

31 August 2023

Ms Juliana McCosker
Manager, Environmental Services Regulation
Coal Business Centre
PO Box 3028 Emerald Qld 4720
Via email: CRMining@DES.qld.gov.au

Dear Juliana,

Re: Updated Minerva Mine Progressive Rehabilitation and Closure Plan (PRCP)

Minerva Mine is the holder of Environment Authority EPML00668613.

I refer to your information request dated 23 August 2022 in relation to further information required to assess an application for a PRCP Schedule. Minerva Mine has reviewed the request and updated the attached PRCP and PRCP Schedule to address the queries. Individual responses to the information request are provided within **Table 1**, with references to the relevant sections of the PRCP and the PRCP Schedule.

This updated PRCP is provided in accordance with your approval (dated 18 December 2023) to extend the information response period to 31 August 2023.

Please contact me if you would like to discuss this resubmission.

Yours Sincerely,



Ann Houston
Head of Environment, Social and Governance
Sojitz Blue Pty Ltd
Ph: 0407 020 310
E: ann.houston@sojitzblue.com.au

Attachments:

Minerva Mine Progressive Rehabilitation and Closure Plan, Version 3. 31 August 2023

Minerva Mine Progressive Rehabilitation and Closure Plan Schedule, Version 3. 31 August 2023

Table 1 – Response to DES Information Request

Item	Relevant Section	DES Information Request	Minerva Response
1	2.5 Existing Rehabilitation	Provide an updated Rehabilitation Planning Part to include a clear distinction between, and further information about, land that has received progressive certification and land where rehabilitation is ongoing.	Section 2.5 Existing Rehabilitation updated with additional information in relation rehabilitation method at each location and progressive certification. It is noted that Section 2.5 refers to Section 6.8.3 and Section 6.8.4 which provide more details on the rehabilitation methodologies.
2	3.1 Community Consultation Register	Provide an updated Rehabilitation Planning Part that includes a community consultation register which includes the following details: • Information provided to the community; • Issues raised/discussed by the community; • How issues have been considered; • Decisions/outcomes of engagement; and • Commitments made by the applicant.	An expanded community consultation register is included in Section 3.1 Community Consultation Register (see Table 7). Information presented includes persons consulted (and dates), consultation activity, closure and PMLU-related engagement, issued related to land outcomes, and commitments made.
3	6.2 Flooding	Provide an updated Rehabilitation Planning Part that includes further information about flood depth and velocity during a range of events including Probable Maximum Flood. Provide further information regarding the methodology used to generate the flood model including limitations and assumptions.	Updated text within Section 6.2 Flooding.
4	2.6.4 Soils 2.6.5 Land Stability Appendix B - Rehabilitation Management Plan 6.3 Soil and Capping Materials	Provide an updated Rehabilitation Planning Part that includes further information which demonstrates that the soil types mapped at Minerva Mine are not prone to dispersion or erosion. Provide an updated Rehabilitation Part which provides further information to demonstrate that the existing topsoil available at Minerva Mine does not require amelioration.	Further information on the predominant soil type at Minerva has been included in Section 2.6.4 Soils. Soil ameliorants are not required at Minerva (see Section 6.3.3 Ameliorants)
5	6.5 Landform Design 6.8 Revegetation	Provide an updated Rehabilitation Planning Part that includes further information about the overall site landform including the waste dumps as required under the heading Landform Design in section 3.6.1 of the PRCP Guideline. Provide an updated Rehabilitation Planning Part that includes further information which demonstrates that the PMLU of grassy open woodland is able to be supported on the out of pit dumps and external batters at the slope and vertical lift proposed.	Section 6.5 Landform Design and Figure 22 - 3D Model of Final Landform have been updated to provide further information as requested. Section 4.1 Grassy Open Woodlands has been updated with further information, see Section 6.3.2 Material Quality for information on rock mulching application for spoil dumps.

6	6.7 Water management PRC Schedule RM7 & RM9 in application to Sandhurst Creek Diversion	Provide an updated PRC plan that incorporates the outcomes specified in ACARP 2001 to demonstrate a stable condition has been achieved. Provide an updated Rehabilitation Planning Part that includes copies of the following supporting documents, and provide an amended version of the PRC Schedule that incorporates appropriate outcomes contained within: The Sandhurst Creek Diversion water licence (water licence number 406741) under the Water Act 2000 as well as any referenced supporting material and/or basis of design/design objectives used to support the original approval.	RM7 and RM9 include appropriate milestone criteria for the Sandhurst Creek diversion PMLU. Water licence number 406741 has been included in Appendix G of the PRCP.
		The ongoing monitoring and maintenance reports for Sandhurst Creek Diversion to demonstrate that the diversion has been fully rehabilitated and that active maintenance programs are no longer required or trending to no ongoing maintenance requirements	See updates to Section 6.7 Water Management in relation to monitoring of the diversion.
		Australian Groundwater and Environmental Consultants Pty Ltd (2017), Minerva Residual Void Investigation – Groundwater Inflow Calculation, dated 21/07/2017, report number G1753D.	The AGE (2017) groundwater inflow calculation has been superseded by a numerical groundwater report completed by AGE (2023).
7	6.8 Revegetation 2.6.8 Vegetation Appendix B – Rehabilitation Management Report	Provide an updated Rehabilitation Planning Part which specifies a seed mix which can provide regional connectivity between the surrounding regional ecosystems and the revegetation and rehabilitation on site. Alternatively, provide an updated Rehabilitation Planning Part which justifies why revegetation and rehabilitation to be conducted at Minerva Mine cannot target a specific regional ecosystem to improve regional connectivity.	Text updated in Section 4.1 Grassy Open Woodlands to demonstrate primary purpose of grassy open woodlands.
8	6.9 Final Void Treatments WK Geotech report Figures – Pit water Appendix A – Residual Void Investigation Report Appendix B of Appendix A – PSM 2021, Highwall Stability Study PSM2432-124L REV1	Provide an updated Rehabilitation Planning Part that demonstrates the pits will remain in a stable condition when standing water levels are at equilibrium. Provide an updated Rehabilitation Planning Part that includes a sensitivity analysis of the factor of safety for a range of standing water levels including no lake scenario. Provide an updated Rehabilitation Planning Part that includes information that demonstrates the determination of FOS meets industry best practice (for example, Geotechnical considerations in open pit mines (DME 1999)). For each water level scenario, provide an updated Rehabilitation Planning Part that includes information regarding the methods used to determine the location of the safety infrastructure demonstrating that it complies with industry best practice (for example, Safety bund walls around abandoned open pit mines (DME 1997).	Table 3 to Table 7 of the WK Geotechnical report (2023) provides the stability analysis for the residual voids at equilibrium and the sensitivity analysis of varying water levels. WA Guidelines have been referenced in WK Geotechnical (2023) report for the criteria for determining closure bund location. WK Geotechnical (2023) and Section 6.9 Final Void Treatments of the PRCP states that the proposed closure bund is located within the mining leases boundaries and is located outside the 0.1% AEP flood extents.

		Provide an updated Rehabilitation Planning Part that includes designs showing locations of the final (redesigned) crests, set back distances, proposed safety berms, any adjacent permanent infrastructure, and the mining lease boundary. Provide an updated Rehabilitation Planning Part that includes the following additional information regarding the pit stability modelling: Assumptions regarding infiltration and recharge from Sandhurst Creek into the mine voids.	
		Information regarding the potential for Sandhurst Creek to influence geotechnical instability, pose additional potential failure modes and whether this was considered in the FoS modelling.	WK Geotechnical (2023) and Section 6.9 Final Void Treatments of the PRCP provided stability information in relation to the Sandhurst Creek diversion.
		The invert level and material characterisation between Sandhurst Creek and the final voids? Provide an updated Rehabilitation Planning Part that includes further clarification regarding the stability of the Southern Pit and whether additional works are required to achieve a minimum FoS while the standing water level achieves equilibrium.	Table 3 to Table 7 of the WK Geotechnical report (2023) provides the stability analysis for the residual voids at equilibrium and the sensitivity analysis of varying water levels.
9	6.9 Final Void Treatments 6.1 Hydrogeology Appendix A – Residual Void Investigation Report	Provide an updated Rehabilitation Planning Part that includes: additional justification that the analytical approach presented in AGE 2017 and consequently KBR 2017 is fit for purpose in determining long term groundwater inflows to the final voids,	A new numerical model has been developed to replace the analytical approach. See Section 3 of AGE (2023) report (Appendix F of PRCP).
		any information available on current mine inflow conditions in comparison to predictions made in AGE 2017 and KBR 2017, and	Operational mine inflows for the numerical model are presented in Section 4.2.4 of AGE (2023).
		any updated operational mine inflow estimates for periods since 2015.	See Section 4.2.4 and 5.1 of AGE (2023) report for operational and post closure groundwater inflows.
10	6.9 Final Void Treatments 6.1 Hydrogeology Appendix A – Residual Void Investigation Report	Provide an updated Rehabilitation Planning Part which addresses the following: Updated advice on any significant differences between the final void and backfill areas and those on which the AGE 2017 and KBR 2017 work was based on.	New numerical groundwater model completed on final voids landforms (AGE 2023) to replace previous analytical groundwater model. Updated numerical model completed on final voids landforms.
		The likely impacts of these differences on predicted final void behaviour.	New numerical groundwater model completed on final voids landforms (AGE 2023) to replace previous analytical groundwater model.

		Observed water level data for the basalt and Permian aquifers to support the assumptions in section 4.2 of AGE 2017 that the water level elevation is 270m in both of these aquifers.	New numerical groundwater model completed on final voids landforms (AGE 2023) to replace previous analytical groundwater model.
		Details of the extent of the capture zone used in the formula for groundwater inflow and the area where recharge was applied for each pit.	New numerical model developed, see Sections 3.3, 3.4, 3.5, 3.7, 4.1, 4.2.1 of AGE (2023) report.
		Details of how recharge rates were determined and whether any calibration of these recharge rates occurred in the process.	New numerical model developed, see Section 4 of AGE (2023) report.
		Details of how the hydraulic conductivity values were determined and whether any calibration of these values occurred in the process.	New numerical model developed, see Sections 2.6, 2.8, 4.2.2 of AGE (2023) report.
11	6.9 Final Void Treatments 6.1 Hydrogeology Appendix A – Residual Void Investigation Report	Provide an updated Rehabilitation Planning Part that provides details of the following: - how increased recharge to the backfill and drainage of groundwater from the spoil backfill to the final voids has been included in the final void investigation; - the various components of the KBR 2017 void water balance model, including: - Groundwater inflow from spoil - Surface water inflow (rainfall, runoff) - Evaporation - Groundwater inflow from basalt - Groundwater inflow from Permians - Drainage between pits	A new final void surface hydrology report (WRM 2023) has been developed for Minerva. See Section 3 of WRM (2023) report (Appendix E of PRCP).
12	6.10 Built Infrastructure 6.7 Water management	Provide an updated Rehabilitation Planning Part that includes a detailed description of the infrastructure to remain.	The list of infrastructure to remain is included within Section 6.10.1 Infrastructure to be Retained and Appendix C of the PRCP, with the specific water storages names and volumes provided in Table 9.
		Include dams that have received water from disturbed areas (including the industrial dam and site dams) in the schedule by including them in a RA and assign RMs that reflect the works required to ensure they are suitable for the PMLU.	RA23 has been included in the PRCP Schedule for the site water dams.
		Provide an updated Rehabilitation Planning Part that clearly identifies the location of infrastructure to be decommissioned and removed and corresponding RAs.	The list of infrastructure to remain is included within Section 6.10.1 Infrastructure to be Retained and Appendix C of the PRCP, with the specific water storages names and volumes provided in Table 9. RA6 Mine Industrial Area does not have infrastructure removal RM1 as the infrastructure in this area is being retained.

			RA7 Orica Compound has been updated to include RM2 Remediation of Contaminated Land for the 1.4 ha. Infrastructure has been removed. RA8 Run of Mine has been updated to include 0.5 ha for infrastructure decommissioning.
		Provide an updated Rehabilitation Planning Part that includes detailed information regarding where general waste will be disposed and how the land will be rehabilitated to achieve a stable condition.	Section 6.10.2 Infrastructure to be Decommissioned updated in relation to the disposal of general waste.
13	7.2 Rehabilitation Trials	Provide an updated Rehabilitation Planning Part that includes further information regarding Rehabilitation trials as required by section 3.7.1 of the PRCP Guideline.	Text updated within Section 7.2 Rehabilitation Trials.
14	8.1 Milestone Criteria Monitoring	Provide an updated Rehabilitation Planning Part that includes information regarding monitoring and maintenance required by section 3.8 of the PRCP Guideline.	The rehabilitation monitoring frequency in Table 19 Rehabilitation Monitoring Activities for RM7 and RM9 has been changed from every 3 years to biennial to help with the trending of monitoring data prior to achieving the completion criteria. Rehabilitation will be monitored every 4 years once it meets the completion criteria.
PRCP Schedule			
15	PRCP Schedule – timing of milestones	Provide an updated Rehabilitation Planning Part includes justification for the proposed date of commencement of rehabilitation activities. Provide an updated Rehabilitation Planning Part includes information demonstrating the timing of each rehabilitation milestone for each RA complies with section 126D (4) of the EP Act.	Section 2.4 Mine Plan has been updated to include information in relation to the mining of additional coal reserves, which is to occur prior to commencing the rehabilitation of milestones for the RAs.
16	MM1 & MM2	Provide an updated PRCP Schedule that includes criteria that reflect a geotechnically stable landform.	Geotech stability of final voids FoS ≥ 1.5 included in PRCP Schedule Milestone Criteria MM2.
		Provide an updated PRCP Schedule that includes criteria regarding improvement measures for all walls of the residual void.	Geotech stability of final voids FoS ≥ 1.5 included in PRCP Schedule Milestone Criteria MM2.
		Provide an updated PRCP Schedule that includes criteria regarding the construction of safety berms and measures to prevent flood water entering the residual voids.	MM2 updated to reflect 5m base width of bund and use of competent materials as advised by WK Geotechnical Report (2023).
		Provide an updated PRCP Schedule that includes criteria providing specific locations, dimensions, and descriptions of the safety measures.	MM1 and MM2 for IA1 and IA2 have been bought forward (from ~2043 to ~2034) to align with completion of rehabilitation works in the Western and Southern voids. This will ensure the safety bund to prevent access to voids is installed following the completion of rehabilitation works.

		Provide an updated PRCP schedule that includes criteria regarding maximum pit water levels to prevent discharge of pit water to the surrounding environment.	AGE (2023) numerical modelling and WRM (2023) Final void surface Hydrology shows that Western and Southern voids remain as groundwater sinks, with maximum modelled water levels over 2500 years not presenting a source to groundwater or surface water systems.
		Provide an updated PRCP schedule that includes criteria to monitor the depth and quality of the water within the voids to ensure it is stable and non-polluting.	AGE (2023) numerical modelling and WRM (2023) Final void surface Hydrology shows that Western and Southern voids remain as groundwater sinks, with maximum modelled water levels over 2500 years not presenting a source to groundwater or surface water systems.
17	RM7 & RM8	Provide an updated PRCP Schedule that includes revised criteria that meet SMART principles. Suggest including criteria that reflect the establishment of vegetation that will support PMLU of low intensity grazing.	Milestone criteria for RM10 Low-intensity grazing included vegetation groundcover $\geq 50\%$ and this is also shown in Table 10 of the PRCP for low-intensity grazing. RM10 is the final completion criteria for the low intensity grazing PMLU. RM8 interim low-intensity grazing milestone criteria has been edited to include a vegetation groundcover of $\geq 25\%$. RM7 and RM9 updated to include interim and completion criteria total groundcover of 25% and 50% respectively. Table 10 of the PRCP has also been updated to reflect the 50% total groundcover for the grassy open woodlands PMLU.
18	RM9 Appendix B Rehab Plan – page 51	Provide an updated PRCP Schedule that includes revised criteria that meet SMART principles and demonstrate the land has achieved a stable condition.	RM9 and RM10 updated to clarify weed presence to be $<10\%$ of vegetative groundcover. Table 10 Completion Criteria for PMLU of PRCP was also updated with this clarification. RM9 includes the milestone criteria a) Rehabilitation dump is geotechnically stable with $FOS \geq 1.5$ for the grassy open woodlands spoil dumps. This completion criteria is also shown in Table 10 of the PRCP. RM9 and RM10 updated to quantify gully erosion criteria not to exceed 0.3m deep, as defined under the Rehabilitation Management Plan Land Outcome Document. Table 10 Completion Criteria for PMLU of the PRCP has also been updated to include this addition. Stem densities for trees are not specified as completion criteria in the Rehabilitation Management Plan Land Outcome Document.

			PRCP Table 14 Seed Species Commonly Used for Rehabilitation includes some exotic grasses and legumes used for the low-intensity grazing PMLU. This is consistent with the Rehabilitation Management Plan Land Outcome Document that states pastures species will be used for establishment of the low intensity grazing PMLU.
19	RM10	Provide criteria that address slope angles and topsoil coverage separately to improve clarity.	The $\leq 5\%$ slope and the 0.2m topsoil criteria has been separated in RM10.
		Provide milestone criteria that will sustain the PMLU, or provide further information demonstrating that the proposed criteria will sustain the proposed PMLU in the long term.	Appendix B cites from a study completed by Emmerton (2003) that proposed cover levels maintained above 70% for rehabilitation areas with slopes up to 12%. The low-intensity grazing PMLU domain does not have slopes that exceed 5% (see Table 10 of PRCP and RM10), so the minimum 50% vegetation cover level is sustainable for the lower slope areas of rehabilitation.
20	RA6-8, RA19	Provide a revised schedule for each RA that includes all relevant milestones that must be completed for the land to achieve a stable condition.	RA6 Mine Industrial Area does not have infrastructure removal RM1 as the infrastructure is being retained. RA7 Orica Compound has been updated to include RM2 Remediation of Contaminated Land for the 1.4 ha. No RM1 infrastructure decommissioning not required as no infrastructure remains. RA8 Run of Mine has been updated to include 0.5 ha for infrastructure decommissioning.
21	Dams	Include site dams that are to remain post closure in the schedule by assigning a RA and RMs that reflect remediation work required to ensure they are suitable for the PMLU. Include final criteria that demonstrate the dams do not contain contaminated sediment or water and are suitable for the PMLU.	PRCP Schedule has been updated with RA23 for Site Water Dams as part of the low intensity grazing PMLU.
22	Schedule generally	Provide a revised schedule that reflects the requirements of the EP Act and section 6.4 of the PRCP guideline.	Some rehabilitation areas include a mix of both rock mulch and topsoil and topsoil only applications. The rock mulch and topsoil areas do not require final trim RM3b as rock is being pushed over the surface to create a rough landscape, reshape only is required. The topsoil only areas are final trimmed as they need a smoother finish prior to topsoil application. PRCP Schedule has been updated to show the commencement of the first milestone and the completion date of all milestones as 10 December for the respective year.

General			
23	Spatial Information	Provide updated spatial files with the removal of overlapping polygons and provide information regarding: 1. Location of sensitive receptors or provide an explanation as to why sensitive receptors have not been included; 2. 0.1% AEP flood zone of the Sandhurst Creek diversion; 3. The discrepancy of the total disturbance and rehabilitation of the site to align with the total area approved by the mining leases.	1. Spatial files for Figure 4 Adjacent Sensitive Receptors has been included within the PRCP files. 2. The modelled 0.1% AEP flood zone for Sandhurst Creek has been provided. 3. Overlapping polygons have been removed and total areas are as follows: Mine Lease 70145 = 931.6ha Mine Lease 70376 = 626.3ha Total ML = 1,557.9 ha Existing rehab area = 451.6ha NUMAs - 89.5ha Proposed Rehab(disturbance) = 530.6ha Total disturbance = 1,071.7 ha
24	Figure 9	Provide an updated map showing the extent and clearly differentiating between the PMLUs.	Figure 9 Post Mining Land Uses has been updated in the PRCP.

Minerva Mine

Progressive Rehabilitation and Closure Plan

ML70145 and ML70376

EA Holder - Minerva Coal Pty Ltd

ID/Version Number	Version 3	31 August 2023
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1 Introduction

1.1 Transitional Arrangements

The Department of Environment and Science provided a Progressive Rehabilitation and Closure Plan (PRCP) transition notice for the Minerva Mine on 9th March 2021. The transition notice required Minerva Coal Pty Ltd to submit a proposed PRCP for Minerva Mine to the Department of Environment and Science by 1st July 2022.

The proposed Minerva Mine *Progressive Rehabilitation and Closure Plan* fulfills the requirements of the PRCP transition notice.

1.2 Land Outcome Documents

The following land outcome documents (LODs) are in place for the Minerva Mine:

- Environmental Authority EPML00668613
- Minerva Mine *Residual Void Investigation Report* (Sojitz Minerva Mining 2021a) (refer to **Appendix A**)
- Minerva Mine *Rehabilitation Management Plan* (Sojitz Minerva Mining 2021b) (refer to **Appendix B**)

2 Project Planning

2.1 Mining Operations

Minerva Mine is managed by Sojitz Plus Pty Ltd on behalf of joint venture partners Sojitz Blue Pty Ltd and Kores Australia Minerva Coal Pty Ltd. Minerva Mine is located approximately 45 km south of Emerald and 25 km north of Springsure in Central Queensland (**Figure 1**). Open-cut mining operations commenced in 2004 and continued until economic coal reserves (as estimated at that time) were depleted by August 2021, with the site currently in care and maintenance, with rehabilitation recommencing in November 2023 as part of mine closure activities.

Thermal coal was produced during active mining at an average rate of approximately 2.6 Mt per annum from multiple seams at a maximum depth of nearly 200 m below the surface. The coal had an average ash content of 15%. The coal did not need to be processed by a coal handling and preparation plant and no coarse rejects or fine tailings were produced. The coal was railed to the RG Tanna export terminal at Gladstone.

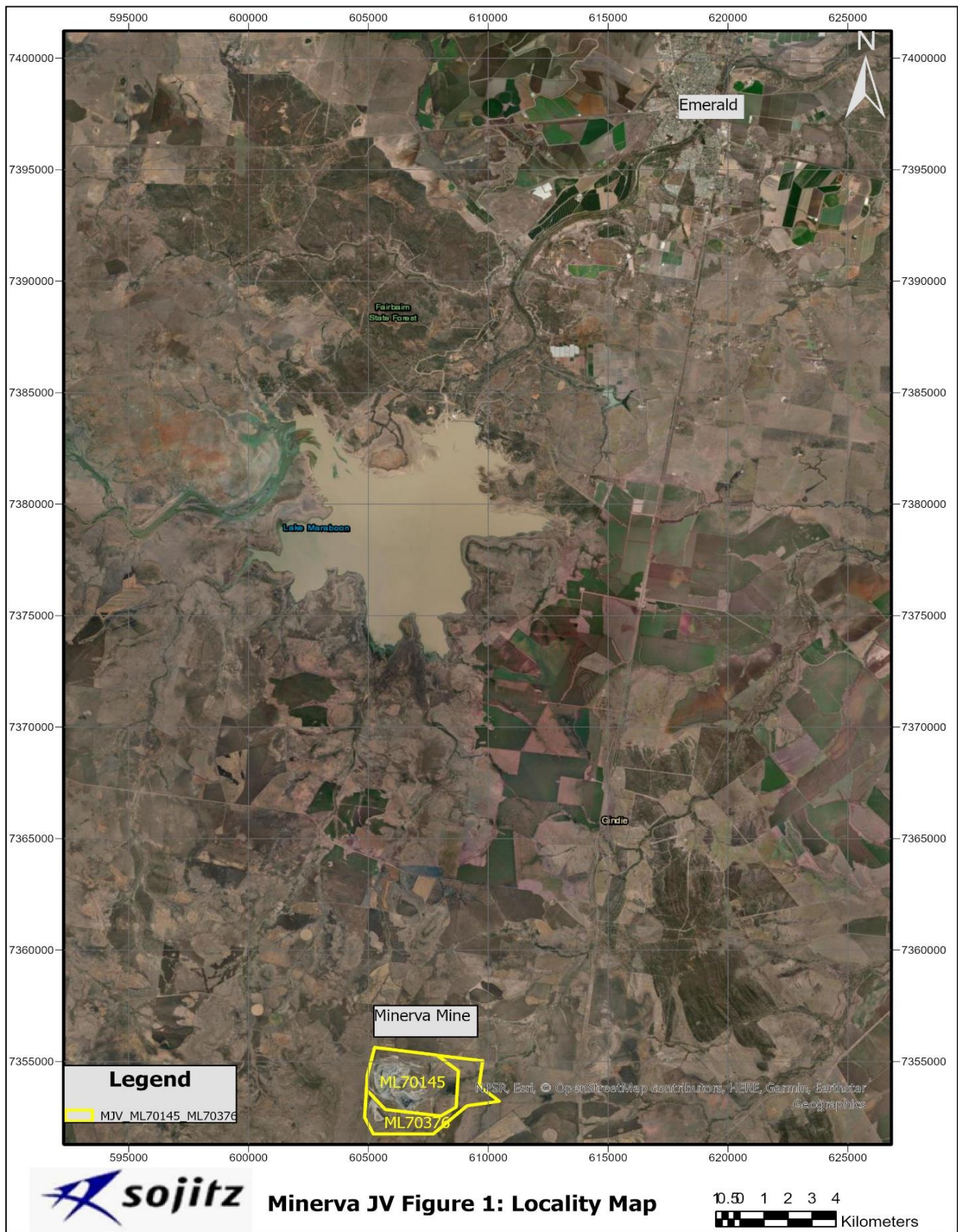


Figure 1 – Locality Map

2.2 Site Activities

The following mining related activities were undertaken at Minerva Mine during the 2004 to 2021 operational phase:

- Conventional open-cut mining using truck and shovel;
- Drill and blast activities;
- Coal haulage to the Run of Mine (ROM) pad and rail load-out;
- Stockpiling and crushing of ROM coal;
- Rail load-out of product coal (rail load-out is located outside the mining leases);
- Workshop maintenance activities for light and heavy vehicles;
- Bulk storage of diesel fuel;
- Storage of regulated waste generated by the mine activities;
- Borefields and water supply pipeline;
- Pit dewatering and storage of excess water;
- Topsoil stripping and haulage ahead of mining;
- Rehabilitation of disturbed areas.

Minerva Mine's Environmental Authority (EA) EPML00668613 authorises the following environmentally relevant activities:

- ERA 13 – Mining Black Coal
- ERA 8 – Chemical Storage
- ERA 56 – Regulated Waste Storage

2.3 Mining Tenements and Land Tenure

The mining leases comprising Minerva Mine, ML70145 and ML70376, are located entirely within the property boundaries of "Lexington", which is freehold land owned by Minerva Coal Pty Ltd. Details of the mining leases and the underlying land tenure are provided in **Table 1** and shown in **Figure 2**. The Lexington property boundary is shown in **Figure 3**, along with a second freehold property owned by Minerva Coal Pty Ltd (Mt Minerva). The location of nearby sensitive receptors are provided in **Figure 4**.

Table 1 – Mining Leases

Mining Lease	Area (ha)	Expiry Date	Real Property Description	Tenure	Owner of Title
ML70145	931.6	30 Nov 2030	Lot 10 and Lot 11 on Plan DN40126	Freehold	Minerva Coal Pty Ltd
ML70376	626.3	30 Nov 2030	Lot 10 and Lot 11 on Plan DN40126, Lot 14 on Plan DN40170	Freehold	Minerva Coal Pty Ltd

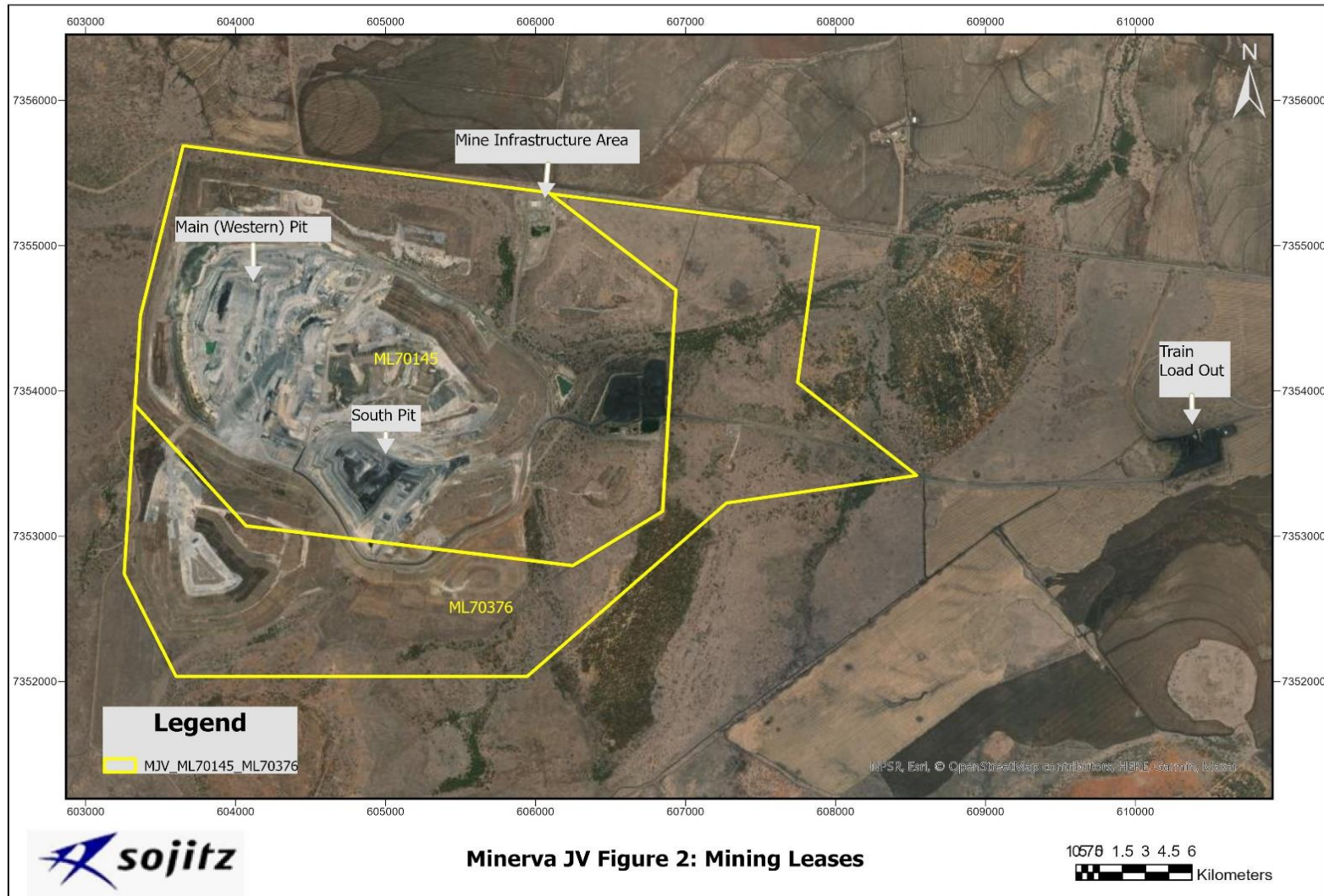


Figure 2 – Mining Leases



Figure 3 - Property Boundaries

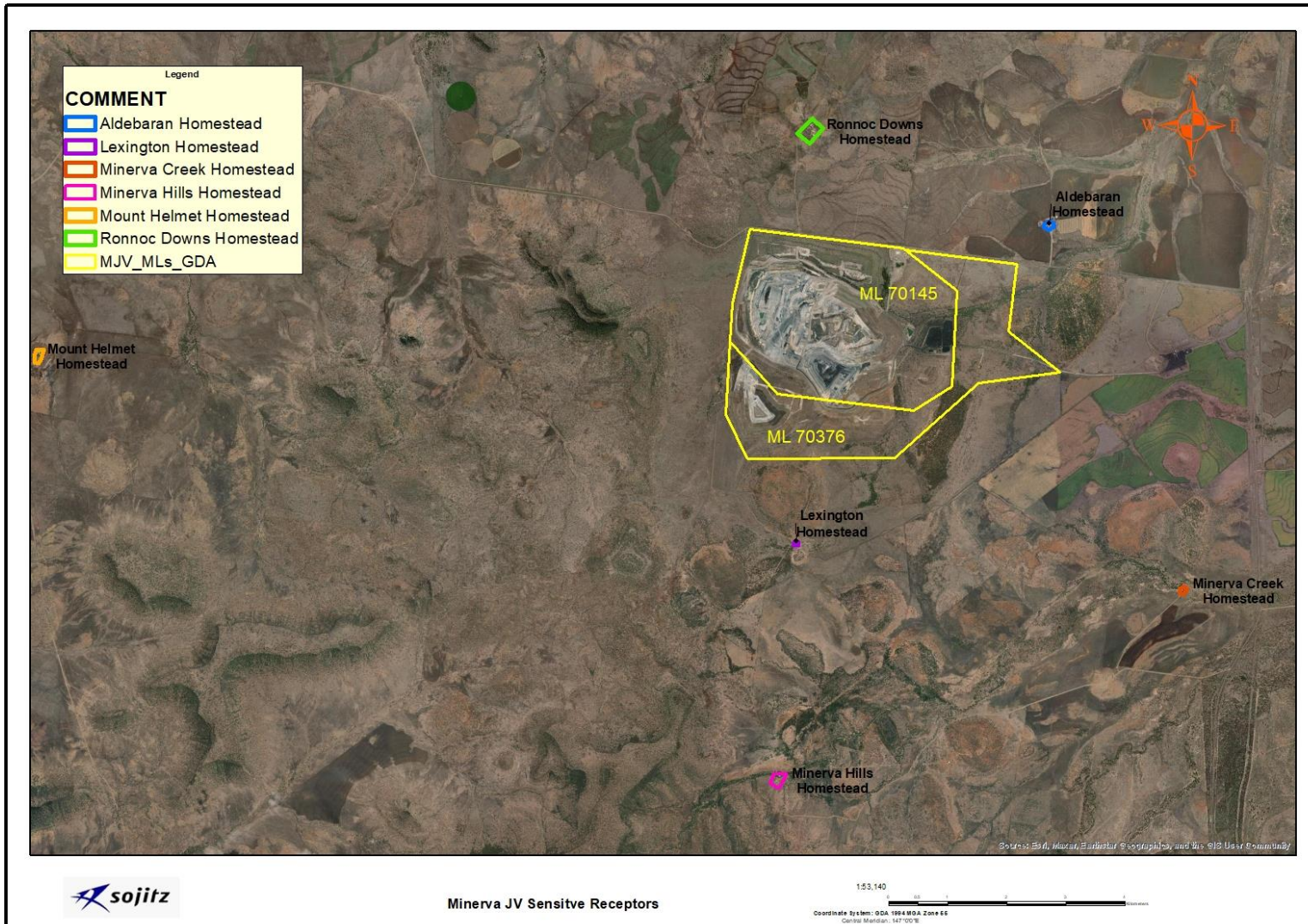


Figure 4 - Adjacent Sensitive Receptors

2.4 Mine Plan

Open-cut mining at Minerva Mine occurred within two pits, the Western Pit and the Southern Pit. Coal was mined in a multi-seam operation, utilising hydraulic excavators and a truck fleet. The Western Pit was mined in an east to west progression, with a final void remaining adjacent to the western boundary of ML 70145. The Southern Pit was mined in a north-east to south-west progression, with a final void remaining in the south.

Coal reserves exist within ML70145 and ML70376, adjacent to the Western and Southern voids. Sojitz has been negotiating with third parties who are considering the purchase of Minerva to extract the remaining coal reserves. There are approximately 3.6 Mt of open cut coal remaining in the Southern void area and 0.8 Mt of coal in the Western void area. The investment group are also interested in a sizable underground in-situ tonnage within the Minerva (20Mt) lease as well as adjoining Athena lease (100Mt) which will be accessed from the Minerva highwalls. This area contains a coal reserve that is to be mined (subject to a sale to a third party) within 10 years after the land would have otherwise become available for rehabilitation (as per s126D(5)(b) of the *Environmental Protection Act 1994*).

The PRCP Schedule proposed for Minerva (see **Section 10**) allows for the winning of remaining coal reserves prior to completing final rehabilitation. In pit and out of pit spoil dumps may be used for the disposal of overburden, so rehabilitation of these areas cannot commence until the remaining coal has been recovered (estimated to be in 2027).

The locations of the Western Pit and the Southern Pit final voids are provided in **Figure 5**.

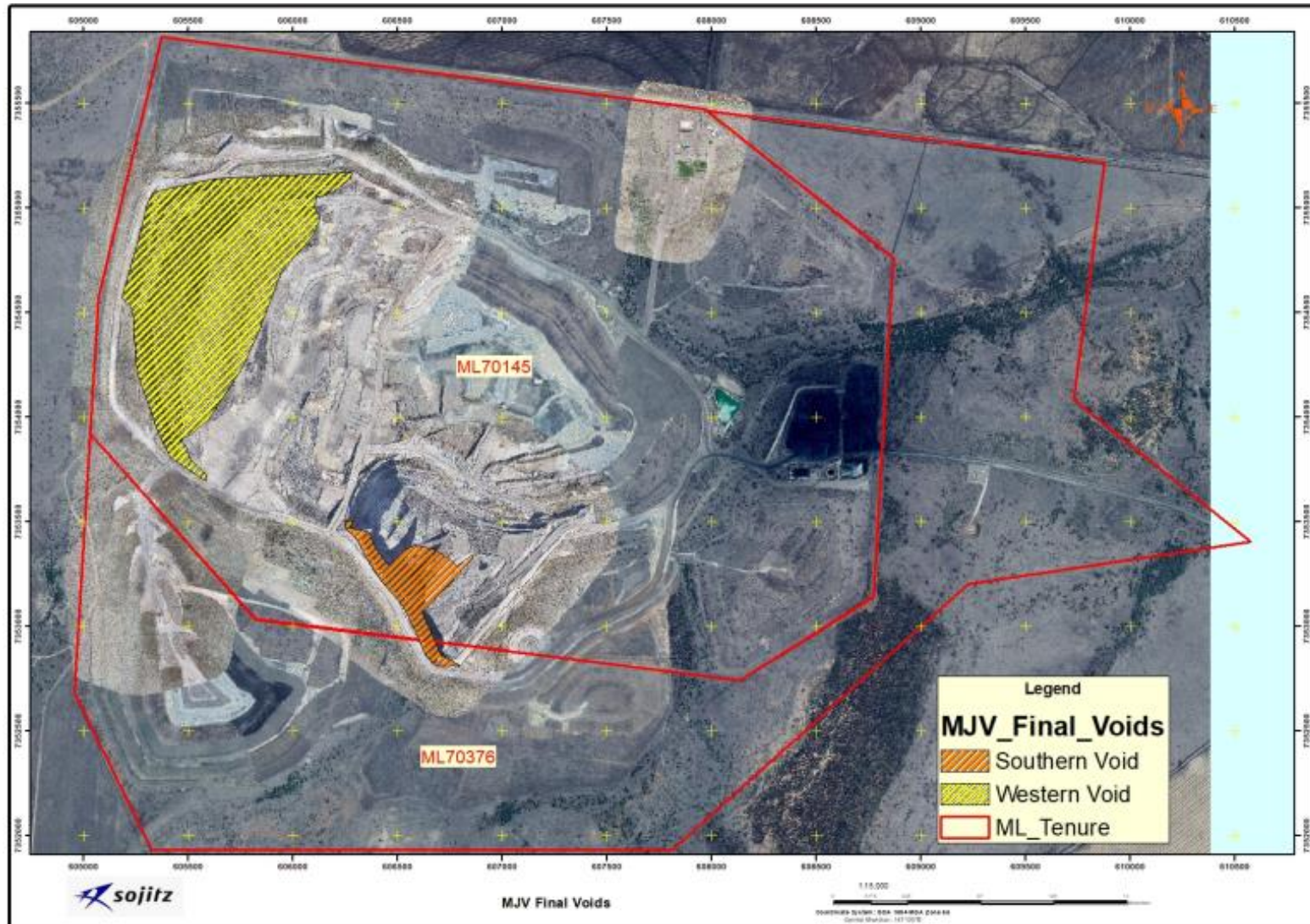


Figure 5 – Location of Final Void

2.5 Existing Rehabilitation

Progressive rehabilitation was undertaken at Minerva Mine during the life of the operations as areas became available. Depending on the rehabilitation treatment applied, post-mining land uses (PMLUs) for rehabilitated mining areas are either grassy open woodlands or low intensity grazing. PMLUs are discussed further in **Section 4**.

Areas disturbed by mining have been rehabilitated using either the (i) rock mulch and topsoil method (see **Section 6.8.3**), or the (ii) topsoil only method (see **Section 6.8.4**). Rehabilitation has been undertaken at the following locations:

- North-West Dump (topsoil only method);
- South-West Dump (rock mulch and topsoil method);
- Main Dump (rock mulch and topsoil method plus topsoil only method);
- Creek Diversion North Dump (rock mulch and topsoil method plus topsoil only method);
- Creek Diversion South Dump (rock mulch and topsoil method); and
- Sandhurst Creek Diversion (rock mulch and topsoil method plus topsoil only method).

The locations of (i) rock mulch and topsoil and (ii) topsoil only rehabilitation area as at April 2022 is shown in **Figure 6** and the timing of the progressive rehabilitation conducted since the commencement of mining is provided in **Figure 7**. The year of rehabilitation shown in **Figure 7** indicates when the rehabilitation was completed (i.e. when the area was sown). Rehabilitation works commence with reshaping, followed by hauling in rock mulch and/or topsoil, spreading same and deep ripping, and finally seeding (see **Section 6.8** for further details). Depending on the mine plan and location, the rehabilitation works may have commenced several years before final seeding.

An application for certification of progressive rehabilitation has not been made for any of the rehabilitation areas. The recommended growth period for native vegetation when applying for progressive certification is 15 years (DES 2022). The spoil dump areas rehabilitated to date have been established for less than this timeframe.

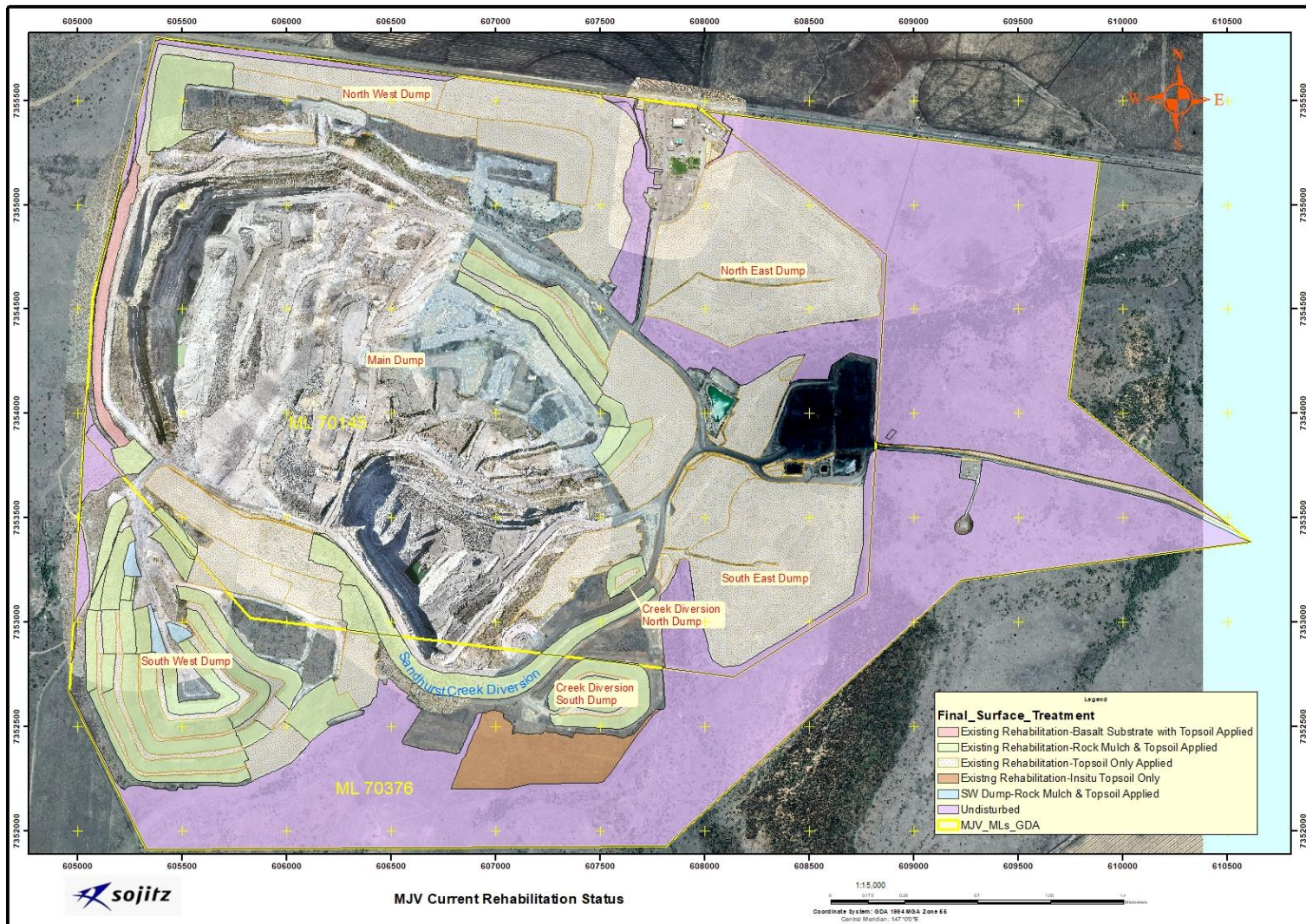


Figure 6 – Current Rehabilitation Status

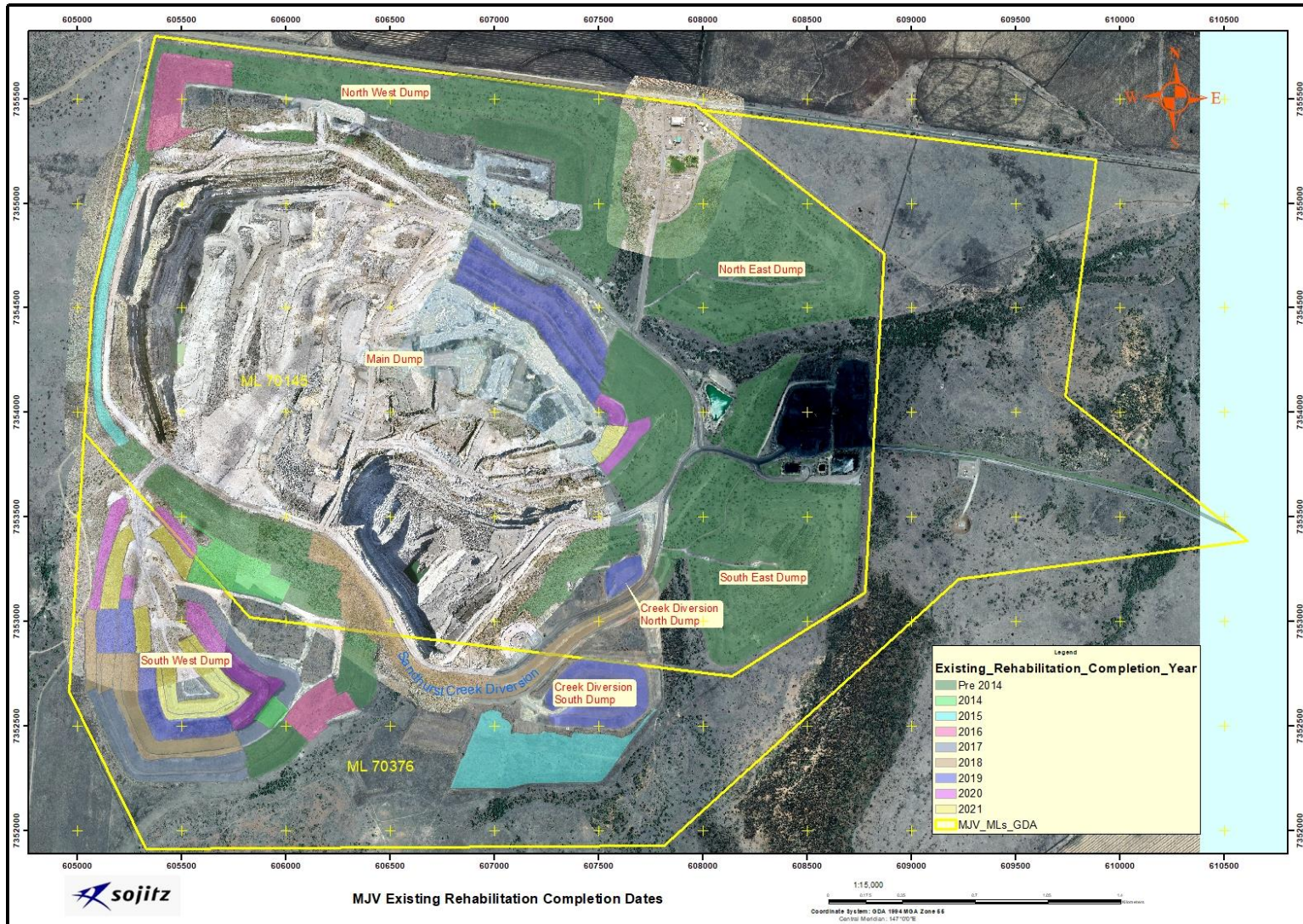


Figure 7 – Rehabilitation Completion Dates

(Version 3 – 31 August 2023)

2.6 Baseline Information

2.6.1 Climate

A summary of meteorological data from the Bureau of Meteorology's closest long-term weather monitoring station (Springsure) is provided in **Table 2** and **Figure 8**. The rainfall data is for 1865 – 2022 and temperature data 1938 – 2022. The humidity data is for 1965 – 2010.

Table 2 – Meteorological Data for Springsure, Comet Street

Month	Average Temperature (°C) (1938 – 2022)		Humidity (%) (1965 – 2010)		Pan Evap (mm) (1956 – 2022)	Rainfall (mm) (1865 – 2022)		
	Min	Max	9am	3pm	Mean	Mean	Median	Highest
January	20.9	34	61	38		110	91	768
February	20.5	32.6	66	44		107	86	552
March	18.9	31.6	62	38		71	51	326
April	14.9	29	59	38		39	21	241
May	10.9	25.3	60	39		34	24	263
June	7.3	22.3	62	40		38	22	296
July	6.4	22.2	60	36		28	14	245
August	7.6	24.1	54	30		24	14	201
September	11.3	27.6	52	29		30	15	324
October	15.3	30.6	52	30		49	39	237
November	17.9	32.8	55	33		64	51	356
December	19.8	34.1	57	37		91	77	522
Annual					2040	687	635	1721

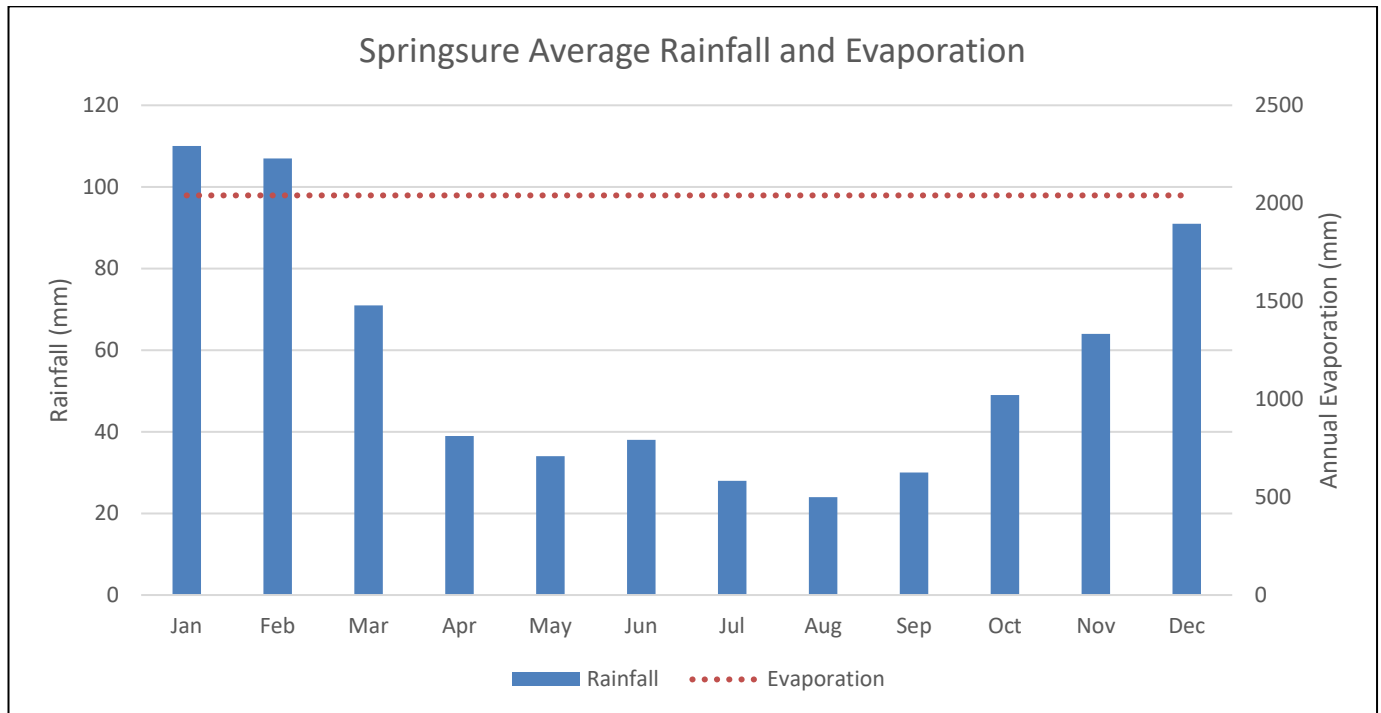


Figure 8 – Annual Average Rainfall and Evaporation

The majority of the annual rainfall occurs during the wet season (November to April), with an annual average rainfall of 687 mm at Springsure. The average pan evaporation rate for the region (2040 mm) greatly exceeds the average rainfall, with a moisture deficit of 1353 mm per annum. The water deficit conditions are a limiting factor with regard to vegetation establishment on disturbed land.

2.6.2 Geology

The general stratigraphy of the area from the surface to basement materials is shown in **Table 3**. Weathered and unweather Tertiary basalt generally overlays the Permian sediments, which contain the Permian coal measures.

Table 3 – Stratigraphy within ML 70376 and ML 70145

Age	Formation
	Soil
Tertiary (Cenozoic)	Basalt
Tertiary (Cenozoic)	Fluvio-lacustrine Sediments
Permian	Cattle Creek Formation
Permian	Reids Dome Bed
Pre-Permian	Faulted Basement

Uplift in the Tertiary materials created the Lexington Dome, a structural feature within Permian aged consolidated sediments. The uplift event was followed by erosion and a series of basalt flows which formed a regional basalt cap.

The thickness of the basalt increases in all directions away from the Lexington Dome, though the central area of the Lexington Dome was not covered by basalt. Coal mining within ML 70145 started in an area with no basalt cover and progressed to the western boundary of ML 70145 where the basalt is 135m thick.

2.6.3 Topography

The pre-mining topography of Minerva Mine consisted of gently undulating open downs of basalt-derived black soil rising towards basaltic lava plateaus to the west and south of the site (mining leases). The relic basalt flows and intrusive volcanic plugs form steep mesa and ridges up to 250 m above the surrounding plains. Elevations range from 260 m AHD on the open downs within the mining leases and rise towards 500 m AHD to the west at the top of Mount Promenade. The surface topography fall across the open downs is from west to east at slopes of generally less than 1%.

Mine spoil dumps have formed rehabilitated landforms rising approximately 50 m above the pre-mining topography on the open downs. The rehabilitated spoil dumps are much lower than the adjacent escarpment and blend into the surrounding mesa landscape.

2.6.4 Soils

A total of 13 soil types have been recognised and mapped at the mine (Ison 1996a). The soils are grouped into five categories based on the geology of the underlying soils. ESys (2005 and 2007) undertook sampling to provide laboratory analysis for fertility and erodibility as part of land capability assessments. A summary of the soil types, land capability and the limiting factors are presented in **Table 4**.

The predominant soil type at Minerva is black vertisol, which has been stripped ahead of mining and stockpiled for use in rehabilitation. Black vertisols are cracking clay soils that have high soil fertility and have a large water holding capacity (Queensland Government 2016). All surface soils of all soil types, apart from alluvium, are water stable and non-dispersible (ESys 2005).

Table 4 – Soil Types Mapped at Minerva Mine

Great Soil Group	Northcote	Australian Soil Classification	Description	Land Capability	Limiting factors
<i>Tertiary Basalt</i>					
Black earth Prairie	Ug5.12; Uf6.22	Black vertisol; Leptic tenosol	Very shallow, stony black cracking clays or dark brown non-cracking clays	VII	Plant available moisture, structure, rockiness
Black earth	Ug5.12	Black vertisol	Shallow cobbly black cracking clay	IV	Plant available moisture, rockiness
Black earth	Ug5.12	Black vertisol	Shallow to moderate deep black cracking clay	III	Plant available moisture
Black earth	Ug5.12	Black vertisol	Deep black cracking clay	III	Plant available moisture, soil workability, erosion
<i>Acid and Intermediate Volcanic Rocks</i>					
Prairie	Uf6.31 Uf6.32	Black or brown dermosol	Shallow cobbly reddish brown clays	VII	Plant available moisture, rockiness
Earthy sand	Um5.42	Tenosol	Shallow cobbly brown massive loam	VII	Plant available moisture, rockiness
<i>Permian Sedimentary Rocks</i>					

Great Soil Group	Northcote	Australian Soil Classification	Description	Land Capability	Limiting factors
-	Uf6.31	Brown dermosol	Shallow cobbly brown or dark non-cracking clay	VI	Plant available moisture
Black earth	Ug5.1	Black vertisol	Deep dark grey or black cracking soils	III	Plant available moisture
Grey clay	Ug5.1	Black vertisol	Deep dark grey cracking clay with gilgai	IV	Plant available moisture, salinity, soil workability
-	Uf6.31	Brown dermosol	Moderately deep brown or reddish brown non-cracking clays	III	Plant available moisture, rockiness, erosion
-	Dr2.13 Db1.14 Dd1.13	Red, brown or black chromosol	Moderately deep, loamy surface, red or brown duplex soils	IV	Plant available moisture
<i>Secondary Calcareous Material</i>					
Black earth	Ug5.11	Black vertisol	Moderately deep to deep black cracking clay	III	Plant available moisture
<i>Alluvium</i>					
Black earth	Ug5.1	Black vertisol	Deep black cracking clay	III	Plant available moisture. Salinity

2.6.5 Land Stability

The land within the mining leases on Lexington was used for grazing and dryland cropping prior to mining activities. Parts of ML70376 not required for mining activities are currently grazed under an agistment agreement. The balance of land owned by Minerva Coal Pty Ltd is used for grazing and dryland cropping. Surrounding properties support grazing, dryland cropping and irrigated cropping. The cracking clay black soils within the mining leases are stable soils that are not prone to dispersion or erosion. Land degradation from previous agricultural activities was not a distinguishing feature of the pre-existing landscape.

The agricultural capability of some soils is limited by rockiness, however the rock component of the soil makes it highly desirable for use on rehabilitated slopes. The use of a rock mulch cladding for mine rehabilitated areas provides a high level of surface roughness and high infiltration rates. Rock mulch cladding provides a very stable rehabilitated post-mining land surface and is discussed further in **Section 6.3.2**.

2.6.6 Surface Water Hydrology

Minerva Mine is located in the headwaters of Sandhurst Creek, which flows from west to east into the Comet River and ultimately the Fitzroy River. Sandhurst Creek is an ephemeral stream and is the main surface water drainage feature within the mining leases. Sandhurst Creek is a Stream Order 2 and 3 within the vicinity of Minerva Mine and has a catchment area of approximately 43 km².

Sandhurst Creek generally does not contain permanent groundwater-derived baseflow within the mining leases, though a spring fed section of the creek is known to occur a few kilometres downstream at the Gregory Highway crossing.

Minerva Mine holds water licence number 406741 issued under the *Water Act 2000* (see **Appendix G**) which authorises interfering with the flow of water in Sandhurst Creek by creating a stream diversion. Sandhurst Creek was permanently diverted to the south of the mine in 2008 to enable access to the coal reserves. Further permanent realignments to the diversion were constructed in 2014 and 2017 to extend the Western and Southern pits. The alignment of the Sandhurst Creek diversion is provided in **Figure 9**.

The Sandhurst Creek diversion is now approximately 5.8 km long and has been fully rehabilitated along the entire length. The diversion has a total width of between 30 – 212 m, a channel depth of between 1 – 22 m and a channel grade of between 0.24 – 0.29%. The diversion has been designed to provide flood protection to the Western and Southern voids during a 0.1% annual exceedance probability (AEP) event.

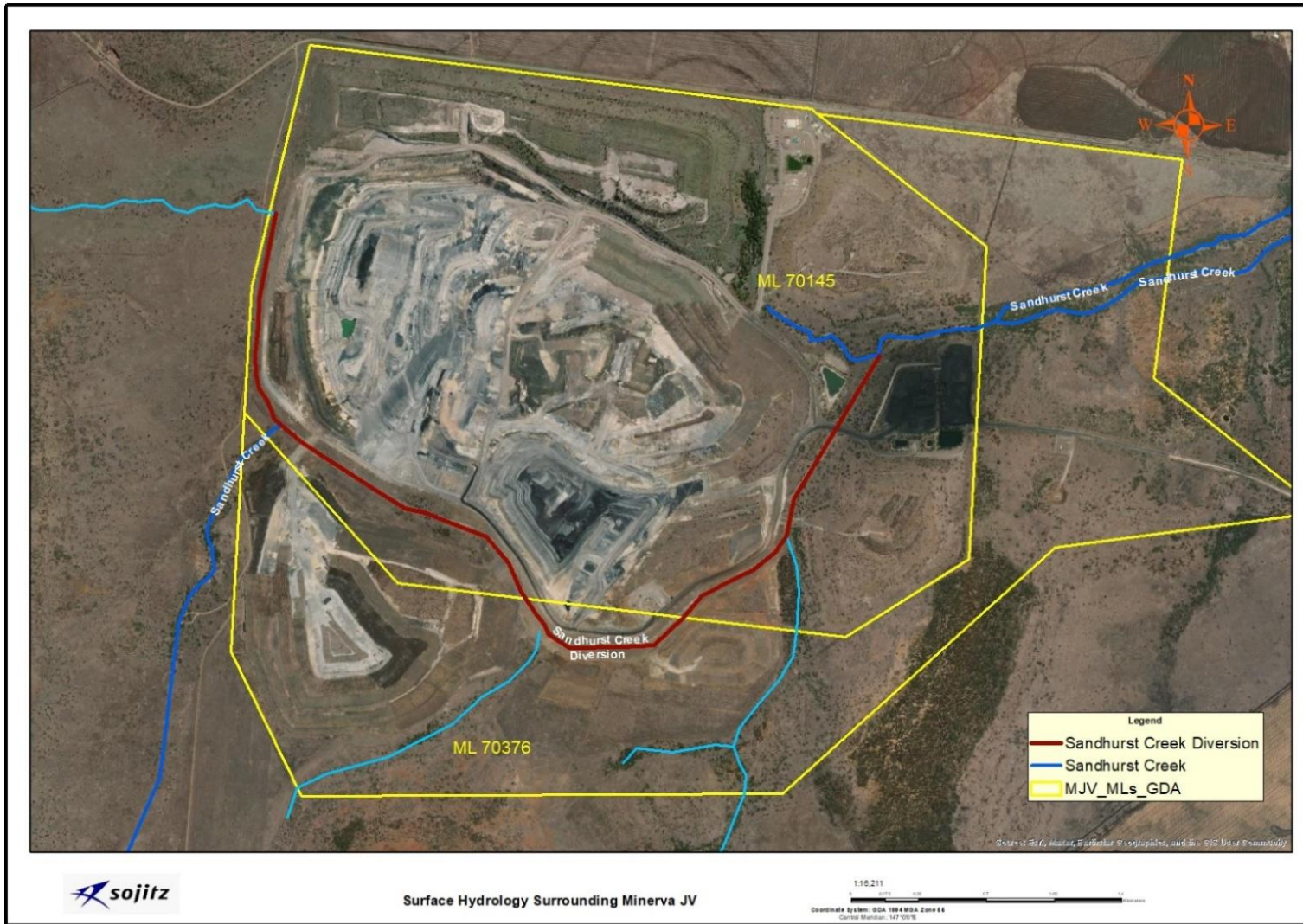


Figure 9 – Surface Water Hydrology

2.6.7 Groundwater

The two main groundwater bearing units within the Minerva mining leases are:

- Upper Tertiary Basalts – vesicular and fractured zones within the basalt flows are water bearing and form productive aquifers, separated by weathered clays zones between basalt flow layers. Water from the basalt aquifer is suitable for stock watering and for irrigation of crops with low salt tolerances.
- Underlying Permian Consolidated Sediments – the coal seam and the Rieds Dome Beds form low yielding aquifers. Water from the Permian sediments is suitable for stock watering but not suitable for irrigation of crops.

Tertiary Basalts

The basalt has a distinct near-surface weathered profile and multiple horizons of fractured and unweathered basalt that may represent separate basalt flows. The uppermost weathered profile extends from the surface to ~ 30m below ground level. The underlying fractured basalt formation is the main aquifer located in the area immediately surrounding ML70145 and the proportion of fractured basalt determines the potential to store and transmit groundwater. Recharge to the basalt aquifer occurs via direct rainfall within the interception zone to the west of Minerva Mine.

Groundwater from the basalt aquifer is used for stock and domestic supplies along with irrigation for some small areas of broad acre cropping. Minerva Mine has historically used two bores located in the tertiary basalt aquifer for mine water requirements (Western bore and Lexington bore). The Western bore was mined out in 2016. The Lexington bore is located on Lot 11 on Plan DN40126, west of the ML70376 western boundary. Minerva Coal Pty Ltd holds Water Licence No.405647 for the Lexington bore. The licence is for 400 ML per annum for industrial purposes. There are two other licensed production bores in the area, both located in the tertiary basalt aquifer outside the Lexington property boundary. The Ronnoc Downs bore is approximately 3 km north of the Western void and the Gidd bore is approximately 7 km north-west of the Western void.

Groundwater flow direction is from the thicker basalt units (west of ML70145) towards the thinner basalt formation within ML70145. The Western residual void is expected to remain a groundwater sink in perpetuity due to the hydraulic gradients of the basalt aquifer towards the open void. Tertiary basalt groundwater inflow to the Southern residual void will not occur because the basalt formation is not intersected by the highwall of the Southern void. (AGE, 2017)

Annual seepage rates from the basalt aquifer to the Western final void were calculated by AGE (2023) using a numerical groundwater model. Inflows from the basalt to the Western void is initially predicted to be around 1 – 2 ML/day until the water level of the void reaches the lower elevation of exposed basalt in the highwall and then decline thereafter as the water level rises. The Western void water level is predicted to reach equilibrium over a period of about 300 years and remain about 30m below the elevation of the regional basalt water table (WRM 2023a). The groundwater hydraulic gradient is expected to be maintained in perpetuity towards the Western residual void and water flow from the void back into the Tertiary basalt is considered unlikely (AGE 2023).

Permian Consolidated Sediments

Groundwater storage and flow in the Permian sediments is predominately associated with natural interconnecting coal seam cleat and joint patterns. The coal seam aquifer is confined above and below by very low permeability interburden that form aquitards. Recharge of the Permian sediments predominantly occurs via vertical seepage from the overlying basalt aquifer where the coal seam sub-crops beneath the basalt or where the coal seam sub-crops near the ground surface.

Annual seepage rates from the Permian sediments to the Western and Southern residual voids were calculated by AGE (2023) using a numerical groundwater model. Inflows from the Permian sediments to Southern residual void was calculated to be approximately 0.02 – 0.04 ML/day. As the void water level increases, the rate of seepage from the Permian sediments is expected to reduce. Equilibrium of the Southern void water level is predicted to be reached over a period of about 250 years and have a maximum elevation of 223 m AHD, which is approximately 50 m below the elevation of the regional water table (WRM 2023a). The groundwater hydraulic gradient is expected to be maintained in perpetuity towards the Southern residual void, which will remain a groundwater sink (AGE 2023).

The Western and Southern voids will remain as residual voids post-mine closure and have been identified as non-use management areas (NUMAs) (Sojitz Minerva Mining 2021a). The management of the Western and Southern residual void NUMAs is discussed further in **Section 5**.

2.6.8 Vegetation

A vegetation survey was undertaken within ML70145 and ML70376 to ground-truth the Queensland Herbarium regional ecosystem (RE) mapping and search for threatened flora species (ESS 2004). The survey found no evidence of protected plants, though ESS (2004) mentioned the late dry season timing of the assessment made it difficult to identify all species.

RE mapping reconciliation has been undertaken for this PRC Plan and a description of the ground-truthed REs and the areas occupied within the mining leases are presented in **Table 5** and shown in **Figure 10**.

Table 5 – Regional Ecosystems Present within the Mining Leases

Regional Ecosystem	Vegetation Management Act 1999 Status	Environmental Protection and Biodiversity Conservation Act 1999 Status	Short Description	Area (ha)
Non-Remnant	NA	NA	Cleared or disturbed areas	1160.6
11.8.5	Not of Concern	Not Listed	<i>Eucalyptus orgadophila</i> open woodland on Cainozoic igneous rocks.	145.2
11.8.11	Of concern	Endangered	<i>Dichanthium sericeum</i> grassland on Cainozoic igneous rocks.	186.4
11.8.11a/11.4.9/11.3.25 (50/40/10)	Of Concern / Endangered / Not of Concern	Endangered / Endangered / Not Listed	<i>Dichanthium sericeum</i> grassland on Cainozoic igneous rocks that includes <i>Melaleuca 24racteate</i> woodland drainage depressions / <i>Acacia harpophylla</i> shrubby woodland with <i>Terminalia oblongata</i> on Cainozoic clay plains / <i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines.	61.4
11.9.1	Endangered	Endangered	<i>Acacia harpophylla</i> - <i>Eucalyptus cambageana</i> woodland to open forest on fine-grained sedimentary rocks.	3.8
TOTAL				1557.4

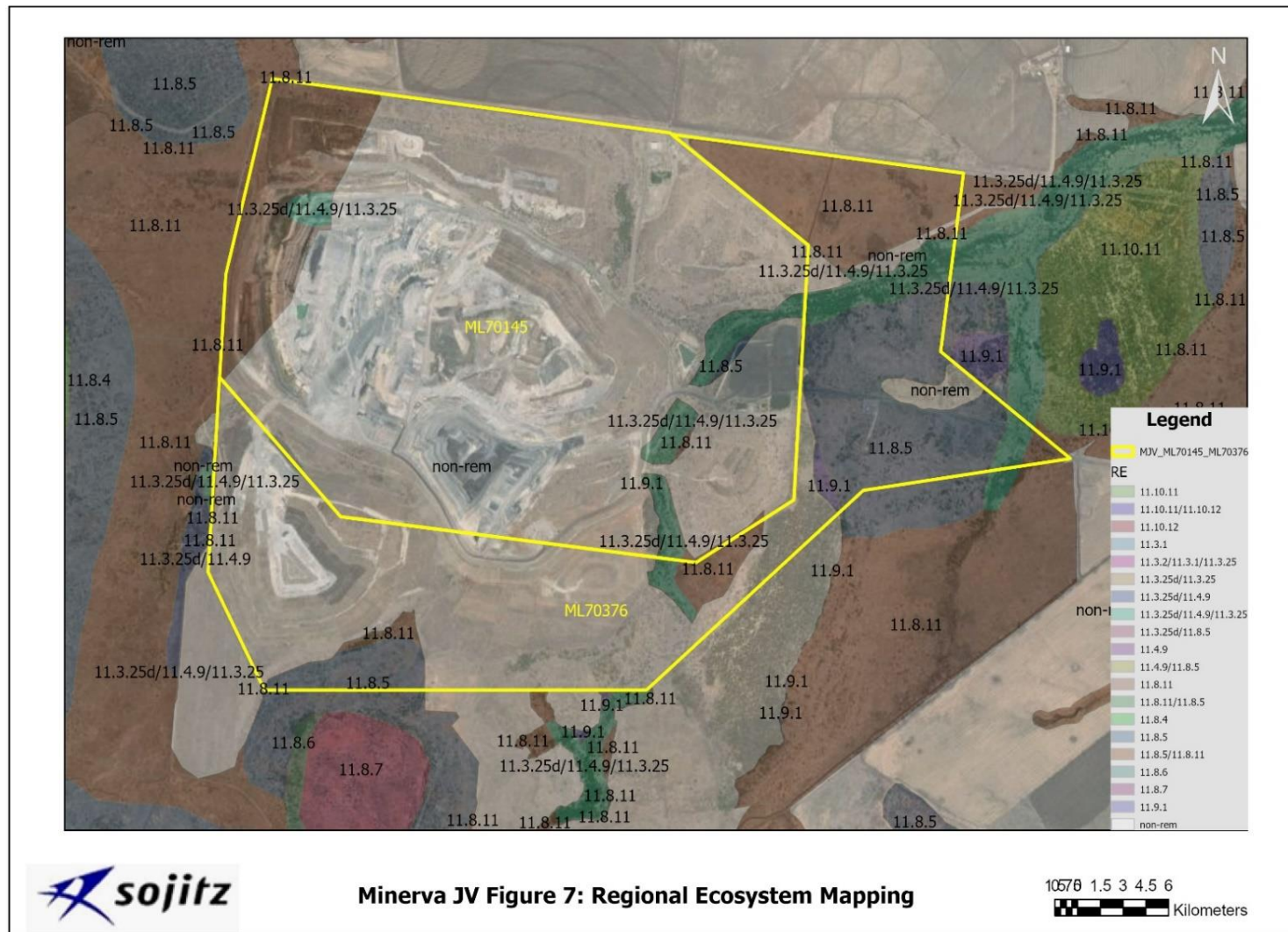


Figure 10 – Regional Ecosystem Mapping

Part of the mining operations for Minerva Mine involved clearing 133 ha of threatened ecological community RE 11.8.11 Natural Grasslands of the Queensland Central Highlands and Northern Fitzroy Basin. This RE is dominated by *Dicanthium sericeum* (Queensland Bluegrass) and is listed under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) as endangered.

The EPBC Act approval (EPBC 2005/2039) for clearing the 133 ha of RE 11.8.11 required the establishment of an equivalent 133 ha offset area of RE 11.8.11. The offset area was established to the east of Minerva Mine on a portion of the Lexington property owned by Minerva Coal Pty Ltd. The natural grasslands offset area is managed by Minerva Mining Pty Ltd in accordance with a Native Grassland Management Plan (Minerva Coal 2015). The area is secured via a Voluntary Declaration under the *Vegetation Management Act 1999*.

2.6.9 Fauna

Earthworks Environmental Services (EES) compiled a list of threatened species following a desktop review of species that could potentially occur in the area and a site visit (EES 2004, EES 2005). The fauna species list included 12 threatened species listed under the *Nature Conservation Act 1992* (NC Act) and the EPBC Act that could potentially occur in the general locality (see **Table 6**).

Table 6 – Threatened Species Potentially Occurring in the Area

Class	Scientific Name	Common Name	NC Act Status	EPBC Act Status	Species Observed within Mining Leases*
Bird	<i>Neochmia ruficaudus</i>	Star Finch	Endangered	Endangered	No
Bird	<i>Geophaps scripta</i>	Squatter Pigeon (Southern sub-species)	Vulnerable	Vulnerable	No
Bird	<i>Hirundapus caudacutus</i>	White-throated Needletail	Vulnerable	Migratory / Vulnerable	No
Bird	<i>Falco hypoleucos</i>	Grey Falcon	Vulnerable	Vulnerable	No
Reptile	<i>Hemisapsis damelii</i>	Grey Snake	Endangered	Not Listed	No
Reptile	<i>Denisonia maculata</i>	Ornamental Snake	Vulnerable	Vulnerable	Yes
Reptile	<i>Egernia rugosa</i>	Yakka Skink	Vulnerable	Vulnerable	No
Reptile	<i>Furina dunmall</i>	Dunmall's Snake	Vulnerable	Vulnerable	No
Reptile	<i>Rheodytes leukops</i>	Fitzroy River Turtle	Vulnerable	Vulnerable	No
Reptile	<i>Acanthophis antarcticus</i>	Common death Adder	Vulnerable	Not Listed	No
Reptile	<i>Strophurus taenicauda</i>	Golden-tailed Gecko	Near Threatened	Not Listed	No
Mammal	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	Vulnerable	Vulnerable	No

*ESS (2004)

The ornamental snake has been recorded in the eastern margins of ML70376 within the open downs regional ecosystem 11.8.11 *Dichanthium sericeum* grasslands on Cainozoic igneous rocks. Essential habitat for the ornamental snake has been identified in this grassland area and along Sandhurst Creek (downstream of the diversion) within ML70376. No other essential habitat for threatened flora or fauna species has been identified within the boundaries of ML70376 and ML70145.

2.6.10 Land Use

Land uses within ML70376 and ML70145 prior to mining were cattle grazing and dryland cropping (mainly sorghum and mung beans). Clearing of native grasslands and woody vegetation on Lexington was required to establish the grazing and cropping activities. Some small areas of irrigated cropping were also undertaken on Lexington to the west of ML70376. Water supplies for irrigation and stock watering were sourced from the basalt aquifer.

Prior to the establishment of Minerva Mine, there was no coal mining in the locality surrounding Lexington or within the broader catchment area of Sandhurst Creek. The land capabilities of some areas on Lexington have been modified by mining activities and the PMLUs for the disturbed areas are discussed in **Section 4**.

3 Community Consultation

3.1 Community Consultation Register

A range of community consultation activities involving closure-related activities, or matters that closure affects, have been undertaken for Minerva Mine since 2015 and these are presented in the Community Consultation Register in

Table 7. The proposed PMLUs and NUMAs identified in this plan remain consistent with the information presented to, and discussed with, the local community, and described in the relevant LOD (*Rehabilitation Management Plan* (Sojitz Minerva Mining 2021b)) required under EA Condition F3. Objections to the Minerva Mine rehabilitation and closure plans have not been received during these community engagement activities.

Minerva Mine Progressive Rehabilitation and Closure Plan

Table 7 – Community Consultation Register

Date	Community Member(s)	Consultation Activity	Closure and PMLU-Related Engagement	Issues Related to Land Outcomes, Commitments
5 April 2015	Hugo Spooner (neighbouring landholder-Avocet). University of Queensland Geography Department Students	On-site presentation and discussions	Overview of mining and rehabilitation methods. Residual voids and proposed bushland habitat and grazing post-mine land uses discussed.	Specific matters related to land outcomes or objections to proposed closure activities not raised by external party. No commitments entered into.
15 October 2015	Cameron Higgins (neighbouring landholder-Ronnoc Downs)	Mine site tour and discussions	Discussion of mining and rehabilitation methods. Residual voids and proposed bushland habitat and grazing post-mine land uses discussed.	Specific matters related to land outcomes or objections to proposed closure activities not raised by external party. No commitments entered into.
27 April 2016	Western Kangoolu Ltd	Joint meeting with Minerva Mine General Manager	Progress of cultural heritage authorisation process. Overview of operations, residual voids and proposed bushland habitat and grazing post-mine land uses discussed.	Specific matters related to land outcomes or objections to proposed closure activities not raised by external party. No commitments entered into.
13 May 2016	Fred Conway – Garringbal	Telecon about cultural heritage	Cultural heritage investigation and management agreement and Garringbal Compensation Agreement	Cultural heritage matters focus, specific matters related to land outcomes not raised.
8 July 2016	University of Queensland Geography Department Students	Presentation and mine site tour	Overview of mining and rehabilitation methods. Residual voids and proposed bushland habitat and grazing post-mine land uses discussed.	Specific matters related to land outcomes or objections to proposed closure activities not raised by external party. No commitments entered into.
13 July 2016	Mark and Joy Comiskey (neighbouring landholder-Ronnoc Downs)	Discussion and mine site tour	Overview of mining and rehabilitation methods. Residual voids and proposed bushland habitat and grazing post-mine land uses discussed.	Specific matters related to land outcomes or objections to proposed closure activities not raised by external party. No commitments entered into.
29 September 2016	Department of Environment and Heritage	Presentation and Inspection of Rehabilitation Areas.	Overview of mining and rehabilitation methods. Residual voids and proposed bushland habitat and grazing post-mine land uses discussed.	Department noted requirement to adhere to land outcomes in Environmental Authority.
27 July 2017	Central Highlands Regional Council	Presentation and Inspection of Rehabilitation Areas.	Overview of mining and rehabilitation methods. Residual voids and proposed bushland habitat and grazing post-mine land uses discussed.	Specific matters related to land outcomes or objections to proposed closure activities not raised by external party. No commitments entered into.

Minerva Mine Progressive Rehabilitation and Closure Plan

Date	Community Member(s)	Consultation Activity	Closure and PMLU-Related Engagement	Issues Related to Land Outcomes, Commitments
11 October 2017	Mark Comiskey, Sean Schimke, Ann Foot, Tim Crocker, D Rolfe (district landholders and interested parties)	Lexington Agistment Agreement – Expression of Interest inspection	Grazing management and infrastructure maintenance requirements related to agisting cattle on mine leases and surrounding areas owned by Minerva Coal Pty. Ltd.	Future access for agistment raised. Outcome: current arrangement is extendable by two years by mutual agreement.
8 November 2017	Department of Environment and Heritage	On-site compliance audit	Review of EA Conditions including rehabilitation approach, residual voids and post-mine land uses discussed. Inspection of rehabilitation areas.	Compliance audit. No commitments entered beyond LOD requirements entered into.
14 December 2017	BHP	On-site inspection and discussions	Overview of mining and rehabilitation methods. Residual voids and proposed bushland habitat and grazing post-mine land uses discussed.	Specific matters related to land outcomes not raised. No commitments entered into.
1 February 2020	Garingbal Kara People	Meeting	Overview of mine closure timeframes and process	Cultural heritage matters focus, specific matters related to land outcomes not raised.
21 January 2021	Garingbal Kara People	Meeting	Overview of mine closure timeframes and process	Cultural heritage matters focus, specific matters related to land outcomes not raised.
1 August 2021	Community open day	On-site tour of mining operations. Presentation on post-mining landform.	Post-mining landform (residual voids and spoil). Overview of mine closure timeframes and process	Specific matters related to land outcomes or objections to proposed closure activities not raised by external parties. No commitments entered into.
15 March 2022	Garingbal Kara People	Meeting	Overview of mine closure timeframes and process	Cultural heritage matters focus, specific matters related to land outcomes not raised.

3.2 Community Consultation Plan

Minerva Mine is in the closure execution phase. On-going community consultation shall be carried out in relation to the rehabilitation being conducted under this PRC Plan.

The objectives of the community consultation are to:

- provide information about the timing and extent of planned rehabilitation and closure-related activities;
- provide information about the progress in implementing rehabilitation;
- receive community feedback on matters concerning rehabilitation; and
- provide timely responses to community feedback and enquiries relating to matters concerning rehabilitation.

The type of planned consultation with various community members, the frequency of engagement and the information to be conveyed are summarised in **Table 8**.

Table 8 – Community Consultation Plan

Community Member(s)	Consultation Type (Frequency)	Information Conveyed
Entities agisting stock and share farming on Lexington	Meeting (as-needs basis) (on-going)	Stock access restrictions (if applicable)
Adjoining landholders (Ronnoc Downs, Avocet properties)	Site tour (Annual or upon request) Meeting (Upon request)	Site tour of rehabilitation, overview of progress
Other nearby landholders	Meeting (Upon request) Site tour (Upon request)	Overview of progress of rehabilitation
Garingbal Kara People	Meeting (Upon request) Site tour (Upon request)	Overview of progress of rehabilitation
District residents	Community open day (2024, then every 5 years)	Site tour of rehabilitation, overview of progress
Central Highlands Regional Council	Meeting (Upon request)	Overview of progress of rehabilitation

Feedback received during consultation activities shall be considered and an assessment made as to whether it is appropriate to modify the timing or manner in which rehabilitation works are being carried out at the time. The outcome of the assessment will be conveyed to the relevant community members and any other relevant third parties in a timely manner.

Should any changes to the PRCP Schedule be proposed that may affect a community member, consultation shall be undertaken regarding the proposal and the details and outcome recorded in the Community Consultation Register.

4 Post-Mining Land Uses

PMLUs for Minerva mining leases were approved in the *Rehabilitation Management Plan* (Sojitz Minerva Mining 2021b), a LOD required to be submitted under the EA. The designated PMLUs are the options that are best suited to the area based on final landforms and surrounding agricultural activities. Land uses such as cropping were not suitable due to limitations of the post mining landforms.

The following PMLUs apply:

- grassy open woodlands; and
- low intensity grazing

The nominated PMLUs can be transitioned into the proposed PRCP Schedule as they are consistent with a LOD required under the EA, and a further detailed selection process is not required for this document (DES 2020). The PMLUs are described in the following sections and their locations shown in **Figure 11**. The associated completion criteria are presented in **Section 4.6**.

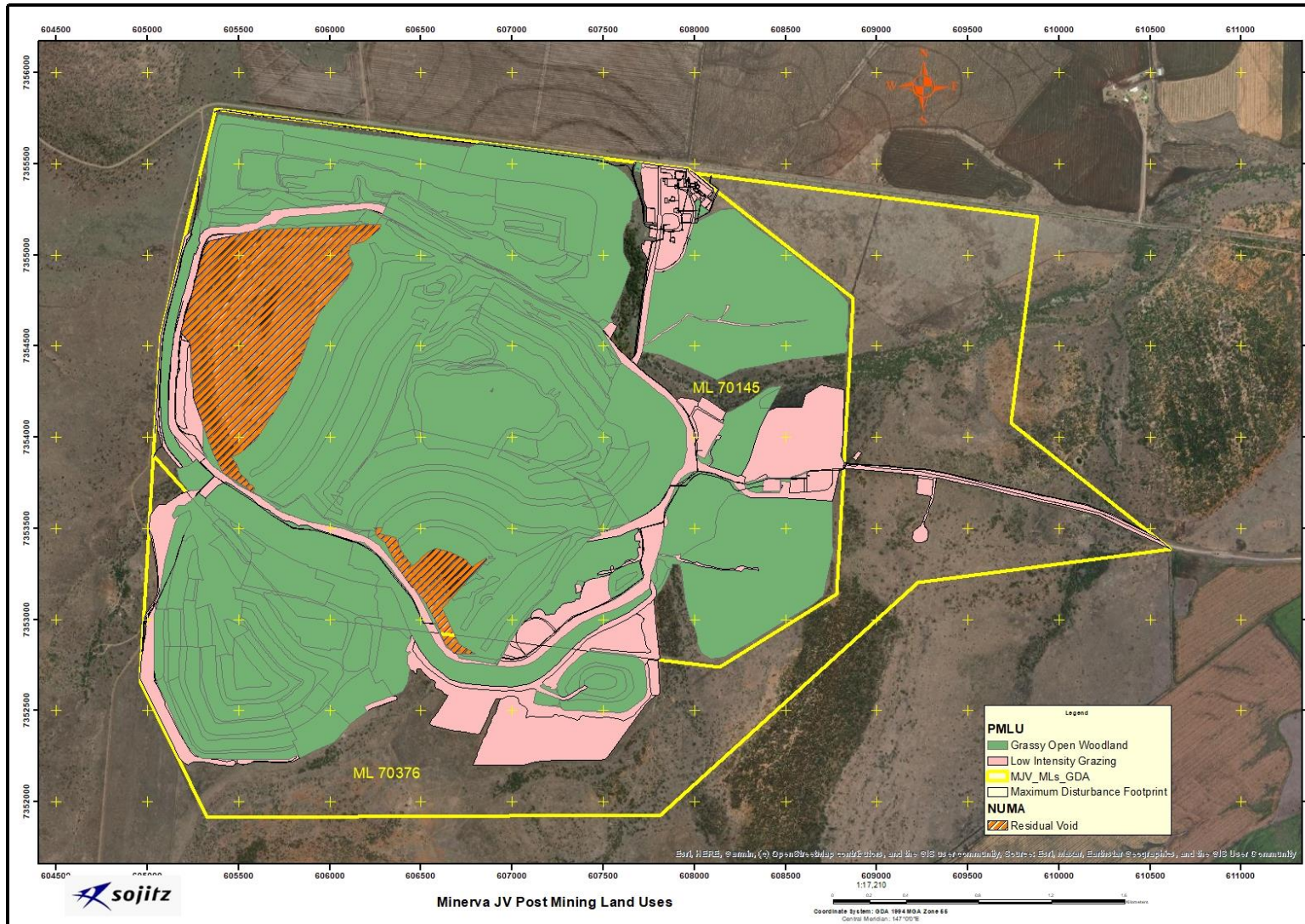


Figure 11 – Post-Mining Land Uses

(Version 3 – 31 August 2023)

4.1 Grassy Open Woodlands

The mine spoil domain shall become a grassy open woodland habitat where the overriding objective is long-term stability of the spoil dumps to ensure that potential impacts on the receiving environment are minimised. Where possible, the plants seeded will be naturally occurring local species, however other species may also be included where they have a functional role that local species cannot fulfil (see **Section 6.8.5**). The established grassy open woodlands PMLU provides foraging opportunities for fauna and vegetation corridors for fauna movement between surrounding regional ecosystems. The grassy open woodlands rehabilitation areas will provide a mix of grass and native trees species intended to stabilise the spoil dumps as the priority, with habitat connectivity a secondary benefit. The primary objective for rehabilitated spoil areas is the creation of stable landforms, occupied by a range of trees, shrubs and pastures forming a bushland domain (Sojitz Minerva Mining 2021b). The grassy open woodlands are not designed to form a distinct regional ecosystem, as the constructed landforms have higher slopes and have different edaphic conditions to the pre-existing environment.

Elevated spoil dumps are constructed from unconsolidated sediments that are more prone to erosion than the original consolidated materials formed along gentle slopes (e.g. basalt flows). The use of rock mulch in rehabilitation of spoil batters offers an effective means of stabilising steeper slopes, particularly in conjunction with grasses, shrubs and trees. With dump batters that are susceptible to erosion, rock mulching, followed by the establishment of vegetation, can provide a permanent surface treatment for prevention of erosion (Sojitz Minerva Mining 2021b).

The rock mulched spoil batters and the top of dumps that have been rehabilitated with topsoil only shall have a grassy open woodland PMLU. The mine spoil domain is most suited to the grassy open woodlands PMLU due to the steeper slopes and rock cladding that exist with this landform, which are not desirable for agricultural activities.

The grassy open woodlands PMLU will result in the following enhanced environmental values:

- Increased landform stability, reflecting slope and rock scree attributes of adjoining landforms and regional ecosystems;
- Reduced potential for sediment-laden runoff entering the downstream receiving environment; and
- Increased flora biodiversity, providing a wider array of fauna habitat types over the longer term.

Grass swards that develop in non-grazed grassy open woodlands PMLUs can become rank over time and lose effectiveness in controlling erosion. Low intensity infrequent fires at the commencement of the dry season can be used as a management tool to re-stimulate plant growth and remove rank grass overgrowth if required. Rehabilitation using rock mulch reduces the reliance of vegetative cover and root structures for erosion protection. The rock mulched spoil batters used for grassy open woodlands PMLUs (> 5% slope) provide enduring erosion protection of the spoil dump, irrespective of the plant growth stages (see **Section 6.3.2**).

The rehabilitation shall be non-polluting, stable, safe to humans and wildlife and able to sustain a grassy open woodland PMLU.

4.2 Low Intensity Grazing

The infrastructure domain is assigned to low intensity grazing PMLU, as the rehabilitated infrastructure areas are most suited to grazing due to limited past surface earthworks disturbance and the favourable shallow slopes of the stable landform. This rehabilitation will meet a minimum land suitability class 3 (suitable grazing land with moderate limitations) according to the *Guidelines for Agricultural Land Evaluation in Queensland* (Queensland Government 2015).

Grazing land units need to be a sufficient size or part of a larger paddock so that overgrazing or degradation of the rehabilitated area does not occur. Grazing shall be managed such that sufficient grass cover is maintained to provide ongoing protection from surface erosion. Pasture species selected for rehabilitation to low intensity grazing are included based on their palatability to stock and their occurrence within adjacent pastoral lands. Plants selected include a mixture of native and improved pastures, with the list of species provide in **Section 6.8.5**. Under low intensity grazing conditions, the post-mining land use would be sustainable, non-polluting, stable and safe to humans, stock and wildlife.

Some mine site infrastructure will be retained after mine closure where the infrastructure provides benefits to the background landholder and surrounding neighbours. A list of the infrastructure to be retained by the landholder to support the low intensity grazing PMLU is provided in **Section 6.10.1** and shown in **Figure 12** and **Figure 13**. A signed landholder statement is included in **Appendix C**. All retained infrastructure provided to the landholder will be in a condition that is safe to humans and wildlife, non-polluting, stable and able to be sustained by the background landholder.

