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Resources Regulator

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Tailings storage facilities management

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Executive summary

This report summarises assessment findings from a targeted assessment program (TAP) across 10 mines, focussing on how the mines are preparing for and implementing controls associated with tailings storage facilities (TSF) management to achieve sustainable rehabilitation outcomes. Assessments were conducted between July 2024 and December 2024. The assessment criteria and corresponding critical controls are shown in Appendix A. Figures 1-2 present the assessment findings for each de-identified mine. Explanatory notes on the assessment system are in Appendix B.

Assessment finding letters were issued to each mine in the program, which included a summary of key observations made by the Regulator during the assessment as well as recommendations for improvement in the medium to longer term. Statutory notices pursuant to section 240 of the *Mining Act 1992* were issued to 2 mines, directing them to take specific actions relating to the management of TSF to achieve sustainable rehabilitation outcomes that will support achievement of the final land use.

The TAP findings suggest the majority of mine operators need to address the following recommendations to improve the implementation of the critical controls required to mitigate risks associated with tailings management:

Rehabilitation risk assessments – Rehabilitation risk assessments should be reviewed to ensure they covers risks and uncertainty (or knowledge gaps) identified in the TAP. As part of this review, all risk controls, follow-up assessments and other actions that are required to address uncertainty should be assigned to the appropriate person or position and timeframes for completion are nominated. For mines who have identified TSF management as a high risk for closure, it is expected that a tailings specialist be involved in the rehabilitation risk assessment review.

For mines that have conducted multiple risk assessments for tailings management, it is also recommended a centralised risk register be provided, listing a summary details of all risk assessments undertaken, their purpose and relationships to each other and the rehabilitation risk assessment.

Characterisation of tailings and TSF construction materials – Undertake ongoing tailing characterisation testing to determine the geochemical properties and if these change over time. For TSF construction materials, verification testing must be undertaken combined with quality assurance to ensure materials used for TSF containment, capping or other rehabilitation cover materials are suitable. For example, characterisation and exclusion of acid metalliferous drainage (AMD) material.

Problematic tailings management – Undertake comprehensive review of groundwater assessments and monitoring that has been undertaken in the vicinity of TSF to determine long-term trends. Develop trigger action response plans (TARPs) for groundwater monitoring, to determine response measures to any seepage detected from TSFs.

Managing tailings deposition – Review the implementation of tailings deposition techniques and surveillance to avoid restricted decant drainage and to maintain freeboard requirements. Furthermore, review the removal of water on tailings and implementation of ongoing programs to manage excessive water.

Determine likely settlement/consolidation and if this is of a magnitude that requires consideration in the capping design (i.e. additional thickness).

Capping performance and design – Undertake an assessment to identify the source and suitability of all capping material required for TSF rehabilitation. The assessment must identify the source of materials to cover any shortfalls, such as borrow-pits.

Assess the risk and risk control for inevitable tree growth in the tailings capping material and embankments in the period following closure. Ideally, the capping should be designed to help tree growth.

Final landform design of the TSF – Finalise the concept design of the final landform for TSFs including the location of drainage and surface water management features.

For mine sites with TSFs approaching decommissioning, an assessment of the final landform surface water management by a suitably qualified tailings engineer is required. This will determine requirements for a spillway or drop structure to manage surface water collected on the TSF during significant rainfall and convey this flow over the embankment. Where required, surface water management structures in the closure landform should be consistent with requirements specified industry-accepted criteria provided by ANCOLD and the Global Tailings Standard guidelines.

Erosion modelling of the final TSFs landform. The erosion modelling should ideally use a landform evolution model and be used to identify high-risk erosion areas and likely risk controls (potential remediation options). The model is also required to verify the suitability of the capping material to manage erosion impacts.

Any revision to the final landform including location of significant drainage features are required to be submitted to the Regulator as part of a revised final landform and rehabilitation plan.

Rehabilitation management plan – reviewing and amending the rehabilitation management plan to ensure the relevant recommendations of this report are documented and implemented.

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Introduction

The Resources Regulator undertakes TAPs at mines in NSW assessing a mine's critical rehabilitation risks and the critical controls required to mitigate these risks.

