NSW GOVERNMENT

NSW Resources Regulator

TARGETTED ASSESSMENT PROGRAM

MATERIALS AND SOIL MANAGEMENT TO SUPPORT THE POST-MINING FINAL LAND USE

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Contents

Executive summary

This report summarises assessment findings from 51 mines in relation to the management of materials and soils to support the post-mining final land use and achieve sustainable rehabilitation outcomes. The assessment included how mines were managing any potential soil or material deficits. Assessments were conducted during the period from March 2020 to December 2020. The threats and critical controls assessed are shown in Appendix B. Figure 1 presents the compliance findings for each de-identified mine and critical control. Explanatory notes on the assessment system are also listed in Appendix C.

A significant portion of the coal mining sites had good topsoil and biological material salvage and management practices. This included detailed pre-clearance reports, inventories of stockpiles, active management of stockpiles (e.g. weed control), direct return of materials during rehabilitation, use of ameliorants, ongoing monitoring and testing. However, there was a lack of these measures at the metalliferous mines assessed.

One of the key issues identified at some sites was in relation to risk assessments that were found to be generic and 'broad-brush' and lacked specificity regarding rehabilitation controls.

A similar theme existed regarding soil and materials characterisation analysis. A number of sites were relying on baseline soils assessments that had been prepared as part of the original development application with no subsequent characterisation analysis of overburden, waste rock, emplacements, tailings, subsoil, or topsoil that will be present in the final landform.

A number of mines did not have a materials balance to determine whether rehabilitation needs could be met with materials on site or whether material would need to be imported.

Finally, there was a wide variance between the rigour of quality assurance processes in relation to materials management. A number of very good quality assurance processes were noted across the coal mining sector.

Statutory notices pursuant to section 240 of the *Mining Act 1992* were issued to seven mines, directing them to take immediate actions to address risks associated with the management of materials and soils. In accordance with section 240(1)(c) of the *Mining Act 1992*, each direction issued included information on the specific risk identified during the TAP and the required actions to address the risk.

Assessment finding letters were issued to 44 mines detailing recommendations for improvement in the medium to longer term.

It is recommended that mine operators review and amend their relevant risk assessment, rehabilitation management plans and management practices to manage the risks associated with materials and soils that are unique to their site.

Introduction

The NSW Resources Regulator undertakes targeted assessments and planned inspection programs 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 targeted assessment programs (TAP). Each TAP focuses on the implementation of 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, including the bowtie risk assessments, are available on our website.

An extract from the bowtie risk assessment is included 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.

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 which includes:
  - the focus areas of the assessment
  - assessment timing and assessment team composition

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

- 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.

- 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 mine 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

MRP1.1 – Rehabilitation risk assessment

What we assessed

A rehabilitation risk assessment should identify, assess and evaluate the risks that need to be addressed when managing materials and soils to achieve sustainable rehabilitation outcomes. The rehabilitation risk assessment should identify the appropriate risk control measures that must be implemented to reduce the risks and the control measures that should be implemented.

What we found

- A significant portion of sites had undertaken generic and broad-brush risk assessments that lacked specificity regarding rehabilitation controls.
- While some sites had identified managing materials and soils as a potential risk, it was found on multiple occasions that there was no specific assessment of these risks, including lack of baseline data, lack of specialist studies/advice and an absence of appropriate risk controls.
- In the majority of cases, the risk assessment had been prepared by a range of suitably qualified people. However, the risk assessments were often not produced by a cross-section

of the workforce but rather by consultants and the environmental personnel on the mine site.

The risk

Without a relevant and robust rehabilitation risk assessment, appropriate controls measures will not be implemented to manage materials and soils to ensure rehabilitation achieves the final (post-mining) landform and land use. This may include a deficit of soil and/or material or poor soil management practices, which result in revegetation failure.

MP1.1 – Characterisation analysis (soil resource salvage and maintenance)

What we assessed

Soil resources should be identified and assessed prior to the clearing phases of mining, to ensure they can be utilised during the rehabilitation phases. This should include:

- A baseline soil survey/assessment of soils undertaken by a suitably qualified soil scientist or equivalent, assessing suitability, thickness, quality of topsoil and subsoil resources, soil texture, fertility, presence of organic matter, presence of weed species and non-target revegetation species.
- Keeping of relevant records.

What we found

- Some sites had very thorough and well documented soil assessment, collection, testing and soil amelioration procedures, including the input of specialist soil scientists and laboratories.
- A significant portion of sites were relying on baseline soil assessments that had been prepared as part of their original development application (e.g. within the environmental impact statement lodged with the development application). In some cases, there had been no subsequent comparison to evaluate/assess the actual soils salvaged.
- In a minority of sites, there had been no assessment of soil resources.
- While some sites had limited records to demonstrate that they characterise soils prior to stripping to identify potential constraints / opportunities for rehabilitation.

The risk

Without the identification and assessment of soil and biological materials prior to the clearing phases of mining there is a risk of poor environmental outcomes and rehabilitation not achieving the final (post-mining) land use. This may include a deficit of suitable topsoil, poor soil viability and inadequate soil management practices resulting in revegetation failure, weed infestation, and a failure to achieve the target vegetation species. In addition, the lack of locally salvaged biological materials could lead to inappropriate and inadequate fauna habitat.

MP2.1 – Characterisation analysis (biological materials)

What we assessed

Biological material resources should be identified and assessed prior to the clearing phases of mining to ensure they can be utilised during the rehabilitation phases (where a native vegetation final land use outcome is proposed). This should include:

- Soil seed bank evaluation, where native revegetation is proposed, to maximise opportunities for salvage or identify need for supplementation.
- A baseline assessment which identifies existing ecological conditions and/or presence and abundance of weed species and/or non-target revegetation species.
- Identification of biological materials for salvage (e.g. vegetative material, seedbank, rocks, tree hollows, stags, translocation species).
- Keeping of relevant records.

What we found

- Some site actively undertook the salvage of biological resources, however, there was no formal register/recording of this (e.g. records of stockpiles).
- The majority of sites had not identified or assessed biological material resources.

The risk

Without the identification and assessment of soil and biological materials prior to the clearing phases of mining, there is a risk of poor environmental outcomes and rehabilitation not achieving a native vegetation final land use. This may include a deficit of suitable seed, the prevalence of non-target revegetation species, weed infestation, a failure to achieve the target vegetation species and the lack of contextually appropriate fauna habitat. To overcome this, biological resources may need to be supplemented by importing material at the time revegetation is undertaken. Depending upon the availability of suitable material (e.g. seed for target species), an additional risk may include possible delays to rehabilitation.

MP3.1 and MP4.1 – Characterisation analysis (geochemical and geotechnical)

What we assessed

The geochemical and geotechnical properties of mine materials (e.g. overburden, tailings, reject materials) need to be understood to enable the selective handling and management of these materials to ensure they do not pose a risk to achieving the final land use during the rehabilitation phase. This should include:

- Understanding the geochemical properties of materials (e.g. spontaneous combustion, acid mine drainage, sodicity).
- Understanding the physical properties of materials (e.g. particle size distribution).
- Implementing a sampling program to identify potential changes in material properties.
- Developing a strategy / procedure for selective handling and management of materials (e.g. potentially acid forming and non-acid forming, inert material).

What we found

- The majority of sites had undertaken some form of geochemical and geotechnical assessments to understand the properties of the mine materials. Some sites had also continued to use data from exploration boreholes during the mine design phase to undertake ongoing characterisation analysis.
- Many sites did not implement a program to test material prior to use in rehabilitation activities. However, the majority of sites which had identified PAF materials, had implemented a selective handling and management strategy.

The risk

There are significant risks to successful and long-term sustainable rehabilitation resulting from use and/or exposure of geotechnically unstable or geochemically unsuitable materials. This includes materials prone to spontaneous combustion, materials prone to acid mine drainage, sodic soils, and tailings.

RP1.1 – Characterisation analysis (revegetation substrate)

What we assessed

The substrate material (topsoil and subsoil) must be assessed to ensure it is suitable to support the proposed revegetation outcome (e.g. native vegetation, agriculture). This should include:

- Understanding the physical properties of materials (e.g. particle size distribution, nutrient levels of materials for planting).
- Seeking advice from a suitably qualified expert (based on the characterisation analysis) on the range of any ameliorants that may be required to address limitations in the revegetation substrate.
- Collecting and analysing representative samples of topsoil stockpiles immediately prior to re-application to determine any potential limitations to vegetation (e.g. sodicity, limited microbial activity, nutrients, organic matter).
- Analysing the prepared substrate prior to revegetation activities to determine whether amelioration measures (e.g. application of gypsum and lime) have been successful.