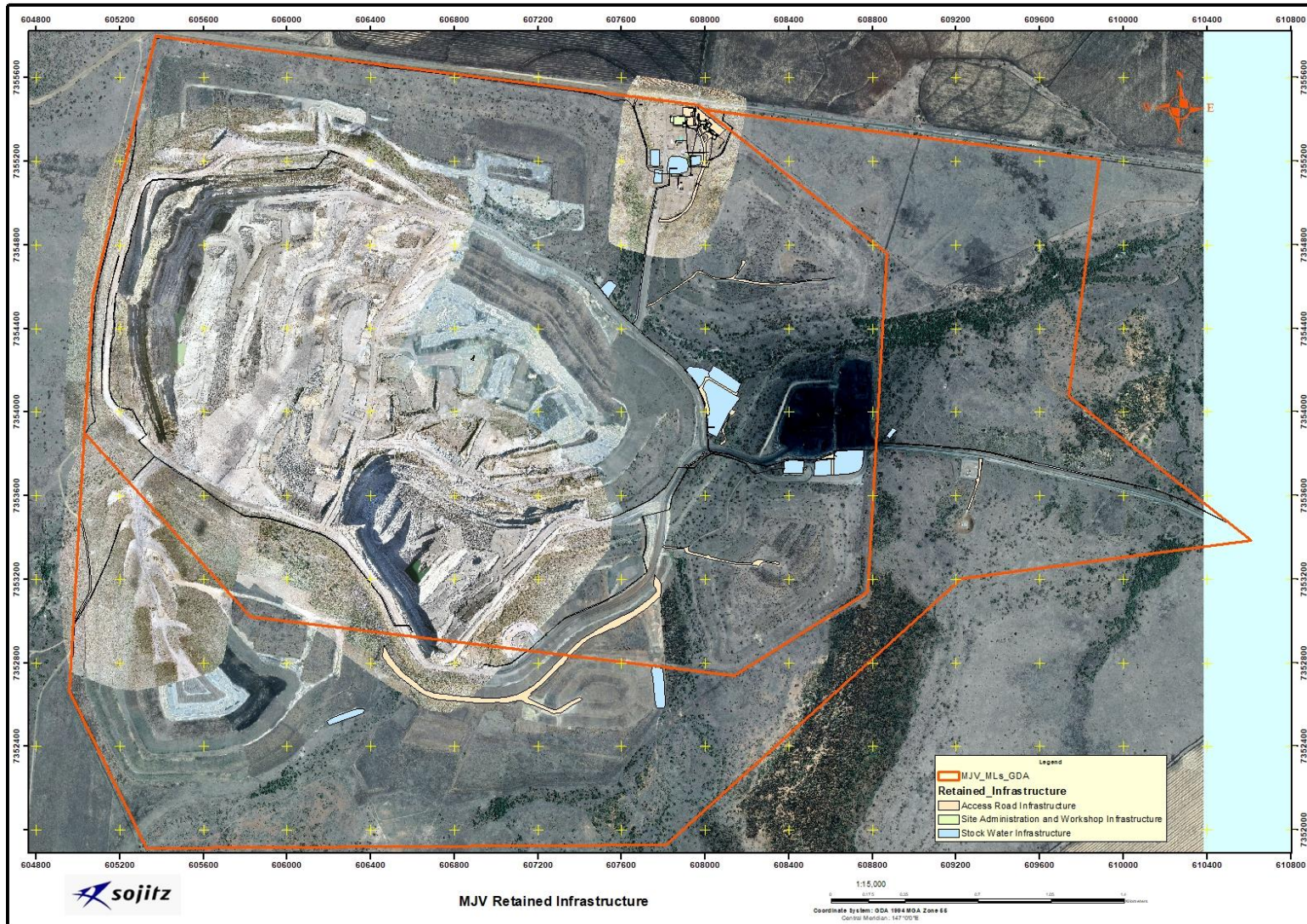


Figure 12 – Site Retained Infrastructure

(Version 3 – 31 August 2023)

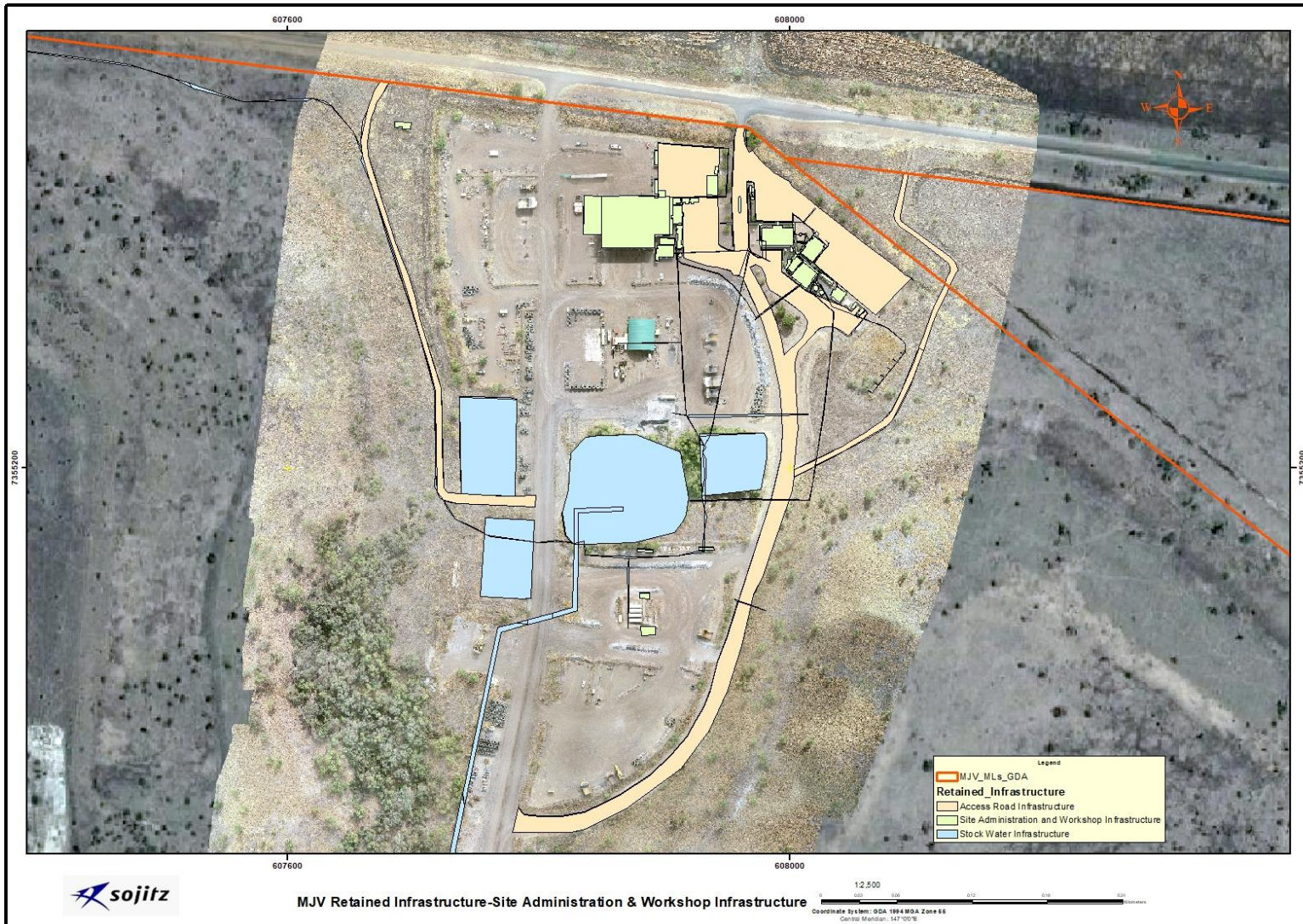


Figure 13 – Retained Infrastructure – Administration and Workshop Area

(Version 3 – 31 August 2023)

The current water storages domain remain as water storages and form part of the low intensity grazing PMLU, providing a water source for stock and fauna. Water quality in the storages was maintained below ANZECC (2000) irrigation and stock water salinity limits when used during active operations. The only ongoing water input to these dams is from rainfall run-off, which provides a clean long-term water source. The water storages listed in **Table 9** will remain following mine closure as part of a land use that is safe to humans and wildlife, non-polluting, stable and a sustainable water supply to stock and fauna. The water storages forming part of the low intensity grazing PMLU are included within the low intensity grazing PMLU in **Figure 11**.

Table 9 – Water Storages

Water Storage	Volume (ML)	Source and Use During Operations	Future Use
Industrial Raw Water Dam	7.8	Groundwater pumping for Industrial area use	Stock water and fauna use
Industrial Area Dam 1	6.2	Collects run-off for Industrial area use	Stock water and fauna use
Industrial Area Dam 2	9.3	Collects run-off for Industrial area use	Stock water and fauna use
Industrial Area Dam 3	3.0	Collects run-off for Industrial area use	Stock water and fauna use
ROM Dam 1	11.5	Collects run-off for mining purposes	Stock water and fauna use
ROM Dam 2	7.4	Collects run-off for mining purposes	Stock water and fauna use
ROM Dam 3	38.2	Pit dewatering point and collects run-off for mining purposes	Stock water and fauna use
Dam 4	66.6	Pit dewatering point for mining related purposes	Stock water and fauna use
Dam 7	25.8	Sediment Dam for spoil dump areas	Stock water and fauna use

4.3 Relevant Government Strategies and Plans

Minerva Mine is located in the “rural zone” under the Central Highlands Regional Council Planning Scheme (CHRC 2016). The rural zone is intended to:

- provide for and encourage a broad range of rural uses such as cropping, intensive horticulture, intensive animal industries, animal husbandry, animal keeping and other primary production;
- provide opportunities for non-rural uses that are compatible with agriculture, the environmental features and the landscape character of the area; and
- protect or manage significant natural resources and processes to maintain capacity for primary production.

The PMLUs nominated for Minerva Mine are consistent with the zoning and other designations of the land under the planning scheme, as well as compatible with the existing adjoining land uses of improved pasture grazing, cropping and natural bushlands. Development approval is not required to establish the PMLUs under the planning scheme.

The PMLUs also align with the regional outcomes under the Central Queensland Regional Plan 2013, which include allowing for agriculture within Central Queensland to continue to grow while supporting resource industries co-existence in the area

4.4 Completion Criteria

The completion criteria for the PMLUs are presented in **Table 10**.

Table 10 – Completion Criteria for PMLU

PMLU	Rehabilitation Goal	Completion Criteria
Grassy Open Woodlands	Safe to humans and cattle	- Rehabilitation dump is geotechnically stable with FoS ≥ 1.5 - No active gully erosion present $>0.3\text{m}$ deep
	Stable	- External batters $\leq 25\%$ slopes covered with minimum 0.5 m thick competent rock mulch - Top of dump $\leq 5\%$ slopes covered with minimum 0.2 m thick topsoil
	Non-polluting	- No acid or saline seepage areas - Median receiving water quality run-off EC $< 1,000\text{ }\mu\text{S/cm}$ and pH $6.0 - 9.0$
	Able to sustain agreed post mining land use	≥ 2 native tree / shrub species present ≥ 3 perennial grass species present - Effective rooting depth $> 0.5\text{ m}$ - Invasive weed species comprise $< 10\%$ of vegetative groundcover - Livestock excluded from area - Total groundcover $\geq 50\%$ (may include dead and alive material or rocky debris)
Low Intensity Grazing	Safe to humans and cattle	- No active gully erosion present $>0.3\text{m}$ deep - Dam walls are geotechnically stable with FoS ≥ 1.5 - Retained infrastructure in accordance with the written Landholder statement - Infrastructure condition assessment report to be completed prior to handover of infrastructure to Landholder
	Stable	- All areas have slopes $\leq 5\%$ covered with minimum 0.2 m thick topsoil - Dams have a functioning bywash with no active erosion - All infrastructure and materials have been removed from site that are not subject to Landholder statement
	Non-polluting	- No acid or saline seepage areas - Median receiving water quality $< 1,000\text{ }\mu\text{S/cm}$ and pH $6.0 - 9.0$ - Dam water quality meets ANZECC 2000 livestock drinking water standards for beef cattle. - Contaminated materials identified by a site investigation report have been removed

PMLU	Rehabilitation Goal	Completion Criteria
	Able to sustain agreed post mining land use	• Vegetative ground cover $\geq 50\%$ • ≥ 3 perennial pastures / shrub species present • Effective rooting depth > 0.5 m • Invasive weed species comprise $< 10\%$ of vegetative groundcover

5 Non-Use Management Areas

The Western and the Southern voids have been identified as NUMAs in the following LODs:

- *Minerva Mine Residual Void Investigation Report* (Sojitz Minerva Mining 2021a)
- *Minerva Mine Rehabilitation Management Plan* (Sojitz Minerva Mining 2021b)

Table F1 of the EA stipulates a maximum void surface area of 91 ha, with a maximum void wall slope of 70 degrees in competent rock. The total area of the Western and Southern final voids equals 88 ha (WRM 2023b). This is subject to minor change as design is refined and physical works progress.

The rehabilitation treatments for the Western and Southern voids are described in Sojitz Minerva Mining (2021a, 2021b) and summarised below in Sections 5.1 and 5.2. The final void hydrology study and stability analysis is provided in the residual void investigation report (Sojitz Minerva Mining, 2021a).

Under the relevant transitional provision, as the Western and Southern voids are pre-approved NUMAs described within land outcome documents, Minerva Mine is not required to:

- justify the proposed NUMAs;
- provide evidence to support the justification of the NUMA;
- be the subject of a Public Interests Evaluation; or
- provide for the rehabilitation of voids located within a floodplain to a stable condition.

Notwithstanding the above, significant evidence to support the justification of the NUMAs is presented in the *Minerva Mine Residual Void Investigation Report* (Sojitz Minerva Mining 2021a).

This PRC Plan also outlines how the residual voids will be managed in a best practice manner that minimises risks to the environment.

5.1 Western Void

The Western residual void is expected to remain a groundwater sink in perpetuity, forming a maximum pit water level of RL 236 m. The maximum surface area of the Western final void at RL 236 m is 75 ha (WRM 2023b).

As part of mine closure activities, a permanent bund shall be installed 50 m from the crest of Western void as a safety measure to restrict access to the highwall. The closure bund will be placed outside the Sandhurst Creek diversion 0.1% AEP flood extent so not to impede flow. If required, fencing and open-hole warning signs will be erected in association with the closure bund installation for additional safety measures.

Rehabilitation of the Western void will include (Sojitz Minerva Mining 2021a):

- reshaping the current low walls to 25% with 30 m wide benches every 30 m of vertical lift;
- reshaping the low wall down to RL 236 m (max water equilibrium level (WRM 2023b)), with fill below this at angle of repose; and
- capping reshaped 25% slopes with 0.5 m thick of basalt rock mulch, plus topsoil.

Reshaped surfaces will internally drain to void area.

5.2 Southern Void

The Southern residual void will remain a groundwater sink in perpetuity, with inflows from the Permian sediments and the Western residual void forming a maximum pit water level of RL 223 m. The maximum surface area of the southern void at RL 223 m is 13 ha (WRM 2023b).

As part of mine closure activities, a permanent bund shall be installed 50 m from the crest of the Southern void as a safety measure to restrict access to the highwall. The closure bund will be placed outside the Sandhurst Creek diversion 0.1% AEP flood extent so as not to impede flow. Fencing and open void warning signs will be erected in association with the closure bund if required as additional safety measures.

Rehabilitation of the Southern void will include (Sojitz Minerva Mining 2021a):

- Reshaping the current low walls to 25% with 30 m wide benches every 30 m of vertical lift;
- Reshaping low wall down to maximum water equilibrium level (RL 223 m (WRM 2023b)), with fill below this at angle of repose;
- Partial reshape of high wall south-east section to 25% to reduce void area;
- Reshaped 25% slopes shall be capped with 0.5 m thick of basalt rock mulch, plus topsoil; while
- Reshaped surfaces will internally drain to void area.

5.3 Completion Criteria

The completion criteria for the residual voids are presented in **Table 11**.

Table 11 – Completion Criteria for NUMAs

NUMA	Completion Criteria
Western Void	• High wall and end wall maximum slope ≤ 70 degrees projected to surface. • Assessment report by Registered Professional Engineer of Queensland (RPEQ) on the Geotech stability of final voids FoS ≥ 1.5. • High wall and end wall bund constructed of competent materials ≥ 2m high and base width of 5m with minimum 50 m setback from crest ($\geq$ FoS of 1.5). No public access with fencing and signage erected if required. • Low wall $\leq 25\%$ slope above RL 236 m, with 0.5 m thick rock mulch cover. • Angle of repose slopes below RL 236 m ($\leq 65\%$). • Sandhurst Creek 0.1% AEP flood event does not enter final void. • Surface and groundwater quality of receiving waters meets the requirements of Schedule W of the EA. • Void has no adverse environmental impact on basalt aquifer.
Southern Void	• High wall and end wall maximum slope ≤ 70 degrees projected to surface. • Assessment report by Registered Professional Engineer of Queensland (RPEQ) on the Geotech stability of final voids FoS ≥ 1.5. • High wall and end wall bund constructed of competent materials ≥ 2m high and base width of 5m with minimum 50 m setback from crest ($\geq$ FoS of 1.5). No public access with fencing and signage erected if required. • Low wall $\leq 25\%$ slopes above RL 223 m, with 0.5 m thick rock mulch cover. • Angle of repose slopes below RL 223 m ($\leq 65\%$). • Sandhurst Creek 0.1% AEP flood event does not enter void. • Surface and groundwater quality of receiving waters meets the requirements of Schedule W of the EA. • Void has no adverse environmental impact on basalt aquifer.

5.4 Voids in Floodplains

Section 126D(3) of the *Environmental Protection Act 1994* states that if the land subject to a proposed PRCP schedule will contain a void situated wholly or partly in a floodplain, the PRCP schedule must provide for rehabilitation of the land to a stable condition. A floodplain is defined under Section 41C(3) of the *Environmental Protection Regulation 2019* as the modelled peak water level at 0.1% AEP for a relevant watercourse.

Section 126D(3) of the *Environmental Protection Act 1994* does not apply where a NUMA has already been identified in a LOD and is transitioned into the PRCP schedule consistent with the LOD (DES 2021). The Western and Southern residual voids have been previously identified and detailed in the LODs for Minerva Mine.

Notwithstanding that section 126D(3) does not apply for Minerva Mine, surface flooding does not represent a threat to the stability of the residual voids, as they are located outside the 0.1% AEP modelled flood extent.

6 Rehabilitation Methodology

6.1 Hydrogeology

A final void surface hydrology study was undertaken by WRM (2023a) (see **Appendix E**) in association with outcomes from the numerical groundwater modelling completed by AGE (2023) (see **Appendix F**). The final void study was completed to achieve the following objectives:

- calculate future groundwater inflow rates to the Western and Southern residual voids;
- determine the long-term water balance in the residual voids, including the long-term equilibrium water level and any potential interactions with surrounding aquifers; and
- estimate the long-term void water quality in the residual voids.

The study outcomes are summarised below.

Western Void

The water balance model for the Western residual void indicates the water level will rise towards an equilibrium over a period of about 300 years (see **Figure 14**). The long-term median equilibrium water level is predicted to be about 233 m AHD, with a range of 230 to 236 m AHD. The maximum water level remains approximately 40m below where the residual void would spill to the surrounding environment.

The long-term equilibrium water level is predicted to be above the base of the basalt exposed in the highwall, though the pit water level is below the regional basalt groundwater level of approximately 265 m AHD (AGE 2023). This is shown in cross-section in **Figure 15**. A groundwater hydraulic gradient is expected to be maintained in perpetuity towards the Western residual void and therefore the likelihood of void water interacting with the basalt aquifer is unlikely (AGE 2023).

Southern Void

The water balance model for the Southern residual void indicates the water level will rise towards an equilibrium over a period of about 250 years (see **Figure 16**). The long-term median equilibrium water level is predicted to be about 215 m AHD, with a range of 204 to 223 m AHD. The maximum water level remains approximately 40m below where the residual void would spill to the surrounding environment.

The long-term equilibrium water level is predicted to be within the upper coal seam group as shown in cross-section in **Figure 17**. The maximum void water level is predicted to remain about 50m below the elevation of the regional groundwater table. A groundwater hydraulic gradient is expected to be maintained in perpetuity towards the Southern residual void and therefore the likelihood of void water leaving the void via coal seams is unlikely (AGE 2023).

The predicted void water equilibrium level for the Southern void is lower than predicted levels for the Western void and a hydraulic gradient is expected to form towards the Southern void. The Southern void will remain a groundwater “sink” where evaporation permanently depresses the water level.

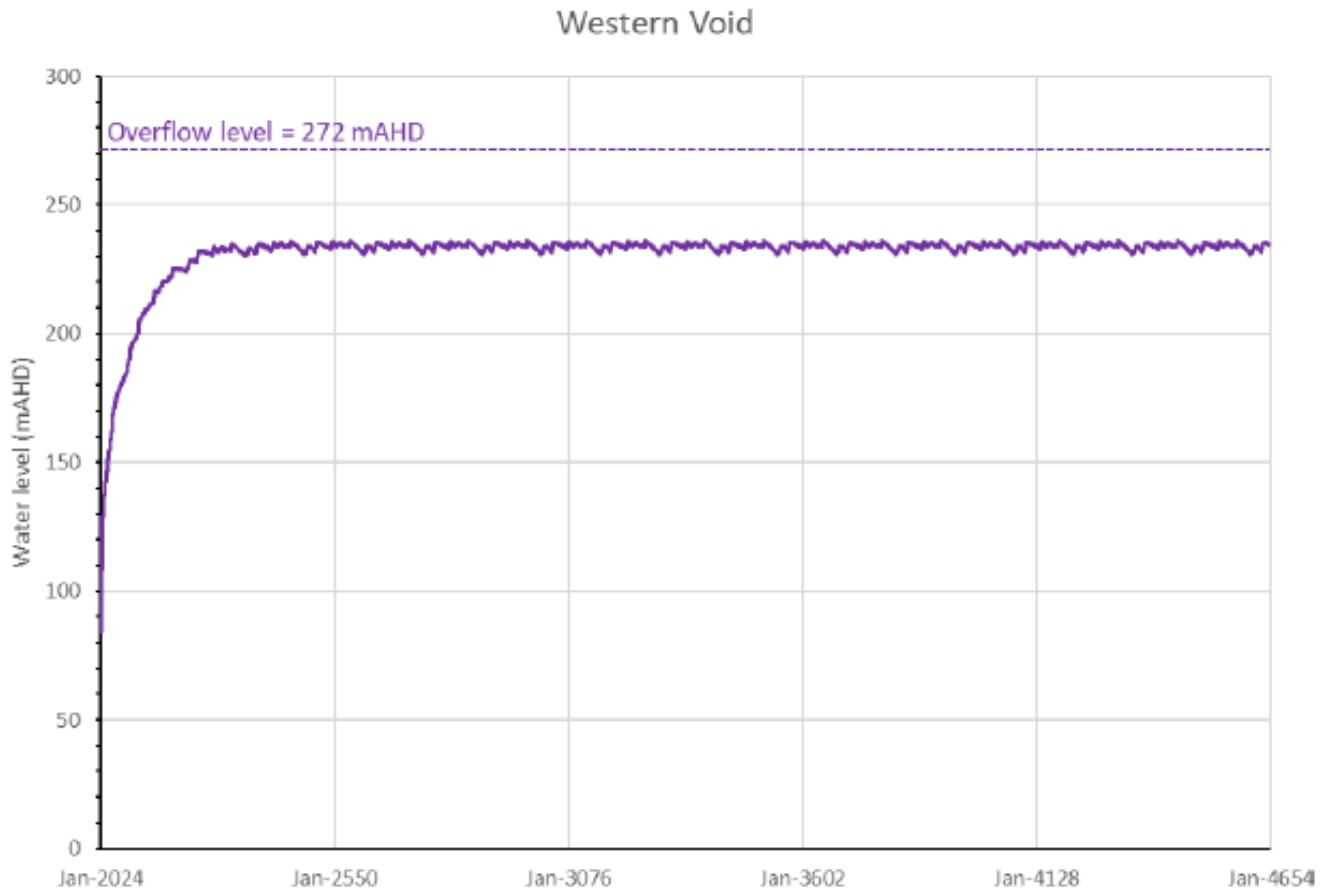


Figure 14 – Western Void Water Level

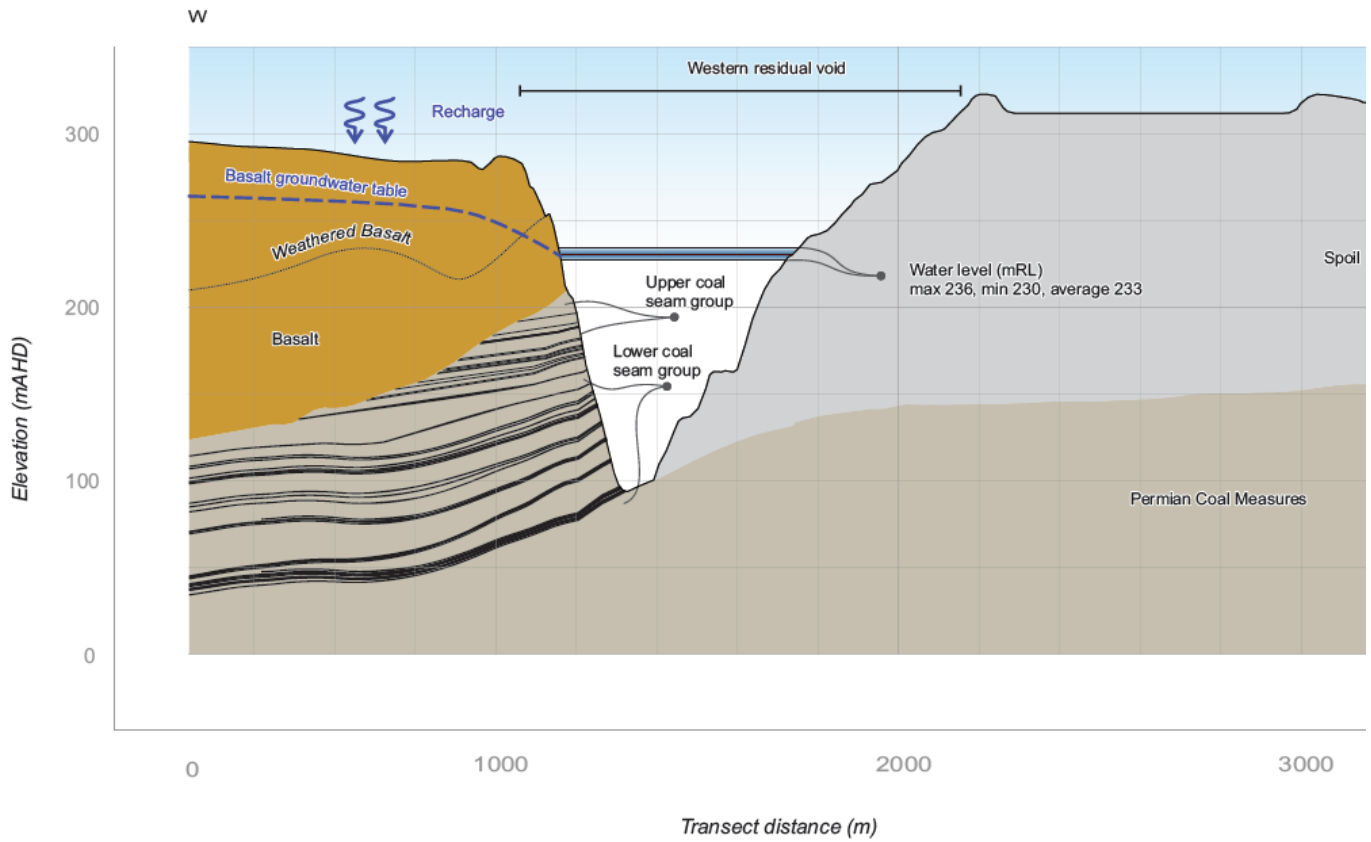


Figure 15 – Western Residual Void Cross Section

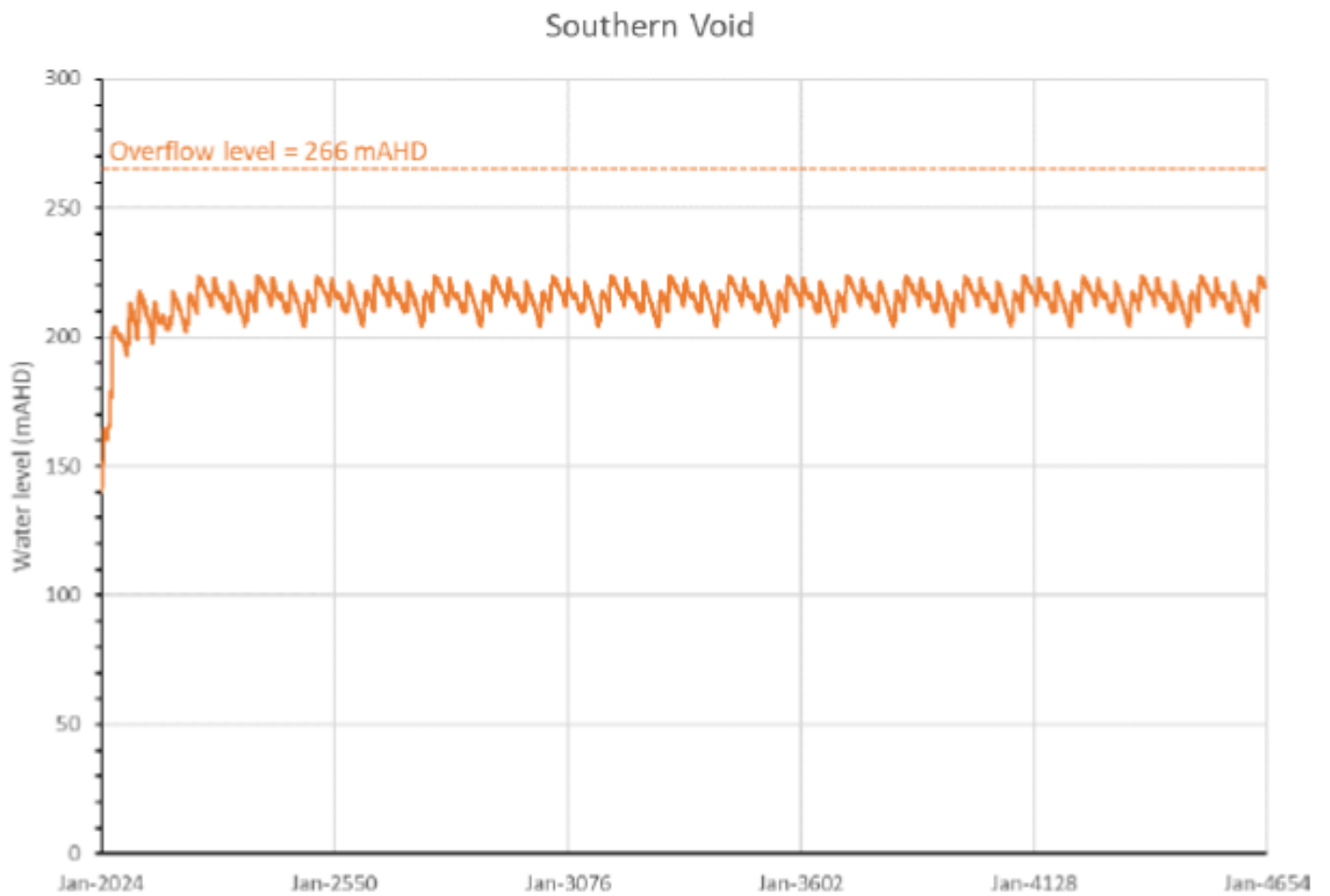


Figure 16 – Southern Void Water Level

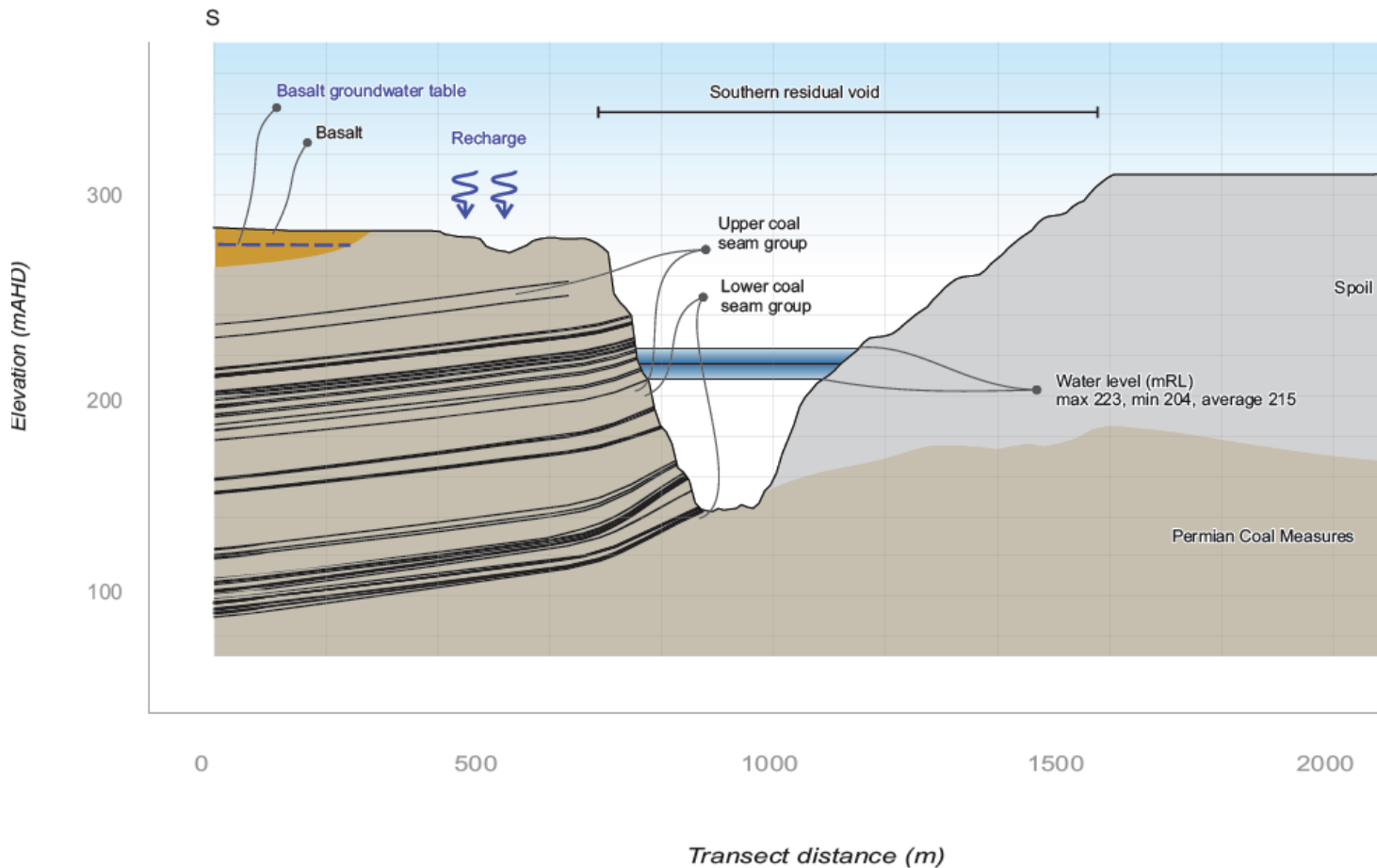


Figure 17 – Southern Residual Void Cross Section

Water Quality

The ANZECC (2000) water quality guidelines classifies irrigation water with a “high salinity rating” as having an electrical conductivity of between 2.9 dS/m and 5.2 dS/m (equivalent to 1,945 – 3,485 mg/L TDS). Adverse effects in beef cattle can be expected to begin when stock drinking water exceeds 4,000 mg/L TDS (ANZECC 2000). In the long-term, the salinity of water in both residual voids is predicted to become unsuitable for irrigation initially and subsequently become unsuitable for stock water for beef cattle as TDS exceeds the ANZECC irrigation and stock water guidelines. Results from salinity modelling for the Western and Southern residual voids are shown in **Figure 18** and **Figure 19**.

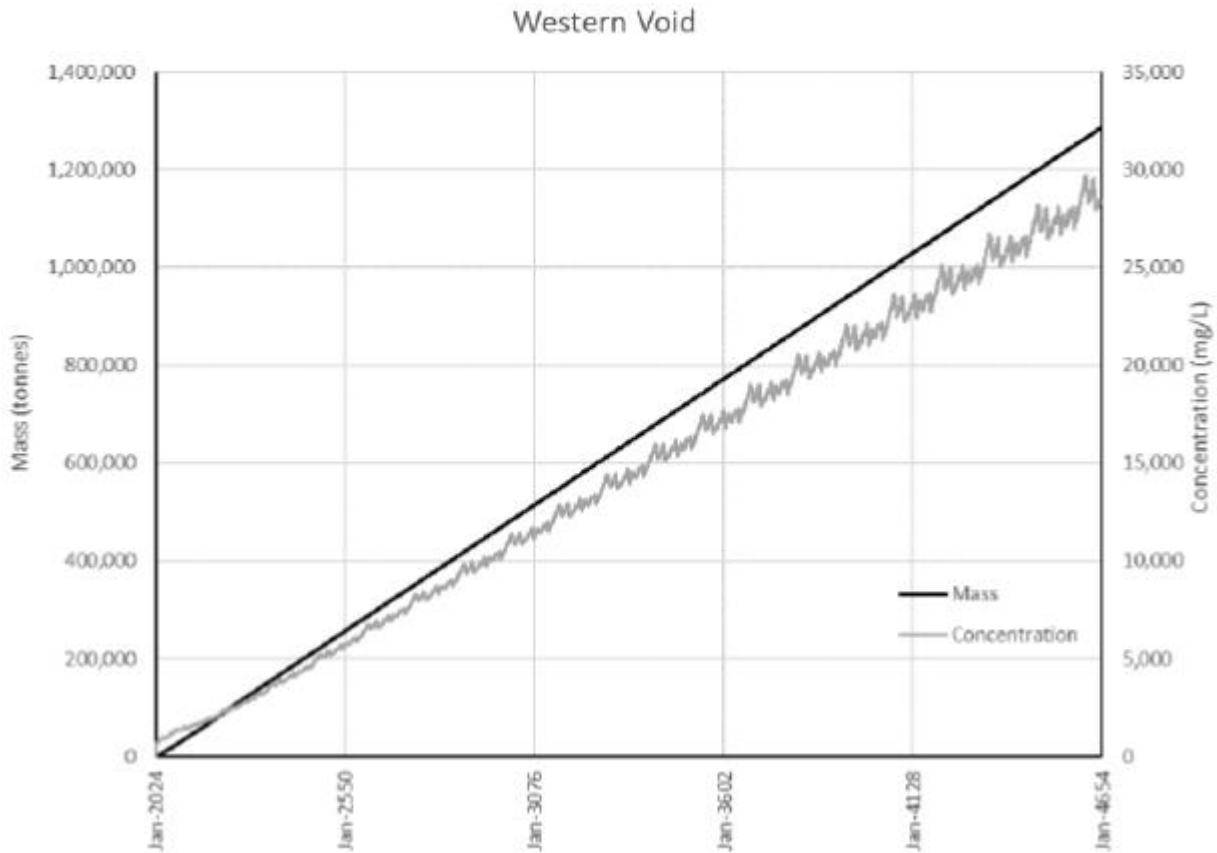


Figure 18 – Western Void Salinity Modelling

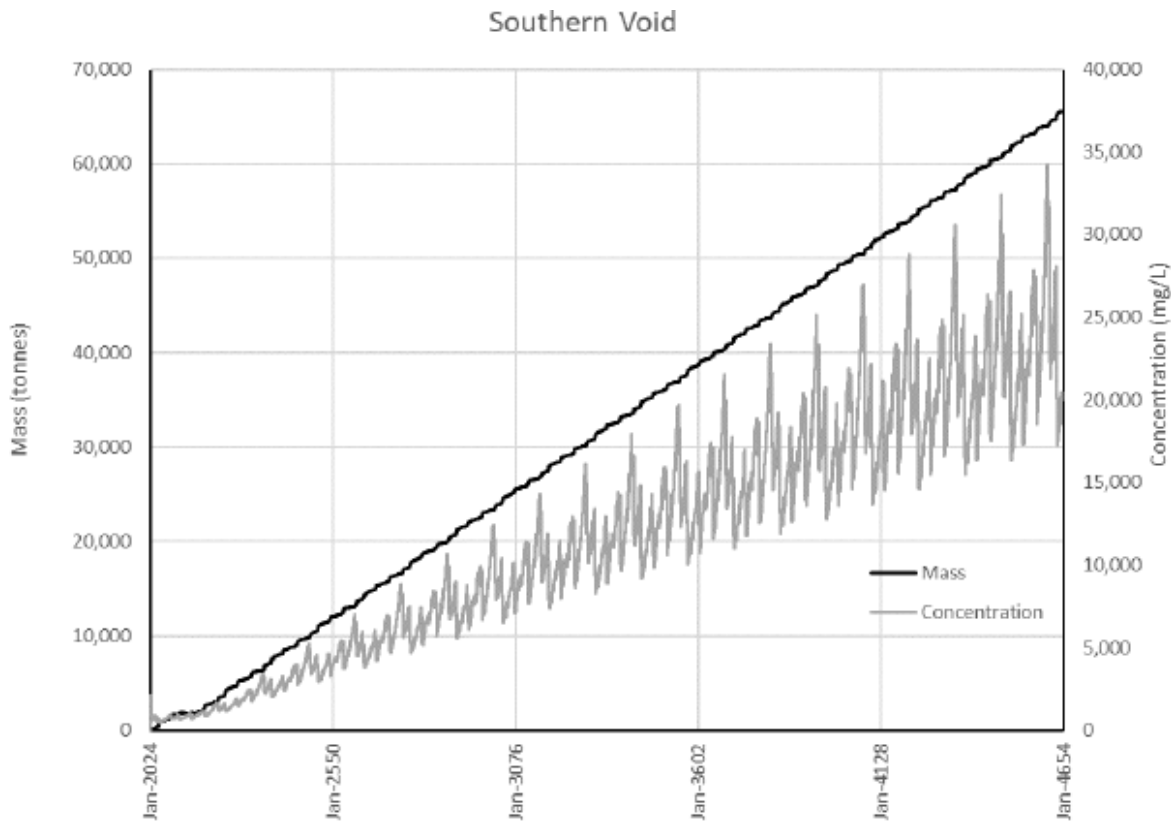


Figure 19 – Southern Void Salinity Modelling

The predicted long-term water levels and time to exceed irrigation and stock water quality in the residual voids is summarised in **Table 12**.

Table 12 – Residual Void Water Level and Water Quality

Characteristic	Western Residual Void	Southern Residual Void
Pit crest (spill) level	272mRL	266mRL
Maximum long-term equilibrium water level	236mRL	223mRL
Average long-term equilibrium water level	233mRL	215mRL
Time to reach equilibrium water level	~300 years	~250 years
Time to reach ANZECC high salinity irrigation water quality	~200 years	~250 years
Time to exceed ANZECC beef cattle stock water quality	~400 years	~420 years
Total Dissolved Solids at 1000 years	5,500 mg/L	8,000 mg/L

Considering the long-term water quality, the authorised residual voids are unable to support a PMLU and are identified NUMAs. The void water would not, however, result in adverse environmental impacts on surrounding aquifers as groundwater hydraulic gradients are expected to be maintained in perpetuity towards both voids. The maximum water level in the voids is approximately 40m below the spill point and void water would not be released to surface waters or surrounding lands. The study confirms the residual voids would not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual voids themselves.

6.2 Flooding

Sojitz Minerva Mining Pty Ltd holds water licence number 406741 issued under the *Water Act 2000* (see **Appendix G**) to divert Sandhurst Creek around the western and southern mine pits to enable access to coal reserves. The diversion was constructed in stages (Western and Southern diversions) and totals 5,819m in length. The design criteria and design parameters for the diversion are described in the *Residual Void Investigation Report* (Sojitz Minerva Mining 2021a).

The diversion was designed to convey flow during a 0.1% AEP flood event such that associated flood waters do not enter the Western or Southern residual voids. Throughout active mining (2004 – 2021), all upstream Sandhurst Creek floodwaters were successfully conveyed via the diversion and there were no instances of floodwaters entering the mining pits. The predicted extent of the 10%, 1% 0.1% AEP and PMF flood events were modelled by WRM (2023b) using the most recent LiDAR survey of the diversion and surrounding landscape (see **Appendix H**). The modelling confirmed the surface flows from a 0.1% AEP flood event did not interact with the authorised residual voids (see **Figure 20**).

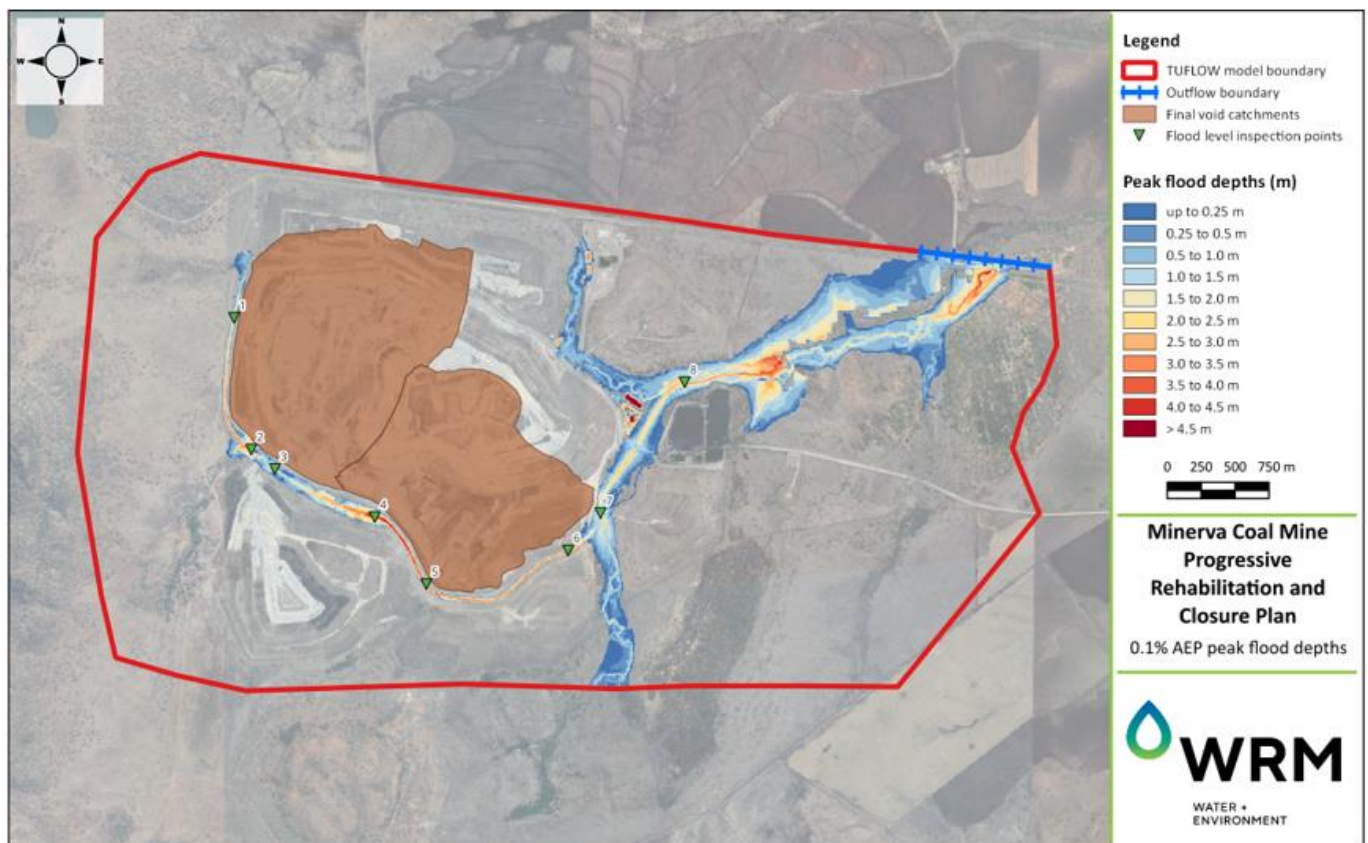


Figure 20 – Sandhurst Creek 0.1% AEP Flood Extent

As part of mine closure activities, a permanent bund shall be installed 50 m from the crest of the residual voids as a safety measure to restrict access to the highwalls. The closure bund is not required to contain a 0.1% AEP flood within the diversion and is deliberately placed outside the flood extent so as not to impede flow.

Surface flooding does not represent a threat to the Western and Southern residual voids, as they are located outside the 0.1% AEP modelled flood extent. The location of the residual voids adjacent to a floodplain and their NUMA status has been described in the *Residual Void Investigation Report* (Sojitz Minerva Mining 2021a) LOD.

6.3 Soil and Capping Materials

6.3.1 Material Volumes

Topsoil

Minerva Mine currently has approximately 1,032,000 m³ of topsoil in stockpiles based on the site's most recent survey reconciliation. The topsoil stockpiles are positioned around the site and were sourced from topsoil stripping activities ahead of mining. The locations and volumes of the topsoil stockpiles are shown in **Figure 21**.

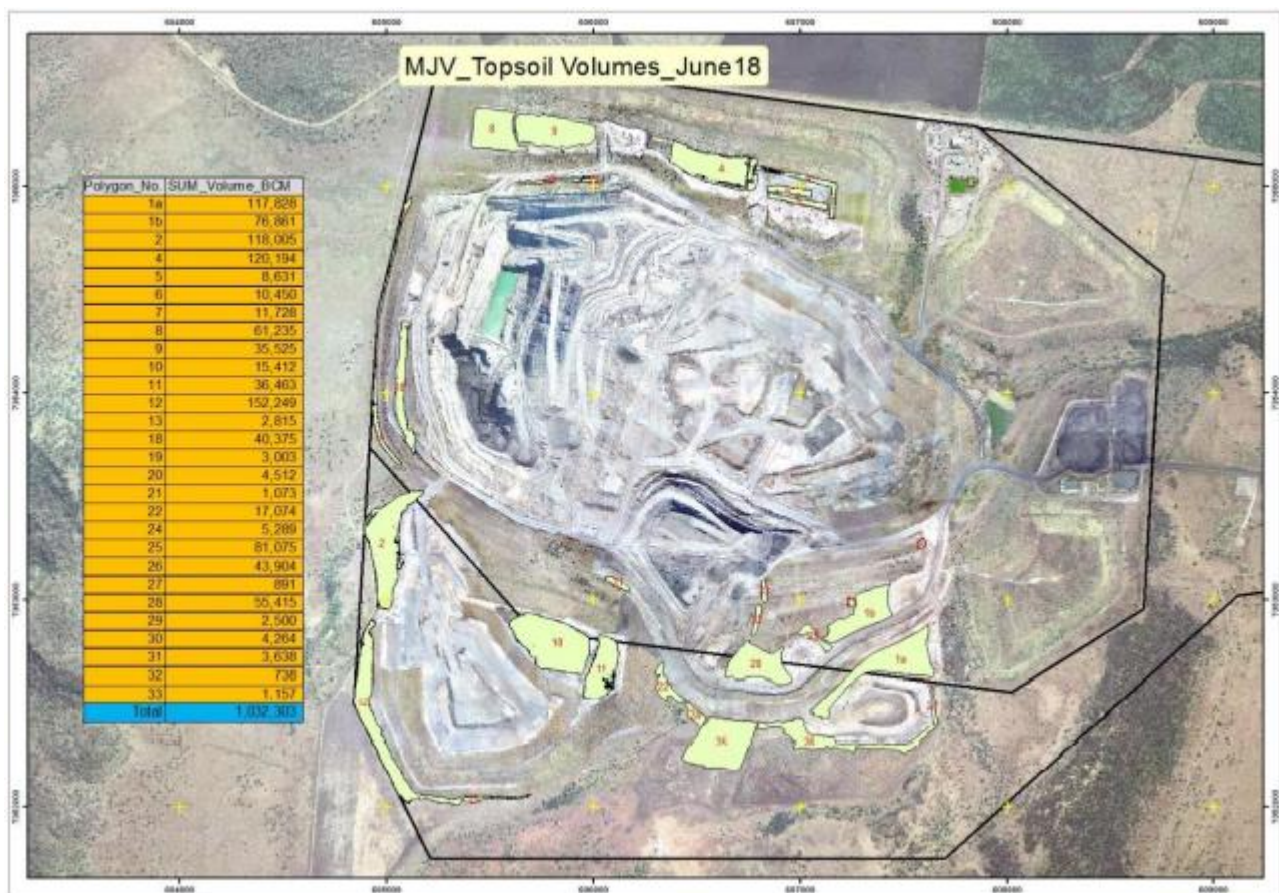


Figure 21 – Topsoil Stockpiles and Volumes

Following cessation of mining in August 2021, no further topsoil will be stripped and stockpiled. The total disturbed area currently requiring topsoil for rehabilitation at the end of mine life is 435.7 ha.

The rehabilitation treatments allow for 100 – 200 mm thick topsoil application for rock mulch areas and greater than 200 mm for topsoil only areas without rock mulch (Sojitz Minerva Mining 2021b). The stockpiled topsoil volume of 1,032,000 m³ provides more than sufficient topsoil to cover the 435.7 ha of disturbance with the required topsoil thickness.

Basalt

The Western pit high wall contained large volumes of competent basalt, with the thickness of the basalt strata reaching ~130 m in the western portion of ML 70145. Basalt from pre-strip activities has been stockpiled for use in rock mulch rehabilitation on dumps that have a re-profiled surface greater than 5% slope. Placement of 0.5 m thick

basalt rock mulch over shaped spoil dumps mimics stable rock scree landforms in the area and promotes the development of a bushland habitat for the rehabilitated areas.

Minerva Mine has stockpiled approximately 2,382,000 m³ of competent basalt on the in Main pit dump and the Southern dump, based on the site's most recent survey reconciliation. The locations and volumes of the basalt stockpiles are provided in **Figure 22**.

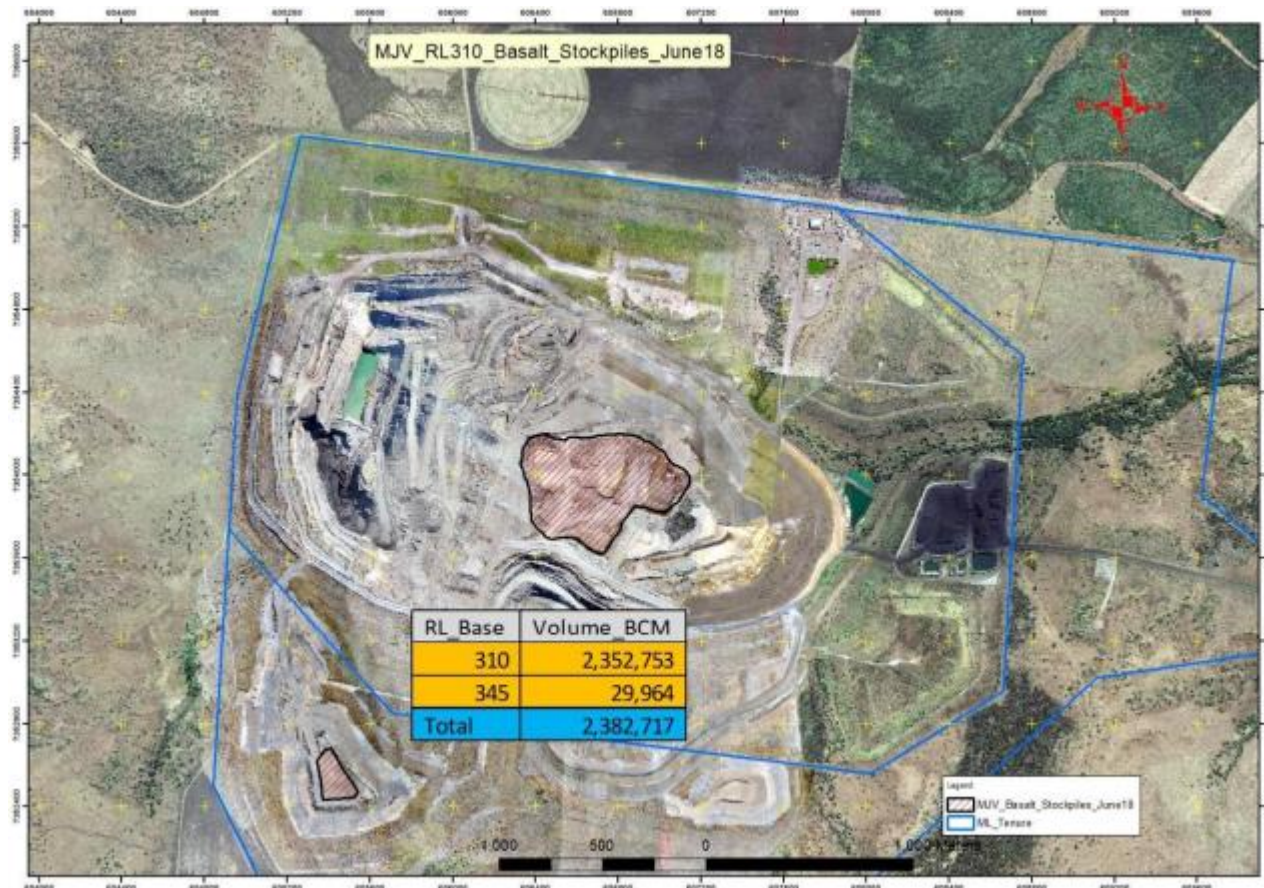


Figure 22 – Basalt Stockpiles and Volumes

The total disturbed area requiring rehabilitation with rock mulch at the end of mine life is 202.5 ha. The rock mulch rehabilitation treatments allow for 0.5 m thick of basalt over the surface of reprofiled areas. The total volume of 2,382,000 m³ of basalt rock provides more than sufficient material to cover the entire 202.5 ha with a minimum rock mulch thickness of 0.5m.

6.3.2 Material Quality

Competent basalt used for rock mulching at Minerva Mine has the following attributes:

- a resilient coarse fragment content that controls surface erosion by mechanical means;
- desirable characteristics for plant growth; and
- desirable infiltration and moisture retention characteristics.

Rock mulching provides a surface with high infiltration rates and a high level of surface roughness. In addition to providing erosion resistance, rock mulching effectively acts as a sponge that minimises surface runoff, increases infiltration and limits concentration of surface flow. Secondly, where a minor pipe structure has formed in underlying spoil, the rock mulch cover is largely resistant to erosive forces.

Moisture captured during rainfall events, slowly drains from the rock mulch into the clayey spoil below and the moistened spoil is weakened and deforms and settles under the weight of the rocky overburden. This process assists in stabilising/repairing erosional features that develop (Emmertson 2019). Basalt is highly resistant to erosion which makes it suitable as rock mulch on slopes up to 25%. The surface treatments are designed to provide a substrate with physical properties that minimise erosion and optimise infiltration, rather than relying on vegetation cover to stabilise the slopes. A total of 13 soil types have been recognised and mapped at the mine (Ison 1996a) (see **Table 4**). Topsoils range from shallow to deep black vertisols on Tertiary basalt interspersed by red brown non-cracking dermosol clays on Permian sediments. The black vertisols are the dominant soil type within the mining leases and are known to have very high soil fertility and a large water holding capacity (Queensland Government 2016).

During operations topsoil was stripped in accordance with depths formulated by Esys (2005) and stockpiled. The topsoil stockpiled is fertile and well suited to form the rehabilitated PMLUs of grassy open woodlands and low intensity grazing.

6.3.3 Ameliorants

The stockpiled black vertisols provide highly fertile growth media for rehabilitation areas. The topsoil used for rehabilitation does not require chemical alterations, fertiliser, or organic matter inputs to achieve the grassy open woodlands and low intensity grazing PMLUs.

Introduced pasture species such as Buffel grass, Rhodes grass and Green Panic are common in the area and are known to germinate from stockpiled topsoil. Applying fertilizer would provide introduced pasture species with an unwanted competitive advantage, enabling them to outcompete native species desired for the PLMUs of grassy open woodlands and low intensity grazing.

6.4 Waste Characterisation

The following characterisation of spoil material based on analysis of 22 drilling core samples taken within the footprint of the mine pit was provided by Esys (2005):

Salinity: 89% of the spoil classes were non-saline with the remaining spoil classes having medium to high salinity. The saline spoil classes were lithologies over the Sandhurst 1 coal seam, the weathered material above the Funnel seams and all coal seams. Based on the spoil material quality, saline drainage is not expected and has not been observed at Minerva Mine during operations.

Chemical induced dispersion: Sodidity was present in all spoil classes but not at excessive levels, ranging from 7-14% ESP. The calcium-magnesium ratio is low in most of the unweathered spoil classes, which is common for Central Queensland spoils.

Mechanical dispersion: The dispersion indices of all tested spoil classes other than Wurba sandstone were moderate again suggesting some mechanical dispersion.

Erodibility: Soil erodibility of the spoil classes were generally on par or lower than that of the soils tested. Spoil with a K factor exceeding 0.045 is considered erodible. The USLE K factor for the tested spoil classes are ranked below and show that the Funnel spoil materials contained the highest K factor:

- i) Funnel = 0.052 > Wurba = 0.43 – 0.46 > Lexington = 0.04 > Wills = 0.038 > Minerva = 0.028.

Acid Mine Drainage: overburden and interburden materials were inert, while some fine-grained materials that occur immediately above the Funnel and Sandhurst 1 coal seams were potentially acid forming. The potentially acid forming material associated with the Funnel and Sandhurst 1 coal seams represented less than 5% of the sampled overburden. Laboratory testing indicated that most of the overburden is non-acid forming and has neutralising capacity, so net acid generating spoil materials is not expected. Results from the testing are provided in **Table 13**.

Table 13 – Acid Producing Potential of Spoil

Acid Producing Potential	Net acid Production (kg H ₂ SO ₄ / t)	Spoil Classes
None (neutralising)	< -15	Lexington, Minerva 4 and 5 lithologies
None (neutralising)	-15 to -10	Wills, Minerva 1 to 3 lithologies
Very low (low neutralising)	-10 to 0	Lexington siltstone, Minerva 5, Sandhurst 2 and Minerva mudstone lithologies
Low (low acid)	0 to 5	Funnel lithologies
Moderate (5% of samples)	>5 (max 7.8)	Sandhurst 1 lithologies

The unweathered Sandhurst 1 seam lithologies represented the only net acid material with moderate acid producing potential. The Sandhurst 1 lithology could be neutralised by mixing Sandhurst 1 with other spoil at a ratio of 1:1 (except spoil surrounding Funnel lithologies). The acid potential was not sufficiently high to warrant encapsulation. Management of Sandhurst 1 material during mining operations involved burying the waste at the base of in-pit dumps.

Major Elements: All seam lithologies were tested for trace elements such as arsenic, chromium, copper, lead, nickel, zinc, cadmium and mercury. Cadmium and mercury levels were below detection levels throughout. The metal levels of the Permian coal measures were less than the QDME (1995) soil investigation threshold levels in all materials. All spoil types were very low in nitrogen and phosphorus, being characteristic of spoils in Central Queensland. Potassium was acceptable or marginally low in most spoil classes with the notable exception of weathered spoil above the Funnel seams and lithologies above the Wurba seam. Calcium, magnesium and sulphur levels were at acceptable levels in all spoil classes tested.

Given the low levels of trace elements, neutral mine drainage is not expected to occur at Minerva Mine due to the absence of enriched elements.

There is no evidence of spontaneous combustion of carbonaceous materials leading to surface heating in rehabilitated areas.

6.5 Landform Design

A final landform has been prepared for Minerva Mine based on the final pit and dump profile that remained at the end of mining in August 2021. The final landform is described in the *Residual Void Investigation Report* (Sojitz Minerva Mining 2021a) LOD and *Rehabilitation Management Plan* (Sojitz Minerva Mining 2021b) LOD.

The following criteria were applied in preparing the final landform design:

Final Voids and Low Walls

- Reshape the current low walls to 25% with 30 m wide benches every 30 m of vertical lift;
- Western pit reshape low wall down to RL 210 m (max water equilibrium level), with fill below this at angle of repose;
- Southern pit reshape low wall down to RL 200 m (max water equilibrium level), with fill below this at angle of repose;
- Southern pit highwall reshaped south-east section to 25% to reduce void area, no reshape of Western pit highwall;
- Reshaped 25% slopes shall be capped with 0.5 m thick of basalt rock mulch, plus topsoil; and
- Shaped surfaces will internally drain to void area.

Out of Pit Spoil Dumps and External Draining Batters

- Batter surfaces with a grade of 25% slope or less with 0.5m basalt rock mulch plus topsoil;
- Benches installed at 15 m or less vertical lifts, wide enough to enable topsoil haulage along the benches;
- With slopes less than 5%, topsoil only application to shaped surfaces; and
- Rehabilitated surfaces designed to shed water to the receiving environment.

A three-dimensional model of the final landform has been prepared and is shown in **Figure 23**, with the green shading indicating the area requiring reshaping. The areas shown in yellow shading are landscapes that do not require further reprofiling as they already meet the final landform design. Out of pit rehabilitated surfaces are designed to shed water to the receiving environment, while the in-pit low walls will drain to the Western and Southern residual voids. Rehabilitation includes a final surface layer of either rock mulch/topsoil or topsoil only applications (see **Section 6.8**) that are used to stabilise the landforms.

Spoil dump settlement that may occur within is stabilised by the rock mulch cover as the underlying spoil settles. This process assists in stabilising and repairing erosional features that may develop (Emmertson 2019).

The final heights of the rehabilitated landforms are provided in **Figure 24**, with the South-West dump forming the highest elevation at RL 345 m.

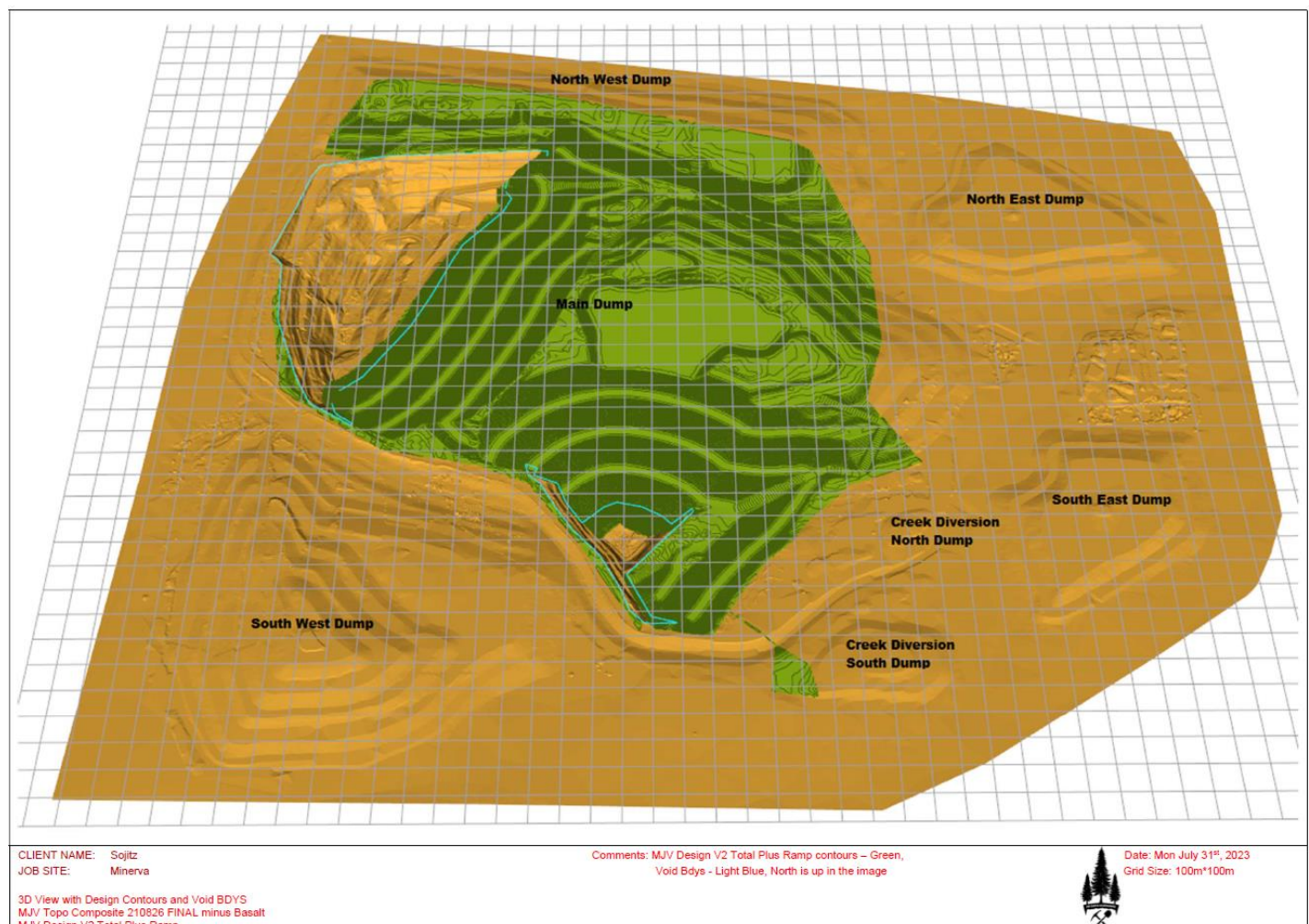


Figure 23 – 3D Model of Final Landform



Figure 24 – Final Heights of Rehabilitated Landforms

6.6 Waste Material Cover Design

The coal produced at Minerva Mine did not need to be processed by a coal handling and preparation plant, so coarse rejects or fine tailings were not generated. All of the ROM coal was crushed on stockpile areas and then loaded onto trains as product coal, with no waste produced. The coal stockpiles will be scalped of all carbonaceous materials and loaded onto trains as product coal prior to being rehabilitated. There are no areas that need to be capped to manage potentially reactive materials.

6.7 Water Management

Water used onsite was obtained from the following sources: (i) basalt aquifer bore, (ii) groundwater seepage to the mining voids, and (iii) rainfall run-off collected in mining voids. The water quality of the water sourced from the basalt aquifer was suitable for unrestricted use across the mining operations for activities such as dust suppression, workshop use, and vehicle washdown (typical electrical conductivity <1,000 $\mu\text{S}/\text{cm}$). Water sourced from pit dewatering (groundwater seepage and rainfall run-off) generally had higher electrical conductivity than the basalt aquifer and was predominately used for watering haul roads (typical electrical conductivity ~ 3,000 $\mu\text{S}/\text{cm}$) (Sojitz Minerva Mining 2017).

The industrial area dams receive run-off from the heavy vehicle workshop, hardstands, and the wash-down pad, after being treated via an oily water separator. These dams capture storm water run-off that may potentially contain residual contaminants from the industrial area. This water captured by the industrial dams is recycled for use onsite.

The ROM dams and the sediment dams are positioned around site to collect run-off from coal stockpiles or spoil dump areas. These dams are designed to capture sediment run-off during heavy storm events and allows by-wash of supernatant water to the environment in accordance with Condition W38 of the EA. Spillway releases of non-mine affected water from ROM dams and sediment dams are suitable for entering the receiving environment due to the high flows and low solute concentrations during the storm events. Site dams will remain after closure as a water supply and forming part of the low intensity grazing PMLU. A list of these dams is provided in **Table 9**.

Rainfall run-off and groundwater seepage shall accumulate in the Western and Southern voids, which will eventually reach long-term equilibrium levels approximately 40m below pit crest (see **Section 6.1**). Groundwater hydraulic gradients are expected to be maintained in perpetuity towards each residual void (AGE 2023). The void water will not interact with the basalt aquifer or the receiving environment and will not overflow (Sojitz Minerva Mining 2021a). The final voids will act in perpetuity as internally draining sediment traps for the catchment of the voids.

The Sandhurst Creek Diversion is a permanent diversion that will remain post mine closure. The diversion Water Licence 406741 requires an on-going monitoring and evaluation program be carried out consistent with ACARP Project C9068 *Monitoring and Evaluation Program for Bowen Basin River Diversions* (ACARP 2001). The water licence cannot be relinquished until the diversion is meeting or progressing towards:

- developing features (including geomorphic and vegetation) present in the landscape and in local watercourses;
- maintenance of a sediment transport regime that allows the diversion to be self-sustaining and not directly impact upstream or downstream reaches; and
- the diversion and associated structures maintain equilibrium and functionality and do not require ongoing maintenance.

A monitoring program in accordance with Water Licence 406741 has yet to be implemented. A program shall be submitted to the Queensland Department of Regional Development, Manufacturing and Water as per condition 2c of the water licence.

6.8 Revegetation

6.8.1 Revegetation Objectives

Minerva Mine reviewed the rehabilitated landform design criteria in 2015 and developed the following rehabilitation objectives to achieve the PMLUs of grassy open woodlands and low intensity grazing (Sojitz Minerva Mining, 2021b):

- Landform stability is paramount;
- Appropriate final surface treatment and sustainable vegetation cover is key to prevention of erosion;
- Optimise in-pit dumping practices in the Main (Western) void to the most cost effective and practicable extent during operations;
- All infrastructure will be removed from site unless otherwise agreed in writing by the post mining land holder;
- Provide landforms that are sufficiently stable such that vegetation is self-sustaining;
- Return land to an agreed land use and capability;
- Ensure downstream surface water quality is of agreed standard during and after mining;
- Ensure surface water on the leases is of agreed standard after mining; and
- Ensure that decommissioned landscapes are safe for humans and wildlife.

The rehabilitation objectives will be met by undertaking the rehabilitation practices described in **Section 6.8.2** to **Section 6.8.6** below.

6.8.2 Shaping Landforms

Spoil dumps formed by the removal of overburden have been placed either out of pit creating new landforms or within the mining footprint to partially backfill the void. Once the spoil has been dumped to the designed levels, reshaping of the surfaces can commence to provide the final landform profile.

Reshaping is undertaken with bulldozers to achieve a maximum slope angle of 25% for externally draining batters, ramps and internally draining low walls. The top of dumps are generally reshaped with slopes less than 5% that may drain towards the residual void low walls or to the external batters.

Benches are incorporated into the spoil reprofiling on the external batters and the internally draining low walls as part of the final landform design. Benches are designed to be relatively flat and free draining, which acts to dissipate concentrated flow of water that may develop from storm water run-off.

Once the landform shaping meets the designed profiles, it is ready for topsoil or rock mulch application to create the final surface.

6.8.3 Topsoil Application Areas

Stockpiled topsoil is spread over the reshaped spoil dumps to provide the physical structure and chemical properties required for vegetation growth. Topsoil is applied to areas with slopes of < 5 % (e.g. top of dumps, infrastructure areas), as rock mulching is not required to stabilise such slopes. Topsoil is applied in accordance with the following methodology:

- The topsoil is delivered to the shaped surface and spread out at depths of at least 200 mm;
- The profile is deep ripped on the contour with bulldozers to slow the surface flow of water (in the absence of established vegetation), de-compact the profile, and promote rainfall infiltration;
- The ripped topsoil surface is then seeded to achieve the PMLU of low intensity grazing. A blend of native and introduced grass and legume species are included in the seed mix; and finally,
- Fertiliser or other ameliorants are not applied to topsoiled areas (see **Section 6.3.3**).

6.8.4 Rock Mulch Application Areas

The use of rock mulch on spoil slopes up to 25% provides an enduring surface armour and offers a growth media to support grass and trees. The competent basalt has been stockpiled from pre-strip operations and will be applied in accordance with the following methodology:

- Basalt is dumped by trucks onto the shaped surface and then pushed out by bulldozers to achieve a 500 mm thick layer;
- Topsoil is then delivered to the rehabilitation area and pushed out over the top of the basalt using bulldozers to achieve 100 – 200 mm thickness;
- The surface is then deep ripped on the contour with bulldozers, which will mix the basalt and topsoil together forming a rock mulch;
- The rock mulch surface is then ripped and seeded to achieve the PMLU of grassy open woodlands. A blend of native species including trees, shrubs and grasses represented in nearby regional ecosystem are included in the seed mix (see **Section 6.8.5**); and note that
- Fertiliser or other ameliorants are not applied to rock mulched areas (see **Section 6.3.3**).

6.8.5 Seed Mixes

The application of seed is the final step for completing the rehabilitation work. Areas are seeded in the cooler months (i.e. April to August) when tree and shrub germination and establishment is not inhibited by competition from introduced grass species. Stock are excluded from newly rehabilitated areas using fencing to prevent damage to young vegetation.

For low intensity grazing areas, native perennial grass species are included in the mix, supplemented with introduced grass/legume species (if required) at an aggregate rate of 15 kg/ha. The species mix for low intensity grazing areas are intended to closely align with RE 11.8.11 *Dicanthium sericeum* grasslands on Cainozoic igneous rocks. For grassy open woodlands areas, where possible a blend of native species including trees and shrubs represented in nearby regional ecosystem (e.g. RE 11.8.4, 11.8.5, RE 11.3.25, RE 11.9.1) are included in the seed mix and applied at an aggregate rate of 15 kg/ha. The mix reflects species that occur in regional ecosystems that portray similar slope and rock mulch substrate to the rehabilitated dumps. Seed species that are commonly applied to rehabilitation at Minerva for rock mulch and topsoil only areas are provided in **Table 14**.

Table 14 – Seed Species Commonly Used for Rehabilitation

Species Used for Grassy Open Woodlands		Species Used for Low Intensity Grazing
<i>Eucalyptus exserta</i>	<i>Lysiphylum hookeri</i>	<i>Dichanthium</i> spp.
<i>Eucalyptus populnea</i>	<i>Cassia brewsterii</i>	<i>Aristida</i> spp.
<i>Eucalyptus crebra</i>	<i>Casuarina cristata</i>	<i>Panicum</i> spp.
<i>Eucalyptus tereticornis</i>	<i>Atalaya hemiglauc</i>	<i>Astrelia</i> spp.
<i>Eucalyptus cambageana</i>	<i>Acacia bancroftii</i>	<i>Stylosanthes scabra</i>
<i>Eucalyptus coolibah</i>	<i>Acacia victoriae</i>	<i>Cynodon dactylon</i>
<i>Eucalyptus moluccana</i>	<i>Acacia coriacea</i>	<i>Heteropogon contortus</i>
<i>Eucalyptus melanophloia</i>	<i>Acacia salicina</i>	
<i>Eucalyptus tessellaris</i>	<i>Acacia harpophylla</i>	
<i>Eucalyptus orgadphila</i>	<i>Acacia excelsa</i>	
<i>Corymbia citriodora</i>	<i>Acacia anuera</i>	
<i>Corymbia erythrophloia</i>	<i>Dodonaea viscosa</i>	
<i>Alphitonia excelsa</i>	<i>Eremophila mitchellii</i>	

Seeds are sourced from only reputable seed suppliers. The preference is for seed harvested from Central Queensland, where possible. Seed germination tests are generally undertaken by the seed suppliers as part of quality assurance to ensure the seeds are viable before packaging and delivery to site.

6.9 Final Void Treatments

The Western and Southern pits will remain as residual void NUMAs and a safety bund will be constructed around the perimeter of the high wall / end walls (see **Section 5**). PSM (2021) completed a stability analysis of the Western and Southern residual voids and noted that a buttress of the Southern Residual Void was recommended to provide a minimum factor of safety of 1.5 to the safety bund. The *Residual Void Investigation Report* (Sojitz Minerva Mining 2021a) included the stability analysis as an appendix, with the report also indicating a review of the PSM (2021) stability analysis would be undertaken before submission of this PRC Plan.

WK Geotechnical were engaged by Minerva Mine to complete a review of the PSM (2021) stability analysis and also other technical information pertaining to the long-term stability of the residual voids (WK Geotechnical 2023) (**Appendix D**). The review assessed the stability of the residual voids under both maximum pit water levels and no pit water scenarios (at closure), along with 10 m water level increments to assess sensitivities. The stability analysis modelling indicated that a 1.5 factor of safety would be maintained to the residual void safety bunds in all scenarios. WK Geotechnical (2023) confirmed that no reshaping or remedial changes (e.g. buttressing) to the residual voids (as described in the LODs) are required in order to meet the 1.5 factor of safety.

Figure 25 provides the crest lines for the Western and South residual voids (dark blue line), the proposed closure bund location (green line) and the 0.1% AEP flood extent (light blue line). The bund remains outside the 0.1% AEP flood extent and inside the mining leases. The closure bund will be constructed from Permian or competent basalt spoil with a minimum height of two metres and a base width of five metres (WK Geotechnical 2023).

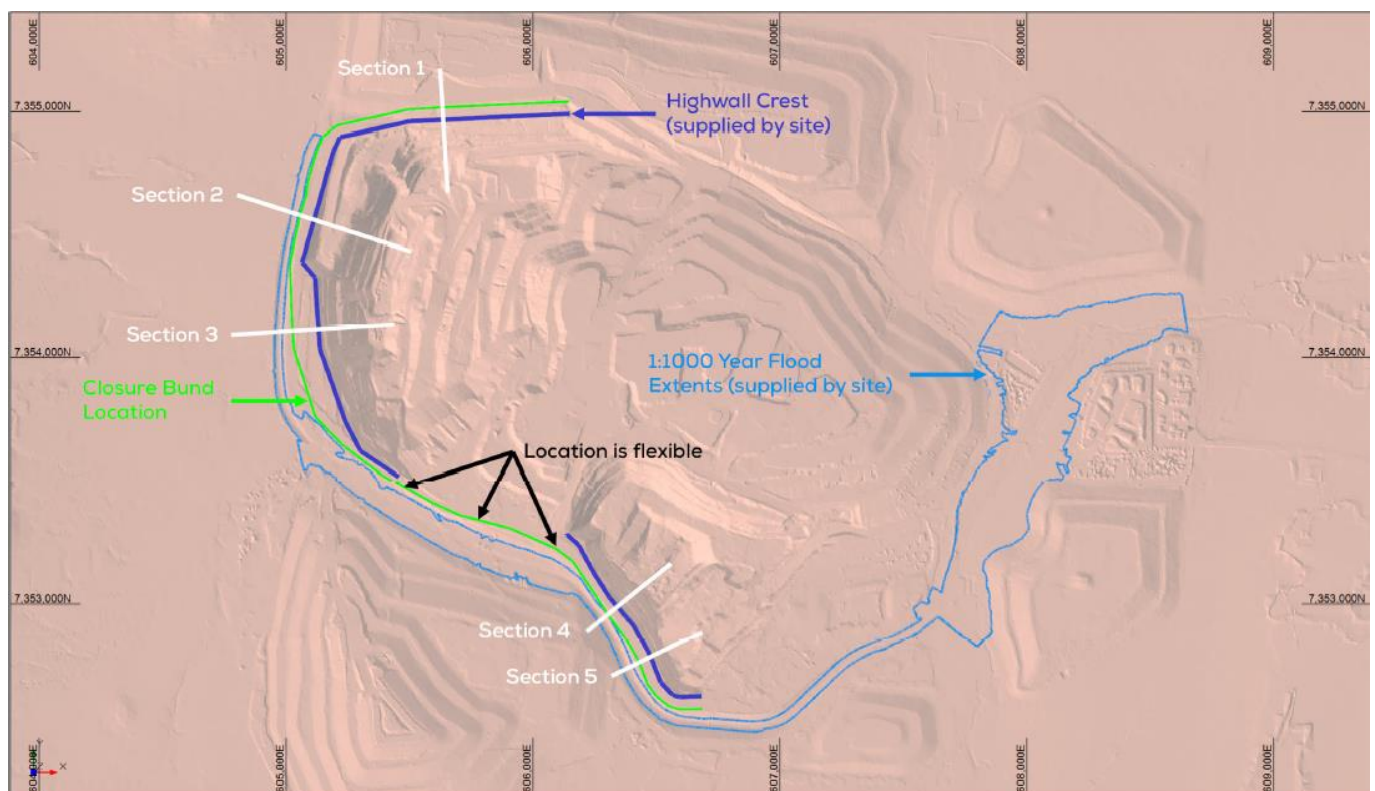


Figure 25 – Residual Void Closure Bund

The residual void investigation report LOD (Sojitz Minerva Mining 2021a) provided final landforms and the rehabilitation treatments for the residual voids (see **Section 6.5**). A numerical groundwater model and a final void hydrology model have been developed and they indicate that the final voids will remain a groundwater sink in perpetuity (AGE 2023, WRM 2023a).

WK Geotechnical (2023) indicated the Sandhurst Creek diversion will not impact the highwall stability of the Western or Southern final voids due to the following factors:

- Sandhurst Creek in the vicinity of Minerva Mine is a small ephemeral waterway, that only flows water for brief periods;
- The large separation distance between the diversion and the highwall crest (closest point is 74 m);
- The diversion is located above the weathering profile, within the less permeable near surface basalt and weathered Permian;
- The 0.1% AEP flood extents do not enter the final voids.

6.10 Built Infrastructure

6.10.1 Infrastructure to be Retained

Minerva Coal Pty Ltd holds ML70145, ML70376, EA EPML00668613 and underlying freehold land on the Lexington property. Certain infrastructure that is beneficial to the running of the Lexington property, and an adjacent property also owned by Minerva Coal Pty Ltd (Mt Minerva), is to be retained. The location of these two properties is shown in **Figure 3**. Lexington covers an area of 3,442ha, which is predominantly grazed with some dryland cropping conducted in the eastern extent. Mt Minerva covers an area of 494ha, which is largely dryland cropping. The retained infrastructure will beneficially support both the PMLUs and the overall productive use of the two properties. Benefits include the provision of water storage and buildings for farm equipment and personnel, and storage of fodder. The infrastructure will also help support the management of Minerva Coal Pty Ltd's natural grasslands offset area established under EPBC Act approval (EPBC 2005/2039) (see **Section 2.6.8**). In addition, the adjoining properties will also have the opportunity to reach appropriate agreements to utilise these facilities for farming purposes.

A statement from Minerva Coal Pty Ltd accepting ownership, responsibility and liability for retained infrastructure is presented in **Appendix C**.

The following infrastructure will remain following mine closure and be owned by the landholder:

- access roads, vehicle parking and associated hardstands;
- dams, with associated groundwater production bores and pipeline to the Industrial Raw Water Dam;
- site administration facility, including muster shed;
- workshop and associated sheds;
- electrical transformers and connections; and
- potable water tanks and on-site septic system.

A site investigation report will be undertaken as part of the closure activities to identify any areas of contamination that require removal or remediation. The investigation will be guided by the locations of former environmentally relevant activities and notifiable activities. If the investigation identifies residual contamination associated with the retained infrastructure that is impractical to remove or remediate due to its location, the infrastructure transfer agreement stipulates the landholder shall have responsibility for the ongoing maintenance and ownership liability for the location in question (see **Appendix C**).

6.10.2 Infrastructure to be Decommissioned

Infrastructure that is not beneficial to the landholder and the PMLUs will be decommissioned as part of mine closure. Demolition activities will remove the physical infrastructure and then rehabilitate the ground that was supporting the infrastructure. The areas will be rehabilitated by covering the exposed ground with at least 200mm mm of topsoil, deep ripping and seeding the surface.

If the site investigation report identifies areas of contamination, then the material would be managed as part of the rehabilitation works prior to the application of topsoil.

The following infrastructure will be removed as part of mine closure:

- truck fill points;
- wash down bay and associated hardstands;
- fuel farm;
- haul roads;
- explosives magazine and compound;
- used tyre stockpiles / used tyre bunds;

- ROM infrastructure;
- fixed lighting towers;
- security / boom gates and security fences; and
- remote crib huts.

Used plant, equipment and salvageable materials (e.g. steel) will be sold or disposed off-site. Waste tyres may be disposed in pit in accordance with the EA conditions E4 and E5. General waste may be disposed of on site within the unrehabilitated spoil dumps adjacent to the Western or Southern voids in accordance with EA condition E11. Waste would be buried above the elevation of the pre-mining water table and covered by a spoil depth in excess of two metres. The covered disposal areas would then be rehabilitated to the grassy open woodlands PMLU.

7 Risk Assessment

7.1 Rehabilitation Risk Assessment

The risks of the PMLUs and NUMAs causing environmental harm and not being safe and structurally stable have been identified. These are non-trivial hazards that may arise during Minerva Mine's closure phase and which may affect the attainment of rehabilitation objectives and completion criteria.

The possible causes of each identified risk were then assessed, along with potential impacts. The next step undertaken was to analyse the risks in terms of likelihood (**Table 15**) and consequence (**Table 16**), taking into consideration the controls and actions either currently undertaken, or to be undertaken, to minimise adverse outcomes or promote beneficial outcomes. The analysis took into account the experience gained from over a decade of mine rehabilitation undertaken Minerva Mine. A 5 x 5 risk matrix format tailored to PRC Plan requirements was used (**Table 17**).

Table 15 - Risk Likelihood

Rare	Unlikely	Possible	Likely	Almost Certain
Very unlikely to occur	May occur over a period of about twenty years	May occur over period of about five years	May occur once a year	May occur more than once a year

Table 16 - Risk Consequence

Very Low	Low	Moderate	High	Very High
Environment				
Localised minor environmental harm, no structural instability, no remediation required, quick recovery.	Localised environmental harm or minor instability, minor remediation takes <2 months.	Localised environmental harm or structural instability, remediation takes <2 years.	Environmental harm or structural instability that is widespread on site. Remediation takes >2 and <10 years.	Environmental harm or structural instability that is widespread, or extends off site. Remediation takes > 10 years.
Safety				
First aid case with no medical treatment.	Medical treatment case injury	Injury requiring in-patient care	Single fatality or single permanent disability	Multiple fatalities or multiple severe permanent disabilities

Table 17 - Risk Matrix

Likelihood	Consequence				
	Very Low	Low	Moderate	High	Very High
Almost Certain	Medium	Significant	High	High	High
Likely	Medium	Significant	Significant	High	High
Possible	Low	Medium	Significant	High	High
Unlikely	Low	Low	Medium	Significant	High
Rare	Low	Low	Medium	Significant	Significant

The evaluation of risks was an iterative process whereby the need, or otherwise, for additional controls (risk treatments) in order to manage risk to an acceptable level was considered. The steps followed were consistent with *AS ISO 13000:2018 Risk management – Guidelines* (Australian Standards 2018).

The final outcome of the risk assessment is presented in **Table 18**

Table 18 - Rehabilitation Risk Assessment

Ref.	Hazard (Risk Description)	Cause	Impact	Controls/Actions	Likelihood	Conse- quence	Risk Rating	Risk Treatment – Contextual Information
1	Insufficient material available for rehabilitation	Insufficient stripping and stockpiling of topsoil and basalt rock mulch.	Inadequate depth of topsoil and basalt rock mulch respreads on rehabilitated areas.	Sufficient topsoil volumes already stockpiled for rehabilitation of PMLUs. Large surplus of basalt material already available for rock mulching.	Rare	Moderate	Medium	Section 6.3.2 Material Quality Rehabilitation material volumes in Section 6.3.1
2	Saline and/or acidic spoil	Saline and/or potentially acid generating spoil exposed on surface.	Poor vegetation establishment. Surface water contamination.	At risk materials buried during operations. Rehabilitation monitoring and maintenance.	Unlikely	Moderate	Medium	Very low proportions of saline and potentially acid materials were excavated (Section 6.4 Waste Characterisation).
3	Poor vegetation establishment of grassy open woodland PMLU	Inadequate depth of topsoil and/or rock mulch. Poor ground preparation. Inappropriate species mix for local environment. Inadequate seeding rate. Competition from weeds and introduced pasture grasses. Uncontrolled fire. Extended droughts. Extreme rainfall periods.	Non-compliance with PRCP milestone criteria. Erosion.	Stockpile adequate topsoil and rock mulch volumes. Species and seeding rates selected based on past local rehabilitation experience. Source seeds from reputable suppliers. Fertilizer not applied. Exclude stock. Rehabilitation monitoring and maintenance.	Possible	Moderate	Significant	Section 6.3.2 Material Quality Section 6.8 Revegetation Section 6.8.5 Seed Mixes Section 8 Monitoring and Maintenance
4	Pastures degrade in low intensity grazing PMLU.	Grazing commences before grasses fully established. Overgrazing.	Weeds and non-beneficial species predominate. Reduced carrying capacity. Erosion. Non-compliance with PRCP milestone criteria.	Only begin grazing once grasses well established. Monitor groundcover and rotate stock to spell paddocks.	Unlikely	Moderate	Medium	Section 6.3.2 Material Quality Section 6.8 Revegetation Section 6.8.5 Seed Mixes Section 8 Monitoring and Maintenance

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Ref.	Hazard (Risk Description)	Cause	Impact	Controls/Actions	Likelihood	Conse- quence	Risk Rating	Risk Treatment – Contextual Information
5	Weeds proliferate in revegetated areas	Topsoil contains seed bank of invasive weeds. Mobile equipment introduce weeds.	Invasive weeds species retard establishment of beneficial flora species. Non-compliance with PRCP milestone criteria.	Topsoil sourced from stockpiles (with declining weed seedbank). Fertilizer not applied (to avoid promoting weed growth). Wash down of earthmoving equipment. Weed spraying program.	Unlikely	Moderate	Medium	Section 6.8 Revegetation Section 8 Monitoring and Maintenance
6	Gully and rill erosion	Concentration of rainfall runoff. Landform slopes too steep for infiltration characteristics of rehabilitated substrate. Inadequate ground cover.	Sedimentation and elevated turbidity in downstream waters. Loss of topsoil and vegetative cover. Non-compliance with PRCP milestone criteria.	Gully formation minimized by (a) low intensity grazing PMLU restricted to slopes $\leq 5\%$, (b) rock mulching of slopes $> 5\%$. Contour ripping. Vegetation cover. Rehabilitation monitoring and maintenance.	Possible	Moderate	Significant	Section 6.3.2 Material Quality Section 6.5 Landform Design Section 6.8 Revegetation Section 8 Monitoring and Maintenance
7	Safety hazard from erosion gullies	Concentration of rainfall runoff. Landform slopes too steep for infiltration characteristics of rehabilitated substrate. Inadequate ground cover.	Injury to people, stock. Non-compliance with PRCP milestone criteria.	Public access to site restricted. Gully formation minimized by (a) low intensity grazing PMLU restricted to slopes $\leq 5\%$, (b) rock mulching of slopes $> 5\%$. Contour ripping. Vegetation cover. Rehabilitation monitoring and maintenance.	Unlikely	Moderate	Medium	Section 6.3.2 Material Quality Section 6.5 Landform Design Section 6.8 Revegetation Section 8 Monitoring and Maintenance
8	Hydrocarbon contaminated land	Hydrocarbon spills in infrastructure area	Soil contamination retarding revegetation. Surface water contamination.	Removal or treatment of contaminated materials identified by a site investigation report.	Unlikely	Low	Low	Section 6.10 Built Infrastructure
9	Extreme flood flows enter residual voids.	Sandhurst Creek flood event spills into residual voids.	Erosion of pit crest at point of entry. Void water level rises above modelled long-term maximum level for a period.	The licenced Sandhurst Creek diversion has been designed and constructed such that a flood event with 0.1% AEP does not enter the Western or Southern residual voids. Design allowance for 50m of pit crest erosion retreat (closure bund constructed minimum 50m from crest)	Rare	Moderate	Medium	Post-event remediation: Construct flood levee between creek and void Section 6.2 Flooding Section 6.7 Water Management Section 6.9 Final Void Treatments

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Ref.	Hazard (Risk Description)	Cause	Impact	Controls/Actions	Likelihood	Consequence	Risk Rating	Risk Treatment – Contextual Information
10	Migration of saline water from residual voids to licenced groundwater production bore in basalt.	Salinity in residual voids increases over time. Hydraulic gradient forms from voids toward adjacent aquifer.	Increased salinity in licenced Lexington groundwater bore.	Hydrogeological conditions are such that hydraulic gradient is maintained in perpetuity from basalt aquifer towards the voids. Monitoring of water quality and level in bores specified in Environmental Authority.	Rare	Moderate	Medium	Section 6.1 Hydrogeology Section 6.9 Final Void Treatments
11	Residual void wall slope failure.	Geotechnical instability	The pit crest extends into Sandhurst Creek 0.1% AEP flood zone.	Maximum void wall slopes < 70 degrees for competent material, angle of repose for incompetent material (as per Environmental Authority). FoS ≥ 1.5 Assessment report by a Registered Professional Engineer of Queensland (RPEQ) on the geotechnical stability of final voids. Design allowance for 50m of pit crest erosion retreat (closure bund constructed minimum 50m from crest).	Rare	Moderate	Medium	Post-event remediation: Construct flood levee between creek and void. Section 6.9 Final Void Treatments
12	Fall into residual void	People, stock have access to pit crest.	Injury or fatality to people, stock.	Public access to site restricted. Public and stock excluded from NUMAs. Fencing, warning signs, as required. Closure bund constructed 50m from crest. Assessment report by a Registered Professional Engineer of Queensland (RPEQ) on the geotechnical stability of final voids.	Rare	High	Significant	Section 6.9 Final Void Treatments

7.2 Rehabilitation Trials

Minerva have undertaken rehabilitation works since 2011 and extensive experience has been gained with techniques that result in stable landforms. Improvements in rehabilitation practices were trialled, including the use of rock mulch cover for spoil dump batters in preference to topsoil-only methods. These techniques were implemented and refined over time by an experienced rehabilitation specialist, Ross Gooley. Rehabilitation trials are not expected to be required in order to meet the proposed PRCP Schedule.

