


Appendix H

Surface water assessment

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Holcim

Surface Water Assessment

Dubbo Quarry Continuation Project

Report Number

J180313 RP#

Client

Holcim (Australia) Pty Ltd

Date

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Version

v2 Draft

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Executive Summary

ES1 Project context

Holcim (Australia) Pty Limited (Holcim) is the owner and operator of Dubbo Quarry (the quarry) located on Sheraton Road, Dubbo. The quarry extracts hard rock (basalt) and has been operating since 1980. The accessible basalt resources are close to exhaustion and planning approval is required to allow the quarry to continue operating. Holcim is, therefore, seeking approval for the Dubbo Quarry Continuation Project (henceforth referred to as 'the project') which involves the continued operation of the quarry through the development of two new resource areas to the south and west of the existing quarry boundary.

The project is classified as State significant development under Part 4, Division 4.1 of the NSW *Environmental Planning Assessment Act 1979*.

This Surface Water Assessment supports the EIS for the project. It describes the existing surface water environment, the water management systems for existing and proposed operations, residual impacts and water licencing requirements. The assessment has been prepared in accordance with the Secretary's Environmental Assessment Requirements for the project, issued 24 April 2020, and considers relevant government and industry guidelines.

ES2 Local watercourses

The quarry is located within the within the Eulomogo Creek catchment. Eulomogo Creek is a 3rd order watercourse that has 52 km^2 catchment area (upstream of the quarry) and an intermittent flow regime. Eulomogo Creek flows in a westerly direction and joins the Macquarie River approximately 2.7 km to west of the quarry.

Two ephemeral 1st order watercourses flow into the existing quarry pit. These watercourses are referred to as the eastern and northern watercourses in this report and are described further below.

The eastern watercourse has a 227 ha catchment area that extends to the east of the quarry. Runoff from the eastern watercourse is captured in a dam located to the east of the existing quarry. Overflows from this dam enter the quarry pits.

The northern watercourse has a 270 ha catchment area that extends to the north of the quarry. All runoff from this catchment is captured in the South Keswick Quarry's water management dams. Any overflows from these dams will enter the quarry pits.

ES3 Water management summary

ES3.1 Existing system

The existing water management system receives inflows from:

- runoff from the quarry area;
- runoff from the eastern watercourse catchment; and
- groundwater inflows into quarry pits.

The system provides water for operational uses which include process plant and haul road dust suppression. Discharges from the water management system occur due to sedimentation dam overflows and dewatering quarry pits. Water balance model results presented in Chapter 4 indicate that operational water requirements are generally lower than inflows, meaning that discharges occur in most years.

ES3.2 Proposed strategy

Holcim are proposing to integrate the water management systems for the two expansion areas with the quarry's existing water management system. This will require construction of new infrastructure, some modifications to existing infrastructure and new operating principles for the quarry.

ES3.2.1 Objectives

A water management strategy for the proposed operations is documented in this report. The key objectives of the strategy are to:

- minimise groundwater inflows into quarry pits;
- minimise controlled discharges from quarry pits; and
- provide industry best practice erosion and sedimentation controls for disturbance areas that do not drain to a pit sump.

ES3.2.2 Proposed modifications and new controls

Proposed modifications to existing system include:

- water levels in existing pits will generally be maintained at or above levels that restrict groundwater inflows; and
- an existing sedimentation dam will be upgraded to comply with industry best practice.

Proposed new controls include:

- new pits will not be developed below the interpreted groundwater table. This will avoid any material groundwater inflows; and
- industry best practice erosion and sedimentation controls for disturbance areas that do not drain to a pit sump.

ES3.2.3 Outcomes

Water balance modelling presented in Chapter 5 of this report demonstrates that the water management strategy for the proposed operations will be effective in substantially reducing both the frequency and magnitude of discharges due to sedimentation basin overflows and pit dewatering, with discharges via both mechanisms occurring during wet conditions only and at reduced magnitudes. These reductions will occur despite the quarry footprint increasing from approximately 34 to 60 ha due to the proposed extensions.

ES4 Proposed creek crossing

A haul road crossing of Eulomogo Creek is proposed to connect the southern extension area to the existing operation. Concept designs for two culvert-based options have been prepared by Pitt and Sherry and are provided as Appendix C. A flood impact assessment was also undertaken by GRC Hydro. The assessment identified that the crossing would result in localised impacts within the quarry site.

ES5 Water licencing

Chapter 8 of this report reviews licensing requirements for the proposed operation. This review concluded that Holcim hold sufficient entitlements for predicted surface water and groundwater take.

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1 Introduction

1.1 Overview

Holcim (Australia) Pty Limited (Holcim) is the owner and operator of Dubbo Quarry (the quarry) located on Sheraton Road, Dubbo (refer Figure 1.1). The quarry has been operating since 1980.

Accessible basalt resources within the existing quarry boundary (refer Figure 1.2) are close to exhaustion and planning approval is required to allow the quarry to continue operating. Holcim is, therefore, seeking approval for the Dubbo Quarry Continuation Project (henceforth referred to as 'the project') which involves the continued operation of the quarry through the development of two new resource areas to the south and west of the existing quarry boundary (refer Figure 1.2).

The project is classified as State significant development (SSD) under Part 4, Division 4.1 of the NSW *Environmental Planning Assessment Act 1979* (EP&A Act). This surface water assessment will accompany the environmental impact statement (EIS) prepared for the project.

1.2 The site

The quarry is located within Dubbo Regional Local Government Area (LGA) approximately 6 km south-east of the city of Dubbo. The quarry is accessed via Sheraton Road which connects to the Mitchell Highway approximately 2 km north-west of the quarry.

The site relates to the following land as shown on Figure 1.2:

- Lot 222 DP 1247780, owned by Holcim; and

- Part Lot 100 DP 628628, under private ownership, for which Holcim proposes to enter into an Access Licence.

Development consent for the quarry was originally granted by Talbragar Shire Council on 18 March 1980 under SPR79/22 (the existing consent). This consent related to the establishment of a basalt quarry on former Portions 208 and 211, Parish Dubbo (the existing site) and contains eight conditions with no restrictions on production rates or operating hours. Holcim also holds Environment Protection Licence (EPL) No. 2212 for land-based extraction activities between 100,000 and 500,000 tonnes per annum (tpa).

The quarry produces high quality aggregates for use in the construction industry. Typical uses include concrete and asphalt production and road base. Precoated sealing aggregates from crushed basalt are also produced. The quarry produces many types of road base, both specification and non-specification, such as the premium road base product Heavy Duty DGB20 which is frequently used by local councils and Roads and Maritime Services (RMS) for the construction and upgrade of roads.

1.3 Project overview

The project involves continued operations within the existing site and into two new resource areas as described below (refer Figure 1.2):

- The existing approved disturbance boundary within Lot 222 DP 1247780;

- The Western Extension Area (WEA) which is north-west of the existing quarry, located within Lot 222 DP 1247780 (north and south of Sheraton Road; and

- The Southern Extension Area (SEA) which is south of the existing quarry boundary on the southern side of Eulomogo Creek, located within part Lot 100 DP 628628.

A new haul road and crossing over Eulomogo Creek will also be constructed as part of the project to connect the existing quarry with the SEA. The quarry's access road, which connects to Sheraton Road, is to be relocated around the northern and eastern boundaries of the WEA.

The existing consent for quarry places no restriction on production. However, the existing infrastructure has capacity to produce a maximum of 500,000 tpa. The two proposed extension areas provide sufficient resource for quarry operations to continue for up to 25 years.

1.4 Report purpose and assessment requirements

This Surface Water Assessment supports the EIS for the project. It describes the existing surface water environment, the existing and proposed operations water management systems, and residual impacts. The assessment has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) for the project, issued 24 April 2020, and considers relevant government and industry guidelines.

Table 1.1 lists SEARs relevant to this assessment and where they are addressed in this report.

Table 1.1 SEARs surface water requirements

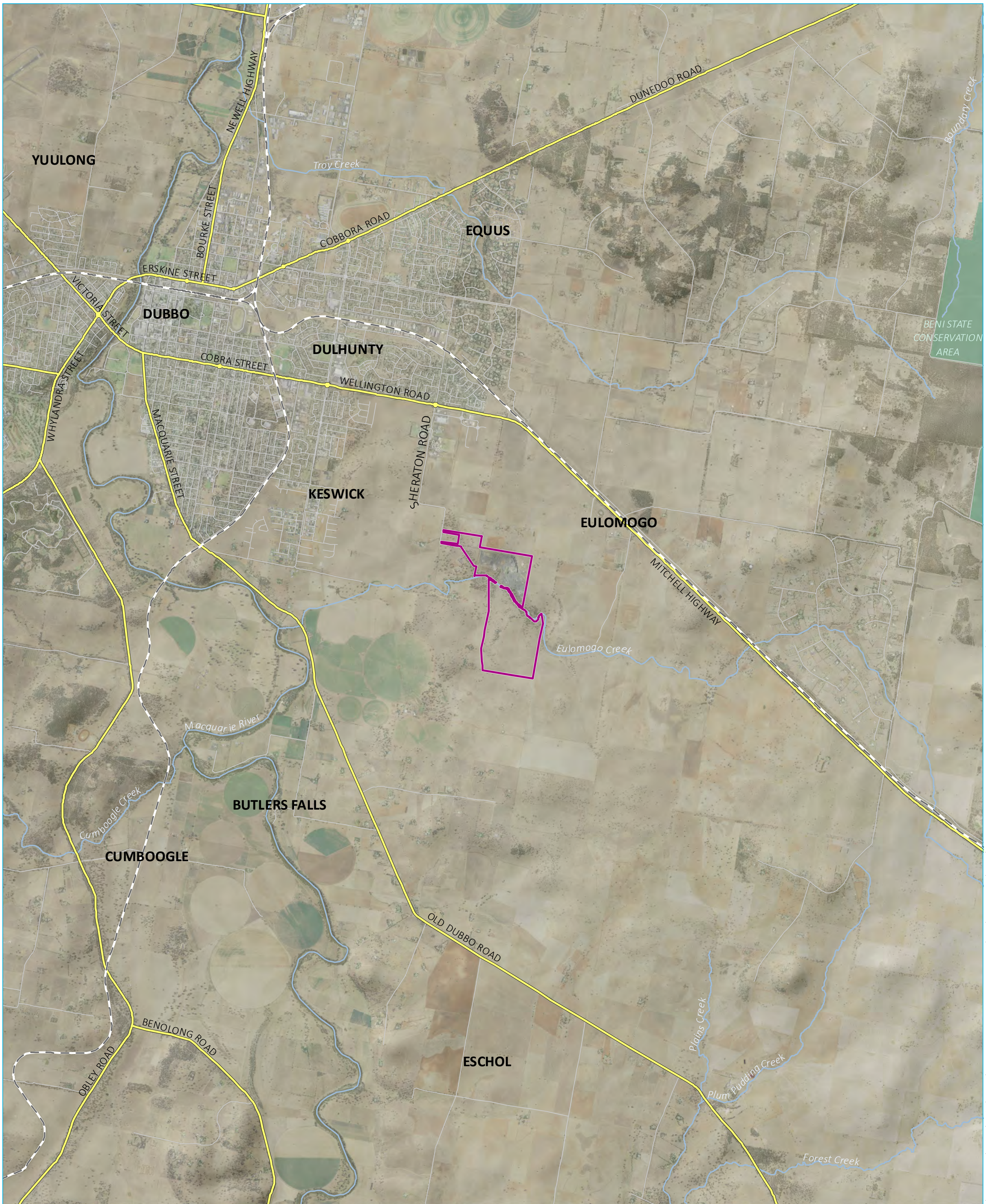
SEARs	Report section
– a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;	Chapter 4 Chapter 5 Appendix B
– identification of any licensing requirements or other approvals under the *Water Act 1912* and/or *Water Management Act 2000*;	Chapter 8
– demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);	Chapter 5
– a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Chapter 5
– an assessment of any likely flooding impacts of the development;	Chapter 6 Appendix A
– an assessment of the likely impacts on the quality and quantity of existing surface and ground water resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives;	Chapter 7
– an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users; and	Section 6.8 of Dubbo Quarry Continuation Project EIS (EMM 2020a) Section 7
– a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts;	Chapter 5

1.5 Report structure

This report is structured as follows:

- Chapter 1 provides an introduction to the project and this report.
- Chapter 2 describes the assessment framework and government and industry and guidelines that have been considered in this assessment.
- Chapter 3 describes the existing environment, as relevant to this assessment.
- Chapter 4 describes the existing water management system.
- Chapter 5 describes the water management strategy for the proposed operations.
- Chapter 6 describes the proposed creek crossing at Eulomogo Creek
- Chapter 7 describes residual impacts to the surface water environment.
- Chapter 8 addresses water licensing requirements.

A flooding assessment prepared by GRC Hydro, a water balance method statement and the Eulomogo Creek crossing concept design drawings are provided as appendices.



DFSI (2017); DFSI (2020); EMM (2020)

0 1 2 km
GDA 1994 MGA Zone 55
N

KEY

- Project area
- Rail line
- Major road
- Minor road
- Named watercourse
- NPWS reserve

Local context

Dubbo Quarry Continuation Project
Surface Water Assessment
Figure 1.1

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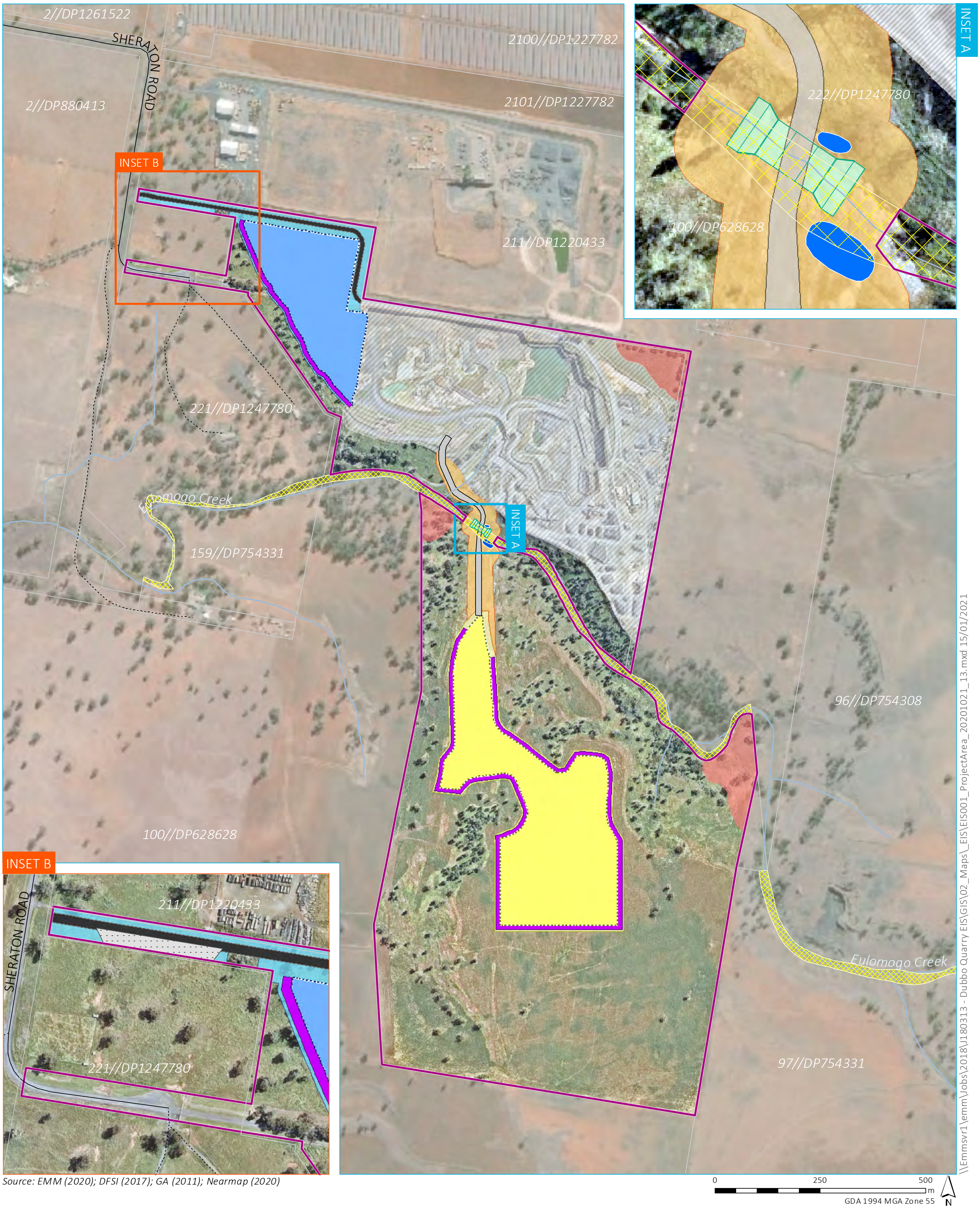

Source: EMM (2020); DFSI (2017); GA (2011); Nearmap (2020)

KEY

- Project area
- Sediment pond
- Aboriginal protection zone
- Indicative existing disturbance area
- Proposed haul road
- Indicative proposed water crossing
- Bund wall
- Proposed access road
- Truck tarping area
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)
- Crown land

Project site

Dubbo Quarry Continuation Project
Surface Water Assessment
Figure 1.2

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2 Assessment framework

This chapter describes government regulation, plans and guidelines that have been considered in this assessment.

2.1 NSW regulatory framework

2.1.1 Protection of the Environment Operations Act 1997

The Protection of the Environment Operations Act 1997 (POEO Act) establishes the NSW environmental regulatory framework and includes licensing requirements for certain activities. Environment Protection Licences (EPLs) are administered by the NSW Environment Protection Authority (EPA) under the POEO Act.

EPL 2122 applies to the existing quarry. EPL 2122 does not currently include any discharge points or water quality monitoring requirements.

2.1.2 Water Management Act 2000

The Water Management Act 2000 (WMA 2000) is the relevant statute for the regulation of water take from surface and alluvial water sources. The act provides for water sharing between different water users, including environmental, basic rights or existing water access licence (WAL) holders and provides security for licence holders. The licensing provisions of the WMA 2000 apply to those areas where a Water Sharing Plan (WSP) has commenced.

WSPs are statutory documents that apply to one or more water sources. They define the rules for sharing and managing water resources within water source areas. WSPs describe the basis for water sharing and document the water available and how it is shared between environmental, extractive and other uses. The WSPs outline the water available for extractive uses within different categories, such as local water utilities, domestic and stock, basic landholder rights, irrigation and industrial uses.

The following WSPs are relevant to the site:

- *Water Sharing Plan for Macquarie-Bogan Unregulated River Water Sources 2012* – the Maryvale Geurie Creek Water Source applies to the surface water in the vicinity of the site;
- *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020* – applies to the Gunnedah-Oxley Basin Murray Darling Basin (MDB) Groundwater Source;
- *Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020* – applies to the Lachlan Ford Belt MDB Groundwater Source; and
- *Water Sharing Plan for the Macquarie-Castlereagh Alluvial Groundwater Sources 2020* – applies to the Macquarie Alluvial Groundwater Source.

Water licencing for the existing and proposed quarry is addressed in Chapter 8.

2.2 Relevant guidelines

2.2.1 Guidelines for waterfront land

The WMA 2000 defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of the riverbanks, lake shore or estuary mean high water mark. Controlled activity approvals can be required for works on waterfront land. Guidelines for controlled activities have been prepared by the NSW Department of Planning, Industry and Environment: Water division (DPIE-Water). These guidelines provide information on design and construction principles for controlled activity, and other ways to protect waterfront land.

Controlled activity approvals are not required for the project as it is a SSD. Notwithstanding, the guidelines for controlled activities have been considered for any proposed works on waterfront land.

2.2.2 Stormwater management guidelines

The following guidelines have been applied to the development of the surface water management strategies for the project.

- Erosion and sediment control guidelines: *Managing Urban Stormwater: Soils and Construction – Volume 1* (Landcom 2004) and Volume 2E (DECC 2008) describe best practice erosion and sediment control methods.

- Bunding and spill management guidelines: *Storing and Handling Liquids: Environmental Protection: Participant's Manual* (DECC 2007) describes best practice storage, handling and spill management procedures for liquid chemicals.

2.2.3 Water quality guidelines

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) provide a framework for:

- assessing and managing water quality for environmental values;

- establishing water quality objectives; and

- establishing protection levels, water quality indicators and trigger values through numerical values and narrative statements.

These guidelines have been applied to establish water quality and environmental values for the project.

2.3 NSW water quality and river flow objectives

The *NSW Water Quality and River Flow Objectives* are provided for catchments throughout NSW (DECCW 2006). Watercourses that can potentially be impacted by the project are in the Macquarie-Bogan River catchment and include Eulomogo Creek and the Macquarie River. Eulomogo Creek is classified as an "Uncontrolled Stream" and the Macquarie River is classified as a "Major Regulated River". Table 2.1 summarises the Water Quality and River Flow Objectives for "Uncontrolled Streams" and "Major Regulated Rivers" and their applicability to the project.

Table 2.1 Water quality and river flow objectives

Environmental value	Objective	Application to Eulomogo Creek and Macquarie River
Water Quality Objectives (Uncontrolled Streams and Major Regulated Rivers)		
Aquatic ecosystems	Maintaining or improving the ecological condition of water bodies and their riparian zones over the long term.	This objective applies to all waterways. This water quality objective is relevant and is assessed in this report.
Visual amenity	Aesthetic qualities of waters.	The objective applies to all waters, particularly those used for aquatic recreation and where scenic qualities are important. This water quality objective is relevant and is assessed in this report.
Secondary contact recreation	Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed.	There is public and private access to downstream waterways. This water quality objective is relevant and is assessed in this report.
Primary contact recreation	Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.	There is public and private access to downstream waterways. This water quality objective is relevant and is assessed in this report.
Livestock water supply	Protecting water quality to maximise the production of healthy livestock.	Livestock is expected to have access to downstream waterways. This water quality objective is relevant and is assessed in this report.
Irrigation water supply	Protecting the quality of waters applied to crops and pasture.	Some downstream users extract surface water for agricultural purposes. This water quality objective is relevant and is assessed in this report.
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.	It is expected that local landowners source water for internal homestead use from rainwater tanks. During dry periods, tanks are likely to be replenished using potable water that is delivered via a water tanker. Hence, this water quality objective is not assessed in this report.
Drinking water at point of supply - Disinfection only Drinking water at point of supply - Clarification and disinfection Drinking water at point of supply - Groundwater	These objectives apply to all current and future licensed offtake points for town water supply and to specific sections of rivers that contribute to drinking water storages or immediately upstream of town water supply offtake points. The objective also applies to sub-catchments or groundwaters used for town water supplies.	Town water supply in the region is provided by Dubbo Regional Council. Water is extracted from Macquarie River downstream of the site for town water supply and treated at the John Gilbert Water Treatment Plan in Macquarie Street south.

Table 2.1 Water quality and river flow objectives

Environmental value	Objective	Application to Eulomogo Creek and Macquarie River
Aquatic foods (cooked)	Refers to protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.	Recreational fishers may use downstream waterways. However, the trigger values for aquatic foods apply to aquaculture not recreational fishing. The required level of protection will be provided by addressing the trigger values for aquatic ecosystems. Hence, impacts to aquatic foods are not assessed in this report.
River Flow Objectives (For uncontrolled streams only)		
Protect pools in dry times	Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows.	The flow regimes of Eulomogo Creek and downstream watercourses have been extensively modified by land clearing, agriculture, extractive activities in the catchment. Discharges from the site will enter Eulomogo Creek. Hence, these river flow objectives are relevant and are assessed in this report.
Protect natural low flows	Share low flows between the environment and water users and fully protect very low flows.	
Protect important rises in water levels	Protect or restore a proportion of moderate flows and high flows.	
Maintain wetland and floodplain inundation	Maintain or restore the natural inundation patterns and distribution of floodwater supporting natural wetland and floodplain ecosystems.	
Maintain natural flow variability	Maintain or mimic natural flow variability in all streams.	
Manage groundwater for ecosystems	Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.	
Minimise effects of weirs and other structures	Minimise the impact of instream structures.	The proposed haul road crossing of Eulomogo Creek is an instream structure. Hence, this river flow objective is relevant and is assessed in this report.

2.4 Water quality targets

The *NSW Water Quality and River Flow Objectives* (DECCW 2006) reference Default Guideline Values (DGVs) from ANZECC/ARMCANZ (2000) water quality guidelines. The ANZECC/ARMCANZ (2000) water quality guidelines have been replaced by the ANZG (2018) guidelines, which have a stated long-term objective of providing regional DGVs for the Murray-Darling basin and other regional basins in Australia. These DGVs are yet to be incorporated into the ANZG (2018) guidelines.

The *Macquarie-Castlereagh water quality management plan* (NSW DoI 2018) provides water quality targets for the Macquarie-Castlereagh water resource plan area, which encompasses the site. The targets were developed as part of the Murry-Darling Basin Plan using the methods recommended in the ANZECC/ARMCANZ (2000) guidelines and include targets for water dependant ecosystems, irrigation water use, town water supply and recreational use. As these targets were developed using catchment specific data, they are considered more relevant than the default values referenced in (DECCW 2006) and are, therefore, adopted as DGVs for this assessment.

The water quality targets are presented in Table 2.2. It is noted that catchment scale water quality targets do not make allowance for site specific factors that may influence water quality. Site specific water quality characteristics are discussed further in Section 3.6.

Table 2.2 Water quality targets – Macquarie-Castlereagh water resource plan

Indicator	Target
Targets for water-dependent ecosystems	
Turbidity	The annual median value should be < 20 NTU
Total phosphorus	The annual median value should be < 35 ug P/L
Total nitrogen	The annual median value should be < 600 ug N/L
Dissolved oxygen	The annual median value should be >8 mg/L or within the 90-110% range
pH	The annual median value should be within the 7.0-8.0 range
Temperature	Between the 20th and 80th percentile of the natural monthly water temperature range
Toxicants	The trigger values for slightly-moderately disturbed ecosystems described in the ANZECC/ARMCANZ (2000) guidelines apply.
Salinity	Median value 504 µS/cm 80th percentile 744 µS/cm
Targets for irrigation water	
Salinity	744 µS/cm
Targets for town water supply	
General target	Refers to the targets for raw water supply that are provided in the Australian Drinking Water Guidelines (2011).
Targets for recreational use	
Blue-green algae	• ≥ 10 µg/L total microcystins; or ≥ 50,000 cells/mL toxic Microcystis aeruginosa; or biovolume equivalent of ≥ 4 mm3 /L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume; or • ≥ 10 mm3 /L for total biovolume of all cyanobacterial material where known toxins are not present; or • Cyanobacterial scums consistently present

3 Existing environment

This chapter provides information on the existing environment as relevant to this Surface Water Assessment. It is noted that the existing water management system is described separately in Chapter 4.

3.1 Land use

i Proposed extension areas

The SEA and WEA are currently predominantly cleared agricultural lands managed as pasture.

ii Surrounding areas

Land-use practices surrounding the site include the South Keswick Quarry to the immediate north, Neoen Energy's South Keswick Solar Farm further north, and rural residential properties. More distant land uses include: low-density housing approximately 1.5 km to the west; a school precinct on Sheraton Road; a commercial precinct at the intersection of Sheraton Road and the Mitchell Highway; and an aged care facility further west.

To the west of the site, a residential subdivision (Southlakes Estate) is under development by Maas Group. This is approved to extend to within approximately 1.4 km west of Sheraton Road. In addition, a 51 lot low-density residential subdivision of Lot 1 DP 880413 was approved by Council (DA ref: D2016-363) in July 2019. This is located immediately west of the South Keswick Solar Farm, approximately 350 m north-west of the proposed quarry access road off Sheraton Road.

3.2 Topography

Topography in and around the site features undulating slopes and plains ranging in elevation from 280–310 m Australian Height Datum (AHD) predominantly on a westerly aspect, with local relief along Eulomogo Creek and within the existing quarry void.

3.3 Climate

The climate of Dubbo is classified as warm temperate. Summers are hot with an average maximum temperature of 31.9–33.0°C. Winters are cold with an average minimum temperature of 2.6–4.1°C. Long-term monthly average rainfall in Dubbo ranges from 42.7–60.7 mm.

Patched point climate data was obtained from the Scientific Information for Land Owners (SILO) database hosted by the Science Division of the Queensland Government's Department of Environment and Science. SILO patched point data is interpolated estimates of rainfall calculated using data from Bureau of Meteorology (BOM) weather stations. For this assessment, SILO data was obtained for SILO grid point located nearest the site.

Key information and statistical data from the historical SILO patched point data between 1919 and 2019 are presented in Table 3.1. The average monthly rainfall and evaporation rates determined from the SILO data are shown in Figure 3.1.

Table 3.1 Key climate statistics

Key annual statistic	Units	Rainfall	Evaporation
Average	mm/year	586	1,793
Minimum	mm/year	245	1,469
5th percentile	mm/year	328	1,616
10th percentile	mm/year	344	1,649
Median	mm/year	582	1,763
90th percentile	mm/year	798	1,953
95th percentile	mm/year	933	2,063
Maximum	mm/year	1,320	2,160

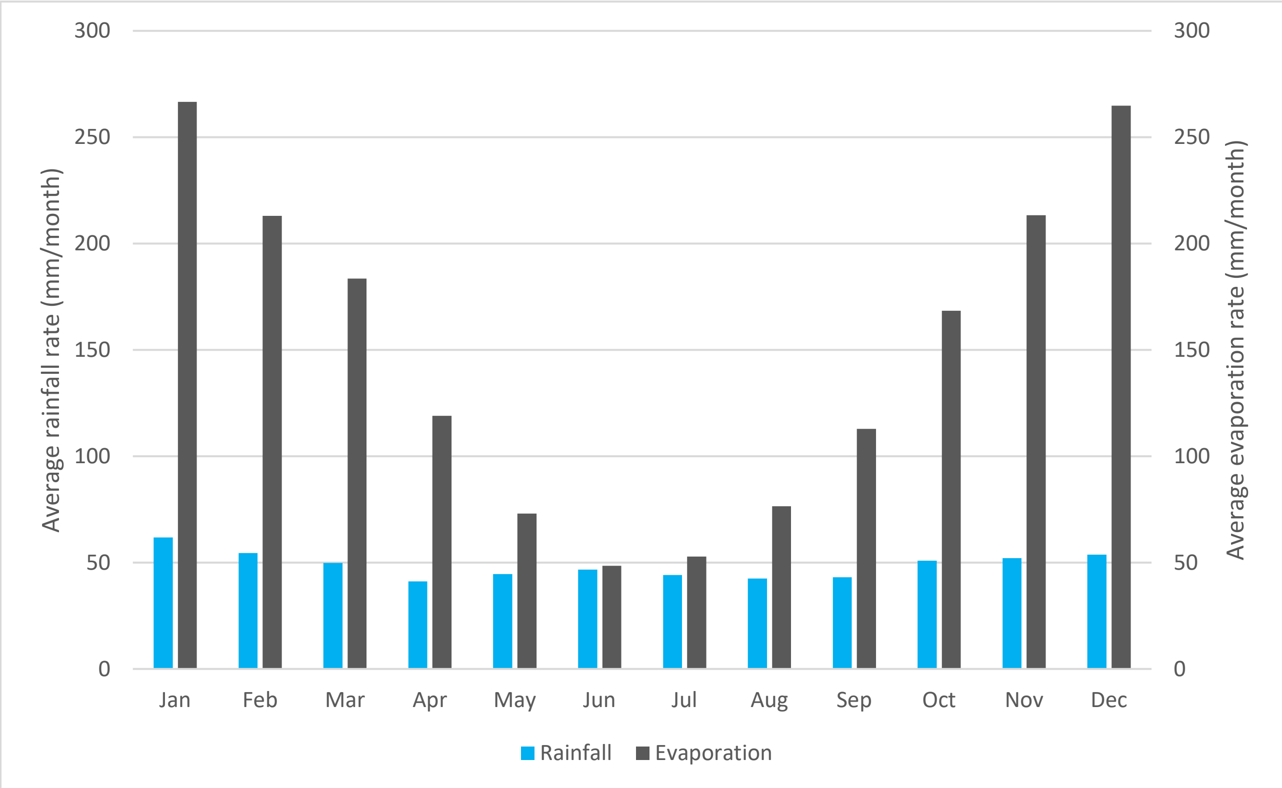


Figure 3.1 Average daily rainfall and evaporation rates

3.4 Geology

The site lies within the Brigalow Belt South Bioregion, and predominantly falls within the Talbragar Basalts ecosystem and Dubbo Basalts landscape unit. The topography of the Dubbo Basalts landscape unit is characterised by slightly elevated plains and low hills on flat lying Tertiary volcanics (basalt and trachyte).

The geology of the site is dominated by basalt deposits and outcropping, with areas of sandstone outcrops. Soils are characterised by friable surface soils with moderate to high susceptibility to erosion. Undisturbed soils typically comprise strongly structured reddish-brown friable or cracking clay loams and light clay topsoils, with a dark reddish-brown clay subsoil at 40 cm.

3.5 Watercourses

The following watercourses are located within the site:

- Eulomogo Creek is a 3rd order watercourse that flows in a westerly direction towards the Macquarie River. The creek is located to the south of the existing quarry. The SEA will be located to the south of the creek and a crossing is proposed for a haul road that will provide access between the existing quarry and the SEA.

- Two 1st order watercourses flow into the existing quarry pits.

These watercourses are shown in Figure 3.2 and discussed further below.

i Eulomogo Creek

The site is within the Eulomogo Creek catchment which has a 52 km² catchment area that extends to the east of the quarry. The catchment is characterised by undulating topography that has been extensively cleared. Current land uses are predominantly agriculture (grazing and cropping) but also include a solar farm, hard rock quarries and a rural residential complex that is in the upper portion of the catchment. Downstream of the quarry, Eulomogo Creek flows in a westerly direction and joins the Macquarie River approximately 2.7 km to west of the site.

The Eulomogo Creek catchment is ungauged. However, it is known to have an intermittent flow regime; meaning that, during an average rainfall year, streamflow will occur for most of the year but may cease for weeks or months, typically in late summer or early autumn. Streamflow would also cease for extended periods of time during dry periods.

In the vicinity of the quarry, Eulomogo Creek has a confined channel that is bedrock controlled. The longitudinal grade of the channel is approximately 0.9% and the channel width (when the creek is in flood) ranges from 20 to 35 m. The channel banks and immediately riparian zone are vegetated with native and exotic species. Photograph 3.1 shows a typical section of the creek.

Photograph 3.1 Typical sections of Eulomogo Creek

A flood assessment has been undertaken by GRC Hydro for Eulomogo Creek. The assessment describes flooding withing Eulomogo Creek as being confined to the channel and immediate overbank areas. No flood waters are predicted to enter existing or proposed quarry pits or impact existing or proposed infrastructure.

Chapter 6 provides a summary of this assessment and includes further information on existing flood characteristics. The GRC assessment is provided as Appendix A.

ii Local watercourses

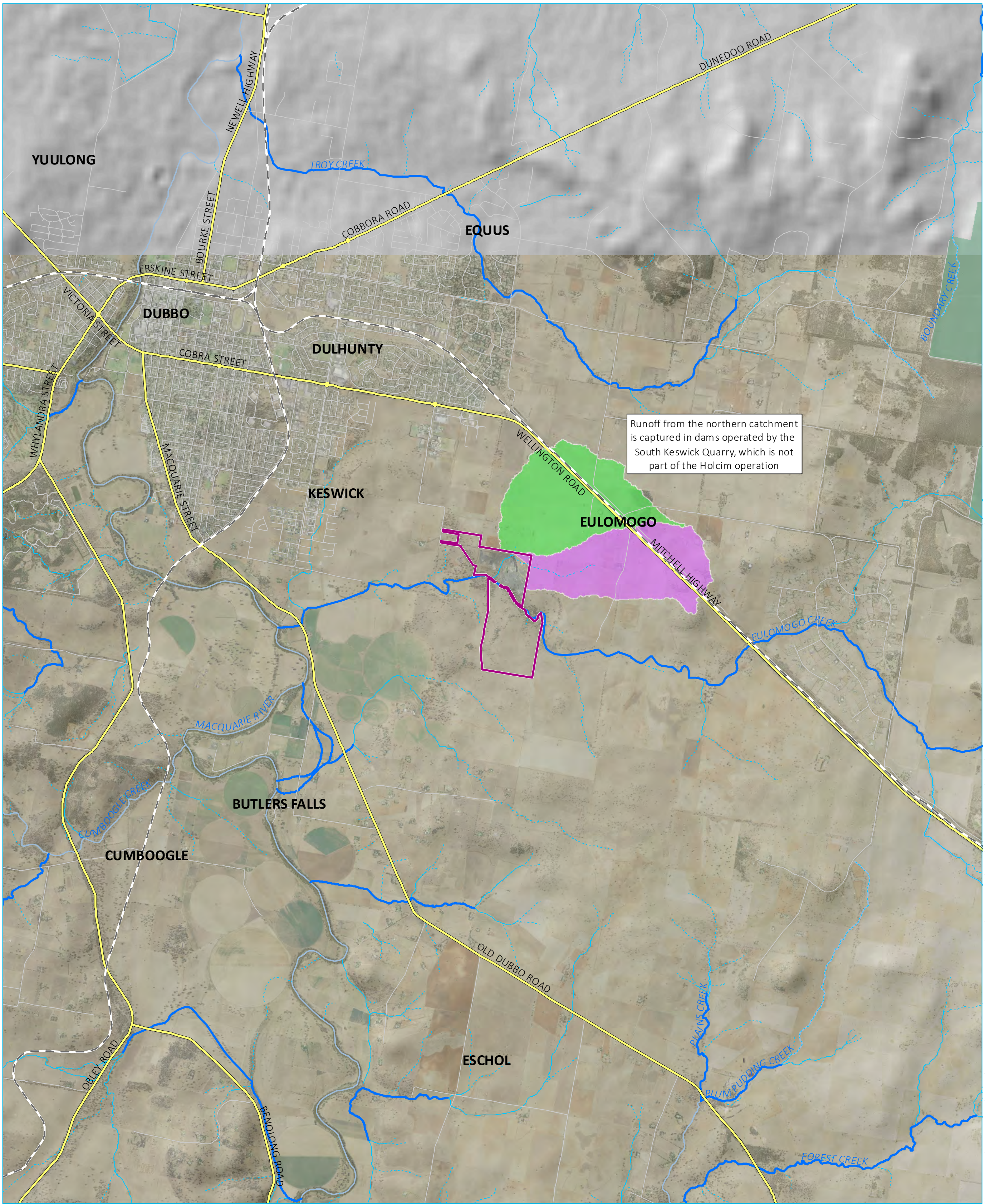
Two 1st order watercourses flow into the existing quarry pit. These watercourses are referred to as the eastern and northern watercourses in this report and are described further below.

The Eastern watercourse has a 227 ha catchment area that extends to the east of the quarry. The watercourse is known to have an ephemeral flow regime which means it only flows following significant rainfall. Runoff from this watercourse is captured in a dam located to the east of the existing quarry (see Photograph 3.2). Overflows from this dam enter the East Pit (see Section 4.1 for further discussion).

The northern watercourse has a 270 ha catchment area that extends to the north of the quarry. The catchment area includes the South Keswick Solar Farm Solar Farm and Quarry. The watercourse is known to have an ephemeral flow regime and only flows following significant rainfall. All runoff from this catchment is captured in the South Keswick Quarry's water management dams. Any overflows from these dams will enter the East Pit (see Section 4.1 for further discussion).

There are no watercourses in the WEA and SEA. All runoff from these areas flows into Eulomogo Creek via ephemeral drainage lines.

Photograph 3.2 Eastern watercourse



Source: EMM (2020); DFSI (2017); DFSI (2020)

0 1 2 km
GDA 1994 MGA Zone 55
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KEY

Project area

Strahler stream order
1st order
2nd order
3rd order

Sub-catchments
The Eastern Watercourse
The Northern Watercourse

Rail line
Major road
Minor road
Named watercourse
NPWS reserve

Local watercourses

Dubbo Quarry Continuation Project
Surface Water Assessment
Figure 3.2

EMM creating opportunities

3.6 Water quality

3.6.1 Sampling program

Water quality data is available from the following sampling programs:

- Holcim sampling – Holcim have monitored water quality in Eulomogo Creek, the Macquarie River and key water management dams at the quarry over the 2013 to 2018 period. Samples have generally been collected during wet weather conditions when overflows from the Settling Pond (see Section 4.1) were occurring.

- EIS sampling – EMM collected samples from Eulomogo Creek and several water management dams at the quarry on 9 July 2020. Samples were collected approximately nine weeks after significant rainfall that occurred in June 2020.

i Sampling locations

Table 3.2 describes the sample locations and number of samples collected from each program. Sample locations are shown in Figure 3.3. It is noted that the existing water management system is described in Chapter 4.

Table 3.2 Sample locations

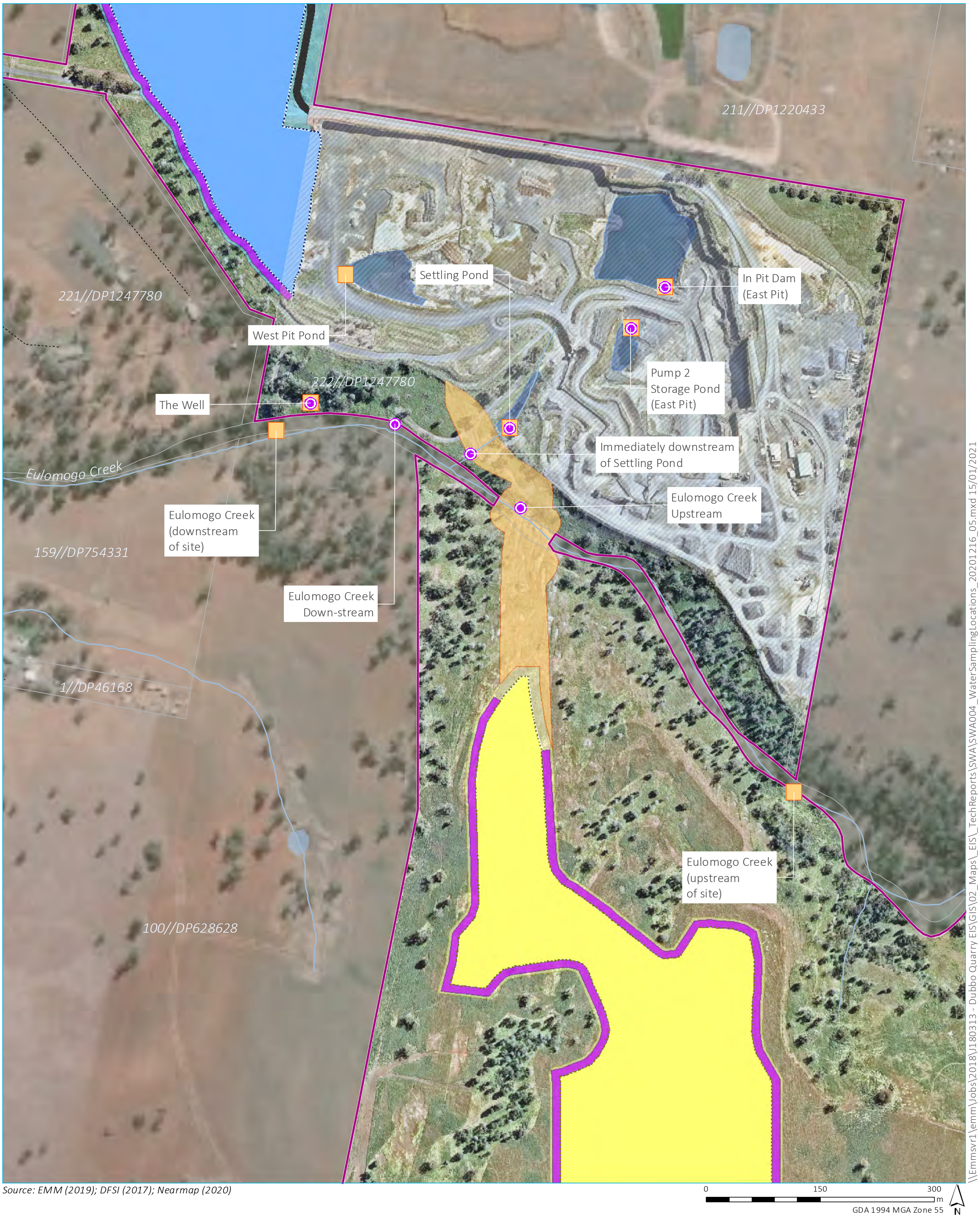
	Number of samples available	
	Holcim Sampling (2013 to 2018)	**EIS sampling** (9 July 2020)
Receiving water		
Eulomogo Creek - upstream of site (Holcim sampling)	20	-
Eulomogo Creek - downstream of site (Holcim sampling)	41	-
Eulomogo Creek - upstream of site (EIS sampling)	-	1
Eulomogo Creek - downstream of site (EIS sampling)	-	1
Macquarie River – downstream of Eulomogo Creek confluence	26	-
Existing quarry		
East pit (In Pit Dam)	45	1
East pit (Pump 2 storage pond)	45	1
Settling Pond	45	1
Settling Pond overflows	24	-
West Pit Pond	-	1
Groundwater		
The well (groundwater supply bore)	21	1

ii Analysis methods

Table 3.3 describes monitoring analytes and analysis methods.

