Appendix 1

WRM EA Amendment
Surface Water Assessment

Vulcan Coal Mine

EA Amendment
Surface water assessment

Vitrinite Pty Ltd

1571-16-G1, 6 December 2021

Report Title	Vulcan Coal Mine Surface water assessment
Client	Vitrinite Pty Ltd
Report Number	1571-16-G1

Revision Number	Report Date	Report Author	Reviewer
0 [DRAFT]	11 March 2020	LZ/RN	JO
1	31 March 2020	LZ/RN	JO/DN
2	17 September 2020	LZ	JO
3 [DRAFT]	2 December 2021	RN	JO
4	6 December 2021	RN	JO

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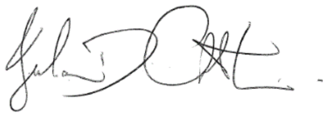

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Principal Engineer

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1 Introduction

1.1 BACKGROUND

The Vulcan Coal Mine (VCM), which is managed by Vitrinite Pty. Ltd., owner of Qld Coal Aust No.1 Pty. Ltd. and Queensland Coking Coal Pty. Ltd. (Vitrinite), is an open pit operation located to the southeast of Moranbah, in Central Queensland. The Project is located on Mining Lease (ML) 700060. The locations of the EPCs and the Project mining lease (ML) area are shown in Figure 1.1.

The proposed amendment primarily includes the establishment of a Coal Handling and Preparation Plant (CHPP), Train Load-out facility (TLO) and a dedicated rail loop on ML700060 (the Project). The proposed mine stage layouts for the Project, including all major surface water infrastructure elements required during operations and post-mining, are shown in Figure 1.2, Figure 1.3 and Figure 1.4.

WRM Water & Environment Pty Ltd (WRM) was engaged by Mining and Energy Technical Services Pty Ltd (METServe), on behalf of Vitrinite, to complete a surface water impact assessment as part of the Environmental Authority (EA) amendment application for the Project. The EA amendment is in support of an application to amend the VCM EA and surface water assessment completed in September 2020 (WRM, 2020).

This report presents the following:

- An overview of the regulatory framework which applies to the Project (including aspects which do not directly relate to the surface water assessment) (Section 2);
- A description of the environmental values (EVs) of the receiving waters surrounding the Project (Section 3);
- A description of the existing surface water environment at the Project (Section 4);
- A description of the proposed water management strategy and details regarding water management infrastructure (Section 5);
- A detailed description of the configuration of the Project water balance model (Section 6);
- An assessment of the Project water management system performance (Section 7);
- An assessment of the potential flooding impacts of the Project (Section 8); and
- A description of the surface water monitoring strategy proposed for the Project (Section 9).

1.2 PROJECT DESCRIPTION

Vitrinite holds approved Environmental Authority (EA0002912) and ML 700060 authorising the extraction of black coal. The Jupiter hard coking coal target has been defined and selected for open cut development via a single pit. The Project is approved to operate for approximately 4 years and will extract approximately 6 million tonnes of run of mine (ROM) hard coking coal at a rate of up to 1.95 million tonnes per annum. The Project will target the Alex and multiple Dysart Lower coal seams. Truck and shovel mining operations will be utilised in the pit. ROM coal is currently trucked off site to a coal handling and preparation plant (CHPP) at a nearby facility between Moranbah and Coppabella on the Peak Downs Highway.

An out-of-pit waste rock dump will be established prior to commencing in-pit dumping activities that will continue for the life of the operation. Ancillary infrastructure, including a ROM pad, Mine Infrastructure Area (MIA), offices, roads and surface water management infrastructure will be established to the west and south of the open cut.

A realignment of the existing Saraji Road and services infrastructure to the eastern boundary of the Project ML, adjacent to the existing rail easement, is also proposed. The re-alignment will occur on lease however the connection back to the existing alignment of Saraji Road to the north will extend off lease and will be subject to a separate approvals process.

In-pit dumping will fill most of the pit during operations with the remaining final void to be backfilled upon cessation of mining, resulting in the establishment of a low waste rock dump landform over the former pit area. The initial out-of-pit waste rock dump will be rehabilitated in-situ.

1.3 PROPOSED AMENDMENT

1.3.1 Overview

The proposed amendment primarily includes the establishment of a Coal Handling and Preparation Plant (CHPP), Train Load-out Facility (TLF) and a dedicated rail loop on ML700060. Establishment of this infrastructure at the Vulcan Coal Mine provides Vitrinite with a reliable and secure mechanism for transport of its coal to market. Ancillary infrastructure will include product stockpiles, updated water management infrastructure, access roads and a number of minor amendments to existing infrastructure layouts. Figure 1.2 and Figure 1.3 presents the proposed infrastructure for the new Project layout.

Construction of the CHPP, TLF and the rail loop, is expected to be completed within 18 months. Once commissioned, operation of the CHPP, TLF and rail loop will replace the current approved road haulage of ROM coal to third party processing facilities.

The amendment will require the inclusion of ERA31(2)(b), specifically:

ERA 31- Mineral Processing (2) processing, in a year, the following quantities of mineral products, other than coke - (b) more than 100,000t.

1.3.2 CHPP

The Project will include a modular CHPP to process ROM coal into a number of marketable products (coking coal and thermal coal). In summary, the CHPP will include:

- a ROM coal handling circuit to size ROM coal for further processing and remove incidental wastes;
- a ROM coal bypass conveyor to provide the option to direct appropriate quality ROM coal to the product stockpile;
- three CHPP circuits (coarse, secondary coarse and mid-sized) for coal beneficiation, producing a single product stream;
- a tailings thickener to thicken ultrafine reject material; and
- a solid bowl centrifuge to dewater tailings to a solid cake for disposal in active waste rock dumps.

The CHPP will be capable of producing dual products with different products produced in campaigns via control of different ROM feed materials. The CHPP will have sufficient capacity to process the current approved maximum 1.95 Mtpa ROM coal production rate.

A single CHPP product conveyor will deliver product coal to a radial product stacker. The system will be able to deliver different products to two different stockpiles. Each of the stockpiles will have a capacity of 200,000 tonnes.

The CHPP will operate 24 hours a day, seven days per week.

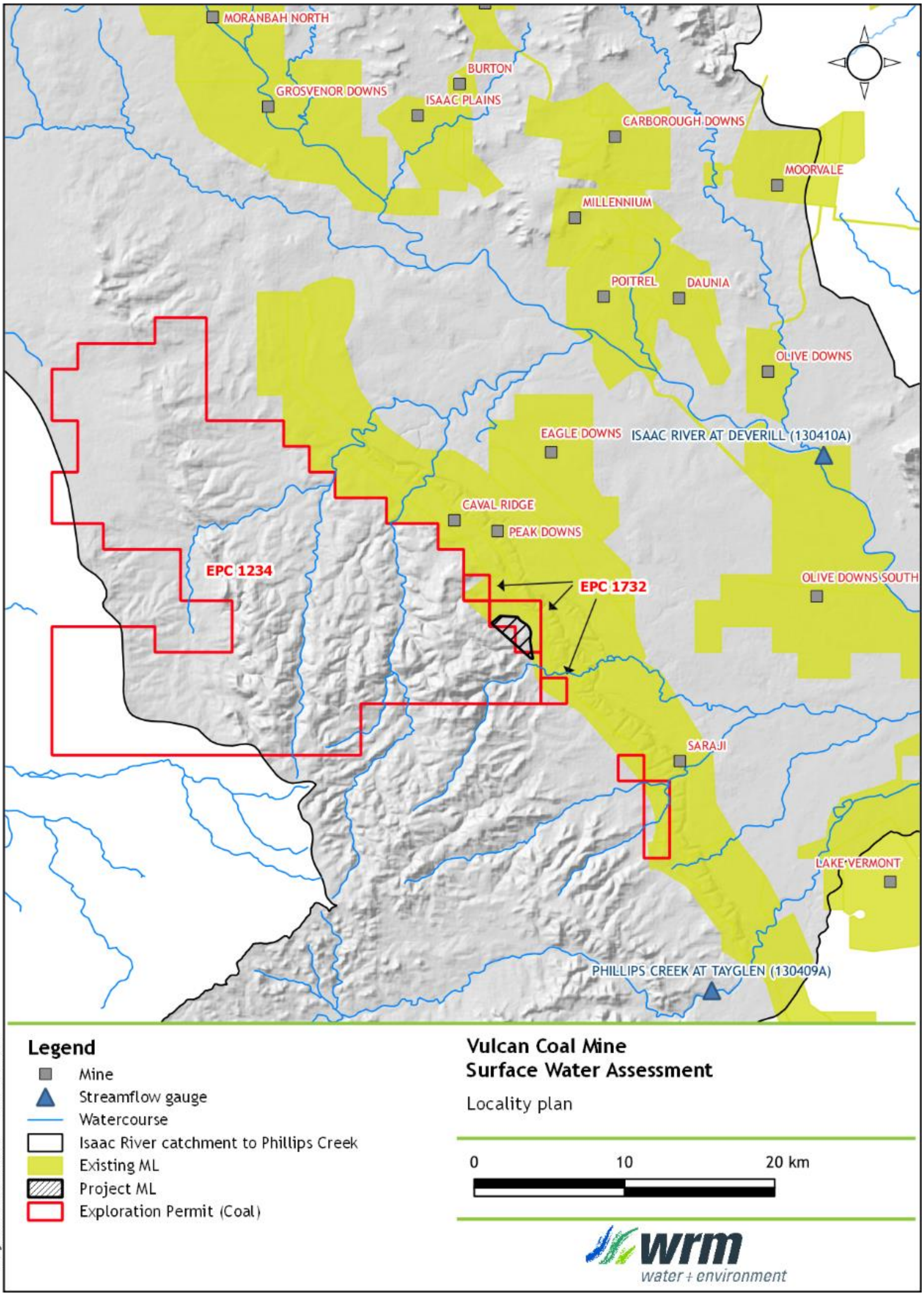


Figure 1.1 – Locality plan

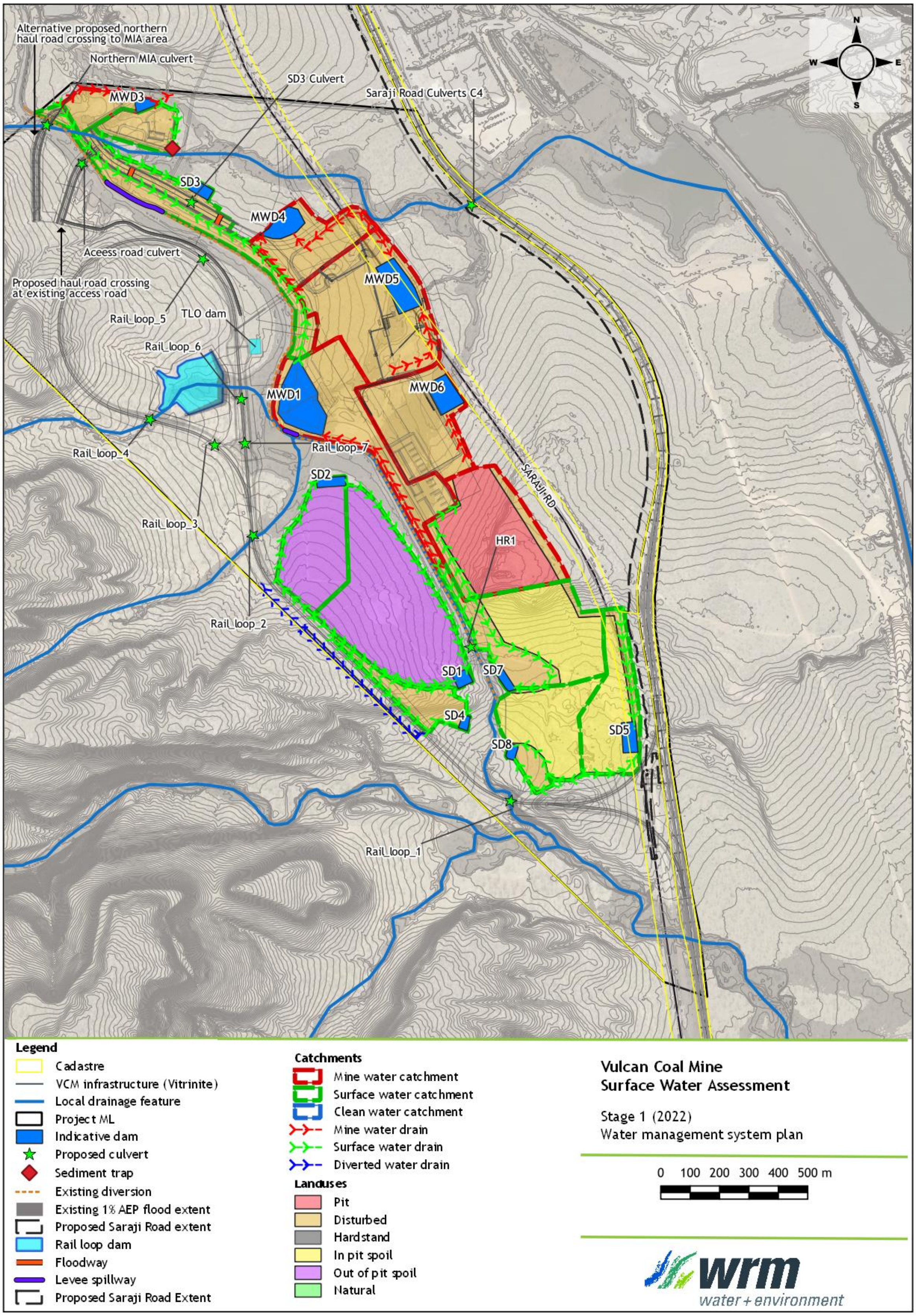


Figure 1.2 – Stage 1 (Year 2022) water management system plan

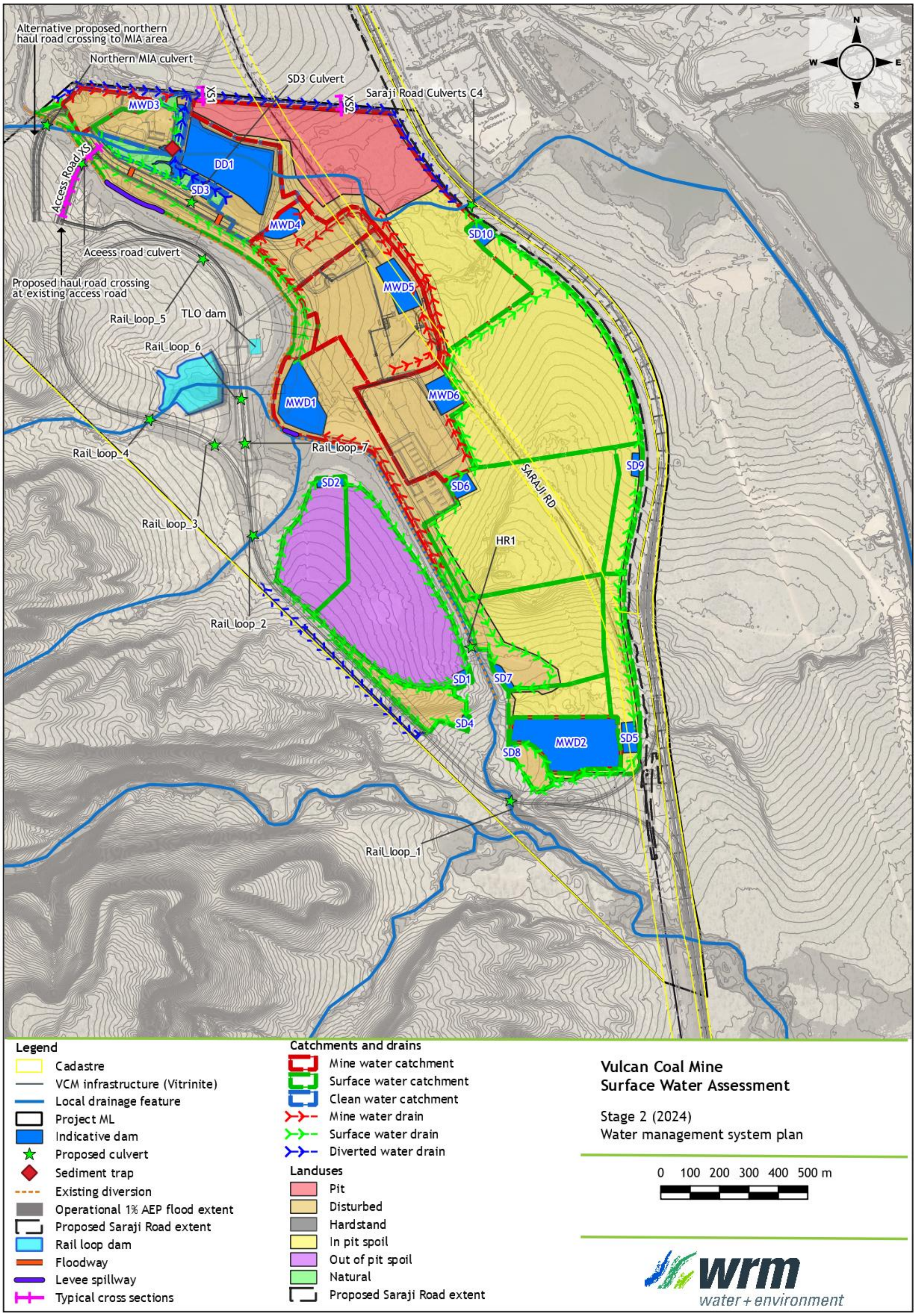


Figure 1.3 - Stage 2 (Year 2024) water management system plan

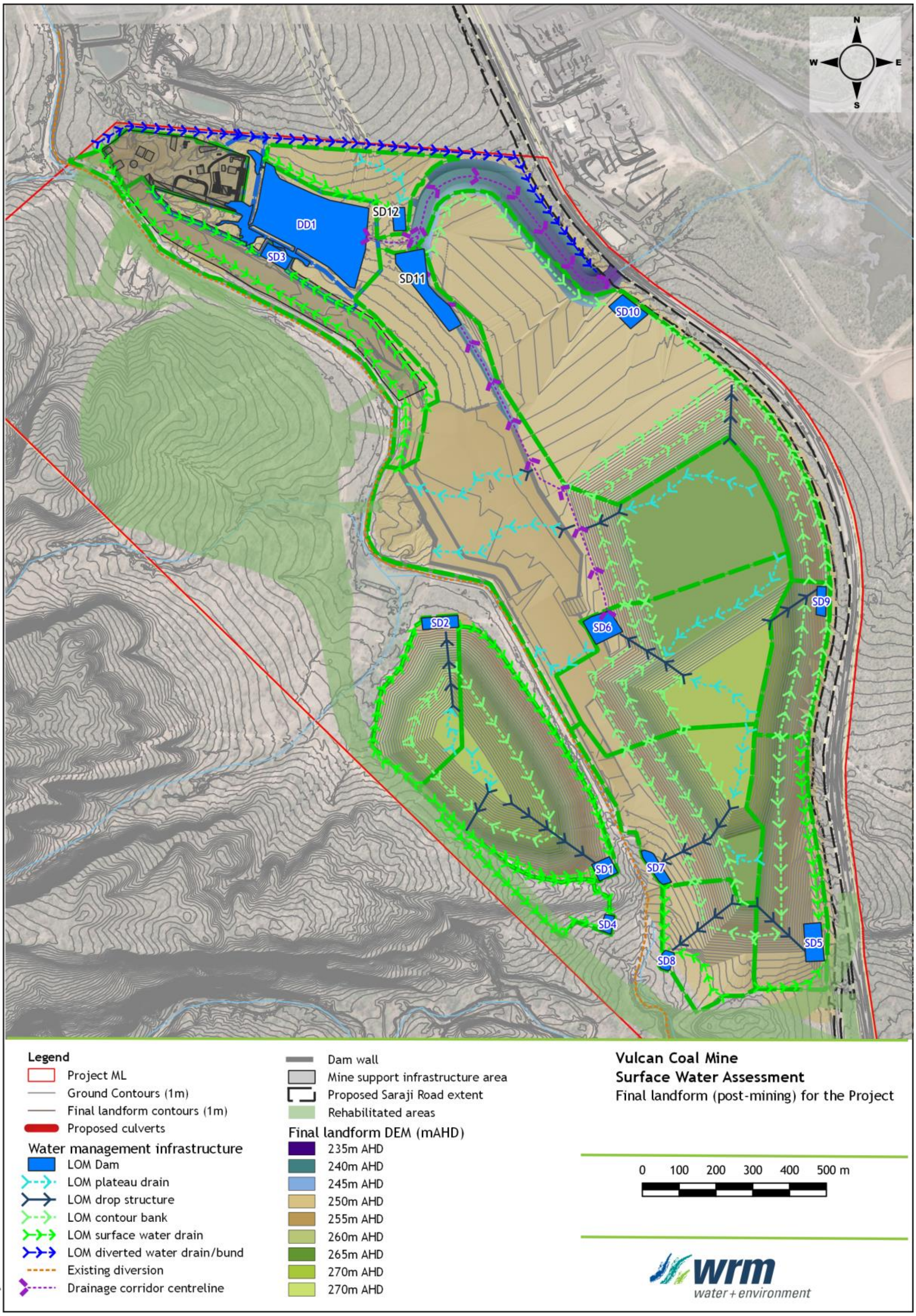


Figure 1.4 – Final landform (post-mining conditions) for the Project

2 Regulatory framework

This section describes the regulatory framework (legislation, policies and standards) at Commonwealth and State level that would apply to surface water management for the Project.

2.1 COMMONWEALTH

The Project will be referred to the Department of the Environment and Energy for consideration under the *Environment Protection and Biodiversity Conservation Act 1999*.

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development has published information guidelines (IESC, 2018) for advice on coal seam gas and large coal mining development proposals. The report sections where the IESC information requirements have been addressed are outlined in Table 2.1.

Table 2.1 - IESC information requirements - surface water

Project information	Report section
Description of the proposal	
Provide a regional overview of the proposed project area including a description of the geological basin; coal resource; surface water catchments; groundwater systems; water-dependent assets; and past, current and reasonably foreseeable coal mining and CSG developments.	Section 1 and Main EA Report
Describe the proposal's location, purpose, scale, duration, disturbance area, and the means by which it is likely to have a significant impact on water resources and water-dependent assets.	Section 1 and Main EA Report
Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies.	Section 2 and Main EIS Report
Describe how impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions.	Section 2
Surface water - context and conceptualisation	
Describe the hydrological regime of all watercourses, standing waters and springs across the site including:	
• geomorphology, including drainage patterns, sediment regime, and floodplain features;	Section 4
• spatial, temporal and seasonal trends in streamflow and/or standing water levels;	Section 4.4
• spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); and	Section 4.5
• current stressors on watercourses, including impacts from any currently approved projects.	Section 4 & 10
Describe the existing flood regime, including flood volume, depth, duration, extent and velocity for a range of annual exceedance probabilities. Provide flood hydrographs and maps identifying peak flood extent, depth and velocity. This assessment should be informed by topographic data that has been acquired using lidar or other reliable survey methods with accuracy stated.	Section 8

Project information	Report section
Provide an assessment of the frequency, volume, seasonal variability and direction of interactions between water resources, including surface water/groundwater connectivity and connectivity with sea water.	Refer to Groundwater report
<u>Surface water – analytical and numerical modelling</u>	
Provide conceptual models at an appropriate scale, including water quality, stores, flows and use of water by ecosystems.	Section 5 & 6
Use methods in accordance with the most recent publication of *Australian Rainfall and Runoff* (Ball et al. 2016).	Section 8
Develop and describe a program for review and update of the models as more data and information becomes available.	Section 6 & 8
Describe and justify model assumptions and limitations and calibrate with appropriate surface water monitoring data.	Section 6 & 8
Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	Section 7.4
Provide a detailed description of any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	N/A
<u>Surface water – impacts to water resources and water-dependent assets</u>	
Describe all potential impacts of the proposed project on surface waters. Include a clear description of the impact to the resource, the resultant impact to any assets dependent on the resource (including water-dependent ecosystems such as riparian zones and floodplains), and the consequence or significance of the impact. Consider:	
• Impacts on streamflow under the full range of flow conditions;	Section 8.8 & 10
• Impacts associated with surface water diversions;	Section 8.8
• Impacts to water quality, including consideration of mixing zones;	Section 7.3.7
• The quality, quantity and ecotoxicological effects of operational discharges of water (including saline water), including potential emergency discharges, and the likely impacts on water resources and water-dependent assets; and	Section 7.3.7
• Landscape modifications such as subsidence, voids, post rehabilitation landform collapses, onsite earthworks (including disturbance of acid-forming or sodic soils, roadway and pipeline networks) and how these could affect surface water flow, surface water quality, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Sections 5, 8.6.2 & 8.8
Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Section 2 & 3
Identify processes to determine surface water guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Section 9
Propose mitigation actions for each identified significant impact.	Section 6 & 8
Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	Section 6 & 8
Describe the cumulative impact of the proposal on surface water resources and water-dependent assets when all developments (past, present and/or reasonably foreseeable) are considered in combination.	Section 10

Project information	Report section
Provide an assessment of the risks of flooding (including channel form and stability, water level, depth, extent, velocity, shear stress and stream power), and impacts to ecosystems, project infrastructure and the final project landform.	Section 8
Surface water – data and monitoring	
Identify monitoring sites representative of the diversity of potentially affected water-dependent assets and the nature and scale of potential impacts, and match with suitable replicated control and reference sites (BACI design) to enable detection and monitoring of potential impacts.	Section 4.5
Ensure water quality monitoring complies with relevant National Water Quality Management Strategy (NWQMS) guidelines (ANZECC/ARMCANZ 2000) and relevant legislated state protocols (e.g. QLD Government 2013).	Section 4.5
Identify data sources, including streamflow data, proximity to rainfall stations, data record duration and a description of data methods, including whether missing data has been patched.	Sections 4.3 & 4.4
Develop and describe a surface water monitoring programme that will collect sufficient data to detect and identify the cause of any changes from established baseline conditions and assess the effectiveness of mitigation and management measures. The program will:	
• include baseline monitoring data for physico-chemical parameters, as well as contaminants (e.g. metals);	Section 4.5
• comparison of physico-chemical data to national/regional guidelines or to site- specific guidelines derived from reference condition monitoring if available; and	Section 4.5
• identify baseline contaminant concentrations and compare these to national guidelines, allowing for local background correction if required.	Section 4.5
Describe the rationale for selected monitoring parameters, duration, frequency and methods, including the use of satellite or aerial imagery to identify and monitor large-scale impacts.	Section 9
Identify dedicated sites to monitor hydrology, water quality, and channel and floodplain geomorphology throughout the life of the proposed project and beyond.	Section 9
Water-dependent assets - context and conceptualisation	
Identify water-dependent assets, including:	
• water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. [in press]); and	Refer to Main EA Report
• public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource.	
Identify GDEs in accordance with the method outlined by Eamus et al. (2006). Information from the GDE Toolbox15 (Richardson et al. 2011) and GDE Atlas (CoA 2017a) may assist in the identification of GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
Describe the conceptualisation and rationale for likely water-dependence, impact pathways, tolerance and resilience of water-dependent assets. Examples of ecological conceptual models can be found in Commonwealth of Australia (2015).	Refer to Groundwater Report
Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody et al. [in press]).	Refer to Groundwater Report

Project information	Report section
Identify the hydrogeological units on which any identified GDEs are dependent (see Doody et al. [in press]).	Refer to Groundwater Report
Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 3 & 4
Describe the process employed to determine water quality and quantity triggers and impact thresholds for water-dependent assets (e.g. threshold at which a significant impact on an asset may occur).	Section 9
Water dependent assets - impacts, risk assessment and management of risk	
Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
Describe the potential range of drawdown at each affected bore, and clearly articulate the scale of impacts to other water users.	Refer to Groundwater Report
Indicate the vulnerability to contamination (e.g. from salt production and salinity) and the likely impacts of contamination on the identified water-dependent assets and ecological processes.	Section 7.3.7
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion and habitat fragmentation of water-dependent species and communities.	Section 5
Provide estimates of the volume, beneficial uses and impact of operational discharges of water (particularly saline water), including potential emergency discharges due to unusual events, on water-dependent assets and ecological processes.	Section 7.3.7 & 7.3.8
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 7 & 8
Identify the proposed acceptable level of impact for each water-dependent asset based on leading-practice science and site-specific data, and ideally developed in conjunction with stakeholders.	Section 7 & 8
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 5 & 9
Water-dependent assets - data and monitoring	
Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions, and test potential responses to impacts of the proposal (see Doody et al. [in press]).	Section 9
Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody et al. [in press]).	
Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody et al. [in press]).	
Describe the process for regular reporting, review and revisions to the monitoring program.	

Project information	Report section
Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna (QLD Government 2015)).	
Water and salt balance, and water management quality	
Provide a quantitative site water balance model describing the total water supply and demand under a range of rainfall conditions and allocation of water for mining activities (e.g. dust suppression, coal washing etc.), including all sources and uses.	Section 7
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	Section 7
Provide estimates of the quality and quantity of operational discharges under dry, median and wet conditions, potential emergency discharges due to unusual events and the likely impacts on water-dependent assets.	Section 7.3.5 & 7.3.8
Provide salt balance modelling that includes stores and the movement of salt between stores and takes into account seasonal and long-term variation.	Section 7.3.6
Cumulative impacts – context and conceptualisation	
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 10
Consider all past, present, and reasonably foreseeable actions, including development proposals, programs and policies that are likely to impact on the water resources of concern in the cumulative impact analysis. Where a proposed project is located within the area of a bioregional assessment consider the results of the bioregional assessment.	Section 10
Cumulative impacts – impacts	
Provide an assessment of the condition of affected water resources which includes: • identification of all water resources likely to be cumulatively impacted by the proposed development; • a description of the current condition and quality of water resources and information on condition trends; • identification of ecological characteristics, processes, conditions, trends and values of water resources; • adequate water and salt balances; and • identification of potential thresholds for each water resource and its likely response to change and capacity to withstand adverse impacts (e.g. altered water quality, drawdown).	Section 4, 7, 9 & 10
Assess the cumulative impacts to water resources considering: • the full extent of potential impacts from the proposed project, (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts), and encompassing all linkages, including both direct and indirect links, operating upstream, downstream, vertically and laterally; • all stages of the development, including exploration, operations and post closure/decommissioning; • appropriately robust, repeatable and transparent methods;	Section 10

Project information	Report section
• the likely spatial magnitude and timeframe over which impacts will occur, and significance of cumulative impacts; and • opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts.	
Cumulative impacts - mitigation, monitoring and management	
Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts. Evidence of the likely success of these measures (e.g. case studies) should be provided.	Section 7.4, 7.5, 9 & 10
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	
Identify cumulative impact environmental objectives.	
Describe appropriate reporting mechanisms.	
Propose adaptive management measures and management responses.	
Final landforms and voids - coal mines	
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Section 5 and Main EA report
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	
Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should consider: • groundwater behaviour - sink or lateral flow from void; • water level recovery - rate, depth, and stabilisation point (e.g. timeframe and level in relation to existing groundwater level, surface elevation); • seepage - geochemistry and potential impacts; • long-term water quality, including salinity, pH, metals and toxicity; and • measures to prevent migration of void water off-site. For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.	
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	N/A
Acid-forming materials and other contaminants of concern	
Identify the presence and potential exposure of acid-sulfate soils (including oxidation from groundwater drawdown).	Refer to Main EA Report, Geochemical Assessment Report and Section 6.8
Identify the presence and volume of potentially acid-forming waste rock, fine-grained amorphous sulphide minerals and coal reject/tailings material and exposure pathways.	
Identify other sources of contaminants, such as high metal concentrations in groundwater, leachate generation potential and seepage paths.	

Project information	Report section
Describe handling and storage plans for acid-forming material (co-disposal, tailings dam, encapsulation).	
Assess the potential impact to water-dependent assets, taking into account dilution factors, and including solute transport modelling where relevant, representative and statistically valid sampling, and appropriate analytical techniques.	
Describe proposed measures to prevent/minimise impacts on water resources, water users and water-dependent ecosystems and species.	

2.2 STATE

2.2.1 EP Act 1994

Resource activities are defined as environmentally relevant activities (ERAs) under the Queensland *Environmental Protection Act 1994* (EP Act) and as such, the development and operation of the Project are governed by the EP Act. The aim of the EP Act is to:

> *Protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).*

2.2.1.1 Environmental Authority

An Environmental Authority (EA) is granted in accordance with the EP Act and details the prescribed conditions that govern the ERA. In the context of surface water management, the EA sets out conditions that will be relevant to the Project, including:

- Management of contained water including release;
- Water management plan requirements;
- Regulation of water structures including dams and levees;
- Saline drainage management;
- Acid rock drainage management; and
- Storm water and sediment laden runoff management.

2.2.1.2 Model Mining Conditions

New mining project applications should apply the model mining conditions as outlined in *Model mining conditions* (DES, 2017). The purpose of the model mining conditions is to provide a set of model conditions to form the general environmental protection commitments given for EA's for mining activities administered under the EP Act. The model conditions may be used as a basis for proposing environmental protection commitments in application documents.

Model conditions can be modified to suit the specific circumstances of a mining project, subject to the assessment criteria outlined in the EP Act. It is unlikely that the administering authority will accept less rigorous environmental protection commitments or EA conditions without clear evidence that the risk of the environmental harm is addressed by environmental management practices, technologies or the nature of the EVs impacted by the Project.

Schedule F – Water (Fitzroy model conditions) form the basis of the requirements for the Project water management system design.

2.2.1.3 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP WWB) is the primary instrument for surface water management under the EP Act. The EPP WWB governs discharge to land, surface water and groundwater, aims to protect EVs and sets water quality guidelines and objectives.

The processes to identify EVs and to determine Water Quality Guidelines (WQGs) and Water Quality Objectives (WQOs) in Queensland waters is based on the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ guidelines).

The EVs for the Project location are outlined in Section 3.

2.2.1.4 Isaac River sub-basin Environmental Values and Water Quality Objectives 2011

The relevant document, pursuant to the EPP WWB, for the Project is the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part),* including all waters of the Isaac River Sub-basin (including Connors River, September 2011 [DEHP, 2011]). The document is made pursuant to the provisions of the EPP WWB. It contains EVs and WQOs for waters in the Isaac River Sub-basin, and they are listed under Schedule 1 of EPP WWB. Refer to Section 3 for further details.

2.2.1.5 Manual for Assessing Consequence Categories and Hydraulic Performance of Structures

The *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (the Manual) defines the methodology and assessment criteria to determine if a structure associated with an ERA should be regulated under the EP Act. The manual details the hydraulic design requirements for regulated structures and this document has been used as a reference in the preliminary design of the water management system and preliminary sizing of dams associated with the Project.

2.2.1.6 Guideline – Application Requirements for Activities with Impacts to Water

This guideline focuses on the types of impacts that environmentally relevant activities (ERAs) can have on water and outlines the information to be provided to the department as part of the ERA application process.

Section 4 of the guideline requires the applicant to provide details on a number of surface water-related issues, including:

- Discharges and releases;
- Unplanned and uncontrolled releases;
- Water infrastructure;
- Wetlands;
- Hydrology of receiving waters; and
- Mixing zones.

Table 2.2 lists the elements of the guideline relevant to this assessment and the sections of this report where those elements are addressed.

The guideline also refers to the department's technical guideline "Wastewater releases to Queensland waters", which is discussed in Section 2.2.1.7.

Table 2.2 – Application requirements for activities with impact to Water – Guideline

Item	Report section
Discharges and releases	
Identify activities that could lead to indirect impacts and unplanned/uncontrolled release of contaminants to water, such as, spills and leaks or stream bed and/or bank disturbance and describe the magnitude of the disturbance	Section 7.3.5 & 7.3.8
Identify the location, depth and configuration (if relevant) of the areas where the unplanned/uncontrolled release could be discharged to waters	Section 5 & 7.3.5
Identify infrastructure (including containment devices) with the potential to release unplanned/uncontrolled contaminants to waters	Section 6.4
Identify the potential contaminant type and quantities that could be released from infrastructure	Section 6.8 & 7.3.5
Water infrastructure	
Provide detail on the location and storage capacity of water infrastructure on the site which may include regulated structures, tailings dams, waste rock dams, water storage dams, levees, heap leach pads and any other water management infrastructure	Section 6.4
Wetlands	
Applicants must describe how the existing environmental values of any wetlands on, or adjacent to, the site will be maintained, or enhanced	Section 3
Ecology and hydrology of receiving waters	
Describe, preferably through the use of water quality monitoring or modelling, how the proposed ERA will impact on hydrology of receiving waters, preferably through modelling	Section 7.3

2.2.1.7 Technical Guideline – Wastewater release to Queensland Waters

This guideline is provided to support a risk-based assessment approach to licensing releases of wastewater to surface water and applies the philosophy of the ANZECC & ARMCANZ (2000) Water Quality Guidelines and the intent of the EPP Water.

The information requirements identified in this guideline are as follows:

- Describe the proposed activity;
- Describe the receiving environment;
- Predict outcomes or impacts of the proposed wastewater release; and
- Set circumstances, limits and monitoring conditions.

Table 2.3 lists the elements of the guideline relevant to this assessment and the sections of this report where those elements are addressed.

Table 2.3 – Wastewater release to Queensland waters – technical guideline

Item	Report section
Step 1 – Describe the proposed activity	
Define industry type and size (estimated production, current and ultimate)	Section 1.2
Identify the potential contaminants of concern in the proposed release	Section 6.8
Location and configuration of the proposed release	Section 6.4
Step 2 – Describe the receiving environment	
Identify water bodies potentially affected by the proposed release	Section 4
Provide all relevant information on the receiving environment based on desktop and field studies (e.g. current, background water quality condition)	
Include special consideration for ephemeral streams	
Identify all relevant EV and WQOs	Section 3
Ensure all government planning requirements applying to the water bodies have been considered	Section 2
Step 3 - Predict outcomes or impacts of the proposed wastewater release	
Assess whether contaminants are potentially toxic	Section 6.8 and 7.3
Predict the assimilative capacity and sustainable load	Section 7.3
Consider other potential impacts	Section 7.3
Step 4 – Set circumstances, limits and monitoring conditions	
Specify any circumstances related to the approved wastewater release	Section 6.4
Include a receiving environment monitoring program (REMP) requirement	Section 0
Include reporting requirements for the approved activity	Section 9

2.2.2 Water Act 2000

In Queensland, the Water Act 2000 (Water Act) is the primary statutory document that establishes a framework for the planning, allocation and use of non-tidal water. The Water Act is primarily administered by the Department of Natural Resources, Mines and Energy (DNRME).

The main purpose of the Water Act is to provide a framework for the following:

- The sustainable management of Queensland's water resources by establishing a system for the planning, allocation and use of water and riverine protection;
- The sustainable and secure water supply for the south-east Queensland region and other designated regions;
- The management of impacts on underground water caused by the exercise of underground water rights by the resource sector; and
- The effective operation of water authorities.

A watercourse is defined by the Water Act as a river, creek or stream, including a stream in the form of an anabranch or a tributary, in which water flows permanently or intermittently. The DNRME have published a watercourse identification map of the state that shows: watercourses (other than their lateral limits); the downstream limit of watercourses; drainage features; lakes; and springs.

A watercourse determination for drainage features in the Project ML area has been undertaken by the DNRME. DNRME determined that no watercourses intersect the Project

ML area and all features are drainage features defined by the Water Act. These features are described in Section 4.

2.2.2.1 Water Plan (Fitzroy Basin) 2011

The Water Plan (Fitzroy Basin) 2011 is subordinate legislation to the Water Act. The plan is developed and administered by DNRME. The purpose of the plan is:

- To define the availability of water in the Fitzroy Basin;
- To provide a framework for sustainably managing water and the taking of water;
- To identify priorities and mechanisms for dealing with future water requirements;
- To provide a framework for establishing water allocations;
- To provide a framework for reversing, where practicable, degradation in natural ecosystems;
- To regulate the taking of overland flow water; and
- To regulate the taking of groundwater.

2.2.2.2 Water Regulation 2016

The Water Regulation 2016 is subordinate legislation to the Water Act and provides details, protocol and instruction for the following:

- Water rights and planning;
- Statutory authorisations to take or interfere with water;
- Matters relating to water licenses;
- Water allocations;
- Water supply and demand management; and
- Declarations about watercourses.

2.2.3 Water Supply (Safety & Reliability) Act 2008

The Water Supply (Safety and Reliability) Act 2008 provides for the safety and reliability of water supply in Queensland. The purpose is achieved primarily by:

- Providing a regulatory framework for providing water and sewerage services in the State;
- Providing a regulatory framework for providing recycled water and drinking water quality, primarily for protecting public health;
- The regulation of referable dams; and
- Stating flood mitigation responsibilities.

3 Environmental Values

The Queensland Water Quality Guidelines and EPP WWB guidelines establish environmental values (EVs) and water quality objectives (WQOs) for natural waters in Queensland. The Project is located within the 'Isaac western upland tributaries' area of the Isaac River sub-basin, shown in Figure 3.1. Under the EPP WWB, the following EVs have been nominated for this area:

- Aquatic ecosystems;
- Irrigation;
- Farm supply/use;
- Stock Water;
- Aquaculture;
- Human consumption;
- Primary recreation;
- Secondary recreation;
- Visual recreation;
- Drinking water;
- Industrial use; and
- Cultural and spiritual values.

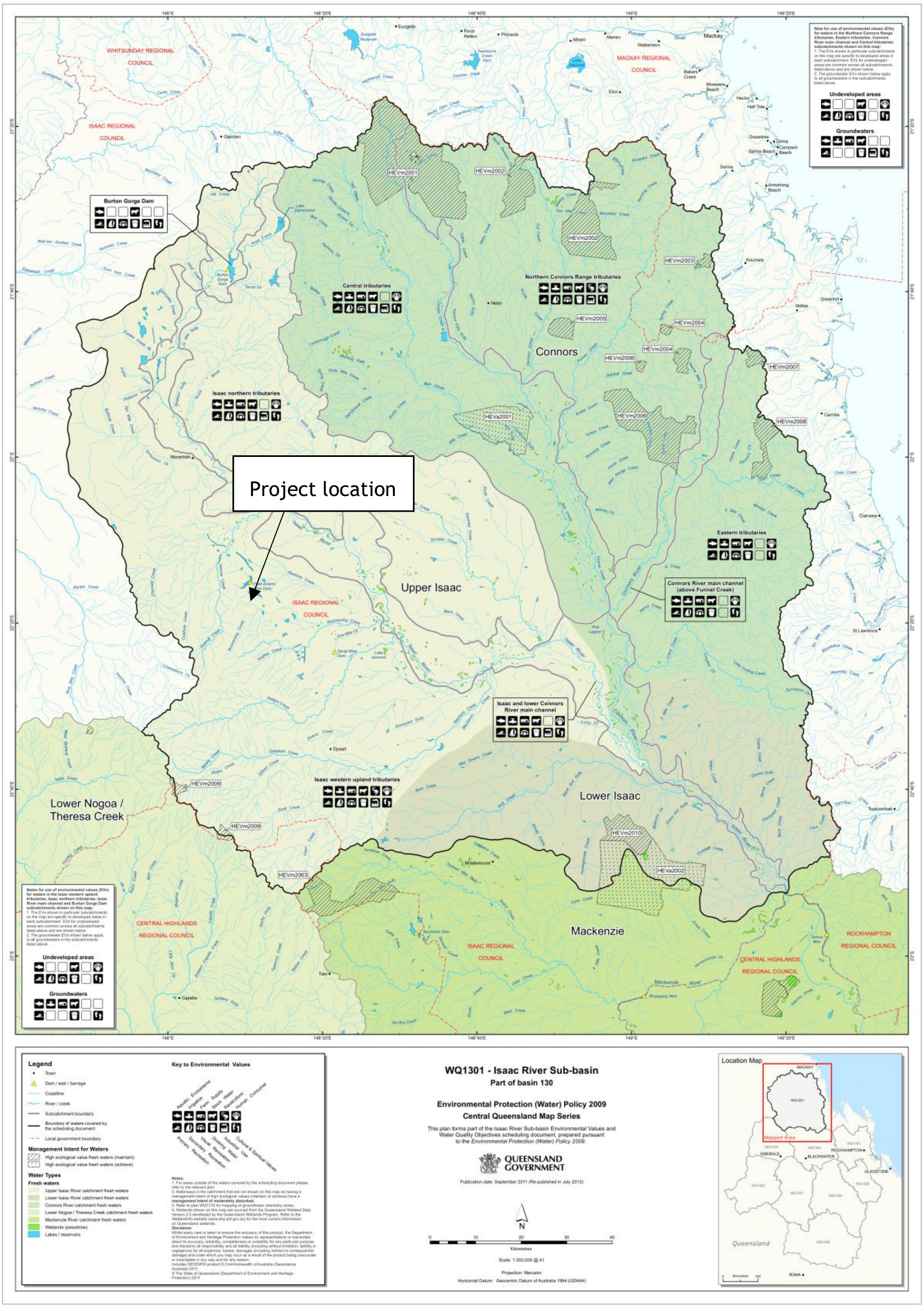


Figure 3.1 - Isaac River Sub-Basin EVs (source: DES, 2013)

The WQO default trigger values for the above EVs are provided in Table 3.1. The indicators and water quality guidelines relevant to the above surface water EVs are listed in Schedule 1 of EPP WWB and the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018).

Where different EVs have different WQOs, the Project has adopted the lowest concentration value for mine water and receiving waters trigger levels. WQO default trigger values are displayed for physio-chemical parameters only.

Table 3.1 - Water Quality Objectives default trigger values for the Project (from EPP WWB for Isaac Western Upland Tributaries)

Parameter	WQO	Relevant EV
Ammonia N	< 20 µg/L	Aquatic ecosystem[a]
Oxidised N	< 60 µg/L	Aquatic ecosystem[a]
Organic N	< 420 µg/L	Aquatic ecosystem[a]
Total nitrogen	< 500 µg/L	Aquatic ecosystem[a]
Filterable Reactive Phosphorus (FRP)	< 20 µg/L	Aquatic ecosystem[a]
Total Phosphorus	< 50 µg/L	Aquatic ecosystem[a]
Chlorophyll a	< 5 µg/L	Aquatic ecosystem[a]
Dissolved oxygen	85-110% saturation > 4 mg/L at surface	Aquatic ecosystem[a] Drinking water[b]
Turbidity	< 50 NTU	Aquatic ecosystem[a]
Suspended solids	< 55 mg/L	Aquatic ecosystem[a]
pH	pH 6.5-8.5	Aquatic ecosystem[a]
Conductivity (EC) baseflow	720 µS/cm	Aquatic ecosystem[a]
Conductivity (EC) high flow	250 µS/cm	Aquatic ecosystem[a]
Sulfate	25 mg/L	Aquatic ecosystem[a]
Total Dissolved Solids	< 2000 mg/L	Stock watering[c]
Colour	50 Hazen Units	Drinking water[b]
Total Hardness	150 mg/L as CaCO3	Drinking water[b]
Sodium	< 30 mg/L	Drinking water[b]
Aluminium	< 5 mg/L < 0.055 mg/L	Stock watering[c] Aquatic ecosystem[d]
Arsenic	2.0 mg/L 0.5 mg/L up to 5 mg/L < 0.024 mg/L	Irrigation[b, e] Stock watering[f] Aquatic ecosystem[d]
Beryllium	< 0.5 mg/L	Irrigation[g]
Boron	< 5 mg/L < 0.37 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Cadmium	< 0.01 mg/L < 0.0002 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Chromium	< 1 mg/L < 0.001 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Cobalt	< 0.1 mg/L	Irrigation[g]
Copper	< 1 mg/L < 0.0014 mg/L	Stock watering (cattle)[f,e] Aquatic ecosystem[d]
Fluoride	< 2 mg/L	Irrigation[g]

Parameter	WQO	Relevant EV
Iron	< 10 mg/L	Irrigation[g]
Lead	< 0.1 mg/L < 0.0034 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Lithium	< 2.5 mg/L	Irrigation[g]
Manganese	< 10 mg/L < 1.9 mg/L	Irrigation[g] Aquatic ecosystem[d]
Mercury	< 0.002 mg/L < 0.00006 mg/L	Irrigation[g] Aquatic ecosystem[d]
Molybdenum	< 0.05 mg/L	Irrigation[g]
Nickel	< 1 mg/L < 0.011 mg/L	Stock watering[f, e] Aquatic ecosystem[d]
Selenium	< 0.02 mg/L < 0.005 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Uranium	< 0.1 mg/L	Irrigation[g]
Vanadium	< 0.5 mg/L	Irrigation[g]
Zinc	< 5 mg/L < 0.008 mg/L	Irrigation[g] Aquatic ecosystem[d]

[a] Table 2 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem - moderately disturbed
[b] Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
[c] Table 10 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering EV: salinity
[d] Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
[e] short-term trigger value
[f] Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering EV: heavy metals and metalloids
[g] Table 9 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Irrigation EV: heavy metals and metalloids

The Queensland Globe service (Queensland Government, 2019) was used to identify any wetlands in the vicinity of the Project. There were no matters of state environmental significance (MSES) wetlands, wetland values or wetland protection areas identified in the vicinity of the Project.

4 Existing surface water environment

4.1 REGIONAL DRAINAGE CHARACTERISTICS

The Project is located within the Isaac River sub-basin of the greater Fitzroy Basin. Figure 4.1 shows the Upper Isaac River catchment to its confluence with Phillips Creek.

The Isaac River commences approximately 100 km to the north of the Project site within the Denham Range. It drains in a south westerly direction through the Carborough and Kerlong Ranges before turning in a south easterly direction near the Goonyella Riverside Mine. It drains approximately 30 km to the east of the Project, and eventually flows to the Mackenzie River some 150 km to the southeast.

Three open water bodies are located in the Isaac upper catchment including Lake Elphinstone, Teviot Creek Dam and Burton Gorge Dam (Figure 4.1). Lake Elphinstone is a natural lake formed behind the Carborough Range whereas Teviot Creek Dam and Burton Gorge Dam are man-made structures that supply water to Burton and North Goonyella mines in the upper catchment.

Other than along the ranges, the majority of the Isaac River catchment has been cleared for agricultural use or for mining. There are several existing coal mines in the catchment, including Burton, North Goonyella, Goonyella Riverside, Broadmeadow, Broadlea North, Isaac Plains, Moranbah North, Millennium, Daunia, Poitrel, Grosvenor, Peak Downs, Saraji, Norwich Park and Lake Vermont.

Figure 4.2 shows the surrounding catchments of the Project area. The Project is located in the headwaters of the Boomerang Creek catchment. Boomerang Creek is a watercourse and tributary of the Isaac River. The catchment area of the Isaac River to Boomerang Creek is 5,226 square kilometres (km^2).

The Boomerang Creek catchment commences to the west of the Project area and drains in an easterly direction towards Saraji Road and the Norwich Park Branch Railway. The Ripstone Creek catchment lies to the north of the Project area and drains into Boomerang Creek approximately 30 km southeast of the Project. The headwater tributaries of Boomerang Creek are ephemeral streams which experience flow only after sustained or intense rainfall.

The predominant catchment land uses of Boomerang Creek include undeveloped areas with some stock grazing to the west of Saraji Road and stock grazing and coal mining to the east. Downstream of the Project, Boomerang Creek, as well as its tributaries to the south, flow into the existing BHP Billiton Mitsubishi Alliance (BMA) operations (Peak Downs and Saraji). The catchment area of Boomerang Creek is 788 km^2. The existing BMA operations have diverted and/or modified the original alignment of Boomerang Creek as shown in Figure 4.2 as well as Harrow Creek to the north. Additional diversions and/or modification of Boomerang Creek and its floodplain are also planned for approved operations further to the east.

4.2 LOCAL DRAINAGE NETWORK

Figure 4.3 shows the local drainage features within the vicinity of the Project. Drainage features that cross the Project area eventually drain to Boomerang Creek and subsequently to the Isaac River. The tributaries of Boomerang Creek which intersect the Project area include (Figure 4.3):

- Drainage Line 1;
- Drainage Line 2; and
- the existing drainage diversion.

