MANAGEMENT PLAN

SNOWY 2.0 MAIN WORKS – SPOIL MANAGEMENT PLAN – APPENDIX H – RAVINE BAY EMPLACEMENT AREA

S2-FGJV-ENV-PLN-0019

APRIL 2024

Schedule 3, Condition 7(e) of the Infrastructure Approval requires detailed plans for each of the permanent spoil emplacement (PSE) areas to be prepared prior to placement of material at each site. This plan has been prepared to address these requirements of Schedule 3, Condition 7(e) for the Ravine Bay (PSE) area.

Revision Record

Rev.	Date	Reason for Issue	Prepared by	Reviewed by
I	05.04.2024	Issued for approval	C. Pedraza E. Porter	E. Martin C. Buscall

Revision Tracking

Rev.	Date	Description of Revision
A	13.01.2022	Initial draft for Snowy Hydro review
B	10.11.2022	Updated to reflect consultation with NPWS, EPA, DPE and Snowy Hydro on the approved Tantangara and GF01 PSE Management Plans
C	13.02.2023	Updated to reflect Snowy Hydro comments and revised design and construction methodology
D	12.04.2023	Updated to reflect the detailed design
E	6.11.2023	Updated in response to DPE, EPA and NPWS comments
F	6.12.2023	Updated in response to DPE, EPA and NPWS meeting & design optimisations
G	19.01.2024	Updated in response to DPE, EPA and NPWS comments on Rev E
H	29.02.2024	Updated in response to NPWS and EPA comments on Rev G
I	5.04.2024	Updated in response to DPE comments on Rev G and DPE, NPWS and EPA comments on Rev H

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ABBREVIATIONS AND DEFINITIONS

Acronym	Definition
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AMD	Acid and metalliferous drainage
ANC	Acid neutralising capacity
APP	Acid producing potential
ASS	Acid Sulfate Soils
Blue Book	*Managing Urban Stormwater: Soils and Construction.* Landcom, (4th Edition) March 2004
CLM Act	*Contaminated Land Management Act 1997*
CLMP	Contaminated Land Management Plan
COA	Conditions of Approval
CSSI	Critical State significant infrastructure
DAWE	Department of Agriculture Water and Environment
DoEE	Department of Environment and Energy (restructured on 1 February 2020, with environmental functions merged into DAWE)
DPE	NSW Department of Planning and Environment
D&B	Drill and blast
EC	Electrical conductivity
ECVT	Emergency egress, cabling and ventilation tunnel
EIS	Environmental Impact Statement
EMMP	Exploratory Works Excavated Material Management Plan
EMS	Environmental Management Strategy
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPL	Environment Protection Licence
ESCP	Erosion and Sediment Control Plan
FSL	Full Supply Level
Future Generation	Future Generation Joint Venture
Future Generation-PMS	Future Generation Project Management System
HCT	Humidity Cell Test
HRT	Head Race Tunnel
KNP	Kosciuszko National Park
LEM	Landscape Evolution Model
MAT	Main access tunnel
Main Works EIS	*Snowy 2.0 Main Works - Environmental Impact Statement*
MSL	Minimum Supply level
MTCP	Marine Traffic Control Plan
NAF	Non-acid Forming

Acronym	Definition
NAG	Net Acid-Generation
NAPP	Non-acid Producing Potential
NOA	Naturally occurring asbestos
NPWS	National Parks and Wildlife Service
NPW Act 1974	*National Parks and Wildlife Act 1974*
NRAR	Natural Resources Access Regulator
OEH	NSW Office of Environment and Heritage
OSOM	Over Size Over Mass vehicle
PAF	Potential acid forming material
PCT	Plant community type
PAF-LC	Potential acid forming material – low capacity
PEP	Project Execution Plan
POEO	*Protection of the Environment Operations Act 1997*
POEO General Regulation	*Protection of the Environment Operations (General) Regulation 2009*
POEO Waste Regulation	*Protection of the Environment Operations (Waste) Regulation 2014*
PPE	Personal Protective Equipment
Project, the	Snowy 2.0 Main Works
PSE	Permanent spoil emplacement area
QMP	Quality Management Plan
REMMs	Revised environmental management measures
SAP	Sensitive Area Plans
SMP	Spoil Management Plan (this Plan)
Snowy Hydro	Snowy Hydro Limited
Spoil volume (m^3)	Unless stated otherwise this represents the volume of spoil in cubic metres when placed including compaction factors
Submissions Report or RTS	*Response to Submissions Snowy 2.0 Main Works*
SWMP	Surface Water Management Plan
TBM	Tunnel boring machine
TfNSW	Transport for New South Wales
TSS	Total suspended solids
WARR Act	*Waste Avoidance and Resource Recovery Act 2001*
Waste Classification Guidelines	*Waste Classification Guidelines,* NSW Environmental Protection Authority, 2014
XRF	X-ray fluorescence

1. INTRODUCTION

1.1. Background

Schedule 3, Condition 7(e) of the Infrastructure Approval requires detailed plans for each of the permanent spoil emplacement (PSE) areas to be prepared prior to placement of material at each site. This plan has been prepared to address these requirements of Condition 7(e) for the Ravine Bay PSE area including adherence to Schedule 3, Condition 4 and the design objectives in Table 1-2.

The Ravine Bay PSE area will receive spoil from the Talbingo Intake, Talbingo Haul Roads, Talbingo Spoil Road and Tailrace Tunnel. The general location of the Ravine Bay PSE is shown in Figure 1-1. While spoil will be placed within the nominated area outlined in Figure 1-1, at this stage all spoil emplacement will only be on land as further discussed in this plan.

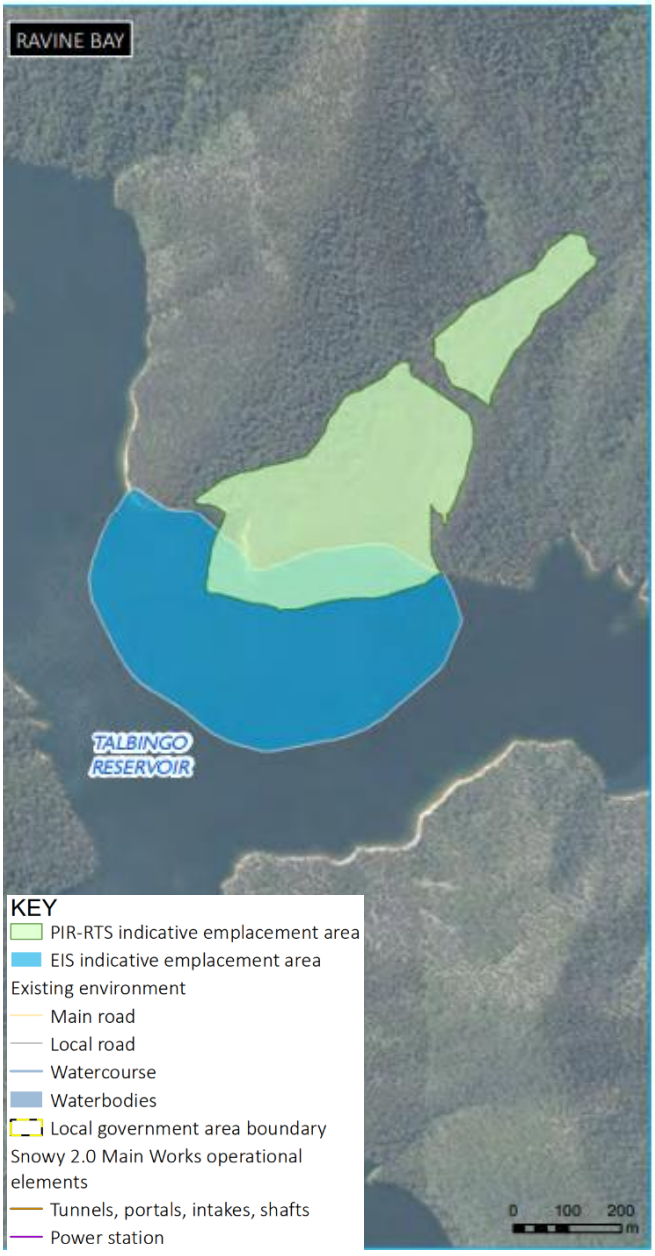


Figure 1-1 PIR-RTS indicative Ravine Bay PSE area location (EMM, 2020)

1.2. Requirements

Schedule 3, Condition 7(e) of the Infrastructure Approval requires detailed plans for each of the PSE areas to be prepared using both analogue and erosional-based methods. Plan requirements are provided in Table 1-1 below.

Table 1-1: Conditions of approval requirements

Requirement	Where addressed
Schedule 3, Condition 7	
(e) detailed plans for each of the permanent spoil emplacement areas that have been prepared using both analogue and erosional-based methods: these plans must:	
• describe how the development of each emplacement area would be co-ordinated with the rehabilitation of the site in accordance with the approved Rehabilitation Management Plan;	Section 4.2
• describe the measures that would be implemented to comply with the spoil management requirements in condition 4 and the design objectives in condition 6 (Table 2) of the Infrastructure Approval;	Table 4-2
• include a topsoil strategy outlining the measures that would be implemented to ensure the surface of the emplacement areas will be suitable to sustain the target plant community types (PCTs) in the long term, having regard to the approved strategy in the Rehabilitation Management Plan;	Section 4.3
• identify the key risks for the successful completion of each emplacement area and the contingency measures that would be implemented to address these risks; and	Table 4-1
• include detailed completion criteria and performance indicators for each emplacement area, including criteria for triggering remedial action (if necessary).	Table 4-2

The application of the design objectives from Schedule 3, Condition 6 (Table 2) of the Infrastructure Approval are set out in Table 1-2.

Table 1-2: Design objectives

Aspect	Objective	Notes
Landforms	As natural as possible, including minimising the use of linear or engineered structures	Included in the design assessment in Section 2.1 and 2.2.
	Sympathetic with the landforms in the surrounding area, particularly from a visual, water management and ecological perspective	Included in the design assessment in Sections 2.1. The landform design has included potential for diversity of habitat. Ecological aspects are still being finalised and will be included in the Rehabilitation Management Plan.
	Suitable drainage density	Drainage density discussed in Section 2.1
	Safe, long-term stable and non-polluting	Erosional stability discussed in Section 2.1.2 Non-polluting discussed in Section 2.1 and 2.2. Golder has only completed a desk top review pending access for further site observations and investigation (Report 20355010-012-TM-Rev0_Ravine Bay geotechnical desk top study). Prior to the emplacement being finalised and rehabilitation occurring, NSW EPA will be consulted regarding the capping layer of the landform.

Aspect	Objective	Notes
	Where feasible, gradients along the water line of the reservoirs that could be exposed under normal conditions (i.e. above the minimum operating level) must be suitable for safe recreational use and consistent with the approved Recreation Management Plan	All spoil placement for the initial stage of placement is located above FSL to minimise impacts to the reservoir and maximise safety.
	Provide suitable access for vehicles and/or all-terrain vehicles for rehabilitation, weed control and firefighting with slopes typically spaced at around 200 metres measured on the slope to allow for spraying from vehicles, or as approved by the NPWS	Access tracks have not yet been indicated – these will be added during construction using the as-built surfaces. See Section 2.3 for ongoing NPWS access requirements.
Water management	Integrate the drainage of the emplacement area with the surrounding drainage network, including any upstream flows and residual run-on water	Upstream catchments are to be diverted into the drainage line on the eastern side of landform, see Section 2.1.4. Creek diversions, clean water drains, a drainage blanket and subsurface drains will divert existing clean catchment flows to nature creek lines. Drainage on the western edge of the PSE will be redirected across constructed landform to reconnect with the existing eastern creek. This will mimic natural flow regimes. Direct runoff from the PSE will be captured in dams.
	Minimise downstream water flows and velocities with any changes to be quantified and addressed though suitable design	Downstream water flows will be intercepted by the 4 dams that surround the PSE. Clean water drains and clean subsurface drains installed below the drainage blanket, will mimic natural flow regimes of the existing Ravine Bay.
	Minimise valley infill	Western edge of landform has infilled the natural drainage line. Flows have been redirected and slowed with the use of sediment dams.
	Create natural drainage lines that are long-term sustainable having regard to the selection of suitable underlying materials, including rock sizing and grading	Rock sizing addressed in Section 2.1.2.
	Minimise the use of large rocks in drainage lines	Rock sizing addressed in Section 2.1.2.
	Minimise the concentration of water on landforms unless this is consistent with accepted drainage density and geomorphic design practices	The design has largely confined higher erosion risk areas to the drainage lines. This information is outlined in Section 2.1.2.
	Minimise the generation and dispersion of sediment in the Talbingo Reservoir, Tantangara Reservoir or other waterways	Sediment control discussed in Section 3.1. All spoil will be placed on land. Monthly water monitoring downstream of emplacement area will be undertaken in accordance with the Main Works Environment Protection Licence (EPL).. If required, and in accordance with Appendix A, Annexure A of the Surface Water Monitoring Program (S2-FGJV-ENV-PLN-0107-F), Trigger Action Response Plans will be followed.

