APPENDIX M

WATER ASSESSMENT

Proposed Segment Factory

Water Assessment

Prepared for Snowy Hydro Limited
September 2019

EMM
creating opportunities

Proposed Segment Factory

Water Assessment

Report Number

J17188 RP101

Client

Snowy Hydro Limited

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Executive Summary

ES1 Introduction

Snowy Hydro Limited (Snowy Hydro) proposes to develop Snowy 2.0, a large-scale pumped hydro-electric storage and generation project which would increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme (Snowy Scheme). Snowy 2.0 is the largest committed renewable energy project in Australia and is critical to underpinning system security and reliability as Australia transitions to a decarbonised economy. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and a new hydro-electric power station will be built underground.

The tunnels for Snowy 2.0 would be excavated, for the most part, using tunnel boring machines (TBMs) and would be lined using precast concrete segments. These segments are proposed to be manufactured at the proposed segment factory to be located on the south-eastern side of Polo Flat (the site), which is an industrial area located to the east of Cooma. Further details of the proposed segment factory are provided in Chapter 2 of this report.

This Water Assessment has been prepared to support an environmental impact statement for the proposed segment factory, and addresses the Secretary's Environmental Assessment Requirements that are relevant to surface water and groundwater.

ES2 Existing environment

The proposed segment factory is located on the south eastern side of Polo Flat, which is an industrial area located to the east of Cooma. The proposed site is within the upper reaches of the Cooma Creek catchment. Cooma Creek flows into the Numeralla River some 40 km downstream of Cooma. Land uses in the upstream catchment comprises a variety of land uses including the Cooma landfill, and abattoir and numerous agricultural properties.

An ephemeral watercourse, herein known as Watercourse A, traverses the site and the site is located on flood prone land. Existing flooding characteristics for the site and surrounds have been established by flood modelling (refer Annexure B), which shows that a large portion of the site is currently subject to out of bank flooding in the 10% and 1% annual exceedance probability (AEP) events and the Probable Maximum Flood (PMF) event. Floodwaters are predominantly associated with runoff from the upstream catchment area entering the site through Watercourse A, however there is also some flow through the eastern and western boundaries from adjacent properties.

Groundwater characteristics were defined by the Contamination Assessment that supports the EIS (Appendix K) for the proposed segment factory. Depth to the water table within the site ranges from between 5 m below ground level (BGL) to 10 m BGL and flows in a westerly direction.

ES3 Proposed water management

The key objectives of the proposed water management system are as follows:

- where practical, divert stormwater from upstream catchments around or through the site to reduce loading on the internal water management system;
- provide water quality treatment and enable reuse to reduce residual water quality risks;
- provide water quality controls that collectively meet industry standard pollutant load reductions;
- provide detention to mitigate increases in peak flows from impervious areas;

- separate potentially contaminating materials from the site stormwater system;
- minimise the infiltration of potentially poor quality surface runoff into the underlying groundwater system; and
- harvest stormwater to reduce stormwater overflows and demand from external water sources.

To achieve the key objectives, the proposed water management system includes:

- Source controls for water quality management.
- Diversions that divert upstream flows around the site. This includes the diversion of Watercourse A around the proposed segment factory with capacity to convey flows for events up to the 10% AEP. Other diversions of local stormwater runoff are proposed along the western and southern site boundaries.
- A water management basin located at the north of the site. The water management basin would have a dual function to provide water quality treatment as well as detention. The water management basin would be designed to achieve industry standard reduction targets for water quality and provide detention for flows from the site for events up to the 10% AEP.
- The separation of potentially cementitious runoff from the stormwater management system. This would be achieved with bunding of cementitious area and treatment of runoff in the area by a first flush tank and further water quality treatment. Further treatment would include pH dosing and dissolved air floatation to remove fine sediment, if proved necessary by testing.

Water supply for the project will be sourced from mains water supply and supplemented by harvested stormwater. Confirmation of suitable water quality will be required for use of harvested stormwater for concrete production.

In addition to the proposed water management system, mitigation measures will be implemented to manage potential water related impacts that include:

- preparation of erosion and sediment control plans to support construction of the proposed segment factory;
- preparation of a flood emergency response plan to manage residual flood risks during construction and operation of the site; and
- consideration to minimising adverse offsite flooding impacts to the extent practicable for events up to and including the 1% AEP as part of future detailed design.

ES4 Residual impacts

The performance of the proposed water management system was assessed through water quality and water balance modelling. Water quality modelling demonstrated that industry standard pollution reduction targets were achievable for the majority of the project duration in the event that harvested stormwater is confirmed as suitable for use in concrete production.

Stormwater discharges will occur due to overflows from the water management basin. The water quality of overflows is expected to be similar to the water quality of the unnamed watercourse on the site, with no significant departures expected. Hence, occasional short duration overflows from the basin are not expected to materially change or degrade the water quality of the unnamed watercourse or immediate downstream areas. No significant impact to water quality or river flow objectives is expected. Water balance modelling demonstrated that harvesting stormwater has the potential to substantially reduce mains water demand should it prove feasible to use stormwater for concrete production.

Earthworks for the proposed segment factory are unlikely to intercept the groundwater table and areas of potential poor water quality are proposed to be sealed to minimise infiltration. The reduction in aquifer recharge due to the reduced infiltration of the developed site are demonstrated to be negligible in the context of the water source. Impacts on groundwater are therefore expected to be negligible.

A flood impact assessment (refer Annexure B) considered the impacts of the proposed site layout on flooding for the 10% AEP, 1% AEP and PMF events. The assessment determined that some impacts will be experienced on surrounding properties which includes both increases and reductions to peak flood levels and hazard, with impacts varying by frequency of flooding. Predicted increases to peak flood level were typically limited to areas adjacent to the project site and found to be in the range of 0.1 to 0.3 m for events up to 1% AEP for industrial properties to the west of the site. Slightly higher impacts in these properties to a maximum of about 0.5 m were found to occur for the PMF.

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1 Introduction

1.1 Snowy 2.0

Snowy Hydro Limited (Snowy Hydro) proposes to develop Snowy 2.0, a large-scale pumped hydro-electric storage and generation project which would increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme (Snowy Scheme). Snowy 2.0 is the largest committed renewable energy project in Australia and is critical to underpinning system security and reliability as Australia transitions to a decarbonised economy. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and a new hydro-electric power station will be built underground.

Snowy 2.0 has been declared to be State significant infrastructure (SSI) and critical State significant infrastructure (CSSI) by the NSW Minister for Planning under Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). CSSI is infrastructure that is deemed by the NSW Minister for Planning and Public Spaces to be essential for the State for economic, environmental or social reasons. An application for CSSI must be accompanied by an environmental impact statement (EIS).

Separate applications are being submitted by Snowy Hydro for different phases of Snowy 2.0, including Exploratory Works for Snowy 2.0 (the Exploratory Works) and Snowy 2.0 Main Works (the Main Works).

The first phase of Snowy 2.0, the Exploratory Works (Application Number SSI 9208), includes an exploratory tunnel and portal and other exploratory and construction activities primarily in the Lobs Hole area of the Kosciuszko National Park (KNP). Exploratory Works has been assessed in a separate EIS and is subject to an approval issued by the former NSW Minister for Planning on 7 February 2019. Construction for Exploratory Works has already commenced.

The second phase of Snowy 2.0, the Snowy 2.0 Main Works (Application Number SSI 9687), covers the major construction elements of Snowy 2.0, including permanent infrastructure (such as the underground power station, power waterways, access tunnels, chambers and shafts), temporary construction infrastructure (such as construction adits, construction compounds and accommodation), management and storage of extracted rock material and establishing supporting infrastructure (such as road upgrades and extensions, water and sewage treatment infrastructure, and the provision of construction power). Snowy 2.0 Main Works also includes the operation of Snowy 2.0. The EIS for Snowy 2.0 Main Works was submitted to the NSW Department of Planning, Industry and Environment (DPIE) in September 2019.

A separate application has also been submitted for a proposed factory that would manufacture precast concrete segments that would line the tunnels being excavated for Snowy 2.0 (Application Number SSI 10034). This Water Assessment supports the EIS for the proposed segment factory.

On 26 June 2019, Snowy Hydro referred the proposed segment factory (Reference Number 2019/8481) to the Commonwealth Minister for the Environment under the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). On 13 August 2019, the proposed segment factory was determined by the Acting Assistant Secretary Assessments and Waste Branch of the Commonwealth Department of the Environment and Energy (DEE), as delegate to the Minister, to be 'not a controlled action' and therefore does not require further assessment or approval under the EPBC Act.

1.2 The proposed segment factory

The tunnels for Snowy 2.0, including the exploratory tunnel for Exploratory Works and underground tunnels linking Tantangara and Talbingo reservoirs for the Main Works, would be excavated, for the most part, using tunnel boring machines (TBMs) and would be lined using precast concrete segments. These segments are proposed to be manufactured at the proposed segment factory to be located on the south-eastern side of Polo Flat (the site), which is an industrial area located to the east of Cooma.

The proposed segment factory would contain a building for the casting and curing of the segments, uncovered storage areas for raw materials and segments, vehicle parking areas and associated offices and workshops.

Main inputs for the segments include aggregate, sand, cement, water and rebar steel. Primary outputs include the segments which would be transported to the TBM launch sites for Exploratory Works and Main Works within KNP.

The construction phase of the proposed segment factory would last about five months utilising a workforce of about 30 people. Construction would take place six days a week (from Monday to Saturday) and for 10 hours per day.

The factory would operate over a period of about 3.5 years utilising a workforce of about 125 people. It would be operational 24 hours a day, seven days a week.

The proposed segment factory would be constructed and operated by Future Generation Joint Venture (FGJV) which has been contracted by Snowy Hydro to construct Snowy 2.0.

At the completion of the construction of Snowy 2.0, the proposed segment factory would be decommissioned.

Further details of the proposed segment factory are provided in Chapter 2 of this report.

1.3 Location of the site

The site of the proposed segment factory is located on the south-eastern side of Polo Flat, predominantly on the southern part of the land owned by Snowy Hydro. The site is located to the east of Polo Flat Road and to the north of Carlaminda Road.

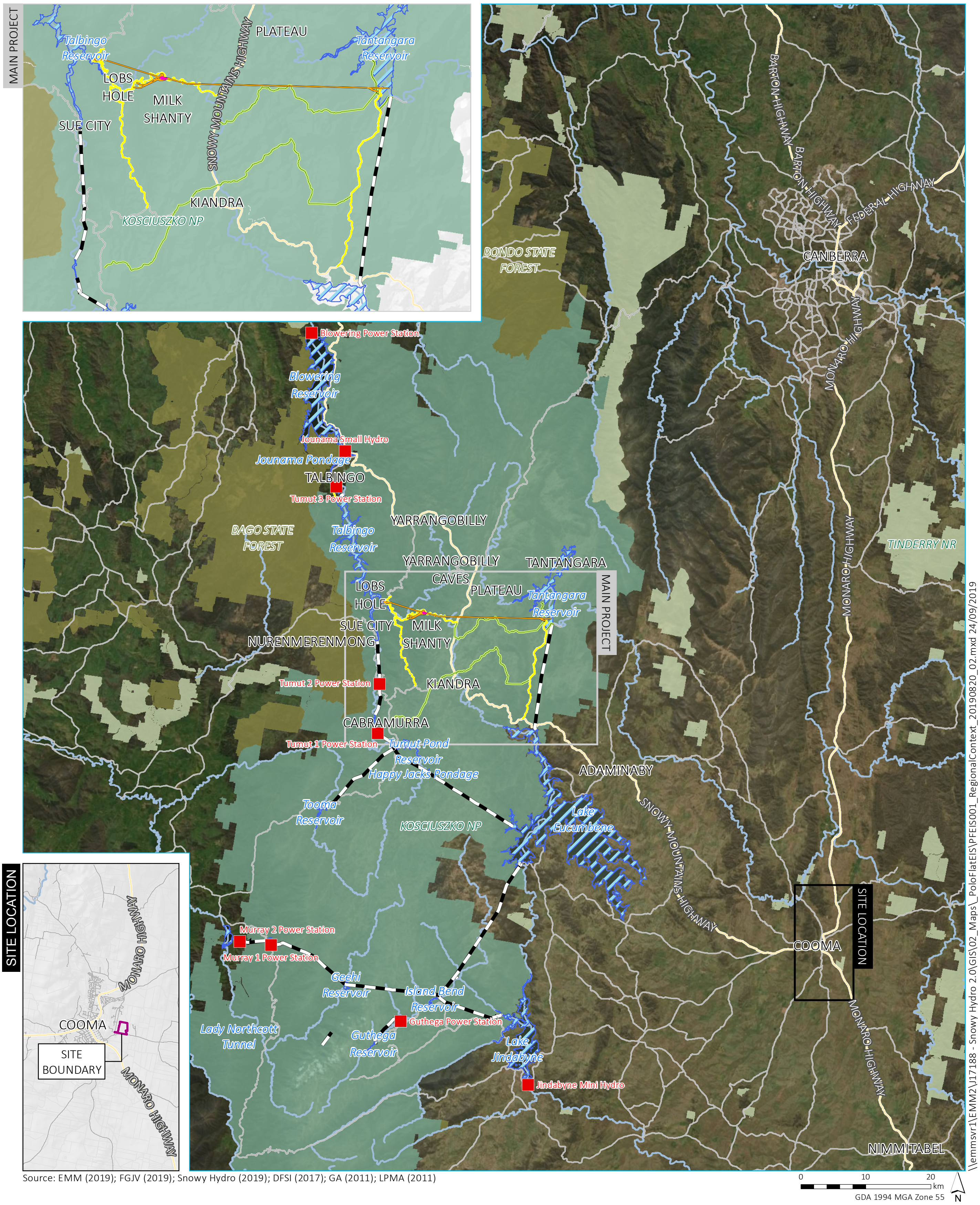
Figure 1.1 shows the location of the site in a regional context and Figure 1.2 shows the site in its local context.

The site contains the following land parcels:

- southern part of Lot 14 in Deposited Plan (DP) 250029 – also known as 9 Polo Flat Road, Polo Flat;
- Lot 3 in DP 238762 – also known as 33 Carlaminda Road, Polo Flat; and
- an unmade road corridor, directly south of the aforementioned lots.

Except for a few buildings located on the southern part of Lot 3 in DP 238762, the site is vacant and dominated by grassland. An unnamed third order watercourse flows in a north-westerly direction through the middle of the site.

Lot 14 in DP 250029 is a large parcel of land which contains a private airfield predominantly located in the middle and northern part of the land. This airfield was originally established in 1921 and further developed in the late 1950s and 1960s to service the Snowy Scheme. It became the base for the Snowy Mountains Hydro-electric Authority's (the predecessor to Snowy Hydro) flying unit and aircraft. The land was sold by Snowy Hydro in 1998 where it continued use as a private airfield. Snowy Hydro purchased the land again in early 2019.



Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); GA (2011); LPMA (2011)

KEY

Site boundary

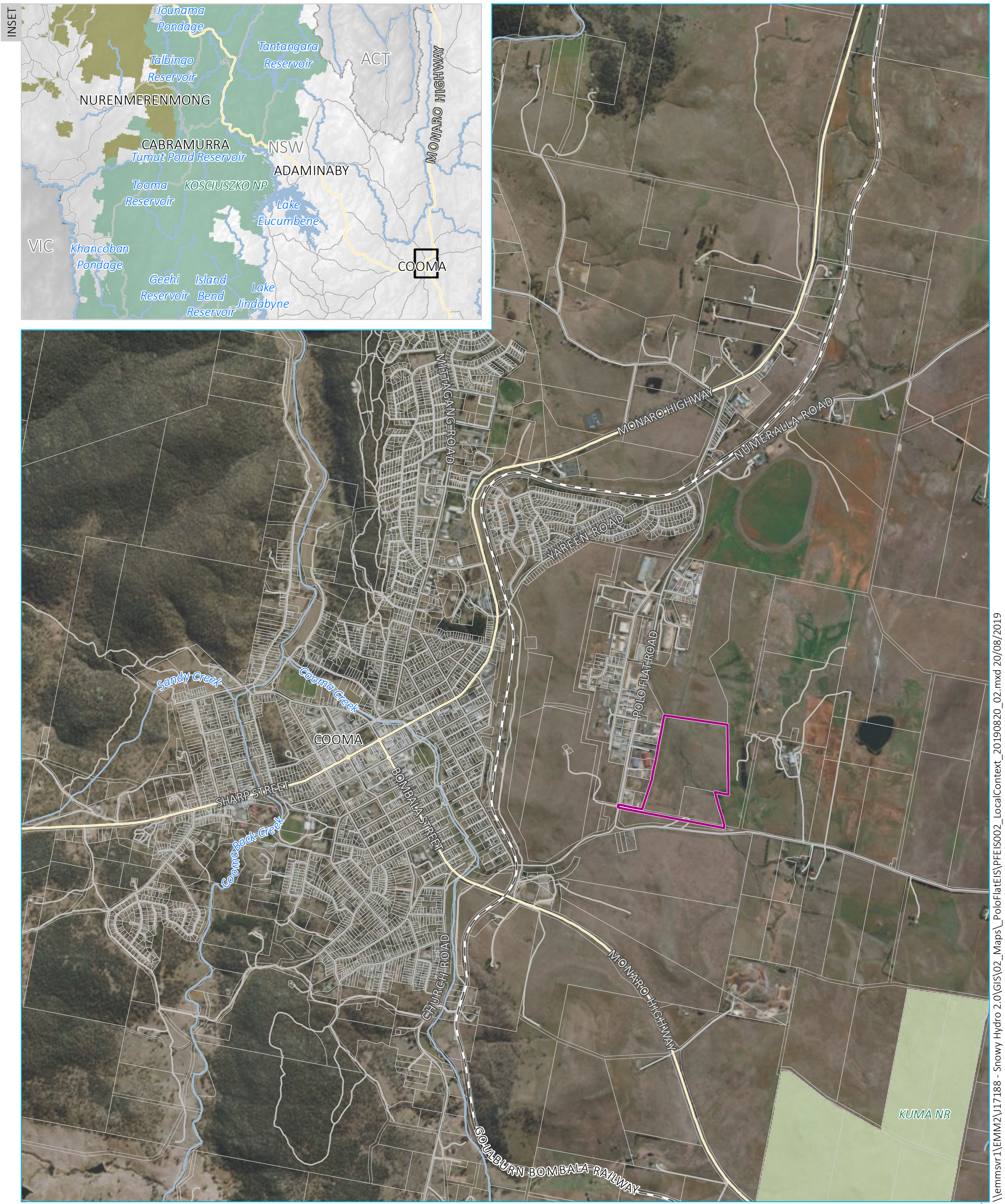
Snowy 2.0 project elements
- Utilities
- Tunnels, portals, intakes
- Power station
- Permanent roads and surface infrastructure

Existing Snowy Scheme
- Existing power station
- Existing pipeline tunnel
- Scheme storage

- Main road
- Local road or track
- Watercourse
- Kosciuszko National Park
- NPWS reserve
- State forest

Location of the project area

Snowy 2.0
Water Assessment
Proposed Segment Factory
Figure 1.1



Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); GA (2011); LPMA (2011)

KEY
- Site boundary
- Rail line
- Main road
- Local road or track
- Watercourse
- Cadastral boundary
- NPWS reserve

Location of site in local context

Snowy 2.0
Water Assessment
Proposed Segment Factory
Figure 1.2

The site is surrounded by industrial development to the west and predominantly rural land to the south and east. To the north of the site is the remainder of Lot 14 in DP 250029 which contains the private airfield, and other industrial development. Snowy Hydro's private airfield contains a main north-south aligned runway, hangers and offices. It also contains an above ground fuel tank for the refuelling of planes and helicopters.

Lot 3 in DP 238762 contains a communications tower which ceased use (ie transmission) in August 2019.

There is an isolated industrial operation containing a residence located about 150 metres (m) to the south-east of the site, and an abattoir located about 350 m to the east.

The nearest residence is a rural residence located about 450 m to the south-south-east of the site. The nearest residences within Cooma are located about 1 km to the west of the site.

1.4 Proponent

Snowy Hydro is the proponent for the proposed segment factory. Snowy Hydro is an integrated energy business – generating energy, providing price risk management products for wholesale customers and delivering energy to homes and businesses. Snowy Hydro is the fourth largest energy retailer in the NEM and is Australia's leading provider of peak, renewable energy.

As previously stated, the proposed segment factory would be constructed and operated by FGJV which has been contracted by Snowy Hydro to construct Snowy 2.0.

1.5 Purpose of this report

This Water Assessment supports the EIS for the proposed segment factory. It characterises the existing environment as relevant to surface water and groundwater based on a combination of desktop based assessments and field investigations and documents the ways in which issues relating to water, particularly with respect to flooding and stormwater management, have been considered in project design. This Water Assessment provides commitments on ongoing mitigation and management strategies to minimise impact to surface water and groundwater and makes an assessment of associated impacts including any unavoidable residual impacts.

The specific objectives of this assessment are to:

- describe and characterise the existing surface water and groundwater environment;
- identify and assess impacts to surface water and groundwater during construction and operation of the proposed segment factory; and
- provide mitigation and management measures to reduce the impacts associated with the proposed segment factory to surface water and groundwater resources.

1.6 Assessment requirements

This Water Assessment has been prepared in accordance with the:

- Secretary's Environmental Assessment Requirements (SEARs), issued by the DPIE on 31 July 2019; and
- Agency submissions issued by DPIE – Water and the Natural Resources Access Regulator (NRAR) dated 1 August 2019.

The SEARs must be addressed in the EIS. Table 1.1 lists the matters relevant to this assessment and where they are addressed in this report.

Table 1.1 Relevant matters raised in SEARs – Surface water and groundwater

Assessment requirements	Comment or section addressed
SEARs	
A detailed site water balance for the project, including the water take from each surface and ground water source	Section 5.4
An assessment of the impacts of the project on the quantity and quality of the area's surface and groundwater resources	Section 7
An assessment of the impacts of the project on hydrological flows, including any potential flooding impacts	Sections 6 and 7.2
An assessment of the impacts of the project key water features on site, including potential impacts on riparian land	Sections 7.2 and 9.2
An assessment of the impacts of the project on water-related infrastructure and water users	Section 7.2

The regulatory framework and context, and relevant guidelines, are described in Section 3.

2 Project description

2.1 Introduction

It is proposed to construct and operate a factory on the site to supply precast concrete segments that would line the tunnels for Snowy 2.0.

The construction phase of the proposed segment factory would last about five months utilising a workforce of about 30 people. The operational phase would last about 3.5 years utilising a workforce of about 125 people.

The proposed segment factory would be decommissioned at the completion of operations.

2.2 Construction

2.2.1 Main activities

The following main activities would be undertaken for the construction of the proposed segment factory:

- demolition and removal of buildings and decommissioned telecommunications tower on the southern part of site;
- clearing, removal of topsoil and vegetation (topsoil excavated would be stockpiled on site for later use if deemed suitable);
- undertaking earthworks to establish level surfaces;
- establishment of primary access road;
- installation of site services (power, water, communications, gas and wastewater);
- establishment of site surfaces (ie concrete, asphalt and cement soil); and
- construction of site facilities and buildings, including precast building, concrete batching plant (CBP), workshops, offices, parking areas, storage areas and associated facilities.

2.2.2 Earthworks

Excavation will be carried out at the site to provide level surfaces, establish the access road and create the required trenches for drainage.

Where possible excavated material would be reused on site for filling and compaction (including benching areas of the site where required). Where there is a deficit of excavated material, additional material would be sourced from local quarries.

2.2.3 Traffic movements

Construction vehicle movements will comprise construction worker's light vehicles and heavy vehicles transporting equipment, building and construction materials, waste, and fill material if required.

2.2.4 Construction timeframe and hours

The construction phase of the proposed segment factory would last about five months (estimated to commence in March 2020 subject to obtaining the required approvals). Construction would be undertaken from Monday to Saturday for 10 hours per day. Access to the site would generally start at 6 am for pre-starts and toolbox talks, and construction would commence at 7 am.

2.2.5 Workforce

A workforce of about 30 people would be required to construct the proposed segment factory.

2.3 Operations

2.3.1 General

The segments would be produced by casting concrete (made in the CBP) in reusable steel moulds which would then be cured in a chamber. Following curing, the segments would be temporarily stored onsite before being transported to the TBM launch sites within KNP.

The casting and curing would be undertaken in the precast building. Storage of the segments would predominantly be undertaken in uncovered storage areas.

Main inputs for the segments include aggregate, sand, cement, water and steel rebar.

Approximately 130,500 segments would be manufactured over the operational period.

2.3.2 Site layout

The layout of the proposed segment factory is shown in Figure 2.1. Details of the site layout are provided below.

i General layout

The CBP and precast building (which contains a casting room and curing chamber) would be located at the southern end of the site. Open storage areas would be located predominantly to the north of the building on the northern part of the site.

Site offices and workshops would be located in the south-western corner of the site.

ii Ingress and egress

Vehicle ingress and egress to the site would be provided on a new access road which would connect to Polo Flat Road. The access road would be constructed on an existing informal service road located in the unmade road corridor immediately north of Carlaminda Road.

iii Raw materials storage

Cement silos, and aggregate and sand storage areas for the CBP would be located adjacent to the CBP. Storage would be sized to hold approximately three days production.

Other raw materials include steel rebar and concrete admixtures which would be stored in, or adjacent to, the precast building.

Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); ESRI (2019); GA (2011); LPMA (2011)

0 100 200 m
GDA 1994 MGA Zone 55
N

KEY

- Site boundary
- Local road or track
- Cadastral boundary
- Indicative site layout
- Precast yard, concrete plant, aggregates area, precast warehouse, segment storage
- Bus stop and parking
- Offices, guard house and first aid
- Mechanical and plant workshop with parking
- Trailer parking
- Storage area
- Emergency storage area
- Detention basin
- Drainage

Proposed layout

Snowy 2.0
Water Assessment
Proposed Segment Factory
Figure 2.1

snowy 2.0

EMM creating opportunities

iv Parking

Two large parking areas are proposed in the south-western corner of the site, and to the north of the precast building. Parking in the south western area would be used for light vehicles, trucks and buses. Parking to the north of the precast building would be used for trucks.

v Drainage

A diversion drain would be constructed around the eastern perimeter of the site to divert water from the unnamed third order watercourse. The drain diversion would be constructed to match the general width and depth of the existing watercourse.

A water management basin would be provided to the north of the site to collect surface flows. Overflows from the basin would be directed into the diversion drain.

Further details of proposed site drainage and general water management are provided in Section 5.

2.3.3 Utility connections

The proposed segment factory would be connected to utility mains, including communications, electricity, water, wastewater and gas.

2.3.4 Segment inputs

As previously stated, main inputs for the precast concrete segments include aggregate, sand, cement, water and steel rebar. These main inputs would likely be sourced from locations in proximity to site and/or from quarries near Canberra.

Water for concrete production would be sourced from harvested stormwater generated within the site, supplemented by mains water supply as required. Further details of water demands and sources of supply are provided in Section 5.

In addition to these main inputs, several accessories are also required to produce the segments, such as reinforcement cages, steel fibres, gaskets and inserts. These inputs would likely be sourced locally or from Canberra.

2.3.5 Segment transport

Following casting, curing and storage, the segments would be transported to the TBM launch sites within KNP.

2.3.6 Traffic movements

Operational vehicle movements will comprise light vehicles (worker's vehicles and service vehicles) and heavy vehicles required for the transportation of the main inputs for the segments and for the transportation of the segments from the site to the TBM launch sites within KNP.

2.3.7 Staff and manpower

A workforce of about 125 people would be required to operate the proposed precast segment factory. As many local workers as possible would be sourced from the Snowy Mountains Regional LGA and surrounding localities.

2.3.8 Hours of operation

It is proposed to operate the proposed segment factory 24 hours a day, seven days a week. It is estimated that the factory would operate for a period of about 3.5 years.

2.4 Decommissioning

As previously stated, the proposed segment factory would be decommissioned at the completion of construction of Snowy 2.0 which would include removal of all plant and equipment. Snowy Hydro would retain the main structures such as the precast building, workshops and offices and seek to use these for an alternative industrial use.

It is envisaged that Snowy Hydro would submit a development application (DA) to SMRC for an alternative use of the site prior to the decommissioning phase of the project.

3 Regulatory framework and context

3.1 Overview

This section describes relevant government regulations, plans, guidelines and studies that have been considered in this Water Assessment. NSW Government water quality and river flow objectives are also presented.

Assessment requirements in terms of the SEARS for the project are set out in Section 1.6.

3.2 Regulatory framework

The primary water related statutes that apply to water management in NSW are the NSW *Water Act 1912 (*Water Act*),* NSW *Water Management Act 2000* (WM Act) and the NSW *Protection of the Environment Operations Act 1997* (POEO Act) and their attendant regulations. There are also local planning instruments which, whilst not strictly applicable to the proposed segment factory as a CSSI, are considered in this Water Assessment, including the Cooma-Monaro Local Environmental Plan 2013 (the LEP) and the Cooma-Monaro Shire Development Control Plan 2014 (Amendment 1) (the DCP).

3.2.1 NSW Water Act 1912

The Water Act is gradually being repealed and replaced by the WM Act as water sharing plans (WSPs) are developed for water sources across NSW, and as new regulations are made.

Whilst some aspects of the Water Act are still operational across all of NSW, there are no provisions relevant to the proposed segment factory.

3.2.2 NSW Water Management Act 2000

The WM Act is based on the principles of ecologically sustainable development and the need to share and manage water resources for future generations. The WM Act recognises that water management decisions must consider: economic, environmental, social, cultural and heritage factors. It recognises that sustainable and efficient use of water delivers economic and social benefits to the state of NSW.

The WM 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 WM Act apply to those areas where a WSP has commenced.

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

Watercourse A is therefore defined as a river under the WM Act and therefore the proposed activities are considered to be on waterfront land. Section 91 of the WM Act details that controlled activity approvals are required for certain activities in, on or under waterfront land. While controlled activity approvals are required for works on waterfront land, Section 5.23 of the EP&A Act details that controlled activity approvals are not required for approved SSI and CSSI projects. The proposed segment factory has been declared as CSSI and therefore, should approval be granted, section 5.23 of the EP&A Act removes the requirement for a controlled activity approval to undertake work on waterfront land.

3.2.3 Water sharing plans

WSPs are statutory documents that apply to one or more water sources. They contain 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 then outline the water available for extractive uses within different categories, such as: local water utilities, domestic and stock, basic rights, and access licences.

The project is not proposed to extract water from the relevant water sources, however the water sharing plans and water sources relevant to the site are:

- *Water Sharing Plan for the Murrumbidgee unregulated and alluvial water sources (2012),* Numeralla West water source in Cooma management zone, which applies to surface and alluvial water sources in the vicinity of the site; and

- *Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011,* Lachlan Fold Belt groundwater source, which applies to groundwater sources in the vicinity of the site.

Section 9 addresses water licensing requirements for the proposed segment factory.

3.2.4 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (AIP) defines activities which are considered an 'aquifer interference activity' and outlines the policy around which activities require a groundwater license. The proposed segment factory is assessed under this guideline in Section 9.

3.2.5 NSW Protection of the Environment Operations Act 1997

The POEO Act establishes the NSW environmental regulatory framework and includes licensing requirements for certain activities. Environment Protection Licences (EPLs) for water discharge are administered by the NSW Environment Protection Authority (EPA) under the POEO Act. The application of the POEO Act for stormwater discharge licensing at the proposed segment factory will be determined through consultation with the EPA.

3.3 Local planning instruments

The LEP and DCP guides planning decisions through zoning and development controls, which include considerations for development on flood prone land. The DCP also provides design guidance for stormwater management and erosion and sediment control. These local planning instruments have been considered in the preparation of this Water Assessment.

3.4 Relevant guidelines

The following guidelines have been considered when preparing this Water Assessment.

3.4.1 Floodplain Development Manual

The NSW Floodplain Development Manual is a document published in 2005 by the NSW Government. The document details flood prone land policy which has the primary objective of reducing the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits from occupation and development of flood prone land.

3.4.2 Erosion and Sediment Control Guidelines

Managing Urban Stormwater: Soils and Construction – Volume 1 (Landcom 2004) provides guidance on best practice erosion and sediment control methods.

3.4.3 Bunding and Spill Management Guidelines

The following NSW Government guidelines detail best practice storage, handling and spill management procedures for liquid chemicals:

- *Liquid Chemical Storage, Handling and Spill Management: Review of Best Practice Regulation* (DECC 2005); and
- *Storing and Handling Liquids: Environmental Protection: Participant's Manual* (DECC 2007).

3.4.4 Australian Rainfall and Runoff 2016

Australian Rainfall and Runoff (Ball et al 2016) is a national guideline document, data and software suite that can be used for the estimation of design flood characteristics in Australia. This guideline is referred to as ARR2016 in the remainder of this document.

3.4.5 Australian Guidelines for Water Quality Monitoring and Reporting

The Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australian and New Zealand (ARMCANZ) published the revised Australian and New Zealand guidelines for fresh and marine water quality in 2000. These guidelines 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.

These guidelines have been applied to establish water quality objectives and environmental values for watercourses that can potentially be impacted by the proposed segment factory. Water quality objectives and environmental values are discussed in Section 3.6.

