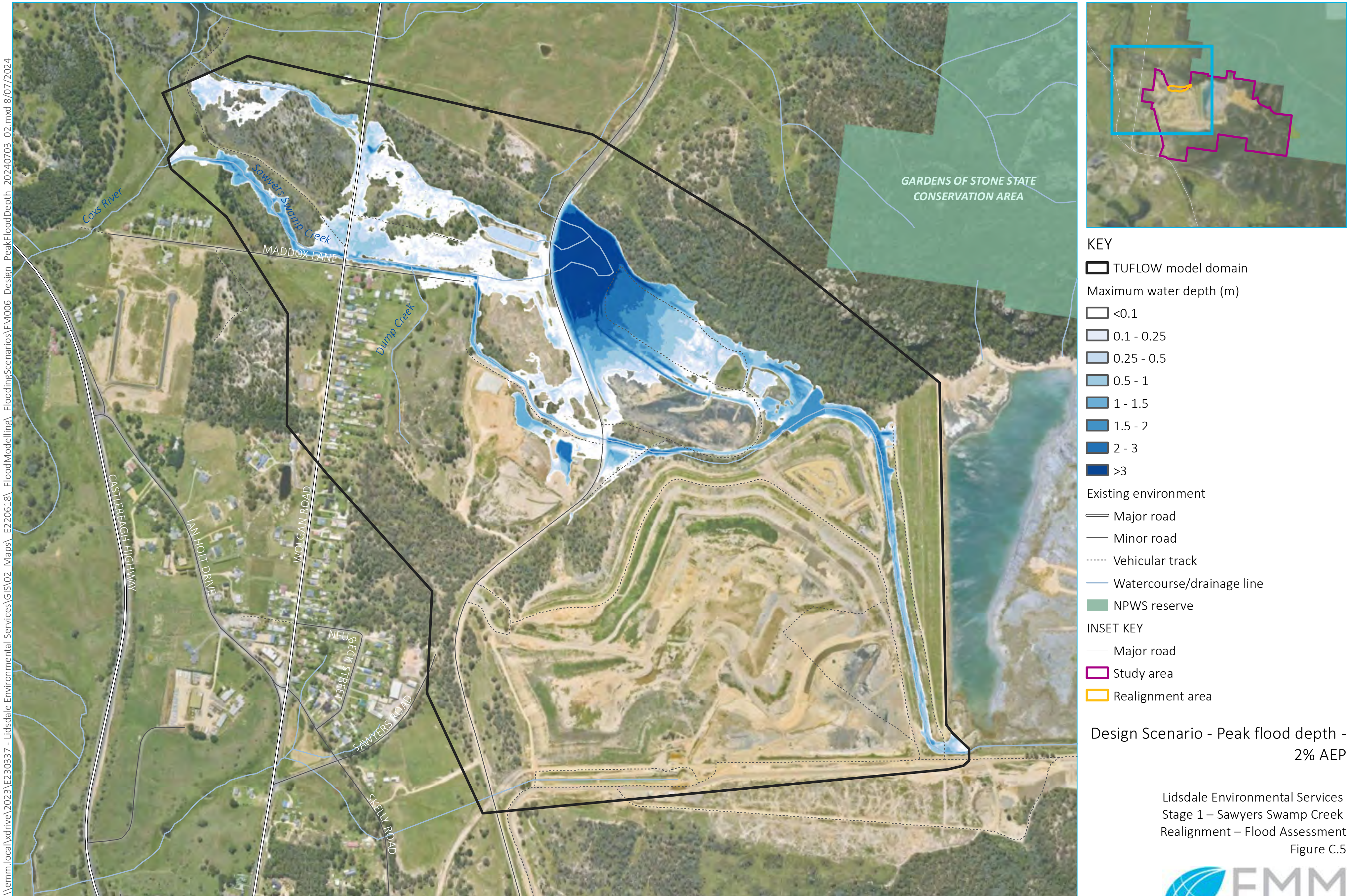

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood depth - 2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure C.5

EMM creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM006_Design_PeakFloodDepth_20240703_02.mxd 8/07/2024

KEY

- TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood depth - 1% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure C.6

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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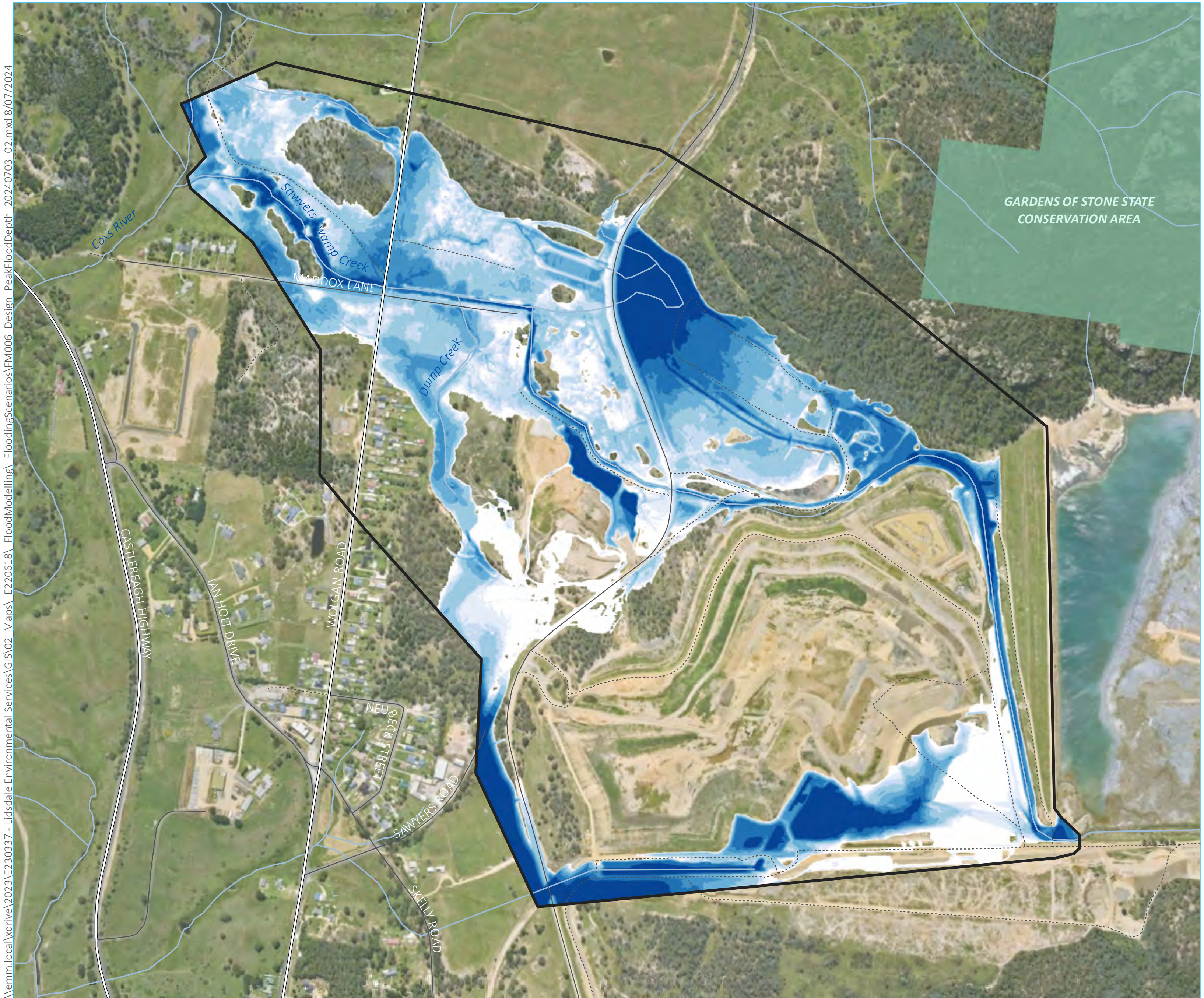
EMM
creating opportunities



KEY

TUFLOW model domain

Maximum water depth (m)

- <0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood depth - PMF

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure C.7

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m
GDA2020 MGA Zone 56
N

Annexure D

Existing Scenario - Peak flood velocity

EMM
creating opportunities

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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m

GDA2020 MGA Zone 56

N

KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood velocity - 63.2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure D.1

EMM
creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

- TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood velocity - 20% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure D.2

EMM creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM007_Existing_PeakFloodVelocity_20240703_02.mxd 8/07/2024

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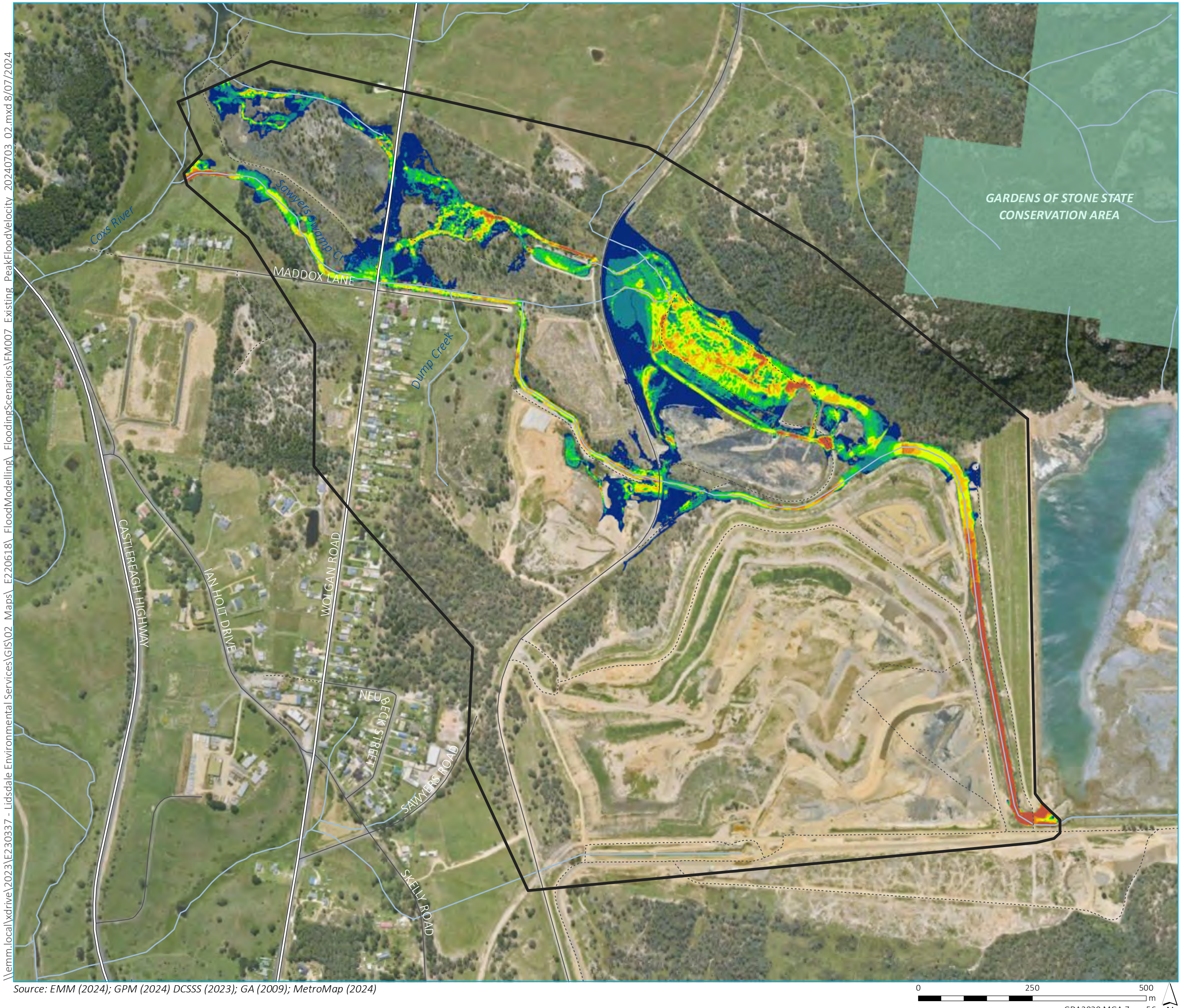


KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

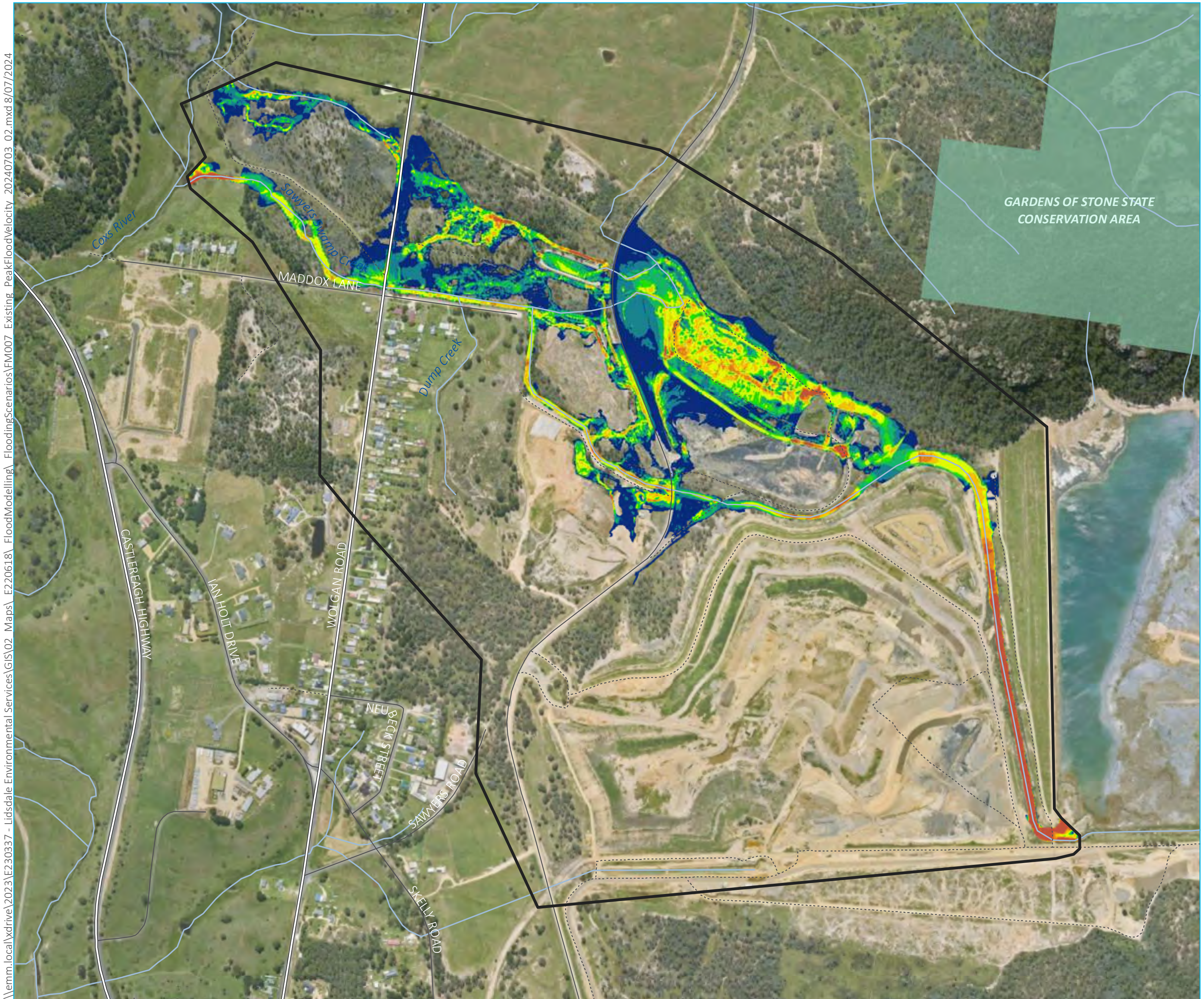
- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood velocity - 10% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure D.3

EMM creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)



Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

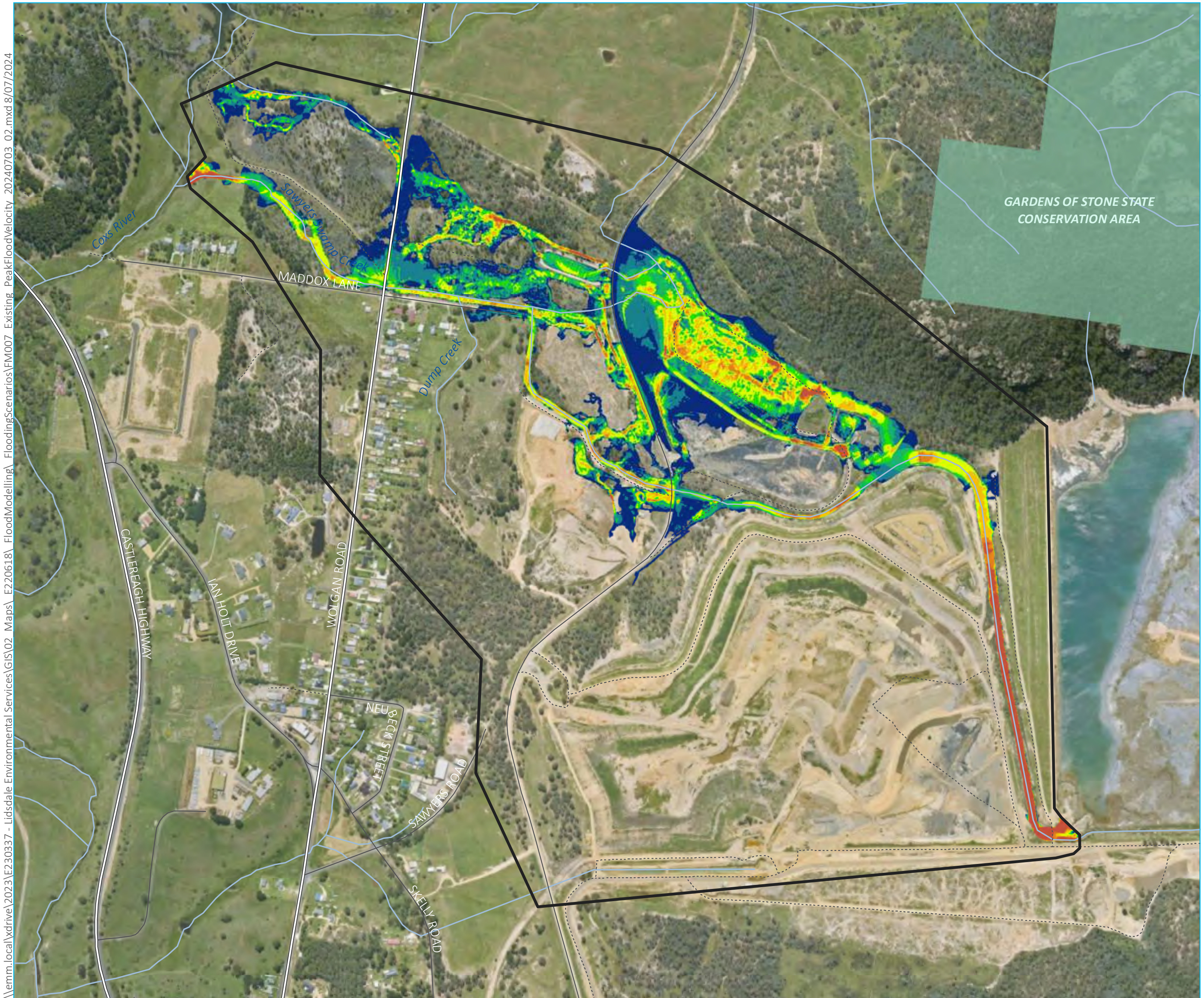
- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood velocity - 5% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure D.4

EMM creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM007_Existing_PeakFloodVelocity_20240703_02.mxd 8/07/2024



Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

- TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

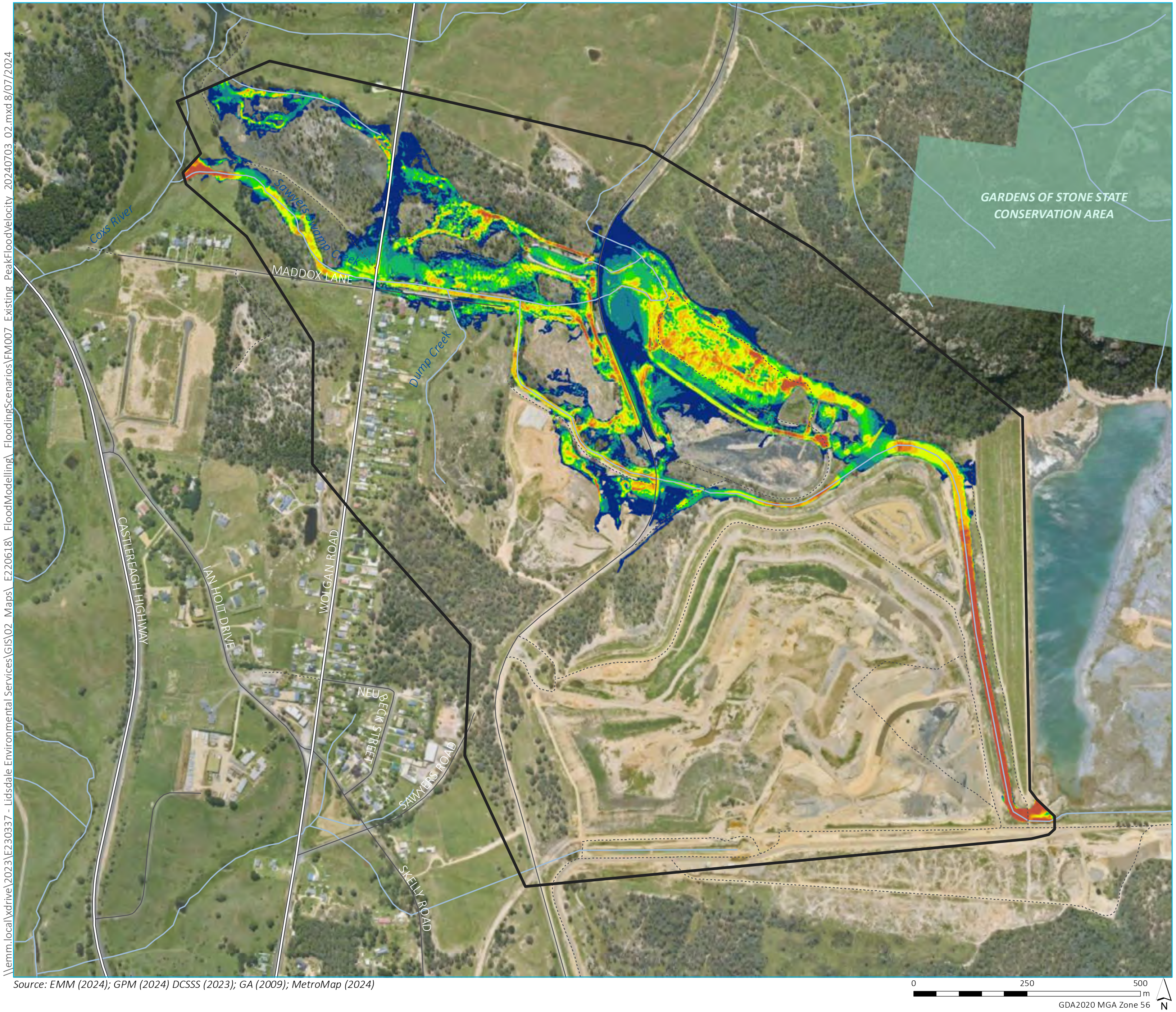
- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood velocity - 2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure D.5

EMM
creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02 Maps\ E220618\ FloodModelling\ FloodingScenarios\FM007 Existing PeakFloodVelocity 20240703 02.mxd 8/07/2024



KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood velocity - 1% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure D.6

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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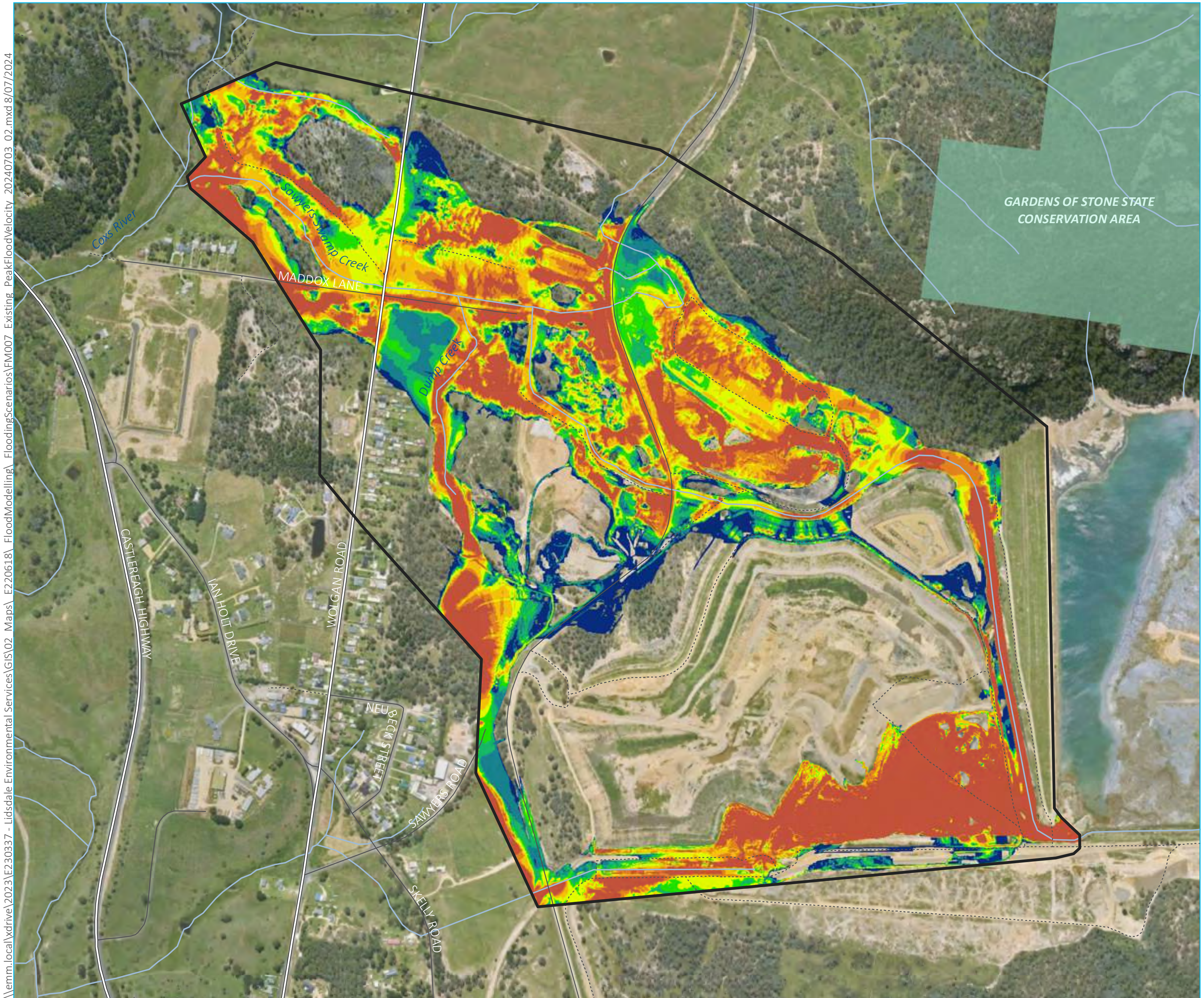
EMM creating opportunities



Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood velocity - PMF

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure D.7

EMM creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps\E220618\FloodModelling\FloodingScenarios\FM007_Existing_PeakFloodVelocity_20240703_02.mxd 8/07/2024

Annexure E

Design Scenario - Peak flood velocity

EMM
creating opportunities

KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

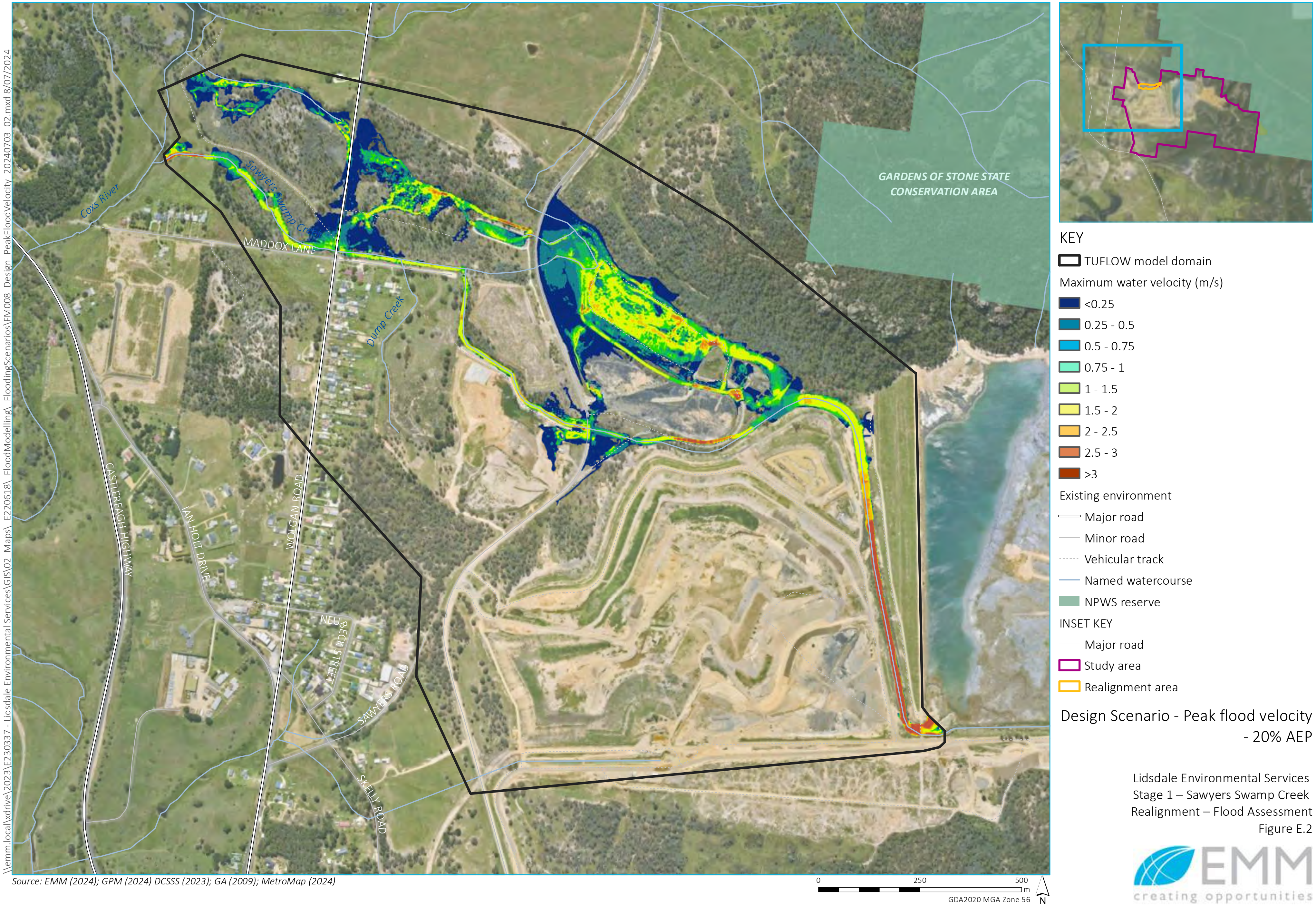
Design Scenario - Peak flood velocity - 63.2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure E.1

EMM
creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM008_Design_PeakFloodVelocity_20240703_02.mxd 8/07/2024



Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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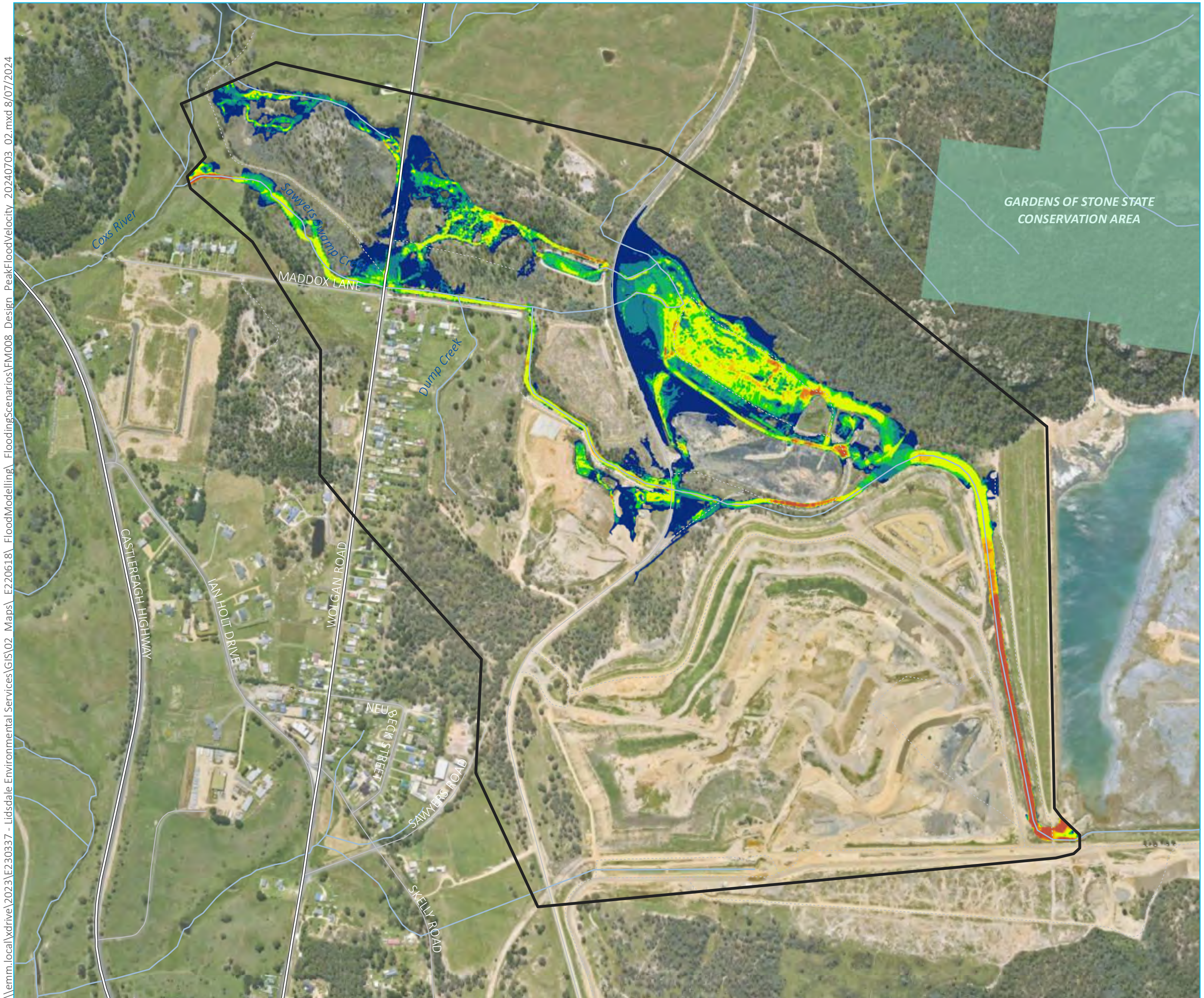
Design Scenario - Peak flood velocity - 20% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure E.2

EMM creating opportunities



KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood velocity - 10% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure E.3

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

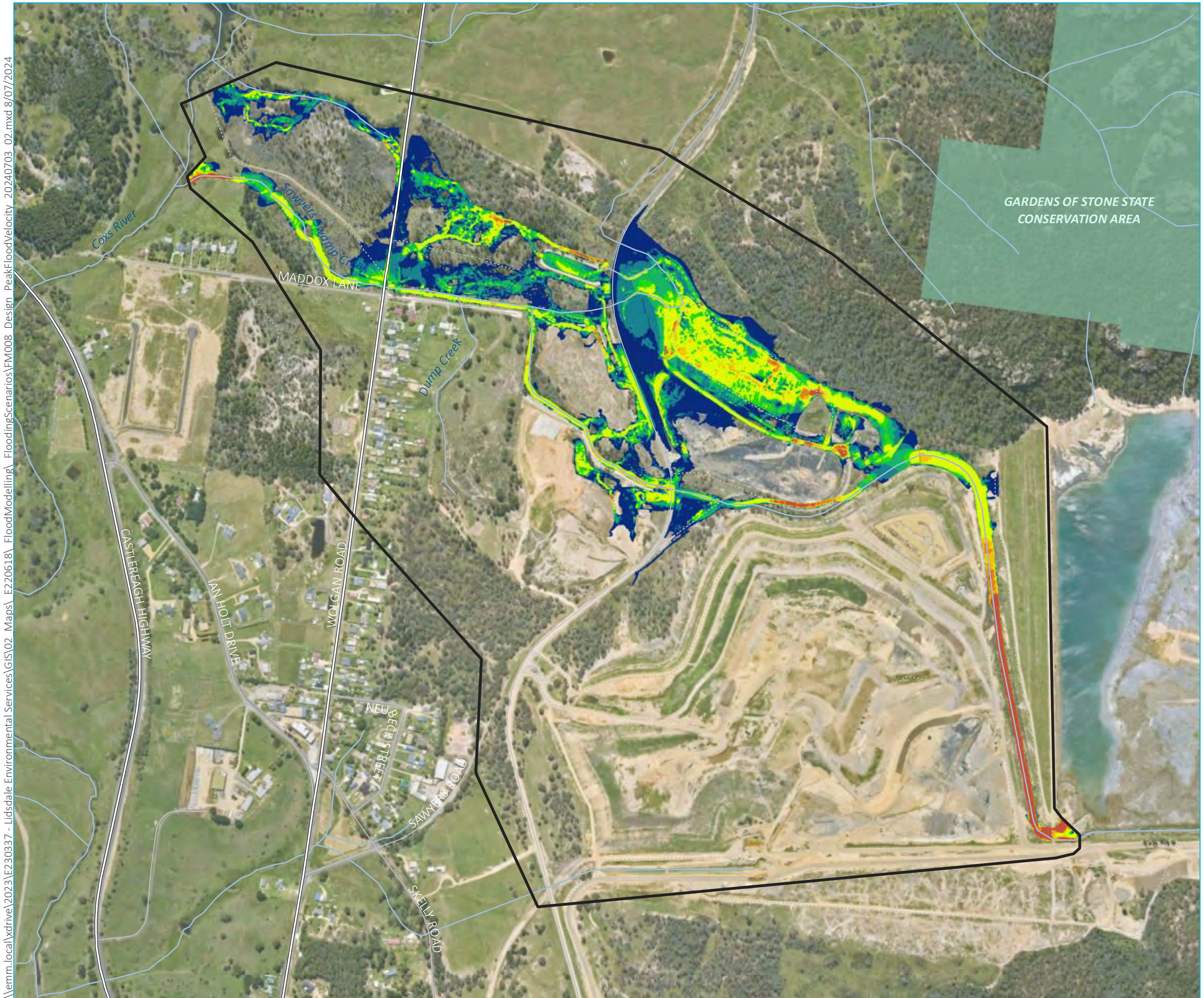
0 250 500 m

GDA2020 MGA Zone 56

N

EMM creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM008_Design_PeakFloodVelocity_20240703_02.mxd 8/07/2024



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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m

GDA2020 MGA Zone 56

N

KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

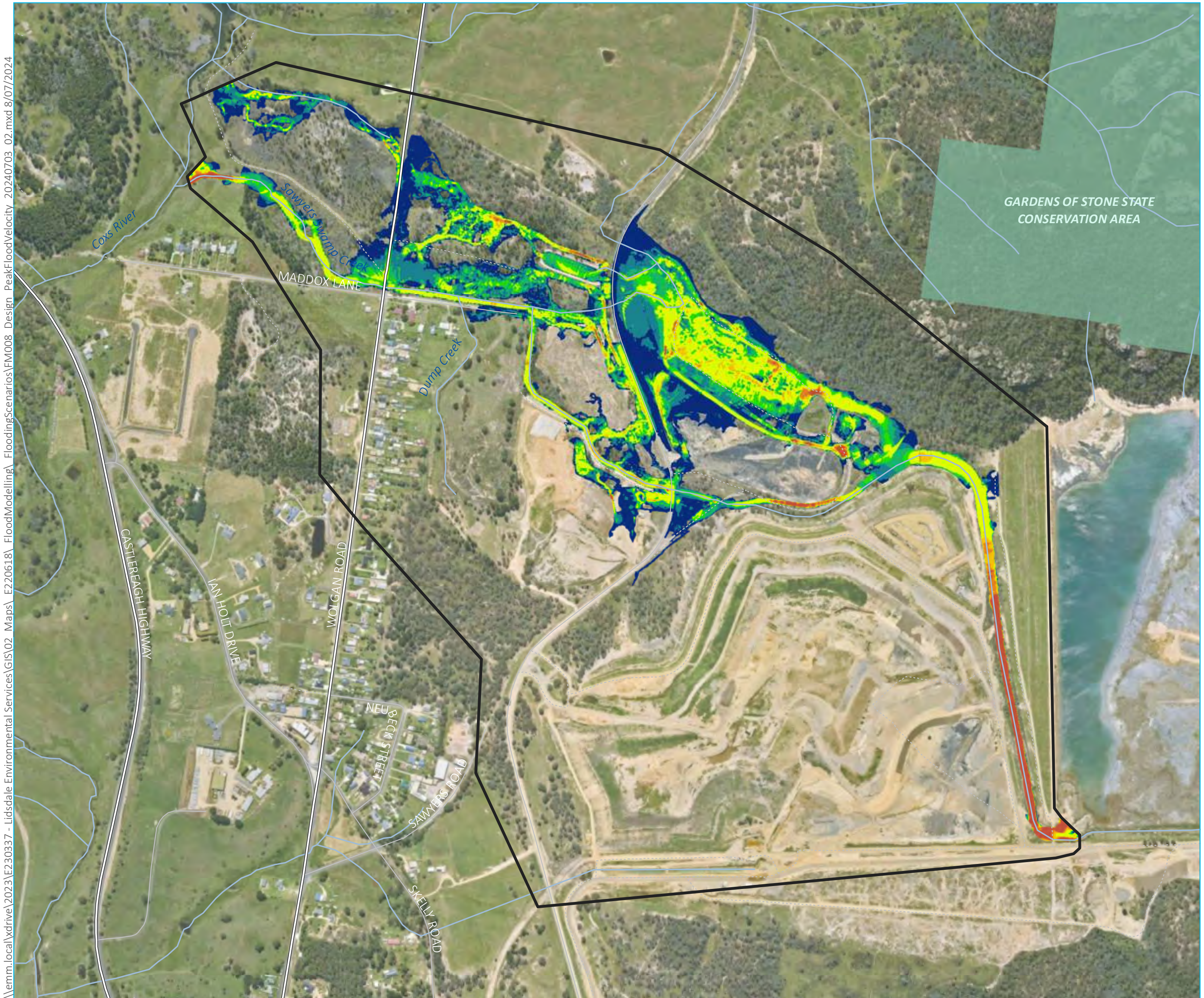
INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood velocity - 5% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure E.4

EMM
creating opportunities



KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

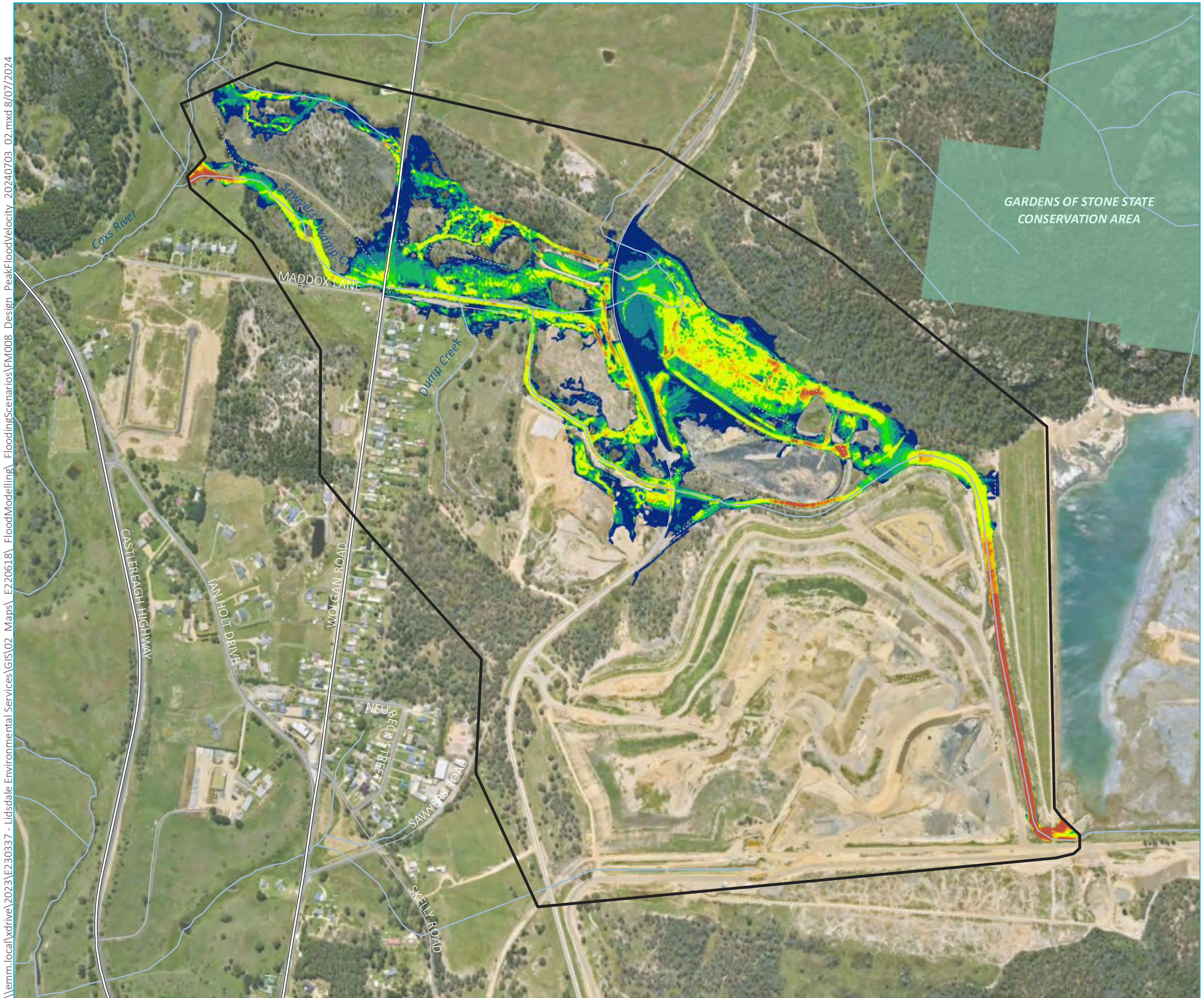
Design Scenario - Peak flood velocity - 2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure E.5

creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM008_Design_PeakFloodVelocity_20240703_02.mxd 8/07/2024



KEY

TUFLOW model domain

Maximum water velocity (m/s)

- <0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- >3

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood velocity - 1% AEP

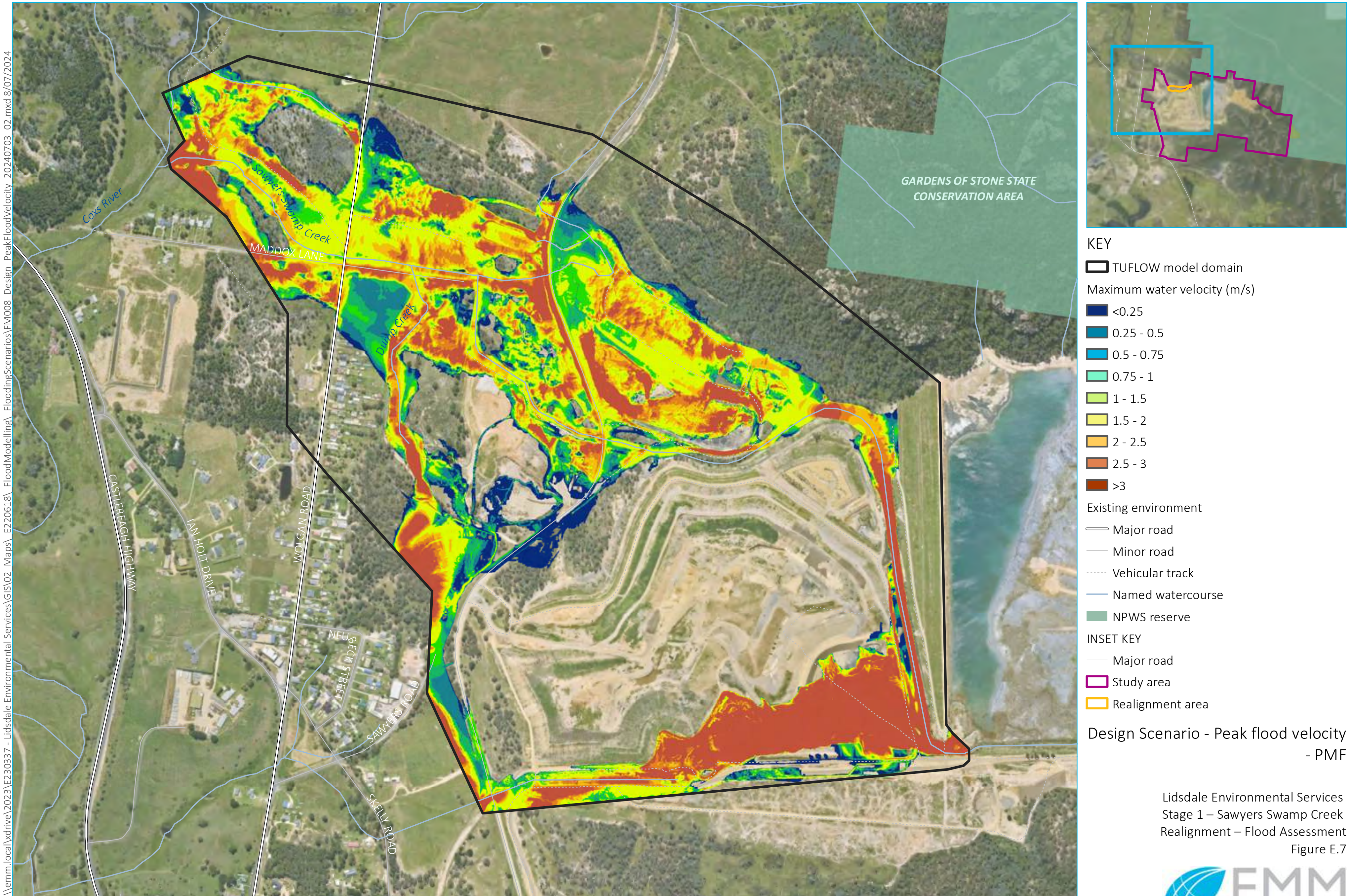
Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure E.6

EMM
creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m
GDA2020 MGA Zone 56
N

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02 Maps\ E220618\ FloodModelling\ FloodingScenarios\FM008 Design PeakFloodVelocity 20240703 02.mxd 8/07/2024



Design Scenario - Peak flood velocity - PMF

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure E.7

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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EMM creating opportunities

Annexure F

Existing Scenario - Peak flood hazard

EMM
creating opportunities

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KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood hazard - 63.2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure F.1

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m
GDA2020 MGA Zone 56
N

EMM creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m
GDA2020 MGA Zone 56
N

KEY
- TUFLOW model domain

Peak flood hazard
- H1
- H2
- H3
- H4
- H5
- H6

Existing environment
- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY
- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood hazard - 20% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure F.2

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM009_Existing_PeakFloodHazard_20240703_02.mxd 8/07/2024

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

- TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood hazard - 10% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure F.3

EMM
creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps\E220618_FloodModelling_FloodingScenarios\FM009_Existing_PeakFloodHazard_20240703_02.mxd 8/07/2024

KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m

GDA2020 MGA Zone 56

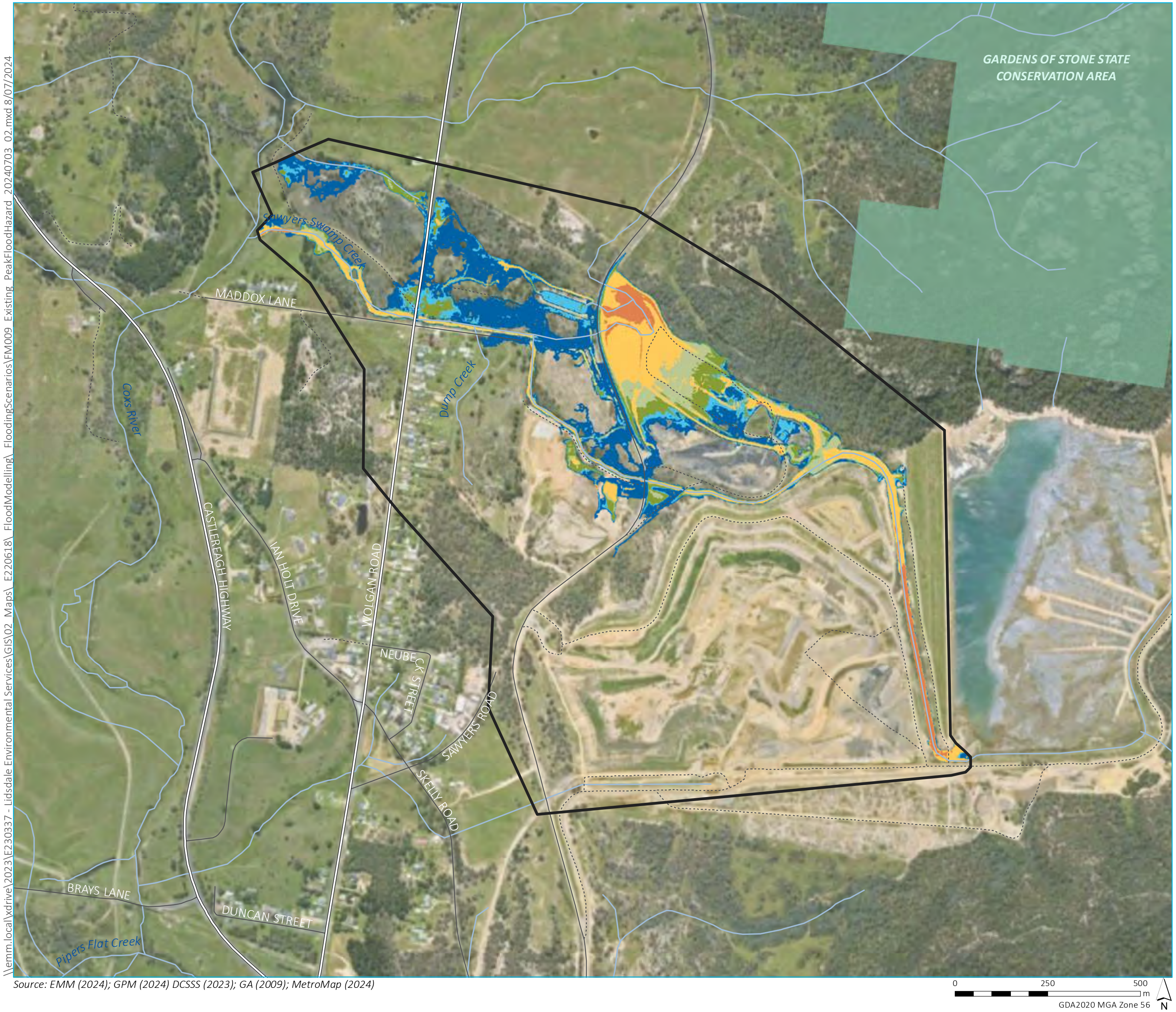
N

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM009_Existing_PeakFloodHazard_20240703_02.mxd 8/07/2024

Existing Scenario - Peak flood hazard - 5% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure F.4

EMM creating opportunities



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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

- TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

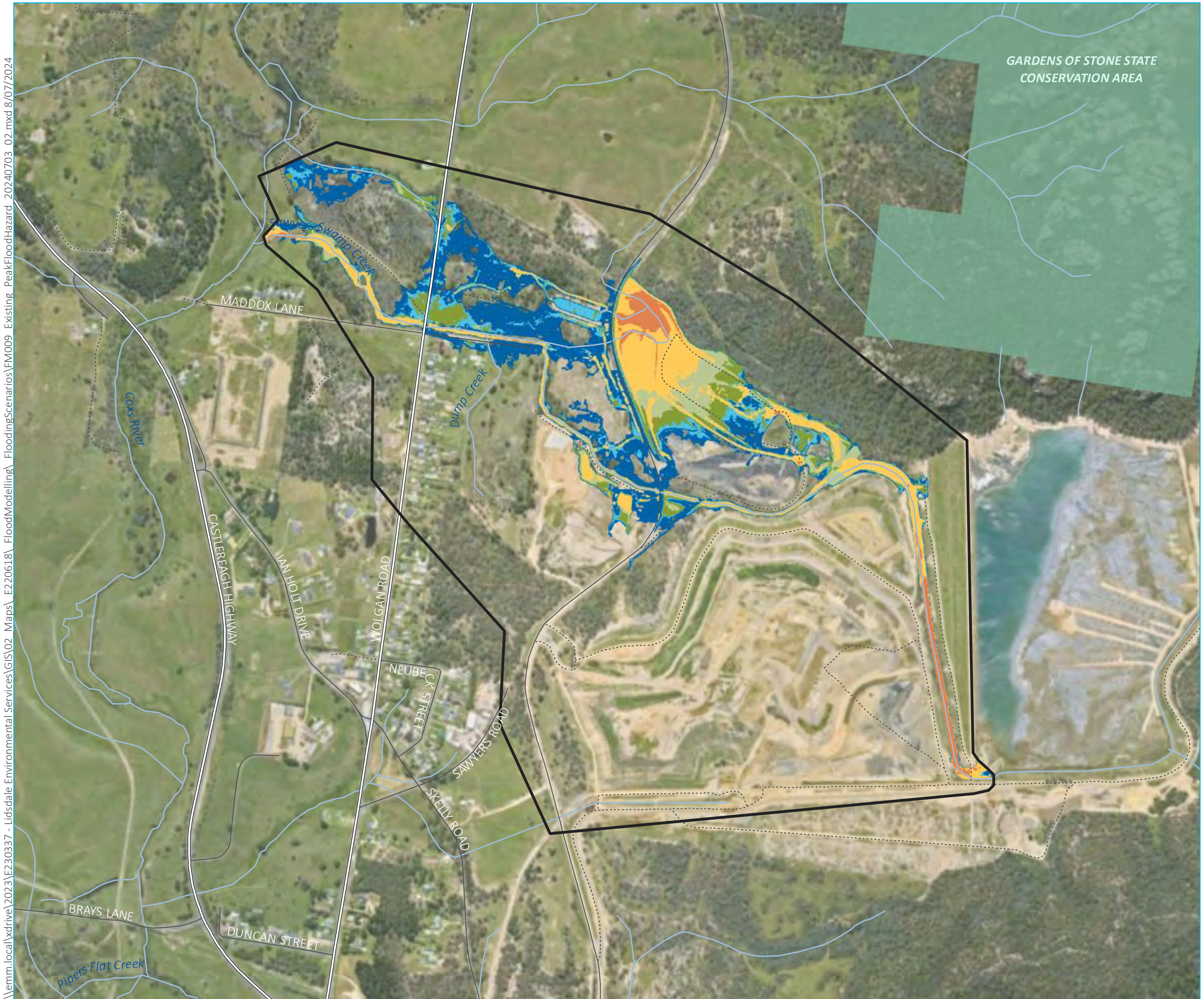
INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood hazard - 2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure F.5

EMM
creating opportunities



KEY

- TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

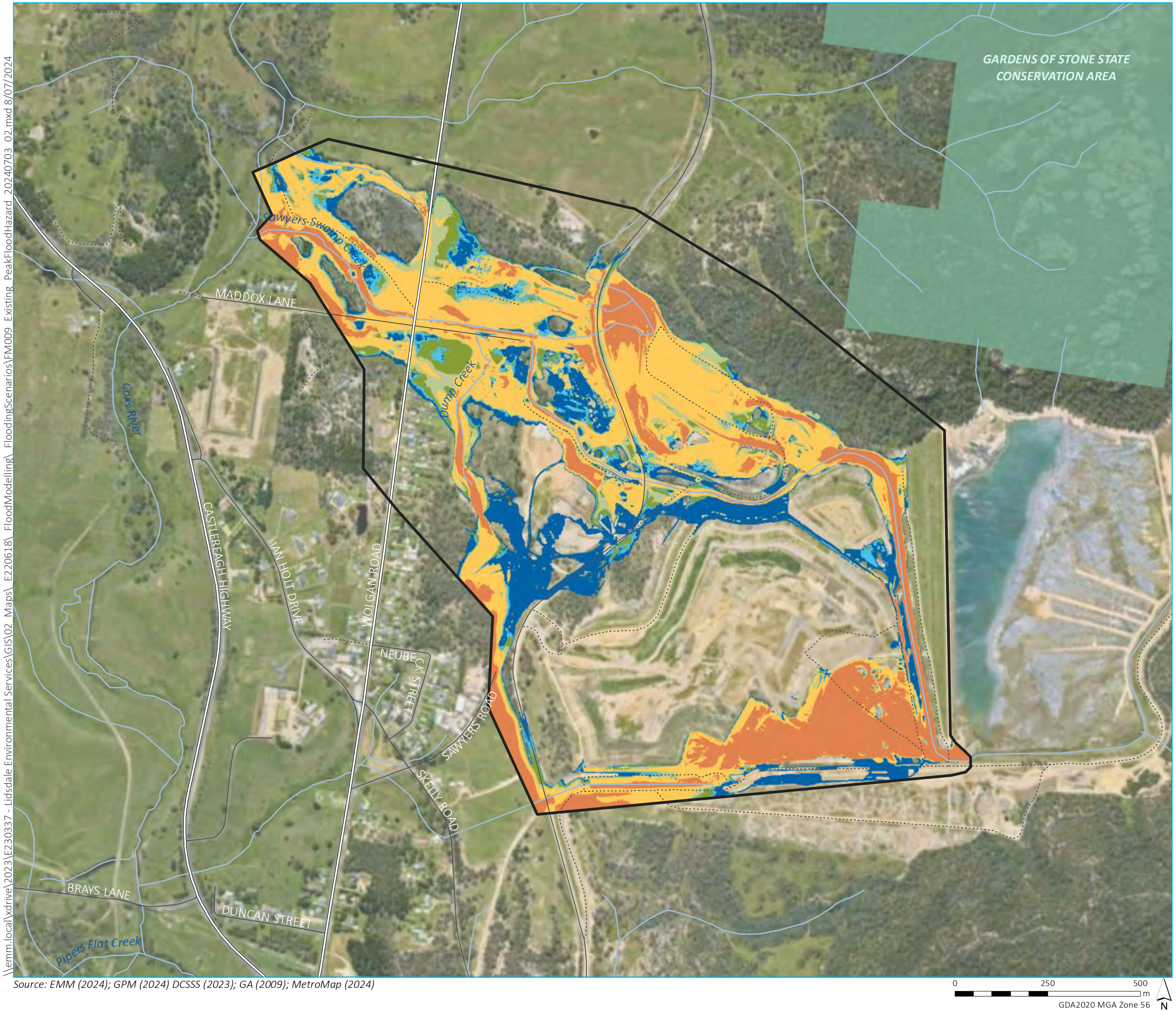
Existing Scenario - Peak flood hazard - 1% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure F.6

EMM creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM009_Existing_PeakFloodHazard_20240703_02.mxd 8/07/2024



KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Existing Scenario - Peak flood hazard - PMF

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure F.7

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM009_Existing_PeakFloodHazard_20240703_02.mxd 8/07/2024

Annexure G

Design Scenario - Peak flood hazard

EMM
creating opportunities

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KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m
GDA2020 MGA Zone 56
N

Design Scenario - Peak flood hazard - 63.2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure G.1

EMM
creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM010_Design_PeakFloodHazard_20240703_02.mxd 9/07/2024

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood hazard - 20% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure G.2

EMM creating opportunities

KEY

TUFLOW model domain

Peak flood hazard
- H1
- H2
- H3
- H4
- H5
- H6

Existing environment
- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY
- Major road
- Study area
- Realignment area

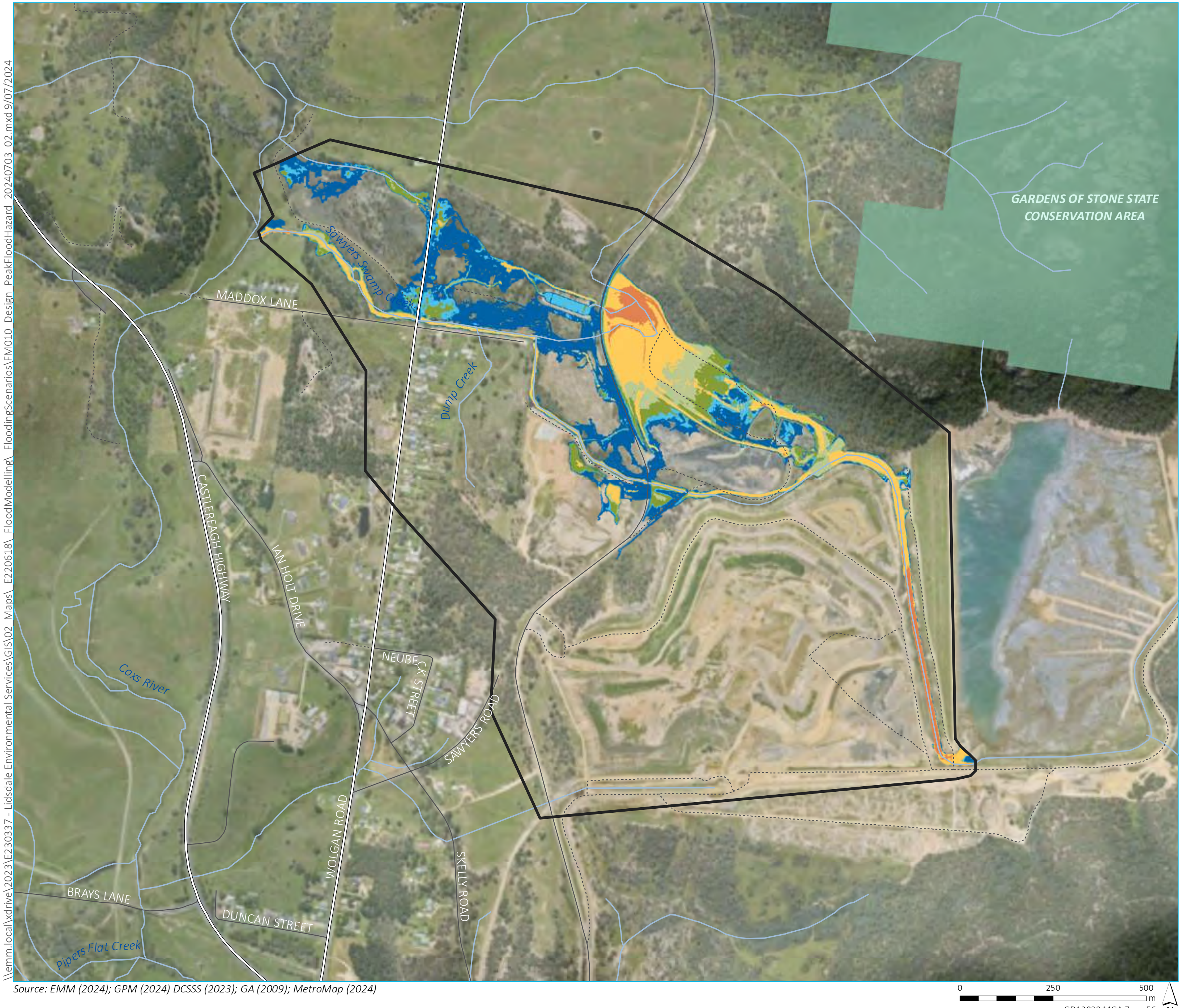
Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

