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The Challenger gold story — do it once, do it well

P Waters *MWH Australia Pty Ltd, Australia*

K Bennett *MWH Australia Pty Ltd, Australia*

B Wingfield *MWH Australia Pty Ltd, Australia*

Abstract

The Challenger gold mine (Challenger) is located in remote South Australia. Discovered in 1995, mining commenced in 2002. As a relatively new site with no mining legacies, Challenger provided an ideal site to plan the full lifecycle of mining based on digital mine planning, learnings from successful rehabilitation elsewhere, and the full awareness of industry legacy issues such as acid mine drainage, tailings storage and long-term landform stability.

This paper describes the key aspects that will impact the Challenger site post-mining, including:

- *Remote site.*
- *Minimising the disturbance footprint.*
- *Integrated management of tailings and waste rock.*
- *Consideration of waste rock properties for landform construction.*

A key success factor for the Challenger site has been the progressive support of management towards sustainable mining. By adopting a life-of-mine approach, environmental considerations were incorporated at the inception of the project and have been actively managed during the life of the mine to the satisfaction of internal and external stakeholders. As a result, the operation has a very clear and concise plan as the operation matures and eventually moves towards closure. Adopting a fit-for-purpose, consistent approach to sustainable mining has resulted in cost-efficient environmental activities and confidence around the cost for mine closure.

1 Project description

Challenger is a gold mine located in the far north of South Australia, 165 km west of the Stuart Highway and 780 km northwest of Adelaide (Figure 1). The mine lease is located within the Woomera Prohibited Area on the Mobella Pastoral lease.

Figure 1 Location map of the Challenger gold operation

The operation is operated by Kingsgate Consolidated Ltd who purchased Challenger from Dominion Gold in 2011.

The operation comprises an open cut and underground gold mine and processing facility (Figure 2). The infrastructure covers an area of approximately 300 ha and includes the processing plant, a mine village housing up to 240 personnel working a fly-in/fly-out roster, aerodrome, reagent and fuel storage facilities, offices, workshops, a laboratory, ancillary buildings and haul roads.

Figure 2 Aerial view of the Challenger gold operation

Challenger is located in an arid climate with an average rainfall of less than 150 mm per year and evaporation rates of approximately 3,700 mm. Water is supplied from a process water bore field located approximately 3 km west of Challenger. A diesel power station (PS1) supplies power to the treatment plant and village. A secondary diesel power station (PS2) supplies power to the underground mine and surface ventilation fan.

The Challenger deposit is located within portions of Christie gneiss, a member of the Mulgathing Complex that is part of the Gawler Craton, a large crystalline basement province consisting of late Archaean to Mesoproterozic rocks that became stabilised around 1,450 Ma. The deposit occurs within a quartz-feldspar-biotite ± garnet-cordierite gneiss, a variation of Christie gneiss. Frequent narrow, cross cutting lamprophyric and mafic dykes also occur. The host to gold mineralisation is a silica rich (flooded), potash (microcline) feldspar-rich greisenised pegmatite. Gold grains contain inclusions of arsenopyrite, pyritised pyrrhotite and native bismuth. Primary sulphides are pyrrhotite, pyrite, chalcopyrite and arsenopyrite. They co-exist with ilmenite (rutile-anastase-leucoxene) and graphite.

2 Project history

The Challenger gold deposit was a virgin gold discovery made by Dominion Gold Operations (DGO) in May 1995 and delineated with a detailed drilling programme in 1998. The project was initially a joint venture between DGO and Resolute Ltd. Pre-feasibility studies were carried out in 1998–1999 by Resolute Ltd, with a detailed feasibility study carried out by DGO after acquiring 100% ownership of Challenger in December 2000.

The mining lease was granted to DGO in November 2001, with open pit mining and plant establishment commencing in April 2002. Open pit mining commenced in mid-2002 and plant and infrastructure were completed during the September 2002 quarter. Plant commissioning commenced in late September 2002 and the first shipment of gold bullion was completed on 24 October 2002.

Mining of the Stage 1 open pit (ultimate depth of 124 m below ground level) and small adjacent auxiliary pit were completed by April 2004, at which time underground development of the Jumbuck decline commenced. As at March 2015 the decline had been developed down to approximately 1,064 m below the surface.