Table 3.3 Analysis methods and parameters

Category	Sampling analytes	Analysis method
Holcim sampling		
Physico-chemical properties	pH, electrical conductivity, turbidity	Analysis undertaken by a NATA certified laboratory
Nutrients	oxidised nitrogen	
Other	Chemical oxygen demand	
EIS sampling		
Physico-chemical properties	pH, electrical conductivity, turbidity, total suspended solids, total dissolved solids	Analysis undertaken by a NATA certified laboratory
Nutrients	total nitrogen, ammonia, oxidised nitrogen and total kjeldahl nitrogen	
	total phosphorus and reactive phosphorus	
Metals (dissolved)	Al, As, Cr (total), Cd, Cu, Fe, Hg, Mn, Ni, Pb, Se and Zn	



Source: EMM (2019); DFSI (2017); Nearmap (2020)

KEY

- Project area
- Holcim sampling location
- EIS sampling location
- Existing water management dam
- Indicative existing disturbance area
- Bund wall
- Proposed access road
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)

Water sampling locations

Dubbo Quarry Continuation Project
Surface Water Assessment
Figure 3.3

EMM
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3.6.2 Monitoring results

A summary of results from the Holcim and EIS sampling programs are provided in Table 3.4 and Table 3.5, respectively. The results are compared to the DGVs established in Section 2.4.

i Receiving water quality

The water quality of Eulomogo Creek is characterised as having a neutral to slightly basic pH, generally low turbidity and electrical conductivity that exceeds DGVs. Reactive phosphorus is significantly higher than the DGV for total phosphorus in both upstream and downstream samples, indicating the greater catchment is the primary source of phosphorus. With reference to the Holcim sampling results (Table 3.4) nitrate concentrations were generally elevated in downstream samples, indicating that discharges from the quarry may increase nitrate concentrations in Eulomogo Creek.

With reference to the EIS sampling results in Table 3.5, all metals sampled were below DGVs.

The water quality of Macquarie River (downstream of Eulomogo Creek) has neutral to slightly basic pH, generally low turbidity and electrical conductivity that is below DGVs. Reactive phosphorus concentrations are lower than concentrations in Eulomogo Creek, but are elevated relative to the DGVs for total phosphorus. Nitrate concentrations are materially lower than in Eulomogo Creek (downstream sample), indicating that any discharges from the quarry are not resulting in similarly higher nitrate concentrations in the Macquarie River.

ii Water management dams

Water quality samples were collected from the existing quarry's West (EIS sampling only) and East Pits, the Settling Pond and Settling Pond overflows (Holcim sampling only). The results indicate that the water quality in all water management dams is similar and is characterised as follows.

- The pH is generally slightly basic but ranges between 6.3 to 8.7.
- The median electrical conductivity is between 800 to 900 µS/cm at all sample locations, but ranges from 77 to 1,260 µS/cm.
- Median turbidity values are below 20 NTU at all sample locations. However, 80th percentile turbidity level in the Settling Pond is 220 NTU, indicating that turbid runoff from the quarry does occur. Collectively, the turbidity results indicate that runoff from disturbed areas within the quarry contain fine and coarse sediment that responds to sedimentation processes and settles out of the water column within several days after runoff ceases.
- Reactive phosphorus concentrations are elevated (relative to DGVs for total phosphorus) at all sample locations, but are similar to the concentrations in Eulomogo Creek.
- Median nitrate concentrations range from 0.3 to 4.2 mg N/L. These concentrations are higher than concentrations in Eulomogo Creek (upstream of the quarry). The source of nitrate has not been identified but may be due to groundwater inflows into the East Pit (discussed in Chapter 4) , accelerated weathering of exposed hard rock and/or explosives residue.
- With reference to the EIS sampling results in Table 3.5, all metals sampled were below DGVs except for:
  - zinc concentrations in the East Pit sampling locations ranged from 0.0070 to 0.0100 mg/L relative to a DGV of 0.0024 mg/L; and
  - the copper concentration in the Settling Pond was 0.0020 mg/L relative to a DGV of 0.0013 mg/L.

iii Groundwater quality

Groundwater was sampled from a single location (the well) that is located between the quarry and Eulomogo Creek. The groundwater quality at this location had a median nitrate of concentration of 12.6 mg N/L and a median reactive phosphorus concentration of 0.415 mg P/L. These concentrations are higher than concentrations in both Eulomogo Creek and the water management dams, indicating that groundwater may be a source of the elevated nutrients.

With reference to the EIS sampling results in Table 3.5, all metals sampled were below DGVs.

Table 3.4 Holcim sampling results

Parameter	Turbidity	Reactive Phosphorus	Nitrate	pH	Salinity	Chemical Oxygen Demand
Units	NTU	mg/L	mg/L	-	µS/cm	mg/L
DGV	20	0.035 (TP DGV adopted)	0.6 (TN DGV adopted)	7.0-8.0	504 (median) 744 (80th percentile)	-
<u>**Eulomogo Creek Upstream**</u>						
Number of samples	20	20	20	20	20	20
Number of detects	20	20	20	20	20	20
Number of exceedances	1	20	6	2	12	-
Minimum concentrations	1.1	**0.072**	0.10	**6.8**	280	6
20th percentile concentration	2.0	**0.173**	0.18	7.3	358	19.4
Median concentration	4.1	**0.292**	0.45	7.6	**840**	42.6
80th percentile concentration	13.3	**0.430**	**0.77**	7.9	**1,352**	61.1
Maximum concentration	**87.1**	**0.836**	**3.93**	**8.1**	**2,150**	133.1
<u>**Eulomogo Creek Downstream**</u>						
Number of samples	41	41	41	41	41	0
Number of detects	41	41	40	41	41	-
Number of exceedances	6	41	24	6	38	-
Minimum concentrations	0.5	**0.077**	0.10	7.0	481	-
20th Percentile	2.1	**0.196**	0.20	7.5	**758**	-
Median concentration	4.9	**0.323**	**2.20**	7.7	**964**	-
80th percentile concentration	**21**	**0.369**	**2.20**	7.8	**1,256**	-

Table 3.4 Holcim sampling results

Parameter	Turbidity	Reactive Phosphorus	Nitrate	pH	Salinity	Chemical Oxygen Demand
Maximum concentration	**102**	**1.152**	**16.5**	**8.4**	**1,891**	-
Units	NTU	mg/L	mg/L	-	µS/cm	mg/L
DGV	20	0.035 (TP DGV adopted)	0.6 (TN DGV adopted)	7.0-8.0	504 (median) 744 (80th percentile)	-
Macquarie River (downstream of Eulomogo Creek)						
Number of samples	26	26	24	27	26	26
Number of detects	26	26	24	27	26	26
Number of exceedances	3	26	**3**	1	3	-
Minimum concentrations	2.2	**0.077**	0.03	7.4	99	14.1
20th percentile concentration	6.2	**0.095**	0.10	7.6	279	16.3
Median concentration	9.0	**0.15**	0.2	7.7	387	21.8
80th percentile concentration	17.5	**0.247**	**0.4**	7.9	481	31.6
Maximum concentration	**59.6**	**0.748**	**1.1**	**8.1**	**849**	51.4
In Pit Dam						
Number of samples	45	45	45	45	45	45
Number of detects	45	45	45	45	45	44
Number of exceedances	1	45	40	**23**	42	-
Minimum concentrations	0.1	**0.088**	0.38	**6.3**	310	0.1
20th Percentile	0.4	**0.194**	**1.5**	**6.6**	**814**	3.1
Median concentration	2.1	**0.292**	**4.2**	7.7	**919**	9.6

Table 3.4 Holcim sampling results

Parameter	Turbidity	Reactive Phosphorus	Nitrate	pH	Salinity	Chemical Oxygen Demand
80th percentile concentration	3.6	**0.438**	**6.1**	**8.0**	**1,007**	16.3
Maximum concentration	**23**	**0.729**	**10.6**	**9.0**	**1,260**	75.6
Units	NTU	mg/L	mg/L	-	µS/cm	mg/L
DGV	20	0.035 (TP DGV adopted)	0.6 (TN DGV adopted)	7.0-8.0	504 (median) 744 (80th percentile)	-
Pump 2 Storage Pond						
Number of samples	45	45	45	45	45	45
Number of detects	45	45	45	45	45	44
Number of exceedances	**5**	45	**16**	39	42	-
Minimum concentrations	1.9	**0.096**	**0.07**	7.0	77	1.0
20th percentile concentration	3.6	**0.185**	**0.10**	**8.1**	**705**	9.5
Median concentration	6.2	**0.259**	**0.32**	**8.4**	**817**	14.1
80th percentile concentration	14.7	**0.371**	**1.35**	**8.7**	**895**	20.3
Maximum concentration	**73**	**0.541**	**2.02**	**9.3**	**1,011**	62.4
Settling Pond						
Number of samples	45	45	45	45	45	45
Number of detects	45	45	45	45	45	45
Number of exceedances	20	45	34	19	36	-
Minimum concentrations	0.4	**0.113**	0.05	6.7	343	0.1
20th Percentile	1.7	**0.224**	0.55	7.2	**508**	6.9

Table 3.4 Holcim sampling results

Parameter	Turbidity	Reactive Phosphorus	Nitrate	pH	Salinity	Chemical Oxygen Demand
Median concentration	13.7	**0.331**	**3.60**	7.9	**841**	14.1
80th percentile concentration	**220**	**0.514**	**5.05**	**8.2**	**999**	36.9
Maximum concentration	**646**	**0.766**	**6.92**	**8.6**	**1,080**	117.6
Units	NTU	mg/L	mg/L	-	µS/cm	mg/L
DGV	20	0.035 (TP DGV adopted)	0.6 (TN DGV adopted)	7.0-8.0	504 (median) 744 (80th percentile)	-
Immediately downstream of Settling Pond						
Number of samples	24	24	24	24	24	24
Number of detects	24	24	24	24	24	23
Number of exceedances	4	24	24	2	21	-
Minimum concentrations	1.1	0.140	**0.64**	7.2	353	3.1
20th percentile concentration	1.4	**0.279**	**3.59**	7.3	**809**	3.2
Median concentration	2.2	**0.364**	**3.89**	7.5	**989**	7.5
80th percentile concentration	19.5	**0.473**	**5.14**	7.8	**1,025**	20.2
Maximum concentration	**246**	**0.566**	**6.17**	**8.3**	**1,090**	40.4
The Well						
Number of samples	21	21	21	21	21	21
Number of detects	21	21	21	21	21	21
Number of exceedances	1	21	20	6	14	-
Minimum concentrations	0.4	**0.096**	0.3	**6.7**	358	1

Table 3.4 Holcim sampling results

Parameter	Turbidity	Reactive Phosphorus	Nitrate	pH	Salinity	Chemical Oxygen Demand
20th Percentile	1.0	**0.261**	**2.14**	**6.8**	442	4.0
Median concentration	1.8	**0.415**	**12.6**	7.2	**647**	9.7
80th percentile concentration	9.0	**0.668**	**20.3**	7.6	**861**	27.4
Maximum concentration	**21.8**	**1.056**	**27.8**	**7.9**	**1,086**	213.1

Table 3.5 EIS water quality results

	Units	LOR	DGV	Eulomogo Creek (upstream of site)	Eulomogo Creek (downstream of site)	In Pit Dam (East Pit)	Pump 2 Storage Pond (East Pit)	Settling Pond	Well	West Pit Pond
General water quality										
pH	-	0.01	7 - 8	**8.4**	**8.6**	**8.5**	**8.7**	**8.6**	**8.5**	**8.2**
Electrical Conductivity	µS/cm	1	504	**811**	**738**	**726**	**1,020**	**676**	**1,200**	464
Turbidity	NTU	0.1	20	3.1	2.5	13.8	4.8	15.6	0.3	10.5
Alkalinity										
Bicarbonate as $CaCO_3$	mg/L	1	-	164	246	236	328	237	367	108
Carbonate as $CaCO_3$	mg/L	1	-	6	24	20	40	<1	29	<1
Hydroxide as $CaCO_3$	mg/L	1	-	<1	<1	<1	<1	<1	<1	<1
Total alkalinity as $CaCO_3$	mg/L	1	-	170	270	256	368	237	396	108
Nutrients										
Ammonia	mg/L	0.01	-	<0.01	<0.01	**0.02**	<0.01	<0.01	<0.01	<0.01

Table 3.5 EIS water quality results

	Units	LOR	DGV	Eulomogo Creek (upstream of site)	Eulomogo Creek (downstream of site)	In Pit Dam (East Pit)	Pump 2 Storage Pond (East Pit)	Settling Pond	Well	West Pit Pond
Oxidised Nitrogen	mg/L	0.01	-	0.6	0.2	2.33	3.8	0.74	1.26	1.52
Total Kjeldahl Nitrogen	mg/L	0.1	-	0.3	0.3	0.5	0.5	0.7	0.2	0.3
Nitrite	mg/L	0.01	-	0.02	<0.01	0.01	0.03	<0.01	<0.01	0.01
Nitrate	mg/L	0.01	-	0.58	0.2	2.32	3.77	0.74	1.26	1.51
Total nitrogen	mg/L	0. 1	0.6	**0.9**	0.5	**2.8**	**4.3**	**1.4**	**1.5**	**1.8**
Total phosphorus	mg/L	0.01	0.035	<0.01	0.01	**0.14**	0.03	**0.07**	**0.04**	**0.07**
Inorganics										
Cyanide	mg/L	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Inorganics										
Calcium	mg/L	1	-	33	34	28	15	26	78	22
Chloride	mg/L	1	-	164	62	58	68	52	164	49
Fluoride	mg/L	0.1	-	0.2	0.4	0.4	0.4	0.5	0.5	0.5
Sodium	mg/L	1	-	57	73	77	177	78	75	38
Magnesium	mg/L	1	-	39	29	28	14	20	66	16
Potassium	mg/L	1	-	6	9	7	14	8	4	5
Sulphate as SO_4	mg/L	1	-	8	23	22	52	23	38	28
Ionic Balance										
Anions	meq/L	0.01	-	8.19	7.62	7.21	10.4	6.68	13.3	4.12
Cations	meq/L	0.01	-	7.49	7.49	7.23	9.96	6.54	12.7	4.2

Table 3.5 EIS water quality results

	Units	LOR	DGV	Eulomogo Creek (upstream of site)	Eulomogo Creek (downstream of site)	In Pit Dam (East Pit)	Pump 2 Storage Pond (East Pit)	Settling Pond	Well	West Pit Pond
Ionic Balance	%	0.01	-	4.46	0.88	0.14	1.95	1.06	2.46	0.87
Dissolved metals										
Arsenic	mg/L	0.001	0.013	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Barium	mg/L	0.001	-	0.032	0.026	0.003	<0.001	<0.001	0.01	0.001
Beryllium	mg/L	0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	0.00006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (III+VI)	mg/L	0.001	0.00001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	0.0014	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dissolved metals										
Copper	mg/L	0.001	0.001	0.001	0.001	0.001	<0.001	**0.002**	<0.001	<0.001
Lead	mg/L	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	1.2	0.02	0.074	<0.001	<0.001	<0.001	0.001	<0.001
Mercury	mg/L	0.0001	0.00006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.001	0.008	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.01	0.006	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.0024	<0.005	<0.005	**0.010**	**0.007**	<0.005	<0.005	<0.005

4 Existing water management

This chapter describes the functionality and key characteristics of the existing water management system. Section 4.1 describes the existing system and Section 4.2 provides a summary of water balance model results. The information presented in this chapter is referenced in Chapter 5 which describes the proposed water management system and includes commitments for some modifications to the existing system to improve environmental performance.

4.1 System description

4.1.1 Overview

The existing water management system receives inflows from:

- runoff from the quarry area;
- runoff from the eastern watercourse catchment; and
- groundwater inflows into quarry pits.

The system provides water for operational uses which include process plant and haul road dust suppression. Discharges from the water management system occur due to sedimentation dam overflows and dewatering quarry pits. The functionality of the existing water management system is diagrammatically described in Figure 4.1 and the system layout is shown in Figure 4.2. Key aspects of the water management system are discussed in detail in Sections 4.1.2 to 4.1.7.

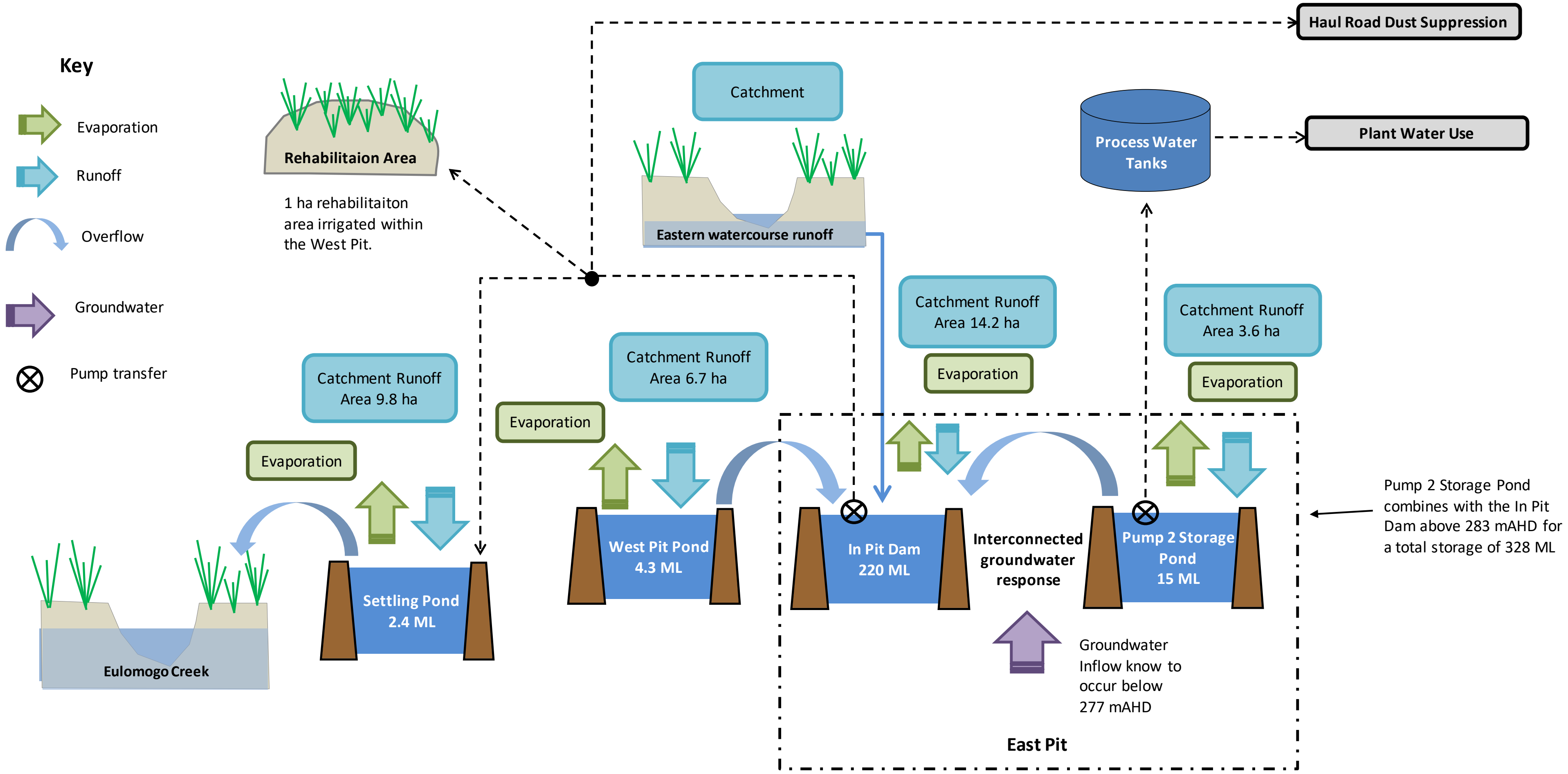
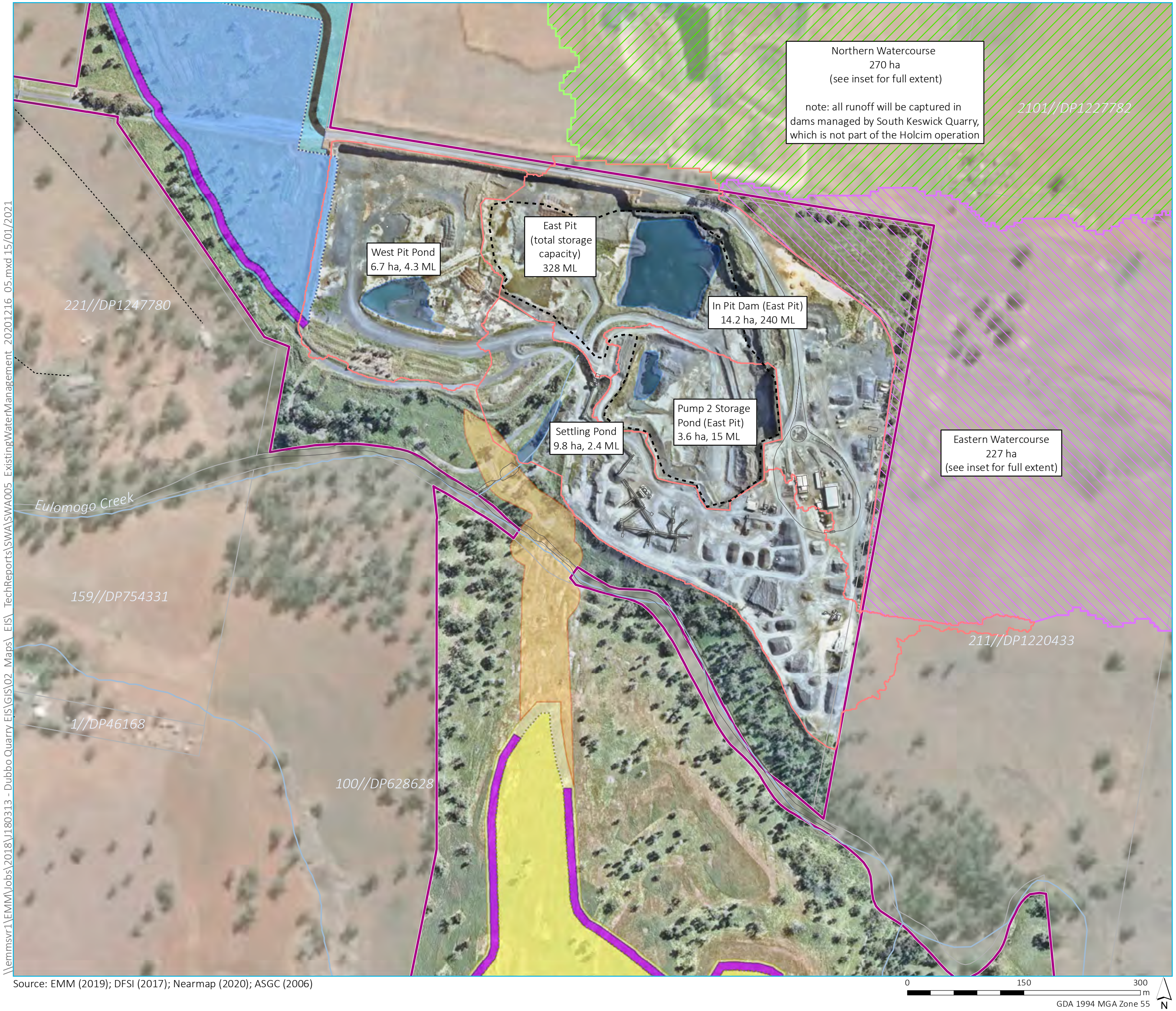
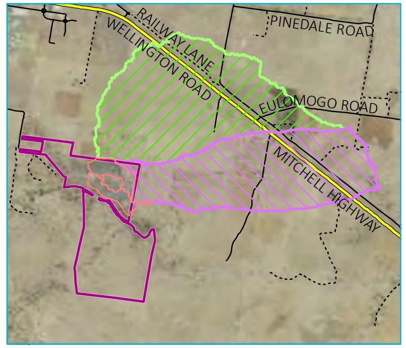


Figure 4.1 **Existing water management system functionality**





KEY
- Project area
- Existing project infrastructure
- The Eastern Watercourse - 277 ha
- The Northern Watercourse - 270 ha
- Existing water management dam
- East Pit (total storage capacity)
- Catchment boundary
- Bund wall
- Proposed access road
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Watercourse/drainage line
- Vehicular track
- Cadastral boundary (data does not align with surveyed site boundary)

Source: EMM (2019); DFSI (2017); Nearmap (2020); ASGC (2006)

Existing water management system layout

Dubbo Quarry Continuation Project
Surface Water Assessment
Figure 4.2

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4.1.2 Existing storages

The water management system includes four key water storages (refer to Figure 4.2). A summary of the key characteristics of each storage is presented in Table 4.1 (overleaf). Photographs of each storage are provided Photograph 4.1 to Photograph 4.4. It is noted that these photographs were taken on 9 June 2020, nine weeks after significant rainfall that occurred in July 2020.

Photograph 4.1 West Pit Pond (looking east)

Photograph 4.2 In Pit Dam, East Pit (looking west)

Photograph 4.3 Pump 2 Storage Pond, East Pit (looking south)

Photograph 4.4 Settling Pond (looking south-west)

Table 4.1 Existing water management storages

Storage	Description / function	Contributing catchment area	Groundwater inflows	Volume	Overflows to
West Pit Pond	The West Pit is a former extraction area. Runoff from a 6.7 ha catchment drains to a small sump. The sump storage is shallow and overflows to the in pit dam via a surface drain.	6.7 ha – quarry area	No groundwater inflows are known to occur.	4.3 ML	In Pit Dam
In Pit Dam (East Pit)	The in pit dam is the main storage within the East Pit that receives runoff from the northern portion of the East Pit, an area to the east of the pit and the Eastern watercourse. Water is extracted from the in pit dam for haul road dust suppression. The pond is hydraulic connected to the Pump 2 storage pond via subsurface flow.	14.2 ha – quarry area 227 ha – Eastern watercourse 241.2 ha - total	Groundwater inflows are known to occur when the sump water levels are below 277 m AHD, 9 m above the pit floor. Inflow regimes have not been determined but anecdotal evidence from the quarry manager confirms it to be substantial when the pit has been fully dewatered to enable extraction.	220 ML – up to 283 m AHD (Combines with Pump 2 above 283 m AHD for a total of 328 ML)	Settling Pond
Pump 2 Storage Pond (East Pit)	Pump 2 storage pond is a smaller storage within the East Pit that receives runoff from the southern portion of the East Pit. Water is extracted from the Pump 2 storage pond for use in the material processing plant. The pond is hydraulic connected to the in pit dam via subsurface flow.	3.6 ha – quarry area	As per In Pit Dam.	15 ML – up to 283 m AHD (Combines with Pump 1 above 283 m AHD for a total of 328 ML)	In Pit Dam
Settling Pond	The Settling Pond receives runoff from the site processing area and immediate surrounds. The pond also receives any water that is dewatered from In Pit Dam following wet weather conditions, or overflows from the East Pit, should this ever occur. When full, the pond overflows to Eulomogo Creek and is the quarry's only discharge location.	9.8 ha – processing and quarry area	No groundwater inflows are known to occur.	2.4 ML. It noted that this volume is below the minimum size for a sedimentation basin calculated using the methods described *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008). This is discussed further in Chapter 5.	Eulomogo Creek

4.1.3 Site water use

4.1.4 Operational uses

The quarry operation uses process water for haul road dust suppression and dust suppression within the processing plant. Table 4.2 provides annual water use estimates that have been provided by Holcim.

Table 4.2 Process water uses

Process water use	Description	Annual water use
Haul road dust suppression	The site operates a 13 kL water cart which completes approximately 15 loads a day.	Between 68 and 74 ML/year for wet and dry years, respectively.
Dust suppression within the processing plant	Water is used for conveyor and stockpile dust suppression within the plant. Two 50 kL process water tanks are filled every 2 days on average for process water use.	Constant at 18 ML/year.

The operation has not historically experienced water shortages as groundwater inflows into the East Pit have generally met or exceeded operational water requirements.

4.1.5 Amenities

Water for amenities use is sourced from rainwater tanks near the site office. The tanks are topped up using water sourced from the Pump 2 storage pond when close to empty. The volume of water used in amenities is small relative to operational water use and is, therefore, not considered in the water balance. Potable water (ie for drinking) is trucked in.

Wastewater from on-site amenities is discharged to a septic tank located near the amenities block. The tank discharges to an absorption trench. The tank is periodically pumped out by an approved licensed contractor as required.

4.1.6 Operating principles

The existing water management system is operated using the following principles:

1. Operational water is extracted from the East Pit via pumps located at the in pit dam and Pump 2 storage pond. The operation has not historically experienced water shortages as groundwater inflows into the East Pit have generally met or exceeded operational water requirements.

2. The water levels in the East Pit are managed to enable extraction from the pit. The following dewatering methods are applied on an as needed basis:

    a) Water is pumped to the 1 ha rehabilitation area that is located to the south of the West Pit. This is typically done to manage the accumulation of water in the pit.

    b) The pit is dewatered to the Settling Pond which overflows to Eulomogo Creek. This is typically done following significant wet weather events or when access to the pit floor is required.

4.1.7 Existing discharge methods

Discharges from the existing operation occur when the Settling Pond is full and overflows. This will typically occur when:

- runoff from the ponds contributing catchment area exceeds the available storage in the pond; and/or
- the East Pit is dewatered (via pumping into the Settling Pond).

Discharge regimes are discussed further in Section 4.2.

4.2 Water balance results summary

Water balance models have been prepared for both the existing and proposed operations water management systems. The objective of the water balance modelling is to describe how water is managed during a full range of weather conditions and provide estimates of water take, project water security and discharge regimes.

This section provides a summary of key results from the existing conditions model. The modelling approach and assumptions are documented in Appendix B. Proposed conditions results and water licencing considerations are discussed in Chapters 5 and 8 respectively.

4.2.1 Model results

The following results are presented:

- Figure 4.3 to Figure 4.5 provide annualised results in flow chart format for typical 10th, 50th and 90th percentile rainfall years respectively.
- Table 4.3 provides a summary of key inflows and outflows in typical 10th, 50th and 90th percentile rainfall years.

The results are discussed following Table 4.3.

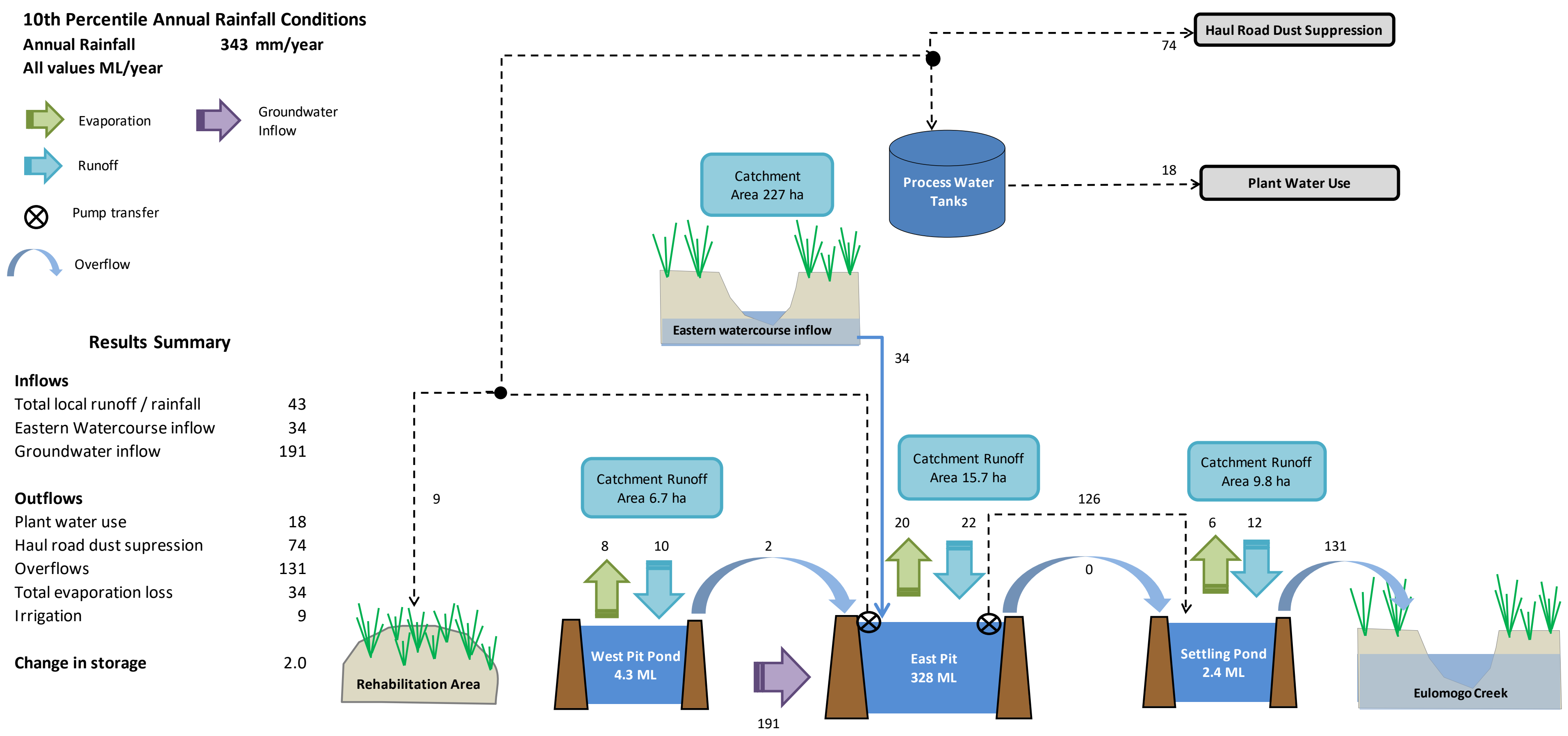


Figure 4.3 Water balance: existing water management system – 10th percentile year

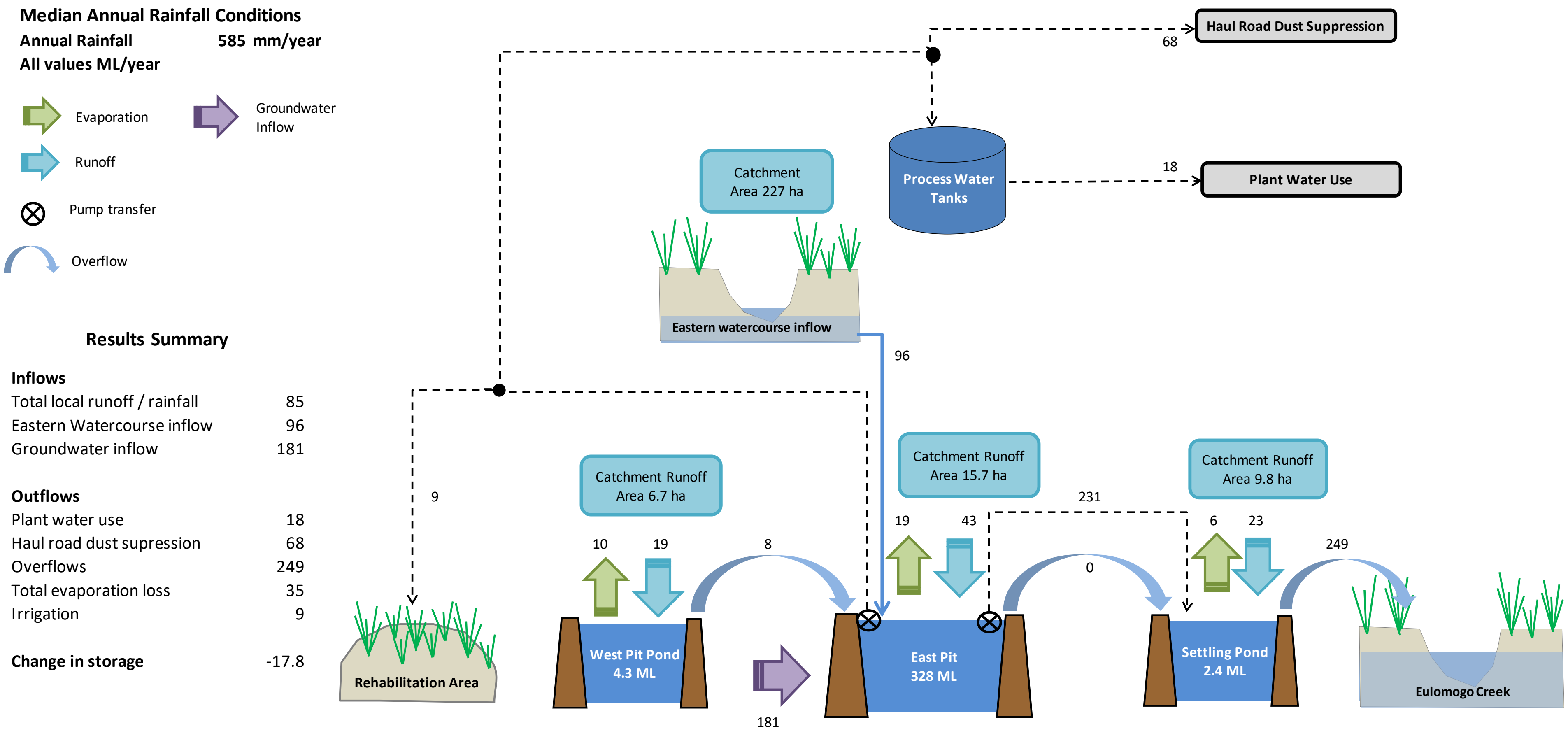
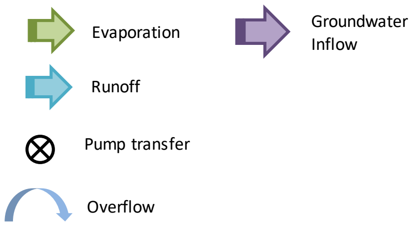


Figure 4.4 Water balance: existing water management system – 50th percentile year

90th Percentile Annual Rainfall Conditions
Annual Rainfall **779 mm/year**
All values ML/year



Results Summary

Inflows	
Total local runoff / rainfall	144
Eastern Watercourse inflow	267
Groundwater inflow	127
Outflows	
Plant water use	18
Haul road dust supression	68
Overflows	411
Total evaporation loss	37
Irrigation	5
Change in storage	-1.0

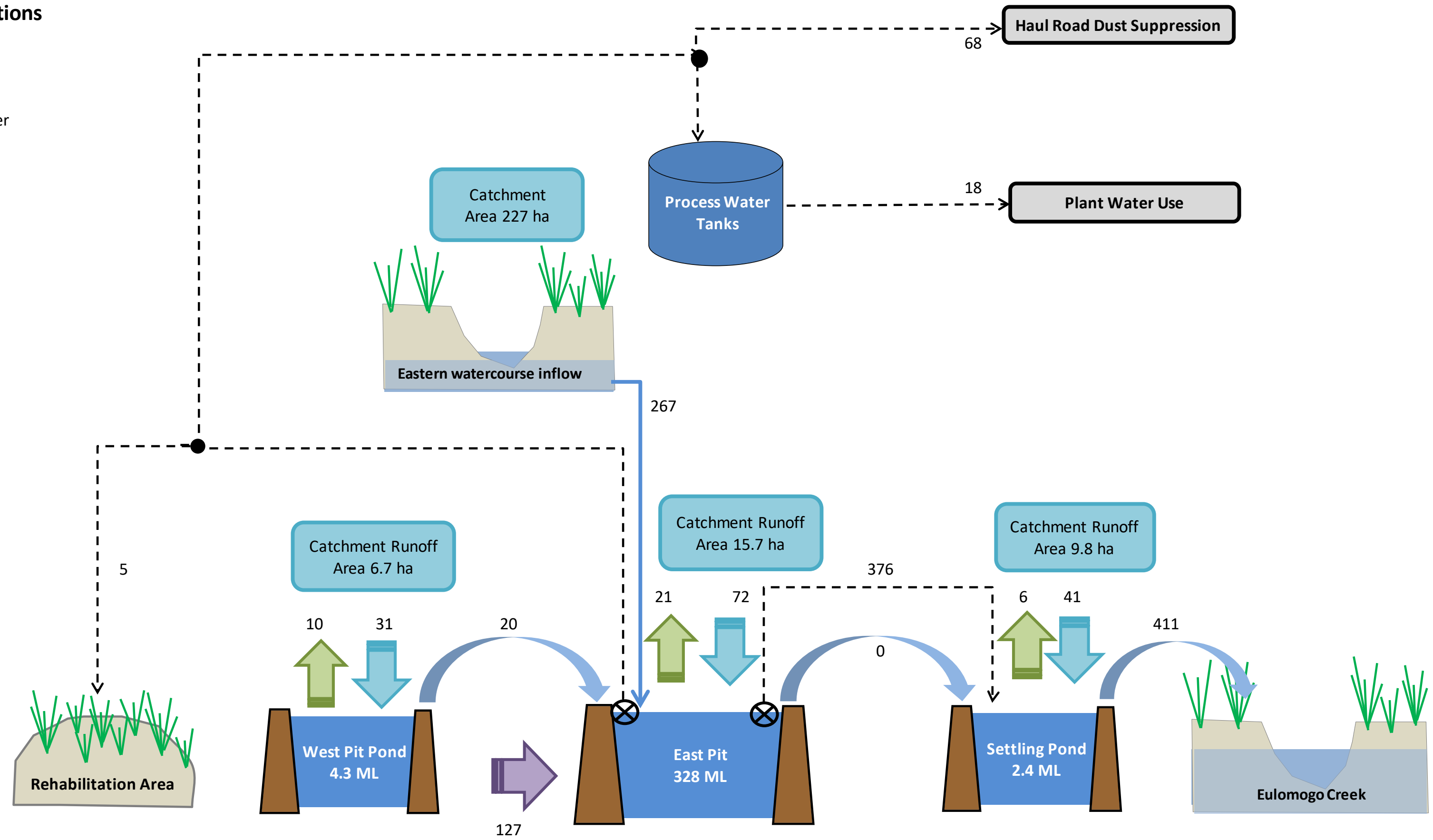


Figure 4.5 **Water balance: existing water management system – 90^{th} percentile year**

Table 4.3 Summary of inflows and outflows: existing water management system

	Units	Dry year	Annualised results Median year	Wet Year
Inflows				
Runoff				
- Quarry catchments	ML / year	43	85	144
- Eastern watercourse	ML / year	34	96	267
Runoff total	ML / year	77	180	411
Groundwater inflows (estimate only)	ML / year	191	181	127
Total inflows	ML / year	**268**	**361**	**538**
Outflows				
Operational water use	ML / year	92	86	86
Irrigation	ML / year	9	9	5
Evaporation	ML / year	34	35	37
Discharges				
- Sediment basin overflows	ML / year	5	18	35
- East Pit dewatering	ML / year	126	231	376
– Discharges total	ML / year	131	249	411
Total outflows	ML / year	**266**	**379**	**539**
Balance (change in storage)	ML / year	**+2**	**-18**	**-1**

Notes: 1. Dry year referes to a typical 10th percentile rainfall year
2. Wet year refers to a typical 90th percentile rainfall year

4.2.2 Results discussion

The water balance results indicate that the water management system is generally in surplus (ie inflows exceed operational water use). Most (approximately 90%) inflows occur due to runoff from the Eastern watercourse and groundwater inflows into the East Pit. Discharges from the water management system occur from the Settling Pond in most years, due mainly to dewatering from the East Pit into the Settling Pond.

It is noted that there is insufficient data available to calibrate the water balance model. The characteristics of groundwater inflows into the pit and runoff volumes from the Eastern watercourse are poorly understood. However, they are considered to be conservatively represented in the water balance model (refer to Appendix B for further information). Lower inflows from either of these sources would materially change the results. Holcim is proposing additional monitoring to allow for an improved understanding of these inflows. This is discussed further in Chapter 5.

5 Proposed water management strategy

Under the project Holcim are proposing to integrate the water management systems for the two expansion areas with the quarry's existing water management system. This will require construction of new infrastructure, some modifications to existing infrastructure and new operating principles for the quarry.