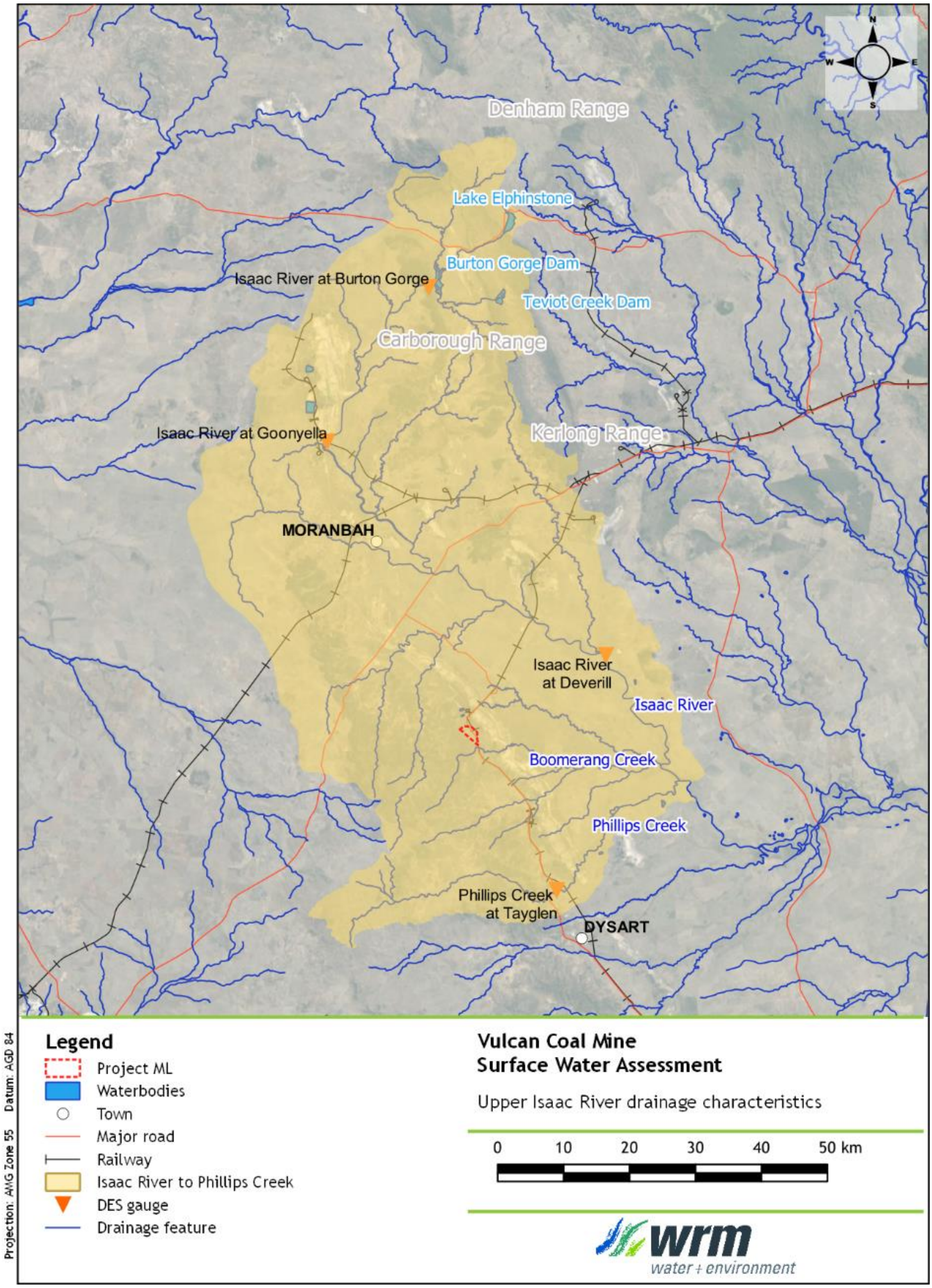


Figure 4.1 – Upper Isaac River drainage characteristics

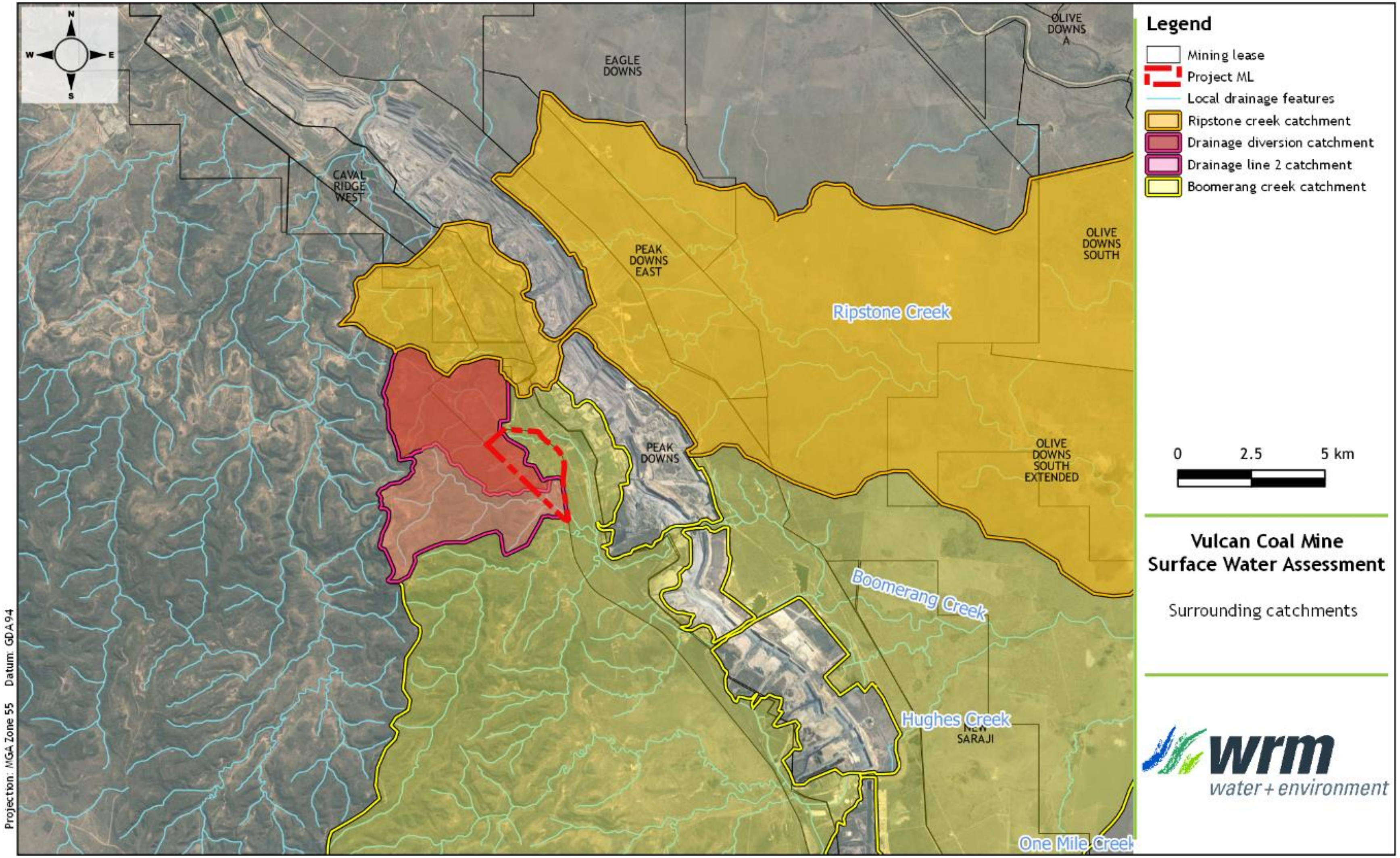


Figure 4.2 – Regional catchments in the vicinity of the Project

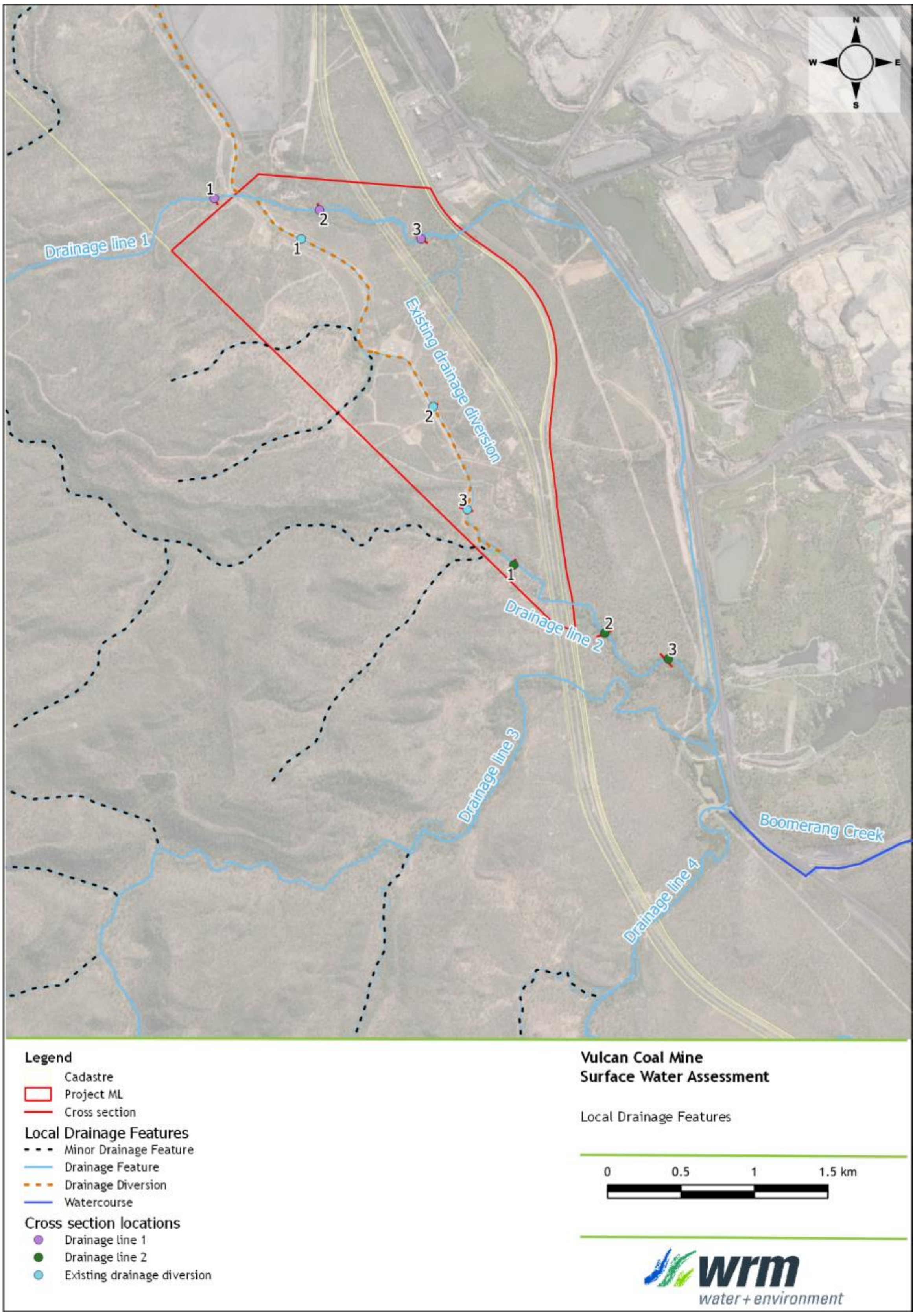


Figure 4.3 – Local drainage features in the vicinity of the Project

Figure 4.8 shows typical cross sections along the three local drainage features through the Project area at the locations shown in Figure 4.3.

4.2.1 Drainage Line 1

Drainage Line 1 drains the northern portion of the Project area to the east of the existing drainage diversion and includes the majority of the operational areas of the Project. Drainage Line 1 crosses the Saraji Road and the Norwich Park branch railway within the Project area before discharging into the Peak Downs Mine Lease (ML) downstream of the railway. Figure 4.4 and Figure 4.6 show photographs of Drainage Line 1 within the Project area and at the Railway culverts respectively.

Drainage Line 1 flows into an existing on-line water storage within the Peak Downs operations before eventually discharging into Drainage Line 2 approximately 1 km southeast of the Project boundary. Drainage Line 1 has been diverted and significantly modified within the Peak Downs ML.

The typical dimensions of the Drainage Line 1 channel through the Project area are (Figure 4.8):

- channel bed widths of 2 m to 5 m;
- channel top widths of 10 m to 25 m;
- channel depths 0.5 to 1 m; and
- overbank floodplain widths of 20 m to 50 m.

Drainage Line 1 will be diverted as part of the Project to allow access to the underlying coal. Drainage Line 1 will be reinstated by constructing a drainage corridor through backfilled spoil as shown in Figure 1.4. A new culvert crossing will be constructed under the realigned Saraji Road just upstream of the existing railway culverts.

Figure 4.4 – Photograph of Drainage Line 1 within the Project area

Figure 4.5 – Photograph of the existing railway culvert crossing of Drainage Line 1 at the eastern (downstream) Project boundary

4.2.2 Existing drainage diversion

An existing drainage diversion runs north-south along the length of the Project and flows into Drainage Line 2. Figure 4.6 shows a photograph of the existing drainage diversion and bund within the Project area. The existing drainage diversion appears to have been constructed in the 1970s to allow the construction of a Tailings Dam within the Peak Downs operations. The diversion flows in a south to southeast direction through the Project area and has a catchment area of approximately 16.0 km^2.

A levee is located along the majority of the existing drainage diversion and has an average height of 1 to 2 m and width of 5 to 10 m. The channel of the existing drainage diversion is located on the western side of the levee, with an average depth of 1 to 2 m and top width of 5 to 10 m (see cross section 1 and 2 in Figure 4.8). The channel width increases and deepens in the southern portion of the existing drainage diversion downstream of the levee (see cross section 3 in Figure 4.8).

The existing drainage diversion discharges into Drainage Line 2 within the Project area to the south of proposed operations. The Project will include upgrades to an existing crossing of the existing drainage diversion (which has been approved as part of the bulk sample). A second vehicle crossing will be included in this Project.

Figure 4.6 – Photograph of the existing drainage diversion and levee within the Project area

4.2.3 Drainage Line 2

Drainage Line 2 drains through the southeastern corner of the Project area and has a catchment area of approximately 30 km^2. Drainage Line 2 crosses the Saraji Road and the Norwich Park branch railway within the Project area before discharging into the Peak Downs ML downstream of the railway. Figure 4.7 shows a photograph of Drainage Line 1 within the Project area and at the Railway culverts respectively.

Drainage Line 1 flows into an existing on-line water storage within the Peak Downs operations before eventually discharging into Drainage Line 2 approximately 1 km southeast of the Project boundary. Drainage Line 2 has been diverted and significantly modified within the Peak Downs ML.

The typical dimensions of the Drainage Line 2 channel are:

- channel bed widths of 3 m to 5 m;
- channel top widths of 10 m to 30 m;
- channel depths 1 to 2 m; and
- overbank floodplain widths of 50 m to 150 m.

Drainage Line 2 will not be modified as part of the Project.

Figure 4.7 – Photograph of Drainage Line 2 within the Project area

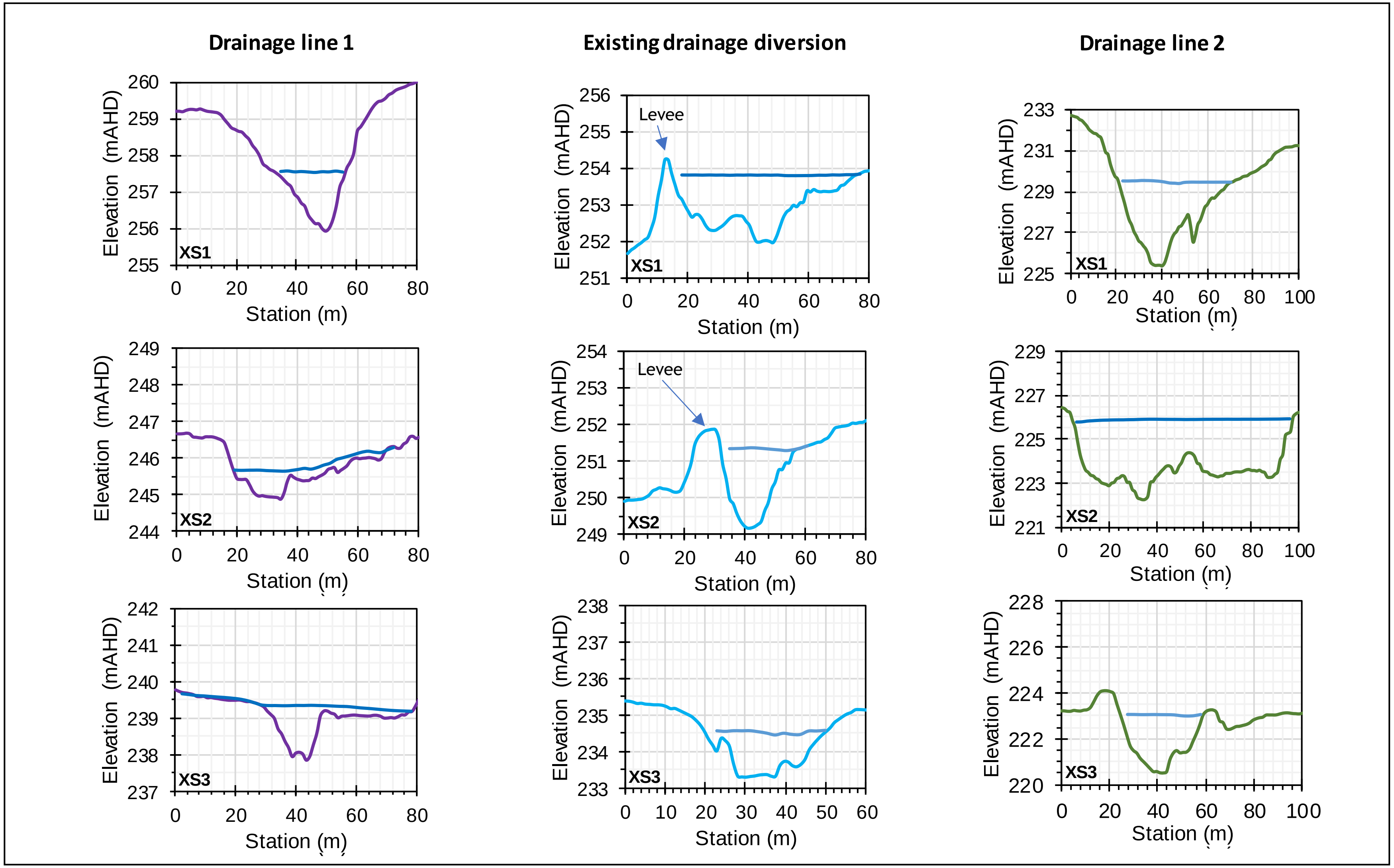


Figure 4.8 - Drainage line cross sections with 1% AEP flood levels

4.3 RAINFALL AND EVAPORATION

Long term rainfall and evaporation data at the Project is not available. Long term daily evaporation and rainfall data was sourced from the DES SILO climate data service at the approximate Project coordinates (Latitude: -22.35, Longitude: 148.2) from January 1889 to January 2019 (i.e. 130 years of data).

Table 4.1 shows statistics for Morton's lake evaporation and Table 4.2 shows statistics for rainfall (as mm/month and mm/year) over the historical dataset.

Figure 4.9 shows a comparison between the evaporation and rainfall. Evaporation rates are generally higher than rainfall throughout the year.

Table 4.1 - Evaporation (Morton's lake) statistics over the historical period (mm)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	240	204	201	152	118	94	103	142	171	215	222	239	1,967
90th %ile	224	190	186	144	109	88	97	125	160	199	214	229	1,891
Median	202	168	167	132	102	80	91	118	152	189	200	212	1,805
10th %ile	171	143	150	121	94	75	83	110	141	174	182	188	1,725
Min	120	122	127	94	76	59	77	97	121	160	121	145	1,506

Table 4.2 - Rainfall statistics over the historical period (mm)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	502	471	324	267	208	168	132	273	134	143	191	351	1254
90th %ile	209	221	160	70	66	74	61	61	48	88	100	150	882
Median	98	85	45	19	15	21	7	7	7	22	40	72	567
10th %ile	20	14	2	0	0	0	0	0	0	0	6	23	362
Min	0	0	0	0	0	0	0	0	0	0	0	2	221

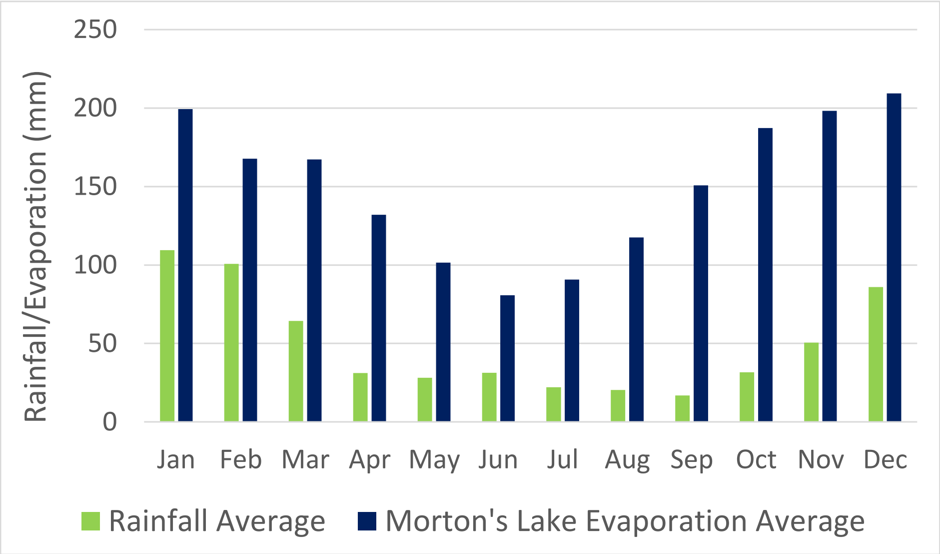


Figure 4.9 - Long term mean monthly rainfall and evaporation from SILO at the Project

4.4 STREAMFLOW

There is no stream flow data available for Boomerang Creek at the time of preparing this report. There are two streamflow gauges operated by the Department of Natural Resources, Mines and Energy (DNRME) in the vicinity of the Project including (see Figure 1.1):

- Isaac River at Deverill (approximately 25 km northeast of the Project); and
- Phillips Creek at Tayglen (approximately 30 km southeast of the Project).

The closest stream gauge is located on the Isaac River at Deverill (Station ID: 130410A). This gauge is located approximately 20 km upstream of where Boomerang Creek meets the Isaac River.

Historical flow and river height monitoring data (1968 to 2018) for the Isaac River at Deverill provides an indication of the flow regime (refer Figure 4.10). Surveyed cross section data for this gauging station collected in September 2014 (DNRME, 2017) indicates that sediment covers the bottom one metre of the gauge range. The mean river height data shown in Figure 4.10 suggests that surface flow above the sand is more likely to occur only in the wetter months from November to April, reducing to shallow subsurface flows from about May to October in an average year.

The Phillips Creek at Tayglen Creek streamflow gauge (Station ID: 130409A) is located on Phillips Creek. Phillips Creek is an easterly draining tributary of the Isaac River. DNRME maintains data for the gauge between 1968 and 1988. The catchment area to the gauge location is 344 km^2.

A typical sequence of recorded flows from this station is shown in Figure 4.11. The creek is characterised by brief periods of flow interspersed by long periods of no flow. This ephemeral behaviour is typical for streams in this part of the Fitzroy Basin.

The median annual flow over the period of record was approximately 12,730 ML/a (52 mm of runoff), most of which occurred in the summer months (as shown in Figure 4.12). Figure 4.13 compares flow frequency curves for a number of gauged catchments in the Isaac River catchment which are located in the vicinity of the Project. Figure 4.13 shows that for Phillips Creek at Tayglen, flow only occurred approximately 22% of the time, which would be similar to other creeks in the vicinity of the Project.

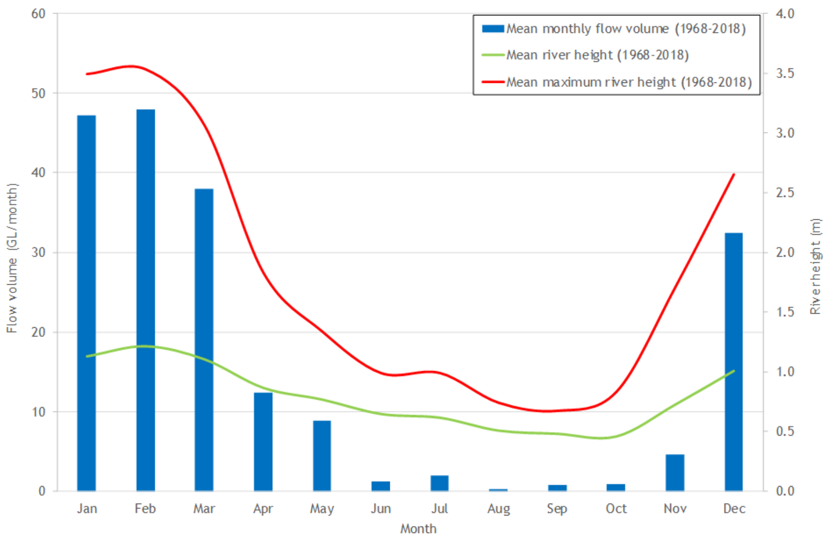


Figure 4.10 – Flow volume and river height in the Isaac River at Deverill

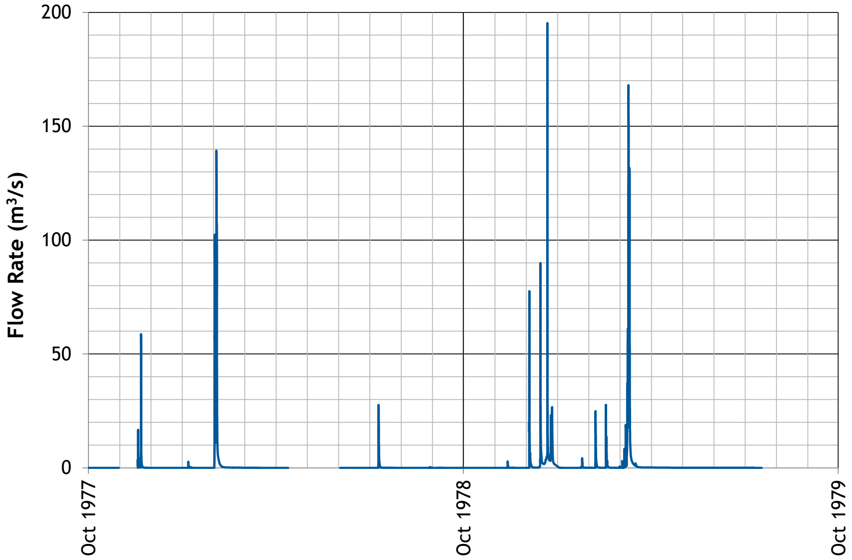


Figure 4.11 - Sample flow sequence - Phillips Creek at Tayglen 1977 - 1979

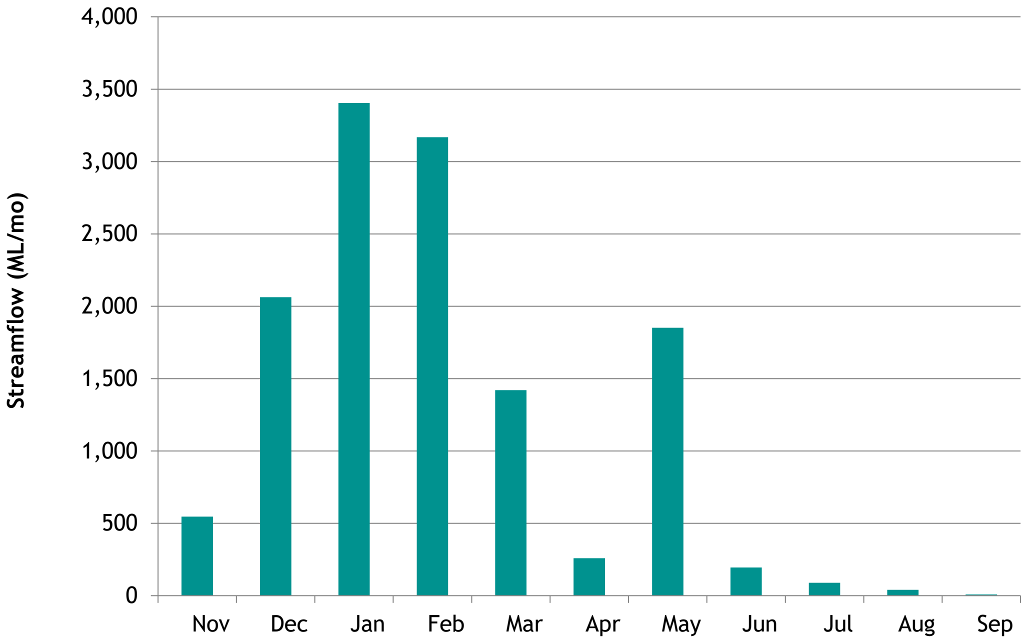


Figure 4.12 - Measured mean monthly streamflow - Phillips Creek at Tayglen 1968-1988

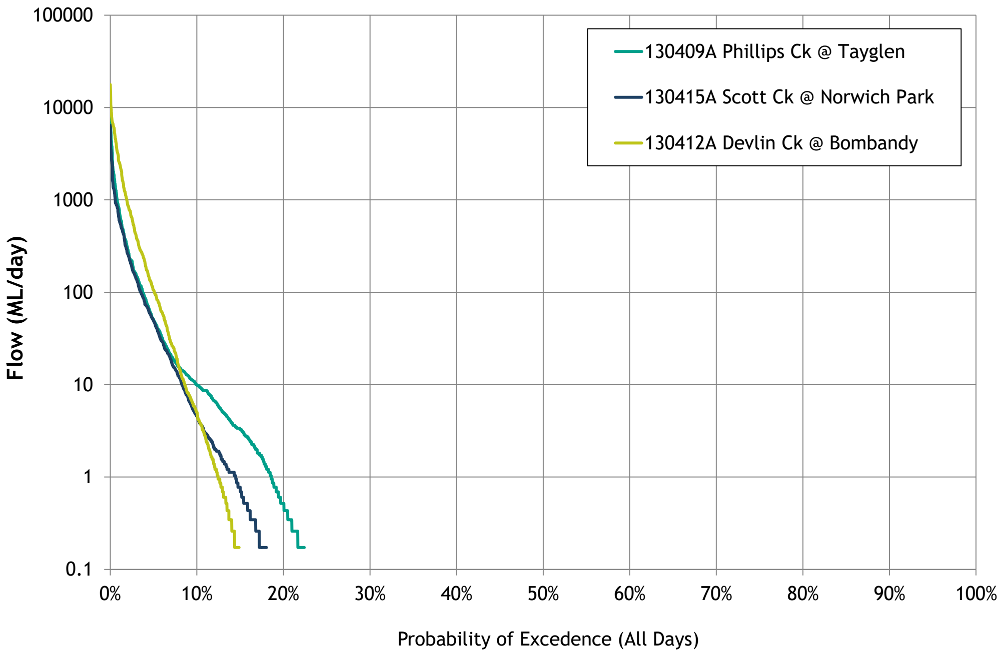


Figure 4.13 – Recorded frequency curves at nearby DNRME gauges (no flow days included)

4.5 WATER QUALITY

4.5.1 Regional Isaac River water quality

Publicly available regional water quality data for the Isaac River at the Deverill Gauging Station has been analysed for median results and are displayed in Table 4.3. This site was selected as complete datasets (i.e. individual sample analysis results) are publicly available, as opposed to summary data only.

DNRME has collected daily electrical conductivity (EC) data at the Isaac River at Deverill gauge. The Deverill gauge is located upstream of the point where Boomerang Creek drains into the Isaac River. The gauge would therefore be representative of water quality in the receiving waters of the Isaac River from the Project.

Figure 4.14 presents a time history of recorded instantaneous EC and stream flow for the Isaac River at Deverill gauging station. Figure 4.15 details the relationship between instantaneous flow and EC at the Isaac River at Deverill gauging station. The data collected by DNRME at the Deverill gauging station spans the period from 2011 to 2018 and indicates:

- The EC values for high flows greater than 200 m^3/s are generally below the high flow WQO EC of 250 µs/cm;
- The EC of instantaneous flows below 100 m^3/s vary significantly from 50 µS/cm to 1,870 µS/cm with many recorded values exceeding the low flow WQO EC of 720 µS/cm but are below the Peak Downs EA receiving waters trigger value of 2000 µS/cm;
- The mean daily EC has exceeded the low flow WQO on a total of 23 days over this period and all of these days experienced some flow (not stagnant flow); and
- The stream flows are highly ephemeral with baseflows ceasing within a few days or weeks of a runoff event, or at least flowing below the top of the sandy bed.

Table 4.3 – Water quality median data in the Isaac River at Deverill

Parameter	Unit	Isaac River at Deverill	WQO default guideline value (refer Table 3.1)
Aluminium - Total	mg/L	-	< 5 (stock)
Aluminium - Dissolved	mg/L	0.05	< 0.055 (aquatic)
Boron - Total	mg/L	0.06	< 5 (stock)
Calcium - Dissolved	mg/L	16	-
Chloride - Total	mg/L	32	-
Copper - Dissolved	mg/L	0.03	< 0.0014 (aquatic)
EC	µS/cm	261	< 720 (baseflow) < 250 (high flow)
Filterable Reactive Phosphorus	µg/L	0.35	< 20 (aquatic)
Fluoride - Total	mg/L	0.14	< 2 (irrigation)
Iron - Dissolved	mg/L	0.06	-
Manganese - Dissolved	mg/L	0.01	< 1.9 (aquatic)
Nitrate - Total	mg/L	1.4	-
Nitrogen – Total	µg/L	0.76	< 500 (aquatic)
pH	-	7.6	pH 6.5–8.5 (aquatic)
Phosphorus - Total	µg/L	0.35	< 50 (aquatic)
Potassium - Total	mg/L	4.55	-
Sodium - Total	mg/L	22	< 30 (drinking water)
Sulfate - Total	mg/L	10.9	< 25 (aquatic)
Total Alkalinity	mg/L	78	-
Total Dissolved Solids	mg/L	155	< 2,000 (stock)
Total Suspended Solids	mg/L	135	< 55 (aquatic)
Turbidity	NTU	247	< 50 (aquatic)
Zinc - Dissolved	mg/L	0.01	< 0.008 (aquatic)

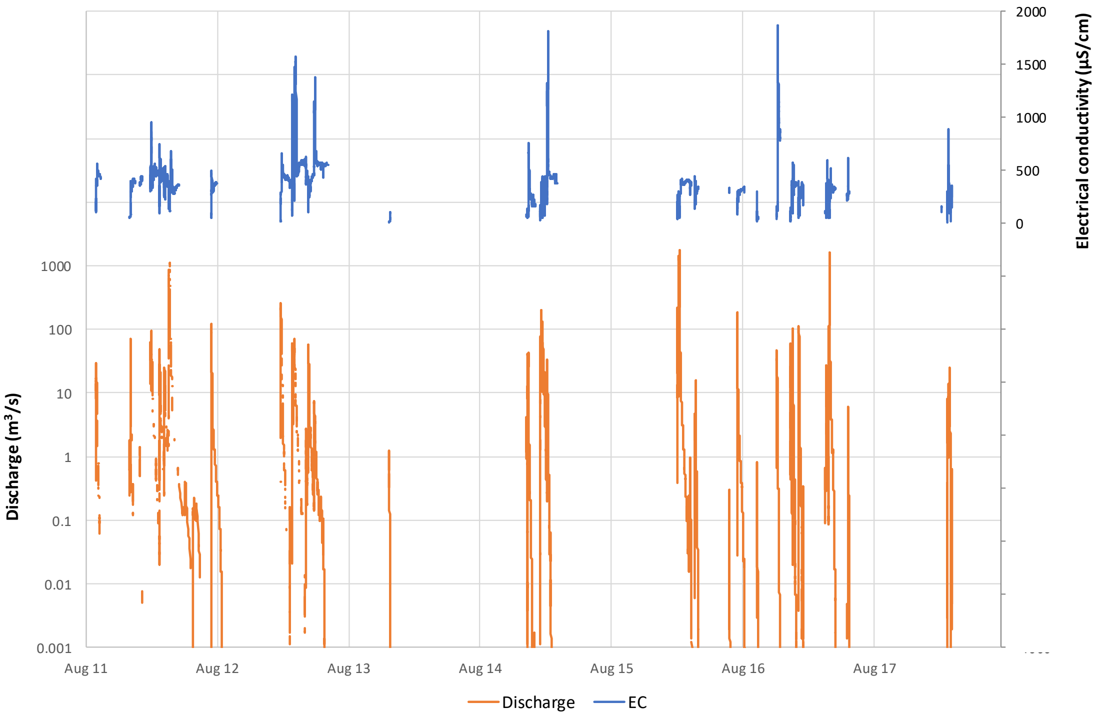


Figure 4.14 - Electrical Conductivity and Flow (Isaac River at Deverill Gauge)

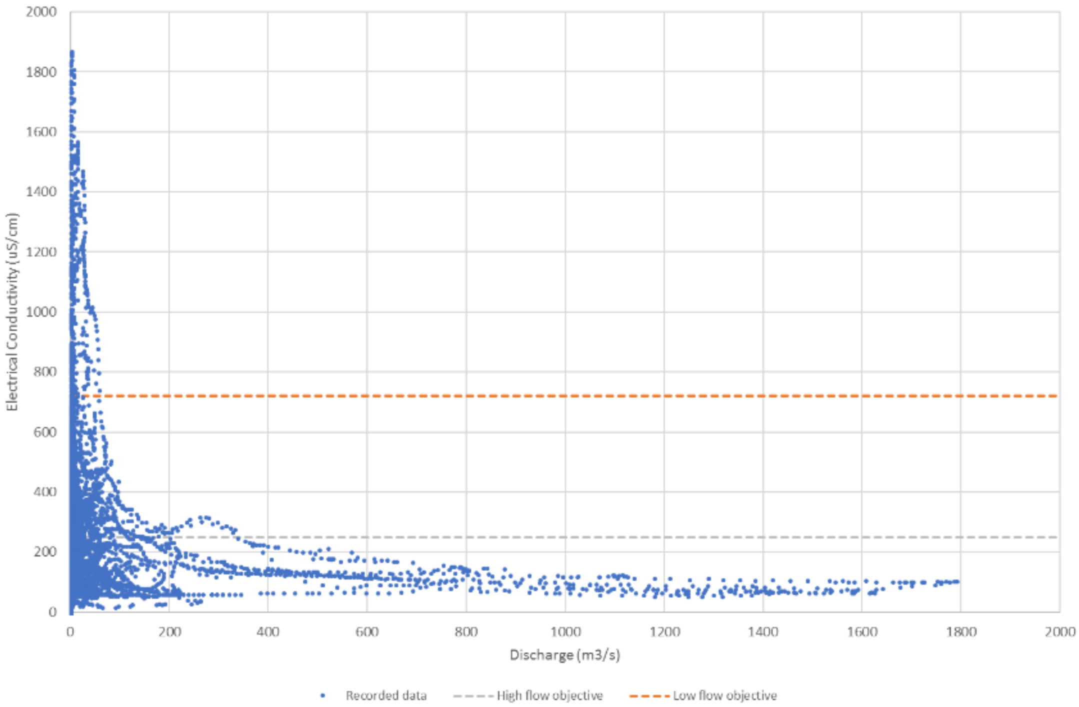


Figure 4.15 - Flow vs Electrical Conductivity (Isaac River at Deverill Gauge)

4.5.2 Local water quality

Water quality sampling was undertaken as a component of the baseline surface water quality sampling in February 2020. Analyses for a range of physico-chemical parameters were completed at sites VSW1, VSW2 and VSW3 (refer Table 4.4 for details and Figure 4.16 for receiving water monitoring locations).

Table 4.4 shows that certain baseline water quality values surrounding the Project do not meet the WQO for the region, these include:

- Electrical conductivity;
- Turbidity;
- Total hardness as CaCO3;
- Sulfate as SO4;
- Sodium;
- Ammonia as N;
- Nitrogen (total);
- Phosphorous (total);
- Dissolved Oxygen;
- Aluminium (filtered);
- Copper (filtered);
- Manganese (filtered); and
- Zinc (total).

Similar to the regional water quality data presented in Section 4.5.1, the local water quality data suggests that a number of parameters may exceed the WQOs. However, it is acknowledged that this is based on only one water quality sampling event.

To establish local water quality objectives, the QWQG require that with 3 or more reference sites, 12 samples are collected over at least 12, but preferably 24 months. Vitrinite has established more than 3 reference sites, which will continue to be either upstream reference sites or reference sites until mining commences. However, data collection is limited to periods of flow in an ephemeral system. Therefore, reliance is placed on regional water quality data to establish water quality objectives until there is sufficient data to develop local water quality objectives.

Table 4.4 – Baseline water quality monitoring

Parameter	Unit	VSW-1 Feb-20	VSW-2 Feb-20	VSW-3 Feb-20	WQO (see Table 3.1
pH Value	-	7.42	6.74	6.54	6.5 - 8.5 (Aquatic ecosystem)
Sodium Adsorption Ratio	-	6.64	2.92	1.69	-
Electrical Conductivity	µS/cm	1400	310	184	< 720 (baseflow) < 250 (high flow) (Aquatic ecosystem)
Total Dissolved Solids (Calc.)	mg/L	910	202	120	< 2,000 (Stock)
Suspended Solids (SS)	mg/L	10	55	20	< 55 (Aquatic ecosystem)
Turbidity	NTU	42.9	221	90.8	< 50 (Aquatic ecosystem)
Total Hardness as CaCO3	mg/L	191	37	26	< 150 (Drinking water)

Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	-
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	-
Bicarbonate Alkalinity as CaCO3	mg/L	63	12	4	-
Total Alkalinity as CaCO3	mg/L	63	12	4	-
Sulfate as SO4 - Turbidimetric	mg/L	212	40	19	< 25 (Aquatic ecosystem)
Chloride	mg/L	275	54	34	-
Calcium	mg/L	27	5	4	-
Magnesium	mg/L	30	6	4	-
Sodium	mg/L	211	41	20	< 30 (Drinking water)
Potassium	mg/L	8	7	7	-
Fluoride	mg/L	<1.0	0.1	<0.1	< 2 (Irrigation)
Ammonia as N	mg/L	0.05	0.1	<0.01	< 0.02 (Aquatic ecosystem)
Nitrite as N	mg/L	0.03	0.01	<0.01	-
Nitrate as N	mg/L	1.7	1.57	1.19	-
Nitrite + Nitrate as N	mg/L	1.73	1.58	1.19	-
Total Kjeldahl Nitrogen as N	mg/L	1.6	1.3	0.9	-
Total Nitrogen as N	mg/L	3.3	2.9	2.1	< 0.5 (Aquatic ecosystem)
Total Phosphorus as P	mg/L	0.04	0.09	0.05	< 0.05 (Aquatic ecosystem)
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	< 0.02
Total Anions	meq/L	13.4	2.6	1.43	-
Total Cations	meq/L	13.2	2.7	1.58	-
Ionic Balance	%	0.87	----	----	-
Chlorophyll a	mg/m^3	<4	<4	<4	-
Dissolved Oxygen	mg/L	6.7	7.3	7.3	> 4 (Drinking water)
			Dissolved Metals		
Aluminium	mg/L	0.11	0.45	0.39	< 0.055 (Aquatic ecosystem)
Arsenic	mg/L	0.001	<0.001	<0.001	< 0.024 (Aquatic ecosystem)
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	< 0.0002 (Aquatic ecosystem)
Chromium	mg/L	<0.001	<0.001	<0.001	< 0.001 (Aquatic ecosystem)
Cobalt	mg/L	<0.001	<0.001	<0.001	-
Copper	mg/L	0.003	0.001	0.002	< 0.0014 (Aquatic ecosystem)
Lead	mg/L	<0.001	<0.001	<0.001	< 0.0034 (Aquatic ecosystem)
Manganese	mg/L	0.039	0.019	0.015	< 1.9 (Aquatic ecosystem)
Molybdenum	mg/L	<0.001	<0.001	<0.001	-
Nickel	mg/L	0.002	0.002	0.002	< 0.011 (Aquatic ecosystem)
Selenium	mg/L	<0.01	<0.01	<0.01	< 0.005 (Aquatic ecosystem)

Silver	mg/L	<0.001	<0.001	<0.001	-
Uranium	mg/L	<0.001	<0.001	<0.001	< 0.1 (Irrigation)
Vanadium	mg/L	<0.01	<0.01	<0.01	< 0.5 (Irrigation)
Zinc	mg/L	0.024	<0.005	0.024	< 0.008 (Aquatic ecosystem)
Boron	mg/L	0.09	<0.05	<0.05	< 0.37 (Aquatic ecosystem)
Iron	mg/L	0.2	0.35	0.35	-
Mercury	mg/L	<0.0001	<0.0001	<0.0001	< 0.00006 (Aquatic ecosystem)
			Total Metals		
Aluminium	mg/L	0.89	3.38	1.56	< 5 (Stock)
Arsenic	mg/L	0.001	0.002	0.001	< 0.5 (Stock)
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	< 0.01 (Stock)
Chromium	mg/L	<0.001	0.002	0.001	< 1 (Stock)
Cobalt	mg/L	<0.001	0.001	<0.001	-
Copper	mg/L	0.004	0.004	0.002	< 1 (Stock)
Lead	mg/L	<0.001	0.004	0.002	< 0.1 (Stock)
Manganese	mg/L	0.042	0.034	0.024	< 10 (Irrigation)
Molybdenum	mg/L	0.001	<0.001	<0.001	< 0.05 (Irrigation)
Nickel	mg/L	0.002	0.004	0.003	< 1 (Stock)
Selenium	mg/L	<0.01	<0.01	<0.01	< 0.02 (Stock)
Silver	mg/L	<0.001	<0.001	<0.001	-
Uranium	mg/L	<0.001	<0.001	<0.001	-
Vanadium	mg/L	<0.01	<0.01	<0.01	-
Zinc	mg/L	0.031	0.017	0.029	< 5 (Irrigation)
Boron	mg/L	0.06	<0.05	<0.05	< 5 (Stock)
Iron	mg/L	0.79	3.26	1.62	< 10 (Irrigation)
Mercury	mg/L	<0.0001	<0.0001	<0.0001	< 0.002 (Irrigation)

Note: Recorded exceedances of the WQOs have been shaded in grey.

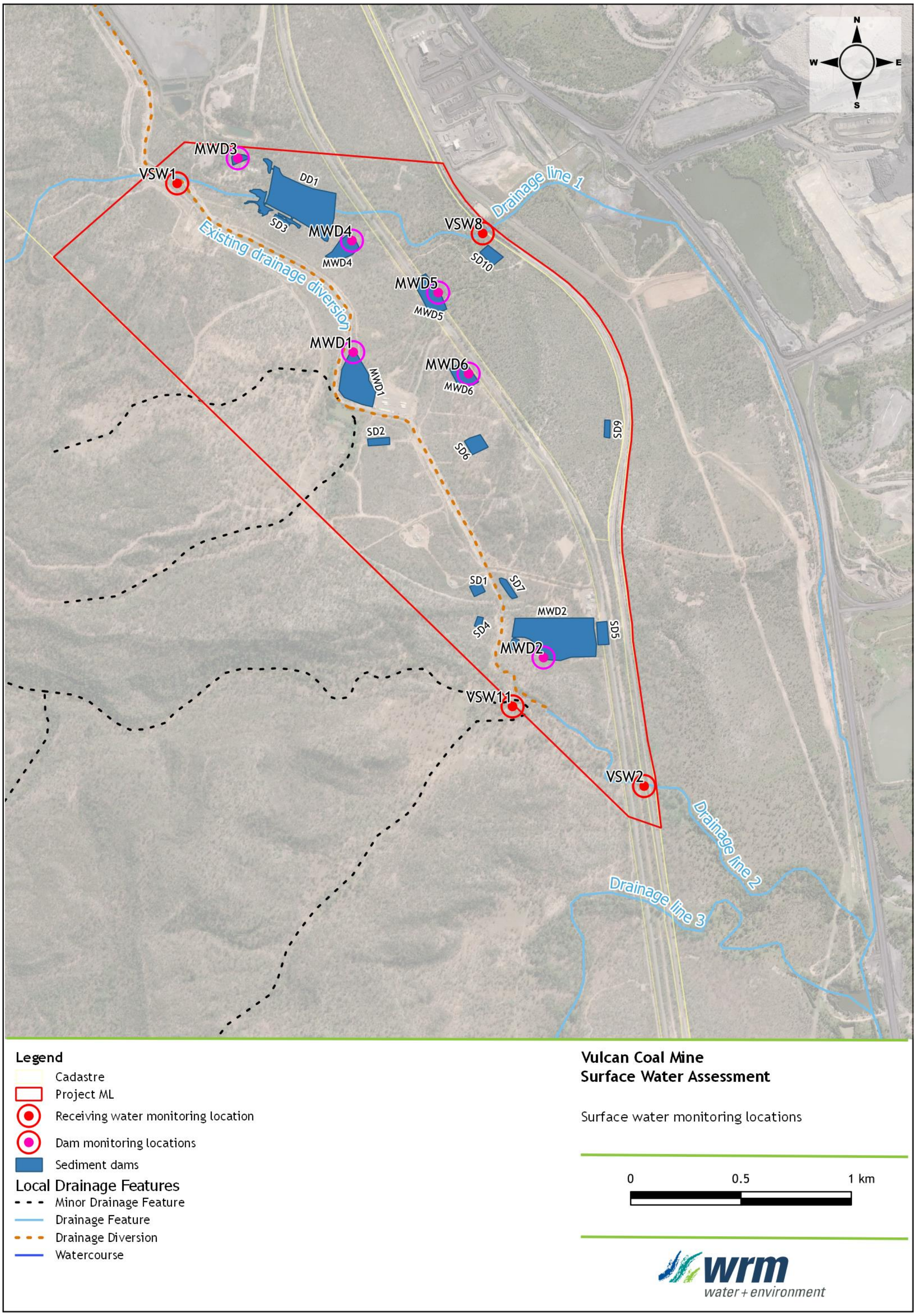


Figure 4.16 - Water monitoring locations

4.6 SOIL CHARACTERISTICS

AARC Environmental Solutions Pty Ltd (2019) completed a *Soil and Land Suitability Assessment* (SLSA) for the Project and surrounds. To characterise the soils at the site, AARC collected 42 detailed soil profiles and analysed 12 laboratory samples from the site and surrounds.

The area surrounding the Project is dominated by clastic sedimentary rocks of marine and lacustrine origin, including sandstones, mudstones, siltstones and coal. Surface geology at the site includes Quaternary clay, silt, sand, gravel and soil with colluvial and residual deposits, as well as late Tertiary to Quaternary poorly consolidated sand, silt, clay, minor gravel and high-level alluvial deposits (AARC, 2019).

4.6.1 Soil management units

AARC mapped the Soil Management Units (SMUs) across the site using the methodologies specified in the *Guidelines for Surveying Soil and Land Resources* (McKenzie et al, 2008) based on soil morphology, parent material and land attributes.

A description of each SMU found within the Project area is outlined in Table 4.5. The majority of the site consists of the Limpopo SMU, with a small southern portion of the Project site consisting of Crocodile and Zambezi SMUs.

Table 4.5 – Soil Management Units surveyed on site (AARC, 2019)

Soil Management Unit	Description
Crocodile	A shallow rocky soil unit associated with hill slopes and plateaus. Soil textures grade from loam at the surface, to loamy sands with depth; often containing rock material with little to no pedologic development throughout the solum.
Limpopo	The Limpopo unit is a brown texture-contrast soil. Soil textures predominantly grade from sands to clay sands in the surface soils to light clays in deeper horizons.
Zambezi	A predominantly grey coloured texture contrast soil with surface soils consisting of sands, increasing in clay content in deeper horizons. Lower horizons display diffuse orange to yellow mottles.

4.6.2 Sodic and dispersive soils

Sodic soils contain large concentrations of Sodium relative to other cations. These soils have a degree of dispersivity and can accelerate erosion.

AARC identified areas of high sodicity on site through the measurement of the Exchangeable sodium percentage and Emerson Class of surveyed soils. The Crocodile SMU was identified as having a low risk of dispersion and was not identified as being sodic.

For the remaining SMUs, AARC (2019) identified the depth horizons with sodic properties as follows:

- Limpopo SMU: Sodic below a depth of 0.5 m; and
- Zambezi SMU: Sodic below a depth of 0.5 m.

To control erosion from sodic dispersive soils, soils will be selectively handled and managed accordingly.

5 Proposed surface water management strategy and infrastructure

5.1 TYPES OF WATER GENERATED ONSITE

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff. The proposed strategy for the management of surface water at the Project is based on the separation of water from different sources based on anticipated water quality.

Definitions of the types of water generated within the Project are shown in Table 5.1.

5.2 PROPOSED WATER MANAGEMENT INFRASTRUCTURE

The operational period of mining is expected to run for four years from 2021 to 2024.

Figure 1.2 and Figure 1.3 show indicative locations of the key features of the mine, including infrastructure related to the management of water on the Project site for two different stages of mining (Stages 1 and 2). The main components of water-related infrastructure include:

- diverted water drains to divert runoff from undisturbed catchments around areas disturbed by mining;
- a flood protection levee along the western side of the proposed Jupiter pit that may be formed by a haul road embankment;
- sediment dams and drains to collect and treat runoff from waste rock emplacement areas;
- mine-affected water drains and dams to store water pumped out of the open cut mining areas and to collect runoff from the infrastructure areas;
- culverts to convey flows through the proposed rail loop and haul road crossings of the existing drainage diversion; and
- minor works to the existing BMA levee (and spillway) and existing drainage diversion in the vicinity of the haul road crossings.

The catchment areas of each of the mine water storages, as well as the assumed landuse contributing to each catchment are also shown in Figure 1.2 and Figure 1.3. Details of proposed water storages, including indicative storage sizes and pumping rules are provided in Section 6.4.

5.3 WATER MANAGEMENT STRATEGY OVERVIEW

The water management system for the Project aims to protect the identified downstream EVs and comprises the following key objectives:

- separate diverted water from mine affected water to ensure that up-catchment water and mine affected water do not mix wherever practicable;
- capture of mine affected runoff (e.g. mine industrial area, haul road/ROM pad runoff), storage and priority reuse as mine water supply;
- divert up-catchment water runoff from upstream catchments around the active mining area;

- limit external catchment runoff draining into pits;
- manage sediment from disturbed catchment areas (e.g. out-of-pit waste rock emplacements, cleared/pre-strip areas) by using erosion and sediment control (ESC) measures prior to release offsite;
- reuse onsite water (e.g. mine affected water) where possible to support mine operational water demands (and therefore limit mine affected water inventories under normal operating conditions); and
- manage any mine affected water releases to the receiving environment to meet environmental release conditions (not currently proposed).

The Project water management system will include mine water drainage, mine water storages, sediment dams, pit water storages and flood protection works (i.e. levees). Further details of the mine water management system are provided in Section 6.4.

Table 5.1 - Types of water managed within the Project

Water type	Definition
Mine affected water	In accordance with the DES *Guideline Model Mining Conditions* (2017), mine affected water means the following types of water: i) pit water, tailings dam water, processing plant water; ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the *Environmental Protection Regulation 2008* if it had not formed part of the mining activity; iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water; iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated; v) groundwater from the mine dewatering activities; and vi) a mix of mine affected water (under any of paragraphs i to v) and other water.
Surface water	Surface water runoff from areas that are disturbed by mining operations (including out-of-pit waste rock emplacements). This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads but does not contain elevated levels of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff must be managed to ensure adequate sediment removal prior to release to receiving waters.
Diverted water	Surface runoff from areas unaffected by mining operations. Diverted catchment water includes runoff from undisturbed areas and fully rehabilitated areas.
Raw water	Untreated water that has not been contaminated by mining activities.
Potable water	Treated water suitable for human consumption.
External water	Water supplied from a source that is external to Project area to make up water shortfalls for onsite water demands when site water sources cannot meet demand.

5.4 DIVERTED RUNOFF WATER MANAGEMENT

5.4.1 Flood protection levee

A flood levee is proposed along the western edge of the proposed mining operations to protect the site from potential floodwater that overflows from the existing drainage diversion. Part of the proposed flood levee may be formed by a haul road that will be located around the western side of the pit. The location of the proposed flood levee is shown in Figure 1.2 and Figure 1.3.

It is proposed to cross BMA's existing drainage diversion and associated levee to the west of the Jupiter Pit (shown in Figure 1.2 and Figure 1.3). Under existing conditions, BMA's existing drainage diversion and levee is overtopped during large flood events. Minor modifications to BMA's existing drainage diversion and associated levee will be undertaken to maintain the existing flow characteristics in the vicinity of the haul road crossings.

The levee will be a regulated structure under the EP Act and will therefore be required to have a crest above the 0.1% annual exceedance probability (AEP) event. An assessment of the levee against the requirements of the EP Act is given in Section 8.6.9.

5.4.2 Diverted water drains and dams

The water management system has been designed to divert undisturbed catchments around mining operations wherever practicable. The key features of the site diverted water management are:

- DD1 (operational in Stage 2) – a diverted water dam, located adjacent to the pit, which has been designed to provide the pit with flood immunity during a 0.1% AEP rainfall event. DD1 has a spillway at 247.0 mAHD located on the northern side of the dam. A pump transfers water which collects in DD1 to the existing drainage diversion. The dam will only collect direct rainfall and flood runoff which overtops the existing drainage diversion during flood events.
- MIA area diverted water bunds (operational in Stages 1 and 2) – diverted water bunds located around the northern side of the northern workshop area and the southern side of the workshop area. The northern bund diverts runoff from the catchment area to the north of the workshop to the east. The southern bund diverts runoff overflowing the haul road floodway to DD1.
- Northern diverted water drains (operational in Stage 2) - a diversion drain which has been designed to divert water around the northern side of the pit. This drain collects the undisturbed catchment to the north of the pit, as well as any overflows from DD1.
- Southern diversion drains (operational in Stages 1 and 2) – two drains on the western side of the out of pit emplacement and rail loop which will drain the undisturbed catchment to the west of the mining area around the out of pit spoil dump and toward the existing drainage diversion, which drains to the receiving waters.

DD1 will be constructed in Stage 2 to collect water from an undisturbed catchment (catchment area of approx. 56.8 ha) adjacent to the Jupiter pit. In addition, DD1 may potentially provide some level of flood protection for the Jupiter pit during the final year of operations.

Temporary drainage management measures including bunds, drains and re-contouring to the north of the pit progression may be constructed as required to prevent runoff and flood waters from flowing into the Jupiter pit. Note that these drainage management measures will be mined through as the Jupiter pit progresses to the north and may be implemented to delay the requirement for DD1. It is expected that temporary drainage measures will be designed to convey at least a 5% AEP (1 in 20-year ARI) flow event.

5.5 SURFACE WATER MANAGEMENT

The following areas of the site have been defined as surface water catchments, consistent with the Guideline Model Mining Conditions (DES, 2017) definitions (see Figure 1.2, Figure 1.3 and Figure 1.4):

- the ex-pit waste rock dump – the runoff from this dump is not expected to come into contact with coal or other carbonaceous materials. This runoff may contain high sediment loads but is not expected to contain elevated levels of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff will be managed to ensure adequate sediment removal prior to release to receiving waters. Consistent with DES (2017), this runoff is classified as surface water as it will drain to sediment dams installed in accordance with an Erosion and Sediment Control Plan and it will not be mixed with pit water, tailings water, processing plant or workshop water;
- topsoil stockpiles – this runoff has the potential to have a high sediment load but will not come into contact with coal or other carbonaceous material;
- the south-eastern portion of the northern mine infrastructure area (reporting to the sediment trap) - this area includes a warehouse, carpark and site offices. The runoff from this area is therefore expected to be relatively benign and will not come into contact with coal; and
- northern mine access road (reporting to SD3) – this road will link the northern mine infrastructure area with the ROM Pad. This road is not expected to have trucks carrying ROM coal as the main internal haulage for the site will be undertaken on haul roads between the pit and southern infrastructure area (to transport coal from the pits to the stockpiles).

The above areas all drain to sediment dams (via overland flow and surface water drains) which will be installed in accordance with an Erosion and Sediment Control Plan. The ESCP will adopt the three cornerstones of erosion and sediment control:

- Drainage control – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of diverted and surface water through the area of concern.
- Erosion control – prevention or minimisation of soil erosion (from dispersive, nondispersive or competent material) caused by rain drop impact and exacerbated overland flow on disturbed surfaces.
- Sediment control – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion) or from windborne particles.

The Project will require a combination of the three control measures to effectively manage sediment and erosion at the site.

5.5.1 Sediment dam locations and sizing

Catchment runoff from both active and newly rehabilitated overburden dumps at the Project will be managed in accordance with an ESCP. The sediment dams have been sized in accordance with the IECA method (IECA, 2008), and have been based on the following design standards and methodology:

- ‘Type D’ sediment basins with a depth of 3m;
- total sediment basin volume = settling zone + sediment storage volume. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone is the minimum required free storage capacity that must be restored within 5 days after a runoff event;

- sediment basin settling volume based on 85th percentile 5-day duration rainfall with an adopted volumetric event runoff coefficient for disturbed catchments of 0.45 (Group C soils – loamy clay); and
- solids storage volume = 50% of settling zone volume.

The adopted design standard does not provide 100% containment for runoff from disturbed areas. Hence, it is possible that overflows will occur from sediment dams several times during a wet season if rainfall exceeds the design standard.

A summary of the conceptual sediment dam capacities and surface areas (based on a depth of 3 m) is provided in Table 5.2.