In December 2014, the gold mine celebrated the pouring of its one millionth ounce of gold, some 12 years after it commenced production. To achieve the million ounces, 5.994 million tonnes of ore has been mined from both the underground and open pit.

3 Mine lifecycle

As a relatively new site with no mining legacies, Challenger provided an ideal site to plan the full lifecycle of mining based on digital mine planning, learnings from successful rehabilitation elsewhere within the mining industry and full awareness of industry legacy issues such as acid mine drainage, tailings storage and long-term landform stability.

Examples of the philosophy of ‘do it once, do it well’ at Challenger include:

- Full material characterisation undertaken during the planning stages of the mine life.
- Adoption of an (then) innovative integrated waste landform for the combined storage of waste rock and tailings (Section 4).
- Constant recovery of growth media and progressive rehabilitation of disturbed areas once available (Section 5).
- Routine performance monitoring and reporting since prior to the commencement of the mine, allowing for the establishment of defined pre-mining conditions and subsequent measurement of impacts during the life of the mine.
- Development and implementation of a site specific Environmental Management System during the construction phase of the mine that remains ongoing.
- An active recycling programme.
- Environmental training and awareness as a default within induction programmes.

A key factor in the success of the Challenger site has been the progressive support of management towards sustainable mining. By adopting a life-of-mine approach, environmental activities were incorporated at the inception of the project and are actively managed to the satisfaction of internal and external stakeholders. Despite the operations being sold more than once during operation, the commitment to the original mining strategy has been maintained. As a result, the operation has a very clear and concise plan as it matures and eventually moves towards closure. Adopting a fit-for-purpose, consistent approach to sustainable mining has resulted in cost-efficient environmental activities and confidence around the cost for mine closure.

4 Integrated waste landform

One of the key project successes was the identification of an opportunity at the planning phase, prior to the commencement of mining, to design and construct an integrated waste landform (IWL). In the case of Challenger, the IWL accommodated both waste rock mined for the operations as well as tailings.

The design principles (Figure 3) for the IWL are:

- Starter embankments are free standing and comprised of inert oxide waste.
- Mine waste rock is then progressively placed to allow for downstream construction.
- Oxide waste is stored (specifically placed) to allow subsequent raising of the internal compacted zone downstream (Figure 4).
- External batters progressively rehabilitated (Figures 5(a) and (b)).
- Internal embankment raised progressively using stored oxide waste.
- Dumping exclusion zone to allow staged construction.
- Compacted clay blanket over the tailings storage floor area.
- Underdrainage water recovery system.
- Central decant for recovery of supernatant water.
- Perimeter spigotting to maintain a centrally located water pond.

