BOWDENS SILVER

Part 6
Surface Water Assessment

State Significant Development No. 5765

Prepared by:

WRM Water and Environment Pty Ltd

May 2020

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Surface Water Assessment

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TABLES

COMMONLY USED ACRONYMS

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
AWBM	Australian Water Balance Model
DECC	Department of Environment and Climate Change
DPIE	Department of Planning Industry and Environment
EC	Electrical Conductivity
ESC	Erosion and Sediment Control
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
EP&A Act	Environmental Planning and Assessment Act
EPL	Environment Protection Licence
EV	Environmental Value
GCL	geosynthetic clay liner
GL	Gigalitres
ML	Megalitres
NAF	Non-acid forming
PAF	Potential-acid forming
PMP	Probable maximum precipitation
PZ	Primary Zone
ROM	Run-of-mine
SEARs	Secretary’s Environmental Assessment Requirements
SILO	Scientific Information for Land Owners
TSF	Tailings Storage Facility
WAL	Water Access Licence
WRE	Waste Rock Emplacement
WSP	Water Sharing Plan

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EXECUTIVE SUMMARY

Site Water Management

A conceptual design of the site water management system has been developed to manage potential impacts on surface water in the receiving environment within and around the Mine Site. The proposed system comprises distinct three distinct water management zones: the containment zone, the erosion and sediment control (ESC) zone and the clean water zone, as described below.

- Containment zone

  Groundwater seepage and surface runoff from the open cut pit areas, the tailings storage facility (TSF), processing plant area, oxide ore stockpile and waste rock emplacement (WRE) are likely to have elevated concentrations of dissolved metals. This water would be managed within a closed water management system.

  Potentially acid forming (PAF) waste rock would be placed within the engineered WRE, overlain by a geosynthetic clay liner (GCL), compacted subsoil, forming (NAF) waste rock and a capping layer of topsoil and subsoil which would then be revegetated/rehabilitated. During operations, runoff from exposed PAF waste rock within the WRE, as well as WRE leachate would be conveyed to a dedicated leachate management dam via a buried pipeline.

  To minimise water accumulating within the leachate management dam, the completed cells of the WRE would be progressively rehabilitated. In order to further reduce stored volumes, the WRE leachate, TSF decant and groundwater inflows to the open cut pits that would be captured within the containment system would be the first priority water source for recycling in processing operations.

- ESC zone

  Runoff from areas disturbed by Project-related activities but outside of the containment zone, including the southern barrier and TSF NAF waste rock stockpile area, which would be constructed using NAF waste rock, would be directed to sediment dams. This would include surface runoff from out-of-pit areas situated within Blackmans Gully upslope of the southern barrier and downslope of the mine access road, which would be directed through the base of the southern barrier itself.

  Bowdens Silver's long-term objective is to discharge as much water collected within the sediment dams to the downstream environment to assist in maintaining environmental flows.

  It is anticipated that after the settlement of suspended sediment in these dams, the water would be suitable for release in accordance with the discharge conditions of the environment protection license (EPL) for the Project which would be issued by the NSW Environment Protection Authority (EPA). However, a program of water quality monitoring would be undertaken characterise runoff from the NAF Waste Rock in the field. Discharges would not occur until it was confirmed that runoff water derived from the placed/stockpiled NAF waste rock is suitable for release, i.e. in accordance with the Project's EPL.

As a minimum, the sediment dams would be sized and operated in accordance with the NSW design guidance document “Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and quarries” (DECC, 2008), (hereafter referred to as the “Blue Book”) requirements for Type F sediment basins. However, if the ongoing program of geochemical testing and characterisation of runoff determines that the it must be contained on site to ensure the water source is not contaminated, sufficient storage capacity would be provided to minimise the likelihood of discharge by returning captured runoff to the Containment Zone.

- Clean water zone

  A clean water diversion channel upslope of the mine access road is proposed to divert runoff from the upper catchment of Blackmans Gully into Price Creek during operations. This channel would largely follow the natural contours of the hill slopes and have a gentle gradient. At the end of operations, the channel would be decommissioned to return flow to Blackmans Gully.

  Clean water diversion channels are also proposed to divert Blackmans Gully and its associated tributary catchments away from the main open cut pit both during operations and after mine closure. Two smaller satellite pits would be backfilled following the cessation of mining operations within them.

Site Water Balance

A daily timestep water balance model was used to assess the site water balance over the Project life under the range of historical rainfall and evaporation conditions.

The principal water use on the Mine Site would be the processing plant, which (including allowance for minor losses within the plant area) would require a total throughput of up to approximately 1 486 ML/a (4.1 ML/d). Much of the water used in the processing plant would be transferred in the tailings stream to the TSF. Tailings bleed water would then drain to the tailings decant pond for eventual return to the processing plant.

Water would also be required for dust suppression on site haul roads and minor miscellaneous site water demands. Haul road watering demands would vary with haul road length and climate conditions, with average annual demands expected to range between 161 ML/a and 318 ML/a.

While the processing plant is operating, average annual total site water demands would range between 1 506 ML/a (in Year 1) and 1 807 ML/a (in Year 8).

During mining operations, (after allowance for pit face evaporation) groundwater inflows to the main open cut pit are expected to range between approximately 450 ML/a and 855 ML/a. Groundwater and surface water collected in the main open cut pit would be used as the first preference for meeting site water demands. Water captured in the water management system, include tailings bleed water collected in the TSF decant pond would make up much of the remainder. However, supplementary supplies would be required to make-up the shortfall in available on-site supplies, especially during dry weather.

During processing operations, water would be imported to a proposed dedicated “turkey nest dam”. When incoming supplies exceed demand (for example following wet weather), the excess would be transferred to the TSF for later reuse. While the processing plant is in operation, water would be delivered at varying rates to maintain water levels in the “turkey nest dam”.

The results of the site water balance model show that the Project can be reliably supplied over the full Project life. Pipeline inflows would cease when the TSF decant level exceeds a maximum operating level. The model suggests TSF spillway overflows would be avoided. Under these conditions, average annual volumes imported from the external water supply pipeline would vary up to approximately 610 ML/a (with significant variations with prevailing climate conditions).

Subject to obtaining the appropriate Water Management Act approvals, there is potential to access supplementary groundwater supply, if required to make up temporary shortfalls in the availability of water from other sources, via the installation of additional groundwater bores within the Mine Site and surrounds.

The site water balance models show that under historical conditions, water captured in the other parts of containment zone can be also contained without discharge or significant interruption to mining operations throughout the Project life.

Impact on downstream water flows

There are two mechanisms whereby the Project could potentially impact on downstream surface water flow:

- Interception of runoff in the water management system
  - Operational period

    Water impacted by the mining activities and captured in the water management system would be contained within the Mine Site and re-used in processing operations (in the case of the containment zone) or in the case of the ESC zone, released, provided it meets EPL limits. However, Bowdens Silver may choose to also utilize the water stored in one or more of the sediment dams as part of its entitlement under the maximum harvestable rights provisions of the NSW Water Management Act, 2000.

    The catchment area of this containment system would vary over the Project life, and is expected to peak at 550 ha (comprising 300 ha in the TSF catchment and 250 ha in the remainder of the water management system) or 2.0% of the Lawsons Creek catchment (of 272 km^2 downstream of the Walkers Creek confluence) would be removed over the Project life. Based on the estimated average undisturbed area runoff in the local catchment, this equates to an average annual loss of flow of 177 ML/a.

    It is proposed to divert part of the undisturbed upslope catchment of Blackmans Gully east to Price Creek. The effect of this diversion is to slightly increase streamflow in Price Creek and the reach of Hawkins Creek between the Price Creek and Blackmans Gully confluences. The area diverted is approximately 50 ha.
  - Post Mine Closure

    At the completion of mining operations, the WRE and the TSF would be capped and rehabilitated, so that runoff can be allowed to flow to the receiving environment once water quality allows. Thus, reinstating some of the catchment area removed during mining operations.

    Flows from the upslope catchment of Blackmans Gully would be reinstated by decommissioning of the diversion to Price Creek.

The final landform would comprise a final void, which would capture runoff and incident rainfall from the immediate catchment. Modelling of the long-term behaviour of the final void lake shows that water would not overflow from the void. The catchment area of the final void after the completion of mining and rehabilitation would be approximately 53.1 ha or 0.2% of the Lawsons Creek catchment (of 272 km^2 downstream of the Walkers Creek confluence). Based on the estimated average undisturbed area runoff in the local catchment, this equates to an average annual loss of flow of 17 ML/a.

- Loss of baseflow contributions to streamflow due to impacts on the local groundwater profile
  - Operational period

    The groundwater assessment (Jacobs, 2020) predicts that drawdown of the groundwater table induced by groundwater inflow to the main open cut pit would result in a reduction in baseflow to both Hawkins Creek and Lawsons Creek. The reduction in baseflow would increase during operations, as the development of the open cut pits progresses, near the conclusion of mining operations, the peak baseflow losses are expected to be up to approximately 0.018 ML/d (6.6 ML/a) and 0.024 ML/d (8.8 ML/a) for Hawkins Creek and Lawsons Creek respectively.

    The peak baseflow losses from each creek do not coincide. The maximum predicted take from the Lawsons Creek Water Source, and therefore the volume of share components required to be held by Bowdens Silver as a water access licence issued under the Water Sharing Plan for Macquarie Bogan Unregulated and Alluvial Water Sources: Lawsons Creek Water Source (2012) during mining is 12.9 ML/a (Jacobs, 2020).
  - Post mining

    The reduction in baseflow would increase as the cone of drawdown grows, and is expected to peak approximately 12 to 18 years post mining at approximately 0.031 ML/d (11.2 ML/a) and 0.029 ML/d (10.4 ML/a) for Hawkins Creek and Lawsons Creek respectively.

The total average annual loss of flow from the Macquarie Bogan Unregulated and Alluvial Water Sources is estimated to be:

- Operational period (peak) – 188 ML/a; and
- Post mining – 37 ML/a.

In summary, the results show that the Project would not impact on:

- Hawkins Creek upstream of the cone of groundwater drawdown, which extends approximately 3.5 km upstream of the Mine Site;
- Lawsons Creek upstream of the Hawkins Creek confluence.

During operations, the maximum impact of the Project on downstream flow would decrease flows in:

- a 3.5 km section of Hawkins Creek extending upstream from the Lawsons Creek confluence by up to 4.4%;

- Lawsons Creek, between the Hawkins Creek confluence and upstream of the Walkers Creek confluence by up to 1.2%; and
- Lawsons Creek downstream of the Walkers Creek confluence by up to 2.2%.

Post mining, the maximum impact of the Project on downstream flow would decrease flows in:

- a 3.5 km section of Hawkins Creek extending upstream from the Lawsons Creek confluence by up to 1.4%;
- Lawsons Creek, between the Hawkins Creek confluence and upstream of the Walkers Creek confluence by up to 0.4%;
- Lawsons Creek downstream of the Walkers Creek confluence by up to 0.4%.

The relative impact on Lawsons Creek would reduce significantly with increasing distance downstream due to the contribution of other tributaries to total streamflow in Lawsons Creek.

Impact on Availability of Water to Downstream Surface Water Users

The Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources states that water must not be taken under an access licence when there is no visible flow or where an access licence permits take from an in river pool, when the volume in that pool is less than its full capacity.

The principal mechanism by which the Project would affect the quantity of water supplies available to other surface water users in the Lawsons Creek Water Source of the Macquarie Bogan Unregulated and Alluvial Water Sources is by reducing flows such that the frequency and duration of cease-to-flow periods is increased.

The impact of the Project on the frequency of flows greater than 1 ML/d (approximately 12 L/s), which occur about 81.0% of the time downstream of the Walkers Creek confluence, is expected to be negligible. Therefore the impact of the loss on the availability of water to downstream water users (whose pump rates would be well in excess of this magnitude) would be negligible.

Impact on Downstream Water Quality

The proposed engineered mitigation and management measures (i.e. liners, capping and cover systems) proposed for storing and encasing the tailings and PAF waste rock have been designed (see ATCW [2020], Advisian [2020a, 2020b]) to be effective in limiting seepage and managing leachate. The receiving waters are therefore unlikely to be impacted by the tailings or PAF waste rock either during operations or after closure and decommissioning of the Project.

Geochemical assessment of NAF suggests it would likely be relatively benign. During operations, runoff from the TSF outer embankment, WRE and southern barrier is to be captured and treated in sediment dams sized in accordance with Bluebook requirements for Type F basins (DECCW, 2008) before offsite release under the EPL. However, based on the testing of leachate from kinetic testing off NAF waste rock samples, there is a possibility that runoff and seepage from NAF would contain dissolved metals.

The southern barrier would be decommissioned during closure and rehabilitation activities, leaving the outer embankment of the TSF, which would be vegetated once the 3rd embankment raise has been completed, and the vegetated store-and-release cover of the WRE as potential sources of NAF runoff. Sediment dams would remain in place until vegetative cover was sufficiently established to control erosion from these areas.

A site water quality monitoring plan would be implemented during operations to verify that the captured water quality is suitable for off-site release in accordance with the conditions of an EPL, and to monitor receiving water conditions. It is proposed to continue the current ambient water quality monitoring program at the existing locations, and in on-site sediment dams located at release points. If water quality is found to be unsuitable for release during operations (outside the EPL limits) sediment dams would be dewatered and the water re-used for dust suppression.

Potential Impacts on Flooding

A detailed flood impact assessment was carried out for the Project.

Key points with regards to predicted peak flood levels and depths across the model domain are summarised below:

- The Project disturbance area is located outside of the predicted Lawsons Creek flood extent for all events up to the probable maximum precipitation (PMP) design event.
- The area along the southeastern Mine Site boundary is affected by flooding from Hawkins Creek. However, the proposed open cut pit, WRE and leachate management dam are located outside of the predicted flood extent for Hawkins Creek for all design events.
- Flooding along the Hawkins Creek and Lawsons Creek tributaries within the Mine Site is characterised by shallow overland flows. Flows in these tributaries are generally confined within narrow flood flow paths, with no breakouts occurring except near the confluences of these tributaries with Hawkins and Lawsons Creeks. Due to the narrow flood flow paths, the difference in predicted flood extents along these tributaries between the 1% Annual Exceedance Probability (AEP) and PMP design events is not significant.
- Predicted peak flood depths along the overbank areas of the Hawkins and Lawsons Creek tributaries are generally below one metre for events up to and including 0.2% (1 in 500) AEP. Peak flood depths of up to 1.5 m for the PMP design event are predicted in some sections along these tributaries.

Key points with regards to predicted peak velocities within the model domain are summarised below:

- Flows in the Hawkins and Lawsons Creeks tributaries are generally confined within narrow flood flow paths with relatively steep ground slopes. This results in relatively high predicted peak flood velocities of up to 2.5 m/s along the channel and overbank areas of these tributaries for events up to and including 0.2% AEP. The proposed mine infrastructure would increase flood velocities in localised areas, and mitigation works would be required to manage erosion risks along the lower perimeter embankment of the WRE during operations and after mine closure. Where necessary, mitigation measures for managing the risk of erosion where velocities are increased, such as the appropriate size of rock armouring on the floodplains of Hawkins and Lawsons Creeks would be developed during detailed design to ensure minimal scour in the 10% AEP flood.

- Existing peak flood velocities in Hawkins Creek for events up to and including 0.2% AEP are generally less than 3 m/s, with peak velocities greater than 4 m/s predicted in some sections. The Project results in some redistribution of tributary inflows to Hawkins Creek, and as a result there would be a minor increase (less than 0.1 m/s) in flood velocities immediately adjacent to the Mine Site. Some areas on the margins of the floodplains would experience reductions in flow velocity. However, the areas affected are small, and would not results in any significant reduction in the transport of sediment
- Existing peak flood velocities in Lawsons Creek are relatively high for all modelled events. For events up to and including 0.2% AEP, peak flood velocities greater than 4 m/s are predicted in many sections along the Lawsons Creek channel and floodplain. The proposed mine infrastructure would have minimal impact on Lawsons Creek flood velocities.

In summary, the works associated with the proposed WRE would result in localised minor flood level increases. The more significant flood level impacts are constrained to within the lease, and would not result in significant impacts to other properties, assets or infrastructure. The proposed WRE would also locally increase flood velocities in its immediate vicinity. Local scour protection measures would need to be developed during detailed design to mitigate the potential erosion impacts in this area. Any expected increases in flood velocities in Hawkins Creek and Lawsons Creek are negligible and would not adversely impact offsite property or infrastructure.

Key points with regards to flood conditions at the proposed relocated Maloneys Road crossing of Lawsons Creek are summarised below.

- The extent of upstream impacts of the proposed crossing decreases with increasing flood magnitude.
- The proposed road crossing would be overtopped during a 10% (1 in 10) AEP flood event. Peak flood depths over the road are up to 1.2 m, while peak flood velocities over the road are up to 3 m/s. Therefore, the proposed road crossing would be non-trafficable by light or heavy vehicles during a 10% AEP event.
- Due to the predicted increase in peak flood levels upstream of the crossing, flows in Lawsons Creek would overtop the northern creek bank immediately upstream of the crossing. In the 10% AEP flood, these overflows would drain to the northwest parallel to Lawsons Creek before re-joining Lawsons Creek about 680 m downstream of the proposed crossing. In larger flows, a greater proportion of flow is directed along the northeast floodplain, resulting in increased floodplain velocities.
- There are predicted reductions in peak 10% AEP flood levels of up to 0.03 m downstream of the Lawsons Creek crossing.

- The predicted increases in peak flood levels and flood extents for the 10% AEP event would not affect any existing dwellings. It is noted that Bowdens Silver either owns or holds the option to purchase all properties that are predicted to be affected by an increase in flood levels.
- The road crossing would be designed to manage the risk of scour induced by increased velocities, for example through the use of dumped rock or other erosion protection measures.

Final Void Pit Lake Behaviour

Based on the proposed open cut pit design, the final void would be up to 141 m deep, with a floor level of 456 mAHD and an overflow level of approximately 597 mAHD. The total potential storage volume to this elevation is approximately 22 GL.

A daily timestep water balance model was prepared for the final void pit lake which would form in the main open cut pit. The model used estimates of long-term groundwater inflows derived as part of numerical modelling undertaken to inform the groundwater assessment for the Project. Permanent clean water diversions would be provided to minimize the catchment runoff draining to the void. The findings of the analysis were as follows:

Under the existing Scientific Information for Land Owners (SILO) climate scenario - the modelled water level reached around 574 mAHD after 125 years and varied in a 6 m band (from 571 mAHD to 577 mAHD) throughout the remainder of the simulation.

The maximum modelled water level was below 577 mAHD – or about 20 m below the void overflow level of 597 mAHD.

Under the modelled climate change scenarios, the equilibrium water level would be lower than the existing climate scenario. Under the climate change scenario closest to the average of all modelled climate scenarios, the equilibrium water level would fluctuate between 566.5 mAHD and 572.5 mAHD. Over the period of simulation, the average groundwater inflow is megalitres per annum (ML/a) 102 ML/a (ranging between approximately 0.3 ML/a and 184 ML/a). Direct rainfall averages 183 ML/a, and runoff contributes and 24 ML/a on average. These inflows are balanced by average evaporation of 309 ML/a.

On the basis of the analysis the final void would not overflow to the surface and remain a groundwater sink post-mining.

1. INTRODUCTION

1.1 BACKGROUND

Bowdens Silver Pty Limited (Bowdens Silver) is seeking approval to develop and operate an open cut silver mine near Lue, NSW (the Project). The Mine Site is located approximately 26 km east of Mudgee, NSW and is currently an undeveloped site. **Figure 1.1** shows the location of the Mine Site.

R.W Corkery & Co. Pty Limited (R.W. Corkery & Co), on behalf of Bowdens Silver, commissioned WRM Water & Environment Pty Ltd (WRM) to undertake a surface water assessment forming part of the Environmental Impact Statement for the Project.

This report addresses the Secretary's Environmental Assessment Requirements for the Project, as they relate to surface water. In particular this report consolidates the results of the following assessments:

- A baseline assessment of the geomorphological condition of watercourses within the project area (R.W. Corkery & Co, 2020) (**Annexure A**);
- A baseline water quality assessment (R.W. Corkery & Co, 2020) (**Annexure A**);
- A flood impact assessment (**Annexure B**);
- A detailed and consolidated site water balance (Section 5);
- An assessment of the impact of the Project on water resources – especially in the adjacent reaches of Hawkins Creek and Lawsons Creek, in terms of water quality and quantity.

1.2 PROJECT DESCRIPTION

Figure 1.2 shows the proposed Mine Site layout. The seven principal components within the Mine Site are:

i) a main open cut pit and two satellite open cut pits, collectively covering approximately 52ha;

ii) a processing plant and related infrastructure covering approximately 22ha;

iii) a waste rock emplacement (WRE) covering approximately 77ha;

iv) a low grade ore stockpile covering approximately 14ha (9ha above WRE);

v) an oxide ore stockpile covering approximately 8ha;

vi) a tailings storage facility (TSF) covering approximately 117ha; and

vii) the southern barrier to provide visual and acoustic protection to properties south of the Mine Site covering approximately 32ha.

The above components would be supported by a range of on-site and off-site infrastructure. The on-site infrastructure comprises haul roads, water management structures, power/water reticulation, workshops, stores, compounds and offices/amenities. The off-site infrastructure comprises a relocated section of Maloneys Road (including a new railway crossing and new crossing of Lawsons Creek) and a water supply pipeline for the delivery of water from the Ulan Coal Mine and/or Moolarben Coal Mine.

Figure 1.1 Locality Plan

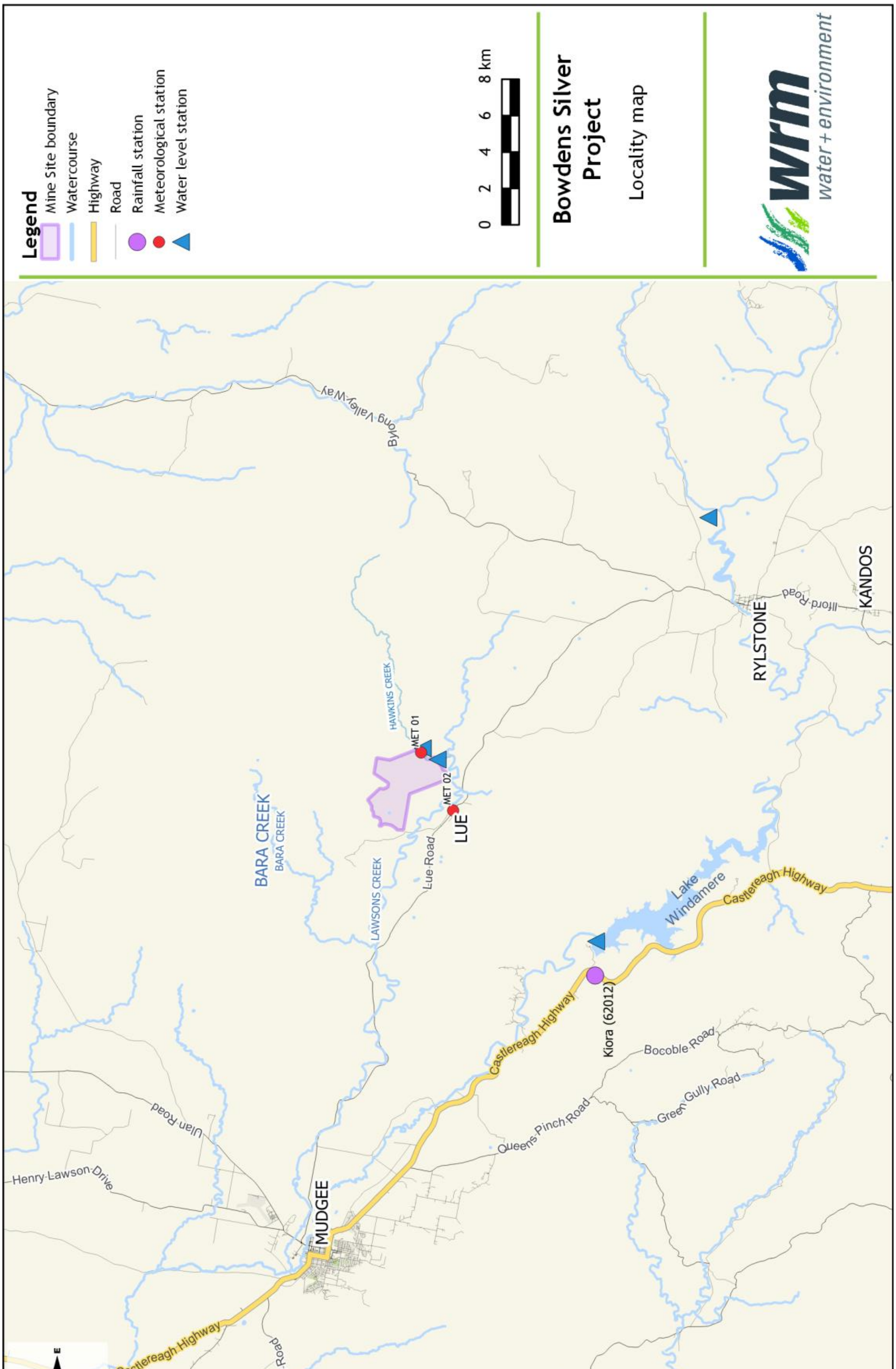
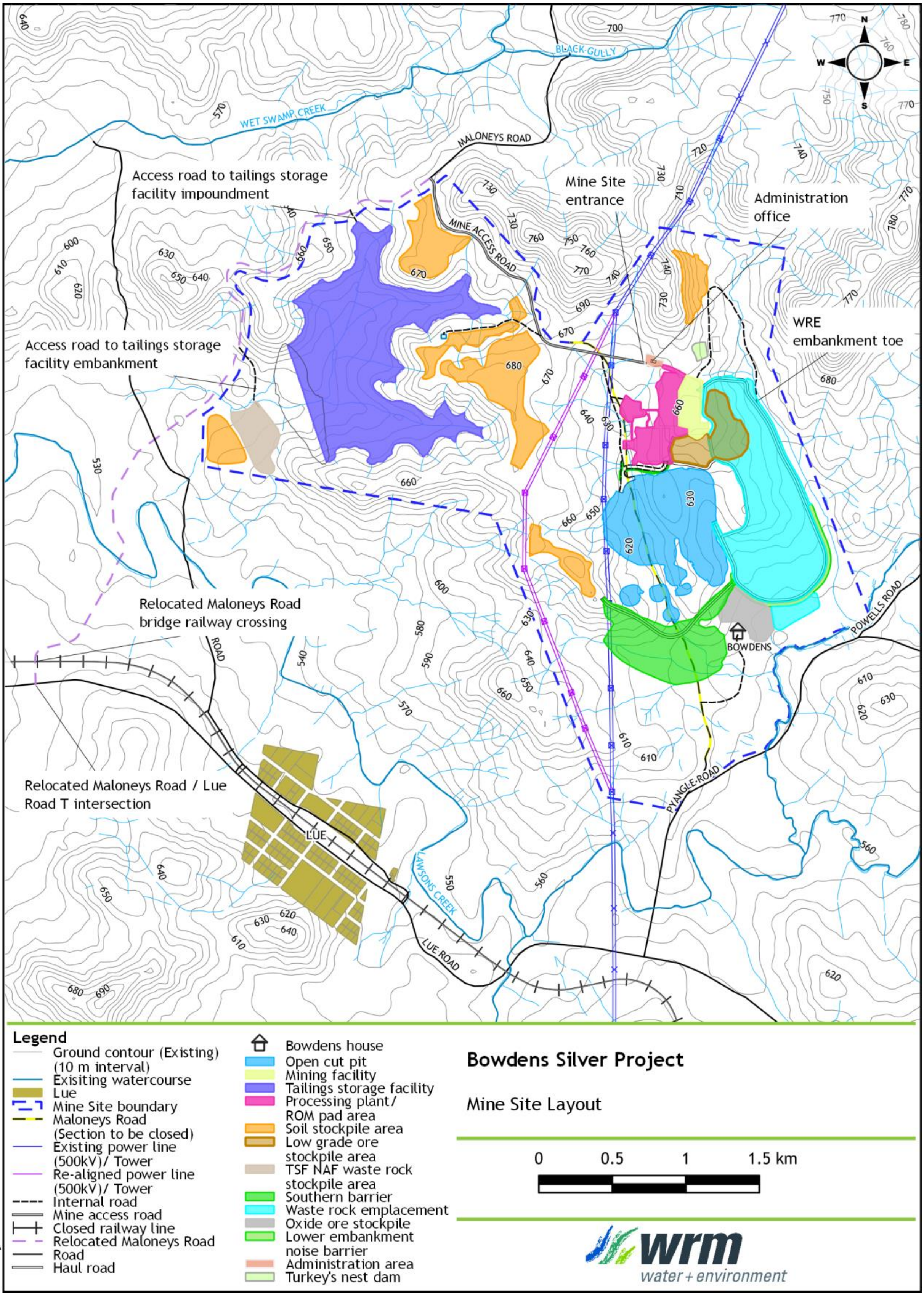


Figure 1.2 Mine Site Layout



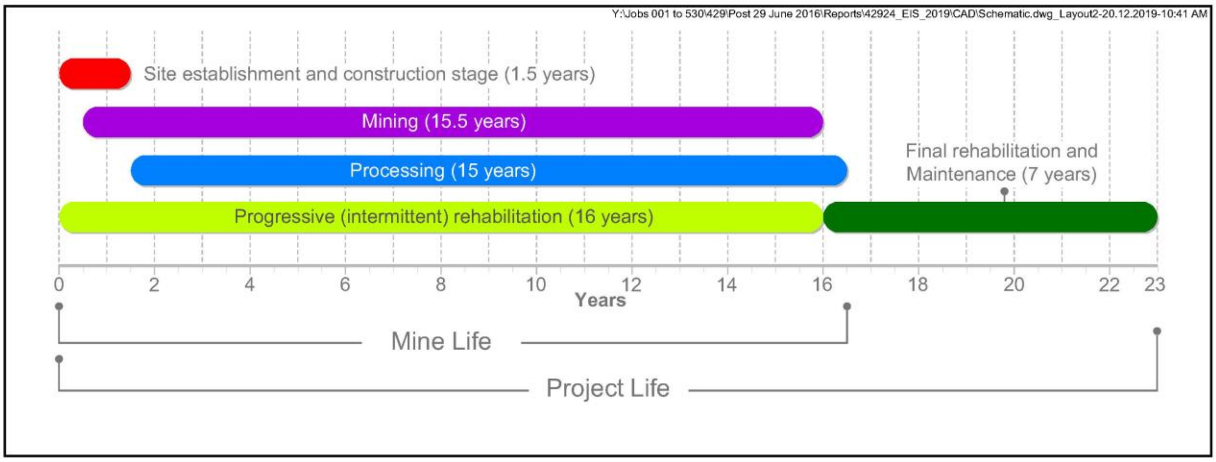
Mining would be undertaken using conventional open cut drill and blast, load and haul mining methods. This would involve the sequential removal/storage or mulching of vegetation, the removal and stockpiling of topsoil and subsoil, the removal and placement or stockpiling of waste rock and the recovery of ore.

Development of the main open cut pit would commence during the site establishment and construction stage with vegetation clearing, followed by the stripping and stockpiling of topsoil and subsoil. This stage is referred to as the open cut pit pre-strip. Emphasis would be placed in this stage upon the recovery of sufficient non-acid forming (NAF) waste rock (WZ1) for the construction of the initial TSF embankment, WRE perimeter embankments and the leachate management dam and ancillary mine infrastructure as well as the accumulation of sufficient ore on the run-of-mine (ROM) pad to enable the processing plant to be commissioned. Excess NAF waste rock extracted during this period would also be used for construction of the initial barrier of the southern barrier.

Any low-grade ore recovered during this stage would be transported by haul truck to the low-grade ore stockpile area that would be located immediately to the east of the ROM pad. During the open cut pit pre-strip, all potential acid forming (PAF) waste rock would be recovered and transported by haul truck and placed in the first cell of the WRE.

The Project would also involve construction of a relocated section of Maloneys Road that would provide access to the Mine Site from an intersection that would be located west of Lue. The relocated Maloneys Road would cross Lawsons Creek and effectively replace 4.5 km of the existing Maloneys Road that would be closed to the public to allow for the development of the Mine Site and mine access road.

The Project would require a site establishment and construction period of approximately 18 months during which the processing plant and all related infrastructure and the initial embankment of the TSF would be constructed. Once operational, Bowdens Silver anticipates the mine would produce concentrates for approximately 15 years. In total, it is proposed the mine life would be approximately 16.5 years, i.e. from the commencement of the site establishment and construction stage to the completion of concentrate production. It is envisaged rehabilitation activities would be completed over a period of approximately 7 years, i.e. from Year 16 to Year 23. The graphic below displays the duration of each of the main components throughout the mine life and Project life.



2. SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS FOR EIS – SURFACE WATER

All mining projects in NSW must be assessed under the Environmental Planning and Assessment Act 1979 (EP&A Act 1979).

The Project is classified as a State Significant Development (SSD) in accordance with the State Environmental Planning Policy (State and Regional Development) 2011.

An Environmental Impact Statement must be prepared in response to the requirements set out by the Secretary of the NSW Department of Planning, Industry and Environment (DPIE). These requirements are known as the Secretary's Environmental Assessment Requirements (SEARs).

The SEARs for the Project (SSD7565), were originally issued to Bowdens Silver by the then NSW Department of Planning and Environment on 23 December 2016 and have most recently been updated on 21 June 2019. The SEARs are prepared in consultation with relevant State and local government agencies and take into consideration concerns and issues raised by community groups and individuals. The key issues identified in the SEARs, government agency correspondence, and the Lue and district community relating to surface water are provided in **Table 2.1**, which also identifies the relevant section(s) where the issues have been addressed in this report.

Table 2.1
Coverage of SEARS and other requirements for the Project – Surface Water

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Relevant Requirement	Coverage
The EIS must include an assessment of: • the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources (including but not limited to, Lawsons Creek and Price Creek), having regards to EPA's, DPI's and OEH's requirements; and	Section 8
• the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure and other water users, including: – a detailed site water balance, including an assessment of the reliability of water supply imported to the site, and management of excess water, supported by sensitivity analysis; and	Section 8 Section 5
– an assessment of the water quality and management of the imported water, including spill/leak management.	By others
Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources	Section 8
NSW State Rivers and Estuary Policy (NOW)	By others
NSW Government Water Quality and River Flow Objectives (EPA)	By others
Water Quality Objectives in NSW (EPA)	Section 3.1
ANZECC Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ)	Section 3.7 (superseded by ANZG (2018))
National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ)	Section 9.2
Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (EPA)	Section 9.2

Table 2.1 (Cont'd)
Final SEARS for the Project – Surface Water

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Relevant Requirement		Report Section
Managing Urban Stormwater: Soils & Construction Volume 2E (DECC, 2008)		Section 4.6.2
Floodplain Development Manual (OEH)		Section 6.2
Floodplain Risk Management Guideline (OEH)		Section 3.6
Relevant Requirements Nominated by Other Government Agencies		
Water – General		
Department of Primary Industry – Water	Details of the water to be taken (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan.	Sections 8 and 5.4
	Assessment of any volumetric water licensing requirements (including those for ongoing water take following completion of the project such as evaporative loss from open voids or inflows).	Section 8
	The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.	Section 8
	Applicability of any exemptions under the Water Management (General) Regulation 2011 to the project	Section 8.1.2
	A detailed and consolidated site water balance	Section 5
	An assessment of impacts on surface and groundwater sources (both quality and quantity), related infrastructure, adjacent licensed users, basic landholder rights, watercourses, riparian land and groundwater dependent ecosystems and measures proposed to reduce and mitigate these impacts	Section 8 and SCSC Part 5
	Full technical details and data of all surface and groundwater modelling and an independent peer review.	Section 5 and Annexure C
	Proposed surface and groundwater monitoring activities and methodologies.	Section 9
	Proposed management and disposal of produced or incidental water.	Section 4
	Details surrounding the final landform of the site, including final void management (where relevant) and rehabilitation measures.	Section 7
	Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	Section 8
	Consider relevant Legislation, Water Sharing Plans, Policies and Guidelines.	Section 8
	Legislation	
	Water Management Act 2000 (WMA) and Water Act 1912. In particular, Objects (s.3) and Water Management Principles (s.5) of the WMA.	Section 8

Table 2.1 (Cont'd)
Final SEARS for the Project – Surface Water

Page 3 of 8

Relevant Requirement		Report Section
Relevant Requirements Nominated by Other Government Agencies (Cont'd)		
Water – General (Cont'd)		
Department of Primary Industry – Water (Cont'd)	**Water Sharing Plans**	
	Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources	Section 8
	The EIS is required to include the following issues relating to water: • Identify water demand and determine whether an adequate and secure water supply is available for the Project;	Sections 5.2 and 5.4
	• Identify water sources (surface and groundwater), water disposal/discharge methods and water storage structures in the form of a detailed and consolidated water balance.	Sections 4.2, 4.7.1, 4.6.1, 4.6.2, 5 and 8.7
	• Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts	Not Applicable
DPI – Water & NRAR	• The identification of an adequate and secure water supply for the life of the project.	Section 4.2
	• A detailed and consolidated site water balance.	Section 5
	• Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Section 8 and SCSC Part 5
	• Proposed surface and groundwater monitoring activities and methodologies.	Sections 9.2 and 9.3
Environment Protection Authority	Describe the proposal including position of any intakes and discharges, volumes, water quality and frequency of all water discharges.	Section 5.4
	Demonstrate that all practical options to avoid discharge have been investigated and implemented and outline measures that have been taken to reduce the pollutant load of the discharge so that the environmental impact minimised where a discharge is necessary.	Sections 4.6.1, 4.6.2, 4.4.2.1, 4.4.2.3 and 4.7.7
	Provide a water balance…including water requirements (quantity, quality and source(s)) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-use options.	Section 5
	If the discharge requires treatment prior to disposal, any treatment measures should be described and the predicted water quality outcomes documented. Include a detailed process diagram/flowchart of the proposal specifying all water inputs, outputs and discharge points.	Section 4.7
	Describe the existing surface and groundwater quality. An assessment needs to be undertaken for any water resource likely to be affected by the project.	Section 3.7
	Where the proponent intends to undertake the assessment using site specific water quality trigger values, detail the water quality of a reference site that has been selected based on the site specific considerations outlined in ANZECC (2000).	Annexure A (Section 1.1)

Table 2.1 (Cont'd)
Final SEARS for the Project – Surface Water

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Relevant Requirement		Report Section
Relevant Requirements Nominated by Other Government Agencies (Cont'd)		
Water – General (Cont'd)		
Environment Protection Authority (Cont'd)	State the Water Quality Objectives for the receiving waters relevant to the proposal…Where groundwater may be impacted the assessment should identify appropriate groundwater environmental values	Annexure A (Section 2.2)
	State the indicators and associated trigger values or criteria for the identified environmental values.	Annexure A (Section 2.3)
	State any locally specific objectives, criteria of targets which have been endorsed by the NSW Government.	Annexure A (Sections 2.1, 2.2 and 2.3)
	Provide detailed water management strategies for all disturbance areas, paying particular attention to the waste rock emplacement areas and potential impacts to groundwater and off site surface water resources including particular reference to the management of channel and overland flows into and within the disturbance area.	Section 4
	Describe how predicted impacts on surface water, groundwater and aquatic ecosystems would be monitored and assessed over time, including monitoring locations, relevant parameters and sampling frequency. The EIS should:	Section 9.2
	• Include a … response management plan, to identify appropriate trigger values and criteria and provide appropriate response actions if impacts are identified through the monitoring program.	Annexure A (Section 9.5)
	• Identify the process for identifying any trends in the monitoring data obtained.	Annexure A
Office of Environment and Heritage	The EIS must map the following features relevant to water … including: • Rivers, streams, wetlands, estuaries (as described in Appendix 2 of the Framework for Biodiversity Assessment).	Section 3
	• Proposed intake and discharge locations.	Section 4.7
	The EIS must describe background conditions for any water resource likely to be affected by the development, including: • Existing surface and groundwater.	Section 3
	• Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations.	Sections 4.6.2 and 5.5
	• Water Quality Objectives (as endorsed by the NSW Government including groundwater as appropriate that represent the community's uses and values for the receiving waters.	Annexure A (Section 2.2)
	• Indicators and trigger values/criteria for the environmental values identified in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government	Annexure A (Section 2.3)

Table 2.1 (Cont'd)
Final SEARS for the Project – Surface Water

Page 5 of 8

Relevant Requirement		Report Section
Relevant Requirements Nominated by Other Government Agencies (Cont'd)		
Water – General (Cont'd)		
Office of Environment and Heritage (Cont'd)	The EIS must assess the impacts of the development on water quality, including: • The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.	Sections 4.6.1 and 8
	• Identification of proposed monitoring of water quality	Section 9.2
NSW Division of Resources & Energy 23/01/15 Department of Resources and Energy 23/12/16	Assess surface water flow and flooding regimes and how these will be impacted and mitigated by the project both during and after mining has ceased. This is to include an evaluation of potential impacts from the final void on both surface and groundwater quality and flow regimes	Section 7
	Where a void is proposed to remain as part of the final landform, include…outcomes of the surface and groundwater assessments in relation to the final water level in the void. This should include an assessment of the potential for fill and spill along with measures required to be implemented to minimise associated impacts to the environment and downstream water users.	Section 7
Mid-Western Regional Council 15/01/15	The assessment clearly identifies the source of water, amount required and proposed method of reticulation to the mine site.	Sections 4.2 and 5.2
Water – Surface Water		
Department of Primary Industry – Water 19/12/14	Identification of all surface water sources as described by the relevant water sharing plan.	Section 8
	Identification of all surface water features including watercourses, wetlands and floodplains transected by or adjacent to the proposed project.	Section 3
	Scaled plans showing the location of: • Wetlands/swamps, watercourses and top of bank;	Annexure A Figure 3
	• Existing riparian vegetation surrounding the watercourses (identifying any areas to be protected or proposed to be removed);	SCSC Part 10
	• The site boundary, the footprint of the proposal in relation to the watercourses and riparian areas; and	Figure 3
	Geomorphic and hydrological assessment of watercourses including details of stream order (Strahler system), river style and energy regimes both in channel and on adjacent floodplains.	Annexure A (Sections 1.5.3, 1.6.3 and 2.6.3) Annexure B
	Information on the purpose, location, construction and expected annual extraction volumes including details on all existing and proposed water supply works which take surface water	Section 4.7