Table 5.2 - Proposed sediment dams

Storage name	Latitude	Longitude	Max. catchment area (ha)	Total volume required (ML)	Dam surface area (ha)	5-day dewatering rate (ML/d)	Sediment dam water source	Receiving waters description
SD1	-22.29316	148.18773	19.5	4.3	0.19	6.6	Out of pit spoil dump	Drainage line 2 via the existing drainage diversion
SD2	-22.28714	148.18329	8.3	1.8	0.08	2.8	Out of pit spoil dump	
SD3	-22.27815	148.17893	12.7	2.8	0.12	4.3	Northern mine access road	Drainage line 1
SD4	-22.29451	148.18781	5.0	1.1	0.05	1.7	Topsoil stockpile south of the out of pit spoil dump	Drainage line 2 via the existing diversion drain
SD5	-22.29490	148.19300	8.5	1.9	0.08	2.9	In pit spoil dump	Drainage line 2
SD6	-22.28710	148.18810	24.6	5.4	0.24	8.3	In pit spoil dump	Drainage line 2 via the existing diversion drain
SD7	-22.29309	148.18911	14.9	3.3	0.14	5.0	In pit spoil dump and topsoil stockpile	
SD8	-22.29542	148.18936	8.8	1.9	0.09	3.0	In pit spoil dump and topsoil stockpile	
SD9	-22.28652	148.19337	3.5	0.8	0.03	1.2	In pit spoil dump	Drainage line 1
SD10	-22.27970	148.1881	31.3	6.9	0.31	10.6	In pit spoil dump	
SD11	-22.27810	148.18280	52.7	11.6	0.51	17.8	In pit spoil dump, topsoil stockpiles and mine access road	Drainage line 1 via the final landform drain
SD12	-22.27728	148.18213	5.7	1.3	0.06	1.9	In pit spoil dump	

5.5.2 Haul road and access road sediment management

Runoff from haul roads and access roads will be managed through the site's Erosion and Sediment Control (ESC) Plan, which will be developed prior to the commencement of construction activities.

Management of runoff from these roads will be a combination of drainage control, erosion control and sediment control measures. The design of the measures will be undertaken during detailed design, but will likely include some of the following measures:

- Catch drains;
- Check dams;
- Grass swales;
- Rock lining/protection;
- Road surface gravelling;
- Sediment traps; and
- Sediment basins.

The sizing of haul/access road sediment basins will be undertaken in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008). Any runoff captured within the sediment basins will be released to the downstream environment in accordance with the site ESCP or pumped back into the mine water system.

5.6 MINE AFFECTED WATER MANAGEMENT

5.6.1 Mine affected water dams

Table 5.3 shows the mine affected dam details for the Project, including the full supply volume (FSV) of each dam and the operating rules for each dam which are applied if the operating volume (OV) is exceeded.

The following areas of the site have been defined as mine water catchments, consistent with the definitions provided in the Guideline Model Mining Conditions (DES, 2017) (see Figure 1.2, Figure 1.3 and Figure 1.4):

- the pit;
- the southern mine infrastructure area – this area contains a number of coal stockpiles and the sorter/crusher and therefore will come into contact with coal;
- the north-western section of the northern mine area (reporting to MWD3) – this area will contain a maintenance workshop, tyre fitting bay and wash bay;
- the proposed CHPP product pad area (reporting to MWD4);
- the proposed CHPP area (reporting to MWD5); and
- the proposed ROM pad area (reporting to MWD6).

The above areas all drain to mine water dams (via overland flow and mine water drains) or to the pit itself. The dams sizes have been determined based on the water balance model (see Section 7) to ensure that the Jupiter pit can be adequately dewatered and limit the spill risk to the receiving waters.

The adopted full storage volumes (FSVs), surface areas and operating volumes (OVs) were refined using the water balance model and available space from site mapping. MWD1 has been designed to keep the pit dewatered for as long as practical. The remaining mine water dams have been sized to limit the risk of spills to the receiving waters.

To limit the risk of uncontrolled discharges from the mine water storages, OVs have been set for these water storages (as shown in Table 5.3) as follows:

- MWD1 has an operating volume (OV) of 73 ML. When the water inventory in MWD1 exceeds its OV, all transfers to MWD1 (i.e. pit dewatering and mine water transfers) cease; and
- MWD2, MWD3, MWD4, MWD5 and MWD6 have OVs. When the water inventory in these dams exceeds their respective OVs, these storages commence dewatering to MWD1.

Table 5.3 - Proposed mine affected water dams

Storage	FSV (ML)	OV (ML)	FSV surface area (ha)	FSV water depth (m)	Adopted dewatering rate (ML/d)	Operating rules
MWD1	107.4	73.0	2.42	9.0	1.0	Above the OV, pit dewatering and MWD3 to MWD6 dewatering to MWD1 ceases. In addition, during Stage 2, MWD1 commences dewatering to MWD2. If near FSV it will pump to the Jupiter Pit.
MWD2	321.2	300.0	6.35	5.0	1.0	Above the OV, pit dewatering to MWD2 ceases. If near FSV it will pump to the Jupiter Pit.
MWD3	5.4	1.1	0.23	5.0	1.0	Above the OV, MWD3 commences dewatering to MWD1
MWD4	22.0	16.4	0.59	5.0	4.4	Above the OV, MWD4 commences dewatering to MWD1
MWD5	52.0	38.9	1.39	5.0	10.4	Above the OV, MWD5 commences dewatering to MWD1
MWD6	34.7	25.9	0.93	5.0	7.0	Above the OV, MWD6 commences dewatering to MWD1

5.6.2 Preliminary consequence assessment

A preliminary consequence assessment of the mine affected water dams using the *Manual for assessing consequence categories and hydraulic performance of structures* (DES, 2016) suggests that the consequence category of mine water dams will be low. This is based on the following:

- The expected harm to humans consequence category is low. The expected population at risk is zero given that most of the mine affected water dams are constructed downstream of any mine infrastructure areas and in the event of failure, would spill to the pit via constructed drains. The proposed MWD locations are not adjacent to any planned buildings (except for MWD3 which is small), other places of occupation or public infrastructure (e.g., roads or rail) that would lie within the failure impact zone. The downstream receiving waters are unlikely to be used for water supply;
- The expected harm to general environment consequence category is low. The downstream receiving waters are heavily modified and have been diverted through the Peak Downs operations. Controlled releases of mine water are not proposed. Further, groundwater assessments predict there will negligible groundwater to manage in the mine water management system. The CHPP mine water runoff will be managed by MWD4, MWD5 and MWD6. Dump runoff quality is expected to be of a suitable quality to release to the receiving waters (following sediment removal). Hence any potential releases of contaminants to the receiving waters from mine water dams are unlikely to have an adverse effect; and
- The expected general economic loss or property damage consequence category is low. This is for similar reasons given for the expected harm to humans consequence category and remedial costs would likely be less than $1 million.

5.6.3 Pit dewatering rates

The timeframes required to dewater the Jupiter pit will be governed by the available pumping capacity. For this assessment, a pit dewatering rate of 100 L/s to MWD1 and MWD2 has been adopted. Alternative pumping capacities based upon the required duration to dewater the pit following a 1% AEP 24 hour storm event (assuming a volumetric rainfall/runoff coefficient of 1.0) are outlined in Table 5.4.

Table 5.4 - 1% AEP 24 hour pit dewatering rates

Stage	Dewatering duration (days)	Pit dewatering (L/s)
1	5	73
	10	37
	30	12
2	5	190
	10	95
	30	32

The alternative dewatering pump rates shown above may be adopted by site depending upon available pumping infrastructure.

5.7 RELEASE OF WATERS TO THE RECEIVING ENVIRONMENT

There are four key mechanisms through which water from the Project can enter the receiving environment:

- dewatering and overflows from sediment dams;
- overflows from mine affected water dams and the open cut pit;
- runoff from diverted water catchments; and
- runoff from rehabilitated catchments.

Sediment dam/mine affected overflows are a point source. Model predictions of volumes from sediment dam and mine affected dam overflows are provided in Section 7.3.5. Runoff from rehabilitated catchments is likely to be both a point and diffuse source of water to the receiving environment. When a sediment dam catchment is completely rehabilitated, and water quality monitoring of the runoff has established that it is consistent with natural background conditions, the sediment dam and associated drainage infrastructure will be decommissioned. Surface runoff and seepage from the rehabilitated catchment will be allowed to shed directly to the receiving environment.

5.8 SEWAGE AND EFFLUENT DISPOSAL

Sewage will be trucked offsite by registered waste transport contractors.

5.9 POST-CLOSURE CONDITIONS WATER MANAGEMENT

Figure 1.4 shows the conceptual final landform water management plan for the Project under Post-closure Conditions. The final landform plan has been developed with an aim to use water infrastructure constructed during operations. The post-closure layout shown in Figure 1.4 is conceptual only and may be updated should the mine plan and final landform plans change over the mine life.

The key features of the final landform include the following:

- No final voids are proposed as part of the final landform. The open cut pit will be backfilled with overburden material;

- Final landform batter slopes will be 17%;
- Contour banks will be constructed on batters to limit topsoil erosion until vegetation has been suitably established;
- Drainage structures will be constructed to direct runoff from disturbed areas to sediment dams;
- The plateau will be shaped to fall to the west with proposed drains and drop structures to drain the top of the landform to natural ground level;
- Mine water dams will be decommissioned following rehabilitation of infrastructure areas;
- A 10 m corridor between the pit shell crest and the toe of the final landform will be provided for drainage on the eastern side of the final landform;
- The constructed channel between SD6 and DD1 will be a permanent landform feature. A drainage corridor will be constructed through the northern side of the final landform; and
- Sediment dams SD9 and SD10 will be implemented on the northern side of the in-pit spoil dump, with specifications as outlined in Section 5.5.1.

When a sediment dam catchment is completely rehabilitated, and water quality monitoring of the runoff has established that it is consistent with EA release conditions, the sediment dam and associated drainage infrastructure will be decommissioned. Surface runoff and seepage from the rehabilitated catchment will be allowed to shed directly to the receiving environment.

When the drainage corridor is rehabilitated, DD1 will be decommissioned. DD1 will remain until this time to allow in-stream vegetation to establish before receiving upstream catchment flows.

6 Water balance model configuration

6.1 OVERVIEW

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project. The OPSIM model dynamically simulates the operation of the water management system and keeps account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operations of all major components of the water management system. The simulated inflows and outflows included in the model are given in Table 6.1.

Table 6.1 - Simulated inflows and outflows to the water management system

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	Haul road dust suppression demand
Groundwater inflows to the open cut pit	Potable water demand
External water supply	Dam overflows
Trucked potable water	CHPP/Moisture stored within products and rejects coal
ROM Coal Moisture	Train loadout (TLO) demand

6.2 SIMULATION METHODOLOGY

The Project water management system will change over the four-year mine life, including changes in catchment areas, production profile and site water demands. To represent the evolution of the mine layout over time, the Project was modelled in two discrete stages. Two representative years of the mine plan have been selected to reflect the average conditions over the mine stage.

The modelled mining stages are summarised in Table 6.2. Approved bulk sampling activities have not been included in the water balance modelling assessment.

Table 6.2 - Application of representative mine stages to full mine life

Mine stage	Representative year	Applied range of mine life	Stage duration
Stage 1	2022	1/1/2021 to 31/12/2022	2 years
Stage 2	2024	1/1/2023 to 31/12/2024	2 years

6.3 CATCHMENT YIELD PARAMETERS

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2003) to estimate runoff from rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff. The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evaporation (surface stores only). Simulated surface runoff occurs when the conceptual storages fill and overflow.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM is converted into a runoff volume by multiplying the contributing catchment area.

The model parameters define the storage depths (C1, C2 and C3), the proportion of the catchment draining to each of the storages (A1, A2 and A3), and the rate of flux between them (K_{base}, K_{surf} and BFI). Catchments across the site have been characterised into the following land use types:

- Natural, representing areas in their undisturbed state;
- Open cut mining pit;
- In pit spoil, representing uncompacted dumped overburden material within the pit shell;
- Out of pit spoil, representing dumped overburden material outside of the pit shell; and
- Disturbed/industrial, representing roads, hardstands and stripped areas.

The adopted AWBM parameters are shown in Table 6.3. The natural runoff parameter was calibrated to the Phillips Creek streamflow gauge. The other AWBM parameters have been based on parameters typical for coal mines in this part of the Bowen Basin. The landuse configurations for the mining areas over the two modelled stages are shown in Figure 1.2 and Figure 1.3.

Table 6.3 - Adopted AWBM parameters

Parameter	Natural	Disturbed/Industrial	Pit	In pit spoil/Out of pit spoil
A1	0.07	0.1	0.134	0.07
A2	0.465	0.9	0.433	0.10
A3	0.465	-	0.433	0.83
C1	12.0	4	2.6	5
C2	100.0	16	26.7	10
C3	300.0	-	53.3	200
C_{avg}	186.8	14.8	35.0	167.4
BFI	0.05	0	0	0.5
k_{base}	0.70	0	0	0.9
k_{surf}	0.35	0	0	0.1
C_{v*}	6.2%	37.6%	28.3%	12.0%

* Long term volumetric runoff coefficient.

6.4 CONCEPTUAL WATER MANAGEMENT SYSTEM CONFIGURATION AND SCHEMATIC

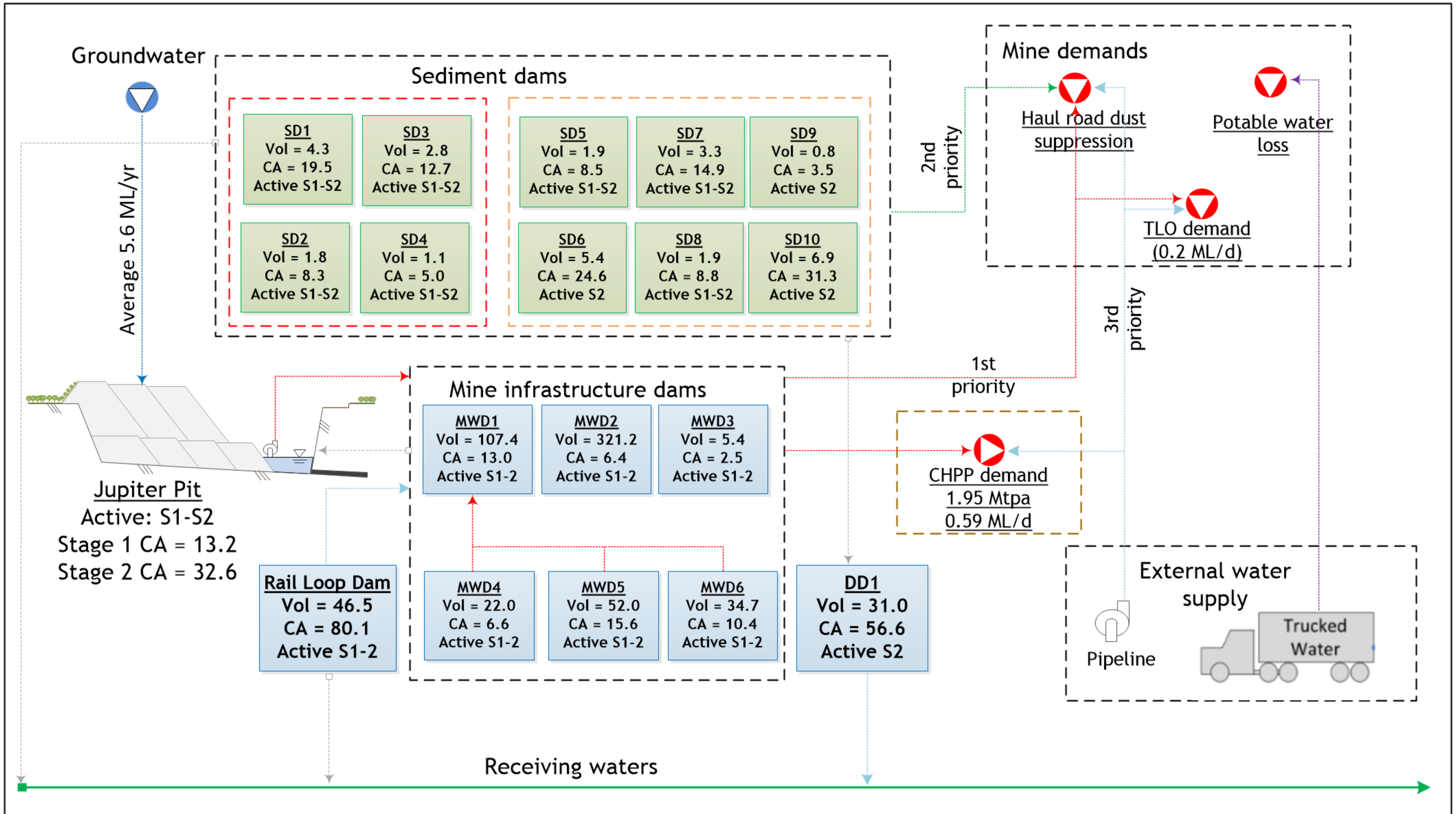
Figure 1.2 and Figure 1.3 show the conceptual Project water management system layout as well as catchment areas and land uses for Stage 1 and Stage 2 respectively. Figure 6.1 shows the schematised plan of the proposed water management system configuration. The modelled water management system configuration is outlined in Table 6.4.

Table 5.2 and Table 5.3 shows the sediment dam and mine water dam sizes respectively that were adopted for the water balance assessment.

Table 6.4 - Water management system operating rules for the Project

Item	Node Name	Operating Rules
1	***External water supply***	
1.1	External water	• Mine affected water can be imported (assumed to be from Peak Downs) to supplement mine water demands; and • Supplies haul road dust suppression demands from MWD1 (3rd priority).
1.2	Trucked water	• Supplies the potable water demand.
2	***Supply to demands***	
2.1	Haul road dust suppression	• Sourced from the following: - 1st priority: MWD system; - 2nd priority: Sediment dams; and - 3rd priority: External water. • 100% loss assumed; and • Demand values outlined in Section 6.5.1.
2.2	CHPP demands	• CHPP makeup demands are supplied by the MWD system (1st Priority); • Supply from BMA pipeline if MWD system is low (2nd priority); and • Demand values outlined in Section 6.5.2.
2.3	TLO demands	• TLO demands are supplied by the MWD system (1st Priority); • Supply from BMA pipeline if MWD system is low (2nd priority); and • Demand values outlined in Section 6.5.3
2.4	Potable water demand	• Sourced from trucked water delivered to site; • 100% loss assumed; and • Assumed constant rate of 50 ML/yr (as outlined in Section 6.5.4).
3	***Pit water***	
3.1	Jupiter pit	• Proposed mining pit active during all stages; • Dewaters to MWD1 or MWD2 at 100 L/s (8.64 ML/d), provided there is available storage in MWD1 or MWD2; and • Receives groundwater inflows as outlined in Section 6.6.1.
4	***Operation of mine affected dams***	
4.1	MWD1	• Proposed primary mine affected water storage; • Receives pump inflows from the Jupiter pit at 100 L/s (8.64 ML/d) until MWD1 reaches its max operating volume at 140 ML, at which point dewatering ceases. Pumped inflows recommence once the MWD1 inventory drops below its maximum operating volume;

		• Receives pumped inflows from MWD3, MWD4, MWD5 and MWD6 (refer to Table 5.3); • Transfer water to MWD2 at 11 L/s until MWD2 if the operating volume is exceeded (Stage 2 only).
4.2	MWD2	• Active in Stage 2; • Receives pumped inflows from the Jupiter pit at 100 L/s (8.64 ML/d) until MWD2 reaches its OV, at which point dewatering ceases. Pumped inflows recommence once the inventory drops below its OV; and • Supplies water to haul road dust suppression (1st priority).
4.3	MWD3	• Collect mine affected (potential) water from the mine workshop and laydown area; and • Transfer water to MWD1 at 11 L/s (1 ML/d) if MWD3 exceeds the operating volumes outlined in Table 5.3.
4.4	MWD4, MWD5 and MWD6	• Mine affected water storages that capture runoff from the product pad/ROM pad/CHPP area; • Supplies water to haul road dust suppression (1st priority); • Transfer water to MWD1 at 5 day pump rate (outlined in Table 5.3) if the operating volumes are exceeded; and • Overflows to the pit.
5	***Operation of sediment dams***	
5.1	Primary sediment dams (SD1, SD2, SD3, SD4, SD5, SD7, SD8, SD9, SD10)	• SD1 & SD2 collect water from the out of pit spoil dump; • SD3 and SD4 collect runoff primarily from topsoil stockpiles and mine access roads; • SD5, SD7, SD8, SD9 and SD10 collect runoff primarily from in pit spoil dump; • Supplies water to the haul road dust suppression as 2nd priority; and • Overflow to Boomerang Creek via Drainage Line 1/Drainage Line 2/existing drainage diversion.
5.2	SD6	• Active in Stage 2; • Collects runoff from the in pit spoil dump; and • Overflows to SD10.
6	***Clean water storages***	
6.1	DD1	• Active in Stage 2; • Diverted water dam used as flood protection for the Jupiter Pit; • Transfers water to the existing drainage diversion at 100 L/s (8.64 ML/d) from empty; and • Overflows to Drainage Line 1 via a diverted water drain which runs around the northern edge of the pit.
6.2	Rail Loop Dam	• Clean water catchment dam used to supplement site water demands via MWD1/MWD2 at 4.32 ML/d (50 L/s).



Vulcan Complex Project	
Figure	Proposed integrated water management system schematic
Job	1571-16
Date	1/12/2021

Legend

- Surface water
- Mine affected water
- Raw water
- Groundwater
- External/diverted water
- Pumped flow
- Spillway/overflow
- Receiving waterway
- In pit runoff
- Out of pit runoff

Notes

Spill Flow Directions:
Good engineering practice is to include a stabilised spillway as a contingency for dam safety. This arrow does not indicate that these discharges (spills/overflows) are a part of the water management system or that spills will occur. The arrow is to show the direction of water flow (by gravity) should the dam water level exceed the dam spillway level.

Volumes (Vol.) recorded in ML, catchment areas (CA) in hectares.

wrm water + environment

Figure 6.1 – Water management system schematic for the Project

Table 6.5 - Water storage catchment areas (Stage 1)

Dam	Landuse area (ha)					Total
	Natural	Disturbed/ Industrial	In Pit spoil	Out of pit spoil	Pit	
SD1	0.0	0.0	0.0	19.5	0.0	19.5
SD2	0.0	0.0	0.0	8.3	0.0	8.3
SD3	0.0	9.3	0.0	0.0	0.0	9.3
SD4	0.0	5.0	0.0	0.0	0.0	5.0
SD5	0.0	2.2	6.3	0.0	0.0	8.5
SD6	0.0	0.0	0.0	0.0	0.0	0.0
SD7	0.0	5.0	8.8	0.0	0.0	13.8
SD8	0.0	1.7	7.0	0.0	0.0	8.8
DD1	N/A	N/A	N/A	N/A	N/A	0
MWD1	0.0	13.0	0.0	0.0	0.0	13.0
MWD2	0.0	6.4	0.0	0.0	0.0	6.4
MWD3	0.0	2.5	0.0	0.0	0.0	2.5
MWD4	0.0	6.6	0.0	0.0	0.0	6.6
MWD5	0.0	15.6	0.0	0.0	0.0	15.6
MWD6	0.0	10.4	0.0	0.0	0.0	10.4
Jupiter Pit	0.0	2.7	0.0	0.0	10.5	13.2

Table 6.6 - Water storage catchment areas (Stage 2)

Dam	Landuse area (ha)					Total
	Natural	Disturbed/ Industrial	In Pit spoil	Out of pit spoil	Pit	
SD1	0.0	0.0	0.0	19.5	0.0	19.5
SD2	0.0	0.0	0.0	8.3	0.0	8.3
SD3	0.0	12.7	0.0	0.0	0.0	12.7
SD4	0.0	5.0	0.0	0.0	0.0	5.0
SD5	0.0	1.2	4.3	0.0	0.0	5.5
SD6	0.0	1.3	23.3	0.0	0.0	24.6
SD7	0.0	4.5	10.4	0.0	0.0	14.9
SD8	0.0	2.0	3.7	0.0	0.0	5.7
SD9	0.0	0.5	3.1	0.0	0.0	3.5
SD10	0.0	1.1	30.2	0.0	0.0	31.3
DD1	48.5	8.13	0	0.0	0.0	56.6
MWD1	0.0	13.0	0.0	0.0	0.0	13.0
MWD2	0.0	6.4	0.0	0.0	0.0	6.4
MWD3	0.0	2.5	0.0	0.0	0.0	2.5
MWD4	0.0	6.6	0.0	0.0	0.0	6.6

MWD5	0.0	15.6	0.0	0.0	0.0	15.6
MWD6	0.0	10.4	0.0	0.0	0.0	10.4
Jupiter Pit	0.0	4.9	12.4	0.0	15.3	32.6

6.5 SITE WATER DEMANDS

6.5.1 Haul road dust suppression

Water for haul road dust suppression is primarily sourced from the mine dams (with the priorities outlined in Table 6.4). Haul road designs were provided by Vitrinite.

Haul road dust suppression demands are estimated using supplied haul road design plans and historical climate data as follows:

- Daily pan evaporation and rainfall rates are sourced from the SILO database;
- For a dry day (zero rainfall), the haul road watering rate is equal to the daily evaporation rate;
- For a rainy day when rainfall is less than the daily evaporation rate, the watering rate is reduced and is only required to make up the remaining depth to the daily evaporation rate; and
- For a rainy day when rainfall exceeds the daily evaporation rate, no haul road watering is required.

Assuming a haul road width of 30 m, an in-pit haul road length of 3 km and 1 km of haulage above surface (i.e. a total haul road length of 4 km), the estimated demand rates averaged over each month are summarised in Table 6.7. These rates were adopted for Stages 1 and 2.

Table 6.7 - Forecast Haul Road Dust Suppression usage

Month	Haul road demand (kL/d)
January	691.2
February	608.1
March	636.7
April	548.9
May	417.9
June	340.5
July	376.0
August	486.5
September	667.6
October	775.4
November	789.5
December	761.3
Annual	591.6

6.5.2 CHPP demand

The projected annual coal production schedule for the Project (provided by Vitrinite), is summarised in Table 6.8. The amount of washed coal for each stage was derived from the average value over the stage period. In addition, Vitrinite indicated that all coking coal would be processed and an initial estimate of 20% of thermal coal would bypass the CHPP. The assumed volumes of washed coal and bypass coal per stage are also provided in Table 6.8.

Table 6.8 - Forecast annual production data

Stage	Year	Total ROM coal (tpa)	Total anticipated product coal (tpa)
	2021*	-	-
1	2022	1,950,000	1,170,000
	2023	1,950,000	1,170,000
2	2024	1,865,000	1,118,210

* Note that CHPP is online in Stage 2 and ROM coal is processed offsite in Stage 1.

Key parameters regarding the CHPP process (provided by DRA Global and also derived from coal physicals) are outlined in Table 6.9.

Table 6.9 - Key CHPP parameters

Parameter	Value
ROM coal moisture	5%
Product coal moisture	9.4%
Coarse reject moisture	14.8%
Tailings moisture	25.4%
Plant efficiency (ROM:Product)	56.5%
Feed rejects (ROM:Coarse reject)	21.5%
Plant tailings (ROM:Tailings)	22.0%

The key CHPP parameters (Table 6.9) and stage washed coal values (Table 6.8) were input to the model to produce water makeup requirements over the mine life. The makeup requirements are supplied by the dams as outlined in Table 6.4.

The average CHPP water makeup requirement for Stage 2 is provided in Table 6.10.

Table 6.10 - Estimated CHPP makeup requirements

Stage	CHPP makeup requirement (ML/d)
1	-
2	0.59

6.5.3 TLO demand

Water for the TLO demand is sourced from the mine dams (with the priorities outlined in Table 6.4). A nominal TLO demand of 0.2 ML/d (200 kL/d) was assumed.

6.5.4 Potable water demand

Potable water demand is supplied by trucked water delivered onsite. Potable water demand was assumed at 50 ML/annum (137 kL/d).

6.6 WATER SOURCES

6.6.1 Groundwater

Groundwater inflow estimates to the open cut pit were provided by Hydrogeologist.com.au and have been provided as a daily rate for six-monthly periods over the mine life. A summary of the predicted groundwater inflows provided by Hydrogeologist.com.au are provided in Table 6.11. Also shown in Table 6.11 is the assumed modelled groundwater inflow for each stage of operations. The estimated groundwater inflow rates are small and will likley have a negligible impact on the Mine water balance. Notwithstanding this, groundwater inflows have been included in the water balance model for completeness.

Table 6.11 - Estimated groundwater inflows

Stage	Period start/end	Groundwater inflow (m^3/day)	Modelled groundwater inflow per stage (m^3/day)
1	1/01/2021	0	4.31
	1/07/2021	10.41	
	1/01/2022	5.91	
	1/07/2022	0.91	
2	1/01/2023	8.9	26.22
	1/07/2023	34.75	
	1/01/2024	39.79	
	1/07/2024	21.42	

6.6.2 External water

A key objective of the mine site water management system is to reuse surface water runoff captured within the mine affected water system. Recycling mine water will minimise the volume of water from external sources that is required to satisfy site demands. However, the volume of water captured on site is highly variable and dependent upon climatic conditions. Hence, under dry conditions there is a requirement to source water from external sources.

For the purposes of the assessment, it has been assumed that Vitrinite will source external mine water (likely from BMA's Peak Downs operation) to provide water as required via a pipeline for the life of the Project. Vitrinite are currently investigating other possible sources of water for the Project. The assessment of other sources of water, if utilised, will be undertaken if required.

The pipeline will transfer mine affected water to be stored in MWD1 when mine affected water inventories are low.

6.7 WATERCOURSE FLOW MODELLING

As outlined in Section 4.4 and 4.5, Boomerang Creek streamflow and water quality data was not available for this assessment.

Flows in the surrounding natural watercourses have therefore been simulated using the calibrated AWBM parameter set previously derived for Philips Creek (WRM, 2012) (as shown in Table 6.12). Phillips Creek is a tributary of the Isaac River and is located approximately 25 km south of the Project area. Phillips Creek drains primarily undisturbed land to the west of the Norwich Park Branch Railway through Saraji Mine to the Isaac River. Phillips Creek drains into the Isaac River approximately 4 km downstream of Boomerang Creek. The undisturbed catchment which drains to Phillips Creek is similar in nature to the undisturbed catchment to the west of the Project which drains to Boomerang Creek.

The catchment area of Boomerang Creek directly downstream of the Project (i.e. approximately where Drainage Line 1 meets Drainage Line 2) is approximately 4,300 ha. This catchment area has been adopted for assessing the potential mixing within the downstream receiving waters.

Table 6.12 - Phillips Creek AWBM parameters

Parameter	Phillips Creek Value
A1	0.013
A2	0.444
A3	0.543
BFI	0.21
C1	15.0
C2	100.0
C3	651.0
C_{av}	398.1
Kbase	0.914
Ksurf	0.502
Average annual runoff co-efficient (C_v)	4.5%

6.8 WATER QUALITY MODELLING

RGS Environmental have undertaken an assessment of the overburden and potential coal reject materials at the Vulcan Complex. RGS (2019) presented initial results from the Jupiter Pit area. A series of geochemical tests were completed on samples from the Jupiter pit to assess the risk of potential oxidation of sulphides, acid and metalliferous drainage, potential presence and potential leaching of soluble metals/metalloids and other salinity/erosion issues. RGS (2019) made the following findings regarding the geochemical characterisation of the potential spoil:

- all samples tested had a high factor of safety and negligible risk of generating acid mine drainage;
- assay of the multi-element concentration present in selected representative samples indicates that there are no elements (metals/metalloids) enriched in the sample materials compared to median crustal abundance in unmineralised soils;
- the initial static and kinetic test results indicate that surface runoff and seepage from the sample materials are likely to be pH neutral with moderate excess alkalinity, and low levels of salinity;
- the initial geochemistry results are consistent with the larger data set of results obtained from geochemical characterisation of 139 samples from 21 drill holes across the broader Jupiter and Vulcan prospect areas in the VCM; and
- the results represent an ‘assumed worst case’ scenario as the samples are pulverised (to minus 75 micrometres) prior to testing. Therefore, samples have a very high surface area compared to materials in the field. This process provides a

greater potential for dissolution and reaction and represents an assumed initial 'worst case' scenario for geochemical testing of these materials.

In consideration of the RGS (2019) findings from the preliminary geochemical characterisation, salinity is considered the key contaminant for assessment purposes. Assessment of other contaminants has not been undertaken as part of this surface water assessment. If subsequent monitoring data indicates that there are other contaminants of concern, the assessment can be updated to include additional water quality parameters.

6.8.1 Adopted salinity parameters

The water balance model is configured to use salinity as an indicator of water quality using electrical conductivity (EC) values of runoff for each landuse type and other sources of water.

The proposed EC values are shown in Table 6.13. EC values have been sourced from previous water balance models for mines in similar areas of the Bowen Basin.

Table 6.13 - Adopted salinity concentrations

Water source/land use	EC (µS/cm)	Comment
Natural/ undisturbed	300	Value adopted for Olive Downs SWA and Lake Vermont Northern Extension SWA.
Disturbed	500	Runoff value typical for cleared/stripped areas.
Mining pit	4,500	Value adopted for Lake Vermont Northern Extension SWA.
In pit spoil/out of pit spoil	350	Value adopted for Olive Downs SWA.
External water (pipelines from BMA Peak Downs)	10,000	Salinity of mine water unknown, conservatively high value adopted.
Industrial area	900	Salinity of ROM coal unknown, conservatively high value adopted.
Groundwater	9,520	Average groundwater salinity reading from historical groundwater monitoring undertaken at site (Hydrogeologist.com.au, 2020).

7 Water management system assessment

7.1 OVERVIEW

The Project OPSIM model was used to assess the performance of the water management system, using the following key performance indicators:

- overall water balance – the average inflows and outflows of the water management system based on all model realisations (Section 7.3.1);
- mine water inventory – the risk of accumulation (or reduction) of the overall mine water inventory (Section 7.3.2);
- in-pit storage – the risk of accumulation of water in the mining pits, and the associated water volumes (Section 7.3.3);
- external water demand – the volumes of imported external water required to supplement site mine water supplies (Section 7.3.4);
- uncontrolled spillway discharges – the risk and associated volumes of uncontrolled discharge from the mine affected water storages and sediment dams to the receiving environment (Section 7.3.5);
- overall salt balance – the average salt loads in and out of the water management system based on all model realisations (Section 7.3.6);
- potential receiving water impacts - predicted water quality in the receiving environment during predicted 'worst case' release scenarios (Section 7.3.7 and 7.3.8); and
- sensitivity analysis - varying the assumed haul road dust suppression over the mine life and the potential impacts of climate change (Section 7.4).

The use of a large number of climate sequences reflecting the full range of historical climatic conditions provides an indication of the system performance under very wet, very dry and average climatic conditions. It is important to note that the results of the water balance modelling are dependent on the accuracy of input assumptions. There is inherent uncertainty with respect to some key site characteristics (e.g. catchment yield/runoff, groundwater inflows etc.).

7.2 INTERPRETATION OF MODEL RESULTS

In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the 4 years of mine life, based on 125 stochastically generated climatic rainfall sequences and historical average monthly evaporation. The model results are presented as a probability of exceedance. For example, the 10%ile represents 10% probability of exceedance and the 90%ile represents 90% probability of exceedance. There is an 80% chance that the result will lie between the 10%ile and 90%ile traces.

Whether a percentile trace corresponds to wet or dry conditions depends upon the parameter being considered. For site water storage, where the risk is that available storage capacity will be exceeded, the lower percentiles correspond to wet conditions. For example, there is only a small chance that the 1%ile storage volume will be exceeded, which would correspond to very wet climatic conditions. For off-site site water supply volumes (for example), where the risk is that insufficient water will be available, there is only a small chance that more than the 1%ile water supply volume would be required. This would correspond to very dry climatic conditions.

It is important to note that a percentile trace shows the likelihood of a particular value on each day and does not represent continuous results from a single model realisation. For example, the 50%ile trace does not represent the model time series for median climatic conditions.

7.3 WATER BALANCE MODEL RESULTS

7.3.1 Overall water balance

Water balance results for all of the 125 model realisations are presented in Table 7.1.The results presented in Table 7.1 are the average of all realisations and will include wet and dry periods distributed throughout the mine life. Rainfall yield and evaporation for each stage is affected by the variation in climatic conditions within the adopted climate sequence.

Table 7.1 provides an indication of the long-term average annual inflows and outflows. Key outcomes from the overall water balance are as follows:

- Average annual inflows from rainfall runoff for mine affected and surface water dams increase from Stage 1 to Stage 2, as the pit progresses, and more catchment runoff is collected in mine affected water dams and sediment dams.
- The proposed water management system is in negative balance under ‘average’ climate conditions. This indicates that the Project will require significant volumes of external water to meet mine water demands.
- External water requirements are greater in Stage 2 when compared to Stage 1 due to the demand required for the CHPP.

It should be recognised that the following items are subject to climatic variability:

- Rainfall runoff;
- Evaporation;
- External water requirement;
- Dust suppression demand; and
- Dam overflows.

Whilst it provides an indication of the long-term average annual inflows and outflows, application of the nominated values for other purposes should only be undertaken with due consideration of the suitability of the nominated value and any potential implications.

In particular, the “average” sediment dam overflows do not necessarily mean that discharges occur under median climatic conditions. It means that there was a discharge in at least one of the 125 model realisations. A more detailed analysis of the performance of the various components of the water management system is provided in the following sections.

Table 7.1 - Average annual water balance - all realisations

Description	Stage 1	Stage 2
	Inflows (ML/year)	
Rainfall Runoff		
Mine affected water	147.0	166.0
Surface water	82.0	127.2
Diverted water	32.0	47.8
Groundwater inflow	1.6	9.6
ROM coal moisture	0.0	97.5
External water	130.9	276.1
Trucked potable water (external water)	50.0	50.0
Total Inflows	443.6	774.1
	Outflows (ML/year)	
Evaporation	36.6	36.6
Dam overflows		
Mine affected water	0.0	0.0
Surface water	47.7	67.0
Diverted water	6.1	16.8
CHPP		
Product moisture	0.0	108.6
Coarse rejects moisture	0.0	69.2
Fine rejects moisture	0.0	138.8
Haul road dust suppression	216.1	216.1
TLO demand	73.1	73.1
Potable water demand	50.0	50.0
Total Outflows	429.6	776.1
	Change in volume (ML/year)	
Change in stored volume	14.0	-2.0

7.3.2 Mine affected water inventory

7.3.2.1 MWD1 inventory

Figure 7.1 shows the forecast inventory for MWD1 which is the key out-of-pit mine affected water storage, controlling the dewatering of the pit. Figure 7.2 shows the annual maximum forecast inventory for MWD1 over the mine life.

These results show the 1%ile (wettest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile traces.

As outlined in Section 5.6.1, to prevent uncontrolled discharges from MWD1 a OV is required. If the OV is exceeded, all transfers to the storage cease (i.e. pit dewatering and mine water dam dewatering). The MWD1 OV, in addition to the FSV are shown in Figure 7.1 and Figure 7.2.

The model results show the following:

- The MWD1 inventory is maintained below the FSV for all climatic conditions assessed and therefore is not predicted to spill under any modelled climate sequence;
- The MWD1 inventory is maintained below its OV for 10%ile and drier conditions in Stage 1 and 5%ile and drier conditions in Stage 2. This means pit and mine dam dewatering is restricted under 5%ile in Stage 1 and 1%ile and wetter conditions in Stage 2;
- Under the 50%ile trace, the MWD1 inventory is maintained below 40 ML for the entire mine life;
- Under very wet (1%ile) conditions, MWD1 has an inventory of up to 105 ML during both Stage 1 and Stage 2; and
- Under wet (10%ile conditions), MWD1 has a maximum inventory of approximately:
    - up to 91 ML during Stage 1; and
    - up to 80 ML during Stage 2.

7.3.2.2 Mine water dam inventories

MWD1, MWD2, MWD3, MWD4, MWD5 and MWD6 are the mine affected water dams on site. MWD1 and MWD2 dewater the pit following rainfall events. The OVs of these dams have been designed to keep the pit as dry as possible while also limiting the requirement to transfer water back to the pit. MWD3 collects runoff from the northern mine workshop area and dewaters to MWD1 when it rises above its OV. MWD4, MWD5 and MWD6 collect runoff from the proposed CHPP/ROM area and dewaters to MWD1 when they accumulate water above their OV.

The mine affected water dams are not predicted to spill under any of the 125 modelled realisations.

Figure 7.3 shows the annual maximum forecast combined inventory for MWD2, MWD3, MWD4, MWD5 and MWD6. The model results show that:

- the combined water inventories remain below the combined FSV under all climatic conditions assessed and therefore are not predicted to spill under any modelled climate sequence;
- under 50%ile and drier conditions, the maximum mine water inventory is maintained below the combined OV for all years; and
- under 10%ile conditions, the maximum mine water inventory is generally below the combined OVs for Stage 1 and Stage 2.

The results indicate that the mine water dams are predicted to store water, to some extent, under the majority of conditions. However, they are not at risk of surpassing their FSVs, even under extremely wet (<1%ile) conditions, due to the proposed dewatering of dams to MWD1 and MWD2 and reuse of water for operational requirements.

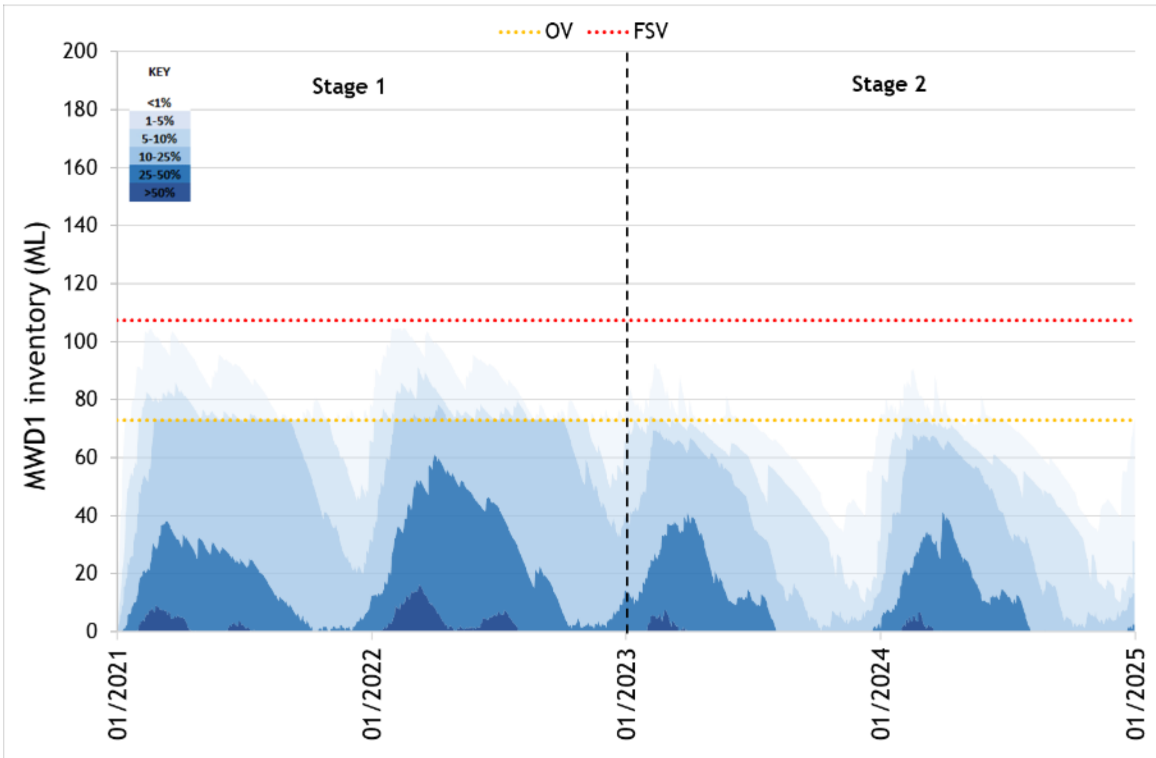


Figure 7.1 – Forecast MWD1 inventory

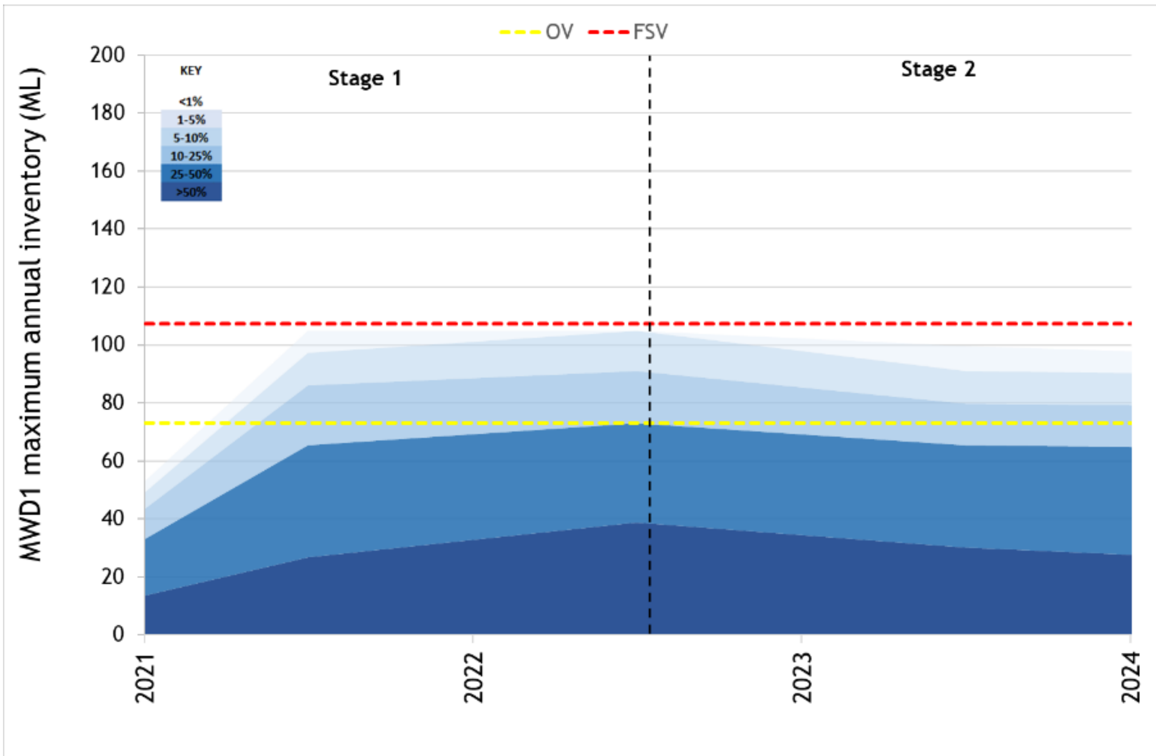


Figure 7.2 – Forecast annual maximum MWD1 inventory

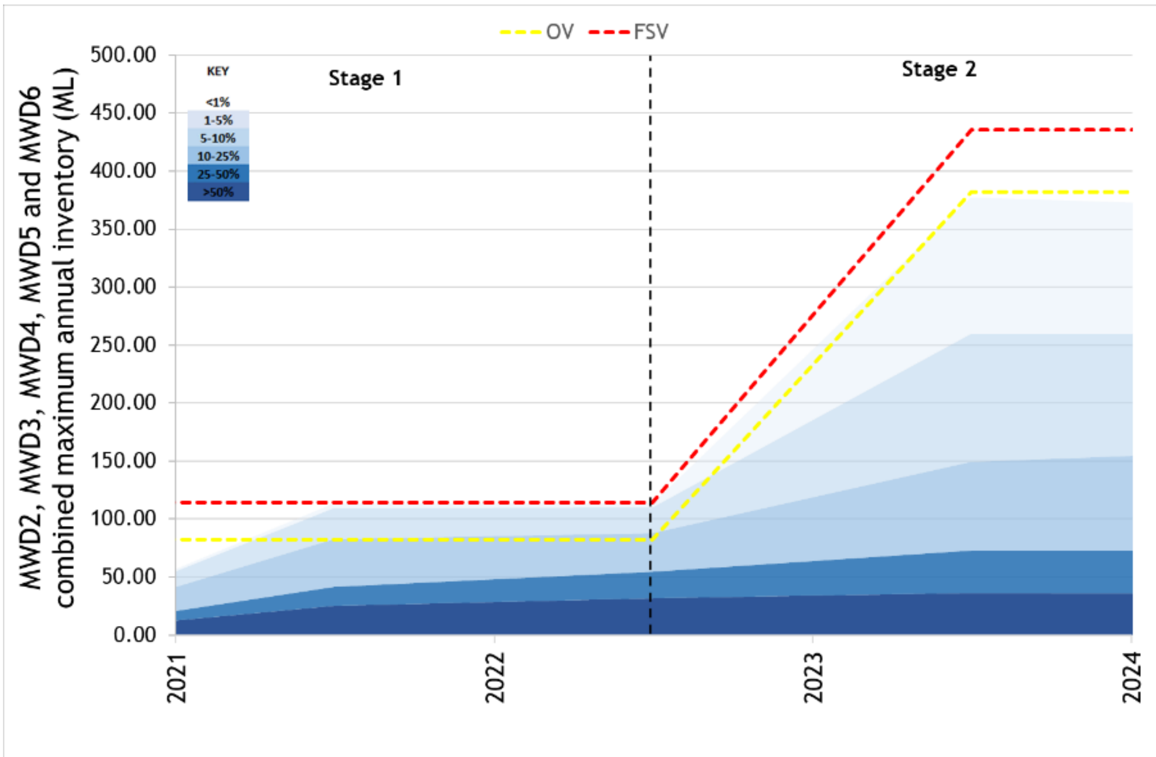


Figure 7.3 - Forecast annual combined maximum water inventory in MWD2, MWD3, MWD4, MWD5 and MWD6

7.3.3 Jupiter pit water inventory

7.3.3.1 In pit storage

Figure 7.4 shows the forecast inventory of the Jupiter mine pit and Figure 7.5 shows the forecast annual maximum Jupiter pit inventory during the 4-year operational period.

The 1%ile (wettest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile percentile traces are shown. As outlined in Section 5.6.1, the pit is continuously dewatered into MWD1 and MWD2 in Stage 2, as long as the mine dams are maintained below their OV. MWD1 and MWD2 have been sized to keep the pit dewatered as long as practical given sizing constraints.

The model results show the following:

- Under very wet (1%ile) conditions, the Jupiter pit will have a forecast inventory of approximately:
  - up to 75 ML during Stage 1; and
  - up to 28 ML during Stage 2.
- Under wet (10%ile conditions), the Jupiter pit will have an inventory of approximately:
  - up to 18 ML during Stage 1; and
  - the pit remains below 7 ML (dewatered to MWD1/MWD2) during Stage 2.
- Under 50%ile conditions, the pit remains empty during Stage 1 and Stage 2.

The results suggest that pit dewatering may be constrained under very wet (between 1%ile and 10%ile) conditions in Stages 1 and 2, accumulating (on average) up to 75 ML. The addition of MWD2 in Stage 2 allows the pit to be dewatered under the majority of climate conditions for Stage 2 and is therefore expected to accumulate water under only the wettest (1%ile – 5%ile) conditions.

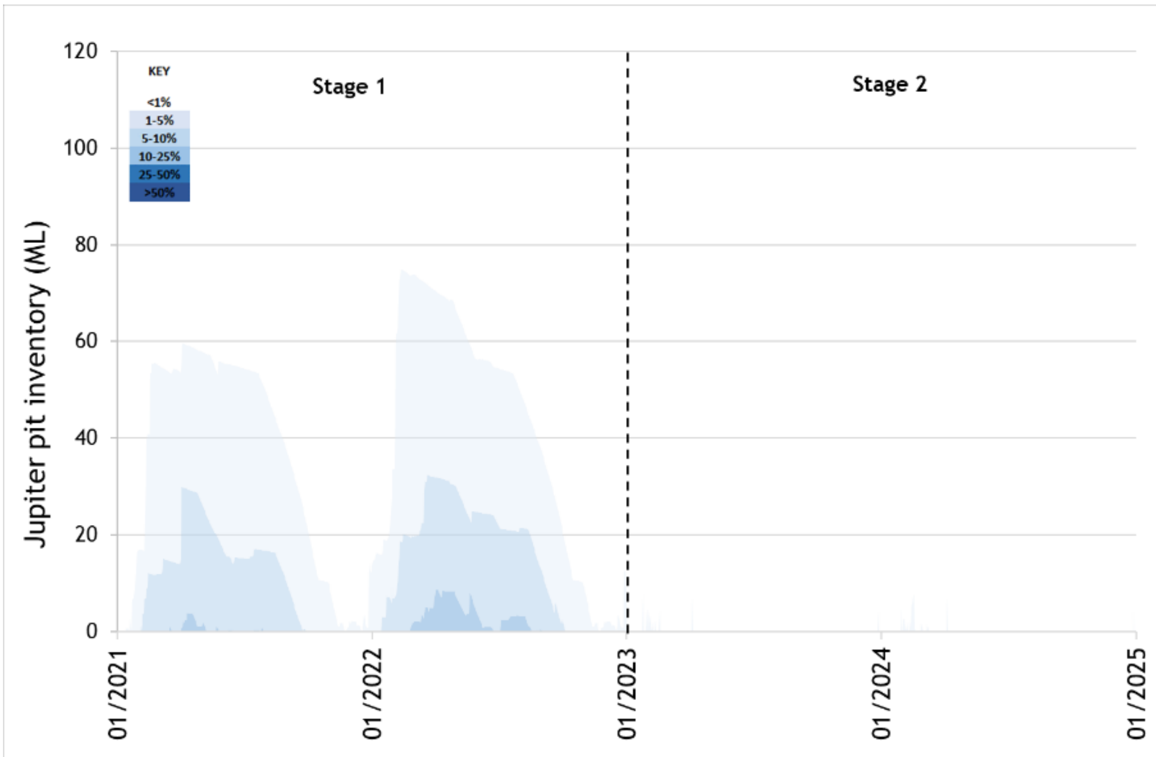


Figure 7.4 - Jupiter forecast mine pit inventory

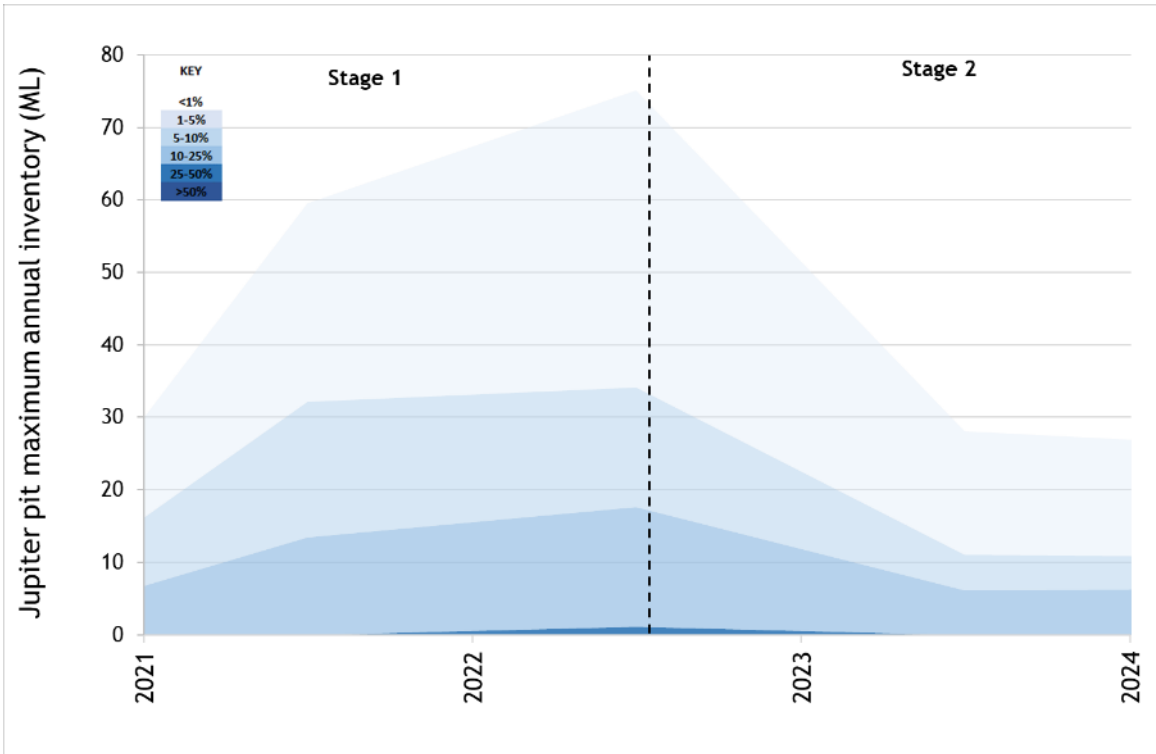


Figure 7.5 - Jupiter forecast annual maximum pit inventory

7.3.4 External water requirements

Figure 7.6 shows the total annual modelled external water required to meet predicted dust suppression, CHPP and TLO demands. The 1%ile (driest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile percentile traces are shown.

The modelling results show the following:

- During the driest (1%ile) climatic conditions, the predicted external water requirement is:
  - up to approximately 272 ML/annum during Stage 1; and
  - up to 478 ML/annum during Stage 2.
- During 50%ile conditions, the predicted external water requirements is:
  - up to approximately 152 ML/annum during Stage 1; and
  - up to approximately 305 ML/annum during Stage 2.