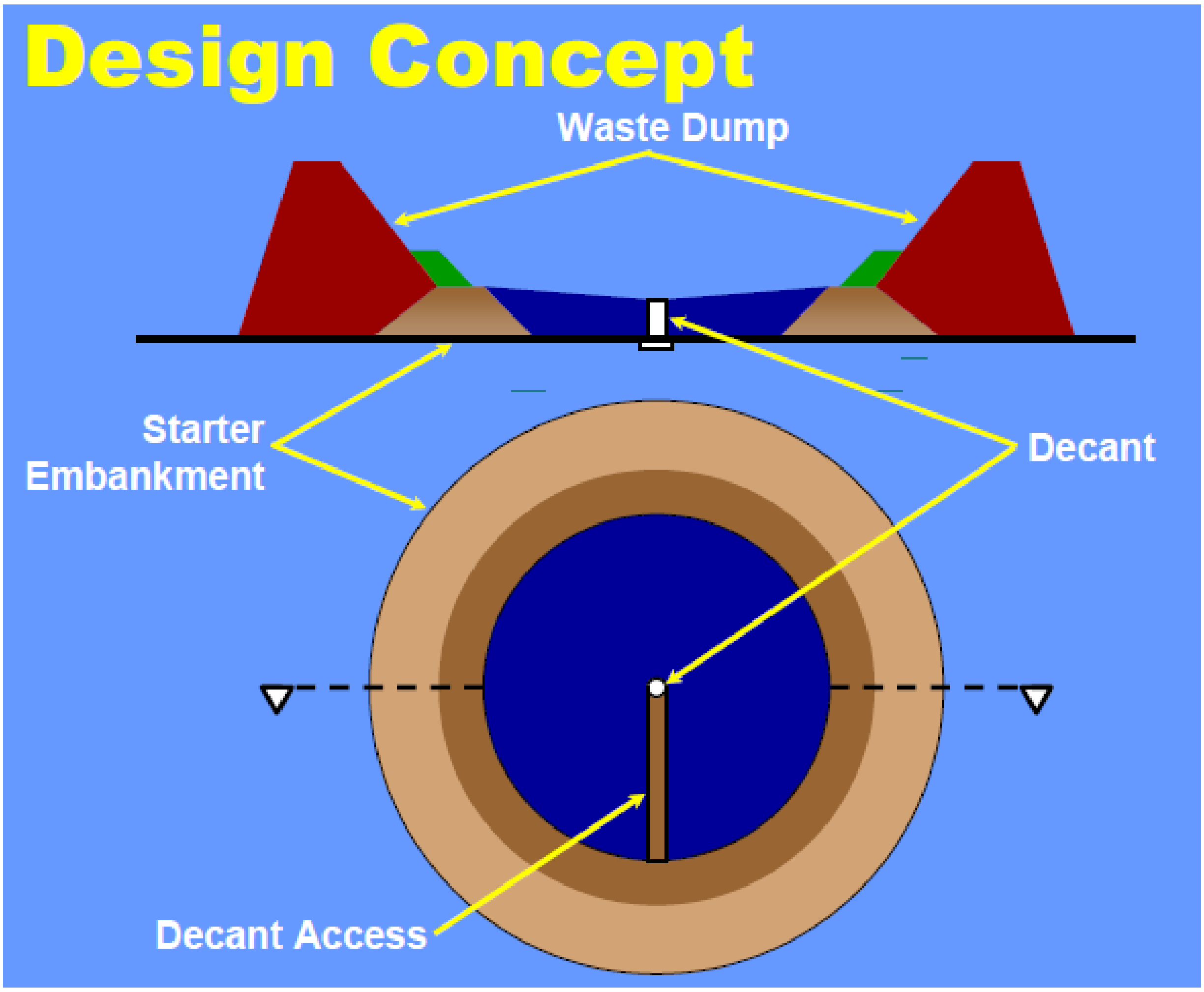

Figure 3 IWL design concept

Figure 4 Aerial view of the IWL during construction

(a) (b)

Figure 5 Images of the rehabilitated outer IWL slopes

There are several benefits to adopting an IWL for the combined storage of waste rock and tailings including:

- Savings in capital costs through optimum use of mine waste.
- Smaller overall footprint for waste landforms compared to separate waste rock landforms and tailings storage facility. It is estimated for the Challenger site that adopting the IWL design resulted in a reduction by 30% of the overall footprint of disturbance.
- Savings in rehabilitation costs and reduced ongoing liability for rehabilitation.
- Savings in operating costs as:
  - Embankment raising works are generally cheaper and easier.
  - Movement of tailings lines reduced to one process instead of two.

  - Continued operation during construction with limited disruption and improved water recovery.
  - Increased reagent recovery.
- Ability to progressive rehabilitate the mine waste and integrated tailings facility (refer Figures 5(a) and (b)). Refer to Sections 5 and 6 for further discussion on progressive rehabilitation and monitoring success.
- Reduced materials rehandling as placement of materials is pre-planned.

In the case of Challenger, subsequent discoveries of economic gold at depth resulted in an expansion of the mining operation and a substantial extension of the life of the mine. As such, the original IWL could not be expanded further and a second, separate tailings storage facility (TSF) was required. As no suitable inert oxide waste was available, an IWL design was suitable for the second TSF (seen in Figure 3). This experience highlights the dynamic nature of mining and understanding that flexibility in design is an important factor in many aspects of mine design – including landform rehabilitation.

5 Progressive rehabilitation

Current rehabilitated areas at Challenger include the outer walls of the IWL (2004 and 2005) and the outer walls of TSF 2 (2011 and 2014). As of March 2015, 22.6 ha had been rehabilitated at Challenger.

