MALABAR

MAXWELL UNDERGROUND MINE PROJECT

APPENDIX C

Surface Water Review

Maxwell Longwall Mining and Ventilation Shaft Modification

Surface Water Review

Malabar Resources Limited

1383-05-C2, 29 June 2022

Report Title	Maxwell Longwall Mining and Ventilation Shaft Modification, Surface Water Review
Client	Malabar Resources Limited
Report Number	1383-05-C2

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1 Introduction

The Maxwell Underground Mine Project (the Project) is an approved underground coal mining operation owned by Maxwell Ventures (Management) Pty Ltd, a wholly owned subsidiary of Malabar Resources Limited (Malabar). The Project is in the Upper Hunter Valley of New South Wales (NSW), east-southeast of Denman and south-southwest of Muswellbrook.

Development Consent SSD 9526 for the Project was granted by the Independent Planning Commission (IPC) on 22 December 2020. The Project was subsequently approved under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 10 March 2021 (EPBC 2018/8287).

Malabar previously sought to modify Development Consent SSD 9526 under section 4.55(1A) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for a minor extension to the mine entry area (MEA) (Modification 1). Modification 1 was subsequently approved on 19 November 2021 and EPBC 2018/8287 was varied on 14 December 2021.

A proposed Modification to Development Consent SSD 9526 is being sought under section 4.55(2) of the EP&A Act. The Modification includes the following components (refer to Figure 1.1 and Figure 1.2):

- re-orientation of the longwall panels in the Woodlands Hill, Arrowfield and Bowfield Seams, resulting in a minor increase in the approved underground mining area extent;
- reduction in the width of some of the longwall panels in the Woodlands Hill Seam, which facilitates earlier commencement of longwall mining;
- repositioning of the upcast ventilation shaft site and associated infrastructure; and
- other minor works and ancillary infrastructure components (e.g. access road and ancillary water management infrastructure for the repositioned ventilation shaft site)

The Modification involves some additional surface development outside of the approved surface development area (refer to Figure 1.1).

The Modification does not change the following approved Project components:

- total resource extraction and maximum annual production;
- the life of the mine;
- coal handling, processing and stockpiling, including management of reject material;
- product coal transport;
- workforce; and
- hours of operation.

WRM Water & Environment (WRM) was engaged by Malabar to undertake a surface water assessment of the proposed Modification.

1.1 APPROVED WATER MANAGEMENT STRATEGY

The objectives and design criteria of the Project site water management system are to:

- protect the integrity of local and regional water resources;
- separate runoff from undisturbed, rehabilitated and mining-affected areas;
- design and manage the system to operate reliably throughout the life of the Project in all seasonal conditions, including both extended wet and dry periods;
- provide water for use in mining operations that is of sufficient volume and quality;

- maximise the re-use of water on-site;
- manage groundwater inflows; and
- control coal handling and preparation plant (CHPP) process water on-site.

The Project will involve the use of a combination of mine water, recycled treated mine water and potable water in underground and surface operations. Water will be required for CHPP operation, underground mining operations (e.g. for cooling and underground dust suppression), dust suppression on roads, stockpile dust suppression, washdown usage, and other minor non-potable uses.

The main water sources for the operation are:

- groundwater inflows to underground workings and existing mine voids;
- recovery from CHPP rejects (through dewatering and/or decant return water);
- catchment runoff and infiltration; and
- small volumes of potable water imported to site.

1.1.1 Up-catchment Runoff Control

Temporary and permanent up-catchment diversion structures will be constructed over the life of the Project to divert runoff from undisturbed areas around the Mine Entry Area (MEA) and the transport and services corridor.

Stabilisation of up-catchment diversions will be achieved by the design of appropriate channel cross-sections and gradients and the use of erosion-resistant channel lining materials, such as grass or rock fill.

1.1.2 Rehabilitated Areas

Malabar is progressing the rehabilitation of previous mining areas at the Maxwell Infrastructure, including overburden emplacement areas.

As vegetation establishes on these areas, Malabar will progressively develop drainage works, with the aim of minimising as far as practicable the long-term catchment areas of the mine voids at the Maxwell Infrastructure.

1.1.3 Water Treatment

The Project will include the development of water treatment facilities, including a reverse osmosis plant (and/or other suitable water treatment technologies), to treat water for supply to underground mining operations (e.g. for cooling and underground dust suppression).

Treated water will be stored in the Treated Water Dam. Brine and/or precipitate from water treatment activities will be temporarily stored in a holding dam (Brine Dam), prior to being co-disposed with the CHPP reject material in the East Void.

1.1.4 Management of Excess Water

The water consumption requirements for an underground mining operation are typically lower than for open cut mines because there is significantly less surface disturbance area that requires watering for dust suppression. Accordingly, under some climate conditions, the Project has the potential to receive groundwater and surface water inflows in excess of its consumption requirements.

In the event that excess water accumulates at the Project, Malabar would manage this excess water according to the following hierarchy:

1. (Highest priority) Sharing mine water with BHP's neighbouring Mt Arthur Mine (e.g. for use in dust suppression), so reducing that operations' reliance on other water sources (e.g. Hunter River).

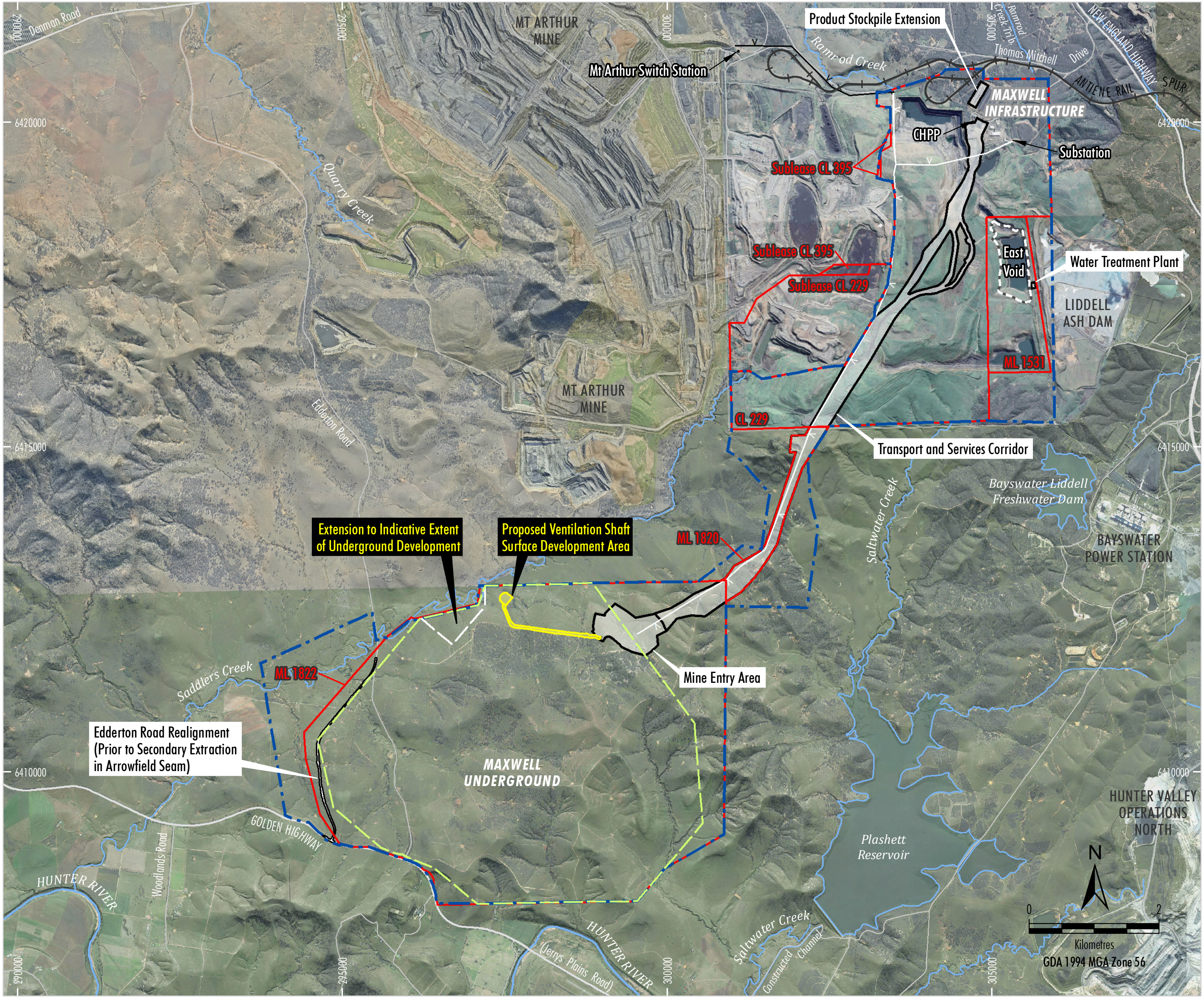
2. Sharing mine water or treated water with other industrial users (e.g. AGL), so reducing their reliance on water sourced from the environment (e.g. the Hunter River).
3. Sharing treated water with agribusiness (e.g. viticulture or equine industries).
4. Irrigation or evaporation of water within the Project site (i.e. on land catchments that report to the site water management system, such as rehabilitation areas). Evaporation cannons may also be used in these areas to remove excess water from the site water management system.
5. (Lowest priority) Beneficial use on Malabar-owned pastoral property (e.g. irrigation with treated water).