Design Scenario - Peak flood hazard - 10% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure G.3

EMM
creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM010_Design_PeakFloodHazard_20240703_02.mxd 9/07/2024



KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

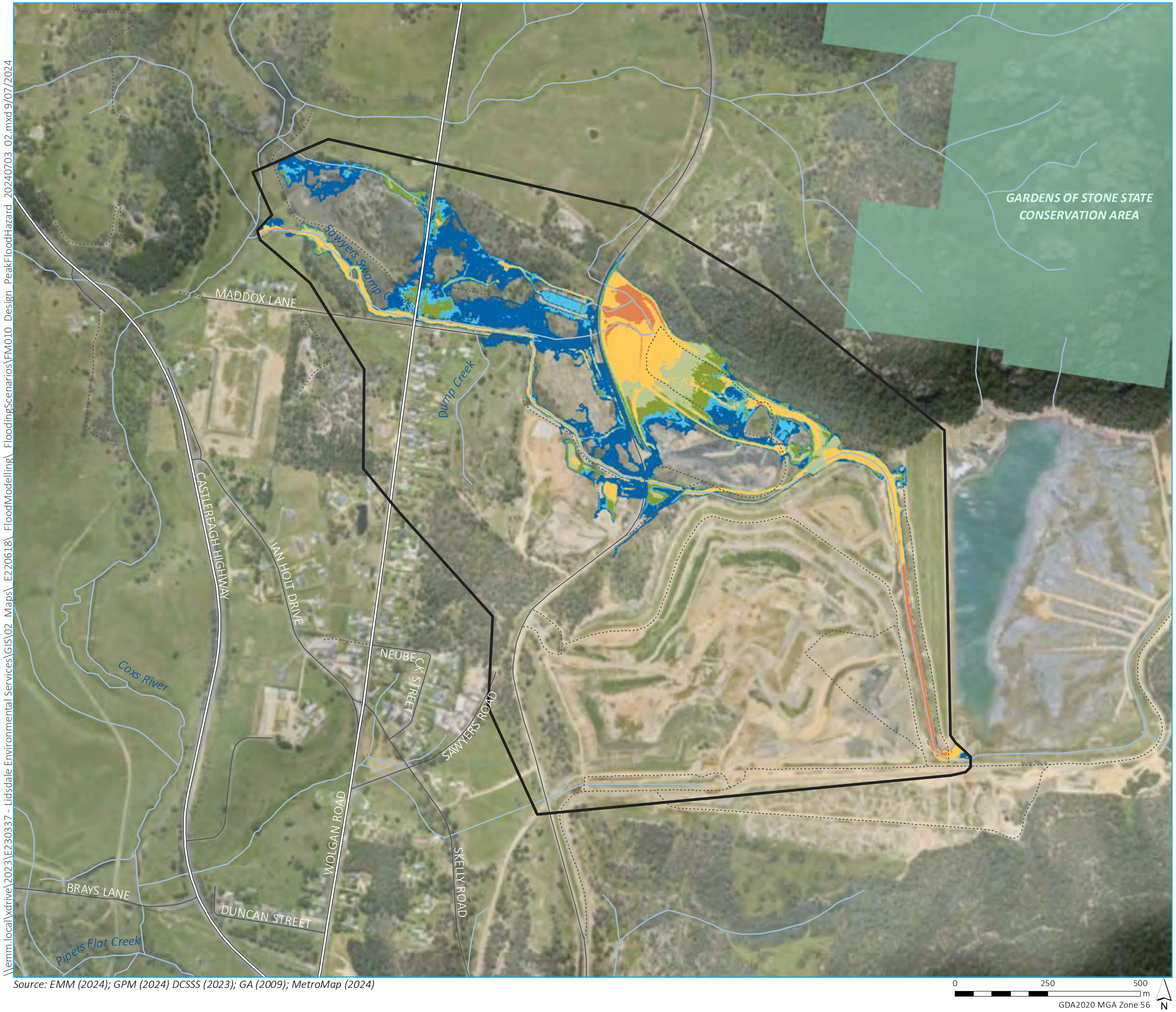
Design Scenario - Peak flood hazard - 5% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure G.4

EMM
creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps\E220618_FloodModelling_FloodingScenarios\FM010_Design_PeakFloodHazard_20240703_02.mxd 9/07/2024



Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

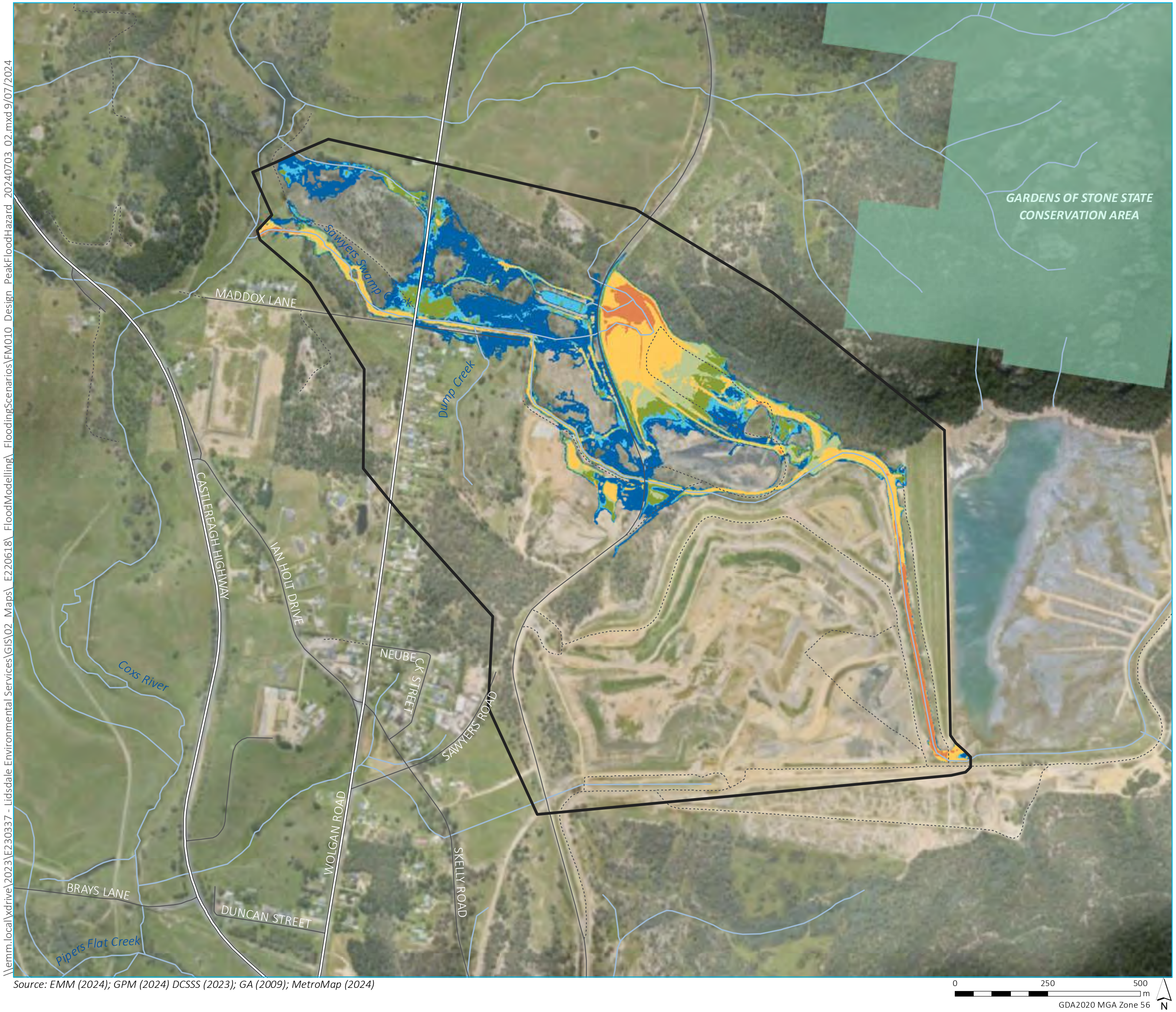
- Major road
- Study area
- Realignment area

Design Scenario - Peak flood hazard - 2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure G.5

EMM creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps\E220618_FloodModelling_FloodingScenarios\FM010_Design_PeakFloodHazard_20240703_02.mxd 9/07/2024



KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

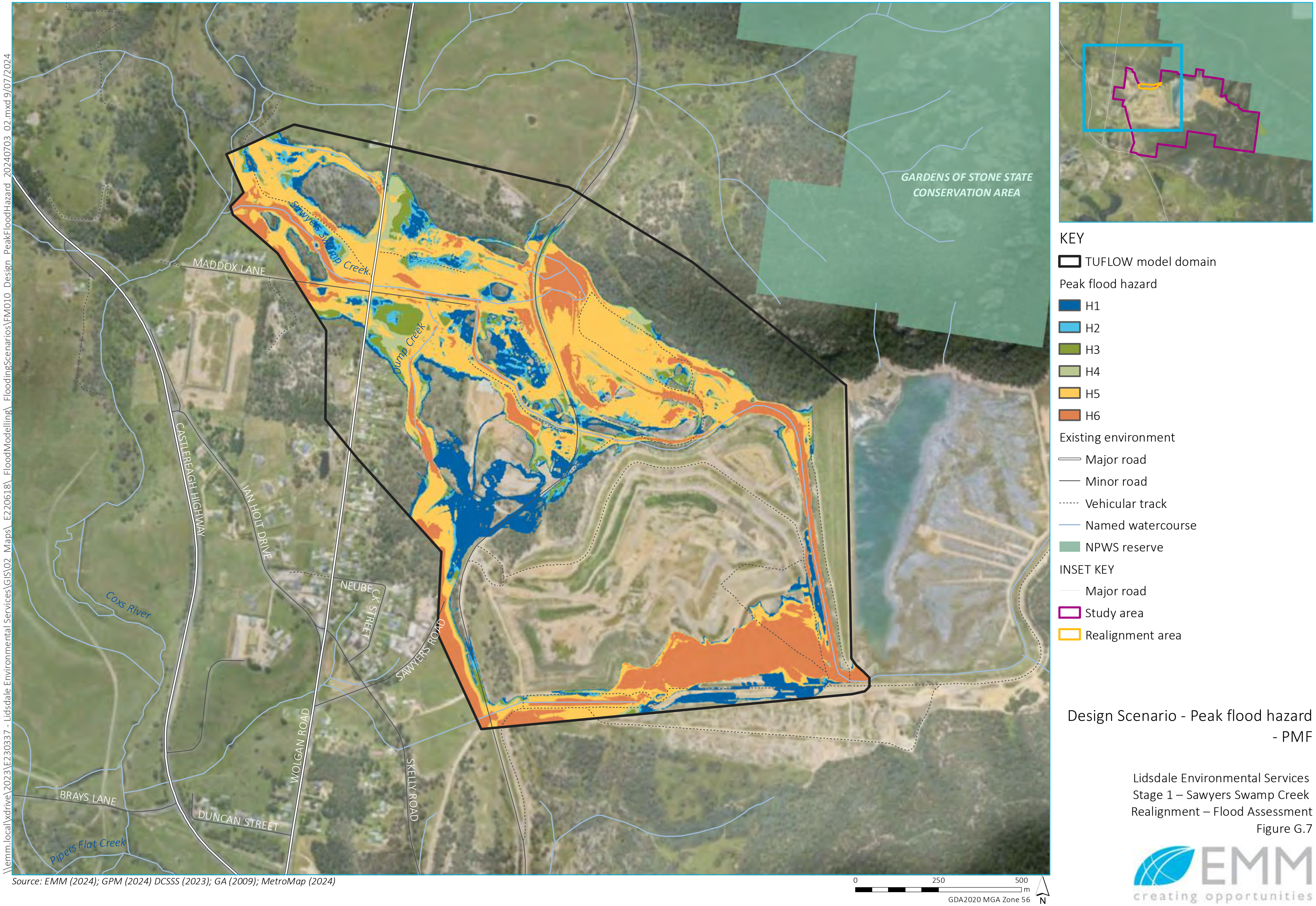
Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps\E220618_FloodModelling_FloodingScenarios\FM010_Design_PeakFloodHazard_20240703_02.mxd 9/07/2024

Design Scenario - Peak flood hazard - 1% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure G.6

EMM
creating opportunities



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KEY

TUFLOW model domain

Peak flood hazard

- H1
- H2
- H3
- H4
- H5
- H6

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Design Scenario - Peak flood hazard - PMF

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure G.7

EMM creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

Annexure H

Flood afflux (relative difference)

EMM
creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Change in peak flood depth (m)

< -1

-1 - -0.5

-0.5 - -0.25

-0.25 - -0.1

-0.1 - -0.05

-0.05 - 0.05

0.05 - 0.1

0.1 - 0.25

0.25 - 0.5

0.5 - 1

> 1

Existing environment

Major road

Minor road

Vehicular track

Named watercourse

NPWS reserve

INSET KEY

Major road

Study area

Realignment area

Flood afflux (relative difference) - 63.2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure H.1

EMM
creating opportunities

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KEY

TUFLOW model domain

Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Flood afflux (relative difference) - 20% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure H.2

EMM creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Flood afflux (relative difference) - 10% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure H.3

EMM
creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM011_FloodAfflux_RelativeDif_20240703_02.mxd 9/07/2024

KEY

TUFLOW model domain

Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Flood afflux (relative difference) - 5% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure H.4

EMM
creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

- TUFLOW model domain

Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Flood afflux (relative difference) - 2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure H.5

creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM011_FloodAfflux_RelativeDif_20240703_02.mxd 9/07/2024

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

- TUFLOW model domain

Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Flood afflux (relative difference) - 1% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure H.6

EMM
creating opportunities

KEY

TUFLOW model domain

Change in peak flood depth (m)

- < -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Flood afflux (relative difference) - PMF

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure H.7

EMM creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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Annexure I

Flood afflux (was dry, now wet)

EMM
creating opportunities

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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m

GDA2020 MGA Zone 56

N

KEY

TUFLOW model domain

Flood afflux

Area that was dry, now wet

Area that was wet, now dry

Existing environment

Major road

Minor road

Vehicular track

Named watercourse

NPWS reserve

INSET KEY

Major road

Study area

Realignment area

Flood afflux (was dry, now wet) - 63.2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure I.1

EMM
creating opportunities

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KEY

- TUFLOW model domain

Flood afflux

- Area that was dry, now wet
- Area that was wet, now dry

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Flood afflux (was dry, now wet) - 20% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure I.2

EMM
creating opportunities

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Flood afflux

Area that was dry, now wet

Area that was wet, now dry

Existing environment

Major road

Minor road

Vehicular track

Named watercourse

NPWS reserve

INSET KEY

Major road

Study area

Realignment area

Flood afflux (was dry, now wet) - 10% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek Realignment – Flood Assessment
Figure I.3

EMM
creating opportunities

KEY

TUFLOW model domain

Flood afflux

Area that was dry, now wet

Area that was wet, now dry

Existing environment

Major road

Minor road

Vehicular track

Named watercourse

NPWS reserve

INSET KEY

Major road

Study area

Realignment area

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

Flood afflux (was dry, now wet) - 5% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure I.4

EMM creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps\E220618\FloodModelling\FloodingScenarios\FM012_FloodAfflux_drywet_20240703_02.mxd 9/07/2024

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

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KEY

- TUFLOW model domain

Flood afflux

- Area that was dry, now wet
- Area that was wet, now dry

Existing environment

- Major road
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve

INSET KEY

- Major road
- Study area
- Realignment area

Flood afflux (was dry, now wet) - 2% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure I.5

EMM creating opportunities

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Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

KEY

TUFLOW model domain

Flood afflux

Area that was dry, now wet

Area that was wet, now dry

Existing environment

Major road

Minor road

Vehicular track

Named watercourse

NPWS reserve

INSET KEY

Major road

Study area

Realignment area

Flood afflux (was dry, now wet) - 1% AEP

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure I.6

EMM
creating opportunities

KEY

TUFLOW model domain

Flood afflux

Area that was dry, now wet

Area that was wet, now dry

Existing environment

Major road

Minor road

Vehicular track

Named watercourse

NPWS reserve

INSET KEY

Major road

Study area

Realignment area

Source: EMM (2024); GPM (2024) DCSSS (2023); GA (2009); MetroMap (2024)

0 250 500 m

GDA2020 MGA Zone 56

N

Flood afflux (was dry, now wet) - PMF

Lidsdale Environmental Services
Stage 1 – Sawyers Swamp Creek
Realignment – Flood Assessment
Figure I.7

EMM
creating opportunities

\\emm.local\xdrive\2023\E230337 - Lidsdale Environmental Services\GIS\02_Maps_E220618_FloodModelling_FloodingScenarios\FM012_FloodAfflux_drywet_20240703_02.mxd 9/07/2024

Appendix D

Geophysics Report: Fender Geophysics 2024, Processing and Interpretation Report

EMM
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Processing and Interpretation Report

EMM

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Report prepared by
James Daniell
May 2024

Project No. 24014

TABLE OF CONTENTS

FIGURES

TABLES

Disclaimer:

Fender Geophysics guarantees to perform a professional survey using high performance Electrical Resistivity Imaging (ERI) equipment in accordance with best industry practice and guidelines.

However, due to the inherent limitations of the electrical resistivity method and the interpretive nature of the results we cannot guarantee 100% detection and accurate representation of subsurface features.

For these reasons, Fender Geophysics does not accept any responsibility or liability for losses or damages of any kind, resulting from undetected, misinterpreted or misrepresented features.

For information about the capabilities and limitations of geophysical survey equipment and case studies, please refer to our website (https://fendergeophysics.com.au).

1.0 INTRODUCTION

This report describes the project brief, logistics, and results of an electrical resistivity imaging (ERI) survey undertaken for EMM at the Wallerawang Power Station, New South Wales on 2-4th May 2024 (Figure 1). The Wallerawang Power Station is located approximately 15km north of Lithgow.

EMM contracted Fender Geophysics to undertake the survey to assist with an investigation of subsurface geology and the nature and distribution of the underlying fill (specifically ash). The survey area is a former open cut coal mine. The site is currently undergoing remediation and was a complex mix of open paddocks, steep slopes, ponded water, and occasional thick vegetation (Figure 2). 6 ERI profiles were used to map the subsurface soil/rock resistivity.

The scope of this project included:

1) Define the extent of infilled open-cut coal deposits.
2) Assess the infill and identify possible voids.
3) Assess the subsurface rock and soil strata and its connectivity between two existing creeks and the infilled coal deposits.

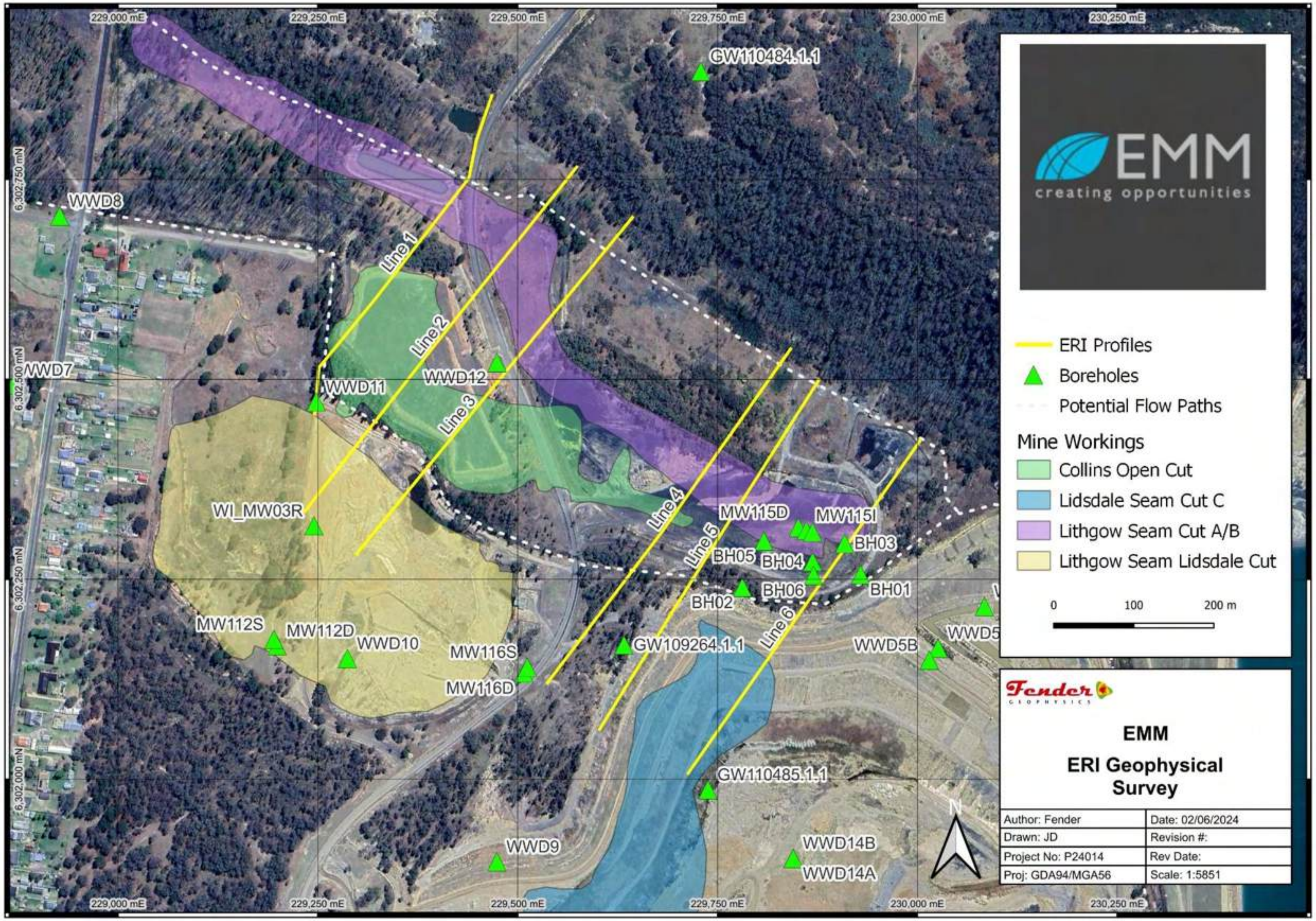


Figure 1. Map of Survey Area showing ERI profiles, boreholes and historical mine workings.

Figure 2. Survey area environments include open flat ground, high gradient slopes associated with dams and ash deposits, ponded water, and occasional thick vegetation

1.1 WORKPLACE HEALTH AND SAFETY

Fender carried out a generalised risk assessment for the project prior to mobilisation which was updated following a review at the survey site. Fender Geophysics staff also undertook a daily vehicle pre-start safety check before heading to the survey site. The results from the site-based risk assessment and pre-start safety check were submitted to Fender management using the Connecteam reporting app.

On site, Fender employees also attended a pre-survey Toolbox meeting with Lachlan Hammersley from EMM. There were no unique hazards associated with the survey area beyond those previously identified, however, slips, trips and falls were considered the most significant risk for the survey given the complex nature of the site.

The following were put in place to ensure safety during the survey:

1. VHF radios were used to ensure clear communication between Fender staff and others working around the site.
2. Clear signage at the start, middle, and end of each profile that high voltage currents were being used. Paths available to the public were also barricaded (Figure 5).
3. Field staff frequently communicated to EMM and Fender Management regarding survey progress.
4. Staff wore safety clothing including high-vis shirts and pants, safety glasses, steel-capped boots, gloves, and helmets.
5. Staff maintained a 3m distance from the ERI array during data acquisition.
6. Fender staff completed the survey and returned to the office before sundown.

EMM staff were kept informed of survey progress throughout the day. Lachlan Hammersley was contacted at the end of the day to inform him of the completion of the survey and Fender's departure from the site. No incidents of any kind occurred during the survey.

1.2 PERSONNEL AND EQUIPMENT

The following personnel were involved with the project:

Site Contact	Sean Little (EMM)
Director/Geophysicist	Andrew Sloot
Operations Manager	Doug Hall
Senior Geophysicist/Survey Manager	Sam Rubino
Field Assistant	Corina Kenny
Field Assistant	Hannah Johns

Table 1. P24014 Personnel

The following equipment was supplied by Fender for this project:

Item	Model
Resistivity	ZZGeo Univeral96 Resistivity System
Cables	2x48 Channel Cables with 6m takeouts (6m electrode spacing was used for the survey).
GPS	Handheld Garmin
Data Processing Laptop	Dell Inspiron 15
Mine Spec 4wd	Minespec Triton
Customary survey support equipment including toolbox, first aid kits etc.	

Table 2. P24014 Equipment

2.0 The Electrical Resistivity Imaging Method

The electrical resistivity imaging (ERI) method is one of the oldest and most frequently used geophysical survey techniques. By taking measurements on the ground surface, electrical surveys aim to ascertain the subsurface resistivity distribution. The true resistivity of the subsoil can be calculated from these observations. The porosity, degree of water saturation in the rock, mineral and fluid content, as well as other geological factors, are all related to the ground resistivity (Figure 3). For many years, hydrogeological, mining, geotechnical, environmental, and even petroleum exploration have all used electrical resistivity studies for subsurface mapping and exploration.

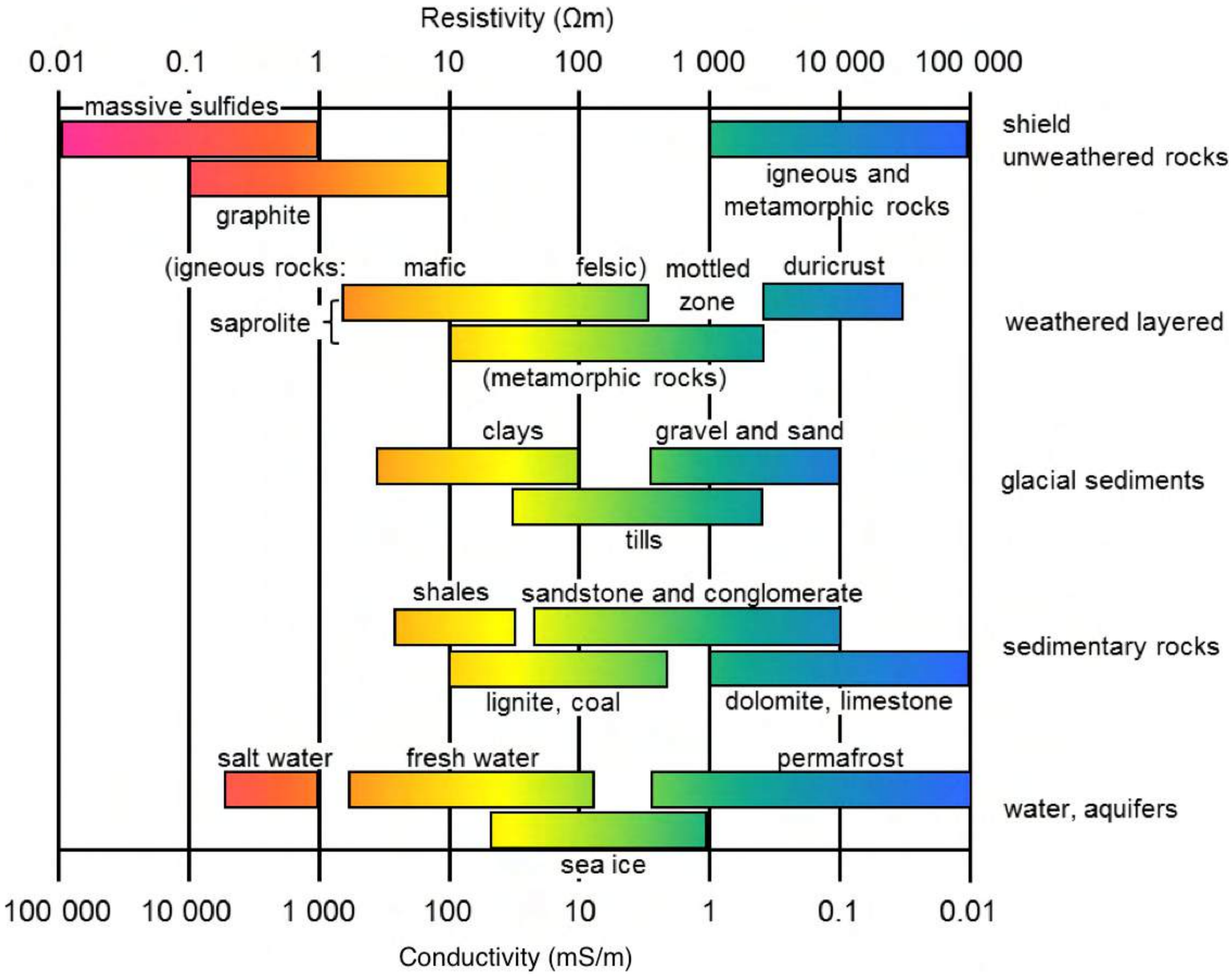


Figure 3. Generalised resistivity of rocks, soils, and aquifers

The fundamental physical law used in resistivity surveys is Ohm's Law that governs the flow of current in the ground. The equation for Ohm's Law for current flow in a continuous medium is given by:

$$V = IR$$

where R is the conductivity of the medium, I is the electrical current and V is the applied voltage. We note that in geophysical surveys the measured resistivity is equal to the reciprocal of the conductivity.

The basic setup for a resistivity survey involves using a resistivity meter and four electrodes, however, modern resistivity systems are 'multi-channel' and automate the acquisition of resistivity values throughout an 'array' of electrodes. The resistivity meter is a device that acts as both a voltmeter (measuring V) and an ammeter (measuring I) and records resistance values (V/I). These resistance values are converted to apparent resistivity values using the formula:

$$\rho_a = \frac{\kappa V}{I}$$

where ρ_a = apparent resistivity and k = geometric factor. The geometric factor varies based on the geometry of each electrode spacing setup. In typical field work, data is acquired as an apparent resistivity. The apparent resistivity value is not the true resistivity of the subsurface, but an "apparent" value that is the resistivity of a homogeneous ground that will give the same resistance value for the same electrode arrangement. The relationship between the "apparent" resistivity and the "true" resistivity is a complex relationship. To determine the true subsurface resistivity from the apparent resistivity values is an "inversion" modelling problem.

The 2-D model used by the inversion program consists of many rectangular blocks that are loosely tied to the distribution of the data points in the acquired resistivity data. The distribution and size of the blocks are automatically generated by the program using the distribution of the data points as a rough guide. The depth of the bottom row of blocks is set to be approximately equal to the median depth of investigation of the data points with the largest electrode spacing (i.e., the electrodes that are imaging to the deepest depths).

Starting from an initial model (usually a homogenous earth model), the program calculates the change in the model parameters that will reduce the difference between a calculated resistivity model and measured apparent resistivity values. The inversion adjusts the resistivity of the model blocks subject to the smoothness constraints that have been selected. A measure of this difference is given by the root-mean-squared (RMS) error. However, the model with the lowest possible RMS error sometimes shows large and unrealistic variations in the model resistivity values and might not always be the "best" model from a geological perspective. In general, the most prudent approach is to choose the model at the iteration after which the RMS error does not change significantly. This usually occurs between the 3rd and 6th iterations.

3.0 Resistivity Acquisition

Fender staff arrived on site on the afternoon of 1/5/2024 and completed an onsite safety meeting with Lachlan Hamersley (EMM). A brief site walk around was undertaken to identify any additional safety concerns and review line locations. The survey was conducted in accordance with Fenders Safe Operating Procedures for ERI surveys. Weather for the duration of the survey was acceptable and ranged from sunny to overcast. No significant rain fell during the surveying activities.

The Wallerawang survey plan consisted of 6 SW/NE orientated ERI profiles (Figure 1). The profiles were designed to intersect a number of poorly mapped coal mine workings that had likely been infilled with ash and other fill once mining activities ceased. The survey was originally planned as a 6 parallel lines, however:

1) The southern end of Line 1 was changed to prevent crossing over into residential land. The northern end of this line was also changed slightly to head further to the north so it would not cross the main roadway through the study area.
2) Line 5 was also moved approximately 30m to the west so it would not interfere with drilling that was being undertaken at that time.