Table 2.1 (Cont'd)
Final SEARS for the Project – Surface Water

Page 6 of 8

Relevant Requirement		Report Section
Water – Surface Water (Cont'd)		
Department of Primary Industry – Water (Cont'd) 19/12/14	Details on existing dams/storages (including date of construction, location, purpose, size and capacity) of any proposal to change the purpose of existing dams/storages	Not Applicable
	Details on the location, purpose, size and capacity of any new proposed dams/storages.	Section 4.7
	Details of all works and surface infrastructure that will intercept, store, convey or otherwise interact with surface water resources	Section 4.7
	An assessment of the impacts to existing surface water systems in terms of potential modifications to natural ecological, hydrological and hydraulic function and potential impacts to local water users and the environment. This needs to be addressed for both during and post mine life with the use of stabilised landforms and mitigation of impacts.	Section 8
Environment Protection Authority 14/05/19	Describe any drainage lines, creeks lines etc. that will be impacted by the Project.	Section 3
	Assessment for discharge to surface waters guided by using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC, 2006).using local Water Quality Objectives determined from the NSW Water Quality and River Flow Objectives (DEC, 2006). Demonstrate how the Project will be designed and operated to: • protect the Water Quality Objectives for receiving waters where they are currently being achieved; and • contribute towards achievement of the Water Quality Objectives over time where they are not currently being achieved.	Section 8.8
	Identify potential impacts on watercourses and the management/mitigation measures that will be implemented where mining activities occur in proximity to or within a watercourse.	Section 8
	Identify whether any discharge, or the location of the Project, will cause erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	Section 8
	Describe how stormwater will be managed both during and after construction including a layout of the proposed stormwater system in accordance with Managing Urban Stormwater, Volume 2E (DECC, 2008), The EIS should:	Section 4
	• Provide the proposed general location of all water management structures. … Clearly indicated on appropriately scaled maps.	Figures 4.4 to 4.7
	• Demonstrate how clean, dirty and contaminated water will be managed (separated) on site throughout the life of the Project.	Section 4
	• Provide detailed water management strategies for all disturbance areas including the management of channel and overland flows into and within the disturbance area.	Section 4
	• Provide the proposed sizing of all water storage dams, sediment dams and other dams as required and justification for the sizing utilised.	Section 4.7

Table 2.1 (Cont'd)
Final SEARS for the Project – Surface Water

Page 7 of 8

Relevant Requirement		Report Section
Water – Surface Water (Cont'd)		
Environment Protection Authority (Cont'd) 14/05/19	• Identify contingency measure which may be implemented during extreme rainfall events.	Section 9
	Where the management of sediment basins requires the use of flocculants, the EIS should include information about the type, toxicity and management of flocculants proposed to treat captured water before discharge.	TBA
	Provide plans for any proposed relocation/realignment of all creeks and/or drainage lines including design, timelines and completion criteria and sufficient evidence to demonstrate that the proposed plans are achievable/sustainable, reasonable and feasible in the short and the long term.	To be included in Water Management Plans
Office of Environment and Heritage 14/05/19	The EIS must assess the impact of the development on hydrology, including: • Water balance including quantity, quality and source.	Section 5
	• Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas.	Section 8
	• Changes to environmental water availability, both regulated/licensed and unregulated/rules based sources of such water.	Section 8
	• Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options.	Section 8
	• Identification of proposed monitoring of hydrological attributes.	Section 9
Water – Flooding		
Office of Environment and Heritage 13/12/16	The EIS must map the following features relevant to flooding as described in the NSW Floodplain Development Manual 2005 including: • Flood prone land. • Flood planning area, the area below the flood planning level. • Hydraulic categorisation (floodways and flood storage areas). • Flood hazard.	Annexure B
	The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.	Section ,6 Annexure B
	The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: • Current flood behaviour for a range of design events as identified above. This includes the 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Section 6, Annexure B

Table 2.1 (Cont'd)
Final SEARS for the Project – Surface Water

Page 8 of 8

Relevant Requirement		Report Section
Water – Flooding (Cont'd)		
Office of Environment and Heritage (Cont'd) 13/12/16	Modelling in the EIS must consider and document: • The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood. • Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. • Relevant provisions of the NSW Floodplain Development Manual 2005.	Section 6, Annexure B
	EIS must assess the impacts on the proposed development on flood behaviour, including: • Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure.	Section 6, Annexure B
	• Consistency with Council floodplain risk management plans.	No Plans Exist
	• Compatibility with the flood hazard of the land	Section 3.6
	• Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site.	Section 6, Annexure B
	• Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	Sections 6.2, 6.3 and Annexure B
	• Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council.	Section 6, Annexure B
	• Whether the proposal incorporates specific measures to manage risk to life from flood.	EIS Section 4.7
	• These matters are to be discussed with the SES and Council.	EIS Section 4.7
	• Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES.	EIS Section 4.7
	• Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	EIS Section 4.7

Table 2.2
Additional Information Requests from Lue and District Community

Page 1 of 2

Issue(s)	**Coverage in Report**
Baseline levels in groundwater and surface water of metals e.g. arsenic and pH.	Annexure A (Sections 2.4 to 2.6)
The need for clean water (meeting potable drinking water guidelines) for the production of extra virgin olive oil.	Location is upstream - Unaffected by surface water runoff
Waste water containment procedures, including tailings storage facility design, based on applicable criteria including material selection and protocols to accommodate significant environmental events.	Section 4.6
Impact to water supply of Windamere Dam arising from sourcing water from the Cudgegong River system. Reference given to drought management water plans.	Windamere Dam is upstream in another catchment - unaffected by surface water runoff
Tailings Storage Facility capacity to prevent overflow and contamination of downstream waterways.	Section 4.7.9
Consider ANZFA food safety guidelines re use of potable water in the processing of extra virgin olive oil.	Location is upstream - unaffected by surface water runoff
Consider the responsibility for the potable drinking water in the town of Lue and surrounding area.	Drinking water is not drawn from the creek system
Potable water supplies for the Rylstone Australian Olive Oil processing plant, situated at Monivae, 8km southeast of Lue.	Location is upstream - unaffected by surface water runoff
Will tailings/water storage dams reduce the flow of water into creeks and rivers downstream.	Yes - Section 8
Effect of the mine to runoff water.	Section 8
When did monitoring of surface water commence? Is this sufficient data to base modelling on?	Section 3.7
What impact will mine water use have on the town’s water supply?	None
Will mining activities result in the drawdown of surface water?	Section 8
Where does Bowdens Silver propose to source water during the developmental and operational phases of the Project? Is this sustainable?	Section 4
Will water be sourced from Dunns Swamp?	No
What is the daily consumption projection for water that Bowdens Silver will need during operations?	Section 5.2
How much water will be diverted around the mine?	Section 4.6.3
How much water will be prevented from entering the natural system (i.e. Lawsons Creek)?	Section 8
I rely on Lawsons Creek for stock watering – will mining result in reduced flow and access?	Section 8.5
Have studies been conducted on potential impacts on the Lawsons Creek catchment?	Section 8
Surface water supplies are already unreliable – how will the mine impact us?	Section 8
What contingencies are in place if Bowdens Silver causes reduced flows in Lawsons Creek?	None proposed

Table 2.2 (Cont'd)
Additional Information Requests from Lue and District Community

Page 2 of 2

Issue(s)	Coverage in Report
Will diverted water remain within the same catchment or be diverted to another catchment?	No out-of-catchment diversions
Will water quality be impacted by mine runoff?	Section 8
Will the mine cause reduced flows on neighbouring properties?	Section 8
What impacts will mining activities have on surface water quality?	Section 8
What is the area of impact for surface water?	Section 7 and 8
What parameters will be monitored (e.g. pH, metals) and what kind of changes to water quality could potentially occur?	Sections 8 and 9
Will background surface water quality data include concentrations of lead and other heavy metals?	Section 9
What are the potential impacts of mining on Lawsons Creek and what measures will be put in place to prevent potentially contaminated water entering the creek?	Section 8
How will you prevent cyanide from entering Lawsons Creek and affecting my water supply?	Section 8.7 (Table 8.2)
Will Bowdens Silver be conducting ongoing water quality monitoring?	Section 9
Will background pH levels of Lawsons Creek be included in the EIS?	Section 9
Will monitoring be self-reported or independent/audited?	Sections 9.2 and 9.3
Will surface water monitoring results be made available on the website?	Yes
Will historical surface water sampling data be made available?	Yes
What extreme weather event planning will be undertaken during the design and ongoing operation of the mine?	Section 6 and Annexure B (Section 7.9)
What mitigation measures will be implemented to prevent any surface water quality issues?	Section 4
How will water be accessed for infrastructure and development before the water storage dams are operational?	Section 4.2
What will the capacity of the dams be on the mine site and what will they be used for?	Section 4.7
What size storm event will the dams be made to withstand?	Section 4.7
How many peer reviews will be conducted?	The Surface Water Assessment has been peer-reviewed (see Annexure C)
Will a detailed Hazard Assessment be included in the EIS?	See Part 4 of SCSC
What reduction in flow in Hawkins Creek and Lawsons Creek will occur as a result of the Mine?	Section 8
Can I access water from water supply pipeline for my stock?	No
I am concerned about the transfer of water from Goulburn River sources to the Mine Site.	-
"you are taking water out of the environment"	Section 8

3. EXISTING SURFACE WATER ENVIRONMENT

3.1 ENVIRONMENTAL VALUES AND OBJECTIVES

The NSW Water Quality Objectives set out the agreed environmental values (EVs) and long-term goals for NSW's surface waters. They set out:

- the community's values and uses for rivers, creeks, estuaries and lakes; and
- a range of water quality indicators to help assess whether the current condition of waterways supports those values and uses.

The Watercourse Assessment (R.W. Corkery & Co., 2020) included in **Annexure A** identifies the following water quality objectives reflecting the ecological, social and economic and ecosystem function values applicable to the receiving waters of the Project:

- Aquatic Ecosystem: Maintaining or improving the ecological condition of waterbodies and their riparian zones over the longer term.
- Visual Amenity (Aesthetic): quality of waters.
- Primary Contact Recreation: Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.
- Secondary Contact Recreation: Maintaining or improving water quality for activities such as boating and wading in which there is a low probability of water being swallowed.
- Livestock Water Supply: Protecting water quality to maximise the production of healthy livestock.
- Irrigation Water Supply: Protecting the quality of waters applied to crops and pasture.
- Homestead Water Supply: Protecting water quality for domestic use in homesteads including drink, cooking and bathing.
- Drinking Water (disinfection only or clarification and disinfection): Protecting the quality water at, and upstream of, offtake points for town water supply and specific sections of rivers that contribute to drinking water storages.
- Aquatic Foods (cooked): Protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.

3.2 LOCAL CLIMATE - RAINFALL AND EVAPORATION DATA

For the purposes of this assessment, long term daily rainfall and evaporation data for the Mine Site from January 1889 to December 2018 (130 years) was obtained from the Queensland Department of Environment and Science’s SILO data service.

SILO can provide a continuous daily time series of data at grid points across Australia SILO “accesses grids of data derived by interpolating the BOM’s station records. Interpolations are calculated by splining and kriging techniques” (Jeffrey et al). The data are all synthetic; there are no original meteorological station data left in the calculated grid fields. Daily rainfall gridded datasets are derived from interpolated monthly rainfall by partitioning the monthly total onto individual days. Partitioning requires estimation of the daily distribution throughout the month. The distribution is obtained by direct interpolation of daily rainfall data throughout the month. At the end of the month, the interpolated monthly rainfall is then partitioned onto individual days according to the computed distribution.

These SILO data sets are well suited for use in water balance modelling. The key advantage of adopting the SILO data is that it has been adjusted to remove accumulated totals over multiple days and to fill periods of missing data using rainfall from nearby stations. However, the interpolation techniques may result in some reduction in the variance of the climate record compared to the observed data.

Data was obtained for a point located at latitude 32.60 degrees S and longitude 149.85 degrees E, which is located 1.6 km north of the Mine Site. Annual rainfall totals from the adopted dataset are presented in **Figure 3.1**, and monthly averages are shown in **Figure 3.2**. Average annual rainfall is 673 mm/a and average annual (pan) evaporation is 1 518 mm/a. Evaporation from the surface of open water bodies was modelled using point estimates of Morton's Lake evaporation from the gridded SILO data (average annual Morton's Lake evaporation is 1 351 mm/a).

Bowdens Silver operates two meteorological stations one within the proposed Mine Site (Met 01) and another in Lue (Met 02), as shown in **Figure 1.1**. The records from these stations are relatively short (less than 5 years). The monthly rainfall data recorded at the proposed Mine Site is compared to the SILO data in **Figure 3.3**. The figure shows that data are well correlated and the SILO data is suitable for use in this surface water assessment.

Figure 3.1 Annual rainfall at the Mine Site - 1889 to 2018 (source: SILO point dataset - Qld Department of Environment and Science)

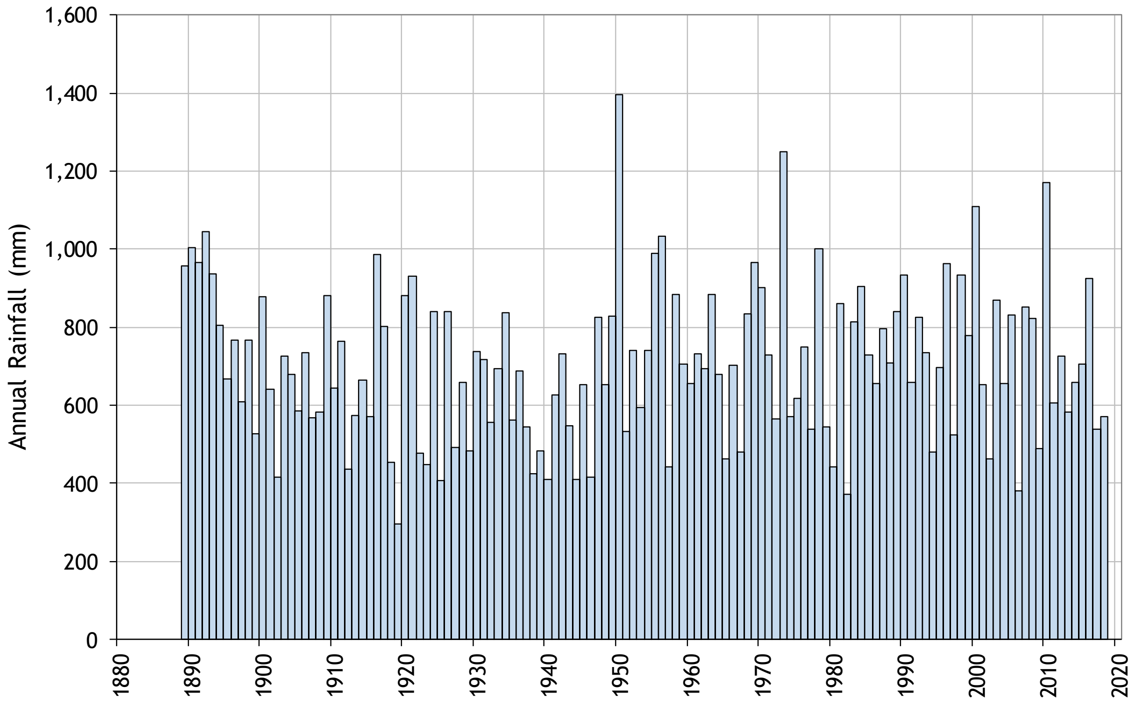


Figure 3.2 Average monthly rainfall and pan evaporation at the Mine Site - 1889 to 2018 (source: SILO point dataset - Qld Department of Environment and Science)

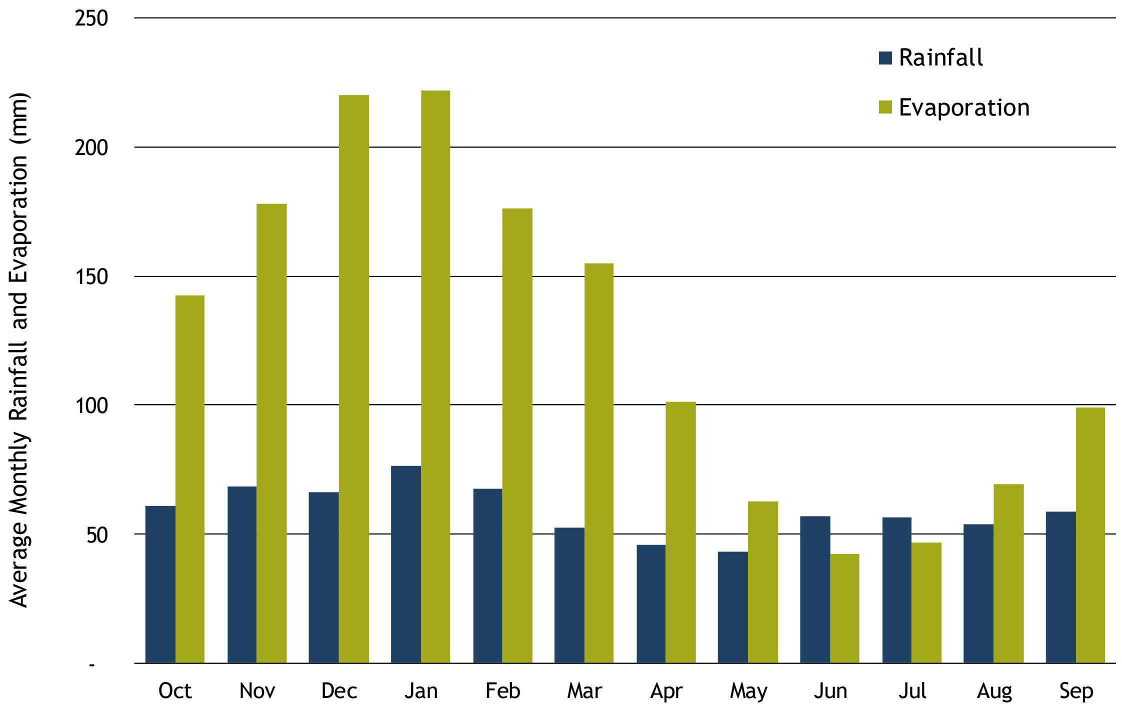
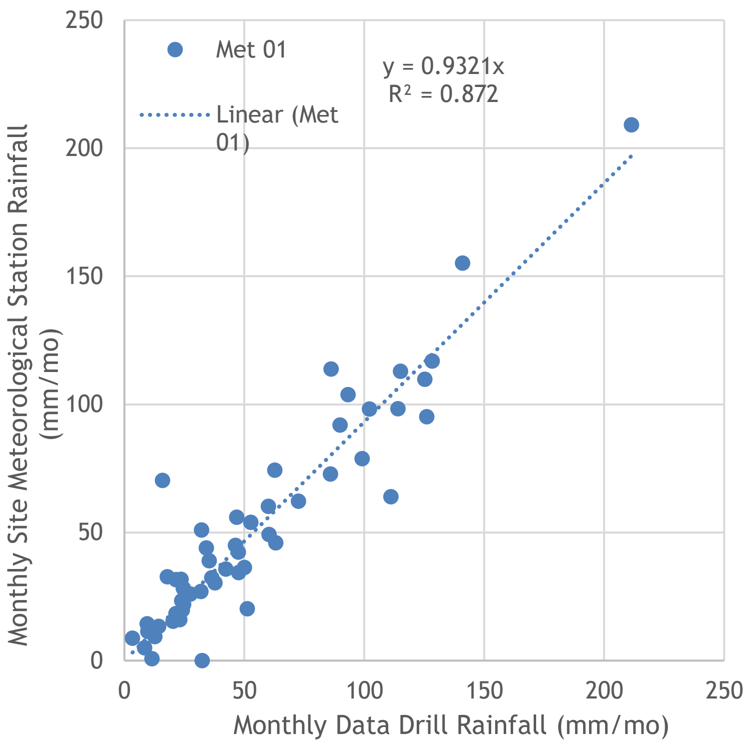


Figure 3.3 Comparison of monthly rainfall data from Bowdens Silver meteorological station and SILO data



3.3 REGIONAL DRAINAGE

Figure 3.4 shows the regional drainage features in the vicinity of the Mine Site. The Mine Site is located within the Lawsons Creek catchment, in the eastern headwaters of the Macquarie River basin. Lawsons Creek flows in a northwesterly direction and drains to the Cudgegong River near Mudgee. The Cudgegong River flows in a northwesterly direction from Mudgee, before turning to the southwest and eventually draining to Lake Burrendong. Lawsons Creek has a catchment area of approximately 507 km^2 to the Cudgegong River confluence (near Mudgee). Lake Burrendong has catchment area of approximately 13 900 km^2.

3.4 LOCAL DRAINAGE

Figure 3.5 shows the Lawsons Creek catchment to a point downstream of Lue. **Figure 3.6** shows the local drainage characteristics within and in the immediate vicinity of the Mine Site boundary.

Hawkins Creek, a tributary of Lawsons Creek, flows in a southwesterly direction near the southeastern boundary of the Mine Site. The boundary of the Mine Site is set back 20 m from the hydroline depicting the alignment of Hawkins Creek as presented on the NSW SEED (Sharing and Enabling Environment Data) Map database. Hawkins Creek has a catchment area of 61 km^2 upstream of the confluence with Lawsons Creek.

The Mine Site is traversed by the following named tributaries of Hawkins Creek and Lawsons Creek (refer to **Figure 3.6** for their locations):

- Price Creek (a south-flowing tributary of Hawkins Creek), which has a catchment area of 5.2 km^2 upstream of the Hawkins Creek confluence;
- Blackmans Gully (a south-flowing tributary of Hawkins Creek), which has a catchment area of 2.3 km^2 upstream of the Hawkins Creek confluence;
- Walkers Creek (a west-flowing tributary of Lawsons Creek), which has a catchment area of 4.9 km^2 upstream of the Lawsons Creek confluence. The proposed TSF would be located in Walkers Creek.

A number of minor unnamed tributary gullies also cross the Mine Site. Baseline geomorphological conditions in drainage features crossing the Mine Site were assessed as part of the *Watercourse Assessment for the Bowdens Silver Project* (R.W. Corkery & Co, 2020) (included as **Annexure A**).

The groundwater assessment for the Project (Jacobs, 2020) identified a number of springs and seeps, including, Wet Swamp Creek and Black Gully to the northwest of the Mine Site, and Blackmans Gully. A number of ephemeral seeps and partial wetlands are also present, particularly in the upper reaches of the minor drainages. These ephemeral swamps and seeps are often developed as farm dams for stock water supply.

In the vicinity of the Mine Site, these seeps are inferred to be the ephemeral expression of a saturated soil profile and result from sub-surface flows (or inter-flow) through the soil profile expressing at surface either due to a break in slope or a barrier to flow such as sub-cropping bedrock (Jacobs, 2020).

Figure 3.4 Regional Drainage Features

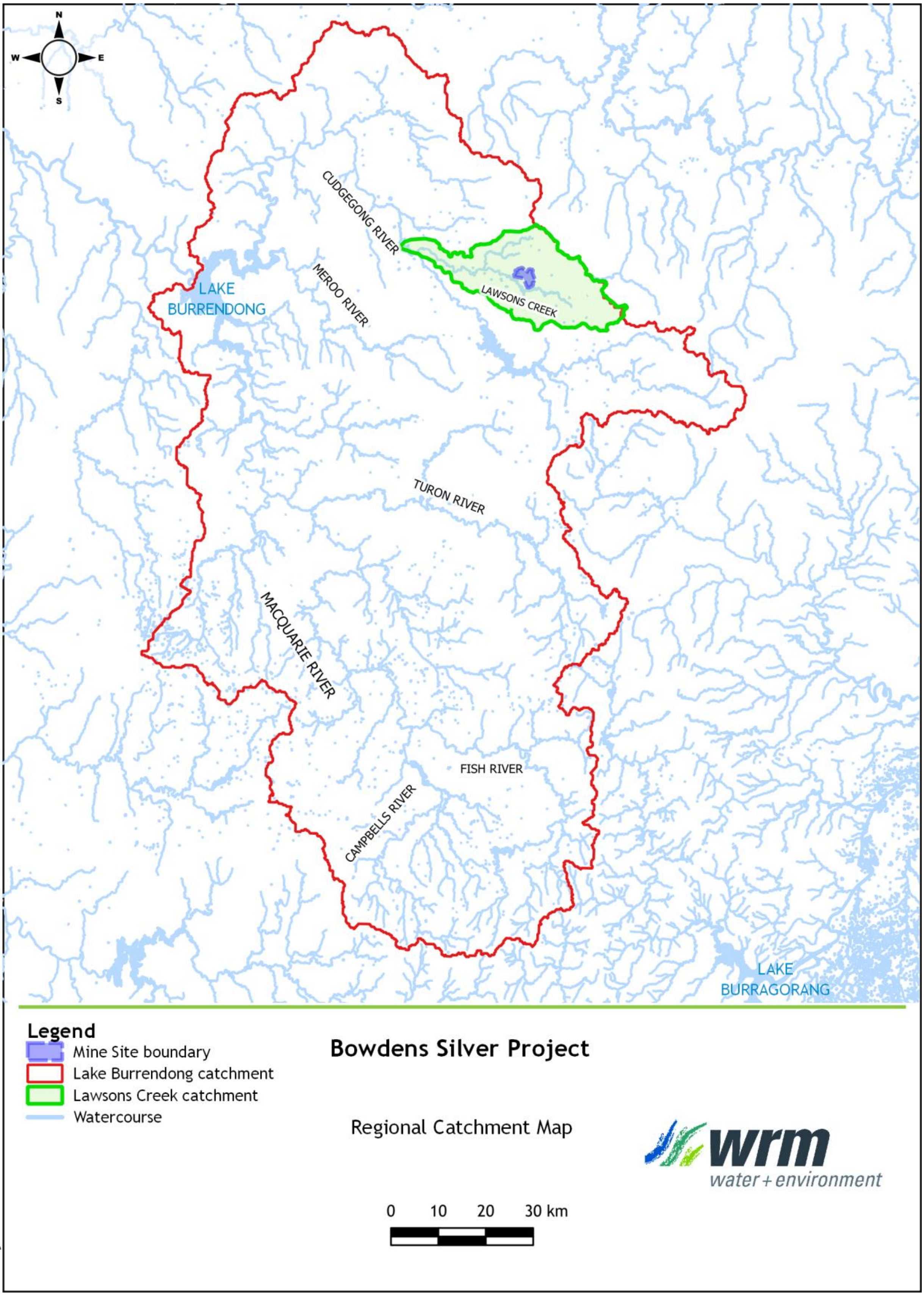


Figure 3.5 Lawsons Creek Catchment and the Locations of Rainfall and Water Level recording Stations Operated by Bowdens Silver

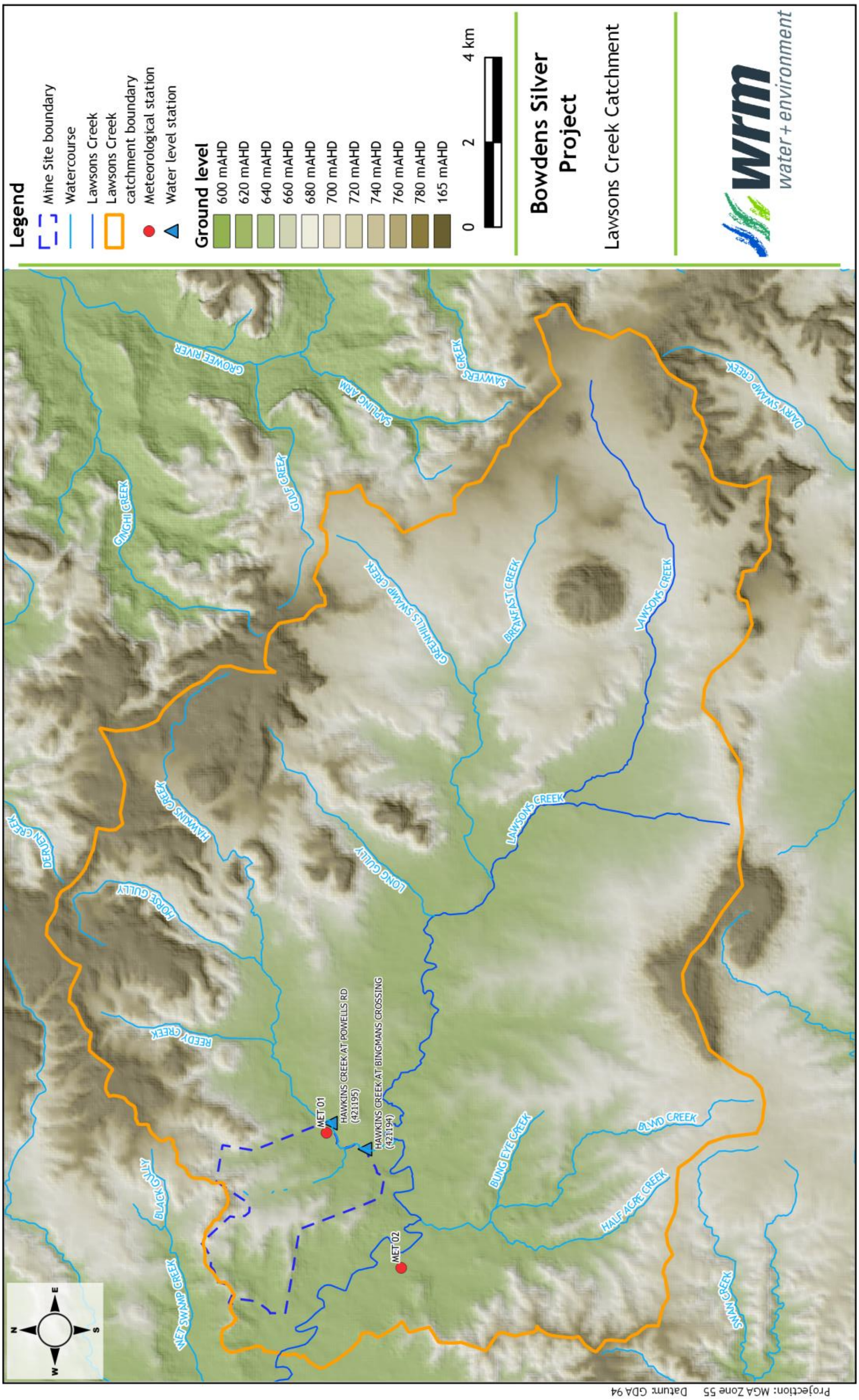
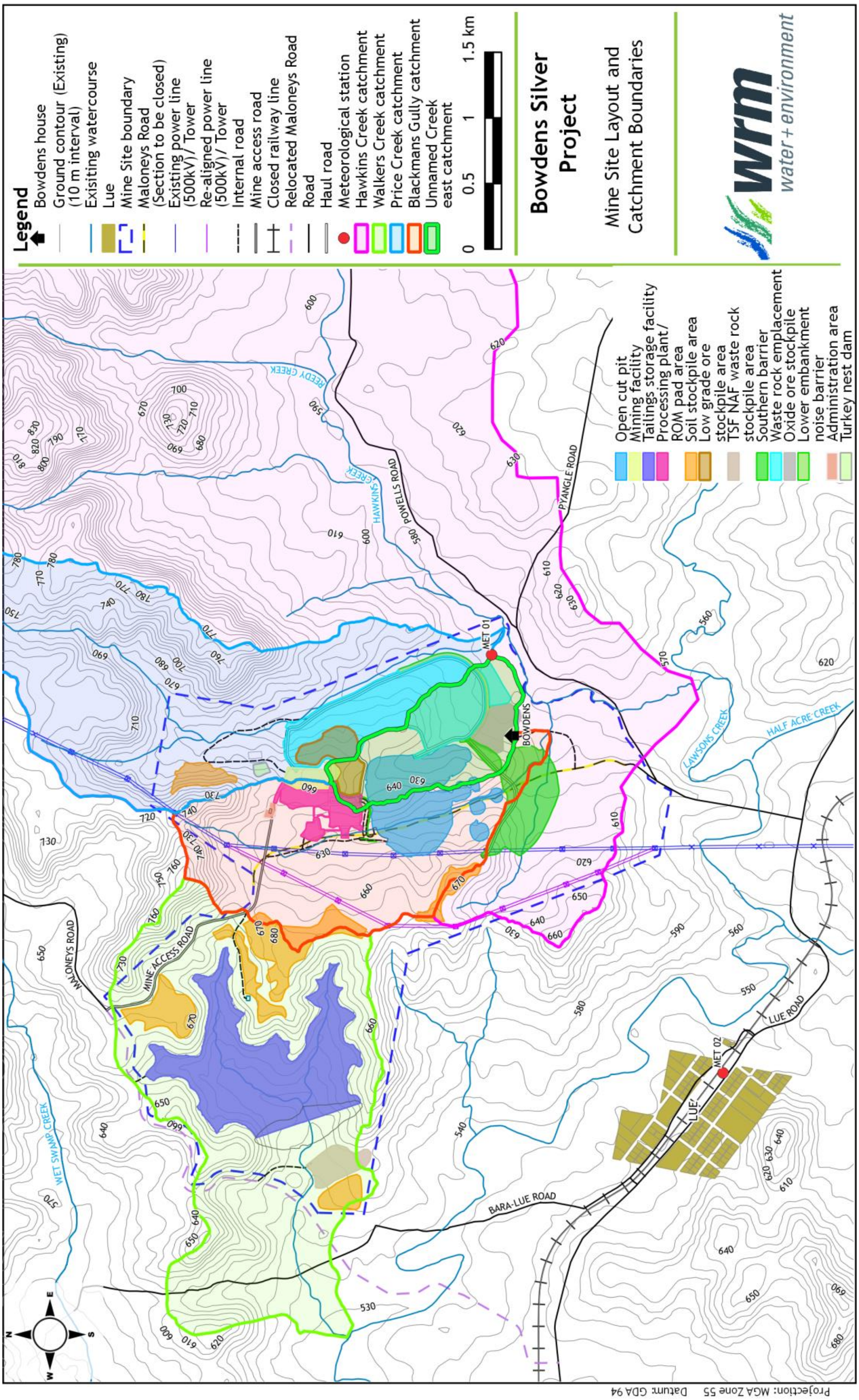


Figure 3.6 Site layout and local catchments crossing the Mine Site



3.5 STREAMFLOW

3.5.1 Streamflow Data

There are no WaterNSW or Bureau of Meteorology (BOM) streamflow recording stations in the immediate vicinity of the Mine Site. Bowdens Silver records water level at two continuous recording stations on Hawkins Creek adjacent to the Mine Site (shown in **Figure 3.5**), and provided the following data:

- Powells Road (Station No. 421195) - 3.2 year record from 26 March 2014 to 30 May 2017; and
- Bingmans Crossing (Station No. 421194) - 4 year period from 16 June 2013 to 30 May 2017.

These stations comprise a v-notch weir mounted on a concrete weir crossing the bottom of the channel. The invert level of the v-notch weir is at 0.5 m gauge height (GH) at both stations.

Figure 3.7 shows recorded water levels in Hawkins Creek at the Bingmans Crossing station (Station No. 421194) over the period of record. As shown in **Figure 3.8**, the period of record includes a period of very wet weather commencing in July 2016, preceded by a period of very dry weather.

Figure 3.7 Recorded Water Levels in Hawkins Creek at Bingmans Crossing

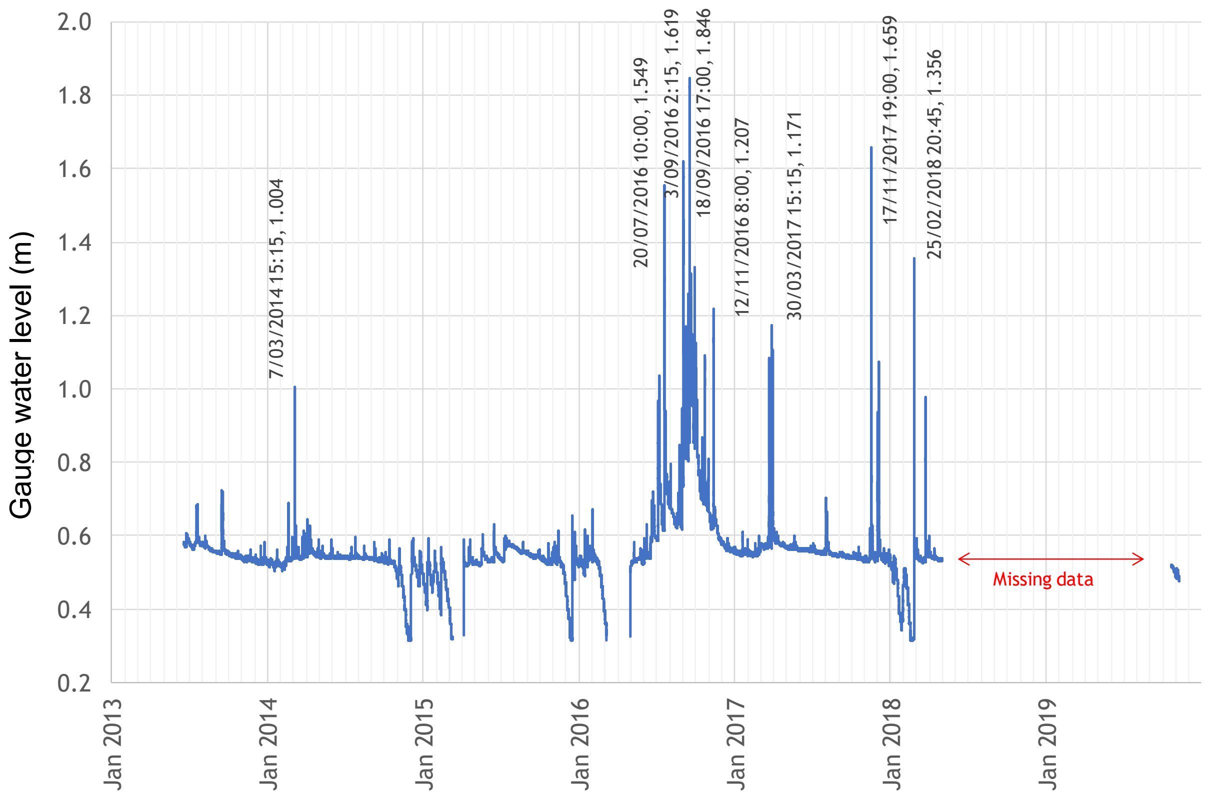
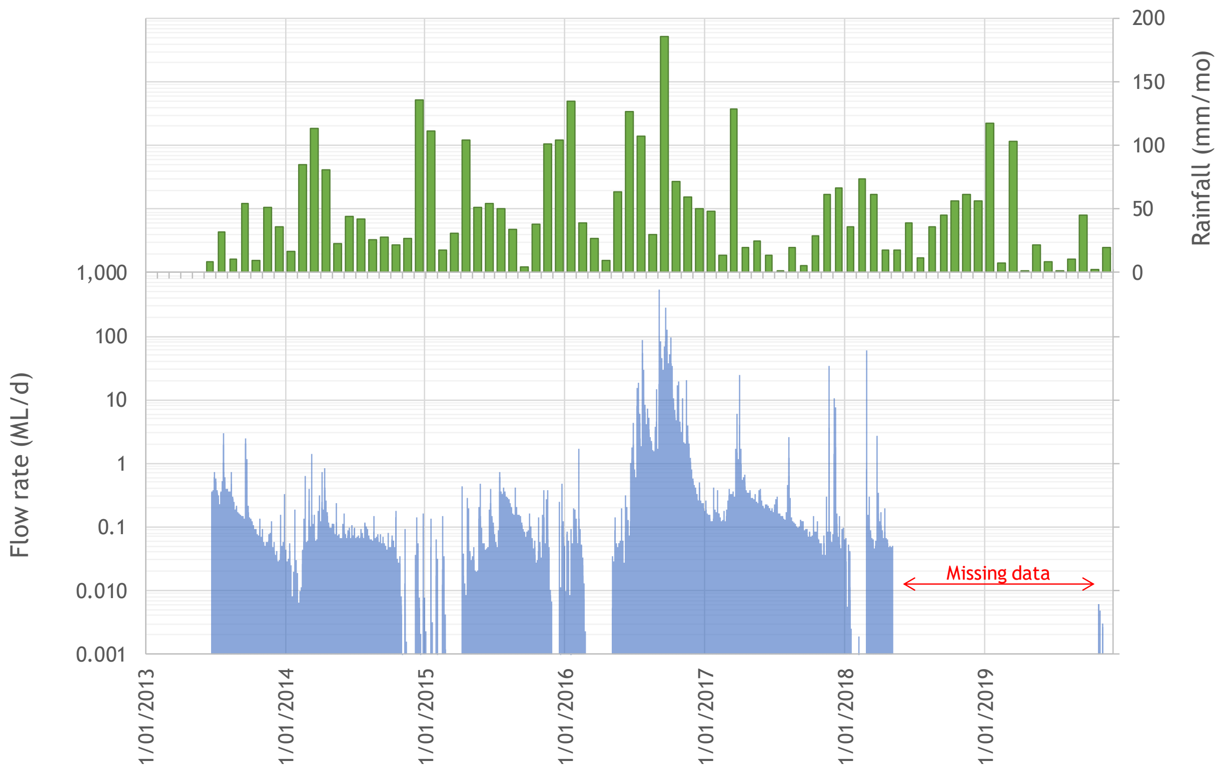


Figure 3.8 Streamflow recorded in Hawkins Creek at Bingmans Crossing



3.5.2 Characterisation of Streamflow

The first order drainage catchments present in the Mine Site are ephemeral in nature with negligible groundwater baseflow (Jacobs, 2020). Baseflow derived from groundwater discharge and bank storage is however considered likely to contribute year round to flows in Hawkins Creek and Lawsons Creek. Groundwater levels can be important in maintaining flows or pools that sustain ecosystems, particularly during times of drought.

3.5.2.1 Hawkins Creek

Figure 3.7 shows that baseflow generated depths of more than 100 mm over the v-notch weir between July and November 2016, and flow peaks exceeding 1 m gauge height (0.5 m above the v-notch weir crest) occurred several times over this period. There are also a number of periods of no flow during the period of record.

Based on this relatively short period of data, Hawkins Creek streamflow could be characterised as ephemeral to semi-perennial at this location.