Aspect	Objective	Notes
Erosional stability	Minimise steep slopes, particularly slopes that will be difficult to access and maintain (such as slopes over 18 degrees or 1V:3H)	The landforms at Ravine Bay are mostly flatter than 1V:4H. Target maximum slopes have been increased from 1V:3H to 1V:2.75H, to accommodate all of the material out of the reservoir. Extent of slopes steeper than 1V:2.75H has been limited as far as practical. Slopes discussed in Section 2.1.1.
	The final surface of the landform must be long-term sustainable with sufficient topsoil (or some other suitable growth medium) to maintain a soil water profile and sustain vegetation	Topsoil (or other growth medium) requirements will be detailed in the Rehabilitation Management Plan.
	Maximise the revegetation of the final surface	Once the Rehabilitation Management Plan is approved, this plan will be reviewed against the Rehabilitated Management Plan for consistency.
	Ensure areas subject to wave action are suitably protected or the slopes are flattened to limit wave action	This is not applicable at this stage.
Land Use	Native vegetation and habitat must be consistent with the approved Rehabilitation Management Plan	Once the Rehabilitation Management Plan is approved, this plan will be reviewed against the Rehabilitated Management Plan for consistency.
	Recreational facilities and use must be consistent with the approved Recreation Management Plan	Once the Recreation Management Plan is approved, this plan will be reviewed against the Recreation Management Plan for consistency.
Constructability	The emplacement area must be constructible having regard to the: • availability of suitable material, including topsoil • erosion and sediment control; • access; • initial shaping of natural ground; • progressive rehabilitation; • shapes and benching; and • safety around water	In terms of constructability: • Vegetation will be mulched and topsoil and subsoils will be stripped and stockpiled to be retained for future use and rehabilitation. Further detail is provided in Section 4.4. • Sediment and erosion assessment and control has been incorporated into design. Further detail is provided in Section 2.1.2. • Slopes to be no steeper than 21deg (1V:2.75H) except where steeper slopes are required to tie into the existing natural landform. Access tracks will be maintained in accordance with the final landform design and rehabilitation management plan. • Natural ground requires only clearing prior to placement, and/or topsoil and subsoil stripping. • Progressive rehabilitation is planned for, but implementation will depend on the sequencing of TBM and D&B and the management of PAF / NOA materials. • Benches are temporary only; surface to be shaped post placement. • The toe of the landform will be near the reservoir edge and safe construction measures are addressed in construction documentation.

1.3. Staging

The work activity of In-reservoir spoil emplacement will require greater detail prior to commencement due to need to further assess the risk and impact of undertaking such an activity. Consequently, this plan will be updated, in consultation with relevant government agencies, and submitted to DPE prior to commencement of specific activities as detailed in Table 1-3.

Table 1-3: Activities that require update to this plan.

Activities	Timing
In-reservoir emplacement trial	• This SMP will be updated for approval prior to undertaking an in-reservoir spoil emplacement trial. This trial is currently under development.
In-reservoir emplacement	• This SMP will be updated for approval prior to undertaking full scale in-reservoir emplacement. This update will include a revised design which accounts for spoil already placed on land to date, in addition to revised management measures based on the results of the trial.

This plan will also be reviewed and updated if required following review as per Schedule 4 Condition 4. This plan will also be reviewed and updated if required following approval of Rehabilitation and Recreation Management Plans. Prior to the updating of this SMP to include the sub-aqueous spoil trial Snowy Hydro commits to engage pro-actively with the NSW EPA regarding the scope and boundaries of this activity. Due to the nature of this work it is acknowledged that there are concerns regarding such activities and that all reasonable and feasible options should be considered prior to the commencement of such trials.

2. DESIGN

2.1. Landform Design Method

The design methodology has been developed through the design and construction of geomorphic landforms in NSW since 2012, mainly on large open cut coal mines in the Hunter Valley. Currently there are approximately 20 sites constructing geomorphic landforms. Within these sites, the landform surfaces can be generally divided into two landform categories namely:

- Hydraulically flat landforms, with overall gradients from the ridge to the toe of the valley of around 5 to 6 per cent or flatter. Based on observation of natural analogues, these flatter catchments can be designed using the parameters derived from stable alluvial analogues in the local environment and should not need rock armouring. Ravine Bay PSE is generally too steep to be designed using alluvial analogues.
- Hydraulically steep landforms, which can be designed using the characteristics of geomorphic landforms, but which are likely to require rock armouring. The design intent is to limit the erosion risk on the areas of overland flow adjacent to the drainage lines so that these can be stabilised using vegetated soils, with the rock armouring only required in the drainage lines. Ravine Bay PSE falls into the hydraulically steep category.

The design still uses appropriate drainage densities and other geomorphic elements such as concave drainage lines and limit the overland flow lengths, but these landform aspects are then combined with erosion risk tracking to assess where rock armouring will be required.

The erosion risk tracking is based on equations used in the SIBERIA Landscape Evolution Model (LEM). The method used is not a full LEM and quantifies risk only without the progressive movement of sediment with time that is modelled within the LEM process. The methodology has been used in parallel with SIBERIA and CAESAR-Lisflood on other sites. It is a good indicator of erosional risk, provided it is calibrated against the actual soil or site data. It is based on successful trials, for example, the Hunter Valley.

Key elements applicable to Ravine Bay PSE include the following:

- The design is for 1.61 million m^3 total (1m D&B and 0.61m TBM material), significantly less than predicted in the EIS (2.8 million m^3) due to project optimisation and removal of scope items. Therefore, the 1.61 million m^3 that is currently expected will all fit on land. No spoil will be placed in the reservoir at this stage.
- The site was selected to limit the extent of run-on from adjacent upstream catchments. To achieve this, the toe of the landform does not extend into the adjacent natural creeks located on either side of the PSE. These natural creeks have a significant upstream catchment and are hydraulically steep.
- For practical construction purposes, the maximum slopes used it 1V:2.75H, with all slopes flatter than this other than a few small areas such where rock drains are cut in. This slope limitation allows cross-ripping of the surface using a dozer to increase infiltration prior to vegetation being established. Slopes flatter than 1V:4H simplify access using agricultural equipment, and a significant proportion of the landform is flatter than 1V:4H.
- Based on the restrictions for PAF placement being between NAF material, this issue has been addressed by ensuring the available footprint at each stage of the PSE development is large enough to allow for multiple tip heads and levels to limit the risk of double handing PAF material.
- The design has a liner as an approach to managing potential contaminants. The specifics of this potential liner (type, specification, extent, construction method and staging) have been refined to meet both the objectives of this plan and the requirements of the NSW EPA. The Project EPL has been updated to include this detail. Placement will not occur without meeting this conditions in the Project EPL.
- Clean water will be captured below this liner through a subsurface drainage system. This will ensure that seepage will flow on top of the liner and be directed to a sealed basin to mitigate water in the basin migrating to the groundwater table, while the clean water currently seeping into the base of the valley will be collected separately and directed off site. Prior to spoil being placed, the basins will be treated as normal sediment basins.
- The western extent of the PSE will impact directly on the natural creek line. Upstream tributaries west of this catchment have been redirected into constructed drains in the landform, and the upstream creek to the north has been redirected into the natural creek line.
- The site will not receive filter cake, wedge pit slurry, fish tank slurry, and balance tank slurry nor untreated water which are materials which have been found to have high levels of nitrates, unless results prove material is inert and non-reactive. Further detail can be found in the Nitrogen Management Plan.

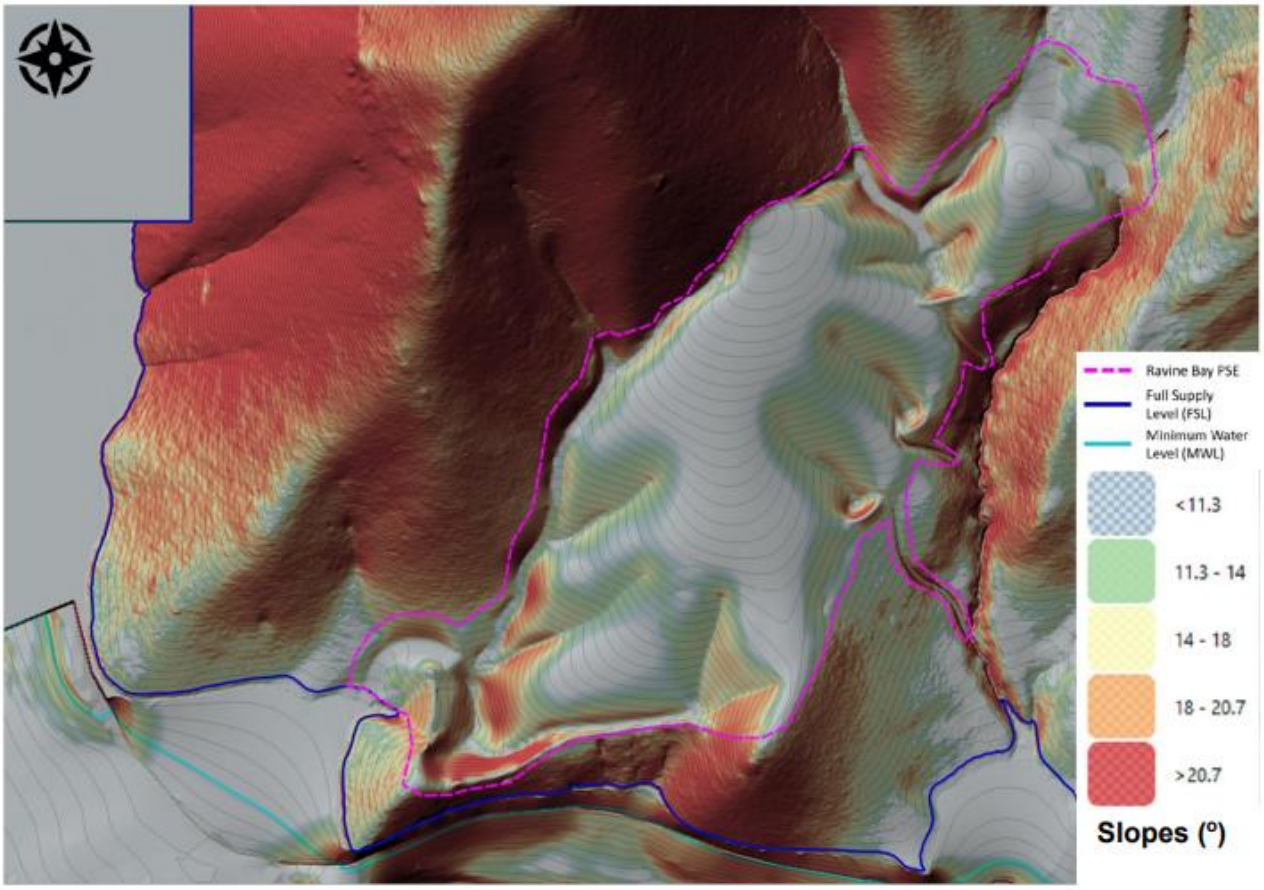
2.1.1. Slopes

A key design element involved targeting 1V:4H slopes (14°) for ease of topsoil placement and revegetation, and to limit the extent of slopes steeper than 1V:2.75H (20.7°) as far as is practical. While 1V:2.75H for some of the slopes at Ravine Bay PSE is steeper than the other PSEs, this is to ensure material is placed on land. However, majority of the landforms are mostly flatter than 1V:4H.