The rock mulch method has proven successful for stabilising steep slopes at Minerva (and elsewhere in Central Queensland (Emmerton 2019)) and this rehabilitation approach has now been adopted for all dump batters with > 5% slope. This experience has been drawn on at all relevant stages, including when previously determining and designing final landforms, and in preparing this document.

8 Monitoring and Maintenance

8.1 Milestone Criteria Monitoring

The rehabilitation monitoring program has been developed to meet the rehabilitation milestone criteria listed in the PRCP Schedule (**Section 9**). The specific monitoring activities and the frequencies of monitoring for each rehabilitation milestone are presented in **Table 19**.

Results from the rehabilitation monitoring program will be used to trend data over time and identify if the rehabilitation is on the trajectory to meet the completion criteria. Rehabilitation that requires maintenance intervention will be managed using the techniques described in **Section 8.2**.

Table 19 – Rehabilitation Monitoring Activities

Rehabilitation Milestone (RM)	Monitoring Activity	Monitoring Frequency
RM1 – Infrastructure Decommissioning and Removal	Visual inspection that all infrastructure has been removed that is not listed in written agreement with landholder.	At mine closure
RM2 – Remediation of Contaminated Land	If remediated areas show signs of ongoing contamination, undertake re-sampling to verify all contaminated materials were removed.	As required
RM3a – Landform Shaping	Survey control on earthmoving equipment or in-field survey scans to track conformance to landform designs.	During rehabilitation works
RM3b – Final Trim	Survey control on earthmoving equipment or in-field survey scans to track conformance to landform designs.	During rehabilitation works
RM4a – Rock Mulch Haulage	Haulage operations – no specific monitoring required.	NA
RM4b – Rock Mulch Application	- Survey control on earthmoving equipment or in-field survey scans to track conformance to design of rock mulch thickness; - Visual inspections to verify rock is competent basalt or sandstone materials that will provide long-term durability; - Visual inspections to verify rock consists of variable sizes with ranges suitable for 0.5 m thick application.	Survey and assessments of rock quality to occur during rehabilitation works
RM5a – Topsoil Haulage	Haulage operations – no specific monitoring required.	NA
RM5b – Topsoil Spreading	Survey control on earthmoving equipment or in-field survey scans to track conformance with thickness specification.	During rehabilitation works

Rehabilitation Milestone (RM)	Monitoring Activity	Monitoring Frequency
RM6a – Deep Ripping	Survey control to mark locations for rip lines on the contour and visual inspections to ensure ripping completed at required depths.	During rehabilitation works
RM6b – Deep Ripping and Seeding	Seed species and application rate to be consistent with Section 6.8.5.	Prior to ordering seed for rehabilitation
RM7 – Revegetation (grassy open woodlands) RM9 – Achievement of a stable PMLU (grassy open woodlands)	The grassy open woodlands rehabilitation areas shall be assessed using the following approach at all monitoring sites: - Monitoring transects to be 50 m long - Soil sampling of topsoil for physical and chemical laboratory analysis to determine if soil limitations - Visual assessment of soil type, soil structure and soil surface condition - Visual assessment of surface rock cover condition for rock mulched sites - Evaluation of gross erosion features and measurements of rill or gully depths, if present (may involve remote sensing techniques). Determine if the erosion is active or if stabilised as part of the landform - Visual inspection for any acid / saline seepage areas or areas of contamination - Identification of grass, shrub or tree species present - Assessment of groundcover % (dead or alive material) - Assessment of rooting depth in soil profile - Visual estimate of % invasive weed prevalence - Downstream receiving environment water quality (pH, EC, sulphate, suspended solids)	Biennial
RM8 – Revegetation (low intensity grazing) RM10 – Achievement of a stable PMLU (low intensity grazing)	The low intensity grazing rehabilitation areas shall be assessed using the following approach at all monitoring sites: - Monitoring transects to be 50 m long - Soil sampling of topsoil for physical and chemical laboratory analysis to determine if soil limitations - Visual assessment of soil type, soil structure and soil surface condition - Evaluation of gross erosion features and measurements of rill or gully depths if present (may involve remote sensing techniques). Determine if the erosion is active or if stabilised as part of the landform - Visual inspection for any acid / saline seepage areas or areas of contamination - Identification of grass species present - Assessment of groundcover % (dead or alive material) - Inspection of rooting depth in soil profile - Determine % invasive weed prevalence - Downstream receiving environment water quality (pH, EC, sulphate, suspended solids)	Every four years once rehabilitation meets completion criteria

8.2 Maintenance Activities

Areas of rehabilitation completed to date have been stable and have required negligible interventions to maintain stability. The results from the monitoring programs in **Table 19** shall inform future maintenance requirements. The monitoring program is important for the early identification of rehabilitated areas that are not on a trajectory to meeting the relevant completion criteria. If the rehabilitation monitoring indicates that areas are not trending towards the interim revegetation milestone criteria (RM7 and RM8), then the following corrective actions would be considered where relevant:

- removal of residual contaminated materials;
- application of soil ameliorants;
- ripping and re-seeding the area;
- enrichment planting;
- additional application of rock mulch;
- additional application of topsoil;
- repairing areas of erosion;
- controlling overland flow pathways; and
- spraying of invasive weeds.

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10 PRCP Schedule

10.1 Final Site Design

All areas of disturbed and undisturbed land within ML 70145 and ML 70376 have been assigned a PMLU or identified as a NUMA consistent with LODs. The assigned PLMUs and NUMAs are presented in the final site design (see **Figure 26**), along with the Sandhurst Creek 0.1% AEP floodplain and the maximum disturbance footprint for Minerva Mine.

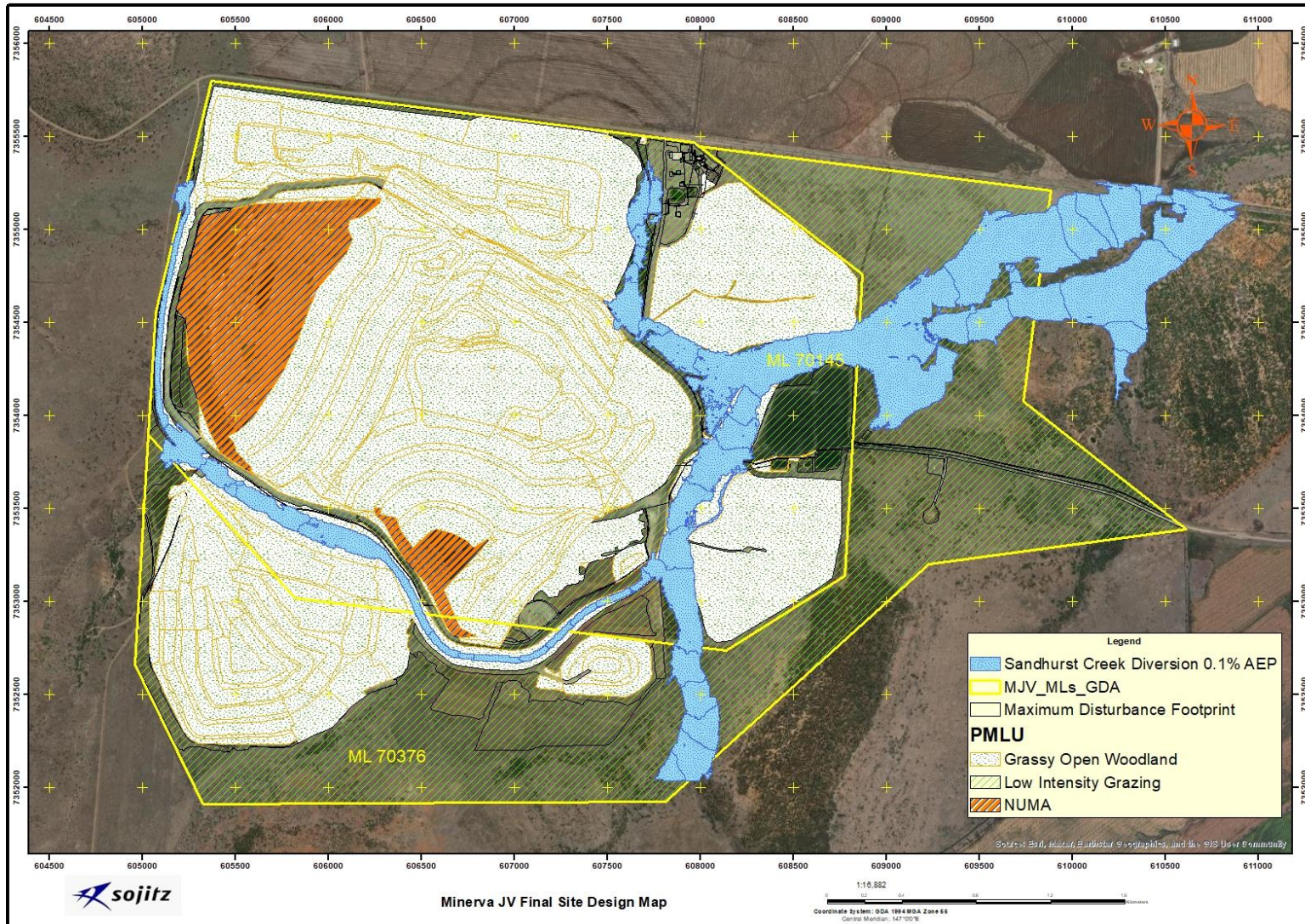


Figure 26 – Final Site Design

(Version 3 – 31 August 2023)

10.2 Reference Map

A total of 23 rehabilitation areas (RAs) have been identified within ML 70145 and ML 70376. RA 11 – RA 22 are existing areas of rehabilitation, with RA 1 – RA 10 nominated for future rehabilitation. RA23 is for the water storages that will remain for stock watering. The Western and the Southern residual voids are shown as improvement areas (IA) IA 1 and IA 2.

The RAs and the IAs are shown in **Figure 27**.

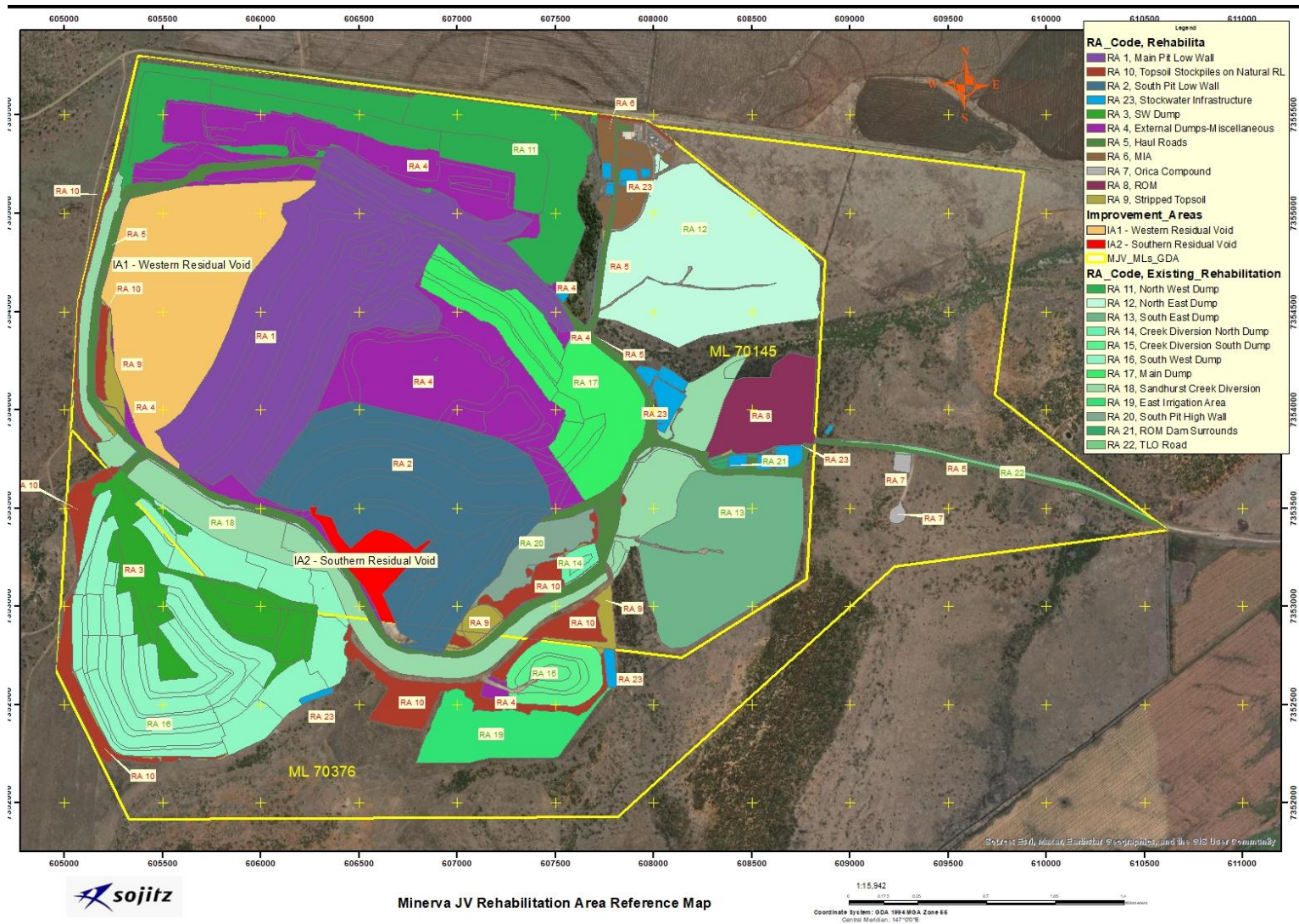


Figure 27 – Rehabilitation Areas

(Version 3 – 31 August 2023)

10.3 Rehabilitation Milestones

Rehabilitation milestones (RMs) and associated criteria have been developed for rehabilitation areas. The milestone criteria will determine if the rehabilitation has fulfilled the requirements for the specified stage of work. The RMs and milestone criteria are presented in **Table 20**.

Table 20 – Rehabilitation Milestones

Milestone Reference	Rehabilitation Milestone	Milestone Criteria
RM1	Infrastructure Decommissioning and Removal	a) All services disconnected, except those to be retained by landholder by agreement b) All buildings demolished and removed, except those to be retained by landholder by agreement
RM2	Remediation of Contaminated Land	a) Contaminated land assessment by suitably qualified person b) Removal of contaminated materials c) Assessment by suitable qualified person that contaminated land has been removed
RM3a	Landform Shaping	<u>External Batters</u> - Landform profiled to $\leq 25\%$ - Benches to be installed at 15m vertical lift intervals, width of benches determined by size of equipment delivering topsoil <u>Low Wall Spoil</u> - Landform profiled to $\leq 25\%$ - Benches to be installed at 30m vertical lift intervals, width of benches to be 30m - Shaping above 236 RL near Western final void, with any fill below this level at angle of repose - Shaping above RL 223 near Southern final void, with any fill below this at angle of repose
RM3b	Final Trim	Final trim of some areas that have been shaped and require an even surface prior to topsoil application
RM4a	Rock Mulch Haulage	Haulage and placement of competent rock mulch onto shaped rehabilitated areas
RM4b	Rock Mulch Application	a) Rock mulched areas reshaped to surface $\leq 25\%$ b) Rock mulch applied at a minimum of 0.5m thick to reshaped surfaces c) Rock mulch not required for shaped areas that are $< 5\%$ slope
RM5a	Topsoil Haulage	a) Haulage and placement of topsoil on rock mulch rehabilitated areas b) Haulage and placement of topsoil on topsoil only rehabilitated areas
RM5b	Topsoil Spreading	a) Spreading topsoil $\geq 0.1\text{m}$ thick on rock mulch areas b) Spreading topsoil $\geq 0.2\text{m}$ thick on topsoil only areas
RM6a	Deep Ripping	Areas deep ripped to mix topsoil into rock mulch substrate
RM6b	Deep Ripping and Seeding	a) Areas deep ripped on the contour to provide seed bed and surface erosion control b) Seed applied at set rates for grassy open woodlands and low intensity grazing PMLUs

Milestone Reference	Rehabilitation Milestone	Milestone Criteria
RM7	Revegetation (grassy open woodlands)	Vegetation has been established and meets interim Grassy Open Woodlands performance requirements as follows: - Effective rooting depth > 0.5 m - No acid or saline seepage areas - Absence of active rills and gullies - Total ground cover ≥25% (may include dead and alive material or rocky debris) - Developing vegetation consisting of native trees, shrubs and grasses - Areas of contamination have been remediated and monitored
RM8	Revegetation (low intensity grazing)	Vegetation has been established and meets interim Low-intensity Grazing performance requirements as follows: - Effective rooting depth > 0.5 m - No acid or saline seepage areas - Absence of active rills and gullies - Vegetative ground cover ≥ 25% - Developing vegetation consisting of native trees, shrubs and grasses - Areas of contamination have been remediated and monitored
RM9	Achievement of a stable PMLU (grassy open woodlands)	a) Rehabilitation dump is geotechnically stable with FoS ≥ 1.5 b) No active gully erosion present > 0.3m deep c) External batters ≤ 25% slopes covered with minimum 0.5 m thick competent rock mulch d) Top of dump ≤ 5% slopes covered with minimum 0.2 m thick topsoil e) No acid or saline seepage areas f) Water quality run-off EC < 1,000 µS/cm and pH 6.0 – 9.0 g) ≥ 2 native tree and shrub species present h) ≥ 3 perennial grass species present i) Effective rooting depth > 0.5 m j) Invasive weed species comprise < 10% of vegetative groundcover k) Livestock excluded from area l) Total ground cover ≥50% (may include dead and alive material or rocky debris)
RM10	Achievement of a stable PMLU (low intensity grazing)	a) No active gully erosion present >0.3m deep b) All areas have slopes ≤ 5% c) Areas covered with minimum 0.2 m thick topsoil d) No acid or saline seepage areas e) Water quality run-off < 1,000 µS/cm and pH 6.0 – 9.0 f) Vegetative ground cover ≥ 50% g) ≥ 3 perennial pasture and shrub species present h) Effective rooting depth > 0.5 m i) Invasive weed species comprise < 10% of vegetative groundcover

10.4 Management Milestones

Management milestones (MMs) and associated criteria have been developed for the Western and Southern residual void NUMA improvement areas. The milestone criteria will determine if the improvement areas have met the outcomes of the NUMA completion criteria. The MMs and milestone criteria are presented in **Table 21**.

Table 21 - Improvement Area Management Milestones

Milestone Reference	Management Milestone	Milestone Criteria
MM1	Achievement of structural stability	a) Highwall and end wall maximum slope ≤ 70 degrees projected to surface b) Assessment report by Registered Professional Engineer of Queensland (RPEQ) on the geotech stability of final voids c) Closure bund installed minimum 50 m from pit crest or distance equal to FoS of 1.5 d) Diversion designed so 0.1% AEP flood event in Sandhurst Creek diversion does not enter final voids
MM2	Achievement of safety and minimisation of environmental harm	a) High wall and end wall bund constructed of competent materials ≥ 2m high and base width of 5m with minimum 50 m setback from crest ($\geq$ FoS of 1.5) b) No public access to highwalls / endwalls (bundling / fencing / signage as required) c) Assessment report by Registered Professional Engineer of Queensland (RPEQ) on the geotechnical stability of final voids FoS ≥ 1.5 d) Surface water and groundwater quality of receiving waters meets the requirements of Schedule W of the Environmental Authority e) Voids have no adverse environmental impacts on basalt aquifer

10.5 Rehabilitation Area Schedules

The following **Tables 22 - 44** provide the schedules for completing the Rehabilitation Milestones for each Rehabilitation Area. The PMLUs and associated Rehabilitation Milestones with completion dates are provided within each table.

Table 22 - RA1

Post-mining land uses (PMLU)										
Rehabilitation area				RA1 - Main Pit Low Wall						
Relevant activities				Rehabilitating pit low wall						
Total rehabilitation area size (ha)				133.6						
Commencement of first milestone: RM3a				8/08/2029						
PMLU				Grassy Open Woodlands						
Date area is available	8/08/2029									
Cumulative area available (ha)	133.6	133.6	133.6	133.6	133.6	133.6	133.6	133.6	133.6	133.6
Milestone completed by	10/12/2031	10/12/2031	10/12/2032	10/12/2032	10/12/2032	10/12/2033	10/12/2033	10/12/2033	10/12/2038	10/12/2048
Milestone Reference	Cumulative area achieved (ha)									
RM3a	133.6									
RM3b		36.7								
RM4a			97.0							
RM4b				97.0						
RM5a					133.6					
RM5b						133.6				
RM6a							133.6			
RM6b								133.6		
RM7									133.6	
RM9										133.6

Table 23 - RA2

Post-mining land uses (PMLU)										
Rehabilitation area				RA2 - South Pit Low Wall						
Relevant activities				Rehabilitating pit low wall						
Total rehabilitation area size (ha)				98.0						
Commencement of first milestone: RM3a				2/12/2027						
PMLU				Grassy Open Woodlands						
Date area is available	2/12/2027									
Cumulative area available (ha)	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4
Milestone completed by	10/12/2029	10/12/2031	10/12/2031	10/12/2031	10/12/2033	10/12/2033	10/12/2033	10/12/2033	10/12/2038	10/12/2048
Milestone Reference	Cumulative area achieved (ha)									
RM3a	97.4									
RM3b		29.1								
RM4a			68.4							
RM4b				68.4						
RM5a					97.4					
RM5b						97.4				
RM6a							97.4			
RM6b								97.4		
RM7									97.4	
RM9										97.4

Table 24 - RA 3

Post-mining land uses (PMLU)										
Rehabilitation area				RA3 - South West Dump						
Relevant activities				Rehabilitating out of pit dump						
Total rehabilitation area size (ha)				36.5						
Commencement of first milestone: RM3b				22/12/2031						
PMLU				Grassy Open Woodlands						
Date area is available	22/12/2031									
Cumulative area available (ha)	20.9	20.9	20.9	20.9	20.9	36.5	36.5	36.5	36.5	
Milestone completed by	10/12/2033	10/12/2031	10/12/2031	10/12/2033	10/12/2033	10/12/2033	10/12/2033	10/12/2038	10/12/2048	
Milestone Reference	Cumulative area achieved (ha)									
RM3b	20.9									
RM4a		12.4								
RM4b			12.4							
RM5a				20.9						
RM5b					20.9					
RM6a						36.5				
RM6b							36.5			
RM7								36.5		
RM9									36.5	

Table 25 - RA4

Post-mining land uses (PMLU)										
Rehabilitation area				RA4 - External Dumps_Miscellaneous						
Relevant activities				Rehabilitating out of pit dumps						
Total rehabilitation area size (ha)				109.6						
Commencement of first milestone: RM3a				13/07/2031						
PMLU				Grassy Open Woodlands						
Date area is available	13/07/2031									
Cumulative area available (ha)	20.9	109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6
Milestone completed by	10/12/2031	10/12/2033	10/12/2032	10/12/2032	10/12/2033	10/12/2033	10/12/2033	10/12/2033	10/12/2038	10/12/2048
Milestone Reference	Cumulative area achieved (ha)									
RM3a	3.0									
RM3b		88.6								
RM4a			20.9							
RM4b				20.9						
RM5a					91.6					
RM5b						91.6				
RM6a							109.6			
RM6b								109.6		
RM7									109.6	
RM9										109.6

Table 26 - RA5

Post-mining land uses (PMLU)										
Rehabilitation area		RA5 - Haul Roads								
Relevant activities		Rehabilitating haul roads								
Total rehabilitation area size (ha)		46.9								
Commencement of first milestone: RM3b		6/07/2032								
PMLU		Low-Intensity Grazing								
Date area is available	6/07/2032									
Cumulative area available (ha)	41	41	41	41	41	41	41			
Milestone completed by	10/12/2032	10/12/2033	10/12/2033	10/12/2033	10/12/2033	10/12/2038	10/12/2048			
Milestone Reference	Cumulative area achieved (ha)									
RM3b	41									
RM5a		41								
RM5b			41							
RM6a				41						
RM6b					41					
RM8						41				
RM10							41			

Table 27- RA6

Post-mining land uses (PMLU)										
Rehabilitation area				RA6 - Mine Industrial Area						
Relevant activities				Infrastructure removal and rehabilitation of land						
Total rehabilitation area size (ha)				9.3						
Commencement of first milestone: RM1				22/06/2032						
PMLU				Low-Intensity Grazing						
Date area is available	22/06/2032									
Cumulative area available (ha)	0	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	
Milestone completed by	10/12/2032	10/12/2032	10/12/2032	10/12/2032	10/12/2032	10/12/2032	10/12/2032	10/12/2038	10/12/2048	
Milestone Reference	Cumulative area achieved (ha)									
RM1	0									
RM2		9.3								
RM3b			9.3							
RM5a				9.3						
RM5b					9.3					
RM6a						9.3				
RM6b							9.3			
RM8								9.3		
RM10									9.3	

Table 28 – RA7

Post-mining land uses (PMLU)										
Rehabilitation area		RA7 - Orica Compound								
Relevant activities		Rehabilitating laydown area								
Total rehabilitation area size (ha)		1.4								
Commencement of first milestone: RM3b		5/08/2031								
PMLU		Low-Intensity Grazing								
Date area is available	5/08/2031									
Cumulative area available (ha)	1.4	1.4	1.4	1.4	1.4	1.4	1.4			
Milestone completed by	10/12/2031	10/12/2033	10/12/2033	10/12/2033	10/12/2033	10/12/2038	10/12/2048			
Milestone Reference	Cumulative area achieved (ha)									
RM2	1.4									
RM3b	1.4									
RM5a		1.4								
RM5b			1.4							
RM6a				1.4						
RM6b					1.4					
RM8						1.4				
RM10							1.4			

Table 29 - RA8

Post-mining land uses (PMLU)										
Rehabilitation area				RA8 - Run of Mine (ROM)						
Relevant activities				Infrastructure removal and rehabilitation of land						
Total rehabilitation area size (ha)				19.9						
Commencement of first milestone: RM1				24/07/2032						
PMLU				Low-Intensity Grazing						
Date area is available	24/07/2032									
Cumulative area available (ha)	0.0	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	
Milestone completed by	10/12/2032	10/12/2032	10/12/2032	10/12/2032	10/12/2032	10/12/2033	10/12/2033	10/12/2038	10/12/2048	
Milestone Reference	Cumulative area achieved (ha)									
RM1	0.5									
RM2		19.9								
RM3b			19.9							
RM5a				19.9						
RM5b					19.9					
RM6a						19.9				
RM6b							19.9			
RM8								19.9		
RM10									19.9	

Table 30 – RA9

Post-mining land uses (PMLU)										
Rehabilitation area		RA9 - Stripped Topsoil								
Relevant activities		Rehabilitating areas that have been stripped of topsoil								
Total rehabilitation area size (ha)		10.6								
Commencement of first milestone: RM3b		6/08/2031								
PMLU		Low-Intensity Grazing								
Date area is available	6/08/2031									
Cumulative area available (ha)	10.6	10.6	10.6	10.6	10.6	10.6	10.6			
Milestone completed by	10/12/2031	10/12/2033	10/12/2033	10/12/2033	10/12/2033	10/12/2038	10/12/2048			
Milestone Reference	Cumulative area achieved (ha)									
RM3b	10.6									
RM5a		10.6								
RM5b			10.6							
RM6a				10.6						
RM6b					10.6					
RM8						10.6				
RM10							10.6			

Table 31 – RA10

Post-mining land uses (PMLU)										
Rehabilitation area		RA10 - Topsoil Stockpiles on Natural RL								
Relevant activities		Rehabilitating areas following topsoil stockpile removal								
Total rehabilitation area size (ha)		40.4								
Commencement of first milestone: RM3b		24/05/2033								
PMLU		Low-Intensity Grazing								
Date area is available	24/05/2033									
Cumulative area available (ha)	40.4	40.4	40.4	40.4	40.4					
Milestone completed by	10/12/2033	10/12/2033	10/12/2033	10/12/2038	10/12/2048					
Milestone Reference	Cumulative area achieved (ha)									
RM3b	40.4									
RM6a		40.4								
RM6b			40.4							
RM8				40.4						
RM10					40.4					

Table 32 – RA11

Post-mining land uses (PMLU)										
Rehabilitation area				RA11 - North West Dump						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				78.9						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Grassy Open Woodlands						
Date area is available	2/07/2033									
Cumulative area available (ha)	78.9	78.9								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM7	78.9									
RM9		78.9								

Table 33 – RA12

Post-mining land uses (PMLU)										
Rehabilitation area				RA 12 - North East Dump						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				69.3						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Grassy Open Woodlands						
Date area is available	2/07/2033									
Cumulative area available (ha)	69.3	69.3								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM7	69.3									
RM9		69.3								

Table 34 – RA13

Post-mining land uses (PMLU)										
Rehabilitation area				RA 13 - South East Dump						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				53.6						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Grassy Open Woodlands						
Date area is available	2/07/2033									
Cumulative area available (ha)	53.6	53.6								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM7	53.6									
RM9		53.6								

Table 35 – RA14

Post-mining land uses (PMLU)										
Rehabilitation area				RA 14 - Creek Diversion North Dump						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				2.5						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Grassy Open Woodlands						
Date area is available	2/07/2033									
Cumulative area available (ha)	2.5	2.5								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM7	2.5									
RM9		2.5								

Table 36 – RA15

Post-mining land uses (PMLU)										
Rehabilitation area				RA 15 - Creek Diversion South Dump						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				13.4						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Grassy Open Woodlands						
Date area is available	2/07/2033									
Cumulative area available (ha)	13.4	13.4								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM7	13.4									
RM9		13.4								

Table 37 – RA16

Post-mining land uses (PMLU)										
Rehabilitation area				RA 16 - South West dump						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				103.7						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Grassy Open Woodlands						
Date area is available	2/07/2033									
Cumulative area available (ha)	103.7	103.7								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM7	103.7									
RM9		103.7								

Table 38 – RA17

Post-mining land uses (PMLU)										
Rehabilitation area				RA 17 - Main Dump						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				46.5						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Grassy Open Woodlands						
Date area is available	2/07/2033									
Cumulative area available (ha)	46.5	46.5								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM7	46.5									
RM9		46.5								

Table 39 – RA18

Post-mining land uses (PMLU)										
Rehabilitation area				RA 18 - Sandhurst Creek Diversion						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				67.1						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Grassy Open Woodlands						
Date area is available	2/07/2033									
Cumulative area available (ha)	67.1	67.1								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM7	67.1									
RM9		67.1								

Table 40 – RA19

Post-mining land uses (PMLU)										
Rehabilitation area				RA 19 - East Irrigation Area						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				20.4						
Commencement of first milestone: RM7				2/07/2033						
PMLU				Low-Intensity Grazing						
Date area is available	2/07/2033									
Cumulative area available (ha)	20.4	20.4								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM8	20.4									
RM10		20.4								

Table 41 – RA20

Post-mining land uses (PMLU)										
Rehabilitation area				RA 20 - South Pit High Wall						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				9.8						
Commencement of first milestone: RM8				2/07/2033						
PMLU				Low-Intensity Grazing						
Date area is available	2/07/2033									
Cumulative area available (ha)	9.8	9.8								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM8	9.8									
RM10		9.8								

Table 42 – RA21

Post-mining land uses (PMLU)										
Rehabilitation area				RA 21 - ROM Dam Surrounds						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				0.9						
Commencement of first milestone: RM8				2/07/2033						
PMLU				Low-Intensity Grazing						
Date area is available	2/07/2033									
Cumulative area available (ha)	0.9	0.9								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM8	0.9									
RM10		0.9								

Table 43 – RA22

Post-mining land uses (PMLU)										
Rehabilitation area			RA 22 - TLO Road							
Relevant activities			Landform meeting completion criteria							
Total rehabilitation area size (ha)			2.7							
Commencement of first milestone: RM8			2/07/2033							
PMLU			Low-Intensity Grazing							
Date area is available	2/07/2033									
Cumulative area available (ha)	2.7	2.7								
Milestone completed by	10/12/2033	10/12/2038								
Milestone Reference	Cumulative area achieved (ha)									
RM8	2.7									
RM10		2.7								

Table 44 - RA23

Post-mining land uses (PMLU)										
Rehabilitation area				RA23 - Site Water Dams						
Relevant activities				Site water dams for stockwatering						
Total rehabilitation area size (ha)				14.1						
Commencement of first milestone: RM1				22/06/2032						
PMLU				Low-Intensity Grazing						
Date area is available	22/06/2032									
Cumulative area available (ha)	14.1	14.1	14.1							
Milestone completed by	10/12/2032	10/12/2037	10/12/2042							
Milestone Reference	Cumulative area achieved (ha)									
RM2	14.1									
RM8		14.1								
RM10			14.1							

10.6 Improvement Area Schedules

The following **Table 45** and **Table 46** provide the schedule for completing the Management Milestones for the Western and Southern residual void Improvement Areas.

Table 45 – IA1

Post-mining land uses (PMLU)										
Rehabilitation area				IA 1 - Western Residual Void						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				78.0						
Commencement of first milestone: MM1				10/12/2033						
PMLU				NUMA						
Date area is available	10/12/2033									
Cumulative area available (ha)	78.0	78.0								
Milestone completed by	10/12/2034	10/12/2035								
Milestone Reference	Cumulative area achieved (ha)									
MM1	78.0									
MM2		78.0								

Table 46 – IA2

Post-mining land uses (PMLU)										
Rehabilitation area				IA 2 - Southern Residual Void						
Relevant activities				Landform meeting completion criteria						
Total rehabilitation area size (ha)				11.6						
Commencement of first milestone: MM1				10/12/2033						
PMLU				NUMA						
Date area is available	10/12/2033									
Cumulative area available (ha)	11.6	11.6								
Milestone completed by	10/12/2034	10/12/2035								
Milestone Reference	Cumulative area achieved (ha)									
MM1	11.6									
MM2		11.6								

Appendices

Appendix A – Residual Void Investigation Report

Residual Void Investigation Report. Minerva Joint Venture. Version 1.0. Sojitz Minerva Mining 5 November 2021.

(Report provided in a separate file)

Appendix B – Rehabilitation Management Plan

Minerva Mine Rehabilitation Management Plan. Version 1.1. Sojitz Minerva Mining. November 2021.

(Report provided in a separate file)

Appendix C – Landholder Statement to Retain Infrastructure

Landholder Statement to Retain Infrastructure. Minerva Coal Pty Ltd. June 2022.

(Report provided in a separate file)

Appendix D – Minerva Final Void Stability Assessment

Minerva Final Void Stability Assessment. Technical Memorandum. WK Geotechnical. 24 August 2023.

(Report provided in a separate file)

Appendix E – Final Void Surface Hydrology

Final Void Surface Hydrology. Minerva Coal Mine. WRM, 25 August 2023

(Report provided in a separate file)

Appendix F – Minerva Mine PRCP Groundwater Assessment

Minerva Mine PRCP Groundwater Assessment. Australasian Groundwater and Environmental Consultants. August 2023

(Report provided in a separate file)

Appendix G – Sandhurst Creek Diversion Water Licence

Water Licence 406741 – Interfere with the flow of water in Sandhurst Creek

(Report provided in a separate file)

Appendix H – Final Landform Flood Assessment

Final Landform Flood Assessment. Minerva Coal Mine, WRM August 2023

(Report provided in a separate file)

Residual Void Investigation Report

Minerva Joint Venture

Version: 1.0 (5 November 2021)

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1 Introduction

The Minerva Mine operates under Environmental Authority EPML00668613 which authorises residual voids to remain following mining provided that the void outcomes in Conditions F7 and F 8 are met. Condition F7 of the Environmental Authority states that residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority.

Condition F8 of the Environmental Authority states that, if residual voids are to be left, an investigation into residual void options and landform design is to be completed.

Table 1 shows where this *Residual Void Investigation Report* addresses Condition F8.

Table 1 – Environmental Authority Condition F8

Condition F8	Addressed in
F7. Residual void outcome Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority.	Section 3 & 7
F8. If residual voids are to be left, an investigation in to residual void options and landform design are to be completed. The subsequent report is to be submitted to the administering authority proposing acceptance criteria to meet the outcomes in Condition F7, landform design criteria in Table F1, final void reduction options and options to reduce the height of the main dumps by 29 November 2021. The investigation shall be completed by a competent person and include detailed research and modelling and at a minimum include the following:	
(a) a study of options available for minimising final void area and volume;	Section 2
(b) a void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources and water quality parameters in the long term;	Section 3
(c) a pit wall stability study, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events;	Section 4
(d) a hydrology study into the long term risk of Sandhurst Creek / final void interaction, including erosion of the banks and spoil and extreme hydrological events, and the consequences of such interaction to the long-term stability of the final voids.	Section 5
(e) study of void capability to support native flora and fauna; and	Section 6
(f) a proposal/s for end of mine void rehabilitation success criteria and final void areas and volumes.	Section 2 & 7

2 Final Void Area and Volume

Coal mining at the Minerva Mine ceased in August 2021. A final landform design has been prepared based on the pit and dump surface configuration at the cessation of coal extraction.

The following criteria have been applied when optimising the design of the final landform:

- reshape the current low walls to 25% with 30m wide benches every 30m of vertical lift;
- Western pit reshaped to 210mRL with fill below this at angle of repose;

- Southern pit reshaped to 200mRL with fill below this at angle of repose;
- Southern pit highwall reshaped in part to reduce void area; and
- reshaped 25% slopes shall be capped with 0.5m of basalt rock mulch.

The optimised final landform design results in the void areas and volumes shown in **Table 2**.

Table 2 – Final Void Areas and Volumes

	Western Void	Southern Void
Low wall backfill and reshaping	Backfill and reshape to 25% slope with 30m benches every 30m vertical interval	
	Backfill and reshape to 210mRL (backfill below at angle of repose)	Backfill and reshape to 200mRL (backfill below at angle of repose)
Highwall reshaping	n.a.	Partial backfill and reshape of south east section to 25% slope to reduce void area
Area*	76.84ha (at 210mRL)	12.18ha (at 200mRL)
Volume*	29.73 Mm ³ (at 210mRL)	1.63Mm ³ (at 200mRL)

*subject to minor change as design is refined and physical works progress

Maximum void slope angles and the total void area (89.02ha) are less than the maximums prescribed in Table F1 of the Environmental Authority (91ha).

The location of the final voids in relation to the mining leases is shown in **Figure 1**.

The reshaping for the final voids is shown in plan view in **Figure 2**. The light blue lines show the final voids and green shows the contours of areas reshaped. A three-dimensional image of the final landform is shown in **Figure 3**. The final height of the main dump is 320mRL and that of the South West Dump 345mRL.

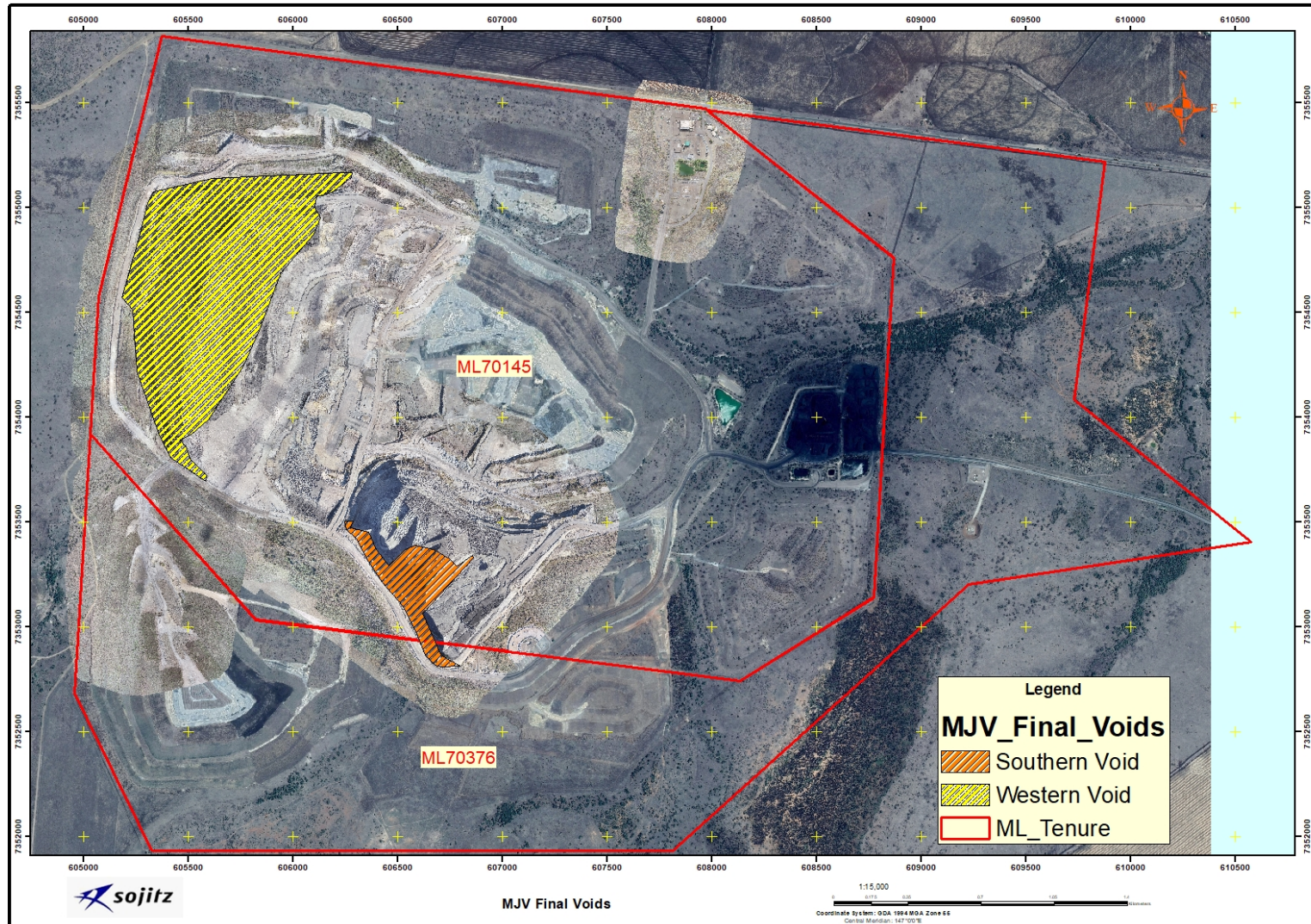




Figure 2 – Plan view of final void reshaping

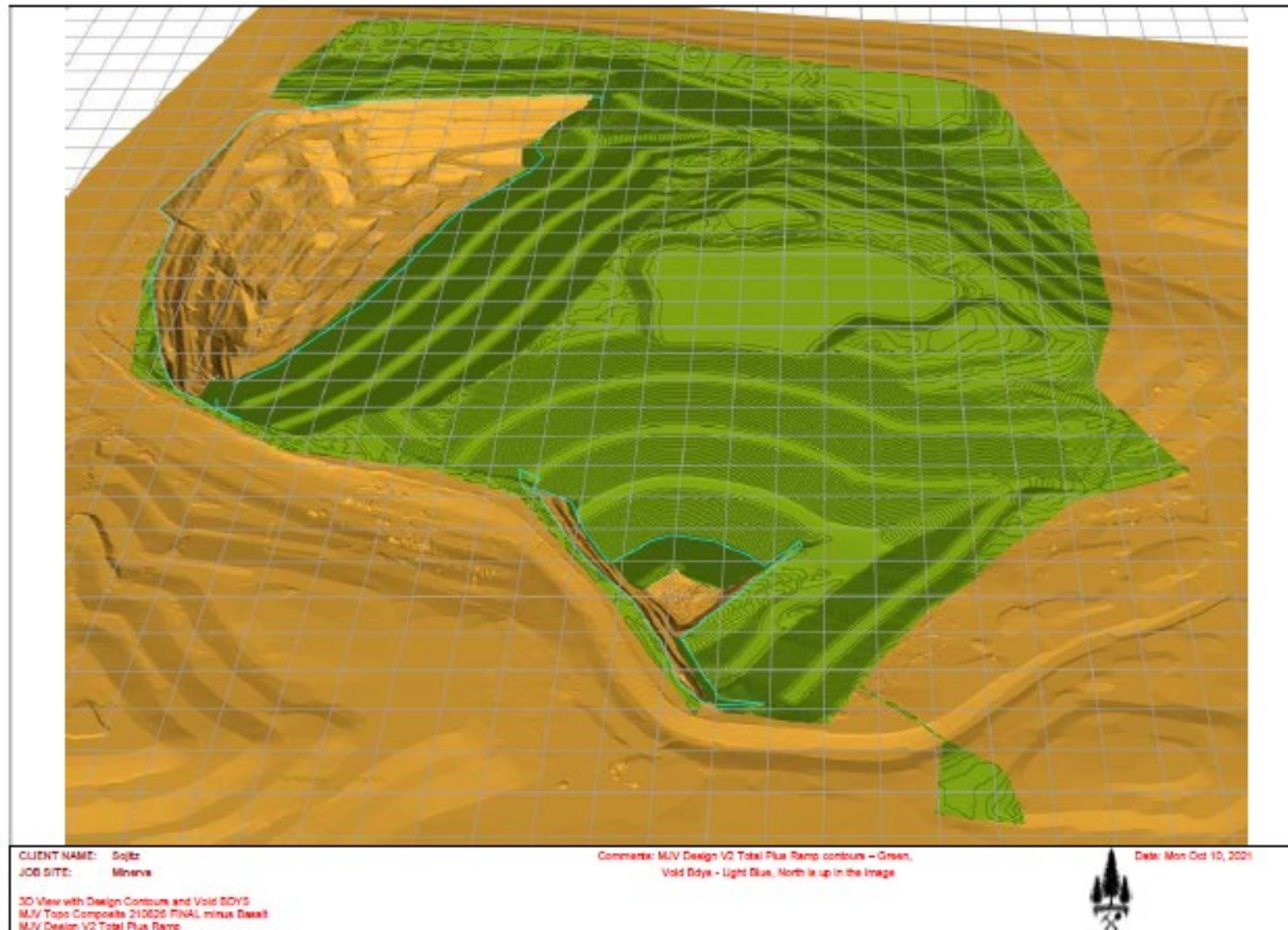


Figure 3 – 3D view of final void reshaping

3 Void Hydrology Study

Residual void hydrological studies have been undertaken to:

- calculate future groundwater inflow rates into the Western and Southern residual voids;
- determine to long-term water balance in the voids (including the long-term equilibrium water level and potential interactions with surrounding aquifers); and
- estimate long-term void water quality.

These studies are summarised below and further details are presented in AGE (2017) (attached as an **Appendix A** to this report).

3.1 Groundwater inflow rates

The lateral and vertical geometry of aquifers contributing to the Western and Southern residual voids was assessed from final pit wall sections. Strata contributing groundwater inflow to the Western void include weathered basalt, basalt, upper Permian coal measures and lower Permian coal measures. Only the upper Permian coal measures and lower Permian coal measures contribute groundwater to the Southern void as basalt strata are not intersected.

The potential rate of groundwater inflow to both residual voids through each highwall segment was calculated using Darcy's equation of flow through a porous media. This equation uses the aquifers hydraulic conductivity, the hydraulic gradient within the aquifer, and the cross-sectional area of the seepage face, to determine the volume of water moving through a vertical plane of aquifer material. In this case the vertical plane of aquifer material is the highwall in the residual voids.

The basalt was assumed to have a hydraulic conductivity of 1 m/day, while a coal seam hydraulic conductivity of 0.01 m/day was applied. A recharge of 6% of rainfall was used to represent recharge into the basalt, while a recharge of 0.1% of rainfall was used to represent recharge into the weathered Permian cover. The regional water table away from the mine impact was assumed to be 270 mAHD. Groundwater inflow estimates were made with void water levels at 5 m increments vertically from the base of each void (i.e. void stage height).

The calculated groundwater inflow rate to the Western void is predicted to be consistently about 408 ML/year because the hydraulic gradient within the basalt aquifer is unlikely to be influenced by the elevation of the void water level in the void.

The calculated groundwater inflow rate to the Southern void is predicted to slightly decline as the void water level increases. The predicted inflow rate from the coal seams reduces from about 7.3 ML/year at the end of mining to about 6.4 ML/year when the long-term equilibrium water level is reached.

3.2 Long-term water balance and mass balance model

A GoldSim water balance and mass balance model was developed to calculate the rate of water level recovery within each void, the long-term equilibrium water level, and the TDS concentration of void water. The GoldSim model made allowances for the following:

- Rainfall reporting to the final voids and runoff from the low-wall spoil area (surface and baseflow);
- Groundwater inflow rates dependent upon the pit water levels in each void;
- A nominal 5% spoil porosity for spoil material and potential storage of water within the spoil for all void water levels;

- Seepage between the voids when water levels in either void exceeded the elevated base of coal level between the mining voids;
- A spoil hydraulic conductivity of 0.2m/day. Seepage through the spoil was estimated using Darcy's equation with estimates of seepage face area and length of seepage path between the pits used; and
- Salt mass balance using TDS concentrations of 655 mg/L for basalt groundwater inflow, 2,039 mg/L for coal measures groundwater inflow and 350 mg/L for runoff from mine areas and rehabilitation. No allowance was made for leaching of salts from spoil material.

A Data Drill of 128 years of rainfall and associated evaporation data was used to generate 100 data sets of daily rainfall and evaporation for a 1,000-year period. All climatic data sets were run through the model to generate a probability assessment of water levels and TDS concentrations within the residual voids. The 50th percentile stable water levels were adopted as representative of mining void performance.

3.3 Water Balance Modelling Results

The water balance model for the Western residual void indicates the water level will rise towards an equilibrium over a period of about 60,000 days (~164 years) (see **Figure 4**). The long-term median equilibrium water level is predicted to be about 195 mAHD, with a range of 185 to 210 mAHD. The maximum water level remains 60m below where the void would spill.

The long-term equilibrium water level is predicted to be 6m below the base of the basalt exposed in the highwall (201 mAHD) and the maximum void water level is predicted to be above the base of the basalt. This is shown in cross-section in **Figure 5**. The maximum void water level is predicted to remain about 60m below the elevation of the regional groundwater table. A groundwater hydraulic gradient is expected to be maintained in perpetuity towards the Western residual void and therefore the likelihood of void water interacting with the basalt aquifer is low.

The water balance model for the Southern residual void indicates the water level will rise towards an equilibrium over a period of about 40,000 days (~110 years) (see **Figure 6**). The long-term median equilibrium water level is predicted to be about 175 mAHD, with a range of 150 to 200 mAHD. The maximum water level remains 60m below where the void would spill.

The long-term equilibrium water level is predicted to be within the lower coal seam group and the maximum void water level is predicted to be within the upper coal seam group. This is shown in cross-section in **Figure 7**. The maximum void water level is predicted to remain about 70m below the elevation of the regional groundwater table. A groundwater hydraulic gradient is expected to be maintained in perpetuity towards the Southern residual void and therefore the likelihood of void water leaving the void via coal seams is low.

The predicted void water equilibrium level for the Southern void is lower than predicted levels for the Western void and a hydraulic gradient is expected to form towards the Southern void. The Southern void will permanently remain a groundwater "sink" where evaporation permanently depresses the water level.

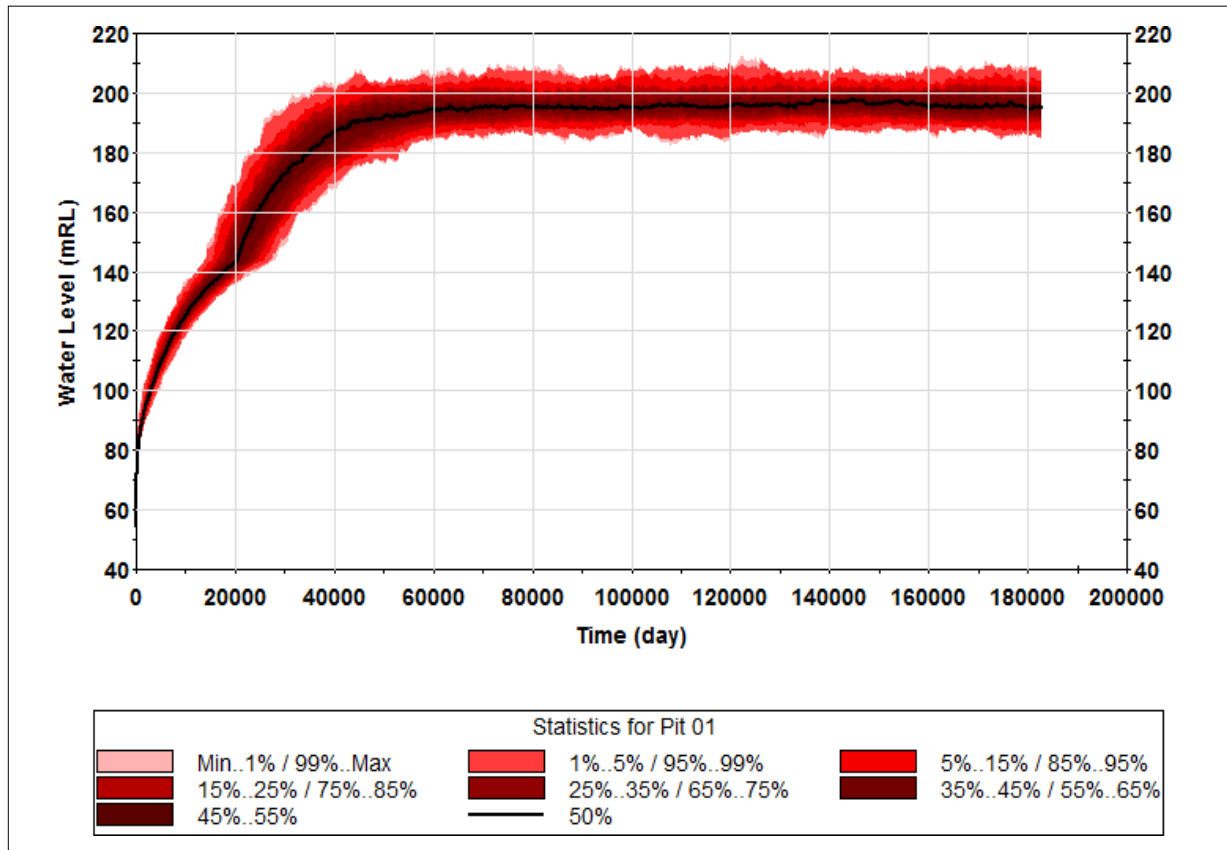


Figure 4 – Predicted equilibrium water level in Western residual void

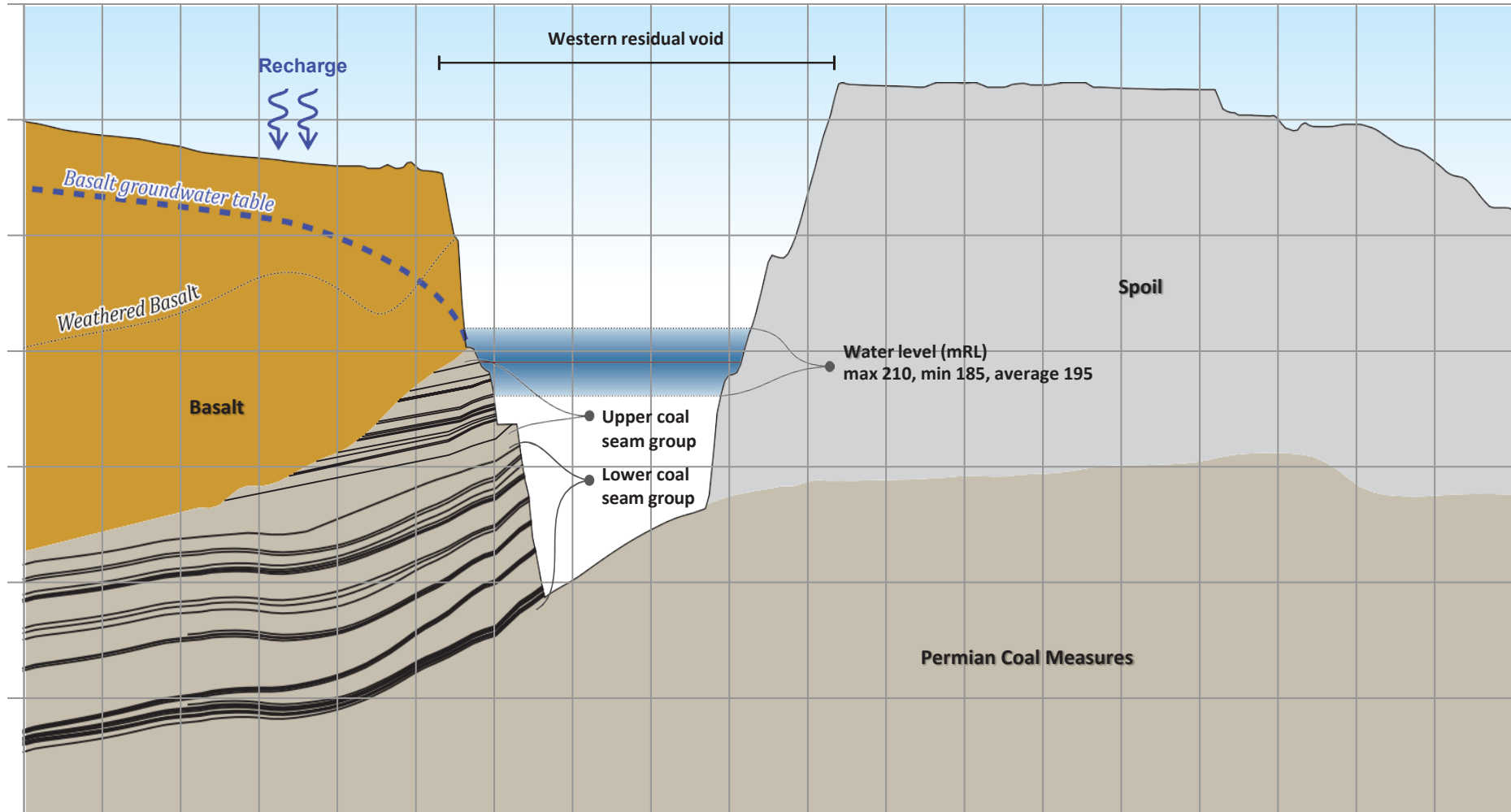


Figure 5 – Western residual void cross-section

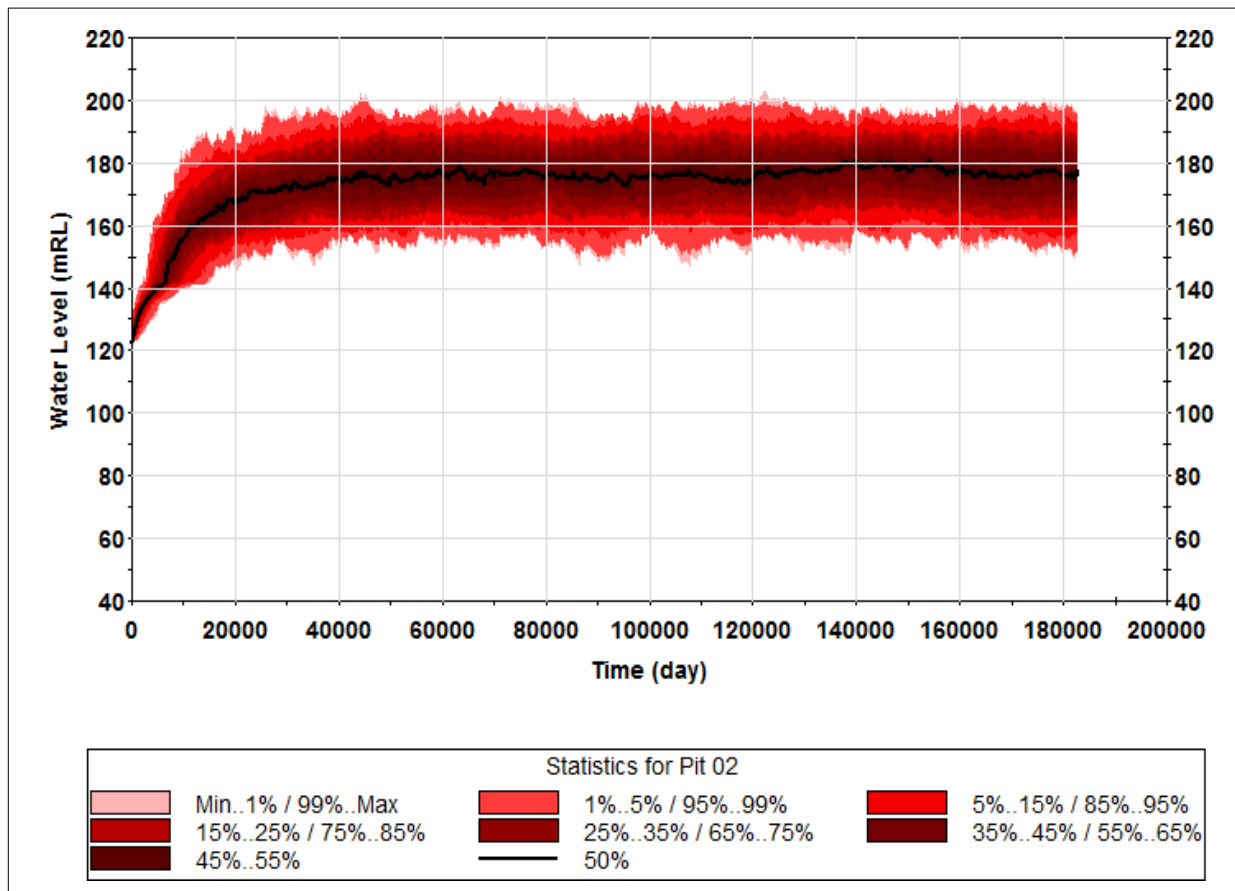


Figure 6 – Predicted equilibrium water level in Southern residual void

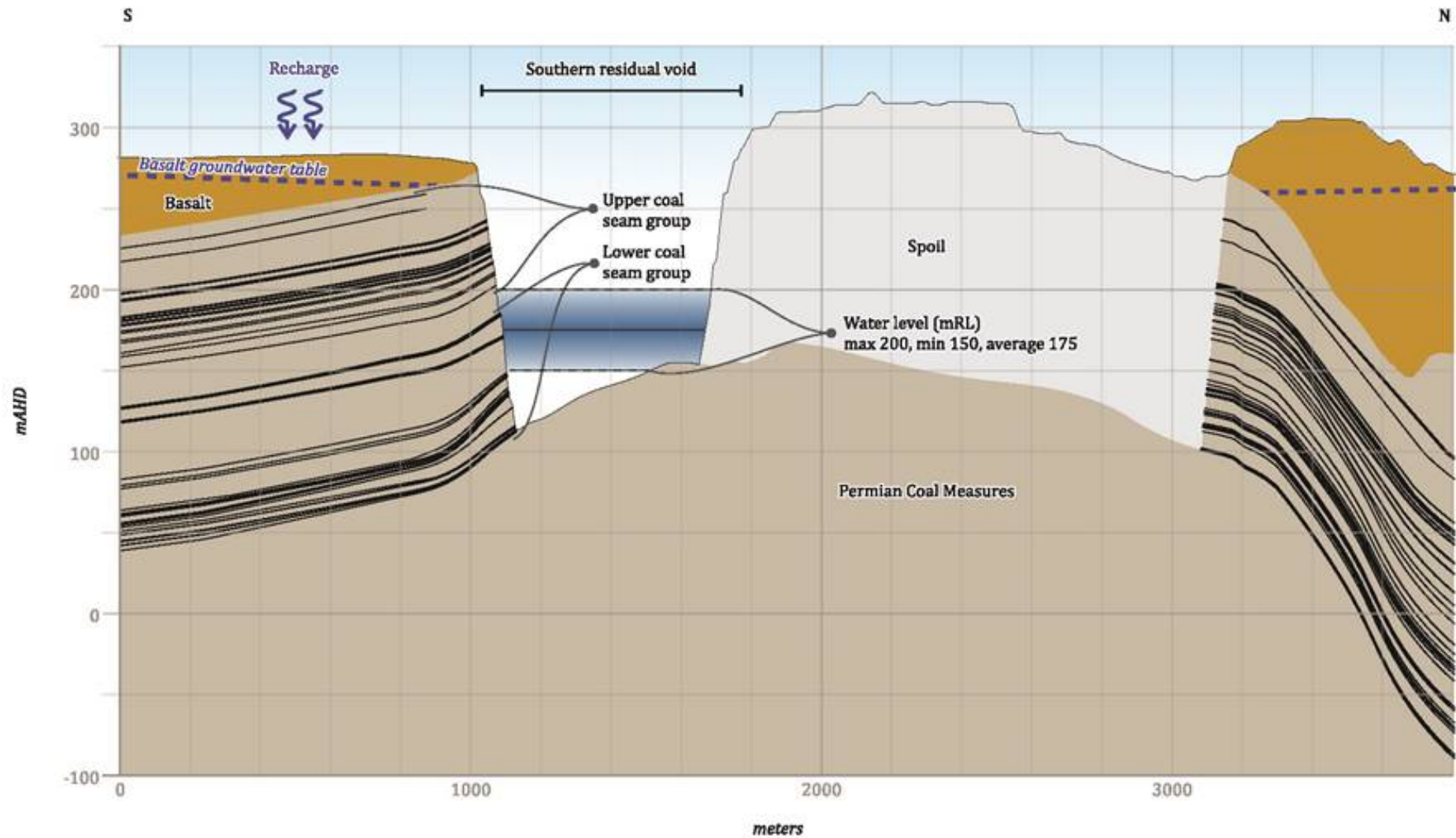


Figure 7 – Southern residual void cross-section

3.4 Mass Balance Modelling Results

The ANZECC (2000) water quality guidelines classifies irrigation water with a “high salinity rating” as having an electrical conductivity of between 2.9 dS/m and 5.2 dS/m (equivalent to 1,945 – 3,485 mg/L TDS). Adverse effects in beef cattle can be expected to begin when stock drinking water exceeds 4,000 mg/L TDS (ANZECC 2000).

The salt mass balance model results for the Western and Southern residual voids are shown in **Figure 8** and **Figure 9** respectively and summarised in **Table 3**.

Table 3 – Salt mass balance model results

Characteristic	Western Residual Void	Southern Residual Void
Long-term equilibrium water level	195mRL	175mRL
Time to reach equilibrium water level	~164 years	~110 years
Time to reach ANZECC high salinity irrigation water quality	~190 years	~90 years
Time to exceed ANZECC beef cattle stock water quality	~465 years (170,000 days)	~164 years (60,000 days)
Median annual increment in TDS	7 mg/L	25 mg/L
TDS at 500 years	4,300 mg/L	16,000 mg/L

In the long-term the salinity of water in both residual voids is predicted to become unsuitable for irrigation initially, and subsequently become unsuitable for stock water for beef cattle as it exceeds the ANZECC irrigation and stock water guidelines. The voids would be unable to support a Post-Mining Land Use and would be Non-Use Management Areas. The void water would not, however, result in adverse environmental impacts on surrounding aquifers as groundwater hydraulic gradients are expected to be maintained in perpetuity towards both voids. The maximum water level in the voids is 60m below the spill point and void water would not be released to surface waters or surrounding lands. In conclusion, the residual voids would not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself.

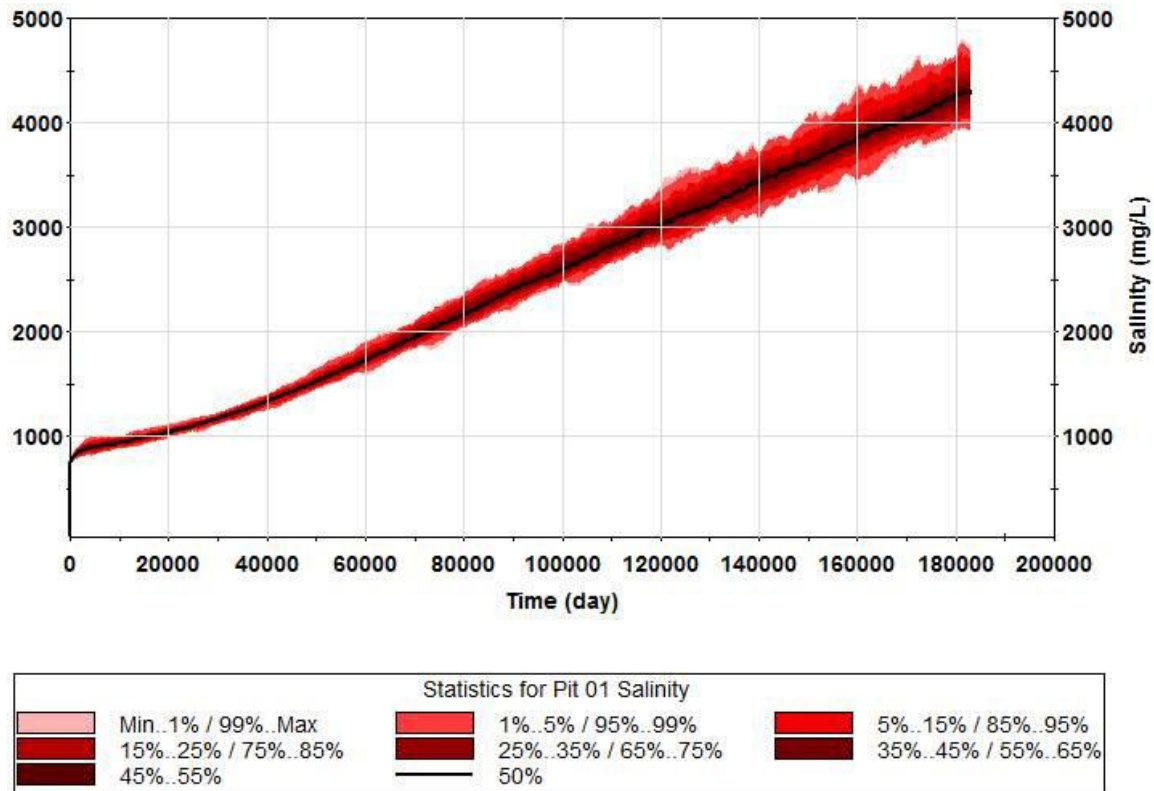


Figure 8 – Predicted TDS concentration in Western residual void

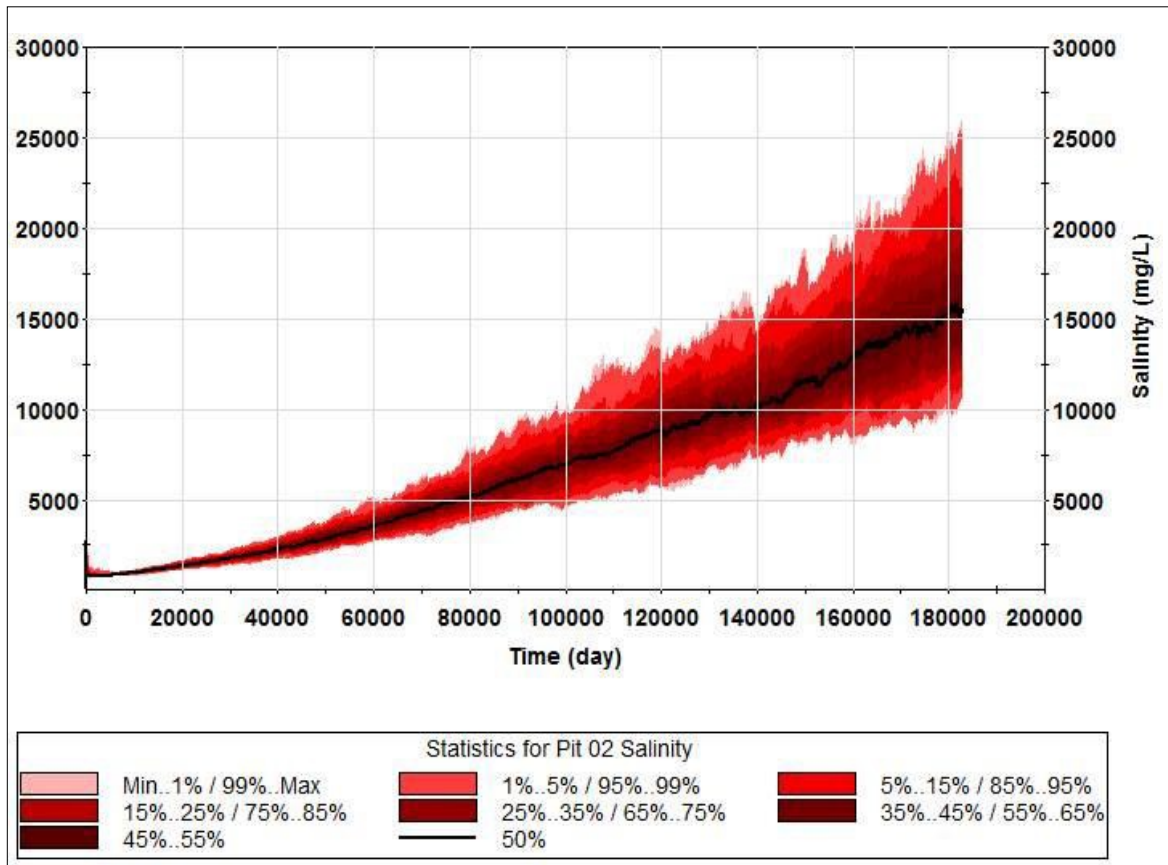


Figure 9 – Predicted TDS concentration in Southern residual void

4 Pit Wall Stability

A stability analysis of both final voids has been undertaken by PSM (2021) to:

- calculate potential failure paths for both circular failure and block sliding mechanisms;
- estimate the distance from the pit crest where a minimum Factor of Safety (FOS) of 1.5 is met; and
- provide guidance on the location of highwall bunds (closure bunds) set back from the pit crest based on stability and erosional considerations.

The analyses are summarised below and further details are presented in PSM (2021) (attached as an **Appendix B** to this report).

2D Limit Equilibrium stability analyses using the GLE-Morgenstern Price Method were completed for three representative cross sections in the Western (Main) pit and two in the Southern Pit. There are no major adversely orientated faults or shear structures present and which would undermine overall pit stability. Pit stability is influenced by water level in the pit, with increasing water level increasing stability, and hence the analyses was undertaken for a range of pit lake water levels.

The results of the Limit Equilibrium analyses are summarised in **Table 4**. The results show that a maximum offset of 125m for the closure bund is required in the location of Section 3 for the Main Pit and 100m for Section 4 in the South Pit. These two cases represent the most adverse conditions in each pit. The other areas require a 50m minimum offset from the closure bund. This 50m minimum allowance is allows for long-term erosion back from the crest and is explained below.

PSM (2021) note that a specific assessment of potential long-term erosion has not been carried out. Such assessment typically assumes a Revised Universal Soil Loss Equation approach (an empirical-based modelling approach that predicts the long-term average annual rate of soil erosion on slopes) or HEC-RAS modelling (sediment transport mobile- bed computations). These were deemed by PSM (2021) to be of limited value for these reasons:

- Much of the north and west walls in the Western (Main) pit are capped by high intact strength basalt and are unlikely to exhibit long-term erosion.
- In other areas the placement of the closure bund will limit the catchment directing potentially erosive runoff to the pit crest.
- PSM assume that all surface water flows will be directed away from closure bunds so that the bunds are not subject to undue erosion.
- For conservatism, and based on closure studies dealing with sedimentary strata for others, long-term erosion of 50m from the crest has been allowed for.

The adoption of a minimum 50m allowance for erosion retreat from the crest is consistent with the findings of central Queensland pit wall erosion studies by Henderson (2018). The studies concluded that, based on prevalent conditions of rainfall, overburden and coal mining practice, over the long-term pit wall crests could retreat an average of 10m to 30m post-mining, depending on the erosivity of the near surface overburden. Individual gullies could extend about twice that if rainfall runoff was particularly concentrated.

Table 4 – Summary of Limit Equilibrium analyses for closure bund offset

Section	Lake Level	Minimum Global FOS	Distance (m) from Pit Crest where FOS = 1.5	Recommended bund offset (m)
Section 1 (Main Pit)	No Lake	1.84 - circular	0	50
	No Lake	1.35	48	
	RL 210	1.84	0	
Section 2 (Main Pit)*	No Lake	1.10 - circular	0	50
	No Lake	1.07	0	
	RL 210	1.81	0	
Section 3 (Main Pit)	No Lake	1.84 - circular	0	125
	No Lake	0.90	126	
	RL 210	1.34	14	
Section 4 (South Pit)	No Lake	Circular not analysed	0	100
	No Lake	1.05	100	
	RL 200	1.25	83	
Section 5 (South Pit)**	No Lake	2.17 - circular	0	50
	No Lake	1.44	22	

*Section 2 has a 110 m wide bench at RL 235, with the crest location modelled as RL 280.

**Section 5 has only been modelled No Lake due to the pit floor being above the maximum lake level of RL 200.

Figure 10 shows the final highwall crests (red lines), the proposed closure bund location (solid green lines) and the 1 in 1,000 AEP flood extent in the Sandhurst Creek diversion (blue area). The initial stability analysis shows that a backfill buttress is required in the Southern pit for the closure bund to align outside the diversion and hence prevent interaction with the 1 in 1,000 AEP flood extent. The results of the initial stability analyses for the recommended buttress are presented in Appendix B.

More design work is being undertaken on the configuration of the buttress to ensure the minimum FOS of 1.5 is met. Final geotechnical review and stability analysis of the southern high wall section relating to the buttress shall be undertaken before submission of the Minerva Mine Progressive Rehabilitation and Closure Plan.

Note that the closure bund is not required to contain a 1 in 1,000 AEP flood with the Sandhurst Creek diversion and is deliberately placed outside the flood extent so as not to impede flow. The diversion and its relationship to the residual voids is discussed in Section 5.

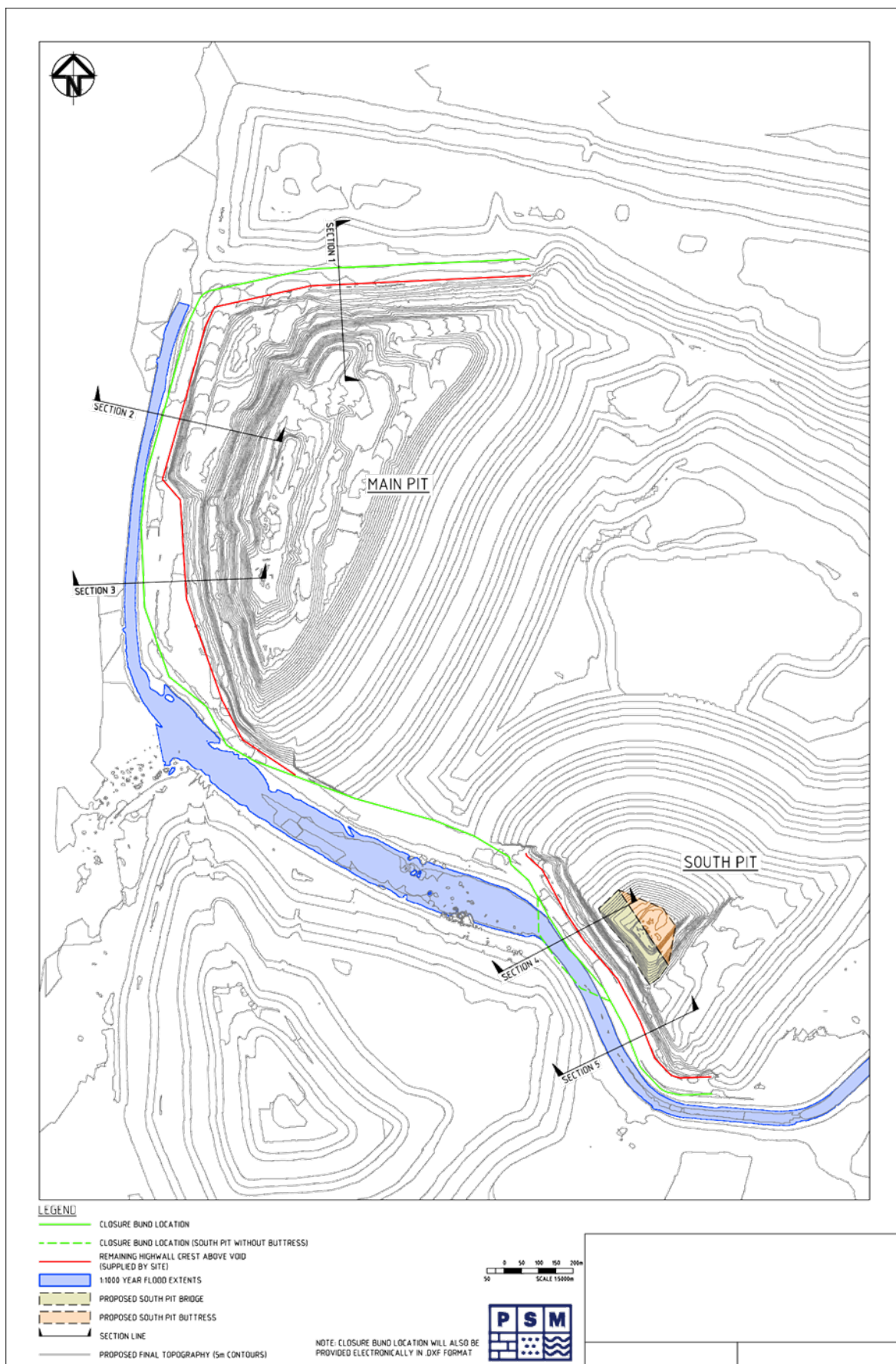


Figure 10 – Closure bunds in relation to highwalls and creek diversion flood extent

5 Sandhurst Creek and Residual Voids

Sojitz Minerva Mining Pty Ltd holds water licence number 406741 issued under the *Water Act 2000* to divert Sandhurst Creek around the western and southern residual voids. The diversion was constructed in stages (Western and Southern diversions) and totals 5,819m in length.

The design criteria and design parameters for the diversion are based on *Watercourse Diversions – Central Queensland Mining Industry* (DERM 2011), which are in turn based on ACARP Project C8030 *Maintenance and Geomorphic Processes in Bowen Basin River Diversions* (ACARP 2000).

The diversion is designed to meet DERM (2011) requirements for stream power, velocity and shear stress for 1 in 2 Annual Exceedance Probability (AEP) and 1 in 50 AEP flow events for the Western and Southern diversion channels. All channel batters are either grassed or provided with rock protection to minimize erosion. Design parameters for the Western and Southern diversion are summarized in **Table 5**.

Table 5 – Diversion design parameters

Parameter	Western Diversion Source: Jacobs (2014)	Southern Diversion Source: Jacobs (2017)
Typical channel depth	1m to 3m (varies)	10m (max 22m)
Bed Width	8m	10m
Overall width	30m to 50m (varies)	20m to 212m (varies)
Batter slope	1:4 V:H	
Overall channel grade	0.24%	0.29%
Minimum offset to residual void	50m	66m*
Stream power, velocity, shear stress	1 in 2 AEP and 1 in 50 AEP	
Flood immunity for voids	1 in 1,000 AEP	

*without buttress (see Section 4)

The diversion was designed to convey flow during a 1 in 1,000 AEP flood event such that associated flood waters do not enter the western or southern residual voids. The predicted extent of the 1 in 1,000 AEP flood event has been modelled again in 2021 with the HEC-RAS hydraulic modelling program using the most recent LiDAR survey of the diversion and surrounds (Cardno 2021). The modelling took into account tributary inflows and any changes to topography since the original design (e.g. road works). The modelling confirmed the surface flows from a 1 in 1,000 AEP flood event did not interact with the final voids.

Flood events with an AEP of 1 in 1,000 or less are defined as “extreme (rare)” in the *Guide for Flood Studies and Mapping in Queensland* (DNRM 2017). By way of comparison, the largest ever recorded Brisbane River flood in 1893 is estimated to be equivalent to an AEP of 1 in 285 (WMA Water 2011). The 1 in 1,000 AEP flood design criterion for the diversion significantly reduces the risk of long-term interaction between Sandhurst Creek and residual voids and provides significant hydrological protection for the void pit walls.

Water licence 406741 requires an on-going monitoring and evaluation program be carried out consistent with ACARP Project C9068 *Monitoring and Evaluation Program for Bowen Basin River Diversions* (ACARP 2001). The water licence cannot be relinquished until the diversion is meeting or progressing towards:

- developing features (including geomorphic and vegetation) present in the landscape and in local watercourses;

- maintenance of a sediment transport regime that allows the diversion to be self-sustaining and not directly impact upstream or downstream reaches; and
- the diversion and associated structures maintain equilibrium and functionality and do not require ongoing maintenance.

6 Void Flora and Fauna

The physical features of the Western and Southern residual voids are likely to restrict the development of diverse and productive aquatic flora and fauna communities. Steep pit walls mean that the littoral zone (depth <1m) would be very narrow and pit floor benthic habitats would be at great depth.

Such pit lakes have low abundance and diversity of structural features such as fallen timber, large rocks and emergent macrophytes (sedges and rushes) (Richardson *et al.* 2021). Richardson *et al.* (2021) found macroinvertebrate diversity in a saline coal mine pit lake was greatly reduced in comparison to a freshwater coal mine pit lake, although salt-tolerant blue green algae and diatoms were present. The absence of connectivity to watercourses would limit the opportunity for fish colonisation of the residual voids.

In an interim report for ACARP Project C27043 *Towards closure of potentially saline pit lakes: understanding biophysical processes for condition assessment and remediation*, Lund and Blanchette (2021) conclude that the main limitations to rehabilitating saline pit lakes are likely to be physical and related to the creation of littoral and riparian areas and developing strategies to enhance natural ecological successional processes.

The voids would be unlikely to support diverse and productive aquatic flora and fauna communities. The voids would not, however, result in adverse environmental impacts on surrounding aquifers as groundwater hydraulic gradients are expected to be maintained in perpetuity towards both voids (see **Section 3.3**).

Western and Southern residual void low walls shall be reshaped above RL210m and RL200m respectively as described in Section 2 and rehabilitated and revegetated in accordance with the Minerva Mine *Rehabilitation Management Plan* (as required under Environmental Authority Conditions F3 and F4).

7 Void Completion Criteria

The residual void completion criteria applicable to the Western and Southern voids are presented in **Table 6**.

Table 6 – Residual Void Completion Criteria

Objective	Indicator	Completion Criteria
Safety hazards minimized	Hazard assessment of access	No public access to highwalls/end walls (bundling/fencing as required)
Final voids are geotechnically stable	Factor of safety	Closure bund installed minimum 50m from pit crest or distance equal to FOS of 1.5 (unless an alternative is justified by an appropriately qualified person).
	Wall slope and area	Maximum slope in competent rock 275% (70 degrees). Maximum slope in incompetent rock 65% (angle of repose). Maximum total void surface area 91ha (measured at maximum water level)

Objective	Indicator	Completion Criteria
	Condition assessed by an appropriately qualified person	Assessment report by a Registered Professional Engineer of Queensland (RPEQ) on the geotechnical stability of final voids.
Maintenance of surface and groundwater quality	Water quality	Surface water and groundwater quality of receiving waters meets the requirements of Schedule W of the Environmental Authority.
		Voids have no adverse environmental impacts on surrounding aquifers
Maintenance of surface water flow	Design for diversion flood	1 in 1,000 AEP flood event in Sandhurst Creek diversion does not enter final void

As noted in Section 3.4, in the long-term the salinity of water in both residual voids is predicted to become unsuitable for irrigation initially, and subsequently become unsuitable for stock water for beef cattle. The voids would be unable to support a Post-Mining Land Use and would be Non-Use Management Areas. The void water would not, however, result in adverse environmental impacts on surrounding aquifers as groundwater hydraulic gradients are expected to be maintained in perpetuity towards both voids. The maximum water level in the voids is 60m below the spill point and void water would not be released to surface waters or surrounding lands. In conclusion, the residual voids would not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself.

8 References

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9 Version Management

Version	Details	Contributors
1.0 ()	November 2021	

Appendix A

AGE (2017). *Minerva Residual Void Investigation – Groundwater Inflow Calculation*. Report to Sojitz Minerva Mining Pty Ltd by Australasian Groundwater and Environmental Consultants Pty Ltd.



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Memorandum

Project number G1753D – Minerva Final Void
To Ross Gooley – Environmental Superintendent
Company Sojitz Minerva Mining Pty Ltd
From Tim Armstrong and Andrew Durick
Date 21/07/2017
RE Minerva Residual Void Investigation – Groundwater Inflow Calculation

1 Introduction and scope of work

Sojitz Minerva Mining Pty Ltd (Sojitz), as manager of Minerva Joint Venture (MJV), operates the Minerva Mine, an open-cut coal mine within mining lease (MLs) 70145 & 70376. The MJV is progressing a southern extension of the main pit. In aggregate, the maximum residual void surface area will not exceed 91 ha, as specified in Table F1 of Environmental Authority (EA) EPML00668613.

A residual void investigation report (MJV, 2010) was previously submitted in accordance with the requirements of EA Condition F8. Updates to this report concerning all elements of Condition F8 relating to future mining activity are being progressed during the 2016-17 MJV Plan of Operations Period. Element updates concerning the residual void investigation will be submitted as Appendices to the 2017-18 MJV Plan of Operations submission.

With respect to groundwater, Sojitz requested Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) contribute towards addressing Condition F8 (b), which states that the residual void investigation must include:

“a void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources, and water quality parameters in the long term”.

The following memo presents groundwater information that supports the void hydrology study. Specifically, this memo summarises the methods and data used to calculate future groundwater inflow rates into the western and southern residual voids. This memo also presents an assessment of the potential for void water to interact with surrounding aquifers.

The groundwater inflow rates provided herein were used within a separate void water balance model developed by KBR as part of the 2017 update of the Water Management Plan. The KBR (2017) GoldSim void water balance model coupled the estimated groundwater inflow rates with with dynamic surface water processes to assess the water level recovery rate, the final (i.e. equilibrium) water level within the voids, and the long-term void water quality.

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2 Background and previous study results

As part of the 2010 residual void investigation, Waste Solutions Australia (WSA, 2010) was engaged to develop a three-dimensional numerical model to calculate rates of groundwater inflow to the final void. The 2010 groundwater model was an update of a previous model, first developed by WSA in 2006. The 2010 groundwater model incorporated the residual void configuration and predicted the average rate of groundwater that would flow into the western residual void.

The 2010 groundwater model produced steady-state results using various recharge and evapotranspiration scenarios. The steady-state results were not time dependent, and as such produced averaged groundwater inflow rates without taking into account seasonal climatic variations.

The 'base-case scenario' of the 2010 groundwater model predicted:

- ~1.8 megalitres per year (ML/year) would flow into the western residual void from the coal seams; and
- ~26.2 ML/year would flow into the western residual void from the basalt aquifer.

AGE consider these model predictions to be very low, especially when compared to the 2015 Minerva Mine water balance estimate of groundwater inflow during mining being ~362 ML/year (MJV, 2015).

To complete the 2010 residual void investigation, the WSA (2010) predicted groundwater inflow rates were incorporated into a "dynamic void water model", developed by ESys Consulting Pty Ltd. This void water balance model accounted for annual inflow rates of surface water, steady-state groundwater inflow rates, and annual rates of evaporation. The void water balance model was developed as a spreadsheet (analytical) transient model that calculated the rate of water level recovery within the western residual void and the equilibrium water level.

The current residual void investigation followed a similar method for the western void and for the planned southern void, details of which are provided below in Section 4.

3 Overview of groundwater regime

There are two main groundwater systems within MLs 70145 & 70376, these being:

- **an upper aquifer system in Tertiary basalts** – where vesicular and fractured zones within the basalt flows are water bearing and form productive aquifers, separated by weathered clay zones between basalt flow layers; and
- **underlying Permian consolidated sediments** – of which the coal seams of the Rieds Dome Beds form low yielding aquifers.

3.1 Tertiary basalt

Uplift in the early Tertiary created the Lexington Dome, a structural feature within Permian aged consolidated sediments. This event was followed by erosion and a series of basalt flows which unconformably overly the Permian sediments, forming a regional cap. The central area of the Lexington Dome was not covered by basalt.

Coal deposits within ML 70145 were initially mined at shallow depths in an area where there was little to no basalt cover.

The thickness of the basalt increases in all directions away from the Lexington Dome. In the area to the west of ML 70145, basalt thickness increases rapidly from ~70 m in the highwall of the western residual void, to ~135 m near the western boundary of ML 70145. Basalt thickness continues to increase to ~175 m at a distance of 1.2 km towards the south-west, and ~150 m at a distance of 0.5 km towards the north-west.

Some conjecture exists about the potential for regional or local scale faults to exist within the Tertiary basalt, but this topic is beyond the scope of this assessment. The potential for faults to influence the hydraulic behaviour of the basalt has not been considered here.

The basalt has a distinct near-surface weathered profile and multiple horizons of fractured and unweathered basalt that may represent separate basalt flows. The weathered zones are less permeable than the underlying fractured and unweathered basalt. The uppermost (and current) weathered profile extends to a depth of ~30 m below ground surface. The underlying fractured basalt formation is the main aquifer located in the area immediately surrounding the Minerva Mine. The relative proportions of fractured basalt (permeable) and non-fractured basalt (non-permeable) within the whole basalt unit greatly influences the potential to store and transmit groundwater.

Anecdotal information from Minerva suggests that high seepage rates persist from the basalt aquifer into the open-cut mine pit. The 2015 water balance calculations undertaken by MJV suggested the seepage (assumed to be predominantly from the basalt) was ~362 ML/year (~11.5 L/s).

3.2 Permian coal measures

Throughout most of the Bowen Basin, the fresh (non-weathered) Permian strata may be categorised into the following hydrogeological units:

- low permeability, low yielding (and often dry), sandstone / siltstone that comprise the majority of the Permian interburden / overburden; and
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian strata.

The coal seams within ML 70145 & ML70376 generally dip in a south-westerly and westerly direction. The coal seams have been named in six groups, these being, Sandhurst, Funnel, Wurba, Willa, Lexington, and Minerva. Most coal seam groups consist of multiple seams and splits. Coal seam thickness ranges from 0.1 m to about 3.5 m.

Groundwater storage and flow is predominantly associated with natural interconnecting coal seam cleat and joint patterns. Recharge of the coal seam aquifers will predominantly occur via vertical seepage from the overlying basalt aquifer where the coal seam sub-crops beneath or where the coal seams sub-crop near the ground surface.

The coal seam aquifers are confined above and below by very low permeability interburden that are relatively impervious, compared to coal seams, and form aquitards. The confining interburden units limit vertical flow and restrict recharge of the coal seam aquifers. On a small scale, features such as fractures, faults, and joints within the overburden can yield localised and variable supplies of low yielding, poor quality groundwater.

Anecdotal information from the Minerva Mine suggests that low seepage rates persist from the coal seams into the open-cut mine pit. However, very little seepage occurs from the sandstone / siltstone overburden and interburden. Groundwater seepage into the mine from the Permian coal seams is generally low and evaporation may remove most of this seepage before it enters the mine pit.

4 Methodology

The following sub-sections describe the methods and data used to calculate potential groundwater inflow rates into the western residual void and the proposed southern residual void.

4.1 Assessment of void geometry

An initial review of the final landform was undertaken prior to developing the groundwater inflow calculations. Firstly, a set of cross-sections through the western and southern residual voids were developed to understand the geometry of the final landform and identify areas of spoil, natural land surface, and excavated areas. The locations of the cross sections are shown in Figure 4.1.