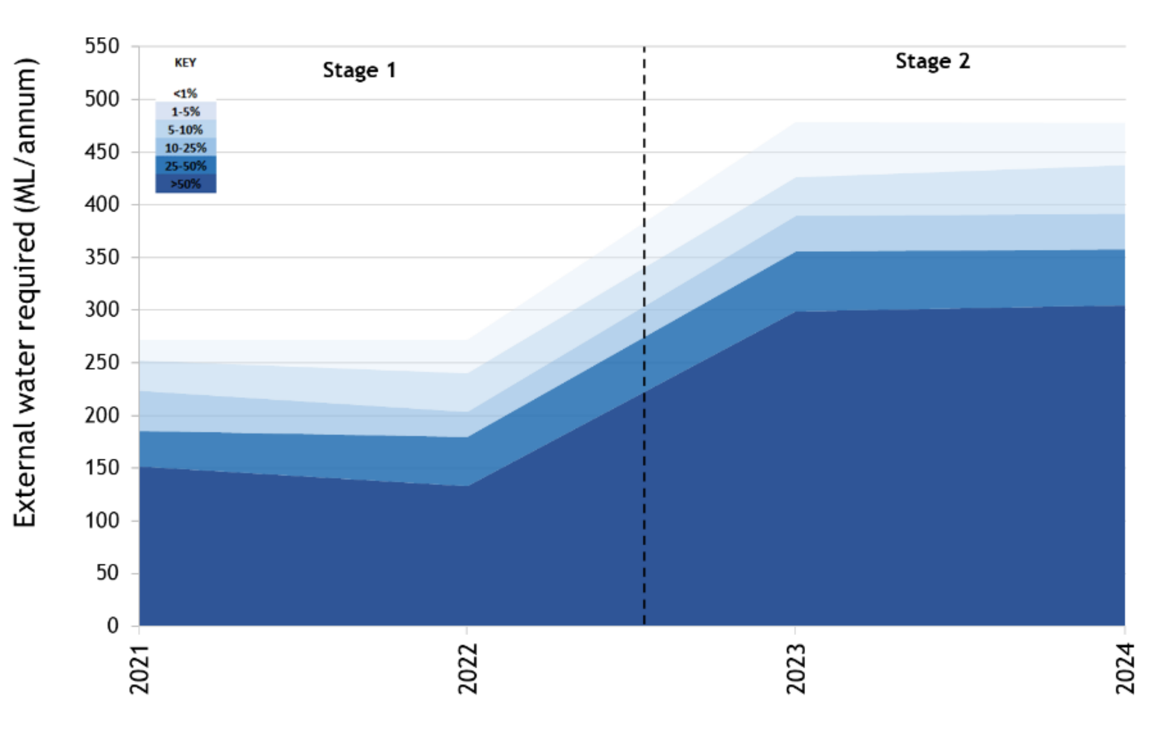


Figure 7.6 – Forecast external water requirement for dust suppression, CHPP and TLO use

7.3.5 Spillway water discharges

7.3.5.1 Mine Affected Water Dams

As outlined in Section 7.3.2, no spills are predicted from any of the mine affected water dams (i.e. MWD1, MWD2, MWD3, MWD4, MWD5 and MWD6) under any of the climate sequences modelled.

7.3.5.2 Sediment Dams

Consistent with the IECA guidelines (2008), sediment dams do not provide 100% containment for captured runoff. Hence releases will occur from sediment dams when rainfall exceeds the design standard.

The potential for releases from the proposed sediment dam has been modelled using a passive overflow rather than active release (to regain storage capacity within 5 days).

Figure 7.7 shows the forecast annual sediment dam releases to the receiving waters which indicates that:

- Under wet (10%ile) conditions, the annual volume of sediment dam releases to the receiving waters are approximately:
  - up to 147 ML/yr during Stage 1; and
  - up to 198 ML/yr during Stage 2.
- Under 50%ile conditions, the annual volume of sediment dam releases to the receiving waters are approximately:
  - up to 29 ML/yr during Stage 1; and
  - up to 28 ML/yr during Stage 2.

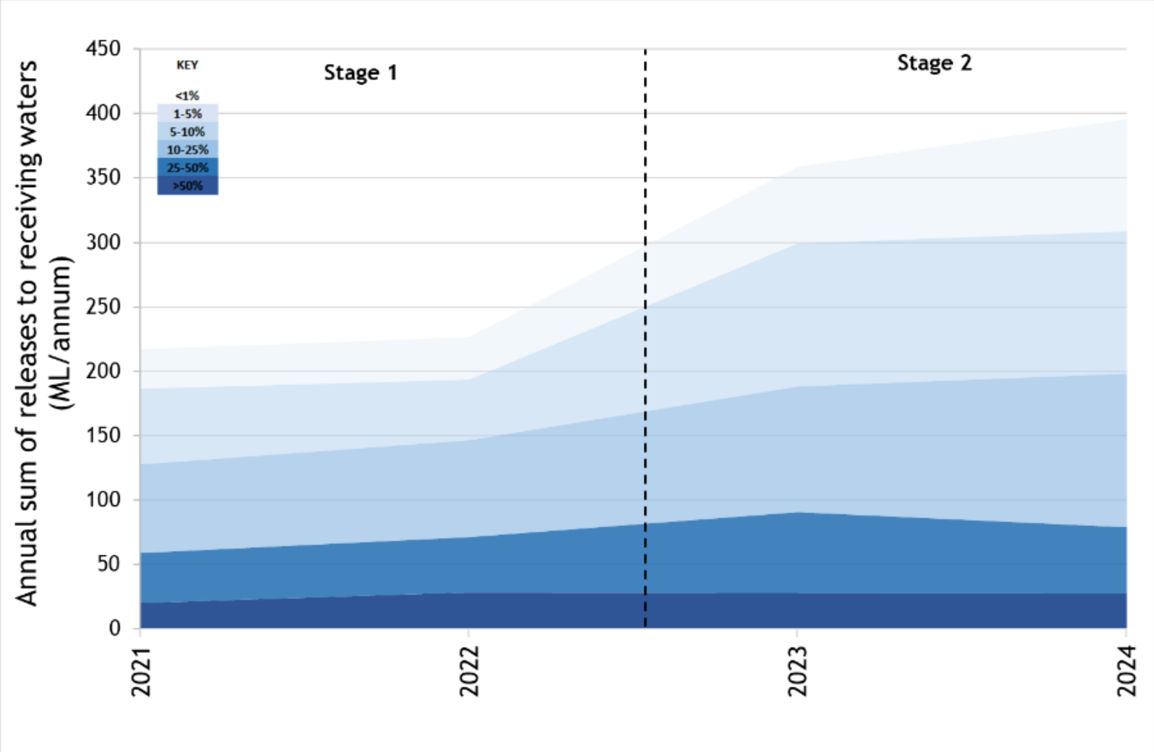


Figure 7.7 - Forecast annual sediment dam releases to the receiving waters

7.3.5.3 DD1

DD1 will be constructed in Stage 2 and will collect water from an undisturbed catchment to the northwest of the Project. All water stored in DD1 will be dewatered to the existing drainage diversion at 100 L/s. If the capacity of DD1 is exceeded, water will spill to Drainage line 1 via the northern diversion drain.

Figure 7.8 shows the annual total pumped flows from DD1 to the existing drainage diversion. The 1%ile (wettest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile percentile traces are shown.

The model results predict the following:

- Under 10%ile conditions, DD1 dewaters up to approximately 31 ML/year to the existing drainage diversion in Stage 2;
- Under 1%ile conditions (wettest climatic conditions), DD1 dewaters up to approximately 41 ML/year to the existing drainage diversion; and
- DD1 does not spill when receiving runoff from its own catchment however there may be a spill risk during large events when external catchments overflow into DD1.

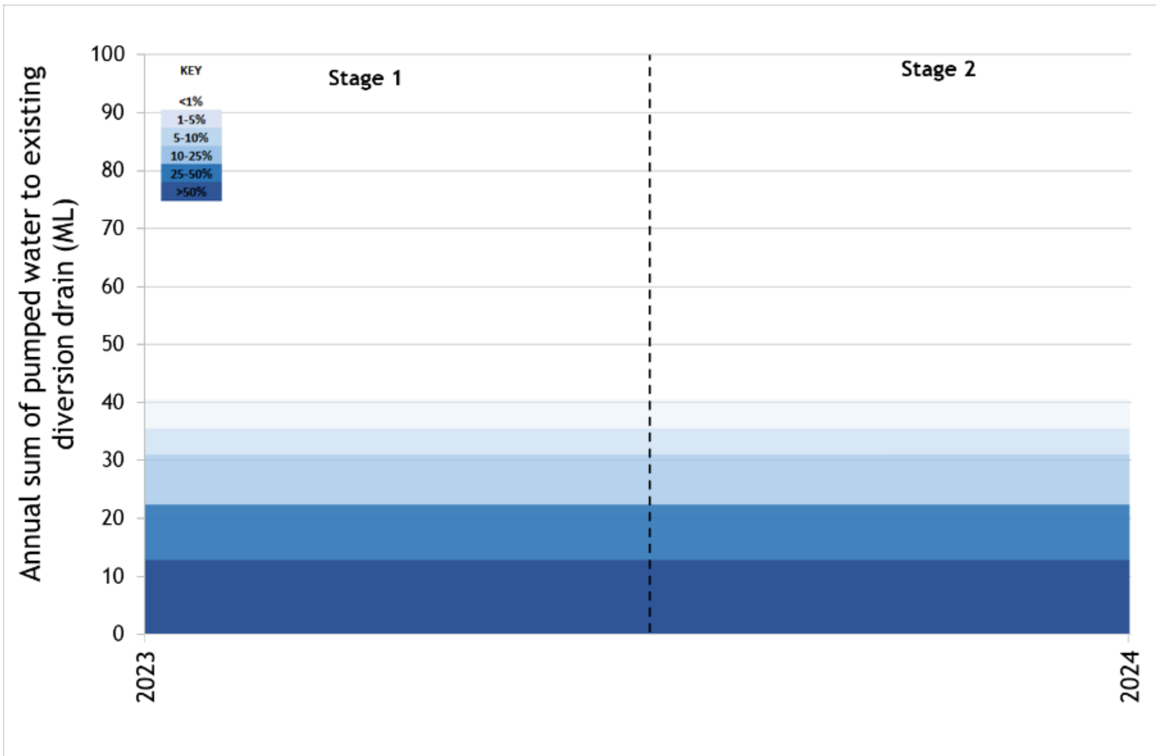


Figure 7.8 - Forecast total annual pumped transfers from DD1 to the existing drainage diversion

7.3.6 Overall salt balance

Table 7.2 shows the average annual salt balance for the Project for each stage.

Salt inputs to the Project include salts in the groundwater inflow, catchment runoff and external water. Salt inputs from direct rainfall was assumed to be zero.

Salt outputs from the Project include site demands and offsite (spillway) discharges from the water management system.

The results indicate the following:

- The largest contributor to the Project salt load is due to external water assuming it is sourced from BMA's operations. This is due to the high assumed salinity of the BMA water (Section 6.8.1);
- The largest outflow in the salt balance from the Project is haul road dust suppression demands; and
- The change in stored salt load is generally low in comparison to the total inputs and outputs, which suggests that salt will not accumulate within the site water management system.

Note that the salt balance is reported in annual tonnes of total dissolved solids (TDS) based on an EC to TDS conversion factor of 0.7.

Table 7.2 - Average annual salt balance (based on TDS)

Description	Stage 1	Stage 2
	Inputs (t/year)	
Rainfall Runoff		
Mine affected water		
Surface water	104.4	118.0
Diverted water	24.7	36.5
Groundwater inflow	6.4	9.9
ROM coal moisture	10.5	63.8
External water	0.0	682.5
Trucked potable water	916.2	1,932.4
Total Input	0.0	0.0
	Outputs (t/year)	
Evaporation	0.0	0.0
Dam overflows		
Mine affected water	0.0	0.0
Surface water	15.0	20.1
Diverted water	1.2	3.5
CHPP		
Product moisture	0.0	543.5
Coarse rejects moisture	0.0	484.3
Fine rejects moisture	0.0	694.5
Haul road dust suppression	738.6	744.8
TLO demand	297.8	297.8
Potable water demand	0.0	0.0
Total Output	1,052.7	2,845.5
	Change in salt (t/year)	
Change in stored salt	9.5	-2.3

7.3.7 Receiving waters water quality

The three potential sources of receiving waters contamination from the water management system are releases from the sediment dams, releases from the mine affected dams and pumped releases from DD1. As outlined in Section 7.3.2, the mine affected dams are not predicted to spill under any of the modelled climate sequences. Releases from DD1 are expected to be of a water quality that is similar to the default WQO trigger values as it primarily collects water from a rural catchment.

Potential impacts to EC in the receiving environment were assessed at a point directly downstream of the Project (where Drainage Line 1 meets Drainage Line 2, approximately 1 km downstream of the Project boundary). The default WQO trigger levels for EC outlined in Section 3 have been used for this assessment.

Figure 7.9 shows the predicted annual maximum EC in the receiving waters over the mine life. Note that most of the time, EC concentrations will be lower due to dilution with natural flows. The 1%ile, 5%ile, 10%ile, 25%ile and 50%ile (median climatic conditions) traces are shown. The results predict that:

- Under 1%ile conditions the maximum EC in the receiving waters is approximately 496 µS/cm in Stage 1 and 529 µS/cm in Stage 2; and
- Under 50%ile conditions the maximum EC in the receiving waters is approximately 393 µS/cm in Stage 1 and 379 µS/cm in Stage 2.

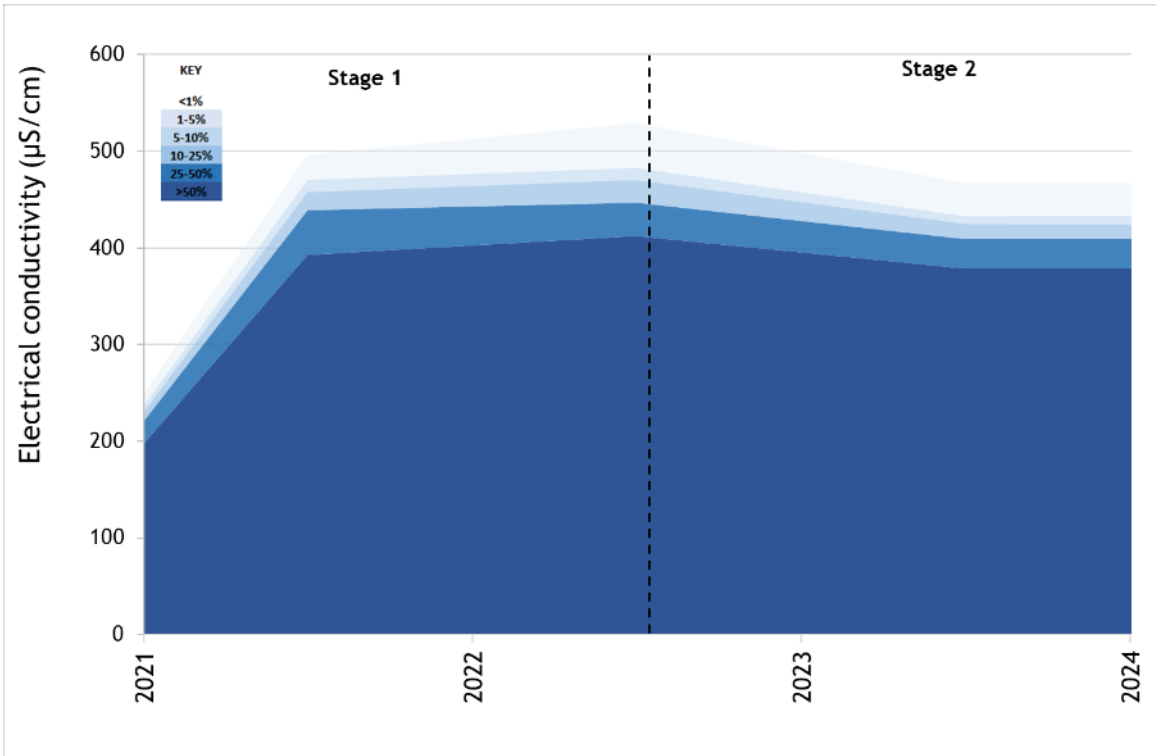


Figure 7.9 – Predicted Boomerang Creek annual maximum EC variation downstream of the Project

7.3.8 Release scenarios

The OPSIM model was used to assess the release (spill or transfer) from sediment dams and DD1. No other dams or storages are predicted to release to the receiving waters. The release scenarios that were investigated include:

- Scenario 1 – The highest EC release from the sediment dams; and
- Scenario 2 – The highest flow rate release from the sediment dams.

The release events were compared to the WQO levels outlined in Section 3.

7.3.8.1 Scenario 1 – Sediment dams highest EC release

The cumulative release with the highest EC from the Project occurs during Stage 2 at approximately 646 µS/cm with a flow rate of approximately 0.54 ML/d. Figure 7.10 and Figure 7.11 show the release rate and EC compared to the rates in the receiving waters. The WQO levels outlined in Section 3 are also shown.

The OPSIM model predicts that during the Scenario 1 release, the release causes a minor increase to EC levels in the receiving waters. This is due to the low flow rate of the release in comparison to the high flows within the receiving waters. The model predicts that during the event both the EC levels of the release, and receiving waters remain above the high flow WQO but below the baseflow WQO. It is noted that for this assessment, the assumed receiving waters EC level (300 µS/cm) is greater than the high flow WQO of 250 µS/cm.

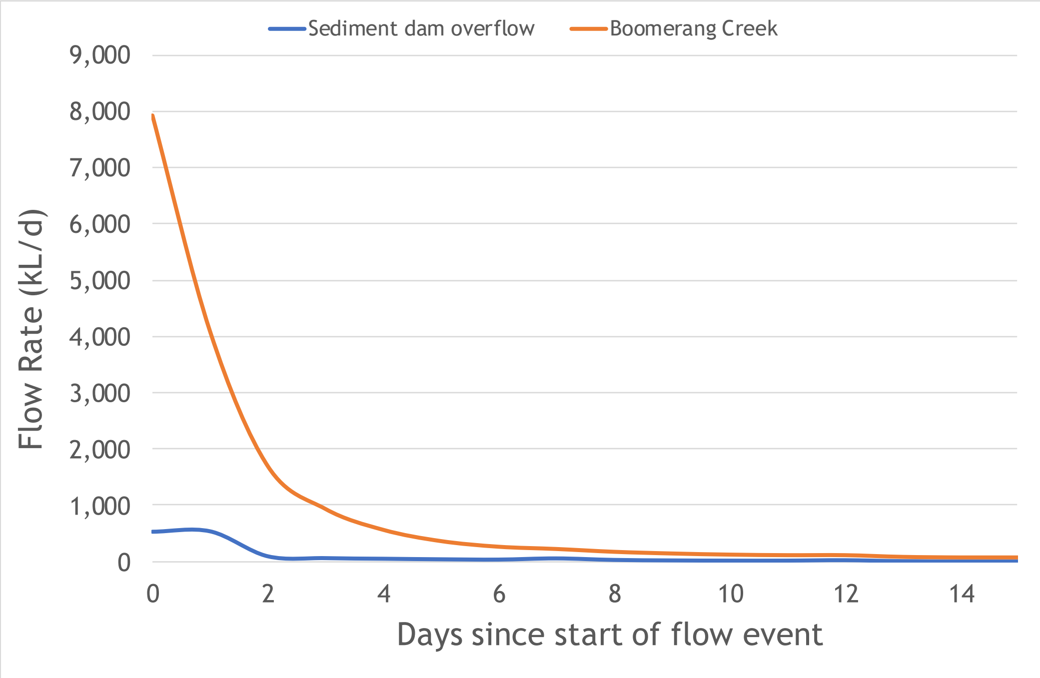


Figure 7.10 - Project release rate compared to flow rate in the receiving waters - Scenario 1

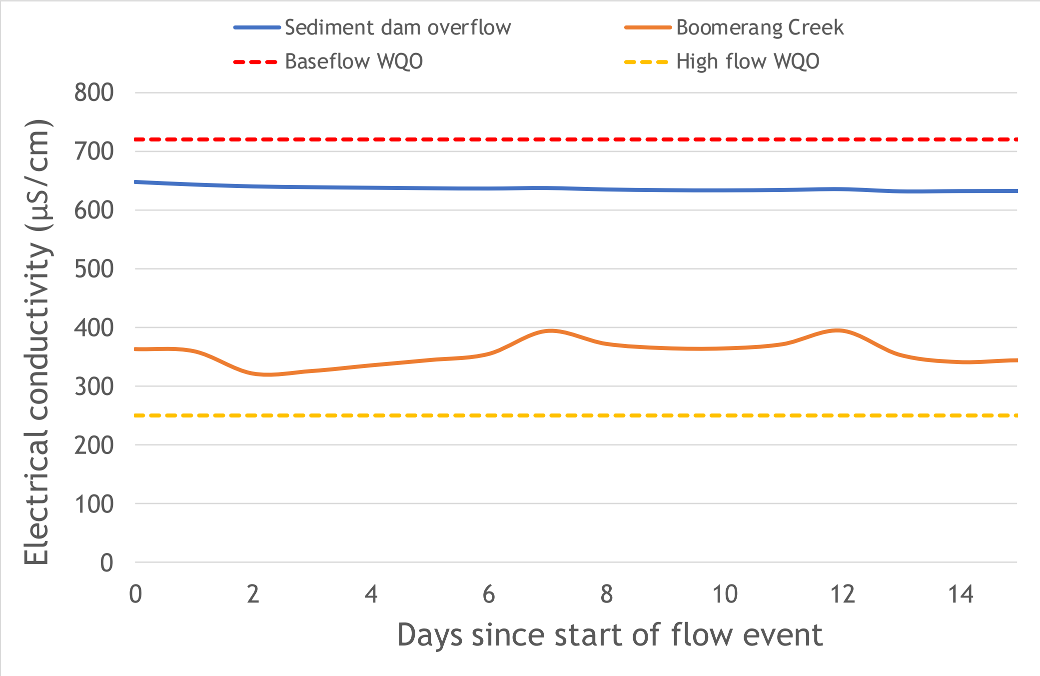


Figure 7.11 - Project release EC levels compared to EC levels in the receiving waters and corresponding water quality criteria - Scenario 1

7.3.8.2 Scenario 2 – Sediment dam highest flow rate

The Scenario 2 highest release rate occurs during Stage 1 with a cumulative release of approximately 39 ML/d. Figure 7.12 and Figure 7.13 shows the Scenario 2 release rate and EC from the cumulative release compared to the flow rate and EC in Boomerang Creek during and following the release event.

The OPSIM model predicts that during the Scenario 2 release, Boomerang Creek will already have a very large flow. The cumulative release has a negligible effect on the Boomerang Creek EC levels due to the already high flows present. The model predicts that during the event both the EC levels of the release, and within Boomerang Creek remain above the high flow WQO but below the baseflow WQO. It is noted that for this assessment, the assumed Boomerang Creek EC is greater than the high flow WQO of 250 µS/cm.

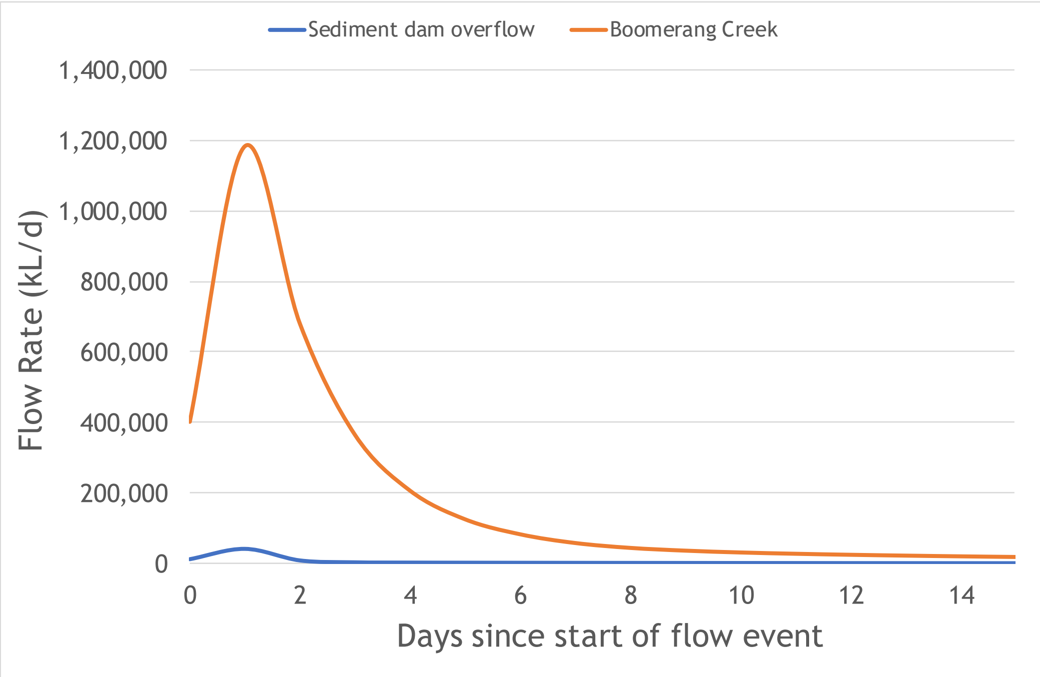


Figure 7.12 – Project release rates compared to flow rates in the receiving waters- Scenario 2

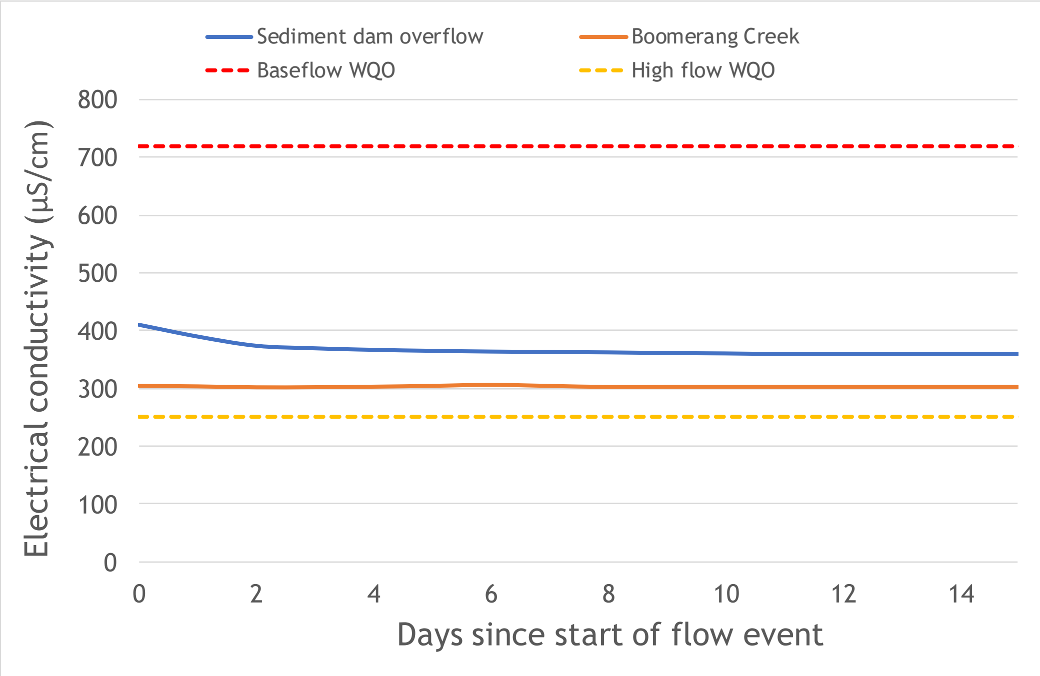


Figure 7.13 - Project release EC levels compared to EC levels in the receiving waters as well as the corresponding water quality criteria - Scenario 2

7.4 SENSITIVITY ANALYSIS

7.4.1 Haul road dust suppression

A sensitivity analysis was undertaken by varying the haul road dust suppression demand to assess the potential impacts on the overall water balance and MWD spill risk.

As outlined in Section 7.3, haul road dust suppression has the biggest influence on the Project water and salt balance. The haul road dust suppression demand has been estimated using the methodology outlined in Section 6.5.1. It is likely that the dust suppression demand will vary over the mine life as operations progress, as well as climatic and seasonal conditions. The haul road dust suppression is therefore likely the largest uncertainty for the water balance model and will have the greatest effect on the overall water balance.

A preliminary haul road dust suppression demand estimate of 1.33 ML/d was adopted for the sensitivity assessment based on preliminary rates adopted for the bulk sample project.

Figure 7.14 shows the annual maximum MWD1 inventory, Figure 7.15 shows the annual maximum Jupiter mine pit inventory and Figure 7.16 shows the forecast annual total external water requirement for the sensitivity assessment.

The results of the sensitivity analysis indicate that:

- Less water would accumulate in onsite water storages and the Jupiter Pit when compared to the base case:
    - Under 10%ile conditions, MWD1 would store up to 85 ML in Stage 1 and 78 ML in Stage 2 when compared with 91 and 80 ML respectively in the base case;
    - During Stage 1, MWD1 would only be filled to capacity in wettest (1%ile) conditions when compared with the 5%ile condition in the base case; and
    - During Stage 2, under 1%ile conditions the Jupiter pit would store up to 54 ML compared to 129 ML in the base case.

- More external water would be required to meet site water demands. During the driest climatic conditions (1%ile), external water demand would be up to 542 ML/annum in Stage 1 and 748 ML/annum in Stage 2. The maximum predicted base case external water demand is up to 272 ML/annum during Stage 1 and 478 ML/annum during Stage 2; and
- No mine affected water dam spills to the environment occur for this sensitivity assessment and the base case.

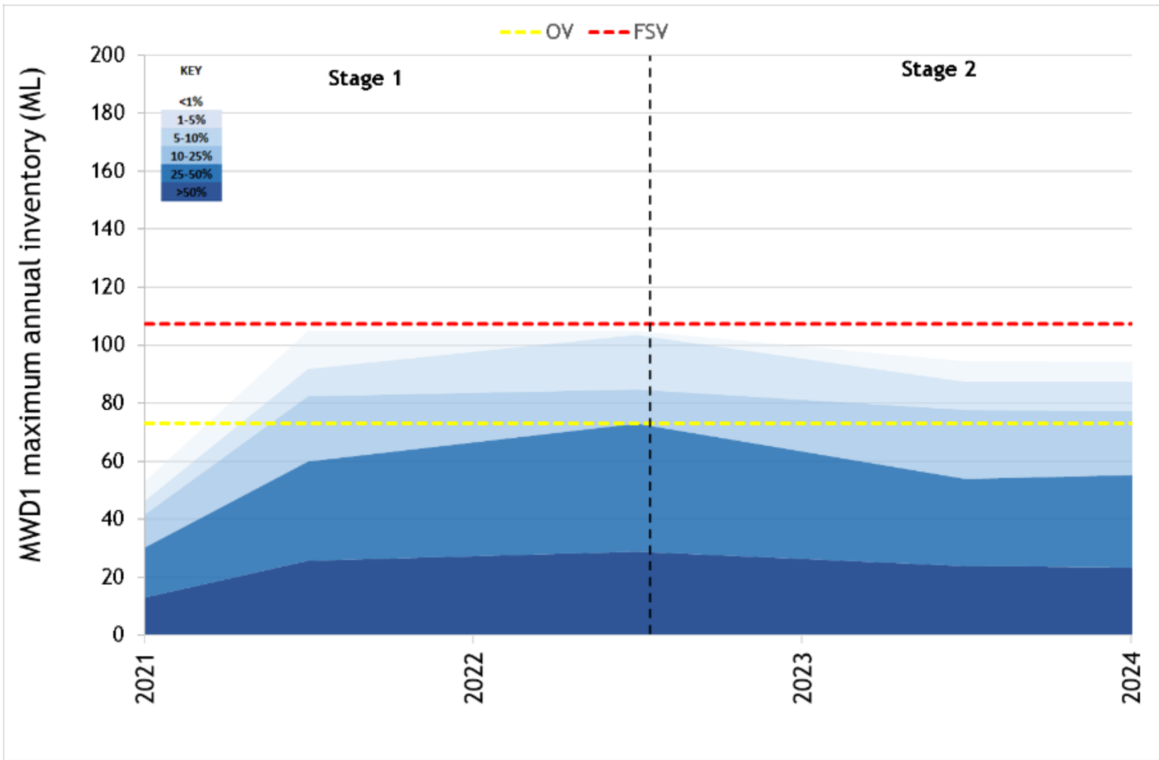


Figure 7.14 – Forecast annual maximum MWD1 inventory – dust suppression sensitivity analysis

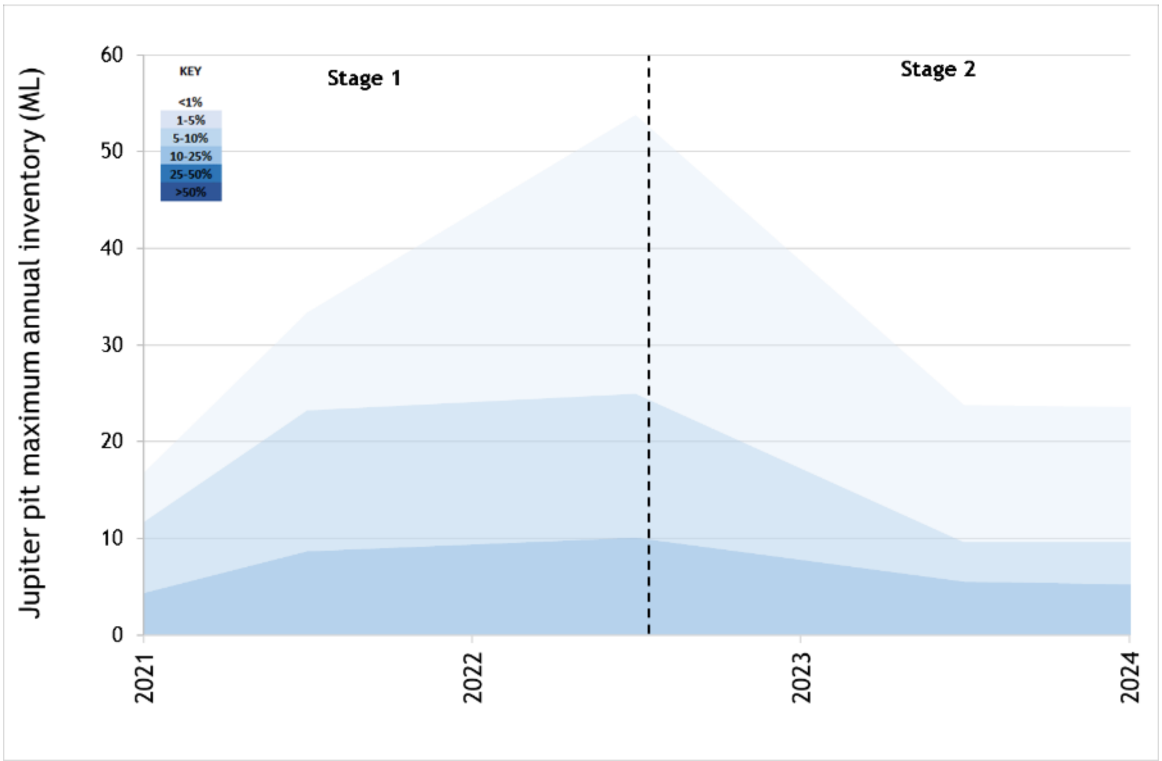


Figure 7.15 – Jupiter forecast annual maximum mine pit inventory – dust suppression sensitivity analysis

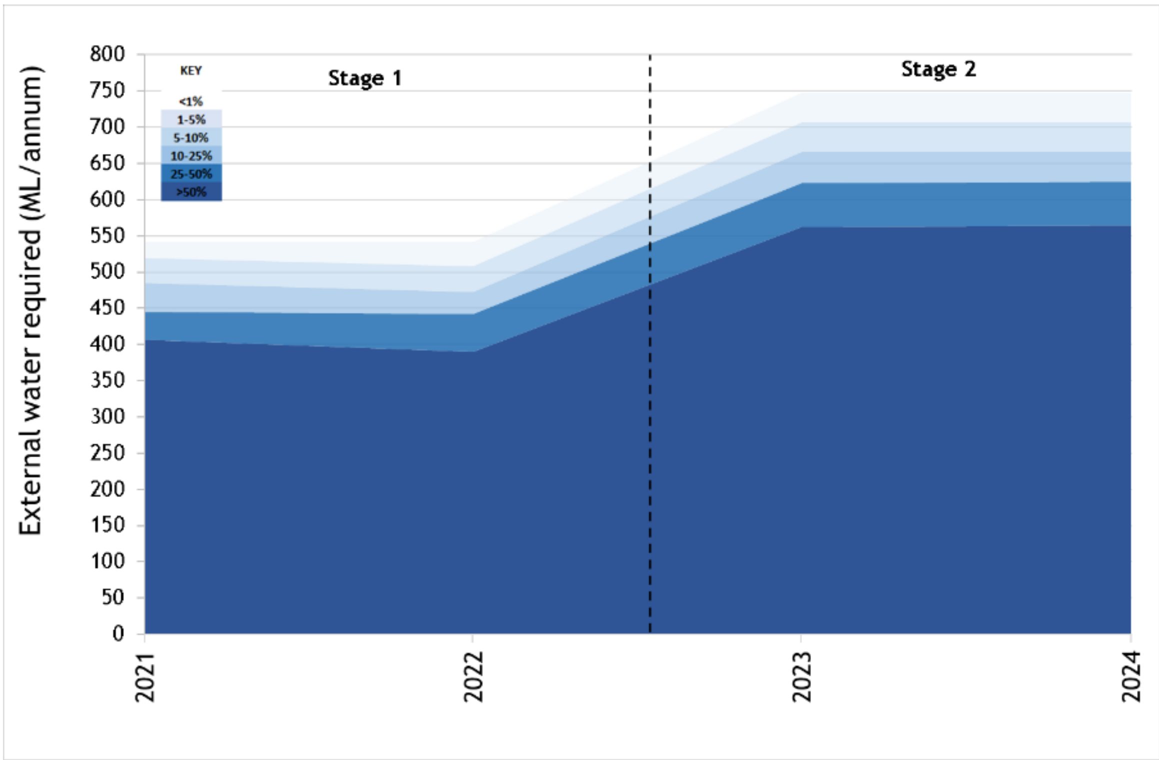


Figure 7.16 – Forecast annual total external water requirement – dust suppression sensitivity analysis

7.4.2 Climate change

The potential changes to climate within the operational life of the Project were assessed using the projections and methodologies given in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Commonwealth Bureau of Meteorology (BoM) report entitled "Climate Change in Australia Technical Report" (CSIRO, 2015). This report provides guidance on the possible projections of future climate for the Australian East Coast based on a current understanding of the climate system, historical trends and model simulations of the climate response to changing greenhouse gas and decreasing aerosol emissions.

Projections are given for a number of climatic variables including (but not limited to) temperature, rainfall, wind speed and potential evapotranspiration. CSIRO (2015) presents a number of possible approaches to quantify risks associated with climate change impacts.

For this assessment, the Representative Concentration Pathway 4.5 (RCP4.5) emissions scenario has been adopted. Potential changes in climate have been obtained using the projection builder tool provided in the Climate Change Australia website. Climate variable inputs for the 'best case', 'maximum consensus' case 'and 'worst case' RCP4.5 climate change scenarios are provided in Table 7.3.

Temperatures are expected to increase by approximately 1°C, rainfall is expected to decline by between 3% and 10% and evapotranspiration is expected to increase by between 3% and 4%.

The climate variable inputs (rainfall and evaporation) to the Project water balance model were adjusted to undertake the climate change impact assessment. Table 7.3 shows the adopted climate projections for the 'best case' and 'worst case' RCP4.5 climate change scenarios. The 'maximum consensus' scenario has not been run as it falls between 'best case' and 'worst case' scenarios.

Table 7.3 - Projections of changes to climate

Scenario	Climate model	Mean surface temperature	Rainfall	Evapotranspiration
		Annual change	Annual change	Annual change
Best case	MIROC5	1.02°C	-3.1%	3.2%
Maximum consensus	MIROC5	1.02°C	-3.1%	3.2%
Worst case	GFDL-ESM2M	1.07°C	-10.4%	3.9%

Figure 7.17 and Figure 7.18 show the forecast annual modelled demand for water from external sources for the 'best' and 'worst' case climate scenarios in comparison to the base case results.

The model results are summarised as follows:

- 'Best' case climate scenario (Figure 7.17):
  - For the 1%ile results (very dry climatic conditions), the 'best' case modelled annual external water demands are up to 7.0 ML/a higher than the base case results; and
  - For the 50%ile results the 'best' case modelled annual external water requirement be up to 16.0 ML/a higher than the base case results.
- 'Worst' case climate scenario (Figure 7.18):

- For the 1%ile results (very dry climatic conditions), the 'worst' case modelled annual external water demands are up to 12 ML/a higher than the base case results; and
- For the 50%ile conditions, the 'worst' case modelled annual external water requirements are up to 41 ML/a higher than the base case.

There is an increase in external water demand requirements under both the 'best' and 'worst' climate scenarios, when compared with the base case results. This is due to the increase in evaporation and decrease in rainfall under both scenarios.

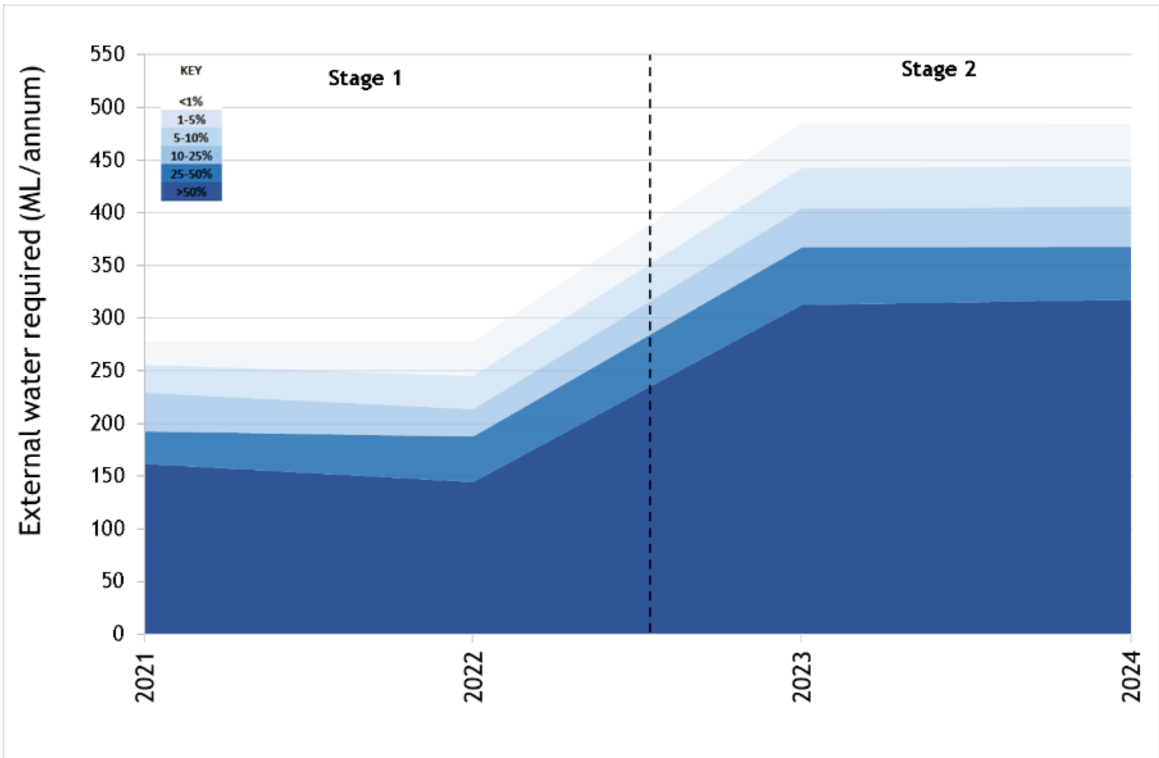


Figure 7.17 - Forecast annual total external water requirement - climate change 'best case' sensitivity analysis

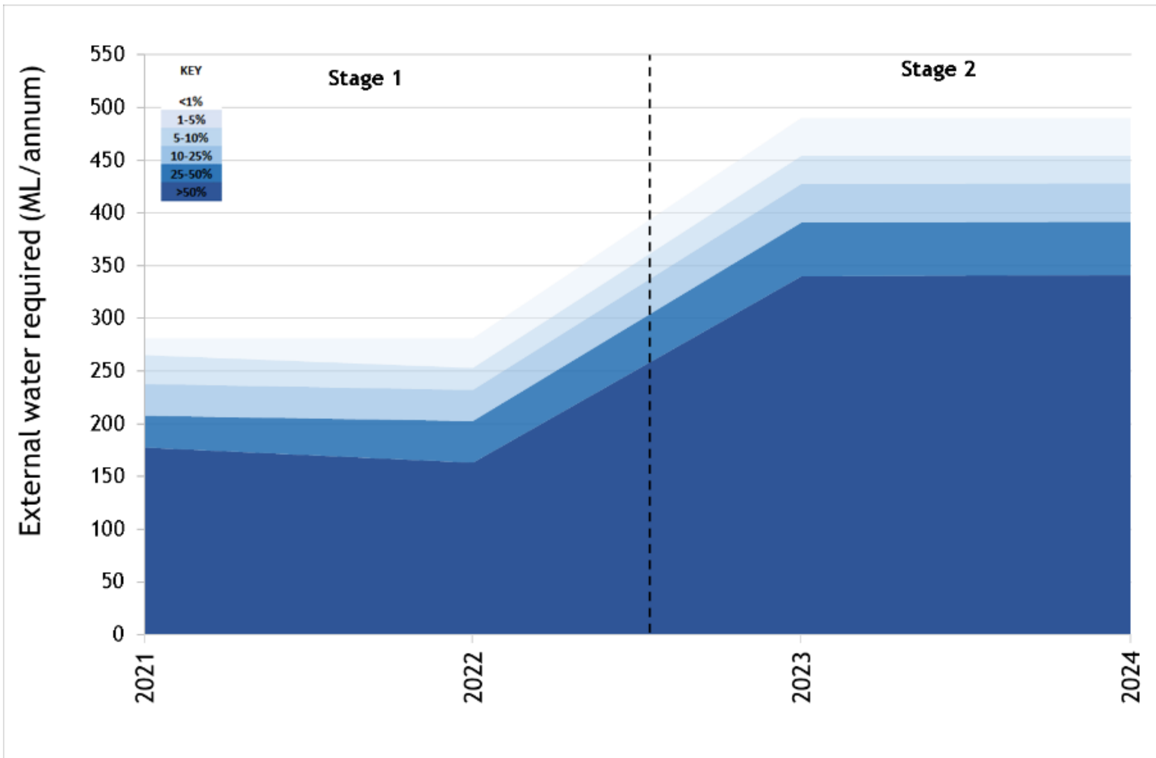


Figure 7.18 – Forecast annual total external water requirement – climate change 'worst case' sensitivity analysis

7.5 ADAPTIVE MANAGEMENT OF THE WATER MANAGEMENT SYSTEM

The model results presented above represent the application of the proposed water management system rules over the mine life, regardless of climatic conditions. There are numerous options for adaptive management of the mine water system to respond to climatic conditions and the current site water inventory in a way that will reduce the risks of impacts to surface water resources.

A site water balance model will be developed once the mine is operational and will be updated regularly (annually or biennially) using site monitoring data.

8 Flood modelling and impact assessment

8.1 OVERVIEW

The drainage features that cross the Project have been assessed to determine the potential impact of the Project on flood behaviour including:

- The potential to impact on flood levels;
- The potential to increase the extent of flooding;
- The potential to increase erosion and/or sedimentation of the impacted waterways;
- The potential to impact on the morphology of the adjacent floodplains; and
- The potential loss of flow from the catchment.

8.2 ADOPTED METHODOLOGY

8.2.1 Hydrological model

A hydrological model was developed for the Boomerang Creek and Hughes Creek catchments, including the features that cross the Project area, using the XP-RAFTS runoff-routing software (Innovyze, 2019). Section 8.2 describes the development, configuration and calibration of the hydrological model.

There was no publicly available recorded streamflow data in the drainage lines that cross the proposed Project area to calibrate the model. As a result, the XP-RAFTS design discharges estimated for Boomerang Creek and Hughes Creek catchments were validated against the Rational Method for the 10% and 1% AEP design flood event.

The Phillips Creek catchment was also included in the hydrologic model because of the availability of recorded water levels and flows. The peak 10% and 1% AEP design discharges estimated for Phillips Creek by the XP-RAFTS model were validated against a Flood Frequency Analysis (FFA) of the annual series peak discharges recorded at the (now closed) Phillips Creek at Tayglen streamflow gauge.

Design flood hydrographs estimated using the calibrated XP-RAFTS model were adopted as inflows in the hydraulic model.

8.2.2 Hydraulic model

The TUFLOW model was used to estimate design flood levels, velocities and extents in Boomerang Creek and its tributaries across the Project area for the 10% (1 in 10) AEP, 1% (1 in 100) AEP and 0.1% (1 in 1000) AEP design flood events for the Pre-mining Conditions, Operational Conditions and the proposed Final Landform Conditions. The model results were used to assess the potential impacts on flood levels, velocities and extents along Boomerang Creek for the Operational and Final Landform Conditions. Section 8.3 and Section 8.4 describe the development and configuration of the hydraulic model and Section 8.5 and Section 8.6 provide the flood modelling results and impact assessment.

8.3 CONDITIONS ASSESSED

8.3.1 General

The potential flood impacts of the Project were assessed for the following two conditions:

- Pre-mining (2019) Conditions;
- Operational Conditions; and

- Post-closure Conditions.

The Project proposes to modify BMA's existing drainage diversion and levee as part of the EA amendment. The Operational Conditions were assessed against the Pre-mining Conditions assuming that the levee would remain operational over the life of the project. Two haul road crossing options of the existing drainage diversion and BMA levee were assessed as part of the Operational Conditions.

For Post-closure Conditions, two possible levee scenarios were considered for the existing drainage diversion and levee to ensure that the Project could cater for future modification/removal of this structure by others. The two scenarios assessed for the Post-closure flood impact assessment were:

- The existing drainage diversion and levee remains operational after the completion of the Project; and
- The existing drainage diversion and levee is removed by others at some time in the future after the completion of the Project.

8.4 EXISTING CONDITIONS HYDROLOGIC MODEL CONFIGURATION

8.4.1 General

Figure 8.1 shows the configuration of the XP-RAFTS model of the Boomerang, Hughes and Phillips Creek catchments. The model consists of a total of 94 sub-catchments, ranging in size from 0.1 km^2 to 59.8 km^2. This includes 50 sub-catchments for Boomerang Creek, 30 sub-catchments for Hughes Creek, 3 sub-catchments for Barrett Creek and 11 sub-catchments for Phillips Creek.

The XP-RAFTS model uses a single sub-catchment approach to determine runoff hydrographs, based on the overall sub-catchment parameters (fraction impervious, slope and roughness). All sub-catchments were assigned a fraction impervious of 0%, catchment slope based on the available topographic data and a Manning's n (roughness) of 0.04. Channel routing was modelled using the Muskingum-Cunge method, based on the channel length and average channel slope for each "link" between catchment nodes.

8.4.2 Design rainfall depths, intensities and temporal patterns

Design rainfall depths and intensities for the design events were derived using intensity-frequency duration (IFD) data obtained from the Bureau of Meteorology's (BOM's) 2019 Rainfall IFD Data System.

The East Coast North temporal patterns were adopted for events up to the 1% AEP as per recommendations in Australian Rainfall and Runoff (AR&R) Data Hub (Geoscience Australia, 2019). For the 0.1% AEP event, one temporal pattern was applied to each storm duration. The 0.1% AEP temporal patterns were adopted from the Generalised Short Duration Method (GSDM) (BOM, 2003) for storm durations of 6 hours and less.

8.4.3 Design rainfall losses

The initial (IL) and continuing loss (CL) method of accounting for rainfall losses was adopted for this assessment. The recommended regional IL and CL values for the Boomerang Creek and Hughes Creek catchments from the AR&R Data Hub (Geoscience Australia, 2019), were 45 mm (prior to adjustment for preburst rainfall) and 1.9 mm/hr respectively. The IL and CL adopted for the 0.1% AEP was 0.0 mm and 1.9 mm/h respectively.

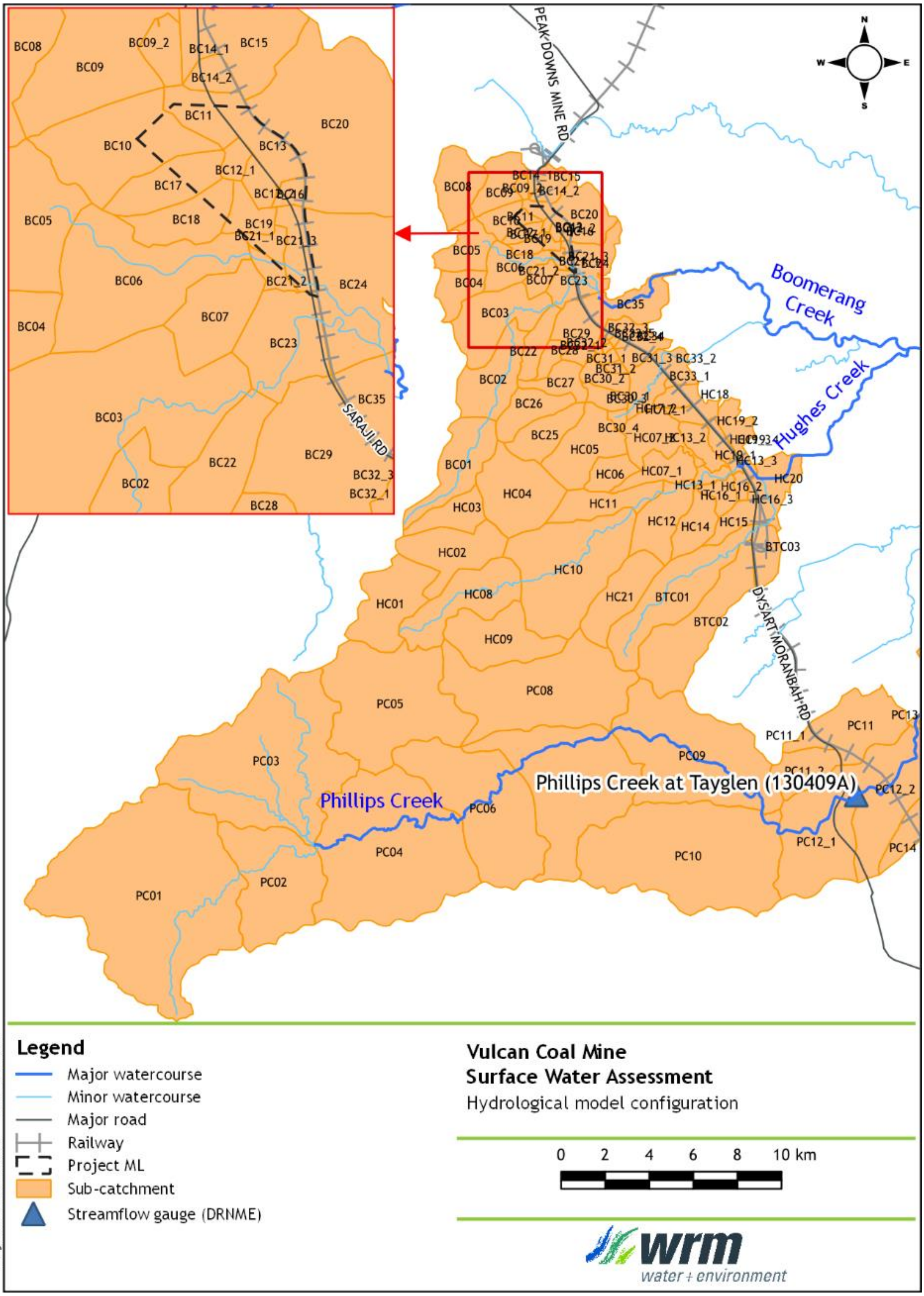


Figure 8.1 – XP-RAFTS model configuration

8.4.4 Peak flow validation

8.4.4.1 Boomerang Creek catchment

The Rational Method was used to validate the 10% and 1% AEP design flood discharges in Boomerang Creek estimated by XP-RAFTS. Table 8.1 compares the XP-RAFTS design discharge estimates for Boomerang Creek at BC11 and BC17 against the Rational Method estimates. The table shows that the design discharges derived by the XP-RAFTS model are generally within 15% of the Rational Method estimates.

Table 8.1 – Peak design discharge comparison between XP-RAFTS and Rational Method

Sub-catchment ID (see Figure 8.1)	Sub-catchment area (ha)	AEP event (%)	Design Discharge (m^3/s)		
			Rational Method	XP-RAFTS	Difference
BC11	61	10%	3.8	3.3	-0.5
		1%	6.7	7.2	0.5
BC17	107	10%	8.1	7.2	-0.9
		1%	14.0	15.5	1.5

8.4.4.2 Phillips Creek catchment

The results of the XP-RAFTS model for Phillips Creek were validated by comparing the peak design discharges from XP-RAFTS to the results of a FFA undertaken to the annual flood peak series from DNRME's Tayglen gauge (gauge no. 130409A), which operated between 1968 and 1988. The catchment to the gauge is approximately 344 km^2.