The following figure and Table 2-1 outline the slopes for Ravine Bay PSE. It should also be noted that a high proportion (just under half of the total) of the slopes steeper than 1V:2.75H are associated with the expected hard rock excavation for Sediment Dam #4. There is also a high proportion that tie into the surrounding natural slopes which are also steep.

Table 2-1: Ravine Bay PSE design slopes

Slope Ranges (°)	Slope	Area Measured on Slope (ha)	Area (%)	Cumulative Area (%)
11.3	1V:5H	57.0	30.3	30.3
14	1V:4H	42.5	22.3	52.6
18	1V:3H	44.3	23	75.6
20.7	1:2.75H	21.2	10.8	86.4
>20.7	>1:2.75H	28	13.6	100



Note: The spoil area is well above the FSL level - the toe of Dam 1, which is a pollution control dam, extends close to the FSL.

Figure 2-1: Ravine Bay PSE slopes

2.1.2. Erosion and Rock Armouring

An erosion risk assessment was carried out based on the Einstein-Brown equation computer in GIS. Based on the risk assessment, erosion risks are most confined to drainage lines. This information was used to inform the hydraulic modelling in computer software Lisflood, from which peak flows and flow widths can be determined. Rock sizing is then based on computing the flows per unit width in the hydraulic analysis together with the flow depth, from which the rock size can be computed.

It is expected that the typical rock size required in the rock drains will be a D50 of 300mm with a target maximum rock size of 400mm. A small portion of larger rock will be used at the stilling pond, but provisionally with a D50 of 450mm and a maximum size of 600mm. These sizes will be confirmed once the geotechnical investigation at Ravine Bay is completed. In addition, overspill from sediment dams #1 to #3 (Figure 3-1) occurs over a natural ridge which could potentially result in scour on the existing natural surface. Competent rock at the surface is however likely and will be assessed by the geotechnical investigation.

Geotextiles are proposed to be used on the drainage lines to minimise the erosion risk immediately post construction. In the longer term the use of correctly graded rocky material will be key to give long term stable surfaces.

The PSE is currently designed to be all on land hence there is no risk of scour from rising and falling water levels. This management plan will be reviewed and updated accordingly if the eventuality of in water placement arises.

2.1.3. Visual

The locality and visibility of the PSE from surrounding viewpoints is an important consideration in the landform design process. The geomorphic landform surface is shown in Figure 2-2 and Figure 2-3 together with the surrounding landform and natural topography post construction of the Ravine Bay PSE.

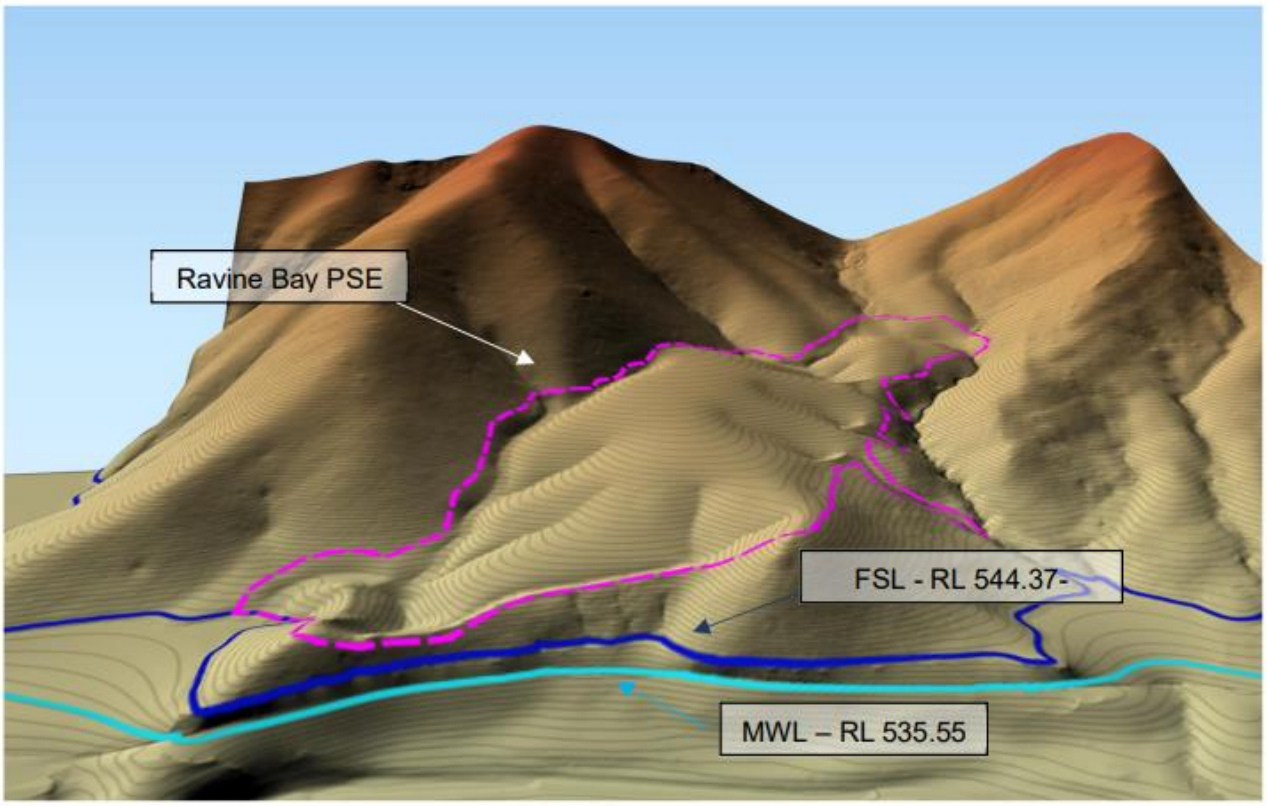


Figure 2-2: Ravine Bay PSE view from the south

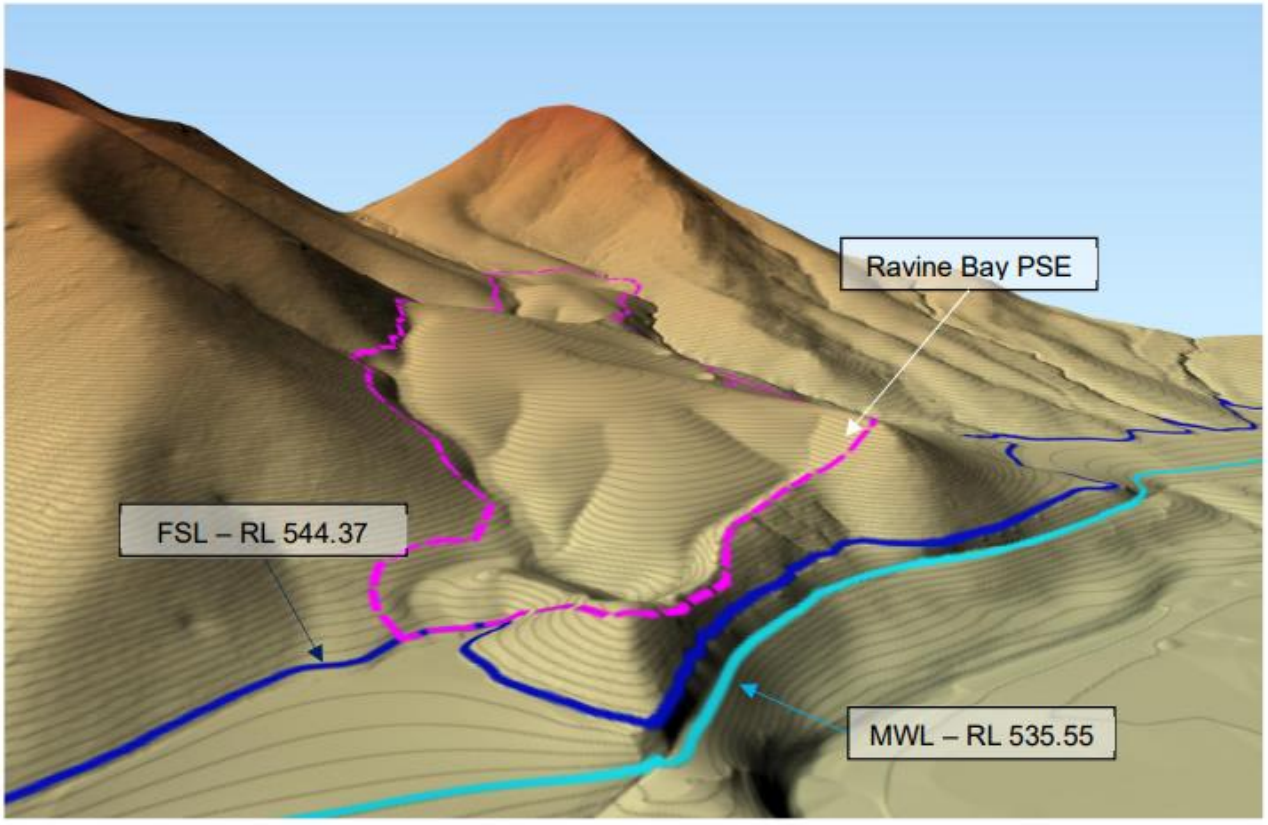


Figure 2-3: **Ravine Bay PSE view from south-west**

2.1.4. Drainage

Rock lined surface drainage channels, an impermeable membrane and subsurface drainage are the primary drainage features for Ravine Bay PSE.

Clean water

- Upstream catchments are to be diverted into the drainage line on the eastern side of landform. Creek diversions, clean water drains, a drainage blanket and subsurface drains will divert existing clean catchment flows to natural creek lines. Drainage on the western edge of the PSE will be redirected across constructed landform to reconnect with the existing eastern creek. This will mimic natural flow regimes.
- Prior to the emplacement being finalised and rehabilitation occurring, NSW EPA and NPWS will be consulted regarding the capping layer of the landform, of which may be required to limit clean water seepage through the final landform.

Sediment laden water

- The liner has been shown in 2D steady state and transient analysis to be effective in limiting the ingress of affected water to the clean water system potentially to below detection levels. This initial modelling was based on a clay permeability of around 7 x 10^{-7}m/s, and while this is based on estimated values for the material, it is also well known that the permeability of materials can vary significantly due to variations associated with construction and variations in the natural materials. It is almost certain that some seepage through the liner is likely to occur, in accordance with the project EPL, the liner must be suitably engineered to achieve a safe, stable and non-polluting landform.

- Four basins (initial sediment and re-classified leachate once placement commences are proposed to be constructed to manage water quality and limit sediment ingress. The basins have been sized above the blue book capacity of 95th percentile and 5-day rainfall (46.8mm) with a runoff of around 0.79 with a further 50% capacity provided for sediment accumulation.

The following table outlines the basin capacities of the four basins. Basin locations are depicted in Figure 3-1.

Table 2-2: Sediment dam capacities

Name	Designed capacity (m^3)	Blue book settling capacity (95th percentile 5-day event) (m^3)	Blue book sediment capacity (m^3)
Sediment basin #1	10,016	4,537	2,287
Sediment basin #2	1,010	355	117
Sediment basin #3	1,397	584	584
Sediment basin #4	27,079	6,302	6,302

2.2. Adopted Landform Design Criteria

The interpretation of the existing completion criteria into specific design criteria has been provided in Table 2-3: Landform design criteria. It is important that the design criteria be sufficiently detailed to ensure that the final landform is able to be measured to demonstrate that it is meeting or has met the required objectives.

The design criteria have been developed to provide precise benchmarking for the purpose of achieving the design objectives in Table 1-2. Deviations from these criteria will trigger remedial action, described in Table 4-2. Where design changes occur, agencies will be consulted in line with Section 2.3 below.