The elevation of the coal seams and the base of the basalt aquifer were also identified to understand the elevation at which groundwater can enter the residual voids, and the level to which the voids can fill before void water would interact with the basalt aquifer.

A representative cross-section through the western and southern residual voids are shown in Figure 4.2 and Figure 4.3, respectively. The results of this data processing were used to define the assumptions about aquifer geometry used within the analytical calculations of groundwater inflow rates into the residual voids.

To simplify the inflow calculations, the highwalls in the western and southern residual voids were divided into three segments each. This division allowed for the inclusion of key aquifer geometry variability along the highwall, while still being practical to undertake calculations. The segments for each residual void are shown in Figure 4.1.

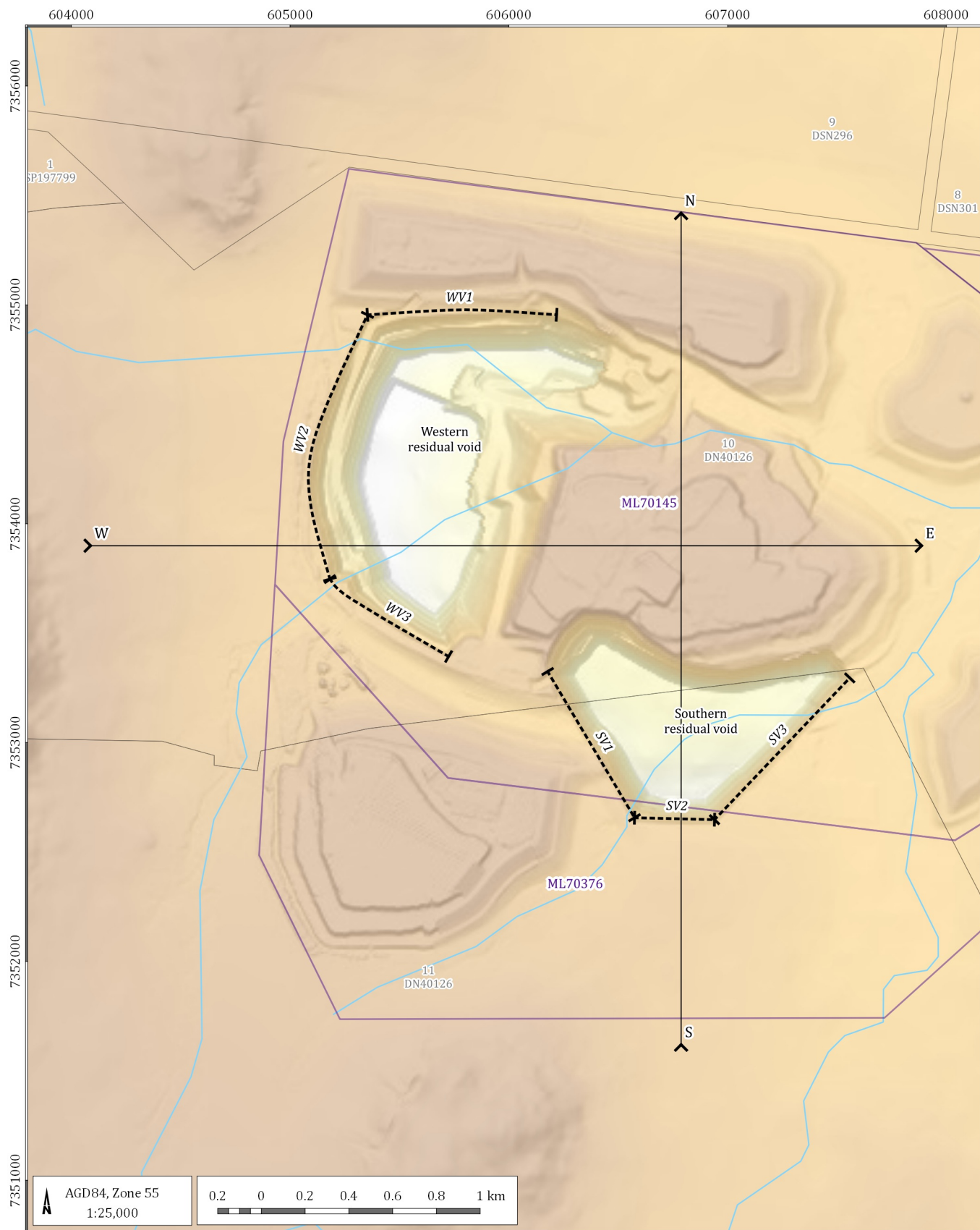
Importantly, the cross-sections confirm there are a number of coal seams that intersect both residual voids, and the basalt aquifer is intersected only by the western residual void. Attempting to calculate the potential groundwater inflow rate from each coal seam is impractical with analytical techniques due to their number, so for simplicity, the coal seams were grouped into an upper and lower grouping, which are separated by a relatively thicker interburden. Within the groupings, the coal seam thicknesses were combined into one total representative thickness.

The contact of the highwall and geological features were analysed for each highwall segment. The key elevations and measures for each segment are summarised in Table 4.1.

Table 4.1 Void geometry information for each pit wall segment

	Western residual void			Southern residual void		
Parameter	WV1	WV2	WV3	SV1	SV2	SV3
Section length (m)	870	1,270	660	780	370	900
Weathered basalt floor (mAHD)	248	250	265	-	-	-
Basalt floor (mAHD)	223	201	202	-	-	-
Basalt seepage face (m)	2	2	2	-	-	-
Upper coal seam floor (mAHD)	153	153	170	204	204	211
Upper coal seam thickness (mAHD)	7.3	5.6	4.9	3.8	4.5	2.8
Lower coal seam floor (mAHD)	108	80	94	115	112	112
Lower coal seam thickness (mAHD)	7.6	9.4	8.8	7.5	7	6.9

Note: mAHD = metres above the Australian height Datum



LEGEND

- Sections
- Sectors
- Minor drainage
- Mining lease
- Property boundaries

Elevation (m)

- 100
- 150
- 270
- 300
- 400
- 600

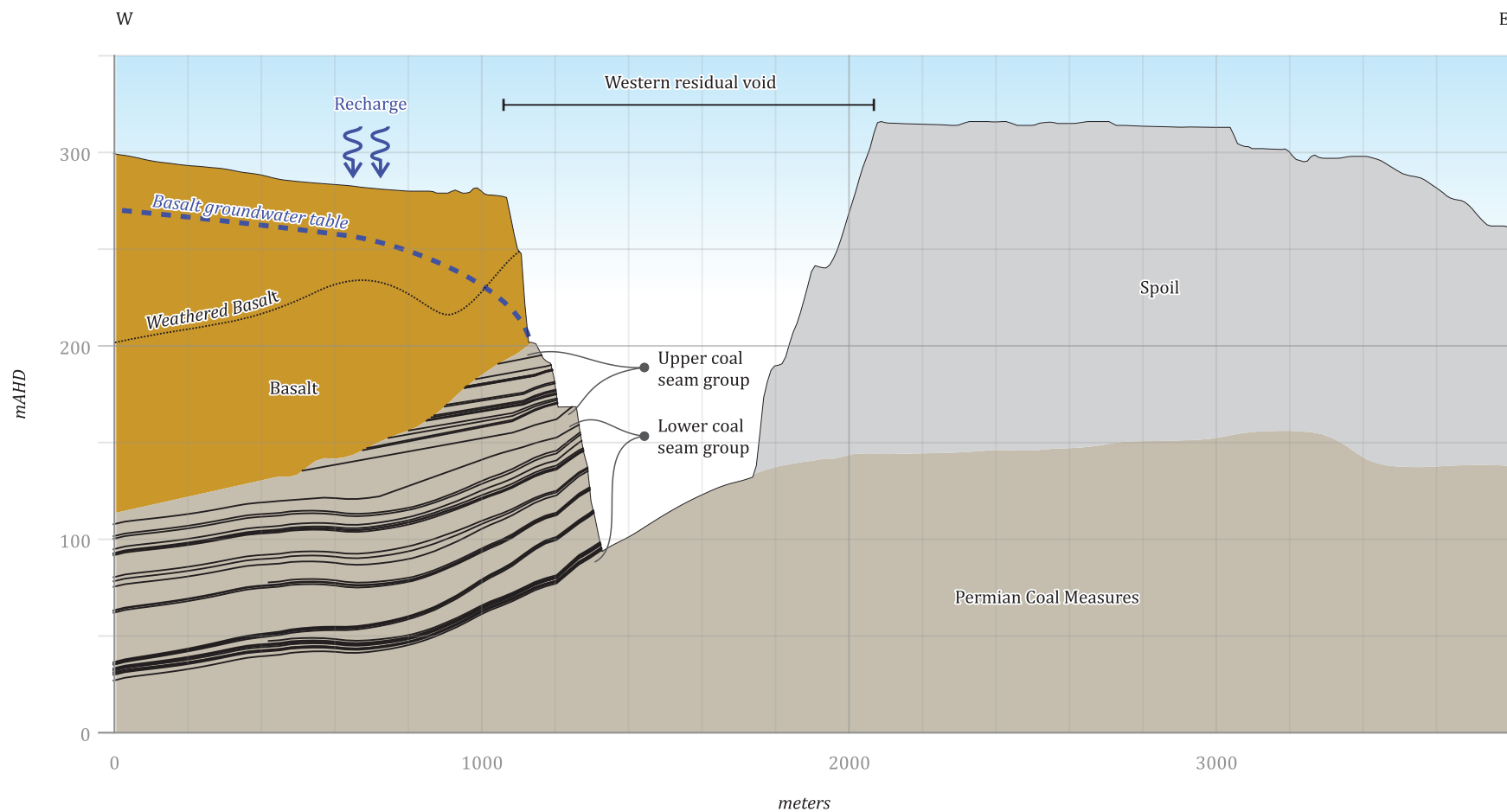
Minerva Final Void (G1753D)

Location of cross-sections



DATE
14/06/2017

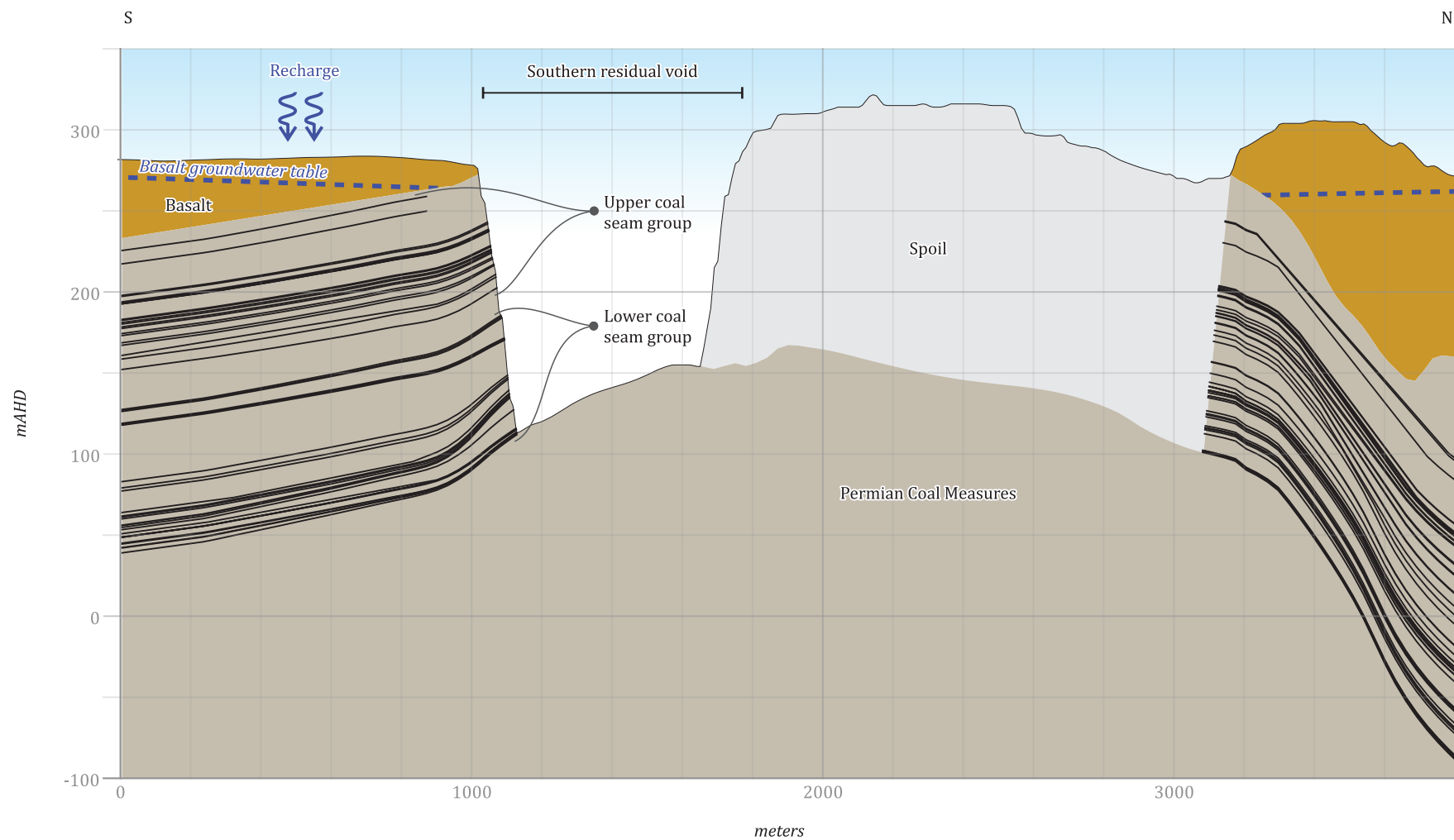
FIGURE No:
4.1



West-East cross-section

Figure 4.2

Minerva Final Void (G1753D)



South-North cross-section

Figure 4.3

Minerva Final Void (G1753D)

Groundwater inflow to the southern residual void will only occur from the coal seams, because the basalt aquifer is not intersected by the highwall of this void (Figure 4.3). The highwall of the western residual void will intersect a significant thickness of basalt as well as the many coal seams (Figure 4.2). The basalt aquifer is considered the major source of inflow to the western residual void.

The seepage face noted for the basalt in Table 4.1 is considered to exist at the base of the basalt in the highwall when the void water level is below the basalt.

4.2 Analytical calculations of groundwater inflow rates

The methods used in this current residual void investigation are similar to those used in 2010. Specifically, the current predicted groundwater inflow rates were developed with the intention of these results being included within a transient and stochastic void water balance model. A surface water consultant (KBR) was engaged by Sojitz to develop the void water balance model because the recovery rate to the void water equilibrium level will be dominated by dynamic surface water processes, and groundwater inflow will be a component of this.

The 2010 groundwater model was not used in this current residual void investigation. The latest model version (from which the 2010 groundwater model was developed) was recently reviewed by AGE and it was found to be not “fit-for-purpose” (AGE, 2017). The review concluded that significant work would be required to update the groundwater model to make it useful for the intended task of predicting groundwater inflow into the western and southern residual voids. In lieu of developing a new numerical groundwater model, an alternative method of estimating groundwater inflow into the voids was undertaken for the current residual void investigation.

Analytical equations of groundwater flow (i.e. using first principles) were used to calculate potential rates of groundwater inflow into the residual voids. Inflow rates from the basalt and coal seam aquifers were calculated for a broad range of different stage heights within each void. The goal here was to create a rating table / curve of groundwater inflow versus void stage height. Following its development, the rating curve was incorporated into the void water balance model to refine the estimate of groundwater contribution as the void fills with water.

The groundwater inflow rating table / curve was provided to KBR as a spreadsheet for inclusion into their void water balance model.

The potential rate of groundwater inflow to both residual voids through each highwall segment (see Figure 4.1) was calculated using Darcy’s equation of flow through a porous media. This equation uses the aquifers hydraulic conductivity, the hydraulic gradient within the aquifer (i.e. to cause the flow), and the cross-sectional area of the seepage face, to determine the volume of water moving through a vertical plane of aquifer material. In this case the vertical plane of aquifer material is the highwall in the residual voids. Darcy’s equation is simply written as:

$$Q = k \times i \times A$$

Where: Q = discharge rate (m³/day)
 k = hydraulic conductivity of material (m/day)
 i = hydraulic gradient (m/m)
and A = cross sectional area (m²)

The following assumptions were used when undertaking the calculations of groundwater inflow:

- The estimates of inflow do not consider direct rainfall on the voids and rainfall runoff into the voids, nor the inflow from the low-wall and spoil. The estimates calculated only relate to the exposed highwall in the residual voids.
- Basalt is in contact with the western residual void, but not the southern residual void (based on available data).
- Recharge that occurs through the surface within the capture zone of the drawdown from each pit / void is calculated and added to the Darcy inflow estimates. For the western residual void a recharge of 6% of rainfall was used to represent recharge into the basalt, while at the southern residual void a recharge of 0.1% of rainfall was used to represent recharge into the weathered Permian cover.
- The regional water table away from the mine impact was assumed to be 270 mAHD, based on recorded groundwater levels from the Minerva Mine groundwater monitoring bore network.
- The rainfall recharge within the capture zones reduces as the water level in the void increases. In a scenario when the water level in the void is equivalent to the regional groundwater level, the rainfall recharge in the capture zone is assumed to be zero. The rainfall recharge is assumed to remain zero in the event that the void water level increases above the regional water table, because the void would be expected to supply water to the surrounding area in a situation such as this.
- The upper coal seam grouping in the WV2 segment of the western residual void is not extensive behind the highwall as it subcrops into the dipping basalt. These seams are expected to be dry after mining and because they are not extensively connected to the west along this segment, they are not considered to contribute to groundwater inflow for the WV2 segment.
- The contributions from the two coal seam groups and the basalt (for the western residual void) are all treated individually in the groundwater inflow estimates, and accumulated into a total reported inflow.
- When the void water level is low, the hydraulic gradient uses the geological elevation data to determine the inflow rates through the coals seams and basalt. When the void water level is set above these elevations, the void water level controls the hydraulic gradient, with the gradient reducing as the void water level rises.
- The basalt is assumed to have a hydraulic conductivity of 1 m/day, while the coal seam hydraulic conductivity is set to 0.01 m/day.
- Groundwater inflow estimates were made with void water levels at 5 m increments vertically from the base of each void to the spill point (i.e. void stage height).
- The void extents have been based on available data and it is understood that final void design (including the level of backfill) are being finalised at the time of writing. This might reduce the extent of highwall exposed in each void, though not likely to be significantly different to the dimensions adopted for this work.

4.3 Groundwater quality input data for mass-balance calculations

The 2010 residual void investigation used a mass-balance water quality assessment of Total Dissolved Solids (TDS) to investigate the long-term quality of void water. The average groundwater quality used in 2010 was obtained from analysis of groundwater samples for the basalt aquifer (WSA, 2009) and the coal aquifer (Sandhurst Mining, 2005).

The groundwater TDS values used in the 2010 mass-balance calculation were:

- 767 milligrams per litre (mg/L) for the basalt aquifer; and
- 2,039 mg/L for the coal seam aquifers.

These groundwater TDS values were combined with other water quality contributors (e.g. TDS of spoil runoff, catchment runoff, and direct rainfall) in the mass-balance calculation. The 2010 mass-balance calculation was then completed by multiplying the TDS value of the inflow contributor by the volume of the inflow into the void from each contributor. A simple TDS mass-balance calculation such as this has been used in previous Bowen Basin residual void investigations (PPK Environment and Infrastructure, 2001).

The 2010 TDS mass-balance method has been replicated for the current residual void investigation. Groundwater TDS values provided herein were used by KBR to couple with other TDS contributors within the current void water balance model.

No new TDS values are available for the coal seam aquifers, so the values used in the 2010 mass-balance equation are considered to be valid still. An updated average TDS value for the basalt aquifer has been obtained from analysis of the most recently published groundwater samples (WSA, 2014).

The groundwater TDS values used in the 2017 mass-balance calculation were:

- 655 mg/L for the basalt aquifer; and
- 2,039 mg/L for the coal seam aquifers.

4.4 Void water balance model

KBR (2017) developed a detailed Goldsim void water balance model to calculate the rate of water level recovery within the voids, the equilibrium water level, and the TDS concentration of void water.

Final topography for the final voids (north and south) and backfilled spoil landform was provided by Sojitz for assessment of the final void hydrology. Sojitz also provided details of the expected base of coal throughout the entire area to allow for definition of the quantity and volume of backfilled spoil material placed in the final void.

The KBR (2017) GoldSim water balance model made allowance for the following:

- Rainfall runoff reporting to the final voids and runoff from the low-wall spoil area (surface and baseflow).
- Groundwater inflow rates dependent upon the pit water levels as defined and provided by AGE for both the basalt aquifer (western void) and coal seam inflows (western and southern voids).
- A nominal 5% spoil porosity was allowed for all spoil material.
- Allowance was made for the potential storage of water within the spoil for all void water levels.

- Seepage between the voids was allowed when water levels in either void exceeded the elevated base of coal level between the mining voids.
- A hydraulic conductivity of 0.2m/day was applied to the spoil. Seepage through the spoil was estimated using Darcy's equation with estimates of seepage face area and length of seepage path between the pits used.
- The spill levels for the western void and southern void were set at level 272 mAHD and 262 mAHD, respectively.
- Associated salinity concentrations were incorporated for salts mass balance and were provided to all groundwater inflows and rainfall runoff. No allowance was made for leeching of salts from spoil material. The TDS concentrations used in the mass balance were:
 - groundwater to western void – 655 mg/L (sourced predominantly from basalt);
 - groundwater to southern void – 2,039 mg/L (sourced from coal seams);
 - runoff from rehabilitated ground surfaces – 350mg/L;
 - runoff from mining areas – 350 mg/L; and
 - runoff from industrial areas – 1,200 mg/L.

TDS concentrations of runoff water were based on historical salinity concentrations from OPSIM water balance modelling.

KBR (2017) applied a DataDrill of 128 years of rainfall and associated evaporation data to generate 100 data sets of daily rainfall and evaporation for a 1000 year period. All climatic data sets were run through the model to generate a probability assessment of water levels and salinity concentrations within the residual voids. The average (50%) stable water levels were adopted as representative of mining void performance.

5 Results

5.1 Groundwater inflow rates to residual voids

The predicted groundwater inflow from the highwall into each residual void is presented below. The calculations below were undertaken in a spreadsheet using the equation and assumptions outlined in Section 4.2.

5.1.1 *Western residual void*

Groundwater inflow to the western residual void is expected to be dominated by flow from the basalt aquifer, and in particular the rainfall recharge occurring within the capture zone of the drawdown from mining. Figure 5.1 below shows the inflow from the highwall is initially predicted to be 1,120 m³/day (~408 ML/year) and remain around this rate until the void water level reaches the lower elevation of exposed basalt in the highwall, if this was to occur. As the void water level increases and more of the basalt is submerged, the inflow from the basalt is expected to reduce as the inflow hydraulic gradient reduces and as the rainfall recharge capture zone also reduces. In the event that the water level in the void exceeds the surrounding regional water table (~270 mAHD), then the flow into the void would become negative, indicating a loss of water from the void into the basalt aquifer.

A rating table of groundwater inflow versus void water level / stage height is provided in Table 5.1.

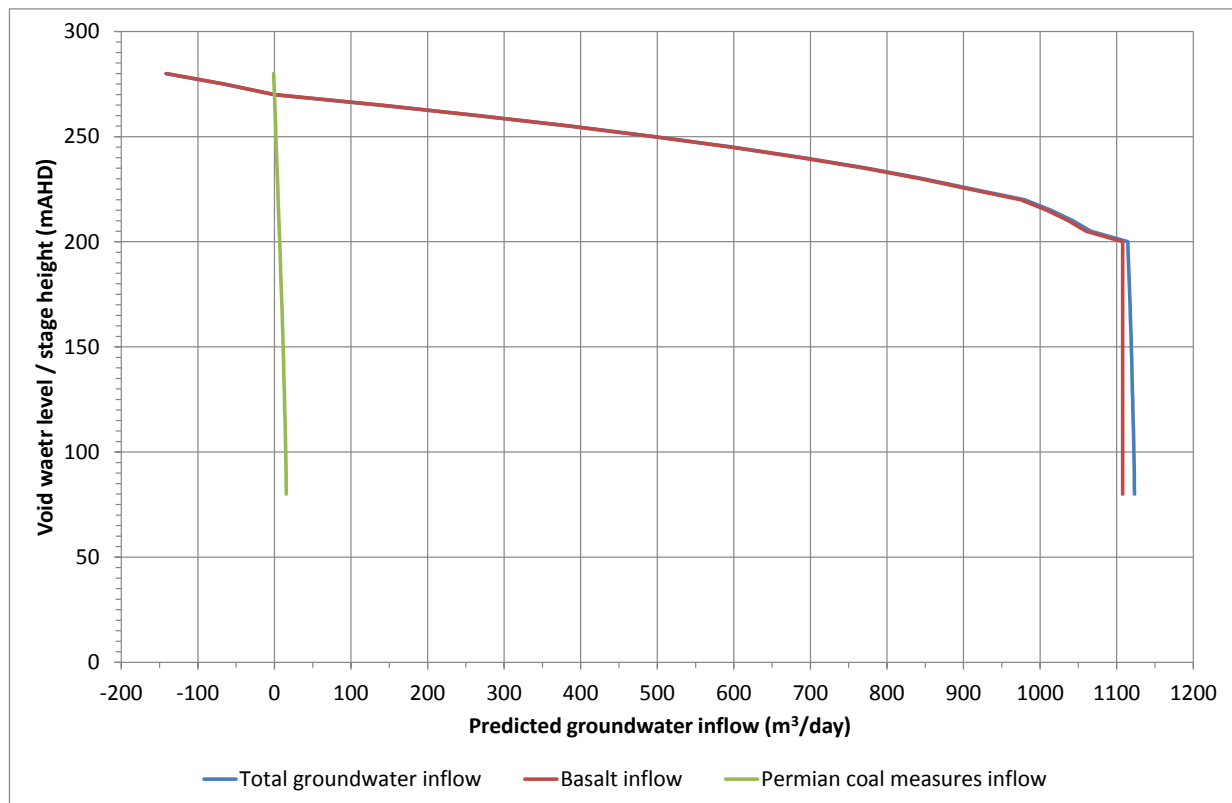


Figure 5.1 Predicted groundwater inflow – western residual void

Table 5.1 Rating table of groundwater inflow – western residual void

Void water level / stage height (m)	WV1 inflow (m³/day)	WV2 inflow (m³/day)	WV3 inflow (m³/day)	Total inflow (m³/day)
80	341.96	514.06	267.25	1,123.27
85	341.96	513.89	267.25	1,123.10
90	341.96	513.72	267.25	1,122.93
95	341.96	513.55	267.23	1,122.74
100	341.96	513.38	267.15	1,122.48
105	341.96	513.21	267.07	1,122.23
110	341.92	513.04	266.98	1,121.94
115	341.83	512.87	266.90	1,121.59
120	341.73	512.70	266.82	1,121.24
125	341.64	512.52	266.73	1,120.90
130	341.54	512.35	266.65	1,120.55
135	341.45	512.18	266.57	1,120.20
140	341.35	512.01	266.49	1,119.85
145	341.26	511.84	266.40	1,119.50

Void water level / stage height (m)	WV1 inflow (m³/day)	WV2 inflow (m³/day)	WV3 inflow (m³/day)	Total inflow (m³/day)
150	341.16	511.67	266.32	1,119.16
155	341.03	511.50	266.24	1,118.77
160	340.85	511.33	266.15	1,118.33
165	340.66	511.16	266.07	1,117.89
170	340.48	510.99	265.99	1,117.46
175	340.29	510.82	265.86	1,116.97
180	340.11	510.65	265.73	1,116.49
185	339.92	510.48	265.60	1,116.00
190	339.74	510.31	265.47	1,115.52
195	339.55	510.14	265.34	1,115.03
200	339.37	509.97	265.21	1,114.55
205	339.18	481.05	246.27	1,066.50
210	339.00	476.71	227.33	1,043.03
215	338.81	466.92	208.38	1,014.11
220	338.63	451.68	189.44	979.75
225	310.95	431.01	170.49	912.45
230	291.31	404.89	151.55	847.75
235	267.95	373.33	132.61	773.88
240	240.86	336.32	113.66	690.84
245	210.04	293.88	94.72	598.63
250	175.49	245.99	75.78	497.25
255	137.21	192.66	56.83	386.69
260	95.20	133.88	37.89	266.97
265	49.46	69.66	18.94	138.07
270	0.00	0.00	0.00	0.00
275	-21.31	-42.99	-2.01	-66.32
280	-46.36	-91.42	-4.03	-141.80

5.1.2 Southern residual void

Groundwater inflow to the southern residual void is predicted to be considerably lower than that predicted for the western residual void. This is because there is no basalt in connection with the highwall of the southern residual void and recharge in the capture zone is at a much lower rate based on the pathway through Permian material to the void highwall. This means that only the coal seams provide groundwater inflow.

Figure 5.2 below shows the inflow from the highwall is initially predicted to be 20.13 m³/day (~7.3 ML/year) but then decline as the void water level increases.

A rating table of groundwater inflow versus void water level / stage height is provided in Table 5.2.

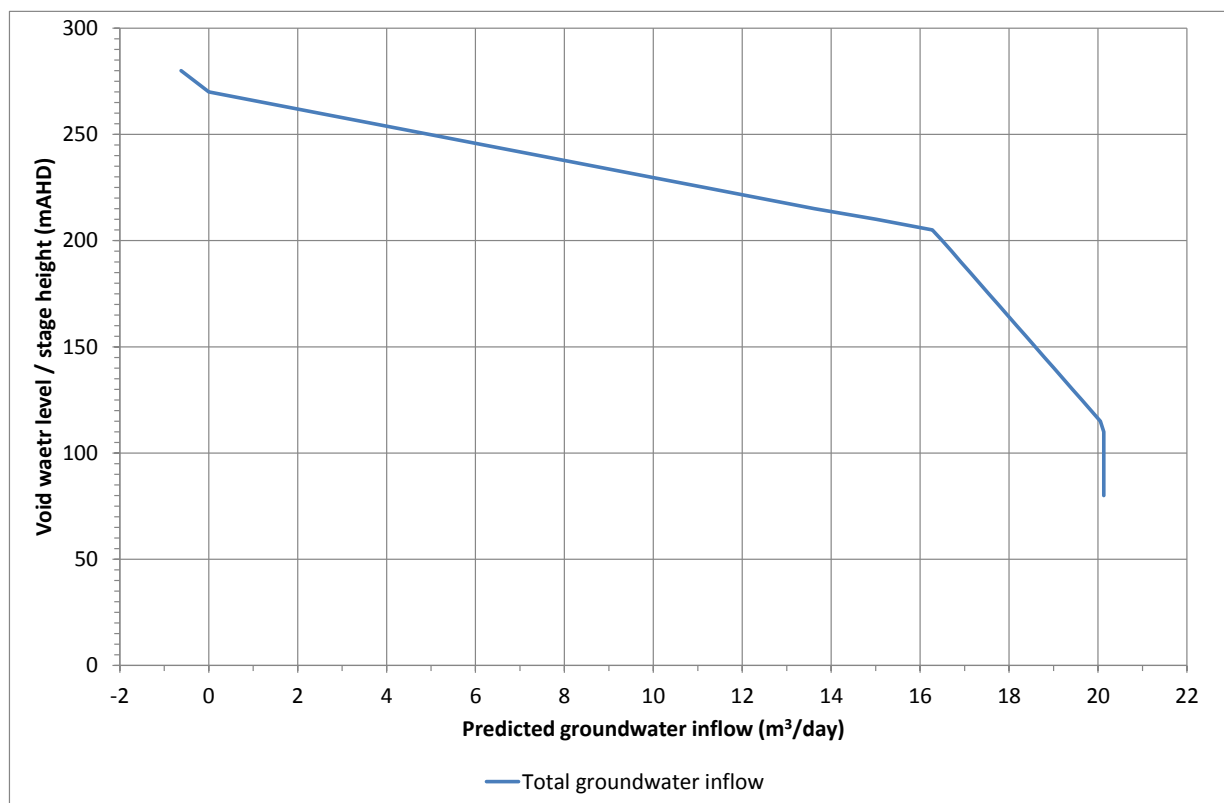


Figure 5.2 Predicted groundwater inflow – southern residual void

Table 5.2 Rating table of groundwater inflow – southern residual void

Void water level / stage height (m)	SV1 inflow (m³/day)	SV2 inflow (m³/day)	SVP3 inflow (m³/day)	Total inflow (m³/day)
80	7.82	3.70	8.61	20.13
85	7.82	3.70	8.61	20.13
90	7.82	3.70	8.61	20.13
95	7.82	3.70	8.61	20.13
100	7.82	3.70	8.61	20.13
105	7.82	3.70	8.61	20.13
110	7.82	3.70	8.61	20.13

Void water level / stage height (m)	SV1 inflow (m³/day)	SV2 inflow (m³/day)	SVP3 inflow (m³/day)	Total inflow (m³/day)
115	7.82	3.68	8.56	20.05
120	7.73	3.64	8.47	19.85
125	7.65	3.60	8.38	19.64
130	7.57	3.56	8.30	19.43
135	7.48	3.53	8.21	19.22
140	7.40	3.49	8.12	19.01
145	7.32	3.45	8.03	18.80
150	7.23	3.42	7.94	18.59
155	7.15	3.38	7.85	18.38
160	7.07	3.34	7.76	18.17
165	6.98	3.31	7.67	17.96
170	6.90	3.27	7.59	17.75
175	6.82	3.23	7.50	17.54
180	6.73	3.19	7.41	17.33
185	6.65	3.16	7.32	17.12
190	6.56	3.12	7.23	16.92
195	6.48	3.08	7.14	16.71
200	6.40	3.05	7.05	16.50
205	6.31	3.00	6.96	16.27
210	5.52	2.61	6.88	15.01
215	5.06	2.40	6.17	13.63
220	4.60	2.18	5.61	12.39
225	4.14	1.96	5.04	11.15
230	3.68	1.74	4.48	9.91
235	3.22	1.52	3.92	8.67
240	2.76	1.31	3.36	7.43
245	2.30	1.09	2.80	6.19
250	1.84	0.87	2.24	4.95
255	1.38	0.65	1.68	3.72
260	0.92	0.44	1.12	2.48
265	0.46	0.22	0.56	1.24
270	0.00	0.00	0.00	0.00
275	-0.13	-0.06	-0.12	-0.31
280	-0.25	-0.12	-0.25	-0.62

5.2 Potential for void water interaction with the basalt aquifer

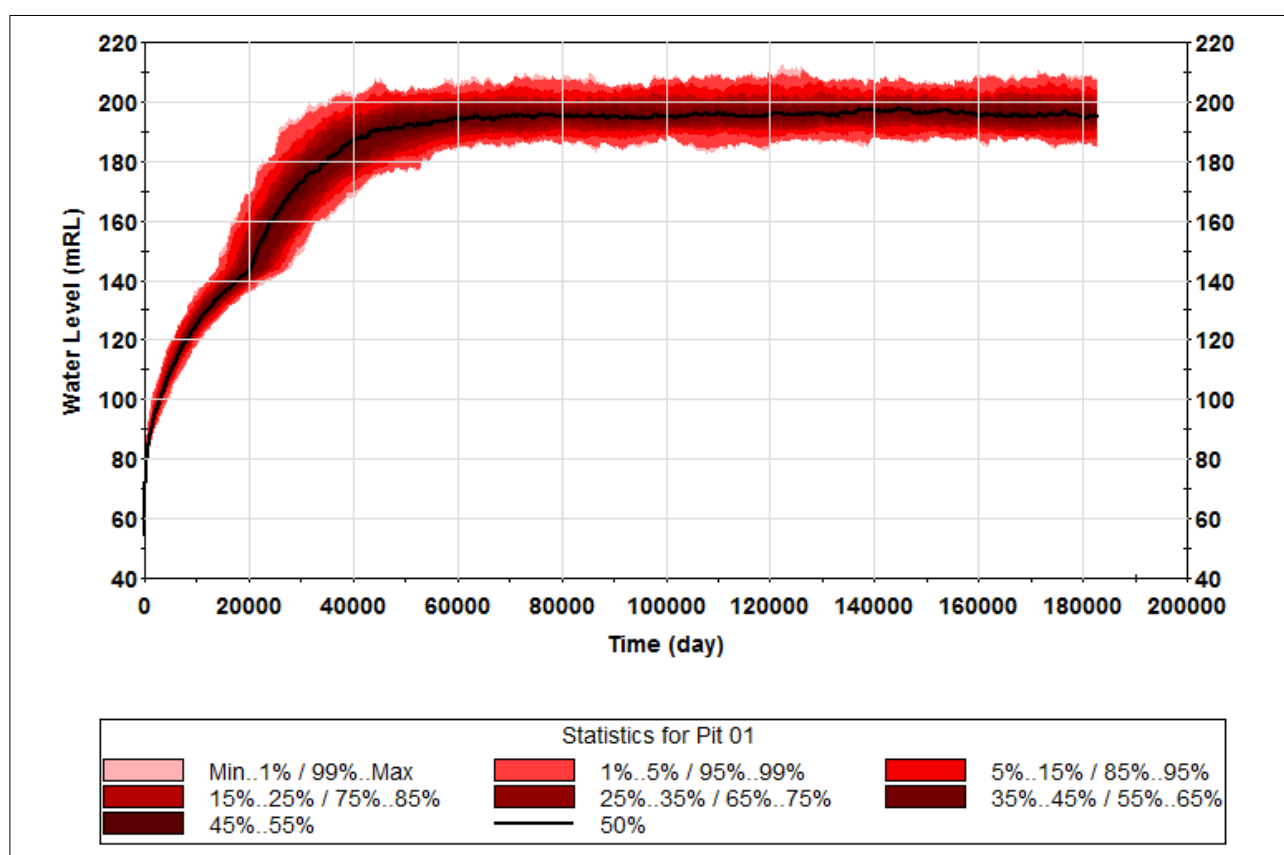
5.2.1 Western residual void

The risk of water leaving the western residual void via the basalt aquifer (and coal seams) is low under all modelled scenarios.

The stochastic water balance model, developed by KBR (2017), predicts the void water level in the western residual void will rise towards an equilibrium over a period of about 60,000 days (~164 years), as shown in Figure 5.3.

The void water equilibrium level is predicted by KBR (2017) to have:

- an average elevation of about 195 mRL (equivalent to mAHD);
- a minimum elevation of 185 mAHD; and
- a maximum elevation of 210 mAHD.

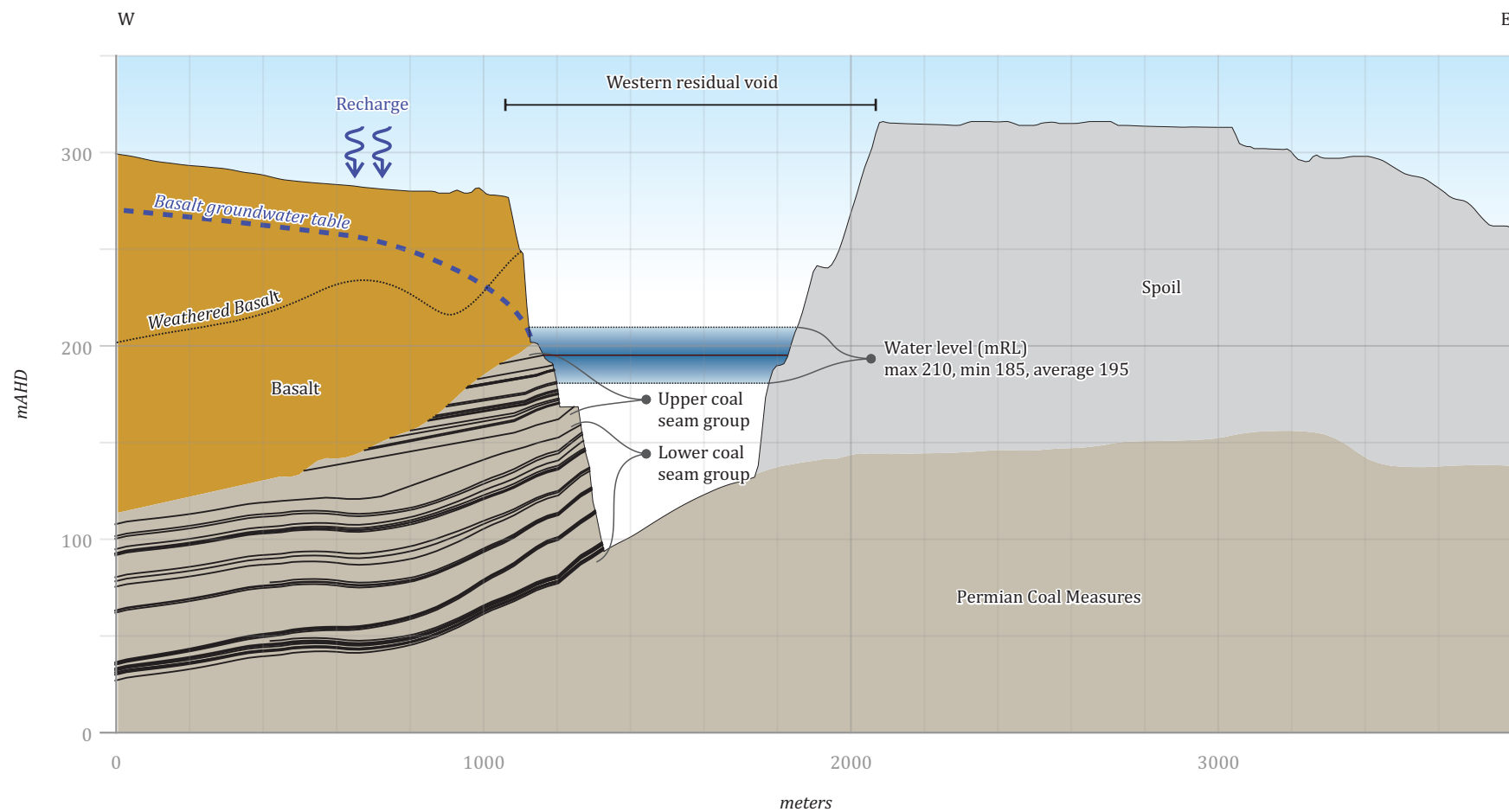


(Source: KBR, 2017)

Figure 5.3 Predicted void water equilibrium level – western residual void

The average and minimum void water equilibrium levels are predicted to be below the base of the basalt exposed in the highwall of the western void, as shown on Figure 5.4. The lowest elevation where basalt is exposed in the highwall of the western void is 201 mAHD. The maximum void water equilibrium level is predicted to be marginally above the base of the basalt exposed in the highwall.

Although the maximum void water equilibrium level is predicted to be above the base of the basalt exposed in the highwall, the maximum void water equilibrium level is predicted to remain about 60 m below the elevation of the regional groundwater table. Therefore, a groundwater hydraulic gradient is expected to be maintained in perpetuity towards the western residual void.



Water level source: KBR, 2017

West-East cross-section with predicted void water equilibrium levels

Figure 5.4

Minerva Final Void (G1753D)

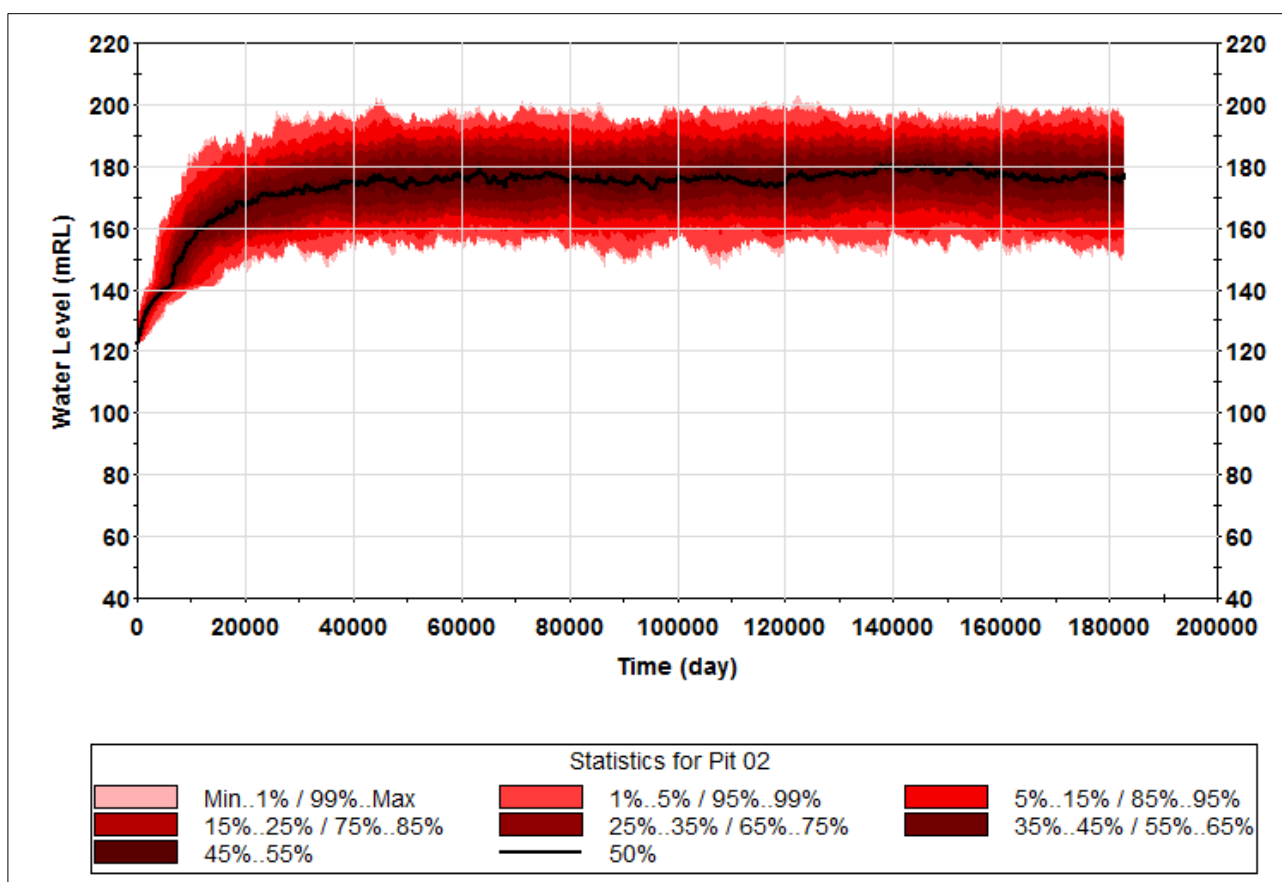
5.2.2 Southern residual void

The risk of water leaving the southern residual void via the coal seams is low under all modelled scenarios.

The stochastic water balance model (KBR, 2017) predicts the void water level in the southern residual void will rise towards an equilibrium over a period of about 40,000 days (~110 years), as shown in Figure 5.5.

The void water equilibrium level is predicted by KBR (2017) to have:

- an average elevation of about 175 mRL (equivalent to m AHD);
- a minimum elevation of 150 m AHD; and
- a maximum elevation of 200 m AHD.

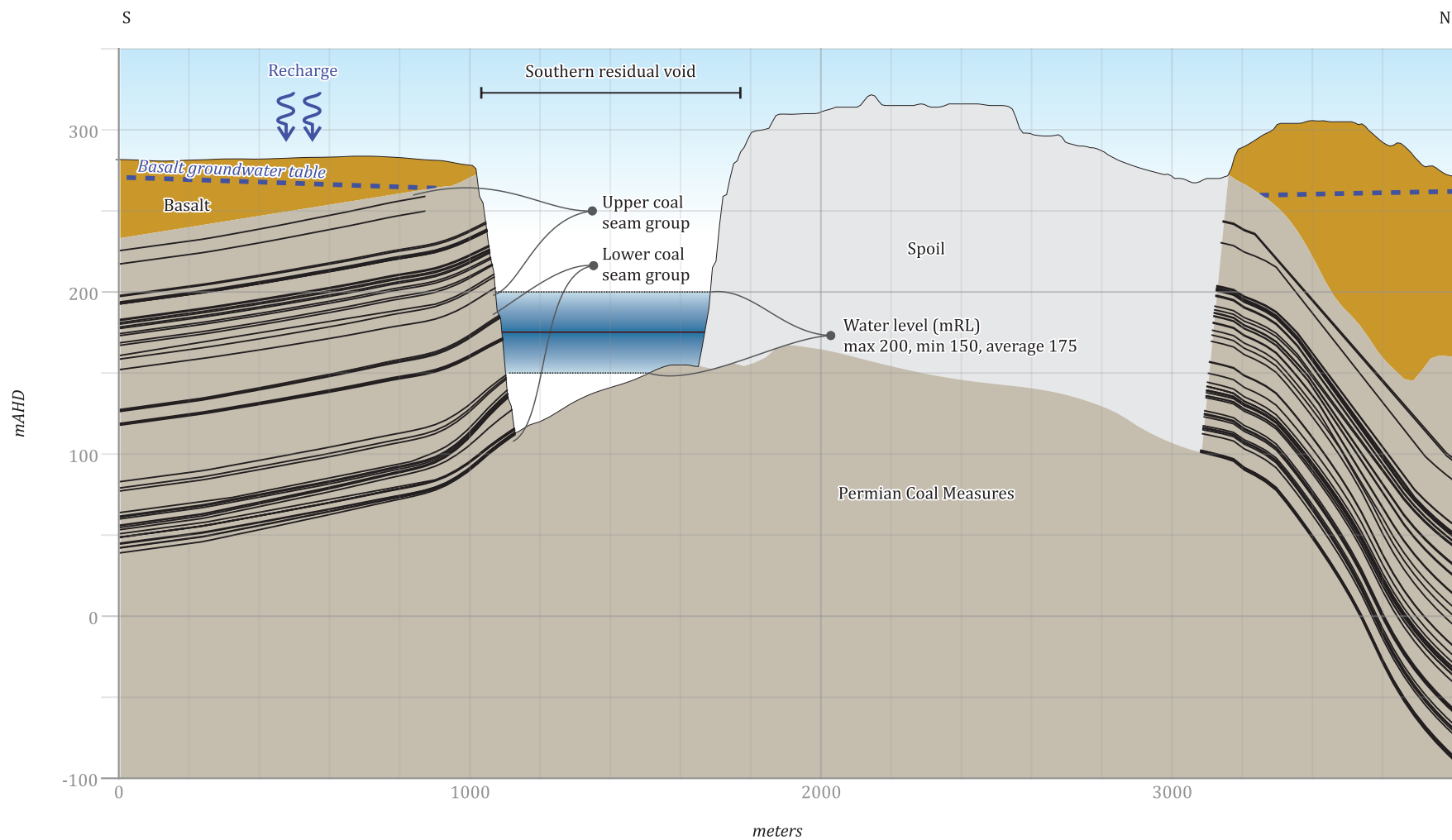


(Source: KBR, 2017)

Figure 5.5 Predicted void water equilibrium level – southern residual void

All of the predicted void water equilibrium levels for the southern void are expected to remain at least 70 m below the elevation of the regional groundwater table, as shown on Figure 5.6. Therefore, a groundwater hydraulic gradient is expected to be maintained in perpetuity towards the southern residual void.

The predicted void water equilibrium level for the southern void is lower than predicted levels for the western void. As a result, a hydraulic gradient is expected to form towards the southern void from the western void. The southern void will permanently remain a groundwater “sink” where evaporation permanently depress the water level.



Water level source: KBR, 2017

South-North cross-section with predicted void water equilibrium levels

Figure 5.6

Minerva Final Void (G1753D)

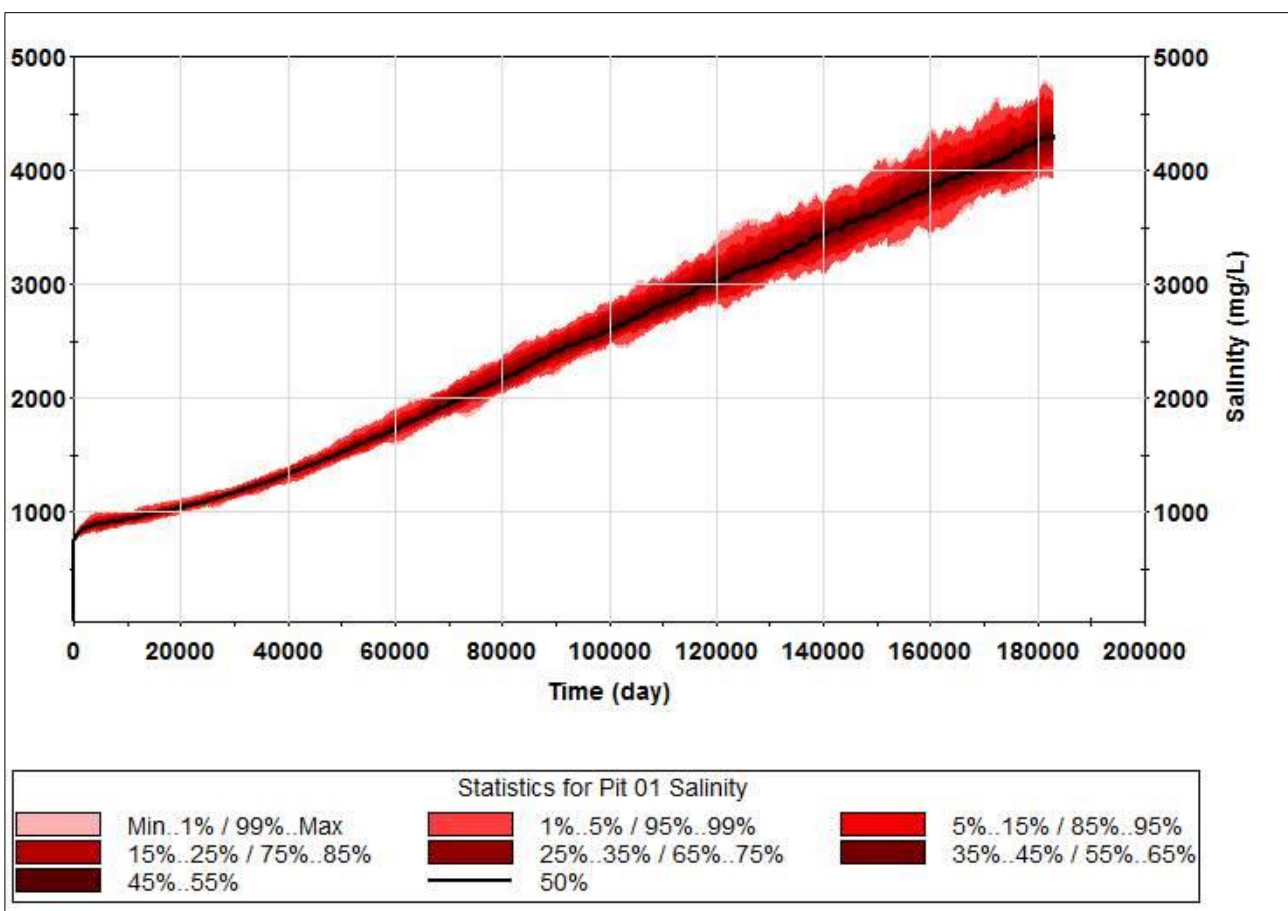
5.3 Potential water quality within the residual voids

5.3.1 Western residual void

The risk of water quality deteriorating within the western void to an un-usable status within the immediate future is low for all modelled scenarios.

The stochastic water balance model (KBR, 2017) predicts the TDS concentration of void water will continuously increase over time. The TDS concentration is expected to be about 800 mg/L soon after mining and increase at a rate of about 7 mg/L per year.

Water is primarily used by neighbours for livestock watering (beef cattle). The ANZECC (2000) guideline confirms that no adverse effects on beef cattle are expected to occur when the TDS concentration of stock drinking water is below 4,000 mg/L. The average TDS concentration of the western void water is predicted to increase to 4,000 mg/L after about 170,000 days (~465 years) post mining, as shown on Figure 5.7.



(Source: KBR, 2017)

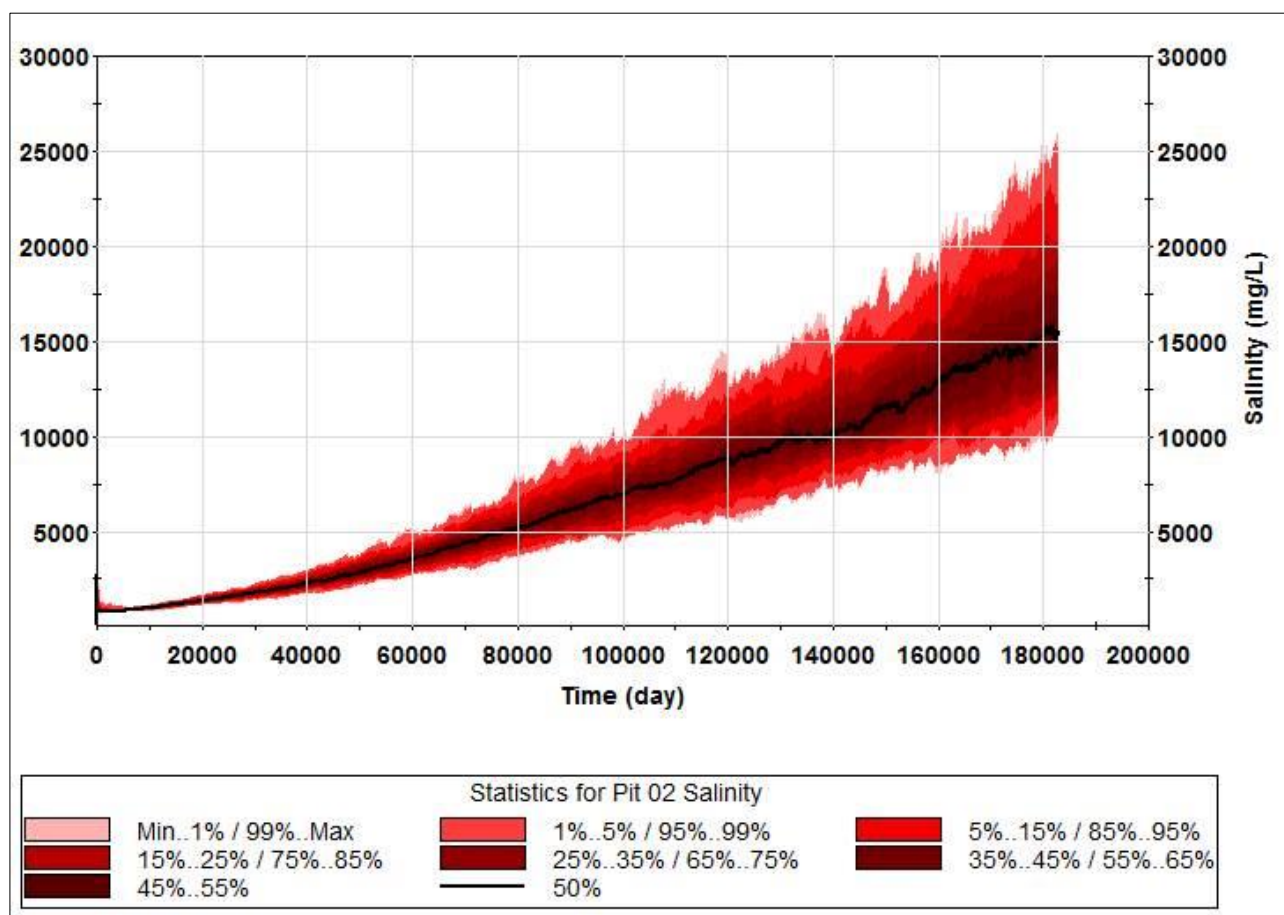
Figure 5.7 Predicted TDS concentration of void water – western residual void

5.3.2 Southern residual void

The risk of water quality deteriorating within the southern void to an un-usable status is higher than for the western void. This is because the southern void will not benefit from the diluting influence of basalt aquifer inflow (i.e. high flow and low TDS concentration) that is received directly by the western void.

The KBR (2017) stochastic water balance model predicts the TDS concentration of water in the southern void will be about 800 mg/L soon after mining. The TDS concentration is predicted to then increase at a rate of between 10 mg/L and 25 mg/L per year.

As a comparison to the western void, the average TDS concentration of the southern void water is predicted to increase to 4,000 mg/L after about 60,000 days (~164 years) post mining, as shown on Figure 5.8.



(Source: KBR, 2017)

Figure 5.8 Predicted TDS concentration of void water – southern residual void

6 Conclusions

The aim of this memo was to support the Minerva Mine void hydrology study by summarising the methods and data used to calculate future groundwater inflow rates into the western and southern residual voids. This memo also presented an assessment of the potential for void water to interact with surrounding aquifers, and the long-term void water quality.

Review of the void geometry confirmed that groundwater inflow to the southern residual void will only occur from the coal seams, because the basalt aquifer is not intersected by the highwall of this void. The highwall of the western residual void will intersect a significant thickness of basalt as well as the many coal seams. The basalt aquifer will be the major source of inflow to the western residual void.

The groundwater inflow rate to the western void is predicted to be consistently about 408 ML/year in the future because the hydraulic gradient within the basalt aquifer is unlikely to be influenced by the elevation of the void water level within the western void.

The groundwater inflow rate into the southern residual void will be considerably lower than the western residual void because the coal seams will be the only source of groundwater inflow. The groundwater inflow rate to the southern void is predicted to slightly decline as the void water level increases. The predicted inflow rate from the coal seams reduces from about 7.3 ML/year at the end of mining, down to about 6.4 ML/year at equilibrium.

All modelled scenarios predict the void water equilibrium level within western void will be at (or below) the base elevation of the basalt exposed in the highwall. These void water elevations will not be sufficient to reverse the hydraulic gradient, so groundwater is expected to perpetually move towards the void. The risk of water leaving the void into the basalt aquifer is low.

Water quality within the western void is predicted to deteriorate slowly over time, but will still be suitable for livestock watering (beef cattle) for about 465 years after mining.

The water quality within the southern void is predicted to deteriorate more quickly, but the southern void will be a regional hydraulic sink and the low quality water is expected to remain within the void.

7 References

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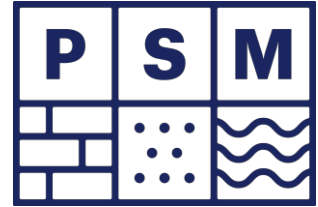
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Appendix B

PSM (2021). Highwall Stability Study – Geotechnical Closure Study. Internal Report to Sojitz Minerva Mining Pty by Pells Sullivan Meynink. 18 October 2021



Our Ref: PSM2432-124L REV1

18 October 2021

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Attention: Peter O'Donnell

Dear Peter

RE: HIGHWALL STABILITY - GEOTECHNICAL CLOSURE STUDY

1. Introduction

This report presents the results of a geotechnical assessment undertaken by PSM to inform the stability of final highwalls for the Main and South Pits at the Minerva Coal Mine (Minerva). The assessment has been undertaken at the request of Peter O'Donnell of Sojitz Minerva Mining Pty Ltd (Sojitz) via email to Alex Duran of PSM¹, with the agreed work package issued via email². The primary aim of the assessment is to assist in defining the closure bund location for final closure.

To complete this assessment, PSM have utilised experience gained by providing geotechnical advice for Minerva since 2014 and observations of wall performance and critical failure mechanisms. This report documents the background information, geotechnical model and parameters, adopted criteria, stability analyses and results of the geotechnical assessment providing a location of the closure bund for the remaining highwalls in the Main and South Pits.

This revision of the letter, to that presented on 6 October, has considered the diversion channel which wraps around the Main and South pits, Figure 1.

2. Overview

Sojitz is proposing to leave an open void in the west and northwest highwall of Main Pit and the west highwall in South Pit as part of the rehabilitation plan for Minerva. Minor spoil buttressing will be left behind in some areas following mining, but no spoil will be dumped as part of the rehabilitation plan. Current floor levels are at final level for both Main and South Pits.

¹ FW: MJV Main & South Pits LOM Reshaping-Remaining High Wall Stability, email from Peter O'Donnell of Sojitz to Alex Duran of PSM, received 31 August 2021.

² RE: MJV Main & South Pits LOM Reshaping-Remaining High Wall Stability, email from Alex Duran of PSM to Peter O'Donnell of Sojitz, sent 10 September 2021.

Figure 1 presents the location of both pits and the location of the highwall crest above the remaining void and with backfill along the eastern part of the Main pit and north wall of the South pit.

PSM have been provided five cross-sections, Figure 1, by Sojitz to undertake the geotechnical assessment. PSM have reviewed the geometries, and these are summarised Table 1.

Table 1 – Summary of slope characteristics

Pit	Section	Highwall Crest (mRL)	Overall Slope Height (m)	Overall Slope Angle (°)	Depth to Permian Rock (m) ¹
Main	1	280	158	41	48
	2	283	198	32	86
	3	280	195	43	86
South	4	280	147	49	17
	5	278	72	42	21

¹ Depth to Permian rock is measured from the highwall crest to the base of weathering as exposed in the highwall face.

3. Scope of Work

The scope of work for the stability study comprises:

1. Assessment of pit wall geotechnical stability, considering the effects of long-term erosion and weathering of the pit wall, on three sections within the Main Pit and two sections within the South Pit.
2. Provide guidance on the location of a closure bund based on the stability analyses and erosion considerations.

4. Approach

The geotechnical requirements for the MJV Residual Void Management Plan are defined as:

“a pit wall stability study, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events”

PSM has undertaken stability analysis to assess the stability of the proposed final void and define a location of a closure bund from the pit crest based on whichever of the following criteria is the furthest from the crest:

1. A minimum Factor of Safety (FOS) of 1.50 resulting from 2D Limit Equilibrium (LE) stability analyses.
2. Instability along adversely orientated major geological structure.
3. Consideration of long-term erosion.

PSM highlight that specific assessment of the potential long-term erosion has not been specifically carried out. Such assessment typically assumes a RUSLE approach (an empirical-based modelling approach that predicts the long-term average annual rate of soil erosion on slopes) or HEC-RAS modelling (sediment transport/mobile bed computations). These were deemed of limited value for several reasons:

- Much of the north and west walls in the Main pit are capped by high intact strength basalt and are unlikely to exhibit long term erosion
- In other areas the placement of the closure bund will limit the catchment providing the potential erosion to the pit crest
- PSM assume that all surface water flows will be directed away from closure bunds so they in turn are not subject to undue erosion
- For conservatism and based on closure studies dealing with sedimentary strata for others, a long term erosion of 50m from the crest line has been allowed for and defines the metric for the third item above.

This report has not assessed bench scale instability as such failures will be localised within the minimum offset of the closure bund.

The long-term stability of the open voids are dependent on several factors, with the most important being:

- The presence and orientation of major geological structures (i.e. faults and shears) within the pit slopes
- The strength of the rock mass within the pit slope
- The depth and characteristics of Tertiary materials and weathered rock within the pit walls, and their susceptibility to erosion over time
- The geometry of the pit wall
- The influence of groundwater and rainfall on slope stability
- The influence of buttressing effects by spoil or lake levels.

5. Data Sources

Sojitz have provided PSM with the following data to assist with the assessment:

- Five cross sections displaying:
 - Base of Tertiary material
 - Base of weathered material
 - Coal seams
 - Final pit void
 - In-situ mined surface.
- Hydrological assessment of the estimated final lake levels
- 1 in 1000 year flood zone within a diversion drain behind highwall crest, Figure 1.

PSM have also utilised previous work and experience for this study:

- Geotechnical parameters as defined in PSM2432-014L³
- Experience from site visit and involvement in geotechnical management during operations.

6. Geotechnical Model

6.1 Rock Mass Units

The rock mass units (RMU's) are based off those adopted in PSM2432-014L, as part of the study for the South Pit, and are summarised along with their relevant geotechnical parameters in Table 2.

Table 2 – Rock Mass Units for Main and South Pits

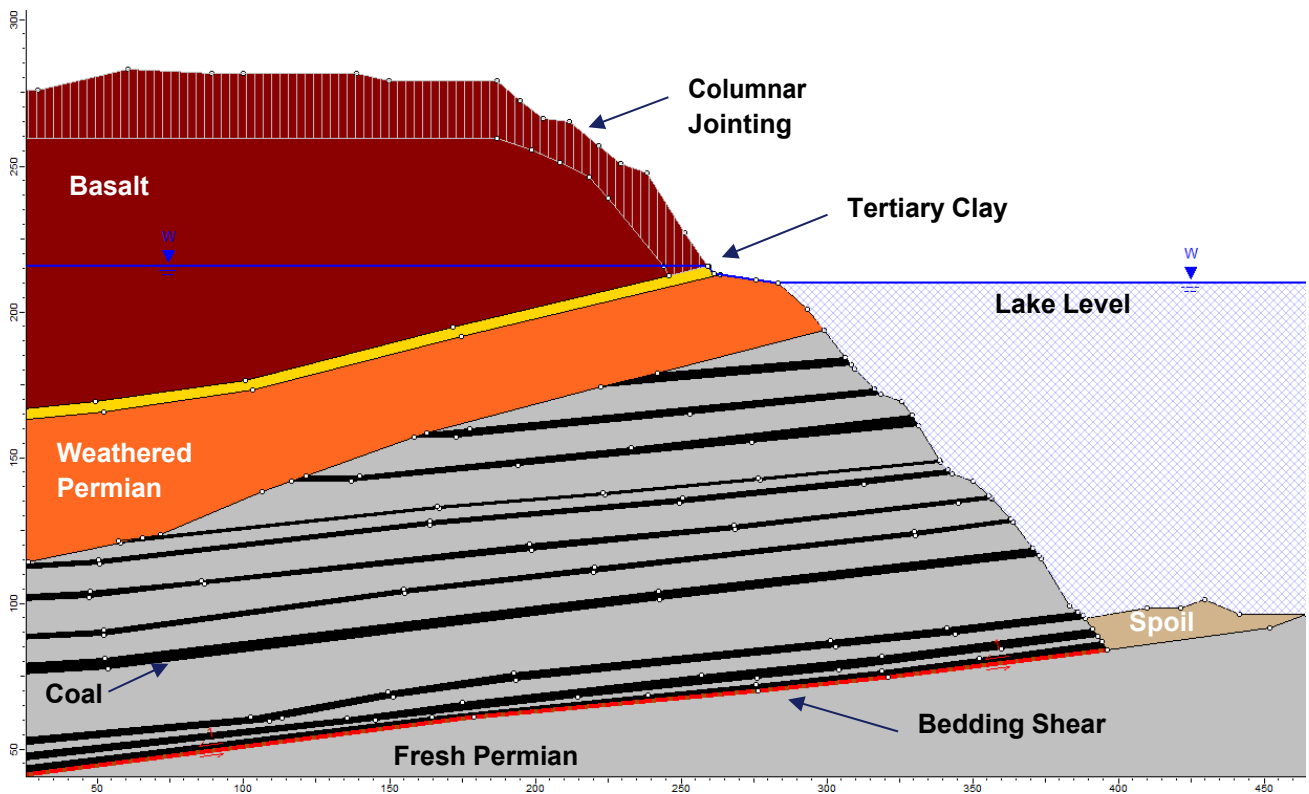
Rock Mass Unit	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (°)
Basalt	27	500	52
Tertiary Clay	20	25	2
Weathered Permian	22	80	30
Fresh Permian	22	450	45
Coal	15	100	35
Spoil (Unsaturated)	18	30	28
Spoil (Saturated)	20	15	23
Bedding Shear	20	0	18

³ Pells Sullivan Meynink (2015). *Highwall Offset from South Pit Creek Diversion*, dated 17 May 2021, referenced as PSM2432-014L.

6.1.1 Main Pit

The geotechnical model for Main Pit is presented in Inset 1 below. Key comments include:

- Base of Tertiary, base of weathering, coal seams and in-situ boundary as supplied by site
- Some coal seams have been excluded or combined for simplicity
- Thickness of Tertiary Clay is modelled as 5 m, as confirmed by site
- Shearing along all coal seams has been assumed, to represent a conservative approach, with the most adverse bedding shear controlling the closure bund offset
- PSM have increased the rock mass strength of the basalt from the assessment reported on 6 October 2021 and have included the presence of columnar jointing which allows tension crack formation.

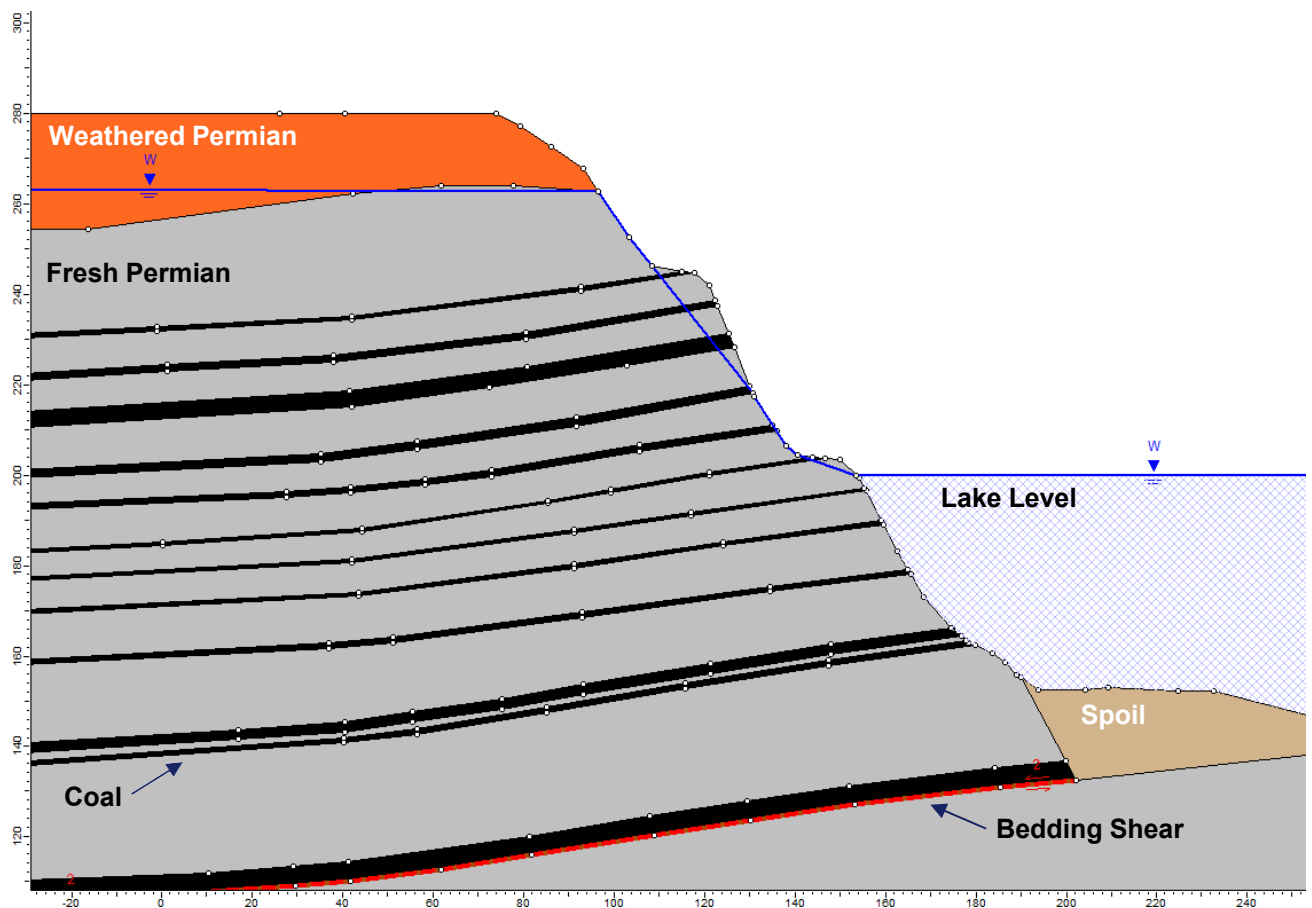


Inset 1: Geotechnical Model for Main Pit (Section 3).

6.1.2 South Pit

The geotechnical model for South Pit is presented in Inset 2 below. Key comments include:

- Base of weathering, coal seams and in-situ boundary as supplied by site
- Some coal seams have been excluded or combined for simplicity
- No Tertiary clay is modelled in South Pit, as confirmed by site
- Shearing along all coal seams has been assumed, to represent a conservative approach, with the most adverse bedding shear controlling the closure bund offset.



Inset 2: Geotechnical Model for South Pit (Section 4).

6.2 Geological Structure

Based on PSM's experience at Minerva, no major geological structures (faults or shears) are adversely orientated to undermine global stability for the pit wall that will remain exposed within the Main and South Pit.

6.3 Hydrogeology

Hydrogeological modelling⁴ has been undertaken as part of the rehabilitation plan for Minerva. PSM have reviewed these results and made the following assumptions which will be incorporated within the stability analyses:

- Maximum Lake Level of RL 210 for Main Pit and RL 200 for South Pit
- Lake Level at RL 185 which is at the low end of the range supplied in the hydrogeological modelling
- Lake Level at RL 140 considered a pessimistic scenario
- No Lake established, which will be the conditions at closure and to assess stability before a lake develop.

The water table is assumed confined by the Tertiary clay in the Main Pit and following the base of weathering in the South Pit with no drawdown considered.

⁴ Australian Groundwater and Environmental Consultants Pty Ltd (2017), *Minerva Residual Void Investigation – Groundwater Inflow Calculation*, dated 21/07/2017, report number G1753D.

7. Pit Slope Stability Assessment

2D LE analyses using the GLE-Morgenstern Price Method have been completed assuming two potential critical failure mechanisms:

- A circular failure mechanism for material above the base of weathering in the Permian

A block sliding failure mechanism controlled by sliding along a bedding shear with parameters defined in Table 2.

Stability analyses were completed for Sections 1 to 3 for the Main Pit and Sections 4 and 5 for the South Pit. The results of the LE analyses are presented in Appendix A and which considered the range of potential lake levels. The key results are summarised below in Table 3 for the end members of no lake and maximum expected lake level. PSM highlight that the critical scenario for stability is where there is no lake developed as the ponded water in the pit acts as a supporting buttress applying pressure to the highwall.

PSM have assessed block sliding along bedding parallel shears within the key coal seams in the highwall to assess the critical location, which typically has comprised the lowest exposed coal seam in the highwall. The potential failure path that provided the furthest distance from the crest whilst achieving a FOS greater than 1.50 will control the closure bund location and is therefore presented below.

Table 3 – Summary of LE analysis for closure bund offset

Section	Lake Level	Minimum Global FOS	Distance (m) from Pit Crest where FOS = 1.50	Recommended Closure bund offset (m)
Section 1 (Main Pit)	No Lake	1.84 - circular	0	50
	No Lake	1.35	48	
	RL 210	1.84	0	
Section 2 (Main Pit) ¹	No Lake	1.10 - circular	0	50
	No Lake	1.07	0	
	RL 210	1.81	0	
Section 3 (Main Pit)	No Lake	1.84 - circular	0	125
	No Lake	0.90	126	
	RL 210	1.34	14	
Section 4 (South Pit)	No Lake	Circular not analysed	0	100
	No Lake	1.05	100	
	RL 200	1.25	83	
Section 5 (South Pit) ²	No Lake	2.17 - circular	0	50
	No Lake	1.44	22	

¹ Section 2 has a 110 m wide bench at RL 235, with the crest location modelled as RL 280.

² Section 5 has only been modelled No Lake due to the pit floor being above the maximum lake level of RL 200.

The results in Table 3 show that a maximum offset for the closure bund is required in the location of Section 3 for the Main Pit of 125 m and for Section 4 in the South Pit of 100 m respectively. These two cases represent the most adverse conditions in each pit. The other areas require the minimum offset from the closure bund of 50 m and which allows for long term erosion.

PSM highlight the analyses indicate the most adverse scenario, i.e. lowest FOS, is associated with the lowest lake level and with global pit wall stability marginally improving as lake levels increase. Thus, whilst maximum

lake levels indicate the closure bund could be located closer to the pit crest, Sojitz should allow for the no lake scenario and in view that final lake levels often take several decades to a century to establish.

Figure 1 highlights that the analyses suggest the closure bund for South Pit interacts with the 1 in 1000 year flood within the diversion channel. As part of this revised assessment, PSM have addressed stability analyses that consider a backfill buttress in the South Pit to mitigate the risk.

The results of the stability analyses for the recommended buttress are within Appendix A. PSM have assumed that the buttress can be emplaced from the wide access available in the south and with the buttress being “locked” into the north wall to ensure adequate 3-dimensional affects. The required spoil buttress design that achieves a closure bund offset of 50 m, to mitigate interaction with the diversion channel, comprises:

- 80 m wide bridge built from the South at RL 205
- Slope angle of 37° as angle of repose in spoil.

PSM flag that the buttress will have an overall height of nominally 80m and will either require that:

1. It is progressively built up in lifts each of nominally 20 to 30m in height, commencing from the pit floor, or
2. Developed utilising a similar approach to the high dump in the Main Pit.

If the latter approach is adopted, it is critical that the dumping be onto clean floor and with no water.

8. Conclusions and Recommendations

The location of the closure bund is presented in Figure 1 with the recommended closure bund offset presented in Table 3. For the South Pit a buttress is recommended to allow the closure bund to remain outside the impacts of the diversion channel, the design for the buttress is provided above and nominally indicated in Figure 1

An electronic copy of the closure bund location has been provided in .dxf format with transmittal of this letter.

9. Closure

We trust this report meets your immediate requirements. Please contact the undersigned if you have any queries or wish to discuss or clarify any aspect of the report.