What we found

- Some sites had very thorough and well documented soil assessment, collection, testing and soil amelioration procedures, including the input of specialist soil scientists and laboratories.
- Many sites were relying on baseline soil assessments that had been prepared as part of their original development application (e.g. within the environmental impact statement lodged with the development application). In some cases, there had been no subsequent comparison to evaluate/assess the actual soils salvaged.
- Many sites did not characterise soils prior to stripping.
- In a minority of sites there had been no assessment of soil resources.

The risk

Utilising unsuitable substrate material presents a risk of poor revegetation outcomes which do not achieve the approved final land use(s) (e.g. native vegetation, agriculture). This may include soil erosion, revegetation failure, weed infestation, and a failure to achieve the target vegetation species. In a worst-case scenario, previous rehabilitation works may need to be redone, including vegetation removal, deep ripping of the land, re-grading works, importing of soil material, additional soil amelioration measures, and revegetation.

MP1.6 and RP2.1 – Develop and maintain materials balance (soil resource)

What we assessed

An inventory of soil resources salvaged during the clearing phases of mining should be developed and maintained to ensure the needs for rehabilitation of the final land use are met. This should include the following information:

- The volume of topsoil and subsoil stockpiled.
- The chronology of treatments (e.g. weed control, application of cover crop) undertaken on the stockpile.
- The volume of topsoil and subsoil required for application to current and future disturbance areas.
- An estimate of the volume of suitable alternative material required to be imported onto site to supplement potential topsoil and subsoil deficits.
- Record data on the location of the stockpiled material including date stripped, source area, indicative volume, pre-strip plant community type, etc (e.g. through a site-based GIS system).

What we found

- A significant portion of the coal mining sites had good topsoil inventories which included location records, inspection records, regular (e.g. monthly) inspections of stockpiles and associated management practices (e.g. weed control). There was an absence of these measures across the metalliferous mines.
- Many sites did not have any formal materials balance documentation to determine whether the rehabilitation needs could be met with materials on site or whether material would need to be imported.

The risk

Without the development and maintenance of a soil balance and database, there is a risk of poor environmental outcomes and rehabilitation not achieving the final land use(s). This may include a deficit of suitable soils, poor soil viability and inadequate soil management practices, resulting in revegetation failure, weed infestation and the need to import additional soil resources from alternative locations.

MP3.4 – Develop and maintain materials balance (exposure of adverse materials)

What we assessed

An inventory of materials should be developed and maintained to ensure there is enough material available for emplacement and/or capping to achieve the nominated final landform and rehabilitation outcomes. This is relevant for mining domains that require a cover (or cap) such as tailings storage facilities and waste rock emplacements. In these circumstances, a cover/cap design should be developed that determines the type and amount of material required to construct cap. A materials balance and database should include the following information:

- Volume of inert capping material stockpiled.
- Location of stockpiles.
- Volume of material required for application to current and future disturbance areas (e.g. capping material for tailings dams, reject emplacement areas).
- An estimate of the volume of suitable alternative material required to be imported onto site to supplement potential material deficits.

What we found

- The majority of sites with material stockpiles had good inventories of these materials (including location and volume records).
- Many sites did not have any formal materials balance documentation to determine whether the rehabilitation needs could be met with materials on site or whether material would need to be imported.
- Most sites had a general understanding if there was a materials deficit on site to complete rehabilitation works, however, this was largely undocumented or quantified.

The risk

Without the development and maintenance of a materials balance and database, there is a risk of poor environmental outcomes and rehabilitation not achieving either the approved final landform or final land use(s). This may include a deficit of suitable materials and the need to import additional resources from alternative locations.

MP1.3a – Implement tailored soil management practices (rehabilitation integration into mine planning systems)

What we assessed

Rehabilitation should be integrated into the mine planning and scheduling systems, including time frames for pre-clearing and stockpiling soil/material resources. This should:

- Provide sufficient time for the implementation of pre-clearance topsoil and biological resources salvage procedures.
- Maximise opportunities for direct return of topsoil/subsoil resources.
- Ensure location of resource stockpiles are protected from future mining operations.

What we found

- Some of the coal mining sites had good soil management practices, including weekly meetings between the environment, mine planning and rehabilitation teams to ensure like-for-like return of soil resources during rehabilitation works (e.g. soil stripped from a native vegetation area is returned to a native revegetation area).
- For many sites, soil management practices were not seen as a priority in mine planning meetings and scheduling systems.
- Direct return of topsoil/subsoil was often difficult in practice, given the extensive time frames between stripping and rehabilitation works (resulting in re-location of stockpiles to avoid mining operations, and deterioration of topsoil qualities over time).
- All sites ensured the protection of stockpiles from current mining operations.

The risk

There is a risk of poor environmental and rehabilitation outcomes without pre-clearance biological resources salvage procedures, maximising the direct return of soils and protecting resource stockpiles. Rehabilitation may fail to achieve the approved final land use(s) and there may be a deficit of suitable materials, poor soil viability and inadequate soil management practices resulting in revegetation failure, weed infestation and the need to import additional resources from alternative locations.

MP1.3b – Implement tailored soil management practices (salvage biological resources)

What we assessed

Techniques should be developed and implemented to salvage biological resources for use in rehabilitation, based on the outcomes of characterisation analyses. Records should be kept and maintained that demonstrate implementation of procedures for the salvage of biological resources (e.g. seed bank, plant material, logs, hollows), for example:

- Stripping topsoil and subsoil when soils are moist (e.g. not saturated nor dry).
- Stripping of topsoil and subsoil stripping using appropriate equipment to the appropriate depths as identified through characterisation assessment.
- Development of stripping techniques to maximise integrity of the seedbank.
- Separate stripping of topsoil and subsoil layers so that they can be stored and/or returned to rehabilitation areas in sequential order.
- Maximising opportunities to direct return topsoil and subsoil to areas for rehabilitation.

What we found

- Some of the coal mining sites had good biological material salvage management practices, including detailed pre-clearance reports, stockpiling habitat features in close proximity to salvage areas for future use and weekly meetings between the environment, mine planning and rehabilitation teams to ensure like-for-like return of soil resources during rehabilitation works (e.g. soil stripped from a native vegetation area is returned to a native revegetation area).
- For many sites, the management practices associated with the salvage of biological materials were not seen as a priority in mine planning meetings and scheduling systems.

- Some sites had records indicating that appropriate smaller sized machinery had been used during stripping of soils to maintain the integrity of the topsoil and subsoil layers.
- Direct return of topsoil/subsoil was often difficult in practice given the extensive time frames between stripping and rehabilitation works (resulting in re-location of stockpiles to avoid mining operations and deterioration of topsoil qualities over time).

The risk

There is a risk of poor environmental and rehabilitation outcomes without the implementation of satisfactory biological resource salvage procedures and maximising the direct return of soils. Rehabilitation may fail to achieve the approved final land use(s) and there may be a deficit of suitable materials, poor soil viability and inadequate soil management practices resulting in revegetation failure, weed infestation and the need to import additional resources from alternative locations.

MM1.1a, MM2.1a, MM3.1a – Implement tailored soil management practices (maintaining biological resources)

What we assessed

Measures should be developed and implemented to protect and maintain biological resources for use in rehabilitation. The measures implemented on site and the records kept should demonstrate that:

- Soil stockpiles are located on gentle sloping ground away from traffic areas and at an appropriate distance from watercourses.
- Soil stockpiles maximise surface exposure and biological activity.
- Appropriate erosion, dust and sediment controls have been implemented.
- A cover is established over stockpiles to reduce soil loss, reduce the potential for weed infestation and maintain the biological health of the stockpile (e.g. seeded with cover crop or target vegetation species or agricultural pasture mix).
- Stockpiles are appropriately signed and protected to minimise the potential for unauthorised use or disturbance.
- Weed growth on stockpiles is monitored and controlled.

What we found

- All sites ensured the protection of stockpiles from current mining operations.
- The majority of stockpiles observed were located in appropriate locations (e.g. on gentle sloping ground and away from watercourses), were appropriately demarcated and had appropriate covers.
- While the majority of sites had implemented monthly monitoring of stockpiles and weed controls, some sites had no formal records of such practices.

The risk

There is a risk of poor environmental and rehabilitation outcomes when soil resources are not protected and maintained for future use in rehabilitation. There may be a deficit of suitable materials and poor soil viability resulting in revegetation failure, weed infestation, the requirement for significant amelioration measures and the need to import additional resources.

RP2.2, MM1.1b, MM2.1b, MM3.1b - Implement tailored soil management practices (characterising and treating substrate material)

What we assessed

Measures should be developed and implemented to ensure that the substrate (topsoil/subsoil) is suitable for the target revegetation outcome. The measures implemented on site and the records kept should demonstrate that:

- Ameliorants and organic materials are applied in accordance with the characterisation analysis.
- Suitable erosion and soil protection measures have been implemented to minimise soil loss from areas until vegetative cover is established.
- Topsoil and subsoil layers are returned in sequential order.
- Appropriate earthmoving equipment is used to avoid compaction.
- Soil structure is restored by scarifying or ripping along the contours based on the target vegetation outcome.
- Ameliorants are applied prior to or in conjunction with the revegetation activities.