Hawkins Creek is likely sustained by groundwater baseflow, as indicated by continued flow (or the presence of 'waterholes') anecdotally observed during the drier seasons. Jacobs (2020) estimated the baseflow contribution calculated from the gauged streamflow data as generally less than 0.2 ML/d.

Average daily flow in Hawkins Creek over the period of record was approximately 1.95 ML/d or 712 ML/a, which equates to approximately 0.12 ML/ha/a over the 61 km^2 catchment to Bingmans Crossing. This is only 1.7% of total rainfall over that period (which was close to the median 4 year total).

3.5.2.2 Lawsons Creek

Lawsons Creek is an unregulated watercourse. The headwaters of the Lawsons Creek system are situated on Mount Graham (elevation approximately 910mAHD) which is approximately 20km east of the Mine Site. The northern and eastern extents of the Lawsons Creek catchment are heavily vegetated and underlain by Permian sediments of the Sydney Basin. The southwestern extent of this catchment is also heavily vegetated but underlain by meta sediments and volcanics associated with the Lachlan Orogen (R.W. Corkery & Co, 2020).

The bulk of the Lawsons Creek catchment has been altered (cleared) to support agricultural activities. Historically, Lawsons Creek was likely to have been an intermittent to perennially discharging watercourse however, subsequent land use changes and the construction of water capture and storage structures to support agriculture have altered the hydrologic regime such that Lawsons Creek may now be described as an intermittent to ephemeral watercourse (R.W. Corkery & Co, 2020).

Based on the hydrological modelling outlined in the following section (using parameters established by calibration to long-term streamflow records in the upper catchment of the nearby Cudgegong River), average daily flows in Lawsons Creek downstream from Hawkins Creek are estimated at 19.5 ML/day or 7 136 ML/a.

3.5.3 Simulated Catchment Runoff and Streamflow

In the absence of site-specific long-term data to characterise streamflow in Hawkins Creek and Lawsons Creek, the Australian Water Balance Model (AWBM) model was used to represent the runoff characteristics of local catchments.

The AWBM uses a group of connected conceptual storages (3 surface storages) to represent catchment runoff. Water in the conceptual storages is replenished by rainfall and reduced by evaporation. Simulated surface runoff occurs when any of these storages fill and overflow. The model parameters define the depth and relative area of each of the storages, as well as the rate of water flux from/between storages. The AWBM model adopted for the Project uses the point estimates of Morton’s Wet evapotranspiration (ET) from the SILO gridded dataset.

There are no rainfall stations located within Hawkins Creek catchment upstream of the Mine Site, and the available flow record is of relatively short duration. As a consequence, while the Hawkins Creek stream gauge data was used to validate the flood model results (see **Annexure B**), it was not considered suitable for calibration of catchment yield models to extend the streamflow time series. AWBM parameters were instead adopted based on the following approaches:

Base case modelling of Mine Site runoff and receiving water runoff
The parameters used for modelling Hawkins Creek and Lawsons Creek streamflow, as well as Mine Site runoff, were selected based on calibration to data collected at the Cudgegong River Upstream of Rylstone streamflow

gauge (421184) operated by WaterNSW, which is the nearest NSW government streamflow gauge to the Mine Site. The representation of low flows was improved by applying a constant loss of 0.0025 mm/d (to account for instream flow losses). Key statistics of the calibration over the period 27/6/2009 to 30/12/2017 (which excludes recent very dry weather when instream losses appear to be most pronounced) are as follows:

– Total runoff: modelled 183.6 mm, observed 182.9 mm (observed/modelled = 99.4%);
– Correlation co-efficient (monthly) – 0.86;
– Root mean square error (monthly) – 1.17 mm/mo;
– Nash Sutcliffe co-efficient (monthly) - 0.73.

Figure 3.9 compares the flow frequency curves for runoff recorded at the Cudgegong River Upstream of Rylstone with the AWBM model runoff. The resulting average annual catchment runoff (prior to instream losses) is approximately 0.39 ML/ha/a or 4.9% of long-term rainfall (when applied to the Patched Point climate dataset for the Olinda (Springdale) rainfall station (62023)). The location of the catchment to the streamflow gauge is shown in **Figure 3.10**.

Figure 3.9 Comparison of Recorded and Modelled Runoff (Cudgegong River Upstream of Rylstone)

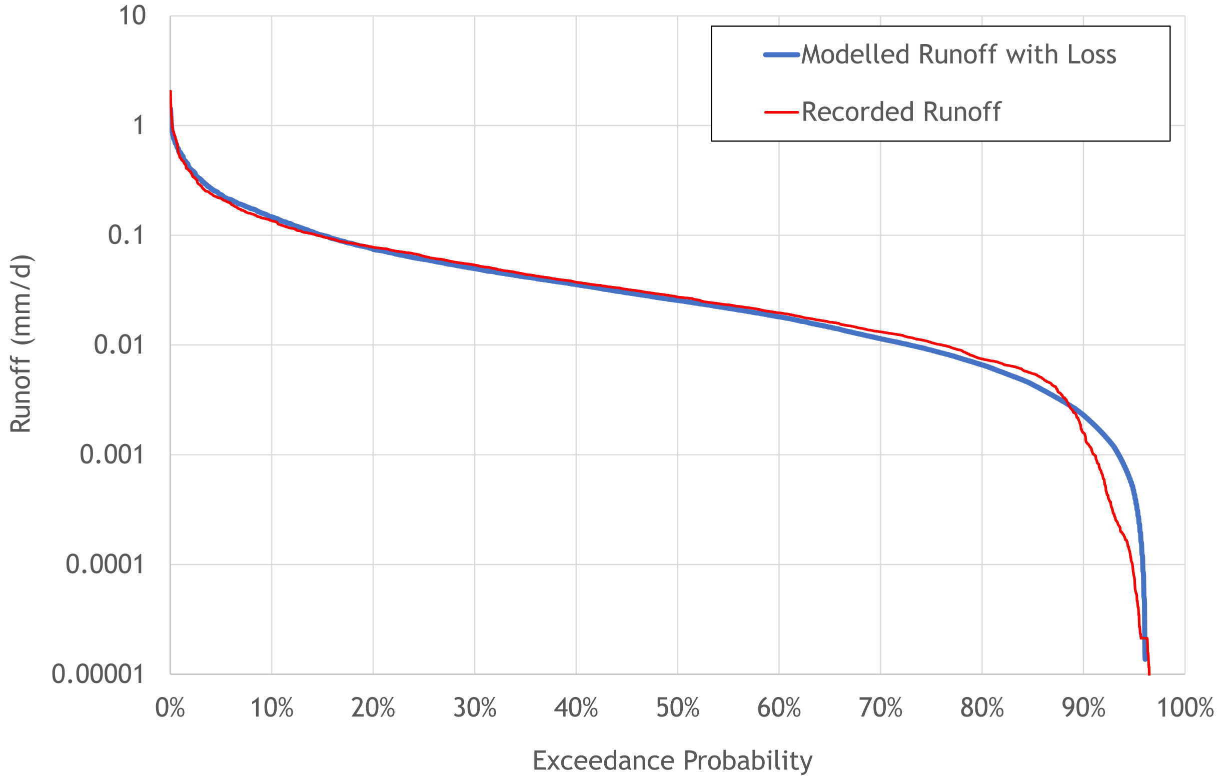
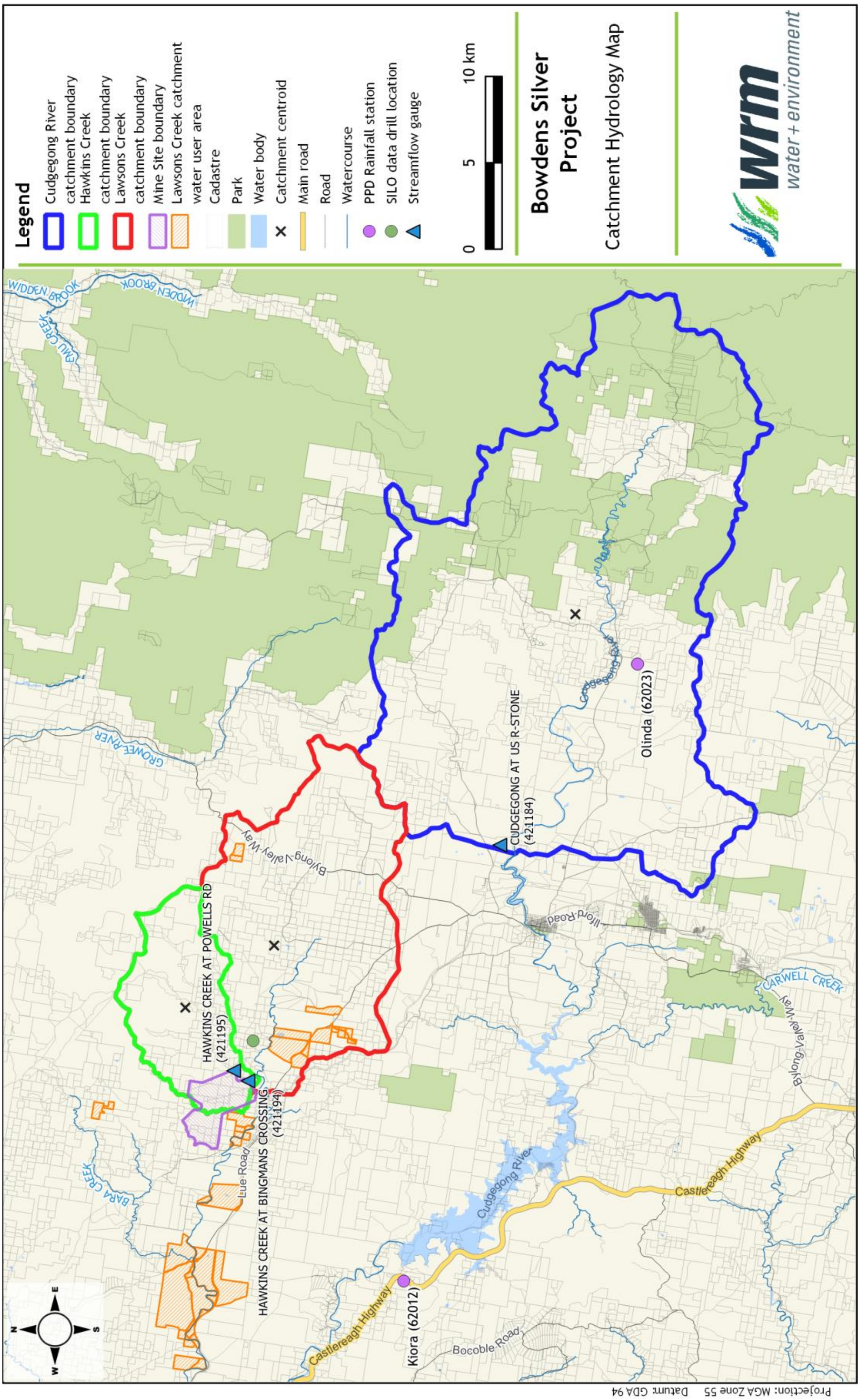


Figure 3.10 Locations of Project Area Catchments and the Cudgegong River at Upstream of Rylstone Streamflow Gauge



- Sensitivity testing of water management system to changes in Mine Site catchment response:
  - low runoff scenario- from experience with catchment modelling in the nearby upper Hunter Valley. The AWBM parameters selected were based upon a calibration to observe mine water inventory data at Moolarben Coal Mine, approximately 38 km north of the Mine Site, with catchments yielding 2.7% of rainfall as runoff (or 0.18 ML/ha/a);
  - high runoff scenario- an artificial parameter set similar to the base case parameters but with the A1 parameter increased and the C3 parameter decreased to generate comparatively high runoff quantities for the area (8.7% of rainfall) (0.62 ML/ha/a).

The AWBM parameters adopted for modelling Lawsons Creek catchment and undisturbed Mine Site area runoff are summarised in **Table 3.1**.

Table 3.1
Adopted AWBM Parameters – Undisturbed Catchments

Parameter	Base Case Mine Site Runoff and Lawsons/Hawkins Creek[1]	Sensitivity Testing of Mine Site Runoff from Undisturbed Areas	
		Low Runoff	High Runoff
A1	0.134	0.2	0.2
A2	0.433	0.2	0.2
A3	0.433	0.6	0.6
C1 (mm)	25	90	25
C2 (mm)	184	170	95
C3 (mm)	214	200	150
C_{avg} (mm)	176	172	114
BFI	0.45	0.6	0.55
K_{base}	0.982	0.7	0.7
K_{surf}	0.820	0.4	0
Average Annual Runoff/ Rainfall[2] (%)	**4.9**	**2.7**	**8.7**
Runoff[2] (ML/ha/a)	**0.33**	**0.18**	**0.62**

[1]Applied a constant loss of 0.0025mm/d for instream loss for creek flows
[2]Over period of climate record from 1889 to 2019 – varies slightly with catchment climate data

3.6 FLOODING

A detailed assessment of flooding has been carried out to establish the extent of flooding in the reaches of Lawsons Creek, Hawkins Creek adjacent to the Mine Site, as well as the main tributaries crossing the Mine Site.

An XP-RAFTS hydrologic model was developed for the catchments of Hawkins Creek and Lawsons Creek and their tributaries and validated using data from the stream gauges. A TUFLOW hydraulic model was then developed for these watercourses to determine the existing flood behaviour based on existing conditions in the vicinity of and within the Mine Site.

The extent, depth and velocity of flooding across the model domain in the 1% AEP flood are shown in **Figure 3.11** and **Figure 3.12**.

Key findings from the flood modelling with regards to predicted peak flood levels and depths across the model domain are summarised below:

- No flood prone land is mapped in the Mid-Western Regional Local Environmental Plan 2012 in the vicinity of the Mine Site.
- The Mine Site disturbance area is located outside of the Lawsons Creek flood extent for all events up to the PMP design event.
- The area along the southeastern Mine Site boundary is affected by flooding from Hawkins Creek. However, the proposed open cut pits, WRE and leachate management dam are located outside of the predicted flood extent for Hawkins Creek for all design events. It is noted that the embankment crests of the WRE and leachate management dam are above the water level of the PMP design event.
- Flooding along the Hawkins Creek and Lawsons Creek tributaries within the Mine Site is characterised by shallow overland flows. Flows in these tributaries are generally confined within the narrow floodplains, with no breakouts occurring except near the confluences of these tributaries with Hawkins Creek and Lawsons Creek. Due to the narrow floodplains, the difference in predicted flood extents along these tributaries between the 1% AEP and PMP design events are not significant.
- Predicted peak flood depths along the overbank areas of the Hawkins Creek and Lawsons Creek tributaries are generally below one metre for events up to and including 0.2% AEP (1 in 500). Peak flood depths of up to 1.5 m for the PMP design event are predicted in some sections along these tributaries.

Key findings with regards to predicted peak velocities across the model domain are summarised below:

- Flows in the Hawkins and Lawsons Creeks tributaries are generally confined within narrow floodplains with relatively steep ground slopes. This results in relatively high predicted peak flood velocities of up to 2.5 m/s along the channel and overbank areas of these tributaries for events up to and including 0.2% AEP (1 in 500).
- Predicted peak flood velocities in Hawkins Creek for events up to and including 0.2% AEP are generally less than 3 m/s, with peak velocities greater than 4 m/s predicted in some sections.
- Predicted peak flood velocities in Lawsons Creek are relatively high for all modelled events. For events up to and including 0.2% AEP, peak flood velocities greater than 4 m/s are predicted in many sections along the Lawsons Creek channel and floodplain.

Full details of the methodology and mapping of baseline flood conditions are provided in the flood impact assessment report in **Annexure B**. The methodology was developed in consideration of the recommendations in the NSW floodplain risk management guideline.

Figure 3.11 Existing Conditions 1% AEP Flood Depths and Water Level Contours

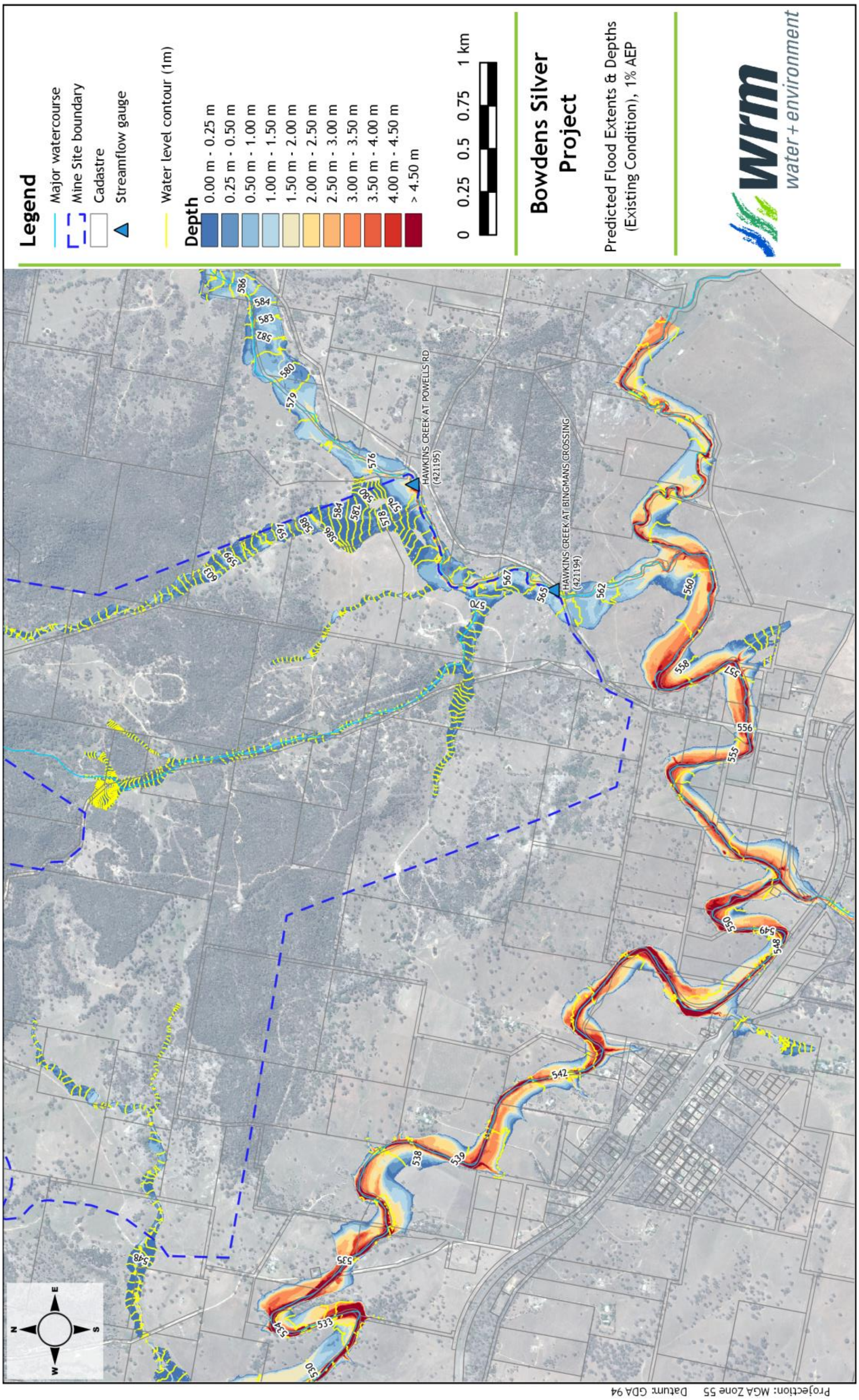
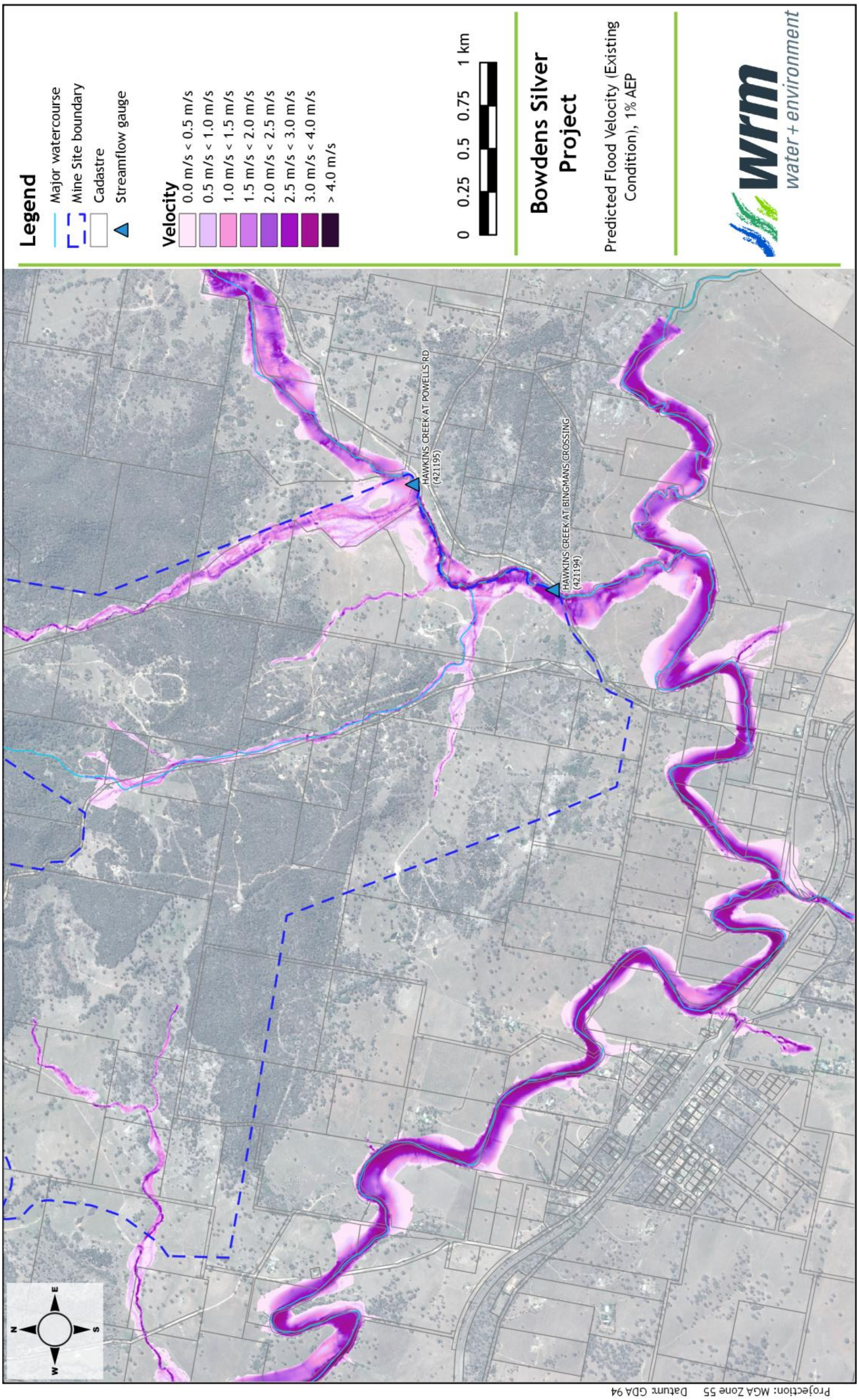


Figure 3.12 1% (1 in 100) AEP Peak Flood Velocities – Existing Conditions - Complete Extent



3.7 WATER QUALITY

Monitoring of surface water in Lawsons Creek, Hawkins Creek and its tributaries has been undertaken since 2012. Full details of the baseline water quality assessment are presented in **Annexure A** (R.W. Corkery & Co, 2020).

The principal guideline for water quality in Australia is ANZG (2018). Most of this guideline relies upon guidance developed by the Australian and New Zealand Environment and Conservation Council (ANZECC) in collaboration with the Agriculture and Resources Management Ministerial Council of Australia and New Zealand (ARMCANZ) and which was published in the (then) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). ANZG (2018) sets quantitative and qualitative guideline values for a range of water quality parameters for the protection of aquatic ecosystems, aquaculture, recreation, drinking and agricultural values.

The baseline water quality assessment concludes water quality in the receiving waters of the Mine Site has been altered as a result of the agricultural activities in the contributing catchment, particularly with regard to nutrients and electrical conductivity (EC). The median values for:

- ammonia exceed the default guideline value at all sampling locations.
- nitrate exceed the default guideline value at all sampling locations.
- total nitrogen is above the default guideline value at all sampling locations.
- total phosphorous exceed the default guideline value at all sampling locations.
- pH is within the desired range for upland rivers although the results for monitoring locations on Lawsons Creek are generally at the upper end of this range.
- sulphate concentrations are below the default guideline value at all locations.
- electrical conductivity is above the desired range.

The assessment also concludes that median (50^{th} percentile) metal concentrations are generally below current default guideline values. **Table 3.2** compares the median percentile of metal concentrations to the default guidelines for protection of aquatic ecosystems. The table shows exceedance for zinc and copper (although copper concentrations do not exceed the hardness modified guideline value) in both Hawkins Creek and Lawsons Creek, but all other metals are at or below the guideline value. Full details of the baseline water quality assessment are presented in **Annexure A** (R.W. Corkery & Co, 2020).

3.8 LICENSED SURFACE EXTRACTION

3.8.1 Water Sharing Plan for Macquarie Bogan Unregulated and Alluvial Water Sources

Water Sharing Plans provide the basis for equitable sharing of surface water and groundwater between water users, including the environment. The Water Management Act (2000) requires:

- a water access licence (WAL) to take water;
- a water supply works approval to construct a work; and
- a water use approval to use the water.

Table 3.2
Summary of Background Dissolved Metal Concentrations and Guideline Levels (µg/L)

Analyte	ANZG Default Guideline Value[1]	50th Percentile from Water Quality Monitoring Data							
		Lawsons Creek				Hawkins Creek			
		BSW28	BSW22	BSW21	BSW20	BSW7	BSW11	BSW12	BSW13
Mn	1900	88.0	87.0	262.0	512.8	225.5	218.5	138.5	293.0
Zn	8	7.0	6.5	7.0	16.0	10.0	9.0	10.0	8.0
Cd	0.2	0.1	0.1	1.0	0.1	0.2	0.1	0.2	Below LOR
Pb	3.4	2.0	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR
Co	N/A	2.0	1.0	1.0	2.0	1.0	2.0	2.0	2.0
As	13	2.0	1.5	2.0	4.0	1.0	2.0	1.0	1.0
Cu	1.4	2.0	2.0	1.0	3.0	2.0	2.0	1.0	2.0
Ni	11	2.0	1.0	1.0	3.0	2.0	3.5	2.0	4.0

LOR – limit of reporting
[1] – for protection of aquatic ecosystems

Surface water in the vicinity of the Project is managed under the Water Sharing Plan (the Plan) for Macquarie Bogan Unregulated and Alluvial Water Sources (2012): Lawsons Creek Water Source. Water taken from the Lawsons Creek Water Source is required to be licensed by way of a water access licence granted under the Plan.

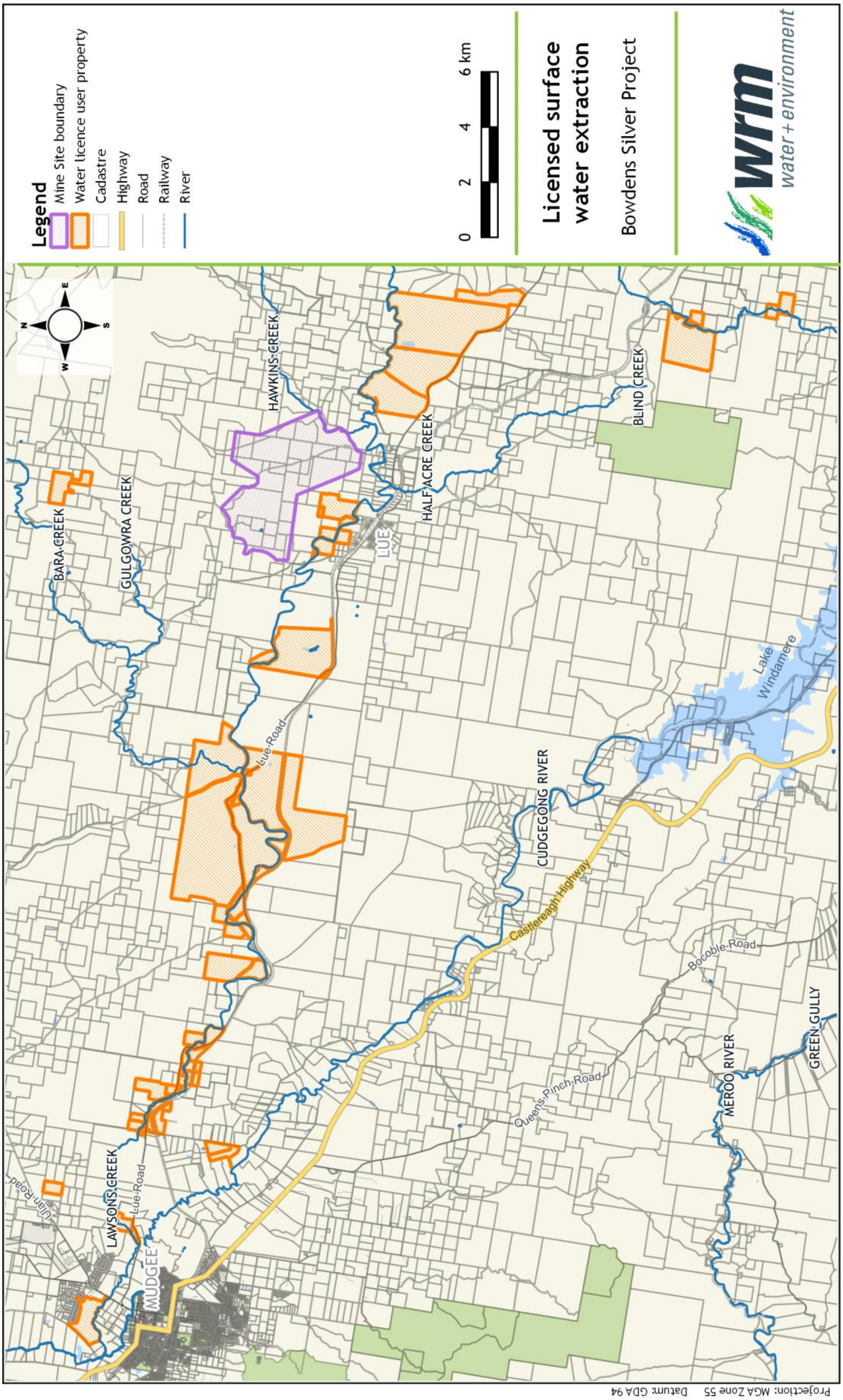
While not detailed in the Plan Maps of the associated Water Sharing Plans, shallow alluvial deposits are present in the vicinity of Hawkins Creek and Lawsons Creek. Drilling along Hawkins Creek has recorded alluvial thickness ranging from 4 m to 6 m with variable saturation, and these alluvial deposits are not considered to be highly productive on the basis of the Aquifer Interference Policy (AIP) yield criteria. Notwithstanding, thicker saturated sequences of alluvium still have potential to be highly productive and the alluvial deposits will be considered as such for the purposes of the groundwater assessment prepared in accordance with the AIP. Alluvial groundwater extraction in this alluvium can therefore potentially impact on surface water flows in the adjoining reaches of Hawkins and Lawsons Creek (Jacobs, 2020).

3.8.2 Water Access Licences Currently Granted in the Lawsons Creek Water Source

Details of existing Water Access Licences held by landholders in the vicinity of the Mine Site were obtained from the NSW Water Register. Surface water in Lawsons Creek is used mainly for irrigation and stock watering.

The total share component for the Lawsons Creek Source 1 496 unit shares (at 1 ML/a per share). A total of 47 water access licences (comprising 35 unregulated river licences and 12 domestic and stock licences) have been granted from the Lawsons Creek Water Source. Of the 42 licences which have associated works approvals, extraction is approved at 27 properties located downstream of the Project, and account for 1 014 unit shares granted from the water source. The locations of the Works Approvals are shown in **Figure 3.13**. There are no approved extraction points on Hawkins Creek.

Figure 3.13 Licensed Surface Water Extraction from the Lawsons Creek Water Source



4. WATER MANAGEMENT STRATEGY

4.1 WATER MANAGEMENT OBJECTIVES

On-site water management within the Mine Site would be required to achieve the following objectives:

- Maximising the recovery of water from contaminated on-site water sources to support processing operations while relying upon the use of imported water as a make-up water supply to meet the on-site water demand (for processing ore, dust suppression, etc).
- Maximising the redirection of upslope surface runoff around operational areas, and where water quality is suitable, maximising the release of runoff.
- Minimising the disruption to mining operations caused by the inflow of groundwater or surface water to the open cut pits.
- Protecting the downstream waters from potential contaminants in Mine Site runoff by:
  - Capturing contaminated seepage from the WRE, tailings decant water, or runoff that may be in contact with potentially reactive material within the site water management system for recycling and reuse in the processing circuit;
  - Minimising the volume of water coming into contact with PAF waste rock or other potentially reactive material by diverting runoff from upstream undisturbed areas around operational areas; and
  - Directing sediment-laden disturbed-area runoff (that has not come into contact with PAF waste rock or other potentially reactive material) to sediment dams for containment on site unless the water quality is adequate for release to the receiving waters after sediment removal.

4.2 WATER SUPPLY

Water for the mining operation would be obtained from the following sources listed preferentially in order and type of use:

1. Surface water collected by the leachate management dam for recycling and reuse in processing operations.
2. Groundwater and surface water accumulating within the open cut pit for recycling and reuse in processing operations.
3. TSF return decant water for recycling and reuse in processing operations.
4. Surface water collected within the sediment dams (but unsuitable for release) or authorised under harvestable rights entitlements for use in dust suppression activities.
5. Excess mine water from the Ulan Coal Mine and/or Moolarben Coal Mine.

During the site establishment and construction stage, Bowdens Silver would construct and commission a water pipeline for the supply of process water requirements . The water pumped from the Ulan Coal Mine and/or Moolarben Coal Mine would effectively be make-up water intended to supplement water recovered from Sources 1 to 4 above. It is the preference of Bowdens Silver that water treatment through reverse osmosis would occur at the source end of the pipeline to enable all water to be treated prior to being pumped to the Mine Site. Emphasis would be placed upon the water treatment reducing the electrical conductivity levels to approximately 800µS/cm.

During processing operations, water would be imported to a proposed dedicated “turkey nest dam”. The “turkey nest dam” would also receive water from the site water management system. External water supplies would be delivered to maintain water levels in this dam such that when supplies delivered from the water management system exceed demand (for example following wet weather), pumping from external supply would cease.

Potable water requirements during the site establishment and construction stage would be delivered to the Mine Site by water tanker until such time as a reverse osmosis (RO) plant is installed. The RO plant would be used during operations to treat a combination of groundwater, surface water and mine water to produce potable water. Brine from the RO plant would be returned to the processing plant dams for reuse.

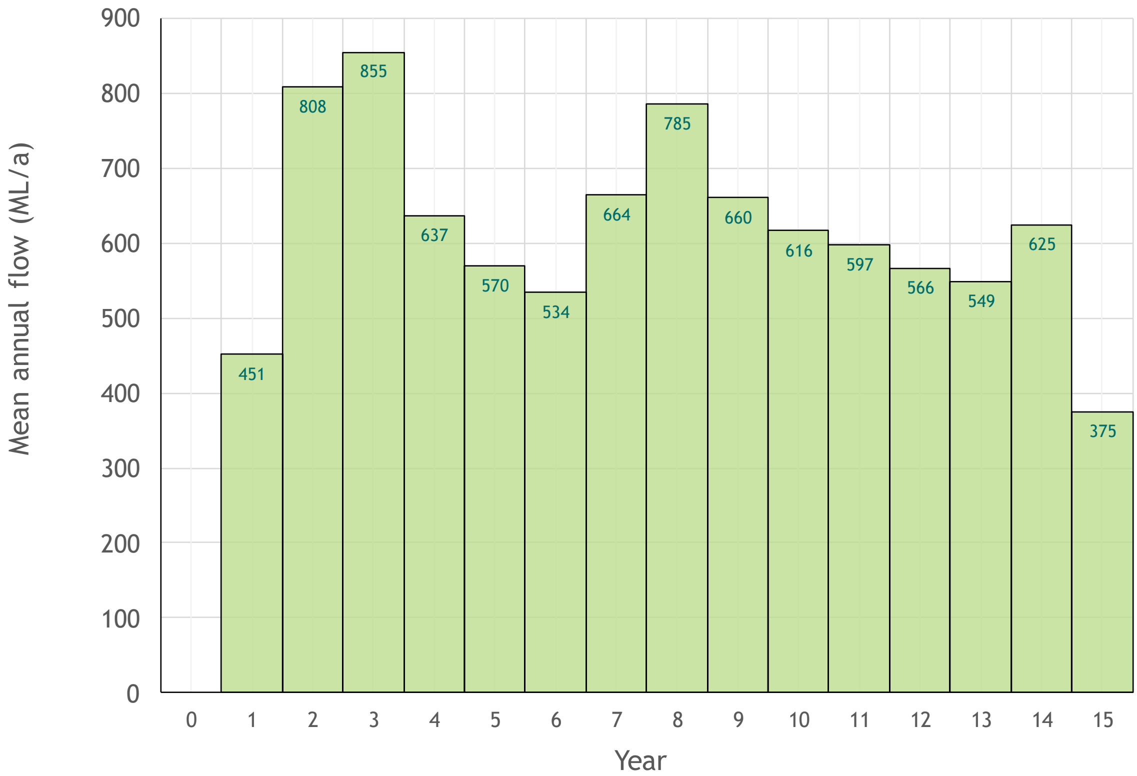
Subject to obtaining the appropriate Water Management Act approvals, there is potential to access supplementary groundwater supply, if required to make up temporary shortfalls in the availability of water from other sources, via the installation of additional groundwater bores within the Mine Site and surrounds.

4.3 MANAGEMENT OF GROUNDWATER INFLOWS TO MINE PIT

Inflow rates to the open cut pits have been estimated by Jacobs Australia Pty Ltd (Jacobs, 2020) using a numerical groundwater model. The predicted average annual groundwater inflows (after allowance for evaporation (20% reduction) from the open cut pit faces) are presented in **Figure 4.1**. For the purposes of the water balance, the average quantity of groundwater to be removed from the main open cut pit would be 1.75 ML/d.

Groundwater accumulating in the open cut pits would be pumped from an in-pit sump to the open cut pit dewatering pond adjacent to the processing plant for reuse.

Figure 4.1 Groundwater Inflow Rate to Open Cut Pit (after Evaporative Losses)



4.4 WASTE ROCK RUNOFF AND SEEPAGE MANAGEMENT

4.4.1 Geochemical Characteristics of Waste Rock and Tailings

The physical and chemical properties of the waste rock and tailings to be generated for the Project have been established by Graeme Campbell and Associates (GCA, 2020) based on static and kinetic geochemical testing of material extracted from exploration drilling core samples. Kinetic testing was carried out to examine the weathering behaviour of a range of waste rock and ore samples representing the expected range of lithological units to be encountered. The results of laboratory testing of leachate samples were compiled by R.W. Corkery & Co. Pty. Ltd. The following sections outline R.W. Corkery & Co. Pty. Ltd.'s conclusions regarding the waste rock as it relates to surface water runoff and seepage.

4.4.1.1 PAF Waste Rock

Approximately 57% of waste rock is expected to be potentially acid forming (PAF) due largely to the presence of iron sulphide minerals (FeS_2) such as pyrite and marcasite leading to sulphide concentrations greater than 0.3% (as S). This material would be extracted from both the weathered zone (i.e. top 20 m to 30 m below ground level) of the ore body and known as "WZ2" and the primary (unweathered) zone of the ore body which is known as "PZ3" (GCA, 2020).

The tailings that would be generated in the processing plant have been identified as PAF, due to the occurrence of traces of pyrite with traces of rhodochrosite ($MnCO_3$) and an absence of reactive carbonate minerals (e.g. calcite).

4.4.1.2 NAF Waste Rock

The remaining 43% of waste rock is expected to be non-acid forming (NAF) in that it contains either no sulphides (i.e. material from the weathered zone, known as “WZ1”) or contain low concentrations of sulphides and ankerite, a carbonate mineral that provides for circum-neutral buffering during weathering (i.e. material known as either “PZ1” [Total-S ≤0.1%] or ”PZ2” [Total 0.1% < S <0.3%]).

The principal NAF waste rock that would be used for construction activities during the site establishment and construction stage (e.g. the initial TSF embankment, WRE and leachate management dam) would be “WZ1”. WZ1 waste rock has been characterised as “benign” (GCA, 2020), and this material would also be utilised as much as practicable during the 2nd and 3rd raises of the TSF embankment. However, it is possible that runoff from NAF waste rock from the primary zone (i.e. PZ1 and PZ2), that would be stockpiled in the southern barrier for use in closure and rehabilitation activities may contain elevated concentrations of some dissolved metals. In particular, the geochemical testing indicates that manganese enrichment is a characteristic feature of mineralisation within the Mine Site, so that soluble forms of manganese may accompany weathering reactions.

The results of laboratory testing of leachate from kinetic and static testing of NAF waste rock samples are summarised in **Table 4.1** (after GCA, 2020) which shows a sample of average analyte concentrations measured in the various forms of NAF identified within the Mine Site.

Table 4.1
Average Dissolved Metal Concentrations in Leachate from Kinetic Testing of NAF Waste Rock Samples Compared to Background Water Quality and Guideline Levels (µg/L)

Analyte	Average Leachate Concentration		ANZG Default Guideline Value	80th Percentile from Background Water Quality Monitoring Data							
				Lawsons Creek				Hawkins Creek			
	WZ1	PZ1/PZ2		BSW28	BSW22	BSW21	BSW20	BSW7	BSW11	BSW12	BSW13
Al	<0.01	<0.02	55	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mn	390	1 606	1 900	136.2	164.6	453.2	512.8	449.8	419.0	286.0	838.2
Zn	35	66	8	14.2	8.8	12.4	16.0	22.2	28.2	23.8	16.6
Cd	0.17	0.32	0.2	0.1	0.1	1.0	0.1	0.2	0.2	0.2	Below LOR
Pb	<0.5	1.0	3.4	2.0	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR
Co	6.6	12.5	N/A	2.0	1.0	1.0	2.0	2.0	3.0	2.0	4.8
As	21.4	2.2	13	3.0	2.0	2.0	4.0	1.4	2.0	1.4	2.8
Cu	<10	<10	1.4	2.0	2.0	2.0	3.0	4.0	5.0	2.0	3.6
Ni	<20	27	11	2.0	2.4	2.0	3.0	2.0	5.0	2.0	6.4
LOR – limit of reporting											

The table shows that the average leachate concentrations from WZ1, the principal construction material, are below the ANZG default guideline value (where available) (with the exception of zinc, arsenic, nickel (and possibly copper)). However, dissolved concentrations of all metals in the table (except potentially copper and lead) exceed the 80th percentile of background water quality data at some locations.