1.2 PROPOSED CHANGES TO SURFACE WATER MANAGEMENT

The key changes to the surface water management system related to the Modification and assessed as part of this review are as follows:

- changes to the surface development area of the MEA associated with the repositioning of the upcast ventilation shaft site and associated infrastructure; and
- re-orientation of the longwall panels.

The re-orientation of the longwall panels would not directly change the water management system for the Project. However, it would result in very minor changes to the profile of groundwater inflows over the life of the Project. The updated groundwater inflows have been considered in the mine site water balance (Section 2.1).



LEGEND

- Railway
- Mining and Coal Lease Boundary
- Proposed Ausgrid 66 kV Power Supply Extension #

Approved Maxwell Underground Mine

- Development Application Area
- Indicative Extent of Underground Development
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- 66 kV Power Supply

Proposed Modification

- Modified Indicative Extent of Underground Development
- Indicative Modification Surface Development Area

Subject to separate assessment and approval.

Source: NSW Spatial Services (2022); MSEC (2019, 2021)
Orthophoto Mosaic: 2020, 2019

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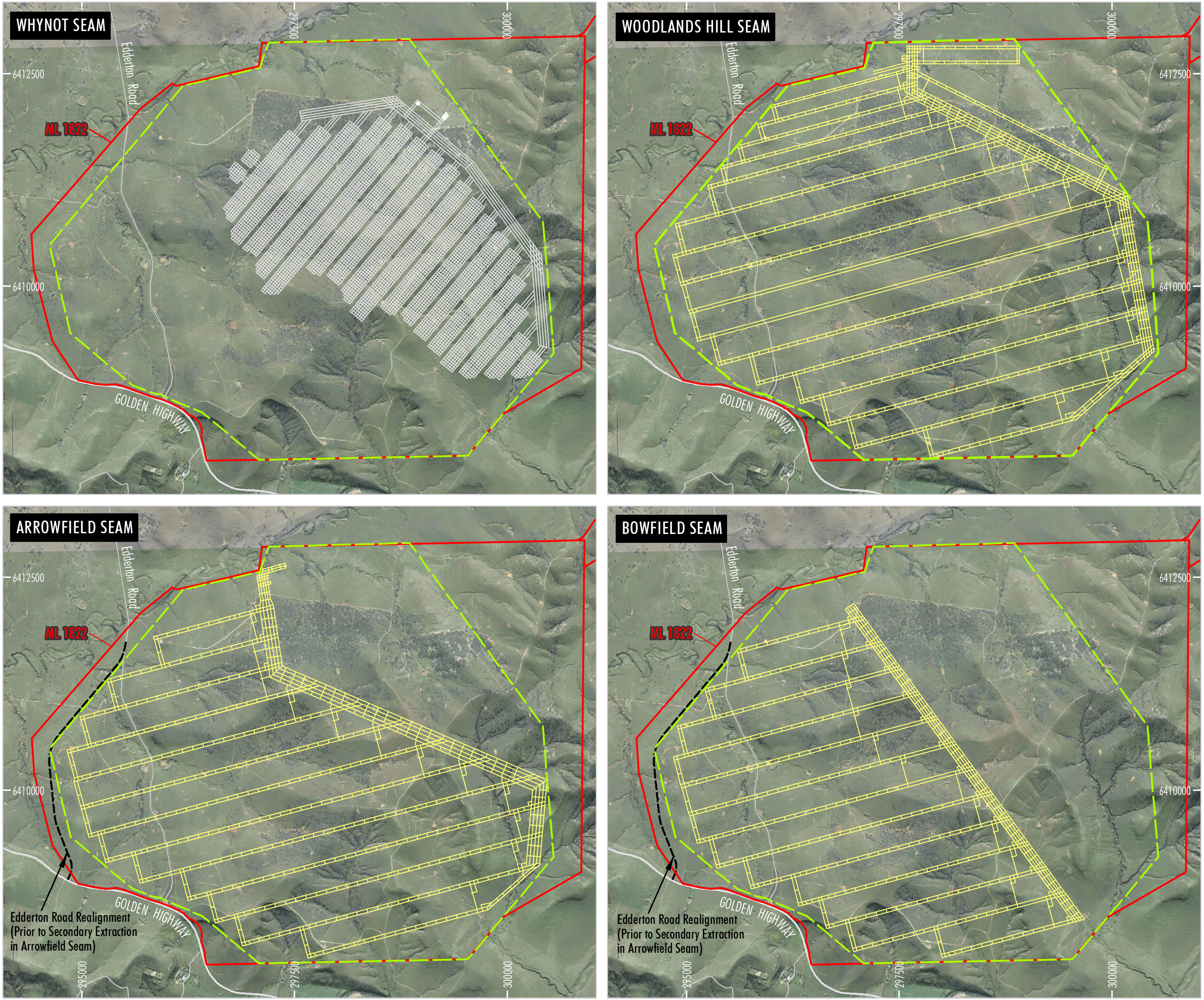
Modification General Arrangement

Figure 1.1



LEGEND

- Mining and Coal Lease Boundary
- Approved Indicative Underground Mining Layout
- Modified Indicative Underground Mining Layout
- Modified Indicative Extent of Underground Development

Source: NSW Spatial Services (2022); Arkhill (2021)
Orthophoto Mosaic: 2019

N

0 2
Kilometres
GDA1994 MGA Zone 56

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Modified Indicative Underground Mining Layout

Figure 1.2

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2 Surface Water Impact Assessment

The assessed impacts of the Modification on surface water resources include:

- changes to the performance of the mine site water balance as a result of minor changes in the catchments reporting to water storages;
- potential impact on Saddlers Creek flood behaviour;
- potential impacts on local stream flows due to catchment excision and subsidence-related ponding;
- potential impacts on Saddlers Creek and Hunter River baseflow; and
- potential impacts on surface water quality.

These potential impacts are discussed in the following sections.

2.1 MINE SITE WATER BALANCE

A water balance model was originally developed for the *Maxwell Project Environmental Impact Statement Surface Water Assessment* (WRM, 2019). This model was amended as part of the *Maxwell Underground Mine Project Mine Entry Area Modification Surface Water Assessment* (WRM, 2021) to incorporate minor changes to the MEA. This amended model was used as the base case scenario for comparison, and then adapted to reflect the changes to the water management system proposed as part of this Modification.

The approved water management system would change over the life of the Project. To represent the progressive development of the Project over time (including the rehabilitation of the Maxwell Infrastructure), the site water balance was modelled in five discrete stages as shown in Table 1.

Table 1 – Water Balance Model Stages

Stage	Representative Mine Configuration	Production Throughput (Mtpa ROM)	Number of Model Years
1	First Stage Rehabilitation Complete	0	1
2	First Stage Rehabilitation Complete	0.5 to 7.0	7
3	Final Landform Drainage Partially Complete	6.0 to 7.9	7
4	Final Landform Drainage Partially Complete	5.2 to 6.7	7
5	Final Landform Drainage Complete	3.0 to 5.5	5

Note: Mtpa = million tonnes per annum, ROM = run-of-mine.