- Topsoil shortages are supplemented with suitable alternatives.

What we found

- The majority of sites had applied ameliorants and organic materials to soil layers as part of the revegetation activities.
- There was a wide variance between how records were kept. There were examples of sophisticated record keeping systems which included GIS systems that incorporated photographic records, amelioration measures, contractor invoices, equipment use, timing, monitoring data.
- There was some evidence across sites of soil structure being restored through scarifying or ripping along the contour lines.
- Some sites had a poor understanding of the extent of any topsoil shortages and sourcing of suitable alternatives.

The risk

Without suitable substrate material, there is a risk of poor revegetation outcomes which do not achieve the approved final land use(s) (e.g. native vegetation, agriculture). This may include soil erosion, revegetation failure, weed infestation, a failure to achieve the target vegetation species. In a worst-case scenario, previous rehabilitation works may need to be redone including vegetation removal, deep ripping of the land, re-grading works, importing of soil material, additional soil amelioration measures, and revegetation.

MRP1.6 – Validation of control measures via monitoring, inspections and records

What we assessed

Rehabilitation control measures should be validated via monitoring, inspections and records to ensure that:

- Materials and soils are handling in accordance with nominated methodologies.
- Identified risks to rehabilitation are adequately addressed before proceeding to the next phase of rehabilitation.

To achieve this, a rehabilitation quality assurance process should be integrated into day-to-day operations to ensure:

- Responsibilities for implementation are identified.
- Processes are formally documented and recorded, tracked and closed out (e.g. inspection test plans which check the implementation and effectiveness of the controls through an inspection/testing process).
- The process is reviewed and refined over time to facilitate continual improvement.

What we found

- The majority of coal mines had good monitoring, validation and formal recording of rehabilitation control measures. However, there was a lack of these measures at the metalliferous mines assessed.
- Some mines had good documentation and management plans detailing rehabilitation control measures. However, there were instances where there was no verification that these measures were being implemented in accordance with the documented obligations.
- There was a wide variance between how records were kept. There were also examples of sophisticated record keeping systems which included GIS systems that incorporated photographic/inspection records, rehabilitation measures, contractor invoices, equipment use, timing, and monitoring data.
- Some coal mines had very good quality assurance programs including inspection test plans which check the implementation and effectiveness of the rehabilitation controls through a continual inspection and testing process. This included regular drone surveys and 'walkover' inspections by suitably qualified personnel.

The risk

Without inspecting, monitoring and evaluating rehabilitation there is a risk of poor environmental outcomes and rehabilitation not achieving the approved final land use(s). In a worst-case scenario, rehabilitation works may need to be redone including vegetation removal, deep ripping of the land, re-grading works, importing of soil material, additional soil amelioration measures, revegetation.

MRP 1.7 – Effective communication to sub-contractors and monitoring

What we assessed

The key rehabilitation risks and controls measures should be effectively communicated to subcontractors and monitored to ensure:

- The mine operator communicates relevant key risks and controls to the subcontractor (e.g. performance specifications, induction processes).
- The mine operator monitors the activities of the subcontractor (e.g. surveillance, audits, inspections).
- The mine operator obtains copies of key records generated by subcontractors to verify compliance with the rehabilitation obligations (e.g. inspection test plans, rehabilitation methodology records, monitoring records).

What we found

- The majority of mine operators communicate relevant key risks and controls to their subcontractors but often this is general environmental awareness training and not specific to rehabilitation.
- The majority of mine operators monitor the activities of the subcontractor (including through planned and unplanned inspections), however, these are often not documented/measured against the rehabilitation commitments outlined in the approved management plans.
- The majority of mine operators obtain copies of key records generated by subcontractors to verify compliance with the rehabilitation obligations (e.g. rehabilitation methodology records, monitoring records, clearing plan checklists).
- Some subcontractors and mine operators had very sophisticated methods to record and communicate rehabilitation progression and performance, including daily inspections, weekly drone surveys, GIS mapping, GPS tracked dig/disturbance limits which are verified by surveys, regular soil analysis.

The risk

Without effective communication and subcontractor management, mine operators risk poor environmental outcomes and rehabilitation not achieving the approved final land use(s). This may result in subcontractors needing to re-do rehabilitation works already completed, including vegetation removal, deep ripping of the land, re-grading works, importing soil materials, additional soil amelioration measures, and revegetation.

MRP 1.8 – Engagement of people with appropriate skills and experience

What we assessed

Personnel with appropriate skills and experience should be engaged in relation to materials and soils management.

The mine operator should:

- Identify core competencies required for positions (including contractors) responsible for materials and soils management.
- Maintain a skills matrix to identify any training gaps.
- Document and maintain training records.
- Implement an induction program which addresses key rehabilitation risks.

What we found

- The majority of sites had at least one suitably qualified person responsible for rehabilitation and the management of materials and soils.
- Most sites did not have a skills matrix for their relevant personnel that was specific to rehabilitation and/or the management of materials and soils.
- Some sites and/or sub-contractors could produce training records, however, these were again general in nature and not specific to rehabilitation and/or the management of materials and soils.
- The majority of sites had an induction program, however, these were often general in nature and dealt with general 'environmental awareness' issues rather than being specific to rehabilitation and the management of materials and soils.

The risk

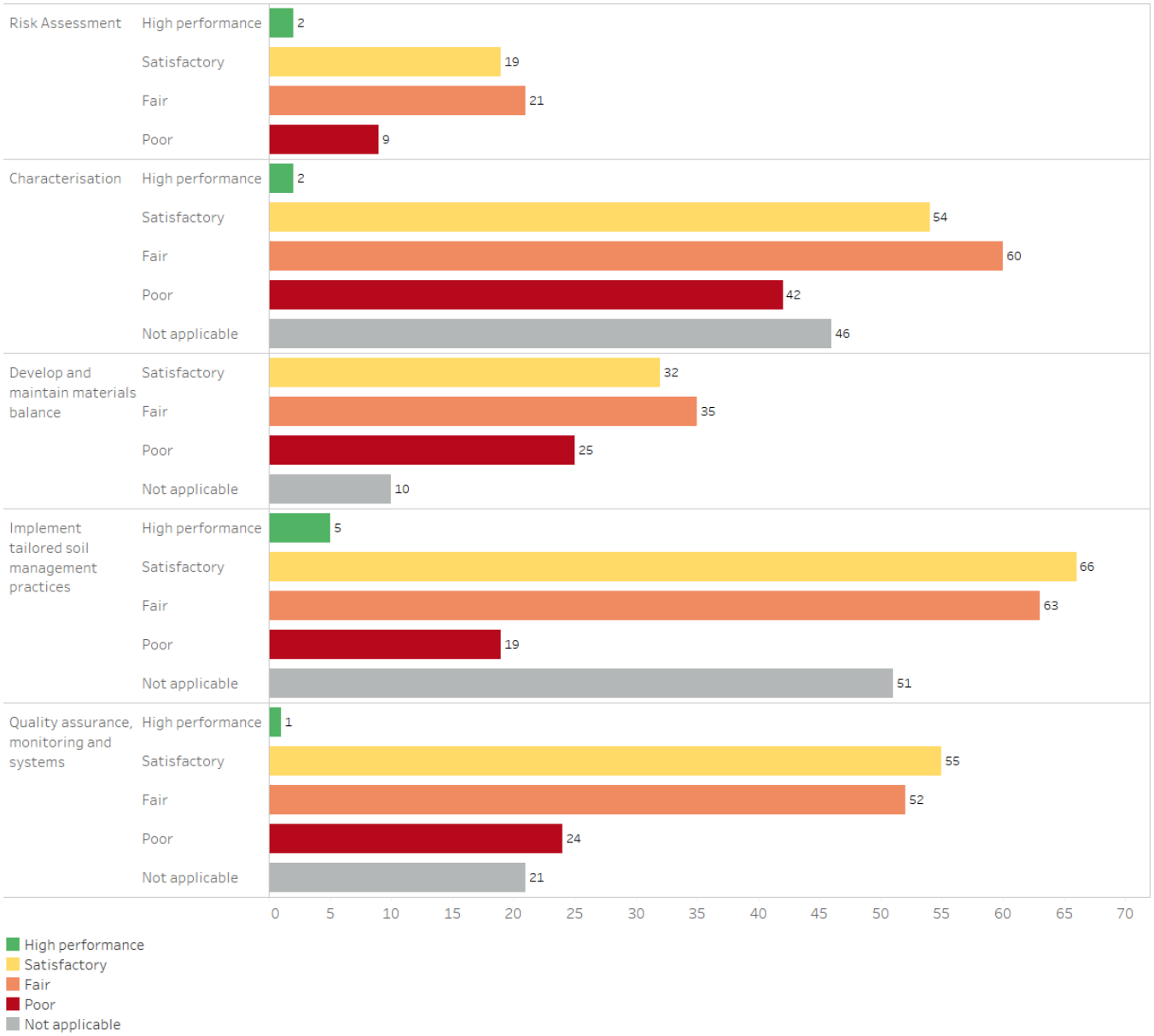
Without utilising personnel with appropriate skills and experience mine operators, there is a risk of poor environmental outcomes and rehabilitation not achieving the approved final land use(s). This may result in rehabilitation failure and the need to re-do works already completed, including vegetation removal, deep ripping of the land, re-grading works, importing new materials, additional soil amelioration measures, and revegetation.