Progressive Rehabilitation and Closure (PRAC®) is an online, mine closure planning software tool that was developed by Outback Ecology (now MWH) over 12 years ago. PRAC enables sites to operationalise static mine closure plans by implementing a systematic approach through a cloud-based, online task management system. The tool is designed to automate data collection, report generation and information visualisations. PRAC is comprised of three key components:

1. Document storage: stores all information pertaining to a mine site's domains and features. Domains are comprised of features with similar rehabilitation requirements, and related information includes environmental data, approvals documents and legal requirements.
2. Knowledge base: development and storage of all information for each feature, acting as a repository for historical information, enabling the user to determine the knowledge gaps for a feature, and the tasks required to close those gaps.
3. Task management: Tasks are identified to close knowledge gaps and undertake specific rehabilitation, closure and decommissioning activities. Tasks are then prioritised and scheduled over time. Task progress is actively tracked and reported on, whilst learnings captured are used to further refine the closure strategy for each domain and feature.

PRAC was implemented at Challenger in 2007 and has been actively used as a tool to track and manage progressive rehabilitation activities and requirements. The use of PRAC at Challenger has provided the following benefits for the operation:

- Early and accurate estimation of closure costs.
- Facilitation of ongoing reduction of environmental liabilities.
- Identification of high risk issues to help prioritise work.
- Facilitation of progressive rehabilitation.
- Reduction of business risk.

6 Rehabilitation monitoring

Rehabilitation at Challenger has been assessed over 12 years using Ecosystem Function Analysis (EFA). This approach for assessing changes in landscape function, vegetation and habitat is described in Tongway et al.

(1997). Challenger have committed to the development and use of closure criteria to help ascertain rehabilitation success through the use of EFA, with data from analogue sites informing suitable criteria.

The establishment of completion criteria is usually based on applying a quantitative standard, using a measurement tool (in this case EFA) to address a specified criteria, designed to fulfil a determined objective. The actual target thresholds must be determined using site-based expectations and the requirements of stakeholders, to establish a value that is going to be readily achievable and acceptable in terms of ecosystem sustainability.

For the Challenger site, initial targets for EFA indices of soil surface stability, infiltration and nutrient cycling were set as “a value exceeding 80% of the mean analogue value for at least three consecutive years” (MWH 2014). In order to measure success, four EFA analogue sites have been established as comparisons against rehabilitated areas and as indicators of climatic influences and general disturbances (Figure 6). These sites are situated within the Challenger gold mine lease ML6103 and represent two vegetation and land unit types on flat land (CH01 and CH02) and sloping land (CH11 and CH12):

- CH01 and CH11 represent *Acacia* woodland, stony plain.
- CH02 and CH12 represent Chenopod, calcareous platform.