3.5 Relevant studies

3.5.1 Snowy Monaro Regional Council Flood Studies

SMRC is currently undertaking a regional flood study which examines flooding throughout several towns, including Cooma (SMEC/GRC Hydro 2019). This study provides the most up to date information on local flood behaviour for the site. SMRC consented for the flood models that were developed as part of the study to be used to inform the flood risk assessment for the proposed segment factory that is documented in Section 6 of this report.

3.6 Water quality and river flow objectives

The *NSW Water Quality and River Flow Objectives* (DECCW 2006) provides Water Quality Objectives (WQOs) that are consistent with ANZECC/ARMCANZ (2000) water quality guidelines for the protection of the aquatic environment. The WQOs are "primarily aimed at maintaining and improving water quality, for the purposes of supporting aquatic ecosystems, recreation and where applicable water supply and the production of aquatic foods suitable for consumption and aquaculture activities" (DECCW 2006).

WQOs are provided for catchments throughout NSW (DECCW 2006). The primary watercourse that can potentially be impacted by the proposed segment factory is an unnamed tributary of Cooma Creek, which lies within the Murrumbidgee River and Lake George Catchment. Cooma Creek and its tributaries are classified as "Uncontrolled Streams" and are classed as upland rivers given elevation above 150 m to Australian Height Datum (AHD).

Table 3.1 summarises the WQOs and river flow objectives (RFOs) for uncontrolled streams and applicability to the site.

Table 3.1 Application of water quality and river flow objectives

Environmental value	Objective	Application to the proposed segment factory
WQOs		
Aquatic ecosystems	Maintaining or improving the ecological condition of water bodies and their riparian zones over the long term.	There are aquatic ecosystems downstream of the project. The protection of aquatic ecosystems is the primary water quality objective to be met.
Visual amenity	Aesthetic qualities of waters.	There are no public views or access to the site watercourse adjacent to the project area or immediate downstream areas
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 no public access to the watercourse adjacent to the project area or immediate downstream areas.
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 no public access to the watercourse adjacent to the project area or immediate downstream areas.
Irrigation water supply	Protecting the quality of waters applied to crops and pasture.	Some downstream users may extract water from Cooma Creek for agricultural purposes.
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.	It is unlikely that any downstream users extract water from Cooma Creek for homestead water supply.
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 to Cooma is sourced from the Murrumbidgee River. No water is extracted from Cooma Creek downstream of the project area for town water supply.
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 Cooma Creek, however, the trigger values for aquatic foods apply to aquaculture not recreational fishing. The required level of protection will be provided by meeting the trigger values for aquatic ecosystems.
RFOs		
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 in Cooma Creek have been modified by land clearing, mining, urban and industrial development,

Table 3.1 Application of water quality and river flow objectives

Environmental value	Objective	Application to the proposed segment factory
Protect natural low flows	Share low flows between the environment and water users and fully protect very low flows.	waste disposal and processing, water harvesting and extraction within the catchment. Stormwater discharges from the project will enter the unnamed watercourse adjacent to the project area prior to entering Cooma Creek. Hence, the project has potential to impact existing flow regimes in Cooma Creek.
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.	Groundwater level across site is between 5–10 m BGL.
Minimise the effects of weirs and other structures	Minimise the impact of instream structures.	The design of the facility will consider mechanisms to reduce watercourse impacts associated with the proposed diversion drain.

3.6.1 Trigger values

The trigger values applicable to each water quality objective are provided in DECCW (2006). The trigger values vary depending on the environmental value, with the trigger values for the protection of aquatic ecosystems generally being the lowest. Default trigger values for upland rivers are provided in Table 3.2. These include an expanded list of analytes that are applicable to the visual amenity, secondary recreational contact and primary recreational contact.

The default trigger values have been applied to this Water Assessment and are referred to as WQO values in the remainder of this report. The WQO values do not make allowance for site specific factors that may influence water quality.

Table 3.2 Default trigger (WQO) values

Indicator	WQO value	Basis (most sensitive use)
Physico-chemical		
pH	6.5 – 8.0	Aquatic ecosystems
Turbidity	2–25 Nephelometric Turbidity Unit (NTU)	Aquatic ecosystems
Salinity (electrical conductivity)	30–350 microsiemens per centimetre (µS/cm)	Aquatic ecosystems
Dissolved oxygen	90-110%	Aquatic ecosystems
Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and litter.	Visual amenity
Chemicals		
Filterable reactive phosphate (FRP)	15 micrograms per litre (µg/L)	Aquatic ecosystems
Total phosphorus	20 µg /L	Aquatic ecosystems
Total ammonia-N	13 µg /L	Aquatic ecosystems
Oxides of nitrogen (NO_x)	15 µg /L	Aquatic ecosystems
Total nitrogen	250 µg /L	Aquatic ecosystems
Chemical contaminants/ toxicants	ANZECC/ARMCANZ (2000), Chapter 3.4 and Table 3.4.1 - see Section 3.6.2 below.	Aquatic ecosystems
Biological		
Chlorophyll-a	Not applicable to upland rivers.	Aquatic ecosystems
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.	Visual amenity
Faecal coliforms	Median over bathing season of < 150 faecal coliforms per 100 mL, with 4 out of 5 samples < 600/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).	Primary contact recreation
Enterococci	Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60-100 organisms/100 mL)	Primary contact recreation
Algae and blue-green algae	An increasing risk to livestock health is likely when cell counts of microcystins exceed 11 500 cells/mL and/or concentrations of microcystins exceed 2.3 µg/L expressed as microcystin-LR toxicity equivalents.	Livestock water supply

3.6.2 Aquatic ecosystem protection

The ANZECC/ARMCANZ (2000) guidelines (Table 3.4.1) present default trigger values for toxicants for the protection of 99%, 95%, 90% and 80% of aquatic species. This table also presents default trigger values for the protection of slightly–moderately disturbed ecosystems that are based on the default trigger values for the protection of 95% of species, but which use the lower default trigger values for the protection of 99% of species for chemicals for which possible bioaccumulation and secondary poisoning effects should be considered.

The ANZECC/ARMCANZ (2000) guidelines (Section 3.1.3) describe slightly-moderately disturbed ecosystems as "ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity''. Cooma Creek and its catchment has been modified by land clearing, mining, urban and industrial development, landfill and waste processing, instream structures, introduced flora and fauna and water extraction. Hence, Cooma Creek is considered to be a slightly-moderately disturbed ecosystem and the default trigger values for the protection of slightly–moderately disturbed ecosystems have been applied.

4 Existing environment

4.1 Overview

This section provides information on the existing environment at the site, as relevant to this Water Assessment.

4.2 Hydrological features and context

4.2.1 Watercourses

The proposed segment factory is located in the upper reaches of the Cooma Creek catchment. Cooma Creek flows into the Numeralla River some 40 km downstream of Cooma. The regional hydrological context is shown in Figure 4.1.

There are three watercourses located in or near the site. As these watercourses are unnamed, they are referred to as Watercourses A, B and C herein for convenience, and their location is shown on Figure 4.2. All watercourses are known to have an ephemeral flow regime. Referenced photographs below are contained in Annexure A.

Watercourse A is a third order watercourse which traverses the site, flowing generally from the south-east to the north-west. The upstream catchment is approximately 4.6 km^2 in area and comprises a variety of land uses including the Cooma landfill which is approximately 1.5 km upstream (south) of the site, the Monbeef abattoir facility 0.5 km to the east of site, as well as numerous agricultural properties. The upper reach of Watercourse A within the site is vegetated primarily with grass cover (Photograph A.1). The watercourse has been piped via a single 750 mm diameter culvert where it runs under the airfield runway (Photograph A.2) before discharging back into a vegetated open channel located along the western edge of the site. Watercourse A continues generally to the north (Photograph A.3), ultimately discharging to Cooma Creek approximately 7.5 km downstream (north) of the site.

Watercourse B is a second order watercourse with a small catchment area of approximately 0.2 km^2, consisting of a portion of the adjoining property to the east of the site. The watercourse enters the site for only a short distance along the northern boundary, and is formed generally as a shallow, grassed depression. Watercourse B joins Watercourse A approximately 100 m downstream of the site.

Watercourse C is a first order watercourse that joins Watercourse B east of the site.

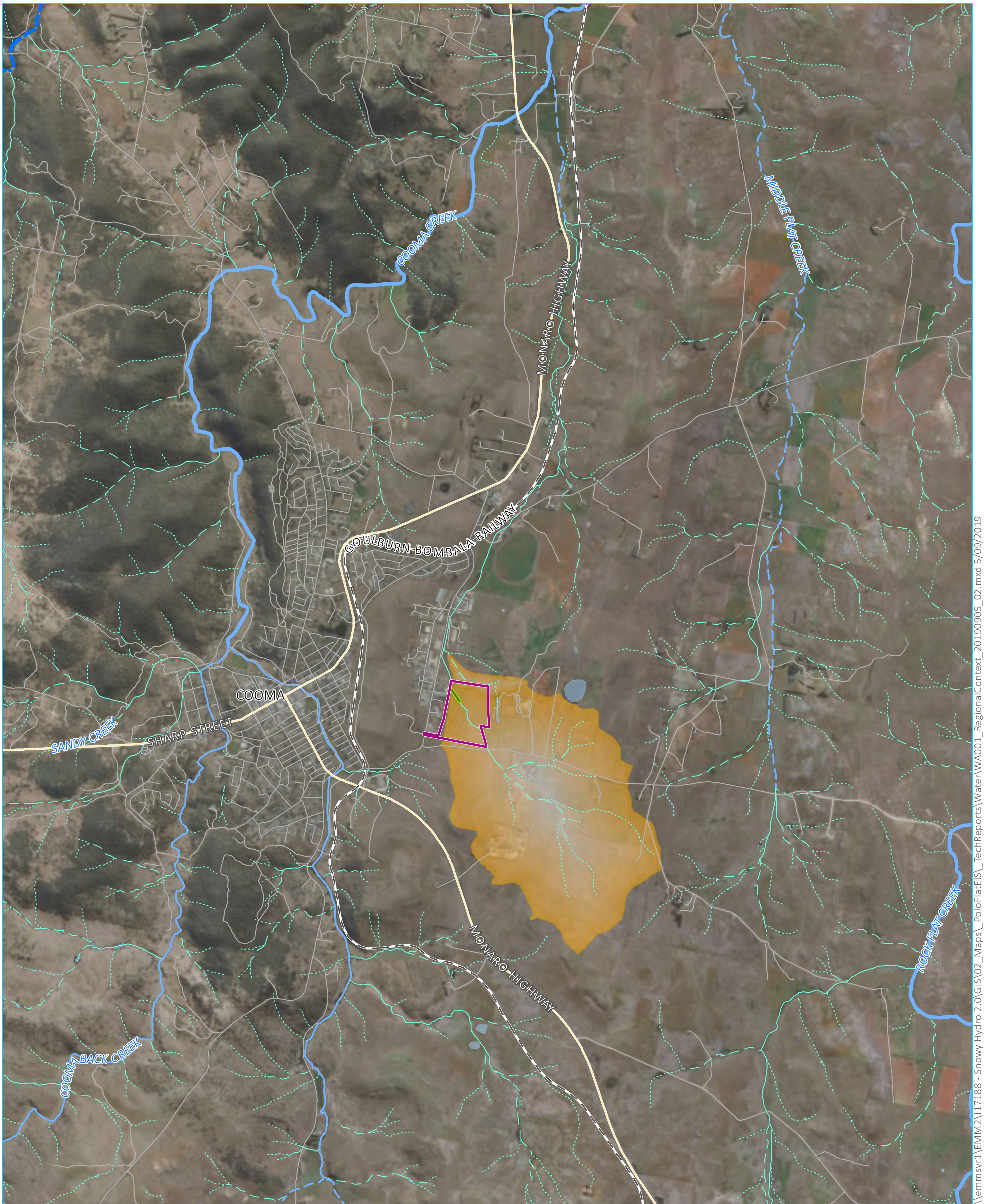
4.2.2 Local drainage

A network of piped drainage conveys stormwater from the surrounding industrial areas to Watercourse A. Some piped drainage and minor flow paths convey stormwater from adjoining properties on the western boundary to the excavated section of Watercourse A. This drainage network is indicated on Figure 4.2.

Natural drainage paths follow the topography, which generally grades gently from east to west. Topography is shown on Figure 4.2.

4.2.3 Water bodies

There are no water bodies on site. There are, however, several constructed farm dams on adjoining property to the east of the site. These capture water from a first-order tributary to Watercourse C and are shown on Figure 4.2.



Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); ESRI (2019); DPI (2013); GA (2011); LPMA (2011)

0 1 2 km

GDA 1994 MGA Zone 55

N

KEY

- Site boundary
- Rail line
- Main road
- Local road or track
- Piped drainage
- Catchment area
- Waterbody

Strahler stream order

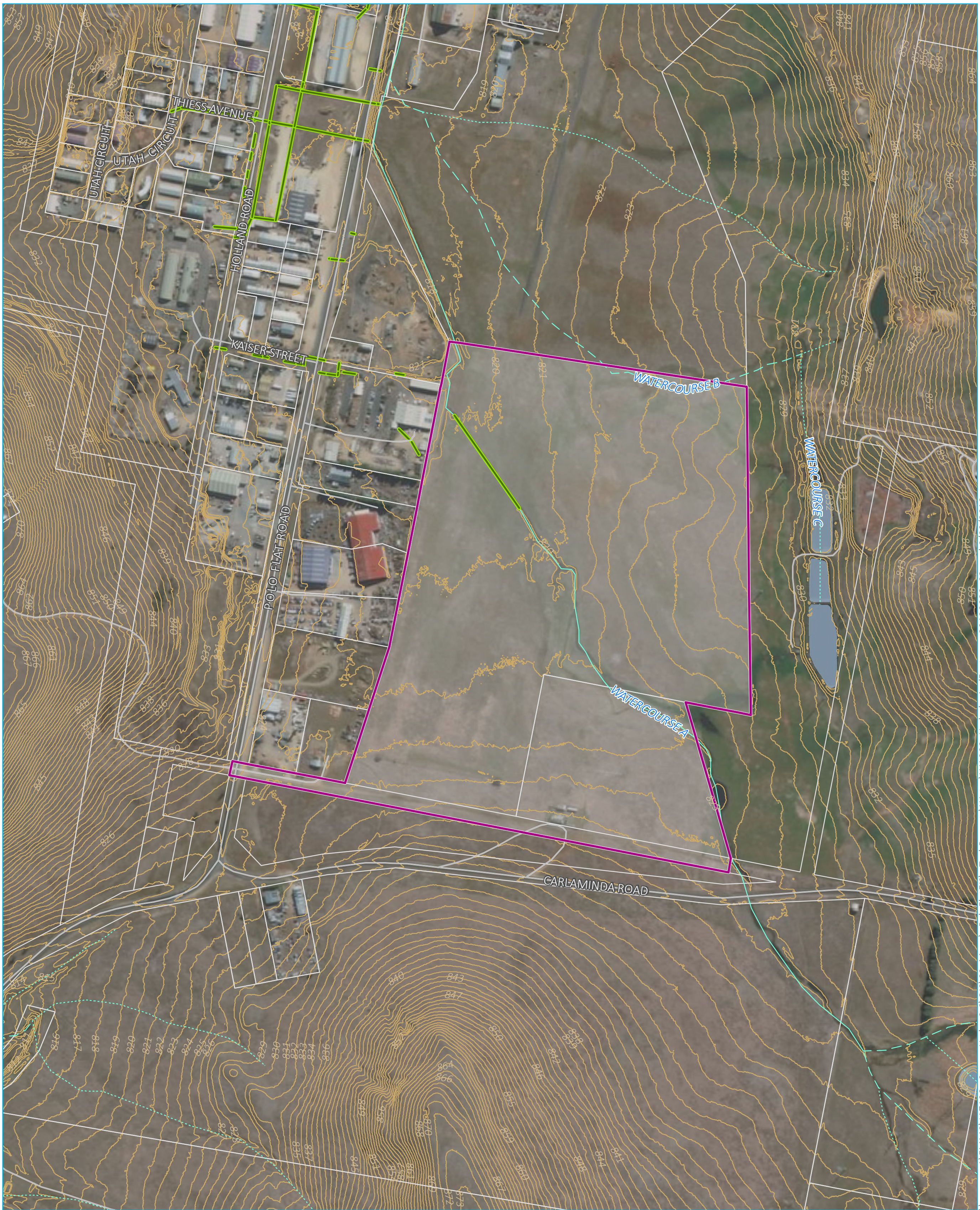
- 1st order
- 2nd order
- 3rd order
- 4th order
- 5th order
- 6th order
- 7th order

Regional hydrological context

Snowy 2.0
Water Assessment
Proposed Segment Factory
Figure 4.1

snowy 2.0

EMM creating opportunities



Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); ESRI (2019); GA (2011); LPMA (2011)

0 100 200 m
GDA 1994 MGA Zone 55

KEY

Site boundary
Local road or track
Contour (1 m)
Piped drainage
Cadastral boundary
Waterbody

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

Hydrological features

Snowy 2.0
Water Assessment
Proposed Segment Factory
Figure 4.2

snowy 2.0

EMM creating opportunities

4.2.4 Other surface water users

Registered surface water use in the Numeralla West water source includes stock and domestic use and unregulated river supply. At the time of writing, all unregulated river WAL allocations were exhausted. There were 5.5 share components available under the stock and domestic access license category.

Town water supply to the Cooma-Monaro region is sourced largely from the Murrumbidgee River. No water is extracted from Watercourse A and immediate downstream areas for town water supply.

4.3 Water quality characterisation

Due to the ephemeral nature of Watercourse A, there has at the time of writing been no water quality sampling undertaken to characterise Watercourse A. However, the site is included in a baseline water quality monitoring program for the broader Snowy 2.0 project and sampling will be undertaken in future during suitable flow events following wet weather.

No known water quality monitoring data is available for watercourses in the vicinity of the site, nor for downstream sites that are likely be representative of these watercourses.

4.4 Rainfall

4.4.1 Local gauge data

There are a number of Bureau of Meteorology (BoM) operated rainfall gauges that provide representative records for the Polo Flat area. Table 4.1 presents key information and statistical data from three local gauges.

Table 4.1 Rainfall statistics

Rainfall statistics	Units	Cooma Visitor's Centre BoM station 70278	Cooma (Kiaora) BoM station 70054	Cooma (Woodend) BoM station 70270
Rainfall record		1973–2019	1904–1926, 1958–2019	1973–2019
Distance from site	km	2.3 km west	8.9 km north-east	10.5 km east
Elevation	m AHD	778 m	870 m	855 m
Average rainfall	mm/year	537.3	538.8	510.0
Lowest rainfall	mm/year	291.8	275.2	246.2
5th percentile rainfall	mm/year	306.8	347.6	323.4
10th percentile rainfall	mm/year	356.9	375.1	343.0
Median rainfall	mm/year	561.5	531.1	471.4
90th percentile rainfall	mm/year	714.4	717.3	723.1
95th percentile rainfall	mm/year	748.5	795.6	781.1
Highest rainfall	mm/year	842.9	922.7	853.0
No. days of rain >10 mm	days/year	15.4	15.0	16.7
No. days of rain >25 mm	days/year	3.6	3.8	3.9

Source: BoM website (Climate Data Online)

The rainfall statistics presented show reasonable consistency across all three gauges.

4.4.2 Design rainfall data

Design rainfall information is used to inform an understanding of flood risk and to calculate aspects of stormwater and flood management systems. The following design information has been established for the site:

- Table 4.2 provides design rainfall depths for a range of annual exceedance probability (AEP) events of varying durations. This information was sourced from the ARR2016 data portal; and
- Table 4.3 presented rainfall depths for 2, 5, 10, and 20-day rainfall events. This information was sourced from Landcom, 2004.

Table 4.2 Design rainfall depths (mm) from Australian Rainfall and Runoff 2016

	Annual exceedance probability						
Duration	**63.2%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**
5 min	4.98	5.6	7.63	9.09	10.6	12.6	14.3
15 min	9.42	10.6	14.7	17.6	20.7	25	28.6
30 min	12.5	14.1	19.3	23.1	27.0	32.4	36.8
1 hour	15.8	17.8	24.1	28.5	33.0	39.1	43.9
2 hour	19.7	22.1	29.6	34.8	39.9	46.9	52.3
3 hour	22.5	25.2	33.6	39.4	45.2	53.0	59.1
6 hour	28.6	31.9	42.7	50.2	57.7	68.0	76.2
9 hour	33.0	36.9	49.6	58.5	67.6	80.2	90.3
12 hour	36.5	41.0	55.3	65.4	75.8	90.4	102
18 hour	42.0	47.2	64.2	76.4	88.9	107	121
24 hour	46.1	51.9	71.1	84.8	98.9	119	135

Note: Data sourced from ARR2016 data portal

Table 4.3 Design rainfall depths (mm) for frequent events

	Rainfall duration			
Percentile	**2 day**	**5 day**	**10 day**	**20 day**
80th	14.2	20.6	31.2	55.4
85th	17.3	24.9	37.6	64.7
90th	22.6	32.0	47.8	76.7
95th	33.4	46.8	64.3	96.4

Note: Data sourced from Landcom 2004 Table 6.3 – values for Jindabyne

4.5 Flooding

The site is located on flood prone land. Existing flooding characteristics are described in Section 6.

4.6 Soils and geology

Soils across the site are broadly described as clayey silt to 0.3 m followed by moist clays of high plasticity to 0.5 m. The site is on an area with an extremely low probability of occurrence (1-5%) of acid sulfate soils. The likelihood of occurrence of salinity is also considered to be low. Further details on soils are contained in the Land and Soils Assessment (EMM 2019a), which forms Appendix L to the EIS.

Alluvial layers (Quaternary Alluvium) are underlaid by Tertiary Basalt. Surficial geology is described in Table 4.4.

Table 4.4 Geological units within project area

Symbol	Group	Unit name	Description
Qa	Quaternary	undifferentiated	Alluvial and colluvial deposits: unconsolidated clay, silt, sand and gravel
Tv	Undifferentiated Cainozoic/Tertiary volcanics	Monaro Volcanics and Bonda Dolerite Member	Basalt, olivine basalt
Srca, Srcb	Bredbo Group (Silurian)	Colinton volcanics	Sheared, medium-grained, crystal-rich dacitic volcanics (dacite, andesite, rhyolite, tuff, limestone)

A contamination investigation identified several contaminants occurring in soils on site, including asbestos containing materials, total recoverable hydrocarbons (TRHs), heavy metals, and poly-fluoroalkyl substances (PFAS). The contamination investigation is documented in the Contamination Assessment (EMM 2019b), which forms Appendix K of the EIS.

4.7 Groundwater

4.7.1 Groundwater investigation

A groundwater investigation was undertaken as part of the broader site contamination characterisation assessment. The groundwater investigation is documented in the Drilling Completion Report (EMM 2019c), which forms an annexure to the Contamination Assessment (Appendix K of the EIS).

The investigation consisted of the installation and testing of a monitoring network, comprising seven groundwater bores. Monitoring bores have been installed as nested sites targeting the shallow aquifer within the Tertiary Basalt and the overlying aquitard (low permeability clays) within the Quaternary Alluvium.

The groundwater monitoring network is presented in Figure 4.3 and summarised in Table 4.5.

Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); ESRI (2019); GA (2011); LPMA (2011)

KEY

- The site
- Indicative site layout
- Cadastral boundary
- Monitoring bore*
- Inferred groundwater contour (m)

*MB04A (shallow) and MB04B (deep) are nested monitoring bores

Groundwater monitoring network and hydrogeological context

Snowy 2.0
Water Assessment
Proposed Segment Factory
Figure 4.3

snowy 2.0

EMM creating opportunities

Table 4.5 Groundwater monitoring network

Bore ID	MGA coordinates		Ground Elevation	Drilled depth	Screened interval	Screened formation	Screened lithology
	Easting	Northing	m AHD	m BGL	m BGL		
PF_MB01	693,090	5,988,456	820.0	13.0	5.0 - 11.0	Tertiary Basalt	Fractured basalt
PF_MB02	693,354	5,988,363	823.8	19.0	12.0 - 18.0	Tertiary Basalt	Slightly fractured, fresh basalt
PF_MB03	693,004	5,988,195	821.0	11.0	3.5 - 9.5	Tertiary Basalt	Fractured/fissured basalt
PF_MB04A	693,394	5,988,023	825.4	13.5	6.5 - 12.5	Quaternary Alluvium	Unconsolidated clay
PF_MB04B	693,391	5,988,024	825.3	30.0	23.0 - 29.0	Tertiary Volcanics	Weakly consolidated Ash/Clay
PF_MB05	692,962	5,987,797	821.0	12.5	5.0 - 11.0	Tertiary Basalt	Fractured/fissured basalt
PF_MB06	692,897	5,987,581	822.3	18.0	11.0 - 17.0	Tertiary Basalt	Slightly weathered to fresh basalt

The key findings of the drilling program are summarised as follows:

- the groundwater flow direction is toward the west, governed by topography;
- the depth to the water table within the site ranges from 5 m BGL towards the north-west to 10 m BGL at the eastern boundary of the site;
- the groundwater system within the Tertiary Basalt is mostly unconfined and has low to moderate permeability;
- the alluvium is present locally along Watercourse A. The unit consists of unconsolidated silty clay of very low permeability; and
- the groundwater quality is characterised as fresh to slightly brackish and slightly alkaline.

Of the contaminants identified in the soil study above, PFAS and some metals were also present in groundwater. No asbestos or TRHs were detected in groundwater in concentrations above the laboratory limit of reporting.

4.7.2 Groundwater dependent ecosystems

BoM groundwater dependent ecosystem (GDE) mapping shows the only GDE within two kilometres of site is Cooma Creek, which is classified as having high potential for groundwater interaction. This interaction likely occurs as baseflow.

4.7.3 Groundwater users

The site is located within the Lachlan Fold Belt MDB groundwater source under the Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011.

There are 19 registered bores within two kilometres of site, four of which have current works approvals. Details of current works approvals are presented in Table 4.6.

Table 4.6 Registered groundwater bores

Station ID	Easting	Northing	Works Approval	Status	License type
GW403981	691560	5987399	40WA411050	Current	Basic Rights (GW extraction)
GW414419	694035	5987143	40WA411484	Current	Basic Rights (GW extraction)
GW414665	695368	5987589	40WA411632	Current	Basic Rights (GW extraction)
GW416155	695157	5986629	40WA412427	Current	Basic Rights (GW extraction)

4.8 Vegetation

Existing vegetation across the site consists of a mix of native and exotic grasslands. Where native grasses dominate the groundcover (vegetation typically aligns with the Natural Temperate Grassland of the South Eastern Highlands). The area is described as a critically endangered ecological community listed under Commonwealth and NSW biodiversity legislation.

Further details are available in the Biodiversity Development Assessment Report (EMM 2019d), which forms Appendix J of the EIS.

5 Water management

5.1 Overview

This section describes the proposed water management system and is structured as follows:

- Section 5.2 describes the key objectives of the proposed water management system;
- Section 5.3 describes the functionality of the proposed water management system;
- Section 5.4 details water balance and water quality modelling that was undertaken for the project;
- Section 5.5 outlines the proposed groundwater management strategy;
- Section 5.6 provides guidance on water management during the construction phase of the projects; and
- Section 5.7 describes planned additional design development and assumptions.

5.2 Water management objectives

The water management system has been designed with consideration of several key objectives, as described in Table 5.1.

Table 5.1 Water management objectives and approach

Water management objectives		Approach
WM_1	Where practical, stormwater from upstream catchments will be diverted around the site to reduce loading on the internal water management system.	Diversion channels and drains will be constructed to divert water around site.
WM_2	Provide water quality treatment and enable reuse to reduce any residual water quality risks.	The water management basin has a water quality control function to reduce sediment and nutrient loading in discharge. A water treatment plant will be installed to treat stormwater runoff from the bunded cementitious area.
WM_3	Provide water quality controls that collectively meet industry standard pollutant load reductions.	The water quality management system has been assessed against the following pollutant load reduction targets: • 85% reduction in total suspended solids; • 60% reduction in total phosphorous; and • 45% reduction in total nitrogen.
WM_4	Provide water quantity controls to mitigate increases in peak flows from impervious areas.	The water management basin will have detention storage to attenuate stormwater runoff from site for events up to the 10% AEP.
WM_5	Runoff which may contact potentially contaminating materials such as cement and aggregates will be separated from site stormwater.	Concrete batching and curing will occur within a bunded cementitious area or inside the concrete plant and warehouse. Aggregate stockpiles will be located within the bunded cementitious area.

Table 5.1 Water management objectives and approach

Water management objectives		Approach
WM_6	Design site drainage to reduce infiltration of potentially poor quality surface runoff into the underlying groundwater system.	All areas will be sealed either in concrete, cement soil, or asphalt, except for the retained grassland area in the centre of the site.
WM_7	Harvest stormwater to reduce stormwater overflows and demand from external water sources.	Water from the water management basin and treated stormwater from the cementitious area will be reused for concrete batching provided water quality requirements are met.

5.3 Proposed water management system

The proposed water management system is presented in Figure 5.1 which shows the system as a schematic and in Figure 5.2 which overlays the proposed water management system on the site layout.

Broadly, the proposed water management system will be separated into two major water management areas as shown in Figure 5.2. Each water management area is targeted towards managing the key risks associated with planned site activities in each area, which are characterised as follows:

- the bunded cementitious area, which contains all activities which have the potential to contaminate stormwater runoff with cementitious material, including concrete batching, storage of cementitious material in silos, and stockpiling of other aggregate materials; and
- the stormwater management area, which comprises the balance of the site area and all other site activities including the storage of cured pre-cast concrete segments, parking and mechanical workshops. This area also includes runoff from covered areas.

The key features of the proposed water management system are described in the following sections, and are summarised as follows:

- external drainage diversions to prevent stormwater ingress from upstream catchments;
- internal drainage network to direct on-site stormwater to the internal stormwater management system;
- water quality controls to meet water quality objectives and industry standard reduction targets;
- water quantity control measures to attenuate site runoff peak flows; and
- water supply considerations to meet ongoing operational water demands.