A ZZGeo U96 Resistivity System was used for the ERI survey. The ERI profiles were set up with 96 channels and 6m electrode spacing to provide a maximum coverage of 576m. A Dipole-Dipole array was used for data acquisition as it is considered to be more effective at mapping vertical structures than the traditionally used Wenner and Schlumberger arrays.

Field data was acquired by a geophysicist with the following verification processes in place:

- Signage and safety cones were deployed to outline the work area.
- All electrodes were watered with salt water for better conductivity (~200-500ml per electrode).
- Manual recording of station location and checking of contact resistance for all electrodes.
- Verification of signal stability for all electrodes.
- Data and any cultural features were recorded in the operator’s field notes for review. in conjunction with later quality control.
- 1 second read times were used for all acquisition.
- Staff maintained a 3m distance from the ERI profile during data acquisition.
- Datasets were checked at the end of data acquisition to ensure data quality was acceptable.

Data acquisition for each array took approximately 2-2.5 hours.

On completion of the field work all electrodes and cables were removed, and all electrode sites returned to their pre-survey state. All field equipment were removed from the survey site. Departure and completion were confirmed with Lachlan Hammersley (EMM).

Station Spacing	6m
Resistivity Array	Dipole-Dipole
Number of Electrodes	96 electrodes
Array Read Time	2.0-2.5 hours
Survey/Positioning Datum	GDA94 MGA56
Elevation Datum	Australian Height Datum (AHD)

Table 3. ERI Acquisition Parameters

Line	Start E/N	Transmitter E/N	End E/N	Length (m)	Adjacent Boreholes	Notes
1	229244 6302454	229321 6302597	229465 6302849	480	WWD11	Line shortened due to residential area
2	229234 6302336	229402 6302543	229568 6302753	550	WI_MW03R	
3	229298 6302281	229464 6302478	229643 6302700	550	WWD12	
4	229538 6302117	229682 6302310	229841 6302536	520	MW116	
5	229604 6302063	229736 6302278	229877 6302497	520	GS109264 BH05, BH02, MW115D	Line moved 30m west due to drilling
6	229713 6302006	229856 6302196	230003 6302423	520	MW115D, BH04, BH06, BH03, BH01 GQ110485	

Table 4. ERI Acquisition Parameters

3.1 Resistivity Data Processing

Data processing was undertaken in the following sequence:

1. Data was downloaded from the field computer and initial QC undertaken after each profile.
2. The raw resistivity data was assessed in the proprietary ZZ-Datacheck software for overall data quality. An *.inp file was then exported for geophysical inversion.
3. Res2Dinv v2024.1 was used for geophysical inversion of the ERI data. The data was initially imported, and the x, y, and z coordinates of the electrodes were added to the data. The data then underwent a visual edit process where data ‘spikes’ were removed from the data. This edited data was then saved.
4. The edited data then underwent geophysical inversion. The inversion used the default values except:
    a. Within the Discretisation (model) a ‘regular’ model was used to give a 2D profile with a triangular cross section.
    b. Within the Discretisation (Horizontal) the ‘Model refinement’ was changed to 0.5 to reduce the inversion model blocks to 0.5 times the electrode spacing. This improves results where there are large resistivity values at the surface an increased the model resolution where there were comparatively few resistivity soundings.
    c. Within the stopping criteria, the converge limit was reduced from 5.0 to 2.0. The value represents the relative change in RMS error between two inversion iterations. Lowering the value allowed to model to further refine the inversion model and reduce the RMS error of the final model.
5. After the initial inversion the error statistics were investigated. All data with a model misfit of greater than 100% were removed.
6. This edited data was reimported into Res2Dinv and underwent inversion for a second and final time.
7. The ASCII data were then imported into Surfer for 2D visualisation of profiles and Voxler for 3D visualisation.

3.2 Borehole Data

Lithology information was available for 38 boreholes within the study area to assist with the interpretation of the ERI data (Table 5). Ash was present in 18 of these boreholes. Most of these boreholes were randomly distributed throughout the study area with a cluster of boreholes adjacent to ERI profiles 5 and 6 to the east. The average borehole depth was 17m. Two boreholes (GW110484.1.1 and GW110485.1.1) were used to provide some stratigraphic control over the area (Tables 6-8). These two boreholes were the deepest of the entire dataset and intersected as deep as the Lithgow Coal Seam. The Lithgow coal seam is significant as it is the deepest coal seam in the region and reasonably marks the approximate maximum depth excavated for coal. It should be noted that neither borehole was provided with an elevation. Elevations have been measured from available LiDAR, but assume no surface elevation change since drilling. This may be an issue for GW110485.1.1 which was acquired within the Kerosene Vale Ash deposit, which may have undergone significant fill since 2009 and therefore may be unreliable.

Hydraulic conductivity and water content measurements of main lithologies in study area (source: Golder Geotechnical Design report). Indicate high hydraulic conductivity and water content for the ash deposits and indicate that resistivity should be an effective technique for mapping them. The report also noted that hydraulic conductivity of rock units (sandstone siltstone and coal) is dominated by fracture flows.

ID	Eastings	Northings	Elevation AHD (m)	Depth (m)	Ash
WWD1A	231655	6301889	943	14.5	Y
WWD1B	231653	6301887	943	23.5	Y
WWD2A	229668	6301679	942.5	23.5	Y
WWD2B	230968	6302197	942.5	32.5	Y
WWD3	230043	6301628	923	12	
WWD4	230084	6302216	916	27.5	Y
WWD5A	230026	6302164	916.8	8.5	Y
WWD5B	230015	6302149	919.4	20.5	
WWD6A	229666	6301677	941	29.7	Y
WWD6B	229667	6301678	941	34.3	
WWD7	228869	6302493	895	6	
WWD8	228927	6302704	890.5	5.5	
WWD9	229474	6301897	915	10	
WWD10	229287	6302151	902.5	13	
WWD11	229248	6302472	895.5	9.6	
WWD12	229474	6302521	901	10.4	
WWD13	229281	6301678	926	20.5	
WWD14A	229844.6	6301901	940	20.6	Y
WWD14B	229844.6	6301901	940	25.6	Y
BH01	229929	6302256	907	10	Y
BH02	229781	6302240	905	10	Y
BH03	229909	6302295	904	10	Y
BH04	229869	6302272	904	10	Y
BH05	229808	6302298	903	10	Y
BH06	229870	6302255	904	10	Y
MW115D	229851	6302315	903	34.5	Y
WI_MW03R	229245	6302317	902	10.5	
MW112D	229199	6302167	902	30	
MW112S	229195	6302175	902	9.8	
MW116D	229508	6302133	902	10	
MW116S	229512	6302140	902	10	
MW115I	229861	6302311	903	22.5	Y
MW115S	229869	6302309	903	15	Y
MW121D	229729	6301528	920	20	
GW109264.1.1	229633	6302168	905	14.3	
GW110485.1.1	229738	6301987	936	65	
GW109263.1.1	230196	6302349	911	6	
GW110484.1.1	229729	6302885	937	70	

Table 5. Summary of borehole within study area.

	GW110484	DW110485
Depth (m)	59	65
Drilled Date	29/07/2009	17/08/2009
Purpose	Monitoring	Monitoring
Lat	-33.3793406	-33.3873604
Lon	150.0947185	150.0945581
X_UTM56	229729	229738
Y_UTM56	6302885	6301987
Reference Elevation (m AHD)	Unknown	Unknown
Est. Reference Elevation (m AHD)	937	936

Table 6. Metadata for boreholes used for stratigraphic control

Depth from (m)	Depth to (m)	Top elevation (m AHD)	Base elevation (m AHD)	Lithology
0	1	936	935	Clayey sand
1	2	935	934	Siltstone
2	3	934	933	Siltstone,l/grey
3	4	933	932	Siltstone orange
4	5	932	931	Siltstone orange grey
5	7	930	928	Siltstone grey brown
7	9	928	926	Siltstone grey
9	11	926	924	Claystone l/grey
11	16	921	916	Mudstone
16	17	920	919	Mudstone dark grey,carb. wet
17	18	919	918	Mudstone dark grey,carb. dry
18	19	918	917	Mudstone dark grey
19	21	916	914	Mudstone grey carbonaceous
21	22	915	914	Mudstone,some coal
22	23	914	913	Mudstone grey,coarse
23	25	912	910	Mudstone l/grey
25	29	908	904	Mudstone,grey brown
29	31	906	904	Mudstone,dark brown,coal
31	32	905	904	Mudstone carbonaceous,l/grey
32	33	904	903	Mudstone carbonaceous dark grey
33	34	903	902	Mudstone dark grey,coal
34	35	902	901	Coal,Irondale seam
35	40	897	892	Mudstone carbonaceous dark grey
40	41	896	895	Mudstone dark grey
41	46	891	886	Mudstone l/grey brown
46	47	890	889	Mudstone very fine dark grey
47	50	887	884	Mudstone, grey carbonaceous
50	55	882	877	Mudstone dark grey black,carb.
55	57.5	879.5	877	Coal,Lidsdale seam
57.5	62	875	870.5	Siltstone very l/grey
62	62.5	874.5	874	Siltstone,l/grey,fine grained
62.5	64.9	872.1	869.7	Coal,Lithgow seam

Table 7. Borehole geology for GW110484.

Depth from (m)	Depth to (m)	Top elevation (m AHD)	Base elevation (m AHD)	Lithology
0	1	934	933	Clayey sand
1	3	932	930	Mudstone,orange siltstone
3	4	931	930	Siltstone orange grey,some coal
4	7	928	925	Siltstone orange grey
7	8	927	926	Siltstone brown
8	9	926	925	Siltstone dark grey
9	10	925	924	Siltstone grey
10	11	924	923	Siltstone grey brown
11	12	923	922	Claystone l/grey
12	15	920	917	Mudstone,carbonaceous l/brown
15	16	919	918	Siltstone grey,mudstone
16	17	918	917	Mudstone,dark grey
17	18	917	916	Mudstone dark grey carb. dry
18	21	914	911	Mudstone dark grey
21	22	913	912	Mudstone,dark grey carb. some coal
22	23	912	911	Coal,Irondale seam
23	25	910	908	Mudstone, carbonaceous and coal
25	27	908	906	Mudstone carbonaceous
27	29	906	904	Mudstone carb. dark brown
29	30	905	904	Mudstone carb.dark brown,coal
30	32	903	901	Mudstone,carb,dark brown,grey
32	43	892	881	Mudstone,dark grey
43	44	891	890	Mudstone,l/grey,siltstone
44	48	887	883	Mudstone carb.dark grey
48	51	884	881	Mudstone l/grey
51	55	880	876	Mudstone,very fine,l/grey
55	57.5	877.5	875	Coal,Lidsdale seam
57.5	62	873	868.5	Siltstone very l/grey
62	62.5	872.5	872	Siltstone,l/grey,fine grained
62.5	64.9	870.1	867.7	Coal,Lithgow seam

Table 8. Borehole geology for GW110485.

Modelled Layer	Horizontal Hydraulic Conductivity (m/sec)*	Residual Water Content (%)
Ash	5×10^{-3}	5
Coal Seams	1×10^{-5}	1
Sandstone	1×10^{-7}	0.5
Siltstone	1×10^{-7}	0.5

Table 9. Hydraulic conductivity and water content of main lithologies in study area (source: Golder Geotechnical Design report). *Note that hydraulic conductivity of rock units is dominated by fracture flows

4.0 DATA ANALYSIS

4.1 ERI Profile 1

The interpretation of profile 1 was aided by boreholes GW110484 and WWD11 (Figures 4 and 5). WWD11 intersects the profile at its southern end and indicates a shallow boundary between fill and bedrock (coal and sandstone) at about 7.5 m depth. This marks a rapid increase in resistivity from <100 Ohm.m for the fill to >100 Ohm.m for the bedrock. This boundary in the resistivity maps out up to 6 concave up lobes that may represent fill within in the profile. The lobes are discontinuous and are up to 20m deep. There is no evidence of ash in borehole WWD11.

The base of the Lithgow seam is approximately 870m RL based on borehole GW110484 and should mark the maximum depth limit of excavations in the area. Between 220-350m along the profile there is a broad and deep concave-up lobe with resistivity values between 200-500 Ohm.m. These resistivity values are comparatively low for sandstone and the areas adjacent and below (interpreted as resistive bedrock). The lobe is interpreted to be bedrock, but with comparatively higher conductivity due to groundwater. The lobe shape may be a result of natural or man-made fracturing in the area (hydraulic conductivity in these sandstones is dominantly driven by fracturing). The fractures may have been exacerbated by drilling and blasting in the area from coal exploration and extraction activities.

The southern and northern creeks intersect the ERI profile at 170m and 450m respectively. The southern creek is adjacent to a lobe mapped as fill. Water from the creek may contribute to the moisture in the fill in this location. The northern creek is located between two lobes mapped as fill and may also be contributing to the increased conductivity in this area. Both creeks are adjacent to large subsurface low resistivity areas interpreted to be fill. Water from the creek may add to the conductivity of the fill.

4.2 Line 2

The interpretation of profile 2 was aided by boreholes GW110484, WWD11, and WI_MW03R (Figures 6 and 7). WWD11 and WI_MW03R intersect the profile at its southern end and indicate a shallow boundary between fill and bedrock (coal and sandstone) at about 7.5 m depth. Similar to profile 1, this marks a rapid increase in resistivity from <100Ohm.m for the fill to >100Ohm.m for the bedrock. This boundary in the resistivity maps out up to 4 concave up lobes that may represent fill within in the profile. The lobes are discontinuous, two of the lobes are ~15m deep while the other two are ~30m deep. There is no evidence of ash in borehole WWD11 but ash is recorded within two thin beds between 1 and 3m deep in WI_MW03R.

The base of the Lithgow seam is approximately 870m RL based on borehole GW110484 and should mark the limit of excavations in the area. Between 0 and 150m and 350-550m this depth marks out comparatively high resistivity values (>1000Ohm.m) indicative of bedrock. Similar to profile 1, there is a broad and deep concave-up lobe with resistivity values between 200-500 Ohm.m between 150 and 350m along the profile. This feature appears to be continuous between profile 1 and 2 as well as other profiles to the east and is interpreted to be bedrock but with comparatively higher conductivity due to groundwater.

The southern and northern creeks intersect the ERI profile at 150m and 540m respectively. The southern creek is adjacent to a lobe mapped in a topographic low between areas moderate to high resistivity. The northern creek is located on a lobe mapped as fill. Resistivity is moderate at ~100Ohm.m.

4.3 Line 3

The interpretation of profile 3 was aided by boreholes WI_MW03R, GW110484, and WWD12 (Figure 8 and 9). WWD12 intersects the profile at approximately 320m and shows a shallow fill/bedrock boundary at approximately 5m depth. The shallow bedrock at this location is consistent with resistivity values of 200-400Ohm.m. However, there are adjacent areas of comparatively low resistivity indicating deeper fill. WI_MW03R is located approximately 75m adjacent to the profile at its southern end and indicates a shallow boundary between fill and bedrock (coal and sandstone) at about 7.5 m depth. However, the resistivity values of 100Ohm.m indicate that there is fill in this location and bedrock is likely deeper in this location. There is no evidence of ash in borehole WWD11 but ash is recorded within two thin beds between 1 and 3m deep in WI_MW03R.

There are four areas mapped as fill based on their comparatively low resistivity. One is at the southern end of the profile, and three to the north. These lobes are approximately 20m deep. These areas of fill sit above base of the Lithgow Seam at 870m RL (based on GW110484). There is a deeper conductive lobe between 150 and 300m along the profile which is 40-50m deep. This lobe is particularly conductive (<50Ohm.m) and shows some indications of a connection with the surface and possibly transport pathway for groundwater.

The southern and northern creeks intersect the ERI profile at 140m and 530m respectively. The southern creek is marked by a small area of reduced resistivity consistent with moist ground. The northern creek is also located on a small area of reduced resistivity. Neither appear to be part of a larger structure or share a connection with the subsurface.

4.4 Line 4

The interpretation of profile 4 was aided by boreholes GW109264, and MW116D (Figure 10 and 11). Neither borehole intersects the ERI profile and are instead located ~40m to the east and west of the southern end of the profile. As a result, the information they provide is indicative only. Both boreholes show a boundary between fill and bedrock at approximately 3m depth. The southern end of the ERI profile shows shallow low resistivity (likely fill) followed by an increasing resistivity (likely bedrock). There is no ash identified in either borehole.

There are four areas mapped as fill based on their comparatively low resistivity. One is at the southern end of the profile, and three to the north. These lobes are approximately 10-25m deep and sit above the base of the Lithgow Seam at 870m RL (based on GW110484). There are two deeper conductive lobes between 130 and 300m along the profile which are 40-50m deep and are interpreted to be related to ground water.

The southern and northern creeks intersect the ERI profile at 140m and 530m respectively. The southern creek is marked by a small area of reduced resistivity consistent with moist ground. The northern creek is also located on a small area of reduced resistivity. Neither appear to be part of a larger structure or share a connection with the subsurface.

4.5 Line 5

The interpretation of profile 5 was aided by boreholes GW110485 and MW115D (Figure 12 and 13). However, boreholes BH02 and BH05 also provide evidence of ash in the area. MW115D is located adjacent to line 6 but it closest at ~340m along the profile (offset ~80m). MW115D shows a thick layer of ash (16m) overlying coal and sandstone. BH02 and BH05 also show ash down to their bases at a depth of 10m.

The profile intersects the Kerosene Vale Ash Dump from 0-200m along the profile. The resistivity within the ash is highly variable ranging from 500-20Ohm.m with numerous discontinuous lobes. Between 350 and 550m along the profile there is a rapid change in resistivity between 100 and 1000Ohm.m. This is interpreted to be a change from fill to bedrock based on MW115D. This is also indicated by the change from fill to bedrock in borehole MW115D. The central portion of the profile is characterised by a deep lobe expected to be a result of groundwater. There are four areas mapped as fill based on their comparatively low resistivity. This fill is also indicated by the ash within boreholes MW115D, BH02 and BH05. The ash/fill lobes are up to 20m deep and are located above the base of the Lithgow Seam at 870m (based on GW110484).

The southern and northern creeks intersect the ERI profile at 220m and 510m respectively. The southern creek is marked by a small area of reduced resistivity consistent with moist ground. The northern creek is also located on a small area of reduced resistivity. Neither appear to be part of a larger structure or share a connection with the subsurface.

4.6 Line 6

The interpretation of profile 6 was aided by boreholes GW110485 and MW115D (Figures 14 and 15). Neither borehole intersects the ERI profile and are instead located ~40m to the east and west of the southern end of the profile. As a result, the information they provide is indicative only. MW115D shows a thick layer of ash (16m) overlying coal and sandstone. BH01-06 also show ash down to their bases at a depth of 10m indicating a thick distribution of ash through the central portion of the profile.

The thick ash unit along profile 6 correlates well with a proposed ash/bedrock boundary between 200-700 Ohm.m. Throughout most of the profile there is a significant and rapid change in resistivities within the profile that marks out the ash/fill and bedrock boundaries. The well-defined boundary between ash and rock maps out an extensive ash unit that is up to 25m deep and is discontinuous across the profile. Boreholes near Line 6 are highly clustered and additional directed drilling would be required to determine which of these areas are ash, and which are fill or mixed. The southern 200m of line 6 intersects the Kerosene Vale ash repository. The ash has a highly heterogeneous character with resistivities ranging from 10-1000Ohm.m. The base of the Lithgow seam is at ~870m RL based on GW110485. This lowermost extent of excavation agrees with the low resistivity ash at the southern end of the profile

The southern and northern creeks intersect the ERI profile at 240m and 540m respectively. The southern creek is marked by a topographic low and a small area of reduced resistivity consistent with moist ground. The northern creek is also located at the far northern end of the profile and appears to be resistive, possibly due to shallow bedrock underneath.

5.0 Project Summary

The survey was conducted with no serious issues regarding safety, access, or equipment performance. The key results from the survey were as follows:

1. The borehole data was clustered around profile 5 and 6 (Figure 16). These boreholes indicated that there was up to 16m of ash deposited in that area. These boreholes also indicated that the ash was generally low conductivity (<100Ohm.m) and could be mapped as broad shallow lobed up to 20m deep.
2. Elsewhere there was little indication of ash within the study area (Figure 16). ‘Fill’ within boreholes had a similar low resistivity.
3. Numerous lobes of ‘fill/ash’ were interpreted in the resistivity data and are broadly distributed through the study area (Figure 16). These lobes are between 10-25m deep. However, it is not possible to differentiate ‘fill’ from ‘ash’ based on the limited drill data intersecting the ERI profiles. These lobes sit on areas if higher resistivity interpreted as bedrock (coal, siltstone, and sandstone).
4. Two groundwater bores indicated that the base of the Lithgow coal seam was at 870m elevation. The Lithgow coal seam is the deepest coal seam in the region and likely marks the base of any excavations in the study area. All lobes mapped as fill sat above this elevation.
5. ERI profiles 1-5 showed large and deep conductive lobes that extended beyond the base of the Lithgow Coal seam. These high conductivity zones are interpreted to be bedrock with significant groundwater and are located through the centre of the survey area but are notably absent from the easternmost profile (Figure 16). Groundwater ingress may have been possible due to fracturing that may have been further enhanced by historical blasting on the site.
6. The two creeks on site typically sit on comparatively conductive ground, indicative of a high moisture content. However, in many places these areas are also mapped as ‘fill’

which is also conductive. Therefore the link, if any, between the creeks and is subsurface is unclear

6.0 DELIVERABLES

The following deliverables were provided following project completion:

- Factual report
- ERI raw field data in ZZgeo format
- ERI field data and inversion results in
- ERI inversion results in *.csv format
- ERI profile images and 2D raster

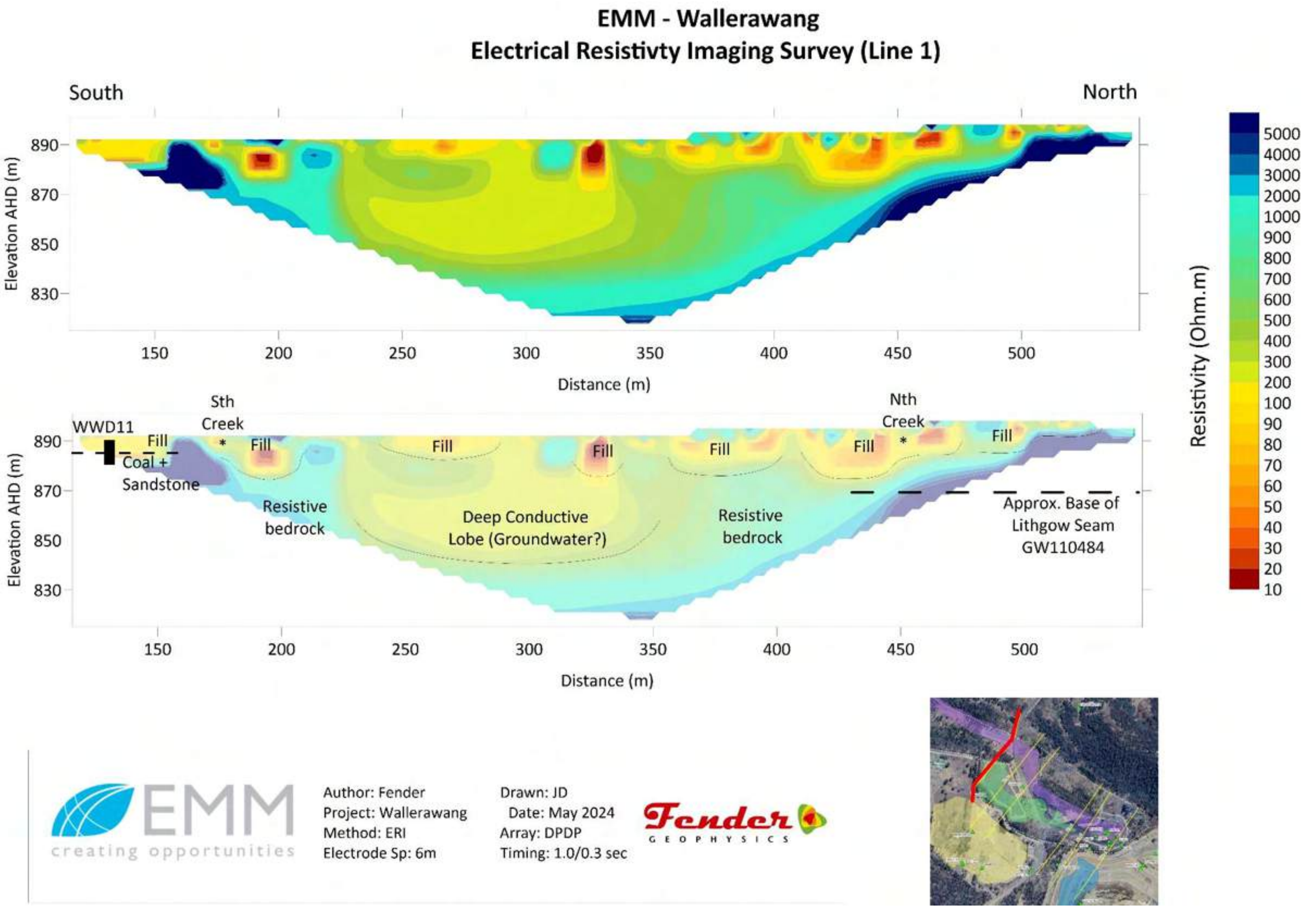


Figure 4. Electrical Resistivity Imaging profile 1 showing raw and interpreted data. Borehole WWD11 is shown.

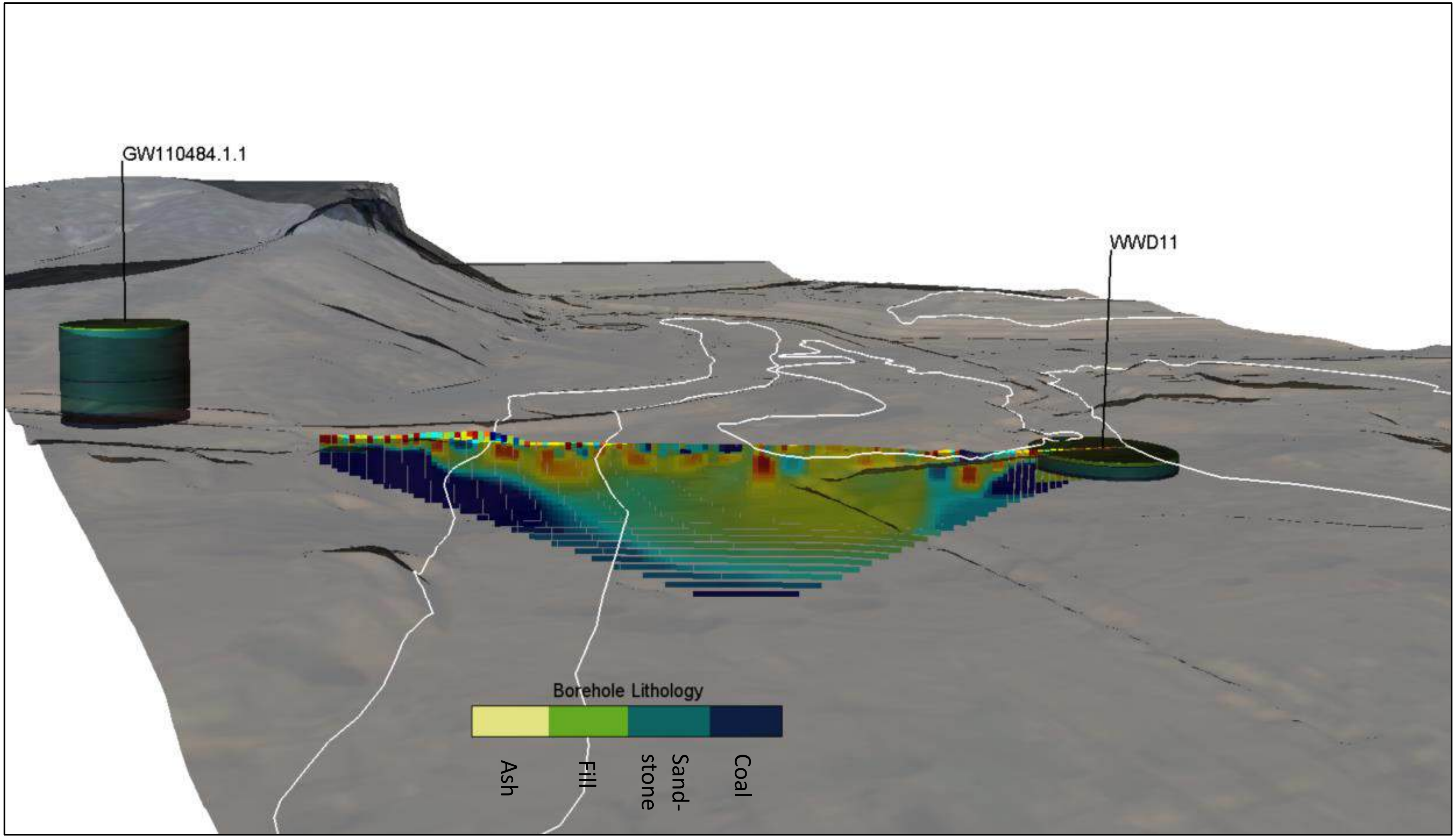


Figure 5. 3D perspective image of ERI profile 1 with boreholes GW110484.1.1 and WWD11.

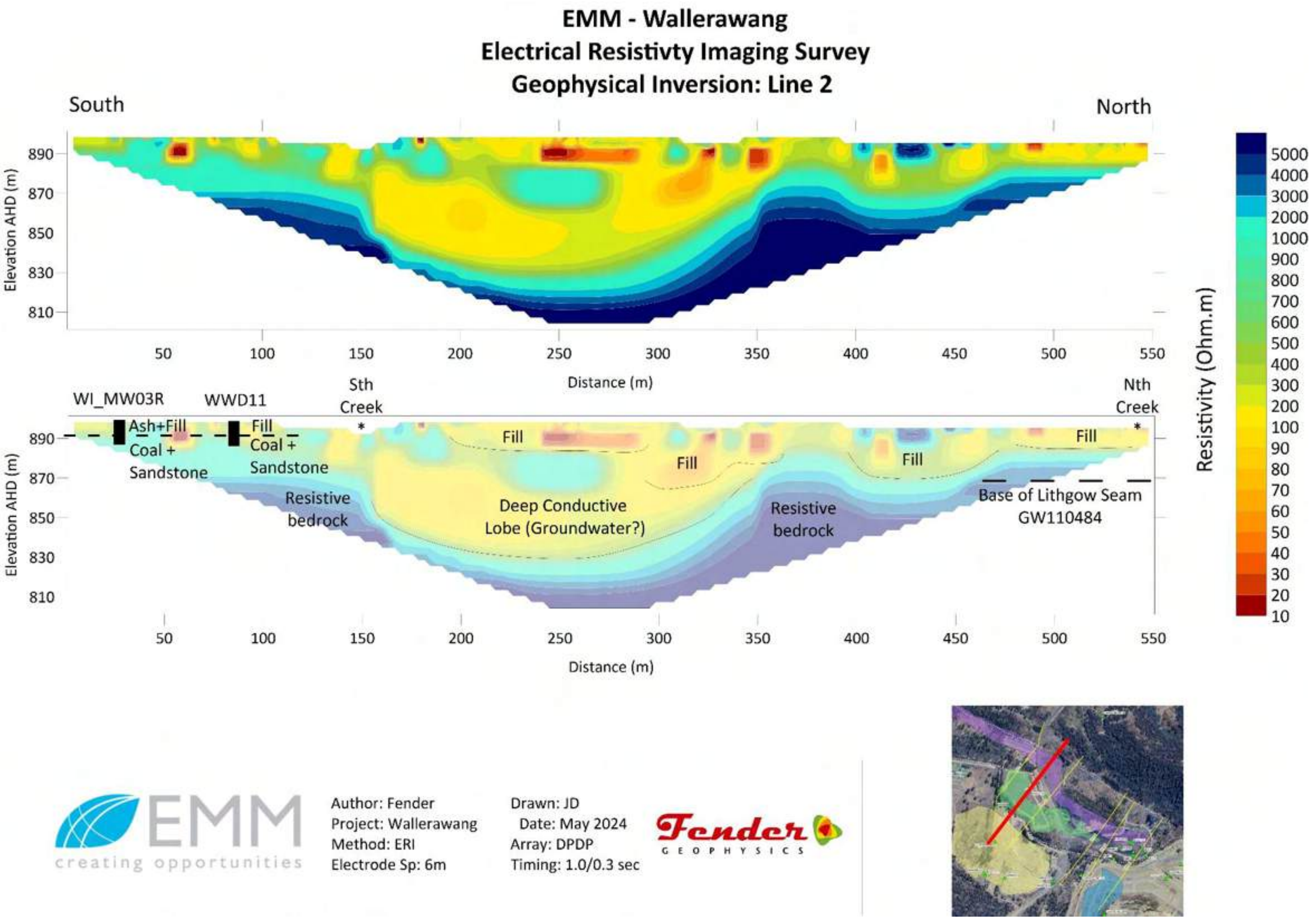


Figure 6. Electrical Resistivity Imaging profile 2 showing raw and interpreted data. Boreholes WWD11 and WI_MW03R.