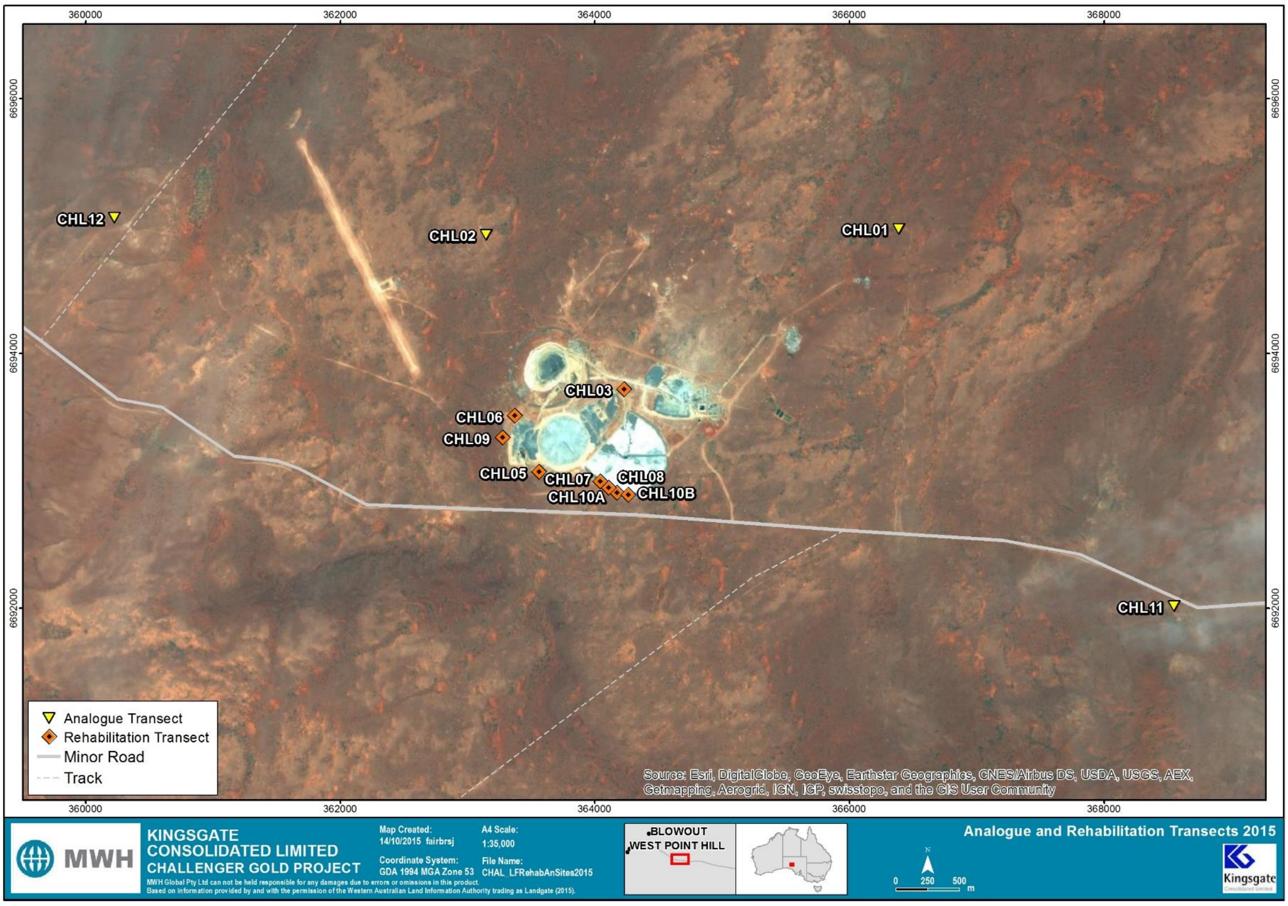

Figure 6 Location map for the Challenger site showing the position of EFA analogue sites and monitoring transects (source: MWH 2015)

These analogue transects were installed in 2004 (CH01 and CH02) and 2014 (CH11 and CH12) and have been monitored annually. The trends observed for both landscape function indices and vegetation indices at both analogue and rehabilitated transects have been similar over time despite the fact that analogue scores were higher than their rehabilitation counterparts, particularly for the vegetation parameters. Vegetation strata were divided into additional categories in 2010 to better represent the vegetation present, following above average rainfall in the months preceding assessment. However, these additional strata of grass and

Sclerolaena species, which are comprised of annual and short-lived perennials, would not always be expected to be present.

EFA transects were established on rehabilitated areas of the eastern and western outer slopes of the IWL in 2004 and have been subject to annual monitoring. In 2010, many of the EFA indices for rehabilitated transects were similar in value to, or exceeded, their respective analogue values (Figures 7 and 8).

