

Revegetation of the McArthur River Diversion Channel

2006 - 2019





About Me

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Senior Environmental Advisor – Rehabilitation
McArthur River Mine

Tasmanian



Worked for:

- BHP
- Rio Tinto
- Murray Zircon
- Arrium Mining
- Sibelco
- Glencore



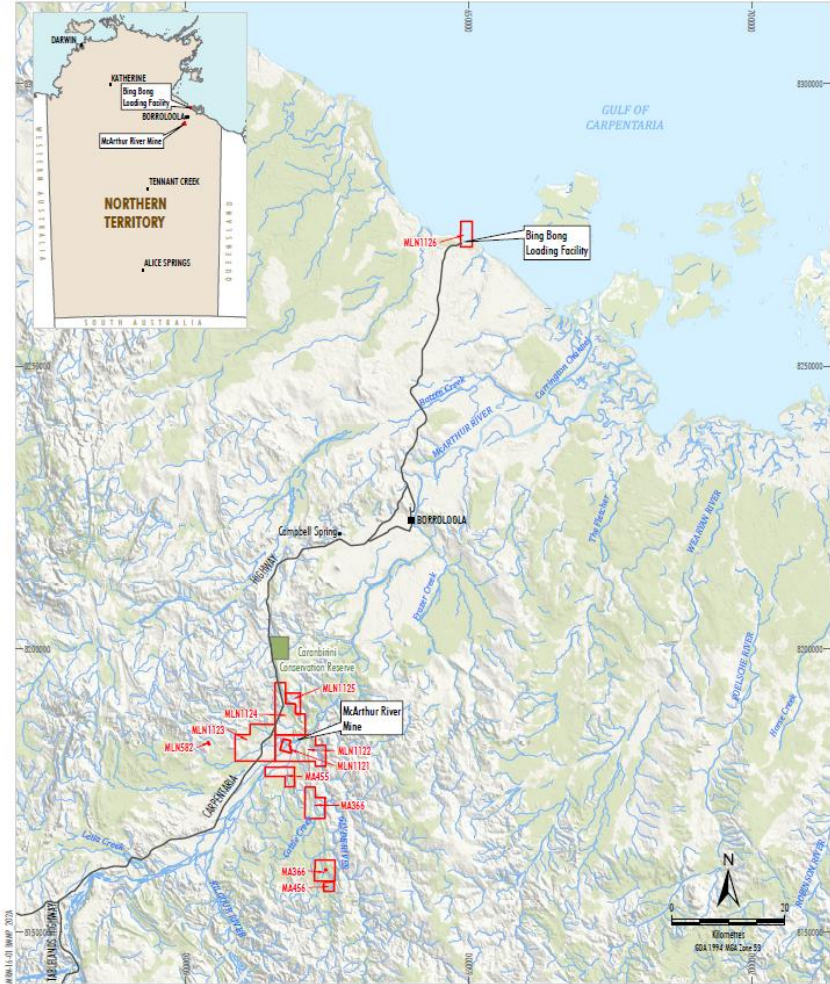
Bachelor of Laws
Bachelor Environmental Science / OHS
Masters Mineral Resources





Background

Background



McArthur River Mine is located in the Gulf Region of the Northern Territory

Approximately:

- 45 km south-west of Borroloola (65km by road)
- 715 km south-east of Darwin (900km by road)