The results compared in Table 8.2 show that the XP-RAFTS 1% AEP peak discharge compares reasonably well with the FFA expected result. The 10% AEP XP-RAFTS peak discharge overestimates the FFA peak discharge, however it is within the 90th percentile confidence limits.

Table 8.2 - FFA at Tayglen gauge compared to XP-RAFTS peak discharge

Design event	XP-RAFTS design peak discharge (m^3/s)	FFA design peak discharges (m^3/s)			% Difference
		Expected result	Lower confidence limit	Upper confidence limit	
10%	490	376	227	622	23%
1%	1,109	1,083	402	2,922	2%

8.4.4.3 Summary

Overall, the XP-RAFTS hydrological model is considered satisfactorily validated and acceptable for estimating design hydrographs for input into the hydraulic model.

8.4.5 Adopted design discharges

Table 8.3 shows the adopted peak design discharges estimated by the XP-RAFTS model at key locations in the vicinity of the Project area for the 10%, 1% and 0.1% AEP design flood events. Table 8.3 also shows the critical storm durations and representative temporal patterns producing the peak discharge at each location.

Table 8.3 - Adopted design discharges, critical storm durations and temporal pattern

Key location	AEP event (%)	XP-RAFTS Ensemble mean peak discharge (m^3/s)	XP-RAFTS adopted design peak discharge (m^3/s)[1]	Critical storm duration (hours)	Temporal pattern number
Boomerang Creek at Peak Downs (BC35)	10%	236.1	236.8	6	7*
	1%	520.5	520.9	6	6
	0.1%	NA	1,037.1	3	NA
Drainage Line 2 upstream of Saraji Road (BC06)	10%	50.9	51.5	3	4*
	1%	102.4	102.8	2	8*
	0.1%	NA	233.4	2	NA
Drainage Line 3 at Saraji Road (BC23)	10%	69.4	71.0	6	7
	1%	164.7	166.8	6	2*
	0.1%	NA	323.9	3	NA
Drainage Line 4 at Saraji Road (BC29)	10%	68.5	70.2	6	4
	1%	143.1	145.2	4.5	2
	0.1%	NA	342.4	2	NA

NA – not applicable; Note that the 1 hour to 6 hour storm durations were all run in the hydraulic model for the 0.1% AEP event.
[1]Adopted design peak discharge calculated from the temporal pattern which generated a peak discharge closest to, but higher than, the ensemble mean.

*Indicates the selected temporal pattern run in the hydraulic model.

8.5 HYDRAULIC MODEL DEVELOPMENT

The two-dimensional TUFLOW hydraulic model (BMT, 2018a) was used to simulate the flow behaviour of Boomerang Creek and its tributaries in the vicinity of (and through) the proposed Project area.

TUFLOW represents hydraulic behaviour on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow (BMT, 2018b). The model automatically calculates breakout points and flow directions within the study area. A 2 m grid cell size was adopted to obtain the best representation of flow distributions between the drainage channels, drainage diversions, hydraulic structures (e.g., culverts) and floodplains.

8.5.1 Topographic data

The TUFLOW model used topographic aerial survey data (LiDAR) supplied by Aerometrex Pty Ltd via Vitrinite. The ground surface data was obtained by LiDAR capture on 7, 8 and 27 May 2019. Aerometrex Pty Ltd quote that the LiDAR data has a vertical root mean squared error of 0.0755 m.

8.5.2 Inflow and outflow boundaries

Figure 8.2 shows the locations of the 2D inflow and outflow boundaries used in the TUFLOW model. The discharge hydrographs estimated using the XP-RAFTS runoff-routing model were adopted as inflows to the TUFLOW model.

Normal depth outflow boundaries were adopted at Peak Downs's Boomerang Creek diversion, located 3.5 km downstream of the Project area to ensure that the boundary assumptions have no material impact on peak flood levels in the study area. The adopted tailwater slope for the Boomerang Creek diversion was set at 0.0025 m/m.

8.5.3 Manning's 'n' values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance. Manning's 'n' values were adopted based on typical published values (e.g. Chow (1959)) and consistent with Manning's 'n' value adopted in nearby flood studies. Manning's 'n' values were mapped within the study area based on aerial photography taken on 27 May 2019. The following Manning's 'n' values were adopted:

- Vegetated channels: 'n' = 0.060;
- Rocky channels: 'n' = 0.045;
- Light vegetation: 'n' = 0.050;
- Dense vegetation: 'n' = 0.080;
- Exposed soil / unsealed roads: 'n' = 0.025;
- Water bodies / dams: 'n' = 0.015;
- Sealed roads: 'n' = 0.020; and
- Buildings: 'n' = 0.300.

8.5.4 Hydraulic structures

There are 21 culvert structures modelled as 1d structures in the 2d domain. The culvert locations are shown in Figure 8.2 and include the culverts beneath Saraji Road and the Norwich Park Branch Railway.

The culvert structures within the Peak Downs and Saraji mining leases were modelled as gaps or openings to represent the culverts as information on these structures was not available for this study.

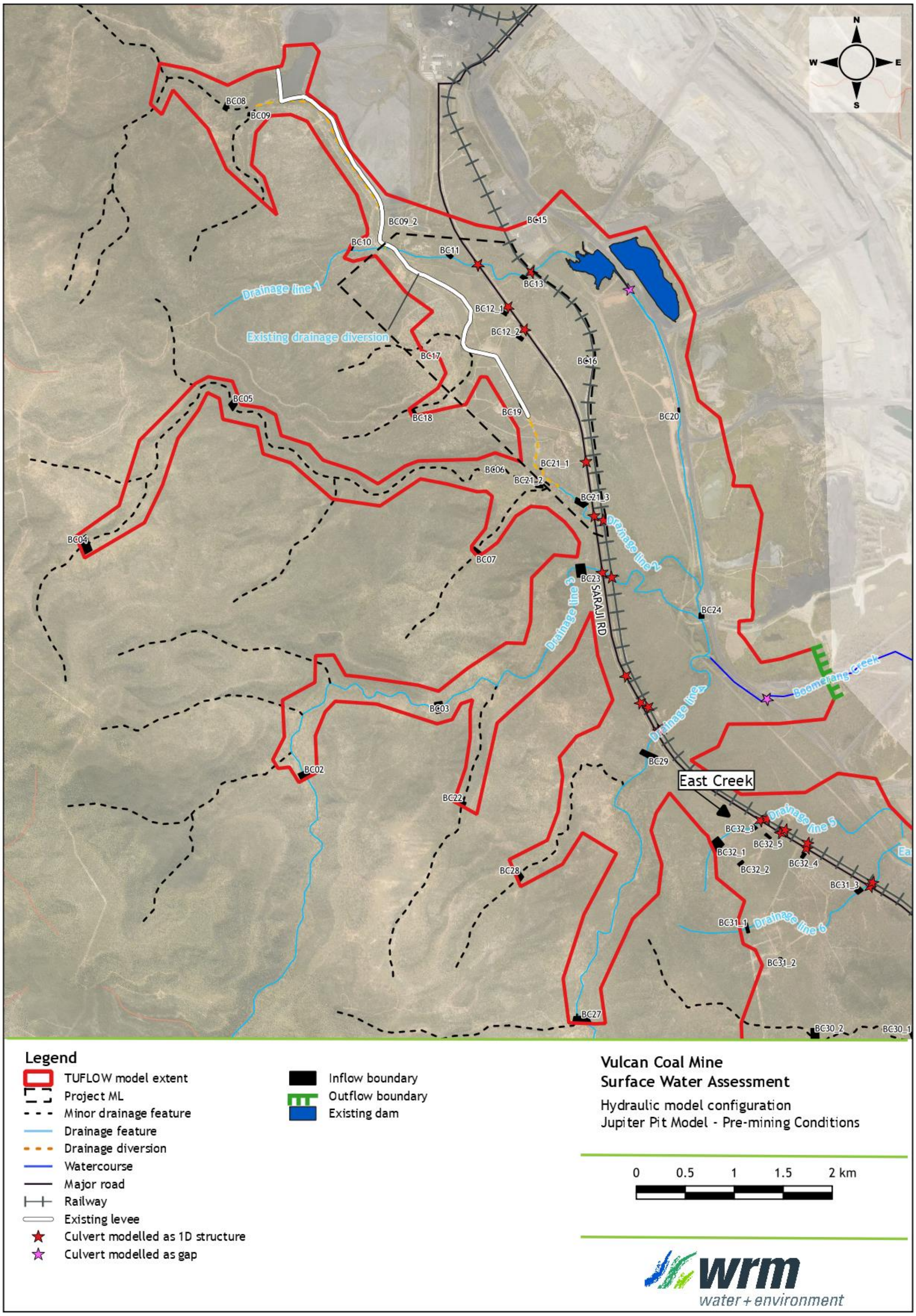


Figure 8.2 – Jupiter Pit Pre-mining Conditions hydraulic model configuration

8.6 CHANGES TO PRE-MINING CONDITIONS

8.6.1 Operational Conditions model changes

The Pre-mining Conditions TUFLOW model developed for the Project was modified were updated to include mine water infrastructure required during operations. The model updates representing the Operational Conditions configuration is shown in Figure 8.3 and include:

- Proposed life-of-mine landforms and open cut pits;
- Modified inflow boundary locations to represent Operational Conditions catchment areas;
- Proposed haul road, haul road crossing and haul road culverts;
- Proposed modifications to BMA's existing drainage diversion and levee;
- Proposed rail loop and associated rail loop drainage infrastructure;
- Proposed CHPP infrastructure area;
- Proposed DD1 dam and diversion drains/bunds;
- Realignment of Saraji Road; and
- Proposed Saraji Road culverts.

8.6.2 Post-closure Conditions model changes

The Pre-mining Conditions TUFLOW model developed for the Project was modified (for both levee scenarios) to include the proposed final landform including drainage channels and the realignment of Saraji Road. The model updates shown in Figure 8.5 include:

- The proposed drainage corridor through backfilled spoil;
- Out-of-pit spoil emplacement;
- Modified inflow boundary locations to represent Post-closure Conditions catchment areas;
- Realignment of Saraji Road; and
- Proposed Saraji Road culverts.

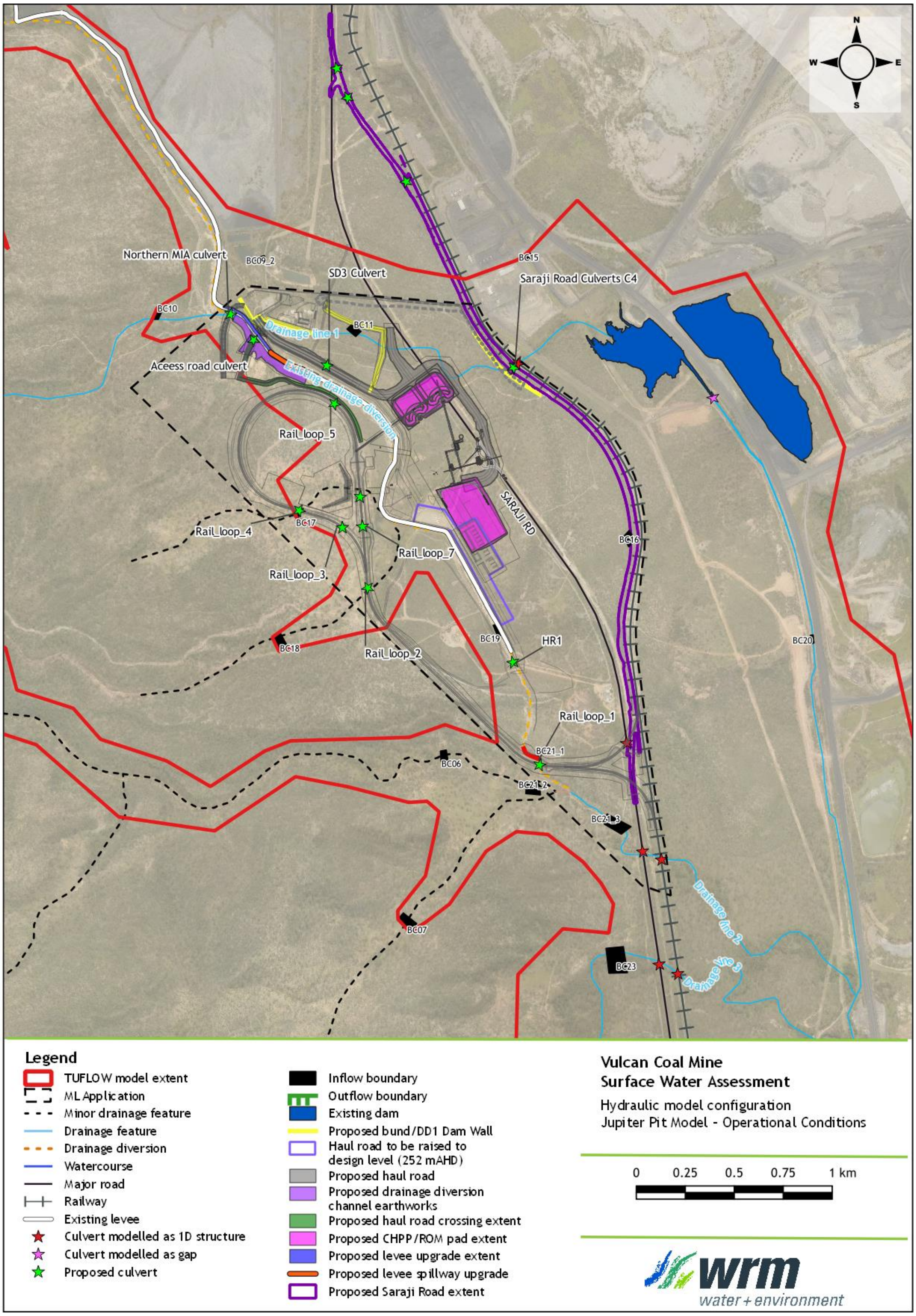


Figure 8.3 – Jupiter Pit Operational Conditions hydraulic model configuration

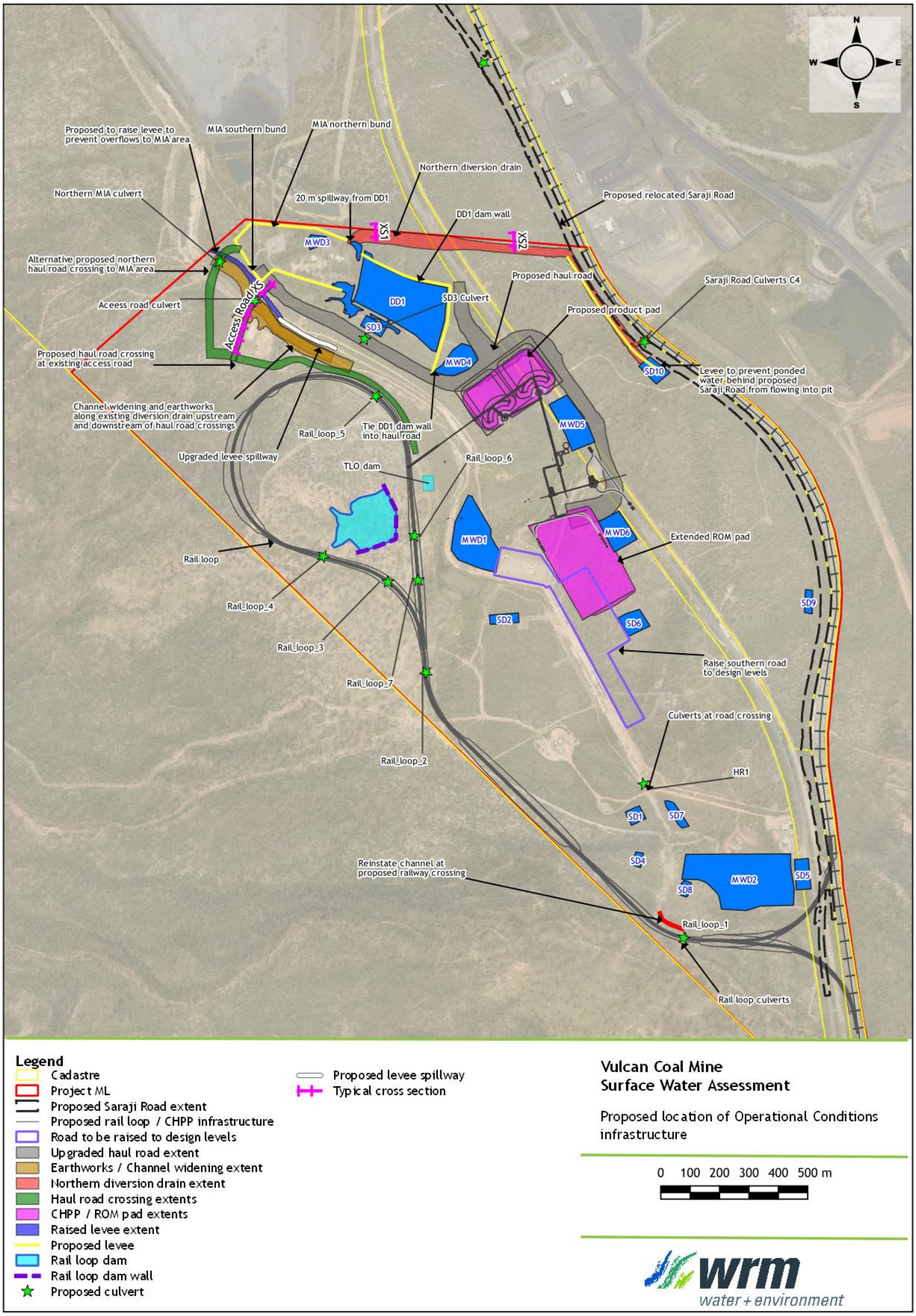


Figure 8.4 – Location and extent of Operational Conditions infrastructure changes

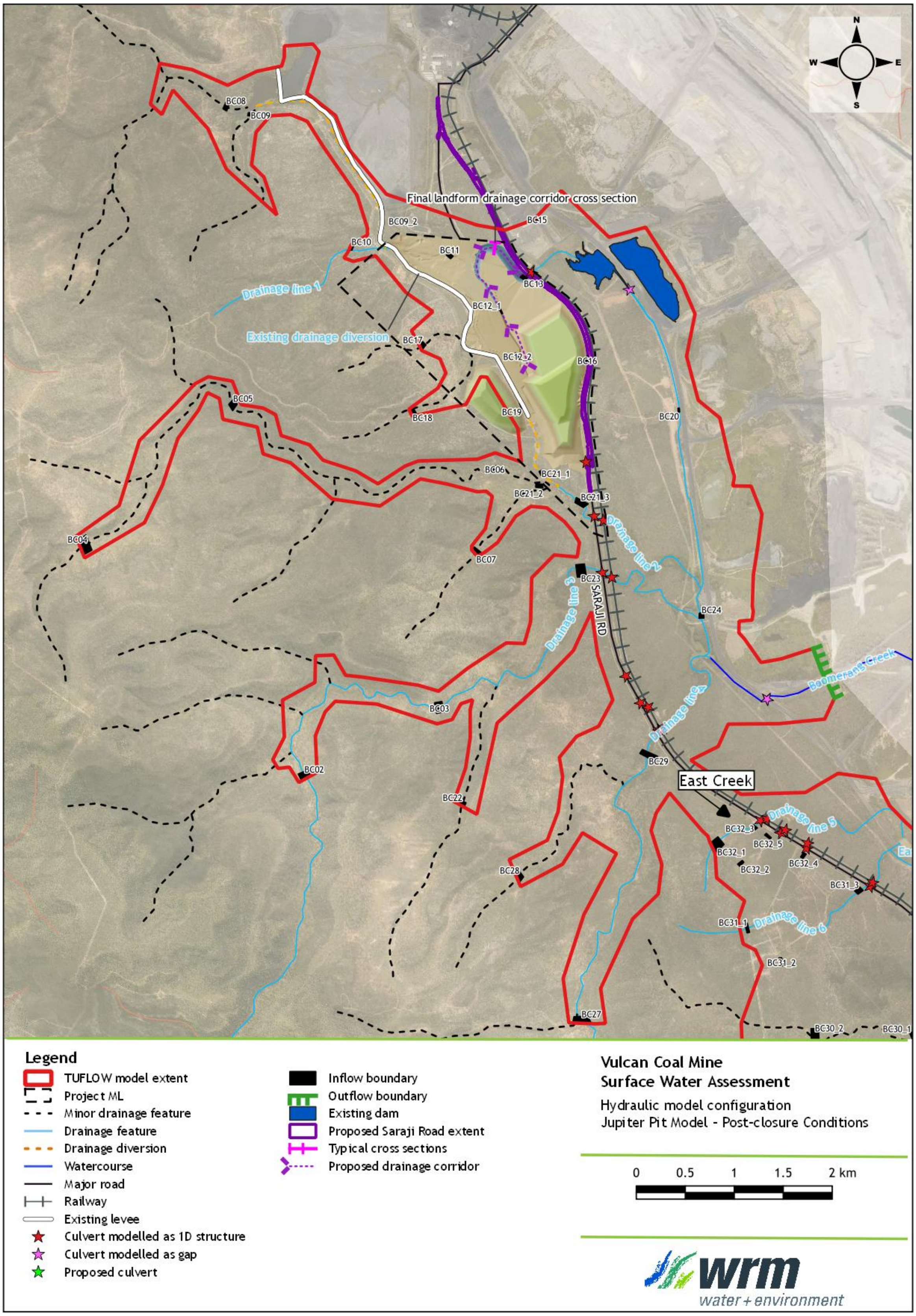


Figure 8.5 – Jupiter Pit Final Landform (Post-closure Conditions) hydraulic model configuration

8.6.3 Proposed haul road crossings and upgraded haul road

Two crossing locations shown in Figure 8.3 and Figure 8.4 were assessed under Operational Conditions as part of the EA amendment:

- Proposed haul road crossing at the existing access road; and
- Proposed haul road crossings at the northern MIA.

The proposed crossings were assessed independently as only one crossing option will be constructed. Notwithstanding this, the two options were assessed. The design surfaces of the haul road crossings were provided by JukesTodd in October and November 2021.

The haul road culvert configuration for each option was preliminarily sized by JukesTodd and confirmed using the TUFLOW model.

Additional culvert crossings were input to the TUFLOW model

Table 8.4 - Adopted culvert configuration for the proposed haul road crossings

Crossing	Type	Diameter (m)	Width (m)	No. of barrels	US invert level (mAHD)	DS invert level (mAHD)
Access road	RCBC	2.1	1.2	5	252.61	252.57
Northern MIA	RCBC	2.1	1.2	5	253.94	253.69

8.6.4 Proposed modifications to the BMA levee and existing drainage diversion

Figure 8.3 and Figure 8.4 shows the location and extent of the levee and drainage diversion modifications and Figure 8.6 shows a typical cross section proposed road crossing and channel. The Project proposes to raise a section of the existing BMA levee and undertake earthworks and channel widening along the existing drainage diversion at the northern end of the ML boundary. The proposed works would be undertaken to mitigate flood impacts of the proposed crossing of the existing drainage diversion which connects the rail loop to the upgraded haul road on the eastern side of the levee. The levee and channel upgrades were iteratively designed to mitigate the impacts of the crossing and include:

- Raising the northern section of the levee (by up to 1 m);
- Widening the existing drainage diversion channel to a base width of 30 m with a batter slope of 1V:6H on the left bank and 1V:20H on the right bank. The widened channel extends from the ML boundary to the end of the spillway (up to 550 m in length); and
- Extending the existing levee spillway width (spillway height of 253.7 mAHD) from 40 m to 200 m.

The existing drainage diversion upstream of the proposed culverts Rail_Loop_1 (see Figure 8.3 and Figure 8.4) was modified to reinstate the existing drainage diversion channel through the rail loop embankment. A similar channel width and channel slope to existing conditions was used and it is recommended that detailed design will undertake suitable erosion and scour protection at the crossing.

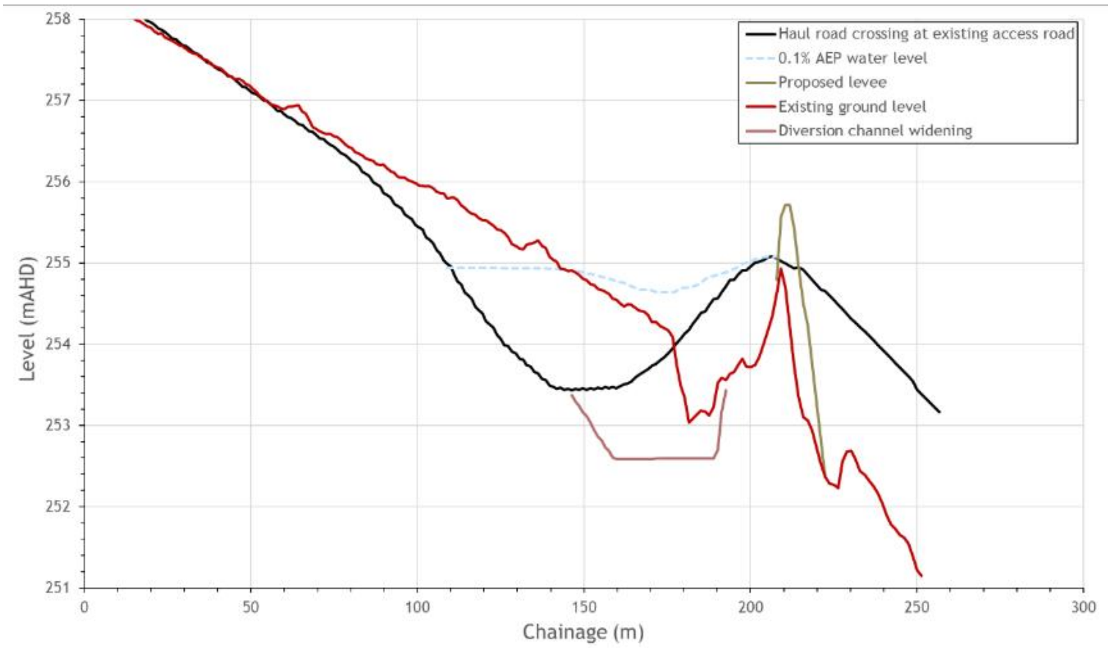


Figure 8.6 – Typical cross section (Access road XS in Figure 8.3) of the proposed levee and drainage diversion modifications at the existing access road haul road crossing upgrade

8.6.5 Proposed rail loop and culverts

Figure 8.3 and Figure 8.4 shows the proposed rail loop design which was undertaken by JukesTodd and the design surface (provided 11 November 2021) was input to the TUFLOW model. Proposed rail loop culverts were sized for the 1% AEP design event using standard culvert nomographs under *Hydraulic design manual: Hydraulics of precast concrete conduits* (CPAA, 2012). Table 8.5 shows the adopted rail loop culverts included in the model.

Table 8.5 – Adopted culvert configuration for the proposed rail loop

Culvert ID	Type	Diameter (m)	No. of barrels	US invert level (mAHD)	DS invert level (mAHD)
Rail_loop_1	CSP	4.05	2	228.7	228.1
Rail_loop_2	CSP	2.4	1	255.2	254.6
Rail_loop_3	CSP	2.7	1	252.9	252.1
Rail_loop_4	CSP	2.7	1	256.6	256.4
Rail_loop_5	CSP	1.5	1	254.5	253.8
Rail_loop_6	CSP	2.7	1	251.9	251.8
Rail_loop_7	CSP	2.7	1	251.8	251.1

8.6.6 Proposed CHPP infrastructure area

Figure 8.3 shows the design strings of the proposed CHPP infrastructure area, including the product stockpile, TLO, CHPP and extended ROM pad. The design was undertaken by Sedgman and provided in November 2021. The design surface was input to the Operational Conditions TUFLOW model.

8.6.7 Proposed DD1 dam, northern diversion drain and bunds

Figure 8.3 shows the proposed DD1 dam and dam wall which were designed to provide flood protection for the pit during a 0.1% AEP flood event (in conjunction with other drainage infrastructure). Overflows from the BMA levee are drained to two floodway crossings along the haul road into DD1. The DD1 dam wall is proposed to be constructed at least 0.5 m above the 0.1% AEP flood event across the spillway.

DD1 overflows via a 20 m wide spillway on the northern corner of the dam into a 20 m wide northern drain and 10 m wide northeastern/eastern drain adjacent to the Jupiter Pit (see typical cross sections in Figure 8.7 and Figure 8.8). A flood protection levee is constructed on the eastern side of the Jupiter Pit to prevent Jupiter Pit to prevent floodwaters backing up from behind Saraji Road and the railway from entering the Jupiter Pit.

The DD1 dam wall, DD1 spillway and northern diversion drain and eastern levee form part of the flood protection levee alignment as discussed in Section 8.6.9.

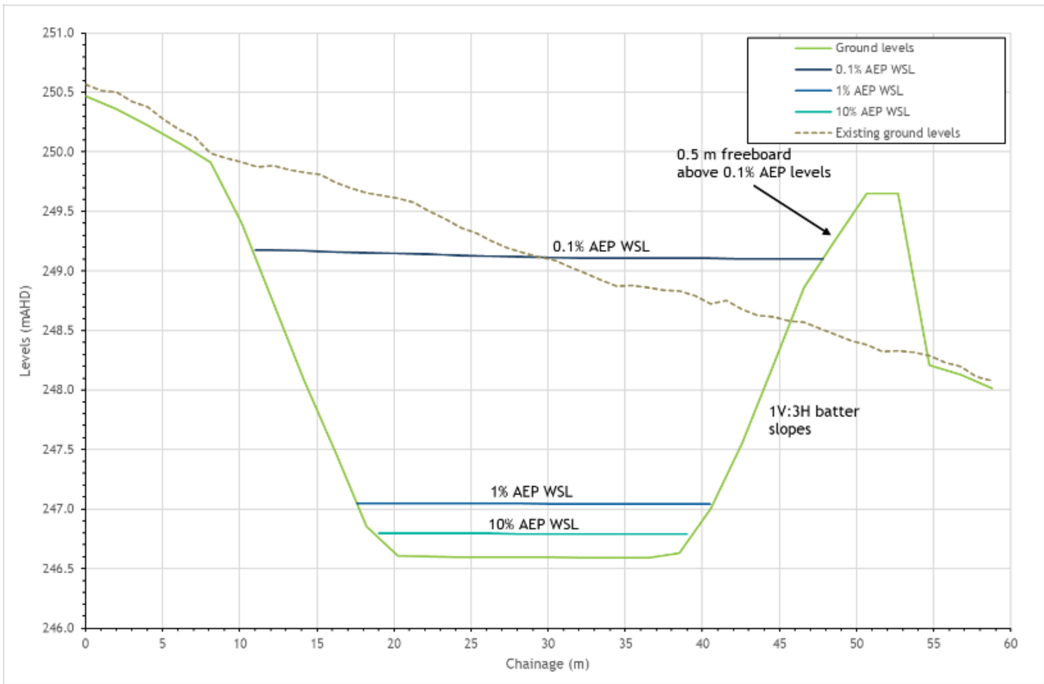


Figure 8.7 - Typical cross section (XS1 in Figure 8.3) of proposed northern diverison drain around Jupiter Pit

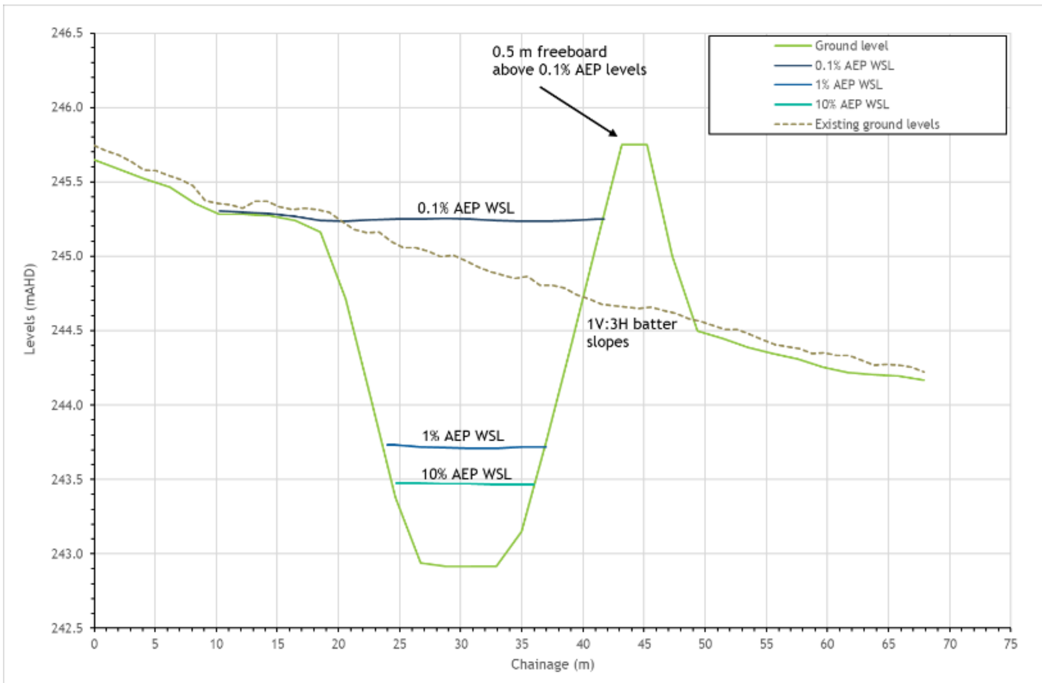


Figure 8.8 – Typical cross section (XS2 in Figure 8.3) of proposed northerneatern/eastern diverison drain around Jupiter Pit

8.6.8 Proposed Saraji Road and culverts

The proposed Saraji Road design was undertaken by Cozens Regan and the design surface provided by Vitrinite (dated 20 July 2021) was input to the hydraulic model. Figure 8.9 shows the proposed design of the Saraji Road culverts (Culverts C4 in Figure 8.3 and Figure 8.4) (undertaken by Cozens Regan), which includes invert levels, scour protection and crossing details at the Drainage Line 1 crossing. The culverts included in the TUFLOW model were four (4) 2.4 m diameter corrugated steel pipes (CSPs).

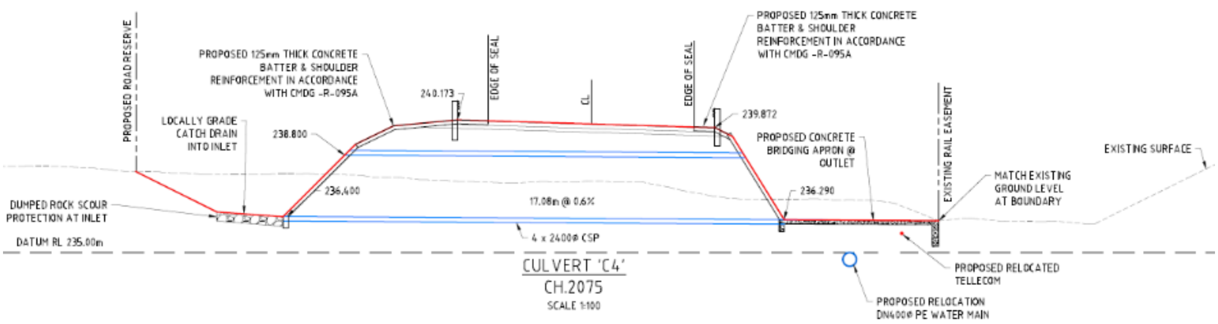


Figure 8.9 – Conceptual design of proposed Saraji Road culverts along Drainage line 1

8.6.9 Proposed flood protection levee

Figure 8.10 shows the proposed flood protection levees, which are required to act as protection from ingress of floodwaters to the mining pit for a 0.1% AEP event during the Operational Conditions of the Project. Four flood protection levees are proposed as part of the Project, with some of the infrastructure proposed for operations to act in place of a levee structure:

- The proposed haul road alignment west of the pit;
- The proposed DD1 dam wall;
- The proposed DD1 spillway and drain; and
- The proposed levee on the eastern side of the pit adjacent to the proposed Saraji Road alignment.

The levels shown in Table 8.6 are the recommended required levee crest levels determined by applying a freeboard of at least 0.5 m above the peak 0.1% AEP levels. These levels were based on the maximum of the Operational Conditions haul road crossing options (the crossing at the existing access road of the northern MIA). Figure 8.10 shows the reported chainage along the proposed flood protection levee. The results show that the proposed flood protection levees will range between 1 m and 6 m (DD1 dam wall) high.

The proposed flood protection levee configurations are preliminary only. The final horizontal and vertical alignment will be confirmed in conjunction with the proposed drainage requirements and potential existing drainage diversion failure assessments during the design phase.

Table 8.6 - 0.1% AEP flood levels adjacent to the proposed flood protection levees required for operations

Chainage (m)	Required minimum crest levee level with 0.5 m freeboard requirement included (mAHD)			
	Haul road levee	DD1 dam wall levee	DD1 drain levee	Eastern pit levee
0	250.6	249.7	249.5	242.8
50	251.6	249.7	249.4	242.5
100	251.6	249.7	248.8	241.9
150	251.7	249.7	248.6	241.5
200	251.7	249.7	248.4	241.3
250	251.7	249.7	248.3	241.2
300	251.7	249.7	248.2	241.2
350	251.7	249.7	248.1	241.2
400	251.7	249.7	247.7	241.2
450	251.7	249.7	247.3	241.2
500	251.7	249.7	246.6	241.2
550	251.7	249.7	246.0	-
600	251.7	249.7	245.3	-
650	251.7	249.7	244.7	-
700	251.7	-	244.0	-
750	251.7	-	243.1	-
800	252.4	-	-	-
850	252.4	-	-	-
900	252.4	-	-	-

950	252.5	-	-	-
1000	252.5	-	-	-
1050	252.5	-	-	-
1100	252.5	-	-	-
1150	252.4	-	-	-
1200	252.4	-	-	-
1250	252.4	-	-	-
1270	252.9	-	-	-

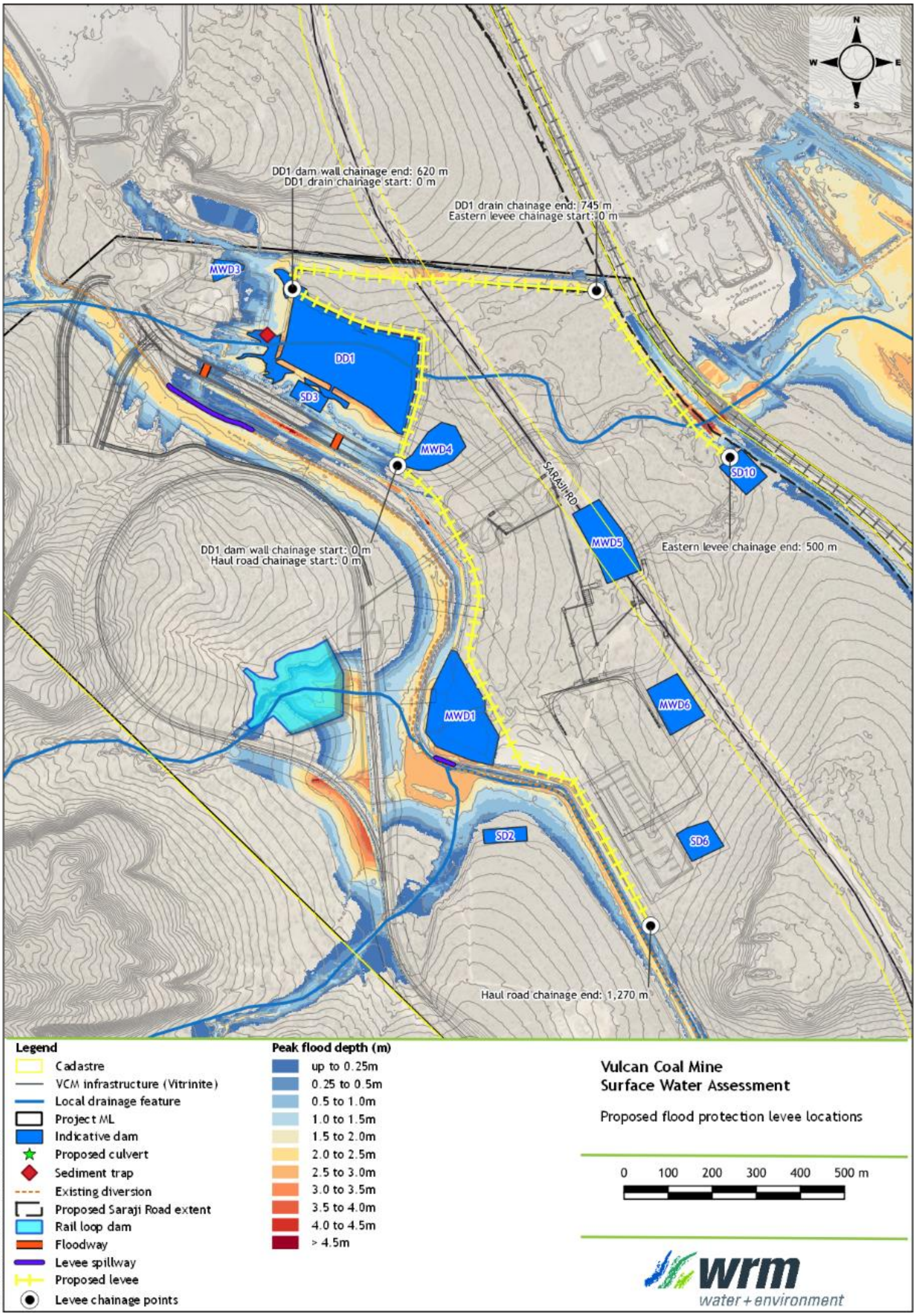


Figure 8.10 – Proposed flood protection levee alignment

8.6.10 Proposed drainage corridor

The proposed drainage corridor was designed to divert runoff from Post-closure Conditions catchments around the proposed Jupiter Final Landform to the existing Drainage Line 1 rail culverts. Figure 8.11 shows a cross-section of the proposed drainage corridor approximately 500 m upstream of the existing Norwich Park Branch Railway culverts under Post-closure Conditions (see Figure 1.4 for cross-section location). Figure 8.11 and Table 8.7 show the modelled flood levels and velocities within the proposed drainage corridor.

The preliminary sizing of the proposed drainage corridor was 40 m wide with 17% batter slopes that grade up to existing ground levels. The results show that the drainage corridor has sufficient capacity under both levee scenarios to convey flood events up to the 0.1% AEP. Refinements to the design will be required to incorporate a meandering low flow channel within the drainage corridor and will be undertaken prior to undertaking detail design. Also, careful consideration of scour protection will be required at the upstream and downstream ends of the drainage corridor as well as at tributary inflow locations.

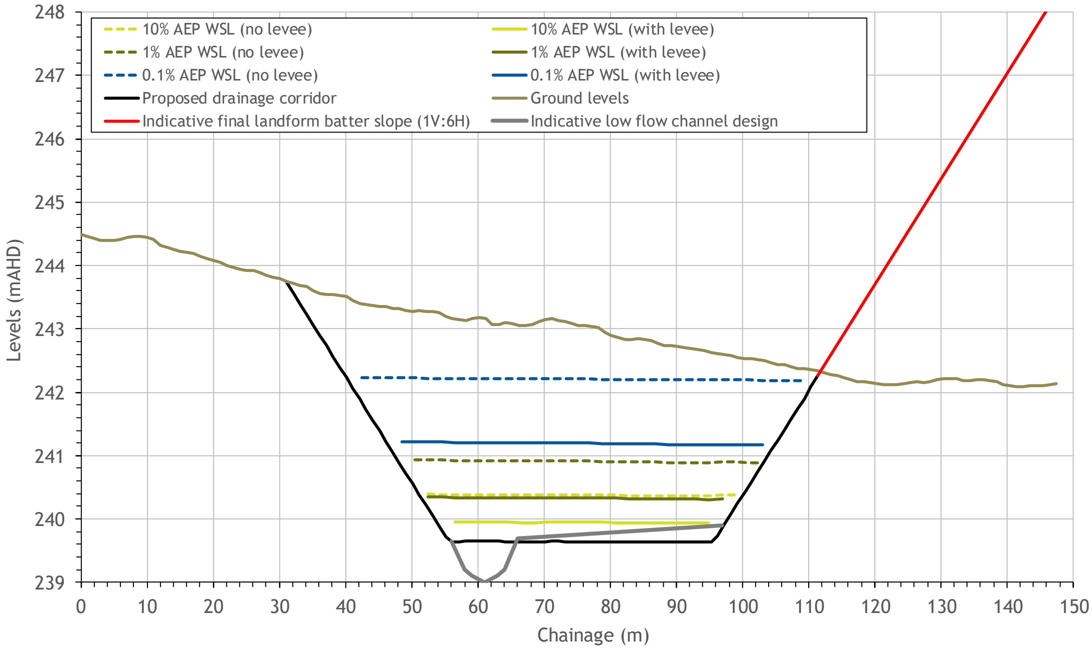


Figure 8.11 - Conceptual cross section of the proposed drainage corridor and the 10%, 1% and 0.1% AEP event water surface elevations for both levee scenarios

Table 8.7 - Indicative drainage corridor depths and velocities during Post-closure Conditions

AEP event (%)	Scenario 1 (with levee)		Scenario 2 (no levee)	
	Depth (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)
10%	0.3	0.7	0.75	1.2
1%	0.7	1.1	1.3	1.6
0.1%	1.6	1.7	2.6	1.9

8.7 PRE-MINING CONDITIONS DESIGN FLOOD LEVELS AND EXTENTS

8.7.1 Pre-mining Conditions modelling results

The TUFLOW model was used to determine the Pre-mining Conditions 10%, 1% and 0.1% AEP design flood levels, depth, extents and velocities in the vicinity of the Project for the two levee scenarios. Figure A.1 to Figure A.6 in Appendix A show the predicted flood depth and flood velocity profiles under Pre-mining Conditions (with levee) for the 10%, 1% and 0.1% AEP events. Figure A.7 to Figure A.12 show the predicted flood depth and flood velocity profiles under Pre-mining Conditions (no levee) for the 10%, 1% and 0.1% AEP events.

8.7.2 Scenario 1 - Pre-mining Conditions (with levee)

Key findings on flooding within the Boomerang Creek catchment and its tributaries are summarised below:

- For the 10% AEP event (see Figure A.1 and Figure A.4):
    - floodwaters through the Project area are generally conveyed within the channel banks of natural drainage lines. Saraji Road is overtopped at some crossing locations. The Norwich Park Branch Railway culverts have sufficient flow capacity to convey the 10% AEP event;
    - peak flood velocities along natural drainage channels are typically elevated in the vicinity of the Project area (greater than 2.0 m/s in localised areas);
    - overbank flood depths adjacent to natural drainage lines are generally shallow (less than 0.5 m); and
    - the existing drainage diversion and levee to the west of the Jupiter Pit diverts all upstream flows to Drainage Line 2. Flood depths within the existing drainage diversion are up to 2.2 m.
- For the 1% AEP event (see Figure A.2 and Figure A.5):
    - floodwaters through the Project area are generally conveyed within the channel banks of natural drainage lines with limited overbank flooding. Saraji Road is overtopped at most crossing locations. The Norwich Park Branch Railway culverts have sufficient flow capacity to convey the 1% AEP event;
    - peak flood velocities in natural drainage channels are typically elevated (greater than 2.0 m/s in localised areas). Overbank velocities are generally up to 1 m/s;
    - flood widths and depths adjacent to natural drainage lines are greatest upstream of Saraji Road and Norwich Park Branch Railway where floodwaters are impounded behind the constructed embankments; and
    - floodwaters overtop the existing drainage diversion and levee to the west of the Jupiter Pit at several locations and drain east across the proposed Jupiter Pit footprint before flowing towards the rail culverts. Flood depths within the existing drainage diversion are up to 2.7 m.
- For the 0.1% AEP event (see Figure A.3 and Figure A.6):
    - floodwaters through the Project area are generally conveyed within the channel banks of natural drainage lines with confined overbank flooding;
    - flood velocities along natural drainage channels are typically elevated (greater than 2.5 m/s in localised areas). Overbank velocities are generally up to 1 m/s;
    - peak flood widths and depths along the eastern side of the Project area increase as natural drainage lines drain towards Saraji Road and Norwich Park Branch Railway where floodwaters are impounded behind the constructed

embankments. Overbank flood depths range from about 2 m at the western boundary of the Project area to greater than 4 m at the eastern boundary; and

- floodwaters overtop the existing drainage diversion at a number of locations.

8.7.3 Scenario 2 - Pre-mining Conditions (no levee)

- For the 10% AEP event (see Figure A.7 and Figure A.10):
  - floodwaters previously diverted by the existing drainage diversion and levee drain east to the existing Saraji Road crossings. Floodplain depths are generally less than 1 m upstream of Saraji Road. The existing crossings at Saraji Road and the Norwich Park Branch Railway culverts have sufficient flow capacity to convey the 10% AEP event; and
  - floodwaters draining east towards Saraji Road have peak flood velocities which are typically less than 1.5 m/s.
- For the 1% AEP event (see Figure A.8 and Figure A.11):
  - floodwaters previously diverted by the existing drainage diversion and levee drain to the existing Saraji Road crossings. The northernmost Saraji Road crossing is overtopped by 0.1 m during the 1% AEP event, however, all other existing crossings at Saraji Road and the Norwich Park Branch Railway culverts have sufficient flow capacity to convey the 1% AEP event; and
  - floodwaters draining east towards Saraji Road have peak flood velocities which are typically less than 2 m/s upstream of Saraji Road.
- For the 0.1% AEP event (see Figure A.9 and Figure A.12):
  - floodwaters previously diverted by the existing drainage diversion and levee drain to the existing Saraji Road crossings, where the existing road is overtopped by up to 0.25 m. Floodwaters are impounded behind the constructed Norwich Park Branch Railway embankment, with flood extents up to 500 m; and
  - floodwaters draining east have peak flood velocities which reach up to 2.5 m/s upstream of Saraji Road within the Project area.

8.8 OPERATIONAL CONDITIONS DESIGN FLOOD LEVELS AND EXTENTS

8.8.1 General

Figure 8.5 shows the proposed Operational Conditions configuration used in the TUFLOW model. The TUFLOW model results show that the proposed Operational Conditions configuration may cause potential flow constraints and flood impacts within the Project area. These include:

- Changed flow conditions between the Norwich Park Branch Railway and the realigned Saraji Road realignment;
- Proposed infrastructure as part of the EA amendment, including the rail loop, CHPP, haul road crossing and upgraded haul road; and
- Diversion of Drainage Line 1 around the proposed pit.

Figure B.1 to Figure B.12 show the change in peak water levels and the change in peak velocities for the 10%, 1% and 0.1% AEP events for Operational Conditions compared to Pre-mining Conditions across the Project.

Table 8.8 and Table 8.9 summarise the changes in peak water levels and peak velocities respectively for the 10%, 1% and 0.1% AEP events at the reporting location points shown in Figure B.1 to Figure B.12.

In general, the results show that impacts created by the Project as a result of the proposed infrastructure during Operational Conditions are within the ML boundary for the 10%, 1% and 0.1% AEP events. The impacts for both the proposed crossing at the existing access road and the proposed crossing at the northern MIA are similar for all events assessed, with minor differences surrounding the respective crossing locations.

Areas that will require erosion control measures include the haul road crossing locations, the levee spillway upgrade, where existing natural drainage paths enter constructed drains and at the upstream and downstream ends of constructed drains.

Hence, the proposed surface water drainage infrastructure for the Project will result in a very low risk of changes to the existing erosion and sedimentation process in the receiving environment.

8.8.2 Operational Conditions impacts

Key findings on potential Operational Conditions (for both haul road crossing options) flooding impacts in the vicinity of the project include:

- For the 10% AEP event (see Figure B.1, Figure B.4, Figure B.7 and Figure B.10):
  - there are no increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor;
  - downstream of the railway corridor, there are no modelled increases in peak water levels and peak velocities; and
  - within the Project ML, there are localised increases in peak water levels and peak velocities in the immediate areas upstream and downstream of the new rail loop embankments and haul road crossing embankment.
- For the 1% AEP event (see Figure B.2, Figure B.5, Figure B.8 and Figure B.11):
  - there are negligible increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor;
  - downstream of the railway corridor, there are no increases in peak water levels;
  - within the Project area, peak water levels increase within the existing drainage diversion and immediately upstream/downstream of the new rail loop embankments and haul road crossing embankments.
  - within the Project area, peak velocities increase within the existing drainage diversion upstream of the rail loop embankments by up to 3 m/s (near afflux reporting location 6) where the channel is diverted around the embankment. However, peak velocities within the minor channel diversion are similar to the peak velocities within the existing drainage diversion under Pre-mining Conditions. Additional erosion protection may be required to limit scour and erosion within the embankment crossing.
- For the 0.1% AEP event (see Figure B.3, Figure B.6, Figure B.9 and Figure B.12):
  - similar to the existing Saraji Road, the realigned Saraji Road is inundated as the culverts have insufficient capacity to convey the 0.1% AEP event flows and floodwaters are impounded behind the constructed Norwich Park Branch Railway embankment;
  - there are negligible increases in peak water levels and velocities at the Norwich Park Branch Railway culverts; and
  - there are increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor and the Jupiter pit northern/eastern diversion drain of up to 0.5 m and 2.3 m/s.

Table 8.8 – Changes in peak water levels under Operational Conditions

Location ID	Modelled change for Operational Conditions compared to Pre-mining Conditions					
	Change in peak water level (m)			Change in velocities (m/s)		
	10%	1%	0.1%	10%	1%	0.1%
1	NA	-0.76	-0.07	NA	0.33	0.46
2	-0.50	-0.87	-0.25	-0.08	-0.09	0.03
3	-0.49	-0.74	-0.03	0.03	0.08	-0.15
4	-0.72	-0.61	-0.27	0.17	0.37	0.46
5	0.02	0.07	0.04	-0.08	-0.01	0.09
6	0.20	0.19	0.09	-2.05	-2.42	-2.48
7	0.11	0.03	-0.01	-0.29	-0.11	-0.08
8	-0.06	-0.05	-0.02	-0.03	-0.01	-0.01
9	0.00	0.00	-0.01	0.00	-0.01	0.00

Table 8.9 – Changes in peak water levels under Operational Conditions

Location ID	Modelled change for Operational Conditions compared to Pre-mining Conditions					
	Change in peak water level (m)			Change in velocities (m/s)		
	10%	1%	0.1%	10%	1%	0.1%
1	NA	-0.71	0.00	NA	0.33	0.46
2	-0.50	-0.82	-0.16	-0.08	-0.09	0.04
3	-0.49	-0.69	-0.02	0.03	0.08	-0.10
4	-0.43	-0.38	-0.21	0.21	0.42	0.51
5	0.02	0.06	0.02	-0.08	-0.02	0.07
6	0.21	0.18	0.09	-2.05	-2.42	-2.48
7	0.11	0.03	-0.03	-0.29	-0.12	-0.13
8	-0.05	-0.05	-0.02	-0.02	-0.01	-0.01
9	0.00	0.00	-0.01	0.00	-0.01	0.00

8.9 POST-CLOSURE CONDITIONS POTENTIAL FLOOD IMPACTS

8.9.1 General

Figure 8.5 shows the proposed Post-closure Conditions configuration used in the TUFLOW model. The TUFLOW model results show that the proposed Post-closure Conditions configuration may cause potential flow constraints and flood impacts within the Project area. These include:

- Changed flow conditions between the Norwich Park Branch Railway and the realigned Saraji Road realignment;
- Changed catchment areas due to the final landform configuration; and
- Diversion of Drainage Line 1 around the proposed pit.

Figure C.1 to Figure C.6 show the change in peak water levels and the change in peak velocities for the 10%, 1% and 0.1% AEP events for Post-closure Conditions compared to Pre-mining Conditions (with levee) across the Project.

Figure C.7 to Figure C.12 show the change in peak water levels and the change in peak velocities for the 10%, 1% and 0.1% AEP events for Post-closure Conditions compared to Pre-mining Conditions (no levee) across the Project.

Table 8.10 and Table 8.11 summarise the changes in peak water levels and peak velocities respectively for the 10%, 1% and 0.1% AEP events at the reporting location points shown in Figure C.1 to Figure C.12.

In general, the results show that there are negligible impacts along Drainage Line 1 with the levee for the 10% and 1% AEP events and small impacts for the 0.1% AEP event. Drainage Line 1 impacts without the levee are greater and may require additional erosion protection to cater for the increase flooding potential. The Post-closure Conditions configuration will not impact on peak water levels or velocities along Drainage Line 2, Drainage Line 3, Drainage Line 4 or Boomerang Creek under both levee scenarios for the 10% to 0.1% AEP events.

There will be some minor areas that will require erosion control measures such as where existing natural drainage paths enter constructed drains and at the upstream and downstream ends of constructed drains.

Hence, the proposed surface water drainage infrastructure for the Project will result in a very low risk of changes to the existing erosion and sedimentation process in the receiving environment.