To this end, we developed a bowtie risk management framework and standardised assessment checklists for a range of TAPs. Each TAP focuses on implementing identified critical controls (categorised in accordance with the ICMM handbook[1]) to determine whether measures have been identified and implemented to ensure sustainable rehabilitation outcomes.

Further details regarding our TAP programs, including the bowtie risk assessments, are available on our website.

A summary of the TAP assessment setup, including objectives and assessment criteria for each critical control is provided in Appendix A.

The TAP applies the following principles:

- Consideration of the mine's risks to achieve effective rehabilitation.
- A focus on the implementation of the identified critical controls.
- Evaluation of the effectiveness of the control measures implemented.

The TSF management TAP was undertaken between July 2024 and December 2024. The TAP assessed the critical controls associated with TSF management activities to achieve sustainable rehabilitation outcomes that will support the final land use.

The program included site inspections at 10 mine sites.

Scope

The TAP incorporates:

- a desktop assessment of documents and records to identify the control measures the mine utilises to prevent and mitigate the risks to achieving sustainable rehabilitation outcomes
- a site inspection of the mine to assess the implementation of those controls.

The process

The process for undertaking a TAP generally involves the following stages:

- written notification to the mine providing details of the proposed TAP. This includes:
  - the focus areas of the assessment
  - assessment timing and assessment team composition
  - a list of the likely documents and records that should be made available for assessment
  - the resources that should be made available by the mine, including site personnel that may be required to participate.

[1] Critical Control Management Implementation Guide, International Council on Mining and Metals (ICMM), 2015.

- a site visit to the mine (normally one day) to undertake both the desktop assessment and site inspection
- verbal discussion and feedback to the mine management team on the findings and likely actions that need to be taken by the miner operators in response
- written feedback to the mine, which may include an assessment finding letter and/or a direction to address certain matters pursuant to section 240 of the *Mining Act 1992*.

Assessment findings

Controls assessed

Rehabilitation risk assessment

Control: MRP1.1 – Rehabilitation risk assessment

The risk

A standard condition of mining leases[2] requires the preparation of a rehabilitation risk assessment that:

- identifies, assesses and evaluates the risks that need to be addressed to achieve the final land use
- identifies the measures that need to be implemented to eliminate, minimise or mitigate the risks.

The measures identified in the rehabilitation risk assessment are required to be implemented and mines must identify and record any reasonably foreseeable hazard that presents a risk to rehabilitation being able to achieve the final land use.

Rehabilitation risk assessments are required for each mine to identify the risks that need to be addressed for TSF management relevant to their site and circumstances. The rehabilitation risk assessment will then identify the appropriate risk control measures that must be implemented and identify how risk control effectiveness will be assessed.

A deficient rehabilitation risk assessment will result in appropriate control measures not being identified and implemented to address risks associated with TSF management to ensure rehabilitation achieves the final land use.

What was assessed

A rehabilitation risk assessment should identify, assess and evaluate the risks that need to be addressed when generating and storing tailings to achieve sustainable rehabilitation outcomes that will support the final land use.

Site-specific rehabilitation risk assessments should:

- identify, assess and evaluate the risks that need to be addressed to achieve the rehabilitation outcome documents (being the rehabilitation objectives statement, rehabilitation completion criteria statement and final landform and rehabilitation plan)
- identify site-specific risks associated with tailings management

[2] Refer to clauses 6(3) and 7 in Schedule 8A Mining Regulation 2016

- identify suitable controls and strategies to treat the identified risks
- are relevant to active mining operations
- be produced by a team of appropriately skilled and experienced people from the workforce with responsibilities for mine rehabilitation
- result in the identified controls being assigned to a responsible and suitably qualified position
- where multiple risks assessments have been conducted, be a centralised document (e.g. risk register) that links all assessments to the requirements set out in Schedule 8A of Mining Regulation 2016.

What we found

We found most rehabilitation risk assessments covered key risks and nominated controls for tailings and TSF management. However, it was noted most risk assessments assessed did not consider post-closure risks associated with tree growth in TSF capping.

We observed a number of risk assessments did not have risk controls assigned to a responsible and suitably qualified position, also timeframes for review of the risk control were missing.