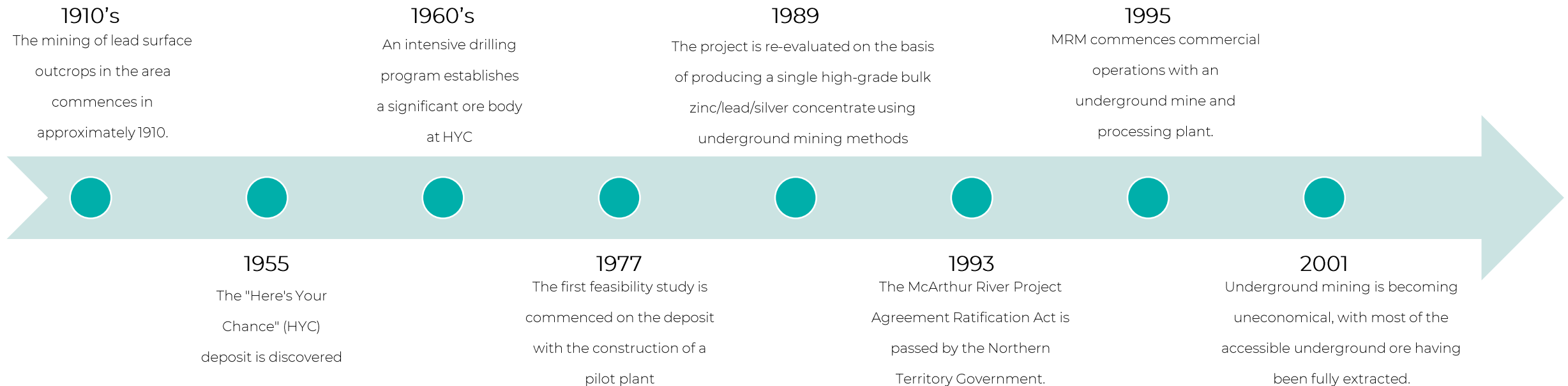


Background

McArthur River Mine is one of the largest known sedimentary stratiform zinc / lead / silver deposits in the world.

Following the preparation of an Environmental Impact Statement (EIS) in 1992, development of MRM's underground operation commenced in 1994, with the first shipment of concentrate commencing in mid-1995.

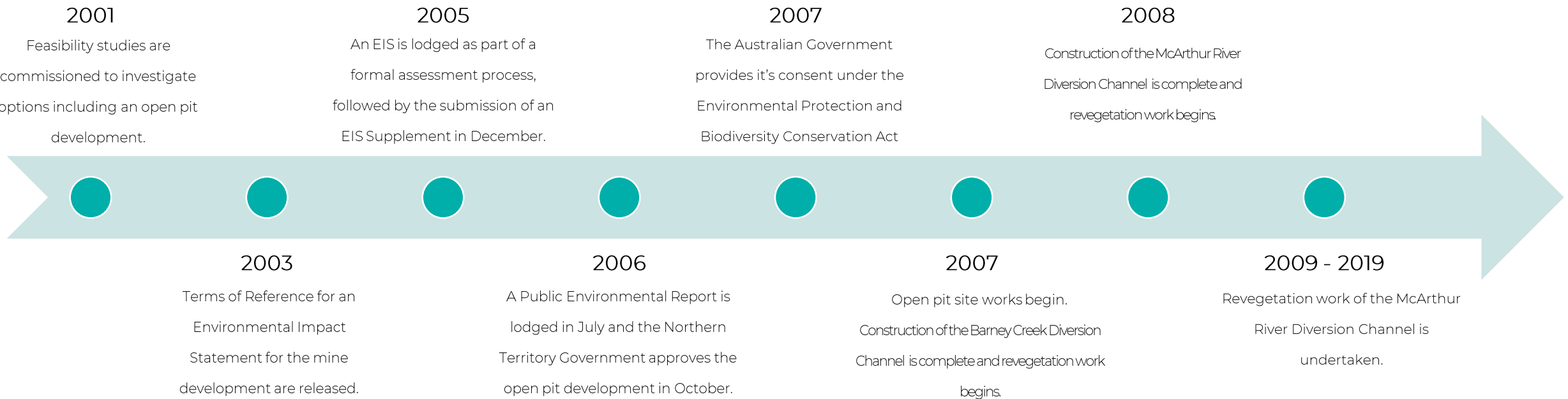
Underground mining was undertaken at MRM between 1995 and 2007.