The table also shows that with the exception of zinc, cadmium and nickel (and possibly copper), leachate from the NAF waste rock from the primary zone is below ANZG default guideline values (where available). However, dissolved concentrations of all metals in the table (except potentially copper) exceed the 80th percentile of background water quality data at all locations.

Metal concentrations measured in laboratory-generated column leachates can overestimate concentrations in runoff because column testing tends to lead to the near-complete elution of solutes from the samples. In practice, this would be unlikely in real-world waste rock emplacements.

R.W. Corkery & Co. Pty. Ltd reviewed the analysis of leachate derived from stream sediment samples collected in the vicinity of the surface water monitoring locations, and concluded that the current concentration of readily mobilised metals in sediment in downstream watercourses are of similar quality to the leachate derived from NAF waste rock (as would be anticipated given the host geology in the contributing catchments). This indicates that the impact of releases of sediment dam water is likely to be small. However, as the average concentrations of zinc, arsenic, cadmium and nickel in the above table exceeded the default guideline values, the potential exists for elevated concentrations in runoff collected in sediment dams. As the metal concentrations above have been established over a comparatively short period of kinetic testing, there would be benefit in further testing to understand the likely longer term dissolved metal concentrations in the NAF waste rock runoff.

4.4.2 Management of Tailings and Waste Rock

4.4.2.1 Tailings Storage Facility

Tailings generated as part of processing activities would be pumped as a slurry and deposited within a down valley deposition tailings storage facility (TSF).

Based on the geochemical assessment (GCA, 2020), the tailings water and decant in the TSF is expected to be neutral-to-alkaline and of low salinity with soluble manganese concentrations in the low tens-of-mg/L range.

The TSF would be designed, constructed and operated in accordance with the Australian National Council on Large Dams (ANCOLD) 2012 Guidelines on Tailings Dams under the supervision of NSW Dam Safety Committee (DSC) (refer: ATCW, 2020).

The water management of the TSF would include as a minimum the following aspects.

- Construction of an appropriate liner and seepage collection system to minimise water losses through seepage.
- Minimising the stored water volume on the TSF by maximising the recovery of water and decant which would be subsequently returned to the processing plant for reuse.
- Designing the embankment crest level on the basis of a Consequence Category of High C to contain the expected pond levels obtained from the water balance together with wave run-up and additional contingency freeboard.

- Allowing for storm storage, plus allowances for wave run-up and additional freeboard based on the ANCOLD guidelines on top of the expected maximum operating pond (with 50% probability of non-exceedance).
- Construction of an emergency spillway as part of the initial TSF embankment and both subsequent raises to facilitate discharge of rainfall runoff during extreme rainfall events to prevent overtopping of the embankment.
- Following the completion of tailings deposition at the end of the Project life, the TSF would be rehabilitated and material placed to establish a vegetated store-and-release cover that has been designed to minimise rainfall runoff infiltrating into the deposited tailings profile. Minimising infiltration reduces the risk of mobilising potential contaminants and their potential transport in seepage from the TSF.
- After decommissioning, the store-and-release capping layers and various seepage management measures would manage seepage from the TSF post mining operations (refer: ATCW, 2020, and Advisian, 2020b).

Relevant aspects of the current TSF design as they relate to the site water balance have been summarised in detail in Section 4.7.9.

4.4.2.2 PAF Waste Rock

PAF waste rock would be compacted and encapsulated in the WRE, a landform designed (Advisian, 2020a) for the long-term storage and containment of this material and any leachate generated within it.

The WRE would form an integrated landform between the ridge immediately east of the main open cut pit and west of Price Creek, and would comprise store-and-release capping layers that would be installed on each completed WRE cell as part of progressive rehabilitation and to reduce the volumes of leachate generated. These layers would prevent rainfall and surface water from ponding and subsequently infiltrating into the encapsulated PAF waste rock. Leachate collected from the WRE would report to the leachate management dam which would then be pumped to the process water circuit for processing operations. The management of runoff and leachate from the WRE cells during the development of the WRE is described in detail in Section .

4.4.2.3 NAF Waste Rock

NAF waste rock would be used as a construction material, particularly in the site establishment and construction stage and for rehabilitation of the final landform, in particular at the:

- **WRE**: construction of the upper and lower embankments and the haul road which would include the flood bund and noise barrier as well as the progressive rehabilitation to create the final landform at the end of the Project life;
- **TSF**: staged construction of the embankment and the retained landform at the end of the Project life;

- **Southern Barrier**: staged construction and landform removed at the end of the Project life comprising two staged components;
  - **Initial Barrier**: Comprising the initial Stage 1 development of the Southern Barrier, constructed by end of Year 5 and retained until the end of Project life when material would be removed and utilised for rehabilitation;
  - **Extended Barrier**: progressively developed in stages over the Project life (beyond Year 5) and utilised for the stockpiling of construction material for the staged development of the TSF embankment raises or the closure and capping of the WRE and TSF. The southern face of this temporary landform would be progressively rehabilitated and retained over the Project life.

Rainfall runoff from the external slopes of the placed NAF waste rock would be collected by drainage infrastructure and directed to a sediment dam to prevent discharge of sediment-laden water. It is anticipated that water stored in this sediment dam would be utilised for dust suppression on the Mine Site or (if necessary, flocculated) and released from site.

4.4.2.4 Capping of TSF and WRE

Prior to mine-closure, the TSF and WRE would be covered and vegetated to protect the downstream environment. The proposed cover (Advisian, 2020b) has been designed to reduce seepage by limiting the percolation of water into encapsulated PAF waste rock in the WRE and tailings deposited in the TSF. It would also provide a suitable revegetation media, while limiting the ingress of oxygen into the underlying waste materials and the upward movement of water in the tailings profile.

The proposed cover design is a combination of the following approaches:

- 'store-and-release' – moisture storage in the near-surface soil cover is maximised, so that it can be removed by evapotranspiration; and
- 'water shedding' – percolation of rainfall into the encapsulated PAF waste rock in the WRE or tailings deposited in the TSF is minimised through the use of a low permeability layer.

The proposed cover system includes the following layers:

- Topsoil, 0.3 m minimum; underlain by
- Subsoil, 0.3 m minimum; underlain by
- NAF waste rock (0.5-30 cm diameter), 0.4 m minimum; underlain by
- NAF waste rock (30-40 cm diameter), 0.4 m to 1.6 m; underlain by
- compacted subsoil, 0.4 m minimum; underlain by
- a geosynthetic clay liner (a thin bentonite layer sandwiched between geotextiles).

4.5 SITE WATER TYPES

Based on the above geochemical characterisation, land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream waters.

For the purpose of site water management, site water has been classified into the types shown in **Table 4.2**, on the basis of the likely water quality characteristics.

Table 4.2
Site Water Types

Water Type	Definition
Mine-affected water	Mine-affected water means the following types of water: 1. groundwater and surface water accumulating in the open cut pits; 2. water from advanced mine dewatering activities; 3. TSF decant water; 4. processing plant water; 5. WRE leachate and runoff from uncapped PAF waste rock. Mine-affected water would be captured within the Mine Site, contained and re-used within the processing plant, eliminating the need for release to the receiving environment.
Sediment-laden water	Surface water runoff from areas that are disturbed by mining operations (including out-of-pit NAF waste rock emplacement). Sediment-laden water excludes water that has come into contact with PAF or other reactive material. It may contain high sediment loads but not contain elevated levels of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals that may be deleterious to receiving waters. This runoff would be managed to ensure adequate sediment removal prior to release to receiving waters. Given the potential for manganese concentrations to be elevated in sediment -laden water (GCA, 2020), monitoring would be required to ensure that sediment-laden water would only be released if manganese or other metalloid concentrations are within limits to be specified in the EPL. If water quality is unsuitable for release, it would either be treated prior to release, or recycled in Mine Site applications.
Clean catchment water	Surface runoff from those areas unaffected by mining operations. Clean catchment water includes runoff from undisturbed areas and fully rehabilitated areas.
Raw water	Water sourced externally via the water supply pipeline.
Potable water	Treated water suitable for human consumption.

4.6 WATER MANAGEMENT SYSTEM ZONES

The proposed strategy for the management of surface water within the Mine Site is based on the separation of water from different sources based on anticipated water quality.

On the basis of the predicted runoff and groundwater inflow quality, the site water management system (WMS) comprises three distinct water management zones, the containment zone, erosion and sediment control (ESC) zone and clean water zone, as defined in the following sections.

4.6.1 Containment Zone

Groundwater seepage and surface runoff from the open cut pit areas, the TSF, processing plant area, oxide ore stockpile and WRE are likely to have elevated dissolved metals levels. This (mine affected) water would be managed within a closed water management system.

PAF waste rock would be deposited within the active WRE cell, which, once complete in each cell, would be overlain by NAF waste rock and a cover and capping layer would be installed as part of progressive rehabilitation activities. Runoff from exposed rock within the WRE, as well as leachate would be conveyed to a dedicated leachate management dam via a buried pipeline.

To minimise water accumulating within the leachate management dam, TSF and open cut pits, water captured within the containment zone system would be the first priority water source for recycling in the processing plant.

4.6.2 Erosion and Sediment Control (ESC) Zone

Runoff (sediment-laden water) from disturbed areas within the Mine Site but outside of the containment zone, including the southern barrier, would be directed to sediment dams. This would include surface runoff from out-of-pit areas upslope of the southern barrier, which would be directed beneath the barrier itself via pipes or box-culverts.

Bowdens Silver's long-term objective is to discharge as much water collected within the sediment dams to the downstream environment to assist in maintaining environmental flows.

All disturbed areas would be rehabilitated and revegetated as soon as practicable to reduce the potential for sediment-laden runoff generation. It is therefore anticipated that after the settlement of suspended sediment in these dams, the water would be suitable for release in accordance with the discharge conditions of the environment protection license (EPL) for the Project which would be issued by the NSW Environment Protection Authority (EPA). However, a program of water quality monitoring would be undertaken characterise runoff from the NAF Waste Rock in the field. Discharges would not occur until it was confirmed that runoff water derived from the placed/stockpiled NAF waste rock is suitable for release, i.e. in accordance with the Project's EPL.

If necessary, Bowdens Silver would use an environmentally inert flocculant to remove suspended sediment and enable the water to be released within 5 days. Details of the flocculant and its management would be included in the Project's Water Management Plan.

As a minimum, the sediment dams would be sized and operated in accordance with "the Blue Book" (DECC, 2008) requirements for Type F sediment basins. However, if the ongoing program of geochemical testing and characterisation of runoff determines that runoff must be contained on site to ensure the water source is not contaminated, sufficient storage capacity would be provided to minimise the likelihood of discharge by returning captured runoff to the Containment Zone. The proposed design storage capacity would be sufficient to contain runoff resulting from the 1 in 20 AEP 72 hour design storm (with a design volumetric runoff coefficient of 0.75) (equivalent to 1.2 ML/ha). In addition, sediment storage equivalent to 50% of the water storage capacity would be provided with each dam. Pumping infrastructure would be provided to enable the water to be transferred into the containment system within 5 days.

The key sediment dams within the Mine Site (and their approximate capacities) would be located:

- downstream from the TSF embankment:
  - north (4.5 ML (13 ML for containment));
  - south (4.5 ML (13 ML for containment));
- adjacent to the TSF NAF waste rock stockpile area (6.5 ML (19 ML for containment));
- downslope from the southern barrier (two dams):
  - east (13.5 ML (40 ML for containment));
  - west (8.5 ML (25 ML for containment));
- downslope from the oxide ore stockpile (4.5 ML (13 ML for containment));
- within the footprint of the WRE at variable locations (varies – typically 5 ML (15 ML for containment)); and
- adjacent to the lower embankment haul road around the perimeter of the WRE (temporary) (4 ML (12 ML for containment)).

The outlets from the sediment dams would be rock-protected, and designed to promote the spread of flow, such that velocities are non-erosive downstream.

4.6.3 Clean Water Zone

The clean water zone water would ensure the volume of water potentially impacted by the Project is minimised by diverting (clean water) runoff from undisturbed areas away from disturbed areas.

During operations, a clean water diversion channel would divert the upper catchment of Blackmans Gully that would be unaffected by Project-related activities into Price Creek. The channel would largely follow the natural contours of the hill slopes and have a gentle gradient. This channel would results in the average annual diversion of approximately 10 ML/a of water from Blackmans Gully to Price Creek during operations.

Clean water diversion channels are also proposed to divert Blackmans Gully and its associated tributary catchments away from the main open cut pit both during operations and after mine closure.

4.7 WATER MANAGEMENT SYSTEM COMPONENTS AND LAYOUT

4.7.1 Water Storages

Table 4.3 lists the water storage structures that form part of the proposed Bowdens Silver water management system. The table includes capacity information (where available) as well as commentary regarding how these structures are represented within the site water balance model.

Table 4.3
Summary of Water Storages within Water Management System

Location	Name	Nominal Capacity	Comments
Processing plant area*	Raw Water Dam	8 ML	The capacities would be reviewed during the detailed design of the processing plant area. Modelling assumes that satellite open cut pits would not store water, and would pump excess to main open cut pit as required.
	Open Cut Pit Dewatering Pond	1 ML	
	Runoff collection dams	100 ML	
	Turkey Nest Dam	65 ML	
WRE	Leachate Management Dam	80 ML	Storage characteristics for leachate management dam based on design by Advisian (2020a).
	WRE Sediment Dam(s)	Varies	Sediment dams would be constructed/relocated as part of each WRE stage, and (unless on the basis of further ongoing geochemical studies, a higher containment standard is required) sized in accordance with Blue Book requirements to accommodate the maximum contributing area of upstream capped (unvegetated) catchment area. (unless on the basis of further ongoing geochemical studies, a higher containment standard is required) (refer 4.6.2).
TSF	Decant pond	Varies	Varies over the life of the TSF depending on the current embankment height, and elevation of tailings against the embankment. Based on details provided by ATC Williams (2020). Decant water would be returned to the processing plant via a pontoon-mounted pump system, leaving a depth of approximately 2 m inaccessible for reuse.
Other	Oxide ore stockpile dam	4.5 ML (12 ML for containment)	Sized in accordance with Blue Book requirements (unless on the basis of further ongoing geochemical studies, a higher containment standard is required) (refer 4.6.2).
Sediment dams	TSF embankment sediment dams	2 dams @ 4.5 ML (2 dams @ 12 ML for containment)	Sized in accordance with Blue Book requirements (unless on the basis of further ongoing geochemical studies, a higher containment standard is required) (refer 4.6.2).
	Southern barrier external embankment sediment dams	13.5 ML, 8.5 ML (40 ML, 25 ML for containment)	
	Haul road sediment dam	4.0 ML (12 ML for containment)	
TBC = To be confirmed			

Catchment runoff from NAF waste rock would be captured in sediment dams, as described in Section 4.6.2. Several catchments have been identified on the periphery of the disturbance area where runoff would be routed to a sediment dam. These catchments, which are indicated in the stage plans in **Figure 4.4** to **Figure 4.7**, include:

- the outer embankment of the TSF;
- the outer catchment of the southern barrier;
- the haul road that bounds the southern and eastern extent of the WRE.

4.7.2 System Configuration

A schematic diagram of the integrated Project water management system configuration is shown in **Figure 4.2**. A summary of the proposed storages within the integrated WMS and their operating strategies are summarised in the following sections.

4.7.3 Development of Key System Components

Figure 4.3 summarises the development sequence for the various mine infrastructure elements throughout the course of the mine life. Four development snapshots presented in **Figure 4.4** to **Figure 4.7** are indicative catchment and land use plans for four discrete points in time. These figures generally correspond to operational years, namely year 0 (site establishment and construction stage), year 3, year 8 and year 10 respectively. The Project year corresponding to each of these snapshots has been highlighted in **Figure 4.3**.

Table 4.4 lists the catchment areas reporting to various water storages, sediment dams and other reference points (clean catchment release points etc) over the mine life.

Further details of key components (open cut pit, southern barrier, WRE, low grade ore stockpile, processing plant area, TSF) of the water management system are described in the following sections.

4.7.4 Processing Plant Area

The processing plant area includes the processing plant, mining facility, ROM ore stockpiles, primary jaw crusher, crushed ROM stockpile and administration area. These elements would be constructed on a series of terraced pads, which are situated on the eastern side of Blackmans Gully – the mine's central drainage feature (upstream of the southern barrier – see **Figure 3.6** and **Figure 4.4**).

Prior to construction of the processing plant and mining facility pad, the upstream undisturbed catchment of Blackmans Gully would be diverted east to Price Creek.

The alignment and specifications of the various drains/bunds/pipelines required to manage processing plant area runoff would be confirmed as part of mine detailed design. Runoff would generally be drained to dams located to the west of the processing plant area. Dam overflows resulting from very large runoff events would be directed to the main open cut pit. However, all dams would be sized to minimise the possibility of overflows, with water collecting in these dams recycled and re-used in the processing circuit.

Figure 4.2 Proposed Integrated Water Management System Schematic

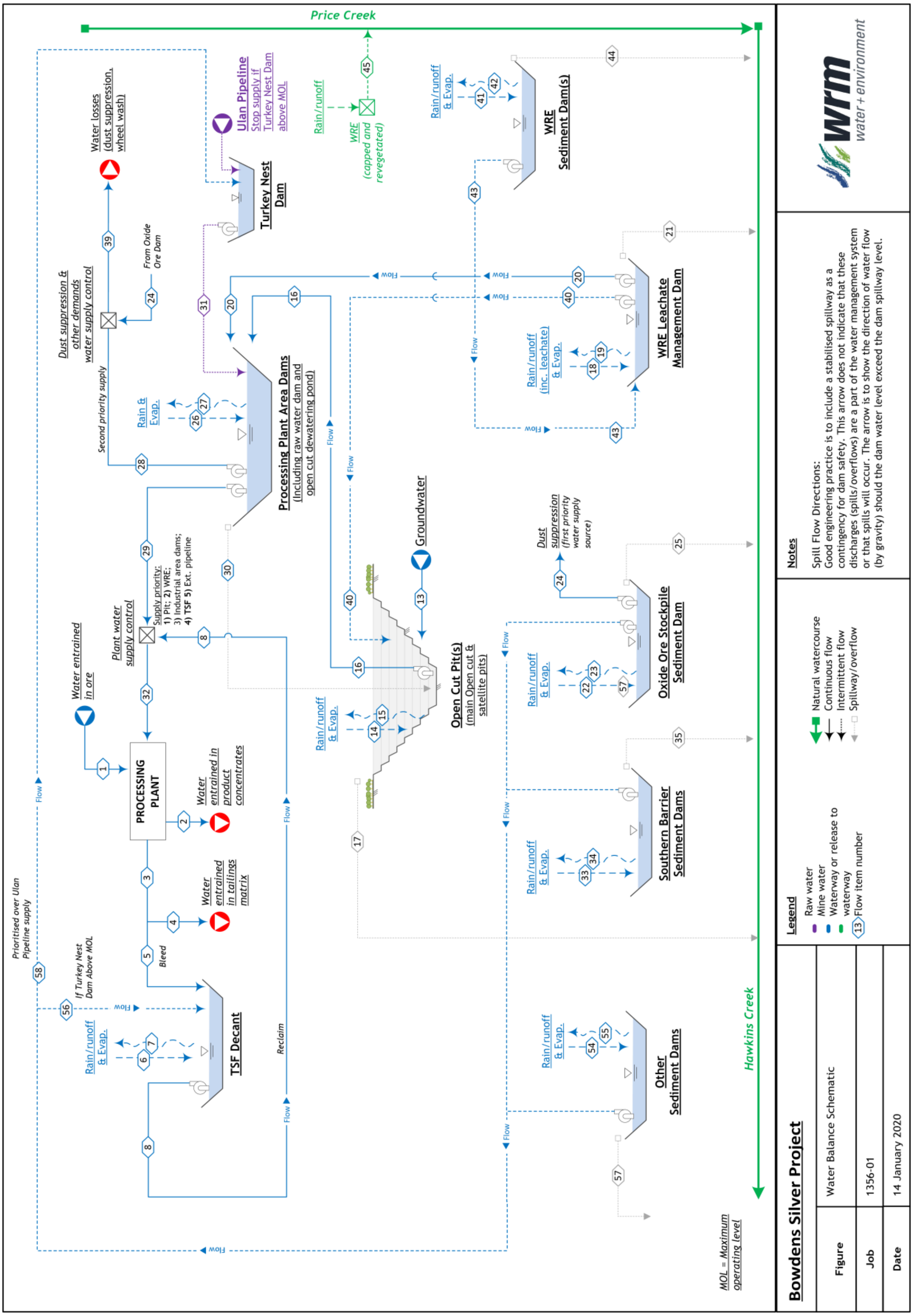


Figure 4.3 Summary of Project Timing

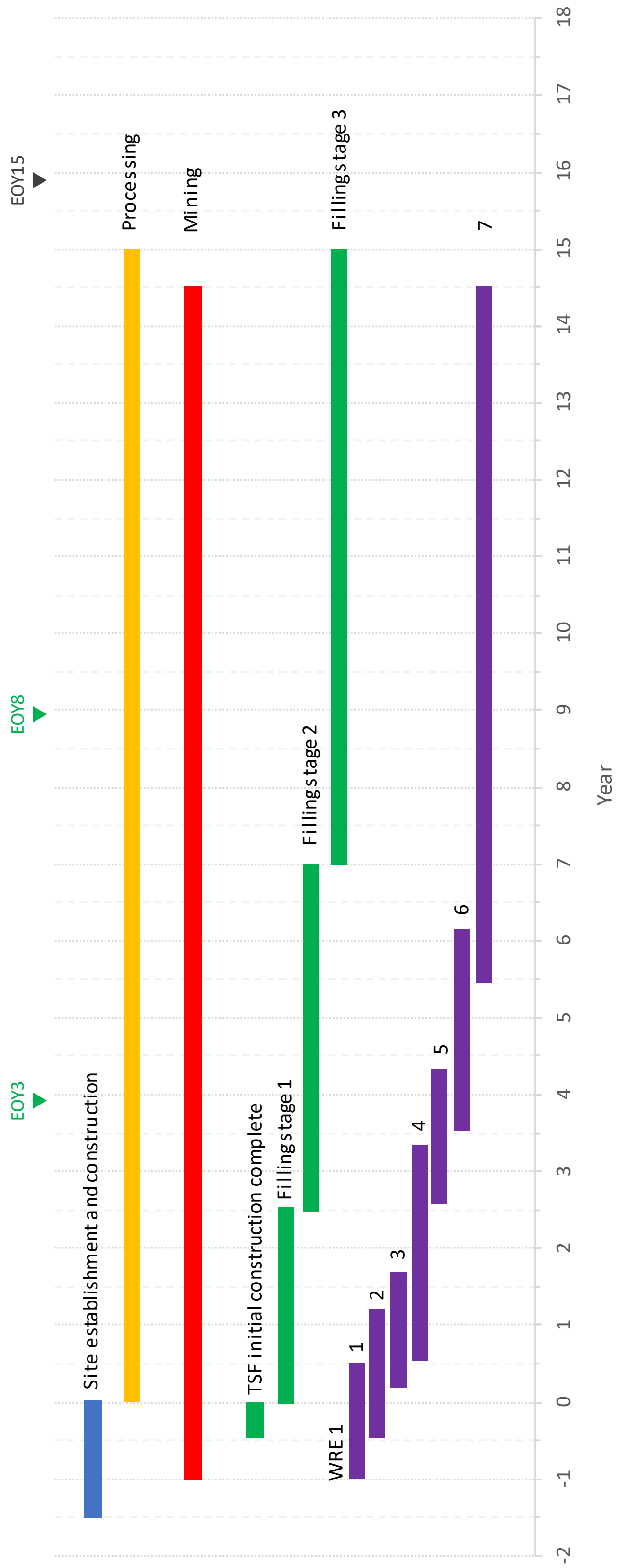


Figure 4.4 Catchment and Land Use Plan – Year 0 (site establishment and construction stage)

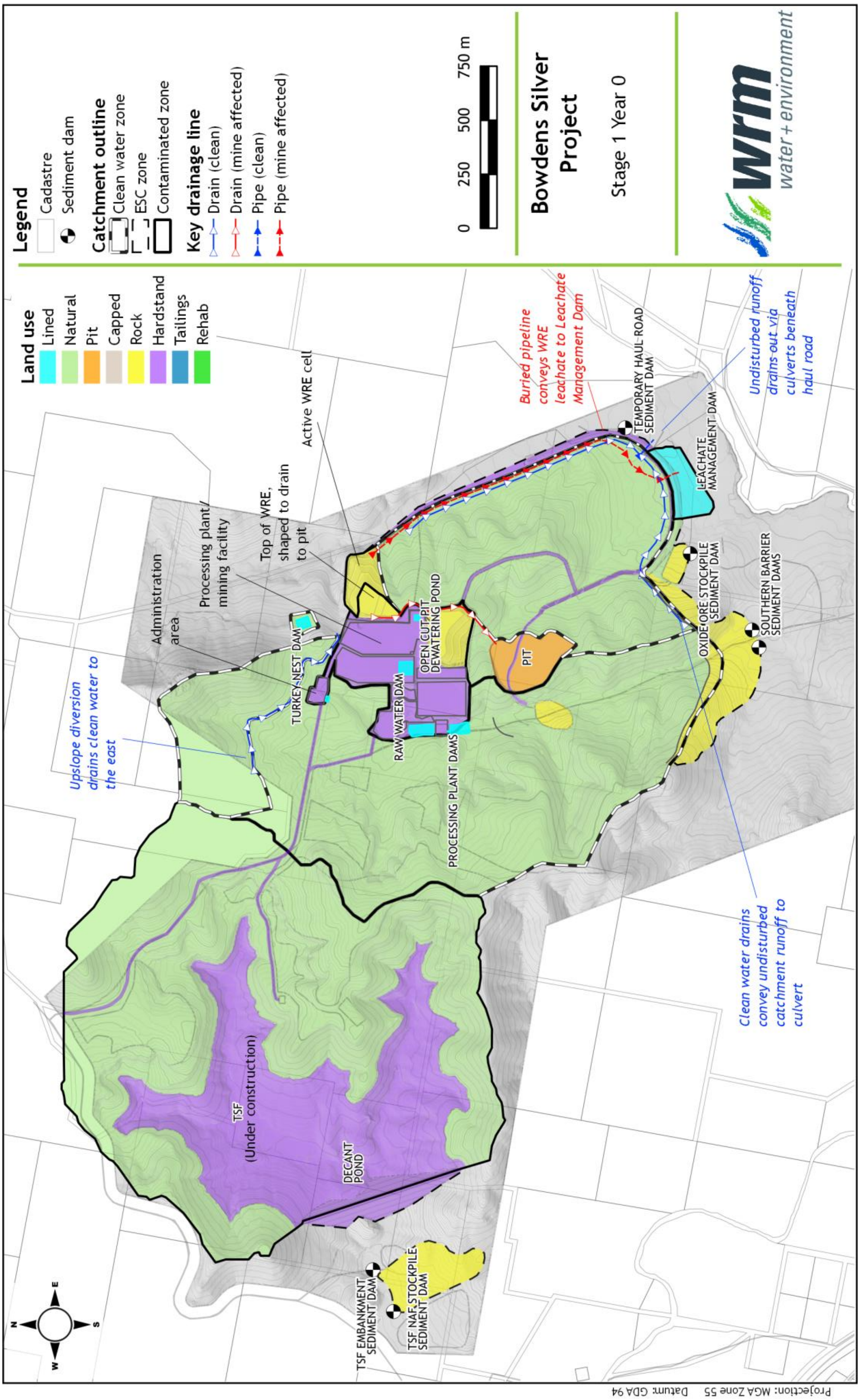


Figure 4.5 Catchment and Land Use Plan – Year 3

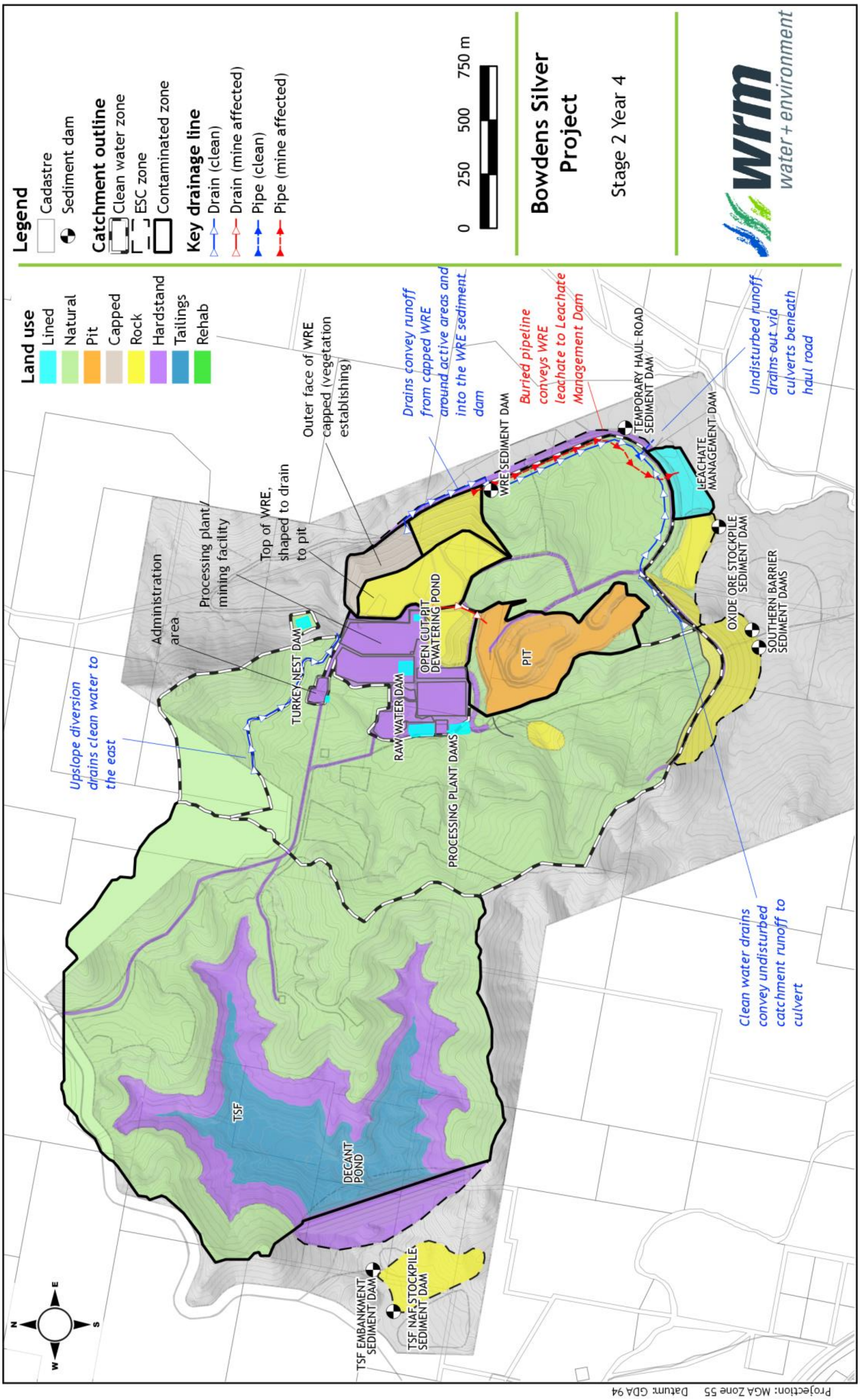


Figure 4.6 Catchment and Land Use Plan – Year 8

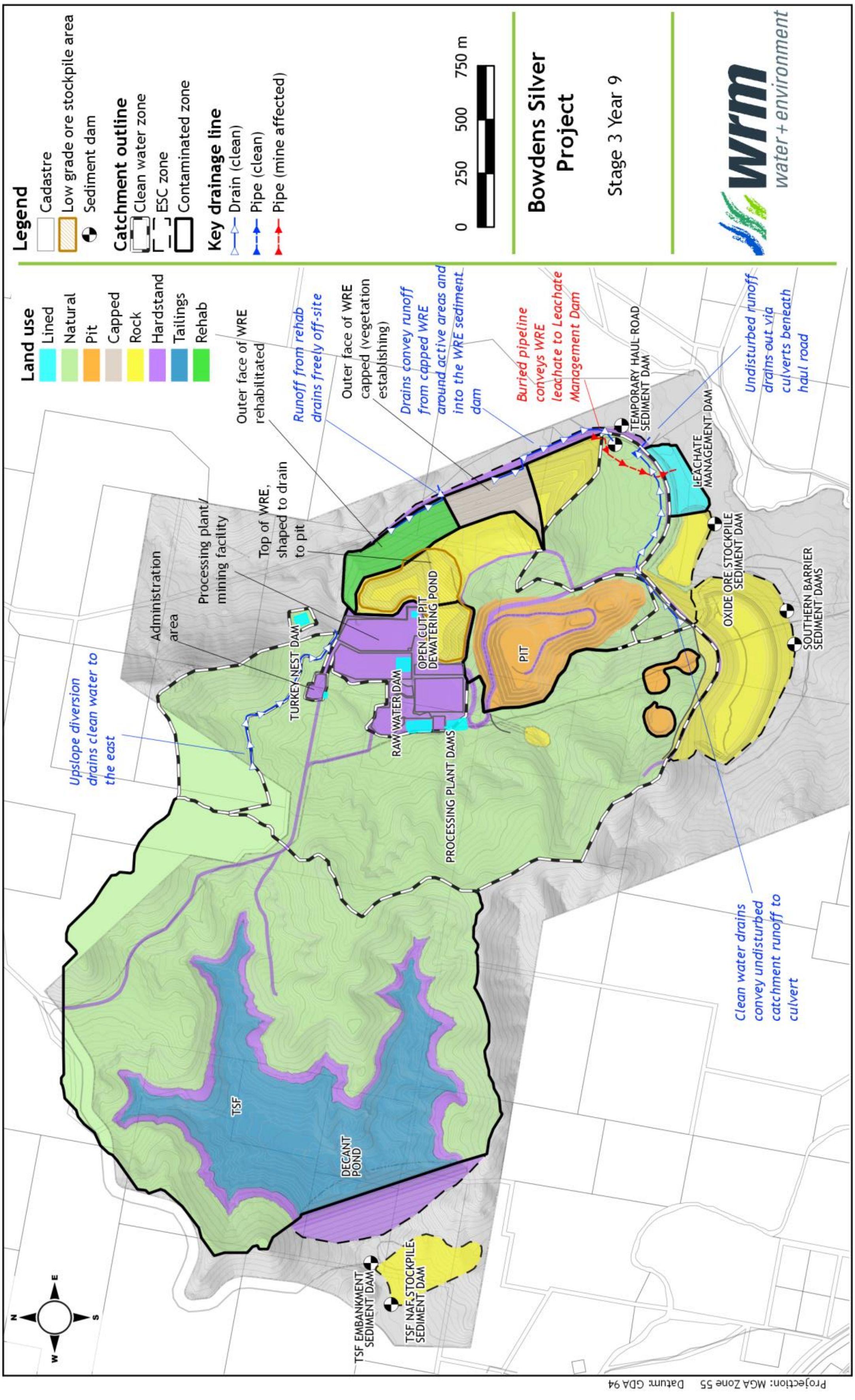


Figure 4.7 Catchment and Land Use Plan – Year 10

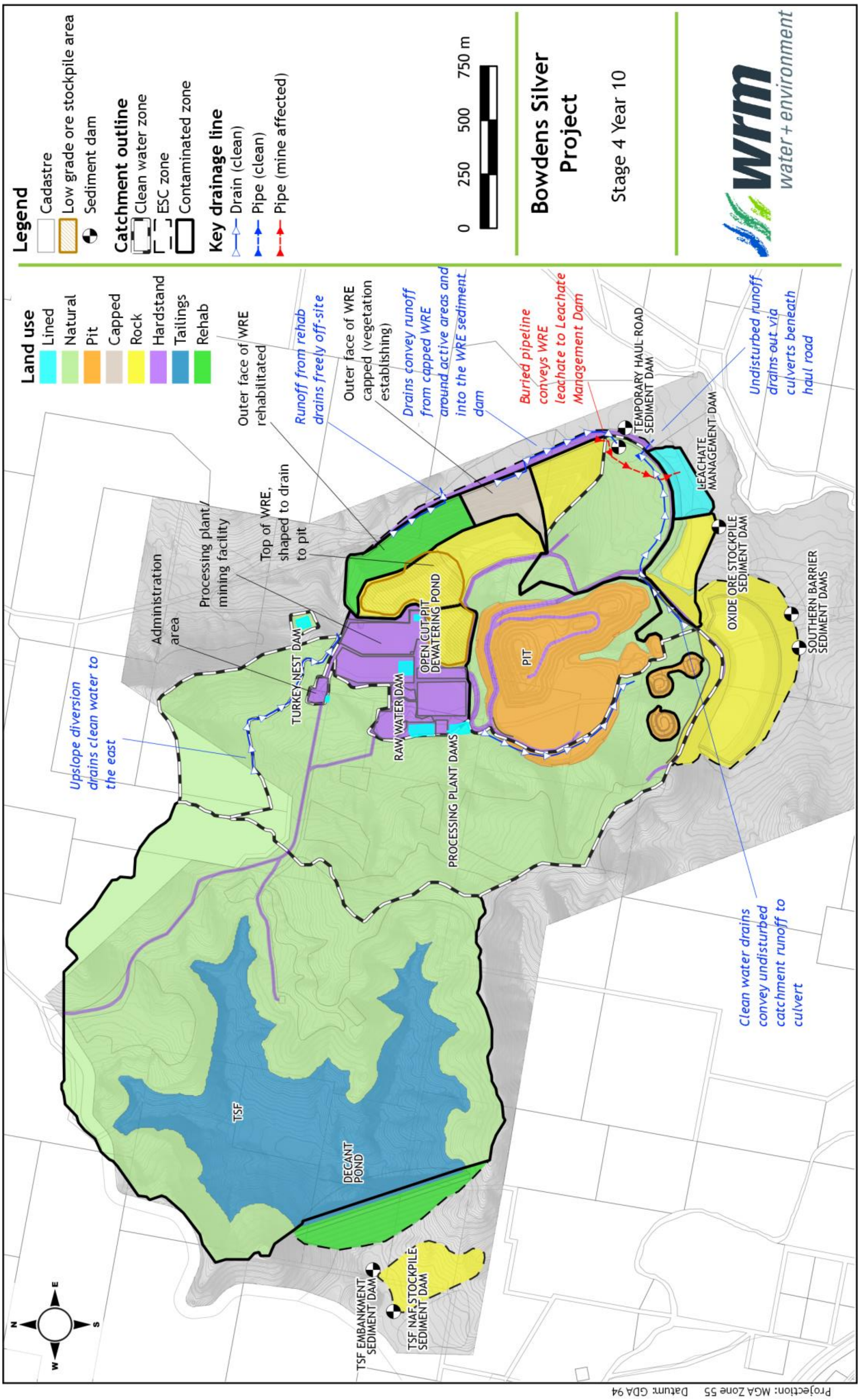


Table 4.4
Catchment Area Breakdown by Year of Mine Development (units: hectares)

	Mine Water Management System						Clean Catchment Release			Sediment Dams			
Operational Year	**Processing Plant Area**	**Main Open Cut**	**Satellite Pit(s)**	**TSF**	**WRE Leachate Management Dam**	**Oxide Ore Dam**	**WRE Rehab**	**Southern Barrier Valley**	**LHR(C7)* Outlet**	**TSF Outer Embankment**	**Southern Barrier Outer Embankment**	**WRE Sediment Dam**	**Haul Road**
-1	30	12.5	-	301.2	10.5	5.3	-	164.1	92.6	-	11.4	1.4	4.3
0	30	14.5	-	301.2	19.5	9.1	-	164.1	77.2	5.2	11.4	5.7	4.3
1	30	22.5	-	301.2	7.7	9.1	-	164.1	77.2	5.2	11.4	9.8	4.3
2	30	22.5	-	301.2	15.4	9.1	-	164.1	68.0	5.2	11.4	11.2	4.3
3	30	26.5	-	301.2	15.3	9.1	-	164.1	60.1	13.4	11.4	14.8	4.3
4	30	62.8	-	301.2	7.5	9.1	0.7	159.4	32.1	13.4	11.4	18.3	4.3
5	30	62.8	3.4	301.2	30.7	9.1	4.4	156.3	6.7	13.4	31.6	17.1	4.3
6	30	62.8	3.4	301.2	26.6	9.1	9.0	156.3	6.7	13.4	31.6	16.0	4.3
7	30	62.8	3.4	301.2	24.5	9.1	10.6	156.3	6.7	13.4	31.6	16.5	4.3
8	30	83.8	-	301.2	22.4	9.1	13.7	132.9	6.4	13.4	31.6	15.5	4.3
9	30	83.8	-	301.2	20.2	9.1	18.4	132.9	6.4	13.4	31.6	12.9	4.3
10	30	83.8	-	301.2	18.1	9.1	20.8	132.9	6.4	13.4	31.6	12.7	4.3
11	30	83.8	-	301.2	16.0	9.1	24.5	132.9	6.4	13.4	31.6	11.1	4.3
12	30	83.8	-	301.2	13.9	9.1	26.6	132.9	6.4	13.4	31.6	11.1	4.3
13	30	83.8	-	301.2	11.8	9.1	28.7	132.9	6.4	13.4	31.6	11.1	4.3
14	30	83.8	-	301.2	9.7	9.1	30.8	132.9	6.4	13.4	31.6	11.1	4.3

Note: * LHR(C7) denotes the lower haul road (future WRE cell 7 area) – this is the basin immediately north of the proposed Leachate Management Dam

4.7.5 Southern Barrier

NAF waste rock would be placed across the southern invert of Blackmans Gully, to form an embankment. A low level pipe or box culvert would allow water to drain from Blackmans Gully beneath the barrier.