We also identified an over-reliance on management plans as a risk control, rather than nominate the specific controls that would be required to be implemented to address the specific risk.

In some circumstances, we found mines had developed several risk assessments associated with tailings and TSF management but were uncertain on how the separate risk assessments relate to rehabilitation risk assessment. In some circumstances, there were inconsistencies, with risk assessments updated and amended at separate times. This also correlated with the absence of a centralised risk register.

Characterisation of both tailings and TSF construction material

Controls: MP 3.1 & 4.1 Characterisation analysis (geochemical and geotechncial)

The risk

Geochemical and geotechnical constraints of tailings and tailings storage facilities construction materials have not been determined to enable management strategies to be implemented during the construction phase.

What was assessed

Characterisation analysis conducted and geochemical and physical properties of waste materials are understood.

Where relevant, an appropriate geological model was adopted to determine the source of the problematic material – typical for acid metalliferous drainage (AMD). Typically block models are used for metalliferous mines ,while regular verification testing would be appropriate for coal.

Ongoing sampling program was in place to identify potential changes in material properties.

Strategy/procedure/management plan was developed for selective handling and management of problematic materials for tailings storage facilities construction material e.g. potential acid forming (PAF) materials.

What we found

We found variable characterisation assessment of both tailings and TSF construction materials. We noted most mines had identified risks associated with geochemical problematic material (such as acid metalliferous drainage) within the rehabilitation risk assessment but had not nominated ongoing verification testing as a control. As a result, most mines included in the TAP relied on characterisation testing undertaken during the initial mine approval environmental assessment with no ongoing testing of tailings to verify characteristics. We also noted verification testing of construction materials was generally deficient.

Problematic tailings management

Controls: TM-RE2.1 Dam construction (environmental) drainage/seepage control TM-RE2.2 Liner/barrier (geomembrane/modified soil/clay)

The risk

Uncontrolled release of contaminants from the tailings storage facility.

What was assessed

If required, TSF liner:

- Type of liner and performance specified (lifespan, thickness, area of placement).
- Construction material and source identified.
- Construction quality assurance program was in place to verify liner performance was achieved during construction e.g. membrane liner welding or geotechnical supervision testing of clay.
- Information on how liner performance was maintained if tailings facility if extended (i.e. additional lifts).

If required, drainage system (i.e. subsurface drainage for seepage collection, not decant management):

- Drainage requirements and performance identified. Collection system for the drainage specified.
- If applicable, information on how drainage system could be modified as the tailings facility was extended (i.e additional lifts).

Monitoring:

- Groundwater monitoring program was in place to determine liner and/or drainage system effectiveness.
- Trigger action response plans (TARPs) in place to respond to monitoring.

What we found

The majority of mines included in the TAP had a liner specified to manage problematic tailings. The information on liner installation including quality control to verify its integrity was generally deficient. We also noted that due to the age of some the TSFs, information on the liner installation was not available.

We noted while most mines had groundwater monitoring program in place, TARPs to outline the response to elevated analytes that may indicate leakage and seepage from the TSFs where only included at 3 mines.

Manage tailings deposition

Controls: TM-PC4.1 Consolidated tailings management practices TM-RE1.2 TSF operation (storage capacity and freeboard)

The risk

Tailings consolidation/settlement is not maximised during tailings placement resulting in impacts from post closure settlement. Tailings deposition does not maintain an appropriate environmental freeboard resulting in tailings discharges during significant rainfall.

What was assessed

Deposition strategy was documented. This included consideration of the following:

- Options analysis for treatment method.
- Treatment methods such as flocculent etc.
- Placement depth and time frames for settlement.
- Type of distribution system e.g. spigot number and layout…
- Additional treatment for breaking up crust.
- Decant design, location and operation.
- Requirements to maintain moisture in tailings for dust control and/or reduce PAF reactions.
- Regular surveying (RL) of tailings undertaken to optimise tailings placement.
- Survey information collected to determine long/term consolidation/settlement.
- Long term consolidation/settlement of tailings modelled.
- Monitoring consolidation and strength profile of previous placed tailings undertaken, when appropriate i.e. inactive TSFs (this may include insitu testing such as CPT, shear vane).
- Operational freeboards are identified and monitoring undertaken to maintain. The environmental containment freeboard is specified and calculated for significant rainfall events (depending on TSF consequence category).
- TARPs in place to respond to monitoring.

