Centre Pit Expansion
Savage River Mine, Tasmania

Environmental Impact Statement

Prepared for

Grange Resources (Tasmania) Pty Ltd

Client representative

Tony Ferguson

Date

14 December 2020

Rev 04

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Prepared by — Leigh Knight		**Date —** 15 December 2020
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Authorised by — David Lenel		**Date —** 15 December 2020

Revision History

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00	Final EIS	L. Knight	D. Lenel	D. Lenel	17/08/2020
01	Updated EIS	L. Knight	D. Lenel	D. Lenel	19/08/2020
02	Updated EIS	L. Knight	D. Lenel	D. Lenel	21/08/2020
03	Updated EIS	D. Lenel	D. Lenel	D. Lenel	24/11/2020
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List of Abbreviations

Abbreviation	Meaning
AADT	Annual Average Daily Traffic
AHD	Australian Height Datum
AHT	Aboriginal Heritage Tasmania
AMD	Acid Mine Drainage
ABS	Australian Bureau of Statistics
BFMP	Bush-Fire Management Plan
Board	Board of the EPA
CP	Centre Pit
CPN	Centre Pit North
CPS	Centre Pit South
DEE	Commonwealth Department of Environment and Energy
DRP	Decommissioning and Rehabilitation Plan
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EL	Exploration License
EMP	Environmental Management Plan
EMPCA	Tasmanian *Environmental Management and Pollution Control Act 1994*
EPA	Tasmanian Environment Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPN	Environmental Protection Notice
ESCP	Erosion and Sediment Control Plan
GL	Gigalitres
HRT	Hydraulic Retention Time
LGA	Local Government Area
LUPAA	Tasmanian *Land Use Planning and Approvals Act 1993*
MCTD	Main Creek Tailings Dam
ML	Mineral Lease
MLA	Mineral Lease Application
NAF	Non-Acid Forming

Abbreviation	Meaning
NC Act	Tasmanian *Nature Conservation Act 2002*
PAF	Potentially Acid Forming
ROM	Run of Mine
RMPS	Tasmanian Resource Management and Planning System
SD	South Deposit
SDTSF	South Deposit Tailings Storage Facility
SLO	South Lens Outflow
SPWQM	State Policy on Water Quality Management 1997
SRRP	Savage River Rehabilitation Project
TSP Act	Tasmanian *Threatened Species Protection Act 1995*
TSF	Tailings Storage Facility
WMA	Tasmanian *Water Management Act 1999*
WRMP	Waste Rock Management Plan
WHS Act	*Work Health and Safety (National Uniform Legislation) Act 2001*

1. Introduction

Grange Resources (Tasmania) Pty Ltd (Grange Resources) operates the Savage River magnetite mine 100 km south west of Burnie, located in north west Tasmania. The mine commenced operations in 1967 and includes several pits, working deposits, water treatment body, tailings dam and storage, rock dump and process facilities. Magnetite concentrate is pumped via pipeline to a pelletising plant at Port Latta, west of Burnie for processing and transport to international and Australian markets via bulk cargo vessel. It is proposed to recommence mining in the central deposit, referred to as Centre Pit. All mining will occur within the existing lease area, 2M/2001 and is expected to yield 31 Mt of ore and 255 Mt of waste rock.

The Savage River mine operates under the Goldamere Pty Ltd (Agreement) Act 1996. The Goldamere Agreement was created in 1996 and indemnifies the owners of the mine (from that date onward) against responsibility for legacy pollution which occurred in the Savage River as a result of mining from the 1960's to the 1990's. The Goldamere Agreement also established the legal foundation for the Savage River Rehabilitation Project (SRRP) which outlines funding arrangements and provided the formation of a joint management committee to allow a cooperative rehabilitation of the Savage River. The proposed expansion will be compliant with the requirements of the SRRP and its current strategic plan.

1.1 Title of the proposal

Savage River Mine Centre Pit Expansion.

1.2 Proponent details

Name of proponent (legal entity)	Grange Resources (Tasmania) Pty Ltd
Name of proponent (trading name)	Grange Resources Tasmania
Registered address of proponent	34a Alexander Street Burnie Tasmania 7320
Postal address of proponent	PO Box 659 Burnie Tasmania 7320
ABN number	30 073 634 581
ACN number (where relevant)	N/A
Contact person's name	Ben Maynard
Telephone	03 6430 0222
Email address	Ben.Maynard@grangeresources.com.au

1.3 Activity operator details

The proponent will be the operator.

1.4 Proponent's background information

Grange Resources is Australia's oldest and most experienced magnetite producer and a proven and reliable commercial producer of Hematite pellets from magnetite concentrate in Australia, combining both mining and pellet production expertise. Grange Resources is a company limited by shares that is incorporated and domiciled in Australia.

Grange Resources operates the Savage River Mine and the Port Latta pelletising plant adjacent its export facility.

1.5 Proposal's background

1.5.1 Current status of the proposal

A Project Description was submitted to the Environment Protection Authority (EPA) in June 2019 seeking statutory approval for the expansion of the Centre Pit ore resource. Subsequently, in September 2019, Grange Resources was issued approval under Environment Protection Notice (EPN) No 248/2 to allow pre-stripping of the east wall of the Centre Pit, in areas previously disturbed by mining.

Advice was provided on 13 January 2020 that the activity would be assessed by the Board as a Class 2B assessment under the *Environmental Management and Pollution Control Act 1994* (the EMPCA). No planning approval is required for the proposed activity under the *Land Use Planning and Approvals Act 1993* (LUPAA) and the activity is being considered under Section 27 I of the EMPCA.

Project Specific Guidelines (PSGs) for the proposed activity were issued on 11 February 2020. The key issues identified to be addressed in the EIS are:

- Waste rock and tailings management
- Surface water impacts from pit dewatering and onsite water management; and
- Geotechnical stability.

Further revision of the EIS has been completed in answer to specific questions issued by the EPA on the 24th September 2020 regarding the draft copy.

1.5.2 Overview of the principal components of the proposal

The Centre Pit is comprised of the former Centre Pit North (CPN) and Centre Pit South (CPS). Extraction from CPN ceased in 2001 and it was subsequently backfilled. Production from CPS continued to 2006 when the design depth was achieved, and now contains water. Both pits form the current Centre Pit location. Principal components of the proposed activity are:

- The former CPS will be dewatered followed by normal mine dewatering
- The Centre Pit will be mined in a series of stages and cutbacks using a Load and Haul operation
- Water (including from dewatering) will be processed through the existing centralised water treatment systems on site
- Waste rock will be managed in accordance with current management practices and potentially acid forming material will be encapsulated to prevent oxidation; and
- Tailings will be deposited within the existing tailings dams and storage facility.

1.5.3 The proposal location

The proposed Centre Pit Expansion is within the existing Savage River Mine footprint. The locality of Savage River is shown in Figure 1 with the footprint of the proposed activity shown on Figure 2.

1.5.4 Anticipated establishment costs

Works will be conducted as part of on-going production at the mine and no new infrastructure is required. As such there are no establishment costs, rather ongoing operational costs.

1.5.5 Likely markets for the product

Product will continue to be shipped to existing markets.

1.6 Relationship to any other proposals

The site is remote and there are no known projects on other operating sites within proximity. The existing facility at Port Latta will be used for pelletising and export and is not altered by this proposed activity.

A Notice of Intent was submitted to the EPA on 2 March 2020 for the proposed North Pit Underground Mine. In the event this proposal is approved, it is not anticipated to result in any additional impacts to the environment. The site's processing rate is not expected to exceed the currently approved limits.

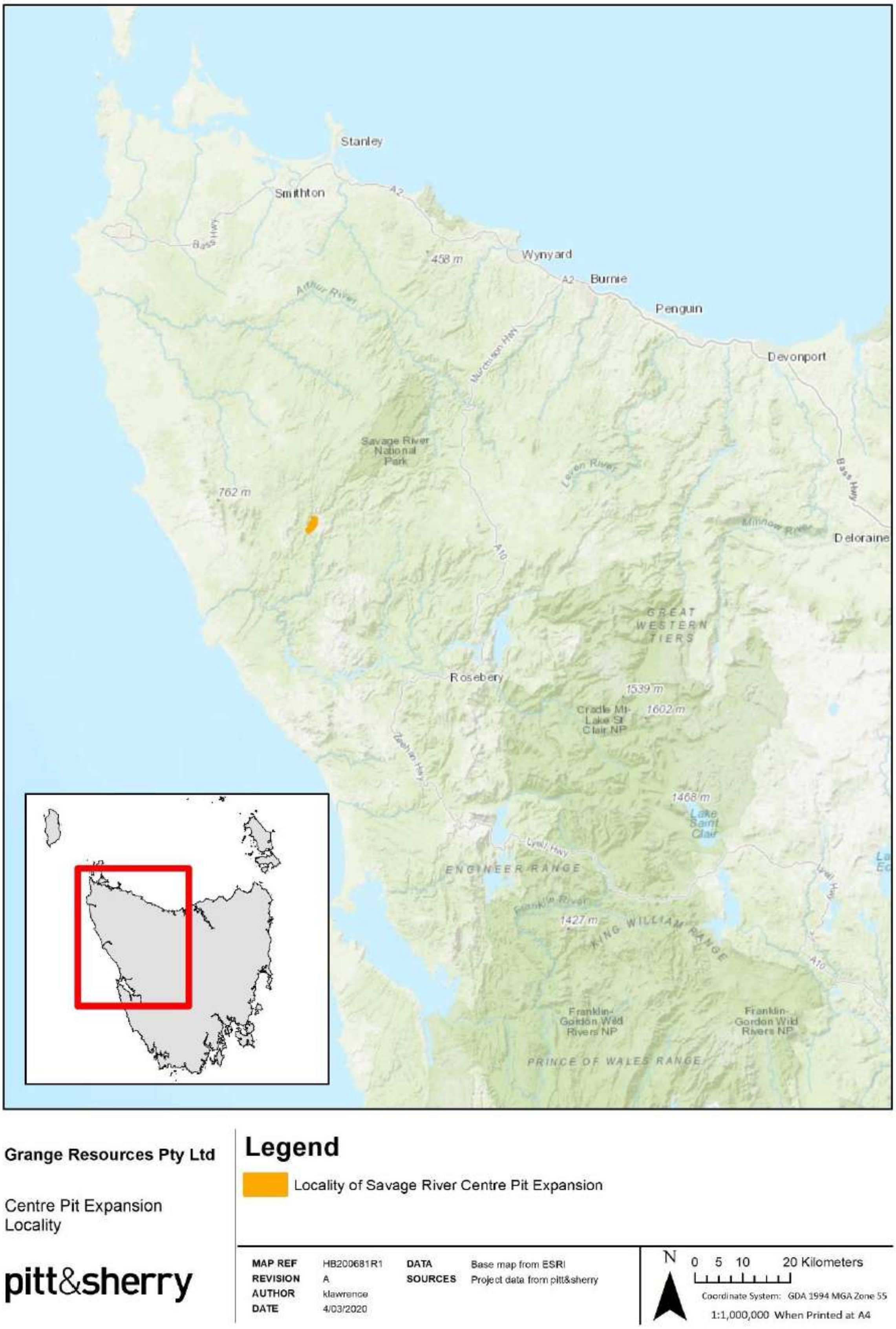


Figure 1: Locality map showing location of Savage River

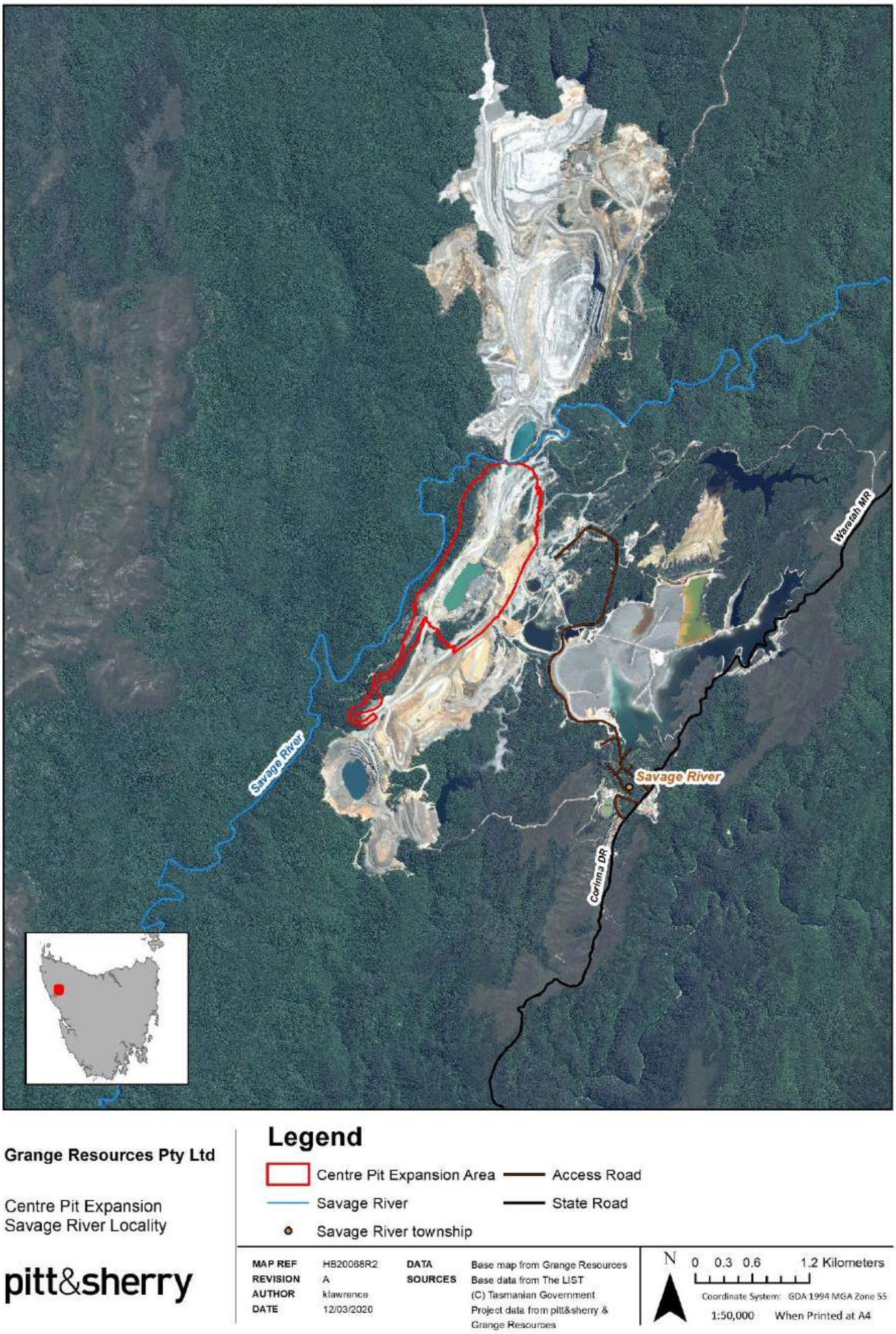


Figure 2: Aerial image showing location of the Centre Pit Expansion area

1.7 Applicable environmental legislation, standards and guidelines

1.7.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Under the Commonwealth Government's EPBC Act the proponent must determine whether or not the project requires referral to the Commonwealth Department of the Environment for a decision as to whether it is a 'controlled action'. An action will require approval from the Minister if the action has, will have, or is likely to have a significant impact on Matters of National Environmental Significance (MNES), which encompass all species and communities listed under the EPBC Act, certain activities and places of national importance. A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity.

This EIS includes a natural values assessment undertaken by North Barker Ecosystem Services which addresses the potential impacts on MNES.

1.7.2 Tasmanian Resource Management and Planning System

All environmental and land management legislation in Tasmania is underpinned by the Resource Management and Planning System (RPMS). This was introduced in 1993 and provides the following common objectives which are included as a schedule in each relevant act:

- To promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity
- To provide for the fair, orderly and sustainable use and development of air, land and water
- To encourage public involvement in resource management and planning
- To facilitate economic development in accordance with the objectives set out in the above paragraphs; and
- To promote the sharing of responsibility for resource management and planning between the different spheres of government, the community and industry in the state.

The EMPCA, LUPAA and the *Water Management Act 1999* all include an obligation to further these objectives,

1.7.3 *Tasmanian Environmental Management and Pollution Control Act 1994* (EMPCA)

This Act establishes the processes for assessment of activities considered to have the potential to cause environmental harm. It also relates to the management of pollution and remediation. Schedule 2 of EMPCA lists those activities (Level 2 activities), and any relevant production or process thresholds, which are required to be referred to the EPA for a decision as to whether the application requires assessment by the Board of the EPA. The proposed expansion is a Level 2 activity as described under Schedule 2 of the EMPCA, falling in to item 5 Extractive industries, which includes (c) *Mines: the extraction of any minerals producing 1,000 tonnes or more of minerals per year*. This EIS presents the information requested by the EPA to allow assessment of potential impacts of the proposal.

1.7.4 Goldamere Pty Ltd (Agreement) Act 1996

The Goldamere Agreement was created in 1996 and indemnifies the owners of the mine (from that date onward) against responsibility for legacy pollution which occurred in the Savage River as a result of mining from the 1960's to the 1990's.

This Act provides that the EMPCA, the *Land Use Planning and Approvals Act 1993* , the *Resource Management and Planning Appeal Tribunal Act 1993* and any other Environmental Legislation is to be applied to the site, however, the operators (now Grange Resources) are not responsible, and is not to be held responsible, for any contamination, pollutant or pollution which resulted from previous operations.

Additionally, any conditions imposed on the operators must not require that measurable environmental standards in respect of water quality, soil contamination or any other criterion relating to contamination or pollution be imposed. As an alternative to this, any approvals should impose management requirements which are based on Best Practice Environmental Management. This is defined in the EMPCA as "*management of the activity to achieve an ongoing minimization of the activity's environmental harm through cost-effective measures assessed against the current international and national standards applicable to the activity*". Accordingly, some typically set parameters and legislative requirements are not applicable to this proposed activity.

1.7.5 Tasmanian Mineral Resources Development Act 1995

Mining leases are administered through the *Minerals Resources Development Act 1995*. Grange Resources currently hold the following leases for mining operations at Savage River:

- ML 2M/2001 (2001) - Amalgamated lease of ML 44M66 and SL1 & SL2 to which the Goldamere Agreement applies
- ML 14M/2007 (2007) – an extension to the mining lease to cover the township and Broderick Creek dump areas
- ML 11M/2008 (2008) – an extension to cover the tailings storage facility (TSF); and
- ML 4M/2019 (2019) – an extension to cover water back up in the Broderick Creek catchment.

No new leases are required, and all works will occur within existing lease areas.

1.7.6 Tasmanian *Water Management Act 1999*

This Act deals with licencing the taking of water from watercourses and wells, management of water districts and dam approvals. Large dams require consideration of the Australian National Committee on Large Dams (ANCOLD) guidelines and possibly registration. No new dams are proposed under this expansion.

1.7.7 *State Policy and Projects Act 1993*

This is the Act under which Tasmanian state policies are made and the National Environmental Protection Measures (NEPMs) are given effect (recognised as state policies). Only one state policy given effect under this act is relevant, the State Policy on Water Quality Management 1997 (discussed below).

1.7.8 *Threatened Species Protection Act 1995*

This Act lists threatened species and regulates activities that may result in their disturbance. A natural values assessment was undertaken by North Barker Ecosystem Services which addresses the implications of this act.

1.7.9 *Nature Conservation Act 2002*

This Act identifies and regulates threatened native vegetation communities. A natural values assessment was undertaken by North Barker Ecosystem Services which addresses the implications of this act.

1.7.10 *Workplace Health and Safety Act 2012*

The proposed activity does not raise any new matters under this act or the associated Mines Work Health and Safety (Supplementary Requirements) Act 2012. This is the expansion of an existing mine operation within the confines of an existing mine footprint. Grange Resources currently operate within established EHS systems and procedures.

1.7.11 *Land Use Planning and Approvals Act 1993*

Under LUPAA, Councils are required to administer the development and use of land within their municipal boundary. The relevant local planning authority is Waratah-Wynyard Council. Council has indicated that it does not require further planning approval under LUPAA for this proposed activity. There are no further obligations under this Act.

1.8 Other relevant policies, strategies and management plans

1.8.1 Savage River Rehabilitation Project and SRRP Strategic Plan 2015

The Goldamere Agreement established the legal foundation for the SRRP funding arrangements and the formation of a joint management committee. The SRRP commenced in 1997 when Australian Bulk Minerals (ABM) acquired the Savage River and Port Latta sites and aims to achieve ongoing remediation on a co-operative basis. Grange Resources has continued this relationship since merging with ABM in 2009.

The Management Committee established under the Goldamere Agreement comprises representation from the EPA, Mineral Resources Tasmania (MRT) and Grange Resources and water quality review data and other information is publicly available on the EPA website.

1.8.2 State Policy on Water Quality Management 1997

The policy allows for the establishment of water quality objectives, however, these are largely over-ridden in this instance by the effect of the Goldamere Agreement. The objectives of this state policy are to:

a. Focus water quality management on the achievement of water quality objectives which will maintain or enhance water quality and further the objectives of Tasmania's Resource Management and Planning System

b. Ensure that diffuse source and point source pollution does not prejudice the achievement of water quality objectives and that pollutants discharged to waterways are reduced as far as is reasonable and practical using best practice environmental management

c. Ensure that efficient and effective water quality monitoring programs are carried out and that the responsibility for monitoring is shared by those who use and benefit from the resource, including polluters, who should bear an appropriate share of the costs arising from their activities, water resource managers and the community

d. Facilitate and promote integrated catchment management through the achievement of objectives (a) to (c) above; and

e. Apply the precautionary principle.

Clause 37 of the state policy relating to Acid drainage from mines, contains provisions requiring that actions to reduce the emission or environmental effects of acid drainage should be included in proposals for mine rework. The current proposal is not inconsistent with that requirement in that systems and processes are established on site to manage and reduce the acidic qualities of discharges from the site.

2. Proposal Description

2.1 Description of the proposed expansion

During the 1960's and 1970's mining occurred in two pits, CPN and CPS. Extraction from CPN ceased in 2001 (see Figure 3) and it was subsequently backfilled. Production from CPS continued to 2006 when the design depth was achieved (see Figure 4). This pit now contains water. Both pits are shown on the aerial image at Figure 5 and form the current Centre Pit location.

Figure 3: Looking south across South Lens to CPN in 2000 – approximately one year before production ceased

Figure 4: View south across CPS in 2007 after the most recent stage of mining at that location

Figure 5: Site layout showing location of CPN (back filled) and CPS

2.1.1 Site plan

Figure 6 shows the indicative development of the Centre Pit expansion within the site. The main haul road and location of roads accessing waste rock dumps is also indicated. As the pit expands the location of roads will vary to accommodate changes in land form and to allow access to the various waste rock dumps indicated for use. The staging is outlined in detail in Section 2.2 and indicates that Stages 2 and 3 can be mined independently and in any order. A degree of flexibility is anticipated in operations, however, the ultimate extent of disturbance and the volumes of extraction will not alter.

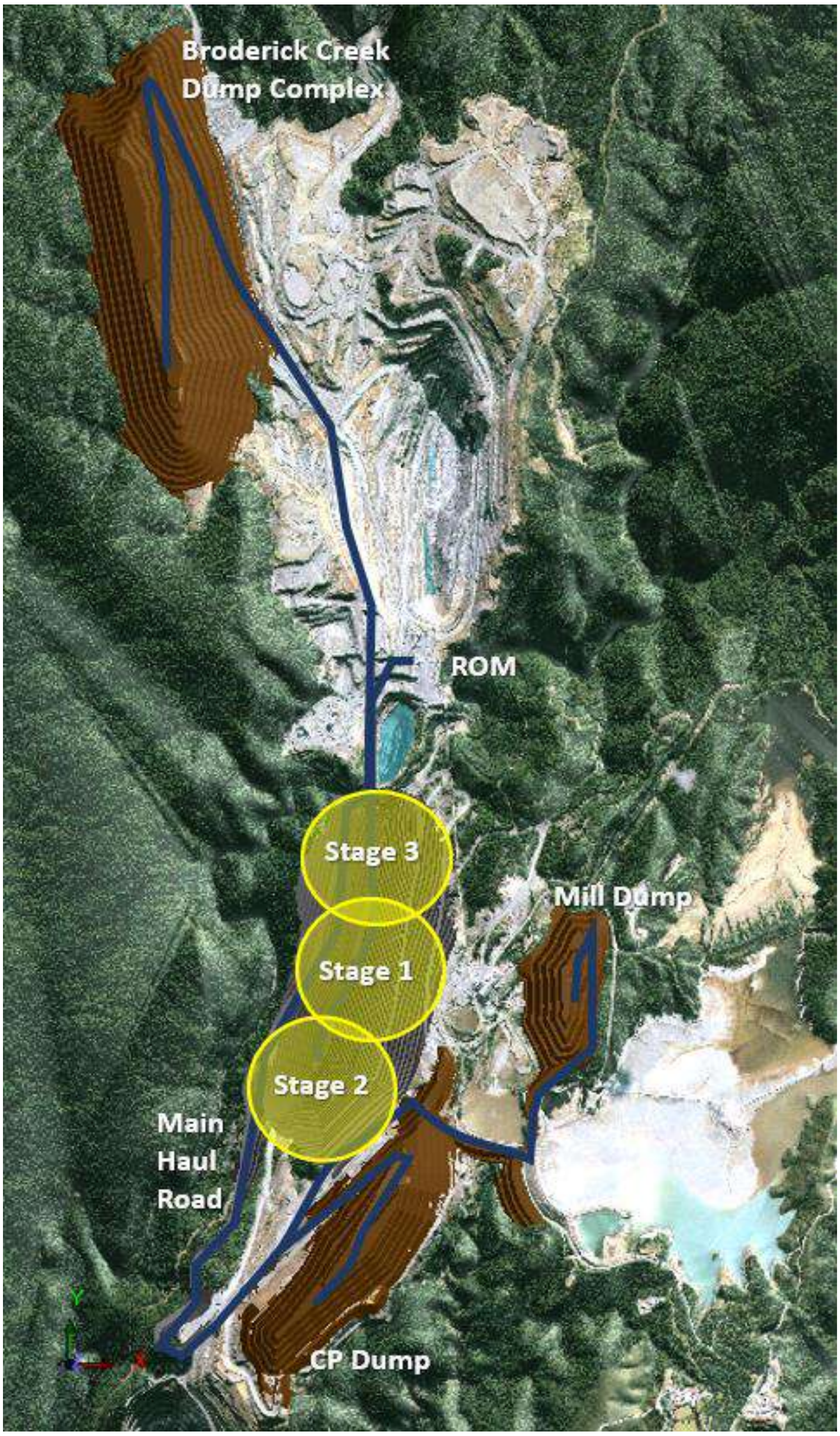


Figure 6: Site plan showing new Centre Pit extent and infrastructure on site

2.1.2 Pit design

Centre pit is proposed to be mined in 3 stages as shown in Figure 6. The proposed final pit at the end of Stage 3 will have a finished depth to RL -25m and is demonstrated graphically on Figure 8, Figure 9 and Figure 10. Sections showing the current surface level and designed pit are provided in Figure 11 to Figure 13. Savage River traverses the site, between the proposed northern extent of the Centre Pit and South Lens. Cross sections are all shown through the pit at the end of stage 3. With reference to Figures 11 to 13, it should be noted that the current depth of CP South is 70mRL. CP North was previously mined to a depth of 30mRL. For the presented designs CP Stage 1 reaches a depth of 35mRL, CP Stage 2 a depth of -10mRL in the south and CP stage 3 a depth of 5mRL in the north.

The cross sections may be similar for Stage 1 & 2, but as the pit expands to south and the north during mining of Stage 2 and 3, the access ramp entering the pit is relocated allowing greater depth to be achieved in each subsequent stage.

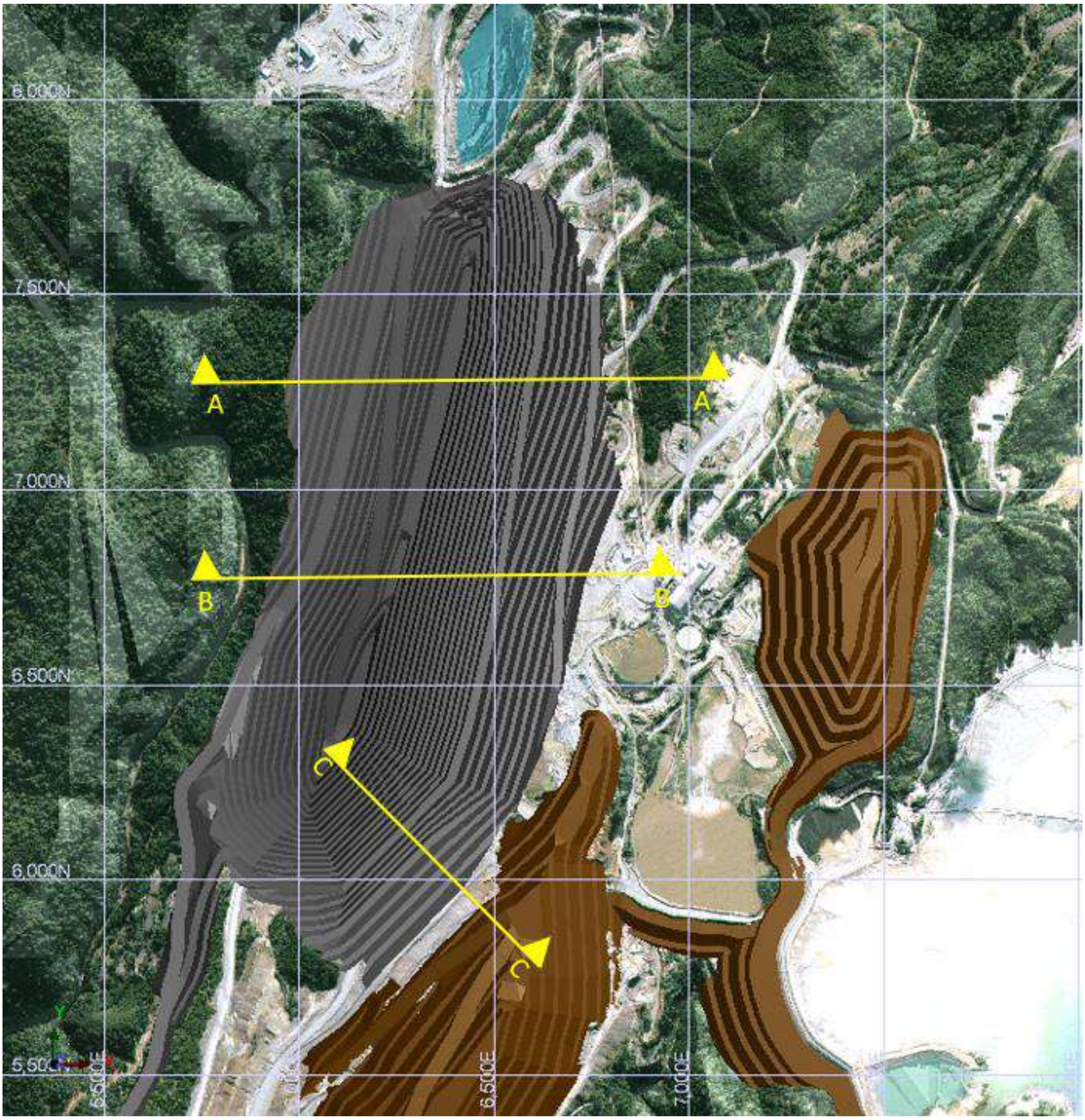


Figure 7: Final Pit design section plan

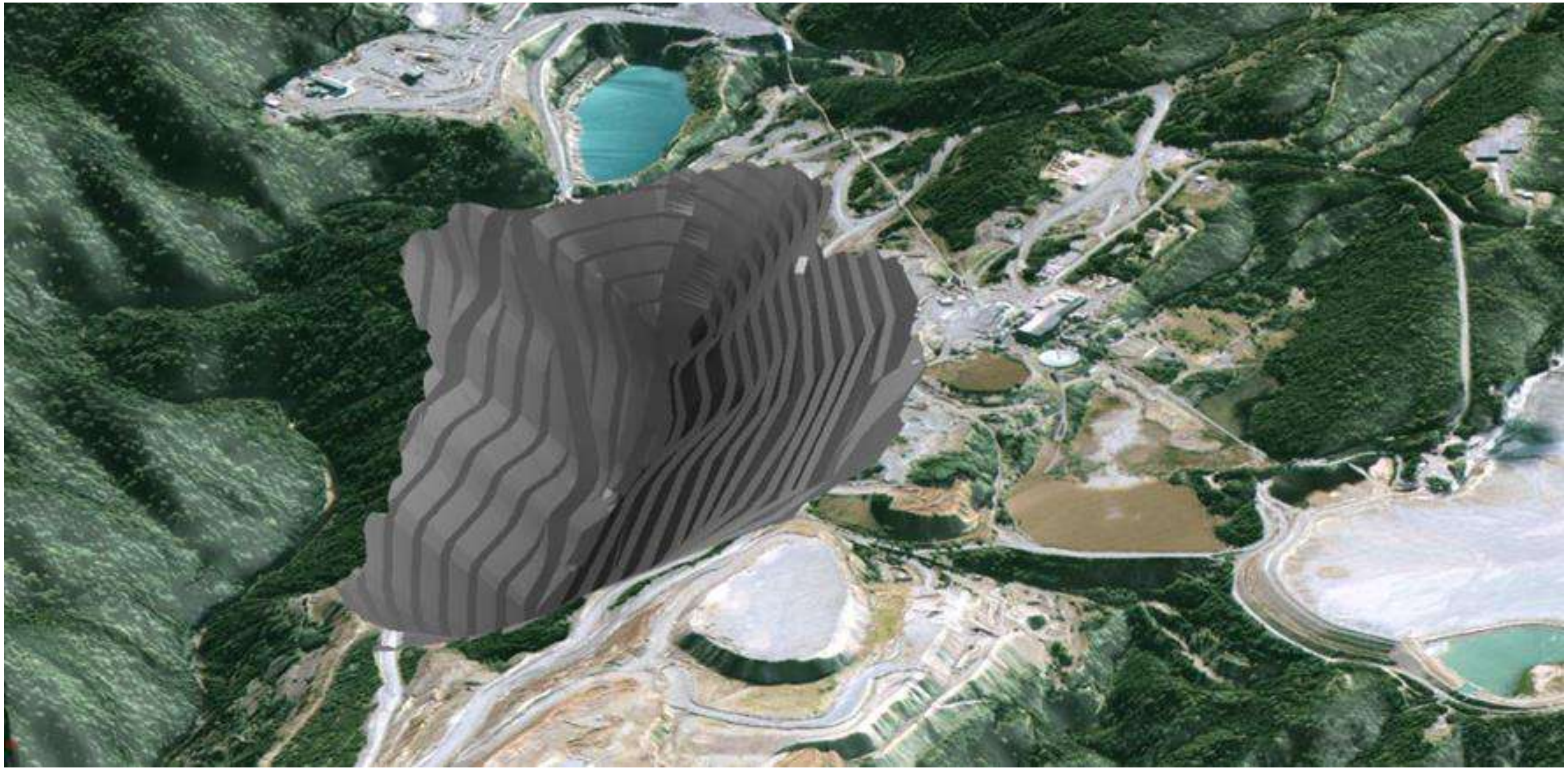


Figure 8: Proposed Centre Pit – looking north (South lens to immediate north)

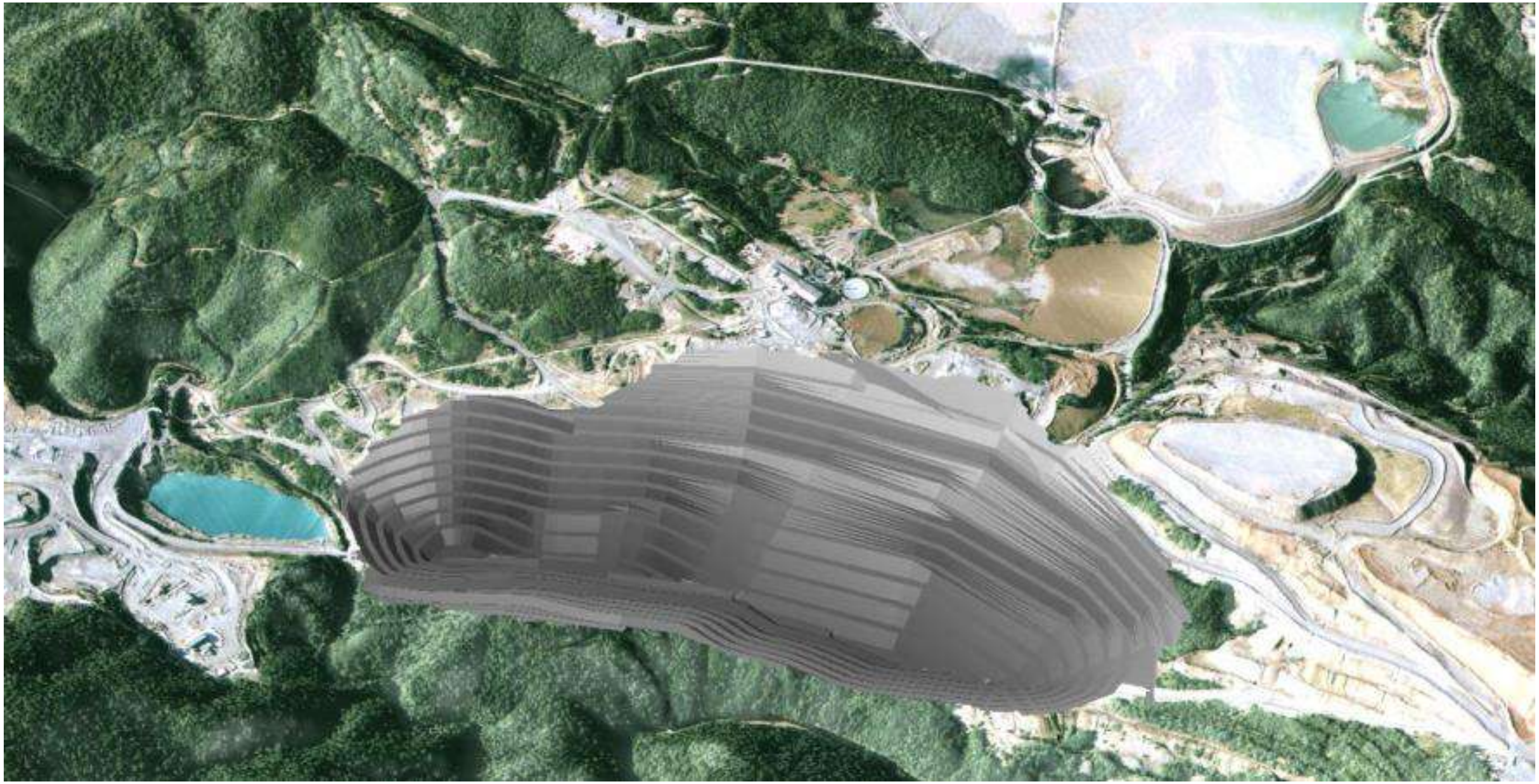


Figure 9: Proposed Centre Pit looking east

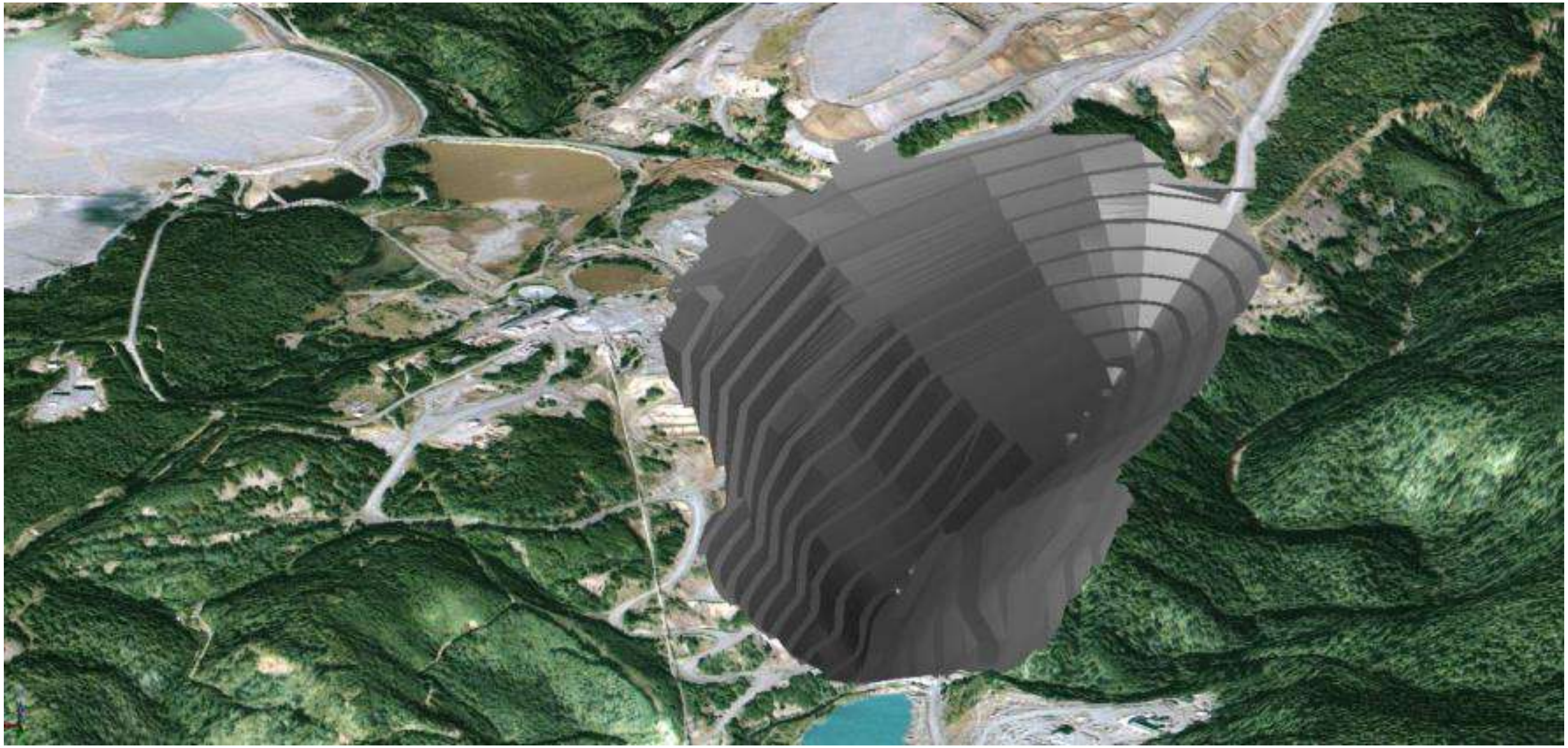


Figure 10: Proposed Centre Pit looking south

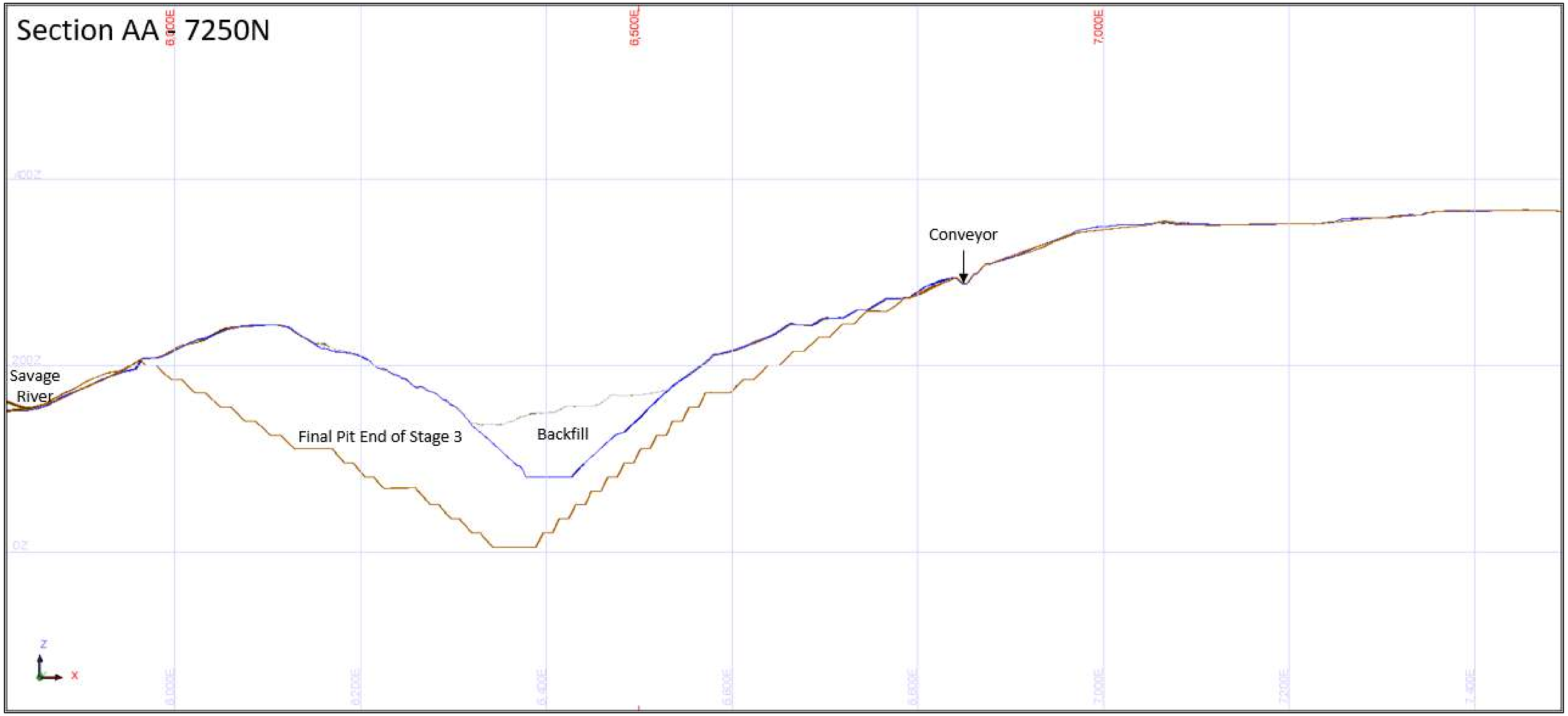


Figure 11: Centre Pit section AA

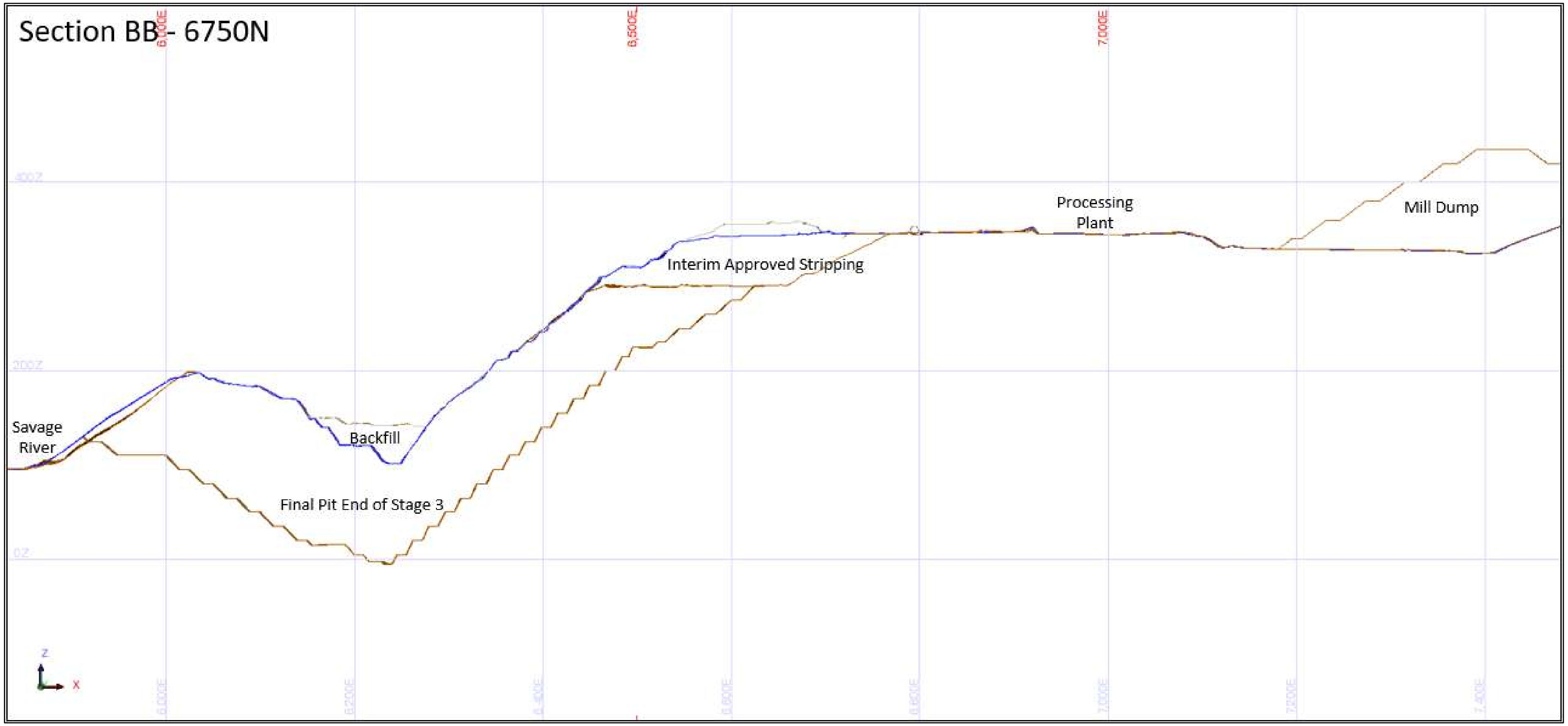


Figure 12: Centre Pit Section BB

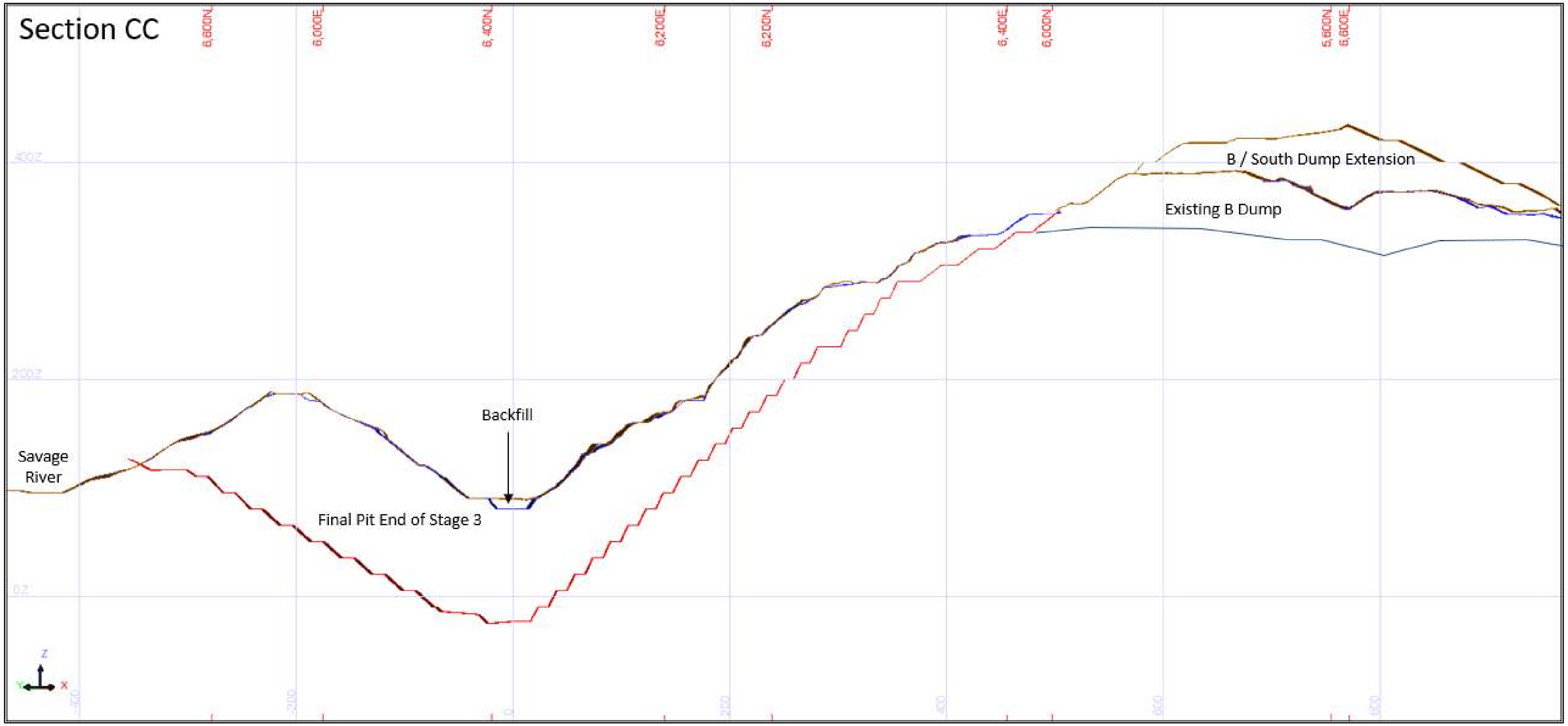


Figure 13: Centre Pit Section CC

2.2 Staged mine plan

The proposed Centre Pit expansion will excavate approximately 31Mt of ore and 255Mt of waste. The pit will be mined in a series of stages and cutbacks as indicated in Figure 14 and on the shell graphics in the following sections. The stage volumes are presented in Table 1. Details of waste management are provided in Section 6.7.

Table 1: Preliminary schedule pit stages

Stage	Timing	Ore (Mt)	Waste (Mt)	Total
Stage 1	2020-2024	8	70	78
Stage 2	2022-2027	11	85	96
Stage 3	2027-2030	12	100	112
Total	2020-2030	31	255	286

Stage 2 and 3 have been designed so that they can be mined independently and in either order. Currently Grange plans to mine these in sequential order but may elect to reverse the order or alternatively mine them concurrently depending on strategic priorities and requirements.

The pit designs presented are final feasibility and permitting designs. Final feasibility designs satisfy the following conditions:

- Ore can be mined for a cash benefit based on Granges current and future cost and revenue assumptions
- Geotechnical risk is at a level deemed suitable by the company. Acceptable geotechnical risk is variable across the pit and it is based the likelihood and consequence of the failure
- Have an accuracy of +/-15%
- Are included in Granges Life of Mine Plan; and
- Contain JORC Resources and Reserves.

Grange has a policy and procedure to continually improve and optimise its plans. Continual improvement in the mine plan is driven by:

- Improved geotechnical knowledge from new drilling, mapping and mining experience
- Improved ore body knowledge
- Updated cost and revenue forecasts
- Improvements to equipment efficiencies; and
- Improvements to occupational health, safety and environmental knowledge as we identify new risks and develop improved controls.

Continual improvement and optimisation of the plan will not result in any additional environmental impacts not discussed or disclosed within this EIS. Specifically, the continued optimisation is unlikely to:

- Increase clearing of vegetation or pit footprint
- Mine additional undisturbed areas
- Increase the risk of acid and metalliferous drainage; or
- Change the construction method for waste dumps.

The mining of Centre Pit may present opportunity for continual environmental improvement during mining and at its completion including:

- Reducing legacy issues associated with historical mining and dumps
- Potentially providing an alternative location for the storage of PAF waste within the pit; and
- Providing additional water storage and residence time for the management of water prior to discharge to the environment.

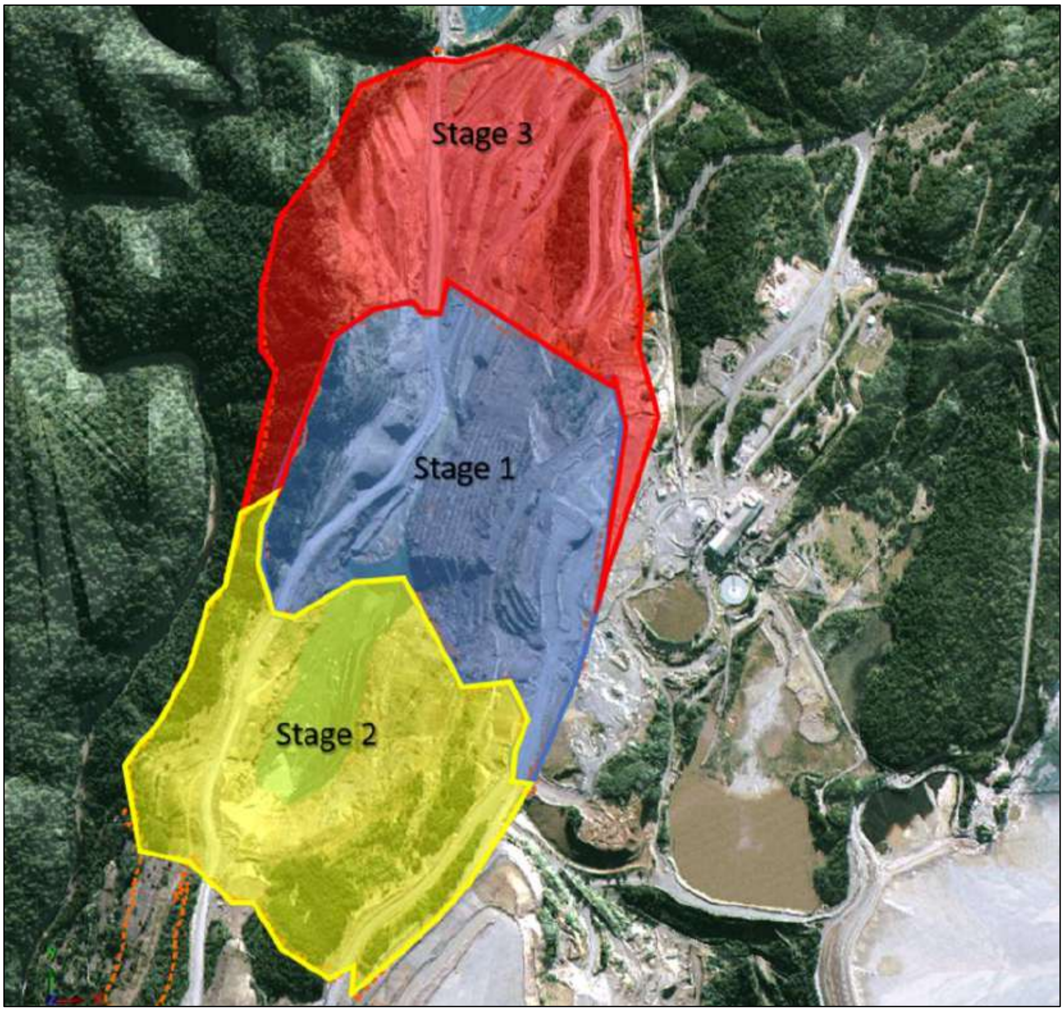


Figure 14: Mine stage plan

2.2.1 Material Flow and Decision Tree

The material flow and decision tree is shown in Figure 15. During the progression of Stage 1 a decision will be made on whether to progress to Stage 2 in the south or Stage 3 in the north. The current planned schedule is to move to the south first. The Stage 2 is currently preferred as it has more ore and lower strip ratio. Stage 3 offers some advantages in requiring less waste to be moved prior to reaching ore and the ore in the north is generally higher grade. The order of progression will have no effect on the environmental impact of the proposal as the final disturbance footprint will be the same.

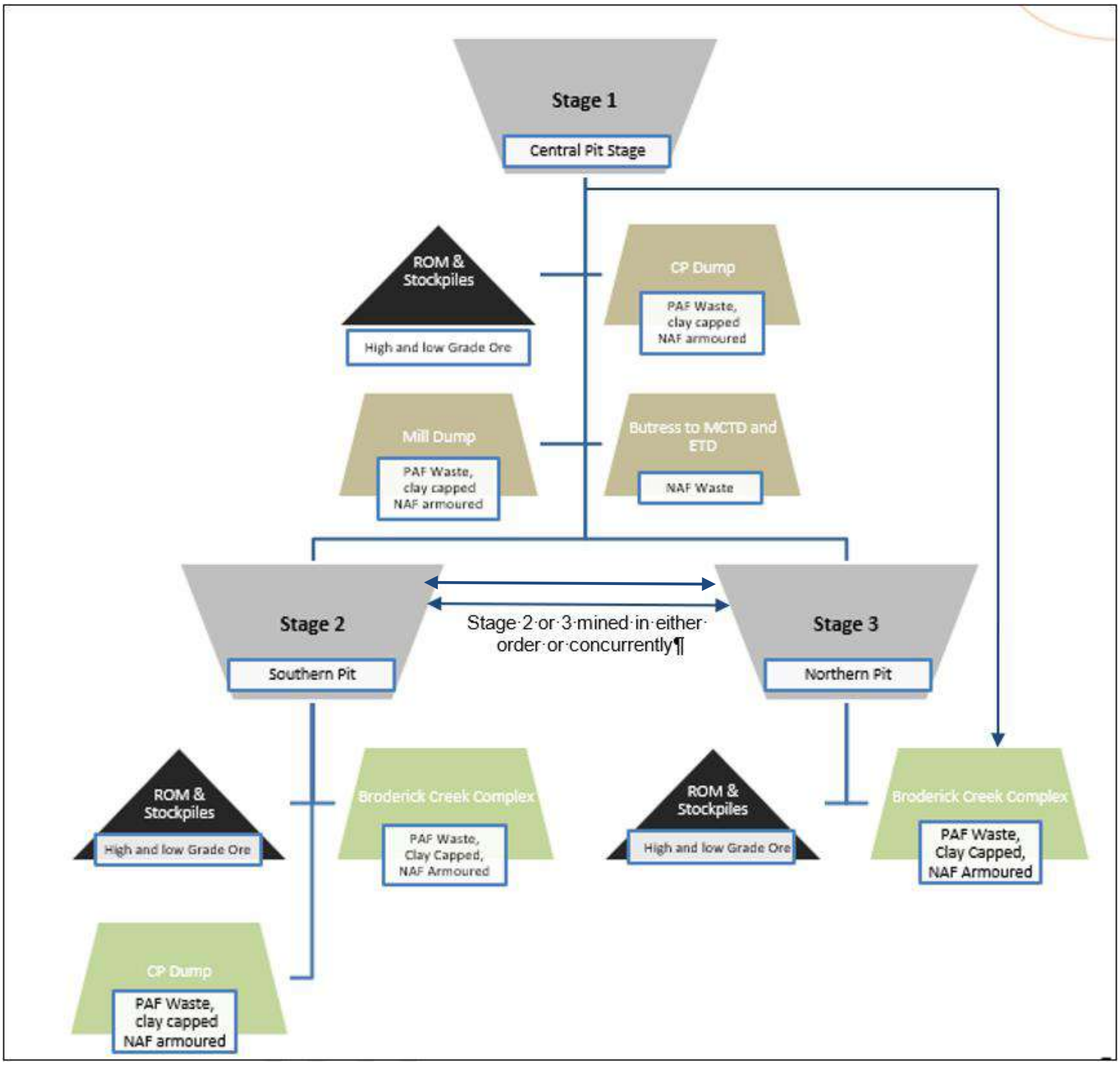


Figure 15: Material flow and decision tree

2.2.2 Stage 1

Stage 1 was designed to meet the short-term needs of supplying ore and concentrate in 2021. A plan view and isometric view of Stage 1 is shown in Figure 16 and a view of Stage 1 looking South East is provided in Figure 17. The material quantities expected to be obtained during Stage 1 are shown in Table 2.

The presented design is the final feasibility design. The initial stripping of the Stage 1 Pit design was given interim approval by the EPA in October 2019 and extended in May 2020. The interim approval is for stripping of the east wall of the Stage 1 Pit down to the 245mRL. The area covered by the interim approval is shown in Figure 17.

Stage 1 ore will be hauled to the ROM or stockpiles at GC1 for processing. Waste from CP Stage 1 will be disposed of in the Centre Pit and Mill dump and the Buttressing of the Main Creek Tailings Dam (MCTD) and Emergency Tailings Dam (ETD) walls. Any excess waste rock that cannot be handled operationally by these dumps will be disposed of in the Broderick Creek Dump Complex (BCDC). A site plan showing the completed Stage 1 pit and the completed dumps is shown in Figure 18. The Mill dump and the Centre Pit Rock Dump will be built from a combination of non-acid forming (NAF) and potentially acid forming (PAF) wastes.

Waste will be classified in accordance with the Savage River Site Waste Rock Management Plan (WRMP) and the dumps will also be built in accordance with the WRMP and other relevant operational procedures. The WRMP is discussed in Section 6.7.6 and a copy presented in Appendix B. Clay for the capping of D Type waste will be sourced from within Centre Pit and from the clay borrow pit in South Deposit (approved under existing EPN 248/2).

Figure 16: Plan view and isometric view of Stage 1

Figure 17: Stripping area covered by interim approval

Table 2: Stage 1 likely material quantities

Material Type	**Million BCM**	**Million Tonnes**
Ore	2	8
Waste A Type	8	22
Waste B Type	5	14
Waste C Type	1	2
Waste D Type	11	31
Total	27	78

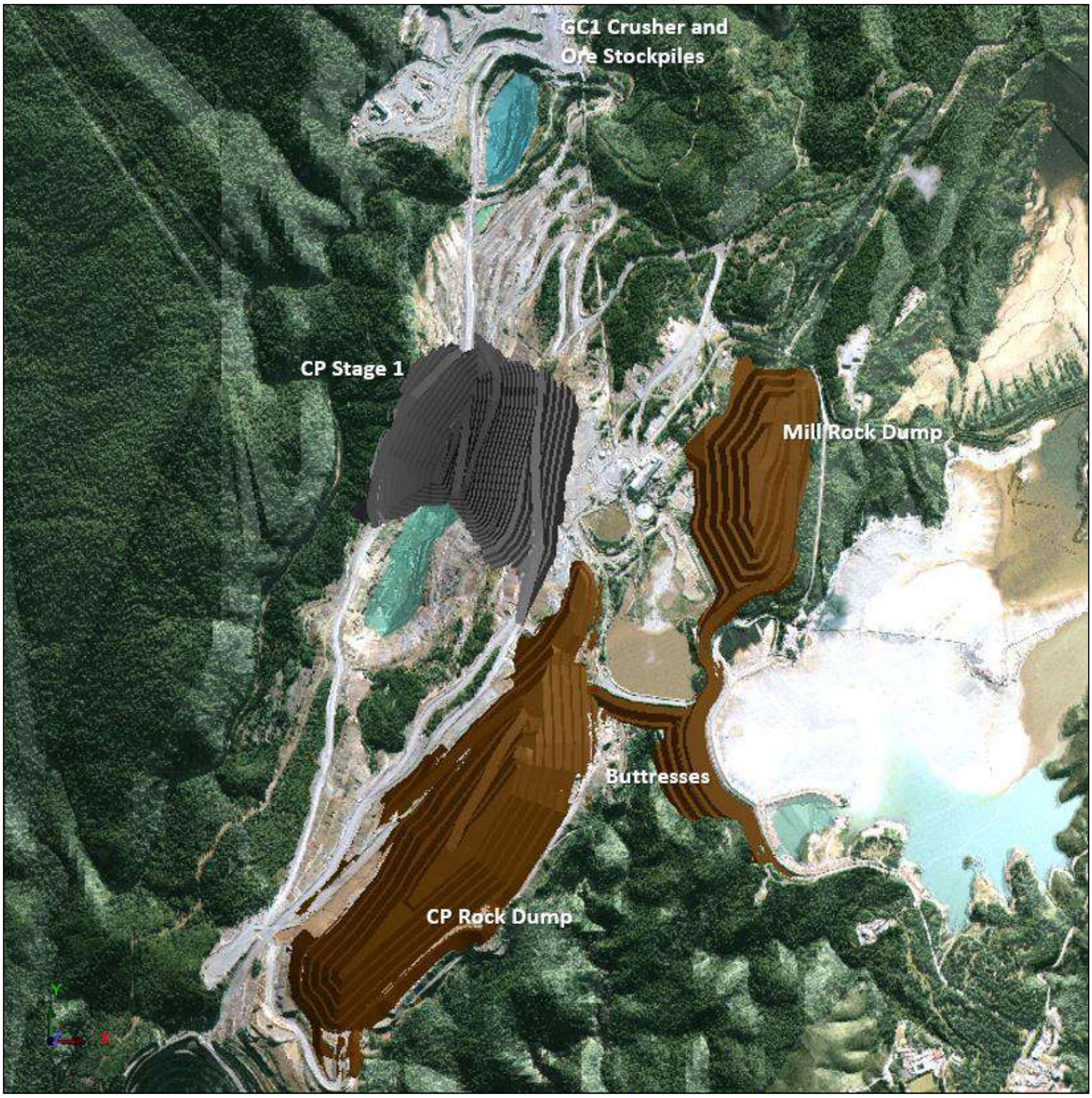


Figure 18: Stage 1 completion showing completed rock dumps and buttressing

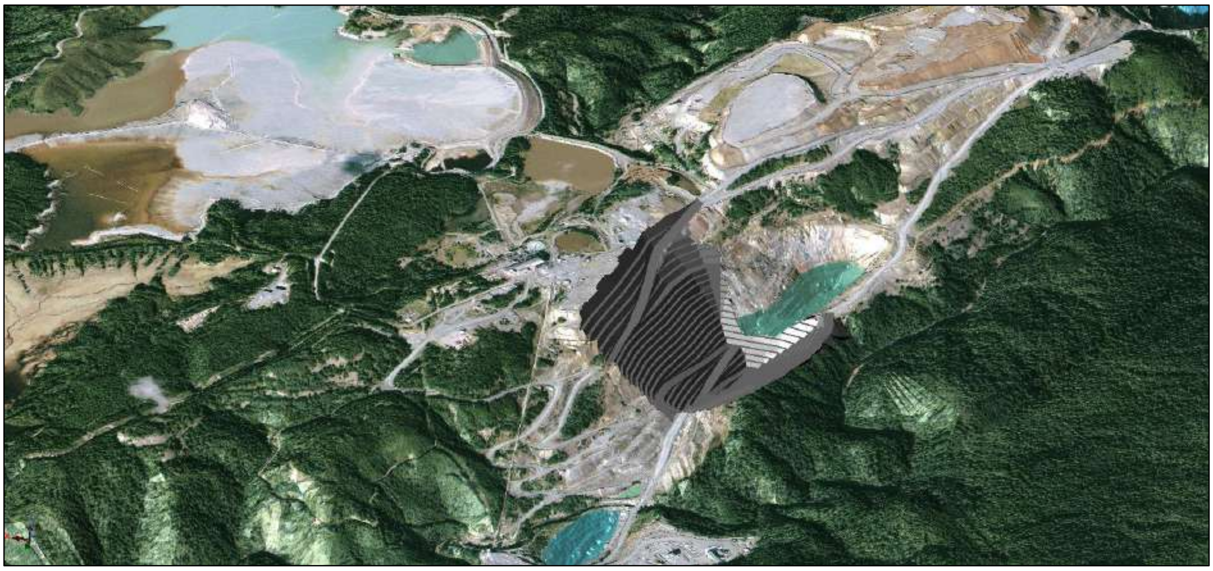


Figure 19: Stage 1 looking south east

2.2.3 Stage 2

Stage 2 is an extension to the south as demonstrated in Figure 20 (plan view) and Figure 21 (looking south east). The material quantities expected to be obtained during Stage 2 are shown in Table 3. Waste Rock from Stage 2 will be taken to the Centre Pit and East Mill Dump for higher mining stages and the Broderick Creek Dump Complex on the north side of Savage River for lower stages. A site plan showing the completed Stage 2 pit and the completed dumps is shown in Figure 22.

The design presented does not require any cut back or removal of pre-existing waste from B Dump. Early draft pit designs were assessed by Mining One consultants (M1) who issued a draft report on the draft designs to guide improvement and for implementation into the final designs. The M1 report did identify in the draft pit design a weak toe section below B Dump where the slope was too steep. The weak foundation toe resulted in failure further up the slope and into the old B Dump. The final feasibility pit design included in this EIS has since been updated to use a shallower pit slope in this toe section and stabilise the wall. The wall in the toe area has been reduced from and inter-ramp slope angle of 42° to an inter-ramp slope angle of 30°. The 30 degree slope is the same angle as used in adjacent stable areas. Outside of the weak zones the pit the east wall of the pit is stable at a 42° inter-ramp slope.

The optimisation of Centre Pit demonstrates that under the current economic basis a cutback of B Dump does not create value. Therefore, there is no planned cut back of B dump. The existing dump faces, and berms will be cleaned and brought up to the current waste dump design standard for safe operation and geotechnical stability. Any cut into the existing dump faces will also be brought up to the current waste dump management standard for cover and armouring.

Table 3: Stage 2 likely material quantities

Material Type	Million BCM	Million Tonnes
Ore	3	11
Waste A Type	12	32
Waste B Type	7	19
Waste C Type	1	3
Waste D Type	11	31
Total	34	96

Figure 20: Stage 2 plan view

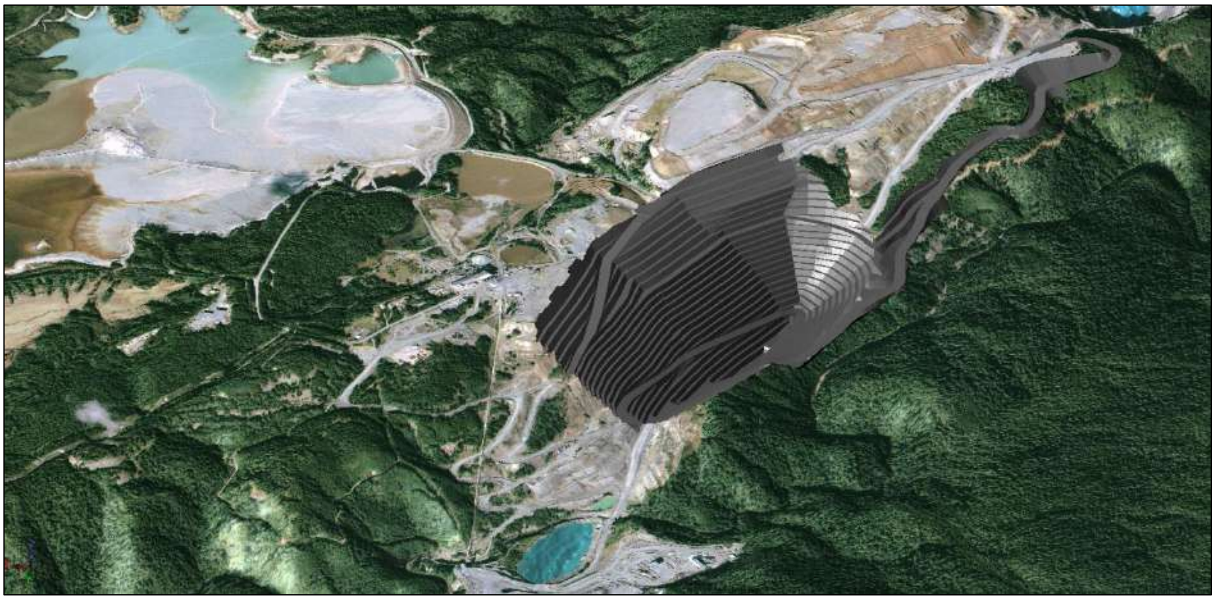


Figure 21: Stage 2 looking south east

Figure 22: End of Stage 2 and completed dumps

2.2.4 Stage 3

Stage 3 is the north end of the pit and is shown in plan view in Figure 23 and viewed across the pit to the south east in Figure 24. Stage 3 is independent of Stage 2 and can be completed before Stage 2 if required. Stage 3 contains waste that was backfilled into the pit when Centre Pit was last mined and completed. The backfilled waste will be treated as D Type Waste. Stage 3 mines adjacent to the Savage River. The northern extent will not mine any closer to the Savage River and South lens than the previous pit. Geotechnical work (Section 2.5) has shown that the northern wall is stable. The pit design does not mine into the Savage River. A levee will be constructed so that during flood conditions up to a 0.1% annual exceedance probability (AEP) event, water will be prevented from entering the pit.

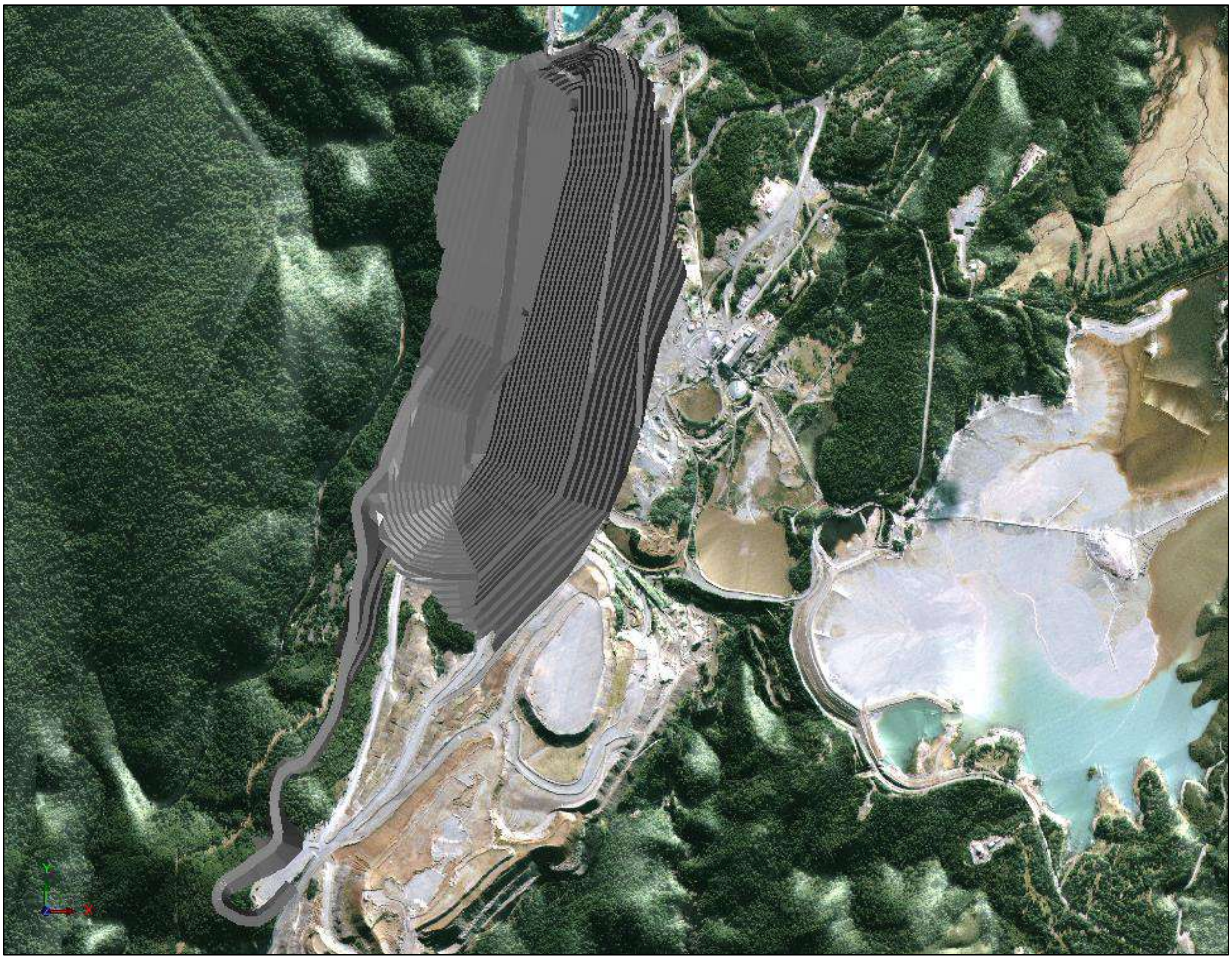


Figure 23: Stage 3 in plan view

The material quantities expected to be obtained during Stage 3 are shown in Table 4.

Table 4: Stage 3 likely material quantities

Material Type	Million BCM	Million Tonnes
Ore	3	12
Waste A Type	8	23
Waste B Type	4	31
Waste C Type	0.4	1
Waste D Type	9	25
Backfill	8	19
Total	32	112

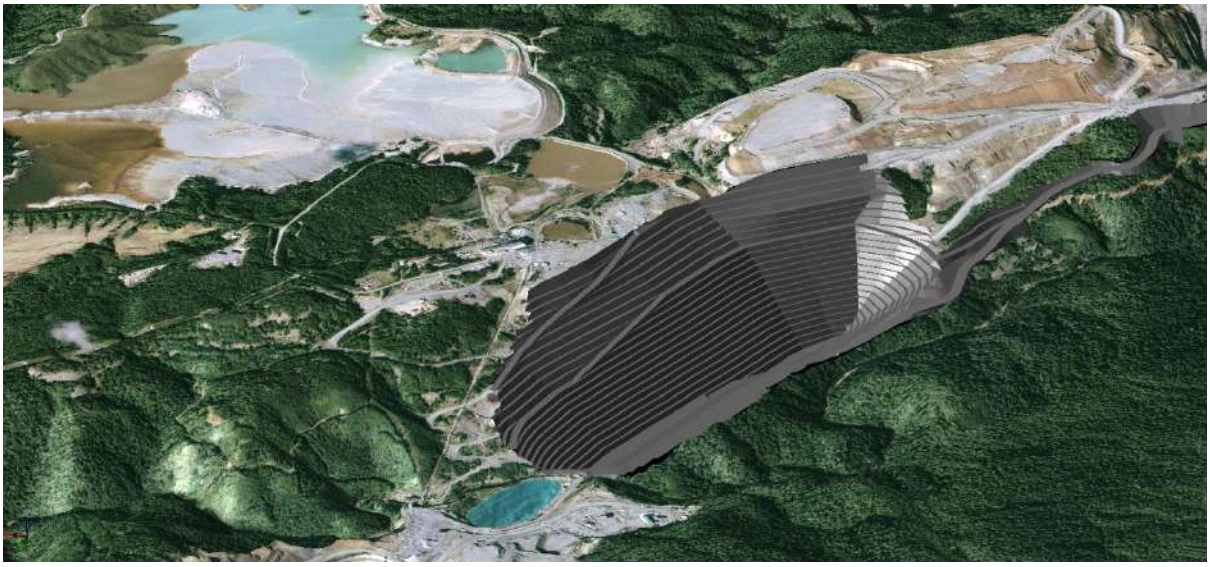


Figure 24: Stage 3 looking south east

Figure 25: Completed CP Stage 3 and dumps

2.2.5 Flood Levee

To reduce the risk posed by a flooding event of the Savage River a levee is planned along the north wall of the Pit (the southern bank of the savage river). The proposed levee is 200 m in length, with a 2 m wide crest and surface RL of 113 m it would mitigate the risk of a flood up the 0.1% AEP flood event and is dealt with in more detail in section 5.2.11.

2.2.6 Centre Pit Mining Schedule

The current mining schedule for Centre Pit is shown in Table 5. The current schedule mines the three Centre Pit stages over 13 years. The current schedule mines the stages in sequential order, but this schedule is revised on an ongoing annual basis to meet the strategic aims of Grange and the prevailing economic conditions.

Table 5: Centre Pit mining schedule

LOMP CP Mining Stages		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	TOTALS
CP STAGE 01															
Total Tonnes	MT	13	29	19	12	6									**78**
Ore Tonnes	MT	0	1	4	2	2									**8**
Waste Tonnes	MT	13	28	15	10	4									**70**
Ore Grade	DTR%	17%	23%	41%	44%	48%									**42%**
WASTE MINING															
WA PRIME	MT	6	9	6	1	0									**22**
WB PRIME	MT	4	8	1	1	0									**14**
WC PRIME	MT	1	1	0	0	0									**2**
WD PRIME	MT	2	10	8	7	4									**31**
Backfill	MT	0	0	0	0	0									**0**
CP_STAGE 02A															
Total Tonnes	MT					19	29	26	16	6					**96**
Ore Tonnes	MT					0	1	4	4	2					**11**
Waste Tonnes	MT					19	28	22	12	4					**85**
Ore Grade	DTR%					41%	37%	43%	46%	45%					**44%**
WASTE MINING															
WA PRIME	MT					1	14	14	3	0					**32**
WB PRIME	MT					11	7	1	1	0					**19**
WC PRIME	MT					2	1	0	0	0					**3**
WD PRIME	MT					4	7	7	9	3					**31**
Backfill	MT					0	0	0	0	0					**0**
CP_STAGE 03A															
Total Tonnes	MT									15	25	26	27	18	**112**
Ore Tonnes	MT									0	0	0	4	8	**12**
Waste Tonnes	MT									15	25	26	23	11	**100**
Backfill	DTR%									0%	44%	30%	42%	45%	**44%**
WASTE MINING															
WA PRIME	MT									1	2	8	9	3	**23**
WB PRIME	MT									0	17	9	5	0	**31**
WC PRIME	MT									1	0	0	0	0	**1**
WD PRIME	MT									0	2	7	9	8	**25**
Backfill	MT									13	3	3	0	0	**19**
CP_STAGE Total															
Total Tonnes	MT	13	29	19	12	24	29	26	16	21	25	26	27	18	**286**
Ore Tonnes	MT	0	1	4	2	2	1	4	4	2	0	0	4	8	**31**
Waste Tonnes	MT	13	28	15	10	23	28	22	12	19	25	26	23	11	**255**
Ore Grade	DTR%	17%	23%	41%	44%	48%	37%	43%	46%	45%	44%	30%	42%	45%	**43%**
WASTE MINING															
WA PRIME	MT	6	9	6	1	2	14	14	3	1	2	8	9	3	**77**
WB PRIME	MT	4	8	1	1	11	7	1	1	0	17	9	5	0	**64**
WC PRIME	MT	1	1	0	0	2	1	0	0	1	0	0	0	0	**6**
WD PRIME	MT	2	10	8	7	8	7	7	9	3	2	7	9	8	**88**
Backfill	MT	0	0	0	0	0	0	0	0	13	3	3	0	0	**19**

2.2.7 Future Pit expansion.

There remains further mineral resources within Centre Pit. These resources could be economic and mineable at a future date. There is substantial ore in north end of the pit that would require the relocation of the main conveyor. Relocating this infrastructure would be considered in the future. The resource is partially open at the southern end and further expansion to the south may also be possible if additional resources were found during exploration.

2.3 Description of proposed mining methods.

The current operational infrastructure will be used to process the ore from the proposed Centre Pit expansion, as follows:

- North Pit and South Deposit extraction areas
- Primary crusher, concentrator and slurry pipeline
- Run of mine (ROM) and stockpile areas
- The Main Creek tailings dam (MCTD)
- The South Deposit tailings storage facility (SDTSF)
- The South Lens water treatment system; and
- Waste rock dumps including Centre Pit Dump, Mill Dump (rock also to be placed for buttressing of the Emergency Tails Dam (ETD) wall and the MCTD wall) and The Broderick Creek Dump Complex.

Other than the Mill Dump and Dam Wall buttressing there are no other changes due to the proposed expansion of Centre Pit.

2.3.1 Major items of equipment

No new plant is required. Current equipment is summarised in Table 6 and identified on the site plan at Figure 6.

Table 6: Equipment and plant

Equipment	Description
Truck and Shovel/Excavator	Mining will be carried out as a Load and Haul operation in accordance with the current mining practices and operational procedures employed in North Pit
Primary Crusher	Currently there are two primary crushers available on site: an Allis Chalmers 54/74 gyratory primary crusher, and an Allis Chalmers 54/62 gyratory crusher.
Concentrator	Two Metso 10.6 m x 3.61 m autogenous grinding mills and two Nordberg 8.84 metre x 3.96 metre ball mills are present on site. Magnetic separators then separate the magnetite from the gangue (valueless material surrounding the mineral).
Slurry Pipeline	The concentrate slurry from the concentrator is pumped 83km through a 229-millimetre internal diameter slurry pipeline to the pellet plant at Port Latta - transportation time is approximately 14 hours.

2.3.2 Dewatering

The current CPS will be dewatered to allow mining to progress below the current water level. Currently it contains approximately 2.7 GL of water to an estimated depth of 70 m. It will be pumped to the South Lens centralised water treatment system, via the CPN Pond and discharged to the Savage River within the parameters of the Goldamere Agreement and any permit conditions in place at that time. Details of proposed dewatering are provided in Section 6.2 and in the Centre Pit Dewatering Assessment and Centre Pit pumping WQ update v1_1 at Appendix C.

Dewatering will commence once final EPA approval of the Centre Pit Project is received or as otherwise agreed between the EPA and Grange. Total inflow to Centre Pit has been determined from the steady state CPN outflow to be approximately 100 L/sec average. Calculations for the dewatering of CPS and the possible need to dewater CPN are shown below. CPN water is contained within void space and may not require dewatering as such. CPN may also dewater naturally to CPS but the CPS pit water level would still need to be controlled / maintained to allow mining. Predicted pump rates are given below as a guide to dewatering time but will be subject to calculated allowed rates.

Table 7: Dewatering timeframes

Centre Pit South contains 2.7 GL water	
Estimated Pump Rate L/sec	Days to dewater
500	78
400	104
300	156
200	312
Centre Pit North is predicted to contain 0.58 GL of water within the void space of the dump	
300	33
200	67

Figure 26: Centre Pit (former CPS) showing water that will be pumped to South Lens

2.3.3 Crushing

Ore mined from the Centre Pit will be transported to High-Grade or Low-Grade Stockpiles within the existing ROMs. These are located between South Lens and the North Pit. Ore from these stockpiles will be fed into the crushers (at the same site) using a front-end loader and truck operation. Ore from North Pit is currently tipped into an Allis Chalmers 54/74 gyratory primary crusher. Ore from the South Deposit was crushed in an Allis Chalmers 54/62 gyratory crusher located at the Top ROM. When the iron ore has been crushed to a maximum size of 200 millimetres, it is transported to the 100,000-tonne capacity crushed ore stockpile at the concentrator via overland conveyor. Water runoff from the ROM is captured and drained to the South Lens prior to discharge.

The current location of the Bottom ROM and crusher, showing the proximity to South Lens and the proposed northern extent of the Centre Pit are shown in Figure 27.

Figure 27: Process facilities

2.3.4 Concentrator

Crushed ore from the crude ore stockpile is reclaimed via a tunnel system and fed into the concentrator. It is initially ground by two Metso 10.6 m x 3.61 m autogenous grinding mills, then by two Nordberg 8.84 m x 3.96 m ball mills. Magnetic separators then separate the magnetite from the gangue, which is then pumped to the tailings dam.

The concentrate slurry from the concentrator is pumped through a 229 mm internal diameter slurry pipeline to the pellet plant at Port Latta. This takes approximately 14 hours to move the material 83 km.

2.3.5 Waste rock

Waste rock from production activities can be split into four geochemical groups. These are discussed in more detail in Section 6.7 and include:

- A Type – non-acid forming (NAF) material which may be suitable for use in construction of flow through or for erosion protection and buttress construction
- B Type – neutral material presenting as friable, weak rock units
- C Type – NAF material, essentially clay; and
- D Type – Potentially acid forming (PAF) material.

The nature of the rock types is identified during geological exploration and drilling programs and during grade control inspections and determines the end use of the material. It also allows for identification of any specific management actions related to the potential for acid generation and the availability for NAF for use on site.

2.3.6 Tailings

Tailings produced from the processing of ore from Centre Pit will be deposited into either the MCTD or the SDTSF, depending on operational requirements at the time of processing. There is adequate capacity in the tailings storage facilities to contain tailings from Centre Pit ore processing. This is discussed in more detail in Section 6.7.

2.3.7 Surface Water Management

Surface water will be managed within the current site wide water management plan. Surface water from the Centre Pit area will be diverted via cut off drains and sumps to the centralised treatment in South Lens or allowed to drain into Centre Pit and pumped to South Lens. All surface waters from disturbed areas will be collected to one of the three centralised locations namely South Lens, South Deposit or the SDTSF.

The emergency tailings dam spillway currently flows into Centre Pit and will need to be redirected to reduce inflow and pumping requirements. This will also manage any impacts on stability of the eastern wall and allow material from the east wall to be placed in the area currently occupied by the spillway.

2.3.8 Groundwater management

Dewatering holes 110 m long will be drilled into the face of the benches to drain groundwater from the pit slopes. This water will be channelled or piped to South Lens or allowed to enter the Centre Pit where it will be treated as part of the dewatering strategy.

2.3.9 Hours of operation

The operations at Savage River and Port Latta operate continuously 24 hours per day, seven days per week. The Tasmanian Operations currently employ approximately 600 FTE personnel and some 90 contractors.

2.3.10 Vehicle movements volume, composition, origin, destination and route (road, rail, shipping and air)

The mine is accessed by a sealed road that branches off the main north-south Link Road from Burnie to Rosebery. Truck movements are limited to internal activity with all material being transported to Port Latta by pipeline. Employee vehicles numbers will not increase as the proposed expansion will facilitate continued production at existing rates.

2.3.11 Raw materials, quantities and characteristics

No raw materials are required for the proposed activity other than the material to be extracted from the pit.

2.3.12 Energy requirements

Increase in energy consumption may occur as a consequence of the proposed expansion if mining fleet increases due to higher strip ratios. The new resource will allow current operations to continue. Energy requirements at present include fuel for extraction vehicles, trucks and processing systems.

2.3.13 Construction

No construction of permanent buildings is required. The current road which passes along the western extent of the pit will be relocated further west. This will occur as production proceeds and as warranted by the reduced proximity to the pit extent. The western Savage River Crossing is currently single lane and will be widened to 40 m to allow 2 lanes of heavy vehicle haulage. The widening will be constructed in a similar manner to the existing crossing and will have no new environmental impact and will not impact the flood level or the natural flow of the Savage River. Water runoff from the crossing will report to the South Lens. The Road past South Lens, the ROM and the Broderick Creek dump complex will also be widened from 22 m to 40 m.

The widening of both the river crossing and the road are required to improve traffic management with safe and efficient haulage. The widening of this road is planned to occur in 2021.

The mine haul roads will be built to Grange Resources current mine standard. The standard is based on current best practice as applied to the operating environment at Savage River. A typical cross-section of the road is shown in Figure 28. Water runoff from roads is directed to drain down the side of the road and into catchment basins and then typically directed to one of the mine pits from where it is pumped or drained to South Lens to settle prior to discharge to the Savage River. Due to the location of the Centre Pit main haul road drainage will be required to take water east into Centre Pit and prevent westerly discharge to the Savage River. Site wide water management is shown in Section 6.2 Water quality (Surface and Discharge).

Roads are typically constructed in all cut to provide a better sub grade. The sub-grade is initially compacted with track and tyred equipment. The next layer, the sub-base, is typical constructed from competent non-acid forming back fill and when built in all cut on hard ground is 200-500mm thick. The final two layers the base and running course are typically built using crushed basalt or hard competent A Type rock between 20-75mm in size. The base and running course are typically each 150-250mm thick. The rocks used in the base course and running course often have higher carbonate levels. Water runoff from the main haul roads generally shows higher alkalinity levels thought to be generated from the grinding and release of these carbonates by vehicle tyres.

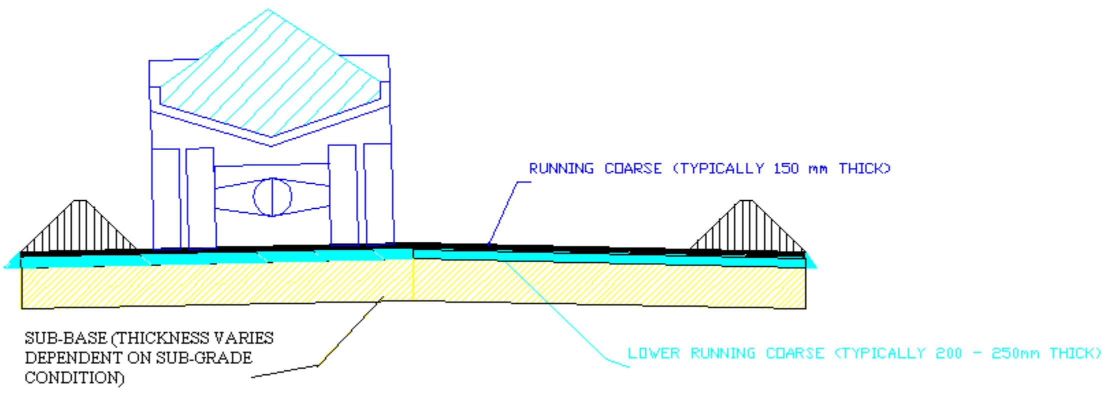


Figure 28: Typical haul road cross-section

2.3.14 Commissioning

The EPA granted interim approval to undertake stripping of the east wall of Centre Pit. Upon approval, works would continue to extract material from the pit in accordance with the staging plan. As this is an existing operation, no formal commissioning process will occur.

2.3.15 Off-site infrastructure

No new off-site infrastructure is required.

2.4 Decommissioning

The entire mine site, including the proposed expanded Centre Pit, will be rehabilitated in accordance with the existing plans - the Closure Report - Decommissioning and Environmental Rehabilitation Plan Savage River and Port Latta.

There are a range of closure options for the final Centre Pit. These options include:

- Allowing the pit to flood
- Continue mining by underground means (subject to approval); or
- Backfilling the pit with waste rock or backfilling the pit with tailings.

The final preferred closure option for the void will be determined by the strategic position of Grange Resource and the EPA nearer to the time of closure.

2.4.1 Description of any alterations to mine infrastructure

The road passing to the west of the proposed Centre Pit will be relocated further west into an area previously disturbed by mining. Existing waste rock dumps and new waste rock dumps and the TSF’s will be expanded to accommodate the additional waste generated by the processing of material from Centre Pit subject to any required approvals. This is discussed in detail in Section 6.7.

2.5 Geotechnical feasibility

Historically, and more considerably over the past 2 years, extensive geotechnical work has been conducted on the CP LOM designs. This has included diamond drilling in 2018 and 2019, ground water monitoring equipment installations and monitoring (VWPs and standpipes), subsequent hydrogeological modelling, 2D limit equilibrium and 2D and 3D numerical stability modelling work. This level of work is considered by Grange Resources to meet industry best practice for geotechnical investigations and analysis.

The following outlines the specifics of the work that has been completed as part of and as a result of the Definitive Feasibility Study (DFS) study:

1. M1 analysis and recommendations were based on an early DFS pit design (cp4_dfs_v8_eom_20180217).
2. As a result of the recommendations contained in the M1 report that was based on the early DFS pit design (cp4_dfs_v8_eom_20180217), multiple design iterations have been made to address the early issues identified.
3. Following on from these design revisions, in Jan 2020 a revised design set was analysed in a full 3D numerical stability model as per the M1 recommendations. This modelling showed that:
    a. CP Stage 1 (CP3_ST01A_VER13): The modelled Stage 1 design that was current at the time (CP3_ST01A_VER13) was stable with the exception of a small section where it intercepted the existing topography in the north. To address this potential instability, the design was amended (northern bullnose removed and RL 320 m batter mined off locally above the area of instability to unload the slope). Robotic Total Stations have already been purchased to monitor movement/stability of survey prisms on the east and west walls of CP Stage 1.
    b. CP Stage 2 (CP3_ST02_V6): An area of potential instability existed in south east corner of the Stage 2 pit. This failure mechanism is controlled by the currently modelled weathering surface. Work will be done to improve this modelled weathered surface, in the interim a pit design is currently being developed that accommodates the current weathering profile and reduces the inter-ramp slope angle within this unit to increase slope stability.

       Work on this design is ongoing with mining not scheduled to occur in the area until Q2 2022 (subject to regulatory approval). Mining will be conducted in accordance with the existing ground control management plan (updated regularly and as required). This will include slope stability monitoring and regular pit inspections by on-site geotechnical engineers.
    c. CP Stage 3 (CP3_ST03_V10): Stage 3 extends the Stage 1 east wall cutback north under the BC-1 conveyor. The Jan 2020 3D modelling has flagged an approximately 5 batter high (~75m high) area of instability within the IFZ weathered material in this eastern slope. Again, this is an area that will be targeted as part of a structural geology update and remodelling with a revised pit design to follow. A pit redesign is required here in the short term regardless to address the stability of the designs in the current plan but due to the timing of Stage 3 mining (Q4 2028) this work is still ongoing.

       Stability of the Savage River “pillar” has been assessed in a 3D numerical model and shown to be stable. This result is in line with previous experience mining the coincident north wall of Centre Pit prior to back filling the pit.

Although some minor areas of potential instability have been identified in the Stage 2 and 3 designs, they will not be mined for 2 years and 8 years respectively. As such, plans have been put in place to modify the designs to improve stability, improve and refine the Orebody Knowledge around these identified areas and refine the geotechnical analysis to feed into the LOM design sets prior to mining these stages. This work will include:

1. Mapping the weathering boundary in currently exposed faces
2. Mapping the weathering boundaries in any faces exposed as part of the Stage 1A early works mining currently occurring
3. Employ a structural geologist to update and refine the structural geology model for CP based on current information and develop a plan to map and refine the model as mining progresses and based on any drilling work that may be required (Senior Structural Geologist started work 16th March 2020)
4. Redesign the LOM pits based on geotechnical recommendations
5. Complete ongoing redesigns, optimisations and geotechnical analysis based on ongoing geotechnical reconciliation. Specifically, we will redesign the Stage 2 pit wall under B-dump and complete renewed stability analysis to ensure the design/pit wall is stable prior to starting mining of Stage 2; and
6. Mining will be conducted in accordance with the existing ground control management plan (updated regularly and as required). This will include slope stability monitoring and regular pit inspections by on-site geotechnical engineers.

It is not Grange Resources' intention to build a pit slope that will jeopardise the stability of the BC1 conveyor (mine critical infrastructure) or any existing dumps (potential high economic and moderate safety impact). Should the mine design require a cutback to the B dump or Southern Dump capping will be replaced in line with the original SRRP capping project.

2.6 Current approvals or regulatory conditions (If the proposal is associated with an existing activity)

Current environmental permits and mining leases are listed in Table 8.

Table 8: Environmental permits and mining leases

Detail	Application	Year	Activities covered
EPN 248/2	Savage River Mine	2001	Applies to operations at Savage River
EPN 8994/1	Main Creek Tailings Dam (MCTD)	2013	Applies to the 336RL and 338RL raises of the Main Creek Tailings Dam and maintenance of the dam to ANCOLD
EPN 8748/4	South Deposit	2014	Applies to the dewatering and mining of South Deposit
PCE 8808	SDTSF	2013	Applies to the construction and operation of the SDTSF
EPN 10006/2	North Pit Exploration Decline	2020	Permit to extend the previously approved exploration decline from 1.3 km to 3 km from the portal located at the southern extend of North Pit.
ML 2M/2001	Savage River Mine	2001	Main Mine Lease
ML 14M/2007	Savage River Mine	2007	Supplementary Mine Lease
ML 11M/2008	Savage River Mine	2008	Supplementary Mine Lease
ML 4M/2019	Savage River Mine	2019	Supplementary Mine Lease

3. Project Alternatives

3.1 Rationale for the project

The expansion of the Savage River Mine to include the area between the former CPN and CPS is the most logical and practical proposal to obtain identified resources on site. The development of this resource uses existing infrastructure and personnel while minimising impacts on natural values surrounding the site. Continued extraction at this mine advances the intent of the Goldamere Agreement and ensures continued support of the SRRP. This has benefits for environmental management and facilitates continued remediation of previous impacts.

3.2 Alternative sites

The proposal relates to reworking and expanding previously mined pits. No sites outside the mine boundary were considered. The intention is to consolidate the extraction from the site rather than expand into previously undisturbed areas. This involves the expansion of waste rock dumps and TSFs within the mine area. Back filling the South Deposit pit is not an option at this time as it still contains ore and may be remined to complete the SDTSF. South Lens is used for settlement of solids and neutralisation by combining with alkaline water sources prior to discharge to the Savage River.

3.3 Other available technologies

The proposed technology, while relatively simple, is the most effective means of extraction of the mineral and makes best use of the systems and infrastructure currently used on site. Continuation of the technologies used avoids downtime while new systems and infrastructure are established.

4. Public Consultation

No specific public consultation has been undertaken for the proposed activity. Grange Resources has had an extended involvement in the SRRP, and the proposed activity is consistent with the objectives and suggested actions of SRRP Strategic Plan. The EIS will undergo an extended public consultation process as part of the EPA assessment.

5. The Existing Environment

5.1 Planning aspects

No approval is required under the Waratah-Wynyard Interim Planning Scheme 2013 as the activity benefits from the existing use provisions under Section 12 of the LUPAA. The land is zoned part Rural Resource and part Environmental Management, as shown on Figure 29. Extractive industries are a Permitted Use in the Rural Resource zone and Discretionary within the Environment Management zone. The site is impacted by the Landslip hazard which would likely trigger discretions, however, the use of the land for mining is not Prohibited under any planning scheme scenario.

5.1.1 Property details

The site address is Mine Rd, Savage River. There is no certificate of title, but the parcel is identified as PID 6998852 and Parks and Wildlife Service listed as the relevant authority.

EPN 248/2 covers the “Leased Land” as defined in the Goldamere Pty Ltd (Agreement) Act. This act defined the leased land as mining lease 11M/1997 which was subsequently amalgamated into the current 2M/2001 lease to which the Act continues to apply. The site of the proposed expansion is entirely within ML 2M/2001.

5.1.2 Adjacent land

The Centre Pit expansion area is approximately 2.3 km from the privately-owned Savage River accommodation area. The closest town is Waratah, located 26.5 km to the east.

Most of the mine, including the Centre Pit expansion area, is located within the Savage River Regional Reserve. This is a regional reserve established under the *Nature Conservation Act 2002*. This is publicly managed land available for mining under the *Mineral Resources Development Act 1995*. This reserve is bordered to the west by the Donaldson River Nature Recreation Area and to the east by the Meredith Range Regional Reserve. The mine is bordered to the north and south by informal reserves identified as future potential production forest managed by the Department of Primary Industries, Parks, Water and Environment (DPIPWE). The Savage River National Park is located 10 km to the north east of the Centre Pit expansion site. The Savage River accommodation area and these reserves are identified on Figure 30.

The site is remote and apart from the accommodation area, there is little public access to the area or adjoining lands.