This chapter describes the proposed water management strategy for the proposed operations and is structured as follows.

- Section 5.1 describes the water management objectives that have been applied to develop the strategy.
- Section 5.2 describes the proposed strategy and includes information on existing system modifications and new controls.
- Section 5.3 provides a summary of water balance model results.

It is noted that the proposed haul crossing of Eulomogo Creek is addressed separately in Chapter 6 and residual impacts and licencing considerations are discussed in Chapters 7 and 8, respectively.

5.1 Water management objectives

Table 5.1 describes the water management objectives and associated management approach that have been applied to develop the water management strategy for the proposed operations.

Table 5.1 Water management objectives: proposed operations

Water management objective	Approach
1. Minimise groundwater inflows into existing and proposed quarry pits.	• The WEA and SEA pits will not be developed below the interpreted groundwater table. This will avoid any material groundwater inflows. Refer to Section 6.8 of the EIS for further information. • Further monitoring will be undertaken to allow for an improved understanding of groundwater inflow regimes into the East Pit. • The East Pit will be allowed to partially fill and will be generally maintained at a water level that restricts groundwater inflows (as determined through monitoring). However, during dry periods, water in the pit may be drawn down to a level that enables groundwater inflows to occur up to Holcim's existing WAL entitlement of 90 ML/year (see Chapter 8 for further detail).
2. Minimise controlled discharges from pits	• As noted above, groundwater inflows into existing and proposed quarry pits will be minimised. This will reduce the volume of water that requires management. • Water collected in the sumps of the WEA and SEA pits will be pumped to the East Pit or managed in a way that does not require discharge of surplus water. The East Pit will provide a significant storage that can be utilised to minimise discharges and provide a reliable supply of water to the quarry. • Haul road dust suppression and irrigation of vegetated bunds will be undertaken to manage water surpluses. • Further monitoring will be undertaken to allow for the reliability of the water balance and water management system to be progressively improved. • If long-term water surpluses occur, Holcim will investigate alternative measures such as supplying water to nearby farming enterprises for beneficial use as irrigation water.

Table 5.1 Water management objectives: proposed operations

Water management objective	Approach
3. Provide industry best practice erosion and sedimentation controls for disturbance areas that do not drain to a pit sump.	• Existing and new sedimentation dams will be designed, constructed and operated in accordance with the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008). • The sedimentation dams will be dewatered to the East Pit within 5 days following the cessation of rainfall to ensure capacity is available to capture runoff from the next event.

5.2 Proposed strategy

The functionality of the proposed water management strategy is diagrammatically described in Figure 5.1 and the system layout is shown in Figure 5.2. Additional information on key aspects of the strategy is provided after the figures.

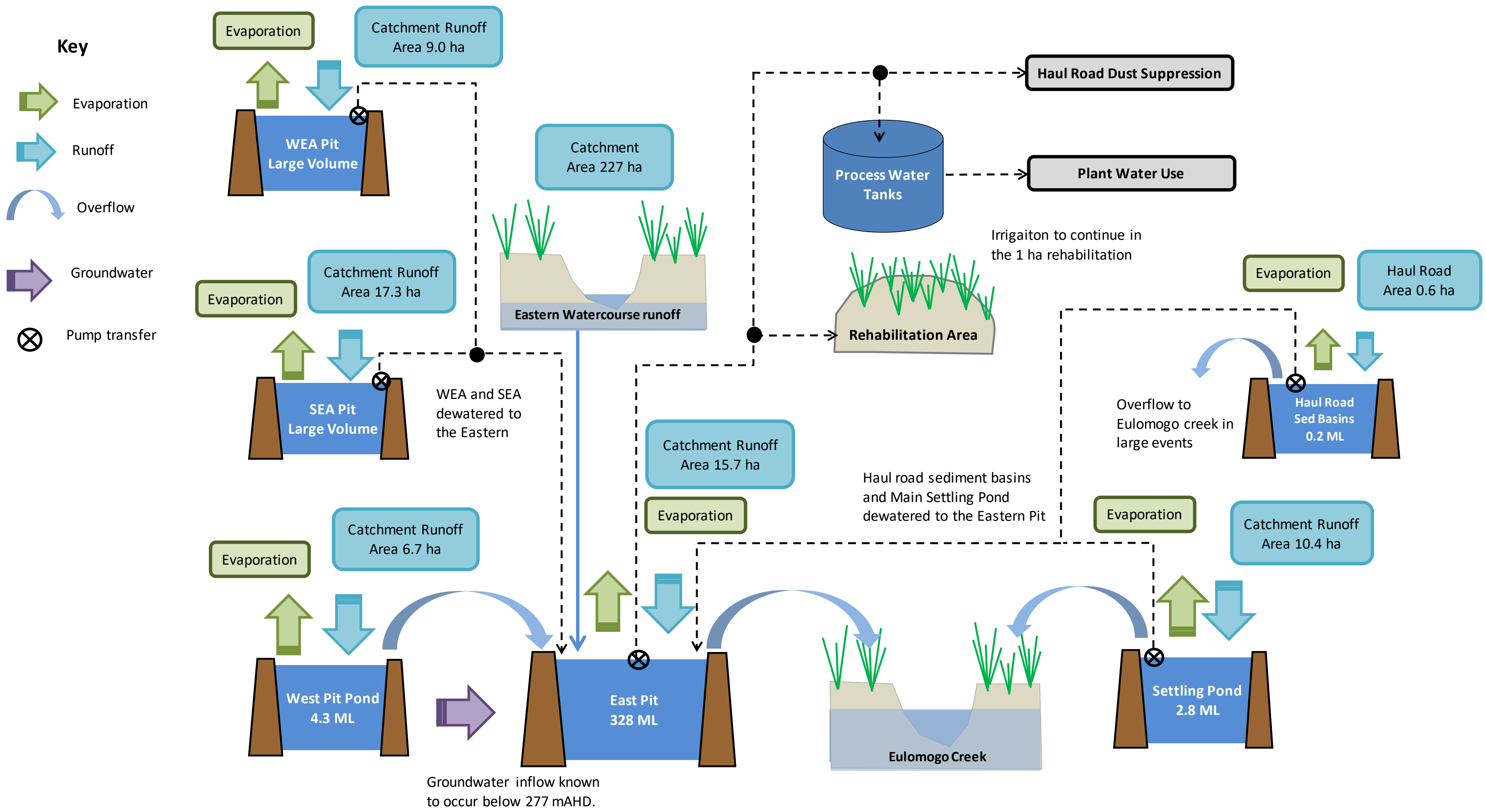
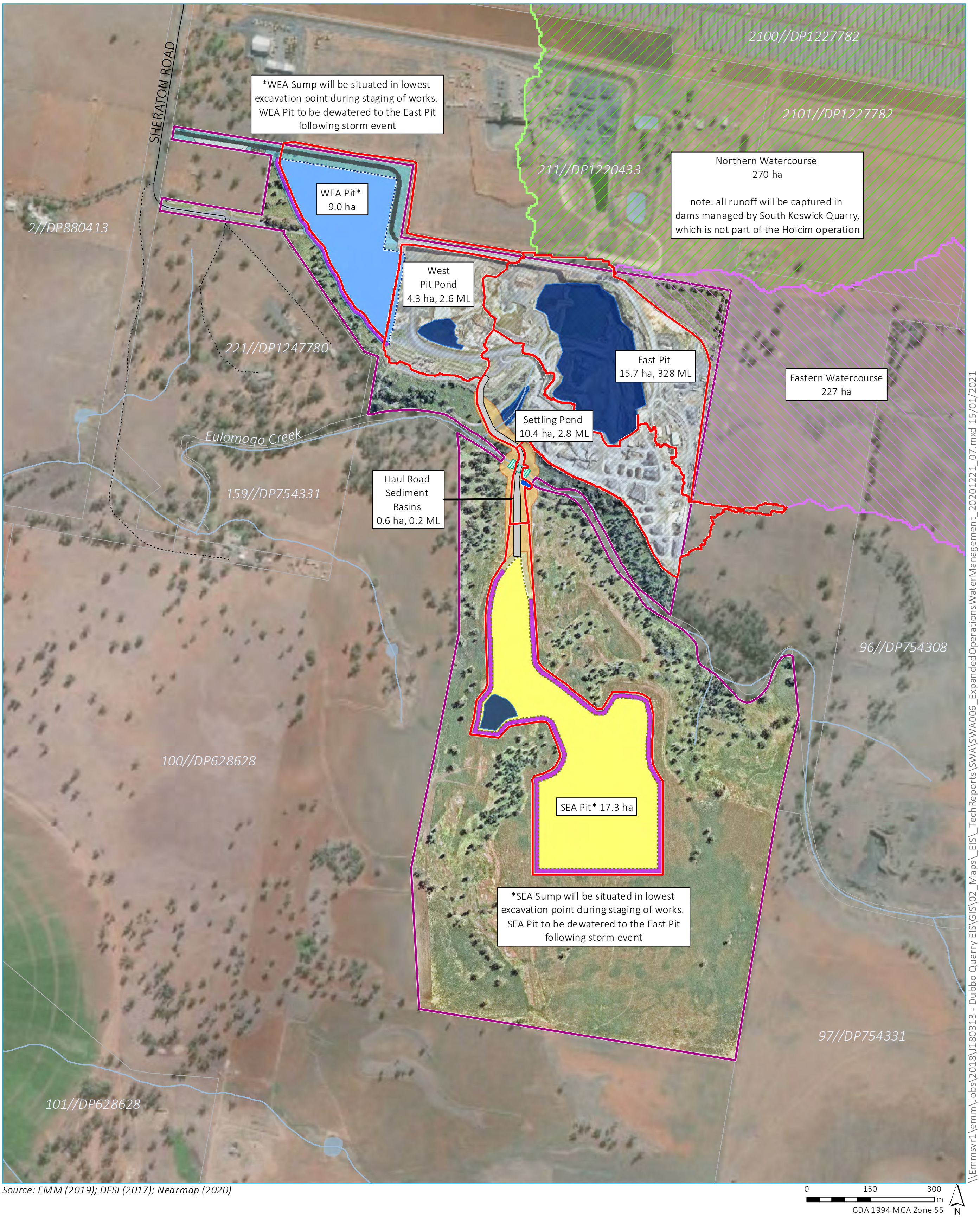


Figure 5.1 Water management system functionality: proposed operations



Source: EMM (2019); DFSI (2017); Nearmap (2020)

KEY

- Project area
- Proposed sub catchment
- The Eastern Watercourse - 227 ML
- The Northern Watercourse - 270 ML
- Proposed water management dams
- Proposed sedimentation pond
- Indicative existing disturbance area
- Proposed haul road
- Indicative proposed water crossing
- Bund wall
- Truck tarping area
- Proposed access road
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)

Proposed water management system layout

Dubbo Quarry Continuation Project
Surface Water Asssessment
Figure 5.2

EMM creating opportunities

5.2.1 Proposed modifications and new controls

Table 5.2 provides a summary of proposed modifications to the existing water management system and new controls.

Table 5.2 Proposed modifications and new controls

Proposed modification / new controls	Outcome
Modifications to the existing system	
1. The water level in the East Pit will generally be maintained at or above a level that restricts groundwater inflows. However, during dry periods, water in the pit may be drawn down to a level that enables groundwater inflows to occur up to Holcim's existing WAL entitlement of 90 ML/year. It is noted that further monitoring and investigation is required to establish pit water levels that relate to no groundwater inflows and 90 ML/year of groundwater inflow.	• Maintaining a higher water level in the pit will minimise groundwater inflows into the pit, reducing the associated water take and need to discharge surplus water.
2. The capacity of the Settling Pond will be increased to 2.8 ML. Water captured in the pond will be dewatered to the East Pit within 5 days following the cessation of rainfall. These modifications will achieve compliance with the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008).	• To achieve an industry best practice standard for erosion and sediment control.
3. Any overflows or pumped dewatering from the East Pit will be discharged directly downstream of the Settling Pond, just upstream of Eulomogo Creek.	• The current practice of dewatering the East Pit into the Settling Pond can keep the pond full for extended periods of time. This reduces the pond's effectiveness in managing runoff from its 10.4 ha contributing catchment area.
New controls	
4. The WEA and SEA pits will not be developed below the interpreted groundwater table.	• To avoid any material groundwater inflows into the pits.
5. During the initial stages of pit development when a pit sump has not been established, surface water runoff from the WEA and SEA will be managed in accordance with the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008).	• To achieve an industry best practice standard for erosion and sediment control.
6. Where practical, runoff from all new haul roads will be managed in accordance with the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008).	• To achieve an industry best practice standard for erosion and sediment control.
7. Water from the WEA and SEA pit sumps will be pumped to the East Pit or managed in a way that does not require discharge of surplus water. For example, water that accumulates in the SEA sump could be used within the SEA for haul road dust suppression and irrigation of bund walls and rehabilitation areas.	• To avoid direct discharge from the WEA and SEA pits and maximise the utilisation of the East Pit storage.

5.2.2 Summary of storages for proposed operations

The water management system for the proposed operations includes seven key storages (refer to Figure 5.2). A summary of the key characteristics of each storage is presented in Table 4.1.

Table 5.3 Water management storages: proposed operations

Storage	Description / function	Contributing catchment area	Groundwater inflows	Volume	Overflows to
Existing storages					
West Pit Pond	The West Pit is a former extraction area. Runoff from a 6.7 ha catchment drains to a small sump. The sump storage is shallow and overflows to the in pit dam via a surface drain. No changes to the management of water in the West Pit Pond are proposed as part of the water management strategy for the proposed operations.	6.7 ha – quarry area	No groundwater inflows are known to occur.	4.3 ML	In Pit Dam
East Pit (Pump Ponds 1 and 2)	The East Pit is currently managed as two separate ponds (Pump Ponds 1 and 2). As described in Table 5.2, the pit will be partially filled to minimise groundwater inflows and will be utilised as a water storage for the quarry. As the water level will be higher it will be managed as a single storage. As shown in Figure 5.1, the pit will receive water pumped from other sumps and sedimentation dams and will supply operational water. The pit will continue to receive runoff from adjoining quarry areas and the Eastern watercourse and will be dewatered (via pumping or a gravity drain) to Eulomogo Creek when it is close to full.	15.7 ha – quarry area 227 ha – Eastern watercourse 242.7 ha - total	Groundwater inflows are known to occur when the pit water levels are below 277 m AHD, 9 m above the pit floor. As described in Table 5.2, the pit water level will generally be maintained at or above a level that restricts groundwater inflows. However, during dry periods, water in the pit may be drawn down to a level that enables groundwater inflows to occur up to Holcim's existing WAL entitlement of 90 ML/year.	328 ML	Eulomogo Creek
Settling Pond	The Settling Pond receives runoff from the site processing area and immediate surrounds. As described in Table 5.2 the following modifications are proposed: • The pond's storage will be increased from 2.4 to 2.8 ML to provide the volume recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008). • Water captured in the pond will be dewatered to the East Pit within 5 days following the cessation of rainfall. Overflows from the pond to Eulomogo Creek will occur when the runoff volume from its contributing catchment exceeds the storage volume. This is likely to occur when the 5-day rainfall exceeds 37 mm.	*Existing catchment* 9.8 ha – processing and quarry area *New catchment* 0.6 ha – haul road to SEA *Total catchment* 10.4 ha	No groundwater inflows are known to occur.	2.8 ML	Eulomogo Creek

Table 5.3 Water management storages: proposed operations

Storage	Description / function	Contributing catchment area	Groundwater inflows	Volume	Overflows to
Proposed storages					
WEA sump	Runoff from the WEA will drain to a pit sump. Accumulated water will be either reticulated back to the East Pit or used within the WEA for haul road dust suppression.	9.0 ha	The pit will not be developed below the groundwater table so no groundwater inflows are expected.	Large	No overflows expected due to large storage and operating principles.
SEA sump	Runoff from the SEA will drain to a pit sump. Accumulated water will be either reticulated back to the East Pit or used within the SEA for haul road dust suppression.	17.3 ha	The pit will not be developed below the groundwater table so no groundwater inflows are expected.	Large	No overflows expected due to large storage and operating principles.
Haul road sedimentation ponds	As indicated in Figure 5.2, two sedimentation ponds will be established near the proposed haul road crossing of Eulomogo Creek. The basins will be designed, constructed and operated in accordance with the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008), which includes dewatering captured water within 5 days following the cessation of rainfall. Overflows from the ponds to Eulomogo Creek will occur when the runoff volume from its contributing catchment exceeds the storage volume. This is likely to occur when the 5-day rainfall exceeds 37 mm.	0.6 ha	The basins will not require deep excavation (around 2m) and are, therefore, not expected to intercept the groundwater.	0.2 ML	Eulomogo Creek

5.2.3 Changes to operational water use

The expanded operation will use process water for dust suppression on haul roads and within the processing plant. Table 5.4 provides estimates of annual water use.

Table 5.4 Process water use (proposed operations)

Process water use	Description	Annual water use
Haul road dust suppression	The haul road area available for dust suppression will be increased as part of the proposed operations due to the increased haul area (refer Appendix B).	Between 166 and 181 ML/year for wet and dry years, respectively.
Dust suppression within the processing plant	No changes to the quarry's production rates are anticipated as part of the proposed operations.	Constant at 18 ML/year.

5.2.4 Monitoring plans

Holcim will prepare the following monitoring plans post approval.

- Quarry pit groundwater inflow management plan. This plan will:
  - provide methods to monitor pit water levels and calculate groundwater inflows into all quarry pits; and
  - establish management protocols to achieve the objectives described in Table 5.1.
- Surface water monitoring plan. This plan will:
  - establish surface water quantity and quality monitoring requirements; and
  - establish trigger action response plans to enable progressive improvement.
- Water management plan. This plan will:
  - describe how water will be managed to achieve compliance with consent and EPL licence conditions; and
  - establish responsibilities and reporting requirements.

All plans will be progressively reviewed and updated.

5.2.5 Contingency measures

Table 5.5 describes a range of contingency measures that could be implemented if required.

Table 5.5 Contingency options

Trigger	Contingency measure
Groundwater inflows exceed existing WAL allocations.	• If practical, maintain higher water levels in pit sumps to reduce groundwater inflows. • Acquire additional WAL entitlements.
The water management system is in surplus and discharges from the East Pit are required frequently, outside of significant wet weather events.	• Irrigation activities can be expanded to include the proposed bund walls around the WEA and SEA, new rehabilitation areas established progressively during the project life and unused haul roads. This would substantially increase water use. • There is potential for Holcim to supply water to nearby irrigators for beneficial use.

5.3 Water balance summary

Water balance models have been prepared for both the existing and proposed operations water management systems. The objective of the water balance modelling is to describe how water is managed during a full range of weather conditions and provide estimates of water take, project water security and discharge regimes.

This section provides a summary of key results from the proposed operations model. The modelling approach and assumptions are documented in Appendix B. Residual impacts and licencing considerations are discussed in Chapters 7 and 8 respectively.

5.3.1 Model results

The following results are presented:

- Figure 5.3 to Figure 5.5 provide annualised results in flow chart format for typical 10th, 50th and 90th percentile rainfall years, respectively.
- Table 5.6 provides a summary of key inflows and outflows in typical 10th, 50th and 90th percentile rainfall years.

The results are discussed following Table 5.6.

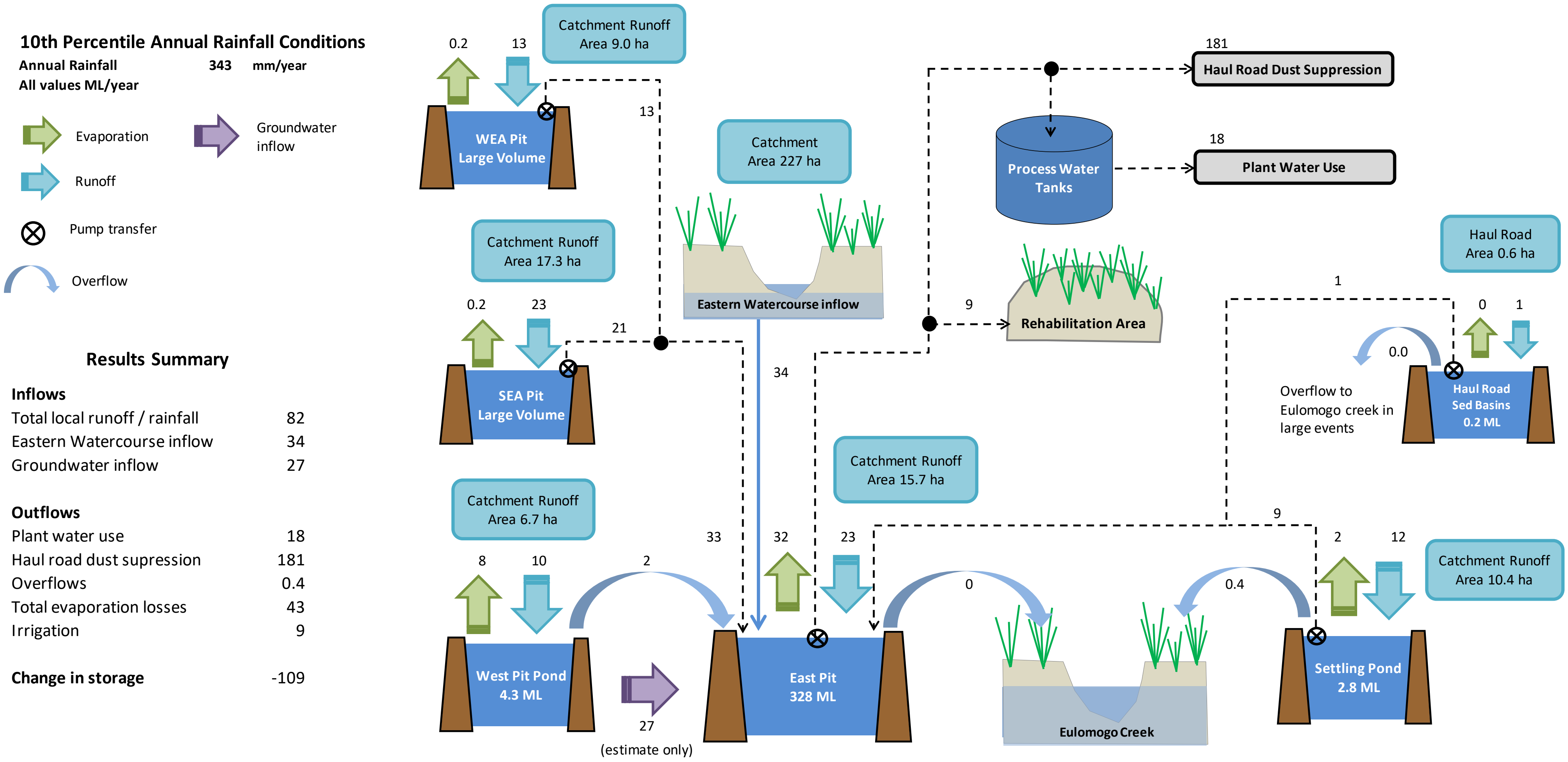


Figure 5.3 Water balance: proposed operations – 10th percentile year

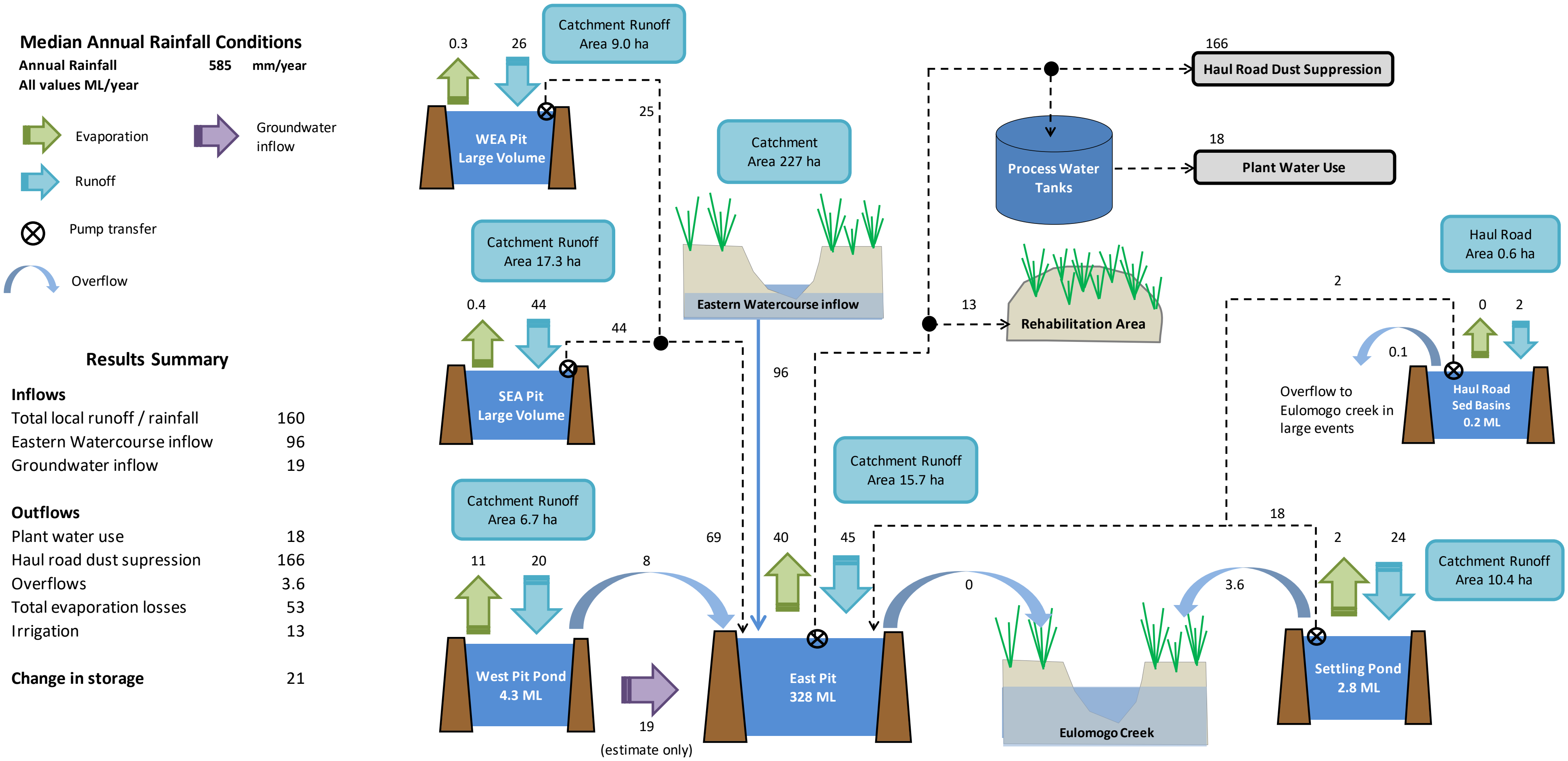


Figure 5.4 Water balance: proposed operations – 50th percentile year

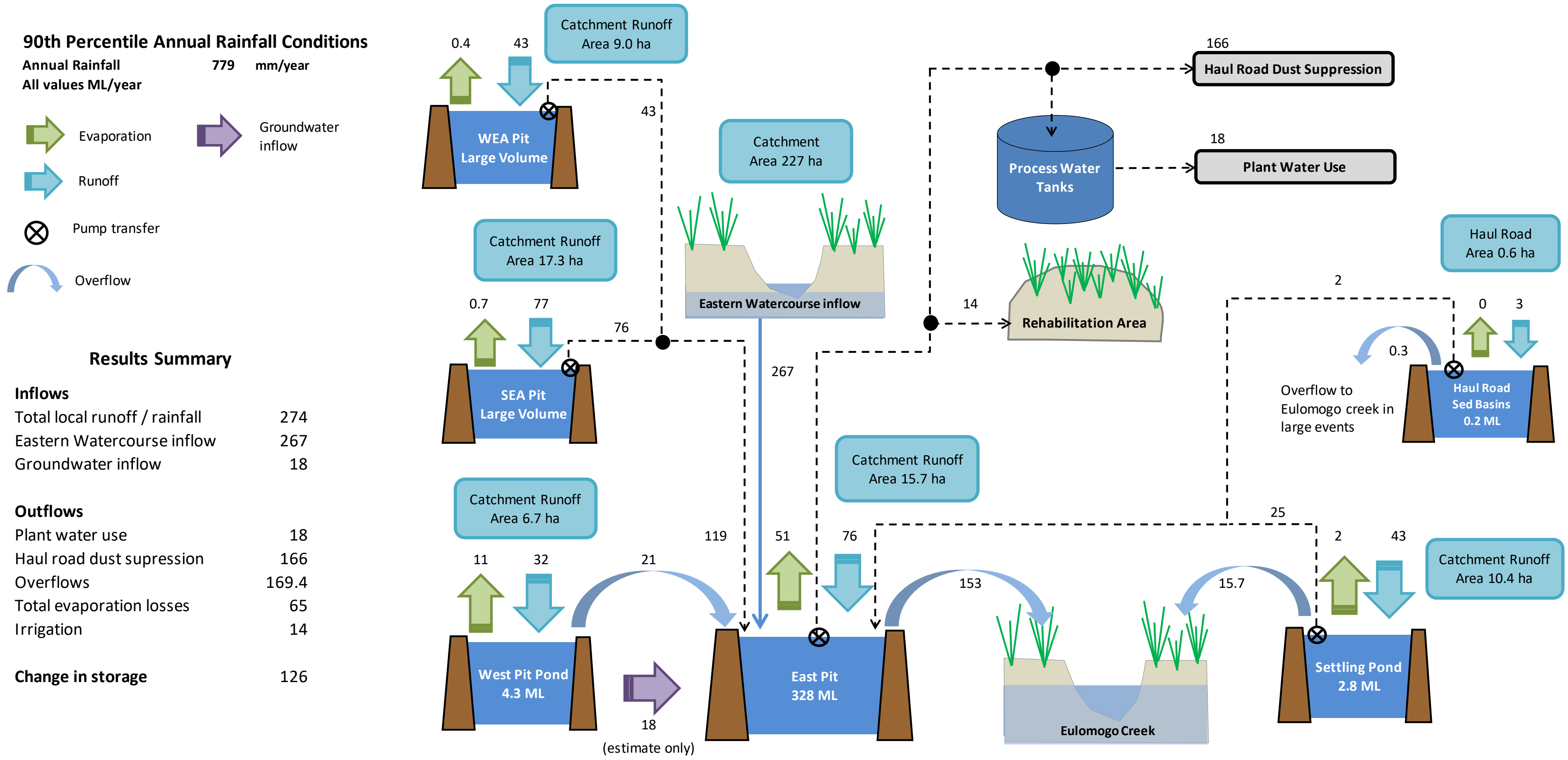


Figure 5.5 Water balance: proposed operations – 90th percentile year

Table 5.6 Summary of inflows and outflows: proposed operations

	Units	Annualised results		
		Dry year	Median year	Wet Year
Inflows				
Runoff				
- Quarry catchments	ML / year	82	160	274
- Eastern watercourse	ML / year	34	96	267
Runoff total	ML / year	115	256	540
Groundwater inflows (estimate only)	ML / year	27	19	18
Total inflows	ML / year	**142**	**275**	**558**
Outflows				
Operational water use	ML / year	200	184	184
Irrigation	ML / year	10	13	14
Evaporation	ML / year	43	54	65
Discharges				
- Sediment basin overflows	ML / year	0.4	3.6	16
- East Pit dewatering	ML / year	0.0	0.0	153
– Discharges (total)	ML / year	0.4	3.6	169
Total outflows	ML / year	**252**	**254**	**432**
Balance (change in storage)	ML / year	**-109**	**+21**	**+126**

Notes: 1. Dry year referes to a typical 10th percentile rainfall year
2. Wet year refers to a typical 90th percentile rainfall year

5.3.2 Results discussion

The water balance results indicate that the water management strategy for the proposed operations will achieve the objectives established in Table 5.1, specifically:

- groundwater inflows into new and existing quarry pits will be minimised (from approximately 191 ML/year to 27 ML/year in a dry year scenario); and
- the frequency and magnitude of discharges from the East Pit and sedimentation dams will be substantially reduced (with minor discharges predicted only from sediment basin overflows during dry years and median years, and discharge volumes during wet years decreasing from 411 ML/year to 169 ML/year respectively).

Residual impacts associated with discharges are discussed in Section 7.1 and water licencing aspects are discussed in Chapter 8.

6 Eulomogo Creek crossing

A haul road crossing of Eulomogo Creek is proposed to connect the SEA to the existing operation. A concept design for the crossing has been prepared by Pitt and Sherry and is provided in Appendix C. A flood impact assessment for the crossing has also been prepared by GRC Hydro and is provided as Appendix A.

This chapter describes the creek crossing proposal and is structured as follows.

- Section 6.1 describes the characteristics of Eulomogo Creek at the crossing site.
- Section 6.2 provides an overview of the proposed crossing concept.
- Section 6.3 provides a summary of flood impacts.

6.1 Eulomogo Creek characteristics

As described in Section 3.5, Eulomogo Creek is a third order watercourse that flows in a westerly direction and joins the Macquarie River, approximately 2.7 km west of the site. The creek is ungauged but is known to have an intermittent flow regime meaning that, during an average rainfall year, streamflow will occur for most of the year but may cease for weeks or months, typically in late summer or early autumn. Streamflow would also cease for extended periods of time during dry periods. The creek has a catchment area of 52 km^2 (upstream of the quarry).

At the crossing site, Eulomogo Creek has a confined channel that is bedrock controlled. The longitudinal grade of the channel is approximately 0.9% and the channel width (when the creek is in flood) ranges from 20 to 35 metres. The channel banks and immediate riparian zone are sparsely vegetated with native and exotic species. Photograph 6.1 shows the creek near the crossing site, looking to the south towards the SEA. Note this photograph is reproduced from Chapter 3.

Photograph 6.1 Eulomogo Creek near the crossing site

The GRC flood study (provided as Appendix A) included hydrologic and hydraulic modelling to characterise flooding at the proposed crossing site. The assessment concluded the following:

- peak flows at the crossing site are estimated to be 83, 111 and 201 m^3/s for the 20, 10 and 1% Annual Exceedance Probability (AEP) events, respectively; and

- hydraulic modelling results characterise flooding within Eulomogo Creek as being confined to the channel and immediate overbank areas. No flood waters are predicted to enter existing quarry pits or impact existing infrastructure. Typical velocities range from 2.5 to 3.5 m/s for the 20 and 1% AEP events, respectively.

Refer to Appendix A for more detailed information on flood characteristics and flood maps.

6.2 Proposed concept

A culvert-based crossing of Eulomogo Creek is proposed. Preliminary engineering designs of two options were prepared by Pitt and Sherry. Option 1 includes five 2.1 m diameter precast pipes and Option 2 includes five 3.0 x 2.1 m Rectangular Box Culverts (RBCs). Both options are similar in terms of the overall design concept and include the following common aspects:

- the haul road will be a single land road to minimise the disturbance footprint and will be slightly skewed relative to the culvert alignment (which will be parallel to the creek). The road surface will be a 400 mm concrete pavement;

- the culverts will be approximately 27 m long and will be located within the creek channel zone with invert levels that are similar to the creek bed levels;

- headwalls and scour protection will be provided at the inlet and outlets;

- 1.4 m high vehicle safety berms will be constructed on either side of the haul road; and

- the height from the culvert invert to the top of the safety berm is approximately 3.9 m.

Concept design drawings for both options are provided in Appendix C. It is noted that the flood levels indicated on the drawings were initial estimates and are superseded by the flood levels given in the flood assessment (refer to Appendix A).

6.3 Flood impacts

The GRC flood study assessed flood impacts associated with the Option 2 (RBC) design. The assessment concluded that:

- the culverts will have a capacity that is similar to the 20% AEP peak flow. This accounts for some culvert blockage (refer to Appendix A for details);

- the haul road and safety berm will be overtopped when flows exceed the culvert capacity. The haul road will be unsafe during these conditions;

- the crossing will result in a flood level impact of up to 3 m in 1% AEP event. The magnitude of the impact is mostly due to the safety berm, which combined with the concrete pavement forms a 1.8 m high blockage above the culverts. Model results indicate that the flood level impact will:

    - extend approximately 300 m upstream of the culvert;

- be confined to the creek channel zone and immediate surrounds; and
- occur only within the quarry site.

- localised increases in velocities are expected immediately downstream of the culvert due to the concentration of flows through the culverts.

Flooding is not anticipated to impact on quarry operations for the following reasons:

- The duration of flooding of Eulomogo Creek is less than 24 hours. Operations can continue during this time on the northern side of Eulomogo Creek.
- Access to the southern side of Eulomogo Creek can be achieved via an alternate light vehicle access road, facilitating storm event preparation (such as moving plant items) and personnel evacuation.

6.4 Consistency with CAA guidelines

As described in Section 2.2.1 guidelines for controlled activities are provided by DPIE-Water. These guidelines provide information on design and construction principles for controlled activities, and other ways to protect waterfront land. Controlled activity approvals are not required for the project as it is a SSD. Notwithstanding, the principles described in the following guidelines have been considered when preparing the concept design:

- *Guidelines for riparian corridors on waterfront land* (NSW Office of Water 2012); and
- *Guidelines for watercourse crossings on waterfront land* (NSW Office of Water 2012).

Table 6.1 describes key design principles from the above guidelines and notes how they have been addressed in the concept design.

Table 6.1 Consistency with guidelines for CAA

Design principle	Concept design response
Guidelines for riparian corridors on waterfront land	
Table 2 from the guideline notes that culvert road crossings are suitable for 3rd and 4th order watercourses.	Eulomogo Creek is a 3rd order watercourse. Hence, the concept design is consistent with this principle.
Guidelines for watercourse crossings on waterfront land	
Minimise the design and construction footprint	A single lane haul road is proposed to minimise the width and footprint of the culvert structure.
Maintain the existing or natural hydraulic, hydrologic, geomorphic and ecological functions of the watercourse Where a raised structure is proposed, demonstrate there will be no detrimental impact to natural hydraulic, hydrologic, geomorphic and ecological functions of the watercourse	**Impacts to hydrology** • No changes to the hydrology of Eulomogo Creek is expected as streamflow will simply pass through the culvert structure. **Impacts to hydraulics** • No material changes to local hydraulics are expected during non-flood conditions as the culvert capacity is large relative to streamflow during non-flood conditions. • Some localised changes to hydraulics are expected during flood conditions. These changes are described in Section 6.3. **Impacts to geomorphology** • The culverts are not expected to block or alter sediment transport along Eulomogo Creek as the culverts are large and located within the creek channel. **Impacts to ecology** • Impacts to ecology from the creek crossing are addressed in the Dubbo Quarry Continuation Project Biodiversity Development Assessment Report (EMM 2020b)
Protect against scour	Culvert headwalls and scour aprons are proposed at the inlets and outlets. However, given that Eulomogo Creek is bed rock controlled at the culvert location, the need for scour aprons will be assessed further at detailed design.
Stabilise and rehabilitate all disturbed areas.	Rehabilitation of areas disturbed by the construction of the culvert will be addressed at detailed design using standard methods.

7 Residual impacts

This chapter describes residual impacts associated with discharges from the proposed operations and addresses the NSW water quality and river flow objectives that were established in Chapter 2. It is noted that impacts associated with the proposed Eulomogo Creek Crossing are described in Chapter 6.

7.1 Water discharge impacts

As described in Chapter 4 discharges from the existing quarry into Eulomogo Creek occur due to sedimentation basin overflows and dewatering of the East Pit. The water management strategy for the proposed operations (described in Chapter 5) seeks to minimise these discharges by modifying existing infrastructure and operating principles and establishing new infrastructure for the expansion areas. This section describes the changes to discharge regimes, the expected water quality of discharges and associated changes to receiving water quality.

7.1.1 Changes to discharge regimes

The water management strategy for the proposed operations applies the following measures to reduce discharges:

- Groundwater inflows into new and existing pits will be minimised by:
  - allowing the East Pit to partially fill and by maintaining a pit water level that generally restricts groundwater inflows; and
  - not developing excavations in the WEA and SEA below the interpreted groundwater table, avoiding any material groundwater inflows.
- The East Pit will be used to store water pumped from pit sumps and sedimentation dams. This reduces the need for discharges during, and shortly following, rainfall events.
- Sedimentation basin overflows will be reduced by:
  - dewatering the basins to the East Pit within 5 days following each rainfall event; and
  - diverting water that is dewatered from the East Pit to downstream of the Settling Pond.

Water balance modelling was used to estimate discharge regimes from both the existing and proposed operations. Key results are presented as follows.

- Table 7.1 compares the annualised discharge volumes for dry, median and wet years.
- Figure 7.1 is a probability of exceedance chart that compares the annualised discharge volumes. It is noted that the y-axis (annual discharge) is presented at a log scale.

Both Table 7.1 and Figure 7.1 provide a break-down of discharges due to sedimentation basin overflows and East Pit dewatering.

Table 7.1 Changes to discharge regimes: existing and proposed operations

		Existing operation			Proposed operations		
	Units	Dry year	Median year	Wet Year	Dry year	Median year	Wet Year
Sediment basin overflows	ML/year	5	18	35	0.4	3.6	16
East Pit dewatering	ML/year	126	231	376	0.0	0.0	153
Total discharges	ML/year	131	249	411	0.4	3.6	169

Notes: 1. Dry year referes to a typical 10th percentile rainfall year
2. Wet year refers to a typical 90th percentile rainfall year

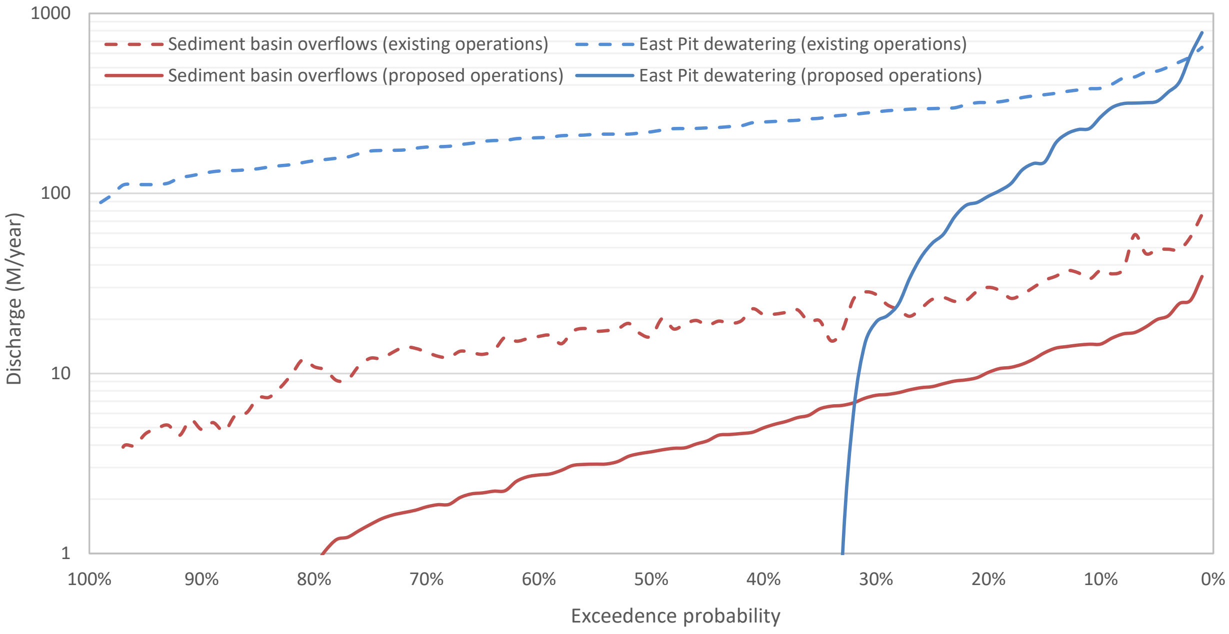


Figure 7.1 Comparison of discharge regimes: existing and proposed operations

The water balance results presented in Table 7.1 and Figure 7.1 demonstrate that the water management strategy for the proposed operations will be effective in substantially reducing both the frequency and magnitude of discharges due to sedimentation basin overflows and East Pit dewatering, with discharges via both mechanisms occurring during wet conditions only and at reduced magnitudes.

7.1.2 Water quality of discharges

The water quality characteristics of water storages was detailed in 3.6.2ii. As described in Chapter 4, groundwater inflows into the East Pit are a primary source of water to the existing water management system and are, therefore, expected to influence the quality of water that discharges from the East Pit and Settling Pond. The water management strategy for the proposed operations (described in Chapter 5) seeks to minimise groundwater inflows. As a result, surface water runoff from quarry areas and the Eastern watercourse will be the primary sources of inflows and some changes to water quality are expected.