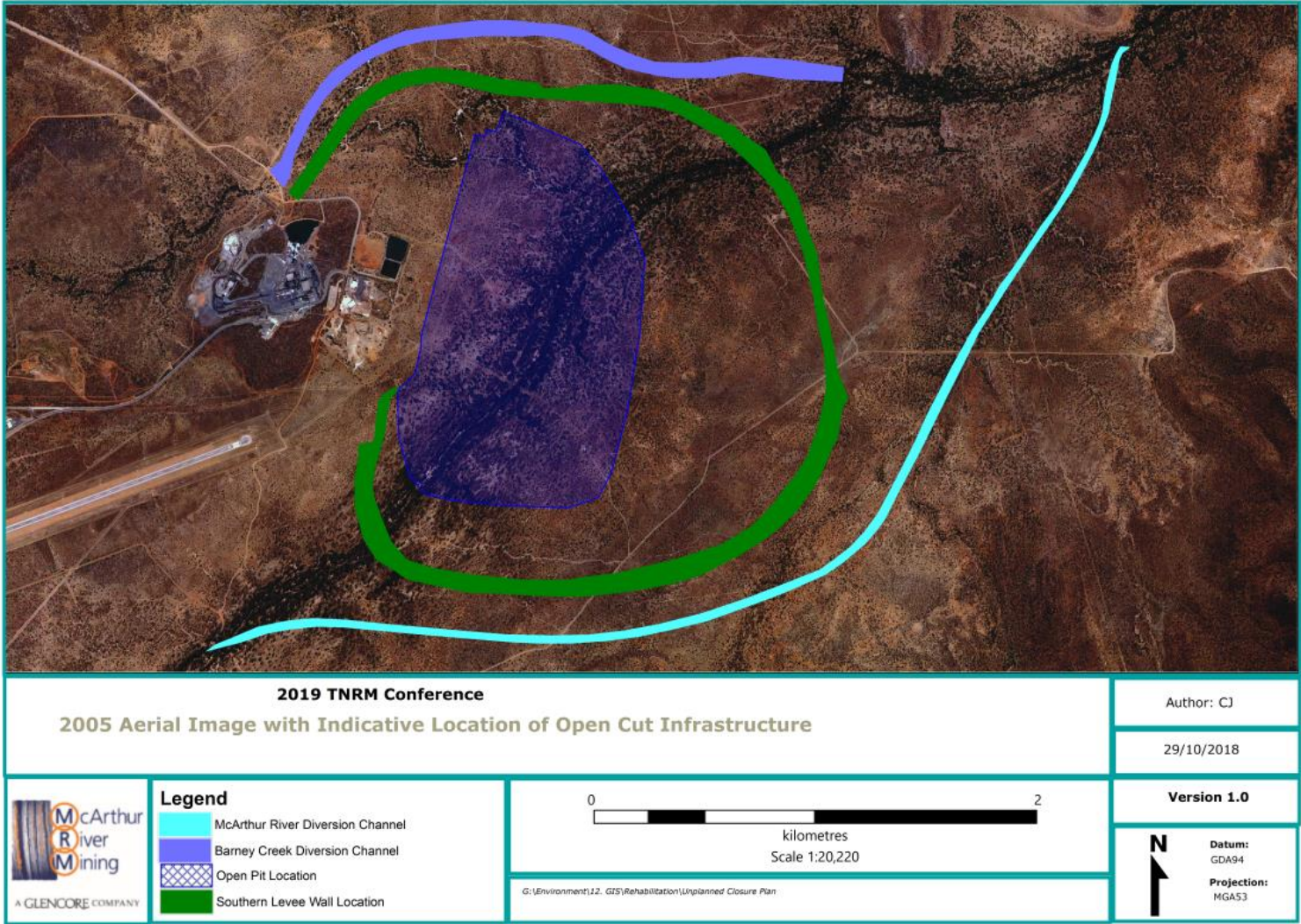
Background

In 2003 MRM commenced the preparation of an Environmental Impact Statement to establish an open cut mine.

This was submitted in 2005, with Northern Territory approval in 2006 and Federal Approval in 2007.



Background



Background

The Barney Creek Diversion Channel is located around the northern edge of the mine levee wall and directs flow from the northwest around to the northeast where it joins the original McArthur River Channel.

The Barney Creek Diversion Channel is approximately 3km long.

Surface water flows are naturally ephemeral, with water flow ceasing during the dry season (May – October)



Barney Creek Diversion Channel - 2008



Barney Creek Diversion Channel - 2012



Barney Creek Diversion Channel - 2019

Background

The McArthur River Diversion Channel is located around the southern edge of the mine levee wall and directs flow from the southwest around to the southeast where it joins the original McArthur River Channel.

The McArthur River Diversion Channel is approximately 5.5km long.

Surface water flows are markedly seasonal, with significantly higher flow during the wet season (November to April) compared to the dry season (May to October).