Table 2-3: Landform design criteria

Objective	Design Criteria Proposed	Notes
Final landforms are compatible with the landscape	• Use of Golder software to smoothing surfaces generated by the Natural Regrade® software, or generation of surfaces similar targeted outcomes to Natural Regrade® but including tools such as erosional risk assessments based on the SIBERIA LEM, and flow tracking. This is then combined with flow modelling, using in-house software that incorporates some of the flood modelling routines used in the CAESAR-Lisflood LEM software. The final surfaces are then checked by LEM modelling and traditional flood modelling tools such as XP-RAFTS. • Use of armouring and size of rock to be limited to D_{50} of typically maximum of 600 mm, except where boulders are used as a landscape feature	Golder software and methodologies will produce a non-linear surface compatible with the local landscape. See note on rock sizing design event below.
Landforms are erosionally stable	• Use topography factor (catchment X slope ^n1) based on experience in the Hunter Valley adjusted for KNP conditions, n1 being the catchment area / slope relationship used in the SIBERIA equation. • Rock to be sized for the 1% AEP storm event. Consequences of larger storms to be considered and mitigated where practical. • Soil loss range of between 5 and 20 t/ha/year measured at any time within the next 500 years, but with a target overall soil loss measured in the long term of less than or equal to 10 t/ha/year.	From the initial design work and assessment of erosion risk, the current design has a drainage density of 81m/ha. Soils testing of the outer capping layer including flume tests will be undertaken as soon as appropriate soils are available.
Landforms are geotechnically stable	• Minimise extent of steep slopes to be 18deg (1V:3H) or flatter for both ease of construction and geotechnical stability • Factor of safety locally on the landform >1.5 under long-term static loading. • Factor of safety overall including the underlying founding conditions and possible groundwater water levels >1.5 under long-term static loading. • Factor of safety ≥1.1 after a 1:10,000 annual exceedance probability (AEP) seismic event.	Design includes 1V:4H slopes (14°) for ease of topsoil placement and revegetation, and to limit the extent of slopes steeper than 1V:2.75H (20.7°) as far as is practical. While 1V:2.75H for some of the slopes at Ravine Bay PSE is steeper than the other PSEs, this is to ensure material is placed on land. However, majority of the landforms are mostly flatter than 1V:4H. Golder has completed geotechnical investigations (Report 20355010-012-TM-Rev0_Ravine Bay geotechnical desk top study and Report S2-CIV-AI-RBS-0002) confirming geotechnical stability for the landform using material properties provided.

Objective	Design Criteria Proposed	Notes
Landforms are appropriate for intended land use	• Provide suitable access for vehicles and/or all-terrain vehicles for rehabilitation, weed control and firefighting to allow for spraying from vehicles (at around 200 metres measured on the slope, or as approved by the NPWS) Minimise slopes over 18deg (1V:3H).	Landforms to be rehabilitated with natural vegetation communities as described in the Rehabilitation Management Plan. This detailed rehabilitation plan for this area will include detail on the tracks that are required during the rehabilitation stage of the project. All tracks will be rehabilitated as per RMP unless NPWS requests a track(s) remain. See Section 3.4 for ongoing NPWS access consultation requirements.
Landform to be suitable and safe for access	• Tracks accessible for 4WD vehicle to access landform during rehabilitation of the landform.	Requirements of Rehabilitation Management Plan to be applied where relevant to the landform. As noted above, the temporary access tracks may be retained for use later if NPWS requests. Otherwise, the tracks will be rehabilitated. See Section 3.4 for ongoing NPWS consultation requirements.
Landform to limit impacts on water quality	• Provide containment on the toe of the PSE. • Sediment controls to be formed upstream of sensitive receptors. All of the landform drains to Talbingo sediment dams are located upstream of sensitive receptors.	Sediment dams are located on the toe of the PSE with sediment fencing and local channels used to ensure sediment control occurs upstream of the reservoir. This is detailed further in the progressive erosion and sediment control plans (temporary) and in the design (permanent).
Landform revegetation	Not detailed here – the surface will be revegetated with appropriate natural plant community types (to minimise erosion) within a reasonably short period of time, typically prior to anticipated late Winter rains.	These issues to be addressed in the Main Works Rehabilitation Management Plan.
Landform constructability	• Include areas 1V:4H or flatter where practical for topsoil storage. • Include temporary sediment control measures in the design sized based on the NSW Blue Book (Soils and Construction, Landcom, NSW). The capacity should be maximised where practical to limit the risk of spilling.	Assess temporary construction access and provide temporary benching layouts. Ensure the design provides a surface that can be progressively rehabilitated where practical and when space permits e.g., outer edges.

2.3. Consultation and Revision

In accordance with the Main Works Approval, this Plan, and the governing Spoil Management Plan (SMP) must be prepared in consultation with the NPWS, EPA, Water Group, NRAR, NSW DPI and TfNSW, prior to approval by the Department of Planning and Environment (DPE).

During onsite inspections or at 12-month intervals from the date of approval of this Plan, this Plan will be reviewed, and relevant agencies consulted on progress and upcoming milestones for design and implementation including but not limited to design changes, internal procedures, placement methodologies and spoil characterisation procedures. This plan will also be reviewed and updated to include information on the proposed in-reservoir spoil trail.

Site specific controls including compaction rates, water quality controls and erosion and sediment controls will be developed and workshopped with the NSW EPA to ensure effective site management. In addition, prior to the emplacement being finalised and rehabilitation occurring, NSW EPA will be consulted regarding a potential capping layer of the landform.

In accordance with Schedule 3, Condition 6 (Table 2) of the Main Works Approval, suitable access for vehicles and/or all-terrain vehicles for rehabilitation, weed control and firefighting will be provided at around 200 m measured on the slope. NPWS will be consulted on access routes for rehabilitation, weed control, and fire fighting, and, if required approval will be sought where the 200 m requirement cannot be provided, prior to finalisation of design.

Once the Rehabilitation and Recreation Management Plans are approved, this Plan will be reviewed for consistency and to ensure effective coordination of rehabilitation.

Following completion of the project and compliance with the Approval, PSEs will be handed back to NPWS for management. As a result, NPWS will be provided with relevant project documentation for information including, but not limited to, geotechnical assessments, erosion and sediment control plans and design drawings. Once internal review processes have been met, documentation will be provided following completion.

3. DEVELOPMENT

Development of the emplacement area will occur over several years, with continual reference to and assessment against the design objectives described Table 1-2, using the design methodologies and criteria described in Section 3 and the completion criteria described in Section 4.

As stated above, this plan will be staged to reflect design and construction progress, and any potential changes. Currently, the design and management measures, reflect spoil emplacement occurring on land. This plan will be updated, and consultation carried out, for any design changes that involve spoil placement in-reservoir.

It is estimated that the Ravine Bay PSE will accommodate approximately 1.61 million m^3 total (1m D&B and 0.61m TBM material). All material, at this stage, will be placed above FSL. The Ravine Bay PSE will broadly be developed as follows (dates are indicative only and are provided to describe sequencing):

- Fourth Quarter 2023:
  - Pre-construction works including identifying weed control and environmental avoidance areas and marking them within the approved disturbance footprint.
- 2024 to 2025:
  - A cut-off drain on the western toe of the PSE collecting affected runoff and directing it to a sediment dam will be established, and appropriate sedimentation controls set in place, including silt curtains as a precautionary water quality control measure.
  - Installation of groundwater monitoring bores.
  - The mulch, topsoil, and subsoils will be stripped in staged approach, and stockpiled temporarily in accordance with Appendix B and C of the Spoil Management Plan.
  - Installation of liner in stages as clearing and spoil placement progresses. If the liner is not ready in time for spoil placement, SHL will place the spoil temporarily at the GF01 spoil site as it is already prepared with necessary environmental controls. The temporary placement of spoil at this site has been assessed under an internal consistency assessment.
  - On-land placement preparation
    - D&B material will be utilised to construction the sediment basin, provided the material is suitable for use as per the characterisation procedure in Attachment A.
    - D&B material will be excavated, temporarily stockpiled at the portals and tested, including testing from probe drilling where spoil is sufficient.
    - Spoil will be transported to the PSE area and stockpiled until NAG (net acid-generation) suite / ANC (acid neutralising capacity) measurements results are obtained and treatment carried out, if required
    - Material will be compacted with rollers until reaching the toe of the design boundary
  - On-land emplacement
    - On-land emplacement will involve a D&B layer being placed and compacted to act as the PAF / NAF barrier layer prior to emplacement of TBM spoil following a conventional bottom-up method.
    - Non-acid forming (NAF) and acid neutralising capacity (ANC) material will be stockpiled so far as practicably possible, as standby material to be used for blending and encapsulation in the event of potential acid forming (PAF) material being identified.
  - TBM spoil excavated, temporarily stockpiled at the portals and tested, including testing from probe drilling where spoil is sufficient.

- Spoil will be transported to the PSE area and stockpiled until NAG suite / ANC measurements results are obtained and treatment carried out, if required.
- Spoil will be placed in accordance with the NAG suite / ANC results, including base-up thin layers to create benches that will be levelled
- Progressive stabilisation throughout to minimise extent of exposed / unconsolidated materials. Depending on the erodibility and dispersion of the material, a layer of D&B material will be placed as a protection layer.

- 2025 to 2026:
  - The material generated from Tunnel Boring Machines (TBM) increases rapidly during this period, it is anticipated that all spoil will be TBM spoil.
- 2026 to 2027:
  - Demobilisation of temporary topsoil stockpiles and infrastructure such as haul roads no longer required.

The landform will be progressively rehabilitated as sections are completed. This process involves potential incorporation of a capping layer (to be determined through consultation with the NSW EPA prior to this stage) and then final shaping and stabilisation of the landform, followed by major rehabilitation works as per Rehabilitation Management Plan.

3.1. Environmental controls

3.1.1. Clearing and grubbing

The PSE will be cleared in progressive stages.

In accordance with the Biodiversity Management Plan (S2-FGJV-ENV-PLN-0028), pre-construction surveys and pre-clearing activities will be completed for land to identify key habitat features, facilitate the egress of fauna, collect seed, and eradicate weeds. Environmental avoidance areas will be identified and marked within the approved disturbance footprint, including the EIS boundary and the progressive disturbance footprint as staged clearing and grubbing is required.

3.1.2. Drainage

As noted in section 2.1.1 and section 2.1.4, prior to emplacement subsurface drains and a lining will be placed to separate natural groundwater flows from PSE drainage and runoff.

The current design has a liner placed over a clean water collection system, the intent being to ensure that seepage will flow on top of the liner, and clean water currently seeping into the base of the valley will be collected separately and directed off site Refer to section 2.1.4 for details on drainage design. The overall drainage design is shown in Figure 3-1 below and includes rock lined drainage channels, one key basin and three stage basins above FSL to limit sediment ingress into the reservoir. A clean water network on the eastern side will be installed directing any surface water run-off away from the construction area. A temporary clean water diversion will also be required during construction to manage the runoff and flows from the existing creek line on the western extent. bearing flows from earth worked areas will be directed to basins.

Basins will be classified as sediment basins during clearing and installation of environmental controls. Once the water draining into the basins has been in contact with spoil, the basins will be reclassified as leachate basins.

It is important to note that for much of the construction period the PSE will comprise a series of terraces linked by haul roads on to which material will be tipped and shaped. Drainage from the terraces will tend to be significant due to the compaction of material but will be managed by incorporating temporary ponds where these terraces shed water, typically at the toe of the ramps from one terrace to another. Temporary bunding will also be placed on the outer edge of the terraces to prevent uncontrolled overspill over the outer edges. At the point where the terraces shed back to natural ground, water will either be directed to the basins on the toe of the landform or contained by temporary ponds within the disturbance footprint. All measures and controls implemented throughout construction including the basins, will be undertaken in compliance with the Surface Water Management Plan (SWMP) (S2-FGJV-ENV-PLN-0011) and at a minimum the Managing Urban Stormwater series (the Blue Book). A leachate detection program (S2-FGJV-ENV-PRO-0062) will be implemented which identifies the analytes, frequency and location of monitoring until this has been proven to not exceed any background criteria for an agreed period with the respective government stakeholder departments (i.e. EPA and NPWS).

To assist with effective management of sediment controls, the basins have been sized above the blue book capacity of 95th percentile and 5-day rainfall (46.8 mm) with a runoff of around 0.79 with a further 50% capacity provided for sediment accumulation. Capacities of each sediment basin are outlined above in Table 2-2.

Sediment control will require active management, including the emptying of sediment basins between rainfall events in accordance with the Surface Water Management Plan (SWMP) (S2-FGJV-ENV-PLN-0011). A comprehensive surface water inspection and monitoring program will be implemented, in accordance with the SWMP and the Project EPL. This program will be more

frequent to begin with and include monitoring after key rainfall or snowmelt events or following deviations to any of the WQO's during in-situ monitoring, to ensure that placement activities are not causing impact to the receiving environment.

The management of basins, including the treatment, reuse or disposal of basin water will be included in the relevant Ravine Bay spoil emplacement site procedures.