2.1.1 Mine Entry Area Water Management System Configuration

The key components of the water management system for the Project and changes proposed as part of the Modification are summarised in Table 2. The water management system would continue to be operated to avoid overflows of mine water to the receiving environment. Figure 2.1 shows the water management system schematic for the Project (incorporating the Modification).

Surface water runoff from the ventilation shaft pad would be captured by a new water storage (VSP Sediment Dam). Runoff from the access corridor would be managed in accordance with the approved Erosion and Sediment Control Plan, which would be reviewed and updated for the Modification (if required).

VSP Sediment Dam and the erosion and sediment controls developed for the access corridor would be designed and operated in accordance with the requirements of *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2E – Mines and Quarries* (DECC, 2008).

No other changes to the Project water management system are proposed as part of the Modification.

Table 2 – Water Management System for the Modified Project

Name^	Infrastructure Type	Storage Capacity (ML)	Proposed Change
Mine Entry Area Dam (MEA Dam)	Mine affected water dam	110	No change
Mine Water Dam (formerly named Water Storage Dam)	Mine affected water dam	17	No change
Sediment Dam*	Mine affected water dam	4	No change
Portal Dams*	Mine affected water dam	14	No change
Treated Water Dam	Treated water storage	15	No change
Brine Dam⁺	Mine affected water dam	4	No change
VSP Sediment Dam	Sediment dam	1.43	New dam at Ventilation Shaft Pad
Water Treatment Facility	Water treatment plant	N/A	No change
Clean Water Diversion	Clean water diversion	N/A	No change

^ There would be no change to the following existing water storages: Access Road Dam, Industrial Dam, Rail Loop Dam, Savoy Dam, Pringles Dam, North Void, East Void and South Void. Minor changes to approved dams based on detailed engineering design (e.g. positioning within approved surface development areas) are not described in this table.

* Not explicitly modelled, included in MEA Dam catchment.

⁺ Malabar may pump brine directly to East Void instead of establishing Brine Dam.

ML = megalitres.

2.1.2 Transport and Services Corridor

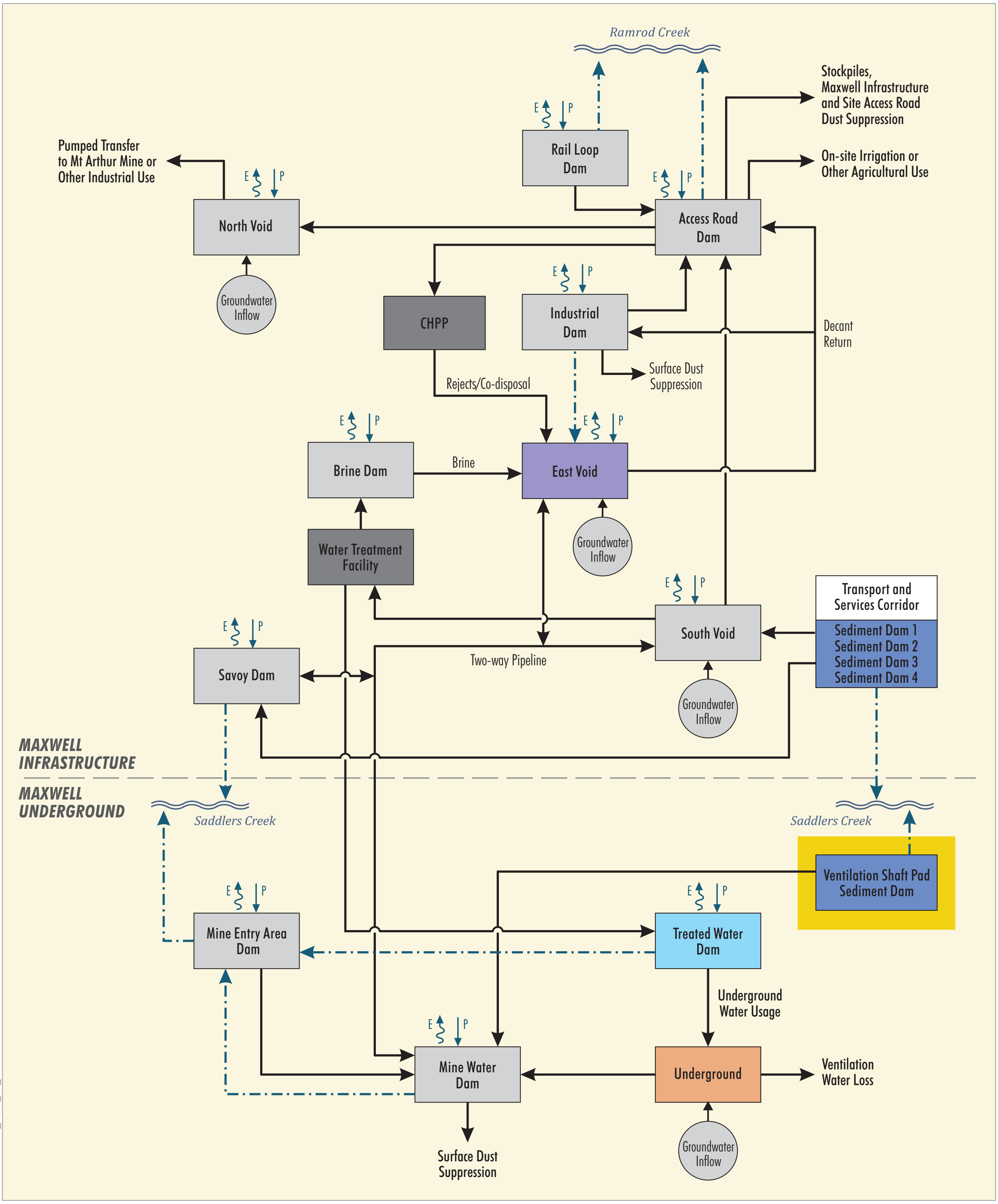
Sediment dams will be established to manage runoff from the transport and services corridor. In accordance with Condition B40 of Development Consent SSD 9526, these sediment dams have been designed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2E Mines and Quarries* (Department of Environment and Climate Change, 2008). The nominal catchment areas and capacity of the transport and services corridor sediment dams are provided in Table 3. The design of these sediment dams (including the nominal capacity and catchment areas) would be finalised through detailed design of the transport and services corridor and therefore may differ from Table 3. However, any updated designs would continue to be in accordance with the relevant guidelines and therefore would not change the key findings of this assessment.

Table 3 – Sediment Dams for the Transport and Services Corridor

Name	Catchment Area (ha)	Storage Capacity (ML)
Sediment Dam 1	6.3	3.6
Sediment Dam 2	3.9	4.3
Sediment Dam 3	7.8	7.6
Sediment Dam 4	4.0	23.6

Conditions B35 and B40 of Development Consent SSD 9526 require Malabar to design, install and maintain sediment dams to avoid off-site discharges, except as permitted under an Environment Protection Licence and the relevant provisions of the *Protection of the Environment Operations Act 1997* (POEO Act). Accordingly, Malabar may dewater sediment dams by pumping to the South Void if water quality monitoring indicates that discharge is not appropriate (e.g. if water quality indicates that discharge would cause pollution to occur under section 120 of the POEO Act).

Temporary erosion and sediment controls will be installed during construction as part of early preparatory works. Potential temporary erosion and sediment controls include, but are not limited to, sediment dams, water diversion banks, sandbags, sediment fences, hay bales, or geotextiles. Where relevant, these erosion and sediment controls will be removed once the associated construction activities are complete.



SHM-20-04 MOD LW_Report_SW_001D

Source: WRM (2022)

LEGEND

- Approved Water Management System
- Modification to Approved Water Management System
- Evaporation
- Precipitation/Catchment Runoff
- Pumped/Siphoned
- Overflow
- Treated Water Dam
- Underground Mine
- Mine Affected Water Storage
- Sediment Dam
- Rejects/Co-disposal Storage

NOTES

Overflow Direction: Good engineering practice is to include a stabilised spillway as a contingency for dam safety. This arrow does not indicate that these discharges (overflows) will occur. The arrow is to show the direction of water flow (by gravity) should the dam water level exceed the dam spillway level.