The southern barrier would then be developed as a NAF construction material stockpile for NAF waste rock that is surplus to the construction requirements of the Project over the course of the operational Project life (i.e. TSF embankment, raises and progressive rehabilitation of completed WRE cells). The full height of the southern barrier would be achieved as part of the initial stage (by the end of Year 5). The subsequent stage would entail placing additional waste rock against the outer face of the southern barrier, increasing its thickness and overall footprint but not its height.

Based on the installation of a low level pipe or culvert outlet at the invert of Blackmans Gully, water would not pond for long periods upstream of the southern barrier. Bowdens Silver proposes to selectively place waste rock with low metals leachate potential at the base of the embankment such that any seepage through this material does not leach metals exceeding background concentrations.

4.7.6 Open Cut Pit Development

Development of the open cut pits can be described as follows.

- The first 6 years entail widening and deepening of the eastern section of the main open cut pit, located to the south of the processing plant area.
- The next two years entail opening two satellite pits to the south-west of the main open cut pit, in the area immediately north of the southern barrier.
- The remaining years entail additional excavation within the western section of the main open cut pit.

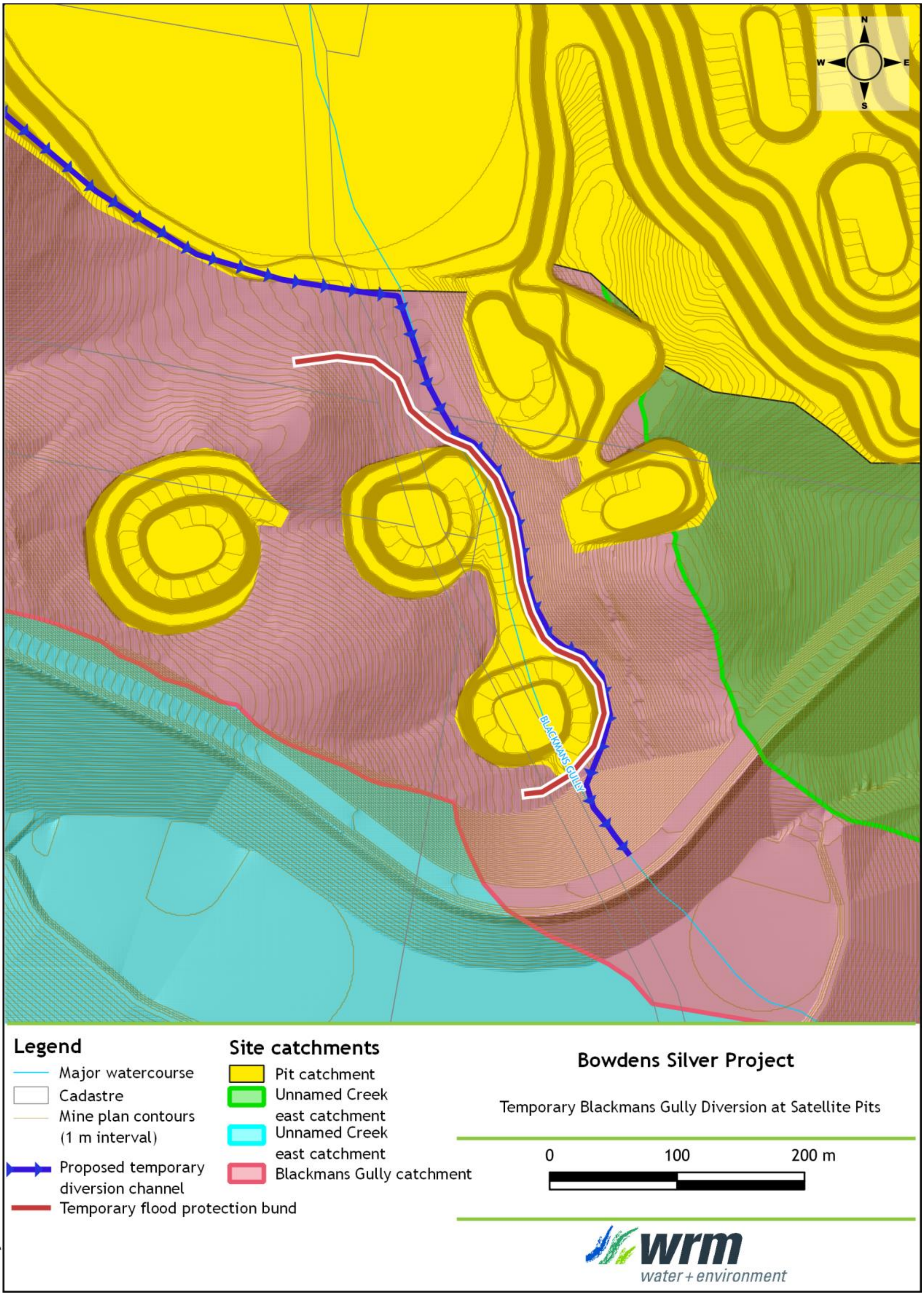
The main open cut pit is centred on the ridgeline separating the catchments of:

- Blackmans Gully (to the west); and
- an unnamed minor gully (and ultimately the southern portion of the WRE (WRE Cell 7 – (to the east).

The impacts of the open cut pit development on these sub-catchments develop as follows:

- The main open cut pit would expand, with corresponding reductions in the two sub-catchments (noting that parts of the upstream catchment of Blackmans Gully would be diverted east or captured in the processing plant dams).
- Initially, the undisturbed portion of Blackmans Gully to the west and northwest of the open cut pit would drain unimpeded towards (and beneath) the base of the southern barrier.
- The satellite pits would be developed across Blackmans Gully upstream of the southern barrier. Bowdens Silver would construct temporary diversion and levee works to ensure runoff in Blackmans Gully does not enter the satellite pits. These works, which are shown indicatively in **Figure 4.8**, would be detailed fully as part of detailed design.

Figure 4.8 Temporary diversion of Blackmans Gully around Satellite Pits



- The main open cut pit would then expand west through the floor of Blackmans Gully and the satellite open cut satellite pits would be progressively backfilled with NAF waste rock from the main open cut pit. A diversion channel would be constructed to divert runoff around the main open cut pit to the southern barrier. The diversion channel would be retained after mine closure and after the removal of the southern barrier.

Elevated sections of the WRE (and adjacent minor catchments) would drain west to the open pit as the WRE develops, however any runoff from these catchments would also be diverted around the main open cut pit. Refer to Section 4.7.7 for further information regarding these areas.

4.7.7 Waste Rock Emplacement

The WRE covers an area of approximately 77 ha, bounded by the lower perimeter embankment that would include a haul road, flood bund and, (in some sections) a noise barrier. The final WRE landform would be constructed across seven discrete stages/cells. PAF waste rock would be placed within the active WRE cell and, upon completion of the active cell, overlain by the capping and cover system. Runoff from exposed PAF waste rock within the active WRE cell, as well as any water infiltrating through the PAF waste rock (referred to herein as leachate) would be collected at the lowest point in each cell and directed via a buried pipeline to the leachate management dam for temporary storage and subsequent transfer to the processing plant. Sufficient storage would be provided in the leachate management dam to ensure no discharge of leachate to the receiving environment.

Surface runoff from sections of the WRE that have been capped would be routed around the active WRE cell and into a sediment dam that would be constructed in the cell immediately downstream of the active cell. Runoff volumes exceeding the capacity of the sediment dam would overflow to the environment. If water intercepted by the sediment dam was unsuitable for release, it would be pumped to the mine water management system. After vegetation has re-established on the capped sections of the WRE, surface runoff would be routed away from the active WRE cell towards Price Creek.

Any water infiltrating through the cover and capping layer would report to the leachate management dam via the buried pipeline. This would allow for the monitoring of leachate volumes so as to establish the effectiveness of the capping and cover system. The upper sections of the WRE would be flat and shaped to drain back towards the main open cut pit during operations and diverted upon closure, once rehabilitation criteria have been met. As described in Section 4.7.8, low grade ore is also proposed to be stockpiled on the surface of Cells 1 to 3 of the WRE, and as a result, would not be capped immediately. For the purpose of the water balance model, the baseflow component of runoff from the upper (low grade ore) section of the WRE is directed to the leachate management dam, and the surface runoff component is directed to the main open cut pit.

The perimeter embankments (including haul roads), buried leachate pipeline, and leachate management dam would be developed as part of the initial WRE construction. The following points generally describe the development of a typical (intermediate) cell, with respect to drainage and water management.

- An internal embankment would be constructed to bound the footprint of the cell and anchor the high-density polyethylene (HDPE) liner.

- A new sediment dam would be constructed downstream of internal embankment, and drainage would be constructed to connect the new dam with capped sections of the WRE upstream.
- Following the installation of the HDPE liner, an inspection pit(s) would be constructed to allow runoff from within the cell to drain into the buried pipeline that runs to the leachate management dam.
- PAF waste rock would be placed in the cell in accordance with the WRE design specification, nominally in a sequence of raises.
- Following completion of each raise, any sections of waste rock that would eventually form the outer face of the final WRE would be covered with the store-and-release cover and capping layer and then seeded.
- Bunding/drainage would be progressively modified to direct runoff from the capped sections of the WRE into the downstream sediment dam (while vegetation establishes).
- Following completion of the final raise, when the cell reaches its maximum height, the top section of the cell would be reshaped, capped and covered to drain back towards the main open cut pit.

4.7.8 Low-grade Ore Stockpile

Depending on commodity prices, a percentage of the mined ore may not be economic to process. Any such low grade ore would be stockpiled so that it could be processed in future, when commodity prices are more amenable. Current mine planning proposes to stockpile low grade ore in two stages. The first of these stages would be located adjacent to the processing plant area (see **Figure 4.6**), to the south of the open cut pit dewatering pond. The subsequent stage would be constructed on the completed upper surface of Cells 1 to 3 of the WRE that drains back towards the main open cut pit.

4.7.9 Tailings Storage Facility

The TSF embankment would be constructed in a staged approach, with an initial embankment and two subsequent downstream type embankment raises. Deposition of tailings within the valley behind the TSF embankment would occur continuously over the operations stage of the Project life. A decant pond would be situated atop the lower tailings beach, adjacent to the TSF embankment. **Table 4.5** summarises the timing of each stage, and key control levels including the invert level of the spillway constructed in the embankment, and the crest level of the embankment. **Table 4.5** (source: ATCW, 2020) shows how the level of the tailings against the embankment increases as more tailings are added to the TSF.

The depth of water in the decant pond would be managed by pumping excess decant water back to the processing plant to be recycled as part of the ore processing operation.

Decant water would be returned to the processing plant via a pontoon-mounted pump system, leaving a depth of approximately 2 m inaccessible for reuse.

Table 4.5
TSF Key Control Levels by Development Stage

Stage	Implemented	Timing (tailings tonnage)	Spillway level (mAHD)	Crest level (mAHD)
Stage 1	Year 0	0 to 6 Mt	599.50	601.50
Stage 2	Year 3	6 to 16 Mt	609.25	611.00
Stage 3	Year 8	16 to 30 Mt	618.20	620.00

In very wet periods, transfers from the TSF the main open cut pit would be initiated if TSF decant pond water levels rise above the TSF Transfer Level. The TSF Transfer level would be set 0.75 m below the TSF spillway crest level. In the final year of processing, decant pond water levels would be drawn down by:

- Reducing the TSF Transfer level to 2.7 m below the spillway crest level;
- Providing additional decant pump equipment to access decant water below the minimum operating depth of the main proposed pontoon mounted decant system.

Following wet weather, the decant pond may accumulate additional water while the processing plant is being supplied with water from the open cut pit or WRE leachate management dam in lieu of water from the TSF.

Excess water imported from the external water supply pipeline would also be stored in the TSF when the Turkey Nest Dam is full.

The potential water storage capacity of the TSF is at its greatest immediately following construction/raises of the embankment. In contrast, the potential water storage capacity of the TSF is at its lowest immediately prior to an embankment raise (when the distance between the tailings beach and embankment crest is at a minimum).

5. SITE WATER BALANCE

5.1 OVERVIEW

The overall Project water balance has been assessed through detailed site water balance modelling.

The performance of the water management system (WMS) was assessed using the GoldSim water balance model. GoldSim is a computer-based operational simulation model that can be used to assess the dynamics of the water balance under varying rainfall and catchment conditions throughout the development of the Project.

The GoldSim model dynamically simulates the operation of the WMS and keeps complete account of all site water volumes and representative water quality on a daily time step. The model was configured to simulate the operations of all major components of the WMS. The simulated inflows and outflows included in the model are given in **Table 5.1**.

Table 5.1
Simulated Inflows and Outflows to WMS

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	Processing Plant demand
Groundwater inflow to open cut pits	Dust suppression demand
Off-site water supply	Losses to tailings entrainment
Ore moisture	Overflows or discharges from storages

The site water balance covers the Months 7 to 18 of the site establishment, 15 years of processing operations (and tailings deposition) and the initial year of final rehabilitation activities. The model was used to predict the performance of the following aspects of the site water balance:

- Overall water balance - the average inflows and outflows of the WMS for a number of representative realisations.
- Mine water inventory – the accumulation of water in the open cut pits, TSF decant pond and leachate management dam as well as the raw water dam and the pit dewatering pond.
- External water demand – the volumes of imported external water required to supplement on site water demands.
- Uncontrolled releases (spillway discharges) – the risk of uncontrolled releases from the surface water storages to the receiving environment.

Key aspects of the site water balance are described in detail in the following sections.

5.2 SITE WATER DEMAND

5.2.1 Processing Plant and TSF Balance

When operating at its design capacity of 2 Mtpa ore feed, the processing plant is expected to require approximately 4.06 ML/d (1 482 ML/a) of total make up water.

Water would be transferred to the TSF in the tailings slurry at a rate of approximately 4.23 ML/d (1 546 ML/a). Flow streams associated with the processing plant are summarised in **Table 5.2**.

Table 5.2
Processing Plant Flow Balance (at design 2 Mtpa Ore Feed)

Direction	Flow stream	Flow Rate		
		m^3/h	ML/d	ML/a
Outflows	Water entrained in concentrates	0.7	0.02	6
	Tailings slurry water (@ 56% w/w solids)	193.3	4.23	1 546
	Other losses	1.7	0.04	14
Inflows	Water entrained in ROM	10.4	0.23	83
	Process water	185.3	4.06	1 482
Note: annual/daily flow rates calculated based on 8 000 hours per year plant operation				

Approximately 25% of the moisture entrained within the tailings slurry stream would be released soon after the slurry is deposited within the TSF, as the deposited tailings consolidates from a 56% w/w solids slurry to a settled solids content of 62.8% w/w (based on dry density of 1.04 t/m^3 and particle density of 2.7 t/m^3, per ATCW 2020). Approximately 1.05 ML/d would report to the TSF decant as an initial bleed stream, and the remaining 3.18 ML/d would be lost to tailings moisture and evaporation.

Processing plant makeup water demands would be sourced from the following locations, in order of priority:

- WRE leachate management dam;
- Open cut pit;
- TSF decant pond;
- Sediment dams; and
- External water supply pipeline (via the Turkey Nest Dam).

5.2.2 Haul Road Dust Suppression

Water would be applied to haul roads to supress dust generation during construction and operations. Haul road water demands would vary over time due to the changes in the length of haul roads as the Project develops. More water would also be required during dry weather when evaporation is high. It would be drawn from the Oxide Ore Dam as a first priority, and then from the processing plant dams or Turkeys Nest Dam, if required. The estimated haul road demands throughout the Project life are shown in **Table 5.3**.

Table 5.3
Modelled Haul Road Watering Demands

Year	Watered Road Area (ha)	Average Annual Demand (ML/a)
0	16.5	187
1	18.2	206
2	19.7	223
3	20.1	228
4	19.2	217
5	16.1	183
6	15.1	171
7	19.6	222
8	28.1	318
9	19.6	222
10	16.2	183
11	13.5	153
12	14.2	161
13	15.1	171
14	16.3	196
15	18.3	208

5.2.3 Potable Water Demands

Potable water requirements during the site establishment and construction stage would be delivered to the Mine Site by water tanker until such time as the reverse osmosis (RO) plant is installed. The RO plant would be used during operations to treat a combination of groundwater, surface water and mine water to produce potable water. Brine from the RO plant would be returned to the processing plant dams for reuse.

The administration area and amenities would require up to 14 ML/a of potable water, based on 250 L per day per person and a workforce of up to 150 people on-site on any one day.

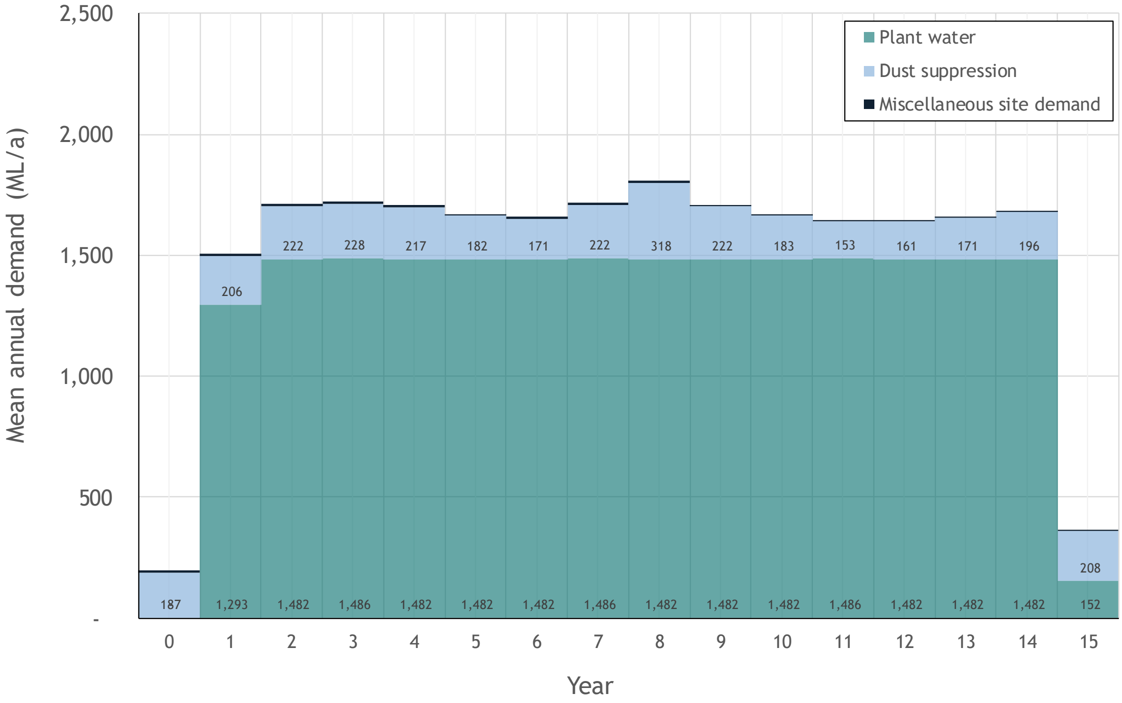
5.2.4 Miscellaneous Water Demands

There would also be minor quantities of water used for miscellaneous purposes around the Mine Site, including for the wheel wash station that would be used for trucks carrying NAF waste rock to the TSF for embankment raises. An allowance has been made for loss rate ranging between 0.2 ML/a and 7.5 ML/a.

5.2.5 Total Water Demand

The makeup of the total site water demand throughout the Project life is illustrated in **Figure 5.1**.

Figure 5.1 Average Annual Project Demands



5.3 MODELLING OF CATCHMENT YIELD

5.3.1 Overview

The Australian Water Balance Model (AWBM) model was used to represent the runoff characteristics of Mine Site catchments. AWBM uses a group of connected conceptual storages (3 surface storages) to represent catchment runoff. Water in the conceptual storages is replenished by rainfall and reduced by evaporation. Simulated surface runoff occurs when any of these storages fill and overflow. The model parameters define the depth and relative area of each of the storages, as well as the rate of water flux from/between storages. The AWBM model adopted for this Project uses the point estimates of Morton's Wet ET from the SILO gridded dataset.

5.3.2 Land Use Types

Runoff characteristics vary by land use. Land use types within each of these catchments are shown in **Figure 4.4** to **Figure 4.7**. The land use mapping discretises the mine catchment into the following land use types:

- Lined (e.g. HDPE liner or equivalent);
- Natural/undisturbed, representing areas in their current state;

- Pit, representing the walls and floor of the open cut pit;
- Hardstand, representing pads, processing plant areas and roads;
- Rock, representing placed NAF/PAF waste rock;
- Capped, representing a soil capping layer installed over PAF waste rock placed in the WRE;
- Rehab, representing fully rehabilitated/revegetated areas; and
- Tailings, representing the tailings beach within the TSF.

For the purposes of GoldSim modelling, the land use types listed above have been consolidated as follows:

- Lined, natural/undisturbed, rehab and tailings remain as they are;
- Pit and hardstand have been consolidated to roads/hardstand/pits; and
- Rock and capped have been consolidated to **spoil**.

The GoldSim model simulates development of the WRE based on the following assumptions, which illustrated in the diagram in **Figure 5.2**:

- The percentage of each cell's footprint covered by rock increases from 0% to 100% over the course of the cell's operational life;
- Redirection of the area at the top of the cell into the pit catchment occurs instantaneously at the completion of the cell (prior to this point, this area reports to the leachate pond);
- The extent of area to be capped within each cell is assumed to be everything except the top surface (i.e. the area that would be shaped to drain to pit) in addition to any area that would be dumped over as part of the next WRE cell (typically the face of the southern embankment). The percentage of this area to be capped increases from 0% to 100% over the course of the cell's life, however a three-month delay has been applied; and
- Capped areas are assumed to be fully revegetated and suitable for release off-site after a five-year delay.

5.3.3 AWBM Model Parameters

Runoff from undisturbed site catchments have been modelled using the approach described in Section 3.5.3.The adopted parameters are summarised in **Table 5.4**.

In the absence of site-specific data, AWBM parameters for disturbed areas have been adopted based on experience with catchment modelling at upper Hunter Valley mine sites.

Note that runoff from the wet component of the tailings beach is calculated assuming zero losses. Any rainfall falling on the wet beach (estimated as 35% of the total beach area) is assumed to be wholly converted to runoff.

Figure 5.2 Land use types – WRE

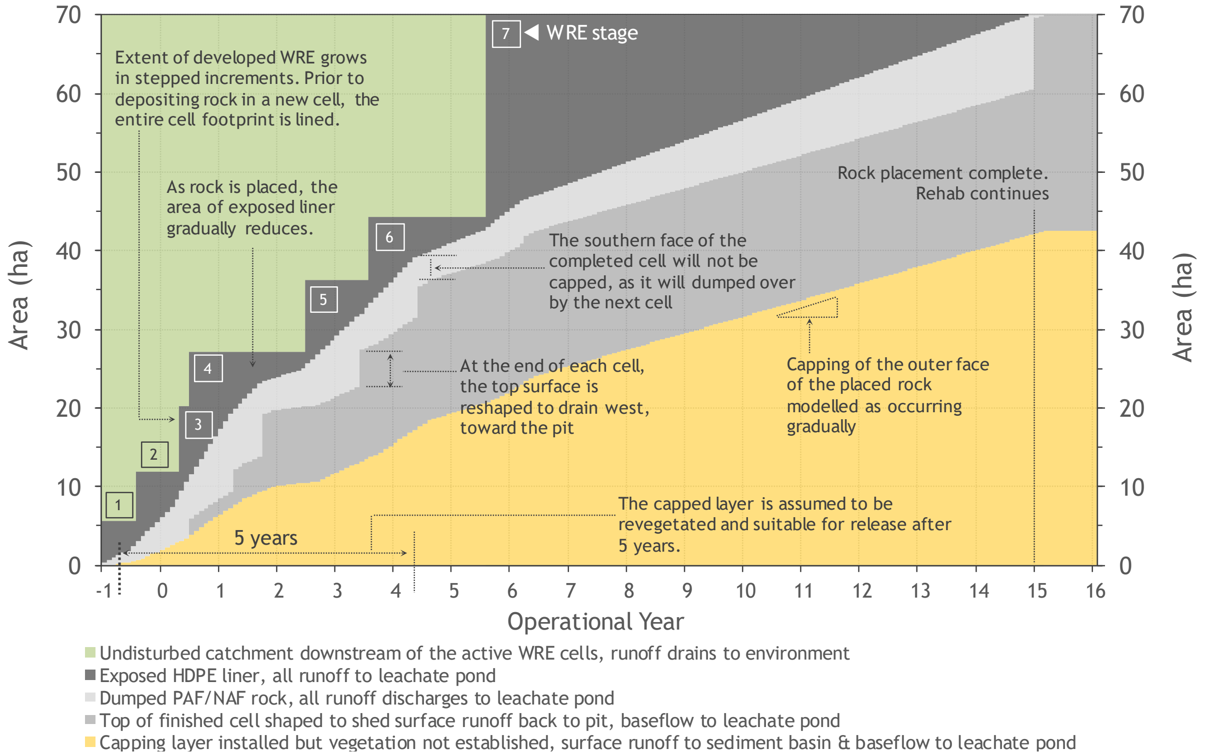


Table 5.4
Adopted AWBM Parameters – Base Case Scenario

Parameter	Dry Tailings Beach (TSF)	Natural/ Undisturbed	Roads/ Hardstand/ Pits	Waste Rock Emplacement	Rehabilitation	Lined
A1	1.0	0.134	0.134	0.2	0.2	1.0
A2	0.0	0.433	0.433	0.2	0.2	0.0
A3	0.0	0.433	0.433	0.6	0.6	0.0
C1 (mm)	8	25	5	90	90	8
C2 (mm)	-	184	20	170	170	-
C3 (mm)	-	214	40	200	200	-
C_{avg} (mm)	8	176	27	172	172	8
BFI	0	0.368	0	0.6	0.6	0
K_{base}	0	0.982	0	0.7	0.7	0
K_{surf}	0	0.820	0	0.4	0.4	0
Average Annual Runoff/ Rainfall (%)	44.6	4.6	26.6	2.7	2.7	44.6
Average Annual Runoff (ML/ha/a)	3.00	0.30	1.79	0.18	0.18	3.00

5.4 TOTAL PROJECT WATER BALANCE

A daily timestep water balance model was used to assess the site water balance over the Project life under the range of historical rainfall and evaporation conditions.

The principal water use on the Mine Site would be the processing plant, which (including allowance for minor losses within the plant area) would require a total throughput of up to approximately 1 486 ML/a (4. 1 ML/d). Much of the water used in the processing plant would be transferred in the tailings stream to the TSF. Tailings bleed water would then drain to the tailings decant pond for eventual return to the processing plant along with rainfall and runoff captured within the TSF.

Water would also be required for dust suppression on site haul roads and minor miscellaneous site water demands. Haul road watering demands would vary with haul road length and climate conditions, with average annual demands expected to range between 161 ML/a and 318 ML/a.

While the processing plant is operating, average annual total site water demands would range between 1 506 ML/a (in Year 1) and 1 807 ML/a (in Year 8).

During mining operations (after allowance for pit face evaporation), groundwater inflows to the main open cut pit are expected to range between approximately 450 ML/a and 855 ML/a. Groundwater and surface water collected in the main open cut pit would be used as the first preference for meeting site water demands. Water captured in the water management system, include tailings bleed water collected in the TSF decant pond would make up much of the remainder. However, water would also be imported to mitigate the risk of water shortfalls. Pipeline inflows would cease following wet weather.

Under these conditions, average annual volumes imported via the external water supply pipeline would vary up to 611 ML/a. This is illustrated in **Figure 5.3**, which shows the average annual inflows from each of the main water sources.

The results of the site water balance model show that the Project can be reliably supplied over the full Project life.

The total site water balance for the mine water management system of the Mine Site over the Project life is summarised in

Table 5.5 All water captured in the containment (mine affected) zone water system is contained without storage overflows throughout the Project life.

The site water balance model also shows that under historical conditions, water captured in the other parts of containment zone would be contained without discharge or significant interruption to mining operations throughout the Project life. This is described in further detail in the following sections.

Figure 5.3 Average Annual Main Water Source Inflows

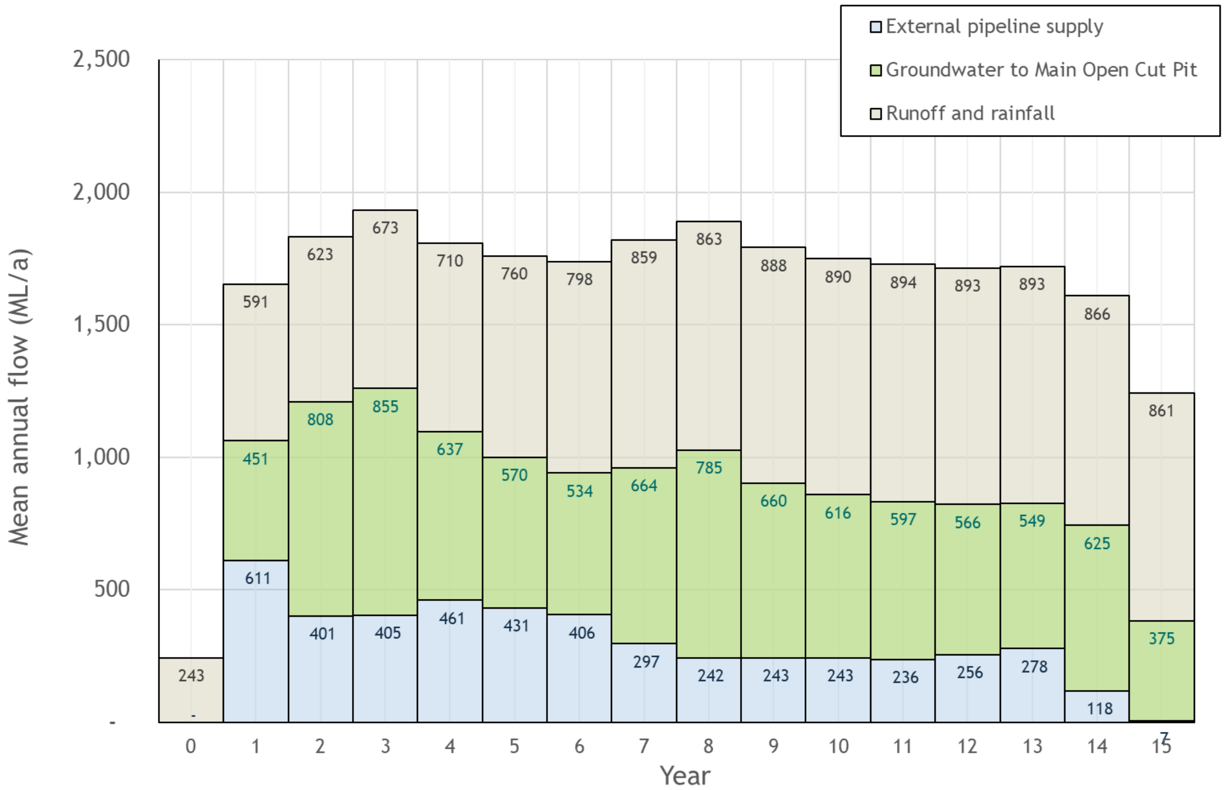


Table 5.5
Average Annual Site Water Balance – Years 1 to 14

Item	Inflow ML/a	Outflow ML/a
Rainfall and runoff	806	
Net groundwater inflows to open cut pit	637	
Imported pipeline water	331	
Ore moisture	83	
Retained tailings moisture		1 151
Evaporation		440
Dust suppression demands supplied		204
Concentrate moisture		22
Dam overflows		0
Annual increase in stored volume		41
Total	**1 857**	**1 857**

5.5 DAM OVERFLOWS AND MAXIMUM STORED WATER VOLUMES

Table 5.6 summarises the maximum stored water volume modelled in each dam. **Table 5.7** summarises the stored TSF decant water volumes modelled during each TSF stage. The model shows that all water in the containment (mine affected) zone water system can be contained on the Mine Site without release under the modelled historic climate conditions.

Table 5.6
Maximum Modelled Stored Water Volumes

Dam	Nominal Design Capacity (ML)	Maximum Modelled Stored Water Volume (ML)
TSF Decant	Varies	1 674[1]
Pit – final year 2 years	N/A	2 324
Pit - prior to final year	N/A	739
WRE leachate management dam	80	56
Oxide ore dam	8[2]	5
Processing plant dams	100	73
Other combined sediment dams (modelled as containment structures)	80[2]	71

[1] Occurs during Year 8
[2] Excludes sediment storage

Table 5.7
TSF Modelled Decant Storage at Each Stage

	Maximum Volume (ML)	Maximum Elevation (m AHD)	99th Percentile Volume (ML)	99th Percentile Elevation (m AHD)
Stage 1	1,407	598.79	1,297	598.50
Stage 2	1,643	608.61	1,421	608.58
Stage 3	1,674	617.16	1,539	616.67

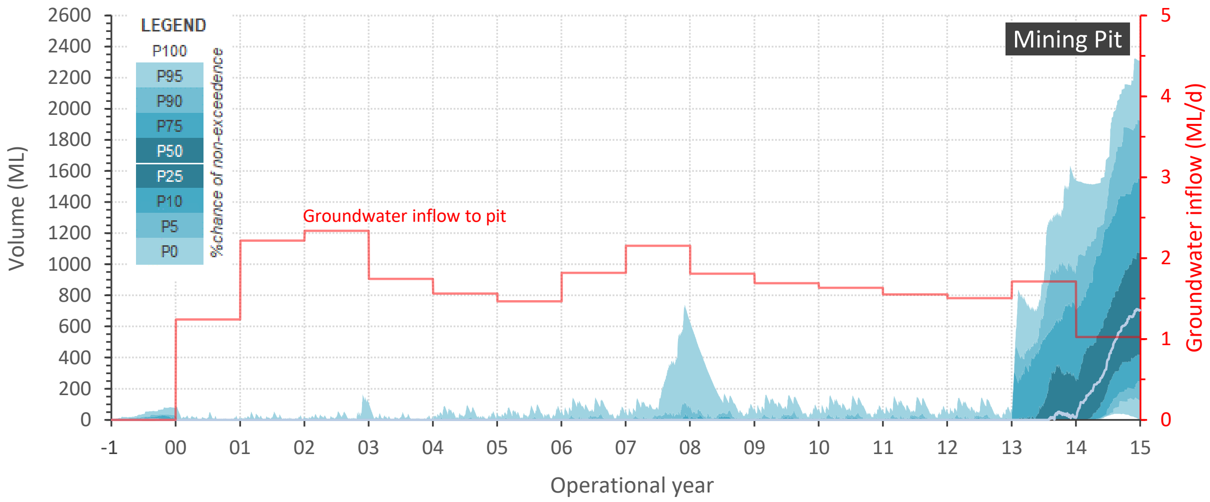
Note that the above elevations don’t necessarily occur on the same date as the corresponding volumes

5.6 SIMULATED SYSTEM BEHAVIOUR

The simulated behaviour of various aspects of the site water management system under the low and high runoff scenarios shows that:

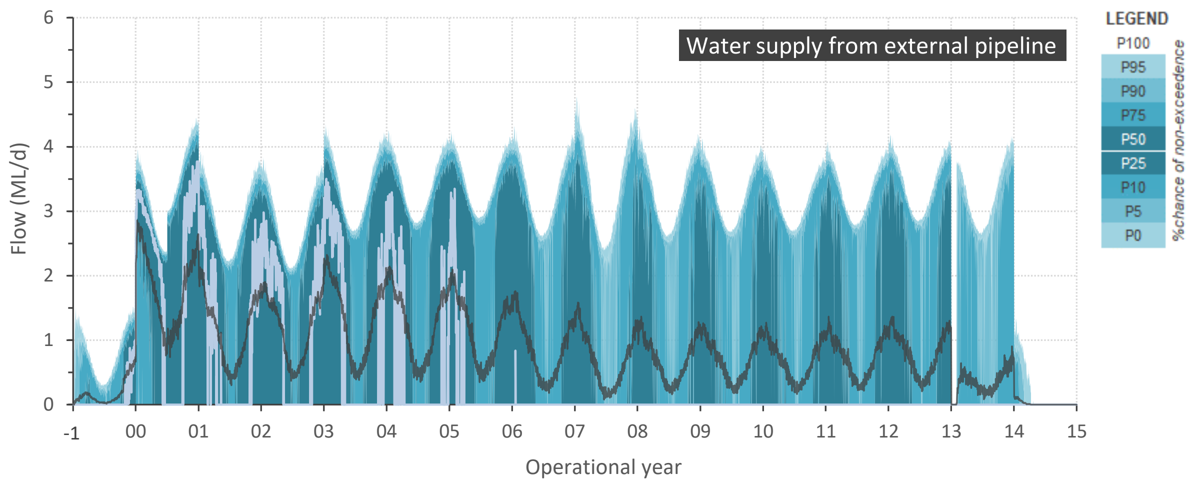
- In-pit water volumes would be unlikely to accumulate to the extent that they would interfere with mining. Even in the first and last (during Year 14) years of mining, when processing plant demands are limited, stored water volumes are unlikely to significantly exceed 500 ML (see **Figure 5.4**).

Figure 5.4 Modelled Open Cut Pit Water Inventory



- Demands for water imported from external supplies would vary depending on the prevailing climate conditions. The predicted imported water requirements would be reduced significantly by the availability of water within the water management system. Water demands are highest during the early years. The modelled external water supplies are shown in **Figure 5.5**. Under the proposed water supply strategy, all project water demands can be supplied without any shortfalls.

Figure 5.5 Modelled External Water Supply Inflows



5.7 SENSITIVITY ANALYSIS

The sensitivity of the water balance to changes in catchment response was tested using two sets of AWBM parameters, representing low and high runoff scenarios.

The adopted parameters are summarised in **Table 5.8** and **Table 5.9**. The resultant average annual site water balances for these scenarios are summarised in **Table 5.10** and **Table 5.11**.

Table 5.8
Adopted AWBM Parameters – Low Runoff Scenario

Parameter	Dry Tailings Beach (TSF)	Natural / Undisturbed	Roads / Hardstand / Pits	Waste Rock Emplacement	Rehabilitation	Lined
A1	0.134	0.2	0.134	0.2	0.2	1.0
A2	0.433	0.2	0.433	0.2	0.2	0.0
A3	0.433	0.6	0.433	0.6	0.6	0.0
C1 (mm)	5	90	5	90	90	8
C2 (mm)	10	170	20	170	170	-
C3 (mm)	20	200	40	200	200	-
C_{avg} (mm)	13.7	172.0	26.7	172.0	172.0	8.0
BFI	0	0.6	0	0.6	0.6	0
K_{base}	0	0.7	0	0.7	0.7	0
K_{surf}	0	0.4	0	0.4	0.4	0
Average Annual Runoff/ Rainfall (%)	38.5	3.1	26.6	3.1	3.1	46.0
Average Annual Runoff (ML/ha/a)	2.72	0.22	1.79	0.22	0.22	3.25

Table 5.9
Adopted AWBM Parameters – High Runoff Scenario

Parameter	Dry Tailings Beach (TSF)	Natural / Undisturbed	Roads / Hardstand / Pits	Waste Rock Emplacement	Rehabilitation	Lined
A1	1.0	0.2	0.134	0.134	0.134	1.0
A2	0.0	0.2	0.433	0.433	0.433	0.0
A3	0.0	0.6	0.433	0.433	0.433	0.0
C1 (mm)	8	25	5	10	11	0
C2 (mm)	-	95	10	50	60	-
C3 (mm)	-	150	20	120	130	-
C_{avg} (mm)	8.0	114.0	13.7	75.0	83.7	8.0
BFI	0	0.55	0	0.35	0.35	0
K_{base}	0	0.7	0	0.6	0.6	0
K_{surf}	0	0	0	0.1	0.1	0
Average Annual Runoff/ Rainfall (%)	46.0	8.7	38.5	14.3	12.7	69.0
Average Annual Runoff (ML/ha/a)	3.25	0.62	2.71	1.01	0.90	4.86

Table 5.10
Average Annual Site Water Balance – Years 1 to 14 – Low Runoff Scenario

Item	Inflow ML/a	Outflow ML/a
Rainfall and runoff	765	
Net groundwater inflows to open cut pit	637	
Imported pipeline water	361	
Ore moisture	83	
Retained tailings moisture		1 151
Evaporation		430
Dust suppression demands supplied		204
Product moisture		22
Dam overflows		0
Annual increase in stored volume		40
Total	**1 846**	**1 846**

Table 5.11
Average Annual Site Water Balance – Years 1 to 14 – High Runoff Scenario

Item	Inflow ML/a	Outflow ML/a
Rainfall and runoff	1 035	
Net groundwater inflows to open cut pit	637	
Imported pipeline water	205	
Ore moisture	83	
Retained tailings moisture		1 151
Evaporation		514
Dust suppression demands supplied		204
Product moisture		22
Dam overflows		0
Annual increase in stored volume		70
Total	**1 960**	**1 960**

Under the high runoff scenario, all site water storages (including (enlarged) sediment dam sizes) are able to be operated without any overflows. Under the low runoff scenario, all water demands are able to be met through the importation of additional water from the Ulan Coal Mine and/or Moolarben Coal Mine (at rates of up to approximately 4.5 ML/d).

A further scenario was developed in which groundwater inflows were assumed to be half the predicted values. The resultant average annual site water balance for this scenario is summarised in **Table 5.12**. Under this scenario, imported water supplies from the Ulan Coal Mine and/or Moolarben Coal Mine (at rates up to approximately 4.5 ML/d) are also able to ensure all water demands are met throughout the project.

Table 5.12
Average Annual Site Water Balance – Years 1 to 14 – Low Groundwater Inflow Scenario

Item	Inflow ML/a	Outflow ML/a
Rainfall and runoff	794	
Net groundwater inflows to open cut pit	319	
Imported pipeline water	613	
Ore moisture	83	
Retained tailings moisture		1 151
Evaporation		400
Dust suppression demands supplied		204
Product moisture		22
Dam overflows		0
Annual increase in stored volume		32
Total	1 808	1 808

6. FLOOD IMPACT ASSESSMENT

6.1 MINE AREA INFRASTRUCTURE POTENTIALLY IMPACTING FLOODING

Proposed mine related infrastructure which could potentially interact with flood flow paths includes the following.