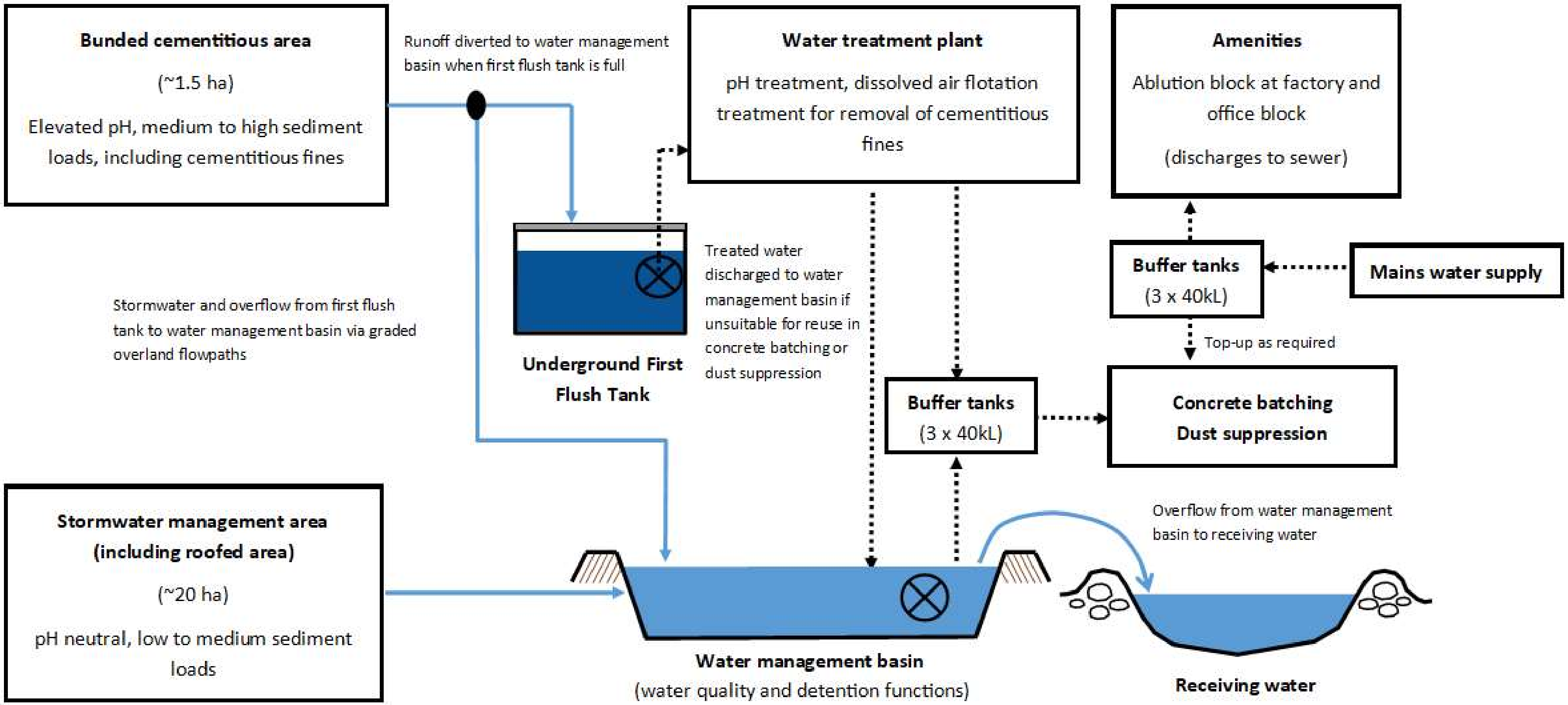
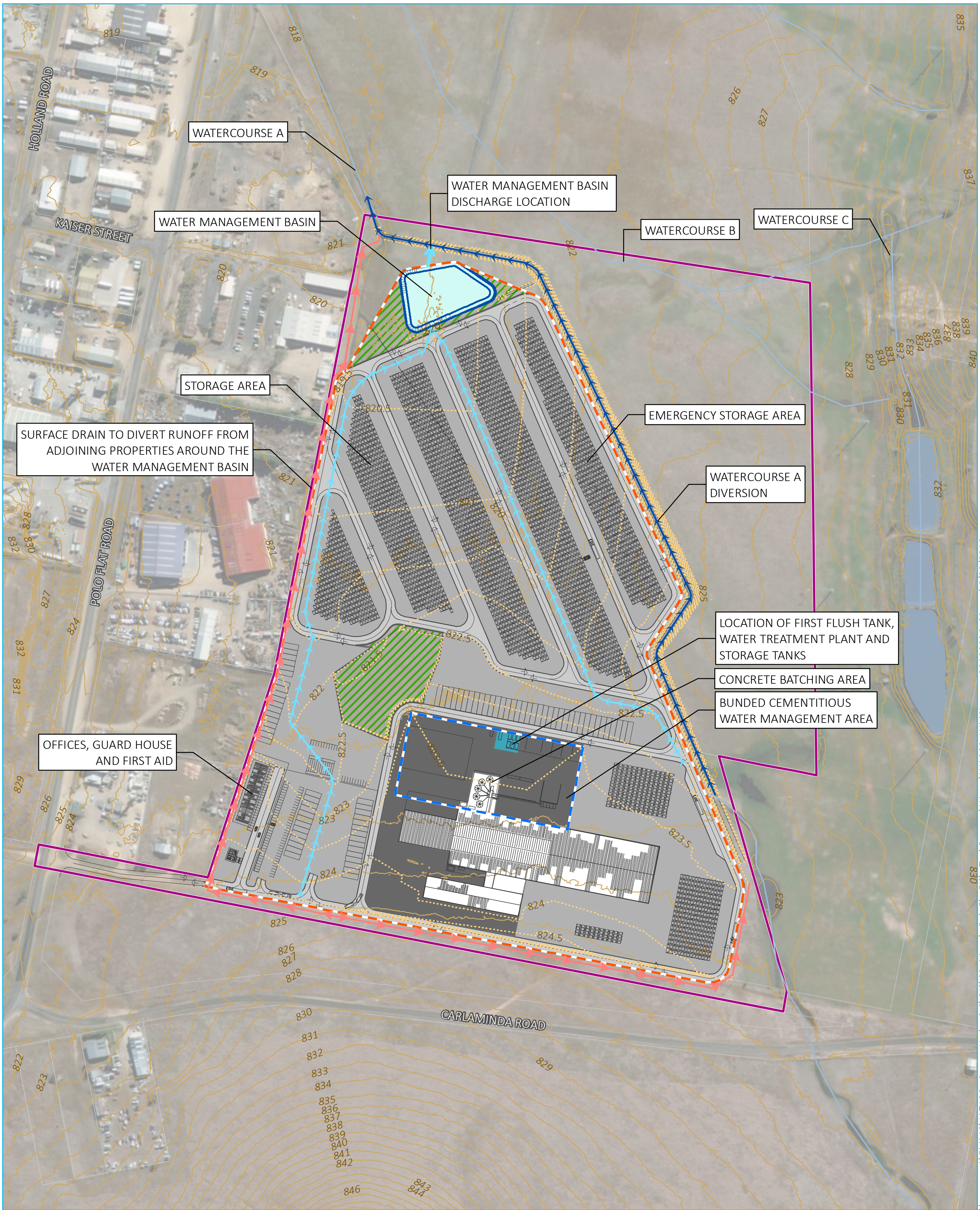


Figure 5.1 Proposed water management system schematic



Source: EMM (2019); FGJV (2019); Snowy Hydro (2019); DFSI (2017); ESRI (2019); LPMA (2011)

0 100 200 m

GDA 1994 MGA Zone 55

N

KEY

- Site boundary
- Indicative site layout
- Internal drainage contours (0.5 m)
- Contour (1 m)
- Cadastral boundary
- Waterbody

Water management system

- Watercourse
- Discharge location
- Watercourse A diversion
- Surface drain (external runoff)
- Surface drainage (internal runoff)
- Water management basin
- First flush tank

Surface material

- Asphalt
- Cement soil
- Cement soil / concrete
- Concrete
- Retained grassland

Water management areas

- Bunded cementitious area
- Stormwater management area

Proposed water management system layout

Snowy 2.0
Water Assessment
Proposed Segment Factory
Figure 5.2

5.3.1 External drainage diversions

Consistent with WM_1, stormwater from surrounding external catchments will be prevented from entering the site water management system by:

- the proposed diversion of Watercourse A around the east of the site; and
- the interception of external catchment runoff along the western and southern site boundaries.

Watercourse A will be diverted around the site in an excavated channel. This channel will be sized to accommodate peak runoff flows from the upstream catchment for events up to the 10% AEP event. Overflows from Watercourse A associated with larger rainfall events will be directed through the site by graded overland flow paths.

Runoff from surrounding industrial areas to the west, as well as grassed area to the south, will be captured by concrete-lined drains and diverted to Watercourse A bypassing the water management basin.

5.3.2 Internal drainage network

All site stormwater will be managed by the internal water management system. This system includes the following key features:

- concrete bunding around cementitious areas;
- an underground first flush tank;
- graded overland flow paths; and
- a water management basin.

Potentially contaminating activities (eg concrete batching and curing) and materials (eg cement and fine aggregates) will be contained within a bunded cementitious water management area. Initial runoff from the cementitious area will be directed to a first flush tank and excess runoff will be directed to the site's stormwater management system.

Stormwater generated by the remainder of the site will drain via two major overland flow paths to the water management basin located at the northern end of the site. The grading of overland flow paths will be developed as part of future detailed design. The water management basin will have a dual function to provide water quality treatment and detention storage for stormwater generated on site.

The contributing catchment areas, design objectives and overflow arrangements for each of the stormwater management areas are presented in Table 5.2.

Table 5.2 Water management infrastructure

Stormwater management area	Contributing catchment area	Storage unit	Design objective	Overflow arrangement
Bunded cementitious area	1.3 ha	First flush tank	10% AEP 5 min rainfall event	Overflow diverted to water management basin
Stormwater management area	19.6 ha	Water management basin	Dual function, designed to achieve: • pollution reduction targets (Section 5.4); and • detention for events up to the 10% AEP	Overflow to Watercourse A

5.3.3 Water quality controls

Water quality from the two water management areas is characterised as follows:

- bunded cementitious area: elevated pH, medium to high sediment loads (including cementitious fines) leading to elevated turbidity, and potentially low concentrations of hydrocarbons, oil and grease associated with operations; and
- stormwater management area: neutral pH, low to medium sediment loads.

The following sections describe proposed water quality controls that have been developed to manage risks associated with each management area and meet the water quality objectives WM_2 and WM_3.

i Source controls

The source controls that will be applied to the site include:

- the separation of potentially contaminating activities such as concrete batching and curing from other general site activities;
- the storage of cementitious materials in sealed silos; and
- the location of uncovered stockpiles within the bunded cementitious area.

ii Cementitious runoff treatment

Runoff from the bunded cementitious area will be treated as follows:

- A first flush tank will capture initial runoff from the cementitious area that may be high in pH and sediment. Stormwater runoff from the bunded cementitious area will flow to the first flush tank through a series of baffles which will enhance the removal of readily settleable solids. The design principle of the first flush tank is to capture the “first flush” runoff of a rainfall event, which will entrain most of the potentially contaminating material which may be present on the ground surface;
- After this “first flush” period, site runoff will be of comparable water quality to runoff from the broader stormwater management area. Accordingly, overflows from the bunded cementitious area in larger rainfall events will be diverted to the stormwater management area;

- A water treatment plant will treat cementitious water captured by the first flush tank. Treatment will likely include pH correction and dissolved air flotation to remove fine cement particles, with treatment requirements to be confirmed by testing. Sludge produced by dissolved air flotation treatment will be contained and disposed of off-site; and

- Treated stormwater will be reused in concrete batching in the event that water quality requirements as per *AS 1379 2007 – Specification and supply of concrete* are met. Otherwise stormwater of unsuitable quality will be transferred to the water management basin.

iii Stormwater treatment

Stormwater from the remaining site areas and overflows from the cementitious area associated with large rainfall events will be directed to the water management basin. During construction the water management basin will provide sedimentation control in accordance with Landcom 2004.

During operations, the water management basin will function to meet industry standard pollution reduction targets (discussed in Section 5.4). This will include sedimentation controls and the storage of stormwater for reuse, if appropriate. Overflows from the water management basin will discharge to Watercourse A.

iv Fuel and hazardous chemical storage

Two 20,000 L diesel tanks and any hazardous chemicals will be stored in bunded facilities in accordance with NSW government guidelines (refer Section 3.4.3) and relevant Australian Standards. This could be located within the bunded cementitious area or other suitably bunded area.

5.3.4 Onsite stormwater detention

Development of the site includes bulk earthworks and changing pervious surfaces to hardstand. These works will reduce the permeability of the site, causing runoff to be conveyed more quickly and potentially increasing peak flow rates from the site. As the size of the site is small in comparison to the greater catchment of Watercourse A, peak flow rates downstream of the site are more likely to affect short duration storm events (extended over several hours), as opposed to long duration events (extending over several days).

The water management basin will function to attenuate stormwater flows from the site (as well as providing water quality treatment). Peak runoff rates from the site, up to the 10% AEP rainfall event, will not exceed runoff generated by existing site conditions.

The water management basin outlets will include scour protection and suitable energy dissipation measures will be constructed in the diversion drain at the point of confluence with Watercourse A. This will reduce erosion potential associated with concentrated discharges and increased runoff rates (for events greater than the 10% AEP).

5.3.5 Water supply

Operational water demands will be driven by demand from the concrete batching process. Water demand for concrete batching is estimated to increase from approximately 1.1 ML/month to 3.8 ML/month over the first five months of the project (EMM 2019e). Water demand is then expected to remain at the maximum rate for the project duration, except for the final few months as production ramps down. Other nominal site water demands will include dust suppression and vehicle and plant wash down, as well as potable water supply for site amenities.

Water for concrete batching, dust suppression and wash down activities will be obtained from the following sources:

- water treatment plant;

- water management basin; and
- reticulated town water supply.

Water for concrete production will be preferentially sourced from the water treatment plant and the water management basin in the event that water quality requirements as per *AS 1379 2007 – Specification and supply of concrete* are met.

Onsite water storage in six 40,000 L tanks will provide buffer storage to ensure required peak flow rates for concrete batching can be met. Site amenities will receive water from reticulated town water supply.

5.3.6 Wastewater

Wastewater from site amenities and ablution blocks at the factory and office will be discharged to SMRC's reticulated sewage system.

5.4 Water balance and water quality modelling

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) water quality model was applied to simulate the volume and quality of runoff from the site and assess the effectiveness of the proposed water quality controls. This was also used to model the site water balance.

MUSIC modelling results estimate:

- the volume of surface water that is captured and used for process water;
- site discharge frequency and volumes; and
- water quality of site runoff.

The model results are compared to industry standard pollution reduction targets and provide an indication of water movement across the site for average annual rainfall conditions.

The following sections document the modelling assumptions and results.

5.4.1 Model assumptions

The MUSIC model was developed in accordance with the NSW MUSIC modelling guidelines (BMT WBM, 2015). This section outlines the assumptions applied to the MUSIC model.

i Rainfall data

MUSIC modelling guidelines recommend the use of pluviograph records for model rainfall. The nearest station with pluviograph data is Chakola (Riversdale) Station (station number 070073), located approximately 23 km north of the site.

Table 5.3 compares characteristics of the Chakola (Riversdale) Station records to the nearest BoM gauge records as presented in Section 4.4, based on daily rainfall statistics.

Table 5.3 MUSIC pluviograph rainfall data

Rainfall statistics	Units	Cooma Visitor's Centre BoM station 70278	Cooma (Kiaora) BoM station 70054	Cooma (Woodend) BoM station 70270	Chakola (Riversdale) Station 070073
Rainfall record		1973–2019	1904–1926, 1958–2019	1973–2019	1965–2010
Distance from site	km	2.3 km west	8.9 km north-east	10.5 km east	23 km north
Elevation	m AHD	778 m	870 m	855 m	716 m
Average rainfall	mm/year	537.3	538.8	510.0	566.5
Lowest rainfall	mm/year	291.8	275.2	246.2	251.2
5th percentile rainfall	mm/year	306.8	347.6	323.4	338.9
10th percentile rainfall	mm/year	356.9	375.1	343.0	393.0
Median rainfall	mm/year	561.5	531.1	471.4	551.1
90th percentile rainfall	mm/year	714.4	717.3	723.1	783.2
95th percentile rainfall	mm/year	748.5	795.6	781.1	820.5
Highest rainfall	mm/year	842.9	922.7	853.0	1011.3

This comparison shows good consistency across the four records, hence the pluviograph data from Station 070073 is considered representative of site conditions. The longest period of consecutive pluviograph data from the site extended from April 1998 to January 2003, for which period the average annual rainfall was 474mm. The data from this period was therefore scaled up by 15% to create a dataset considered more representative of average annual rainfall conditions (approximately 545mm).

ii Potential evapotranspiration data

Potential evapotranspiration (PET) values were obtained from the BoM gridded average areal PET maps. The monthly PET values applied to the MUSIC model are presented in Table 5.4.

Table 5.4 Monthly potential evapotranspiration data

Month	Monthly PET (mm)
Jan	159
Feb	115
Mar	99
Apr	65
May	43
June	34
July	37
Aug	52

Table 5.4 Monthly potential evapotranspiration data

Month	Monthly PET (mm)
Sept	70
Oct	111
Nov	139
Dec	140

iii Stormwater runoff

Runoff parameterisation characteristics for the various surface types and corresponding surface areas are presented in Table 5.5. The land use allocated to each surface type relates to pollutant generation parameters provided in Section vii.

Table 5.5 MUSIC runoff parameterisation and land-use

Surface type	Area (ha)	Runoff parameterisation	Land-use allocated
Asphalt (roads)	3.1	Initial loss 2.5mm	Sealed road
Roof and concrete	1.5	Initial loss 2.5mm	Roof
Cement soil / concrete	2.0	Runoff response consistent with Hydrologic Soils Group B (Landcom 2004)	Unsealed road
Cement soil	12.9	Runoff response consistent with Hydrologic Soils Group B (Landcom 2004)	Unsealed road
Retained grassland	1.3	Pervious surface with average annual runoff coefficient 0.25 (representative of low infiltration clayey soils)	Revegetated land

iv Stormwater harvesting

The MUSIC model simulates the likely scenario that treated stormwater will be suitable for reuse in concrete batching, and therefore this water is harvested. It is noted that this is not a firm operational commitment, however it is the design intent provided water quality is found to be suitable for concrete production, hence it is appropriate to represent this reuse in the water quality model.

Modelling assumes water is sourced from the water treatment plant (first priority) and the water management basin (second priority) for concrete batching.

v Operational water demands

Operational water demands for concrete batching are predicted to be within the range of 1.1 to 3.8 ML/month. Maximum and minimum expected water demand scenarios have been modelled.

Water demand for other site activities including dust suppression and vehicle and plant wash down, as well as potable water supply for site amenities are considered negligible compared to the overall concrete batching demands of the site and therefore have not been included in the modelling.

vi Treatment controls

The following treatment controls were included in the water modelling for the site.

a Stormwater basins

The first flush pit and the water management basin were applied to the model using the 'sedimentation basin' treatment node. The following parameters were adopted:

- first flush pit capacity was applied which contains the 10% AEP 5min storm event (no losses) for the cementitious area; and
- water management basin sized to meet pollution reduction targets (for maximum water usage which is expected for the majority of the operational duration).

The volumes of these features will be finalised during detailed design however it is anticipated the model validity will not be significantly impacted by any minor changes.

b Stormwater harvesting storage

Storage of harvested stormwater from the first flush tank and water management basin was assumed to be available in up to three of the six 40,000 L buffer storage tanks to be kept onsite. Three additional tanks (not modelled) were assumed to be maintained full at all times for contingency supply.

vii Pollutant concentrations

MUSIC applies a stochastic approach to simulating pollutant concentrations in runoff using a mean and standard deviation value for each pollutant. Typical values for land-use that are recommended in the NSW MUSIC modelling guideline (BMT WBM 2015) were adopted. The land use allocated to each surface type and the pollutant generation characteristics are presented in Table 5.5 and Table 5.6, respectively.

Table 5.6 Adopted pollutant generation parameters

Sealed Road							
		Baseflow			Stormwater runoff		
	Units	Mean	Std Dev (log)	Mean (log)	Mean	Std Dev (log)	Mean (log)
Total Suspended Solids (TSS)	mg/L	15.8	0.17	1.20	269	0.320	2.430
Total Phosphorous (TP)	mg/L	0.141	0.190	-0.85	0.501	0.250	-0.300
Total Nitrogen (TN)	mg/L	1.29	0.120	0.11	2.19	0.190	0.340
Roof							
		Baseflow			Stormwater runoff		
		Mean	Std Dev (log)	Mean (log)	Mean	Std Dev (log)	Mean (log)
Total Suspended Solids (TSS)	mg/L	12.6	0.170	1.100	20	0.320	1.300
Total Phosphorous (TP)	mg/L	0.151	0.190	-0.820	0.129	0.250	-0.890
Total Nitrogen (TN)	mg/L	2.09	0.120	0.320	2	0.190	0.300
Unsealed Road							
		Baseflow			Stormwater runoff		
		Mean	Std Dev (log)	Mean (log)	Mean	Std Dev (log)	Mean (log)
Total Suspended Solids (TSS)	mg/L	15.8	0.170	1.200	1000	0.320	3.000
Total Phosphorous (TP)	mg/L	0.141	0.190	-0.850	0.501	0.250	-0.300
Total Nitrogen (TN)	mg/L	1.29	0.120	0.110	2.19	0.190	0.340
Revegetated							
		Baseflow			Stormwater runoff		
		Mean	Std Dev (log)	Mean (log)	Mean	Std Dev (log)	Mean (log)
Total Suspended Solids (TSS)	mg/L	14.1	0.170	1.150	89.1	0.320	1.950
Total Phosphorous (TP)	mg/L	0.0603	0.190	-1.220	0.219	0.250	-0.660
Total Nitrogen (TN)	mg/L	0.891	0.120	-0.050	2	0.190	0.300

5.4.2 Modelling results

The MUSIC model was applied to simulate the volume and quality of runoff from the site. The effectiveness of the proposed water quality controls was assessed and the annualised distribution of water across the site was estimated for average annual rainfall conditions.

Two model scenarios were simulated to represent the maximum (3.8 ML/month) and minimum (1.1 ML/month) water demand for the batch plant. The maximum water reuse extends for the majority of the project duration, whilst the minimum reuse is applicable to initial and final months of the project duration.

i Water quality

The MUSIC model results are compared to industry standard pollutant reduction targets below.

To test the sensitivity of the system to the concrete batching water demand, the system was also modelled for both 3.8 ML/month and 1.1 ML/month water demand scenarios. The maximum water demand is applicable for the majority of the operational timeframe.

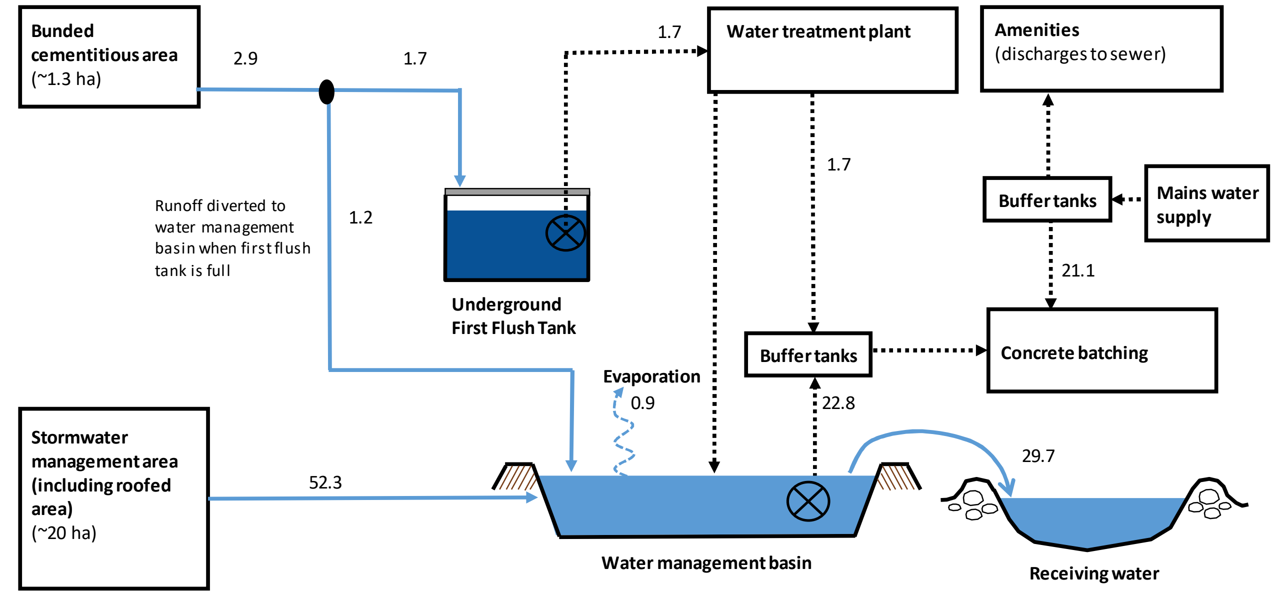
Table 5.7 Water Quality Results

Water reuse rate 3.8 ML/month						
		Annual Volume / Load		**Volume / Load reduction**		
	Units	**Source**	**Residual**	**Reduction**	**Target**	**Target Achieved**
Runoff Volume	ML/yr	55.2	29.7	46.3%	NA	NA
Total Suspended Solids (TSS)	kg/yr	50,500	7,340	85.5%	85%	Yes
Total Phosphorus (TP)	kg/yr	29.8	7.23	75.8%	60%	Yes
Total Nitrogen (TN)	kg/yr	131	62.1	52.6%	45%	Yes
Water reuse rate 1.1 ML/month						
		Annual Volume / Load		**Volume / Load reduction**		
	Units	**Source**	**Residual**	**Reduction**	**Target**	**Target Achieved**
Runoff Volume	ML/yr	55.2	41.2	25.3%	NA	NA
Total Suspended Solids (TSS)	kg/yr	50,500	9,550	81.1%	85%	No
Total Phosphorus (TP)	kg/yr	29.8	9.64	67.7%	60%	Yes
Total Nitrogen (TN)	kg/yr	131	81.9	37.4%	45%	No

Model results presented in Table 5.7 indicate that pollutant load reductions for TSS, TN and TP meet industry standard targets when the batching plant operates at maximum demand. The pollutant load reduction targets for TSS and TN are not met during the initial stages of the operational duration when water demand for the batching plant is approximately 1.1 ML/month. However, significant reductions in pollutant loads are still achieved by the water treatment system during these short stages.

ii Water balance

Water balance results are presented for both 3.8 ML/month and 1.1 ML/month water demand scenarios in Figure 5.3 and Figure 5.4, respectively.



NOTE: all values are average annual transfers in ML/yr

WATER BALANCE SUMMARY

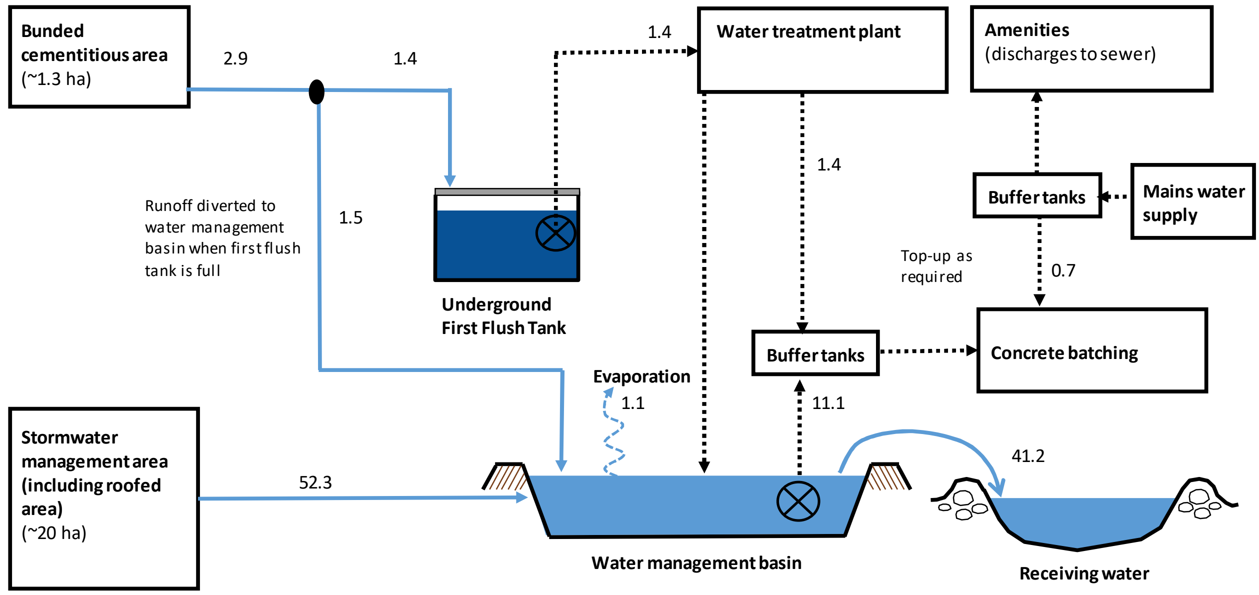
Stormwater Summary

	Average Annual	Proportion of total runoff
Total runoff	55.2 ML/yr	*100%*
Harvested runoff	24.5 ML/yr	*44%*
Managed overflows	29.7 ML/yr	*54%*
Evaporation loss	0.9 ML/yr	*2%*
Change in storage	0.0 ML/yr	*0%*

Process Water Summary

	Average Annual	Proportion of total process water use
Total process water use	45.6 ML/yr	*100%*
Reuse from stormwater	24.5 ML/yr	*54%*
Mains water supply	21.1 ML/yr	*46%*

Figure 5.3 Water balance results – average annual rainfall – 3.8 ML/month batching plant demand



NOTE: all values are average annual transfers in ML/yr

WATER BALANCE SUMMARY

Stormwater Summary

	Average Annual	Proportion of total runoff
Total runoff	55.2 ML/yr	*100%*
Harvested runoff	12.5 ML/yr	*23%*
Managed overflows	41.2 ML/yr	*75%*
Evaporation loss	1.1 ML/yr	*2%*
Change in storage	0.4 ML/yr	*1%*

Process Water Summary

	Average Annual	Proportion of total process water use
Total process water use	13.2 ML/yr	*100%*
Reuse from stormwater	12.5 ML/yr	*95%*
Mains water supply	0.7 ML/yr	*5%*

Figure 5.4 Water balance results – average annual rainfall – 1.1 ML/month batching plant demand

Results show that for the maximum water demand scenario (3.8 ML/month), which will occur for most of the project duration, approximately 44% of the total runoff from the site will be able to be harvested and reused, meeting 54% of the water demand for concrete batching. For the minimum water usage scenario (1.1 ML/month), 23% of total runoff generated will be able to be harvested and reused, meeting 95% of the water demand for concrete batching.

For above average annual rainfall conditions, it is expected that the overflow volume from the water management basin would increase and more water would be able to be harvested for reuse (particularly for the 3.8ML/month water usage scenario).

For below average annual rainfall conditions, it is expected that the overflow volume from the water management basin would decrease and less water would be available for harvesting and reuse for both scenarios.

Modelling and the interpretation of results is representative of average annual conditions and typical responses to the water management system. Intensity and duration of individual storm events will also affect how the water management system will respond on an individual storm event basis.

5.5 Groundwater management

Key potential impact mechanisms to groundwater and how they will be managed by the project design are discussed in the following sections.

5.5.1 Interception of groundwater

Excavations below the groundwater table may cause the ingress of groundwater, thereby reducing the available groundwater resource.

As described in Section 4.7, the depth to groundwater across the site ranges between 5–10 m BGL. The deepest excavations for the project below current ground levels are associated with construction of the diversion drain for Watercourse A and the water management basin. It is not anticipated that groundwater will be intercepted by either of these construction activities.

5.5.2 Reduction in aquifer recharge

Reduction of the infiltration capacity of the surface by constructing hardstand areas that were previously grassland will reduce aquifer recharge into the underlying groundwater systems.

The site's groundwater sources are part of the broader Lachlan Fold Belt groundwater source which covers an area of about 16.7 million ha (DPI Office of Water 2012). Compared with a development site area of 22 ha, any reduction in recharge associated with site development is negligible compared with total groundwater source recharge.

5.5.3 Infiltration

The water quality of the underlying groundwater system has potential to be affected by infiltration of poor quality surface runoff to shallow groundwater.

Consistent with WM_6, areas of likely poor water quality such as the bunded cementitious area will be sealed to prevent infiltration of water which could impact the water quality of local groundwater sources. The underground first flush tank will be concrete lined and maintained to prevent seepage of cementitious water to shallow groundwater. The water management basin will be constructed with an impervious lining to limit infiltration into the shallow groundwater.

5.6 Water management during construction

Construction of the proposed segment factory will be undertaken over a five month period. Erosion and sediment control plans will be prepared for each construction stage as part of the detailed design documentation. The erosion and sediment control plans will be prepared in accordance with the methods recommended in Landcom 2004.

Some phases of the construction will require excavations. It is anticipated that these excavations will not intercept groundwater.

6 Flood assessment

6.1 Overview

A flood assessment for the project has been prepared by GRC Hydro (2019). The objectives of the flood assessment were to:

- establish the existing flooding characteristics at the site;
- establish the flooding characteristics of the proposed site layout; and
- assess the flood impacts of the proposed site layout.

The following sections describe existing flood characteristics at the site and potential flood impacts due to construction and operation of the proposed segment factory. The GRC Hydro report is provided in Annexure B.

6.2 Existing conditions

Existing flooding characteristics for the site and surrounds have been established by flood modelling undertaken by GRC Hydro (2019). This applied the hydrologic and hydraulic models developed as part of the Snowy Monaro Regional Council Flood Studies (SMEC / GRC Hydro, 2019), which provides the most up to date information on local flood behaviour.

GRC Hydro 2019 (refer Annexure B) contains an overview of the adopted modelling approach and presents results including flood mapping. Flood mapping showing depths of inundation, peak water surface elevation contours and flood hazard for the 10% AEP, 1% AEP and PMF events.

Existing flood conditions show the site is subject to flooding from Watercourse A which passes through the site from south the north. The flood assessment shows that a large portion of the site is currently subject to out of bank flooding for all events assessed up to and including the PMF.

Flood waters are predominantly associated with runoff from the upstream catchment area entering site through Watercourse A, however there is also some flow through the eastern and western boundaries from adjacent properties.

6.3 Proposed conditions

6.3.1 Model assumptions

Flood modelling for the proposed project conditions included the following amendments:

- Incorporation of the bulk earthworks and landform changes associated with the development, including bunding around the cementitious area, internal drainage channels, the diversion channel for Watercourse A and the water management basin.
- Changes to surface roughness to reflect various surface types associated with the development.
- The exclusion of specific areas to convey or store floodwaters, such as segment storage areas and buildings.
- Updates to the hydrologic model to reflect changes to the pervious properties of the developed surface.

Further detail regarding the modelling assumptions is provided in GRC Hydro 2019 (refer Annexure B).

6.3.2 Project site flood characteristics

The intent of the site design is to provide immunity from external flooding in events up to the 10% AEP. Flood modelling for the 10% AEP storm shows that some flows from Watercourse A break out just upstream of the site. This breakout causes a shallow flow path (typically less than 0.1m) to enter the site under the proposed conditions. These flows are minor and are shown to be typically conveyed by site grading to the internal water management system.

There is potential to eliminate this minor flow path through the site by constructing a low bund or raised ground levels in the south-east corner of the site if desirable, and could be further investigated as part of future detailed design.

Modelling of the 1% AEP storm shows flood hazard across the site being limited to H1 and H2 hazard classifications (refer Annexure B). The areas of inundation affect eastern portions of the site including hardstand areas in and around segment storage areas and an internal drainage channel. Depth of flooding in the 1% AEP event is greatest within the internal drainage channel, with depths between 0.3 and 0.5 m. The remainder of the area affected by flooding experiences flooding typically around 0.1 m deep and up to 0.3 m deep. The bunded cementitious area is not affected by flooding in the 1% AEP event.