Seepage between voids/storages may occur through previously emplaced waste rock, including seepage between voids and native water storages.

Water management system would change if Malabar pursue an alternative management option for excess water (refer excess water management hierarchy in Section 3.10.3 of the EIS).

Dirty water management system storages are not shown.

Portal Dams and Sediment Dam at the Mine Entry Area are not shown as these are located within the catchment of and report to the Mine Entry Area Dam.

Savoy Dam may be used a staging storage to transfer water to the South Void.

Pringles Dam, which is used to supply water for livestock, is not shown as it does not form part of the mine water management system.

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Indicative Water Management Schematic

Figure 2.1

2.1.3 Water Balance Modelling Results

2.1.3.1 Overall Water Balance

Water balance results for the 103 model realisations of the base case (the approved Project) and Modification are presented in Table 4 and Table 5, averaged over each model phase. The results in Table 4 and Table 5 are the average of all realisations and include wet and dry periods distributed throughout the Project life.

The Modification results in very small increases in catchment runoff, direct rainfall and evaporation when compared to the base case. There is an average 5 to 7 megalitres per year (ML/year) increase (<1%) in catchment runoff and direct rainfall, and a 1 to 2 ML/year increase in evaporation. The change in the volume of water stored increases by up to 6 ML/year across all stages.

Overall, the impact of the Modification on the average annual water balance is negligible.

Table 4 – Base Case Average Annual Water Balance – All Realisations

Component	Process	Average Annual Volume per Model Stage (ML/year)				
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Inflows	Catchment runoff & direct rainfall	1,694	1,638	1,705	1,776	1,712
	Underground groundwater inflows	0	370	924	909	714
	Total inflows	**1,694**	**2,007**	**2,629**	**2,685**	**2,425**
Outflows	Evaporation	803	731	751	838	955
	Dust suppression	0	26	25	21	16
	Net CHPP demand	0	727	755	332	307
	Vent/moisture losses	0	191	301	297	221
	Spillway overflows - off-site	2	1	0	0	0
	Total outflows	**805**	**1,677**	**1,833**	**1,489**	**1,499**
	Change in volume	**888**	**330**	**795**	**1,195**	**926**

Note: Totals may not add due to rounding.

Table 5 – Modification Annual Water Balance – All Realisations

Component	Process	Average Annual Volume per Model Stage (ML/year)				
		Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 5**
Inflows	Catchment runoff & direct rainfall	1,699	1,643	1,710	1,782	1,719
	Underground groundwater inflows	0	370	924	909	714
	Total inflows	**1,699**	**2,013**	**2,634**	**2,692**	**2,432**
Outflows	Evaporation	803	731	752	839	957
	Dust suppression	0	26	25	21	16
	Net CHPP demand	0	727	755	332	307
	Vent/moisture losses	0	191	301	297	221
	Spillway overflows - off-site*	1	2	1	2	1
	Total outflows	**804**	**1,677**	**1,834**	**1,491**	**1,502**
	Change in volume	**894**	**335**	**800**	**1,200**	**930**

Note: Totals may not add due to rounding. * Includes spills from sediment dams that are designed to overflow during rainfall events that exceed the relevant design criteria.

2.1.3.2 Mine Affected Water Inventory

The South Void functions as the primary mine water storage for the Project. To prevent potential interaction between stored mine water and the surrounding groundwater system, a maximum operating level (MOL) of 174 metres (m) Australian Height Datum (AHD) has been set for South Void (i.e. the South Void is operated to a maximum water level of 174 mAHD to prevent spills occurring). This is 1 m below the Full Supply Level of 175 mAHD.

The forecast water levels in South Void and North Void for the Modification (see Figure 2.2 and Figure 2.3) were similar to the base-case.

The minor increases in water level (less than 0.3 m) over the period of simulation are negligible.