Sensitive Area Plans (SAPs) and Erosion and Sediment Control Plans (ESCPs) will be prepared and implemented, consistent with the SWMP to manage specific environmental aspects at each of the construction sites. Controls required for works on waterfront land will be managed in line with management approaches in Table 3-1.

Basins will remain in place until the site is rehabilitated such that the sediment loading, and suspended solids are suitable for discharge to the reservoir. Concrete lining will be removed from basins, and disposed of at a location certified to accept it and the basins will be left to naturally fill with sediment. If the basin's water quality doesn't meet the WQO criteria, SHL manage the water in accordance with relevant water licences or in consultation with the EPA.

To manage potential leachate seepage from the PSE, the Leachate Detection Procedure will be implemented and followed (S2-FGJV-ENV-PRO-0062). Seepage and runoff will be collected in Leachate Basins downstream of the emplacement area. Collected water will be tested for potential contamination which will be guided by the Project EPL. PAF validation audits will be also be undertaken regularly (further detail provided in section 3.6). The above controls, and others deemed necessary, will be developed, in consultation with relevant agencies or as directed by the EPA through the Environmental Protection Licensing mechanism to ensure best practice emplacement area management and protection of water quality. This includes the consideration of a capping layer on the landform.

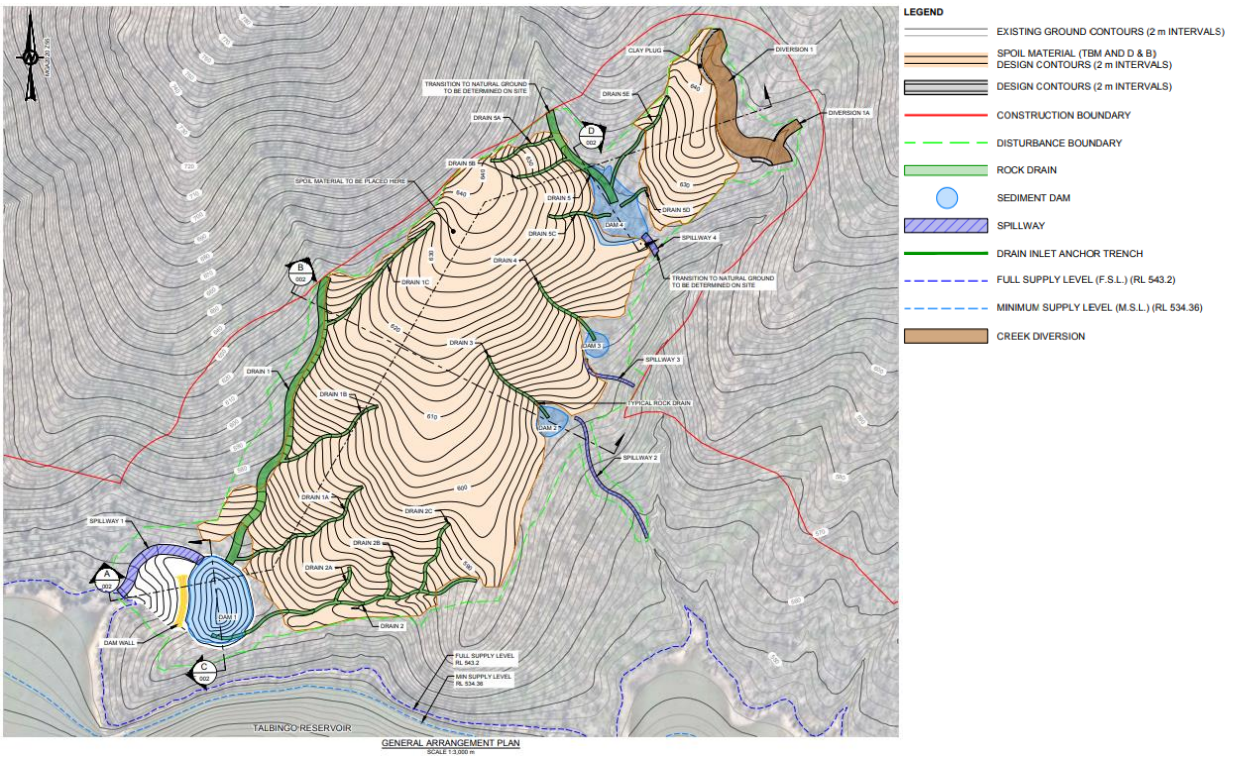


Figure 3-1 Indicative Ravine Bay PSE Layout

3.2. Works on waterfront land and instream works

The *Water Management Act 2000* defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of a riverbank, lake shore or estuary mean high water mark. Instream works refer to modifications or enhancements to a watercourse. All instream works or development within 40 m of any watercourse will be undertaken generally in accordance with the requirements in the *Guidelines for Controlled Activities on Waterfront Land.*

Table 3-1 below outlines types of work expected at Ravine Bay PSE and how the management approaches outline in the SWMP are addressed.

Table 3-1. Management approaches for works on waterfront land and instream works at PSE.

Type	Description	Management approach	Where addressed
Permanent watercourse diversions	Any watercourse that traverses the project disturbance area may be permanently diverted.	Any watercourse that will be permanently diverted around permanent infrastructure will: • be a piped and/or surface drainage system; • be designed and constructed to have non-erosive hydraulic capacity and be structurally sound for the1% AEP event; and • have adequate scour protection at the system inlets and outlets. During detailed design a risk assessment will be undertaken to identify risks associated with by-pass flows that may occur because of system blockage or an event greater than the design event. Watercourses will be rehabilitated in accordance with Rehabilitation Management Plan.	Design, including rock armouring, accounts for the 1% AEP as per Table 2-3.
Temporary watercourse diversions	Any watercourse that traverses the project disturbance area may be temporarily diverted.	Where practical, any watercourse that will be temporarily diverted will; • be a piped and/or surface drainage system; • be designed and constructed to have non-erosive hydraulic capacity and be structurally sound for a design event (that will be established by a rick assessment); and • have adequate scour protection at the system inlets and outlets. A risk assessment will be undertaken to identify risks associated with by-pass flows that may occur as a result of system blockage or an event greater than the design event. Watercourses will be rehabilitated in accordance with Rehabilitation Management Plan.	Any temporary watercourse diversions will be documented in ESCPs in line with the management approach.
Works within 40m of a watercourse	Disturbance may occur on any land within the project disturbance area that is within 40 m of a watercourse or reservoir.	ESCPs are to dictate the specific controls to be used on waterfront land. Typical measures include: • monitoring weather forecasts and taking appropriate action prior; • minimising the extent of work and the amount of time disturbance where possible; • isolating work areas from natural flows where possible; • stockpiles to be located outside of the waterfront area; • use of temporary ground covers in areas of concentrated flow to minimise erosion of exposed soils during rainfall; • Stabilisation of exposed batters within 40m of a natural watercourse prior to forecasted 80% chance of 10mm rain.	Specific controls will be documented in ESCPs as per Section 3.1

		• completing and stabilising works as quickly as possible after works are complete	

3.3. Expected geology

Lobs Hole is located in the Ravine area, west of the Long Plain Fault Zone. The following table is a summary of the geochemical acid base accounting characteristics relevant to two key Lobs Hole geological units. The summary is based on the Geotechnical Baseline Report for Snowy Hydro 2.0 (2019), which indicates the low risk of AMD.

Table 3-2: Count and average geochemical material characteristics

	NAF count	PAF count	Avg %S	Avg ANC (kg H2SO4/t)	Avg MPA (kg H2SO4/t)	NPR
Boraig Group	23	0	0.03	42.8	0.8	53.1
Ravine Beds	229	26	0.15	27.1	4.5	6.0

3.4. Testing

Tunnelling works commenced at the MAT in July 2021, and at ECVT in January 2022. Testing on the MAT and ECVT material has been carried out in accordance with the overarching Spoil Management Plan consisting of the following:

- Sulfur, NAG pH suite, pH, and EC screening
- Validation by a NATA accredited laboratory

While the Ravine Bay PSE will not receive spoil from the ECVT and MAT portals, the results of the testing carried out to date are outlined in the following table and are reflective of the Ravine Bed geological unit.

Table 3-3: Spoil characterisation testing

	Avg XFR S%	Avg Total S%	Avg Chromium Reducible Sulfur (S%)	Avg Net Acid Production Potential (NAPP)	Avg Acid Neutralising Capacity - as H2SO4	Avg Acid Neutralising Capacity - as CaCO3	Avg pH After oxidation
ECVT	0.12	0.11	0.03	-24.41	25.06	2.57	8.98
MAT	0.11	0.11	0.07	-23.12	25.22	2.59	8.91

3.5. Kinetic Testing

Previous geochemical studies undertaken have shown that the material from the different units can potentially be reactive and leach acid, salinity and metals. Geochemical kinetic testing, using the humidity cell test (HCT), have been run on selected material from the key lithological units. The outcomes will be used to better understand the reactivity of sulfides in excavated rocks, the release rates of contaminants, and the water quality evolution in response to long-term oxidation and weathering that may affect the design of the final landforms and the quality of surface and groundwater.

These tests were run for 12 months on each of the seven lithologies of interest that have been identified in previous works.

Samples used in the HCTs were selected by reviewing the geology database and existing borehole logs with a focus on the description of the lithological units and the sulfur content. Key findings are summarised as follows:

- All HCT leachates were characterised by a circum-neutral pH over the course of the 53-week program. No HCT for any of the tested lithologies produced acidic leachates by the end of the column testing period.
- EC values decrease as a function of time, indicating the leaching of readily soluble salts. The main analytes controlling EC were sulfate, bicarbonate, sodium and calcium.
- Most of the metal(loid)s were released during the initial flush, with concentration then dropping below the selected threshold values. Exception to this were the concentrations of Al in all HCTs, and a few peak concentrations of As, Co, V and Zn measured in the Ravine Beds East (RBE) and Ravine Beds West (RBW) HCTs.
- The comparison of the geochemical characteristics of the samples pre- and post-kinetics did not indicate that significant changes to the materials had occurred during the test. This exemplifies the unreactive nature of these materials at the target total sulfur (TS) contents.

3.6. Potential acid forming (PAF) validation audits

SHL will conduct regular Potential acid forming (PAF) validation audits to assess the effectiveness of the PAF management strategy. An independent audit will be initiated within the first 6 months of placement of spoil, with the results of this audit to be provided to DPE. The frequency of subsequent audits will be determined in consultation with DPE. These audits will involve:

- Testing and analysis of leachate (pH, electrical conductivity (EC), oxidation reduction potential (ORP) and Temperature) from active emplacement areas;
- Sampling and analysis of geochemical properties of selected stockpiles (Total S, Acid Neutralising capacity (ANC), net-acid generation (NAG) suite parameters, pH and EC) to ensure that all PAF is being identified; and
- Visual assessment of stockpiles to confirm volume, chemical analysis, blending calculations and mixing method of PAF materials with non-acid forming (NF) materials is in line with that proposed as part of the PAF management strategy.