8.9.2 Scenario 1 - Post-closure Conditions impacts (with levee)

Key findings on potential Post-closure Conditions (with levee) flooding impacts in the vicinity of the project include:

- For the 10% AEP event (see Figure C.1 and Figure C.4):
  - there are no increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor;
  - downstream of the railway corridor, there are no modelled increases in peak water levels and peak velocities; and
  - within the Project ML, peak water levels and peak velocities generally do not change significantly.
- For the 1% AEP event (see Figure C.2 and Figure C.5):
  - there are negligible increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor;
  - downstream of the railway corridor, there are no increases in peak water levels;
  - within the Project area, peak water levels generally do not increase. Peak velocities at the upstream end of the proposed drainage corridor are up to 1.4 m/s. This highlights the need to construct and revegetate the drainage corridor prior to removing DD1 and allowing upstream inflows into the drainage corridor. If vegetation is not allowed to establish, additional erosion protection may be required to limit scour and erosion within the drainage corridor.
- For the 0.1% AEP event (see Figure C.3 and Figure C.6):
  - similar to the existing Saraji Road, the realigned Saraji Road is inundated as the culverts have insufficient capacity to convey the 0.1% AEP event flows and floodwaters are impounded behind the constructed Norwich Park Branch Railway embankment;
  - there are increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor of up to 0.25 m and 0.4 m/s;

- downstream of the Norwich Park Branch Railway there are minor increases in peak water levels of 0.08 m; and
- within the Project ML, there are generally no increases in peak water levels and peak velocities along Drainage Line 1, except where it connects with the proposed drainage corridor, where maximum velocities are up to 1.9 m/s.

8.9.3 Scenario 2 – Post-closure Conditions impacts (no levee)

Key findings on potential Post-closure Conditions (no levee) flooding impacts in the vicinity of the project include:

- For the 10% AEP event (see Figure C.7 and Figure C.10):
  - within the Norwich Park Branch Railway corridor, there are minor increases in peak water levels of 0.08 m and increases in peak velocities of up to 0.3 m/s;
  - downstream of the railway corridor, there are localised increases in peak water levels and peak velocities of 0.2 m and 0.5 m/s, respectively;
  - within the Project area, there are generally no increases in peak water levels and peak velocities. Typical peak velocities along the proposed drainage corridor are 1.2 m/s. Maximum velocities of up to 1.8 m/s occur at the inlet to the drainage corridor.
- For the 1% AEP event (see Figure C.8 and Figure C.11):
  - the proposed Saraji Road is overtopped during the 1% AEP event under the no levee scenario;
  - within the Norwich Park Branch Railway corridor, there are minor increases in peak water levels of up to 0.09 m and there are increases in peak velocities of up to 0.45 m/s;
  - downstream of the railway corridor, there are negligible increases in peak water levels and increases in peak velocities are 0.3 m/s along the existing dirt road downstream of the railway culverts; and
  - Typical peak velocities along the proposed drainage corridor are 1.6 m/s. Maximum velocities of up to 2.6 m/s occur at the inlet to the drainage corridor.
- For the 0.1% AEP event (see Figure C.9 and Figure C.12):
  - floodwaters are impounded behind the constructed embankment of the Norwich Park Branch Railway with extents spanning 600 m upstream of the railway;
  - within the Norwich Park Branch Railway corridor, there are increases in peak water levels and peak velocities of 0.35 m and 0.35 m/s, respectively;
  - downstream of the railway corridor, there are increases in peak water levels of 0.15 m and increases in peak velocities of 0.75 m/s;
  - there are minor impacts of up to 0.11 m downstream of the Project, however, these impacts do not extend downstream of the railway; and
  - Typical peak velocities along the proposed drainage corridor are 1.9 m/s. Maximum velocities of up to 2.8 m/s occur at the inlet to the drainage corridor.

Table 8.10 - Changes in peak water levels under Post-closure Conditions

Location ID	Modelled change in peak water level (m)					
	Scenario 1 (with levee)			Scenario 2 (no levee)		
	10%	1%	0.1%	10%	1%	0.1%
1	0.00	0.01	0.20	0.28	0.23	0.03
2	0.00	-0.21	0.09	-0.09	-0.10	0.01
3	0.00	-0.15	0.01	-0.04	-0.02	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.54	0.78	1.14
6	0.00	0.00	0.00	-0.01	0.05	0.14
7	0.00	0.00	0.01	0.04	0.17	0.28
8	0.00	0.00	0.00	0.00	0.02	0.10
9	0.00	0.00	0.00	0.00	0.02	0.03

Table 8.11 - Changes in peak velocities under Post-closure Conditions

Location ID	Modelled change in peak velocity (m/s)					
	Scenario 1 (with levee)			Scenario 2 (no levee)		
	10%	1%	0.1%	10%	1%	0.1%
1	0.00	0.14	0.03	0.14	0.06	0.04
2	0.00	-0.02	0.03	-0.01	-0.04	0.01
3	-0.16	-0.01	0.05	-0.04	-0.04	0.01
4	0.00	0.00	0.00	0.00	0.00	0.01
5	-0.02	0.02	0.00	0.00	-0.11	-0.13
6	0.00	0.00	0.00	-0.01	0.00	-0.01
7	0.00	0.00	0.00	0.10	0.40	0.78
8	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.01	0.00	0.00

9 Surface water monitoring

9.1 OVERVIEW

Monitoring of surface water quality both within and external to the mine site will form a key component of the surface water management system. Monitoring of upstream, onsite and downstream water quality will assist in demonstrating that the site water management system is effective in meeting its objective of minimal impact on receiving water quality and will allow for early detection of any impacts and appropriate corrective action.

Further details regarding the monitoring program, including the sampling methodology and analysis process of the monitoring program, is described in the REMP (Vitrinite, 2021).

Details of the receiving water quality monitoring, mine affected water quality monitoring and sediment dam water monitoring program are outlined in Section 9.2, Section 9.3 and Section 9.4 respectively. Locations of the proposed surface water monitoring locations and mine affected dam monitoring locations are shown in Figure 4.16 and summarised in Table 9.1. Note that the mine water release points are the same as the mine water monitoring locations (i.e. at the spillway).

Table 9.1 – Proposed surface water and mine water dam quality monitoring locations

Station ID	Catchment Area	Easting*	Northing*	Description
		Receiving water monitoring sites		
Upstream sites				
VSW1	Boomerang Ck	621,003	7,536,086	Diversion bund approximately 3.1 km upstream of Drainage Line 2. Used as an upstream monitoring site for all site dams.
VSW11	Boomerang Ck	622,541	7,533,675	Minor drainage line, upstream of confluence of Drainage Line 2.
Downstream sites				
VSW2	Boomerang Ck	623,117	7,533,362	Drainage Line 2 upstream of the railway. Used as a downstream monitoring site for MWD2, SD1, SD2, SD4, SD5, SD7, SD8.
VSW8	Boomerang Ck	622,370	7,535,855	Drainage Line 1 upstream of the railway. Used as a downstream site for MWD1, MWD3, MWD4 MWD5, and MWD6 as well as SD3, SD6, SD9 and SD10.
		Mine water dam monitoring locations/release points		
MWD1	13.0 ha	621,787	7,535,320	MWD1 spillway
MWD2	6.2 ha	622,650	7,533,934	MWD2 spillway
MWD3	4.5 ha	621,264	7,536,200	MWD3 spillway
MWD4	6.6 ha	621,782	7,535,826	MWD4 spillway
MWD5	15.6 ha	622,173	7,535,590	MWD5 spillway
MWD6	10.4 ha	622,311	7,535,222	MWD6 spillway

* Projection – MGA94 (Zone 55)

9.2 RECEIVING WATER QUALITY MONITORING

The proponent has undertaken a round of baseline monitoring at a number of surface water locations in the Project vicinity (as detailed in Section 4.5.2). In accordance with condition F10 of the Project EA, Vitrinite will monitor the receiving water locations shown in Figure 4.16 and summarised in Table 9.1. These locations will be monitored during natural flow events and release events (i.e. releases from sediment or mine dams) to achieve at least 24 sampling events over a 2-year period. Vitrinite will submit the results of the receiving waters monitoring to DES no more than 2 years from the commencement of activities to evaluate whether the site-specific trigger values prescribed in the Project EA are suitable.

In addition, in accordance with condition F7 of the Project EA, Vitrinite will ensure streamflow gauging stations are operated and maintained at the receiving water locations to determine and record streamflows. The receiving water monitoring points are required to be monitored for the parameters specified in Table 9.2.

The receiving water locations will be monitored against the WQOs for the Project (outlined in Table 9.2). In addition, preliminary release contaminant trigger investigation levels have been proposed for downstream monitoring sites.

- Receiving waters monitoring locations are classified as upstream or downstream sites to assist with trigger investigations. The sites are classified as follows:
- VSW1 and VSW11 are classified as upstream sites; and
- VSW2 and VSW8 are classified as downstream sites. These sites are classified as downstream sites corresponding to particular storages, as outlined in Table 5.2.

Table 9.2 – Receiving water contaminant trigger investigation levels

Parameter	Interim dam release point trigger value	Interim downstream monitoring point trigger value	Frequency
pH (pH units)	6.5 - 8.5	6.5 - 8.5	Upon commencement (the first sample must be taken within 2 hours of commencement of release), daily during release, and within 2 hours after cessation of release.
Electrical Conductivity (µS/cm)	Low Flow[1] <864 Medium Flow[2] <600 High Flow[3] <300	Low Flow[1] <720 Medium Flow[2] <500 High Flow[3] <250	
Total suspended solids (mg/L)[4]	109.2	91	
Turbidity (NTU)[4]	243.5	203	
Dissolved oxygen	64% - 132% saturation	80% - 110% saturation	
Sulphate (mg/L)	924	770	
Filtered metals and metalloids			
Filtered Lead (µg/L)	4.8	4	Upon commencement (the first sample must be taken within 2 hours of commencement of release), daily during release, and within 2 hours after cessation of release.
Filtered Mercury (µg/L)	0.72	0.6	
Filtered Arsenic (µg/L)	28.8	24	
Filtered Aluminium (µg/L)	362.4	302	
Filtered Molybdenum (µg/L)	40.8	34	
Filtered Selenium (µg/L)	13.2	11	

9.3 MINE AFFECTED WATER QUALITY MONITORING

The water quality monitoring program will also include monitoring at all dams which contain mine affected water with the potential to discharge to the receiving waters. This includes the following dams:

- MWD1;
- MWD2;
- MWD3;
- MWD4;
- MWD5; and
- MWD6

Locations of the proposed mine water monitoring locations are shown in Figure 4.16 and summarised in Table 9.1.

In accordance with condition F13 of the Project EA, in the event of an uncontrolled release from a mine affected water dam as a result of a rainfall event that exceeds design specifications, Vitrinite will:

1. notify the administering authority via WaTERS within 24 hours of the commencement of the release;
2. notify the administering authority via WaTERS within 24 hours of the cessation of the release; and
3. conduct an investigation within 20 business days of cessation of the release.

In accordance with condition F14 of the Project EA, the investigation required under condition 3 above must determine:

1. whether environmental harm has or may occur;
2. cause of the uncontrolled release;
3. where relevant, measures to address environmental harm; and
4. where relevant, measures to prevent recurrence of uncontrolled release(s).

Vitrinite will submit the results of the investigation to the administering authority within 28 days after completing the investigation. Water quality parameters which will be collected for the mine water dams are outlined in Table 9.2. Note that the metals listed in Table 9.2 will be analysed for both total and dissolved concentrations.

9.4 SEDIMENT DAM MONITORING

In accordance with condition F5 of the Project EA releases from sediment dams will be monitored at their release points for the water quality parameters specified in Table 9.2 The Project sediment dams are shown in Figure 4.16 and details regarding the sediment dams (including the location of release points) is outlined in Table 5.2.

9.5 TRIGGER INVESTIGATION

In accordance with condition F6 of the Project EA, Vitrinite will complete an investigation if water quality sampling identifies 3 consecutive exceedances of:

a) interim sediment dam release trigger values detailed in Table 9.2, at the sediment dams specified in Table 5.2; and

b) interim downstream monitoring point trigger values detailed in Table 9.2, at the receiving water locations specified in Section 9.1.

In accordance with condition F8 of the Project EA, where the quality characteristics of the release exceed any of the trigger values specified in Table 9.2 on 3 consecutive occasions, the environmental authority holder must compare the downstream results to the upstream results and:

a) where the downstream result is the same or a lower value than the upstream value for the quality characteristic and the trigger values are not exceeded, then no action is to be taken; or

b) where the downstream result exceeds the values specified in Table 9.2:

   1. if the result is less than the upstream monitoring site data, then no action is to be taken, or

   2. if the result is greater than the upstream monitoring site data, complete an investigation and provide a written report to the administering authority via WaTERS within 90 days of receiving the result, outlining:

      i. details of the investigations carried out;

      ii. determine if the exceedance is a result of:

         a. activities authorised under the Project EA;

         b. natural variation; or

         c. neighbouring land uses;

   3. if exceedances are a result of activities authorised under the Project EA, detail:

      i. level of environmental harm; and

      ii. actions taken to prevent environmental harm.

Where an exceedance of a trigger level has occurred and is being investigated, in accordance with a) and b) (1) above, no further reporting is required for subsequent trigger events for that quality characteristic.

In accordance with condition F9 of the Project EA, if an investigation occurs in accordance with condition b) (3) above, Vitrinite will determine whether environmental harm has or may occur, and detail:

a) strategies to implement immediate measures to reduce the potential for environmental harm; and

b) develop long-term mitigation measures to address any surface water contamination and prevent recurrence of surface water contamination.

Vitrinite must provide details of the measures implemented or to be implemented to reduce the potential for environmental harm as well as the long-term mitigation measures to the administering authority within 28 days after completing the investigation.

9.6 RECEIVING ENVIRONMENT MONITORING PROGRAM (REMP)

Further details regarding the monitoring program, including the sampling methodology and analysis process of the monitoring program, is described in the REMP (Vitrinite, 2021). The REMP will incorporate the historical and proposed monitoring as described in Section 4.5.2 and in the sections above.

The main objective of the REMP will be to report against WQOs for local waterways potentially affected by discharge from the Project and will assist in assessing general aquatic ecosystem health.

10 Cumulative impacts

10.1 OVERVIEW

The objective of this assessment is to identify the potential for impacts from the Project to have compounding interactions with similar impacts from other projects, including activities proposed, under development or already in operation within a suitable region of influence of the Project.

There are two levels at which cumulative impacts have been assessed:

- Localised cumulative impacts – These are the impacts that may result from multiple existing or proposed mining operations in the immediate vicinity of the Project. Localised cumulative impacts include the effect from concurrent operations that are close enough to potentially cause additive effect on the receiving environment. For the purposes of this assessment, all existing and proposed projects located within the Isaac River catchment have been included; and
- Regional cumulative impacts – These include the Project's contribution to impacts that are caused by mining operations throughout the Bowen Basin region or at a catchment level. Each coal mining operations in itself may not represent a substantial impact at a regional level; however, the cumulative effect on the receiving environment may warrant consideration.

10.2 EXISTING PROJECTS

Projects which are currently operating within the Isaac River catchment upstream of the Deverill gauging station and have been included in the cumulative impacts assessment for the project are listed in Table 10.1.

10.3 NEW OR DEVELOPING PROJECTS

Relevant projects that have been considered include:

- Projects within the predicted sphere of influence of the Project, as listed on the Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) website that are undergoing assessment under the State Development and Public Works Organisation Act 1971 (SDPWO Act) for which an Initial Advice Statement (IAS) or an EIS are available;
- Projects within the predicted sphere of influence of the Project, which are listed on the website of the Department of Environment and Science (DES) that are undergoing assessment under the Environmental Protection Act 1994 (EP Act) for which an IAS or an EIS are available; and
- Projects within the predicted sphere of influence of the Project, which are listed on the website of the Department of Infrastructure, Local Government and Planning (DILGP) that are undergoing assessment under the Regional Planning Interests Act 2014 (RPI Act) for which an Assessment Application is available.

Projects currently undergoing assessment or having recently completed assessment under these processes and included in the cumulative impact assessment for the Project are listed in Table 10.2.

10.4 CUMULATIVE IMPACTS – SURFACE WATER RESOURCES

10.4.1 Water quality

The Project is located in the Isaac River catchment, which is a major tributary within the Fitzroy basin. The Fitzroy basin is the largest catchment in Queensland draining into the Pacific Ocean and also the largest catchment that drains to the Great Barrier Reef, although it does not contribute significant freshwater flows to the coastal environment when compared to river systems further north.

In 2008, the Queensland Government undertook an investigation into the cumulative effects of coal mining in the Fitzroy River basin on water quality (EPA, 2009). The investigation found that:

- There were inconsistencies in discharge quality limits and operating requirements for coal mine water discharges as imposed through environmental authorities; and
- In some cases, discharge limits and operating conditions of coal mines were not adequately protecting downstream environmental values.

These conclusions led to a number of inter-related actions by Queensland Government and other stakeholders:

- Water quality objectives were developed for the Fitzroy Basin and added to Schedule 1 of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (WWB)) in October 2011;
- Model water conditions were developed for coal mines in the Fitzroy basin (DERM February 2012). These model water conditions are designed to manage water discharges to meet the water quality objectives set out in the EPP (WWB) and to provide consistency between mining operations in the Fitzroy basin;
- Environmental authorities for a number of mining operations were amended to introduce conditions consistent with the model water conditions; and
- A number of mining operations entered into Transitional Environmental Programs (TEP) under the EP Act. These TEPs were focussed on actions that would allow mines to achieve compliance with new environmental authority conditions and upgrade operating conditions.

With these measures in place, a strong strategic and policy framework is now in place for management of cumulative water quality impacts from mining activities. This framework allows for management of individual mining activities in such a way that overarching water quality objectives can be achieved.

Mine affected water from the proposed Project will be managed through a mine water management system which is designed to operate in accordance with proposed EA conditions that are based on Model Mining Conditions, and incorporated into the release criteria used in modelling the mine water management system in this report.

It is noted that the Project is located within the Boomerang Creek catchment, which has already been significantly disturbed by existing mining operations in the Project vicinity.

In addition, given that the Project water releases will be managed within an existing overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine water from the project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

Table 10.1 – Existing projects considered in the cumulative impact assessment

Project - Proponent	Description	Operational status	Relationship to the Project Mining Lease: Timing	Relationship to the Project Mining Lease: Location
Burton Mine - Peabody Energy Australia	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project, although unlikely given the current operational status.	Located 75 km to the north of the Project area. Located within the Isaac River catchment (upstream).
North Goonyella Mine - Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 75 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Goonyella Riverside Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 60 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Moranbah North Mine - Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 50 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Grosvenor Mine - Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 40 km to the north of the Project area. Located within the Isaac River catchment (upstream).
Broadlea Mine - Fitzroy Australia Resources	Open cut coal mine	Care and maintenance	May have overlapping operational phases with the construction and operations of the project.	Located 40 km to the north of the Project area. Located within the headwaters of Smoky Creek, within the Isaac River catchment.
Carborough Downs Mine - Fitzroy Australia Resources	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 35 km to the northeast of the Project area. Located within the headwaters of Billy's Gully, within the Isaac River catchment.
Isaac Plains Mine - Stanmore Coal	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 35 km to the north of the Project area. Located within the headwaters of Billy's Gully, within the Isaac River catchment.
Millennium Mine - Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the northeast of the Project area. Located within the headwaters of Southern Gully, within the Isaac River catchment.

Daunia Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 25 km to the northeast of the Project area. Located within the Isaac River catchment (upstream).
Poitrel Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 20 km to the northeast of the Project area. Located within the Isaac River catchment (upstream).
Caval Ridge Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 10 km to the north of the Project area. Located within the Isaac River catchment (upstream).
Peak Downs Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located directly adjacent (i.e. less than 1 km to the north and east of the Project area. Located within the Isaac River catchment.
Moorvale Mine - Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 35 km to the northeast of the Project area. Located within the headwaters of North Creek, within the Isaac River catchment.
Saraji Mine – BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 10 km to the southeast of the Project area. Located within the Isaac River catchment.
Norwich Park Mine – BMA	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project, although unlikely given the current operational status.	Located 45 km to the southeast of the Project area. Located within the Isaac River catchment (downstream).
Lake Vermont Mine - Jellinbah Group	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the southeast of the Project area. Located within the Isaac River catchment (downstream).

Table 10.2 – Proposed projects considered in the cumulative impact assessment

Project - Proponent	Description	Project status	Relationship to the Project Mining Lease: Timing	Relationship to the Project Mining Lease: Location
Moranbah South Project - Anglo American	Underground coal mine	Approved project	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Moorvale South Project - Peabody Energy Australia	Open cut coal mine	Approved project	May have overlapping operational phases with the construction and operations of the project.	Located 25 km to the northeast of the Project area. Located within the Isaac River catchment (upstream).
Eagle Downs Mine - Bowen Central Coal Joint Venture	Underground coal mine	Construction on hold - site on care and maintenance	May have overlapping operational phases with the construction and operations of the project.	Located 10 km to the north of the Project area. Located within the Isaac River catchment upstream).
Winchester South Project - Whitehaven Coal	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	Located 15 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Olive Downs Coking Coal Project - Pembroke Olive Downs Pty Ltd	Open cut coal mine	Approved with conditions	May have overlapping operational phases with the construction and operations of the project.	Located 10 km to the west of the Project area. Located within the Isaac River catchment (downstream).
Saraji East Mine - BMA	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	Located 15 km to the southwest of the Project area. Located within the Isaac River catchment (downstream).
Dysart East Coal Mine - Bengal Coal	Underground coal mine	ML granted	May have overlapping operational phases with the construction and operations of the project.	Located 35 km to the southwest of the Project area. Located within the Isaac River catchment (downstream).
Red Hill - BMA	Underground coal mine	Approved with conditions	May have overlapping operational phases with the construction and operations of the project.	Located 60 km to the northeast of the Project area. Located within the Isaac River catchment (upstream).
Isaac Downs Project	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the north of the Project area. Located within the Isaac River catchment (upstream).

10.4.2 Loss of catchment and stream flows in the Isaac River

The Project will result in a loss of catchment to the Isaac River during operations, which will be reinstated after closure. The surface runoff volume lost from the catchment will generally be in proportion to the loss of catchment area. The Project area is less than 0.03% of the catchment area of the Isaac River to the confluence of Phillips Creek. Of this, around 60% of this area is managed through the ESCP and then released to the downstream environment.

There are approximately 18 existing coal mines in the vicinity of the Project that also capture runoff from the Isaac River catchment, as shown in Figure 10.1. The total estimated captured area of all these projects (including the Project) combined represents around 7.1% of the Isaac River catchment to the Phillips Creek confluence.

A comparison of the captured catchment areas of the existing mining projects considered in the cumulative impact assessment with the Isaac River catchment to the Phillips Creek confluence is provided in Table 10.3, which indicates the following:

- The combined total catchment area of the existing mines (including the Project) represents around 7.1% of the total catchment area of the Isaac River to the Phillips Creek confluence; and
- The combined mine affected catchment area (estimated) represents less than 2.4% of the total Isaac River catchment area to the Philips Creek confluence.

When taking into account potential discharges from the operating mines in accordance with their current approved release rules, the overall loss of catchment area and associated stream flow is relatively small. In practical terms, impacts on the volume of water flow in the Isaac River would be negligible.

Table 10.3 - Catchment area of existing projects considered in the cumulative impact assessment

Catchment	Total catchment area (km^2)	Estimated mine affected catchment area (km^2)
Vulcan Coal Mine (the Project)	2.64	1.1
Other mines	551	182
Combined	554	183
Isaac River (to the Phillips Creek confluence)	7,731	-

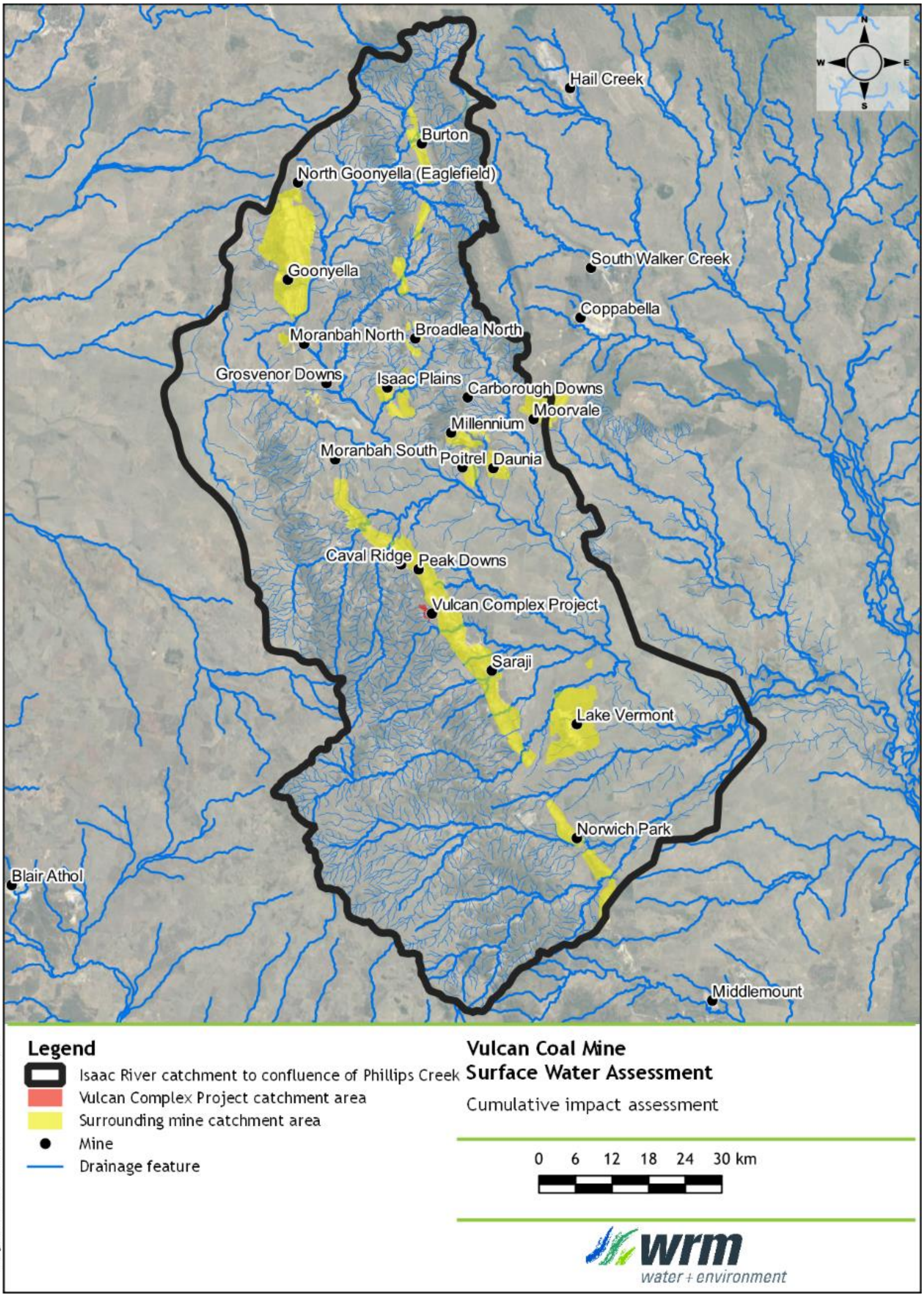


Figure 10.1 – Cumulative impact assessment

11 Summary of findings

11.1 OVERVIEW

The potential impacts of the Project on surface water resources will be mitigated through the implementation of a mine site water management system to control the flow and storage of water of different qualities across the site. A surface water monitoring program will be implemented to monitor potential environmental impacts and ensure that the site water management system is meeting its objectives.

11.2 WATER MANAGEMENT SYSTEM PERFORMANCE

The performance of the mine water management system has been investigated using a detailed site water balance model. The model simulated water inflows and outflows through the various stages of mine development, based on 125 realisations with different climatic sequences.

Water collected on the site will be used as first priority to satisfy site demands. Mine affected water from the infrastructure areas and open cut pit will be collected in MWD1 and reused to meet operational needs.

External water will be supplied to MWD1 when the site water inventory is at a low level, in order to meet site water demands.

The water balance results show that although water collected on site will be used as a first priority to meet mine demands, the Project will frequently require external water to operate. Under 50%ile conditions, the Project is predicted to require up to 305 ML/annum in external water under 50%ile conditions.

The water balance model was used to assess the risk of uncontrolled offsite spills from the mine affected water dams that can potentially overflow directly to the receiving environment (MWD1, MWD2, MWD3, MWD4, MWD5 and MWD6). There were no modelled overflows from the mine affected water dams to the receiving environment during any of the model realisations over the life of the Project.

11.3 FLOODING

The flood impact assessment undertaken for the Project showed that Operational and Post-closure conditions compared with Pre-mining Conditions results in changes to flood levels and velocities, however, impacts are generally confined within the Project ML.

The operational conditions infrastructure creates impacts (temporarily for the life of the Project) that are generally confined within the Project ML, and does not impact on flood levels upstream or downstream of the Project area. Impacts in waterways within the Project ML occur upstream of proposed embankments (rail and road crossing) of the waterways and it is recommended that erosion and scour protection options are implemented to key in these embankments.

For the modelled scenario with the existing drainage diversion and levee, the changes in peak water levels and peak velocities were relatively small under the 10% and 1% AEP events. The modelled scenario with no existing drainage diversion and levee resulted in increased flows draining east through the site and showed that the potential impacts under the 10% and 1% AEP events are slightly higher than the scenario with the levee.

For rare events (0.1% AEP), the predicted change in flood level and velocity in the vicinity of the Project ML extends downstream of the proposed Saraji Road realignment and the Norwich Park Branch Railway corridor. The predicted increase in water level and velocity is less than 0.35 m and 0.4 m/s respectively for both levee scenarios. It is recommended that erosion and scour protection options are considered along the proposed drainage corridor and existing channels where these increases occur as required to mitigate the risk of rapid geomorphic change.

Overall, the impact of the Project on the hydraulic characteristics of Boomerang Creek and its tributaries do not affect the Pre-mining Conditions significantly. It is expected that the channel and floodplain will undergo little, if any, adjustment to the altered hydraulic conditions upstream or downstream of the Project as a result of the Project. It is critical that suitable erosion protection and revegetation is implemented along permanent drainage structures as soon as possible to mitigate the risk of any rapid geomorphic change.

11.4 IMPACTS ON DOWNSTREAM WATER QUALITY

Preliminary baseline monitoring indicates that water quality in the surrounding environment is of poor quality. Notwithstanding, the water balance modelling indicates that no mine affected spills are predicted from mine operations. In addition, modelling predicts that spills from the sediment dams will be below the 720 µS/cm WQO for low flows. Baseline salinity exceeds the WQO for high flows.

In consideration of the already heavily disturbed nature of the surrounding catchment, it is unlikely that Project releases will have a measurable impact on receiving water quality or environmental values.

11.5 CUMULATIVE IMPACTS

The Project will reduce the catchment area draining to receiving waters due to capture of runoff from disturbed catchment areas within the water management system. The Project catchment area represents approximately 0.03% of the total catchment area of the Isaac River to its confluence with Phillips Creek. Of this, approximately 60% will be managed through the Project ESC and released back to receiving waters. The combined total catchment area of the existing mines (including the Project) represents around 7.1% of the total catchment area of the Isaac River to the Phillips Creek confluence.

The site water management system has been designed such that the risk of offsite release of mine affected water is very low (with no modelled mine affected dam uncontrolled releases under any climatic conditions).

11.6 OPERATIONAL CONDITIONS

A conceptual operational conditions water management plan for the Project over the life-of-mine plan has been developed. The key features of the operational conditions are:

- Proposed life-of-mine landforms and open cut pits;
- Proposed haul road, haul road crossing and haul road culverts;
- Proposed modifications to BMA’s existing drainage diversion and levee;
- Proposed rail loop and associated rail loop drainage infrastructure;
- Proposed CHPP infrastructure area;
- Proposed DD1 dam and diversion drains/bunds;
- Realignment of Saraji Road; and
- Proposed Saraji Road culverts.

In summary, the proposed infrastructure over the life of the Project will create temporary impacts within the Project ML, however, is not considered likely to have a long-term significant impact on the receiving waters.

11.7 FINAL LANDFORM

A conceptual final landform water management plan for the Project under post-closure conditions has been developed. The key features of the final landform are:

- No final voids are proposed. All open cut pits will be backfilled with overburden material.
- Drainage structures will be implemented on and around the final landform to ensure that the landform is free draining.
- When sediment dam catchments are completely rehabilitated, and water quality monitoring of the runoff has established that it is consistent with natural background conditions, the sediment dam and associated drainage infrastructure will be decommissioned.

In summary, the conceptual final landform is not considered likely to have a long-term significant impact on the receiving waters.

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Appendix A - Pre-mining Conditions flood maps and results

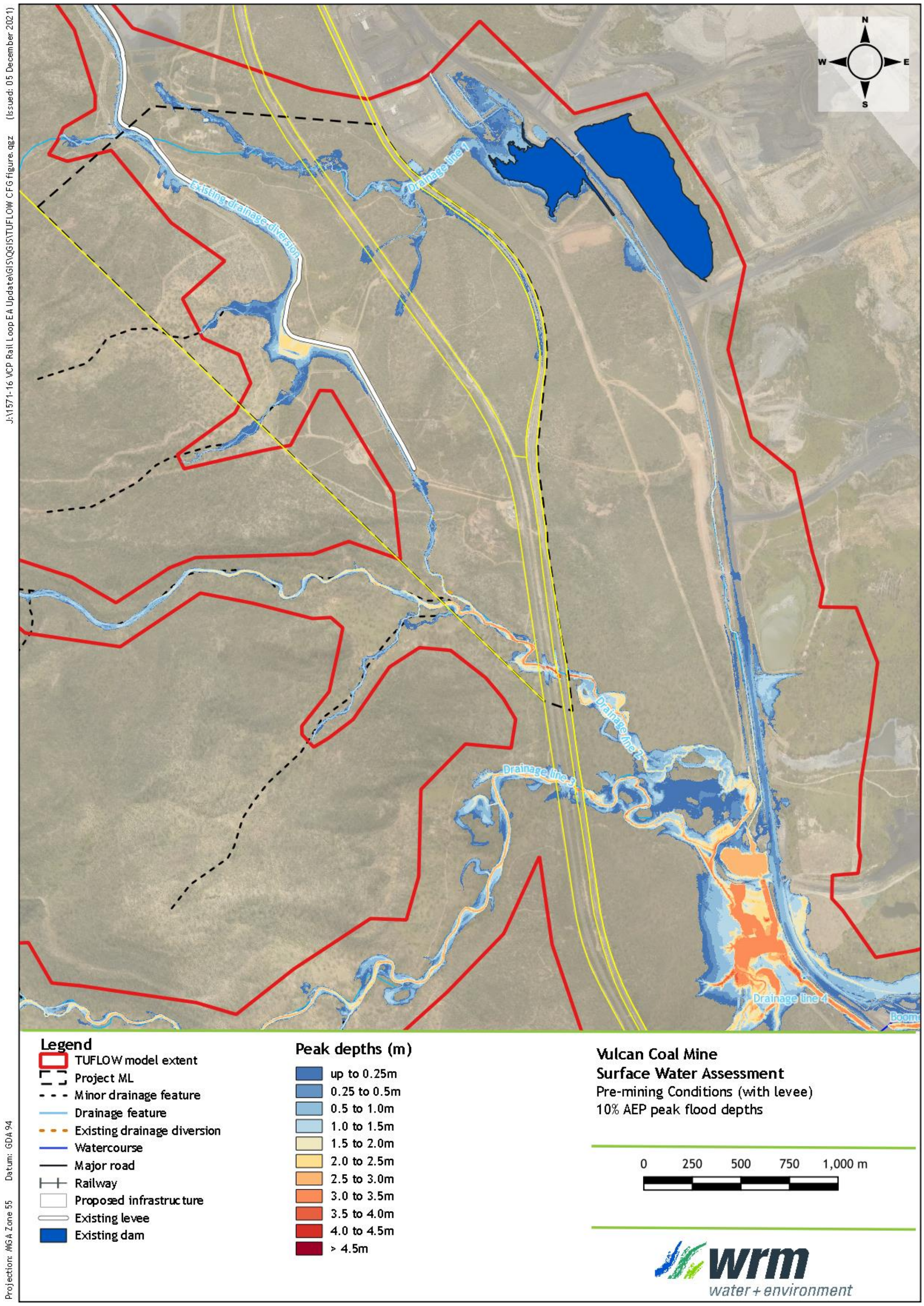

Figure A.1 – 10% AEP peak flood depths – Pre-mining Conditions (with levee)

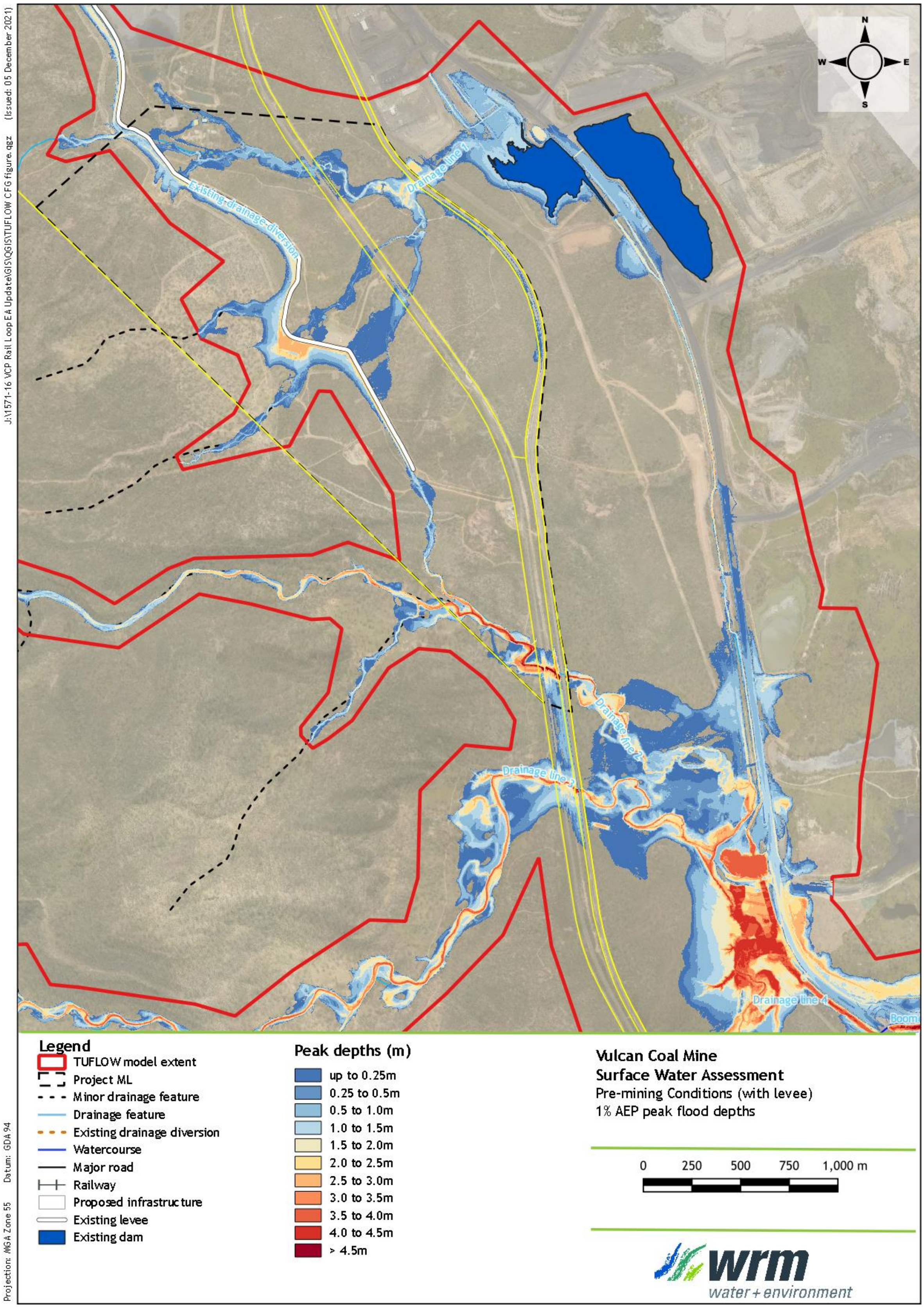

Figure A.2 – 1% AEP peak flood depths – Pre-mining Conditions (with levee)

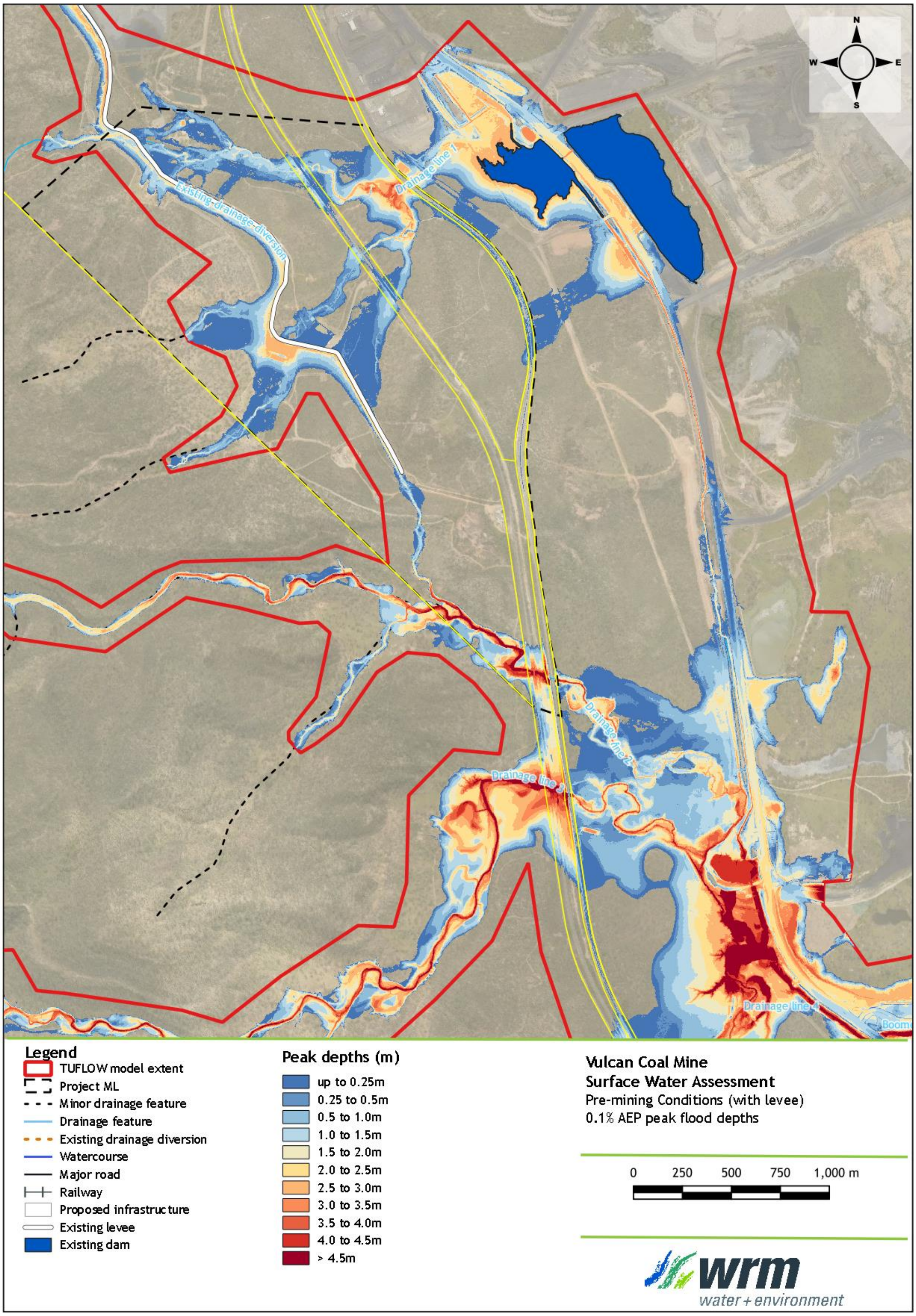

Figure A.3 – 0.1% AEP peak flood depths – Pre-mining Conditions (with levee)

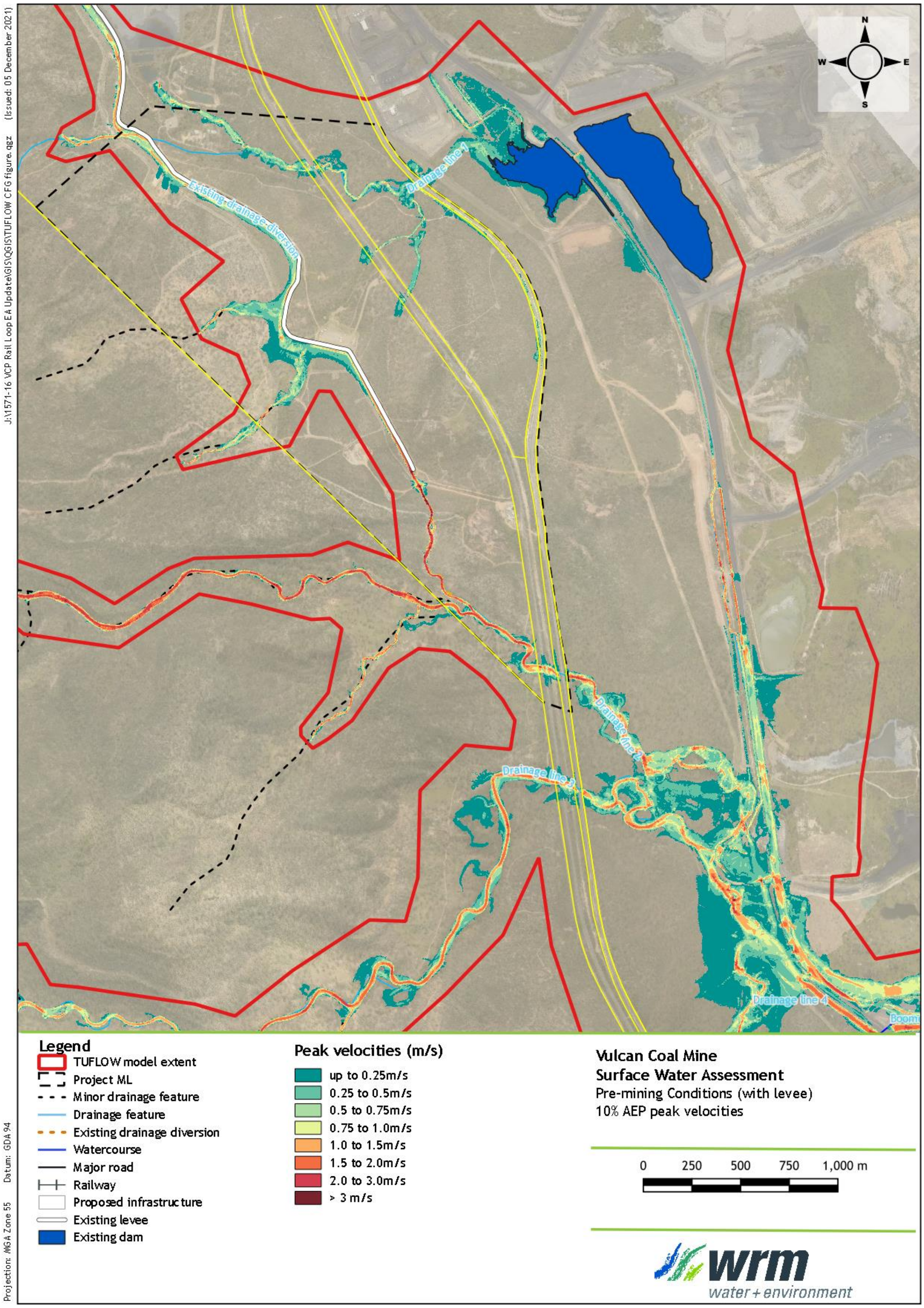

Figure A.4 – 10% AEP peak velocities – Pre-mining Conditions (with levee)

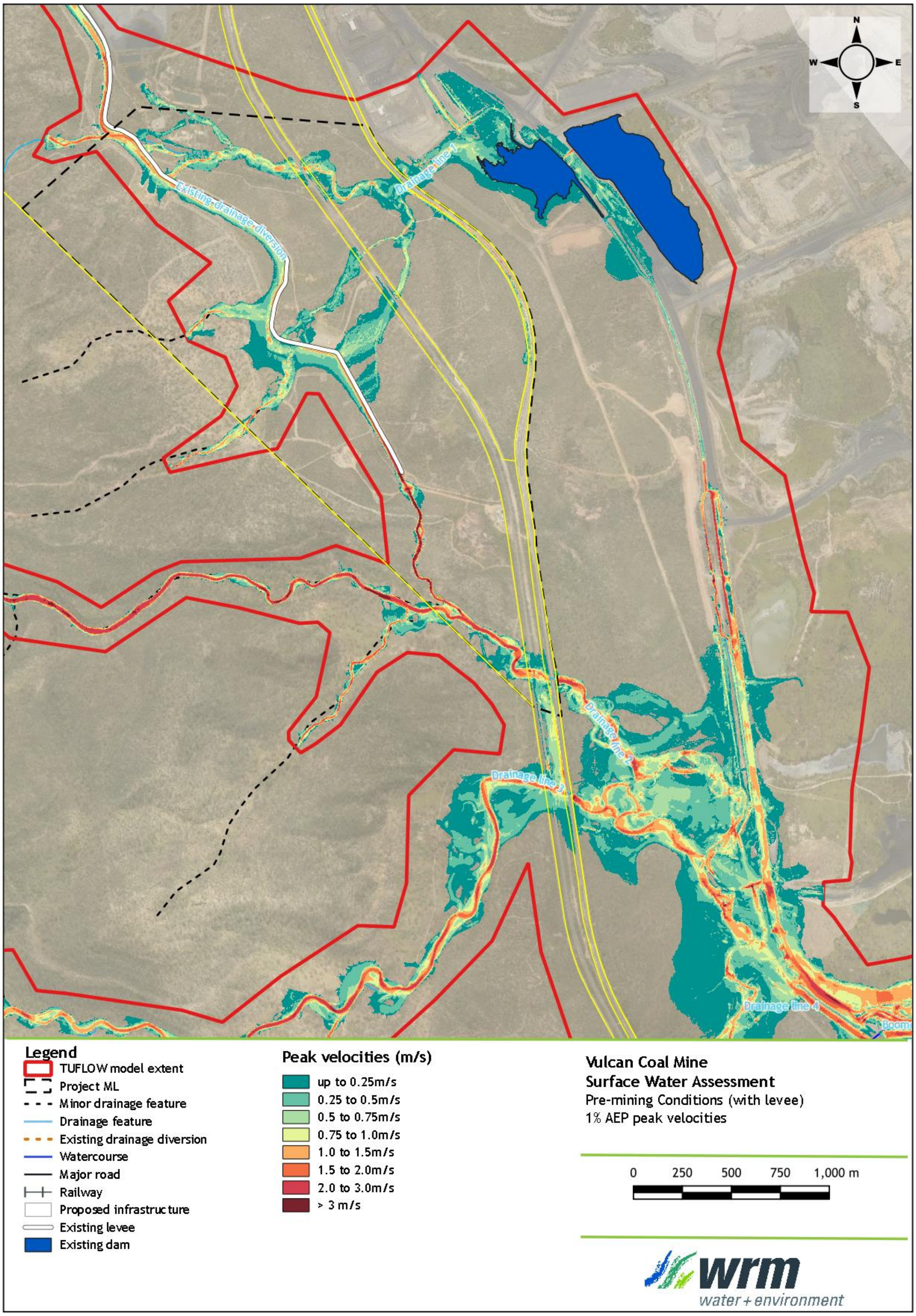

Figure A.5 – 1% AEP peak velocities – Pre-mining Conditions (with levee)

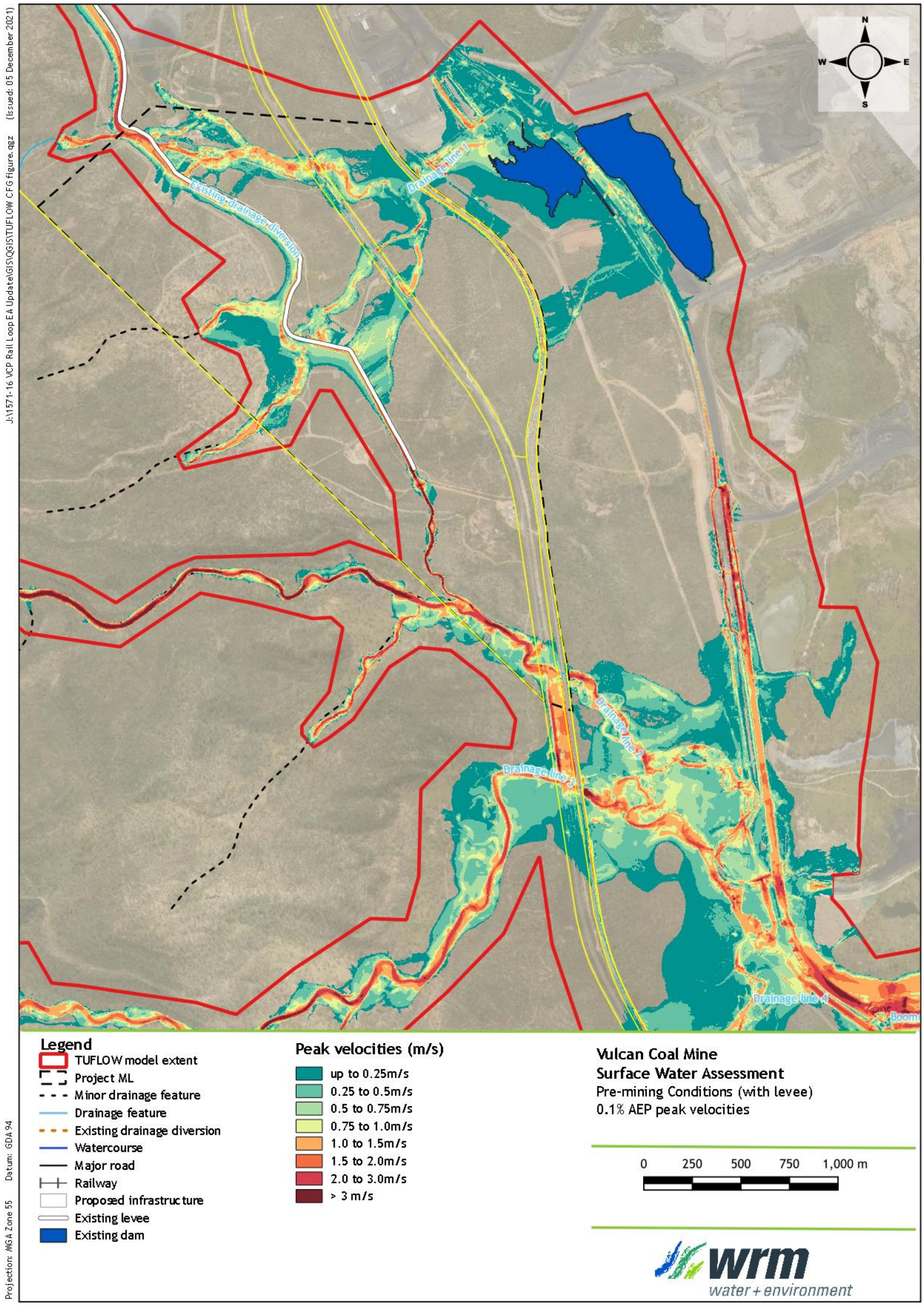

Figure A.6 – 0.1% AEP peak velocities – Pre-mining Conditions (with levee)