McArthur River Diversion Channel - 2008

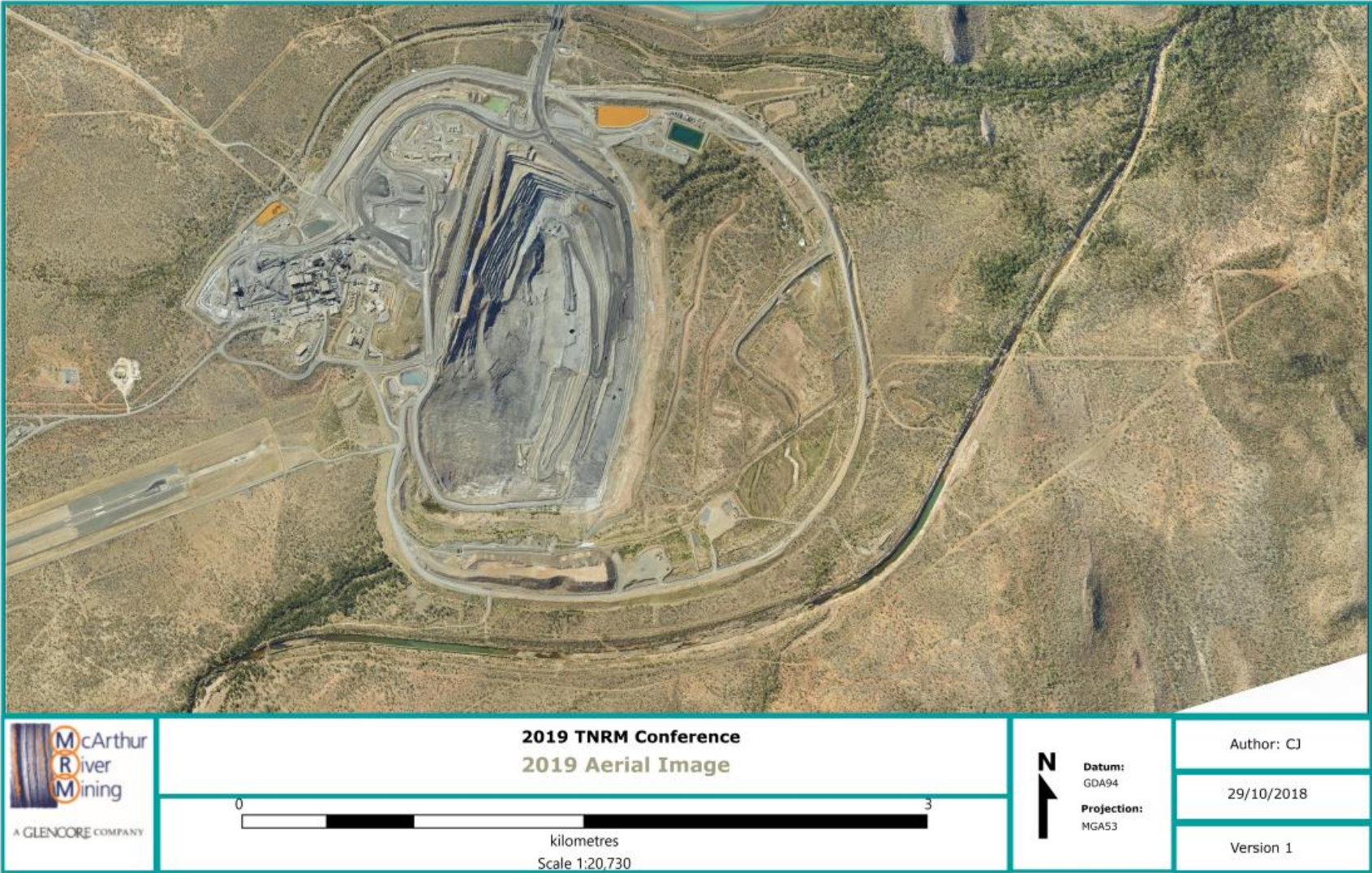


McArthur River Diversion Channel - 2014



McArthur River Diversion Channel - 2019

Background





Approvals & Compliance

Revegetation of the McArthur River Diversion Channel

Approvals & Compliance

[1992 Phase I EIS \(Underground Operations\)](#)

[2005 Phase II EIS \(Open Cut Operations\)](#)

[2006 Public Environment Report](#)

The 2006 PER described the overarching goal of the rehabilitation program to create:

“A functioning aquatic, riparian and riverine system in the diverted river channel should be established and sustained within a timeframe that would not cause fragmentation of fauna populations in the medium- to long-terms”

[2012 Phase III EIS \(Mine Expansion\)](#)



Revegetation of the McArthur River Diversion Channel

Approvals & Compliance

[2017 Overburden Management Project EIS](#)

A Conceptual Mine Closure Plan was developed as part of the OMP EIS to assess the optimal and most cost effective methods related to rehabilitation, decommissioning and closure.