Yours Sincerely



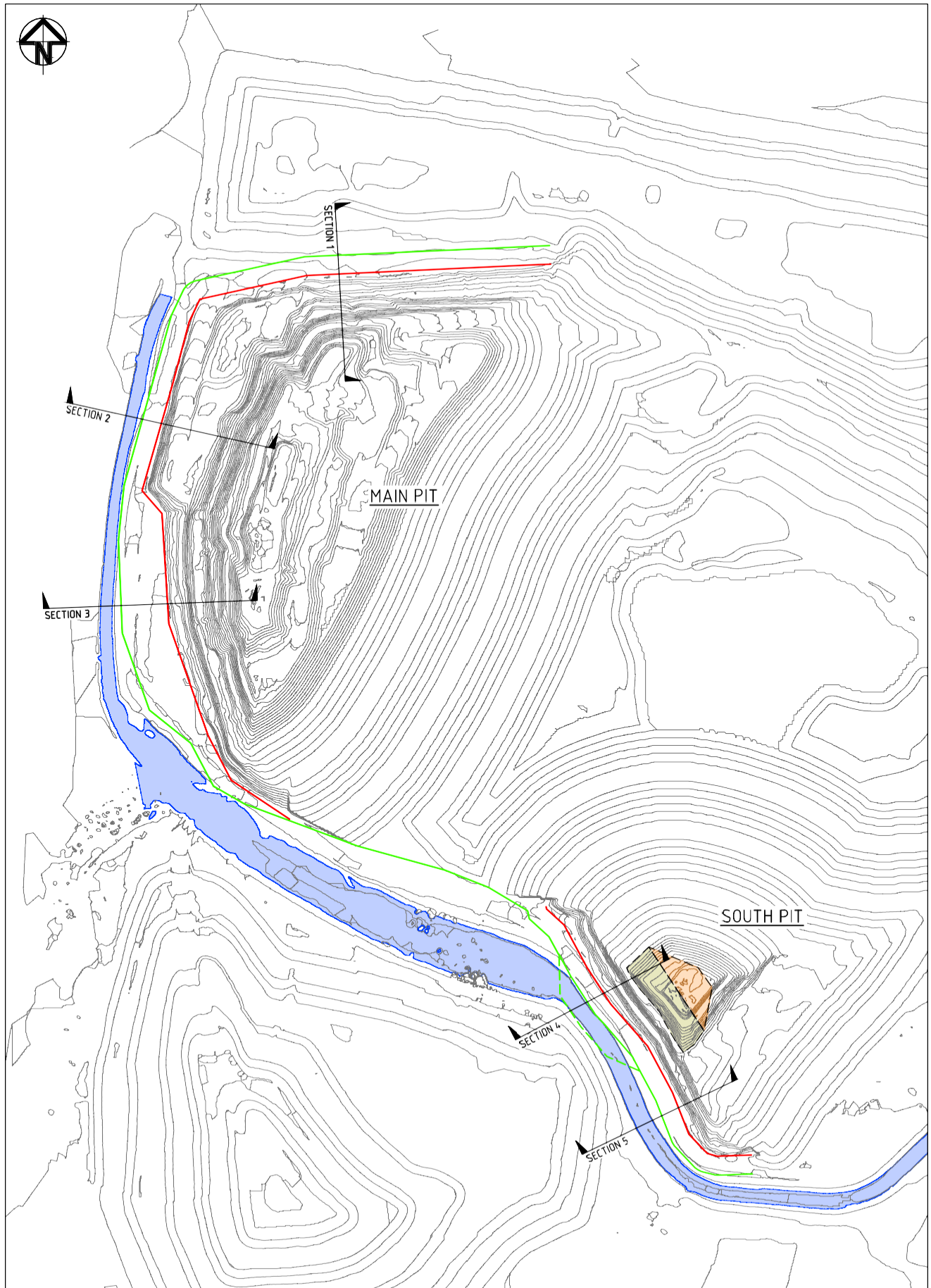
HARRISON CROOKS
ENGINEERING GEOLOGIST



ALEX DURAN
PRINCIPAL
RPEQ 10461

Enc. Figure 1: Main Pit and South Pit Locality Plan

Appendix A: Stability Analyses



LEGEND

- CLOSURE BUND LOCATION
- - - CLOSURE BUND LOCATION (SOUTH PIT WITHOUT BUTTRESS)
- REMAINING HIGHWALL CREST ABOVE VOID (SUPPLIED BY SITE)
- 1:1000 YEAR FLOOD EXTENTS
- PROPOSED SOUTH PIT BRIDGE
- PROPOSED SOUTH PIT BUTTRESS
- SECTION LINE
- PROPOSED FINAL TOPOGRAPHY (5m CONTOURS)

0 50 100 150 200m
SCALE 1:5000m



NOTE: CLOSURE BUND LOCATION WILL ALSO BE PROVIDED ELECTRONICALLY IN .DXF FORMAT

Sojitz Minerva Mining Pty Ltd
Minerva Coal Mine
Highwall Geotechnical Closure Study
MAIN PIT AND SOUTH PIT
LOCALITY PLAN

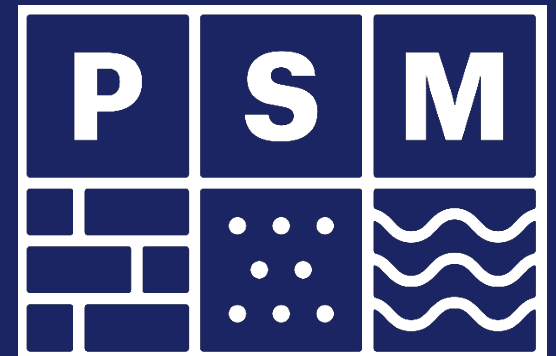
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Figure 1

Appendix A

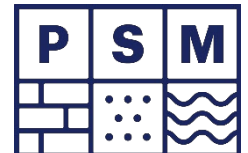
Stability Analyses

Minerva Main and South Pits – Remaining Highwall Stability

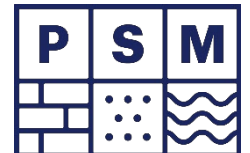
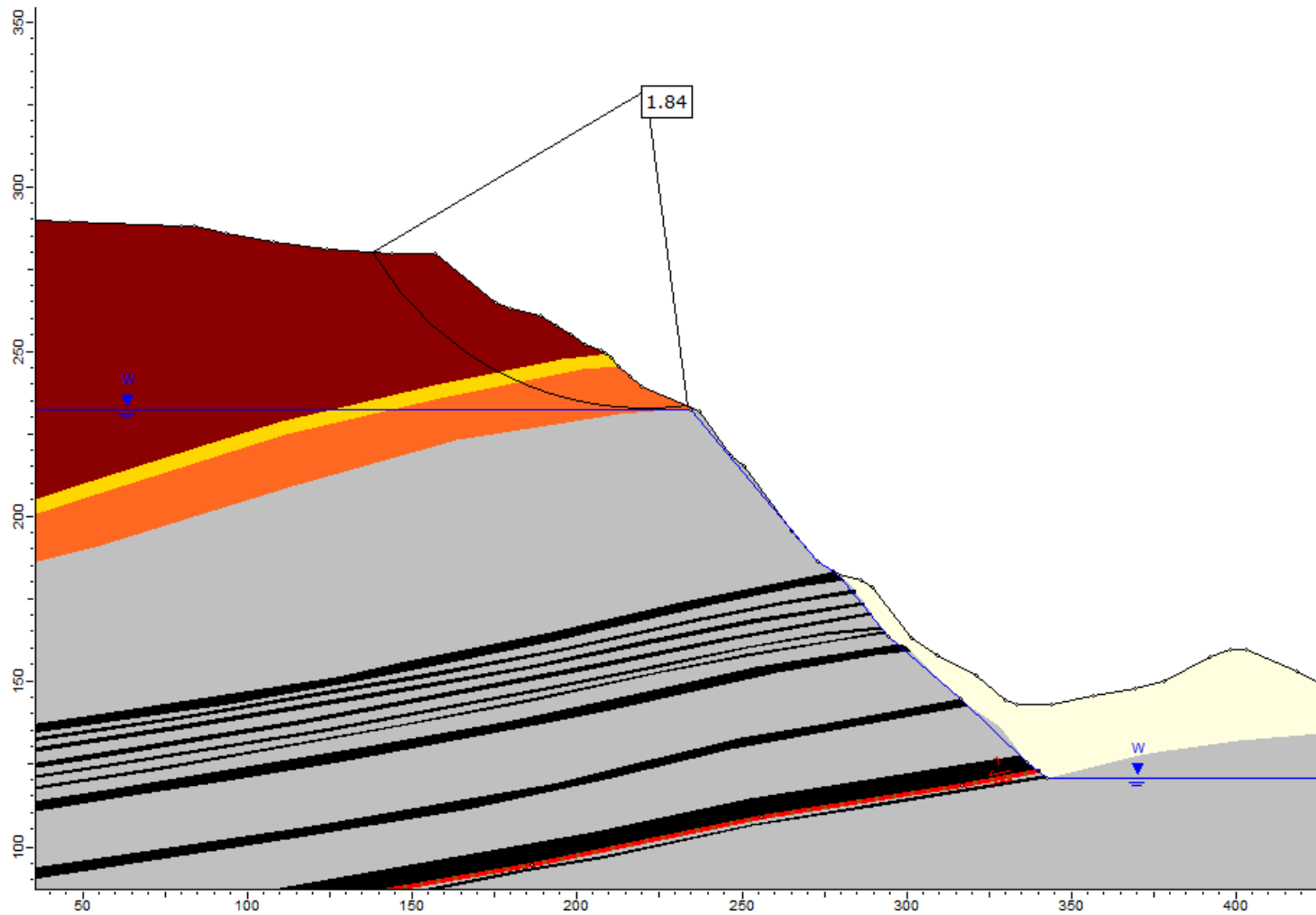


Material Properties

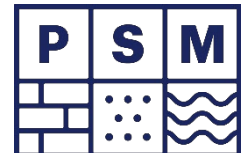
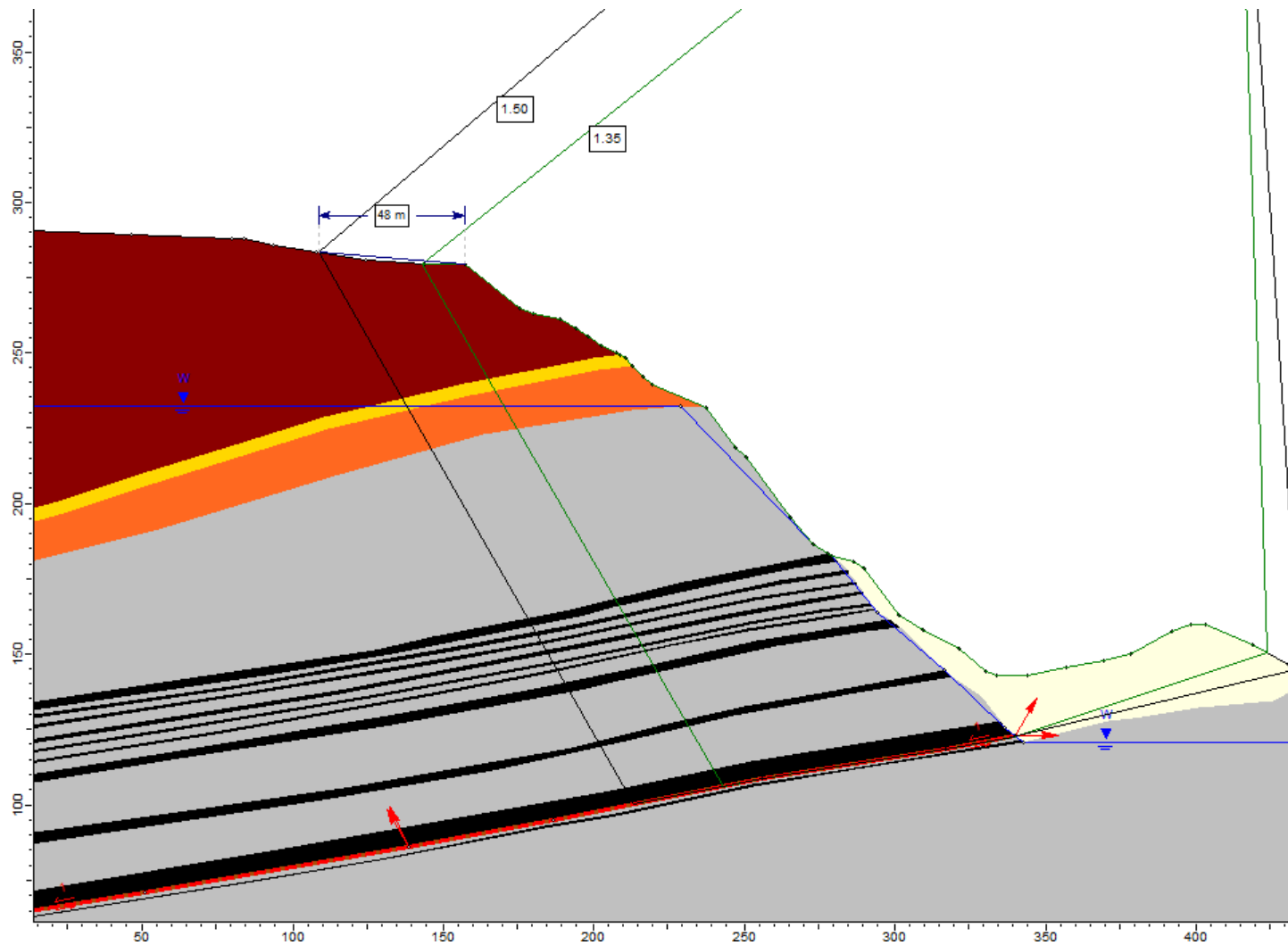
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface
Basalt		27	Mohr-Coulomb	500	52	Water Surface
Tertiary Clay		20	Mohr-Coulomb	25	2	Water Surface
Weathered Permian		22	Mohr-Coulomb	80	30	Water Surface
Fresh Permian		22	Mohr-Coulomb	450	45	Water Surface
Coal		15	Mohr-Coulomb	100	35	Water Surface
Cat2U		18	Mohr-Coulomb	30	28	Water Surface
Cat2S		18	Mohr-Coulomb	15	23	Water Surface
Shear 0/18		20	Mohr-Coulomb	0	18	Water Surface



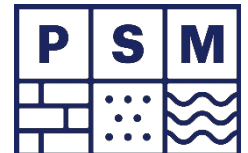
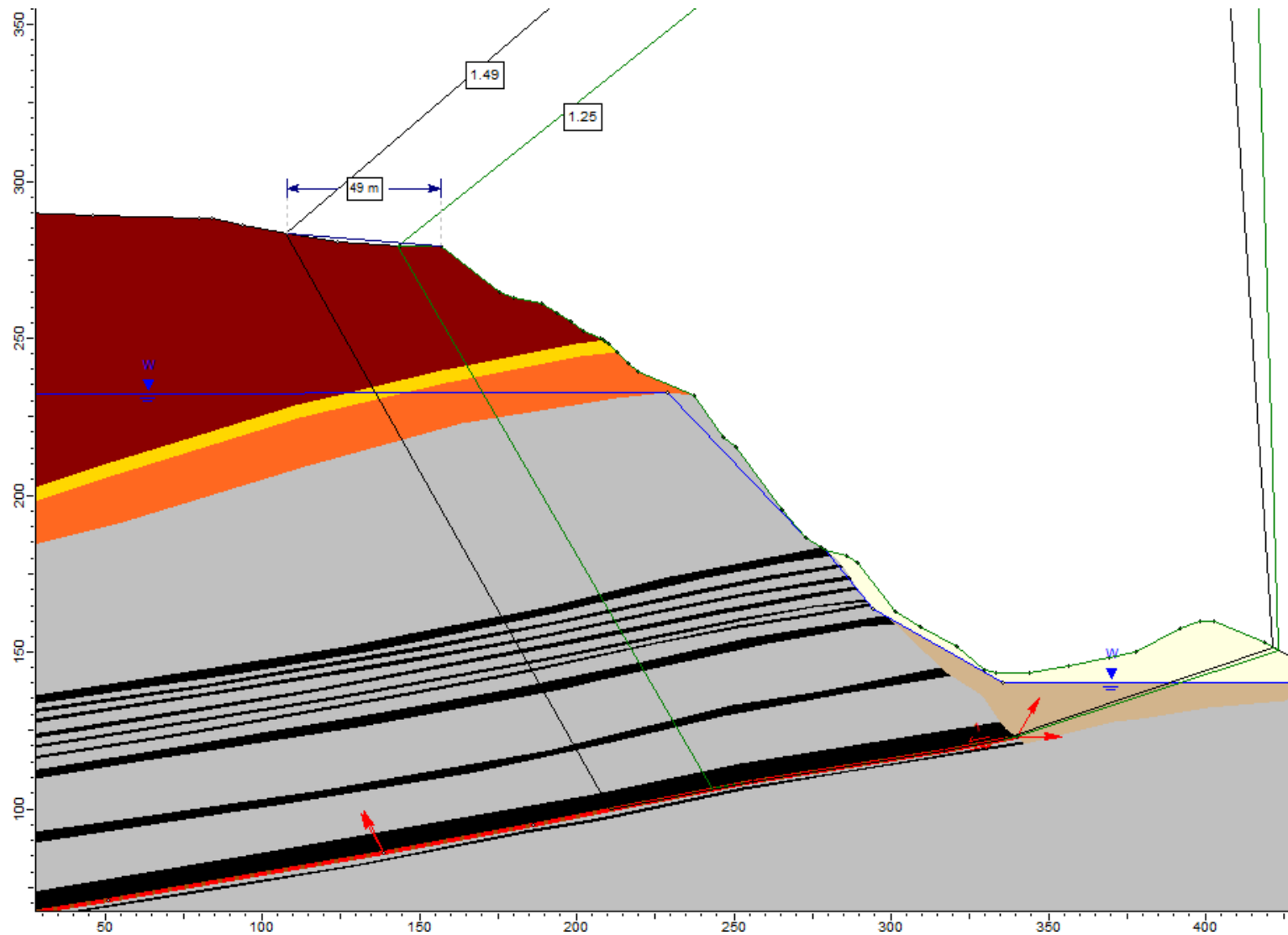
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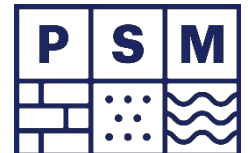
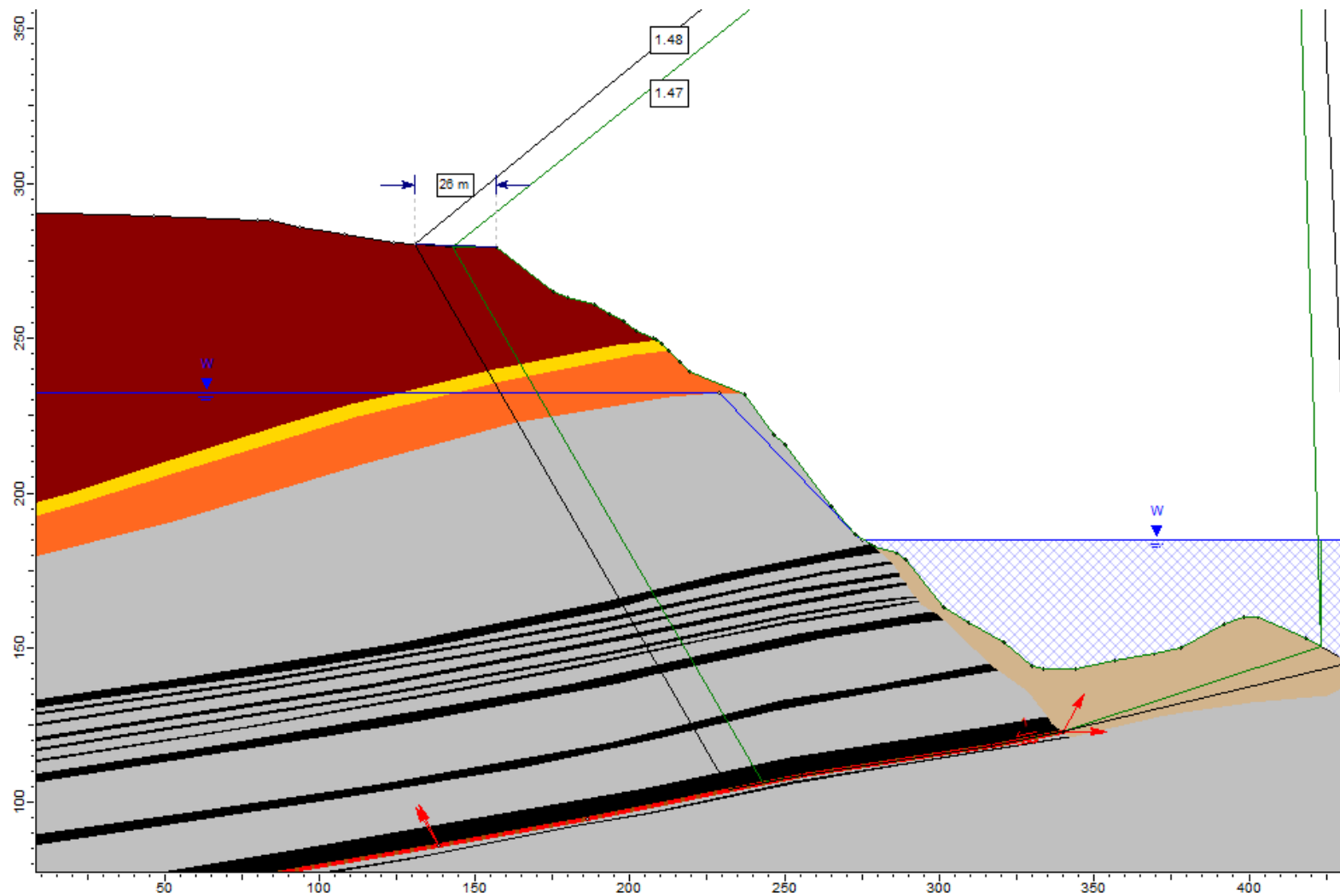
Section 1 –No Lake, Sliding along MN4 Seam



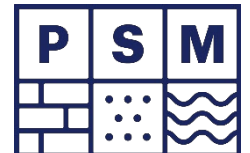
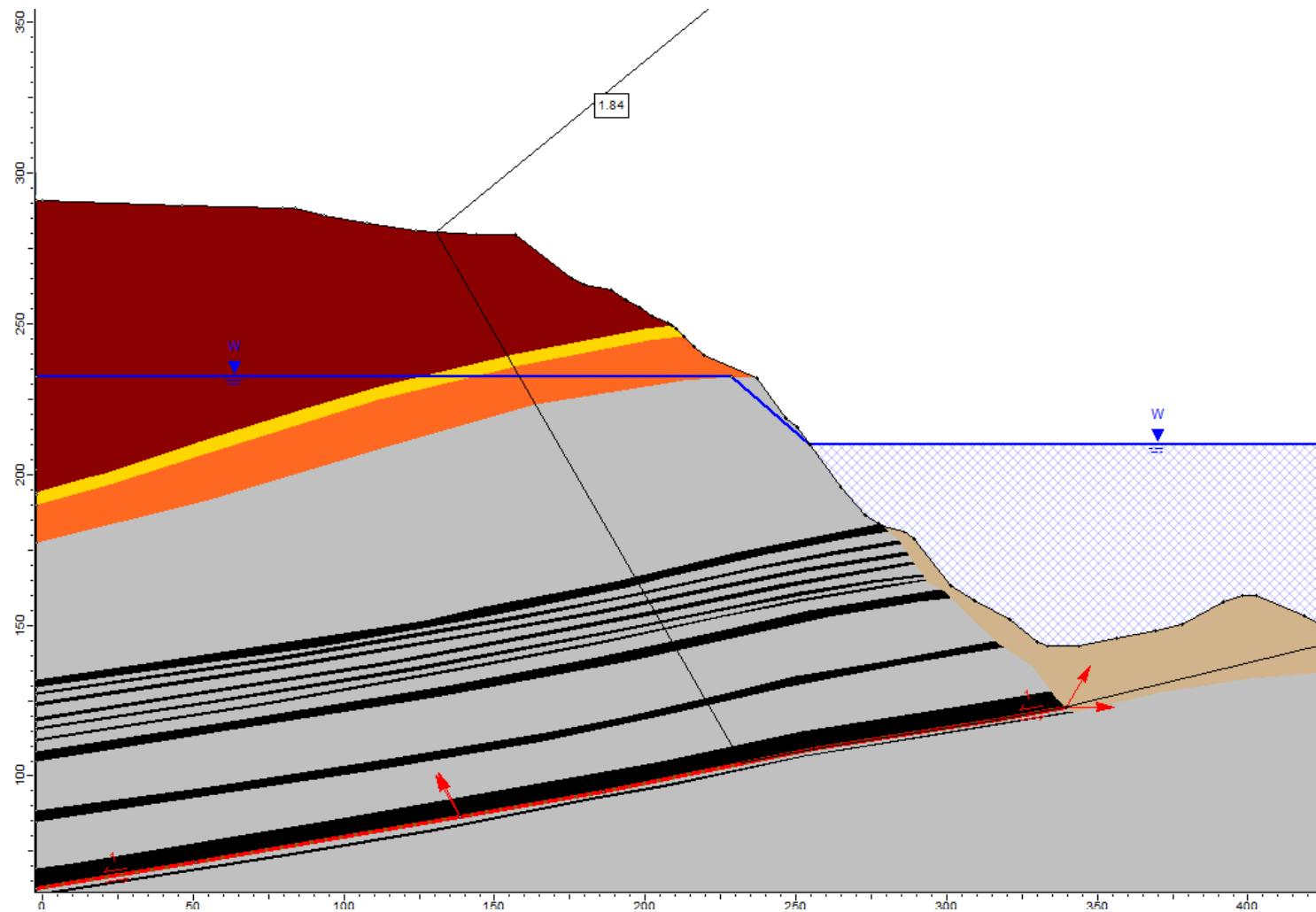
Section 1 –Lake at RL140, Sliding MN4 Seam



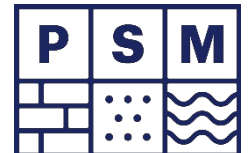
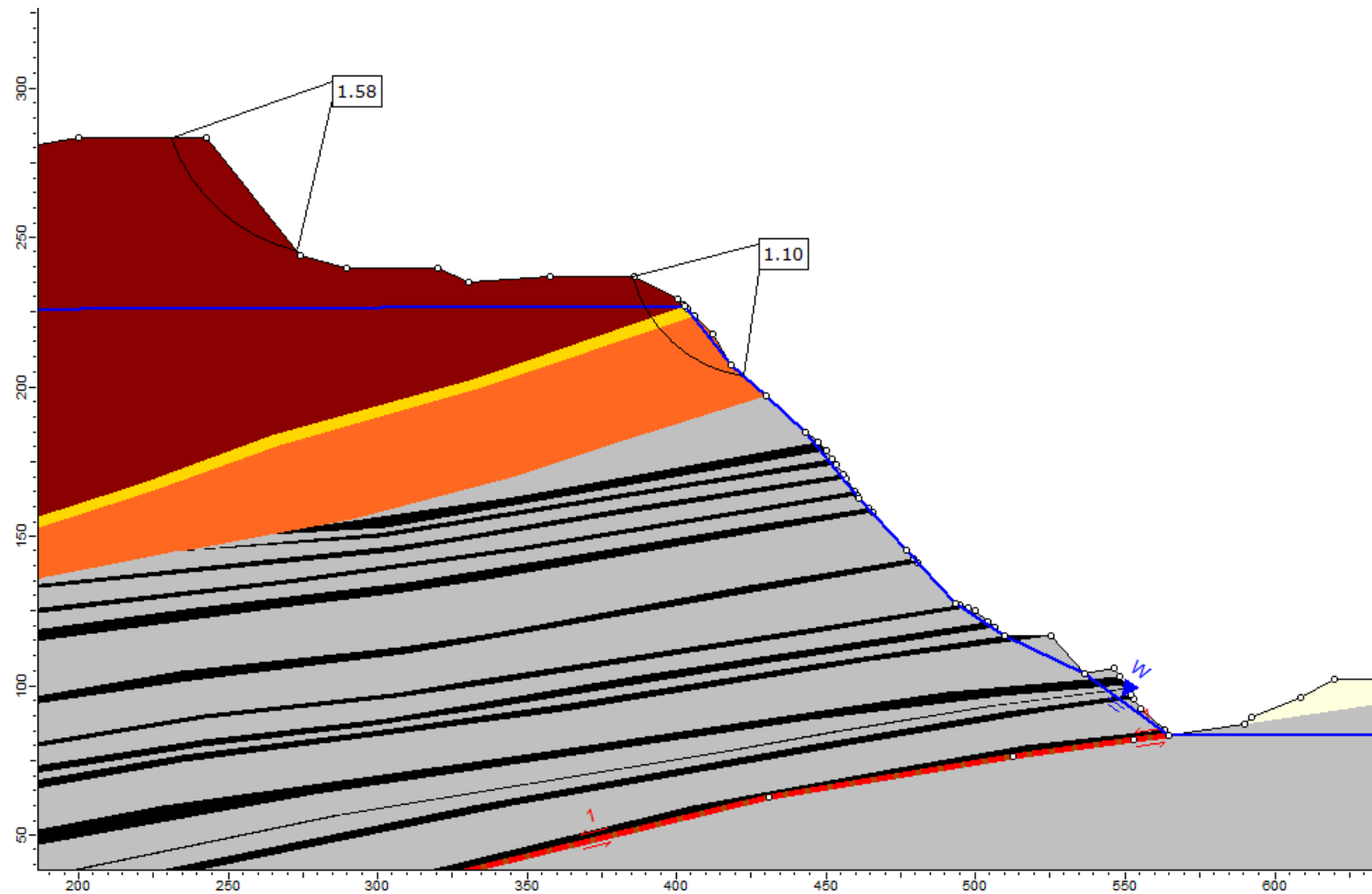
Section 1 –Lake at RL185, Sliding MN4 Seam



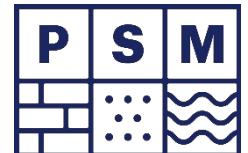
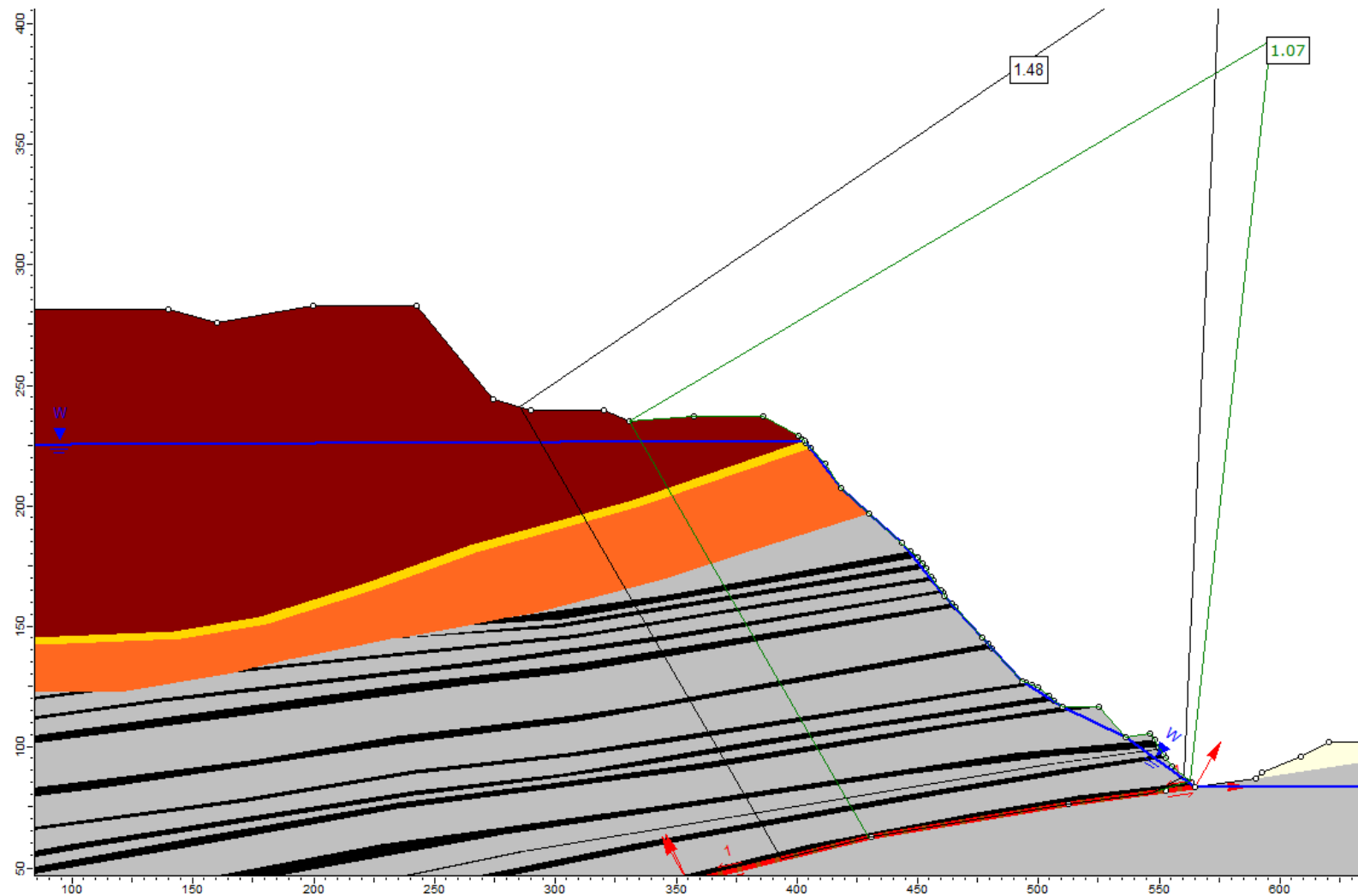
Section 1 –Lake at RL210, Sliding MN4 Seam



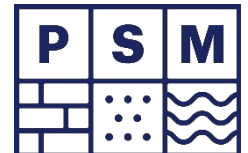
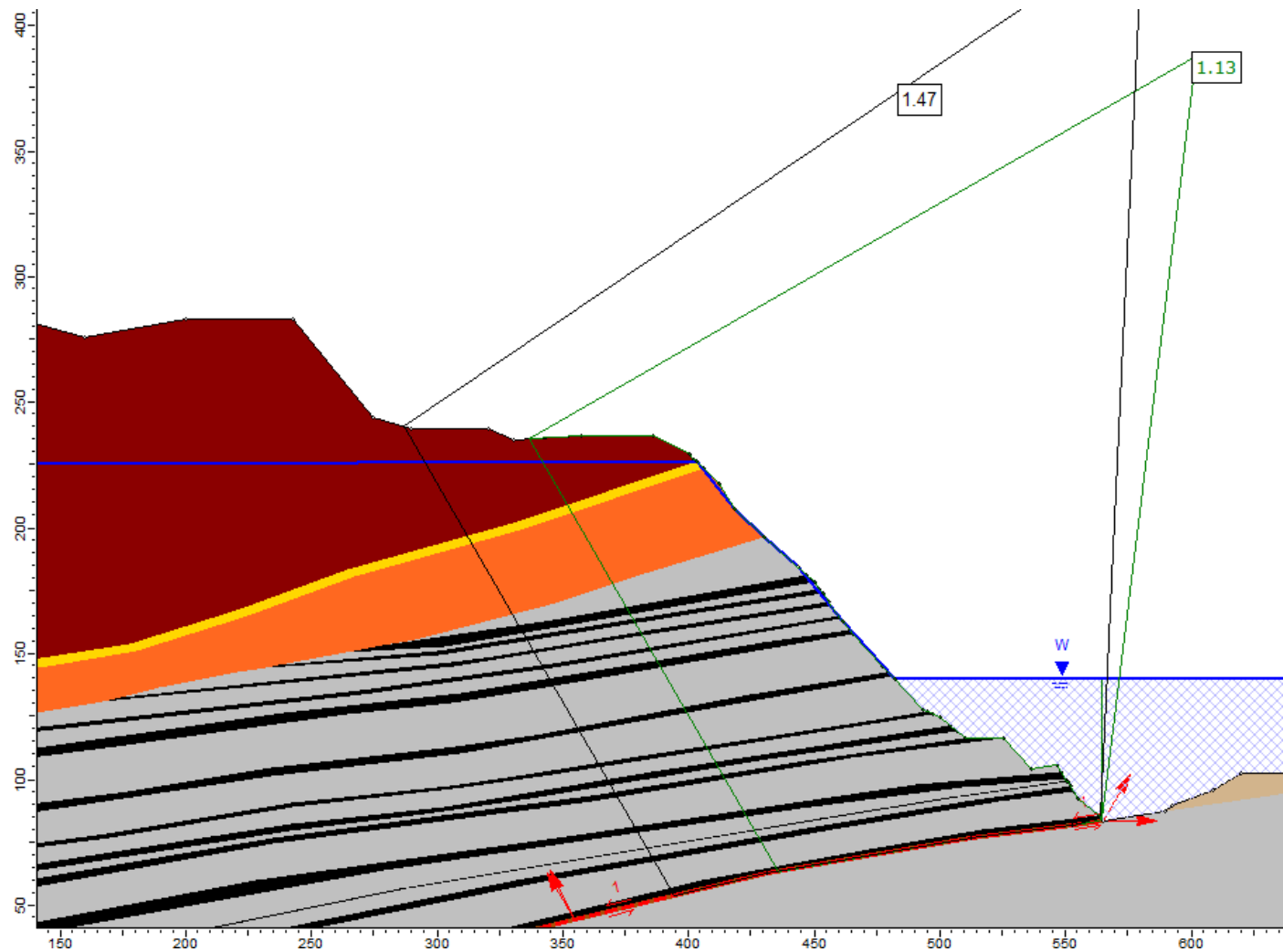
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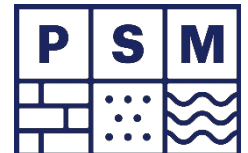
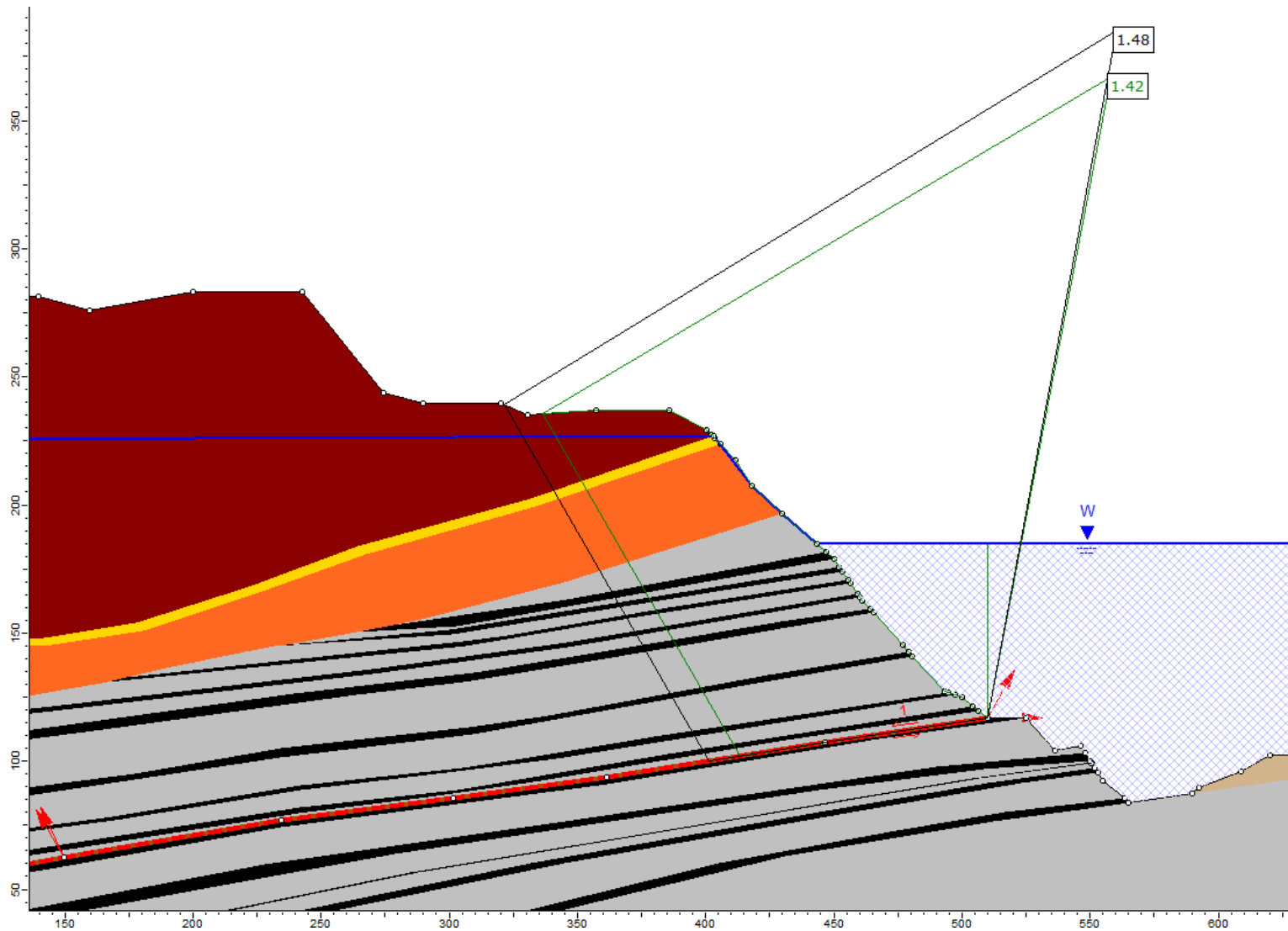
Section 2 –No Lake, Sliding MN10 Seam



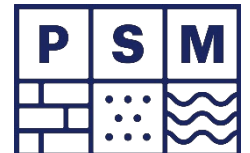
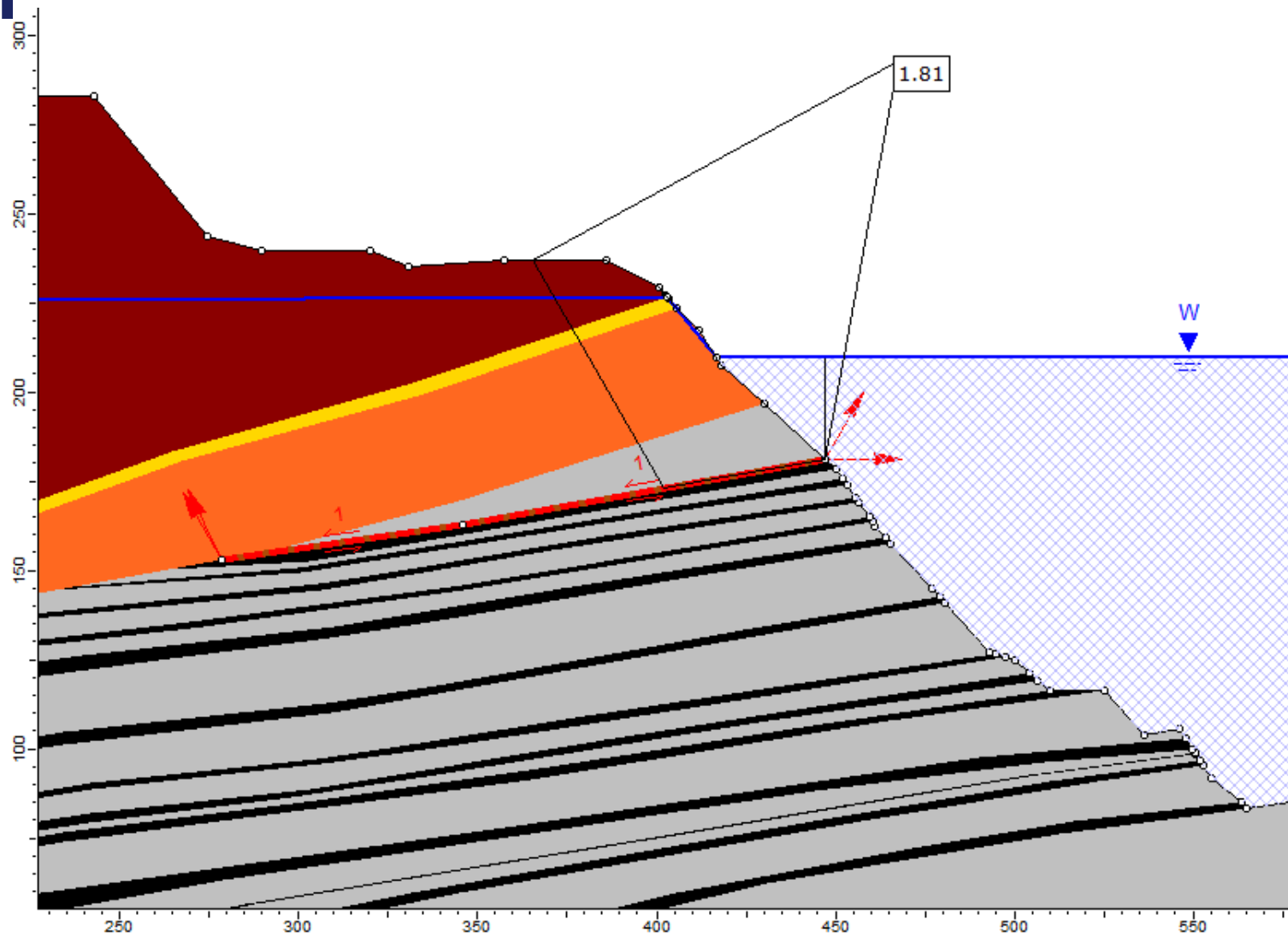
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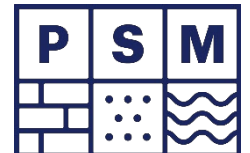
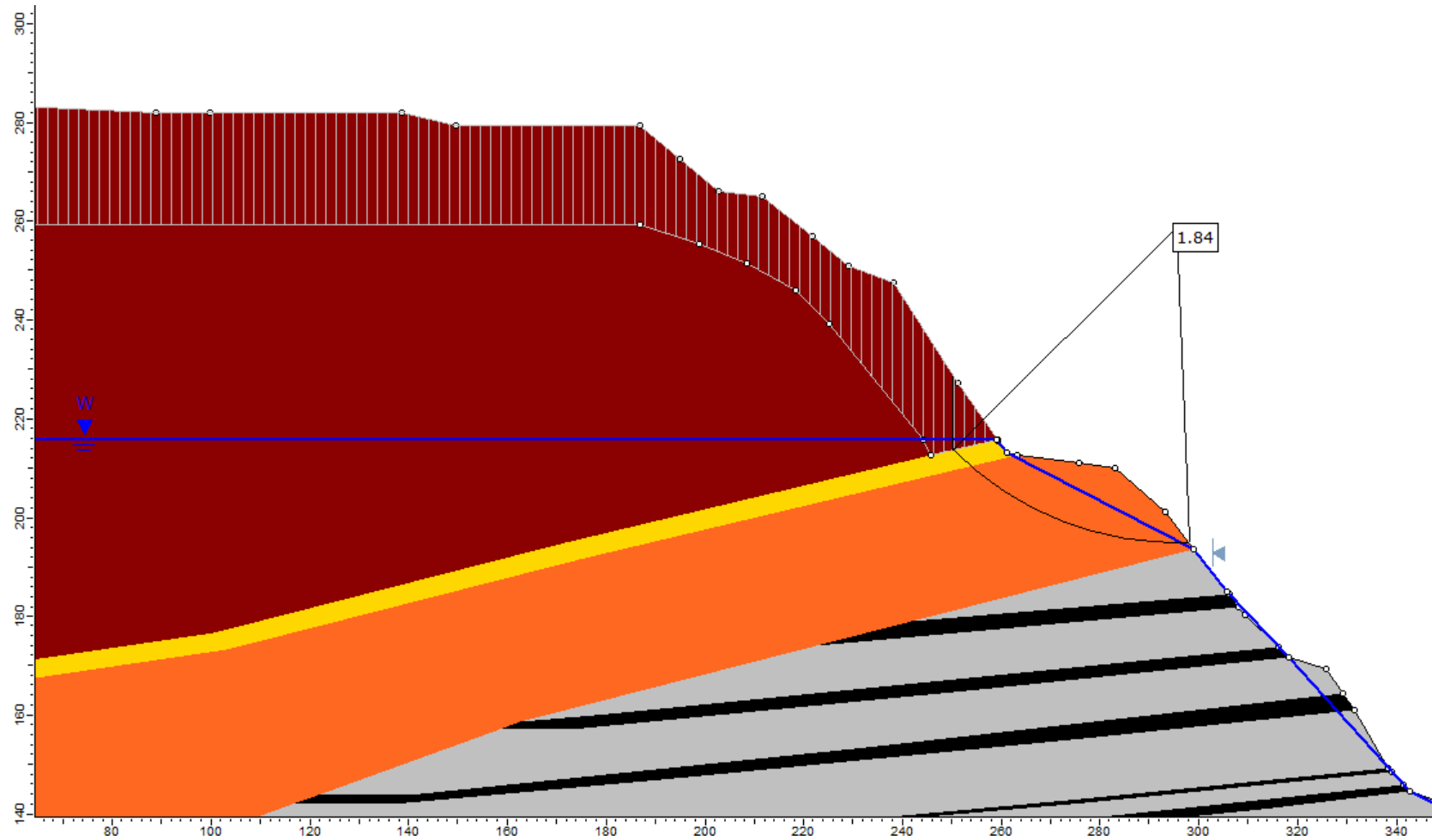
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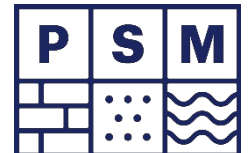
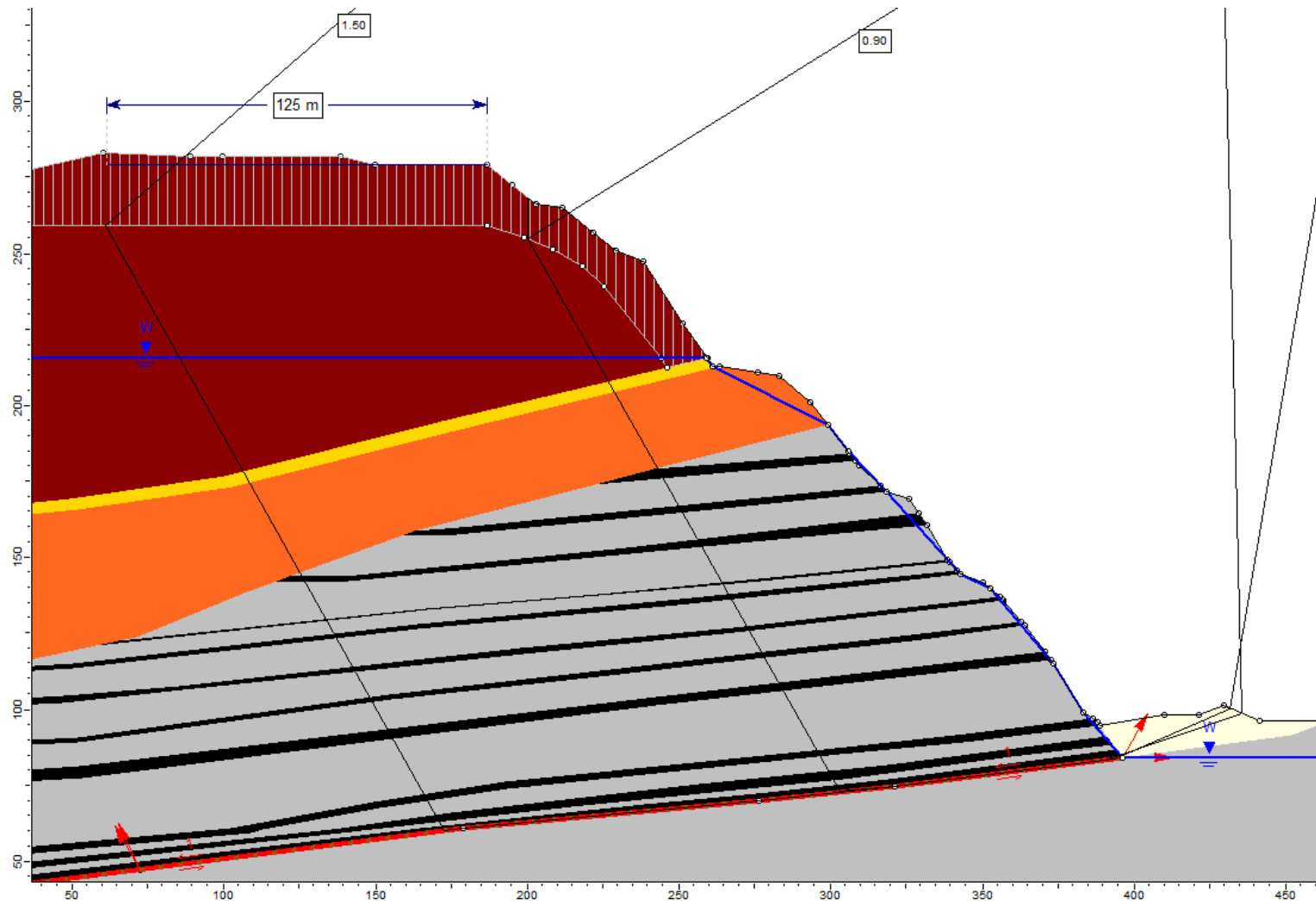
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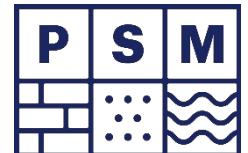
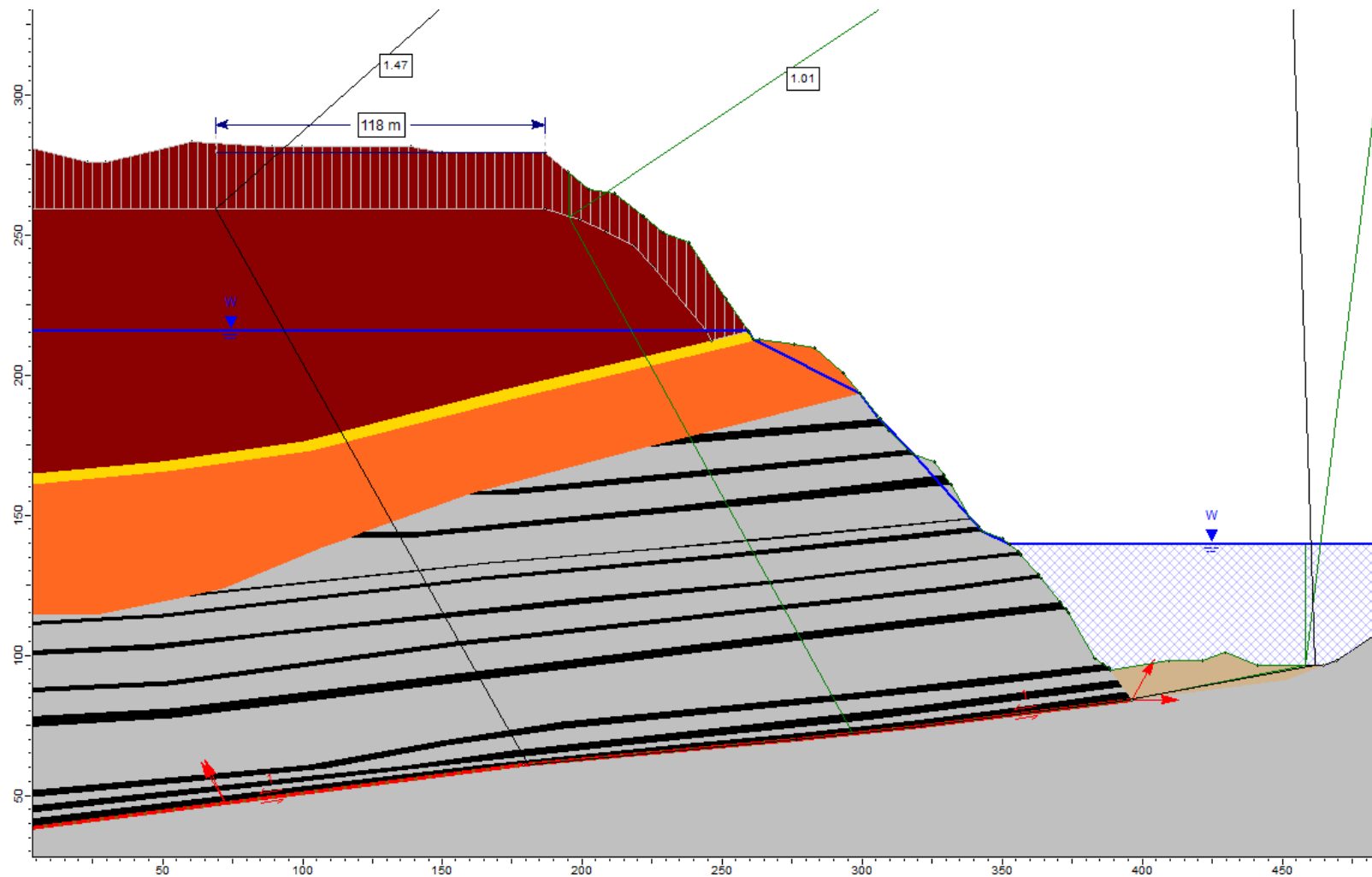
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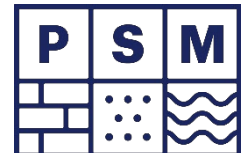
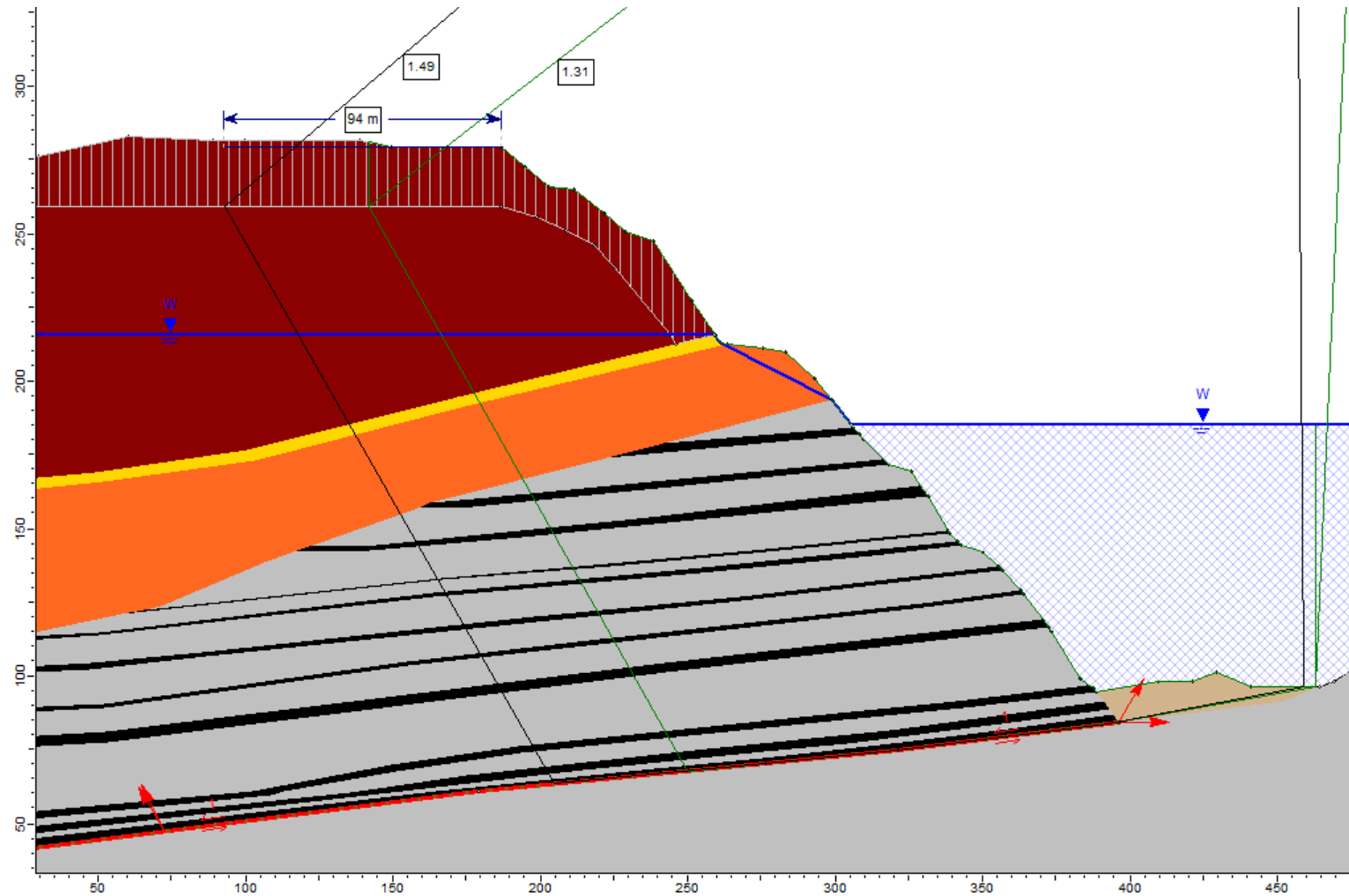
Section 3 –No Lake, Sliding MN10 Seam



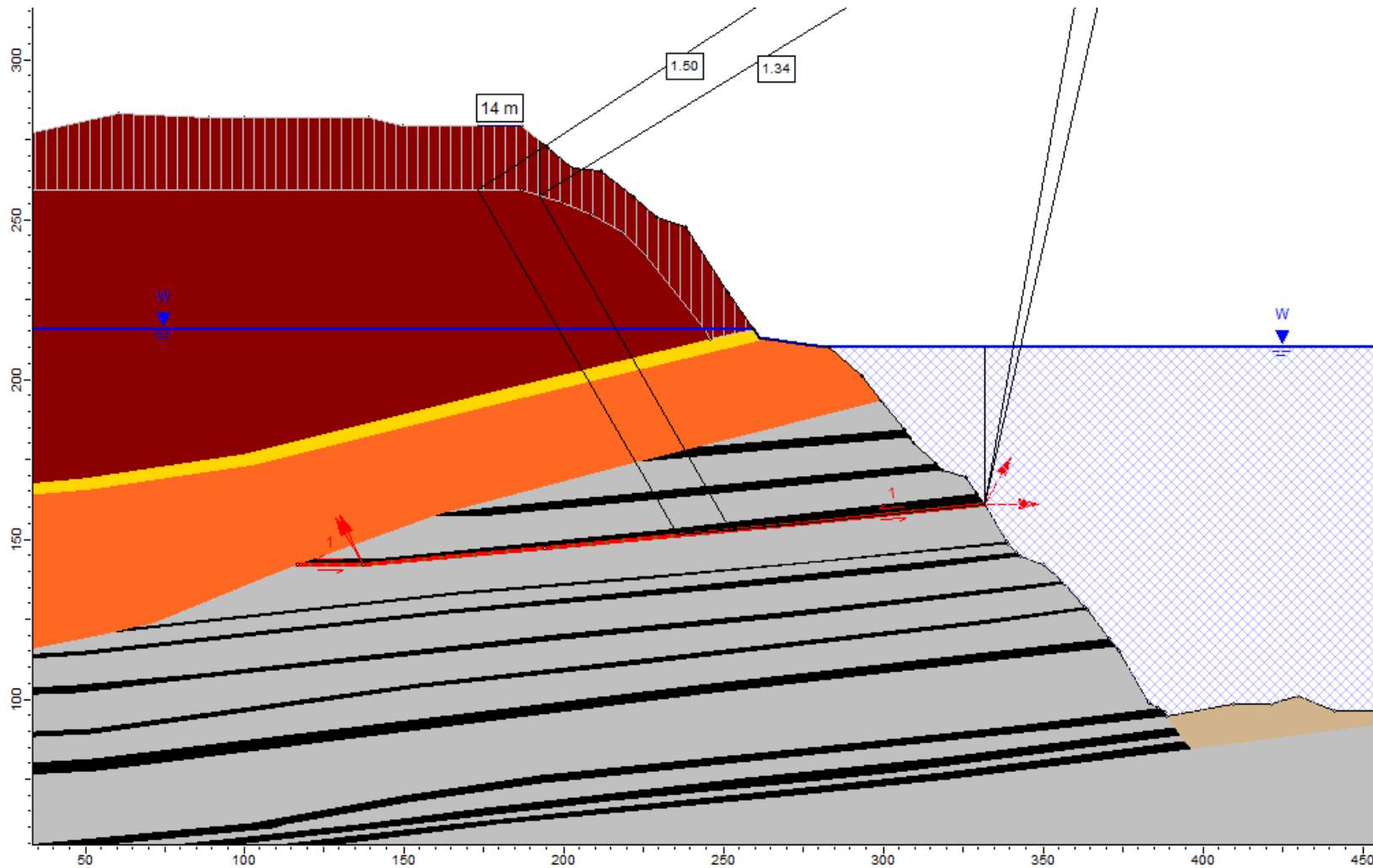
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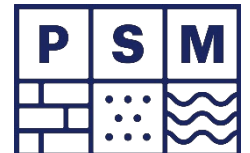
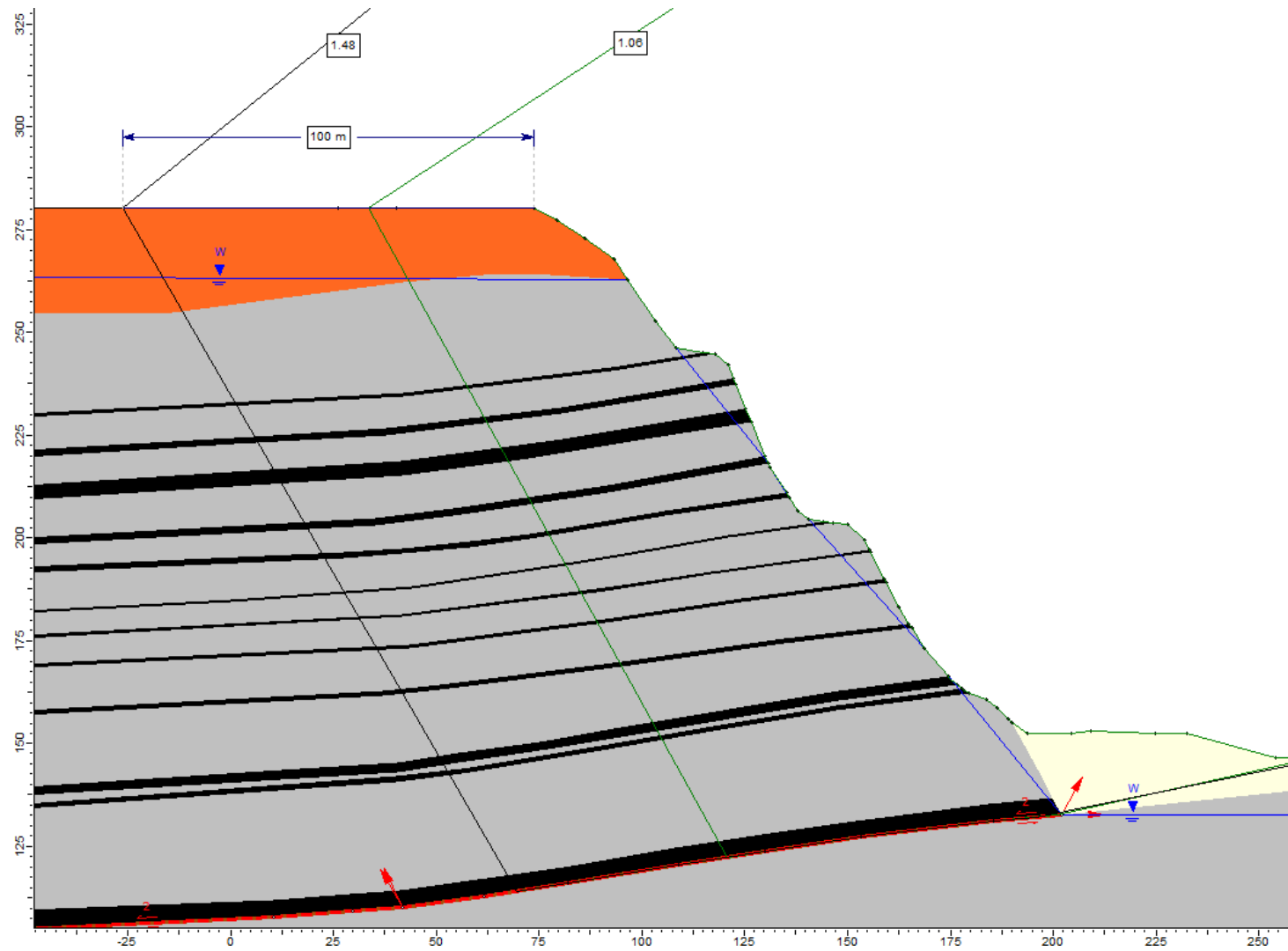
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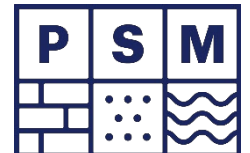
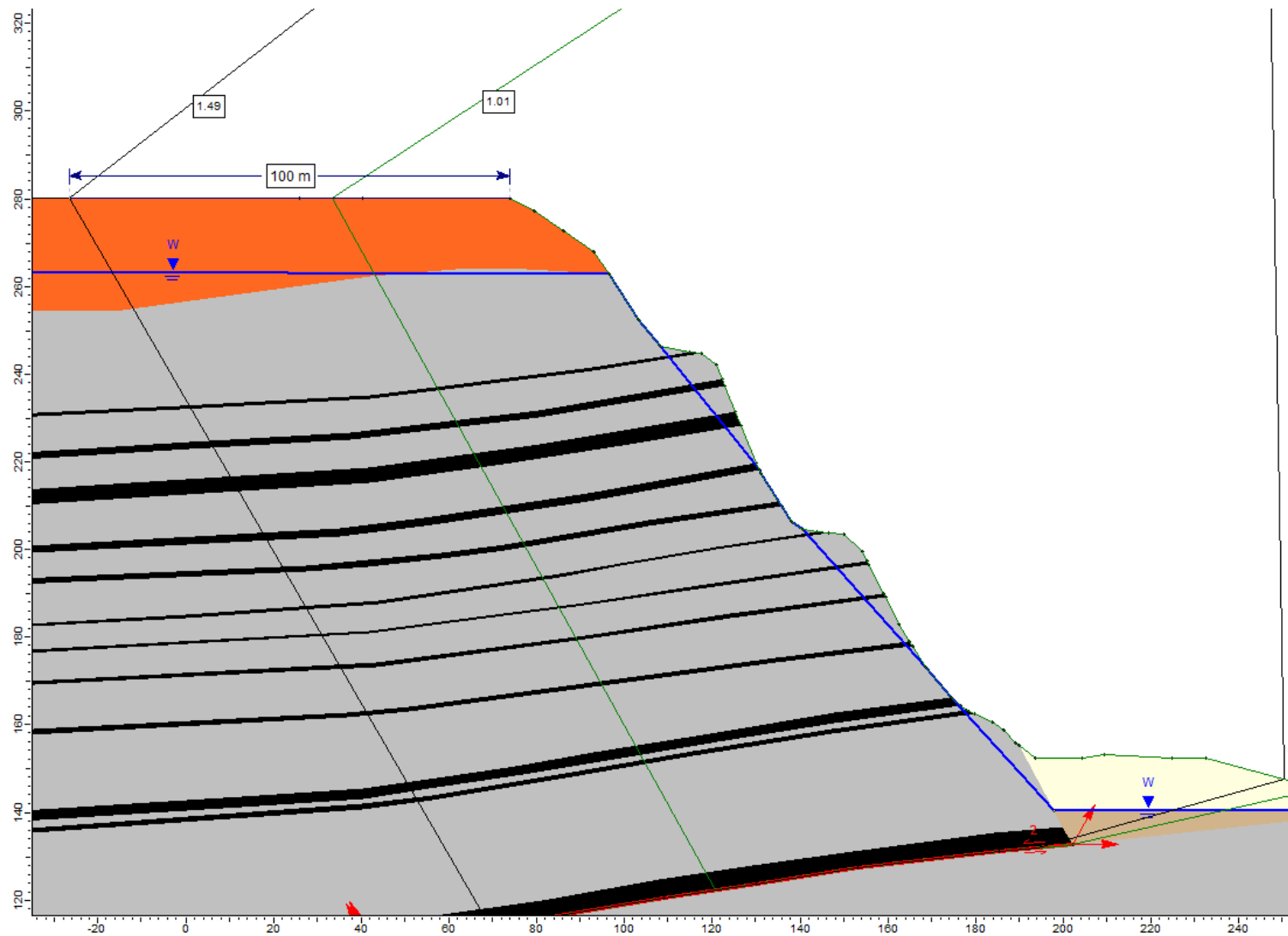
Section 3 –Lake at RL210, Sliding WU Seam



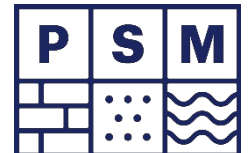
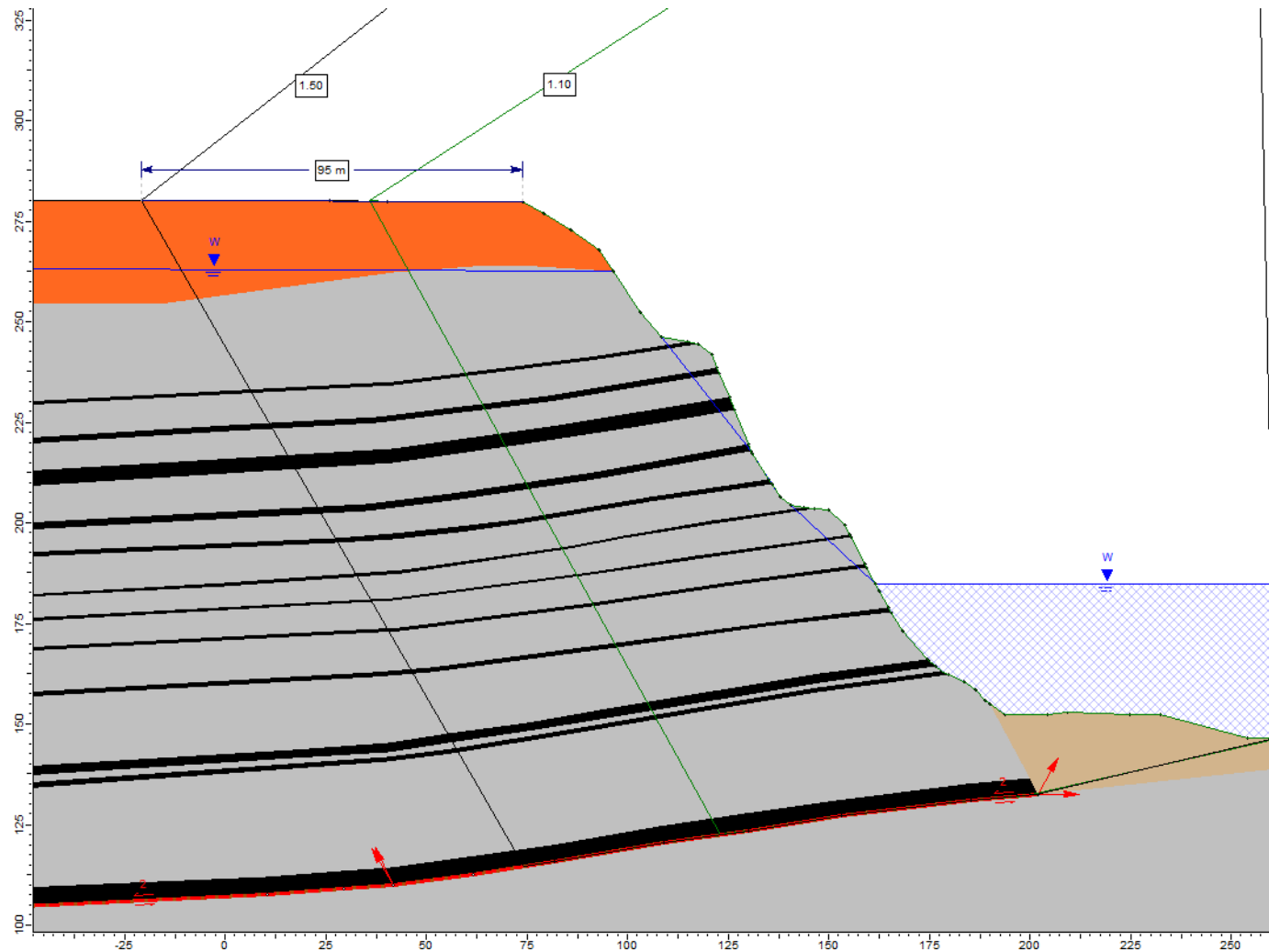
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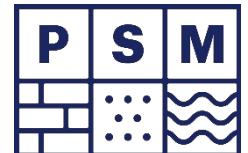
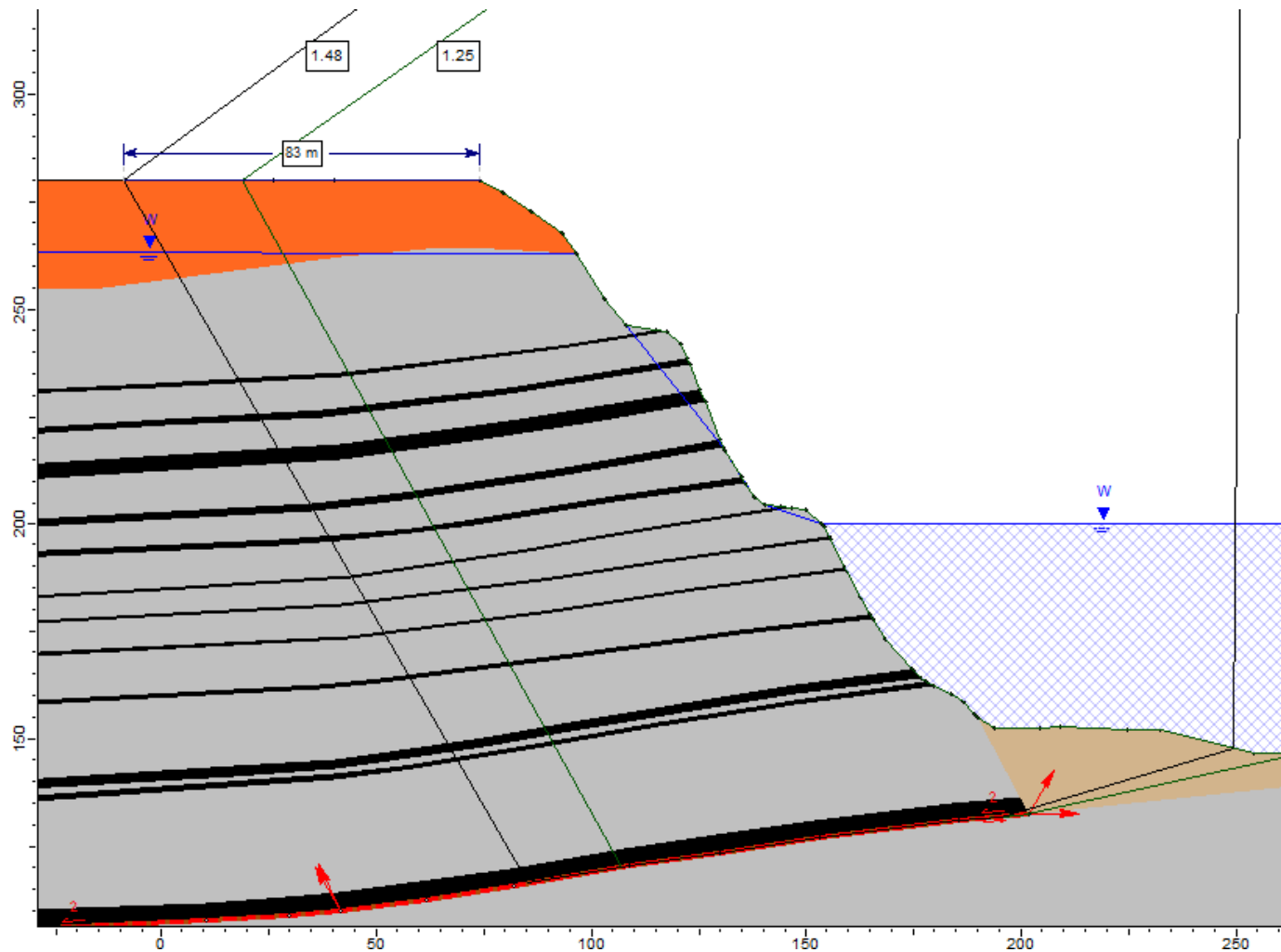
Section 4 –Lake at RL140, Sliding MN10 Seam



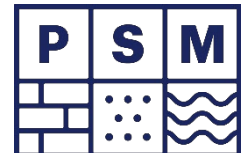
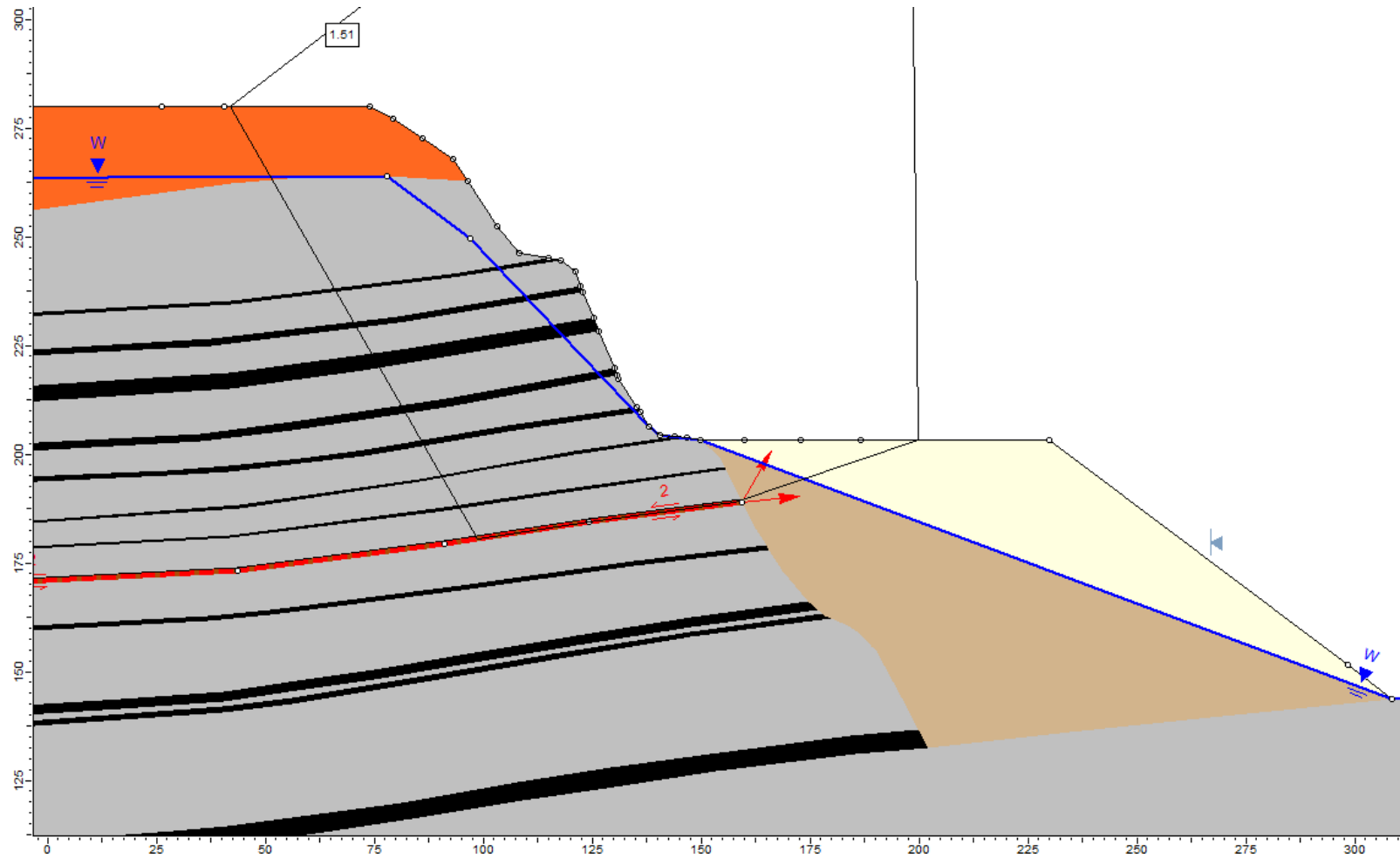
Section 4 –Lake at RL185, Sliding MN10 Seam



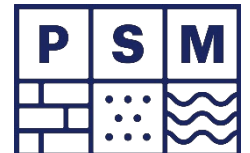
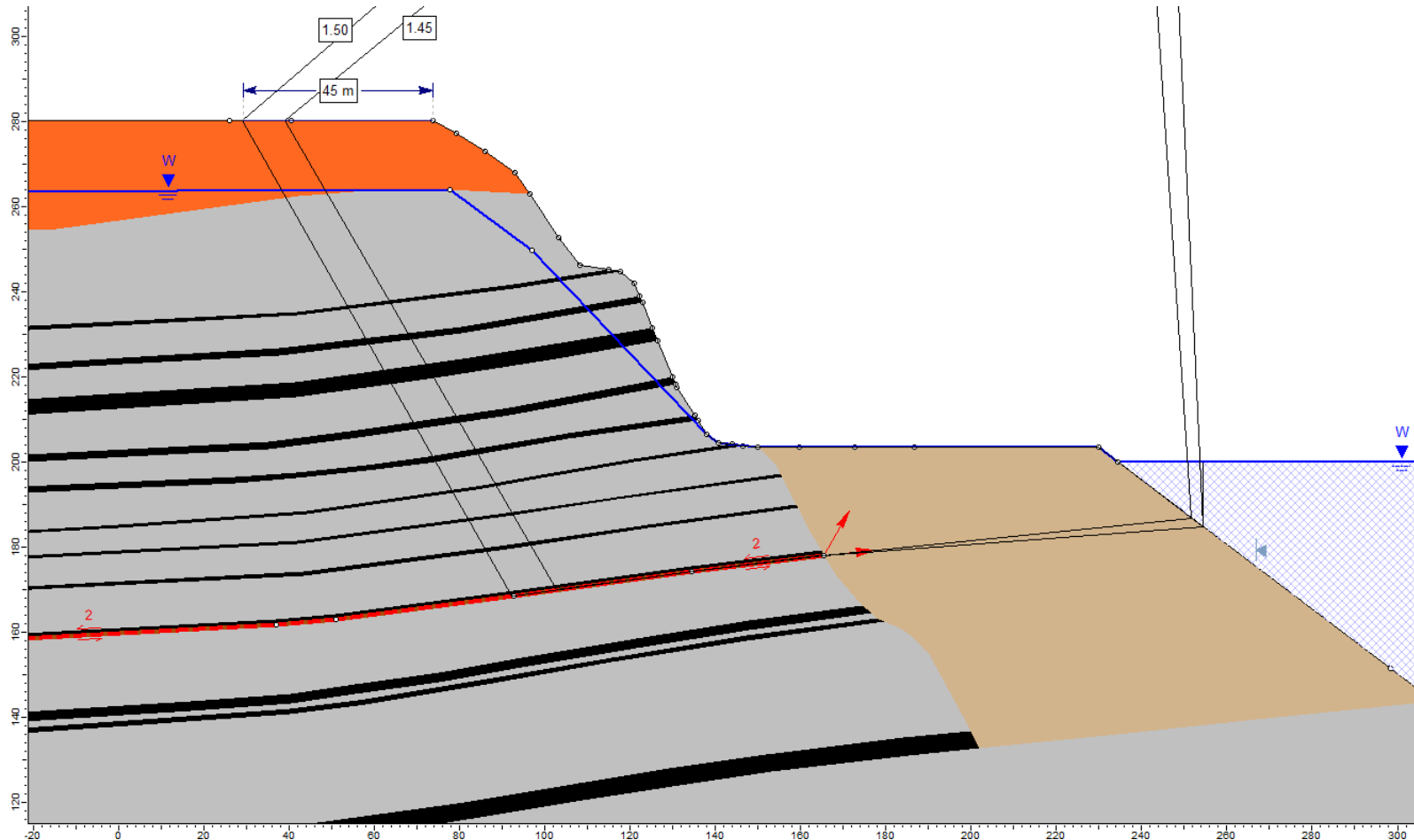
Section 4 –Lake at RL200, Sliding MN10 Seam



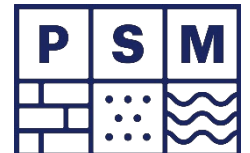
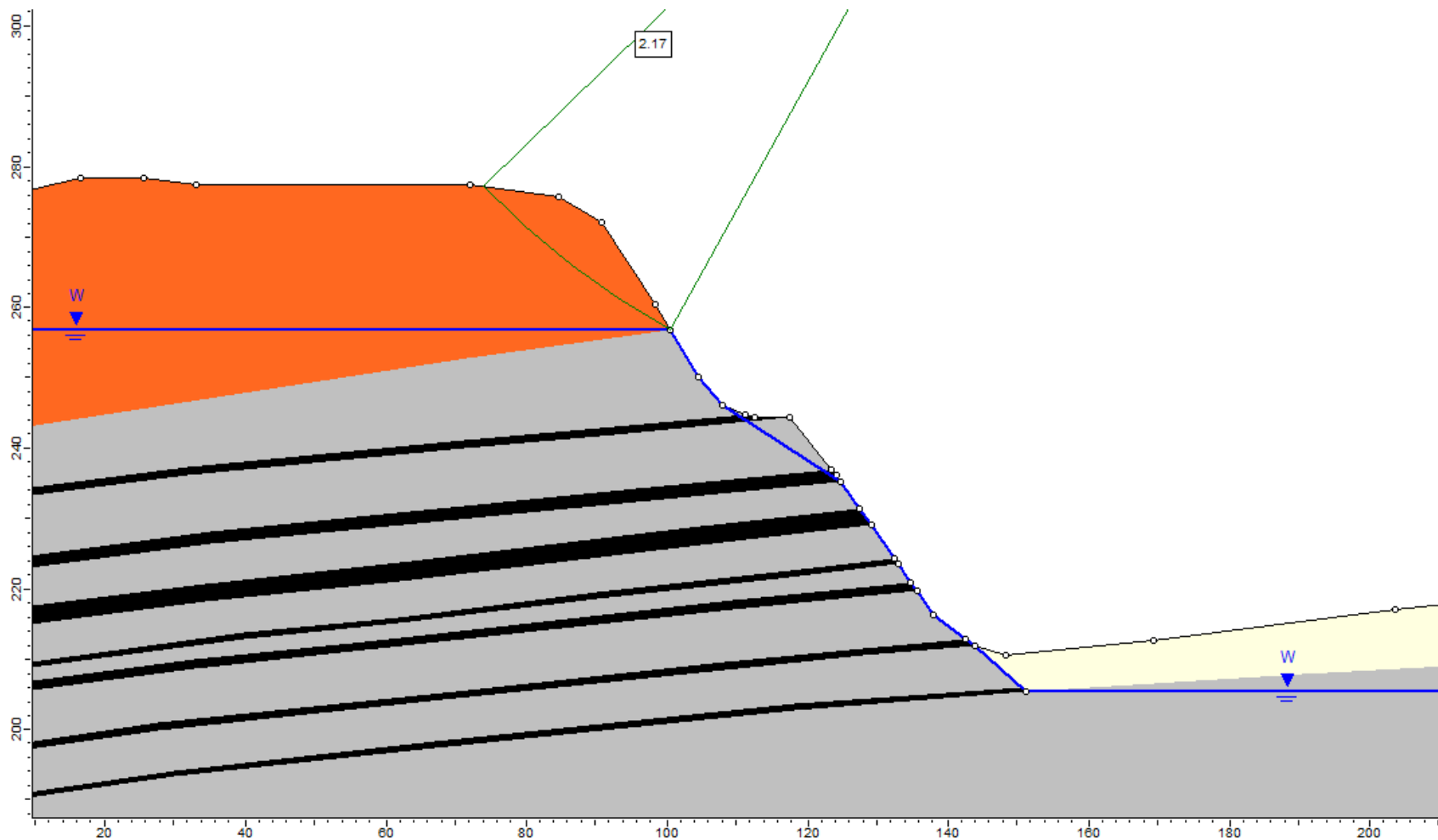
Section 4 –No Lake with Buttress, Sliding MN2 Seam



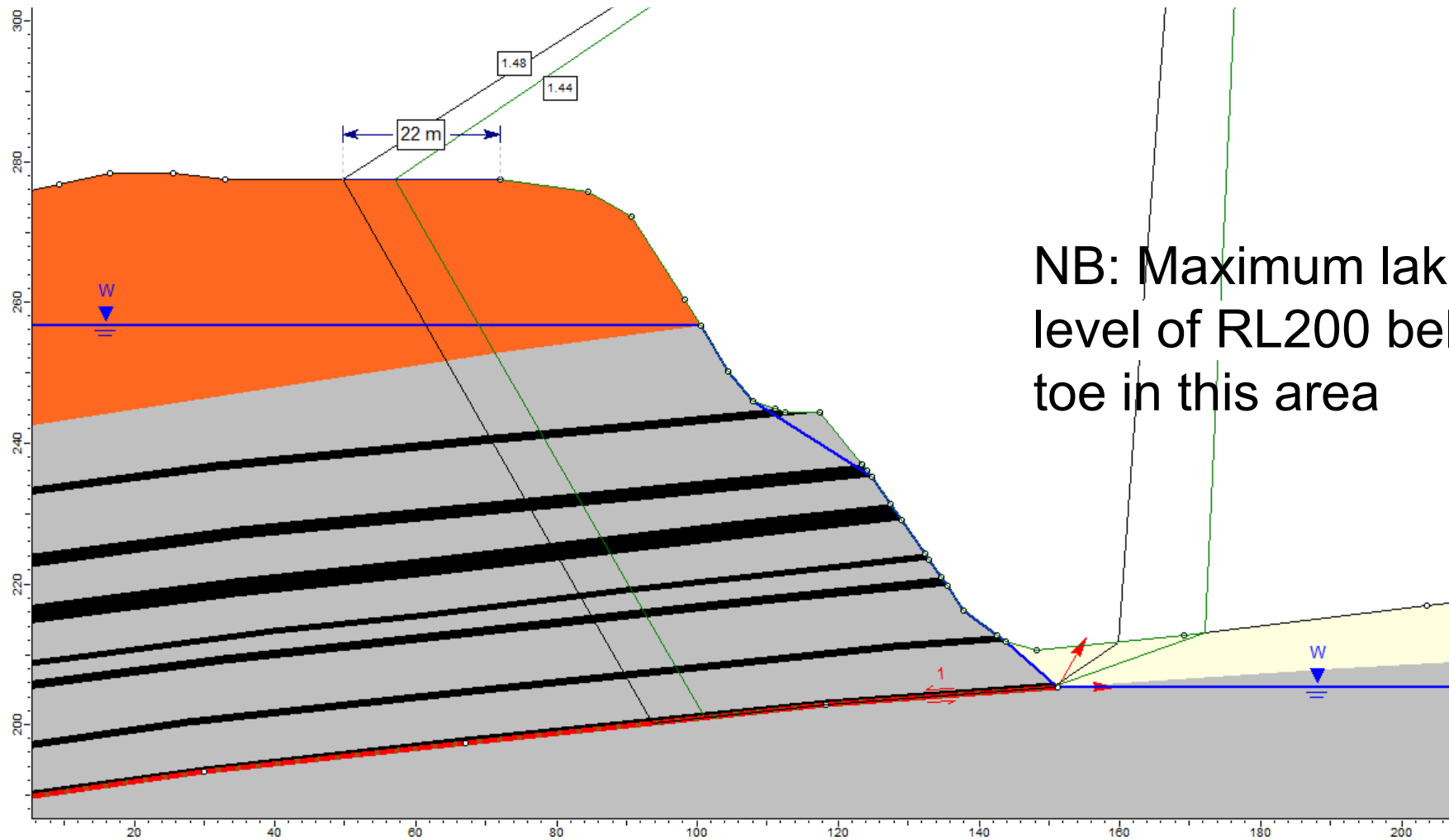
Section 4 –Lake at RL200 with Buttress, Sliding MN31 Seam



Section 5 –Circular in Weathered



Section 5 –No Lake, Sliding WI Seam



NB: Maximum lake level of RL200 below toe in this area

Minerva Mine

Rehabilitation Management Plan

Version: 1.1 (8 November 2021)

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Executive Summary

- 1 Environmental Authority EPML00668613 includes a condition that a Rehabilitation Plan must be developed by 1st July 2015. The Minerva Mine Rehabilitation Management Plan (Version 1.0) was submitted to the administering authority by the due date. The Environmental Authority requires any update to the RMP be submitted to the administering authority. Minor updates have been made to the Minerva Mine Rehabilitation Management Plan in the current version (Version 1.1) to make it consistent with a new Residual Void Investigation Report (5 November 2021) (prepared in accordance with Environmental Authority Condition F8). Certain other minor changes have been made to reflect current terminology.
- 2 The Rehabilitation Management Plan (RMP) outlines how the rehabilitation goals, objectives and strategies have been established and managed at Minerva Mine and has been formulated from various sources including:
 - a Statutory documents e.g. Plan of Operations, Environmental Authority and Guideline EM1122-*Rehabilitation requirements for mining resource activities*;
 - b *Minerva Mine Environmental Management Plan*;
 - c *Supplementary Report on Land Capability, Minerva Mine*;
 - d Rehabilitation monitoring data;
 - e Aerial images, maps and plans, and
 - f Plan of Operation disturbance statistics.
- 3 The results of rehabilitation monitoring at Minerva Mine will be used to update this RMP (Rehabilitation Management Plan) to review objectives for the final rehabilitation of the site as well as drive the landform criteria and surface treatments. Monitoring provides a clear understanding that the primary driver for rehabilitation at the site is to achieve, safe, stable and sustainable landforms on a basis which recognises the challenging nature of the spoil material, the harsh climate, the elevated spoil landforms and the scarcity of topsoil resources.
- 4 The major aspect which is delivering change to the rehabilitation concept for the site relates to pre-strip spoil placement. This has by far the most important controlling influence on final landform and its ultimate stability. Current concepts involve in-pit dumping sequentially during mine life to enable in-pit disposal of large quantities of pre-strip material, thus reducing spoil elevation to enhance overall final landform stability.
- 5 In addition, the use of rock mulch in rehabilitation of fragile spoil batters offers an effective means of stabilizing steep slopes, particularly in conjunction with pastures and native trees/shrubs. Operations to end of mine life will encounter significant volumes of competent basalt strata. Salvage of this rock will allow the mine to apply competent rock mulch over any existing slopes where erosion is evident or planned future slopes where erosion risks may be elevated because of poor dispersive spoil sediment presence. Minerva Mine plans to implement this practice solely as a means of improving long term stability of outer slopes that may already exhibit or be at risk of unacceptable sediment loss. To implement these risk mitigation measures with due regard to Safe, Stable and Sustainable outcomes, it is proposed;
 - a Basalt and/or competent Permian Sandstone strata is to be placed on final dump batter slopes to enhance integrity of the long term stability and surface erosion attributes of these surfaces;
 - b Placement of Basalt and/or competent Permian Sandstone rock mulch over unconsolidated batter surfaces to a depth of approximately 50 cm in erosion susceptible areas will mimic existing natural stable rock scree landforms in the area.
 - c These rock mulched areas are then to be topsoiled, deep ripped and seeded with a grass/tree seed mix to promote the development of a stable bushland habitat for these dump slope areas;
- 6 An approach of rock mulching dump batters followed by the establishment Acacia and Eucalypt species reflecting Regional Ecosystems in the area with similar slope attributes will result in the following enhanced environmental values;

- a Reduced potential sediment load runoff concerning downstream water quality attributes off lease;
 - b Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames;
 - c Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term.
- 7 Spoil characterisation is an integral tool in the rehabilitation process with regard to achieving safe and stable landforms. It allows a greater opportunity for spoil dumps to be planned with rehabilitation in mind, as well as providing a means for opportunistic salvage of competent rock material suitable for rehabilitation purposes. Spoil strata characterisation enables competent material to be identified and salvaged on a planned basis. Reference to *Supplementary Report on Land Capability, Minerva Mine* concerns characterisation of soils and overburden plus land capability assessment for Minerva Coal Mine prior to the commencement of operations. Findings as related to physical and chemical characterisation support Minerva Mine's proposal to rock mulch dump batter slopes with appropriate Basalt and/or competent Permian Sandstone strata.
- 8 Application of this rehabilitation methodology is enhanced via operational integration of excavation/dumping schedules for the selection and placement of competent rock strata for final surface thus greatly reducing the possible end of mine life liability to rock armour unstable batter slopes.
- 9 This RMP provides direction for all aspects of the rehabilitation of lands disturbed by mining and associated activities. The RMP is a 'moving' document which will evolve with the Project. It is subject to annual review so that changes which occur over time such as the mine plan, rehabilitation methods, new technologies or legislative requirements are incorporated in a timely manner.

1 Introduction

Purpose

- 10 The primary purpose of this Rehabilitation Management Plan (RMP) is to address the **Minerva Mine Environmental Authority EPML00668613 (EA)** requirements to review the site's rehabilitation commitments and program as well as facilitate a mechanism for ongoing update and refinement of key aspects of mine rehabilitation which include;
- a Construction of stable self-sustaining landforms in designated mine disturbance areas,
 - b Long term rehabilitation planning on the basis of the latest long term mine plan,
 - c Strategies for preservation and enhancement of existing Regional Ecosystems and adjoining grazing lands,
 - d Identification of opportunities and strategies for enhancement of corridor connectivity and biodiversity,
 - e Monitoring programs verify that rehabilitation performance criteria are being met and designs are appropriate.
- 11 This RMP outlines how the rehabilitation goals, objectives and strategies have been established and managed at Minerva Mine and has been formulated from various sources including:
- a Statutory documents e.g. Plan of Operations, Environmental Authority and EHP Guideline EM1122-*Rehabilitation requirements for mining resource activities*;
 - b *Minerva Mine Environmental Management Plan*;
 - c *Supplementary Report on Land Capability, Minerva Mine*;
 - d Rehabilitation monitoring data;

- e Aerial images, maps and plans, and
 - f Plan of Operation disturbance statistics.
- 12** A key component of the rehabilitation program is the demonstration of satisfactory rehabilitation performance; thus rehabilitation monitoring sites are to be established to test performance across site variability in spoil characteristics, topography and rehabilitation methods. Representative areas of undisturbed nearby land will also be monitored for comparison purposes.
- 13** Once sites are deemed to have fulfilled and maintained rehabilitation criteria for appropriate time periods, they will progress to 'demonstration' site status (i.e. monitoring indicates that stable or improving conditions are occurring in soil profile chemistry, erosion, mass stability, vegetative abundance and diversity). The success of rehabilitation performance for other areas may then be compared with these sites.
- 14** Minerva Mine continues to develop Life of Mine (LOM) based plans and is progressively improving methods in stabilizing mine disturbed land. The process of refining rehabilitation methods for spoil areas, including pre-strip spoil dumps, ramps and voids plus developing appropriate land use goals for land disturbed by mining is on-going. Thus changed rehabilitation treatments and different performance criteria may be implemented, particularly for newly disturbed and future disturbed areas in response to site experience and final landform plan development. This RMP will be updated before significant landform or rehabilitation criteria are implemented.

2 Regulatory Requirements

- 15** This RMP is based upon [Environmental Authority EPML00668613](#) in which condition F3 states the operator must:
- a A Rehabilitation Plan must be developed by 1 July 2015 by a suitably qualified person and implemented. The Rehabilitation Plan and must include:
 - i Rehabilitation objectives to achieve the rehabilitation goals for all disturbed areas;
 - ii Detailed rehabilitation methods for each disturbed area;
 - iii Rehabilitation indicators to measure the success of the rehabilitation against the rehabilitation objectives;
 - iv Final completion criteria that will achieve the rehabilitation goals and objectives; and
 - v Details of appropriate monitoring and maintenance of rehabilitation.

Environmental Management Plan

- 16** Minerva Mine submitted an [Environmental Management Plan](#) (EMP) to Queensland EHP in October 2007. This document *Minerva Mine Environmental Management Plan* is referred to as an Environmental Management Plan (EM Plan). The EM Plan provides supporting information on how the site is managed and has been used to establish the conditions of the [Environmental Authority](#). However, it must be noted that this EM Plan is no longer a regulatory requirement. The EM Plan is a valuable reference document that describes the proposed outcome for the rehabilitation of mined land (spoil areas) as a mosaic of pasture and bushland habitats in the following three general land types;
- a Bushland habitat areas, which are seeded with a mixture of native species, which include trees, shrubs and grass.
 - b Open grassland habitat areas seeded with a mixture of native and exotic grass and legume species. Grasslands are included to provide habitat diversity and facilitate protection against erosion processes.
 - c Rugged topography with water storage areas, vegetation establishment will be dependent on spoil type and slope.

Lease Surrender

- 17 The QLD Regulator has developed guidelines for surrender of mining leases which require that at lease surrender, the lease holder must lodge a Mining Lease Surrender form to the Department of Environment and Heritage Protection accompanied by an audit report confirming that requirements for rehabilitation and decommissioning as described in the [Environmental Authority EPML00668613](#) and [MJV Plan of Operations](#) have been met. In addition, a Final Rehabilitation Report (FRR) shall be submitted which describes the status of rehabilitation work. The Regulator should be advised within 14 days of proposed cessation of operations and plans should be submitted within one month.
- 18 Environmental Authorities may be surrendered at any time with written notice.
- 19 The Regulator may accept surrender only if satisfied that the lease holder has rehabilitated the land in a manner described in the Environmental Authority and / or lease conditions. The Regulator may give further directions to the lease holder if not satisfied with any details of the request. Authority to accept a lease surrender request may be delegated to regional Departmental staff depending on the magnitude and impact of the project. There is no defined time period in which the Regulator must accept or reject a lease surrender request.

3 Rehabilitation Objectives

- 20 Growing evidence from over 30 years of rehabilitation monitoring in spoil regimes in the Bowen Basin indicates that rehabilitation based on duplication of adjoining natural ecosystems is unrealistic. The major reason being the significant differences between mine spoil and natural soil profiles and topography. Rehabilitated landscapes are often elevated with greater slope gradients; growth mediums are often unweathered, unconsolidated, sodic, saline and quite different in physical chemical makeup than surrounding natural soils.
- 21 The objectives for rehabilitation at Minerva Mine are based on an understanding of the Regulatory requirements for acceptable rehabilitation when considered against the array of background limits and opportunities posed by characterisation of the mine site and the results of the sites rehabilitation monitoring to date. That is, whilst endeavouring to comply with the regulatory requirements; the environmental and physical constraints of the site must be the primary drivers in setting strategies and performance outcomes. It is imperative that spoil, topsoil and climatic characteristics plus mining programs which deliver the final landform underpin the rehabilitation objectives.
- 22 Characteristics important to the identification of the rehabilitation goals and objectives are briefly explained in various sections of this report. The overall requirements for rehabilitation of the Minerva Mine site recognise government policies as defined through the following guidelines;
 - a EHP Guideline EM1122-*Rehabilitation requirements for mining resource activities*.
 - b [Environmental Authority EPML00668613](#)

Environmental Authority Requirements

- 23 The existing regulatory pertinent requirements for rehabilitation for mined landform outcomes which are stated in [Environmental Authority EPML00668613](#) and the commitment provided by Minerva mine to achieve these conditions are outlined in **Error! Reference source not found.**

EA Condition	Interpreted Requirement - Objectives
Rehabilitation	
F1 All areas significantly disturbed by mining activities must be rehabilitated to achieve the following rehabilitation goals: a) Safe to humans and wildlife; b) Stable; c) Non-polluting; d) Self-sustaining for the post-mining land use.	Landform stability is paramount. Appropriate final surface treatment and sustainable vegetation cover is a key objective with regard to prevention of erosion, land degradation and off lease /downstream impacts.
F2 Rehabilitation must commence progressively in accordance with the plan of operations.	Areas available will be determined by the mine plan.
F3 A Rehabilitation Plan must be developed by 1 July 2015 by a suitably qualified person and implemented.	Minerva Mine Rehabilitation Plan to be submitted to administering authority by 1 July 2015.
F4 The Rehabilitation Plan and must include: a) Rehabilitation objectives to achieve the rehabilitation goals for all disturbed areas; b) Detailed rehabilitation methods for each disturbed area; c) Rehabilitation indicators to measure the success of the rehabilitation against the rehabilitation objectives; d) Final completion criteria that will achieve the rehabilitation goals and objectives; and e) Details of appropriate monitoring and maintenance of rehabilitation.	Minerva Mine Rehabilitation Plan to be submitted to administering authority by 1 July 2015.
F5 The environmental authority holder must notify the administering authority of any changes to the Rehabilitation Plan, and submit to the administering authority.	Notification and submission of the Minerva Mine Rehabilitation Plan to the administering authority will be undertaken with regard to update and amendment of this document.
F6 All areas significantly disturbed by mining activities must be rehabilitated in accordance with the Rehabilitation Plan to achieve the final completion criteria.	Rehabilitation methodology and approach will be defined within the Minerva Mine Rehabilitation Plan concerning achievement of final completion criteria for all areas significantly disturbed by mining activities.
Residual Void	
F7 Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority.	In recognition of the principles of safe, stable and sustainable, Minerva Mine plans to optimise current in-pit dumping practices to backfill the main void to the most cost effective and practicable extent during operations. Refer to the Residual Void Investigation Report (5 November 2021) which provides an update of the planned likely extent of final void at closure and treatment strategies.