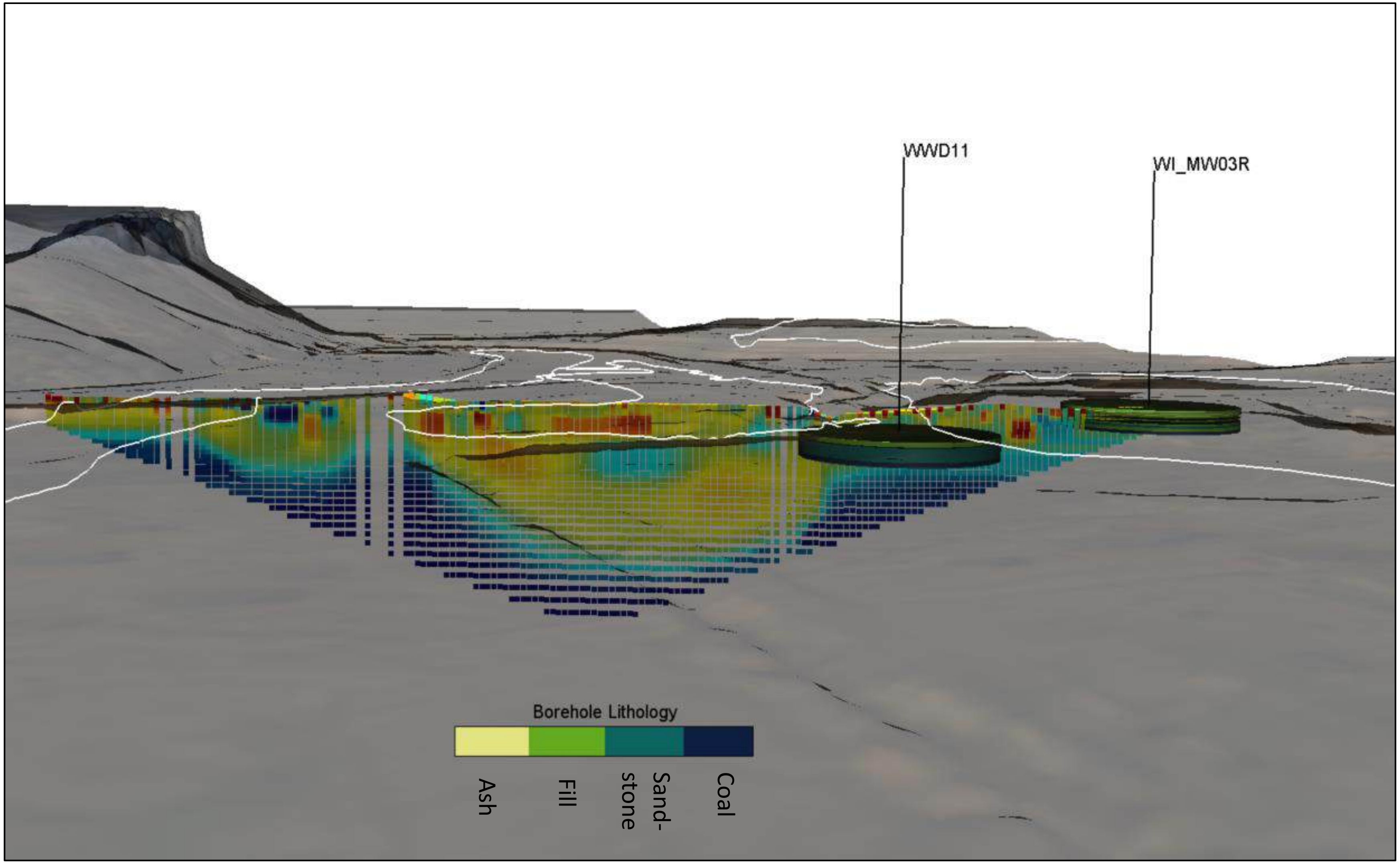


Figure 7. 3D perspective image of ERI profile 2 with boreholes WWD11 and WI_MW03R are shown.

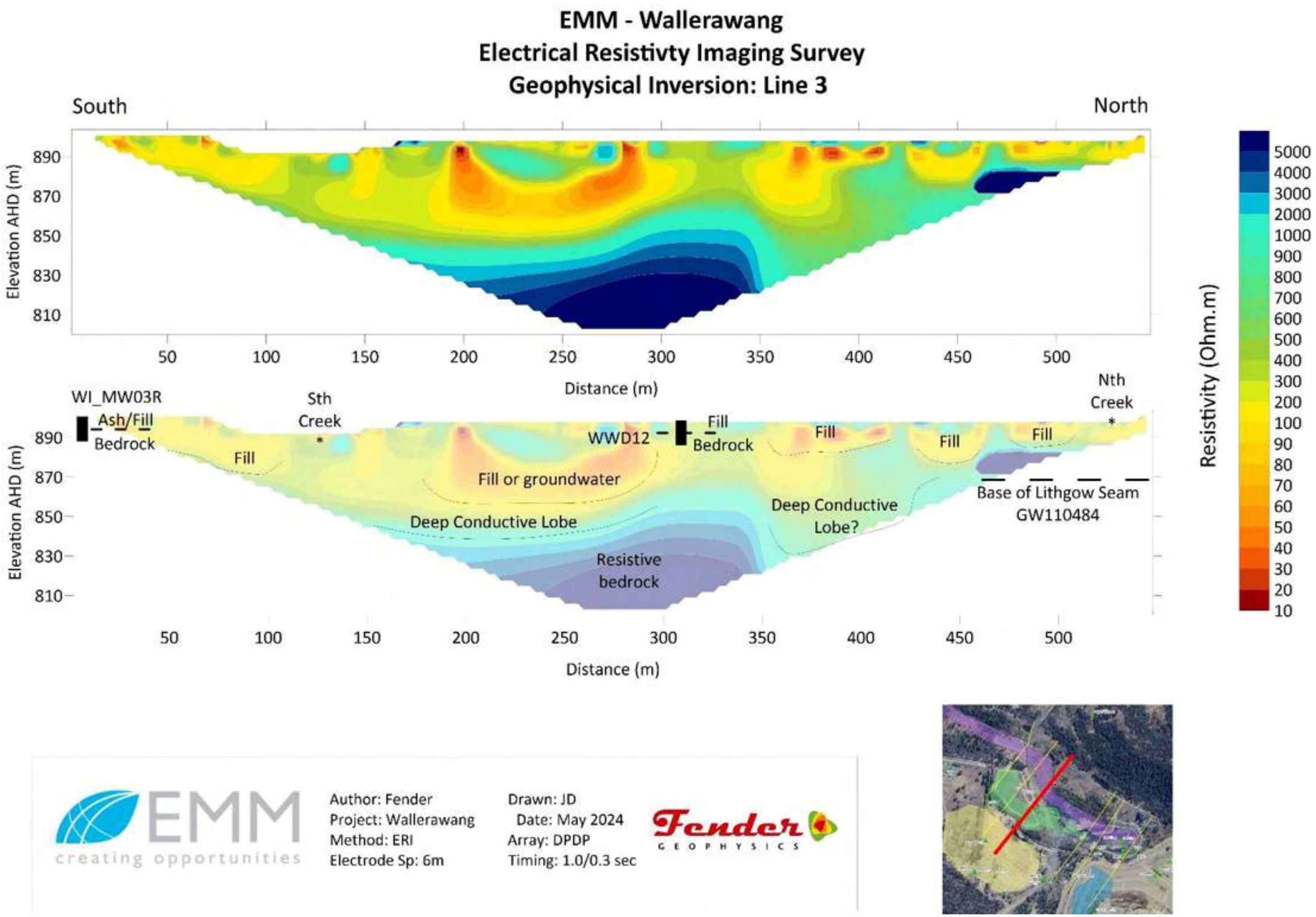


Figure 8. Electrical Resistivity Imaging profile 3 showing raw and interpreted data. Boreholes WWD12 and WI_MW03R are shown.

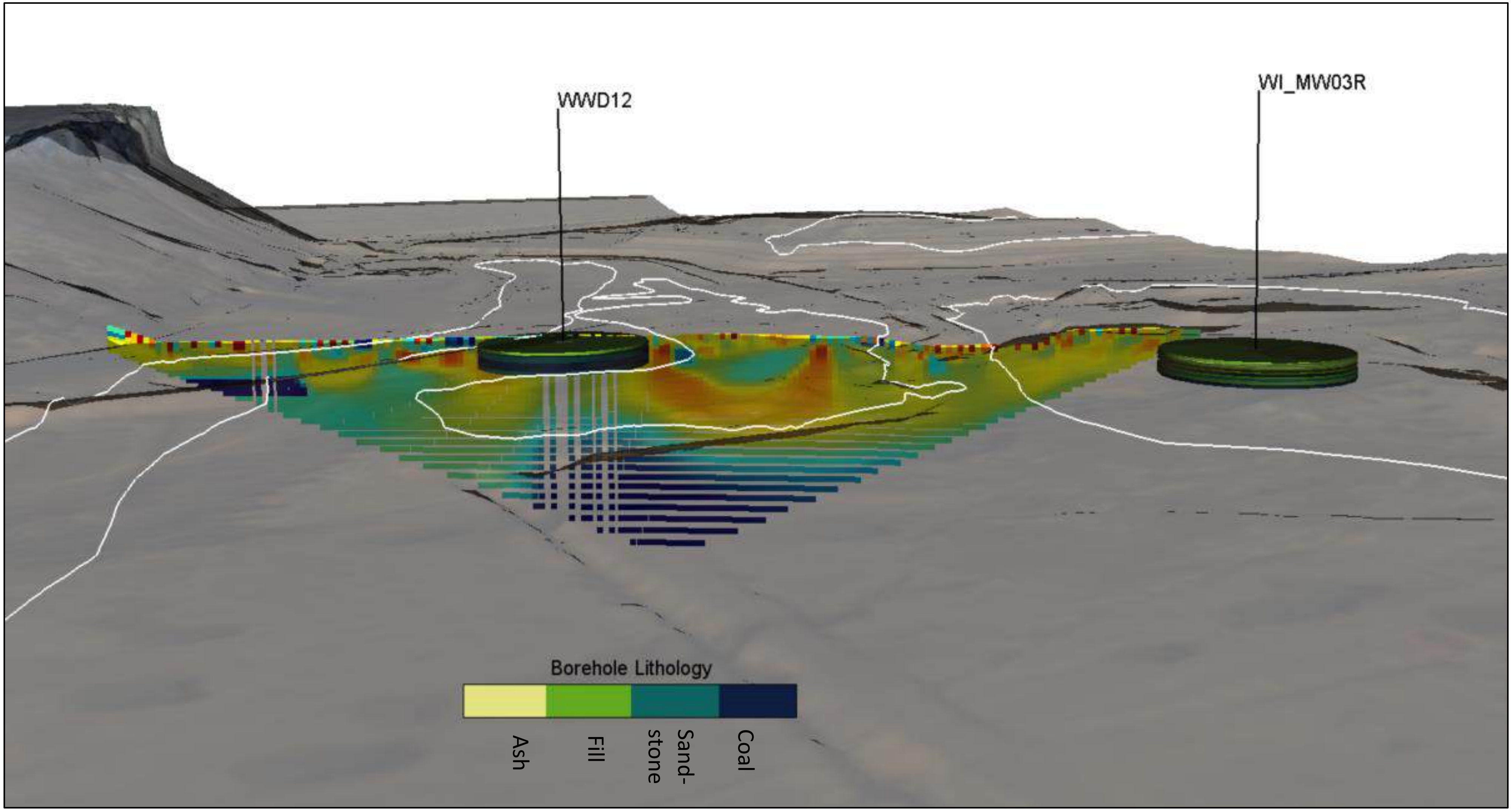


Figure 9. 3D perspective image of ERI profile 3 with boreholes WWD12 and WI_MW03R are shown.

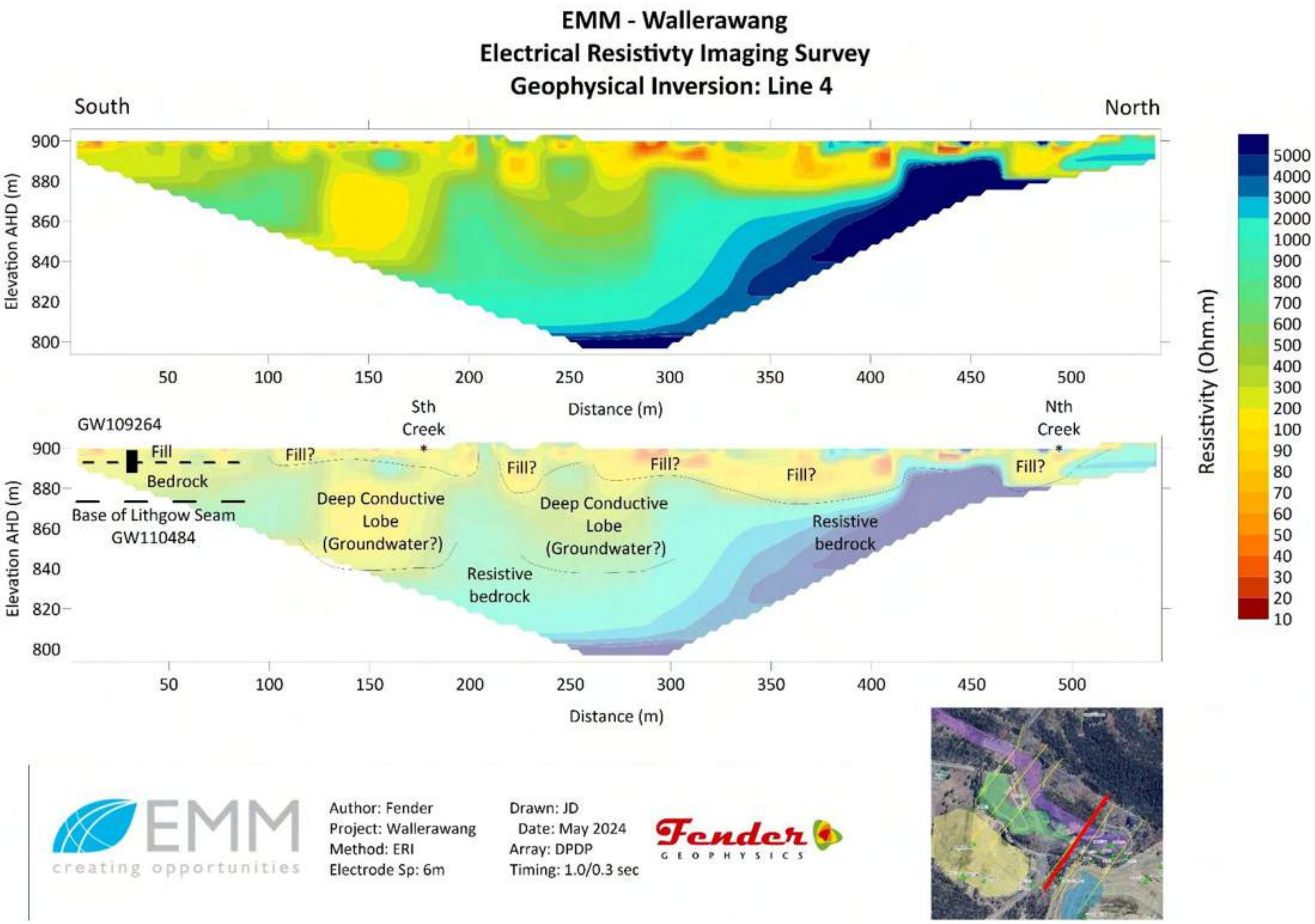


Figure 10. Electrical Resistivity Imaging profile 4 showing raw and interpreted data. Borehole GW109264 is shown.

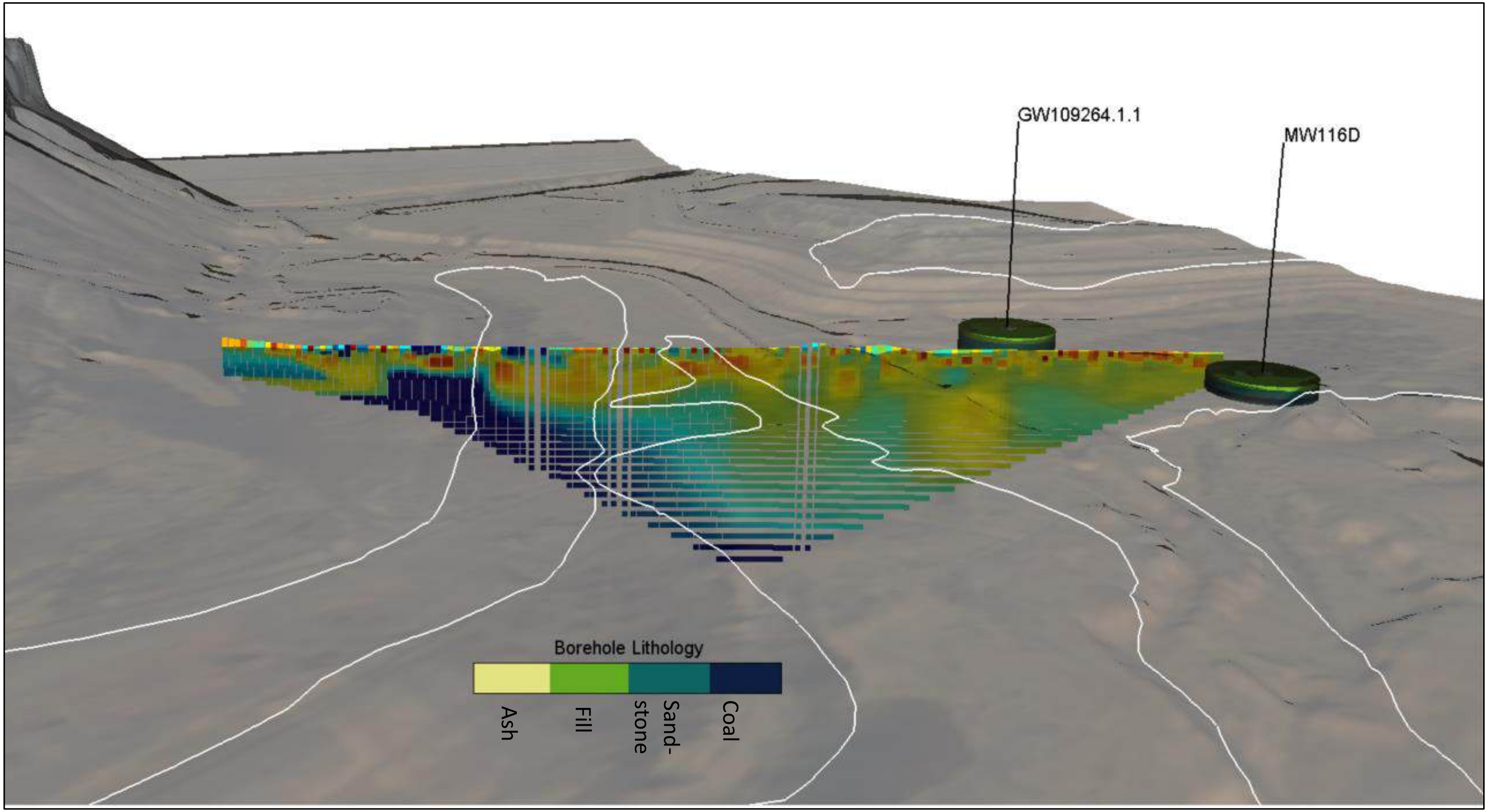


Figure 11. 3D perspective image of ERI profile 4 with boreholes GW109264.1.1 and MW116D.

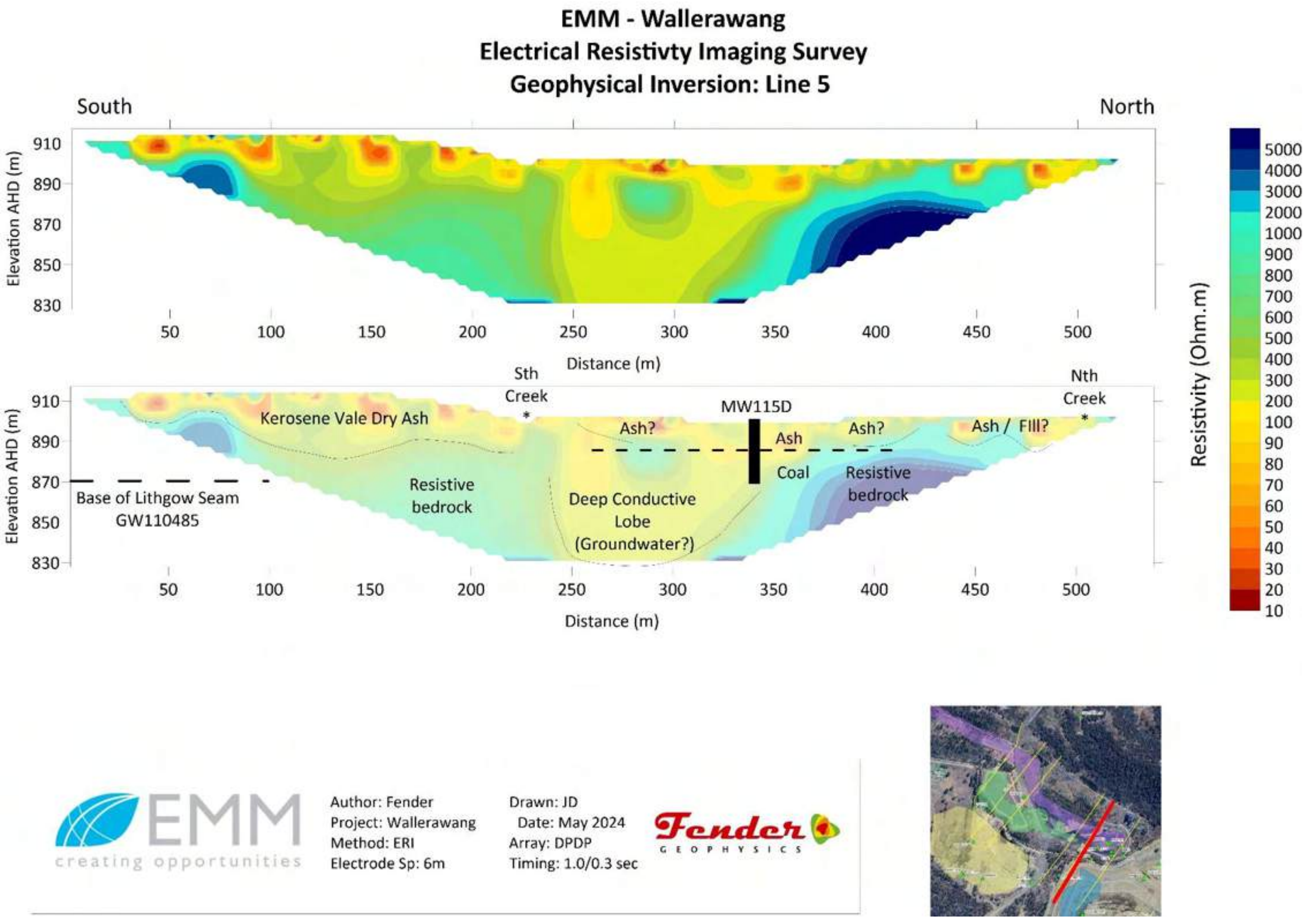


Figure 12. Electrical Resistivity Imaging profile 5 showing raw and interpreted data. Borehole MW115D is shown.

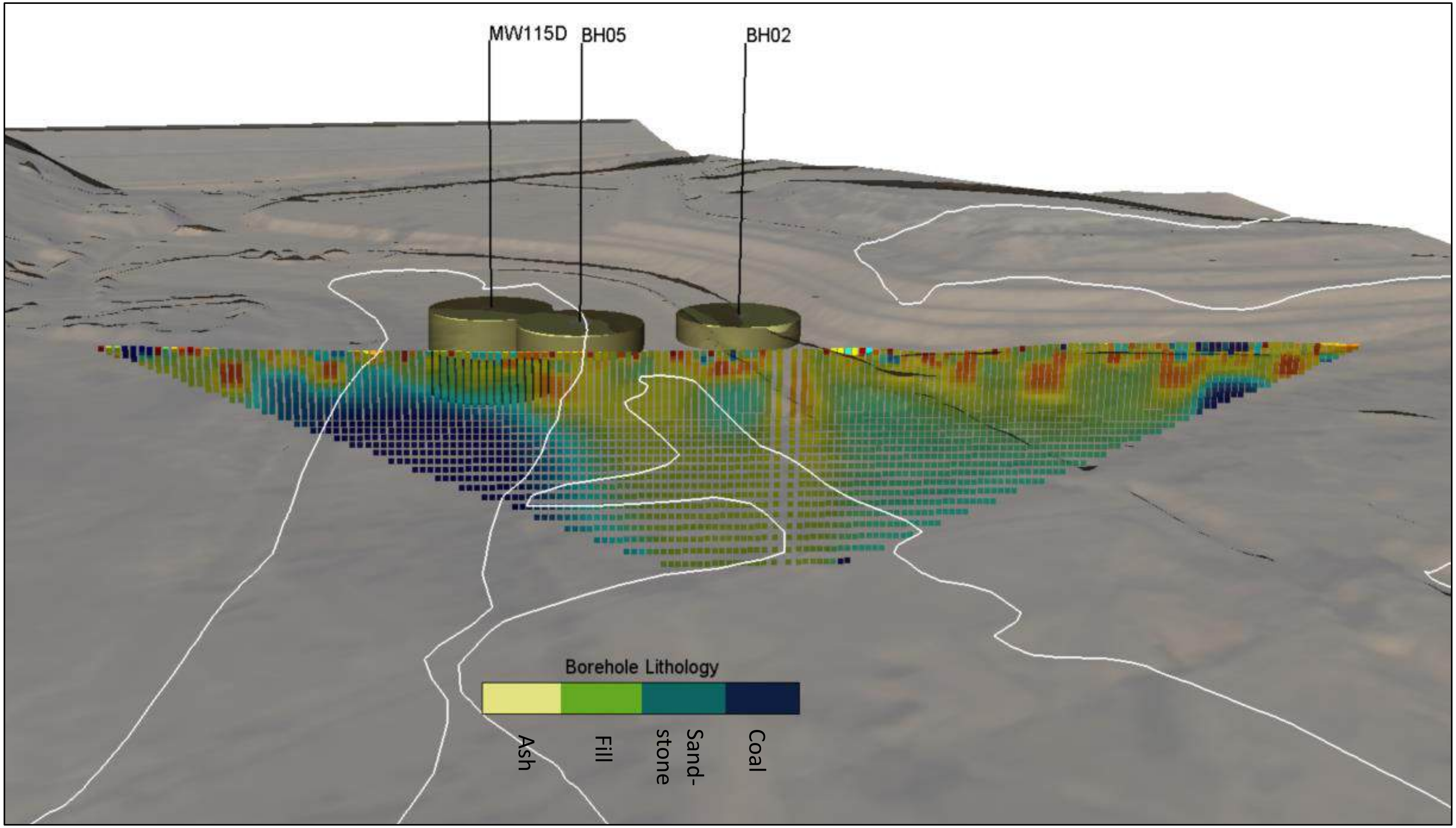


Figure 13. 3D perspective image of ERI profile 5 with boreholes MW115D, BH05 and BH02.

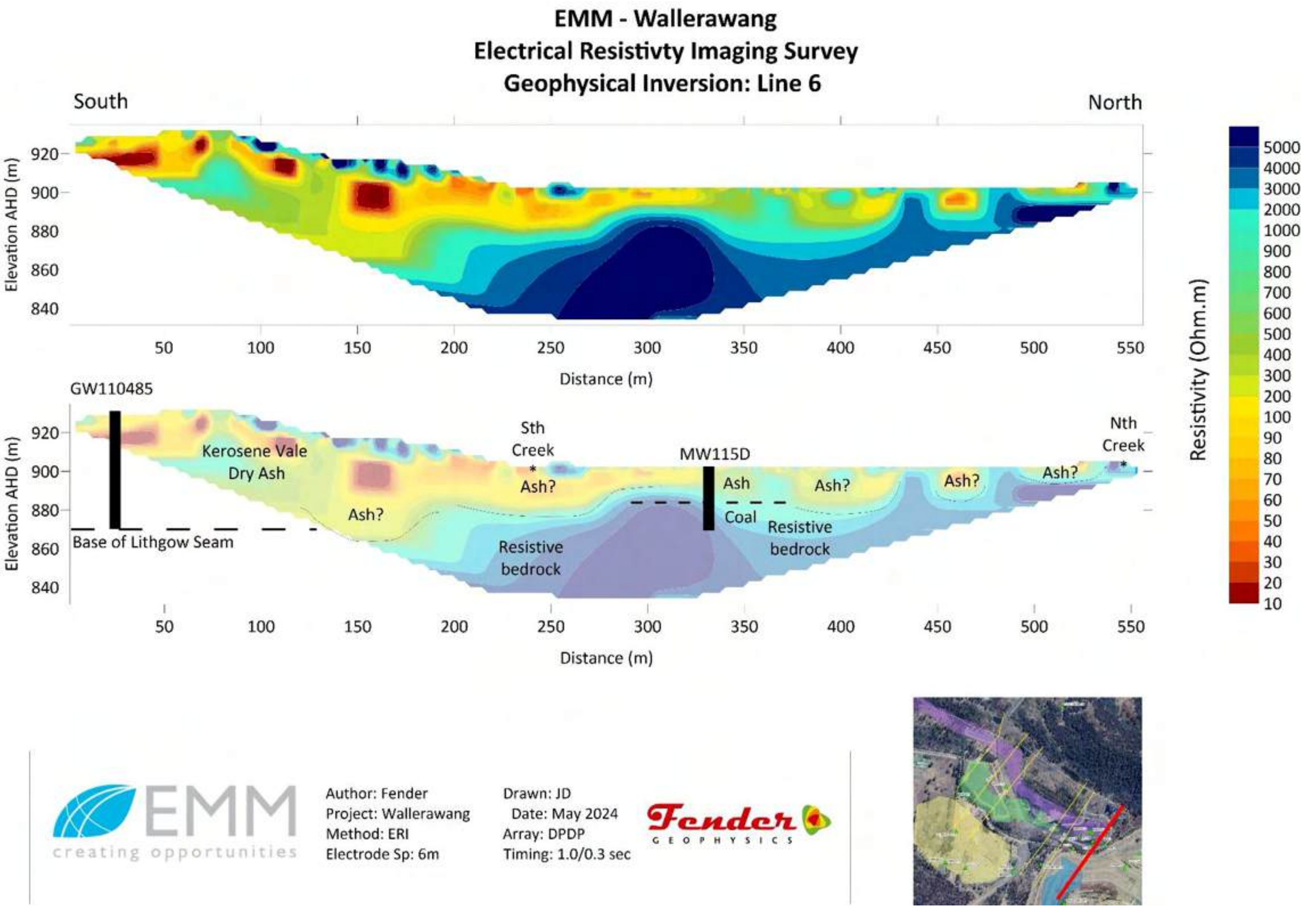


Figure 14. Electrical Resistivity Imaging profile 6 showing raw and interpreted data. Boreholes GW110485 and MW115D are shown.

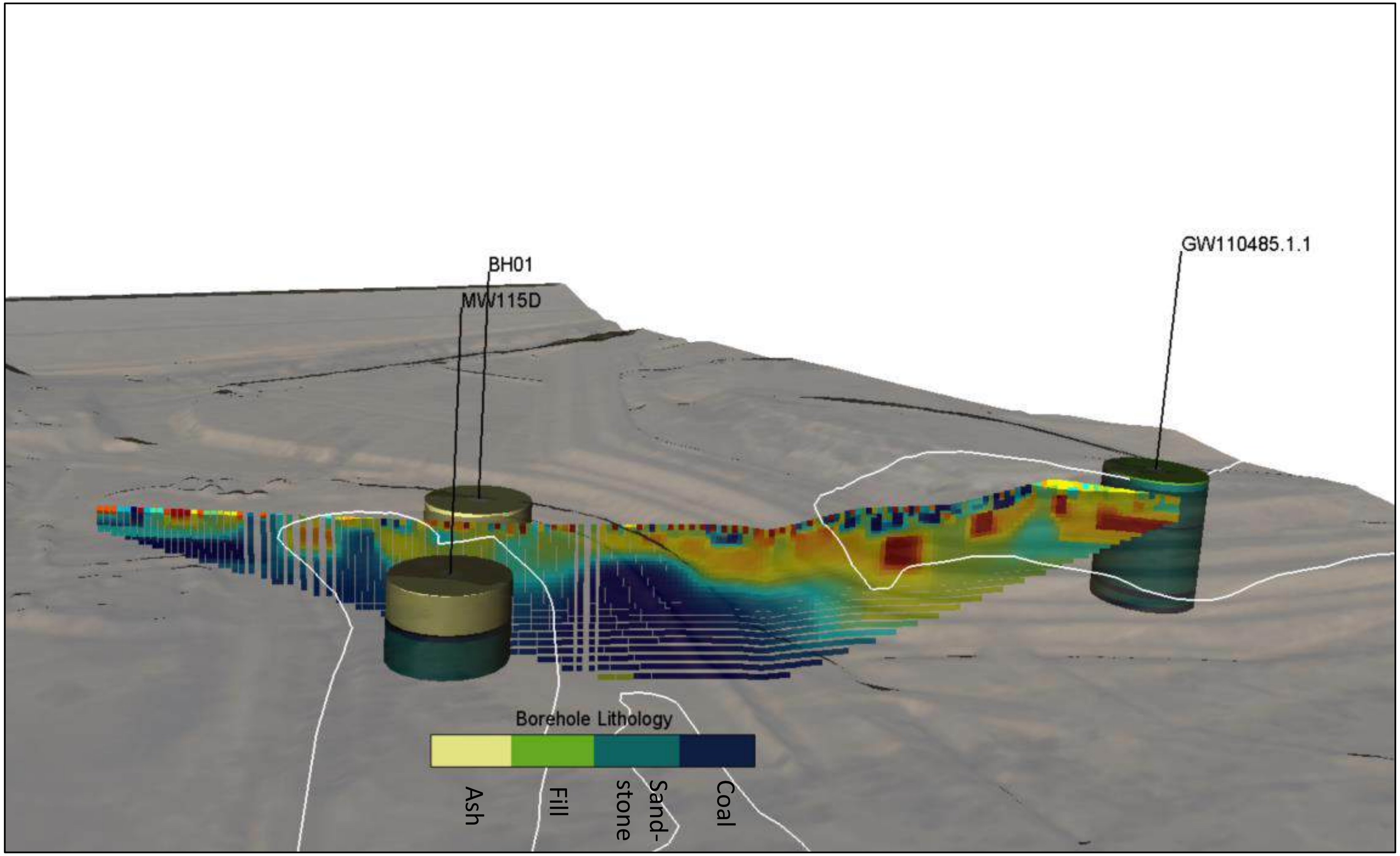


Figure 15. 3D perspective image of ERI profile 6 with boreholes MW115D, BH01 and GW110485.