As part of the 2018 Overburden Management Project Supplementary EIS a Rehabilitation Management Plan was developed and submitted to describe the rehabilitation of Barney Creek, the McArthur River and progressive rehabilitation of mine landforms.

[NT Environmental Protection Authority Assessment Report](#)



Revegetation of the McArthur River Diversion Channel

Approvals & Compliance

[2009 EPBC Approval](#)

In 2009 MRM were granted federal approval to construct and operate an open cut mine to replace the underground mine and upgrade the processing plant infrastructure.

The approval has effect for:

- Listed threatened species and communities (Freshwater Sawfish)
- Listed migratory species (Eastern Curlew, Alaskan Bar-tailed Godwit, Sandpiper Curlew, Great Knot, Red Knot, Lesser Sand Plover, Asian Dowitcher)

[2019 EPBC Approval](#)

In 2019 MRM were granted federal approval for changes to mining operations as described in the 2017 EIS.

The approval has effect for:

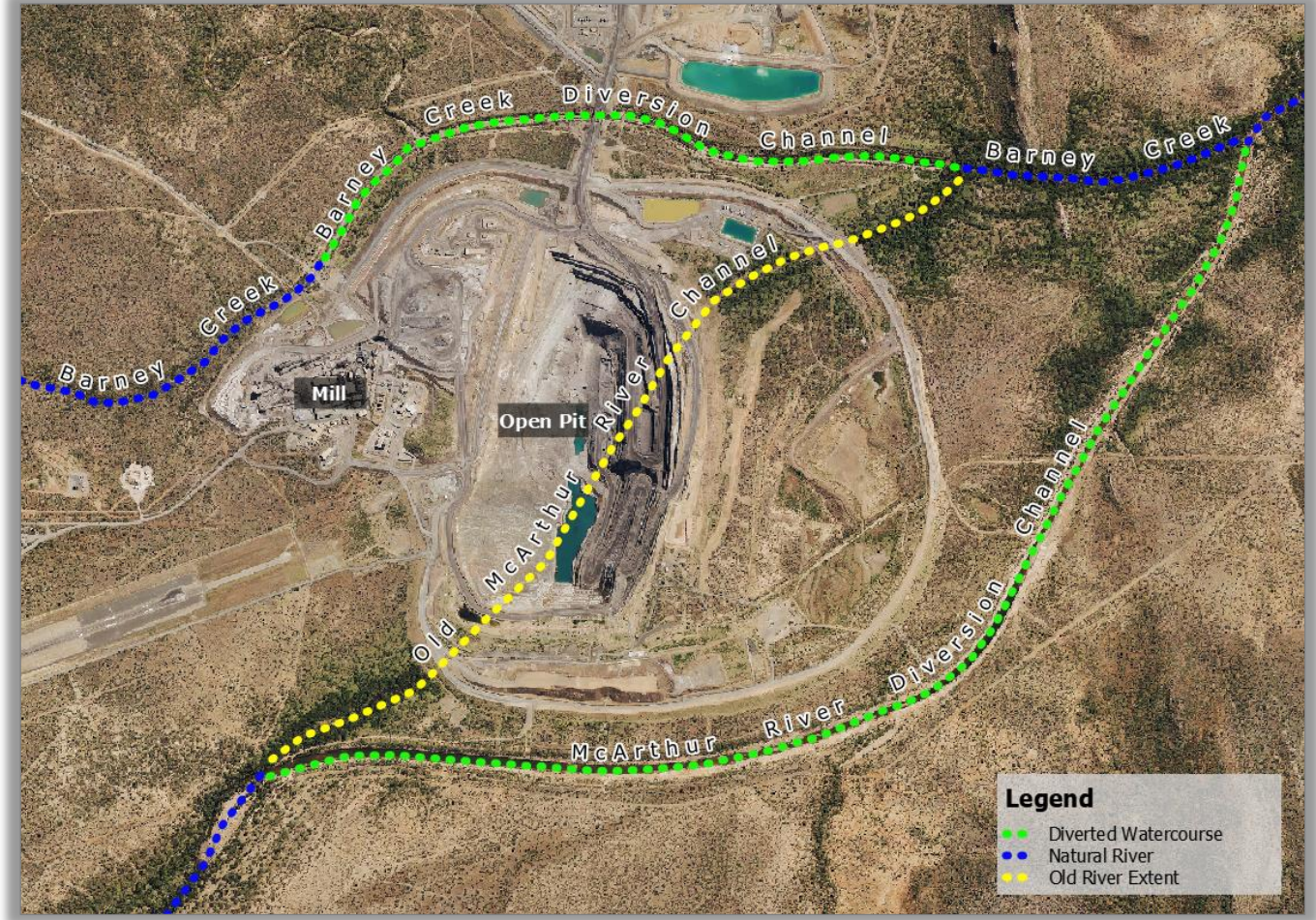
- Listed threatened species and communities (Freshwater Sawfish & Gouldian Finch)