The water quality of groundwater inflows is poorly understood. However, there is potential that groundwater inflows have higher salinity and nitrate concentrations then surface water runoff and that the salinity levels and nitrate concentrations in the East Pit may decline overtime as the water management strategy for the proposed operations is implemented.

Surface water monitoring is proposed (see Section 5.2.4) which will enable changes to water quality to be identified and the water management approach to be adjusted if required.

7.1.3 Potential changes to receiving water quality

The water management strategy for the proposed operations will substantially reduce the frequency and magnitude of discharges to Eulomogo Creek from both sedimentation basin overflows and East Pit dewatering, with discharges via both mechanisms occurring during wet conditions only, and at reduced magnitudes. These reductions will occur despite the quarry footprint increasing from approximately 34 to 60 ha due to the proposed WEA and SEA extensions.

Table 7.2 provides a summary of expected changes to nutrient loads, sediment laden and turbid water, salt loads and metals and toxicants in discharges. Overall, the reduced frequency and magnitude of discharges is expected to beneficially change receiving water quality.

Table 7.2 Changes to the water quality profile of discharge

Aspect	Description of changes
Nutrient loads	Water quality monitoring data has identified that nutrients (particularly nitrate and reactive phosphorus) in the existing water management system storages are elevated relative to DGVs. The water management strategy for the proposed operations will reduce nutrient loads in discharges, primarily due to the lower discharge volumes. However, if existing groundwater inflows into the East Pit are the primary source of the nutrients, there is potential for additional reductions to occur given that groundwater inflows will be substantially reduced. The magnitude of the overall reduction cannot be reliably quantified but is expected to be substantial.
Sediment laden or turbid water	As described in Section 7.1.1, the frequency and magnitude of sedimentation basin overflows is expected to be substantially reduced relative to existing conditions. This is primarily due to the proposed changes to the Settling Pond, which is currently operating below the standard recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008). Water quality monitoring data presented in Section 3.6.2 indicates that the turbidity in the East Pit is generally below the DGV. Hence, discharges from the East Pit are not expected to be either turbid or sediment laden.
Salt loads	Salt loads in discharges are expected to be significantly reduced due to the lower frequency and magnitude of discharges and decreases to (likely moderately saline) groundwater inflows into the East Pit.
Metals and toxicants	The occurrence of metals and other toxicants in quarry water is poorly understood. A single sample collected as part of the EIS sampling (see Section 3.6.2) identified potential for zinc and copper concentrations above DGVs in select samples from existing water management storages. Discharges from the water management system for the proposed operations are only expected to occur during or shortly after material wet weather events, when streamflow in receiving waters will be naturally high. Hence, the risk of discharges increasing the toxicity of receiving waters is substantially reduced relative to the existing discharge regime where discharges outside of wet weather events occur.

7.2 NSW water quality and river flow objectives

Section 2.3 established the water quality and river flow objectives for receiving waters relevant to the project. Table 7.3 describes potential impacts to the objectives due to the project (ie the proposed operations).

Table 7.3 Assessment of water quality and river flow objectives

Environmental value	Objective	Application to proposed development
Water quality objectives		
Aquatic ecosystems	Maintaining or improving the ecological condition of water bodies and their riparian zones over the long term.	As described in Section 7.1.3, the reduced frequency and magnitude of discharges is expected to beneficially change receiving water quality. This may result in improved ecological conditions.
Visual amenity	Aesthetic qualities of waters.	As described in Section 7.1.3, the water management strategy for the proposed operations will reduce nutrient loads in discharges. This may reduce the risk of blue-green-algae blooms in downstream watercourses. It is also noted that discharges are not expected to have elevated concentrations of oils, petrol chemicals or floating debris which can impact the visual amenity of water (ANZECC 2000).
Secondary contact recreation	Maintaining or improving water quality for activities such as boating or wading, where there is a low probability of water being swallowed.	As described in Section 7.1.3, the water management strategy for the proposed operations will reduce nutrient loads in discharges. This may reduce the risk of blue-green-algae blooms in downstream watercourses. It is also noted that discharges are not expected to have elevated concentrations of coliforms, enterococci or protozoans as there is no source of these pollutants in the surface water management system.
Primary contact recreation	Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.	
Livestock water supply	Protecting water quality to maximise the production of healthy livestock.	The water quality of discharges is expected to be suitable for both livestock consumption and irrigation. As described in Section 7.1.3, the water management strategy for the proposed operations is expected to reduce salt loads in discharge which will make a small contribution to achieving the catchment wide salinity targets noted in Table 2.2.
Irrigation water supply	Protecting the quality of waters applied to crops or pasture.	
Drinking water at point of supply – disinfection only	These objectives apply to all current and future licensed offtake points for town water supply and to specific sections of rivers that contribute to drinking water storages or immediately upstream of town water supply offtake points. The objectives also apply to sub-catchments or groundwater used for town water supplies.	Town water supply in the region is provided by Dubbo Regional Council. Water is extracted from Macquarie River downstream of the site for town water supply and treated at the John Gilbert Water Treatment Plan in Macquarie Street south. As described in Section 7.1.3, the reduced frequency and magnitude of discharges is expected to beneficially change receiving water quality. It is also noted that discharges are not expected to have elevated concentrations of coliforms, enterococci or protozoans as there is no source of these pollutants in the surface water management system.
Drinking water at point of supply – clarification and disinfection		
Drinking water at point of supply – groundwater		

Table 7.3 Assessment of water quality and river flow objectives

<table>
<tr><th>Environmental value</th><th>Objective</th><th>Application to proposed development</th></tr>
<tr><td colspan="3">River flow objectives</td></tr>
<tr><td>Protect pools in dry times</td><td>Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows.</td><td rowspan="6">The water management strategy for the proposed operations will reduce the frequency and magnitude of discharges to Eulomogo Creek and groundwater take from the local hard rock aquifer. Resulting changes to the streamflow regime of Eulomogo Creek are expected to be beneficial (ie closer to a naturalised flow regime).</td></tr>
<tr><td>Protect natural low flows</td><td>Share low flows between the environment and water users and fully protect very low flows.</td></tr>
<tr><td>Protect important rises in water levels</td><td>Protect or restore a proportion of moderate flows and high flows.</td></tr>
<tr><td>Maintain wetland and floodplain inundation</td><td>Maintain or restore the natural inundation patterns and distribution of floodwater supporting natural wetland and floodplain ecosystems.</td></tr>
<tr><td>Maintain natural flow variability</td><td>Maintain or mimic natural flow variability in all streams.</td></tr>
<tr><td>Manage groundwater for ecosystems</td><td>Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.</td></tr>
<tr><td>Minimise effects of weirs and other structures</td><td>Minimise the impact of instream structures.</td><td>As described in Section 6.4, the concept design for the proposed haul road crossing of Eulomogo Creek has considered relevant guidelines for controlled activities and no detrimental impact to natural hydraulic, hydrologic, geomorphic and ecological functions of the watercourse are expected.</td></tr>
</table>

8 Water licencing

8.1 Approvals

Clause 4.41(1)(g) of the EP&A Act exempts an SSD authorised by a development consent from requiring a water use approval under section 89, a water management work approval under section 90, or an activity approval (other than an aquifer interference approval) under section 91 of the WM Act. These exemptions apply to the project as it has been declared an SSD and, therefore, there is no requirement to obtain approvals under the WM Act, including water use, water management work or controlled activity approvals.

8.2 Groundwater

Holcim currently holds WAL 34573 for 90 ML to account for groundwater flows into the East Pit. The WAL is held within the Gunnedah-Oxley Basin MDB (Other) Management Zone of the Gunnedah-Oxley Basin MDB Groundwater Source that is regulated by the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources*.

As discussed in Section 5.3.1, water balance modelling for the proposed operations estimated groundwater inflows to the quarry's water management system to be 15-22 ML/year. Therefore, WAL 34573 is considered to be sufficient for the predicted groundwater inflows and no additional groundwater entitlements are required.

8.3 Surface water

8.3.1 Eastern watercourse

As discussed in Section 3.5, the eastern watercourse is an ephemeral drainage line that receives runoff from a 227 ha catchment to the east of the quarry. The watercourse flows infrequently, however, when significant rainfall occurs

Holcim have recently acquired a WAL 43440 for 136 ML of surface water entitlement within the Maryvale Geurie Creek Water Source regulated by the *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources*. This WAL amount, combined with the quarry's harvestable right, exceed the calculated surface water take from the eastern watercourse by the quarry. Table 8.1 provides the calculated water take and Holcim's total entitlement.

Table 8.1 Calculated water take and entitlements

	Volume	Methodology
Calculated water take	136 ML	Calculated as the Eastern watercourse catchment area (227 ha) x the Maximum Harvestable Rights Dam Capacity (MHRDC) (0.06 ML/ha) x 10[1]
Calculated water entitlement		
WAL	136 ML	WAL 43440
Harvestable right	8 ML	Calculated as Holcim's landholdings[2] (140 ha) x the MHRDC (0.06 ML/ha)
Total entitlement	144 ML	

Notes:

1. The calculation of water take using the MHRDC extrapolation methods was discussed and agreed with WaterNSW via email correspondence dated 30 March 2020.
2. Refers to the landholdings for the epanded operations.

8.3.2 Excluded works

Dams that are solely for the capture, containment or recirculation of drainage, consistent with best management practice to prevent the contamination of a water source, and that are located on a minor stream are considered to be excluded works under Schedule 1, item 3 of the NSW Water Management (General) Regulation 2018. The storages that form the existing and proposed operations water management system at the quarry (refer to Table 5.3 and Figure 5.2) are considered to be excluded works under this definition as the primary use of the storages are for water quality control by capturing sediment-laden runoff and retaining sediment to prevent pollution of the downstream receiving environment.

Water stored within the water management system is proposed to be used for dust suppression activities and to supply the processing plant. The take of water from the water management system is exempt from requiring a licence under Schedule 4, item 12 of the NSW Water Management (General) Regulation 2018.

References

ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management Strategy, Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

ANZG (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Governments and Australian state and territory governments, http://www.waterquality.gov.au/anz-guidelines/.

Chiew, F.H.S and Siriwardena, L (2005) *Estimation of SIMHYD Parameter Values for Application in Ungauged Catchments*.

DEC (2004) *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales*, NSW Department of Environment and Conservation.

DEC (2005) *Liquid Chemical Storage, Handling and Spill Management: Review of Best Practice Regulation*, NSW Department of Environment and Conservation.

DECC (2007) *Storing and Handling Liquids: Environmental Protection: Participant's Manual*, NSW Department of Environment and Climate Change.

DECC (2008) *Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries*, NSW Department of Environment and Climate Change.

DECCW (2006) *NSW Water Quality and River Flow Objectives*, NSW Department of Environment, Climate Change and Water, http://www.environment.nsw.gov.au/ieo/.

EMM (2020a) *Dubbo Quarry Continuation Project: Environmental Impact Statement*

EMM (2020b) *Dubbo Quarry Continuation Project: Biodiversity Development Assessment Report*

Landcom (2004) *Managing Urban Stormwater: Soils and Construction – Volume 1*, 4th edition.

NSW DoI (2018) *Macquarie-Castlereagh Surface Water Resource Plan, Schedule H – Macquarie-Castlereagh water quality management plan,* NSW Department of Industry

OEH (2016) eSPADE NSW Soil and Land Information Database, Version 2.0. NSW Department of Planning, Industry and Environment, available https://www.environment.nsw.gov.au/eSpade2Webapp.

Abbreviations

AHD	Australian Height Datum
ARI	average recurrence interval
BOM	Bureau of Meteorology
DCP	development control plan
DGV	default guideline value
DPIE-Water	Department of Planning Industry and Environment: Water Division
DRC	Dubbo Regional Council
EIS	environmental impact statement
EPA	Environment Protection Authority
EPL	environment protection licence
LDP	licensed discharge point
LGA	Local Government Area
MDB	Murray Darling Basin
MHRDC	Maximum harvestable rights dam capacity
Mt	Million tonnes
NATA	National Association of Testing Authorities
PMF	probable maximum flood
POEO Act	*Protection of the Environment Operations Act 1997*
RCBC	Rectangular concrete box culvert
RMS	Roads and Maritime Services
SEA	Southern Extension Area
SILO	Scientific Information for Land Owners
SSD	State significant development
tpa	tonnes per annum
WAL	water access licence
WEA	Western Extension Area
WMA	*Water Management Act 2000*
WSP	water sharing plan

Appendix A

Flood assessment

DUBBO QUARRY CONTINUATION PROJECT

FLOOD STUDY AND IMPACT ASSESSMENT

Final Report

October 2020

Dubbo Quarry Continuation Project

Flood Study and Impact Assessment

Project:	Dubbo Quarry Continuation Project – Flood Study and Impact Assessment
Project Number:	190036
Client:	Holcim / EMM Consulting Pty Ltd
Report Author:	Nicola De Paolis, Zac Richards
Verified by:	Zac Richards

Date	Version	Description
15-July-2019	1	Preliminary Report
23-July-2019	2	Draft Report
20-October-2020	3	Final Report

Filepath: J:\190036\Admin\Report\Dubbo Quarry - Flood Study and Impact Assessment -Draft Final Report.docx

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Cover image: Satellite picture of Dubbo Quarry

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EXECUTIVE SUMMARY

Introduction

Holcim's Dubbo Quarry is located approximately 6 km south-east of the Dubbo town centre and to the north of Eulomogo Creek. Holcim are proposing to expand the quarry's existing operations to the southern side of Eulomogo Creek. To facilitate the expansion, a haul road crossing is proposed to connect the southern and northern sides of the Creek.

GRC Hydro has been appointed to undertake a flood study for the Site and to assess flood impact associated with the proposed Eulomogo Creek crossing concept design.

Hydrology

Hydrologic modelling has been undertaken using XP-RAFTS, with design flows derived for the site for the 1%, 10% and 20% AEP events. Validation of the derived design flow estimates has been undertaken via comparison to ARR2016 Regional Flood Frequency Estimates (RFFE) and results from a coarse direct rainfall TUFLOW model developed for the catchment upstream of the site.

The validation results were found to improve the robustness of the XP-RAFTS design flow estimates.

Hydraulics

A TUFLOW hydraulic model was constructed for the site on a 2 m grid resolution. Upstream and internal boundary conditions were applied based on outputs from the XP-RAFTS model, and the Macquarie River 1% AEP flood level was applied as a static tailwater level at the downstream boundary. Applied Manning values were consistent with nearby studies and ARR2016 guidelines.

Results

Flood maps for the 1%, 10% and 20% AEP events were produced. The maps present peak flood depths and levels in the existing and proposed scenarios and flood impact maps to assess the change in water levels caused by the proposed road embankment and culverts.

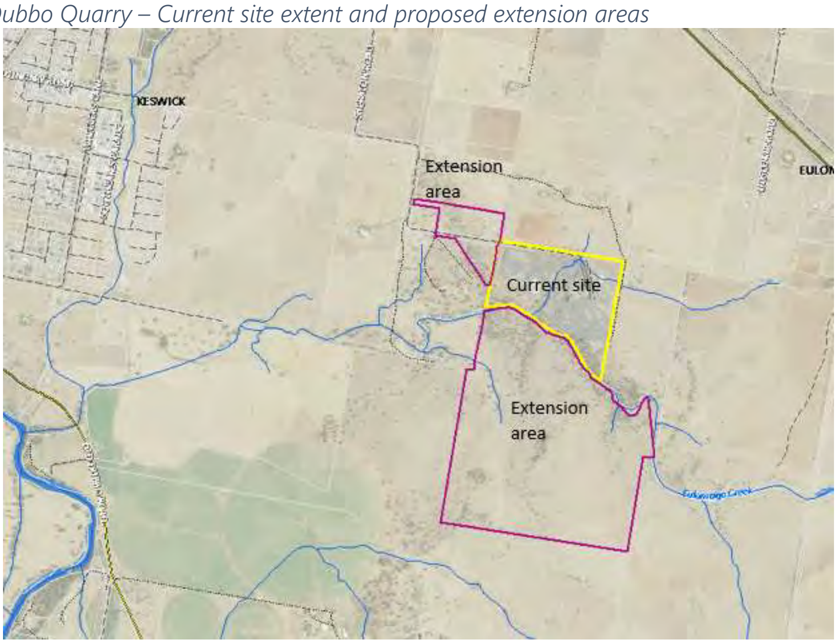
Flood levels are expected to overtop the proposed road crossing during the 20% AEP and greater magnitude events. However, Holcim have advised that alternate road access is available to the site which can be used during periods of flood. Flooding of the creek crossing may pose a risk to vehicles attempting to use the crossing during times of flood and operating protocols should be implemented to manage this risk. It is also noted that there is no public access to the road crossing.

Comparison of peak flood levels between the existing and proposed conditions show a water level increase up to 3 meters in the 1% AEP event, however flood impacts are confined to land owned by Holcim.

1. INTRODUCTION

Holcim's Dubbo Quarry is located approximately 6 km south-east of the Dubbo town centre and to the north of Eulomogo Creek. Holcim are proposing to expand the quarry's existing operations to the north-west as well as to the southern side of Eulomogo Creek, as presented in Image 1.

Image 1: Holcim Dubbo Quarry – Current site extent and proposed extension areas



Eulomogo creek is an intermittent watercourse and a tributary of the Macquarie River. The Eulomogo creek catchment area to the site is ~52 km². A key component of the proposed works is the connection of the southern and northern sides of Eulomogo Creek.

GRC Hydro has been appointed to undertake a flood study for the Site and to assess the proposed Eulomogo Creek crossing concept design.

1.1 Objectives

The objectives of this study are to define 1%, 10% and 20% AEP flood behaviour for Eulomogo Creek at the project site under the existing and proposed conditions scenarios and assess the flood impact caused by the proposed Eulomogo Creek crossing. This study is focused on mainstream flooding only and minor overland flow paths within the site have not been assessed.

2.HYDROLOGY

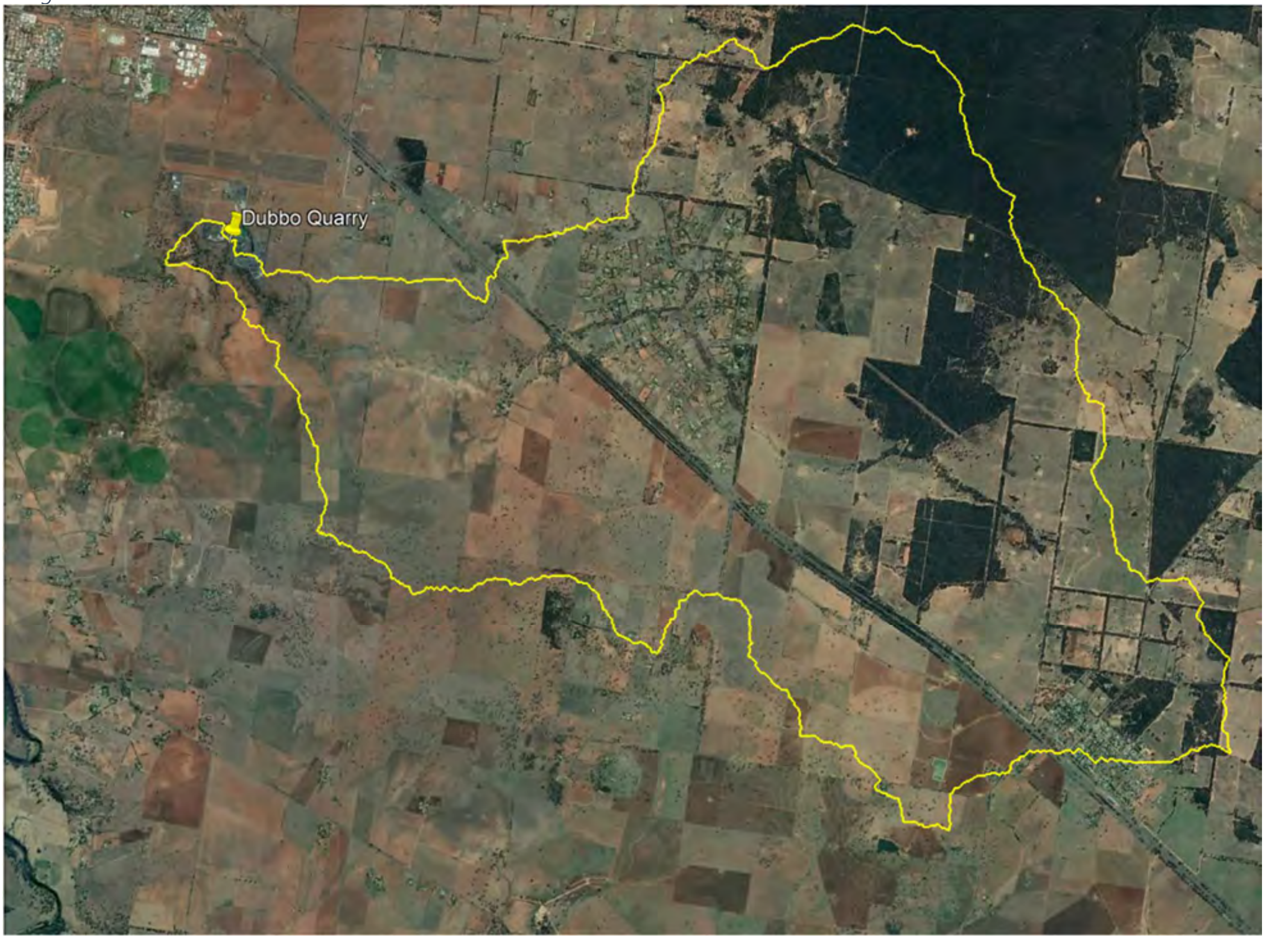
2.1 Catchment Description

Eulomogo Creek is an intermittent watercourse and a tributary of the Macquarie River. The Creek catchment at Dubbo Quarry has an area of 52 km^2, with ground elevations ranging between approximately 277 to 421 mAHD. Typical catchment slopes range between 1.1% to 2.6% with a maximum stream length of 16 km from the upper catchment to the site. The Eulomogo Creek catchment area upstream of the quarry is presented in Image 2.

The region is predominantly rural in nature; however, some rural residential development is present to the north of the A32 Highway, which crosses the catchment from north-east to south-west.

In western areas of the catchment, land use is predominately pastural grasslands with typically sparse vegetation, with more dense vegetation noted along the watercourse. In the upper catchment, to the north-east, woodlands of medium vegetation density are noted.

Image 2: Catchment Area



Local catchments to the north and east of the quarry have not been assessed in the hydrologic analysis, due to the following reasons (as advised by EMM):

- Local catchment directly to the north – a quarry has recently been established to the north of the site which captures all runoff from this catchment; and
- Local catchment to the east of the quarry – runoff from this catchment is contained by the quarry's water management system (i.e. void).

2.2 Hydrologic Modelling

The hydrologic aspects of this study have been undertaken using XP-RAFTS. XP-RAFTS is a software program used to simulate runoff hydrographs at defined points throughout a watershed based on a set of catchment characteristics and specific rainfall events. The software is suitable for use in both rural and urban catchments, making is suitable for use in the current study.

There is no stream gauge present within the Eulomogo Creek catchment and accordingly, event base model calibration was not possible. In lieu of suitable calibration data, validation of the derived design flow estimates has been undertaken via the following methods:

- Comparison to ARR2016 Regional Flood Frequency Estimates (RFFE); and
- Comparison to results from a coarse (10m) direct rainfall TUFLOW model for the upstream catchment.

The following sections discuss the XP-RAFTS model build, model parameters, design flow results and flow validation.

2.2.1 XP-RAFTS Hydrologic Model Build

2.2.1.1 Model Schematisation and Parameters

The XP-RAFTS hydrologic model requires the derivation of sub-catchment areas and associated catchment characteristics. The catchment described in Section 2.1 was divided into 11 sub-catchments with comparable surface area, shape and ground slopes characteristics. Table 1 summarises the features of each sub-catchment, with the sub-catchments layout presented in Figure 1.

Table 1: XP-RAFTS model schematisation

Sub Catchment ID#	AREA (ha)	slope %
1	541.8	1.45
2	696.4	1.82
3	635.5	1.15
4	662.6	1.14
5	220.2	2.20
6	507.9	2.20
7	483.2	1.42
8	719.3	1.72
9	263.0	2.63
10	437.1	1.51
11	178.0	1.78

XP-RAFTS model parameters were determined via inspection of available data, including aerial imagery and a 1m DEM obtained from NSW Spatial Services ('*Dubbo201407-LID1-AHD*' dataset).

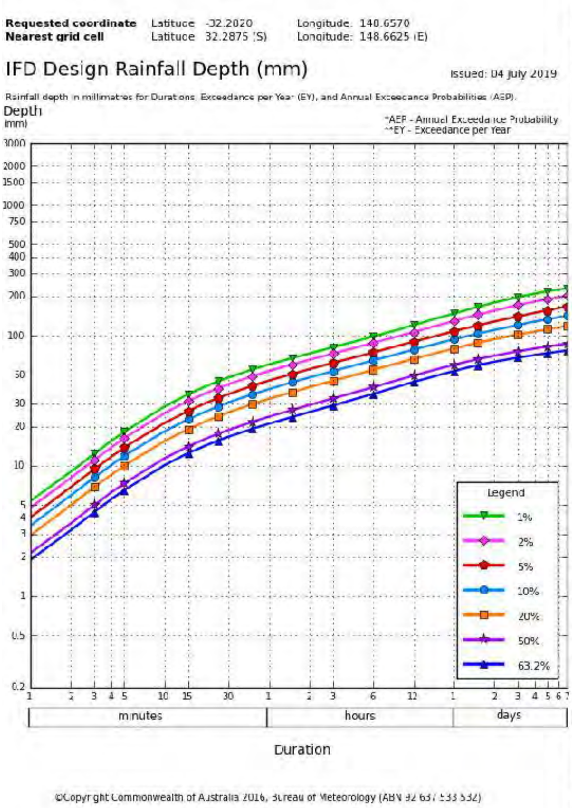
Sub-catchment slopes were determined via methods outlined in the XP-RAFTS user manual, where an 'equal angle slope' was calculated based on a sub-catchment's minimum and maximum elevation and maximum stream length (via interrogation of the 1 m DEM). Lag times for inter-catchment routing were determined using the major flow path length (L) and slope (S) and the formula outlined in the Laurenson's method (lag time = $L / S^{0.5}$).

A global Manning value of 0.04 was implemented which is generally consistent with rural land uses in the catchment (confirmed using relative guidelines including ARR2016, Chow 1959). As discussed in Section 2.1, areas of medium density vegetation are present which have higher Manning values, however application of a lower Manning value leads to conservative flow estimates and is therefore appropriate.

2.2.1.2 Design Rainfall

ARR2016 design rainfall depths for various durations were obtained from the Bureau of Meteorology (BoM). Details are presented in Image 3 and Attachment A.

Image 3: Design rainfall information obtained from the BoM



Duration	Annual Exceedance Probability (AEP)						
	63.2%	50%#	20%*	10%	5%	2%	1%
1 min	1.90	2.14	2.92	3.47	4.02	4.77	5.37
2 min	3.20	3.62	4.98	5.92	6.86	8.07	8.99
3 min	4.42	5.00	6.86	8.15	9.44	11.1	12.4
4 min	5.53	6.24	8.53	10.1	11.7	13.8	15.5
5 min	6.50	7.33	10.0	11.9	13.8	16.3	18.2
10 min	10.1	11.4	15.5	18.4	21.3	25.3	28.5
15 min	12.5	14.1	19.1	22.7	26.3	31.4	35.4
20 min	14.2	16.0	21.8	25.9	30.1	35.8	40.4
25 min	15.6	17.6	23.9	28.5	33.0	39.3	44.4
30 min	16.7	18.8	25.7	30.6	35.5	42.2	47.6
45 min	19.2	21.7	29.7	35.3	41.0	48.7	54.8
1 hour	21.0	23.8	32.6	38.7	45.0	53.3	59.9
1.5 hour	23.7	26.8	36.8	43.8	50.7	60.0	67.2
2 hour	25.8	29.2	40.0	47.5	55.0	65.0	72.7
3 hour	29.0	32.8	44.8	53.2	61.5	72.5	81.1
4.5 hour	32.7	36.9	50.2	59.4	68.6	81.0	90.6
6 hour	35.6	40.1	54.4	64.3	74.1	87.6	98.2
9 hour	40.3	45.2	61.0	71.9	82.8	98.1	110
12 hour	43.9	49.2	66.0	77.8	89.5	106	120
18 hour	49.3	55.1	73.7	86.7	99.7	119	136
24 hour	53.3	59.5	79.4	93.4	108	129	147
30 hour	56.5	62.9	83.9	98.8	114	138	157
36 hour	59.0	65.7	87.7	103	119	144	165
48 hour	62.8	70.0	93.5	110	128	155	179
72 hour	67.7	75.6	102	120	140	171	197
96 hour	70.8	79.3	107	128	149	182	209
120 hour	73.2	82.1	112	133	156	190	218

The recommended ARR2016 ensemble approach to applying temporal patterns has been utilised in the current study. The ensemble approach to flood modelling applies a suite of 10 different temporal patterns for each duration. The temporal patterns were obtained from ARR2016 for the 'Murray-Darling Basin` region and applied using the XP-RAFTS software.

2.2.1.3 Rainfall Losses

An Initial and Continuous Loss (IL / CL) model was implemented with losses obtained from the ARR2016 datahub. The Probability Neutral Burst initial loss was implemented based on recommendations in the OEH Floodplain Risk Management Guide (2019). The losses presented in Table 2 were applied to the model.

Table 2: Initial and Continuous Losses

AEP	IL (mm)	CL (mm/hr)
1%	7	2
10%	11.8	2
20%	13.4	2

A review of neighbouring studies that are available online, was undertaken to validate the applied loss values. Only one study close to Dubbo was found, namely the '*Narromine River Bank Levee Feasibility Study*' (Lyall & Associates, 2013). This study implemented an initial loss of 15 mm and a continuing loss of 2.5 mm/h. These losses were noted to be similar, but slightly higher than that recommended by ARR2016 and implemented in the current study. This finding improves confidence in the applied loss values.

2.2.1.4 Areal Reduction Factor

An Areal Reduction Factor (ARF) was applied to rainfall depths to adjust for the catchment's areal average rainfall intensity. The ARF was determined following the methods outlined in ARR2016 using the XP-RAFTS software.

2.2.2 Hydrologic Model Results

Design flows (Critical Storm Flow) for each AEP at the site are presented in Table 3, along with the critical duration, average ensemble flow and critical storm event.

Table 3: Hydrologic model results

AEP (%)	Critical Duration (hours)	Average Ensemble Flow (m^3/s)	Critical Storm	Critical Storm Flow (m^3/s)
20	9	79.0	Storm 6	83.4
10	6	111.2	Storm 7	111.2
1	3	194.6	Storm 4	200.7

The temporal pattern ensemble results extracted from the XP-RAFTS model are presented in Image 4 to Image 6.

Image 4: XP-RAFTS 1%AEP hydrologic model design flows at the site

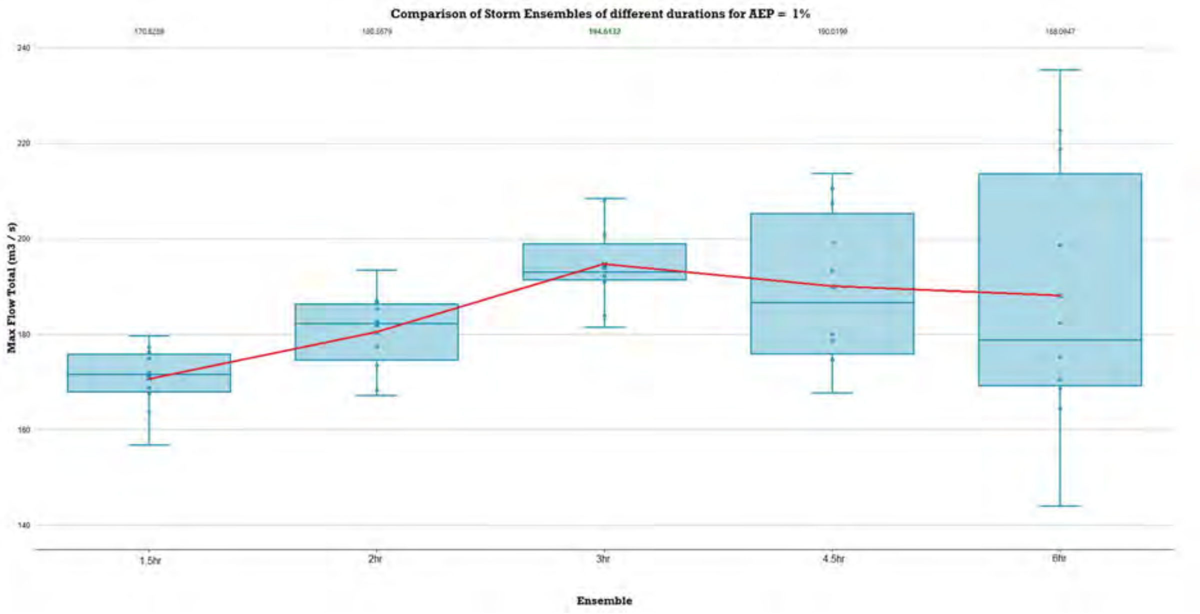


Image 5: XP-RAFTS 10%AEP hydrologic model design flows at the site

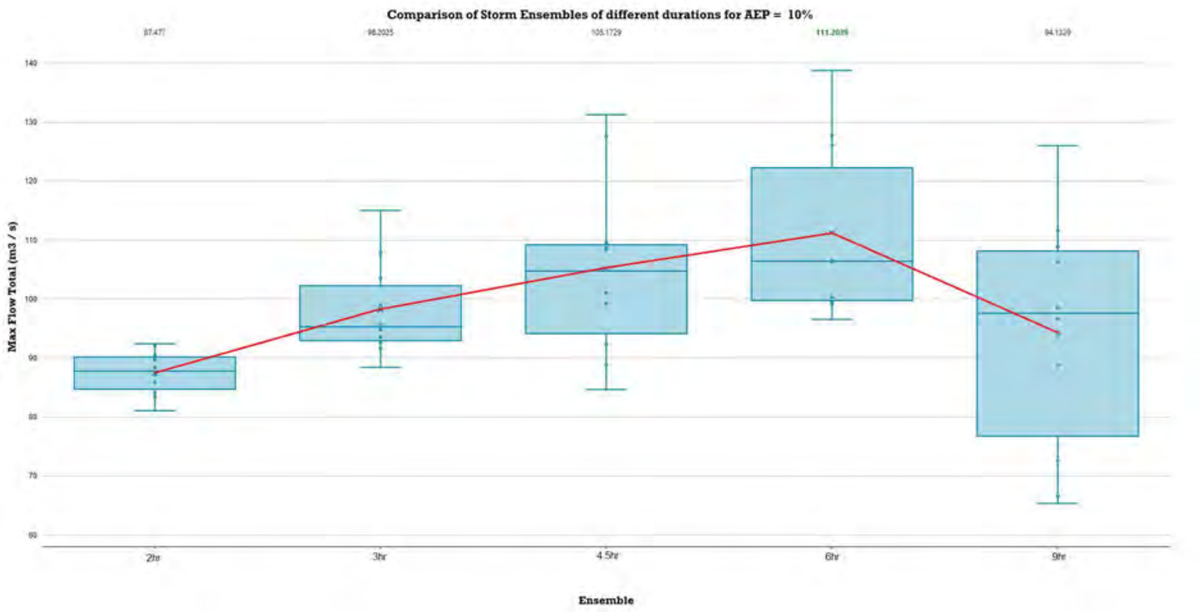
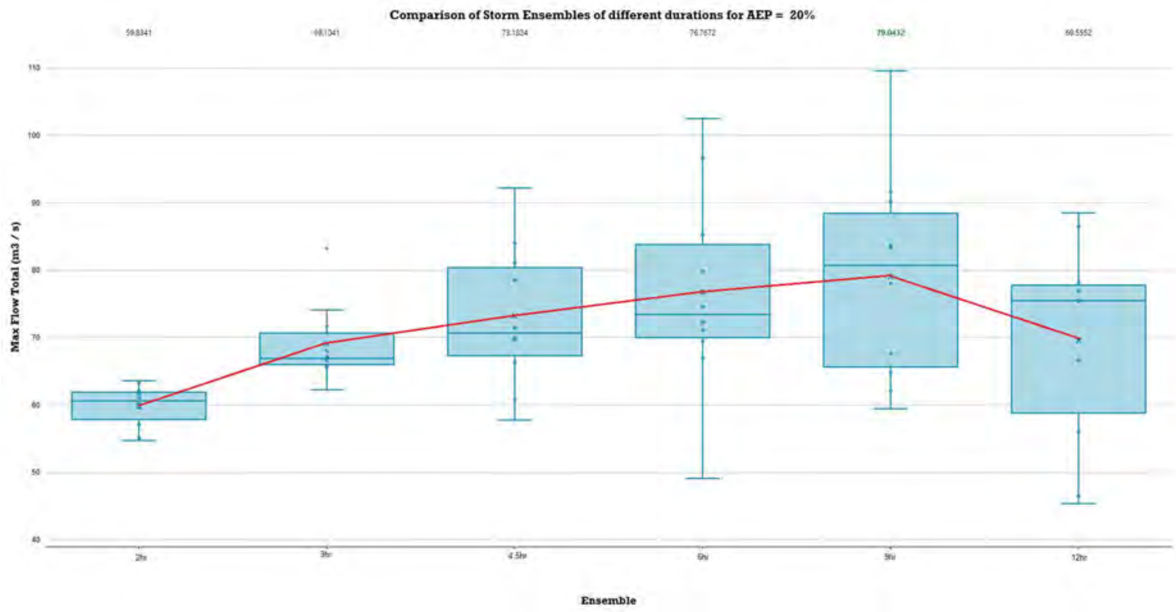


Image 6: XP-RAFTS 20%AEP hydrologic model design flows at the site



2.2.3 Design Flow Validation

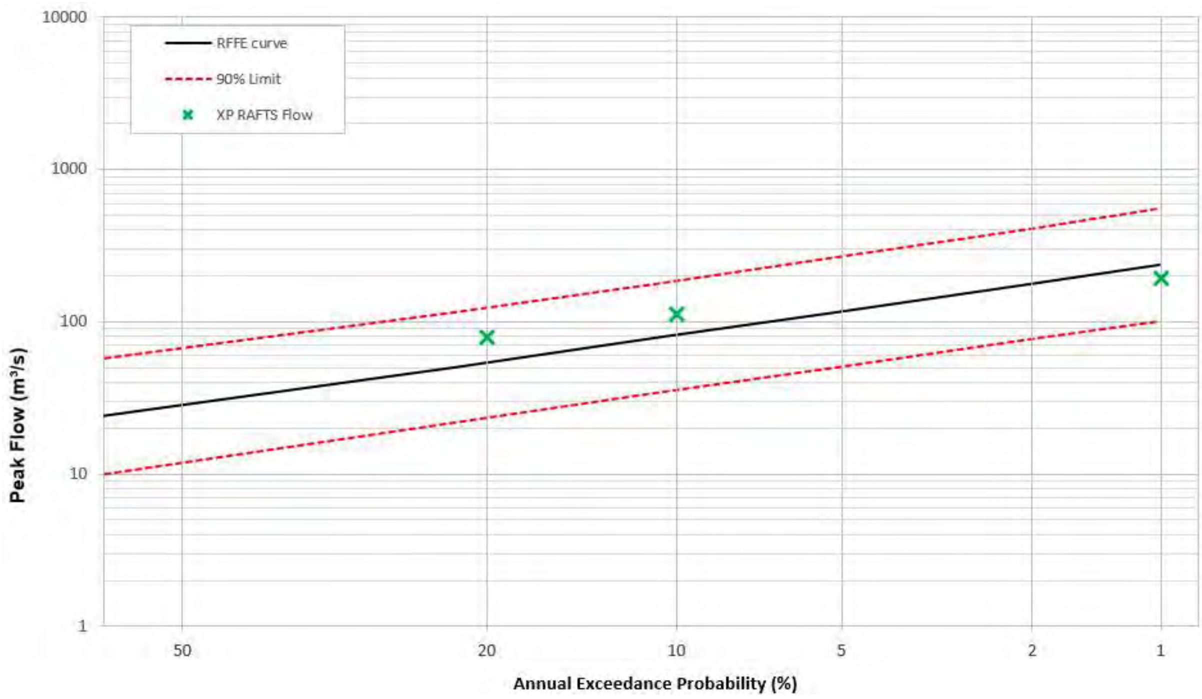
2.2.3.1 Comparison to RFFE

ARR2016 Regional Flood Frequency Estimation (RFFE) design flow estimates were obtained from https://rffe.arr-software.org/. The RFFE model has been developed as part of ARR2016 for the estimation of flows on ungauged small to medium sized rural catchments. The results of the RFFE for the Eulomogo Creek catchment to the site are presented in Attachment C.

It is important to note the ARR2016 states '*that the relative accuracy of regional flood estimates using the RFFE model is likely to be within ± 50% of the true value*' and as such, RFFE design flows estimates should be carefully considered. Accordingly, the 'output_nearby.csv' file was downloaded from the RFFE website and analysed for outliers that have the potential to adversely affect RFFE results. No obvious outliers were noted, providing some confidence in the RFFE model flow estimates for the site.

A comparison of XP-RAFTS flows to RFFE design flow estimates has been made with the results presented in Image 7 on a discharge frequency plot. The analysis indicates that the XP-RAFTS and RFFE design flow estimates are comparable, with the XP-RAFTS flow being higher than RFFE estimates for the 20% and 10% AEP events, and slightly lower than the 1% AEP estimate.

Image 7: Comparison of XP-RAFTS design flows and RFFE flow distribution



2.2.3.2 Comparison to TUFLOW rainfall on grid

A coarse (10m) Rainfall on Grid (RoG) TUFLOW model of the Eulomogo Creek catchment was used to further validate hydrologic model design flow estimates. The critical storms discussed above were applied to the RoG TUFLOW model using the direct rainfall method. Use of the direct rainfall method allowed TUFLOW to calculate catchment routing characteristics to validate the XP-RAFTS model parameters.

Table 4 presents a comparison of XP-RAFTS and RoG TUFLOW model peak flows at the site. The results indicate that the flows are comparable for all three events examined. The results improve the robustness of the XP-RAFTS design flow estimates.

Table 4: Comparison of XP-RAFTS and TUFLOW

AEP	XP RAFTS Peak Flow (m^3/s)	TUFLOW RoG Peak Flow (m^3/s)	Difference (%)
1%	200	234	+17%
10%	111	120	+8%
20%	83	80	-3%

3.HYDRAULICS

3.1 Hydraulic Model Setup

A TUFLOW hydraulic model was developed for the site. TUFLOW is a 1D/2D fully dynamic fixed grid-based model which is widely used throughout NSW and Australia for the assessment of flood hydraulics. The TUFLOW model was developed using best practices modelling methods, and parameters consistent with Australian Rainfall and Runoff.

3.1.1 Existing Conditions

A TUFLOW hydraulic model was constructed to represent existing conditions for the site. Various data and parameters implemented in the existing conditions TUFLOW model are outlined below:

- Model Domain and Grid Size – The hydraulic model domain covers an area of 785ha, extending from Sub-Catchment 11 (see Figure 1, ~600m to the East of the site) to the floodplain of the Macquarie river to west. A model grid size of 2 m x 2 m was implemented, which allowed for a minimum of 15 active cells perpendicular to flow direction. This grid resolution is considered adequate to model Eulomogo Creek channel characteristics.
- Digital Elevation Model (DEM) – The 1 m DEM ('*Dubbo201407-LID1-AHD*' dataset) has been used to inform the topography of the 2D hydraulic model.
- Manning Roughness – Manning values were selected based on inspection of aerial imagery. A Manning value of 0.055 has been applied to the creek and riparian areas, and a Manning of 0.05 to the floodplains and rural areas. This reflects the presence of vegetation along the intermittent water course discussed in Section 2.1. Areas of exposed basalt were assigned a Manning value of 0.03 and a value of 0.02 was assigned to the proposed road surface. The selected Manning values are consistent with previous studies conducted by others ("New Dubbo Bridge – Hydrology and hydraulics working paper – Roads and Maritime Services – February 2019") and ARR2016 guidelines.
- Boundary Conditions – XP-RAFTS flow hydrograph downstream of Sub-Catchment 10 was input as an upstream boundary condition and Sub-Catchment 11 hydrograph was included in the model as internal boundary condition. The downstream model boundary was applied as a static tailwater level. The applied level was the 1% AEP Macquarie River flood level obtained from the '*Dubbo City Council, Flood Prone Land Policy*' (May, 2013). The applied downstream boundary was noted not to influence flood levels at the site due to it being situated 1.5 km downstream, with over 10 m difference in elevation.