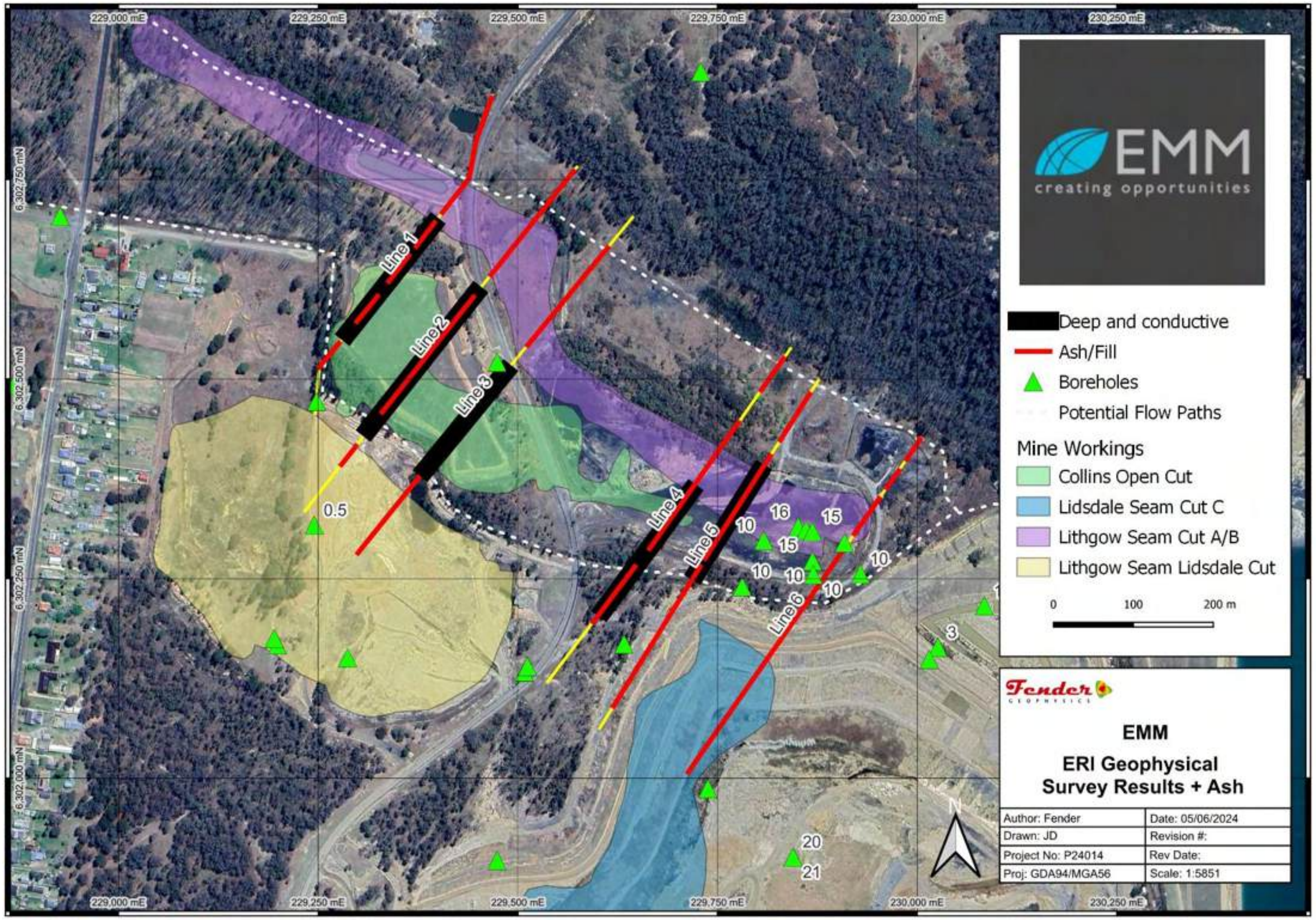


Figure 16.Distribution of Ash/Fill (Red) and deep conductive ground (black) within survey area. The depth of ash in meters is marked against the boreholes.

Appendix E

Geotechnical Report: Macquarie Geotech 2024, KVAR Creek Realignment – Geotechnical Investigation

creating opportunities

MACQUARIE GEOTECH

KVAR Creek Realignment – Geotechnical Investigation

Job No.: G23994

Submitted to:

Generator Property Management (GPM)

110 Skelly Road

Lidsdale NSW 2790

Attn: Paul Glasson

Geotechnical Investigation Report

Report No.: G23994

Client – KVAR Creek Realignment

REVISION CONTROL

Revision	Date	Details	Prepared By	Reviewed By
00	8 April 2024	Draft	M.Williams	C.Green
01	11 April 2024	Final	M.Williams	C.Green

Contents

Figures

Tables

Appendices

1 INTRODUCTION

At the request of Generator Property Management (GPM), Macquarie Geotechnical (MG) has carried out a Geotechnical Investigation for the proposed realignment of a creek at Kerosene Vale Ash Repository (KVAR).

The objective of the investigation is to provide a geotechnical Interpretive report.

The comments and opinions expressed in this report are based on the ground conditions encountered during the site work and on the results of tests carried out in the field and in the laboratory. There may, however, be special conditions prevailing on the site which have not been disclosed by this investigation and which have not been taken into account by this report.

2 SCOPE OF INVESTIGATION

The client requirements of the investigation are as follows:

- Assess the likely ground conditions along the proposed route of the creek re-alignment.
- Six holes were drilled to delineate the creek re-alignment from a nearby infilled open cut coal mine'.
- Determine the presence/depth to water table, if encountered.
- Characterise in situ materials and provide advice in relation to soil types, erodibility, permeability and excavated material management/reuse implications.

  It is understood that EMM Consulting will evaluate samples and laboratory testing in relation to a detailed site contamination investigation being undertaken.
- Assess whether in-situ soils can support revegetation.

The agreed scope of works are as follows:

- Undertake a brief desk study of the site to confirm the likely geological conditions of the site and to develop a geological model for the site.
- Undertake Dial Before You Dig (DBYD) services search.
- Mobilisation of one drill rig, drilling, logging and sampling of six boreholes as per Table 1 below with allowance for rock coring made for each borehole. In-situ testing comprised of Standard Penetration Tests (SPT) at 1.50m intervals.

Table 1: Borehole Scope

Hole ID	Eastings	Northings	RL (m AHD)	Depth (m)
BH01	229929	6302256	937.0	10.00
BH02	229781	6302240	935.0	10.25
BH03	229909	6302295	934.0	10.50
BH04	229869	6302272	935.0	10.50
BH05	229808	6302298	934.0	10.50
BH06	229870	6302255	936.0	3.22

- Samples were taken at regular intervals and at every change of strata to allow for laboratory testing and returned to our NATA accredited laboratory in Bathurst, NSW. Laboratory testing comprised the following:
    - Five Atterberg Limits
    - Five Emerson Class tests.
    - One falling head permeability test.
    - Ten suite (metals, TRH, PAH and BTEX) of soil contamination tests, undertaken on behalf of EMM Consulting.

3 SITE DESCRIPTION

The project is located approximately 1 km north east of Lidsdale within the Lithgow City Council government area.

Figure 1: Site Location

4 GEOLOGY

Reference was made to the Minview website and an extract of the geology map is shown in Figure 2 below:

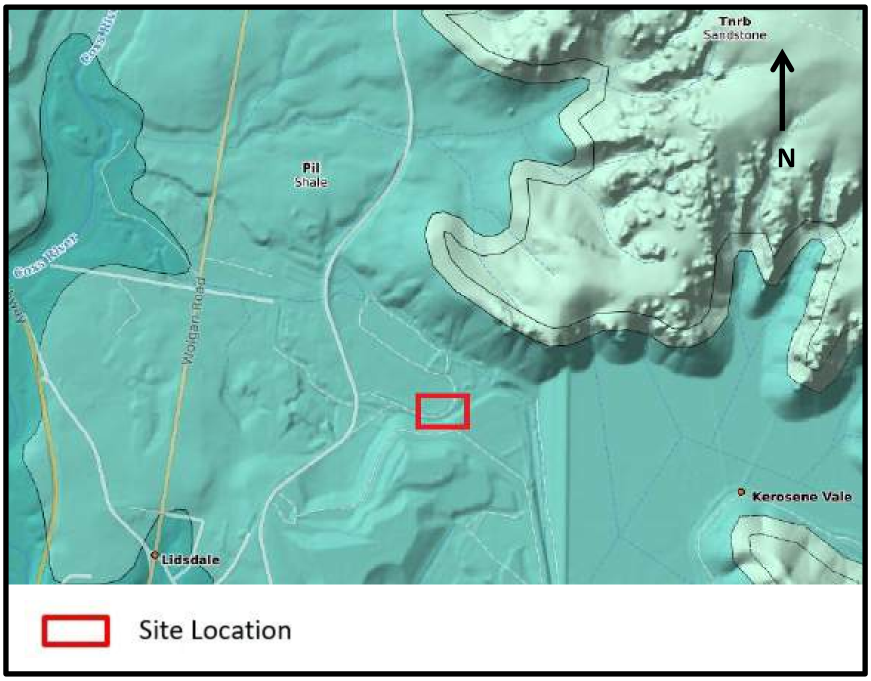


Figure 2: Geology map extract

With reference to the Minview NSW Seamless geological map the site is underlain by the following:

Table 2: Summary of Geology

Geological Symbol	Group	Lithology
Pil	Illawarra Coal Measures	Shale, quartz-lithic sandstone, conglomerate, chert, sporadically carbonaceous mudstone, coal and torbanite seams

5 FIELDWORK

Fieldwork was undertaken between the 10th to 12th February 2024 by a team of Engineering Geologists and Drillers from our Bathurst and Sydney offices. The fieldwork was undertaken in accordance with our proposal and AS1726 Geotechnical Site Investigation.

5.1 Service Location

Macquarie Geotechnical obtained underground services and utility plans through 'Before You Dig Australia (BYDA)' services.

5.2 GPS

All test locations were surveyed using a handheld GPS with co-ordinates recorded in MGA Zone 56 format and elevations in Australian Height Datum (AHD).

5.3 Boreholes

The boreholes were drilled at locations nominated by the client and are summarised in Table 1.

A SRS ML Duo (MG82) (Sonic Rig) was used to drill six boreholes to depths of up to 10.5m utilising sonic drilling (Vibra Core) and HQ3 wireline coring. In situ testing comprised of Standard Penetration Tests (SPT).

The boreholes were backfilled with arisings on completion. Borehole logs and photographs are presented in Appendix C.

5.4 Sampling

The sampling was undertaken in general accordance with AS1289 1.2.1 and based on that defined in the proposal and considered the engineering requirements of the investigation and the nature of the materials encountered.

5.5 In Situ Testing

In-situ testing as specified by the client or our proposal was carried out in selected exploratory holes in accordance with the techniques outlined in the relevant Australian Standards and Macquarie Geotechnical Quality procedures. The results are presented on the relevant exploratory hole logs in Appendix C.

5.5.1 Standard Penetration Testing

Standard Penetration Tests (SPT) were carried out in the boreholes with techniques outlined in AS1289 6.3.1 in order to determine the relative density and consistency of the strata encountered. The SPT “N” value (number of blows per 300mm penetration) or the blow count / penetration were recorded for each test.

5.5.2 Pocket Penetrometer Testing

Pocket Penetrometer (PP) testing was carried out on selected SPT split spoon samples.

5.6 Laboratory Testing

The samples were returned to Macquarie Geotechnical NATA accredited laboratory at Bathurst for further assessment and testing. The laboratory tests were carried out as per the laboratory test request provided by the client.

Table 3: Summary of Laboratory Tests

Hole ID	Depth (m)	Laboratory Test
BH01	0.50 - 0.95	Atterberg Limits (AS 1289.3.1.1, 3.2.1, 3.3.1) Emerson Class (AS 1289.3.8.1)
BH01	1.50 - 1.95	
BH02	0.50 - 0.95	
BH02	2.00 - 2.50	
BH06	0.50 - 0.95	
BH2, 3 & 4	0.5-3.0m Blend	Standard Compaction (AS 1289 5.1.1) Falling Head Permeability (AS 1289 6.7.2 & 2.1.1)

In addition to the above, ten soil samples have been tested for a suite (metals, TRH, PAH and BTEX) of contaminants, undertaken on behalf of EMM Consulting.

Results of laboratory testing are attached in Appendix D.

6 EXISTING SUBSURFACE CONDITIONS

The subsurface conditions encountered in the boreholes are presented in detail in the attached borehole logs (refer Appendix C). The subsurface conditions encountered in the boreholes are broadly summarised in Table 4 (Creek Alignment) and Table 5 (Infilled Open Cut Coal Mine) below.

6.1 Exploratory Hole Summary

Table 4: Borehole Summary (Creek Alignment – BH1, BH2 and BH6)

Unit	Name	Depth Range (m)	Maximum Thickness (m)	Material Description
1	Topsoil	GL - 0.10	0.1	Clay with roots (BH1 only)
2	FILL	GL – 0.50	0.50	Coal and ash
3	Residual	0.10 – 6.00	>5.90	Silty CLAY & Silty SAND
4	Rock	1.00 to >10.00	Not determined	Shale, Sandstone and Coal

Table 5: Borehole Summary (Infilled Open Cut Coal Mine – BH3, BH4 and BH5)

Unit	Name	Depth Range (m)	Maximum Thickness (m)	Material Description
1	FILL	GL to >10.5	>10.5	Black and grey, coal, ash, sand and clay

6.2 Groundwater

The comments on groundwater are based on the observations made at the time of the investigation. Groundwater was not encountered in any of the boreholes at the time of investigation. It is possible that elevated groundwater levels may occur during wet periods.

Seasonal variation in groundwater may also occur and should be considered as part of design process.

7 LABORATORY TEST RESULTS

The laboratory tests were carried out on the samples nominated by Macquarie Geotechnical. The geotechnical test results are summarised in Tables 6 and 7 below, and test result certificates are attached in Appendix D. Soil contamination test results, undertaken on behalf of EMM Consulting, have not been summarized with only test certificates supplied in Appendix D.

Table 6: Laboratory Test Results - Classification

Hole ID	Depth (m)	Sample Description (USCS)	Atterberg Limits			Emerson Class
			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	
BH01	0.50 - 0.95	Silty CLAY*	25	18	7	5
BH01	1.50 - 1.95	Silty CLAY*	37	15	22	5
BH02	0.50 - 0.95	Silty CLAY*	33	25	8	5
BH02	2.00 - 2.50	Silty CLAY*	36	23	13	5
BH06	0.50 - 0.95	Silty CLAY*	41	25	16	6

Note: USCS – Unified Soil Classification System.
*Visual description.

Table 7: Laboratory Test Results – California Bearing Ratio (CBR)

Hole ID	Depth (m)	Sample Description (USCS)	California Bearing Ratio (CBR)		Permeability (m/sec)
			MDD (t/m^3)	OMC (%)	
BH2, 3 & 4	0.5 - 3.0 Blend	Blended	1.82	13.5	$2x10^{-10}$

Note: USCS – Unified Soil Classification System, MDD – Maximum Dry Density, OMC – Optimum Moisture Content.
* Visual description.

8 GEOTECHNICAL ASSESSMENT

The creek realignment characterised by BH1, BH2 and BH6 comprises a thin cover of fill material overlying residual soils grading into rock. Groundwater was not observed.

The creek alignment boreholes differ significantly from the other open cut coal mine backfill boreholes and suggest that the creek alignment does not cross the infilled open cut coal mine.

It is understood that excavation for the creek is unlikely to exceed 3m.

In re-aligning the creek, the key features are as follows:

- Excavatability of the soils along the new creek alignment.
- Suitability of the excavated soils for re-use and to infill the former creek alignment.
- Permeability and erodibility of the shallow soils in which the creek bed will flow; and
- Whether the in-situ soils can support revegetation.

8.1 Permeability

Unfortunately, insufficient suitable sample volume was obtained by the sonic drilling method at shallow depth, consequently samples were blended to form one composite for standard compaction and falling head permeability testing.

A permeability value of 2×10^{-10} m/sec was recorded for the blended predominantly clay soil samples.

8.2 Erodibility

The Emerson Class tests predominantly gave a value of 5 and also a 6, indicating a relatively low dispersion potential.

8.3 Earthworks

8.3.1 Excavatability

The creek alignment holes are ostensibly in natural residual clays and sands. Highly weathered rock material was indicated at 1.0m in BH2.

Excavation in the soils and highly weathered rock should be achievable by conventional earth moving plant.

Cut batters in the soils should be formed at around 1V:3H and certainly no steeper than 1V:2H, as anything steeper will likely result in long term slumping and continual failure, especially in proximity to flowing water.

8.3.2 Filling

The following scope of work is required as a minimum to prepare the former creek alignment prior to infilling. Structural support upon the fill is not envisaged:

- Prior to construction and placement of any fill, the proposed subgrade and sides should be stripped to remove all vegetation, topsoil, organic, root affected or other potentially deleterious material;
- Where practicable the ground should be benched to allow the fill material to key into the natural ground and also provide level platforms for the compaction works.

- Following stripping, the exposed subgrade materials should be proof rolled in the presence of a suitably qualified and experienced Geotechnical Engineer to identify any wet or excessively deflecting material.
- Site filling should be undertaken to the provisions of AS3798-2007: "Earthworks for Residential and Commercial Developments", ie. above 95% standard maximum dry density. Since support of structures or equipment is not envisaged, Level 2 earthworks inspection and testing requirements as per the standard, would be considered sufficient.

8.3.3 Re-use of Site Material

Careful extraction and stockpile management will be required to optimise the potential volume of site won materials. Where feasible, material should be trucked directly to the placement site to avoid double handling and associated time and cost implications.

With the exception of the topsoil, the majority of the site won soil material from the new creek alignment is considered suitable for use as general fill material.

A balanced cut and fill will be dependent on a survey take-off of the cut and fill volumes based on the final design reduced levels and layout for the new and former creek alignments. It is expected that importation of some earthwork fill materials may be required.

8.3.4 Trafficability

The clay subgrades would likely be trafficable during dry periods. Some desiccation of exposed surfaces can be expected and large quantities of dust could be generated during dry periods under traffic. The soils will be soft and difficult to traverse following wet weather or inundation. Drying out of these soils could take several days or weeks before being able to accommodate construction traffic.

8.4 Revegetation

MG have compared the heavy metal concentrations of copper, nickel and zinc obtained from the contamination testing against the following values of phytotoxicity (poisonous to plants) stated in the UK ICRCL (Interdepartmental Committee for the Redevelopment of Contaminated Land) 1983 guidelines.

- Copper – 130 mg/kg
- Nickel – 70 mg/kg
- Zinc – 300 mg/kg

These values are not exceeded for copper and zinc. One value from BH1 (0.1 – 0.5m) marginally exceeds the value for nickel with 72 mg/kg.

Consequently, it is MG's opinion that the natural soils along the proposed creek alignment and the site won fill materials would likely be amenable to revegetation.

9 CONCLUSION

The findings of our report were based on our fieldwork, in-situ testing, laboratory testing, technical assessment and local knowledge for this site.

We trust the foregoing is sufficient for your present purposes, and if you have any questions please contact the undersigned.

Martin Williams
Principal Geotechnical Engineer
MSc CPEng

Craig Green
Geotechnical Manager
BSc (Hons)

Attached: Limitations of Geotechnical Site Investigation

References: Australian Standard 1726 – 2017 Geotechnical Site Investigations

Australian Standard 3798 - 2007 Earthworks for Residential and Commercial Developments

LIMITATIONS OF GEOTECHNICAL SITE INVESTIGATION

Scope of Services

This report has been prepared for the Client in accordance with the Services Engagement Form (SEF), between the Client and Macquarie Geotechnical.

Reliance on Data

Macquarie Geotechnical has relied upon data and other information provided by the Client and other individuals. Macquarie Geotechnical has not verified the accuracy or completeness of the data, except as otherwise stated in the report. Recommendations in the report are based on the data.

Macquarie Geotechnical will not be liable in relation to incorrect recommendations should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed.

Geotechnical Investigation

Findings of Geotechnical Investigations are based extensively on judgment and experience. Geotechnical reports are prepared to meet the specific needs of individual clients. This report was prepared expressly for the Client and expressly for the Clients purposes.

This report is based on a subsurface investigation, which was designed for project-specific factors. Unless further geotechnical advice is obtained this report cannot be applied to an adjacent site nor can it be used when the nature of any proposed development is changed.

Limitations of Site investigation

As a result of the limited number of sub-surface excavations or boreholes there is the possibility that variations may occur between test locations. The investigation undertaken is an estimate of the general profile of the subsurface conditions. The data derived from the investigation and laboratory testing are extrapolated across the site to form a geological model. This geological model infers the subsurface conditions and their likely behavior with regard to the proposed development.

The actual conditions at the site might differ from those inferred to exist.

No subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

Time Dependence

This report is based on conditions, which existed at the time of subsurface exploration. Construction operations at or adjacent to the site, and natural events such as floods, or groundwater fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report.

Macquarie Geotechnical should be kept appraised of any such events, and should be consulted for further geotechnical advice if any changes are noted.

Avoid Misinterpretation

A geotechnical engineer or engineering geologist should be retained to work with other design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their plans and specifications relative to geotechnical issues.

No part of this report should be separated from the Final Report.

Sub-surface Logs

Sub-surface logs are developed by geoscientific professionals based upon their interpretation of field logs and laboratory evaluation of field samples. These logs should not under any circumstances be redrawn for inclusion in any drawings.

Geotechnical Involvement During Construction

During construction, excavation frequently exposes subsurface conditions. Geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. Other parties should not rely upon the report or the accuracy or completeness of any recommendations and should make their own enquiries and obtain independent advice in relation to such matters

Macquarie Geotechnical assumes no responsibility and will not be liable to any other person or organisations for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisations arising from matters dealt with or conclusions expressed in the report.

Other limitations

Macquarie Geotechnical will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

Other Information

For further information reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by the Institution of Engineers Australia, 1987.

MACQUARIE GEOTECH

Appendix A – Geotechnical Explanatory Notes

MACQUARIE GEOTECH

Geotechnical Explanatory Notes

Soil Description

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer as follows:

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry – Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist – Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet – Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.

MC~PL Moisture Content near the Plastic Limit.

MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS – CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by the pocket penetrometer values and by resistance to deformation to hand moulding.

A Pocket Penetrometer may be used in the field or the laboratory to provide approximate assessment of unconfined compressive strength of cohesive soils. The values are recorded in kPa, as follows:

Strength	Symbol	Pocket Penetrometer Reading (kPa)
Very Soft	VS	< 25
Soft	S	20 to 50
Firm	F	50 to 100
Stiff	St	100 to 200
Very Stiff	VSt	200 to 400
Hard	H	> 400

COHESIONLESS SOILS – RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

The Standard Penetration Test (SPT) is carried out in accordance with AS 1289, 6.3.1. For completed tests the number of blows required to drive the split spoon sampler 300 mm are recorded as the N value. For incomplete tests the number of blows and the penetration beyond the seating depth of 150 mm are recorded. If the 150 mm seating penetration is not achieved the number of blows to achieve the measured penetration is recorded. SPT correlations may be subject to corrections for overburden pressure and equipment type.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	19 mm to 63 mm
	medium	6.7 mm to 19 mm
	fine	2.36 mm to 6.7 mm
Sand	coarse	600 μm to 2.36 mm
	medium	210 μm to 600 μm
	fine	75 μm to 210 μm

Rock Description

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$RQD\ (\%) = \frac{\text{Sum of Axial lengths of core} > 100\text{mm long}}{\text{total length considered}}$$

$$TCR\ (\%) = \frac{\text{length of core recovered}}{\text{length of core run}}$$

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM – Commission on Standardisation of Laboratory and Field Tests, "Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index", as follows:

Term	Symbol	Point Load Index $Is_{(50)}$ (MPa)
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

ROCK MATERIAL WEATHERING

Rock weathering is described using the following abbreviation and definitions used in AS1726:

Abbreviation	Term
RS	Residual soil
XW	Extremely weathered
DW	Distinctly weathered
HW	Highly weathered
MW	Moderately weathered
SW	Slightly weathered
FR	Fresh

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Description
B	Bedding
F	Fault
C	Cleavage
J	Joint
S	Shear Zone
D	Drill break

Planarity/Roughness:

Class	Description
I	rough or irregular, stepped
II	smooth, stepped
III	slickensided, stepped
IV	rough or irregular, undulating
V	smooth, undulating
VI	slickensided, undulating
VII	rough or irregular, planar
VIII	smooth, planar
IX	slickensided, planar

The inclination if defects are measured from perpendicular to the core axis.

WATER

▽ Water level at date shown ◁ Partial water loss

▷ Water inflow ◀ Complete water loss

Groundwater not observed: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

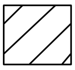
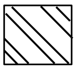
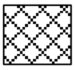
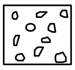
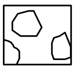
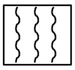
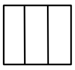
Groundwater not encountered: The borehole/test pit was dry soon after excavation, however groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

Graphic Symbols for Soils and Rocks

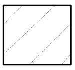
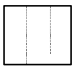
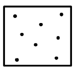
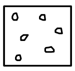
Typical symbols for soils and rocks are as follows. Combinations of these symbols may be used to indicated mixed materials such as clayey sand.

Soil Symbols

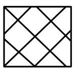
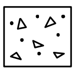
Main components

Symbol	Material
	CLAY - CL
	CLAY - CH
	SAND
	GRAVEL
	BOULDERS / COBBLES
	TOPSOIL
	SILT

Minor Components

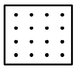
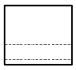
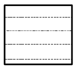
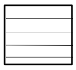
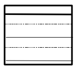
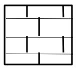
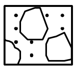
Symbol	Material
	Clayey
	Silty
	Sandy
	Gravelly

Other

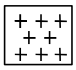
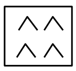
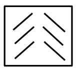
Symbol	Material
	FILL
	BITUMEN
	CONCRETE

Rock Symbols

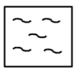
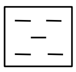
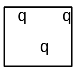
Sedimentary Rocks

Symbol	Material
	SANDSTONE
	SILTSTONE
	CLAYSTONE, MUDSTONE
	SHALE
	LAMINITE
	ASPHALT
	LIMESTONE
	CONGLOMERATE

Igneous Rocks

Symbol	Material
	GRANITE
	BASALT
	UNDIFFERENTIATED IGNEOUS

Metamorphic Rocks

Symbol	Material
	SLATE, PHYLLITE, SCHIST
	GNEISS
	QUARTZITE

Engineering Classification of Shales and Sandstones in the Sydney Region – A Summary Guide

The Sydney Rock Class classification system is based on rock strength, defect spacing and allowable seams as set out below. All three factors must be satisfied.

CLASSIFICATION FOR SANDSTONE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>24	>600	<1.5
II	>12	>600	<3
III	>7	>200	<5
IV	>2	>60	<10
V	>1	N.A.	N.A.

CLASSIFICATION FOR SHALE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>16	>600	<2
II	>7	>200	<4
III	>2	>60	<8
IV	>1	>20	<25
V	>1	N.A.	N.A.

MACQUARIE GEOTECH

UNIAXIAL COMPRESSIVE STRENGTH (UCS)

For expedience in field/construction situations the uniaxial (unconfined) compressive strength of the rock is often inferred, or assessed using the point load strength index (Is_{50}) test (AS 4133.4.1 - 1993). For Sydney Basin sedimentary rocks the uniaxial compressive strength is typically about 20 x (Is_{50}) but the multiplier may range from about 10 to 30 depending on the rock type and characteristics. In the absence of UCS tests, the assigned Sydney Rock Class classification may therefore include rock strengths outside the nominated UCS range.

DEFECT SPACING

The terms relate to spacing of natural fractures in NMLC, NQ and HQ diamond drill cores and have the following definitions:

Defect Spacing (mm)	Terms Used to Describe Defect Spacing[1]
>2000	Very widely spaced
600 - 2000	Widely spaced
200 - 600	Moderately spaced
60 - 200	Closely spaced
20 - 60	Very closely spaced
<20	Extremely closely spaced

[1]After ISO/CD14689 and ISRM.

ALLOWABLE SEAMS

Seams include clay, fragmented, highly weathered or similar zones, usually sub-parallel to the loaded surface. The limits suggested in the tables relate to a defined zone of influence. For pad footings, the zone of influence is defined as 1.5 times the least footing dimension. For socketed footings, the zone includes the length of the socket plus a further depth equal to the width of the footing. For tunnel or excavation assessment purposes the defects are assessed over a length of core of similar characteristics.

Source: Based on Pells et al (1978), as revised by Pells et al (1998).
Pells, P.J.N, Mostyn, G. and Walker, B.F. - Foundations on Sandstone and Shale in the Sydney Region. Australian Geomechanics Journal, No 33 Part 3, December 1998.

MACQUARIE GEOTECH

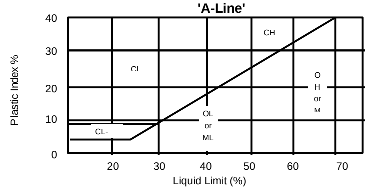
Summary of Soil Logging Procedures

Coarse Material: grain size - colour - particle shape - secondary components - minor constituents - moisture condition - relative density - origin - additional observations.

Fine Material: plasticity - colour - secondary components - minor constituents - moisture w.r.t. plasticity - consistency - origin - additional observations.

Guide to the Description, Identification and Classification of Soils

Major Divisions				SYMBOL	Typical Names
> 200mm	BOULDERS				
60 to 200mm	COBBLES				
COARSE GRAINED SOILS	More than 65% by dry mass less than 63mm is greater that 0.075mm	GRAVEL	More than 50% of coarse fraction > 2.36mm	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels.
		Gravelly Soils		GM	Silty gravels, gravel-sand-silt mixtures.
				GC	Clayey gravels, gravel-sand-clay mixtures
		SANDS	More than 50% of coarse fraction < 2.36mm	SW	Well-graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands.
		Sandy Soils		SM	Silty sands, sand-silt mixtures.
				SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	More than 35% by dry mass less than 60mm is less than 0.076mm	Liquid Limit < 50%		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
				OL	Organic silts and organic silty clays of low plasticity.
		Liquid Limit > 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
				CH	Inorganic clays of high plasticity, fat clays.
				OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS				Pt	Peat and other highly organic soils.



Grain sizes	
Gravel	Sand
Coarse - 63 to 19mm	Coarse - 2.36 to 0.6mm
Medium - 19 to 6.7 mm	Medium - 0.6 to 0.21mm
Fine - 6.7 to 2.36mm	Fine - 0.21 to 0.075mm

GEOLOGICAL ORIGIN:-

Fill - artificial soils / deposits
Alluvial - soils deposited by the action of water
Aeolian - soils deposited by the action of wind
Topsoil - soils supporting plant life containing significant organic content
Residual - soils derived from insitu weathering of parent rock.
Colluvial - transported debris usually unsorted, loose and deposited

Field Identification of Fine Grained Soils - Silt or Clay?

Dry Strength - Allow the soil to dry completely and then test its strength by breaking and crumbling between the fingers.
High dry strength - Clays; Very slight dry strength - Silts.

Toughness Test - the soil is rolled by hand into a thread about 3mm in diameter. The thread is then folded and re-rolled repeatedly until it has dried sufficiently to break into lumps. In this condition inorganic clays are fairly stiff and tough while inorganic silts produce a weak and often soft thread which may be difficult to form and readily breaks and crumbles.

Dilatancy Test - Add sufficient water to the soil, held in the palm of the hand, to make it soft but not sticky. Shake horizontally, striking vigorously against the other hand several times. Dilatancy is indicated by the appearance of a shiny film on the surface of the soil. If the soil is then squeezed or pressed with the fingers, the surface becomes dull as the soil stiffens and eventually crumbles. These reactions are pronounced only for predominantly silt size material. Plastic clays give no reaction.