What we found

Controls to manage tailings deposition was generally satisfactory. Most mines had infrastructure in place to minimise tailings placement depth, increase desiccation and minimise decant, as well as adequate operation procedures. However, due to seasonal conditions, some mines had retained too much water on TSFs and in some circumstances minimal freeboard was being maintained.

Monitoring and modelling of long term settlement of tailings was generally deficient, with no mines included in the TAP being able to provide a prediction of long term settlement of tailings to inform landform considerations at closure.

Capping performance/design

Controls: TM-PC1.2,2.3,3.1,4.2 Capping design/performance

The risk

TSF capping does not provide an adequate final barrier to contain tailings and prevent release to the environment, manage seepage and support the final land use.

What was assessed

Principle function of capping identified i.e. 'rainfall shedding', 'store and release'.

Performance requirements for capping for tailings with low strength (bearing capacity – if identified as a consideration:

- Testing undertaken to verify tailings had sufficient bearing capacity to allow capping placement.
- Use of geotextiles and other engineering materials nominated (if required) and the installation process documented.
- Thickness of capping specified to reach strength performance nominated.

Performance requirements for capping to reduce permeability and seepage into tailings – if identified as a consideration:

- Post closure water balance when determining likely seepage.
- Consideration of oxygen flux in capping for geochemically unstable tailings.

Performance requirements for capping taking into account final land use:

- Capping thickness to support final land use.
- Consideration of capping surcharge to offset expected settlement of tailings.
- Consideration of vegetation death on capping performance (i.e tree death and fall, material removed with root ball exposing tailings).
- Other potential problematic materials impacted final land use assessed if proposed for use in capping, such as PAF or other contaminants of concern, sodicity/dispersive soils. (note that erosion is assessed under assessment finding for final landform design of tailings storage facility).
- Capping performance to address any potential combustibility issues (typically coal mining).

Capping material identified:

- Location of source, quantity required identified.
- Methods to quarantine adequate quantity of capping material specified.

What we found

Although information on capping design was available for each mine (capping thickness and material), information to verify the capping performance in relation to seepage and/or support of the final land use was not provided for most of the mines in the TAP.

While many mines identified the source of capping material, some mines had not verified adequate volumes of material was available via a recent soil/material balance assessment.

We also noted tree growth within the TSF capping was not considered in the capping design/performance at most mines included in the assessment. Only one mine undertook previous trails of tree vegetation within the tailings material to verify the suitability of the TSF to support native tree growth post closure. Risks and appropriate controls associated with post-closure tree growth on TSFs was not addressed in the rehabilitation risk assessments reviewed as part of this TAP.

Final landform design of TSF facility

Controls: TM-RE1.1 and TM-PC1.1 Surface water management and erosion control (final landform)

The risk

The TSF containment structure (embankments) and capping was not adequately protected from scour/erosion for surface water movement (significant rainfall).

What was assessed

Final landform design takes into account:

- Surface water management for significant rainfall events.
- The location and types of surface water management structures, and consideration of positioning of these structures and construction material required.
- Erosion control measures over extended time periods.
- Long term settlement of tailings modelled and consideration of controls documented as part of final landform design.

What we found

While 2 mines undertook assessment of the final landform of the TSF using landform evolution models, the remaining mines had not undertaken any formal assessment to demonstrate the final landform would be stable in the long term with regards to erosion and that the capping would remain intact.

Information on surface water management structures was also deficient, with some mines not providing any information on the need for closure spillways or drop structures. For mines that had nominated the need for a spillway or drop structure, no assessment was undertaken to confirm the design (size) required to convey the volume and scour protection for surface water flows from a significant rainfall event. There was no evidence that ANCOLD requirements were considered for final landform spillway or drop structure design.

Assessment findings by mine

The assessment findings by mine are summarised in the figures below. More details explaining the assessment system are found at Appendix B.