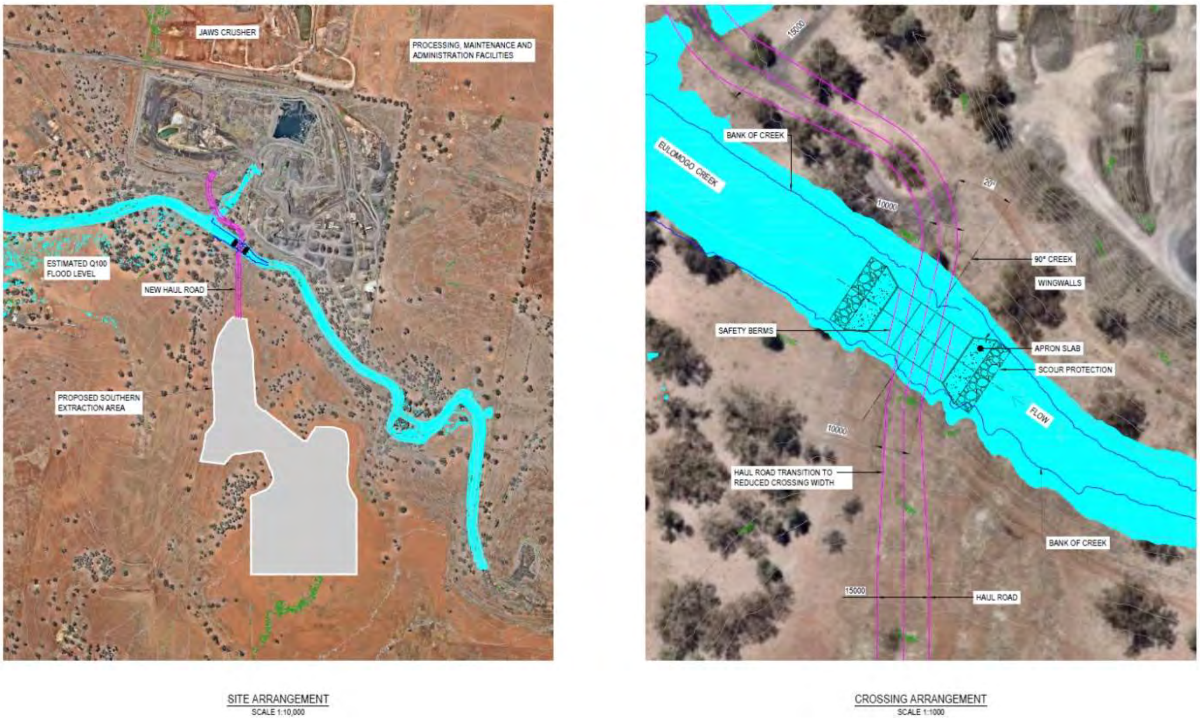
The existing conditions TUFLOW model schematisation is presented in Figure 2.

3.1.2 Proposed Conditions

The proposed Eulomogo Creek crossing concept design was implemented into the existing conditions TUFLOW model to develop a proposed conditions model. Proposed sediment basins were also assessed. The concept design was provided by EMM and was based on concept designs proposed in the *'Dubbo Quarry Continuation Project, Eulomogo Creek – Concept Options Report (Pitt & Sherry, May 2020)'*. A summary of the model changes are outlined below:

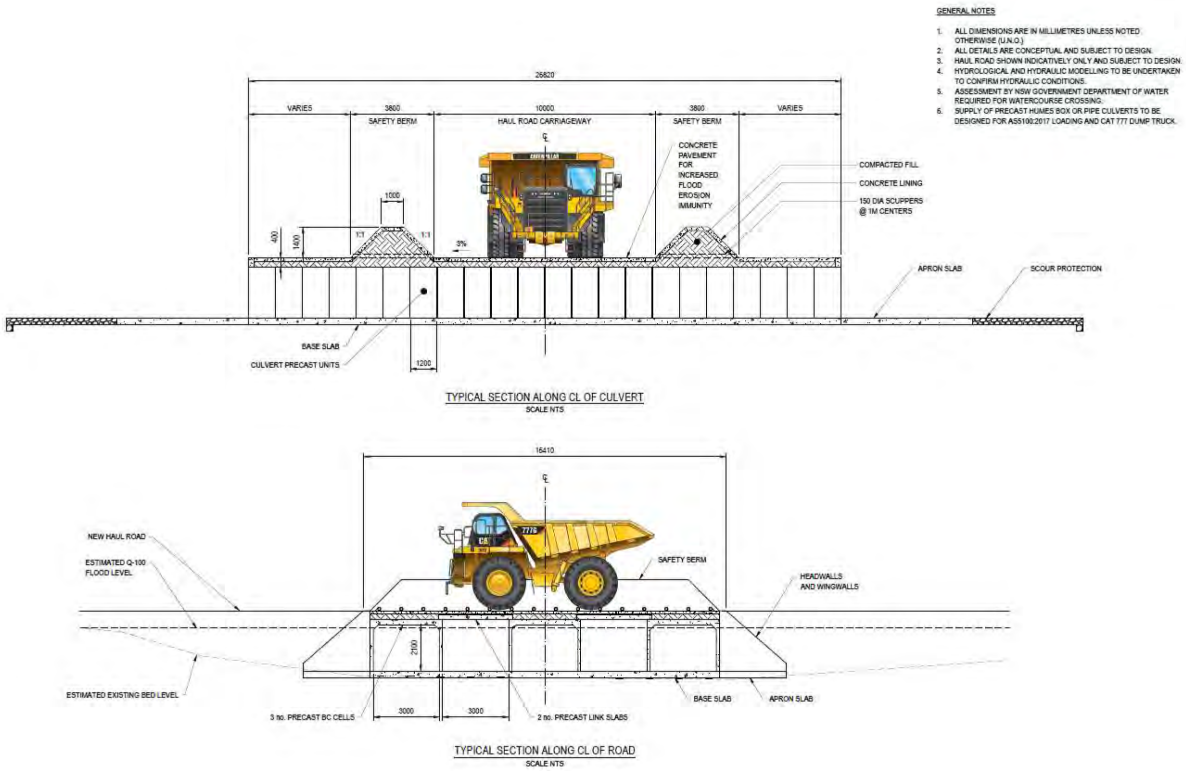
- Road Embankment – The Eulomogo Creek crossing road embankment was implemented into the model as per the alignment presented in the Pitt & Sherry (2020) report. The road alignment is presented in Image 8 and was set at a level of 280.40mAHD. The road feature includes two 1.4m height safety berms in accordance with Pitt & Sherry (2020) design drawings. The berms are not meant for flood protection (i.e. are not constructed with flood resistant materials) but do represent an obstruction to the flow and as such were included into the model.

Image 8: Eulomogo Creek Crossing Road Alignment (extract from Pitt & Sherry, 2020 report)



- Culverts – 5 x 3m x 2.1m concrete box culverts were included in the model to convey flow through the proposed road embankment as per the concept design presented in the Pitt & Sherry (2020) report (reproduced below in Image 9). Blockage was applied as per ARR2019 guidelines, with details presented in Attachment D. Culverts invert levels were set at the thalweg of the creek, upstream and downstream the road. Grading of the creek bed will be required to accommodate the structure.

Image 9: Eulomogo Creek Crossing Road Sections (extract from Pitt & Sherry, 2020 report)



The proposed conditions TUFLOW model schematisation for the concept crossing is presented in Figures 6.

3.2 Hydraulic Model Results

3.2.1 Existing Conditions

Existing conditions design flood depths and levels for the 1%, 10% and 20% AEP event are presented in Figure 3, 4 and 5 respectively.

Typical stream velocities are 3.5 m/s for the 1% AEP event, 3.0m/s for the 10% AEP event and 2.5m/s for the 20%AEP. Localised areas of higher velocities are noted.

Channel and floodplain cross sections have been extracted at three locations as presented in Image 10. These cross sections, presented in Image 11 to Image 13, aim to assist in visualising channel characteristics near the proposed creek crossing.

Image 10: Channel Cross Section and Flood Level – Location Map

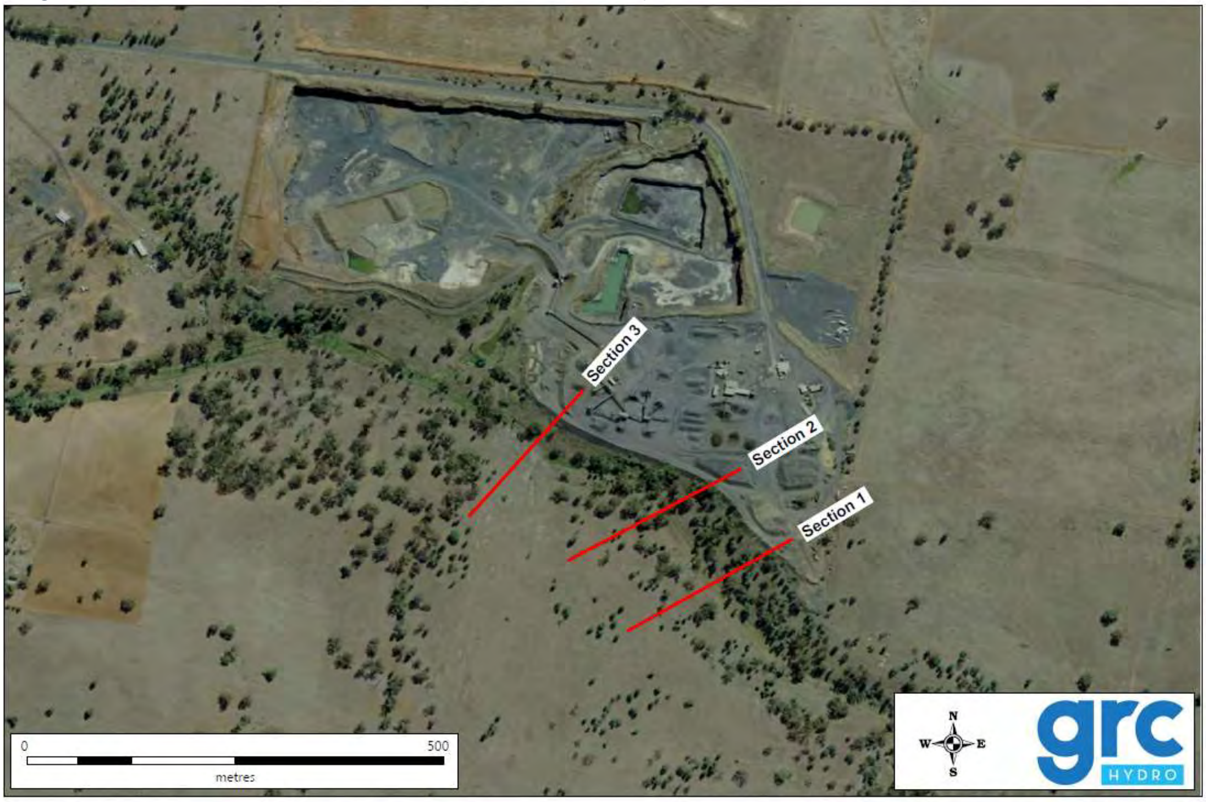


Image 11: Channel Cross Section #1 – Ground Elevation and Flood Levels (mAHD)

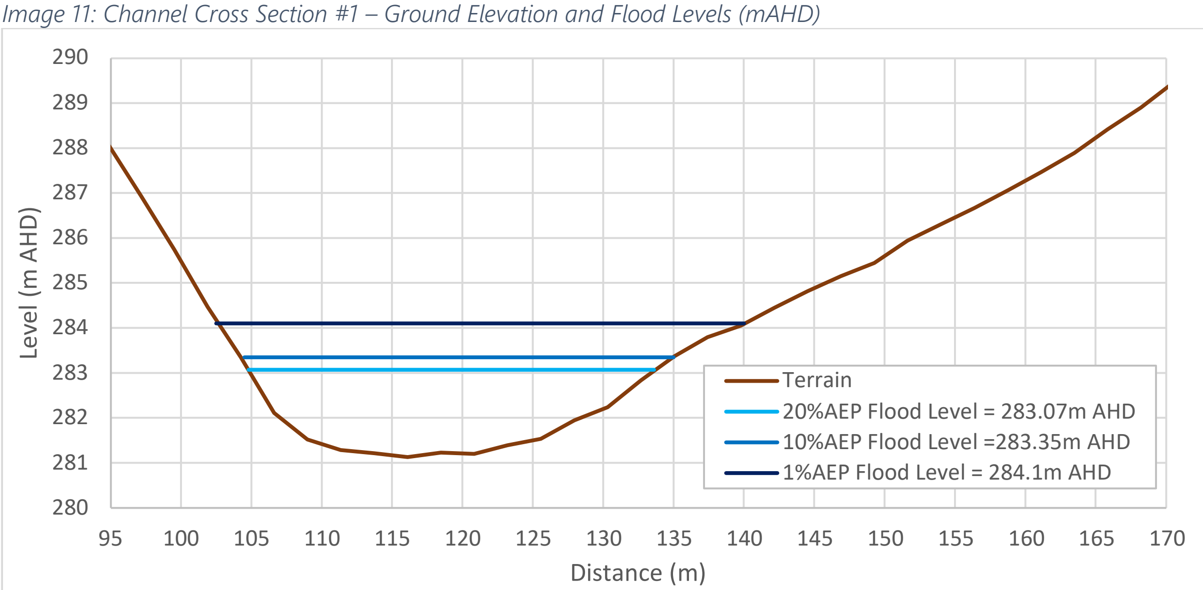


Image 12: Channel Cross Section #2 – Ground Elevation and Flood Levels (mAHD)

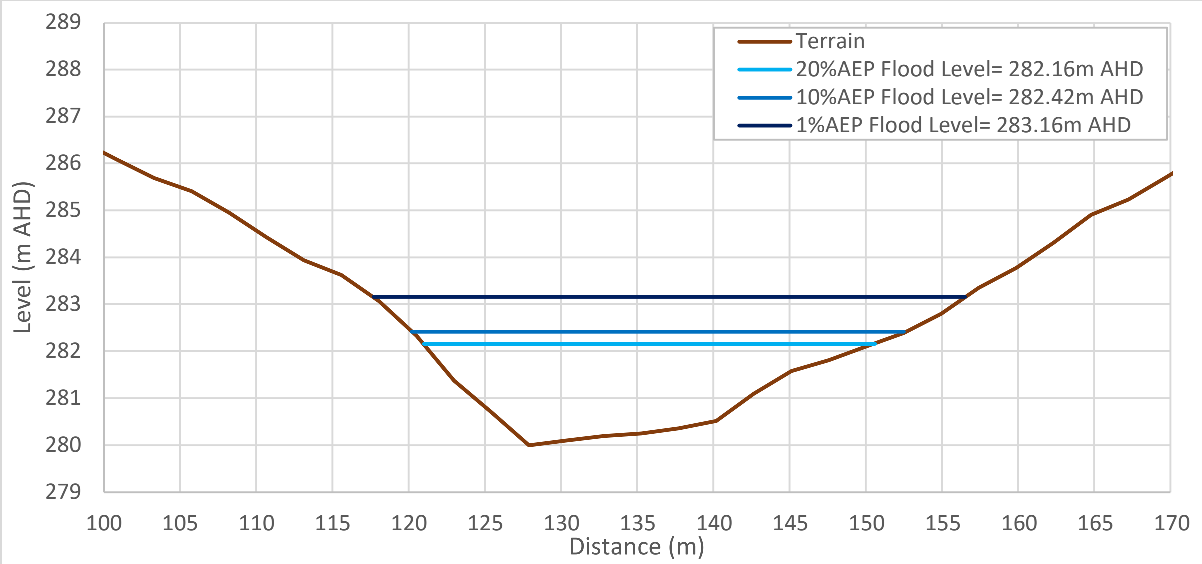
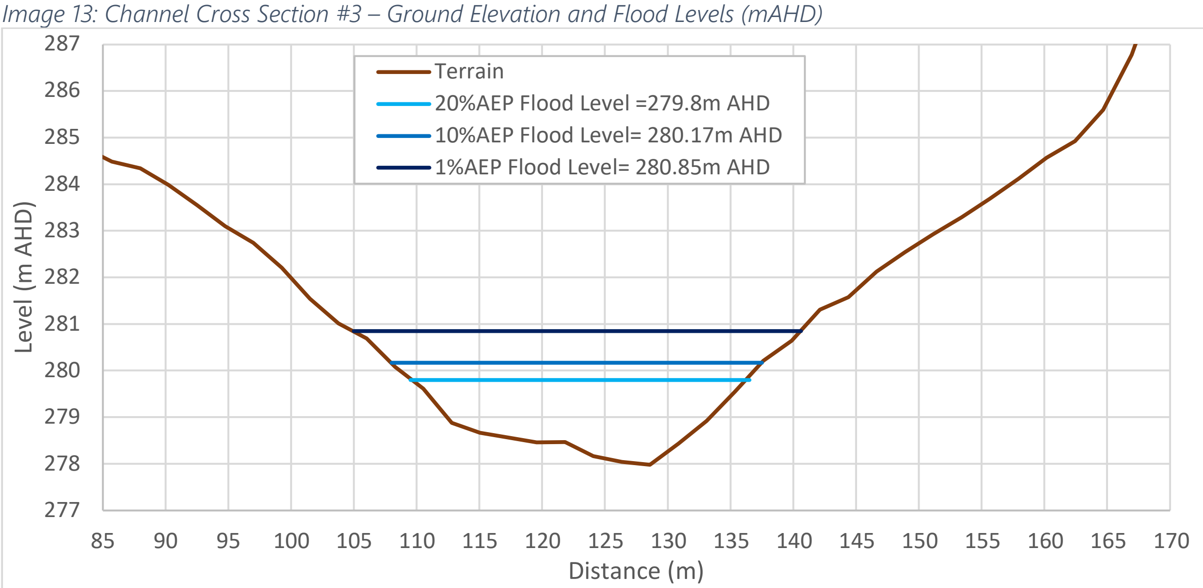


Image 13: Channel Cross Section #3 – Ground Elevation and Flood Levels (mAHD)



3.2.2 Proposed Conditions

Proposed Conditions design flood depths and levels for the 1%, 10% and 20% AEP event are presented in Figures 7, 8 and 9 respectively. A long section of the proposed creek crossing with design flood levels is presented in Image 14.

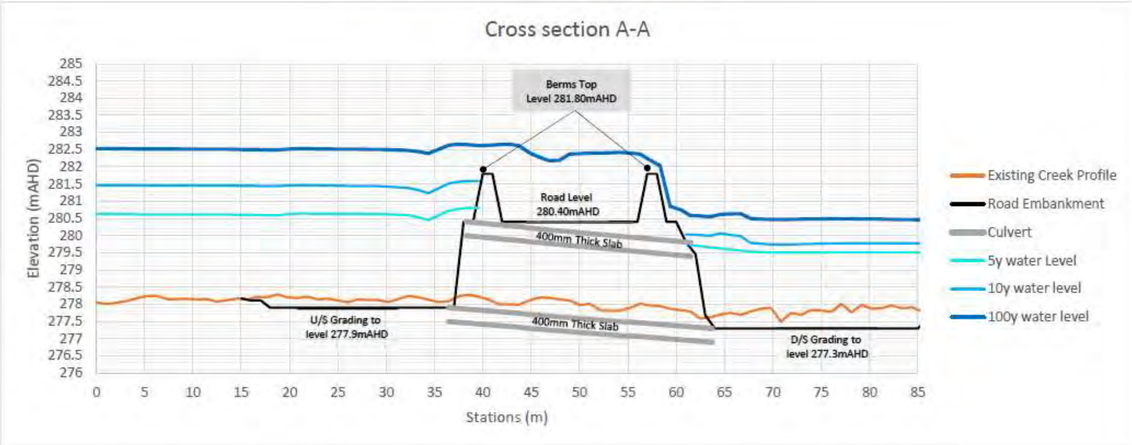
Expected average velocities through the culvert barrels are 4.3 m/s for the 1% AEP event and 3.6 m/s for the 10% AEP event and 20% AEP events.

Flood levels are expected to overtop the proposed road crossing as frequently as the 20% AEP event (assuming that the safety berms do not provide flood protection). However, Holcim have advised that alternate road access is available to the site which can be used during periods of flood if required for emergency access.

Image 14: Eulomogo Creek Crossing Long Section and Flood Levels

CULVERT DATA	
TYPE	CONCRETE BOX CULVERT
NUMBER OF CELLS	5
CELL WIDTH (m)	3
CELL HEIGHT (m)	2.1
Length (m)	~30
U/S I.L (m)	277.9
D/S I.L. (m)	277.3
SLOPE	2.00%

HYDRAULIC DATA	
5-Year Total Flow (m^3/s)	83.58
5-Year Flow in the Culverts (m^3/s)	83.58
5-Year Average Velocity in Culverts (m/s)	3.62
10-Year Total Flow (m^3/s)	111.5
10-Year Flow in the Culverts (m^3/s)	111.5
10-Year Average Velocity in Culverts (m/s)	3.63
100-Year Total Flow (m^3/s)	201.3
100-Year Flow in the Culverts (m^3/s)	115.6
100-Year Average Velocity in Culverts (m^3/s)	4.32



Flooding of the creek crossing may pose a risk to vehicles attempting to use the crossing during times of flood. Appropriate warning signage and operating protocols should be implemented to manage this risk.

3.2.3 Flood Impact Assessment

A flood impact assessment has been undertaken by comparing existing and proposed conditions peak flood levels. Figures 10, 11 and 12 show the expected change in flood level associated with implementation of the proposed creek crossing.

Increases in flood level of up to 3 m are expected in the 1% AEP event, with impact reducing for more frequent events (maximum of 2.2m in the 10% AEP event and 1.7m in the 20%AEP event). However, the increases in water level are contained within the Quarry site (i.e. do not affect neighbouring properties) and do not extend more than ~300m upstream of the crossing.

4. CONCLUSIONS

Holcim's Dubbo Quarry is located approximately 6 km south-east of the Dubbo town centre and to the north of Eulomogo Creek. Holcim are proposing to expand the quarry's existing operations to the southern side of Eulomogo Creek. To facilitate the expansion, a haul road crossing is proposed to connect the southern and northern sides of Eulomogo Creek.

GRC Hydro has been appointed to undertake a flood study for the Site and to assess flood impacts associated with the proposed Eulomogo Creek crossing concept design.

Hydrologic modelling has been undertaken using XP-RAFTS, with design flows derived for the site for the 1%, 10% and 20% AEP events. Validation of the derived design flow estimates has been undertaken via comparison to ARR2016 Regional Flood Frequency Estimates (RFFE) and results from a coarse direct rainfall TUFLOW model developed for the upstream catchment. The validation results were found to improve the robustness of the XP-RAFTS design flow estimates.

A TUFLOW hydraulic model was constructed for the site on a 2 m grid resolution. Upstream and internal boundary conditions were applied based on outputs from the XP-RAFTS model, and the Macquarie River 1% AEP flood level was applied as a static tailwater level at the downstream boundary. Applied Manning values were consistent with nearby studies and ARR2016 guidelines.

Following feedback and discussion with Holcim, the Eulomogo Creek crossing concept design was developed by Pitt & Sherry (2020) and incorporated into the flood model as proposed conditions scenario.

Flood maps for the 1%, 10% and 20% AEP events were produced which present peak flood depths and levels for both existing and proposed conditions.

Flood levels are expected to overtop the proposed road crossing during the 20% AEP and greater magnitude events. However, Holcim have advised that alternate road access is available to the site which can be used during periods of flood if required for emergency access. Flooding of the creek crossing may pose a risk to vehicles attempting to use the crossing during times of flood and appropriate warning signage and operating protocols should be implemented to manage this risk.

Comparison of peak flood levels between the existing and proposed conditions show a water level increase up to 3 meters in the 1% AEP event, however flood impacts are confined to land owned by Holcim.

FIGURES

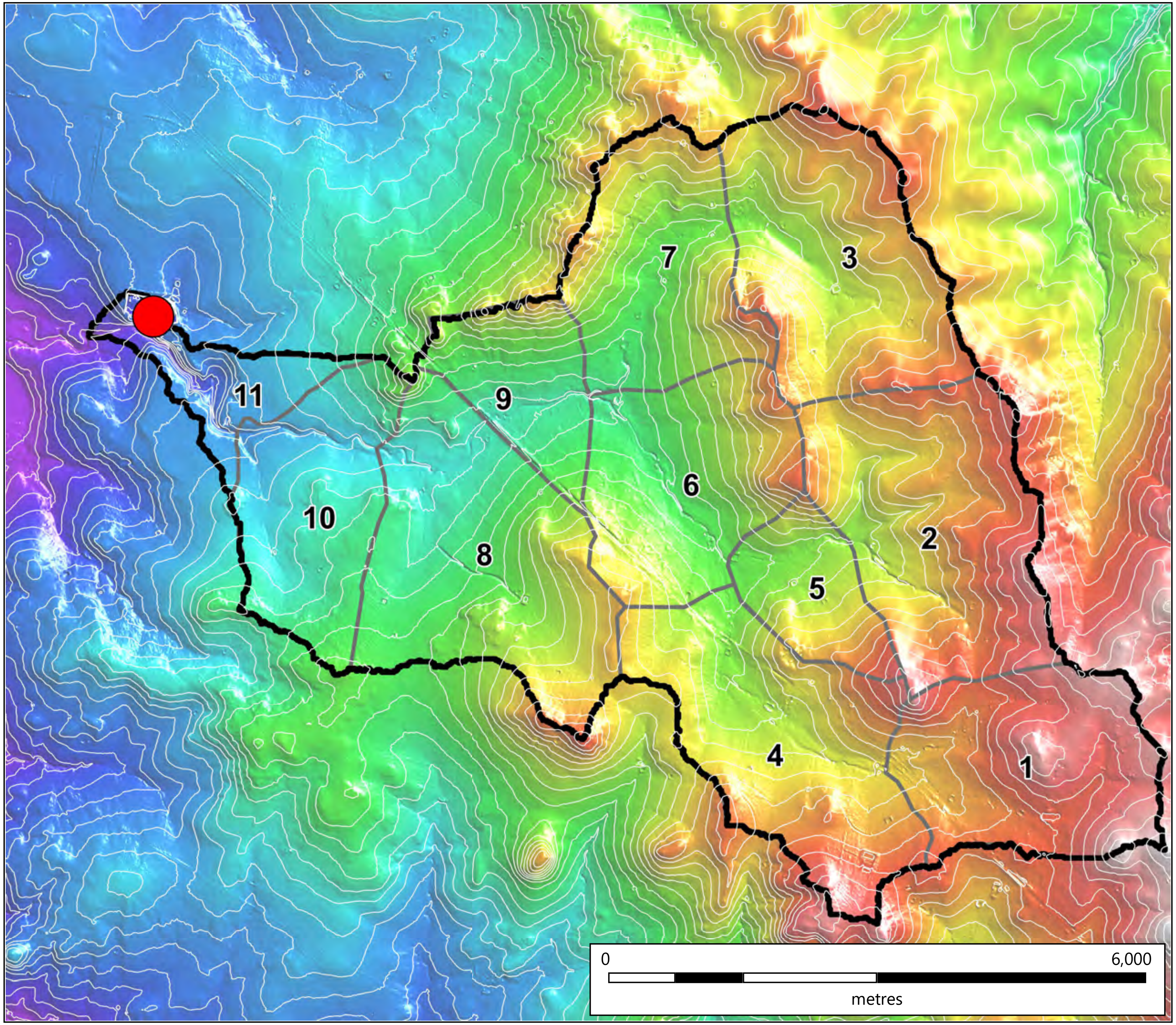


FIGURE NUMBER:	1
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	190036
SCENARIO:	
EVENT:	
TITLE: **GROUND LEVELS AND CATCHMENT AREA**	

Ground Levels (m AHD)

250 to 270
270 to 280
280 to 290
290 to 310
310 to 320
320 to 330
330 to 340
340 to 350
350 to 360
360 to 370
370 to 380
380 to 390
390 to 400
400 to 410
410 to 420

Project Location

Ground Level Contour Lines (5m Spacing)

2 Sub-Catchment Areas

N W E S

grc HYDRO

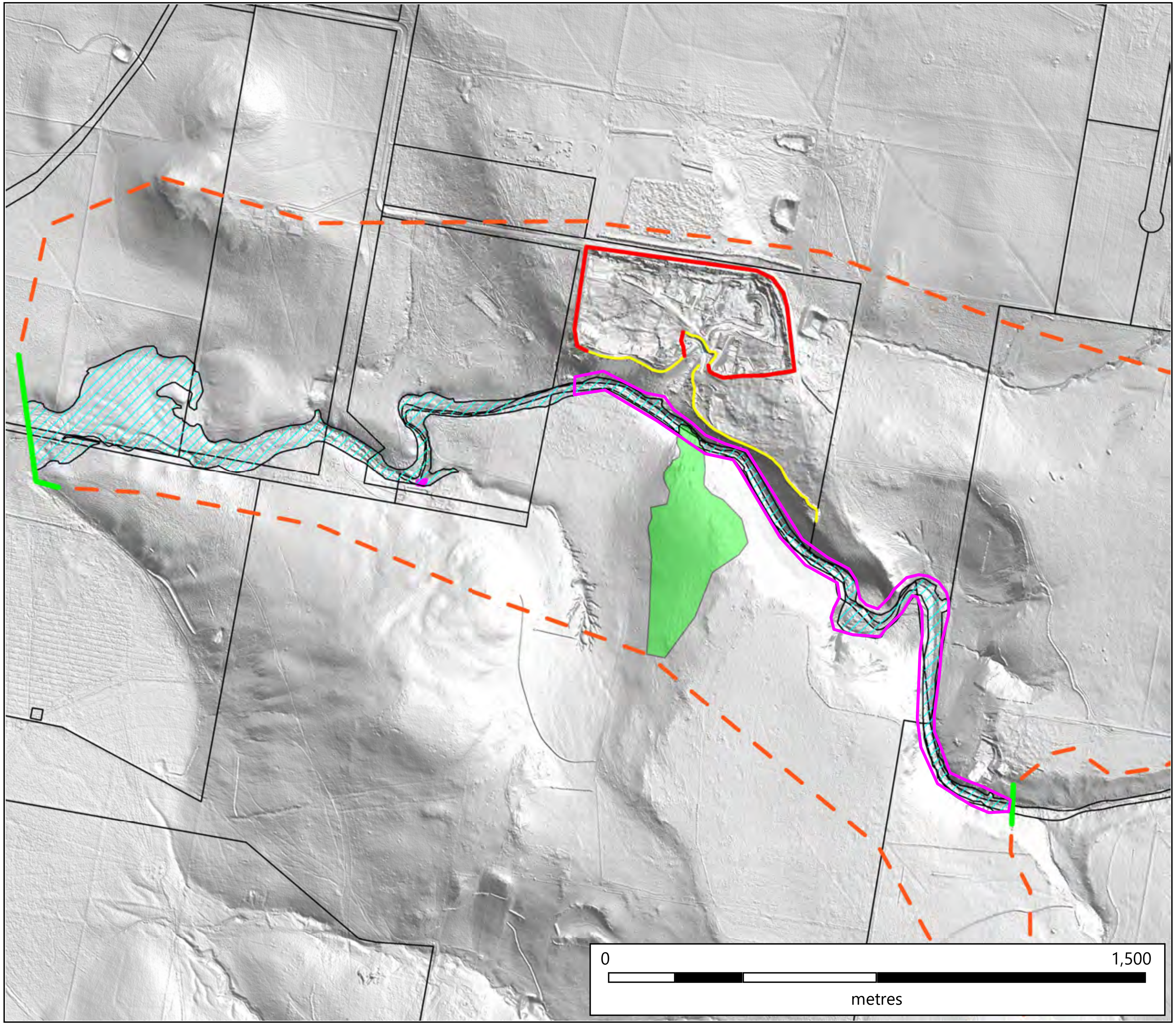


FIGURE NUMBER:	2
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**EXISTING CONDITIONS**
EVENT:	

TITLE: **2D HYDRAULIC MODEL SETUP**

- Dubbo Quarry - Existing Area
- 2D Model Extent
- Upstream and Downstream Boundary Conditions
- Internal Boundary Conditions (Storage Areas)
- Creek Area (Manning = 0.055)
- Exposed Layer of Basalt (Manning = 0.03)
- Breaklines
- Cadastral Boundaries

N W E S

grc HYDRO

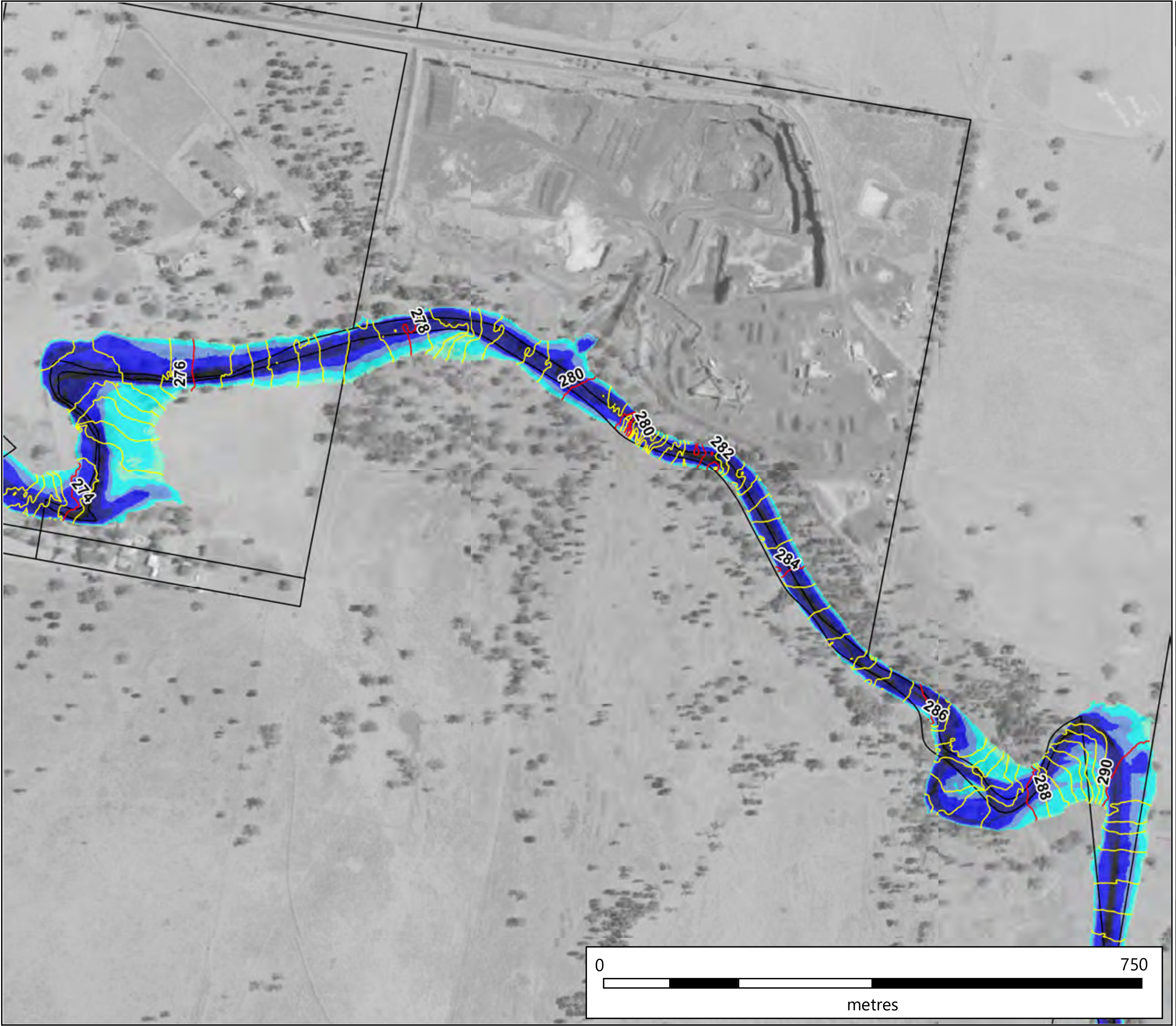


FIGURE NUMBER:	3
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	190036
SCENARIO:	**EXISTING CONDITIONS**
EVENT:	**1% AEP**
TITLE:	**FLOOD DEPTH AND LEVELS**

Flood Depth (m)

- < 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- > 3.0

Major Flood Level Contours (2.0m Spacing)

Minor Flood Level Contours (0.25m Spacing)

Cadastral Boundaries

N W E S

grc HYDRO

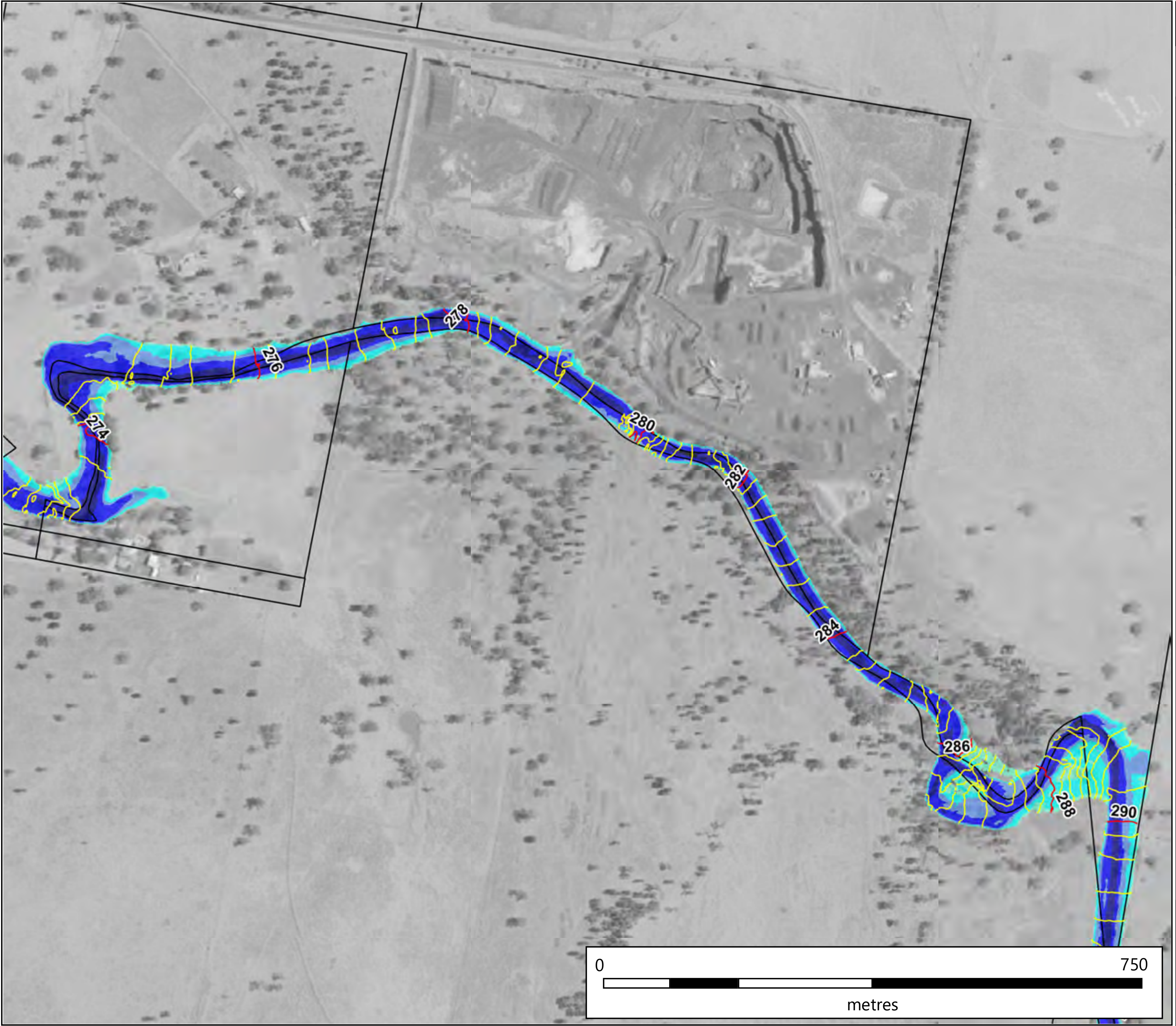


FIGURE NUMBER:	4
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**EXISTING CONDITIONS**
EVENT:	**10% AEP**
TITLE:	**FLOOD DEPTH AND LEVELS**

Flood Depth (m)

- < 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- > 3.0

Major Flood Level Contours (2.0m Spacing)

Minor Flood Level Contours (0.25m Spacing)

Cadastral Boundaries

N W E S

grc HYDRO

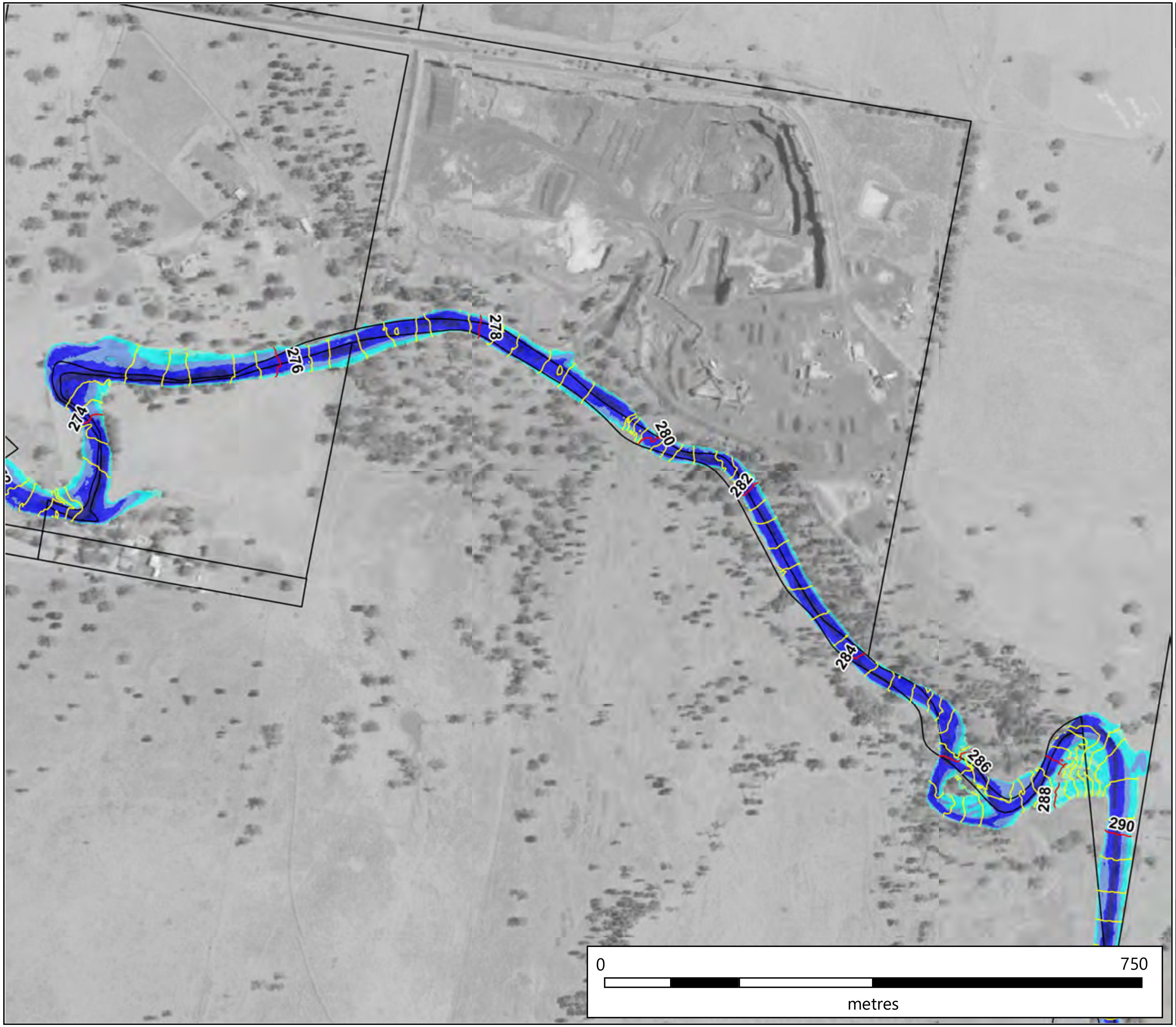


FIGURE NUMBER:	5
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**EXISTING CONDITIONS**
EVENT:	**20% AEP**
TITLE: **FLOOD DEPTH AND LEVELS**	

Flood Depth (m)
- < 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- > 3.0

Major Flood Level Contours (2.0m Spacing)

Minor Flood Level Contours (0.25m Spacing)