Descriptive Terms for Material Portions

COARSE GRAINED SOILS		FINE GRAINED SOILS	
% Fines	*Term/Modifier*	*% Coarse*	*Term/Modifier*
$\leq$ 5	Omit, or use "trace"	$\leq$ 15	Omit, or use "trace"
> 5, $\leq$ 12	"with clay/silt" as applicable	> 15, $\leq$ 30	"with sand/gravel" as applicable
> 12	Prefix soil as "silty/clayey"	> 30	Prefix as "sandy/gravelly"

Moisture Condition

for non-cohesive soils:

Dry -	runs freely through fingers.
Moist -	does not run freely but no free water visible on soil surface.
Wet -	free water visible on soil surface.

for cohesive soils:

MC > PL	Moisture content estimated to be greater than the plastic limit.
MC ~ PL	Moisture content estimated to be approximately equal to the plastic limit. The soil can be moulded
MC < PL	Moisture content estimated to be less than the plastic limit. The soil is hard and friable, or powdery.

The plastic limit (PL) is defined as the moisture content (percentage) at which the soil crumbles when rolled into threads of 3mm dia.

Consistency - For Clays & Silts

Description	*UCS (kPa)*	*Field guide to consistency*
Very soft	< 25	Exudes between the fingers when squeezed in hand
Soft	25 - 50	Can be moulded by light finger pressure
Firm	50 - 100	Can be moulded by strong finger pressure
Stiff	100 - 200	Cannot be moulded by fingers. Can be indented by thumb.
Very stiff	200 - 400	Can be indented by thumb nail
Hard	> 400	Can be indented with difficulty by thumb nail
Friable	-	Crumbles or powders when scraped by thumbnail

Relative Density for Gravels and Sands

Description	*SPT "N" Value*	*Density Index (ID) Range %*
Very loose	0 - 4	< 15
Loose	4 - 10	15 - 35
Medium dense	10 - 30	35 - 65
Dense	30 - 50	65 - 85
Very dense	> 50	> 85

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Summary of Rock Logging Procedures

Description order: constituents - rock name - grain size - colour - weathering - strength - minor constituents - additional observations.
· minor constituents - moisture w.r.t. plasticity - consistency - origin - additional observations.

Definition - Sedimentary Rock	
Conglomerate	more than 50% of the rock consists of gravel (>2mm) sized fragments
Sandstone	more than 50% of the rock consists of sand (0.06 to 2mm) sized grains
Siltstone	more than 50% of the rock consists of silt sized granular particles and the rock is not laminated
Claystone	more than 50% of the rock consists of clay or mica material and the rock is not laminated
Shale	more than 50% of the rock consists of clay or silt sized particles and the rock is laminated

Weathering		
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a change in volume but the soil has not significantly transported.
Extremely Weathered	EW	Rock is weathered to such an extent that it has 'soil' properties; ie. it either disintegrates or can be remoulded, in water.
Distinctly Weathered	DW	**Highly Weathered (HW)** - Rock is wholly discoloured and rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals **Moderately Weathered (MW)** - The whole of the rock is discoloured, usually by iron staining and bleaching. Shows little or no change in rock strength.
Slightly Weathered	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh	FR	Rock shows no sign of decomposition or staining.

Stratification			
thinly laminated	<6mm	medium bedded	0.2 - 0.6m
laminated	6 - 20mm	thickly bedded	0.6 - 2m
very thinly bedded	20 - 60mm	very thickly bedded	>2m
thinly bedded	60mm - 0.2m		

Discontinuities

order of description: depth - type - orientation - spacing - roughness / planarity - thickness - coating

	Type	Class	Roughness/Planarity	Class	Roughness/Planarity
B	Bedding	I	rough or irregular, stepped	VI	slickensided, undulating
F	Fault	II	smooth, stepped	VII	rough or irregular, planar
C	Cleavage	III	slickensided, stepped	VIII	smooth, planar
J	Joint	IV	rough or irregular, undulating	IX	slickensided, planar
S	Shear Zone	V	smooth, undulating		
D	Drill break				

Rock Strength

Term		Is (50)	Field Guide
		0.03	
Very low	VL		Material crumbles under firm blows with sharp end of pick; can be peeled with knive. Pieces up to 30mm thick can be broken by finger pressure.
		0.1	
Low	L		A piece of core 150 mm long x 50 mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
		0.3	
Medium	M		A piece of core 150 mm long x 50 mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.
		1	
High	H		A piece of core 150 mm long x 50 mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.
		3	
Very High	VH		A piece of core 150 mm long x 50 mm dia. May be broken readily with hand held hammer. Cannot be scratched with pen knife.
		10	
Extremely High	EH		A piece of core 150 mm long x 50 mm dia. Is difficult to break with hand held hammer. Rings when struck with a hammer.

* - rock strength defined by point load strength (Is 50) in direction normal to bedding

Degree of fracturing	
fragmented	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than the core diameter
highly fractured	Core lengths are generally less than 20mm - 40mm with occasional fragments.
fractured	Core lengths are mainly 30mm - 100mm with occasional shorter and longer lengths
slightly fractured	Core lengths are generally 300mm - 1000mm with occasional longer sections and shorter sections of 100mm -- 300mm.
unbroken	The core does not contain any fracture.

- spacing of all types of natural fractures, but not artificial breaks, in cored bores.

The fracture spacing is shown where applicable and the Rock Quality Designation is given by: RQD (%) = sum of unbroken core pieces 100 mm or longer

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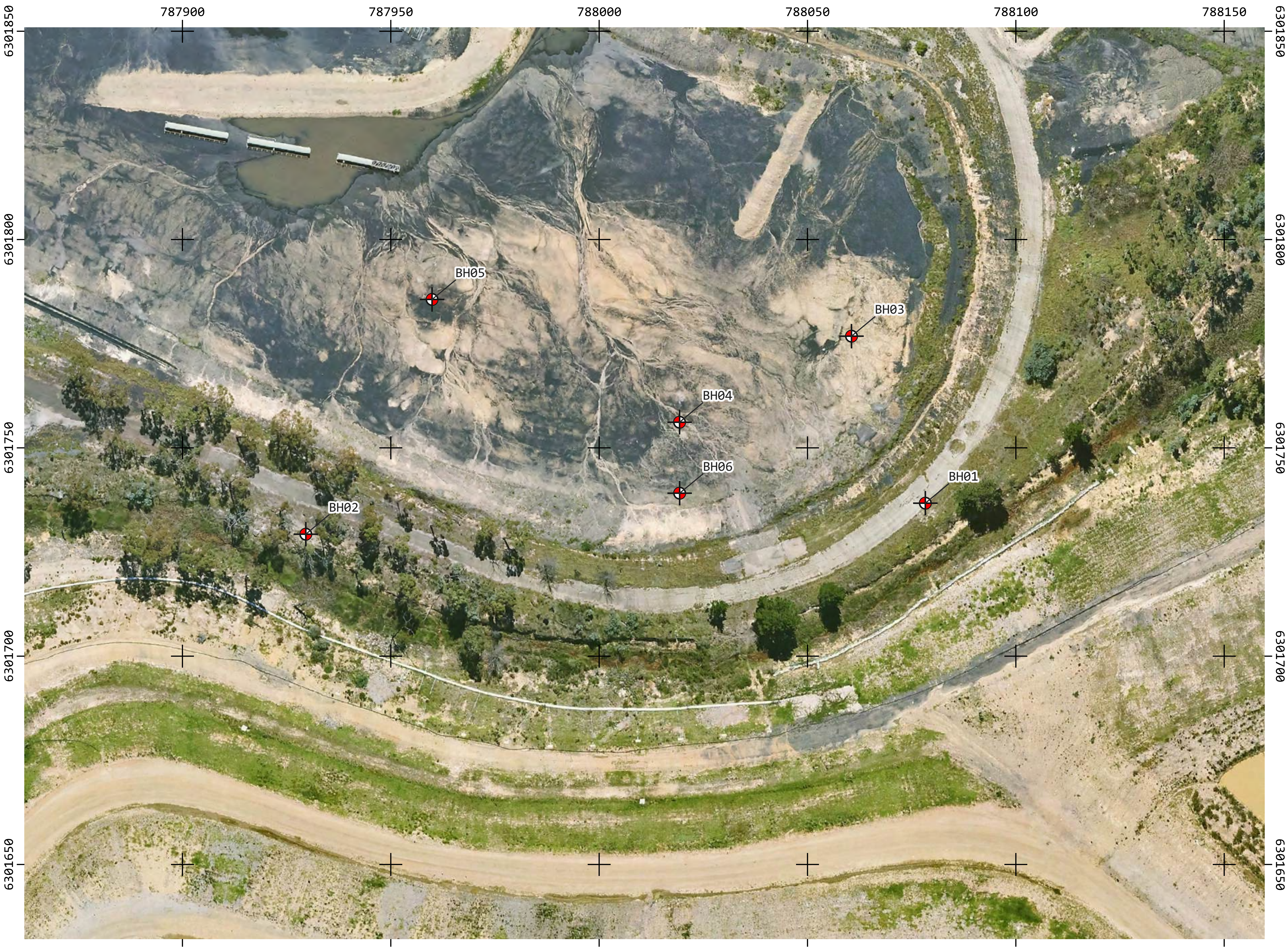
Appendix B – Site Plan



Legend

Borehole

Note:
Basemap imagery provided by Aerometrix.

MACQUARIE GEOTECH	Client: GPM	Drawn: JH	KVAR Creek Realignment Test Location Plan		Project ID: G23994
	Project: KVAR Creek Realignment	Checked: MW			
	Location: Lisdale NSW	Date:24-04-04	20 40 60 80 m		Drawing ID: G23994_TLP_01
Macquarie Geotechnical Pty Ltd 3 Watt Drive, Bathurst NSW 2795 - www.macgeo.com.au		CRS: GDA2020 / MGA zone 55 (EPSG:7855)	Scale - 1:917 at A3		

Appendix C – Borehole Logs

MACQUARIE GEOTECH

Borehole No.

BH01

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229929.0 m E 6302256.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) Inclination: -90° RL Surface: 937.00 m
Hole Diameter: Bearing: Datum: AHD Operator: T.L.

Drilling Information | **Soil Description** | **Observations**

Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
VC			Not Observed	D 0.10-0.50 m					NA	TOPSOIL Silty CLAY with sand: low to medium plasticity, Grey/ dark grey; with rootlets <5mm.	NA	NA		TOPSOIL
				SPT 0.50-0.95 m 5,11,8 N=19		936.0	1		CL-CI	Sandy Silty CLAY: low to medium plasticity, Pale yellow mottled grey; sand fine to coarse grained.	w<PL	VSt	×	RESIDUAL SOIL 1.50: HP Samp = 450 kPa
				D 1.00-1.50 m										
				SPT 1.50-1.95 m 4,7,9 N=16										
				D 2.00-3.00 m		935.0	2		SP-SM	Gravelly Silty SAND: fine to coarse grained, Pale yellow and Dark grey.	M	VD		
				SPT 3.00-3.10 m 30/100mm HB		934.0	3							
				D 3.50-4.60 m		933.0	4		CI-CH	Sandy Silty CLAY with gravel: medium to high plasticity, Dark yellow and grey; sand fine to coarse grained; gravel fine to coarse, rounded to sub-rounded.	w<PL	H		ROCK HWM
				SPT 4.60-4.66 m 30/60mm HB		932.0	5			Continued on cored borehole sheet				
						931.0	6							
						930.0	7							

Continued on cored borehole sheet

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Support
C - Casing

Penetration
No resistance ranging to refusal

Core recovered (hatching indicates material)
Core loss

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U(x) - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
pp - Pocket Penetrometer (UCS kPa)
x=size in mm

Classification Symbols and Soil Descriptions
AS1726:2017

Moisture Condition
D - Dry
M - Moist
W - Wet

Plastic Limit
w < PL
w = PL
w > PL
w = LL
w > LL

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

MACQUARIE GEOTECH

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229929.0 m E 6302256.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) Inclination: -90° RL Surface: 937.00 m
Hole Diameter: Bearing: Datum: AHD Operator: T.L.

BH01 Depth Range: 1.50 - 1.95 m

BH01 Depth Range: 3.00 - 3.01 m

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229929.0 m E 6302256.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) Inclination: -90° RL Surface: 937.00 m

Hole Diameter: Bearing: Datum: AHD Operator: T.L.

BH01 Depth Range: 4.60 - 4.66 m

MACQUARIE GEOTECH

Cored Borehole No.

BH01

Engineering Log - Cored Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229929.0 m E 6302256.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	937.00 m		
Barrel Type and Length:		Bearing:		Datum:	AHD	Operator:	T.L.

Drilling Information | **Rock Substance** | **Rock Mass Defects**

Method	Support	Water	TCR (%)	RQD (%)	RL (m)	Depth (m)	Graphic Log	Material Description (rock type: grain characteristics, colour, structure, minor components)	Weathering	Strength Is(50) (● - Axial, ○ - Diametral) (soil) VL L M H VH EH	Defect Spacing (mm) 30 100 300 1000 3000	Visual	Defect Description (thickness, type, inclination, planarity, roughness, coating/infilling) Particular	General
					936.0	1								
					935.0	2								
					934.0	3								
					933.0	4								
						4.66m		Continued from non-cored borehole sheet						
HQ3		Not Observed	72		932.0			Silty CLAY: medium to high plasticity, Dark grey.	SW to FR					
						5.00m / 5		NO CORE 0.40m (5.00-5.40)						
						5.40m		SANDSTONE: Dark grey.						
					931.0	5.60m								
			40			6.10m / 6		NO CORE 0.90m (6.10-7.00)						
					930.0	7.00m / 7		SHALE: Dark grey.						
			43			7.60m		NO CORE 0.80m (7.60-8.40)						

Method
AS - Auger Screwing
WB- Washbore
HQ3 HQ3 Core Barrel
NQ3 NQ3 Core Barrel

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Support
T - Timbering

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Weathering
FR - Fresh
SW - Slightly Weathered
DW - Distinctly Weathered
XW - Extremely Weathered
RS - Residual Soil

Strength
(indirect tensile strength)
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

MACQUARIE GEOTECH

Cored Borehole No.

BH01

Engineering Log - Cored Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229929.0 m E 6302256.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) Inclination: -90° RL Surface: 937.00 m
Barrel Type and Length: Bearing: Datum: AHD Operator: T.L.

Method	Support	Water	TCR (%)	RQD (%)	RL (m)	Depth (m)	Material Description	Weathering	Strength Is(50)	Defect Spacing (mm)	Defect Description
HQ3		Not Observed	43			8.40m	NO CORE 0.80m (7.60-8.40)*(continued)*	SW to FR			
					928.0	9.00m	SHALE: Dark grey.				
			16			9.84m	NO CORE 0.84m (9.00-9.84)				
					927.0	10.00m	SHALE: Dark grey.				
							Hole Terminated at 10.00 m Criteria Satisfied				

Depth scale: 9, 10, 11, 12, 13, 14, 15. RL scale: 928.0, 927.0, 926.0, 925.0, 924.0, 923.0, 922.0.

Strength: ● - Axial, ○ - Diametral; (soil) VL L M H VH EH. Defect Spacing: 30 100 300 1000 3000. Defect Description: thickness, type, inclination, planarity, roughness, coating/infilling — Particular, General.

Method
AS - Auger Screwing
WB- Washbore
HQ3 HQ3 Core Barrel
NQ3 NQ3 Core Barrel

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Support
T - Timbering

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Weathering
FR - Fresh
SW - Slightly Weathered
DW - Distinctly Weathered
XW - Extremely Weathered
RS - Residual Soil

Strength
(indirect tensile strength)
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

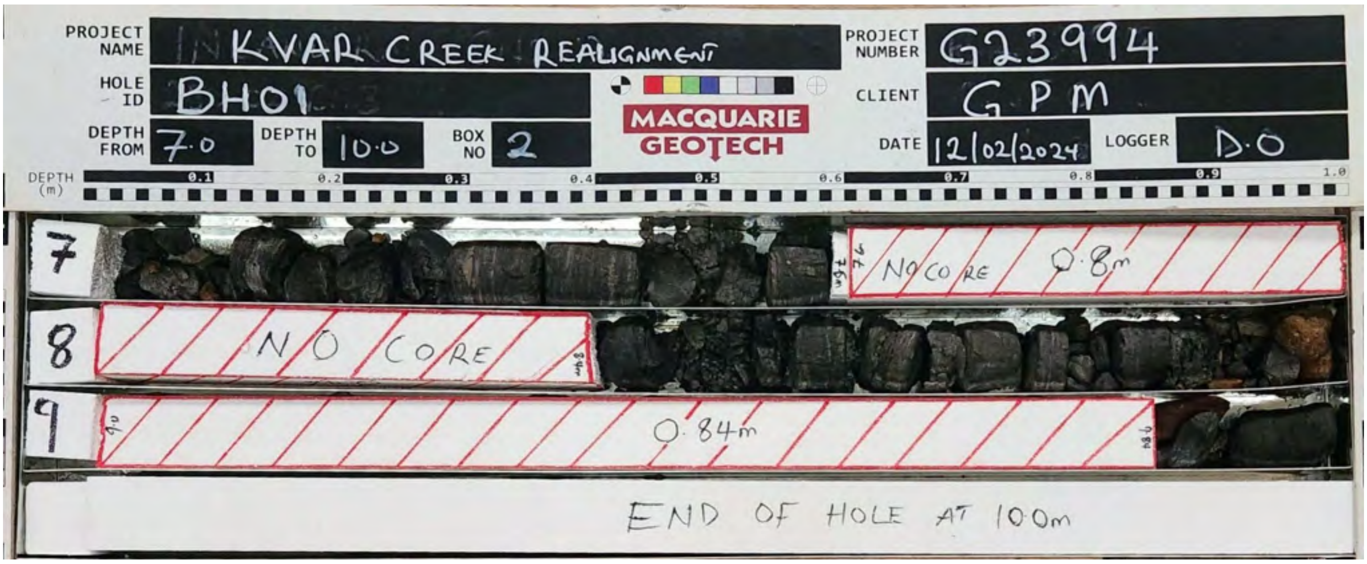
Engineering Log - Cored Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229929.0 m E 6302256.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	937.00 m		
Barrel Type and Length:		Bearing:		Datum:	AHD	Operator:	T.L.

PointID : BH01 Depth Range: 4.66 - 7.00 m



PointID : BH01 Depth Range: 7.00 - 10.00 m

MACQUARIE GEOTECH

Borehole No.
BH02

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	12/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229781.0 m E 6302240.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	935.00 m
Hole Diameter:		Bearing:		Datum:	AHD — Operator: T.L.

Drilling Information | **Soil Description** | **Observations**

Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
VC			Not Observed	D 0.00-0.50 m					NA	FILL Sandy Silty CLAY with gravel: medium to high plasticity, Dark grey/brown; sand fine to coarse grained; gravel fine to coarse, rounded to sub-angular.	NA	NA		FILL
				SPT 0.50-0.95 m 9,8,5 N=13		934.0	1		CI-CH	Sandy Silty CLAY: medium to high plasticity, Grey mottled pale yellow; sand fine to coarse grained.		St		RESIDUAL SOIL 0.50: HP Samp >600 kPa
				D 1.00-1.50 m SPT 1.50-1.95 m 12,16,25 N=41 D 2.00-2.50 m		933.0	2		CI-CH	Sandy Silty CLAY with gravel: medium to high plasticity, Pale yellow and pale grey; sand fine grained; gravel rounded to sub-rounded.	w<PL			ROCK HWM 1.50: HP Samp = 570 kPa
				D 2.50-3.00 m SPT 3.00-3.30 m 16,30 HB N=R D 3.30-4.50 m SPT 4.50-4.70 m 30,20/50mm HB N=R		932.0 931.0	3 4		CH	Silty CLAY: high plasticity, Dark grey and yellow.		H		3.00: HP Samp >600 kPa
				D 4.70-6.00 m		930.0	5		CH	Silty CLAY: high plasticity, Grey.	D			
						929.0 928.0	6 7			Continued on cored borehole sheet				

Method	Penetration	Water	Samples and Tests	Moisture Condition	Consistency/Relative Density
AS - Auger Screwing RR - Rock Roller WB- Washbore	No resistance ranging to refusal	Level (Date) Inflow Partial Loss Complete Loss	U(x) - Undisturbed Sample D - Disturbed Sample SPT - Standard Penetration Test pp - Pocket Penetrometer (UCS kPa) x=size in mm	D - Dry M - Moist W - Wet	VS - Very Soft S - Soft F - Firm VSt - Very Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense
Support C - Casing	Core recovered (hatching indicates material) Core loss		**Classification Symbols and Soil Descriptions** AS1726:2017	**Plastic Limit** w < PL w = PL w > PL w = LL w > LL	

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	12/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229781.0 m E 6302240.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	935.00 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	T.L.

BH02 Depth Range: 0.50 - 0.95 m

BH02 Depth Range: 1.50 - 1.95 m

MACQUARIE GEOTECH

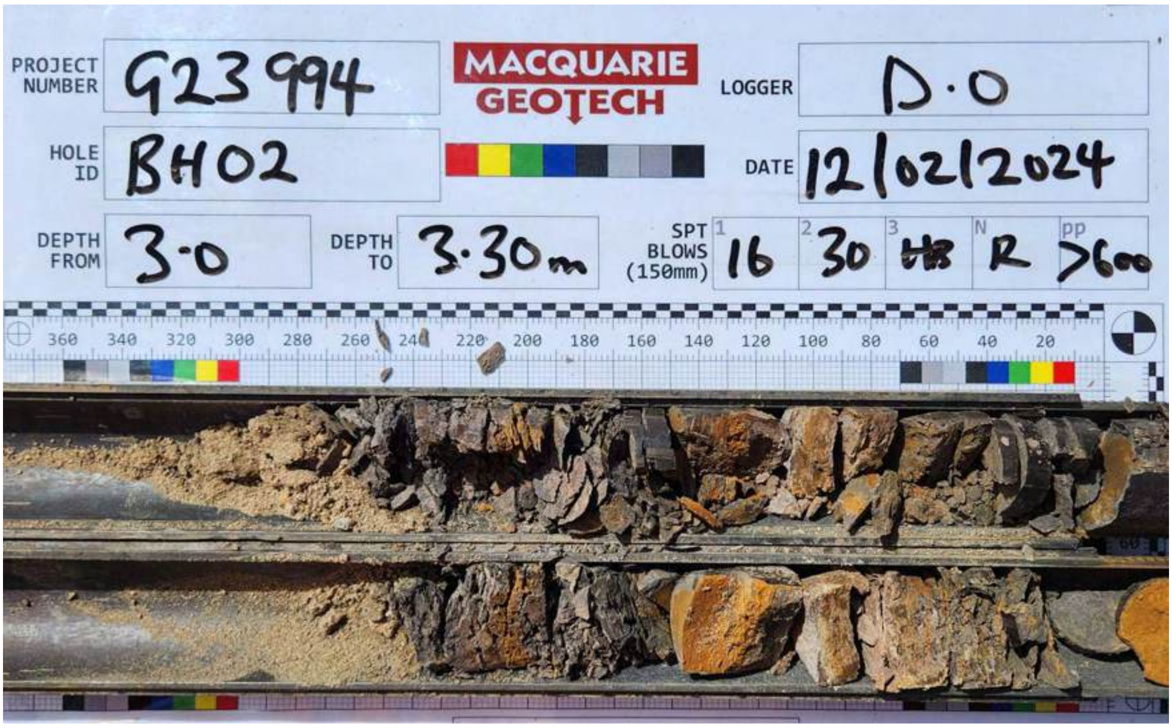
Borehole No.
BH02
Page 3 of 5

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	12/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229781.0 m E 6302240.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	935.00 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	T.L.



BH02 Depth Range: 3.00 - 3.30 m

BH02 Depth Range: 4.50 - 4.70 m

MACQUARIE GEOTECH

Cored Borehole No.

BH02

Engineering Log - Cored Borehole

Project No.: G23994

Client:	GPM	Commenced:	12/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229781.0 m E 6302240.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	935.00 m		
Barrel Type and Length:		Bearing:		Datum:	AHD	Operator:	T.L.

Drilling Information | ***Rock Substance*** | ***Rock Mass Defects***

Method	Support	Water	TCR (%)	RQD (%)	RL (m)	Depth (m)	Graphic Log	Material Description rock type: grain characteristics, colour, structure, minor components	Weathering	Strength Is(50) ● - Axial ○ - Diametral (soil) VL L M H VH EH	Defect Spacing (mm) 30 100 300 1000 3000	Visual	Defect Description thickness, type, inclination, planarity, roughness, coating/infilling — Particular	General
					934.0	1								
					933.0	2								
					932.0	3								
					931.0	4								
					930.0	5								
								Continued from non-cored borehole sheet						
HQ3		Not Observed	100		929.0	6.00m 6		SHALE: Dark grey.	FR					
			63	34	928.0	7								
						7.50m		NO CORE 0.70m (7.50-8.20)						

Method
AS - Auger Screwing
WB- Washbore
HQ3 HQ3 Core Barrel
NQ3 NQ3 Core Barrel

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Support
T - Timbering

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Weathering
FR - Fresh
SW - Slightly Weathered
DW - Distinctly Weathered
XW - Extremely Weathered
RS - Residual Soil

Strength
(indirect tensile strength)
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

LOCA: BH02
PGID: BH02_005
PUB: 24040513

MACQUARIE GEOTECH

Cored Borehole No.

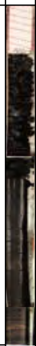
BH02

Engineering Log - Cored Borehole

Project No.: G23994

Client:	GPM	Commenced:	12/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229781.0 m E 6302240.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) Inclination: -90° RL Surface: 935.00 m
Barrel Type and Length: Bearing: Datum: AHD Operator: T.L.

Method	Support	Water	TCR (%)	RQD (%)	RL (m)	Depth (m)	Graphic Log	Material Description (rock type: grain characteristics, colour, structure, minor components)	Weathering	Strength Is(50) (● - Axial, ○ - Diametral)	Defect Spacing (mm)	Visual	Defect Description (Particular / General)
HQ3		Not Observed	63	34		8.20m		NO CORE 0.70m (7.50-8.20)*(continued)*					
			100	61	926.0	9, 9.16m		COAL: Dark grey.	FR				
					925.0	10, 10.25m		SANDSTONE: Dark grey.					
					924.0, 923.0, 922.0, 921.0, 920.0	11, 12, 13, 14, 15		Hole Terminated at 10.25 m Criteria Satisfied					

Strength scale: (soil) VL L M H VH EH
Defect spacing scale: 30 100 300 1000 3000

Drilling Information / ***Rock Substance*** / ***Rock Mass Defects***

Method
AS - Auger Screwing
WB- Washbore
HQ3 HQ3 Core Barrel
NQ3 NQ3 Core Barrel

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Support
T - Timbering

Graphic Log/Core Loss
Core recovered (hatching indicates material)
Core loss

Weathering
FR - Fresh
SW - Slightly Weathered
DW - Distinctly Weathered
XW - Extremely Weathered
RS - Residual Soil

Strength
(indirect tensile strength)
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High
EH - Extremely High

MACQUARIE GEOTECH

Cored Borehole No.

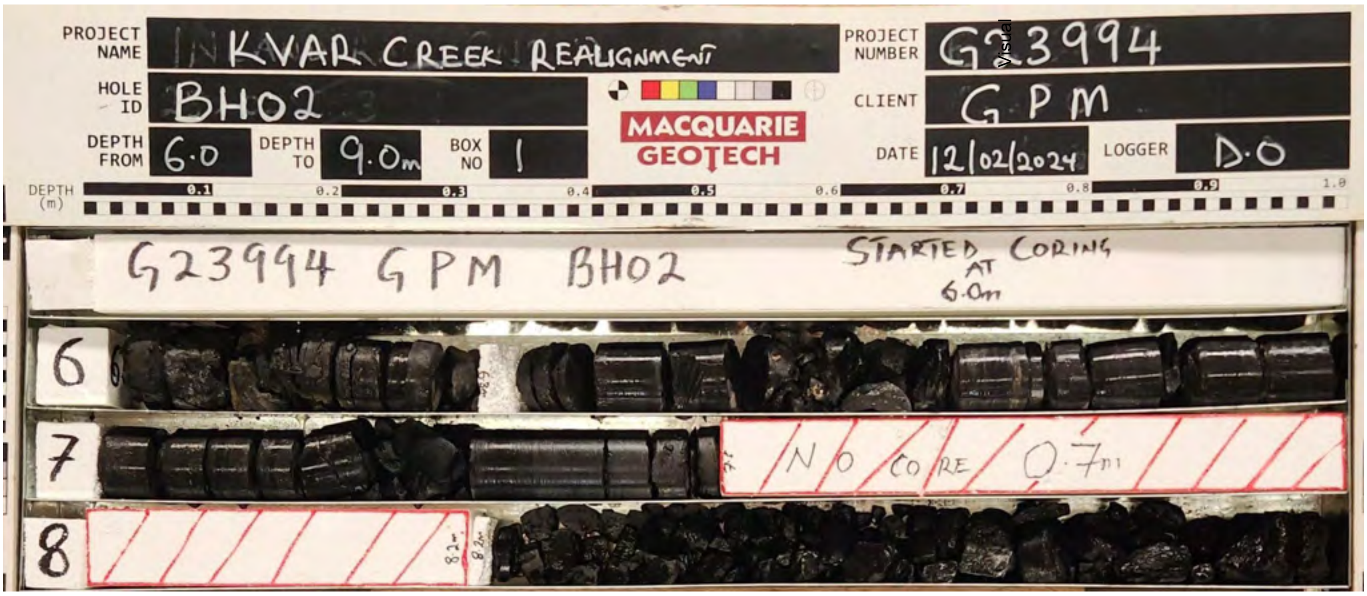
BH02

Engineering Log - Cored Borehole

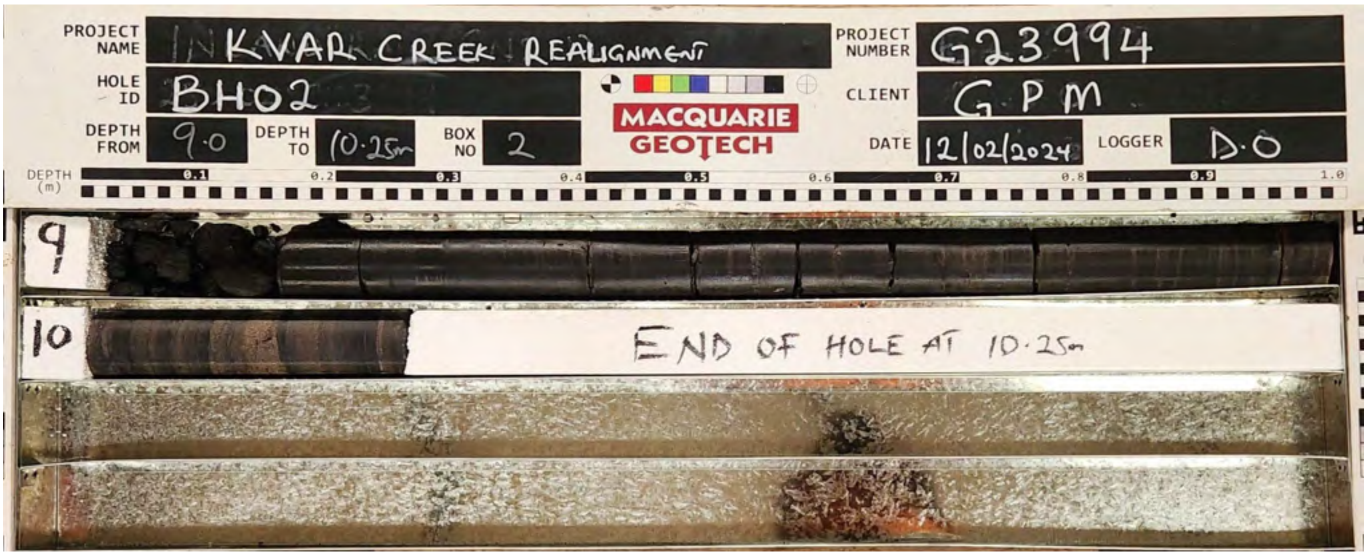
Project No.: G23994

Client:	GPM	Commenced:	12/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229781.0 m E 6302240.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	935.00 m		
Barrel Type and Length:		Bearing:		Datum:	AHD	Operator:	T.L.



PointID : BH02 Depth Range: 6.00 - 9.00 m



PointID : BH02 Depth Range: 9.00 - 10.25 m

MACQUARIE GEOTECH

Borehole No.

BH03

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	10/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	10/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229909.0 m E 6302295.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) Inclination: -90° RL Surface: 934.00 m
Hole Diameter: Bearing: Datum: AHD Operator: T.L.

Drilling Information | **Soil Description** | **Observations**

Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
VC			Not Observed						NA	FILL ORGANIC MATTER: Dark grey; Coal.	NA	NA		FILL
									NA	FILL ORGANIC MATTER: Dark grey/grey; Ash.				
						933.0	1							
						932.0	2							
						931.0	3							
						930.0	4							
						929.0	5							
						928.0	6							
						927.0	7							

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U(x) - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
pp - Pocket Penetrometer (UCS kPa)
x=size in mm

Moisture Condition
D - Dry
M - Moist
W - Wet

Plastic Limit
w < PL
w = PL
w > PL
w = LL
w > LL

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
AS1726:2017

MACQUARIE GEOTECH

Borehole No.

BH03

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	10/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	10/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229909.0 m E 6302295.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	934.00 m
Hole Diameter:		Bearing:		Datum:	AHD

Operator: T.L.