4. FINAL PLACEMENT AND REHABILITATION

4.1. Transport

- The Ravine Bay PSE area will receive spoil from the Talbingo Intake, Talbingo Haul Roads, Talbingo Spoil Road and Tailrace Tunnel. Ravine Bay spoil will be transported from its source destinations via truck using the internal road network only, no local or state roads will be utilised for the movement of Ravine Bay spoil. Transport routes from the Talbingo Work Areas (A) to the Ravine Bay PSE (B) are summarised in Figure 4-1: PSE spoil transport routes

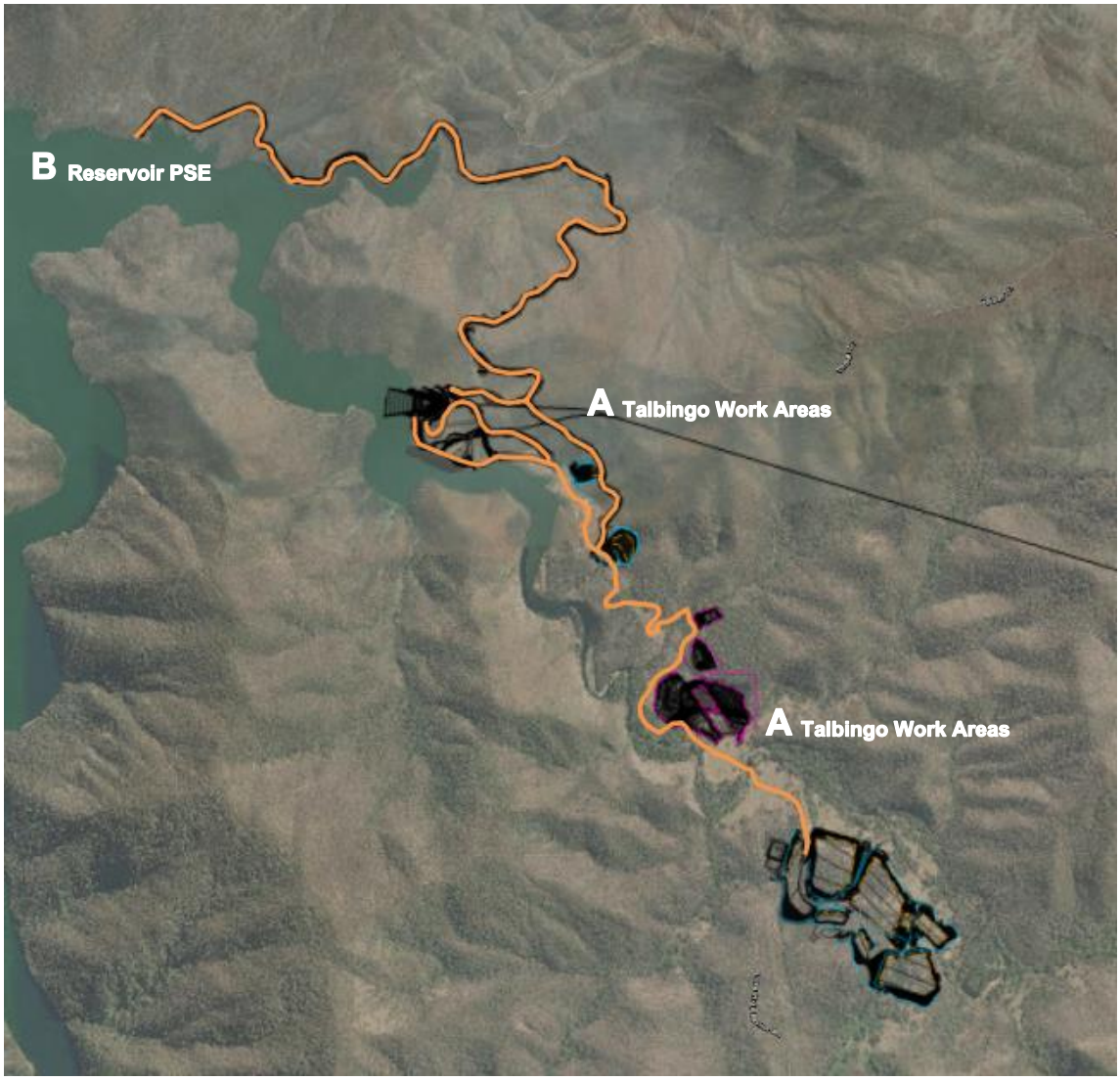


Figure 4-1: PSE spoil transport routes

As described in the Main Works Transport Management Plan and Spoil Management Plan, Vehicle Management Plans will detail internal haulage routes, vehicle types and traffic controls to ensure the safe and efficient movement of vehicles across the project.

Spoil placement at the Ravine Bay PSE will not require water-based placement methods (barge etc.). All spoil will be placed above FSL.

Where marine support is required (e.g. access or installation of the silt curtain), appropriate controls will be used in accordance with the Marine Transport Management Plan, including Marine Traffic Control Plans (MTCPs) and Exclusion Zones. Where required, MTCPs will be developed in consultation with NSW Maritime, and Exclusion Zones will adhere to required licencing, notice and consultation.

The project will use communication tools to inform stakeholders and the community of periodic traffic-related impacts, including the movement of OSOM vehicles and access impacts within the KNP. Further information is provided in the Transport Communications Strategy (Transport Management Plan Appendix E).

4.2. Placement

Ravine Bay PSE is to be constructed with all material to be placed above FSL (RL544.37). In line with the Main Works RTS, material testing of Lobs Hole D&B material shows that only 2% of material is less than 63 µm (closest test faction is 0.075 mm or 75 µm) and 4% of material is less than 2.36 mm.

The management of runoff at Ravine Bay PSE is simplified by the absence of run-on from the natural catchment by having the eastern drain separating clean and dirty water. Water quality will be controlled on the edges of the PSE as describes in section 3.1.

Vehicles shall traverse an access road and utilize a turnaround bay to dump spoil.

Lighting will be set up along the haul route and in the dumping area as required. This will allow for safe, continuous operations throughout the night. All lighting will be in accordance with the Infrastructure Approval:

- Schedule 3 Condition 17 (f); minimise the light spill from night works, including using directional and LED lighting.
- Schedule 3 Condition 53 (d); minimise the lighting impacts of the development, including ensuring that all external lighting associated with the development:
    - is consistent with the good lighting design principles in the Dark Sky Planning Guideline, (DPE 2016), or its latest version; and
    - complies with Australian Standard AS4282 (INT) 1997 – Control of Obtrusive Effects of Outdoor Lighting, or its latest version

Most of the landform will be placed in benches, and once the outer benches are at line and level, these can be dozed down to form the final surface. The benches are non-linear so that the internal or concave corners (in plan view) become the drainage line, and the external or convex corners the ridge lines. Dozing down is done perpendicular to the benches to form the geomorphic landform.

The outer surface will be formed using NAF material to form benches tipped to angle of repose, these benches being temporary to facilitate access and construction.

Progressive rehabilitation will be confined to the areas on land where the landform can be shaped as construction progresses. Portions that are completed during construction can be rehabilitated.

In general terms the construction of the embankments is a bottom-up approach undertaken with conventional earthmoving techniques. The process will be as follows:

- Stage 1: Weed removal and trimming vegetation and topsoil where this is substantial ahead of the placement. In some areas such as on the base of the landform, this stripping could be relatively thick, likely at least 1 m depending on the value of the material. Topsoil or other usable material will be stockpiled in accordance with applicable procedures. Installation of clean water diversions around the emplacement area. Watering monitoring

points will be set up as per the Leachate Detection Procedure (S2-FGJV-ENV-PRO-0062) prior to the placement of confirmed PAF. Silt curtains will be installed around the emplacement area as a precautionary measure.

- Stage 2: Spoil emplacement
  - Prior to emplacement subsurface drains and a lining will be placed to separate natural groundwater flows from PSE drainage and runoff.
  - Spoil will be encapsulated in horizontal layers. PAF material is expected to be placed into the Ravine Bay PSE, so it is important to limit air ingress. Ideally this will involve compaction of the outer layers. PAF material will be placed in thin layers, with thickness adequate to facilitate addition of alkaline additives or NAF material if and when required (300 mm – 500 mm thick). Blending will be carried out to convert PAF materials to NAF materials with a minimum ANC/MPA ratio of at least 3.
  - PAF material will be placed away from the outer edges of the surface with an initial layer of NAF on the natural ground level and spread across the site to not have concentrated areas of PAF.
  - NAF material may be placed in thicker layers adequate to facilitate suitable compaction and will be placed on standby to manage the neutralising processes, if PAF is present. The dozing down of a bench is a bulk earthworks process that cannot be easily done in thin layers with compaction which makes an alternative strategy important. It is proposed that:
    - A D&B layer will be placed and compacted to act as the PAF / NAF barrier layer prior to emplacement of spoil,provided the material is suitable for use as per the characterisation procedure in Attachment A. Compaction testing will be carried out to ensure barrier layer has achieved the required level. A compaction assessment will be carried out via nuke testing to ascertain a compaction level of 70% has been achieved. 70% is compaction level that can be achieved using the TBM and D&B material.
    - The required density for the materials being excavated will be assessed in view of the geochemical data obtained for Talbingo PSE, both at the current time, and as updated through ongoing geochemical testing. From the initial design work and assessment of erosion risk, the current design has a drainage density of 81m/ha.
    - On site, an assessment will be made of the compaction achieved through the trafficking of equipment used for the bulk shaping for areas that will not be reshaped through dozing. Where necessary, material that will not be reshaped through dozing will be compacted using an appropriate roller and layer thickness to achieve the required density. Note that these areas are largely within the Talbingo PSE and not on the outer edges where the air ingress will occur.
    - Placement strategy will be approached from the base up with small lifts at 300 – 500 mm thick.
    - The need for additional compaction for the outer edges during and after dozing will then be reviewed based on the density achieved on site, particularly focussing on the outer edges.
    - Options to achieve additional compaction as required will then be assessed. The outer slopes are generally much flatter than 1V:3H, and compaction would not be difficult, although the layer thickness control may require consideration. The size of roller, type of roller and preferred strategy will then be evaluated to determine the optimal approach.

  - Compaction rates and the geotechnical/geochemical integrity will be progressively workshopped with the EPA.

- Stage 3: Further detail of rehabilitation methodologies will be described in the Rehabilitation Management Plan. At this stage works still to be undertaken would include:
  - The rock drains would be shaped to ensure even widths and so that rock is bedded into the final surface. It will be necessary to remove any dispersive material that is within the trimmed final surface.
  - Rock would then be placed into the drains as and where required, typically with a geotextile underlay.
  - Depending on the nature of the material to be placed on to the outer surface, the final surface may be just topsoil, or some other combination of topsoil, subsoil, and D&B material or some other material. This would be placed in a layer on the outer surface.
  - Prior to revegetation, deep ripping to a depth of around 0.5 m is likely to be required, either on the contour or with a slight gradient towards the drains (but less than 2 per cent).
  - The surface will then be vegetated.

4.2.1. PAF Material

Details of the transport, emplacement, treatment and validation of PAF material are provided in the AMD Management Plan (SMP Appendix E). Further to characterisation and validation (Appendix A), PAF and/or NOA material will be placed in the central parts of the landforms, away from the final surface edges. The key objectives being:

- Achieving and maintaining an overall risk reduction approach by assigning PAF into the lower risk areas of the final landform;
- Reducing the potential need to rehandle material; and
- Providing a dedicated area in which to apply neutralising reagents (if required).

4.2.2. NOA Material

It is not anticipated that NOA will be intercepted at the source locations for the Ravine Bay PSE. NOA screening will only be carried out in areas of confirmed or potential NOA. Where NOA is intercepted methods for transport and emplacement detailed in the NOA Management Plan (SMP) and on-site procedures will be adhered to.

4.3. Rehabilitation

The permanent structure will be rehabilitated consistent with project approval requirements (Schedule 3, Condition 9 and 10) and the Rehabilitation Management Plan and Recreation Management Plan undertaking a staged approach, rehabilitating the landform progressively where possible. For other areas which were only required temporarily for construction, the site will be decommissioned, appropriately land-formed and planted consistent with project approval requirements (Schedule 3, Condition 9 and 10) and the Rehabilitation Management Plan and Recreation Management Plan.

Suitable access for vehicles and/or all-terrain vehicles for rehabilitation, weed control and firefighting will be provided at around 200 m measured on the slope, or as approved by NPWS, in accordance with Schedule 3, Condition 6. Provision in the design for the access tracks is yet to be finalised and will be addressed at a later stage.

All areas will be left in a stable and safe condition, including access tracks which will be maintained, consistent with the Rehabilitation Management Plan required to be prepared in accordance with Schedule 3, Condition 9 and 10).

The Rehabilitation Management Plan will be implemented and will include measures to minimise:

- loss of soil;
- loss of organic matter and nutrient decline;
- soil structural decline; and
- compaction.

Progressive rehabilitation will be confined to the areas on land where the landform can be shaped as construction progresses. Portions that are completed during construction will be rehabilitated.

Following completion of the spoil emplacement, the PSE will be left in a condition that is safe, suitable and non-polluting as well as being suitable for the emplacement area to sustain target PCTs. The requirements for PSE handover, including required depths of surface materials such as topsoil will be established and approved within the Rehabilitation Management Plan, in accordance with Schedule 3, Condition 9 and 10.