Cadastral Boundaries

N W E S

grc HYDRO

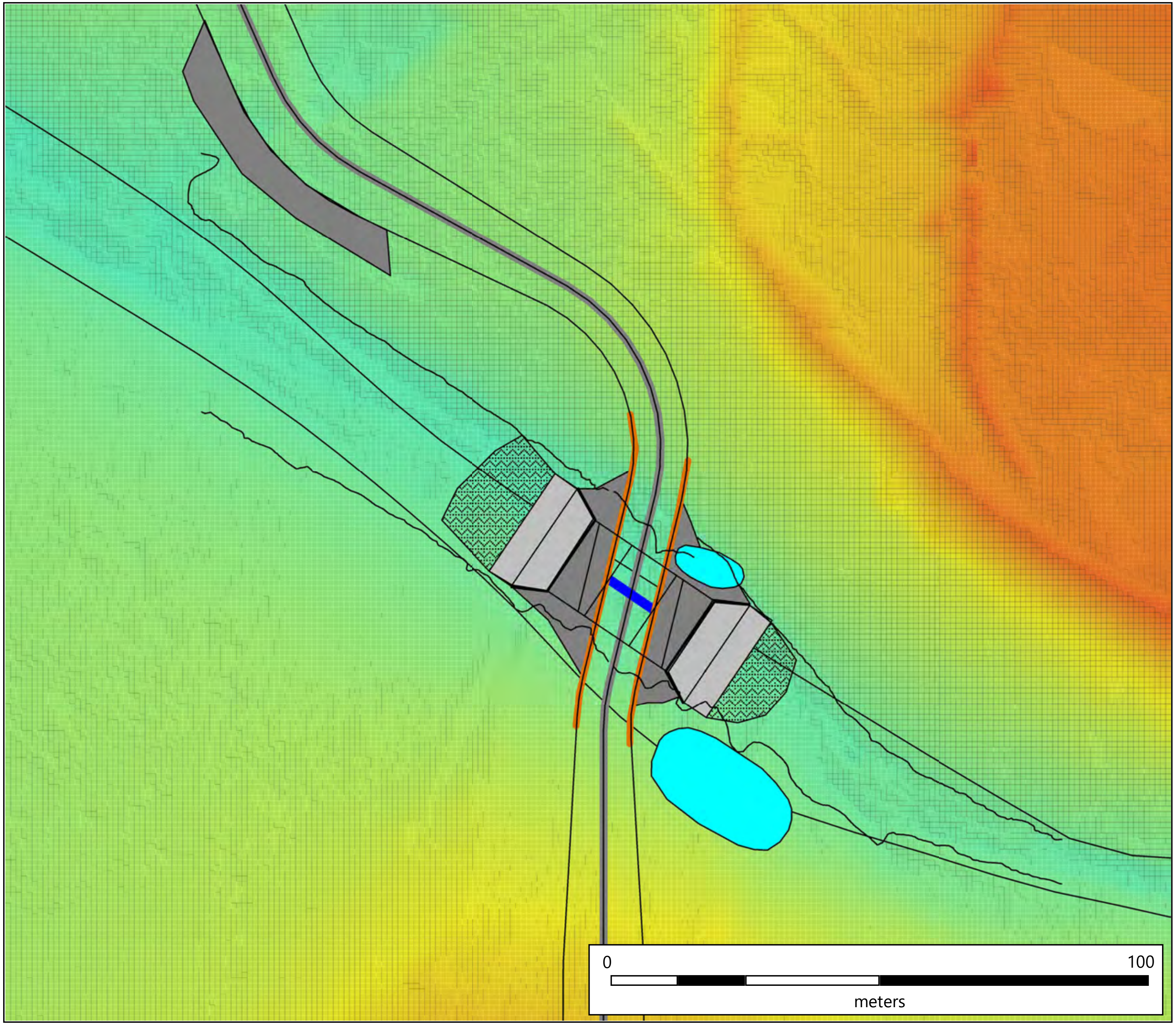


FIGURE NUMBER:	6
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	
TITLE: **2D HYDRAULIC MODEL SETUP**	

- Proposed Road
- Road Embankment
- Culvert Base Slab
- Grading
- Culvert Barrels Centreline
- Berm
- Sediment basin

grc HYDRO

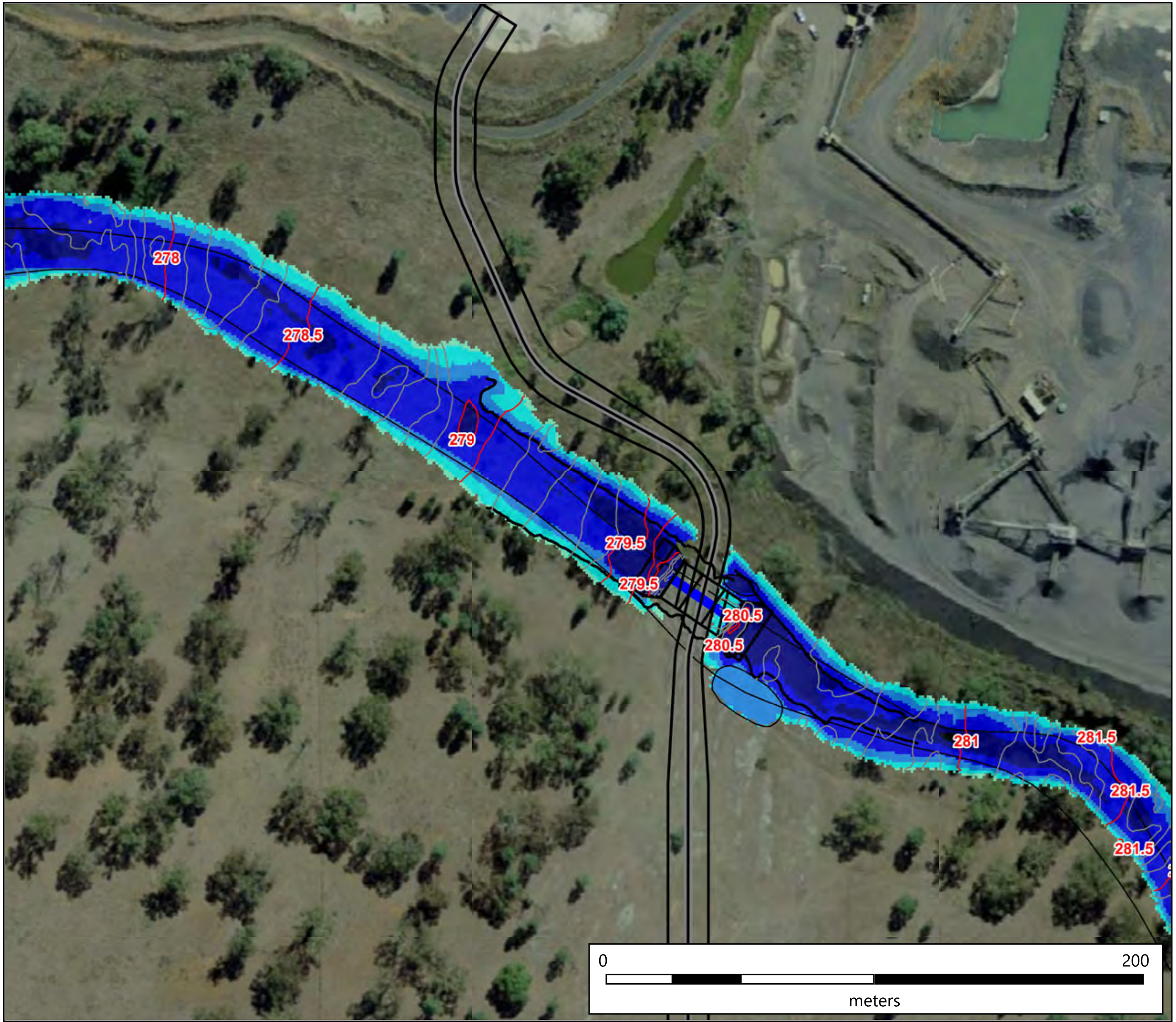


FIGURE NUMBER:	7
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	**20% AEP**

TITLE: **FLOOD DEPTH AND LEVELS**

Proposed Road

Culvert Barrels Centreline

Flood depth (m)

- < 0.1
- 0.1 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3.0

Major Flood Level Contour (0.5m Spacing)

Minor Flood Level Contour (0.1m Spacing)

N W E S

grc HYDRO

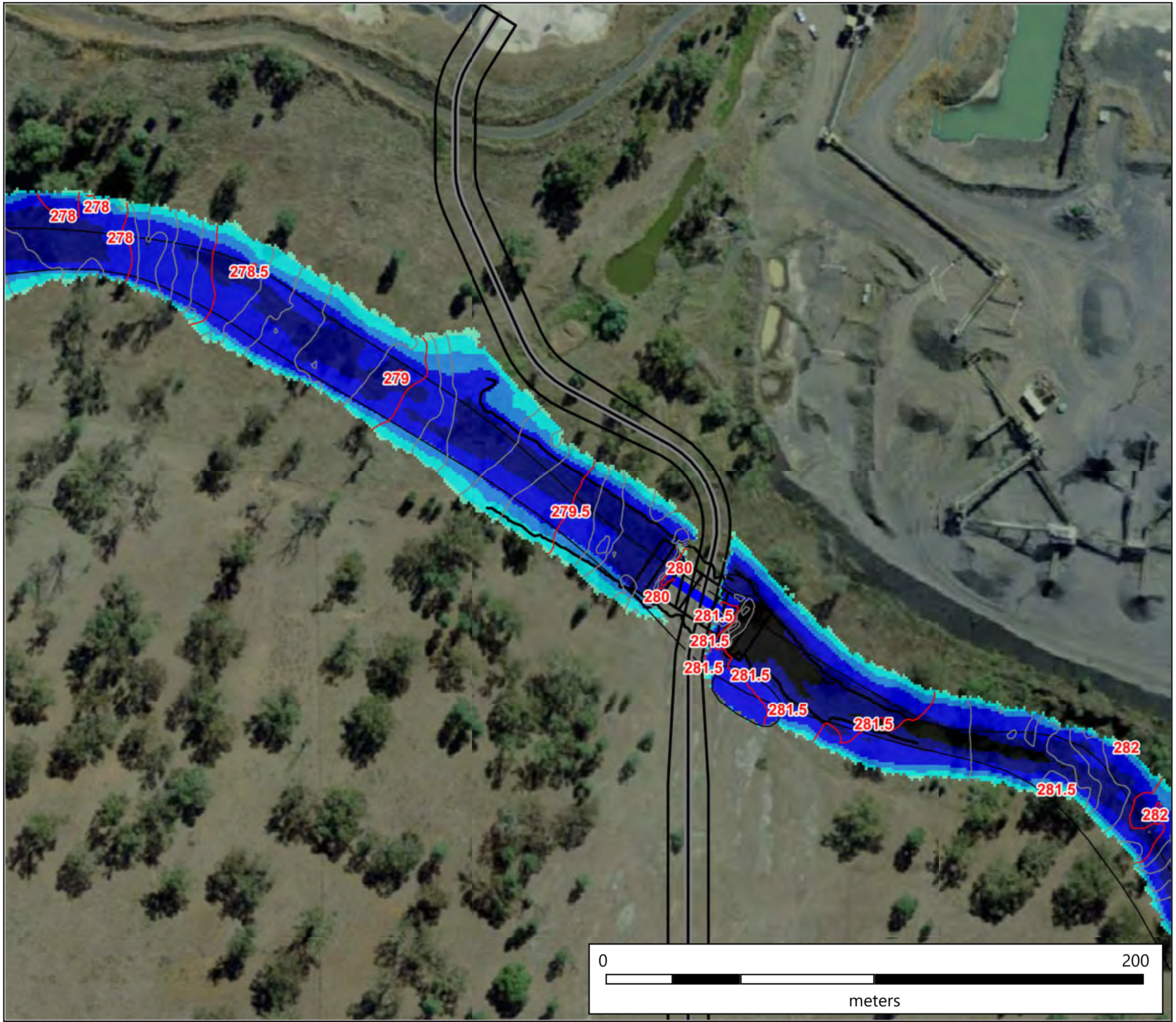


FIGURE NUMBER:	8
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	**10% AEP**
TITLE: **FLOOD DEPTH AND LEVELS**	

Proposed Road

Culvert Barrels Centreline

Flood depth (m)

< 0.1

0.1 to 0.5

0.5 to 1

1 to 2

2 to 3

> 3.0

Major Flood Level Contour (0.5m Spacing)

Minor Flood Level Contour (0.1m Spacing)

N W E S

HYDRO

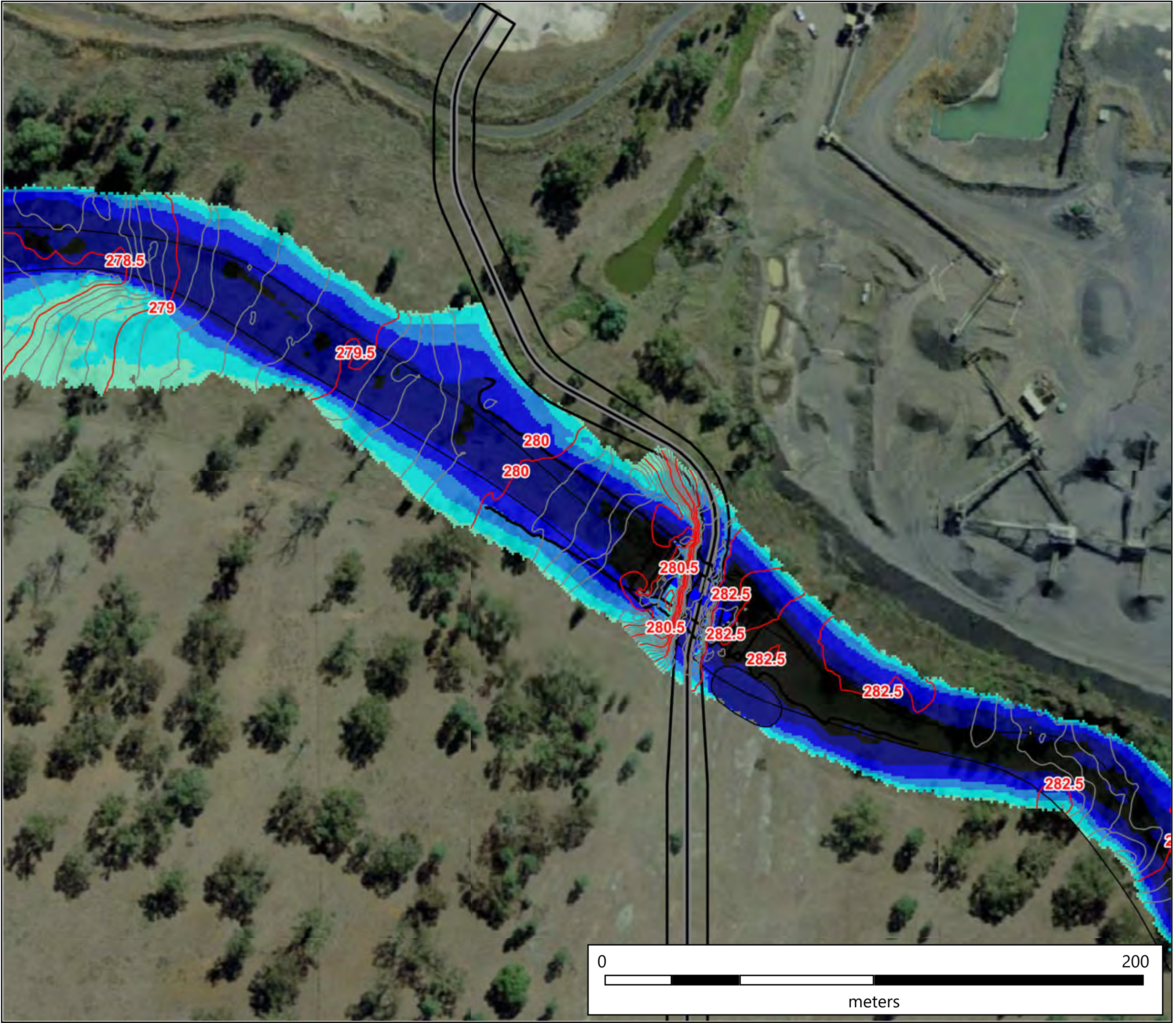


FIGURE NUMBER:	**9**
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	**1% AEP**
TITLE: **FLOOD DEPTH AND LEVELS**	

Proposed Road

Culvert Barrels Centreline

Flood depth (m)

- < 0.1
- 0.1 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3.0

Major Flood Level Contour (0.5m Spacing)

Minor Flood Level Contour (0.1m Spacing)

grc HYDRO

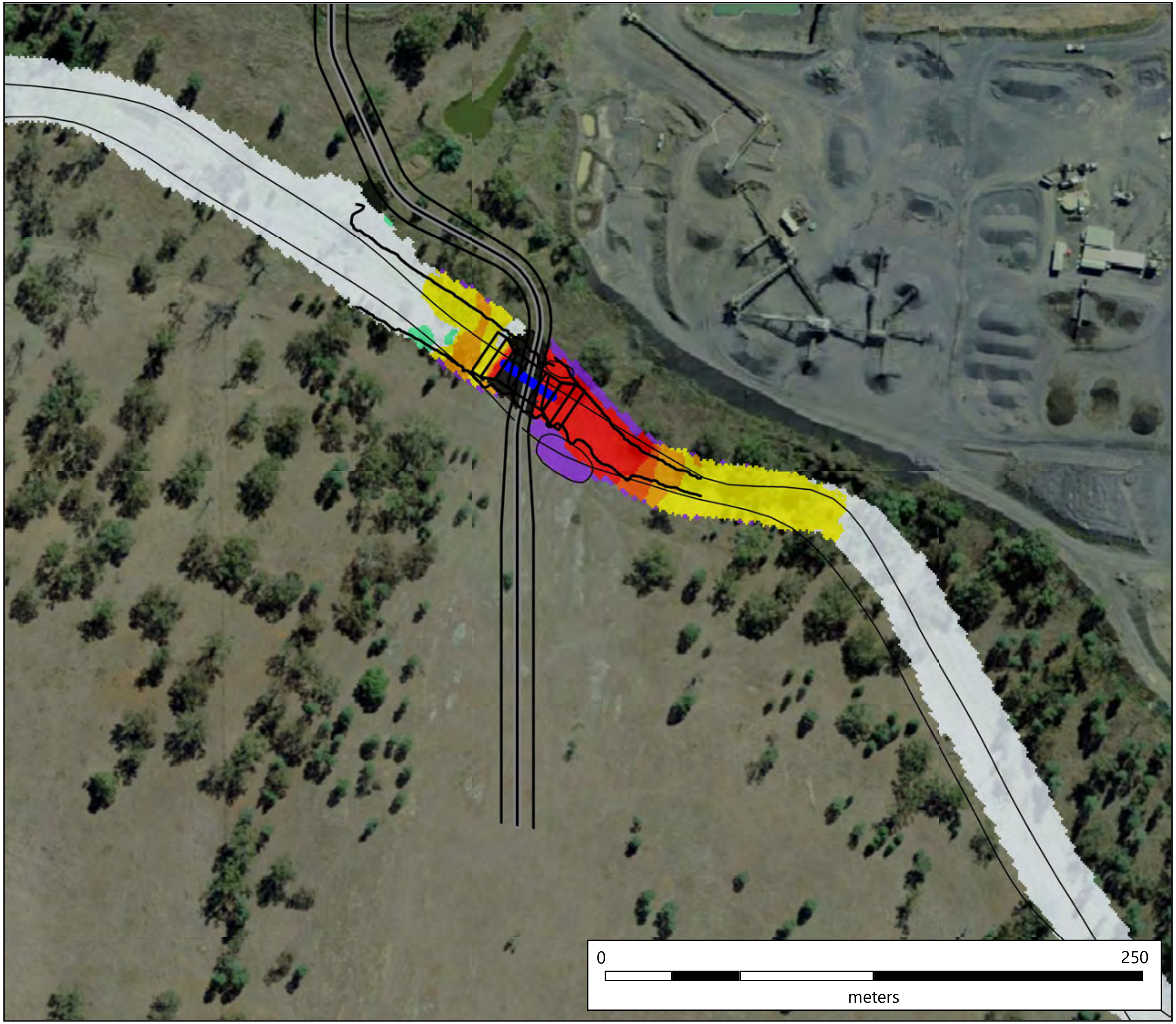


FIGURE NUMBER:	**10**
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	**20% AEP**
TITLE: **FLOOD IMPACT**	

Proposed Road

Culvert Barrels Centreline

Change In Flood Level (m)

- No Impact
- 0.01 to 0.5
- 0.5 to 1
- 1 to 2
- >2.0

- No Longer Flooded
- Newly Flooded

N W E S

grc HYDRO

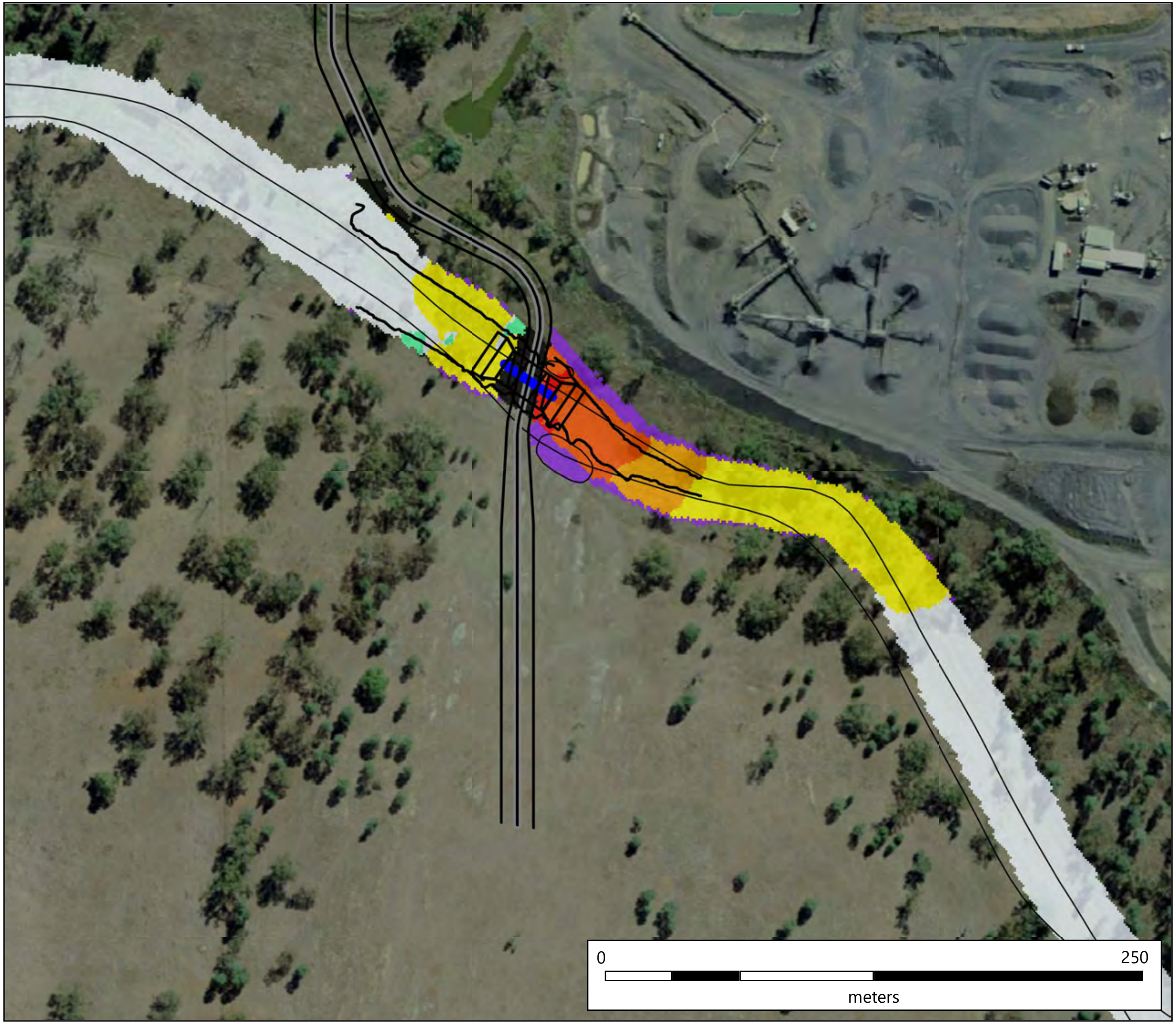


FIGURE NUMBER:	**11**
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	**10% AEP**
TITLE: **FLOOD IMPACT**	

Proposed Road

Culvert Barrels Centreline

Change In Flood Level (m)

No Impact

0.01 to 0.5

0.5 to 1

1 to 2

>2.0

No Longer Flooded

Newly Flooded

N W E S

grc HYDRO

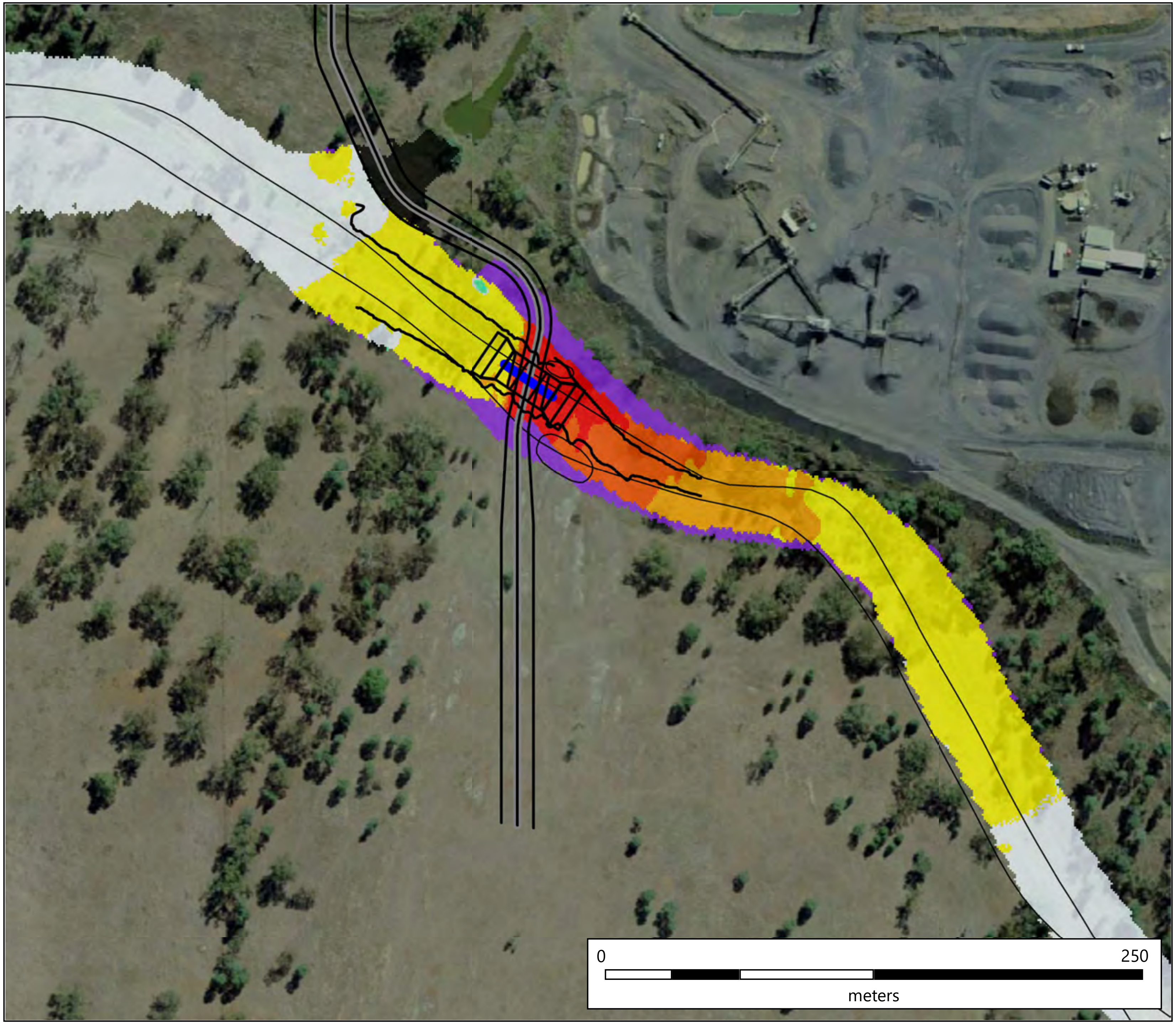


FIGURE NUMBER:	12
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	190036
SCENARIO:	PROPOSED CONDITIONS
EVENT:	1% AEP
TITLE: **FLOOD IMPACT**	

Proposed Road

Culvert Barrels Centreline

Change In Flood Level (m)

No Impact

0.01 to 0.5

0.5 to 1

1 to 2

>2.0

No Longer Flooded

Newly Flooded

grc HYDRO

FIGURE NUMBER:	13
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	**20% AEP**
TITLE:	**VELOCITY IMPACT**

Change in Peak Velocity (m/s)

- < -3
- -3 to -2
- -2 to -1
- -1 to -0.2
- No Impact
- 0.2 to 1
- 1 to 2
- 2 to 3
- > 3

N W E S

grc HYDRO

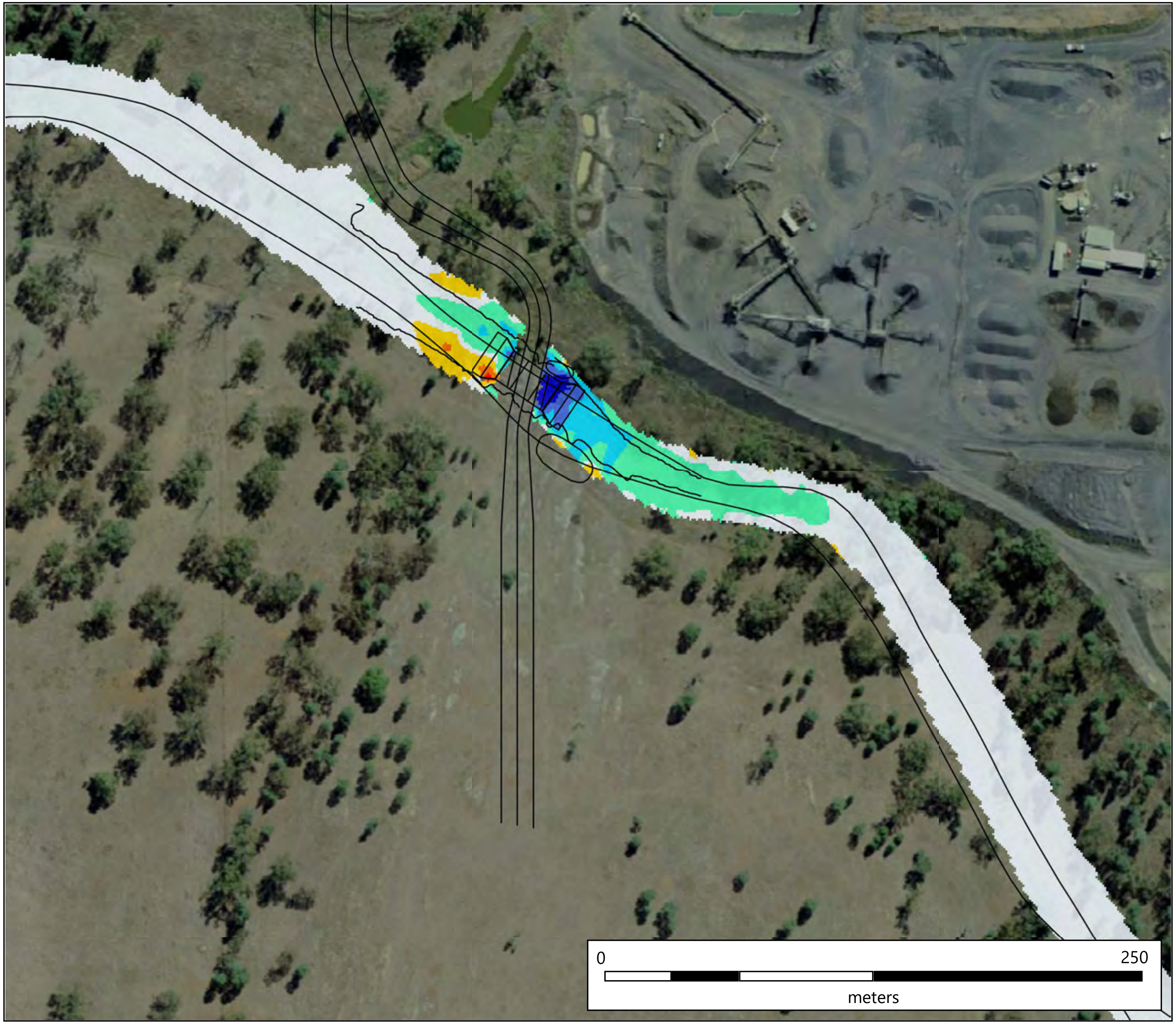


FIGURE NUMBER:	14
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	**10% AEP**
TITLE **VELOCITY IMPACT**	

Change in Peak Velocity (m/s)

- < -3
- -3 to -2
- -2 to -1
- -1 to -0.2
- No Impact
- 0.2 to 1
- 1 to 2
- 2 to 3
- > 3

N
W E
S

HYDRO

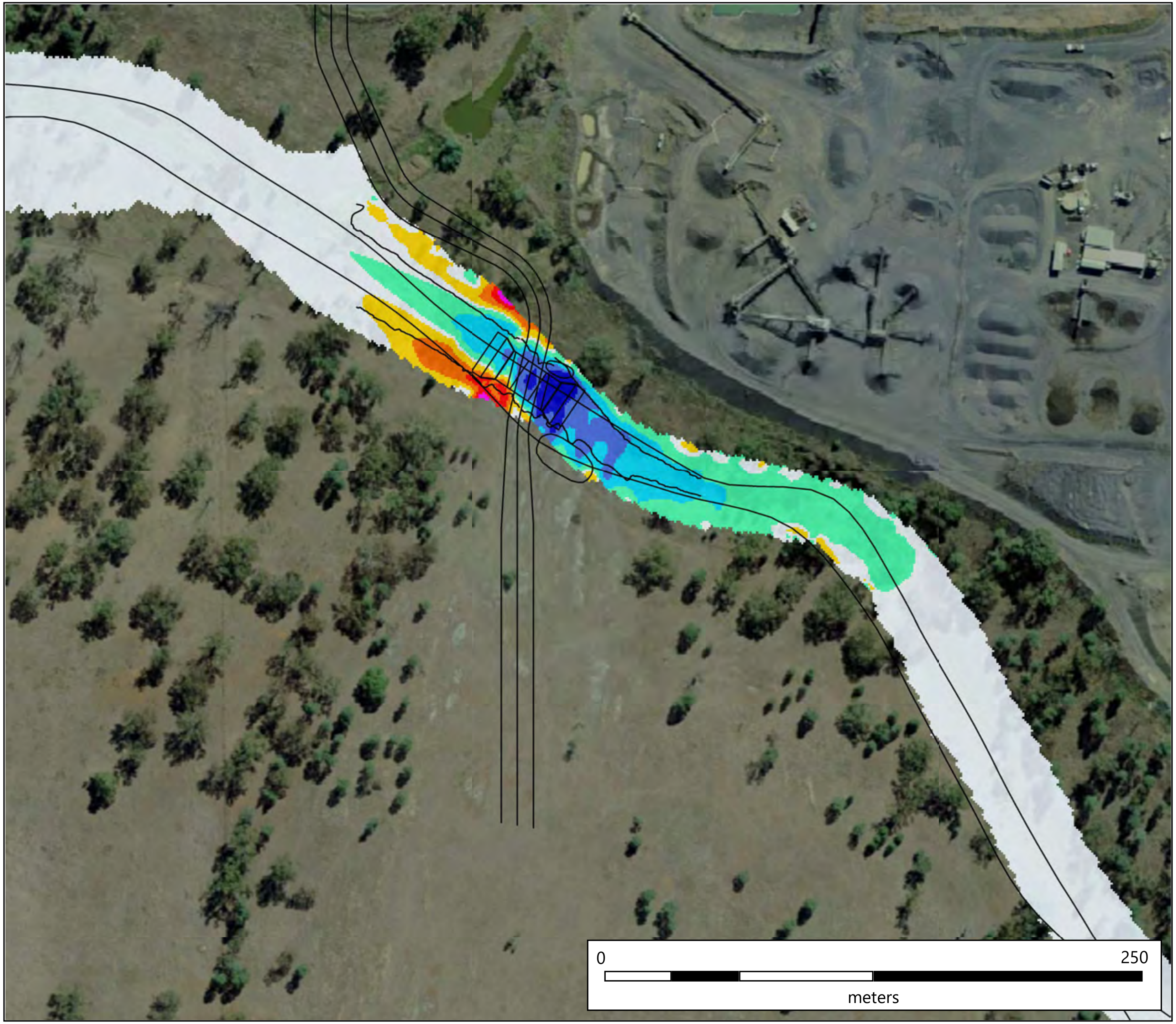


FIGURE NUMBER:	**15**
PROJECT: **DUBBO QUARRY - FLOOD STUDY**	
PROJECT NUMBER:	**190036**
SCENARIO:	**PROPOSED CONDITIONS**
EVENT:	**1% AEP**
TITLE	**VELOCITY IMPACT**

Change in Peak Velocity (m/s)

- < -3
- -3 to -2
- -2 to -1
- -1 to -0.2
- No Impact
- 0.2 to 1
- 1 to 2
- 2 to 3
- > 3

N W E S

grc HYDRO

ATTACHMENT A – IDF DESIGN RAINFALL DEPTHS

Australian Government
Bureau of Meteorology

Location

Label: Not provided

Latitude: -32.282 [Nearest grid cell: 32.2875 (S)]

Longitude: 148.657 [Nearest grid cell: 148.6625 (E)]

IFD Design Rainfall Depth (mm)

Issued: 04 July 2019

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	1.90	2.14	2.92	3.47	4.02	4.77	5.37
2 min	3.20	3.62	4.98	5.92	6.86	8.07	8.99
3 min	4.42	5.00	6.86	8.15	9.44	11.1	12.4
4 min	5.53	6.24	8.53	10.1	11.7	13.8	15.5
5 min	6.50	7.33	10.0	11.9	13.8	16.3	18.2
10 min	10.1	11.4	15.5	18.4	21.3	25.3	28.5
15 min	12.5	14.1	19.1	22.7	26.3	31.4	35.4
20 min	14.2	16.0	21.8	25.9	30.1	35.8	40.4
25 min	15.6	17.6	23.9	28.5	33.0	39.3	44.4
30 min	16.7	18.8	25.7	30.6	35.5	42.2	47.6
45 min	19.2	21.7	29.7	35.3	41.0	48.7	54.8
1 hour	21.0	23.8	32.6	38.7	45.0	53.3	59.9
1.5 hour	23.7	26.8	36.8	43.8	50.7	60.0	67.2
2 hour	25.8	29.2	40.0	47.5	55.0	65.0	72.7
3 hour	29.0	32.8	44.8	53.2	61.5	72.5	81.1
4.5 hour	32.7	36.9	50.2	59.4	68.6	81.0	90.6
6 hour	35.6	40.1	54.4	64.3	74.1	87.6	98.2
9 hour	40.3	45.2	61.0	71.9	82.8	98.1	110
12 hour	43.9	49.2	66.0	77.8	89.5	106	120
18 hour	49.3	55.1	73.7	86.7	99.7	119	136
24 hour	53.3	59.5	79.4	93.4	108	129	147
30 hour	56.5	62.9	83.9	98.8	114	138	157
36 hour	59.0	65.7	87.7	103	119	144	165
48 hour	62.8	70.0	93.5	110	128	155	179
72 hour	67.7	75.6	102	120	140	171	197
96 hour	70.8	79.3	107	128	149	182	209
120 hour	73.2	82.1	112	133	156	190	218

144 hour	75.1	84.4	115	138	162	196	225
168 hour	76.8	86.5	119	142	167	202	230

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

This page was created at **16:26 on Thursday 04 July 2019 (AEST)**

ATTACHMENT B – ARR DATA HUB RESULTS

ATTENTION: This site was updated recently, changing some of the functionality. Please see the changelog (./changelog) for further information

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	148.657
Latitude	-32.282
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show
Baseflow Factors	show

Data

River Region

Division	Murray-Darling Basin
River Number	22
River Name	Macquarie-Bogan Rivers

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^b - c\log_{10}Duration\right)Duration^{-d} + eArea^f Duration^g\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
Central NSW	0.265	0.241	0.505	0.321	0.00056	0.414	-0.021	0.015	-0.00033

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^2}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	5634.0
Storm Initial Losses (mm)	33.0
Storm Continuing Losses (mm/h)	2.0

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/CS.zip)

code	CS
Label	Central Slopes

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_CS.zip)

code	CS
arealabel	Central Slopes

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-32.282&longitude=148.657&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	04 July 2019 04:11PM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	1.4 (0.060)	1.1 (0.034)	0.9 (0.024)	0.7 (0.016)	0.6 (0.011)	0.5 (0.008)
90 (1.5)	0.7 (0.027)	1.1 (0.029)	1.3 (0.029)	1.5 (0.029)	1.0 (0.016)	0.6 (0.009)
120 (2.0)	0.9 (0.032)	1.0 (0.026)	1.1 (0.023)	1.2 (0.021)	1.5 (0.023)	1.7 (0.024)
180 (3.0)	1.2 (0.038)	1.1 (0.025)	1.0 (0.020)	1.0 (0.016)	1.1 (0.016)	1.3 (0.015)
360 (6.0)	1.0 (0.026)	2.3 (0.043)	3.2 (0.049)	4.0 (0.054)	7.9 (0.090)	10.8 (0.110)
720 (12.0)	0.0 (0.000)	2.6 (0.040)	4.4 (0.056)	6.1 (0.068)	9.3 (0.088)	11.8 (0.098)
1080 (18.0)	0.0 (0.000)	0.7 (0.009)	1.1 (0.013)	1.5 (0.015)	4.6 (0.038)	6.9 (0.051)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.1 (0.001)	0.1 (0.001)	3.2 (0.025)	5.6 (0.038)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.4 (0.003)	0.7 (0.004)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.1 (0.001)	0.1 (0.001)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	14.2 (0.599)	10.3 (0.316)	7.7 (0.198)	5.2 (0.115)	9.5 (0.178)	12.7 (0.213)
90 (1.5)	12.7 (0.472)	13.6 (0.370)	14.2 (0.325)	14.8 (0.292)	16.7 (0.279)	18.2 (0.270)
120 (2.0)	15.5 (0.533)	16.7 (0.417)	17.4 (0.367)	18.1 (0.330)	20.9 (0.321)	22.9 (0.315)
180 (3.0)	13.8 (0.421)	15.2 (0.340)	16.2 (0.304)	17.1 (0.278)	21.8 (0.300)	25.3 (0.312)
360 (6.0)	13.0 (0.323)	21.4 (0.393)	26.9 (0.418)	32.2 (0.435)	40.5 (0.462)	46.7 (0.476)
720 (12.0)	8.1 (0.165)	16.5 (0.250)	22.0 (0.283)	27.4 (0.306)	41.9 (0.394)	52.8 (0.440)
1080 (18.0)	4.3 (0.079)	9.6 (0.130)	13.0 (0.150)	16.4 (0.164)	26.5 (0.222)	34.0 (0.251)
1440 (24.0)	0.5 (0.009)	4.8 (0.060)	7.6 (0.081)	10.3 (0.096)	18.1 (0.140)	24.0 (0.163)
2160 (36.0)	0.0 (0.000)	2.4 (0.028)	4.0 (0.039)	5.6 (0.047)	9.4 (0.065)	12.3 (0.075)
2880 (48.0)	0.0 (0.000)	1.2 (0.012)	1.9 (0.017)	2.6 (0.021)	7.4 (0.048)	11.0 (0.062)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.4 (0.008)	2.4 (0.012)

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	35.8 (1.509)	28.4 (0.873)	23.5 (0.607)	18.8 (0.418)	35.9 (0.673)	48.7 (0.813)
90 (1.5)	33.7 (1.257)	45.0 (1.222)	52.4 (1.198)	59.6 (1.174)	67.2 (1.119)	72.9 (1.084)
120 (2.0)	33.1 (1.136)	40.9 (1.024)	46.1 (0.970)	51.0 (0.928)	64.6 (0.993)	74.7 (1.027)
180 (3.0)	48.4 (1.477)	49.4 (1.102)	50.0 (0.940)	50.6 (0.823)	63.1 (0.870)	72.5 (0.893)
360 (6.0)	27.1 (0.675)	41.7 (0.765)	51.3 (0.798)	60.6 (0.817)	83.8 (0.957)	101.3 (1.031)
720 (12.0)	22.2 (0.451)	38.5 (0.583)	49.3 (0.633)	59.6 (0.666)	82.7 (0.776)	99.9 (0.832)
1080 (18.0)	16.1 (0.292)	27.4 (0.372)	34.9 (0.402)	42.0 (0.421)	62.6 (0.524)	78.1 (0.576)
1440 (24.0)	10.9 (0.183)	18.1 (0.227)	22.8 (0.244)	27.4 (0.254)	46.5 (0.359)	60.9 (0.413)
2160 (36.0)	3.7 (0.056)	12.3 (0.140)	18.0 (0.175)	23.5 (0.197)	35.8 (0.248)	45.0 (0.272)
2880 (48.0)	5.4 (0.077)	10.1 (0.108)	13.2 (0.120)	16.2 (0.127)	26.3 (0.169)	33.8 (0.189)
4320 (72.0)	0.2 (0.003)	4.2 (0.041)	6.9 (0.057)	9.4 (0.067)	22.1 (0.129)	31.6 (0.160)

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.972 (4.9%)**	0.847 (4.2%)	**1.052 (5.3%)**
2040	**1.225 (6.2%)**	1.127 (5.7%)	**1.495 (7.6%)**
2050	**1.452 (7.3%)**	1.406 (7.1%)	**1.971 (10.1%)**
2060	**1.653 (8.4%)**	1.685 (8.6%)	**2.480 (12.9%)**
2070	**1.827 (9.3%)**	1.963 (10.1%)	**3.023 (15.9%)**
2080	**1.974 (10.1%)**	2.241 (11.6%)	**3.599 (19.2%)**
2090	**2.095 (10.8%)**	2.518 (13.1%)	**4.208 (22.8%)**

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	**50**	**20**	**10**	**5**	**2**	**1**
60 (1.0)	19.3	12.1	12.2	13.9	12.3	9.3
90 (1.5)	19.2	12.3	11.2	11.2	9.8	7.8
120 (2.0)	18.7	12.4	11.3	11.6	9.8	7.1
180 (3.0)	17.9	12.7	11.8	12.6	10.3	7.0
360 (6.0)	19.4	13.4	11.8	10.7	8.8	4.8
720 (12.0)	21.2	14.8	13.2	11.7	10.2	5.4
1080 (18.0)	23.3	17.7	16.8	15.9	13.3	7.6
1440 (24.0)	25.2	20.0	19.2	19.1	15.5	7.4
2160 (36.0)	27.1	21.7	21.1	21.8	18.5	9.9
2880 (48.0)	27.2	22.1	21.9	23.9	19.6	14.6
4320 (72.0)	28.1	23.9	25.1	27.4	22.7	16.6

Layer Info

Time Accessed	04 July 2019 04:11PM

Version	2018_v1
Note	As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

Baseflow Factors

Downstream	9529
Area (km2)	19380.5058911
Catchment Number	9605
Volume Factor	0.14291
Peak Factor	0.034415

Layer Info

Time Accessed	04 July 2019 04:11PM
Version	2016_v1

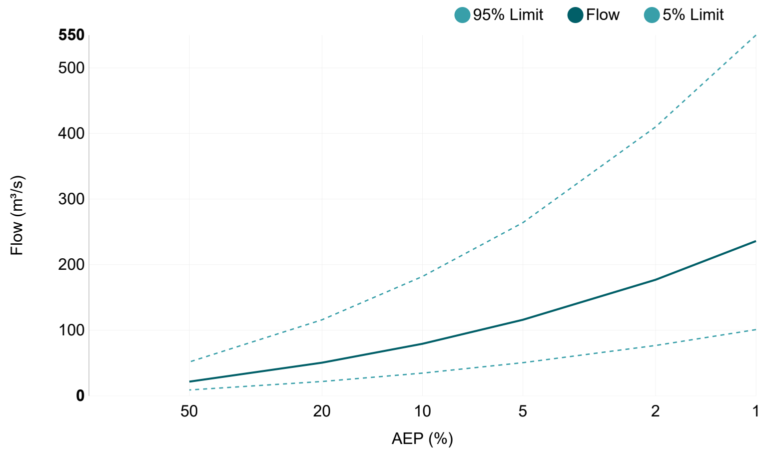
Download TXT (downloads/fd17ba7a-49f8-4be9-800d-685a1f2d50a7.txt)

Download JSON (downloads/271e5cf2-6b6e-4172-afec-1d388baae37c.json)

Generating PDF... (downloads/2f7dad18-f3eb-4a3a-85b7-384b7c5ba54d.pdf)

ATTACHMENT C – RFFE MODEL RESULTS

Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	21.7	9.00	51.7
20	50.6	21.9	116
10	79.4	34.7	182
5	116	50.6	264
2	177	76.8	410
1	236	101	550

Statistics

Variable	Value	Standard Dev
Mean	3.034	0.523
Standard Dev	1.016	0.109
Skew	0.076	0.026

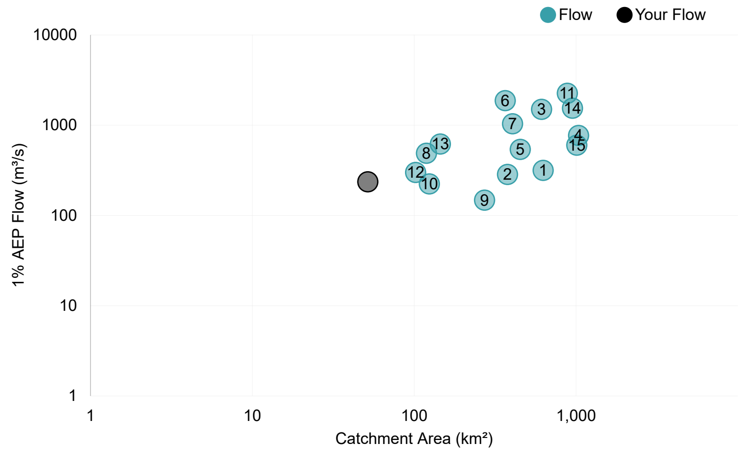
Note: These statistics come from the nearest gauged catchment. Details.