Drilling Information								Soil Description						Observations
Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
VC			Not Observed			925.0, 924.0	9, 10		NA	FILL ORGANIC MATTER: Dark grey/grey; Ash. *(continued)*	NA	NA		FILL
						923.0, 922.0, 921.0, 920.0, 919.0	11, 12, 13, 14, 15			Hole Terminated at 10.50 m Criteria Satisfied				

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Support
C - Casing

Penetration
No resistance ranging to refusal

Core recovered (hatching indicates material)
Core loss

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U(*x*) - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
pp - Pocket Penetrometer (UCS kPa)
x=size in mm

Classification Symbols and Soil Descriptions
AS1726:2017

Moisture Condition
D - Dry
M - Moist
W - Wet

Plastic Limit
w < PL
w = PL
w > PL
w = LL
w > LL

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

MACQUARIE GEOTECH

Borehole No.
BH04

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	11/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229869.0 m E 6302272.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) Inclination: -90° RL Surface: 935.00 m
Hole Diameter: Bearing: Datum: AHD Operator: T.L.

Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description (Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional)	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
VC			Not Observed				0.0–0.5		NA	FILL ORGANIC MATTER: Dark grey; Coal.	NA	NA		FILL
						934.0	0.5–1.5 (1)		NA	FILL Sandy Silty CLAY: medium to high plasticity, Dark yellow mottled pale grey; sand fine to coarse grained.				
						933.0 / 932.0 / 931.0 / 930.0 / 929.0 / 928.0	1.5–8.0 (2, 3, 4, 5, 6, 7)		NA	FILL ORGANIC MATTER: Grey; Ash.				

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Support
C - Casing

Penetration
No resistance ranging to refusal

Core recovered (hatching indicates material)
Core loss

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U(x) - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
pp - Pocket Penetrometer (UCS kPa)
x=size in mm

Classification Symbols and Soil Descriptions
AS1726:2017

Moisture Condition
D - Dry
M - Moist
W - Wet

Plastic Limit
w < PL
w = PL
w > PL
w = LL
w > LL

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

MACQUARIE GEOTECH

Borehole No.
BH04

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	11/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229869.0 m E 6302272.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	935.00 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	T.L.

Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
VC			Not Observed						NA	FILL ORGANIC MATTER: Grey; Ash. *(continued)*	NA	NA		FILL
						926.0	9		NA	FILL Sandy Silty CLAY: low to medium plasticity, Grey and pale yellow and dark grey; sand fine to coarse grained.				
						925.0	10		NA	FILL ORGANIC MATTER: Dark grey; Coal.				
						924.0	11			Hole Terminated at 10.50 m Criteria Satisfied				
						923.0	12							
						922.0	13							
						921.0	14							
						920.0	15							

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Support
C - Casing

Penetration
No resistance ranging to refusal

Core recovered (hatching indicates material)
Core loss

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U(x) - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
pp - Pocket Penetrometer (UCS kPa)
x=size in mm

Classification Symbols and Soil Descriptions
AS1726:2017

Moisture Condition
D - Dry
M - Moist
W - Wet

Plastic Limit
w < PL
w = PL
w > PL
w = LL
w > LL

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

MACQUARIE GEOTECH

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	11/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229808.0 m E 6302298.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	934.00 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	T.L.

Drilling Information | **Soil Description** | **Observations**

Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
VC									NA	FILL ORGANIC MATTER: Dark grey; Coal.				FILL
									NA	FILL Silty SAND: fine to coarse grained, Dark yellow mottled pale grey.				
						933.0	1		NA	FILL ORGANIC MATTER: Pale grey/grey; Ash.				
						932.0	2							
						931.0	3							
						930.0	4							
						929.0	5							
						928.0	6							
						927.0	7							

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Support
C - Casing

Penetration
No resistance ranging to refusal

Core recovered (hatching indicates material)
Core loss

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U(x) - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
pp - Pocket Penetrometer (UCS kPa)
x=size in mm

Classification Symbols and Soil Descriptions
AS1726:2017

Moisture Condition
D - Dry
M - Moist
W - Wet

Plastic Limit
w < PL
w = PL
w > PL
w = LL
w > LL

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

MACQUARIE GEOTECH

Borehole No.

BH05

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	11/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	11/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229808.0 m E 6302298.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) | Inclination: -90° | RL Surface: 934.00 m
Hole Diameter: | Bearing: | Datum: AHD | Operator: T.L.

Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa) 100 200 300 400 500	Structure and Additional Observations
VC						925.0 924.0	9 10		NA	FILL ORGANIC MATTER: Pale grey/grey; Ash. *(continued)*				FILL
						923.0 922.0 921.0 920.0 919.0	11 12 13 14 15			Hole Terminated at 10.50 m Criteria Satisfied				

Method
AS - Auger Screwing
RR - Rock Roller
WB - Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U(*x*) - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
pp - Pocket Penetrometer (UCS kPa)
x=size in mm

Moisture Condition
D - Dry
M - Moist
W - Wet

Plastic Limit
w < PL
w = PL
w > PL
w = LL
w > LL

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
AS1726:2017

MACQUARIE GEOTECH

Borehole No.
BH06

Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	12/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229870.0 m E 6302255.0 m N	Checked By:	M.W

Drill Model and Mounting: SRS ML Duo (MG82) Inclination: -90° RL Surface: 936.00 m
Hole Diameter: Bearing: Datum: AHD Operator: T.L.

Method	Penetration	Support	Water	Samples Tests Remarks	Recovery	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description Fraction, Colour, Structure, Bedding, Plasticity, Sensitivity, Additional	Moisture Condition	Consistency Relative Density	Pocket Penetrometer UCS (kPa)	Structure and Additional Observations
VC			Not Observed	D 0.00-0.50 m					NA	FILL ORGANIC MATTER: Dark grey; Coal.	NA	NA		FILL
				SPT 0.50-0.95 m 8,9,17 N=26		935.0	1		CI	Sandy Silty CLAY with gravel: medium plasticity, yellow and pale grey; sand fine to coarse grained; gravel fine to coarse, rounded to sub-angular.	w<PL	VSt	310	RESIDUAL SOIL 0.50: HP Samp = 310 kPa
				D 1.00-1.50 m SPT 1.50-1.95 m 11,12,17 N=29 D 2.00-3.00 m		934.0	2		SC	Clayey Silty SAND with gravel: fine to coarse grained, yellow and pale grey and orange; clay low to medium plasticity; gravel fine to sub-angular.	M	MD		
				SPT 3.00-3.22 m 23,30/70mm HB N=30/70mm		933.0	3		CI-CH	Silty CLAY: medium to high plasticity, Grey mottled yellow.	w<PL	H		HWM
						932.0	4			Hole Terminated at 3.22 m Criteria Satisfied				
						931.0	5							
						930.0	6							
						929.0	7							

Method
AS - Auger Screwing
RR - Rock Roller
WB- Washbore

Penetration
No resistance ranging to refusal

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Samples and Tests
U(x) - Undisturbed Sample
D - Disturbed Sample
SPT - Standard Penetration Test
pp - Pocket Penetrometer (UCS kPa)
x=size in mm

Moisture Condition
D - Dry
M - Moist
W - Wet

Plastic Limit
w < PL
w = PL
w > PL
w = LL
w > LL

Consistency/Relative Density
VS - Very Soft
S - Soft
F - Firm
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Support
C - Casing

Core recovered (hatching indicates material)
Core loss

Classification Symbols and Soil Descriptions
AS1726:2017

MACQUARIE GEOTECH

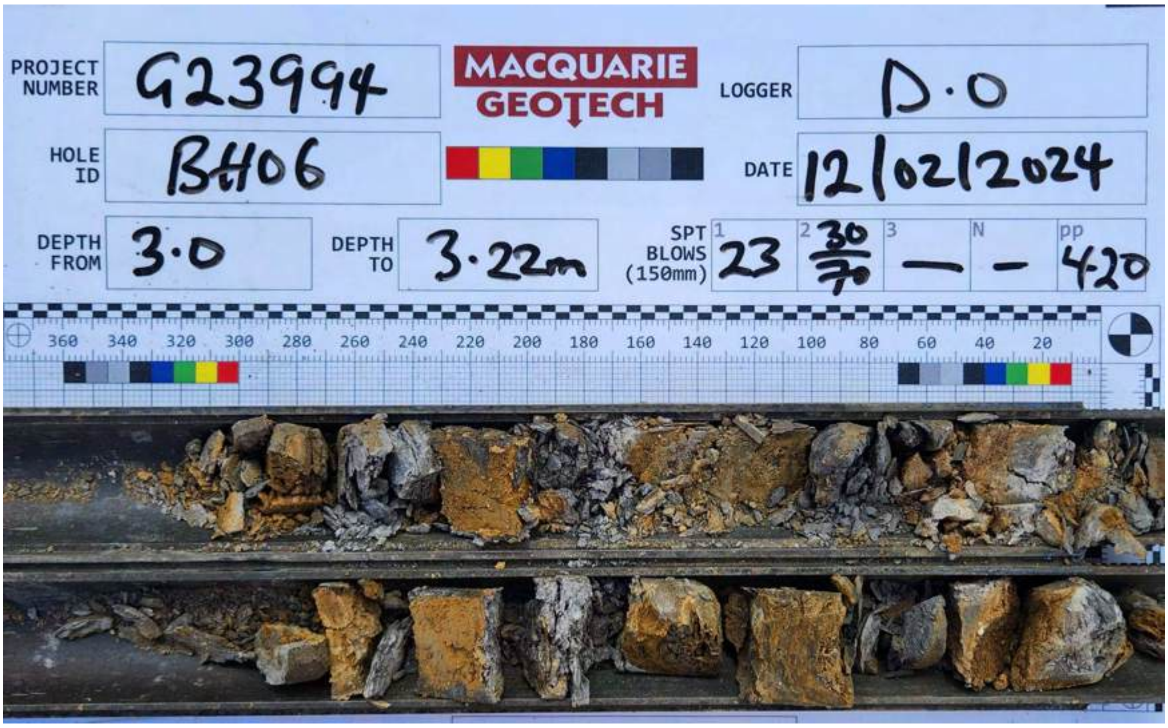
Engineering Log - Borehole

Project No.: G23994

Client:	GPM	Commenced:	12/02/2024
Project Name:	KVAR Creek Redirection - Wallerawang	Completed:	12/02/2024
Hole Location:	Wallerawang	Logged By:	D.O.
Hole Position:	229870.0 m E 6302255.0 m N	Checked By:	M.W

Drill Model and Mounting:	SRS ML Duo (MG82)	Inclination:	-90°	RL Surface:	936.00 m		
Hole Diameter:		Bearing:		Datum:	AHD	Operator:	T.L.

BH06 Depth Range: 0.50 - 0.95 m



BH06 Depth Range: 3.00 - 3.22 m

MACQUARIE GEOTECH

Appendix D – Laboratoty Test Results

Material Test Report

Report Number:	**B24002-10**
Issue Number:	1
Date Issued:	28/03/2024
Client:	Macquarie Geotechnical 3 Watt Drive, Bathurst NSW 2795
Contact:	Craig Green
Project Number:	B24002
Project Name:	GEO/Drillers-Bathurst Laboratory Testing
Work Request:	4284
Sample Number:	BTH-4284B
Date Sampled:	11/02/2024
Dates Tested:	14/03/2024 - 25/03/2024
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Preparation Method:	In accordance with the test method
Sample Location:	**BH1 0.5-0.95**
Lot No:	**G23994**

Macquarie Geotechnical Pty Ltd
Bathurst Laboratory
3 Watt Drive Bathurst NSW 2795
Phone: (02) 6332 2011
Email: macgeo@macgeo.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Barry Froebel
Laboratory Manager
NATA Accredited Laboratory Number: 14874

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	25		
Plastic Limit (%)	18		
Plasticity Index (%)	**7**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**5**		
Soil Description			
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

Report Number: **B24002-10**
Issue Number: 1
Date Issued: 28/03/2024
Client: Macquarie Geotechnical
3 Watt Drive, Bathurst NSW 2795
Contact: Craig Green
Project Number: B24002
Project Name: GEO/Drillers-Bathurst Laboratory Testing
Work Request: 4284
Sample Number: BTH-4284D
Date Sampled: 11/02/2024
Dates Tested: 14/03/2024 - 26/03/2024
Sampling Method: Sampled by Client
The results apply to the sample as received
Preparation Method: In accordance with the test method
Sample Location: **BH1 1.5-1.95**
Lot No: **G23994**

MACQUARIE GEOTECH
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Bathurst Laboratory
3 Watt Drive Bathurst NSW 2795
Phone: (02) 6332 2011
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NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Barry Froebel
Laboratory Manager
NATA Accredited Laboratory Number: 14874

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	37		
Plastic Limit (%)	15		
Plasticity Index (%)	**22**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**5**		
Soil Description			
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

Report Number:	**B24002-10**
Issue Number:	1
Date Issued:	28/03/2024
Client:	Macquarie Geotechnical 3 Watt Drive, Bathurst NSW 2795
Contact:	Craig Green
Project Number:	B24002
Project Name:	GEO/Drillers-Bathurst Laboratory Testing
Work Request:	4284
Sample Number:	BTH-4284G
Date Sampled:	11/02/2024
Dates Tested:	14/03/2024 - 25/03/2024
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Preparation Method:	In accordance with the test method
Sample Location:	**BH2 0.5-0.95**
Lot No:	**G23994**

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Approved Signatory: Barry Froebel
Laboratory Manager
NATA Accredited Laboratory Number: 14874

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	33		
Plastic Limit (%)	25		
Plasticity Index (%)	**8**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**5**		
Soil Description			
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

Report Number: **B24002-10**
Issue Number: 1
Date Issued: 28/03/2024
Client: Macquarie Geotechnical
3 Watt Drive, Bathurst NSW 2795
Contact: Craig Green
Project Number: B24002
Project Name: GEO/Drillers-Bathurst Laboratory Testing
Work Request: 4284
Sample Number: BTH-4284I
Date Sampled: 11/02/2024
Dates Tested: 14/03/2024 - 25/03/2024
Sampling Method: Sampled by Client
The results apply to the sample as received
Preparation Method: In accordance with the test method
Sample Location: **BH2 2.0-2.5**
Lot No: **G23994**

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Approved Signatory: Barry Froebel
Laboratory Manager
NATA Accredited Laboratory Number: 14874

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	36		
Plastic Limit (%)	23		
Plasticity Index (%)	**13**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**5**		
Soil Description			
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

Report Number: **B24002-10**
Issue Number: 1
Date Issued: 28/03/2024
Client: Macquarie Geotechnical
3 Watt Drive, Bathurst NSW 2795
Contact: Craig Green
Project Number: B24002
Project Name: GEO/Drillers-Bathurst Laboratory Testing
Work Request: 4284
Sample Number: BTH-4284K
Date Sampled: 11/02/2024
Dates Tested: 14/03/2024 - 25/03/2024
Sampling Method: Sampled by Client
The results apply to the sample as received
Preparation Method: In accordance with the test method
Sample Location: **BH6 0.5-0.95**
Lot No: **G23994**

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Approved Signatory: Barry Froebel
Laboratory Manager
NATA Accredited Laboratory Number: 14874

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	41		
Plastic Limit (%)	25		
Plasticity Index (%)	**16**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description			
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

Report Number: **B24002-10**
Issue Number: 1
Date Issued: 28/03/2024
Client: Macquarie Geotechnical
3 Watt Drive, Bathurst NSW 2795
Contact: Craig Green
Project Number: B24002
Project Name: GEO/Drillers-Bathurst Laboratory Testing
Work Request: 4284
Sample Number: BTH-4284M
Date Sampled: 11/02/2024
Dates Tested: 14/03/2024 - 22/03/2024
Sampling Method: Sampled by Client
The results apply to the sample as received
Preparation Method: In accordance with the test method
Sample Location: **BH2, 3 & 4 0.5-3.0m Blend**
Lot No: **G23994**

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Approved Signatory: Barry Froebel
Laboratory Manager
NATA Accredited Laboratory Number: 14874

Falling Head Permeability (AS 1289 6.7.2 & 2.1.1)		Min	Max
Coefficient of Permeability (m/sec)	$2x10^{-10}$		
Method of Compactive Effort	Standard		
Method used to Determine MDD	Supplied by client		
Maximum Dry Density (t/m^3)	1.82		
Optimum Moisture Content (%)	13.5		
Field Moisture Content (%)	17.7		
Sieve for Oversize (mm)	9.5		
Oversize Material (%)	0		
Placement Moisture Content (%)	13.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	99.9		
Surcharges and Pressure Applied	-		

Envirolab Services Pty Ltd
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CERTIFICATE OF ANALYSIS 346705

Client Details

Client	Macquarie Geotech (Bathurst)
Attention	Mark Dawson, Barry Froebel
Address	3 Watt Dr, Bathurst, NSW, 2795

Sample Details

Your Reference	**KVAR Creek Realignment**
Number of Samples	10 Soil
Date samples received	18/03/2024
Date completed instructions received	18/03/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	25/03/2024
Date of Issue	21/03/2024

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Results Approved By
Diego Bigolin, Inorganics Supervisor
Dragana Tomas, Senior Chemist
Hannah Nguyen, Metals Supervisor
Timothy Toll, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

vTRH(C6-C10)/BTEXN in Soil						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	20/03/2024	20/03/2024	20/03/2024	20/03/2024	20/03/2024
TRH C_6 - C_9	mg/kg	<25	<25	<25	<25	<25
TRH C_6 - C_{10}	mg/kg	<25	<25	<25	<25	<25
vTRH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	<25	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1	<1	<1
Naphthalene	mg/kg	<1	<1	<1	<1	<1
Total +ve Xylenes	mg/kg	<1	<1	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	85	87	94	87	92

vTRH(C6-C10)/BTEXN in Soil						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	20/03/2024	20/03/2024	20/03/2024	20/03/2024	20/03/2024
TRH C_6 - C_9	mg/kg	<25	<25	<25	<25	<25
TRH C_6 - C_{10}	mg/kg	<25	<25	<25	<25	<25
vTRH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	<25	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	4	4	<0.5
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1	<1	<1
Naphthalene	mg/kg	<1	<1	<1	<1	<1
Total +ve Xylenes	mg/kg	<1	<1	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	93	97	83	87	91

svTRH (C10-C40) in Soil						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
TRH C_{10} - C_{14}	mg/kg	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	mg/kg	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	mg/kg	<100	<100	<100	<100	<100
Total +ve TRH (C10-C36)	mg/kg	<50	<50	<50	<50	<50
TRH $>C_{10}$-C_{16}	mg/kg	<50	<50	<50	<50	<50
TRH $>C_{10}$-C_{16} less Naphthalene (F2)	mg/kg	<50	<50	<50	<50	<50
TRH $>C_{16}$-C_{34}	mg/kg	110	<100	<100	<100	<100
TRH $>C_{34}$-C_{40}	mg/kg	<100	<100	<100	<100	<100
Total +ve TRH (>C10-C40)	mg/kg	110	<50	<50	<50	<50
Surrogate o-Terphenyl	%	73	73	69	70	74

svTRH (C10-C40) in Soil						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
TRH C_{10} - C_{14}	mg/kg	<50	<50	93	<50	<50
TRH C_{15} - C_{28}	mg/kg	<100	<100	380	140	<100
TRH C_{29} - C_{36}	mg/kg	<100	<100	190	<100	<100
Total +ve TRH (C10-C36)	mg/kg	<50	<50	660	140	<50
TRH $>C_{10}$-C_{16}	mg/kg	<50	<50	120	<50	<50
TRH $>C_{10}$-C_{16} less Naphthalene (F2)	mg/kg	<50	<50	120	<50	<50
TRH $>C_{16}$-C_{34}	mg/kg	<100	<100	480	190	<100
TRH $>C_{34}$-C_{40}	mg/kg	<100	<100	<100	<100	<100
Total +ve TRH (>C10-C40)	mg/kg	<50	<50	600	190	<50
Surrogate o-Terphenyl	%	72	72	86	77	70

PAHs in Soil						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Naphthalene	mg/kg	1.1	0.8	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	0.6	0.7	<0.1	<0.1	0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	0.2	0.2	<0.1	<0.1	0.1
Pyrene	mg/kg	0.1	0.2	<0.1	<0.1	<0.1
Benzo(a)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	mg/kg	0.1	0.2	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	0.2	0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	mg/kg	<0.05	0.06	<0.05	<0.05	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	0.1	0.1	<0.1	<0.1	<0.1
Total +ve PAH's	mg/kg	2.6	2.5	<0.05	<0.05	0.2
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Surrogate p-Terphenyl-d14	%	87	86	86	92	90

PAHs in Soil						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Naphthalene	mg/kg	0.1	<0.1	<0.1	0.3	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	0.1	<0.1	1.5	0.4	<0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	<0.1	0.7	0.2	<0.1
Pyrene	mg/kg	<0.1	<0.1	0.6	0.1	<0.1
Benzo(a)anthracene	mg/kg	<0.1	<0.1	0.4	<0.1	<0.1
Chrysene	mg/kg	<0.1	<0.1	0.5	0.1	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2	<0.2	0.4	<0.2	<0.2
Benzo(a)pyrene	mg/kg	0.06	<0.05	0.2	0.07	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total +ve PAH's	mg/kg	0.3	<0.05	4.2	1.2	<0.05
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Surrogate *p*-Terphenyl-d14	%	90	90	88	89	87

Organochlorine Pesticides in soil						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Mirex	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total +ve DDT+DDD+DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate 4-Chloro-3-NBTF	%	81	80	79	83	82

Organochlorine Pesticides in soil						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Mirex	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total +ve DDT+DDD+DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate 4-Chloro-3-NBTF	%	82	82	83	84	77

Organophosphorus Pesticides in Soil						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Dichlorvos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Mevinphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phorate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dimethoate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Diazinon	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Disulfoton	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyrifos-methyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Parathion-Methyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ronnel	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenitrothion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Malathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyriphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenthion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Parathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Bromophos-ethyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methidathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenamiphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ethion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phosalone	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Azinphos-methyl (Guthion)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Coumaphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate 4-Chloro-3-NBTF	%	81	80	79	83	82

Organophosphorus Pesticides in Soil						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Dichlorvos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Mevinphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phorate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dimethoate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Diazinon	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Disulfoton	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyrifos-methyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Parathion-Methyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ronnel	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenitrothion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Malathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyriphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenthion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Parathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Bromophos-ethyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methidathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenamiphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ethion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phosalone	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Azinphos-methyl (Guthion)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Coumaphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate 4-Chloro-3-NBTF	%	82	82	83	84	77

PCBs in Soil						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Aroclor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total +ve PCBs (1016-1260)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate 2-Fluorobiphenyl	%	89	87	86	89	90

PCBs in Soil						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date extracted	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Aroclor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total +ve PCBs (1016-1260)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate 2-Fluorobiphenyl	%	89	89	92	91	85

Acid Extractable metals in soil						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/03/2024	20/03/2024	20/03/2024	20/03/2024	20/03/2024
Date analysed	-	20/03/2024	20/03/2024	20/03/2024	20/03/2024	20/03/2024
Arsenic	mg/kg	9	8	<4	7	7
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	12	9	4	7	7
Copper	mg/kg	29	28	1	12	19
Lead	mg/kg	21	21	5	10	16
Mercury	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/kg	72	69	2	4	14
Zinc	mg/kg	79	69	3	20	40

Acid Extractable metals in soil						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/03/2024	20/03/2024	20/03/2024	20/03/2024	20/03/2024
Date analysed	-	20/03/2024	20/03/2024	20/03/2024	20/03/2024	20/03/2024
Arsenic	mg/kg	<4	4	<4	6	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	4	23	6	17	19
Copper	mg/kg	5	13	8	15	10
Lead	mg/kg	8	8	9	9	10
Mercury	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/kg	10	9	4	6	7
Zinc	mg/kg	42	25	19	37	35

Misc Soil - Inorg						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Total Cyanide	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Total Phenolics (as Phenol)	mg/kg	<5	<5	<5	<5	<5

Misc Soil - Inorg						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Total Cyanide	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Total Phenolics (as Phenol)	mg/kg	<5	<5	<5	<5	<5

Moisture						
Our Reference		346705-1	346705-2	346705-3	346705-4	346705-5
Your Reference	UNITS	BTH-4284A	BTH-4284B	BTH-4284C	BTH-4284E	BTH-4284F
Depth		BH1 0.1-0.5	BH1 0.5-0.95	BH1 1.0-1.5	BH1 2.0-3.0	BH2 0.0-0.5
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	20/03/2024	20/03/2024	20/03/2024	20/03/2024	20/03/2024
Moisture	%	12	12	12	3.0	12

Moisture						
Our Reference		346705-6	346705-7	346705-8	346705-9	346705-10
Your Reference	UNITS	BTH-4284H	BTH-4284I	BTH-4284J	BTH-4284K	BTH-4284L
Depth		BH2 1.0-1.5	BH2 2.0-2.5	BH6 0.0-0.5	BH6 0.5-0.95	BH6 1.5-1.95
Date Sampled		11/02/2024	11/02/2024	11/02/2024	11/02/2024	11/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	19/03/2024	19/03/2024	19/03/2024	19/03/2024	19/03/2024
Date analysed	-	20/03/2024	20/03/2024	20/03/2024	20/03/2024	20/03/2024
Moisture	%	6.1	8.4	13	10	7.8

Method ID	Methodology Summary
Inorg-008	Moisture content determined by heating at 105+/-5 °C for a minimum of 12 hours.
Inorg-014	Cyanide - free, total, weak acid dissociable by segmented flow analyser (in line dialysis with colourimetric finish). Solids/Filters and sorbents are extracted in a caustic media prior to analysis. Impingers are pH adjusted as required prior to analysis. Cyanides amenable to Chlorination - samples are analysed untreated and treated with hypochlorite to assess the potential for chlorination of cyanide forms. Based on APHA latest edition, 4500-CN_G,H.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis. Note, the Total +ve TRH PQL is reflective of the lowest individual PQL and is therefore "Total +ve TRH" is simply a sum of the positive individual TRH fractions (>C10-C40).
Org-021/022/025	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-ECD and/or GC-MS/GC-MSMS. Note, the Total +ve PCBs PQL is reflective of the lowest individual PQL and is therefore" Total +ve PCBs" is simply a sum of the positive individual PCBs.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS.

Method ID	Methodology Summary
Org-022/025	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-MS/GC-MSMS. Note, the Total +ve reported DDD+DDE+DDT PQL is reflective of the lowest individual PQL and is therefore simply a sum of the positive individually report DDD+DDE+DDT.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS and/or GC-MS/MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'EQ PQL'values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'EQ zero'values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'EQ half PQL'values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore "Total +ve PAHs" is simply a sum of the positive individual PAHs.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater. Note, the Total +ve Xylene PQL is reflective of the lowest individual PQL and is therefore "Total +ve Xylenes" is simply a sum of the positive individual Xylenes.

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Date analysed	-			20/03/2024	1	20/03/2024	20/03/2024		20/03/2024	[NT]
TRH C_6 - C_9	mg/kg	25	Org-023	<25	1	<25	<25	0	88	[NT]
TRH C_6 - C_{10}	mg/kg	25	Org-023	<25	1	<25	<25	0	88	[NT]
Benzene	mg/kg	0.2	Org-023	<0.2	1	<0.2	<0.2	0	89	[NT]
Toluene	mg/kg	0.5	Org-023	<0.5	1	<0.5	<0.5	0	86	[NT]
Ethylbenzene	mg/kg	1	Org-023	<1	1	<1	<1	0	80	[NT]
m+p-xylene	mg/kg	2	Org-023	<2	1	<2	<2	0	93	[NT]
o-Xylene	mg/kg	1	Org-023	<1	1	<1	<1	0	93	[NT]
Naphthalene	mg/kg	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
Surrogate aaa-Trifluorotoluene	%		Org-023	93	1	85	94	10	100	[NT]

QUALITY CONTROL: svTRH (C10-C40) in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Date analysed	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
TRH C_{10} - C_{14}	mg/kg	50	Org-020	<50	1	<50	<50	0	111	[NT]
TRH C_{15} - C_{28}	mg/kg	100	Org-020	<100	1	<100	<100	0	105	[NT]
TRH C_{29} - C_{36}	mg/kg	100	Org-020	<100	1	<100	<100	0	114	[NT]
TRH >C_{10}-C_{16}	mg/kg	50	Org-020	<50	1	<50	<50	0	111	[NT]
TRH >C_{16}-C_{34}	mg/kg	100	Org-020	<100	1	110	<100	10	105	[NT]
TRH >C_{34}-C_{40}	mg/kg	100	Org-020	<100	1	<100	<100	0	114	[NT]
Surrogate o-Terphenyl	%		Org-020	70	1	73	72	1	82	[NT]

QUALITY CONTROL: PAHs in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Date analysed	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Naphthalene	mg/kg	0.1	Org-022/025	<0.1	1	1.1	0.7	44	82	[NT]
Acenaphthylene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Acenaphthene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	84	[NT]
Fluorene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	84	[NT]
Phenanthrene	mg/kg	0.1	Org-022/025	<0.1	1	0.6	0.5	18	90	[NT]
Anthracene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Fluoranthene	mg/kg	0.1	Org-022/025	<0.1	1	0.2	0.2	0	92	[NT]
Pyrene	mg/kg	0.1	Org-022/025	<0.1	1	0.1	0.1	0	88	[NT]
Benzo(a)anthracene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Chrysene	mg/kg	0.1	Org-022/025	<0.1	1	0.1	0.1	0	78	[NT]
Benzo(b,j+k)fluoranthene	mg/kg	0.2	Org-022/025	<0.2	1	0.2	0.2	0	[NT]	[NT]
Benzo(a)pyrene	mg/kg	0.05	Org-022/025	<0.05	1	<0.05	<0.05	0	94	[NT]
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-022/025	<0.1	1	0.1	0.1	0	[NT]	[NT]
Surrogate p-Terphenyl-d14	%		Org-022/025	87	1	87	88	1	85	[NT]

QUALITY CONTROL: Organochlorine Pesticides in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Date analysed	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
alpha-BHC	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	108	[NT]
HCB	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
beta-BHC	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	116	[NT]
gamma-BHC	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Heptachlor	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	106	[NT]
delta-BHC	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Aldrin	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	94	[NT]
Heptachlor Epoxide	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	126	[NT]
gamma-Chlordane	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
alpha-chlordane	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Endosulfan I	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
pp-DDE	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	126	[NT]
Dieldrin	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	136	[NT]
Endrin	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	114	[NT]
Endosulfan II	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
pp-DDD	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	112	[NT]
Endrin Aldehyde	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
pp-DDT	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Endosulfan Sulphate	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	136	[NT]
Methoxychlor	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Mirex	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Surrogate 4-Chloro-3-NBTF	%		Org-022/025	81	1	81	81	0	81	[NT]

Client Reference: KVAR Creek Realignment

QUALITY CONTROL: Organophosphorus Pesticides in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Date analysed	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Dichlorvos	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	126	[NT]
Mevinphos	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Phorate	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Dimethoate	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Diazinon	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Disulfoton	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Chlorpyrifos-methyl	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Parathion-Methyl	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Ronnel	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	88	[NT]
Fenitrothion	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	86	[NT]
Malathion	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	108	[NT]
Chlorpyriphos	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	90	[NT]
Fenthion	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Parathion	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	88	[NT]
Bromophos-ethyl	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Methidathion	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Fenamiphos	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Ethion	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	90	[NT]
Phosalone	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Azinphos-methyl (Guthion)	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Coumaphos	mg/kg	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Surrogate 4-Chloro-3-NBTF	%		Org-022/025	81	1	81	81	0	81	[NT]

QUALITY CONTROL: PCBs in Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Date analysed	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	[NT]
Aroclor 1016	mg/kg	0.1	Org-021/022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Aroclor 1221	mg/kg	0.1	Org-021/022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Aroclor 1232	mg/kg	0.1	Org-021/022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Aroclor 1242	mg/kg	0.1	Org-021/022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Aroclor 1248	mg/kg	0.1	Org-021/022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Aroclor 1254	mg/kg	0.1	Org-021/022/025	<0.1	1	<0.1	<0.1	0	91	[NT]
Aroclor 1260	mg/kg	0.1	Org-021/022/025	<0.1	1	<0.1	<0.1	0	[NT]	[NT]
Surrogate 2-Fluorobiphenyl	%		Org-021/022/025	89	1	89	89	0	90	[NT]

QUALITY CONTROL: Acid Extractable metals in soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			20/03/2024	1	20/03/2024	20/03/2024		20/03/2024	[NT]
Date analysed	-			20/03/2024	1	20/03/2024	20/03/2024		20/03/2024	[NT]
Arsenic	mg/kg	4	Metals-020	<4	1	9	7	25	111	[NT]
Cadmium	mg/kg	0.4	Metals-020	<0.4	1	<0.4	<0.4	0	113	[NT]
Chromium	mg/kg	1	Metals-020	<1	1	12	14	15	113	[NT]
Copper	mg/kg	1	Metals-020	<1	1	29	28	4	111	[NT]
Lead	mg/kg	1	Metals-020	<1	1	21	21	0	112	[NT]
Mercury	mg/kg	0.1	Metals-021	<0.1	1	<0.1	<0.1	0	103	[NT]
Nickel	mg/kg	1	Metals-020	<1	1	72	69	4	112	[NT]
Zinc	mg/kg	1	Metals-020	<1	1	79	72	9	109	[NT]

QUALITY CONTROL: Misc Soil - Inorg					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	346705-2
Date prepared	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	19/03/2024
Date analysed	-			19/03/2024	1	19/03/2024	19/03/2024		19/03/2024	19/03/2024
Total Cyanide	mg/kg	0.5	Inorg-014	<0.5	1	<0.5	<0.5	0	109	103
Total Phenolics (as Phenol)	mg/kg	5	Inorg-031	<5	1	<5	<5	0	103	99

Client Reference: KVAR Creek Realignment

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

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