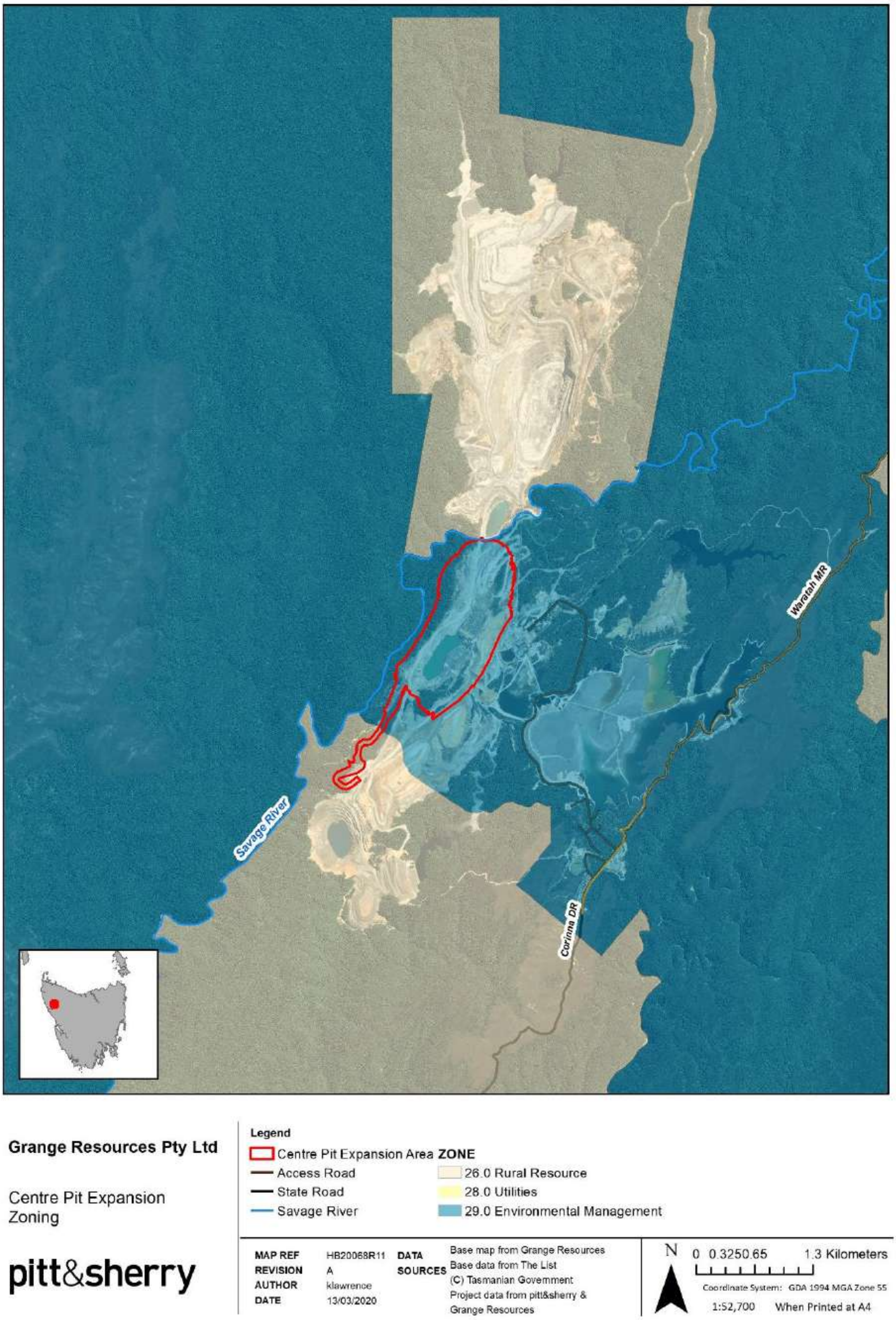


Figure 29: Zoning of the site and surrounding areas under Waratah-Wynyard Interim Planning Scheme 2013

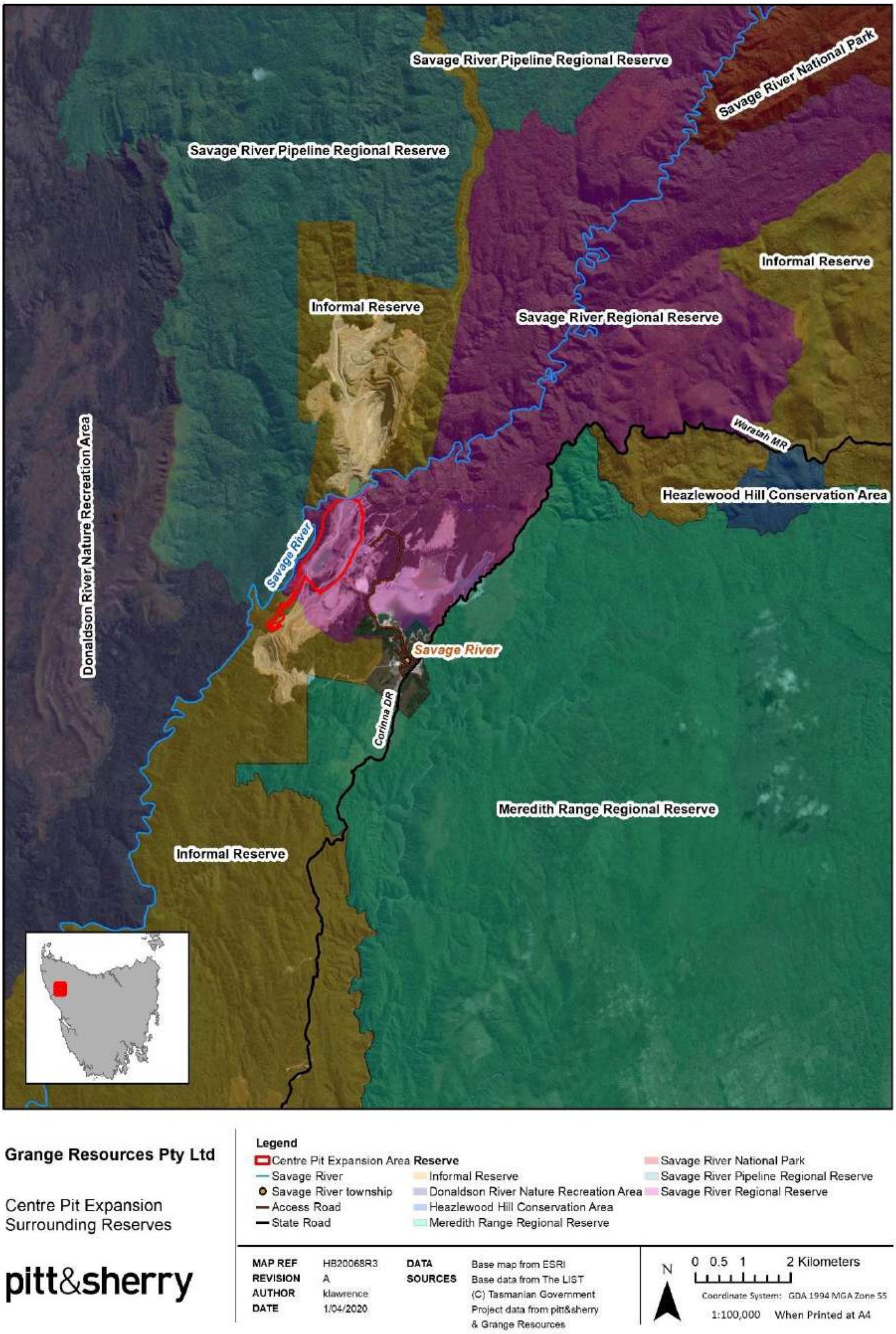


Figure 30: Adjacent land uses and residential areas (Savage River accommodation area)

5.2 Environmental aspects of site and surrounding area

5.2.1 Topography, geology, geomorphology, soils (including erodibility and acid sulphate soils)

Savage River mine is located within the Arthur Metamorphic Complex and exploits a series of magnetite-rich lenses which extend from north of the Savage River, to north of the Pieman River. Specifically, the resources are within the Bowry Formation which contains deposits of varying width and length throughout its extent. Geological data from the Listmap is presented in Figure 31.

The Arthur Metamorphic Complex is also known as the Arthur Lineament, which is a listed geoconservation site, as identified on Figure 32. It is a narrow, 100 km long, northeast-trending belt of sheared metamorphic rocks that was subject to multiple deformation in the Middle to Late Cambrian period[1]. It extends north east from the coast north of Granville Harbour, 100 km to near Wynyard. This feature is significant as it corresponds to a major change in crustal thickness and marks the maximum extent of the complex.

5.2.2 Local climate

There is a weather station at Savage River mine which has been collecting data since 1966. Monthly rainfall and temperature statistics are presented in Table 9 and Table 10 respectively. Average monthly rainfall is highest during late autumn and early spring. There is generally a low diurnal range.

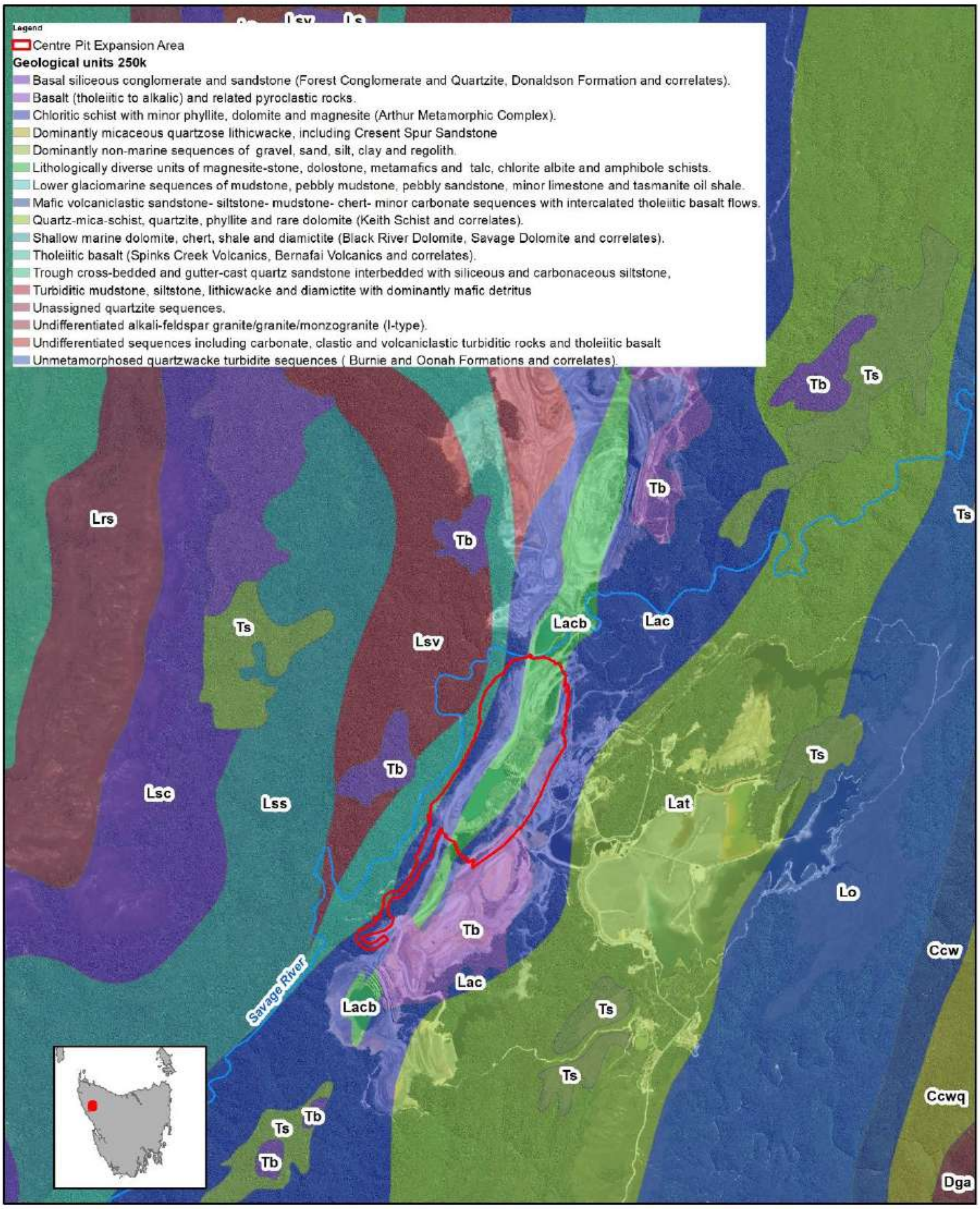
Table 9: Monthly rainfall statistics from 1966 to 2019

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lowest	7	15	21	46	57	24	87	101	64	13	26	27	1529
Highest	206	208	232	311.5	440	404	386	448	382	392	335	299	2828
Mean	96	79	110	151	202	194	241	235	200	166	127	122	1961

Table 10: Monthly temperature statistics from 1966 to 1988

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lowest	15.0	17.6	15.2	12.5	9.9	8.8	8.4	8.9	9.1	11.7	11.8	14.9	13.7
Highest	22.9	22.8	20.1	19.0	14.9	11.9	11.3	11.7	14.0	15.3	17.6	20.4	16.2
Mean	19.1	20.1	17.7	15.1	12.3	10.2	9.4	10.1	11.2	13.5	15.5	17.3	14.4

[1] Geosite ID 2837 on the Natural Values Atlas Geodiversity page.



Grange Resources Pty Ltd

Centre Pit Expansion
Geology

pitt&sherry

MAP REF	HB20068R9	DATA SOURCES	Base map from Grange Resources Base data from The LIST & MRT (C) Tasmanian Government Project data from pitt&sherry & Grange Resources
REVISION	A		
AUTHOR	klawrence		
DATE	13/03/2020		

N 0 0.3 0.6 1.2 Kilometers
Coordinate System: GDA 1994 MGA Zone 55
1:49,417 When Printed at A4

Figure 31: Geology across the site and surrounding areas

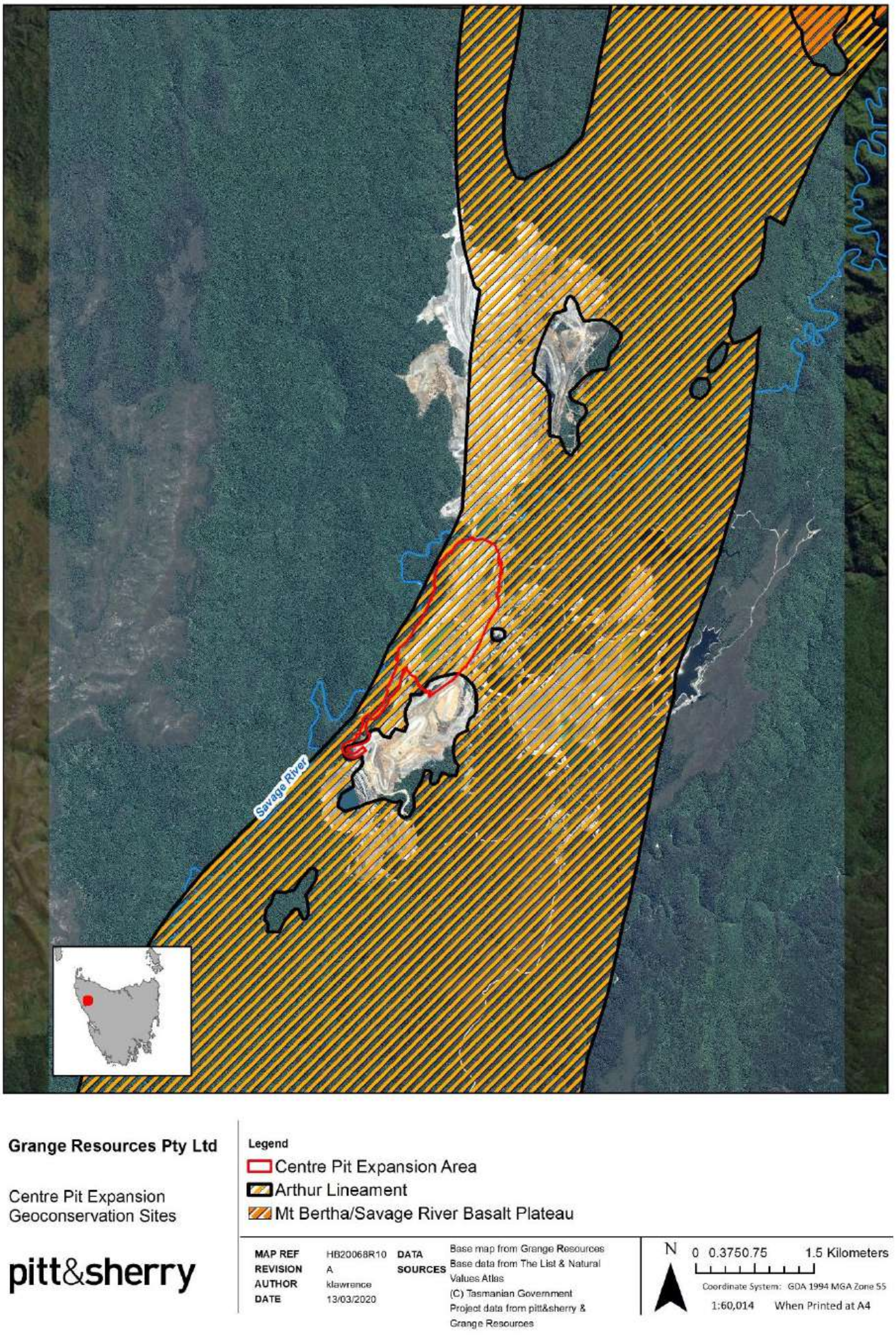


Figure 32: Location of the Arthur Lineament Geoconservation site

5.2.3 Vegetation

A Natural Values Assessment was undertaken by North Barker Ecosystem Services (NBES) in 2018 and a supplement prepared in March 2020 with a further addendum prepared in October 2020. These are attached at Appendix E. The following vegetation communities were recorded within the Centre Pit expansion area:

Nothofagus - Atherosperma rainforest (RMT) – 29.87 ha

Acacia melanoxylon forest on rises (NAR) – 11.08 ha

Acacia dealbata forest (NAD) – 5.40 ha

Leptospermum lanigerum – Melaleuca squarrosa swamp forest (NLM) – 1.11 ha

Eucalyptus nitida forest over rainforest (WNR) – 8.38 ha

Eucalyptus obliqua forest over rainforest (WOR) – 1.82

The native vegetation communities were recorded to the east and west of the former CPN, adjacent to the South Lens, south of CPS and the Mill Dump area. This is largely consistent with the TasVeg 3.0 mapping presented in 7. None of these are listed as threatened communities under the Tasmanian *Nature Conservation Act 2002* (NC Act) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

No threatened flora species listed under either the Tasmanian *Threatened Species Protection Act 1995* (TSP Act) or the Commonwealth EPBC Act were recorded or are considered likely to occur.

5.2.4 Fauna

No threatened fauna species under state or Commonwealth legislation have been recorded (refer Figure 34), however, two listed species are considered likely to occur. The spotted-tailed quoll could utilise habitats present within the site, but these habitats extend well beyond the disturbance area. Tasmanian devil is known to occur within the survey area, but denning habitat is sub-optimal, and no dens were found. Potential foraging and nesting habitat for the state listed grey goshawk is present on site, however, no nests or individuals were recorded. This habitat is present within the riparian vegetation and Acacia community near Savage River.

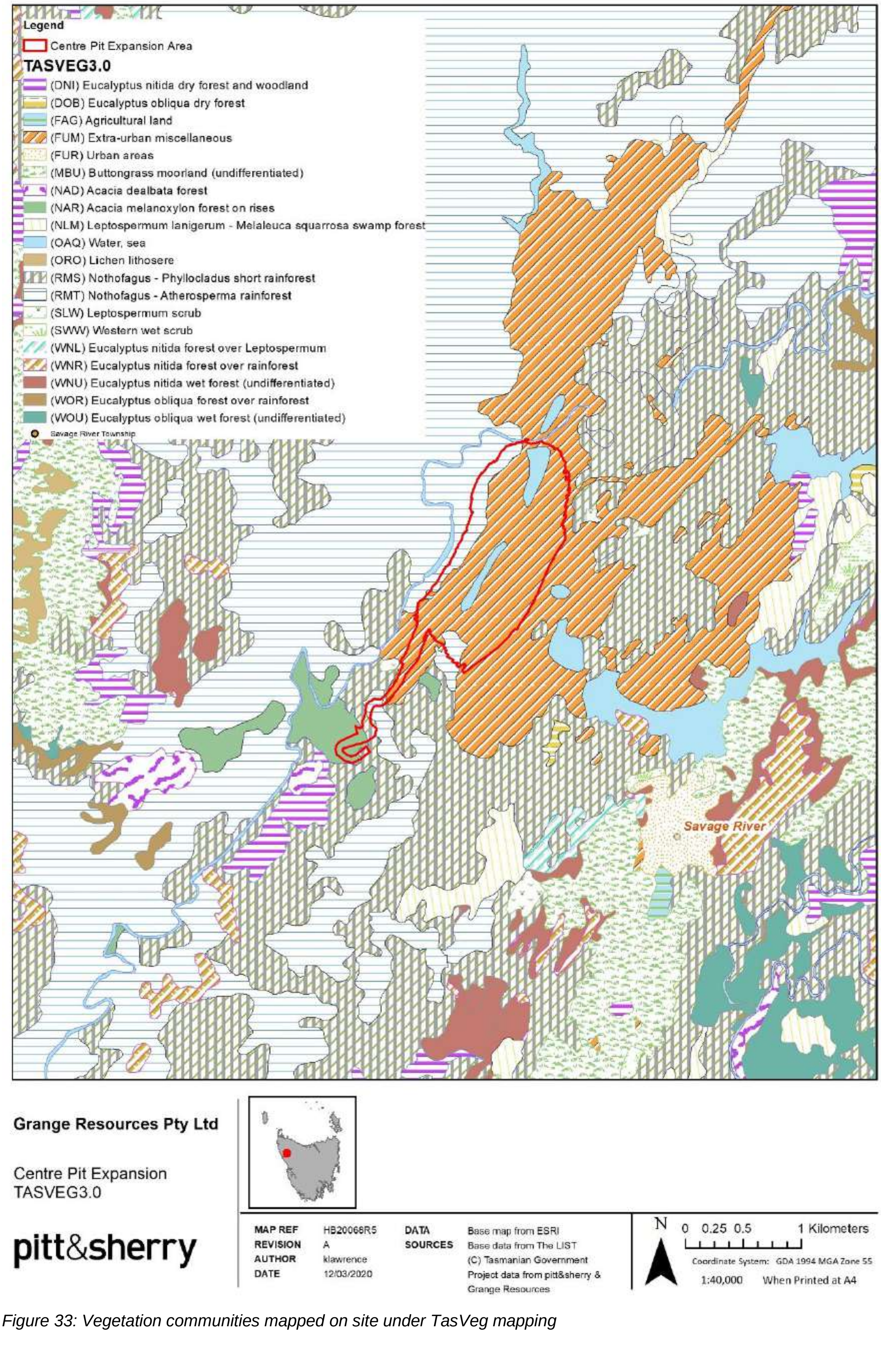


Figure 33: Vegetation communities mapped on site under TasVeg mapping

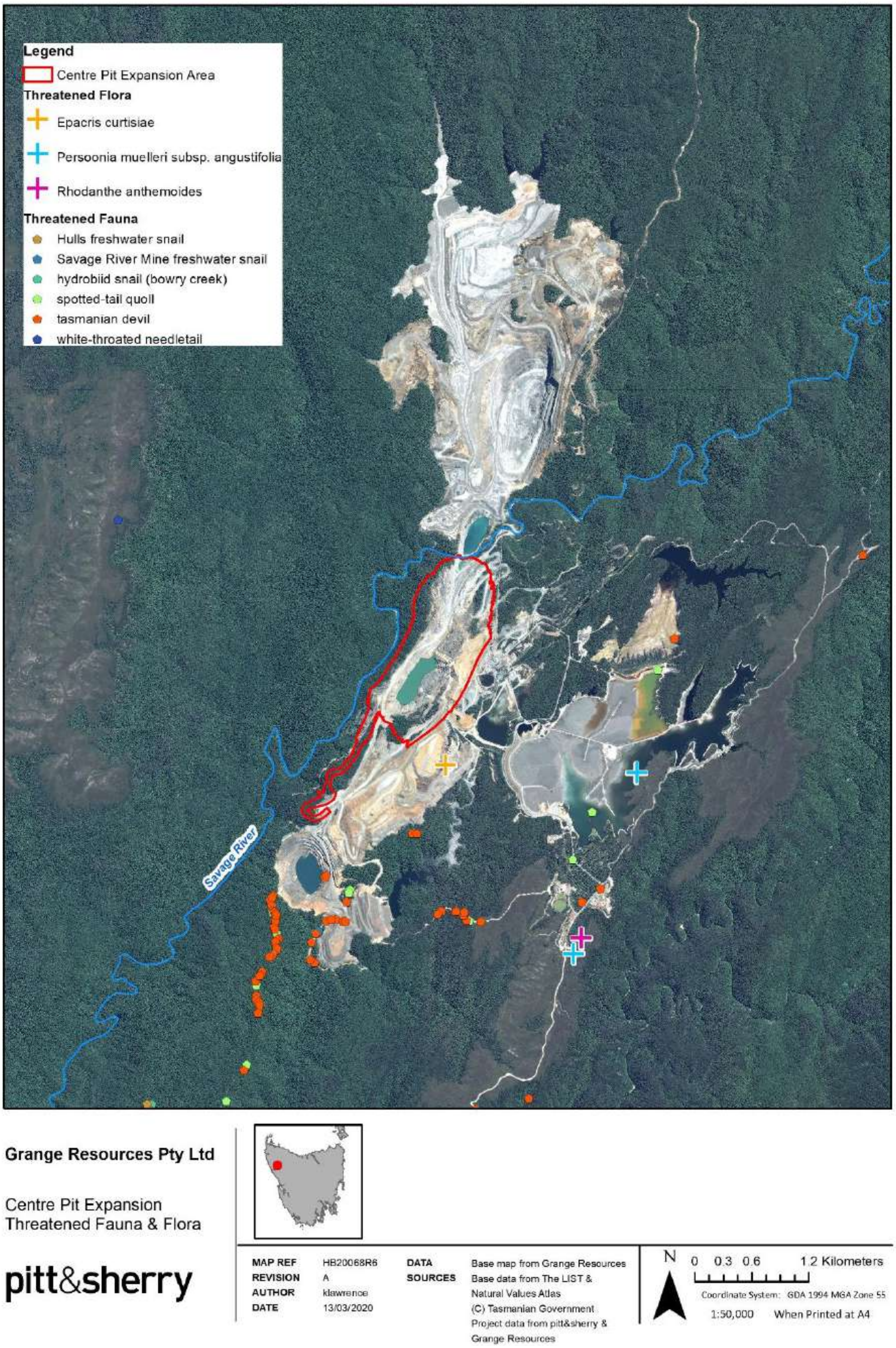


Figure 34: Threatened flora and fauna records (Source: theLIST)

5.2.5 Groundwater and surface drainage (including waterways, lakes, wetlands, coastal areas etc)

The site is dissected by the Savage River, between the former CPN and the South Lens. Savage River joins the Pieman River approximately 16 km upstream from the coast. The site is dominated by man-made surface water bodies associated with the mine and tailings ponds, as shown on Figure 35.

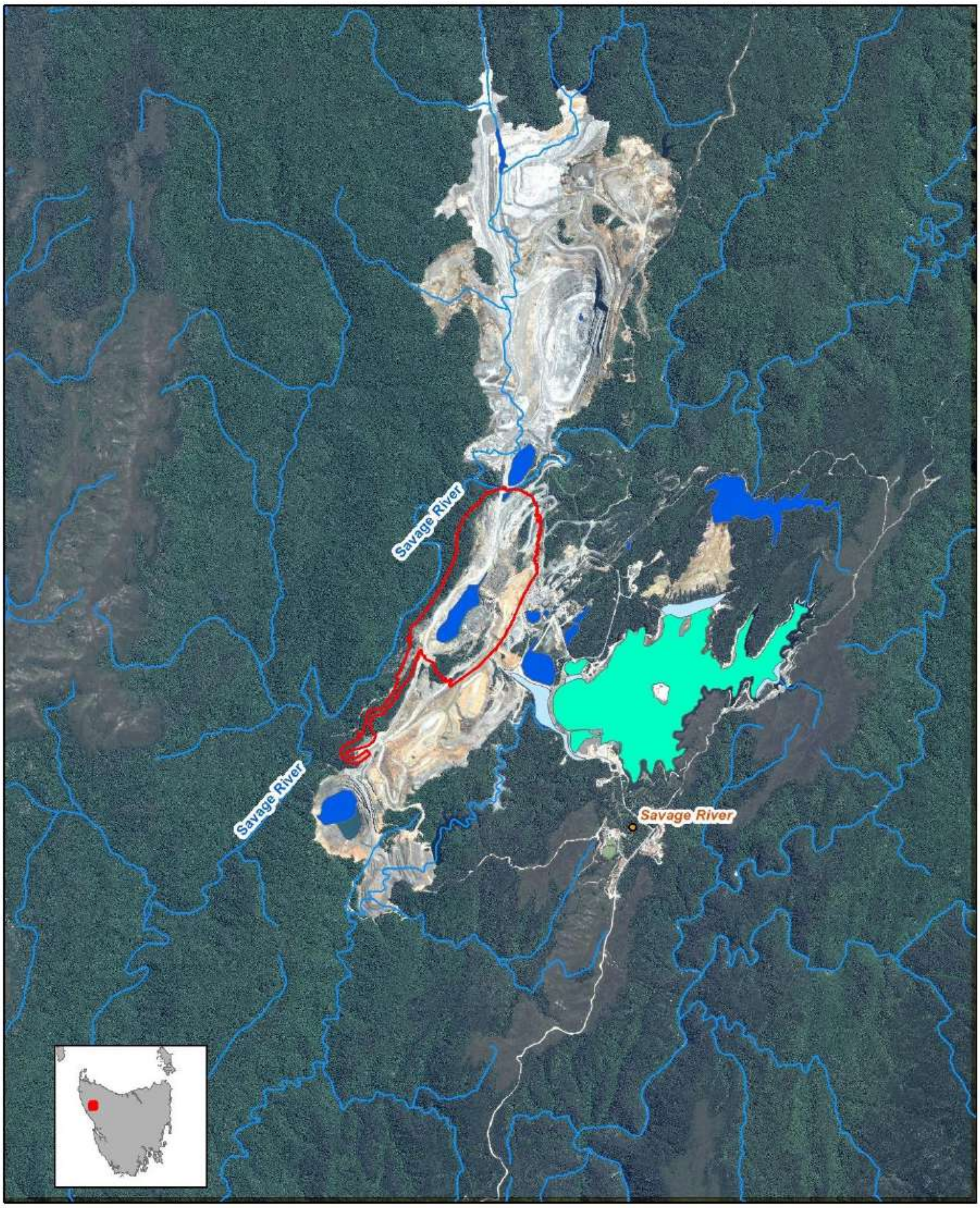
Savage River was impacted by previous operations for a period of 30 years and consequently the Goldamere Agreement and the SRRP were enacted to facilitate ongoing use and active contribution to management of water quality and rehabilitation of habitats within the river. The CPS contains approximately 2.7 GL of water, with additional water inflow to be derived from the groundwater of the catchment as water level in the pit is lowered. This water will be transferred to the South Lens as part of the proposed expansion. The catchment of CPS is estimated at 195 km^2, including the ETD catchment, comprising 80% of the Centre Pit catchment. Note it is intended to redirect the ETD catchment to Main Creek.

The report prepared by Koehnken and Ray (2018), *Water quality implications of dewatering Centre Pit South* , provided an assessment of water quality within the CPS. The water quality profiles from two locations in the CPS (Table 11) show the lake was thermally stratified, but oxygen concentrations did not decrease much with depth. This is consistent with there being a low organic and chemical oxygen demand (e.g. ferrous iron) loading to the water body. pH is also uniform over depth and electrical conductivity (EC) ranges from ~1,600 µS /cm to 1,700 µS /cm.

Table 11: Water quality results at north and south test location in CPS

Site	Acidity (mg/L)	Tot Alkalinity (mg/L)	Ca (mg/L)	Sulphate (mg/L)
Surface (north site)	1.5	94	194	912
Middle (north site)	6	104	189	831
Bottom (north site)	9	110	213	896
Surface (south site)	1.5	94	197	900
Middle (south site)	6	102	188	827
Bottom (south site)	9	111	205	892
CPS avg	6	103	198	876
South Lens Average	6	139	188	812

Metal concentrations recorded at the two CPS testing locations are presented in Table 12. Copper concentrations in Centre Pit South are higher at mid-depth. During sampling for the report in 2018, the water was observed to be slightly coloured, which was thought to be due to a low-level algal bloom. The results for ions and metals show that alkalinity and acidity increase with depth, which is consistent with algal activity lowering the carbonate buffer capacity of the surface water. The high pH (pH > 8) of the surface water is also consistent with algal activity. Water quality results were taken from two locations within CPS and were very similar, as shown in Table 11 and were lower than average concentrations for South Lens. Overall, the water quality in CPS is generally better than in South Lens.



Grange Resources Pty Ltd

Centre Pit Expansion
Hydrology

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Legend

Centre Pit Expansion Area
Dam
Natural or dammed freshwa
Tailings pond
Hydrological feature
Savage River Township

MAP REF	HB20068R7	DATA SOURCES	Base map from Grange Resources Base data from The LIST (C) Tasmanian Government Project data from pitt&sherry & Grange Resources
REVISION	A		
AUTHOR	klawrence		
DATE	1/04/2020		

N

0 0.325 0.65 1.3 Kilometers

Coordinate System: GDA 1994 MGA Zone 55

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Figure 35: Rivers and waterbodies on site and adjoining areas

Table 12: Total metals (µg/L) in water quality samples collected from the surface, mid-depth and bottom water in Centre Pit South

Site	Al µg/L	Co µg/L	Cu µg/L	Fe µg/L	Mn µg/L /L	Ni µg/L /L	Zn µg/L /L
Surface (north site)	<20	111	4	701	1650	107	20
Middle (north site)	<20	60	8	198	964	76	22
Bottom (north site)	<20	5	1	115	62	60	10
Surface (south site)	<20	116	4	793	1690	109	23
Middle (south site)	<20	61	7	196	972	75	22
Bottom (south site)	<20	9	1	229	107	65	13
CPS avg	<20	60	4	372	908	82	18
South Lens avg	64	147	28	178	1320	113	24

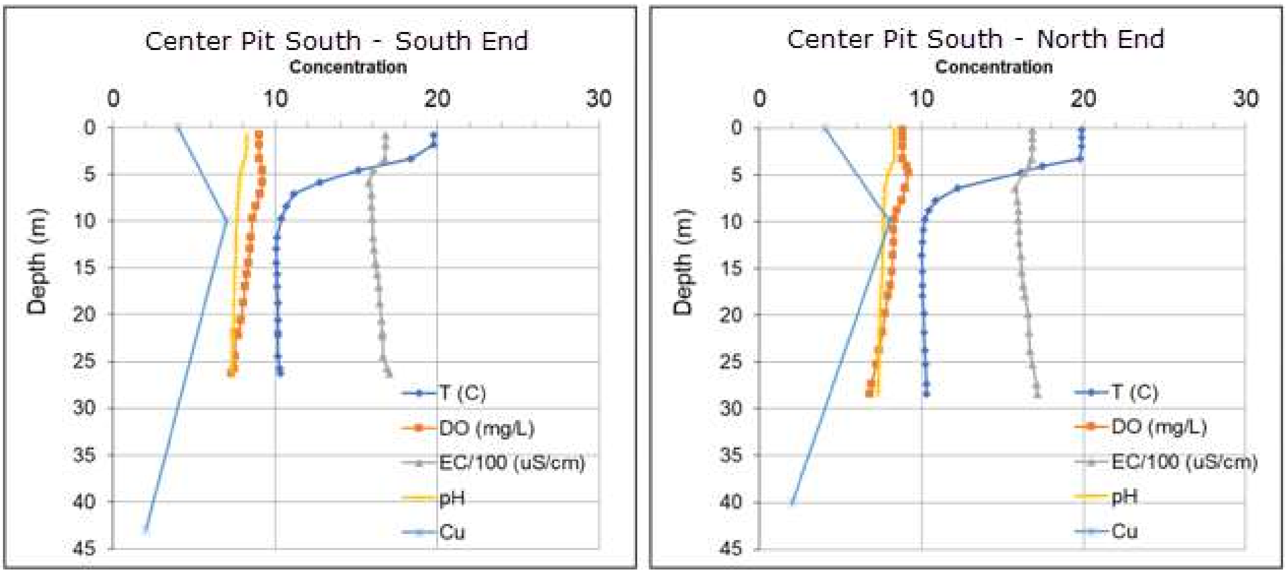

Figure 36: Water column profiles collected on 20/12/2017 in Centre Pit South (Note EC values divided by 100 for graphing purposes)

5.2.6 Natural processes of importance for the maintenance of the existing environment

The area of the proposed expansion has been extensively disturbed. There are no natural systems present within the expansion area which are essential to the surrounding environment. The mine site in general is dissected by Savage River, however, there are extensive controls in place to protect and monitor water quality within the river.

5.2.7 Conservation reserves on or within 500 m

There are no conservation areas within 500 m. Savage River National Park is located 10 km to the north east of the Centre Pit expansion site. The mine is bordered to the north and south by informal reserves identified as future potential production forest managed by DPIPWE.

5.2.8 Wilderness areas identified in the Tasmanian Regional Forest Agreement near the site

There are no wilderness areas near the site.

5.2.9 Species affected by the proposal

No threatened species are present within the expansion area. Much of the land has been previously disturbed by mining (Figure 37).

Figure 37: Aerial image showing extent of disturbance in 1979

5.2.10 Sites or areas of landscape significance affected by the proposal

The expansion works are proposed within an existing mine site. There are no sites of landscape significance present.

5.2.11 Natural hazards assessment (e.g. flooding, seismic activity, fire, landslips or strong winds).

The site is surrounded by native vegetation which would be considered a bushfire threat. The extensive cleared areas on site, however, minimise the level of threat to any assets or personnel.

There are two crossings in this area of the river:

- Eastern Crossing: a circular and a square culvert, of 4.5 m in diameter and 2.4 x 2.4 m; and
- Western Crossing: three adjoining rectangular culverts of 3.6 x 3.6 m.

A hydraulic model was prepared by GHD (2019 – copy at Appendix F), which drew upon the Savage River Mine Flood Study – July 2018, also prepared by GHD. Design floods of 0.1% AEP - peak flow of 440 m3/s and 1%AEP - peak flow of 202 m^3/s were used.

In the design it was assumed that these openings would all be blocked and a levee along the southern riverbank was proposed to eliminate the risk of flow towards Centre Pit. Several scenarios, including the presence or absence of a levee on the southern or northern riverbank, and the South lens being full or empty, were run. The model showed that, in the event South lens is full, a levee is required to manage the inflow of water to the Centre Pit. Consequently, a levee of 200m length, width of 5m (2m crest) and surface RL of 113m was recommended. This could be achieved by constructing a roller compacted concrete levee, a concrete and gabion combination levee or pre-cast concrete panel levee.

The proposed pit does not mine any closer to the Savage River than previous mining in CP North. The north end of the Stage 3 Pit is wider than previous mining but the sections adjacent to the River have all been previously mined to a depth of at least 30m.

The buffer between the Savage River and the pit varies with the river flow depth (see Figure 38). The typical winter flow in Savage River has a height of 106mRL, at this depth the minimum buffer between the pit wall and river is 28m. The levee crest will provide a minimum 2.2m buffer with a 0.1m freeboard during a 0.1% AEP flood event (112.9mRL flood height).

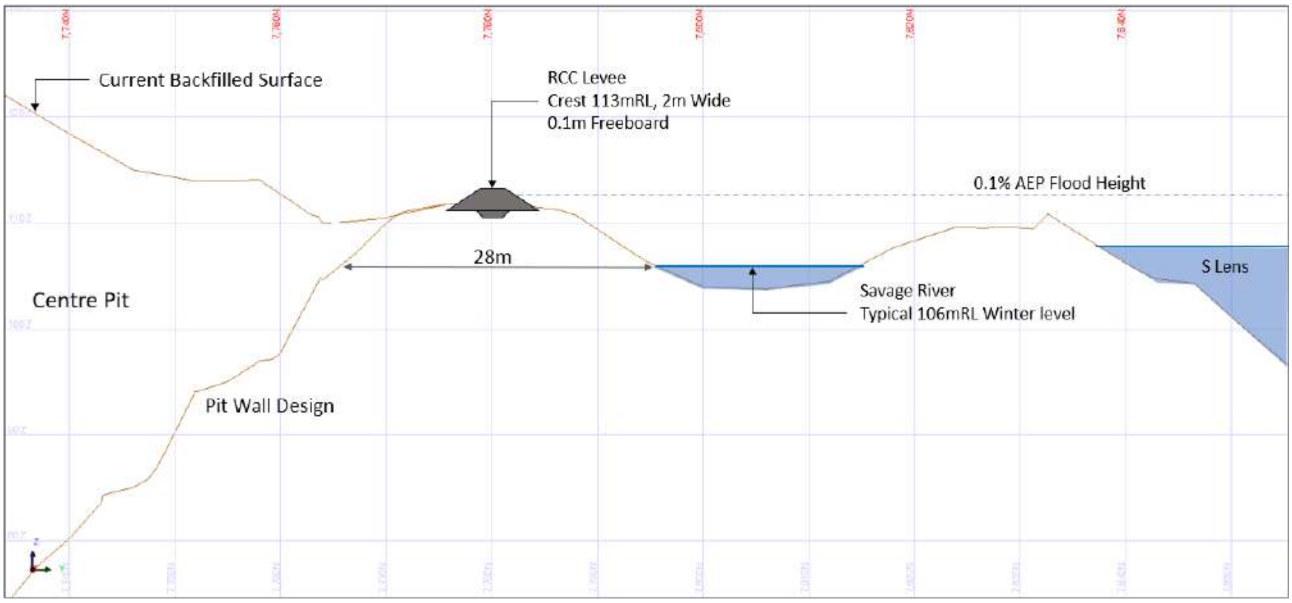

Figure 38: Savage River and buffer between river and pit

A roller compacted concrete levee is the preferred design solution. A typical section is shown in Figure 39. Detail design of the levee will be completed prior to commencement of mining in Stage 3. The preliminary design is based on survey data of mined surface completed during the previous mining of Centre Pit.

A bore hole completed on the north side of the Savage River and drilled to the south under the river was designed to provide data for the assessment of the geotechnical stability of the north wall and the hydro-geological connectivity of Centre Pit and the Savage River. The first 20m of the bore hole was in backfill associated with South Lens Pit and South Lens Haul Road and the River Crossing. The first 20m of this hole is not representative of the ground in the North Wall of Centre Pit. Core at greater depth in this hole shows that the north wall is competent, stable and suitable to build a levee on. As recommended in the GHD report detailed design requires the completion of geotechnical drilling in the north wall to confirm the accuracy of previously as mined surface and the required depth and RL of solid rock for the keyway. A roller compacted concrete levee design has been chosen as it is the most flexible design and is adaptable to variations in existing bedrock. Additional geotechnical investigations during detailed design is unlikely to impact the selection of the preferred design.

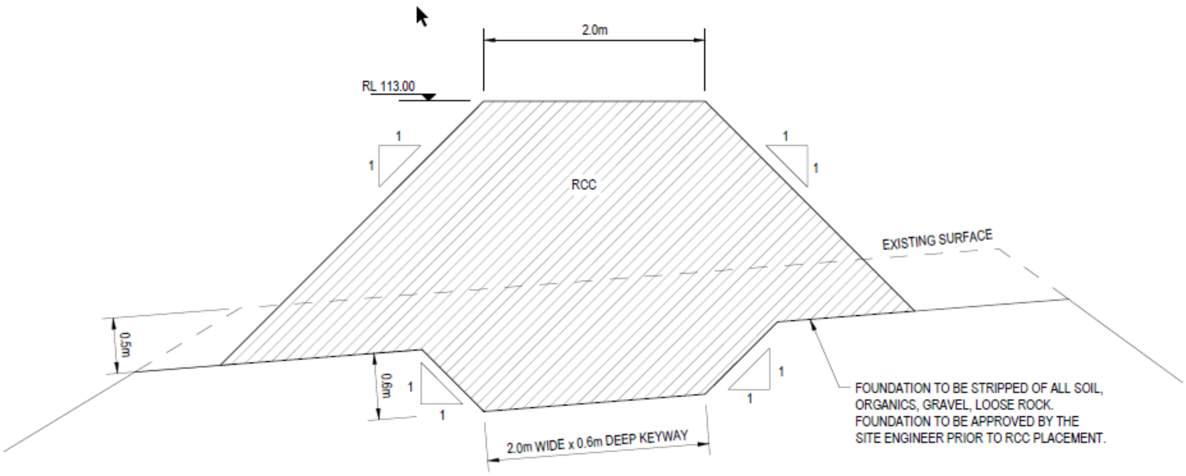

Figure 39: Typical section RCC levee

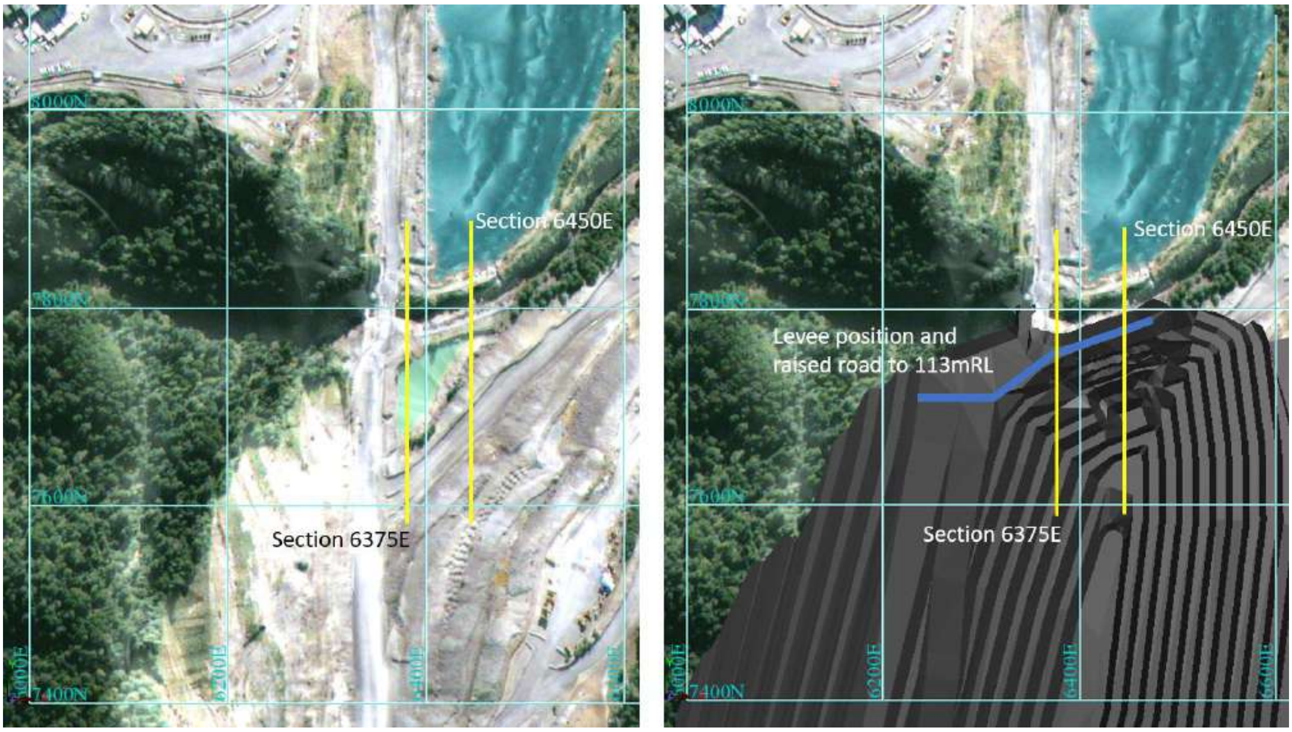

Figure 40: Aerial photo showing levee location on the pit design and Section locations

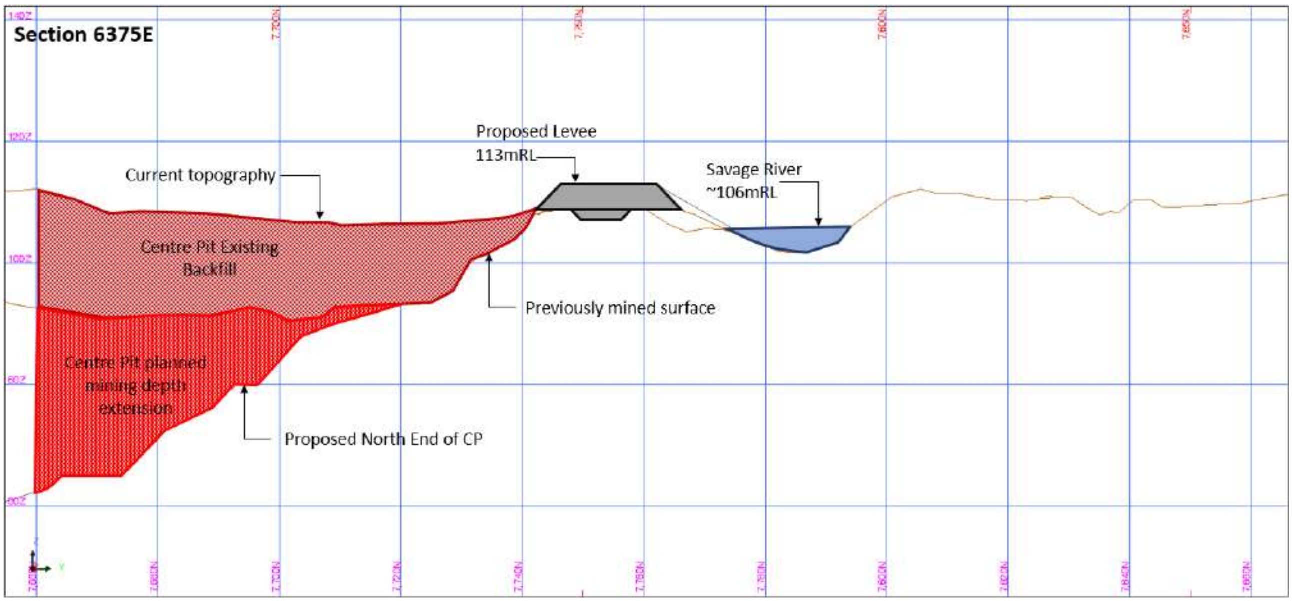

Figure 41: 6375 east section though CP and the Levee

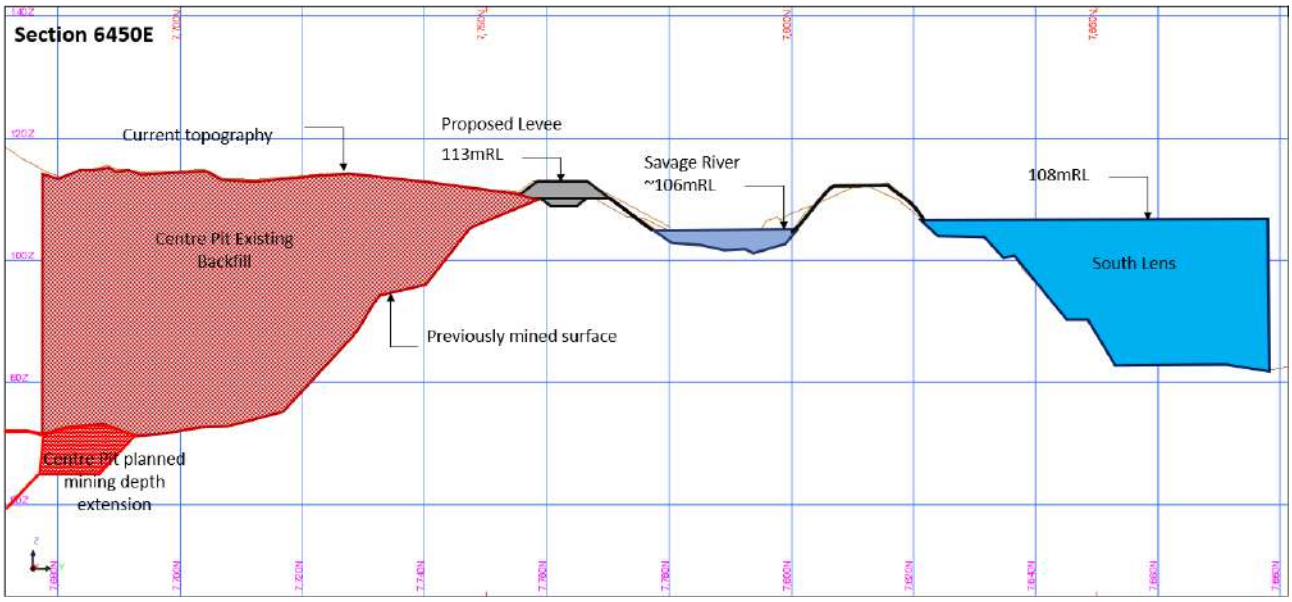

Figure 42: 6450 east section through CP and South Lens

5.2.12 Current regulatory approvals and licences

Current approvals or regulatory conditions and current environmental permits and mining leases are listed in Table 13.

Table 13: Environmental permits

Detail	Application	Year	Activities covered
EPN 248/2	Savage River Mine	2001	Applies to operations at Savage River
EPN 8994/1	Main Creek Tailings Dam (MCTD)	2013	Applies to the 336RL and 338RL raises of the Main Creek Tailings Dam and maintenance of the dam to ANCOLD
EPN 8748/4	South Deposit	2014	Applies to the dewatering and mining of South Deposit
PCE 8808	SDTSF	2013	Applies to the construction and operation of the SDTSF
EPN 10006/2	North Pit Exploration Decline	2020	Permit to extend the previously approved exploration decline from 1.3 km to 3 km from the portal located at the southern extend of North Pit.

5.3 Socio-economic aspects

The proposed Centre Pit expansion will allow the continued operation of the Savage River Mine. The mine is the subject of the Goldamere Agreement, a legislative provision enacted to allow the continued development of the mine and its consequent economic contribution to the wider Tasmanian community. The enduring operation of the mine will build upon this agreement and facilitate continued contribution to environmental management programs under the SRRP, aimed at improving water quality in Savage River and downstream environments.

6. Potential Impacts and their Management

6.1 Air quality

Grange Resources operates the Savage River mine in accordance with the requirements of the Goldamere Agreement. This requires that activities on site be conducted in accordance with best practice environmental management (BPEM). This refers to the management of the activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the current international and national standards applicable to the activity.

Savage River mine is operated under several EPNs issued for the operation of the mine and mineral works and various activities on site, as outlined in Section 5.2.12. None of these refer specifically to management of dust on site or air quality.

6.1.1 Potential impacts of the proposal on the local and regional air environment

The proposal relates to expansion of Centre Pit, within the existing Savage River mine. This is an active mine site in a remote location with no sensitive uses located within 2 km of the mine extent. There are no emissions from the site and no odours generated. Any air quality impacts are limited to those related to dust generation.

Extraction is via a truck and shovel operation and material is transported on site by trucks during some processes. The movement of materials, and the movement of vehicles around the site, will generate dust. Ore from stockpiles is fed into the crushers by a front-end loader and truck which also generates dust. The crushers used are gyratory crushers where material is crushed between an inner cone-shaped mantle and an outer casing. As this is an internalised process there is little potential for dust generation during crushing. Crushed ore is transported to the concentrator stockpile via an overland conveyor for further processing, mineral extraction and slurry generation. The slurry is pumped to Port Latta via an overland pipeline.

Access to the mine is via a sealed road. The only truck movements associated with extraction and processing are internal to the site. This is limited to some degree using overland conveyors. There will be dust generation from the proposed expansion and will be consistent with the nature and level of dust generation occurring currently.

Impacts of dust in this case are limited to potential harm to the health of workers and impacts on vegetation surrounding the mine. Employee health is managed under workplace health and safety (HSE) legislation and Grange Resources operates under approved systems. Excessive dust cover can impact plant health by reducing the plant's ability to photosynthesize as a result of reduced sunlight exposure. Mean annual rainfall at Savage River is 1,961 mm with the lowest monthly average being 79 mm (in February). This consistent level of rainfall experienced is likely to prevent an accumulation of dust on plants, avoiding significant impacts.

6.1.2 New point source atmospheric discharge points.

There are no new point sources of emissions.

6.1.3 Potential sources of fugitive emissions

Dust generation on site is diffuse and there are no processes undertaken on site likely to result in emissions other than dust.

6.1.4 Tasmanian Environment Protection Policy (Air Quality)

This policy deals primarily with the avoidance and management of emissions. Point source discharges and the potential for harmful or polluting substances are addressed. The environmental values to be protected under the policy are:

- The health and well-being of humans
- The health and well-being of other life forms
- Visual amenity; and
- The useful life and appearance of assets.

In this instance there are no emissions that will endanger human life. Employees on site are protected by adopted and successful HSE measures and operational safeguards on site. Residents at Savage River are in excess of 2 km from the mine and unlikely to be impacted by dust generated by extraction works. Plant life around the mine is sufficiently clear of active areas to avoid direct impacts and the high levels of rainfall experienced will ensure excessive dust does not accumulate on leaves, impacting plant health.

The mine site is remote, and any dust generated during operations is unlikely to be visible from any public places. Due to the remote nature of the site there are no buildings or other features that are likely to be impacted or diminished. It is considered that the operation is operating in accordance with BPEM.

6.2 Water quality (Surface and Discharge)

The key hydrological value potentially impacted by the proposed Centre Pit expansion is the Savage River. The river traverses the site between the South Lens and the northern extent of the Centre Pit extension. The location of the river can be seen on the Centre Pit section 6450E at Figure 43, which shows the previously mined surface in CPN, the current waste rock level, and the profile of the South Lens to the north. Dewatering of operating pits is always required at Savage River with rainfall approaching 2,000 mm per year.

The Centre Pit Expansion requires the emptying of some 2.7 GL of water from CPS prior to mining of stage 1 below the 135 mRL with targeted pump flows ranging between 100 L/s to 500 L/s depending on flow in the Savage River and relevant trigger values. After this dewatering some inflow will occur to CPS as stage 1 continues downward. Following the initial dewatering of CPS it is expected that normal dewatering practices will be followed and that the likely flows will be between 50 L/s and 250 L/s in line with current CPN outflows into South Lens. An overview of the water quality in the different water sources discussed in this section is presented in Table 14, with more detailed water quality information contained in subsequent sections.

6.2.1 Description of the existing and proposed water management practices

South Lens is the central water treatment facility and acts as a sediment retention pond for site workings' run-off. Alkaline waters from numerous sources within the mine site are mixed with acidic and metal rich drainage derived from historic mining areas. Retention of water within the South Lens encourages neutralisation of acid drainage and the precipitation of metal hydroxides. A plan showing surface water management paths and catchments is provided in Figure 45. The Centre Pit Expansion requires dewatering of CPS. This water will be pumped around CPN to a dewatering tank, mixed with the reduced discharge from CPN in the existing small downstream pond, then enter the South Lens via an existing viaduct. Once pumping is initiated, the existing flow from CPS to CPN will cease. Dewatering and monitoring plans are detailed in section 5.25.

CPS contains approximately 2.7 GL of water (at the time of investigation), comprised of inflows from the mine catchment and some groundwater when water levels are lower. Inflows include water from the B Dump and South Dump complexes, groundwater from the pit walls and in pit catchment, mine road runoff from North Dump, the concentrator and historical AMD from the Crusher Gully area. CPN has been back filled but holds water below the fill surface level, so appears dry. This water presently flows to SL. Emptying the pit will temporarily accelerate the rate of water movement from CP into SL, but will not affect the overall volume of water generated and directed to SL, except for any increase in groundwater due to drawing down the water level in the pit.

CPS and CPN are connected at 135 mRL. Currently, water overflows from CPS to CPN at the 135 mRL then percolates through permeable waste rock. Water is discharged from CPN to SL through a viaduct located at 109 mRL, with the groundwater gradient reducing from 135 mRL to 109m RL through CPN. Once the water level in CPS is less than 135 mRL water will not flow between the two historic pits.

CPN is estimated to contain 0.58 GL of water. This is based on the calculation of 25% void space within the backfilled waste and a saturation height of 109 mRL. During the mining of Stage 1, 0.14GL of the water in the CPN will drain into CPS. During the mining of Stage 3 the remaining 0.44GL will be pumped either from the south end of CPS as the waste drains south or from sumps in the north end of CPN as per normal pit dewatering practice. All water pumped from CP (north or south) during mining will be first pumped to the dewatering tank prior to flowing into South Lens. During Stage 3 mining this tank will be relocated across the Savage River and will discharge directly into South Lens, as the CPN pond will disappear during Stage 3 mining. All water pumped from CP will follow the management plan described below.

Table 14: Water quality indicators

Water Quality Averages				
Parameter	**Site**			
	Savage River at Pump Station	**South Lens Outflow**	**Centre Pit North Outflow**	**Centre Pit South**
pH	6.95	7.79	7.07	7.68
Conductivity us/cm	81	1398	2282	1642
Flow m3/s	7.40	0.35	0.10	Not Applicable
Alkalinity Total mg CaCO3/L	7	132	149	103
Acidity mg CaCO3/L	4	5	19	8
Ca Total mg/L	2	161	328	198
Mg Total mg/L	4	100	217	117
Sulphate mg/L	5	642	1532	873
Al Total µg/L	378	245	838	54
Co Total µg/L	3	106	245	60
Cu Total µg/L	5	30	142	6
Fe Total µg/L	608	174	1272	372
Mn Total µg/L	38	1094	2622	908
Ni Total µg/L	5	82	197	82
Zn Total µg/L	3	14	53	18

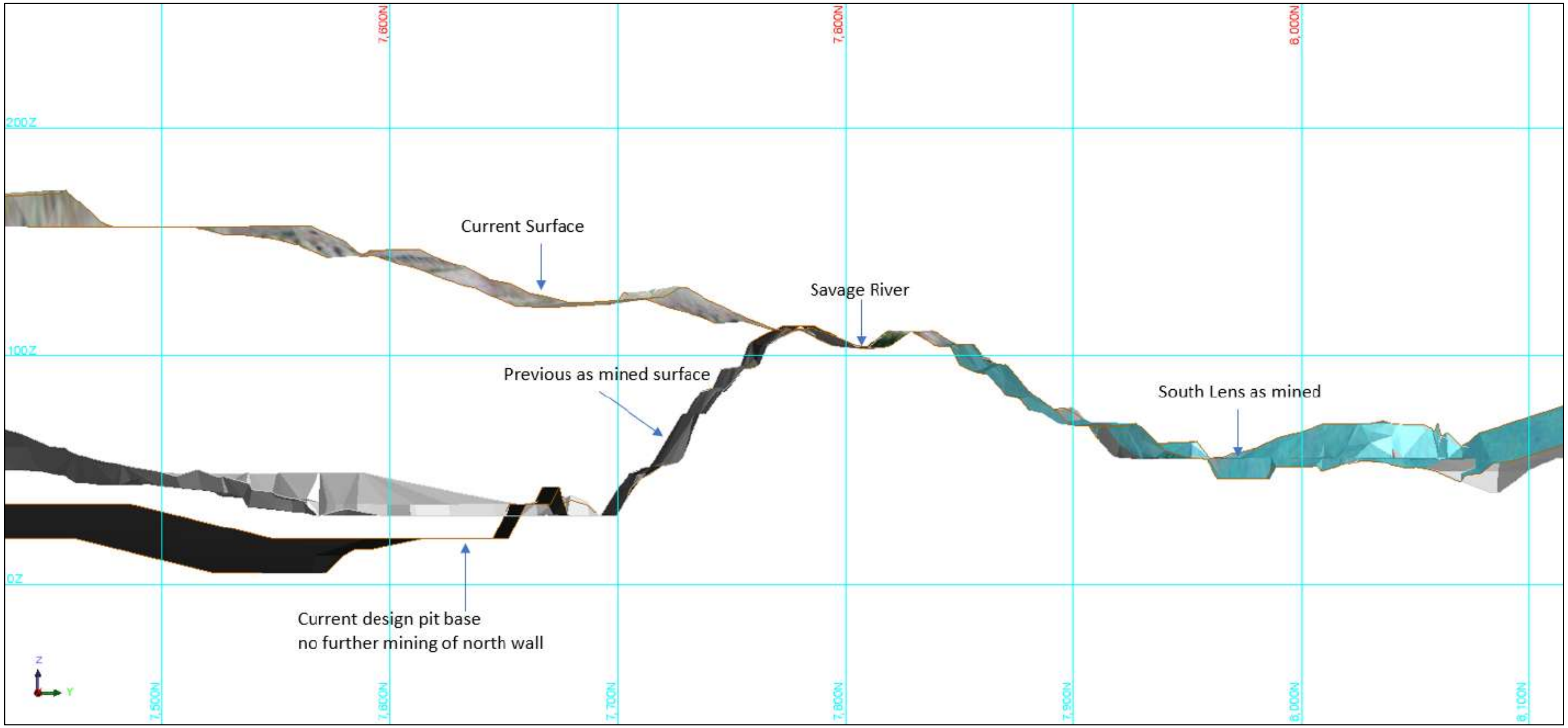

Figure 43: Centre Pit section 6450E showing location of Savage River

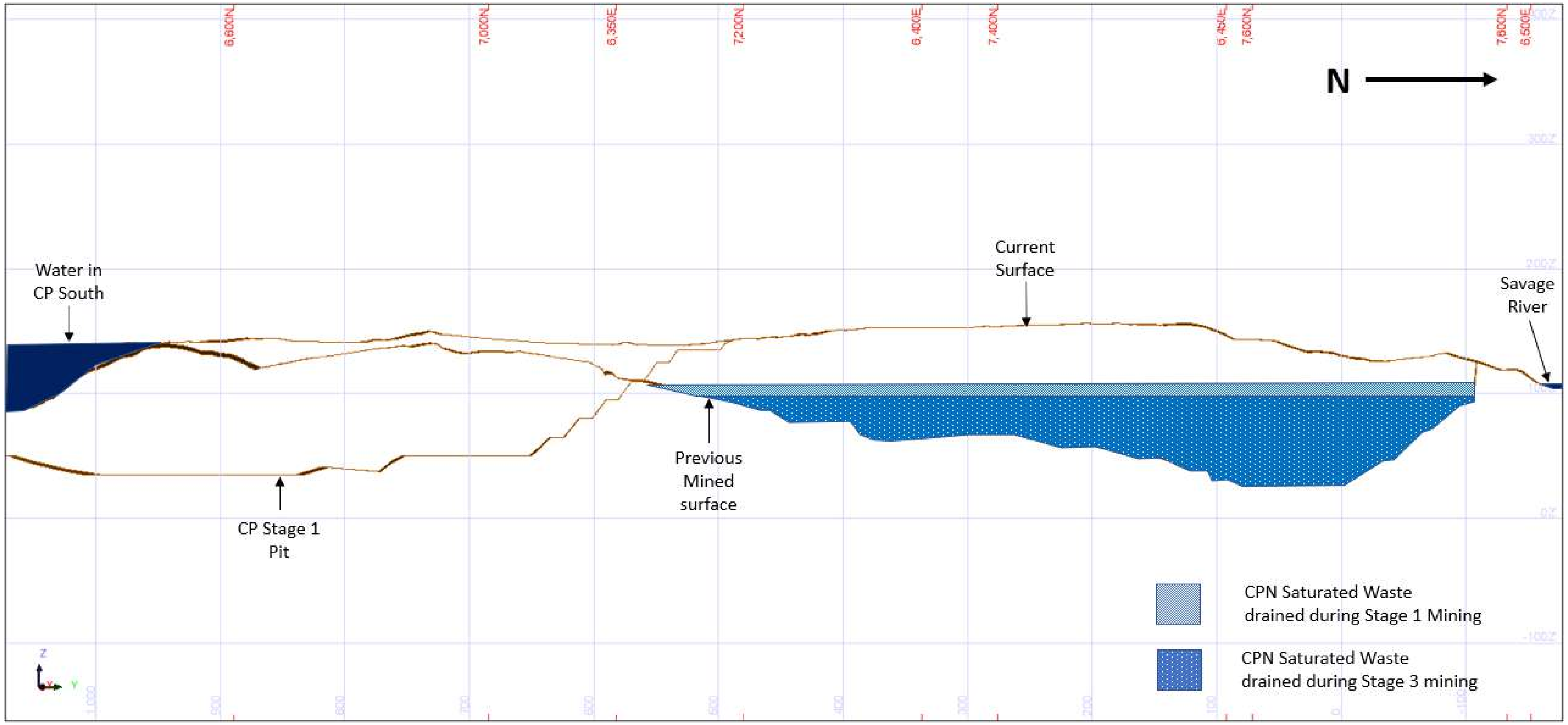

Figure 44: Centre Pit oblique section showing Centre Pit north saturated backfill

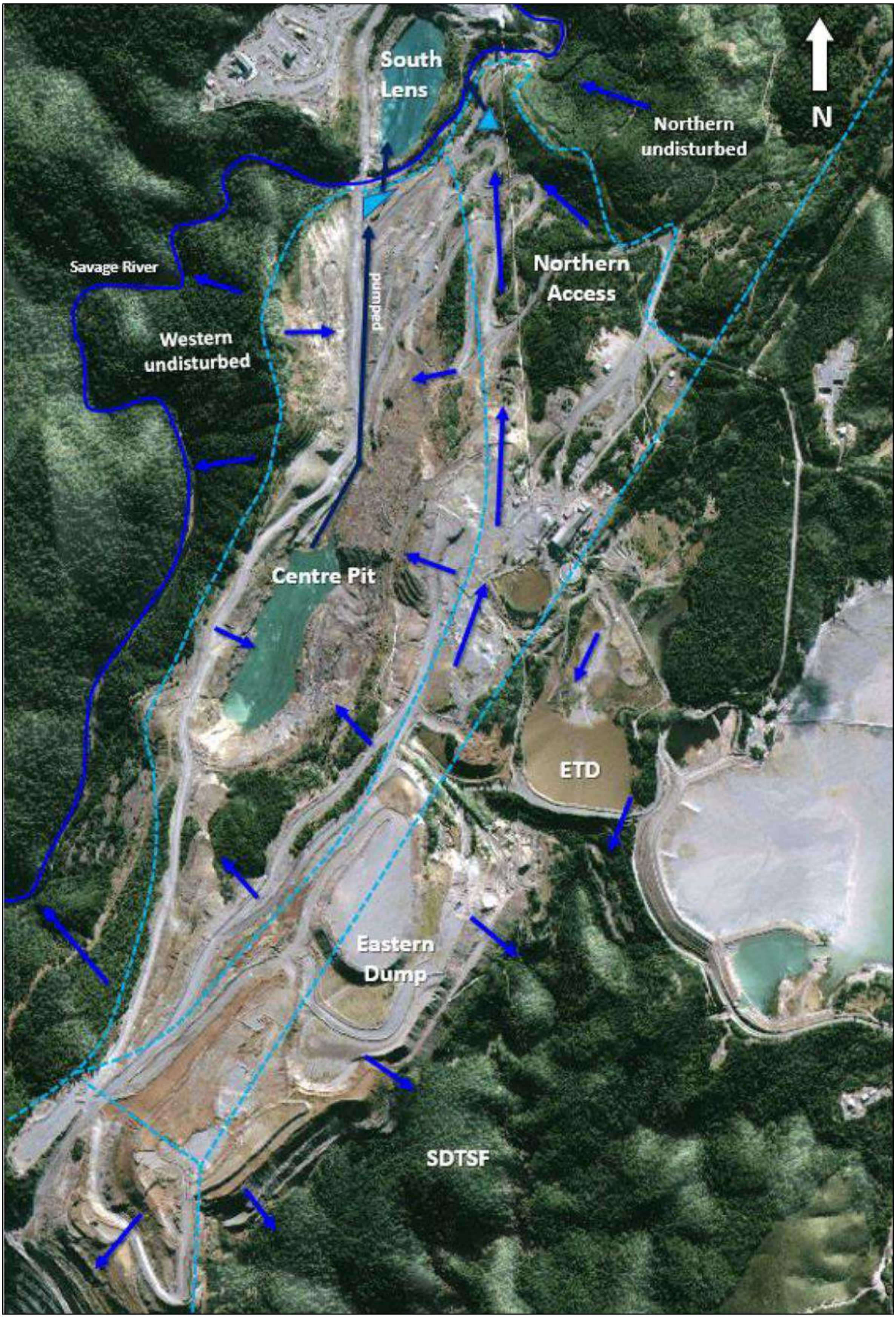

Figure 45: Surface water management plan

6.2.2 On-site water quality

Historically, copper has been identified as the toxicant of most concern in the Savage River. The aim of the SRRP is to restore the Savage River to a modified but healthy ecosystem. Site specific water quality criteria derived for fish and invertebrates in the Savage River guide and gauge remediation works on site. The criteria have also been used to guide the assessment of water quality in SL, CPN, CPS and Savage River for the Centre Pit expansion. Maintaining the health of the Savage River is the environmental focus of the dewatering management plan.

The potential impact of dewatering Centre Pit via South Lens was initially investigated in 2018 (L Koehnken Pty & Aquatic Science, 2018) based on water quality monitoring results from 2011- 2017. The work built upon a previous investigation by Aquatic Science (2014) that linked hydraulic retention time in South Lens to copper (and other metal) removal. The 2014 study estimated that a 20% reduction in retention time (HRT) in South Lens could increase copper concentrations by up to 10 μg/L in the SL outflow.

The 2018 investigation concluded that dewatering CPS at a rate of 120 L/s would have a variable impact on the HRT of South Lens. The 2018 work concluded that dewatering at a pump rate of up to 120 L/s would not have a deleterious impact on the metal treatment capacity of South Lens or the water quality in the Savage River. No assessment was made of higher pump rates.

Since the completion of the 2018 investigation, the hydrology of South Lens has been altered by the inflow of a large volume of Broderick Creek derived water via North Pit which has affected the HRT of South Lens, and increased the alkalinity and sediment flux entering the water body. At the same time Grange has identified the need to dewater CPS at higher rates, up to 500 L/s, in order to reduce water levels within an operationally acceptable time-frame. Grange's operational pumps effectively pump at 100L/s and the management strategy has been developed based on increases/decreases of 100L/s increments by turning off and on additional pumps.

Understanding how flows have changed within South Lens is important for understanding metal removal and how additional inflows may affect water quality in the future. Continuous flow data for the SL Outflow is episodic. To provide a more complete flow history, machine learning has been used to develop a tool to predict discharge from South Lens based on rainfall. Data collected prior to the large increase in flow occurring from North Pit (2010 to 2014) was used to develop the technique, and hence provides a model for historic flows into South Lens.

Measured and predicted flows based on the machine learning output are shown in Figure 46. There is good agreement between the measured and modelled results through 2017. Discrepancies typically coincide with very high rainfall events. Comparing predicted and real flows from late 2017 to present shows a large increase in real flow from South Lens outflow. The timing is consistent with the observed inflow of large volumes of water from North Pit into South Lens. The increase in flow through North Pit is mainly attributable to the interception of Broderick Creek water by the western expansion of the North Pit.

Comparing the modelled and measured flows suggests that up to 0.6 m^3/s of additional flow is entering South Lens, with the largest increases occurring during winter.

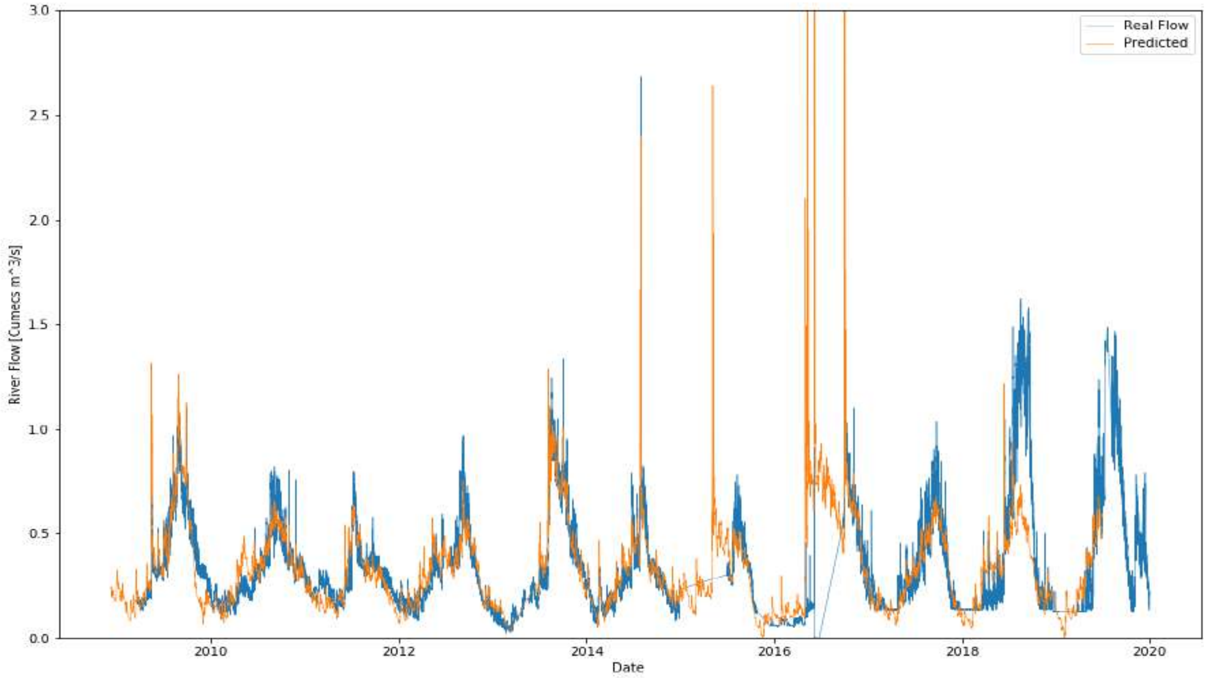

Figure 46: Comparison of modelled and measured flows South Lens

Copper is the toxicant of most concern at Savage River, and is a primary focus of the SRRP. Figure 47 shows copper concentrations and flow at SLO from 2011 to 2017. In the early years, there is a high correlation between the two parameters, with elevated concentrations coinciding with periods of high flow. This has been interpreted as reduced HRT limiting copper removal (Aquatic Science 2014). From 2018 to September 2020 the flow has risen substantially and there is poor correlation with copper levels. This is a marked departure from previous observations. The flux of copper discharged from South Lens Figure 48 suggests that the copper flux has remained similar or shown a slight decline since 2017.

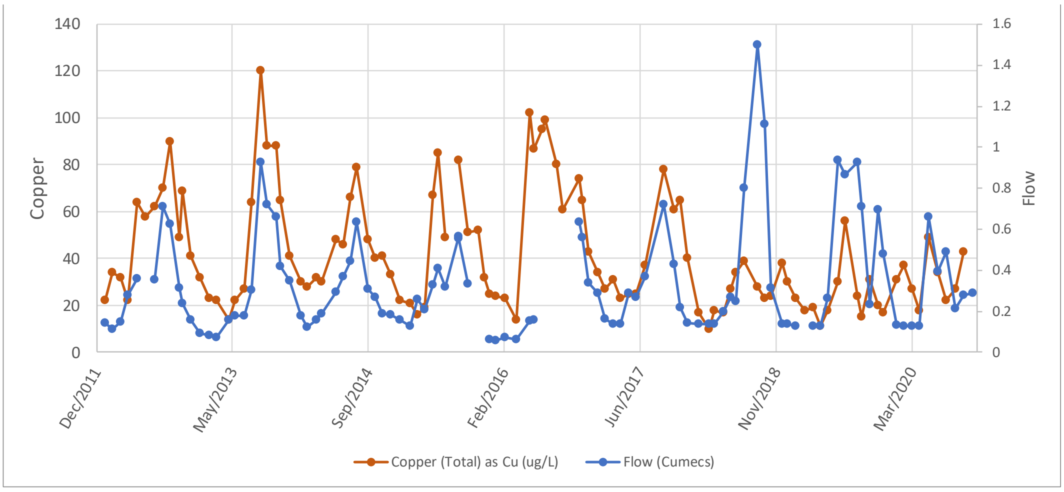

Figure 47: Total Copper concentration with flow over time

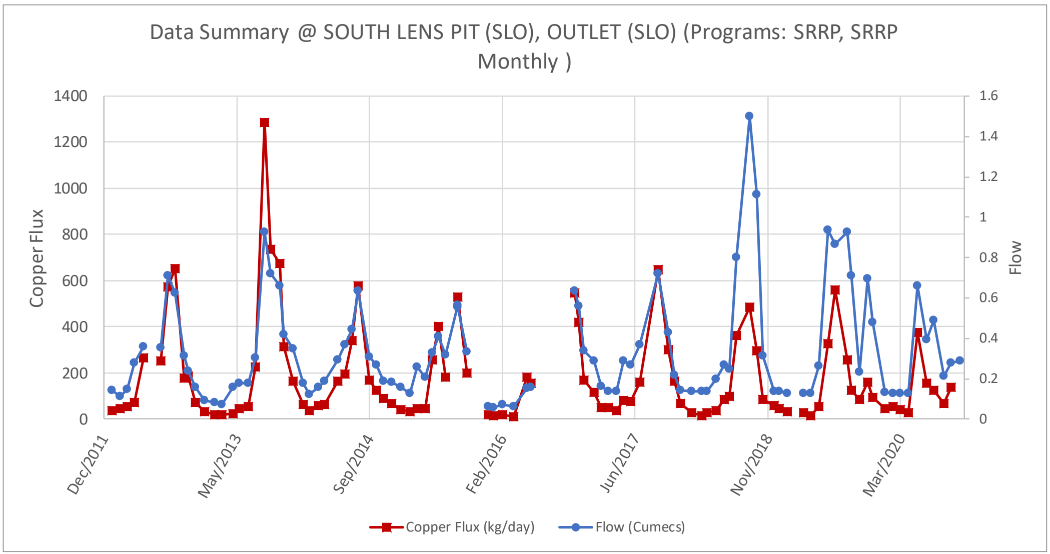

Figure 48: Total Copper flux with flow over time

Concentrations of copper and nickel at the SRbSWRD monitoring site have also shown a decline since 2017. This site is located downstream of the confluence with Broderick Creek, so the only change is that more of the Broderick Creek water is passing through South Lens before entering the Savage River, e.g., the decrease in concentrations cannot be attributed to dilution by new inflows. This data provides additional evidence that decreased metal loads may be being discharged from South Lens.

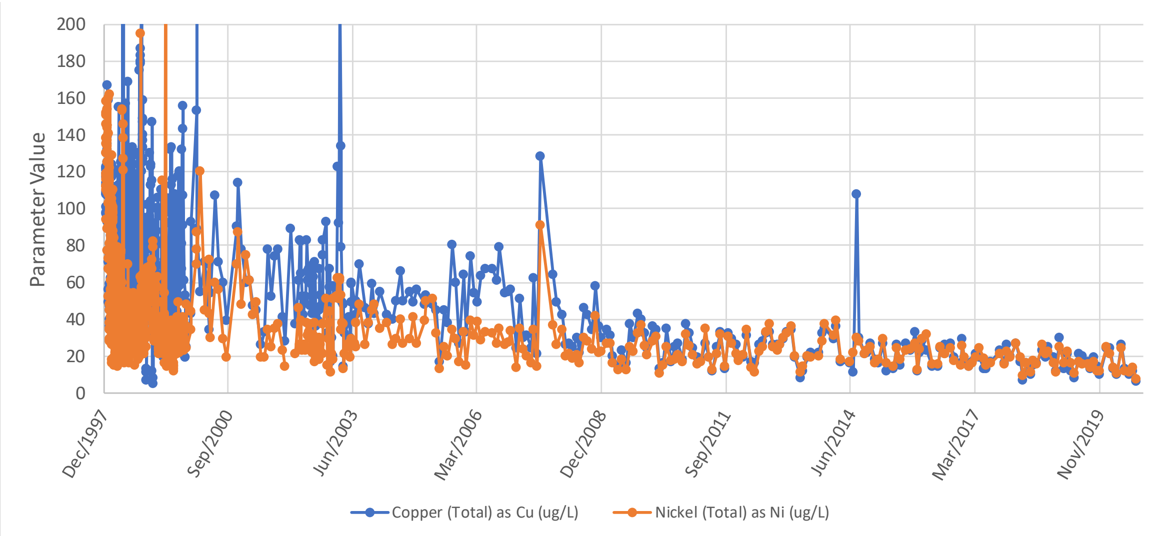

Figure 49: Copper and Nickel concentration over time Savage River below South Est Rock Dump

If metal fluxes have declined, or even remained constant, then the efficiency of metal removal within South Lens has not declined as the HRT has decreased. If this has occurred, then drivers in addition to HRT must be contributing to metal removal. These could include: changes in pH, changes in alkalinity, a decrease in metal inputs to South Lens or the physical processes governing metal removal have been changed. Each of these factors are discussed in the Water Quality Report in Appendix C, with an increase in sediment input and associated increase in surface identified as the most likely processes affecting metal removal in South Lens since 2017.

The metal removal discussion is relevant to copper and other metals (aluminium, iron, lead, chromium) which can be removed through neutralisation reactions at the pH conditions within South Lens. Metals such as manganese, and to a lesser extent nickel, cobalt and zinc, are not as efficiently removed under these conditions. A copper balance for South Lens suggests that 5.3 kg/day are entering the water body, with 1.3 kg/day discharged, resulting in a 75% reduction in flux. For nickel, the estimated inputs are 3.2 kg/day, with the average outflow estimated as 2.9 kg/day suggesting a 10% removal. Removal efficiency for cobalt and zinc would be expected to be similar to nickel.

Table 15: Estimated average copper and nickel balance in South Lens. 'Not adjusted' values based on flow and water quality measurements at the site. Based on monitoring results 2015 – 2020

Site	Cu tot (kg/day	Ni tot (kg/day)	Adjustments
NDD (input)	4.3	2.1	Reduced 5% as declined over period
CPN (input)	0.5	0.8	Not adjusted
Brod Ck (input)	0.3	0.3	Estimate 50% SLO flow *Cu_{avg} in Broderick Ck
Total In	5.1	3.2	
SLO (output)	1.3	2.9	Not Adjusted
% removal	75%	10%	

The recent investigations can be summarised as follows:

- The water quality in the discharge from South Lens has not shown an increase in metal concentrations or loads following a substantial increase in flow through the water body. The previous correlation between copper removal and HRT is no longer observable in the monitoring data
- The input from North Dump Drain has not changed substantially, and cannot account for the maintenance of good water quality in the South Lens discharge despite the reduction in residence time
- The input from North Pit contains high concentrations of alkalinity and sediment which have increased the alkalinity load into South Lens, and may have increased metal removal through increased surface area provided by the suspended solids; and
- The water quality results since 2017 suggest that the metal removal in South Lens has been at least maintained, and likely increased since the increase in inflow from North Pit, despite a reduction in HRT.

A multiple-lines of evidence approach suggests that increased surface area due to increased suspended solids in South Lens has increased the rate of metal removal by increasing available surface area for metal precipitation and adsorption.

The alkaline inflows to South Lens include water derived from Broderick Creek (Bretts Drain, North Pit discharge) and Centre Pit. Discharges derived from Broderick Creek (Bretts Drains and North Pit) will continue to enter South Lens as presently occurs. The North Pit inflow is not monitored but would be expected to be similar to Broderick Creek (Table 16). These inflows are characterised by neutral pH, low metal concentrations, elevated concentrations of alkalinity, and moderate (~300 -400 mg/L) sulphate. It is these inflows that provide the majority of the neutralisation capacity within South Lens.

Table 16: Total metals (μg/L) in water quality samples collected from Broderick Creek below Waste Rock Dump between 01/10/2017 and 01/10/2020

Statistic	Al Tot (mg/L)	Co Tot (mg/L)	Cu Tot (mg/L)	Fe Tot (mg/L)	Mn Tot (mg/L)	Ni Tot (mg/L)	Zn Tot (mg/L)
Mean	76	3	8	106	33	10	3
80th Percentile	57	3	11	84	38	10	4
Median	31	3	7	40	21	10	3
20th Percentile	20	3	5	20	10	10	2

Statistic	pH	Acidity (mg/L)	Tot Alkalinity (mg/L)	Ca (mg/L)	Sulphate (mg/L)
Mean	7.46	10	190	131	364
80th	7.56	12	219	148	408
Median	7.465	10	183	127	354
20th	7.34	8	166	113	294

Once pumping commences, the overflow from CPN will continue to enter the South Lens as presently occurs, but the volume will decrease as the groundwater gradient between Centre Pit North and Centre Pit South is lowered and eventually slopes towards CPS, as previously discussed. As pumping progresses, the overflow from CPN will cease and, all discharge will be via the pump system from CPS to the tank located near the CPN collection pond. The existing water quality in the CPN discharge is summarised in Table 17, and shows characteristics consistent with neutral mine drainage, i.e. pH values over 7, high levels of alkalinity, and increased concentrations of metals not removed at the pH of the discharge (e.g. Co, Zn, Ni, Mn).

Table 17: Summary of water quality from Centre Pit North based on monthly monitoring results September 2019 to September 2020.

Parameter	20th Percentile	Median	80th Percentile	Average
pH	6.96	7.06	7.17	7.07
Cond	2346	2440	2560	2282
Alk	132	150	166	149
Acidity	13	17.5	26.2	19.2
Ca	301.2	321	366.8	328.0
Mg	200.8	215	235	216.
Sulphate	1424	1485	1688	1532
Al	348.4	558	908.8	837.9
Co	227	236	271.2	245.3
Cu	92.4	137.5	185.6	142.2
Fe	410	585	1486	1272
Mn	2472	2580	2776	2622
Ni	184.2	193	210.2	197.1
Zn	48	51	58.4	52.7

The available water quality results from the pit lake in CPS are presented in Table 18 and shows the water body has low concentrations of copper and zinc, and variable concentrations of cobalt, nickel, manganese and iron. The metal concentrations correlate well with iron, suggesting that the elevated surface concentrations are attributable to adsorption onto iron floc. Oxygen profiles collected at the same time showed the water column was well oxygenated with depth.

The average metal concentrations from Broderick Creek are compared to water quality results in Centre Pit and South Lens from Centre Pit in Table 18. The comparison indicates that with the exception of iron, the concentration of metals in Broderick Creek and CPS are lower than the concentrations within South Lens, demonstrating that the inflow of these waters will dilute concentrations even without any removal due to neutralisation. The water quality results from CPS also indicate that if the more concentrated water from CPN is drawn into CPS dilution will occur, and the final quality of water pumped into South Lens will reflect the mixing of waters from the north and south pits.

Although lower than in South Lens, nickel and cobalt concentrations, and to a lesser extent zinc, are higher than present in the Savage River below Southwest Rock Dump. CPS dewatering could increase concentrations in the river if the proportion of flow derived from South Lens increases relative to present. The potential impact of the discharge on the Savage River is discussed in 6.2.4.

Table 18: Total metals (μg/L) in water quality samples collected on 20/12/2017 from the surface, mid-depth and bottom water in Centre Pit North and South Lens. In both pit lakes two locations were sampled (North and South).

Site	**Al (μg/L)**	**Co (μg/L)**	**Cu (μg/L)**	**Fe (μg/L)**	**Mn (μg/L)**	**Ni (μg/L)**	**Zn (μg/L)**
CPS N Surf	<20	111	4	701	1650	107	20
CPS N Mid	<20	60	8	198	964	76	22
CPS N Bot	<20	5	1	115	62	60	10
CPS S Surf	<20	116	4	793	1690	109	23
CPS S Mid	<20	61	7	196	972	75	22
CPS S Bot	<20	9	1	229	107	65	13
SLens N Surf	113	147	35	157	1420	109	22
SLens N Mid	53	144	25	269	1250	111	24
SLens N Bot	25	147	22	218	1270	117	27
SLens S Surf	115	146	34	181	1420	108	22
SLens S Mid	52	144	28	131	1270	110	24
SLens S Bot	28	153	23	110	1290	121	27
CPS avg	<20	60	4	372	908	82	18
Brod avg	76	3	8	106	33	10	3
S Lens avg	64	147	28	178	1320	113	24

A comparison between CPS and South Lens (Table 19) shows that alkalinity is lower in CPS (~100 mg/L) and average sulphate is about 10% higher than in South Lens These comparisons suggest that dewatering from CPS will not substantially alter the alkalinity balance or sulphate concentrations within South Lens. The same values for Broderick Creek are provided for comparison, and show higher alkalinity, and lower sulphate values.

Table 19: Comparison of water quality results from profiles in Centre Pit with average values in South Lens and Broderick Creek

Site	Acidity (mg/L)	Tot Alkalinity (mg/L)	Ca (mg/L)	Sulphate (mg/L)
CPS N Surf	1.5	94	194	912
CPS N Mid	6	104	189	831
CPS N Bot	9	110	213	896
CPS S Surf	1.5	94	197	900
CPS S Mid	6	102	188	827
CPS S Bot	9	111	205	892
CPS avg	6	103	198	876
South Lens Average	6	139	188	812
Broderick Ck Avg	10	194	131	364

As summarised above:

- The additional water being pumped to South Lens (in addition to that which flows in from Centre Pit North) contains high alkalinity and relatively low metals
- Dewatering of CPS will not affect the existing alkalinity / suspended solids / NDD interactions occurring within South Lens, as the same inflow from North Pit will continue to enter South Lens
- The HRT of water in South Lens is no longer considered the controlling factor for metal removal in South Lens, and pump rates should be guided by monitoring rather than calculated hydraulic retention time; and
- The increase in water discharged to South Lens will effectively be less than the pumped rate from CPS because once the water level within CPS is decreased, water contained within CPN may flow into CPS and be pumped, rather than flowing directly into South Lens.

Under the present water management scenario at Grange, water from CPN enters South Lens, with the volume reflecting rainfall (Figure 50). Average inflow rates are about 100 L/s, but regularly range up to ~250 L/s during rainfall events. As water level in the CP decreases, this water will be pumped via CPS rather than flowing directly into SL as discussed in Section 6.2.4. Therefore, the effective increase in discharge to South Lens will be the net difference between the pump volume and the seasonal overflow volume.

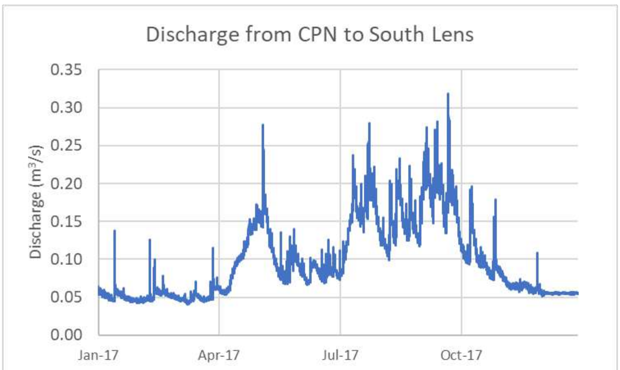

Figure 50: Discharge from Centre Pit North showing range of discharge rates

During the dewatering of South Deposit, the following equation was derived to link the maximum allowable pump rate to the flow in the Savage River at Pump Station (SRaPS) monitoring site. Sulphate levels in South Deposit were factored into the equation to ensure that sulphate concentrations within the Savage River remained within acceptable levels. Grange proposes to apply this same equation to the dewatering of Centre Pit, with the additional conditions that at flow rates of <1.5m^3/s at the SRaPS site, pump rates will be maintained at 100 L/s, and that pump rates will be capped at 500 L/s. Applying this equation and these conditions to the available flow rates at SRaPS in 2020, and assuming a sulphate concentration of 800 mg/L in Centre Pit, results in the pump rates shown in Figure 51Figure 51: Flow at the Savage River at Pump Station (m3/s) monitoring site and calculated pump rates (L/s) based on a sulphate concentration of 800 mg/L in the pumped water. The pumped water contributes between <1% of the combined flow (SRaPS + Pump Flow) during periods of high flow, to 14% during the driest periods when pump rates are maintained at 100 L/s.

$$Max_{Pump} = \frac{\left(SRaPS\ flow\ rate\ in\ \frac{m3}{s}\right) x\ 1000\ x\ 1.85\ x\ 0.57}{0.0189\ x\ (CPS\ SO_4^{2-}\ concentration\ in\ mg/L) - 2.6415}$$

$$Sulphate\ in\ mg/L = 0.3424\ x\ Conductivity\ in\ \mu s/cm - 14.935$$

Equation 1: Maximum pump rate from Centre Pit as a function of flow in the Savage River at Pump Station and sulphate in CPS.

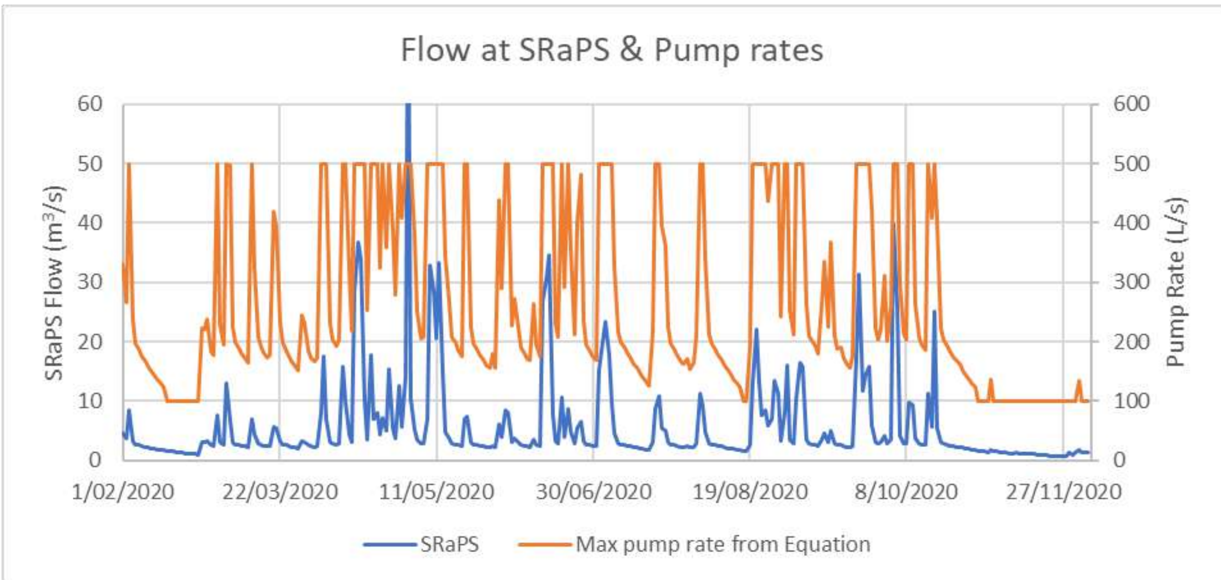

Figure 51: Flow at the Savage River at Pump Station (m3/s) monitoring site and calculated pump rates (L/s) based on a sulphate concentration of 800 mg/L in the pumped water

The volume and timing of water discharged from South Lens will be affected by the Centre Pit dewatering, with relatively higher flows discharged during dry periods when pumping is maintained at 100 L/s. As discussed in the previous section, concentrations in South Lens may not change substantially, however the increased discharge from South Lens during these periods could increase sulphate and metal concentrations in the Savage River as compared to present conditions due to the proportion of water derived from South Lens increasing.

6.2.3 Potential for acid and metalliferous drainage formation and management

Waste rock will be managed in accordance with the current WRMP (Appendix A) and is discussed in detail in Section 6.7. In summary, the waste that has been backfilled into CPN will be excavated and will be treated as D Type (potentially acid forming) waste unless able to be characterised otherwise. This waste will be deposited within one of the PAF areas in the Broderick Creek dumps or within a new PAF dump on the east side of the pit (Mill Dump). If deposited within the Mill Dump, it will be within an encapsulated D type waste area in accordance with the management plan.

All stormwater generated on site will be diverted to South Lens, or the Centre Pit and pumped to South Lens.

6.2.4 Potential water quality changes to Savage River due to pumping of Centre Pit

To evaluate the potential impact of the dewatering on the Savage River, it is assumed that all other inflows with respect to both water quality and water quantity to South Lens remain unchanged during the pumping period. Based on this, the increase in water discharged from South Lens is directly related to the increased quantity of water pumped into South Lens from Centre Pit. This assumption does not preclude mixing and dilution occurring within South Lens altering the quality of water pumped from CP, but only that the increase in discharge from South Lens will be controlled by the pumped volume.

The allowable pump rate from Centre Pit is governed by Equation 1. The relationship is effective at limiting the increase in sulphate, and can also be used to determine the mixing ratio that will occur between the pumped water from Centre Pit and the Savage River under different flow and sulphate conditions.

Mixing ratios between pumped water and flow in the river for flow rates in the SRaPS of 1.5 m^3/s to 7 m^3/s are shown in Table 20, and demonstrate that the pumped water will be diluted by a minimum 14.6-fold at sulphate concentrations of 900 mg/L, and up to 20-fold if sulphate concentrations increase to 1,200 mg/L in CPS.

Table 20:Mixing ratios (River Flow/Pump Flow) for South Lens discharge in the Savage River at different sulphate concentrations and flow rates in the Savage River below Pump Station. Pump rates based on Equation 1

SRaPS Flow	Sulphate in CP	Max Pump Rate	Mixing Ratio
(m^3/s)	(mg/L)	(L/s)	(River Flow+ Pump Flow)/Pump Flow
1.5	900	100	16.0
3.0	900	220	14.6
5.0	900	367	14.6
7.0	900	514	14.6
1.5	1200	100	16.0
3	1200	158	20.0
5	1200	263	20.0
7	1200	368	20.0

Copper, nickel, cobalt, zinc and sulphate are the parameters of most concern with respect to water quality in Centre Pit. The proposed trigger levels for water pumped from CPS are listed in Table 21.

Table 21: Trigger values for discharge from Centre Pit to Savage River based on the 90th / 10th percentile values of the monitoring results from November 2019 – Nov 2020

Parameter	90^{th} percentile trigger (10^{th} for Alkalinity)
Copper (total)	>221µg/L
Nickel (total)	>220 µg/L
Cobalt(total)	>282 µg/L
Zinc	>74 µg/L
Acidity	>30 mg/L
Alkalinity	<128 mg/L
EC	2725 µS/cm equivalent to 1660 mg/L SO4

The maximum potential increase in concentration in the Savage River due to dewatering CP is related to the volume of water pumped, the percent metal removal occurring within South Lens and the flow in the Savage River (Equation 2).

$$Potential\ increase\ in\ Savage\ River = \frac{Pump\ Rate * Concentration\ in\ Centre\ Pit * \%\ Removal}{Flow\ in\ the\ Savage\ River}$$

Equation 2. Potential increase in concentration in the Savage River due to pumping.

The relationship between the pump rate and flow in the Savage River has been previously described (Equation 1) and results in mixing ratios of between ~14 and 20-fold for the pump volume:river flow. Because metal and sulphate concentrations tend to be well correlated, if sulphate (and metals) increase, pump rates will decrease, providing higher mixing ratios.

The estimated removal rates for copper and nickel in South Lens are 75% and 10%, respectively, based on recent mass-balances (Table 15). Cobalt and zinc would be expected to have similar removal rates to nickel, as they precipitate in a similar pH range. Applying these removal rates to the CP trigger values (Table 22, column 2) provides an estimate of the maximum concentration of these parameters in the equivalent amount of water discharged from South Lens (Table 22, column 3). Applying the range of mixing ratios derived from Equation 1 provides an estimate of the potential increase in concentration in the Savage River due to the pumped volume after mixing in Savage River (Table 22, column 4).

Table 22: Predicted maximum increase in concentration of metals and sulphate in the SRbSWRD dump monitoring site

Parameter	Dewatering tank 90th percentile trigger	SL outflow concentration after removal	Increase at SRbSWRD attributable to pumping (14-20-fold mixing)
Copper (total)	>221µg/L	55µg/L	3 - 4 µg/L
Nickel(total)	>220 µg/L	198µg/L	10 - 14 µg/L
Cobalt (total)	>282 µg/L	254µg/L	13 – 18 µg/L
Sulphate	1,660 mg/L	1,660 mg/	83 - 118mg/L

This analysis shows the maximum estimated increase in water quality in the Savage River assuming the water in CPS has the same composition as the water being discharged from CPN. Metal concentrations in CPS are considerably lower and therefore more likely estimates of increases at SRbSWRD are shown in Table 24.

Table 23: Predicted likely increase in concentration of nickel, copper and sulphate in the Savage River at the Southwest Rock Dump

Parameter	Max value in CPS	Concentration after removal in SL	Increase attributable to pumping at SRbSWRD (16-20-fold mixing)
Copper (total)	10 µg/L	2.5 µg/L	<1 µg/L
Nickel(total)	110 µg/L	99 µg/L	5 - 6 µg/L
Cobalt (total)	116 µg/L	105 µg/L	5 – 7 µg/L
Zinc (total)	23 µg/L	21 µg/L	1
Sulphate	900 mg/L	900 mg/L	45 - 56

Based on these estimates, the maximum increase in copper concentrations in the Savage River is likely to be restricted to <5 µg/L, which is well within the existing variability of concentrations in the river and is likely to pose a low risk to the environment.

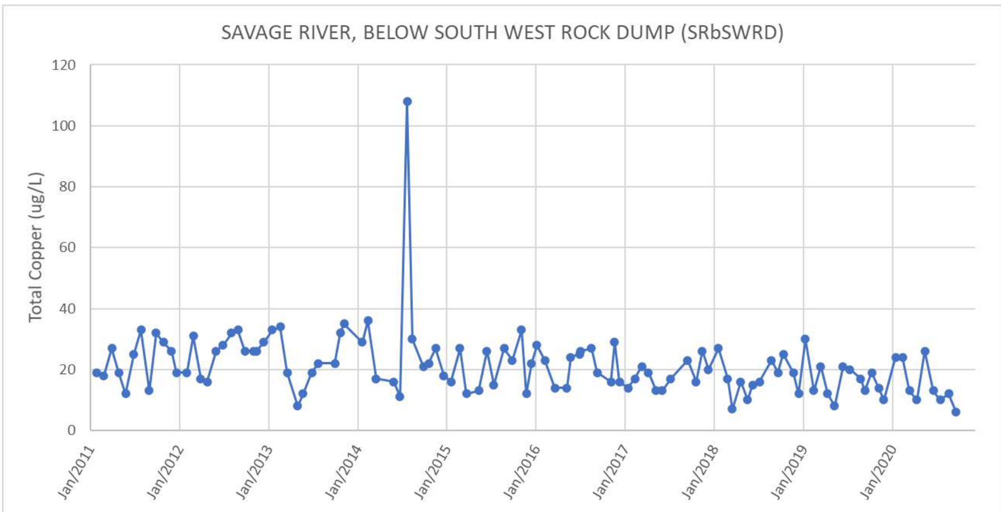

Figure 52: Total copper in the Savage River at Southwest Rock Dump 2011 - present

Nickel concentrations presently range from about 5 to 25 µg/L at SRbSWRD. Pumping CP could increase concentrations to between 15 to 40 µg/L under a worst case scenario of nickel in CP being equivalent to the trigger value. More likely, the increase will remain <10 µg/L. The maximum increase would increase concentrations at SRbSWRD above recent levels. The maximum estimated increase of up to 16 µg/L Co could also increase concentrations above the range of recent results. The potential increase in zinc of <5 µg/L could increase concentrations above recent values, but remain well within values recorded over the past few years, and would be unlikely to pose an environmental risk (Figure 53).

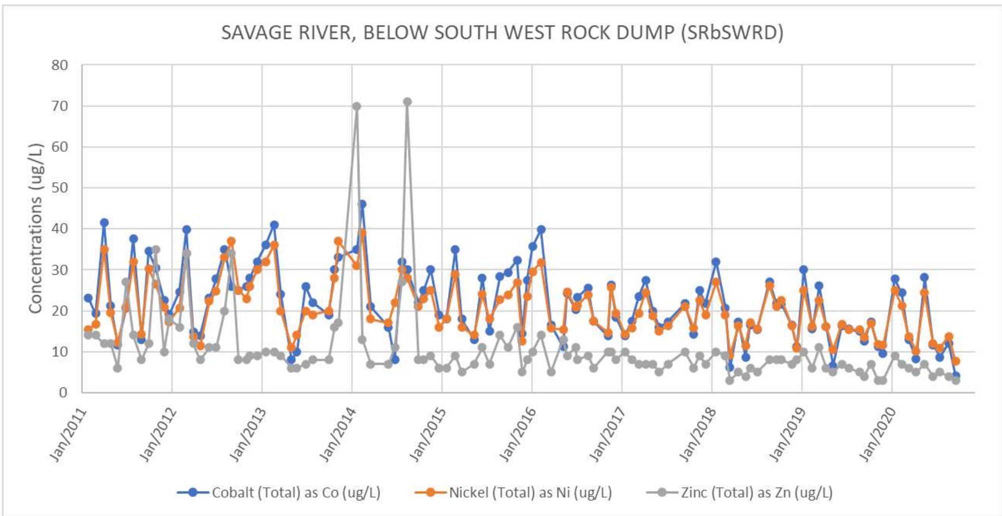

Figure 53: Time-series of dissolved nickel, cobalt and zinc in the SRbSWRD

The toxicity of nickel is related to the hardness of the water (ANZG, 2018). The ANZG (2018) formula for nickel toxicity has been used to revise trigger values in the Savage River. Applying the formula yields the following Trigger Values for Ni at SRbSWRD, see Table 24.