Figure 1: Overall assessment findings ratings by assessment criteria

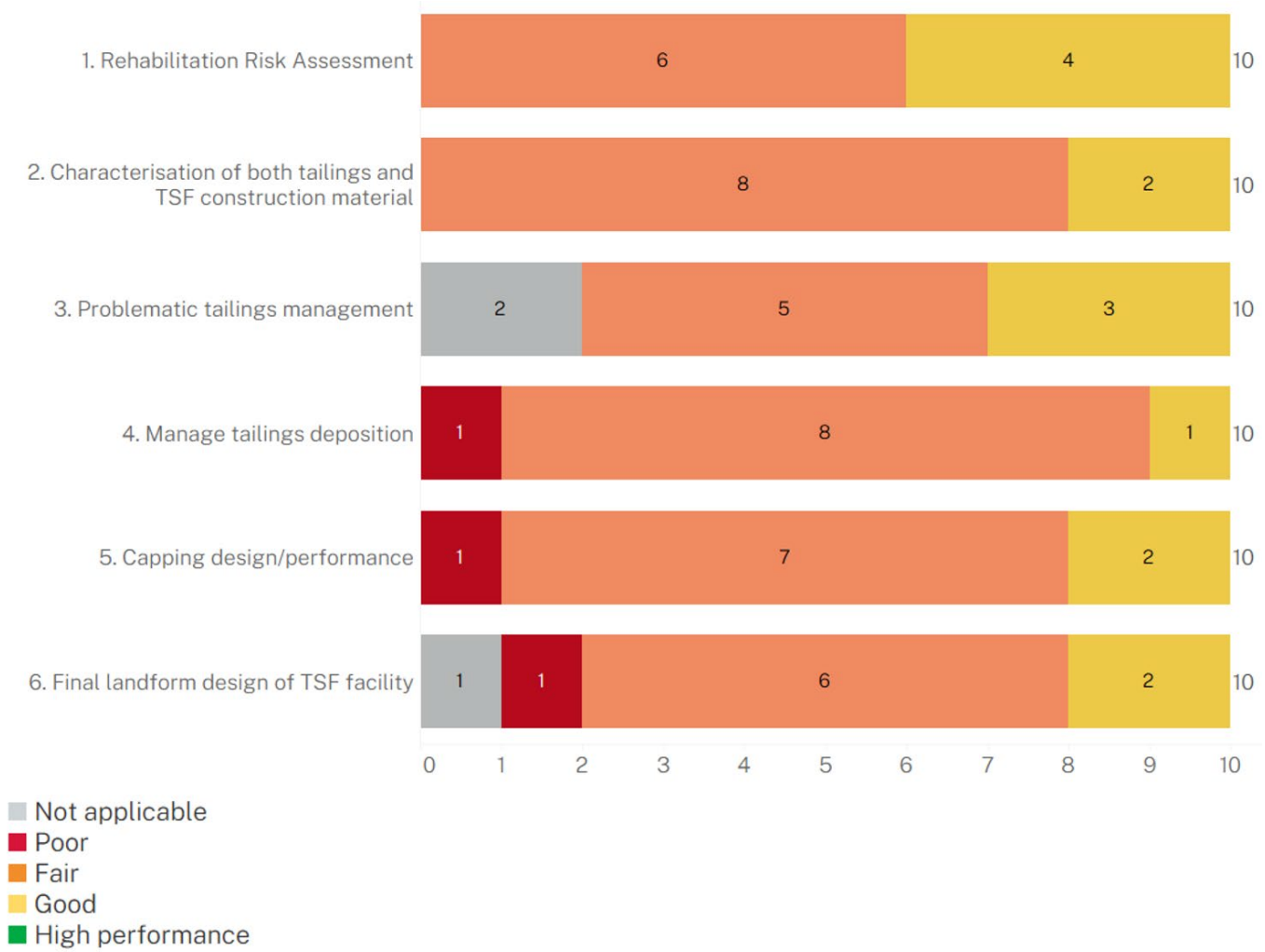

Figure 2: Finding results by mine and assessment criteria

Mine Location	1. Rehabilitation Risk Assessment	2. Characterisation of both tailings and TSF construction material	3. Problematic tailings management	4. Manage tailings deposition	5. Capping design/performance	6. Final landform design of TSF facility	Grand Total
Mine A	50%	50%	50%	50%	25%	50%	46%
Mine D	50%	50%	50%	25%	50%	50%	46%
Mine G	50%	50%	50%	50%	50%	25%	46%
Mine F	50%	50%	50%	50%	50%	50%	50%
Mine I	75%	50%	50%	50%	50%	50%	54%
Mine H	75%	50%		50%	50%	50%	55%
Mine B	75%	75%	75%	50%	50%	50%	63%
Mine C	75%	50%	75%	50%	50%	75%	63%
Mine J	50%	50%		75%	75%		63%
Mine E	50%	75%	75%	50%	75%	75%	67%
Grand Total	60%	55%	59%	50%	53%	53%	55%

- Green (>75%)
- Yellow (>50% and <=75%)
- Orange (>25% and <=50%)
- Red (<=25%)
- Not applicable

Response to mines

Assessment finding letters were issued to each mine in the program, which included a summary of key observations made by the Regulator during the assessment as well as recommendations for improvement in the medium to longer term. The key recommendations included the following:

Rehabilitation risk assessment

The rehabilitation risk assessment should be reviewed to ensure it covers risks and uncertainty (or knowledge gaps) identified in the TAP. As part of this review, all risk controls, follow-up assessments and other actions that are required to address uncertainty should be assigned to the appropriate person or position and timeframes for completion are nominated. For mines that have identified TSF management as high risk for closure, it is expected that a tailings specialist be involved in the rehabilitation risk assessment review.

For mines that have conducted multiply risk assessment for tailings management, it is also recommended that a risk register be provided in their RMP listing summary details of all risk assessments undertaken, their purpose and relationships to each other and the Rehabilitation Risk Assessment.

Characterisation of both tailings and TSF construction material

Undertake ongoing tailing characterisation testing to determine geochemical properties and if these change over time.

For TSF construction materials, verification testing must be undertaken combined with quality assurance to ensure materials utilised for TSF containment, capping or other rehabilitation cover materials are suitable. For example, characterisation and exclusion of Acid Metalliferous Drainage (AMD) material.