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 C.

Figure 1 presents the overall assessment findings for each assessment category.

Figure 1: Overall assessment findings by assessment category



Figures 2 and 3 present the overall assessment findings for each of the assessment categories. Figure 1 shows mines that scored ≤55% of possible points. Figure 2 shows mines that scored >55%.

Figure 2: Overall assessment findings for each of the assessment categories – overall result ≤55%

	Risk Assessment	Characterisation				Develop and maintain materials balance		Implement tailored soil management practices				Quality assurance, monitoring and systems			Grand Total
	1	2	3	4	5	7	8	9	10	11	12	13	14	15	
Mine Location	MRP 1.1	MP 1.1	MP 2.1	MP 3.1 & MP 4.1	RP 1.1	MP 1.6 & RP 2.1	MP 3.4	MP 1.3a	MP 1.3b	MM 1.1a, 2.1a, 3.1a	RP 2.2 & MM 1.1b, 2.1b, 3.1b	MRP 1.6	MRP 1.7	MRP 1.8	
Mine A	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Mine B	25%	25%	50%	25%	25%	25%	25%	25%	50%	25%	25%	25%	25%	25%	29%
Mine C	25%			25%	25%	25%	25%			25%	25%	25%	50%	50%	30%
Mine D	50%	25%	25%		25%	25%				25%	25%	50%		50%	33%
Mine E	25%	25%	25%	25%	25%	25%	50%			50%	25%	25%	50%	50%	33%
Mine F	75%	25%	50%	25%	25%	25%	25%	50%	50%	25%	25%	25%	25%	25%	34%
Mine G	50%			25%	25%	25%	50%	50%		50%	50%	25%	25%	25%	36%
Mine H	75%			50%	25%	25%	50%			25%	25%	50%		50%	42%
Mine I	25%	25%	25%	50%	50%	25%	50%	50%	50%	50%		50%	50%	50%	42%
Mine J	75%	50%	25%	25%	25%	50%	50%	50%	50%	25%		25%	50%	50%	42%
Mine K	50%					75%				25%		25%			44%
Mine L	50%	50%				50%						25%	50%		45%
Mine M	50%	50%	50%	25%		50%	25%				50%	50%	50%	50%	45%
Mine N	25%	50%	25%	50%	50%	50%	50%	50%	50%	50%	75%	50%	50%	50%	48%
Mine O	50%	50%		50%	50%	50%		50%	75%	50%	50%	50%	50%	25%	50%
Mine P	50%	50%		50%		50%	50%					50%			50%
Mine Q	50%	50%	50%	50%	50%	50%		50%	50%	50%		50%	50%		50%
Mine R	25%			50%	75%	25%	25%	50%		50%	75%	50%	75%	75%	52%
Mine S	50%		75%	50%	50%	50%	50%	50%	75%	75%	25%	25%			52%
Mine T	75%	50%	50%	50%	50%	50%	50%	50%	50%			25%		75%	52%
Mine U	50%	25%	25%	50%	75%	25%	25%	75%	75%	75%	75%	50%	50%	75%	54%
Mine V	50%	50%	50%	75%	50%	50%	50%	50%	50%	50%	50%	75%	75%	50%	55%

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

Figure 3: Overall assessment findings for each of the assessment categories – overall result >55%.

	Risk Assessment	Characterisation				Develop and maintain materials balance		Implement tailored soil management practices				Quality assurance, monitoring and systems			Grand Total
	1	2	3	4	5	7	8	9	10	11	12	13	14	15	
Mine Location	MRP 1.1	MP 1.1	MP 2.1	MP 3.1 & MP 4.1	RP 1.1	MP 1.6 & RP 2.1	MP 3.4	MP 1.3a	MP 1.3b	MM 1.1a, 2.1a, 3.1a	RP 2.2 & MM 1.1b, 2.1b, 3.1b	MRP 1.6	MRP 1.7	MRP 1.8	
Mine W	50%	50%	25%	75%	25%	75%	75%	75%		75%	50%	25%	50%	75%	56%
Mine X	75%	50%		50%	50%	50%	75%	50%	50%	50%	50%	75%	50%	50%	56%
Mine Y	50%	50%	25%	75%	25%	75%	75%	75%		75%	50%	25%	50%	75%	56%
Mine Z	50%	50%	25%	75%	25%	75%	75%	75%		75%	50%	25%	50%	75%	56%
Mine AA	50%	50%	50%	50%	50%	50%	50%	75%	50%	75%	50%	75%		50%	56%
Mine AB	75%	50%			50%	50%					50%	50%	50%	75%	56%
Mine AC	50%	75%	75%	25%	50%	50%	50%	75%	50%	75%	75%	50%	50%	50%	57%
Mine AD	25%	25%	75%			25%	75%	75%	75%	75%	75%	50%			58%
Mine AE	50%	50%		50%	50%	50%	50%	75%	75%	50%	50%	75%	75%	75%	60%
Mine AF	50%	75%	75%	75%	50%	75%	75%	50%	75%	50%	50%	50%	50%	50%	61%
Mine AG	75%	75%	75%		50%	25%	25%	75%	75%	75%	75%	50%	50%	75%	62%
Mine AH	50%	75%	50%	25%	75%	75%	25%	75%		50%	75%	75%	75%	75%	62%
Mine AI	75%	75%	75%	75%	75%	50%	75%	50%	50%	50%	50%	75%	50%	50%	63%
Mine AJ	50%			50%		50%	75%			50%		75%	75%	75%	63%
Mine AK	75%				75%	50%	25%	75%			50%	75%	75%	75%	64%
Mine AL	25%	75%	50%	75%	75%	50%	75%	75%	75%	75%	75%	50%	50%	75%	64%
Mine AM	75%			75%		50%	25%	75%				75%	75%	75%	66%
Mine AN	75%	50%	50%	75%	75%	75%	75%	75%		50%	50%	75%	75%	75%	67%
Mine AO	50%		75%	75%	50%	75%	75%			50%	75%	75%		75%	68%
Mine AP	75%	75%	50%	50%	75%	75%	50%	75%	50%	75%	75%	75%	75%	75%	68%
Mine AQ	75%			75%	75%	75%	75%	75%		50%	50%	50%	75%	75%	68%
Mine AR	75%	75%	75%	75%	50%	75%		75%	50%	50%	75%	75%	75%	75%	69%
Mine AS	100%	25%	25%	100%	100%	25%	75%	100%	75%	75%	100%	75%	25%	75%	70%
Mine AT	75%	50%	75%			75%	75%	75%	75%	75%	75%	50%			70%
Mine AU	100%	75%	75%	75%	75%	50%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Mine AV	75%				75%		75%		75%					75%	75%
Mine AW	75%	75%	75%		75%	75%		75%	75%	75%	75%	75%			75%
Mine AX	75%	75%	75%	75%	75%	75%		100%	100%	50%	75%	75%	75%	75%	77%
Mine AY	75%	75%	75%	75%	75%	75%	75%	100%	75%	75%	75%	75%	75%	100%	79%

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

Figures 4 to 8 present the results by mine for each of the assessment categories.