EA Condition	Interpreted Requirement - Objectives
F8 If residual voids are to be left an investigation into residual void options and landform design are to be completed. The subsequent report is to be submitted to the administering authority proposing acceptance criteria to meet the outcomes in condition F7, landform design criteria in Table F1, void volume reduction options and options to reduce the height of the main dumps by 1 December 2009. The investigation shall be completed by a competent person, and include detailed research and modelling and at a minimum include the following: a) a study of options available for minimising residual void area and volume; b) a void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources and water quality parameters in the long term; c) a pit wall stability study, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events; d) a hydrological study into the long-term risk of the Sandhurst Creek / final void interaction, including erosion of the banks and spoil and extreme hydrological events, and the consequences of such interaction to the long-term stability of the final voids; e) a study of void capability to support native flora and fauna; and f) a proposal/s for end of mine void rehabilitation success criteria and final void areas and volumes.	Draft Residual Void Investigation submitted to EHP 9th April 2010. A final Residual Void Investigation Report (5 November 2021) has been submitted to the administering authority.
Topsoil	
F9 Topsoil resources that are suitable for use in rehabilitation must be identified and salvaged ahead of mining for strategic use in rehabilitation of the mine area.	Stripping depths of topsoil removal ahead of mining operations are expedited as per soil survey data and attributes defined within <i>Supplementary Report on Land Capability, Minerva Mine</i>.
F10 Where practicable stripped topsoil must be directly placed on rehabilitation areas. Where direct placement is not practicable, topsoil must be stored in stockpiles less than four (4) metres high and vegetated.	Where mine schedule does not allow for direct placement onto rehabilitation, topsoil stockpiles established will be below 4 metres with location tracked via GIS (Geographic Information System).
F11 An inventory of topsoil resources must be maintained.	Topsoil inventories are maintained via GIS and updated on an annual basis. Data from these inventories is then detailed in the annual Plan of Operations.
Infrastructure	
F12 All infrastructure, constructed by or for the environmental authority holder during the mining activities including water storage structures, must be removed from the site prior to mining lease surrender, except where agreed in writing by the post mining land owner/holder.	All infrastructure including water storage structures will be removed from site unless otherwise agreed in writing by the post mining land owner/holder.

Table 1 – EA Requirements and Minerva Mine Commitments.

General and Specific Rehabilitation Goals

General Rehabilitation Goals

- 24 The Queensland Government policy objectives for rehabilitation are described as Rehabilitation Goals to distinguish them from the Rehabilitation Objectives selected by mining companies in their rehabilitation strategies for a particular mine.
- 25 The four general Rehabilitation Goals set by the Queensland regulator requires that areas disturbed by mining are rehabilitated to a safe, stable, non-polluting state with an agreed post mine land use. This RMP provides meaningful site wide strategies on how the Queensland Government's rehabilitation goals will be achieved with due regard to the physical and environmental characteristics of the site. This is effectively what the RMP is meant to deliver. These strategies that Minerva Mine has developed to deliver these outcomes are outlined in **Error! Reference source not found.** (EHP Guideline EM1122-*Rehabilitation requirements for mining resource activities*).

EHP Rehabilitation Goals	Minerva Mine Overall Rehabilitation Strategy
Safe to humans and wildlife	- Spoil dump slopes will be regraded to allow safe access for humans and wildlife and possibly livestock in selected areas. - Mine voids will be backfilled to the most practicable and cost effective extent during operations. - Sumps, pits and areas of unstable ground will be stabilized as appropriate to ensure that there is no risk to stock, fauna or humans.
Non-polluting	Leachate will be prevented from mobilization from potential sources of contaminants such as spoil and coal fines to watercourses or useful groundwater.
Stable	All residual slopes will be geotechnically and erosionally stable, areas of dispersible mine spoil will strategically be covered with more competent Basalt spoil.
Able to sustain an agreed post-mining land use	The mine-scape (areas previously mined, excavated, dumped over or topsoil stripped) will be formed into a mosaic of bushland habitat and grassland areas.

Table 2 – Summary of Guideline EM1122 Goals and Minerva Mine Commitments

Rehabilitation Hierarchy

- 26 Guideline EM1122 states that in assessing the acceptability of rehabilitation objectives, indicators and completion criteria that may be proposed for a mining project, that EHP will have regard to a hierarchy for mine rehabilitation that is similar to the waste hierarchy. That is in order of decreasing capacity to prevent or minimize environmental harm.
- 27 The Regulators preference is that strategies listed higher in the hierarchy should be adopted in preference to those listed lower, unless there are significant environmental, economic or social issues that override such a selection. This RMP provides a range of supporting information on how Minerva Mine has adopted the most feasible strategy for the final land use of the site. Minerva Mine's overall reasoning as to the setting of an appropriate hierarchical rehabilitation land use strategy is outlined in Table 3.
- 28 The final land use objectives for domains which have been greatly affected by mining are of a lower value in terms of potential economic yield, but offer improved prospect for longer term stability. This is aligned with the Guideline EM1122 which states that:
- a "Developing a lower value use may be acceptable if that use is acceptable to the relevant stakeholders and all higher strategies are impractical" and "While it may be appropriate to attempt

to restore the pre-mining conditions after mining has ceased for some smaller mines and mines in areas with special values, this may not be possible or an optimum result across mine sites particularly in specific domains."

- 29 This may be the case for some mine spoil and void domain areas at Minerva Mine. Other areas of the lease excluding areas with inherent residual risk such as final void or areas of known conservation significance (e.g. offsets) will return to a grazing or grazing support use. This is feasible, given that a portion of land within the Minerva Mining Leases will not be significantly disturbed by mining or mining relating activities.

4 Environmental Characterisation

Pre-Mining Land Suitability and Use

- 30 Details for pre-mining land use and soils have been described by Ison *et al* (1996) indicating the land in general was capable of supporting crop and pastoral development predominantly ranging from Shallow to Deep Black Vertisols on Tertiary Basalt interspersed by Red Brown Non-Cracking Clays and Duplex soils on Permian Sediments. Summaries of this information are included in the **EMP** (Minerva Mining 2007).
- 31 The pre-mining landscape was a flat to gently rolling terrain with occasional hill features with maximum variation over the area of around 14m. Nearby to the west and south, there are a number of relic basalt flows and intrusive volcanic plugs that form steep hills and ridges up to 250m above the surrounding black soil plains. This backdrop of steep sided basalt formations forms the dominant visual character of the locality.

Climate

- 32 The climate for the area is typical of the region with high daytime summer temperatures, mild winters and low-moderate humidity. Rainfall is highly variable and seasonal with most recorded during the warmer months from December to March (Table 4). Average annual rainfall at the Springsure weather station is 689 mm.
- 33 As there were some gaps in Bureau of Meteorology (BOM) data at stations nearest to the study area, the following were selected to best represent local conditions:
- a Seasonal long term climate and rainfall statistics - Springsure Comet St (ID: 35065);
 - b Seasonal monthly rainfall statistics – Woorarra (ID: 35205).
- 34 In cases where rainfall data was not recorded during a particular month at the above stations, results were taken from Ronnoc Downs (ID: 35212).
- 35 Table 4 rainfall data shows that 65% of annual rainfall is received in the November to March period, with 45% of the annual total received in the three month period December to February. Rainfall of medium to high intensity can occur during the November to March period due to cyclonic rain depressions or summer thunderstorms. A typical rainfall pattern for Minerva may include:
- a Thunderstorms during late spring/early summer (i.e. October – December) with erratic frequency and rainfall.
 - b Wet season rainfall (typically through January – March) with heavy soaking falls for periods of up to several days.
 - c Dry season winter/early spring (i.e. April – September) with infrequent falls from passing cold fronts.
- 36 High rainfall events are common hence surface runoff can be substantial. As for the region, evaporation greatly exceeds precipitation, hence water stress is expected to be significant factor in the performance of future rehabilitation of disturbed land, particularly on slopes and or where topsoil thickness is limited and the under lying spoil may be compacted.

EHP Guideline EM1122 Hierarchy	Site Capabilities
Avoid disturbance that will require rehabilitation	Not applicable for areas of existing mine disturbance or for areas properly set aside for future mining. Limit mining area to that which is necessary for efficient exploitation of the coal resource.
Reinstate a “natural” ecosystem as similar as possible to the original ecosystem	RMP intent is the development of a mosaic of bushland habitat and grassland areas that reflects Regional Ecosystems in the area. Where feasible bushland habitat areas will entail rock mulching dump batters followed by application of topsoil that is subsequently deep ripped and seeded to a mix of tree and shrub species reflecting Regional Ecosystems in the area with similar slope attributes. This approach will result in the following enhanced environmental values; ➤ Reduced potential sediment load runoff concerning downstream water quality attributes off lease; ➤ Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames; ➤ Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term. As per abovementioned rationale with regard to reflecting Regional Ecosystems with similar slope attributes, grassland areas are to be established on slopes of less than 5 %. The abovementioned approach is to be implemented for erosive prone areas or current rehabilitation domains that have failed. Reconciliation of rehabilitation monitoring concerning reference sites and treatment areas will provide appropriate criteria and a means of validation of rehabilitation treatment approach.
Develop an alternative outcome with a higher economic value than the previous land use	Not feasible in this region considering the large area of disturbed land and the grazing/cropping land use to which it was utilized for prior to mining.
Reinstate previous land use (e.g. grazing or cropping)	ACARP research in 1996 suggested a number of parameters which are indicative of mine rehabilitation which is suitable for a sustained grazing use. A major parameter identified was slope gradient for areas in excess of 12% slope would not be suited to grazing due to excessive risk from erosion. However, it proposed that selected low slope areas below 5 % reflecting comparable unconsolidated sediment land types in the region may be appropriate for grazing land use. Rehabilitation monitoring will facilitate validation of this attribute of rehabilitation hierarchy.
Develop lower value land use	The proposed land use for mining disturbed areas – spoil and voids is that of a mosaic of bushland habitat and grassland areas. Development of safe, stable and self-sustainable landforms that are non-polluting is the primary consideration with regard to achievement of Regulatory Goals defined in this RMP.
Leave the site in an unusable condition or with a potential to generate future pollution or adversely affect environmental values.	Minerva Mine acknowledges that leaving land in an unstable or polluting state is unacceptable and that the principal objective is to achieve safe, stable and sustainable outcomes that do not generate pollution or affect regional environmental values. This RMP provides an overview of the site’s environmental and physical characteristics; as well summarizes the historical rehabilitation performance and proposes means to improve the stability and sustainability of spoil landforms.

Table 3 – Guideline EM1122 Hierarchical Rehabilitation Goals and Minerva Mine Position

Month	Temperature (°C)		Relative Humidity %		Wind (km/hr)	Rainfall (mm)		
	Average Min	Average Max	9am	3pm	3pm	Mean	Highest Daily	Highest Monthly
	1938-2014	1938-2014	1938-2010	1966-2010	1965-2010	1865-2014	1865-2014	1865-2014
Jan	20.8	34	61	38	5.8	108.9	172	768.3
Feb	20.5	32.4	66	44	5.7	109.6	171.5	552.7
Mar	18.8	31.6	62	38	5.7	70.1	129	326.4
Apr	14.9	29	59	38	5.9	39.8	129	240.6
May	10.9	25.3	60	39	5.1	35.5	104.5	263
Jun	7.2	22.2	62	40	5.7	37.8	92.7	296
Jul	6.3	22.1	60	36	6.2	28.2	119.4	244.5
Aug	7.5	24	54	30	6.3	24	63.9	200.7
Sep	11.2	27.6	52	29	6.7	29.7	90.2	324.2
Oct	15.2	30.6	52	30	6.8	47.1	86	237
Nov	17.9	32.8	55	33	7.3	65	156.2	355.9
Dec	19.8	34	57	37	6.1	93.2	110.5	522

Climate statistics taken from BOM station at Springsure Comet St (ID: 35065).

Table 4 – Long Term Climate Statistics (1865 to 2014)

- 37** High rainfall events are common hence surface runoff can be substantial. As for the region, evaporation greatly exceeds precipitation, hence water stress is expected to be significant factor in the performance of future rehabilitation of disturbed land, particularly on slopes and or where topsoil thickness is limited and the under lying spoil may be compacted.

Spoil Characteristics

- 38** Spoil characterisation is an integral tool in the rehabilitation process with regard to achieving safe and stable landforms. It allows a greater opportunity for spoil dumps to be planned with rehabilitation in mind, as well as providing a means for opportunistic salvage of competent rock material suitable for rehabilitation purposes. Spoil strata characterisation enables competent material to be identified and salvaged on a planned basis. Reference to *Supplementary Report on Land Capability, Minerva Mine* (ESys Consulting Pty. Ltd. May 2005) concerns characterisation of soils and overburden plus land capability assessment for Minerva Coal Mine prior to the commencement of operations.
- 39** Overburden and inter-burden (collectively referred to as spoil henceforth) was assessed by Ison Environmental Planners (1996a). This assessment comprised two drill holes located in the centre and north-west of the deposit. Ninety-five metres of spoil was collected for sampling from DH 1078 (deposit north-west) to a depth of 118m and approximately 46m from DH1043C (deposit centre) to a depth of 54m. Composites samples were formed over depth increments ranging from 1 to 21m with an average increment of 6.4m. Spoil composites were tested for pH, salinity, major cations and metals.
- 40** Seven additional holes were sampled as part of this supplementary programme increasing the holes sampled from two to nine and increasing the vertical sampling depth by 323m. Drill hole samples were still held in storage by New Hope Corporation and additional drilling was being conducted at the time of this study in 2004. A selection of holes representing different geologies across the deposit from within the available holes was made with the assistance of the project geologist. Four holes were selected from the drill programme with a further three holes selected from the New Hope core library. Each core was sampled at approximately 1m increments. Adjacent samples within a core that were logged within the bore log as of similar geology were later combined into a single composite. The maximum increment was 8m with the average increment thickness being 2.6m.

- 41 All composites were crushed by ALS (NATA registered laboratory) until at least 80% of the sample passed through a 2.36mm sieve. Each sample was tested for pH and EC on a 1:5 spoil: water ratio by volume. Twenty-two spoil classes were formed based on similarity of geology, underlying coal seam, weathering, pH and EC. ESys Consulting Pty. Ltd. (May 2005) defined these resulting spoil classes as per Table 5.

Spoil class	Seam ID		Dominant lithology	Drilled	Metres included in composite
1	Funnel	unweathered	siltstone & sandstone		8
2	Funnel	weathered	siltstone & sandstone		19
3	Lexington	unweathered	siltstone	1995	16.5
4	Lexington	unweathered	siltstone & sandstone	2004	60
5	Minerva	unweathered	siltstone & sandstone	1995	22
6	Minerva	unweathered	siltstone & sandstone	2004	77
7	Sandhurst	unweathered	siltstone & sandstone		3
8	Wills	unweathered	siltstone & sandstone		24.5
9	Wurba	unweathered	siltstone & sandstone		50
10	Wurba	weathered	sandstone		28
11		unweathered	coal		3
12	Wills	unweathered	basic intrusion		4
13	Minerva	unweathered	sandstone		24
14	Minerva	unweathered	siltstone		65.5
15	Minerva 1	unweathered	siltstone & sandstone		26
16	Minerva 2	unweathered	siltstone & sandstone		18.5
17	Minerva 3	unweathered	siltstone & sandstone		28.5
18	Minerva 4	unweathered	siltstone & sandstone		20.5
19	Minerva 5	unweathered	siltstone & sandstone		7.5
20	Sandhurst 1	unweathered	siltstone & sandstone		2
21	Sandhurst 2	unweathered	siltstone & sandstone		1
22	Minerva	unweathered	mudstone		9.5

Table 5 – MJV Spoil Classification Extract

- 42 Composite samples were forwarded to NATA registered laboratories for chemical and physical testing that included pH, electrical conductivity, fertility, soil particle size/dispersion, metals and acid production potential. Attributes described by ESys Consulting Pty. Ltd. (May 2005) are as follows:
- a *Soil reaction:* Most of the spoil classes (87% of material forming the composites) were mildly to strongly alkaline with two classes being strongly acid. These latter spoil classes represented the siltstones and sandstones associated with the Sandhurst 1 seam. The remaining spoil classes (12% of material forming the composites) were mildly acid or neutral.
 - b *Salinity:* Most of the spoil classes were non-saline (89% of the composite material) with the remaining spoil classes having medium to high salinity. The saline spoil classes were lithologies over the Sandhurst 1 seam, coal and the weathered material above the Funnel seams.
 - c *Major elements:* All spoil types were very low in nitrogen and phosphorus being characteristic of spoils in Central Queensland. Potassium was acceptable or marginally low in most spoil classes with the notable exception of weathered spoil above the Funnel seams and lithologies above the Wurba seam. Calcium, magnesium and sulphur levels were acceptable in all spoil classes tested.
 - d *Trace elements:* All trace elements were at acceptable levels. Notably, boron was low in these Permian lithologies as compared to the basalt derived soils. Boron toxicity is not expected.
 - e *Chemical induced dispersion:* Sodidity was present in all spoil classes but not excessive ranging from 7-14%. The calcium-magnesium ratio is low in most of the unweathered spoil classes. This characteristic is common to Central Queensland spoils.

- f** *Mechanical dispersion:* The dispersion indices of all tested spoil classes other than Wurba sandstone were moderate again suggesting some mechanical dispersion.
- g** *Erodibility:* Soil erodibility of the spoil classes were generally on par or lower than that of the soils tested. A K factor exceeding 0.045 is considered erodible. The USLE K factor for the tested spoil classes were ranked as follows:
- i** Funnel 0.052>Wurba 0.43-0.46>Lexington 0.04>Wills 0.038>Minerva 0.028.
- h** *Acid production potential:* Eighteen of the 22 spoil classes were tested for acid production potential. The untested spoil classes represented either weathered spoil or composite samples represented better by other spoil classes. The spoil is generally neutralising with only two spoil classes exhibiting net acid production. The spoil classes have been placed into five groups as per Table 6.

Acid production potential	Net acid production potential (kg H ₂ SO ₄ /t)	Spoil classes
None (neutralising)	< -15	Lexington, Minerva 4 and 5 lithologies
None (neutralising)	-15 to -10	Wills, Minerva 1 to 3 lithologies
Very low (low neutralising)	-10 to 0	Lexington siltstone, Minerva 5, Sandhurst 2 and Minerva mudstone lithologies
Low (low acid)	0 to 5	Funnel lithologies
Moderate	>5	Sandhurst 1 lithologies

Table 6 – MJV Spoil Acid Production Potential Classification Extract

The low net acid production potential of the Funnel lithologies can be neutralised either with limestone (2-5t/ha) if the spoil appeared on the surface or by mixing this material with other spoil in a ratio of 3:1 Funnel to any other lithology other than Sandhurst 1. The main limitation with this material would relate more to the impact on nutrient availability rather than adverse acid affects. It is recommended that this material should not be placed within 2m of the surface. As the soils of the area are alkaline, surface expression of acid is not expected. Acid mine drainage into aquifers is not expected from this material.

The unweathered Sandhurst 1 seam lithologies represent the only net acid material of concern. Though the acid potential is not sufficiently high to warrant encapsulation, this material should not be placed within 10m of the surface. Mixing with any other spoil class other than Funnel material in a 1:1 ratio would be sufficient to neutralise potential acid. There is ample neutralising capacity in the remaining spoil to neutralise any resulting leachate.

- i** *Metals:* All seam lithologies were tested for environmental metal levels though Minerva and Sandhurst seams were not tested individually. The materials were analysed for arsenic, chromium, copper, lead, nickel, zinc, cadmium and mercury. Cadmium and mercury levels were below detection levels throughout. The metal levels of the Permian coal measures were less than 40% of investigation threshold levels QDME (1993) in all materials for all metals except Minerva mudstone which recorded a level of 60% of the threshold level for zinc. In general, the levels were less than 20% of the respective investigation threshold levels.

The basic intrusion sample exhibited elevated chromium, copper and nickel levels. While the chromium and copper levels were below the investigation threshold levels, the nickel level was 220% of the investigation level. The basic intrusions have surface expression in the vicinity of the mine and consequently, localised elevated nickel may occur elsewhere. Furthermore, the volume of basic intrusion in the spoil is very low and the likelihood of this material occurring on

the surface is low. Any surface expression of basic intrusion in the spoil should be covered with topsoil.

- 43 The use of rock mulch in rehabilitation of fragile spoil batters offers an effective means of stabilizing steep slopes, particularly in conjunction with pastures and native trees/shrubs. Operations to end of mine life will encounter significant volumes of competent basalt strata as per below Figure 1 depicted with regard to conceptual depths of basalt strata on site. Salvage of this rock will allow the mine to apply competent rock mulch over any existing slopes where erosion is evident or planned future slopes where erosion risks may be elevated because of poor dispersive spoil sediment presence. Minerva Mine plans to implement this practice as a means of improving long term stability of outer slopes that may already exhibit or be at risk of unacceptable sediment loss.
- 44 Application of this rehabilitation methodology is enhanced via operational integration of excavation/dumping schedules for the selection and placement of competent rock strata for final surface thus greatly reducing the possible end of mine life liability to rock armour unstable batter slopes.
- 45 The major variables for rehabilitation performance are spoil physical and chemical attributes, slope gradient, use of topsoil, seasonal weather, initial vegetation establishment and age of rehabilitation.

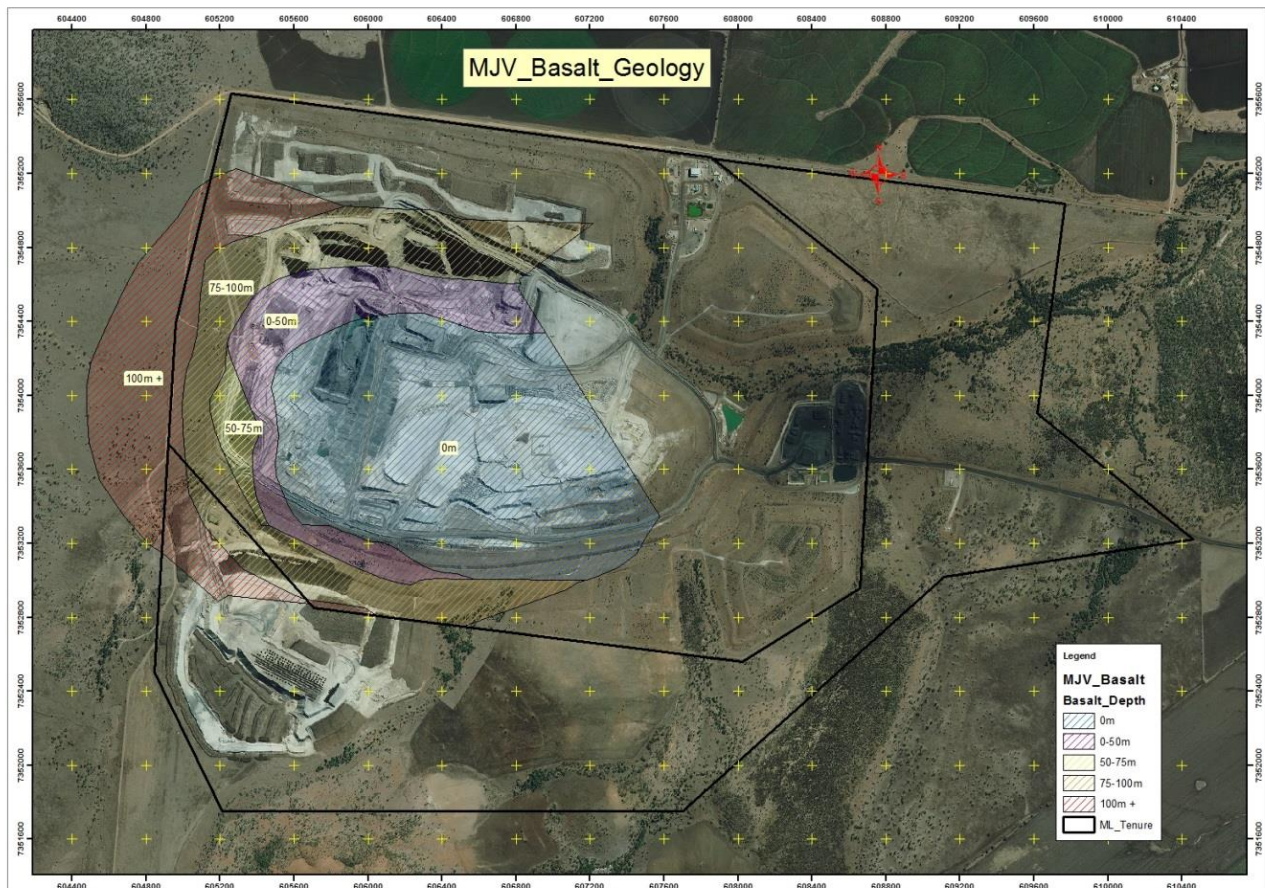


Figure 1 – MJV Conceptual Basalt Model

Topsoil Resources

- 46 Topsoil inventories are maintained via GIS and updated on an annual basis. Data from these inventories is detailed in the Plan of Operations.
- 47 Pending final landform planning outcomes, topsoil application rates will have to be reduced for strategic areas to cover the entire disturbed area.

- 48 An approach of rock mulching erosive prone dump batters followed by reduced topsoil application rates that are subsequently deep ripped and seeded to a mix of Acacia and Eucalypt Species reflecting Regional Ecosystems in the area with similar slope attributes will need to be employed. Hence in these circumstances topsoil is being utilized as an inoculation and germination resource for the development of bushland habitat areas.
- 49 Topsoil resources have been assessed for soil type and pre-mining land suitability with stripping depths formulated as per *Supplementary Report on Land Capability, Minerva Mine* (ESys Consulting Pty. Ltd. May 2005). As previously described soils predominantly range from Shallow to Deep Black Vertisols on Tertiary Basalt interspersed by Red Brown Non-Cracking Clays and Duplex soils on Permian Sediments. All topsoil in advance of mining is stripped to recommended depths and either stockpiled or replaced over rehabilitation.

Water Quality Aspects

- 50 Minerva Mine is located in the upper catchment of Sandhurst Creek which drains to the Comet River near its confluence with the Mackenzie River. For the purposes of the Queensland Water Quality Guidelines, Sandhurst Creek is located in the western tributaries of the Comet River sub-region, in the Fitzroy River basin (Basin 130) which is part of the Central Coast Region (QWQG, 2009; FBA, 2010).
- 51 The waterways on Minerva Mine, and within 10kms downstream, are ephemeral with flow only after significant rainfall and for limited periods each year. The catchment area upstream and downstream of mining is predominately rural cropping and grazing land and natural bushland.
- 52 The creeks in the study area generally receive no permanent groundwater base flow that contributes to surface flows, with the exception of sections of Sandhurst Creek near the Gregory Highway which is thought to be replenished by local spring water (pers.comm, Downstream Landholder, 2014)
- 53 Detailed surface water monitoring programs have been maintained over a life of mine and have developed a strong profile of water quality and variability in mine disturbed areas plus natural areas.
- 54 Minerva Mine water resources are obtained predominately from pit dewatering to onsite mine water dams. The mine water management system comprises a drainage network, which captures all mine affected water. A series of catch drains, pipelines, dams and pumping infrastructure is used to convey mine water that is used for dust mitigation purposes as related to haul road circuits and ROM/Train Load Out infrastructure. These operational demands are supplemented with groundwater from the licenced site bore field.
- 55 *Minerva Mine Hazardous Dam Inspection and Category Review-2014* identified all storage structures as being of a Low Hazard Category status.
- 56 *Minerva Mine Receiving Environment Monitoring Program (REMP)-2014* concluded, changes in median water quality after mining were within acceptable limits for slightly-to-moderately disturbed systems or remained within applicable guidelines or trigger values.

Spoil Runoff Quality

- 57 Pit/spoil water quality as reflected by mine water and sediment dam water quality data is variable across the site. Table 7 provides *in situ* values of pH and conductivity for site mine water and sediment dam storages measured in December 2014 as depicted in Figure 2.
- 58 The below data provides indication that runoff from spoil areas is alkaline and saline.

Dam Storage ID	Date	pH	Electrical Conductivity uS/cm
IND DAM 1	16/12/2014	7.26	145
IND DAM 2	16/12/2014	8.18	701
DAM 4	16/12/2014	8.75	3320
DAM 7	16/12/2014	8.24	924
ROM 3	16/12/2014	8.41	1360
TLO DAM 2	16/12/2014	7.44	428
Crusher Pad Dam	16/12/2014	7.30	937

Table 7 – MJV Mine Water and Sediment Dam Water Quality - December 2014.

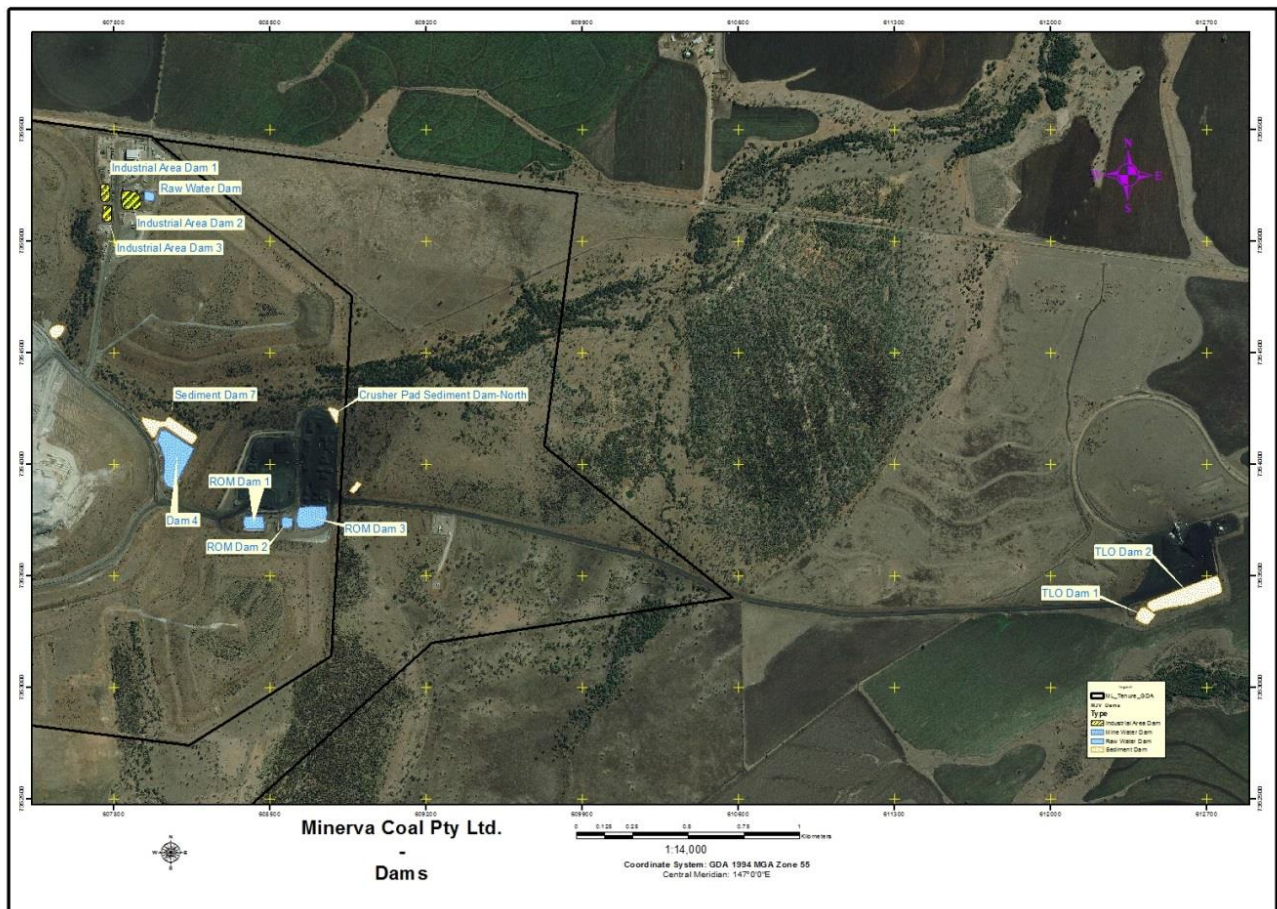


Figure 2 – MJV Mine Water and Sediment Dams

Groundwater Regime and Quality

- 59 The Minerva Mining Leases are within a Proclaimed Area under the *Water Resources Act 1989* and there are several bores licensed for the extraction of water present in the area. These bores are used primarily for irrigation of crops and water is sourced from within the basalt surrounding the coal deposit. There are no licensed bores within the Permian coal measures. Lexington property, within which the mine deposit resides, currently holds a water allocation for 400ML per year for irrigation use drawn from basalt aquifers. Studies undertaken by Waste Solutions Australia (1996, 1998) indicated no sizeable, useable groundwater resource to the east of the mine site.
- 60 The lack of extensive, hydraulic connections between the open pit area and the surrounding basalt aquifers suggests that any adverse impact of open pit mining on the basalt groundwater resources will be limited to areas around fault zones which connect aquifers within the basalt to the mine area (Waste Solutions Australia

1996a, 1996b). The main basalt aquifers appear to be several kilometres to the west of the mine area. These aquifers were originally formed in areas of major faulting within the basement rocks.

- 61 Pre-mining monitoring of ground water occurred between 1996 and 1998 and resumed late in 2004. A summary of groundwater quality is presented in Table 8. Sampling clearly indicates a decrease in water quality from the basalt aquifers to the water sourced from the intrusions with a further deterioration in water quality within the coal measures. Hydrology studies (Waste Solutions Australia 1996a) indicate that groundwater within the Reid Dome Beds is limited and expected to be confined to intrusions to the south east and west of the deposit. Groundwater yields in exploration drill holes varied between 0.25 and 0.6 L/s.

Parameter	Units	Average ground water quality from different water sources		
		Basalt aquifers	Deposit intrusions	Coal measures
Sample number		9	3	7
pH	N/A	7.7	8.4	7.8
TDS	mg/L	531	817	2039
EC	uS/cm	831	1260	3200
Cl	mg/L	57	170	521
SO ₄	mg/L	5.1	132	457
Na	mg/L	103	260	454
K	mg/L	3.9	4.9	14
Hardness	mg/L	213	57	636
Ca	mg/L	37	14	61
Mg	mg/L	30	5.4	119
Fe	mg/L	0.3	8.9	n.t.

Table 8 – Minerva Ground Water Quality

- 62 All ground waters were suitable for consumption by cattle as assessed by the above parameters, though the quality was poor for water from the coal measures. The basalt aquifers were suitable for irrigation of crops with low salt tolerance. Water sourced from the intrusions on average could be used to irrigate crops of moderate tolerance, albeit some samples exceeded recommended limits. Water from the coal measures was unsuitable for irrigation, especially when applied to clay soils.
- 63 There are several bores licensed for the extraction of water present in the area. These bores are used primarily for irrigation of crops and water is sourced from within the basalt surrounding the coal deposit. There are no licensed bores within the Permian coal measures. Sojitz Minerva Mining holds two water licences under the Department of Natural Resources and Mines (DNRM); Water Licence 405674 permits 100ML/yr of underground water to be extracted for irrigation purposes, and Water Licence 405647 permits the taking of 400ML/yr of underground water for industrial uses.
- 64 Monthly dipping, annual water sampling/analysis with subsequent Bore Field Performance Review of the monitoring bore network (i.e. as depicted by Figure 3) is conducted as per Water Licence 405647 requirements. The most recent Bore Field Performance Review concluded that there was no material departure of groundwater performance of the bore field and limited piezometric impact caused by the operation of the bore field on the surrounding aquifer.
- 65 EPML00668613 requires bi-annual water sampling/analysis of the Environmental Authority monitoring bores (1077, 1114 & 1116) depicted as per Figure 3.
- 66 A Residual Void Investigation Report (5 November 2021) has been prepared in accordance with Environmental Authority Condition F8. The report contains predictions of the long-term equilibrium water level and water quality in the Main (Western) and Southern residual voids. The report predicts the long-term the salinity of water in both residual voids will become unsuitable for irrigation initially, and subsequently become unsuitable for stock water for beef cattle. The voids would be unable to support a Post-Mining Land Use and would be Non-Use Management Areas. The void water would not, however, result in adverse environmental impacts on surrounding aquifers, including the basalt aquifer, as groundwater hydraulic gradients are expected to be maintained in perpetuity towards both voids. The maximum water level in the voids is 60m below the spill point and void water would not be released to

surface waters or surrounding lands. In conclusion, the residual voids would not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself.

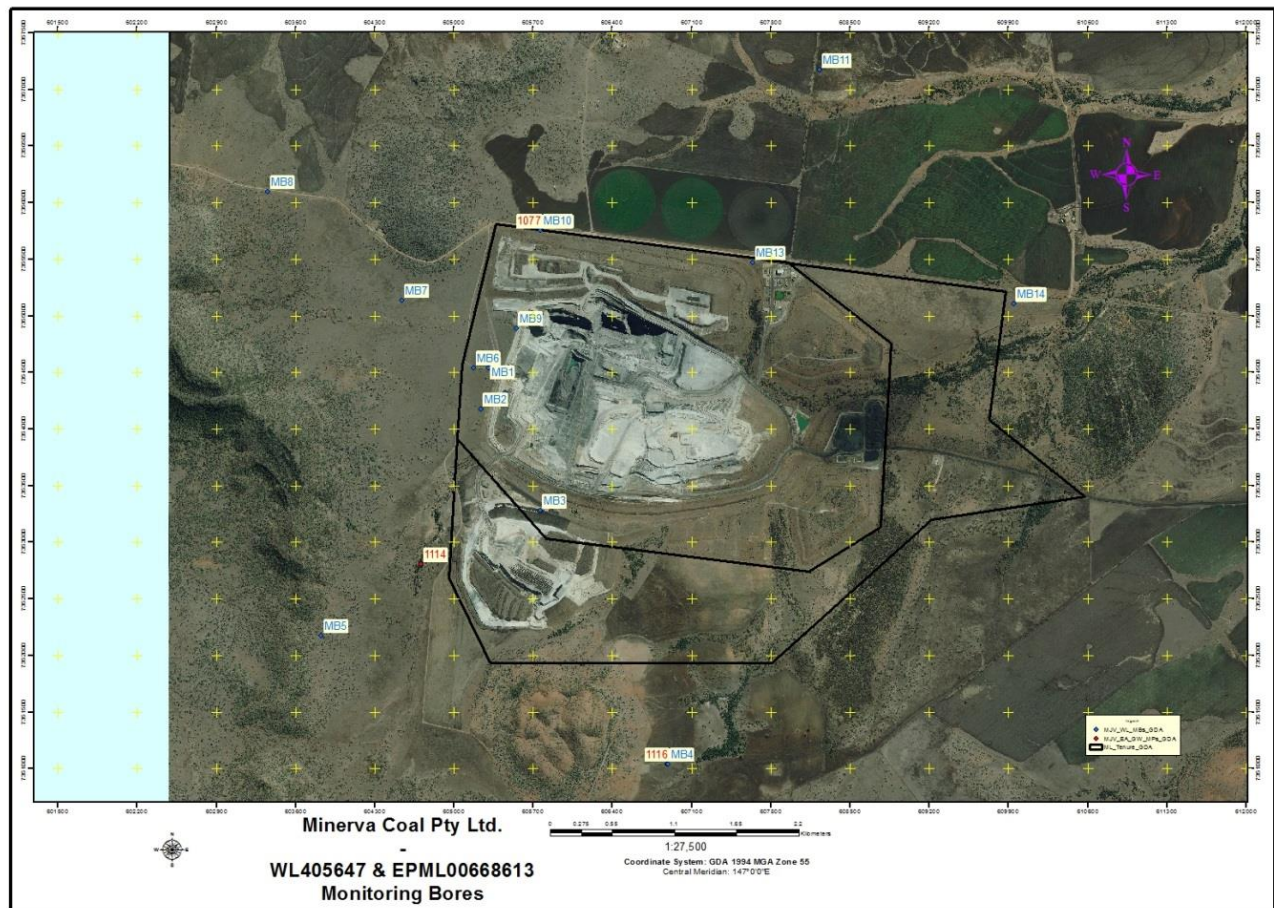


Figure 3 – MJV WL405647 & EPML00668613 Monitoring Bores

Contaminated Land

- 67 Records are maintained which show the type, location and extent of infrastructure and activities with potential to contaminate land. Hydrocarbon and metals analysis/assessment is captured via the Quarterly Dam sampling schedule and the Receiving Environment Monitoring Program.

Biodiversity

- 68 The Queensland Herbarium updated regional ecosystems in 2001 for central Queensland including the Minerva project area describing the regional ecosystems present within the Mining Lease. Table 9 provides an overview of current Regional Ecosystem mapping reconciliation and description within the Minerva Mine leases.
- 69 Figure 4 depicts the layout of these Regional Ecosystems and Non-Remnant areas within the Mine Lease.
- 70 Bluegrass grassland (RE 11.8.11) is considered endangered under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999, and of concern under the Queensland Vegetation Management Act 1999. This Regional Ecosystem has been disturbed for cropping elsewhere in Queensland and has been impacted locally by grazing pressure and weed invasion (especially parthenium).

Regional Ecosystem	PERCENT	VMA_Class	Short Description	Total (Ha)
Non-Remnant	100			1235.65
11.8.5	100	Not of Concern	<i>Eucalyptus orgadophila</i> open woodland on Cainozoic igneous rocks.	138.73
11.8.11	100	Of concern	<i>Dichanthium sericeum</i> grassland on Cainozoic igneous rocks.	111.91
11.8.11a/11.4.9/11.3.25	50/40/10	Of Concern/Endangered/Not of Concern	<i>Dichanthium sericeum</i> grassland on Cainozoic igneous rocks that includes <i>Melaleuca bracteata</i> woodland drainage depressions / <i>Acacia harpophylla</i> shrubby woodland with <i>Terminalia oblongata</i> on Cainozoic clay plains / <i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines.	60.09
11.4.9	100	Endangered	<i>Acacia harpophylla</i> shrubby woodland with <i>Terminalia oblongata</i> on Cainozoic clay plains.	5.53
11.9.1	100	Endangered	<i>Acacia harpophylla</i> - <i>Eucalyptus cambageana</i> woodland to open forest on fine-grained sedimentary rocks.	3.87
11.8.11a/11.4.9	80/20	Of Concern/Endangered	<i>Dichanthium sericeum</i> grassland on Cainozoic igneous rocks that includes <i>Melaleuca bracteata</i> woodland drainage depressions / <i>Acacia harpophylla</i> shrubby woodland with <i>Terminalia oblongata</i> on Cainozoic clay plains / <i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines.	0.01
Total				1555.80

Table 9 – Minerva Mine Regional Ecosystems

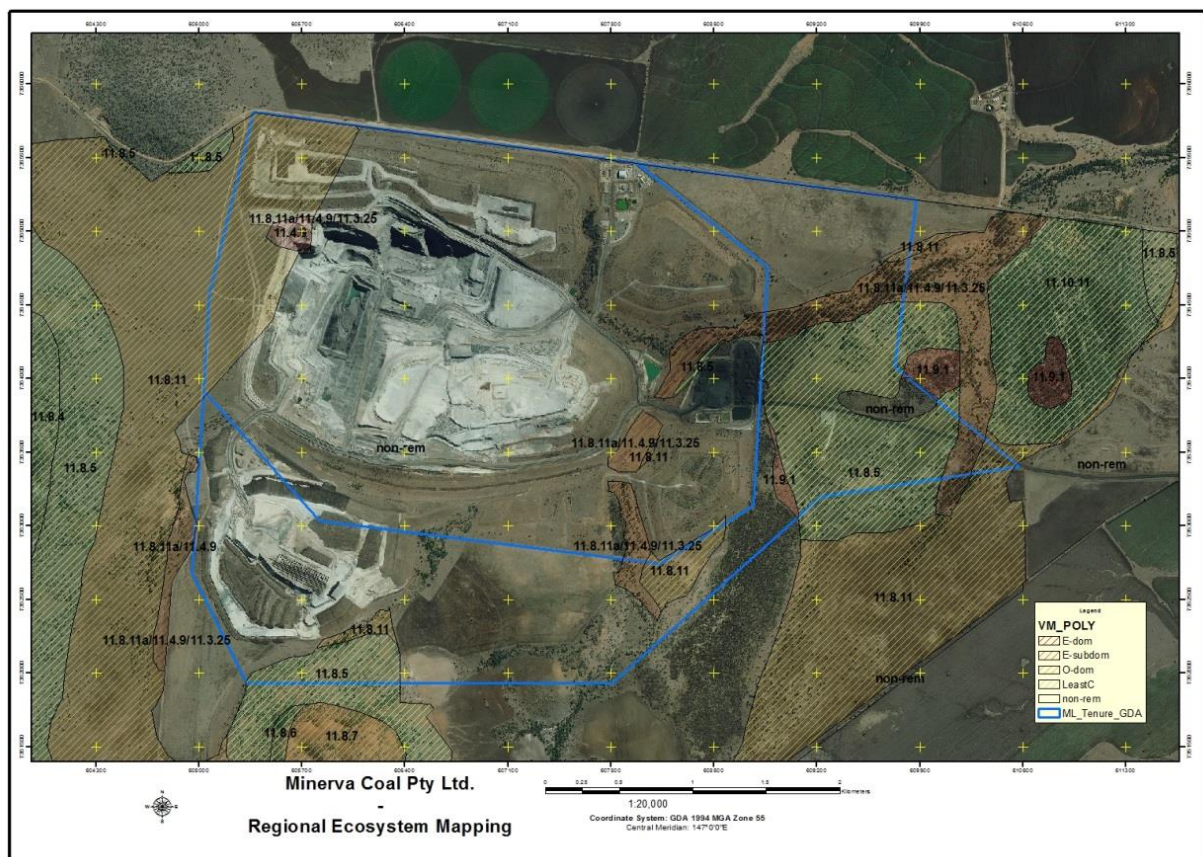


Figure 4 – Minerva Mine Regional Ecosystem Mapping

- 71 In March 2005, Sandhurst Mining Pty Ltd (now Sojitz Minerva Mining Pty Ltd) as operator of the Minerva mine (owned by Minerva Coal Pty Ltd), made application to the Commonwealth Department of Environment and Heritage (DEH) to disturb up to 133 ha of Regional Ecosystem 11.8.11. This ecosystem is dominated by *Dichanthium sericeum* grassland on Cainozoic igneous rocks and is listed under the Federal Environment Protection and Biodiversity Conservation Act (EPBC Act) as a threatened ecological community. The originally disturbed grassland area is located within the Lexington rural property and on Mining Lease 70145. The Approval Instrument was issued by DEH on 19 December 2005 subject to Conditions. One Condition required conservation of an offset area of 133 ha of RE 11.8.11 acceptable to DEH and managed in accordance with a management plan approved by DEH.
- 72 As there were no further areas of the RE on the mining lease, an agreement was reached with the landholder of Lexington Station at the time to secure an area of land to the east of the mining lease. An offset area on the Lexington property was selected and accepted by DEH based on a vegetation survey of the area. DEH required that the conservation of the proposed area was binding on future landholders and would accept a nature refuge under the Queensland Conservation Act over the area. Queensland Parks and Wildlife Services Emerald (QPWS) inspected the proposed offset area and being aware that acceptance of the area in principle was required by DEH, notified Sandhurst Mining by email on 11 November 2005 that the area was acceptable as a nature refuge. On the basis of this preliminary consent by the QPWS, the landholder of Lexington entered into a civil agreement dated 11 October 2005 with Sandhurst Mining to make application to protect the agreed 133 ha. DEH subsequently issued the Approval Instrument to Sandhurst Mining. The Management of Native Grasslands Plan for the proposed offset area was approved by DEH on 21 December 2005. This plan outlined a preferred pathway to apply for nature refuge status of the proposed offset area.
- 73 Minerva Mine is now the owner of Lexington Station that encompasses the defined offset area.
- 74 Given the difficulties with regard to attaining stakeholder ratification for the establishment of Nature Refuge tenure or the development of a Statutory Covenant, a Voluntary Declaration under the *Vegetation Management Act 1999* an application has been lodged concerning the protection of 133 Ha of native grasslands described as Regional Ecosystem 11.8.11 as depicted within Figure 5.

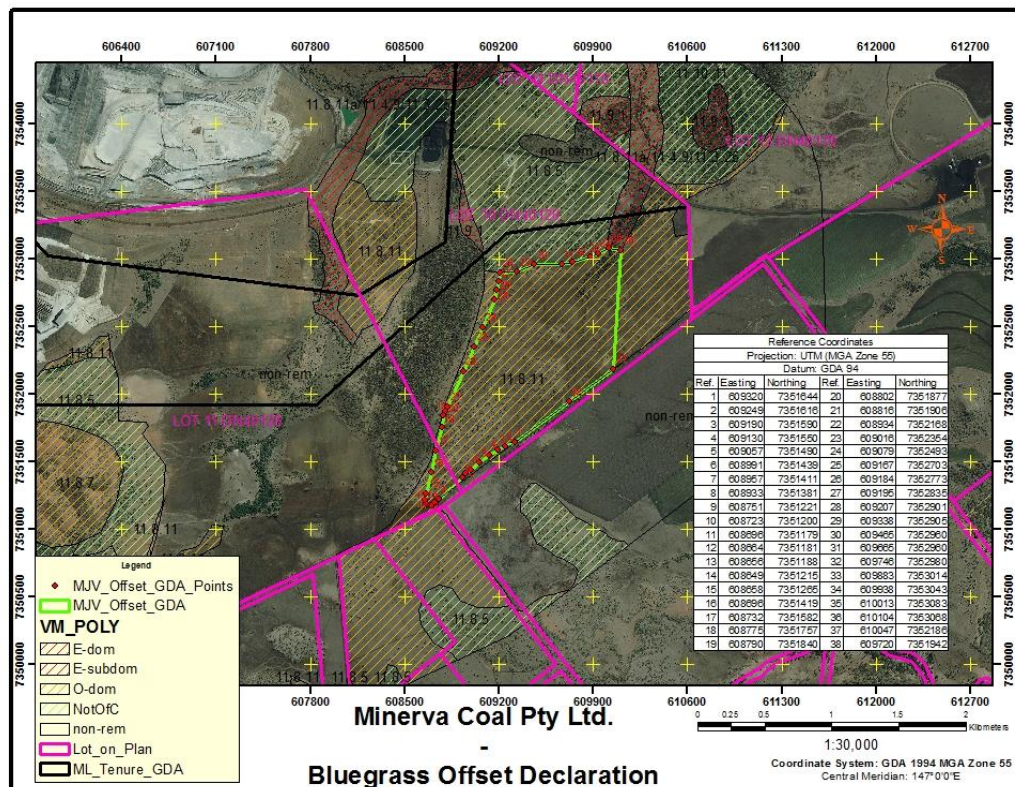


Figure 5 – Minerva Mine Bluegrass Offset Declaration

Fauna

- 75 The *Minerva Mine Environmental Management Plan* indicates that twenty-seven significant fauna species potentially occur within, or in the case of the single aquatic species, downstream of the site and are listed in Table 10. The actual rare and threatened fauna community of the site will be a subset of this list. This list was compiled by Earthworks Environmental Services after a site visit (EES 2004) and desktop review (EES 2005).

Biodiversity Area Protection Strategies

- 76 The preservation and enhancement of biodiversity values will be facilitated by;
- a All unnecessary clearing will be avoided and significant areas of remnant vegetation will be retained where possible. The clearing strategy will allow for linkages of vegetation throughout the Mine area where feasible and will aim to prevent isolation of vegetation;
 - b Implementation and maintenance of appropriate buffer zones to conserve and protect riparian vegetation;
 - c The removal of native habitats will be minimized where possible however, due to previous land clearing, some loss of connectivity between remnant groups may be unavoidable;
 - d Dust settling on flora will be minimized through conventional dust suppression techniques (such as watering haul roads);
 - e Speed limits and restrictions on access will be set to reduce the potential for accidents as well as impacts to fauna and cultural heritage areas;
 - f Locate and assess values of rare or endangered fauna and flora;
 - g Weed management strategies will be implemented throughout the life of the Mine;
 - h Where practicable re-use cleared timber residue to create habitat refuges in appropriate areas.

Corridor Connectivity Assessment

- 77 The elements of corridor suitability include the width and length of desirable communities (i.e. endangered and of concern only) and the assessment of negative edge effects (based on ongoing mining activities, weed species, community intrusiveness from adjacent communities and habitat characteristics). These characteristics will determine the appropriate dedication of suitable areas.

5 Disturbance Type and Extent

Domains

- 78 The Regulator requires that the mine site be classified into a number of disturbance domains and that the rehabilitation objectives provided for each domain must provide a clear description of proposed rehabilitation outcomes within the individual domains in the mine site. Domains are defined as:
- a Land management units within a mine site, usually with similar geophysical characteristics.
- 79 Within domains, elements may be designated where different rehabilitation techniques and/or timing of work is required (i.e. an access road).
- 80 One domain may contain elements that require different rehabilitation treatments. If the elements are essential components of a single land management unit (i.e. a waste rock dump with battered slopes and a flat top), it is preferable for the elements to be included in the same domain with different treatments.
- 81 The principal domains are identified in Table 11 and cover all elements of mine disturbance.
- 82 From a cost perspective the spoil and void domains represent the most challenging areas.

Class	Scientific name	Common name	NCA status	EPBC status	Other ¹ status	Habitat ²	Comment
Birds	<i>Neochmia ruficaudus</i>	Star Finch	E	E		?	Not likely to use site
Reptiles	<i>Hemiaspisis damelii</i>	Grey Snake	E			All	
Birds	<i>Geophaps scripta scripta</i>	Squatter Pigeon (southern subspecies)	V	V		11.8.5, 11.8.11	
Birds	<i>Neochmia phaeton (eastern)</i>	Crimson Finch	V			?	Not likely to use site
Birds	<i>Poephila cincta cincta</i>	Black-throated Finch	V	V		?	Not likely to use site
Reptiles	<i>Denisonia maculata</i>	Ornamental Snake	V	V		All	
Reptiles	<i>Egernia rugosa</i>	Yakka Skink	V	V		11.8.5, 11.3.25d	State wide distributions
Reptiles	<i>Furina dunmall</i>	Dunmall's Snake	V	V		All	Not likely to use site
Reptiles	<i>Paradelma orientalis</i>	Brigalow Scaly-foot	V	V		11.3.25d	Not likely to use site
Reptiles	<i>Rheodytes leukops</i>	Fitzroy River Turtle	V	V		Instream	Not likely in Sandhurst Ck
Birds	<i>Accipiter novaehollandiae</i>	Grey Goshawk	R			11.8.5, 11.3.25d	Highly mobile
Birds	<i>Lophoictinia isura</i>	Square-tailed Kite	R			11.8.5, 11.3.25d	Highly mobile
Birds	<i>Falco hypoleucos</i>	Grey Falcon	R			Aerial	Highly mobile
Birds	<i>Melithreptis gularis</i>	Black-throated Honey-eater	R			11.8.5, 11.3.25d	Highly mobile
Mammals	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	R	V		11.8.5, 11.3.25d	
Mammals	<i>Chalinolobus picatus</i>	Little Pied Bat	R			11.8.5, 11.3.25d	
Reptiles	<i>Acanthophis antarcticus</i>	Common Death Adder	R			All	State wide distributions
Reptiles	<i>Anomalopus brevicollis</i>	Burrowing Skink	R			11.8.5, 11.3.25d	
Reptiles	<i>Furina barnardi</i>	Yellow-naped Snake	R			11.8.5, 11.3.25d	State wide distributions
Reptiles	<i>Strophurus taenicauda</i>	Golden-tailed Gecko	R			11.8.5, 11.3.25d	Not likely to use site
Birds	<i>Hirundapus caudacutus</i>	White-throated Needletail			Y	Aerial	Highly mobile
Birds	<i>Falco cenchroides</i>	Nankeen Kestrel			Y	11.8.5, 11.8.11	Highly mobile
Birds	<i>Merops ornatus</i>	Rainbow Bee-eater			Y	11.8.5, 11.3.25d	Highly mobile
Birds	<i>Falco longipennis</i>	Hobby			Y	11.8.5, 11.3.25d	Highly mobile
Birds	<i>Cuculus saturatus</i>	Oriental Cuckoo			Y	11.8.5, 11.3.25d	Highly mobile
Mammals	<i>Rattus sp cf villosissimus/sordidus</i>	Emerald Rat			Y	11.8.5, 11.8.11	

1. NCA/EPBC status: E – endangered, V – vulnerable, R rare; Other status: Listed as Migratory under EPBC (birds) or undescribed species (Emerald Rat)

2. Habitat is based on regional ecosystem codes identified for the site by Earthworks 2005.

Table 10 – Significant vertebrate fauna species potentially occurring at the Minerva site

Domain	Description
Undisturbed	That area of the ML which remains largely unaffected by mining activity includes areas cleared for grazing or for mining purposes.
Voids – Pits and Ramps	The open excavation – active or inactive mining voids and land pre-stripped of soil or benched forward of the highwall.
Spoil Domain	Unreclaimed spoil: Pre-strip Dumps comprising a range of spoil types including benign and hostile types. Plus: Existing Rehabilitation Areas: Areas that have been rehabilitated under a range of different treatment strategies, which may also differ from revised strategies outlined in this RMP. Areas may also be at various stages of rehabilitation – e.g. regraded, capped, topsoiled, ripped and seeded.
Stream Diversion and Drainage works	Dams, stream diversions, drainage lines
Infrastructure Areas	Areas under buildings, plant or hardstands, contaminated areas and areas which have been stripped of soil cover.

Table 11 – Minerva Mine Disturbance Domains

Map of Existing Rehabilitation Areas

- 83** Coal extraction at the Minerva Mine ceased in August 2021. Areas of disturbance and rehabilitation as at September 2021 are summarised in Table 12 with existing areas depicted in [Appendix 1](#). Details of mining methods over the projected life of the mine are discussed in the [Environmental Management Plan](#) and updated in annual Plans of Operations.

Area Category	Area Sept. 2021 (ha)
Total Lease Area	1,562.99
Undisturbed Area	474.92
Total Area of Disturbance	1,088.07
Disturbance Category	
Pit and Ramps	282.64
Tailings	0
Rejects	0
Active Dump	133.46
Infrastructure	145.16
Stockpiled topsoil	34.93
Diversions and dams	55.78
Rehabilitation - Topsoiled	2.83
Rehabilitation - Seeded	242.34
Rehabilitation - Established	190.92
Disturbance sub-total	1,088.07

Table 12 – Summary of Projected Disturbance Categories – September 2021

6 Final Landform Planning Program

Mine Life Protection

- 84 Coal mining at the Minerva Mine ceased in August 2021. A final landform design has been prepared based on the pit and dump surface configuration at the cessation of coal extraction.
- 85 The following criteria have been applied when optimising the design of the final landform:
- reshape the current low walls to 25% with 30m wide benches every 30m of vertical lift;
 - Western pit reshaped to 210mRL with fill below this at angle of repose;
 - Southern pit reshaped to 200mRL with fill below this at angle of repose;
 - Southern pit south east highwall reshaped in part to reduce void area; and
 - reshaped 25% slopes shall be capped with 0.5m of basalt rock mulch.

Long Term Planning and Spoil Fit Investigations

- 86 Pre-strip spoil placement has by far the most important controlling influence on final landform and its ultimate stability. Current operations involve backfilling to enable in-pit disposal of large quantities of pre-strip material to enhance final landform stability plus provide a cost effective means for spoil disposal. Investigations are in progress with regard to the extent of mine life in-pit dumping and interaction with possible underground development. These attributes will be major determinants with regard to final void extent.
- 87 Truck and shovel will continue to be the primary method for creating the final rehabilitation surface. A major aspect of the mine planning process will highlight locations of future overburden removal, volumes (swelled) and timing. Minerva Mine is developing a Spoil Placement Strategy which not only meets mining objectives but also develops preferred final landform configurations which maximize the proportion of better quality post-mine landform.
- 88 The final landform planning process recognises the requirement to optimise in-pit dumping as far as practicable during operations. Optimisation of in-pit dumping will increase the area of 'beneficial' rehabilitation as spoil dumps will consequently be lower and flatter. Going forward critical attributes pertaining to the Final Landform Planning process will entail;
- a Optimisation of in-pit dumping taking into account potential underground development;
 - b Basalt excavation schedules with regard to rock mulching final batter surfaces.
- 89 Base case final landform planning review entailing life of mine spoil balance assessment and options analysis is work in progress by the Mine Planning Section. Options analysis will essentially relate to potential pit reconfiguration assessment and associated in-pit dumping strategies pertaining to interaction with potential underground development. Metrics of assessment include NPV (Net Present Value), Haul Cycle times and Dump RL.

Rehabilitation Cost - Risk Assessment

- 90 Risk assessment and cost ranging for rehabilitation outcomes is routine practice for industry. Embedded risk management processes into critical business systems enable the company to adopt a precautionary approach to business management.
- 91 Risk ranging and cost assessments conducted via the EWRM (Enterprise Wide Risk Management) Policy framework across industry have identified a number of common risks. Nearly all of these risks were related to landform stability and the adequacy of the site's rehabilitation programs. These risks included:

- a Rehabilitation Criteria – company may not meet performance criteria or government raises goal posts.
 - b Landform Stability – if inadequate or poor design parameters are used, inherent high erosion risks would result.
 - c Final Voids – voids with incompetent wall and spoil materials may need substantial treatment.
 - d Community Pressure – possible community outrage if landforms fail.
 - e Water Management Criteria – if rehabilitation is ineffective, sediments and salts could migrate to creeks and rivers.
 - f Creek Diversions – If poorly designed or constructed, erosion of batters and siltation further downstream could occur.
 - g Groundwater – saline waters or draw down may impact on regional aquifer.
 - h Contaminated Sites – groundwater may be impacted by mobilization of contaminants.
 - i Infrastructure Workshop, ROM – decommissioning costs could be higher than expected.
 - j Haul Roads – decommissioning costs may be higher than expected.
- 92** Historical industry EWRM risk assessments show that the most substantive risks which have greatest potential impact to the business relate to the erosional and geotechnical stability of the final landform. Landscape disturbance is the major impact of open cut mine operations and represents by far the greatest element of the rehabilitation liability.
- 93** The EWRM process highlights that the final landform should not be considered as merely a consequence of an excavation program, but rather the outcome of a planned mining and spoil placement program by which a stable landform has been reinstated.
- 94** Ultimately the most substantive costs for an open cut mine site such as Minerva are associated with stabilizing large areas of elevated spoil and residual voids. These costs are typically an order of magnitude higher than for other mine disturbance categories. Thus spoil volume balance and placement studies have been instigated with a view to leaving the mine landform in which spoil elevation is reduced as much as is practicable, whilst allowing the mine to profitably extract its coal reserves.
- 95** Life of asset mine planning is underpinned by recognition that more conservative spoil treatments are required to achieve a stable and sustainable landform. This RMP describes how Minerva is endeavouring to align its whole of asset life mining program with the requirement to achieve stable and sustainable landforms. Strategies include optimisation of in-pit dumping operations plus regrading and rock mulching of spoil slopes reflecting Regional Ecosystems in the area with similar slope attributes. This approach is to be implemented for erosive prone areas or current rehabilitation domains that have failed.
- 96** There is an intimate cost relationship existing between mining schedules, spoil placement and ultimate mine closure costs. Current costs to rehabilitate the mine site are detailed in the [Plan of Operations](#) which is submitted to the administering authority.

Sustainable Landform Planning

- 97** The EWRM process facilitates re-evaluating the effectiveness of its rehabilitation and mine development processes. This includes designs for future spoil emplacement areas including residual voids in order to ensure that such areas are safe, stable and sustainable after cessation of operations.
- 98** Sustainable Landform Planning guides closure planning processes aimed at the achievement of sustainable rehabilitated landforms on a cost effective basis.
- 99** Rehabilitation of mine disturbed land is not simply an environmental task. The work is of a complex and expensive nature. Satisfactory outcomes can only be available if closure planning is embraced at the corporate, site management and operational levels.
- 100** Planning, design and scheduling of excavation/spoil placement should be aligned with a mine closure plan so that cost effective practices can be implemented during the operational phase of mining with a

goal of substantially reduced rehabilitation expenditures at closure. This is the essential basis of closure/rehabilitation requirements.

- 101** A framework for implementation of the closure process is based on the following tenets:
 - a** Embedding closure/landform requirements into the responsibilities and accountabilities of all senior personnel. This is necessary as the ability of the operation to implement satisfactory closure planning and implementation processes will necessarily impact on the business and its long term viability.
 - b** Outlining preferred strategies/practices for improved spoil placement and reduction of void volume by closure, hence progressive backfill when practicable is encouraged.
 - c** Describing various treatments which could be used to better stabilize spoil placement and in particular recognition that long dispersive spoil slopes are exceedingly difficult to stabilize without rock mulching.
- 102** Spoil characterisation is an integral tool in the rehabilitation process with regard to achieving safe and stable landforms. It allows a greater opportunity for spoil dumps to be planned with rehabilitation in mind, as well as providing a means for opportunistic salvage of competent rock material suitable for rehabilitation purposes. Spoil strata characterisation enables competent material to be identified and salvaged on a planned basis. Reference to *Supplementary Report on Land Capability, Minerva Mine* concerns characterisation of soils and overburden plus land capability assessment for Minerva Coal Mine prior to the commencement of operations. Findings as related to physical and chemical characterisation support Minerva Mine's proposal to rock mulch dump batter slopes concerning areas prone to erosion with appropriate Basalt and/or competent Permian Sandstone strata.
- 103** Application of this rehabilitation methodology is enhanced via operational integration of excavation/dumping schedules for the selection and placement of competent rock strata for final surface thus greatly reducing the possible end of mine life liability to rock armour unstable batter slopes.
- 104** In addition, consideration also needs to be directed towards rehabilitation resource inventory programs; given that rock mulching is seen to be an important aspect of stabilizing steep slopes. Knowledge of the available resource and routine salvage during stripping /excavation operations is essential.
- 105** The Minerva Mine RMP identifies the opportunity of progressive in-pit dumping during operations to improve spoil fit and reduce haul costs as well as minimise the amount of open void at cessation of mining. The Minerva Mine RMP will require annual updating to ensure that improvements in outcomes from operational experiences and learning's are retained.
- 106** The Minerva Mine RMP provides for a range of conservative treatments aimed at making spoil dumps and residual voids safe and stable once rehabilitation of the site has been completed. Thus previous commitments on landform design for spoil emplacement areas and voids contained in the [Environmental Management Plan](#) may need revision to assure uniformity, given the sites intentions to apply a more conservative approach to the treatment of these higher risk areas. Treatments discussed are intended as being applicable for future spoil placement and erosive prone areas.

7 Rehabilitation Design and Treatment Practice

Spoil Domain

- 107** Deeper mining practices in recent years is resulting in increased elevation of spoil emplacement areas, built by the truck and shovel fleet. The extent of dispersible spoil is increasing, spoil fit is becoming more confined and traditional regrade and topsoil rehabilitation treatments are not suitable in some areas. Thus Minerva Mine has developed a range of alternative spoil treatments which are aimed at improved erosional stability hence treatments for all major disturbance domains have been revised. The rehabilitation challenge is to create safe, stable and sustainable landforms from areas of elevated challenging spoil types.

- 108** Truck and shovel will continue to be the primary method for creating the final rehabilitation surface. In line with sustainable landform planning, Minerva Mine is developing long term spoil placement plans for the life of mine extent. It includes such considerations as total spoil volumes, expected final landform configurations, final surface material type, and alignment of in-pit dumping operations to optimise void infill opportunity. This work is ongoing and forms a key part of the Minerva Mine Life Plan.
- 109** Progressive rehabilitation will be undertaken throughout the mine life in conformance with planning requirements included in the Minerva Mine Life of Asset Plan. Specific annual rehabilitation targets will be reported in Plans of Operation.
- 110** Table 13 summarises the control strategies adopted for various aspects of the rehabilitation process.

Landform Element - Spoil Placement

- 111** Spoil should be placed according to mine plans and designs which meet key closure requirements for cost effective stable landform and rehabilitation outcomes. Strategies that are being implemented to meet closure requirements include:
- a** Progressive in-pit dump dumping to enable backfilling of redundant voids/ramps that have been identified as no longer needed for other strategic uses e.g. water supply/containment purposes;
 - b** Batter surfaces with a grade of 25% slope or less providing;
 - i** A minimum 0.5 metre depth of competent rock mulch is placed on final surface prior to application of topsoil;
 - ii** Benching configuration is installed with lifts between benches being less than or equal to 15 m;
 - iii** Bench width dimensions ensure;
 - The establishment of an appropriate drainage containment bund structures to contain a maximum rainfall event;
 - Allow sufficient width for equipment to import topsoil onto batter surfaces;
 - c** Rock mulching operations will not be instigated for flatter plateau areas with slopes of less than 5 % or areas not prone to erosion. Historical rehabilitation areas where rock mulching has not been undertaken will be monitored. Remedial rock mulching works will be scheduled as required for those historical rehabilitation domains where monitoring data demonstrates a trend to failure.
 - d** Taking into account material types and selective handling requirements. Overburden characterisation has complemented the development of an overburden model based on lithological interpretations and correlation of available geophysical data. It is intended that site waste rock strata modelling hence be embedded into the mine planning process, so that excavation/dumping schedules can be amended to ensure competent material is placed onto final surface as part of the operations and not as a separate process.
 - e** Unless backfill is planned, rehabilitation of spoil adjacent to ramps and low walls should allow sufficient buffer width for future spoil regrade so that rehabilitation is not destroyed when these features are regarded.

Aspect	Controls
Spoil quality variation	Spoil and waste characterisation for mining areas; Monitoring of rehabilitation; Analysis of exploration core samples and logging.
Spoil Placement	Encapsulation of saline and dispersive spoil types. Selective handling of basalt strata to facilitate placement on final rehabilitation surface. Strata modelling to understand availability/volumes of basalt strata and excavation schedule for placement on final surface.
Landform design and stability	Planning to ensure that spoil can be accommodated in mined out areas rather than out-of-pit waste dumps. Spoil will be selectively placed or reshaped to create terraced landforms which will allow the return to a useful, stable capability. Spoil will be reshaped to slopes at no steeper than 25% clad with approximately 50cm of competent rock mulch material to prevent erosion and hence mimic steeper natural slope areas west of the mine lease that are underlain by a rock scree. Historical rehabilitation areas where rock mulching has not been undertaken will be monitored. Remedial rock mulching works will be scheduled as required for those historical rehabilitation domains where monitoring data demonstrates a trend to failure. Strategies for landform stability are based on self-sustaining vegetative cover and use of durable rock mulching rather than relying on artificial structures, such as graded banks and drop structures with ongoing maintenance requirements.
Vegetation establishment	Vegetation on flatter slopes is established by contour deep ripping simultaneously seeded to grasses and native tree/shrubs reflecting Regional Ecosystems in the area.
Drainage	Landforms are designed so as to facilitate the establishment and maintenance of stable vegetation cover by adequate infiltration and control of erosion from runoff. Rock mulching plus topsoil application is a key approach with regard to achievement of this outcome rather than reliance on artificial drop structures that are prone to long term failure. Bench and Plateau bunding is to be installed to contain a potential maximum rainfall event from these surface areas.
Performance of Rehabilitation	Regular monitoring of a range of representative sites for each proposed post-mining land type. Aspects to be monitored include erosive stability, soil profile development and vegetative cover, vigour and diversity. Monitoring data will form the basis of success criteria which determines when rehabilitation has reached a stable, acceptable 'steady-state'.
Use of Topsoil	Topsoil will be stripped and used strategically to a depth of 10 – 20 cm over rock mulched batter slope domains designated for bushland habitat with deeper applications for grassland areas as related to flatter aspects. Topsoil stripping is scheduled in the Plan of Operations and undertaken in accordance with soil survey recommendations.
Scheduling rehabilitation activity	The Plan of Operations establishes annual rehabilitation targets. Audits confirm the achievement of rehabilitation targets.

Table 13 – Overburden Spoil Rehabilitation – Aspects and Controls

Void Domain

- 112** This domain is characterised by two voids with associated steep highwalls. The pit floor generally comprises carbonaceous shales which under laid the mined out coal seam. Opposite to the highwall is the low wall which comprises angle of repose spoil rising to well above original ground level. The void is served with ramp structures which allow heavy vehicle access through mined out spoil into the pit. [Minerva Mine Residual Void Investigation Report](#) (5 November 2021) indicates extent of the projected Western (Main) and Southern final void areas. The hierarchy of preferred landform treatments which Minerva proposes to implement for the void domain are outlined below.

High Wall

- 113** Highwall geomorphic and geotechnical stability in perpetuity is paramount with regard to achievement of safe stable and sustainable landforms. Treatments for the highwall include:
- a** Sequential backfilling of final void with pre-strip spoil via current in-pit dumping operations;
 - b** Pending geomorphic/geotechnical evaluation, regrading to a stable slope % and clad with competent rock mulch. Note that the lowwall should be regraded first to minimize the amount of natural ground that will be disturbed by regrading the highwall;
 - c** In situ highwalls can remain with limited fence and bund treatment provided safe, sustainable and stable outcomes are demonstrated by a geotechnical assessment required as part of EA Condition F8. Reference to Figure 1 (MJV Conceptual Basalt Model) depicts depths of in-situ basalt strata of up to 100 metres. Steep sided natural basalt formations to the west of lease form the dominant visual character for the locality;
 - d** Pending completion of groundwater investigations and geomorphic/geotechnical evaluation, it is most likely treatment expedited will be a combination of the above mentioned as related to the competency and lithology of material remaining.

Low Wall

- 114** Treatments for erosive prone low wall spoil areas include:
- a** Backfilled sequentially with mine spoil as related to in-pit dumping operations;
 - b** Batter surfaces with a grade of 25% slope or less providing;
 - i** A minimum 0.5 metre depth of competent rock mulch is placed on final surface prior to application of topsoil;
 - ii** Benching configuration is installed with lifts between benches being 30 m;
Bench width dimensions ensure sufficient width for equipment to import of competent rock mulch and topsoil onto batter surfaces;
 - c** Drainage off adjacent pre-strip dumps should be integrated into the low wall treatment design.

Ramp

- 115** Treatments for Ramps include:
- a** Backfilled sequentially with mine spoil as related to in-pit dumping operations;
 - b** Batter surfaces with a grade of 25% slope or less providing;
 - i** A minimum 0.5 metre depth of competent rock mulch is placed on final surface prior to application of topsoil;
 - ii** Benching configuration is installed with lifts between benches being 30m;

Bench width dimensions ensure sufficient width for equipment to import of competent rock mulch and topsoil onto batter surfaces;

- c** Drainage off adjacent pre-strip dumps should be integrated into the ramp backfill design.

- 116** At Minerva Mine given the existence of significant areas of rehabilitation, the abovementioned revised landform and rehabilitation guidelines are to be implemented for erosive prone areas or current rehabilitation domains that have failed.

Steam Diversion and Channel Works Domain

- 117** Most water control structures will be retained as drainage pathways or permanent storages for use by cattle and wildlife in post mine landforms.
- 118** Minerva Mine has a licence under the Water Act for the diversion of Sandhurst Creek around mining operations to facilitate access to the coal resource. Batters and spillways may require stabilisation works such as the lowering of slope gradients to 25% or less and cladding with competent Basalt material plus topdressing with topsoil. Referable structures will be decommissioned according to requirements of the Administering Authority.
- 119** The primary focus of creek diversions in an operating mine is to prevent flooding of mining areas and not breach Environmental Authority conditions of downstream water quality. This is achieved with ongoing management which includes periodic inspections and maintenance works as required. The focus will vary in the end-of-mining scenario as permanent, self-sustaining stability is the basic objective. For this reason, remedial earthworks may be needed to facilitate ongoing stability.
- 120** If diversion of a major creek or waterway is necessary, the following matters should be considered.
- a** The investment decision includes a full realistic cost estimate for the construction of a diversion which meets at least the Department Natural Resources and Water (DNRW) 2005, Watercourse Diversions - Central Queensland Mining Industry Guideline Version No 1. This guideline is based on Earth Tech, (2002). Bowen Basin River Diversions, Design and Rehabilitation Criteria, Australian Coal Association Research Program (ACARP).
 - b** If dispersive earth forms the embankments, batter slopes of less than 15%, are required unless the batters are lined with competent coarse durable sandstone, volcanic rock or some other equivalent permanently durable rock material.
 - c** Maintain buffer around existing creeks, rivers and diversions sufficient to demonstrate that there is a 50 m wide clearance between crest of the creek, river or diversion embankment and the projected toe of the spoil emplacement after it has been regraded.
 - d** Where practicable, the existing stream length should be re-established in the diversion planning. The Regulator does not often approve diversions which do not meet stream length / stream power criteria.
 - e** Where existing diversions require realignment, sustainable channel and embankment designs need to adopt NRW guidelines. Early construction of the new channel forward of an upstream plug is preferred to enable enhanced establishment and stability of riparian vegetation, before the plug is excavated and the new channel is exposed to river flows.

Infrastructure Domain

- 121** The infrastructure domain includes the mine industrial area, roads, tracks, plant areas, built areas, hardstand areas, ROM, crusher pad, electrical infrastructure, water treatment plant, sewerage treatment plant etc. In summation, areas which have been disturbed for development of some structure, access, or lay down area. These areas for the main, following demolition of built infrastructure and decontamination require only minimal earthworks before conventional rehabilitation treatments such as ripping and seeding are undertaken. Some of these areas might remain post mining if useful for an intended purpose.
- 122** Records are maintained which show the type, location and extent of infrastructure and activities with potential to contaminate land. In future, all such facilities will be assessed by contamination surveys which will also provide strategies for their rehabilitation. Facilities not required after relinquishment of the leases will be rehabilitated after plant and equipment has been removed. Consultation with appropriate stakeholders is planned to determine preferred disposal or retention options. Contour deep ripping and

seeding will be the predominant method of surface preparation with the application of appropriate substrate material and topsoil. Haul roads will be further assessed and may have crushed aggregate either reclaimed for reuse, placed in voids or rehabilitated in-situ. Specific decommissioning plans will be finalized in association with key stakeholders for all facilities as actual closure draws near.

- 123** Areas shown to be contaminated will be rehabilitated in accordance with remediation standards in use in Queensland in consultation with the Regulator. The mine closure requirements for potentially contaminated areas will involve the following stages:
- a** Preliminary (Stage 1) Contaminated Land Assessment - Describes historical processes, locations and severity of sites with potential for contamination. It serves as a guide for detailed Stage 2 assessment of sites as having some potential for contamination.
 - b** Stage 2 Assessment - The appropriate time to conduct a Stage 2 assessment will vary as some sites may become available for rehabilitation during the working life of the mine while many will not be available until actual mine closure. At an appropriate time, potentially contaminated sites identified in Stage 1 surveys will be individually sampled, analysed and rigorously assessed for contamination in line with Regulatory Guidelines.
 - c** Contaminated Land Management Plan - This plan will be developed in conjunction with the Stage 2 assessment. The full scope of remedial works for each area of contamination are documented and accompanied with cost projections. Should contaminated materials requiring disposal be identified, the following options exist::
 - i** Off Site Disposal – Contaminated material is transported to a registered landfill. The material is regulated waste and can only be transported and handled by persons registered to handle such waste. Samples of the material being moved must be taken and analysed for the identified contaminant. One sample per 25m³ of soil is required.
 - ii** On-Site Land Farming – This is an ongoing, regulated process with costs incurred in meeting analytical requirements and managing the facility (e.g., turning and irrigating soil), until remediation is complete.
 - iii** On-site Disposal – The mine may register an on-site landfill for the purpose of disposing of contaminated material to a single location. This appears to be the preferred option for Minerva and needs to be done in consultation with the Regulator.
 - iv** Import clean fill and rehabilitate area - Fill must be clean and may require analytical certification. The area may be topsoiled and seeded.

8 Rehabilitation Monitoring Performance

Existing-Future Rehabilitation Areas

- 124** When operations commenced in 2005, Minerva Mine lease rehabilitation efforts focused on the establishment of pasture based grazing systems on batter slopes at approximately 18% with tube stock forestry on dump plateau areas. This approach has been completed for the NE and SE Dumps that is a total area of 123 Ha.
- 125** An Environmental Authority amendment pertaining to EPML00668613 with regard to review of Landform Design Criteria was undertaken in February 2015. In summation, the intent of review relating to Landform Design Criteria proposed within this Environmental Authority amendment was as follows;
- a** Rehabilitation practices provide appropriate risk mitigation with regard to the ensuring post mining landform outcomes are aligned with EM Plan objectives to:
 - i** Return landforms to the extent that they will be sufficiently stable such that vegetation is self-sustaining;
 - ii** Return land to an agreed land use and capability;
 - iii** Ensure downstream surface water quality is of agreed standard during and after mining;

- iv Ensure surface water quality on the leases is of agreed standard after mining;
 - v Ensure that decommissioned landscapes are safe for humans and wildlife.
 - b Risk mitigation for post mining landforms and uses must recognise that completed areas of the waste dump rehabilitation are formed from unconsolidated sediments that carry a higher risk for erosion than the original undulating terrain formed on consolidated materials such as basalt flows, thus in some areas beneficial use of rock mulch is desirable on some of the existing and erosive prone outer batter slopes to hence mimic steeper natural slope areas west of the mine lease that are underlain by a rock scree;
 - c Use of rock mulch will allow external batters in erosive prone areas to be marginally steepened to 25% plus application of rock mulch to mitigate erosion to any existing slopes showing significant signs of erosion processes;
- 126** Following an onsite EHP inspection (9/12/14) of recent and older rehabilitation areas, it was identified that the application of metrics defined within Land Suitability/Capability Guidelines within the current Environmental Authority EPML00668613 at the time did not align with the core tenets of rehabilitation outcomes concerning the achievement of safe and sustainable landforms. It was therefore agreed that Land Suitability/Capability Guidelines within EPML00668613 needed to be removed.
- 127** The use of rock mulch in rehabilitation of fragile spoil batters offers an effective means of stabilizing steep slopes, particularly in conjunction with pastures and native trees/shrubs. Operations to end of mine life will encounter significant volumes of weathered and competent basalt strata. Salvage of this rock will allow the mine to apply competent rock mulch over any existing slopes where erosion is evident or planned future slopes where erosion risks may be elevated because of poor dispersive spoil sediment presence. Minerva Mine plans to implement this practice as a means of improving long term stability of outer slopes that may already exhibit or be at risk of unacceptable sediment loss. To implement these risk mitigation measures concerning post mine landform stability plus development of bushland habitat on outer batters, it is proposed;
- a Basalt and/or competent Permian Sandstone strata is to be placed on final dump batter slopes to enhance integrity of the long term stability and surface erosion attributes of these surfaces;
 - b Placement of competent Basalt or Permian sandstone rock mulch over unconsolidated batter surfaces to a depth of approximately 50 cm in erosion susceptible areas will mimic existing natural stable rock scree landforms in the area.
 - c These rock mulched areas are then to be topsoiled, deep ripped and seeded with a grass/tree seed mix to promote the development of a stable bushland habitat for these dump slope areas;
 - d Dump plateau areas will not be rock mulched as erosion risks are minimal. Thicker topsoil may be applied in some areas to promote sustainable pasture cover in drought periods and provide improved grazing capability in stressful times.
- 128** An approach of rock mulching dump batters followed by topsoil application that is subsequently deep ripped and seeded to a mix of Acacia and Eucalypt Species reflecting Regional Ecosystems in the area with similar slope attributes will result in the following enhanced environmental values;
- a Reduced potential sediment load runoff concerning downstream water quality attributes off lease;
 - b Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames;
 - c Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term.
- 129** The intent of the proposed Environmental Authority amendment (EPML00668613) was to enable Minerva Mine to implement a rock mulch/native vegetation strategy across some marginally steeper existing outer batters of the mine and erosive prone areas. This will enhance both the stability and visual amenity of the mine post closure. A slope limit of 25% will be maintained for these rock mulched areas. These measures are consistent with the Regulators guideline for safe, stable rehabilitation outcomes.
- 130** The primary rehabilitation objective for spoil areas at Minerva Mine is the creation of stable landforms occupied by a range of native trees, shrubs and pastures. This is essentially a bushland domain in which

occasional grazing may be feasible on flat to gently sloping spoil areas; however, the overall objective for the spoil areas being landform stability. The vegetated areas will provide useful fauna habitat as well as act as bushland corridors for surrounding natural habitat communities.

Overview of Rehabilitation Performance

- 131** Rehabilitation monitoring has been conducted at Minerva Mine since 2008; however no assessment/interpretation of data collected has been undertaken to define trends with regard to rehabilitation performance concerning attributes of profile leaching/nutrition, cover, species diversity and erosion. Characterisation of these attributes is defined within the rehabilitation monitoring methods section of this document.
- 132** Reconciliation of these attributes concerning applicable reference sites and rehabilitation treatments will then be required to facilitate the development of rehabilitation indicators and completion criteria.

Monitoring Sites

- 133** Rehabilitation monitoring with regard to characterisation of attributes concerning profile leaching/nutrition, cover, species diversity and erosion is to commence in 2015. The sites to be monitored are as follows.
 - a** 4 pre-existing sites on topsoiled side slopes of older spoil emplacements;
 - b** 1 new site on rock clad side slopes of a more recent emplacement;
 - c** 1 pre-existing natural site on flat bluegrass areas;
 - d** 3 new reference sites on unmined sloping basaltic landforms.
- 134** The natural/reference sites will facilitate develop of completion criteria as related to the rehabilitation treatments expedited.
- 135** This Rehabilitation Monitoring Plan will be updated with regard to coordinate locations of monitoring sites plus provision of aerial images depicting layout of monitoring sites.

Monitoring Methods

- 136** This section presents the proposed methodology as defined by B.R. Emmerton Pty. Ltd. of *Minerva Mine SE Waste Dump Grazing Trial Design and Monitoring Plan* (Chamberlain and Emmerton, 2014).to census long term monitoring sites at Minerva Mine. It documents the techniques and measurements to be used and data to be collected during monitoring events. Specifically, it describes the preferred techniques and measures to:
 - a** Describe, classify, sample and analyse topsoil and underlying spoil materials to investigate profile development and water relations under different monitoring scenarios;
 - b** Measure gross erosion features (calculated on a per hectare basis) to provide a practical local site based assessment of erosion status that can be compared with other sites and rehabilitation scenarios; and
 - c** Assess vegetation growth and ecological characteristics over time through the measurement of groundcover levels, species diversity, tree density/basal area and crown cover (in the upper-storey).
- 137** As a broad generalisation, the reasoning underlying the need for rehabilitation monitoring by mine site personnel and government regulators, has been seen as;
 - a** Primarily a requirement to determine success or failure of rehabilitation works; and
 - b** Secondly as a basis for determining compliance categories in relation to environmental performance and security deposits.

- 138** It is recognised that the levels of environmental research required to unequivocally understand and document rehabilitation “success or failure”, are time and cost prohibitive. Past monitoring activities on other mine sites have to date largely been concerned with the following three components:
- a** Soil/spoil profile monitoring;
 - b** Vegetation monitoring; and
 - c** Erosion monitoring.
- 139** These components have traditionally been assessed as the minimum basic building blocks required to achieve a functional understanding of the requirements for stable and sustainable post mining rehabilitation outcomes.
- 140** Ideally, assessment should be undertaken when a site is first established and then yearly for 3 years thereafter until an adequate baseline is established, followed by ongoing assessment at longer intervals for as long as monitoring is required. The program should undertake sufficient monitoring activities over an initial ten to twelve year period (i.e. at least several monitoring events) to provide the basis for review and to provide recommendations concerning the direction of future work. In particular, review is required to determine exactly where future resources should be best targeted to achieve an effective rehabilitation outcome.

Soil and spoil characterisation

- 141** The methodology presented below outlines the techniques and measurements to describe, sample, analyse and classify topsoil and underlying spoil materials at long term rehabilitation sites.
- a Site transect location**
 - i** In the longer term, the initial selection of monitoring sites as rehabilitation progresses should ensure the site network adequately represents the diversity of soil, spoil and landform conditions known to occur, as well as the range of likely rehabilitation treatments to be implemented. Each site transect should be located so that it is broadly representative of the rehabilitation type in the immediate surrounding area and will be easily accessible for repeat monitoring activities in the future. It should also preferably be located in a lower slope position within the reshaped landform type to capture maximum effects associated with hydrologic and erosion processes operating at the site. Ideally, the site to be measured should be selected so that it represents an area which is borderline between obvious stability and obvious failure. By selecting sites in this manner it is hoped that in the longer term, combinations of maximum slope angle, maximum slope length and levels of vegetative cover required to achieve slope stability can be predicted for different spoil types.
 - ii** Typically, a central 10m transect is marked by two permanent pegs that are carefully positioned at an angle to the contour and also to any rip lines or other rehabilitation features running through the site. In addition, the endpoints of a 50m transect are pegged along the same line 20m either side of the central points. Each transect is numbered and accurately located with GPS co-ordinates (local mine site datum) marking start and finish points of the central 10m transect. The central 10m monitoring transect is photographed at each monitoring event, typically looking upslope from the lower peg.
 - b Sampling of soil and spoil materials**
 - i** In rehabilitation sites, sampling of the soil/spoil profile in three locations to a depth of 1.0m (or deeper to ensure substrate is sampled if cladding is present) is undertaken in broadly relocatable positions approximately 3m downslope of the central 10m of the vegetation transect. Sampling is conducted at each census at all rehabilitation sites. In unmined sites (i.e. natural ecosystem comparative sites) only one location requires sampling. The following activities and measurements are typically undertaken during sampling at each site:
 - ii** Document an overview of the site including rehab age, visible/perceived rehabilitation treatments, re-disturbance effects, fire history, storm events and general site condition.
 - iii** Measure and record slope % up and down slope (using a clinometer or equivalent) and slope length above the central monitoring point (lower peg of the 10m central transect).

- iv Core and sample three relocatable positions approximately 3m below the central 10m transect to a depth of 1.0m or greater using percussion driven, thin walled soil coring tubes to minimise site disturbance and destruction (if this is not possible, then hand augering is the next preferred option, but is more destructive of the site). On unmined or natural analogue sites one hand augered hole to 1.0m will generally suffice. In rock clad areas destructive sampling (cladding removal by backhoe or excavator) may be required to allow sampling of the cladding and also coring of the substrate below. Experience to date indicates core tubes and hand tools are typically unable to penetrate thicker rock cladding.
- v Estimate and record the level (heavy, moderate, sparse, patchy) and type of vegetative cover in the immediate sampling area for each core.
- vi Extract 1.0m cores and extrude for logging and sampling. Log the nature and depth of differing materials in each core according Australian Standards (National Committee on Soil and Terrain (2009)) particularly, colour, field texture, structure and consistence of all soil/spoil materials encountered. The presence of profile moisture and root density should also be recorded.
- vii Classify soil materials (where present) according to Broad soil categories defined for rehabilitation purposes (Emmertson and Burgess pers. comm.) and the underlying spoil materials according to Spoil classification for rehabilitation purposes (Emmertson and Burgess pers. comm.).
- viii Divide and sample cores in 0.1m increments and bag all increments separately. The immediate surface 0.1m and any interface zones within the core (e.g. soil/spoil boundary) should be sampled in 0.05m increments.
- c pH and EC _{1:5} analysis of soil and spoil materials**
 - i Sampled 0.1m increments from each core at each monitoring site should be routinely analysed for pH and electrical conductivity (EC _{1:5}) according to the following methodology:
 - ii Samples will be air dried, crushed and sieved to <2mm.
 - iii pH and E.C. of each 0.1m increment (approximately 36 measurements per site) is measured using a standard 1:5 soil:water extract as detailed in Methods 3A1 and 4A1 from the Australian standard (ACLEP) laboratory handbook – *Australian Laboratory Handbook of Soil and Water Chemical Methods* (Rayment and Higginson 1992). All results should be reported in full and mean E.C. values graphed against profile depth at each census to track leaching.
 - iv The remainder of spoil samples not used for pH and E.C. analyses should be bulked for subsequent physical and chemical laboratory analysis if required.
- d Full chemical and physical analysis of soil and spoil materials**
 - i During initial monitoring events a representative bulk surface soil sample and a representative bulk spoil/subsoil sample (as well as a cladding sample if present) from each site should be sampled and analysed for the following parameters:
 - pH, EC, Cl and sulphate (SO₄);
 - exchangeable cations (CEC and ESP);
 - PSA and R1 dispersion index;
 - ½ and 15 bar moisture content;
 - organic carbon;
 - nitrate and total nitrogen;
 - extractable and total phosphorus; and
 - copper, manganese, iron and zinc.
 - ii In most subsequent sampling events, only topsoil materials require complete laboratory analyses to track nutritional and structural stability, although spoil/subsoil materials (as well as cladding samples if present) may be further analysed if different characteristics or

unusual behaviour are noted in the field or periodically as profile leaching progresses. Detailed descriptions of the analytical methodologies are available from the Australian Standard (ACLEP) laboratory handbooks *Australian Laboratory Handbook of Soil and Water Chemical Methods* (Rayment and Higginson 1992) and *Soil Physical Measurement and Interpretation for Land Evaluation* (McKenzie et al 2002).

e Description of soil and spoil

- i Field observations collected include geology/parent material, landform (pattern and element) where relevant, slope, relief/modal slope class, substrate lithology, site disturbance, microrelief, surface rock, surface condition, detailed soil profile morphology, site drainage and permeability. Field assessment of soil profile/spoil morphology includes description of soil horizons, boundaries, texture, colour, mottling, bleaching, structure, consistence, gravel, segregations and substrate material (where present); as well as field assessment of sodicity, dispersive behaviour and likely sand/silt fractions. Soil profiles are examined and described in the field either from 32mm intact soil cores or hand auger exposures where access is limited. Detailed profile morphology is described to a depth of 1.0m or to impenetrable rock or gravel prior to sampling for subsequent laboratory analysis.

f Assessment of soil surface condition

- i Surface soils exhibit a characteristic appearance/behaviour when dry which is often indicative of the physical nature of the material and also relevant to its behaviour following disturbance. Soil surface condition is examined and described in the field in accordance with standards outlined by the National Committee on Soil and Terrain (2009).

g Assessment of soil/spoil structure

- i Soils with a high degree of aggregation (and associated void spaces) will generally have a high degree of porosity, while soils that lack aggregation and also possess a range of primary particle sizes can pack to form a dense soil mass which will have low porosity. Soil structure is described in terms of grade or distinctness of pedality, size of peds (average least dimension in mm) and type (or shape) of soil aggregates.
- ii Visual assessment of the structural condition in the surface soil material at each site is undertaken within 5m of the lower vegetation transect peg, and usually below the central transect line. All surface structural data are collected in accordance with classes and standards outlined by the National Committee on Soil and Terrain (2009).
- iii In practice, a 0.2m diameter surface soil plug to a depth of 0.3m is excavated with a drainage spade and examined in detail for evidence of existing/developing structural integrity. Ideally, assessment should be undertaken at each census event.

h Assessment of surface rock cover

- i Lag gravel and rock cover play an important role in assisting surface stability and providing erosion control at rehabilitation sites. Ground cover estimations undertaken as part of vegetation monitoring assessments routinely record the abundance, size, nature and strength/hardness of gravel and rock cover (>6mm - >2000mm). Typically, surface gravel/rock cover data is presented as a summed figure for all coarse fragments as part of overall groundcover estimates. The individual gravel or rock data (size, abundance and strength) is useful however when looking at erosion processes operating at different sites and the possible effects lag surface cover may be having in moderating soil loss. In addition, collection of clearer information on the effect different size fractions and rock abundances have on surface stability is of increasing importance as the use of rock cladding in stabilizing landforms increases. All gravel and rock data are collected in accordance with classes and standards outlined by the National Committee on Soil and Terrain (2009).

i Broad soil categories defined for rehabilitation purposes

- i Soils in the northern Bowen Basin have been extensively researched (Burgess 2003a, 2003b) and factors contributing to potential behaviour following disturbance are well understood. The availability of comprehensive, catchment based soil knowledge has enabled the development of a practical soil classification for rehabilitation purposes. The scheme groups known soil types from the northern Bowen Basin in terms of likely

behavioural characteristics, and classifies topsoil materials into seven broad categories. Categories are based on expected physical and chemical attributes and are ranked in order of increasing structural stability and erosion resistance from least stable to most resilient. The soil classification, when used in conjunction with the Bowen Basin spoil classification, presents a powerful planning tool for predicting rehabilitation response under differing scenarios. It is important to note that both the soil and spoil classifications are live documents and are under continued development (Emmerton and Burgess pers. comm.). The soil classification draws heavily on the soil data presented by Burgess (2003a, 2003b), as well as rehabilitation soil groupings previously developed by Emmerton (pers. comm.).

j Spoil classification for rehabilitation purposes

- i Coal mining activities in the Bowen Basin have mostly targeted the same group of related seams along the north-south length of the outcropping strike. As a result, spoil materials left exposed by open cut operations show considerable repetition across different mine sites within the basin. Typically, the spatial distribution of different spoil types within open cut mining operations is controlled by two main factors, namely:
 - The stratigraphic position of the spoil within the sedimentary (occasionally including igneous material) sequence; and
 - The mining method used to excavate and place the spoil material.
- ii In general, distinct phases of mining and spoil placement/handling occur during the life of a mine. Each phase differs significantly in terms of the spoil resource produced, particularly the spatial distribution, elevation and inherent characteristics of the material. Spoil generated by each phase includes:
 - boxcut spoil which is variable in nature, often highly weathered, but exhibits some degree of spatial predictability;
 - pre-strip spoil which is normally shifted by truck shovel operations and is highly variable and often highly weathered, and also spatially very unpredictable.
- iii Substantial laboratory data and detailed field observations gathered as part of long term spoil monitoring activities undertaken by *B. R. Emmerton Pty Ltd* at a range of mine sites across the Bowen Basin during the past 10-15 years has provided valuable information on the leaching and erosive behaviour of various spoil materials. Based on the amassed information of *B.R. Emmerton Pty Ltd* and *Soil Mapping and Monitoring Pty Ltd* in combination with the landscape data of Burgess (2003a, 2003b) a spoil classification for rehabilitation purposes has been developed (Emmerton and Burgess pers. comm.) to allow categorization of the spoil type present at each long term monitoring site.
- iv The spoil classification recognises and groups the range of substrate materials typically exposed by coal mining activities within the Bowen Basin and describes them in a framework suited to spoil behaviour and rehabilitation outcomes. It classifies spoil materials into broad categories based on geological age, *in situ* weathering status (of the undisturbed strata), dominant lithology, known measured physical and chemical attributes and expected behavioural characteristics following exposure and weathering. It also provides a valuable guide to the infiltration and leaching characteristics, reactivity and chemistry of different spoil materials, as well as qualitative prediction regarding degree of competency and response to accelerated weathering. When the spoil classification is used in conjunction with the topsoil classification discussed in Section 1.9 they form a powerful planning tool for predicting rehabilitation response under differing scenarios. It is important to note that both the soil and spoil classifications are live documents and are under continued development (Emmerton and Burgess pers. comm.).