Approvals & Compliance

- McArthur River Diversion Channel was constructed in 2006 - 2008 to divert the McArthur River around the approved open cut McArthur River Mine footprint.
- As a condition of development approval, MRM is required to rehabilitate these two channels to achieve:

“Stream channels shall be stable with minimal impact on the surrounding environment and clean disturbed areas will be returned to native bushland”

“In the alluvial sections the channel will be fully revegetated and in the rocky sections the high parts of the realigned banks (alluvial soils) will be fully revegetated with strategic revegetation of the lower rocky banks”



Approvals & Compliance

Independent Monitor

As a condition of MRM's Mining Authorisation an independent assessment is required to monitor the environmental performance of the mine and compliance of the McArthur River Mine Operator, by reviewing:

- Environmental assessments and monitoring activities undertaken by the operator
- Compliance with the conditions of the Mining Authorisation under which the Operator is permitted to operate the Mine
- Environmental assessments and audits undertaken by the Department of Primary Industry and Resources (the Department) including overseeing the approval
- Review and audit reports provided by third party experts on targeted areas of the Mine.





Rehabilitation Challenges

2008 - 2019

Rehabilitation Challenges

Revegetation – Window of Opportunity

Access only possible during the dry season

Survival of planted vegetation is dependent on establishment prior to river flows

Wet Season Water Velocity

During Large Flood Events (1 % Annual Exceedance Probability)

- Barney Creek water flows between 4 m/s and 6 m/s
- McArthur River water flows between 2 m/s and 4 m/s



McArthur River – 2016 Wet Season



Barney Creek – 2016 Wet Season

Rehabilitation Challenges

Growth Medium

Clay dominant soils

Steep batters of Diversion Channel

Soil Nutrients

High exchangeable calcium and magnesium in all soils

Dominating alkaline conditions

Low macro-nutrient and trace elements in all soils

Soil Erosion

Soil is highly erodible (Diversion Channel and natural soils)