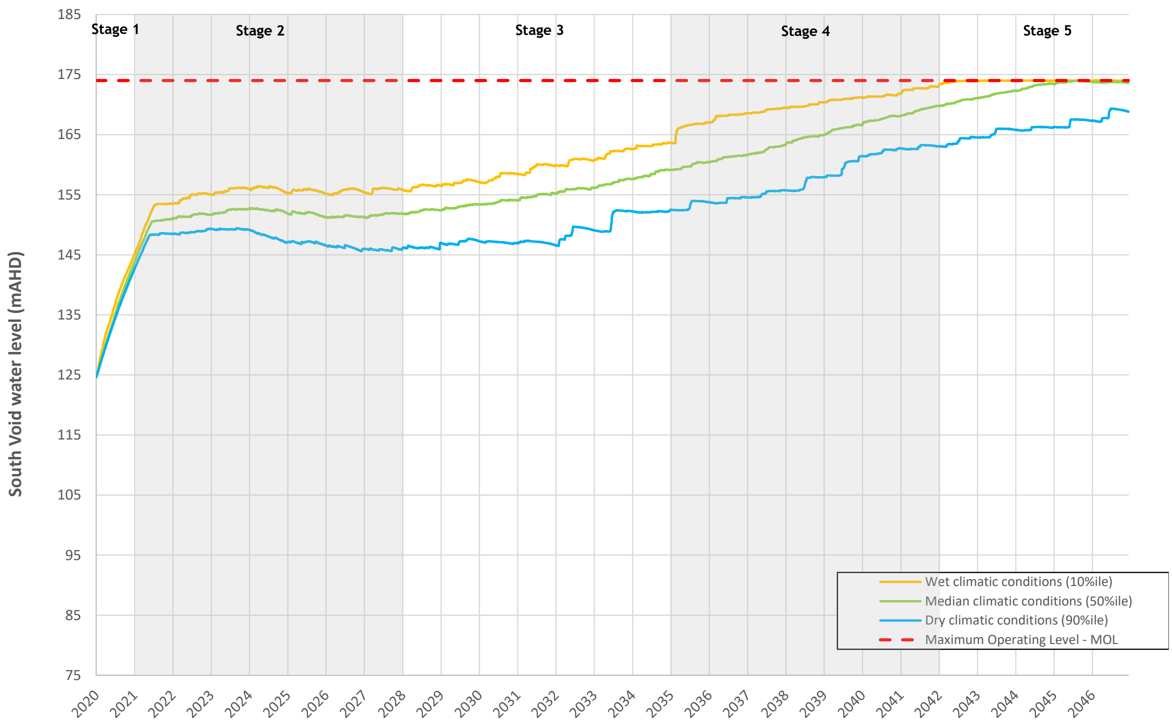

Figure 2.2 - Forecast South Void Water Level - Modified Project

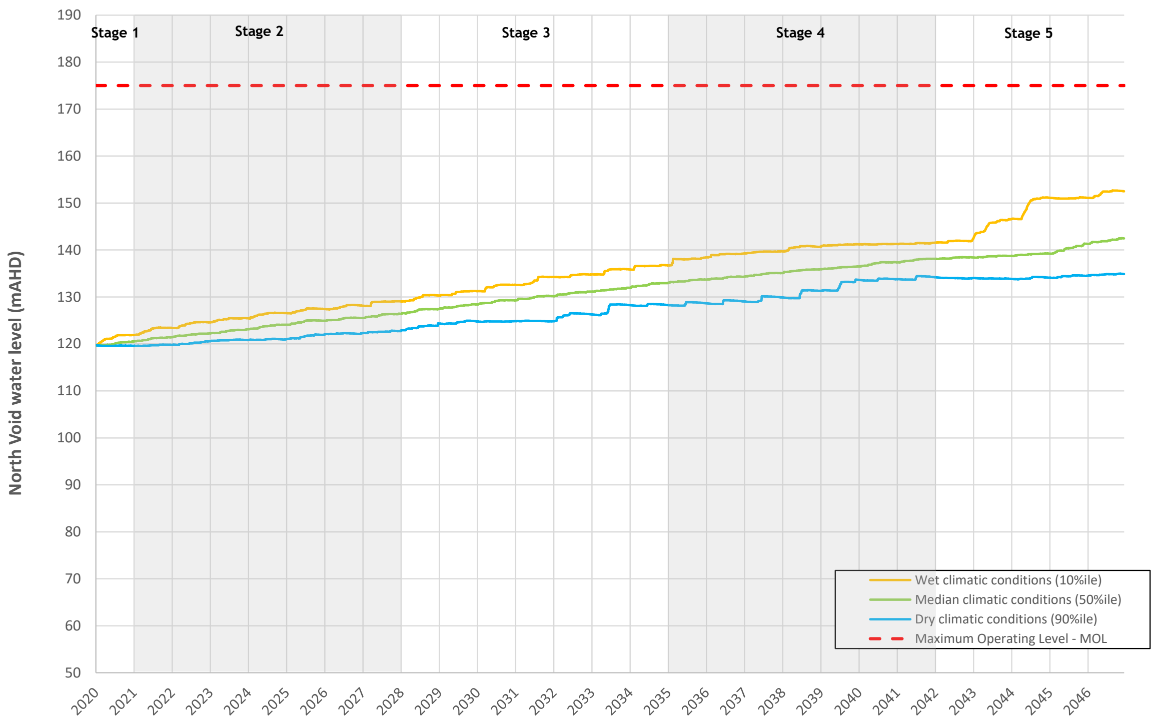

Figure 2.3 - Forecast North Void Water Level - Modified Project

2.1.3.3 Mine Entry Area Dam Inventory

The MEA Dam will be operated to avoid overflows to the receiving environment. To achieve this, the MEA Dam was set with a MOL around 1.6 m below the spillway level. The MEA Dam would pump to the Mine Water Dam as a priority to provide a storm buffer, before pumping to the South Void.

The water balance modelling shows that the MEA Dam would not overflow to the receiving environment under any of the modelled climatic conditions. Figure 2.4 shows the forecast water levels of the MEA Dam across the simulation period.

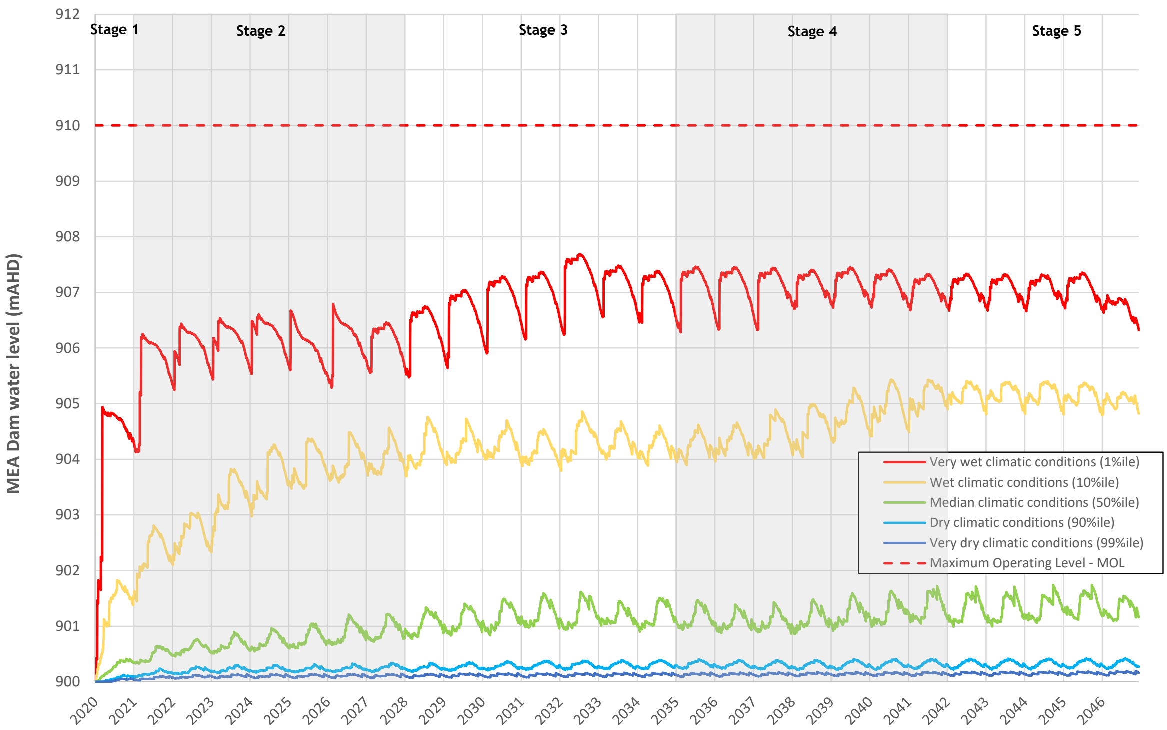

Figure 2.4 – Forecast MEA Dam Water Level - Modification

2.1.3.4 Uncontrolled Spillway Discharges

The water balance model was used to assess the risk of uncontrolled spillway discharges off-site from the mine water management system. The mine water dams that could potentially flow directly to the receiving environment include:

- Rail Loop Dam (to Ramrod Creek).
- Access Road Dam (to Ramrod Creek).
- Savoy Dam (to Saddlers Creek).
- MEA Dam (to Saddlers Creek).
- VSP Sediment Dam (to Saddlers Creek).

The model results indicate no overflows from MEA Dam, Treated Water Dam and the Savoy Dam. Consistent with the base case scenario, Rail Loop Dam and the Access Road Dam have a 1% Annual Exceedance Probability (AEP) risk of overflowing to the receiving environment. Consistent with Condition B36 of Development Consent SSD 9526, Malabar would operate Access Road Dam and Rail Loop Dam to avoid off-site discharges from these dams.

The Modification has no impact on the risk of uncontrolled spillway discharges to the receiving environment from existing/approved water storages.

The proposed VSP Sediment Dam has a 1% AEP risk of overflowing to Saddlers Creek. This is expected given its function as a sediment dam (i.e. it is designed to overflow when rainfall events exceed the design criteria).

2.1.3.5 Transport and Services Corridor

Water may be pumped from sediment dams in the transport and services corridor to the South Void, East Void or MEA Dam (where water quality indicates discharge to receiving waters is not appropriate, refer Section 2.1.2). The volume of any water that may need to be periodically pumped to the South Void from these sediment dams is anticipated to be negligible in the context of the surplus available storage in the South Void and North Void.

2.2 IMPACT ON SADDLERS CREEK FLOOD BEHAVIOUR

The Saddlers Creek Probable Maximum Flood (PMF) modelling has been updated using contemporary modelling techniques and methodologies. Specifically, the hydraulic model is now developed in the TUFLOW two-dimensional hydraulic modelling platform, compared with previous modelling which used the one-dimensional HEC-RAS modelling platform. The hydrological modelling and design flows has been updated using the latest Australian Rainfall and Runoff 2019 (ARR) Guideline and temporal patterns (previously modelling was based on the ARR 1987 Guideline). Details of the updated hydrological and hydraulic model development are provided in Appendix A.

The modelled PMF flood extents and depth are shown in Figure B.2. It shows that the main Saddlers Creek channel does not experience breakouts which enter the subsidence footprints. There are two minor interactions between the PMF flood extent and the Project:

- At the northern unnamed tributary (with the proposed Vent Shaft Pad footprint); and
- At the southern tributary, with backwater flow overlapping a very small section of the subsidence zone.

The impact of the Vent Shaft Pad on PMF flood levels and extents has been assessed and is presented in Figure B.3. It shows that there are local flood level increases of up to 0.1 m in the vicinity of the Vent Shaft Pad. The minor increases do not extend into the main Saddlers Creek channel and are considered very minor.

The potential impact of the Modification on Saddlers Creek flood behaviour is negligible and only applies to the PMF flood event (which is the largest flood that could conceivably be expected to occur in Saddlers Creek).