Table 24: Calculated trigger values for nickel in the Savage River at South West Rock Dump based on Hardness

Hardness (mg/L $CaCO_3$) at SRbSWRD	**Revised Nickel Trigger Value (μg/L)**
Average Hardness = 195 mg/L	54
Median Hardness = 180 mg/L	50
20^{th} Percentile Hardness = 110 mg/L	33

The water in CPS is very hard (>1,000 mg/L) so is likely to increase the hardness of water within South Lens and the Savage River. Based on this, increasing Ni at SRbSWRD from 2 - 25 □g/L up to potentially 40 □g/L (worst case scenario) should pose a low risk to the river.

For cobalt, the ANZG (2018) guidelines contain an ‘unknown’ percentile protection level for cobalt of 1.4 □g/L, which is well below the existing concentrations in the Savage River. The ANZG (2018) technical brief for cobalt states that a freshwater moderate reliability trigger value of 90 □g/L could be derived for cobalt, but there are some experimental results for chronic toxicity that are below this value making the moderate reliability trigger ambiguous. The ANZG (2018) technical brief also states that cobalt is adsorbed by suspended particulates and the solubility of cobalt may be increased by its complexation with dissolved organic matter. Whilst increasing the concentration of cobalt or any metal in the Savage River is not desirable, there is a low risk that the projected temporary increase in cobalt will have a deleterious impact on the river as compared to present, as the concentrations should remain well below the moderate, low reliability trigger of 90 □g/L.

Sulphate concentrations in the SRbSWRD range from 58 (10th percentile) to 247 mg/L (90th percentile) with a median value of 146 mg/L for the period 2016 – 2020. Compared to these values an increase of up to 118mg/L would be substantial, but the more likely range of 45 – 55 mg/L would retain concentrations within the recent range. The EC and sulphate trigger value set for SRbSWRD will alert Grange if concentrations are nearing the 90th percentile values, and management actions can be implemented if required. In general, sulphate is considered a low risk parameter with respect to toxicity, with environmental impacts linked to increased salinity, which is why monitoring EC is an effective approach.

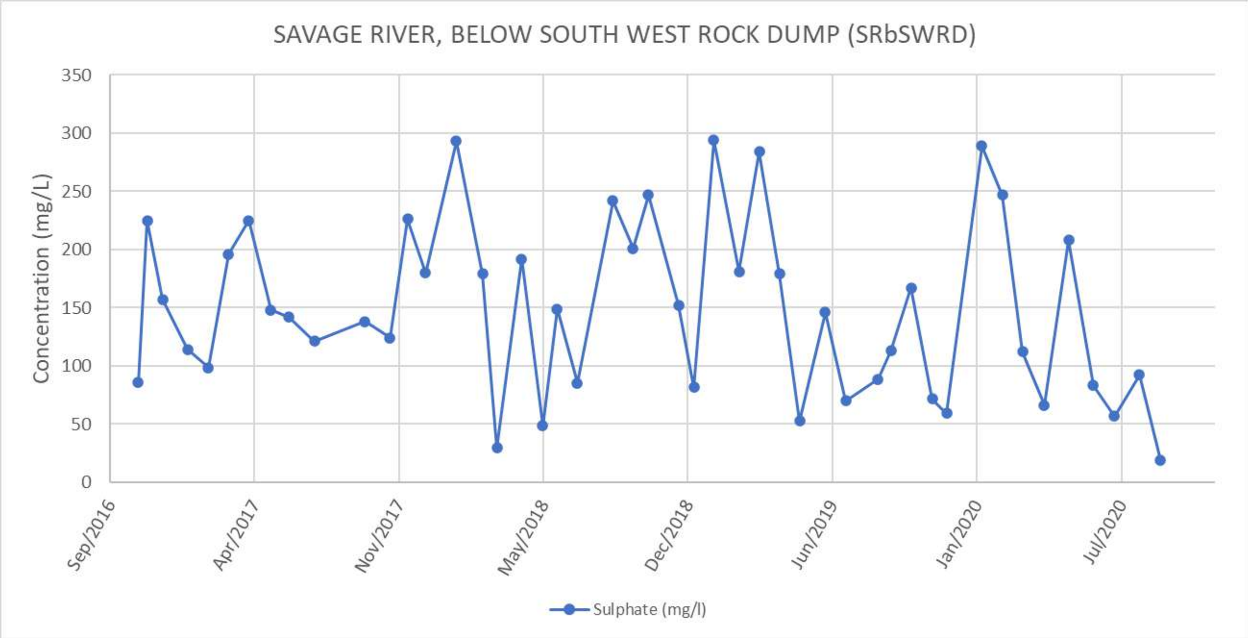

Figure 54: Sulphate concentrations in the Savage River below Southwest Rock Dump

The potential impact from the dewatering is over-estimated in this analysis because the existing input from CPN is included in the background concentrations in South Lens and the Savage River. In this sense there is some double accounting of the metals and sulphate during dewatering and in the existing concentrations in South Lens and SRbSWRD.

6.3 Pumping and monitoring regime and management responses

The following pumping strategy, monitoring schedule and Trigger Action Response Plan (TARP) summarises how Grange will manage the dewatering of CPS.

Continuous flow, EC, turbidity and pH monitoring will occur at the discharge tank between CPS and the CPN pond, the overflow from CPN pond to South Lens, SL outflow, the SRaPS, and the SRbSWRD monitoring sites. The pump rate will be adjusted once a day using Equation 1 and the most recent monitoring result for EC from the CPS dewatering tank. The flow rate used in the equation will be the average flow at SRaPS based on the previous 12-hours. If during any day the flow rate in the SRaPS decreases by more than 50% of the previous 12-hour average flow, an email alert will be sent to Grange and a pump adjustment will be made as soon as practicable. Flows will be adjusted up or down by increments of 100L/s rounded down to the nearest 100L/s based on the formula e.g. a permissible pump rate of 280 L/s rounds down to an actual pump rate of 200 L/s.

The continuous probes at these sites are linked to the Ajenti water information system. Alarm conditions will be implemented within Ajenti, and an email alert will be sent to Grange if alarm conditions are registered. These include:

- If flow in the Savage River at Pump Station falls below 1.5 m^3/s
- As flow increases or decreases at SRaPS to allow changes to pump rates
- If EC values recorded at any of the sites exceeds the trigger values for the site; and
- If the monitoring probe loses communication with the Ajenti system.

Table 26 summarises the monitoring strategy that will be implemented during dewatering of Centre Pit. At the initiation of pumping, weekly monitoring will be implemented, along with the continuous EC, pH, turbidity and flow monitoring. The water samples will be submitted to a NATA registered laboratory for analysis, and total copper and nickel concentrations will also be determined on site to provide near real time results. Zinc and cobalt are not easily monitored on site, but are strongly correlated with nickel (Figure 55). By monitoring nickel there should be a continuous understanding of how these metals are trending in the pump water.

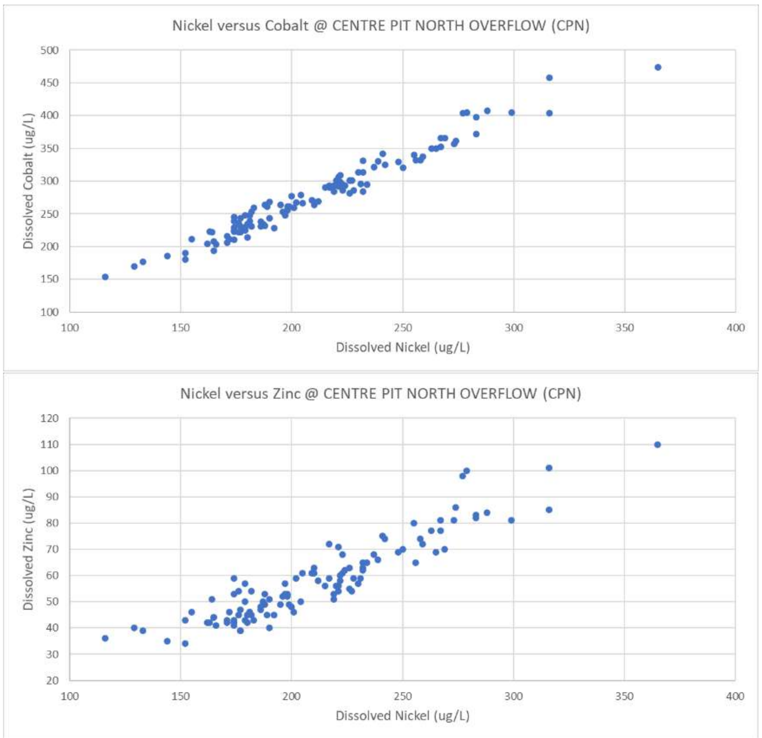

Figure 55: Relationship between dissolved nickel and dissolved cobalt (left) and dissolved zinc (right)

The parameter suite to be determined on the weekly samples submitted for analysis includes: alkalinity, acidity, total and filtered metals and metalloids (Al, As, B, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se, Zn) cations (Na, K, Ca, Mg) anions (SO_4, F, Cl) and TSS. In situ measurements of pH, EC, turbidity and temperature will also be determined during monitoring.

Weekly monitoring will continue throughout the first 3-months of dewatering. If dewatering extends beyond 3-months, the sampling strategy will be reviewed with the potential to reduce monitoring. Once dewatering of the pit is completed, monitoring will revert to monthly as is presently implemented.

Table 25: Monitoring strategy during dewatering of Centre Pit

Location	Parameters	Method and Frequency	Comment
* CPS Pump discharge to CPN pond at dewatering tank	Total Metals, sulphate, alkalinity, acidity, TSS	Grab sample weekly for laboratory analysis of all parameters Copper and nickel analyses completed on site weekly to provide immediate results Monitoring frequency re assessed after 3 months	To determine if water quality is changing as pit is dewatered
	Flow, EC, pH	Online continuous	Indicators of change
CPN to South Lens (the combined discharge of CPN and the pump water to South Lens)	Total Metals, sulphate, alkalinity, acidity, TSS	Grab sample weekly monitoring frequency re assessed after 3 months	Samples may show high variability if water is not well mixed in the CPN pond
	Flow, EC, pH	Online continuous	Indicators of change
South Lens Outflow (SLO)	Total Metals, sulphate, alkalinity, acidity, TSS	Grab sample weekly monitoring frequency re assessed after 3 months	To compare predictions with reality & ensure no major change in WQ
	Flow, EC, pH, turbidity	Online continuous	Indicators of change
Savage River at Pump Station) (SRaPS)	Total Metals, sulphate, alkalinity, acidity, TSS	Grab sample monthly	As per EPN 248/2 to document any changes in water quality during pumping
	Flow, EC, pH, turbidity	Online continuous	Indicators of change
Savage River below South-West Rock Dump (SRbSWRD)	Total Metals, sulphate, alkalinity, acidity, TSS	Grab sample weekly	To document any changes in water quality during pumping
	Flow, EC, pH, turbidity	Online continuous	Indicators of change

The dewatering process will be guided by the monitoring results, with the management actions in Table 26 implemented if trigger values are exceeded. It should be stressed that exceeding a trigger value does not indicate environmental harm is occurring, rather, the triggers signal that the water quality is nearing the limits (90^{th} percentile) of the existing range of results, and a review is warranted.

Table 26: Management actions in response to monitoring results exceeding trigger values

Control	Trigger	Action	Implementation
Pump operations	Flow at SRaPS	Based on equation 1, and adjusted every 24 hours based on average flow over preceding 12-hours	Automated through Ajenti, with email notification sent to Grange Alarm set and email notice sent if flow decreases more than 50% from previous 12-hour average
Pump operations	Flow at SRaPS < 1.5 m3/s	Pump rate decreased to 100 L/s	Automated email from Ajenti alerts when flow decreases below 1.5 m3/s and above 1.5 m3/s
Water quality	Water quality at CPN exceeds triggers including EC values based on previous 12 hour average EC	Increase onsite Cu and Ni monitoring at SL outflow to 2/week	
Water quality	Water quality at SL outflow exceeds triggers, including EC values based on previous 12 hour average EC	Decrease pump rate by 100 L/s & investigate cause Increase monitoring at CPN and SL outflow to 2/week If triggers exceeded for an additional week, decrease pump rate by another 100 L/s to a minimum of 100 L/s If water quality at SRbSWRD remain within trigger limits, re-evaluate SL outflow triggers	
Water quality	Water quality at SRbSWRD exceeds triggers, including EC values based on previous 12 hour average EC	Decrease pump rates by 100 L/s Increase monitoring at SL outflow and SRbSWRD to 2/week Evaluate change and report to EPA	

The proposed water quality trigger values during dewatering for the discharge from South Lens and the SRbSWRD are shown in Table 32, Table 33 and Table 34. The triggers for CPN are based on the most recent 12-months of results to reflect the present water quality being discharged to SL. The triggers for SL and SRbSWRD are based on the past five-years of available results to capture the variability inherent in the river system.

Table 27: Summary of trigger values for dewatering based on monitoring at CPN October 2019 – September 2020

Parameter	90th percentile trigger	10th percentile trigger
Copper (total)	>230 µg/L	
Nickel (total)	>222µg/L	
Cobalt	>282 µg/L	
Zinc	>74 µg/L	
Acidity	>20 mg/L	
Alkalinity		<167 mg/L
EC	>2758 µS/cm	

Table 28: Summary of trigger values for discharge from South Lens based on monitoring at SLO 2016 - 2020

Parameter	90th percentile trigger	10th percentile trigger
Copper (total)	>76 µg/L	
Nickel (total)	>129µg/L	
Cobalt (total)	173 µg/L	
Zinc (total)	35 µg/L	
Acidity	>9 mg/L	
Alkalinity		<128mg/L
EC	1815 µS/cm	

Table 29: 90th percentile pH value and concentrations in the Savage River below Southwest Waste Rock Dump based on monthly monitoring results 2016 – 2020

Parameter	90th Percentile	10th Percentile trigger
Copper (total)	26 µg/L	
Nickel (total)	25 µg/L	
Cobalt (total)	28 µg/L	
Zinc (total)	10 µg/L	
pH		7.0
Alkalinity		<21 mg/L
Acidity	>5 mg/L	
EC	788 µS/cm	

6.4 Reporting

Grange will notify the EPA as soon as practicable if a trigger value has been exceeded, the suspected reason for the exceedance, and what management action(s) have been implemented.

Grange will summarise and report monitoring results and management actions on a weekly basis via email to the EPA. The summary will provide any updates regarding trigger levels that may have been exceeded, including any additional management actions that may have been implemented, or intending to be removed. The range of pump rates implemented during the week will also be included.

Monthly reporting to the EPA will include a more detailed summary of the monitoring results, including time-series graphs showing EC results from the CPN pump tank, SL outflow and SRbSWRD monitoring sites. The monthly report will compare the monitoring results to the trigger values and discuss whether the water quality trends are within expected ranges. The monthly report will also include an update as to when the dewatering is likely to be completed, and routine mining commencing.

6.5 Groundwater

6.5.1 Potential impacts of the proposal on groundwater (quality and quantity)

An assessment of groundwater inflows was undertaken by AQ2 (Appendix G) based on geotechnical drilling undertaken by Grange Resources in 2018. Specifically, the assessment was intended to estimate potential groundwater inflows to the north wall of Centre Pit (i.e. water flows from South Lens and/or the Savage River) to Centre Pit.

Key outcomes of this assessment were:

- The hydrogeological units are interpreted to be:
  - Transition Zone – weathered/fractured rocks down to a vertical depth of around 30 m with a bulk permeability of around 0.2 m/d, through which most of the inflows are likely to occur
  - Fresh Rock – variably fractured rocks with a bulk permeability of around 0.003 m/d, through which minor inflows will occur.
- Historical inflows to the existing Centre Pit from the northern wall have been estimated at 2 L/s, although this is conservative
- An analytical flow model was used to predict future inflows to the final pit from the northern wall. The model predicts future inflows in the range of 2 to 3 L/s
- Inflows will collect at the toe of the northern pit slope and can be effectively managed by pit floor sump pumping and pumped back to South Lens for treatment/polishing (as with dewatering production from North Pit) before being discharged to the Savage River; and
- CP inflows and CP outflows have been at steady state for many years. Therefore CPN outflows represent all of pit inflows. Average outflow for CPN is 0.1 cumecs or 100 Litres/sec.

6.5.2 Map showing the location of any groundwater bores.

The location of groundwater bores in the area is shown in Figure 56 These are as identified in the Groundwater Information Management System managed by DPIPWE and are shown as abandoned or the status is unknown.

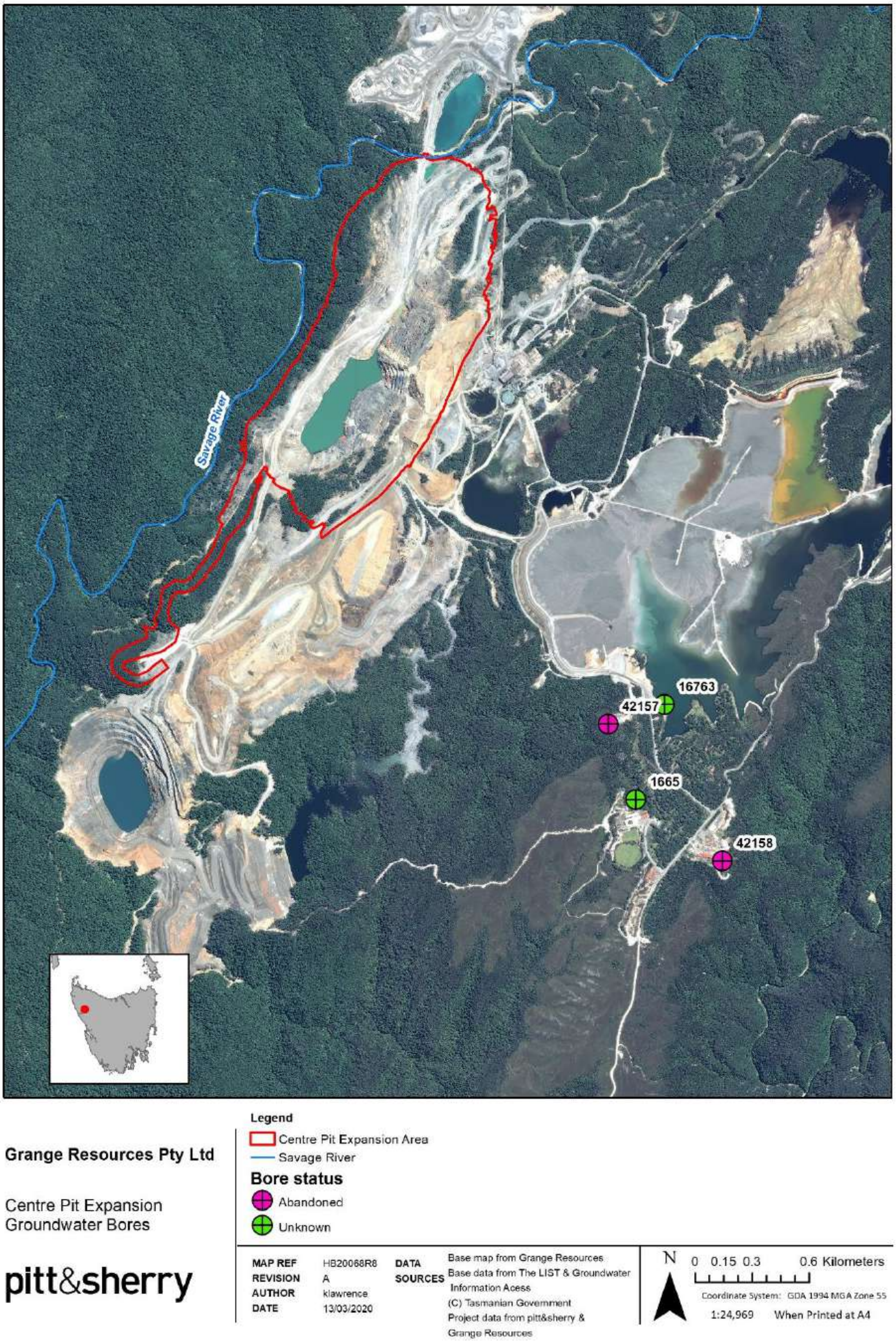

Figure 56: Groundwater bores in the locality

6.6 Noise emissions

6.6.1 Potential impacts of the proposal on ambient noise levels

The proposal relates to expansion of Centre Pit, within the existing Savage River mine. This is an active mine site in a remote location with no sensitive uses located within 2 km of the mine extent.

Savage River mine is operated in accordance with the requirements of the Goldamere Agreement. This requires that activities on site be conducted in accordance with best practice environmental management (BPEM). This refers to the management of the activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the current international and national standards applicable to the activity.

Savage River mine is regulated under several EPNs issued for the operation of mining and mineral works and various activities on site, as outlined in Section 5.2.12. None of these refer specifically to management of noise generated on site.

6.6.2 Identify and describe all major sources of noise

Noise generating activities on site include:

- Extraction via truck and shovel operation
- Material transportation on site by trucks
- Use of front-end loader and truck to feed ore from stockpiles into the crushers
- Operation of the gyratory crushers
- Transport of crushed ore to the concentrator stockpile via an overland conveyor; and
- Pumping of slurry to Port Latta via an overland pipeline.

6.6.3 Map of the location of all major sources of noise

The site plan at Figure 6 identifies all plant and equipment.

6.6.4 Potential for noise emissions (during both the construction and operational phases)

None of the processes outlined above will change and the noise levels on site are not expected to increase above existing levels as a result of the Centre Pit expansion.

6.6.5 Potential to cause nuisance for nearby land users, particularly at noise sensitive premises.[2]

The nearest sensitive premises are in excess of 2.3 km from the mine site. The required attenuation zone for open cut mines under the adopted State Planning provisions of the Tasmanian Planning Scheme is 2 km. The buffer to rock grinding works is 750 m. The proposed expansion will comply with these standards and is therefore considered to meet this best practice recommendation.

[2] 'noise sensitive premise' is defined as: residences and residential zones (whether occupied or not), schools, hospitals, caravan parks and similar land uses involving the presence of individual people for extended periods, except in the course of their employment or for recreation.

6.6.6 Potential for noise emissions to affect terrestrial, marine and freshwater wildlife and livestock

The noise levels on site will not change. Any fauna in the adjacent native vegetation communities will be experiencing that level of noise now and is unlikely to be disturbed by the proposed expansion. Expansion works will occur over time and accordingly any shift toward Savage River and western vegetation will occur gradually which allows animals to move away at their own pace if necessary.

6.6.7 Consistency with requirements of the Tasmanian Environment Protection Policy (Noise) 2009

The environmental values to be protected under the policy are:

- The wellbeing of the community or a part of the community, including its social and economic amenity; or
- The wellbeing of an individual, including the individual's health and opportunity to work and study and to have sleep, relaxation and conversation without unreasonable interference from noise.

Residents at Savage River are in excess of 2.3 km from the mine and outside any prescribed attenuation zone. If any noise is experienced those levels will not be increased by the proposed expansion. Employees on site are protected by adopted and successful HSE measures and operational safeguards on site.

6.7 Waste management

6.7.1 Potential impacts of waste generated by the proposal

Large quantities of rock are extracted and crushed to obtain the ore leaving a large volume of waste rock for disposal or re-use. The key management issue for waste rock at Savage River mine is that some of it has the potential to oxidise and form acid when exposed to air. This acid can be taken up by water moving through the site. This acid alters the chemistry of surface and drainage waters on site which if untreated, or poorly managed, can have serious ecological consequences if discharged to natural environments. Currently Grange Resources implements a WRMP (Appendix B) to ensure all waste rock is dumped in an appropriate manner to prevent acid formation. This plan is approved by the EPA and described in the current Environmental Management Plan for the mine. The mine also manages all water on site, so it passes through the South Lens centralised water treatment system prior to discharge.

6.7.2 Geochemical characteristics of Centre Pit Waste Rock

A geochemical summary of each Savage River deposit/pit is shown below. Centre Pit North and Centre Pit South have similar paste pH values, however, Total S is higher for Centre Pit South and correspondingly, the NAG pH values are lower whilst ANC is higher for Centre Pit North. In comparison to other evaluated deposits/pits Centre Pit presents the lowest AMD risk with lower Total S reported and higher NAPP values measured.

The geochemical data reported for Centre Pit North and South is within the range reported for all geochemically studied Grange Resources samples. This suggests that the management of waste material and AMD generated by future wastes by the Centre Pit Project is not going to present any new (significant) geochemical challenges for the site.

Table 30: Waste rock geochemical indicators

	Paste pH	**Total S (%)**	**NAG pH**	**NAPP**	**ANC**
Centre Pit North	9	1.21	6.65	-16	53
Centre Pit South	9.2	3.2	2.6	78	21
North Pit	8.9	2.6	5.6	-38	118
South Deposit	9.1	1.2	8.3	-192	229

Grange has an extensive database of ABA / geochemical data from waste rock sampling and analysis at Savage River. Geochemical and AMD predictive plots are shown below for CPN and CPS, displayed left to right respectively. Centre Pit samples / data are displayed in red and overlaid on the all of site data in blue.

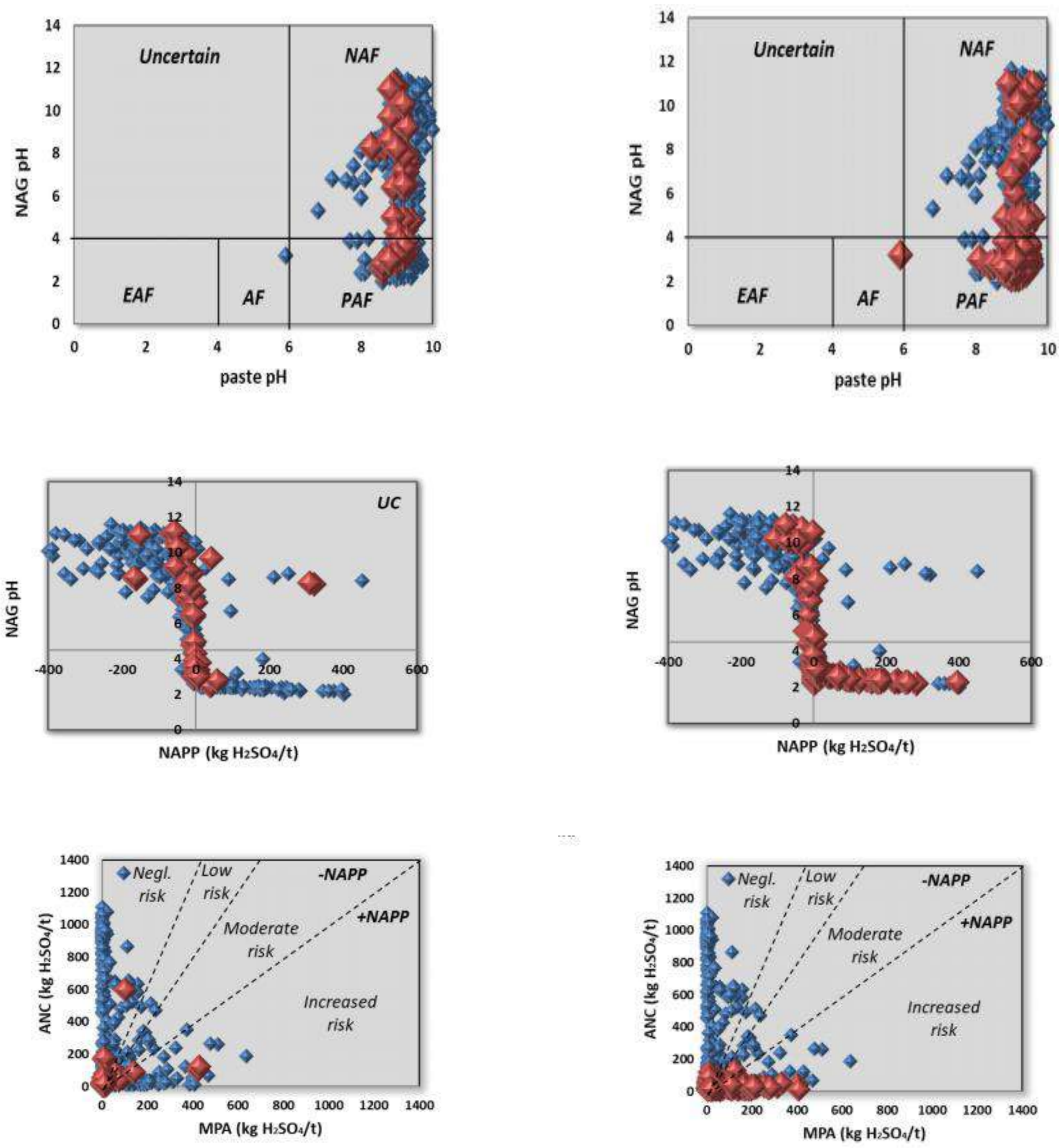

Figure 57: Waste characterisation graphs

6.7.3 Nature of waste rock

Waste types are identified during the geological exploration phase. Samples are obtained from surface collection and drill cores and the following Acid Based Account Tests are conducted:

- NAG - net acid generation
- NAGpH –pH measure
- MAP – Maximum Acid Potential
- ANC - Acid neutralising capacity; and
- NAPP – net acid producing potential.

This is discussed in more detail in the WRMP. No kinetic test work has been undertaken due to the approximate two-year time frame required to obtain results.

Waste rock types are classified into four groups based on geochemical characteristics such as acid producing potential, presence of sulphides and geology. These waste types, and their treatment or suitability for use on site, are summarised Table 31 and described in more detail in Table 32: Waste type definition

Table 31: Waste types and treatment or reuse options

Waste Type	Acid formation	Treatment or use
A Type	Non-acid forming (NAF)	If hard and in block form this is reserved for construction of flow through. Weaker A type is used for erosion protection or disposed in standard dumps with B Type waste
B Type rock	Neutral - low risk material.	This material does not require encapsulation as it contains sufficient alkalinity to prevent the long term forming of acid mine drainage.
C Type	NAF	These clays are reserved for capping of the PAF cells
D Type	Potentially acid forming (PAF)	This waste rock must be encapsulated to prevent oxidation. D Type dumps should be finished with an external end dumped clay layer and an outer end dumped layer of A Type rock

Table 32: Waste type definition

Waste Type	Material Lithology	Material Character	Flow Through Suitability	Net Acid Producing Potential (NAPP)	Presence of Sulphides	Acid Forming
A	Fresh chlorite, carbonate, calcite schist, magnesite or dolomite	Hard weather resistant and durable	Yes	<-30 kgH_2SO_4/t, Alkalinity ≥ Max Acidity	No or minimal visible pyrite	NAF
	Weathered magnesite, dolomite or chlorite – carbonate schist	Soft liable to break down by weathering or compaction	No	<-30 kgH_2SO_4/t, Alkalinity ≥ Max Acidity	No or minimal visible pyrite	NAF
	Metamorphosed gabbro, dolerite and basalt	Hard weather resistant and durable	Yes	<-30 kgH_2SO_4/t, Alkalinity ≥ Max Acidity	No or minimal visible pyrite	NAF
B	Western stratigraphic units with albite / chlorite / muscovite.	Friable, weak rock units	No	Neutral, ANC = MPA	Some visible pyrite – sufficient capacity for self-neutralisation	Neutral
C	Schist, low sulphide serpentinite and clay	Soft liable to breakdown by weathering or compaction	No			NAF
D	Chlorite – sulphide schist, sulphide intrusives, serpentinite, talc schist, mixed waste rock and unidentified materials		No	>+30kg H_2SO_4/t, ANC < MPA	Significant visible pyrite	PAF

6.7.4 Estimated quantities and production rates of waste rock types

The proposed final pit contains the quantities of waste by category as shown in Table 28.

Table 33: Volume of waste by categorisation

Material Type	Million BCM*	Million Tonnes
A Type	27	77
B Type	23	64
C Type	3	6
D type	30	88
backfill	8	19
Total	91	255

*Million bulk cubic metres

6.7.5 Potential for acid and metalliferous drainage formation

If stored inappropriately, waste dumps have the potential to generate acid runoff and resultant ecological impacts (Figure 58. To prevent this a soil cover is placed over the dump to reduce the movement of oxygen and water into the dump. Typically, compacted layers of clay are used, however, soils with suitably low permeability are also sufficient. Clay sediments found on site have been determined to be suitable for this purpose. The higher rainfall at Savage River assists in maintaining soil saturation which helps reduce oxygen diffusion to effectively negligible levels. Testing of material in Centre Pit indicates that the current practices for the management of waste rock are sufficient for the nature of waste present.

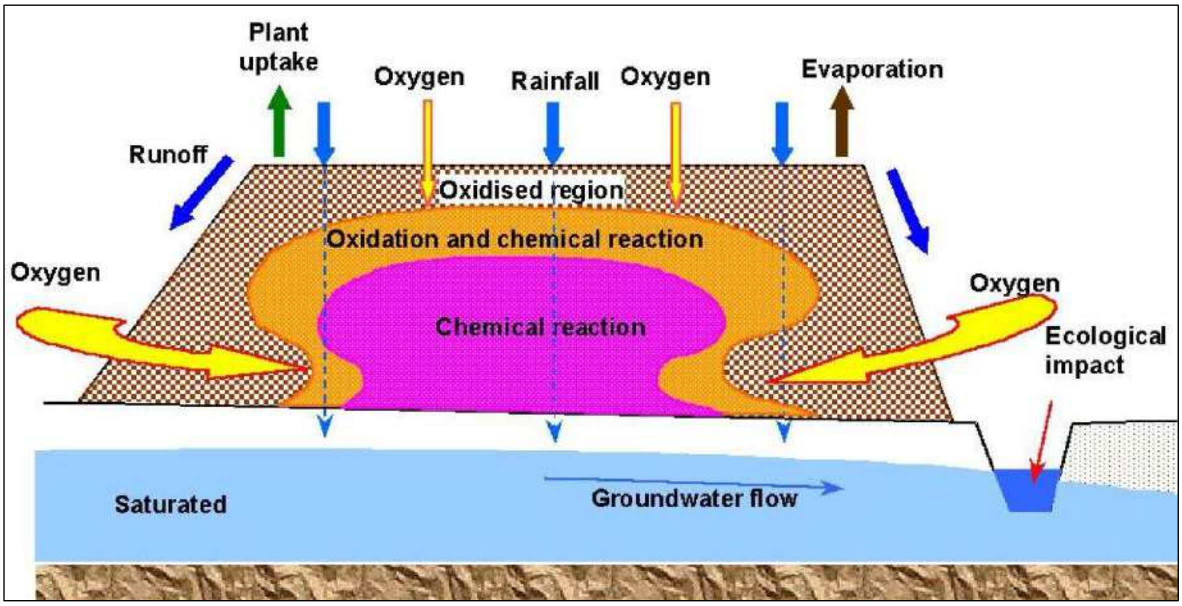

Figure 58: Diagram demonstrating oxygen and water transport into waste dump

A range of modelling scenarios were investigated (WRMP – Appendix B) and it was determined that D-type waste dumps are to be constructed by:

- Covering the base and top of the D-type dump with a minimum of 2 m of compacted C-type "clay". Track rolling successive paddock dumped layers is an acceptable method of compacting the C-type where further dump layers (>15 m) are to be placed above
- Covering the sides of the D-type dump with a minimum of 3-5m of un-compacted C-type "clay"; and
- An outer layer of A-type armouring, at least 5 m thick, shall be placed over the final layer of C-type capping to prevent erosion of the C-type and provide stability.

A section through a typical D-type cell is provided in Figure 59.

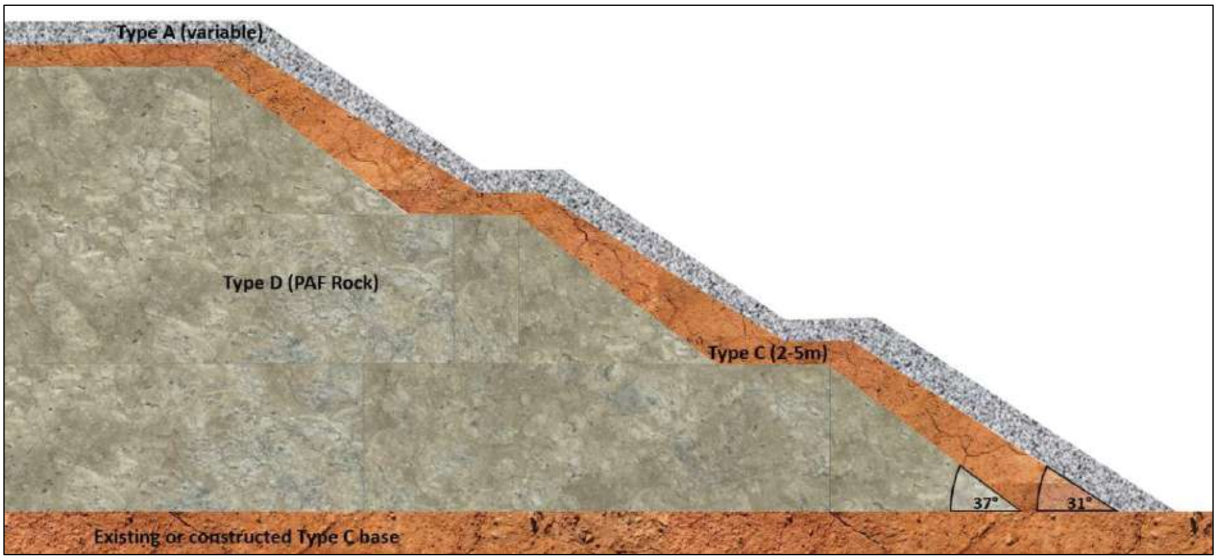

Figure 59: Section through D-type cell

6.7.6 Waste rock management

Waste rock will be managed in accordance with the current WRMP. Waste rock that has been backfilled into Centre pit will be excavated and will be treated as D Type (potentially acid forming) waste unless able to be reclassified to other waste classifications. This waste will be deposited within one of the PAF areas in the Broderick Creek dumps or within a new PAF dump on the east side of the pit (East Mill Dump). If deposited with the East Mill Dump, it will be within an encapsulated D type waste area in accordance with the management plan. New waste rock from Centre Pit will also be disposed of in accordance with the WRMP as outlined in the following sections. Waste is proposed to be stored in the locations listed in Table 29 and as shown on Figure 60.

Table 34: Waste dumps to be used

Dump Name	**Capacity**	
	Million m^3	**Million Tonnes**
Centre Pit Dump	28	65
Mill Dump	11	25
Buttress	0.5	1.2
Broderick Creek Dump Complex (Contains CP and NP Rock Waste)	352	810

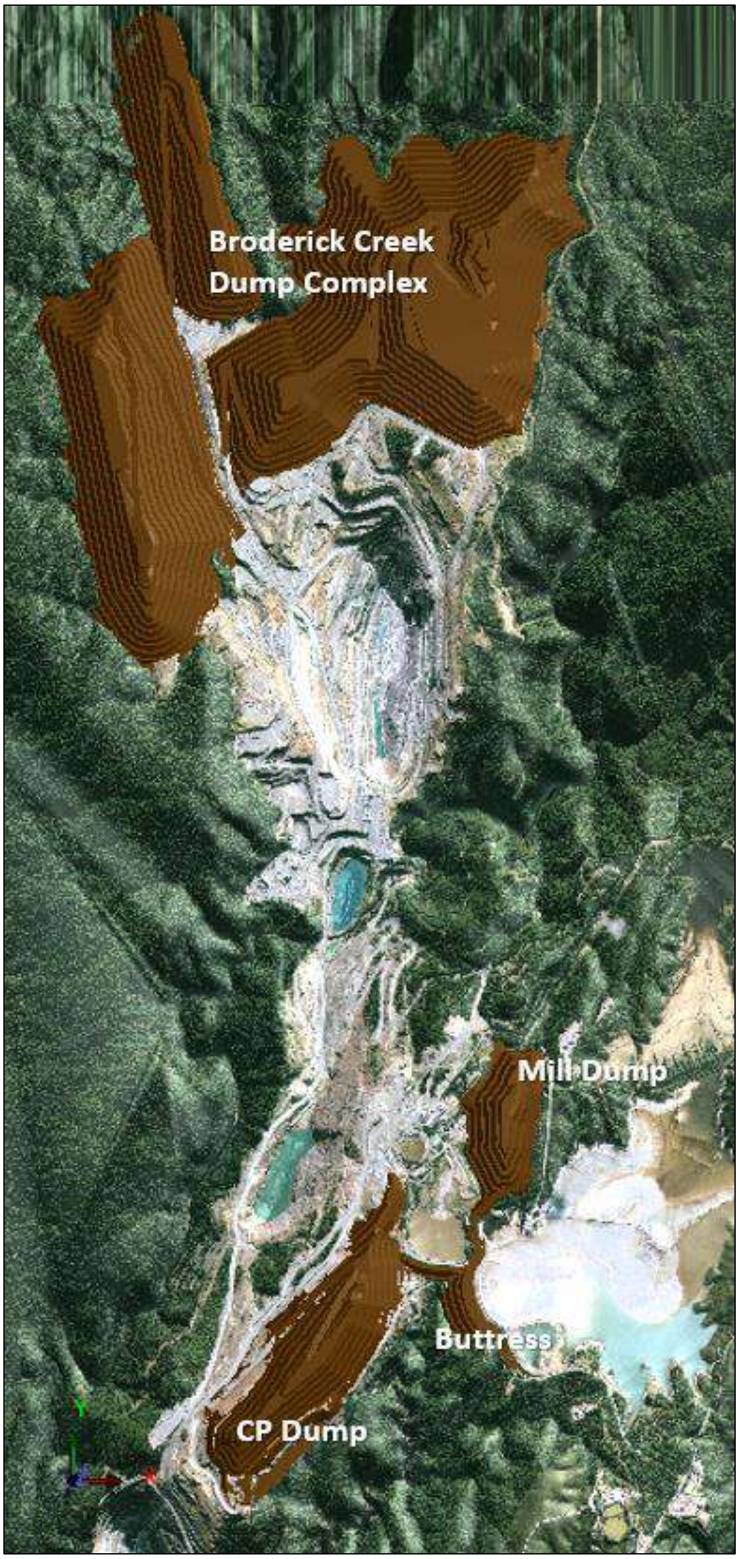

Figure 60: Location of waste rock dumps

6.7.7 Centre Pit Dump

B Dump and the Southern Dump are existing dumps on site that contain a mixture of waste types. It is proposed to increase the height of these dumps with a combination of waste rock types. D type waste will be encapsulated as outlined above and detailed in the WRMP. The dump has been designed to contain an additional 28 million m^3 of waste rock material. The current proposed design for the extended B Dump and Southern Dump, (Centre Pit Dump) is shown in Figure 61.

At completion, the dump will be 140m high from the original natural surface. The dump will have overall slope of 30 degrees on the eastern side and 25 degrees on the west due to the placement of truck ramps and access.

The integrity of the water shedding cover previously placed on the top of B dump is not likely impacted by the placement of additional waste and weight onto the dump. Additional waste may even improve the existing cover by providing additional compacting force and further reducing the ingress of water and oxygen into the old dump.

Geotechnical modelling during the feasibility stage of the mine design did show instability in the south east corner of CP that had the potential to impact the northern western corner of this dump. The pit design has since been modified to reduce the pit wall angle and reduce this risk. Geotechnical analysis and monitoring of this wall and the dump will take place on a continual basis during the mining of CP to ensure its safe management. Monitoring will be conducted using robotic total stations or similar and regular pit inspections will be conducted by on-site geotechnical engineers. Analysis will be triggered and based on ongoing reconciliation of geotechnical design assumptions as mining progresses.

In the event that a failure of the dump did occur and exposed PAF material the newly exposed PAF material would be removed and placed in an alternative PAF storage location. Clay encapsulation and erosion protection would then be established in the failed area.

If that is required, the waste to be removed will be sampled and categorised in accordance with the WRMP. The removed waste would be sent to an alternative waste dump, either the Mill Dump or the Broderick Creek Dump Complex. If this resulted in the exposure of PAF material in the dump a new clay cover and erosion protection would be established to the standard and as described in the WRMP over the exposed area. There is a 10m wide berm at the base of the waste dump backfill between the pit and the dump.

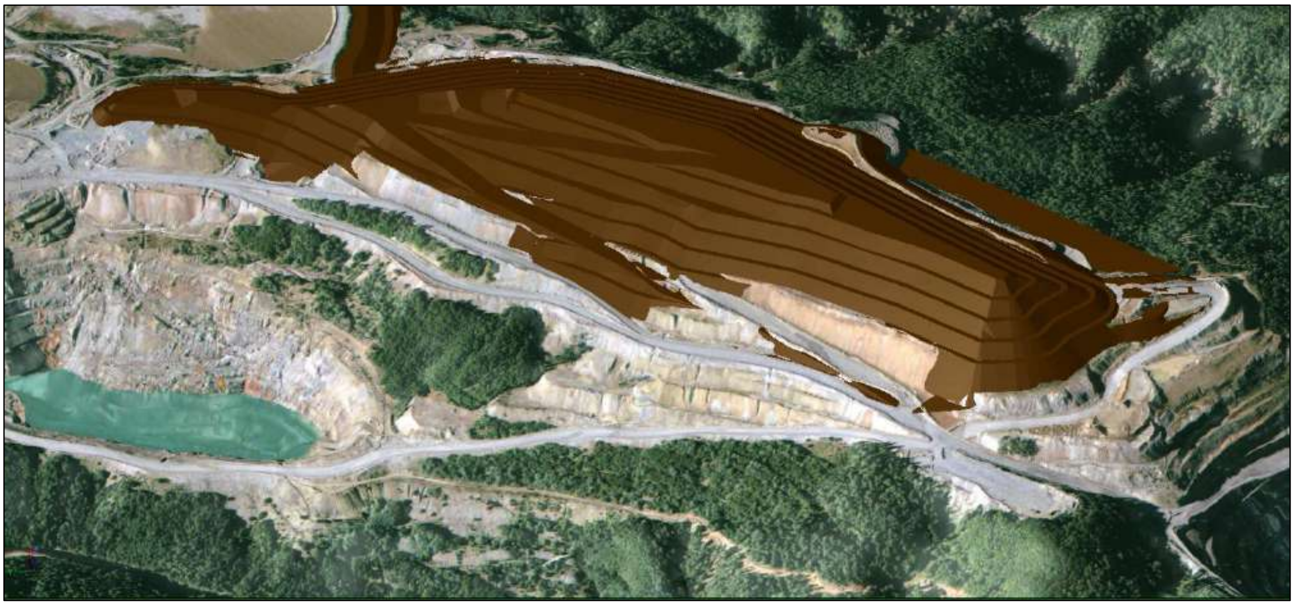

Figure 61: Expanded B and Southern Dump

6.7.8 East Mill Dump

The East Mill Dump is adjacent to the current mill in a previously disturbed valley area. The site contains excavated rock waste from the construction of the mill and infrastructure at the start of the mine. The east mill dump will contain a combination of material types. D type waste will be encapsulated as outlined above and detailed in the WRMP. The dump has been designed to contain 11 million m^3 of rock waste material and the current proposed design is shown in Figure 62.

Figure 62: East Mill Dump

6.7.9 MCTD Buttress

A buttress will be constructed against the MCTD wall. The buttress requires 0.5 million m^3 of rock waste material. This will be built from A type and B type. The buttress is required to improve the long-term and closure factor of safety to the Main Creek Tailings Dam wall. The proposed buttress design is shown in Figure 63. The MCTD buttress does not require keying into the existing MCTD wall. There will be no removal of material or alterations to the existing MCTD wall.

The buttress provides weight to the existing MCTD wall and reduces the overall slope angle on the downstream face. The waste thus requires no specific physical properties to achieve this aim. B Type waste is suitable despite it being generally weak and more friable than A Type. The final outside face will be armoured with competent rock to prevent erosion as per the WRMP standard. Waste material for the buttress will be end tipped and dozed as per the standard operating practice for building of waste dumps. Due to the existing topography and the width of the buttress paddock dumping and subsequent dozer levelling is unlikely to be used. The placement of armouring for erosion protection will be completed with each 20m lift.

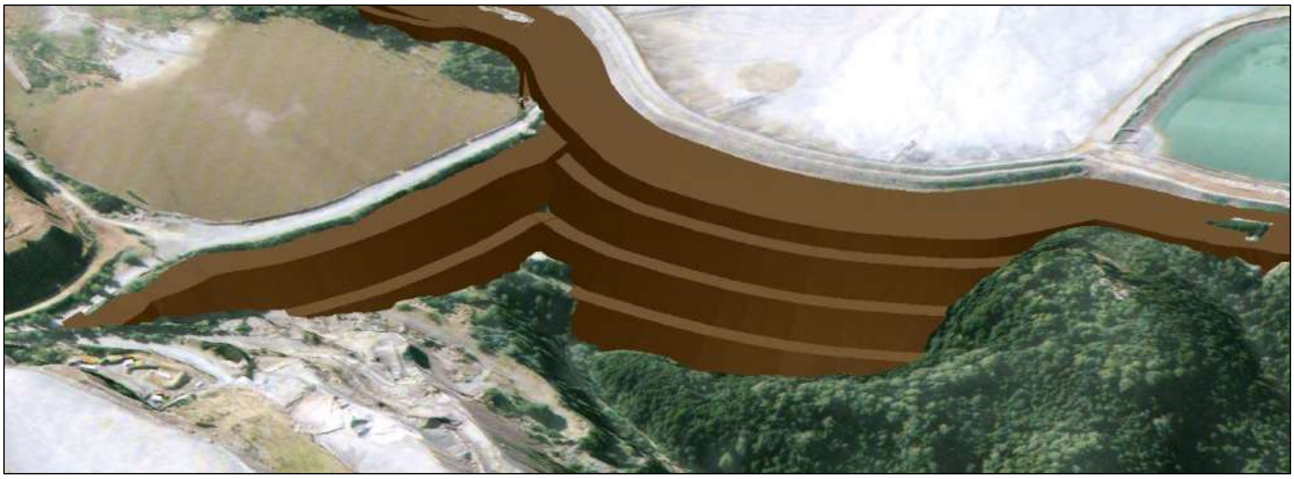

Figure 63: MTCD Buttress design

6.7.10 Broderick Creek Dump Complex

The Broderick Creek dump complex is approved under the current EPN 248/2 and contains a flow through system constructed across Broderick Creek. Blocks of A type rock were placed in the creek and covered with a layer of clay. An encapsulating D type dump was then created above the rock. Flows through the creek continue through the coarse A type rock underneath. This dump will contain the remaining 98 million m^3 of waste rock material. The current model of the final dump is provided at Table 62. Waste from Centre Pit Stage 2 and 3 will most likely be deposited within the southernmost dump on the west side of North Pit. This South Western dump is designed to contain 275MT of combined waste types from Centre Pit and North Pit

Figure 64: Broderick Creek Dump complex

The South Western dump is scheduled to contain the types and volumes of materials demonstrated in Table 35.

Table 35: South Western dump composition

	A Type (MT)	B Type (MT)	Clay Capping (MT)	D Type (MT)	Total (MT)
260mRL - 280mRL	3.9	3.6	0.31	7.2	15.0
280mRL - 300mRL	6.4	6.0	0.40	12.0	24.9
300mRL - 320mRL	9.2	8.7	0.48	17.4	35.7
320mRL - 340mRL	11.1	10.6	0.53	21.1	43.3
340mRL - 360mRL	11.5	10.9	0.54	21.8	44.8
360mRL - 380mRL	9.8	9.3	0.50	18.6	38.3
380mRL - 400mRL	7.6	7.2	0.44	14.3	29.5
400mRL - 420mRL	5.6	5.2	0.37	10.4	21.6
420mRL - 440mRL	3.7	3.4	0.30	6.8	14.3
440mRL - 460mRL	1.8	1.6	0.20	3.1	6.7
460mRL - 480mRL	0.7		0.7		1.4
Total	71.4	66.4	4.74	132.8	275.3

6.7.11 Pit Backfilling

Centre Pit and South Deposit potentially will be filled with waste rock. Both Stage 2 and 3 can be mined independently and could be back filled with waste rock from one of the other stages or from North Pit. At this stage backfilling has not been scheduled as both Centre Pit and South Deposit contain economic mineral resources. If it is determined that these resources are unlikely to be economically mined in the future and the resources are closed off with Mineral Resources Tasmania then the pits will be backfilled with D Type waste before being capped with clay and protected with rock armouring or inundated. Backfilling of completed pits with PAF rock waste is often considered best practice and will be completed where it does not limit future economic extraction of ore reserves and can be completed economically with waste rock presently being extracted.

6.7.12 Clay Borrow Pits

Clay for the encapsulation of D Type waste will be sourced initially from within the Centre Pit footprint as far as possible. The current final pit is scheduled to produce 6MT of clay suitable for capping. Additional clay for the capping of the CP dump and the Mill dump will be sourced from the borrow pits in South Deposit shown in Figure 63. The South Deposit clay borrow pit is current approved under the South Deposit EPN. Clay for capping D Type waste in the Broderick Creek Complex will be supplied from within the North Pit foot print and from within clay borrow pits with the dump complex area.

Figure 65: Clay borrow pit location

6.7.13 Tailings

Tailings produced from the processing of Centre Pit ore will be deposited into either the MCTD or the SDTSF depending on operational requirements at the time of processing. There is adequate capacity in the tailings storage facilities to contain the tailings produced from Centre Pit ore processing. No operational changes are required to accommodate the tailings from Centre Pit. The estimated fill level is identified on Figure 66. Current tails placement is sub-aerial with recovering of tails as required to ensure continuing saturation. The current downstream fall of the Main Creek valley aids in this.

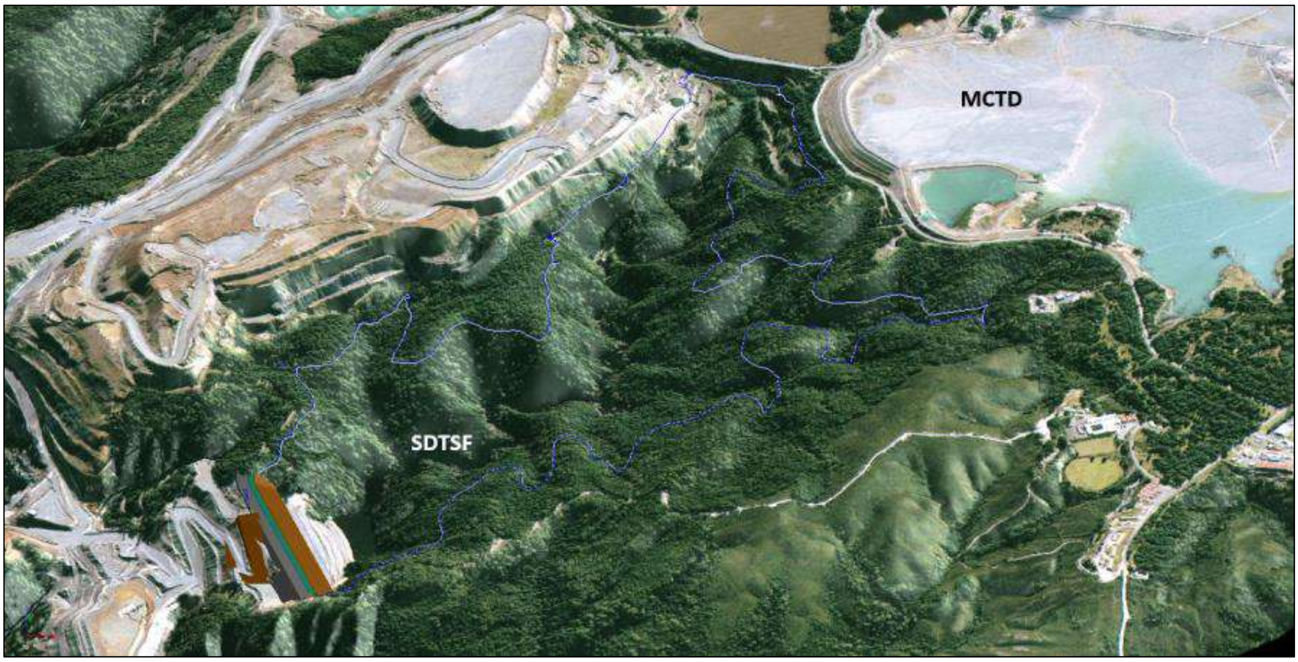

Figure 66: Existing MCTD with New SDTSF with fill level marked in blue

In predicting tailings geochemistry and possible leachate chemistry from Centre Pit tails Grange as taken several pathways.

The first was to look at data from Jackson (2014) BSc. Honours study that looked at tails data available from the Old Tails Dam (OTD) Savage River. It is known that the tails placed in the OTD were from Centre Pit. XRD analysis shows that these tails are dominated by Actinolite ~20%, Albite ~13%, Chlorite ~26%, Kaolinite ~9%, Pyrite ~9% and Serpentine ~17%.

Grange has then undertaken laboratory work to assess tailings geochemistry and likely metal leaching potential through the collection of Davis Tube Recovery (DTR) tails. The DTR test mimics the recovery of Fe from Magnetite ore processing. The tails from this experiment will be similar to tails from the milling process. Laboratory Pulps from the original drilling programs were combined to give samples representing likely ore delivered to the mill and the tails from the DTR machine collected for analysis.

Five samples were analysed after being composited from available cores at approximately twenty composites from the North Pit sample and five each for the Centre Pit samples. The resultant DTR tails samples were then sent for XRD analysis at MRT Tasmania and CODES for ICPMS analysis.

XRD results from the manufactured DTR tails were compared to the OTD results. Antigorite varied greatly in the DTR samples measuring from 54 to 5% against an average of 17% for Serpentine in the OTD samples. Chlorite varied in the DTR samples from 48 to 10% compared to an average 26% in the OTD tails. Pyrite in the DTR samples varied from 31 to 6% compared with the OTD average of 9%. Amphibole in the DTR sample varied from 20 to 4% compared to the average of 20% in the OTD sample. Given likely weathering, leaching and dilution in the OTD these DTR tails samples appear to be acceptable for further work.

The remaining laboratory samples were then analysed by ICPMS for an extensive sweet of elements. Results were then converted to Geochemical Abundance Index (GAI) enrichment values with the elevated values shown below. Leachate analysis of tailings is presented in Appendix H.

Table 36: Tailings enrichment values

GAI Enrichment Factor					
Sample	G410301	G410302	G410303	G410304	G410305
Source	North Pit HG Lens	Centre Pit *LG Lens*	Centre Pit HG *Lens*	Centre Pit LG Lens	Centre Pit HG Lens
Results					
V(ppm)	4.9	1.8	3.8	1.9	4.3
Mn(ppm)	1.8	1.2	1.5	1.0	0.9
Co(ppm)	7.6	4.9	30.3	30.9	26.2
Ni(ppm)	1.5	4.2	10.2	21.9	8.6
Cu(ppm)	7.0	8.2	41.1	82.3	42.3
Zn(ppm)	1.6	1.2	1.6	0.9	1.4
As(ppm)	0.6	0.5	2.1	6.8	2.6
A*g(ppm)*	1.2	0.6	3.4	6.4	2.5
Bi(ppm)	1.0	0.9	7.8	20.2	8.7

While the digestion of the samples prevents exact leachate determinations it does give an indication of possible leachate. Metals such as Cu, Co and Ni are likely to be more mobile under acidic conditions however the SDTSF currently runs at between pH 7.00 and 7.50 indicating that mobilisation is less likely. Under these conditions current tails management practices should be suitable for tails generated from Centre Pit.

6.7.14 Monitoring, Reporting and Auditing

Monitoring of waste rock will be conducted in accordance with EPA requirements, the WRMP and geotechnical requirements including:

- Waste rock is first visually assessed during the grade control process via blast hole drill cones prior to blasting and mining. Samples are gathered for laboratory testing and confirmation from each shot with at least one sample for each identified waste type per shot and at least 5 samples per week during active mining
- Samples are sent for laboratory testing at least for Total S, Total C and NAG and NAG pH analysis
- Where mining is to occur under free digging conditions daily visual inspections must be carried out and grab samples taken at comparable rates to cone sampling. Until identified as otherwise by laboratory testing free dug materials will be considered as D type waste
- Waste rock types for each shot will be communicated through the daily meeting and via mining plans
- Active waste rock dumps shall be inspected daily for correct placement of waste rock type and sampled weekly for laboratory analysis confirmation
- Oxygen and temperature probes shall be installed in the North and South sections of Centre Pit Dump and the Mill Dump initially at the lowest level possible and close to the final closure height prior to encapsulation
- Waste rock disposal facilities are inspected on a risk based schedule, documenting:
    - Water ponding on top of the waste rock disposal facility
    - Seepage from the toe
    - Adverse settlement, cracking or signs of instability; and
- Waste rock classification performance shall be reported on quarterly through the Technical Services Group and be externally audited yearly commencing in Q1 2021.

6.8 Dangerous goods and environmentally hazardous materials

6.8.1 Potential impacts relating to dangerous goods and environmentally hazardous materials

The proposed expansion relates to any existing operational mine site. All dangerous or hazardous goods are stored in accordance with Australian standards and approved operational systems. These will not change to accommodate the proposed Centre Pit expansion which relates to reworking of mined surfaces south of all processing plant and facilities.

6.9 Heritage

6.9.1 Potential impacts relating to historical heritage values

The proposed expansion relates to any existing operational mine site. A historical heritage assessment was undertaken by Austral Tasmania (Appendix I). Through a process of historical research and review of previous assessments, the report concludes that there is low potential for significant historic heritage sites or features to be present within the study area. Areas of late nineteenth, early twentieth century iron ore exploration and mining now largely coincide with the Savage River Central Pit which would have destroyed any evidence of historic mining activity in this location, as well as other associated features such as historic track networks and occupation sites. No further field assessments have been recommended.

6.10 Biodiversity and Natural Values

6.10.1 Potential impacts on biodiversity and nature conservation values (terrestrial and aquatic)

Impacts can be a result of direct actions, or from activities that have an indirect consequence. Direct impacts may arise as a result of clearing native vegetation to accommodate the pit expansion and road relocation. Threatened communities or plants may be destroyed or disturbed. Indirect impacts such as loss of fauna due to reduced habitat values may occur as a result of vegetation clearance or loss of water quality in waterways downstream of the site. The proposed Centre Pit expansion will be located primarily within the current mine site and areas required for the expansion are comparatively minor.

6.10.2 Map of existing vegetation and type and threatened species.

The Natural Values Assessment and addendums by NBES (Appendix E) confirmed the following vegetation communities would be impacted by the proposed expansion:

- *Nothofagus - Atherosperma* rainforest (RMT) – 29.87 ha
- *Acacia melanoxylon forest on rises (NAR) – 11.08 ha*
- *Acacia dealbata forest (NAD) – 5.40 ha*
- *Leptospermum lanigerum – Melaleuca squarrosa swamp forest (NLM) – 1.11 ha*
- *Eucalyptus nitida forest over rainforest (WNR) – 8.38 ha; and*
- *Eucalyptus obliqua forest over rainforest* (WOR) – 1.82.

These areas are identified in Appendix E. The original assessment covered a wider survey area and a refined impact footprint was used to confirm the above areas.

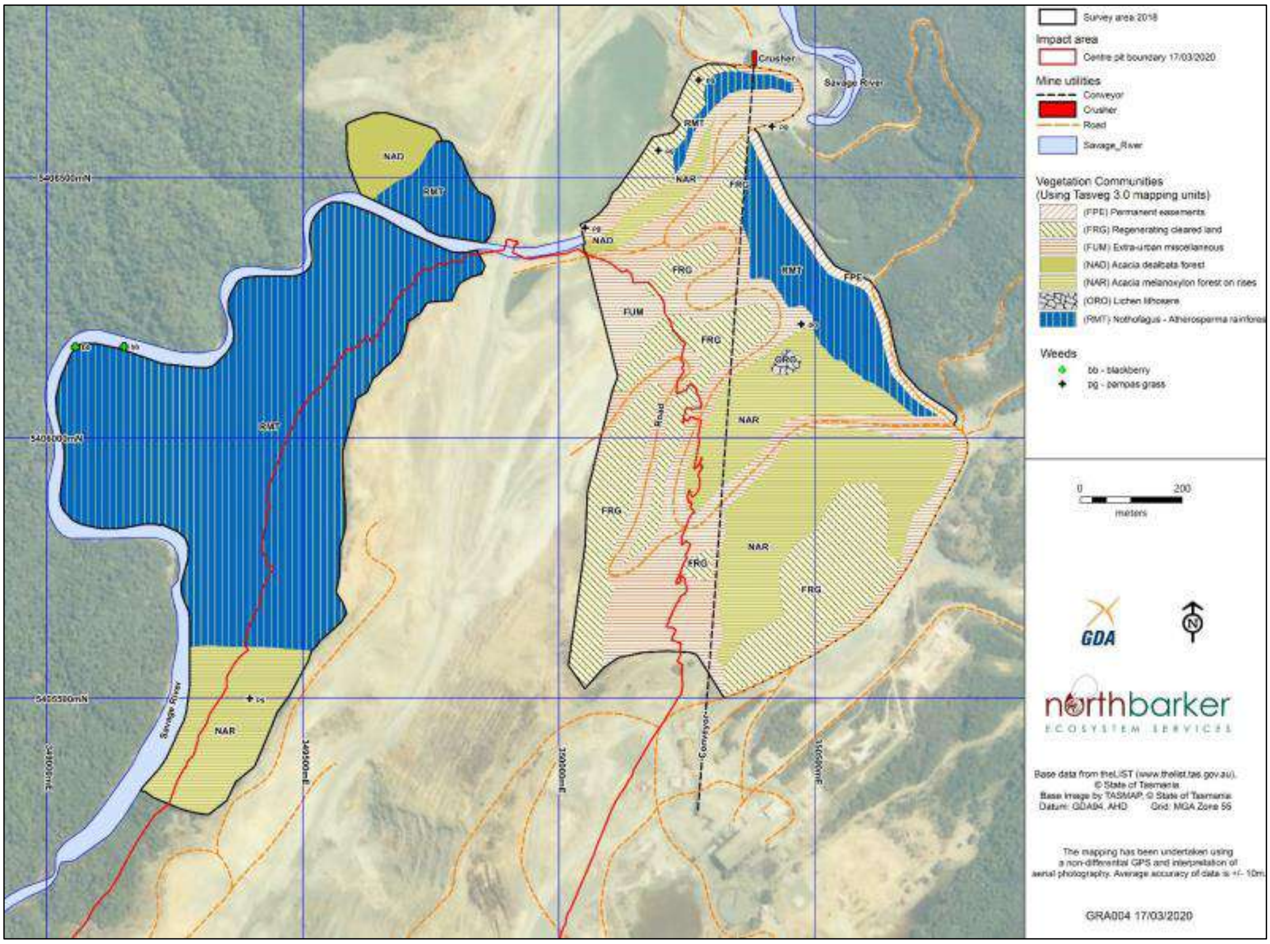

Figure 67: Vegetation communities as mapped by NBES (note CPS is dry in this image)

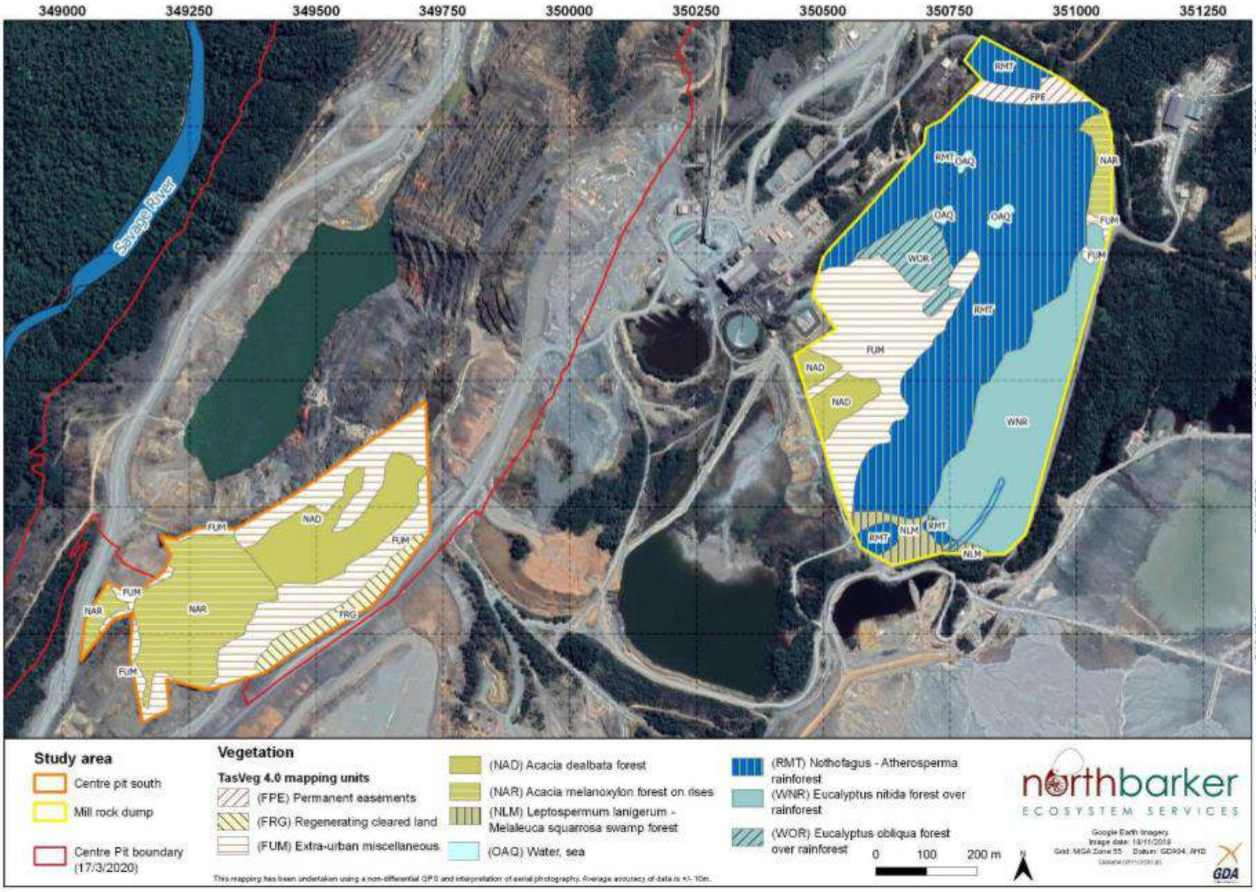

Figure 68: Vegetation communities logged by NBES for extra areas

6.10.3 Impacts on flora, vegetation communities and habitats

A total of 57.67 ha of vegetation will be impacted, however, none of these are listed as threatened communities under the Nature Conservation Act or the Commonwealth EPBC Act. This is a comparatively small area of vegetation loss and is not considered likely to have any significant impact considering the conservation status.

No threatened flora species listed under either the Threatened Species Protection Act or the Commonwealth EPBC Act were recorded or are considered likely to occur.

6.10.4 Impacts on fauna, including impacts on species, communities and habitats

No threatened fauna species under state or Commonwealth legislation have been recorded, however, the areas may be utilised by threatened species.

The spotted-tailed quoll could utilise habitats present within the site, but these habitats extend well beyond the disturbance area. Tasmanian devil is known to occur within the survey area, but denning habitat is sub-optimal, and no dens were found. A significant Impact Assessment was prepared by NorthBarker Ecosystem Services, and has been attached as Appendix J.

Potential foraging and nesting habitat for the state listed grey goshawk is present on site, however, no nests or individuals were recorded. This habitat is present within the riparian vegetation and *Acacia* community near Savage River identified on Figure 69.and within *Acacia melanoxylon* forest on rises near Centre Pit South Figure 68.

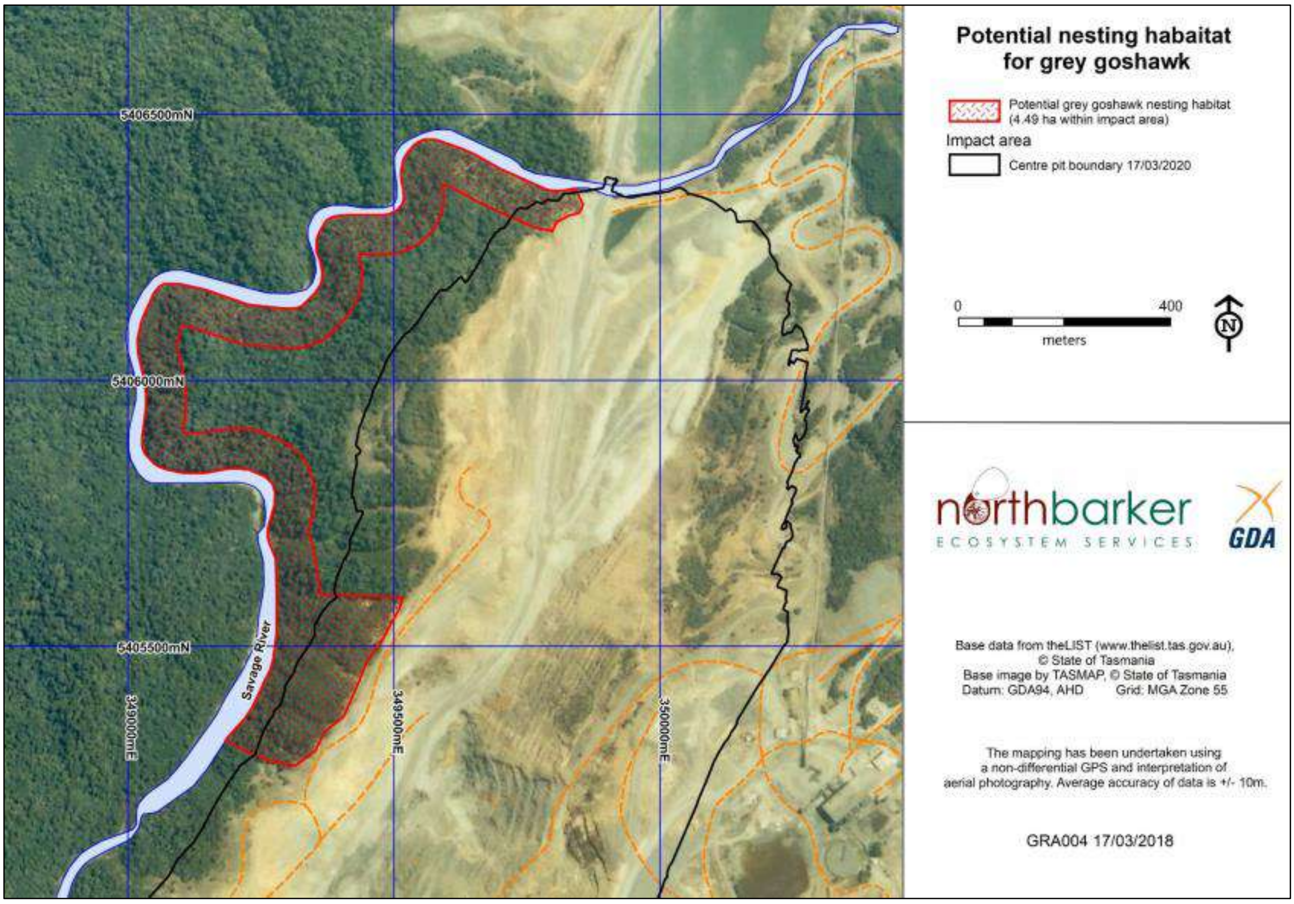

Figure 69: Location of potential grey goshawk habitat

One creek in the south of the Mill Dump area has been identified as potential habitat for hydrobiid snails. The creek is identified in Figure 70.

Figure 70: location of creek identified as potential hydrobiid snail habitat

Several trees in the Mill Rock dump area were identified as potentially hollow forming, suitable for the Tasmanian masked owl however habitat is suboptimal. The species is unlikely to occur in this area.

There are no other identified habitats or areas of conservation significance within or adjoining the impact area.

6.10.5 Identify any freshwater ecosystems of high conservation management priority

Savage River runs through the site between South Lens and the northern extent of the Centre Pit expansion. The river is not directly impacted by the proposed expansion and its course will not be altered. The operations discharge water to Savage River after processing on site. The SRRP and Strategic Plan establish standards and management objectives for the receiving waters. This is part of an ongoing process aimed at rehabilitation of aquatic ecosystems within Savage River and is discussed in detail in Section 6.2.

6.10.6 Impacts on sites of geoconservation significance or natural processes

The Arthur Metamorphic Complex, also known as the Arthur Lineament, is a listed geoconservation site which passes through the site. There is no geoconservation reserve over this feature.

6.10.7 Impacts on any high-quality wilderness areas

No wilderness areas occur on site or in proximity.

6.10.8 Impacts on other species, sites or areas of special conservation significance

Savage River National Park is located 10 km to the north east of the mine and there will not be impacts on the conservation of the reserve as a result of the Centre Pit expansion.

6.10.9 Impact of any clearing on sites, species or ecological communities of special conservation significance

As outlined above, there will be no impacts on threatened plants or vegetation communities. Impacts on spotted-tailed quoll and Tasmanian devil are considered unlikely. These are mobile species with large territories and the loss of a small area of habitat is not likely to have a significant impact. The avoidance of potential breeding sites will reduce the likelihood of disturbance of nesting individuals and help maintain population densities.

6.10.10 The potential for migration and/or introduction of pests, weeds and plant and animal diseases

Current EPNs require procedures to be established to reduce the risk of introduction and spread of plant pathogens such as *Phytophthora cinnamomi* and declared and environmental weeds. Appropriate weed and hygiene management measures will be implemented in line with current site practices.

6.10.11 Proposed measures to mitigate and/or compensate adverse impacts

Pre-clearance devil and quoll den surveys will be completed prior to any vegetation clearance to ensure no breeding habitats are disturbed.

A targeted grey goshawk nest survey will be conducted within suitable habitat within the impact area prior to disturbance works.

A targeted survey for hydrobiid snails will be conducted within the identified creek south of the Mill Rock Dump.

Appropriate weed and plant pathogen hygiene management measures will be implemented in line with current site practices.

6.10.12 Rehabilitation of disturbed areas

Rehabilitation will occur in accordance with existing and future mine decommissioning and closure plans.

6.11 Greenhouse gases and ozone depleting substances

The Centre Pit expansion will allow the continued operation of the Savage River mine. Generation of greenhouse emissions may increase because of this proposed activity as additional machinery may be required to satisfy increased stripping ratios and greater haul distances. The period of generation will increase as the life of the mine is extended due to the availability of additional resource.

6.12 Socio-economic issues

The Goldamere Agreement was created to indemnify owners of the mine against responsibility for legacy pollution which occurred in the Savage River as a result of earlier mining activities. This encouraged continued investment and employment at the mine. The support for operations on site, and the positive impact that makes to the economy and work force, continues under the agreement and the SRRP. The improvements in downstream water quality, since the commencement of the SRRP, have progressed throughout the river system to areas accessed by the public, providing a positive recreational and social outcome.

There will be no changes to processes or workforce, and no major capital expenditure other than the cost of increased mining fleet. Extracted mineral will still be sent to Port Latta for pelletisation and shipment to established markets.

6.13 Hazard analysis and risk assessment

No new hazard analysis is required for this proposal.

6.14 Fire risk

No new bushfire analysis is required for this proposal. Existing bushfire management and safety procedures will be implemented. Materials on site and processes involved do not pose any special fire risk.

6.15 Infrastructure and off-site ancillary facilities

The only infrastructure works proposed is the relocation of the western road (further west) to accommodate the new Centre Pit extent. No new plant is required, and no new off-site facilities are proposed. No impacts are considered likely.

6.16 Environmental Management Systems

Grange Resources' existing environmental management systems will continue to be implemented across the entire mine site which will include the expanded Centre Pit.

6.17 Environmental Impacts of Traffic

No new roads are required off site. An existing internal road will be relocated to the west and the impacts associated with vegetation clearance have been addressed in Section 6.10. No threatened flora or vegetation communities will be impacted, and pre-disturbance survey will avoid any disturbance of Tasmanian devil, spotted-tailed quoll or grey goshawk breeding habitat. Surface drainage from the relocated road will be managed within the current site wide water management plan. Surface water from the Centre Pit area will be diverted via cut off drains and sumps to the centralised treatment in South Lens or allowed to drain into Centre Pit and pumped to South Lens. All surface waters from disturbed areas will be collected to one of the three centralised locations namely South Lens, South Deposit or the SDTSF.

6.18 Cumulative and interactive impacts

Savage River mine is remotely located but supported by the Port Latta pelletising plant. There are no other mines in proximity. The closest settlement is the Waratah township to the east. Environments in the area are in a largely untouched state and there is limited pressure for land use or development other than forestry. The mine has operated since 1967 and initially resulted in significant environmental impacts on the Savage River. The establishment of the SRRP under the Goldamere Agreement has led to a cooperative approach to rehabilitation and measured improvements in aquatic health downstream of the mine discharge. The continued operation of the mine, with the ongoing management of water quality and acid forming material that it entails, is a sustainable alternative to a cessation of operations. Under the Goldamere Agreement the current operator assumes no liabilities for previous environmental damage and the rehabilitation would fall solely to the state without the agreement.

The proposed Centre Pit expansion will allow continued operations, and continued contribution to the restoration fund. The land will be actively managed, and rehabilitation continued and monitored. The proposal will result in very little impact on natural vegetation, and pre-disturbance surveys are proposed to avoid impacts on any breeding habitats. Roads and services in the area are sufficient for the proposed expansion and existing labour forces will be utilised. Production at the mine supports the Port Latta facility and there is a clear nexus between the continued operation of that facility if mining at Savage River were to cease.

7. Monitoring and Review

7.1.1 Proposed monitoring

Extensive monitoring of water discharges and water quality within pits is already undertaken. The location of existing monitoring sites is shown on Figure 69. The monitoring program for the duration of dewatering of CPS, including parameters and frequency, is detailed in Section 6.2.4 of this report.

Monitoring of waste dumps is undertaken in line with the WRMP and summarised in Section 6.7.14.

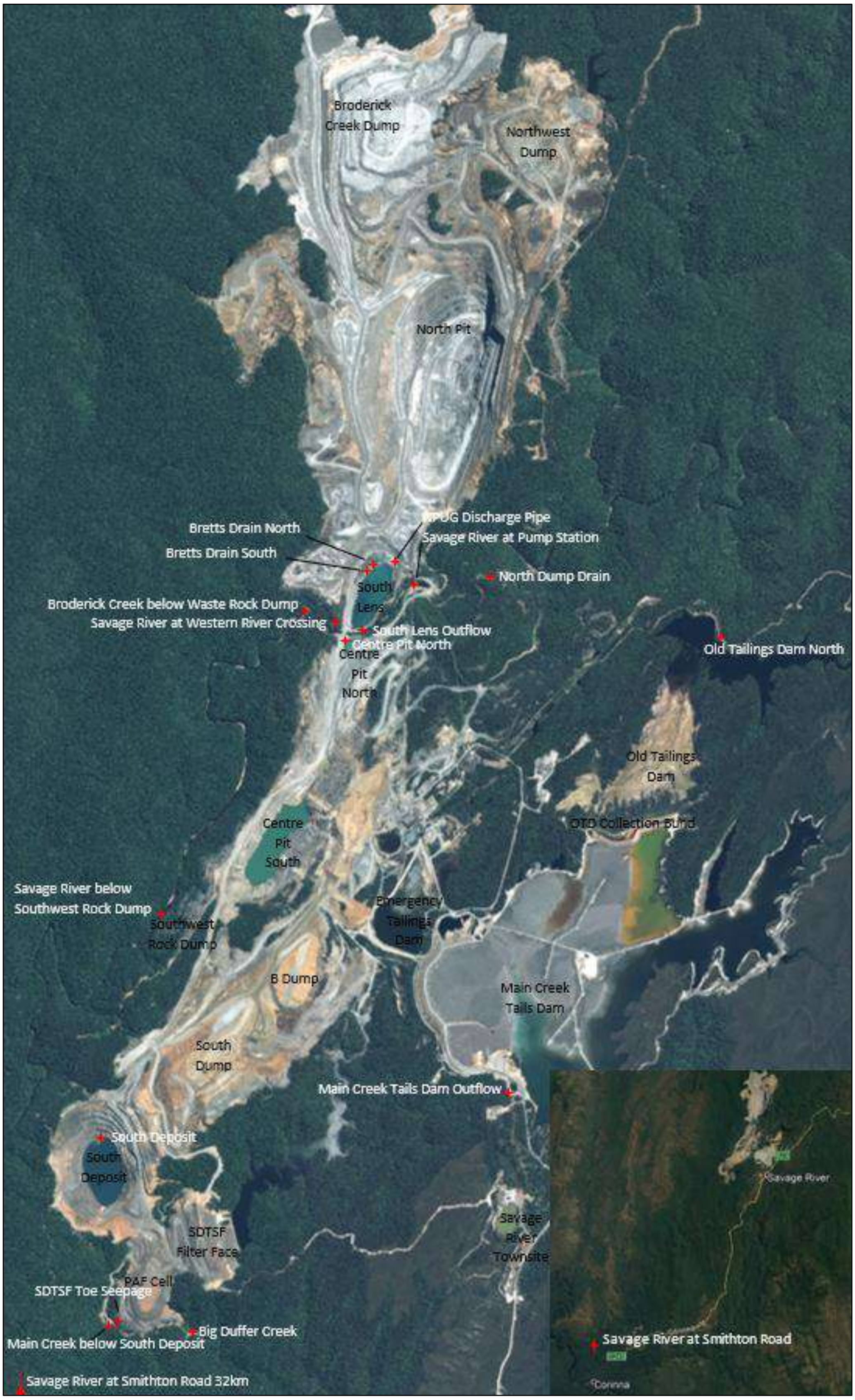

Figure 71: Map showing the location of existing monitoring sites

8. Decommissioning and Rehabilitation

8.1.1 Description of the on-going, staged approach to site decommissioning and rehabilitation

The Centre Pit expansion will form part of the ongoing operation and final rehabilitation and closure of the Savage River mine. The following comments relate only to the proposed expansion of Centre Pit and the associated waste rock dumps.

8.1.2 Preliminary Decommissioning and Rehabilitation Plan or Closure Plan

Several options have been identified for the Centre Pit final void. The option chosen will be determined by the strategic position of Grange Resources and additional resources and opportunities identified within the mine closer to the time of closure. These are outlined Table 37.

Table 37: Final pit void options

Option	Description
Allowing the pit to flood.	Flooding is a potential suitable closure option as water quality in CPS is currently maintaining a neutral pH with reserve alkalinity and this is expected to be the case once the large pit floods post closure.
Continue mining by underground means	Further mining of the Centre Pit resource by underground mining methods may be possible, particularly if a successful underground operation has been established on the North Pit resource.
Backfilling the pit with waste	Backfilling the pit with waste would be a suitable option if further open cut extraction of resources in Centre Pit are considered improbable and a waste rock dump location is required for open pit mining of a nearby resource.
Backfilling the pit with tailings	Backfilling the pit with tailings may be a suitable use of the void if further open cut extraction of resources and underground mining are both considered to be improbable.

In addition to final void treatment, the following will be undertaken to rehabilitate associated areas of the mine site:

- Maintenance on drains, roadways and erosion control structures around pit
- Maintenance of berms around pit; and
- Provision of warning signs around pit.

Table 38: Rehabilitation principles for waste rock dumps

Option	Description
Mill dump and B dump	• Clay capping and A type armouring of any remaining dump faces • Maintenance of drains, erosion control structures and berms around dump edges • Some revegetation on strips near dump edges; and • Dumps will be graded for water to drain into the SDTSF and ultimately into Main Creek.
Broderick Creek dumps	• Clay capping and A type armouring of any remaining dump faces • Maintenance of drains, erosion control structures and berms around dump edges • Some revegetation on strips near dump edges; and • Provision of an armoured diversion channel to take upstream water into North Pit.

9. Management Measures

This section should contain a consolidated management measures table listing all the management measures made throughout the EIS. Measures must be sequentially numbered, unambiguous statements of intent. For each measure, the table must specify when it is to be implemented and refer to the section of the EIS where the measure is detailed.

Table 39: Management measures

	Management measure	Timing for implementation	EIS section containing the measure
1	Establishment of water quality monitoring program as outlined in the report by Koehnken and Ray	Prior to dewatering of CPS	6.2.6
2	Waste rock will be managed in accordance with the current Waste Rock Management Plan	Throughout operation	6.5.5
3	Monitoring of rock dumps is conducted in accordance with the Waste Rock Management Plan	Throughout operation	6.5.13
4	Pre-clearance survey for denning habitats for Tasmanian devil and spotted-tailed quoll	Prior to vegetation clearance	6.7.11
5	Pre-clearance survey for potential habitat for grey goshawk	Prior to vegetation clearance	6.7.11
6	Permit to take as required	Prior to vegetation clearance	6.7.11
7	Appropriate weed and hygiene management measures will be implemented in line with current OMS	Throughout operations	6.7.11

10. Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

No threatened ecological communities listed under the EPBC Act are present on site. No threatened flora species was identified and although no threatened fauna was observed, the site could offer marginal habitat for Tasmania devil and spotted-tailed quoll. Avoidance measures to reduce the potential for impacts to breeding places of these species will be implemented. Pre-clearance devil and quoll den surveys will be completed prior to any vegetation clearance to ensure no breeding habitats are disturbed.

No significant impact on any matter of national environmental significance is considered likely. No referral to the Department of Agriculture, Water and the Environment is considered necessary.

11. Compliance with Project Specific Guidelines

The EIS should contain a summary table showing compliance with the project specific guidelines and the relevant sections of these general guidelines.

Table 40: Compliance with project specific guidelines

Key Issues	EPA Explanation	Comment
Waste rock and tailings management	Waste rock and tailings geochemical test work, including mineralogy, acid-base accounting (ANC, MPA, NAPP), NAG pH, kinetic test work, and assessment of elemental enrichment and potential for leaching.	Details of waste rock types and management are provided in Section 6.5. This includes details of the anticipated volumes of each type of rock and proposed disposal options, including management of PAF rock and run-off. A Waste Rock Management Plan, which includes Planning and Segregation Procedures, is attached to this EIS at Appendix B.
Surface water impacts from pit dewatering and onsite water	Water quality study assessing the potential to impact Savage River as a result of pit dewatering and onsite water management, considering pit water quality, proposed dewatering rates, and South Lens treatment efficacy.	Appendix C establishes the appropriate pump rate for dewatering of Centre Pit. Appendix C addresses the water quality implications of dewatering Centre Pit.
Geotechnical stability	Finalised geotechnical feasibility study of the proposed pit shell (pit design), incorporating assessment of the North Wall Savage River pillar section and the potential for the East Wall cut back to impact, or require set back to, the B dump and Southern Dump.	Geotechnical assessment is included at Section 2.5 and details the options considered and the proposed ongoing analysis to refine the pit design. Comprehensive shell diagrams are included to demonstrate the location of design levels.
Water Quality (surface and Discharge)	Discussion of the potential for acid and metalliferous drainage formation as a result of the management and storage of Centre Pit waste rock. The discussion must consider the design and construction of the new East Mill Dump and placement of waste rock on the	Details of existing surface waters and the surface water management plan are provided in Section 6.2. Appendix C addresses the water quality implications of dewatering Centre Pit. Waste rock dumps are discussed in Section 6.5.

Key Issues	EPA Explanation	Comment
	existing dumps and as utilised for the MCTD buttress (See also Section 6.5).	
	Description of best practice environmental management measures (as relevant) to prevent and mitigate the formation of acid and metalliferous drainage, and for collection and treatment of acid and metalliferous drainage which cannot be prevented from occurring.	Details of waste rock types and management are provided in Section 6.5. This includes details of the anticipated volumes of each type of rock and proposed disposal options, including management of PAF rock and run-off. A Waste Rock Management Plan, which includes Planning and Segregation Procedures, is attached to this EIS at Appendix B.
	Description of the existing and proposed water management practices on the mine site, including the proposed dewatering strategy prior to and during mining of Centre Pit and details of the proposed pumping rate, including proposed pumping algorithm (equations).	Details of existing surface waters and the surface water management plan are provided in Section 6.2. A dewatering schematic is provided in Section 6.2.1. Proposed dewatering rate and equation are discussed in Section 6.2.2.
	Description of the potential impacts to South Lens (including its capacity to treat AMD) and the Savage River as a result of Centre Pit dewatering Including: • the proposed monitoring and reporting regime • proposed water quality triggers, and management actions in response to exceedance of triggers • assessment of the potential for dewatering (loss of flow) from Savage River as a result of pit wall fracturing	Hydrology on the site, including South Lens water quality and hydrology, is discussed in Section 5.2.5 and Section 6.2. The proposed water quality monitoring and reporting regime is provided in Section 6.2.6. Proposed water quality triggers, and management actions in response to exceedance of triggers are outlined in 6.2.7. The geotechnical assessment in Section 2.5 considers the potential for pit wall fracture.
Waste Rock and Tailings Management	Description of Centre Pit waste rock lithology and mineralogy.	Waste rock lithology and management is discussed in Section 6.5 and the Waste Rock Management Plan in Appendix B.
	Results of geochemical test work characterising Centre Pit waste rock that will be excavated.	Details of waste rock types and management are provided in Section 6.5. This includes details of the anticipated volumes of each type of rock and potential forAMD.
	Provide estimated quantities and production rates of potentially acid forming (PAF) waste rock, non-acid forming (NAF) waste rock and acid consuming (AC) waste rock.	The nature and volumes of waste rock are discussed in Sections 6.5.2 and 6.5.3.
	Description of waste rock disposal practices, including:	Details of waste rock types and management are provided in Section 6.5 and the Waste Rock Management Plan in Appendix B.

Key Issues	EPA Explanation	Comment
	• Staged use of the existing waste rock dumps. • Acknowledgment that existing waste rock auditing practices will be applied • Disposal and encapsulation practices for the existing dumps • how additional waste rock placement on B dump and Southern Dumps will be managed • Location, dimensions etc for the proposed new Mill Dump	Staging details and the proposed use of each waste rock dump are outlined in Section 2.2. Details of all rock dumps are provided in Section 6.5.
	Management of waste rock currently within Centre Pit North	Waste rock that has been backfilled into Centre pit will be excavated and will be treated as D Type (potentially acid forming) waste unless it can be characterized otherwise. D type waste will be deposited within one of the PAF areas in the Broderick Creek dumps or within the Mill Dump.
	Description of tailings geochemistry, including an assessment of the acid generating (or neutralising) potential and estimated quantities and production rates, and proposed deposition within the existing TSFs.	Tailings management is addressed in Section 6.5.12.
	Description of the management of the existing TSFs, with consideration of any changes required to current practices as a result of differing tailings geochemistry.	Tailings management is addressed in Section 6.5.12 .
Other Information Required	General	A background to the proposed activity, including history of extraction on site, is provided in Sections 1 and 2.
	Project Alternatives	Project alternatives are considered in Section 3
	Existing Environment - Environmental aspects	The existing environment is described in Section 5.2.
	Natural Values including: • an estimate of the land clearance required • potential for impacts on threatened fauna and flora species, and vegetation • communities and habitats • measures to mitigate and/or compensate adverse impacts	57.26 ha of vegetation will be impacted, however, none is listed as threatened. No threatened flora is present. Pre-clearance surveys are proposed to prevent disturbance of breeding sites for Tasmanian devils, quolls, grey goshawk, masked owl and habitat of hydrobiid snails.

12. Conclusion

Savage River mine has been operating since 1967. Now under the management of Grange Resources, assessment of opportunities to enhance and extend production identified the potential to rework the former CPN and CPS. A consolidated Centre Pit will be created which will yield 55 Mt of ore and 360 Mt of waste rock. To enable the reworking of the site, CPS is required to be dewatered. CPN has been backfilled and that material will need to be removed and placed in a suitable waste rock dump on site. New production will also generate waste rock, and rainfall and groundwater seepage will continue to direct water to the pit. The issues associated with management of waste rock, some of it potentially acid forming, and treatment and discharge of surface waters from the mine site, are the key issues facing this proposal. Minor issues relate to the potential disturbance of threatened fauna.

Savage River mine has procedures and management systems in place which will be relied upon to accommodate the dewatering process and the management of the waste rock material. The WRMP contains the measures to assess and dump, or reuse, waste rock. Proven methods for encapsulation of potentially acid forming waste rock will be continued across the mine site.

The SRRP established a strategic plan to achieve habitat restoration in Savage River. This included the establishment of a set of specific water quality objectives and water quality monitoring protocols. The current proposal builds upon those protocols for monitoring during dewatering and throughout the life of the mine. Recent operations at the mine have resulted in the discharge of improved quality waters and there has been an improvement in aquatic habitat health. This will continue under the current proposal.

No threatened flora or vegetation communities will be impacted. There is a limited area of potential habitat for threatened fauna present which will be impacted. Pre-disturbance surveys will be undertaken to ensure no breeding habitats are disturbed. The site is not near any sensitive uses that may be impacted.

The mine operates under the Goldamere Agreement which provides that the works on site be undertaken in accordance with best practice environmental management. This EIS details the measures to be undertaken to ensure the best ecological, social and economic outcomes are achieved using best accepted practice. Many of the management actions proposed are currently implemented on site in accordance with existing licenses and requirements. The proposal is consistent with the requirements of relevant Commonwealth and State legislation, policies, plans and strategies. This should be done by itemising the RMPS and EMPCA objectives and providing a commentary about how the proposal addresses each of the objectives.

Other Issues and Agency Contacts

Appendix A

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In addition to a permit under the LUPA Act and the EMPC Act, there may be other legal requirements to allow your proposal to proceed. These may include other permits, licences or landowner consent. You may also need to contact other Government agencies to obtain information for the purpose of assessment under the LUPA Act or the EMPC Act. The following list identifies some of the key agencies you may need to contact:

Note: your proposal may be referred to other agencies in the process of preparing guidelines. Should assessments or approval outside of the Board's responsibilities be required, the respective agency will engage with you to progress them.

Natural values including flora, fauna, and geoconservation values, or permits to deal with threatened species:

Policy and Conservation Advice Branch

Telephone: (03) 6165 4395

Email: conservationassessments@dpipwe.tas.gov.au

Website: www.dpipwe.tas.gov.au

Historic cultural heritage, including State-level site listings, impacts and permits as required under the Historic Cultural Heritage Act 1995:

Heritage Tasmania

Telephone: (03) 6165 3700

Email: enquiries@heritage.tas.gov.au

Website: www.heritage.tas.gov.au

Note: Where works are proposed in or near a heritage place entered on the Tasmanian Heritage Register or likely to be of heritage significance to the whole of Tasmania, and a permit is required under the Land Use Planning and Approvals Act 1993, the proposal will be referred to Heritage Tasmania by the planning authority. There may also be additional sites listed under local planning schemes, impacts on which are assessed by the relevant planning authority.

Aboriginal heritage, including desktop assessment, artefact survey requirements, permits:

Aboriginal Heritage Tasmania

Telephone: (03) 6165 3152

Email: aboriginal@heritage.tas.gov.au

Website: http://www.aboriginalheritage.tas.gov.au

Note: your proposal will be referred to Aboriginal Heritage Tasmania (AHT) on submission or referral to the Board. If Aboriginal Heritage matters are identified, AHT will engage directly with the proponent regarding relevant assessments and approvals.

Parks and reserves, including where any proposal may impact on land managed by Parks & Wildlife:

Parks and Wildlife Service

Telephone: 1300 827 727

Website: www.parks.tas.gov.au and www.thelist.tas.gov.au

Crown land, including where any proposal may impact on land owned by the Crown:

Crown Land Services

Telephone: (03) 6233 6413

Email: cls.enquiries@dpipwe.tas.gov.au

Website: www.parks.tas.gov.au

State roads, including where any proposal requires works on or access from a State-managed road asset:

State Roads

Telephone: (03) 6166 3369

Email: permits@stategrowth.tas.gov.au

Website: www.transport.tas.gov.au

Mining leases:

Mineral Resources Tasmania

Telephone: 03 6165 4800

Email: info@mrt.tas.gov.au

Website: www.mrt.tas.gov.au

Works impacting natural waterway flow, e.g. dams or fords:

Water Management and Assessment Branch

Telephone: (03) 6165 3222

Email: Water.Enquiries@dpipwe.tas.gov.au

Website: www.dpipwe.tas.gov.au/water

Waste Rock Management Plan

Appendix B

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GRANGE RESOURCES

EMS-04 Waste Rock Management Plan

Table of Contents

Document Control

Version	Date	Description	Author	Approved
Draft 1	Feb 2014	EMS-04 Waste Rock Management Procedure	OSH & ESR Team	
Draft 1 Review - Tony Ferguson, Daniel Lester, Stephen Kent and Karen Ashley				
Draft 2	May 2019	EMS-04 Waste Rock Management Plan	HSE, Geology and Planning Team	
Draft 2 Review – Tony Ferguson and Nicholas Van Der Hout				
Draft 3	June 2020	EMS-04 Waste Rock Management Plan	HSE, Geology, Planning Team	
Draft 3 Review – Lisa Georgiou, Tony Ferguson, Roger Hill				
Draft 3	July 2020	EMS-04 Waste Rock Management Plan	HSE, Geology	

1 INTRODUCTION

1.1 Purpose

To define the required plan for the management of waste rock to prevent environmental impacts, promote beneficial post-mining land uses and reduce post mining closure and rehabilitation liability.

1.2 Scope

This plan applies to the design, construction, operational and closure phases of Grange Operations and addresses waste rock management.

1.3 Summary

Grange commits to employing Best Practice Environmental Management (BPEM) in the identification, storage and monitoring of waste rock. At Savage River Grange's Waste Rock Management Plan commits to:

- Identify waste types during all stages of exploration and extraction and in particular any Potential Acid Forming (PAF) waste rock
- Waste rock will be disposed of in current approved dumps or as approved by the EPA Director and/or the EPA Board.
- Dumps will be designed to be geotechnically stable
- PAF waste rock will be encapsulated with a cover (currently 2-m of track or Truck compacted clay at the completion of active dumping to prevent oxidation and reduce the formation of Acid and Metalliferous Drainage (AMD)
- This encapsulation will be protected from erosion with a protective cover of Non-Acid Forming waste rock to a minimum of 5 metres. A-type encapsulation also contributes to oxygen ingress reduction
- Dumps will be allowed to naturally revegetate once completed and closed subject to protection of encapsulation to prevent oxygen ingress.
- Performance monitoring of the Waste Rock Management Plan will be conducted with an aim of continual correction and improvement
- Grange will seek to improve legacy issues at the site through approved Savage River Rehabilitation Projects (SRRP) in conjunction with normal operations

1.4 Responsibilities

Director / General Manager Operations	➢ Ensure adequate resources are provided to effectively manage waste rock in compliance with licence conditions and requirements of this plan and associated management plans.
Senior Management	➢ Ensure all statutory requirements for waste rock management are carried out and complied with.
Mine Manager	➢ Ensure adequate resources are provided to effectively manage waste rock in compliance with licence conditions and requirements of this procedure and associated management plans. ➢ Ensure waste rock management responsibilities are communicated to all relevant staff and supervisors. ➢ Ensure all surveillance and inspection programs are followed. ➢ Ensure systems are in place to manage waste rock tracking and dumping. ➢ Ensure compliant waste rock storage facilities.
Mine Superintendent	➢ Implement the weekly mine plan in relation to the waste rock management plan ➢ Monitor the waste rock dump for stability on a shift basis. ➢ Ensure the correct waste types are being placed in the designated dumps according to the weekly plan.
Mine Supervisors/Leading Hands	➢ Ensure excavator operators have appropriate mining plans and are familiar with waste rock management requirements. ➢ Communicate required waste rock management programs to operational staff during pre-start meetings. ➢ Ensure all waste rock dumping procedures are adhered to as per the technical specifications of the Waste Rock Management Plan.
Geotechnical Department	➢ Providing and assessing the design parameters for the geotechnical stability of the waste dumps ➢ Inspecting, monitoring, assessing, and reporting on the geotechnical stability of the waste dumps ➢ Conducting regular inspections (risk based) of all active waste dumps.
Health Safety and Environment Team	➢ Develop and manage Environmental Management Plans (EMPs) relating to pit and waste dump proposals ➢ Provide the design parameters relating to environmental requirements and mine closure; for example, prevention of sulphide oxidation, erosion protection, landforms, etc. ➢ Monitoring and reporting to the Environmental Protection Authority (EPA) against the requirements for relevant Environmental Protection Notice (EPN) and/or Environmental Management Plan (EMP). ➢ Ensure licence conditions are maintained and advise operational personnel of any changes required to Waste Management Plans. ➢ Analyse and report waste rock management data and report on performance statistics.

	➢ Provide awareness information to relevant personnel on waste rock management ➢ Carry out required monitoring, water sampling and testing as per licence conditions ➢ Facilitate the investigation of waste rock management and acid and metalliferous drainage incidents and ensure appropriate reports are disseminated and where required facilitate the reporting to external regulators.
The Geology Department	➢ Carry out waste rock classification as per the Waste Rock Management Plan ➢ Undertake required training for waste rock management. ➢ Developing and updating the resource and waste rock block model for planning purposes ➢ The field assessment, characterisation and sampling of waste rock types. These characterisations shall be reported to operations on a daily basis with frequent checks during the excavation process. ➢ Frequently check waste rock dumps to ensure that the correct waste type is being placed in a dump. ➢ Ensuring that training for all pit personnel includes waste rock management instruction; including understanding of waste rock types and appropriate disposal requirements.
Employees	Comply with, record and monitor waste rock digging and dumping requirements.

1.5 Legislative Requirements

The Environment Protection Authority (EPA) is Tasmania's principal environmental regulator. The EPA administers the Environmental Management and Pollution Control Act 1994 (EMPCA) which is the principal environmental legislation that impacts on Grange Resources Savage River Operations. The EPA imposes conditions attached to the planning permit issued by the planning authority. These conditions are issued in the form of an Environment Protection Notice (EPN) or Permit Conditions Environmental (PCE) and set the environmental conditions for the operation.

Waste rock storage facilities in use are designed, constructed, decommissioned and rehabilitated according to Grange's Environmental Management Plan (EMP) as approved by the EPA who details operating requirements through the EPN or PCE. Requirements of the sites EPN's, PCE's are incorporated into the EMS-04 Waste Rock Management Plan which details technical specifications, waste rock requirements and standards.

The EMS-04 Waste Rock Management Plan is designed to meet the requirements of Savage River environmental approvals and detail compliance with waste rock requirements that in summary include:

- Notification of incidents;
- Requirements to review EMP each 3 years;
- Implementation of an Environmental Management System that meets the requirements of the ISO 14000 series;
- Requirement for catch drains for run off waters containing sediment or discolouration to be delivered to settling dams and treated to BPEM prior to discharge to natural drainage lines;
- Requirements for storm water diversion and treatment;
- The undertaking of a monitoring and reporting regime as outlined in the EMP;
- Disposal of mine wastes to be undertaken in accordance with the EMP;
- Representative samples of waste rock types should be subjected to long-term (at least 6 months) column leach tests and ABA accounting and characterised to each waste type according to the ABA results, with requirement to report the results to the Director as required;
- Identification and segregation of potentially acid forming and non-acid forming waste rocks types;
- The development and implementation of a Waste Rock Management Plan, with a copy submitted to the Director as required.