In the PMF, the entire site is inundated, with the exception of a small portion of the site in the south-west corner which includes the offices, guard house and first aid. Flooding within the site in the PMF ranges up to 2.0 m deep. Flood hazard in the PMF ranges from H1 to H5, with approximately half the site categorised as H5 (hazard classifications explained further in Annexure B).

6.3.3 External flood impacts

GRC Hydro 2019 (refer Annexure B) graphically presents the impact of the project compared to the existing flood conditions. Impacts on flood depth and hazard categorisation are presented for the 10% AEP, 1% AEP and PMF events in Figures C7 to C12 and a detailed analysis of changes to flood characteristics for properties surrounding the site are presented in table format. Impacts of the project include both increases and reductions to flood depth and hazard to surrounding properties.

Table 6.1 provides an overview of the identified adverse flooding impacts of the project on surrounding properties.

Table 6.1 Overview of adverse flood impacts to surrounding properties

Location	Property Address	Summary of adverse flood impacts		
		10% AEP	1% AEP	PMF
West of the project site	• 81 Polo Flat Road • 79 Polo Flat Road • 77 Polo Flat Road • 73 Polo Flat Road	Newly flooded areas with flood depths up to 0.3 m and hazard classification H1.	Newly flooded areas with flood depths up to 0.3 m and hazard classification H1.	Increased flood depth of up to 0.5 m and hazard increase by one to two categories.
West of the project site	• 71 Polo Flat Road • 69 Polo Flat Road	Newly flooded areas and increased flood depths of up to 0.1 m with hazard classification of H1.	Increased flood depth of up to 0.1 m (no change to hazard category).	N/A (ie flood conditions reduced)

Table 6.1 Overview of adverse flood impacts to surrounding properties

Location	Property Address	Summary of adverse flood impacts		
		10% AEP	**1% AEP**	**PMF**
East of the project site	• 123 Carlaminda Road	Newly flooded areas and flood depth increases up to 0.1 m (no change to hazard category).	Increased flood depth of up to 0.2 m and hazard increase by one category.	Increased flood depth up to 0.5 m and hazard increase by up to two categories.

6.4 Risk management considerations

This section identifies the flood risks associated with the project site. Key flood risk considerations are categorised as follows:

- the potential for materials to be entrained in flood waters; and
- the flood risk to staff and visitors.

A summary of the proposed controls to reduce the site's exposure to flood risk is provided in Section 6.4.3.

6.4.1 Entrainment in flood waters

As discussed in Section 6.3.2, there is a risk of entrainment of site materials for events from the 10% AEP and increases up to the PMF. Associated environmental risks are a function of the potential for waste to be entrained in flood water and the consequences if mobilised. Table 6.2 provides a risk assessment of each category that is expected to be stored at the facility.

Table 6.2 Material entrainment risk assessment

Material category	Potential to be mobilised in floodwaters	Consequence if mobilised in flood waters	Risk to environment
Concrete products (including concrete segments)	**Low risk –** as concrete is not buoyant	**Low risk –** concrete is non-toxic, any mobilised material would be deposited near the facility	**Negligible risk** – due to low risk of mobilisation
Fines (including cementitious materials)	**Low risk** – fines are to be located in the cementitious areas and therefore exposure to risk only in events greater than the 1% AEP. Some fines could be mobilised in larger events if exposed to flood waters with sufficient depth and velocity.	**Low risk –** mobilised fines are likely to remain entrained in floodwaters for some time and would be deposited in downstream floodplain areas	**Low risk** – as fines would be dispersed over a large area, along with other entrained sediment
Concrete admixtures	**Variable risk** – depending on the storage location of specific admixtures	**High risk** – some concrete admixtures are toxic and therefore toxic materials could be deposited or entrained in floodwaters	**High risk –** due to the consequence if mobilised

Table 6.3 describes proposed controls to reduce the risk of waste being entrained in floodwaters.

Table 6.3 Proposed measures to reduce entrainment risk

Risk to environment	Proposed Controls	Applicable areas of the facility
Low risk (fines including cementitious materials)	Isolate cementitious areas from the surrounding stormwater management system with low bunding	Cementitious area
High risk (concrete admixtures)	Waste and hazardous materials will be stored outside the 1% AEP flood extent	Storages areas for concrete admixtures

6.4.2 Risk to life

Model results indicate that:

- In the 10% AEP event the flood hazard for affected areas is H1, except for the water management basin and areas downstream of the hardstand area. Thus, the site is generally considered safe for people, vehicles and buildings.
- In the 1% AEP event, the flood hazard of affected areas is H1 and H2, except for the water management basin and areas downstream of the hardstand area. Thus, the site is generally considered safe although internal drains may not be considered safe for small vehicles.
- For a PMF or similar magnitude event, a large portion of the site (comprising of mostly segment storage areas, internal roads and associated hardstand) are categorised as H5 (unsafe for people, vehicles and buildings). Remaining flood affected areas are expected range from H1 to H3. In such events, the majority of the site has rising road (or pedestrian) access. Therefore, floodwaters will gradually extend from the flood affected area and occupants have flood free access egress from the site. The one area without rising road access is between the central internal drainage line and Watercourse A, however, it is unlikely staff will be located in this area as it is proposed to be used an emergency segment storage area.

A flood emergency response plan will be prepared for the site that will include triggers for evacuation, closure, site preparation and evacuation protocols.

6.4.3 Summary of proposed controls

In addition to the proposed controls for entrainment risk, the following controls are proposed:

- habitable buildings, electrical wiring and equipment will be located 500mm above the 1% AEP level;
- non-habitable building floor level will be a minimum of 300mm above the 1% AEP; and
- preparation of flood emergency response plan.

7 Residual impacts

7.1 Overview

This section describes residual impacts associated with surface water and groundwater. Residual flooding impacts are described in Section 6.

7.2 Surface water impacts

7.2.1 Water quality

Stormwater discharges will occur due to overflows from the water management basin. The basin receives runoff from the 19.6 ha stormwater management area, as well as overflow from the 1.3 ha bunded cementitious area and the diversion channel during rainfall events which exceed the design capacity. Reuse of captured stormwater will reduce the volume and frequency of overflows from the basin, particularly where stormwater can be used for concrete production.

Water balance modelling indicates overflows will be approximately 54% of total runoff in the event that concrete batching will use harvested stormwater at a rate of 3.8 ML/month. In the event that captured and treated stormwater does not meet water quality requirements for reuse in concrete batching, overflow volume and frequency will exceed modelled outcomes.

The water quality of discharges from site will be characterised by the circumstances that cause the overflow. Factors including the source of the water during the overflow and the functionality of the treatment devices during an overflow event will influence the water quality at the time of discharge. Table 7.1 provides an overview the various overflow events and the indicative discharge water quality.

Table 7.1 Overview of discharge water quality

Circumstances for overflow	Overflow description	Source of water	Water quality treatment	Description of discharge water quality
Overflows during a significant rain event	Overflows will occur during and shortly after rainfall events when total runoff exceeds the volume of the water management basin. Once the basin is full, overflows will occur at the same rate as inflows to the basin.	Site stormwater management area and overflows from the bunded cementitious area.	The first flush tank will capture the 'first flush' runoff from the cementitious area which will entrain most of the potentially contaminating material which may be present on the ground surface. The water treatment plant will remove contaminants from the 'first flush' runoff. After the 'first flush' period, overflows from the cementitious area are expected to be of a comparable water quality of the stormwater management area. During these conditions, the water management basin will perform some water quality control function, likely at a reduced efficiency. Site stormwater may have elevated TSS.	Discharges may have elevated TSS.
Overflows during extended wet periods	Overflows will occur during extended wet periods when there is not sufficient time to restore the capacity of the water management basin between small rainfall events (ie events not in excess of the design event), or when runoff exceeds extractive demand from concrete batching.	Site stormwater management area and potentially overflows from the bunded cementitious area.	As above for the cementitious areas, however a greater volume of runoff from the cementitious area may be captured by the first flush tank as contents of the tank will be progressively removed and treated by the water treatment plant. During these conditions, it is expected stormwater will remain in the water management basin for sufficient time for the water quality controls to be effective.	Discharges may have slightly elevated TSS.
Overflows when the diversion channel exceeds capacity	Overflows will occur when runoff in the Watercourse A diversion channel exceeds the 10% AEP. Flows from the upstream catchment of Watercourse A will pass through the site, with a proportion of the flow entering the water management basin, causing overflows.	Majority of flows will be from the upstream catchment of Watercourse A which flow across the stormwater management area.	During these conditions the water management basin will perform limited water quality control function.	Discharge water quality is likely to be reflective of upstream water quality and potentially elevated TSS from the mobilisation of sediments from the stormwater management area that are inundated infrequently. Water quality for Watercourse A is currently unavailable but is likely to contain elevated nutrients and TSS due to the disturbed agricultural catchment upstream.

7.2.2 Assessment against WQOs and RFOs

It is expected that WQO values for turbidity will be occasionally exceeded. Broadly, the water quality of overflows is expected to be similar to the water quality of Watercourse A and immediate downstream areas, with no significant departures expected. Hence, occasional short duration overflows from the basin are not expected to materially change or degrade the water quality of Watercourse A or immediate downstream areas.

Table 7.2 assesses the performance of the proposed water management system against the WQOs and RFOs.

Table 7.2 Assessment of water quality and river flow objectives

Environmental value	Objective	Potential impacts
WQOs		
Aquatic ecosystems	Maintaining or improving the ecological condition of water bodies and their riparian zones over the long term.	No impacts to aquatic ecosystems are expected as the water quality of overflows is expected to be similar to the water quality of Watercourse A
Visual amenity	Aesthetic qualities of waters.	No impacts to the visual amenity of Watercourse A Watercourse A and immediate downstream areas is anticipated as the water quality of overflows is similar to expected water quality of Watercourse A and immediate downstream areas. In particular, overflows are not expected to have elevated concentrations of oils, suspended solids, petrochemicals and floating debris and nuisance organisms such as algae.
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.	No impacts to secondary or primary contact recreation activities are expected as the water quality of overflows is similar to the water quality of Watercourse A. In particular, overflows are not expected to have elevated concentrations of faecal coliforms, enterococci or protozoans as there is no source of these pollutants within the stormwater 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.	
Irrigation water supply	Protecting the quality of waters applied to crops and pasture.	No impacts to downstream irrigators are expected as the water quality of overflows is similar to the water quality of Watercourse A.
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.	It is unlikely that downstream users extract water from Watercourse A and immediate downstream areas for homestead water supply. Hence, impacts to homestead water supply are not assessed and assumed negligible.
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 to the Cooma-Monaro region is sourced largely from the Murrumbidgee River. No water is extracted from Watercourse A and immediate downstream areas for town water supply. Hence, impacts to drinking water supply are not assessed and assumed negligible.
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 Cooma Creek. However, the trigger values for aquatic foods apply to aquaculture not recreational fishing. The required level of protection will be provided by meeting the trigger values for aquatic ecosystems.

Table 7.2 Assessment of water quality and river flow objectives

Environmental value	Objective	Potential impacts
RFOs		
Protect pools in dry times	Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows.	No impacts to river flow objectives are expected as: • no extraction from Watercourse A is proposed; and • any increase in runoff volume due to increasing the concrete hardstand area and sealing the basin will be mitigated by stormwater harvesting, which is expected to reduce overflow volumes to be approximately between 54% (majority of project duration) and 73% (during project commencement).
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.	No anticipated impact
Minimise the effects of weirs and other structures	Minimise the impact of instream structures.	The proposed in-stream energy dissipation and scour protection measures will be designed to contribute to beneficial erosion control and is therefore not likely to have negative impacts to Watercourse A and immediate downstream areas.

7.2.3 Peak flows

The water management basin will attenuate stormwater flows from the site such that that peak runoff rates from the site, up to the 10% AEP rainfall event, will not exceed runoff generated by existing site conditions. For events less frequent than the 10% AEP, peak discharges from the site may exceed runoff generated under existing conditions.

Scour protection and energy dissipation will be constructed at the discharge location and at the confluence with Watercourse A to reduce erosion potential associated with the increased flow rates from the immediate site. The increased peak flow rates from the site will not occur at the same time as peak flows in Watercourse A. Therefore, peak flows, and erosion potential, in Watercourse A downstream of the site are unlikely to increase as a result of the project.

7.3 Groundwater impacts

The project includes several management measures to mitigate impacts to groundwater quality and quantity. These measures and assessed residual impacts are summarised in Table 7.3.

Table 7.3 Groundwater residual impacts

Impact mechanism	Management strategy/measures	Residual impact
Reduction in available groundwater resources due to interception of groundwater during cut and fill activities	Groundwater is not anticipated to be intercepted by planned works	No residual impact is anticipated
Reduction in aquifer recharge due to increased impervious surface area	No proposed water management strategy.	Development area is very small compared with groundwater source recharge area and these impacts are negligible. No residual impact is anticipated.
Water quality impacts due to infiltration of poor quality surface runoff to shallow groundwater systems	Sealing of all project areas with likely poor water quality. Ongoing maintenance of site water storages to prevent seepage of poor-quality water to shallow groundwater systems.	No residual impact is anticipated.

In the unlikely event that groundwater is intercepted, there is not anticipated to be any material impact at the nearest GDE at Cooma Creek, given both:

- any groundwater intercepted by the project will be very small compared with the total aquifer storage; and
- the distance to this sensitive receiver would likely negate the localised groundwater drawdown impact.

8 Water monitoring

8.1 Overview

Baseline water quality monitoring for Watercourse A and monitoring to assess the effectiveness of the proposed water management system will be undertaken. The objectives of the monitoring program are to collect data to:

- assist with characterisation of receiving water quality;
- assess the effectiveness of water quality controls and broader water management system;
- identify and quantify water quality impacts; and
- assess compliance against relevant consent and licence conditions (should these be applied).

The following sections outlines the proposed water monitoring strategy.

8.2 Monitoring program

The monitoring program, including monitoring locations, will be developed as part of the environmental management plan for the proposed segment factory. This would include:

- visual inspection of stormwater infrastructure for functionality and sediment accumulation;
- determination of ongoing monitoring locations;
- determination of frequency of required monitoring (typically would occur during wet weather to monitor site overflows);
- development of a targeted analytical suite; and
- formalisation of a reporting strategy for water quality monitoring results.

Monitoring locations would target site discharge and receiving waters both upstream and downstream of site. The established groundwater monitoring network could be used to monitor groundwater quality and quantity, however, considering the unlikelihood of groundwater impact, this is not considered necessary.

An indicative analytical suite for a concrete batching facility is presented in Table 8.1.

Table 8.1 Indicative analytical suite for concrete batching facility

Category	Sampling analytes	Analysis method
Physico-chemical parameters	pH, electrical conductivity, turbidity, total dissolved solids, total hardness	Calibrated hand-held water quality meter
	Total suspended solids	Analysis undertaken at NATA certified laboratory
Nutrients	Total nitrogen, ammonia, oxidised nitrogen and total kjeldahl nitrogen	Analysis undertaken at NATA certified laboratory
	Total phosphorus and reactive phosphorus	

Table 8.1 Indicative analytical suite for concrete batching facility

Category	Sampling analytes	Analysis method
	Total organic carbon, dissolved organic carbon	
Inorganics	Cyanide, fluoride	Analysis undertaken at NATA certified laboratory
Hydrocarbons	Total petroleum hydrocarbons, benzene, toluene, ethylbenzene, xylene and naphthalene (BTEXN)	Analysis undertaken at NATA certified laboratory
Metals (dissolved)	Al, As, Ag, B, Cr (III, VI and total), Co, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se, V and Zn	Analysis undertaken at NATA certified laboratory

9 Water licensing and approvals

9.1 Water licensing

Stormwater will be extracted from the first flush tank and the proposed water management basin. Extracted water will be either reused to meet operational demands or discharged to Watercourse A from the water management basin.

Water extraction (or water take) from the proposed first flush tank and water management basin is excluded works under *Water Management (General) Regulation 2011*, Schedule 1, item 3 (dams solely for the capture, containment or recirculation of drainage). Dams used for the containment and reuse of stormwater in line with industry best practice to prevent the contamination of a water course is also excluded from harvestable rights calculations. Accordingly, the project is expected to have no requirements for water licensing.

In the unlikely event that groundwater is intercepted by project activities, and aquifer access license may be required. At the time of writing, there were 69,248 unit shares of aquifer licenses available within the water sharing plan, 67,256.7 unit shares of which are currently allocated to WALs. Therefore, there are 1991.3 unit shares available for aquifer access licenses, should this be required.

9.1.1 NSW Aquifer Interference Policy

The dictionary to the WM Act defines an 'aquifer interference activity' as an activity involving any of the following:

- penetration of an aquifer;
- interference with water in an aquifer;
- obstruction of the flow of water in an aquifer;
- taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations; or
- disposal of water taken from an aquifer in the course of carrying our mining or any other activity prescribed in the regulations.

Section 91 (3) of the WM Act relates to aquifer interference approvals. The requirement to obtain an aquifer interference approval under Section 91 is triggered only when a proclamation has been made under Section 88A that the particular type of approval is required. To date, no proclamation has been made specifying that an aquifer interference approval is required in any part of NSW. This is expected to remain the case for the proposed segment factory.

In the meantime, the AIP sets the policy with respect to aquifer interference. The policy explains the role and requirements of the Minister in determining applications for aquifer interference activities. There is a series of seven fact sheets relating to the AIP. Six of these factsheets are relevant to this assessment and have been considered with the policy itself.

The AIP specifically refers to 'take' that is 'required to allow for the effective and safe operation of an activity, for example dewatering to allow mining' (p.3), regardless of whether the take is required to be used. The take, use, and incidental interception of groundwater requires a licence. The AIP states that, unless specifically exempt, a WAL is required under the WM Act where any act by a person carrying out an aquifer interference activity causes:

- the removal of water from a water source;

- the movement of water from one part of an aquifer to another part of an aquifer; and
- the movement of water from one water source to another water source, such as:
  - from an aquifer to an adjacent aquifer; or
  - from an aquifer to a river/lake; or
  - from a river/lake to an aquifer.

The proposed segment factory will not intercept groundwater and therefore will not require an entitlement. As such the proposed segment factory has not been assessed as an aquifer interference activity.

9.2 Water approvals

9.2.1 Impacts to waterfront land

The WM Act defines waterfront land as the bed and bank of any river, lake or estuary and all land within 40 m of the highest bank of the river, lake or estuary. A controlled activity includes any works which occur on waterfront land. Under this guideline the diversion of Watercourse A and the construction of the proposed segment factory would be considered controlled activities.

Permissible activities under this guideline are determined by the stream order of the relevant watercourse. As a third order watercourse, stream realignment would typically require a controlled activity approval. Approval would also typically be required for the encroachment on the vegetated riparian zone (30 m either side of the watercourse for a third order stream), which is proposed by this project for Watercourse A.

There is no proposed encroachment on the riparian zones for Watercourse B and C.

Section 5.23 of the EP&A Act provides that authorisations are not required for approved SSI and CSSI, including controlled activity approvals. The proposed segment factory is categorised as CSSI and therefore, should approval be granted, section 5.23 of the EP&A Act removes the requirement for a controlled activity approval to undertake work on waterfront land.

10 Summary

10.1 Project context

Snowy Hydro propose to develop a segment factory in Polo Flat. This facility will import material for concrete batching and export concrete products such as precast concrete segments to support the construction of the Snowy 2.0 scheme.

This water assessment forms part of the Environmental Impact Assessment that has been prepared for the proposed segment factory and addresses the Secretary's Environmental Assessment Requirements that are relevant to surface and groundwater management.

10.2 Water management strategy

10.2.1 Objectives

The proposed water management system is designed to achieve the following objectives:

- where practical, stormwater from upstream catchments will be diverted around the site to reduce loading on the internal water management system;
- provide water quality treatment and enable reuse to reduce any residual water quality risks;
- provide water quality controls that collectively meet industry standard pollutant load reductions;
- provide detention to mitigate increases in peak flows from impervious areas;
- separate runoff which may contact potentially contaminating materials such as cement and aggregates from clean stormwater;
- design site drainage to reduce infiltration or poor-quality water into the underlying groundwater system; and
- harvest stormwater to reduce stormwater overflows and demand from external water sources.

10.2.2 Expected outcomes

The water management system is expected to achieve the following outcomes:

- water quality modelling concluded industry standard pollution reduction targets can be achieved for the majority of the project duration in the event that harvested stormwater is suitable for use in concrete production;
- stormwater discharges will occur due to overflows from the water management basin. The water quality of overflows is expected to be similar to the water quality of Watercourse A and immediate downstream areas, with no significant departures expected. Hence, occasional short duration overflows from the basin are not expected to materially change or degrade the water quality of Watercourse A or immediate downstream areas. No significant impact to WQOs or RFOs is expected;
- diversion of upstream catchments for events up to the 10% AEP, with the exception of minor break out flows from Watercourse A which are managed by site drainage;

- detention of flows from the site up to the 10% AEP;
- minimal infiltration of poor-quality water into groundwater; and
- sourcing of water from a secure water supply which can be reduced by stormwater harvesting.

10.3 Flood risk management strategy

10.3.1 Overview

A flood assessment for the project was undertaken by GRC Hydro (2019). The objectives of the assessment were to characterise the existing flood conditions and assess the impacts on flooding due to the proposed site layout. Section 6 provides a summary of the existing and proposed flood conditions and describes the flood risk considerations associated with the project. The flood assessment is provided in Annexure B.

10.3.2 Flood impacts

The flood assessment concludes that in the 10% AEP minor breakout flows from Watercourse A will enter the site. The flows in such an event are minor and manageable, however, achieving immunity in the 10% AEP may be achieved by low level bunding or raising of ground levels.

Flood modelling indicates the project will cause both increases and decreases to flood depths and hazard on surrounding properties for the 10% AEP, 1% AEP and PMF events. Table 6.1 provides an overview of worsening impacts to flood depth and hazard on surrounding properties, located to the west and east of the site.

10.3.3 Risk management considerations

Flood risk management considerations include the risk of entrainment and risk to life.

An assessment of the flood risk of the project concluded that entrainment risk includes the following:

- low risk – fines (including cementitious material) and concrete admixtures; and
- high risk – concrete admixtures.

Proposed controls are presented in Section 10.3.4 below to reduce the risks associated with entrainment in flood waters.

Consideration of the risk to life concluded that risk to life as a result of the project is low. A flood emergency response plan will be prepared for the site that will include triggers for evacuation, closure, site preparation and evacuation protocols.

10.3.4 Proposed controls

The following flood risk management controls are proposed for the project:

- bunding of the cementitious area from the site stormwater management system;
- waste and hazardous materials will be located outside the 1% AEP extent;
- habitable buildings, electrical wiring and equipment will be located 500mm above the 1% AEP level;
- non-habitable building floor level will be a minimum of 300mm above the 1% AEP; and

- preparation of flood emergency response plan.

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Abbreviations

AEP	annual exceedance probability
AHD	Australian Height Datum
AIP	NSW Aquifer Interference Policy
ARR2016	Australian Rainfall and Runoff 2016
BGL	below ground level
BoM	Bureau of Meteorology
CBP	concrete batching plant
CSSI	Critical State significant infrastructure
DA	development application
DCP	Development Control Plan
DEE	Department of Environment and Energy
DP	Deposited Plan
DPIE	Department of Planning, Industry and Environment
DPIE – Water	Department of Planning, Industry and Environment – Water
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FGJV	Future Generation Joint Venture
GDE	groundwater dependent ecosystem
KNP	Kosciuszko National Park
LEP	Local Environmental Plan
LGA	Local Government Area
NRAR	Natural Resources Access Regulator
NTU	Nephelometric Turbidity Unit
PET	potential evapotranspiration
PFAS	poly-fluoroalkyl substances
PMF	Probable Maximum Flood
POEO	*Protection of the Environment Operations Act 1997*

RFO	river flow objective
SEARs	Secretary's Environmental Assessment Requirements
SMRC	Snowy Monaro Regional Council
SSI	State significant infrastructure
TBM	tunnel boring machine
TRH	total recoverable hydrocarbons
WAL	Water Access Licence
Water Act	*Water Act 1912*
WQO	water quality objective
WSP	Water Sharing Plan
WM Act	*Water Management Act 2000*

Annexure A

Photographs

Photograph A.1 Watercourse A showing channel form at southern (upstream) end of the site

Photograph A.2 Watercourse A showing existing piped crossing of airfield runway

Photograph A.3 Watercourse A showing channel form at northern (downstream) end of the site

Annexure B

Flood Assessment

SNOWY 2.0, POLO FLAT - FLOOD ASSESSMENT

Final Report

SEPTEMBER 2019

Snowy 2.0, Polo Flat – Flood Assessment

Project Number: 190014

Client: EMM Consulting Pty Ltd

Client Contact: Nick Bartho

Report Author: Zac Richards, William Tang

Date: 17 September 2019

Verified By: Zac Richards

Date	Version	Description
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EXECUTIVE SUMMARY

A flood study was undertaken for the Polo Flat site which is part of the Snowy 2.0 project. Polo Flat is subject to flooding from an unnamed flow path which passes through the site from south to north.

The '*Snowy Monaro Flood Studies Draft Final Report*' (SMEC Australia Pty Ltd and GRC Hydro Pty Ltd, 2019) and associated models, have been used as the basis of the current study with refinement of the Council models made to better assess the proposed works.

Flood characteristics for the 10% AEP, 1% AEP and PMF events have been assessed. Existing catchment conditions have been assessed using TUFLOW. The TUFLOW model was then modified to incorporate changes to the site that reflect the proposed conditions when the site is being used as segment casting yard and storage facility for the Snowy 2.0 project.

The proposed design approach was to divert flow around the site, such that the site is flood free for events up to the 10% AEP. A shallow flow break out (typically less than 0.1 m deep) from the existing channel was noted to enter the site under proposed conditions during this event. Additional measures would need to be considered to meet the design approach for 10% AEP event.

Comparison of pre and post development conditions was undertaken to assess the impact of the development on adjoining properties. 1% AEP event flood level impacts affecting adjoining properties were typically noted to be less than 0.1 m. A description of flood liability and flood impacts for properties adjoining the Polo Flat site has been provided in tabular format.

1. INTRODUCTION

This report has been prepared by GRC Hydro Pty Ltd on behalf of EMM Consulting Pty Ltd (EMM) for submission to Snowy Hydro Limited (Snowy Hydro) as part of the Snowy 2.0, Polo Flat, Secretary's Environmental Assessment Requirements (SEARs).

Flood characteristics for the Polo Flat site have been assessed. Existing conditions design flood behaviour has been defined for a range of events and proposed (post development) conditions flood behaviour has been analysed.

The Snowy Monaro Regional Council Flood Studies are being undertaken concurrently on behalf of Council by SMEC Australia Pty Ltd (SMEC) and GRC Hydro Pty Ltd (GRC Hydro). The *'Snowy Monaro Flood Studies Draft Final Report*' (SMEC/GRC Hydro, 2019) and associated models, have been used as the basis of the current study. Pertinent details of the draft flood study are discussed in Section 2.

1.1 The Project

Snowy Hydro proposes to develop Snowy 2.0, a large scale pumped hydro-electric storage and generation project which would increase hydro-electric capacity within the existing Snowy Mountains Hydro-electric Scheme. This would be achieved by establishing a new underground hydro-electric power station that would increase the generation capacity of the Snowy Scheme by almost 50%, providing an additional 2,000 megawatts generating capacity, and providing approximately 350 gigawatt hours of storage available to the National Electricity Market (NEM) at any one time, which is critical to ensuring system security as Australia transitions to a decarbonised NEM. Snowy 2.0 will link the existing Tantangara and Talbingo reservoirs within the Snowy Scheme through a series of underground tunnels and hydro-electric power station.

The tunnels for Snowy 2.0 would be excavated, for the most part, using tunnel boring machines and would be lined using precast concrete segments. These segments are to be manufactured at a proposed segment factory to be located at the Polo Flat site. The proposed segment factory would contain a building for the casting and curing of the segments, uncovered storage areas for raw materials and segments, vehicle parking areas and associated offices and workshops.

The NSW Department of Planning and Environment requires Secretary's Environmental Assessment Requirements (SEARs) to be undertaken for critical infrastructure. The current flooding assessment has been undertaken to address the relevant SEARs for the project, which include the assessment of potential flooding impacts and flood hazard considerations for the site.

1.2 Study Area

The Polo Flat site is situated on the eastern edge of the township of Cooma, NSW. The site is located on the site of a private airfield owned by Snowy Hydro and is traversed by an unnamed overland flow path (named Watercourse A for the purpose of this assessment) which flows in a northerly direction and joins Cooma Creek 5 km north of town. The upstream catchment area to the site is approximately 6 km^2. A study area map is presented in Image 1.

Image 1: Polo Flat Study Area Map

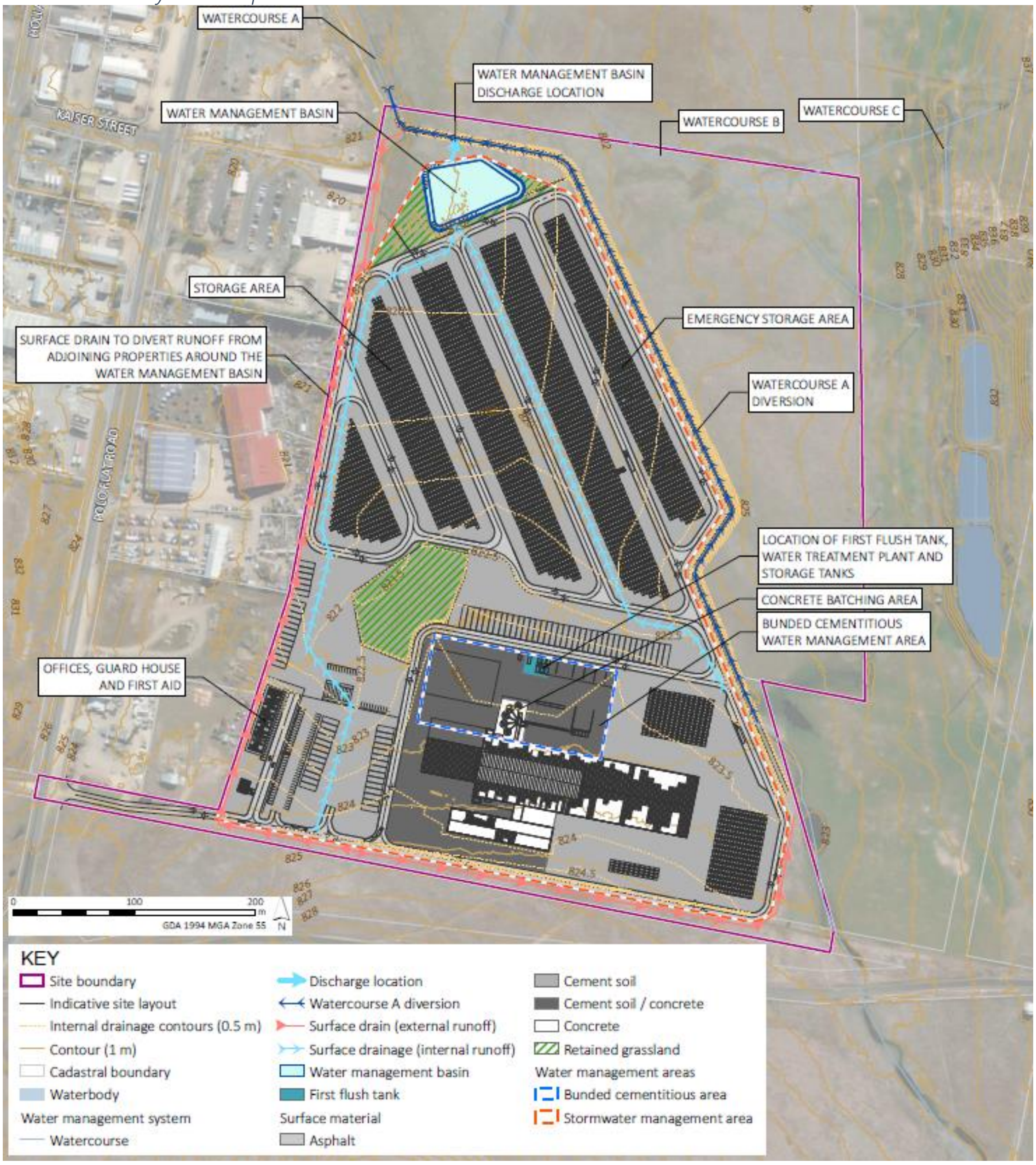


Table 1 presents observations of the Polo Flat site characteristics based on findings from a site visit undertaken in March 2019. These findings have been considered during model update and development.

Table 1: Polo Flat Characteristics

Observation	Photographs
Topography characterised as flat with average grades estimated to generally not exceed 5%.	
Sparse vegetation density noted within the proposed project site, composed of grazed grasslands and urban uses. Low Mannings values ranging from 0.04 to 0.05 are suspected for grassed areas (Chow 1959, ARR2019). Urban Mannings values ranging from 0.04 – 0.07.	
The Polo Flat channel that runs through the site is a combination of natural and manmade channels. Channel are typically earthen/grass based with Mannings estimated to be 0.04 to 0.05. The capacity of the natural channel in-bank is negligible for flood hydraulics, with greater capacity noted in the manmade channel.	
The catchment is used for mixed grazing with significant soil compaction expected due to hoven animals. Combination of sparse vegetation and compacted soils are consistent with low rainfall losses.	
A culvert under the Snowy Hydro private airfield runway was examined and noted to be a 1 x 750 mm dia. pipe connecting to the manmade channel to the west of the runway.	