Correlation

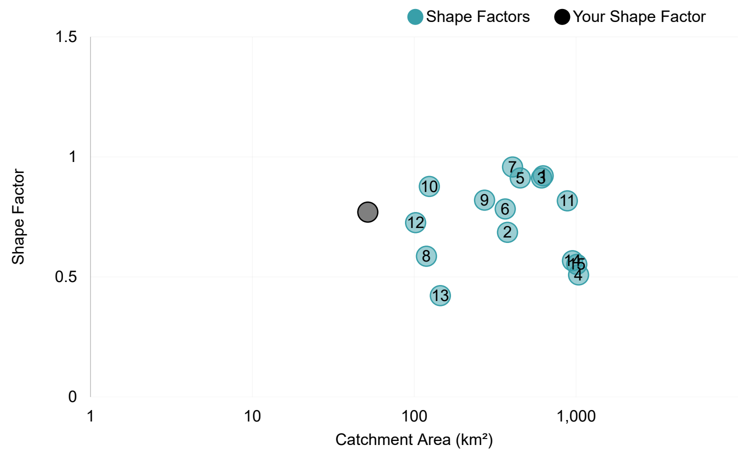
1.000		
-0.330	1.000	
0.170	-0.280	1.000

Note: These statistics are common to each region. Details.

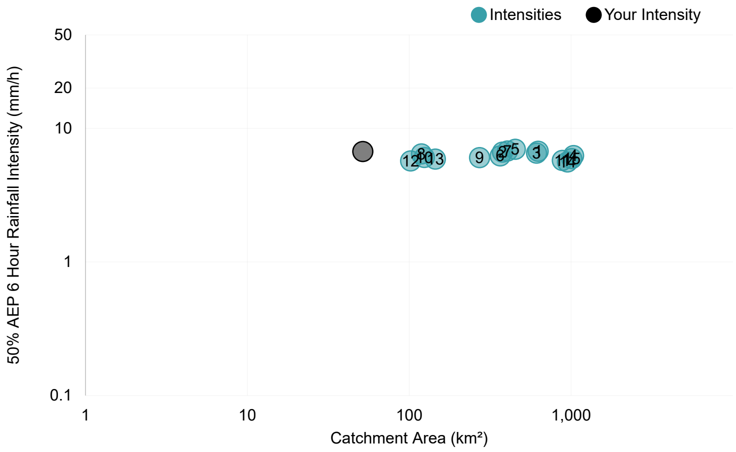
1% AEP Flow vs Catchment Area



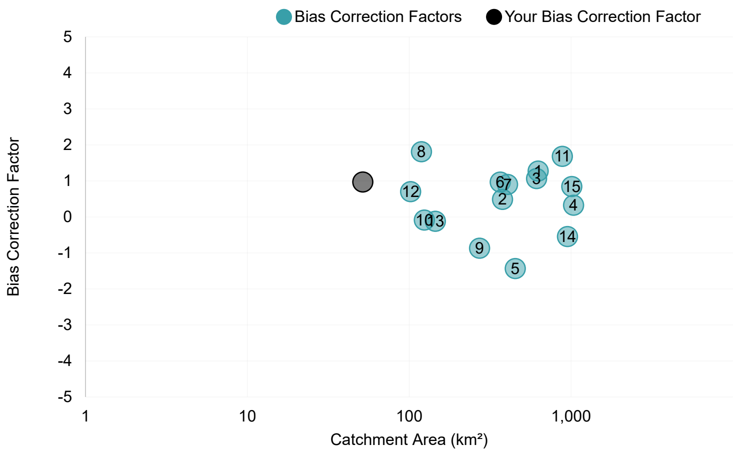
Shape Factor vs Catchment Area



Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area



Download

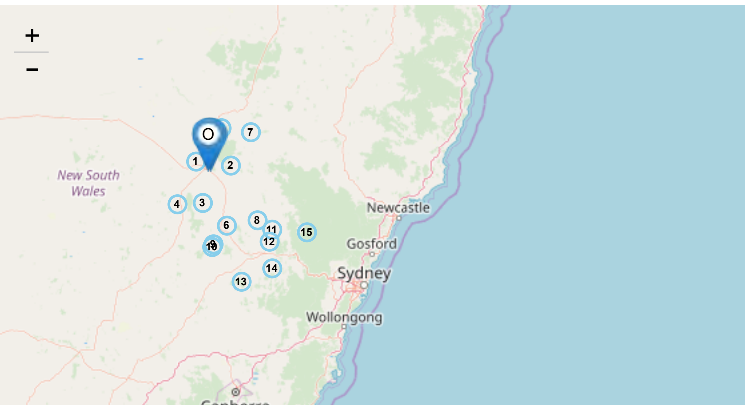
TXT Nearby JSON

Input Data

Date/Time	2019-07-04 17:15

Input Data

Catchment Name	Catchment1
Latitude (Outlet)	-32.282
Longitude (Outlet)	148.657
Latitude (Centroid)	-32.292
Longitude (Centroid)	148.715
Catchment Area (km^2)	51.67
Distance to Nearest Gauged Catchment (km)	24.36
50% AEP 6 Hour Rainfall Intensity (mm/h)	6.702953
2% AEP 6 Hour Rainfall Intensity (mm/h)	14.483112
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.77
Interpolation Method	Natural Neighbour
Bias Correction Value	0.97



Leaflet (http://leafletjs.com) | © OpenStreetMap (http://osm.org/copyright) contributors

Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the project page (http://arr.ga.gov.au/revision-projects/project-list/projects/project-5) on the ARR website. Send any questions regarding the method or project here (mailto:admin@arr-software.org).

ENGINEERS AUSTRALIA (http://www.engineersaustralia.org.au)

WESTERN SYDNEY UNIVERSITY (http://www.uws.edu.au)

ATTACHMENT D – ARR2019 BLOCKAGE ASSESSMENT

BLOCKAGE ASSESSMENT FORM ARR2019

STUDY AREA: EUMOLOGO CREEK - DUBBO

DEBRIS TYPE / MATERIAL / L_{10} / SOURCE AREA

Debris Type/Material	L_{10}	Source Area	How Assessed
Floating	3 m	Vegetation	Satellite Inspection
Non-floating	Silty Clay/Sand	High erosion hazard.	Satellite Inspection

DEBRIS AVAILABILITY (HML) – *for the selected debris type/size and its source area*

Availability	Typical Source Area Characteristics	Notes
High	• *Dense forest, thick vegetation, extensive canopy, difficult to walk through with considerable fallen limbs, leaves and high levels of floor litter.* • *Streams with boulder/cobble beds and steep bed slopes and banks showing signs of substantial past bed/bank movements.* • *Arid areas, where loose vegetation and exposed loose soils occur and vegetation is sparse.* • *Urban areas that are not well maintained and/or old paling fences, sheds, cars and/or stored loose material etc., are present on the floodplain close to the water course.*	
Medium	• *State forest areas with clear understory, grazing land with stands of trees* • *Source areas generally falling between the High and Low categories.*	**Non-floating: Area has a high level of soil erosion hazard.** **Floating trees, bushes and shrubs**
Low	• *Well maintained rural lands and paddocks, with minimal outbuildings* • *Streams with moderate to flat slopes and stable beds and banks.* • *Arid areas where vegetation is deep rooted and soils resistant to scour* • *Urban areas that are well maintained with limited debris present in the source area.*	

DEBRIS MOBILITY (HML) - *for the selected debris type/size and its source area*

Mobility	Typical Source Area Characteristics	Notes
High	• *Steep source area with fast response times and high annual rainfall and/or storm intensities and/or source areas subject to high rainfall intensities with sparse vegetation cover.* • *Receiving streams that frequently overtop their banks.* • *Main debris source areas close to streams*	
Medium	• *Source areas generally falling between the High and Low categories.*	**Non-floating: velocities around 2.5 m/s in the 5-year event determine mobility of creek bed material** **Floating: dry shrubs have relatively high mobility**
Low	• *Low rainfall intensities and large, flat source areas.* • *Receiving streams that Infrequently overtop their banks.* • *Main source areas well away from streams*	

DEBRIS TRANSPORTABILITY (HML) - *for the selected debris type/size and stream characteristics*

Transportability	Typical Transporting Stream Characteristics	Notes
High	• *Steep bed slopes (> 3%).and/or high stream velocity (V>2.5m/sec)* • *Deep stream relative to vertical debris dimension (D>0.5L10)* • *Wide streams relative to horizontal debris dimension. (W>L10)* • *Streams relatively straight and free of constrictions/snag points.* • *High temporal variability in maximum stream flows*	**Non -floating: high velocity (>2.5m/s) in the 5y event** **Floating: high velocity (>2.5m/s) in the 5y event**
Medium	• *Streams generally falling between High and Low categories*	
Low	• *Flat bed slopes (< 1%).and/or low stream velocity (V<1m/sec)* • *Shallow stream relative to vertical debris dimension (D<0.5L10)* • *Narrow streams relative to horizontal debris dimension. (W<L10)* • *Streams meander with frequent constrictions/snag points.* • *Low temporal variability in maximum stream flows*	

SITE BASED DEBRIS POTENTIAL 1%AEP (HML) - *for the selected debris type/size arriving at the site*

Debris Potential	Combinations of the Above (any order)	Notes
High	*HHH or HHM*	
Medium	*MMM or HML or HMM or HLL*	**MMH for both floating and not floating Debris**
Low	*LLL or MML or MLL*	

AEP ADJUSTED SITE DEBRIS POTENTIAL (HML) - *for the selected debris type/size*

Event AEP	At Site 1% AEP Debris Potential			AEP Adjusted at Site Debris Potential	
	High	Medium	Low	FLOATING	NON-FLOATING
AEP > 5% (frequent)	*Medium*	*Low*	*Low*	**low**	**Low**
AEP 5% - AEP 0.5%	*High*	*Medium*	*Low*	**medium**	**medium**
AEP < 0.5%	*High*	*High*	*Medium*	**High**	**High**

MOST LIKELY DESIGN INLET BLOCKAGE LEVEL (B_{DES}%) *for the selected debris type/size*

Control Dimension Inlet Width W (m)	At Site 1% AEP Debris Potential		
	High	Medium	Low
$W < L_{10}$	*100%*	*50%*	*25%*
$W \geq L_{10} \leq 3L_{10}$	*20%*	*10%*	*0%*
$W > 3L_{10}$	*10%*	*0%*	*0%*

Event AEP	Bdes% Floating	Bdes% Non-Floating
AEP > 5% (frequent)	***0%***	***0%***
AEP 5% - AEP 0.5%	***10%***	***0%***
AEP < 0.5%	***20%***	***10%***

BARREL BLOCKAGE

The following tables are only relevant to sites subject to a significant debris load of sediment. Where inlet blockage and barrel blockage are both likely, the blockage producing the greatest impact on flood behaviour should be used in design.

LIKELIHOOD OF SEDIMENT BEING DEPOSITED IN WATERWAY (HML)

Peak Velocity through Structure (m/s)	Particle Type				
	Clay/Silt	Sand	Gravel	Cobbles	Boulders
>= 3	*L*	*L*	*L*	*L*	*M*
1.0 to 3	***L***	***L***	*L*	*M*	*M*
0.5 to 1	*L*	*L*	*L*	*M*	*H*
0.1 to 0.5	*L*	*L*	*M*	*H*	*H*
< 0.1	*L*	*M*	*H*	*H*	*H*

MOST LIKELY DEPOSITIONAL BLOACKAGE LEVELS – B_{DES}%

Likelihood that deposition will occur	AEP Adjusted Debris Potential		
	High	**Medium**	**Low**
High	*100%*	*60%*	*25%*
Medium	*60%*	*40%*	*15%*
Low	*25%*	*15%*	*0%*

Event AEP	Bdes% Non-Floating
AEP > 5% (frequent)	*0%*
AEP 5% - AEP 0.5%	*15%*
AEP < 0.5%	*25%*

ESTIMATED BLOCKAGE LEVELS – B_{DES}%

Event AEP	Bdes% fLOAT	Bdes% Non-float	Bdes% Final
AEP > 5% (frequent)	*0%*	*0%*	*0%*
AEP 5% - AEP 0.5%	*10%*	*15%*	*15%*
AEP < 0.5%	*20%*	*25%*	*25%*

Appendix B

Water balance method statement

B.1 Overview

A water balance model was developed for the existing and expanded water management systems. The objectives of the model were to estimate the volume of water that is captured by the water management system and used for dust suppression and site discharge volumes.

B.2 Modelling approach

The water balance model was developed in GoldSim version 12.1 (GoldSim Technologies 2017). The model applies a continuous simulation methodology that assesses the performance of the modelled water management system under a range of rainfall and evaporation sequences. The model was created by representing the water cycle as a series of elements, each containing pre-set rules and data, that were linked together to simulate the interaction of these elements. Key features of the model are described below:

- The model runs on a daily time-step and requires daily rainfall and evaporation rates as model inputs. The model results are available on a daily time step but are reported as annual averages to simplify the results presentation.
- The model runs as a continuous simulation and applies a long term (101 year) rainfall record that includes a wide range of embedded dry and wet periods as well as major flood events. The model results are processed to provide a statistical representation of the performance of each surface water management system, under a full range of climatic conditions.
- Results are presented in flow chart format for typical dry (10^{th} Percentile), median (50^{th} Percentile) and wet (90^{th} Percentile) years. Select results such as dam overflows are also presented as summary charts.

The model was broadly parametrised to approximate anecdotal information provided by Holcim.

B.3 Model assumptions

This section details the assumptions applied to the water balance model.

a Climatic data

To facilitate a comprehensive assessment of a range of climatic conditions, a 101-year simulation period was adopted for the water balance model based on the available rainfall record. This simulation period applies the daily rainfall record that is described in Section 3.3.

b Calculation of runoff

The SIMHYD rainfall / runoff model was applied to simulate the rainfall runoff response from the catchments within the quarry's surface water management system. SIMHYD is one of the most used rainfall runoff models in Australia and has been extensively tested using data from across Australia (Chiew, 2005).

Each water management dam catchment was delineated into material types that reflected soil hydrologic groups consistent with *Managing Urban Stormwater: Volume 1* (Landcom 2004). A runoff model for each soil group was parameterised to best represent the 5-day runoff coefficients presented in Table F2 (Landcom 2004). The Eastern watercourse was parameterised independently to achieve an average annual runoff rate reflective of the maximum harvestable rights calculator (DPIE) at 0.6 ML/ ha.

The annual average runoff coefficient achieved for each runoff model type is presented in Table B.1.

Table B.1 SIMHYD model runoff coefficients

Soil hydrologic group (Landcom 2004)	Representative material types on site	Annual runoff coefficient
Type A	Stockpiles	0.22
Type B	Vegetated batters, farmland	0.33
Type D	Pit floor, compacted road base, hard stand etc.	0.51

It is noted that SIMHYD calculates runoff on a daily time step, as a function of soil moisture storage. Hence, C_v for any given rainfall event will generally be below the long term average C_v during dry conditions (due to the soils being dry before the event) and above the long term average C_v during wet conditions when the soils are close to saturated before the event. This represents the effects of antecedent soil moisture conditions when calculating daily runoff.

c Process water demands

The process water demands documented in Section 4.1.4 were applied equally to all scenarios. Haul road dust suppression demands were calculated on a daily time step by applying the following equation:

$$DSupp(t) = ((Evap(t) - Rain(t)) + LossFactor) \times (Area \times 10)$$

A daily loss factor of 1 mm/day and an application area of 0.6 Ha produced a good representation of the anecdotal application rates that are reported in Table 4.2. For the proposed operations model, the application area was increased to 0.98 ha, representing the additional area of haul road connecting to the SEA.

Plant water use was applied at a constant rate of 70 kL/day in the water balance model.

d Water management dams

The water management dams shown on each of the model results figures in Sections 4 and 5 were included in the model for each scenario, where the stated volumes in the relevant figures are consistent with the modelled volume. The level / storage characteristics for each dam were estimate by EMM from LiDAR levels, aerial photos and information provided by Holcim.

e Evaporation losses

Evaporation losses occur from all water storages. The model calculates evaporation losses on a daily timestep as a function of:

- Evaporation rates – daily pan evaporation extracted from SILO was included in the model. A Pan Coefficient of 0.9 was applied to all evaporation loss calculated from the water management dams.

- Dam surface area – is a function of the dam volume and the surface area / volume properties of the storage. The surface area is calculated at each daily time step based on the storage volume and estimated area characteristics for each storage.

f Groundwater inflows

Groundwater inflows were simulated via a linear relationship between groundwater inflow and the East Pit Storage level. It was assumed that groundwater inflow into the East Pit was 1 ML/day when the pit level is approximately 268 mAHD decreasing linearly to 0 ML/day at the anecdotal equilibrium level of 277 mAHD.

g Irrigation

Irrigation was only applied to the model when the following conditions were met during a model timestep:

- capacity was available in the soil moisture storage component of the SIMHYD catchment model representing the rehabilitation area; and

- the current PET rate exceeded the current rainfall rate.

The irrigation applied was limited to the minimum of the soil moisture storage capacity and the difference of PET and rainfall. Applied irrigation was added to the next timestep of the SIMHYD model in addition to rainfall to ensure the irrigation amount was not lost from the model processes.

h Water transfers

Water transfers between storages, demands and sources are controlled using transfer rules that are based on storage levels, demand requirements and source availability. It was assumed that all pumps on site were limited to 25 L/s capacity.

Appendix C

Eulomogo Creek crossing concept design

pitt&sherry

Dubbo Quarry Continuation Project

Eulomogo Creek - Concept Options Report

Prepared for
Holcim

Client representative
Luke Edminson

Date
08 May 2020

Rev A

Table of Contents

List of figures

List of tables

Appendices

Prepared by — Frazer McCloy		**Date — 08/05/2020**
Reviewed by — Russel Odendaal		**Date — 08/05/2020**
Authorised by — David Crowe		**Date — 08/05/2020**

Revision History					
Rev No.	**Description**	**Prepared by**	**Reviewed by**	**Authorised by**	**Date**
A	Draft	F. McCloy	R.Odendaal	D. Crowe	08/05/2020

1. Introduction

Holcim has engaged pitt&sherry to undertake concept designs for a crossing structure over Eulomogo Creek. This forms part of the Dubbo Quarry Continuation Project, involving the development of a new resource extraction area to the South of the existing quarry boundary. The Dubbo Quarry is located on Sheraton Road, and the proposed crossing location is demonstrated in Figure 1 below.

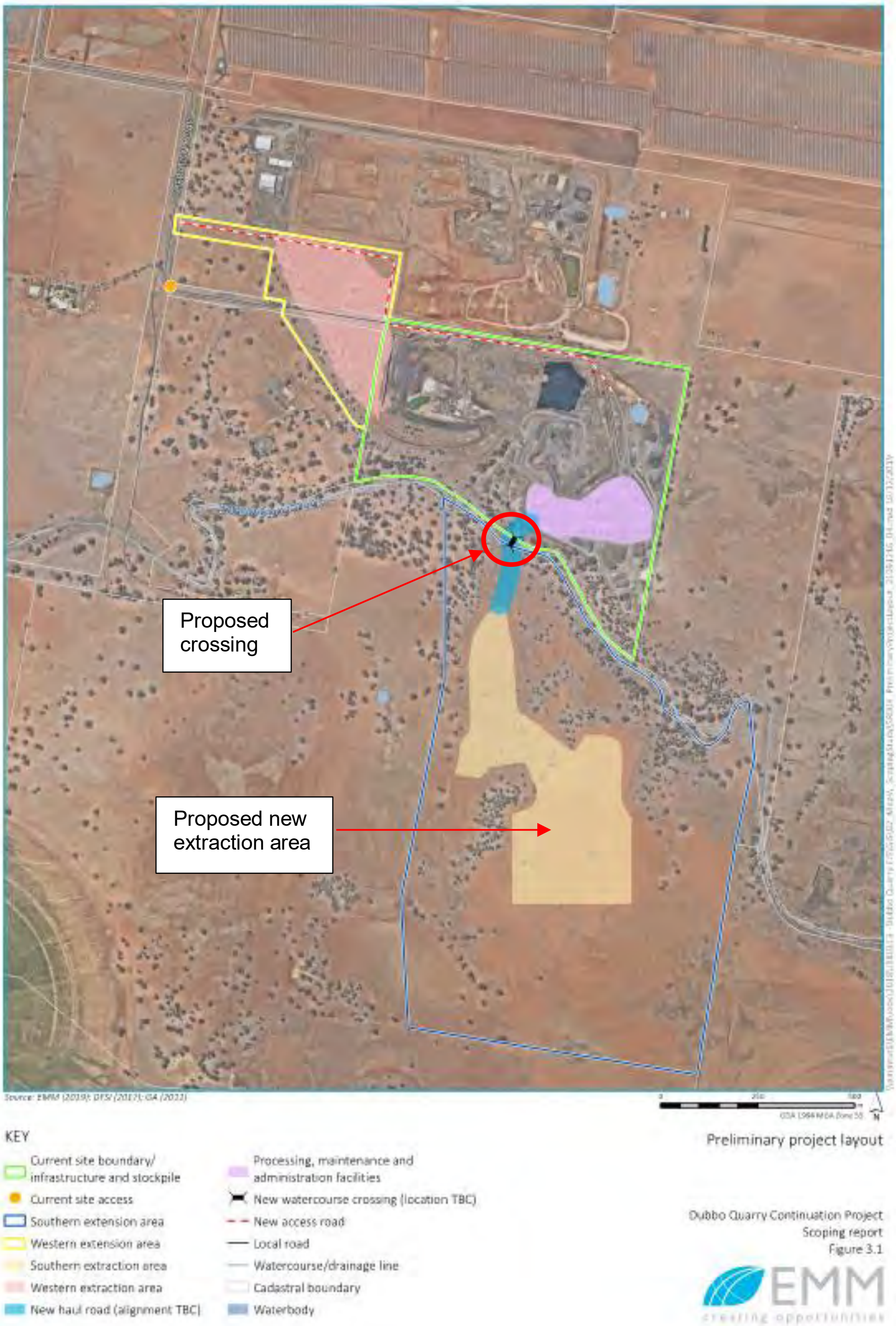


Figure 1: Dubbo Quarry Location

2. Design Development

The concept designs were developed taking into consideration the available site information, design criteria as well as the known site constraints. Details of these considerations are outlined below.

2.1 Available Information

2.1.1 Site Inspection

As part of the scope, pitt&sherry undertook a site inspection on the 19 December 2019. Russel Odendaal (pitt&sherry – Senior Bridge Engineer) along with Luke Edminson (Holcim – Planning & Environmental Manager) and Alasdair Webb (Holcim – Dubbo Quarry Manager) inspected the site to obtain key dimensions, photographs and site layouts for the proposed crossing. The site inspection indicated the proposed crossing would need to be between 15-20m span and require a skew to tie into the indicative haul road geometry.

2.1.2 Client Supplied

Client supplied information has been included in Appendix A. The client supplied the following information to inform the concept design:

- Project Area Location (Figure 1.1 - SR001_ProjectAreaLocation_20191216_03);
- Project Site (Figure 1.2 - SR002_ProjectSite_21091216_04);
- Surrounding Environment (Figure 2.1 - SR003_SurroundingEnvironment_21091216_03);
- Preliminary Project Layout (Figure 3.1 - SR004_PreliminaryProjectLayout_21091216_04); and
- Environmental Constraints (Figure 5.1 - SR005_PreliminaryEnvironmentalConstraints_20191216_03).

2.1.3 pitt&sherry obtained

pitt&sherry obtained the following information to inform the concept design:

- Nearmap high resolution Imagery; and
- LIDAR Data – GIS at 1m accuracy.

2.2 Design Criteria

2.2.1 Design Standards

The following standards were used in preparation of the concept design:

- AS5100:2017 – Bridge Design;
- AS/NZS 3725:2007- Design for Installation of Buried Concrete Pipes;
- AS/NZS 4058:2007- Precast Concrete Pipes;
- AS 1597:2013 - Precast Reinforced Concrete Box Culverts; and
- Recognised standard 19 (August 2019) – Design and construction of mine roads.

2.2.2 Design Loading

Concept design of the Eulomogo Creek Crossing considered the following design loading:

- Vertical loads in accordance with AS5100.2:2017, including dead loads, superimposed dead loads and vehicle loads; and
- CAT 796C with provisions for future CAT777 Dump Truck.

No other design loading, including hydraulic and horizontal earth pressure loading has been considered at this stage.

2.2.3 Design Geometrical Requirements

- Haul road width = 10m over crossing; and
- Haul road width = 15m elsewhere.

2.2.4 Design Structural Preferences

Holcim confirmed that culvert type structures are preferred and that a bridge option should not be considered.

2.3 Site Constraints

2.3.1 Environmental

Protected Trees – EMM environmental has provided details of protected tree species Blakley's Red Gum which are located nearby to the proposed crossing. The design has been developed to minimise the required footprint and removal of trees where possible.

Riparian Corridor – The proposed crossing has been developed considering the Department of Primary Industries Office of Water – Guidelines for watercourse crossing on waterfront land.

2.3.2 Geotechnical

The site inspection identified high lying rock strata below the proposed crossing. The design has been developed to minimise the need to excavate any rock material.

2.3.3 Hydraulic and Hydrological

The design has been developed to maintain the creek function and flow with minimal disturbance where possible.

2.4 Assumptions & Limitations

The following assumptions and limitations have been considered in the concept design:

- The details shown are conceptual and should be confirmed during the detailed design process;
- The haul road has been shown indicatively and is subject to detailed design;
- Hydrological and hydraulic modelling to be undertaken to confirm hydraulic conditions required and scour protection. No modelling has been undertaken to date;
- An assessment by NSW government department of water required for watercourse crossing;
- No geotechnical information about the site is currently available. It is assumed the material below the culvert crossing has sufficient strength for the required bearing capacity;

- Engineers costs estimates are based on concept details and subject to detailed design. They are indicative costs for the crossing structures only and do not include any allowance for approach works and haul road construction; and
- The culvert is located in a non-aggressive environment for durability of the concrete. This should be confirmed by soil and groundwater testing during detailed design.

3. Concept Options

3.1 Crossing General Arrangement

Two concept design options have been developed to determine the most effective design to span across Eulomogo Creek. Both concept options consider utilisation of a precast concrete culvert to facilitate access to the proposed southern extraction area. The culverts are proposed to span 16.41m between the Eulomogo Creek banks. The culvert cells are parallel to the flow of the creek, with the haul road skewed at 20° to enable minimal impact and disturbance to the adjacent land and creek, whilst retaining a safe travel path for haul road users.

Both concept options consider concrete lined safety berms either side of a 10m wide haul road carriageway. The safety berms are 1.4m in height above the carriageway and are intended to safely deflect any vehicle crossing the culvert away from the edge of the road. Safety berms are included in lieu of bridge barriers due to the large vehicles expected to utilise the structure.

The proposed culvert options include a concrete pavement, as well as a concrete lining covering the safety berms and fill material above culvert cells to provide increased flood immunity. In the event of culvert overtopping, the concrete lining and pavement will provide the structure with a physical barrier to mitigate the impact of roadway scour. The haul road allows for a 3% crossfall to allow for drainage of the culvert surface. 150mm diameter scuppers are provided at 1m centres along the safety berms to enable drainage through the safety berms and to prevent water pooling.

Rip-rap is proposed either side of the culvert apron slabs to provide scour protection to the culvert structure. The rip-rap extends across the width of the apron slab and consists of a downturn transverse to the creek flow to prevent undermining of the apron slab.

General arrangements of the proposed design are provided on drawing NC19061-SK001. A section view of the culvert carriageway surface is presented in Figure 2.

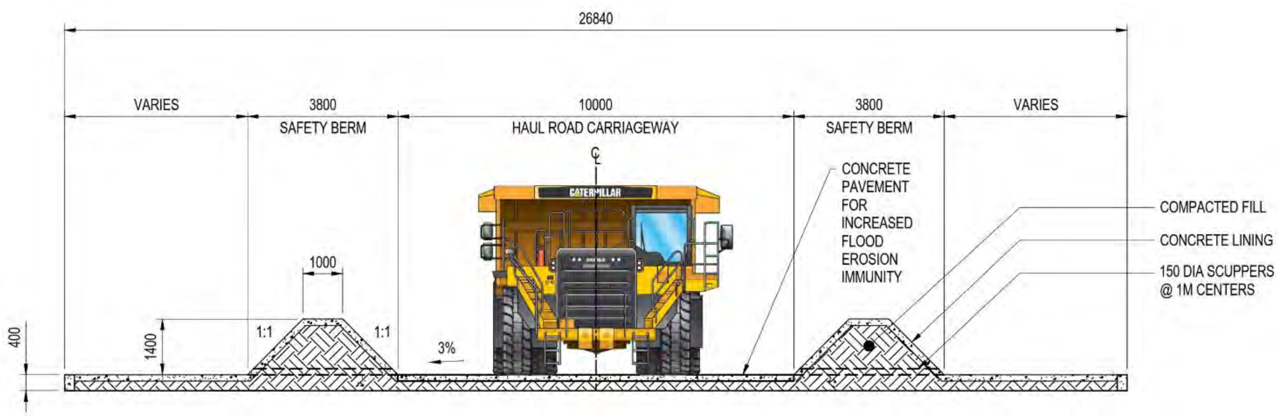


Figure 2: Culvert Carriageway General Arrangement

3.2 Option 1 – Precast Concrete Pipes

Option 1 consists of a 5-cell precast pipe culvert to span the proposed section of Eulomogo Creek. The solution comprises of pipe culvert units with an internal diameter of 2.1m. The pipe culvert units are encased with compacted fill and are spaced at approx. 3.1m centres. Reinforced concrete wingwalls surround the pipe cells which are supported by a compacted fill pipe bedding. A typical section view of the pipe culvert solution along the haul road centreline is presented in Figure 3. Concept design drawings of option 1 are presented in drawing NC19061-SK002 included in Appendix B.

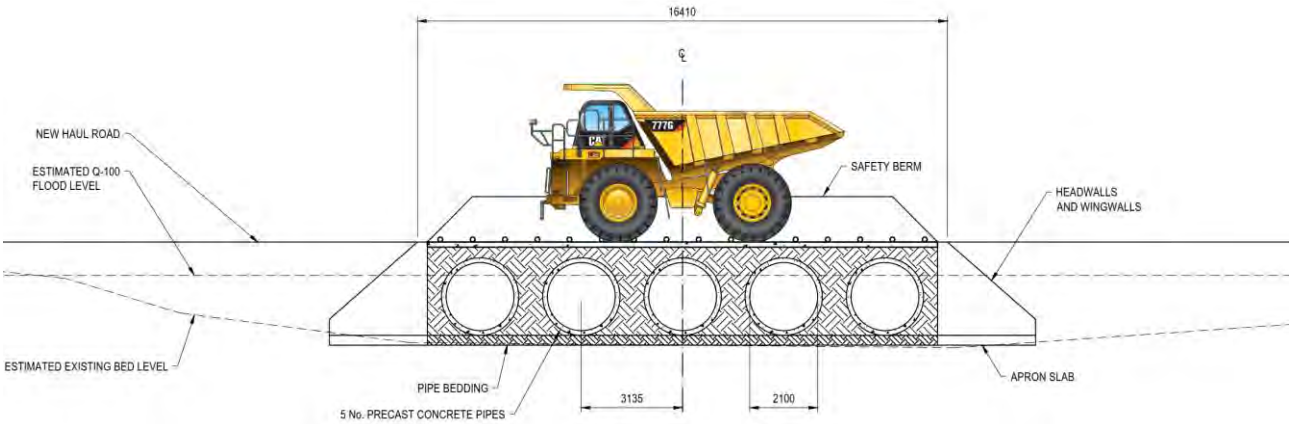


Figure 3: Option 1 Typical Section

Engineers cost estimates have been developed for this option. They have been based on precast unit pricing supplied by Holcim and industry rates for required items. Estimates for the cost of detailed design, contractor preliminaries, contractor margin and an allowance for risk contingency have been included. A detailed breakdown of the pricing estimates has been included in Appendix C. Due the concept nature of the scheme an upperbound and lowerbound cost estimate has been produced, which is indicated in Table 1 below.

Table 1: Option 1 Engineers Cost Estimate

Lowerbound	Upperbound
$ 729,000	$ 1,199,000

3.3 Option 2 – Precast Concrete Box Culverts

Option 2 consists of a 5-cell precast box culvert to span the proposed section of Eulomogo Creek. The solution comprises of 3 no. precast concrete box culvert cells with 2 no. precast concrete link slabs bridging between the box cells. The box culvert units are 1.2m long and have a 3m internal width and 2.1m internal height. Similarly, the link slab units are 1.2m long and with a span of 3m. The box culvert units are encased by reinforced concrete wingwalls and supported by a reinforced concrete base slab. A typical section view of the box culvert solution along the haul road centreline is presented in Figure 4. Concept design drawings of option 2 are presented in drawing NC19061-SK002 included in Appendix B.

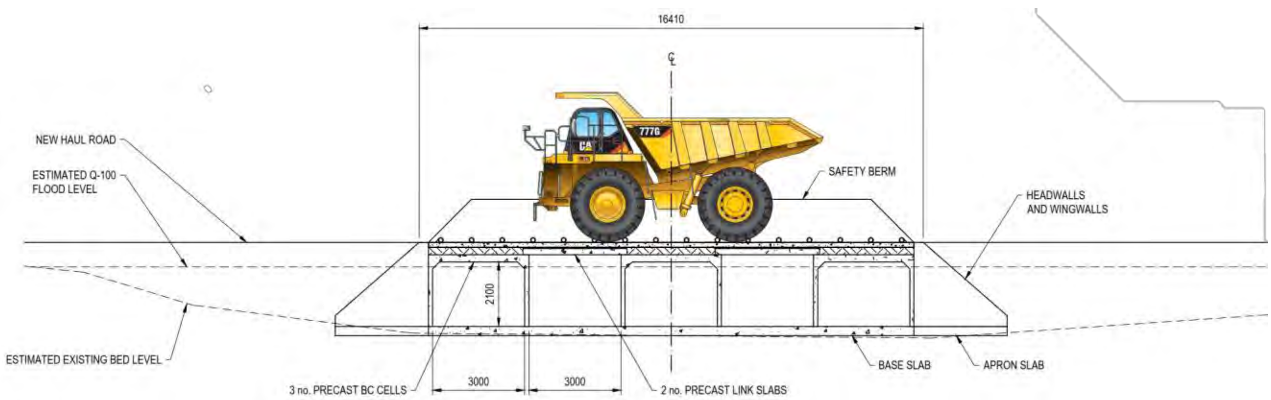


Figure 4: Option 2 Typical Section

Engineers cost estimates have been developed for this option. They have been based on precast unit pricing supplied by Holcim and industry rates for required items. Estimates for the cost of detailed design, contractor preliminaries, contractor margin and an allowance for risk contingency have been included. A detailed breakdown of the pricing estimates has been included in Appendix C. Due the concept nature of the scheme an upperbound and lowerbound cost estimate has been produced, which is indicated in Table 2 below.

Table 2: Option 2 Engineers Cost Estimate

Lowerbound	Upperbound
$ 1,180,000	$ 1,940,000

4. Multi-criteria Analysis

To assess and compare the identified options, a multi-criteria analysis (MCA) has been undertaken. This analysis has been performed to identify the best crossing option. In the MCA, each option is scored against the five criteria, and the scores tallied to identify the preferred option. Scores are provided on a scale of 1 (worst) to 5 (best).

Scoring for the criteria is also weighted to consider more significant criteria as agreed with Holcim, shown in Table 3. The results of the MCA are provided in Table 4. The 'Cost' criteria of the MCA take into consideration the engineers cost estimates developed for each option. These have been included in Appendix C for further information.

Table 3: Multi criteria analysis weightings

Criteria	Weighting
Design Life	5%
Environmental Impact	20%
Safety	5%
Hydraulic Performance	10%
Cost	60%

Table 4: MCA Scoring

Criteria for Comparison	Option 1 – Precast Concrete Pipes	Option 2 – Precast Concrete Box Culverts
Design Life	5	5
Environmental Impact	4	3
Hydraulic Performance	3	5
Safety	4	4
Cost	5	3
Overall Weighted Rank	**4.6**	**3.3**

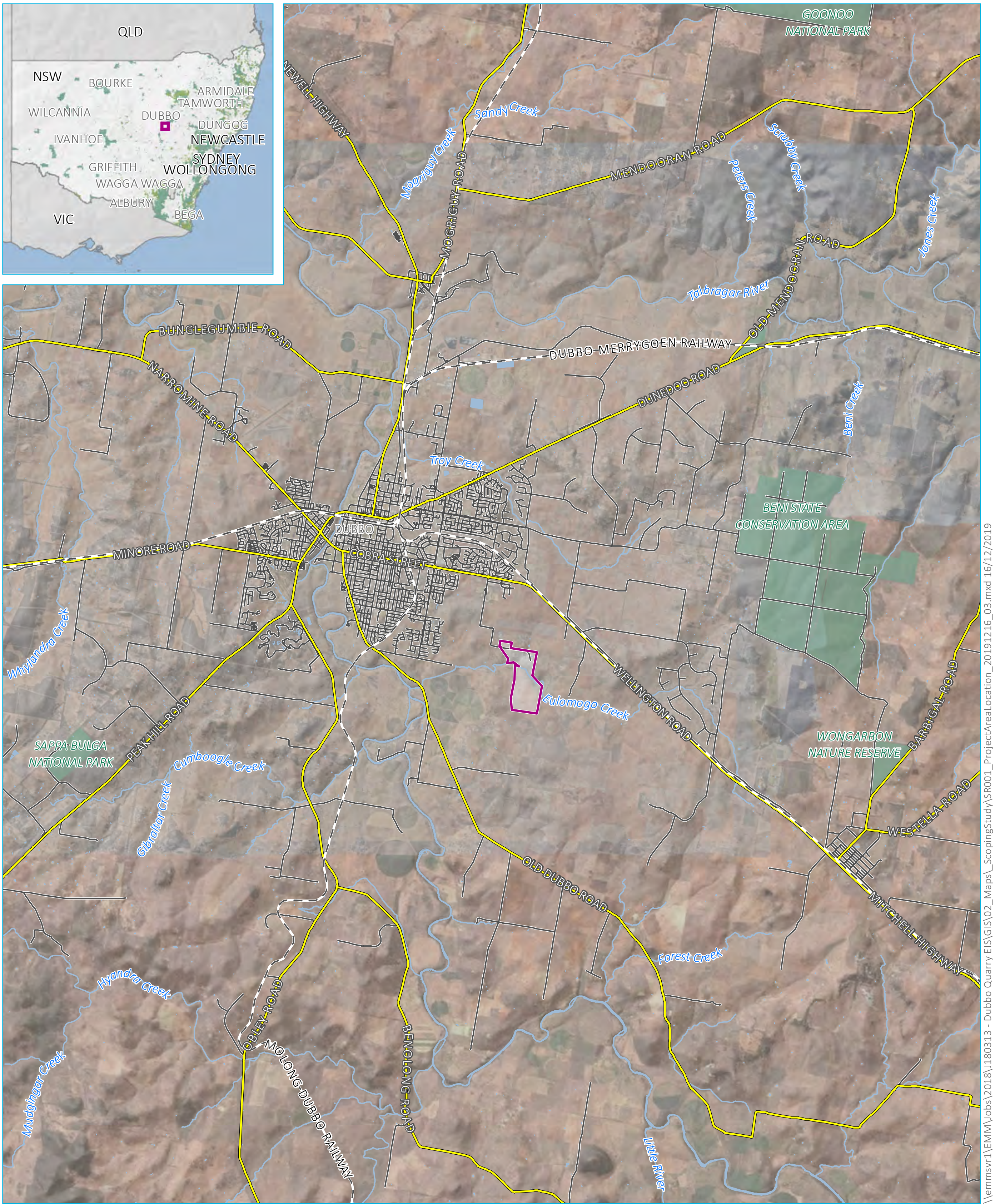
5. Conclusions & Recommendations

Concept design options were explored for the Eulomogo Creek Crossing, proposed to provide access to the southern extension area of the Holcim Dubbo Quarry. Based on an initial review of the client’s criteria and the site-specific information, it was determined that a precast concrete culvert solution would best achieve the design intent. The presented options consisted of precast concrete box culvert and precast concrete pipe culvert.