Figure 4: Overall assessment for the 'risk assessment' category

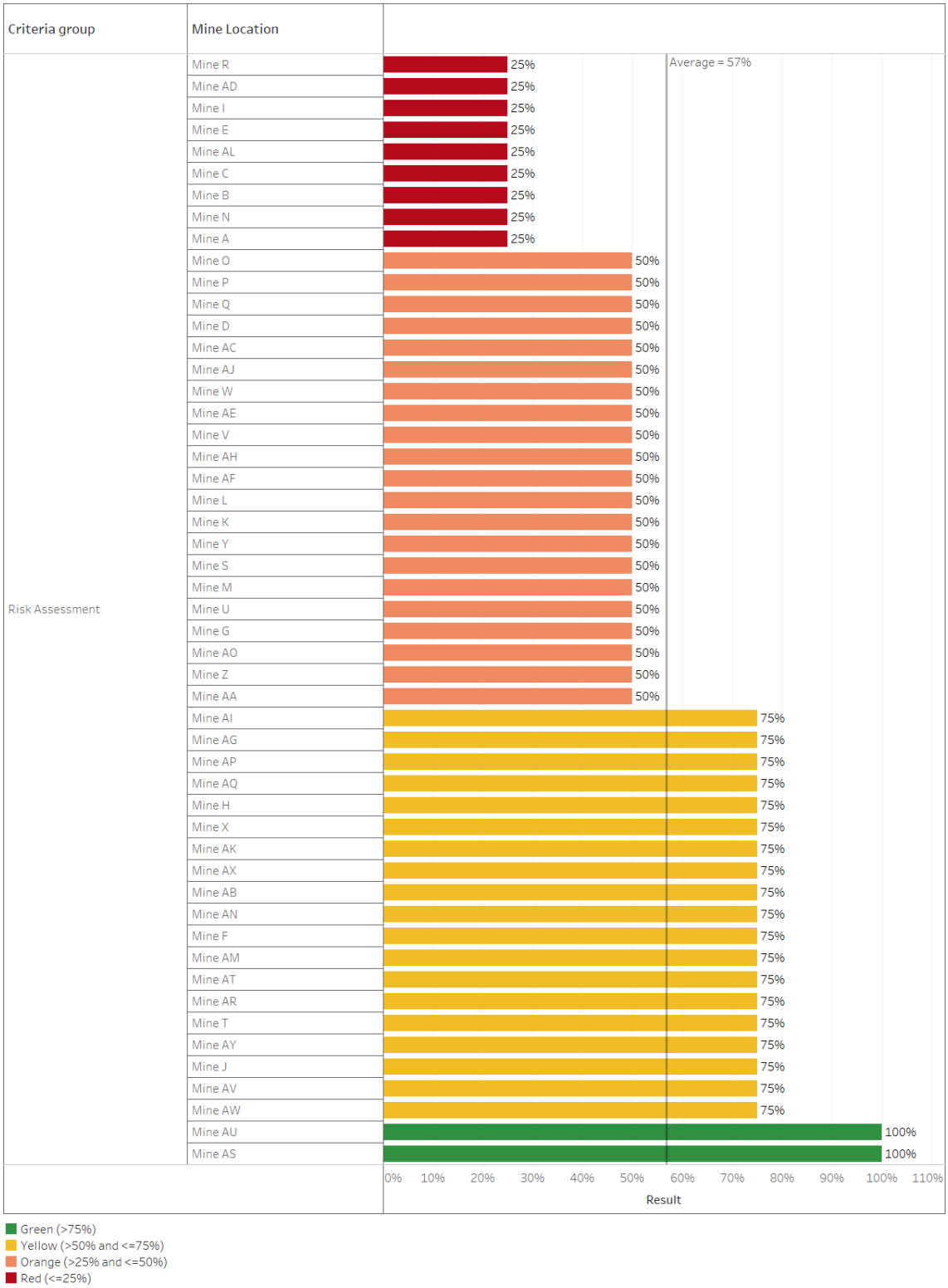


Figure 5: Overall assessment for the 'characterisation' category

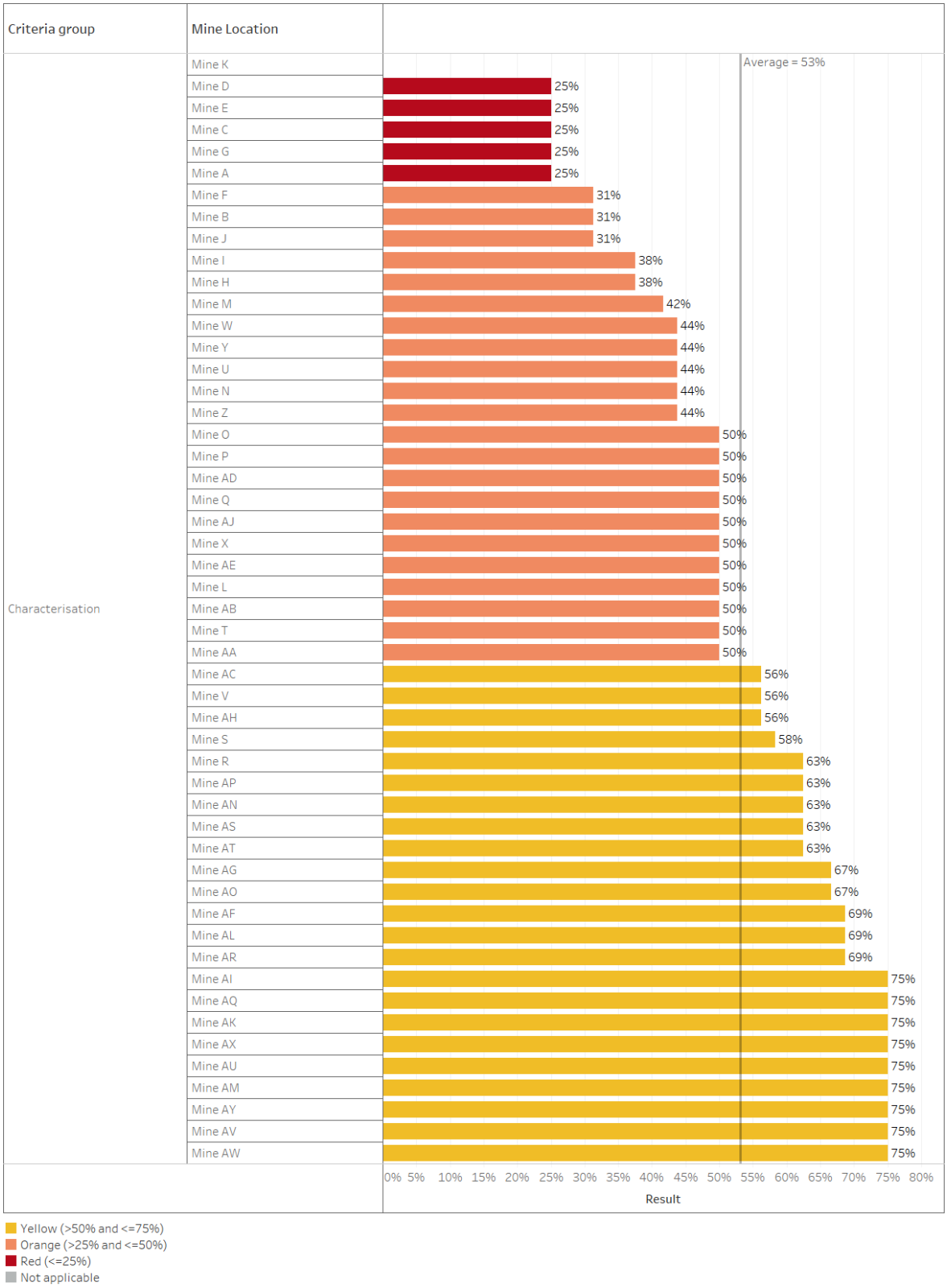


Figure 6: Overall assessment for the 'develop and maintain materials balance' category