4.4. Topsoil strategy

Topsoils and subsoils will be stripped and stockpiled to be retained for future use and rehabilitation. Topsoil and subsoils will be screened or sorted to remove stumps, roots, clay lumps or stones and stockpiled no higher than 2.5m where possible to minimise the risk of compaction and to maintain the viability of the spoil seed bank. Soil stockpiles may be subject to application of weed-free mulch, from clearing activities on the project in the locality from which the topsoil was sourced (where possible), to manage nutrient decline. Soil stockpiles to be covered with weed-free mulch, jute mesh, geofabric or similar to assist with reducing temperature extremes and reducing weeds and helps to maintain its integrity for future use. Soil will not be compacted so as to minimise soil structural decline.

Prior to reuse, the soil will be tested by a NATA accredited laboratory to ascertain its suitability for use in revegetation works. The soil test certificate will contain the date of testing and details of the types of tests undertaken and their results, including cation analysis, pH values, salt content, particle analysis and any recommendations on the use of the topsoil. If the soil test certificate indicates any stockpiled soil to be unsuitable for use in revegetation works, the measures recommended in the soil test certificate to improve the stockpiled topsoil will be implemented as agreed to by Snowy Hydro and NPWS. To assist in preventing possible dispersion of soilborne pathogens, topsoils will be used in the general area from which they were sourced where possible.

4.5. Key risks for the successful completion and contingency measures

The key risks and contingency measures relevant to the transition of the Ravine Bay PSE as a designated PSE area are provided in Table 4-1 below.

Table 4-1: Key risks and contingency measures for successful completion of the Ravine Bay PSE

Risk	Contingency
Clearing and grubbing outside approved area.	Disturbance boundaries are set out on site with no-go areas clearly demarcated.
The works deviate from the design criteria specified.	The design criteria form the Basis of Design (BoD) and these will be used to ensure the achievement of the objectives. Measurement tools are in place to ensure the construction does not deviate from these design criteria. This will be managed through the FGJV technical team design review process. Where concept design changes or deviation from the design criteria is expected, agencies will be consulted.
The timing of construction stages results in insufficient or excessive spoil volume being available for development of the final landform.	There is flexibility around landform volumes which can be increased or decreased by changing the slopes and adjusting the footprint. However, the area on land is constrained by the adjacent drainage line.
Material placed into the Ravine Bay PSE contains contamination (other than the PAF and NOA material).	The proposed design involves placement of all material above FSL. Respond to incidents as per the Unexpected Finds Protocol and Section 6.6 of the Spoil Management Plan. The current planning is to utilise the liner and clean water collection system to limit the footprint of the PSE that is in contact with the environment.
Temporary foreign or unsuitable objects prevent effective filling and / or compaction	Ensure only spoil is placed in the area. Undertake inspections of spoil being laid and compacted. Retain records. These are considered “business as usual” controls.
Soil and water impact(s) during construction	Develop and maintain specific erosion and sediment control plans throughout construction based on risk for each of the spoil layers. Implement and maintain the controls as specified by the erosion and sediment control plans.
The Ravine Bay PSE design is modified and this results in changes to the landform’s future intended use, or approved form.	Check any changes to the Ravine Bay PSE design against the criteria and objectives in the design for the final emplacement area, the Rehabilitation Management Plan, and the Recreation Management Plan. Any changes required need to align with the currently proposed outcomes.
Rehabilitation is inadequate and does not achieve the required outcomes	Ensure that the Rehabilitation Management Plan is followed, including requirements for topsoil placement and surface finishing prior to rehabilitation, ensuring a successful handover.
Volumes of topsoil and subsoils are inadequate	Topsoil volumes requirements will be calculated and if there is not enough topsoil within the site that can be reused, topsoil and other required materials may be ordered from an external source to meet the demand. Procedures to prevent the import of pathogens and weeds in any imported topsoil will be included in the Rehabilitation Management Plan.
Material placed has a higher risk of erosion than expected.	Although an outer topsoil layer is expected to be placed over the excavated tunnel material, there is the risk that the TBM material will be highly erodible due to the possible percentage of silt sized particles. It may be necessary to place a layer of coarser D&B material over the final surface before topsoiling. The surface will then be ripped to increase infiltration and form a coarser final surface.

Risk	Contingency
PAF presence to be managed	To be treated and placed in accordance with Appendices A and E of the SMP and outlined in Attachment A of this plan. Site specific controls including compaction rates, water quality controls and erosion and sediment controls will be developed and workshopped with the NSW EPA to ensure effective site management and will be monitored under the Project EPL. PAF validation audits will also be undertaken to assess the effectiveness of PAF management.
NOA presence to be managed	It is not anticipated that NOA will be intercepted at the source locations for the Ravine Bay PSE. Where pre-placement screening identifies the presence of NOA, methods for transport and emplacement detailed in the NOA Management Plan (SMP) and on-site procedures will be adhered to.
Rock drainage lines not constructed correctly or rock too small and experiences erosion.	Ensure robust rock sizing for drainage lines, use of suitable rock with the correct grading, and proper construction controls. TARP to address deficiencies.
Soil and water impact(s) during removal of controls	Sediment dams can remain in place until rehabilitation is completed and an acceptable water quality achieved.
Long term stability not demonstrated	Undertake LEM to confirm long term stability and address any areas of higher erosion risk.
Final dozing occurs towards water	The landforms current staging is fully on land, no dozing will into the water.
Post construction recreational use changes or is not achieved	The landform has been sloped to meet targets that are similar to natural slopes in the general area and should allow easy access. Rock has also been limited to ensure that passage on to the surface is easily achieved.
The varying water level causes scour through wave action	The design has been revised to ensure, at this stage, all spoil is placed on-land. Risks from varying water levels and subsequent scouring are therefore avoided.
Risk of scour in relation to pump operation	The design has been revised to ensure, at this stage, all spoil is placed on-land. Risks from varying water levels and subsequent scouring are therefore avoided.
Water rising (flooding) the area due to high rainfall	Sediment basins and surface water will be monitored regularly during routine site inspections, particularly prior to rainfall and any shutdowns.
Public risks associated with the reservoir	Ensure appropriate exclusion zones and notifications to the community have been undertaken appropriately.
Risk of differential settlement during construction	Stability to be monitored at regular intervals during placement, separate stockpiles to differentiate material placement.
Climate change changing the occurrence of extreme events	Design, including rock armouring, accounts for the 1% Annual Exceedance Probability (AEP) risk, or a 1 in 100 year Average Recurrence Interval (ARI) storm event.
Leachate from the spoil emplacement	A spoil characterisation program has been prepared involving XRF, NAG suite analysis, pH, EC, and nutrient screening and validation testing by a NATA accredited laboratory (Appendix A of the SMP) to ensure material is neutralised prior to placement. Basins will be constructed on site and tested for potential contamination prior to reuse on the stockpile. Site specific controls including compaction rates, water quality controls, erosion and sediment controls and a potential capping layer will be developed and workshopped with the NSW EPA to ensure effective site management and will be monitored under the Project EPL.

Risk	Contingency
Neutral mine drainage	Kinetic testing has been carried out to understand the reactivity of the excavated rock. The outcomes will be used to better understand the reactivity of sulfides in excavated rocks, the release rates of contaminants, and the water quality evolution in response to long-term oxidation and weathering that may affect the design of the final landforms and the quality of surface and groundwater. Site specific controls including compaction rates, water quality controls and erosion and sediment controls will be developed and workshopped with the NSW EPA to ensure effective site management and will be monitored under the Project EPL.
Nitrates in spoil entering environment	Whilst there is not expected to be an issue at Ravine Bay with no placement of materials with concentrated levels of nitrates, Snowy Hydro has worked with the NSW EPA on a precautionary liner option to prevent seepage of water into the groundwater table, with details covered in the Project EPL. Additional controls include: • The basins will be impermeable. • The spoil testing and water monitoring programs will be increased following learnings from GF01. • A Nitrogen Management Plan is under development in consultation with the NSW EPA which will detail measures to be minimise the impacts of nitrogen and associated contaminants derived from spoil. If materials with high nitrate levels are encountered, these are currently proposed to be treated prior to placement or alternatively taken off site. Snowy Hydro is also exploring the potential to encapsulate untreated materials at the Ravine Bay PSE however this will require additional consultation with NPWS and the NSW EPA, and changes to the Project EPL prior to work being undertaken.

It is also noted that the Ravine Bay PSE could be subject to scour within the Talbingo Reservoir through the generation of high velocities during pumping or power generation if spoil is placed in water. Review of this will be included in the in-reservoir emplacement trial. This plan will be updated, and consultation carried out, for any design changes that involve spoil placement in-reservoir prior to placement as per section 1.3.

4.6. Completion criteria, performance indicators and criteria for triggering remedial action

Using the design approach described in Section 3 of this plan, FGJV has developed designs for the Ravine Bay PSE that satisfy the requirements from infrastructure approval Schedule 3, Condition 6 (Table 2). The outcomes are detailed below.

Completion criteria for the whole of project have been developed, and those relevant to landform design have been identified and are presented in Table 4-2. These criteria will form the basis of specific landform design criteria used to measure achievement of the objectives listed in Table 1-2. This will be an iterative process informed by the design criteria in Table 2-3 and continually assessed and revised as the design progresses.

The completion criteria will also be aligned with the existing environmental impact register in the Environmental Management Strategy for the Main Works phase where relevant and practical (FGJV, 2020a).

Table 4-2: Completion criteria

Objective	Objective	Performance Indicators	Measurement Tools
Final landforms are compatible with the landscape	• As natural as possible, including minimising the use of linear or engineered structures. Sympathetic with the landforms of the surrounding area, particularly from a visual, water management and ecological perspective. • Minimise the use of large rocks in the drainage lines (taken to be rocks typically with a D_{50} or median diameter of over 600mm in diameter).	• Final landform is representative of typical landforms in the area (but still appropriate to the materials on the outer surface). • Rocky drains blend into the overall landscape	• Confirmation of final landform using a combination of drone imagery and manual survey. • Long sections and cross sections show smooth integration with adjacent natural surface. • Max rock size to be appropriate to the channel width.
Landforms are stable from erosion	• Suitable drainage density to limit overland flow lengths. • Safe, long-term and non-polluting. • Integrate the drainage of the emplacement area with the surrounding drainage network, including any upstream flows and residual run-on water. • Minimise valley infill (to limit run on). • Create natural drainage lines that are long-term sustainable having regard to the selection of suitable underlying materials, including rock sizing and grading. • Minimise the concentration of water on landforms unless this is consistent with accepted drainage density and geomorphic design practices. • Minimise changes to stream power and velocities above and below the landforms. • Ensure areas subject to wave action are suitably protected or the slopes are flattened to limit wave action.	• Soil loss range of between 5 and 20t/ha/year measured at any time within the next 500 years, but with a target overall soil loss measured in the long term of less than or equal to 10t/ha/year. This value is subject to review through use of an LEM to ensure it is reasonable for a long-term stable surface in this location. • Erosion/deposition processes within parameters of surrounding landscape and similar landforms relative to materials present	• As built design reports including erosion risk assessment (qualitative) including high level assessment of stability under wave action. • LEM (such as SIBERIA or CAESAR) will confirm acceptable future outcomes. This will be a requirement for the regulator to demonstrate long term sustainability and compliance. • While standard practice involves acceptable erosion rates against natural landforms of similar materials within the existing landscape bounds, this is unlikely to be practical as the material being placed differs from the dominant landforms of the KNP. It is proposed to use generally accepted erosion rates as indicated in the completion criteria together with a review of the landform performance as determined by the LEM. • All material will be placed above FSL and subsequently not at risk of wave action