Problematic tailings management

Undertake comprehensive review of groundwater assessments and monitoring that has been undertaken in the vicinity of TSF to determine long-term trends.

Develop TARPs for groundwater monitoring, to determine response measures to any seepage detected from TSFs.

Manage tailings deposition

Review the implementation of tailings deposition techniques and surveillance to avoid restricted decant drainage and to maintain freeboard requirements.

Removal of water on tailings and implement an ongoing program to manage excessive water.

Determine likely settlement/consolidation and if this is of a magnitude that requires consideration in the capping design (i.e. additional thickness).

Capping performance/design

Undertake an assessment to identify the source and suitability of all capping material required for TSF rehabilitation. The assessment must identify the source of materials to cover any shortfalls, such as borrow-pits.

Assess the risk and risk control for inevitable tree growth in the tailings capping material and embankments in the period following closure. Ideally, the capping should be designed to facilitate tree growth.

Final landform design of TSF

Finalise the concept design of the final landform for TSFs including the location of drainage and surface water management features.

For mine sites with TSFs approaching decommissioning, an assessment of the final landform surface water management by a suitably qualified tailings engineer is required to determine requirements for a spillway or drop structure to manage surface water collected on the TSF during significant rainfall and convey this flow over the embankment. Where required, surface water management structures in the closure landform should be consistent with requirements specified by industry-accepted criteria provided by ANCOLD and the Global Tailings Standard guidelines.

Erosion modelling of the final TSFs landform. The erosion modelling should ideally use a Landform Evolution Model and be used to identify high-risk erosion areas and likely risk controls (potential remediation options). The model is also required to verify the suitability of the capping material to manage erosion impacts.

Any revision to the final landform including location of significant drainage features is required to be submitted to the Regulator as part of a revised Final Landform and Rehabilitation Plan.