2.3 LOSS OF CATCHMENT RUNOFF DUE TO CATCHMENT EXCISION

As part of the Modification, there would be a small increase in surface development area due to the re-positioning of the upcast ventilation shaft pad. This results in a small increase in the catchment area excised from Saddlers Creek, and a subsequent increase in the loss of catchment runoff (i.e. associated with the catchment of VSP Sediment Dam).

The Modification increases the catchment excised from Saddlers Creek by 2.4 hectares (ha). The total pre-development catchment area of Saddlers Creek is 9,714 ha. Therefore, the Modification increases the loss of catchment (and hence loss of catchment runoff) by around 0.02%.

The impact of the Modification on catchment excision (and loss of flows) in Saddlers Creek is negligible and would not be measurable.

2.4 LOSS OF STREAM BASEFLOW

The potential impact of the Project on baseflow in Saddlers Creek and the Hunter River has been undertaken by SLR (2022). The assessment concluded the following:

- Zero impact on baseflow in Saddlers Creek; and
- A maximum incremental baseflow reduction of 0.18 ML/year in the Hunter River (i.e. a total reduction in baseflow of 0.71 ML/year due to the Project incorporating the Modification).

The median annual flow in the Hunter River at the Liddell Gauging Station (210083) is approximately 87,600 ML/year. In the context of the Hunter River regulated system, a baseflow loss of 0.12 ML/year is negligible. Hence, the Project would not measurably affect baseflow in the downstream waterways.

2.5 LOSS OF CATCHMENT FLOWS DUE TO MINE SUBSIDENCE

The Hunter River and Saddlers Creek are located outside the Maxwell Underground area and would not be subject to direct subsidence effects (MSEC, 2022). Notwithstanding, potential subsidence impacts on the unnamed drainage lines draining to Saddlers Creek and Saltwater Creek are considered below.

2.5.1 Increased Ponding

The Geomorphology Assessment (see Appendix D of the EIS) found that subsidence from the approved Project was predicted to increase the surface area of depressions in drainage lines from 8.9 ha (existing case) to 12.9 ha (impacted case). A further 2.5 ha of the depressions present under the existing case were predicted to become deeper under the impacted case.

MSEC (2022) has mapped areas that may form topographic depressions as a result of the Modification. Topographical depressions greater than 50 cm in depth that coincide with drainage lines are considered to represent potential ponding areas. The Modification is predicted to result in additional potential ponding areas of approximately 3.5 hectares.

The EIS Geomorphology Assessment found that the in-channel subsided areas would naturally fill with sediment over time. Sediment loads were not estimated. However, sediment is likely to fill the subsidence areas incrementally over the 26 year Project life and therefore the maximum increase in surface ponding would be associated with one or two panels only or a fraction of this increase.

The EIS estimated that the total volume of water that would be retained in local waterways due to ponding would be 32 ML, if all of the surface depressions develop at the same, no infilling occurs and the average increase in depth of the surface depressions is 0.5 m. Applying these same conservative assumptions, the total volume of water that would be retained in ponding areas as a result of the Modification is 18 ML.

Given that the average annual flows recorded at the Bowfield stream gauge (GS210043) on Saddlers Creek is 1,000 ML, the potential reduction in flows due to subsidence is negligible.

2.5.2 Surface Fracturing

Some fracturing of exposed bedrock and bedrock beneath the soil beds of drainage lines is predicted to occur as a result of the Project (MSEC, 2019). Rock slabs have been identified along the drainage lines in four locations within the Maxwell Underground area (Fluvial Systems, 2019). MSEC (2019) describe that fracturing could develop in three of these rock slabs that are located directly above the proposed mining panels as a result of the approved Project.

No change to the risk of fracturing in these rock slabs is predicted to occur as a result of the Modification (i.e. the same three rock slabs are predicted to be impacted) (MSEC, 2022).

Accordingly, given the ephemeral nature of the drainage lines overlying the Maxwell Underground, the potential diversion of flows into the underlying strata during low flow events would remain negligible for the Project incorporating the Modification.

2.6 SURFACE WATER QUALITY

The Modification results in a very minor increase in risk of overflows, due to the re-positioning of the Vent Shaft Pad. The water balance modelling indicates that there is a very low (1%) probability (in any one year) that VSP Dam could overflow to Saddlers Creek. The water within VSP Dam is not mine-affected, and any overflows from this storage would only occur during extreme rainfall events and be heavily diluted by background flow in Saddlers Creek.

The potential impact of the Modification on surface water quality in Saddlers Creek is negligible.

3 Summary

A summary of the surface water impact assessment of the Modification is as follows:

- The Modification results in negligible changes to the site water balance, including overall water balance, predicted mine affected water levels and overflows to the receiving environment.
- The Modification increases the catchment excised from Saddlers Creek by 2.4 ha, which is around 0.02% of the Saddlers Creek pre-development catchment area. The impact of the Modification on loss of flow due to catchment excision in Saddlers Creek is negligible and would not be measurable.
- The potential impacts of the Vent Shaft Pad on PMF flood levels are limited to the local backwater flow within the tributary, with increases of less than 0.1 m.
- The total volume of water retained in the local waterways by the additional surface depressions due to mine subsidence, assuming no infilling, is conservatively estimated to be 18 ML. Given that the average annual flows recorded at the Bowfield stream gauge on Saddlers Creek is 1,000 ML, the potential reduction in flows due to subsidence is negligible.
- Given the ephemeral nature of the drainage lines overlying the Maxwell Underground, the potential diversion of flows into the underlying strata during low flow events would remain negligible for the Project incorporating the Modification.
- The potential impact of the Modification on surface water quality in Saddlers Creek is negligible and is limited to a slight increase in overflows from a sediment dam (VSP Dam) during extreme rainfall events.

In summary, the impact assessment shows the Modification causes negligible additional impacts on surface water resources and the surrounding surface water environment when compared to the approved Project.

4 References

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Appendix A - Saddlers Creek XP-RAFTS Hydrological & Hydraulic Model Setup

A1 Overview

A hydrological model was developed of the study area using the XP-RAFTS runoff-routing model (Innovyze, 2019) in combination with the Bureau of Meteorology's guideline *The Estimation of Probable Maximum Precipitations in Australia: Generalised Short Duration Method (GSDM)* (BOM, 2003). This updated model adopts contemporary techniques and methodologies to estimate the Probably Maximum Flood (PMF) design discharges in Saddlers Creek.

The PMF is the largest flood that could conceivably be expected to occur in Saddlers Creek and is therefore very conservative for impact assessment purposes.

A1.1 SADDLERS CREEK XP-RAFTS REGIONAL HYDROLOGICAL MODEL

A1.1.1 Spatial Configuration

Figure A.1 shows the XP-RAFTS Saddlers Creek hydrological model configuration. The model extends downstream of the subsidence area of interest and covers a total catchment area of 76.9 km^2. It includes 13 sub-catchments ranging in size from 2.5 km^2 to 14.9 km^2.

A1.1.2 Sub-catchment parameters

Model parameters for each sub-catchment were determined as follows:

- A percentage impervious of zero was adopted for all sub-catchments;
- Catchment slopes were determined based on the available topographic data;
- A sub-catchment storage coefficient multiplication factor 'Bx' of 1.0 was adopted for all events;
- Sub-catchment PERN 'n' values were determined based on the density of vegetation in each sub-catchment. The adopted sub-catchment PERN 'n' values range between 0.06 and 0.08; and
- Initial and continuing losses of zero were applied for the PMF.

A1.1.3 Spatial and areal variability

No areal reduction factor (ARF) was adopted for the PMP rainfall as catchment area is already incorporated into the Probably Maximum Precipitation (PMP) rainfall estimate.

A1.1.4 Temporal patterns

Due to Saddlers Creek being within the GSAM-GTSMR Coastal Transition Zone, for PMP events, ARR recommends using both the GTSMR and GSAM (BOM, 2005) temporal patterns for storm durations of 24 hours and longer for the area of the site. However, peak flows in the catchment are caused by storm durations shorter than 24 hours. Accordingly, the GSDM was applied as per ARR recommendations with temporal patterns developed by Jordan et al. (2005).