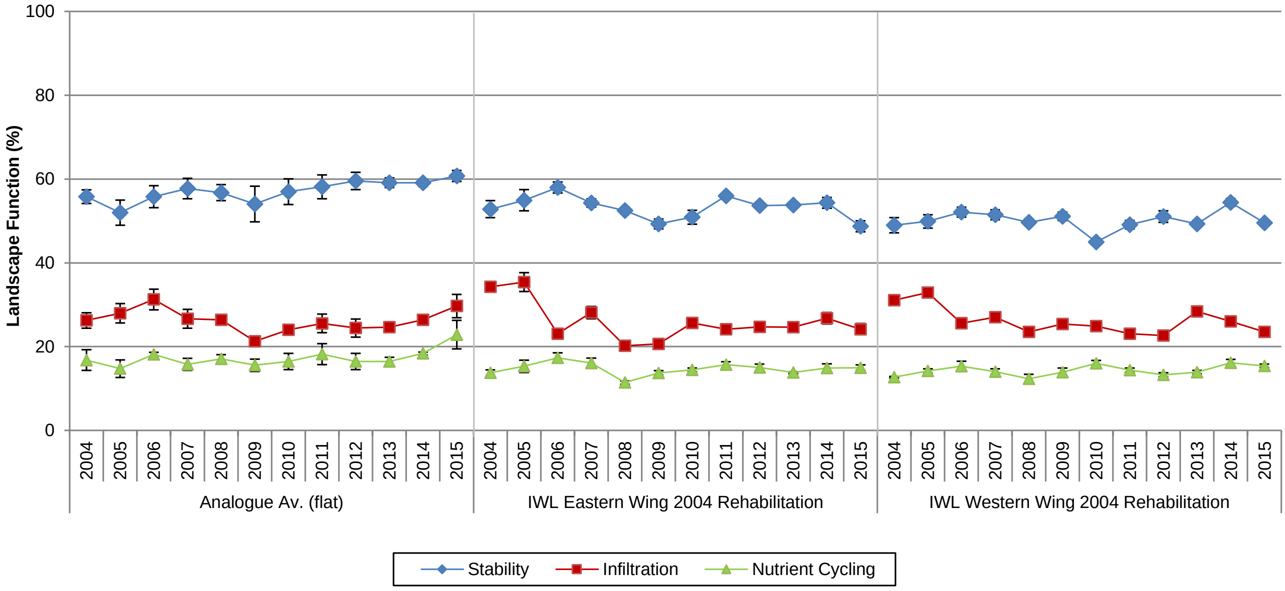

Figure 7 Changes in the landscape function indices over time for analogue and rehabilitation plots (MWH 2015)

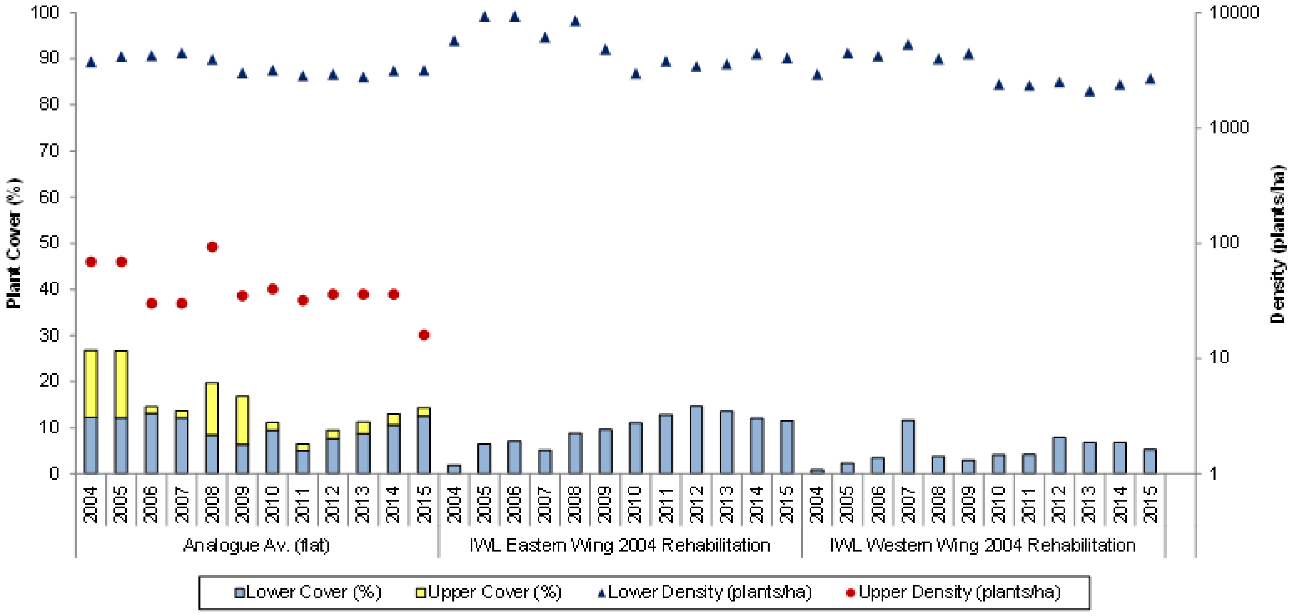

Figure 8 Changes in the plant cover and density over time for the analogue and rehabilitation plots (MWH 2015)