- **WRE and associated haul road, flood bund and noise barrier -** these works have the potential to impact flood conditions on the western margin of the Price Creek floodplain and would interact with existing contour banks and other drainage structures. For the purpose of this assessment, and for conservatism, the impacts of the Project in conjunction with existing structures has been assessed. During detailed design of the WRE, consideration would be given to the mitigation of these impacts in conjunction with the decommissioning of existing drainage works.
- **WRE leachate management dam -** the proposed WRE leachate management dam would be located on the margin of the Lawsons Creek floodplain. The potential effect of this structure on the Lawsons Creek flooding and local runoff from Price Creek has been assessed by incorporating the design surface into the hydraulic model.
- **Southern barrier** - the southern barrier would be constructed across Blackmans Gully, with a low-level pipe or culvert outlet beneath the barrier, and during operations would attenuate flood flows entering Hawkins Creek downstream. Runoff from adjacent (downstream) clean catchments would be diverted around the toe of the southern barrier. The southern barrier would be decommissioned during closure and rehabilitation activities post-mining, and the pre-mine flow paths would be reinstated.
- **Clean water diversion system from Blackmans Gully to Price Creek -** the upper part of the Blackmans Gully catchment would be diverted east to Price Creek, to reduce the potential for clean water to enter the active mining areas. The channel conveying this flow would be decommissioned post-mining. The effect of this channel has been modelled by directing the upper sub-catchment inflows to Price Creek instead of Blackmans Gully.

6.2 FLOOD IMPACTS ADJACENT TO THE MINE SITE

The footprint of the Mine Site would be largest during operations. At the completion of mining operations and following rehabilitation of the Mine Site, some of the mining-related infrastructure would be decommissioned (i.e. the southern barrier and WRE haul road). The flood impact, assessment has been based on two scenarios – maximum disturbance, and post-closure.

The results are summarised briefly in the following sections. Full details, including flood maps showing design peak flood levels, depths and velocities for the 10% AEP (1 in 10), 5% AEP (1 in 20), 2% AEP (1 in 50), 1% AEP (1 in 100), 0.5% AEP (1 in 200), 0.2% AEP (1 in 500), and probable maximum precipitation (PMP) design events are provided in **Annexure B**.

The approach to assessing and managing flood risks is consistent with the approach of the NSW Floodplain Development Manual. The manual supports the NSW Government's Flood Prone Land Policy in providing for the sustainable development and use of the floodplain by considering risk management principles based upon a hierarchy of avoidance, minimisation and mitigation. This approach examines the frequency of flooding, flood consequences, the vulnerability of the community, and its resilience to recover from flood events.

6.2.1 Maximum Disturbance Scenario

Figure 6.1 shows predicted peak flood levels and depths for the 1% AEP event under the Maximum Disturbance Scenario in the vicinity of the proposed WRE. **Figure 6.2** shows the predicted 1% AEP peak velocities along Price Creek adjacent to the WRE for the Maximum Disturbance Scenario. The modelled impacts of the Project on peak 1% AEP flood levels are shown in **Figure 6.3**.

The model results for this scenario indicate the following.

- The surface of the proposed haul road at the toe of the proposed WRE would have immunity from flooding for all events up to the PMP design event.
- The northeastern section of the proposed haul road embankment would constrict flows in Price Creek. As a result, high peak velocities are predicted here. The predicted maximum velocities just downstream of this constriction range from 3.2 m/s for 10% AEP event to 4.9 m/s for the 1% AEP event. Mitigation measures for managing the short-term risk of erosion in these areas, such as the appropriate size of rock armouring would be developed during detailed design of the WRE.
- Some sections of the proposed haul road and WRE encroach into the edge of the Price Creek floodplain. As a result, the toe of the haul road located within the Price Creek flood extent would potentially be affected by high velocities. The predicted maximum velocities along the eastern edge of the proposed haul road range from 3.2 m/s for the 10% AEP event to 3.5 m/s for the 1% AEP event.
- There would be generally no increases in peak flood levels and velocities in Price Creek upstream of the proposed WRE for all modelled events.
- Flood levels would be increased at a number of locations in the Price Creek and Hawkins Creek channel and associated floodplain as described below.
  - Along the Price Creek floodplain adjacent to the WRE, there are predicted increases in peak flood levels of up to 0.3 m for the 10% AEP event, up to 0.4 m for the 1% AEP event and up to 0.5 m for the 0.2% AEP event. This is due to the proposed WRE forcing more water to flow along the western floodplain of Price Creek.
  - In Hawkins Creek, there would be minor increases in peak flood levels of up to 0.05 m for the 10% AEP event, up to 0.04 m for the 1% AEP event and up to 0.03 m for the 0.2% AEP event. These impacts dissipate to less than 0.01 m about 150 m upstream and downstream of the Bingmans Crossing stream gauge.

Figure 6.1 1% (1 in 100) AEP Peak Flood Levels and Depths in the Vicinity of the Proposed WRE - Maximum Disturbance Scenario

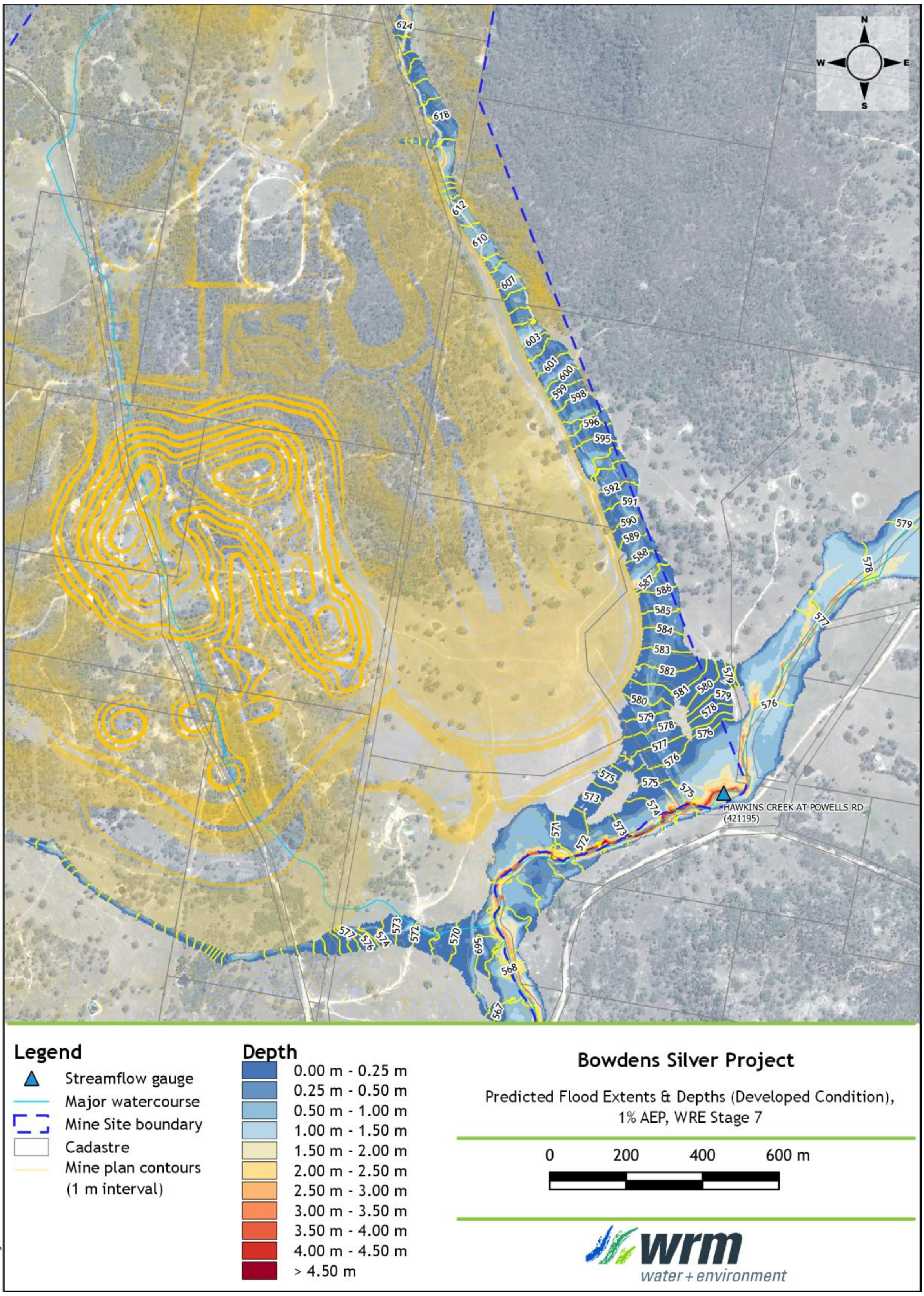


Figure 6.2 1% (1 in 100) AEP Peak Velocities along Price Creek adjacent to the Proposed WRE - Maximum Disturbance Scenario

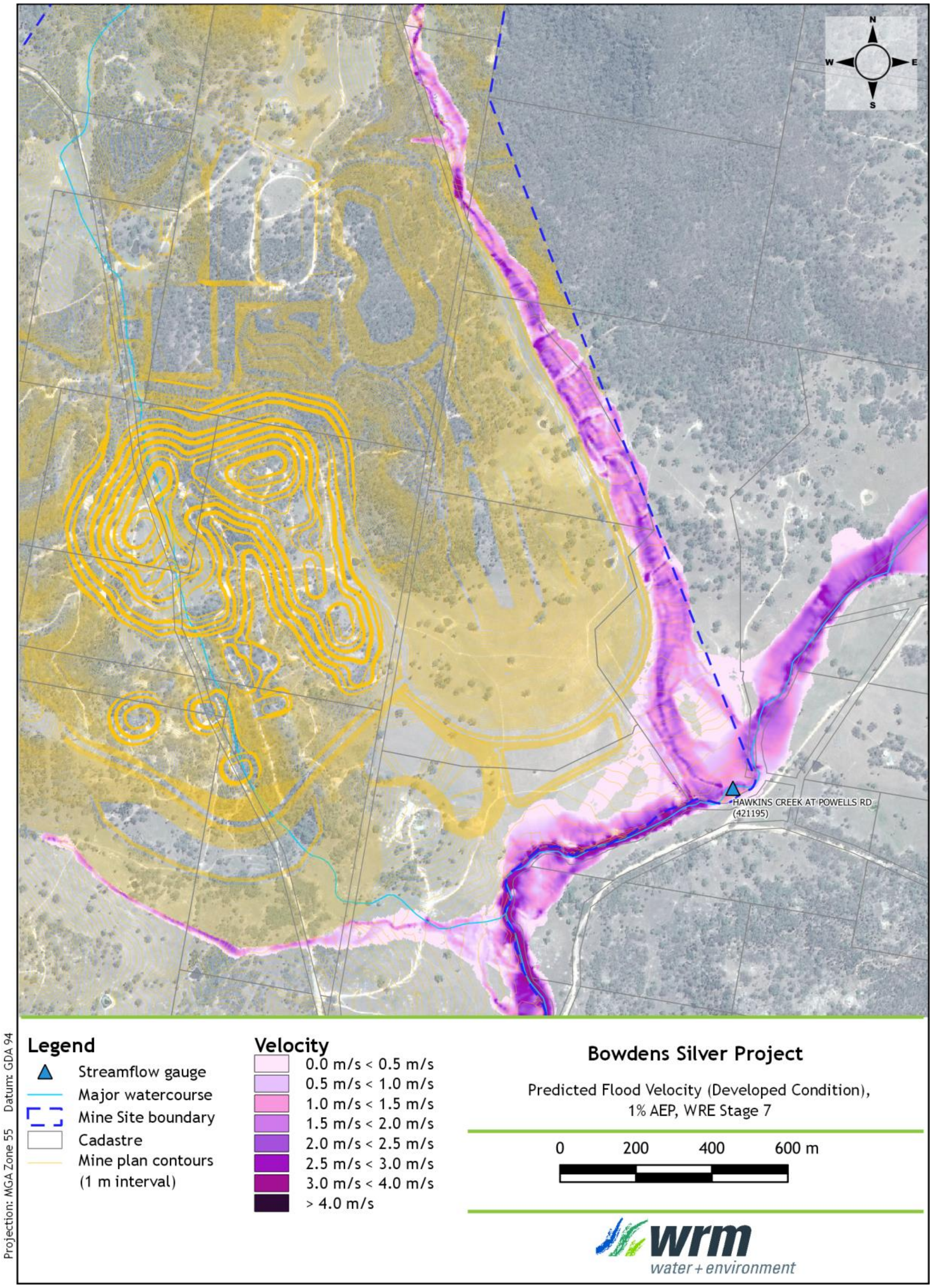
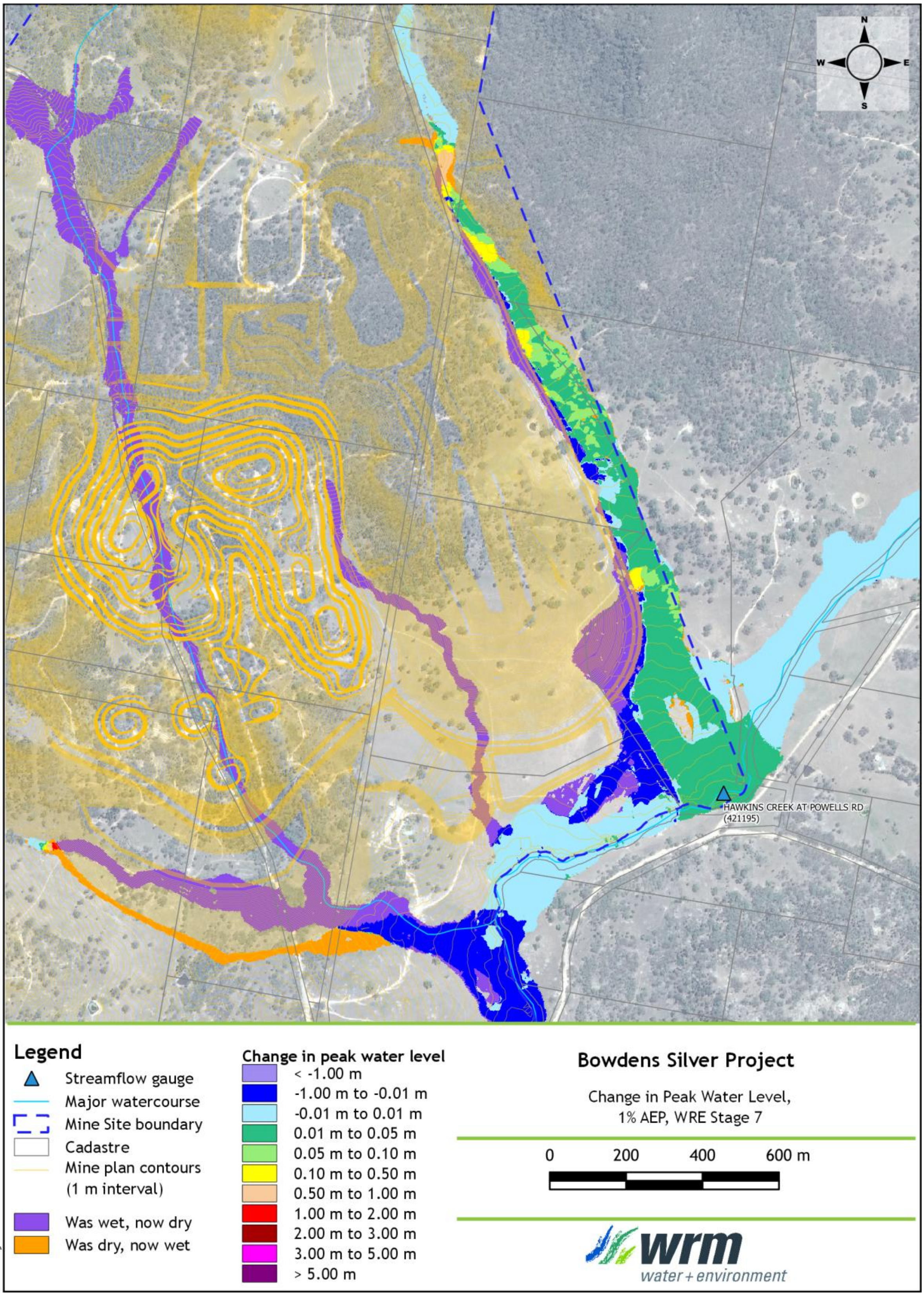


Figure 6.3 1% (1 in 100) AEP Predicted Impacts on Peak Flood Levels along Price Creek Adjacent to the Proposed WRE - Maximum Disturbance Scenario



- Flood velocities would also be increased at number of locations in the Price Creek and Hawkins Creek channel and floodplain as described below.
  - There would be increases in peak velocities along the Price Creek floodplain of up to 1.8 m/s for the 10% AEP event and up to 1.1 m/s for the 1% and 0.2% AEP events. This is due to the proposed WRE forcing more water to flow along the western floodplain of Price Creek.
  - Just downstream of the constriction at the northeastern corner of the proposed WRE lower embankment haul road flood bund, there would be localised increases in peak velocities of up to 3.1 m/s for the 10% AEP event, up to 3.5 m/s for the 1% AEP event and up to 3.7 m/s for the 0.2% AEP event.

    Where necessary, mitigation measures for managing the risk of erosion in these areas, such as the appropriate size of rock armouring would be developed during detailed design to ensure minimal scour in the 10% AEP flood.
  - Along the eastern toe of the WRE lower embankment haul road flood bund (along the western side of the Price Creek floodplain), there would be localised increases in peak velocities of up to 1.4 m/s, 1.1 m/s and 1.1 m/s for the 10%, 1% and 0.2% AEP events respectively.
  - There would be increases in peak velocities of up to 0.9 m/s for the 10%, up to 0.6 m/s for the 1% AEP event and up to 0.5 m/s for the 0.2% AEP event near the southeastern corner of the proposed WRE lower embankment haul road flood bund/noise barrier toe.
  - In the Hawkins Creek floodplain, there would be minor increases in peak velocities of up to 0.14 m/s for the 10% AEP event, up to 0.08 m/s for the 1% AEP event and up to 0.07 m/s for the 0.2% AEP event. These impacts dissipate to less than 0.01 m/s about 550 m downstream of the Bingmans Crossing stream gauge.

6.2.2 Post Closure Scenario

Figure 6.4 shows the predicted 1% AEP peak velocities along Price Creek adjacent to the WRE for the Post Closure Scenario. The modelled impacts of the Project on peak 1% AEP flood levels and velocities are shown in and **Figure 6.5** and **Figure 6.6** respectively. The model results for this scenario indicate the following:

- The proposed haul road, flood bund and noise barrier (where constructed) would be reshaped from the toe of the WRE towards the existing ground level at the edge of the Price Creek floodplain as part of rehabilitation at mine closure. However, the predicted flood extent, depths and velocities along Price Creek are very similar to those predicted for the Maximum Disturbance Scenario and therefore the rock protection that would be installed along the toe of the haul road embankment would be retained.
- The constriction at the northeastern corner of the WRE would remain in the Post Closure Scenario. As a result, high peak velocities are also predicted here. The predicted maximum velocities just downstream of this constriction range from 3.2 m/s for the 10% AEP event to 4.9 m/s for the 1% AEP event. Therefore, the rock protection that would be installed along the toe of the haul road embankment would need to be retained as a long-term measures for mitigating the consequent risk of erosion and would be incorporated into the final WRE rehabilitation design.

Figure 6.4 1% (1 in 100) AEP Peak Velocities along Price Creek Adjacent to the Proposed WRE – Final Landform Scenario

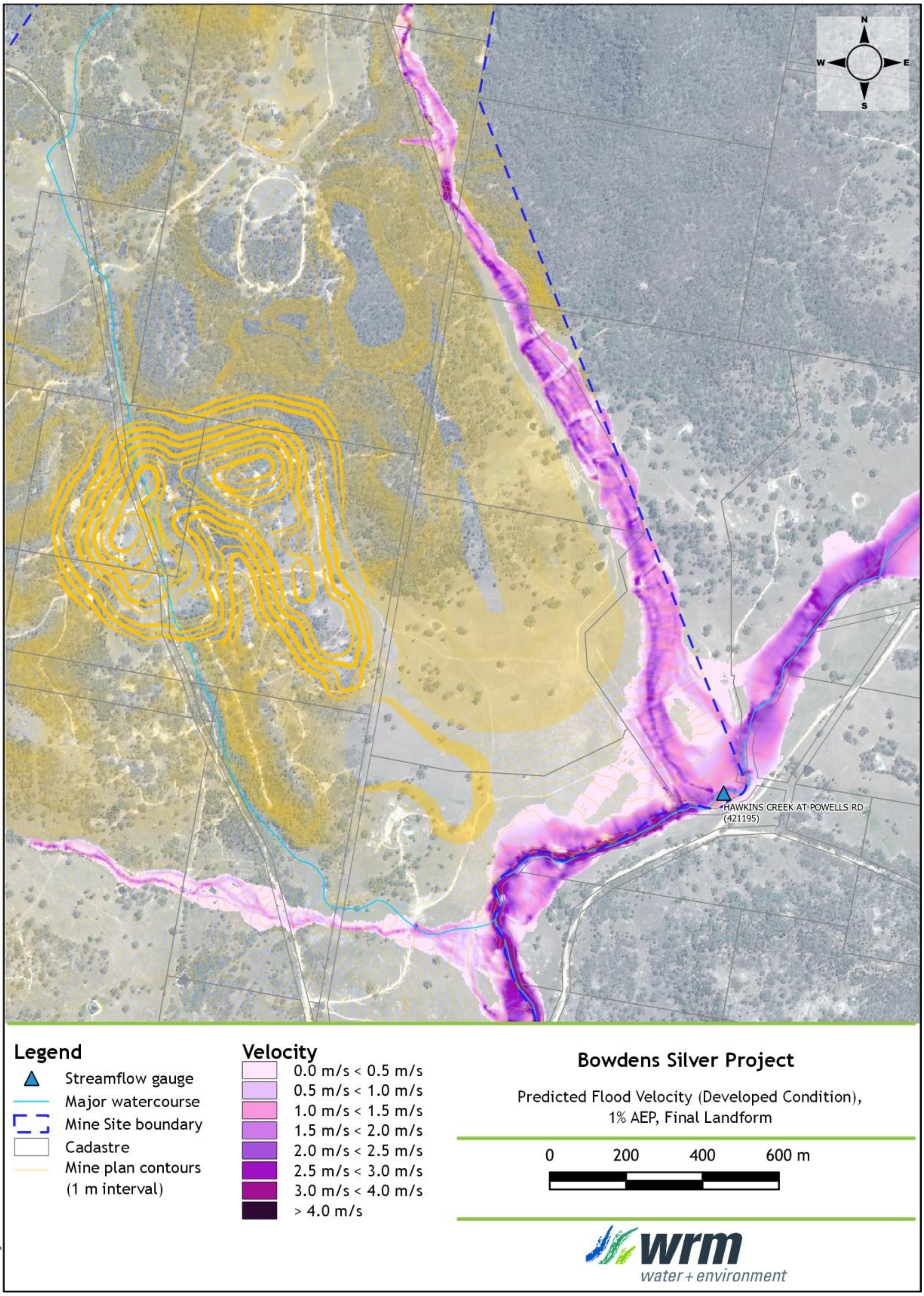


Figure 6.5 1% (1 in 100) AEP Predicted Impacts on Peak Flood Levels along Price Creek adjacent to the Proposed WRE – Post Closure Scenario

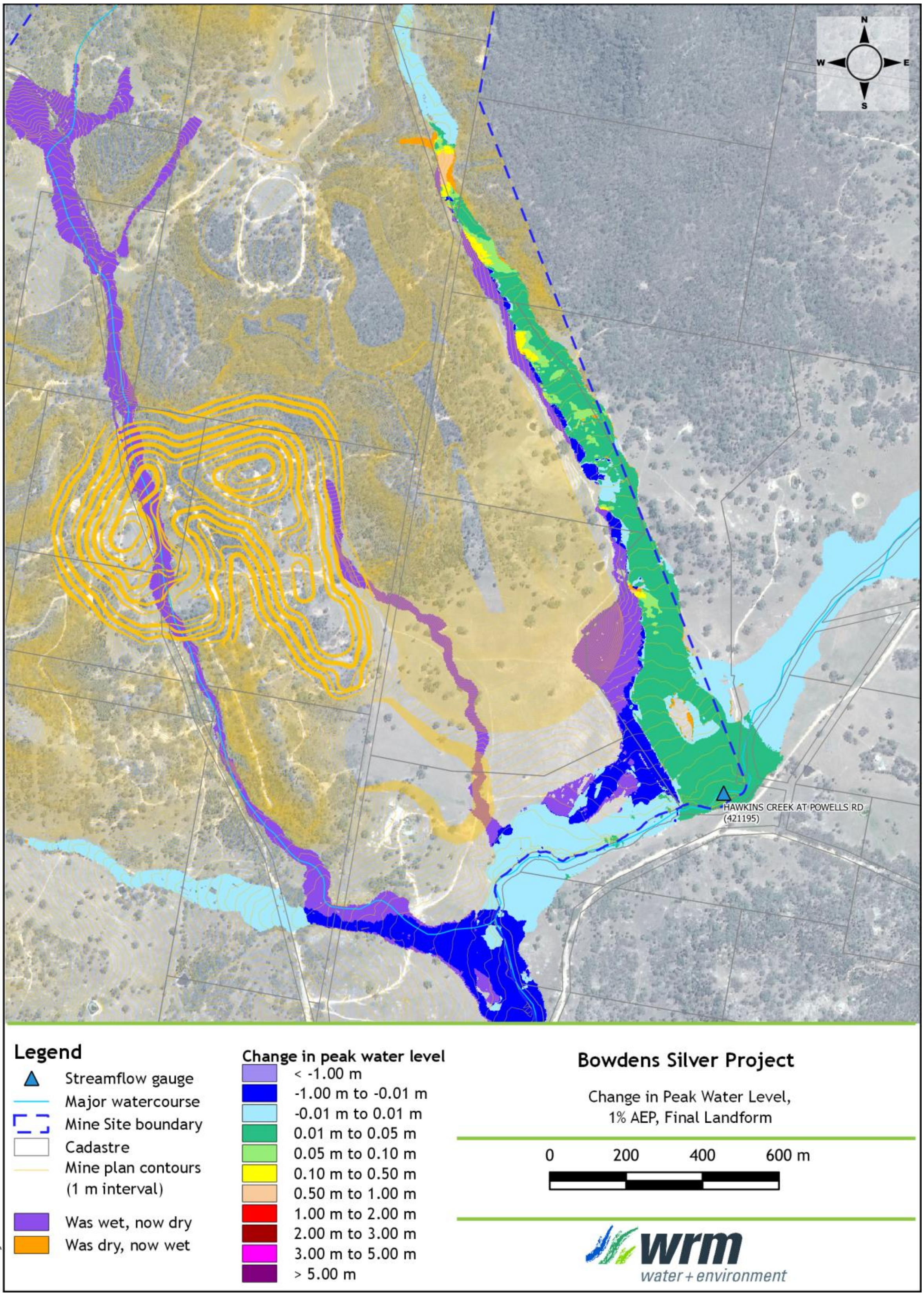
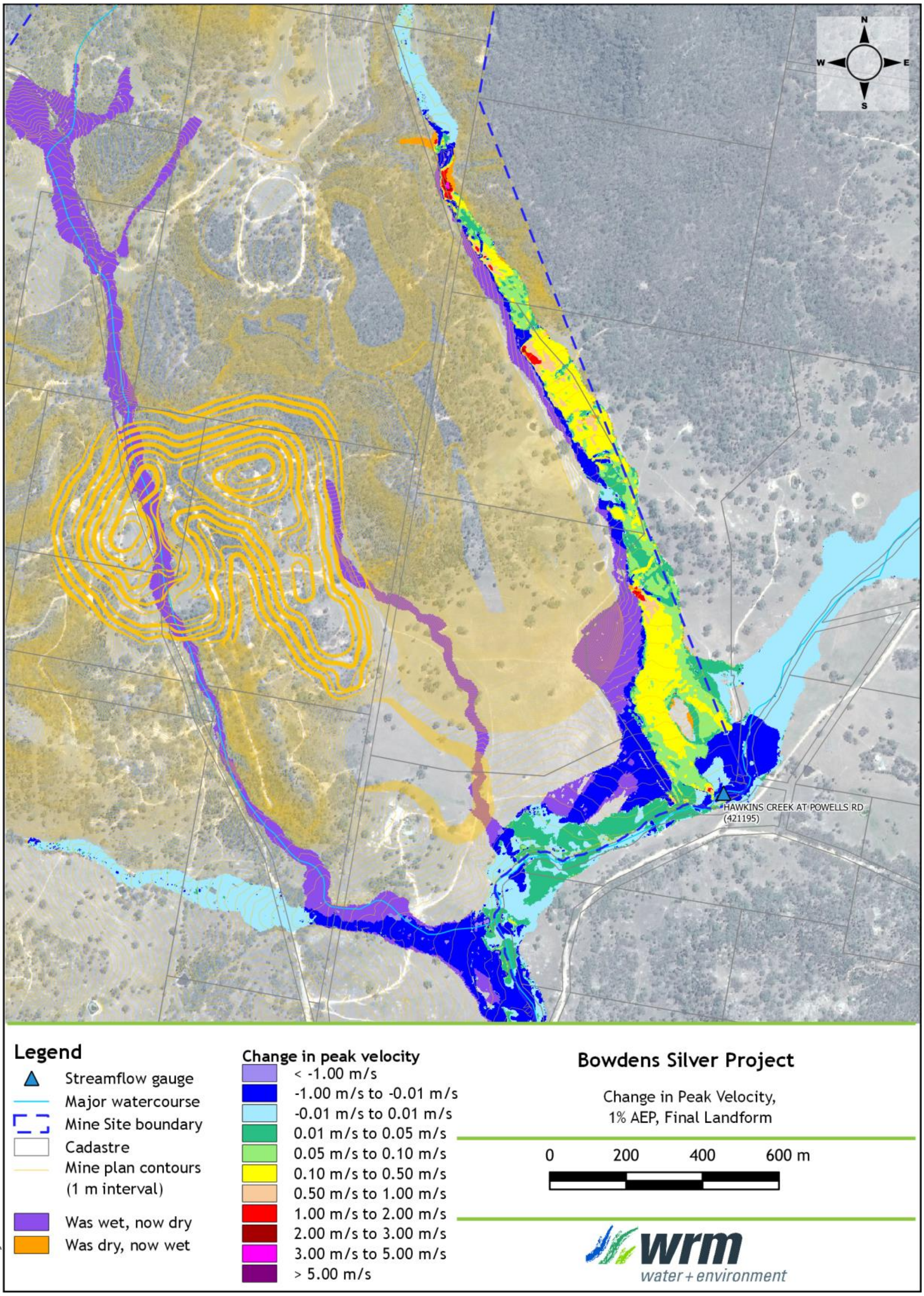


Figure 6.6 1% (1 in 100) AEP Predicted Impacts on Peak Flood Velocities along Price Creek adjacent to the Proposed WRE – Post Closure Scenario



- Some sections of the WRE would still encroach into the Price Creek floodplain. As a result, the toe of the WRE located within the Price Creek flood extent would potentially be affected by high velocities. The predicted maximum velocities along the eastern edge of the proposed haul road range from 2.5 m/s for the 10% AEP event to 3.4 m/s for the 1% AEP event. Therefore, the rock protection that would need to be installed along the toe of the haul road embankment would be retained as a long-term measure for mitigating the consequent risk of erosion and would be incorporated into the final WRE rehabilitation design.
- The predicted impacts for the Post Closure Scenario are generally similar to those observed for the Maximum Disturbance Scenario.
- There would be generally no increases in peak flood levels and velocities in Price Creek upstream of the proposed WRE for all modelled events.
- Flood levels would be increased at number of locations in the Price Creek and Hawkins Creek channel and floodplain as described below:
  - Along the Price Creek floodplain adjacent to the WRE, there are predicted increases in peak flood levels of up to 0.3 m for the 10% AEP event, up to 0.4 m for the 1% AEP event and up to 0.5 m for the 0.2% AEP event. This is due to the proposed WRE forcing more water to flow along the western floodplain of Price Creek.
  - In Hawkins Creek, there would be minor increases in peak flood levels of up to 0.05 m for the 10% AEP event, up to 0.03 m for the 1% AEP event and up to 0.03 m for the 0.2% AEP event. These impacts dissipate to less than 0.01 m about 150 m upstream and downstream of the Bingmans Crossing stream gauge.
- Flood velocities would also be increased at a number of locations in the Price Creek and Hawkins Creek channel and floodplain as described below:
  - There would be increases in peak velocities along the Price Creek floodplain of up to 1.8 m/s for the 10% AEP event and up to 3.2 m/s for the 1% and 0.2% AEP events. This is due to the WRE forcing more water to flow along the eastern floodplain of Price Creek.
  - Just downstream of the constriction at the northeastern corner of the proposed WRE and haul road, there would be localised increases in peak velocities of up to 2.7 m/s for the 10% AEP event, up to 4.5 m/s for the 1% AEP event and up to 5.2 m/s for the 0.2% AEP event.
  - Along the eastern toe of the WRE and haul road (along the western side of the Price Creek floodplain), there would be localised increases in peak velocities of up to 1.7 m/s, 3.1 m/s and 3.6 m/s for the 10%, 1% and 0.2% AEP events respectively.
  - There would be increases in peak velocities of up to 0.8 m/s for the 10% AEP event, up to 2.4 m/s for the 1% AEP event and up to 2.7 m/s for the 0.2% AEP event near the southeastern corner of the proposed WRE.
  - In the Hawkins Creek floodplain, there would be minor increases in peak velocities of up to 0.2 m/s for the 10% AEP event and up to 0.08 m/s for the 1% AEP and up to 0.2% AEP events. As these impacts are minor and dissipate to less than 0.01 m/s about 550 m downstream of the Bingmans Crossing stream gauge, i.e. before the confluence with Lawsons Creek, no works are required to mitigate erosion risks in this area.

6.2.3 Conclusion

The proposed works associated with the WRE would result in localised minor flood level increases. The more significant flood level impacts are constrained to within the Mine Site, and would not result in significant impacts to other properties, assets or infrastructure.

The proposed WRE would locally increase flood velocities in its immediate vicinity. Local scour protection measures would need to be developed during detailed design to mitigate the potential erosion impacts in this area. Any expected increases in flood velocities in Hawkins Creek and Lawsons Creek would be negligible and would not adversely impact offsite property or infrastructure.

6.3 RELOCATED MALONEYS ROAD CROSSING OF LAWSONS CREEK

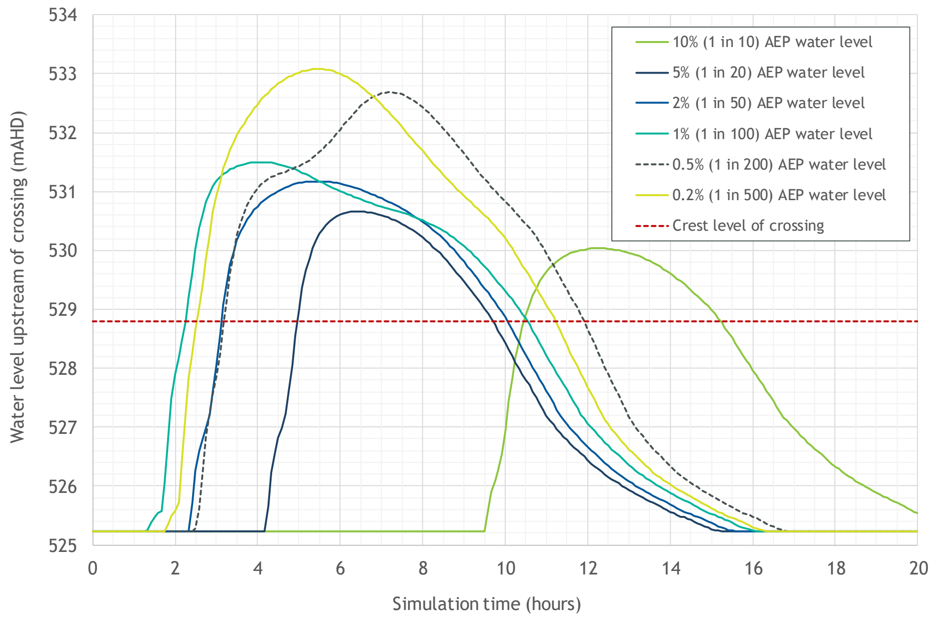
6.3.1 Proposed Configuration

Bowdens Silver proposes a floodway crossing of the relocated Maloneys Road over Lawsons Creek. Full details of the crossing would be established during detailed design, however, for the purposes of this assessment the following key design features were adopted:

- A road crest level of 528.8 mAHD (i.e. the existing 10% (1 in 10) AEP flood level);
- A road width of 7 m;
- A two-way cross fall of 3%; and
- A road embankment (cut and fill) slope of 1V:3H;
- Reinforced concrete box culverts (10 barrels - 2.7 m high by 2.4 m wide).

The road embankment would have a maximum height of 5 m above the Lawsons Creek bed, with the outer embankment slopes extending up to 17 m upstream and 15 m downstream of the crossing as shown in **Figure 6.7**. The frequency of overtopping of the relocated crossing will be significantly reduced compared to the existing low-level of crossing of Lawsons Creek.

Figure 6.7 Design Flood Hydrographs at Proposed Relocated Maloneys Road Crossing



6.3.2 Design Flood Conditions

Figure 6.8 shows the 10% AEP predicted peak flood levels, depths and extents in Lawsons Creek with the proposed crossing in place. **Figure 6.9** shows the corresponding 10% AEP peak flood velocities.

The model results show that the proposed road crossing would be overtopped during a 10% AEP flood event. Peak flood depths over the road are up to 1.2 m, while peak flood velocities over the road are up to 3 m/s. Therefore, the proposed road crossing would be non-trafficable by light or heavy vehicles during a 10% AEP event.

The 10% AEP peak flow rate at the proposed crossing location is approximately 290 m^3/s. The model results indicate that during a 10% AEP event the culverts convey a maximum flow rate of about 190 m^3/s, with 100 m^3/s flowing over the road. The proposed Lawsons Creek crossing configuration modelled in this assessment has a flood immunity of between 20% (1 in 5) AEP and 10% (1 in 10) AEP.

Figure 6.7 shows design flood water level hydrographs for a range of design AEPs. The figure shows that flood levels at the crossing are likely to subside below the road crest level within 12 hours of the flood peak. And therefore, if the crossing is undamaged, road closures due to flooding would be expected to be less than 12 hours.

Design flood conditions in the vicinity of the crossing are described in detail in the Flood Impact Assessment report included as **Annexure B**.

6.3.3 Impact on Peak Flood Conditions

Figure 6.10 shows the predicted changes in 10% AEP peak flood levels in Lawsons Creek due to the proposed crossing. The impacts of the crossing for a range of flood events are presented in the Flood Impact Assessment in **Annexure B**. The model results indicate the following:

- The proposed road crossing would increase peak flood levels upstream of the road:
  - For the 10% AEP event, peak flood levels would increase by up to 1.4 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 1.4 km upstream of the crossing.
  - The predicted increase in peak flood levels upstream of the crossing for the 10% AEP event would cause flows in Lawsons Creek to overtop the northern creek bank immediately upstream of the crossing. These overflows would drain to the northwest parallel to the Lawsons Creek before re-joining Lawsons Creek about 680 m downstream of the proposed crossing. These overflows would not occur under existing conditions for the 10% AEP event, but it would occur for larger events.