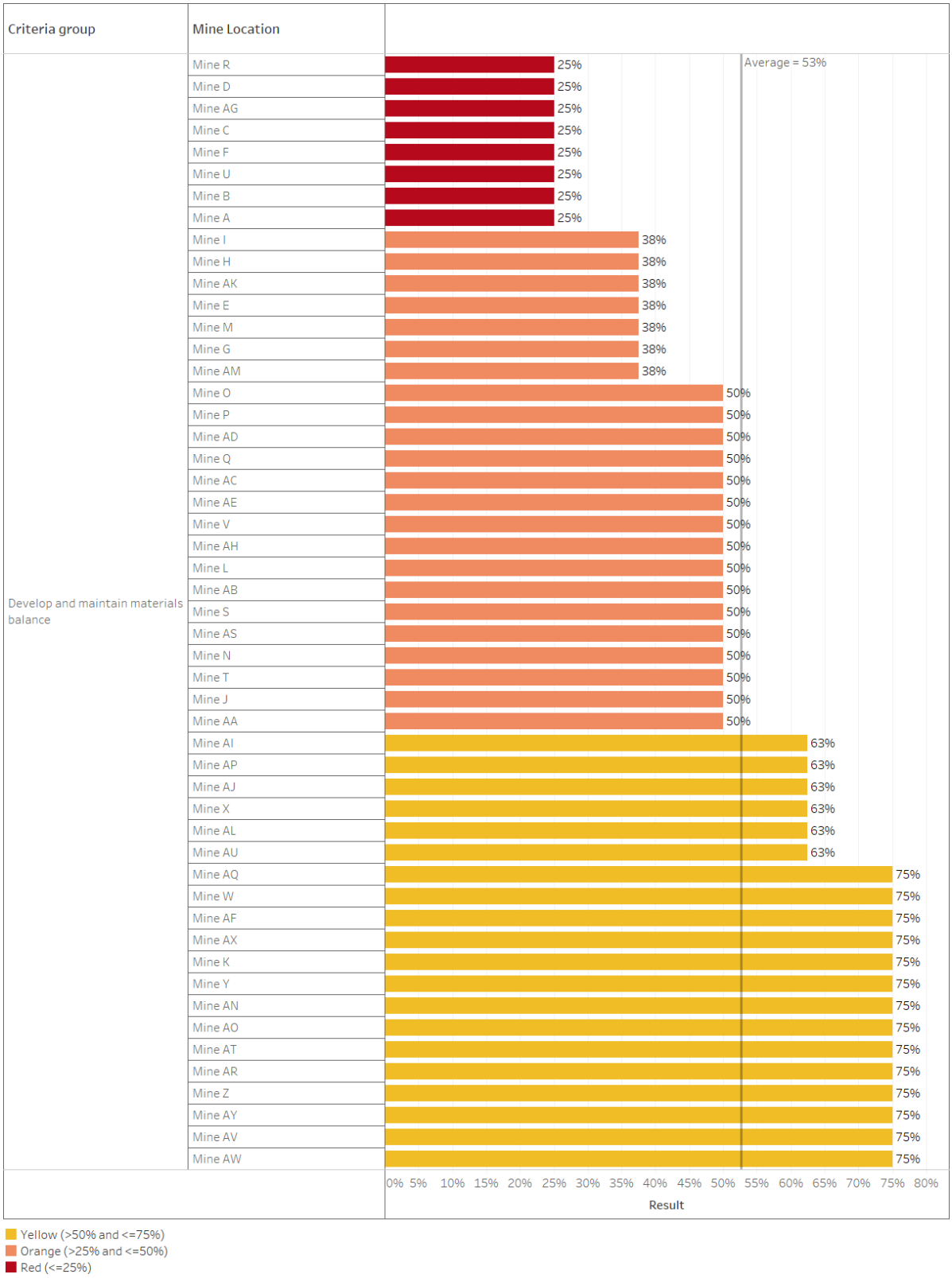


Figure 7: Overall assessment for the 'implement tailored soil management practices' category

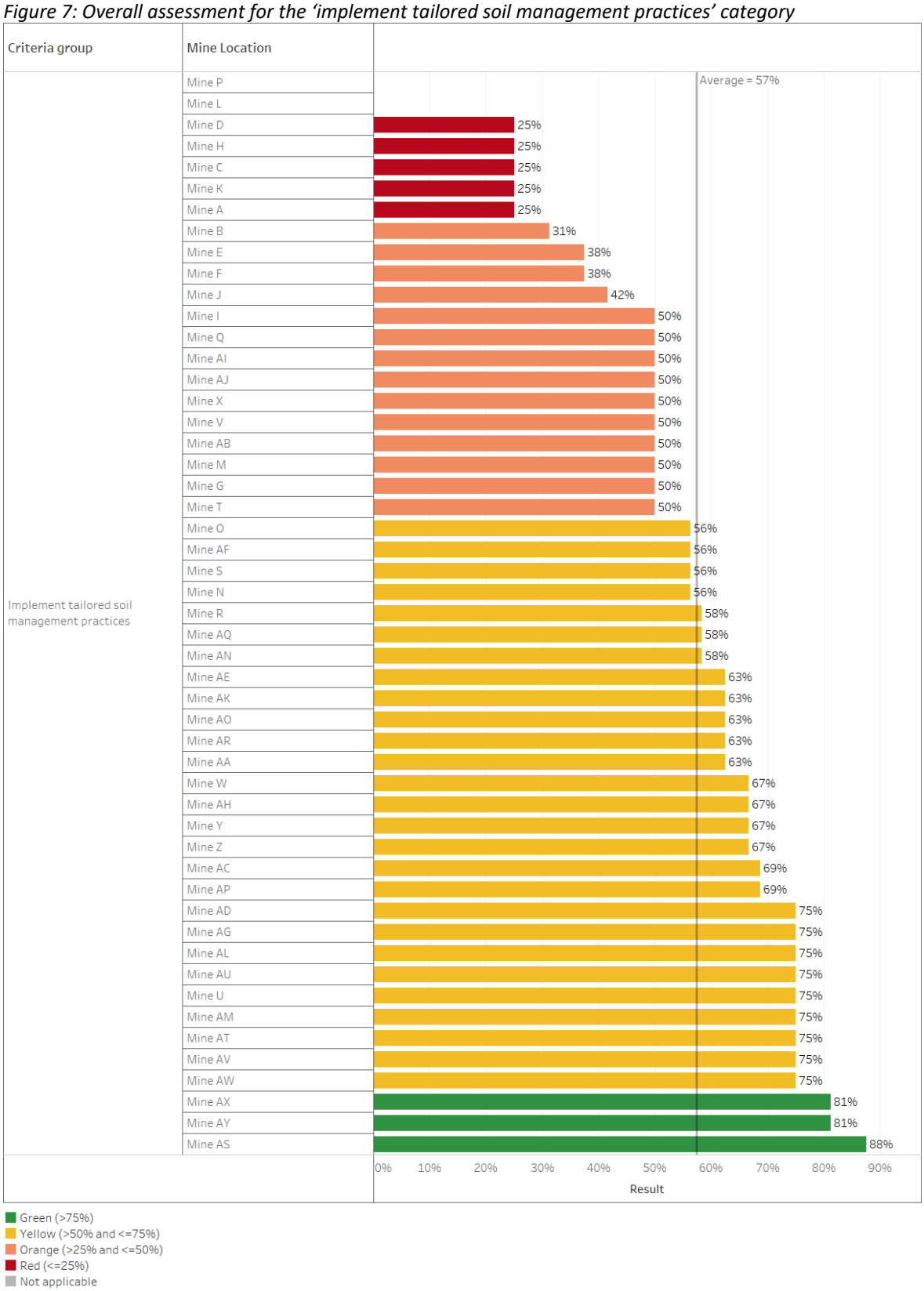
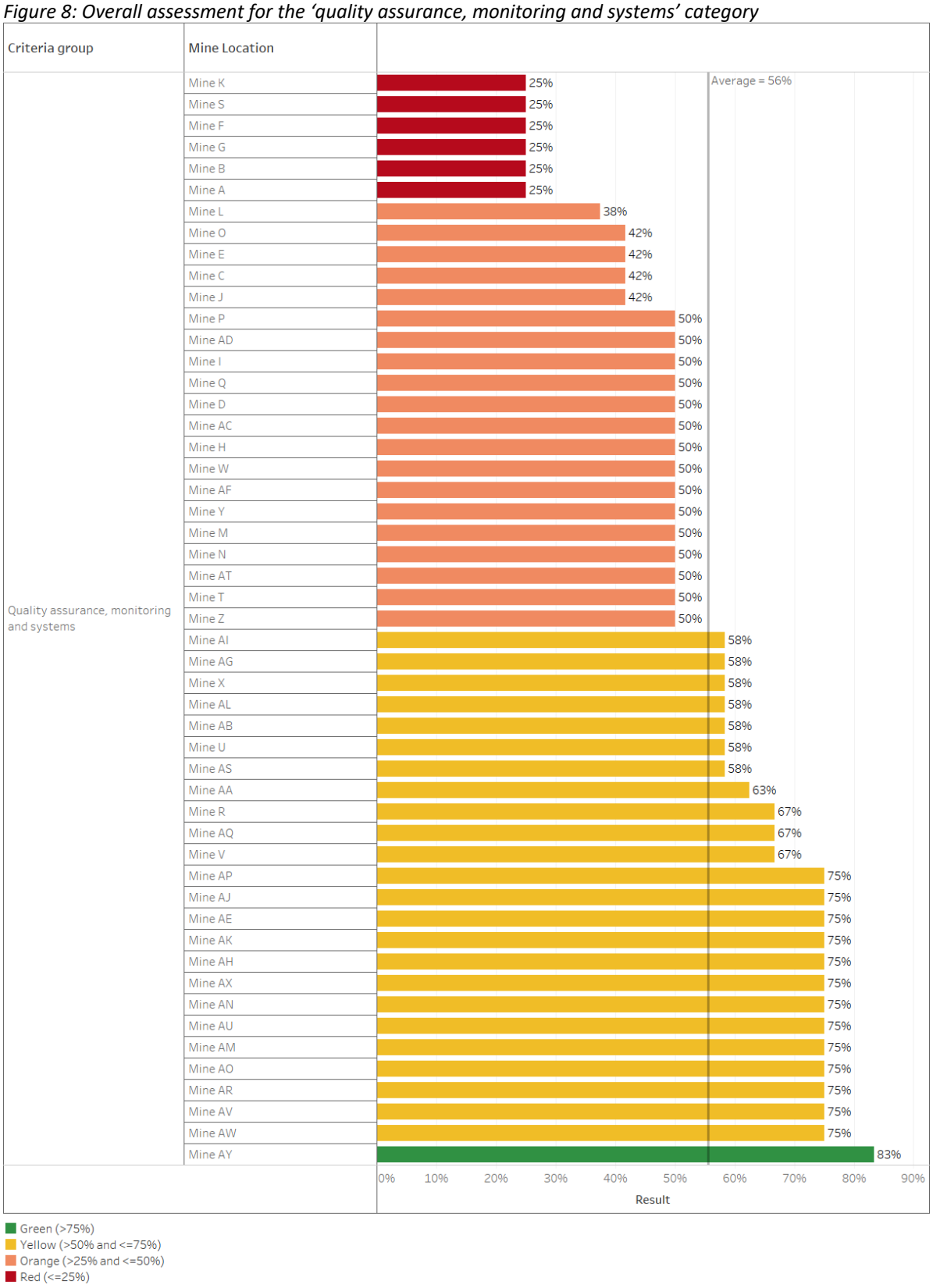