Maintenance of the index value above the assigned threshold for a determined number of years is essential to demonstrate that the levels achieved can be maintained. Due to the variability of the Challenger environment, it is proposed that only analogue data from the year of assessment be used in determining these values. As such, the thresholds would not be constant, but rather floating targets that vary based on conditions in the period preceding the assessment. Table 1 provides a summary of how all rehabilitation is performing against the completion criteria targets. For 2015, rehabilitation transects failed to meet the completion criteria targets; this was a result of the increase from the analogues rather than a decline in the quality of the rehabilitation.

Table 1 Summary of rehabilitation status in terms of agreed criteria threshold targets (MWH 2015)

	Landform/year of monitoring													
	IWL Eastern Slope				IWL Western Slope				TSF 2 — Lift 1				TSF 2 — Lift 2	
Criteria	**2012**	**2013**	**2014**	**2015**	**2012**	**2013**	**2014**	**2015**	**2012**	**2013**	**2014**	**2015**	**2014**	**2015**
Stability	✓	✓	✓		✓	✓	✓				✓	✓	✓	
Infiltration	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	
Nutrient cycling	✓	✓	✓		✓		✓							
Erosion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lower shrub cover	✓	✓	✓	✓	✓		✓							
Lower shrub density	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		
Species richness	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

Key: ✓ means that the criteria was met or exceeded.

Table 1 demonstrates that the foundation elements of erosion, stability and infiltrations are met or exceeded in nearly all monitoring periods. This gives the confidence that the fundamentals of the landforms have established and provides a suitable platform for the establishment of native vegetation into the future.

The amount of quality topsoil available for use in rehabilitation activities has been identified as a key factor in closure criteria being successfully met in the future. The results of a survey conducted in March 2011 indicate there was approximately 140,000 m^3 of stockpiled rehabilitation material available for use at the time. Furthermore, it was estimated that the volume required to spread topsoil to a depth of 100 mm over the disturbed areas was approximately 115,000 m^3.

The cover and abundance of weeds was also considered an appropriate measure for Challenger, to ensure the floral integrity of the rehabilitated ecosystem. Given that seed resources often remain un-expressed in the soil profile until such time that conditions induce their germination, a criteria stating that the cover and abundance of alien species should not exceed the analogue average for any given year of assessment was established.

7 Conclusion

The Challenger Mine site functions as a committed environmental exponent within the South Australian mining industry, utilising innovative landform designs, a progressive rehabilitation strategy, ongoing rehabilitation research and environmental monitoring to ensure regulatory compliance during all stages of the project's operation. This was recognised in 2005 when the project was a finalist for the prestigious Banksia Environmental Awards, nominated in the Sustainable Development Leadership category.

The primary objective of progressive rehabilitation and closure at Challenger is to achieve stable, non-erosive landforms, and the secondary objective is to achieve a self-sustaining ecosystem that exhibits comparable characteristics to the local natural environment in a timely and cost-effective manner. The framework of rehabilitation objectives proposed here, supported by completion criteria and quantitative standards, is focused on ensuring that the key elements required for a stable landform and functioning ecosystem are developed, together with ensuring other critical outcomes such as public safety. The process of assessing the extent to which the objectives are achieved is made up of a phase of ensuring compliance with commitments, complemented subsequently by assessments of ecosystem development.

There are numerous benefits enjoyed by the operators of the Challenger Mine that other operators and the industry can learn from including:

- Reduced closure costs by executing successful rehabilitation during the life of the mine.
- Monitoring can be undertaken to demonstrate the effectiveness of rehabilitation efforts, providing stakeholder confidence that rehabilitation efforts are successful and sustainable.
- Where rehabilitation efforts have not been successful, there is the chance to undertake remedial activities whilst operations are still progressing.

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