1.3 Objectives

The key objective of the Polo Flat Flood Study is to address relevant aspects of the Snowy 2.0 Segment Factory (SSI 10034) SEARs for the project, as presented in Table 2.

Table 2: Snowy 2.0 Segment Factory (SSI 10034) – General Requirements relevant to flooding

Requirement	Addressed in Section
Water: - An assessment of the impacts of the project on: o ... any potential flooding impacts;	A discussion of Proposed Conditions flood behaviour, inclusive of flooding impacts is presented in Section 4.2 and 4.3.
Hazards: an assessment of any potential hazardous impacts or public safety risks on the project;	A discussion of potential hazardous impacts associated with flooding is presented in Section 4.2.

To assist in this assessment, the Flood Study defined design flood characteristics for Existing and Proposed Conditions for the Polo Flat site. The analysis has used the hydrologic and hydraulic models developed as part of the *'Snowy Monaro Flood Studies Draft Final Report'* (SMEC/GRC Hydro, 2019), which applies the methods outlined in ARR2016. Peak flood level, depth, extent and flood hazard have been produced for the 10% AEP, 1% AEP and Probable Maximum Flood (PMF) events.

To satisfy the key objective outlined above, the following analysis has been undertaken:

- Review of the *'Snowy Monaro Flood Studies Draft Final Report'* (SMEC/GRC Hydro, 2019) hydrologic and hydraulic models, to confirm suitability for implementation in the current study;
- Refinement of the Council models based on observations made as part of the site visit and to suit the proposed works;
    - Modelling of the 10% and 1% AEP events and the PMF for Existing Conditions;
- Implementing the proposed design developed by Future Generations Joint Venture (FGJV) to produce Proposed Conditions hydrologic and hydraulic models;
    - Modelling of the 10% and 1% AEP events and the PMF for Proposed Conditions; and
- Provide an assessment of flood liability and impacts for properties surrounding the site.

The results of this analysis are presented in the sections outlined below:

- Section 4.1 - Existing Conditions;
- Section 4.2 - Proposed Conditions; and
- Section 4.3 - Assessment of flood liability and impacts for existing properties.

2. SNOWY MONARO COUNCIL FLOOD STUDIES

The WBNM and TUFLOW models from the *'Snowy Monaro Flood Studies Draft Final Report'* (SMEC/GRC Hydro, 2019) form the basis of the current study analysis. Pertinent details of the Council study are discussed in this section.

2.1 Study Overview

SMEC and GRC Hydro are undertaking the Snowy Monaro Regional Council Flood Studies on behalf of Council. A Draft Final report was completed in July 2019. The study area covers four towns, namely; Cooma, Bredbo, Berridale and Michelago. The objective of the flood studies is to develop a comprehensive technical investigation of flood behaviour that provides the main technical foundation for the development of a robust floodplain risk management plan. A key component of the flood studies is the development of hydrologic and hydraulic flood models for which model calibration and validation was undertaken. ARR2016 methods have been applied for design flood modelling.

The Cooma study area includes the Polo Flat site. Further details presented herein pertain specifically to the Cooma aspects of the Snowy Monaro Regional Council Flood Studies, which has been used to inform the current study. Additional information is available in the *'Snowy Monaro Flood Studies Draft Final Report'* (SMEC/GRC Hydro, 2019).

Hydrologic models were developed using the WBNM software to simulate the rainfall/runoff response in the vicinity of Cooma, with these flows then being applied to the hydraulic model (TUFLOW). The hydraulic model was developed incorporating key hydraulic features including topography, bathymetry, roads, levees, buildings, bridges, culverts and stormwater drainage.

Calibration of the hydrologic model at Cooma was undertaken via comparison of model results to historic event data recorded at the Cooma Creek @ Cooma #2 (410081) stream gauge. Six historic rainfall events were analysed. Hydrologic model validation was undertaken by comparing design flows derived by the hydrologic model to Flood Frequency Analysis.

The Cooma hydraulic model was calibrated to available, albeit limited, historic flood observations of the February 2012 event. Additional validation was undertaken for the 1991 flood event at Cooma with flooding observations obtained from previous studies (SMEC, 1994).

The ensuing sections provide a summary of hydrologic and hydraulic model parameters and model calibration/validation for Cooma obtained from the *'Snowy Monaro Flood Studies Draft Final Report'* (SMEC/GRC Hydro, 2019). These parameters form the basis of the modelling works undertaken for the current study.

2.2 Hydrology

2.2.1 Hydrologic Model Build

2.2.1.1 Model schematisation and parameters

Two WBNM models were developed for Cooma:

- Mainstream model - with focus on Cooma Creek and Cooma Back Creek; and
- Local catchment model - for smaller tributaries and overland flow, inclusive of flow paths affecting the Polo Flat site.

Model calibration was undertaken for the mainstream model, with the calibrated model parameters applied to the local catchment model. It is assumed that due to the close proximity of the Cooma

Creek (the calibrated catchment) and Polo Flat catchment, model parameters in both catchments will be relatively consistent.

Details of the WBNM model schematisation are presented in Table 3. Sub-catchment delineation is presented in the *'Snowy Monaro Flood Studies Draft Final Report'* (SMEC/GRC Hydro, 2019).

Table 3: WBNM Model Schematisation

Model	Total model area (km^2)	Number of Catchments	Average catchment size (km^2)
Mainstream	260	15	17
Local	61	1,293	0.05

Table 4 presents the model parameters determined via the calibration/validation process. These parameters were used to model the historic events presented in the 'Model Calibration' section of this report, except for the initial loss value which was varied to account for variations in antecedent rainfall conditions for each event. These same parameters were implemented in design event modelling, with the Initial Loss adjusted for preburst as recommended in ARR2016.

Table 4: WBNM Design model parameters

Routing Parameter "C"	Continuing Loss (mm/hr)	Initial Loss (mm)	Impervious Initial Loss (mm)
1.0	0.5	27	1.5

*Adjusted for preburst as per ARR2016 guidelines.

2.2.1.2 *Design rainfall*

ARR2016 design rainfall grids for various durations were obtained from the Bureau of Meteorology (BoM). These grids account for the spatial variation in design rainfall across the catchment. Table 5 presents the rainfall depths at the Polo Flat site applied for the 10% and 1% AEP events.

Table 5: Design rainfall depths (mm)

Duration (min)	10% AEP Event	1% AEP Event
360	50.2	76.2
540	58.5	90.3
720	65.4	102
1080	76.4	121
1440	84.8	135

Probable Maximum Precipitation (PMP) rainfall depths were determined using the methods outlined in the Generalised Short Duration Method (GSDM). Cooma was defined as 100% 'Rough' with a Moisture Adjustment Factor of 0.63 and Elevation Adjustment Factor of 1.0.

2.2.1.3 *Rainfall losses*

Calibrated continuing losses (0.5 mm/hr) were implemented for design event modelling, whilst ARR2016 recommended initial losses (with allowances for pre-burst) were implemented.

PMF rainfall losses have been applied as an IL / CL model (IL = 0 mm, CL = 1 mm/hr) as per the methods outlined in the GSDM.

2.2.1.4 *Design rainfall temporal patterns*

Design rainfall temporal patterns are used to describe how rainfall is distributed as a function of time. The recommended ARR2016 ensemble approach to applying temporal patterns has been implemented. Point Temporal Patterns have been implemented as the catchment size is less than 75 km². The temporal patterns were obtained from ARR2016 for the 'Murray Basin' region.

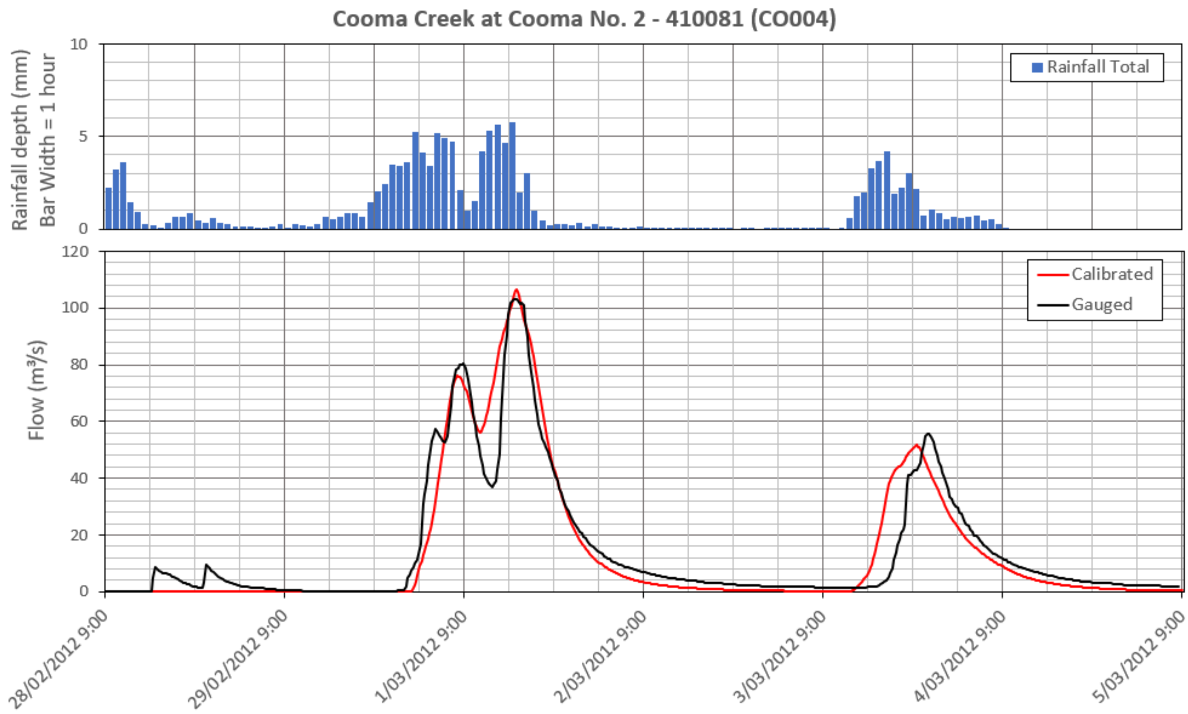
The GSDM temporal pattern was used in analysis of the PMF.

2.2.2 Hydrologic Model Calibration

Hydrologic model calibration was undertaken to provide robustness in hydrologic model flow estimates. The process was undertaken by adjusting model parameters (within the recommended guideline values) such that the model flow hydrograph results match stream gauge records for historic flood events. Hydrologic model calibration was undertaken for the February 2010, December 2010, February 2012, December 2014, April 2015 and June 2016 rainfall events.

Due to the magnitude of the February 2012 event and data availability, this event formed the focus of the model calibration exercise. The 2012 event was a widespread, long duration event, with rainfall estimates for ~12-18 hour duration noted to slightly exceed 1% AEP estimates at the Cooma AWS (70217). Chart 1 presents the calibration results for the 2012 event.

Chart 1: February 2012 hydrologic model calibration at Cooma Creek gauge



Calibration results for the remaining historic events are shown in Chart 2 to Chart 6. It was found that the hydrologic model generally provided good results for peak discharge. Hydrograph shape, flow volume and peak timing, generally provided reasonable results given the rainfall data limitation described in the SMEC/GRC Hydro (2019) report.

Chart 2: February 2010 hydrologic model calibration at Cooma Creek gauge

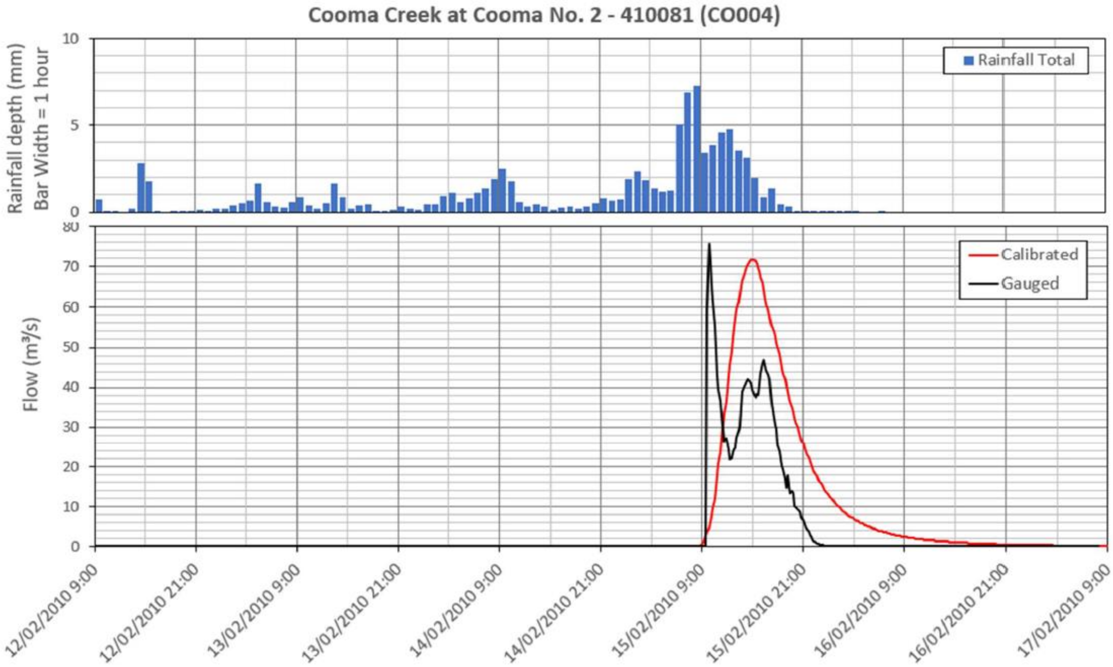


Chart 3: December 2010 hydrologic model calibration at Cooma Creek gauge

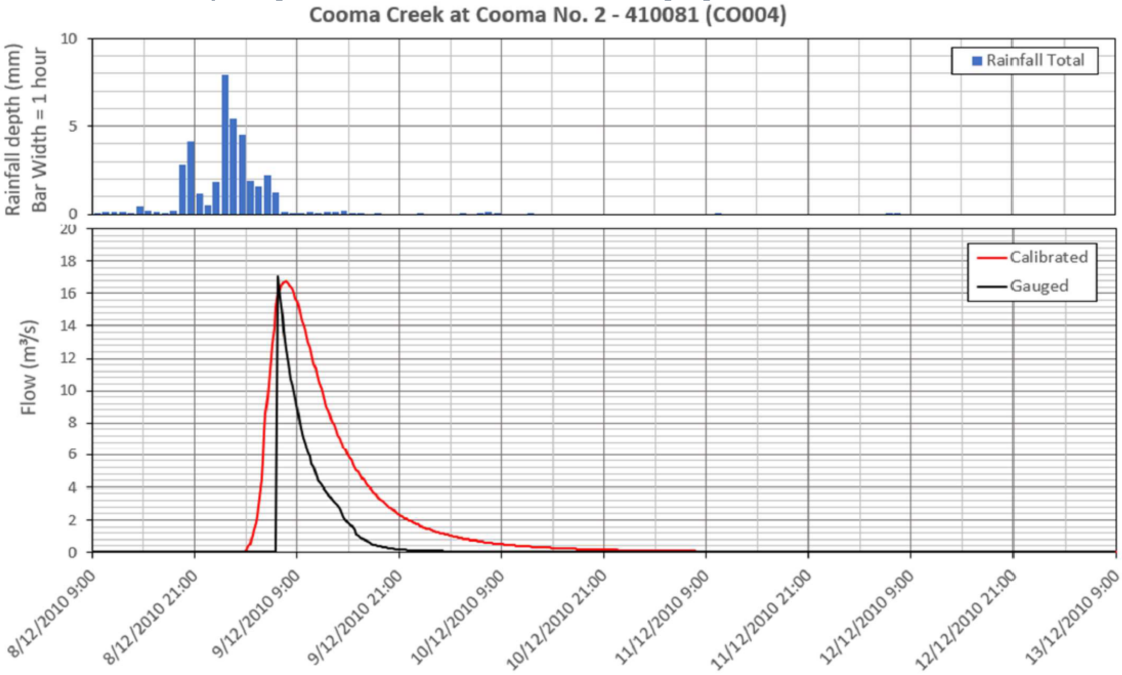


Chart 4: December 2014 hydrologic model calibration at Cooma Creek gauge

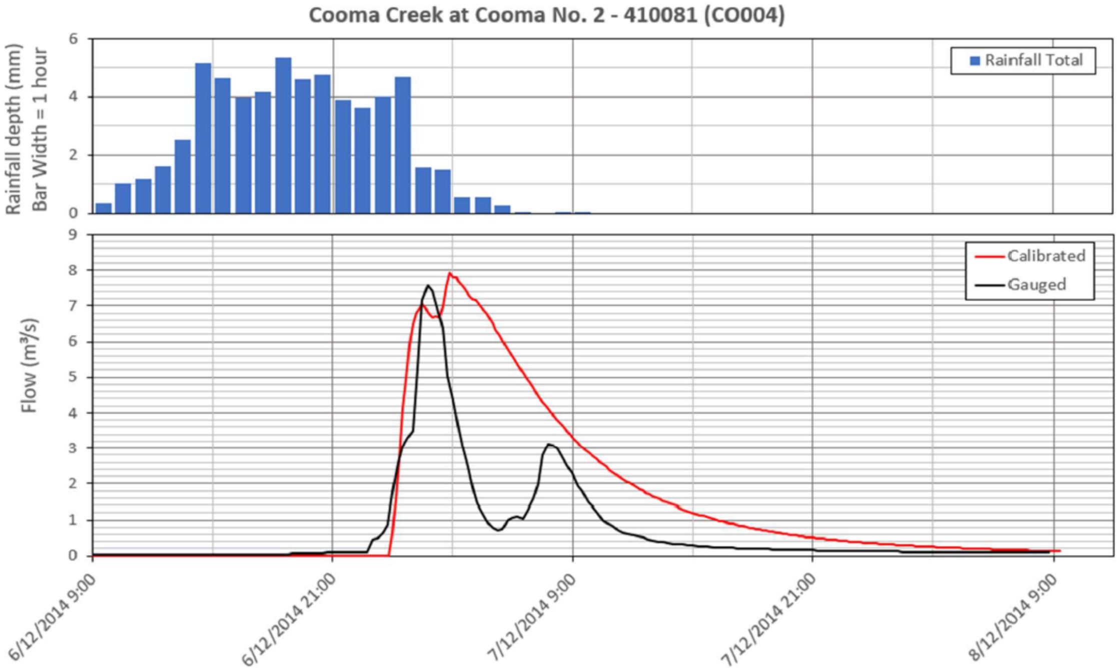


Chart 5: April 2015 hydrologic model calibration at Cooma Creek gauge

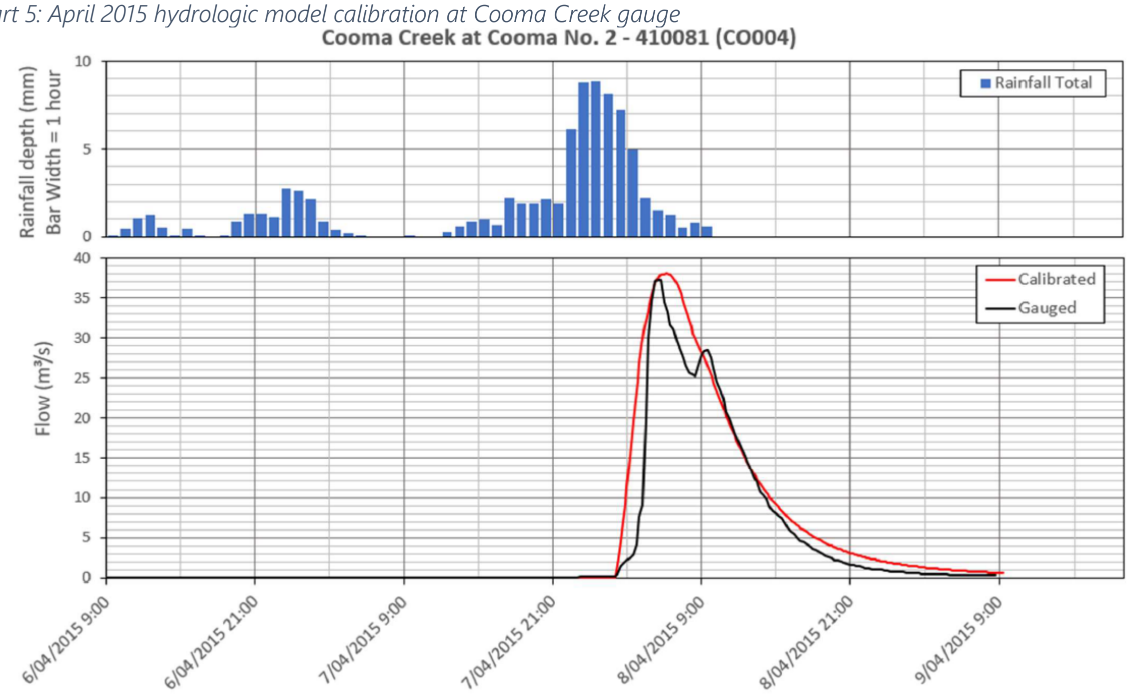
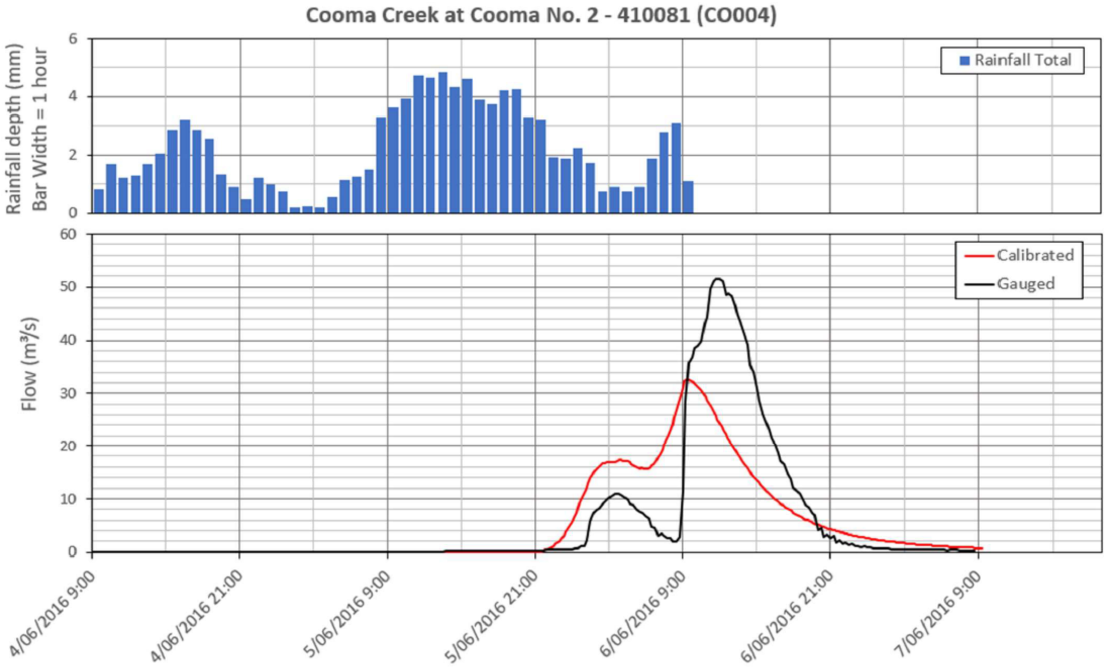


Chart 6: June 2016 hydrologic model calibration at Cooma Creek gauge



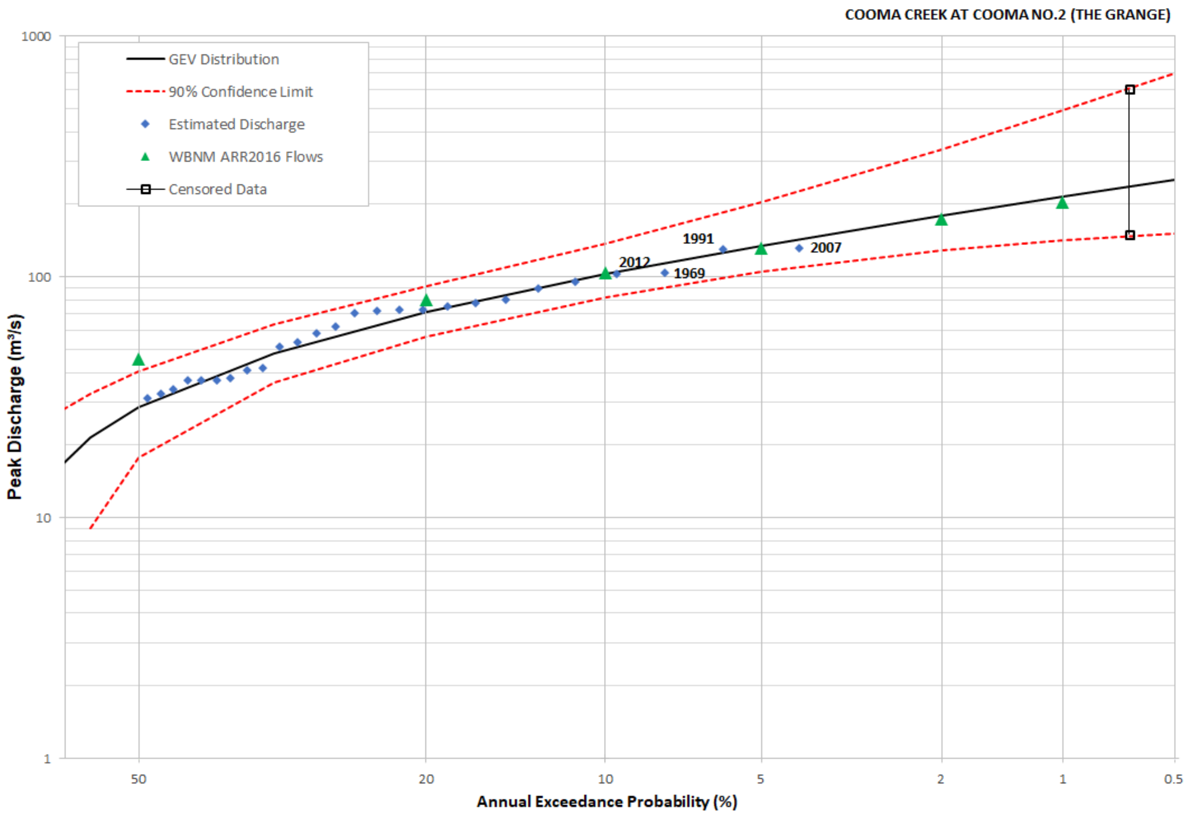
2.2.3 Hydrologic Model Validation

Hydrologic model validation was undertaken to provide confidence in design flow estimates. Validation was undertaken by comparing design flow estimates to Flood Frequency Analysis (FFA) undertaken for the Cooma Creek @ Cooma #2 (410081) stream gauge.

Flood Frequency Analysis (FFA) was performed on the annual maximum series of flows recorded at the gauge for the period between 1964 and 2017. The record period was extended to include two major events of unknown magnitude (1956, 1961) which were included in the analysis as censored events assuming that these events are the largest to occur at Cooma since 1955 (based on information provided in the 1994 SMEC study). The Grubbs-Beck Test for statistical outliers was applied, with outlier events censored from the record during analysis. The extreme value analysis software package 'FLIKE' was used for this analysis, following the procedures outlined in ARR2016. The Generalised Extreme Value (GEV) distribution was fitted to the annual series data and was noted to have the best fit relative to the other distributions that were examined.

Comparison of hydrologic model design flow estimates to FFA (see Chart 7) found that the two methods are in good agreement, thus providing additional confidence in the performance of the hydrologic model.

Chart 7: Flood Frequency curve for Cooma Creek at Cooma No. 2 gauge



2.3 Hydraulic Modelling

A TUFLOW hydraulic model was developed for the township of Cooma. Further details of the hydraulic model setup are presented in the *'Snowy Monaro Flood Studies Draft Final Report'* (SMEC/GRC Hydro, 2019). TUFLOW is 2D numerical modelling package which is suitable for modelling complex flood behaviour of channels and floodplains such as those at the site.

Various data and parameters implemented in the TUFLOW model are discussed below:

- Model Domain and Grid Size – The hydraulic model domain covers an area of 43.4 km^2, extending 750 m upstream of the site. The downstream boundary is situated approximately 7.7 km downstream of Polo Flat. The TUFLOW model implemented a grid size of 5 m x 5 m.
- Digital Elevation Model (DEM) – 1 m LiDAR data obtained from the NSW Government Spatial Services has been used to inform the topography of the 2D hydraulic model.
- Buildings - Buildings have been 'coded' out of the model domain, thus resulting in no conveyance or storage within the building footprint;
- Mannings Roughness – Mannings values were selected based on the site visit undertaken in April 2019 and inspection of aerial imagery. Selected Mannings values are consistent with the ranges described in ARR2016 and are presented in Table 6;

Table 6: Mannings roughness value

Land Use	Mannings
Pasture	0.04
Roads	0.02
Dense Vegetation	0.07
Spare Vegetation	0.04
Light Residential	0.06
Dense Residential	0.05
Commercial	0.04
Industrial	0.04 – 0.07
Creeks	0.035 - 0.05

- Boundary Conditions – The inflows to the TUFLOW model were obtained from the local WBNM model discussed previously. The downstream boundary was set a significant distance downstream to ensure that the boundary does not influence model results at the site.
- Hydraulic Features – Key hydraulic features such the drainage network, cross drainage structures and bridges have been included in the hydraulic model.

2.3.1 Hydraulic Model Calibration/Validation

The '*Snowy Monaro Flood Studies Draft Final Report*' (SMEC/GRC Hydro, 2019) undertook model calibration using the February 2012 event at Cooma. Peak flood level marks and observations of flooding submitted by the community were compared to modelled flood results. Only three calibration marks, all situated on Cooma Creek, were available for calibration. Calibration results indicated a reasonable match to observed flood behaviour with an absolute average error of 0.21 m.

Validation of the Cooma hydraulic model was undertaken by modelling of the 1991 flood event for Cooma Creek. The 1991 event was noted to have caused inundation at numerous properties within Cooma and flood marks were available from the SMEC 1994 study. The hydraulic model was modified to match the floodplain characteristics during the 1991 event. A peak flood profile and flood marks from the 1991 event were compared to the modelled flood behaviour. Generally, the Cooma Flood study found that the results provided a reasonable match to observed flood behaviour.

In lieu of suitable calibration data for the Polo Flat catchment, hydraulic model calibration was only able to be undertaken for Cooma Creek. Due to the proximity of the Cooma Creek and Polo Flat catchments, it is assumed that calibrated model parameters are suitable for both catchments.

3. CURRENT STUDY MODELLING METHODOLOGY

The WBNM and TUFLOW models from the '*Snowy Monaro Flood Studies Draft Final Report*' (SMEC/GRC Hydro, 2019) form the basis of the current study analysis.