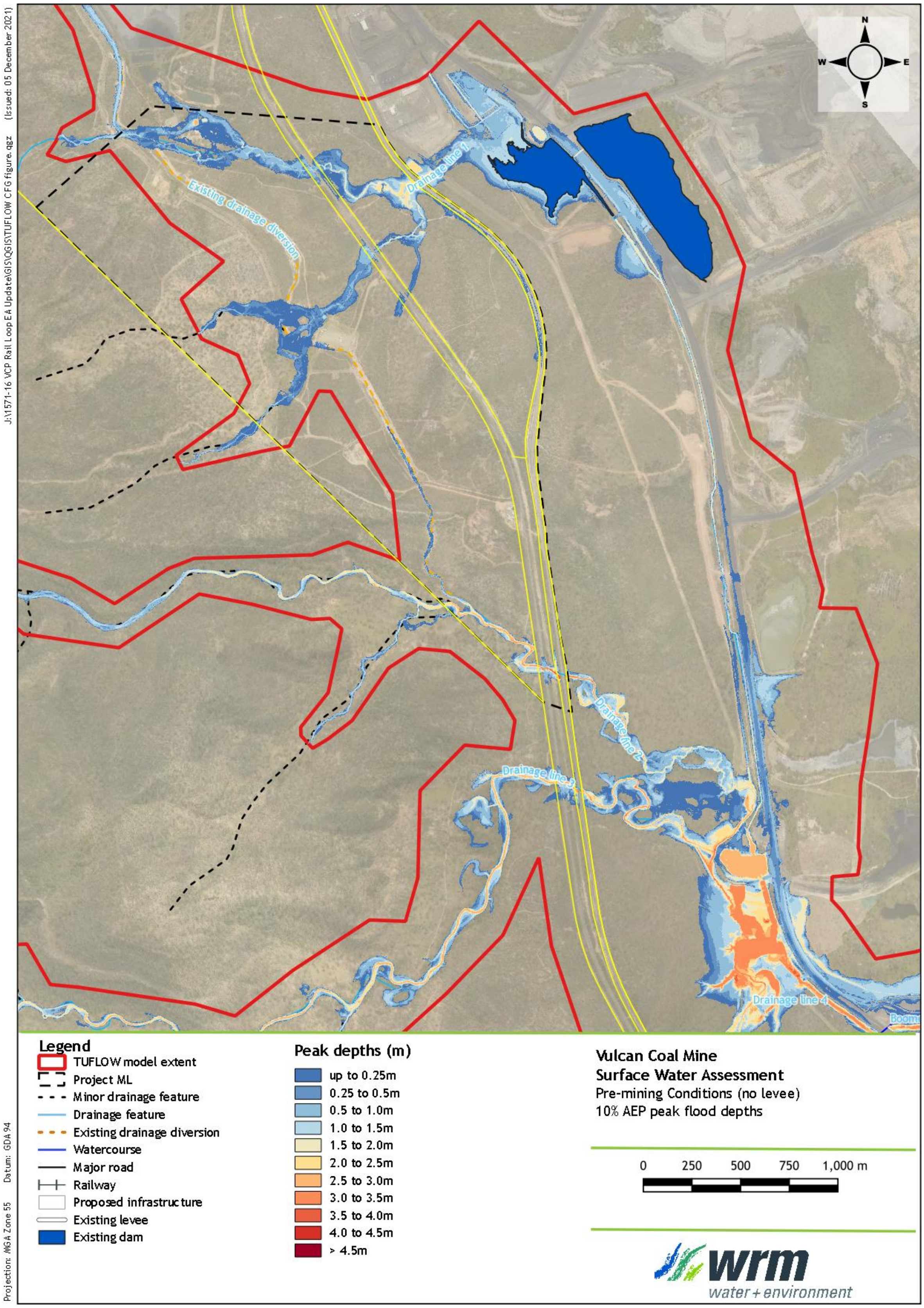

Figure A.7 – 10% AEP peak flood depths – Pre-mining Conditions (no levee)

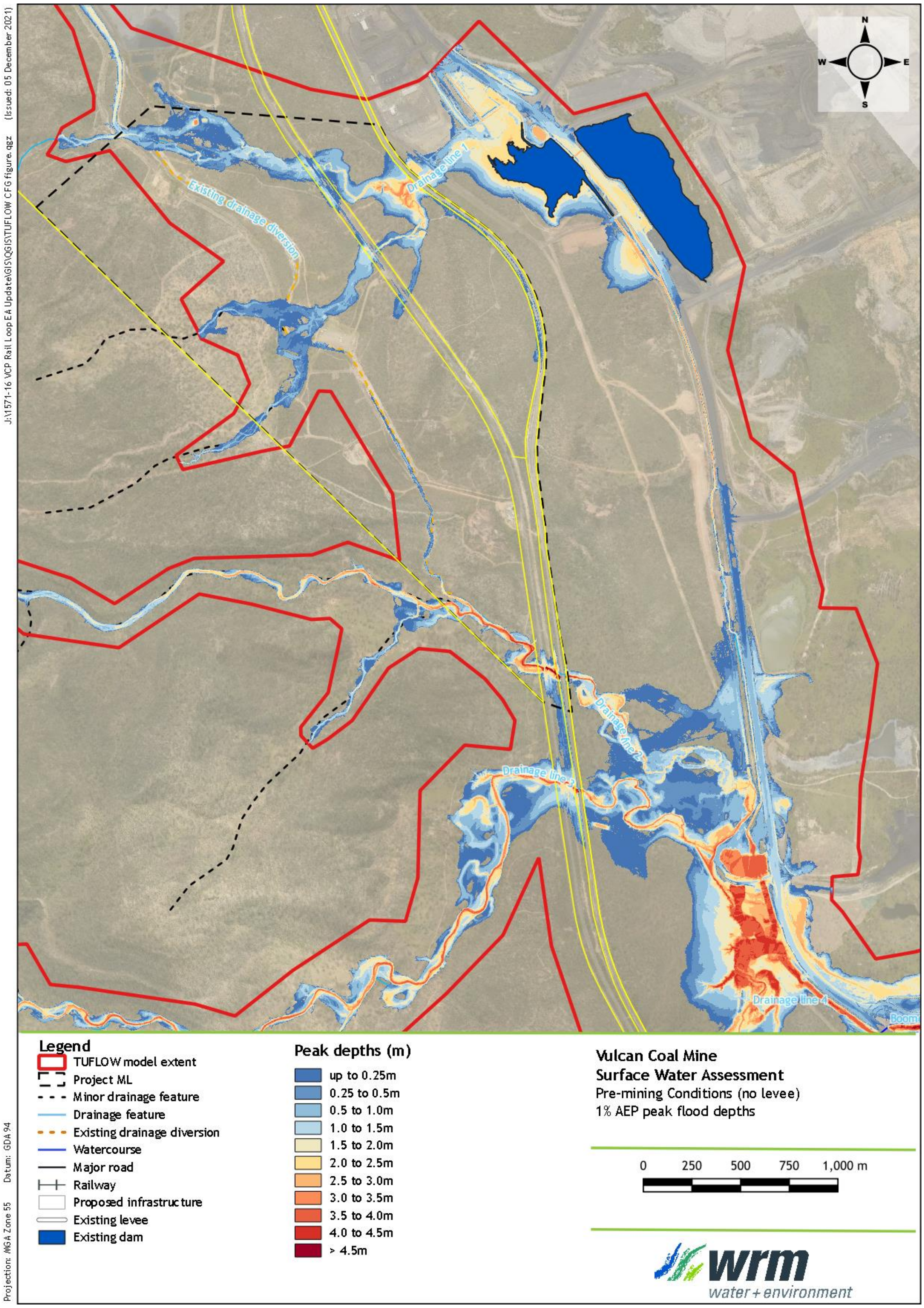

Figure A.8 – 1% AEP peak flood depths – Pre-mining Conditions (no levee)

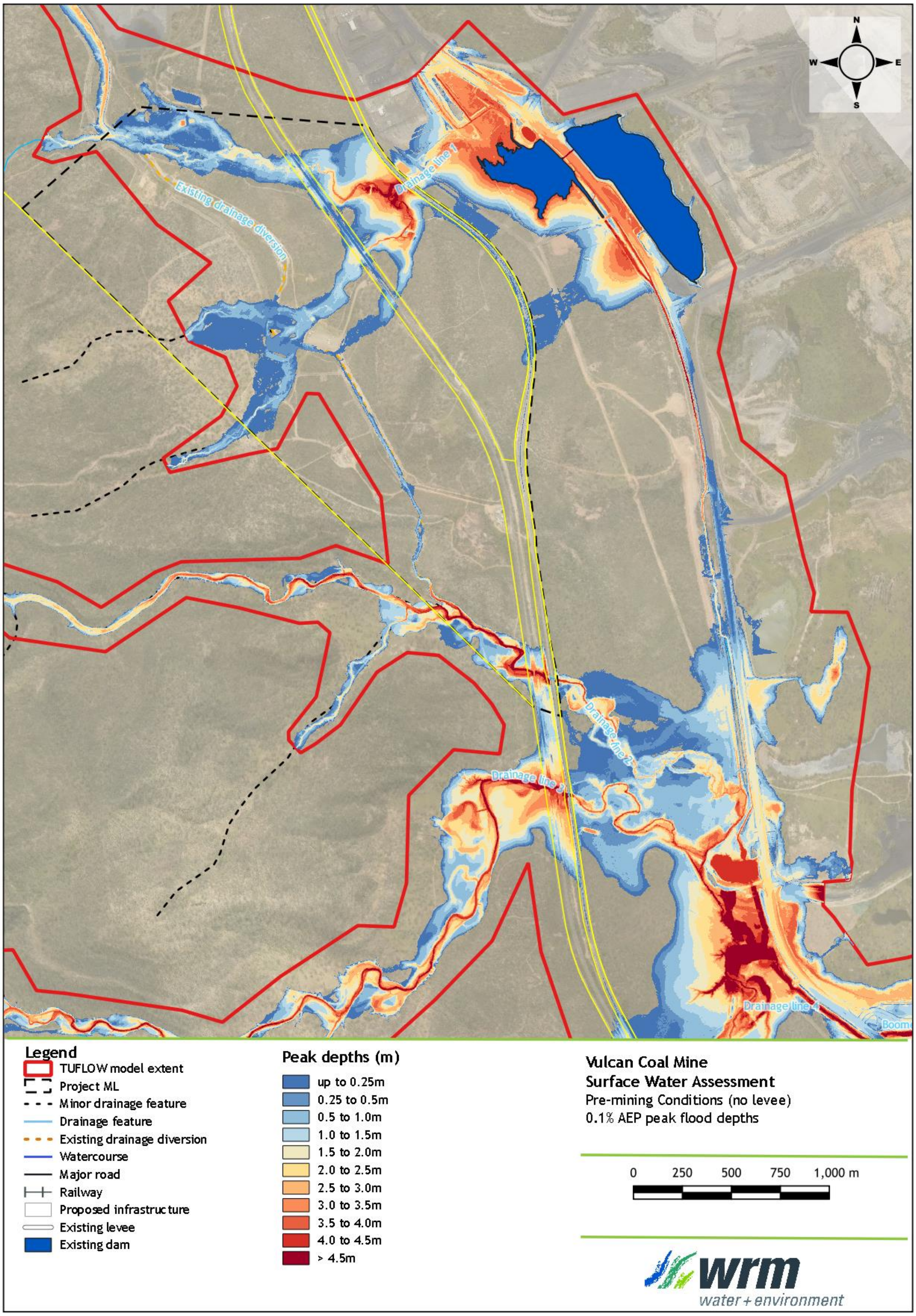

Figure A.9 – 0.1% AEP peak flood depths – Pre-mining Conditions (no levee)

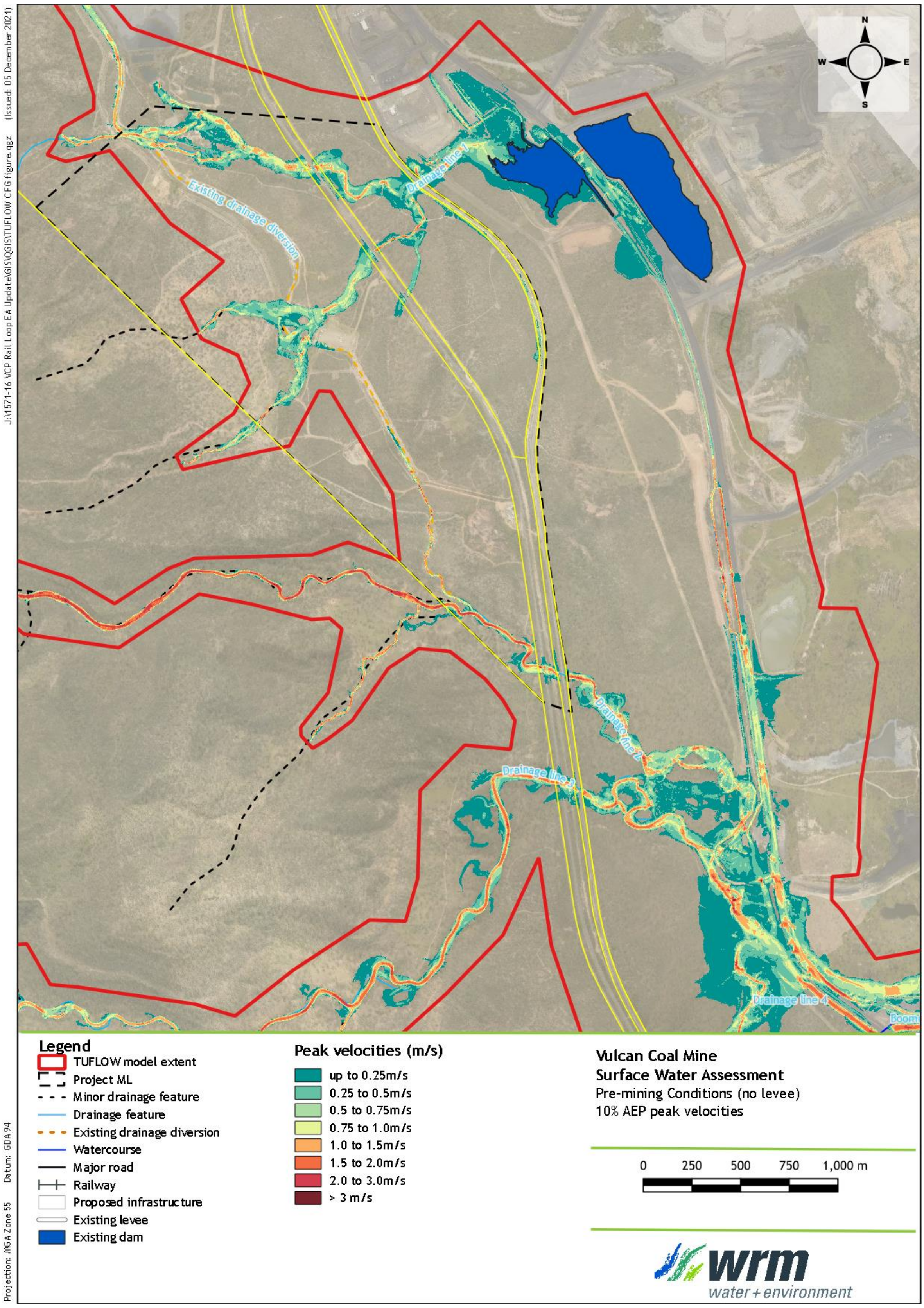

Figure A.10 – 10% AEP peak velocities – Pre-mining Conditions (no levee)

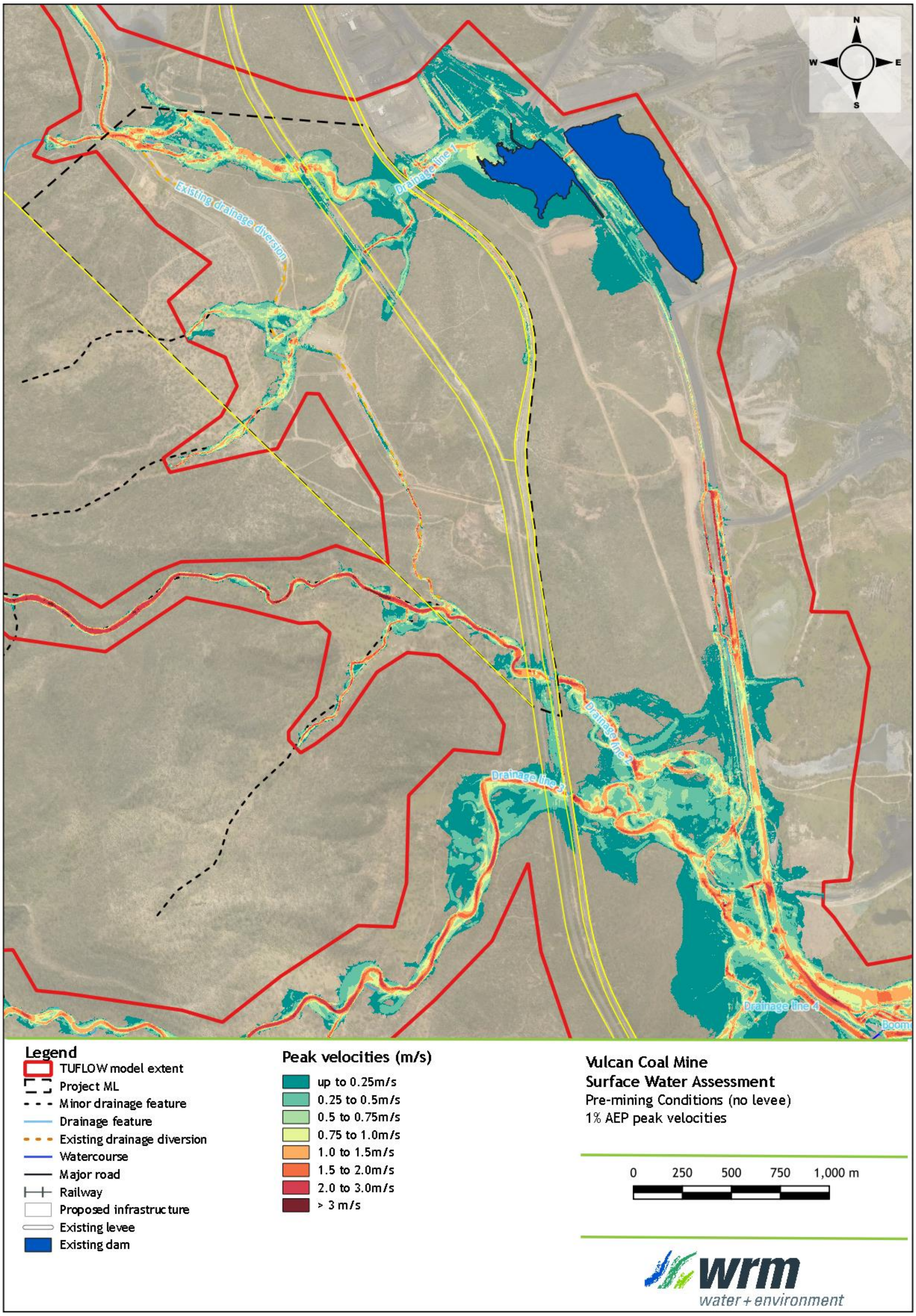

Figure A.11 – 1% AEP peak velocities – Pre-mining Conditions (no levee)

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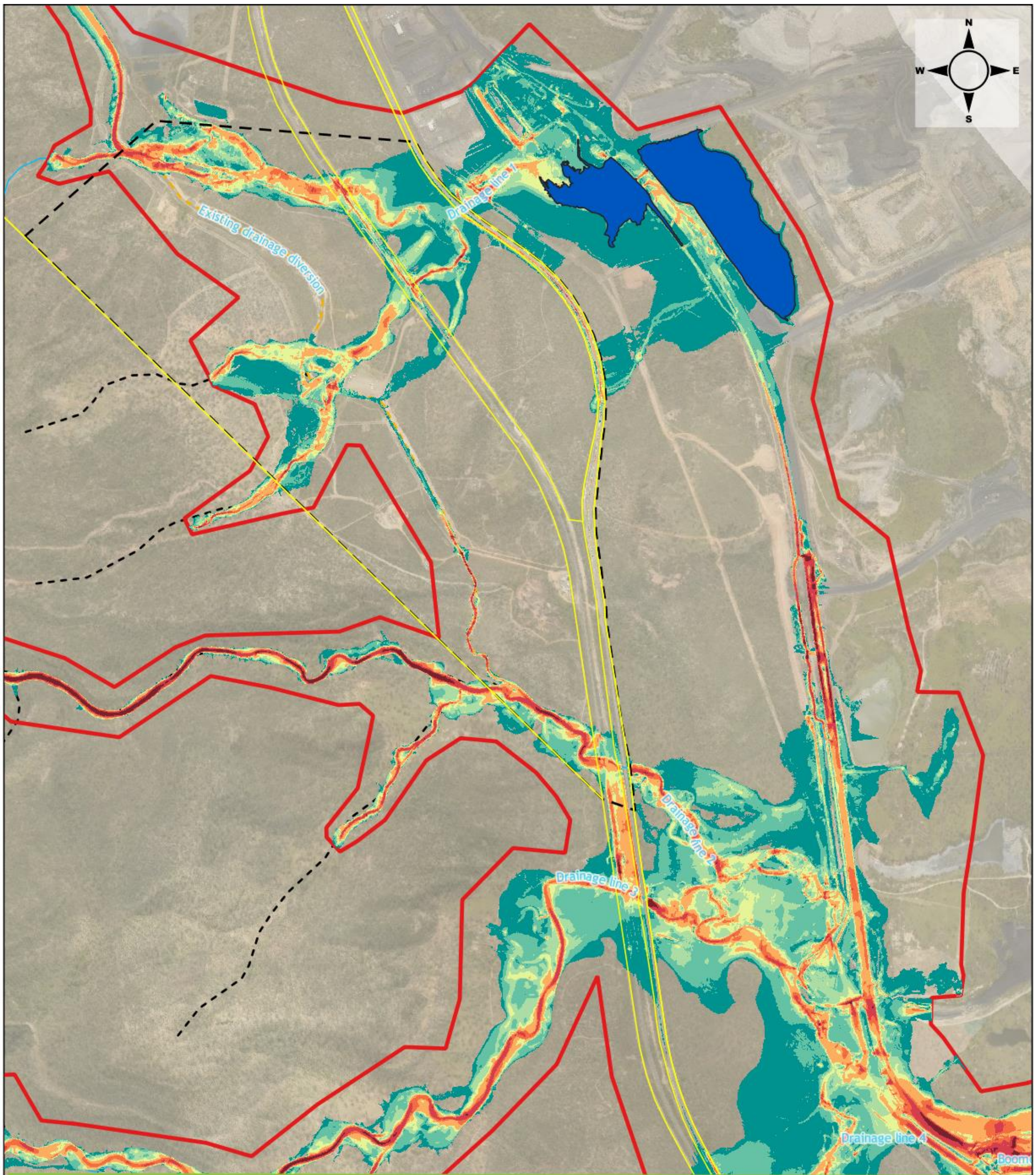

Legend

- TUFLOW model extent
- Project ML
- Minor drainage feature
- Drainage feature
- Existing drainage diversion
- Watercourse
- Major road
- Railway
- Proposed infrastructure
- Existing levee
- Existing dam

Peak velocities (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Vulcan Coal Mine
Surface Water Assessment
Pre-mining Conditions (no levee)
0.1% AEP peak velocities

0 250 500 750 1,000 m

Projection: MGA Zone 55 Datum: GDA94

wrm water + environment

Figure A.12 – 0.1% AEP peak velocities – Pre-mining Conditions (no levee)

Appendix B - Operational Conditions flood maps and results

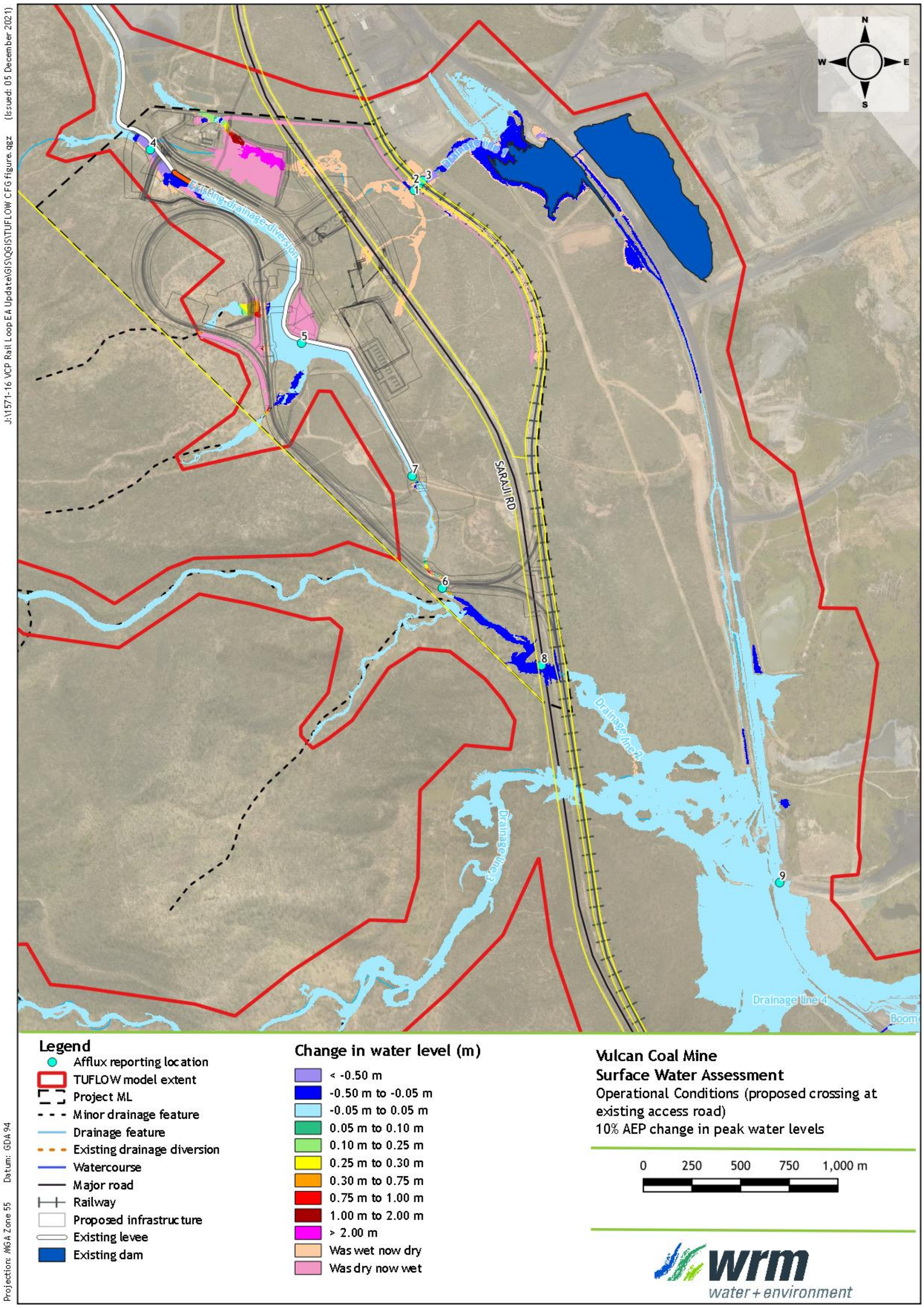

Figure B.1 – 10% AEP change in peak water levels – Operational Conditions (proposed crossing at existing access road) impacts

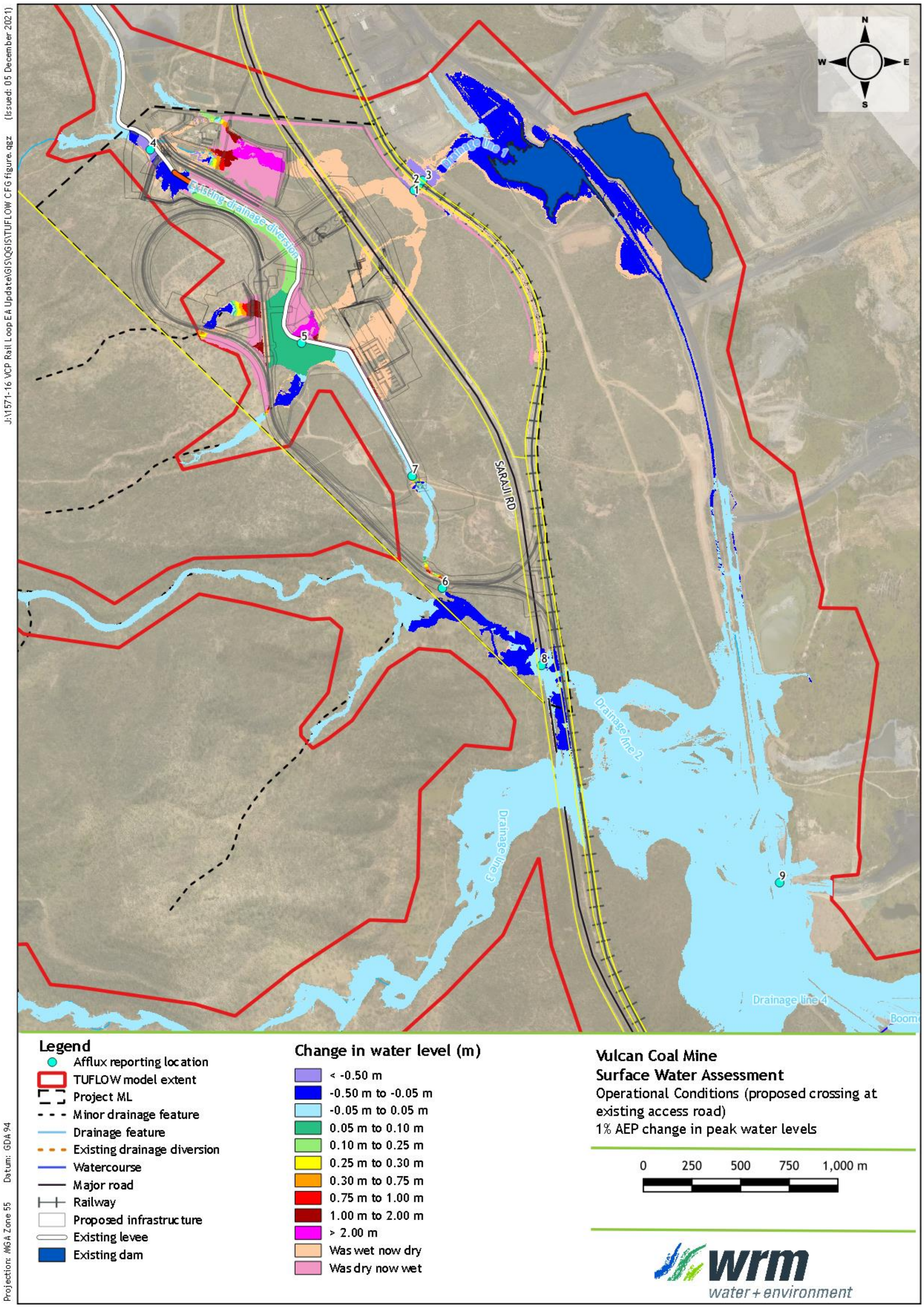

Figure B.2 - 1% AEP change in peak water levels – Operational Conditions (proposed crossing at existing access road) impacts

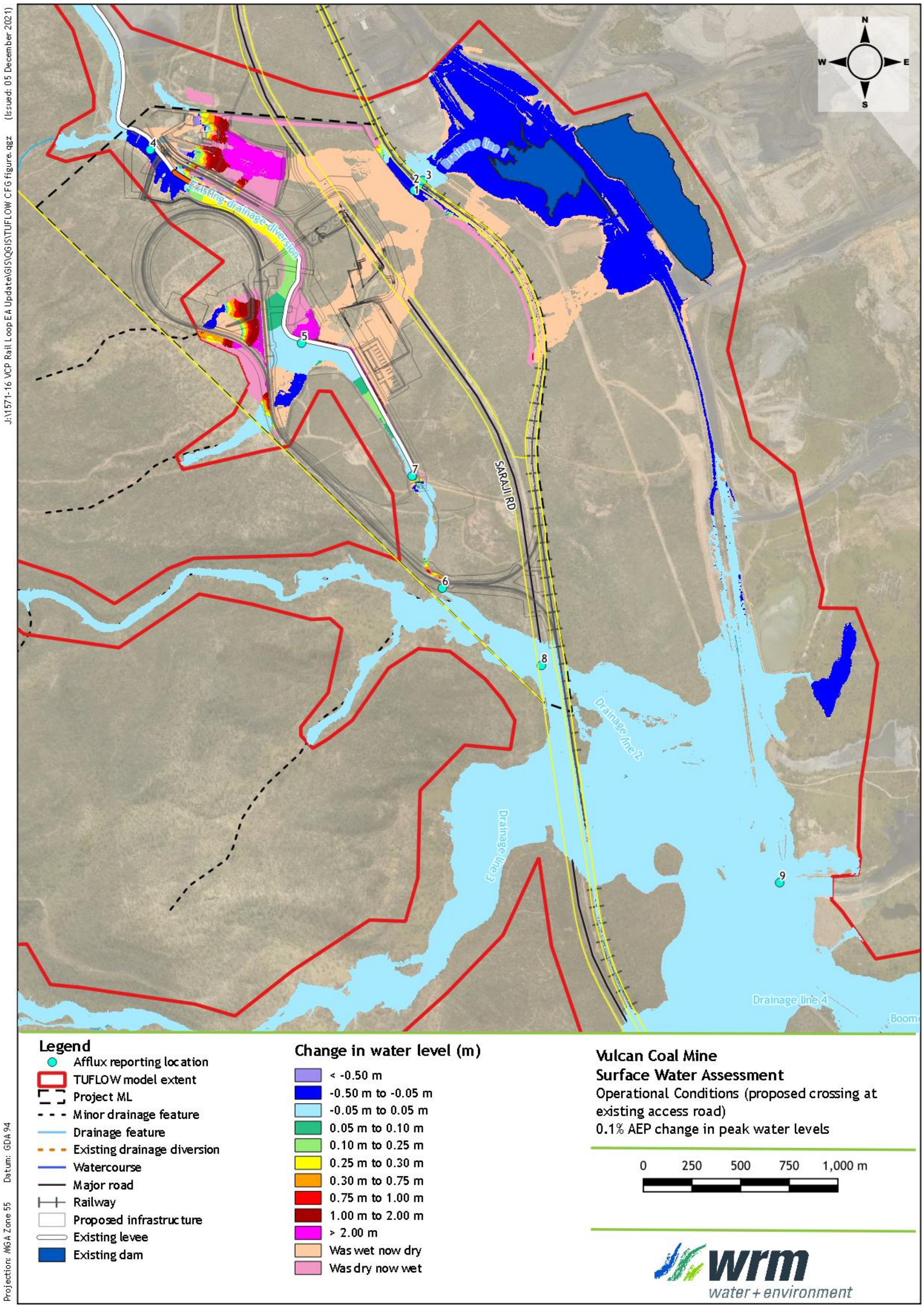

Figure B.3 - 0.1% AEP change in peak water levels – Operational Conditions (proposed crossing at existing access road) impacts

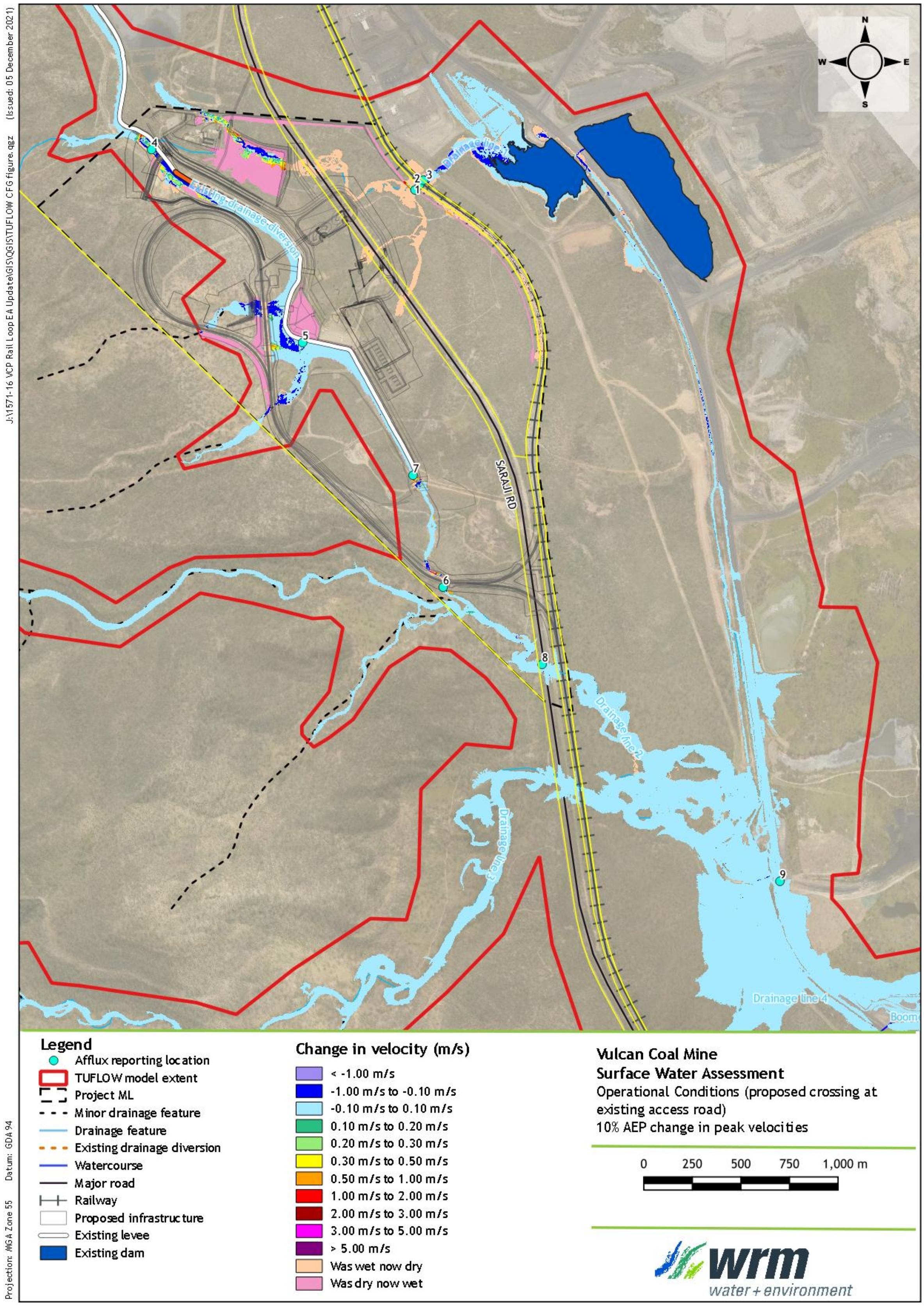

Figure B.4 - 10% AEP change in peak velocities – Operational Conditions (proposed crossing at existing access road) impacts

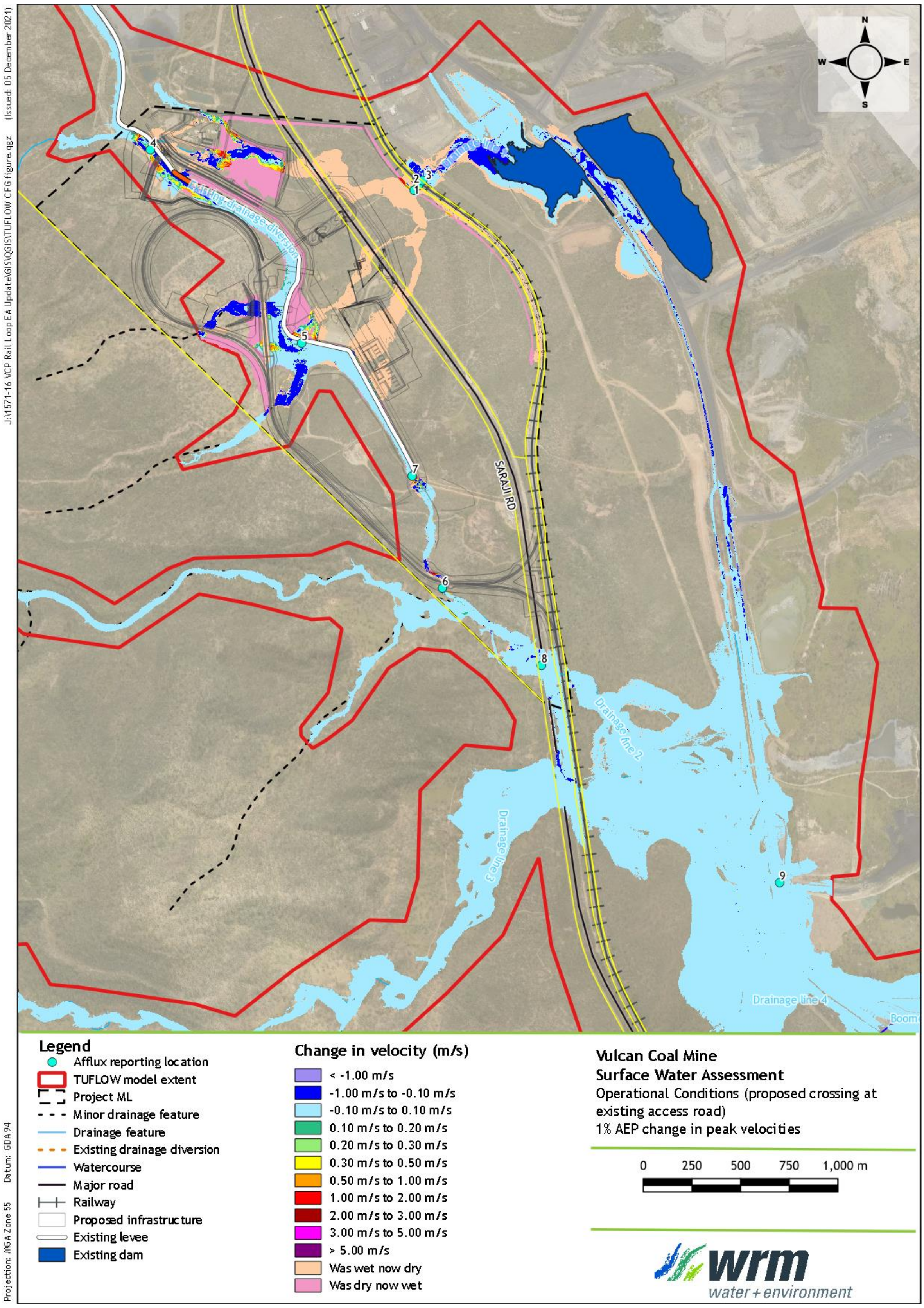

Figure B.5 - 1% AEP change in peak velocities – Operational Conditions (proposed crossing at existing access road) impacts

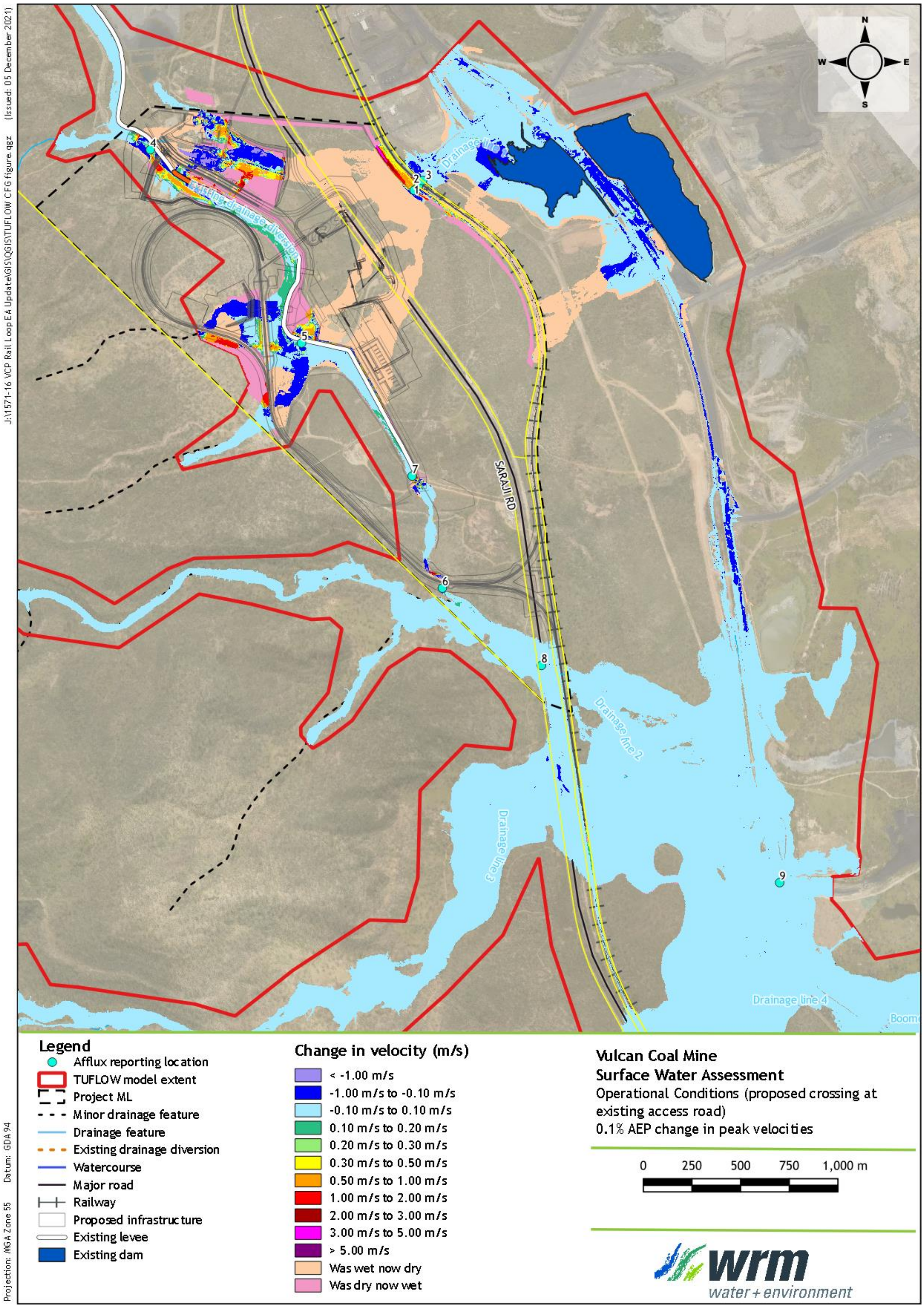

Figure B.6 - 0.1% AEP change in peak velocities – Operational Conditions (proposed crossing at existing access road) impacts

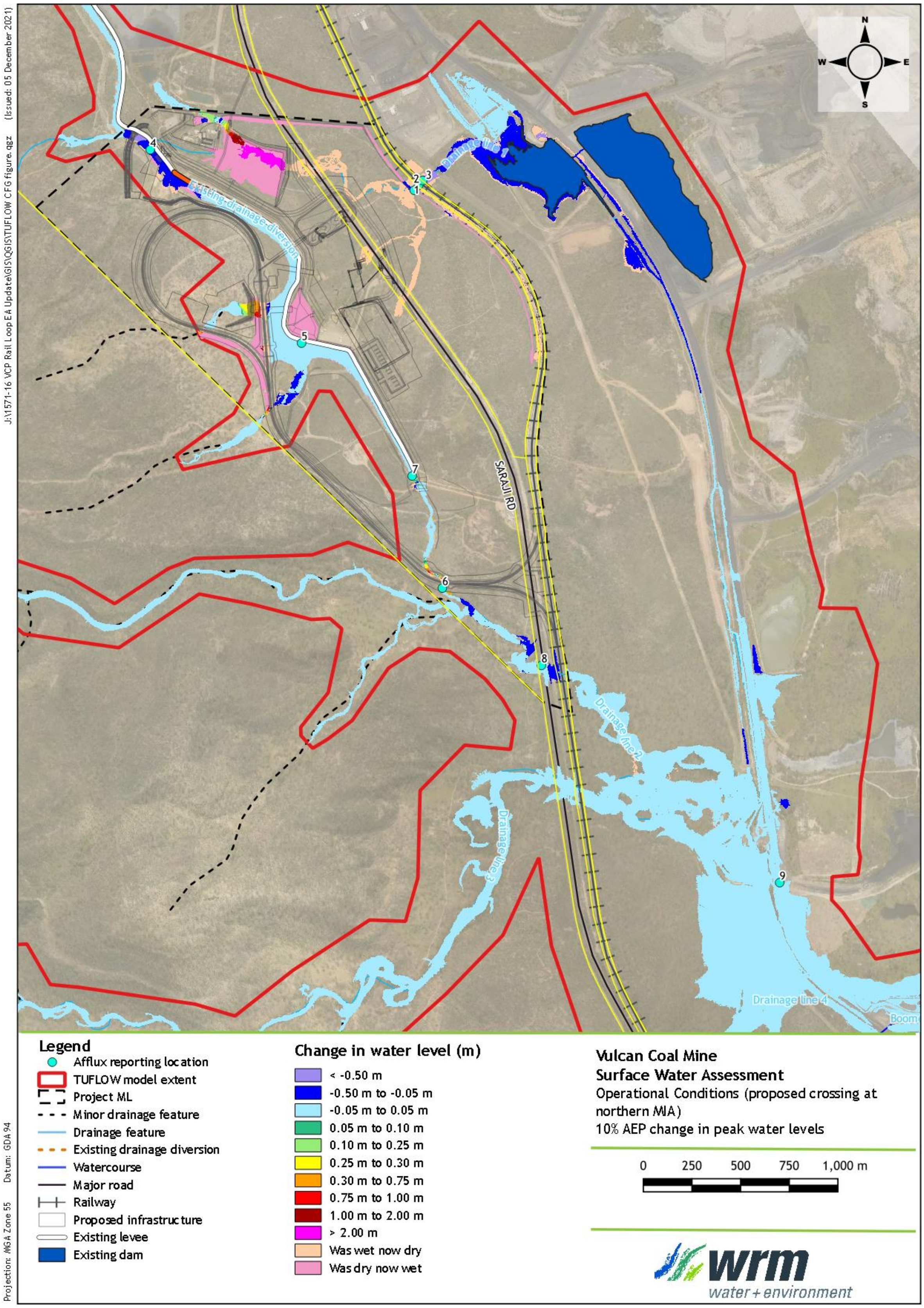

Figure B.7 - 10% AEP change in peak water levels – Operational Conditions (proposed crossing at northern MIA) impacts

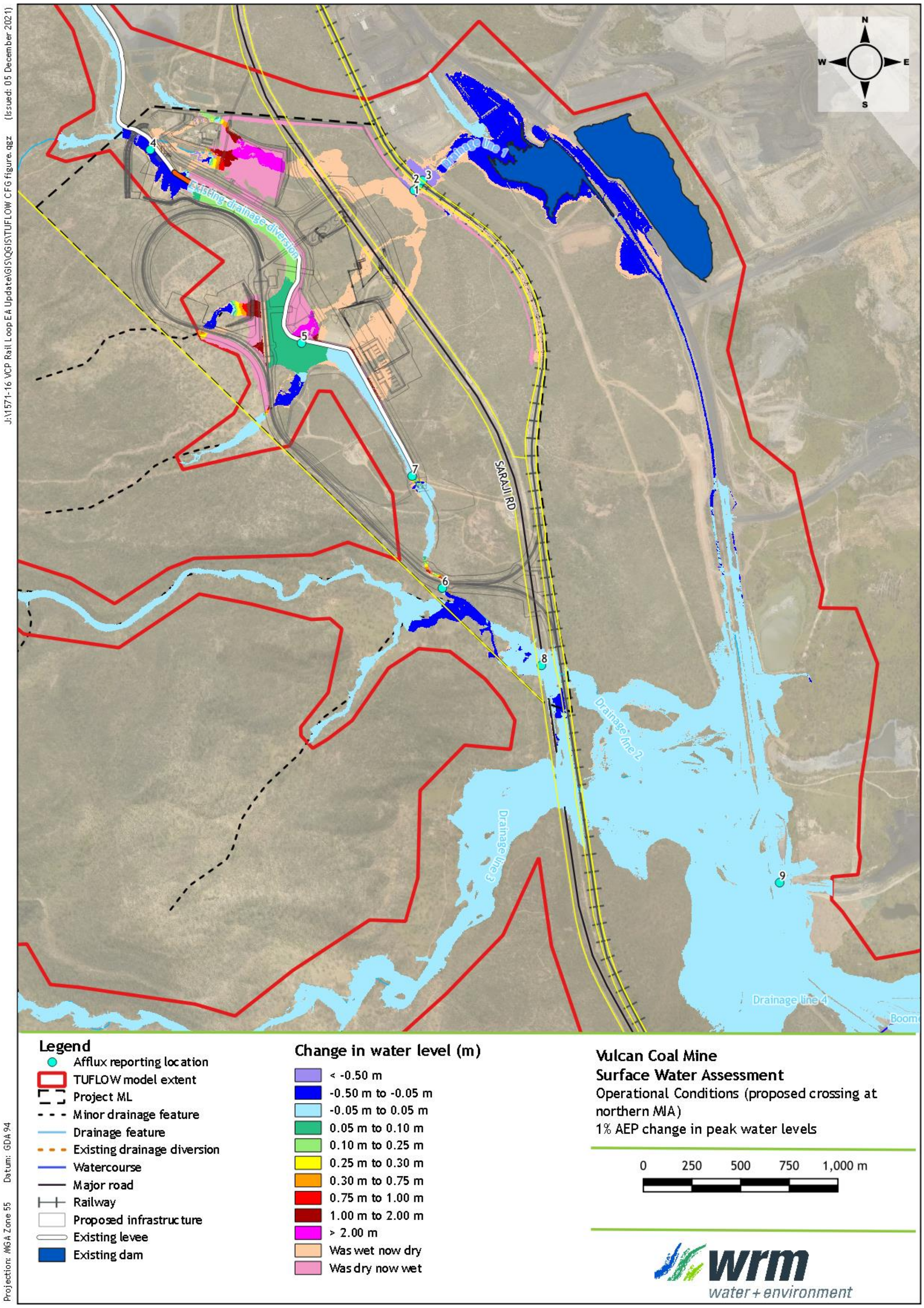

Figure B.8 - 1% AEP change in peak water levels – Operational Conditions (proposed crossing at northern MIA) impact

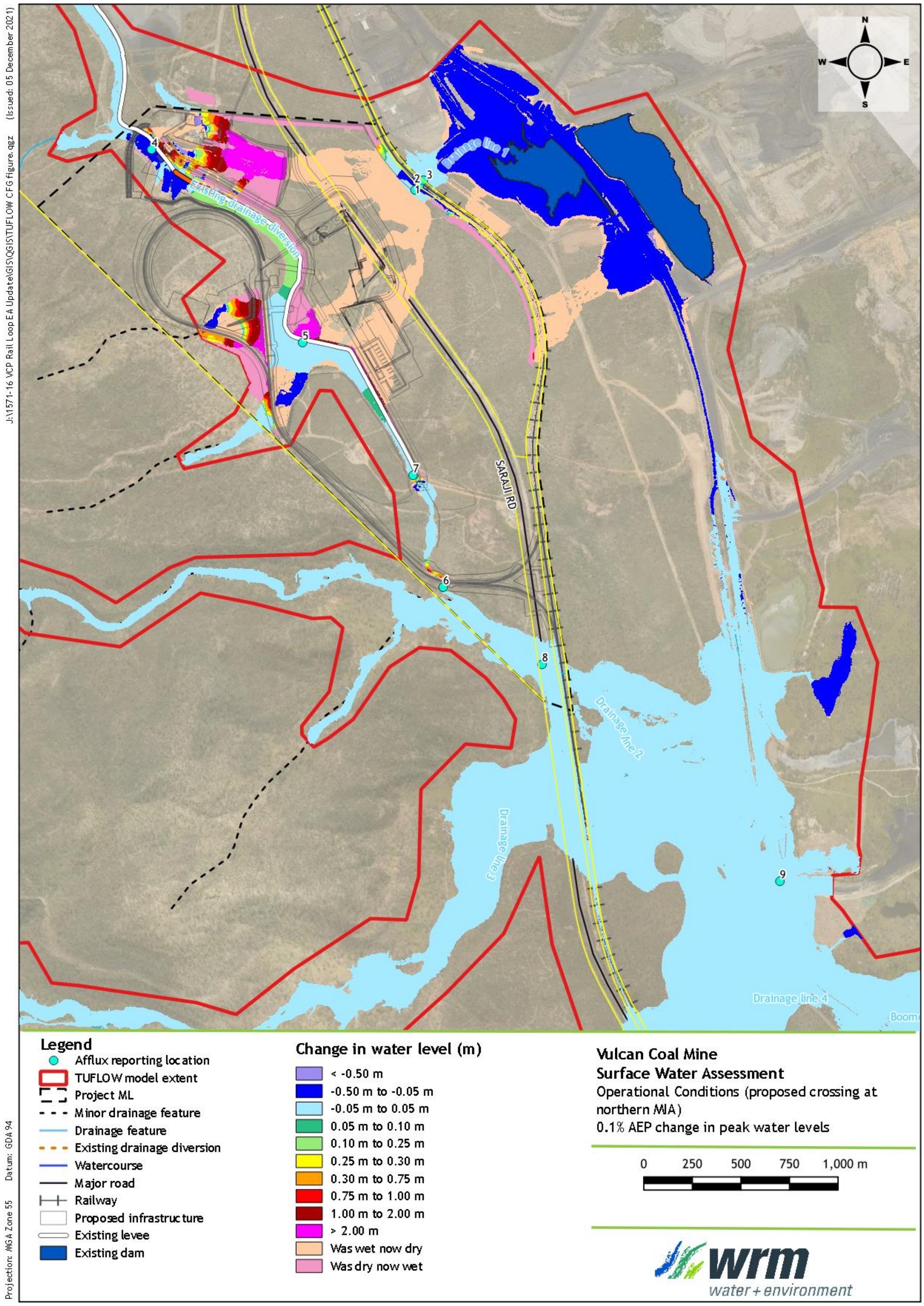

Figure B.9 - 0.1% AEP change in peak water levels – Operational Conditions (proposed crossing at northern MIA) impacts