Notices issued

Of the 10 mines assessed under the inspection program, 2 mines also received notices pursuant to section 240 of the *Mining Act 1992*. These notices directed the mines to take specific actions relating to characterisation of rehabilitation materials or the assessment of surface water management on the TSF in order to achieve sustainable rehabilitation outcomes that will support achievement of the final land use. These notices included the following directions:

- Engage a suitably qualified expert to undertake an assessment of the surface water management on the TSF to address identified scour (erosion) and instability risks. The assessment must include the following:
  - A hydrological assessment of the existing landform to determine surface water flows from significant rainfall events using a model to simulate significant rainfall events that meet projections – annual exceedance probability as determined by guidelines - ANCOLD and the ICMM Global Tailings Standard.
  - Design (including size, construction methodology and location) of the measures to the landform and surface water management structures to address the scour (erosion) and instability risks identified based on the hydrological assessment.
  - Information on the design of the measure that ensures the landform remains stable based on peak flow of the surface water runoff determined from the hydrological assessment (i.e. maintain sufficient capacity as well as channel stability when conveying peak surface water flows, in terms of peak velocity and bed shear stress - including drain/channel dimensions and rock armour sizing).
  - Construction quality control requirements including requirements for subsequent validation modelling.

  - An implementation schedule for the works and subsequent quality control/validation requirements.

- Engage a suitably qualified and experienced soil science expert to undertake an assessment involving the characterisation of the soils and materials on the mine site to determine the management and amelioration measures that will need to be implemented to achieve the final land use within the mine. The assessment must include the following:
  - Characterisation (including the volume, physical, and chemical properties) of overburden, waste rock.
  - Emplacements, subsoil, topsoil, and any other material that will be present in the final landform.
  - Identification of available materials for rehabilitation activities to develop a detailed rehabilitation material inventory. This inventory must outline the type, volumes, and suitability of materials for the construction/rehabilitation/remediation activities identified as being required i.e. capping of tailings and other waste rock emplacements.
  - Justification of sample collection and testing protocols: sampling location; density; field testing and analytical testing undertaken. Note that testing will be required to focus on characterisation of material that presents a risk due to potential problematic geochemical properties, such as Acid Metalliferous Drainage (AMD) potential as well as dispersive properties.
  - An assessment of the potential for soil and material properties to affect the final land use, establishment of vegetation and or the quality of surface runoff and groundwater seepage.

Comparison to previous TAP

The previous TSF management TAP was conducted between November 2019 and May 2020 and involved the assessment of 19 mines. The TAP assessment report published in August 2021 is found on our website*).*

It is worth noting that the assessment criteria was amended slightly since the previous TAP was undertaken in 2020, however this change was primarily associated with grouping and order of assessment of critical controls, rather than the controls themselves.

Key findings from the from the previous 2020 TAP found the need for mines to place increased focus on implementing the following critical controls:

- Tailings characterisation (primarily geochemical properties).
- Final landform design to take into account long-term settlement/ consolidation of tailings.
- Final landform design and surface water management requirements to ensure the long-term stability of the tailings storage facility post-closure.
- Capping design and performance requirements to support approved post-mining land use.

It would appear these findings correlate with the assessment findings for the current TAP. Note that only one mine from the 2019/2020 TAP program was assessed as part of the 2024 program. For this specific mine, the 2024 TAP program identified that independent experts were engaged to address capping design deficiencies as identified in the 2019/2020 program. This contributed to an overall improvement in the performance score for this mine.

Recommendations

It is recommended that mine operators, upon reading this report, review and amend (where relevant), their site's rehabilitation risk assessment, rehabilitation management plan, monitoring and management practices to manage the risks associated with tailings storage facility management activities that are unique to their site.

During the review process, mine operators are encouraged to consider the matters outlined above in the 'response to mines' and implement these recommendations as relevant to their site.

Further information

For more information on targeted assessment programs, the findings outlined in this report, or other mine rehabilitation information, please contact the Regulator:

Contact type	Contact details
Email	info@sys.resources.nsw.gov.au
Phone	1300 814 609 (option 2, then 5)
Website	www.resources.nsw.gov.au
Address	516 High Street Maitland NSW 2320

Appendix A TAP assessment set-up

The critical control consolidation process resulted in six critical control groups for assessment in the TAP. For each of these assessment criteria groupings, the critical controls, associated threats that they address, the control objectives used in the TAP are listed in Table 1 below.