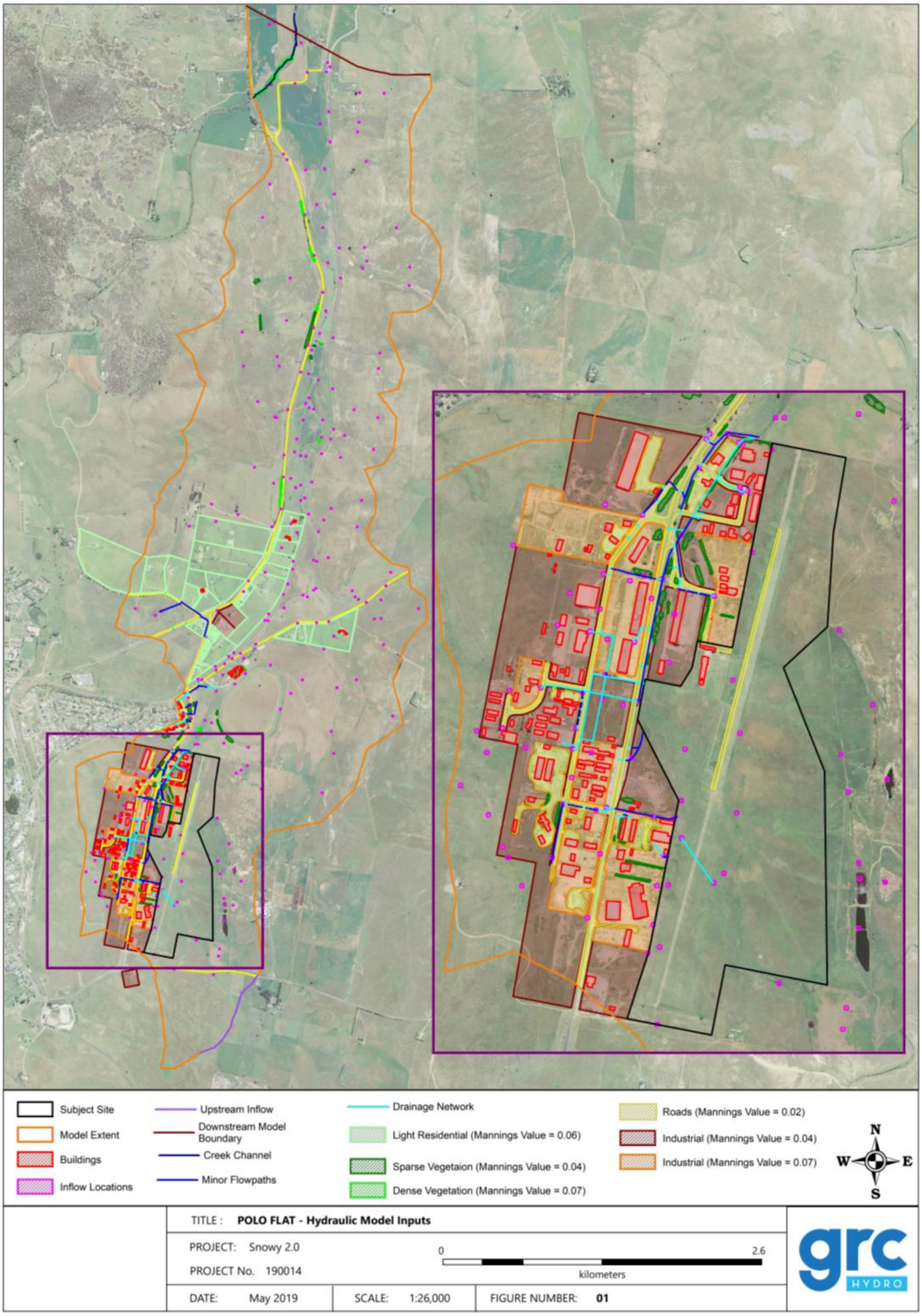
3.1.1 Existing Conditions models

Some refinement of the '*Snowy Monaro Flood Studies Draft Final Report*' (SMEC/GRC Hydro, 2019) TUFLOW model was made to better assess Existing Conditions for the site. The model refinement measures included:

- Truncation of the Council TUFLOW model such that only the Polo Flat catchment is assessed. This modification was made to optimise model run times;
- Increased resolution of the TUFLOW grid size from a 5 m x 5 m grid to a 2 m x 2 m grid to more accurately model key hydraulic features of the proposed design; and
- Refinement of Mannings roughness values to match observations made during the site visit. Specifically, some areas of 'industrial' zoned land roughness values were increased from 0.04 to 0.07 to account of blockage associated with fencing and other scattered debris.

Image 2 presents the TUFLOW hydraulic model layout for Existing Conditions. Modification to the Existing Conditions model were made to assess Proposed Conditions associated with the development as described in Section 3.1.2.

Image 2: Existing Conditions Hydraulic Model Setup



3.1.2 Proposed Conditions models

The Existing Conditions WBNM and TUFLOW models were modified to produce the Proposed Conditions models. The Proposed Conditions scenario represents the altered conditions during the time when the site is being used as the concrete segment casting facility and storage yard for the Snowy 2.0 project. The Proposed Conditions design was provided by FGJV with key features of the design presented in Image 1.

Key changes to the models included:

- Incorporation of a 3d TIN (provided by FGJV) into TUFLOW which represents bulk earthworks and landform changes associated with the development;
- Amendment of Mannings roughness values in the TUFLOW model to represent the surface materials presented in Image 1;
- Proposed segment storage areas have the potential to significantly reduce flood storage and conveyance when in use. As a conservative assumption, the segment storage areas have been 'coded' out of the model domain, thus resulting in no flood conveyance or storage in these areas under Proposed Conditions;
- Buildings have been 'coded' out of the model domain, thus resulting in no conveyance or storage within the building footprint;
- The 'bunded cementitious water management area' has been modelled with a 0.2 m high bund around the area (see Image 1); and
- Update of the WBNM hydrologic model to incorporate changes to land use and percentage perviousness of sub-catchments.

It should be noted that proposed v-drains on the western and southern site boundaries were not included in the TUFLOW model.

4. HYDRAULIC MODEL RESULTS

Hydraulic model results are presented in Sections 4.1 and 4.2 for Existing and Proposed Conditions respectively. A description of flood liability for the Polo Flat site as well as existing properties surrounding the site is presented in Section 4.3 for the Existing and Proposed Conditions scenarios.

4.1 Existing Conditions

Existing Conditions have been assessed using the TUFLOW model discussed in Section 3.1.1. Results are presented in Appendix A for the 10% AEP, 1% AEP and PMF events. Peak flood depths and levels are presented in figures:

- Figure A 1: Peak flood depths and levels – Existing Conditions – 10% AEP;
- Figure A 2: Peak flood depths and levels – Existing Conditions – 1% AEP; and
- Figure A 3: Peak flood depths and levels – Existing Conditions – PMF.

ARR2016 flood hazard based on the Australian Emergency Management Institute Handbook 7 Guidelines (AEMI) are presented in figures:

- Figure A 4: Flood hazard – Existing Conditions – 10% AEP;
- Figure A 5: Flood hazard – Existing Conditions – 1% AEP; and
- Figure A 6: Flood hazard – Existing Conditions – PMF.

Flood hazard is defined as a source of potential harm or a situation with the potential to result in loss (ARR2016). AEMI flood hazard considers the threat to people, vehicles and buildings based on flood depth and velocity at a specific location. The AEMI flood hazard mapping can be used to assess the flood hazard for site occupants and proposed site usage, as well as for the community surrounding the site.

Chart 8 and Table 7 present the relationship between the velocity and depth of floodwaters and the corresponding classification.

Chart 8: Flood Hazard Curves (Australian Emergency Management Handbook 7)

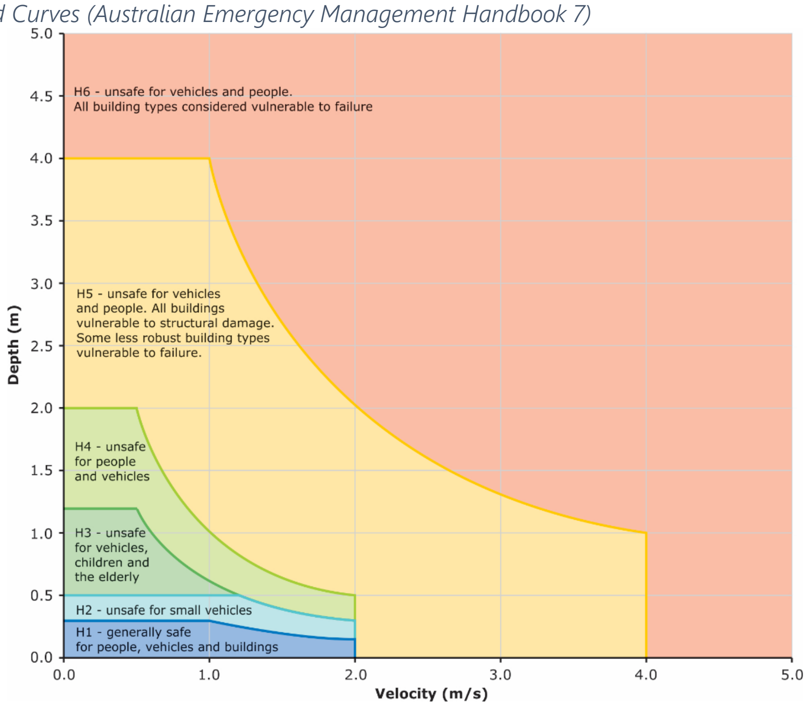


Table 7: Flood Hazard – Vulnerability Thresholds

Hazard Classification	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles, children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

4.2 Proposed Conditions

Proposed Conditions have been assessed using the TUFLOW model discussed in Section 3.1.2. Proposed Conditions results are presented in Appendix B for the 10% AEP, 1% AEP and PMF events. Peak flood depths and levels are presented in figures:

- Figure B 1: Peak flood depths and levels – Proposed Conditions – 10% AEP;
- Figure B 2: Peak flood depths and levels – Proposed Conditions – 1% AEP; and
- Figure B 3: Peak flood depths and levels – Proposed Conditions – PMF.

ARR2016 flood hazard based on the Australian Emergency Management Institute Handbook 7 Guidelines (AEMI) are presented in figures:

- Figure B 4: Flood hazard – Proposed Conditions – 10% AEP;
- Figure B 5: Flood hazard – Proposed Conditions – 1% AEP; and
- Figure B 6: Flood hazard – Proposed Conditions – PMF.

Flood level impact maps that compared the change in flood level between Existing and Proposed Conditions are presented in figures:

- Figure B 7: Flood level impact map – Proposed Conditions – 10% AEP;
- Figure B 8: Flood level impact map – Proposed Conditions – 1% AEP; and
- Figure B 9: Flood level impact map – Proposed Conditions – PMF.

Flood hazard impact maps that compared the change in flood hazard between Existing and Proposed Conditions are presented in figures:

- Figure B 10: Flood hazard impact map – Proposed Conditions – 10% AEP;
- Figure B 11: Flood hazard impact map – Proposed Conditions – 1% AEP; and
- Figure B 12: Flood hazard impact map – Proposed Conditions – PMF.

4.2.1 Proposed Conditions flood characteristics

Proposed Conditions flood characteristics for the site are discussed herein.

4.2.1.1 Site flood immunity

The proposed design approach was to divert the 10% AEP event around the site, such that the site is flood free for events up to the 10% AEP. A shallow flow break out (typically less than 0.1 m deep) from the existing channel was noted to enter the site under proposed conditions during this event. Additional measures would need to be considered to meet the design approach for 10% AEP event.

4.2.1.2 Discussion of site flood behaviour

The 1% AEP results presented in Figure B 2 and Figure B 5 (Appendix B) show that under Proposed Conditions the site is typically subject to flood depths less than 0.3 m and H1 to H2 hazard classifications, indicating limited flood risk to pedestrians and larger vehicles. There is a potential risk for smaller vehicles, that can float once flood depths exceed 0.3 m (or H2 hazard), which may result in vehicles being washed into areas of higher hazard. Higher areas of flood hazard are present in the Watercourse A diversion channel and the proposed water quality basin. Both the channel and the basin experience hazard categories between H4 and H5 and thus pose a significant risk to site personnel.

The PMF event results are presented in Appendix B, Figure B 3 and Figure B 6. Flood depths exceeding 1.0 m cover much of the site, with H5 flood hazard passing through the site between the segment storage areas. There is a significant risk to life for site personnel during extreme events such as the PMF.

During extreme events there is potential for the precast segments to shift or be moved downstream. Preliminary analysis was undertaken by resolving resultant forces experienced by the precast segments during the PMF event. The analysis outlined the potential for movement of the precast segments which may need to be considered during detailed design. The movement of segments in the event of an extreme flood may need to be considered to minimise risk for downstream properties and roads. It should be noted that there is little risk of segment movement in the 1% AEP event. Due to the low probability of occurrence of extreme floods, coupled with the temporary nature of the segment storage, the chance of segment movement due to flooding is low.

4.2.1.3 Discussion of flood impacts

Flood level impacts for the 10% and 1% AEP events are noted to be largely confined to the Polo Flat site. Increases in flood level are typically associated with changes in ground level due to bulk earthworks. For example, on Watercourse B, the proposed design has raised flood ground which results in an increase in flood level. In this situation the flood impact typically does not lead to an increase in flood depth.

Increases in potential flood liability are noted to impact on existing properties along the western property boundary. These areas are presented as 'Newly Flooded' areas on the flood impact maps and are associated with runoff from small local catchments being blocked by proposed raising of ground levels within the site. The proposed design indicates that v-drains are proposed along the western property boundary. V-drains could potentially be used to mitigate this impact if sized accordingly.

PMF flood impacts are again noted to predominantly impact the site. However, some increases in flood level and hazard do impact properties surrounding the site. Further detail of flood impacts on lot by lot basis are presented in Section 4.3.

4.3 Assessment of Flood Liability and Impacts for Existing Properties

Analysis of flood characteristics for existing properties surrounding the site is presented in Table 8. Each property has been assigned a unique identifier, presented on each of the appendix figures, which corresponds to Table 8.

Table 8 presents the Existing Conditions flood liability as well as potential flood impacts associated with the Proposed Conditions scenario, for the 10% AEP, 1% AEP and PMF events. This table can be used to assess the impact of the proposed works on existing development.

Table 8: Existing properties flood liability and impacts associated with the Polo Flat site development

Lot #	Address	Event	Existing Flood Liability	Impacts due to Proposed Works	Comment
01	89 Polo Flat Road	10% AEP	Minor flooding of the north-east corner of the lot, due to small local catchments to the south of the site. Maximum depth 0.05m with a flood hazard category of H1.	No Longer Flooded.	Floodwaters are diverted north due to raising of the western boundary of the site. Note that local drainage flows at a lot by lot resolution is beyond the resolution of the TUFLOW model. Site raising may lead to local drainage issues which have not been assessed using TUFLOW. A v-drain or similar should be considered to address local drainage issues for properties to the west of the site.
		1% AEP	Minor flooding of the north-east corner of the lot, due to small local catchments to the south of the site. Maximum depth 0.05m with a flood hazard category of H1.	No Longer Flooded.	
		PMF	Minor flooding of the north-east corner of the lot, due to small local catchments to the south of the site. Maximum depth 0.3m with a flood hazard category of H1.	No Longer Flooded.	
02	81 Polo Flat Road	10% AEP	Minor flooding of the north-east corner of the lot, due to minor local catchments to the south of the site. Maximum depth 0.1m with a flood hazard category H1.	Localised 'Newly Flooded' areas at the north-east corner with depths up to 0.3m and hazard level H1, and 'No Longer Flooded' areas at south-east corner.	A v-drain or similar should be considered to address local drainage issues and minor flood impacts for properties to the west of the site.
		1% AEP	Minor flooding of the north-east corner of the lot, due to minor local catchments to the south of the site. Maximum depth 0.1m with a flood hazard category of H1.	Localised 'Newly Flooded' areas at the north-east corner with depths up to 0.3m and hazard level H1, and 'No Longer Flooded' areas at south-east corner.	
		PMF	Minor flooding of the north-east corner of the lot, due to minor local catchments to the south of the site. Maximum depth 0.5m with a flood hazard category of H2.	Increased water levels by up to 0.3m with flood hazard increased by one category to maximum H3.	
03	79 Polo Flat Road	10% AEP	Not Flooded.	'Newly Flooded' areas at the east boundary with depths up to 0.3m and flood hazard category of H1.	
		1% AEP	Not Flooded.	'Newly Flooded' areas at the east boundary with depths up to 0.3m and flood hazard category of H1.	
		PMF	Flood depths of up to 0.5m with a maximum flood hazard category of H2 at eastern boundary.	Increased water levels by up to 0.5m with flood hazard increased by two categories to maximum H4.	
04	77 Polo Flat Road	10% AEP	Not Flooded.	'Newly Flooded' areas at the east boundary with depths less than 0.3m and a maximum flood hazard category of H1	
		1% AEP	Not Flooded.	'Newly Flooded' areas at the east boundary with depths less than 0.3m and a maximum flood hazard category of H1	
		PMF	Flood depths of less than 1.0 m with a maximum flood hazard category of H3 at east lot boundary.	Increased water levels by up to 0.5m with flood hazard increased by two categories to maximum H4.	
05	73 Polo Flat Road	10% AEP	Minor flooding of the north-east corner of the lot due to minor local catchments to the south and west of the site. Maximum depth of 0.3m with a flood hazard category of H1.	'Newly Flooded' areas and increased water levels by up to 0.2m at the eastern property boundary, with flood hazard category unchanged	
		1% AEP	Minor flooding of the north-east corner of the lot due to minor local catchments to the south and west of the site. Maximum depth of 0.3m with a flood hazard category of H1.	'Newly Flooded' areas and increased water levels by up to 0.2m at the eastern boundary, with flood hazard category increased to H2.	
		PMF	Flood depths of up to 1.0 m with a flood hazard category of up to H3 at east boundary.	Increased water levels by up to 0.3m with flood hazard increased by one category to maximum H3.	

Lot #	Address	Event	Existing Flood Liability	Impacts due to Proposed Works	Comment
06	71 Polo Flat Road	10% AEP	Flood depths of less than 0.3m with a flood hazard category of H1 at east boundary.	Increased flood levels at north-east corner of the lot by up to 0.1m and 'Newly Flooded' areas with a flood hazard category of H1.	A v-drain or similar should be considered to address local drainage issues and minor flood impacts for properties to the west of the site.
		1% AEP	Flood depths of less than 0.3m with a maximum flood hazard category of H2 at east boundary.	Increased flood levels at south-east corner of the lot of up to 0.1m, transitioning into a reduced water level of up to 0.1m at the north-east corner. Flood hazard category remains unchanged.	
		PMF	Flood depths of less than 1.0m with a flood hazard category of up to H5 at east boundary.	Decreased water levels by up to 0.2m, with typically no change in flood hazard category.	
07	69 Polo Flat Road	10% AEP	Not Flooded.	'Newly Flooded' areas at the south-east corner with depths up to 0.05m and a flood hazard category of H1.	
		1% AEP	Flood depths of less than 0.3m with a flood hazard category of H1 at east boundary.	Decreased flood levels at site by up to 0.2m, with flood hazard category unchanged.	
		PMF	Flood depths exceeding 1.0m with a flood hazard category of up to H4 on the eastern and northern property boundaries.	Decreased water levels by up to 0.2m, with typically no change in flood hazard category.	
08	63 Polo Flat Road	10% AEP	Flows are contained within the channel on the south boundary, with depths of up to 1.0m and a flood hazard category of up to H3.	Reduced flood levels of up to 0.2m in the channel, with unchanged flood hazard.	
		1% AEP	Flows are contained within the channel on the south boundary, with depths of up to 1.0m and a flood hazard category of up to H3.	Reduced flood levels of up to 0.1m in the channel, with unchanged flood hazard.	
		PMF	Flood depths exceeding 1.0 m in the channel, with much of the lot experiencing flood depths exceeding 0.3m. Flood hazard categories ranging from H2 to H4.	Reduced flood levels of up to 0.1m in the channel, with unchanged flood hazard.	
09	53 Polo Flat Road	10% AEP	Flows are contained within the channel on the south boundary, with depths of up to 1.0m and a flood hazard category of up to H3.	Reduced flood levels of up to 0.1m in the channel, with unchanged flood hazard.	
		1% AEP	Flows are contained within the channel on the south boundary, with depths of up to 1.0m and a flood hazard category of up to H3.	Reduced flood levels of up to 0.1m in the channel, with unchanged flood hazard.	
		PMF	Flood depths exceeding 1.0 m in the channel, with much of the lot experiencing flood depths exceeding 0.3m. Flood hazard categories ranging from H2 to H5.	Reduced flood levels of up to 0.1m at the south-west corner of the lot, with increased water levels of up to 0.1m at the south-east corner. Flood hazard remains unchanged.	
10	9 Polo Flat Road	10% AEP	Shallow sheet flow from catchments to the east of the site affect the property. Watercourse A causes the most significant flood liability with flow depths exceeding 1.0m and a flood hazard categories hazard level of up to H5.	No Impact.	Location of where the proposed channel converges with existing channel.
		1% AEP	Shallow sheet flow from catchments to the east of the site affect the property. Watercourse A causes the most significant flood liability with flow depths exceeding 1.0m and a flood hazard categories hazard level of up to H5.	Decreased flood levels of up to 0.1m, with a small area that increases by less than 0.1m. Flood hazard category generally remains unchanged.	
		PMF	Watercourse A flow depths exceed 2.0m and hazard level of up to H6. Minor flow paths are present coming from the east.	Decreased water level by up to 0.1m, with a small area that increases by up to 0.1m, with typically no change in flood hazard category.	
11	123 Carlaminda Road	10% AEP	Shallow overland flow affected. No mainstream flood affectation.	No Impact.	The proposed works do not affect this lot.

Lot #	Address	Event	Existing Flood Liability	Impacts due to Proposed Works	Comment
		1% AEP	Shallow overland flow affected. No mainstream flood affectation.	No Impact.	
		PMF	Shallow overland flow affected. No mainstream flood affectation.	No Impact.	
12	123 Carlaminda Road	10% AEP	Shallow overland flow affected. No mainstream flood affectation.	No Impact.	
		1% AEP	Shallow overland flow affected. No mainstream flood affectation.	No Impact.	
		PMF	Shallow overland flow affected. No mainstream flood affectation.	No Impact.	
13	123 Carlaminda Road	10% AEP	Western boundary within flow path of Watercourse A, with depths exceeding 1.0m and hazard level of up to H5.	Flood level impacts are noted with both increases and decreases in flood level between ±0.1m experienced dependant on location. No significant impact on flood hazard is noted.	
		1% AEP	Western boundary within flow path of Watercourse A, with depths exceeding 1.0m and hazard level of up to H5.	Flood level impacts are noted with both increases (<0.2m) and decreases (<0.1m) in flood level experienced dependant on location. Both increases and decreases of one flood hazard category are experienced for localised areas.	
		PMF	West boundary within flow path of Watercourse A, with depths exceeding 2.0m hazard level of up to H6.	Increased water levels by up to 0.5m with flood hazard increased by typically less than two categories to maximum H5.	

5. CONCLUSIONS

A flood study was undertaken for the Polo Flat site which is part of the Snowy 2.0 project. In its current condition, the Polo Flat site is subject to flooding from an unnamed flow path which passes through the site from south to north.

The '*Snowy Monaro Flood Studies Draft Final Report*' (SMEC/GRC Hydro, 2019) and associated models, have been used as the basis of the current study with refinement of the Council models made to better assess the proposed works.

Flood characteristics for the 10% AEP, 1% AEP and PMF events have been assessed. Existing catchment conditions have been assessed using TUFLOW. The TUFLOW model was then modified to incorporate changes to the site that reflect the proposed conditions when the site is being used as segment casting yard and storage facility for the Snowy 2.0 project.

The proposed design approach was to divert flow around the site, such that the site is flood free for events up to the 10% AEP. A shallow flow break out (typically less than 0.1 m deep) from the existing channel was noted to enter the site under proposed conditions during this event. Additional measures would need to be considered to meet the design approach for 10% AEP event.

Comparison of pre and post development conditions was undertaken to assess the impact of the development on adjoining properties. 1% AEP event flood level impacts affecting adjoining properties were typically noted to be less than 0.1 m. A description of flood liability and flood impacts for properties adjoining the Polo Flat site has been provided in tabular format.

6. REFERENCES

1. Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I
   Australian Rainfall and Runoff (ARR2016)
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2. SMEC Australia Pty Ltd & GRC Hydro Pty Ltd
   Snowy Monaro Regional Council Flood Studies – Draft Final Report
   Snowy Monaro Regional Council, July 2019

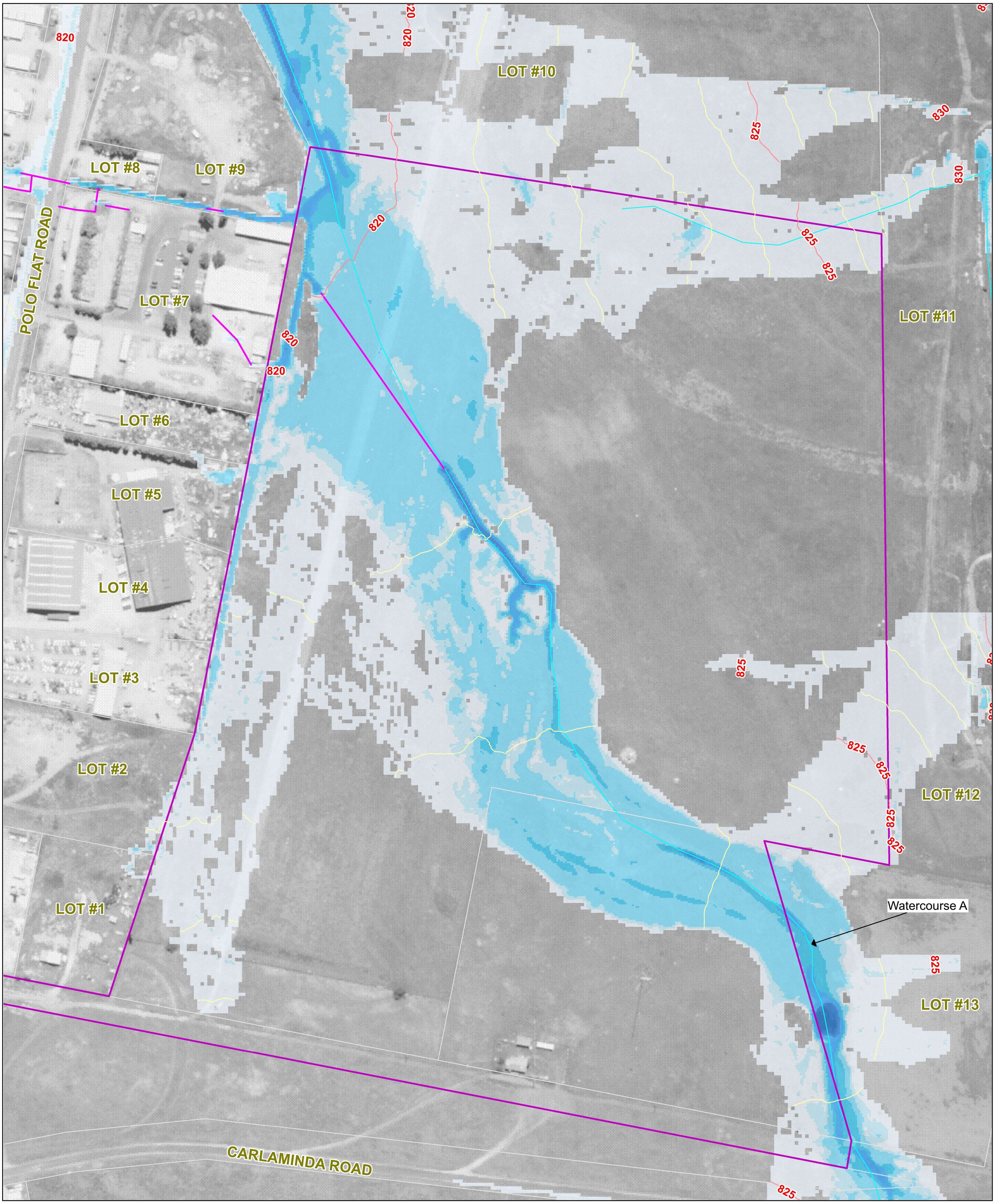
3. NSW Office of Environment and Heritage
   Floodplain Risk Management Guide, Incorporating 2016 Australian Rainfall and Runoff in Studies
   NSW Government, 2019

4. BMT WBM
   TUFLOW User Manual - Build 2016-03-AA
   TUFLOW, 2016

5. Australian Government
   The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method
   Bureau of Meteorology, 2006

6. Australian Government
   AEM Handbook 7, Technical flood risk management guideline – Flood Hazard
   Australian Emergency Management Institute, 2014

Appendix A:



Site Boundary
Cadastral Boundary
Existing piped stormwater network
Watercourse
Water Level - Major Contour (Spacing = 5.0m)
Water Level - Minor Contour (Spacing = 1.0m)

Flood Depth (m)

0.00 to 0.05	0.5 to 1.0
0.05 to 0.1	1.0 to 2.0
0.1 to 0.3	> 2.0
0.3 to 0.5	

N W E S

snowyhydro Limited
renewable energy

TITLE : **POLO FLAT BASE CONDITIONS: 10% AEP DESIGN EVENT - Peak flood depth and levels**

PROJECT: Snowy 2.0

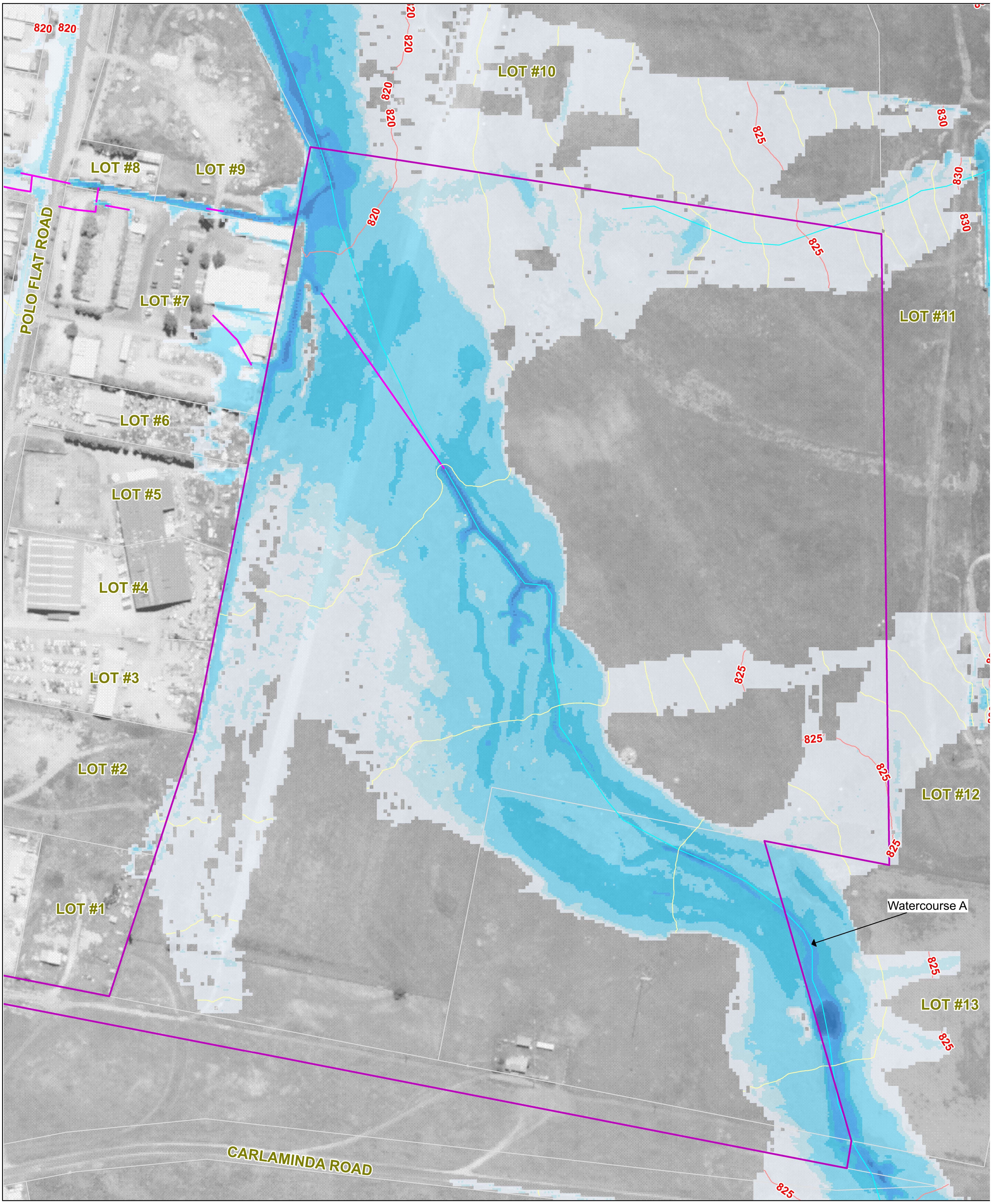
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **A01**

grc HYDRO

EMM creating opportunities



Site Boundary
Cadastral Boundary
Existing piped stormwater network
Watercourse
Water Level - Major Contour (Spacing = 5.0m)
Water Level - Minor Contour (Spacing = 1.0m)

Flood Depth (m)

0.00 to 0.05	0.5 to 1.0
0.05 to 0.1	1.0 to 2.0
0.1 to 0.3	> 2.0
0.3 to 0.5	

N W E S

snowyhydro Limited renewable energy

TITLE : **POLO FLAT BASE CONDITIONS: 1% AEP DESIGN EVENT - Peak flood depth and levels**