Erosion Assessment

- 142** The methodology presented outlines the techniques and measurements used to describe the state/activity, type and degree of erosion at a site and provide some simple measures to quantify the extent and severity of any erosion processes operating.

a Visual erosion assessment-immediate site area

- i Visual assessment of the erosion features in the immediate site area at each site is undertaken within 5m of the lower vegetation transect peg and is centred around the central transect line. This assessment is conducted in conjunction with the description and assessment of surface soil condition and structure parameters because it is likely that surface soil behaviour and surface erosion processes are closely related. Ideally, assessment should be undertaken each time a site is censused. Typically, the visual assessment of the immediate site area involves:
 - Determining the presence of sheet erosion, (percentage of the area affected, exposure of roots or depth of removal from stone/root pedestals and presence of lag gravel);
 - Determining the presence of terracettes; and
 - Determining the presence and depth of remaining rip lines.
- b **Assessment of gross erosion features – transect measurements**
 - i The frequency and dimensions of all **rill, gully, piping, cracking and mass movement features** observed along a 50m transect line are recorded for a defined area either side of the transects centreline (i.e. typically numbers of observed features within a 50 x 2m plot centred around the erosion transects centreline). Collection of gross erosion data in this way allows calculation of erosion statistics on a per hectare basis (i.e. numbers and dimensions of rills, gullies, pipes and mass movement features per ha). Such data allows a more practical understanding of erosion status at different sites and provides a convenient platform for comparing erosion status between different rehabilitation scenarios (erosion outcomes from different soil – spoil – landform – treatment combinations).
 - ii **Initial selection and setup of the erosion transect** at a site involves locating the midpoint and two endpoints of the transect using a 50m tape. The lower (downslope) 10m vegetation transect peg is used as the centre point of the transect and the tape is then run out 25m in either direction at an angle effectively perpendicular to the slope (i.e. approximately on the contour). The ends of the transect are carefully positioned to ensure the three pegs are in alignment. This ensures the transect line can be accurately located during assessments using any two pegs from any point on the transect. The transect endpoints are permanently pegged and GPS locations recorded. Positioning of the transect may require modification at some sites where slope angle and site area constraints require a different alignment.
 - iii **Measurement of rill and gully features along the transect** requires initial assessment of rill/gully erosion features >0.05m deep that intercept the transect centre line, irrespective of whether they are active or not. Differentiation between rills and gullies is depth based, with rills being recorded for features with depths <0.3m and gullies where depths are >0.3m. At each observation point along the transect the following is recorded:
 - Location and size of the rill or gully feature (width and depth);
 - Activity state of the rill or gully (active, stabilised, partly stabilised);
 - Gully morphology (U shaped, square, V shaped, trough or broad trough, V or broad V);
 - Presence of layers which may impede or increase erosion rates (e.g. dispersive layers, rock cladding etc); and
 - Degree of development/severity of the rill or gully; categories recorded include minor (isolated, linear discontinuous), moderate (linear, continuous, primary or minor drainage lines), severe (continuous or discontinuous and incorporating secondary drainage lines/multiple branches) or deeply incised.
 - iv **Measurement of sheet erosion and any piping or mass movement features** that may be present in a predetermined area running either side of the transect centreline is also undertaken. The width of the observation area running either side of the 50m transect can be varied to suit conditions (calculations can be presented on a per hectare basis). The width of the observation area should be set at a distance that allows easy and practical observations, but be large enough to be representative of the wider rehabilitation area being

investigated. Typical widths (either side of the centreline) range from as narrow as 0.5m where vegetative cover is very thick to wider than 5m where groundcover is extremely sparse and erosion features are easily observable.

- v For **each erosion feature** observed along the transect the following is recorded:
 - Type/nature of the erosion feature (sheet, rill, gully or piping/mass movement);
 - Dimensions of the erosion feature (width and depth for rills/gullies, diameter and depth for piping/mass movement); and
 - Severity of the erosion feature (maximum width/length/depth) to allow investigation and comparison at future monitoring events.
- vi In situations where piping/cracking/mass movement are not recorded as part of the erosion transect, but are observed elsewhere within the wider monitoring site area, then estimated numbers per 1000m² should be recorded.
- vii **Measures of erosion status** calculated from erosion transect data include:
 - Piping density (pipe structures per hectare);
 - Sheet erosion extent (%) along the transect; and
 - Gully index. Obtained by summing gully cross sectional area in m² (gully width (m) x gully depth (m)) over the length of the transect.

Vegetation Monitoring

143 The methodology presented outlines the techniques and measurements used to attributes of vegetation established.

a Monitoring site design

- i Selection of monitoring sites should ensure the site network at the mine represents the diversity of soil, spoil and landform conditions known to occur, as well as the range of likely rehabilitation treatments to be implemented. Because temporal vegetation monitoring requires periodic repeat assessment, monitoring site design needs to ensure that:
 - Any transect or quadrat layout is scientifically valid;
 - Vegetation measurements and any sampling are non-destructive;
 - Soil and spoil sampling is non-destructive (to the degree possible) and vegetative cover is left intact (other than some trampling around access pathways); and
 - Adequate access is available to all site components to ensure each monitoring activity does not negatively impact on any other activity and that subsequent re-measurement is not influenced by previous monitoring events.
- ii At each monitoring site, species identification as well as various measures of cover, density and vegetative change are measured and recorded for ground layer species and also above ground canopy species. The transect is marked by two permanent pegs 10m apart and carefully positioned at an angle to the contour and also to any rip lines or other surface treatments running through the site. Each transect is numbered and accurately located with GPS co-ordinates (local site datum) marking start and finish points. Central monitoring transects are photographed at each monitoring event. Transect photographs are typically taken from the downslope 10m central transect peg looking upslope along the transect. Photo aspect should match pre-existing records wherever possible.

b Overview of vegetation monitoring measurements

- i The basic units of measurement used to determine vegetation growth and ecological characteristics at each monitoring site include groundcover measurement (%), species diversity counts, stem density (stems/ha)/basal area (m²/ha) assessment and crown cover measurement (%). In addition, a number of calculated live groundcover parameters such as species dominance, proportional similarity and community flux are used to characterize

ecological development or change. During each rehabilitation monitoring event, the following quantifiable measurement and sampling routines are undertaken:

- **Groundcover analysis (%)** along the permanent central 10m transect;
- **Species diversity counts** within 10m², 100m² and 1000m² permanent plots;
- **Live groundcover parameters** (species dominance measured as Simpsons Index (C) and effective species number);
- **Tree density (stems/ha) and basal area (m²/ha)** for individual species and also summed for broader ecological groups;
- **Crown cover (%)** for individual species and also summed for the entire canopy.

c Groundcover analysis (%)

- i Groundcover is measured as a direct percentage (%) from 100 vertical intercepts along the permanent central 10m transect during each monitoring event. Data collection in the field uses crosshair sightings from a 1.0m high vertical sighting tube every 0.1m along the length a 10m tape strung between the permanent central transect markers. Measurements are quantifiable and repeatable and provide very clear data on the components of groundcover within and between years at each location. Groundcover measurements are typically collected first at a site to avoid possible trampling from other monitoring activities. During each monitoring event **live cover (LC)**, **standing dry cover (SD)**, **litter (L)**, **fallen timber (T)**, **surface gravel and/or rock cover (R)** and **bare ground (B)** are measured. **Vegetative groundcover (VGC)** is calculated by summing all components except fallen timber, gravel/rock and bare ground, while **total groundcover (TGC)** includes all components except bare ground.
- ii The **abundance, size and nature of gravel and rock cover (>6mm - >2000mm)** is routinely recorded during groundcover field data collection at all monitoring sites (the raw data is generally not presented in monitoring summaries but is available if required). This recognises the important role lag gravel and rock cover play in surface stability and erosion control at rehabilitation sites. Collection of clearer information on the effect different size fractions and abundances have on surface stability is of increasing importance as the use of rock clad landforms in rehabilitation increases. All gravel and rock data are collected in accordance with classes and standards outlined by the National Committee on Soil and Terrain (2009).

d Species (by area) diversity

- i Species diversity on rehabilitated sites is typically lower than in natural situations and often reduces further over time following initial rehabilitation, as the number of coloniser species declines. Diversity is assessed on an area basis for monitoring sites and measures species counts from predefined/permanent and repeatable sampling plots of varying sizes. The area sampled for diversity increases progressively in size from an initial 10 x 1m transect (10m²) to a 10 x 10m sample plot (100m²) and finally a 50 x 20m sample plot (1000m²); all centred around the permanent central 10m site transect. Each incremental increase in plot size incorporates the species counts from the previously sampled area and only additional species are added to the counts for larger plots. Species are identified and listed at each census event.
 - The **species count for the 10m² plot** is measured between the two permanent pegs of the central 10m transect, approximately 0.5m either side of the transect centreline (10m x 1m).
 - The **species count for the 100m² plot** is measured by adding to the previous count, additional species that are present within an area 5m either side of the permanent 10m transect centreline (10m x 10m).
 - The **species count for the 1000m² plot** is measured by adding to the previous count, additional species that are present within an area 10m either side of the permanent 10m transect centreline and extending 20m distant from both end pegs (50m x 20m).

e Live groundcover parameters

i Species dominance

- Species dominance is a calculated parameter derived from the relative **proportions of one species compared with the other species present**. Dominance is typically lowest in natural vegetation communities (i.e. where species diversity is highest) and much higher (although variable) in rehabilitation situations. Assessment of species dominance (or concentration) is based on the probability that two randomly chosen plant specimens from the central 10m groundcover transect will belong to the same species. The dominance estimate for a site is determined statistically from live cover proportions and is known as **Simpson's Index (C)**.
- It is calculated as the sum of squares of species importance values. These are proportional values for each of the live species present and are derived from live cover (%) measurements collected during the central 10m groundcover transect. Simpson's Index varies from a value of 0 (an infinite number of non-dominating species) to a maximum of 1.0 (only one species present). Essentially, the lower the index then the lower the concentration or dominance shown by individual species and the higher the heterogeneity.

ii Number of effective species (1/C)

- In most rehabilitation scenarios, total groundcover levels significantly exceed those measured in natural situations. However, measured data shows that often only a few effective live species are normally present. This compares with much higher numbers in more diverse natural situations. Because Simpson's Index (C) varies inversely with heterogeneity, its reciprocal (1/C) which is defined as the **number of effective species**, can be interpreted as the number of equally represented species that would account for the variation present at a particular site.
- As such, the **number of effective species (1/C)** is a useful tool for interpreting dominance data. For example, a Simpson's Index of 0.1 or 0.2 can be interpreted as the equivalent of 10 or 5 equally represented or effective species at a site, suggesting a very diverse groundcover layer. Conversely a Simpson's Index of 0.5 or 1.0 would mean only 2 or even just 1 equally represented or effective species was present; a result often seen in buffel grass situations.

f Tree density and basal area

- i Tree density numbers (stems/ha) and basal area figures (stem cross-sectional area in m²/ha calculated from tree girth at breast height within a known plot size) are collected as part of the vegetation monitoring suite to provide surrogate measures of tree biomass. Tree density is assessed by counting all stems irrespective of height, within a known plot size. Plants with multiple stems are counted only once. Basal area is recorded for all stems >0.1m girth at breast height within the nominated plot.
- ii Typically, the measured plot covers 500m² and is located 5m either side of the permanent 10m groundcover transect centreline and extends 20m distant from both central marker pegs (50m x 10m). This size plot allows representative assessment of density and basal area data at most sites, while keeping measurements relevant to the other monitoring activities being undertaken (particularly groundcover, soil characteristics and erosion measures) within close proximity of the central 10m transect at each site.
- iii Whilst a 500m² plot is preferable for consistency, plot size can be varied to suit particular circumstances, as final tree density and basal area data are calculated on a per ha basis. Typically, plot sizes are only varied in situations where:
 - Tree densities are very low. In such cases, plot size can be increased to 1000m² located 10m either side of the permanent 10m groundcover transect centreline and extending 20m distant from both central marker pegs (50 x 20m - equivalent to the largest species diversity plot); or
 - Conversely, where tree densities are very high. In such cases, plot size can be reduced to 100m² located 1.0m either side of the permanent 10m groundcover

transect centreline and extending 20m distant from both central marker pegs (50 x 2m).

- iv **Stem density** varies from year to year, either through recruitment of seedlings or through the death of mature individuals. Species and stem height (m) (minimum of 3 typical specimens for each species) are recorded for all stems within the nominated sample area. Stem counts for individual species from either a 100m², 500m² or 1000m² plot size are converted to stems/ha to allow comparison of data between years and across sites. Stem numbers for each species may also be summed to provide stem density data on a broad vegetation group basis or for the site as a whole.
 - v **Basal area** is recorded for all stems within the nominated plot where girth (m) measured 1.3m above ground level is greater than 0.1m. Girth measurements (stem circumference in m) provide a rapid and reliable surrogate for diameter at breast height (dbh). Girth values (m) are converted to a radius value (m) before calculating cross-sectional area (m²) for each stem. Individual stem cross sectional area figures for each species either from a 100m², 500m² or 1000m² plot size are then summed and converted to basal area figures in m²/ha (calculations vary depending on plot size). Figures for individual species may also be summed to provide basal area data (m²/ha) on a broad vegetation group basis or for the site as a whole.
- g Crown cover (%)**
- i Crown cover (%) data for above ground canopy forming species is routinely recorded during field data collection at all monitoring sites. This recognises the importance that crown cover potentially plays in moderating rainfall impact and erosion risk and also as a component of ecosystem functionality. Collection of more detailed information on the level of canopy cover under different rehabilitation scenarios and also in comparable natural analogue situations will be important when characterising the ecosystem value of rehabilitated vegetation during future mine decommissioning and relinquishment.
 - ii Current methodology used in the collection of **crown cover (%)** data at individual sites records the extent of canopy intercepts along a 50m tape. The start and finish of each crown is recorded and summed as a total canopy distance for each individual species. Canopy intercepts are then converted to crown cover % as a simple proportion (i.e. crown cover % = total canopy distance in 50m x 2) and calculated either on an individual species basis or as a total value for the site as a whole.
 - iii Crown cover measurements are undertaken along the central 50m transect running through the centre of each monitoring site. This transect is permanently positioned by the 2 central 10m marker pegs (delineating the 10m groundcover transect) and extends 20m distant from each peg. It is important to recognise that the positioning of this transect has been determined by monitoring requirements other than the measurement of crown cover (%). Whilst crown cover data collected along this transect will be spatially relevant to other monitoring measures collected at the site, it may not necessarily be representative of crown sizes or crown separation ratios across the wider site area. Conversely, the advantage of measuring crown data in its current format is that it allows accurate, relocatable and repeatable measurements between census events and ensures temporal changes are observed and quantified. In addition, crown cover measurements collected in this way will be spatially relevant to other monitoring data collected at the site such as tree density, species diversity and groundcover analyses.

Monitoring Schedule

144 Monitoring programs at Minerva Mine are outlined in Table 14.

TYPE OF DISTURBANCE	TYPE OF MONITORING	SCHEDULE Going Forward
Overburden dumps	Rehabilitation monitoring as defined within the Monitoring Methods Section of the Rehabilitation Management Plan concerning; • Soil profile attributes • Vegetation establishment • Surface Stability • Surface/Soil Fertility	Every 2 years or as considered necessary for each site by 3 rd Party Scientists.
Undisturbed RE areas in ML's	Bluegrass Offset Area monitoring.	Annual
Final void, Dams	Water quality. Geotechnical stability/safety of high and low wall areas.	Quarterly Dam sampling as defined by Environmental Authority EPML00668613. Monthly standing groundwater levels. Bi-annual groundwater sampling as defined by Environmental Authority EPML00668613. Annual groundwater sampling as per Water Licence requirements. Ongoing pit inspections during operations. Post closure, geotechnical inspection and assessment conducted on an annual basis over a 5 year period.
Creek Diversions	<u>Vegetation Cover Assessment & Structural Stability</u> Examine the full length of diversions using high resolution aerial photogrammetry and / or detailed ground observations.	Surveillance inspections as per Water Licence requirements.
	Assess whether water quality might be adversely affected during passage through the diversion (i.e. upstream and downstream water quality sampling for key analytes including pH, EC, Sulphate, Suspended Solids and Metals).	Annual REMP monitoring process as defined by Environmental Authority EPML00668613.
Standing highwalls	Highwall geotechnical stability status. Field inspections and aerial imagery.	Ongoing pit inspections during operations. Post closure, geotechnical inspection and assessment conducted on an annual basis over a 5 year period.

Table 14 – Rehabilitation Monitoring Program

9 Rehabilitation Performance Criteria

- 145** Growing evidence from over 30 years of rehabilitation monitoring in the Bowen Basin indicates that direct duplication of adjoining natural ecosystems is impractical on most rehabilitated overburden spoil. The major reason being the significant differences between mine spoil and natural soils chemical and physical makeup; as well rehabilitated spoil landscapes are often more elevated with greater slope gradients. The spoil growth media is often unweathered, unconsolidated, sodic, and saline; thus is different in physical and chemical makeup than surrounding natural subsoil. However, an approach of rock mulching erosive prone dump batters followed by topsoil application that is subsequently deep ripped and seeded to a mix of Acacia and Eucalypt Species reflecting Regional Ecosystems in the area with similar slope attributes will result in the following enhanced environmental values;
- a** Reduced potential sediment load runoff concerning downstream water quality attributes off lease;
 - b** Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames;
 - c** Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term.
- 146** The rehabilitation success criteria for mine disturbance areas must be primarily based on achieving a stable landform. Rehabilitated areas will be monitored using the selected parameters and trends tracked to demonstrate progress towards a self-sustaining vegetation cover. The natural/reference sites will facilitate develop of completion criteria as related to the rehabilitation treatments expedited.
- 147** General aspects for consideration in the validation of rehabilitation performance criteria include;
- a** Geotechnical and hydrological landform stability, including final void highwall, with no mass failure of slopes;
 - b** Effective drainage structures, including creek diversions, with similar characteristics to natural waterways in the vicinity of the site;
 - c** Downstream water quality complying with conditions of the Environmental Authority (sediment, salinity values).
 - d** Externally draining areas must be stable in terms of erosion processes.
- 148** Table 15 outlines the performance indicators which Minerva will take into consideration when assessing the sustainability of its rehabilitation programs for each post-mining land use (PMLU) and non-use management area (NUMA). A conceptual map of PMLUs and NUMAs at closure is presented in **Appendix 2**. Performance Criteria will be updated as further characterisation and understanding of natural/reference site attributes is developed via the rehabilitation monitoring program.

Demonstration Sites

- 149** Rehabilitation monitoring sites which have met the performance criteria for at least 3 successive monitoring events will be proposed as demonstration sites. These sites are those deemed to have reached a desirable steady-state condition in terms of stability, soil profile and floral characteristics. These sites will continue to be monitored and will become the compliance standard for success of rehabilitation.
- 150** Natural Sites
- a** Representative natural sites will continue to be monitored. The main purpose is to document the natural range of vegetative variation in grazing and bushland settings with a view to returning land which mimics it as best as can be achieved (i.e., bushland and grazing compatibility/connectivity as is possible). However as indicated, a return of rehabilitated spoil to the same native analogue function is not feasible nor is it proposed in this RMP.

Disturbance Type	PMLU/NUMA	Performance Requirements
Overburden spoil.	Grassy open woodland	Effective rooting depth > 50cm (indicated by acceptable soil profile pH/EC, salinity or hard layers) No acid or saline seepage areas derived by inspections and interrogation of imagery at resolution of 1:5k to 1:10K Absence of active rills and gullies as evidenced from surveillance from high resolution photogrammetry and ground observation/measurement. Ground cover stable or improving. Ground cover is defined as any cover that assists in controlling erosion and may include live or dead cover and possibly rocky debris. Developing vegetative community consisting of a mixture of predominantly native trees, shrubs and grasses. Specific areas of potential contamination have been identified, remediated and monitored according to the Regulator's requirements.
Infrastructure, including ROM areas, creek diversions	Low-intensity grazing	Effective rooting depth > 50cm (indicated by acceptable soil profile pH/EC, salinity or hard layers) No acid or saline seepage areas derived by inspections and interrogation of imagery at resolution of 1:5k to 1:10K Absence of active rills and gullies as evidenced from surveillance from high resolution photogrammetry and ground observation/measurement. Ground cover stable or improving. Ground cover is defined as any cover that assists in controlling erosion and may include live or dead cover and possibly rocky debris. Specific areas of potential contamination have been identified, remediated and monitored according to the Regulator's requirements.
Final Voids	Non-Use Management Area*	No public access to highwalls/end walls (bundling/fencing as required) Closure bund installed minimum 50m from pit crest or distance equal to Factor of Safety of 1.5 (unless an alternative is justified by an appropriately qualified person). Maximum slope in competent rock 275% (70 degrees). Maximum slope in incompetent rock 65% (angle of repose). Maximum total void surface area 91ha (measured at maximum water level) Assessment report by a Registered Professional Engineer of Queensland (RPEQ) on the geotechnical stability of final voids. Surface water and groundwater quality of receiving waters meets the requirements of Schedule W of the Environmental Authority. Voids have no adverse environmental impacts on surrounding aquifers 1 in 1,000 AEP flood event in Sandhurst Creek diversion does not enter final void.
Dams	Water storage	Water quality is suitable for beef cattle drinking water (EA Table W6). Functioning bywash or spillway with adequate flow capacity provided for dams. Sign-off by post-mining landholder (for retained dams).

* Western and Southern voids as determined by Residual Void Investigation Report (5 November 2021)

Table 15 – Rehabilitation Performance Criteria

Performance Review & Corrective Actions

- 151** Annual review and update will include:
- a** Ensure that any significant changes to the long term mine plan are incorporated;
 - b** Mine site disturbance is updated on mine plans and conforms with the Plan of Operations;
 - c** All environmental monitoring programs are being conducted to the required standards of the Environmental Authority and data is readily available;
 - d** Suitably qualified persons conduct reviews of all monitoring data at least every 2 years to determine data trends, coverage is adequate and methods are appropriate;
 - e** Rehabilitation performance is trending towards final completion criteria and required rehabilitation repair works are scheduled;
 - f** Spoil and topsoil chemistry characterization is current;
 - g** Topsoil records (stockpiles and spread over rehabilitation) are current;
 - h** Actual costs for rehabilitation activities conform to Plan of Operations requirements.
- 152** The annual review should provide direction and evidence for auditors in the verification of Performance Category for annual Plan of Operations.

10 Post Mine Land Capability

Post Mine Land Use

- 153** The objective of spoil reshaping is to maximise areas of higher potential suitable land which will remain stable and not impact downstream. Overriding goals are to re-contour to acceptable slopes and establish vegetation suited to the area that is compatible with established regional land use patterns. Appropriate management of particular domain areas where slope is not an attribute limitation may allow grazing activities to be sustainable for those areas.
- 154** If research or monitoring shows grazing to be undesirable, all areas will revert to a bushland habitat with stable self-sustaining land types being the overriding concept.
- 155** Proposed post mining land uses include:
- a** Low-intensity grazing;
 - b** Grassy open woodland; and
 - c** Water storage areas (dams).

Land Suitability Assessment Process

- 156** The steps involved in the assessment of grazing suitability for post mine lands are summarized below.
- a** Requirements for a grazing use were expressed as limitations, which may be measured or estimated in various ways. Assessment of limitations is based on Shields and Williams (1991) for grazing in the Kilcummin area near Clermont. The severity and relevance of certain limitations in the agricultural environment may differ to reclaimed mine lands, e.g., high salinity in the root zone of an agricultural soil may be irrelevant in certain types of mine spoil which are known to leach salts out over time.
 - b** **Table 16** lists the major land use requirements for grazing and limiting factors deemed relevant to rehabilitated domains.

- c The various baseline data attributes used to measure or approximate the severity of limitations were then determined. Such attributes are referred to as diagnostic attributes by Land Resources Branch (1990) and are listed in Table 17.
- d Critical values for each diagnostic attribute need to be determined from established standards. In the case of this Plan, the adopted standards are either that from Shields and Williams (1991), or are to be validated via forthcoming rehabilitation monitoring processes.
- e Each post-mining land type is then allocated a grazing suitability class based on the most severe limitation or combination of limitations.

Grazing Use Requirement	Limitation
acceptable long term soil loss rates	erosion (e)
adequate water supply	water availability (m)
adequate nutrient supply	nutrient deficiency (n)
low levels of toxic elements	element toxicity (nt)
favourable levels of soluble salts	soil profile salinity (sa)
adequate soil aeration	soil physical factors (p)
suitable water quality	water quality in voids and spoil
adequate soil depth for plant roots	effective rooting depth (r)
favourable soil reaction	pH (pH)
surface gravel, coal and rock not excessive	rockiness (r)
minimum wet ground conditions	wetness (w),
ability to access stock or stock to graze	landscape complexity (lc)

Table 16 – Land Characteristics Requirements for Grazing

Grazing Suitability

- 157 The potential for a beef cattle grazing land use for rehabilitated spoil is to be assessed using the methodology of Land Resources Branch (1990) and suitability classes assigned according to Shields and Williams 1991. The five class grazing suitability classification as proposed by Shields and Williams (1991) is shown as the following Table 18.
- 158 Areas of rehabilitation will be identified at Minerva Mine via rehabilitation monitoring processes which demonstrates potential for grazing. Grazing land units need to be significant in size and uniform in nature such that excessive risk of degradation does not occur.
- 159 The best grazing potential can expected to be on the rehabilitated infrastructure domain, which have low, stable, slopes. These areas are likely to be at best class 3 grazing land which Shields and Williams (1991) considers to be; suitable land with moderate limitations which require incorporation of various management practices to maintain economic production. A low-intensity grazing post-mining land use is proposed (see Table 15 and Appendix 2). Under such low-intensity grazing conditions, the post-mining land use would be sustainable, non-polluting, stable and safe to humans, stock and wildlife.

Limitation	Diagnostic attributes
erosion (e)	slope gradient slope length use of topsoil size, frequency and stability status of gullies texture spoil type internally or externally draining
water availability (m)	spoil type and slope topsoil type and depth effective rooting depth compaction (PSA, Ca:Mg ratio on surface) clay % limit of wetting front (depth to salt layer) landscape position ESP profile vegetation types and vigour rainfall distribution gravimetric water contents at –33 , –1500KPa
nutrient deficiency (n)	topsoil or spoil type pH profile, texture Al or Fe content organic matter (not organic Carbon) cation exchange capacity fertility laboratory analysis
salinity (sa)	mean root zone salinity via EC extent of wetting front to salt accumulation
water quality	EC, pH and sulphates levels of void and spoil water bodies.
soil physical factors (p)	surface condition – texture / structure % surface gravels or coal size and frequency of gullies
wetness (w)	vegetation type period & frequency of saturation or free water depth of possible inundation
landscape complexity (lc)	size and shape of suitable land types effects of adjoining non-suitable land

Table 17 – Diagnostic attributes used to evaluate severity of limitations

160 Emmerton (2003) proposed a set of landform parameters which were considered indicative of a possible grazing use of rehabilitated domains which include;

- a** A maximum slope of 12%
- b** Cover levels maintained above 70%
- c** Adequate slope configurations, cation exchange capacity, salinity profiles, pH and structure.

Table 19 lists the major limiting factors which are relevant to this assessment of a potential grazing use on domains of rehabilitation.

Class	Description
1	Suitable for grazing with negligible limitations.
2	Suitable for grazing with minor limitations.
3	Suitable land with moderate limitations which require incorporation of various management practices to maintain economic production.
4	Marginal land which is presently unsuitable due to severe limitations where the long term significance of the limitations is not known. The use of this land is dependent on outcomes of additional studies.
5	Unsuitable with extreme limitations.

Table 18 – Grazing Land Suitability Classes

Rehabilitation Type	Limitations	Severity (1 – 5)	Grazing class
Spoil generally less than 12% slope with >70% cover maintained.	erosion potential rootzone salinity moisture availability nutrient availability	3 2 - 3 2 3	3
Spoil generally less than 12% slope with <70% cover maintained.	erosion potential rootzone salinity moisture availability nutrient availability	4 2-3 3 3	4
Spoil generally in the range 12% – 17% slope	erosion potential rootzone salinity moisture availability nutrient availability	5 3 3 3	5

Table 19 – Major Limiting Factors and Severity for Grazing

Grassy Open Woodland Suitability

161 The spoil domain shall be become a grassy open woodland habitat where the overriding concept is long term stability to ensure that downstream effects are minimal. Where possible, the vegetated flora will be naturally occurring local eucalypt/acacia species, however other species may also be included where they have a functional role that local species cannot fill. As previously documented, an approach of rock mulching erosive prone dump batters followed by topsoil application that is subsequently deep ripped and seeded to a mix of Acacia and eucalypt Species reflecting Regional Ecosystems in the area with similar slope attributes will result in the following enhanced environmental values;

- a** Reduced potential sediment load runoff concerning downstream water quality attributes off lease;
- b** Increased stable landform features reflecting slope and rock scree attributes of adjoining Regional Ecosystems in the area that provide reference with regard to weathering process consequences in terms of geomorphological time frames;
- c** Increased flora biodiversity thus resulting in a wider array of fauna habitat types over the longer term.

The rehabilitation shall be non-polluting, stable, safe to humans and wildlife and able to sustain a grassy open woodland post-mining land use.

- 162** In grassy open woodland rehabilitation on spoil, grass swards may become moribund in the long-term and have reduced effectiveness for erosion control. In such areas, managed infrequent low-intensity grazing and/or managed infrequent cool burning is likely to be employed in a manner which does not adversely affect long-term tree and shrub cover.
- 163** The assessment process of the types, composition and classification of proposed grassy open woodland habitat will be further characterised via forthcoming rehabilitation monitoring processes that will include recording species diversity, density and vigour in representative areas of rehabilitation.

Water Storages

- 164** Dams may be left after mine closure with the agreement of the background land holder (EA Condition F12). This is the intention when the water quality in dams is suitable to beef cattle drinking water set out in EA Table W6. Retained dams would have a functioning bywash or spillway with adequate flow capacity provided. Under such conditions, the water storages would be safe to humans and wildlife, non-polluting, stable and able to sustain an appropriate land use by providing water to stock and wildlife.

Land Management Strategies

- 165** Details for pre-mining land use and soils have been described by Ison *et al* (1996) indicating the land in general was capable of supporting crop and pastoral development predominantly ranging from Shallow to Deep Black Vertisols on Tertiary Basalt interspersed by Red Brown Non-Cracking Clays and Duplex soils on Permian Sediments. Summaries of this information are included in the **EMP** (Minerva Mining 2007).
- 166** The pre-mining landscape was a flat to gently rolling terrain with occasional hill features with maximum variation over the area of around 14m. Nearby to the west and south, there are a number of relic basalt flows and intrusive volcanic plugs that form steep hills and ridges up to 250m above the surrounding black soil plains. This backdrop of steep sided basalt formations forms the dominant visual character of the locality.
- 167** Recommended management strategies for all ML areas are described in this Section.
- 168** The range of requirements for all mine lease areas is included in Table 20.

Active Mining Areas

- 169** General principles to be applied for active mining disturbance include;
- a** Overburden waste dumps to be constructed progressively to final landform design, such that reshaping is mitigated prior to revegetation activity;
 - b** Competent basalt resources will be managed to ensure optimised final landform surface application;
 - c** Suitable topsoil will either be stockpiled until recontoured areas are available, or respread immediately to an average depth of 10-20cm across available recontoured areas;
 - d** Contour ripping as an erosion control measure immediately after topsoil placement;
 - e** Seeding with an appropriate seed mix into the ripped seedbed;
 - f** Construction and revegetation of permanent creek diversions to mimic the natural morphological characteristics of the original watercourse; and
 - g** Final voids will be fenced and/or bunded to prevent access. Voids will then collect water from groundwater inflow, direct rainfall and runoff from the rehabilitated landform.

Visual Amenity

- 170** The pre-mining landscape was a flat to gently rolling terrain with occasional hill features with maximum variation over the area of around 14m. Nearby to the west and south, there are a number of relic basalt flows and intrusive volcanic plugs that form steep hills and ridges up to 250m above the surrounding black soil plains. This backdrop of steep sided basalt formations forms the dominant visual character of the locality.
- 171** Open cut coal mining involving deep stripping to access coal seams results in a significant change to the local landscape. Prior to rehabilitation the contrast between mined areas and surrounding undisturbed areas can be stark due to elevated spoil mounds that are visible from access roads and one or more local homesteads in vicinity of the mining operation.
- 172** Thus landscape disturbance represents an impact to the visual amenity for the immediate area; however this is against a backdrop of steep sided basalt formations to the west and south. This is a temporary situation until rehabilitation works have been completed. The Minerva Mine Final Landform Plan is still being developed; nonetheless the concepts have been established and are consistent with creation of a landform which will not be in stark contrast with the surrounding environment. All areas are planned to be revegetated to form a mosaic of grassland and bushland habitat. Hence the final landform should blend into the surrounding terrain provided the outcome is stable and vegetated, visual impacts will be mitigated.

Aspect	Objective	Controls
Declared plants and weeds	Identify and control such species and prevent the introduction of declared plant pests On Minerva Mine ML's, declared weeds identified are; <i>Parthenium hysterophorus</i>, ragweed <i>Opuntia stricta</i>, prickly pear <i>Cryptostegia grandiflora</i> rubber vine <i>Eriocereus spp.</i> harissa cactus <i>Acacia nilotica</i>, prickly acacia <i>Ziizphus mauritiana</i> chinee apple Other species which may occur in the region are; <i>Harrisia martinii</i>, <i>Jatropha gossypifolia</i>, <i>Lantana camara</i> and <i>Bryophyllum elagoense</i>. <i>Hymenachne amplexicaulis</i> (water storages). <i>Acacia farnesiana</i> is seen as a potential threat by out competing other native species.	Discussions held with appropriate Shire Council Representatives regarding weed management protocols. Provision of, and requirements for vehicle wash down facilities. Wash down bays will collect seeds that are washed from the vehicles to prevent ingress to drainage lines. Appropriate grazing management is a key strategy with regard to weed control. A Paddock Authorisation process has been developed to control grazing intensity and duration.
Fauna pests	Control of Cats and rodents	Waste management and facilities to minimise food sources for introduced rodents (rats and mice) around industrial areas, offices and crib huts. Conduct ongoing cat trapping programs as required following Local Government Guidelines.
	Control feral pigs	Scheduled baiting and aerial shooting programs are expedited.
	Wild dogs	Baiting activities are coordinated with Local Government Programs.
Interfering with creeks	Preserve riparian and possible cultural heritage values.	Water course assessment as conditioned in the site Environmental Authority is required prior to any disturbance of water courses in accordance with the administering authority's <i>Guideline-Activities in a Watercourse, Lake or Spring associated with Mining Activities</i>. A Cultural Heritage Management Plan shows the locations of all known areas of significance and requirements prior to any land disturbance.
Unauthorised disturbance	Reduce vegetation removal and other disturbance to essential areas. Prevent possible cultural heritage disturbance.	Operations Planning Meeting processes include Environment Section Representatives to provide input with regard to delineation of unauthorised disturbance. This includes lighting of fires. Requirements conveyed in awareness training. A Waste Management Plan to be maintained and employees made aware.
Unauthorised fires	Prevent unnecessary environmental harm and air pollution	
waste disposal	Prevent contamination of land and health of the environment.	
Field maintenance	Prevent pollution from regulated waste including oils, chemicals and grease.	

Table 20 – Management Requirements for Mine Lease Lands

11 Terms & Definitions

Term	Definition
Domains	Land management units within a mine site, usually with similar geophysical characteristics
DNRM	Queensland Department of Natural Resources and Mines
Environmental Authority (EA)	Administering authority 'Licence to Operate' which mandates environmental compliance conditions, monitoring, investigation, and notification requirements.
EA Conditions	Compliance conditions of the Environmental Authority pertaining to environmentally relevant activities
EM Plan	Environmental Management Plan
Endwall	The lengthwise extremities of the pit (as opposed to the side extremities which are the highwall and lowwall).
Final void	The last mining pit and remaining ramps
FRR	Final Rehabilitation Report
Highwall	The pit wall of un-mined land
Lowwall	The spoil placed immediately adjacent to the pit in the previously mined strip and can rise to crest of a pre-strip dump.
NUMA	Non-use management area
PMLU	Post-mining land use
Pre-stripping	The operation to remove overburden with truck and shovel
RMP	Rehabilitation Management Plan
Residual void	A void remaining after mine closure
Salinity	Generally refers to the concentration of sodium chloride and other salts either in soil or water
Spoil	Overburden after removal to expose the coal seam
Topsoil	The upper layer of the soil profile removed for reuse in rehabilitation as an inoculant and growth medium.

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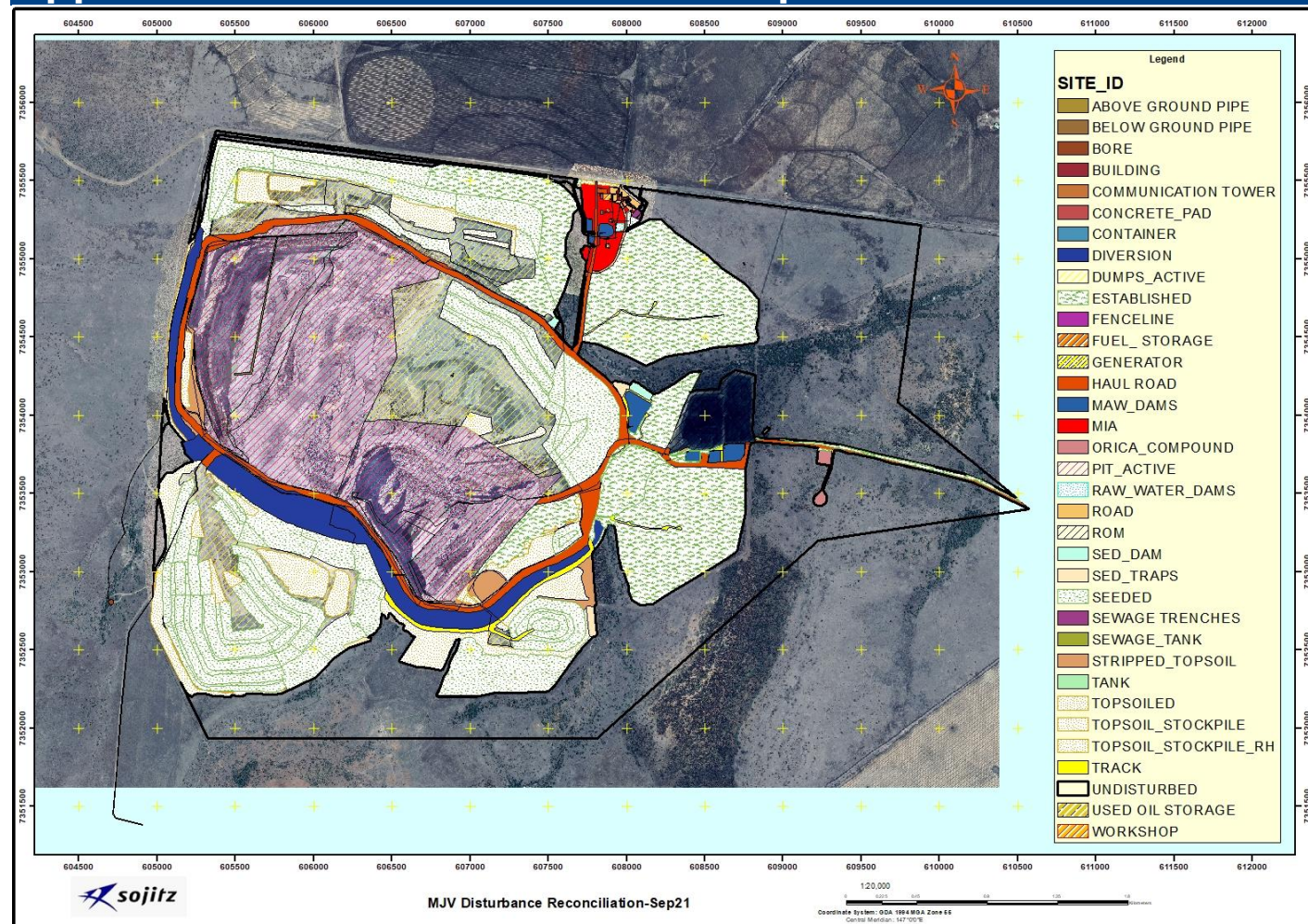
13 Version Management

Version	Details	Contributors
1.0	June 2015	MJV Environmental Superintendent (R. Gooley)
1.1	Minor revision, November 2021. Final void information updated, consistent with Residual Void Investigation Report. Updated disturbance, rehabilitation and land use information and terminology. Updated maps in Appendices.	Rehabilitation Manager (R Gooley)

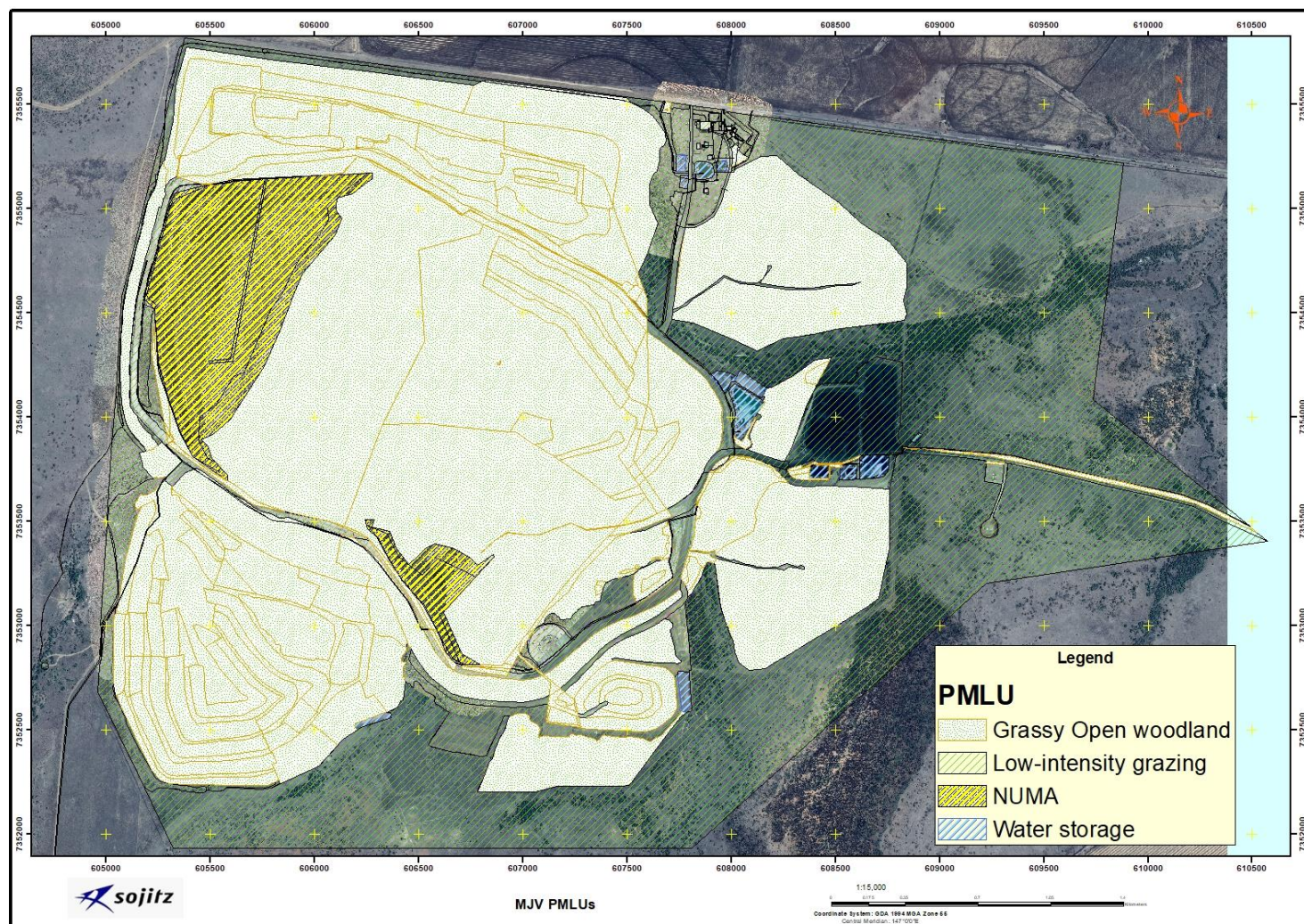
14 Environmental Authority Compliance Summary

EA Requirement F4	Refer to Section
a) Rehabilitation objectives to achieve the rehabilitation goals for all disturbed areas.	3
b) Detailed rehabilitation methods for each disturbed area.	7
c) Rehabilitation indicators to measure the success of the rehabilitation against the rehabilitation objectives.	8, 9
d) Final completion criteria that will achieve the rehabilitation goals and objectives.	8, 9
e) Details of appropriate monitoring and maintenance of rehabilitation.	8, 9

Appendix 1 – Mine Disturbance – September 2021



Appendix 2 – Conceptual PMLU and NUMA Extent



Landholder statement for the retention of infrastructure

Background

- 1 Minerva Coal Pty Ltd (**Landowner**) is the registered owner of Lots 10 and 11 on DN40126 (**Property**).
- 2 Mining leases 70145 and 70376 (**MLs**) overlap the Property.
- 3 The MLs and associated environmental authority EPML00668613 (**EA**) are also held by Landowner.

Infrastructure

- 4 The following infrastructure has been constructed on the Property within the area of the MLs:
 - (a) access roads;
 - (b) dams and associated stock water infrastructure;
 - (c) site administration facility including muster shed; and
 - (d) workshop and sheds; and
 - (e) services associated with these buildings, including electricity connections and water and sewage,(collectively, the **Infrastructure**).
- 5 Further details of the Infrastructure, including a map showing its general location and photos of the Infrastructure, are included in the Schedule.

Landowner's acceptance of responsibility

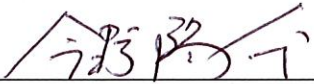
- 6 The Landowner:
 - (a) consents to the Infrastructure remaining on the Property; and
 - (b) accepts it will have ownership of, and responsibility and liability for the Infrastructure, once mining has ceased.

Benefits of retained Infrastructure

- 7 The Infrastructure will continue to be used in connection with grazing and agricultural activities conducted both on the Property and on immediately adjacent parcels. It will allow for increased efficiencies in that ongoing productive use of the Property once mining has ceased, without cost to the Landowner.

- 8 There are current pastoral agistment and sharefarming agreements in place with the Landowner under which the Infrastructure can optimise operational aspects of these use of the Property. Further, there is opportunity for adjoining properties through appropriate arrangements with the Landholder to also utilise these facilities thus strengthening relationships with neighbouring landholders and ensuring that the facilities (and the Property) are not under-utilised into the future.
- 9 The Landholder is also (and has been in recent years) pursuing a program of repairs to other existing but run-down pastoral and agricultural infrastructure in place on the property, so as to strengthen its overall operation as well as support ongoing biodiversity offset management activities. The Infrastructure will also support this ongoing strategic intent for the Property.

Signed by
Minerva Coal Pty Ltd ACN 075 056 058
on 6/6/2022
by its duly authorised officer in the presence of:

^ 
Signature of witness

^ Yosuke Konno
Name of witness (print)

^ 
Signature of Authorised Officer
^ CAMERON JAMES VORIAS
Full Name of Authorised Officer

^ Managing Director
Office Held

Schedule

Infrastructure

Part A: Description

Description of Infrastructure	Location of Infrastructure	Landowner's proposed use
Access roads, vehicle parking and associated agricultural hardstand areas, as generally shown in the pictures Part C.	As generally shown in the map at Part B.	General access.
Dams as generally shown in the pictures Part C, with associated production bore and pipeline.	As generally shown in the map at Part B.	Stock watering.
Site administration facility including muster shed, as generally shown in the pictures Part C.	As generally shown in the map at Part B.	Homestead.
Workshop and associated sheds, as generally shown in the pictures Part C.	As generally shown in the map at Part B.	Work shed.



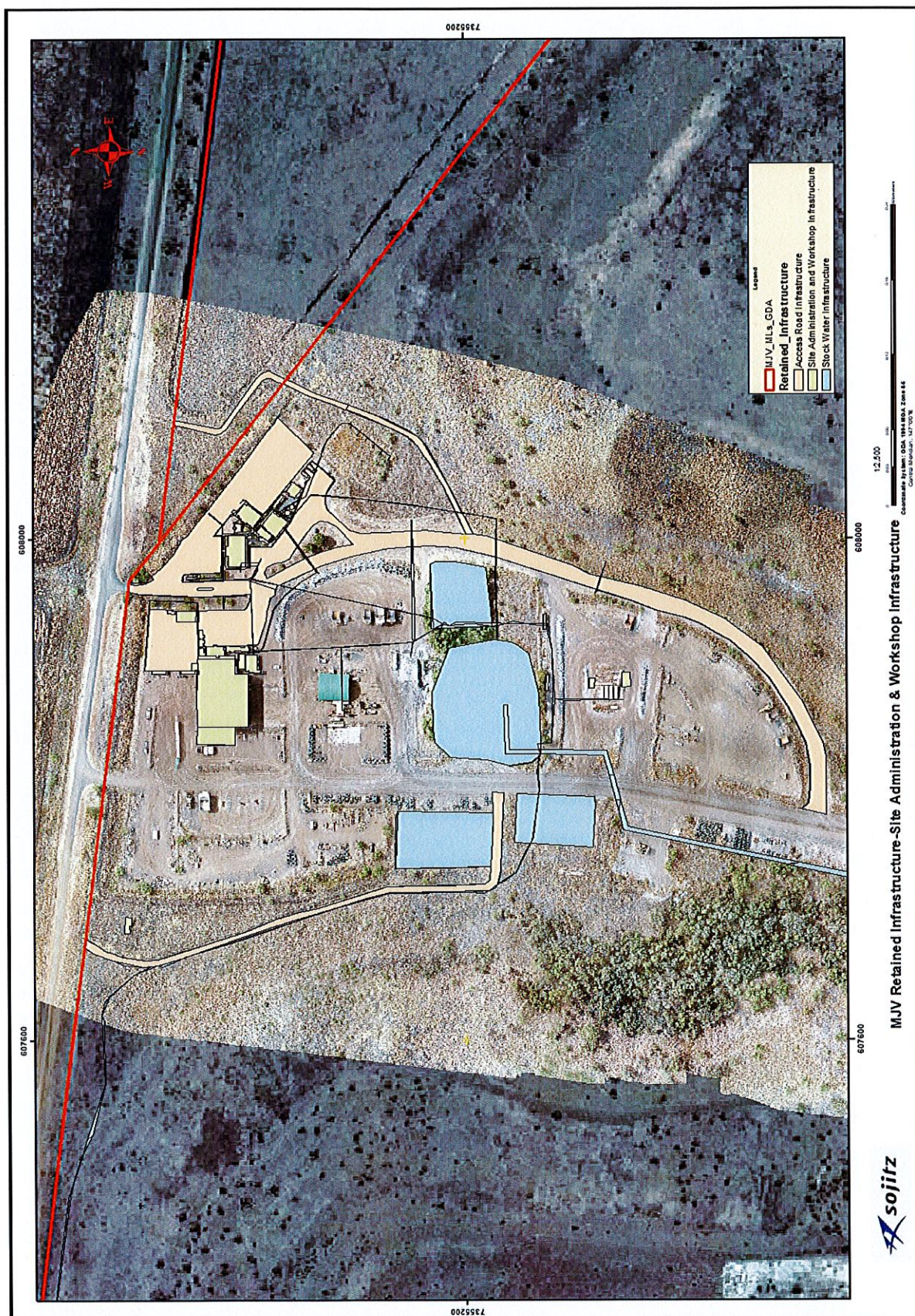
MINERVA COAL PTY LTD

A Sojitz Group Company

Part B: Map

Level 27 Central Plaza One
345 Queen Street, Brisbane, Qld 4000
GPO Box 126, Brisbane, Qld 4001
Tel: (07) 3054 6901 Fax: (07) 3229 4803
ABN: 15 075 056 058





Part C: Images of Infrastructure



Workshop and Associated sheds



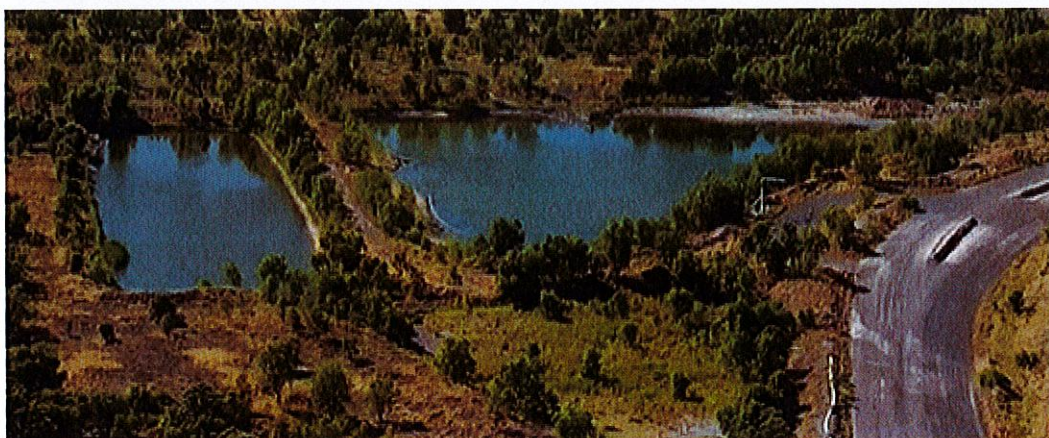
Site Administration and Muster Shed



Site Administration and Muster Shed



Workshop Area Dam



Dams/ Stock Water

Access Roads



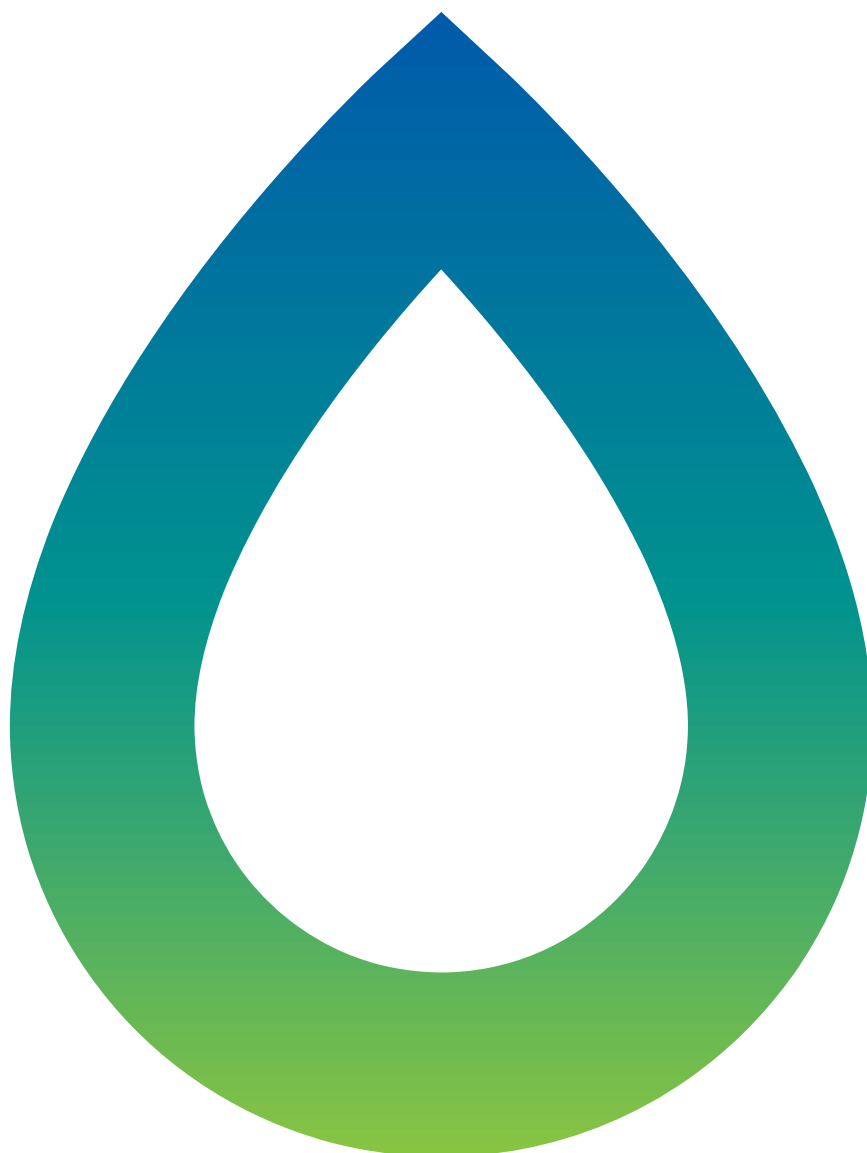
FINAL VOID SURFACE HYDROLOGY

Minerva Coal Mine

Sojitz Blue Pty Ltd

31 August 2023

1917-01-C1



DETAILS

Report Title	Final void surface hydrology, Minerva Coal Mine
Client	Sojitz Blue Pty Ltd

THIS REVISION

Report Number	1917-01-C1
Date	31 August 2023
Author	RN/TP
Reviewer	GR

NOTE: This report has been prepared on the assumption that all information, data and reports provided to us by our client, on behalf of our client, or by third parties (e.g. government agencies) is complete and accurate and on the basis that such other assumptions we have identified (whether or not those assumptions have been identified in this advice) are correct. You must inform us if any of the assumptions are not complete or accurate. We retain ownership of all copyright in this report. Except where you obtain our prior written consent, this report may only be used by our client for the purpose for which it has been provided by us.

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1 INTRODUCTION

WRM Water & Environment Pty Ltd (WRM) was engaged by Sojitz Blue Pty Ltd to undertake a final void hydrology assessment to support the Progressive Rehabilitation and Closure (PRC) Plan for the Minerva Coal Mine, located about 45 km south of Emerald in the Central Highlands Regional Council, Queensland. Two final voids are proposed as Non-use Management Areas (NUMA's), which are referred to as the western void and southern void in this report. Figure 1.1 shows the final void configuration.

WRM has modelled the long-term final void hydrology and water quality behaviour of the western and southern voids over a long post-closure period to inform whether the voids would be safe, stable and non-polluting. This report outlines the methodology and assessment of the expected final void pit lake behaviour, which has been modelled using the GoldSim water balance simulation software.



Figure 1.1 Final void configuration

2 FINAL VOID GEOMETRY

2.1 VOID STAGE-STORAGE-SURFACE AREA CURVE

The final landscape at the Minerva Coal Mine incorporates elevated spoil (overburden waste rock) dumps and the western and southern voids. The voids are the remnant components of the mined pit shells, which have mostly been filled with spoil. A digital elevation model (DEM) of the final landforms (i.e. the final surface expected at the end of the mine life) was provided by Sojitz Blue.

Stage-storage-surface area curves were generated from the DEM to represent the free water in the final void water balance model. Figure 2.1 and Figure 2.2 show the stage-storage curves derived for the western void and the southern void, respectively.

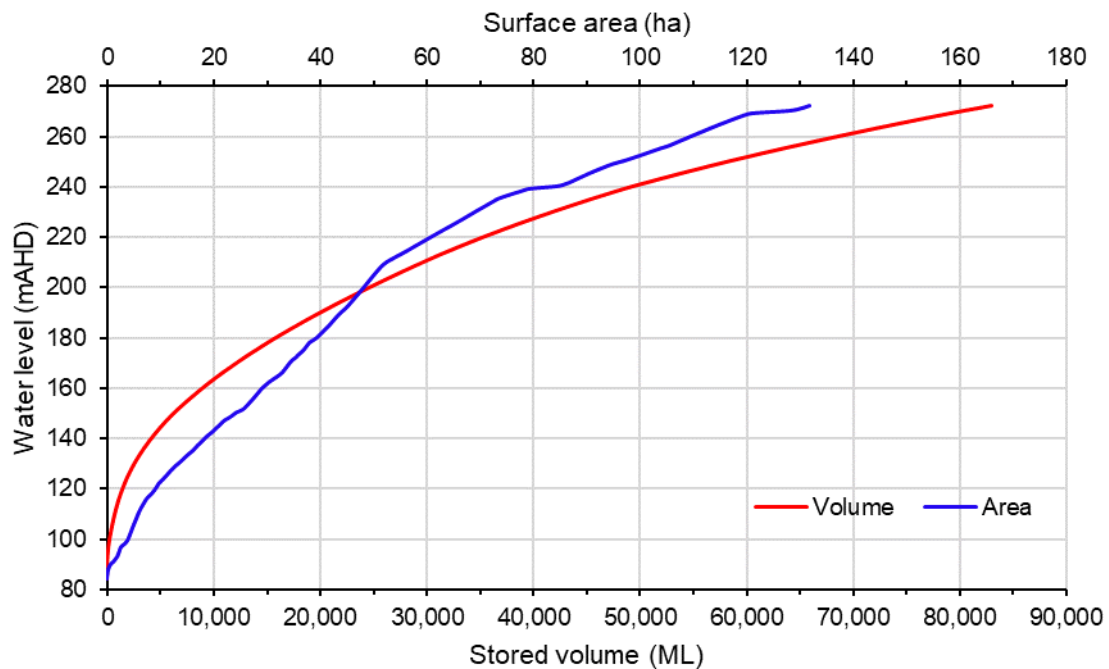


Figure 2.1 Western void surface area and volume storage curve

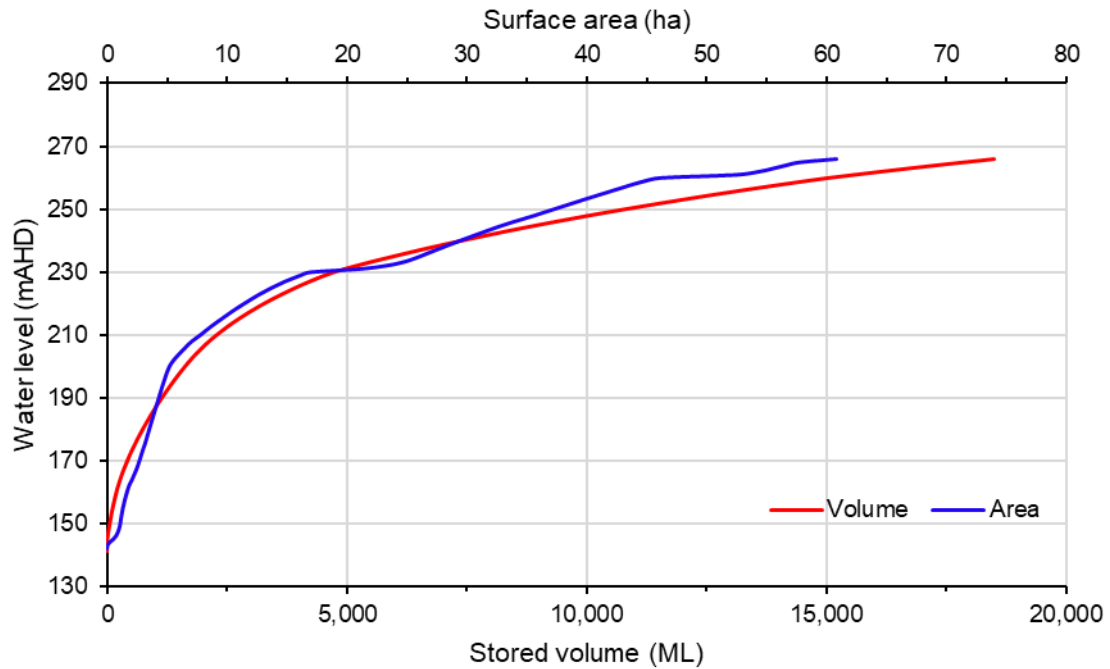


Figure 2.2 Southern void surface area and volume storage curve

2.2 IN-PIT SPOIL WATER STORAGE

The proposed final void would receive catchment runoff inflows from the adjacent rehabilitated spoil dump and groundwater inflows. This water would be stored within the void and within the pore space of the backfilled spoil both below and adjacent to the void.

The modelled long-term interaction between the free void water and the spoil pore space water has been provided as part of the groundwater assessment (AGE, 2023) and as such the pore space volume has not been included in the void storage volume.

3 MODEL CONFIGURATION

3.1 MODELLING APPROACH

The GoldSim water balance simulation model was used to simulate the long-term void water levels and salinity behaviour. Water levels in the residual voids would vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses, inflows from rainfall, surface runoff and groundwater and outflows from the void into the spoil and surrounding groundwater.

The GoldSim model was used to simulate the generation, movement, and loss of water and salts on a daily time-step within the final void, over a long-term period. The volume of water in the void was 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 system.

Key components of the model are summarised in the following sub-sections, including descriptions of key model inputs, assumptions, and sensitivity parameters.

3.2 RAINFALL AND EVAPORATION

Long-term daily rainfall and evaporation data for the area from January 1890 to December 2022 (133 years) obtained from the Department of Environment and Science (DES) SILO database forms the basis of the simulation (DES, 2023).

Morton's Lake evaporation has been used to estimate evaporation losses from storages. Figure 3.1 shows the long-term monthly averages for Morton's Lake evaporation and rainfall data. The 133 years of SILO rainfall and evaporation data was looped to create an indicative long-term climate sequence.

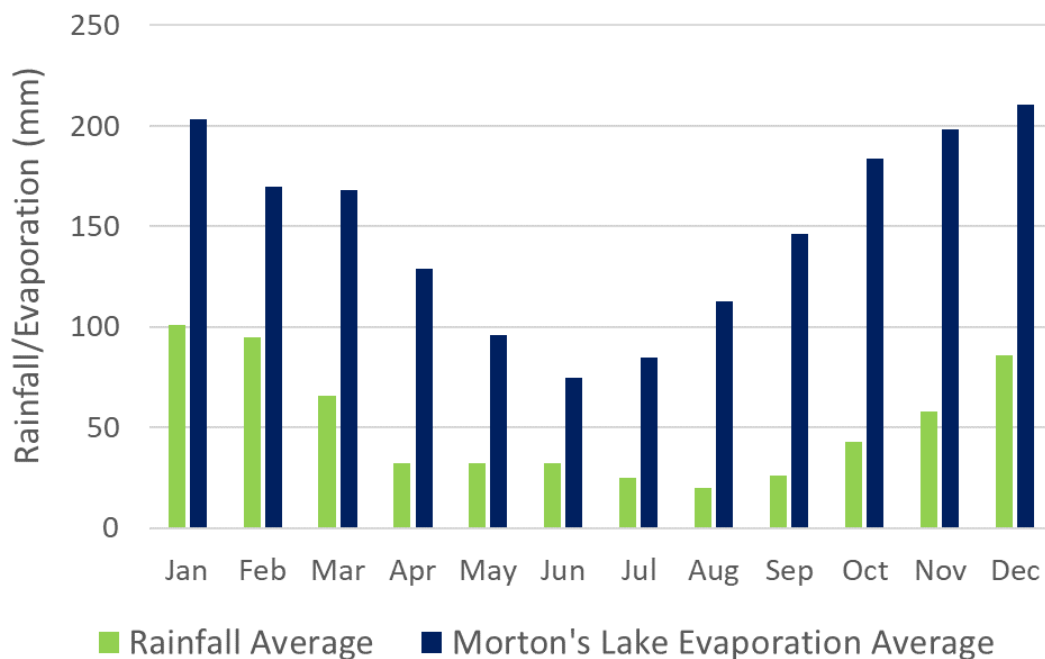


Figure 3.1 Distribution of monthly rainfall and evaporation (SILO 1890 - 2022)

Evaporation from the final void pit lake is impacted by the final void geometry. The pit walls shade the pit lake, which would reduce the hours of direct sunlight on the pit lake and reduce evaporation. The depth of the pit lake below natural surface can reduce wind velocities, which increase humidity at the pit lake surface and reduce evaporation. A pit evaporation factor is applied to the daily evaporation to account for these factors.

To simulate this variation in the pit lake shape, the evaporation rate has been varied using a factor. A factor of 0.7 was applied for evaporation from the void.

3.3 CATCHMENT RUNOFF

3.3.1 Catchment areas

The final landform catchment areas have been generated using the final landform surface provided by Sojitz Blue. The final void catchments have been characterised into the following land use types:

- Natural/rehabilitated spoil, representing areas in their natural state or long-term established rehabilitated spoil areas; and
- Unrehabilitated spoil within the void and the pit lake water surface.

All other disturbed areas within the mine footprint (infrastructure, overburden, stockpile and haul roads) have been assumed to be rehabilitated post-mining. The unrehabilitated spoil component was represented by the area below an elevation of 233 mAHD within the western void and 215 mAHD within the southern void, which are representative of the long-term average modelled void water levels.

Figure 3.2 shows the catchment boundary and land uses assumed for the final voids. The catchment and land use values used in the GoldSim model are shown in Table 3.1.

The surface water area of the voids has been dynamically modelled, based on the volume stored in the pits, and the volume/surface area relationships presented in Figure 2.1 and Figure 2.2. The void water surface area would determine the volume of direct rainfall collected by the void and the volume of water lost to evaporation from the water surface. The surface runoff catchment area reporting to the void would be reduced to account for the void water surface area, to prevent 'double-counting' of runoff inflows entering the void.

Table 3.1 Final void catchment and land use areas (ha)

Catchment (ha)	Natural/rehabilitated spoil	Unrehabilitated spoil	Total
Western void	71.6	162.8	234.4
Southern void	9.9	171.1	181.0

3.3.2 AWBM parameters

Catchment runoff has been modelled using the AWBM rainfall-runoff model. The adopted rainfall runoff parameters are based on the AWBM parameters used for sites in the vicinity of the Minerva Coal Mine. The AWBM parameters from the model have been summarised in Table 3.2.

The interaction between the backfilled spoil pore space and the free water in the final void has already been accounted for in the AGE (2023) modelling. Hence, the baseflow components of the modelled AWBM runoff inflows would not be read into the model, to avoid 'double-counting' these inflows.



Figure 3.2 Final void site catchment and landuse

Table 3.2 Adopted AWBM parameters

Parameter	Natural / rehabilitated spoil	Unrehabilitated spoil
A1	0.134	0.02
A2	0.433	0.195
A3	0.433	0.785
C1 (mm)	50	10
C2 (mm)	130	40
C3 (mm)	190	80
BFI	0.15	0.1
K _{base}	0.99	0
K _{surf}	0.35	0
Cv* (%)	6.6%	14.7%

* Cv= calculated volumetric runoff coefficient (percent of rainfall that converts to runoff)

3.4 SALINITY OF THE PIT LAKE

Sources of the salinity in the final void pit lake include:

- Surface runoff from the final void catchments;
- Groundwater inflows; and
- Seepage of water stored in the spoil.

The water balance model was configured to use salinity as an indicator of water quality. This was achieved by assigning representative Total Dissolved Solids (TDS) concentrations to runoff from catchments and other sources of water.

The adopted salinity values for the natural/rehabilitated spoil and groundwater inflows from the tertiary, permian and regolith aquifers has been adopted from KBR (2017). Spoil seepage salinity is adopted from the Gregory Crinum PRCP (KCB, 2023). Spoil runoff salinity concentration has been adopted from the modelling completed for the nearby Meteor Downs South PRCP (WRM, 2023).

Table 3.3 Adopted salinity concentrations

Source	Salinity (mg/L)	Source/comments
Tertiary aquifer	655	From KBR (2017) based on historical salinity concentrations
Permian and Regolith aquifer	2,039	From KBR (2017) based on historical salinity concentrations
Spoil seepage	1,600	From KCB (2023) Gregory Crinum PRCP
Rainfall	20	Queensland Government (2008)
Natural/rehabilitated spoil runoff	350	From KBR (2017) based on historical salinity concentrations
Spoil runoff	540	From WRM (2023) based on salinity concentrations at MDS

3.5 GROUNDWATER INFLOWS

Groundwater inflow rates have been provided by AGE (2023). An iterative process was undertaken to reconcile the water balance model and the groundwater model to achieve a refined groundwater inflow input by providing AGE with predicted rainfall, runoff and evaporation for input to the groundwater model. Three groundwater aquifer sources have been modelled; Regolith, Tertiary and Permian. The groundwater inflow rates were provided as a time series from July 2021 to January 4600 and are shown in Figure 3.3 and Figure 3.4.

The AGE (2023) report concludes that the regional groundwater table in vicinity of the Minerva Project is about 265 mAHD to 270 mAHD based on the recorded groundwater levels from the Minerva Coal Mine groundwater monitoring bore network.

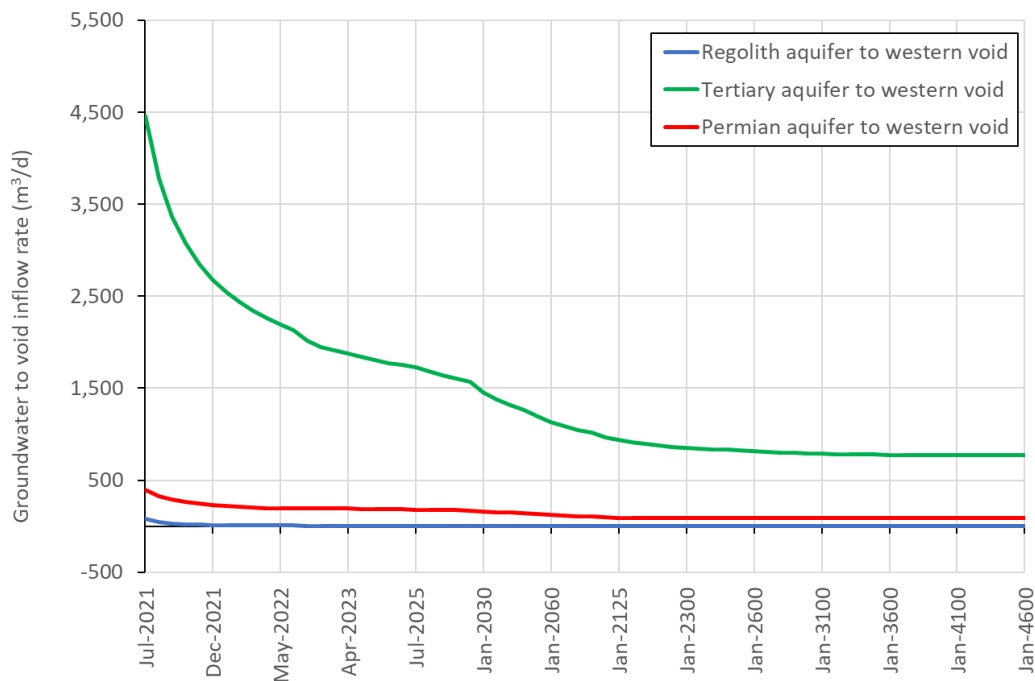


Figure 3.3 Time series of modelled groundwater inflow to the western void (AGE, 2023)

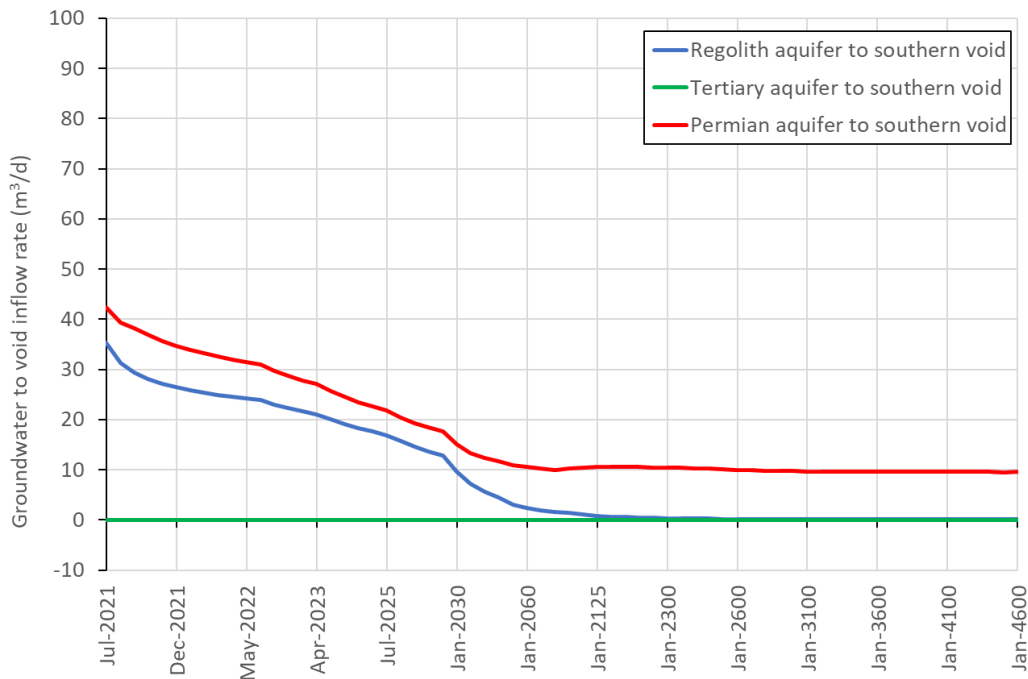


Figure 3.4 Time series of modelled groundwater inflow to the southern void (AGE, 2023)

3.6 FINAL VOID IN-PIT SPOIL SEEPAGE

The groundwater modelling (AGE, 2023) found that water stored in the voids would seep out into the surrounding in-pit spoil. The water stored in the voids would initially seep out into the pore spacing of backfilled spoil within the pit shell until it becomes saturated. The saturated spoil would then flow back to the void.

Figure 3.5 shows the timeseries of predicted spoil flow rates (inflows and outflows) from the voids provided by AGE. The time series results were modelled as a time series where:

- Negative flow rates (values less than 0 m³/d) shown in Figure 3.5 were modelled as outflow rates, representing water from the void seeping to the in-pit spoil;
- Positive flow (values greater than 0 m³/d) shown in Figure 3.5 were modelled as inflow rates, representing water from the in-pit spoil seeping to the void.
- The time series shows that initially, the western void seeps to the surrounding in-pit spoil before the spoil becomes saturated and water stored in the in-pit spoil would flow back into the western void.
- The time series shows that water in the southern void does not saturate the in-pit spoil over time and water in the southern void would continue to seep into the void in-pit spoil storage.
- The AGE model (2023) identified that there is no predicted interaction between the two final voids and seepage through the backfilled spoil from one void to another would be negligible.

The WRM model assesses the volume stored in the void only and does not attempt to model the destination of water that may seep into the in-pit spoil. Further discussion of the spoil seepage rates is provided in AGE (2023).

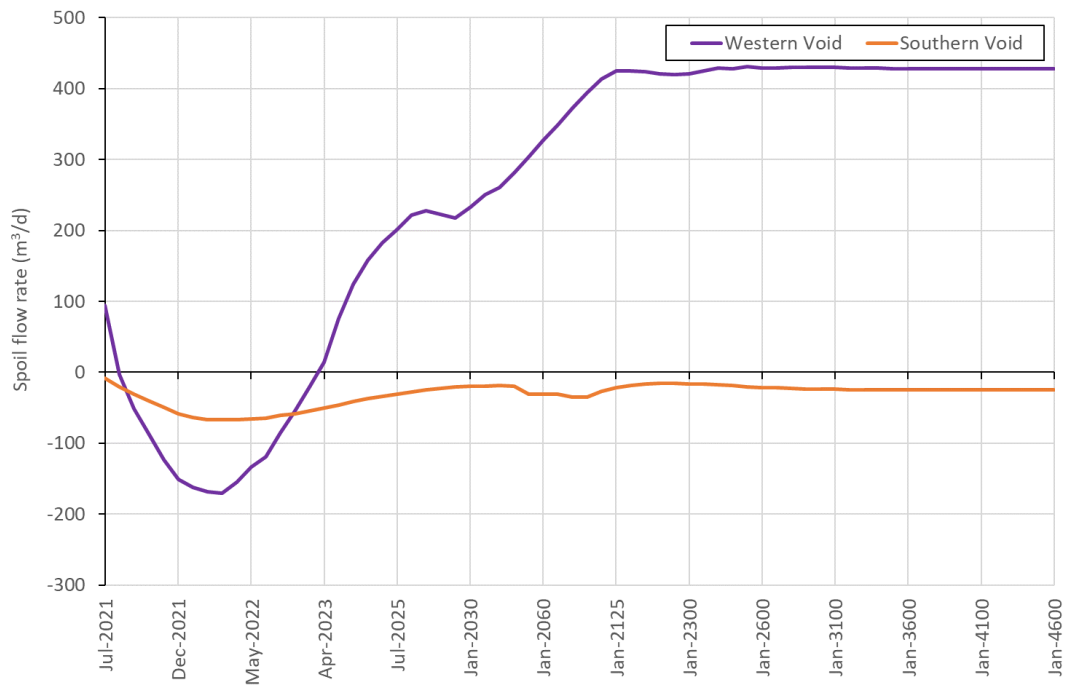


Figure 3.5 Time series of modelled spoil seepage flow rates from the voids (AGE, 2023)

4 FINAL VOID RESULTS

4.1 OVERVIEW

The Goldsim model was set up to simulate the daily water level behaviour in the void over a 2,626-year period. To do this, the 133 years of daily rainfall and evaporation data, described in Section 3.2, was looped to create an indicative long-term climate sequence. Table 4.1 summarises the annual average water long term water balance results for the simulation.

Table 4.1 Annual average long term water balance results (ML/year) (from Jan 2024 to Jan 4650)

Parameter	Western void	Southern void
Inflows (ML/year)		
Direct rainfall	409	52
Average runoff	43	69
Groundwater inflow	328	4
Outflows (ML/year)		
Spoil seepage outflow	0	-9
Evaporation	-917	-117
Total balance	-137 ML/yr	-1 ML/yr

4.2 MAXIMUM VOID WATER SURFACE AREA

Table 4.2 provides the maximum water surface area for the western and southern voids over the 2,626-year period. The maximum combined water surface area is up to 88 ha for the voids.

Table 4.2 Final void water surface area

Void	Max water level (mAHD)	Max volume (ML)	Max surface area (ha)
Western Void	236	46,200	74.6
Southern Void	223	3,700	13.2
Total	-	49,900	87.8

4.3 LONG-TERM WATER LEVEL BEHAVIOUR

Figure 4.1 and Figure 4.2 shows the long term behaviour of the western and southern void water levels, respectively, over the 2,626-year period. Table 4.3 summarises the results of the void water level modelling and compares them to the void storage details including the overflow level and the adjacent bed level of Sandhurst Creek. The model results show:

- The western void reaches equilibrium after about 300 years, with the void oscillating between 230 mAHD and 236 mAHD.
- The maximum modelled water level in the western void is about 36 m below the western void overflow level and 31 m below the Sandhurst Creek bed level. Hence, water stored in the western void will not report to the receiving surface water environment.

- The southern void reaches equilibrium after about 250 years, with the void oscillating between 204 mAHD and 223 mAHD.
- The maximum modelled water level in the southern void is about 43 m below the southern void overflow level and 41 m below the Sandhurst Creek bed level adjacent to the void. Hence, water stored in the southern void will not report to the receiving surface water environment.
- Both voids are thus predicted to be sinks as the groundwater report (AGE, 2023) states *“the long-term equilibrium groundwater level of the Tertiary basalt is approximately 265 mAHD about 700 m from the Western Void’s pit crest and about 270 mAHD about 500 m from the Southern Void’s pit crest.”*

Table 4.3 Final void modelling results summary

Level	Elevation (mAHD)	
	Western void	Southern void
Final landform floor level	84	140
Overflow level	272	266
Sandhurst Creek diversion bed level	267	264
Modelled long-term water levels	230 to 236	204 to 223
Average long-term water level	233	215
Modelled peak long-term water level	236	223

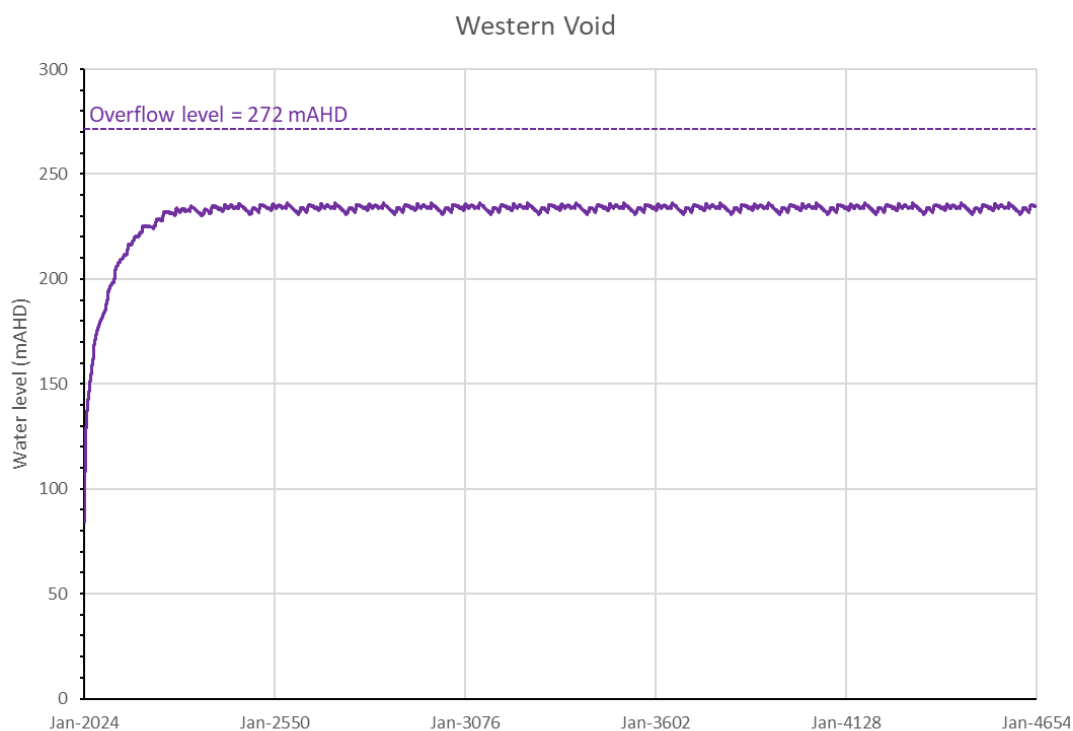


Figure 4.1 Minerva Coal Mine western void long-term water level

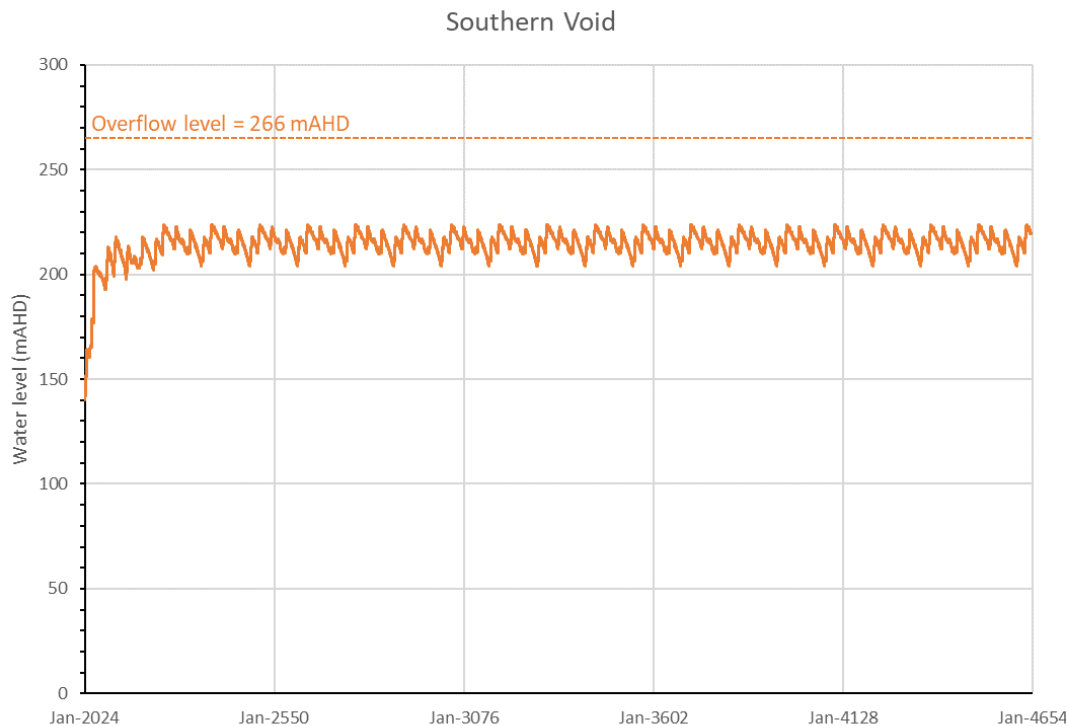


Figure 4.2 Minerva Coal Mine southern void long-term water level

4.4 LONG-TERM SALINITY

Figure 4.3 and Figure 4.4 shows the long-term behaviour of the western and southern final void salinity concentrations and total salt loads over the 2,626-year simulation period, respectively.

The model results show the following:

- The predicted maximum salinity of the western void by the end of the simulation is about 30,000 mg/L.
- The predicted maximum salinity of the southern void by the end of the simulation is about 35,000 mg/L.
- The salt load of the western and southern void pit lakes progressively increases. The western and southern void salt load reaches 1,280,000 tonnes and 65,000 tonnes, respectively after the 2,626-year modelled period.
- The salinity of the western and southern void pit lakes progressively increases. The western and southern void surface water levels do not reach the regional groundwater table and therefore considered as groundwater sinks, hence salinity will continue to increase over time. Furthermore, both voids are considered NUMA's and will not be used post-closure for purposes such as livestock watering.