Figure 8: Overall assessment for the 'quality assurance, monitoring and systems' category



Responses to mines and notices issued

Of the 51 sites assessed under the inspection program, 44 mines were issued with assessment finding letters detailing recommendation for improvement in the medium to longer term. These recommendations included:

- undertaking a targeted rehabilitation risk assessment which addresses materials and soils management
- undertaking characterisation analysis of materials and soils to maximise the salvage and use of suitable materials for rehabilitation
- undertaking a materials and soils balance to ensure there is enough material to support the final landform and land use
- developing formalised quality assurance processes throughout the life cycle of rehabilitation.

Seven mines received notices pursuant to section 240 of the *Mining Act 1992*. These notices directed the mines to take immediate actions associated with the management of materials and soils, in order to achieve sustainable rehabilitation outcomes that will support the final land use. In accordance with section 240(1)(c) of the *Mining Act 1992*, each direction issued included information on the specific risk identified during the TAP and the required actions to address the risk.

Of the combined seven notices issued, there were some common themes which were apparent throughout the program plan. Table 1 summarises these themes and outlines the total occurrences encountered. These themes can be related back to the critical controls outlined earlier and identify some trends which are of concern.

Table 1: Notices issued – actions required

IDENTIFIED ACTIONS REQUIRED	TOTAL OCCURRENCES IN NOTICES
Undertake an assessment of the risk associated with the management of materials and soils to achieve sustainable rehabilitation outcomes and support the final land use.	2
Undertake characterisation analysis of overburden, waste rock, emplacements, tailings, subsoil, topsoil, etc that will be present in the final landform – focusing on characterisation of material that presents a risk to rehabilitation (e.g. problematic geochemical or geotechnical properties).	6

IDENTIFIED ACTIONS REQUIRED	TOTAL OCCURRENCES IN NOTICES
Undertake 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.	6
Identify controls, including management and amelioration measures, to ensure materials and soils are able to achieve sustainable rehabilitation outcomes.	7

Recommendations

Mine operators should:

- Conduct a comprehensive rehabilitation risk assessment that identifies, assesses and evaluates the risks that need to be addressed when managing materials and soils to achieve sustainable rehabilitation outcomes. The rehabilitation risk assessment should identify the appropriate risk control measures that must be implemented to reduce the risks and the controls measures that should be implemented.
- Identify and assess soil and biological material resources prior to the clearing phases of mining to ensure they can be utilised during the rehabilitation phases.
- Characterise the geochemical and geotechnical properties of mine materials (e.g. overburden, tailings, reject materials) to enable the selective handling and management of these materials so they do not pose a risk to achieving the final land use.
- Assess the substrate material (topsoil and subsoil) to ensure it is suitable to support the proposed revegetation outcome.
- Develop and maintain an inventory of soil and material resources to ensure the needs for rehabilitation of the final land use are met.
- Integrate rehabilitation into the mine planning and scheduling systems, including time frames for preclearing and stockpiling soil/material resources.
- Develop and implement measures to protect, salvage and maintain biological resources for use in rehabilitation based on the outcomes of characterisation analyses. Records should be kept and maintained that demonstrate implementation of procedures.

- Validate rehabilitation control measures via monitoring, inspections and records to ensure that materials and soils are handled in accordance with nominated methodologies and identified risks are addressed before proceeding to the next phase of rehabilitation.
- Communicate the key rehabilitation risks and controls measures to subcontractors and ensure ongoing monitoring.
- Engage personnel with appropriate skills and experience.

It is recommended that mine operators, upon reading this report, review and amend (where relevant), their site's relevant risk assessment, rehabilitation management plans and management practices to manage the risks associated with materials and soils that are unique to their site. During the review process, mine operators are also encouraged to consider and implement the above recommendations as a minimum.

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	nswresourcesregulator@service-now.com
Phone	1300 814 609 (option 2, then 5)
Website	www.resourcesregulator.nsw.gov.au
Address	NSW Resources Regulator 516 High Street Maitland NSW 2320

Appendix A. Bowtie risk assessment framework

A risk assessment focusing on rehabilitation and mine closure has been conducted by the Regulator in consultation with industry stakeholders and other government agencies. The bowtie risk assessment method was used to clearly display the links between the potential causes, the preventative and mitigative controls and the consequences of the material unwanted event - being where the post-mining conditions and environment are unsuitable to support the final land use(s).

The bowtie assessment addressed the rehabilitation risks during the operational mining phase and the rehabilitation phase.

The mining phase included:

- land clearing
- active mining operations
- decommissioning following completion of mining
- construction of the final landform.

The key unwanted event during the mining phase is that the material and landform is unsuitable to support the final land use(s).

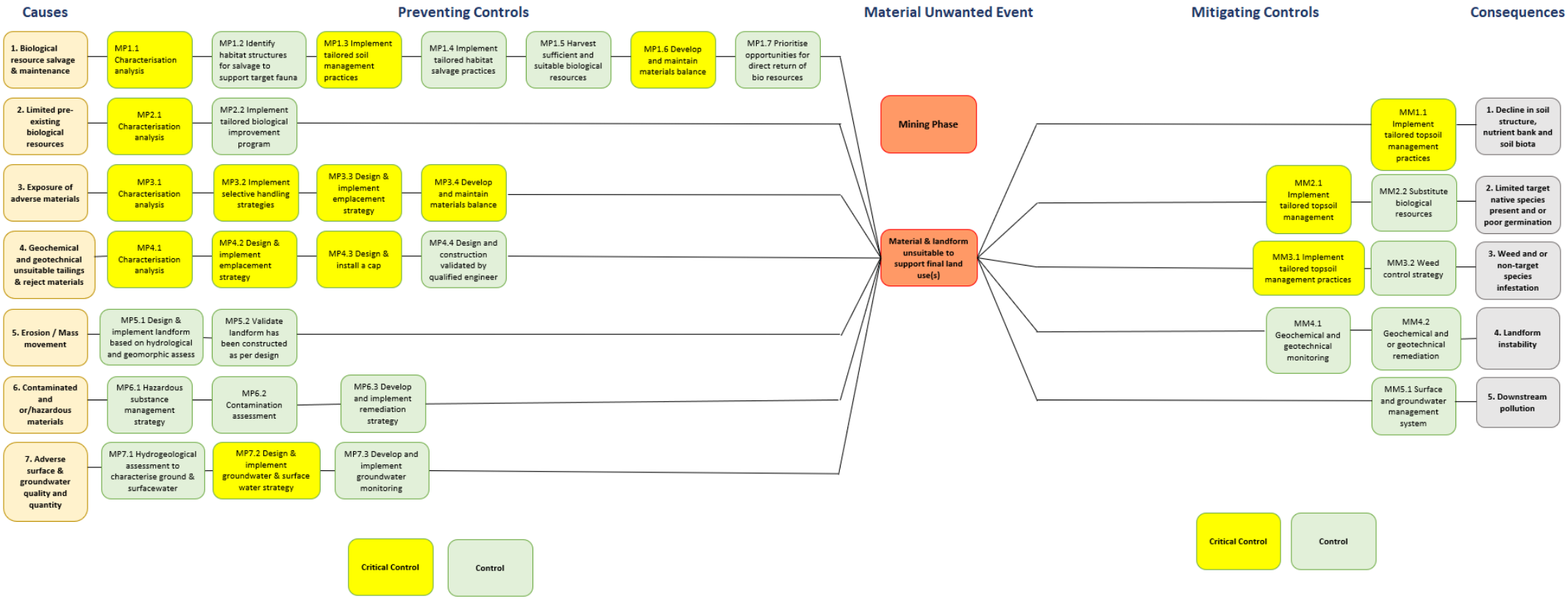
The rehabilitation phase included:

- growth medium development
- ecosystem and land use establishment
- ecosystem and land use development to achieve a sustainable, post-mining land use.