Given the results of the MCA, which explored the design life, environmental impact, safety and cost of each option, it is apparent that the precast concrete pipe culvert solution (Option 1) is the best option to span the Eulomogo Creek. The presented option provides an increased benefit in terms of environmental impact and cost in comparison to the precast concrete box culvert solution. The precast concrete pipe culvert solution (Option 1) has an engineer’s cost estimate between $729,000 - $ 1,199,000 compared to the precast concrete box culvert (Option 2) with an engineer’s cost estimate between $ 1,180,000 - $ 1,940,000. It is therefore recommended that Holcim adopt the precast concrete pipe solution (Option 1) for the Eulomogo Creek Crossing.

Client Supplied Information

Appendix A



Source: EMM (2019); DFSI (2017); GA (2011)

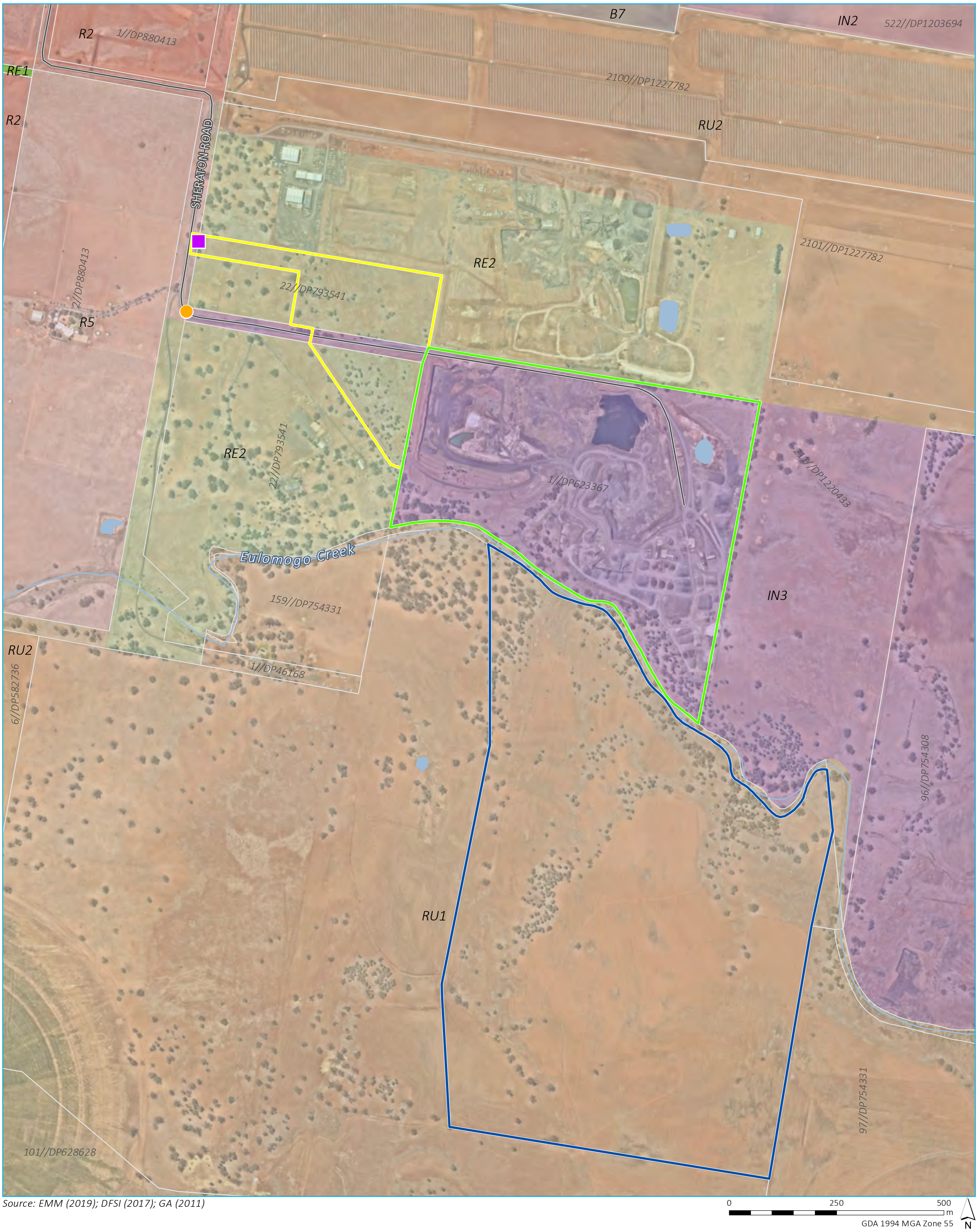
KEY

- Project area
- Rail line
- Main road
- Local road
- Watercourse/drainage line
- NPWS reserve
- State forest
- Waterbody

Project location

Dubbo Quarry Continuation Project
Scoping report
Figure 1.1

EMM
creating opportunities



Source: EMM (2019); DFSI (2017); GA (2011)

\\emmsvr1\EMM\Jobs\2018\J180313 - Dubbo Quarry EIS\GIS\02_Maps_ScopingStudy\SR002_ProjectSite_21091216_04.mxd 16/12/2019

KEY

- Current site boundary/ infrastructure and stockpile
- Current site access
- Southern extension area
- Western extension area
- Proposed future site access
- Local road
- Watercourse/drainage line
- Cadastral boundary
- Waterbody

Land zoning

- B7 Business park
- IN2 Light industrial
- IN3 Heavy industrial
- R2 Low density residential
- R5 Large lot residential
- RE1 Public recreation
- RE2 Private recreation
- RU1 Primary production
- RU2 Rural landscape

Project site

Dubbo Quarry Continuation Project
Scoping report
Figure 1.2

EMM
creating opportunities

Source: EMM (2019); DFSI (2017); GA (2011)

KEY

- Current site boundary/ infrastructure and stockpile
- Current site access
- Southern extension area
- Western extension area
- Proposed future site access
- Rail line
- Main road
- Local road
- Watercourse/drainage line
- Waterbody

Surrounding environment

Dubbo Quarry Continuation Project
Scoping report
Figure 2.1

creating opportunities

Source: EMM (2019); DFSI (2017); GA (2011)

0 250 500 m
GDA 1994 MGA Zone 55
N

\\emmsvr1\EMM\Jobs\2018\J180313 - Dubbo Quarry EIS\GIS\02_Maps_ScopingStudy\SR004_PreliminaryProjectLayout_21091216_04.mxd 16/12/2019

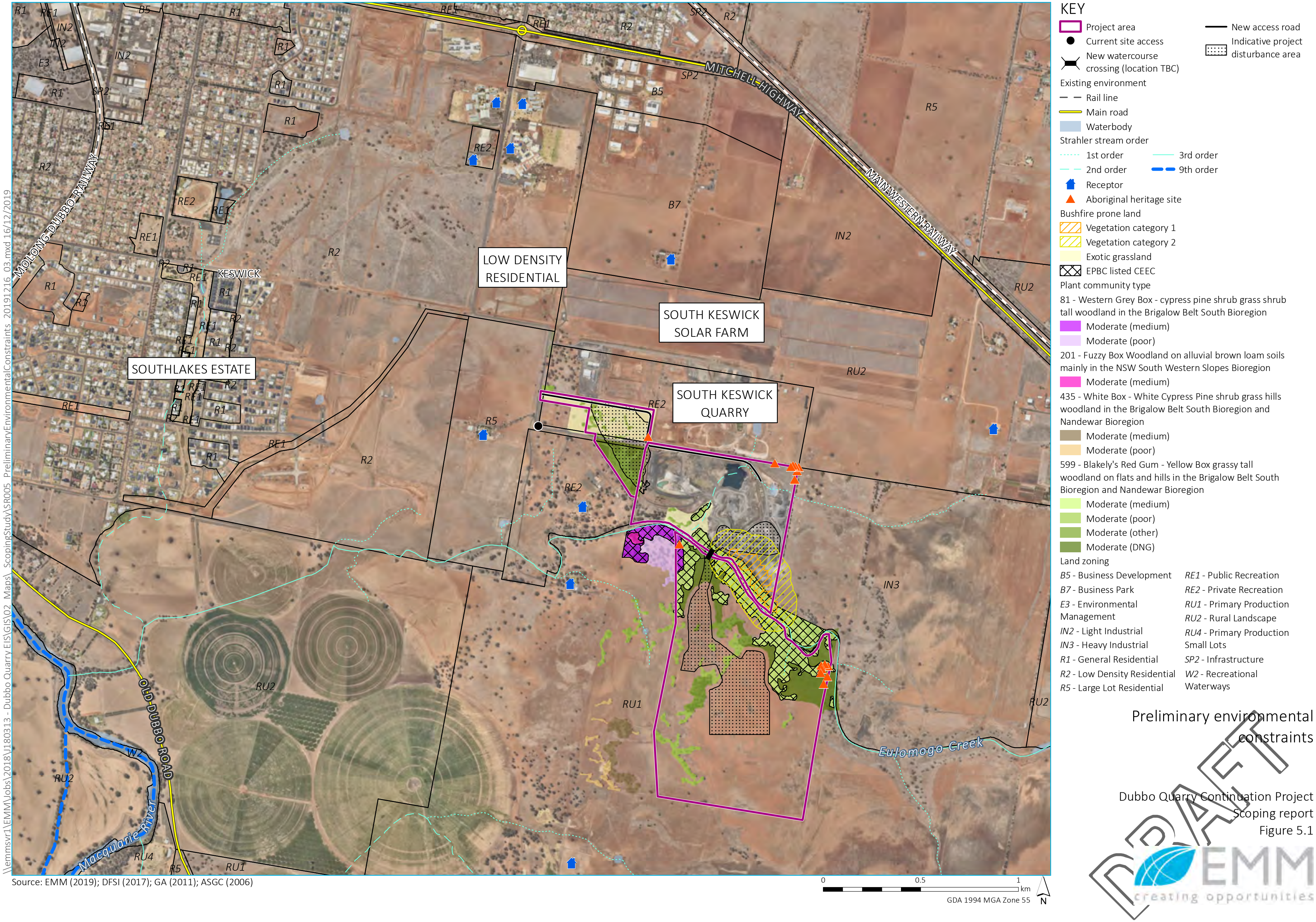
KEY

- Current site boundary/ infrastructure and stockpile
- Current site access
- Southern extension area
- Western extension area
- Southern extraction area
- Western extraction area
- New haul road (alignment TBC)
- Processing, maintenance and administration facilities
- New watercourse crossing (location TBC)
- New access road
- Local road
- Watercourse/drainage line
- Cadastral boundary
- Waterbody

Preliminary project layout

Dubbo Quarry Continuation Project
Scoping report
Figure 3.1

creating opportunities



Source: EMM (2019); DFSI (2017); GA (2011); ASGC (2006)

Preliminary environmental constraints

Dubbo Quarry Continuation Project
Scoping report
Figure 5.1

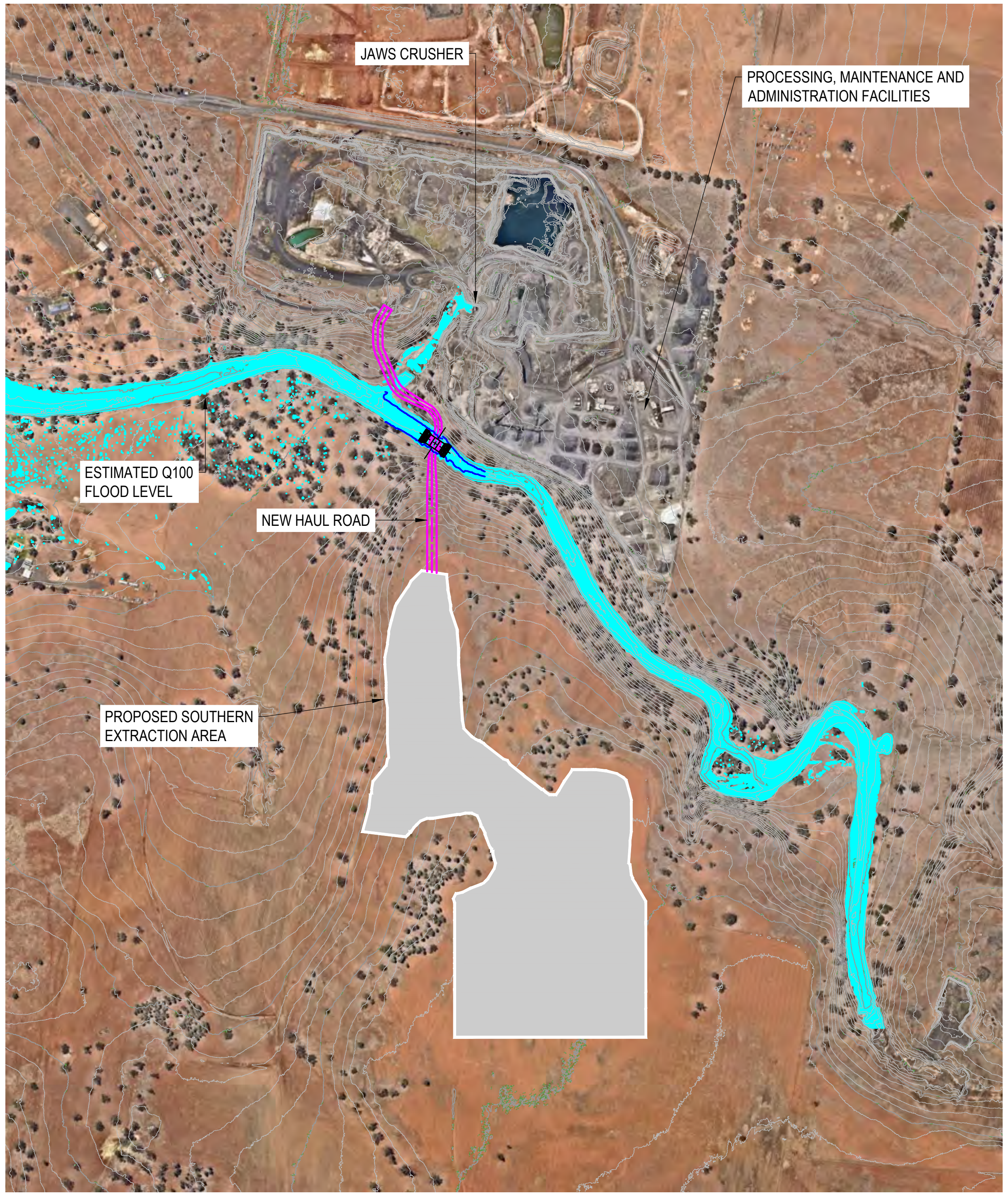
DRAFT

EMM creating opportunities

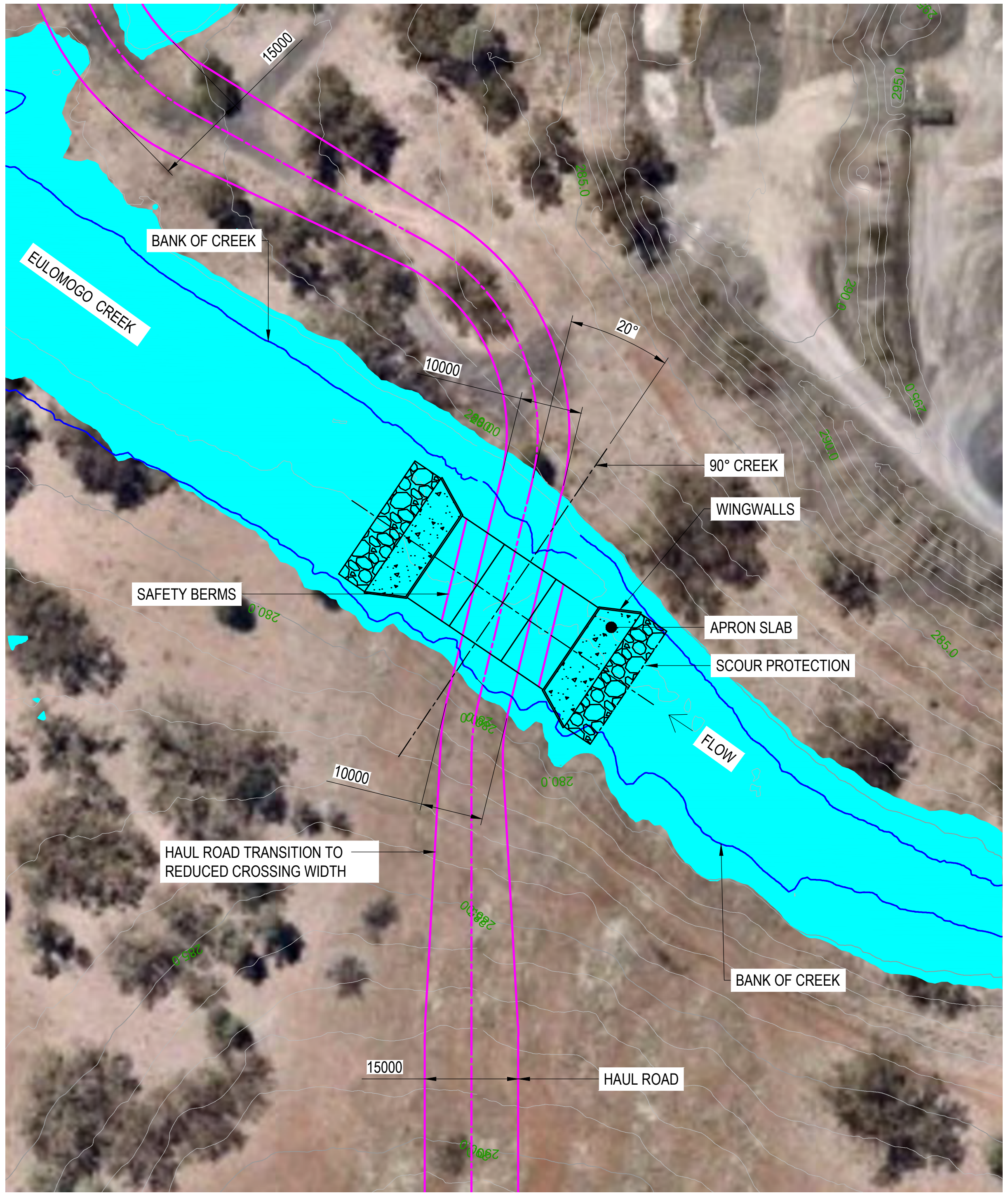
Concept Drawings

Appendix B

NORTH



SITE ARRANGEMENT
SCALE 1:10,000



CROSSING ARRANGEMENT
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REFERENCE FILES ATTACHED: NC19061_dubbo_DEM_Contours_Existing_2d; NC19061_estimated_Q100_flood_level

P&S FORM DRG-A3 REV - 8

DRAWING REVISION HISTORY

No.	DESCRIPTION	DRAWN	DESIGNED	REVIEWED	DATE
B	CONCEPT DESIGN	D.BRANCH		R.ODENDAAL	05-05-20
A	CONCEPT DESIGN	D.BRANCH		R.ODENDAAL	03-02-20

APPROVED
ORIGINAL COPY ON FILE
"e" SIGNED BY
SIGNED
DATE

SCALE (PLOTTED FULL SIZE) AS SHOWN (A3)
SHEET SIZE A3

100000 0 100000 200000 300000 400000
SCALE IN MILLIMETRES - 1:10000

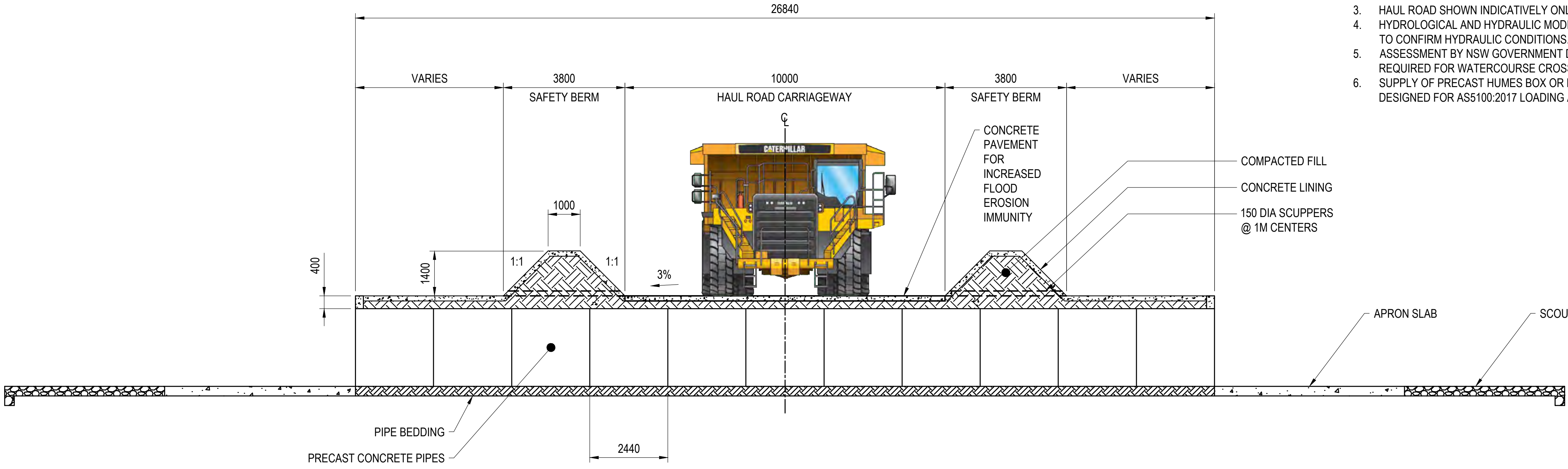
pitt&sherry

CLIENT: HOLCIM
PROJECT: DUBBO QUARRY CONTINUATION PROJECT
STATUS: CONCEPT

DRAWING TITLE: GENERAL ARRANGEMENT SKETCH SHEET 1 OF 3
DATUMS: AHD / MGA
CLIENT No. -
DRAWING No. NC19061-SK001
REVISION B
May. 5, 20 - 13:46:36 Name: NC19061-SK001.dwg Updated By: David Branch

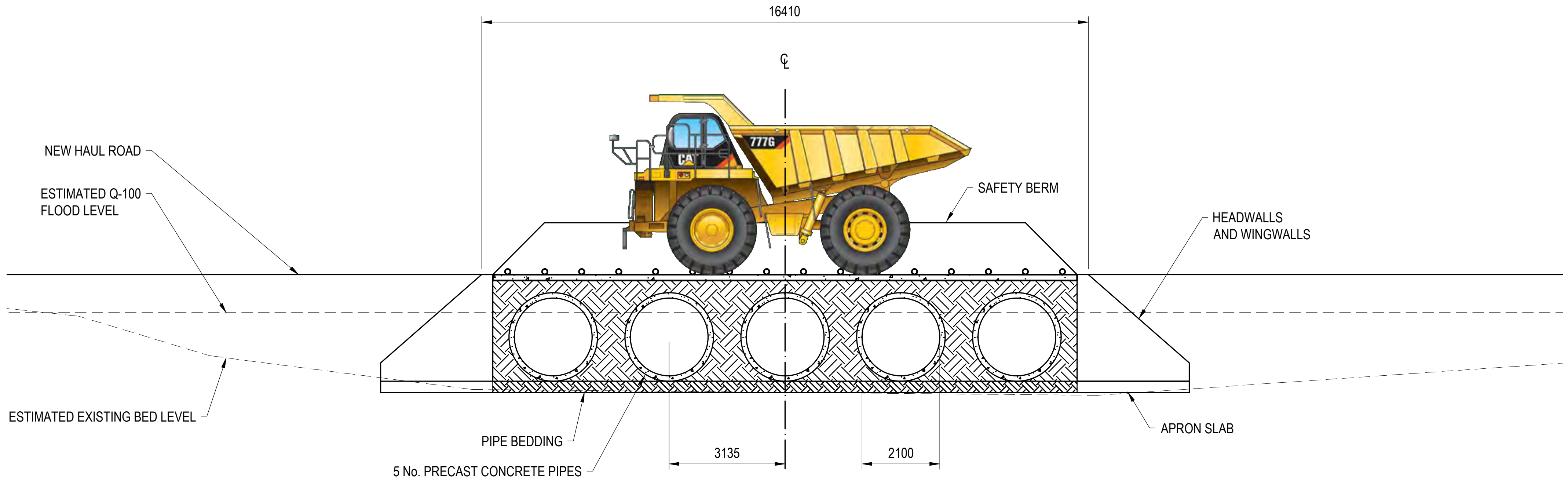
GENERAL NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE (U.N.O.)
2. ALL DETAILS ARE CONCEPTUAL AND SUBJECT TO DESIGN.
3. HAUL ROAD SHOWN INDICATIVELY ONLY AND SUBJECT TO DESIGN.
4. HYDROLOGICAL AND HYDRAULIC MODELLING TO BE UNDERTAKEN TO CONFIRM HYDRAULIC CONDITIONS.
5. ASSESSMENT BY NSW GOVERNMENT DEPARTMENT OF WATER REQUIRED FOR WATERCOURSE CROSSING.
6. SUPPLY OF PRECAST HUMES BOX OR PIPE CULVERTS TO BE DESIGNED FOR AS5100:2017 LOADING AND CAT 777 DUMP TRUCK.



TYPICAL SECTION ALONG CL OF CULVERT

SCALE NTS



TYPICAL SECTION ALONG CL OF ROAD

SCALE NTS

REFERENCE FILES ATTACHED:

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No.	DESCRIPTION	DRAWN	DESIGNED	REVIEWED	DATE
B	CONCEPT DESIGN	D.BRANCH		R.ODENDAAL	05-05-20
A	CONCEPT DESIGN	D.BRANCH		R.ODENDAAL	03-02-20

APPROVED

ORIGINAL COPY ON FILE "e" SIGNED BY

SIGNED

DATE

SCALE (PLOTTED FULL SIZE) AS SHOWN (A3)

SHEET SIZE A3

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SCALE IN MILLIMETRES - 1:150

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CLIENT HOLCIM

PROJECT DUBBO QUARRY CONTINUATION PROJECT

STATUS CONCEPT

DRAWING TITLE OPTION 1 : PRECAST PIPES SHEET 2 OF 3

DATUMS: AHD

CLIENT No. -

DRAWING No. NC19061-SK002

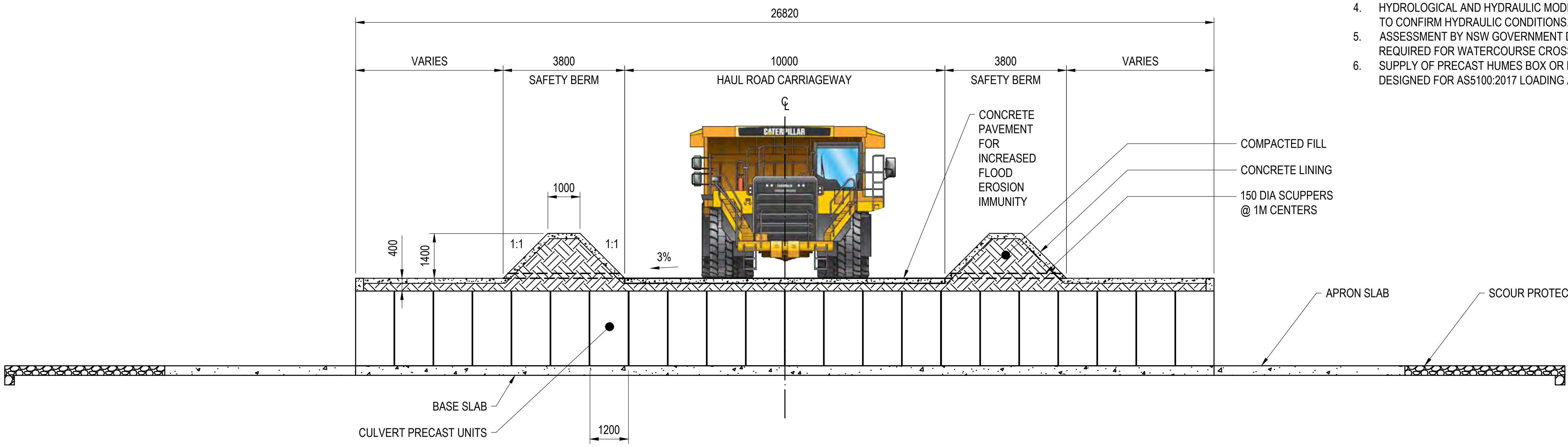
REVISION B

May. 5, 20 - 13:40:47 Name: NC19061-SK002.dwg Updated By: David Branch

P&S FORM DRG-A3 REV - 8

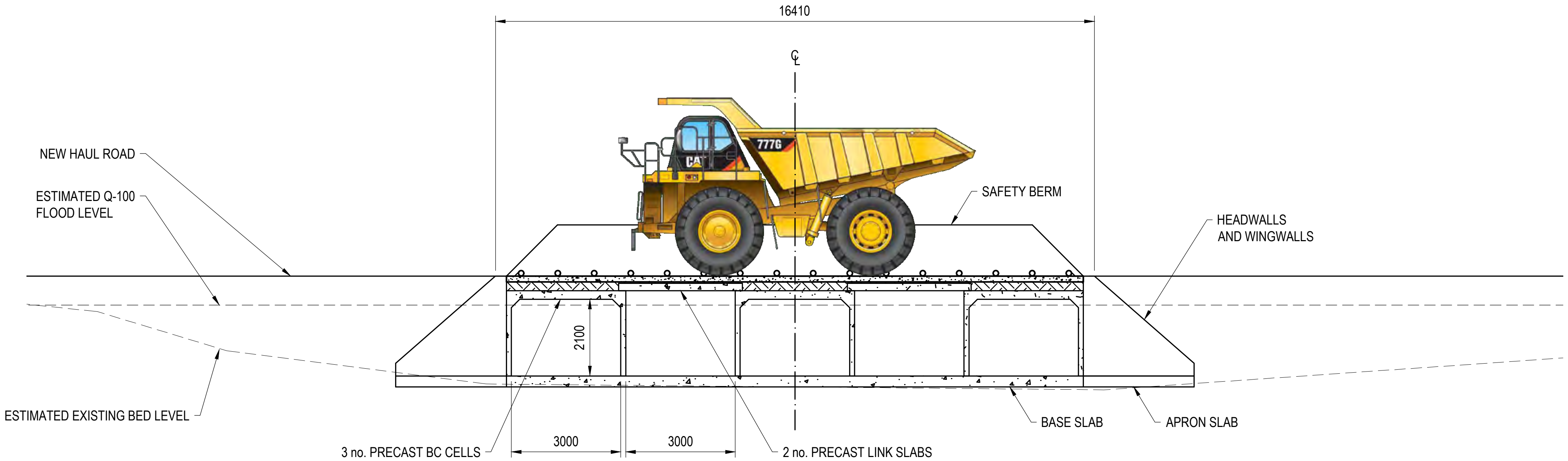
GENERAL NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE (U.N.O.)
2. ALL DETAILS ARE CONCEPTUAL AND SUBJECT TO DESIGN.
3. HAUL ROAD SHOWN INDICATIVELY ONLY AND SUBJECT TO DESIGN.
4. HYDROLOGICAL AND HYDRAULIC MODELLING TO BE UNDERTAKEN TO CONFIRM HYDRAULIC CONDITIONS.
5. ASSESSMENT BY NSW GOVERNMENT DEPARTMENT OF WATER REQUIRED FOR WATERCOURSE CROSSING.
6. SUPPLY OF PRECAST HUMES BOX OR PIPE CULVERTS TO BE DESIGNED FOR AS5100:2017 LOADING AND CAT 777 DUMP TRUCK.



TYPICAL SECTION ALONG CL OF CULVERT

SCALE NTS



TYPICAL SECTION ALONG CL OF ROAD

SCALE NTS

REFERENCE FILES ATTACHED:

P&S FORM DRG-A3 REV - B

DRAWING REVISION HISTORY

No.	DESCRIPTION	DRAWN	DESIGNED	REVIEWED	DATE
B	CONCEPT DESIGN	D.BRANCH		R.ODENDAAL	05-05-20
A	CONCEPT DESIGN	D.BRANCH		R.ODENDAAL	03-02-20

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ORIGINAL COPY ON FILE "e" SIGNED BY
SIGNED
DATE

SCALE (PLOTTED FULL SIZE): AS SHOWN (A3)
SHEET SIZE: A3
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SCALE IN MILLIMETRES - 1:150

pitt&sherry

CLIENT: HOLCIM
PROJECT: DUBBO QUARRY CONTINUATION PROJECT
STATUS: CONCEPT

DRAWING TITLE: OPTION 2 : PRECAST CULVERTS SHEET 3 OF 3
DATUMS: AHD
CLIENT No. -
DRAWING No. NC19061-SK003
REVISION B

May. 5, 20 - 13:41:18 Name: NC19061-SK003.dwg Updated By: David Branch

Engineers Cost Estimates

Appendix C

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PIPE CULVERT LOWERBOUND

Code	Descritption	Quantity	Unit	Rate (adjusted)	Total
1.0	**GENERAL EARTHWORKS**				
1.0.1	**EARTHWORKS, EXCAVATION**				
	Excavation for wingwalls, base slab, apron slab, all materials	27	cum	$ 23	$ 612
1.0.2	**BLINDING CONCRETE**				
	N20 Blinding concrete, 50 mm nominal thickness across base slab and apron slabs	17	sqm	$ 414	$ 6,955
1.0.3	**SELECT FILL**				
	Granular fill on top of culverts	132	cum	$ 59	$ 7,836
	Safety berm	84	cum	$ 59	$ 4,977
	Pipe bedding	130	cum	$ 59	$ 7,707
	Wingwall fill	268	cum	$ 59	$ 15,917
	Fill around pipes	547	cum	$ 59	$ 32,441
2.0	**CULVERT STRUCTURE**				
2.0.1	**CONCRETE**				
	Concrete Class S40 apron slabs	101	cum	$ 234	$ 23,567
	Concrete Class S40 wingwalls	6	cum	$ 234	$ 1,403
	Concrete Class S40 headwalls	19	cum	$ 234	$ 4,445
	Concrete Class 6 precast pipe	70	units	$ 2,800	$ 194,767
	Concrete pavement, including mesh	164	sqm	$ 95	$ 15,646
	Safety Berm Lining	192	sqm	$ 95	$ 18,306
2.0.2	**SCOUR PROTECTION**				
	Rockfill scour protection	70	cum	$ 95	$ 6,665
2.0.3	**BAR REINFORCEMENT**				
	Steel reinforcing bar in apron slabs	20	t	$ 2,515	$ 50,698
	Steel reinforcing bar in wingwalls	1.2	t	$ 2,515	$ 3,018
	Steel reinforcing bar in headwalls	3.8	t	$ 2,515	$ 9,563
2.0.4	**FORMWORK**				
	Class F2 formwork to edge of apron slab	14	sqm	$ 220	$ 3,082
	Class F2 formwork to wingwalls	30	sqm	$ 233	$ 6,980
	Class F2 formwork to headwalls	26	sqm	$ 233	$ 6,049
	DETAILED DESIGN	7.5%			$ 31,547.52
	CONTRACTOR PRELIMINARIES	40%			$ 168,253.42
	CONTRACTOR MARGIN	10%			$ 42,063.36
	PROJECT CONTINGENCY	10%			$ 66,250
	TOTAL				**$ 728,748**

PIPE CULVERT UPPERBOUND

Code	Description	Quantity	Unit	Rate (adjusted)	Total
1.0	**GENERAL EARTHWORKS**				
1.0.1	**EARTHWORKS, EXCAVATION**				
	Excavation for wingwalls, base slab, apron slab, all materials	27	cum	$ 23	$ 612
1.0.2	**BLINDING CONCRETE**				
	N20 Blinding concrete, 50 mm nominal thickness across base slab and apron slabs	17	sqm	$ 414	$ 6,955
1.0.3	**SELECT FILL**				
	Granular fill on top of culverts	132	cum	$ 59	$ 7,836
	Safety berm	84	cum	$ 59	$ 4,977
	Pipe bedding	130	cum	$ 59	$ 7,707
	Wingwall fill	268	cum	$ 59	$ 15,917
	Fill around pipes	547	cum	$ 59	$ 32,441
2.0	**CULVERT STRUCTURE**				
2.0.1	**CONCRETE**				
	Concrete Class S40 apron slabs	101	cum	$ 234	$ 23,567
	Concrete Class S40 wingwalls	6	cum	$ 234	$ 1,403
	Concrete Class S40 headwalls	19	cum	$ 234	$ 4,445
	Concrete Class 6 precast pipe	70	units	$ 2,800	$ 194,767
	Concrete pavement, including mesh	164	sqm	$ 95	$ 15,646
	Safety Berm Lining	192	sqm	$ 95	$ 18,306
2.0.2	**SCOUR PROTECTION**				
	Rockfill scour protection	70	cum	$ 95	$ 6,665
2.0.3	**BAR REINFORCEMENT**				
	Steel reinforcing bar in apron slabs	20	t	$ 2,515	$ 50,698
	Steel reinforcing bar in wingwalls	1.2	t	$ 2,515	$ 3,018
	Steel reinforcing bar in headwalls	3.8	t	$ 2,515	$ 9,563
2.0.4	**FORMWORK**				
	Class F2 formwork to edge of apron slab	14	sqm	$ 220	$ 3,082
	Class F2 formwork to wingwalls	30	sqm	$ 233	$ 6,980
	Class F2 formwork to headwalls	26	sqm	$ 233	$ 6,049
	DETAILED DESIGN	10%			$ 42,063.36
	CONTRACTOR PRELIMINARIES	70%			$ 294,443.49
	CONTRACTOR MARGIN	10%			$ 42,063.36
	PROJECT CONTINGENCY	50%			$ 399,602
	TOTAL				**$ 1,198,806**

BOX CULVERT LOWERBOUND

Code	Description	Quantity	Unit	Rate (adjusted)	Total
1.0	**GENERAL EARTHWORKS**				
1.0.1	**EARTHWORKS, EXCAVATION**				
	Excavation for wingwalls, base slab, apron slab, all materials	27	cum	$ 23	$ 612
1.0.2	**BLINDING CONCRETE**				
	N20 Blinding concrete, 50 mm nominal thickness across base slab and apron slabs	39	cum	$ 414	$ 16,065
1.0.3	**SELECT FILL**				
	Granular fill on top of culverts	132	cum	$ 59	$ 7,836
	Safety berm	84	cum	$ 59	$ 4,977
	Wingwall fill	268	cum	$ 59	$ 15,917
2.0	**CULVERT STRUCTURE**				
2.0.1	**CONCRETE**				
	Concrete Class S40 base slab	132	cum	$ 234	$ 30,870
	Concrete Class S40 apron slabs	101	cum	$ 234	$ 23,567
	Concrete Class S40 wingwalls	6	cum	$ 234	$ 1,403
	Concrete Class S40 headwalls	2	cum	$ 234	$ 539
	Concrete Class S50 precast box culvert units	66	units	$ 3,756	$ 247,896
	Concrete Class S50 precast link slab units	44	units	$ 2,606	$ 114,664
	Concrete pavement, including mesh	164.1	sqm	$ 95	$ 15,646
	Safety Berm Lining	192	sqm	$ 95	$ 18,306
2.0.2	**SCOUR PROTECTION**				
	Rockfill scour protection	70.4	cum	$ 95	$ 6,665
2.0.3	**BAR REINFORCEMENT**				
	Steel reinforcing bar in base slab	26	t	$ 2,515	$ 66,407
	Steel reinforcing bar in apron slabs	20.2	t	$ 2,515	$ 50,698
	Steel reinforcing bar in wingwalls	1	t	$ 2,515	$ 3,018
	Steel reinforcing bar in headwalls	0.5	t	$ 2,515	$ 1,160
	Steel reinforcing bar in link slab	13.2	t	$ 2,515	$ 33,195
2.0.4	**FORMWORK**				
	Class F2 formwork to edge of base and apron slab	37	sqm	$ 220	$ 8,144
	Class F2 formwork to wingwalls	30	sqm	$ 233	$ 6,980
	Class F2 formwork to headwalls	26	sqm	$ 233	$ 6,049
	DETAILED DESIGN	7.5%			$ 51,000
	CONTRACTOR PRELIMINARIES	40%			$ 272,245.52
	CONTRACTOR MARGIN	10%			$ 68,061.38
	PROJECT CONTINGENCY	10%			$ 107,192
	TOTAL				**$ 1,179,113**

BOX CULVERT UPPERBOUND

Code	Description	Quantity	Unit	Rate (adjusted)	Total
1.0	**GENERAL EARTHWORKS**				
1.0.1	**EARTHWORKS, EXCAVATION**				
	Excavation for wingwalls, base slab, apron slab, all materials	27	cum	$ 23	$ 612
1.0.2	**BLINDING CONCRETE**				
	N20 Blinding concrete, 50 mm nominal thickness across base slab and apron slabs	39	cum	$ 414	$ 16,065
1.0.3	**SELECT FILL**				
	Granular fill on top of culverts	132	cum	$ 59	$ 7,836
	Safety berm	84	cum	$ 59	$ 4,977
	Wingwall fill	268	cum	$ 59	$ 15,917
2.0	**CULVERT STRUCTURE**				
2.0.1	**CONCRETE**				
	Concrete Class S40 base slab	132	cum	$ 234	$ 30,870
	Concrete Class S40 apron slabs	101	cum	$ 234	$ 23,567
	Concrete Class S40 wingwalls	6	cum	$ 234	$ 1,403
	Concrete Class S40 headwalls	2	cum	$ 234	$ 539
	Concrete Class S50 precast box culvert units	66	units	$ 3,756	$ 247,896
	Concrete Class S50 precast link slab	44	units	$ 2,606	$ 114,664
	Concrete pavement, including mesh	164.1	sqm	$ 95	$ 15,646
	Safety Berm Lining	192	sqm	$ 95	$ 18,306
2.0.2	**SCOUR PROTECTION**				
	Rockfill scour protection	70.4	cum	$ 95	$ 6,665
2.0.3	**BAR REINFORCEMENT**				
	Steel reinforcing bar in base slab	26	t	$ 2,515	$ 66,407
	Steel reinforcing bar in apron slabs	20.2	t	$ 2,515	$ 50,698
	Steel reinforcing bar in wingwalls	1	t	$ 2,515	$ 3,018
	Steel reinforcing bar in headwalls	0.5	t	$ 2,515	$ 1,160
	Steel reinforcing bar in link slab	13.2	t	$ 2,515	$ 33,195
2.0.4	**FORMWORK**				
	Class F2 formwork to edge of base and apron slab	37	sqm	$ 220	$ 8,144
	Class F2 formwork to wingwalls	30	sqm	$ 233	$ 6,980
	Class F2 formwork to headwalls	26	sqm	$ 233	$ 6,049
	DETAILED DESIGN	10%			$ 68,000.16
	CONTRACTOR PRELIMINARIES	70%			$ 476,429.66
	CONTRACTOR MARGIN	10%			$ 68,061.38
	PROJECT CONTINGENCY	50%			$ 646,553
	TOTAL				**$ 1,939,658**

Dubbo Quarry Continuation Project

Eulomogo Creek - Concept Options Report

Contact

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Brisbane
Hobart
Launceston
Newcastle
Devonport
Wagga Wagga

ref: NC19061B001 Concept Options Rep 31P Rev A