A1.1.5 Probable Maximum Precipitation storm

The Saddlers Creek catchment is less than 300km², so the standard area procedure for PMP analysis was 1,000 km². The site was governed by short duration events therefore GSDM procedure was used for storm durations up to 6 hours. GTSMR and GSAM for the standard area size was also investigated due to the site being in the GTSM-GSAM Coastal Transitional Zone, however these did not provide critical flows in hydrological modelling. Table A.1 summarises the rainfall adjustment factors applied for GSDM analysis of Saddlers Creek catchment.

Table A.1: PMP GSDM factors for regional model

Smoothness	Roughness	Moisture Adjustment Factor (MAF)	Elevation Adjustment Factor
0	1.0	0.725	1

A1.1.6 Design discharges

Design discharges were determined using an 'ensemble' of 11 temporal patterns, which produces 11 design hydrographs (and peak discharges) for the PMP (Jordan, et al. 2005). For a PMP storm, the storm producing the maximum peak discharge was selected. The adopted design discharge is summarised in Table A.2.

Table A.2: PMP GSDM factors for regional model

Key location	Event	XP-RAFTS adopted design peak discharge (m^3/s)	Critical storm duration (hours)	Temporal pattern storm*
SCT10/SCT11 Total Flow Junction	PMF	1,821	6	ME7

Note Temporal Pattern Storms are referenced in Jordan, et al. 2005*

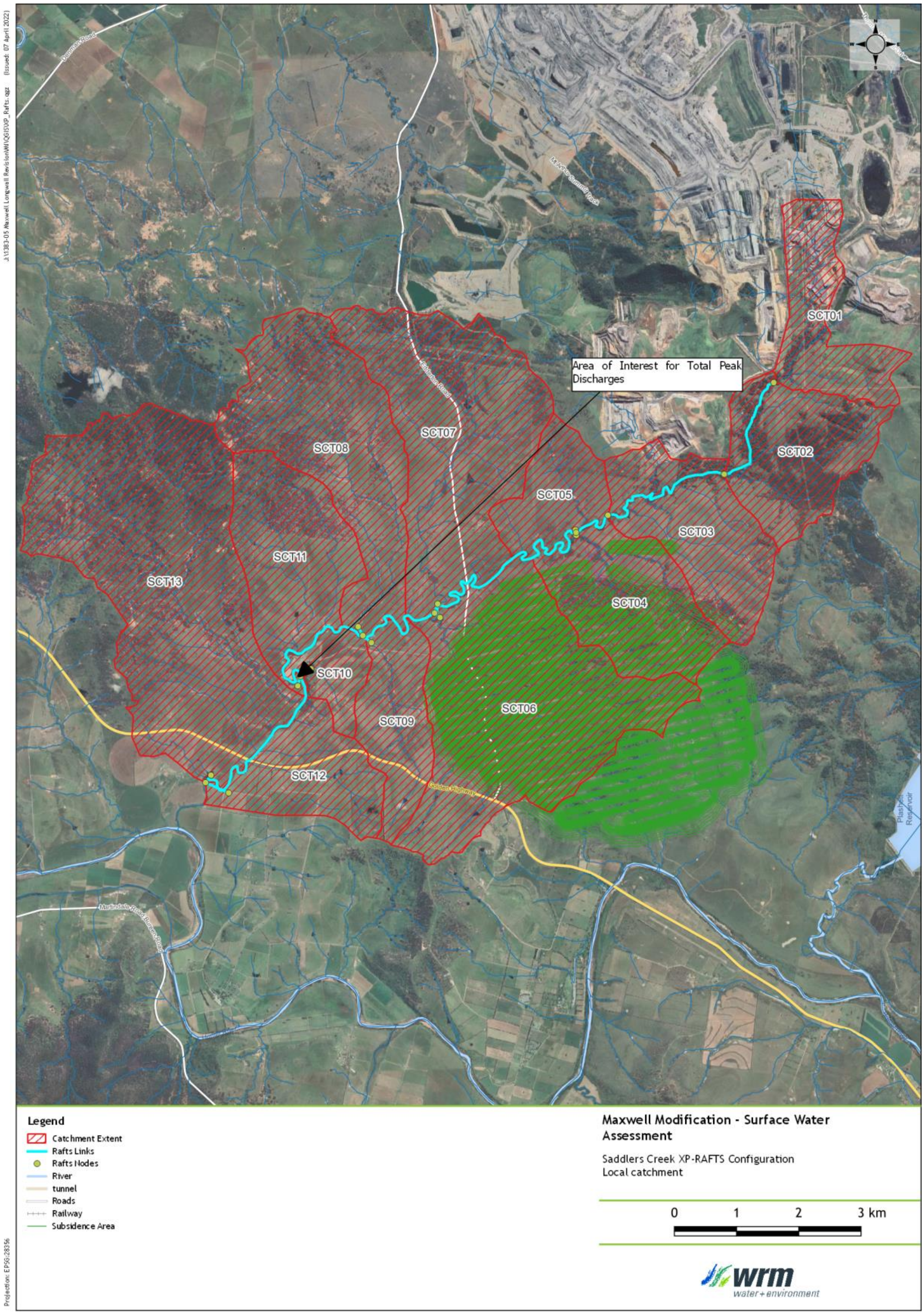

Figure A.1: Saddlers Creek XP-Rafts Configuration

Appendix B - Hydraulic modelling

B1 Overview

To investigate the interaction of overbank flows with the predicted subsidence areas and proposed Vent Shaft Pad, a two-dimensional hydraulic model was adopted to ensure that the movement of water across the floodplain was adequately simulated.

The TUFLOW hydrodynamic model (BMT, 2018) was used to simulate the flow behaviour of Saddlers Creek in the vicinity of the Project.

TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow (BMT, 2018). The model automatically calculates breakout points and flow directions within the Project area. The most recent version of the TUFLOW software (Build 2020-10-AB) was used for this study.

The TUFLOW model was run using the Heavily Parallelised Compute (HPC) GPU solver which uses adaptive time stepping. The Maximum Courant Number was limited to 0.8 to improve model stability under extreme event conditions.

Hydraulic models were prepared for two scenarios:

- Existing conditions, and
- With the proposed Ventilation Shaft Pad in place.

B1.1 TUFLOW MODEL CONFIGURATION – EXISTING CONDITIONS

B1.1.1 Model extent and resolution

Figure B.1 shows the configuration of the TUFLOW model. The model extends approximately 4.0 km upstream and 4.0 km downstream of the predicted extent of subsidence adjacent to Saddlers Creek. The modelled area covers approximately 37.3 km^2.

The TUFLOW model uses topographic aerial survey data (LiDAR) supplied by ELVIS (https://elevation.fsdf.org.au/) over the Muswellbrook region on a 2 m grid. The ground surface model was obtained by LiDAR capture on November 2017 and has an accuracy of 0.3m (95% Confidence Interval) vertical and 0.8m (95% Confidence Interval) horizontal. The LiDAR's 2 m resolution was used as the basis for the TUFLOW model.

B1.1.2 Inflow and outflow boundaries

Figure B.1 shows the locations of the 2D inflow and outflow boundaries used in the TUFLOW model. The discharge hydrographs estimated using the XP-RAFTS runoff-routing model were adopted as inflows to the TUFLOW model. The names of the inflow boundaries correspond to the names of the sub-catchments shown in Figure A.1. The XP-RAFTS inflows for all sub-catchments were applied concurrently.

Inflows from the hydrological model draining to the upstream extents of the hydraulic model were applied as hydrograph inflows for each sub catchment at representative node locations. The positions of these inflow boundaries were chosen so that flows were as confined as possible at their point of entry into the hydraulic model - with minimum flow break out. The flows from the sub-catchments within the hydraulic model were applied as local source area inflows. These source areas supply the flow to the lowest cells within the source area polygons.

The outflow boundary on Saddlers Creek is approximately 1.21 km downstream from SCT08 and SCT09 confluence and uses an automatically generated rating curve based on a 1% slope.

B1.1.3 Adopted Manning's 'n' roughness

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance. Manning's 'n' values were adopted based on typical published values (for example those of Chow (1959)).

Table B.1 shows the adopted Manning's 'n' values for the TUFLOW model and Figure B.2 shows the location of each land use.