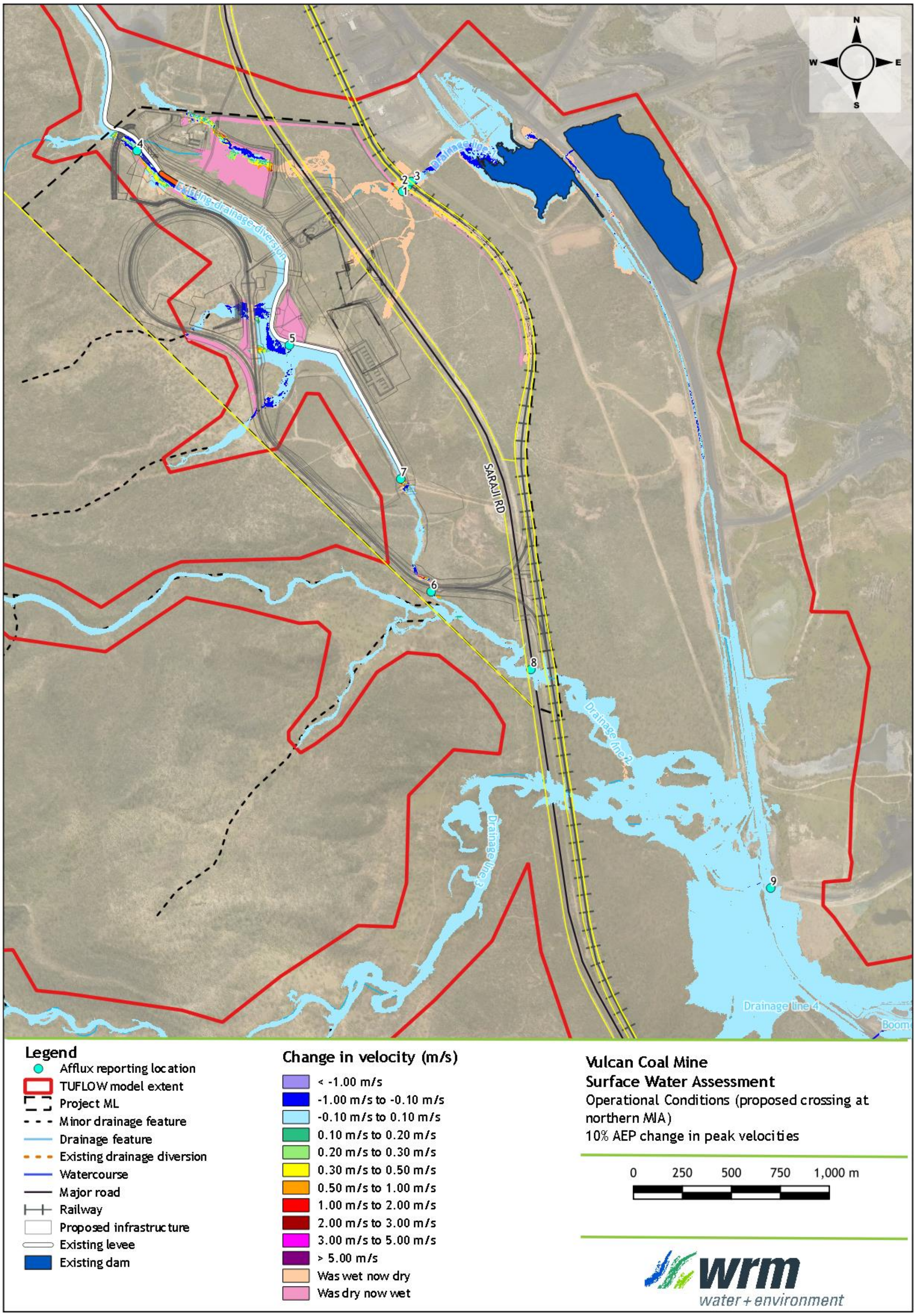

Figure B.10 - 10% AEP change in peak velocities – Operational Conditions (proposed crossing at northern MIA) impacts

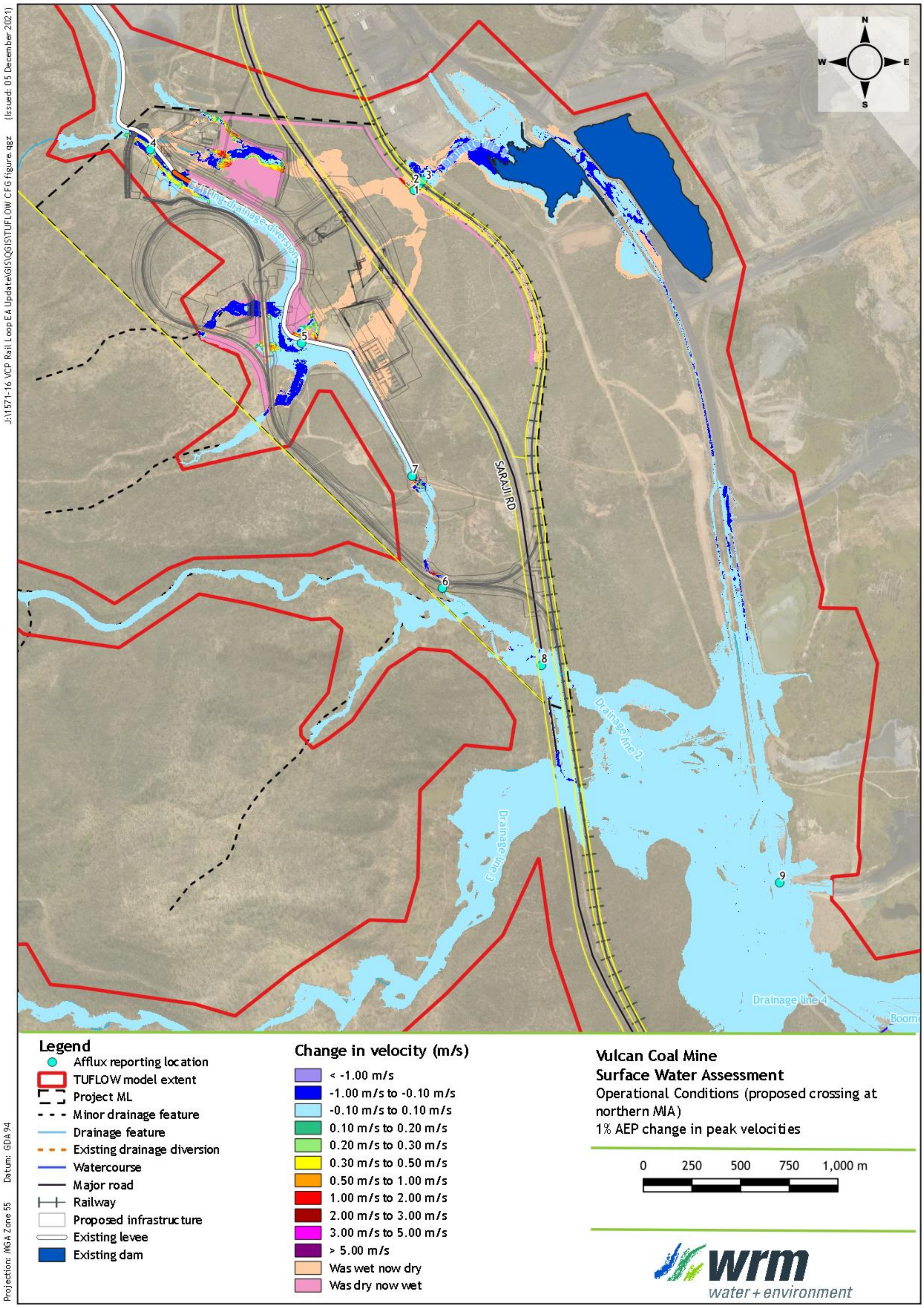

Figure B.11 - 1% AEP change in peak velocities – Operational Conditions (proposed crossing at northern MIA) impacts

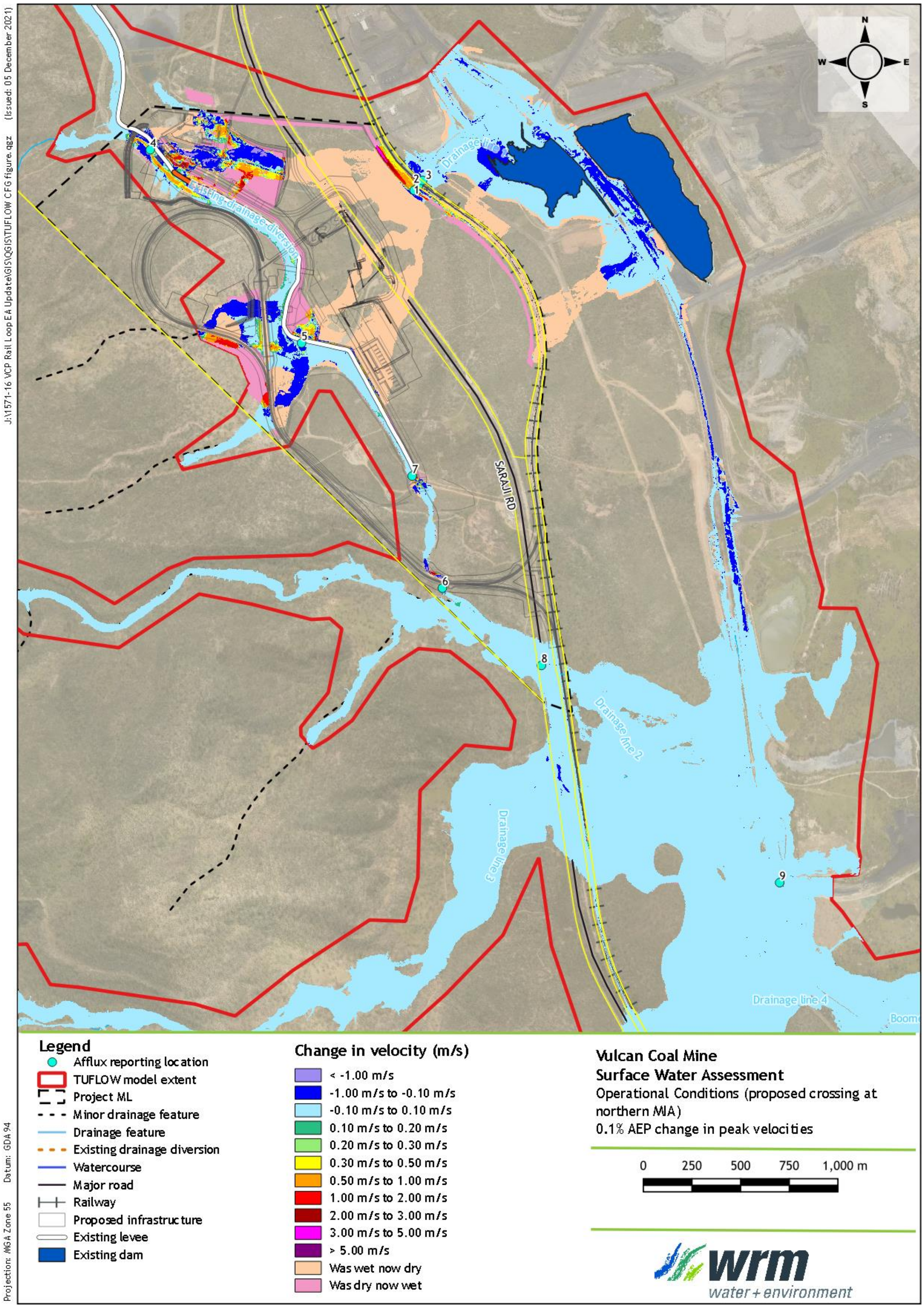

Figure B.12 - 0.1% AEP change in peak velocities – Operational Conditions (proposed crossing at northern MIA) impacts

Appendix C - Post-closure Conditions flood impact maps

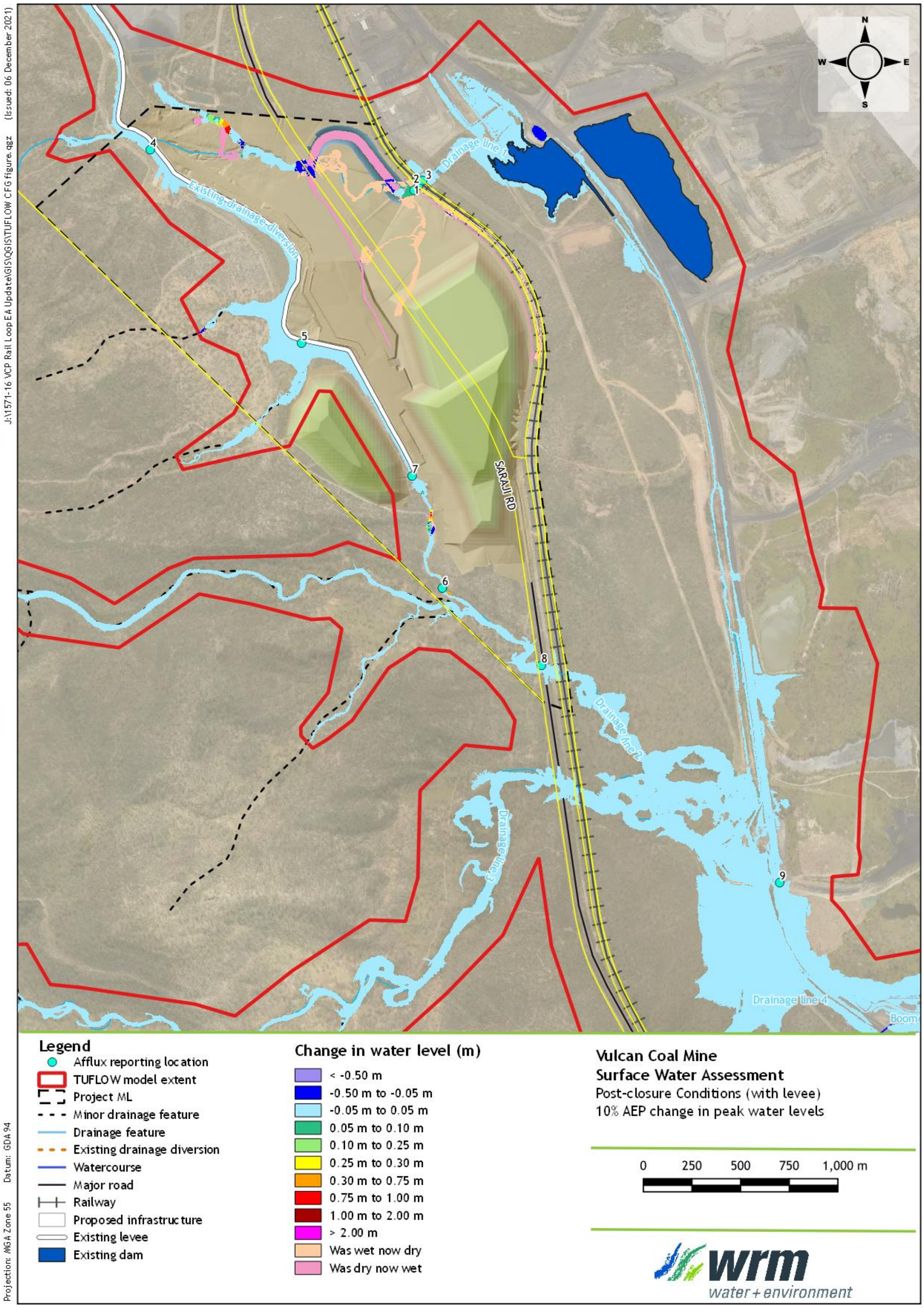

Figure C.1 – 10% AEP change in peak water levels – Post-closure Conditions (with levee) impacts

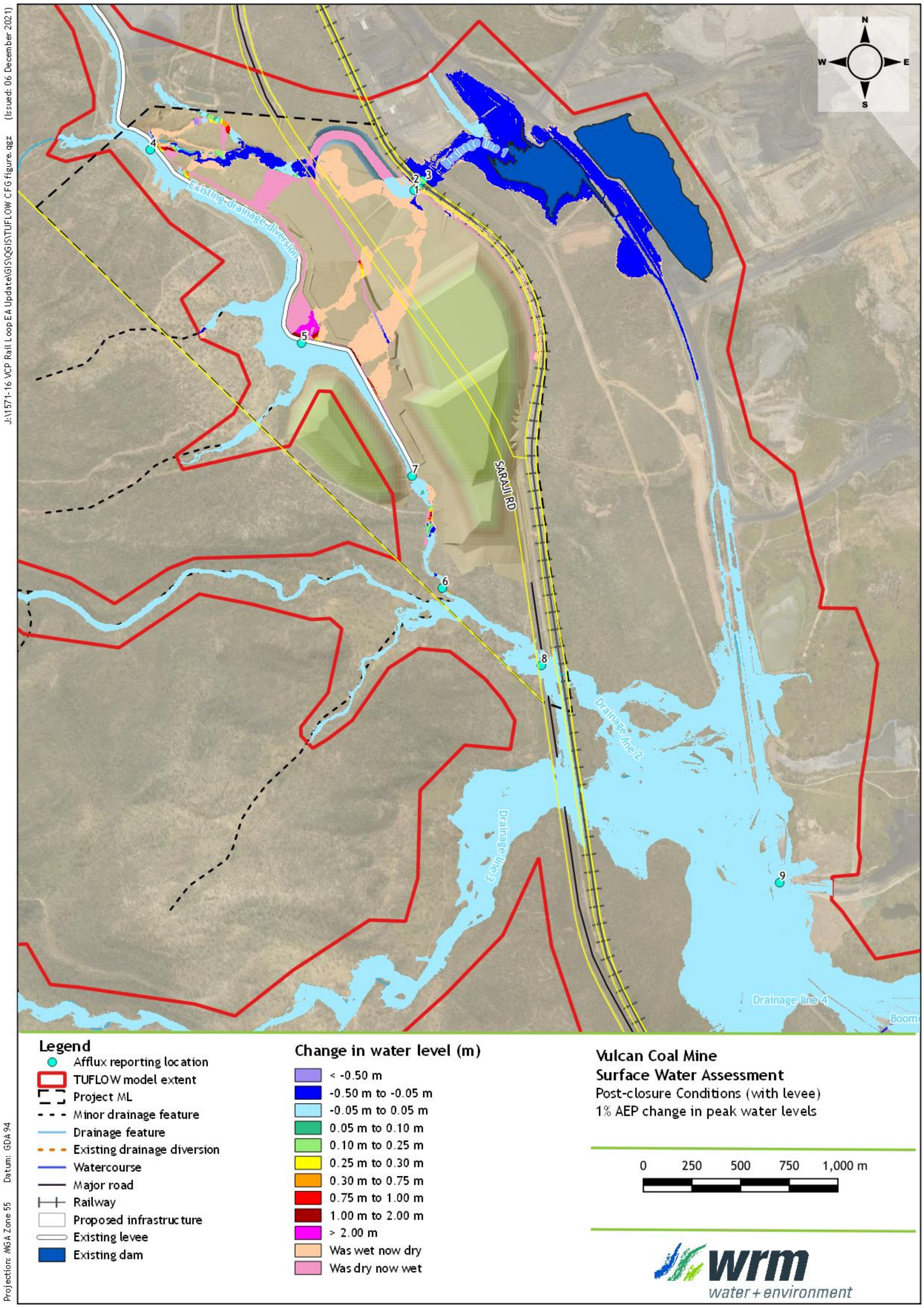

Figure C.2 - 1% AEP change in peak water levels - Post-closure Conditions (with levee) impacts

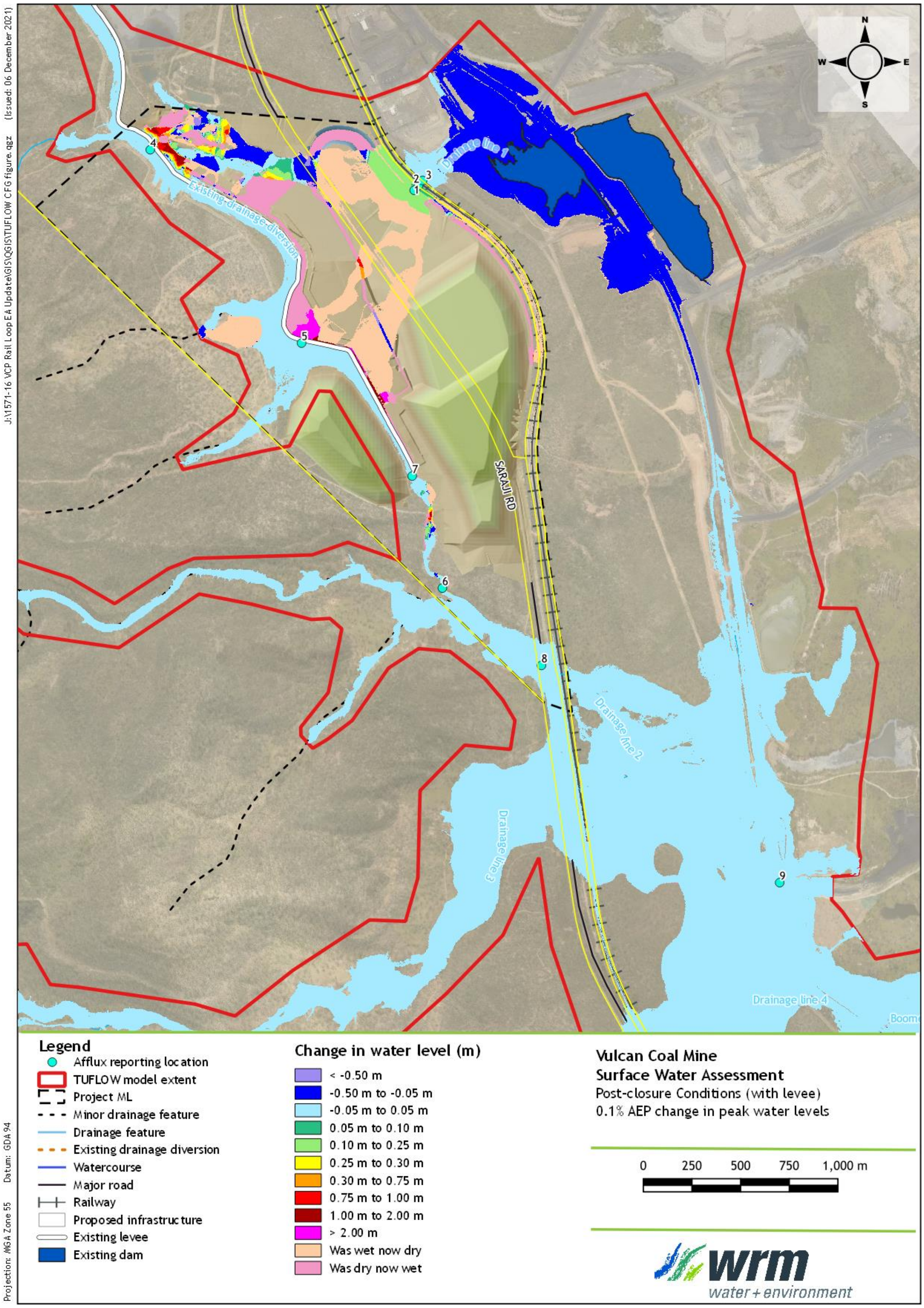

Figure C.3 - 0.1% AEP change in peak water levels – Post-closure Conditions (with levee) impacts

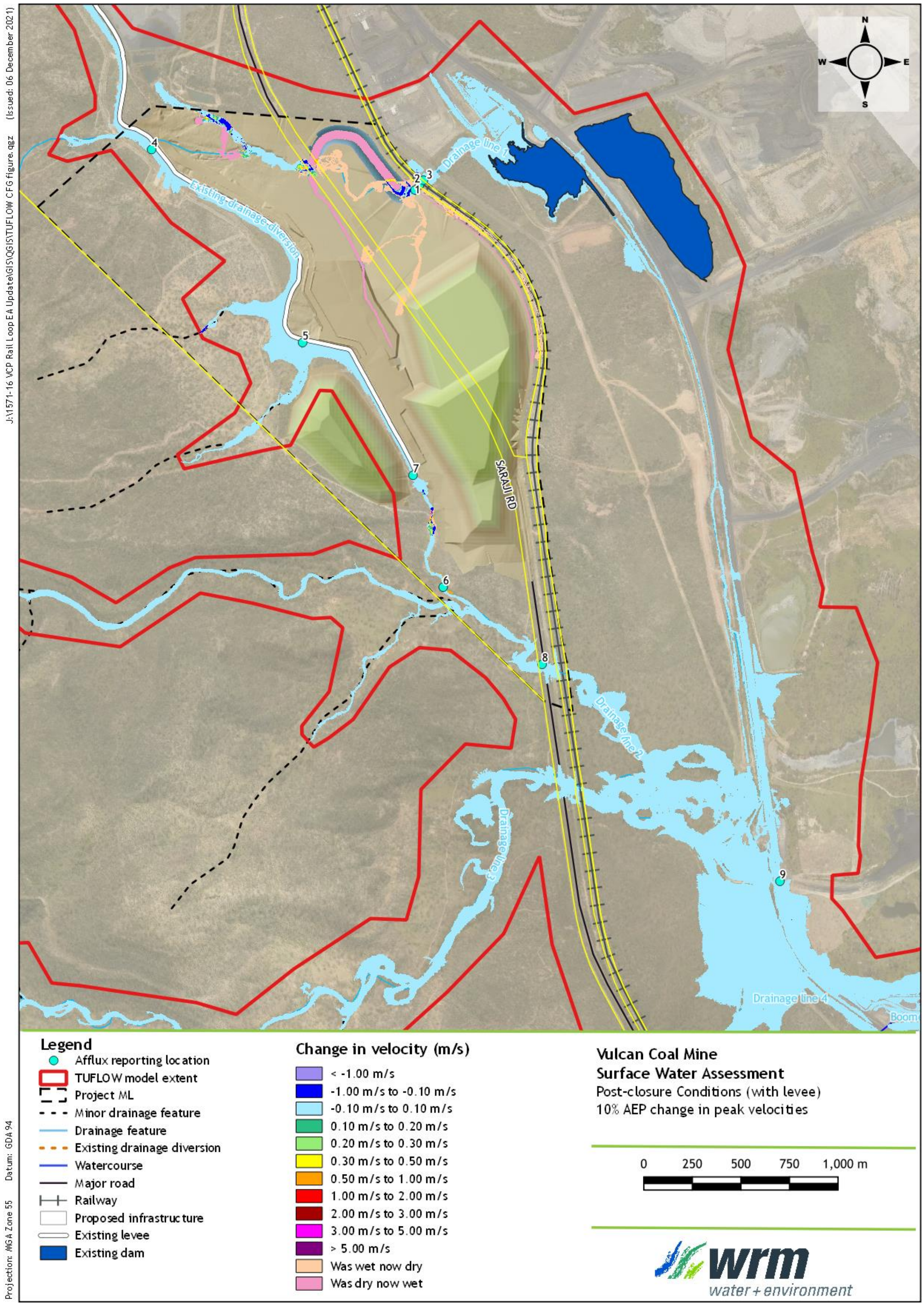

Figure C.4 - 10% AEP change in peak velocities – Post-closure Conditions (with levee) impacts

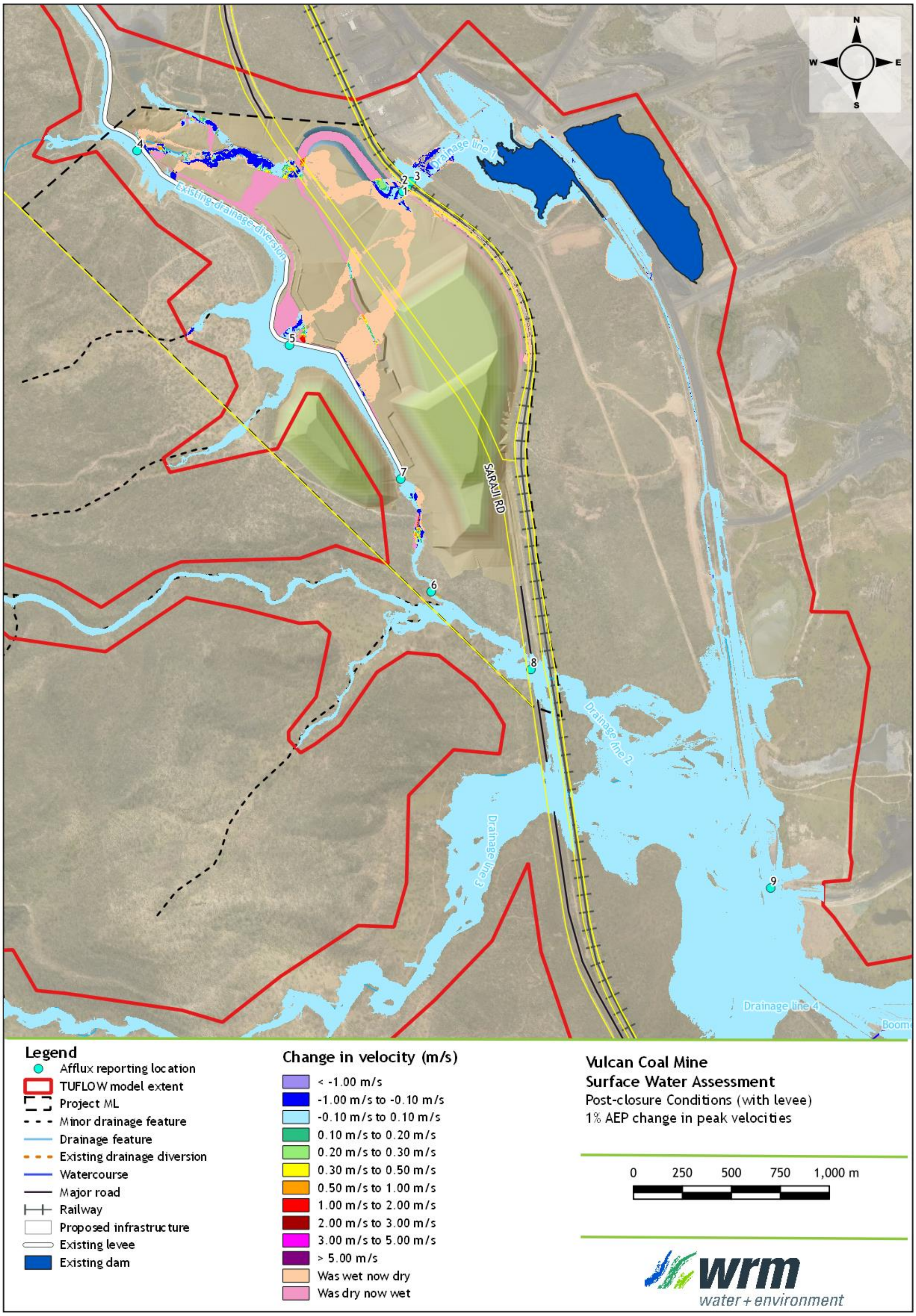

Figure C.5 - 1% AEP change in peak velocities – Post-closure Conditions (with levee) impacts

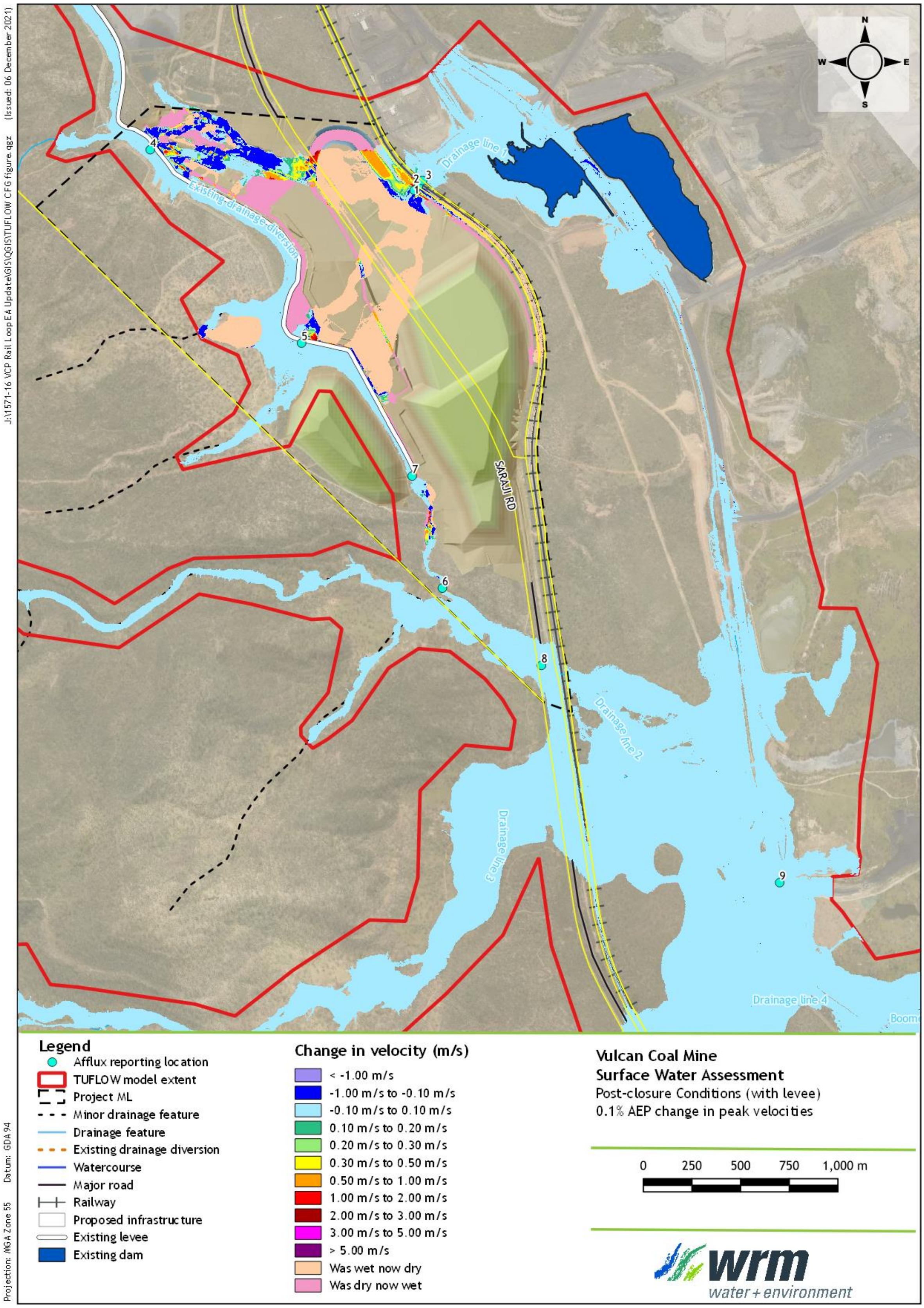

Figure C.6 - 0.1% AEP change in peak velocities – Post-closure Conditions (with levee) impacts

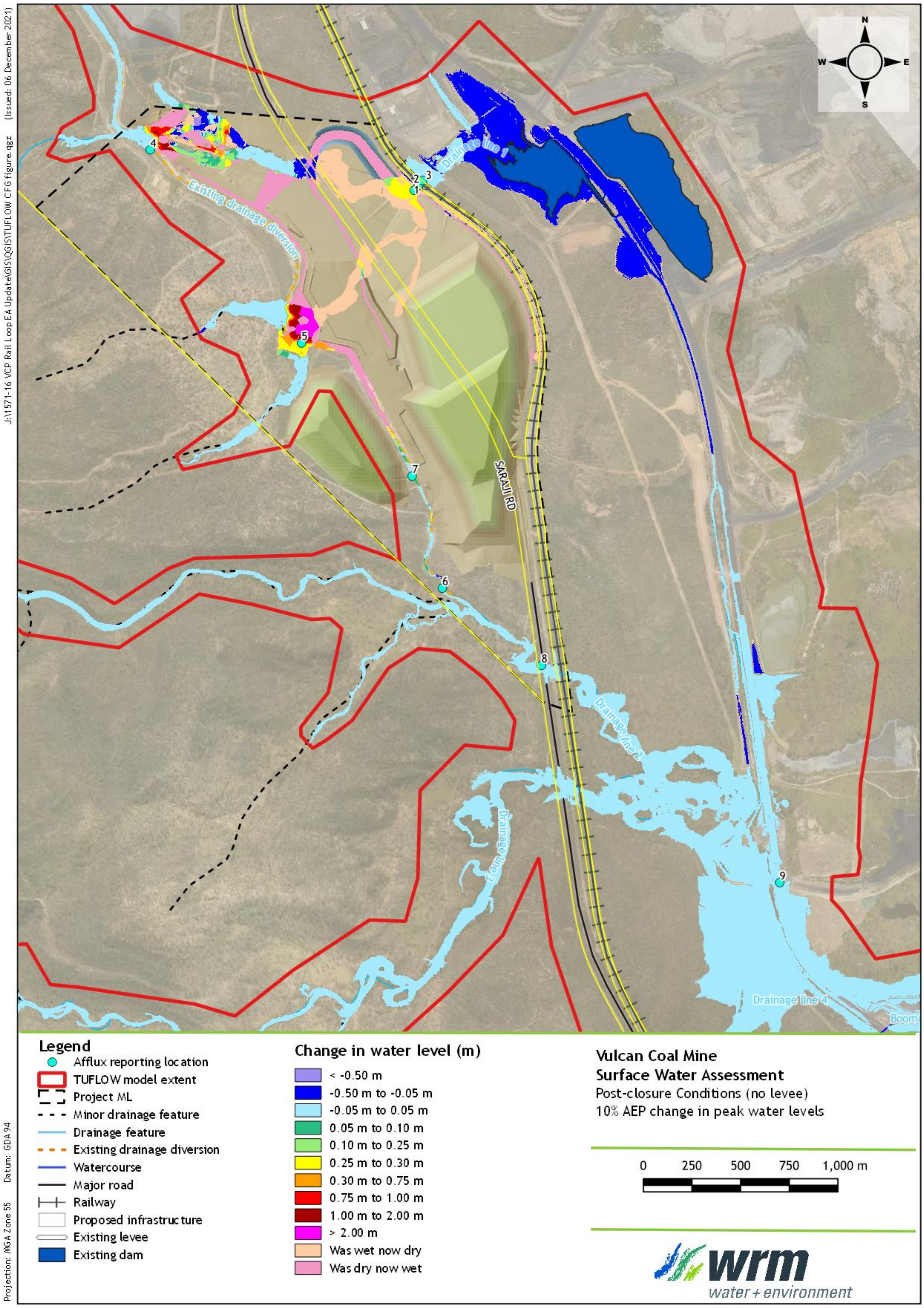

Figure C.7 - 10% AEP change in peak water levels – Post-closure Conditions (no levee) impacts

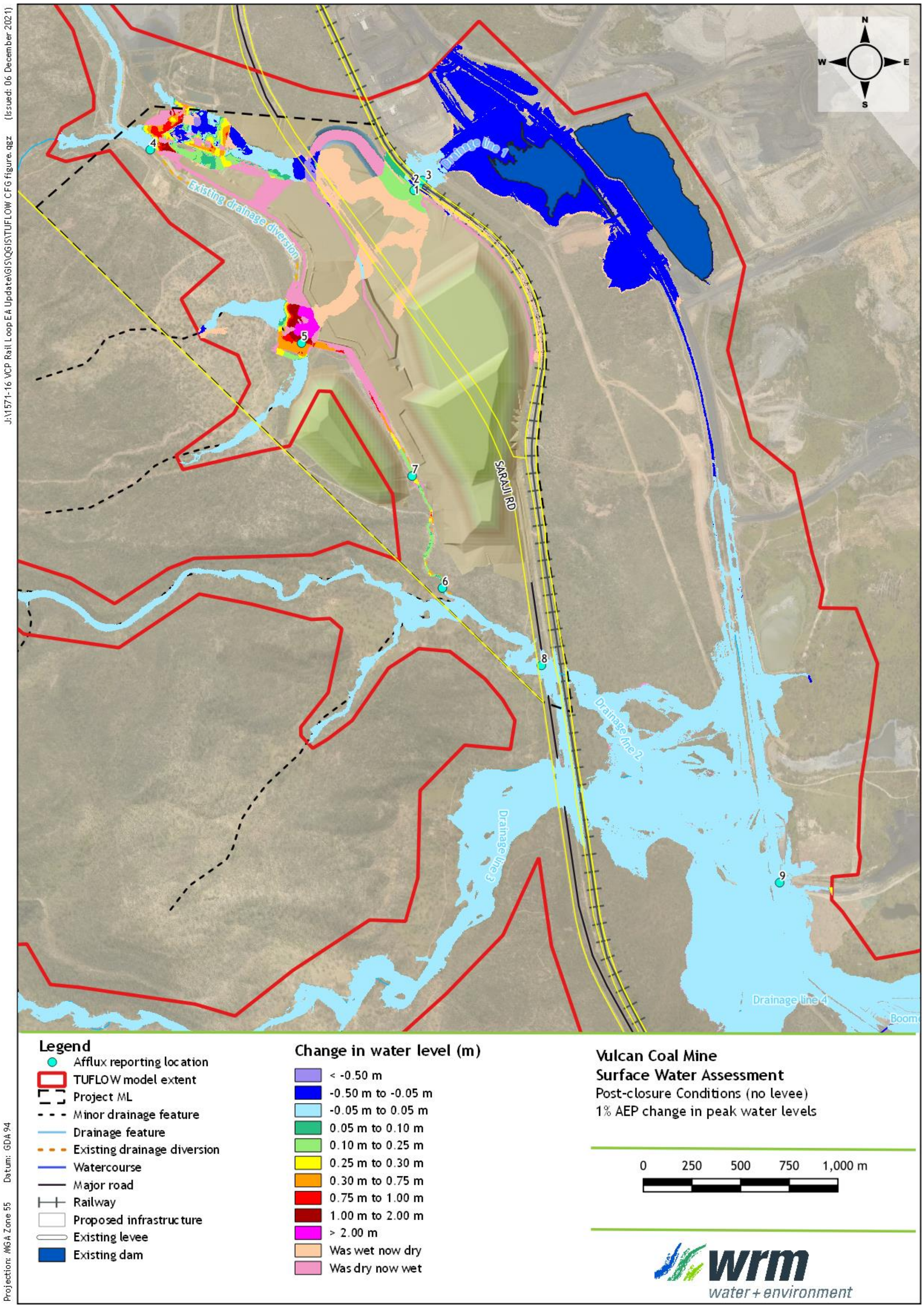

Figure C.8 - 1% AEP change in peak water levels – Post-closure Conditions (no levee) impacts

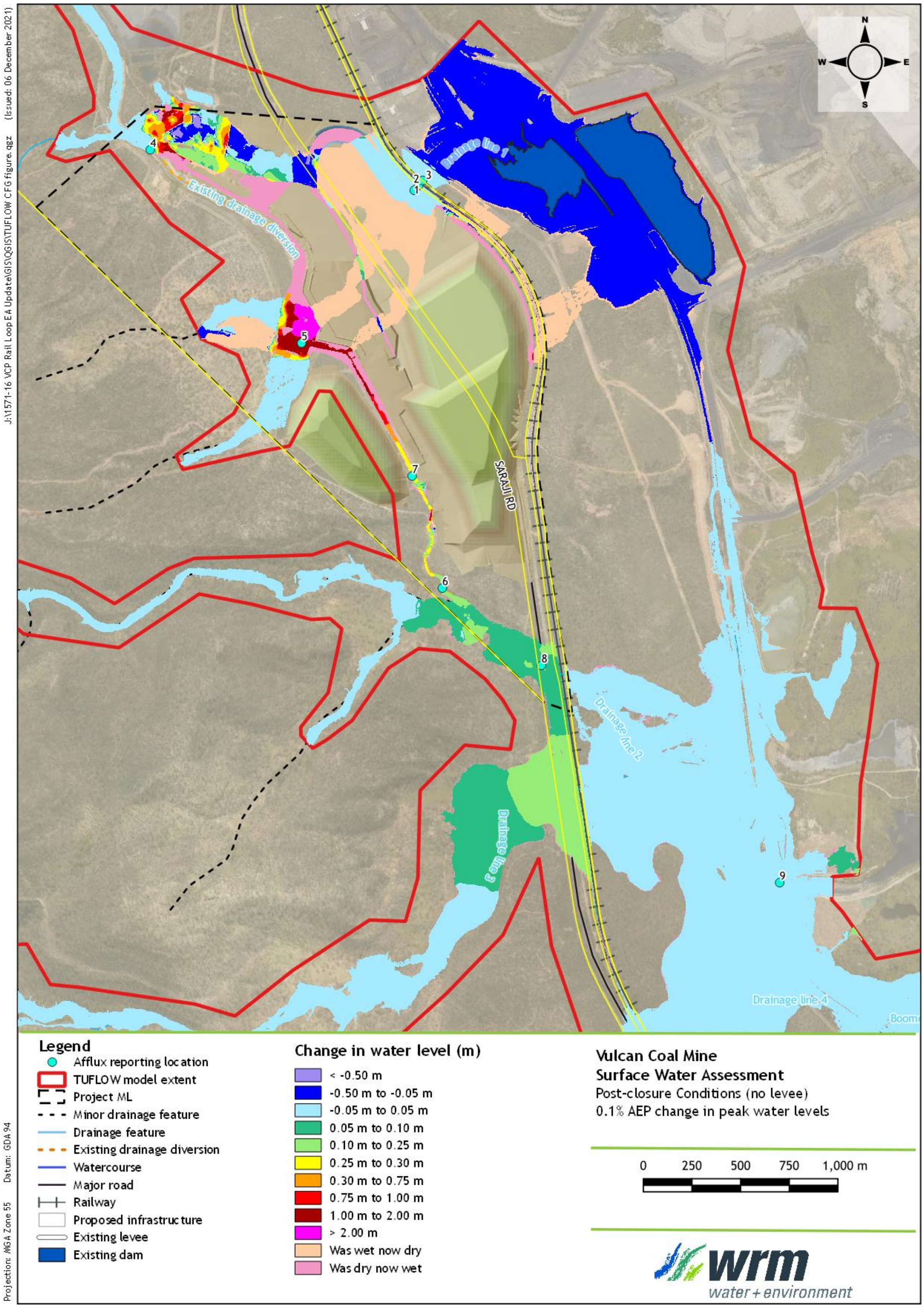

Figure C.9 - 0.1% AEP change in peak water levels – Post-closure Conditions (no levee) impacts

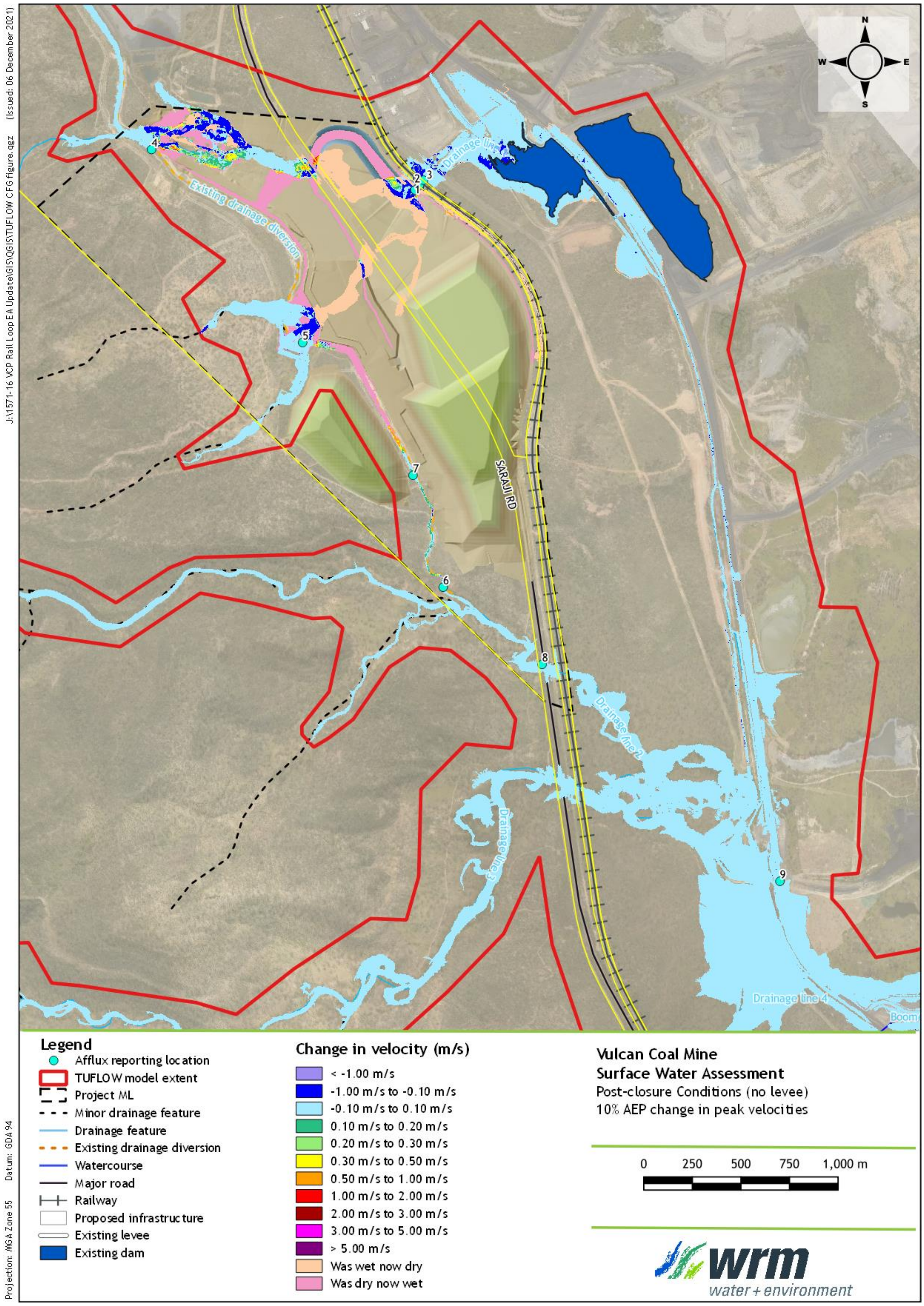

Figure C.10 - 10% AEP change in peak velocities - Post-closure Conditions (no levee) impacts

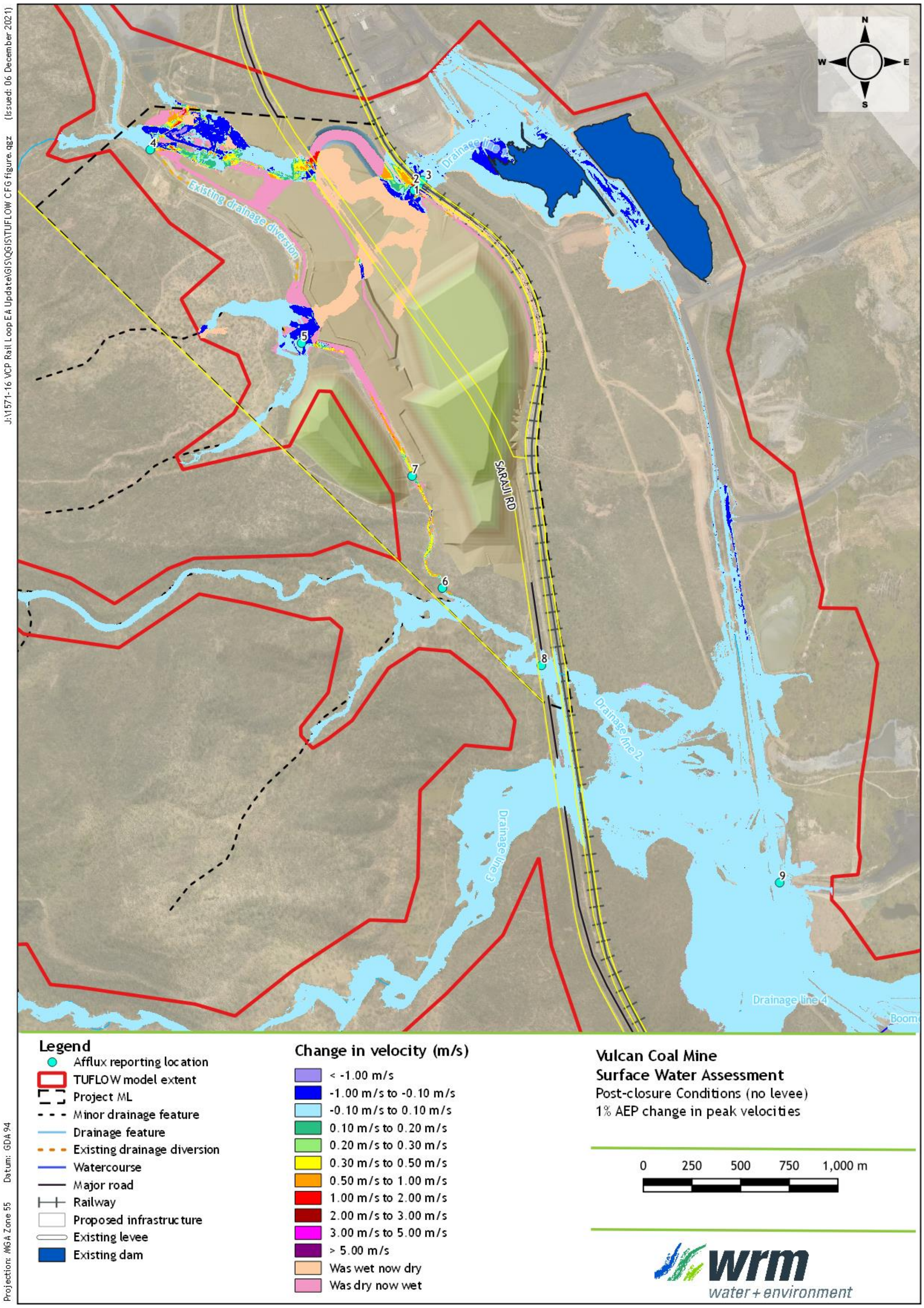

Figure C.11 - 1% AEP change in peak velocities – Post-closure Conditions (no levee) impacts

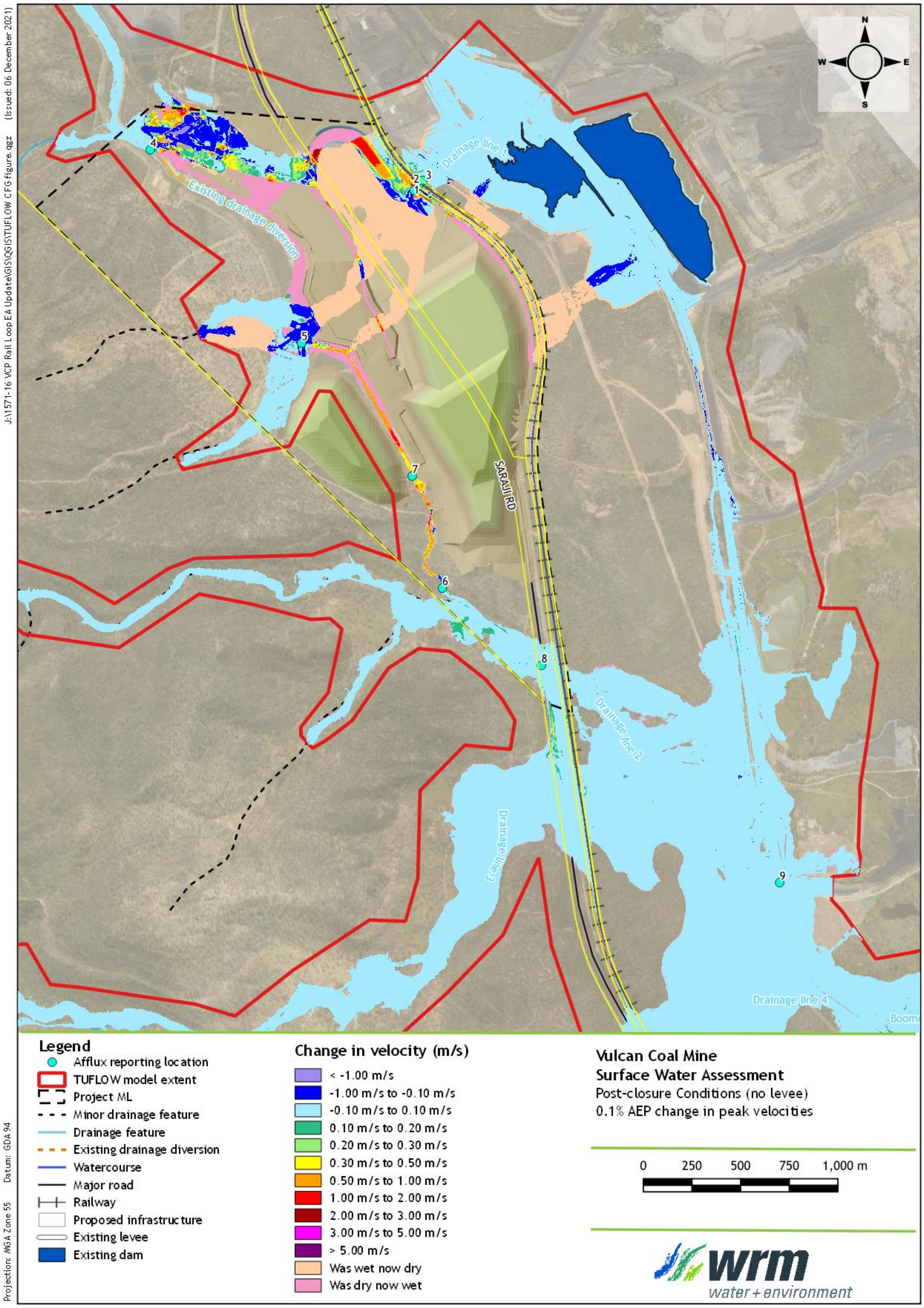

Figure C.12 - 0.1% AEP change in peak velocities – Post-closure Conditions (no levee) impacts