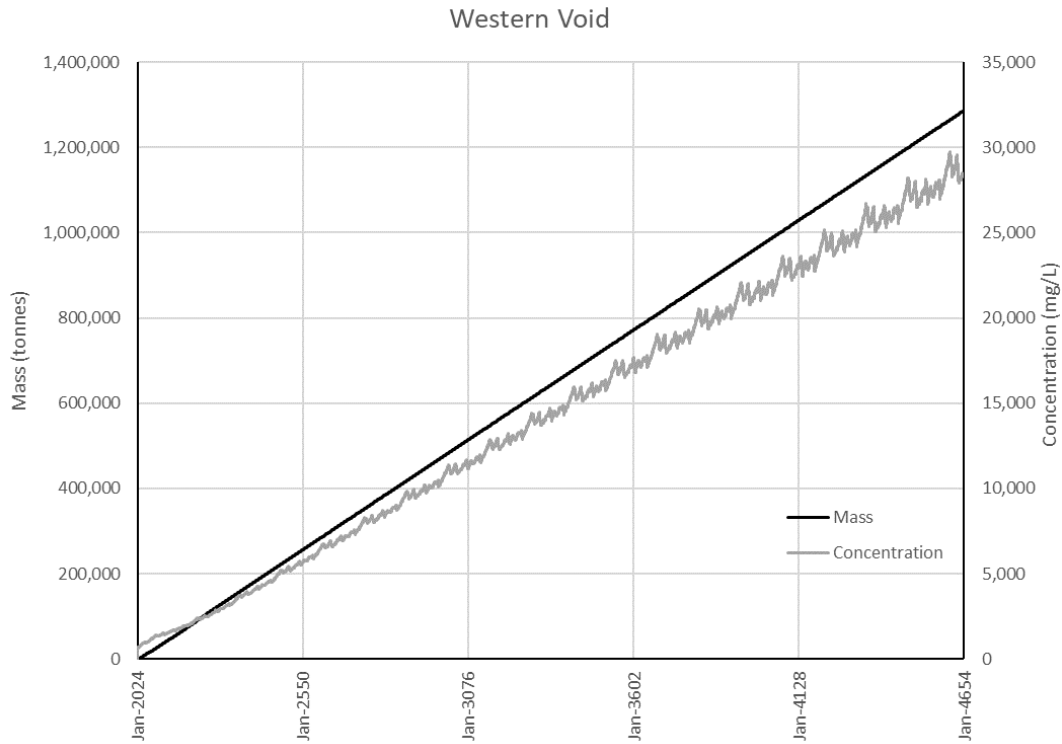


Figure 4.3 Minerva Coal Mine western void long-term salinity and mass accumulation

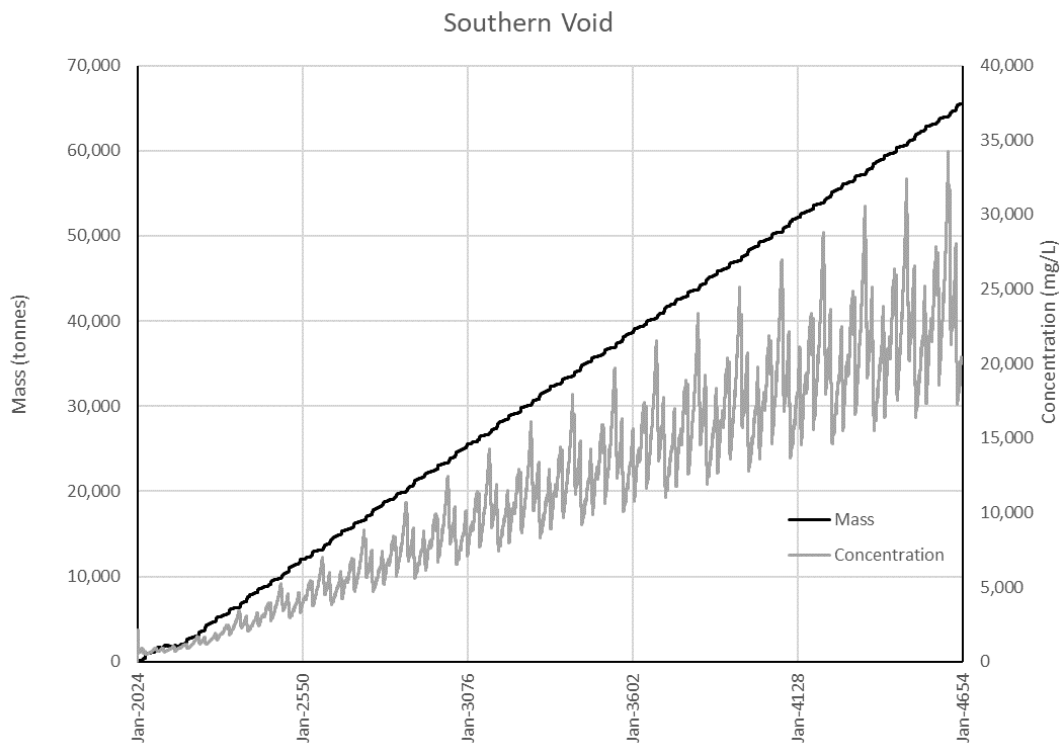


Figure 4.4 Minerva Coal Mine southern void long-term salinity and mass accumulation

5 SUMMARY

A GoldSim water balance model was developed to assess the long-term water level and salinity behaviour of the proposed western and southern final voids at the Minerva Coal Mine. The final voids were modelled for a long-term period following mine closure.

The final void model results show the following:

- The western void reaches its equilibrium levels within a period of about 300 years post-mining.
- The southern void reaches its equilibrium levels within a period of about 250 years post-mining.
- The maximum modelled water levels in both the western and the southern voids are well below their respective overflow levels and below the level of the adjacent Sandhurst Creek. Therefore, there is no risk of in pit water reporting to the surrounding surface water environment.
- The voids at Minerva Coal Mine are considered sinks and are do not have water and salts exiting the voids to the surrounding groundwater once the spoil becomes saturated. Hence, the water quality deteriorates over time. By the end of the model simulation (after 2,626 years), the western void reaches a total dissolved salts concentration of up to 30,000 mg/L and the southern void reaches a total dissolved salts concentration of up to 35,000 mg/L. The voids are considered NUMA's and water stored in the voids after closure will not be used for purposes such as livestock watering.

6 REFERENCES

- AGE, 2023 *'Minerva Mine PRCP Groundwater Assessment, v01.02'*, Australasian Groundwater & Environmental Consultants Pty Ltd (AGE), Prepared for Sojitz Minerva Mining Pty Ltd. Project No. MIN5000.001, August 2023.
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WATER LICENCE
Water Act 2000



Reference	406741	Expiry Date	30/06/2111
Licensee	SOJITZ MINERVA MINING PTY LTD		
Authorised Activity	Interfere with the flow of water in Sandhurst Creek by changing the course of flow on or adjoining land described as Mining Lease 70145 and Mining Lease 70376. Interference with the flow by a total length of 5819 metres (Southern Diversion and Western Diversion).		
Authorised Purpose	Diverting the Flow of Water		

This water licence is subject to the conditions endorsed hereon or attached hereto.

Given at Emerald this FOURTH day of SEPTEMBER 2017.

Delegate of the Chief Executive
Department of Natural Resources and Mines

Water Licence: 406741
Expiry Date: 30/06/2111

Conditions: Schedule B

Refer to Schedule B attachment

1. Interference

The interference with flow authorised by this water licence is the interference that is described in the following document(s) for the Southern Diversion;

- "Minerva Coal Project - Design of Diversion Channels", Hydrobiology Pty Ltd, October 2007
- "Minerva Coal Project - Design of Diversion Channels - Addendum to Report", Hydrobiology Pty Ltd, February 2008
- Sandhurst Creek Southern Diversion Design R1 V5 Southern Final, Jacobs, 24 April 2017
- Southern Diversion Design R1 Vs Southern Tech Spec Final, Jacobs, 24 April 2017
- Southern Diversion Realignment drawings:
 - IS183300-0000-CI-DRG-0001 to 0009 –C.

and the following document(s) for the Western Diversion;

- "Minerva Springsure Mine Western Diversion Design Sojitz Minerva Mining Design Report R1 Final", Jacobs Group (Australia) Pty Limited, 30 October 2014.
- Design drawings:
 - WT02584-ECC-DG-0001-C
 - WT02584-ECC-DG-0100-C
 - WT02584-ECC-DG-0110-C
 - WT02584-ECC-DG-0120-C
 - WT02584-ECC-DG-0130-C
 - WT02584-ECC-DG-0131-C
 - WT02584-ECC-DG-0140-C.

2. Monitoring

a) The licensee must:

- maintain and implement a monitoring and evaluation program that quantifies that the outcomes of the approved design of the interference authorised under this water licence are being achieved; or
- maintain and implement a monitoring and evaluation program that quantifies that the interference authorised under this water licence is meeting or progressing towards achieving the following outcomes:
 - Developing features (including geomorphic and vegetation) present in the landscape and in local watercourses.
 - The watercourse diversion maintains a sediment transport regime that allows the diversion to be self-sustaining and not directly impact on upstream and downstream reaches.
 - The watercourse diversion and associated structures maintain equilibrium and functionality and do not require ongoing maintenance.

b) The monitoring and evaluation program must include recommendations as per ACARP Project C9068 "Monitoring and Evaluation Program for Bowen Basin River Diversions".

c) An electronic copy of the monitoring and evaluation report, prepared by a registered professional engineer (RPEQ), must be provided to the chief executive on request.

d) The report required under Schedule B condition 2. c) must include an evaluation of monitoring activities between reporting periods that demonstrates the diversion is meeting the outcomes of the approved design, or meeting or progressing towards achieving the outcomes in Schedule B condition 2. a). If the diversion is not meeting these outcomes, appropriate measures must be implemented and monitored to ensure that the development of the diversion will meet these outcomes, and the report must detail these including a timetable for completing the proposed measures.

3. As Built Plans

The licensee must within 90 business days after constructing the diversion, provide the Chief Executive with an electronic copy of "as built" plans in the same scale and line form as the approved design drawings.

4. Maintenance

The licensee must maintain to the satisfaction of the chief executive, maintain the diversion in accordance with the conditions of the licence and must carry out any activities or make any alteration deemed necessary by the chief executive, after discussion and consultation with the licence holder, for the protection and proper maintenance of the diversion.

5. Modification

Where the operation of the diversion channel in the opinion of the chief executive has demonstrated that channel equilibrium cannot be achieved the chief executive may direct the licensee to take whatever measures and modifications are mutually agreed as necessary, over a time period agreed to by the licence holder, for the protection and proper maintenance of the diversion.

6. Relinquishment

Relinquishment of this water licence can only occur when it is deemed by the chief executive to satisfy the outcomes in Schedule B condition 2. a). Any request for relinquishment will be negotiated with the chief executive and will require the submission of a final monitoring and evaluation report prepared and certified by a RPEQ. The report must contain an evaluation of operational and relinquishment monitoring information that demonstrate that the diversion has been subjected to a suitable range of flow events determined by the certifier and has achieved the outcomes in Schedule B condition 2. a).



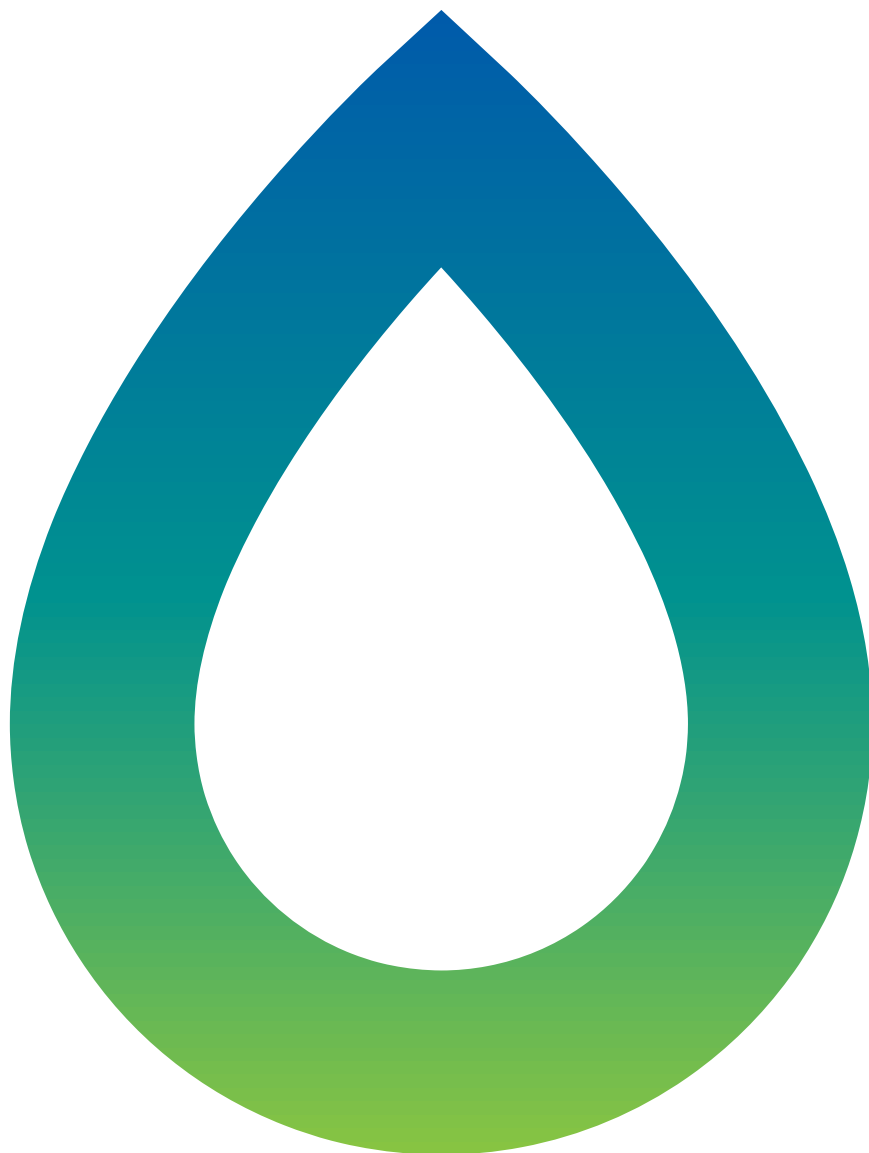
FINAL LANDFORM FLOOD ASSESSMENT

Minerva Coal Mine

Sojitz Blue Pty Ltd

30 August 2023

1917-01-D1



DETAILS

Report Title	Final Landform flood assessment, Minerva Coal Mine
Client	Sojitz Blue Pty Ltd

THIS REVISION

Report Number	1917-01-D1
Date	30 August 2023
Author	TP/RN
Reviewer	DN

NOTE: This report has been prepared on the assumption that all information, data and reports provided to us by our client, on behalf of our client, or by third parties (e.g. government agencies) is complete and accurate and on the basis that such other assumptions we have identified (whether or not those assumptions have been identified in this advice) are correct. You must inform us if any of the assumptions are not complete or accurate. We retain ownership of all copyright in this report. Except where you obtain our prior written consent, this report may only be used by our client for the purpose for which it has been provided by us.

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1 INTRODUCTION

WRM Water & Environment Pty Ltd (WRM) was engaged by Sojitz Blue Pty Ltd to undertake a final void flood assessment to support the Progressive Rehabilitation and Closure Plan (PRCP) for the Minerva Coal Mine (Minerva), located about 45 km south of Emerald in the Central Highlands Regional Council local government area, Queensland. The location of the Minerva Coal Mine is shown in Figure 1.1.

This report outlines the methodology and assessment of the potential flood risk to the final voids and is structured as follows:

- Section 2 describes the regulatory framework for PRCPs with respect to flooding.
- Section 3 describes the local and regional drainage characteristics.
- Section 4 describes the methodology and results of hydrological modelling undertaken to estimate design discharges for the watercourses in the vicinity of the Minerva Coal Mine.
- Section 5 describes the methodology and results of hydraulic modelling undertaken to estimate design flood depths, extents and levels for the final landform in the vicinity of the Minerva Coal Mine.
- Section 6 summarises the results of this assessment.
- Section 7 provides a list of references.

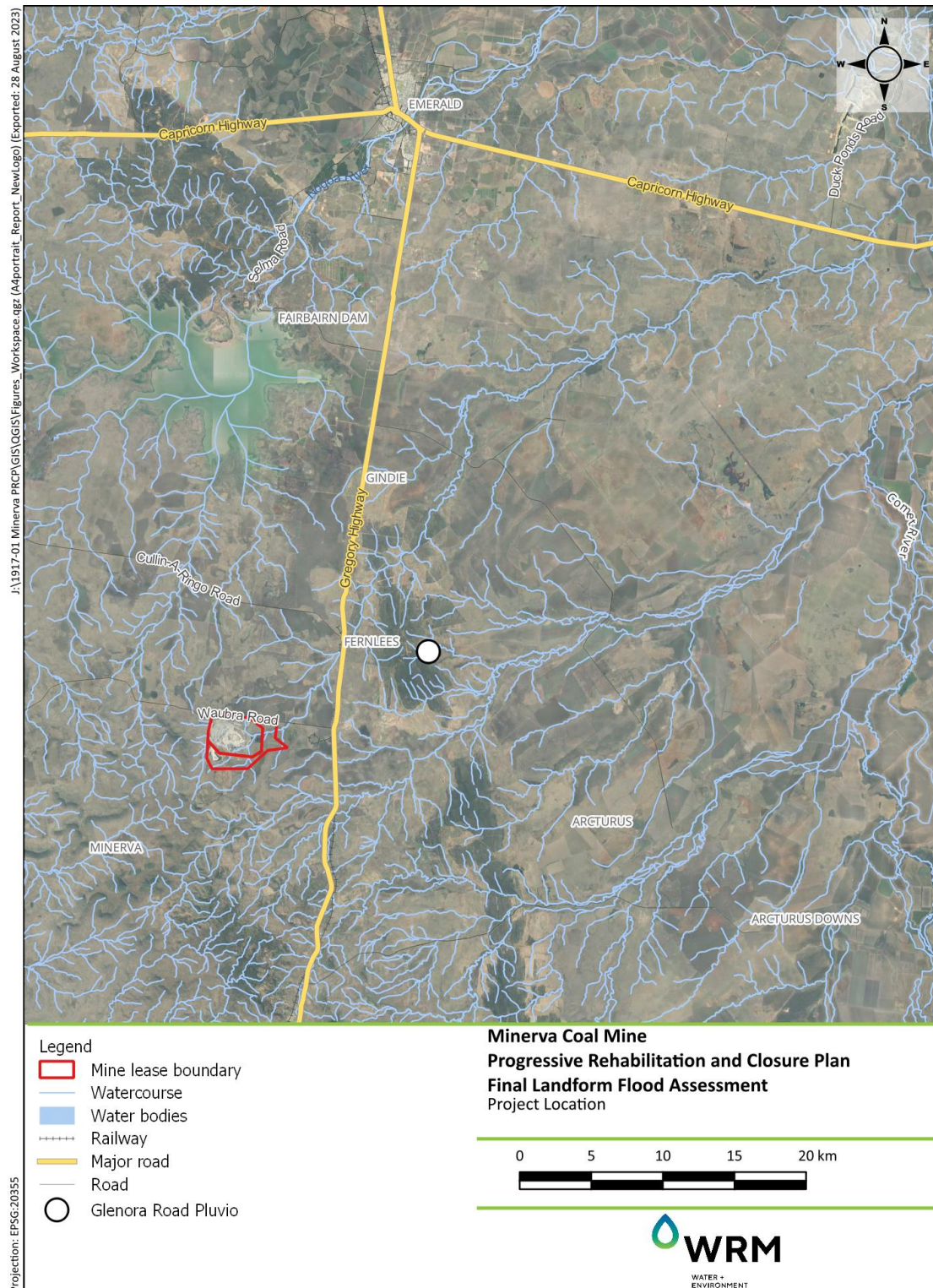


Figure 1.1 Project location

2 REGULATORY FRAMEWORK

PRCP requirements for resource activities take effect from the 1 November 2019 to implement key elements of the Queensland Government Mined Land Rehabilitation Policy. All mines with a site-specific environmental authority (EA) must prepare a PRC plan.

A PRCP requires the EA holder to plan for how and where activities will be carried out on the land in a way that maximises the progressive rehabilitation of the land to a stable condition. The PRCP must meet the requirements set out under the Environment Protection Act 1994 (EP Act) and the *Progressive Rehabilitation and Closure Plan Guideline* (ESR/2019/4964) (the Guideline).

In accordance with Section 126D (3) of the EP Act, if land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.

Section 41C of the EP Regulation states the decision considerations for a void situated wholly or partly in a flood plain. A void is considered to be located in a floodplain if the floodplain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% annual exceedance probability (AEP) for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019) (ARR) (Ball, et al, 2019).

Floodplain modelling must be carried out in accordance with ARR and exclude any artificial features for the land within the tenure boundary. In accordance with section 126C (1)(j) of the EP Act, the administering authority considers the following information necessary to make a decision on the PRCP schedule. The rehabilitation planning part must include a floodplain model report developed by an appropriately qualified person that includes, but is not limited to:

- details of the data used to develop the model in accordance with section 4.13.3 of ARR;
- identification of all artificial features proposed or present within the tenure boundary;
- identification of all watercourses within the immediate catchment with the Strahler method of stream ordering applied;
- identification of any approved permanent watercourse diversions within the tenure boundaries and the relevant approval of the diversion;
- consideration of how groundwater may impact the floodplain extent;
- a hydrologic model;
- a hydraulic model;
- model assumptions and limitations;
- model calibration and sensitivity analysis; and
- spatial data outlining the extent of the floodplain.

3 DRAINAGE CHARACTERISTICS

3.1.1 Regional drainage characteristics

Figure 1.1 shows the regional drainage network in the vicinity of the project. The Minerva Coal Mine is located within the Sandhurst Creek catchment, which is a tributary of the Comet River. Sandhurst Creek drains into the Comet River about 68 km downstream (to the northeast) of the Minerva Coal Mine. The Comet River is a major tributary of the Fitzroy River.

3.1.2 Local drainage characteristics

Figure 3.1 shows the drainage features across the Minerva Coal Mine lease area, including Strahler stream order, extracted from Queensland Globe (2023). The Minerva Coal Mine is located in the headwaters of the Sandhurst Creek catchment. Sandhurst Creek flows in an easterly direction through the mine lease area before draining northeast across the mine lease boundary. There are several first order and second order watercourses that drain across the Minerva mining area into an existing diversion drain. The diversion drain was constructed during Minerva operations to divert the upstream clean water catchment around the active mining pits. The diversion drain will remain post-closure. Downstream of the diversion drain, the Sandhurst Creek tributary has been identified as a third order watercourse under the Strahler method of stream ordering on Queensland Globe.

Sandhurst Creek has a catchment area of about 18.3 km² upstream (southwest) of the mine lease boundary. The creek is ephemeral and flows only after rainfall events, although some shallow waterholes may persist for several months after flow ceases. The dominant land use in the Sandhurst Creek catchment upstream of Minerva is low intensity grazing. Currently, none of the Sandhurst Creek catchment upstream of Minerva has been disturbed by mining.

There are no DEHP stream gauging or water quality monitoring stations on Sandhurst Creek. Recorded water level data was available for a gauge at the Waubra Road crossing (location shown in Figure 2.1), but the gauge does not have a rating curve to provide flood discharges.



Figure 3.1 Local drainage network showing stream order (source: [Queensland Globe](#))

4 ESTIMATION OF DESIGN DISCHARGES

4.1 OVERVIEW

The XP-RAFTS hydrologic modelling package was used to estimate design flood discharges in the Sandhurst Creek catchment.

Design discharges were determined for the 10% (1 in 10), 1% (1 in 100) 0.1% (1 in 1000) AEP and Probable Maximum Flood (PMF) design flood events. Design rainfall intensities were derived by the Commonwealth Bureau of Meteorology (BOM)¹, and probable maximum precipitation (PMP) design rainfall depths were estimated using the Generalised Short-Duration Method (GSDM) for durations up to 6 hours (BoM, 2003).

The recorded water level data from the Waubra Road crossing gauge (location shown in Figure 3.1) was used to calibrate the RAFTS model routing parameters to match the timing of recorded flows. Predicted design flood discharges were validated against the Rational Method and regional peak flow estimates.

4.2 RAFTS MODEL DEVELOPMENT

Figure 4.1 shows the adopted RAFTS model configuration. The model covers a catchment area of 36.8 km², primarily covered by pasture and scattered light bushes. The model consists of 9 sub-catchments, ranging in size from 2 km² to 6.7 km².

The catchment extends to the Waubra Road crossing gauge, 1 km east of the Minerva mine lease boundary. LiDAR data was used to delineate the sub-catchments draining the study area. The area draining to the final voids was excluded from the RAFTS modelling as it was assumed no runoff entering the final voids would report to the receiving environment.

Table 4.1 shows the adopted RAFTS model subcatchment parameters:

- Subcatchment slopes were derived using available topography data;
- Catchment PERN 'n' values were derived from aerial images;
- Channel routing was determined using the Muskingum method with 'K' values (in hours) calculated based on link length and an assumed channel velocity using:
 - A constant channel velocity of 1.5 m/s adopted for all links; and
 - A channel storage exponent 'x' of 0.25 adopted for all links.
- Catchment imperviousness was based on aerial images.

Figure 4.2 compares the predicted RAFTS model discharge hydrograph to the recorded water level data at the Waubra Road crossing gauge (gauge 333470) for a rainfall event in October 2022. Rainfall data for the event was taken from the nearby Glenora Road standalone pluviometer station (Station number 130P002). The recorded water level data was provided by Sojitz Blue. The results show that the adopted RAFTS model catchment and channel routing parameters provide a good match to the timing of the recorded water level peaks. A rating curve at the water level gauge was unable to be derived due to poor quality topography data. However, the results show that the adopted RAFTS model parameters match the expected timing and flow durations well.

¹ <http://www.bom.gov.au/water/designRainfalls/revised-ifd/>

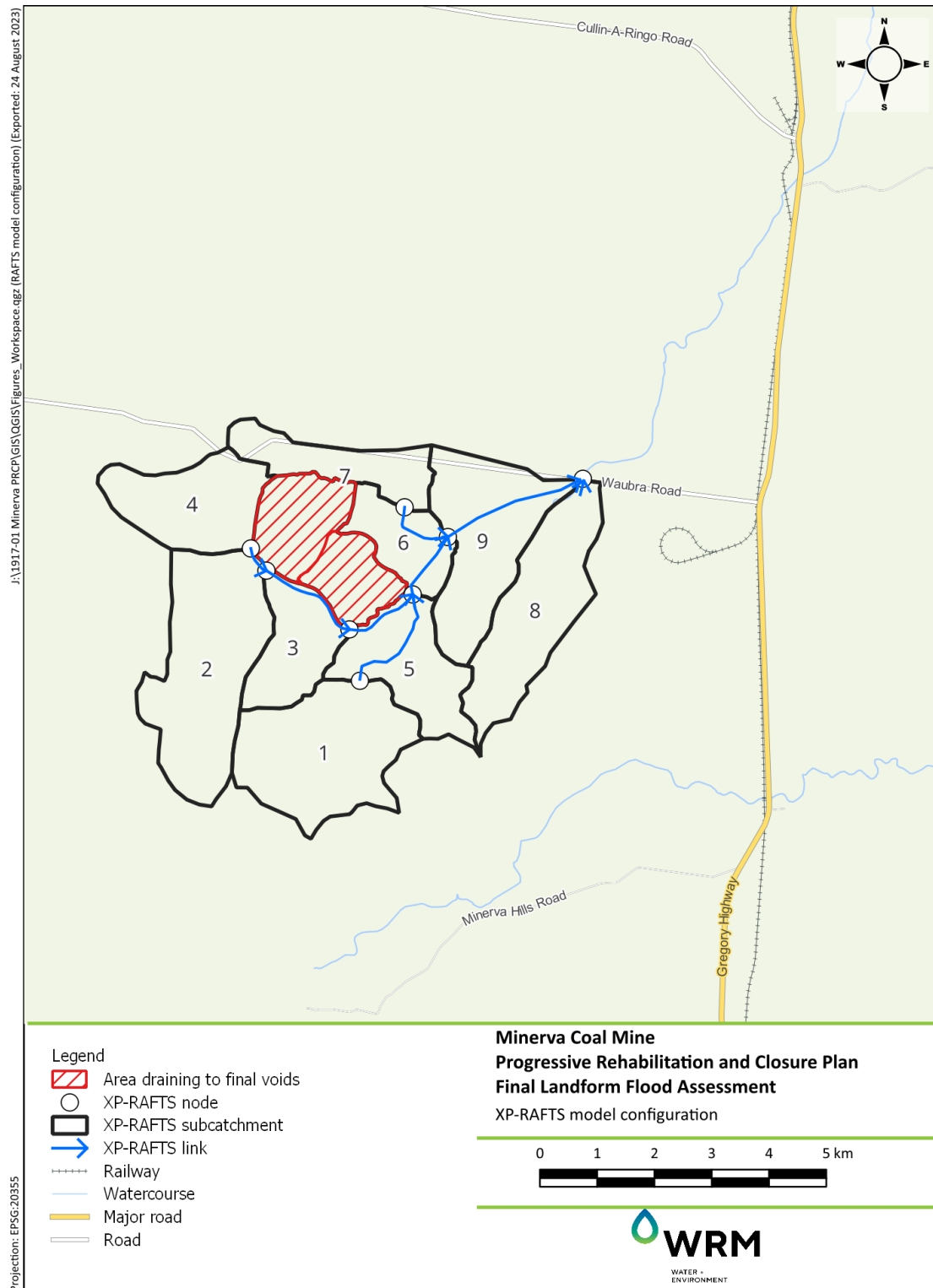


Figure 4.1 XP-RAFTS model configuration

Table 4.1 RAFTS model subcatchment parameters

Subcatchment ID	Area (ha)	Vectored Slope (%)	Pern 'n' value	Imperviousness
1	594.6	0.95	0.050	0
2	667.3	2.27	0.050	0
3	264.5	3.85	0.045	16
4	365.3	2.31	0.050	0
5	348.9	1.02	0.050	0
6	200.0	1.79	0.045	31
7	240.5	2.72	0.050	8
8	492.2	1.00	0.050	0
9	504.4	0.78	0.055	0

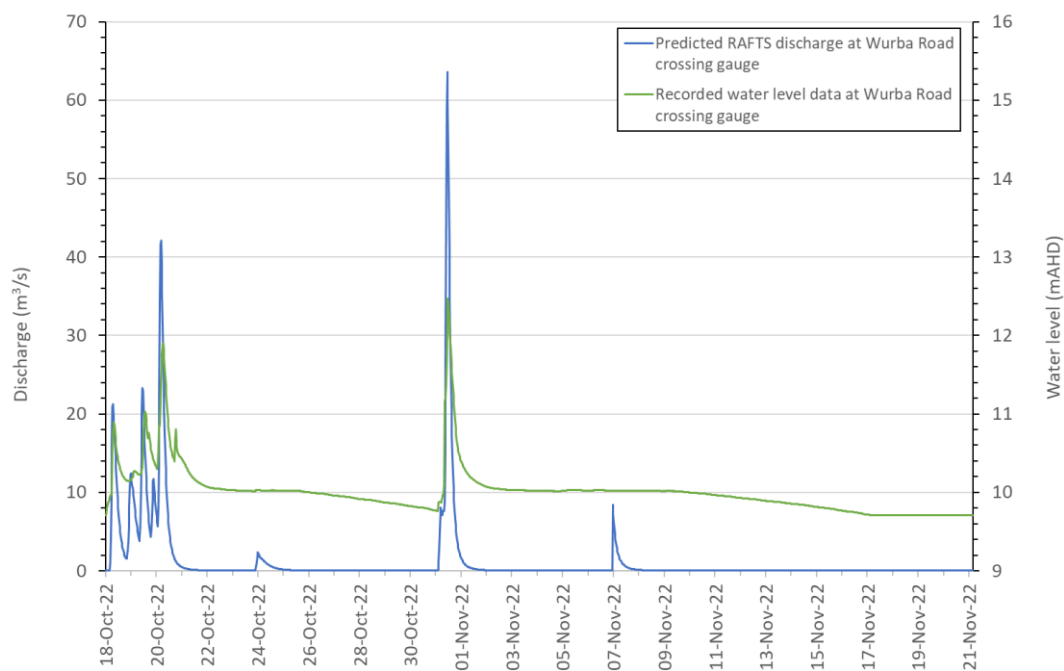


Figure 4.2 Predicted RAFTS model discharge compared to recorded water level data for the Sandhurst Creek catchment to Waubra Road crossing

4.3 DESIGN RAINFALLS AND TEMPORAL PATTERNS

Design rainfalls were based on a single point at the centroid of the Sandhurst Creek catchment to Waubra Road. Design rainfalls were determined for different storm durations from 1 hour to 24 hours for the 10% (1 in 10), 1% (1 in 100) and 0.1% (1 in 1,000) AEP events.

The ensemble methodology given in the ARR guidelines was used using temporal patterns obtained from the ARR DataHub². The 10 temporal patterns result in 10 design storms for each duration for

² <https://data.arr-software.org/>

each AEP were used. The URBS model was run for all 10 temporal patterns for various storm durations for the 10%, 1% and 0.1% AEP events. The critical storm duration was identified as the duration which produces the highest median peak discharge from the 10 design storms for each storm duration.

Design rainfall depths and temporal patterns for the Probable Maximum Precipitation (PMP) event for the Sandhurst Creek catchment were estimated for storm durations ranging from 15 minutes to 6 hours using the Generalised Short-Duration Method (GSDM) outlined in BoM (2003).

4.4 DESIGN RAINFALL LOSSES

The initial loss (IL) and continuing loss (CL) method of accounting for rainfall losses was adopted based on ARR Data Hub recommendations. An initial loss (IL) of 10 mm and a continuing loss (CL) of 1.1 mm/hr were adopted with median pre-burst depths obtained from the ARR Data Hub used to adjust the initial loss with AEP. The IL of 10 mm was adjusted from the ARR Data Hub IL of 65 mm to better reconcile design discharges (see Section 4.6) to regional peak flow estimates as the IL of 65 mm was found to significantly underestimate peak flows.

Zero rainfall losses were adopted for the 0.1% AEP and PMF events.

4.5 DESIGN DISCHARGES

Table 4.2 shows the design discharges estimated for the Sandhurst Creek catchment draining to the Waubra Road crossing and for the Sandhurst Creek catchment draining to the diversion drain.

The critical duration storm and adopted temporal pattern are also shown. The model was run for storm durations from 1 hour to 24 hours with the 10 temporal patterns obtained for the East Coast North region. Areal reduction factors were determined using the methodology given in ARR. Box plots of the RAFTS design discharges are given in Appendix A.

Table 4.2 RAFTS design discharges, critical duration and adopted temporal pattern, Sandhurst Creek to the Waubra Road crossing

Design event (AEP)	Sandhurst Creek to Waubra Road			Sandhurst Creek to diversion drain		
	Design discharge (m ³ /s)	Critical duration (hours)	Adopted temporal pattern	Design discharge (m ³ /s)	Critical duration (hours)	Adopted temporal pattern
10%	140	6	7	28	3	4
1%	259	4.5	3	77	2	8
0.1%	379	6	10	156	2	6
PMF	2,019	3	-	763	2	-

4.6 RAFTS MODEL VALIDATION

The RAFTS design discharges were validated against peak flow estimates derived using the following methodologies:

- The Rational Method.
- The Regional Flood Frequency Estimation (RFFE) approach.

4.6.1 Rational Method

Table 4.3 shows the Rational Method parameters and estimated peak discharges for Sandhurst Creek to the Waubra Road crossing for the 10% and 1% AEP design events.

Table 4.3 Rational Method Parameters and Discharges, Sandhurst Creek to Waubra Road crossing

Rational Method	Unit	Design Storm Event	
		10% AEP	1% AEP
Catchment Area	ha	3,680	3,680
Time of concentration			
Overland Flow Time (Friend's Equation)	min	19.0	19.0
Length	m	200	200
Mannings 'n'		0.035	0.035
Slope of Surface	m/m	0.02	0.02
Channel Flow Time			
Length	m	11,450	11,450
Mannings 'n'		0.045	0.045
Slope of Surface	m/m	0.01	0.01
Total time of concentration	min	250.1	216.3
Runoff Coefficient (Cy)		0.53	0.64
Frequency Factor (Fy)		1.00	1.20
Rainfall Intensity (Iy)	mm/hr	20.8	37.5
Discharge (m ³ /s)		112.4	243.6

4.6.2 Regional Flood Frequency Estimation methodology

Table 4.4 shows the RFFE discharges for Sandhurst Creek to the Waubra Road crossing. The RFFE estimates for this location are significantly higher than both the RAFTS and Rational Method estimates, particularly for the 1% AEP event.

Table 4.4 RFFE discharges, Sandhurst Creek to Waubra Road crossing

AEP	Expected quantile (m ³ /s)	5% confidence limit	95% confidence limit
10	195	79	485
1	580	172	1,930

The RFFE website also supplies design discharges for the nearest 10 stream flow gauging stations that were used to derive the RFFE estimate. The catchments to these stations are greater than the Sandhurst Creek catchment and vary in distance between 82 km and 278 km away. However, they can also be used to provide an indication of the likely runoff characteristics in Sandhurst Creek.

Figure 4.3 shows the 10% and 1% AEP discharge estimates for the 10 stations (obtained from the RFFE website) scaled down to the Sandhurst Creek catchment area (station design discharge / station catchment area x Sandhurst Creek catchment area). These discharges are plotted against each station's catchment area. The RFFE Sandhurst Creek discharge estimates for the 10% and 1% AEP events plotted against the Sandhurst Creek catchment area is also shown.

The comparison shows that nearby stations produce significantly lower runoff and peak discharges for the same catchment area for both events, with the exception of one gauged catchment (84 km²).

The scaled discharge for the 84 km² catchment is 316 m³/s for the 10% AEP event and 611 m³/s for the 1% AEP event, however, for the other 9 stations, the maximum scaled discharge is 128 m³/s for the 10% AEP event and 375 m³/s for the 1% AEP event.

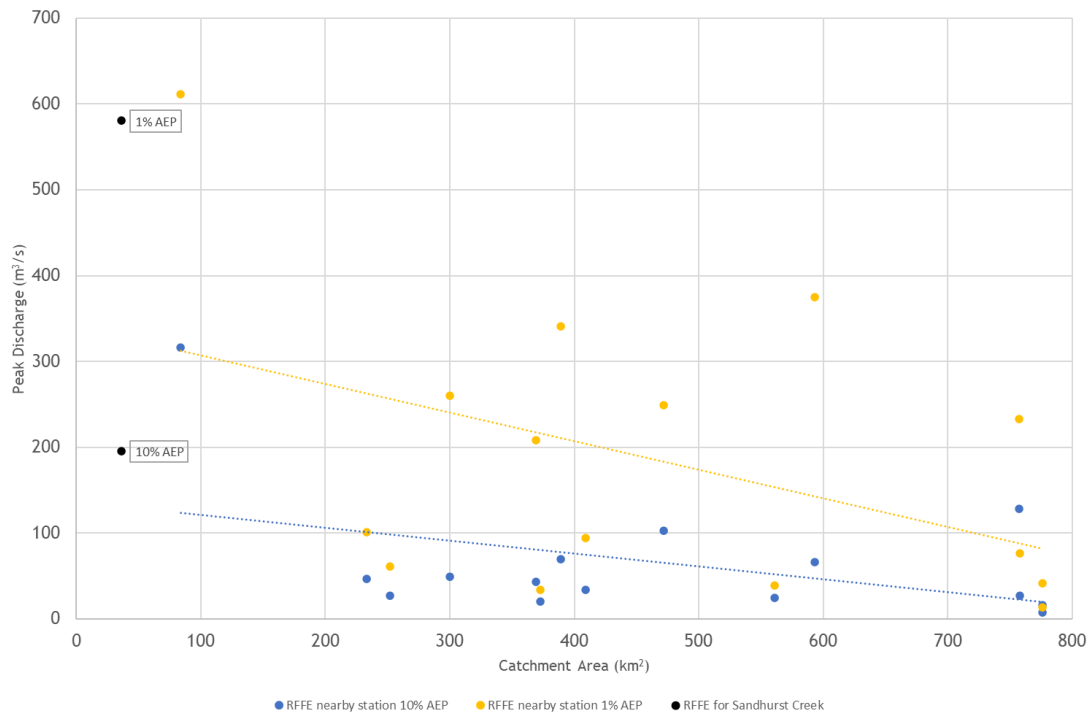


Figure 4.3 RFFE discharges for Sandhurst Creek catchment to Waubra Road crossing and the 10 nearby gauges (scaled to Sandhurst Creek catchment area) plotted against catchment area

4.6.3 Validation results

The above comparison suggests that the RFFE estimates are significantly higher than the RAFTS and Rational Method peak discharge estimates. With the exception of one gauged catchment nearby, the 1% AEP RFFE discharge is about double the scaled peak from the next highest site. An attempt was made to match the RAFTS model results with the RFFE estimates but unrealistic catchment and routing parameters were required. As a result, the RAFTS model discharges given in Table 4.3, which are similar to the Rational Method estimates, were adopted for the assessment.

5 HYDRAULIC MODELLING

5.1 OVERVIEW

The two-dimensional TUFLOW hydrodynamic model (BMT, 2023a) was used to simulate the flow behaviour of Sandhurst Creek and the diversion drain through Minerva to identify the potential flood risk to the final voids. The model configuration was based on the proposed final landform, which is essentially the same as existing conditions outside the final void.

TUFLOW represents hydraulic behaviour on a fixed grid by solving the full two-dimensional depth-averaged momentum and continuity equations for free surface flow. The model automatically calculates breakout points and flow directions within the study area. An adaptive time step is used by the computational engine to maintain simulation stability. A grid size of 5 m was adopted for this study using sub-grid sampling.

A description of the development of the TUFLOW model of existing conditions is outlined below.

5.2 MODEL CONFIGURATION

5.2.1 Model extent

Figure 5.1 shows the extent of the TUFLOW hydraulic model. The modelled study area is approximately 23.9 km², commencing at the western ML boundary upstream of the diversion drain and extending 1 km downstream of the eastern ML boundary to the Waubra Road crossing. The Waubra Road crossing was included in the model at the model outflow boundary.

5.2.2 Topographic data

Topographic aerial survey data for the study area was provided by Sojitz Blue in 2023. The data consisted of 3 m LiDAR data. This data was converted into a digital terrain model (DTM) for use in the hydraulic modelling and mapping tasks. The design surface of the final landform, consisting of the approximate final void shell was also provided by Sojitz Blue and input to the model. Downstream of the final voids, the survey appears to a lower order of accuracy. The area of lower accuracy includes the downstream boundary and the Waubra Road crossing and as a result, a rating curve of Sandhurst Creek at the Waubra Road crossing gauge was not able to be developed to calibrate the hydraulic model to recorded water levels.

5.2.3 Manning's 'n' values

The model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). Manning's 'n' values were selected based on typical published values (Chow, 1959). The adopted Manning's n values for the TUFLOW model are shown in Table 5.1. Landuse types were delineated based on recent aerial imagery. Default values in the channel and floodplain were adopted as 'Light vegetation'.

Table 5.1 Adopted Manning's 'n' values

Landuse	Manning's 'n' value
Light vegetation	0.045
Medium vegetation	0.060
Unsealed road	0.025
Road	0.020



Figure 5.1 TUFLOW model configuration

5.2.4 Boundary conditions

The RAFTS model local flow hydrographs were input to the TUFLOW model as ‘source-area’ boundaries (flow versus time). A normal depth of 0.005 m/m was adopted for the downstream boundary at the Waubra Road crossing. This normal depth slope is equal to the bed slope of Sandhurst Creek at the downstream model boundary. The peak water level results at the diversion drain adjacent to the final voids are insensitive to the adopted downstream boundary condition, which is some 10 m lower.

5.3 MODEL RESULTS

The TUFLOW model was used to simulate the critical storm duration and adopted temporal patterns shown in Table 4.2 and the model results were post-processed using the ascii to ascii utility (BMT, 2023b) to create ‘max-max’ peak flood level grids. The diversion drain provides adequate flood protection for the final void for events up to and including the 0.1% AEP.

5.3.1 Flood levels

Figure 5.2 to Figure 5.5 show the peak depths across the study area for the 10%, 1%, 0.1% AEP and PMF events. The figures also show the final void catchments. Peak flood levels at selected locations within the diversion drain and mine lease are given in Table 5.2. The results show that at the location ID’s, peak flood levels vary between 258.8 mAHD to 279.3 mAHD. The diversion drain top of bank level provides a freeboard of at least 1.6 m for these locations.

Table 5.2 Peak flood depth level results within the Minerva mine lease

Location ID	Peak flood level at point location ID (mAHD)				Diversion drain top of bank level (mAHD)
	10% AEP event	1% AEP event	0.1% AEP event	PMF event	
1	278.3	278.8	279.3	280.7	282.0
2	277.7	278.1	278.4	279.8	280.0
3	276.2	276.5	276.8	278.1	280.9
4	273.0	273.8	274.4	277.8	282.0
5	272.4	273.0	273.6	276.6	279.0
6	265.6	266.2	266.7	268.8	268.9
7	263.3	263.7	264.1	266.0	267.0*
8	258.1	258.5	258.8	260.9	N/A

*Note: Height of the southern void crest at this location

5.3.2 Diversion drain freeboard

Figure 5.1 shows the alignment of the diversion drain. Table 5.3 shows the diversion drain top of bank level and adjacent 0.1% AEP water level along the longitudinal profile of the diversion drain, as well as the freeboard from the 0.1% AEP water level to the diversion drain top of bank level. The minimum freeboard for the 0.1% AEP event is 0.7 m (Ch100 to Ch300), with an average freeboard of 6.1 m.

Table 5.3 Diversion drain freeboard to peak 0.1% AEP flood level

Chainage (m)	0.1% AEP flood level	Diversion drain top of bank level (mAHD)	Freeboard (m)
0	279.3	281.0	1.7
100	279.3	280.0	0.7
200	279.3	280.0	0.7
300	279.3	280.0	0.7
400	279.3	283.0	3.7
500	279.2	284.0	4.8
600	279.2	286.0	6.8
700	279.0	286.0	7.0
800	278.9	284.0	5.1
900	278.8	283.0	4.2
1000	278.8	282.0	3.2
1100	278.7	281.1	2.4
1200	278.7	280.6	1.9
1300	278.4	281.0	2.6
1400	278.4	280.8	2.4
1500	277.8	280.0	2.2
1600	277.0	280.0	3.0
1700	276.4	279.8	3.4
1800	275.2	281.2	6.0
1900	275.0	282.3	7.3
2000	274.8	284.0	9.2
2100	274.7	285.3	10.6
2200	274.5	285.0	10.5
2300	274.5	286.3	11.8
2400	274.4	285.0	10.6
2500	274.4	285.0	10.6
2600	274.3	282.0	7.7
2700	274.1	279.0	4.9
2800	274.1	280.0	5.9
2900	274.0	280.0	6.0
3000	273.8	278.6	4.8
3100	273.7	279.0	5.3
3200	273.1	279.0	5.9
3300	272.5	279.0	6.5
3400	271.4	281.0	9.6
3500	271.1	281.0	9.9
3600	270.8	280.8	10.0
3700	270.2	280.3	10.1
3800	269.5	279.9	10.4
3900	269.0	278.0	9.0
4000	268.4	277.4	9.0
4100	267.8	273.7	5.9
4200	267.2	275.8	8.6
4300	266.8	273.5	6.7
4400	266.3	269.3	3.0
4500	265.1	273.2	8.1
4600	264.5	271.7	7.2

5.3.3 Flood velocities

Figure 5.6 to Figure 5.9 show the peak velocities across the study area for the 10%, 1%, 0.1% AEP and PMF events. The figures also show the final void catchments. Peak flood velocities within the diversion drain and mine lease are given in Table 5.4. The results show that peak flood velocities vary along the diversion drain. The 0.1% AEP event peak flood velocities at the location ID's vary between 0.4 m/s to a maximum flood velocity of 3.8 m/s adjacent to the western void.

The diversion drain should be checked for potential scour and erosion after large runoff events within the Sandhurst Creek catchment due to the somewhat high velocities, particularly at locations where there are bends in the diversion drain. The upstream section and straight sections of the diversion drain convey flows with lower velocities and will be less prone to scour and erosion effects.

Table 5.4 Peak flood velocities results within the Minerva mine lease

Location ID	Peak flood velocity at point location ID (m/s)			
	10% AEP event	1% AEP event	0.1% AEP event	PMF event
1	0.23	0.26	0.35	0.79
2	0.99	1.45	1.78	2.45
3	1.34	1.72	1.99	3.42
4	0.79	0.79	0.81	1.15
5	1.33	1.62	1.84	2.84
6	2.68	3.36	3.80	4.79
7	1.92	2.37	2.74	4.14
8	1.74	1.88	1.95	2.63

5.4 DISCUSSION OF FINDINGS

The flood modelling has demonstrated that the final voids are located outside of the 0.1% AEP flood extent. The diversion drain constructed for operations is able to sufficiently convey the 0.1% AEP peak discharges to prevent floodwater ingress to the final voids.

The flood results show that the diversion drain does not provide a higher level of protection up to the PMF. The PMF event modelling shows that the diversion drain is overtopped at two locations. The upstream section of the diversion drain, which is overtopped by up to 0.5 m drains to the western void. The downstream section of the diversion drain which is overtopped by up to 0.25 m drains to the southern void. Other than these two locations, the diversion drain is not overtopped during the PMF event.

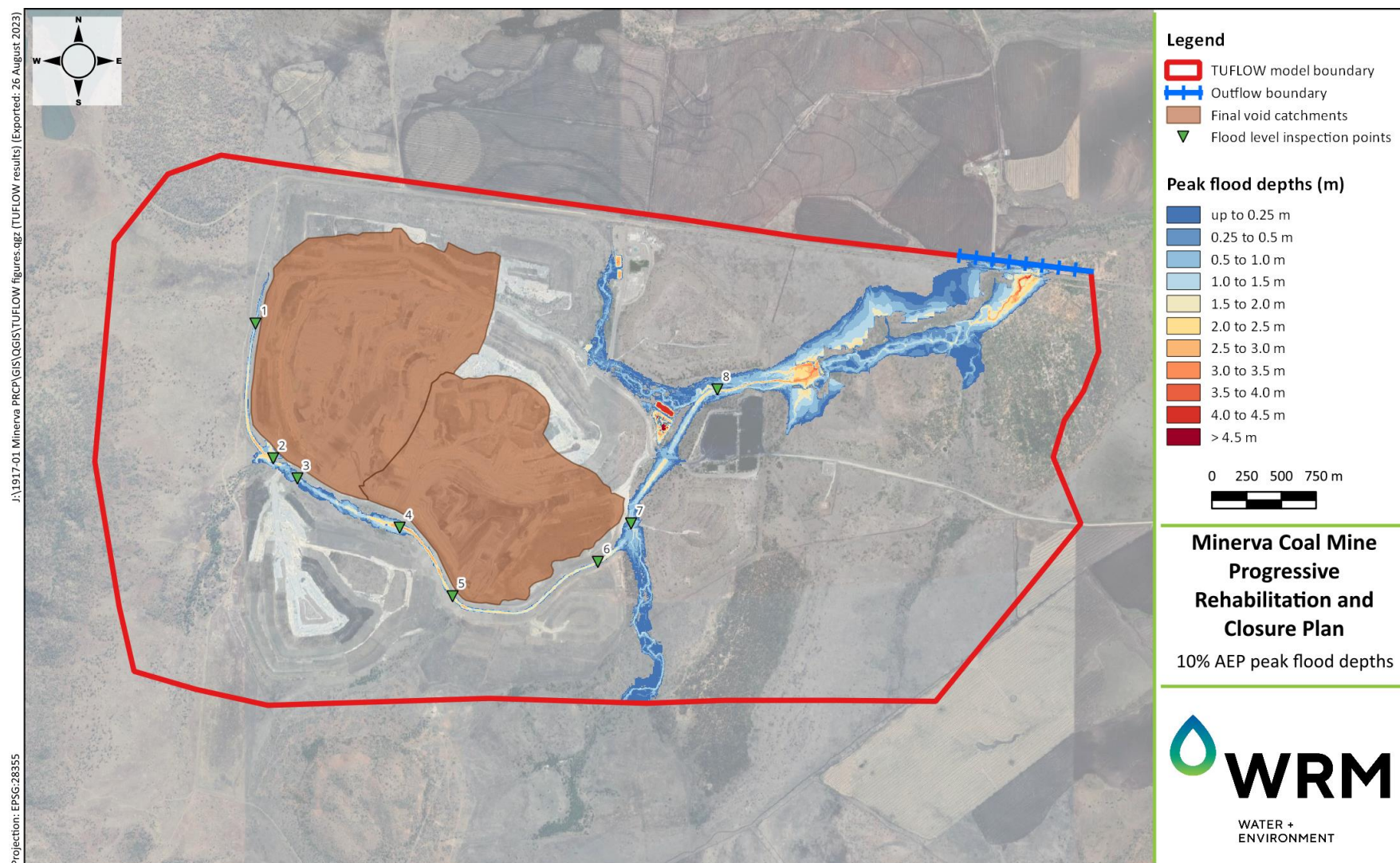


Figure 5.2 Peak flood depths, 10% AEP event

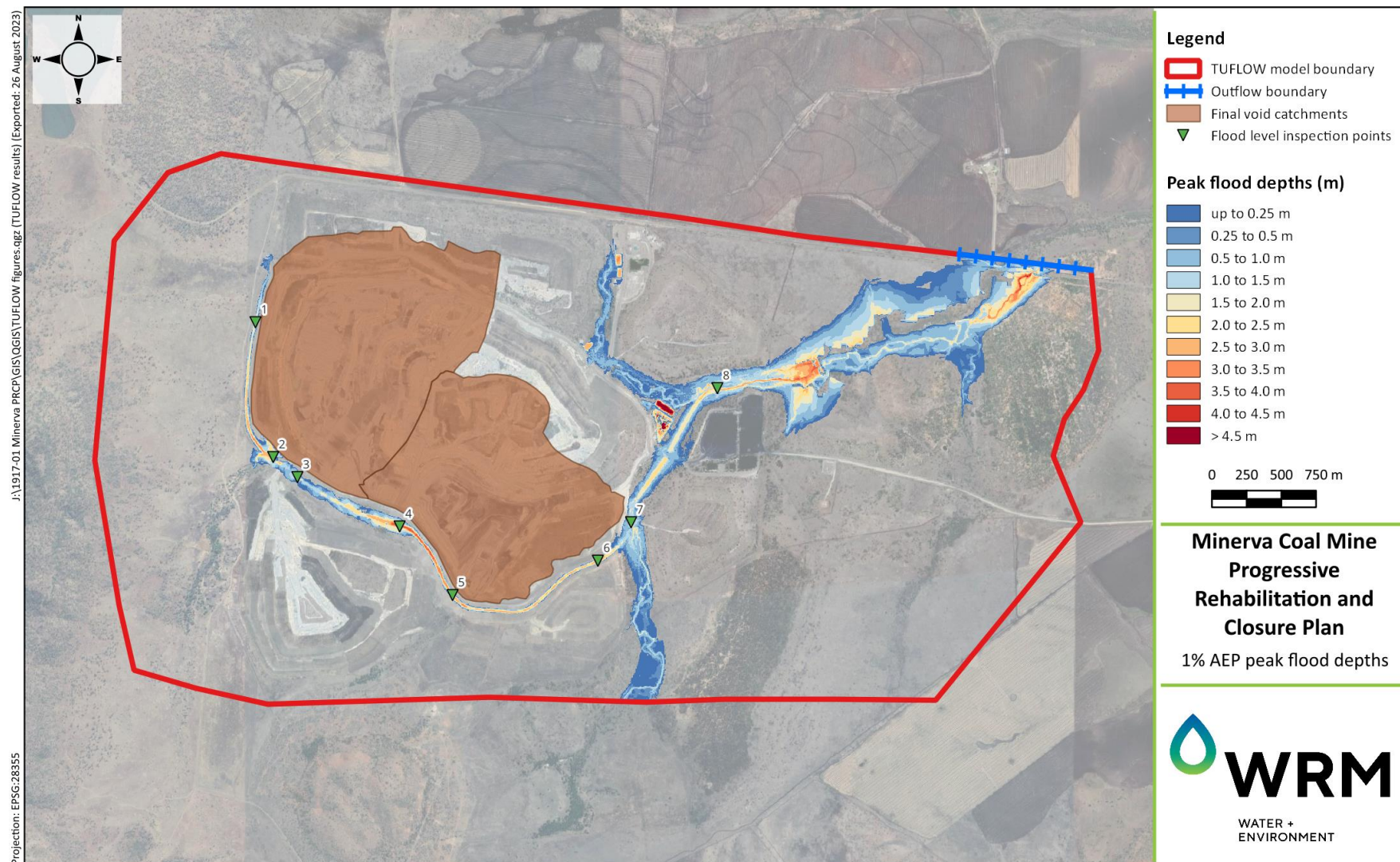


Figure 5.3 Peak flood depths, 1% AEP event

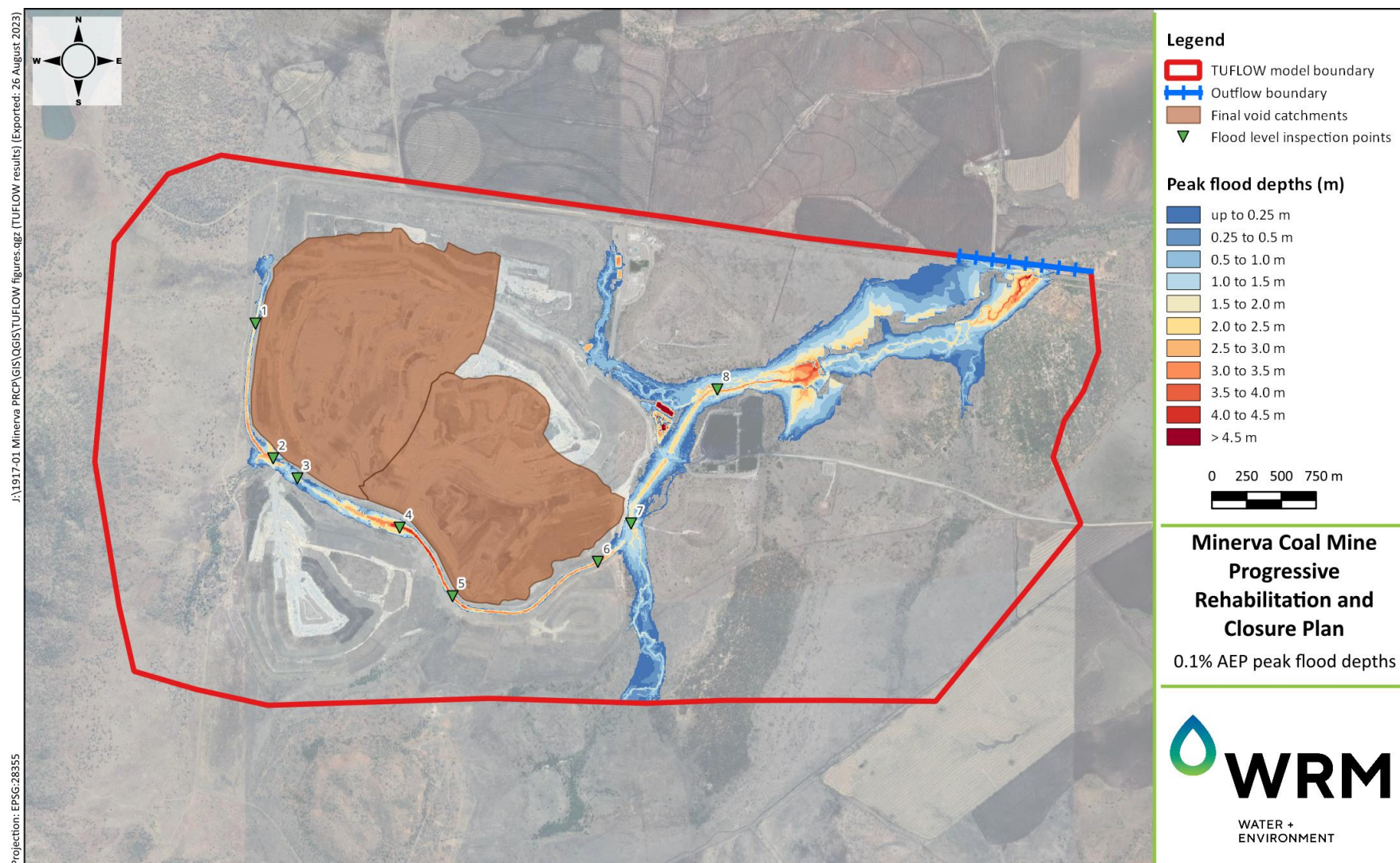


Figure 5.4 Peak flood depths, 0.1% AEP event

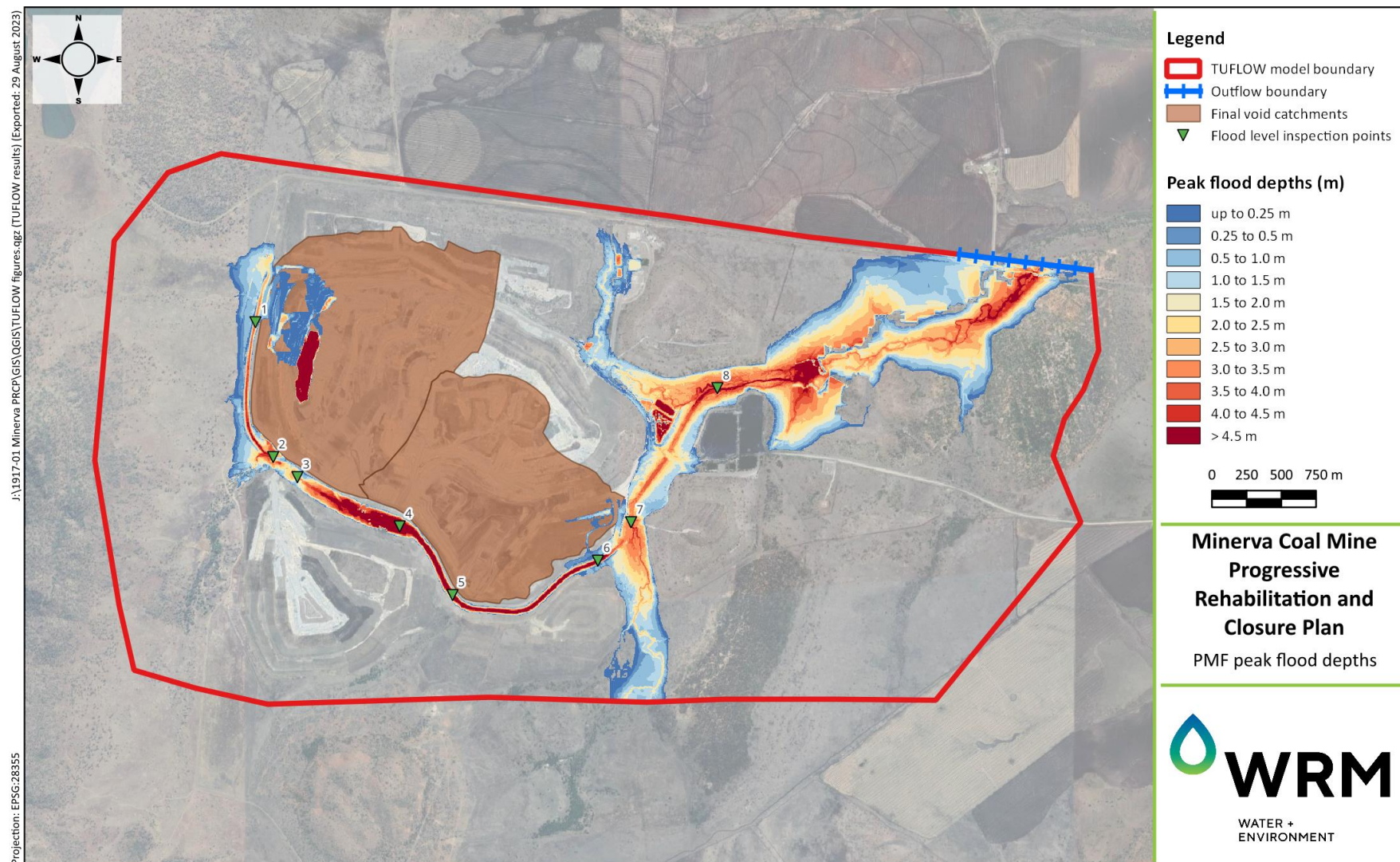


Figure 5.5 Peak flood depths, PMF event

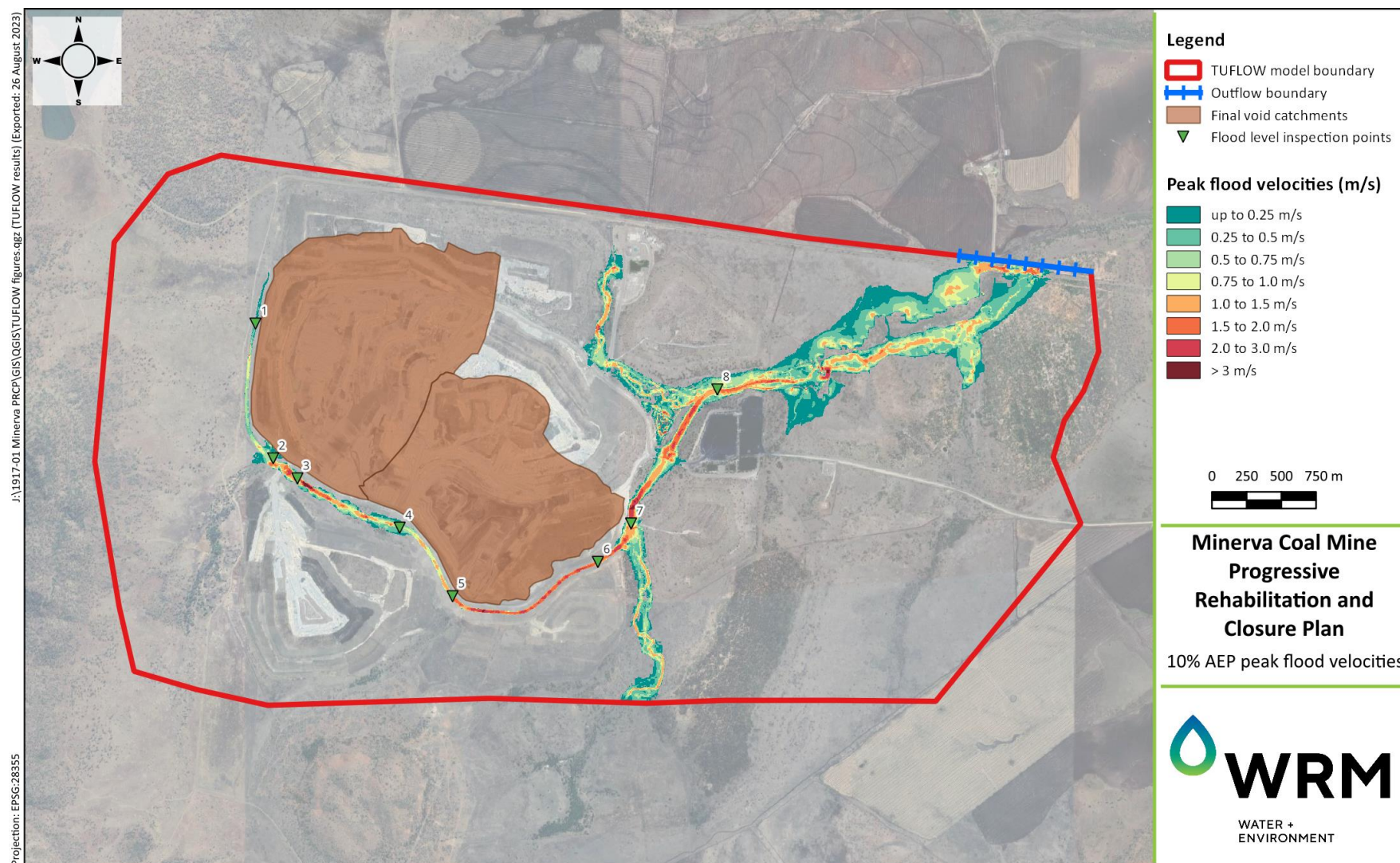


Figure 5.6 Peak flood velocities, 10% AEP event

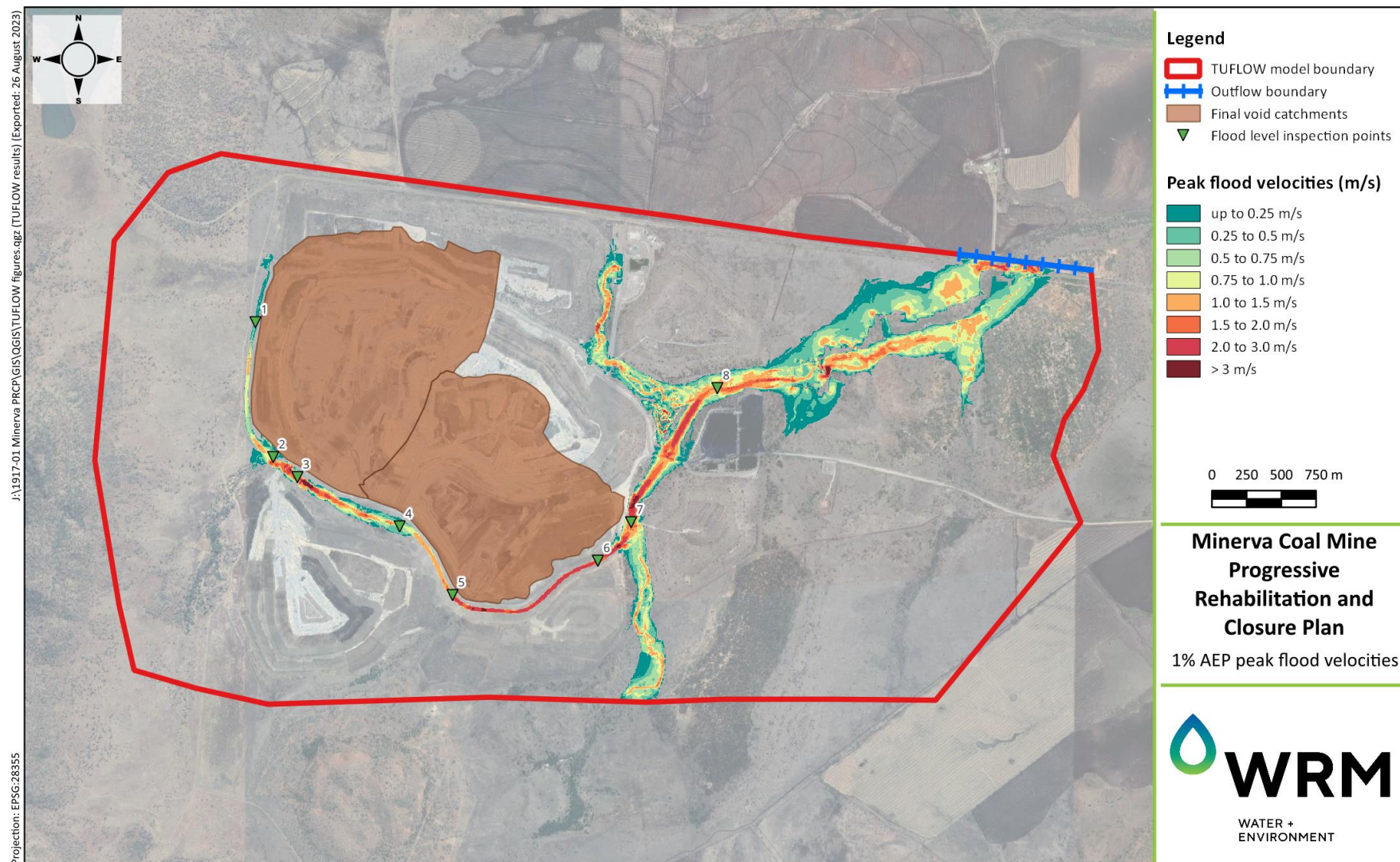


Figure 5.7 Peak flood velocities, 1% AEP event

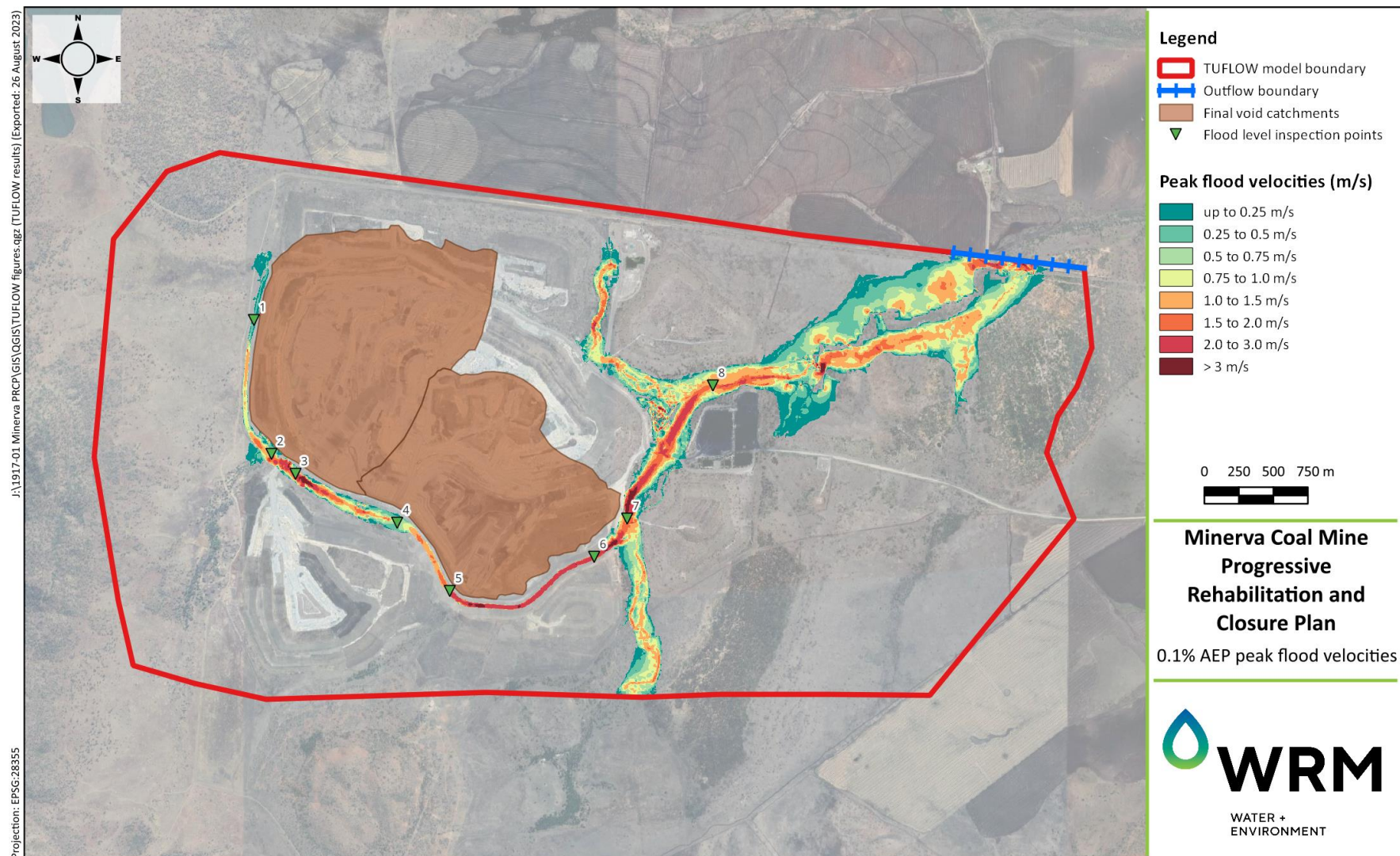


Figure 5.8 Peak flood velocities, 0.1% AEP event

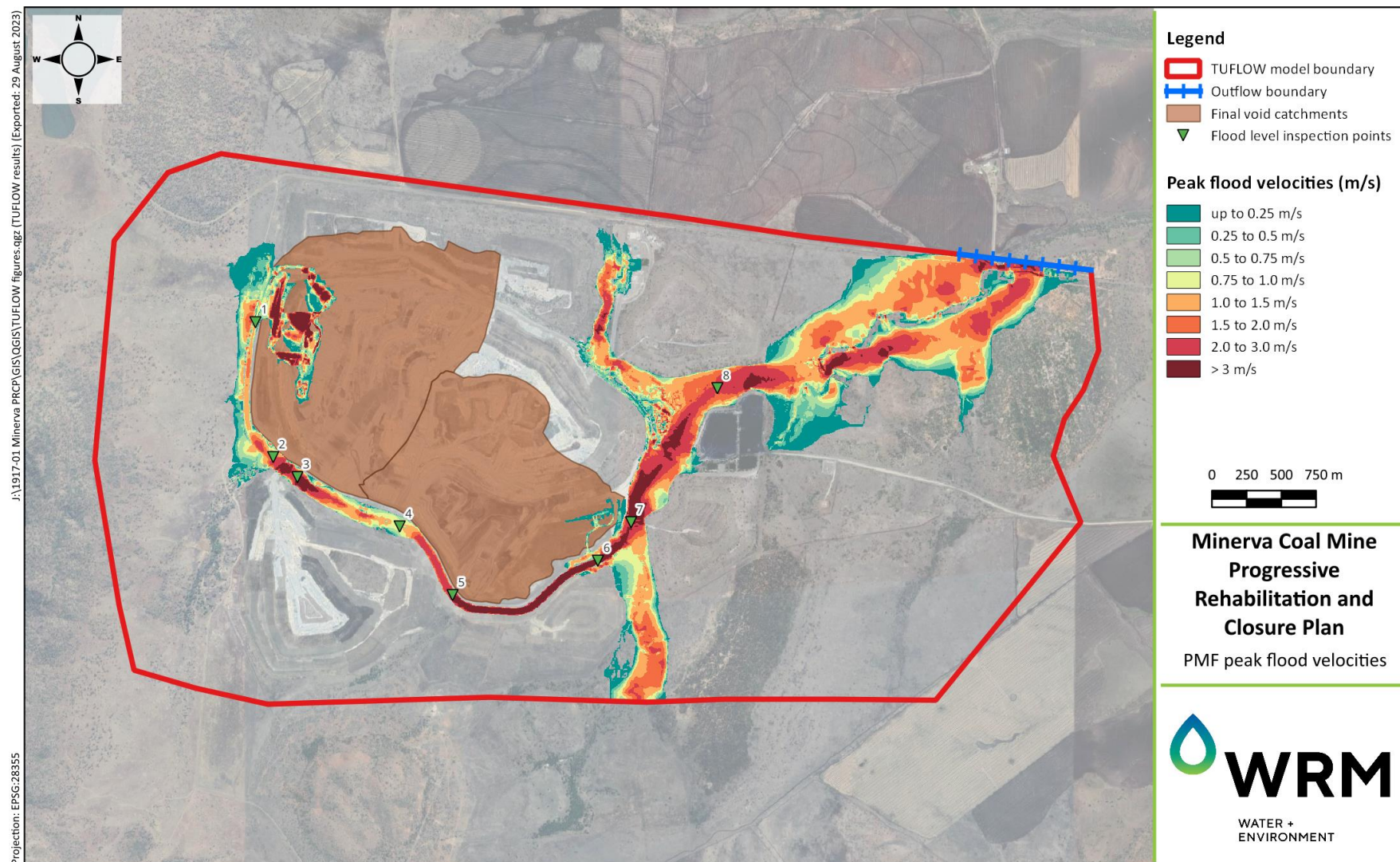


Figure 5.9 Peak flood velocities, PMF event

6 SUMMARY OF FINDINGS

This flood assessment has been prepared to support the Minerva Coal Mine Progressive Rehabilitation and Closure Plan. Downstream of the final landform and final void areas, Sandhurst Creek is defined as a third order watercourse based on the Strahler method of stream ordering. There are only first and second order watercourses that drain around the final landform areas. The diversion drain around the final landform would also be classified as a second order watercourse.

Hydrological and hydraulic computer models have been developed of the Sandhurst Creek catchment to the Waubra Road crossing. The model results show that the diversion drain that is proposed to remain as part of the final landform configuration provides flood protection to the final voids for the 0.1% AEP event. The results show that peak flood depths vary along the diversion drain. The diversion drain provides a minimum freeboard of 0.7 m from the 0.1% AEP event peak flood levels.

The diversion drain should be checked for potential scour and erosion after large runoff events within the Sandhurst Creek catchment due to the somewhat high velocities, particularly at locations where there are bends in the diversion drain. The upstream section and straight sections of the diversion drain convey flows with lower velocities and will be less prone to scour and erosion effects.

The diversion drain does not provide flood immunity for the PMF event and is overtopped at two locations. The upstream section which drains to the western void is overtopped by up to 0.5 m and the downstream section which drains to the southern void is overtopped by up to 0.25 m. Notwithstanding this, the final landform proposed at Minerva is expected to be situated outside of the 0.1% AEP event floodplain and will not have an impact on Sandhurst Creek.

7 REFERENCES

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APPENDIX A RAFTS MODEL DESIGN DISCHARGE BOX PLOTS

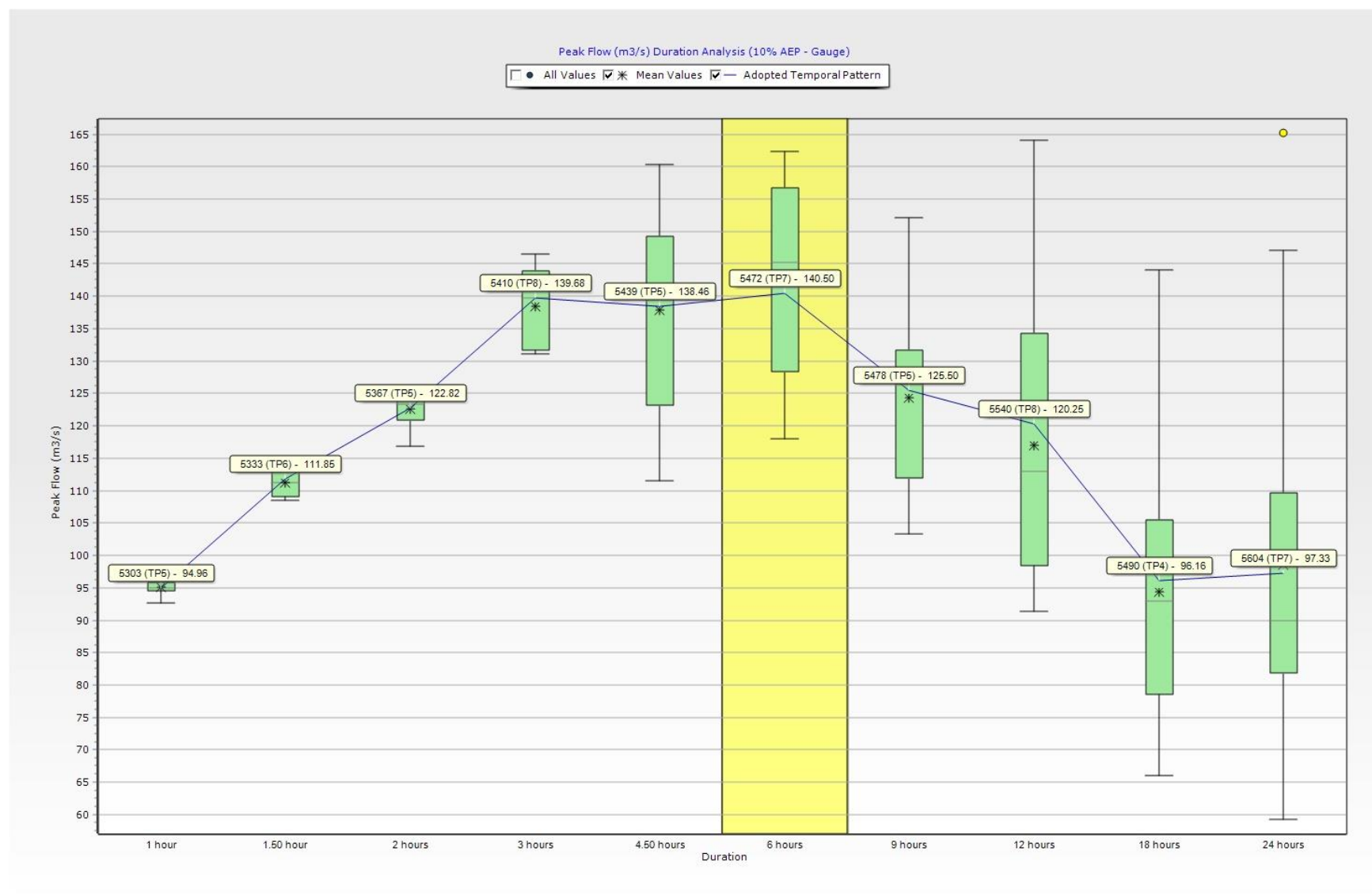


Figure A.1 RAFTS box plot of discharges, 10% AEP event

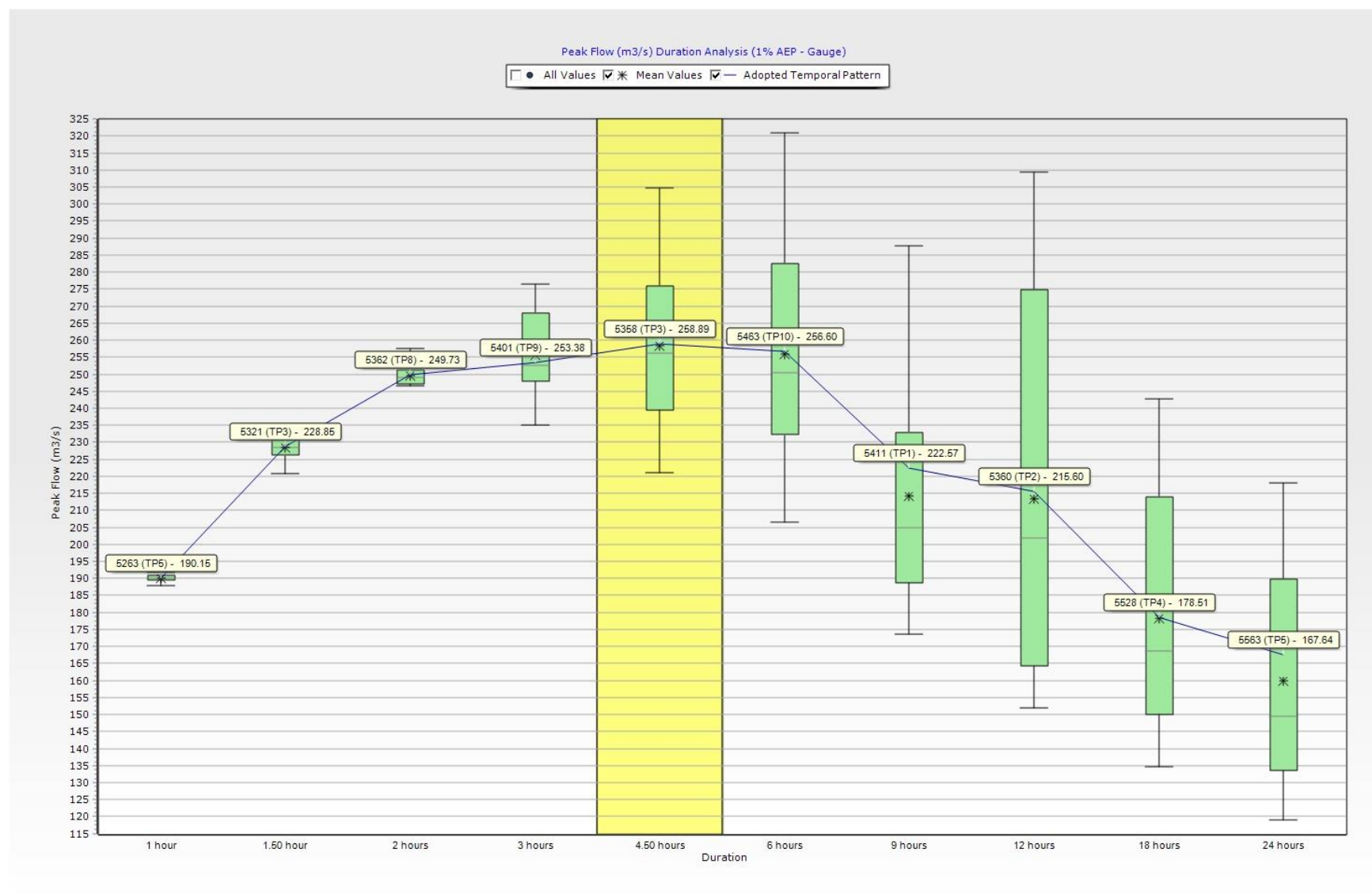


Figure A.2 RAFTS box plot of discharges, 1% AEP event

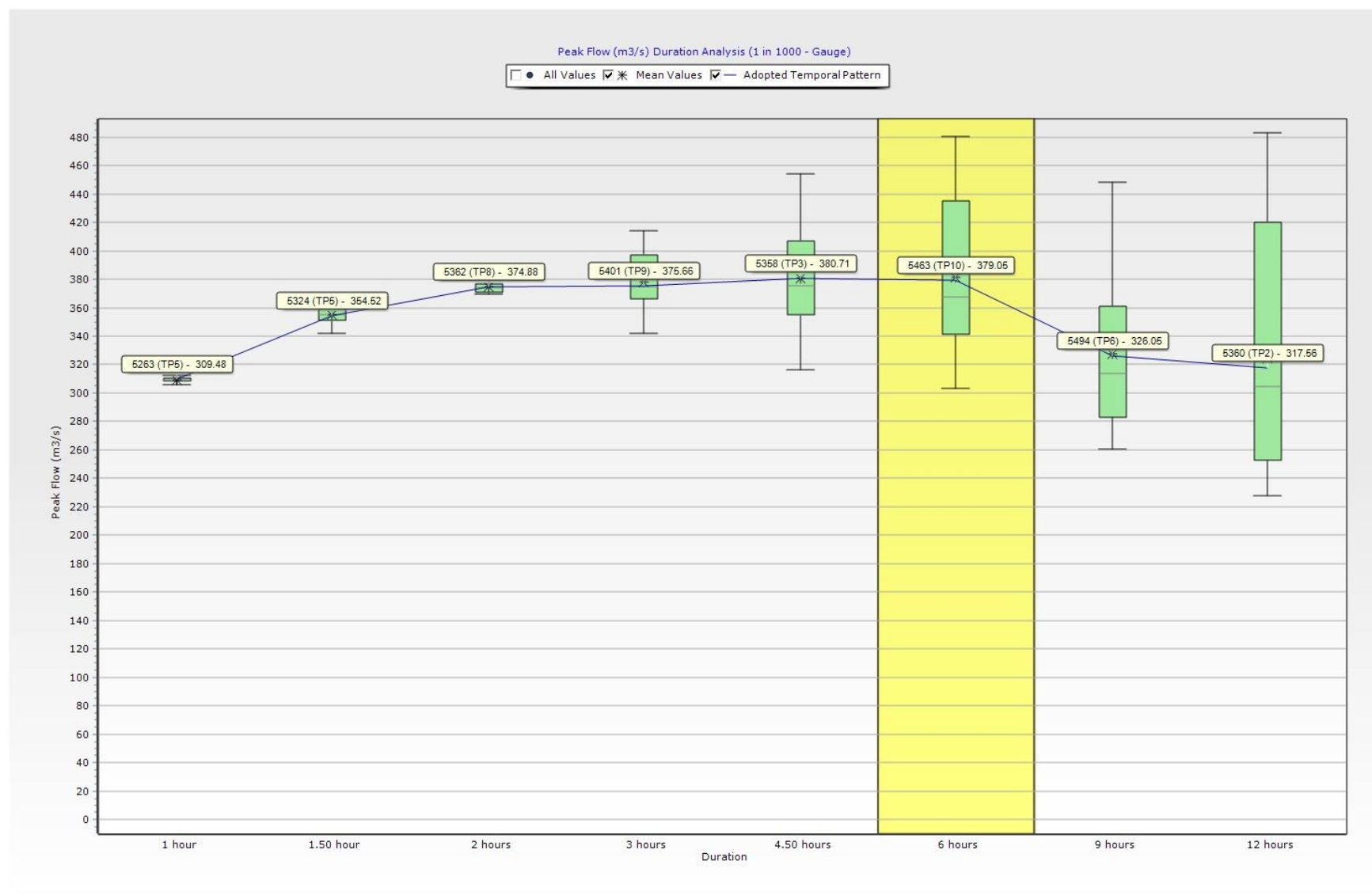


Figure A.3 RAFTS box plot of discharges, 0.1% AEP event

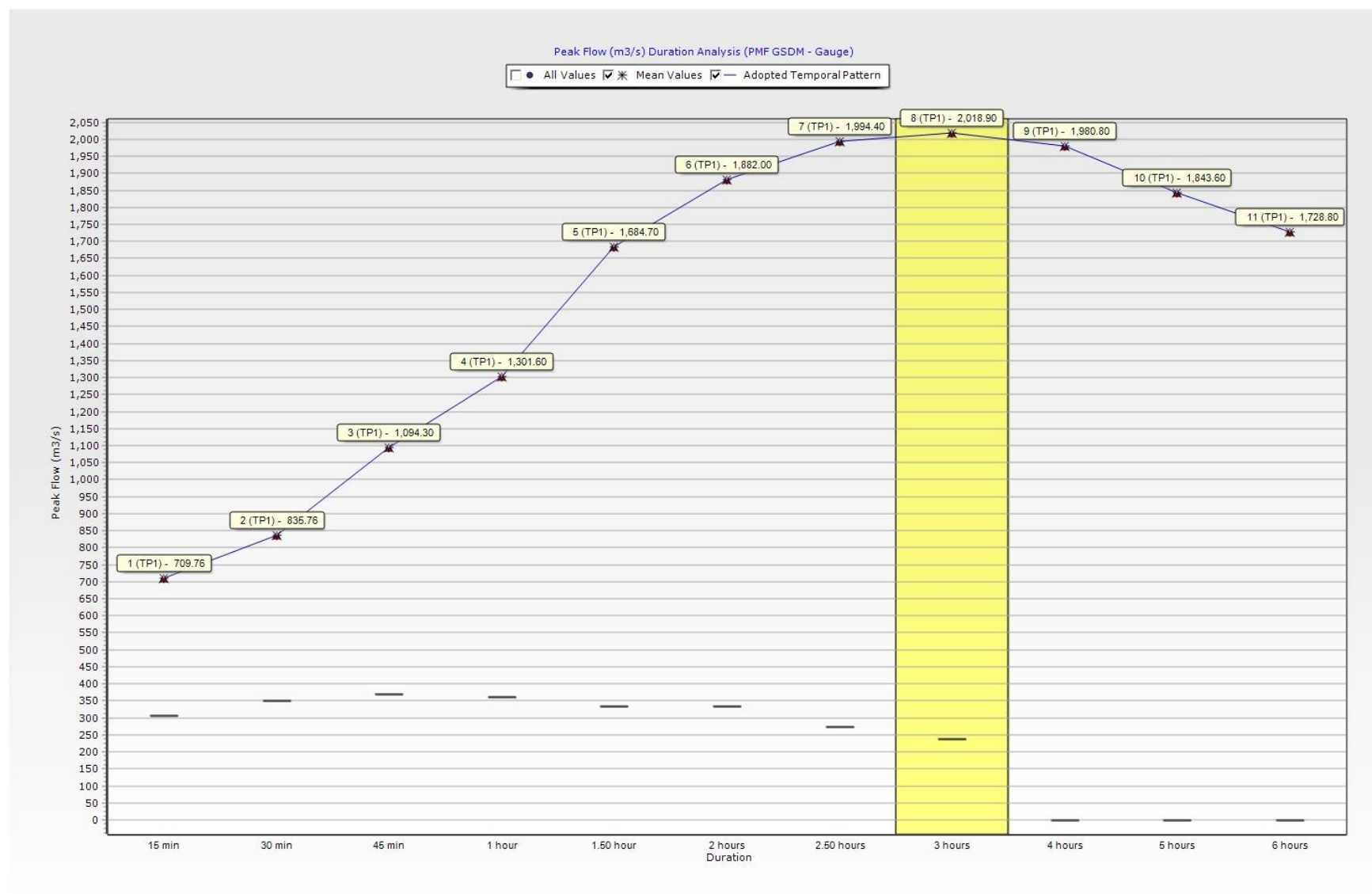


Figure A.4 RAFTS box plot of discharges, PMF event



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