2 WASTE ROCK TYPES

2.1 General Requirements

Waste rock disposal facilities in use are approved by the EPA and are described in the current approved Environment Management Plan (EMP) and the current Environmental Rehabilitation Plan (ERP).

2.2 Waste Rock Classification

Waste types at Savage River are classified into four main geochemical groups as shown in Table 1.

Table 1 Savage River Waste Rock Classification

Waste Type	Material Lithology	Material Character	Flow Through Suitability	Net Acid Producing Potential (NAPP)	Presence of Sulphides	Acid Forming
A	Fresh Chlorite, Carbonate, Calcite Schist, Magnesite or dolomite.	Hard weather resistant & durable	Yes	<-30 kgH_2SO_4 Alkalinity ≥ Max Acidity	No or Minimal Visible Pyrite	NAF
A	Weathered Magnesite, Dolomite or Chlorite - Carbonate Schist.	Soft liable to break down by weathering or compaction	No	<-30 kgH_2SO_4 Alkalinity ≥ Max Acidity	No or Minimal Visible Pyrite	NAF
A	Metamorphosed gabbro, dolerite and basalt.	Hard weather resistant & durable	Yes	<-30 kgH_2SO_4 Alkalinity ≥ Max Acidity	No or Minimal Visible Pyrite	NAF
B	Western stratigraphic units. with albite / chlorite / muscovite.	Friable, weak rock units	No	Neutral ANC = MPA	Some Visible Pyrite – sufficient capacity for self-neutralisation	Neutral
C	Schist, low sulphide serpentinite and clay.	Soft liable to breakdown by weathering or compaction	No			NAF
D	Chlorite – sulphide schists, sulphide intrusives, serpentinite, talc schist, mixed waste rock and unidentified materials.		No	>+30kg H_2SO_4 ANC < MPA	Significant Visible Pyrite	PAF

2.3 Management of A-Type Waste

A-Type waste is intended to contain the hard, durable, non–acid forming rocks. Type A waste rocks are dominantly magnesite or calcite chlorite schist rocks with an ANC ≥ 30 kg H_2SO_4/tonne and with low or no visible sulphides. A-type is used for rock armouring completed dump complexes. It is also used to build haul roads and flow-throughs.

2.4 Management of B-Type Waste

Type B-Type waste compacts to a low level of permeability when consistently run over by loaded haul truck movements. B-type waste is segregated and generally dumped with D type waste.

2.5 Management of C-Type Waste

C-Type waste is characterised as non-acid forming clay and silt material. C-Type is segregated from other waste types and stockpiled on site for use in D-type dump encapsulation. Compacted C-type waste prevents water and oxygen ingress and is used for encapsulating D-type waste to prevent oxidation.

In general C-Type waste is free dug and therefore should be subject to inspection and testing to ensure it is not PAF.

2.6 Management of D-Type Waste

D-Type waste is Reactive PAF Rock or rock of unknown classification requiring encapsulation to prevent oxidation.

2.7 Management of Waste Initially Classified as Uncertain

During the current laboratory classification of waste rock through NAG testing samples may be classified as uncertain (UC). Further testing may allow these samples to be reclassified to another waste class. If this is not possible within the time frame of sampling to diging then these samples must be treated as D-Type waste.

2.8 Management of Unclassified Waste

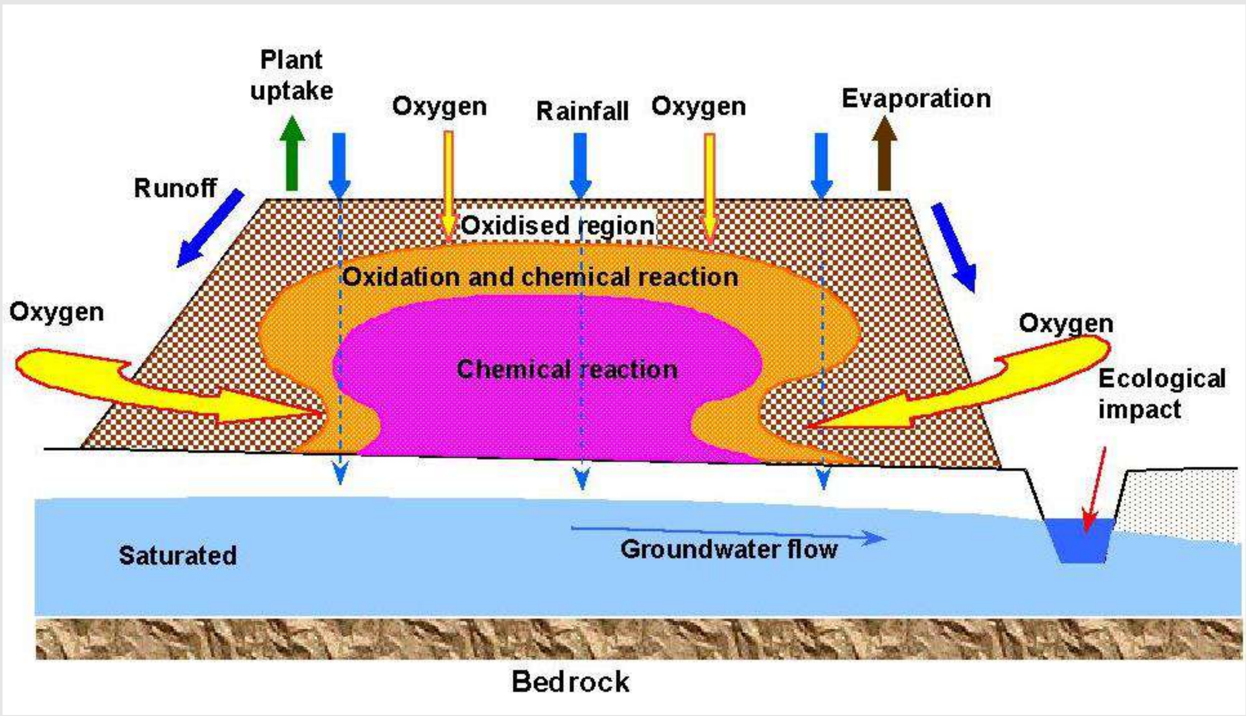
Waste rock that cannot be classified through normal sampling and classification procedures should be classified as D-Type waste. This can occur when mining through legacy waste dumps.

3 WASTE ROCK DUMP DESIGNS

3.1 Acid and Metalliferous Drainage

Acid and Metalliferous Drainage (AMD) occurs when PAF material and specifically sulphides are left exposed to oxygen. The oxidation of sulphide minerals in the rock results in products that are characterised by low pH (acidic), and high metal concentrations. The chemical processes that take place in a waste dump are depicted in Error! Reference source not found..

Figure 1 Pictorial Diagram of Oxygen and Water Transport into a Waste Dump

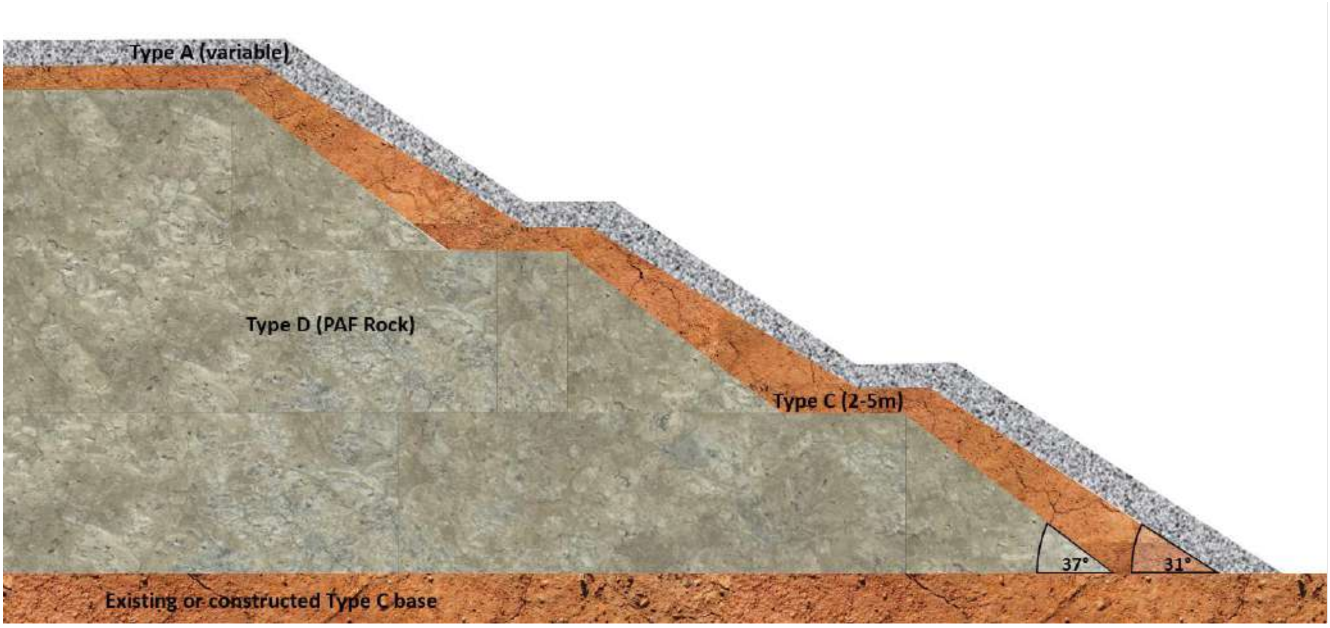


3.2 Waste Rock Dump Encapsulation

All dumps containing D-Type waste (PAF waste) shall be sealed through the use of C-Type encapsulation to minimise oxygen diffusion through the barrier and maintain the percentage reduction of the Acid Sulphate Generation Rate (ASGR) at greater than 95%. To achieve a 95% reduction of ASGR, D-type waste dumps are to be constructed by:

- Covering the base and top of the D-type dump with a minimum of 2m of compacted C-type “clay”. Note that track or truck rolling successive paddock dumped layers is an acceptable method of compacting the C-type where further dump layers (>15m) are to be placed above.
- Covering the sides of the D-type dump with a minimum of 2m of un-compacted C-type “clay”.

Figure 2 Pictorial representation of C-type capping of D-type cells



Note: most waste rock, when end-tipped from a truck, rills out at 37º. The clay however is much finer material and it therefore rills out at a lesser angle at around 28º-33º. This means that 2m of clay at the top will typically place about 5m of clay at the toe of the tip head.

An outer layer of A-type armouring, at least 5m thick, shall be placed over the final layer of C-type capping to prevent erosion of the C-type and provide stability to the end dumped C-type. The thickness of the armouring is dependent on the height of the overall dump and needs to be assessed by the Geotechnical Engineer for stability.

An additional layer of clay may be placed on the outer edges of the top of the A-type armouring to assist in the re-growth of vegetation. By restricting the re-vegetation media to the outside edges, the potential for tree root ingress into the oxygen excluding barrier is minimised.

Increasing temperature and oxygen within the dump indicates that sulphide oxidation is occurring and will trigger corrective action to increase alkalinity, reduce the available oxygen and increase saturation within the dump. This will be achieved by:

- decreasing the PAF layer thickness
- increasing compaction of the layers
- adding alkalinity to the PAF layers
- increasing the clay encapsulation thickness

3.3 Active Waste Dump Designs

The current waste rock dump designs are generally updated annually or as required to meet operational requirements. The current designs are contained within Life of Mine Waste Dump Plan which are developed in accordance with MHS-16 Mine Planning Procedure.

3.4 Broderick Creek Dump Complex

Waste rock from all of the pits may be disposed of in the Broderick Creek Dump Complex and associated dumps.

The Broderick Creek flow through dump has been constructed across Broderick Creek by placing blocky A type rock into the creek covering with a layer of clay and then encapsulating D type rock over the clay and against the clay lined walls of the valley.

Figure 3 Broderick Creek Indicative Cross Section

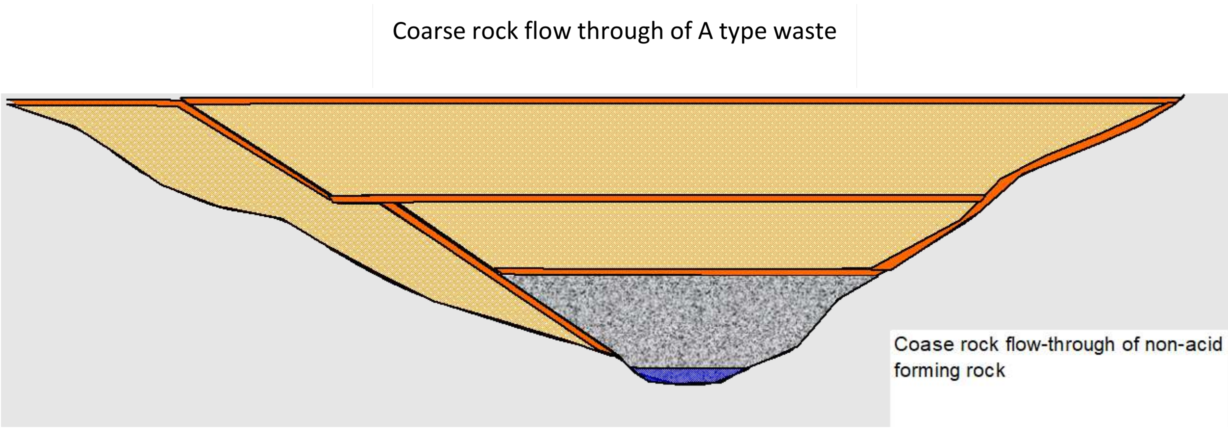
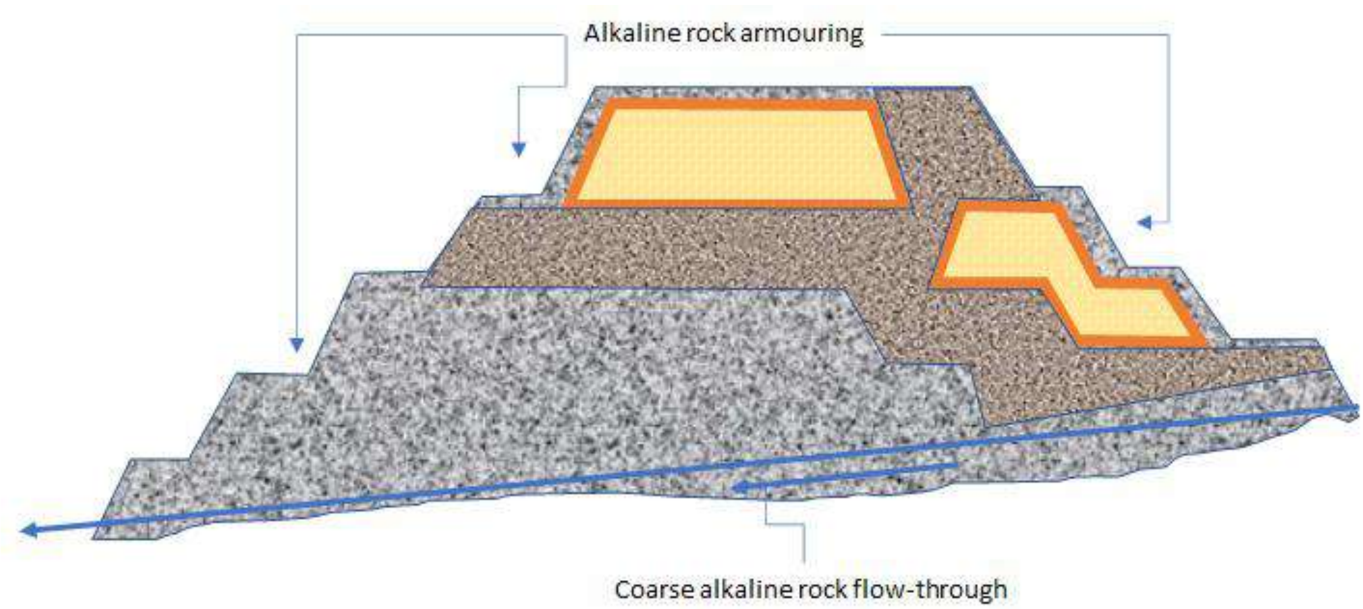


Figure 4 Broderick Creek Dump – Long Section



3.5 South Deposit Tailings Storage Facility

The South Deposit Tailings Storage Facility (SDTSF) and its associated dumps are built and managed in accordance with requirements detailed in Permit Conditions Environmental PCE8808. These conditions are specific to the

SDTSF and have resulted in a separate WRMP. The SDTSF will become the primary tailings storage facility when the MCTD is closed.

3.6 Centre Pit Waste Rock Dumps

Grange has interim approval from the EPA for the pre-stripping of the Eastern wall of Centre Pit. This interim approval allows use of the B and South Dumps for the placement of waste rock subject to the conditions within the interim approval. Grange is preparing an Environmental Impact Statement (EIS) for full approval of the Centre Pit Project.

3.7 Management of Legacy Waste Rock Materials

Under the Goldamere Agreement Act Grange is not to be held responsible for AMD associated with pre 1997 waste rock placement at Savage River. No emission limits on water quality can be set where influences of pre 1997 waste rock dumping may contribute to water quality. Through the Savage River Rehabilitation Project (SRRP) Grange may assist with the rehabilitation of pre 1997 waste rock dumps through SRRP contracts resulting in reduction of the purchase price. Grange should investigate ways to assist the SRRP with rehabilitation objectives through integration with current operational planning.

4 OPERATIONAL WASTE ROCK MANAGEMENT

4.1 PLANNING AND SEGREGATION PROCEDURES

Waste rock material classification is normally defined during the drill and blast cycle, through logging of the drill cuttings at the hole collar. All blasted collars are visually assessed in the field for waste type and one sample from each discreet waste type identified in a blasted shot is sent for NAG testing to confirm the field assessment.

Where materials are free-dug, regular visual field assessment of waste type is required and in addition grab samples need to be taken frequently while free-digging is in progress and sent for NAG testing.

The logging process (drill cuttings or grab samples) records details of:

- Location
  - linked to survey collars in the case of drill cuttings or
  - direct GPS coordinates in the case of free-dig samples.
- Magnetic susceptibility (DTR)
- Rock type, mineralisation, alteration,
- Accessory minerals,
- Colour,
- Grain size'
- Results of HCL 'Fiz' test
- Paste pH and Conductivity
- NAGpH, NAG, Total S and C and ABA Accounting

Both the drill hole survey and the logged geological data are uploaded into Surpac mining software. The boundaries of the ore and different waste types are digitised into three-dimensional coordinates from the plan. Based on the logging data, the waste areas are subdivided into the different waste categories, i.e. 'A', 'B', 'C' or 'D' type. The digitised data is used for pegging on the ground to identify the boundaries of the mining blocks.

Additional information on the identified risks and controls to carry out these activities safely and in detail can be found in the relevant SOPs and Handbooks.

Table 2 Sampling and Testing Standard Operating Procedures and Handbooks

Grange Standard Operating Procedures	Document Type
Blast Hole Sampling	Procedure
NAG Sampling Procedure	Procedure
Testing Procedures as specified in AMIRA 2002 ARD Test Handbook	External Resource

4.2 EXCAVATION AND TRANSPORT PROCEDURES

The level plan information is translated for survey and marked up on the ground for excavation. Mining plans issued to the Pit Supervisor and Excavator Operators clearly identifying the ore or waste type boundaries. Procedures are in place to ensure each step of the process is managed by the excavator calling the material type during loading and the truck operator recording the load number, material source and destination on the truck sheet for each load during the shift. Pre-shift meetings ensure that all operators are familiar with the designated dumping areas for the various material types including waste.

A pre-shift briefing is conducted at the start of each mining shift to ensure that all operators are familiar with the designated dumping areas for the differing material types.

Additional information on the identified risks and controls to carry out these activities safely and in detail can be found in the relevant SOPs.

Table 3 Operational Standard Operating Procedures

Grange Documents	Document Type
SAVMINSOP_Excavator Loading Operation	Procedure
SAVMINSOP_Haul Truck Operation	Procedure
SAVMINSOP_Dozer Operations	Procedure
SAVMINSOP_Waste Rock Dumping into Water	Procedure
SAVMINSOP_Production Study	Procedure

4.3 Waste Rock Dump Design and Construction Procedures

SOPs and JHAs and other administrative steps are in place to ensure the risk associated with waste rock dump construction activity are identified and controlled.

Table 4 Planning Standard Operating Procedures

Grange Documents	Document Type
MHS-16 Mine Planning Procedure	Procedure
MTS-Mine Planning Management Manual	Manual
MTS-Geology Management Plan Manual	Manual
MHS-04 Ground Control Management Plan	Procedure

SAVMINSOP_Waste Rock Dumping into Water	Procedure

4.4 Water Management

Water management strategies are focused on acceptable discharge water quality. EMS-06 Surface and Ground Water Management details water management requirements including:

- Requirements of the water management plan;
- Hydrology assessment and controls;
- Water quality limits;
- Water management instrumentation, locations and inspection / testing frequency.

All water management sampling, testing and monitoring is scheduled within MHS-01 Monitoring and Measurement Management Plan located on the SharePoint intranet site SEMS.

5 MONITORING

5.1 Operational Waste Rock Sampling

Sampling of waste is a vital part of the mining cycle. If the sample is not representative of the ground to be mined, all Grade Control procedures undertaken after this point cannot compensate for this error. Sampling provides the geological / geochemical data for interpreting waste types. For the drill, blast and load cycle the samples are collected from drill cones.

Cones should be cut with a pelican pick following the requirements detailed in the Blast Hole and NAG Sampling Procedure.

All drill collars are visually assessed in the field for waste type and one sample from each discreet waste type identified in a blasted shot is sent for NAG testing to confirm the field assessment.

NAG samples are bagged and identified for dispatch to NATA registered laboratories.

Where mining occurs in undrilled ground a procedure will be developed for sampling of this area. Sampling should be carried out to allow required laboratory testing.

Eg: Where materials are free-dug, daily visual field assessment of waste type is required and in addition grab samples need to be taken each day that free-digging is in progress and sent for NAG testing.

5.2 Waste Rock Laboratory Testing

A number of test procedures are used to assess the acid forming characteristics of mine waste materials. The most widely used assessment methods are the acid-base account (ABA) and the net acid generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

The acid-base account involves NATA certified laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates). The values arising from the acid-base account are referred to as the maximum potential acidity (MPA) and the acid neutralising capacity (ANC), respectively. The difference between the MPA and ANC value is referred to as the net acid producing potential (NAPP).

Kinetic test procedures involve a number of measurements over time, and are used to assess a range of ARD issues including sulphide reactivity, oxidation kinetics, metal solubility and the leaching behaviour of test materials. Kinetic NAG and Leach column tests are examples of kinetic procedures.

A suggested test program may include the following stages dependent on the test materials, the information required and the speed with which the information is required:

Stage 1: Screening – samples are screened and categorised using relatively rapid and inexpensive static tests;

Stage 2: Follow up testing – to obtain more information on acid forming capacities and resolve samples with uncertain classifications. A variety of static and kinetic NAG test methods may be employed at this stage; and

Stage 3: Leach Column testing – longer term kinetic column testing to provide data reaction rates and leachate chemistry.

5.2.1 $pH_{1:2}$ and Electrical Conductivity $(EC)_{1:2}$

The $pH_{1:2}$ and electrical conductivity $(EC)_{1:2}$ of a sample is determined by equilibrating the sample in deionised water for 12 –16 hours (or overnight), at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area. A modified field test can be used to quickly identify PAF material.

Paste pH generally indicates whether or not a material has already become acidic and may be used to infer the degree of weathering. Low paste pH values (pH<5) generally are indicative of stored acidity (i.e. potential for net acid generation) and net acid generating conditions. High paste pH values (i.e. pH 7 or above) indicates the presence of reactive neutralising minerals.

5.2.2 NAG pH

NAGpH samples are collected by site personal and shipped to the lab at SGS Renison Bell for testing. The NAGpH test involves the forced oxidation of the sample with hydrogen peroxide. Once the sample has fully reacted it is heated to drive off excess peroxide and returned to room temperature for pH measurement.

5.2.3 Maximum Potential Acidity (MPA)

MPA is a measure of the total acid producing potential of a material, irrespective of whether that material may also have the potential to produce alkali. MPA is determined from the analysis of total sulphur in the sample and is calculated assuming a total conversion of sulphur to sulphuric acid. MPA is reported as kg H2SO4 per tonne.

$$MPA\ (kg\ H_2SO_4/t) = (Total\ \%S) * 30.6$$

5.2.4 Acid Neutralising Potential (ANC)

ANC measures the capacity of a sample to neutralise any acid that is produced. In the ANC analysis a finely ground sample is reactive with a known amount of hydrochloric acid. The resultant solution is back titrated to pH 7.0 with sodium hydroxide to determine the amount of acid neutralised by the carbonates and other acid consuming minerals present in the original sample. ANC is reported by the laboratory as either Kg $CaCO_3$ or Kg H_2SO_4 equivalent per tonne. For calculation of NAPP Kg H_2SO_4 equivalent per tonne should be used. An estimate of ANC can be determined by calculation from the % C assuming all C is present as $CaCO_3$.

$$ANC\ (kg\ H_2SO_4/t) = (Total\ \%S) * 83.3$$

5.2.5 Net Acid Production Potential (NAPP)

NAPP gives a theoretical prediction of whether the acid production potential of a material is greater than its acid consumption capacity. The results are usually provided as either a positive or negative number. The difference between the MPA and ANC value is referred to as the net acid producing potential (NAPP). A negative NAPP indicates that ANC exceeds MPA.

$$NAPP = MPA - ANC$$

5.2.6 Net Acid Generation (NAG)

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. Therefore, the end result represents a direct measurement of the net amount of acid generated by the sample. This value is commonly referred to as the NAG capacity and is expressed in the same units as NAPP, that is kg H2SO4/t.

5.3 Interpretation of Results

Results from grade control observation and laboratory analysis are entered into the Geology Database and /or the Geology Calculation Spreadsheets. The spreadsheets calculate the waste type from the analytical results and compare these with the grade control observation. Waste is classified into waste type generally on the basis of the following.

The acid forming potential of a sample is preliminarily classified on the basis of the NAGpH, Acid-base account and static NAG test results and fall into one of the following categories:

- Non Acid Forming (NAF)
- Potentially Acid Forming (PAF)
- Acid Forming (AF)
- Uncertain (UC)

Non-Acid Forming (NAF): A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and a final NAGpH ≥ 4.5.

Potentially Acid Forming (PAF): A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH is circa neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Uncertain (UC): An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH < 4.5). Uncertain classifications may be moved to other waste classes by further testing procedures. If there is insufficient time for further testing within the mining cycle UC classified waste must be treated as D-Type.

Acid Forming (AF): A sample classified as AF has the same characteristics as the PAF samples however these samples also have an existing pH of less than 4.5. This indicates that acid conditions have already been developed, confirming the acid forming nature of the sample.

Figure 3 NAGpH vs NAPP

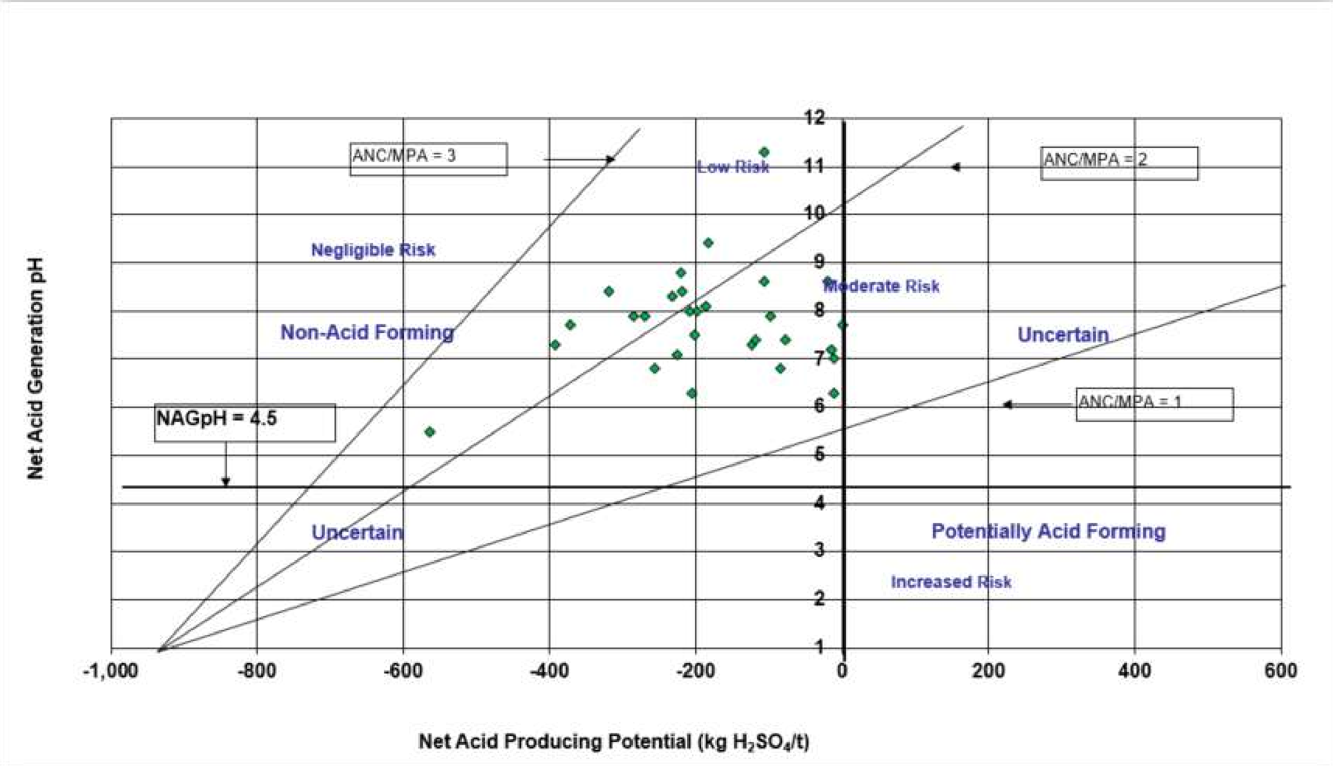
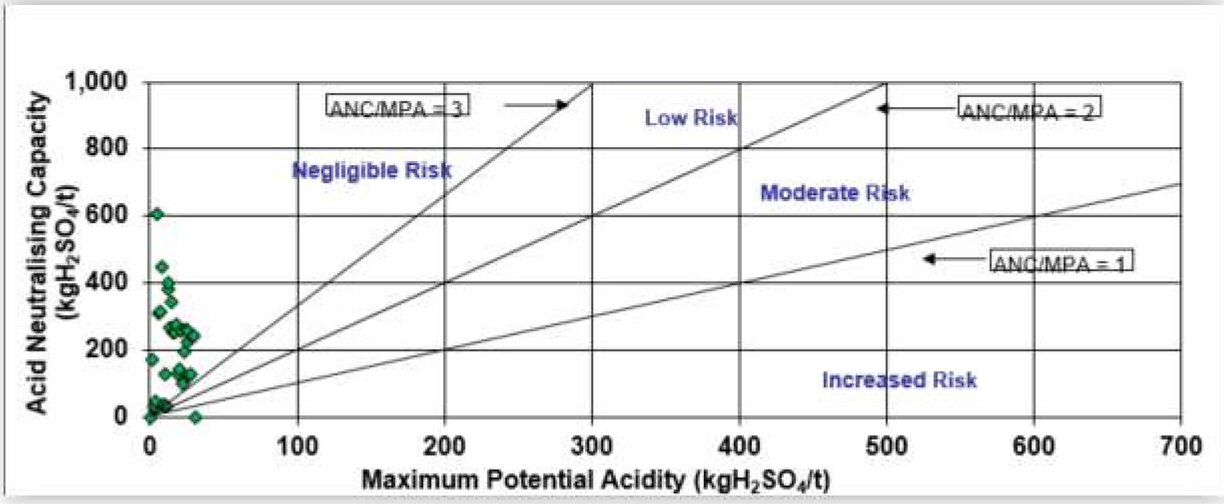


Figure 4 ANC vs MPA



5.4 Column Leachate Monitoring

Leach columns are used to develop further understanding of the waste materials drainage chemistry. Free draining leach columns simulate dump conditions to provide information on a range of issues including oxidation, metal solubility and the leaching behaviour of the test materials. Understanding reactivity of mixing waste rock types for future waste dump designs is also generated through this monitoring study.

5.5 Waste Rock Dump Construction Monitoring

Geotechnical monitoring of waste rock disposal facilities is conducted on a routine basis to detect any possible abnormal conditions such as subsidence and to verify the integrity of the run on and run off controls.

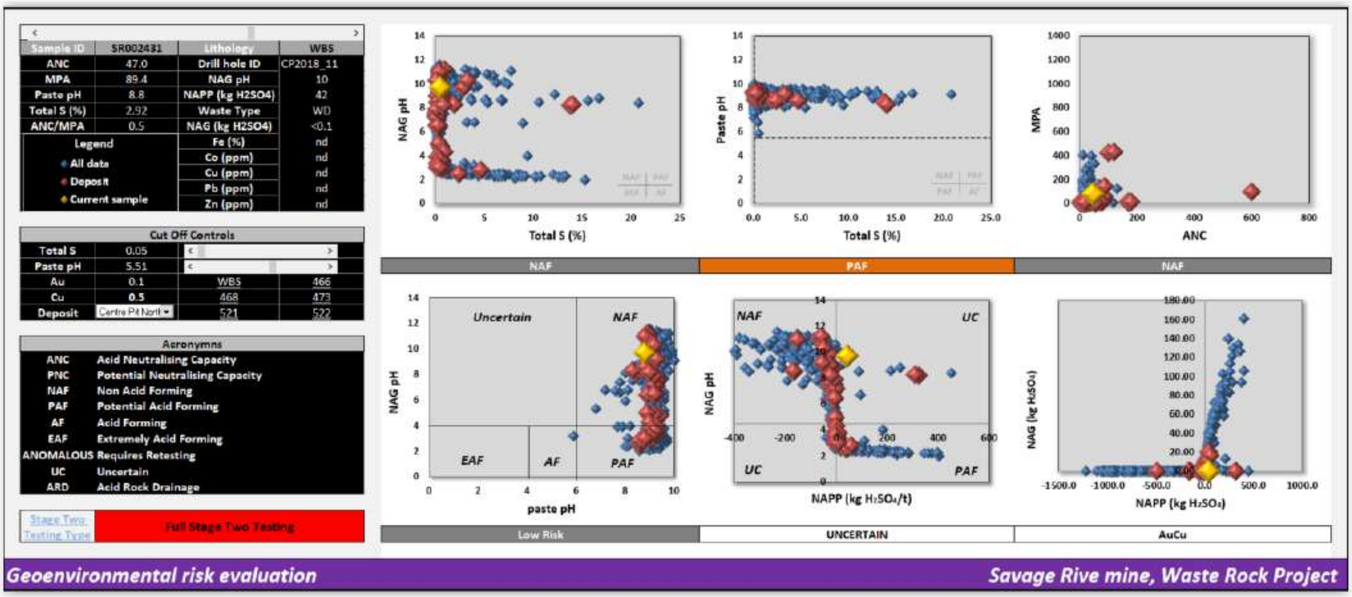
Waste rock disposal facilities are inspected on a risk based schedule, the inspection documents:

- Water ponding on top of the waste rock disposal facility;
- Seepage from the toe;
- Adverse settlement, cracking or signs of instability;

5.6 CONTINUAL IMPROVEMENT

Grange continues to apply BPEM principals to the classification and management of waste rock at the Savage River operations. Recently grange has been involved in the development of a Geo-environmental Risk Evaluation Dashboard and is currently assessing the suitability of this dashboard for use in classification of waste types and auditing of performance in waste rock management at Savage River.

Figure 5 Geo-environmental Risk Evaluation Dashboard Snapshot



Further work is also to be carried out on the use of portable XRD equipment for waste classification and 'Equotip' equipment for hardness testing to further improve waste classification.

5.7 Geochemical Monitoring Frequency

Grange Resources at Savage River uses the NAGpH test for operational categorisation of waste types. The suite of Acid Based Accounting Tests (MAP, ANC, NAPP and NAG) are carried out on drill core for geological waste model construction and for initial waste categorisation and to verify, reconcile and audit waste rock classification. Testing is carried out as per Table 5.

Table 5 Testing Application and Frequency

Waste Type Testing Point	Test Type	Frequency	Parameter
During Exploration Activities			
Diamond Drill core	NAGpH MAP, ANC & NAPP NAG	Per drill campaign in waste	Several ABA samples are taken per lithological unit within an assemblage domain with no less than 30 samples per domain to establish a statistically valid preliminary classification.
During Mining Operations			
Active pit benches: A) Blast hole cone sampling Or B) Free-dig areas (grab samples)	Visual assessment NAGpH	Daily Per pit blast	Visual and field characterisation of waste type of each blast-hole Collect sample of each unique waste type in a blast or daily in the case of free dig.
	ABA Accounting	Monthly	Confirm Waste Types
Active Waste Rock Dumps	Visual assessment NAGpH	Daily Weekly	Visual inspection to check for mis-dumping Collect sample of each active dump to validate that correct material is being dumped.
	ABA Accounting	Monthly	Confirm Waste Types

6 QUALITY CONTROL AND REVIEW

6.1 Competence Awareness Training

Technical and operational staff including geologists, grade controllers, mine planners and other relevant mining personnel will be provided independent geochemical training on a regular basis and at least every five years. All relevant staff holding responsibilities for waste rock management are trained in the requirements of the EMS-04 Waste Rock Management Plan.

6.2 Review of Waste Rock Classification

Grade control classifications are assessed against laboratory NAGpH analysis to verify accuracy and waste rock segregation. NAGpH is also assessed against full geochemical test results from NATA certified laboratories.

Performance of Grade Control classification against laboratory test results will be analysed over time by the Environmental and Geology Groups and by suitably qualified external contractors. Variations between field classification and laboratory results will be addressed as soon as is practical. These will also be reported in Technical Services Group meetings. Quality control is carried out as per Table 6.

Table 6 Waste Rock Quality Control Testing and Frequency

Quality Control	Type	Frequency	Parameter
Review results of NAGpH data	Grade Control vs NAGpH	Weekly	Check Grade Control Classification vs NAGpH Classification to verify correct dumping.
Graph results of all waste rock classification data.	NAGpH vs NAG & NAPP	Monthly	Determine variance between Classifications
Review available publications	Knowledge Base	Yearly	Update on AMD Prevention current thinking and analytical methods
Attend Workshops and Conferences	Knowledge Base	As Available	Update on AMD Prevention current thinking and analytical methods
Review Waste Type availability against Planned and Required Type	Waste Types Available and Required	Yearly	Waste Volumes

6.3 Internal Review of Waste Rock Segregation

Grange will review grade control vs laboratory classification regularly along with confirmation of correct dumping by waste type. Mine planning volumes by waste type shall also be reviewed against actual dumped volumes by waste type.

6.4 Review of Waste Rock Management Plan

Operations perform an audit of the waste rock management system at intervals required by licence conditions, determined by risk or in any event no less once every two years. Reviews, assessments, and audits are conducted by competent personnel.

In addition, Grange will ensure that independent auditing of waste rock selection, segregation, management and disposal is undertaken every 2 years during mining and construction of waste rock dumps, PAF cells, flow-throughs and filter faces. Audits are detailed in Table 4.

Table 7 Audit Frequency

Audit	Type	Frequency	Parameter
Audit compliance to WRMP and EPA approved permit conditions	Internal Audit	At least every 2 years	As required by licence conditions
Audit compliance to WRMP and EPA approved permit conditions	Independent External Audit	Every 2 years	Off-site NAG testing Updating and use of the site's resource block model waste attributes Blast holes sampling, geological logging and analyses for NAG testing Development and use of day-to-day bench plans showing boundaries between different material types occurring on respective benches Demarcation of block boundaries Information dissemination at toolbox meetings Accuracy of the material tracking system Daily routine field testing at the mine face for the prediction and identification of PAF/NAF materials Conformance with the segregation and allocation of waste to both the PAF cell dump and the flow-through dump Assessing the accuracy of PAF identification on site by reviewing results obtained to date Undertaking duplicate analytical assessment for acid base accounting of a suite of

			samples to compare in-house and external results. PAF cell performance (oxygen/temperature array)

6.5 Record Keeping

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Records will be kept of the amount of waste rock by geochemical type including source and final location. Grange will maintain a haulage database of the daily source of waste rock by waste type, by quantity, noting source and eventual dump location. Records of all data generated by EMS-04 Waste Rock Management Plan will be kept as described in Table 8.

Table 8 Record Keeping

Record Type	Minimum Records	Where to Access
Waste Rock Type, Source and Destination	10 Years	Grange's Haulage Database
ABA Accounting	10 Years	Geology Department
Internal Review Grade Control classification vs NAGpH classification	2 Years	Geology Department
Internal Review of NAGpH vs NAG & NAPP	2 Years	Geology Department
Water Analysis Results	10 Years	HSE Department
Staff Competence Training	2 Years	HSE Department (Training)
Internal review of EMS-04 WRMP	10 Years	HSE Department
External Review of EMS-04 WRMP	10 Years	HSE Department

7 REPORTING

Grange reports waste rock by type, source and destination as required by relevant EPN's. to the EPA. Waste Rock type and movement details are separately reported to the EPA for the South Deposit Tailings Storage Facility and are audited when actual movements occur.

8 EXTERNAL RESOURCES

Table 9 External Resources

Document	Description	Link
Global Acid Rock Drainage Guide	The GARD Guide is a detailed international resource on AMD prediction and management. The resource has been developed by world leaders in the industry and forms the basis for assessment of proposals worldwide.	http://www.gardguide.com
Preventing Acid and Metalliferous Drainage | Leading Practice Sustainable Development Program for the Mining Industry	This resource is provided by the Australian Government as a more local resource of the prediction and management of AMD on site. Designed to be more simplistic than the GARD guide, with Australian case studies, this document forms the basis for regulators assessment within Tasmania	https://www.industry.gov.au/sites/default/files/2019-04/lpsdp-preventing-acid-and-metalliferous-drainage-handbook-english.pdf
AMIRA International | ARD Test Handbook | Project P387A Prediction & Kinetic Control of Acid Mine Drainage	The AMIRA ARD Handbook forms the basis in Australia for AMD prediction and waste characterisation. The manual also has the lab methods used by many NATA labs to undertake the tests.	http://amirainternational.com/documents/downloads/P387AProtocolBooklet.pdf
	Alternate Handbook Download	Grange File
MEND | Guidance Documents	Mine Environment Neutral Drainage (MEND) program is based in Canada and provides much of the technical guidance for AMD management throughout the world, this link provides links to all their resources throughout the mining lifecycle.	http://mend-nedem.org/guidance-documents/
Good Practice Guide for Management of Metalliferous Drainage in Tasmania	The Good Practice Guide for Management of Acid and Metalliferous Drainage (AMD) has been developed to provide guidance on how AMD is best managed on sites within Tasmania.	https://www.mrt.tas.gov.au/land_and_resource_management/management_of_acid_and_metalliferous_drainage_in_tasmania

9 DEFINITIONS

Table 10 Definitions

Term	Definition
Potentially Acid Forming (PAF)	A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material.
Acid Forming (AF)	A sample with a significant sulphur content and a low pH indicating that oxidation has commenced.
Acid Neutralising Capacity (ANC)	The inherent acid buffering which occurs when acid formed from pyrite oxidation reacts with acid neutralising minerals contained within the sample.
Maximum Potential Acidity (MPA)	The MPA of a sample is calculated from the total sulphur content and assumes that all the sulphur measured in the sample occurs as pyrite (FeS_2) and that the pyrite reacts under oxidising conditions to generate acid.
Net Acid Generation (NAG)	The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample.
Net Acid Producing Potential (NAPP)	Represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC).
Acid and Metalliferous Drainage (AMD)	Drainage or seepage produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water.
Acid Base Accounting (ABA)	The use of chemical reactions and indicators, as a tool to identify in advance any mine materials that could potentially produce ARD, being static laboratory procedures that evaluate the balance between acid generation processes and acid neutralising processes
Non Acid Forming (NAF)	A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals
Uncertain (UC)	An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results. (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH $\leq$4.5).

Centre Pit Dewatering Assessment

Appendix C

pitt&sherry

Water quality implications of dewatering Centre Pit - Update

V1.1

20 November 2020

L. Koehnken – L Koehnken Pty Ltd

D. Ray – Aquatic Science

DOCUMENT TYPE:	Report	
TITLE:	Water quality implications of dewatering Centre Pit - Update	
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CLIENT:	Grange Resources	
PREPARED BY:	Lois Koehnken- L Koehnken Pty Ltd Daniel Ray – Aquatic Science	V1, 16 Mar 2018 Update V1, 19 Nov 2020 Update V1.1 20 Nov 2020
DISTRIBUTED TO:	Tony Ferguson, Grange Resources Lisa Georgiou	V1, 16 Mar 2018 Update V1, 19 Nov 2020 Update V1.1 20 Nov 2020 Electronic Copy: MS Word

1 Introduction

Grange Resources is proposing to expand mining in Centre Pit. This will require dewatering of the pit lake present in Centre Pit South (CPS) and the water contained within the waste rock deposited in Centre Pit North (CPN). The dewatering will require pumping, and Grange proposes to discharge the water into South Lens at a rate of up to 500 L/s. After mixing within South Lens the water will be discharged to the Savage River at the existing South Lens Outflow (SLO) point.

1.1 Background

The potential impact of dewatering Centre Pit via South Lens was initially investigated in 2018 (L Koehnken Pty & Aquatic Science, 2018) based on water quality monitoring results from 2011- 2017. The work built upon a previous investigation by Aquatic Science (2014) that linked hydraulic retention time in South Lens to copper (and other metal) removal. The 2014 study estimated that a 20% reduction in retention time (HRT) in South Lens could increase copper concentrations by up to 10 μg/L in the SLO discharge. The 2018 investigation concluded that dewatering CP at a rate of 120 L/s would have a variable impact on the HRT of South Lens, with HRT decreased in summer, when contaminant loads were generally low, but increased in winter due to the inflow from Centre Pit being limited to 120 L/s, as compared to the existing situation where the discharge from CPN to South Lens is much higher (frequently >200 L/s). The 2018 work concluded that dewatering at a pump rate of up to 120 L/s would not have a deleterious impact on the metal treatment capacity of South Lens or the water quality in the Savage River. No assessment was made of higher pump rates.

Since 2017, the hydrology of South Lens has been altered by the inflow of a large volume of Broderick Creek derived water via North Pit which has affected the HRT of South Lens, and also increased the alkalinity and sediment flux entering the water body. At the same time Grange has identified the need to dewater Centre Pit at considerably higher rates, of up to 500 L/s, in order to reduce water levels within an operationally acceptable time-frame.

This report reviews:

- how the inflow of water into South Lens has affected the quality of discharge from the water body and the metal removal mechanisms within the pit;, and,
- evaluates the water quality implications of pumping from Centre Pit at rates of up to 500 L/s to South Lens.

2 South Lens Flows

Understanding how flows have changed within South Lens is critical for understanding metal removal and how additional inflows may affect water quality in the future. Continuous flow data for the discharge from South Lens is episodic. To provide a more complete flow history, machine learning has been used to develop a tool to predict discharge from South Lens based on rainfall. Data from before the large increase in flow from North Pit occurred (2010 to 2014) was used to develop the technique, and hence provides a model for historic flows into South Lens.

Measured and predicted flows based on the machine learning output are shown in Figure 2-1. There is good agreement between the measured and modelled results through 2017. Discrepancies typically coincide with very high rainfall events. Comparing the predicted flows from 2017 to present with the measured flows shows a large increase in discharge from South Lens. The timing is consistent with the observed inflow of large volumes of water from North Pit into South Lens. The increase in flow through North Pit is mainly attributable to the interception of Broderick Creek water by the western expansion of the North Pit.

Comparing the modelled and measured flows suggests that up to 0.6 m^3/s of additional flow is entering South Lens, with the largest increases occurring during winter.

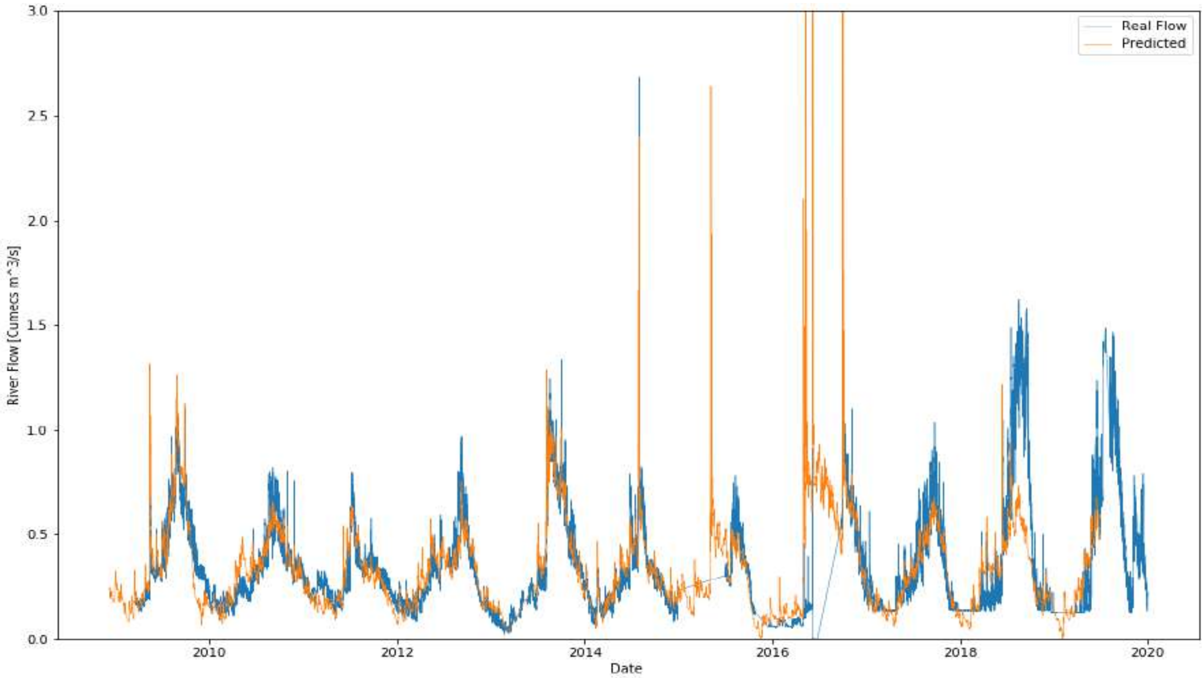


Figure 2-1. Comparison of measured and modelled flow from SLO based on machine learning.

Figure 2-2.(left photo) South Lens showing inflow of Broderick Creek derived water from North Pit (left inflow) and inflow of drainage from North Dump Drain (right inflow)into South Lens (right photo) detail of inflow of water from North Pit

The following sections summarises recent water quality results and evaluates how this large inflow has affected the discharge quality of South Lens.

3 Water quality review of South Lens & inputs

3.1 Recent trends

Copper is the toxicant of most concern at Savage River, and is a primary focus of the Savage River Remediation Project (SRRP). Figure 3-1 shows copper concentrations and flow at SLO from 2011 to 1017. In the early years, there is a high correlation between the two parameters, with elevated concentrations coinciding with periods of high flow. This has been interpreted as low retention times limiting copper removal (Aquatic Science 2014). From mid-2017 to September 2020 the flow has risen substantially and there is poor correlation with copper levels. This is a marked departure from previous observations. The flux of copper discharged from South Lens Figure 3-2 suggests that the copper flux has remained similar, or shown a slight decline since 2017.

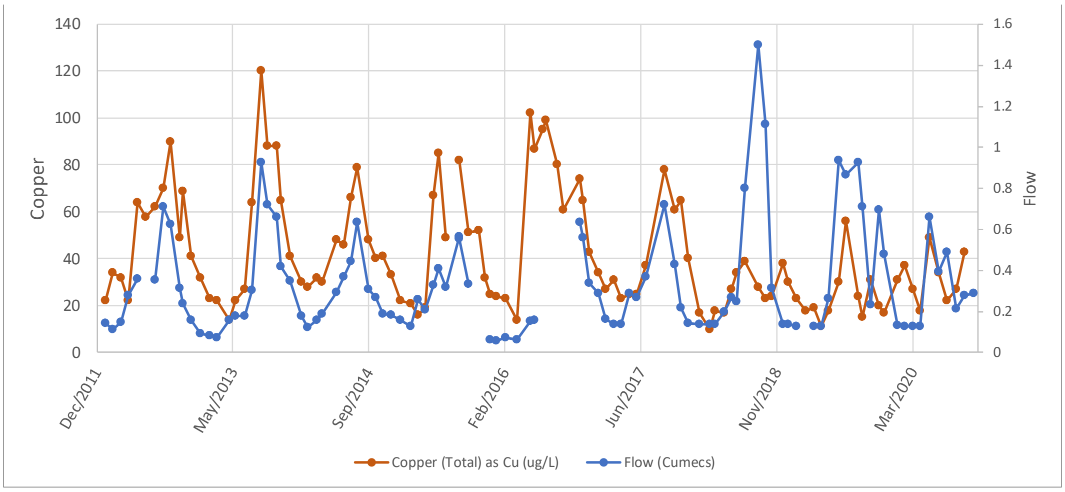


Figure 3-1 – Total Copper concentration with flow over time

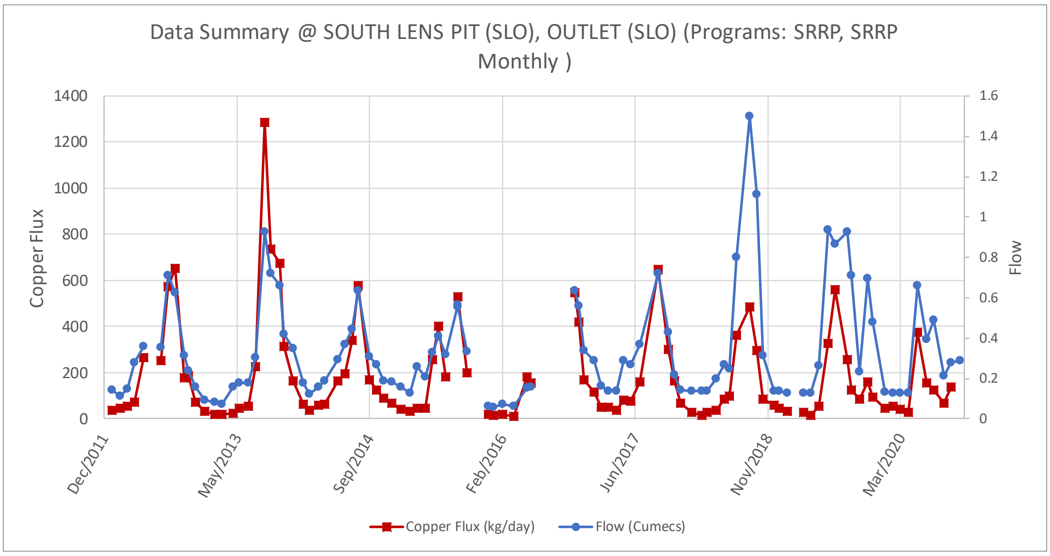
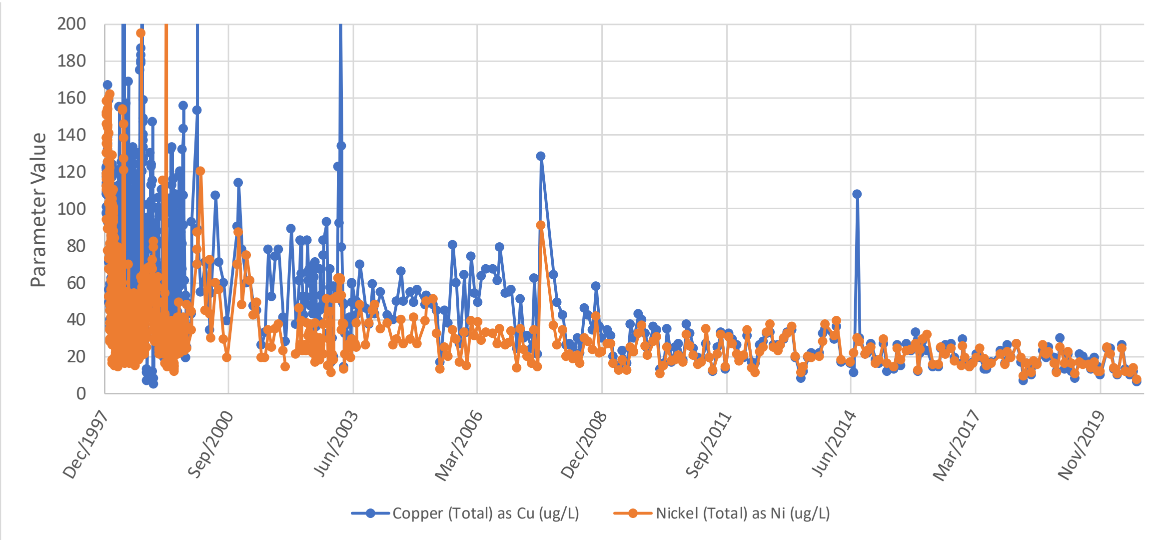


Figure 3-2 – Total Copper flux with flow over time

Concentrations of copper and nickel in the Savage River downstream of the Southwest Waste Rock Dump have also shown a decline since 2017. This site is located downstream of the confluence with Broderick Creek, so the only change is that more of the Broderick Creek water is passing through South Lens before entering the Savage River, e.g., the decrease in concentrations cannot be attributed to dilution by new inflows. These data provide additional evidence that decreased metal loads may be being discharged from South Lens.



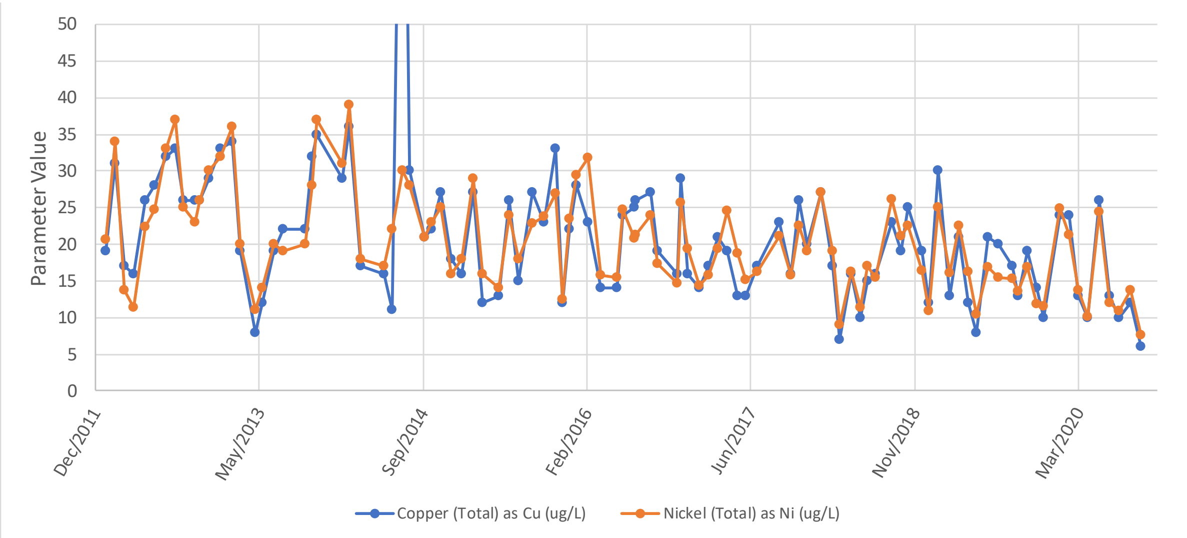


Figure 3-3 - Total copper and nickel concentrations over time in the Savage River below South West Rock Dump. Top graph shows since 1997, bottom graph since 2011.

If metal fluxes have declined, or even remained constant, then the efficiency of metal removal within South Lens has not declined as the HRT has decreased. If this has occurred, then drivers in addition to HRT must be contributing to metal removal. These could include: changes in pH, changes in alkalinity, a decrease in metal inputs to South Lens or the physical processes governing metal removal have been changed.

pH and alkalinity trends

Figure 3-3 compares total copper at SLO with pH. pH values have not increased since 2017, except for one period in late 2017 when values increased to 8.5. The pH range in South Lens largely coincides with the range over which maximum copper removal occurs (Figure 3-5). This is one reason why retention time for the settlement of solids was previously identified as a controlling factor.

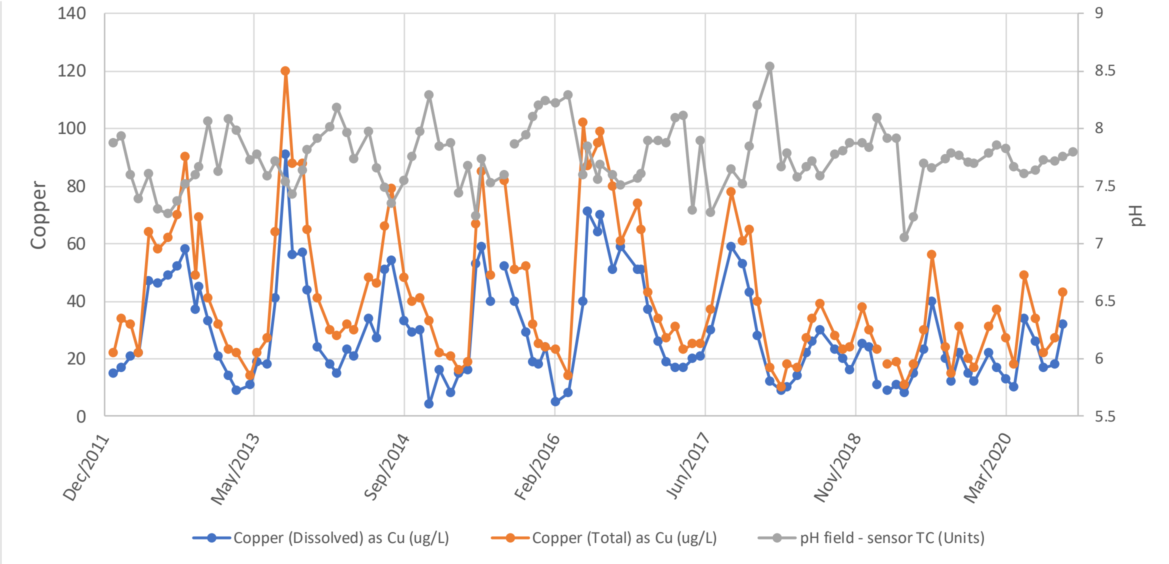


Figure 3-4 – Total and dissolved copper with pH over time for South Lens Outflow.

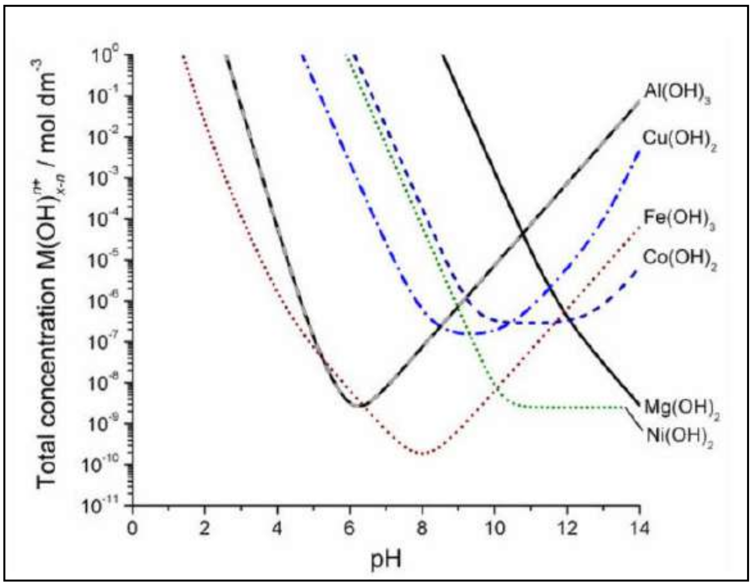


Figure 3-5 – Solubility of copper as a function of pH. Y-axis shows ratio of dissolved hydroxide to total metal, e.g. 10^0 = 100% dissolved, 10^{-2}=0.01% dissolved, 10^{-4}=0.0001% dissolved (McKerracher, 2012).

Alkalinity concentrations in South Lens (Figure 3-6) shows a small reduction at the beginning of 2016, but little change since. Changes to alkalinity are therefore unlikely to be contributing to changes in metal loads.

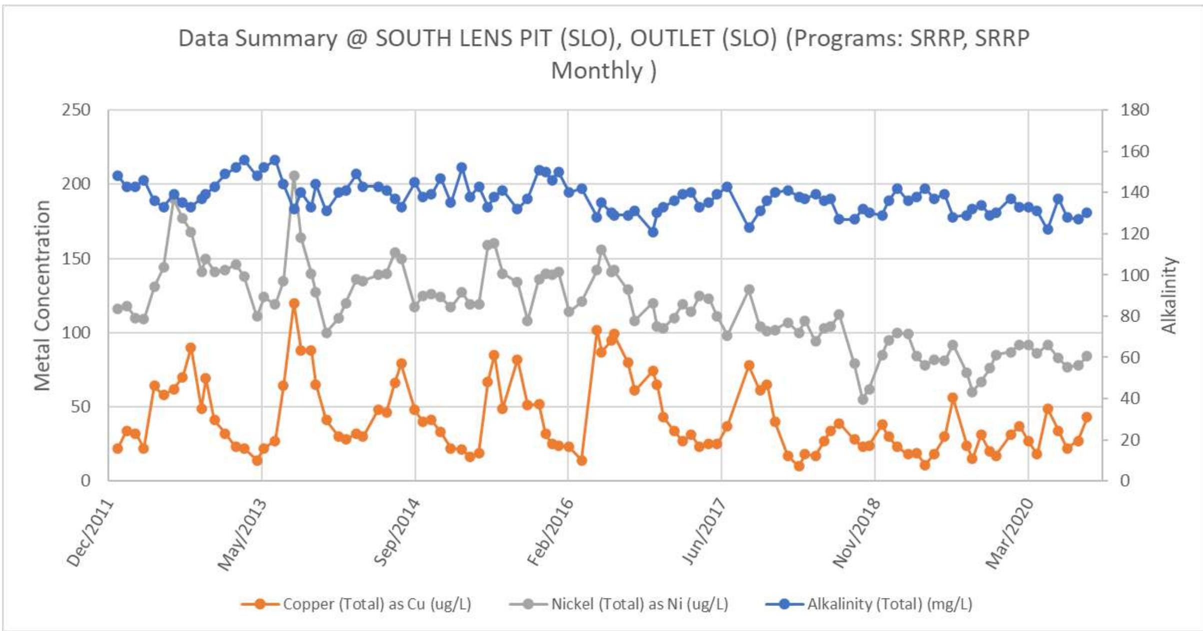


Figure 3-6. Comparison of alkalinity, total copper and total nickel concentrations in South Lens.

Reduction in input from North Dump Drain

The North Dump Drain is the major source of metals, sulphate and acidity to South Lens. There is a minor reduction in metal concentrations with time (Figure 3-7), but not sufficient to explain the performance of the South Lens metal removal with the decrease in residence time.

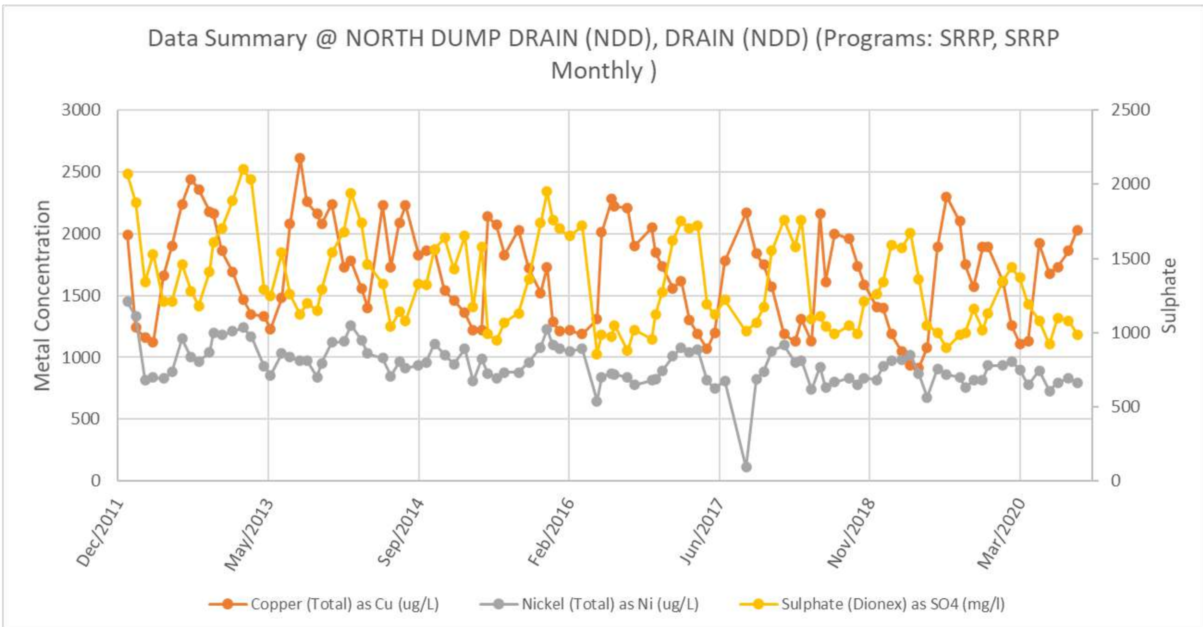


Figure 3-7. Copper sulphate and acidity concentrations in North Dump Drain.

Monitoring results show a reduction in aluminium and acidity in the North Dump Drain water. Dissolved aluminium is a source of acidity and represents most of the aluminium present, Figure 3-12. Reduced acidity load would assist metal removal within South Lens, but is not believed to be the cause of the sustained water quality performance. In Figure 3-6 there is a slight reduction in total alkalinity. If a reduction of acidity load from North Dump Drain was responsible, there would be an increase in alkalinity expected.

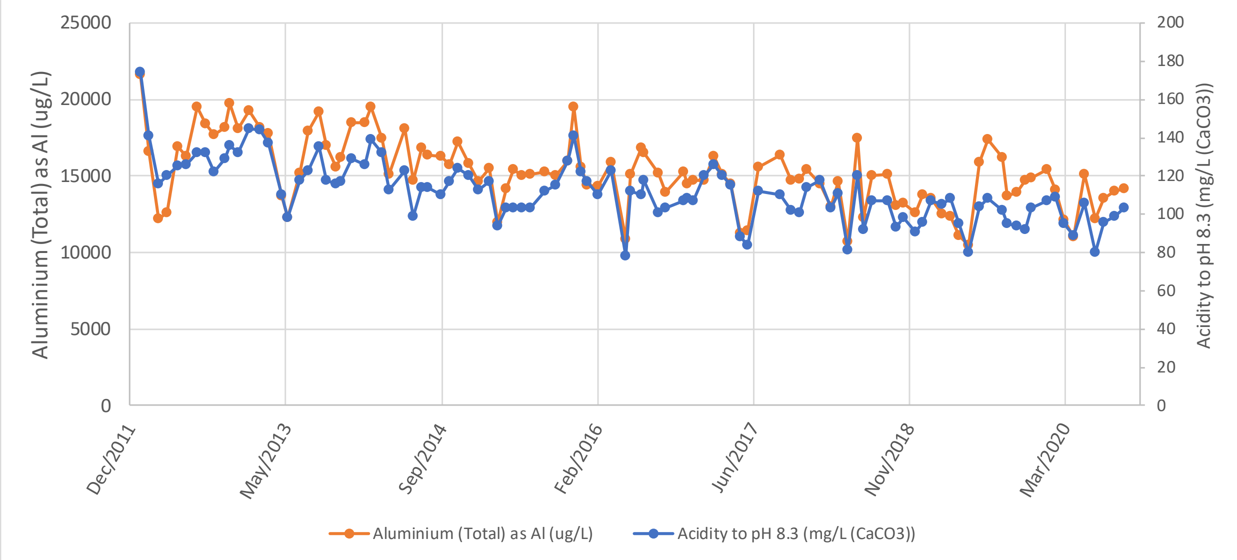


Figure 3-8. Aluminium and acidity in NDD.

Sediment Loads entering South Lens

The water entering south Lens from North Pit has increased sediment loads entering South Lens due to the turbid conditions occurring within the base of the North Pit sump (Tony Ferguson Pers Comm). There is a strong possibility that the sediment is providing substrate for the precipitation and adsorption of metal precipitates and possibly nuclei to catalyse the formation of precipitates. The water pumped from underground may also contribute to increased suspended solids in South Lens as shown in Figure 3-9.

Figure 3-9 – Plume of sediment from underground water pumping looking north to south over South Lens.

The increased removal of metal hydroxides through precipitation and adsorption onto sediment surfaces would be consistent with reducing the relationship with hydraulic retention time, as the metals are rapidly removed by settling particulates rather than the dependent on the much lower settling rate of fine metal hydroxides.

There are no data showing increased TSS in South Lens, as monitoring is only completed at the outflow point, and the sediment is retained within the water body, along with associated metals.

Nickel, cobalt and manganese

The preceding discussion is relevant to copper and other metals (aluminium, iron, lead, chromium) which can be removed through neutralisation reactions at the pH conditions within South Lens. Metals such as manganese, and to a lesser extent nickel and cobalt (Figure 3-5), are not as efficiently removed under these conditions. A copper balance for South Lens suggests that 5.3 kg/day are entering the water body, with 1.3 kg/day discharged, resulting in a 75% reduction in flux. For nickel, the estimated inputs are 3.2 kg/day, with the average outflow estimated as 2.9 kg/day.

Table 3-1. Estimated average copper and nickel balance in South Lens. 'Not adjusted' values based on on flow and water quality measurements at the site. Based on monitoring results 2015 – 2020.

Site	Cu tot (kg/day	Ni tot (kg/day)	Adjustments
NDD (input)	4.3	2.1	Reduced 5% as declined over period
CPN (input)	0.5	0.8	Not adjusted
Brod Ck (input)	0.3	0.3	Estimate 50% SLO flow *Cu_{avg} in Broderick Ck
Total In	5.1	3.2	
SLO (output)	1.3	2.9	Not Adjusted
% removal	75%	10%	

3.2 Summary of water quality trends in South Lens 2017 - 2020

- The water quality in the discharge from South Lens has not shown an increase in metal concentrations or loads following a substantial increase in flow through the water body. The previous correlation between copper removal and hydraulic retention time is no longer observable in the monitoring data;
- The input from North Dump Drain has not changed substantially, and cannot account for the maintenance of good water quality in the South Lens discharge despite the reduction in residence time;
- The input from North Pit contains high concentrations of alkalinity and sediment which have increased the alkalinity load into South Lens, and may have increased metal removal through increased surface area provided by the suspended solids;
- The water quality results since 2017 suggest that the metal removal in South Lens has been at least maintained, and likely increased since the increase in inflow from North Pit, despite a reduction in residence time;
- A multiple-lines of evidence approach suggests that increased surface area due to increased suspended solids in South Lens has increased the rate of metal removal by increasing available surface area for metal precipitation and adsorption.

3.3 Inputs from Broderick Creek and Centre Pit to South Lens

The alkaline inflows to South Lens include water derived from Broderick Creek (Bretts Drain, North Pit discharge) and Centre Pit. Discharges derived from Broderick Creek (Bretts Drains and North Pit) will continue to enter South Lens as presently occurs. The North Pit inflow is not monitored but would be expected to be similar to Broderick Creek (Table 3-2). These inflows are characterised by neutral pH, low metal concentrations, elevated concentrations of alkalinity, and moderate (~300 -400 mg/L) sulphate (Table 3-2). It is these inflows that provide the majority of the neutralisation capacity within South Lens

Table 3-2. Total metals (μg/L) in water quality samples collected from Broderick Creek below Waste Rock Dump between 01/10/2017 and 01/10/2020.

Statistic	Al Tot (mg/L)	Co Tot (mg/L)	Cu Tot (mg/L)	Fe Tot (mg/L)	Mn Tot (mg/L)	Ni Tot (mg/L)	Zn Tot (mg/L)
Mean	76	3	8	106	33	10	3
80th Percentile	57	3	11	84	38	10	4
Median	31	3	7	40	21	10	3
20th Percentile	20	3	5	20	10	10	2

Statistic	pH	Acidity (mg/L)	Tot Alkalinity (mg/L)	Ca (mg/L)	Sulphate (mg/L)
Mean	7.46	10	190	131	364
80^{th}	7.56	12	219	148	408
Median	7.465	10	183	127	354
20th	7.34	8	166	113	294

Once pumping commences, the overflow from the Centre Pit North will continue to enter the South Lens as presently occurs, but the volume will decrease as the groundwater gradient between Centre Pit North and Centre Pit South is lowered and eventually slopes towards Centre Pit South (groundwater presently flows towards CPN). As pumping progresses, the overflow from CPN will cease and, and all discharge will be via the pump system from CPS to the tank located near the CPN collection pond. The existing water quality in the CPN discharge is summarised in Table 3-3, and shows characteristics consistent with neutral mine drainage, i.e. pH values over 7, high levels of alkalinity, and increased concentrations of metals not removed at the pH of the discharge (e.g. Co, Zn, Ni, Mn).

Table 3-3. Summary of water quality from Centre Pit North based on monthly monitoring results September 2019 to September 2020.

Parameter	20^{th} Percentile	Median	80^{th} Percentile	Average
pH	6.96	7.06	7.17	7.07
Cond	2346	2440	2560	2282
Alk	132	150	166	149
Acidity	13	17.5	26.2	19.2
Ca	301.2	321	366.8	328.0
Mg	200.8	215	235	216.
Sulphate	1424	1485	1688	1532
Al	348.4	558	908.8	837.9
Co	227	236	271.2	245.3

Parameter	20th Percentile	Median	80th Percentile	Average
Cu	92.4	137.5	185.6	142.2
Fe	410	585	1486	1272
Mn	2472	2580	2776	2622
Ni	184.2	193	210.2	197.1
Zn	48	51	58.4	52.7

The available water quality results from the pit lake in CPS are presented in Table 3-4, and show the water body has low concentrations of copper and zinc, and variable concentrations of cobalt, nickel, manganese and iron. The metal concentrations correlate well with iron, suggesting that the elevated surface concentrations are attributable to adsorption onto iron floc. Oxygen profiles collected at the same time showed the water column was well oxygenated with depth. The 2018 summary report shows details of the water column.

The average metal concentrations from Broderick Creek are compared to water quality results in Centre Pit and South Lens from Centre Pit in Table 3-4. The comparison indicates that with the exception of iron, the concentration of metals in Broderick Creek and Centre Pit are lower than the concentrations within South Lens, demonstrating that the inflow of these waters will dilute concentrations even without any removal due to neutralisation. It is likely that as the CPN water is drawn into CPS south, dilution will occur, and the concentrations of metals entering South Lens will decrease.

Although lower than in South Lens, nickel concentrations are considerably higher than copper values in Centre Pit, and nickel is removed less efficiently in South Lens as compared to copper. This may result in nickel posing an environmental risk during periods when the discharge from South Lens contributes the majority of flow in the Savage River.

Table 3-4. Total metals (µg/L) in water quality samples collected on 20/12/2017 from the surface, mid-depth and bottom water in Centre Pit North and South Lens. In both pit lakes two locations were sampled (North and South).

Site	Al µg/L	Co µg/L	Cu µg/L	Fe µg/L	Mn µg/L	Ni µg/L	Zn µg/L
CPS N Surf	<20	111	4	701	1650	107	20
CPS N Mid	<20	60	8	198	964	76	22
CPS N Bot	<20	5	1	115	62	60	10
CPS S Surf	<20	116	4	793	1690	109	23
CPS S Mid	<20	61	7	196	972	75	22
CPS S Bot	<20	9	1	229	107	65	13
SLens N Surf	113	147	35	157	1420	109	22
SLens N Mid	53	144	25	269	1250	111	24
SLens N Bot	25	147	22	218	1270	117	27
SLens S Surf	115	146	34	181	1420	108	22
SLens S Mid	52	144	28	131	1270	110	24
SLens S Bot	28	153	23	110	1290	121	27
CPS avg	<20	60	4	372	908	82	18
Brod avg	76	3	8	106	33	10	3

S Lens avg	64	147	28	178	1320	113	24

A similar comparison for acidity, alkalinity, calcium and sulphate (Table 3-5) between CPS, South Lens and Broderick Creek shows that alkalinity is somewhat lower in Centre Pit (~100 mg/L) as compared to Broderick Creek or the water within South Lens, and average sulphate is about 10% higher than in South Lens. These comparisons suggest that discharging additional water form CPS will not substantially alter the nature of South Lens.

Table 3-5. Comparison of water quality results from profiles in Centre Pit with average values in South Lens and Broderick Creek

Site	Acidity (mg/L)	Tot Alkalinity (mg/L)	Ca (mg/L)	Sulphate (mg/L)
CPS N Surf	1.5	94	194	912
CPS N Mid	6	104	189	831
CPS N Bot	9	110	213	896
CPS S Surf	1.5	94	197	900
CPS S Mid	6	102	188	827
CPS S Bot	9	111	205	892
CPS avg	6	103	198	876
South Lens Average	6	139	188	812
Broderick Ck Avg	10	194	131	364

4 Potential changes to water quality in South Lens from pumping from Centre Pit

Under the present water management scenario at Grange, water from Centre Pit enters South Lens, with the volume reflecting rainfall (Figure 4-1). Average inflow rates are about 100 L/s, but range up to ~250 L/s during periods of high rainfall. This discharge from Centre Pit will cease once the groundwater level in Centre Pit South is drawn down by pumping, and the water contained within the waste rock in Centre Pit North drains southward. At this time all water will be discharged via the pumping system. Therefore, the effective increase in discharge to South Lens will be the net difference between the pump volume and the seasonal overflow volume. The quality of water discharged into South Lens should improve, due to the better quality of water present in CPS as compared to CPN (although fluxes will likely remain the same, and increase as pump rates increase).

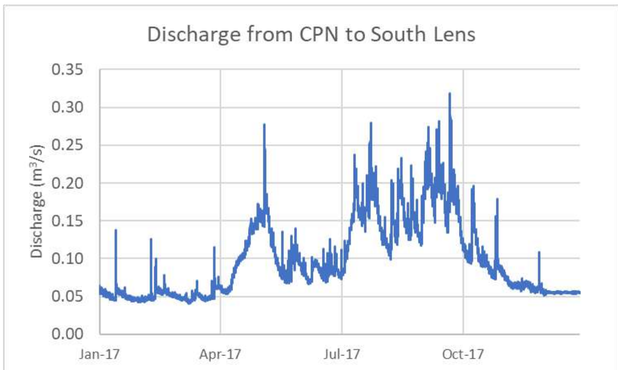


Figure 4-1. Discharge from Centre Pit North showing range of discharge rates.

The timing of water discharge from South Lens will be affected by the pumping, with relatively higher flows discharged from South Lens during dry periods. This is demonstrated in Figure 4-2 where the flow in the Savage River at SW WRD is shown with and without an additional 500 L/s of discharge. This is an extreme example as it does not account for the flow from CPN that would be included in the Savage Flow, and it assumes maximum pumping during dry periods, which will not occur (See Section 4.1). As discussed in the previous section, concentrations in South Lens may not change substantially, however the increased discharge from South Lens during these periods could increase metal concentrations in the Savage River as compared to present conditions due to the proportion of water derived from South Lens increasing.

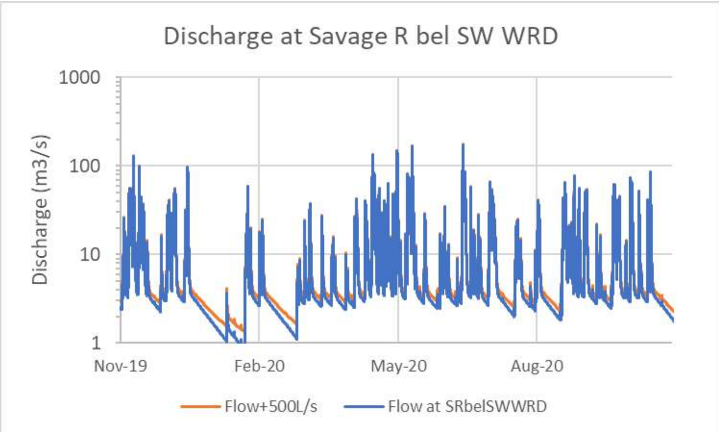


Figure 4-2. Comparison of flow in the Savage River below the SW Waste Rock Dump with and without an additional 500 L/s.

As summarised above:

- The additional water being pumped to South Lens (in addition to that which flows in from Centre Pit North) contains high alkalinity and relatively low metals;
- The inflow from Centre Pit will not affect the existing alkalinity / suspended solids / NDD interactions occurring within South Lens, as the same inflow from North Pit will continue to enter South Lens;
- The increase in water discharge to South Lens will effectively be less than 500 L/s, because once the water level within Centre Pit South is decreased, water contained within Centre Pit North will flow into Centre Pit South and be pumped, rather than flowing directly into South Lens
- Due to the observed changes in water quality trends and understanding of the system, pumping at rates of >120 L/s should not directly affect metal removal in South Lens or the quality of the discharge from South Lens as residence time is no longer the controlling factor in water treatment.

4.1 Recommended guidance for pumping

The water quality results suggest that residence time is no longer the limiting factor for metal removal, but the data do not indicate what is the limiting factor, and / or how close the conditions are in South to approaching this limit. Based on this, it is recommended that an adaptive management approach is adopted, and incremental increases in pump rates be guided by intensive monitoring of the Centre Pit discharge and South Lens outflow, and monitoring within the Savage River.

The 2018 investigations derived trigger values to guide pumping based on the 90th percentile values for copper and acidity, and 10th percentile values for alkalinity in the discharge from Centre Pit North and South Lens for the 2013-2017 period. The same values based on the most recent 12 months of data available (Sept 2019 to Sept 2020) are summarised in Table 4-1. In addition to these parameters, it is recommended that a nickel trigger value be included, as this metal is not removed as efficiently in South Lens, and poses a moderate toxicity risk to the Savage River. Implementing these triggers will ensure that concentrations in the water entering South Lens from Centre Pit and in the water discharged from South Lens will remain within the range of conditions experienced in the recent past.

Table 4-1. Summary of trigger values for pumping from Centre Pit based on previous modelling

Parameter	90th percentile trigger	10th percentile trigger
Copper (total)	>221 μg/L	
Acidity	>30 mg/L	
Nickel (total)	>220 μg/L	
Alkalinity		<128 mg/L

Table 4-2. Summary of trigger values for discharge from South Lens based on previous modelling.

Parameter	90th percentile trigger	10th percentile trigger
Copper (total)	>45 μg/L	
Acidity	>7 mg/L	
Nickel (total)	>91μg/L	
Alkalinity		<123mg/L

These triggers are recommended in addition to the previously derived constraints on pumping based on sulphate (conductivity), as described in the EIS, which include a maximum pump rate of 120 L/s if flow in the Savage River at Pump Station is <1.5 m^3/s, and a maximum pump rate defined by the following equations. (Note the sulphate concentrations will be linked to the concentration in the monitoring tank near the CPN pond rather than the CPS pump).

$$Max_{Pump} = \frac{\left(SRaPS\ flow\ rate\ in \frac{m3}{s}\right) x\ 1000\ x\ 1.85\ x\ 0.57}{0.0189\ x\ (CPS\ SO_4^{2-}\ concentration\ in\ mg/L) - 2.6415}$$

$$Sulphate\ in\ mg/L = 0.3424\ x\ Conductivity\ in\ \mu s/cm - 14.935$$

This constraint will limit pump rates as shown in Table 4-3, and provide a high level of mixing in the receiving environment. A minimum mixing rate of 13-fold will occur when sulphate is 900 mg/L, and this increases to 19-fold if sulphate is 1200 mg/L. The flow conditions required to pump 500 L/s are superimposed over the 2011 flow results in Table 4-3, and demonstrate that maximum pump rates will only be permitted during high flow events.

Table 4-3. Allowable pump rates based on sulphate in Centre Pit and flow in the Savage River at Pump Station.

SRaPS Flow (m^3/s)	Sulphate in CP (mg/L)	Max Pump (L/s)		SRaPS Flow (m^3/s)	Sulphate in CP (mg/L)	Max Pump (L/s)
1.5	900	110		1.5	1200	120
2	900	147		3	1200	158
3	900	220		5	1200	263
4	900	294		7	1200	368
5	900	367		8	1200	421
6	900	440		9	1200	474
7	900	514		10	1200	526

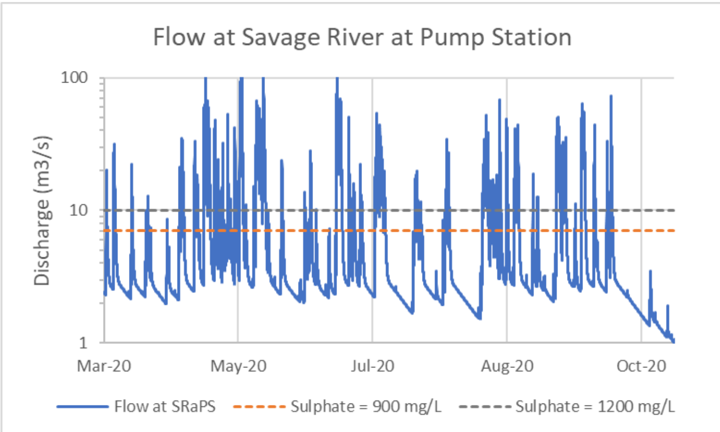


Figure 4-3. Flow conditions required at Savage River at Pump Station to allow pumping at 500 L/s. Orange line indicates required flow when sulphate at CP = 900 mg/L; grey line indicates required flow when sulphate at CP = 1200 mg/L.

It is recommended that discharge to South Lens commences at 200 L/s or less (based on sulphate restriction), with daily monitoring of copper and nickel at the CPN, Monitoring tank, and SLO. Monitoring of EC for the sulphate calculation should be monitored continuously online

Following 2 weeks of copper, nickel and conductivity values remaining within the trigger values, discharge rates to South Lens may increase by 100 L/s if flow in the Savage River is sufficiently high. In addition to the daily monitoring to guide pump rates, the following monitoring is recommended

Table 4-4. Recommended monitoring during dewatering of Centre Pit

Location	Parameters	Frequency	Comment
CPS_{Pump} discharge to CPN_{pond} at dewatering tank	Total Metals, sulphate, alkalinity, acidity, TSS,	Grab sample fortnightly monitoring frequency re assessed after 3 months	To determine if water quality is changing as pit is dewatered
	Flow, EC, pH	6-hourly to continuous	Indicators of change
CPN to South Lens (combined discharge of CPN and pump water)	Total Metals, sulphate, alkalinity, acidity	Daily copper and nickel Fortnightly monitoring frequency re assessed after 3 months	Samples may show high variability if water is not well mixed in the CPN_{pond}
	Flow, EC, pH	6-hourly to continuous	Indicators of change
SLO	Total Metals, sulphate, alkalinity, acidity, TSS	Daily copper and nickel	To compare predictions with

Location	Parameters	Frequency	Comment
		Fortnightly monitoring of all other parameters with the frequency re assessed after 3 months	reality & ensure no major change in WQ
	Flow, EC, pH	6-hourly to continuous	Indicators of change
SRbelSWRD	Total Metals, sulphate, alkalinity, acidity, TSS	Monthly	As per EPN to document any changes in water quality during pumping
	Flow, EC, pH	6-hourly to continuous	Indicators of change

This approach reduces environmental risks, as there are four check points at which the impact of the pumped water will be monitored: at the CP tank prior to discharge to CPN, at the CPN outflow, at the South Lens outflow, and in the Savage River below South West Waste Rock Dump. These monitoring points will provide detailed information about water quality before, during and after its discharge to South Lens.

As discussed in the Management responses, the discharge from CPS *could* be considered for direct discharge to the Savage River, as it poses a very low risk to the environment when mixed with the ambient waters. This approach has not been adopted as there would not be the multiple opportunities to monitor the impact of water as it passes through South Lens. Directing the water to South Lens also provides security of retaining suspended solids should the concentration increase as water levels are drawn down in Centre Pit South.

4.2 Recommended management responses

Based on monitoring results, the following management responses are recommended if trigger values at CP or SL are exceeded:

- Review results to determine if change can be attributable to factors other than increased pumping from Centre Pit. If the change is linked to the pumping, then immediately decrease pump rates by 100 L/s and continue to monitor for 2 weeks and re-evaluate, and / or investigate direct pumping to Savage River, or altering the discharge point into the South Lens if short-circuiting is occurring.
- If the source of any metal increase is considered to be unrelated to the pumping from Centre Pit, notify the SRRP to investigate potential causes, such as changes at other inflows (NDD, BD, etc), or extreme hydrologic events;
- Implement weekly monitoring at SRbSWRD to evaluate the impact on the river. If concentrations remain within the 20th to 80th percentile range of results from 2017 to present, re-evaluate the trigger values.

If trigger values are not exceeded, but concentrations at SRbSWRD increase above the 90th percentile values listed in Table 4-5, the following is recommended:

- Decrease pump rates by 100 L/s and evaluate the potential impact of the concentrations. Increased concentrations in the Savage River are most likely to occur during the dry summer when the South Lens discharge is contributing a greater proportion of the flow. Maintain lower pump rates until flows in the river have increased and concentrations have returned to within the 90th percentile values.

Table 4-5. 90th percentile pH value and concentrations in the Savage River below Southwest Waste Rock Dump based on monthly monitoring results 2016 – 2020.

Parameter	90th Percentile (10th Percentile for pH)
pH	7.1
Sulphate	258 mg/L
Copper	27 μg/L
Cobalt	30 μg/L
Nickel	26 μg/L
Zinc	11 μg/L

References

Aquatic Science, 2014. Waste rock disposal into South Lens Pit Study, Report prepared for Grange Resources.

Koehnken, L and Ray, D, 2018, Water quality implications for dewatering Centre Pit South. Report prepared for Grange Resources.

Natural Values Assessment and Addendums

Appendix D

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northbarker

ECOSYSTEM SERVICES

Savage River Mine - center pit extension
Savage River

Natural Values Assessment

1 March 2018

For Grange Resources
GRA004

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Contributors:

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Report: Richard White and Dave Sayers

Mapping: Richard White

Review: Andrew North

Photos: Richard White

Summary

Grange Resources is proposing to extend the centre pit of their mine at Savage River, Tasmania. A botanical survey and fauna habitat assessment was undertaken to determine and document the conservation significant natural values within the potential area to be impacted by the proposal. This will facilitate mitigation measures for minimising environmental impact. This report documents the results and recommendations in accordance with the Guidelines for Natural Values Assessment by the Tasmanian Department of Primary Industries, Parks, Water and Environment.

Vegetation

The following TASVEG 3.0 vegetation communities were identified and surveyed in the study area:

- ***Nothofagus-Atherosperma* rainforest (RMT)**: A portion east of the pit, and much of the area west of the pit (45 ha).
- ***Acacia melanoxylon* forest on rises (NAR)**: An area to the east, and a smaller area to the west, of the pit (21 ha).
- ***Acacia dealbata* forest (NAD)**: Two small areas, both in the north of the study area (2 ha).
- **Regenerating cleared land (FRG)**: A formerly disturbed area on east of the pit (16 ha).

None of the TASVEG units recorded on site corresponded to threatened communities listed under the Tasmanian *Nature Conservation Act 2002* (NCA) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA). In addition, no EPBCA listed ecological communities are predicted to occur within the study area by the EPBC Protected Matters Search Tool. It is considered unlikely that any threatened communities have been overlooked.

Flora

No threatened flora species listed under either the Tasmanian *Threatened Species Protection Act 1995* (TSPA) or the Commonwealth EPBCA were recorded or thought likely to occur.

Fauna

No threatened fauna species listed under either the Tasmanian TSPA or the Commonwealth EPBCA were recorded.

The spotted-tailed quoll is listed as vulnerable on the EPBCA and rare on the TSPA and is likely to be present within the study area based on habitat suitability. Equally suitable quoll habitat is extensive beyond the footprint.

The Tasmanian devil is listed as endangered on the EPBCA and TSPA and is known to occur within the study area. Habitat suitability is sub-optimal and no denning features where recorded.

The TSPA endangered grey goshawk has viable nesting and foraging habitat on site, but no nests or individuals were observed. Potential nesting habitat occurs within the riparian vegetation along Savage River.

Legislative implications and recommendations

Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Quoll

The project will not have a significant impact on the 'vulnerable' spotted-tailed quoll under the significant impact criteria as the area does not support an 'important population' as defined under this legislation.

Devil

The scale of impact to the habitat of the Tasmanian devil is not significant in the context of the extent of habitat in the area and the character of the sub optimal denning habitat being disturbed. While it remains possible that one or more natal dens may be present no obvious preferred structure was identified during targeted surveys.

Pre-clearance den surveys for the quoll and den are recommended to mitigate the risk of impact.

The proposal is very unlikely to have a measurable impact upon any other MNES.

Tasmanian *Threatened Species Protection Act 1995*

The TSPA definition of "take" does not usually extend to the disturbance of foraging habitat for fauna, but does include nests and dens, which are "products of wildlife".

No potential dens for spotted-tailed quoll were found. No direct impact to spotted-tailed quoll are anticipated that could be quantified sufficiently to require a permit under this legislation.

No raptor nests were observed within the study area, although there is potential nesting habitat for the grey goshawk.

No other nests of fauna listed under the TSPA were recorded and it is unlikely that nesting habitats will be impacted.

Weed Management Act 1999.

The declared weed pampas grass is listed as Zone A species for the Waratah/ Wynyard municipality and was observed within the study area. Eradication is the required management objective for Zone A species. A management program could be implemented to control the spread of this and other environmental weeds during and following works. Blackberry was also observed, and is listed as Zone B where containment is the objective.

Recommendations

Efforts to mitigate the impacts of the development should focus on reducing the risk of introduction and spread of plant pathogens, and declared and environmental weeds, during and after works, by implementing appropriate weed and hygiene management plans. Furthermore, reducing the clearance and impact on riparian vegetation on the Savage River should be considered to minimise the potential for impacting on potential habitat for grey goshawk.

This report should be updated post final design to accurately quantify impacts.

Undertake a targeted grey goshawk nest survey if potential habitat is impacted. Pre-clearance devil and quoll den surveys should be included.

Table of Contents

1 Introduction

1.1 Project details

Background: Grange Resources (Grange) is proposing to develop an open pit (centre pit) at the Savage River Mine. This development will require new access routes to the east, and potentially the west, of the pit. As part of the planning and design phase, Grange have engaged North Barker Ecosystem Services (NBES) to undertake a natural values assessment to determine significant natural values that may be impacted by the proposal. This will facilitate mitigation measures for minimising environmental impact. Our report documents the results and recommendations in accordance with the *Guidelines for Natural Values Surveys* by the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE)[1].

1.2 Study area

Savage River is located within the Tasmanian 'West' bioregion[2], approximately 100 km from Burnie, and within the municipality of Waratah-Wynyard. The study area (Figure 1) is located to the north-west of the Savage River town, and is south of the existing operations at North Pit, and north of South Pit. The study area is divided into areas east and west of the pit of approximately 60 and 45 ha, respectively. To the west, the study area is bound by the Savage River and to the east by the powerline easement above the old haul road that runs up the eastern side of the pit.

Savage River receives a mean of 1,957 mm of rain per annum with a mean of 186 rain days per year (days with > 1 mm). The mean monthly maximum varies from 9.4 °C (July) to 20.1 °C (February) with the mean minimum temperature varying from 3.3 °C to 9.9 °C in equivalent months[3].

The site occurs within the West Coast mineral belt, in the Bowry Formation of the Proterozoic Arthur Metamorphic Complex. This complex is 10 km wide. In the Savage River area it is dominated by Whyte schist consisting mainly of quartz-mica rocks, including thin micaceous quartzite beds, schist and phyllite.

The study area varies between 125 m to 350 m in altitude. The areas to the east of the pit are largely regrowth native vegetation, with some planting evident in places. To the west of the pit the vegetation is largely intact.

[1] DPIPWE 2015
[2] IBRA 5 (Peters & Thackway 1998)
[3] Australian Bureau of Meteorology

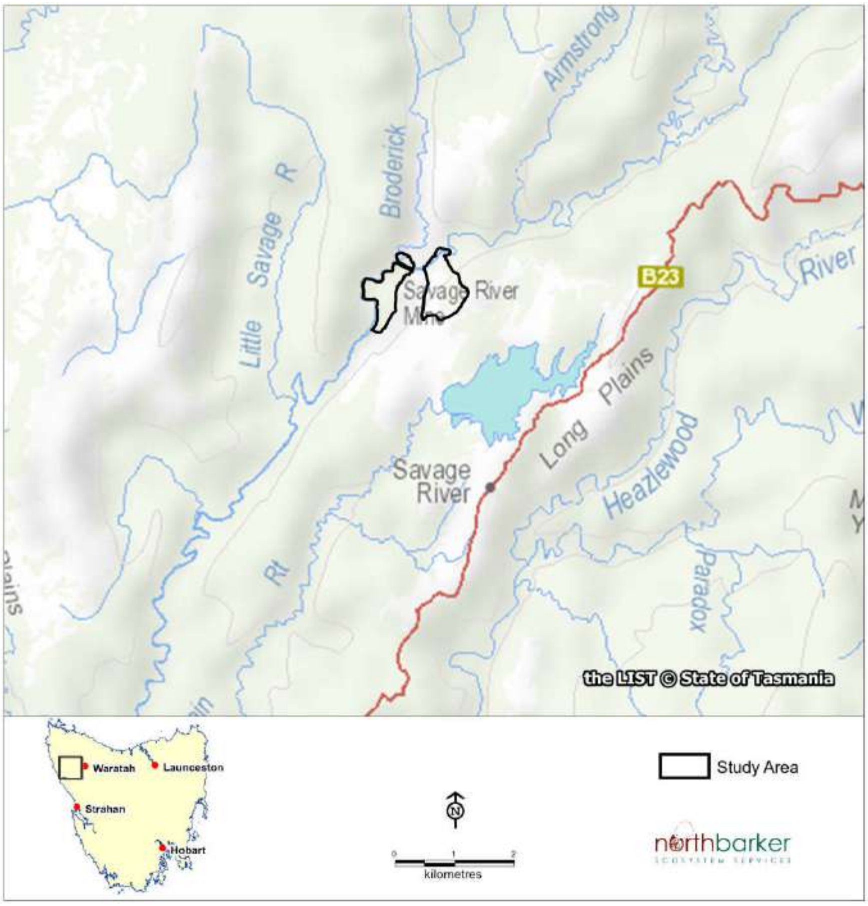

Figure 1: Location of the study area at Savage River mine

2 Methods

2.1 The following sources were used for biological records for the region:

- TASVEG version 3.0 digital layer;
- Natural Values Atlas (NVA) - all threatened species records within 5 km of the study area and threatened fauna considered possible to occur in suitable habitat;
- EPBCA Matters of National Environmental Significance database - a 5 km buffer was used to search for potential values; and
- Previous work by NBES, specifically flora and fauna habitat surveys of adjacent and nearby sections of the Savage River mine.

2.2 Botanical Survey

This assessment was undertaken in accordance with the *Guidelines for Natural Values Surveys*[4]. Field work was carried out by two observers on foot on the 17th and 18th of January 2018. Native vegetation was mapped by field observations, aided with aerial imagery, and done in accordance with units defined in TASVEG 3.0[5]. The mine site was mapped using a meandering area search technique[6]. Particular attention was given to habitats suitable for threatened species (under Tasmanian TSPA and/or the Commonwealth EPBCA), and to 'declared' weeds. Botanical nomenclature follows the

4 DPIPWE 2015
5 Kitchener and Harris 2013
6 Goff et al. 1982

current census of Tasmanian plants[7]. All location data were recorded with a handheld GPS.

2.2.1 **Fauna survey**

Observations of habitat suitability for fauna were made concurrently with the flora survey. In terms of direct observations, due to the density of the vegetation it was determined that scats and other indirect signs would give the best chance of detecting the presence of ground-dwelling threatened species[8]. Due to the limited value of simply identifying the presence/absence of fauna species, our search included looking for suitable habitat elements (such as nest/den sites).

2.2.2 **Limitations**

No biological survey can guarantee that all species will be recorded during a single visit, due to limitations of sampling techniques and variations in species presence, detectability, and the presence of material needed for identification. The field survey was undertaken in mid-summer. Seasonal and ephemeral species may have been overlooked or are seasonally absent, including spring flowering herbs and orchids. The present study area is variably steep and includes dense forest that inhibits access and limits opportunities for complete coverage. It is thus possible that the study area contains additional species and species habitats that could be recorded by repeated visits over several years and in different seasons. Nevertheless, we are confident the present survey sufficiently captured community level diversity. Given the general homogeneity of forest communities in the region it can thus be expected that we have captured most of the species diversity. In addition, we further compensate for survey limitations by considering all listed threatened species from data from the Tasmanian *Natural Values Atlas* (NVA)[9] and an EPBCA Protected Matters Report[10]. These data include records of all threatened species known to occur, or with the potential to occur, up to 5 km from the study area.

3 Results - Biological values

3.1 Vegetation communities

The following TASVEG 3.0 communities were recorded in the study area, and are shown in Figure 2. The species in each of the vegetation communities is presented in Appendix A.

- ***Nothofagus-Atherosperma* rainforest (RMT)**: A portion east of the pit, and much of the area west of the pit.
- ***Acacia melanoxylon* forest on rises (NAR)**: A large area east, and a small area to the west, of the pit.
- ***Acacia dealbata* forest (NAD)**: Two small areas, both in the north of the study area.
- **Regenerating cleared land (FRG)**: A large formerly disturbed area on east of the pit.
- **Permanent Easements (FPE)**: eastern boundary of the study area, not discussed further.
- **Extra Urban miscellaneous (FUM)**: a highly disturbed, largely bare unit, not discussed further.
- **Lichen lithosphere (ORO)** – a rocky tree slope, mostly devoid of vegetation, not discussed further.