Table B.1: Adopted Manning's 'n' values

Land use	Manning's 'n'
Light Vegetation	0.055
Medium Vegetation	0.07
Dense Vegetation	0.08
Channel	0.06
Water	0.04

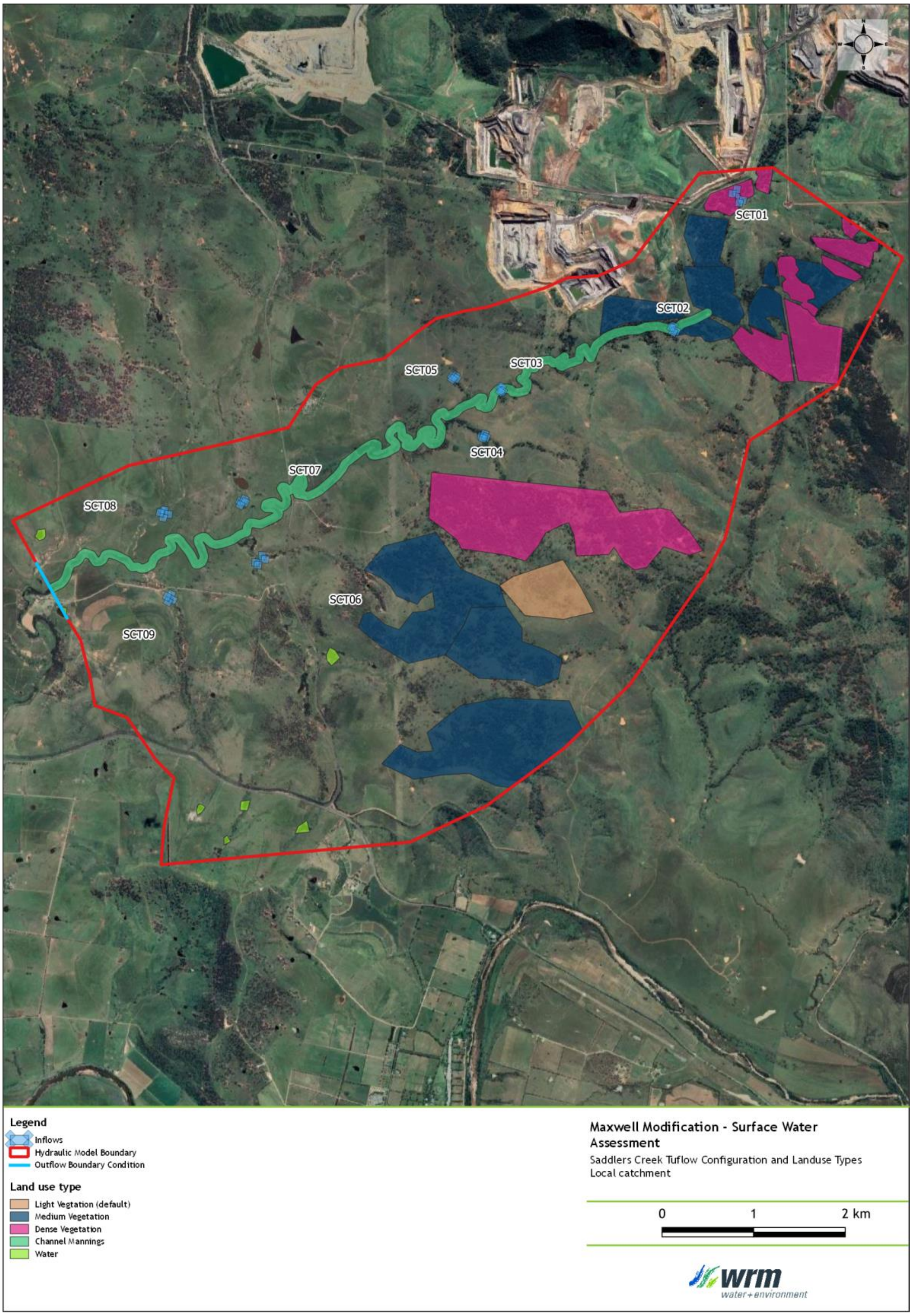

Figure B.1: TUFLOW model configuration and land use types

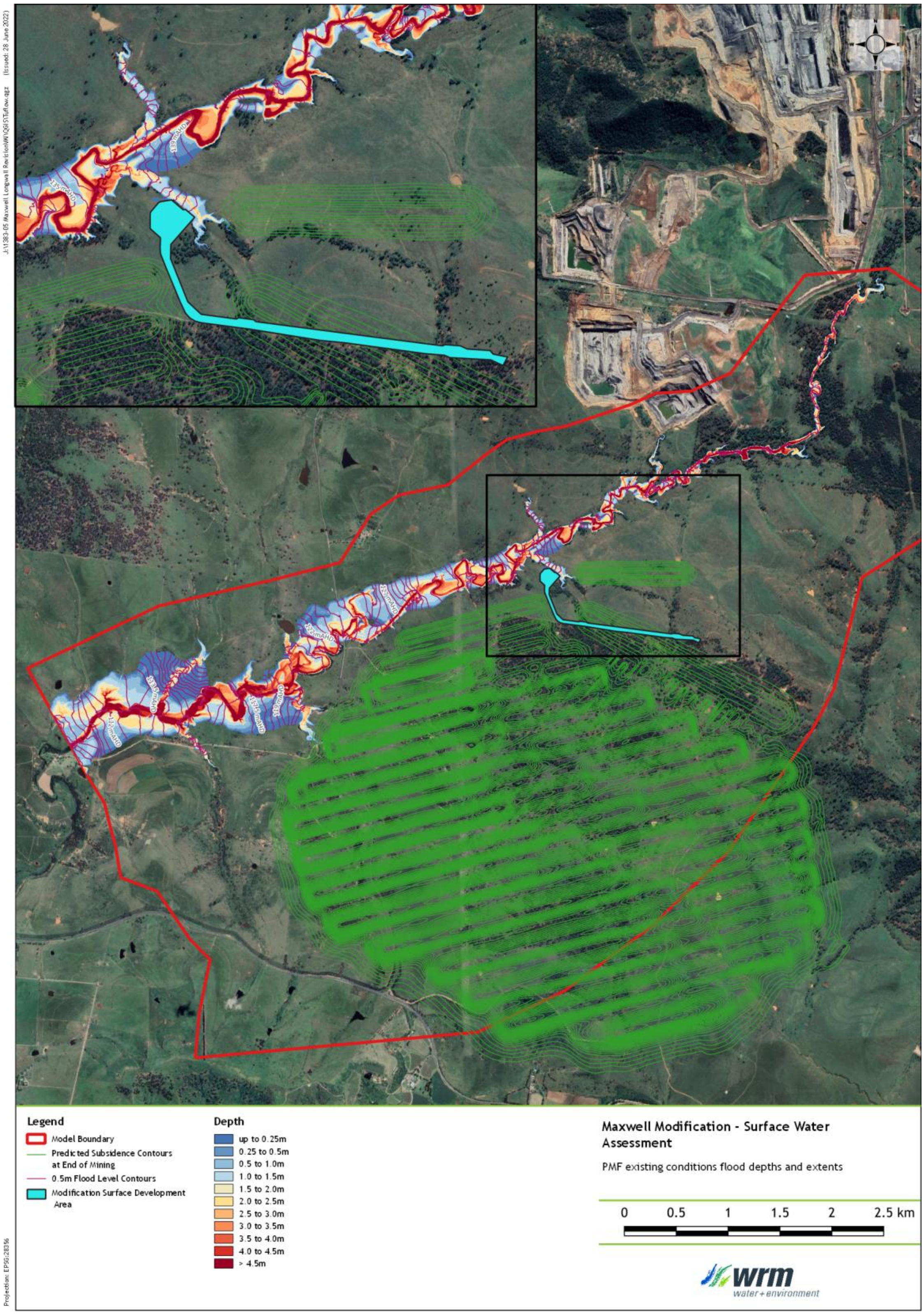

Figure B.2: PMF existing conditions flood depths and extents

Figure B.3: PMF water level impact with proposed Vent Shaft Pad