Objective	Objective	Performance Indicators	Measurement Tools
Landforms are geotechnically stable	• Ensure placed material for the landform is stable geotechnically by ensuring slopes within the final surface are appropriate to the materials being used (excludes material underlying the PSE).	• Slopes to be geotechnically stable in accordance with the Design. • Any slopes with a lower factor of safety to require individual sign off by a suitably qualified professional based on a risk assessment for that feature. • Landforms that are not constructed in accordance with the design will be deemed a non-conformance by Snowy Hydro and be managed through this process.	• Most of the landforms are inherently stable if the founding conditions are adequate because the slopes are typically flatter than 1V:4H. • In accordance with the Earthworks specification (including ITP compliance and inspection records) regular geotechnical inspections of the Ravine Bay PSE will be undertaken. Relevant ITPs include: ○ Surface Excavation, Protection and Support - S2-FGJV-QUA-ITP-0002. ○ General Fill Placement - S2-FGJV-QUA-ITP-0008. ○ Handling and Characterisation Spoil Management – S2-FGJV-QUA-ITP-0048. • The long-term geotechnical monitoring of the landforms will include regular aerial surveys, quarterly site inspections and annual monitoring as per Rehabilitation Management Plan.
	• Ensure overall geotechnical stability considering the strength of materials underlying the PSE, bedding angles, and the possible impact of groundwater on the overall stability.	• Overall landform to be geotechnically stable in accordance with the Design. • Any overall landforms with a lower factor of safety to require individual sign off based on a risk assessment for that feature. • Groundwater seepage and fluctuating dam water level management strategy if required and where appropriate.	• Slope stability analyses for the overall PSEs including the footprint and accounting for groundwater conditions • Management of potential stability risks at the edge of the reservoir where there is thick fill and potentially unconsolidated alluvial sediments will be investigated and verified by intrusive investigations once site access is available.
Landforms are appropriate for intended land use	• Landform to be safe for access where required. • Provide suitable access for vehicles and/or all-terrain vehicles for rehabilitation, weed control and firefighting to allow for spraying from vehicles (at around 200 metres measured on the slope, or as approved by the NPWS). Minimise steep slopes that will be difficult to access and maintain (such as slopes over 18deg (1V:3H)).	• Landform to meet capability classes. • Slopes to be no steeper than 18deg (1V:3H) except where steeper slopes are required to tie into the existing natural landform. • Access tracks have not yet been indicated – these will be added during construction using the as-built surfaces. Where practical, access tracks to be left in the landform.	• Land capability assessment to be undertaken– in this environment this may focus more on the soil capping and revegetation than the landform itself. • “Heat maps” to confirm the constructed surfaces and slopes are within the required tolerances of the design surfaces

Objective	Objective	Performance Indicators	Measurement Tools
Landform to be suitable and safe for access	• Recreational facilities and use must be consistent with the approved Recreation Management Plan.	• Requirements of Recreation Management Plan to be applied where relevant to the landform.	• Document to include details on how the requirements of the Recreation Management Plan have been addressed.
Landform to limit impacts on water quality	• Minimise the generation and dispersion of sediment in the Talbingo Reservoir, or other waterways. • Outer surface to be geochemically benign to not impact on water quality in the reservoirs. • Groundwater ingress to be managed where needed to limit impact on water quality.	• Surface water quality from runoff off the landforms to remain within the agreed parameters. • Groundwater associated with perched aquifers flowing on to surface of landforms or seepage from direct rainfall and infiltration into the landform to be incorporated into the landform surface water management where relevant.	• Design reporting and refinement. • Design report to document sediment control measures such as sediment basins immediately downstream of the landform. • Design report to flag construction issues and management. Overall geochemistry to be assessed through sampling of seepage where present on the toe. Trends and performance relative to anticipated qualities will be monitored and measured and if necessary, remedial measures implemented if required. • Monthly EPL monitoring downstream of emplacement area. If required, and in accordance with Appendix A, Annexure A of the Surface Water Monitoring Program (S2-FGJV-ENV-PLN-0107-F), Trigger Action Response Plans will be followed.
Landform revegetation	• The final surface of the landform must be long-term sustainable including sufficient topsoil (or some other suitable growth medium and amelioration, if required) to maintain a soil water profile and sustain vegetation. • Maximise the revegetation of the final surface. • Native vegetation and habitat must be consistent with the approved RMP	Revegetation performance indicators to be detailed in the Rehabilitation Management Plan.	Revegetation measurement tools to be detailed in the Rehabilitation Management Plan.

Objective	Objective	Performance Indicators	Measurement Tools
Landform constructability	The emplacement area must be constructible having regard to the: • construction methodology accounting for PAF and NOA materials management • availability and storage of suitable materials, including topsoil. • erosion and sediment control. • access. • initial shaping of the natural ground. • shapes and benching. • progressive rehabilitation. • safety around water.	• Landform design to include areas for temporary topsoil storage. • Adequate temporary sediment control measures to be provided where needed. • Temporary benches for the final surface to be provided. • Design to allow for safe access during construction, and progressive rehabilitation. • Landform design to consider safety around water where appropriate.	Design report to document: • Areas designated for PAF and NOA materials outside of drainage and full supply extent lines highlighted in the design report. • Areas of the landform flatter than 1V:4H to be highlighted in the design report for topsoil storage. • Temporary features including sediment control and benches. • High level access planning (detail planning by others).

ATTACHMENT A – RAVINE BAY MATERIAL CHARACTERISATION AND HANDLING STRATEGY

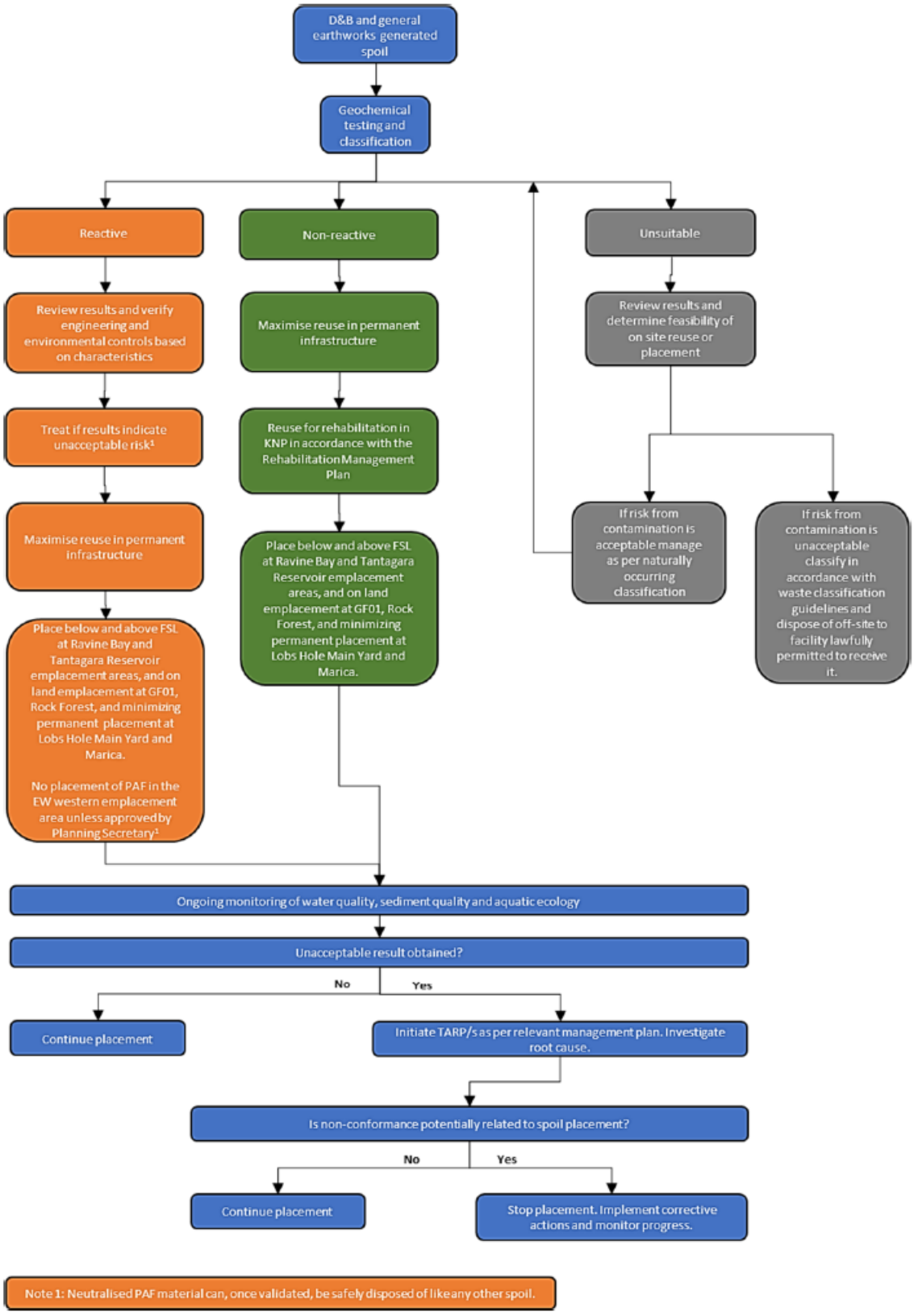


Figure A1 – D&B and earthworks generated material flow chart

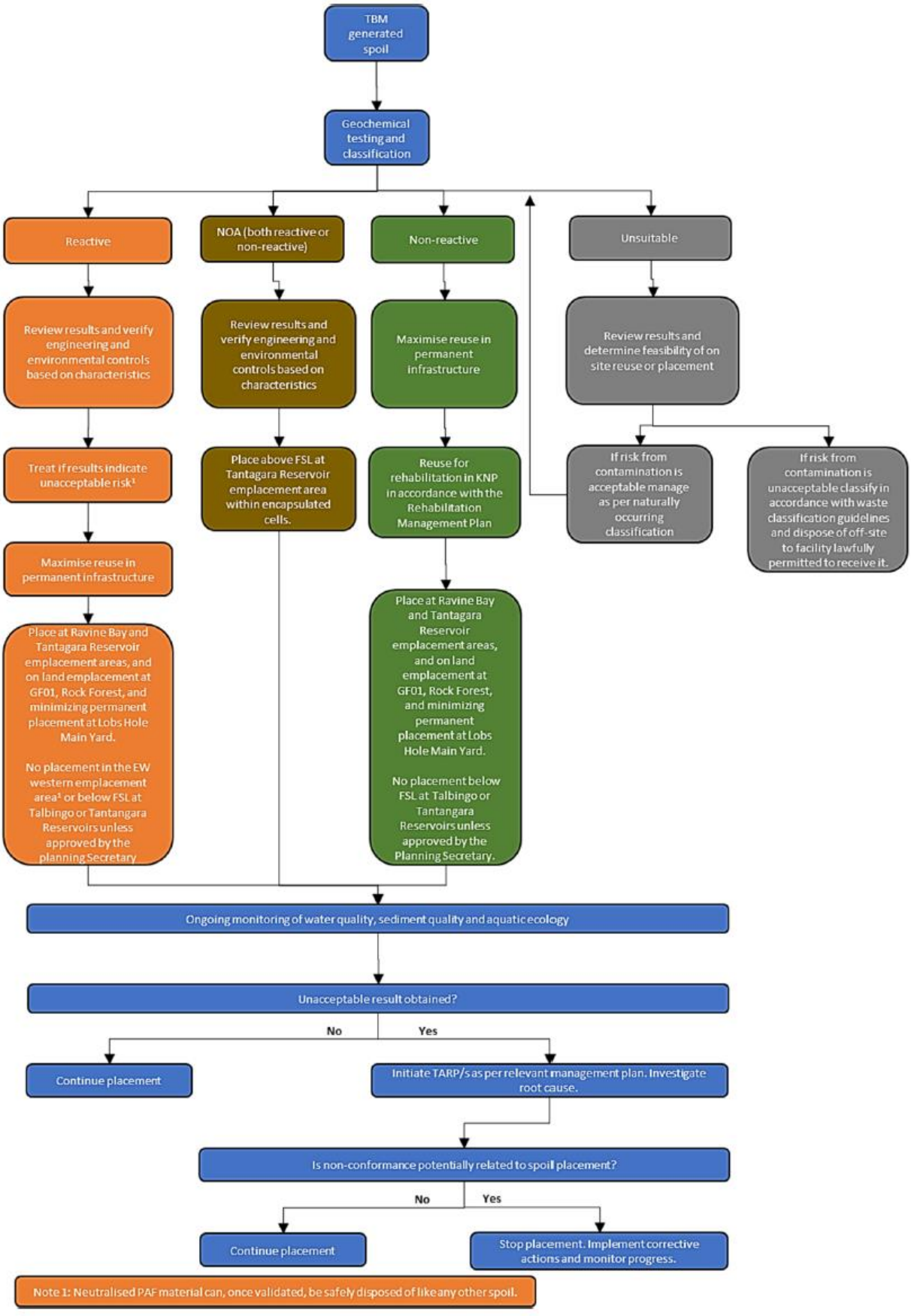


Figure A2 – TBM generated material flow chart