7 Tasmanian State Government 1995; Commonwealth of Australia 1999
8 Commonwealth of Australia 2011 – survey guidelines for Australia's threatened mammals and birds.
9 Natural Values Report, January 2018
10 Commonwealth of Australia, EPBC Protected Matters Report # PMST_W0TAH4

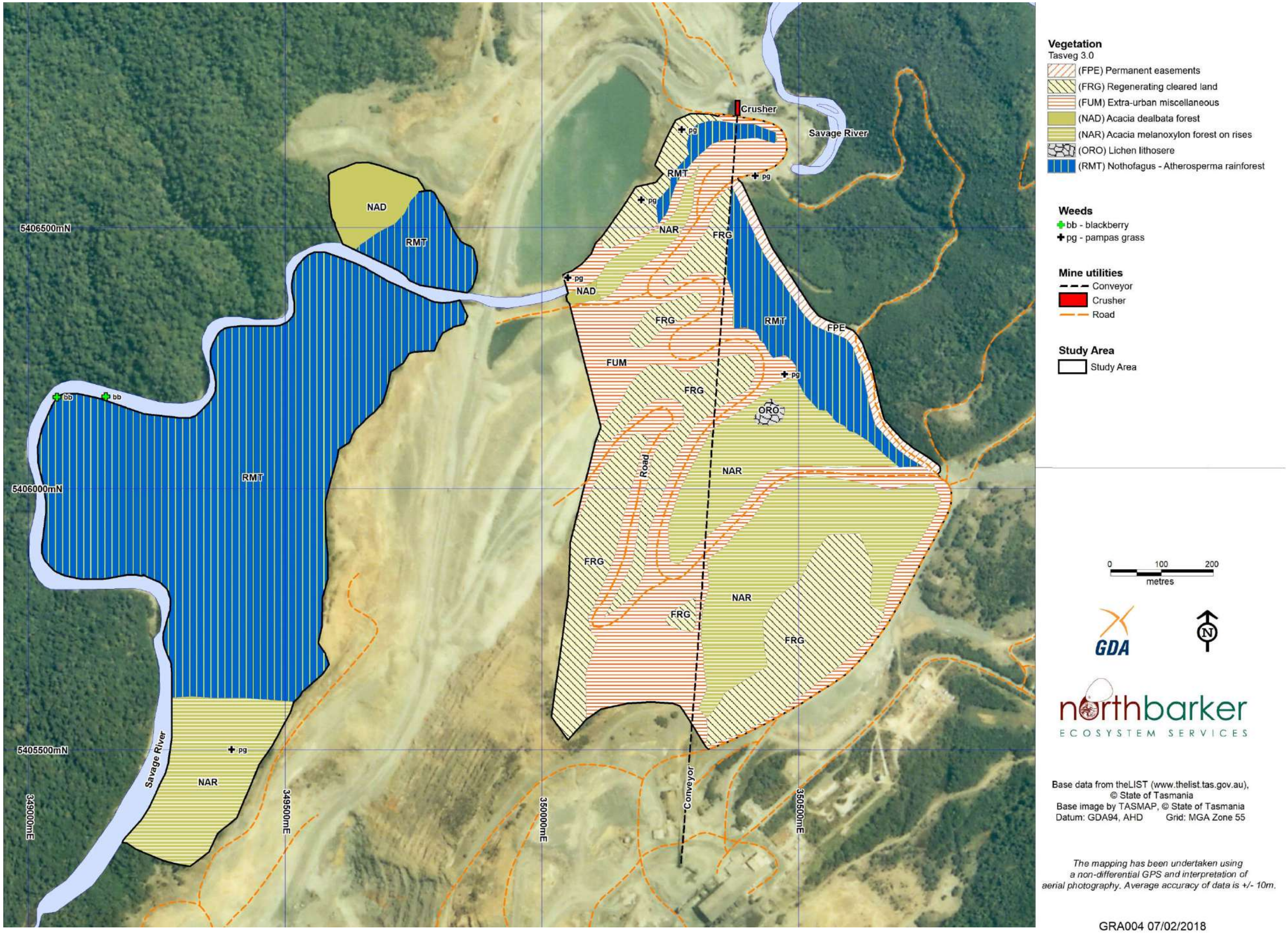

Figure 2: Location of the TASVEG 3.0 communities and declared weeds in the study area

Our field survey resulted in amendments to the distribution and extent of TASVEG 3.0 vegetation units. This included mapping areas of NAR and NAD formerly mapped as RMT. Table 1 summarises the State and regional extent of these forested units. These, and the FRG community, are summarised in the text below. A complete species list from the field survey is presented in Appendix B.

Table 1: Extent and listing statuses of native forest communities in study area

Community (TASVEG)	Current extent (ha)	Current reservation extent (ha)	Current extent (ha)	Current reservation extent (ha)	Status NCA/ EPBCA
Region	**TAS**	**TAS**	**West**	**West**	
Nothofagus-Atherosperma rainforest (RMT)	183,000	153,700	94,000	84,000	Not threatened NCA Not threatened EPBCA
Acacia dealbata forest (NAD)	40,800	16,100	900	600	Not threatened NCA Not threatened EPBCA
Acacia melanoxylon forest on rises (NAR)	19,500	9,500	6,400	4,800	Not threatened NCA Not threatened EPBCA

3.1.1 ***Nothofagus-Atherosperma* rainforest (RMT)**

RMT is evident throughout much of the study area (Plates 1 and 2). It occurs in varying stages of maturity, from mature (west of the pit) to regrowth (east of the pit). Much of the regrowth may be classed as thamnic rainforest, with medium to tall rainforest trees, and a tall understorey of shrubs and small trees. The canopy is 15 to 20 m in height, dominated by *Nothofagus cunninghamii*, with *Eucryphia lucida*, *Atherosperma moschatum* and *Acacia melanoxylon* as sub-dominants. The understorey is dominated by *Pomaderris apetala* up to 10 m in height in places. *Olearia argophylla* and *Nematolepis squamea* are also common in this layer. More frequently encountered sub-shrubs include *Pimelea cinerea* and *Leptecophylla juniperina*. The ground cover is sparsely vegetated with ferns; of these *Blechnum wattsii*, *Polystichum proliferum*, and *Dicksonia antarctica* were most common. Several epiphytic fern species were also present, including *Grammatis billardierei* and *Hymenophyllum rarum*. Younger regrowth RMT occurs close to the mine pit, especially around the crusher. The forest in these areas is typically shorter, and forest-edge species such as *Cassinia aculeata*, *Olearia lirata* and *Leptospermum scoparium* are common. In places occasional *Eucalyptus* spp. (e.g. *E. obliqua* and *E. nitens*) are evident, some of which were planted in previous rehabilitation work (pers. comm. Tony Ferguson).

In the RMT west of the pit the rainforest has been less disturbed, and more mature rainforest elements are evident. In this area the rainforest grades into callidendrous rainforest dominated by old-growth *Nothofagus cunninghamii*, with a more open understorey. Canopy subdominants and understorey species are much the same as the RMT on the eastern side of the pit. In rainforest adjacent to the Savage River *Leptospermum riparium* occurs, and *Libertia pulchella* is regular on the forest floor. Blackberry (*Rubus fruticosus*), a declared weed, was seen in two places on the western bank of the river.

The RMT mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

Plate 1: *Nothofagus-Atherosperma* rainforest (RMT) in the west of the study area

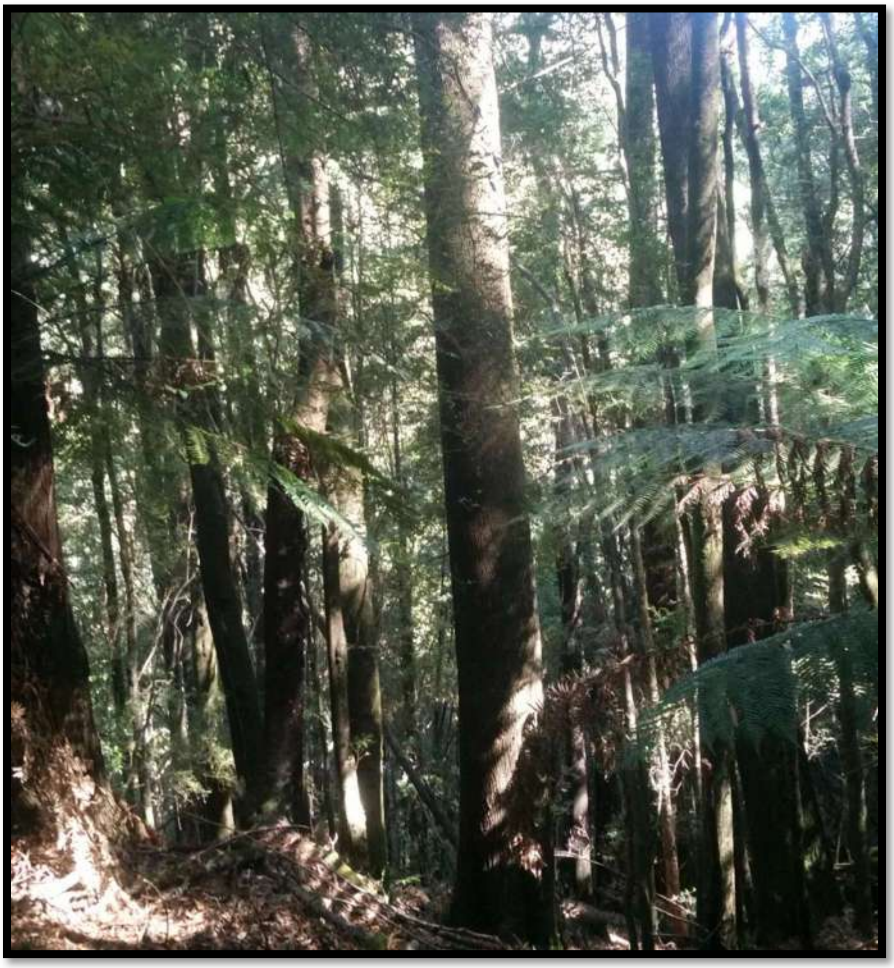

Plate 2: The understorey of *Nothofagus-Atherosperma* rainforest (RMT) in the study area

3.1.2 ***Acacia melanoxylon* forest on rises (NAR)**

Acacia melanoxylon is the dominant canopy species in a few areas that have experienced anthropogenic or natural disturbance events (Plates 3 and 4). In these areas, especially west of the pit, the topography is steep, and the slopes unstable. The NAR to the west of the pit is more mature with some large trees present. The canopy of this community reaches up to 25 m, and in places *Nothofagus cunninghamii* is apparent in the sub canopy layers. In areas east of the pit this community is typically less mature, and *Eucalyptus* species (e.g. *E. nitida*) occur occasionally in the canopy layer. Across the study area *Pomaderris apetala* forms the understorey layer at approximately 10 to 15 m, under which a mix of sclerophyllous subshrubs and small trees are found; most common of which are *Olearia argophylla*, and *Coprosma quadrifida*. Occasional rainforest saplings (e.g. *Phyllocladus asplenifolia*), and smaller rainforest species, such as *Cenarrhenes nitida* also occur in the understorey.

The NAR mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

Plate 3: A mature blackwood stem in *Acacia melanoxylon* forest (NAR) in the west of the study area

Plate 4: The understorey of relatively mature *Acacia melanoxylon* forest (NAR) in the west of the study area

3.1.3 ***Acacia dealbata* forest (NAD)**

NAD is a successional community found on disturbed sites. It is found in the north of the study area in two small patches that have experienced disturbance from mine activities (Plate 5). In these patches *Acacia dealbata subsp. dealbata* is the dominant canopy species at up to 10 m. The understorey is dominated by *Pomaderris apetala*, *Cassinia* *aculeata*, and *Coprosma quadrifida.* Also in this layer are young rainforest species, such as *Nothofagus cunninghamii* and *Eucryphia lucida*. The ground cover consists of a thick covering of moss, and mix of monocots and ferns (e.g. *Carex appressa, Juncus procerus, Histriopsis incisa, Hypolepis rugosula*).

The NAD mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

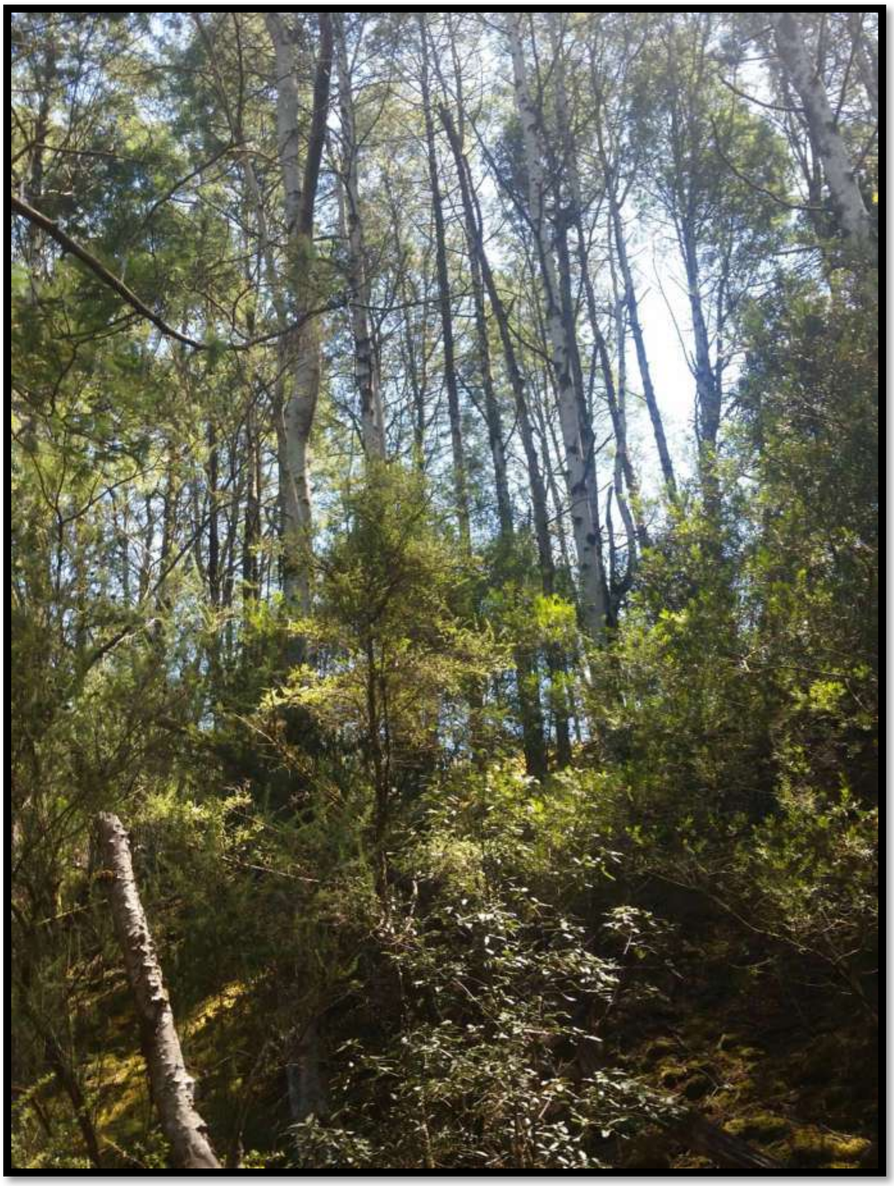

Plate 5: *Acacia dealbata* forest (NAD) in the northwest or the study area

3.1.4 **Regenerating cleared land (FRG)**

In the study site, areas disturbed by previous mining activities that are now colonised by a mix of mostly native, and some introduced species, are mapped as FRG. In places, introduced and indigenous *Eucalyptus* species have been aerially seeded to stimulate regeneration (pers. comm. Tony Ferguson), resulting in mixed cohort of tree species that also includes *Acacia melanoxylon* and *Nothofagus cunninghamii*. A menagerie of shrub species, especially those tolerant or dependant on disturbances, occur; common species include *Leptospermum scoparium*, *Cassinia aculeata*, and *Olearia ramulosa*. Introduced species include the declared weed, *Cortaderia* sp. (pampas grass), as well as *Cirsium vulgare* and *Pinus radiata*. Some patches of FRG are mature with developed canopies, while in other areas disturbance is more recent, or regeneration is less rapid, such as the areas under the conveyor south of the crusher.

The FRG mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

Plate 6: Patches of regenerating cleared land (FRG) in the east of the study area

3.2 Plant species

Eighty-nine species of plant were recorded for the study area, including 21 fern species, and five introduced species, of which two are declared weeds. No threatened flora listed under either the TSPA and EPBCA were recorded in the study area. In previous surveys in the area NBES have recorded *Persoonia muelleri subsp. angustifolia*.

According to data within the Tasmanian Natural Values Atlas[11], no observations of threatened flora are known within 500 m of the site, and only four species are known within a 5 km radius. No further threatened species are considered to have potential habitat in the region according to the EPBCA Protected Matters Search Tool[12].

Each threatened flora species known from the area is discussed in Table 2 in relation to the suitability of habitat within the study area and the likelihood of occurrence. Of these species, *Persoonia muelleri subsp. angustifolia* (narrowleaf geebung) has a low potential to occur: while there is potential habitat, it is unlikely to have been overlooked during the

[11] Natural Values Atlas Report January 2018
[12] EPBC Protected Matters Report January 2018

survey. Chances of the remaining three species occurring are very low to nil; this is primarily due to a lack of suitable habitat in the study area.

Table 1: Flora species of conservation significance known within a 5 km radius of the site[13]

Species	Status[14] TSPA / EPBCA	Potential to occur in study area	Observations and Preferred Habitat[15]
Epacris curtisiae northwest heath	Rare/ -	Very low	*Epacris curtisiae* (northwest heath) is a slender shrub restricted to peaty soils in undulating terrain in association with locally common heathlands, graminoid heaths and scrub in the northwest in altitudes below 300 m. The closest record of this species is approximately 1 km away to the south east of the study area. This record is from 1971, and that area is cleared for mining activities. There is no suitable habitat in the study area. The field survey was undertaken during the potential time for species observation and identification.
Micrantheum serpentinum western tridentbush	Rare/-	Very low	*Micrantheum serpentinum* is a straggly shrub in the Euphorbiaceae (spurge) family, restricted to ultramafics (Cambrian serpentinite) in Tasmania's northwest. Habitat includes low open eucalypt woodland, shrubland and heathland, generally on lateritic soils[16], as well as shaded riparian areas. Observed geology within the study area is unsuitable for this species. The closest location is approximately 5 km away, on the road to Savage River.
Persoonia muelleri subsp. angustifolia narrowleaf geebung	Rare/-	Low	This species occurs in central and western Tasmania in rainforest and dense scrub (and perhaps sub-alpine heath) in a variety of sedimentary and metamorphic substrata. It typically occurs in the ecotone between dry scrub and rainforest, particularly where high light levels occur on the ground due to a short and open canopy. It is known from between 50 to 700 m altitude[17]. This species has been recorded in a previous NBES survey approximately 5 km north of the mine on the Pipeline Road. Its occurrence there was likely a result of clearing for the road allowing light levels to allow recruitment. This species has also been recorded approximately 2 km from the study area in heathland, a habitat not found in our study area. The field survey was undertaken during the potential time for identification, and while there is suitable habitat in the study area, this is a suitable species that is unlikely to have been overlooked.

[13] DPIPWE 2018, nvr_1_09-Jan-2018, Commonwealth of Australia, EPBC Protected Matters Report # PMST_NXNLQ7
[14] Tasmanian State Government 1999
[15] Lazarus *et al.* 2003; Jones *et al.* 1999
[16] Threatened Species Section (2018A)
[17] Threatened Species Section (2018B)

Species	Status[14] TSPA / EPBCA	Potential to occur in study area	Observations and Preferred Habitat[15]
Rhodanthe anthemoides chamomile sunray	Rare/-	None	*Rhodanthe anthemoides* (chamomile sunray) *is* perennial herb with a woody rootstock. The Tasmanian distribution of this species includes montane grasslands, heath and heathy scrub in central and north-western Tasmania[18]. The closest record of this species is approximately 2 km away in buttongrass moorland to the south east of the study area. There is no suitable habitat for this species in the study area.

3.3 Introduced plants

Two introduced plants listed as 'declared' weeds under the *Weed Management Act 1999* were recorded in the study area (Figure 2, Plate 7). Two *Rubus fruticosus* (blackberry) plants was recorded in the west of the study area on the western bank of the Savage River, and *Cordigera sp.* (pampas grass) was recorded widely in the study area, with infestations of seedlings evident in places. It should be notes that the mapping of weeds in the study area is indicative as detailed coverage of the entire study area was not possible; hence it is likely that both of these species are more widespread than indicated.

Plate 7: Blackberry (left) and pampas grass (right) in the study area

3.4 Plant Pathogens

3.4.1 Root rot fungus (*Phytophthora cinnamomi*)

Phytophthora cinnamomi (PC) is a pathogen which affects a wide range of species, (notably those in the Epacridaceae and Proteaceae families). It is a soil borne fungal pathogen that invades the roots of plants and starves them of nutrients and water. Nearly 50 % of rainforest species which occur in the climatic range of PC are susceptible to infection. However, due to the cool nature of most rainforest communities, this species susceptibility does not generally translate into the rainforest communities being highly susceptible. This soil borne fungus moves naturally through the soil, more rapidly with

[18] Threatened Species Section (2018C)

drainage, and more slowly upslope. It is transported long distances by animals and humans.

PC can be accidentally introduced through the transportation of soil on vehicles, construction machinery and walking boots. The establishment and spread of Phytophthora is favoured in areas that receive above 600 mm of rainfall per annum and are below about 800 m altitude. The project site falls within this climatic zone. Rainforests are generally only susceptible to infection when severely disturbed so that the soil temperature can be raised by sun exposure to a temperature suitable to sustain PC. No symptomatic evidence of PC was noted in the study area. However it should be noted that PC was located in a previous NBES survey approximately 5.5 km to the north of the study site on Pipeline Road.

3.4.2 **Myrtle wilt fungus (*Chalara australis*)**

Chalara australis is a naturally occurring fungus that causes a disease in older myrtle beech (*Nothofagus cunninghamii*) regeneration (40-60 years), as well as mature myrtle, which results in death of the trees. This disease is commonly referred to as 'myrtle wilt'. Symptoms are wilting, followed by leaf death with the dead leaves being retained on the tree for some time. Myrtle wilt is the main cause of disease in undisturbed stands of rainforest and mixed forest. Disturbance within the stand exacerbates the effect of myrtle wilt. Disease incidence has been shown to be higher in callidendrous than in thamnic or implicate rainforests; higher in mixed forests the greater the myrtle densities; higher at lower altitudes; higher with increased diameter of tree; and higher where there is stem and crown damage[19].

No symptomatic evidence of myrtle wilt was observed within the present study area.

3.5 Fauna conservation values (incl. habitat trees)

During our field survey, no species of listed threatened fauna were observed. The site is also considered to have a high likelihood of supporting the spotted-tailed quoll *Dasyurus maculatus ssp. maculatus* (TSPA rare and EPBCA vulnerable), and a single carnivore scat that may belong to this species was observed on the powerline easement that forms the eastern boundary of the study site (Plate 8). The study area also contains patches of category 1 and 2 habitat for the grey goshawk (*Accipiter novaehollandiae*, TSPA endangered).

In previous NBES and other surveys, a number of listed species have been recorded within 5 km of the study area. None have been recorded within 500 m. An annotated list of species previously recorded and those with the potential to occur within 5 km of the study area is presented in Table 2 (note: marine, coastal and estuarine species are included in the *EPBC Act Protected Matters Report* – these are not considered here).

[19] Packham, 1990

Plate 8: A carnivore scat in the study area

Table 2: Fauna species of conservation significance previously recorded, or which may potentially occur, within 5 km of the study area[20]

Species	Status TSPA/ EPBCA	Likelihood of occurrence	Observations and preferred habitat[21]
Accipiter novaehollandiae grey goshawk	Endangered/ -	Moderate Category 1 and 2 habitat within RMT and NAR Priority nesting habitat, some foraging habitat	Inhabits large tracts of wet forest and swamp forest, particularly patches with closed canopies above an open understorey, but with dense stands of prey habitat nearby. Mature trees provide the best nesting sites. The mature patches of the RMT and the riparian habitat on the Savage River (western boundary of the study area) are considered good nesting habitat, and may be classed as Category 1 habitat[22]. The NAR habitat on site may be classed as category 2 habitat primarily based on the closed canopy and medium understorey stem density. Dense stands of *Leptospermum* or *Melaleuca* were not evident in nearby the stands of NAR, but the area does have some potential to support prey species, however not as desirable as *Leptospermum* or *Melaleuca*. While there is suitable habitat for this species no nests were observed and no individuals were seen or heard.

[20] Natural Values Atlas Report January 2018, EPBC Protected Matters Report January 2018
[21] Bryant & Jackson 1999
[22] Forest Practices Authority 2011A

Species	Status TSPA/ EPBCA	Likelihood of occurrence	Observations and preferred habitat[21]
Alcedo azurea ssp. *Diemenensis* azure kingfisher	Endangered/ ENDANGERED	Low	Has undergone a large range contraction in Tasmania and occurs on major rivers in the western half of the State. Requires native riparian vegetation, typically with a eucalypt component[23]. No nest sites or observation records are known from within 5 km of the study area. Watercourses in the study area do not constitute major rivers, and while it is possible this species may occasionally be present on the Savage River, this is likely to be sporadic and infrequent.
Beddomeia bowryensis hydrobiid snail *and Beddomeia trochiformis* Savage River Mine freshwater snail *Phrantela marginata* Heazlewood River hydrobiid snail	Rare/ -	Very low	Hydrobiid snails live in sheltered habitats such as under rock slabs in streams, and each species has an extremely limited distribution often being found in only one stream. Their distribution in Tasmania occurs in the northern and western parts of the state. They have been observed within 5 km of the study area in suitable habitat. The very steep rainforested slopes in the west of the study area are not conducive to stream formations suitable for this species. No suitable habitat was observed.
Aquila audax subsp. *fleayi* wedge-tailed eagle	Endangered/ ENDANGERED	Very low (foraging and nesting)	Requires large sheltered trees for nesting and is highly sensitive to disturbance during the breeding season. Use of rainforest tree species for nesting is extremely rare. The site has no observable evidence of large eucalypt trees in sufficiently sheltered locations to support nests. The survey area is likely to be infrequently utilised for hunting and foraging only. No nests known within 5000 m.
Apus pacificus fork-tailed swift	- / MIGRATORY	NIL	Most records of the Fork-tailed swift are from Bass Strait Islands with fewer on mainland northern Tasmania. Almost exclusively an aerial species, with no likelihood of roosting in the study area.
Ardea alba great egret	- / MIGRATORY	NIL	The great egret breeds in northern Australia only. It is a regular visitor to Tasmania where it favours freshwater wetlands, farm dams and brackish lagoons. There is no suitable habitat present.
Ardea ibis cattle egret	- / MIGRATORY	NIL	The cattle egret breeds mostly along the central eastern coast of Australia and not in Tasmania. Non-breeding individuals in Tasmania favour pasture and freshwater wetlands along the north coast and southeast. There is no suitable habitat present.
Botaurus poiciloptilus Australasian bittern	-/ ENDANGERED	NIL	The Australasian bittern occurs mainly in densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands. No suitable habitat for this species.

[23] Wapstra *et al.* 2010

Species	Status TSPA/ EPBCA	Likelihood of occurrence	Observations and preferred habitat[21]
Dasyurus maculatus subsp. *maculatus* spotted-tail quoll	Rare/ VULNERABLE	High	This naturally rare forest-dweller most commonly inhabits rainforest, wet forest and blackwood swamp forest. It forages and hunts over distances of up to 20 km at night. During the day it shelters in logs, rocks or thick vegetation. One scat was found that may belong to this species. This species has been recorded in surveys within 5 km of the study area. Based on the extent of suitable habitat in the region and the broad home range size of this species, we do not consider it likely that the site contains any traits that could be critical to the local survival of the species at a population level.
Dasyurus viverrinus eastern quoll	- / ENDANGERED	Very low	Potential habitat for the eastern quoll includes rainforest, heathland, alpine areas and scrub. However, it seems to prefer dry forest and native grassland mosaics which are bounded by agricultural land. There is no suitable core habitat in th4e study area.
Haliaeetus leucogaster white-bellied sea-eagle	Vulnerable/ -	Very low (foraging) None (nesting)	Occurs in coastal habitats and large inland waterways. May hunt over the site, and staff at the mine have reported this species once (pers. comm. Tony Fergusson). However, this species is highly unlikely to be a regular visitor to the area. Nesting habitat is tall eucalypt trees in large tracts (usually more than 10 ha) of eucalypt or mixed forest. No known nests within 5 km.
Hirundapus caudacutus white-throated needletail	-/MIGRATORY	NIL	Almost exclusively an aerial species, with no likelihood of roosting in the study area.
Lathamus discolor swift parrot	Endangered/ CRITICALLY ENDANGERED	Low	This migratory species is more frequent in eastern Tasmania, but is occasionally recorded on the west coast and does have a semi-regular population in the northwest around Devonport. Records in western Tasmania tend to be during post-breeding dispersal, where a broader diversity of species are utilised for foraging, including planted eucalypts and *Eucalyptus nitida* (Smithton peppermint). Based on habitat suitability, the likelihood of this species occurring in the study area is low. For breeding, the species requires tree hollows, and feeds on nectar of blue gum (*E. globulus*) and black gum (*E. ovata*) flowers. While *Eucalyptus* species were present in the NAD on site, they were occasional components of the canopy, and not in a density that would conceivably provide meaningful post-breeding foraging habitat. No observations are known within 5 km of the study area.
Limnodynastes peronii striped marsh-frog	Endangered / -	NIL	Potential habitat for the striped marsh frog is natural and artificial coastal and near-coastal wetlands, lagoons, marshes, swamps and ponds (including dams), with permanent freshwater and abundant marginal, emergent and submerged aquatic vegetation. There is no suitable habitat in the study area.

Species	Status TSPA/ EPBCA	Likelihood of occurrence	Observations and preferred habitat[21]
Myiagra cyanoleuca satin flycatcher	- / MIGRATORY	Very low	There are no NVA records of the satin flycatcher within 5 km of the study area. The species is relatively widespread across Tasmania, but is more frequent within wet sclerophyll than in rainforest, and is least common in western Tasmania.
Prototroctes maraena australian grayling	vulnerable/ VULNERABLE	Very low	Inhabits the middle and lower reaches of unpolluted rivers and streams that open to the sea. The study area includes the Savage River that is relatively far from coastal waters, and likely includes several downstream impediments to the presence of the species, including small waterfalls. This species was not specifically targeted in our survey but it is considered unlikely that this species occurs in the study area.
Pseudemoia pagenstecheri tussock skink	vulnerable/ -	NIL	Inhabits tussock grassland habitats (with at least 20 % native species), where trees are absent, or occasional. No suitable tussock grassland present.
Sarcophilus harrisii Tasmanian devil	Endangered/ ENDANGERED	Low	Potential habitat for the Tasmanian devil is all terrestrial native habitats, forestry plantations and pasture. Devils require shelter (e.g. dense vegetation, hollow logs, burrows or caves) and hunting habitat (open understorey mixed with patches of dense vegetation) within their home range (4-27 km^2). Known within 5 km. Most of the study area is largely unsuitable for this species due to the dense canopy, complex topography and steep terrain, factors that limit their occurrence[24]. Areas of suitable foraging habitat occur in the study area, but no suitable denning sites were observed. We consider that the site has a low probability of containing refuges that can be considered as potential devil dens on the weight of observable evidence. The site does not therefore qualify as significant habitat in accordance with the definition from FPA guidelines.
Tyto novaehollandiae masked owl	Endangered/ VULNERABLE	Very low (foraging) None (nesting)	Primary habitat is lowland dry forest and woodland, with nesting occurring in old growth eucalypts with large main-stem hollows. The vegetation within the study area is considered unsuitable for nesting and of very low suitability for foraging.

[24] Forest Practices Authority 2011B

4 Assessment of Impact and Mitigation

4.1 Vegetation

There are 82 ha of vegetation within the study area (Table 4). No impact is anticipated to vegetation communities listed on the EPBCA or the Tasmanian NCA.

Table 4: Extent of vegetation within study area

TASVEG - community	Area (ha)
RMT - *Nothofagus/Atherosperma* rainforest	43
NAR - *Acacia melanoxylon* forest on rises	21
FRG – Regenerating cleared land	16
NAD - *Acacia dealbata* forest	2
TOTAL	**82**

4.2 Threatened Flora

No threatened flora species listed on the EPBCA or TSPA were observed within the study area, and so no impact is expected on threatened flora.

4.3 Threatened fauna habitat

No threatened fauna species listed on the EPBCA or TSP were observed within the study area. One carnivore scat, potentially belonging to spotted-tailed quoll, was observed, and it is likely that this species forages in the study site. Also, patches of NAD, and the forested margins of the Savage River, are potential nesting and foraging habitat for grey goshawk. These species are dealt with below. All other species have a low to nil potential to occur in the study area.

4.3.1 **Spotted-tailed quoll (*Dasyurus maculatus maculatus*)**

The known threats to the spotted-tailed quoll include the following:

- **Habitat loss and modification:** Considered the greatest threat to the species. In Tasmania 50 % of the species core habitat has been removed by logging or agriculture. Of the remaining 50 %, half has been subject to logging in the past 20 years – particularly in the north and northwest regions of the State where clearance has occurred for plantations.
- **Fragmentation:** In many areas their habitat is fragmented, resulting in isolated populations. This leads to breeding complications, including difficulty in locating breeding partners and a lack of genetic diversity. The species naturally occurs in low population densities (breeds only once a year) meaning isolated populations have inherent breeding difficulties. Isolated populations are also vulnerable to stochastic events and the species is slow to recolonise following local extinction.
- **Timber harvesting:** Research suggests that forestry practices that remove or reduce prey or critical habitat (including trees with hollows, hollow logs and complex vegetation structure) may render habitat unsuitable.
- **Poison baiting:** In the past, 1080 baiting (used to control red fox, wild dogs and rabbit) has been blamed. However, recent research indicates that 1080 baiting is in fact not a threat.
- **Competition and predation:** On the mainland, habitat preferences of the European red fox overlap with much of the spotted-tailed quoll. If foxes become established in Tasmania they could displace native carnivores. Not only would they be direct competition, they are also likely to predate on younger quolls.

- **Deliberate killing and dog attacks**.
- **Road mortality**: Road mortality is believed to be a significant factor in the decline of some populations. It is estimated that 1–2 individuals are killed daily on the main road between Hobart and the northwest of the state. Juvenile males are most at risk due to extensive range. The full impacts of road mortality on the species are not well known, although local studies have demonstrated this to be significant at Cradle Mountain and near Arthur River.
- **Wildfire and prescription burning:** The impacts of wildfire and prescription burning are not well known but it may reduce prey and habitat. However, recent research found that fire may be beneficial as it can increase the formation of tree hollows used by the species and its prey.

Habitat loss

The exact extent of loss frrm the current proposal is not yet known however any removal of habitat for this species will reduce the effective carrying capacity of the forests in the area. It is unknown exactly how many quolls could be displaced by the expected loss of habitat, but a rough estimate of density in non-core habitat is approximately 1 animal per 300 ha. A viable population of about 50 quolls is thought to require about 15,000 ha of continuous habitat. Given the extent of habitat in the region (large tracts of continuous native vegetation) it is likely that the area for a minimum viable population of 50 individuals is exceeded and that a potentially small decline in the overall carrying capacity is not significant (the suitable habitat in the study site is < 100 ha).

The species is considered to be distributed throughout mainland Tasmania[25]. Key sites for the spotted-tailed quoll in Tasmania according to the Tasmanian Threatened Fauna Handbook[26] include:

- northern forested areas bounded by Wynyard, Gladstone and the central and north-eastern highlands,
- the north-western wet forests; including the catchments of the Arthur and Montagu Rivers,
- the Dry eucalypt forests in the central north coastal regions bounded by the Tamar, Devonport and Western Tiers,
- patches between the King River and Strahan, the Gordon River and Huon River Catchments as well as the coastal strip from Strahan to Temma.

The Draft National Recovery Plan[27] identifies "important populations" for the spotted-tailed quoll in Tasmania. These are identified in Table 5.

Table 5: Important populations identified in the Draft National Recovery Plan

Population	Basis for 'importance' classification
Freycinet National Park	research population
Central-north Tasmania (including Great Western Tiers to Narawntapu)	stronghold & research population
Cradle Mountain National Park	stronghold & research population
Far north-western Tasmania (including the Smithton and Marrawah regions)	stronghold & research population
Eastern Tiers/northern Midlands (including Nugent and Ross regions)	stronghold population
Southern forests/South Coast (including the Hastings region)	stronghold population
Gordon River system	stronghold population
South-west Cape	stronghold population

[25] TMAG 1990
[26] Bryant & Jackson 1999
[27] DSEWPC (2012a)

Figure 3 presents a composite map of the likely areas occupied by the above two sets of definitions of key sites and important populations in relation to the location of the study area.

Habitat modification

Construction works will bring a heightened level of disturbance from noise and vibrations. These will tend to disperse sheltering animals greater distances from the site. Thus there is a small possibility that any dens being utilised in close proximity to the development could be abandoned.

Fragmentation

The extensive interconnected expanse of native vegetation in the broader landscape means that the footprint of the centre pit extension will not lead to habitat fragmentation.

Road kill

Changes to traffic usage during the construction period may result in increased incidences of road kill, especially if this involves contractors travelling around dusk or dawn. Significant increases in traffic volumes and/or speed levels are likely to increase the incidence of road kill unless mitigation measures are adopted (such as daytime only transport). Changes to traffic usage from the proposal is unknown at this stage.

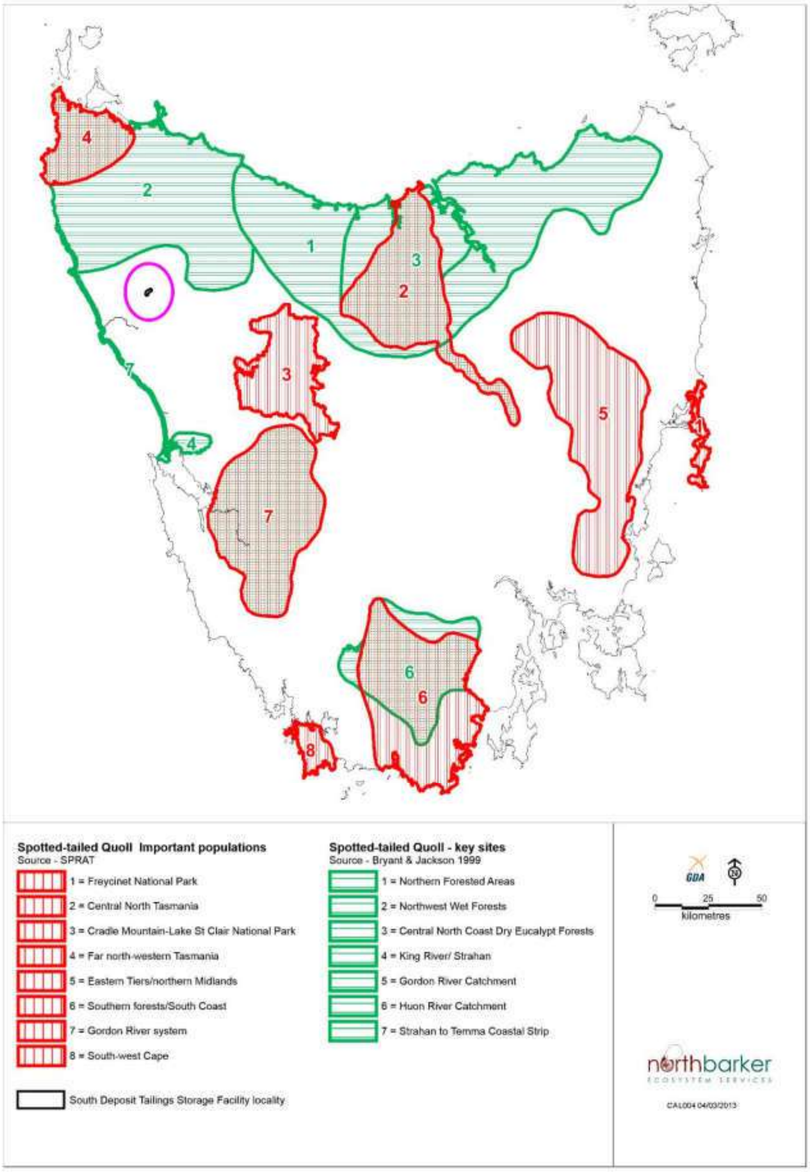

Figure 3: Spotted-tailed quoll key sites and important population

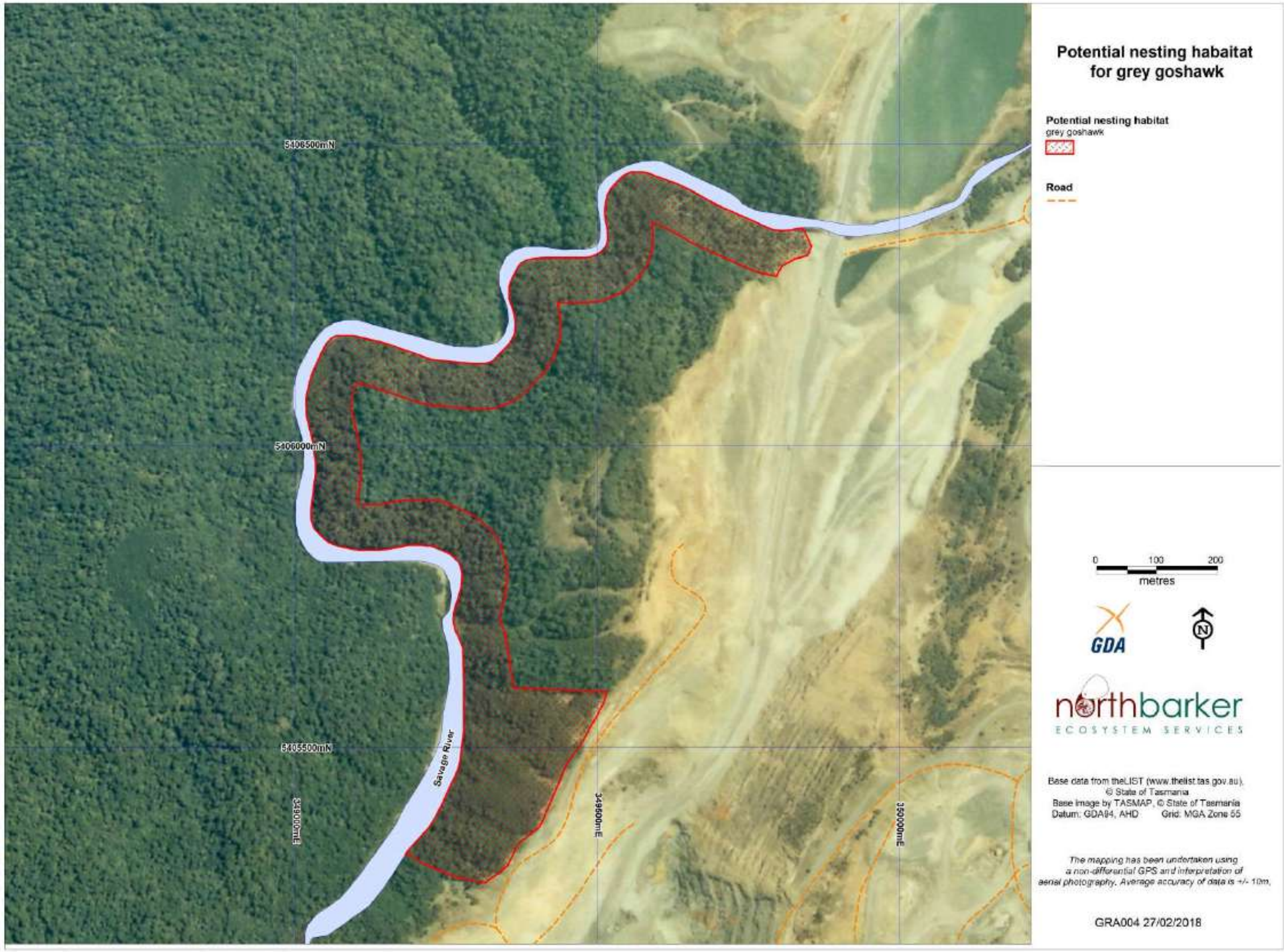

Figure 4: Potential nesting habitat for grey goshawk

4.3.2 **Grey goshawk (*Accipiter novaehollandiae*)**

There is currently no listing statement or recovery plan under the TSPA for this species.

'Key breeding sites'[28] extend into the west of the study area in the NAR forest and RMT forest on the Savage River (refer to Figure 4).

'Key threats'[29] include:

- Clearing, fragmentation and plantation conversion of old growth and wet forest habitat, especially blackwood swamps and streamside forest;
- Deliberate persecution; and
- Accidental death from poisoning, electrocution, collision etc.

While there is potential nesting habitat within the riparian zone and the taller patches of NAR in the study area, no nests were observed, and no individuals were seen or heard.

Potential habitat is extensive in the broader region. It could be argued that due to seemingly low population densities, this species is unlikely to be limited by habitat availability in the region; although this may be dependent on territory size which is currently unknown. The study area occurs within this species core habitat range.

January 2012 surveys found an active nest 11 km south of the study area within a mature myrtle tree as well as sightings from motion camera and call back surveys. This nest is outside any impact from the current proposal. There is extensive undisturbed habitat in the surrounding area, so any impact upon this species is anticipated to be relatively localised.

4.3.3 **Tasmanian devil (*Sarcophilus harrisii*)**

The listing of the Tasmanian devil on the *TSPA* and *EPBCA* has occurred due to the threat to the species brought about by the Devil Facial Tumour Disease (DFTD) which has ravaged some populations.

Persecuted along with the Tasmanian tiger, the species was in threat of extinction by the early 20th century. However changes in policy allowed the species to recover so that it reached historically high levels by the 1990's. Some estimates suggest the population may have exceeded 150,000 individuals at that time[30].

The Tasmanian devil (*Sarcophilus harrisii*) is Australia's largest surviving marsupial carnivore and only specialist scavenger. Although variable in size, adult males can weigh up to 12kg (average 10kg) and be 30cm high at the shoulder with females weighing up to 7kg on average[31]. Devils have a short life span of generally no more than 6 years[32]. The species is now confined to Tasmania where it is widely distributed across all environments throughout the State.

Devils are usually solitary animals but they share continuously overlapping home ranges and come into contact with other devils around prey carcasses and during the mating season[33]. They mate once a year giving birth in April through to July, and can produce up to four young which develop for up to 20 weeks in the pouch. The young are fully weaned at 10 months of age.

The animals are active during the day where there is no human disturbance but otherwise hunt during the night (Pemberton pers. comm.). In daytime animals hole up in shelters, including underground dens, wombat burrows, hollows and caves. Communal denning, particularly natal dens, occur in clusters associated with suitable

[28] Bryant & Jackson 1999
[29] Bryant & Jackson 1999
[30] N. Mooney cited in McGlashan *et. al.* 2006
[31] Lachish, McCallum and Jones 2009
[32] Lee & Cockburn 1985
[33] Hamede *et. al.* 2009

geomorphology in secure sites above the water table. Females are careful to select dens that are difficult to find without the use of electronic tracking devices. Mating occurs in copulation dens which are male dominated and distinct from the natal dens. When not copulating or raising young, devils may shelter in tree buttresses or thick vegetation.

Animals typically travel around 8km a night, although individuals have been recorded covering more than 50km in a single night[34]. They have home ranges of 8 to 20 square kilometres (800 to 2,000 ha), although more recent studies suggest smaller ranges[35] probably reflecting higher carrying capacity. The home ranges overlap to a very large extent with other individuals but they forage separately and are antagonistic toward each other on meeting. The average density of pre-disease devils in unmodified habitat ranges between 0.3 and 0.7 per km^2 [36].

The overlapping ranges and high density of animals results in a population of devils that utilises the whole of the landscape as a single entity. Pemberton (1990) showed that for a population of 250 devils occupying about 45 km^2, each devil having a home range of about 15 km^2; then about 30% of animals share a majority of their home range and about 80% have at least some overlap of the home range. The high degree of overlap reflects a myriad range of home range shapes.

As a result of the high degree of shared range, the clearance of an area equal to one home range (15 km^2) can effect up to 80% of the population to some degree.

Devils thrive in a landscape mosaic of native habitat and agricultural land. The population uses all of the habitat mosaic but typically does not use areas of pasture more than 500m from continuous habitat. Dense wet eucalypt and rainforest (as within the study area), alpine areas, dense wet heath and open grassland all support only low densities of devils[37] . Devils are more abundant in habitats (open eucalypt forests and woodlands, coastal scrub) that support dense populations of their prey (macropods, wombats, possums)[38].

Devils displaced by habitat loss will move to other home ranges but ultimately the population will decrease due to the limits of carrying capacity. This is likely to be over a period of the lifespan of the displaced animals. If native non breeding habitat is lost, a population can be sustained if the prey abundance and seasonal availability is sustained. If the prey abundance and seasonal availability is not sustained then the carrying capacity and the population size will fall.

Habitat Present:

The survey area was found to be largely unsuitable for denning at the macro scale. Particularly unsuitable macro traits were the dense canopy (resulting in a relatively dark and dank microclimate at ground level) and the steep contours (which can be relatively slow and difficult to traverse, a factor only compounded by the high stem density). Caves, rocky outcrops and the like were not observed and are not likely to have been overlooked. Log piles were present mostly in the form of cleared subcanopy trees on the margin of the study area. Thus, these have neither been present for long nor have the traits of a log pile that could potentially be used for shelter (larger, particularly hollow-bearing logs create more suitable refuges). In addition, the prevailing dark conditions (in conjunction with the sites moisture-retentive ferrosols) have led to high soil moisture levels that contrast with the dry and warm soils needed for denning.

[34] Tarkine Devil Forum (2009)
[35] S. Troy *pers. comm.* –" Landscape ecology of the Tasmanian devil and spotted-tailed quoll"
[36] DPIPWE 2010b
[37] Jones et al. 2004
[38] Jones & Barmuta 1998

At the micro scale, refuges were limited to infrequent hollow and/or rotten tree bases, and very infrequent hollow-bearing fallen logs. Without exception, all of the refuges observed and inspected were too shallow and wet to be considered suitable den sites. No indications of devil use were observed around refuges.

Subsequently, the site is not considered to contain any refuges that can be considered as potential devil dens on the weight of observable evidence. Needless to say, the site does not therefore qualify as significant habitat in accordance with the above definition from FPA guidelines.

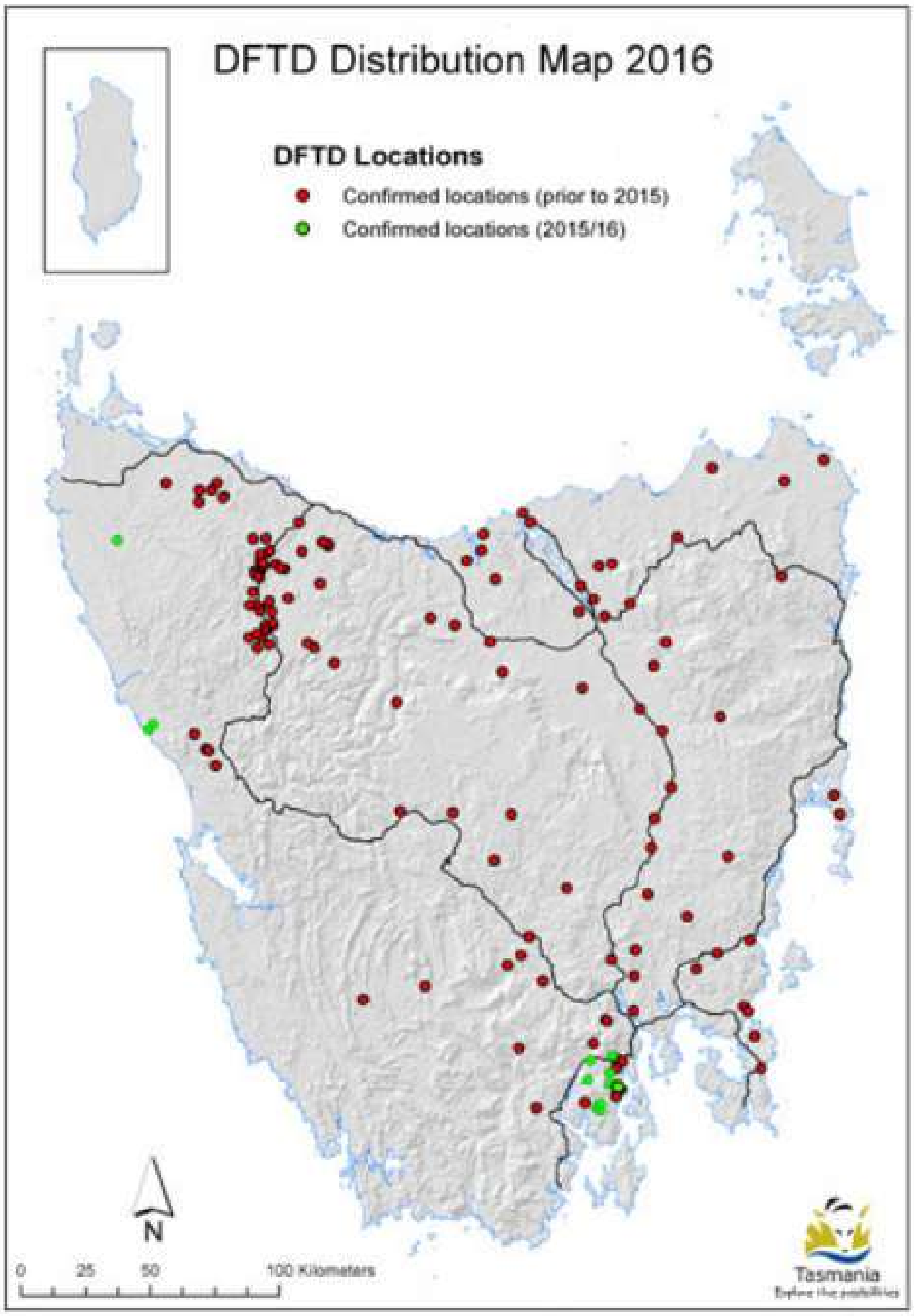

Figure 5: Distribution of DFTD

Devil Facial Tumour Disease

Studies of devil facial tumour disease (DFTD) have shown that it has spread across more than 60% of Tasmania (Figure 6) with population declines averaging 84% although the population in the north-east has declined by up to 96%.[39] The last remaining stronghold of disease free devils is in the north-west with the west and south-west areas supporting much lower densities. A reduced population such as that affected by DFTD is considered highly vulnerable to other causes of mortality such as road kill or loss of den habitat.

Particular interest has been taken in the western front of the disease in north-west Tasmania. Intensive sampling undertaken in 2009 and repeated in 2010[40] indicates it continued to progress westwards at about 7 km a year. This is markedly slower than the rate of spread elsewhere in Tasmania.

The devil facial tumour disease (DFTD) is the single most significant cause of mortality and therefore threat to the conservation of the Tasmanian devil. The retention of naturally occurring disease free populations is a key factor in ensuring the long term survival of the species in the wild. The north-west population of Tasmanian devils is disease free[41] (Figure 5), although outlying diseased animals have been reported.

4.3.4 **Tasmanian wedge-tailed eagle (*Aquila audax ssp. fleayi*)**

The nearest nest record is 7.2 km to the north-east of Savage River, last confirmed in 1993. This is well beyond the range of likely disturbance.

No evidence was recorded of large eucalypt trees in sufficiently sheltered locations to support nests. There were some old growth myrtle trees within the western study area near Savage River, however use of myrtle beech for nesting is extremely rare and the western aspect is of low suitability. Sightings by mine staff are very sporadic and not indicative of breeding nearby. No sightings of the species have been recorded during the various surveys conducted for past projects for the mine.

Modelling of prospective nesting habitat is being developed by the Tasmanian Forest Practices Authority. Figure 5 shows that the forested vegetation, in the vicinity of the study, is of low potential for nesting habitat. The nearest areas of moderate potential as nesting habitat occurs over 3km to the west on the upper slopes of tributaries on the far side of Savage River or in some sheltered gullies flowing into Whyte River to the east.

Wedge-tailed eagles nest in a range of old growth native forests and the species is dependent on forest for nesting. It nests almost exclusively in mature eucalypts capable of supporting their nests, which can develop after many years of use into massive structures over 2 m in diameter. The eagles choose old growth trees in relatively sheltered sites for locating their nests. Territories can contain multiple nests and up to five alternate nests have been located. Nests within a territory are usually close to each other but may be up to 1 km apart where habitat is locally restricted. Wedge-tailed eagles prey and scavenge on a wide variety of fauna including fish, reptiles, birds and mammals.

The survey area is likely to be utilised for hunting and foraging but not for breeding.

[39] Save the Tasmanian Devil Program website 2018
[40] Save the Tasmanian Devil Program website 2018
[41] Save the Tasmanian Devil Program website 2018

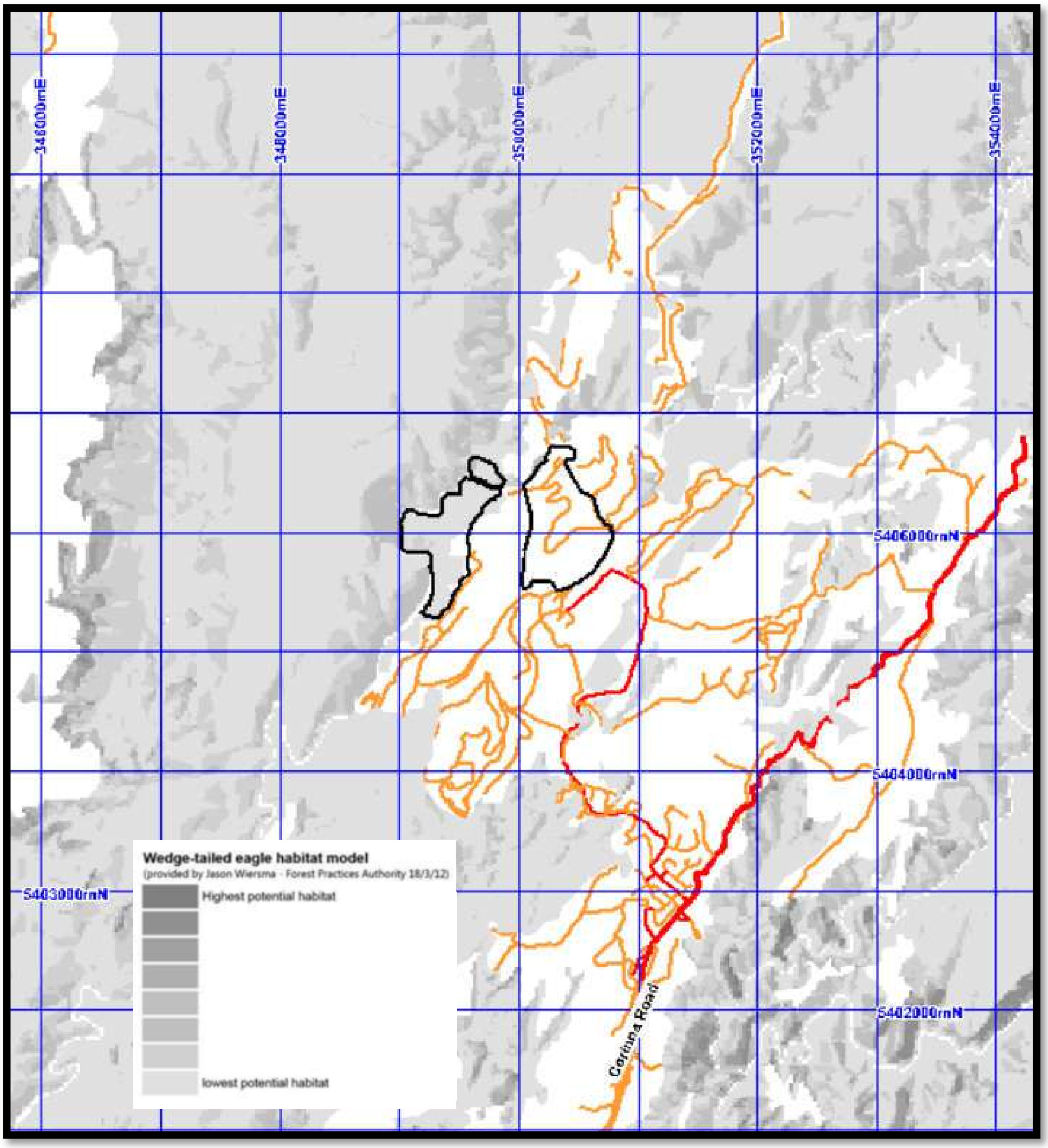

Figure 5: Modelling of Tasmanian wedge-tailed eagle habitat

4.3.5 Tasmanian azure kingfisher (*Ceyx azureus diemenensis*)

No suitable waterway habitat has been recorded within the study area and the closest record is a sighting over 10km to the south-west. The nearest habitat occurs on the Donaldson River (over 7km to the north-west) and the Whyte River (4km south-east). However both these rivers are in separate catchments. Savage River is likely to have once provided habitat but is likely to be unsuitable due to acid drainage. The Savage River empties into the Pieman River which is known to support a breeding population. The main threat from the proposed project is from downstream effects of unmanaged acid mine drainage or tailings pollution.

4.4 Weeds

It is recommended that a set of weed management and hygiene protocols be developed to cover the works. Weed management planning and hygiene should address the following areas:

1) A Weed Management Plan should cover all relevant aspects of the control and management of declared weeds and weeds that are considered to have significant impacts on agriculture and natural values. A Weed Management Plan should cover, but not be limited to:

    - Overarching set of objectives and the context in which they are to be achieved.
    - An accurate assessment of the distribution of declared weeds and significant environmental weeds.
    - Priorities developed for management and control of weeds, both in the short term as well as long term.
    - An assessment of the potential impact of those weeds, including immediate and adjacent areas which are free of particular declared weeds.
    - Strategies for managing weeds including their eradication within the study area and on any public roads used for mine related transport.
    - Strategies for ongoing monitoring and control of weeds within the study area.
    - Identification of appropriate herbicides for control and how they are to be used.

2) A hygiene plan can be developed as part of the Weed Management Plan so as to ensure there is no introduction of new declared weeds or significant environmental weed species into the area and no translocation of weeds within the study area. The hygiene plan should cover, but not be limited to:

    - Vehicle, machinery and equipment hygiene.
    - It may be necessary to implement washdown protocols when travelling between clean and contaminated areas and also vehicles entering clean or leaving contaminated sites.
    - The location and management of washdown areas and facilities, including management of effluent.
    - Maintaining logbooks detailing adherence to hygiene protocols for all contractors.
    - Material hygiene (soils, gravel, plant material etc.) – ensuring that no materials contaminated with weed propagules (seed, propagative vegetative material) are imported into the study area.

4.5 Plant Pathogens

4.5.1 **Root rot fungus (*Phytophthora cinnamomi*)**

Active management to continually limit the spread of *Phytophthora* remains a focus of Tasmania's control strategy. Ongoing monitoring for future infections plays an important role. Soil disturbance should be restricted to the footprint of the works to protect adjacent vegetation.

The vehicle wash down hygiene protocols adopted in the weed management strategy will also be effective in minimising the risk of introducing *Phytophthora*.

4.5.2 **Myrtle wilt fungus (*Chalara australis*)**

The spread or establishment of myrtle wilt can be mitigated by minimising damage to adjacent *Nothofagus cunninghamii* trees when felling trees. Felling should be carried out so that trees fall away from the retained trees and are removed from site.

5 Mitigation

5.1 Vegetation Clearance

The site does not contain any vegetation communities listed as threatened under the Tasmanian NCA or the EPBCA. All of the observed communities are well reserved at the state and regional level. Consequently, negligible impact is anticipated at the community level, requiring no specific mitigation.

The impacts of vegetation clearance are difficult to mitigate. However, the risk of unnecessary and indirect impacts on vegetation outside the footprint of the development could be minimised by following these protocols:

a) Clearly define the extent of clearance required for the project, and ensure that any additional impacts are considered.
b) The works area should be marked and all works, vehicles and materials should be confined to the works area.
c) Ensure there are appropriate runoff controls to avoid disturbance to the vegetation that falls outside the footprint but is potentially at risk of sediment influx. (Prepare a Sediment and Erosion control Plan).

5.2 Threatened Flora

The site has not been found to support any species of threatened flora, and is not thought to have a high likelihood of doing so. Consequently, no mitigation regarding threatened flora species is required.

5.3 Threatened Fauna

5.3.1 Spotted-tailed quoll and Tasmanian devil

While quolls and devils are likely to forage in the area, the extent of the impact area is less than the suggested area for a single quoll (300 ha) or devil (800 ha to 2000 ha). While it may be reasonably assumed that density will exceed this in optimum habitat, the impact to this species by the development is likely to be negligible. Final impact is likely to be less than the area surveyed however this should be reviewed post design.

Nevertheless, it is prudent that pre-clearance devil and quoll den surveys are undertaken prior to any construction activities.

5.3.2 Grey goshawk

Avoiding clearing the vegetation adjacent to the Savage River will reduce the potential to impact on this species. Should in final design vegetation near Savage River be required, a targeted grey goshawk nest survey may be warranted.

It is recommended that this report is reviewed post final design to ensure the recommendations are tailored to the final environmental impact.

6 Legislative implications

6.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

The EPBCA is structured for self-assessment; the proponent must determine whether or not the project is considered a 'controlled action' which if confirmed would require approval from the Commonwealth Minister.

Referral under the EPBC Act will be necessary if, as the Act states:

'An action has, will have, or is likely to have a significant impact on an endangered or vulnerable species if it does, will, or is likely to (amongst other things):

modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.'

Quoll

The project will not have a significant impact on the 'vulnerable' spotted-tailed quoll under the significant impact criteria as the area does not support an 'important population' as defined under this legislation.

Devil

The scale of impact to the habitat of the Tasmanian devil is not significant in the context of the extent of habitat in the area and the character of the sub optimal denning habitat being disturbed. While it remains possible that one or more natal dens may be present no obvious preferred structure was identified during targeted surveys.

Pre-clearance den surveys for the quoll and den are recommended as appropriate mitigation measures.

6.2 Tasmanian *Threatened Species Protection Act 1995*

No threatened species were recorded within the impact area. The TSPA definition of "take" does not usually extend to the disturbance of foraging habitat for fauna, but does include nests and dens, which are "products of wildlife".

No potential dens for spotted-tailed quoll or devil were found. No direct impact could be quantified sufficiently to require a permit under this legislation.

No raptor nests were observed within the study area, although there is potential nesting habitat for the grey goshawk.

No other nests of fauna listed under the TSPA were recorded and it is unlikely that nesting habitats will be impacted.

A grey goshawk nest survey would be prudent should vegetation clearance be required within the west of the study area near Savage River.

6.3 Tasmanian *Forest Practices Act 1985*

Under the *Forest Practices Act 1995*, a Forest Practices Plan is required for clearing of land. However, Section 6 states that this does not apply in prescribed circumstances. The prescribed circumstances are defined in the *Forest Practices Regulations 2007*.

Section 4 of the Regulations states under what circumstances a Forest Practices Plan is not required. These circumstances include mineral exploration activities or mining activities that are authorised under:

(i) a permit granted under the Land Use Planning and Approvals Act 1993; or

(ii) an exploration licence within the meaning of the Mineral Resources Development Act 1995; or

(iii) a retention licence within the meaning of the Mineral Resources Development Act 1995; or

(iv) a mining lease within the meaning of the Mineral Resources Development Act 1995;

If the activity has been authorised under a retention licence granted under the *Mineral Resources Development Act 1995*, a Forest Practices Plan is not required.

6.4 Tasmanian *Land Use Planning and Approvals Act 1993*

LUPAA states that 'in determining an application for a permit, a planning authority must (amongst other things) seek out the objectives set out in Schedule 1. [42]

Schedule 1 includes 'The objectives of the Resource Management and Planning System of Tasmania' which are (amongst other things) 'To promote sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity'.

Sustainable development includes 'avoiding, remedying or mitigating any adverse effects of activities on the environment'[43].

Over and above threatened species and forest clearance issues, it should be incumbent on the proponent to demonstrate that the works will include measures to fulfil the aims of LUPPA by:

- incorporating measures to prevent environmental weeds and plant pathogens; and
- maintain general environmental quality through the proper management of erosion and drainage.

6.5 Tasmanian *Weed Management Act 1999*

Two declared weeds were recorded within the study area, pampas grass (*Cortaderia* sp.) and blackberry (*Rubus fruticosus*). Numerous infestations of Spanish heath (*Erica lusitanica*) occurs outside the study area, but infestations are present on the approach road to the mine site.

Pampas grass and Spanish heath are listed as Zone A species for the Waratah/ Wynyard municipality. Eradication is the required management objective for Zone A municipalities. The ultimate management outcome for these municipalities is achieving and maintaining the total absence of the weed from within municipal boundaries. Blackberry is listed as Zone B where containment is the main objective.

7 Conclusion

The area for the proposed development of the centre pit and access routes is situated in a topographically steep area dominated by myrtle beech rainforest, and notable patches of blackwood forest. Much of the area in the east of the study site has been disturbed by previous mining activities, while the habitat in the west of the area is typically more mature, less disturbed forest. This vegetation is typical for the region and none of the observed communities are listed as threatened.

No threatened flora or fauna species were observed. The study area offers habitat of varying quality to three threatened fauna species: the spotted-tailed quoll, Tasmanian devil and the grey goshawk. For these species, the impact of the development is not considered to have a significant impact on a population of either species. Other threatened fauna are also considered unlikely to be impacted. A review of this report

42 section 51(2) (b) – Part 4 Enforcement of Planning Control – Division 2 Development Control LUPA 1993
43 pp56 LUPA 1993

should be undertaken post final design. A targeted grey goshawk nest survey would be prudent should vegetation to the west along Savage River be impacted.

The extent of vegetation in the study area there is approximately 82 ha; a small area in the context of the surrounding environment – a large tract of native vegetation including the Tasmanian Wilderness World Heritage Area, National Parks, Regional Reserves and State Forest. Consequently, considerable alternative habitat will remain in the surrounding vegetation.

Efforts to mitigate the impacts of the development should focus on reducing the risk of introduction and spread of plant pathogens, and declared and environmental weeds, during and after works, by implementing appropriate weed and hygiene management plans. Furthermore, reducing the clearance and impact on riparian vegetation on the Savage River should be considered to minimise the potential for impacting on potential habitat for grey goshawk. A pre-clearance den survey for devils and quolls should also be included.

This report should be reviewed post design.

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Appendix A: Species by TASVEG v3.0 community

Site: 1 RMT	
Grid Reference:	350651E, 5406137N
Accuracy:	GPS (within 10 metres)
Recorder:	Richard White
Date of Survey:	17 Jan 2018
Trees:	*Acacia melanoxylon, Atherosperma moschatum subsp. moschatum, Eucalyptus nitida, Eucalyptus obliqua, Eucryphia lucida, Nothofagus cunninghamii, Phyllocladus aspleniifolius*
Tall Shrubs:	*Acacia mucronata, Anodopetalum biglandulosum, Anopterus glandulosus, Leptospermum nitidum, Leptospermum scoparium, Monotoca glauca, Nematolepis squamea, Olearia argophylla, Pittosporum bicolor, Pomaderris apetala, Prostanthera lasianthos var. lasianthos*
Shrubs:	*Aristotelia peduncularis, Cassinia aculeata subsp. aculeata, Cenarrhenes nitida, Coprosma quadrifida, Gaultheria hispida, Leptecophylla juniperina, Olearia lirata, Olearia ramulosa, Pimelea cinerea, Pimelea drupacea, Trochocarpa cunninghamii*
Herbs:	*Acaena novae-zelandiae, Dianella tasmanica, Epilobium sp., Gonocarpus teucrioides, Hydrocotyle hirta, Libertia pulchella, Lobelia pedunculata, Oxalis perennans, Senecio minimus, Viola hederacea, Wahlenbergia sp.*
Graminoids:	*Carex appressa, Gahnia grandis, Luzula sp.*
Grasses:	*Poa labillardierei*
Ferns:	*Asplenium flaccidum subsp. flaccidum, Blechnum fluviatile, Blechnum nudum, Blechnum wattsii, Dicksonia antarctica, Histiopteris incisa, Hymenophyllum cupressiforme, Hymenophyllum flabellatum, Hymenophyllum rarum, Hypolepis rugosula, Microsorum pustulatum subsp. pustulatum, Notogrammitis billardierei, Notogrammitis heterophylla, Phlegmarius varius, Polyphlebium venosum, Polystichum proliferum, Pteridium esculentum subsp. esculentum, Rumohra adiantiformis, Sticherus tener, Tmesipteris obliqua*
Climbers:	*Clematis aristata, Parsonsia brownii*
Weeds:	*Centaurium erythraea, Cirsium vulgare, Cortaderia sp, Hypochaeris radicata, Rubus fruticosus*

Site: 2 NAR	
Grid Reference:	350589E, 5406039N
Accuracy:	GPS (within 10 metres)
Recorder:	Richard White
Date of Survey:	18 Jan 2018
Trees:	*Acacia melanoxylon, Atherosperma moschatum subsp. moschatum, Eucalyptus nitida, Eucalyptus obliqua, Eucalyptus regnans, Eucalyptus sp., Phyllocladus aspleniifolius*
Tall Shrubs:	*Acacia verticillata, Olearia argophylla, Pomaderris apetala*
Shrubs:	*Cassinia aculeata subsp. aculeata, Cenarrhenes nitida, Coprosma nitida, Coprosma quadrifida, Tasmannia lanceolata*
Herbs:	*Microtis arenaria, Oxalis perennans, Urtica incisa*
Ferns:	*Hymenophyllum cupressiforme, Hymenophyllum rarum, Hypolepis rugosula, Microsorum pustulatum subsp. pustulatum, Notogrammitis billardierei, Rumohra adiantiformis*
Weeds:	*Eucalyptus nitens*

Site: 3 NAD	
Grid Reference:	349630E, 5406566N
Accuracy:	GPS (within 10 metres)
Recorder:	Richard White
Date of Survey:	18 Jan 2018
Trees:	*Eucalyptus obliqua, Eucryphia lucida, Nothofagus cunninghamii*
Tall Shrubs:	*Acacia dealbata subsp. dealbata, Acacia mucronata, Leptospermum scoparium, Pomaderris apetala*
Shrubs:	*Cassinia aculeata subsp. aculeata, Coprosma quadrifida, Pimelea linifolia*
Herbs:	*Acaena novae-zelandiae, Hydrocotyle hirta, Oxalis perennans, Senecio hispidissimus, Urtica incisa*
Graminoids:	*Carex appressa, Juncus procerus, Juncus sarophorus*
Ferns:	*Histiopteris incisa, Hypolepis rugosula, Pteris comans*

Site: 4 FRG

Grid Reference:	350028E, 5406390N
Accuracy:	GPS (within 10 metres)
Recorder:	Richard White
Date of Survey:	18 Jan 2018
Trees:	*Acacia melanoxylon, Eucalyptus globulus subsp. globulus, Eucalyptus nitida, Eucalyptus sp., Nothofagus cunninghamii*
Tall Shrubs:	*Leptospermum scoparium, Monotoca glauca, Pomaderris apetala*
Shrubs:	*Cassinia aculeata subsp. aculeata, Gaultheria hispida, Hakea lissosperma, Olearia lirata, Olearia ramulosa, Pimelea drupacea*
Herbs:	*Acaena novae-zelandiae, Epilobium sp., Gonocarpus teucrioides*
Graminoids:	*Carex appressa, Juncus bassianus, Juncus procerus*
Ferns:	*Polystichum proliferum*
Weeds:	*Centaurium erythraea, Cirsium vulgare, Cortaderia sp, Eucalyptus nitens, Hypochaeris radicata, Pinus radiata*

Appendix B: Vascular Plant Species list

Status codes:

ORIGIN	NATIONAL SCHEDULE	STATE SCHEDULE
i - introduced	EPBC Act 1999	TSP Act 1995
d - declared weed WM Act	CR - critically endangered	e - endangered
en - endemic to Tasmania	EN - endangered	v - vulnerable
t - within Australia, occurs only in Tas.	VU - vulnerable	r - rare

Sites:

1	RMT - E350651, N5406137	17/01/2018	Richard	White
2	NAR - E350589, N5406039	18/01/2018	Richard	White
3	NAD - E349630, N5406566	18/01/2018	Richard	White
4	FRG - E350028, N5406390	18/01/2018	Richard	White

Site	Name	Common name	Status
	DICOTYLEDONAE		
	APIACEAE		
1 3	*Hydrocotyle hirta*	hairy pennywort	
	APOCYNACEAE		
1	*Parsonsia brownii*	twining silkpod	
	ASTERACEAE		
1 2 3 4	*Cassinia aculeata subsp. aculeata*	dollybush	
1 4	*Cirsium vulgare*	spear thistle	i
1 4	*Hypochaeris radicata*	rough catsear	i
1 2	*Olearia argophylla*	musk daisybush	
1 4	*Olearia lirata*	forest daisybush	
1 4	*Olearia ramulosa*	twiggy daisybush	
3	*Senecio hispidissimus*	coarse fireweed	
1	*Senecio minimus*	shrubby fireweed	
	ATHEROSPERMATACEAE		
1 2	*Atherosperma moschatum subsp. moschatum*	sassafras	
	CAMPANULACEAE		
1	*Lobelia pedunculata*	matted lobelia	
1	*Wahlenbergia sp.*	bluebell	
	CUNONIACEAE		
1	*Anodopetalum biglandulosum*	horizontal	en
	ELAEOCARPACEAE		
1	*Aristotelia peduncularis*	heartberry	en
	EPACRIDACEAE		
1	*Leptecophylla juniperina*	pink or crimson berry	
1 4	*Monotoca glauca*	goldey wood	
1	*Trochocarpa cunninghamii*	straggling purpleberry	en
	ERICACEAE		
1 4	*Gaultheria hispida*	copperleaf snowberry	en
	ESCALLONIACEAE		
1	*Anopterus glandulosus*	tasmanian laurel	en
	EUCRYPHIACEAE		
1 3	*Eucryphia lucida*	leatherwood	en
	FAGACEAE		
1 3 4	*Nothofagus cunninghamii*	myrtle beech	

	GENTIANACEAE		
1 4	*Centaurium erythraea*	common centaury	i
	HALORAGACEAE		
1 4	*Gonocarpus teucrioides*	forest raspwort	
	LAMIACEAE		
1	*Prostanthera lasianthos var. lasianthos*	christmas mintbush	
	MIMOSACEAE		
3	*Acacia dealbata subsp. dealbata*	silver wattle	
1 2 4	*Acacia melanoxylon*	blackwood	
1 3	*Acacia mucronata*	variable sallow wattle	
2	*Acacia verticillata*	prickly moses	
	MYRTACEAE		
2	*Eucalyptus nitens*	shining gum	i
1 2	*Eucalyptus nitida*	western peppermint	en
1 2 3	*Eucalyptus obliqua*	stringybark	
2	*Eucalyptus regnans*	giant ash	
2	*Eucalyptus sp.*	gum	
1	*Leptospermum nitidum*	shiny teatree	en
1 3 4	*Leptospermum scoparium*	common tea-tree	
	ONAGRACEAE		
1 4	*Epilobium sp.*	willowherb	
	OXALIDACEAE		
1 2 3	*Oxalis perennans*	grassland woodsorrel	
	PITTOSPORACEAE		
1	*Pittosporum bicolor*	cheesewood	
	PROTEACEAE		
1 2	*Cenarrhenes nitida*	native plum	en
4	*Hakea lissosperma*	mountain needlebush	
	RANUNCULACEAE		
1	*Clematis aristata*	mountain clematis	
	RHAMNACEAE		
1 2 3 4	*Pomaderris apetala*	common dogwood	
	ROSACEAE		
1 3 4	*Acaena novae-zelandiae*	common buzzy	
1	*Rubus fruticosus*	blackberry	d
	RUBIACEAE		
2	*Coprosma nitida*	mountain currant	
1 2 3	*Coprosma quadrifida*	native currant	
	RUTACEAE		
1	*Nematolepis squamea*	satinwood	
	THYMELAEACEAE		
1	*Pimelea cinerea*	grey riceflower	en
1 4	*Pimelea drupacea*	cherry riceflower	
3	*Pimelea linifolia*	slender riceflower	
	URTICACEAE		
2 3	*Urtica incisa*	scrub nettle	
	VIOLACEAE		
1	*Viola hederacea*	ivyleaf violet	
	WINTERACEAE		
2	*Tasmannia lanceolata*	mountain pepper	
	GYMNOSPERMAE		
	PHYLLOCLADACEAE		
1 2	*Phyllocladus aspleniifolius*	celerytop pine	en
	PINACEAE		
4	*Pinus radiata*	radiata pine	i

	MONOCOTYLEDONAE		
	CYPERACEAE		
1 3 4	*Carex appressa*	tall sedge	
1	*Gahnia grandis*	cutting grass	
	IRIDACEAE		
1	*Libertia pulchella*	pretty grass-flag	
	JUNCACEAE		
4	*Juncus bassianus*	forest rush	
3 4	*Juncus procerus*	tall rush	
3	*Juncus sarophorus*	broom rush	
1	*Luzula sp.*	luzula	
	LILIACEAE		
1	*Dianella tasmanica*	forest flaxlily	
	ORCHIDACEAE		
2	*Microtis arenaria*	notched onion-orchid	
	POACEAE		
1 4	*Cortaderia sp*	pampasgrass	d
1	*Poa labillardierei*	silver tussockgrass	
	TYPHACEAE		
3	*Typha sp.*		
	PTERIDOPHYTA		
	ASPIDIACEAE		
1 4	*Polystichum proliferum*	mother shieldfern	
1 2	*Rumohra adiantiformis*	leathery shieldfern	
	ASPLENIACEAE		
1	*Asplenium flaccidum subsp. flaccidum*	weeping spleenwort	
	BLECHNACEAE		
1	*Blechnum fluviatile*	ray waterfern	
1	*Blechnum nudum*	fishbone waterfern	
1	*Blechnum wattsii*	hard waterfern	
	DENNSTAEDTIACEAE		
1 3	*Histiopteris incisa*	batswing fern	
1 2 3	*Hypolepis rugosula*	ruddy groundfern	
1	*Pteridium esculentum subsp. esculentum*	bracken	
	DICKSONIACEAE		
1	*Dicksonia antarctica*	soft treefern	
	GLEICHENIACEAE		
1	*Sticherus tener*	silky fanfern	
	GRAMMITIDACEAE		
1 2	*Notogrammitis billardierei*	common fingerfern	
1	*Notogrammitis heterophylla*	gypsy fern	
	HYMENOPHYLLACEAE		
1 2	*Hymenophyllum cupressiforme*	common filmyfern	
1	*Hymenophyllum flabellatum*	shiny filmyfern	
1 2	*Hymenophyllum rarum*	narrow filmyfern	
1	*Polyphlebium venosum*	bristle filmyfern	
	LYCOPODIACEAE		
1	*Phlegmarius varius*	long clubmoss	
	POLYPODIACEAE		
1 2	*Microsorum pustulatum subsp.*	kangaroo fern	
	PTERIDACEAE		
3	*Pteris comans*	netted brake	
	TMESIPTERIDACEAE		
1	*Tmesipteris obliqua*	common forkfern	

Savage River Mine - center pit extension
Savage River
Addendum to the Natural Values Assessment

22nd October 2020

For Grange Resources
GRA004

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Mapping: Jacques Demange

Review: Richard White

Summary

Two areas not previously surveyed for natural values are to be included in the proposal to extend the centre pit at Grange's Savage River Mine in Tasmania (the original Centre Pit extension Natural Values Assessment was completed in March 2018). The two new areas are the Mill Rock Dump area east of the main mine site; and the Centre Pit South area (Figure 1). These areas were surveyed for natural values in October 2020 and the current addendum deals with the potential impacts to these areas.

The following TASVEG 4.0 vegetation communities were identified and surveyed in the study area:

- *Acacia dealbata* forest (NAD) – 5.40 ha
- *Acacia melanoxylon* forest on rises (NAR) – 6.86 ha
- *Leptospermum lanigerum – Melaleuca squarrosa* swamp forest (NLM) – 1.11 ha
- *Nothofagus - Atherosperma* rainforest (RMT) – 20.81 ha
- *Eucalyptus nitida* forest over rainforest (WNR) – 8.38 ha
- *Eucalyptus obliqua* forest over rainforest (WOR) – 1.82
- Regenerating cleared land (FRG) – 1.41 ha
- Permanent easements (FPE) – 0.81 ha
- Extra-urban miscellaneous (FUM) – 13.82

The vegetation is typical for the region and none of the observed communities are listed as threatened.

No threatened flora or fauna species were observed. The survey area may be utilised by four threatened fauna species: the spotted-tailed quoll, Tasmanian devil and the grey goshawk, and *Beddomeia bowrensis* or *B. trochiformis*. The impact of the development is not likely to have a significant impact on a population of these species; however, a survey of the potential Beddomeia habitat is required to determine and quantify the potential impact to the snail.

The legislative implications and recommendations remain largely unchanged from the original report. Recommendations based on the results of the current survey are as follows:

- To reduce potential to impact threatened carnivores, pre-clearance devil and quoll den surveys should be completed in both the Centre Pit South and Mill Rock Dump areas.
- A targeted survey for hydrobiid snails (*Beddomeia bowrensis, B, trochiformis*), to be conducted within the suitable creek habitat in the south of the Mill Rock Dump area.
- Efforts to mitigate the impacts of the development should focus on reducing the risk of introduction and spread of plant pathogens, and declared and environmental weeds, during and after works, by implementing appropriate weed and hygiene management plans.

TABLE OF CONTENTS

1 Introduction

Two areas not previously surveyed for natural values are to be included in the proposal to extend the centre pit at Grange's Savage River Mine in Tasmania. These areas are: the Mill Rock Dump area east of the main mine site; and the Centre Pit South area (Figure 1). These areas were surveyed for natural values in October 2020 and the current addendum deals with the potential impacts to these areas.

Previous natural values reports specific to the centre pit proposal include the original Natural Values Assessment of the main impact area that was undertaken by North Barker Ecosystem Services (NBES) in March 2018 to determine and document the conservation significant natural values within the potential area to be impacted by the proposal.[1] Grange also provided an updated impact area to NBES on 06/03/2020 and requested an addendum[2] that detailed the potential extent and significance of impacts on natural values in the updated area.

This addendum reports on the type and extent of natural values, including vegetation communities, flora and fauna within areas surveyed within the impact area. The conclusions of the original report[3] are largely unchanged; this addendum should be read in conjunction with the original report.

1.1 Survey Area

The study area is divided into two distinct areas: The Mill Rock Dump in the east of the mine site, and the smaller, Centre Pit South area (Figure 1). The Mill Rock Dump is bound by the main site access road to the east, and the access road to the old tailings dam on the west. The Centre Pit South area is surrounded by heavily disturbed land, with a haulage road to the east and the west.

The study areas range between 230 m and 390 m altitude. The Mill Rock Dump area has large swathes of relatively undisturbed forest in the east, and cleared/heavily disturbed land in the west. The Centre Pit South area has been disturbed in the past; however, the southernmost extent is relatively mature forest. The area northeast of here is heavily disturbed. Both survey areas contain small areas of planted *Eucalyptus* trees, which are likely to have been seeded aerially (pers. comm. Tony Ferguson).

[1] North Barker Ecosystem Services (2018) 'Savage River Mine - center pit extension. Natural Values Assessment'. Hobart, Tasmania.
[2] North Barker Ecosystem Services (2020) 'Savage River Mine - center pit extension. Addendum to the Natural Values Assessment'. Hobart, Tasmania.
[3] North Barker Ecosystem Services (2018) 'Savage River Mine - center pit extension. Natural Values Assessment'. Hobart, Tasmania.

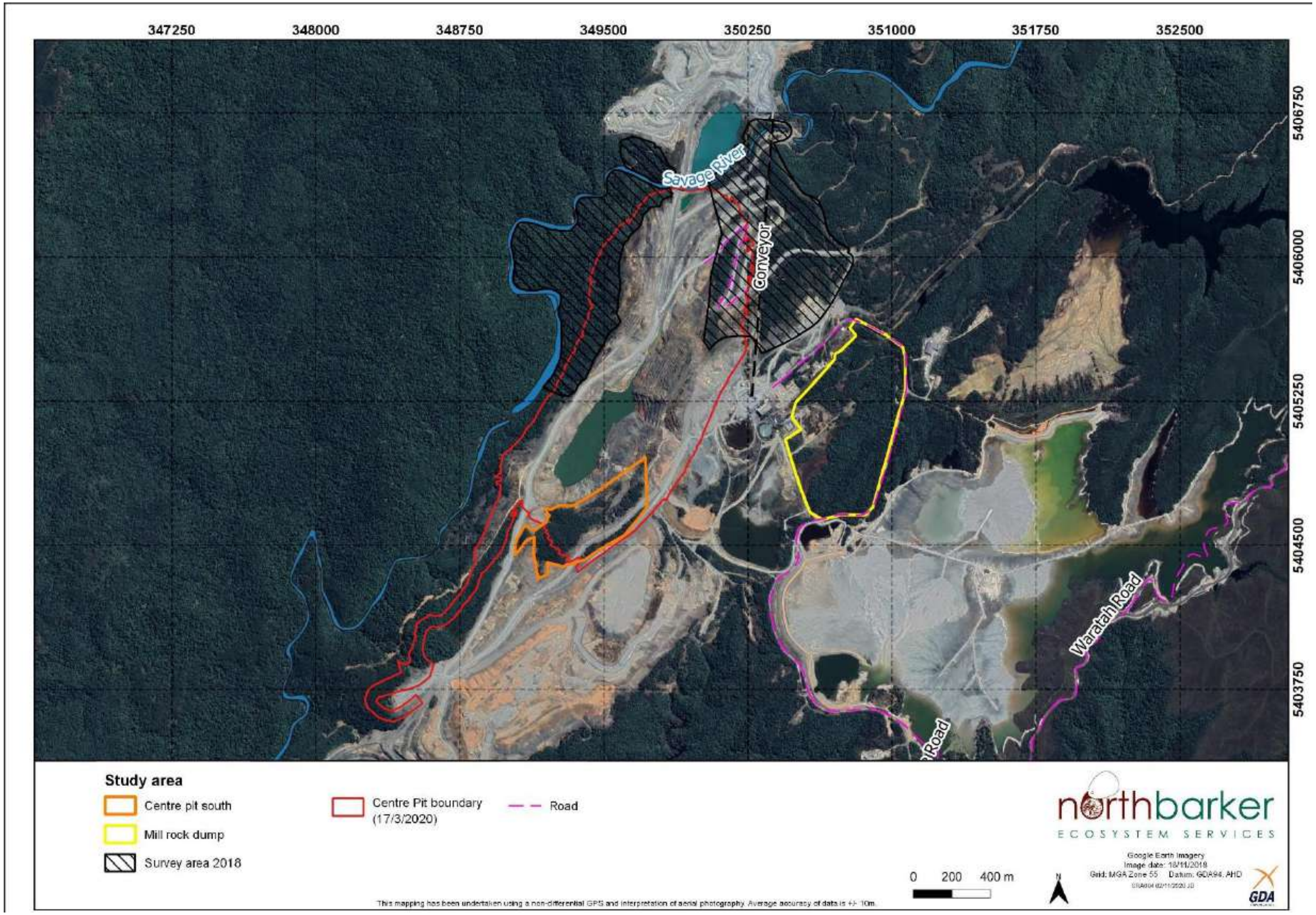

Figure 1: Areas surveyed 15-16 October 2020 with reference to the 2018 survey areas.

2 Methods

This assessment was undertaken in accordance with the *Guidelines for Natural Values Surveys*[4]. Field work was carried out by two observers on foot on the 15th and 16th of October 2020. Native vegetation was mapped by field observations, aided with aerial imagery, and done in accordance with units defined in TASVEG 4.0[5]. The mine site was mapped using a meandering area search technique[6]. Particular attention was given to habitats suitable for threatened species (under Tasmanian TSPA and/or the Commonwealth EPBCA), and to 'declared' weeds listed under the Tasmanian *Weed Management Act 1999* (WMA). Botanical nomenclature follows the current census of Tasmanian plants[7]. All location data were recorded with a handheld GPS.

Observations of habitat suitability for fauna were made concurrently with the flora survey. In terms of direct observations, due to the density of the vegetation it was determined that scats and other indirect signs would give the best chance of detecting the presence of ground-dwelling threatened species[8]. Due to the limited value of simply identifying the presence/absence of fauna species, our search included looking for suitable habitat elements (such as potential nest/den habitat/sites).

3 Results

3.1.1 Vegetation communities

The five native vegetation communities, and two modified land communities occur within the surveyed areas:

- *Acacia dealbata* forest (NAD) – 5.40 ha
- *Acacia melanoxylon* forest on rises (NAR) – 6.86 ha
- *Leptospermum lanigerum – Melaleuca squarrosa* swamp forest (NLM) – 1.11 ha
- *Nothofagus - Atherosperma* rainforest (RMT) – 20.81 ha
- *Eucalyptus nitida* forest over rainforest (WNR) – 8.38 ha
- *Eucalyptus obliqua* forest over rainforest (WOR) – 1.82
- Regenerating cleared land (FRG) – 1.41 ha
- Permanent easements (FPE) – 0.81 ha
- Extra-urban miscellaneous (FUM) – 13.82

Acacia dealbata forest (NAD)

This community occurred in two patches: in the southwest corner of the Mill Rock Dump area (Plate 1), and in the northeast of the Centre Pit South area. Both patches have been heavily disturbed in the past. The dominant canopy species is *Acacia dealbata*, with small *Acacia melanoxylon* and *Nothofagus cunninghamii* common sub-dominant species. Common shrubs and small trees are *Cassinia aculeata* and *Monotoca glauca*. The Centre Pit South patch has small, rocky clearings that have infestations of pampas grass (declared weed under the WMA) throughout.

The NAD mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

4 DPIPWE 2015
5 Kitchener and Harris 2013
6 Goff et al. 1982
7 Tasmanian State Government 1995; Commonwealth of Australia 1999
8 Commonwealth of Australia 2011 – survey guidelines for Australia's threatened mammals and birds.

Plate 1: NAD vegetation in the southwest of the Mill Rock Dump area.

Acacia melanoxylon forest on rises (NAR)

This community is dominated by a tall canopy of *Acacia melanoxylon* up to 25 m tall, with an understorey of immature *Nothofagus cunninghamii* and *Eucryphia lucida*. The understorey is mostly open, with the dominant small trees and shrubs being *Cenarrhenes nitida, Coprosma quadrifida* and *Leptecophylla parviflora*. *Dicksonia antarctica* and *Polystichum proliferum* are common ferns in this community.

The patch of NAR in the northeast of the Mill Rock Dump area is more mature than the larger patch in the Centre Pit South area (Plate 2), and transitions into RMT rainforest downslope. The Centre Pit South patch is on a steep slope, much of which was inaccessible due to cliff bands and unstable rocky areas. This patch has evidence of past disturbance with rocky channels and discarded tyres scattered throughout the patch.

The NAR mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

Plate 2: NAR forest in the Centre Pit South area.

Leptospermum lanigerum – Melaleuca squarrosa swamp forest (NLM)

This community occurs at the southernmost extent of the Mill Rock Dump area. It occurs arounds the edges of a small creek, and around two old vehicle tracks located in this area. The community transitions into RMT and WNR to the north.

Melaleuca squarrosa is the dominant canopy species. The understorey has a high component of wet species such as *Cenarrhenes nitida*, *Phyllocladus aspleniifolius*, *Notelaea ligustrina*, and *Monotoca glauca*. *Acacia mucronata* was common on the exposed southern edge of the patch. *Bauera rubioides* and *Calorophus elongatus* were common at the ground level, as well as *Blechnum wattsii* and *Gleichenia dicarpa*.

The NLM mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

Nothofagus - Atherosperma rainforest (RMT)

RMT is the dominant community on the west facing slope of the Mill Rock Dump area (Plate 3). The community is thamnic in structure, with medium to tall rainforest trees and an understorey of tall shrubs and trees. The canopy is dominated by *Nothofagus cunninghamii*, with *Eucryphia lucida*, *Atherosperma moschatum* and *Acacia melanoxylon* as sub-dominants. The understorey is dominated by *Anodpetalum biglandulosum* and *Cenarrhenes nitida*, and *Pimelea cinerea*. The ground cover is sparsely vegetated with ferns; most commonly *Blechnum wattsii* and *Polystichum proliferum*, and the epiphytic ferns *Grammatis billardierei* and *Hymenophyllum rarum* were common throughout.

The RMT mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

Eucalyptus nitida forest over rainforest (WNR)

This community was dominant on the east facing slope of the Mill Rock Dump area (Plate 4). *Eucalyptus nitida* is the dominant canopy species, *Nothofagus cunninghamii* sub-dominant. The understorey is similar floristically to the RMT community however *Bauera rubioides* replaces *Anodopetalum biglandulosum* as a dominant species at the ground level.

The WNR mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

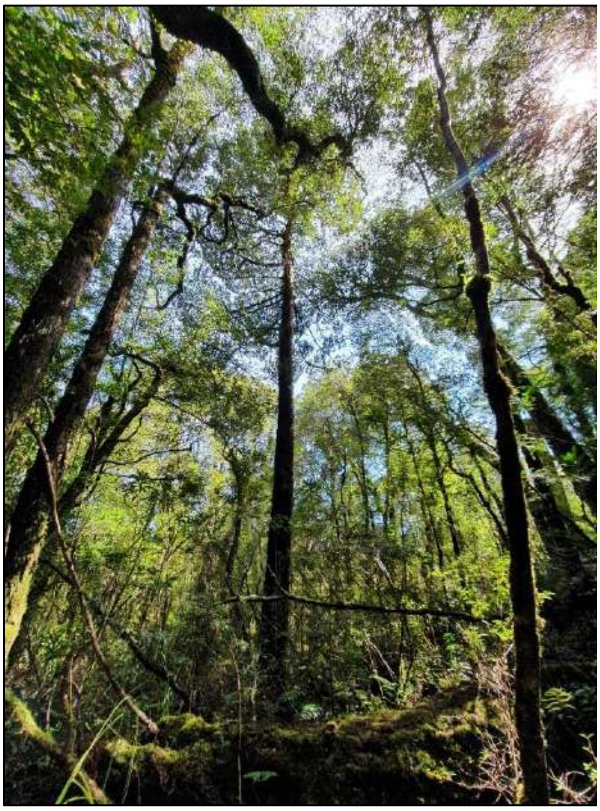

Plate 3: Typical understorey in the RMT community.

Plate 4: Dense Bauera rubioides understorey in WNR forest.

Eucalyptus obliqua forest over rainforest (WOR)

This community is a modified facies of WOR and occurs in the western part of the Mill Rock Dump area. *Eucalyptus obliqua* trees, which are likely to have been seeded aerially (pers. comm. Tony Ferguson), are the dominant canopy species, with an understorey of immature rainforest species such as *Nothofagus cunninghamii* and *Acacia melanoxylon*. Species that thrive in disturbed land such as *Gahnia grandis* and *Cassinia aculeata* were common in this patch.

The WOR mapping unit does not correspond to any threatened community listed under the NCA or the EPBCA.

Regenerating cleared land (FRG)

A small area in the Centre Pit South that has planted *Eucalyptus obliqua* present with a small number of native shrubs present in the understorey. This patch is steep and rocky and is located on the edge of a haulage road. Pampas grass is widespread along the flanks of this area.

Permanent easements (FPE)

A small area cleared for electricity transmission lines was recorded in the north of the Mill Rock Dump area. This is an area of low regenerating rainforest (~2 m) comprising rainforest and regrowth species such as: *Gahnia grandis, Leptospermum lanigerum, Nematolepis squamea* and *Nothofagus cunninghamii*.

Extra-urban miscellaneous (FUM)

This mapping unit refers to areas that are actively utilised as part of the mine or areas of infrastructure. This includes two patches of water (Plate 5) in the Mill Rock Dump area that are remnants of historic mining operations. The dominant species in the aquatic area is *Juncus procerus*, *Isolepis sp*., and *Typha latifolia*, an introduced bulrush. Additional largely unvegetated patches of open water that are likely anthropogenically derived occur in the RMT – these are not considered wetlands as per TASVEG and are mapped as water (OAQ).

Plate 5: Swampy area in the west of the Mill Rock Dump area, looking towards RMT rainforest.

3.1.2 **Threatened flora**

Seventy vascular plant species were recorded within the two survey areas including five introduced species, one of which is listed as a declared weed under the Tasmanian Weed Management Act 1999. A full species list is found in Appendix A.

No threatened flora species listed under either the Tasmanian *Threatened Species Protection Act 1995* (TSPA) or the Commonwealth EPBCA were recorded or thought likely to occur. The likelihood of occurrence based on known observations and habitat is discussed in the original natural values assessment.

According to data within the Tasmanian Natural Values Atlas[9], no observations of threatened flora are known within 500 m of the site, and only four species are known from within 5 km (*Epacris curtisiae, Micrantheum serpentinum, Persoonia muelleri subsp. angustifolia, and Rhodanthe anthemoides*). None of these have more than a low chance of occurring in the proposal area; this is consistent with the findings reported in original NVA where more detail on the likelihood of occurrence is provided.

3.1.3 **Introduced plants**

One introduced plant listed as 'declared' under the WMA was recorded in the survey areas (Figure 3). *Cortaderia sp.* (pampas grass) was widespread in the Centre Pit South survey area (Plate 6), and two instances were recorded in the Mill Rock Dump area. It should be noted that the mapping of weeds in the study area is indicative as detailed coverage of the entire study area was not possible; hence it is likely that this species is more widespread than indicated.

[9] nvr_1_13-Oct-2020

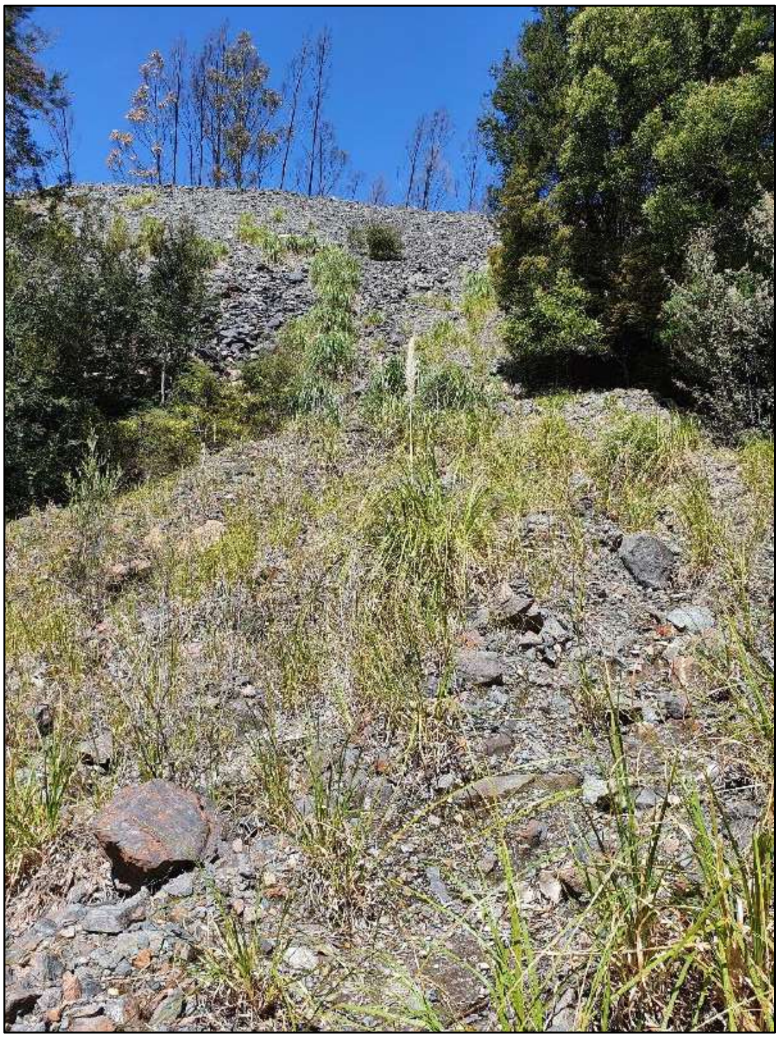

Plate 6: Pampas grass infestation in the Centre Pit South area. Infestations were common in open, rocky areas.

3.1.4 **Threatened fauna & threatened fauna habitat**

No threatened fauna species listed under either the Tasmanian TSPA or the Commonwealth EPBCA were recorded during the original survey or during the current survey. A table discussing the likelihood of threatened species recorded within 5 km of the mine site occurring in the survey areas is provided the original report; our findings from the present survey are largely consistent with these findings; however, further comments on species with some chance of occurring are addressed below.

Spotted-tail quoll & Tasmanian Devil

Suitable foraging habitat for these carnivore species occurs, and no denning sites were observed, however rocky areas in the Centre Pit South area may provide suitable denning sites for both species, particularly around the base of the cliff bands and rock scree.

Two carnivore scats (Plate 7), likely belonging to Tasmanian devil, were observed in the Mill Rock Dump area. It is quite possible that both Tasmanian devil and spotted tailed quoll utilise the Mill Rock Dump area and perhaps the Centre Pit South area; it should be noted that the latter is perhaps less suitable given that it is entirely surrounded by cleared area including haulage road.

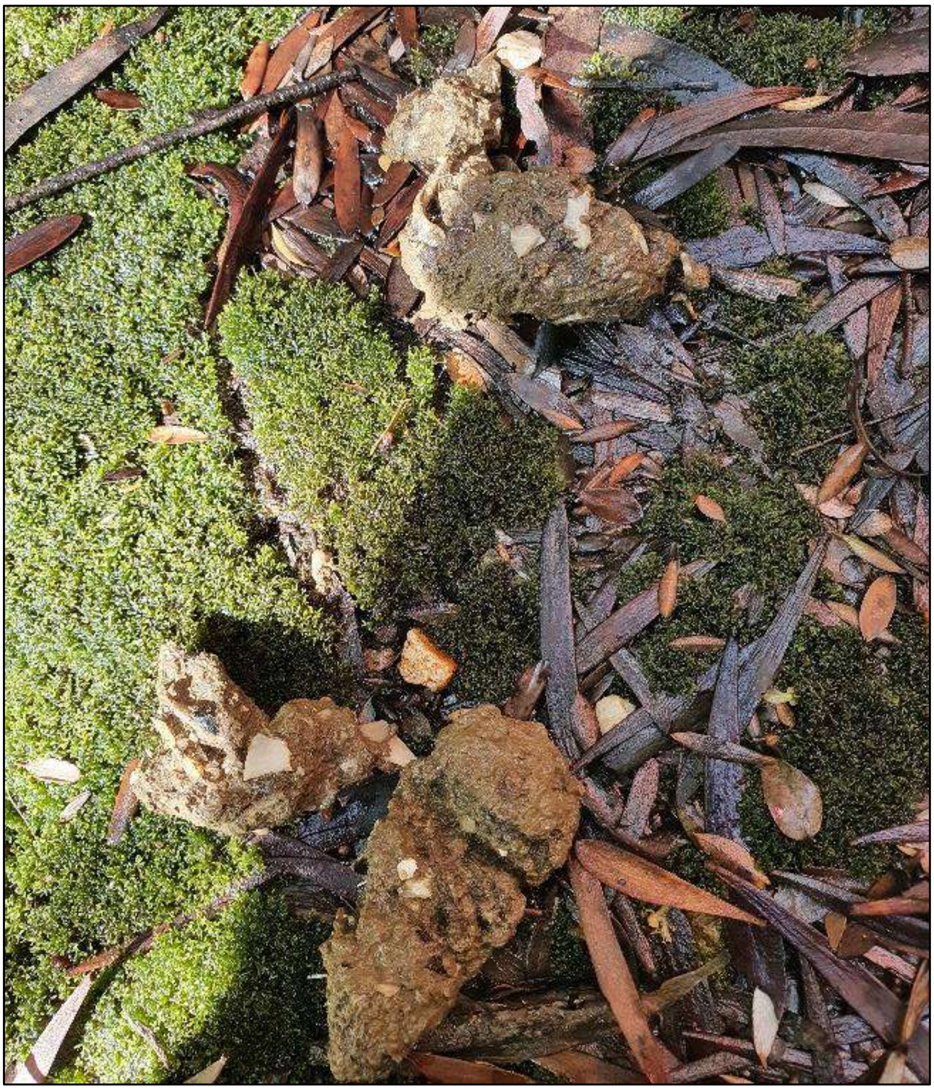

Plate 7: Tasmanian devil scat observed in the WNR forest.

Hydrobiid snails

These snails (*Beddomeia spp.* with *B. trochiformis* the most likely species here) live in sheltered habitats such as under rock slabs in streams. These species have extremely limited distributions and are known from within 5 km of the survey area. One creek in the south of the Mill Rock Dump area (Plate 8, Figure 4) has been identified as potential habitat for the TSPA rare listed Savage River Mine freshwater snail and the hydrobiid snail. This permanent creek has a gravelly substrate, with ~10% leaf litter, and ~20% coarse woody debris. Large rocks are absent from the creek bed. This creek flows through both RMT and *NLM* forest.