Figure 6.8 10% (1 in 10) AEP Peak Flood Levels, Depths and Extents at the Proposed Lawsons Creek Crossing

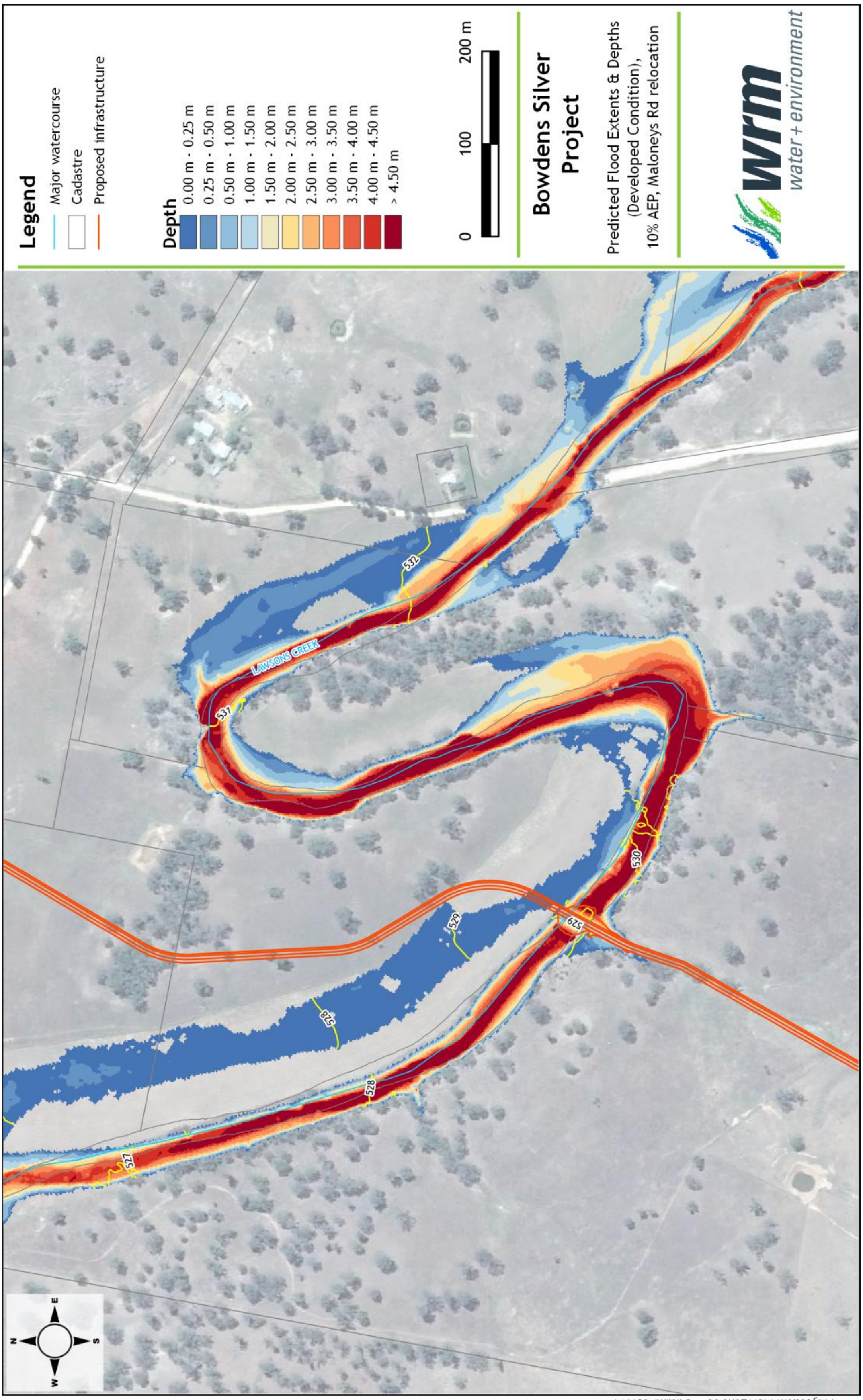
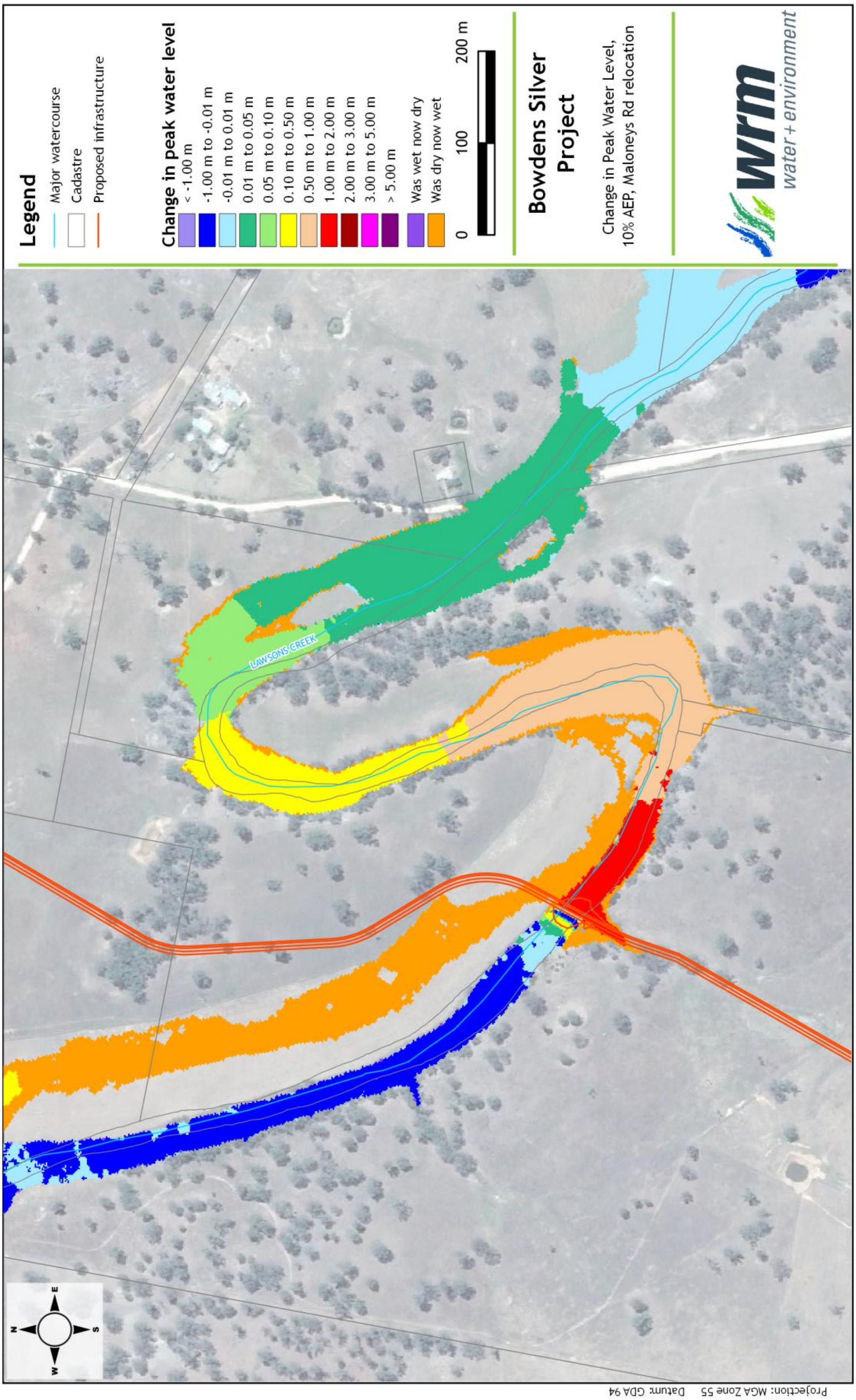


Figure 6.9 10% (1 in 10) AEP Peak Flood Velocities at the proposed Lawsons Creek Crossing

Figure 6.10 Predicted changes in Peak Flood Levels due to the proposed Lawsons Creek crossing, 10% (1 in 10) AEP Event

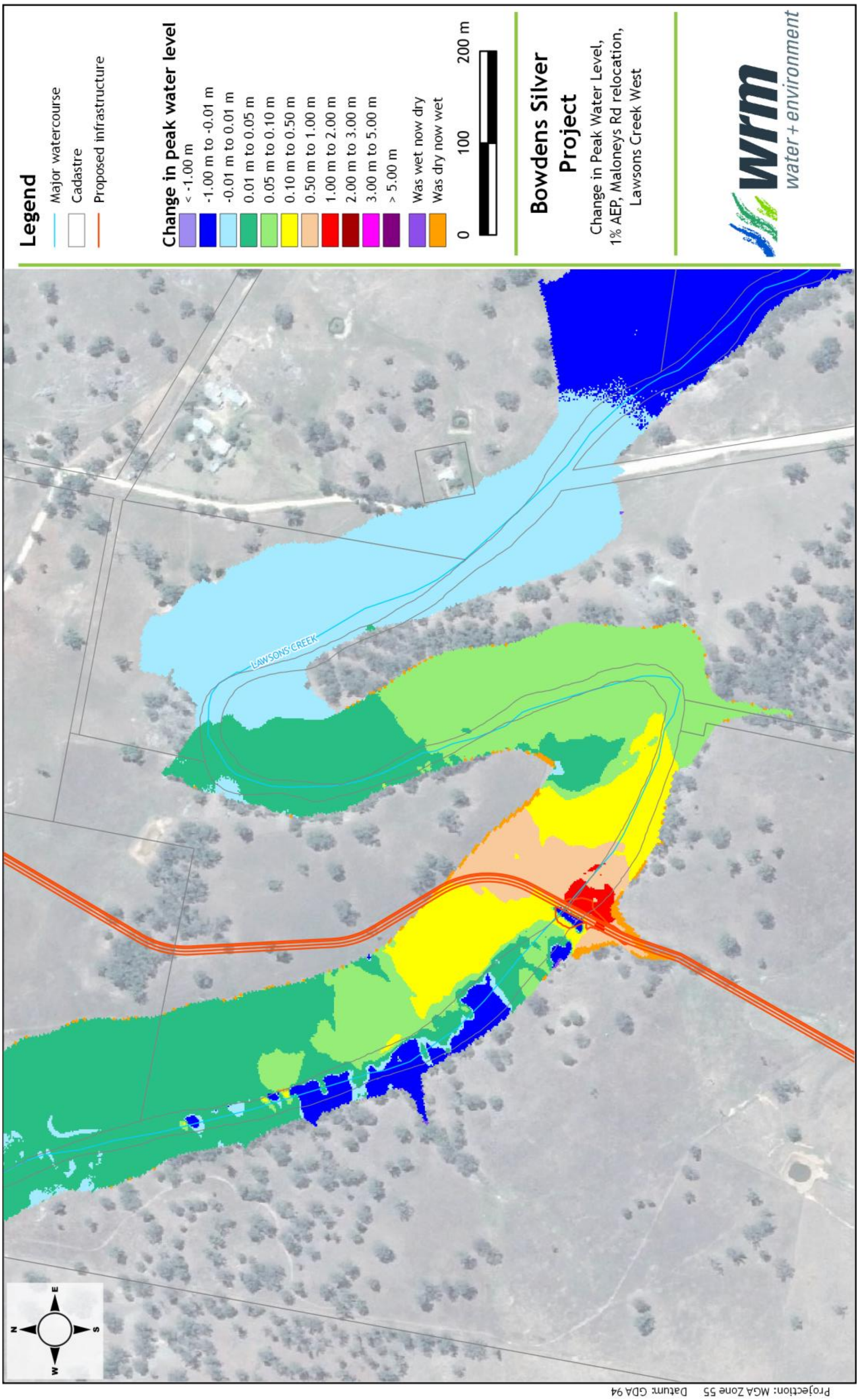


- For the 1% (1 in 100) AEP event (see **Figure 6.11**), peak flood levels would increase by up to 1.4 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 700 m upstream of the crossing.
- For the 0.2% (1 in 500) AEP event, peak flood levels would increase by up to 1.8 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 700 m upstream of the crossing.

- There are predicted reductions in peak flood levels of up to 0.03 m downstream of the Lawsons Creek crossing for the 10% AEP event. However, peak flood levels would increase downstream of the crossing for the 1% (1 in 100) AEP and 0.2% (1 in 500) AEP events:
  - For the 1% (1 in 100) AEP event, peak flood levels would increase by up to 0.5 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 750 m downstream of the crossing.
  - For the 0.2% (1 in 500) AEP event, peak flood levels would increase by up to 0.5 m. These impacts decrease in magnitude further away from the road crossing, dissipating to less than 0.01 m approximately 550 m downstream of the crossing.
- The proposed road crossing would reduce peak velocities in the Lawsons Creek channel. However, peak velocities would increase along the northern Lawsons Creek floodplain downstream of the crossing. This is due to the proposed crossing forcing water to flow to the northern bank of Lawsons Creek. For the 0.2% (1 in 500) AEP and 1% (1 in 100) AEP events, velocities on the northern bank of Lawsons Creek would increase by up to 0.55 m/s, dissipating to less than 0.05 m/s approximately 800 m downstream of the crossing.
- The predicted increases in peak flood levels, extents and velocities do not appear to affect any existing dwellings for all events up to and including 0.2% (1 in 500) AEP. It is noted that all increases in flood levels, as the result of the relocated Maloneys Road crossing of Lawsons Creek, would occur on land either owned or under an acquisition agreement with Bowdens Silver.

The road crossing would be designed to manage the risk of scour induced by increased velocities, for example through the use of dumped rock or other erosion protection measures.

Figure 6.11 Predicted changes in Peak Flood Levels due to the Proposed Lawsons Creek Crossing, 1% (1 in 100) AEP Event



7. FINAL VOID PIT LAKE BEHAVIOUR

7.1 OVERVIEW

Water levels in the final main open cut pit void would vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses and inflows from rainfall, surface runoff and groundwater.

A separate GoldSIM model was used to assess the likely long-term behaviour of the final void pit lake. The historical rainfall and evaporation sequences were repeated five times to create a long-term climate record for use in the model.

The potential effects of climate change were also assessed using climate-change adjusted SILO climate data developed as part of the Consistent Climate Scenarios (CCS) Project by the Queensland Government's Department of Environment and Science (DES).

7.2 FINAL VOID CONFIGURATION

The final void configuration and contributing catchment area are shown in **Figure 7.1**. **Figure 7.2** shows the extent of the PMP design event for the Post Closure Scenario.

The proposed final landform limits the contributing catchment of the final void to its own surface area, with all upslope catchments being diverted around the final void. This implies that all final diversion and levee structures are sufficiently robust to exclude all diverted inflows after mine closure.

Based on the proposed open cut pit design, the final void would be up to 141 m deep, with a floor level of 456 mAHD and an overflow level of approximately 597 mAHD. It is predicted that once equilibrium is achieved, the final level of the pit lake would vary in elevation from 571 mAHD to 577 mAHD with an average elevation of 574 mAHD. The theoretical total potential storage volume to 597 mAHD is approximately 22 GL and the stored water volume at the predicted final level of 574 mAHD would be approximately 14.2 GL.

7.3 CONCEPTUAL MODEL

It is proposed that the final void would remain a groundwater sink following mine closure, thereby preventing discharge to the surrounding aquifers as well as limiting the oxidation of any remaining sulphide minerals on the terminal walls of the open cut pit.

This would be achieved by limiting the amount of surface water directed to the final void such that the evaporation exceeds the long-term rate of rainfall and runoff in the final void.

A representative schematisation of a conceptual final void water balance is presented in **Figure 7.3**.

The figure shows that key water inputs include rainfall on the pit lake water surface, runoff from pit faces (runoff from upstream areas is to be largely diverted around the final void), and groundwater inflow. Outflows are limited to evaporation.

Figure 7.1 Final Landform and Final Void Catchment

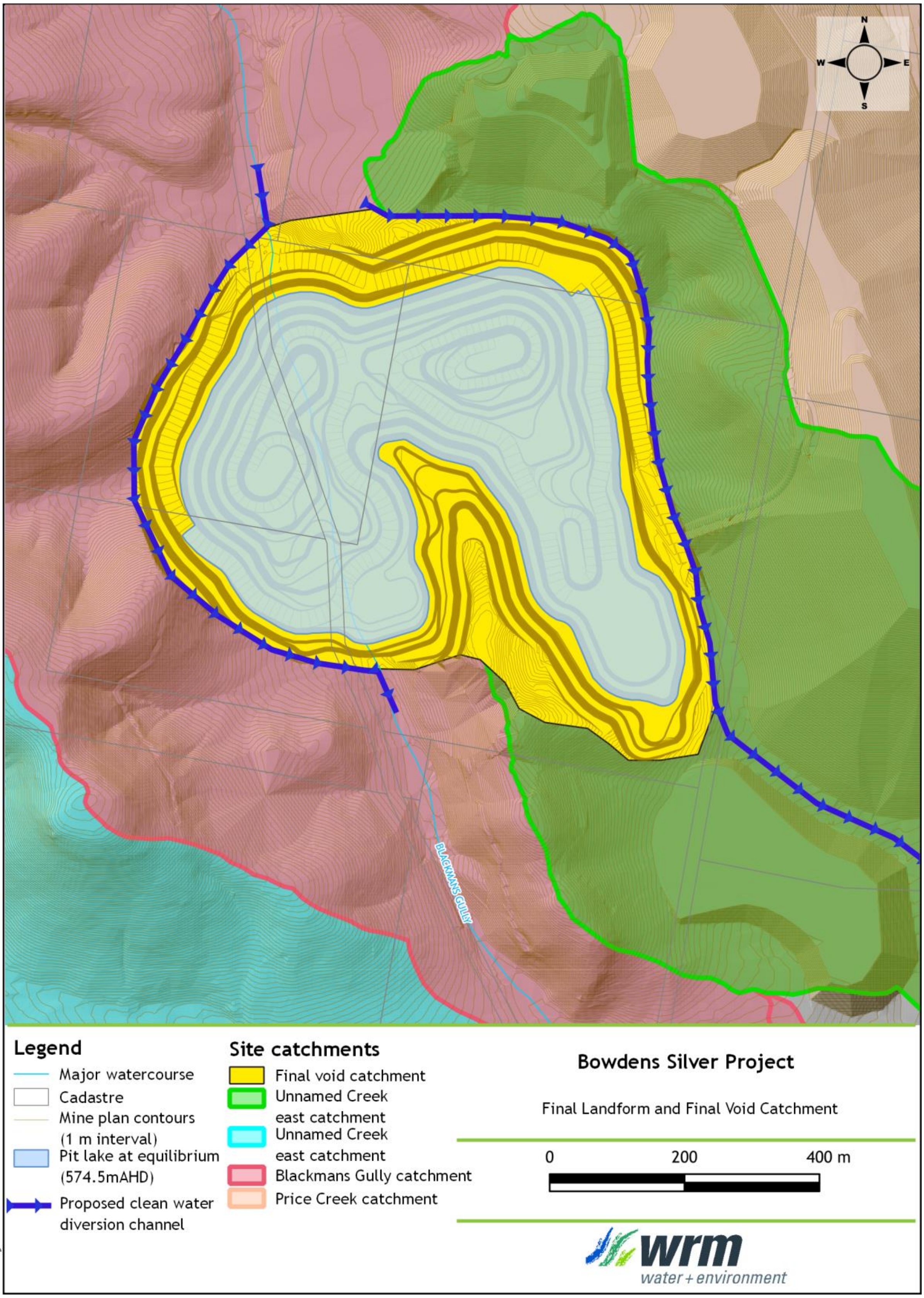


Figure 7.2 Final Landform and Flood Levels in Probable Maximum Flood

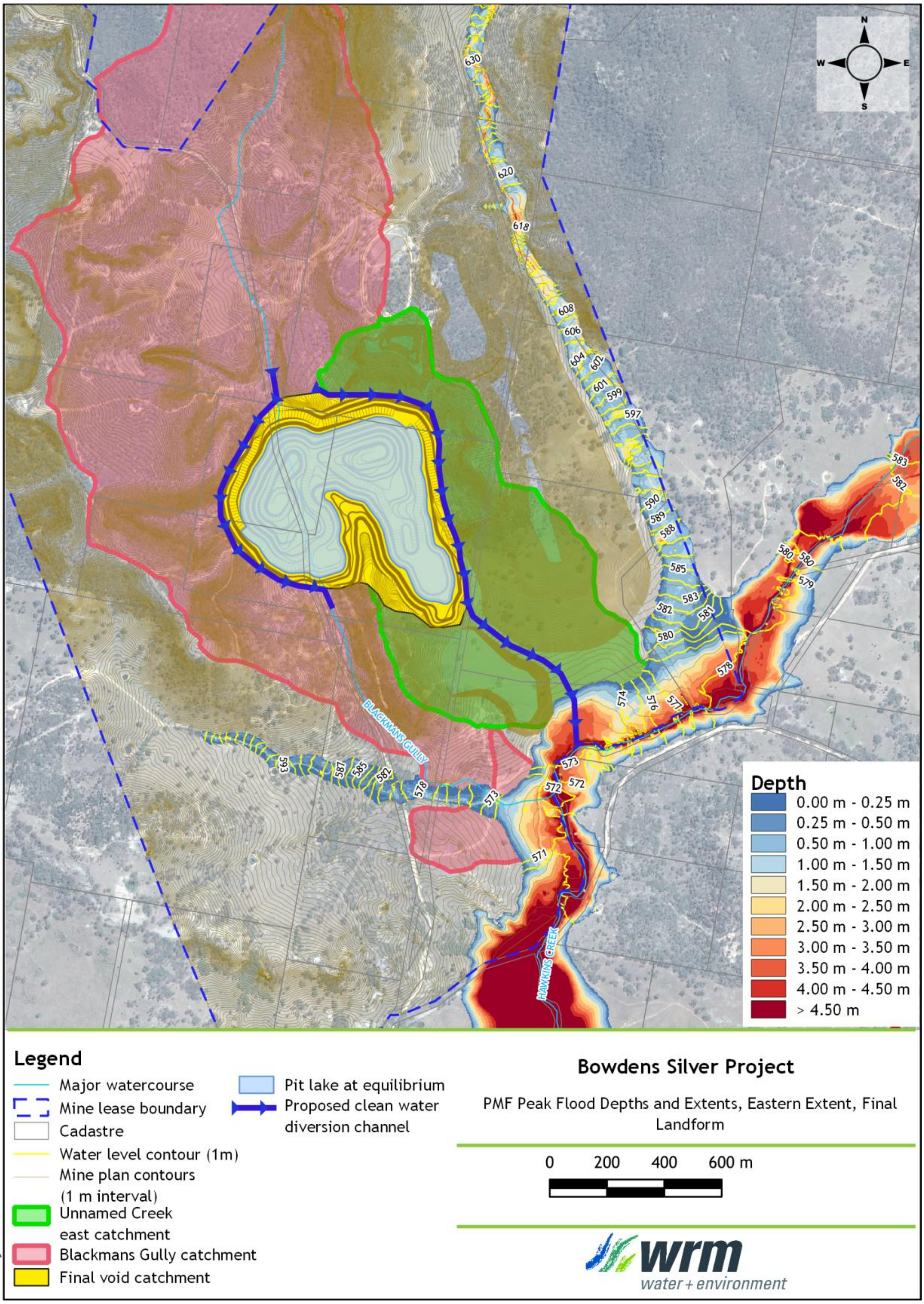
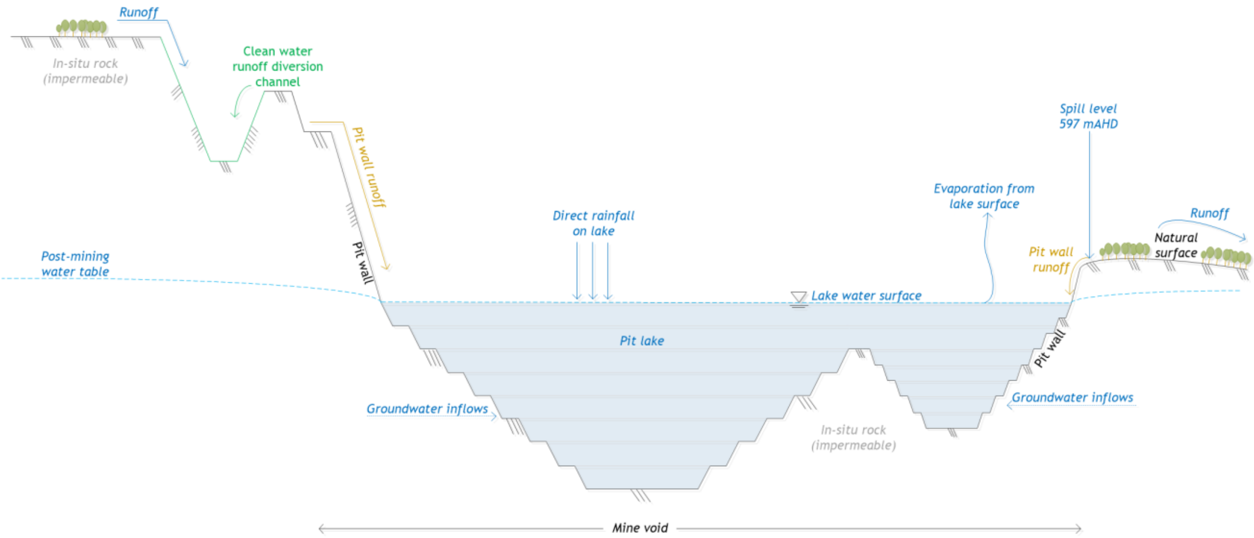


Figure 7.3 Final Void Model Schematic



Sources of salt include chemical constituents dissolved in groundwater and catchment runoff. In the absence of any seepage or surface outflows to the environment, there is generally no removal of chemical constituents from the system, and thus, chemical constituents are expected to accumulate over time.

In principle, for an initially empty void, water is expected to accumulate until evaporative losses from the wetted surface area balance the combined influence of catchment runoff, rainfall and groundwater inflow. Where catchment inflows are limited, over a sufficiently long time-scale, water levels are expected to reach a nominal steady state, with some variation about the steady state level during prolonged periods of wet or dry climate bias. This principle works in reverse for any voids that are filled (e.g. by pumping) above their steady state level prior to relinquishment; water levels would reduce due to evaporation until the wetted surface contracts to a point where evaporative losses balance all inflows.

7.4 NUMERICAL MODELLING APPROACH

The GoldSIM model simulates the generation, movement and loss of water on a daily time-step within the final void, over a 400-year period. The volume of water in the void is calculated at each time step as the sum of direct rainfall to the void surface, catchment runoff, and groundwater inflows, less evaporation losses.

The model also tracks the quantity of salt captured and stored within the final void. Key components of the model are summarised in the following subsections, including descriptions of key model inputs, assumptions and sensitivity parameters.

7.5 STAGE-STORAGE CHARACTERISTICS

The stage-storage and stage-area curves for the void were estimated from the final open cut pit plan for the Project (AMC, 2018).

7.6 CATCHMENT RUNOFF

Surface runoff catchment areas draining to the final void were determined based on the adopted final landform. It was assumed that the surface catchment draining to the void would be minimised by:

- Diverting Blackmans Gully around the western margin of the final void; and
- Diverting the undisturbed areas to the north and east of the void around the eastern margin of the final void.

The AWBM was used to model surface water runoff. After diversion of the above catchments, the remaining surface catchment is essentially all pit wall and pit lake surface. The AWBM parameters adopted for the open cut pit in the operational water balance were also used for the final void analysis. The surface water catchment is 53.1 ha.

For estimating the contribution of catchment runoff to void lake salinity, a catchment runoff salinity of 130 µS/cm (based on the results of waste rock leachate sample data GCA (2020)) was adopted.

7.7 PIT SURFACE EVAPORATION

Evaporation from the final void pit lake water surface was modelled using estimates of Morton's Lake evaporation. The reduced evaporation resulting from shading and wind shielding provided by the pit walls was modelled using an adjustment factor referred to herein as the 'pit factor'. A linearly varying depth-dependent storage evaporation factor was applied to the final void to simulate the change in evaporation as void water levels increase. The storage evaporation factors are as follows:

- Bottom of void – 0.5; and
- Top of void – 0.8.

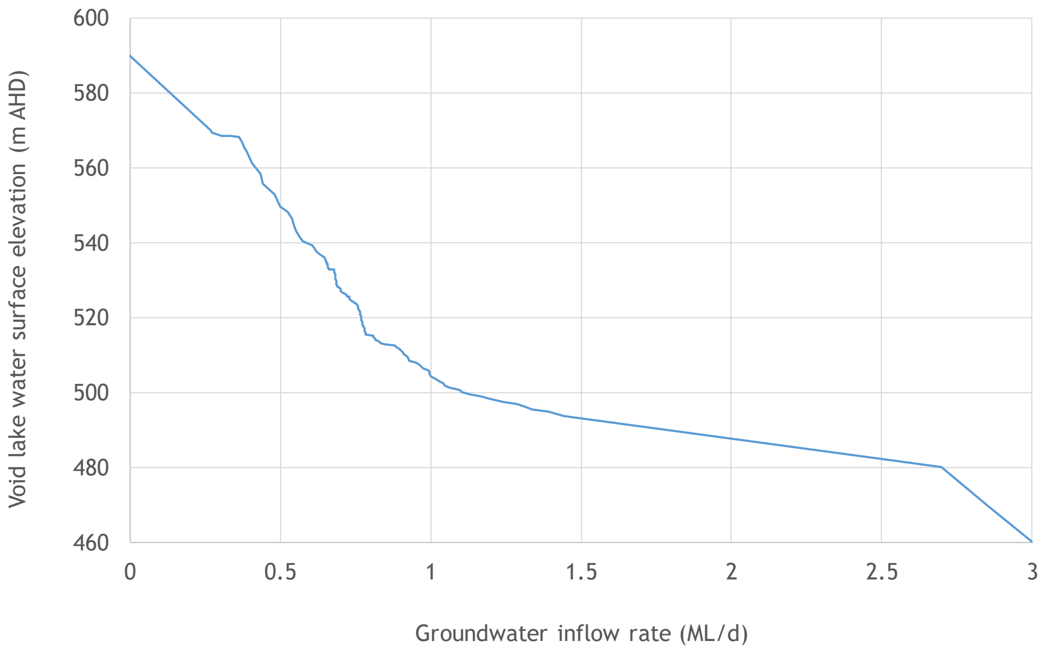
7.8 GROUNDWATER

Groundwater inflows to the final void were based on the results of groundwater modelling undertaken by Jacobs (2020). **Figure 7.4** shows the pit lake water level versus groundwater inflow rates provided by Jacobs and used in the analysis.

The curve shows that for void lake water levels up to approximately 500 mAHD, the expected inflow rate exceeds 1 ML/d. At higher levels, the inflow rate would reduce, eventually reaching zero at an elevation of approximately 590 mAHD.

For estimating the contribution of groundwater to void lake salinity, a groundwater inflow salinity (EC) of 1 420 µS/cm (which is the median of site bore samples) was adopted.

Figure 7.4 Water Elevation vs Groundwater Inflow Relationship



7.9 CLIMATE CHANGE IMPACTS

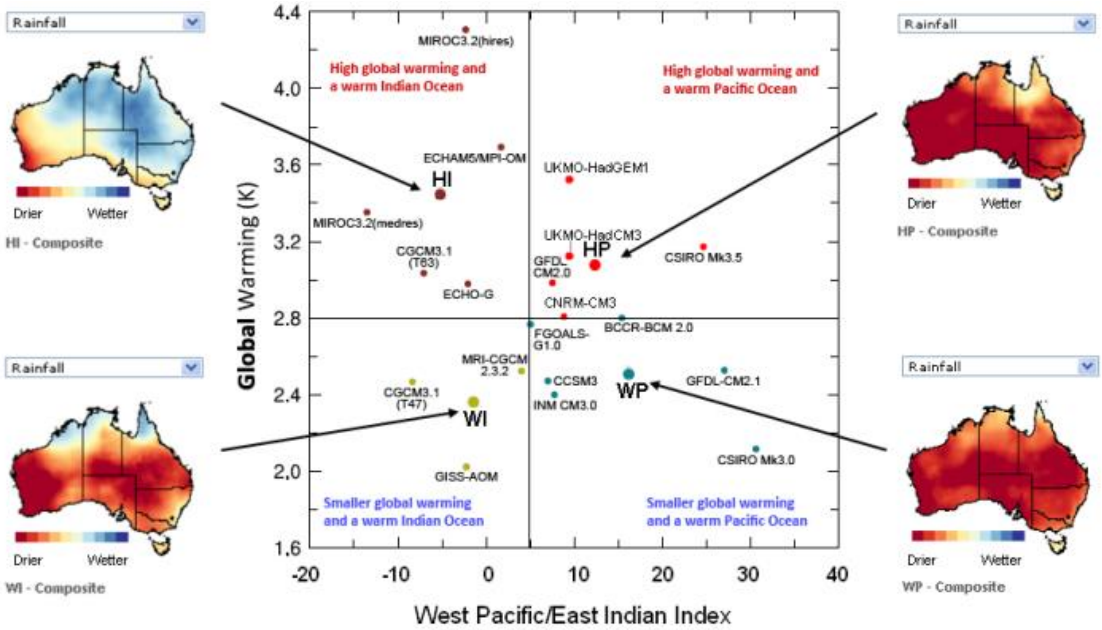
Climate-change adjusted SILO climate data are available from the Queensland Government Department of Environment and Science (DES), and were developed as part of the Consistent Climate Scenarios (CCS) project. The CCS project hosts data from 19 separate global climate models (GCMs), which explore four emissions scenarios, three timing horizons and three climate warming sensitivities. The nineteen separate models can be split into four Representative Future Climate (RFC) partitions, defined below:

- **HI**: a high level of global warming, where the Eastern Indian Ocean (EIO) warms faster than the Western Pacific Ocean (WPO);
- HP: a high level of global warming, where the WPO warms faster than the EIO;
- WI: a low level of global warming, where the EIO warms faster than the WPO; and
- WP: a low level of global warming, where the WPO warms faster than the EIO.

Figure 7.5 is an excerpt from the CCS project user guide (DSITIA, 2015) showing the four RFC quadrants, component models and indicative rainfall trends. The caption associated with the original version of this figure has been reproduced as a footnote to **Figure 7.5**.

Data based on the mean result of all models within each RFC quadrant is offered by the CCS for applications where considering the output of all 19 models is not feasible/practical. This approach has been followed for the purposes of assessing climate change sensitivity as part of current investigations. **Table 7.1** and **Table 7.2** list the percentage change in evaporation and rainfall respectively, based on mean output for the four RFC quadrants. Data is based on the most conservative carbon emission rate (RCP8.5) available in the CCS dataset, and expected climate as at 2070. Data has been listed for the low, medium and high sensitivities. Information is for the Mine Site location.

Figure 7.5 A partition of Global Climate Models for Future Climate using Global Warming Sensitivity and Ocean Warming Indices (source: DSITIA, 2015)



Note: From DSITIA, 2015 – Figure 8.1 (verbatim): A partition of CMIP3 Global Climate Models (GCMs) for future climate using global warming sensitivity and ocean warming indices (adapted from Watterson, 2011). Values for nineteen individual GCMs (forced by the SRES A1B emissions scenario) are represented by the small dots and labelled by their GCM model code (Table 8.2). The central horizontal and vertical lines separate the four Representative Future Climate (RFC) partitions. The larger dots indicate the CCS composite means for GCMs within each of the four RFC responses: (HI) high global warming and a warmer Indian Ocean; (HP) high global warming and a warmer Pacific Ocean; (WP) lower global warming and a warmer Indian Ocean and (WP) lower global warming and a warmer Pacific Ocean. The maps show projected 21st Century changes in rainfall for the GCMs clustered in each of the four (HI, HP, WI and WP) RFC partitions.

The adjustments listed in **Table 7.1** and **Table 7.2** have been applied to the long-term SILO daily climate time-series, and passed through the AWBM rainfall runoff sub-model to produce daily estimates of runoff (rehabilitated land use AWBM parameter set used). Annual average runoff depths have been plotted against average annual net evaporation depths (evaporation minus rainfall) in **Figure 7.6** to illustrate the potential to impact long-term water levels in the final void pit lake. Note the naming convention used in the figure, and henceforth in this document, is XX.Y where XX is the scenario (e.g. HI) and Y is the sensitivity (medium).

Table 7.1
Percentage change in Evaporation by Model and Sensitivity

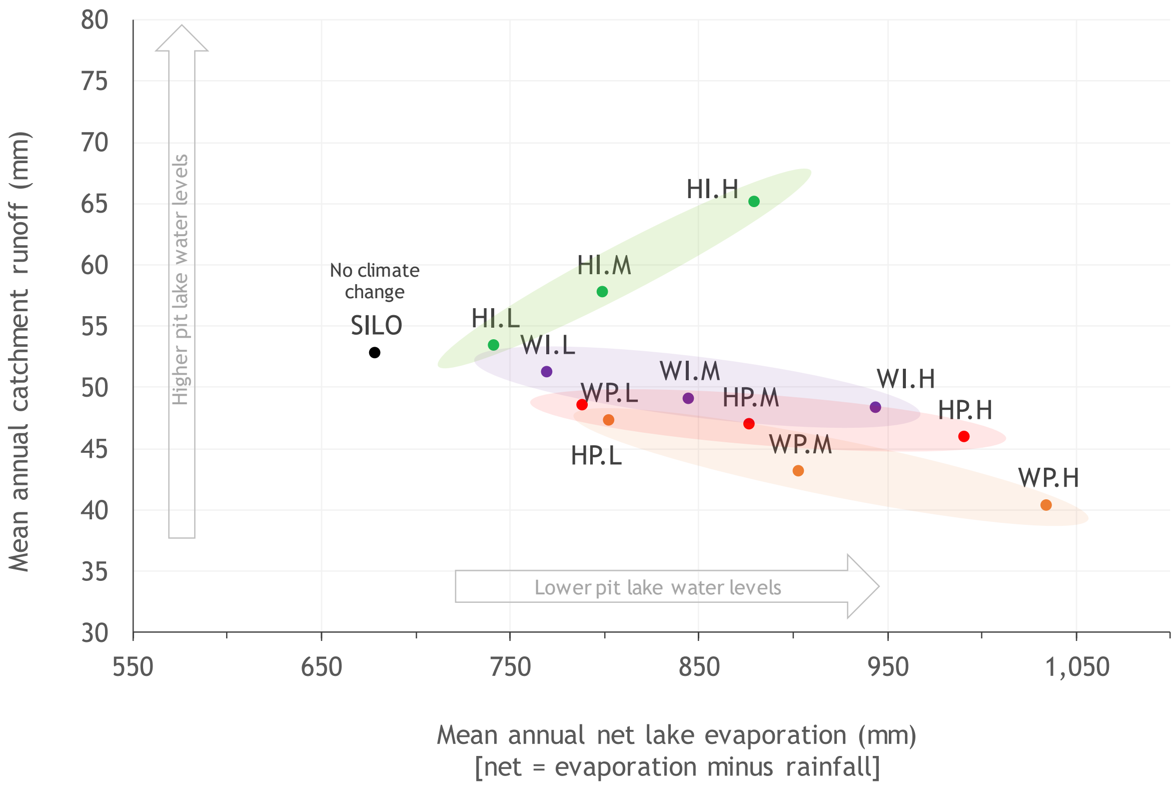
Model*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HI (high)	4.5	8.5	12.1	14.8	11.2	4.3	15.9	29.8	30.4	29.6	23.3	14.2	17.1
HI (med)	2.5	5.1	7.1	8.8	6.7	2.7	10.2	18.6	18.6	18.2	14.2	8.5	10.8
HI (low)	1.2	2.6	3.7	4.5	3.5	1.5	5.7	10.2	10.0	9.8	7.6	4.4	6.2
HP (high)	13.2	10.2	13.8	17.0	16.2	11.3	18.7	27.2	33.2	34.7	21.6	15.4	19.9
HP (med)	8.2	6.3	8.6	10.4	10.2	7.4	12.0	17.3	21.0	21.8	13.5	9.6	12.8
HP (low)	4.5	3.4	4.6	5.6	5.6	4.2	6.7	9.6	11.6	12.0	7.4	5.3	7.5
WI (high)	13.9	16.7	15.4	17.1	13.2	13.0	19.3	23.6	28.6	24.2	20.1	18.1	19.7
WI (med)	8.6	10.4	9.6	10.5	8.1	8.5	12.3	14.8	17.9	15.0	12.6	11.3	12.6
WI (low)	4.7	5.7	5.2	5.6	4.4	4.8	6.9	8.1	9.8	8.1	6.9	6.2	7.3
WP (high)	11.8	14.0	16.3	27.1	16.2	11.8	23.7	28.6	35.8	39.0	27.6	15.5	22.7
WP (med)	7.3	8.8	10.1	17.0	10.0	7.7	15.3	18.0	22.4	24.1	17.1	9.6	14.5
WP (low)	3.9	4.8	5.5	9.3	5.4	4.4	8.6	9.9	12.2	13.0	9.3	5.2	8.4
Note: * model is RFC partition, text in brackets is the sensitivity													

Table 7.2
Percentage change in Rainfall by Model and Sensitivity

Model*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HI (high)	68.9	35.5	14.8	9.4	-1.1	-22.1	-58.4	-73.7	-13.4	-30.3	3.0	62.6	4.2
HI (med)	46.2	23.8	9.9	6.3	-0.7	-14.8	-39.2	-49.4	-9.0	-20.3	2.0	42.0	2.8
HI (low)	26.8	13.8	5.8	3.6	-0.4	-8.6	-22.7	-28.7	-5.2	-11.8	1.2	24.4	1.6
HP (high)	22.9	17.4	11.5	-2.3	-22.6	-22.9	-17.8	-28.7	-41.3	-35.3	-5.3	8.8	-7.6
HP (med)	15.3	11.7	7.7	-1.6	-15.1	-15.4	-11.9	-19.3	-27.7	-23.7	-3.6	5.9	-5.1
HP (low)	8.9	6.8	4.5	-0.9	-8.8	-8.9	-6.9	-11.2	-16.1	-13.7	-2.1	3.4	-3.0
WI (high)	-1.5	2.6	6.9	-0.1	-11.3	-17.0	-16.6	-0.7	-8.1	9.0	6.9	0.5	-1.7
WI (med)	-1.0	1.8	4.6	0.0	-7.6	-11.4	-11.2	-0.4	-5.4	6.0	4.6	0.3	-1.1
WI (low)	-0.6	1.0	2.7	0.0	-4.4	-6.6	-6.5	-0.3	-3.2	3.5	2.7	0.2	-0.7
WP (high)	17.4	-5.7	-6.8	-40.5	-47.1	5.5	-36.6	-6.8	-8.6	-16.0	-23.1	34.4	-8.8
WP (med)	11.7	-3.8	-4.6	-27.2	-31.6	3.7	-24.6	-4.5	-5.7	-10.7	-15.5	23.0	-5.9
WP (low)	6.8	-2.2	-2.6	-15.8	-18.3	2.1	-14.3	-2.6	-3.3	-6.2	-9.0	13.4	-3.4
Note: * model is RFC partition, text in brackets is the sensitivity													

Figure 7.6 shows that all scenarios predict increases in net evaporation, and that (with the exception of the HI models) all scenarios predict reductions in runoff. The sensitivity of final void pit lake water levels to changes in future climate change have been assessed by modelling all the above scenarios.

Figure 7.6 Plot of Net Evaporation versus Runoff for HI, HP, WI and WP GCM Groupings



7.10 MODEL RESULTS

Figure 7.7 shows the simulated long-term water levels in the main final open cut pit void. The results show the following:

- Under the existing (SILO) climate scenario - the water level would reach around 574.5 mAHD after 125 years and varies in a 6.5 m band throughout the remainder of the simulation. At this elevation, the stored water volume is approximately 14.2 GL.
- The maximum modelled water level is below 577.3 mAHD – or about 19.7 m below the void overflow level of 597 mAHD.
- As there are no outflows from the void, salinity would increase over time. **Figure 7.8** shows that the modelled salinity after 500 years is approximately 5 000 μS/cm. The following pit lake salinities are predicted to develop over time:
  - 100 years – 2 000 μS/cm
  - 200 years – 2 880 μS/cm
  - 300 years – 3 725 μS/cm
  - 400 years – 4 375 μS/cm
  - 500 years – 5 375 μS/cm
- Under the climate change scenarios, the equilibrium water level would be lower than the existing climate scenario as the result of the increased evaporation.

Table 7.3 summarises the simulated long-term water balance under the WI.M scenario, which is closest to the average of all modelled climate scenarios. Under this scenario, at equilibrium the water level fluctuates between 566.5 mAHD and 572.5 mAHD. The table shows that over the period of simulation, the average groundwater inflow is 102 ML/a (ranging between approximately 0.3 ML/a and 184 ML/a). Direct rainfall averages 183 ML/a, and runoff contributes 24 ML/a on average. These inflows are balanced by average evaporation of 309 ML/a.