PROJECT: Snowy 2.0

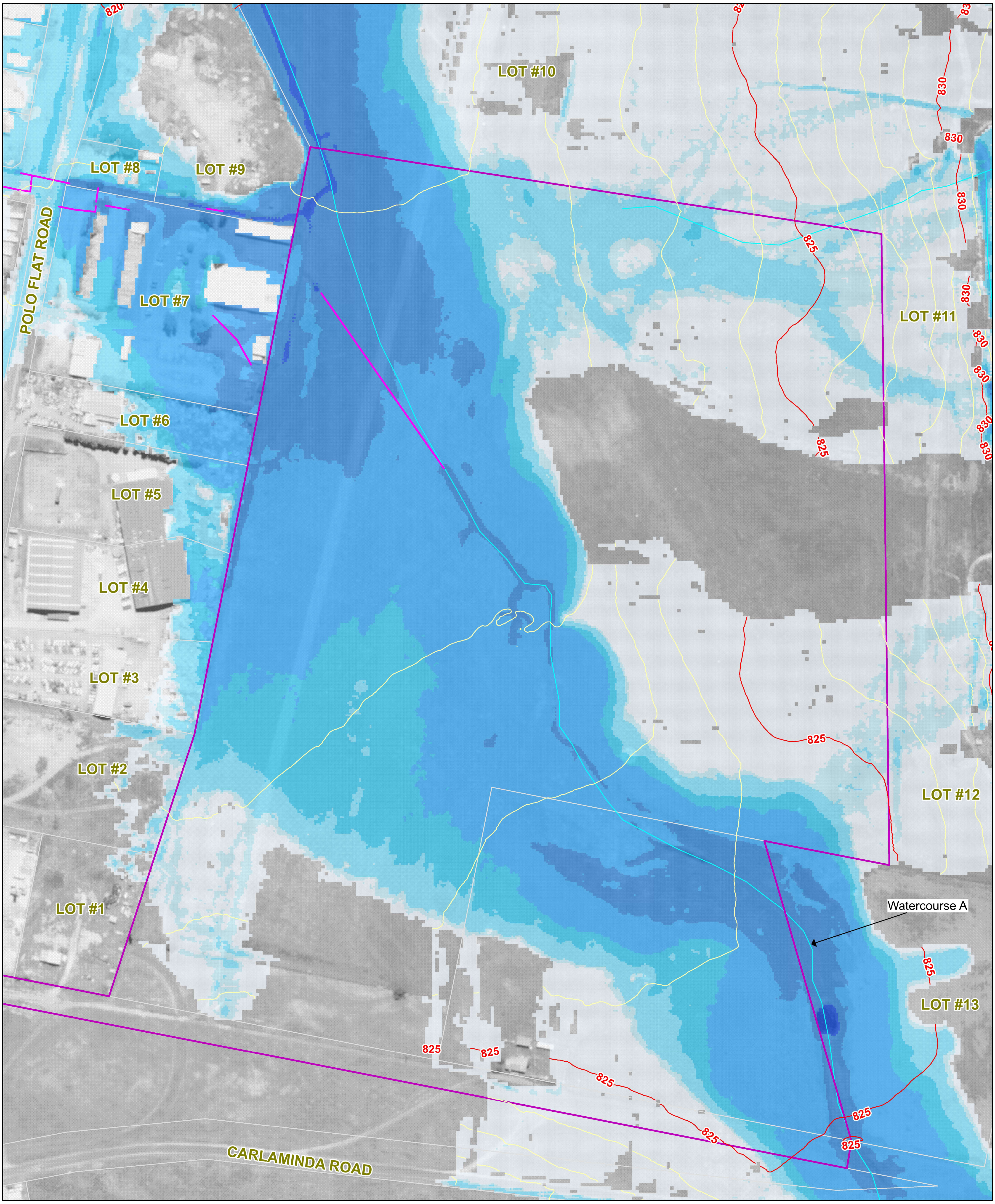
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **A02**

grc HYDRO

EMM creating opportunities



Site Boundary
Cadastral Boundary
Existing piped stormwater network
Watercourse
Water Level - Major Contour (Spacing = 5.0m)
Water Level - Minor Contour (Spacing = 1.0m)

Flood Depth (m)

0.00 to 0.05	0.5 to 1.0
0.05 to 0.1	1.0 to 2.0
0.1 to 0.3	> 2.0
0.3 to 0.5	

N W E S

snowyhydro Limited renewable energy

TITLE : **POLO FLAT BASE CONDITIONS: PMF DESIGN EVENT - Peak flood depth and levels**

PROJECT: Snowy 2.0

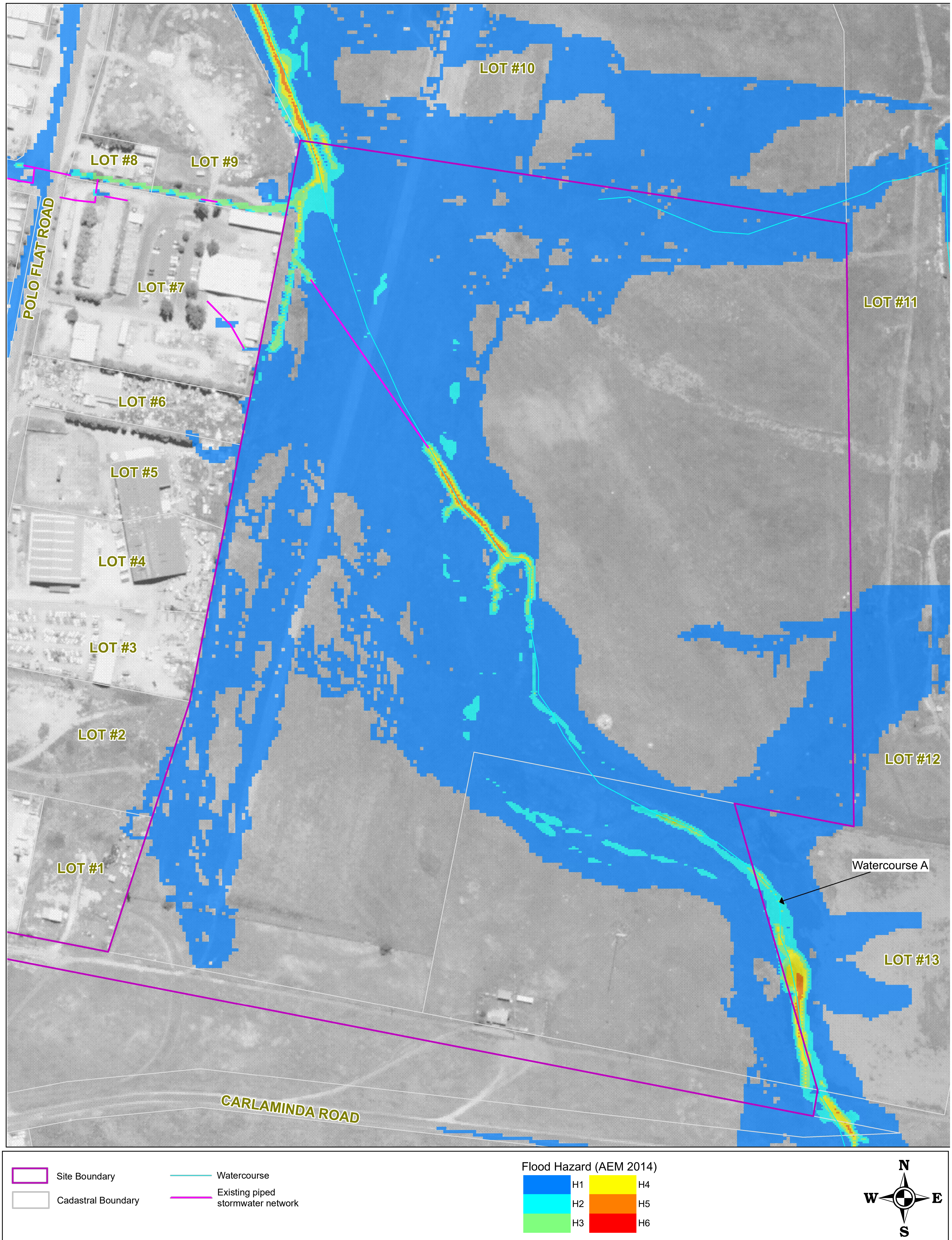
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **A03**

grc HYDRO

EMM creating opportunities



snowyhydro Limited renewable energy

TITLE : **POLO FLAT BASE CONDITIONS: 10% AEP DESIGN EVENT - Flood Hazard**

PROJECT: Snowy 2.0

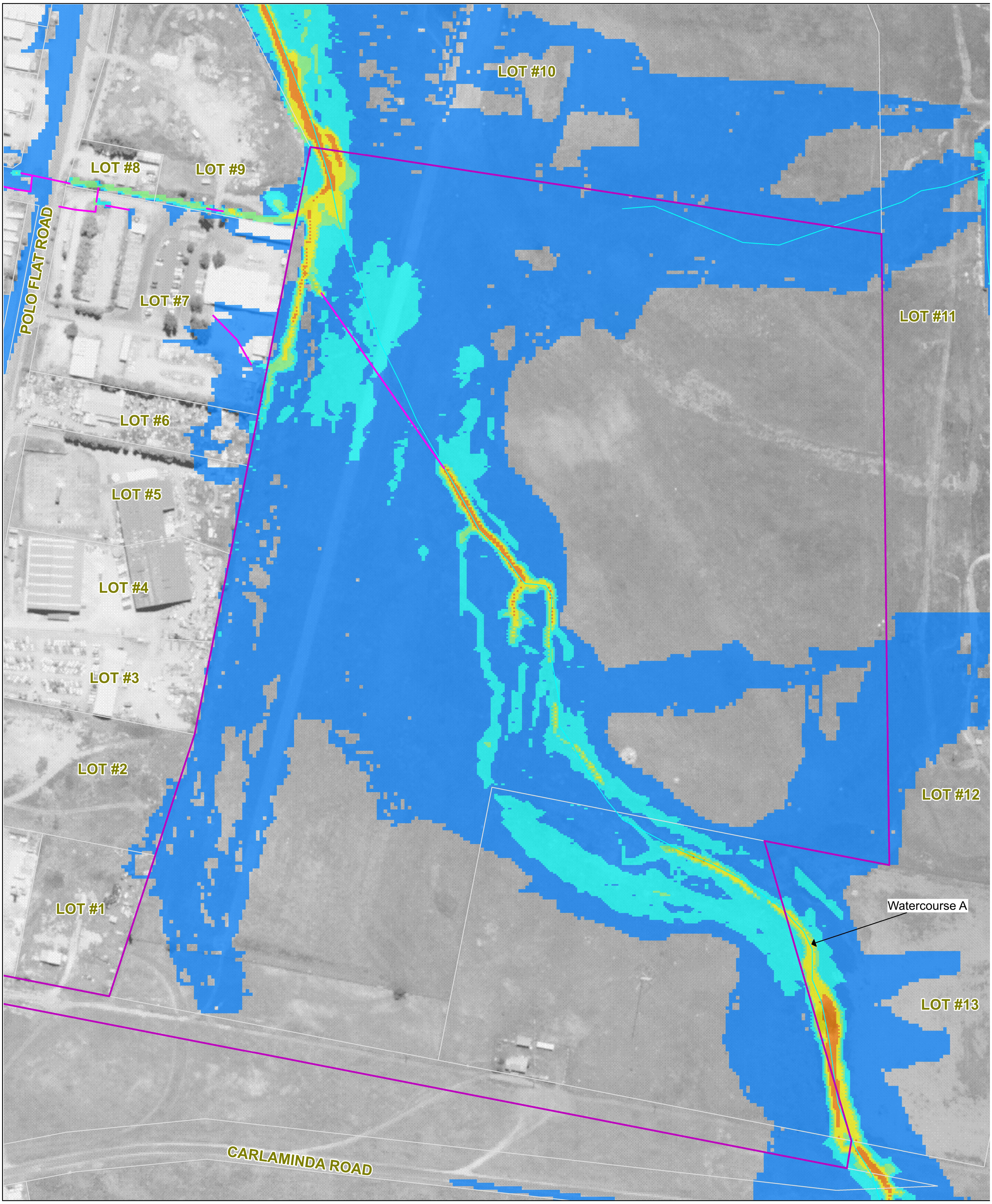
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **A04**

grc HYDRO

EMM creating opportunities



snowyhydro Limited renewable energy

TITLE : **POLO FLAT BASE CONDITIONS: 1% AEP DESIGN EVENT - Flood Hazard**

PROJECT: Snowy 2.0

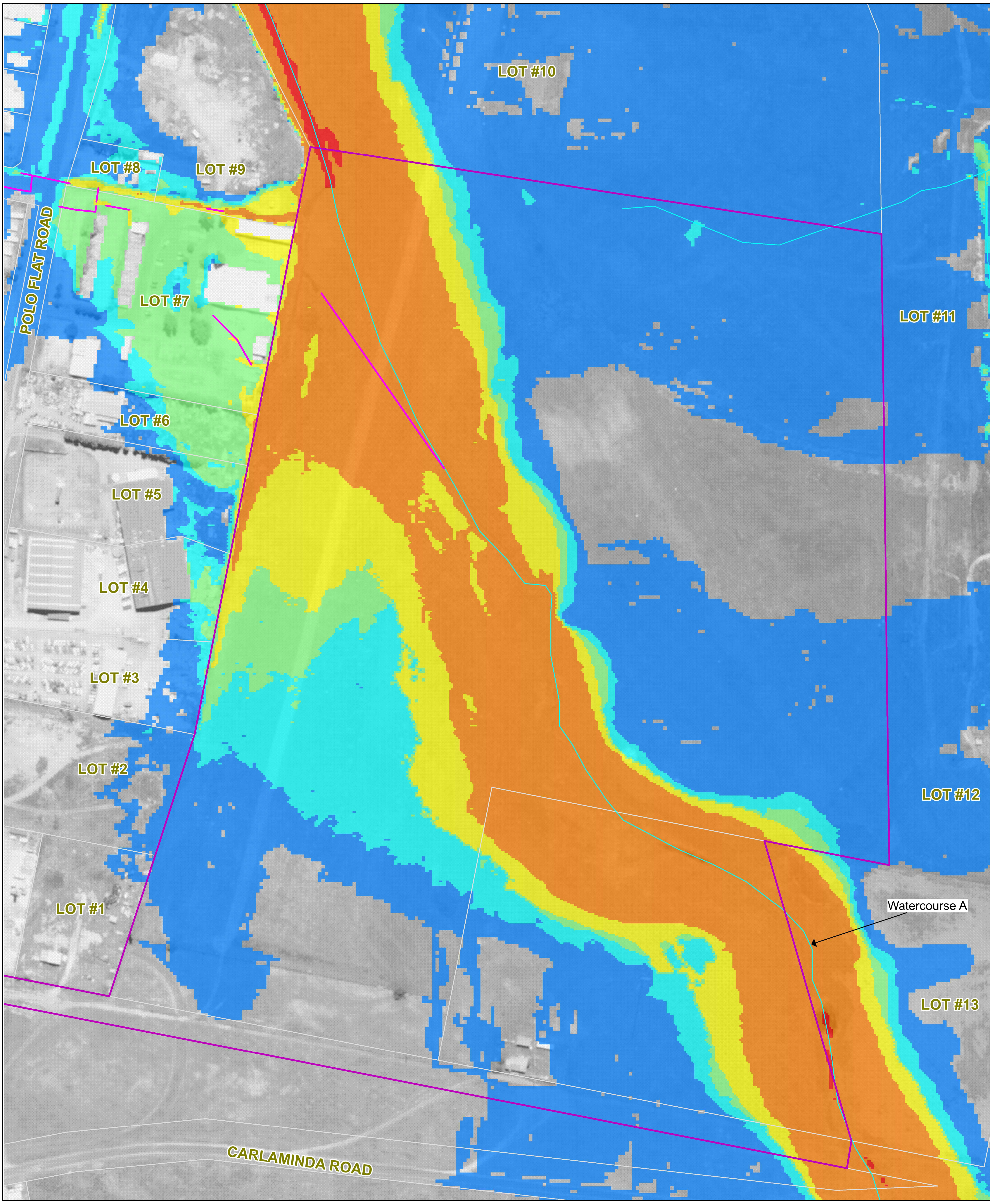
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **A05**

grc HYDRO

EMM creating opportunities



Site Boundary
Cadastral Boundary
Watercourse
Existing piped stormwater network

Flood Hazard (AEM 2014)

H1 H4
H2 H5
H3 H6

N W E S

snowyhydro Limited renewable energy

TITLE : **POLO FLAT BASE CONDITIONS: PMF DESIGN EVENT - Flood Hazard**

PROJECT: Snowy 2.0

PROJECT No. 190014

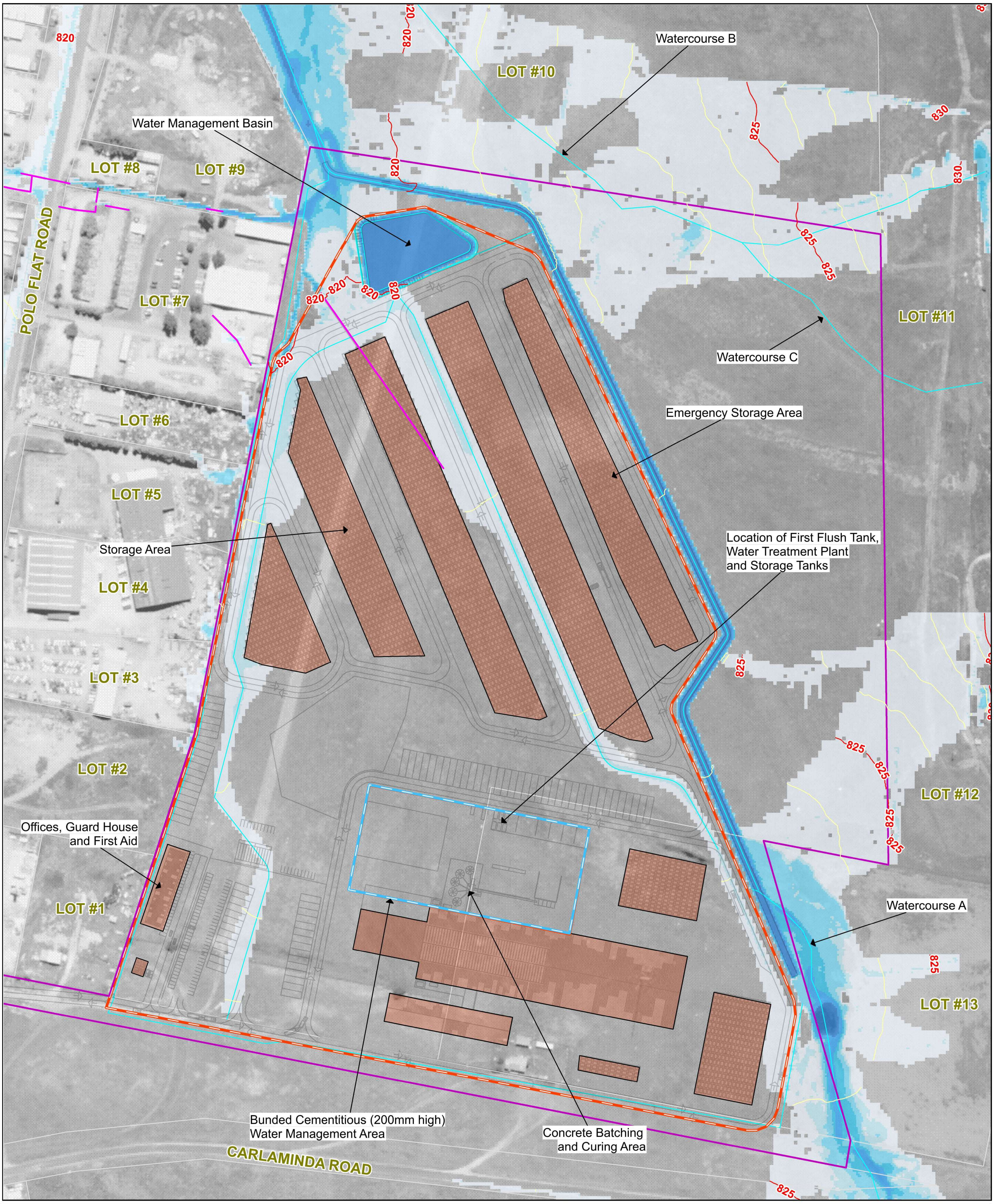
0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **A06**

grc HYDRO

EMM creating opportunities

Appendix B:



Existing piped stormwater network
Site Boundary
Stormwater Management Area
Bunded Cementitious Area
Cadastral Boundary
Blocked Areas
Indicative Site Layout
Watercourse
Water Level - Major Contour (Spacing = 5.0m)
Water Level - Minor Contour (Spacing = 1.0m)

Flood Depth (m)

0.00 to 0.05	0.5 to 1.0
0.05 to 0.1	1.0 to 2.0
0.1 to 0.3	> 2.0
0.3 to 0.5	

N E S W

snowyhydro Limited renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: 10% AEP DESIGN EVENT - Peak flood depth and levels**

PROJECT: Snowy 2.0

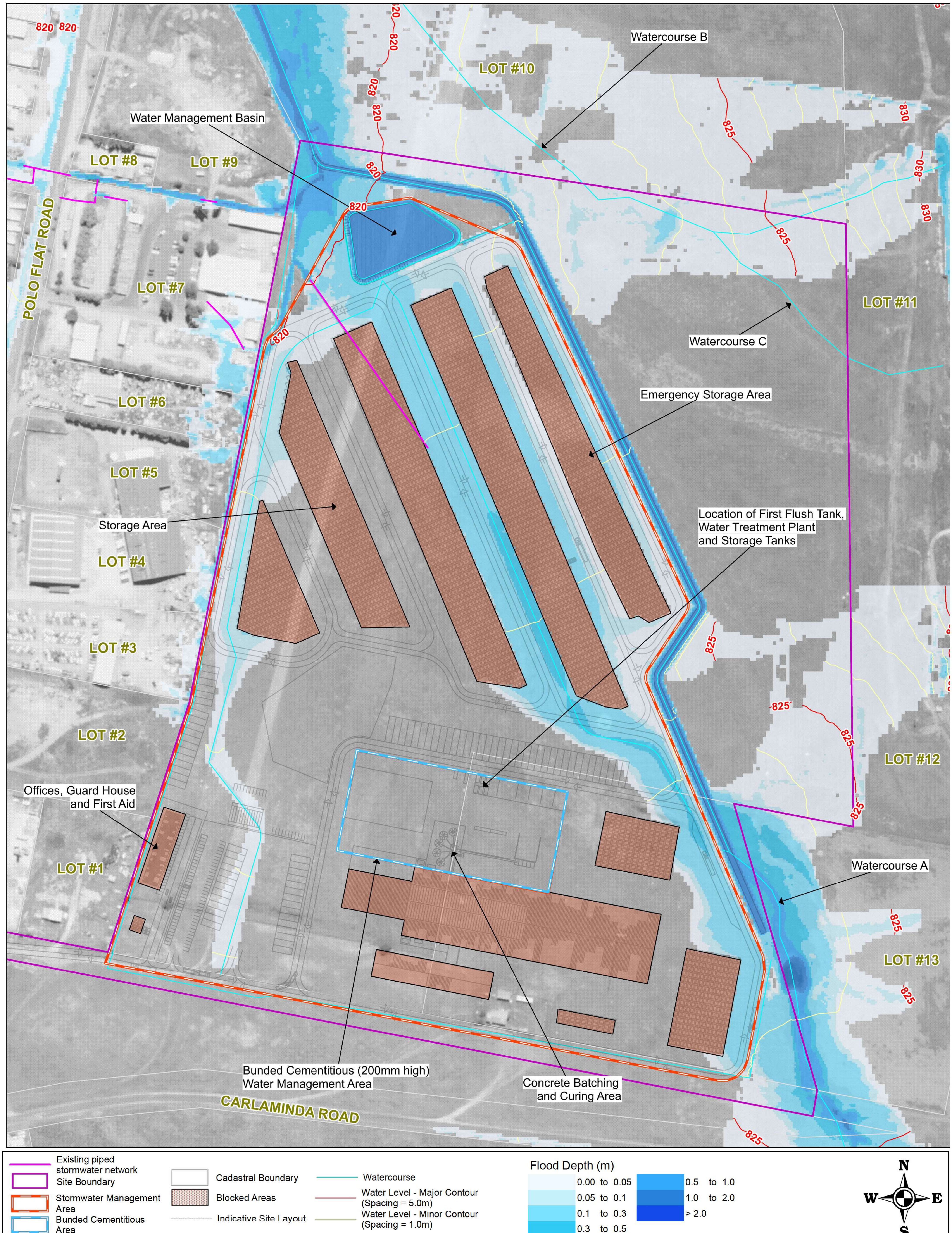
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 SCALE: 1:2500 FIGURE NUMBER: **B01**

grc HYDRO

EMM creating opportunities



snowyhydro Limited
renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: 1% AEP DESIGN EVENT - Peak flood depth and levels**

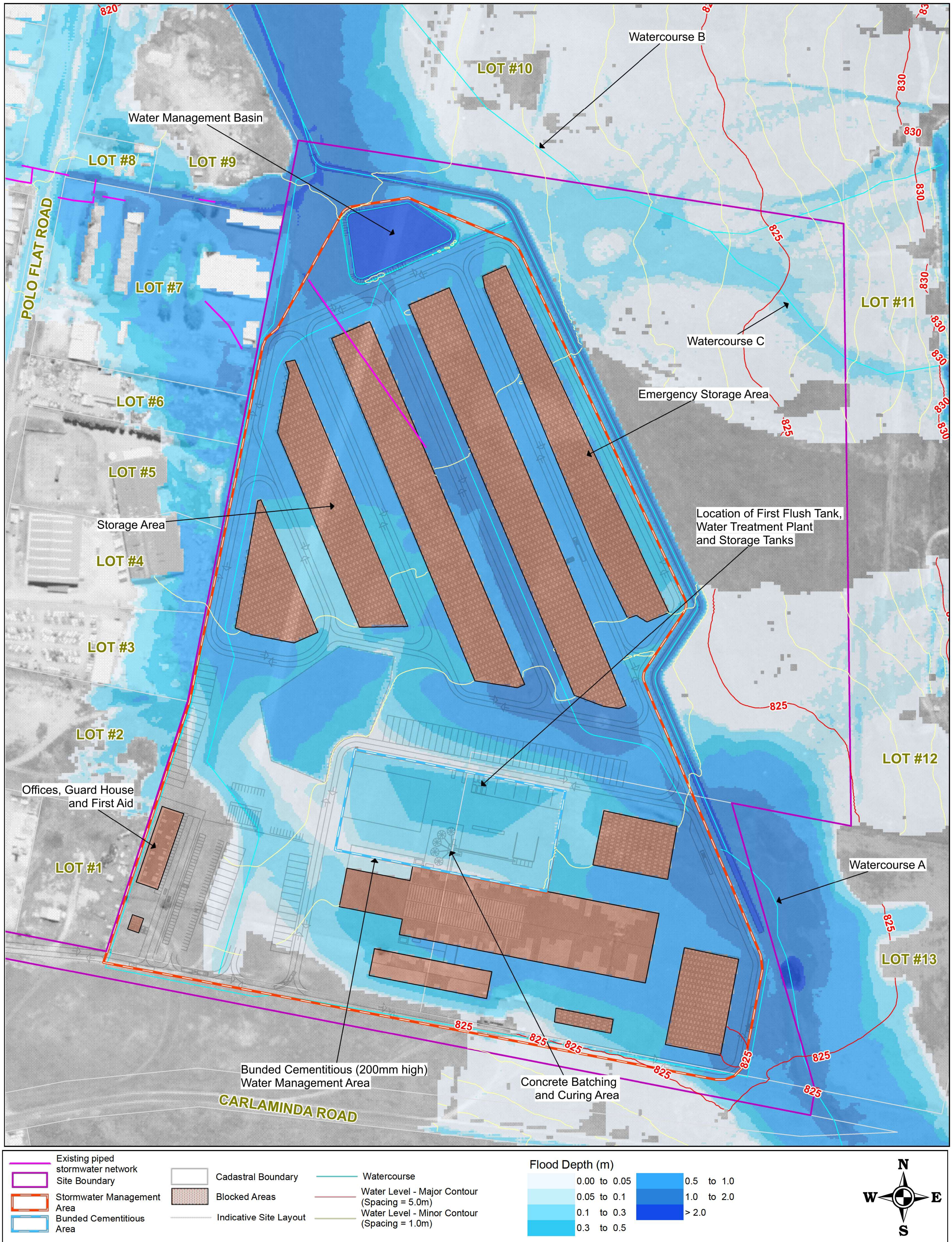
PROJECT: Snowy 2.0

PROJECT No. 190014

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B02**

grc HYDRO

EMM creating opportunities



snowyhydro renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: PMF DESIGN EVENT - Peak flood depth and levels**

PROJECT: Snowy 2.0

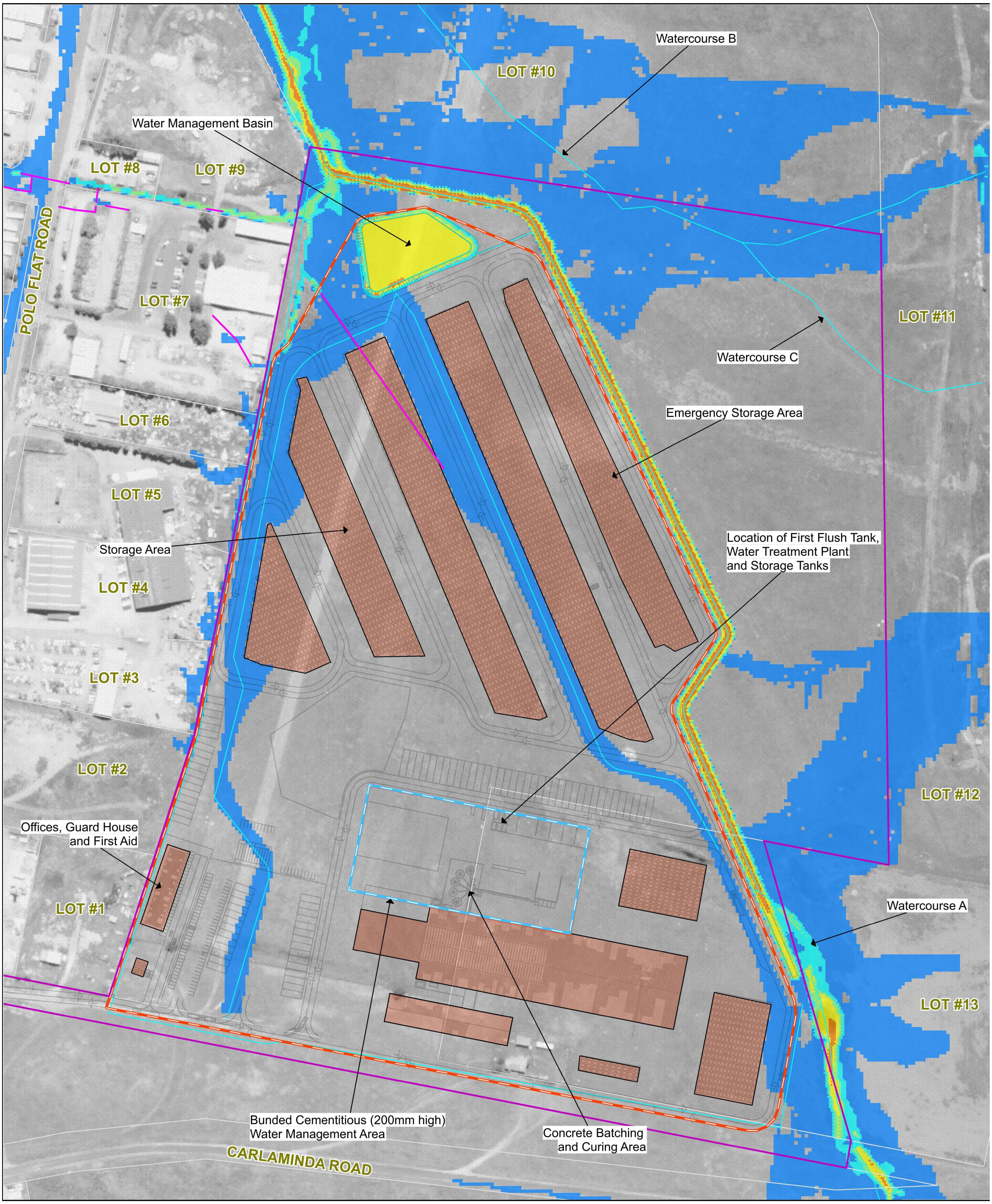
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B03**

grc HYDRO

EMM creating opportunities



Site Boundary
Stormwater Management Area
Bunded Cementitious Area
Cadastral Boundary
Blocked Areas
Indicative Site Layout
Watercourse
Existing piped stormwater network

Flood Hazard (AEM 2014)
H1 H2 H3 H4 H5 H6

N E S W

snowyhydro Limited renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: 10% AEP DESIGN EVENT - Flood Hazard**