Plate 8: Small creek surrounded by RMT vegetation in the south of the Mill Rock Dump area – this creek is potentially suitable for Beddomeia snails.

Grey goshawk

The Centre Pit South area contains 5.53 ha of NAR forest (Figure 4, Plate 9) with *Acacia melanoxylon* throughout – this tree species is favoured by grey goshawk as a nesting tree. However, based on suitability categories as per Forest Practices guidelines, this habitat is classified as a category 2 habitat for the grey goshawk[10]. The patch has a medium stem density and few large trees suitable for nesting. No nests were observed but a full survey of this patch was not possible due to the steep topography of this patch. However, given the quality and age of the patch and the high level of disturbance in the vicinity (haul roads and cleared area), it is not considered likely that this species nests in the patch but it may be utilised for foraging.

Masked owl

Three *Eucalyptus nitida* trees with a diameter at breast height (DBH) > 1 m were recorded in the Mill Rock Dump area, and several trees with a DBH between 70 cm and 1 m were observed throughout the WNR vegetation community (Plate 10). Although these trees of

[10] Forest Practices Authority (2011) 'Goshawk habitat categories', Fauna Technical Note No. 12, Forest Practices Authority, Hobart, Tasmania.

a size that has potential for forming hollows for the Tasmanian masked owl (*Tyto novaehollandiae subsp. castanops*), this is a wet forest area and is suboptimal for this species. It is not considered likely that this species occurs in the proposed impact area.

Plate 9: Category 2 grey goshawk habitat in NAR forest in the Centre Pit South area.

Plate 10: Large Eucalyptus nitida tree in WNR forest. This tree has a stag formation above the lateral branches.

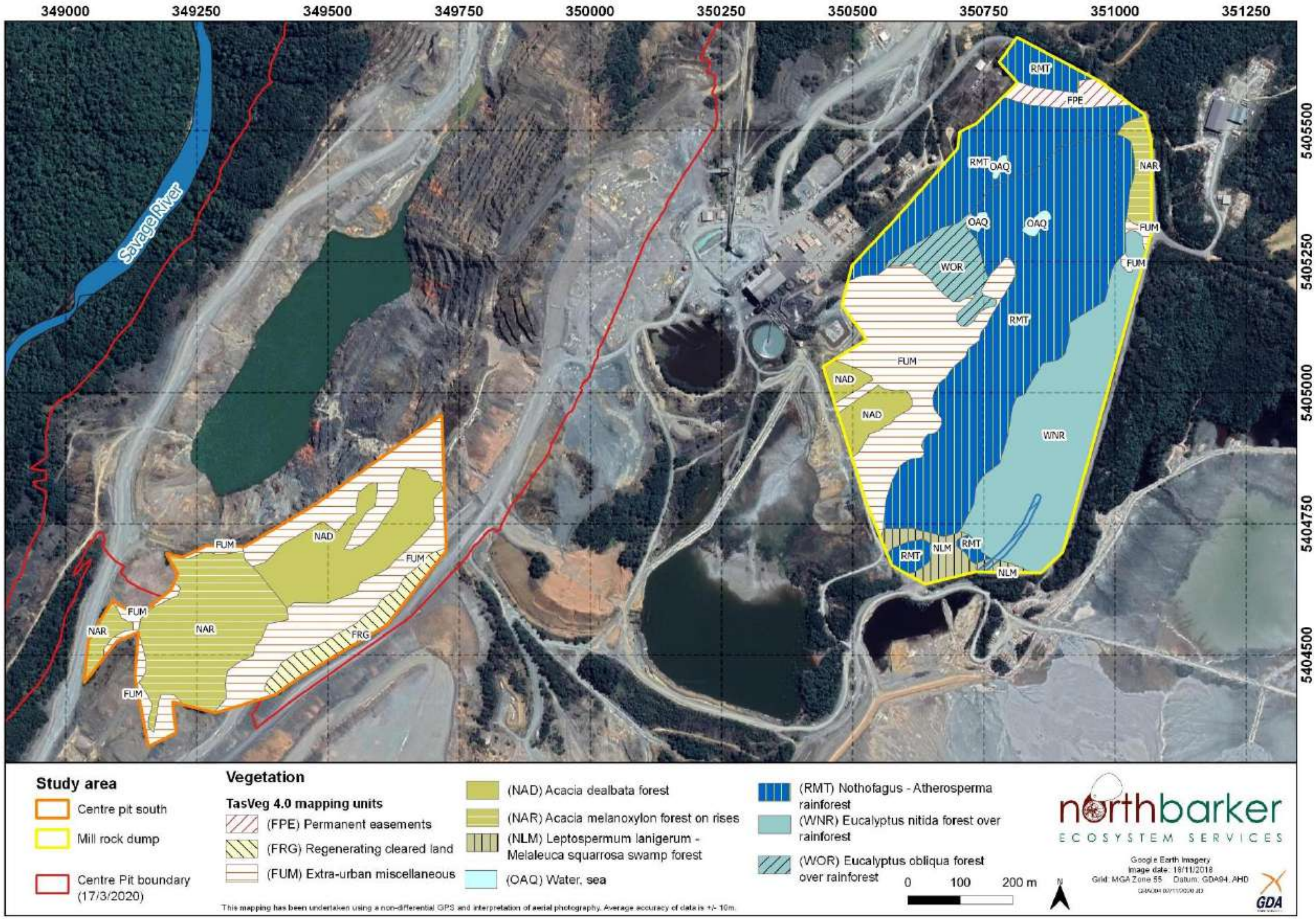

Figure 2: Map of vegetation communities according to TASVEG 4.0 classifications.

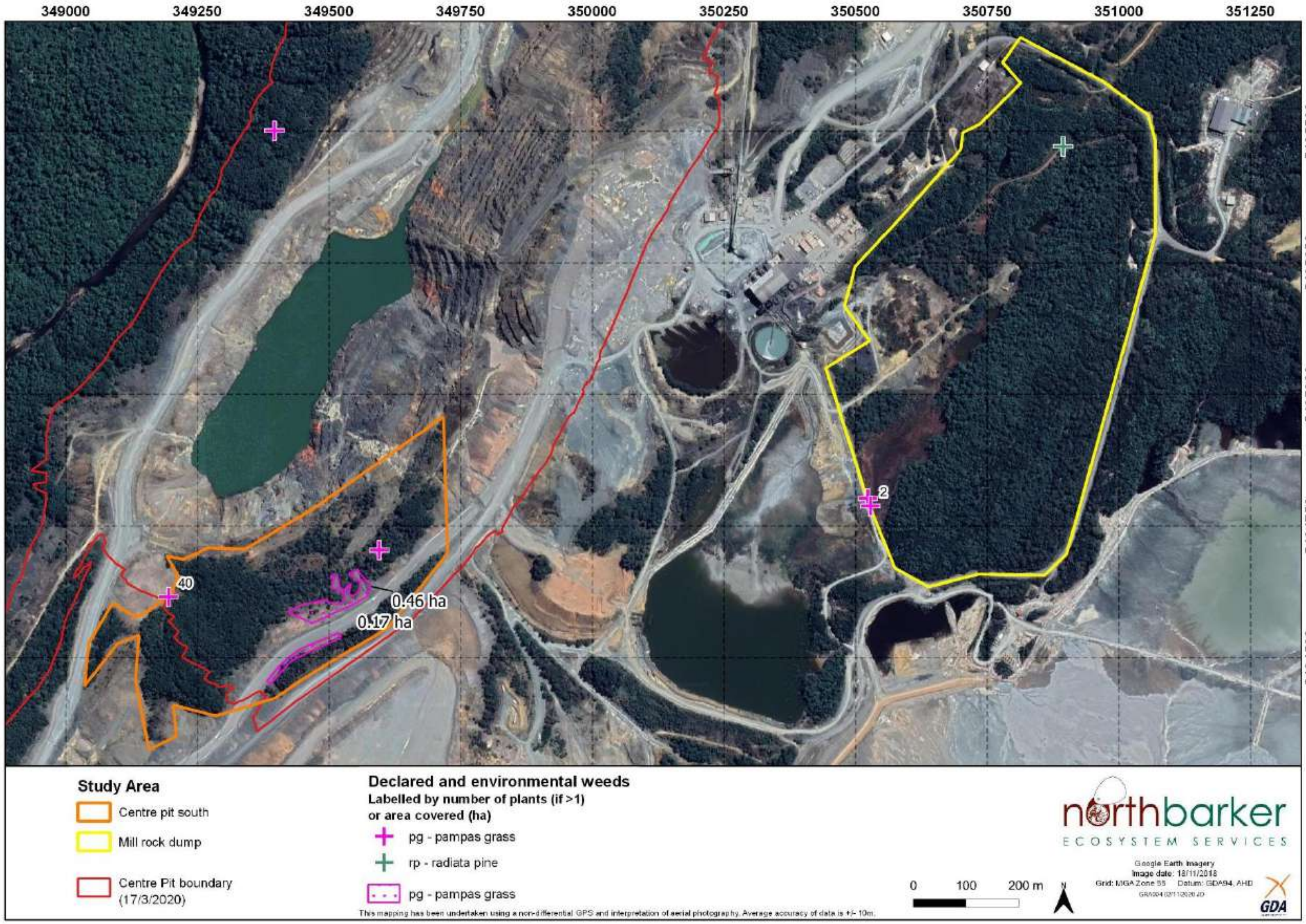

Figure 3: Map of declared and environmental weeds. Note that the extent of pampas grass in the Centre Pit South area is likely to be more widespread than is indicated.

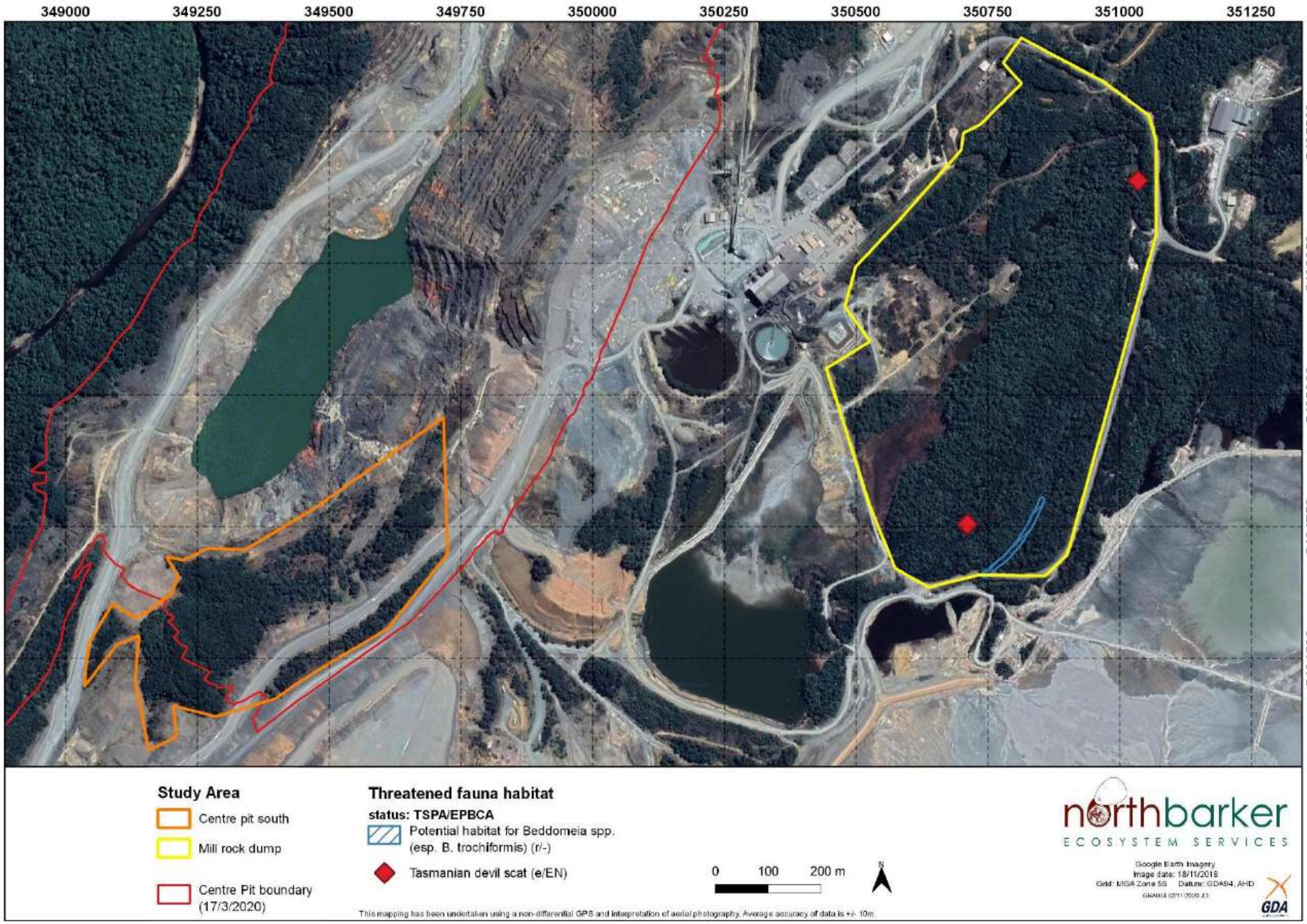

Figure 4: Location of potential *Beddomeia* habitat within surveyed area and centre pit boundary (impact area).

4 Impacts and mitigation

4.1.1 Vegetation

The proposal will impact upon 44.39 ha of native vegetation, and 16 ha of non-native vegetation. The total impact area of each vegetation community is listed in Table 1.

Table 1: Area of impact for each vegetation community.

Community	Area Impacted (ha)
Acacia dealbata forest (NAD)	5.40
Acacia melanoxylon forest on rises (NAR)	6.86
Leptospermum lanigerum – Melaleuca squarrosa swamp forest (NLM)	1.11
Nothofagus - Atherosperma rainforest (RMT)	20.81
Eucalyptus nitida forest over rainforest (WNR)	8.38
Eucalyptus obliqua forest over rainforest (WOR)	1.82

The proposal does not impact on any NCA or EPBCA listed communities and thus no specific mitigation is required.

4.1.2 Threatened flora

The proposal does not impact on any TSPA or EPBCA listed flora species and thus no specific mitigation is recommended.

4.1.3 Threatened fauna & threatened fauna habitat

The four species identified as having some potential of occurring on site that may be impacted are discussed below.

<u>Spotted-tail quoll and Tasmanian devil</u>

While quolls and devils are likely to forage in the area, the extent of the impact area (< 10 ha) is considerably less than the suggested area for a single quoll (300 ha) or devil (800 ha to 2000 ha). While it may be reasonably assumed that density will exceed this in optimum habitat, the impact to these species by the development is not likely to be significant.

Regardless, there is some potential denning habitat in the Centre Pit South area, and consistent with the recommendations in the main NVA report[11], pre-clearance den surveys for the quoll and devil are recommended as appropriate mitigation measures.

<u>Grey goshawk</u>

A patch of NAR forest (5.53 ha) in the Centre Pit South survey area is classified as category 2 habitat area but the likelihood of nesting occurring in this patch is considered low. Although occasional medium-large *Acacia melanoxylon* trees are scattered throughout the patch much of this forest has been disturbed previously and is surrounded by haulage roads. There are some areas of clear vegetation that may be suitable for foraging, however the patch in the main has a moderate stem density.

Given the suboptimal nature of this patch it is our assessment that this patch is unlikely to contain a nest of this species, and thus a targeted survey is not warranted.

<u>Hydrobiid snails</u>

These are snails of aquatic freshwater ecosystems. Two species of hydrobiid snails (*Beddomeia bowrensis and B. trochiformis,* with the latter more likely) are known from within 5

[11] North Barker Ecosystem Services (2018) 'Savage River Mine - center pit extension. Natural Values Assessment'. Hobart, Tasmania.

km of the mine site. Potentially suitable habitat occurs One stream offers potential habitat for these species in the south of the Mill Rock Dump area (Figure 4). A targeted search of this creek is recommended to determine if either of these species is present.

5 Legislative implications

Conclusions regarding legislative implications are broadly consistent with the original NVA[14]; however, it should be noted that if Beddomeia snails are found in the impact area a permit to take under the TSPA will be required.

6 Conclusion and recommendations

The area for the proposed Mill Rock Dump is situated on a steep ridge dominated by myrtle beech rainforest, and *Eucalyptus nitida* rainforest. Much of the area in the west of this survey area has been disturbed by previous mining activities. The forest component of this area has had minor disturbance in the past; however, the area is largely mature forest. This vegetation is typical for the region and none of the observed communities are listed as threatened.

The area for the proposed development of the Centre Pit South is situated in a steep area dominated by silver wattle forest, and a notable patch of blackwood forest. This area has been heavily disturbed and is surrounded by active mine infrastructure. The WMA listed pampas grass is widespread in this area. None of the observed communities are listed as threatened.

No threatened flora or fauna species were observed. The survey area may be utilised by four threatened fauna species: the spotted-tailed quoll, Tasmanian devil and the grey goshawk, and *Beddomeia bowrensis* or *B. trochiformis*. The impact of the development is not likely to have a significant impact on a population of these species; however, a survey of the potential Beddomeia habitat is required to determine and quantify the potential impact to the snail.

The legislative implications and recommendations remain largely unchanged from the original report. Recommendations based on the results of the current survey are as follows:

- To reduce potential to impact threatened carnivores, pre-clearance devil and quoll den surveys should be completed in both the Centre Pit South and Mill Rock Dump areas.
- A targeted survey for hydrobiid snails (*Beddomeia bowrensis, B, trochiformis*), to be conducted within the suitable creek habitat in the south of the Mill Rock Dump area.
- Efforts to mitigate the impacts of the development should focus on reducing the risk of introduction and spread of plant pathogens, and declared and environmental weeds, during and after works, by implementing appropriate weed and hygiene management plans.

[14] North Barker Ecosystem Services (2018) 'Savage River Mine - center pit extension. Natural Values Assessment'. Hobart, Tasmania.

Appendix A: List of vascular Plant Species for Centre Pit Proposal

Status codes:

ORIGIN	NATIONAL SCHEDULE	STATE SCHEDULE
i - introduced	EPBC Act 1999	TSP Act 1995
d - declared weed WM Act	CR - critically endangered	e - endangered
en - endemic to Tasmania	EN - endangered	v - vulnerable
t - within Australia, occurs only in Tas.		VU - vulnerable r - rare

Sites:

1	RMT - E350651, N5406137	17/01/2018	Richard White
2	NAR - E350589, N5406039	18/01/2018	Richard White
3	NAD - E349630, N5406566	18/01/2018	Richard White
4	FRG - E350028, N5406390	18/01/2018	Richard White
5	NAD - E349456, N5404607	16/10/2020	Jared Parry
6	FRG - E350766, N5405157	15/10/2020	Jared Parry
7	NAD - E350573, N5404984	15/10/2020	Jared Parry
8	RMT - E350575, N5404691	15/10/2020	Jared Parry
9	NLM - E350633, N5404667	15/10/2020	Jared Parry
10	WNR - E350684, N5404700	15/10/2020	Jared Parry
11	FRG - E.obliqua seeded. South Pit - E349518, N5404547	16/10/2020	Jared Parry
12	NAR - E349640, N5404691	16/10/2020	Jared Parry
13	WOR - E350716, N5405315	15/10/2020	Jared Parry

Site	**Name**	**Common name**	**Status**
	DICOTYLEDONAE		
	APIACEAE		
1 3 5 6 7 11 12	*Hydrocotyle hirta*	hairy pennywort	
	APOCYNACEAE		
1	*Parsonsia brownii*	twining silkpod	
	ASTERACEAE		
1 2 3 4 5 6 11 12 13	*Cassinia aculeata subsp. aculeata*	dollybush	
1 4 11	*Cirsium vulgare*	spear thistle	i
5 6 11 12	*Euchiton japonicus*	common cottonleaf	
1 4 11	*Hypochaeris radicata*	rough catsear	i
1 2	*Olearia argophylla*	musk daisybush	
1 4 12	*Olearia lirata*	forest daisybush	
1 4	*Olearia ramulosa*	twiggy daisybush	
3 5 6 7 11 12	*Senecio hispidissimus*	coarse fireweed	
1	*Senecio minimus*	shrubby fireweed	
	ATHEROSPERMATACEAE		
1 2 8 12	*Atherosperma moschatum subsp. moschatum*	sassafras	
	CAMPANULACEAE		
1 5 6 7 11 12	*Lobelia pedunculata*	matted lobelia	
1	*Wahlenbergia sp.*	bluebell	

CUNONIACEAE
1 8 10 12 *Anodopetalum biglandulosum* horizontal
en
9 10 *Bauera rubioides* wiry bauera
DROSERACEAE
9 *Drosera peltata* pale sundew
ELAEOCARPACEAE
1 *Aristotelia peduncularis* heartberry en
ERICACEAE
10 *Epacris impressa* common heath
1 4 5 6 12 *Gaultheria hispida* copperleaf snowberry en
13
1 8 *Leptecophylla juniperina* pink or crimson berry
6 7 8 9 12 *Leptecophylla juniperina subsp.* common pinkberry t

1 4 5 6 7 *Monotoca glauca* goldey wood
8 9 12 13
10 *Sprengelia incarnata* pink swampheath
1 *Trochocarpa cunninghamii* straggling purpleberry en
ESCALLONIACEAE
1 *Anopterus glandulosus* tasmanian laurel en
EUCRYPHIACEAE
1 3 8 10 *Eucryphia lucida* leatherwood en
12
FABACEAE
3 5 6 7 11 *Acacia dealbata subsp. dealbata* silver wattle
12 13
1 2 4 5 6 *Acacia melanoxylon* blackwood
7 8 11 12
13
1 3 6 7 8 *Acacia mucronata* variable sallow wattle
9 11 13
2 5 6 7 11 *Acacia verticillata* prickly moses
12 13
FAGACEAE
1 3 4 5 6 *Nothofagus cunninghamii* myrtle beech
7 8 11 12
13
GENTIANACEAE
1 4 *Centaurium erythraea* common centaury i
HALORAGACEAE
1 4 *Gonocarpus teucrioides* forest raspwort
HEMEROCALLIDACEAE
1 5 7 8 9 *Dianella tasmanica* forest flaxlily
11 12
LAMIACEAE
1 *Prostanthera lasianthos var. lasianthos* christmas mintbush

	MYRTACEAE		
4	*Eucalyptus globulus subsp. globulus*	tasmanian blue gum	
2 4	*Eucalyptus nitens*	shining gum	i
1 2 4 10 13	*Eucalyptus nitida*	western peppermint	en
1 2 3 6 7 11 13	*Eucalyptus obliqua*	stringybark	
2	*Eucalyptus regnans*	giant ash	
2 4	*Eucalyptus sp.*	gum	
11	*Leptospermum lanigerum*	woolly teatree	
1	*Leptospermum nitidum*	shiny teatree	en
1 3 4 7 8 10 11 13	*Leptospermum scoparium*	common tea-tree	
7 8 13	*Melaleuca ericifolia*	coast paperbark	
8 9 10	*Melaleuca squarrosa*	scented paperbark	
	OLEACEAE		
8 9 10	*Notelaea ligustrina*	native olive	
	ONAGRACEAE		
1 4	*Epilobium sp.*	willowherb	
	OXALIDACEAE		
1 2 3 12	*Oxalis perennans*	grassland woodsorrel	
	PITTOSPORACEAE		
6 8 10	*Billardiera longiflora*	purple appleberry	en
1	*Pittosporum bicolor*	cheesewood	
	POLYGALACEAE		
12	*Comesperma volubile*	blue lovecreeper	
	PROTEACEAE		
1 2 6 7 8 9 10 12	*Cenarrhenes nitida*	native plum	en
4	*Hakea lissosperma*	mountain needlebush	
	RANUNCULACEAE		
1 12	*Clematis aristata*	mountain clematis	
	RHAMNACEAE		
1 2 3 4 5 12	*Pomaderris apetala*	common dogwood	
	ROSACEAE		
1 3 4 5 7 12 13	*Acaena novae-zelandiae*	common buzzy	
1	*Rubus fruticosus*	blackberry	d
	RUBIACEAE		
2	*Coprosma nitida*	mountain currant	
1 2 3 5 6 7 12 13	*Coprosma quadrifida*	native currant	
	RUTACEAE		
1 6	*Nematolepis squamea*	satinwood	
	THYMELAEACEAE		
1 8 10	*Pimelea cinerea*	grey riceflower	en
1 4 8	*Pimelea drupacea*	cherry riceflower	
3 8	*Pimelea linifolia*	slender riceflower	
	URTICACEAE		
2 3	*Urtica incisa*	scrub nettle	
	VIOLACEAE		
1	*Viola hederacea*	ivyleaf violet	
	WINTERACEAE		
2	*Tasmannia lanceolata*	mountain pepper	

	GYMNOSPERMAE		
	PHYLLOCLADACEAE		
1 2 5 6 7 9 10 12	*Phyllocladus aspleniifolius*	celerytop pine	en
	PINACEAE		
4	*Pinus radiata*	radiata pine	i
	MONOCOTYLEDONAE		
	CYPERACEAE		
1 3 4 6	*Carex appressa*	tall sedge	
1 5 6 7 8 9 10 12 13	*Gahnia grandis*	cutting grass	
6	*Isolepis sp.*	club rush	
	IRIDACEAE		
1	*Libertia pulchella*	pretty grass-flag	
	JUNCACEAE		
4 5 11 12	*Juncus bassianus*	forest rush	
11 12	*Juncus pauciflorus*	looseflower rush	
3 4 6	*Juncus procerus*	tall rush	
3 6 7 13	*Juncus sarophorus*	broom rush	
1 5 12	*Luzula sp.*	luzula	
	ORCHIDACEAE		
2	*Microtis arenaria*	notched onion-orchid	
	POACEAE		
1 4 5 7 11	*Cortaderia sp*	pampasgrass	d
13	*Microlaena tasmanica var. tasmanica*	tasmanian ricegrass	en
1 5 12	*Poa labillardierei*	silver tussockgrass	
6 7 11 13		*Poa sp.*	poa
	RESTIONACEAE		
9 10	*Calorophus elongatus*	long roperush	
	TYPHACEAE		
6	*Typha latifolia*	great reedmace	i
	PTERIDOPHYTA		
ASPIDIACEAE			
1 4 6 7 11 12 13	*Polystichum proliferum*	mother shieldfern	
1 2 8 12	*Rumohra adiantiformis*	leathery shieldfern	
	ASPLENIACEAE		
1	*Asplenium flaccidum subsp. flaccidum*	weeping spleenwort	
	BLECHNACEAE		
1	*Blechnum fluviatile*	ray waterfern	
1 7	*Blechnum nudum*	fishbone waterfern	
1 8 9 10 12	*Blechnum wattsii*	hard waterfern	
	DENNSTAEDTIACEAE		
1 3 5 6 7 11 12 13	*Histiopteris incisa*	batswing fern	
1 2 3	*Hypolepis rugosula*	ruddy groundfern	
1 5 10 11 12	*Pteridium esculentum subsp. esculentum*	bracken	
	DICKSONIACEAE		
1 6 13	*Dicksonia antarctica*	soft treefern	
	GLEICHENIACEAE		
9 10 12	*Gleichenia dicarpa*	pouched coralfern	
1	*Sticherus tener*	silky fanfern	

	GRAMMITIDACEAE	
1 2 8 10 12	*Notogrammitis billardierei*	common fingerfern
1	*Notogrammitis heterophylla*	gypsy fern
	HYMENOPHYLLACEAE	
1 2 12	*Hymenophyllum cupressiforme*	common filmyfern
1	*Hymenophyllum flabellatum*	shiny filmyfern
1 2 8 10 12	*Hymenophyllum rarum*	narrow filmyfern
1	*Polyphlebium venosum*	bristle filmyfern
	LYCOPODIACEAE	
1	*Phlegmarius varius*	long clubmoss
	POLYPODIACEAE	
1 2 5 7 11 12 13	*Microsorum pustulatum subsp.*	kangaroo fern
	PTERIDACEAE	
3	*Pteris comans*	netted brake
	TMESIPTERIDACEAE	
1	*Tmesipteris obliqua*	common forkfern

Hydraulic Model and Levee Design

Appendix E

pitt&sherry

Grange Resources (Tasmania) P/L

Savage River Flood Levee

Savage River Hydraulic Model

August 2020

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Appendices

1. Introduction

1.1 Background

Grange Tasmania Pty Ltd (Grange) have engaged GHD Pty Ltd (GHD) to develop a concept design for a new flood levee structure to protect the proposed centre pit cutback during fllod events.

The scope of this report is to provide an update of the previous 1D hydraulic model considering the modifications that result the introduction of this new structure. Taking into consideration the geometry and the nature of the extreme event to be modelled, a new model using software HEC-RAS 2D, is provided to give more accuracy to the analysis.

The design of the levee will be determined for the level that the model shows as critical from the hydraulic point of view and the stability and constructability constraints from the civil/geotechnical point of view.

1.2 Purpose of this report

The purpose is to update the one-dimensional hydraulic model of the south bank of the Savage river (adjacent to the levee) and develop a two-dimensional hydraulic model using HEC-RAS 2D.

One-dimensional hydraulic model

The existing one-dimensional hydraulic model will be updated to include the future protective levee located on the south bank of the Savage River. The former will be done using the "Lateral Structure" module on the geometric schematic on HEC-RAS to obtain the new flood depths, velocities and area.

Two-dimensional hydraulic model

A two-dimensional hydraulic model will be developed with the objective to characterize and estimate the main flow parameters such as flow depth and velocity. For this purpose, two flood event periods (1:100 and 1:1000) will be modelled to simulate the flooding of the river along the study area. This model will be developed using the 2D module of HEC-RAS.

1.3 Scope and limitations

This report: has been prepared by GHD for Grange Resources (Tasmania) P/L and may only be used and relied on by Grange Resources (Tasmania) P/L for the purpose agreed between GHD and the Grange Resources (Tasmania) P/L as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Grange Resources (Tasmania) P/L arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report section 1.4. GHD disclaims liability arising from any of the assumptions being incorrect.

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1.4 Assumptions

- The design floods were extracted from the Savage River Mine Flood Study – July 2018, developed by GHD and approved by Grange.
- As a base for the 2D model, a Digital Elevation Model (DEM) is available, received via email on Agust 1st 2019 (File eom1802.zip), that contains Surpac survey file with existing and projected mine surfaces.
- GHD is assuming that no other modifications in the surface available from the SURPAC survey or any changes in the river crossing structures are projected. I.e. raising the crossing level.

2. Calculation Basis

As indicated in the scope, the aim is to provide a hydraulic model in the interest area to simulate the hydraulic behaviour of the river under design flood conditions. GHD have used HEC-RAS software to do this. HEC-RAS is widely accepted within the industry.

HEC-RAS is a software package that models the hydraulics of water flow through natural rivers and other channels. It is designed to perform one-dimensional (1D) and two-dimensional (2D) hydraulic calculations for a full network of natural or constructed channels, overbank, floodplain areas, etc. The software allows simulating flow in natural or artificial channels to calculate the water level for performing flood studies and determine the areas that are likely to flood.

In this case, it is being used separately for 1D and 2D modelling. The 1D has been used prior and 2D modelling is being introduced to check the 1D outputs, obtain additional information such as velocities profiles and a graphic interface that allow a better understanding of the hydraulic behaviour of the river.

2.1 HEC-RAS 1D

The HEC RAS 1D model operates with both supercritical and subcritical flow, and considers the effects of obstructions such as bridges or other elements within the flood zone. The numerical algorithm is based on solving the Energy and Momentum Equation, in its one-dimensional form; with energy losses due to friction calculated by the Manning equation and singularities originated by section variations.

Gradually varied runoff is calculated with the energy balance equation between two consecutive cross-sections (1 and 2), that is:

$$B_1 = B_2 + \Delta h$$

Where:

- B_1 : Energy level in upstream section.
- B_2 : Energy level in downstream section.
- Δh : Frictional and singular head losses due to section changes.

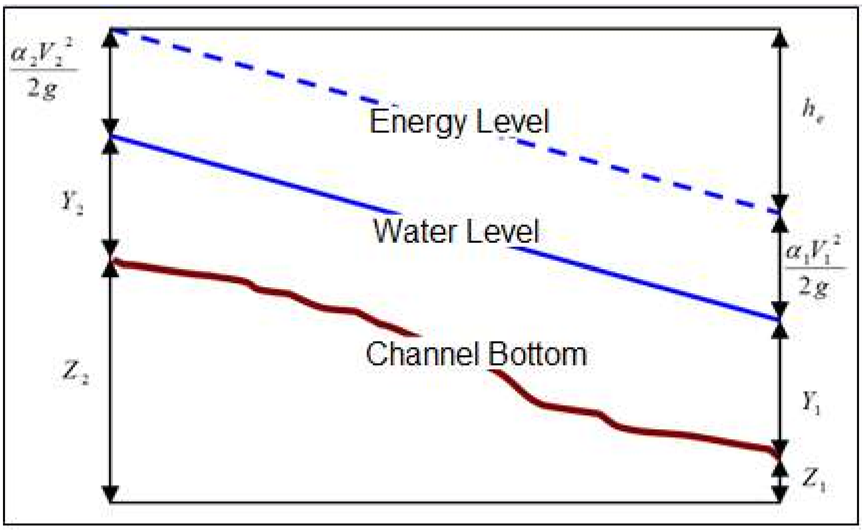

Figure 2-1 Energy Equation

In case the flow is rapidly varied or there are singularities where the current lines are not parallel (bridges, culverts, etc.), the momentum equation is applied instead of the energy equation.

The momentum equation is derived from Newton's second law of motion. The change of momentum per time unit applied to a body of water contained between two cross sections is shown in Figure 2-2.

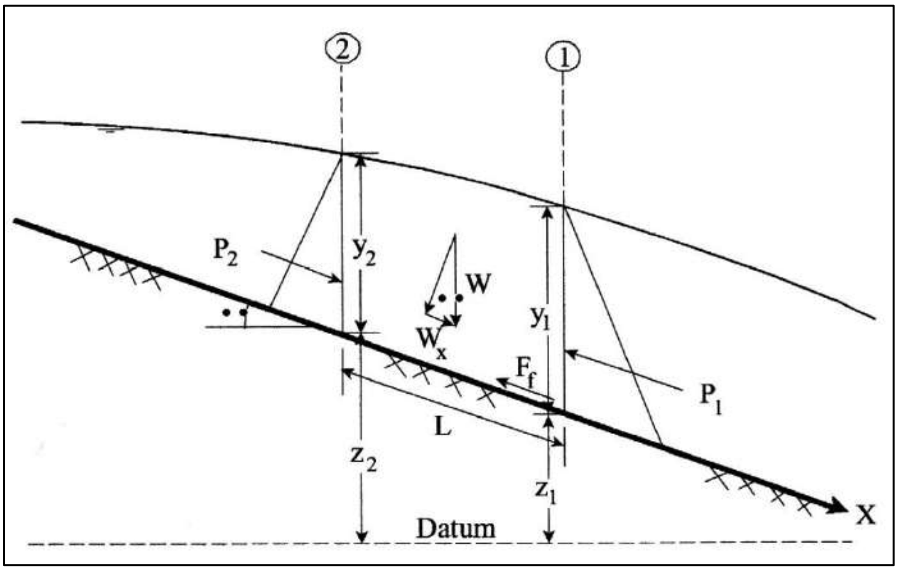

Figure 2-2 Momentum Principle

$$P_2 - P_1 + W_X - F_f = Q \cdot \rho \cdot \Delta V_X$$

Where:

- P_i : Hydrostatic pressure on section i.
- W_X : Force of the weight of water in the x axis.
- F_f : External friction force between 2 and 1.
- Q : Flow.
- ρ : Water density.
- ΔV_X : Change of velocity in the x axis between 2 and 1.

2.2 HEC-RAS 2D

This module of the software, introduced in version 5.0, is capable of solving the full Saint-Venant equations in 2D and the simplified diffusive wave equations. The continuity and momentum equations are derived from a balance of mass and a balance of forces respectively, and they are as follows:

$$\frac{\partial \xi}{\partial t} + \frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} = 0$$

$$\frac{\partial q_x}{\partial t}+\frac{\partial}{\partial x}\left(\frac{q_x{}^2}{h}\right)+\frac{\partial}{\partial y}\left(\frac{q_x q_y}{h}\right)+\frac{n^2 q_x g\sqrt{q_x^2+q_y^2}}{h^2}+gh\frac{\partial\xi}{\partial x}=q_x f+\frac{\partial}{\rho\partial x}(h\tau_{xx})+\frac{\partial}{\rho\partial y}(h\tau_{xy})$$

$$\frac{\partial q_y}{\partial t}+\frac{\partial}{\partial y}\left(\frac{q_y{}^2}{h}\right)+\frac{\partial}{\partial x}\left(\frac{q_x q_y}{h}\right)+\frac{n^2 q_y g\sqrt{q_x^2+q_y^2}}{h^2}+gh\frac{\partial\xi}{\partial y}=q_y f+\frac{\partial}{\rho\partial y}(h\tau_{yy})+\frac{\partial}{\rho\partial x}(h\tau_{xy})$$

Where:

q_x : flowrate per unit width in x axis (m^2/s).

q_y : flowrate per unit width in y axis (m^2/s).

h : Water level (m).

ξ : Minimum channel level (m).

ρ : Density (kg/m^3).

g : Gravity (m/s^2).

n : Manning friction coefficient.

f : Coriolis coefficient (1/s).

τ : Components of effective shear stress.

Previous studies have determined that solving the simplified diffusive wave equation takes approximately 20 times less time than solving the full Saint Venant equation, giving similar results.

As a consequence of the above, the present study considers the solution of the simplified diffusive wave equation, which considers that inertial terms (local acceleration and convective acceleration) are negligible compared to the terms pressure, gravitational force and frictional force.

The resolution domain is defined by a closed polygon divided into cells contained inside of it. These cells are made up of polygons from 3 to 8 sides, which compose a grid that may or may not be regular (equal cells).

The equations are solved through the use of an implicit finite volume scheme, which allows a more general resolution in the case of unstructured meshes as is the case of this study.

3. Model Set-Up

3.1 Design Floods

The design floods were extracted from the Savage River Mine Flood Study – July 2018, developed by GHD. These are as follows:

- AEP 0.1% (1:1000 years): peak flow of 440 m^3/s.
- AEP 1% (1:100 years): peak flow of 202 m^3/s.

3.2 Topography

As a base for the 2D model, a Digital Elevation Model (DEM) is available, received via email on August 1st 2019 (File eom1802.zip), that contains Surpac survey file with existing mine surfaces. It is shown in Figure 3-1.

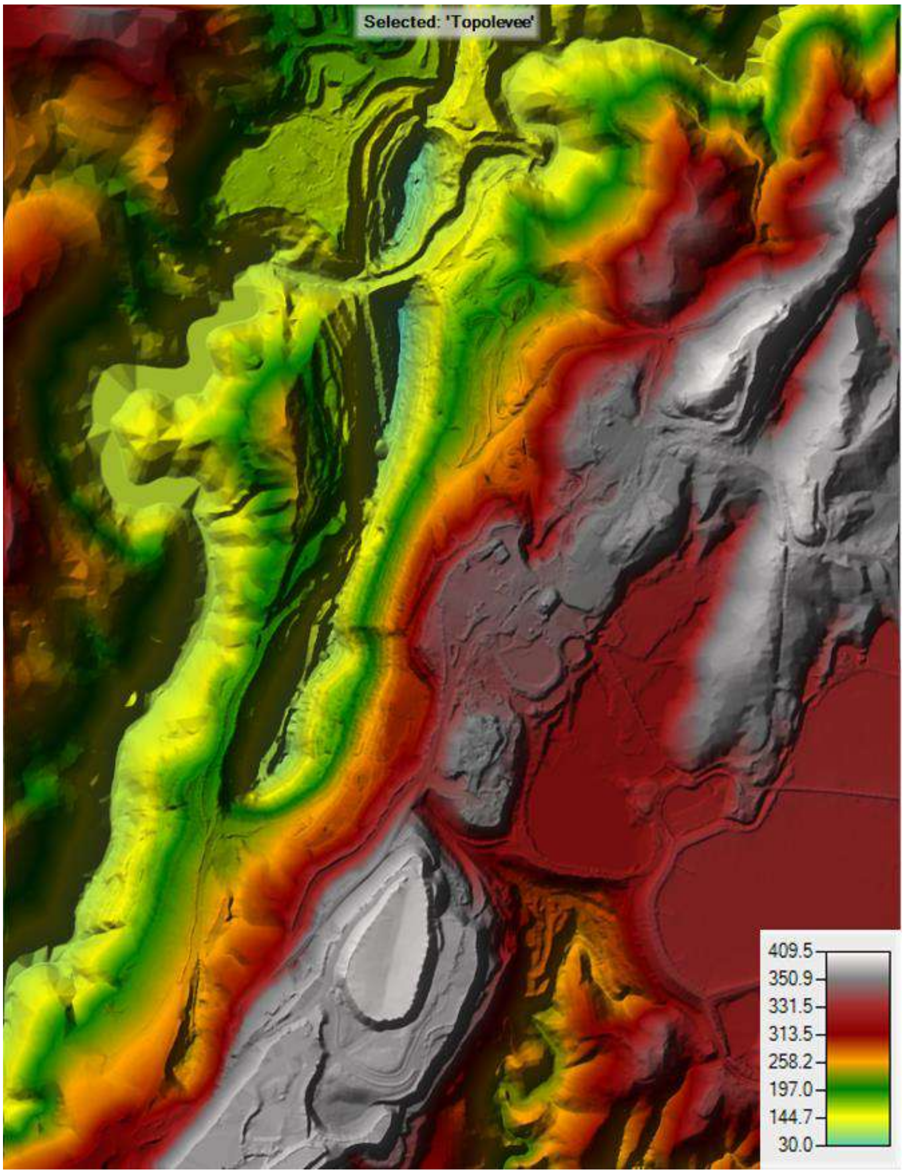

Figure 3-1 SURPAC Topography

3.3 Culverts

There are two crossings in this area of the river, called Eastern and Western Crossing. Each of them consist of:

- Eastern Crossing: a circular and a square culvert, of 4.5 m in diameter and 2.4 x 2.4 m, respectively, as shown in the following figure:

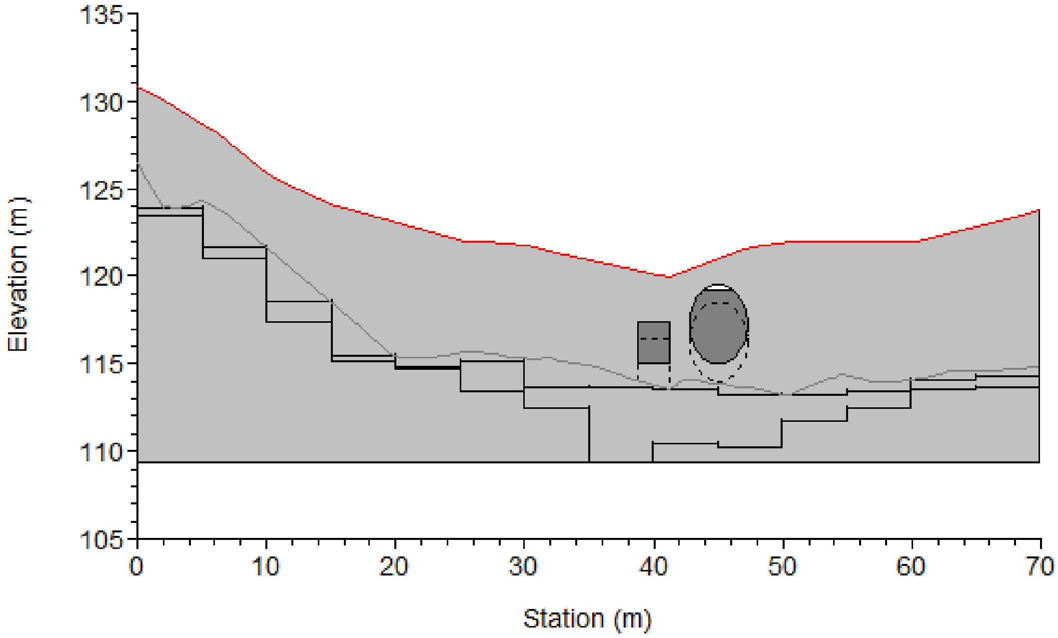

Figure 3-2 Eastern Crossing

- Western Crossing: three rectangular culverts of 3.6 x 3.6 m, as shown in the following figure:

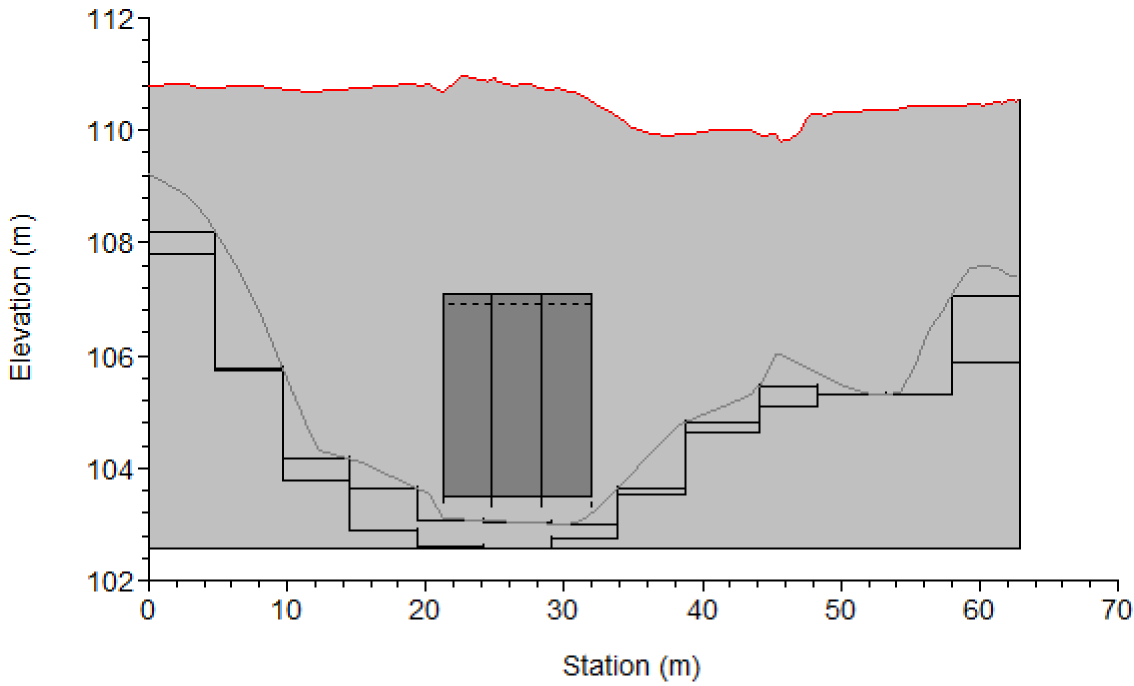

Figure 3-3 Western Crossing

In every case, they will be considered as 100% blocked, as experience has shown this can occur during flood events and is a conservative assumption.

3.4 Grid Size

The model is constructed with a base grid of 20 x 20 m squares with a 10 x 10 refinement along the river and its banks.

In the cases in which there is a levee (or multiple levees) near the Western Crossing area, there is an additional refinement of 2 x 2 m.

3.5 Boundary Conditions

The upstream boundary condition (BC) is the flow hydrograph with a slope of 1.6% to distribute the flow along the BC. On the other hand, the downstream BC is normal depth with a slope of 1.6%.

3.6 Roughness Coefficient

The selected roughness coefficient for this model is Manning's n, taken from the Savage River Mine Flood Study – July 2018, developed by GHD. The value for Manning's n is 0.035. A sensitivity analysis was performed to determine the effect of this parameter and it concluded that it was not significant for this model.

4. Results

As mentioned before, a levee along the southern riverbank has been proposed to eliminate the risk of flow towards centre pit, which has been included in the model.

4.1 1D Model

A 1D model was previously developed, which results are summarized in this chapter. On Figure 4-1 and Table 4-1, the cross sections of the model and its water surface (WS) elevation and velocity are shown for a 0.1% AEP event.

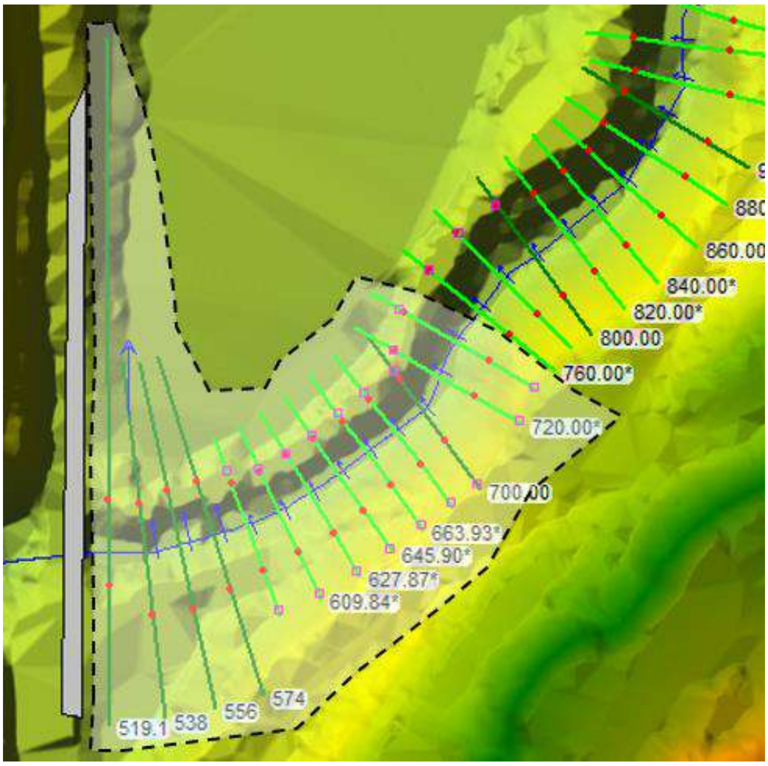

Figure 4-1 1D Model

Table 4-1 1D Model Results

Cross Section N°	W.S. Elevation (m.a.s.l.)	Average Velocity (m/s)
740	112.49	2.09

Cross Section N°	W.S. Elevation (m.a.s.l.)	Average Velocity (m/s)
720	112.45	2.16
700	112.42	2.09
681.97	112.42	2.02
663.93	112.42	1.72
645.90	112.46	1.65
627.87	112.46	1.60
609.84	112.46	1.54
591.80	112.45	0.90
574	112.51	0.88
556	112.51	1.01
538	112.50	1.01
519.1	**112.50**	**2.09**

In bold, the cross section with the highest velocity along the levee is shown which is 2.09 m/s immediately upstream of the Western Crossing. The cross section is shown in Figure 4-2.

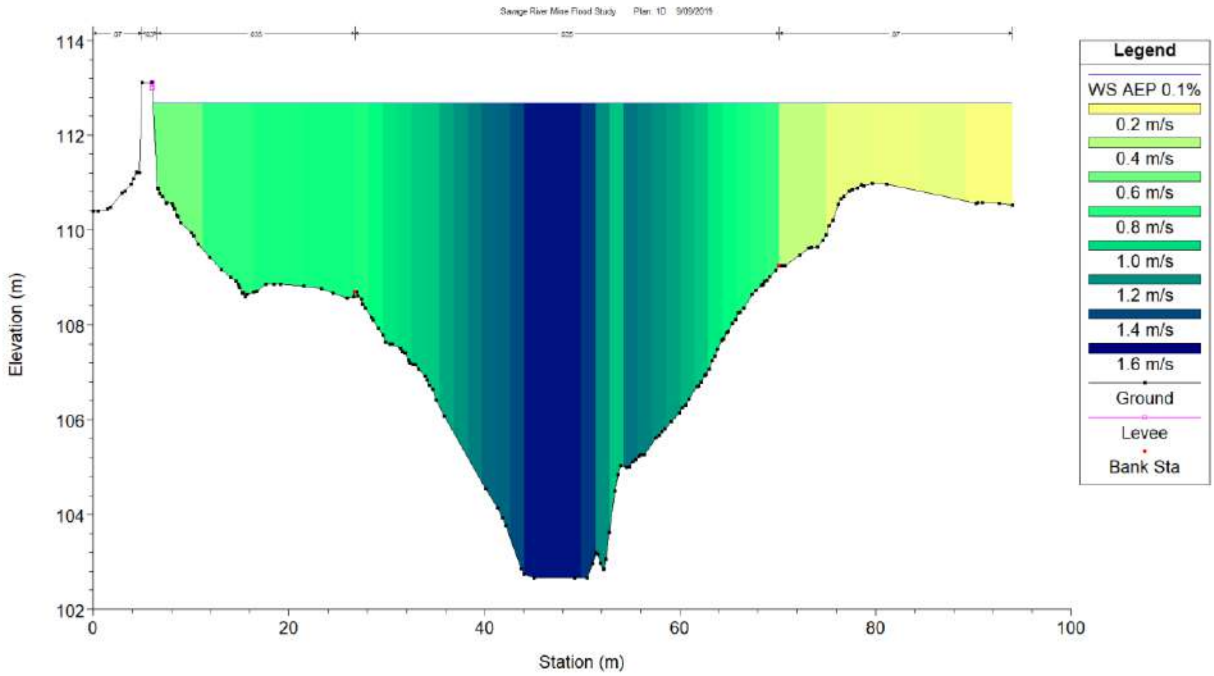

Figure 4-2 Cross Section 519.67

4.2 2D Model

For a better understanding of the cases that were modelled and studied, they have been named and numbered as indicated in the table below:

Table 4-2 List of Cases Studied

Case Number	Case Name
1	No Levee – South Lens Pit empty
2	No Levee – South Lens Pit Full
3	Southern Levee - South Lens Pit empty
4	Southern Levee and Northern Levee

4.2.1 Case 1: No Levee – South Lens Pit empty

The results of the 2D model without levees are shown in Figure 4-3. It can be seen that there is an overtopping of the main channel and as a result, flow into South Lens and Centre Pit.

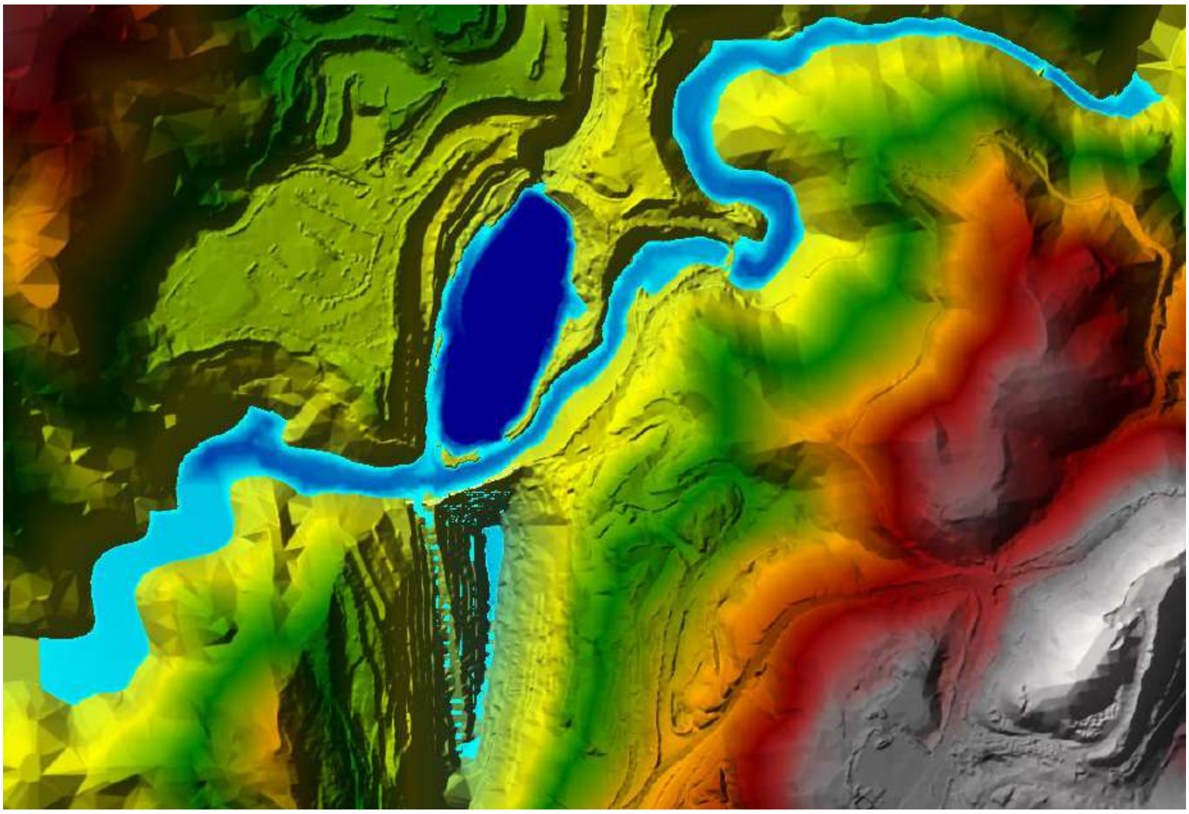

Figure 4-3 Case 1 – AEP 0.1% Flood Area

In Figure 4-4 and Figure 4-5, the flow along into South Lens and Centre Pit is shown. These results indicate that the magnitude of the flow into South Lens is around 1,500,000 m^3 during the flood.

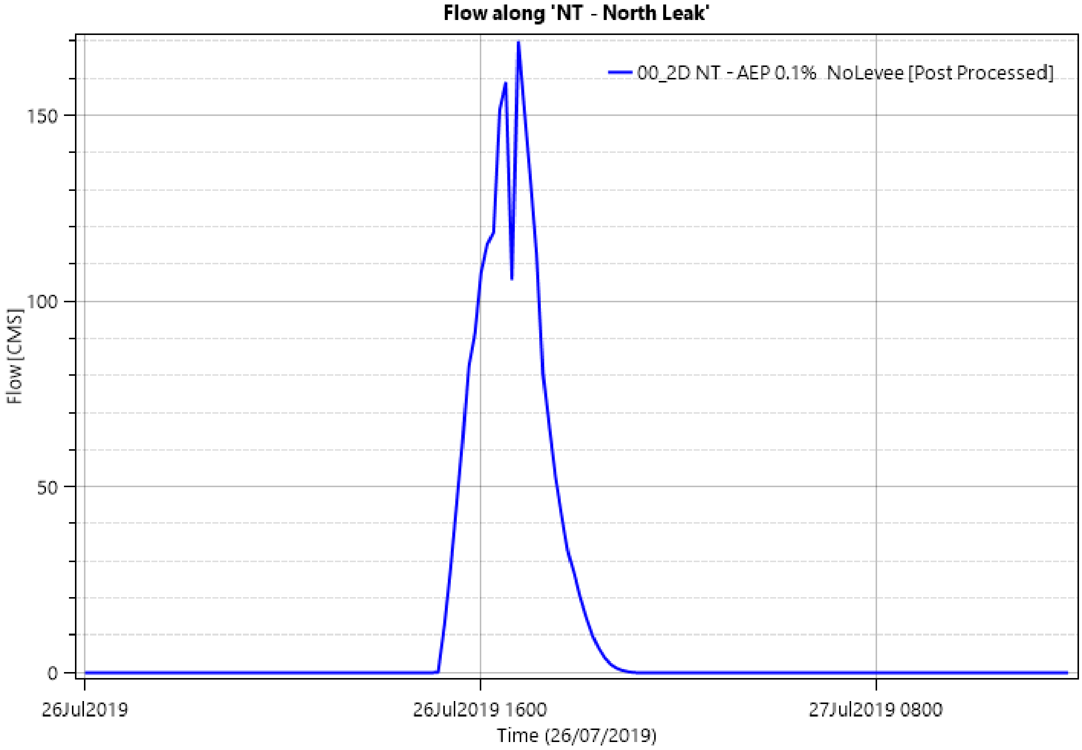

Figure 4-4 Case 1- Flow into South Lens - AEP 0.1%

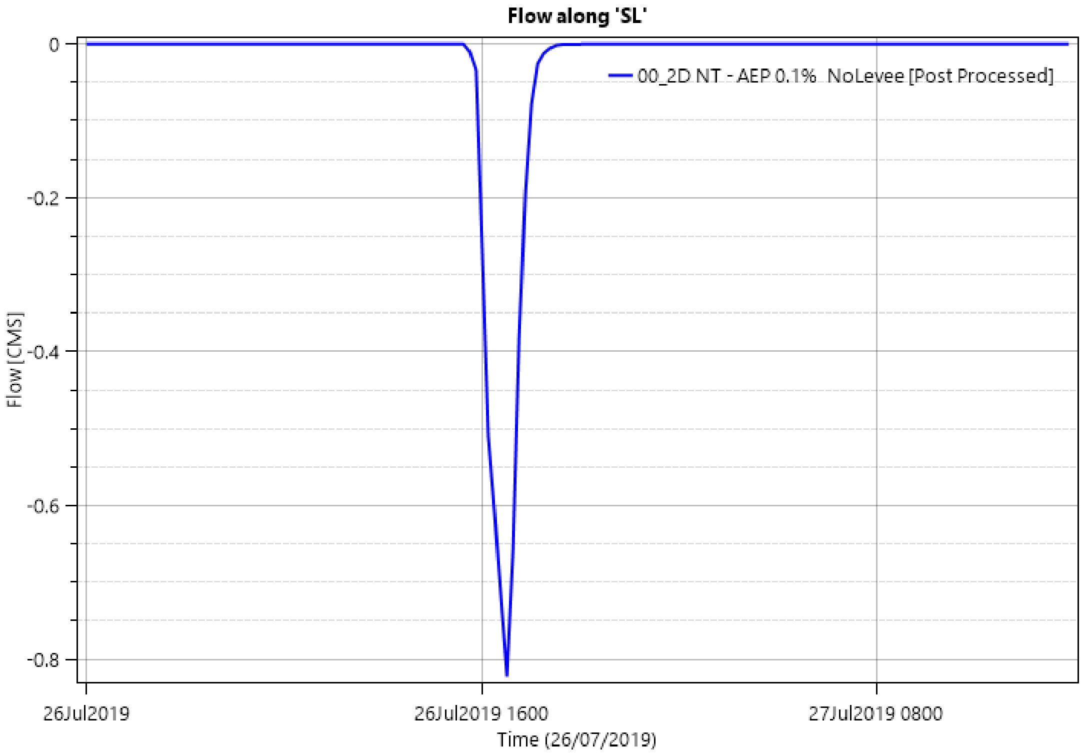

Figure 4-5 Case 1- Flow into Centre Pit - AEP 0.1%

4.2.2 Case 2: No Levee – South Lens Pit Full

in **Error! Reference source not found.**, a case in which there is no levee on the southern riverbank and overflood is prevented from going into the South Lens is modelled. This shows that a significant volume of water would flow into the Centre Pit.

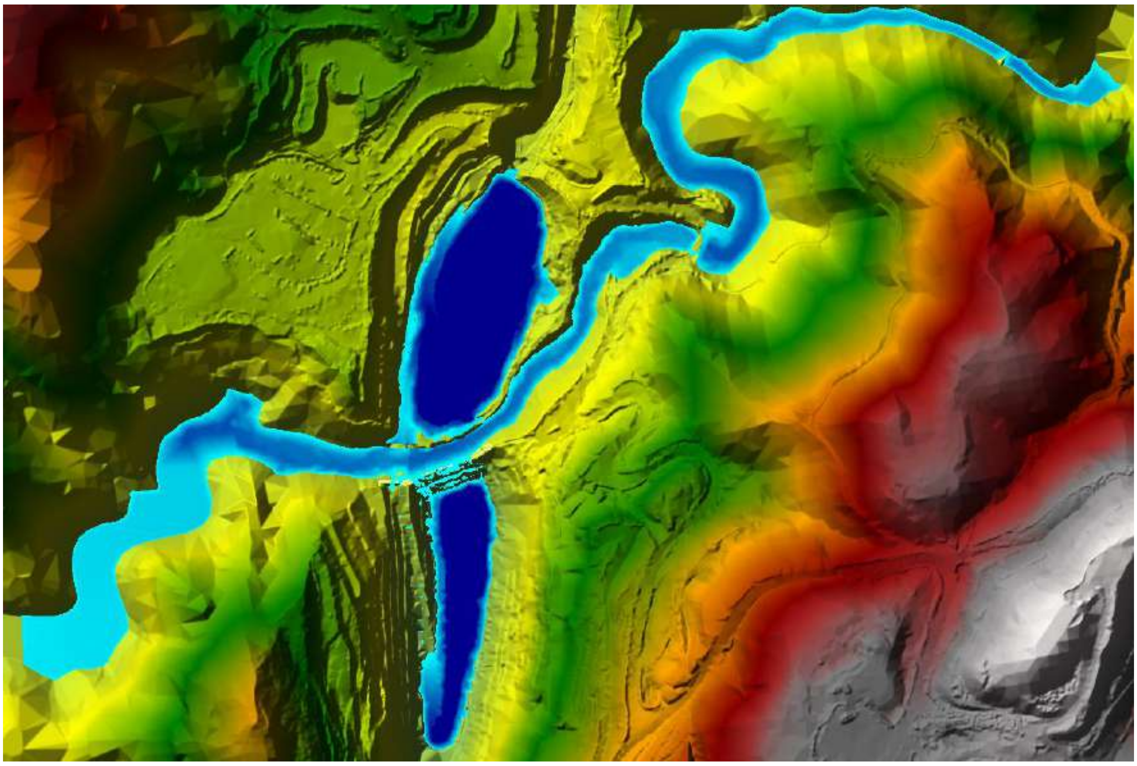

Figure 4-6 Case 2 – AEP 0.1% Flood Area

In **Error! Reference source not found.**, the volume accumulation that flows into the Centre Pit is shown, adding up to approximately 800.000 m³.

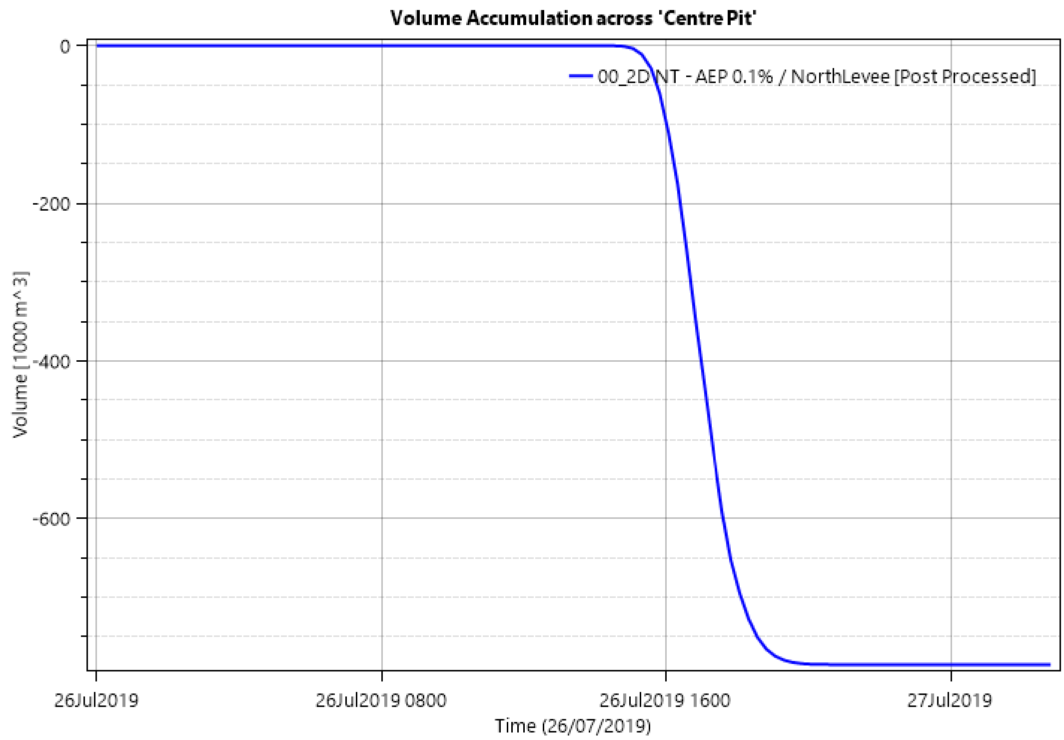

Figure 4-7 Case 2 - Total Volume Accumulation towards Centre Pit

4.2.3 Case 3: Southern Levee - South Lens Pit empty

This case considers an extended levee on the southern riverbank to prevent overflood into the Centre Pit. The flood area is show in Figure 4-8.

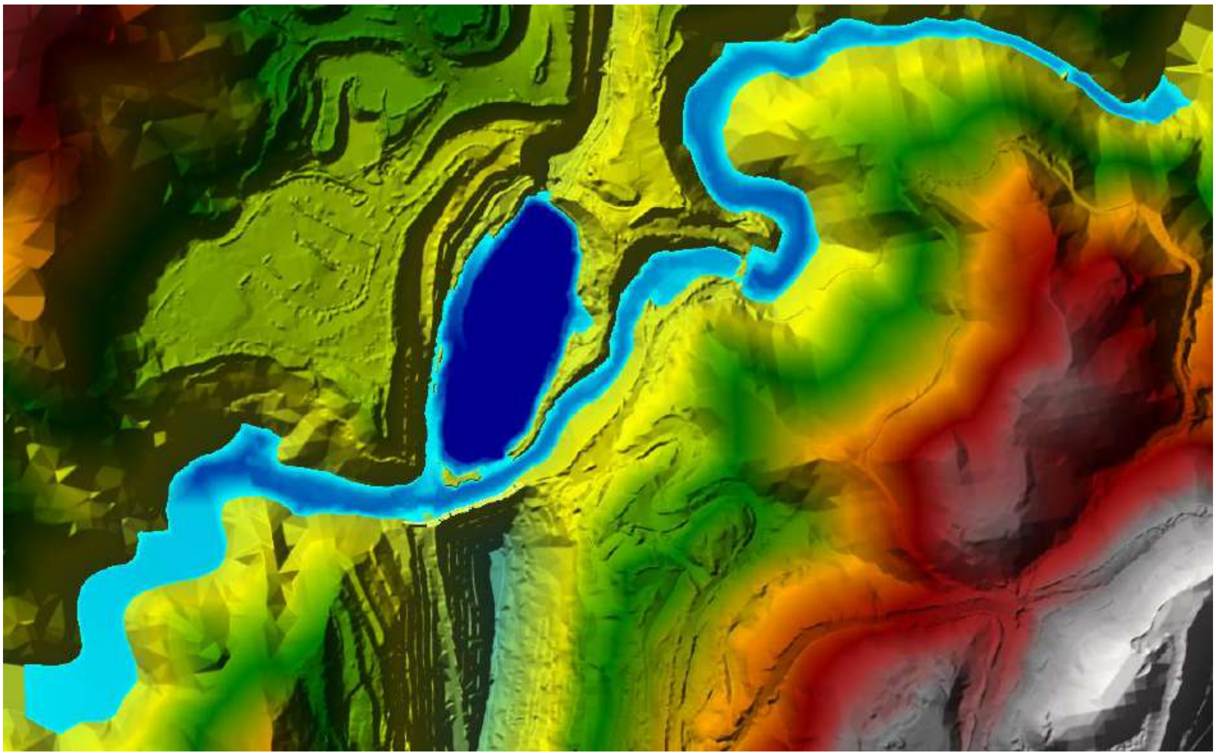

Figure 4-8 Case 3 - AEP 0.1% Flood Area

The velocity along the southern levee is shown in Figure 4-9 and Figure 4-10.

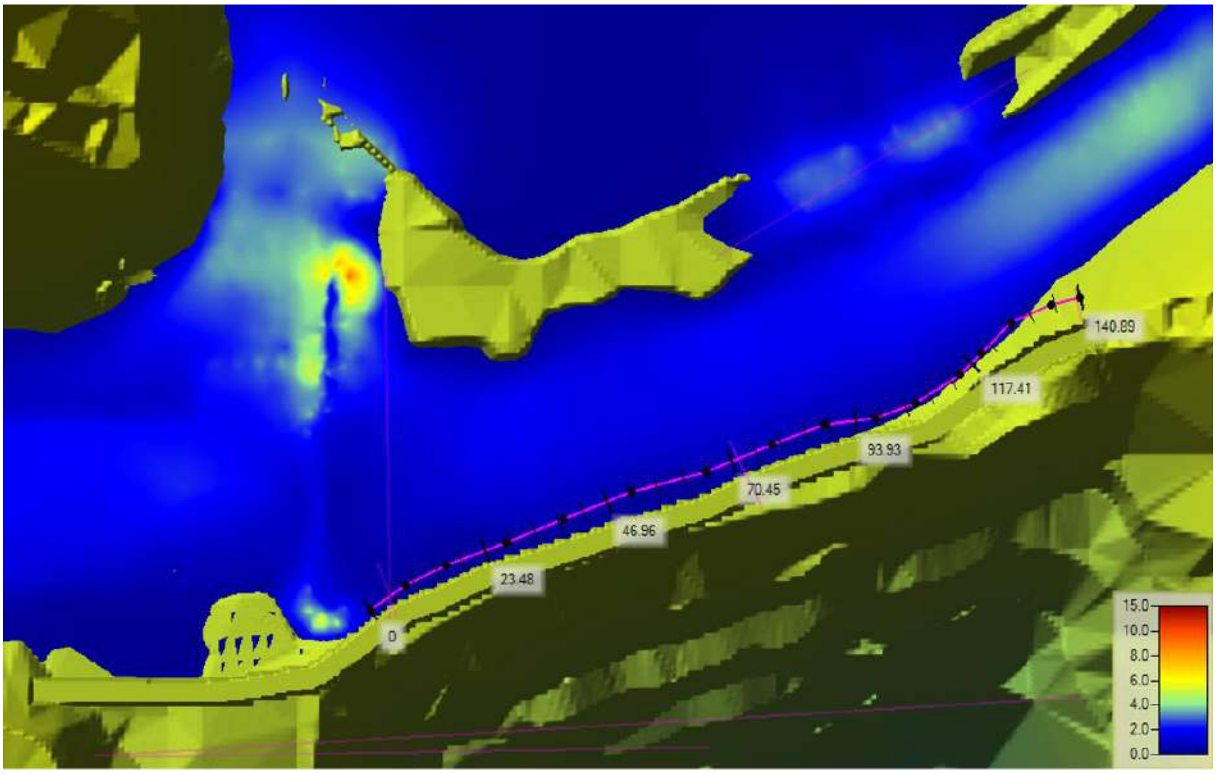

Figure 4-9 Case 3 - Velocity (m/s) along southern levee

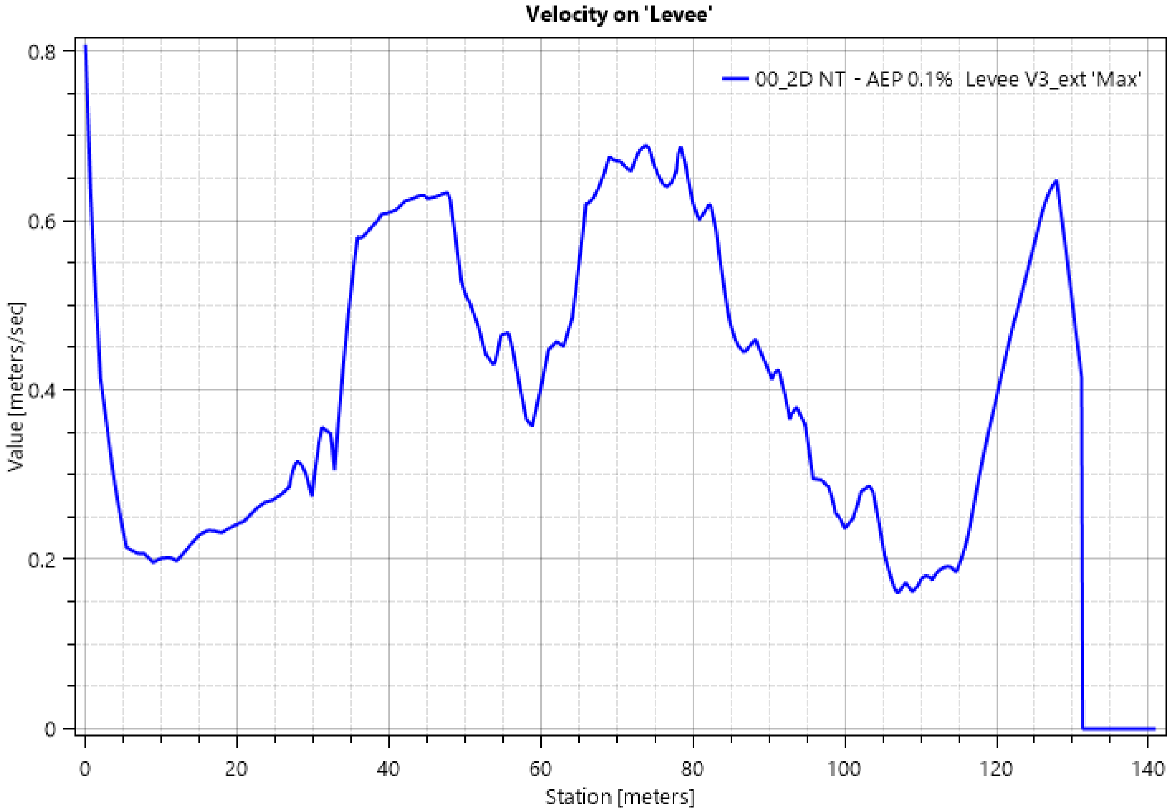

Figure 4-10 Case 3 - Velocity (m/s) profile along the levee

4.2.4 Case 4: Levee South and North Riverbank

The other case that was modelled included an additional levee on the north riverbank. The flood area is show in Figure 4-11. This case is equivalent to have no capacity to overflood to the south lens pit.

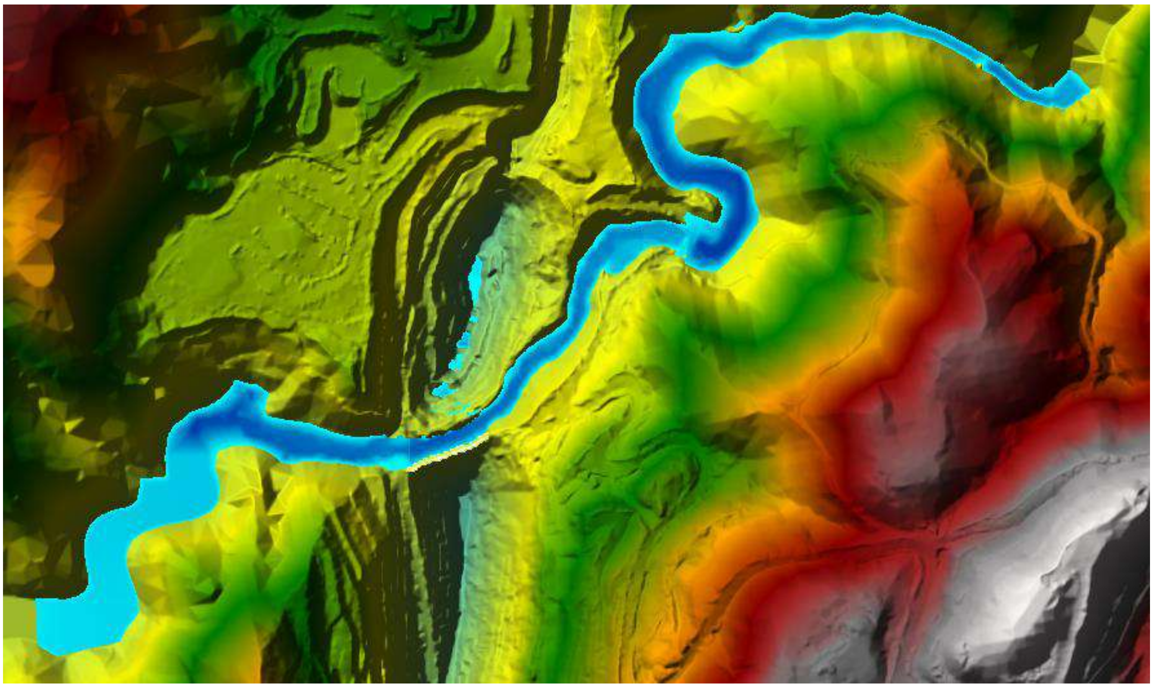

Figure 4-11 Case 4 – AEP 0.1% Flood Area

Considering that the flow into South Lens showed in Case 2 has a peak flow of around 100 m³/s, it is expected that when preventing it, the water level will have a considerable increase and so will the velocity of the flow. This is shown in Figure 4-13, where it can be seen that the speed increased around 0.2 m/s on average.

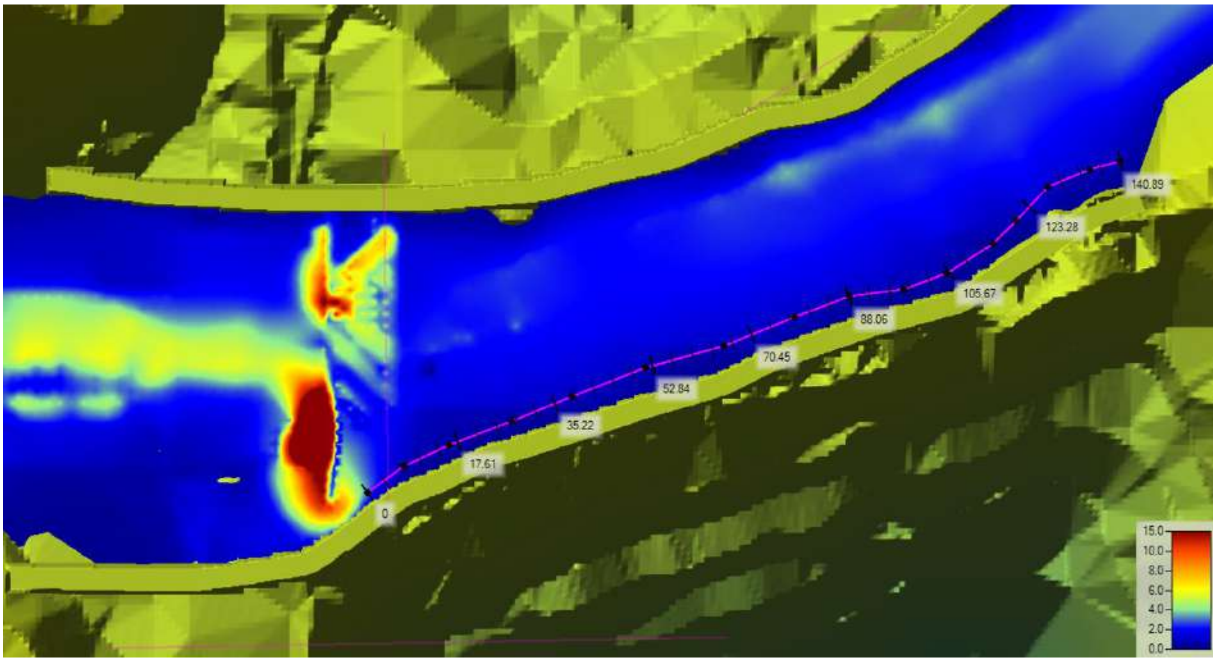

Figure 4-12 Case 4 - Velocity (m/s) along the levee

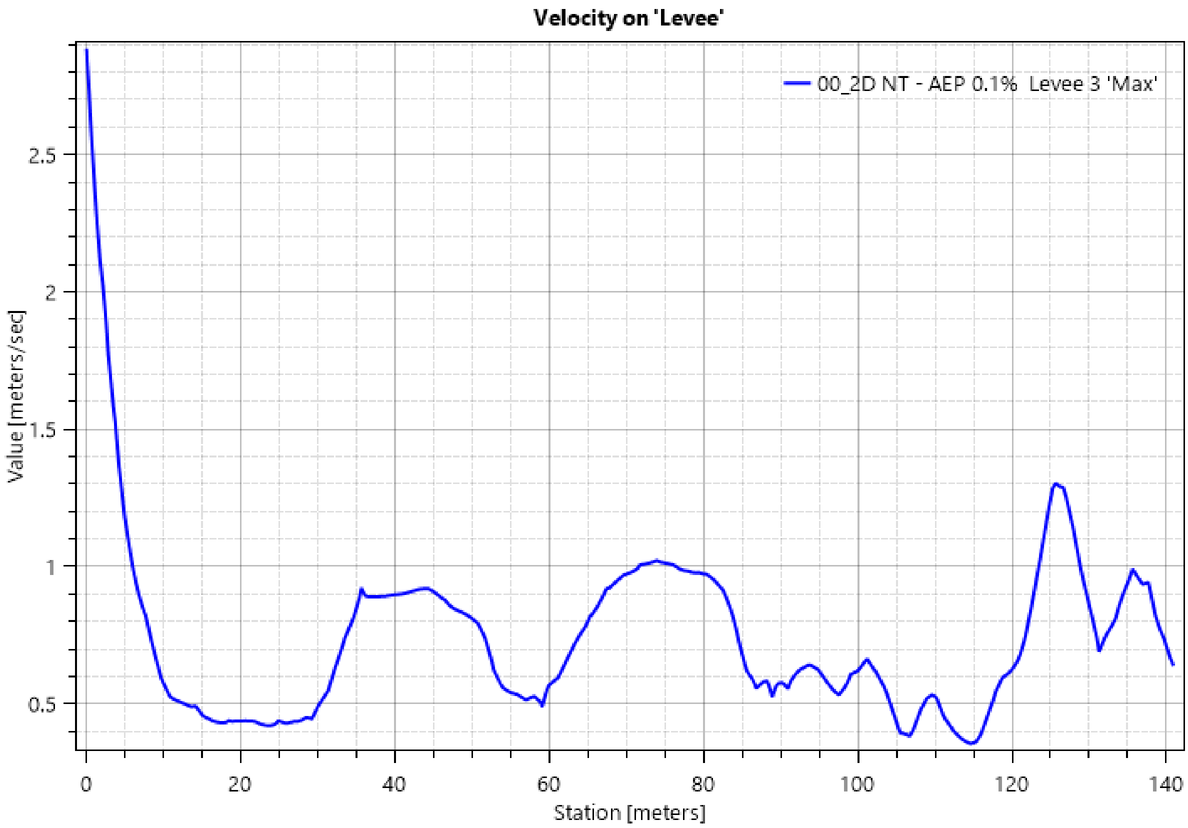

Figure 4-13 Case 4 - Velocity (m/s) profile along the levee

4.2.5

4.3 Comparison of Results

A summary of 1D and 2D results is shown on Table 4-3 and Table 4-4, respectively. The water level shown is directly upstream of the Western Crossing.

The 1D Case is showed as a reference and is not directly comparable to the 2D cases since it is a different methodology.

Table 4-3 1D Results - Water level and velocity upstream of Western Crossing

Case	Water level (m.a.s.l.)	Velocity nearby southern levee (m/s)
1D	112.50	2.09

In the case of the 2D results, the velocity shown is the one in the vicinity the riverbank, in increments of 0.5 m towards the center of the river. As shown in Figure 4-14, this was done in three sections of the levee to represent the average velocity along its profile: start, middle and ending, starting upstream.

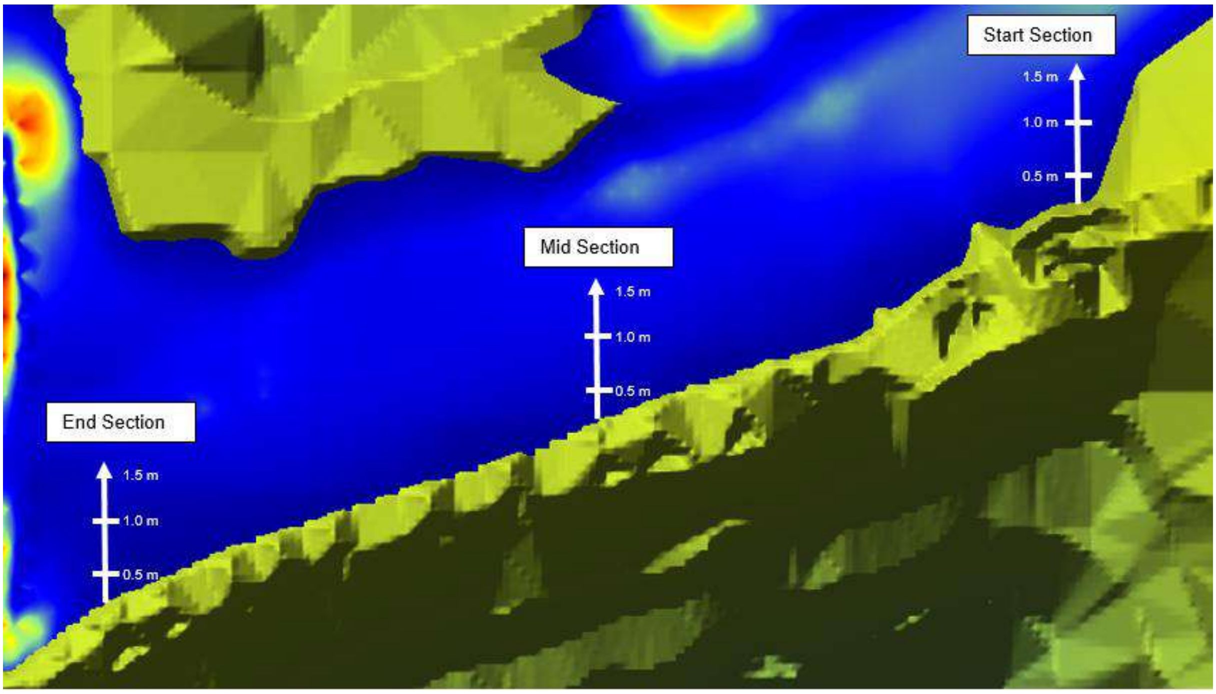

Figure 4-14 2D Results - Velocity along levee (m/s)

Table 4-4 2D Results - Water level and velocity upstream of Western Crossing

Case	Water level (m.a.s.l.)	Velocity nearby southern levee (m/s)								
		Start			Mid-Section			Ending		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
2D / 1	111.7	No Levee								
2D / 2	111.7	No Levee								
2D / 3	111.8	0.01	0.01	0.01	0.32	0.40	0.47	0.21	0.23	0.23
2D / 4	112.9	0.08	0.13	0.20	0.32	0.52	0.65	0.78	1.01	1.22

As expected, when preventing flow into South Lens in Case 4, both water level and velocity along the levee increase because a considerable volume of water is added to the main channel.

When comparing 1D and 2D with levee model results, the water level is approximately 0.9 m higher in the 1D model than the 2D model. This shows the 1D model as more conservative output. However, the 2D model give us more information and is capable to describe better the hydraulic behaviour in singularities such as contractions, abrupt changes, obstacles, etc.

5. Conclusions

The model shows an estimation that the volume of inflow to Centre pit needs to be managed with a levee. This is assuming that South Lens is full of water previous to the event.

The design of the levee will be completed in an additional report once discussed this result with Grange.

GHD is also available to conduct a Risk Assessment to assess the options for Grange, assess current risks, available mitigation methods. The risk assessment will guide future works for this project and design of a flood levee if the risk assessment process deems it necessary.

GHD

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12509616-83002-21/https://projectsportal.ghd.com/sites/pp16_04/savageriverfloodleve/ProjectDocs/12509616-REP-0-SavageRiverHydraulicModel.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	C.Delgado	M.Ruz		R.Longey		1/6/20

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Grange Resources (Tasmania) P/L

Savage River Flood Levee
Concept Design Report

August 2020

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1. Introduction

1.1 Introduction

Grange Tasmania Pty Ltd (Grange) have engaged GHD Pty Ltd (GHD) to develop a concept design for a new flood levee structure to protect the proposed centre pit cutback during flood events.

The Savage River runs through Grange's Savage River Mine Site. Centre Pit is located south of the Savage River and North Pit located to the north. During large rainfall events the flow in the Savage River can increase significantly due to the large catchment area upstream of the mine.

Currently, Grange are planning to commence a larger cutback in Centre Pit to access the deeper ore body. The pit design is limited by the location of the Savage River to the north. Due to the proximity to the river, overtopping of the pit and flooding is a high risk to Grange.

It is proposed to construct a flood levee between the Savage River and Centre Pit to reduce the likelihood of flooding Centre Pit. Hydraulic modelling will provide data to determine the crest level of the flood levee.

The concept design for the levee is presented in this report and recommendations for future work is provided.

1.2 Purpose of this report

The scope of this report is to summarise the hydraulic modelling and detail the concept design for the proposed levee. A bill of quantities and cost estimate has also been prepared to support future planning and budgeting.

1.3 Scope and limitations

This report: has been prepared by GHD for Grange Resources (Tasmania) P/L and may only be used and relied on by Grange Resources (Tasmania) P/L for the purpose agreed between GHD and the Grange Resources (Tasmania) P/L as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Grange Resources (Tasmania) P/L arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Grange Resources (Tasmania) P/L and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared the preliminary cost estimate/prices set out in section 4 of this report using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.

The Cost Estimate has been prepared for the purpose of comparison of options and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the project can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

1.4 Assumptions

The design floods for the hydraulic modelling were extracted from the Savage River Mine Flood Study – July 2018, developed by GHD and approved by Grange.

The design levels used herein were extracted from Savage River Hydraulic Model 12509616-REP-A_SavageRiveHydraulicModel developed by GHD and approved by Grange.

The updated survey was provided by Grange email receive 30/04/2020, file “CP Survey and Design.zip”.

2. Hydrology and Hydraulics

2.1 Hydrology

GHD undertook a flood study in 2018 (GHD, 2018) for the Savage River mine to inform the location of the underground portal. This report reviewed the hydrology for the Savage River site and determined the flood flow rates at each of the river crossings. These flow rates were used as a basis for the detailed 3D hydraulic modelling of the Savage River. The adopted flow rates:

- AEP 0.1% (1:1,000 years): Peak flow rate of 440 m^3/s
- AEP 1% (1:100 years): Peak flow rate 202 m^3/s

2.2 Hydraulic Modelling

The flood study undertaken in 2018 focussed on a different area of the river upstream of Centre Pit. The hydraulic modelling undertaken for the proposed levee focussed on the area between the eastern and western river crossings. The 1% and 0.1% AEP flood events were modelled.

Hydraulic modelling was undertaken in the HEC-RAS software package in both 2D and 3D scenarios. The design flows shown in section 2.1 were adopted for the modelling. Topography was based on a digital elevation model (DEM) provided by Grange on August 1st 2019. A number of cases were run for the 3D models to assess the requirement for a levee and the water levels in the river with levee in place.

The critical results for the 2D analysis are shown in Table 1 for the AEP 0.1% event. The critical results for the 3D modelling with a levee in place on both riverbanks is shown in Table 2 for the AEP 0.1% event.

Table 1 1D Modelling Results

Parameter	Value
Water Level (elevation)	RL 112.50 m
Average Velocity	2.09 m/s

Table 2 2D Modelling Results

Parameter	Value
Water Level (elevation)	RL 112.9 m
Velocity – 0.5m from Levee	0.78 m/s
Velocity – 1.0m from Levee	1.01 m/s
Velocity – 1.5m from Levee	1.22 m/s

The results and comparison between the 1% and 0.1% AEP event have been discussed with Grange. It was agreed that the design would be based upon the 0.1% AEP event.

3. Concept Design

Three concept options have been developed for the proposed Savage River Levee. The options have been developed based on the available area for construction.

Figure 1 shows a reference location of the levee.

Figure 1 Site Location

3.1 Basis of Design

The following main basis of design have been taken into account for the conceptual design.

- Design flood = 0.1% AEP event
- Maximum flood level = RL 112.9 m
- Average current surface level = RL111.7 m
- Available width at remaining bench adjacent to Savage River: Approx. 5m.
- The existing haul road will have a high point of RL113.0m prior to dropping into Centre Pit.

3.2 Options Assessment

Three options considered are listed below:

- Option A – RCC Levee
- Option B – RCC and Gabion Levee
- Option C – Precast Concrete Levee

3.2.1 A description of each option is presented in the following sections and in sketches (refer Appendix A). Option A – RCC Levee

Option A comprises a Roller Compacted Concrete (RCC) levee with a crest level of RL113m. A typical section is shown in Appendix A.

The RCC will have batter slopes of 1H:1V and a maximum crest width of 2m. RCC shall be placed in layers approximately 300 mm thick and compacted with conventional earthmoving equipment. RCC will be resistant to erosion. Due to the low head on the levee, minimal seepage into centre pit is expected in comparison the rainfall falling into the pit in such an event. Anchors into the rock may be required depending on geotechnical conditions.

3.2.2 Option B – RCC and Gabion Levee

Option B is a combined Gabion and RCC levee with a crest level of RL113m. The Gabions provide erosion protection and enable a vertical wall to be constructed adjacent to Savage River. RCC provides a relatively low permeability zone to limit seepage into centre pit. Gabions would be placed prior to placing RCC against the gabions. Terramesh would tie the gabions into the RCC structure. Anchors into the rock may be required depending on geotechnical conditions.

3.2.3 Option C – Precast Concrete Levee

Option C uses precast concrete panels to construct a vertical wall between Centre Pit and Savage River. The panels would be constructed off site and transported and installed. It is expected the panels would be in the order of 300 mm thick and 3 m in length. The wall would be anchored into rock at the end of each panel. The precast levee requires less width than Option A and B. Geotechnical investigations will be required to confirm anchorage requirements.

4. Cost Estimation

The following assumptions have been made in preparing the comparative cost estimates:

- Excludes any other site improvement works.
- Cost estimate based on levee works only.
- Includes 50% contingency.

Based on the above assumptions, the preliminary estimates of comparative costs have been developed and are presented in Table 3. Detailed breakdown of the costs are presented in Appendix B.

Table 3 Preliminary Comparative Cost Estimates

Option	Cost (ex GST)	Specific assumptions
Option A – RCC Levee	***$1,000,725***	Volume RCC inc 10% wastage. Unit cost of RCC= $300/m^3, Based on Concrete cost of $405/m^3 including agi-truck, 2x operators, cement, sand and aggregate.
Option B – RCC and Gabion Levee	***$863,300***	Volume RCC inc 10% wastage. Unit cost of RCC= $300/m^3, Based on Concrete cost of $405/m^3 including agi-truck, 2x operators, cement, sand and aggregate. Gabion [2,4m long x 1,0m Wide x 1,0m]= $295/Ea

Option C – Precast Concrete Levee	***$926,862***	Precast Concrete Panels [3m Long, 300mm]= $2,000/$m^3$ Anchors= $5,000/Ea

5. Discussion & Preferred Option

All options presented here are susceptible to pit wall movements. However, Option A and B extend to the pit crest and require confirmation of the geotechnical conditions and detailed survey prior to detailed design.

Grange provided information from a borehole which was drilled from the northern side of the Savage River angled south. The intent of the borehole was to assess the permeability of the insitu rock to assess seepage potential into Centre Pit. The key area of interest for the levee design is the conditions in the 10m below the surface, as this borehole was drilled on the northern side of the river opposed to the south side where the levee is proposed we are not able to obtain this information and additional boreholes will need to be drilled and geotechnically logged prior to or during detailed design. This information could also inform Grange in terms of risk of pit failure in this area. The information shows that there was poor core recovery to 20m depth in the borehole. Low Rock Quality Designation (RQD) was recorded for recovered core. The pore recovery and low RQD indicate that the rock is highly fractured and may contain seams of highly/extremely weathered material (which were not recovered). Given the conditions encountered a drilling company with a high level of experience in geotechnical boreholes should be utilized for this investigation.

The existing crest width between Centre Pit and Savage River should not be reduced.

GHD has also briefly reviewed the proposed design for the Centre Pit by Grange in regards to impacts on the levee design. The current Grange design has a high point on the haul road south of the river crossing. The design level of the levee is 3m higher than the haul road, this would allow flood waters to flow into Centre Pit. To prevent this Grange have agreed to raise the high point to RL113m. As the pit will be in fresh rock there is low risk for erosion of this section in flood events. Additionally the haul road and high point will be out the direct line of flow, resulting in low velocities.

Based on the options available, the preferred concept is Option A Roller Compacted Concrete, which has been confirmed with discussions with Grange. RCC has been used extensively at Savage River previously in the Eastern and Western river crossings and Main Creek Tailings Dam. RCC is proven on site to be suitable material for this type of structure. Construction using RCC can occur using earthmoving equipment which is typically available on site. A mobile batch plant would be required to mobilise to site, however the construction period would be relatively short (~1 month) assuming minimal weather delays, i.e. summer construction period.

6. Safety in Design

A risk assessment for the design, construction and operation of the Centre Pit Levee has been completed by GHD and requires workshopping with key Grange and GHD personnel. The risk register considers risk encountered during the conceptual design phase and the mitigation measures applied to reduce the likelihood of the risk occurring. Future mitigation measures are also listed where applicable to further reduce risks.

A summary of the key risks and mitigation measures are presented in Appendix C.

7. Recommendations

The preferred Option A is an RCC Levee which addresses the main objective of the structure. A forward work plan to develop the option preferred to commissioning comprises;

- Geotechnical investigation and assessment.
- Review and update Risk Assessment.
- Detailed design, costing, technical specification.
- Approvals (internal/external).
- Tender / Construction.

8. References

GHD, 2018 – Savage River Mine Flood Study, July 2018.