Table 1: Assessment criteria, critical controls and associated threats and control objectives assessed in TAP

Assessment criteria	Critical control	Threat	Control objective
Risk assessment	MRP1.1 Rehabilitation risk assessment	N/A	To ensure that the range of risks associated with tailings management are identified and appropriate controls are in place to facilitate sustainable rehabilitation outcomes.
Characterisation of both tailings and TSF construction material	MP 3.1 & 4.1 Characterisation analysis (geochemical & geotechnical)	Exposure of adverse materials Geochemical and geotechnical unsuitable tailings and reject materials	To determine geochemical and geotechnical constraints of tailings and TSF construction materials, to enable management strategies (TSF construction requirements)
Problematic tailings management	TM-RE2.1 Dam construction (environmental) drainage/seepage control TM-RE2.2 Liner/barrier (geomembrane/modified soil/clay)	Problematic tailings properties (geochemical and physical).	To control or limit the release of contaminants from tailings containment
Manage tailings deposition	TM-PC4.1 Consolidated tailings management practices TM-RE1.2 TSF Operation (storage capacity and freeboard)	Excessive and/or differential tailings settlement. Significant rainfall.	Tailings consolidation/settlement is maximised during placement to reduce impacts from settlement post closure. Tailings deposition maintains environmental freeboard.
Capping performance/design	TM-PC1.2,2.3,3.1,4.2 Capping design/performance	Significant rainfall (erosion/ mass movement).	Provides a final barrier to contain tailings and prevent release to

Assessment criteria	Critical control	Threat	Control objective
		Problematic tailings properties (geochemical and physical). Tailings exposed/released to environment. Excessive and/or differential tailings settlement.	environment, manage seepage and to support final land use
Final landform design of TSF facility	TM-RE1.1 and TM-PC1.1 Surface water management and erosion control (final landform)	Significant rainfall (erosion/ mass movement).	Ensure tailings containment structure and capping is protected from scour/erosion from water movement resulting from rainfall

Appendix B Assessment system explained

We used a bowtie framework to proactively assess how mine sites managed the risks to rehabilitation. Bowties are a widely used risk management tool that integrate preventative and mitigating controls onto threat lines that relate to a material unwanted event.

As part of program planning, controls were categorised in accordance with the ICMM handbook[3] to identify the critical controls.

Standardised assessment checklists for a range of TAPs have been developed. Each TAP focuses on the implementation of an identified critical control(s) to determine whether measures have been identified and implemented to ensure sustainable rehabilitation outcomes.

Assessment findings

During each mine's site assessment, inspectors rate each control support and record the findings. Points are awarded depending on whether there was evidence that the control support had been documented and/or implemented, as summarised in the table below.

Table 2: Assessment system scoring

Scoring	Finding outcome	Points
High performance	As per satisfactory criteria, however, continued improvement can be demonstrated. For example, the scope of control support methodology has been updated to reflect feedback from research and monitoring.	4
Good	Methodology is described/documented in the Rehabilitation Management Plan (or other relevant document) and is reflective of constraints and opportunities that have been identified. Methodology has been implemented.	3
Fair	Methodology is described/documented in the Rehabilitation Management Plan (or other relevant document) but is limited (in terms of scope and implementation).	2
Poor	Not documented and not implemented.	1
N/A	Circumstances where the critical control / control support does not apply	N/A

For each critical control, an overall result was calculated based on the total points scored as a proportion of the maximum possible points for that critical control. For example, if a critical control comprises ten control supports and five were assessed as 'high performance' and five were found to be 'poor' then the overall assessment result for that critical control would be 62.5%.

[3] Critical Control Management Implementation Guide, International Council on Mining and Metals (ICMM), 2015.

Critical control calculations have taken into account instances where control supports were not applicable to the mine being assessed or when control supports were not able to be assessed during a site visit.

The overall assessment result for each critical control has been assigned a colour based on the assessment bands presented in the table below. The colour band results are then used to identify industry focus areas requiring improvement.

Table 3: Scoring criteria and assessment colour bands

Criteria	Colour
An assessment result of >75% of possible points	Green
An assessment result of >50% but ≤75% of possible points	Yellow
An assessment result of >25% but ≤50% of possible points	Orange
An assessment result of ≤25% of possible points	Red
N/A	