PROJECT: Snowy 2.0

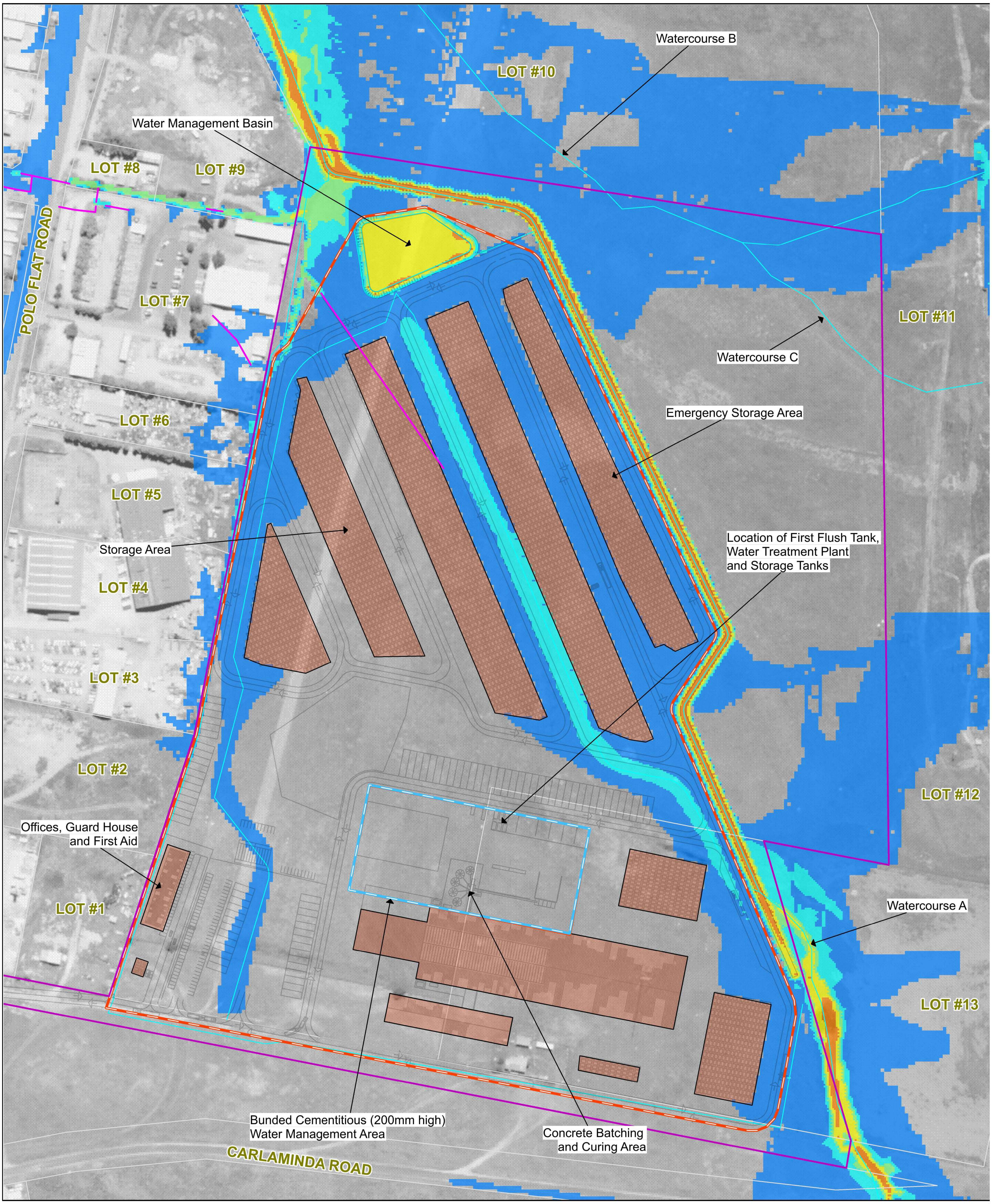
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B04**

grc HYDRO

EMM creating opportunities



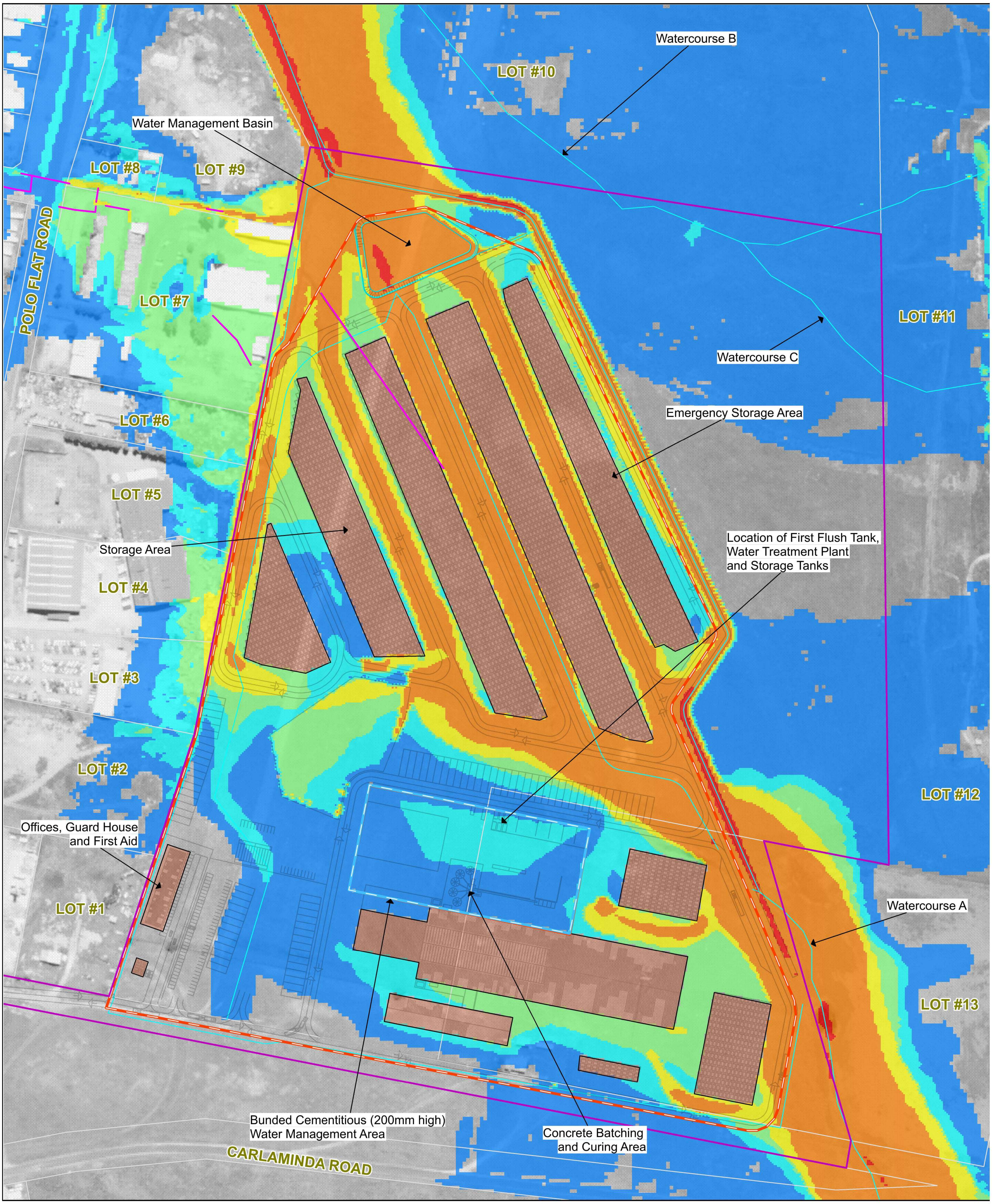
TITLE :	**POLO FLAT PROPOSED WORKS: 1% AEP DESIGN EVENT - Flood Hazard**
PROJECT:	Snowy 2.0
PROJECT No.	190014
DATE:	Aug 2019
SCALE:	1:2500
FIGURE NUMBER:	**B05**

0 250 meters

snowyhydro Limited renewable energy

grc HYDRO

EMM creating opportunities



Site Boundary
Stormwater Management Area
Bunded Cementitious Area
Cadastral Boundary
Blocked Areas
Indicative Site Layout
Watercourse
Existing piped stormwater network

Flood Hazard (AEM 2014)

H1 H4
H2 H5
H3 H6

N W E S

snowyhydro Limited renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: PMF DESIGN EVENT - Flood Hazard**

PROJECT: Snowy 2.0

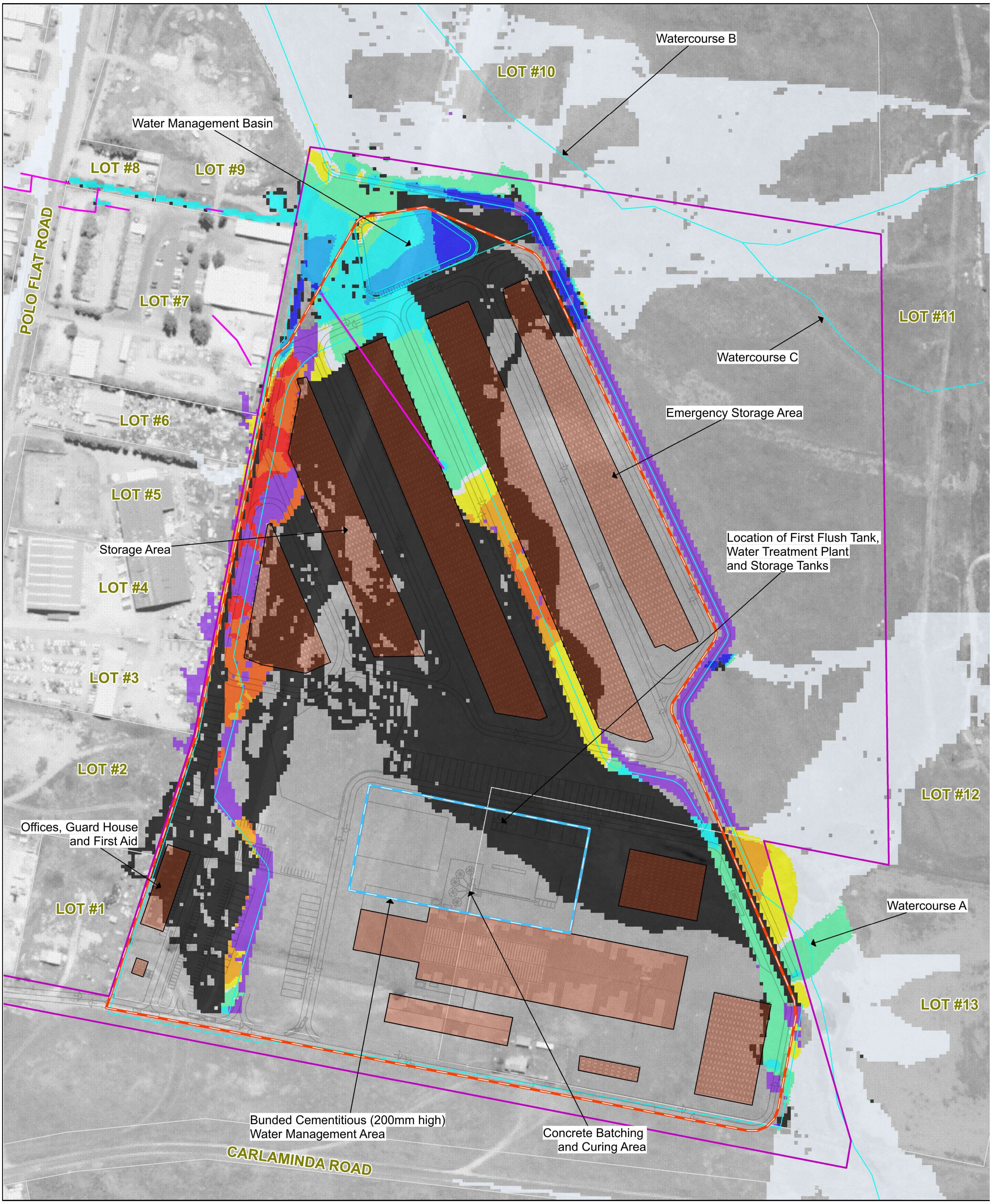
0 250 meters

PROJECT No. 190014

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B06**

grc HYDRO

EMM creating opportunities



Existing piped stormwater network
Site Boundary
Stormwater Management Area
Bunded Cementitious Area
Watercourse
Cadastral Boundary
Blocked Areas
Indicative Site Layout

Water Level Difference (m)

< -0.3	No Impact	0.3 to 0.5
-0.3 to -0.2	0.01 to 0.1	> 0.5
-0.2 to -0.1	0.1 to 0.2	Newly Flooded
-0.1 to -0.01	0.2 to 0.3	No Longer Flooded

N W E S

snowyhydro Limited renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: 10% AEP DESIGN EVENT - Flood Level Impacts**

PROJECT: Snowy 2.0

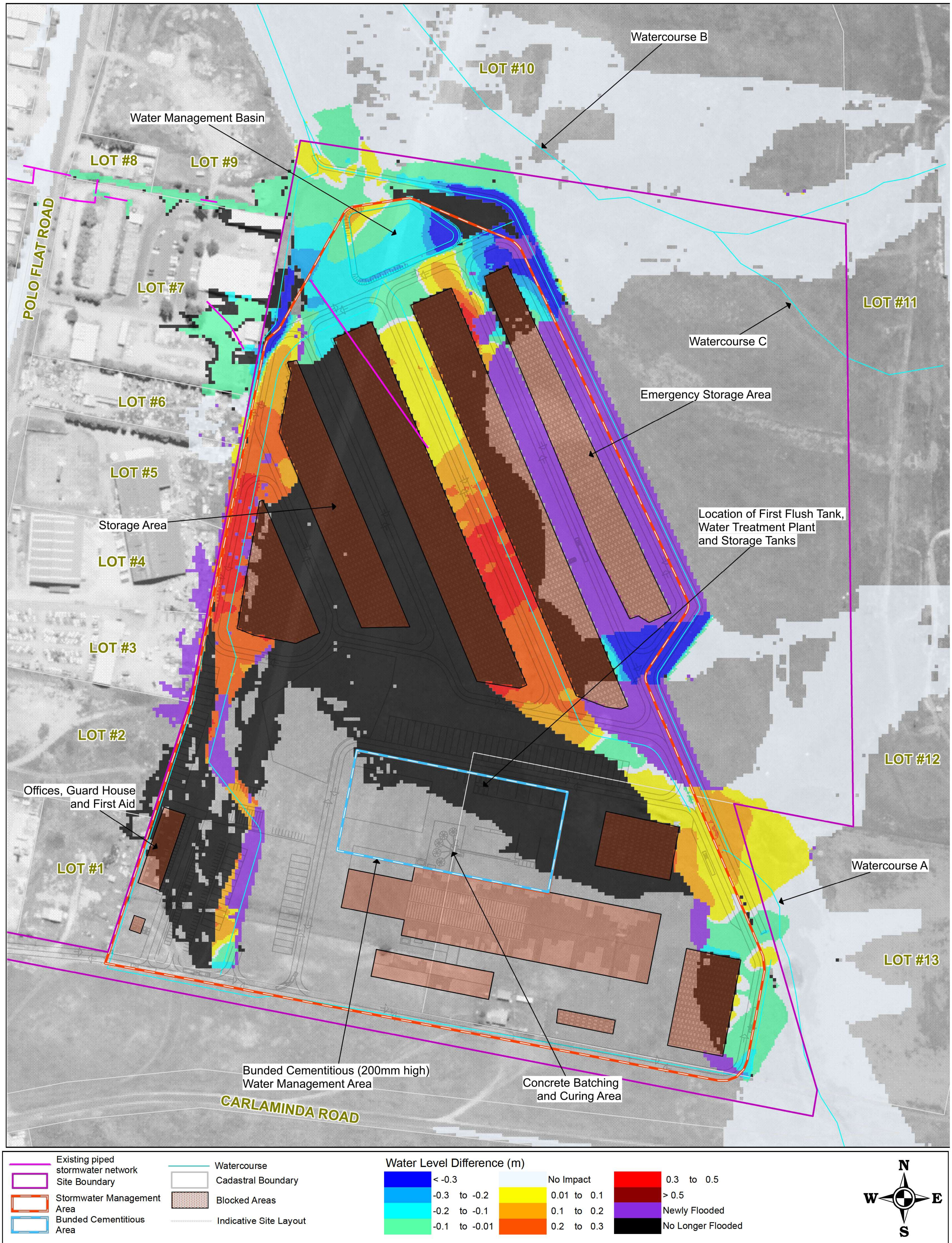
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B07**

grc HYDRO

EMM creating opportunities



snowyhydro Limited renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: 1% AEP DESIGN EVENT - Flood Level Impacts**

PROJECT: Snowy 2.0

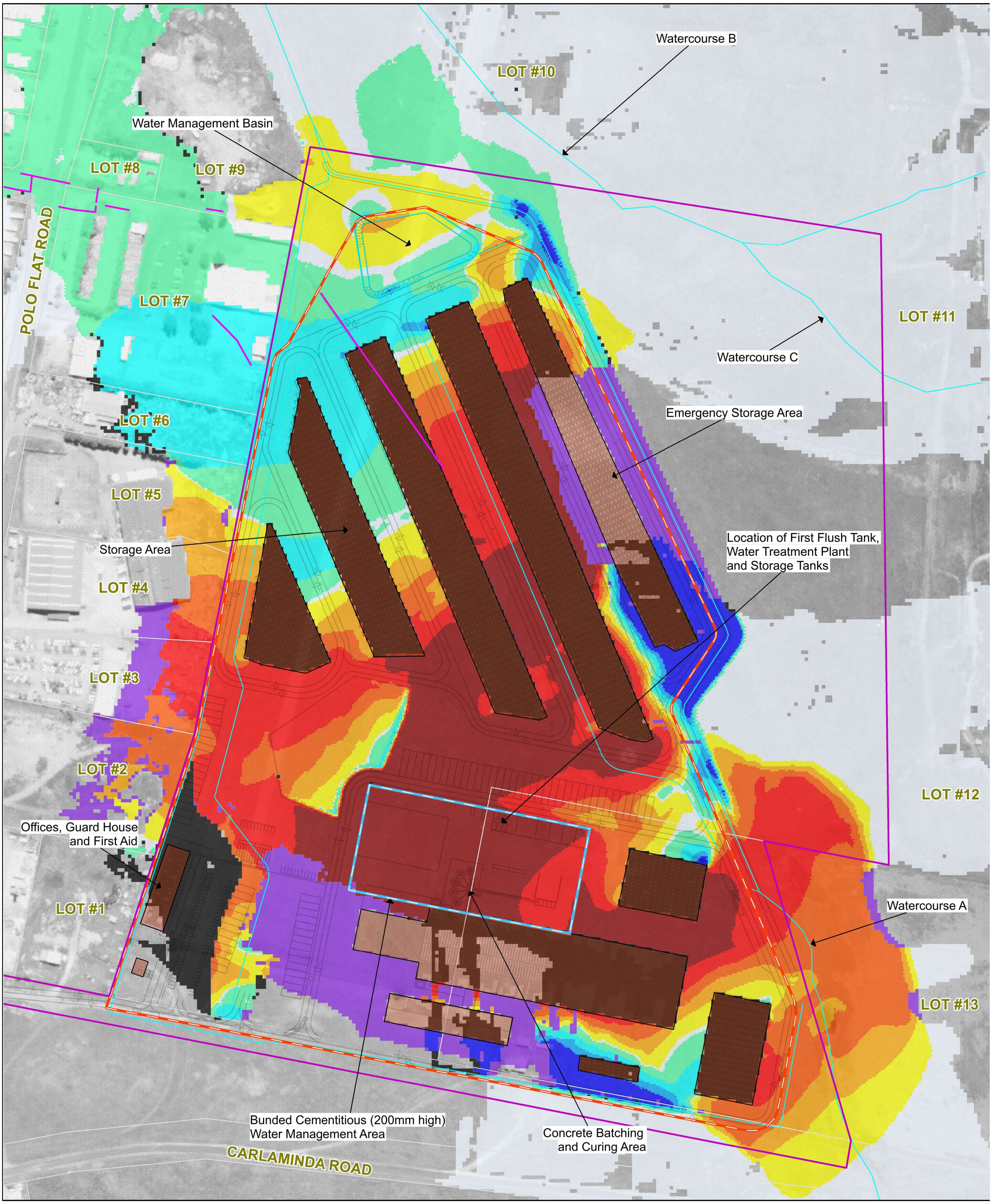
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B08**

grc HYDRO

EMM creating opportunities



Existing piped stormwater network
Site Boundary
Stormwater Management Area
Bunded Cementitious Area
Watercourse
Cadastral Boundary
Blocked Areas
Indicative Site Layout

Water Level Difference (m)

< -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.01
No Impact
0.01 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.5
> 0.5
Newly Flooded
No Longer Flooded

N W E S

snowyhydro Limited renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: PMF DESIGN EVENT -Flood Level Impacts**

PROJECT: Snowy 2.0

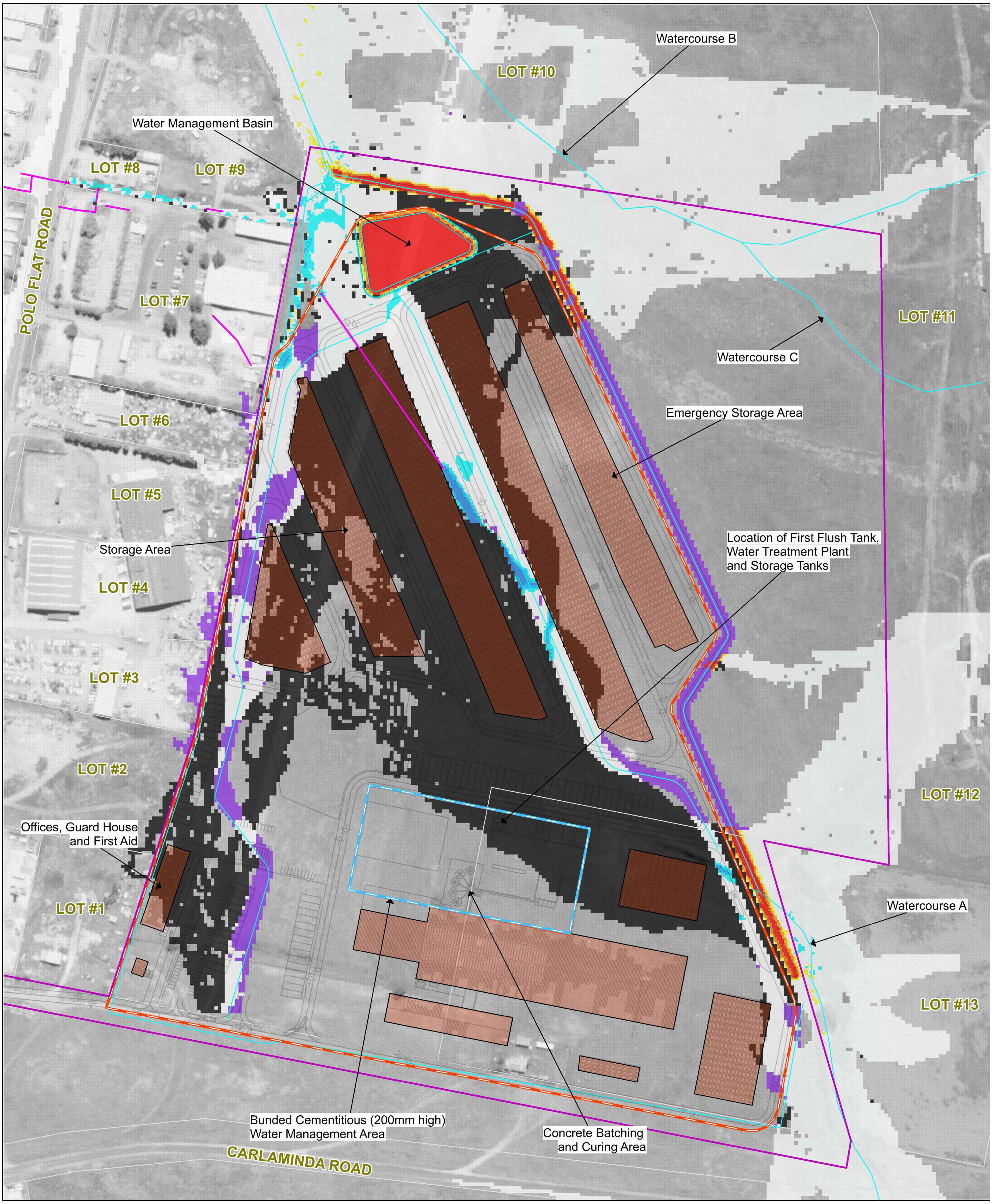
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B09**

grc HYDRO

EMM creating opportunities



Existing piped stormwater network
Site Boundary
Stormwater Management Area
Bunded Cementitious Area
Watercourse
Cadastral Boundary
Blocked Areas
Indicative Site Layout

Hazard Category Change

Increased by more than 3 categories
Increased by 2 category
Increased by 2 category
Same category
Descreased by 1 category
Descreased by 2 category
Descreased by more than 3 categories
Newly Flooded
No Longer Flooded

N W E S

snowyhydro Limited renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: 10% AEP DESIGN EVENT - Flood Hazard Impacts**

PROJECT: Snowy 2.0

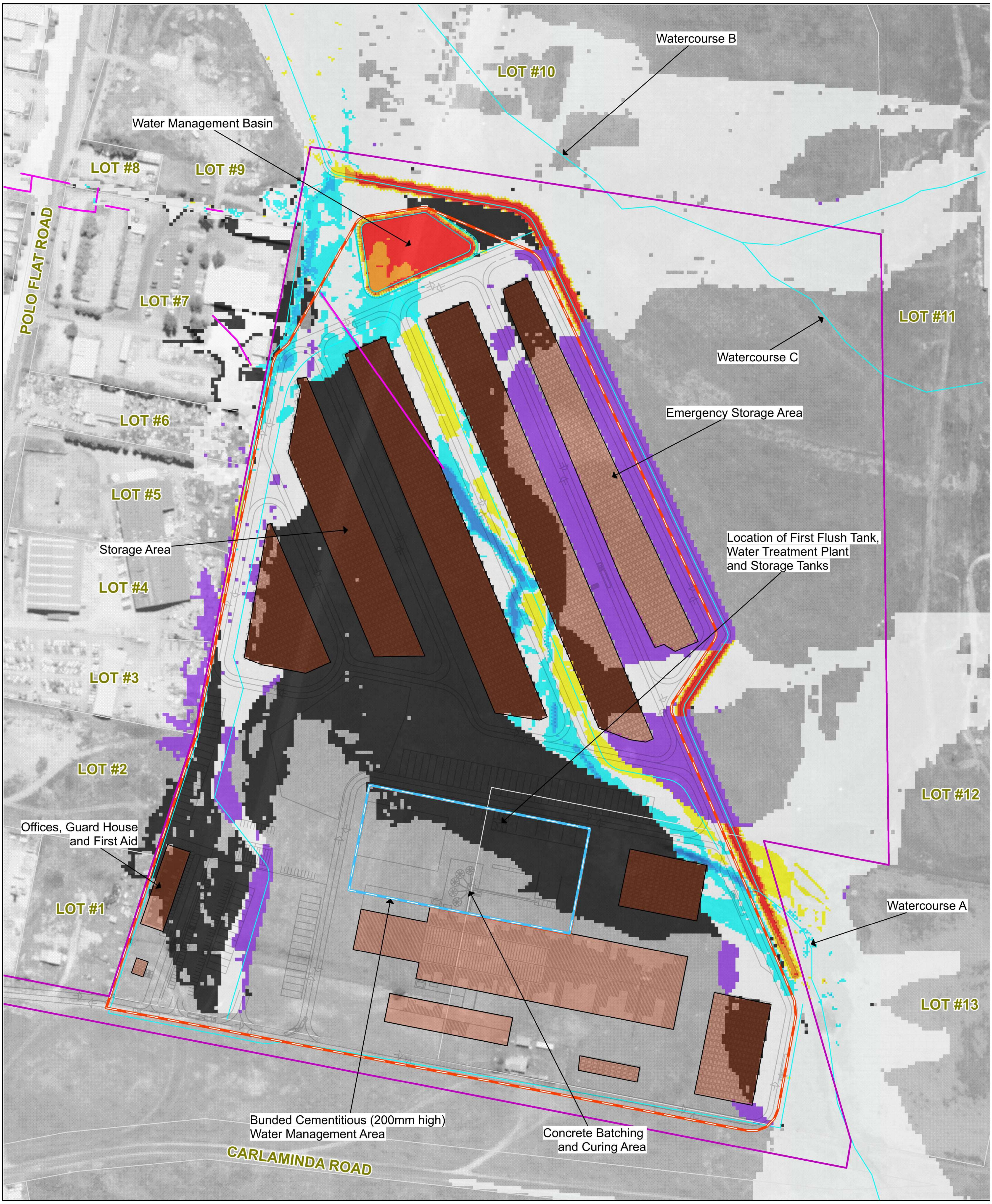
PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B10**

grc HYDRO

EMM creating opportunities



Existing piped stormwater network
Site Boundary
Stormwater Management Area
Bunded Cementitious Area
Watercourse
Cadastral Boundary
Blocked Areas
Indicative Site Layout

Hazard Category Change

- Increased by more than 3 categories
- Increased by 2 category
- Increased by 1 category
- Same Category
- Decreased by 1 category
- Decreased by 2 category
- Decreased by more than 3 categories
- Newly Flooded
- No Longer Flooded

N W E S

snowyhydro renewable energy Limited

TITLE : **POLO FLAT PROPOSED WORKS: 1% AEP DESIGN EVENT - Flood Hazard Impacts**

PROJECT: Snowy 2.0

PROJECT No. 190014

0 250 meters

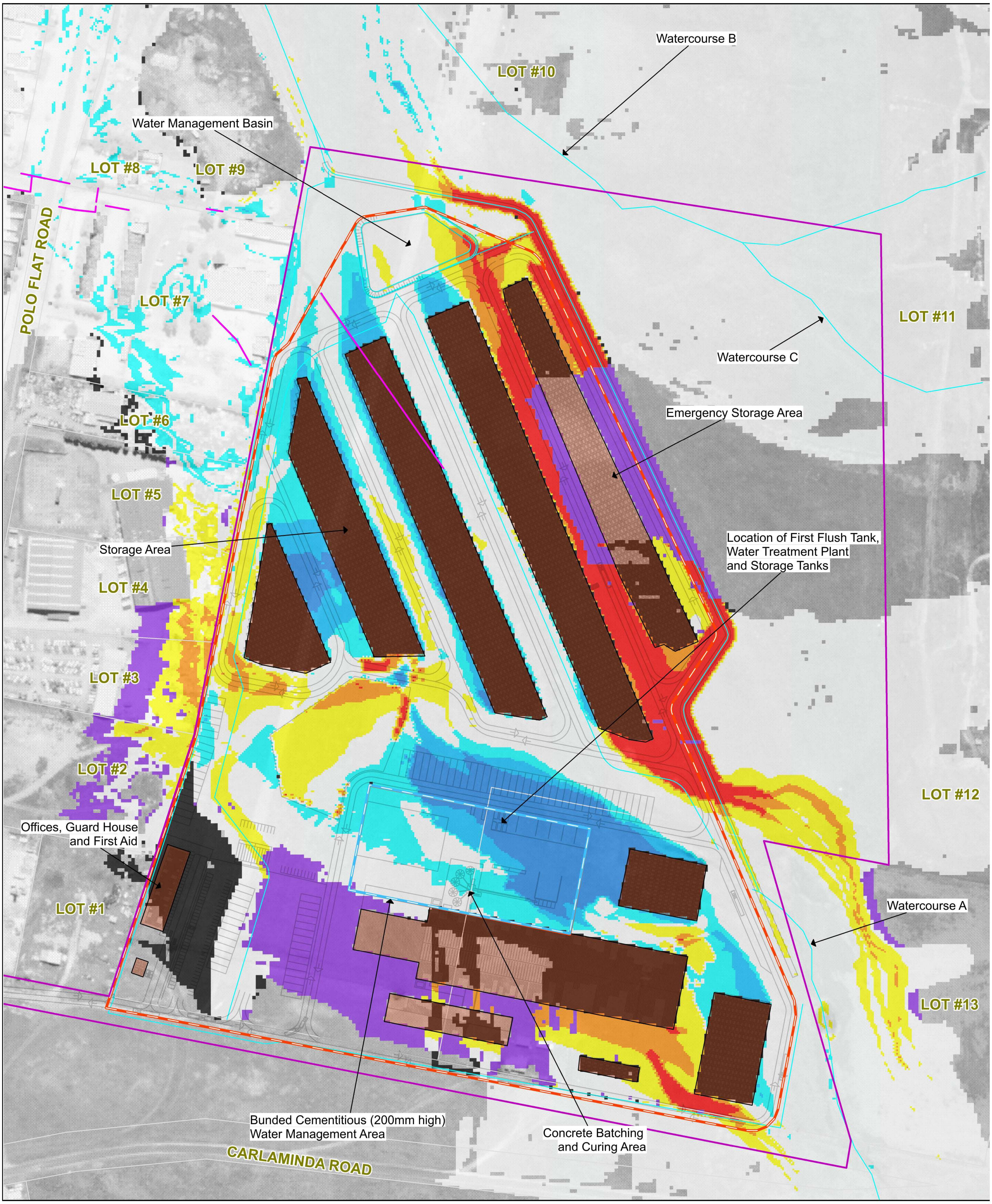
DATE: Aug 2019

SCALE: 1:2500

FIGURE NUMBER: **B11**

grc HYDRO

EMM creating opportunities



Existing piped stormwater network
Site Boundary
Stormwater Management Area
Bunded Cementitious Area
Watercourse
Cadastral Boundary
Blocked Areas
Indicative Site Layout

Hazard Category Change

Increased by more than 3 categories
Increased by 2 category
Increased by 1 category
Same Category
Decreased by 1 category
Decreased by 2 category
Decreased by more than 3 categories
Newly Flooded
No Longer Flooded

N W E S

snowyhydro renewable energy

TITLE : **POLO FLAT PROPOSED WORKS: PMF DESIGN EVENT - Flood Hazard Impacts**

PROJECT: Snowy 2.0

PROJECT No. 190014

0 250 meters

DATE: Aug 2019 | SCALE: 1:2500 | FIGURE NUMBER: **B12**

grc HYDRO

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