GHD, 2019 – Savage River Flood Levee, Savage River Hydraulic Model, September 2019

Appendices

Appendix A - Sketches

SETOUT POINTS

POINT	EASTING	NORTHING
1	6290.246	7712.460
2	6296.945	7717.742
3	6304.045	7721.665
4	6334.651	7732.554
5	6336.199	7733.163
6	6357.769	7742.497
7	6359.159	7743.149
8	6388.109	7757.848
9	6392.493	7759.575
10	6420.542	7767.672
11	6421.991	7768.138
12	6451.381	7778.598
13	6454.128	7779.401
14	6470.980	7783.300

PRELIMINARY

rev	description	app'd	date

GRANGE RESOURCES (TASMANIA) P/L
CENTRE PIT FLOOD LEVEE

GENERAL ARRANGEMENT PLAN

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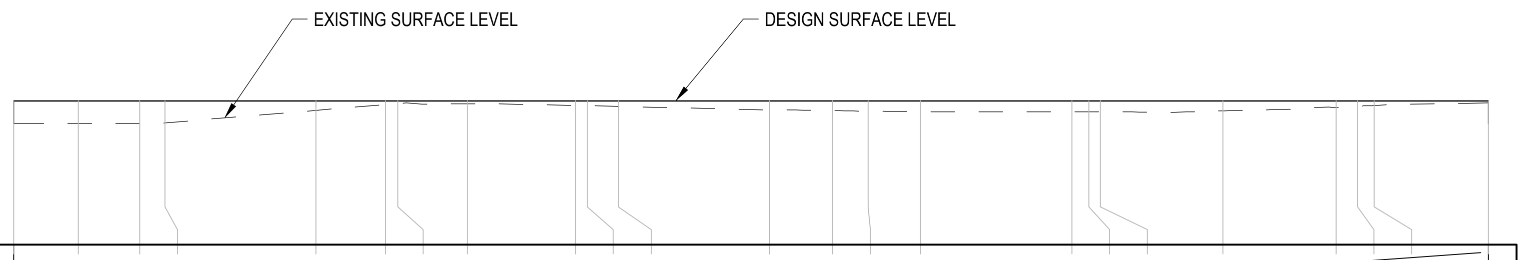
E hbamail@ghd.com **W** www.ghd.com

scale 1:1000 for A3 job no. 12509616
date rev no.
approved (PD) . . . . SK 001

BASE SURVEY & IMAGERY SUPPLIED BY GRANGE RESOURCES (TASMANIA) P/L
SURVEYED ON: APR 2020
HORIZONTAL DATUM: MINE GRID
LEVEL DATUM: AHD

GENERAL ARRANGEMENT PLAN
SCALE 1:1000

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

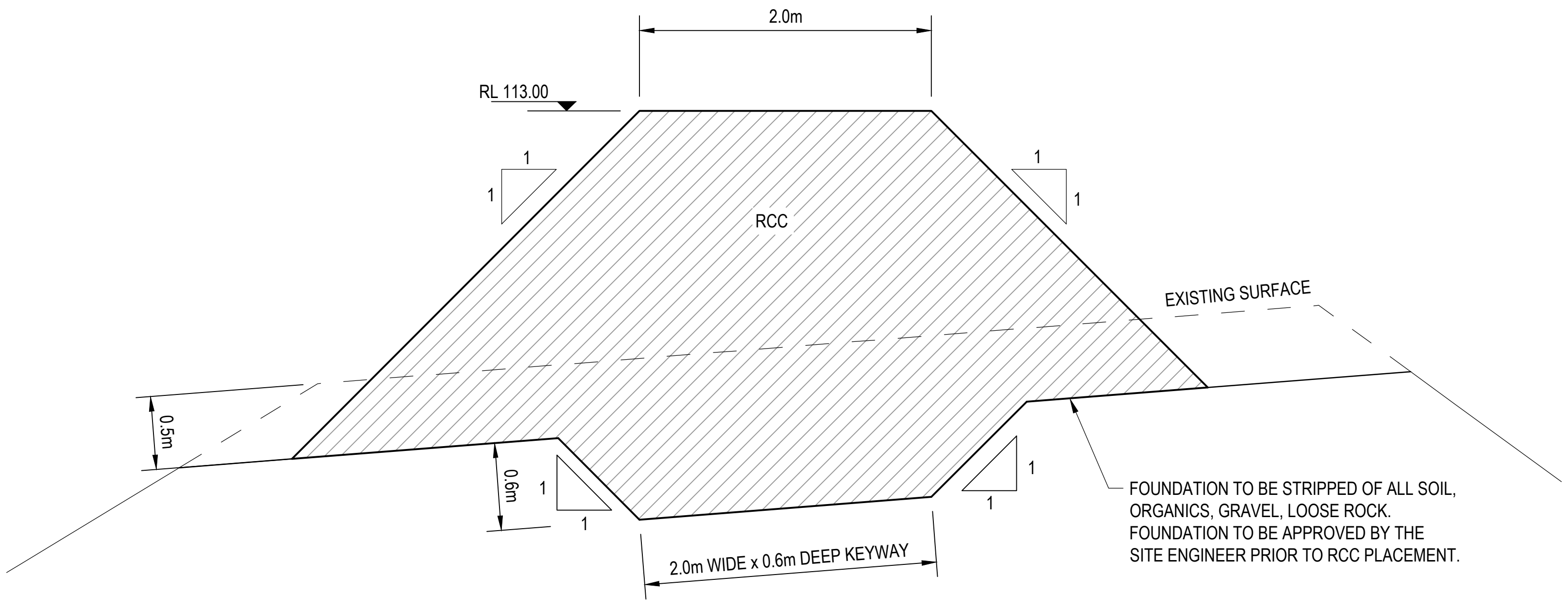


DATUM RL. 94.00

VERTICAL ALIGNMENT	L=195.13m G=0%																						
LEVEL DIFFERENCE CUT - / FILL +	3.00	2.99	2.96	2.91	1.25	0.48	0.35	0.38	0.59	0.62	0.72	1.21	1.28	1.36	1.42	1.42	1.42	1.42	1.33	0.87	0.70	0.61	0.27
DESIGN SURFACE LEVEL	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000	113.000
EXISTING SURFACE LEVEL	110.00	110.01	110.04	110.09	111.75	112.52	112.65	112.62	112.41	112.38	112.28	111.79	111.72	111.64	111.58	111.58	111.58	111.58	111.67	112.13	112.30	112.39	112.73
CHAINAGE	0.00	8.53	16.68	20.00	40.00	49.16	50.83	60.00	74.33	75.87	80.00	100.00	108.33	113.05	120.00	140.00	142.25	143.77	160.00	174.97	177.83	180.00	195.13

LONGITUDINAL SECTION OPTION 1 - RCC

SCALE 1:1000



TYPICAL SECTION OPTION 1 - RCC LEVEE

SCALE 1:50

0 0.5 1.0 1.5m
SCALE 1:50 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

PRELIMINARY

rev	description	app'd	date

GRANGE RESOURCES (TASMANIA) P/L
CENTRE PIT FLOOD LEVEE
LONGITUDINAL SECTION AND TYPICAL SECTION - OPTION 1

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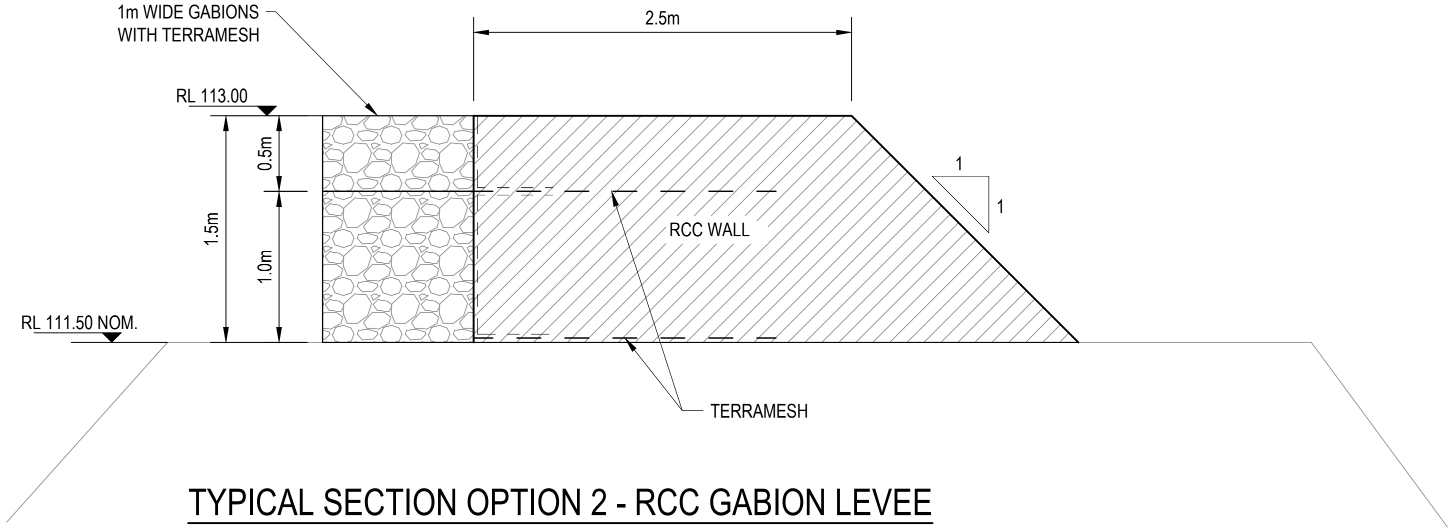
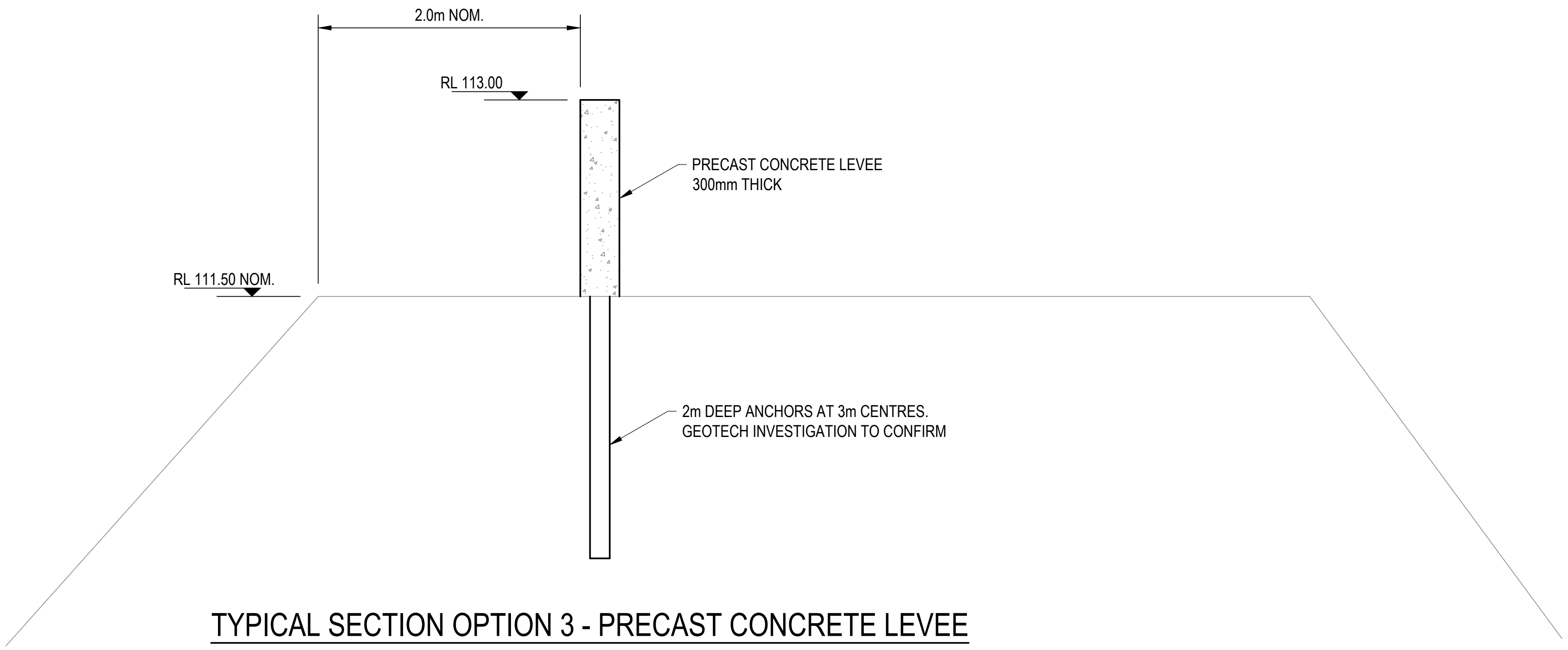
scale	AS SHOWNfor A3	job no.	12509616
date		rev no.	

approved (PD) . . . . SK 002



TYPICAL SECTION OPTION 2 - RCC GABION LEVEE

SCALE 1:50



TYPICAL SECTION OPTION 3 - PRECAST CONCRETE LEVEE

SCALE 1:50

0 0.5 1.0 1.5m

SCALE 1:50 AT ORIGINAL SIZE

PRELIMINARY

rev	description	app'd	date

GRANGE RESOURCES (TASMANIA) P/L

CENTRE PIT FLOOD LEVEE

TYPICAL SECTIONS
OPTION 2 AND 3

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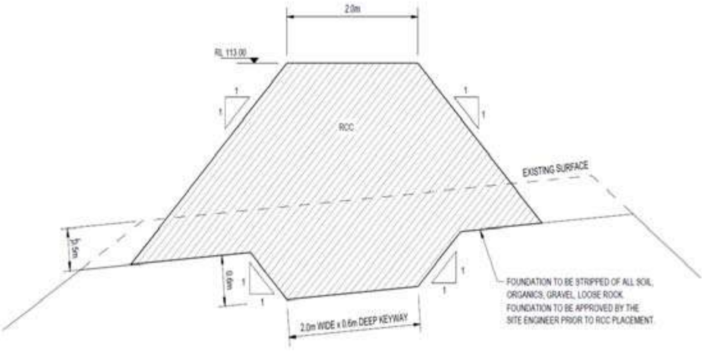
scale	AS SHOWN for A3	job no.	12509616
date		rev no.	

approved (PD) . . . . SK 003

Plot Date: 14 May 2020 - 3:55 PM Plotted by: Victoria Jenkins Cad File No: G:\32\12509616\CADD\Drawings\32-12509616-SK001-SK002-SK003.dwg

Appendix B – Cost Estimation

BILL OF QUANTITIES - SAVAGE RIVER FLOOD LEVEE

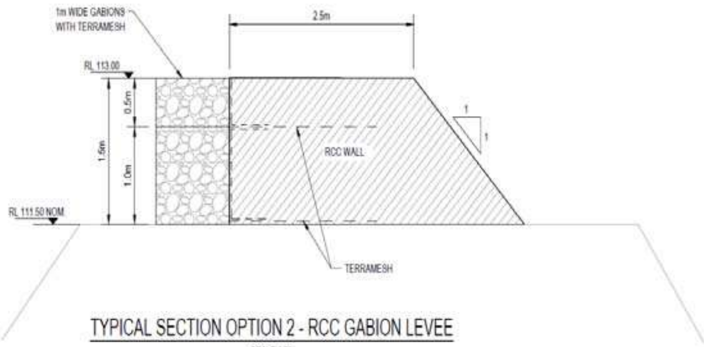


TYPICAL SECTION OPTION 1 - RCC LEVEE

SCALE 1:50

Option A

Item	Amount	Unit
RCC	1805.0	m3
Stripping	487.5	m3
Keyway	304.2	m3

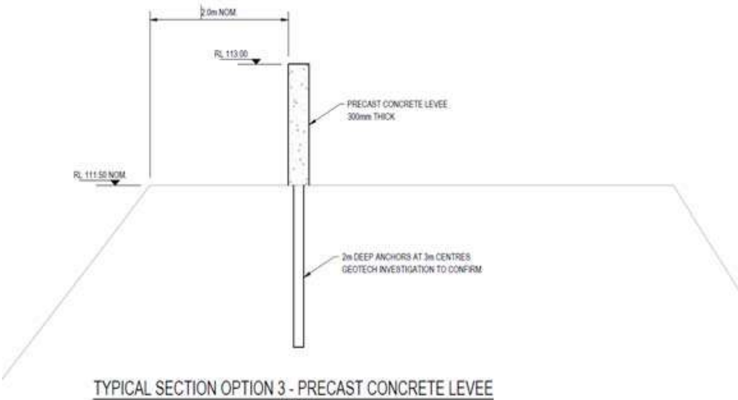


TYPICAL SECTION OPTION 2 - RCC GABION LEVEE

SCALE 1:50

Option B

Item	Amount	Unit
RCC	1295.0	m3
Gabions	392.0	m3
Stripping	487.5	m3
Keyway	304.2	m3



TYPICAL SECTION OPTION 3 - PRECAST CONCRETE LEVEE

SCALE 1:50

Option C

Item	Amount	Unit
Precast Concrete Levee	106.0	m3
Stripping	487.5	m3
Anchors	65.0	GI

Grange Resources (Tasmania) Ltd
Savage River Flood Levee
OPTION A: RCC LEVEE

Revision: A
GHD Project No.: 12509616

Item No.	Description	Quantity	Unit	Rate	Amount
1.0	Equipment Costs				
	Mob/Demob of Batch Plant	1	Ea	$ 20,000.00	$ 20,000
	Moxy	10	day	$ 3,000.00	$ 30,000
	Excavator	10	day	$ 1,150.00	$ 11,500
	Smooth Drum Roller	10	day	$ 1,000.00	$ 10,000
	Production Rate 200m3/day, 2Moxy, 1 Excavator, 1 Smooth Drum Roller				
	Subtotal				$ 71,500.00
2.0	RCC LEVEE				
	RCC (Incl 10% wastage)	1985.5	m3	$ 300.00	$ 595,650
	Based on Concrete cost of $405/m3 including agi, 2x operators, cement, sand and aggregate - only 1x operator, sand and cement required for RCC				
	Subtotal				$ 595,650
	TOTAL				$ 667,150
	Contingency [50%]				$ 333,575
	GRAND-TOTAL				**$ 1,000,725**

Grange Resources (Tasmania) Ltd
Savage River Flood Levee
OPTION B: RCC GABION LEVEE

Revision: A
GHD Project No.: 12509616

Item No.	Description	Quantity	Unit	Rate	Amount
1.0	Equipment Costs				
	Mob/Demob of Batch Plant	1	Ea	$ 20,000.00	$ 20,000
	Moxy	8	day	$ 3,000.00	$ 24,000
	Excavator	8	day	$ 1,150.00	$ 9,200
	Smooth Drum Roller	8	day	$ 1,000.00	$ 8,000
	Production Rate 200m3/day, 2Moxy, 1 Excavator, 1 Smooth Drum Roller				
	Subtotal				$ 61,200.00
2.0	RCC LEVEE				
	RCC (Incl 10% wastage)	1425	m3	$ 300.00	$ 427,350
	Based on Concrete cost of $405/m3 including agi, 2x operators, cement, sand and aggregate				
	Subtotal				$ 427,350
3.0	GABIONS				
	Screened Rockfill [50mm-150mm]	392	m3	$ 150.00	$ 58,800
	Gabion [2,4m long x 1,0m Wide x 1,0m]	163	Ea	$ 295.00	$ 48,183
	Subtotal				$ 106,983
	TOTAL				$ 595,533.3
	Contingency [50%]				$ 297,766.7
	GRAND-TOTAL				**$ 893,300.0**

Grange Resources (Tasmania) Ltd
Savage River Flood Levee
OPTION C: PRECAST CONCRETE LEVEE

Revision: A
GHD Project No.: 12509616

Item No.	Description	Quantity	Unit		Rate		Amount
1.0	PRELIMINARY ITEMS						
	Equipment Costs	1	Ea	$	50,000.00	$	50,000
	Subtotal					$	50,000.00
2.0	PRECAST CONCRETE LEVEE						
	Precast Concrete Panels [3m Long, 300mm]	117	Ea	$	2,000.00	$	233,158
	Anchors	65	Ea	$	5,000.00	$	325,000
	Excavation Stripping	488	m3	$	20.00	$	9,750
	Subtotal					$	567,908
	TOTAL					$	617,908
	Contingency [50%]					$	308,954
	GRAND-TOTAL					**$**	**926,862**

Appendix C – Safety in Design

HSE040 Safety in Design Risk Assessment

Notes: *Designs with significant quantities of dangerous goods may require detailed risk assessments under Dangerous Goods or Major Hazard legislation
* Most industrial processes will require an industry specific assessment, e.g. HAZOP and/or Quantitative Risk Assessment for facilities that have chemical or high-pressure processes under Dangerous Goods or Major Hazard legislation.

Design Life Cycle:	Investigation and Design	Setup, Construction and Commissioning	Operation	Maintenance	Disposal		Date:	1/06/2020	Revision No:	A
Job Name:	Savage River Flood Levee		Job No:	12509616	Client	Grange Resources	Design:	Protective levee		
People involved in Risk Assessment:		Mauricio Ruz, Clem Cahill								

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	Initial Risk Rating L	Initial Risk Rating RR	Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	Residual Risk Rating L	Residual Risk Rating RR	Comments
001	Setup, Construction and Commissioning	Flow Events during Operation	Flow event exceed design level and overtop to centre pit	Hydrology based on information available. Design considering 1:1000 event.	C- Severe	2 - Unlikely	Low	TARP to be developed to trigger evacuation of Centre Pit	Grange	Prior to commissioning		C- Severe	1 - Very Unlikely	Low	
002	Setup, Construction and Commissioning	Flow Events during Construction	Flow event exceed design level and overtop to centre pit	Construction strategy needs to be revised carefully considering seasons and using forecast.	B - Major	3 - Possible	Low	Construction to occur in summer if practicable to reduce risk of overtopping. Monitor weather during construction	Grange	Prior to Construction	Controls TBC	B - Major	2 - Unlikely	Negligible	
003	Setup, Construction and Commissioning	Stability of Levee	Insufficient factor of safety for stability of Gabion and/or RCC structure	Stability of structure sections must be checked in detail engineering phase.	D - Critical	3 - Possible	Significant	Detailed geotechncial investigation and stability analysis	GHD	Detailed Design		D - Critical	1 - Very Unlikely	Moderate	
004	Setup, Construction and Commissioning	Constructability	Levee not constructible or slow to construct.	Constructability needs to be revised in detail during detail engineering.	D - Critical	3 - Possible	Significant	Construction methodology to be worked through with Grange in detailed design phase.	GHD/Grange	Detailed Design		D - Critical	2 - Unlikely	Moderate	
005	Setup, Construction and Commissioning	Materials of construction	Availability of Materials.	Concept designs consider materials which are readily available, some of which have been previously used on site.	C- Severe	1 - Very Unlikely	Low	Review material availibility of selected option in detailed design.	GHD/Grange	Detailed Design		C- Severe	1 - Very Unlikely	Low	
006	Setup, Construction and Commissioning	Vehicle drives off crest road/ramps/levee	Vehicle drives off crest road/ramps, leading to injury or fatality of personnel.	Safety Bunds to be included in detail design	E- Catastrophic	2 - Unlikely	Significant	Review construction methodology and develop procedure to reduce likelihood of incidents in construction. Design to include bunds to prevent access onto the levee post construction	GHD/Grange	Detailed Design/ Construction/ Operation		E- Catastrophic	1 - Very Unlikely	Moderate	
007	Setup, Construction and Commissioning	Change in Design conditions	Change in mine design to be impacted in levee design	Mine design updated to be revised in detail phase.	B - Major	3 - Possible	Low	Changes to be communicated between Grange and GHD to allow designs to be updated if required	GHD/Grange	Detailed Design		B - Major	3 - Possible	Low	
008	Operation	Overtopping	Settlement of crest level	RCC levee will not settle, levee will be constructed on rock	B - Major	1 - Very Unlikely	Negligible	Appropriate freeboard to be confirmed during detailed design.	GHD	Detailed Design		B - Major	1 - Very Unlikely	Negligible	
009	Investigation and Design	Poor geotechnical conditions	Failure of Levee and Pit Wall	Risk Identified	D - Critical	2 - Unlikely	Moderate	Geotechnical investigation to be performed to confirm geotechnical conditions during detailed design.	GHD/Grange	Detailed Design		D - Critical	2 - Unlikely	Moderate	

GHD

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	M.Ruz	C.Cahill		R.Longey		1/6/20
0	M.Ruz			R.Longey		18/08/20

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Groundwater Inflows Assessment

Appendix F

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AQ2 Pty Ltd
ABN 38 164 858 075

Memo

To	Tony Ferguson, Will Darlington	**Company**	Grange Resources – Savage River Mine
From	Jon Hall	**Job No.**	209-E1
Date	31st January 2020	**Doc No.**	024a
Subject	Savage River – Predicted Inflows to Final Centre Pit		

Hi Tony/Will,

We have completed our review of available data and we are pleased to present the following brief report on potential inflows from South Lens (and Savage River) to the final Centre Pit.

1. SUMMARY

The approach to assessing potential future inflows to Centre Pit was as follows:

- Packer testing data for drill-hole CP2018-12 (located between South Lens and Centre Pit) were analysed to derived permeability over a number of specific test intervals.
- Drill logs and core photos for the drill-hole were reviewed and compared with the packer test intervals, and bulk average permeabilities were assigned to specific hydrogeological units.
- A simple Darcy flow model was set up to simulate inflows to the existing and planned future Centre Pits. The model was initially calibrated against observed historical inflows to confirm the ranges of appropriate permeability for each hydrogeological unit.
- The Darcy flow model was then used to predict inflows to the future final pit.

Key outcomes of this assessment are as follows:

- The hydrogeological units are interpreted to be:
  - Transition Zone – weathered/fractured rocks down to a vertical depth of around 30m with a bulk permeability of around 0.2m/d, through which most of the inflows are likely to occur.
  - Fresh Rock – variably fractured rocks with a bulk permeability of around 0.003m/d, through which minor inflows will occur.
- Historical inflows to the existing Centre Pit have been estimated at 2L/s, although it is reported that this figure may include some pipework leakage and is thus conservative.
- An analytical flow model (Darcy model), using the derived permeabilities from the packer testing and calibrated against observed historical inflows, was used to predict future inflows to the final pit. The model predicts future inflows in the range 2 to 3L/s.
- Inflows can be effectively managed by pit floor sump pumping and pumped back to South Lens for treatment/polishing (as with dewatering production from North Pit) before being discharged to the Savage River.

2. BACKGROUND

As part of planning for the further development of the Centre Pit at the Savage River Mine, Grange Resources completed a geotechnical drilling programme (in 2018) behind the north wall of the Centre Pit which also forms the saddle between Centre Pit and South Lens (which is used for the interim storage and treatment/polishing of dewatering discharge from the North Pit and drainage from some waste dumps. Hydraulic testing (packer testing) was undertaken on one of these drill-holes (CP2018-12) in July 2018.

AQ2 were commissioned to review the packer test data (and other available information) and to estimate potential groundwater inflows to the north wall of Centre Pit (i.e. water flows from South Lens and/or the Savage River) to Centre Pit.

3. PACKER TESTING (DRILL-HOLE CP2018-12)

Packer testing was undertaken at the completion of drilling in July 2018. The testing (constant head hydraulic injection testing) was undertaken using a standard straddle packer assembly over five discrete intervals (each over a 5m length of drill-hole). The raw data were compiled and analysed by Mining One to estimate the insitu permeability over each test interval using standard analytical techniques (Lugeon method and Hoek and Bray method).

Following review of the reduced data plots, we concur with the permeability estimates derived by Mining One. In summary the test data indicate the following permeabilities:

Table 1: Summary of Packer Test Analysis Results

Test Interval		Derived Permeability		Comments
Drill-hole Depth (m)	Vertical Depth (m)*	(m/s)	(m/d)	
28 to 33	20 to 23	2.2×10^{-6}	1.9×10^{-1}	
59 to 64	42 to 45	3.7×10^{-8}	3.2×10^{-3}	
118 to 123	83 to 87	4×10^{-8}	3.4×10^{-3}	Appears to be minor elastic joint expansion at higher test pressures
180 to 185	127 to 131	3.6×10^{-8}	3.1×10^{-3}	
222 to 227	157 to 161	3.8×10^{-8}	3.3×10^{-3}	Appears to be minor elastic joint expansion at higher test pressures

* Corrected for hole declination (45°) to nearest 1m.

It is noted that there appears to have been some minor expansion of joints at higher test pressures at two of the test intervals (which results in higher derived permeability at these pressures). However, the joint expansion also appears to have been elastic with no permanent deformation (i.e. no hydro-fracking).

The core photos of the drill-hole were reviewed and key hydrogeological features identified. The packer test data were then assigned as being representative of various depth intervals of the drill-hole. This is shown in Appendix A. The key outcomes of this assessment are as follows:

- The transition zone appears to extend to 41m hole depth (29m vertical depth) below surface and has a bulk permeability of around 0.2m/d.
- Fresh rock from 41 to 267m hole depth (29 to 189m vertical depth), and possibly deeper, is variably fractured and jointed but bulk permeability is generally consistent over the various test intervals at around 0.003m/d.

4. HISTORICAL CENTRE PIT INFLOWS

There are no quantitative data records for inflows to the Centre Pit during previous mining. However, anecdotal evidence (pers. com. Bruce Hutchinson, 2019) suggests that total inflows to the north end of the Centre Pit were up to 2L/s, although it was also commented that this may have included some pipeline leakage. As such, the 2L/s inflow estimate is likely to be conservative (i.e. overestimate).

For the purposes of this assessment a historical pit inflow of 2L/s has been adopted.

5. PIT INFLOW PREDICTION

5.1 Approach

The approach to predicting likely future inflows to the north end of Centre Pit was as follows:

- A simple conceptual hydrogeological model for flows from South Lens (and Savage River) to Centre Pit was developed.
- A simple Darcy flow model was then set up to simulate the conceptual hydrogeological model and calibrated against historical inflows to derive bulk permeability for various assumed flow paths. It is noted that the historical pit inflows provide the best empirical indication of potential future pit inflows.
- Packer test analysis results (derived permeability) were then compared with the outcomes of the above and used to refine the conceptual and hydrogeological and Darcy Flow models.
- The refined Darcy flow model was then modified to simulate future conditions (planned pit depth/width) and predict inflows to the final Centre Pit.

5.2 Conceptual Hydrogeological Model

The simple conceptual hydrogeological model developed for this assessment includes the following:

- A two-aquifer system as follows:
  - Shallow transition zone aquifer down to 80mRL, with permeability associated with fractures/joints and weathering.
  - Deeper, variably fractured fresh rock aquifer with a base at 0mRL, with the major fractures being oriented north-south consistent with local bedding and fault orientations.
- Most water/groundwater flows to the north wall of Centre Pit are from South Lens via the above aquifers (although flow from Savage River has also been considered).
- Minimal inflows from surrounding country rocks.

Figure 1 shows plans of the Centre Pit and South Lens with the interpreted width of the groundwater flow pathways for the current and final pits. Figure 2 shows a north-south section from South Lens to the current and future Centre Pits. It is noted from Figures 1 and 2 that the final pit depth in the northern end of Centre Pit is only marginally deeper than the current pit depth, but that the interpreted width of the groundwater flow path to the final pit is around 50% higher than for the current pit.

Figure 3 shows a schematic of the conceptual hydrogeological model.

5.3 Darcy Flow Model

The simple Darcy flow model is described by following equation:

$$Q = KbiL$$

where:
Q = Flow (m^3/d)
K = Bulk permeability (m/d)
b = Aquifer thickness (m)
i = Hydraulic Gradient
L = Width of flow pathway (m)

Aquifer thickness, hydraulic gradient and width of low path can be measured on plans and sections. Flow is calculated in the prediction model and assumed in the calibration model, while permeability is derived in the calibration model and assumed in the prediction model (refer Sections 5.3.2 and 5.3.3).

5.3.1 Calibration Model

The Darcy flow model was run to assess various combinations of bulk permeability (K) that would result in the observed historical inflow of 2L/s (173m^3/d). The outcomes of initial model calibration runs are included in Figure 3.

The calibration model was initially run for various single aquifer system and single flow pathway conditions. These results were as follows:

- Shallow aquifer flow from the Savage River only – K ~ 0.1m/d;
- Shallow aquifer flow from South Lens only – K ~ 0.3m/d;
- Deep aquifer flow from South lens only - K ~ 0.03m/d.

None of the above results are consistent with the results of packer testing and confirm that a two-aquifer system with flow components in each (as per the conceptual hydrogeological model) is more likely.

The best calibration using a two-aquifer model and assuming a historical inflow of 2L/s was as follows:

- K (shallow aquifer) = 0.2m/d, consistent with packer testing results.
- K (deep aquifer) = 0.01m/d, around three times higher than the packer test results indicate.

If a permeability of 0.003m/d is used for the deep aquifer, consistent with the packer test results, the model predicts a total inflow of 1.7L/s. This also consistent with observed inflows given that the adopted 2L/s is reported to be a conservative upper limit. For the purposes of this assessment a permeability for the deep aquifer of 0.003m/d was adopted.

It is noted that no set of calibration parameters is unique. That is, there can be a number of combinations of parameters that will produce the same predicted inflow. However, given that the adopted calibration parameters are consistent with packer test results, we believe that the adopted parameters are appropriate.

5.3.2 Prediction Model

The Darcy Flow model was modified to reflect a wider flow pathway and then run to predict inflows to the final pit. No change to the pit depth was required as the deepest groundwater flow emergence point in Centre Pit will be the toe of the existing pit slope.

The model predicts a total inflow of 2.6L/s, comprising 2.3L/s via the shallow aquifer and 0.3L/s through the deep aquifer.

5.3.3 Uncertainty Assessment

As outlined in Section 5.3.1, the calibrated model is considered to provide reliable prediction appropriate for inflow prediction of future inflows. Given that the only model parameter that is different in the prediction model (compared with the calibration model) is the width of flow pathway, this is the only model input parameter that results in some possible prediction uncertainty.

Given the linear nature of the Darcy flow model, if the flow pathway width was, say, 20% more or less than assumed (currently 190m as shown on Figure 1), the resulting inflow predictions would be 20% higher or lower.

As such, it is considered that likely future inflows would be better described as ranging from around 2 to 3L/s.

6. INFLOW MANAGEMENT

The predicted range of likely inflows to the northern end of Centre Pit are minimal (2 to 3L/s). The bulk of the inflows are likely to flow through the shallow aquifer and, as such, there could be some seepage faces at or just below the base of the transition zone. However, as the shallow flows approach the pit face, some or all of the water may infiltrate the near pit face damage zone (sub-blast and relaxation zones) and emerge at the toe of the slope along with the deeper flow pathway water.

Regardless of locations of any seepage faces, the total inflows will collect at the toe of the northern pit slope. These should be easily managed by pit floor sump pumping.

The water will be turbid and may also be affected by ARD processes. As such, the water should be pumped to South Lens for treatment and polishing prior to discharge to Savage River.

We trust this brief report is sufficient for your immediate needs. If you have any question, please do not hesitate to contact us.

Regards

Jon Hall

Consulting Hydrogeologist

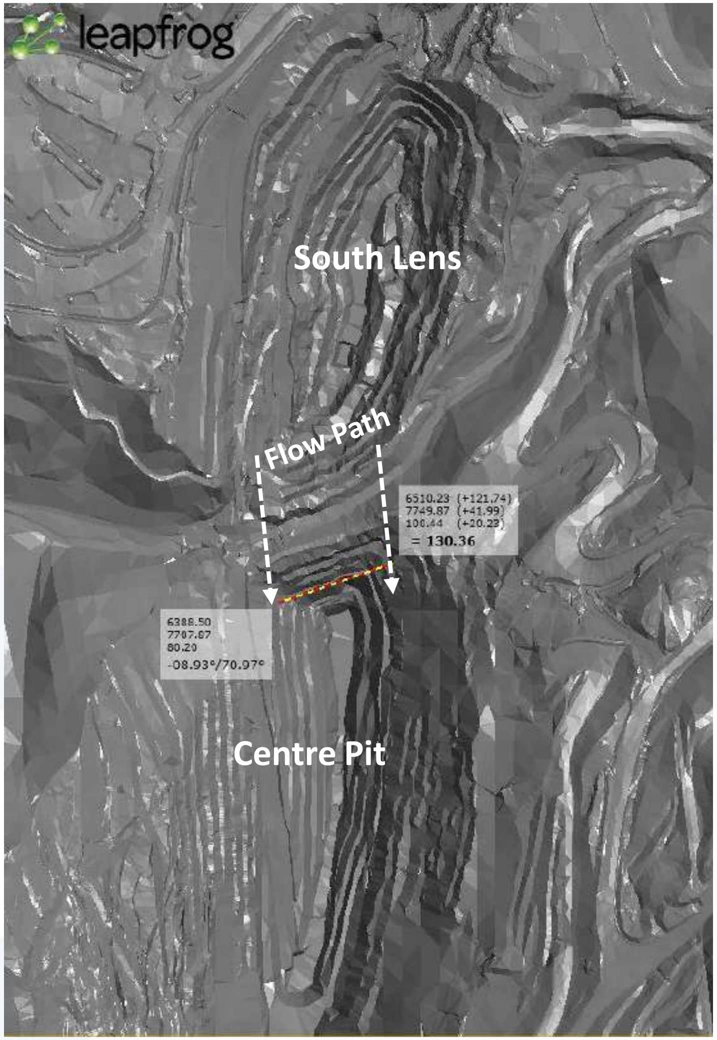
Duncan Storey

Consulting Hydrogeologist - Director

Author: JWH (30/01/20)
Reviewed: DGS (30/01/20)

Attached: Figures 1 to 3
Appendix A

Existing Pit (Pre-Infill)



EOM Pit

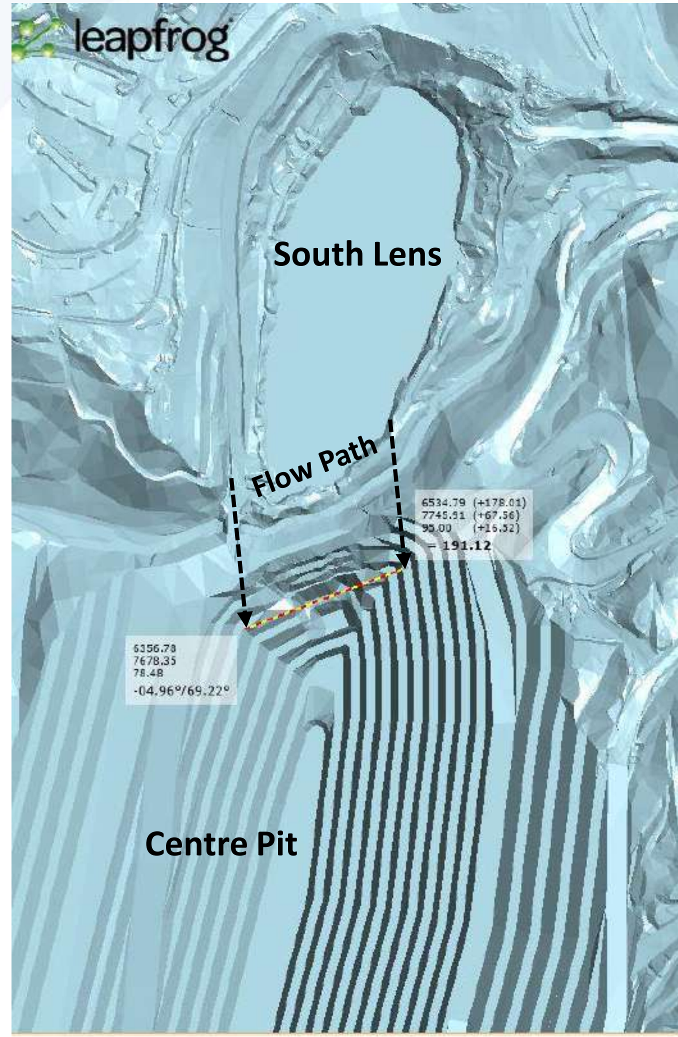


Figure 1

Centre Pit – South Lens Plans

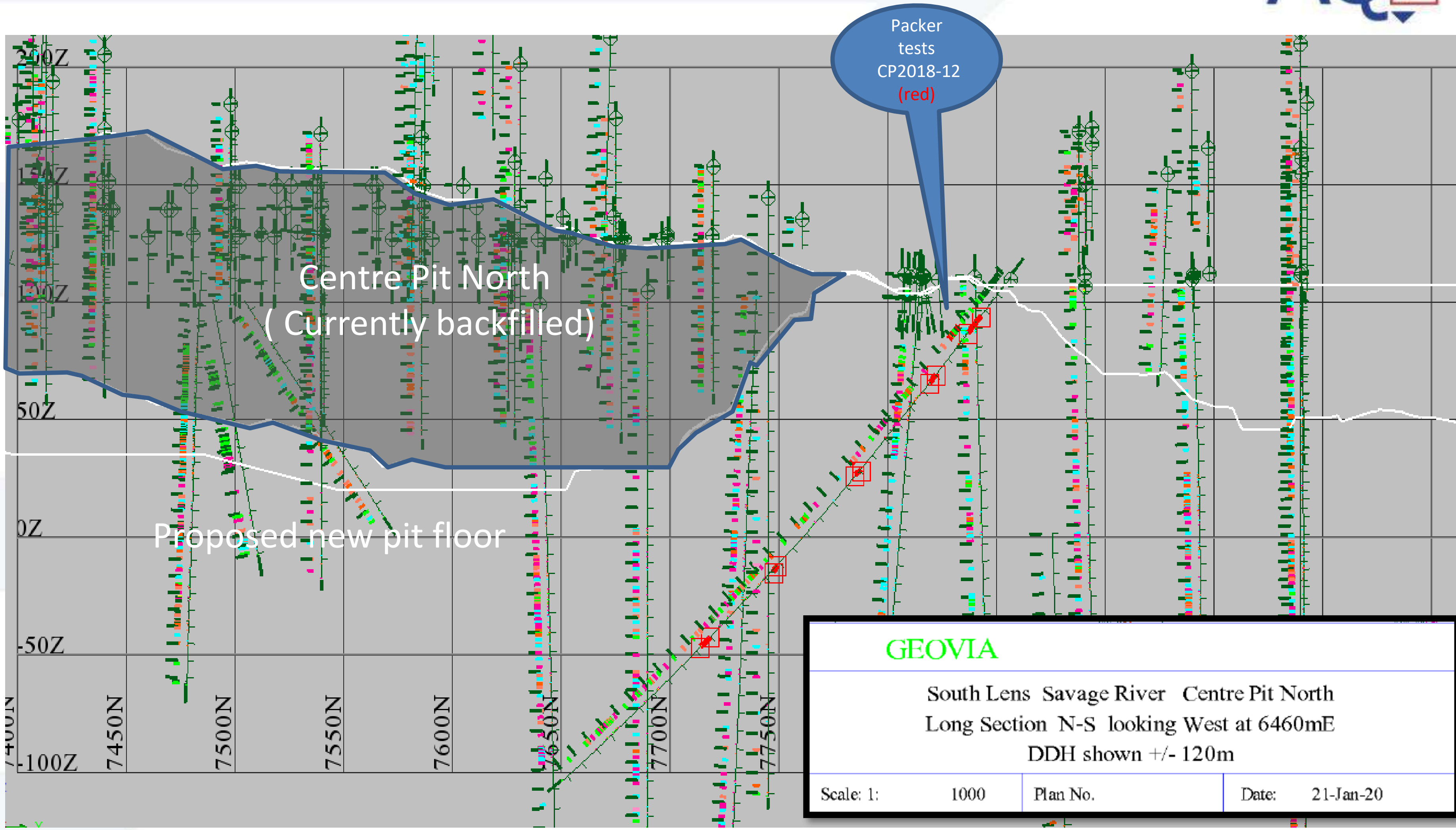
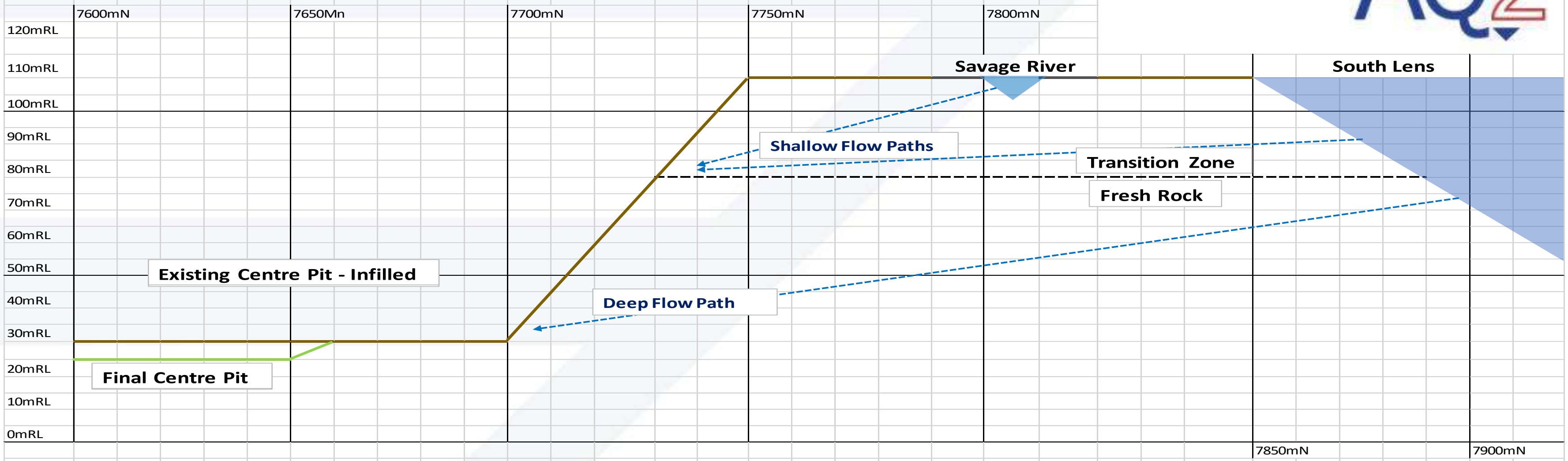


Figure 2

N-S Section



Darcy Model **Q = KbiL**

			Calibration to Historical Inflows (2L/s)					
			Individual (exclusive flow path model)			Two flow path model		
			Shallow Flow Path from Savage River	Shallow Flow Path from South Lens	Deep Flow Path from South Lens	Shallow Flow Path from South Lens	Deep Flow Path from South Lens	Total Inflows
where:	Q =	**Flow to Centre Pit - observed (m3/d)**	**172 m3/d**	**174 m3/d**	**170 m3/d**	**134 m3/d**	**14 m3/d**	**148 m3/d**
			2.0 L/s	2.0 L/s	2.0 L/s	1.5 L/s	0.2 L/s	1.7 L/s
	K =	Bulk permability - calibrated (m/d)	0.11	0.26	0.03	0.20	0.0	
	b =	Aquifer thickness (m)	30	30	110	30	80	
	i =	Hydraulic Gradient (=Δh/Δx)	0.40	0.17	0.46	0.17	0.46	
	Δh =	Head difference between source and outflow point (m)	30	30	80	30	80	
	Δx =	Lateral distance between source and outflow point (m)	75	175	175	175	175	
	L =	Width of flow pathway (m)	130	130	130	130	130	

		Predicted Inflows to final pit based on calibrated model		
		Shallow Flow Path from South Lens	Deep Flow Path from South Lens	Total Inflows
Q =	**Flow to Centre Pit - predicted (m3/d)**	**195 m3/d**	**29 m3/d**	**224 m3/d**
		2.3 L/s	0.3 L/s	2.6 L/s
K =	Bulk permability from Packer Tests (m/d)	0.20	0.003	
b =	Aquifer thickness (m)	30	110	
i =	Hydraulic Gradient (=Δh/Δx)	0.17	0.46	
Δh =	Head difference between source and outflow point (m)	30	80	
Δx =	Lateral distance between source and outflow point (m)	175	175	
L =	Width of flow pathway (m)	190	190	

Adopted (green)
Derived/calibrated (yellow)

Figure 3

Concept Hydro and Inflow Model

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APPENDIX A

Hole CP2018-12 - Summary Geological Log (with Hydro Testing Data and Interp)

			Geology				Description	AQ2 Interpreted Zone	Hydro Features	Packer Test Interval	Derived K (m/d) and zone of representation	Comments
FROM	TO	INTERVAL	QUAL	ROCK	ROCK	WEATH	Comments / Remarks					
m	m	m	qual-ifier	rock type	Rock Unit	amt weath						
0.00	0.80	0.80		WST		SW	rubble start of hole					
0.80	3.60	2.80		LOS			core loss					
3.60	4.10	0.50		WST		MW		MW Weathered Zone				
4.10	6.60	2.50		LOS			core loss		Rubble			
6.60	7.10	0.50	fo1	WST		MW	Waste material fallen into hole					
7.10	9.60	2.50		LOS			core loss					
9.60	10.50	0.90	fo1	WST		MW	Waste material fallen into hole					
10.50	12.60	2.10		LOS			core loss					
12.60	13.80	1.20	ma	WST		FR						
13.80	14.75	0.95		LOS			core loss					
14.75	16.60	1.85	ma	MXC	MHA	FR	Main host assemblage					
16.60	16.70	0.10		LOS			core loss					
16.70	20.30	3.60	ma	MXC	MHA	FR						
20.30	20.40	0.10		LOS			core loss		Heavily Jointed			
20.40	27.50	7.10	ma	MXC	MHA	FR						
27.50	27.60	0.10		LOS			core loss					
27.60	34.40	6.80	ma	MXC	MHA	FR		Transition Zone		28 to 33m	0.2	
34.40	35.00	0.60	sh	XSC	MHA	SW	shear within the MHA					
35.00	35.20	0.20		LOS			core loss					
35.20	36.50	1.30	sh	XSC	MHA	SW						
36.50	36.60	0.10		LOS			core loss					
36.60	38.30	1.70	fo1	MXC	MHA	FR						
38.30	39.40	1.10	sh	XSC	MHA	FR	chlorite shears with +- se					
39.40	39.90	0.50		LOS			core loss		Rubble zone			
39.90	40.10	0.20	fo1	MXC	MHA	FR						
40.10	41.00	0.90	fo3	ZSP	MHA	FR	serpentine shear					Vertical Depth ~30m
41.00	41.30	0.30	sh	XSB	MHA	FR						
41.30	51.35	10.05	ma	ZMP	MHA	FR	pyritic ore					
51.35	69.38	18.03	ma	ZAP	MHA	FR	pyritic ore			59 to 64m	0.003	
69.38	72.00	2.62	fo	ZAP	MHA	FR	actinolite and tremolite veins scattered thru mineralisation					
72.00	72.90	0.90	ma	MRC	MHA	FR						
72.90	73.50	0.60	ma	ZMP	MHA	FR						
73.50	73.91	0.41	bx	MRC	MHA	FR						
73.91	74.52	0.61	bx	ZSP	MHA	FR	pyritic ore					
74.52	75.08	0.56	bx	ZSC	MHA	FR						
75.08	76.00	0.92	bx	ZSP	MHA	FR	pyritic ore					
76.00	76.50	0.50	bx	MRC	MHA	FR	magnetite spotted thru chlorite matrix with talc infill					
76.50	77.31	0.81	bx	ZSP	MHA	FR	pyritic ore					
77.31	77.80	0.49	bx	MRC	MHA	FR	magnetite spotted thru chlorite matrix with talc infill					
77.80	91.70	13.90	bx	ZAP	MHA	FR	actinolite and tremolite veins scattered thru mineralisation					
91.70	92.40	0.70	fr	ZAP	MHA	FR	Ground fractured. Might be possible fault					
92.40	92.90	0.50		LOS			core loss					
92.90	94.50	1.60	fr	ZAP	MHA	FR	Ground fractured. Might be possible fault or could be brittle core.		Fault Zone ?			
94.50	94.80	0.30		LOS			core loss					
94.80	98.90	4.10	fr	ZAP	MHA	FR						
98.90	99.50	0.60	sh	XSB	MHA	FR	faulted contact with mineralisation and Gabbros					
99.50	99.60	0.10		LOS			core loss					
99.60	107.73	8.13	ma	MGE	MHA	FR	coarse grained gabbro texture.					

FROM	TO	INTERVAL	Geology				Description	AQ2 Interpreted Zone	Hydro Features	Packer Test Interval	Derived K (m/d) and zone of representation	Comments
			QUAL	ROCK	ROCK	WEATH	Comments / Remarks					
m	m	m	qual-ifier	rock type	Rock Unit	amt weath						
107.73	112.90	5.17	bx	ZSP	MHA	FR	with bands of < .20 massive chloritic rock and spotted mt					
112.90	114.60	1.70	ma	ZAP	MHA	FR	pyritic ore					
114.60	118.50	3.90	bx	ZMP	MHA	FR	pyritic ore		V-jointed			
118.50	119.20	0.70	sh	XSC	MHA	FR	shear contact with mineralisation and MBO			118 to 123m	0.003	Appears to be elastic joint expansion during testing at P>1,000KPa
119.20	139.33	20.13	ma	MBO	MHA	FR	fine grain intrusive with chlorite and epidote alteration					
139.33	153.40	14.07	bx	ZAP	MHA	FR	small shear contact with the magnetite.					
153.40	154.55	1.15	ma	MRC	MHA	FR	Massive rock with chlorite alteration and epidote vns.					
154.55	156.28	1.73	bd	ZSC	MHA	FR	banded mineralisation with pyrite and chloritic section >.1m					
156.28	156.40	0.12	sh	XSC	MHA	FR	shear within a chlorite and epidote rich rock					
156.40	157.30	0.90	ma	MRC	MHA	FR	Massive rock with chlorite alteration and epidote vns.					
157.30	163.55	6.25	bx	ZSP	MHA	FR			Fault Zone ?			
163.55	178.24	14.69	ma	MRC	MHA	FR	Massive rock with chlorite alteration and epidote vns. More py towa					
178.24	182.85	4.61	bx	ZSC	MHA	FR	brecciated mineralisation within a chlorite, talc and pyrites.			180 to 185m	0.003	
182.85	184.70	1.85	ff	MRE	MHA	FR	healed fractured ground that has been healed with ep alteration.					
184.70	190.70	6.00	sp	ZAP	MHA	FR	shear contact with					
190.70	191.65	0.95	ff	MRC	MHA	FR	this rock is fractures and cemented with talc alteration					
191.65	192.84	1.19	bx	ZSP	MHA	FR						
192.84	193.41	0.57	ma	MRC	MHA	FR	Massive rock with chlorite alteration					
193.41	194.70	1.29	ds	ZSP	MHA	FR						
194.70	195.97	1.27	ma	MRC	MHA	FR						
195.97	199.14	3.17	bx	ZMP	MHA	FR	sheared contact with MRC					
199.14	200.21	1.07	ma	MRC	MHA	FR						
200.21	202.50	2.29	bx	ZMP	MHA	FR	more serpentine within the magnetite					
202.50	203.00	0.50	sh	XSC	MHA	FR	sheared zone with .2m of larger broken ground and back into shear					
203.00	203.20	0.20	ff	MRC	MHA	FR						
203.20	203.40	0.20		LOS	MHA	FR			Fault Zone ?			
203.40	204.50	1.10	ds	ZSP	MHA	FR						
204.50	205.20	0.70	ma	MRC	MHA	FR						
205.20	208.61	3.41	ds	ZAP	MHA	FR						
208.61	208.86	0.25	ma	MRC	MHA	FR						
208.86	216.75	7.89	ds	ZAP	MHA	FR		Fresh Rock				
216.75	217.00	0.25	ma	MRC	MHA	FR						
217.00	222.35	5.35	ds	ZAP	MHA	FR						
222.35	222.60	0.25	fo	MXS	MHA	FR	serpentine rich rock with talc shear					
222.60	223.05	0.45	ds	ZAP	MHA	FR				222 to 227m	0.003	Appears to be elastic joint expansion during testing at P>1,000KPa
223.05	223.60	0.55	fo	MXS	MHA	FR	serpentine rich rock with talc shear		V-jointed			
223.60	223.70	0.10		LOS								
223.70	231.16	7.46	ds	ZAP	MHA	FR						
231.16	231.60	0.44	vn	ZMQ	MHA	FR						
231.60	235.60	4.00	vn	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
235.60	236.40	0.80	fo	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
236.40	237.25	0.85	fo	MRA	MHA	FR	Minor pyrite within mafic host intrusive					
237.25	249.95	12.70	fo	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
249.95	251.08	1.13	fo	MRA	MHA	FR	Minor pyrite within mafic host intrusive					
251.08	261.18	10.10	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
261.18	261.60	0.42	vn	MRA	MHA	FR	Low mafic composition intrusive. Contact metamorphism present eit					
261.60	266.00	4.40	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou		Fault Zone ?			
266.00	266.85	0.85	vn	ZSA	MHA	FR	Heavily fractured and rotten core. Sporadic magnetic intervals withir					Vertical Depth ~ 190m
266.85	267.20	0.35	fo	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
267.20	267.50	0.30	vn	MRA	MHA	FR	Low mafic composition intrusive. Contact metamorphism present eit					

			Geology				Description	AQ2 Interpreted Zone	Hydro Features	Packer Test Interval	Derived K (m/d) and zone of representation	Comments
FROM	TO	INTERVAL	QUAL	ROCK	ROCK	WEATH	Comments / Remarks					
m	m	m	qual-ifier	rock type	Rock Unit	amt weath						
267.50	274.80	7.30	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
274.80	275.10	0.30	vn	MRA	MHA	FR	Low mafic composition intrusive. Contact metamorphism present eit					
275.10	276.10	1.00	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
276.10	276.40	0.30	vn	MRA	MHA	FR	Low mafic composition intrusive. Contact metamorphism present eit					
276.40	280.00	3.60	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
280.00	281.00	1.00	vn	MRA	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
281.00	289.40	8.40	vn	MRA	MHA	FR	Low mafic composition intrusive. Contact metamorphism present eit					
289.40	294.30	4.90	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
294.30	294.80	0.50	vn	MRA	MHA	FR	Low mafic composition intrusive. Contact metamorphism present eit					
294.80	295.00	0.20	fo	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
295.00	295.40	0.40	fo	MRA	MHA	FR	Low mafic composition intrusive. Contact metamorphism present eit					
295.40	295.55	0.15	vn	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
295.55	295.75	0.20	fo	MRA	MHA	FR	Low mafic composition intrusive.					
295.75	296.10	0.35	vn	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
296.10	296.20	0.10	fo	MRA	MHA	FR	Low mafic composition intrusive.					
296.20	296.30	0.10	vn	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
296.30	296.40	0.10	fo	MRA	MHA	FR	Low mafic composition intrusive.					
296.40	297.00	0.60	vn	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
297.00	297.05	0.05	fo	MRA	MHA	FR	Fibrous decomposing serpentinite. Tramelite. Vein within magnetite					
297.05	298.00	0.95	vn	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
298.00	298.40	0.40	fo	MRA	MHA	FR	Low mafic composition intrusive.					
298.40	299.70	1.30	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
299.70	300.25	0.55	fo	MRA	MHA	FR	Low mafic composition intrusive. Crosscutting veins of pyrite and he					
300.25	302.10	1.85	fo	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
302.10	302.45	0.35	fo	MRA	MHA	FR	Low mafic composition intrusive. Crosscutting veins of pyrite and he					
302.45	303.30	0.85	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
303.30	304.85	1.55	fo	MRA	MHA	FR	Low mafic composition intrusive. Veinlets of magnetite throughout.					
304.85	310.20	5.35	fo	ZAP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
310.20	310.75	0.55	fo	MRA	MHA	FR	Low mafic composition intrusive. Veinlets of magnetite throughout.					
310.75	310.90	0.15	fo	ZMP	MHA	FR	Massive magnetite within mafic host. Disseminated pyrite throughou					
310.90	314.00	3.10	fo	MRA	MHA	FR	Low mafic composition intrusive. Veinlets of magnetite throughout.					
314.00	333.50	19.50	ma	MRE	MHA	FR	Host mafic interval. Rare pyrites throughout. EOH at 333.50m					

Tailings Leachate Chemistry

Appendix G

pitt&sherry

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Memorandum

To	Tony Ferguson, Grange Resources
From	Anita Parbhakar-Fox, Sustainable Minerals Institute, University of Queensland
Date	18 September 2020
Subject	Leachate analysis of tailings– interpretation of metal leaching potential

Tony Ferguson has provided leachate chemistry data on future tailings samples (n=5) in order to assist with the request (from the EPA) to provide:

- *Description of future tailings geochemistry, including an assessment of the acid generating (or neutralising) potential and estimated quantities and production rates.*
- *Waste rock and tailings geochemical test work, including mineralogy, acid-base accounting (ANC, MPA, NAPP), NAG pH, kinetic test work, and assessment of elemental enrichment and potential for leaching.*

Tailings leachate chemistry- Metal leaching potential

New chemical data provided by Grange Resources are from future tailings material (n=5). These composite materials derive from North Pit and Centre Pit (Table 1) and were sent to Mineral Resources Tasmania (MRT) for XRD analysis. The mineralogical characteristics of these tailings were reported in a memorandum submitted to Grange Resources in July 2020 (*Appendix A*).

Table 1. *Details of 'new' tailings samples used in this study.*

Reg#	Location	Sample description
G410301	NP Savage	NPUG2-18_12 NP HG Lens 1
G410302	CP Savage	CP2018_07 CP LG Lens 1
G410303	CP Savage	CP2018_02 CP HG Lens 2
G410304	CP Savage	CP2018_02 CP LG Lens 3
G410305	CP Savage	CP2018_02 CP HG Lens 4

These same samples were submitted to CODES, University of Tasmania (via MRT) for solution ICPMS analysis (see *Appendix B for the methodology*) with concentrations of the following elements measured: Li, Be, Sc, Ti, V , Cr, Mn, Co, Ni, Cu, Zn, As, Rb, Sr, Y , Zr, Nb, Mo, Ag, Cd, Sn, Sb, Cs, Ba, REE (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu), Hf, Ta, Tl, Pb, Bi, Th, U. Notably, Se is absent. The measured concentrations of these elements are given in *Appendix B* however Geochemical Abundance Index (GAI) values were calculated for each (using crustal abundance values from WebElements and Bowen, 1979) as shown in Table 2. These data report high concentrations of V, Co, Ni and Cu. The GAI enrichment factors for the Centre Pit samples are higher for Co, Ni, Cu, As, Bi and Pb compared to North Pit. Considering the mineralogy of these samples, these elements concentrations are expected as V is typically associated with magnetite (measured between 2 to 4 wt. %), Cu with chalcopyrite (not measured by XRD- below instrument detection limit) likely present as inclusions in pyrite (petrographic evidence from other studies have shown this), and Co and Ni associated with pyrite (measured between 6 and 31 wt. %). The bulk content of other potentially eco-toxic elements including As, Pb are relatively low in these samples (< 10.2 ppm and <14.6 ppm respectively) although for As, GAI values are >2 for the 3 Centre Pit samples measured as the most pyritic (31 wt. %, 27 wt. % and 25 wt. % respectively).

Table 2. *Geochemical abundance index (GAI) values for elements measured by solution ICPMS in 'new' tailings material.*

	GAI enrichment factor				
	G410301	**G410302**	**G410303**	**G410304**	**G410305**
Li (ppm)	0.5	0.8	0.5	0.7	0.4
Be (ppm)	0.2	0.4	0.1	0.2	0.1
39 K (ppm)	0.2	0.2	0.1	0.1	0.0
Sc (ppm)	1.1	1.5	1.1	0.9	0.9
Ti (ppm)	2.4	1.1	1.4	0.6	0.5
V (ppm)	**4.9**	**1.8**	**3.8**	**1.9**	**4.3**
Cr (ppm)	0.3	0.4	0.2	0.3	0.1
Mn (ppm)	1.8	1.2	1.5	1.0	0.9
Co (ppm)	**7.6**	**4.9**	**30.3**	**30.9**	**26.2**
Ni (ppm)	**1.5**	**4.2**	**10.2**	**21.9**	**8.6**
Cu (ppm)	**7.0**	**8.2**	**41.1**	**82.3**	**42.3**
Zn (ppm)	1.6	1.2	1.6	0.9	1.4
As (ppm)	0.6	0.5	**2.1**	**6.8**	**2.6**
Rb (ppm)	0.2	0.2	0.0	0.0	0.0
Sr (ppm)	0.2	0.1	0.0	0.2	0.1
Y (ppm)	0.6	1.0	0.5	0.6	0.5
Zr (ppm)	0.2	0.5	0.1	0.3	0.1
Nb (ppm)	2.9	3.5	2.5	2.0	1.5
Mo (ppm)	0.4	0.8	2.8	1.6	0.6
Ag (ppm)	1.2	0.6	3.4	6.4	2.5
Sn (ppm)	1.8	0.8	2.2	0.9	1.5
Sb (ppm)	0.6	0.5	0.9	1.9	1.4
Cs (ppm)	0.4	0.6	0.2	0.1	0.1
Ba (ppm)	0.1	0.1	0.0	0.0	0.0
La (ppm)	0.3	0.5	0.5	0.3	0.3
Ce (ppm)	0.4	0.7	0.5	0.3	0.4
Pr (ppm)	0.3	0.5	0.4	0.3	0.4
Nd (ppm)	0.3	0.6	0.4	0.3	0.4
Sm (ppm)	0.4	0.7	0.4	0.5	0.5
Eu (ppm)	0.3	0.6	0.2	0.3	0.3
Gd (ppm)	0.5	0.9	0.4	0.6	0.6
Tb (ppm)	0.5	0.9	0.4	0.5	0.5
Dy (ppm)	0.4	0.8	0.4	0.5	0.4
Ho (ppm)	0.5	0.9	0.4	0.6	0.5
Er (ppm)	0.6	1.1	0.5	0.6	0.5
Tm (ppm)	0.6	1.1	0.6	0.7	0.4
Yb (ppm)	0.6	1.1	0.7	0.7	0.4
Lu (ppm)					
Hf (ppm)	0.3	0.6	0.2	0.3	0.1
Ta (ppm)	0.2	0.2	0.1	0.1	0.1

Tl (ppm)	0.1	0.1	0.0	0.2	0.0
Pb (ppm)	0.3	0.2	0.2	1.0	0.6
Bi (ppm)	**1.0**	**0.9**	**7.8**	**20.2**	**8.7**
Th (ppm)	0.1	0.4	0.3	0.1	0.2
U (ppm)	0.2	0.3	0.3	0.2	0.1

As these values have been generated from total digestions, it is not possible based on these 5 samples alone, to ascertain the exact leachate chemistry of the future tailings. However, metals including Cu, Co and Ni are likely to be more mobile under acidic conditions (Reddy et al., 1995). The anticipated pH range of the fluids associated with these tailings is likely to be between ~6.5 and 7.5 as these tailings will be deposited, for the most part, into the SDTSF where the Dam pH is between 7 and 7.5 (Ferguson, *Pers. Comm*). On examination of monitoring stations around this location, the pH is within this range as shown in Figure 1(NB. the fall in the MCTD was due to the influence of OTD seepage).

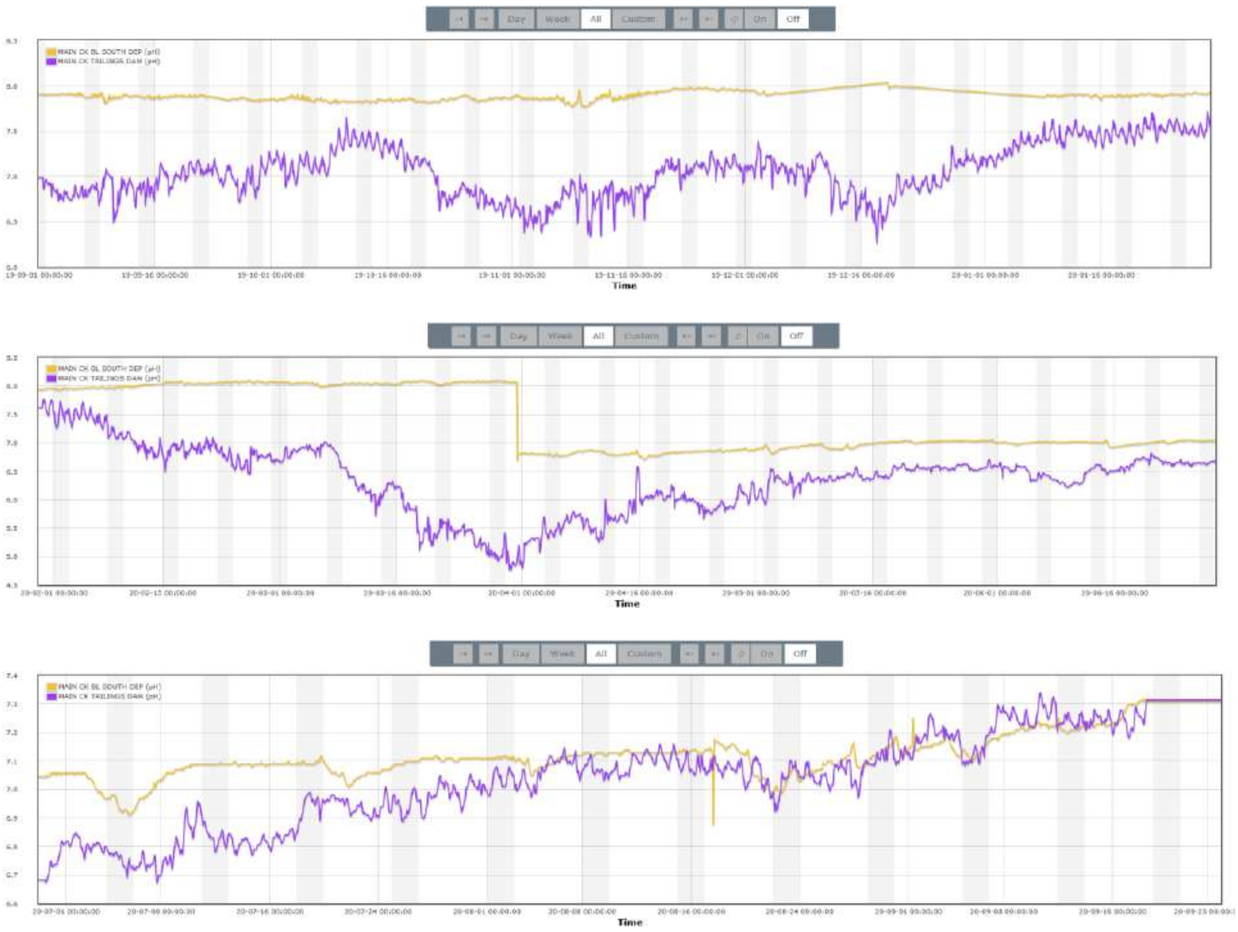

Figure 1. *Main Creek below South Deposit and Mains Creek Tailings Dam pH monitoring undertaken in 2019/2020.*

Given the OTD tailings are reported to have originated from Centre Pit, they can be used as proxy for understanding the behaviour of these future tailings. Based on this information, these elements are not anticipated to significantly mobilise if stored subaqueously under a water cover (~ 1.5 m depth; sulphide oxidation is retarded; Jackson, 2014) as is the situation at the OTD's Northern Pond. Further, paste pH testing undertaken on tailings collected by Jackson (2014) in the Northern Pond area confirmed that under this water cover, the tailings are geochemical stable and less-reactive (paste pH values ~8,1) despite having high sulphur contents (~26 %). Chemical measurements of water collected in Jackson's (2014) study (for As, Ca, Co, Cu, Ni, SO_4 and Zn) were below ANZECC (2000) DWG values, though it is noted, that comparison to other guidelines (i.e., ANZECC (2000) aquatic protection guidelines) should have been undertaken. The original data collected in this study is being sought for this purpose.

Recommendations

- It is recommended that establishing (saturated) kinetic column leach trials, on material representative of future tailings deriving from the Centre Pit, should be made a priority to confirm this anticipated behaviour.
- To ensure a greater number of samples are tested an additional quantity of short-term kinetic proxy tests (including the OxCon test- Earth Systems or the accelerated pH testing (including short-term Buchner funnel tests- Figure 2, or the MATE pH test; Noble et al., 2015) should also be considered.

Figure 2. *Accelerated kinetic leachate testing on Tasmanian mine waste using mini-Buchner funnels (Moyo et al., 2020).*

- Alternatively, simply collecting paste pH or NAG pH leachates, as part of an integrated ABA testing program and analysing these by ICP-MS, will provide an insight into metal leaching potential.
- The content of Co is considered to be relatively high for mine tailings. Separation of the tailings into a sulphide-rich and sulphide-poor stream should be considered from the outset. The benign or less reactive material could be considered for integration into a cover for waste rock materials on site, whilst the sulphidic tailings could be further processed for Co recovery. Ultimately, this approach will remove the majority of leaching risks associated with these materials.

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THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Memorandum

To Tony Ferguson, Grange Resources

From Anita Parbhakar-Fox, Sustainable Minerals Institute, University of Queensland

Date 10 July 2020

Subject XRD analysis of tailings data – interpretation of AMD potential

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Tony Ferguson has provided X-ray diffractometry (XRD) and microscopy data on future tailings samples (n=5) to complement the recent SMI report (submitted on 30/06/2020) entitled '*Centre pit waste characterisation: Savage River mine, Tasmania*'. Part of the scope of this original study was to provide a:

- *Description of future tailings geochemistry, including an assessment of the acid generating (or neutralising) potential and estimated quantities and production rates.*

At the time of report finalisation, the most relevant tailings data available was from the Jackson (2014) BSc. Honours study undertaken at the Old Tailings Dam (OTD) where it is reported that gangue from Centre Pit was deposited after processing. Considering the provenance of these materials, it was assumed that these provided the best proxy for future tailings deriving from the proposed Centre Pit extension. X-ray diffractometry (XRD) data from this study and summarised in Jackson and Parbhakar-Fox (2016) did not identify calcite in the tailings assemblage. Rather actinolite, albite, chlorite, serpentinite, quartz and kaolinite dominated with pyrite measured between 3.4 wt. % and 9.6 wt. %. A summary of these data are shown in Table. 1.

Mineral	Formula	Zone A	Zone B	Zone C	Zone D
Actinolite	$(Ca_2)(Mg_{4.5-2.5}Fe_{0.5-2.5})(Si_8O_{22})(OH)_2$	29.2	18.1	20.9	14.5
Albite	$Na(AlSi_3O_8)$	16.4	12.0	11.9	9.0
Chlorite	$(Mg_5Al)(AlSi_3)O_{10}(OH)_8$	20.8	28.3	25.6	30.3
Ferrihydrite	$Fe^{3+}_{10}O_{14}(OH)_2$	1	1.7	1.3	1
Goethite	α-$Fe^{3+}O(OH)$	BDL	BDL	BDL	BDL
Hematite	Fe_2O_3	BDL	BDL	BDL	BDL
Jarosite	$KFe^{3+}{}_3(OH)_6(SO_4)_2$	0.3	BDL	0.3	BDL
Kaolinite	$Al_2(Si_2O_5)(OH)_4$	6.4	9.6	6.8	9.0
Pyrite	FeS_2	6.7	8.9	9.6	3.4
Quartz	SiO_2	BDL	0.8	0.6	1.9
Serpentine	$(Mg,Fe,Ni,Al,Zn,Mn)_{2-3}(Si,Al,Fe)_2O_5(OH)_4$.	12.8	15.4	16.7	22.7
Spencerite	$Zn_4(PO_4)_2(OH)_2\cdot 3(H_2O)$	2.5	4.1	3.3	3.4
Talc	$Mg_3Si_4O_{10}(OH)_2$	0.5	2.9	1.9	2.6
Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$	1.1	0.1	0.9	2.1

Table 1. *Semi-quantitative bulk mineralogy data (n=55) as measured by XRD (wt. %) with average values shown for each Zone identified at the Old Tailings Dam (BDL- below detection limit of 0.3 wt. %) from Jackson and Parbhakar-Fox (2016).*

Mineral Liberation Analyser (MLA) evaluations were performed on a sub-set of samples (n=8) characterised by Jackson and Parbhakar-Fox (2016). Whilst these data are not available, Fig. 1 shown in Jackson and Parbhakar-Fox (2016) indicates that trace carbonates (identified as dolomite) were present and associated with pyrite. The original dataset can be requested from the Central Science Laboratory (CSL), University of Tasmania, where the analysis was performed, but it is understood that these data are kept on external drives and will take some time to locate. Regardless, the geochemical data associated with these studied OTD tailings indicate these samples are potentially acid forming (as documented in the SMI Report, June 2020). In summary, the net budget of carbonates to sulphides in these historic materials is insufficient to buffer acid generated from sulphide oxidation.

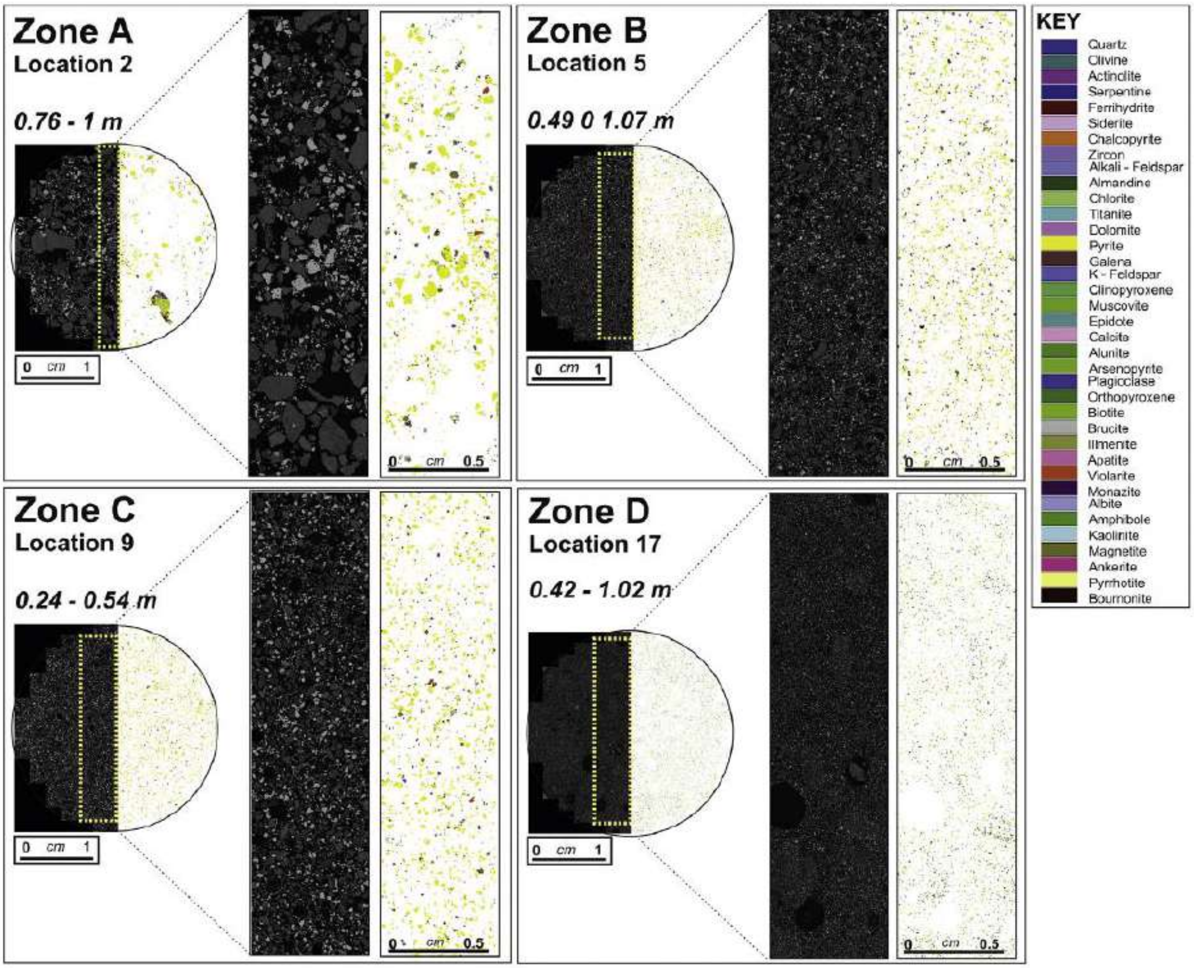

Figure 1. *Representative images of pyrite grains and their mineral associations from sediments sampled at each Zone (A to D) across the Old Tailings Dam (OTD) showing back scattered electron images and classified MLA data. Image from Jackson and Parbhakar-Fox (2016).*

New data provided by Grange is from future tailings material (n=5). These composite materials derive from North Pit and Centre Pit (Table 2) and were sent to Mineral Resources Tasmania (MRT).

Table 2. *Detail of samples used in new tailings XRD study*

Reg#	Location	Sample description
G410301	NO Savage	NPUG2-18_12 NP HG Lens 1
G410302	CP Savage	CP2018_07 CP LG Lens 1
G410303	CP Savage	CP2018_02 CP HG Lens 2
G410304	CP Savage	CP2018_02 CP LG Lens 3
G410305	CP Savage	CP2018_02 CP HG Lens 4

At MRT, these samples were prepared and subjected to stereomicroscopy evaluations, Carbon-Sulphur analysis and XRD to evaluate and quantify the mineralogy. Using microscopy techniques, the samples were difficult to assess, though 'black' opaque phases identified as pyrite and magnetite were observed in all analysed microscopy blocks. Based on the C-S data, Bottrill and Coyte (2020) estimated the dolomite and pyrite content with these data plotted as shown in Fig. 3. Three of the Centre Pit samples classified as potentially acid forming (PAF) whilst one was non-acid forming (based on the 3:1 carbonate to sulphide classification- see Parbhakar-Fox, 2017). The North Pit sample (GD10301) was considered weakly PAF (10.8 wt. % estimated dolomite, 3.8 wt. % estimated pyrite) as three times the pyrite abundance is typically required (Paktunc, 1999) to classify a sample as non-acid forming (NAF), and in this case, it is 0.9 wt. % below the required quantity.

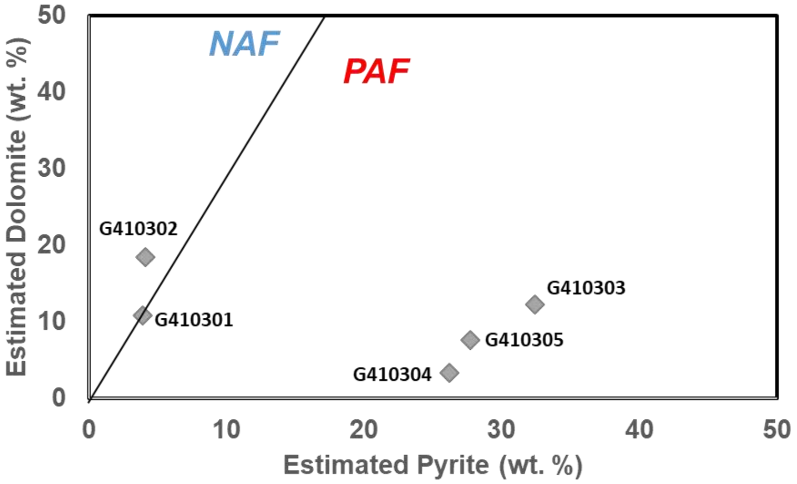

Figure 2. *Bivariate plot of estimated pyrite vs. estimated dolomite for 5 'future tailings' samples analysed by MRT (plot modified from Paktunc, 1999 and Craw, 2000 in Parbhakar-Fox, 2017).*

Bottrill and Coyte (2020) also undertook quantitative mineralogy by XRD to cross-check the results presented in Fig. 2 and the results of this work are shown in Fig. 3. Using a mineralogical bivariate AMD classification plot described in Parbhakar-Fox (2017) these tailings samples all classify as PAF. The content of calcite and dolomite does not satisfy the 3:1 ratio required to classify these as NAF.

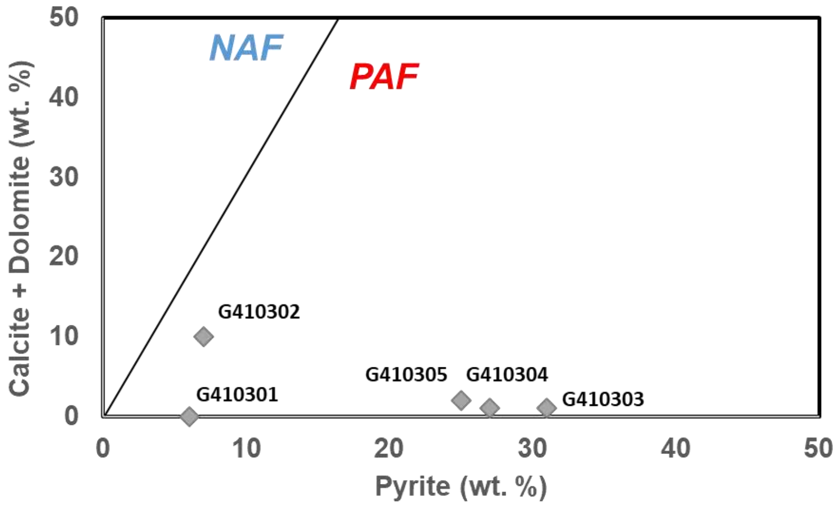

Figure 3. *Bivariate plot of XRD measured pyrite vs. calcite + dolomite for 5 'future tailings' samples analysed by MRT (plot modified from Paktunc, 1999 and Craw, 2000 in Parbhakar-Fox, 2017).*

These findings are consistent with the previously reported behaviour, based on mineralogy, of the OTD tailings (Jackson and Parbhakar-Fox, 2016). Further, they support the conclusions given in the Bottrill and Coyte (2020) MRT report which states that based on the high pyrite content, these samples are likely to be PAF. Whilst serpentinite, antigorite and chlorite are present; their neutralising potential (Table 3) may be insufficient to buffer acid from these pyritic materials, particularly when considering their relative reactivity under different pH conditions (Sverdrup, 2000 *in* Parbhakar-Fox and Lottermoser, 2015). Whilst the neutralising potential contribution of these silicates can be geochemically modelled, it is recommended that establishing ***kinetic column leach trials*** should be made a priority. To ensure a greater number of samples are tested an additional quantity of ***short-term kinetic proxy tests*** (including the OxCon test-Earth Systems or the accelerated pH testing (including short-term Buchner funnel tests or the MATE pH test; Noble et al., 2015) should also be considered.

Table 3. *Selected Sobek neutralising potential (NP) values for minerals and mineral groups (Jambor et al., 2007).*

Group/mineral	Selected Neutralising Potential	Reference
Clay/kaolinite	0	Jambor et al. (2002)
Quartz	0	-
Epidote	1	Jambor et al. (2002)
Ilmenite	1	Estimated
K-feldspar	1	Jambor et al. (2000)
Mica/muscovite	1	Jambor et al. (2000)
Plagioclase	1	Jambor et al. (2006, 2007)
Hematite	2	Jambor et al. (2002)
Magnetite	2	Jambor et al. (2002)
Talc	2	Jambor et al. (2002)
Titanite	2	Jambor et al. (2007)
Amphibole	3	Jambor et al. (2002)
Garnet/almandine	3	Jambor et al. (2002)
Cordierite	4	Jambor et al. (2007)
Pyroxene	5	Jambor et al. (2002)
Garnet/grossular	6	Jambor et al. (2002)
Chlorite/clinochlore	6	Jambor et al. (2002)
Apatite	8	Jambor et al. (2002)
Clay/smectite	8	Jambor et al. (2002)
Mica/phlogopite	8	Jambor et al. (2002)
Analcime	11	Jambor et al. (2006)
Thomsonite-Ca	13	Jambor et al. (2006)
Nepheline	25	Jambor et al. (2006)
Serpentine	32	Jambor et al. (2006, 2007)
Olivine/forsterite	38	Jambor et al. (2002, 2004)
Siderite	864	Calculated
Calcite	1,000	Calculated
Dolomite	1,086	Calculated

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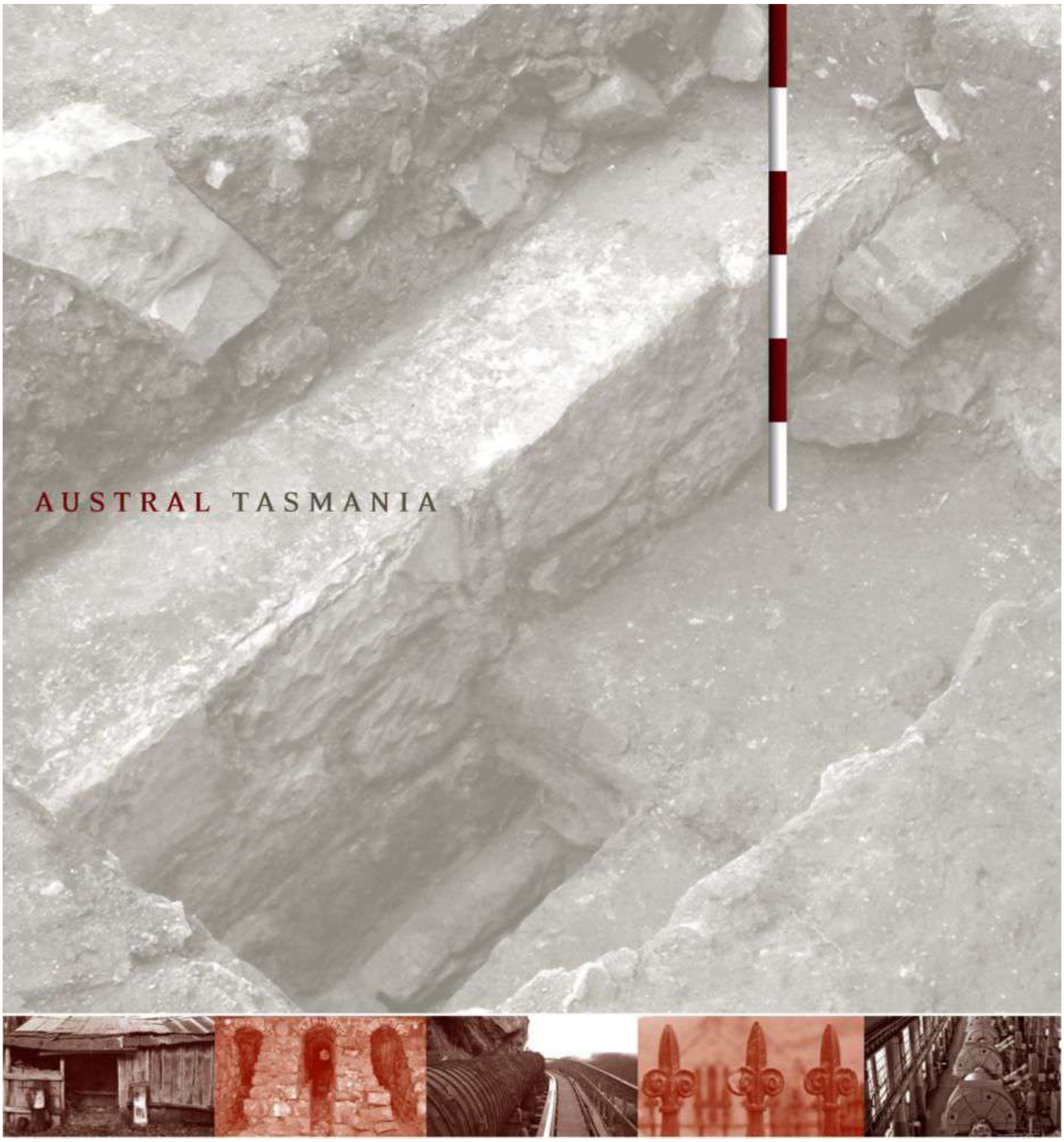
Historic Heritage Assessment

Appendix H

pitt&sherry



Savage River Mine Central Pit Crest Expansion

Desktop Heritage Assessment

Final Report prepared for Grange Resources (Tasmania) Pty Ltd

AT0256

21 February 2019

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EXECUTIVE SUMMARY

Introduction

Grange Resources (Tasmania) Pty Ltd has proposed the expansion of the crest boundary of the existing Central Pit mining operation at their Savage River mine site. The Central Pit is to the east of Savage River, with an expanded boundary surrounding the entire site.

The proposed development area is not currently subject to statutory heritage management. Project Specific Guidelines for the preparation of Development Proposal and Environmental Management Plan (DPEMP), have yet to be released. However, the General Guidelines for a DPEMP do require a level of analysis of potential heritage impacts.[1] Austral Tasmania Pty Ltd has been commissioned by Grange Resources to assist with this process.

The Potential for Heritage Sites or Features to be present in the Study Area

Through a process of historical research and review of previous assessments, this report concludes that there is low potential for significant historic heritage sites or features to be present within the study area. Areas of late nineteenth, early twentieth century iron ore exploration and mining now largely coincide with the Savage River Central Pit which would have destroyed any evidence of historic mining activity in this location, as well as other associated features such as historic track networks and occupation sites.

The western margins of the crest expansion area are outside of current mining areas associated with the Central Pit and these locations correspond with several speculative mining leases taken up for short periods during the late nineteenth and early twentieth centuries. An undefined potential exists for these margins to contain evidence of minor workings such as prospecting pits, trenches or adits. However, the potential for such sites to exist in this locality is low given subsequent exploration and mining activity has focussed within what is now the Central Pit. Some caution should be exercised during works in this area, however further investigations at this stage are not considered warranted.

Potential exists for evidence of historic gold and osmiridium alluvial mining sites within and on the margins of the Savage River. Such sites may include test pits, trenches, mullock heaps and sites of occupation. The western margin of the expanded crest varies in its proximity to the River, but at its narrowest is approximately 50 m distant. Given the steep topography of the river valley, it is unlikely that alluvial mining sites would extend this far inland from the river. However, caution should be exercised should works have the potential to extend closer to the river.

No field investigations are recommended for the expanded crest area based on its low potential to contain historic sites or features. Some caution should be exercised along the western margins of the expanded crest area, and protocols for managing unanticipated historic heritage discoveries within these locations should form part of the project specifications.

Recommendations

1. Managing Potential Aboriginal Heritage

    - The Unanticipated Discovery Plan for managing Aboriginal heritage (Appendix 1) should form part of the project specifications.

2. Dealing With Unanticipated Historic Heritage Discoveries

    - Although historic heritage sites or features are unlikely to be of relevance to the crest expansion, project specifications should include protocols for managing unanticipated historic heritage discoveries during works. This is likely to have greater relevance to the western margins of the crest expansion, but unlikely to be applicable to other areas of the development.
    - If newly identified sites are encountered during works, they should be recorded and assessed before they are impacted, in accordance with Mineral Resources Tasmania's Mining Heritage Guidelines (Appendix 2). Further specialist advice may be required

[1] Board of the Environment Protection Authority, *General Guidelines for preparing a Development Proposal and Environmental Management Plan for Level 2 activities and 'called in' Activities*, January 2014

for the identification, assessment and recording of particularly complex or significant heritage sites.

3. Further Assessment – Works in Close Proximity to the Savage River

    - It is recommended that a further assessment be undertaken if it becomes apparent that the works associated with the proposed crest expansion will extend beyond the nominated study area to the Savage River itself, and its immediate surrounds, that is, within +/- 25 metres of the River.

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Client and project details

Grange Resources (Tasmania) Pty Ltd has proposed the expansion of the crest boundary of the existing Central Pit mining operation at their Savage River mine site. The Central Pit is to the east of Savage River, with an expanded boundary surrounding the entire site (Figure 1).

A Notice of Intent (NoI) for the proposal to be assessed under the *Environmental Management and Pollution Control Act 1994* is yet to be lodged. As such Project Specific Guidelines for the preparation of a Development Proposal and Environmental Management Plan (DPEMP) have not been issued.

The DPEMP General Guidelines do however assist in identifying the key issues which are expected to be addressed in DPEMP.[2] This includes the consideration of potential impacts on cultural heritage. Austral Tasmania Pty Ltd (Austral Tasmania) has been commissioned by Grange Resources to assist with this process.

This report provides a desktop assessment of potential cultural heritage issues related to the proposed expansion of the Central Pit crest boundary. It advises on statutory heritage requirements; documents the history of the area; and assesses the potential of the study areas to contain sites or features of heritage significance which may warrant further consideration through the planning processes for the development.

[2] Board of the Environment Protection Authority, *General Guidelines for preparing a Development Proposal and Environmental Management Plan for Level 2 activities and 'called in' Activities*, January 2014

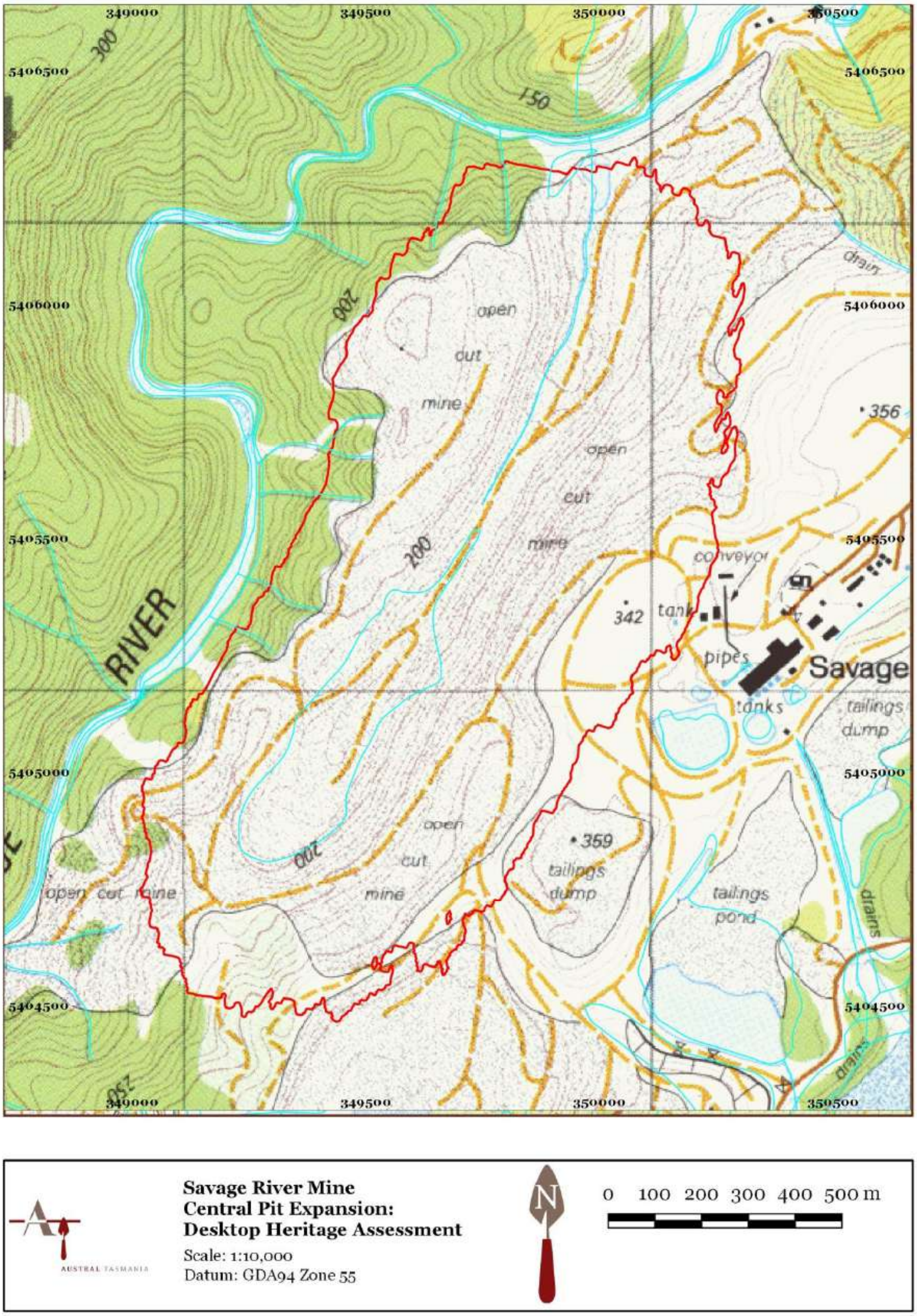

Figure 1: Study area outlined in red (Base image by TASMAP (www.tasmap.tas.gov.au), © State of Tasmania)

1.2 Authorship

This report was written by James Puustinen and Justin McCarthy and reviewed by Alan Hay.

1.3 Approach & Limitations

Austral Tasmania's approach to this project has been to provide a systematic desktop heritage assessment. Statutory heritage registers and lists have been reviewed to identify any historic heritage requirements relevant to the study areas.

As part of the research carried out for this report a range of documentary (including primary and secondary) sources were consulted. This includes historic mining charts and plans, geological reports and previous heritage assessments for the region.

The results and judgements contained in this report are constrained by the limitations inherent in overview type, desktop assessments, primarily accessibility of historical information. Historic maps are reproduced in this report, including those sourced from Mineral Resources Tasmania. These maps are freely available and not subject to copyright. All sources are attributed. All maps and historical overlays are oriented with north at the top of the page unless otherwise assigned. Based on historic sketch plans, often of a large scale, the overlays should be considered an indicative 'best fit', and not necessarily spatially accurate.

An Aboriginal Heritage Property Search has been conducted and the results incorporated into the recommendations made in this report.[3]

Whilst every effort has been made to gain insight to the historic heritage profile of the subject study area, Austral Tasmania Pty Ltd cannot be held accountable for errors or omissions arising from such constraining factors.

1.4 Acknowledgements

The assistance of the following people and organisations is gratefully acknowledged:

- Mr Tony Ferguson, Grange Resources (Tasmania) Pty Ltd;
- Mr Nicholas Van Der Hout, Grange Resources (Tasmania) Pty Ltd; and
- Staff of the Tasmanian Archives and Heritage Office.

[3] Aboriginal Heritage Search Record PS0049639: Mine Rd Savage River Tas 7321 (PID 6998852), 23 January 2019

2.0 HISTORIC HERITAGE ASSESSMENT

2.1 Desktop review of registered and listed heritage places

Both Federal and State Acts of Parliament may have a bearing on the management of cultural heritage within or adjacent to the subject study area. Key legislation is summarised below. The summary is intended as a guide only and should be confirmed with the administering agency and, where necessary, specialist legal opinion.

2.2 National Heritage Management Provisions

2.2.1 World/National/Commonwealth Heritage Lists

There is an established framework for the identification, protection and care of places of significance to the nation and/or Commonwealth. Entry in the National and/or Commonwealth Heritage Lists triggers statutory processes under the terms and provisions of the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. Actions which will or may have a significant impact upon the recognised values of a listed place are required to be referred to the Australian Government Minister for the Environment, after which a judgement will be made as to whether the proposed action will require formal assessment and approval. The Act also provides for consideration of actions that may occur outside of a listed place that may have significant impact upon national heritage values, or actions taken on Commonwealth land or by Commonwealth agencies that are likely to have a significant impact on the environment (anywhere). Listing occurs by nomination, which may be made by any one at any time. The Act also provides for emergency listing where National Heritage values are considered to be under threat.

As at January 2019, the study area is not included in or nominated to the World, National or Commonwealth Heritage Lists.[4]

2.3 State Heritage Management Provisions

2.3.1 *Historic Cultural Heritage Act 1995*

The *Historic Cultural Heritage Act 1995* (*HCH Act*) is the key piece of Tasmanian legislation for the identification, assessment and management of historic cultural heritage places.

The *HCH Act* establishes the THR as an inventory of places of State significance; to recognise the importance of these places to Tasmania; and to establish mechanisms for their protection. 'State historic cultural heritage significance' is not defined, however the amended Act allows for the production of 'Guidelines', which presumably will use the existing assessment guidelines for the purposes of defining State level significance.[5]

A place of historic cultural heritage significance may be entered in the THR where it meets one of eight criteria. The criteria recognise historical significance, rarity, research potential, important examples of certain types of places, creative and technical achievement, social significance, associations with important groups or people, and aesthetic importance.

Works to places included in the THR require approval, either through a Certificate of Exemption for works which will have no or negligible impact, or through a discretionary permit for those works which may impact on the significance of the place.

Discretionary permit applications are lodged with the relevant local planning authority. On receipt, the application is sent to the Heritage Council, which will firstly decide whether they have an interest in determining the application. If the Heritage Council has no interest in the matter, the local planning authority will determine the application.

If the Heritage Council has an interest in determining the application, a number of matters may be relevant to its decision. This includes the likely impact of the works on the significance of the place; any representations; and any regulations and works guidelines issued under the *HCH Act*. The Heritage Council may also consult with the planning authority when making a decision.

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[4] http://www.environment.gov.au/cgi-bin/ahdb/search.pl

[5] *Assessing historic heritage significance for Application with the Historic Cultural Heritage Act 1995*

In making a decision, the Heritage Council will exercise one of three options: consent to the discretionary permit being granted; consent to the discretionary permit being granted subject to certain conditions; or advise the planning authority that the discretionary permit should be refused.

As at January 2019, the study area is not included in the THR.[6]

2.3.2 *Aboriginal Heritage Act 1975*

The *Aboriginal Heritage Act 1975* (*AHA 1975*) is the key Tasmanian legislation providing for the conservation of Aboriginal heritage. The *AHA 1975* applies to 'relics' which are defined as:

> 2 (3)(a) any artefact, painting, carving, engraving, arrangement of stones, midden, or other object, made or created by any of the original inhabitants of Australia or the descendants of any such inhabitants, which is of significance to the Aboriginal People of Tasmania; or;
>
> (b) any object, site, or place that bears signs of the activities of any such original inhabitants or their descendants, which is of significance to the Aboriginal People of Tasmania; or
>
> (c) the remains of the body of such an original inhabitant or of a descendant of such an inhabitant that are not interred in –
>
> (i) any land that is or has been held, set aside, reserved, or used for the purposes of a burial-ground or cemetery pursuant to any Act, deed, or other instrument; or
> (ii) a marked grave in any other land
>
> 2 (4) Despite subsection (3)(a) or (b), objects made, or likely to have been made, for the purposes of sale (otherwise than by way of barter or exchange in accordance with Aboriginal tradition) are not relics for the purposes of this Act.[7]

All relics are protected under the provisions of the *AHA 1975*, including those found during works. Permits are required for a range of activities, including to:

(a) destroy, damage, deface, conceal, or otherwise interfere with a relic;

(b) make a copy or replica of a carving or engraving that is a relic by rubbing, tracing, casting, or other means that involve direct contact with the carving or engraving;

(c) remove a relic from the place where it is found or abandoned;

(d) sell or offer or expose for sale, exchange, or otherwise dispose of a relic or any other object that so nearly resembles a relic as to be likely to deceive or be capable of being mistaken for a relic;

(e) take a relic, or cause or permit a relic to be taken, out of this State; or

(f) cause an excavation to be made or any other work to be carried out on Crown land for the purpose of searching for a relic.[8]

An Aboriginal Heritage Property Search has been conducted for the study area to determine if it contains any previously recorded Aboriginal heritage sites, or if there are any specific Aboriginal heritage constraints that apply to the place. The search has not identified any registered Aboriginal relics or apparent risk of impacting Aboriginal relics. These results remain valid until 23 July 2019.[9]

The absence of registered Aboriginal relics does not mean that the study area does not have the potential to contain such items. All Aboriginal relics are protected under the *AHA 1975*, including those found during works. An Unanticipated Discovery Plan should be implemented should Aboriginal Heritage be discovered during ground disturbance works.[10] This Unanticipated Discovery Plan is included at Appendix 1.

2.4 Local Heritage Management

2.4.1 *Waratah-Wynyard Interim Planning Scheme 2013*

The study area is located within the planning area of the *Waratah-Wynyard Interim Planning Scheme 2013*. The Scheme establishes in section E5 a Local Heritage Code, which in part, has a

[6] LIST Map, Search 23 January 2019
[7] *Aboriginal Heritage Act* 1975, s2(3)
[8] *Ibid*, s14
[9] Aboriginal Heritage Search Record PS0049639: Mine Rd Savage River Tas 7321 (PID 6998852), 23 January 2019
[10] *Ibid*

purpose to conserve buildings, areas, and other places identified by the Code to have scientific, aesthetic, architectural or historic interest or otherwise of special cultural value.[11]

The provisions of the Code apply to places or conservation areas indentified in 'E5.1 Table to the Local Heritage Code'. This Table remains unpopulated, and therefore there are no places or conservation areas within the study areas included in the Table.

2.5 Non-Statutory Management and Identification

2.5.1 Register of the National Estate

The Register of the National Estate (RNE) was established in 1976 as a list of natural, Indigenous and historic heritage places throughout Australia, with limited statutory mechanisms relating to actions taken by the Commonwealth. As of February 2007, the RNE ceased to be an active register, with places no longer able to added or removed and the expectation that the States and Territories would consider places included on the RNE for management under relevant State legislation. The RNE ceased to exist as a statutory register on 19 February 2012 and references to the RNE were removed from the *EPBC Act*. The RNE continues to exist as a non-statutory information source. Coincidence with other heritage lists and registers (including the THR and planning scheme heritage schedules) is not uncommon. The Tarkine Wilderness Area and Savage River Region are included in the RNE under the natural places class. There are no cultural heritage places within the study area included in the RNE.

2.6 Section Summary

Table 1 below summarises the various statutory and non-statutory mechanisms and identifies those in which part of the site is listed.

Register/Listing	Inclusion	Statutory Implications
National Heritage List	No	No
Commonwealth Heritage List	No	No
Tasmanian Heritage Register	No	No
Aboriginal Heritage Act 1975	No	Yes
Waratah-Wynyard Interim Planning Scheme 2013	No	No
Register of the National Estate	No	No

Table 1: Summary of statutory and non-statutory mechanisms

[11] W-W IPS 2013, Cl.E5.1(a)

3.0 HISTORICAL OVERVIEW

3.1 Introduction

The purpose of the following section is to analyse and summarise the known past uses and development of the region. This in turn assists in understanding the potential for the study area to contain sites or features of heritage significance.

The study is located in the vicinity of Savage River, on the north west coast of Tasmania. Mining activity, both past and present are the key relevant land uses, and are described below. Of some benefit to this project are the series of geological reports and investigations dating from the late nineteenth century. In combination with historical plans and newspaper reports, a certain level of understanding of the study area can be constructed. Arranged chronologically, the following key phases of post colonisation land uses are discussed:

- The European exploration of the region;
- The emergence and development of gold mining;
- Osmiridium mining in the district;
- Speculative mining leases in the area; and
- The development of iron ore resources.

3.2 The European Exploration of the Region

For much of the nineteenth century, the rugged and impenetrable forests of the west coast constrained European exploration to the coastal fringe. With the exception of loggers in search of huon pine, the area appears to have been largely ignored.

Interest was revived during the 1860s in the hope of finding rich mineral deposits. In 1864 the government employed Gordon Burgess to cut a track through the country to the north of the Pieman River. Burgess followed the higher, more open land through to the Savage River. He was accompanied by two men, Savage and Heazlewood, and it is believed that Burgess named these two rivers after his companions.[12]

Despite this work, it was not until 1871 and the discovery of tin at Mount Bischoff that any real incentive existed to enter the region when the hope of finding tin and other minerals, in particular gold, pushed prospectors into the area along the Pieman and its tributaries.[13]

Surveyor Charles Sprent was engaged to survey new track routes in the region and investigate its mineral potential. Several expeditions were carried out over 1876-77. In the vicinity of the Donaldson River, he wrote of:

> Noticing some pebbles of iron ore in the creeks we traced the gullies up and soon came to an immense quantity of iron ore, thousands of tons strewing the surface of the ground. ....
>
> We traced the iron over some half a mile of country up the river, and also examined the river for gold but on the immense quantity of iron sand in every dish we had not much success. ... Altogether this is a country well worth prospecting.[14]

The resulting survey works were documented in an 1879 sketch map, which although not spatially accurate, locates the key geographical features in relation to the study area (Figure 2). It also notes the key mineral discoveries, including iron and gold.