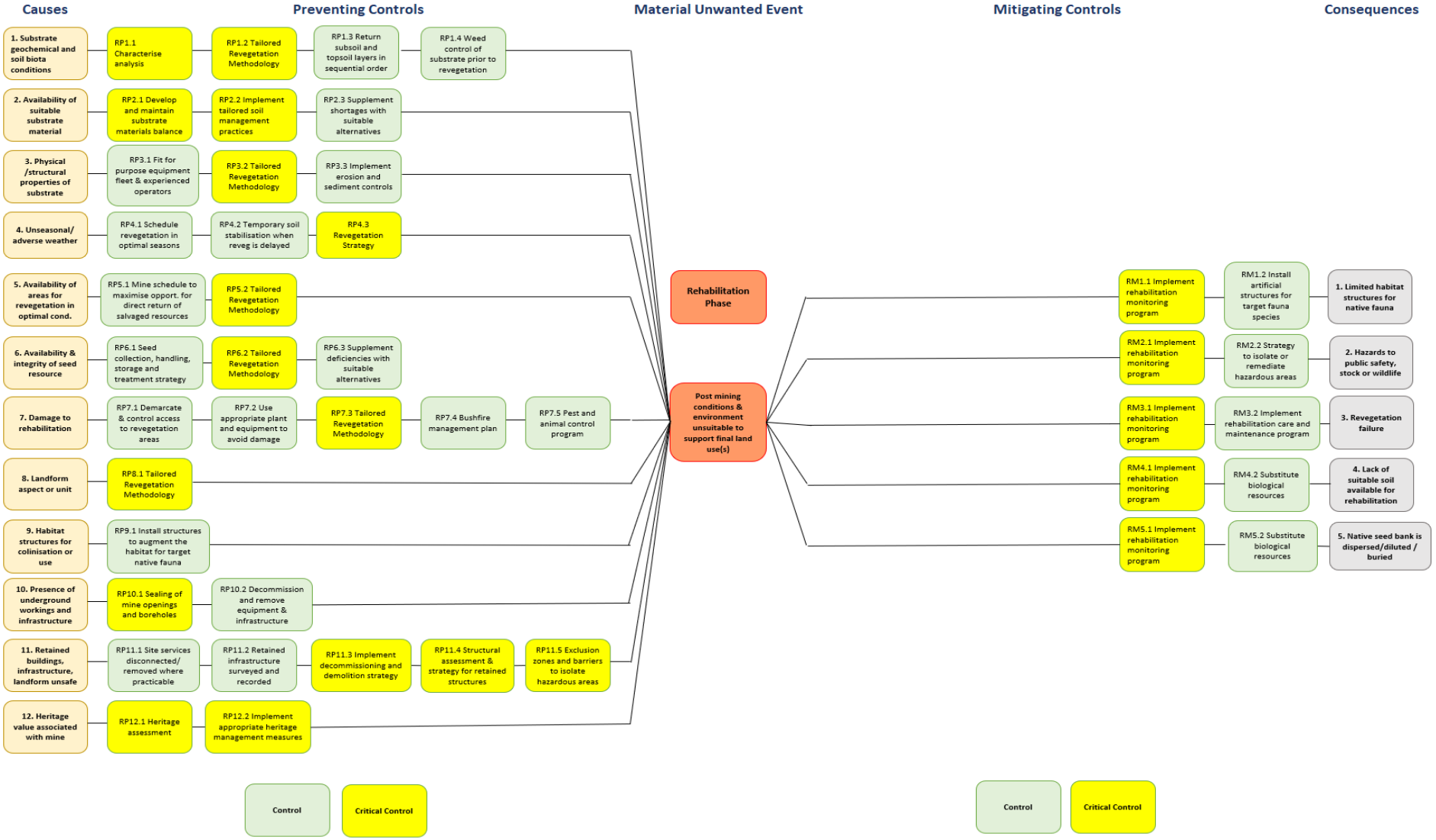
The key unwanted event during the rehabilitation phase is that the post-mining conditions and environment are unsuitable to support the final land use(s).

The bowtie risk assessments addressing the mining and rehabilitation phases are depicted overleaf and are also available on our website.

MP = Mining Phase Preventing Control; RP = Rehabilitation Phase Preventing Control; MM = Mining Phase Mitigating Control; RM = Rehabilitation Phase Mitigating Control



MP = Mining Phase Preventing Control; RP = Rehabilitation Phase Preventing Control; MM = Mining Phase Mitigating Control; RM = Rehabilitation Phase Mitigating Control



MP = Mining Phase Preventing Control; RP = Rehabilitation Phase Preventing Control; MM = Mining Phase Mitigating Control; RM = Rehabilitation Phase Mitigating Control

Appendix B. Threats and critical controls assessed

The threats and critical controls assessed are shown in the table below. The mines were also assessed for the following (which are not identified as 'critical controls' in the Regulator's bowtie risk management framework):

- whether risks associated with materials and soils management have been identified and appropriate controls implemented (MRP1.1)
- whether control measures were validated via monitoring, inspections and records (MRP1.6)
- whether control measures are effectively communicated to sub-contractors and monitored (MRP1.7)
- whether people with appropriate skills and experience have been engaged in relation to materials and soils management (MRP1.8).

ASSESSMENT CATEGORY	THREAT	CRITICAL CONTROL[2]
Risk Assessment	N/A (not identified in bowtie risk assessment)	MRP1.1 – Rehabilitation risk assessment (not a critical control)
Characterisation	Lack of biological resource salvage and maintenance	MP1.1 – Characterisation analysis (biological resource salvage and maintenance)
	Limited pre-existing biological resources	MP2.1 – Characterisation analysis (biological materials)
	Exposure of adverse materials	MP3.1 and MP4.1 – Characterisation analysis (geochemical and geotechnical)

[2] Refer to bowtie risk assessment in Appendix A for nomenclature of controls. MP = Mining Phase Preventing Control; RP = Rehabilitation Phase Preventing Control; MM = Mining Phase Mitigation Control; MRP = Mining & Rehabilitation Phase Preventing Control

ASSESSMENT CATEGORY	THREAT	CRITICAL CONTROL[2]
	Geochemically and geotechnically unsuitable tailings and rejects	
	Geochemically unsuitable substrate and inadequate soil biota	RP1.1 – Characterisation analysis (revegetation substrate)
Develop and maintain materials balance	Lack of biological resource salvage and maintenance Lack of and/or damage to suitable substrate material	MP1.6 and RP2.1 – Develop and maintain materials balance (soil resource)
	Exposure of adverse materials	MP 3.4 – Development and maintain materials balance (exposure of adverse materials)
Implement tailored soil management practices	Lack of biological resource salvage and maintenance	MP1.3a – Implement tailored soil management practices (rehabilitation integration into mine planning systems) MP1.3b – Implement tailored soil management practices (salvage biological resources)
	Decline in soil structure, nutrient bank and soil biota Limited target native species present and or poor germination Weed and or non-target species infestation	MM1.1a, MM2.1a, MM3.1a – Implement tailored soil management practices (maintaining biological resources)

ASSESSMENT CATEGORY	THREAT	CRITICAL CONTROL[2]
	Availability of suitable substrate material Decline in soil structure, nutrient bank and soil biota Limited target native species present and or poor germination Weed and or non-target species infestation	RP2.2, MM1.1b, MM2.1b, MM3.1b – Implement tailored soil management practices (characterising and treating substrate material)
Quality assurance, monitoring and systems	N/A (not identified in bowtie risk assessment)	MRP1.6 – Validation of control measures via monitoring, inspections and records (not a critical control)
	N/A (not identified in bowtie risk assessment)	MRP1.7 – Effective communication to sub-contractors and monitoring (not a critical control)
	N/A (not identified in bowtie risk assessment)	MRP1.8 – Engagement of people with appropriate skills and experience (not a critical control)

Appendix C. Assessment system explained

We use a bowtie framework to proactively assess how mine sites manage 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.

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
Satisfactory	Methodology is described/documented in the Mining Operations Plan/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 Mining Operations Plan/Rehabilitation Management Plan (or other relevant document) but is limited (in terms of scope and implementation).	2
Poor	Not documented and not implemented	1
NA	Circumstances where the critical control/control support does not apply.	NA

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

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%.

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.

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
Not Applicable	