7.11 SENSITIVITY ANALYSIS

The sensitivity of the equilibrium water level to uncertainty in the key input parameters was tested by:

- reducing the evaporation factor to 0.7 at the maximum void water; and
- reducing the AWBM USC values for pit wall catchments to half their original values (C_{av} = 13.3 mm) – to increase runoff to the void.

Under these conditions, the maximum modelled water level is 583.3 mAHD for existing climate conditions. If the groundwater inflow relationship is also increased (noting that this is unlikely (Jacobs, 2020)), the maximum water levels increase to the following:

- GW inflow x 1.5 = 586.0 mAHD (49.7 ML/a on average at equilibrium).
- GW inflow x 2.0 = 587.3 mAHD (52.2 ML/a on average at equilibrium).

Figure 7.7 Results of Final Void Modelling – Lake Water Levels

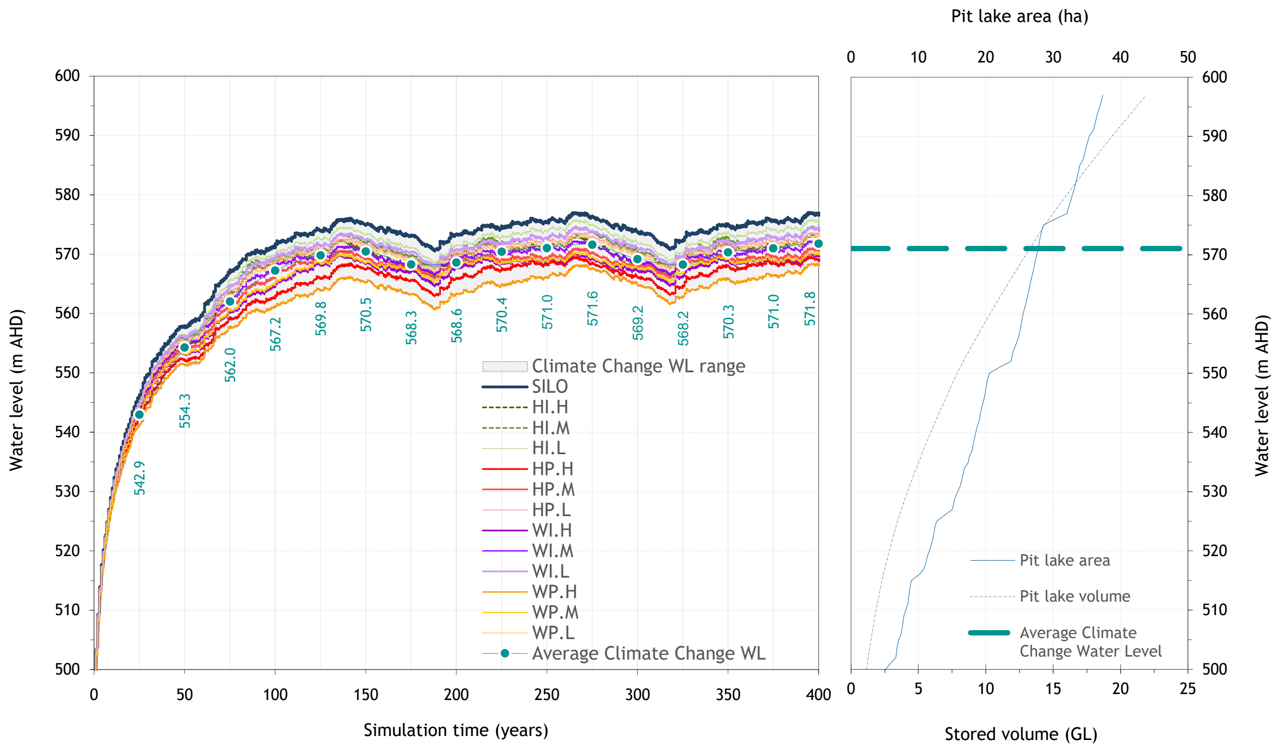


Figure 7.8 Results of Final Void Modelling – Lake Salinity (Existing Climate Scenario)

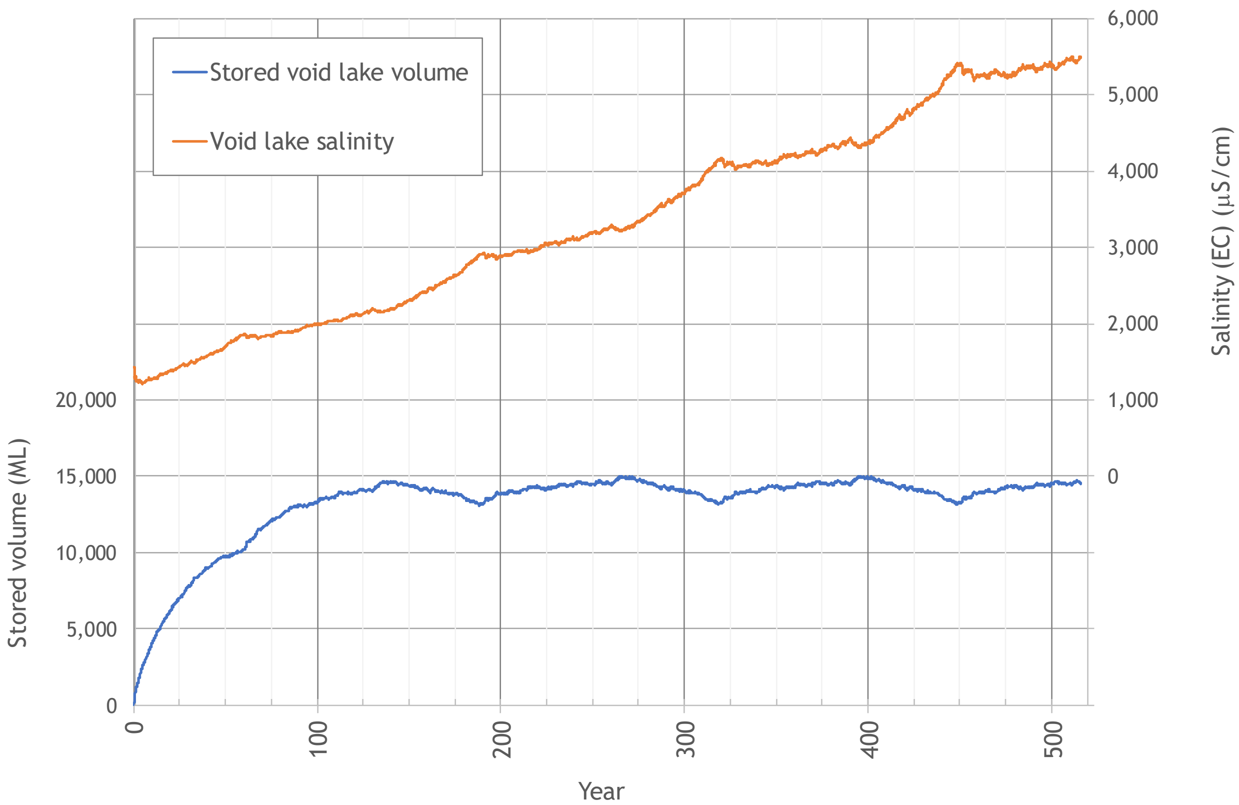


Table 7.3
Average Annual Final Void Water Balance – at Equilibrium

		Climate Scenario	
		Existing (SILO)	**Average Climate Change (WI.M)**
Climate Averages			
Evaporation	mm/a	1 354	1 513
Rainfall	mm/a	674	665
Runoff characteristics			
Pit Wall Runoff	mm/a	*100*	*93*
Pit Wall runoff/rainfall		14.8%	14.0%
Inflows			
Direct Rainfall	ML/a	195	183
Pit runoff	ML/a	24	24
GW inflow	ML/a	76	102
Outflows			
Pit evaporation	ML/a	295	309

Bowdens Silver is giving consideration to increasing the rate of initial fill of the final void to reduce the extent of the cone of groundwater drawdown and minimise oxidation of the exposed mineralisation on the pit walls. This could be achieved by transferring excess water from the TSF prior to its decommissioning and by temporarily directing runoff from the upslope Blackmans Gully catchment (150 ha) to the final void. Based on sensitivity testing of the final void water balance, runoff from the additional catchment would see the stored water level rise a further 8 m (approximately 1,200 ML (modelled range +/- 1.8 m depending on prevailing weather conditions)) in the first 10 years post-mining compared to the base case. This additional rise in water level would limit the generation of acidic drainage from the exposed faces within the main open cut pit, a feature that would limit the dissolved metal content in the final pit void lake.

8. POTENTIAL SURFACE WATER IMPACTS AND MITIGATION MEASURES

There are a number of mechanisms whereby the Project could potentially impact on downstream surface water flow in Lawsons Creek and its tributaries:

- interception of runoff by the mine water management system;
- change in runoff characteristics in areas disturbed by the mining and related activities; and
- loss of baseflow recharge to streamflow due to impacts on the local groundwater profile.

These impacts, and associated licensing requirements are quantified for the operational and post-mining periods in the following sections.

8.1 WATER ENTITLEMENT REQUIREMENTS

Surface water intercepted by the project is required to be licensed by way of a water access licence (WAL) granted under the Water Sharing Plan (the Plan) for Macquarie Bogan Unregulated and Alluvial Water Sources (2012): Lawsons Creek Water Source.

While the principal make-up water source for the Project would be water delivered from the Ulan Coal Mine and/or Moolarben Coal Mine, there are two main mechanisms by which the Project could reduce surface water flows in the Lawsons Creek Water Source:

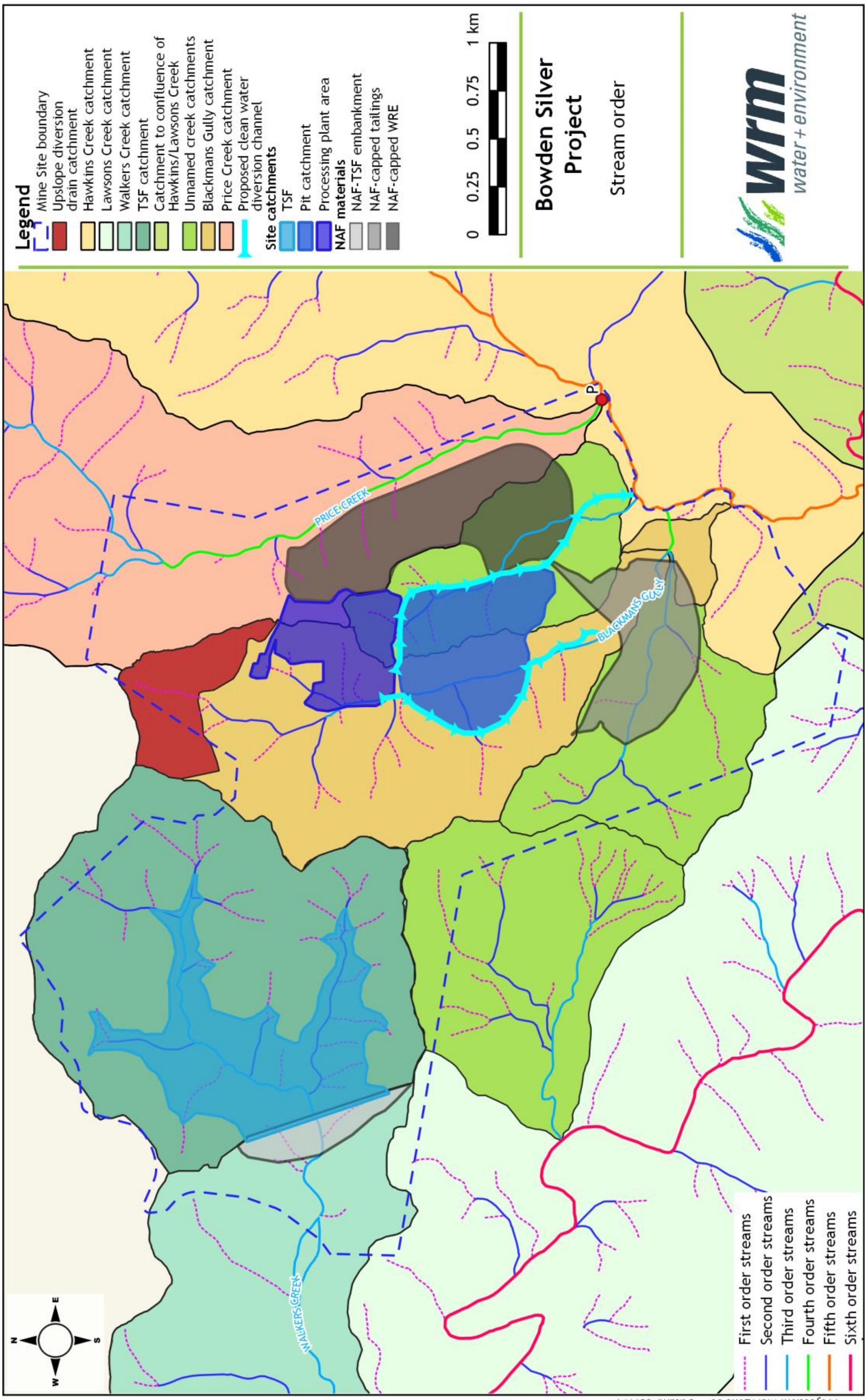
- Loss of baseflow contributions to streamflow, due to the impact of drawdown on the local groundwater profile by the open cut pit; and
- Interception of runoff in the water management system.

However, exemptions apply to the Project where water is taken from a minor stream (a first or second order stream (under the Strahler system) (that does not maintain a permanent flow of water), and is defined in the hydroline spatial data published on the Department's website).

Figure 8.1 shows (based on the hydroline spatial data) the Strahler stream order for streams crossing parts of the Mine Site where water would be intercepted during operations. The figure shows that all proposed water storages would be off-stream storages, except that:

- Walkers Creek is a third order stream where it would be crossed by the proposed TSF embankment.
- Blackmans Gully and the unnamed gully to the east are both third order streams where they would be crossed by the proposed open cut pit. However, these streams are to be diverted around the pit.

Figure 8.1 Strahler stream order of existing streams crossing the Mine Site



8.1.1 Exemptions under the Water Management Regulation 2018 (the Regulation)

Schedule 5 of the Water Management (General) Regulation 2018 (the Regulation) provides a water access licence is not required for water take that is caused by an “excluded work” as outlined in Schedule 1 of the Regulation. Schedule 1, lists a number of exemptions, two of which potentially apply to this Project:

1 Dams solely for the control or prevention of soil erosion—

(a) from which no water is reticulated (unless, if the dam is fenced off for erosion control purposes, to a stock drinking trough in an adjoining paddock) or pumped, and

(b) the structural size of which is the minimum necessary to fulfil the erosion control function, and

(c) that are located on a minor stream.

3 Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority (other than Landcom or the Superannuation Administration Corporation or any of their subsidiaries) to prevent the contamination of a water source, that are located on a minor stream.

8.1.2 Harvestable Rights

Under the Water Management Act 2000, landholders in most rural areas are permitted to collect a proportion of the rainfall runoff on their property and store it in one or more dams up to a certain size. This is known as a 'harvestable right'. A dam can capture up to 10 percent of the average regional rainfall runoff for their landholding without requiring a licence. The harvestable rights provisions are based on the assumption that the dam capacity is the same as this portion of the annual runoff. Harvestable rights dams must be located off-stream or on a minor stream.

The NSW Office of Water Harvestable Rights calculator estimates the harvestable right dam capacity at the Mine Site as 0.07 ML/ha. This capacity represents 10% of the mean regional annual runoff of 0.7 ML/ha or 70 mm.

Using the Bowdens Silver landholding area of 1,990 ha and the above multiple of 0.07 ML/ha RWC has calculated the maximum harvestable rights capacity permissible volume of 139.3 ML.

Bowdens’ landholding includes approximately 76 existing farm dams, the total capacity of which is estimated at 49.6 ML. A total of 25 dams with a combined capacity of approximately 16.3 ML would be removed during the Project life. This would leave a total of 51 dams, with a total capacity of approximately 33.3 ML.

The harvestable right dam capacity for the remainder of the Bowdens Silver property would therefore be 139.3ML – 33.3ML = 106 ML.

8.1.3 Proposed WAL requirements

8.1.3.1 Sediment Dams

Water captured in sediment dams would be released in accordance with best practice, and would therefore be exempt from licensing.

In the event that (even after the addition of a flocculant) the quality of water captured in the Containment Zone was such that it could not be released it would be contained on site. No sediment dams would be constructed on a major stream. Therefore, these dams would be used "solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority to prevent the contamination of a water source", and the captured runoff would be exempt from licensing.

8.1.3.2 Water Management Dams Within the Containment Zone

None of the dams within the Water Management System's Containment Zone would be constructed on major streams. As these dams would be constructed "solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority to prevent the contamination of a water source", water captured in these dams would be exempt from licensing.

8.1.3.3 Open Cut Pit

Similarly, while Blackmans Gully is a 3rd order stream where it crosses the proposed main open cut pit, it would be permanently diverted to minimise the quantity runoff captured in the open cut pit. Rainfall and runoff captured within the Open Cut Pit and its final void would be contained within the site water management system to prevent contamination of the water source, and would therefore be exempt from licensing. As water would not be allowed to pond in the diversion, the water diverted by the diversion would be exempt from requiring a water entitlement.

8.1.3.4 Tailings storage facility

As the TSF embankment would be constructed across a 3rd order stream, WAL exemptions do not apply. Bowdens Silver would obtain WALs for water captured in the TSF prior to decommissioning and rehabilitation. WALs would be obtained for the 80th percentile of annual runoff (estimated as 0.41 ML/ha based on modelling of catchment runoff using the AWBM calibrated as described in section 3.5) from the pre-mine catchment area (up to 301.2 ha), i.e. an entitlement equivalent to 123 ML/a. Bowdens Silver would investigate the potential for reducing the WAL requirement by capturing clean runoff (in accordance with its Harvestable Rights) in additional clean water dams to be constructed upslope of the TSF on minor streams.

8.1.3.5 Baseflow loss due to groundwater drawdown

Due to the impact of drawdown on the local groundwater profile by the open cut pit. The groundwater assessment (Jacobs, 2020) predicts the reduction in baseflow would increase during operations such that at the conclusion of mining operations, the baseflow loss would be up to approximately 12.9 ML/a, increasing to up to 22 ML/a post mining. A water access licence would be obtained for this loss as described in the groundwater assessment (Jacobs, 2020).

8.1.3.6 Total WAL required

Based on the above estimates, the total entitlement required for the Project would be as follows:

- During operations – 136 ML/a;
- Post closure – 22 ML/a.

8.2 INTERCEPTION OF RUNOFF IN THE WATER MANAGEMENT SYSTEM

8.2.1 Operational Stage

Water impacted by the mining-related activities and captured in the water management system would be contained on site and re-used.

The catchment area of this containment system would vary over the Project life, and is expected to peak at approximately 550 ha (comprising approximately 300 ha in the TSF catchment and 250 ha in the remainder of the water management system), i.e. or 2.1% of the Lawsons Creek catchment (of 272 km^2 downstream of the Walkers Creek confluence) would be lost. Based on the estimated average undisturbed area runoff in the local catchment, this equates to an average annual loss of flow of 177 ML/a.

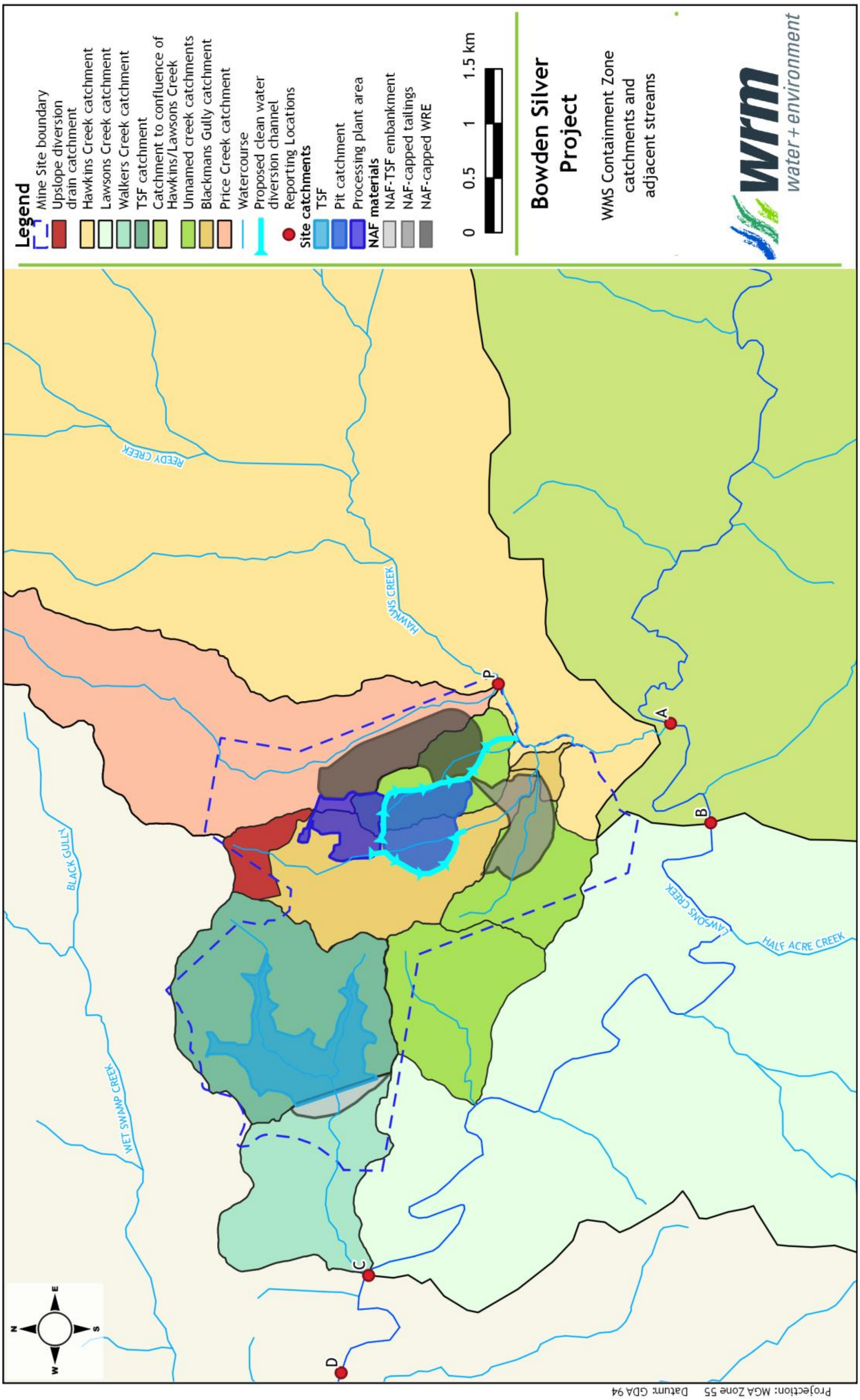
Note also that during operations, part of the undisturbed upslope catchment of Blackmans Gully would be diverted east to Price Creek. The effect of this diversion is to slightly increase streamflow in Price Creek and the reach of Hawkins Creek between the Price Creek and Blackmans Gully confluences. The area diverted is approximately 50 ha. In an average year, approximately 10 ML would be diverted from the Blackmans Gully catchment. As this minor change in flow distribution between Blackmans Gully and Price Creek is small, no mitigation measures are proposed for this temporary change.

8.2.2 Post-mining Period

At the completion of mining and processing operations, the WRE and the TSF would be capped and rehabilitated, so that runoff, once rehabilitation criteria relating to water quality have been met, would be allowed to freely discharge to the receiving environment.

The final post-mining landform would comprise a final void, which would capture runoff from the immediate surface catchment. Modelling of the long-term behaviour of the final void pit lake shows that water would not overflow from the final void, and runoff from this area would be lost from the surface catchment contributing to downstream flow. The catchment area of the final void after the completion of closure and rehabilitation activities would be approximately 53 ha or 0.2% of the total 272 km^2 Lawsons Creek catchment that is downstream of the Walkers Creek confluence (see **Figure 8.2**). Based on the estimated average undisturbed area runoff in the local catchment, this equates to an average annual loss of flow of 17 ML/a.

Figure 8.2 WMS Containment Zone catchments and reaches of adjacent streams potentially impacted by the Project



8.3 CHANGE IN RUNOFF CHARACTERISTICS POST-MINING

8.3.1 Post-mining Period

The rehabilitated WRE and TSF landforms would be capped, covered and revegetated, and the runoff characteristics of the post mining landform are expected to be similar to those existing prior to the development of the Project.

As a result, the post-mining change in surface runoff volume from these landforms to the downstream waters is expected to be minimal.

8.4 LOSS OF BASEFLOW

8.4.1 Operational Period

The groundwater assessment (Jacobs, 2020) predicts that drawdown of the local groundwater system that would be induced by groundwater inflow to the open cut pits would result in a reduction in baseflow contributions to both Hawkins Creek and Lawsons Creek. The reduction in baseflow would increase during operations, and near the conclusion of mining, the peak baseflow losses are expected to be up to approximately 0.018 ML/d (6.6 ML/a) and 0.024 ML/d (8.8 ML/a) for Hawkins Creek and Lawsons Creek respectively.

The peak baseflow losses from each creek would not coincide. The maximum predicted take from the Lawsons Creek Water Source, and therefore the volume of share components required to be held by Bowdens Silver as a water access licence (WAL) issued under the Water Sharing Plan (WSP) for Macquarie Bogan Unregulated and Alluvial Water Sources: Lawsons Creek Water Source (2012) during mining is 12.9 ML/a (Jacobs, 2020).

Impacts on baseflow would reduce with distance upstream of the cone of groundwater drawdown. At the end of mining, the 1 m drawdown contour extends to a point on Hawkins Creek approximately 3.5 km upstream from the Lawsons Creek confluence. The impacts of the Project on upstream flow conditions would be minimal.

8.4.2 Post-mining Period

The reduction in baseflow is predicted to increase as the cone of groundwater drawdown grows post-mining, and is expected to peak approximately 12 to 18 years post mining at approximately 0.031 ML/d (11.2 ML/a) for Hawkins Creek and 0.029 ML/d (10.4 ML/a) for Lawsons Creek.

Impacts on baseflow would reduce with distance upstream of the cone of groundwater drawdown. Fifty years post-mining, the 1 m drawdown contour would extend to a point on Hawkins Creek approximately 3.5 km upstream from the Lawsons Creek confluence. The impacts of the Project on upstream flow conditions would be minimal.

For the purpose of this assessment, impacts have been assessed for the following locations shown in **Figure 8.2**:

- The 2.1 km reach of Hawkins Creek from Price Creek to the confluence with Lawsons Creek, i.e. P - A.

- The 12 km reach of Lawsons Creek from Hawkins Creek confluence to upstream of the confluence with Walkers Creek A - C (based on the catchments to B).
- The reach of Lawsons Creek, immediately downstream of the Walkers Creek confluence (C - D) (based on the catchments to location C).

Table 8.1 shows the estimated combined peak impact of the Project on mean annual streamflow in each of the effected reaches. The analysis includes the following key assumptions:

- Areas intercepted by the water management system are the maximum areas over the Project life.
- No water is released from the containment (mine affected) zone water management system.
- Water captured in sediment dams is conservatively assumed to be returned to the water containment system.
- Mean annual runoff (prior to application of instream losses) is approximately 4.9% of mean annual rainfall (based on the runoff model parameters described in **Table 5.4**).

Any additional licensed water extractions under entitlement have been excluded.

Table 8.1
Impact of Project on Mean Annual Streamflow in Downstream Waters

Reach Number	Unit	Operations			Post closure		
		1	2	3	1	2	3
Watercourse and reach		Hawkins Creek	Lawsons Creek	Lawsons Creek	Hawkins Creek	Lawsons Creek	Lawsons Creek
		P - A	B - C	C - D	P - A	B - C	C - D
Pre-mining catchment area	km^2	61.0	222.3	272.1	61.0	222.3	272.1
Catchment area contained in WMS	km^2	2.50	2.50	5.50	0.53	0.53	0.53
Mean annual flow							
Pre-mining	ML/a	1 958	7 136	8 735	1 958	7 136	8 735
Loss due to Mine Site WMS Capture*	ML/a	80.3	80.3	176.6	17.0	17.0	17.0
Potential baseflow reduction*	ML/a	6.6	8.8	12.9	11.2	10.4	21.7
Total change due to the Project	ML/a	-86.2	-88.2	-188.3	-27.2	-26.5	-36.7
Percent change due to the Project		-4.4%	-1.2%	-2.2%	-1.4%	-0.4%	-0.4%
Note that in low flow the reduction reduces to zero on zero flow days The baseflow losses from each creek would not coincide							

In summary, the results show that:

- The total average annual loss of flow from the Macquarie Bogan Unregulated and Alluvial Water Sources is estimated to be:
  - Operational period (peak) – 188 ML/a; and
  - Post mining – 37 ML/a.

  Water entitlements for these losses will be obtained as detailed in the following sections.

- The Project would not impact on:
  - Hawkins Creek upstream of the cone of groundwater drawdown, which extends approximately 3.5 km upstream of the Project;
  - Lawsons Creek upstream of the Hawkins Creek confluence.
- During operations, the maximum impact of the Project on downstream flow would be to decrease flows in:
  - the downstream 3.5 km of Hawkins Creek to the Lawsons Creek confluence by up to 4.4%;
  - Lawsons Creek downstream of Hawkins Creek and the Mine Site and upstream of the Walkers Creek confluence by up to 1.2%;
  - Lawsons Creek downstream of the Walkers Creek confluence by up to 2.2%. The relative impact on Lawsons Creek would reduce significantly downstream due to the contribution of other tributaries in the 235 km^2 catchment downstream of Point C to total streamflow.
- Post mining, the maximum impact of the Project on downstream flow would be to decrease flows in:
  - the 3.5 km reach of Hawkins Creek upstream of the Lawsons Creek confluence by up to 1.4%;
  - Lawsons Creek downstream of Hawkins Creek and the Mine Site and upstream of the TSF by up to 0.4%;
  - Lawsons Creek downstream of Walkers Creek and the TSF by up to 0.4%. The relative impact on Lawsons Creek would reduce significantly downstream due to the contribution of other tributaries in the 235 km^2 catchment downstream of Point C to total streamflow.

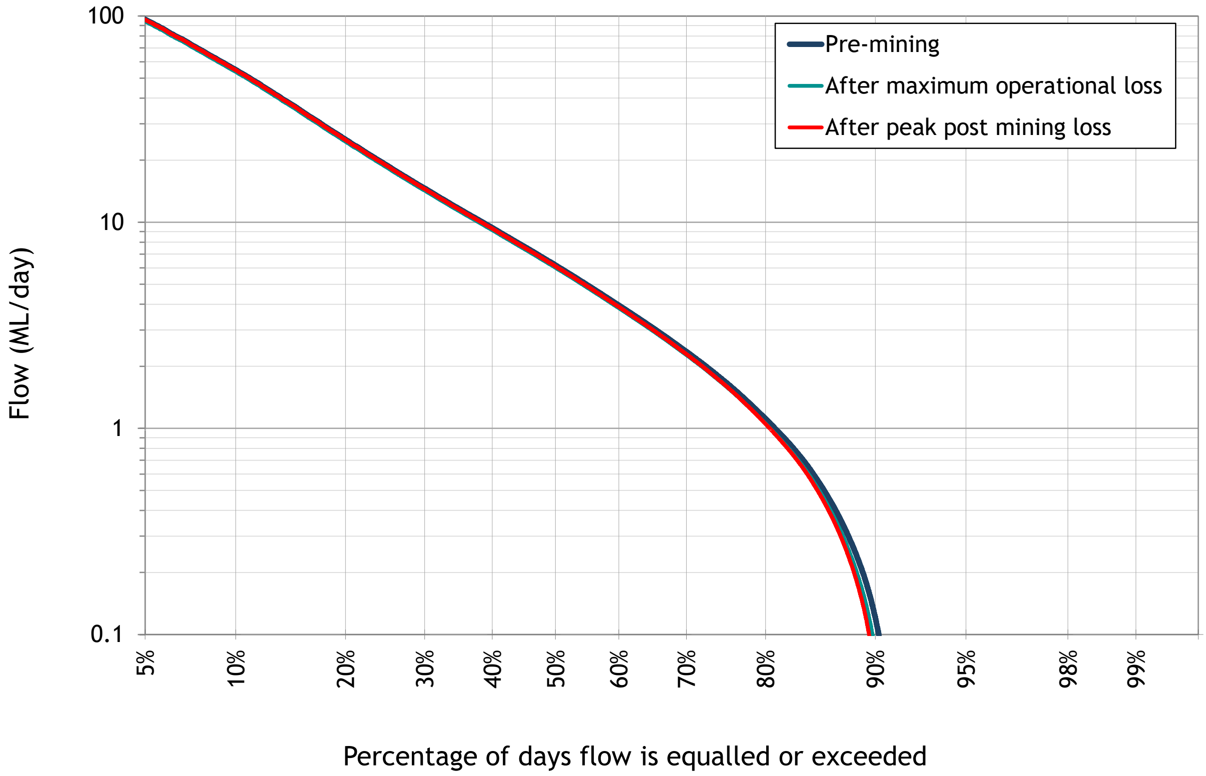
8.5 IMPACTS OF STREAMFLOW LOSS ON OTHER SURFACE WATER USERS

The Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources states that water must not be taken under a WAL when there is no visible flow or where a licence permits take from an in-river pool, when the volume in that pool is less than its full capacity.

The principal mechanism by which the Project would affect the quantity of water supplies available to other surface water users in the Lawsons Creek Water Source of the Macquarie Bogan Unregulated and Alluvial Water Sources is by reducing flows such that the frequency and duration of cease-to-flow periods is increased.

Figure 8.3 shows the estimated impact of the Project on the frequency of flows at location C in Lawsons Creek that was conducted by comparing the outputs of the AWBM model of the pre-mining catchment areas (described in Section 3.5.3) with the corresponding results of a model with the reduced catchment area.

Figure 8.3 Effect of Loss on Lawsons Creek Streamflow Frequency - Location C



At this location, flows greater than 1 ML/d (approximately 12 L/s) occur about 81.0% of the time. The results show that the impact of the Project on the frequency of flows greater than 1 ML/d is expected to be minimal (flows greater than 1 ML/day would occur for approximately 80.5% of the time, i.e. a reduction of 0.5% of the time or up to 2 days per year on average) and therefore the impact of the loss on the availability of water to downstream water users would be negligible.

Similarly, the impact on cease-to-flow periods would be minimal, with flows greater than 0.1 ML/d reducing in frequency from 90.2% to 89.8% of the time during operations, and 89.6% of the time after decommissioning.

8.6 POTENTIAL SOURCES OF RUNOFF CONTAMINANTS

The potential sources of contaminants to the surface water environment during operations and after mine closure are listed in **Table 8.2** and **Table 8.3** respectively. The tables list the source catchment and receiving waters for each source and the mitigation measures proposed to prevent contamination of the receiving waters.

Table 8.2
Potential Contaminant sources and Mitigation Measures during Operations

Source Component	Mitigation Measure	Source Catchment / Receiving Waters
Processing Area		
Processing area runoff	Processing plant dams and water management system operation	Blackmans Gully/ Hawkins Creek/ Lawsons Creek
ROM pad – ore stockpile	Processing plant dams	Blackmans Gully/Hawkins Creek
Oxide ore stockpile		
Oxide ore stockpile runoff	Oxide ore stockpile dam	Hawkins Creek/Lawsons Creek
WRE Outer Embankment		
NAF outer embankment runoff	Haul road sediment dam	Price Creek/ Hawkins Creek/ Lawsons Creek
PAF waste rock runoff	PAF waste rock encapsulation and WRE design	Price Creek/ Hawkins Creek/ Lawsons Creek
PAF waste rock leachate	WRE liner and encapsulation design and leachate management dam design	Price Creek/ Hawkins Creek/ Lawsons Creek
Southern Barrier		
Blackmans Gully upslope runoff flowing beneath NAF waste rock in southern barrier	Low level size and culvert	Blackmans Gully/ Hawkins Creek/ Lawsons Creek
NAF waste rock outer embankment runoff	Southern barrier sediment dam	Blackmans Gully/ Hawkins Creek/ Lawsons Creek
TSF		
NAF waste rock embankment runoff	TSF embankment sediment dam	Walkers Creek/ Lawsons Creek
NAF waste rock stockpile area runoff	NAF waste rock stockpile sediment dam	Walkers Creek/ Lawsons Creek
Tailings seepage	TSF liner	Walkers Creek/ Lawsons Creek
Tailings surface runoff	TSF decant design & operation	Walkers Creek/ Lawsons Creek
Tailings liquid fraction containing cyanide and other process reagents	All tailings decant water is returned to the processing plant	Walkers Creek/ Lawsons Creek

Table 8.3
Potential Post-closure Contaminant Sources

Source Component	Mitigation Measure	Source Catchment / Receiving Waters
WRE Outer Embankment		
NAF outer embankment runoff	Vegetated store-and-release cover Haul road sediment dam	Price Creek/ Hawkins Creek/ Lawsons Creek
PAF waste rock leachate	WRE liner and encapsulation	Price Creek/ Hawkins Creek/ Lawsons Creek
TSF		
NAF waste rock outer embankment runoff	Embankment covered with soil and revegetated	Walkers Creek/ Lawsons Creek
Tailings seepage	Vegetated store-and-release cover to eliminate seepage	Walkers Creek/ Lawsons Creek
Tailings surface runoff	Vegetated store-and-release cover to encapsulate tailings	Walkers Creek/ Lawsons Creek
Final Void		
Void lake	Upstream catchment diversion to minimise surface catchment and prevent surface or seepage overflows	Blackmans Gully/ Hawkins Creek/Lawsons Creek

8.6.1 Potential for Contamination due to PAF Waste Rock and Tailings Runoff, Leachate or Seepage

Operations Stage

During operations, runoff, leachate and seepage from PAF waste rock and tailings would be contained in the WRE and TSF respectively. Runoff from the processing plant, mining facility and ore stockpiles would be captured and contained within the containment (mine affected) zone water management system, which would be designed and operated such that any discharge from these sources is directed to the main open cut pit and away from the external surface water environment.

Post-mining Period

At the end of mining and processing operations, any retained low grade ore would be encapsulated above the WRE and similarly covered with a store and release cover. The southern barrier, and processing areas would be decommissioned with all NAF waste rock used to rehabilitate the WRE and TSF. All processing areas would be decommissioned and a final undulating landform created.

The final void pit lake water balance shows that, with the expected groundwater inflows (Jacobs, 2020), and effective catchment diversions in place, the final void would remain a groundwater sink and would not overflow under either the historic climate or the projected climate change scenarios.

All PAF waste rock would be encapsulated in the final WRE landform that would include a vegetated store-and-release capping and cover system, and assuming the liner and capping system are effective, seepage and leachate collection would be eliminated. Similarly, in conjunction with the liner and seepage collection system, the vegetated store-and-release capping and cover system of the TSF would also eliminate runoff and seepage from tailings. The effectiveness of the proposed closure and rehabilitation measures would be trialled, monitored and evaluated during operations, as part of progressive rehabilitation of the Mine Site

With the above mechanisms effectively managing seepage, leachate and runoff, the receiving waters are unlikely to be impacted by seepage, leachate or runoff from the PAF material either during operations or after closure and decommissioning.

8.6.2 Potential for Contamination due to NAF Waste Rock Runoff and Seepage

During operations, runoff from the TSF NAF waste rock stockpile area, TSF outer embankment (which would be vegetated upon the completion of the 3rd embankment raise), WRE lower embankment (which would be vegetated following construction in the site establishment and construction stage) and southern barrier would be captured and treated in sediment dams sized as described in Section 4.6.2.

The southern barrier would be decommissioned after closure, leaving the outer embankment of the TSF, and the store-and-release cover of the WRE as potential sources of NAF runoff. Sediment dams would remain in place until vegetative cover was sufficiently established to control erosion from these embankments.

9. WATER MANAGEMENT PLAN

9.1 INTRODUCTION

Prior to the commencement of the site establishment and construction activities, Bowdens Silver would be required to prepare a Water Management Plan for approval that by DPIE and NRAR. The Water Management Plan would include (but not be restricted to) the following elements.

9.2 WATER QUALITY MONITORING PROGRAM

The existing downstream ambient water quality monitoring program would be retained until the commencement of the site establishment and construction stage. Once operations commence, regular monitoring of Mine Site water storages within both the containment (mine affected) zone and ESC zone would be undertaken to ascertain the characteristics of Mine Site runoff and leachate.

Water quality monitoring would be undertaken in a manner that is consistent with the National Water Quality Management Strategy. Samples would be initially collected monthly (in the case of ambient water quality) or during a flow event, where possible. The monitoring program would be implemented in accordance with the Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (EPA). The sample locations, frequency of sampling and analytes tested would be reviewed annually, and the monitoring results would be reported in accordance with the requirements of the EPA and the DPIE.

9.3 WATER VOLUME MONITORING PROGRAM

The Water Management Plan would document the methods by which all inflows (raw water or groundwater inflows) and transfers within the Mine Site would be recorded for comparison with the volumes predicted in the site water balance. The recorded volumes would then be used to refine the site water balance.

It is also anticipated that all inflows would be documented and recorded under the conditions of any water access licences required to account for groundwater as well as surface water storages that exceed the maximum harvestable rights provisions of the Water Management Act 2000.

9.4 WATER MANAGEMENT INFRASTRUCTURE MONITORING PROGRAM

The Water Management Plan would document the frequency and scope under which all water management infrastructure would be inspected. Inspections would include infrastructure in the containment (mine affected) zone, ESC zone as well as clean water diversions. The inspections program presented in the Water Management Plan would not cover the TSF which would be separately managed via plans approved by the NSW DSC.

9.5 TRIGGER ACTION RESPONSE PLANS

The Water Management Plan would include specific reference to the required actions should established triggers be reached with regards to the management of water captured within the containment (mine affected) zone and the ESC zone. This may include water levels that, once reached, would require active pumping and transfers between the various components of the water management system in order to prevent discharge from the Mine Site.

10. REFERENCES

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ANZG, 2018	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines*
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