[12] McConnell, *Cultural Heritage Survey and Assessment of the Extension to Broderick Creek Waste Rock Dump & Lower Conveyor Footings, Savage River Mine, Northwest Tasmania*, report for Australian Bulk Minerals, Burnie, Tasmania, September 1997, p.15

[13] Pink, K, *The West Coast Story. A History of Western Tasmania and its Mining Fields*, Zeehan: West Coast Pioneers' Memorial Museum, 1982, pp.126-127

[14] Sprent, CP, Western Country Reports by the Hon J. R. Scott and Mr C. P. Sprent , MRT Report OS_023, 1877, p. 7

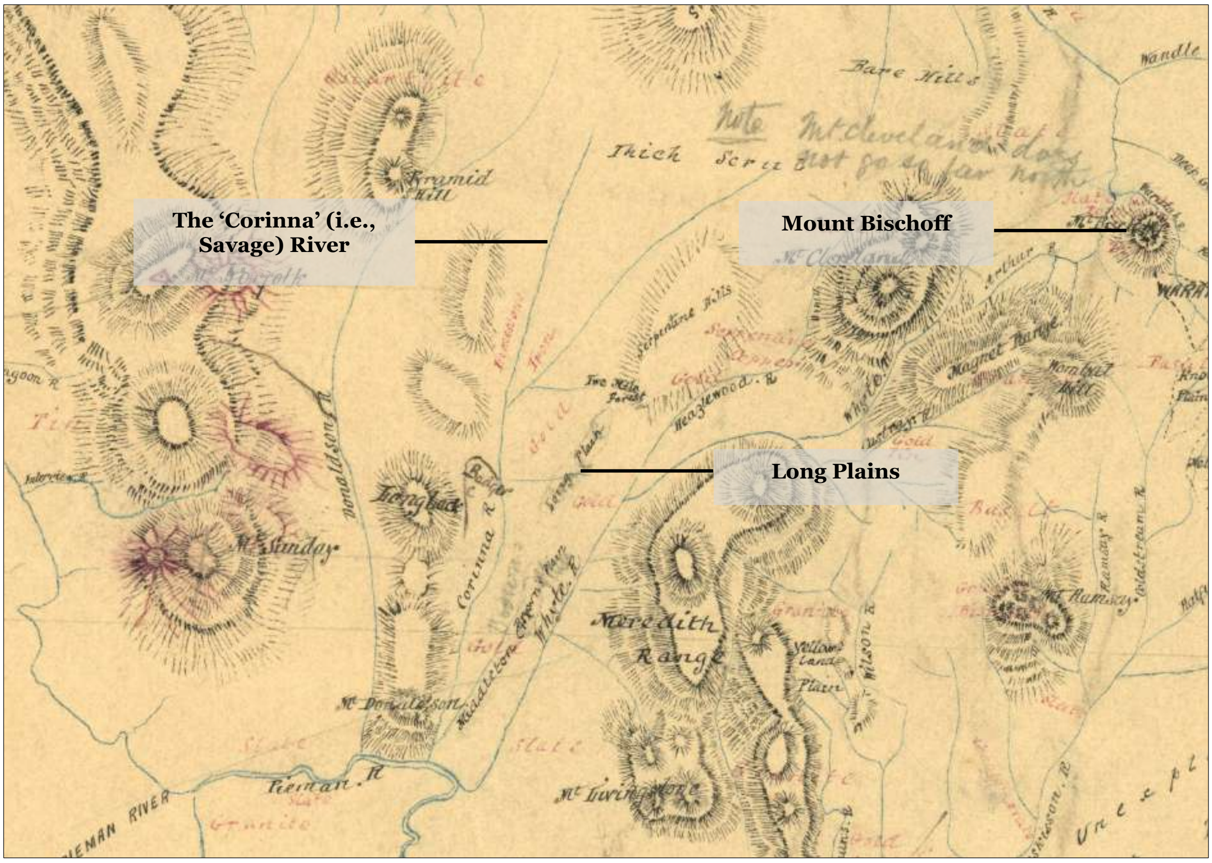

Figure 2: Detail from Charles Sprent's 1879 exploration map. The Savage River is labelled the 'Corinna River' on the map. Note also the descriptions of gold, serpentine and iron (CPO, Exploration Chart No. 28, compiled from all authentic data by Mr Charles Sprent, 1879. Reproduced with the permission of the Department of Primary Industries, Parks, Water and Environment, Information and Land Services Division © State of Tasmania)

3.3 The Emergence and Development of Gold Mining

Interest in gold brought many prospectors to the remote and challenging district during the late 1870s. In January 1879, alluvial gold in payable quantities was found in the area between the Whyte and Savage rivers, with newspaper reports predicting the 'probability of a rush'.[15]

The prediction proved correct. Within weeks, 400 prospectors were exploring the Middleton Creek area near Corinna located to the south of the study area. Gold was later discovered by TB Moore and Foster on the Donaldson River, and by the end of 1879, Johnson and Peevor found gold at Long Plains, sparking interest in the Savage River area. These first discoveries were mainly of small amounts of alluvial gold within Savage River and its tributaries. These sources were soon exhausted, but were followed by major discoveries at Long Plains and Specimen Reef, to the north and south of the study area. At the time, the Long Plains field was forecast as being 'the richest alluvial field ... yet discovered in Tasmania'.[16]

The Long Plains and Specimen Reef areas were discovered and developed during the same period. The key area of workings at Long Plains on the area termed the Golden Ridge is located some 1.5 kilometres to the south of the study area, with Specimen Reef located some 4.9 kilometres to the north (Figure 3).

Weather, isolation and the difficult environment made working the fields a difficult prospect. The route linking Waratah to Corinna remained a very rough pack track. Both private and government huts were established along the track to service the influx of miners. It was not until the 1890s that better tracks were established with the formation of the Waratah to Corinna cart road. Because of the

[15] *The Mercury*, Tuesday 7 January 1879, p. 3
[16] *Launceston Examiner*, Wednesday 26 April 1882, p.3; McConnell, *op. cit.*, September 1997, p. 16

terrain and weather, many kilometres of the track were corded. It was at the time, the only inland road to the mining fields on which a vehicle could travel.[17]

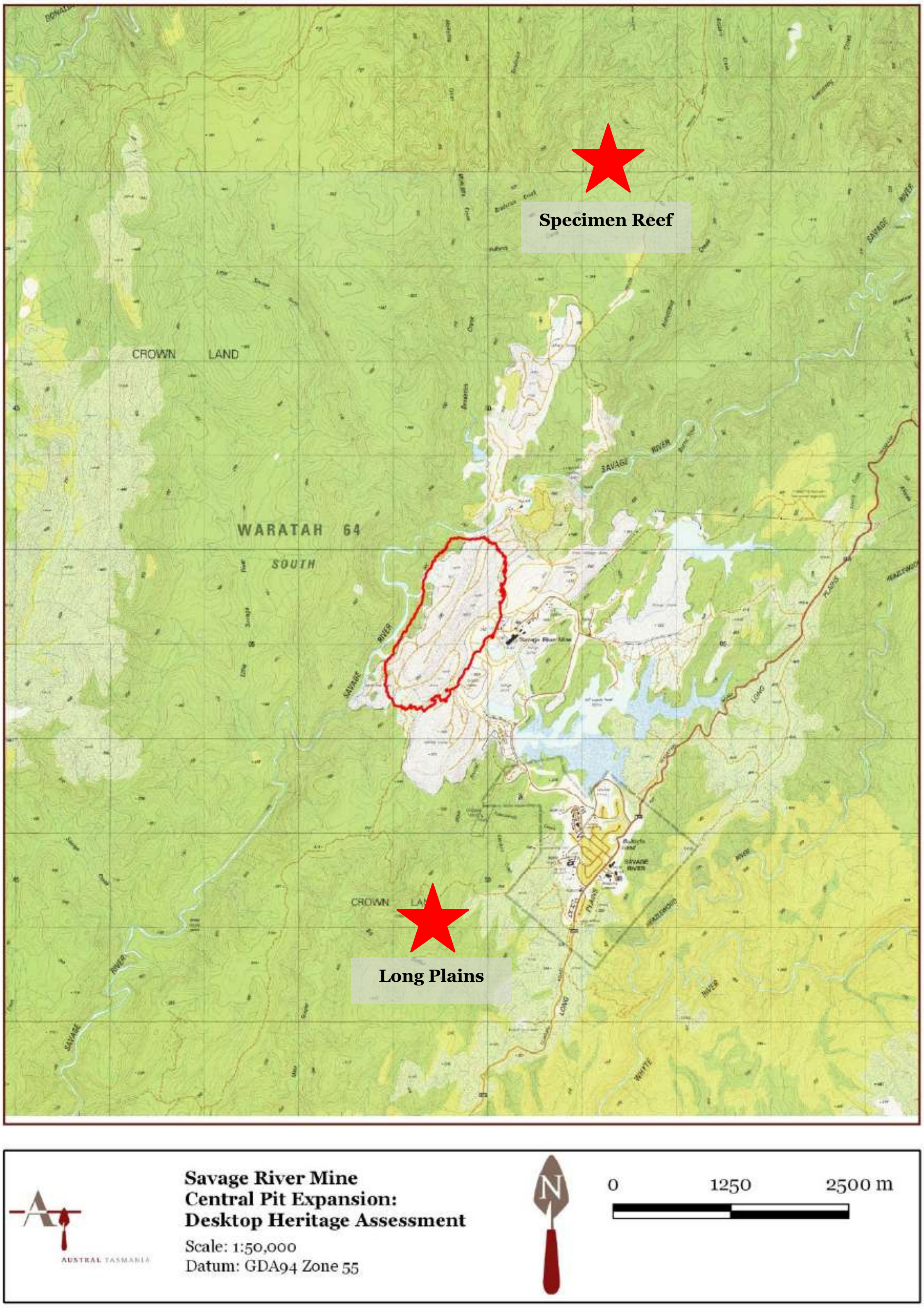

Figure 3: Key areas of historic gold mining activity in relation to the study area - Long Plains and Specimen Reef (Base image by TASMAP (www.tasmap.tas.gov.au), © State of Tasmania)

[17] *Ibid*; McConnell, *op. cit.*, September 1997, p.17

3.3.1 The Long Plains Gold Field

The earliest prospecting and mining work at Long Plains was carried out by the partnership of Tom Smith and Harry Howard, most likely in the vicinity of Townsends Creek and beginning in 1882. A gold rush soon followed, with about 150 diggers working the field by April, with exploration of the various small watercourses leading into Main Rivulet. Rich deposits of very coarse alluvial gold were found in these creeks, the largest single nugget being over 113 grams. The exact amount of gold extracted from the field is somewhat of a mystery, with an 1882 report noting that some 104 kilograms had been recovered. The area was first worked by panning and sluicing, and then a process developed by which diggers worked a patch of a creek, abandoned it after extracting the observable gold, before others turned to the same area and successfully discovered new, unworked deposits.[18]

The largest single area of development within the Long Plains field was undertaken by D Weetman and H and E Crockford on the area known as Golden Ridge. The party had found two gold-bearing veins of quartz on their prospecting claim, located on a ridge dividing Gray's from Obsidian creeks. Outcrops of the veins were found on opposite sides of the ridge, and two 15 acre reward claims were issued. Most of the surrounding creeks had been worked out by the time Weetman and Crockford took up their reward claims.[19]

By 1888 work had only progressed on the southern of the two reward claims. Here, shafts, winzes and adits had been driven to follow the course of the gold-bearing quartz veins, extracting more than 1.1 kilograms of gold. Weetman and Crockford established a mining company in 1888 to work the deposits. The operation extracted the gold by puddling, and after having spent £2,500, abandoned work the following year. The hope of finding a gold reef did not eventuate.[20]

Whilst being a very rich field, production only lasted a few years. By 1897, HH Gill held Weetman and Crockford's two reward claims. The two sections were crossed by a spur covered with quartz gravel of varying depths. Three tunnels had been cut on the western side of the ridge and connected by winzes, that is, shafts or inclined passages leading from one level to another. Rich patches of quartz had been found in the rises from the No. 2 to the No. 1 tunnel. At the time of Harcourt Smith's inspection the No. 3 tunnel was flooded. A good deal of 'driving' (i.e. of adits and winzes) had been undertaken, but the geologist struggled to understand why more exploratory work had not been carried out.[21]

The area was again officially investigated in 1900 by government geologist WH Twelvetrees; Workings noted included open cuts, and some eight tunnels cut into the side of the hill, one extending for approximately 304 metres. Twelvetrees considered that the claim had been well prospected in different directions, but doubted the site warranted any considerable outlay, with no signs of solid reefs existing. He also noted that all the neighbouring creeks had yielded gold, reputedly some 113.4 kilograms, found in both the quartz, and in the magnetite.[22]

A further examination of the area was made by Twelvetrees in 1903. By this time, activity on the field had substantially declined. Alluvial deposits from the creeks had been worked out, to be replaced by a limited number of small mines and hydraulic sluicing operations.[23]

Weetman and Crockford's workings (at the time held by Gill) was the largest on the Long Plains field and some of the underground developments on the Golden Ridge were depicted on a sketch plan prepared by Twelvetrees in 1903 (Figure 4). Four gold bearing formations were located on the ridge, running largely parallel with each other and notated on the plan as A, B, C and D. Of the various tunnels driven into the hill, none had been successful in opening up any permanent run of gold-bearing material. Gold mining on the Golden Ridge had largely ended by 1900, but small-scale and intermittent work continued over the coming decades.[24]

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[18] *Launceston Examiner*, Wednesday 26 April 1882, p.3; *The Mercury*, Saturday 1 July 1882, p.3
[19] *Launceston Examiner*, Friday 30 January 1885, p.3; Twelvetrees, WH, *Report on the Mineral Fields between Waratah and Corinna*, 1900, MRT Report OS_158, p.5
[20] *Launceston Examiner*, Monday 26 November 1888, p.4; Twelvetrees, *op. cit.*, 1900, p.6; Haygarth, N, Cubit, S (ed.), *A Peopled Frontier: The European Heritage of the Tarkine Area*, Circular Head Council: Smithton, 2008, p.21
[21] Harcourt Smith, J, *Report on the mineral district between Corinna and Waratah*, MRT Report OS_128, 1897, p.3
[22] Twelvetrees, 1900, *op. cit.*, pp.3, 50-52
[23] Twelvetrees, 1903, *op. cit.*, p.2
[24] Nye, PB, *Shores Surprise Mine, Long Plains*, 1931, MRT Report UR1931_049, p.1

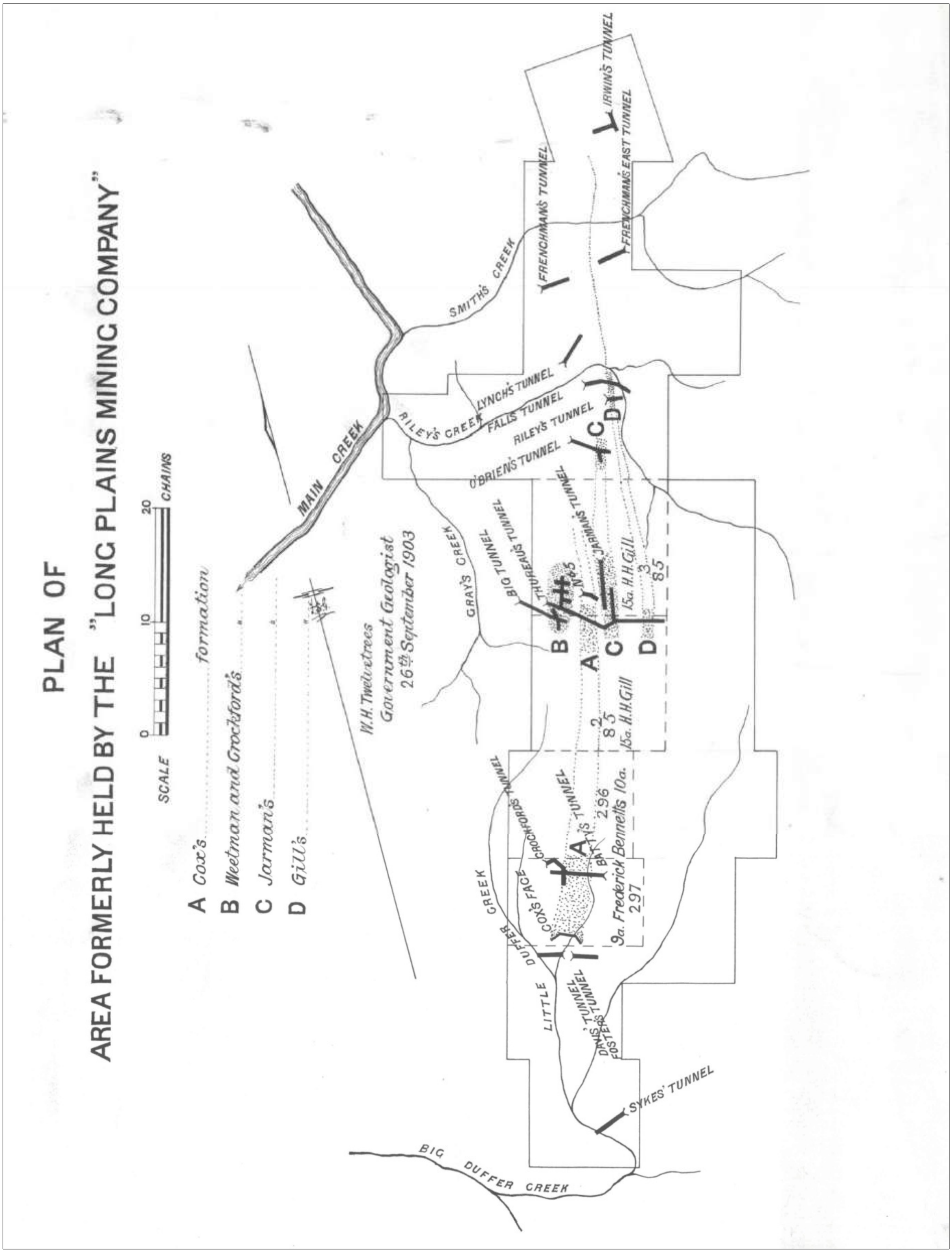

Figure 4: Twelvetrees' 1903 plan of the Long Plains gold field. North to top of Figure (Twelvetrees, WH, Long Plains Gold Mining Company, Workings, 1903, MRT Plan 43. Plan obtained from Mineral Resources Tasmania).

3.3.2 The Specimen Reef

Gold was discovered in the Specimen Reef area by late 1882 by prospectors Joseph Thunder and Thomas Greenway who reportedly extracted some 1.1 kilograms of the precious metal from the head of the creek. Already it was considered likely that a reef would exist and prospector's claims were quickly applied for under the name of the Specimen Reef Company and subscribed to by local shareholders. Thunder and Greenway were soon joined by others, with 12 leases of 10 acres each positioned over the various creeks.[25]

Initial work by Thunder and Greenway focussed on alluvial mining in the creek, but by April 1883 works had begun on constructing huts for the coming winter and cutting about 40 metres of an exploratory tunnel. The first official visit by a government geologist took place in April 1884, who was encouraged by the progress of works, with the Upper Tunnel extending for some 91 metres which located gold bearing stone, while the longer, Lower or Main Adit reached some 182 metres, but without successful discoveries. The installation of machinery to crush the ore was recommended.[26]

Expertise from Victoria was sought to assist with further development, including providing advice on the heavy outlays needed for the erection of stamper batteries and ensuring they were appropriately located to maximise the amount of water power. The chosen location for the machinery site was on Specimen Creek, about 42 metres downstream from the Lower Adit. The adit could then be connected to the machinery through a tramway, built for a 'very moderate cost'.[27] Progress however was a slow affair and transport was a key impediment. Despite initial positive results, it was decided in 1886 to wind up the existing Specimen Reef Gold Mining Company and establish a new enterprise in the hope of attracting Victorian investors.[28]

The New Specimen Reef Gold Mining Company was soon formed, and with more shareholders, infrastructure works began. By December 1887 continuous work was being carried out to prepare the battery site and the pit for the water wheel. A contract had been issued to erect a six-head battery, to be delivered to site in early January 1888.[29]

Progress was made in the construction of plant and machinery, all brought to the site on pack horses, This was the first mine beyond Mount Bischoff at which machinery was installed. The machinery site was located on the creek and had to be blasted out of the solid rock to a depth of approximately 8.5 metres. Within this location, the 10.36 metre diameter water wheel was erected. The beams connecting the wheel to the machinery were approximately 8.53 metres long and had to be dragged by the miners to the site through thick forest and a deep gorge. Excavated stone from the tunnels was brought to the site via tramways.[30]

Water was required to turn the wheel, and a dam over Specimen Creek was constructed above the machinery site. The dam was approximately 9.1 metres across and 3.6 metres wide at the top. It aimed to capture enough water during the wetter months to power three shifts of the battery a day. From the dam, water was directed to the wheel via 45 metres of fluming. After powering the wheel, the water was returned to the creek via a 30 metre long tail race.[31]

Despite these works, the lack of water would appear to have been a key problem with the natural flow of Specimen Creek and the dam insufficient to effectively power the wheel and drive the battery. Works soon began on cutting water races using contract labour. By September 1889 some 3.6 kilometres of the race had been cut, and men were engaged in puddling its base to stop leaks. Eventually, approximately 6.4 kilometres of races were cut to feed the plant.[32]

Some level of production at Specimen Creek had begun by January 1890 with the completion of the amalgamating and concentrating machinery. The tailings were then run through the first

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[25] *Launceston Examiner*, Saturday 11 November 1882, p.2
[26] *Launceston Examiner*, Monday 23 April 1883, p.3; Thureau, G, *Report on Mount Cleveland and Corinna Gold Fields*, MRT Report 1884, Os_053
[27] *Daily Telegraph*, Monday 14 July 1884, p.3
[28] *Launceston Examiner*, 3 March 1885, p.3
[29] *Daily Telegraph*, Tuesday 27 December 1887, p.3
[30] *Daily Telegraph*, Wednesday 17 October 1888, p.3; The *Tasmanian*, Saturday 10 November 1883, p.1298; Haygarth, *op. cit.*, p.21
[31] *Daily Telegraph*, Wednesday 17 October 1888, p.3
[32] *Daily Telegraph*, Wednesday 28 August 1889, p.3; *The Colonist*, Saturday 14 September 1889, p.3; *Daily Telegraph*, Thursday 26 September 1889, p.3; Kostoglou, *op. cit.*, p.5

concentrator, to be followed by processing the concentrate over reducing tables. Some 37 grams of gold had been retrieved towards the end of the month.[33]

It would appear that that the expensive works of installing machinery, cutting water races and dams, and forming tramways was completed by May of 1890. Although some extremely rich stone had been obtained from the lease near the ground surface, underground production had been minimal. The lack of water to drive the machinery was a factor in the difficulties of the mine, but access was also a key impediment, with the poor standard of the tracks greatly increasing the costs and time required to bring stores and tools to the site.[34]

Unable to address the challenges, the Company entered into liquidation later that year with all plant and equipment to be put up for auction and sought to dispose of its lease.[35] The Company may not have been able to find a buyer and the site was leased to tributors.[36] A useful plan of the mine was prepared during this period, indicating key features at the site including the battery, two dams, three water races and the tracks which accessed the area (Figure 5).

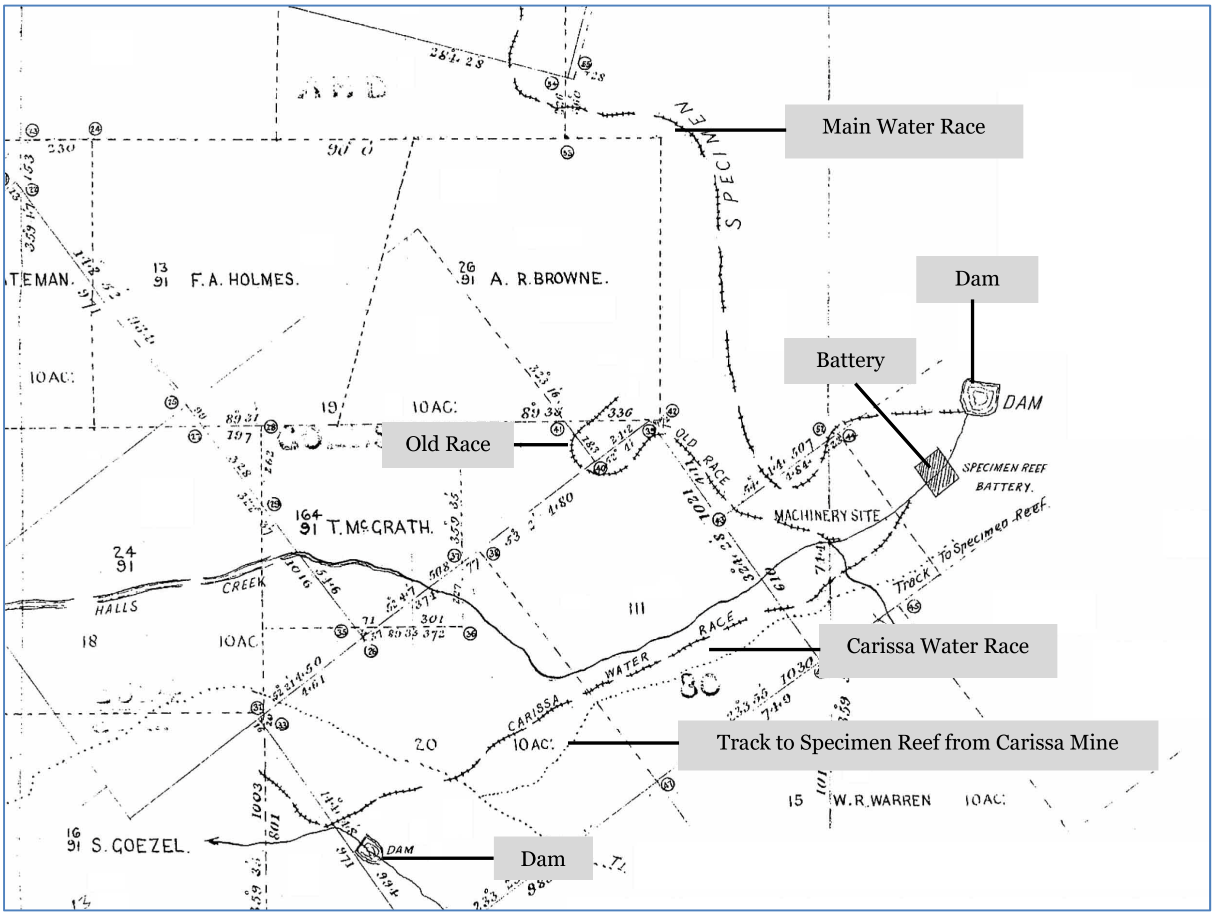

Figure 5: Detail from 1891 geological sketch plan of the Specimen Reef area with key features indicated. North to right of figure (Reproduced from Kostoglou, P, *Archaeological Survey Report 1999/10. An Archaeological Survey of the Historic Specimen Reef Goldfield*, report prepared for Mineral Resources Tasmania, 1999).

Minor tribute works or prospecting characterised operations on the Specimen Reef for the remainder of the nineteenth century. The last attempt to mine the site began in 1898 but again with little success. The Specimen Reef mine was closed by 1901-02, and the leases forfeited in 1903. The last gold lease at Specimen Reef became void in December 1908. Some level of interest remained over the coming decades, and sampling of the water course took place in 1933, but very little gold was found.[37]

33 *Daily Telegraph*, Thursday 23 January 1890, p.3

34 Kostoglou, P, *Archaeological Survey Report 1999/10. An Archaeological Survey of the Historic Specimen Reef Goldfield*, report prepared for Mineral Resources Tasmania, 1999, p.5

35 *The Mercury*, Saturday 17 May 1890, p.1S; *Daily Telegraph*, Friday 12 December 1890, p.3; *Launceston Examiner*, Saturday 10 September 1892, p.6

36 *Launceston Examiner*, Tuesday 9 April 1895, p.7

37 Kostoglou, *op. cit.*, p.5

3.4 Osmiridium Mining in the District

During the early twentieth century the broader district became an important source of osmiridium, a rare metal associated with platinum, although with its own unique attributes. The key use for the extremely hard and non-corrosive metal was in the manufacture of pen nibs for fountain pens. Other uses included electrical work, photography and jewellery.[38]

Tasmania's osmiridium deposits were found at various locations on the west coast, including within the Savage River, where it had originated from Nineteen Mile Creek, located to the north an area later termed the Bald Hill Osmiridium Field. All such areas shared the common characteristics of holding large deposits of serpentine, a mottled stone formed from hydrated magnesium silicate, and located within creek beds, on hillsides and even plateaus. Osmiridium had been located as part of the gold mining on the Savage River from the 1880s. However, the metal had no market at the time, and miners were penalised for its presence in their gold. Indeed, all osmiridium recovered in gold sluicing operations was thrown away. By 1900, the metal had begun to achieve a value, and osmiridium was regularly being taken to Waratah for sale where good prices were received.[39]

In 1910 the Tasmanian Government first recognised osmiridium as a mineral resource, enabling the State to enter the world trading market. In c.1912, 150 diggers were working on the Savage River and Nineteen Mile Creek areas, with number falling to about 65 miners the following year. More valuable than gold, it was reported that prospectors in the Savage and Wilson River areas in late 1912 were making as much as 25 to 30 shillings a day from osmiridium.[40]

It was in the post-war period that the interest returned to the mineral and parties began to work the Savage River sands, gradually extending up to Nineteen Mile Creek, flowing from Bald Hill, which developed into the main source of the metal in the region.[41]

The Bald Hill field occupied an area approximately 48 kilometres long and some 4.8 - 8 kilometres wide. Until the later discoveries at Adamsfield, it formed the most important source of osmiridium in Tasmania. Key areas of workings were found on Nineteen Mile Creek, Warner Creek, Jones Creek, Burgess Creek and the Heazlewood River.

The main source of osmiridium deposits within the Savage River originated from Nineteen Mile Creek to the north. The richest deposits had been found on the bed of the stream and near the water's edge. It was also found on the terraces elevated above the valley walls, although the steepness of the terrain prevented these terraces from containing substantial amounts of the metal. Very little of the precious metal had been discovered above the confluence of Nineteen Mile Creek with Savage River. Being so far from its source, the Savage River deposits were characterised as being very fine, commanding a high market rate.[42]

A more unusual operation was carried out by William Caudry on a 40 acre claim awarded to him in 1913 for the discovery of osmiridium in the serpentine rock. Caudry's prospect was located on the western end of Bald Hill, some 9 kilometres to the north east of the Savage River township site. The initial discovery was made on the north side of McGinty Creek, and its source was followed up the side of the hill. Here, Caudry and George Fenton discovered osmiridium within its host serpentine rock. Reputedly, the only precedent for such a find was at Nizhni Tagil in the Urals of the Soviet Union. Caudry attempted to undertake hard rock mining of the osmiridium, by crushing the stone in a 5-head stamper battery, before grinding the ore. Using this method, he crushed 75 tons of rock, returning about 5.6 kilograms of osmiridium, valued at £6,200. Age and ill health forced his retirement in 1926, ending Tasmania's first attempt at hard rock mining.[43]

In 1921, the Department of Mines published their most thorough investigation into the Tasmanian osmiridium industry to date. This work seems to have been prompted by the substantial increase in international demand for the metal, which in turn resulted in the growth of the industry. This growth was strengthened by Tasmania's enviable position of being the sole producer on a large scale of

[38] Brown, C, *A Review of the Osmiridium Mining Industry of Tasmania*, John Vail, Government Printer: Hobart, 1919, MRT Report: OS-258, pp.1, 3-4, 21; Bacon, C, *Notes on the History of Mining and Exploration at Adamsfield. Mineral Resources Tasmania Report 1992/20*, 1992, MRT Report: UR1992_20, p.1; Reid, A.M, *Geological Survey Bulletin No. 32, Osmiridium in Tasmania*, GSB32, 1921, p.109
[39] *Ibid*, p.66
[40] Twelvetrees, WH, *The Bald Hill Osmiridium Field. Geological Survey Bulletin No. 17*, Department of Mines: Hobart, 1914, MRT Report: GSB17, p.35
[41] *Ibid*, 1914, p.11; McIntosh Reid, *op. cit.*, p.45
[42] Reid, *op. cit.*, pp. 49-50, 66
[43] Haygarth, N, 'Pen-Pushers with Pans: 20th-century Tasmanian Osmiridium Mining', in *Mining History: The Bulletin of the Peak District Mines Historical Society*, Vol. 17, No. 4, 2009, p. 84

granular metal. By the time Reid visited the field in 1920, osmiridium had become scarce within Nineteen Mile Creek, with comparatively little unworked ground left available. In many places the bed of the stream had been worked multiple times by the diggers. The general method of mining on the creek was to pick or blast the creek bottom and empty the stone into sluice boxes.[44] During Reid's investigations, about 70 to 80 miners were working Savage River over a distance of approximately 24 kilometres. Mining took place during the brief summers, when the low water levels allowed the river to be safely worked. The largest and richest deposits were found to be within the bed of the stream and on the riverbanks. The general method of mining involved the construction of wing dams, providing access to the wash and dirt which was then sluiced, although he noted that the most primitive methods using pans and cradling were also employed (Figure 6).[45]

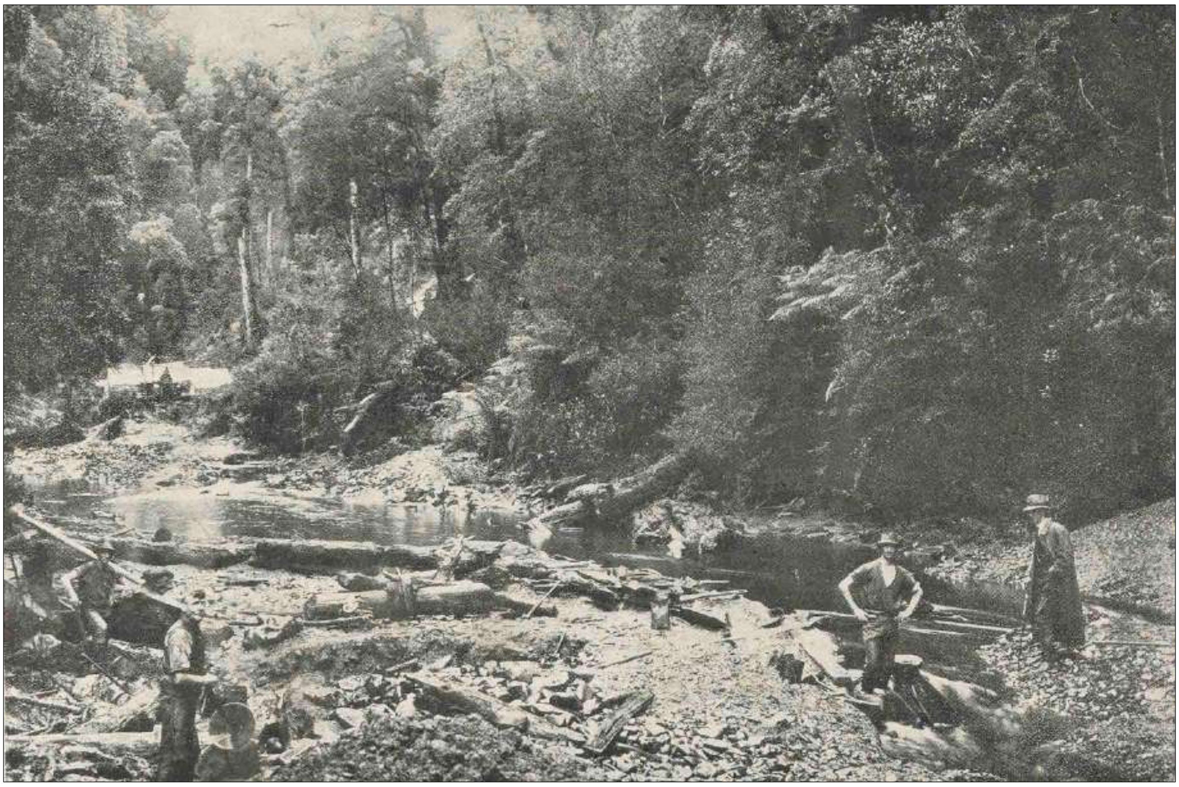

Figure 6: Osmiridium prospecting on the Savage River (TAHO, *The Weekly Courier*, 25 March 1920, p.22, Reproduced with permission).

Who these miners were and the specific locations of their work has not been established, although this is not of itself unusual, and relates to the manner in which production and sales were regulated. Government policy was to protect the interest of individual miners or small groups, and prevent monopolies being established by a single person or a company.[46] This was achieved through regulating who, where and how a person could claim and develop land. Single miners or small groups were entitled to make claims for miner's rights. A single miner was eligible to a half-acre claim, to be marked off in the form of a square - 50 yards by 50 yards. Larger, consolidated claims could also be made by groups of miners. This ranged from 1 acre claims for parties of two miners working together, up to a maximum of 5 acres for a party of 10 miners.[47]

It is through this system that the Tasmanian osmiridium industry emerged, allowing for individuals or small groups to develop the fields without the need for large amounts of capital. Following the pegging of their claim, each miner was required to submit a notice to the Mines Office. Many of these Miner's Right claims were for areas as small as half an acre, which once exhausted were abandoned and new areas taken up. Old Miner's Right claims would also be reworked. It would seem most logical that claims for the Savage River-Bald Hill area would be lodged with the Mines Office in Waratah. Unfortunately, these records do not appear to have been retained. Although charts of Miner's Rights

[44] *Ibid*, p. 53; Twelvetrees, *op. cit.* 1914, p.11
[45] Reid, *op. cit.*, p., 66
[46] TAHO, AD948/1/97, Secretary of Mines to State Mining Engineer, 3 June 1913
[47] Reid, *op. cit.*, pp.112-114, 118

claims were made at the later Adamsfield workings,[48] no such chart or similar survey has been found showing areas worked by the diggers on the Bald Hill field or the study area. The most useful plan is the 1921 sketch of the Bald Hill osmiridium field, which indicates Savage River crossing through a wide belt of serpentine, gabbro and pyroxenite (Figure 7).

[48] See Bacon, 1992, *op. cit.*, p.12

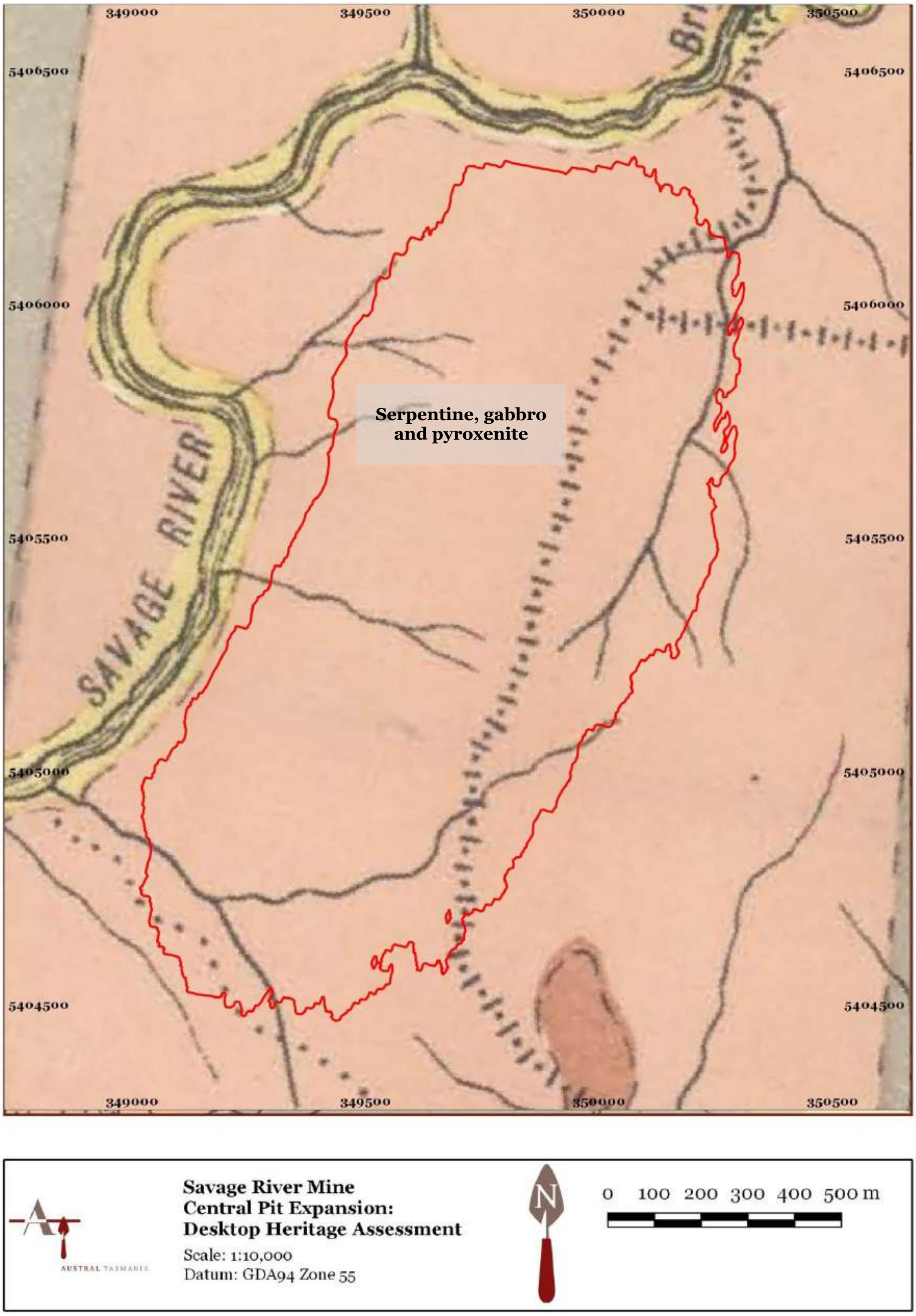

Figure 7: Indicative overlay of the study area on 1921 geological plan of the Long Plains district. Note also the track leading north to the Specimen Reef field (Reid, A.M. *Osmiridium in Tasmania. Geological Survey Bulletin No. 32*, Department of Mines: Hobart, 1921, Plate VII: 'Geological Sketch Map of Long Plain District'. Plan obtained from Mineral Resources Tasmania).

3.5 Speculative Mining Leases in the Area

The discovery of gold in the district led to a rush in the search for other minerals. Magnetite had been located in the Savage River area during the 1870s, but it was the hope of copper and silver which first brought prospectors to the vicinity of the study area. During the late nineteenth and early twentieth centuries, 21 mining leases were taken up to the east of the Savage River and corresponding with what is now the Central Pit (Figure 8). Summary information about these leases is provided in Table 2 below, and arranged chronologically in order of registration. The key historic plan used to create this overlay is shown in Figure 9, which also indicates the various tracks connecting each lot, as well as continuing through to Specimen Creek.

The earliest leases were issued in 1891. It would appear that the hopes of mineral riches were speculative. Leases were taken up for a range of commodities including silver, silver-lead, copper, pyrites, and sometimes just for unspecified minerals. Without exception, all leases had been cancelled within a few years, some lasting only a few months. New leases were often re-issued over the same plot of land, and further exploration and prospecting for iron ore resources took place during the early twentieth century (see section 3.6). However, it was not until the mid-late twentieth century that substantial mining activity took place.

Fig. 8 Ref. No.	Date of Registration	Lease No.	Description
1	5 January 1891	3508/87	80 acre lease issued to Bartholomew Cahill for silver. Lease cancelled 1892.[49]
	21 October 1895	442/93M	66 acre lease issued to William Whittaker Stewart for copper and silver. Lease cancelled 29 December 1896.[50]
	14 March 1907	3064M	66 acre lease issued to Howard Edward Wright for unspecified 'minerals'. Lease cancelled 25 February 1908.[51]
2	14 January 1891	3518/87M	80 acre lease issued to James Kenny for silver. Lease cancelled 14 June 1892.[52]
3	30 January 1891	3604/87M	80 acre lease issued to John Kenny for silver-lead. Lease cancelled 6 December 1892. The lease was also crossed by the track to Specimen Creek.[53]
	7 April 1896	806/93M	50 acre lease issued to James Henry Thorne for copper and pyrites. Lease cancelled 7 December 1897.[54]
	14 March 1907	3066M	50 acre leased issued to Howard Edward Wright for unspecified 'minerals'. Lease cancelled 25 February 1908.[55]
4	1 March 1891	50/91	10 acre lease issued to William Arthur Stuart for silver-lead. Lease cancelled 15 May 1891.[56]
5	22 May 1891	316/91M	20 acre lease issued to Henry Field Marsh for silver-lead. Lease cancelled 6 December 1892. The lease was also crossed by the track to Specimen Creek.[57]
	7 April 1896	805/93M	20 acre lease issued to James Henry Thorne for copper and pyrites. Lease cancelled 7 December 1897.[58]

[49] TAHO, MIN83/1/7/3508/87M
[50] TAHO, MIN83/1/11/442/93M
[51] TAHO, MIN83/1/18/3064M
[52] TAHO, MIN83/1/7/3518/87M
[53] TAHO, MIN83/1/10/179/93M
[54] TAHO, MIN83/1/11/806/93M
[55] TAHO, MIN83/1/18/3066M
[56] TAHO, MIN83/1/7/50/91
[57] TAHO, MIN83/1/8/316/91M
[58] TAHO, MIN83/1/11/805/93M

Fig. 8 Ref. No.	Date of Registration	Lease No.	Description
	14 March 1907	3065M	20 acre lease issued to Howard Edward Wright for unspecified 'minerals'. Lease cancelled 25 February 1908.[59]
	13 December 1909	4503M	20 acre lease issued to Charles Greenwood for copper. Lease cancelled 10 April 1911.[60]
6	22 December 1894	179/93M	80 acre lease issued to Robert James Sadler for unspecified 'minerals'. Lease cancelled 12 December 1899. The lease was also crossed by the track to Specimen Creek.[61]
	23 December 1905	1918M	80 acre lease issued to T Creighton for copper. Lease cancelled 14 March 1906.[62]
	2 May 1906	2259M	80 acre lease issued to William Sydney Monks for copper and other minerals. Lease cancelled 15 December 1908.[63]
7	27 December 1894	694/93M	40 acre lease issued to James Henry Thorne for copper pyrites. Lease cancelled 28 June 1898.[64]
8	18 April 1895	274/93M	40 acre lease issued to Robert James Sadler for unspecified 'minerals'. Lease cancelled 12 December 1899.[65]
	14 March 1907	2518M	40 acre lease issued to George Turner for copper. Lease cancelled 15 December 1908. The lease was also crossed by the track to Specimen Creek.[66]
9	19 October 1897	2113/93	80 acre lease issued to James Kenny and B Stafford Bird for silver and copper. Lease cancelled 12 December 1899.[67]
10	2 May 1906	2260M	80 acre lease issued to William Sydney Monks for copper and other minerals. Lease cancelled 15 December 1908. The lease was also crossed by the track to Specimen Creek.[68]
11	14 March 1907	3067M	80 acre lease issued to Howard Edward Wright for unspecified 'minerals'. Lease cancelled 25 February 1908. The lease was also crossed by the track to Specimen Creek.[69]

Table 2: Summary of Mining Lease Information

[59] TAHO, MIN83/1/18/3065M
[60] TAHO, MIN83/1/19/4503M
[61] TAHO, MIN83/1/10/179/93M
[62] TAHO, MIN83/1/16/1918M
[63] TAHO, MIN83/1/17/2259M
[64] TAHO, MIN83/1/11/694/93M
[65] TAHO, MIN83/1/10/274/93M
[66] TAHO, MIN83/1/18/3064M
[67] TAHO, MIN83/1/13/2113/93M
[68] TAHO, MIN83/1/17/2250M
[69] TAHO, MIN83/1/18/3064M

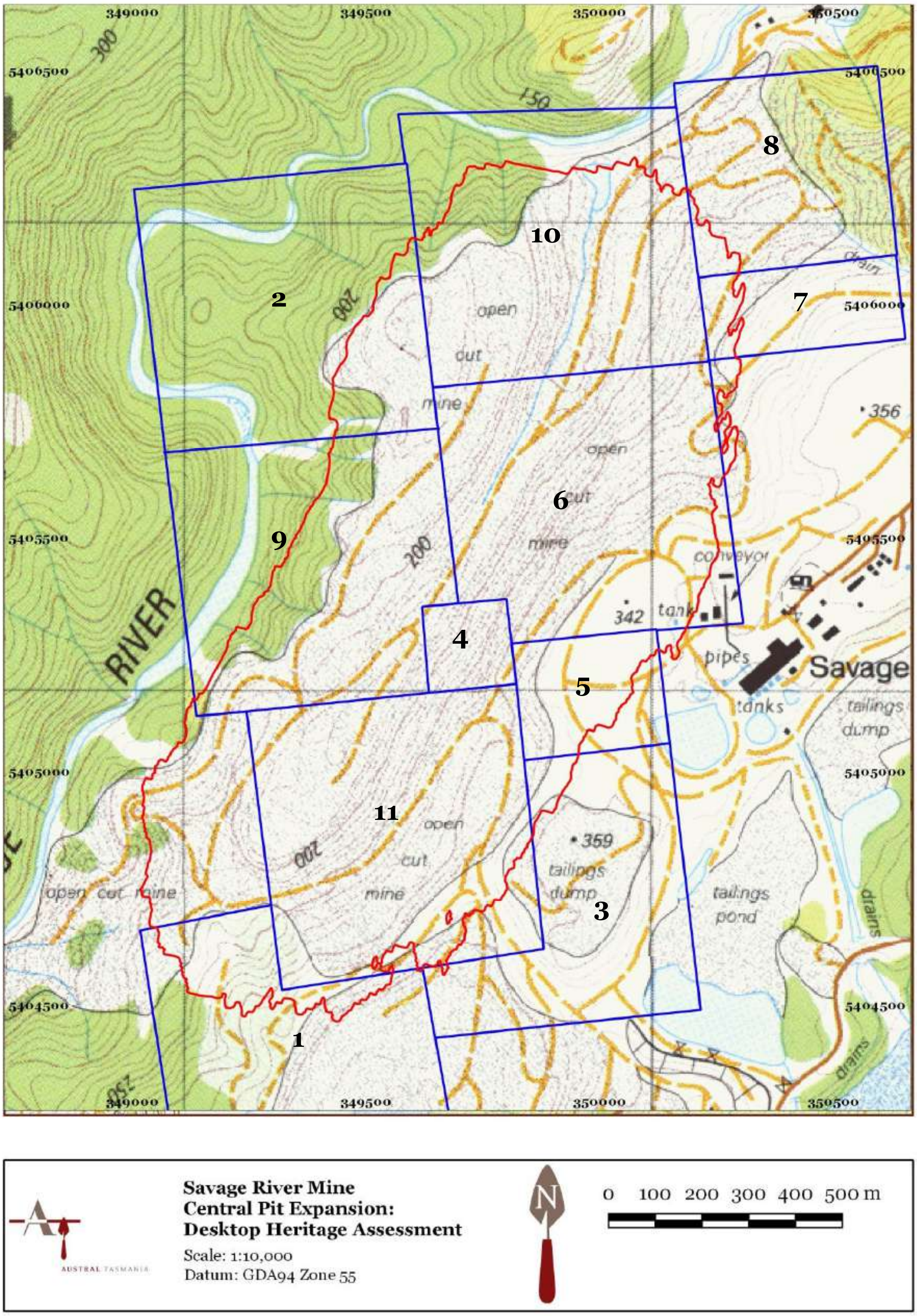

Figure 8: Indicative overlay of historic mining leases on current topographic base map. Notations refer to the chronological order in which the leases were registered (Base image by TASMAP (www.tasmap.tas.gov.au), © State of Tasmania).

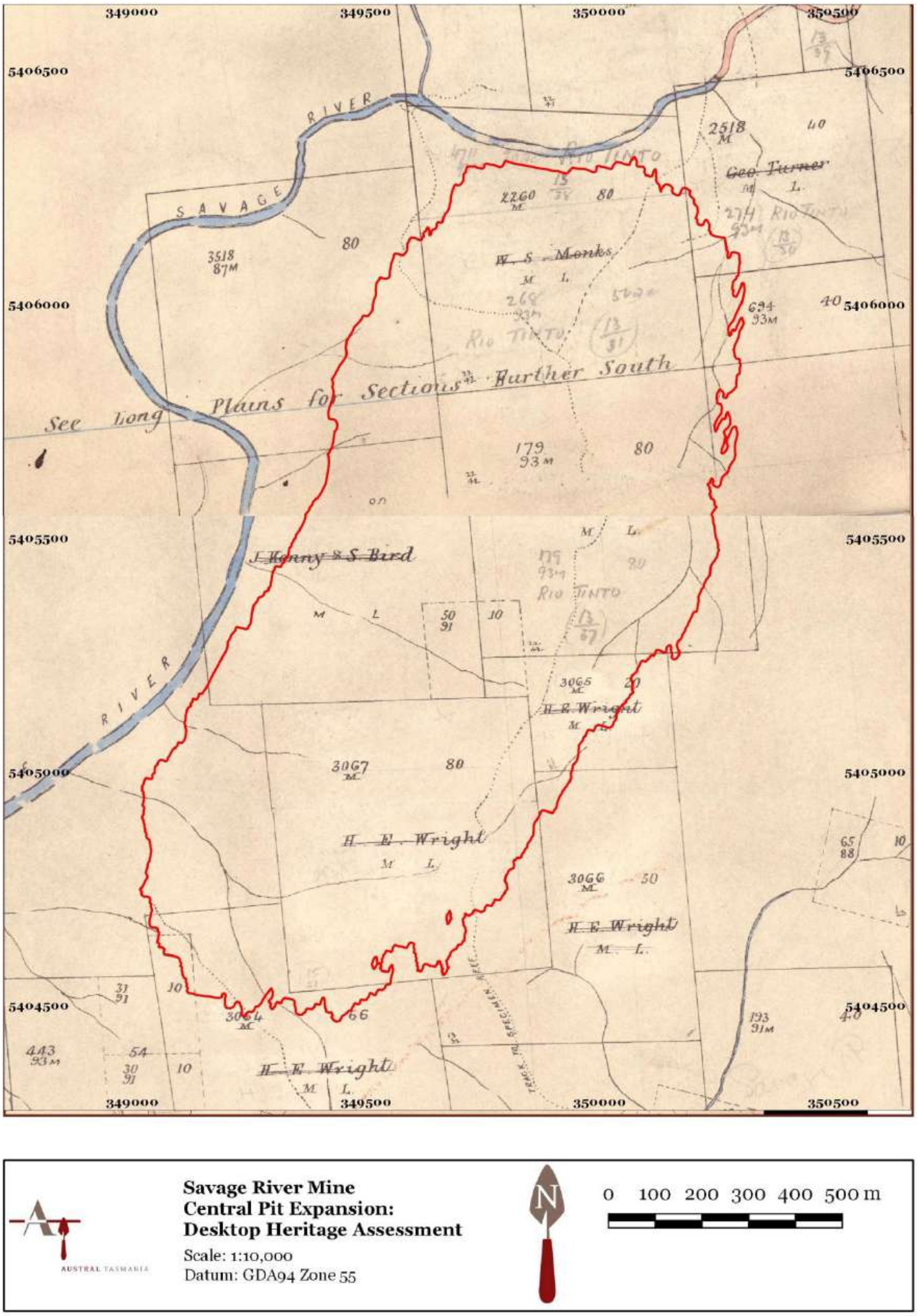

Figure 9: Composite of two, c.1908 historic mining charts showing mineral leases and track alignments through the study area (MRT Plans 156 and 156B, Vicinity of Specimen Reef, c.1908).

3.6 The Development of Iron Ore Resources

Magnetite deposits in the Savage River area had been located by Surveyor Sprent during his explorations in 1876-77, but attracted little interest compared to gold. Limited exploration and mining activity of the resource took place during the late nineteenth century in the hope of discovering another 'iron blow' which led to the development of the rich Mount Lyell Copper deposits. At first it was considered that the magnetite outcrops were the cappings of tinstone deposits, and when this failed to eventuate, the prospects were abandoned. These were later resumed on the pyritic ore bodies, which were found to contain chalcopyrite, gold and silver. By 1891 the lode on the southern side of the Savage River (i.e., the Central Pit Savage River Mine deposit) was being worked by the Savage River Silver Prospecting Company. Works included driving a cross-cut to intersect the lode at a depth of some 121 metres. Gold, silver, copper and iron pyrites were found, and further works was recommended. This included excavating a deep tunnel near the river, and establishing some 17 kilometres of tramway to connect with Corrina in the south. However, such works did not progress beyond the planning stage.[70]

From 1895 the leases were taken over by the Rio Tinto Company which worked the area for a few years, and drove about 470 metres of exploratory works in an unsuccessful search for gold and copper. There was initially little interest in the iron ore, which could not be economically processed because of its low grade. Prospecting for iron ore in the Pieman Region had substantially declined by c.1900. Despite the lack of returns, the first detailed examination of iron prospects was carried out in 1919. The Rio Tinto holdings were found to contain high-grade iron ore in much larger quantities than anticipated. It occurred in disconnected masses contained in a belt half a mile wide and mostly to the east of the Savage River, extending between the Long Plains and Specimen Reef goldfields.[71]

In 1919, the leases between Long Plains and Specimen Reef (and being in the locality of the study area) were held by a local Waratah syndicate, carrying out exploratory works with a view to supplying iron ore to Australian markets. The iron ore field was one of the largest in Tasmania, consisting of a number of magnetite and hematite masses almost continuously over a distance of some 4.8 kilometres. Generally, the ore was fairly coarse-grained, very compact and hard.[72]

The ore body had been traced through a number of leases, commencing in the south with the number 1 ore body located on Magnetite Creek (and now corresponding with the Central Pit of the Savage River mine) and was found to be some 15 metres wide, and of an as yet unknown length (Figure 10).[73]

Ore body number 2 was located on the southern side of the Savage River, at what is now the northern end of the Central Pit. This ore body was found to extend for a distance over 600 metres and across the lease areas 4090M and into 4092M, and with a width varying from 12-18 metres. A 60 metre long tunnel had been cut eastwards across a parallel ore formation. The ore body had also been investigated on the northern side of Savage River, with two parallel tunnels cut into the hematite, within lease area 4091M. Tunnels Number 3 and 4 were driven some 54 metres through similar material, to the north of the junction of Savage River and Halls Creek. Ore bodies 3, 4 and 5 were located to the north of the Savage River, and therefore outside of the Central Pit area.[74]

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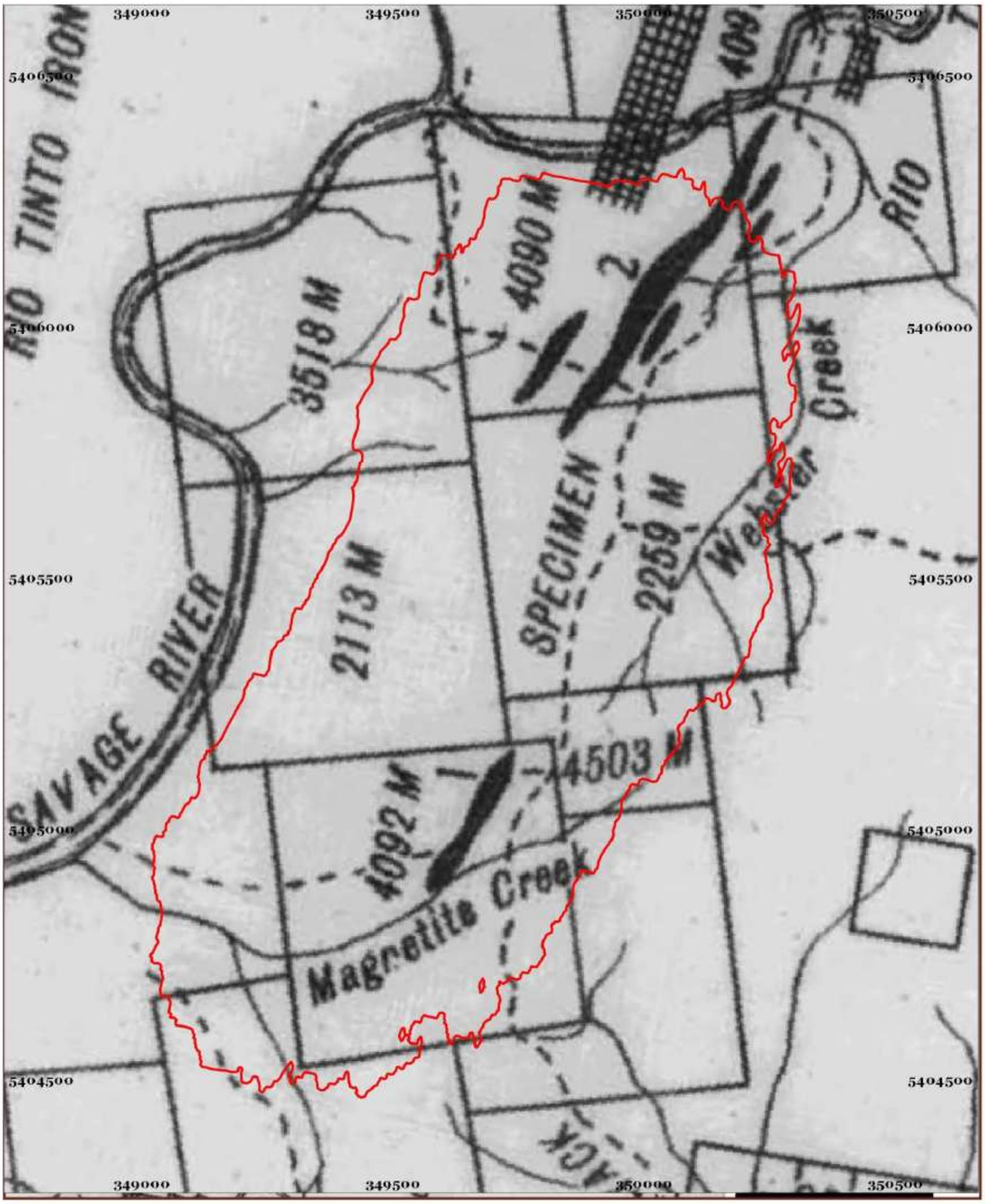
[70] Twelvetrees, 1903, *op. cit.*, pp.14-15; McConnell, *op. cit.*, September 1997, p.16
[71] Twelvetrees, WH, Reid, AM, *Geological Survey Mineral Resources No. 6. The Iron Ore Deposits of Tasmania*, Tasmania: Department of Mines, 1919, MRT Report GSMR06, pp.67-68, 73; McConnell, 2000, *op. cit.* p.6
[72] *Ibid*, p.68
[73] *Ibid*, pp.73-74
[74] *Ibid*, p.75



Savage River Mine
Central Pit Expansion:
Desktop Heritage Assessment
Scale: 1:10,000
Datum: GDA94 Zone 55

0 100 200 300 400 500 m

Figure 10: Indicative overlay of the study area on 1919 geological plan showing the iron ore bodies at Savage River (Twelvetrees, WH, Reid, AM, *Geological Survey Mineral Resources No. 6. The Iron Ore Deposits of Tasmania*, Tasmania: Department of Mines, 1919 MRT Report GSMR06, Plate VII: 'Long Plain District'. Plan obtained from Mineral Resources Tasmania)

The very difficult terrain was a key impediment to the development of mining at this stage. Rail connections existed between the ports of Burnie and Waratah, but the remaining distance to Long Plains was blocked by the Magnet Range which was an insurmountable barrier for rail. A rail link to connect Long Plains with Corinna on the Pieman River was seen as more viable, but too costly to pursue.[75]

Urquhart notes a revived interest in Savage River in 1926 with the excavation of 16 trenches by the Hoskins Iron and Steel Company. These were the first exploratory works carried out to test the site as a source of iron, but the results found that the deposits were too pyritic to justify further work. Later analysis suggested that the nature and quality of the ore was unsuitable for the blast furnace smelting technologies of the 1930s and therefore further investment in developing the resource was unviable.[76]

Mining activity had largely ceased by the 1930s, except for a few large mines. There was not a renewed interest in the area until the mid-twentieth century when new processing technologies emerged which would make it economical to mine the low grade iron ore. The area was declared a reserve in 1955 to allow the Mines Department to carry out detailed exploration and assessments. A pack track was cut through in 1956 allowing for systematic geological investigations, including geological mapping and magnetic surveys. The results were encouraging, and diamond drilling and smelting tests were carried out. Access to the remote area was also improved, with the construction of an access road from the Corinna-Waratah road, leading to the central area of the Savage River deposit.[77]

Improved mining and processing technology made working the Savage River deposits economically viable. Work carried out in the United States by Pickands Mather & Co. during the late 1950s and early 1960s found economical ways to treat the ore, with the American company becoming a key partner in the Savage River mine. The prospects and viability of the Savage River Mine were confirmed in the 1960s with the establishment of an open cut mine in the valley between the Savage and Rocky rivers. The current Savage River mine was established by Roy Hudson of Industrial Mining Investigations. The company was granted a large exploration licence, with the plan to establish a Tasmanian steel industry using the Savage River iron ore and coal from the east coast. Further exploration found large deposits of iron ore, suitable for commercial development.[78]

These were progressively worked over the coming decades, initially focussed on the central deposit, before progressing to new northern and southern pits. By the late twentieth century, the Central Pit had expanded to cover most of the historic lease areas which previously existed (Figure 11).

Ore was crushed on site and ground into a slurry concentrate which was then pumped to a pellet plant near Port Latta on Bass Strait for export. This 85 kilometre pipeline was the longest slurry pipeline in the southern hemisphere, with the first shipments made in 1968. To support the mining operation, the Savage River township was built nearby, housing a workforce of around 375 (Figure 12). In 1990, production was reduced from 2.5 mega tonnes a year to 1.3, but was increased from 1999 under new owners, Australian Bulk Minerals. Grange Resources currently operates the site.[79]

[75] *Ibid*, pp.75-76, 79
[76] Urquhart, G, *Geological Survey Bulletin No. 48 Magnetite deposits of the Savage River-Rocky River Region*, MRT Report GSB48, 1966, p.14
[77] *Ibid*, p.15
[78] Bacon, C, Dickens, G, 'Savage River Iron Ore Deposits', in Alexander, A, (ed.), *The Companion to Tasmanian History*, Centre for Tasmanian Historical Studies, University of Tasmania: Hobart, 2005; McConnell, A, *Historic Heritage Survey and Assessment - Southern Deposit, Savage River Mine, Northwest* Tasmania, report for Australian Bulk Minerals, Burnie, Tasmania, August 2000, pp.5-6
[79] Haygarth, *op. cit.*, pp.33-34; Bacon, Dickens, *op. cit.*

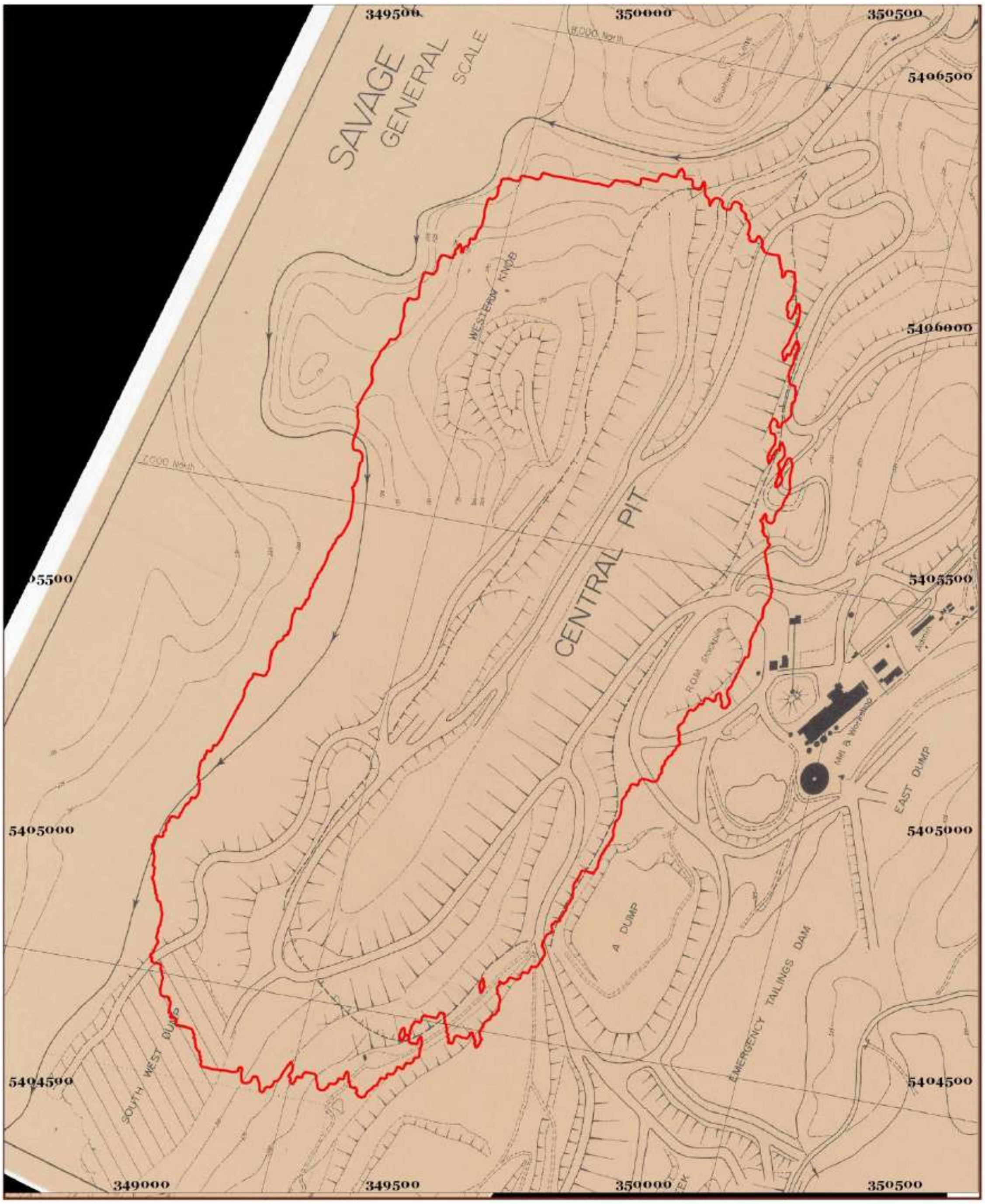


Figure 11: 1985 plan of the Central Pit with indicative overlay of the study area (1985, MRT Plan 0400_120, General Area Plan. Plan obtained from Mineral Resources Tasmania)

Figure 12: c.1960s photograph of the Savage River township, looking north to the tailings dam and mine site in the distance (TAHO, AB713/1/11918A Photograph - Savage River mine, aerial view, Reproduced with permission).

4.0 POTENTIAL FOR HISTORIC SITES

4.1 Introduction

It is possible to provide a level of assessment of the potential of the study area to contain sites or features of heritage significance through the process of historical research and the review of previous heritage studies related to the region. Historical mining activity is the key past land use, and can be divided chronologically into the following key phases:

1. 1879-c.1900 gold mining. Alluvial gold mining of Savage River and its numerous tributaries began in 1879, and was rapidly exhausted. This soon transferred to underground mining centred in two key areas: Long Plains (Golden Ridge) and Specimen Reef. Significant heritage sites and features in both areas have previously been recorded.[80] The Golden Ridge and Specimen Reef are some distance from the study area and are not relevant for further investigations as part of the crest expansion of the Central Pit. The study area was crossed by the historic track network linking the Specimen Reef. However, evidence of this track would have been destroyed by the Central Pit.
2. 1879-1920s osmiridium mining. Osmiridium was extracted as part of alluvial gold mining of the Savage River and its tributaries beginning in 1879. It was however a waste product at this time and was thrown away. The metal did not gain an economic value until the early twentieth century. By 1920, some 70 to 80 miners were working Savage River for its osmiridium deposits, over a distance of some 24 kilometres.
3. 1891-c.1900 speculative leases. During the late-nineteenth and early twentieth century, a series of leases were taken up over the study area, for a variety of commodities. Minor workings such as prospecting pits, trenches or adits are likely to have occurred during this period, but nearly all leases were void within a number of years, suggesting little exploration work.
4. 1891- 1930s iron ore prospecting and minor workings. Iron ore mining was taking place by 1891 on the southern side of the Savage River, and corresponding with what is now the Central Pit. The low grade ore and the difficult terrain were impediments to the development of the resource. The key achievement during this period was the exploration and mapping of the ore bodies.
5. 1950s-present - iron ore mining. It was not until the mid-late twentieth century that new processing technologies emerged allowing for the ore to be economically worked, and the establishment of the Savage River mine. The initial area of workings was at the Central Pit, which had reached its approximate area (but not depth) of excavation by the late-twentieth century. The Central Pit area corresponds with the areas of previous leases taken up during the late-nineteenth and early twentieth centuries.

4.2 Assessing the Potential for Heritage Sites within the Study Area

There is low potential for significant historic heritage sites or features to be present within the study area. Areas of late nineteenth, early twentieth century iron ore exploration and mining now largely coincide with the Savage River Central Pit which would have destroyed any evidence of historic mining activity in this location, as well as other associated features such as historic track networks and occupation sites.

The western margins of the crest expansion area are outside of current mining areas associated with the Central Pit and these locations correspond with several speculative mining leases taken up for short periods during the late nineteenth and early twentieth centuries. An undefined potential exists for these margins to contain evidence of minor workings such as prospecting pits, trenches or adits. However, the potential for such sites to exist in this locality is low given subsequent exploration and mining activity has focussed within what is now the Central Pit. Some caution should be exercised during works in this area, however further investigations at this stage are not considered warranted.

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[80] Austral Tasmania Pty Ltd, *Savage River, North Pit Extension and Long Plains Historic Heritage Assessment*, AT0195, report prepared for Grange Resources (Tasmania) Pty Ltd, 22 January 2016; McConnell, A, *Historic Heritage Assessment - New Tailings Dam, Savage River Mine, Northwest Tasmania*, report prepared for Australian Bulk Minerals, Burnie, Tasmania, May 2006; Kostoglou, P, *Archaeological Survey Report 1999/10. An Archaeological Survey of the Historic Specimen Reef Goldfield*, report prepared for Mineral Resources Tasmania, 1999

Potential exists for evidence of historic gold and osmiridium alluvial mining sites within and on the margins of the Savage River. Such sites may include test pits, trenches, mullock heaps and sites of occupation. The western margin of the expanded crest varies in its proximity to the River, but at its narrowest is approximately 50 m distant. Given the steep topography of the river valley, it is unlikely that alluvial mining sites would extend this far inland from the river. However, caution should be exercised should works have the potential to extend closer to the river.

No field investigations are recommended for the expanded crest area based on its low potential to contain historic sites or features. Some caution should be exercised along the western margins of the expanded crest area, and protocols for managing unanticipated historic heritage discoveries within these locations should form part of the project specifications.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This report presents the results of a desktop heritage assessment for the proposed Central Pit crest expansion. There are no current statutory heritage management requirements for the proposed development, however the consideration of potential heritage impacts will be a likely requirement for the Development Proposal and Environmental Management Plan.

This report finds that there is a low potential for historic heritage sites or constraints to be relevant to the proposed development. Evidence of historic mining activity within the study area is likely to have been destroyed by the excavation and expansion of the Central Pit since the mid-late twentieth century. Narrow margins along the western edge of the crest expansion were historically held as mining leases during the late nineteenth and early twentieth centuries, however the potential for historic sites to exist in these locations is assessed as being low given subsequent exploration and mining activity has focussed within what is now the Central Pit. Having notification protocols in place to manage unanticipated discoveries in these areas is considered the appropriate management response.

Alluvial gold and osmiridium mining also took place within the Savage Rive and immediate surrounds during the late nineteenth and early twentieth centuries. However, again there is a low potential of such sites to be encountered by the crest expansion works, although further assessment should be considered where works extend to the margins of the Savage River.

The following recommendations have been made to assist with ongoing planning for the proposed underground mine.

5.2 Management Guidelines

1. Managing Potential Aboriginal Heritage

    - The Unanticipated Discovery Plan for managing Aboriginal heritage (Appendix 1) should form part of the project specifications.

2. Dealing With Unanticipated Historic Heritage Discoveries

    - Although historic heritage sites or features are unlikely to be of relevance to the crest expansion, project specifications should include protocols for managing unanticipated historic heritage discoveries during works. This is likely to have greater relevance to the western margins of the crest expansion, but unlikely to be applicable to other areas of the development.
    - If newly identified sites are encountered during works, they should be recorded and assessed before they are impacted, in accordance with Mineral Resources Tasmania's Mining Heritage Guidelines (Appendix 2). Further specialist advice may be required for the identification, assessment and recording of particularly complex or significant heritage sites.

3. Further Assessment – Works in Close Proximity to the Savage River

    - It is recommended that a further assessment be undertaken if it becomes apparent that the works associated with the proposed crest expansion will extend beyond the nominated study area to the Savage River itself, and its immediate surrounds, that is, within +/- 25 metres of the River.

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TAHO, AB713/1/11918A Photograph - Savage River mine, aerial view

TAHO, *The Weekly Courier*, 25 March 1920, p.22, Reproduced with permission

APPENDIX 1: ABORIGINAL HERITAGE UNANTICIPATED DISCOVERY PLAN

Unanticipated Discovery Plan

Procedure for the management of unanticipated discoveries of Aboriginal relics in Tasmania

For the management of unanticipated discoveries of Aboriginal relics in accordance with the *Aboriginal Heritage Act 1975* and the *Coroners Act 1995*. The Unanticipated Discovery Plan is in two sections.

Discovery of Aboriginal Relics other than Skeletal Material

Step 1:
Any person who believes they have uncovered Aboriginal relics should notify all employees or contractors working in the immediate area that all earth disturbance works must cease immediately.

Step 2:
A temporary 'no-go' or buffer zone of at least 10m x 10m should be implemented to protect the suspected Aboriginal relics, where practicable. No unauthorised entry or works will be allowed within this 'no-go' zone until the suspected Aboriginal relics have been assessed by a consulting archaeologist, Aboriginal Heritage Officer or Aboriginal Heritage Tasmania staff member.

Step 3:
Contact Aboriginal Heritage Tasmania on **1300 487 045** as soon as possible and inform them of the discovery. Documentation of the find should be emailed to **aboriginal@heritage.tas.gov.au** as soon as possible. Aboriginal Heritage Tasmania will then provide further advice in accordance with the *Aboriginal Heritage Act 1975.*

Discovery of Skeletal Material

Step 1:
Call the Police immediately. Under no circumstances should the suspected skeletal material be touched or disturbed. The area should be managed as a crime scene. It is a criminal offence to interfere with a crime scene.

Step 2:
Any person who believes they have uncovered skeletal material should notify all employees or contractors working in the immediate area that all earth disturbance works cease immediately.

Step 3:
A temporary 'no-go' or buffer zone of at least 50m x 50m should be implemented to protect the suspected skeletal material, where practicable. No unauthorised entry or works will be allowed within this 'no-go' zone until the suspected skeletal remains have been assessed by the Police and/or Coroner.

Step 4:
If it is suspected that the skeletal material is Aboriginal, Aboriginal Heritage Tasmania should be notified.

Step 5:
Should the skeletal material be determined to be Aboriginal, the Coroner will contact the Aboriginal organisation approved by the Attorney-General, as per the *Coroners Act 1995.*

Aboriginal Heritage Tasmania
Department of Primary Industries, Parks, Water and Environment

Tasmanian Government

Guide to Aboriginal site types

Stone Artefact Scatters

A stone artefact is any stone or rock fractured or modified by Aboriginal people to produce cutting, scraping or grinding implements. Stone artefacts are indicative of past Aboriginal living spaces, trade and movement throughout Tasmania. Aboriginal people used hornfels, chalcedony, spongelite, quartzite, chert and silcrete depending on stone quality and availability. Stone artefacts are typically recorded as being 'isolated' (single stone artefact) or as an 'artefact scatter' (multiple stone artefacts).

Shell Middens

Middens are distinct concentrations of discarded shell that have accumulated as a result of past Aboriginal camping and food processing activities. These sites are usually found near waterways and coastal areas, and range in size from large mounds to small scatters. Tasmanian Aboriginal middens commonly contain fragments of mature edible shellfish such as abalone, oyster, mussel, warrener and limpet, however they can also contain stone tools, animal bone and charcoal.

Rockshelters

An occupied rockshelter is a cave or overhang that contains evidence of past Aboriginal use and occupation, such as stone tools, middens and hearths, and in some cases, rock markings. Rockshelters are usually found in geological formations that are naturally prone to weathering, such as limestone, dolerite and sandstone

Quarries

An Aboriginal quarry is a place where stone or ochre has been extracted from a natural source by Aboriginal people. Quarries can be recognised by evidence of human manipulation such as battering of an outcrop, stone fracturing debris or ochre pits left behind from processing the raw material. Stone and ochre quarries can vary in terms of size, quality and the frequency of use.

Rock Marking

Rock marking is the term used in Tasmania to define markings on rocks which are the result of Aboriginal practices. Rock markings come in two forms; engraving and painting. Engravings are made by removing the surface of a rock through pecking, abrading or grinding, whilst paintings are made by adding pigment or ochre to the surface of a rock.

Burials

Aboriginal burial sites are highly sensitive and may be found in a variety of places, including sand dunes, shell middens and rock shelters. Despite few records of pre-contact practices, cremation appears to have been more common than burial. Family members carried bones or ashes of recently deceased relatives. The Aboriginal community has fought long campaigns for the return of the remains of ancestral Aboriginal people.

Further information on Aboriginal Heritage is available from:

Aboriginal Heritage Tasmania
Natural and Cultural Heritage Division
Department of Primary Industries, Parks, Water and Environment
GPO Box 44 Hobart TAS 7001

Telephone: **1300 487 045**
Email: **aboriginal@heritage.tas.gov.au**
Web: **www.aboriginalheritage.tas.gov.au**

Tasmanian Government

APPENDIX 2: MINING HERITAGE GUIDELINES

Mineral Resources Tasmania

Tasmania

Tasmanian Geological Survey Record 1996/02

Mining Heritage Guidelines for use by MRT staff:

Re-opening, re-working or exploring a previously worked deposit

by C. A. Bacon

PURPOSE

The purpose of these guidelines is to give a preliminary, easy to understand guide to some of the issues which should be considered prior to the reworking or re-opening of old mines, or the treatment of tailings from previous operations.

Such issues will usually be addressed in detail in the Environmental Management Plan (EMP) prepared for the issue of a *Licence to Operate a Scheduled Premises* by the Department of Environment and Land Management. The licence will detail site-specific conditions relating to heritage matters if these are needed. However, as the EMP is usually not drawn up until after some initial investigations have begun, these guidelines may be of use in the interim.

The guidelines are not intended to impose any undue hardship or inconvenience on the re-opening or re-working of a deposit. In virtually all cases specific sites of cultural heritage value should be able to be protected within the framework of a modern mine. Other issues may be solved very simply by recording of the site being done prior to change.

The care and attention a site should receive prior to re-development can be related to the significance of that site, which may be important at a local, regional, state or national level. As no register of sites and an accompanying statement of significance exists, agency staff and developers will have to work with whatever information is available.

These commonsense guidelines give an outline of issues which should be considered prior to redevelopment, and will be used by Mineral Resources Tasmania (MRT) field staff. Issues are listed under individual items likely to be of cultural heritage significance.

The aim of new work should be to avoid disturbance to mining heritage artefacts wherever possible. If disturbance is unavoidable then details of the artefacts being reworked (e.g. mullock heaps) or relocated (batteries, crushers) should be recorded prior to work commencing.

RECORDING OF PHYSICAL EVIDENCE

The physical evidence should be recorded by measurement, sketch and photography, and should include:–

(1) accurate location of sites and features;

(2) a detailed description of components of a site, and how it was worked. (What was mined or processed? How i.e underground, open cut, underhand stoping etc.? Who did the work? When? Where on site was the mining, the processing, the tailings disposal etc.?);

(3) a statement on the condition of site (i.e. whether the operation of the site can be understood from the remaining features).

Ideally the recording should be done by persons with training or expertise in this type of work, and the records should be lodged with Mineral Resources Tasmania.

RELOCATION

This should only be done where the artefact (battery, etc.) would otherwise be destroyed by the new work. The fact that the machinery is old, rusty, falling apart and in a state of disrepair is **not** a sufficient reason alone to move the item.

Professional help should be sought prior to **any** relocation work being done.

MULLOCK HEAPS / TAILINGS / ORE STOCKPILES

Mullock heaps and tailings dumps from yesterday's mining can nearly always be considered to be today's raw material. Tailings from washeries and mills are highly prized as construction material, being used instead of sand or gravel in a wide variety of uses. Tailings are commonly crushed, sized and graded piles of excellent quality aggregate and road material, and are frequently re-worked. In some cases tailings can be re-treated to remove minerals which were not captured in the previous treatment/s. Modern technology can extract, at a profit, gold and other metals which were missed by earlier processing.

In practical terms, preservation or conservation of all tailings and mullock heaps is not possible. In some cases, mounds of fine tailings may also be an environmental dust and siltation hazard. Fine tailings are often difficult and slow to revegetate, due to the material being of uniform grain size, easily compacted, with poor drainage and low in plant nutrients. Retreatment can remedy a visual and environmental problem by recycling the tailings.

In most cases, if the mine was of regional significance, the tailings/mullock heap should be photographed and measured prior to being reworked. If covering an extensive area (more than one hectare), the area of tailings should be estimated and a record made of the extent of the deposit (for any large-scale operation this would have to be done in any case).

JIG FLOATS

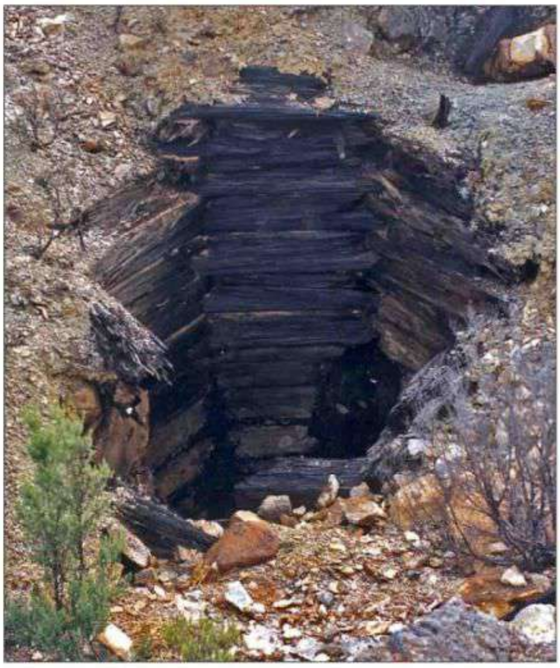
These are often favoured as a source of gravel, containing ready-sized crushed rock fractions from previous treatment. Floats are usually piled up around old treatment plants and the landforms produced should be recorded prior to re-mining.

SHAFTS: FILLING IN

Sometimes shafts close to new workings are filled in for safety reasons. The mound of tailings surrounding a shaft is usually of more interest (both geologically and archaeologically) than the actual hole.

Shafts should be made safe by fencing, capping, or filling with material OTHER THAN the material around the shaft collar.

A photographic record and measurements of the dimensions of the shaft and timbering should be taken prior to work commencing.



SHAFTS: RE-OPENING

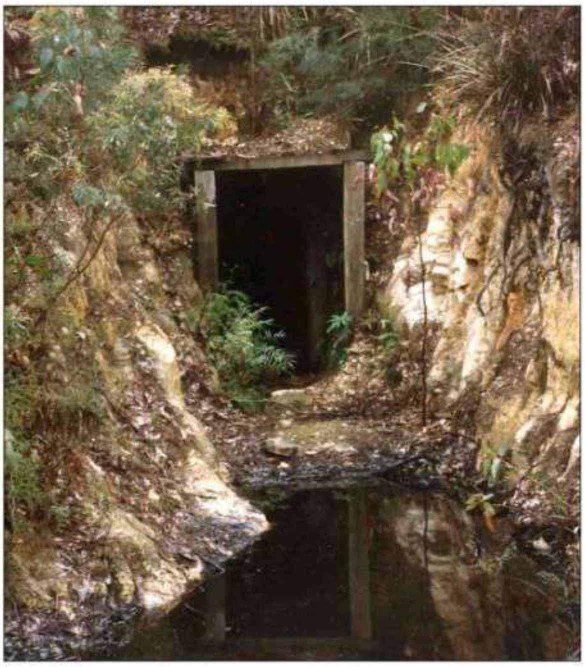
A photographic record should be made of the opening to the shaft, and a description made of the timbering therein.

NOTE: For safety reasons, detailed examination of any abandoned shaft is **not** recommended.

Tasmanian Geological Survey Record 1996/02 2

ADITS: CLOSING

If closed by blasting, pulling timbers or filling the entrance, a record should be made prior to closure. The dimensions of the adit, direction of heading, dip, sizes of timbering or other supports should be made. The reason for closure should be noted (e.g. to close access, coal seam on fire, etc.).



ADITS: RE-OPENING

A photographic record should be made and measurements taken of the height and width of the adit and the sizes, spacing and type of timber used in the original supports, e.g. legs, sets, horizontals, lagging (if any), props, stulls. If possible note if there is more than one phase of timbering.

Note length of original adit after re-opening and retimbering prior to any new extensions. Note crosscuts or galleries, and any deviations from existing plans prior to new work commencing. Such recording must only be made when the adit is in a SAFE condition. Inspection of abandoned adits is DANGEROUS.

ABANDONED MACHINERY AND EQUIPMENT

Under the provisions of the *Mineral Resources Development Act 1995*, abandoned mining machinery belongs to the Crown. On re-opening an old mine every effort should be made to leave such machinery as it is, where it is. Under no circumstances should such items be bulldozed 'out of the way'.

Pieces of old 'machinery' should not be 'souvenired' by workers or visitors to the site. The remains of old machinery can give a valuable insight into the history of working a deposit, and every effort should be made to have such relics left as they are found. The inclination to 'rebuild' or 'reconstruct' machinery by cannibalising parts from a number of sites should be resisted. Machinery should not be moved simply to be in a place which is more convenient for visitors to view.

In re-opening an old site, the developer should **not** gather into a central heap pieces of equipment such as skips, pulley wheels, stamper shafts, chains and so on. Leave items where they are — undisturbed.

Similarly, such items must not be 'tidied up' and buried just to improve the aesthetic appearance of a site.

BATTERIES, STAMPERS, CRUSHERS

If at all possible, leave the machinery in place; try and locate tracks/dumps/dams/building sites so that existing machinery does not have to be moved.

If this is not possible, record item by photographing, sketching and measuring. Note manufacturer's name and date.

As a last resort, equipment can be moved — but **only** after a proper assessment has been made. Professional help should be sought **before** the item is moved. The principles embodied in the Australian ICOMOS Burra Charter (1992) must be followed.

Pieces of machinery should **not** be used as convenient sources of scrap metal.

HOUSE SITES

House sites and camps are almost always of interest, and every effort should be made to avoid any disturbance. If this is not possible photograph and record the site.

BUILDINGS

Few buildings are usually left standing at old mine sites. Safety is the first consideration. Is the structure sound? Cladding firm? If possible leave, or incorporate, old buildings in the new development. If demolition is needed for development of the site or safety considerations, the structure should be recorded and photographed prior to work commencing.

CHIMNEYS

Some chimneys, connected to workings for ventilation, are of great interest and assist in demonstrating previous mining techniques. Chimneys connected to processing works are also important. Every effort should be made to avoid disturbance of either ground-hugging chimneys or stacks.

WATER RACES — DUG AND PIPED

Many hundreds of kilometres of water races have been constructed throughout Tasmania. Races of regional significance, such as the Mt Cameron Water Race, or large races built to service a particular mining field, are generally of greater significance than small races built to a particular set of workings. More caution is required when developing around a large, regional race than for work near small, minor races.

Tasmanian Geological Survey Record 1996/02 4

As a general rule, avoid any unnecessary disturbance and build bridges (or use temporary iron supports) over large races instead of destroying the banks to make a ford.

If disturbance is unavoidable ensure that details of the race (width, depth, flow rate, length, location) are recorded.

WATER RACES — AQUEDUCTS AND SYPHONS, INTAKES

Almost all are quite significant. Try to avoid disturbance.

PILES OF FORKINGS NEAR RACES

On occasions these will be seen as 'walls' built near races. Try to leave wherever possible. If forkings are in an area of proposed development, a record should be made prior to disturbance. Forkings must **not** be used routinely as pot hole filling in nearby tracks.

ALLUVIAL WORKINGS — SLUICING

Sites of ground sluicing are extremely common and are unlikely to be of great significance, but an effort should be made to record the area of previous work before new work starts.

Sites of hydraulic sluicing are also common, but most have now collapsed under natural forces. The position of these faces, which moved daily when the mines were in operation, is of some interest and should be recorded.

MACHINERY SITES AND FOOTINGS

Occasionally the site of an old machinery shed, engine house or battery house will be discovered. As the position of these sites is of importance in establishing how the mine previously worked, the sites should be avoided where possible, or at least recorded prior to any new disturbance. Protruding bolts and metal pieces may be cut off footings for safety reasons, but the concrete bases should not be removed.

OLD COSTEANS ('UNDERHAND STOPES')

Old mine workings, which demonstrate in a practical way the technology available at various times, are always of interest and disturbance should be avoided if at all possible. At least a representative portion should be left if development is planned.

QUARRIES

Safety is an issue where high faces are exposed, even if the rocks were convict hewn. Very old quarries are usually of historic interest, and some quarries expose rock types or formations which are of great scientific interest and geological importance.

If a quarry of historic or geological interest is to be reworked, at least a part of the area of interest should be preserved.

Old pits and quarries in the vicinity of new workings can be fenced off for safety reasons.

PITS

Prospecting pits, of which there are sometimes thousands in any one mining field, are probably of little interest and can be filled in or re-opened with little or no recording needed.

PUDDLING CIRCLES

These are rare, of small size, and confined (now) to old goldfields. Every effort should be made to conserve these features, and no alluvial mining or exploration should be permitted to obliterate these circles.

DAMS — WATER

Alterations to dams of 2000 m^3 capacity or greater can only be made in accordance with plans submitted to, and approved by, the Chief Inspector of Mines.

Recommissioning or reconstruction plans should aim to incorporate as much of the original structure as is commensurate with sound engineering principles.

Small dams should be left undisturbed wherever possible, where safety and pollution issues are not a concern.

RAILWAY CUTTINGS

Try to leave in an undisturbed state.

RAILWAY FORMATIONS

Usually these have been used subsequently as 4WD tracks, and are quite robust. Care is needed when upgrading these tracks, as every effort should be made to retain the formation structure.

DAMS — TAILINGS

Often these are the largest piece of tangible evidence of a previous phase of mining. Tailings are often favoured for retreatment, in which case the original dam should be photographed and properly recorded; size, location, height of wall, depth, size of tailings, volume of tailings, metallurgical characteristics. These details should be collected for the retreatment process and should not impose any extra burden on the developer. Alterations to dams above 2000 m^3 capacity can only be made with the approval of the Chief Inspector of Mines.

ORE BINS

Provided the structure is sound these should be left as is.

OLD TRACKS

Re-opening old tracks usually causes less environmental disturbance than creating a brand new track. Usually no special treatment is needed. See relevant section of the *Mineral Exploration Code of Practice*.

CORDED TRACKS/PACKHORSE TRAILS

Whilst there were hundreds of kilometres of these tracks in Tasmania at the turn of the century, most are now overgrown. They are usually of historic interest and disturbance is to be avoided wherever possible. Such tracks can be re-opened for foot or 4WD bike access with little disturbance.

However, if a development is planned which will obliterate a portion of such a track, then a record should be made (on a 1:25 000 scale map or better) or on an air photo of the location, and details of construction should be noted.

REFERENCES

Requirements for assessments of Features of Significance in Historic Mining Reserves. Department of Conservation and Environment Victoria.

[26 February 1996]

Tasmanian Devil SIA

Appendix I

pitt&sherry

Grange Resources, Savage River – potential for significant impact to the Tasmanian devil *Sarcophilus harrisii* under the EPBCA guidelines

The Environment Protection and Biodiversity Conservation (EPBC) Act is structured for self-assessment; the proponent must indicate whether or not the project is considered a 'controlled action', which, if confirmed, would require approval from the Commonwealth Minister. An action will require approval from the Minister if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance, which encompasses all species and habitats listed under the Act. A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity.

Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts. A proponent must consider all of these factors when determining whether an action is 'likely' to have a significant impact on matters of national environmental significance. If there is scientific uncertainty about the impacts of an action and potential impacts are serious or irreversible, the precautionary principle is applicable. Accordingly, a lack of scientific certainty about the potential impacts of an action will not itself justify a decision that the action is not likely to have a significant impact on the environment. For species listed under the EPBCA as endangered, such as the Tasmanian devil *Sarcophilus harrisii*, an action is considered likely to have a significant impact if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of the species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to the species becoming established in the species' habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

Each of the nine significant impact criteria is considered separately. Impacts that need to be considered include the direct impacts of the action, facilitated impacts that may occur on or off site and the contribution to accumulated impacts in the region.

An important definition in understanding these criteria is the term '*population*'. The Tasmanian devil is considered to occur in Tasmania in a single population in the context of the EPBC Act. However, local groups of interacting animals are also defined as populations. Pemberton defines a devil population in the north east of Tasmania as about 250 adults occupying about 45 km^2 based on interaction through a high degree of range overlap[1]. Certain areas are also reported as supporting regional populations. Accordingly, notwithstanding the EPBC definition we have considered the regional population in the following assessment to allow for the proposals context to be used as evidence.

Following this definition of population at the regional level, each of the nine significant impact criteria is discussed below in the context of the present proposal and the likelihood of a significant impact upon the Tasmanian devil. The conclusion for each criterion is italicised at the bottom of each section.

Note this has been prepared prior to any project design and thus should be re-considered once impacts can be accurately quantified.

1. Lead to a long-term decrease in the size of a population

The only conceivable way that the proposal could lead to a long-term decrease in the size of the Tasmanian devil population across the entire Tasmanian West bioregion would be if the proposal led to substantive changes in habitat availability or substantially increased demographic pressures on the species, at the regional level.

The total survey area only constitutes an area of 65 ha native vegetation (of which the final impact will be less), which is only 0.004 % of the entire West bioregion (1,562,000 ha). Even if the entire site was rendered unsuitable to devils (unlikely), this is not considered a substantial enough area to result in a regional population decline.

The site itself is likely only big enough and productive enough to constitute a fraction of an individual devil's required range.

If the site was the location of a communal denning area, with a cluster of natal dens it might be expected to support more individuals. However, such a communal denning site is ostensibly more likely to be found in an area with optimal geological and structural conditions for denning, rather than suboptimal as found. Furthermore, if the site was a communal denning location, it is reasonable to expect that some direct evidence of den use would have been observed during our surveys.

In terms of demographics, there is no conceivable way that the proposal will impact devil survival to such an extent that the regional population would suffer a decrease. Increases in road-traffic are likely to be negligible considering the immediate area is already the mine site which contains speed limits..

Thus, this action is not considered likely to lead to a long-term decrease in the size of a population.

2. Reduce the area of occupancy of the species

Area of occupancy is defined by the IUCN[2] as "the area within the 'extent of occurrence' which is occupied by a taxon, excluding cases of vagrancy." One approach for quantifying area of occupancy is to determine the number of occupied grid squares[3], the accuracy of

[1] Pemberton 1990

[2] IUCN, 2012

[3] This is explained in the Guideline for nomination under the EPBCA Part C

which is dependent upon the scale of resolution; the IUCN recommends 2 km x 2 km. Although there is no state-wide map depicting the distribution of the Tasmanian devil at the scale of 2 x 2 km grid squares, it is not necessary for a proposal of this scale. The proposals survey area is 65 ha of native vegetation. The scale of the present proposal is such that it is not likely to reduce the area of occupancy beyond an area the size of a 1 km x 1 km square at worst. In reality it is likely to be much less than this (especially after design which will impact less of the survey area), particularly as the residual impacts across some of the site will have a negligible impact on the likelihood of foraging or the potential for denning (which is already very low across the site).

Thus, this action will not reduce the area of occupancy of the species.

3. <u>Fragment an existing population into two or more populations</u>

The action is a proposed extension to the centre pit and no areas of vegetation will be fragmented by the extension. The proposed site is surrounded by very extensive areas of unbroken native vegetation. The loss of at most 65 ha of native vegetation (with an additional (16 ha of regenerating cleared land) will not result in fragmentation of these larger areas. In addition, the loss of a confined area within the extensive habitat will not fragment the population as it would not prevent ongoing interaction of all of the devils in the population nor the ability for devils to continue to disperse within the surrounding landscape.

Thus, this action will not fragment an existing population into two or more populations.

4. <u>Adversely affect habitat critical to the survival of the species</u>

The Devil Recovery Plan states that "all disease free areas within mainland Tasmania with suitable devil habitat" are considered to be "habitat critical to the survival of the Tasmanian devil". Disease in this case refers to the Devil Facial Tumour Disease (DFTD), which is known to occur in the Tasmanian West bioregion (Figure 1).

It is however, not known if the disease occurs within devils on site, however given the long history of disturbance in the area and the presence of DFTD in the Tasmanian West bioregion it is considered highly likely to occur. In any case, the areas considered critical under the definition of the Recovery Plan may not necessarily constitute 'critical habitat' under the EPBCA, nor be included on the EPBC Register of Critical Habitat. The study area also does not contain core habitat as mapped in the Devil Recovery Plan.

The present location and (to the best of our knowledge) no other similar location within reasonable distance, has been officially identified as an area of habitat critical to the survival of the Tasmanian devil under the Devil Recovery Plan[4] or Department of Environment (DOE) Species Profile and Threats Database (SPRAT)[5]. Based on our observations, the present site would not be considered to be critical to its survival. At best it is suboptimal for breeding opportunities across a limited area, and across most of the site it is not suitable. Current evidence indicates no active den use and only sparse signs of any activity. The site is highly unlikely to be critical to the survival of the species at even a regional level.

Thus, this action will not adversely affect habitat critical to the survival of the species.

5. <u>Disrupt the breeding cycle of a population</u>

[4] DPIPWE (2010)

[5] DoE SPRAT profile (2018)

The proposal is highly unlikely to prevent the genetic exchange between Tasmanian devil individuals within the population. Observations during past surveys suggest that a breeding den is unlikely on site. Based on the overall low suitability of the site for the species, the low total number of observed potential dens and the lack of signs of activity around potential dens considering the level of survey around the mine site over the past years, the disruption of the breeding cycle of even an individual is considered highly unlikely. The likelihood of any disruption will be further lessened by conducting vegetation clearance outside of the potential natal season, or by pre clearance den surveys and buffers around occupied dens if vegetation clearance is proposed during the natal season.

Thus, this action will not disrupt the breeding cycle of a population.

6. Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The total direct impact to vegetation resulting from the proposal is not yet known but 65 ha of native vegetation is present within the survey area. This is approximately 18ha (0.004% of the Western Bioregion) of suboptimal habitat for a species that occurs throughout the entire state. Although the total population of the devil across Tasmania is relatively quite low, this is due to the impacts of the fatal Devil Facial Tumour Disease. Historically the species has been quite resilient to small scale anthropogenic activities and has attained very high population numbers at various points during the European development of Tasmania. Thus, modifications and alterations to at most 65ha of suboptimal habitat is highly unlikely to result in a decline in the species.

Thus, this action will not modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. Result in invasive species that are harmful to the species becoming established in the species' habitat

Invasive species other than the red fox *Vulpes vulpes* (which is not currently known from Tasmania and in no conceivable way could be introduced or benefited by the present proposal) are not considered to be a significant threat to the Tasmanian devil. Several species of introduced plants are found on site, however with appropriate hygiene measures, introduced plants are unlikely to increase in threat due to the present proposal. In addition, the species of weeds already found on site are not likely to alter vegetation in the area to such a degree that it would become unsuitable for the devil.

Therefore, this action is unlikely to result in invasive species that are harmful to the species becoming established in the species' habitat.

8. Introduce disease that may cause the species to decline

The fatal Devil Facial Tumour Disease is already known to occur in the Tasmanian West bioregion, as it does in every other bioregion in Tasmania (Figure 1). Given that the disease spreads through contact between individuals, and that the proposal will not result in an increase in interaction between devils, the present proposal could not conceivably promote the prevalence of the disease within the population.

No other disease is recognised as a threat to the devil, nor is one likely to be found on site, nor will one be introduced in association with the present proposal.

Thus, this action is unlikely to introduce disease that may cause the species to decline.

9. Interfere with the recovery of the species

Given that the main threat to the Tasmanian devil is the Devil Facial Tumour Disease, the recovery of the species is contingent upon work to cure this disease or cultivate safeguards against the loss of all wild individuals. Currently the recovery of the Tasmanian devil is based around the work being undertaken by the 'Save the Tasmanian Devil Program'. The Recovery Plan for the Tasmanian devil identifies the following actions to guide the recovery of the Tasmanian devil:

1. Maintain and manage insurance population
2. Manage DFTD in the wild
3. Monitor Tasmanian devils
4. Conduct disease investigations
5. Manage other threats
6. Research and measure habitat variables
7. Coordinate recovery program
8. Communicate with the community and stakeholders

'Other threats' in Action 5 include the threat of foxes in Tasmania, collisions with vehicles, habitat loss and illegal culling. With regard to habitat loss the role is to monitor and collate data. None of these actions appear in any way to be disrupted by the present proposal.

The proposal will not result in any outcome that is potentially limiting to the recovery of the species.

Thus, this action will not interfere with the recovery of the species.

Summary

Based on an assessment of each of the significant impact criteria in relation to the site, it is considered that the proposal has no to limited potential to significantly impact the Tasmanian devil. The impact from the proposal will only impact 0.004% of vegetation within the western bioregion and this habitat has been assessed as sub-optimal for the Tasmanian devil. This negligible impact is very unlikely to trigger any of the significant impact criteria as discussed.

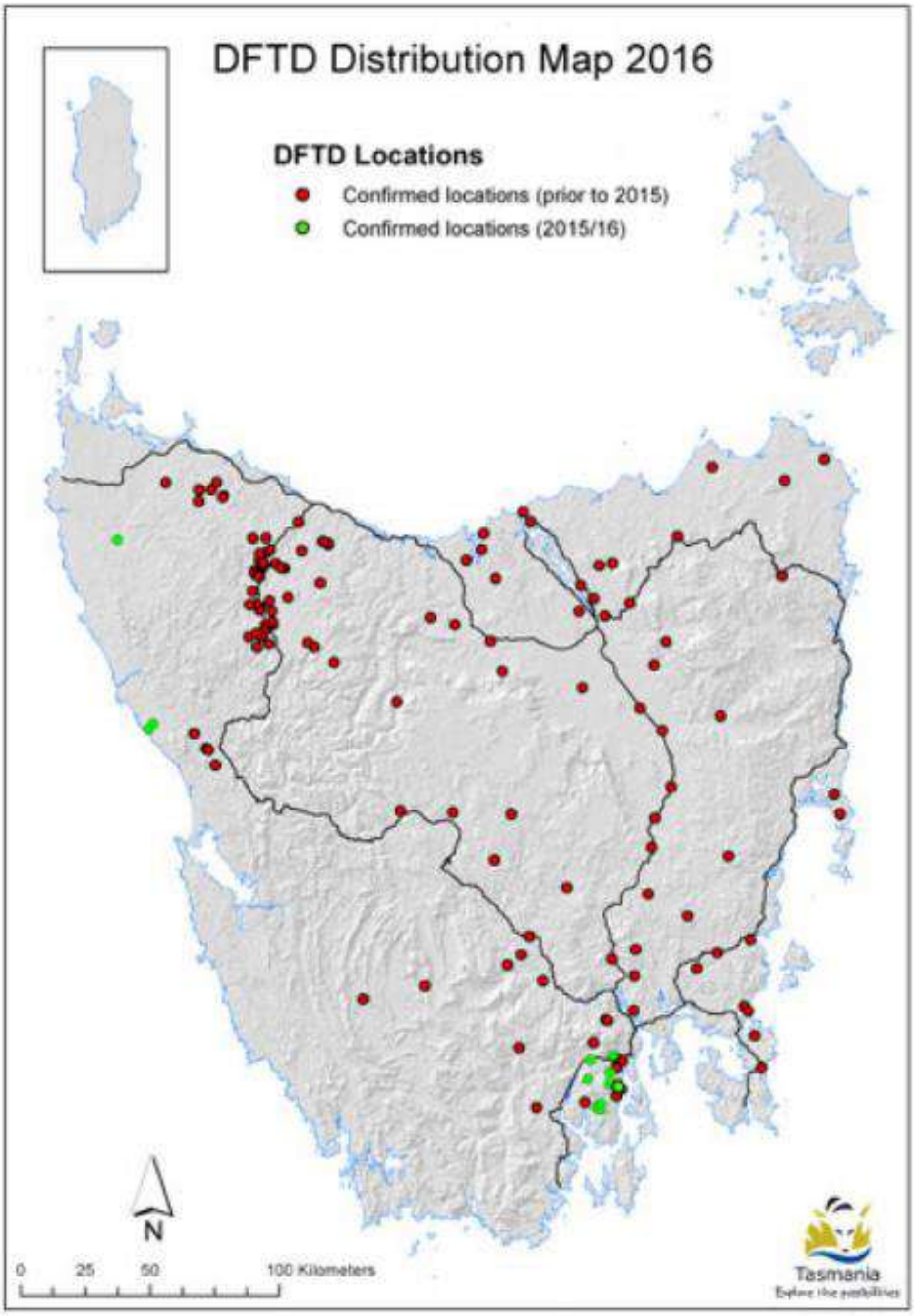


Figure 1: Distribution of Devil Facial Tumour Disease
(Source: Save the Tasmanian Devil website (www.tassiedevil.com.au) (27 February 2018)).

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Centre Pit Expansion Savage River Mine, Tasmania
Environmental Impact Statement

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