Erosion due to surface water flow and rainfall



Growth Medium on the Diversion Channel

Rehabilitation Challenges

Approx. Start Depth (m) below upper bank	Approx. Finish Depth (m) below upper bank	MRM US1	MRM US2	MRM US3	MRM US4	MRM US5	MRM DS1	MRM DS2
0	0.1	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	SAND
0.1	1.0	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	SAND
1.0	2.0	ROCK FILL OVER CLAY	CLAY	ROCK FILL WITH SAND	ROCK FILL WITH SAND	ROCK FILL WITH SAND	CLAY	SAND
2.0	3.0	CLAY	ROCK FILL WITH SAND	ROCK FILL WITH SAND	ROCK FILL WITH SAND	ROCK FILL WITH SAND	CLAYEY SAND	SAND
3.0	4.0	CLAY	ROCK FILL WITH SAND	ROCK FILL WITH SAND	ROCK FILL WITH SAND	ROCK FILL WITH SAND	ROCK	SAND
4.0	5.0	CLAY	ROCK FILL WITH SAND	CLAY	ROCK FILL WITH SAND	CLAY	ROCK	SAND
5.0	6.0	CLAY	ROCK FILL WITH SAND	CLAY	ROCK FILL WITH SAND	CLAY	ROCK	SAND
6.0	7.0	CLAY	CLAY	CLAY	CLAY	CLAY, CLAYEY SAND	ROCK	SAND
7.0	8.0	CLAY	SAND & GRAVEL, CLAY	CLAY, CLAYEY SAND	CLAY	CLAY, CLAYEY SAND	ROCK	SAND
8.0	9.0	CLAY	SAND & GRAVEL, CLAY	CLAY, CLAYEY SAND	CLAY, CLAYEY SAND	CLAY	ROCK	SAND & GRAVEL
9.0	10.0	CLAY	CLAY	CLAY	CLAY, CLAYEY SAND	CLAY	ROCK	SAND & GRAVEL
10.0	11.0	ROCK	CLAY	CLAY	CLAY	CLAY, CLAYEY SAND	SAND, GRAVEL & ROCK	SAND & GRAVEL
11.0	12.0	ROCK	CLAY	ROCK, SAND & GRAVEL	CLAY	CLAY, CLAYEY SAND		
12.0	13.0	CLAY & CLAYEY SAND	CLAY	ROCK, SAND & GRAVEL	ROCK, SAND & GRAVEL	ROCK, SAND & GRAVEL		
13.0	14.0		CLAY, SAND & GRAVEL	SAND & ROCK	ROCK, SAND & GRAVEL	ROCK, SAND & GRAVEL		
14.0	15.0					ROCK, SAND & GRAVEL		

Green zones reflect those deemed stable with successful plantings where soils erosion is minimal

Red zones reflect those unstable soil conditions and a lack of success with natural plant establishment or plantings occur across exposed clays on the mid-batter sections

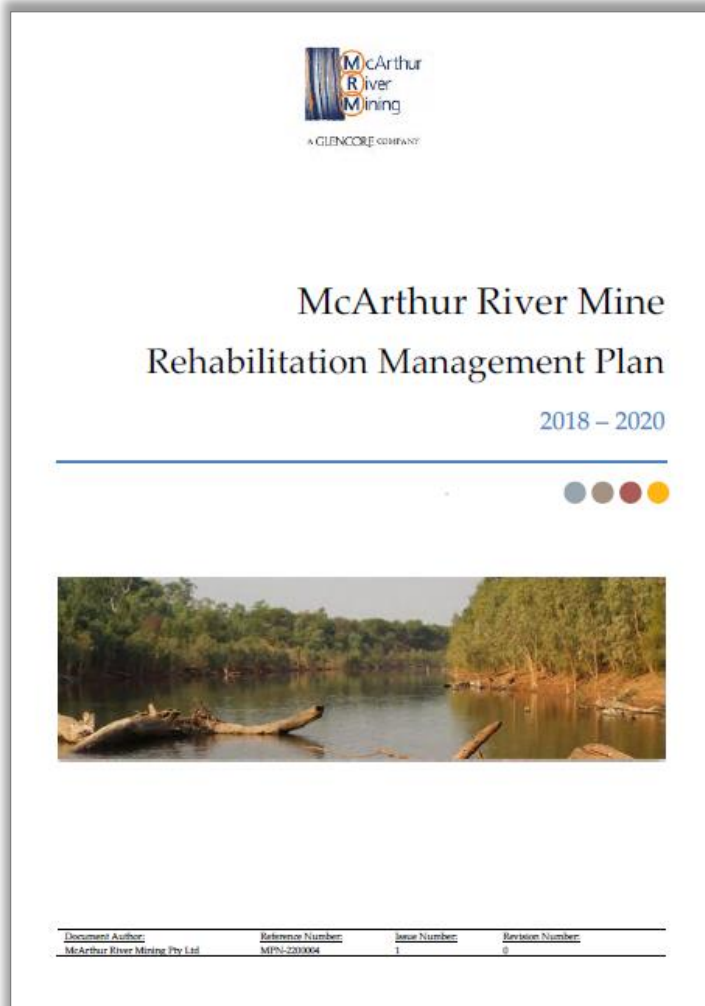
Orange zones reflect those of low or moderate stability, where there are mixed erosion impacts and success in revegetation.



Rehabilitation Management Plan

2018 - 2020

Rehabilitation Management Plan



MRM's Rehabilitation Management Plan (2018 - 2020) was developed to establish a defined approach to undertake rehabilitation of McArthur River, Barney Creek and mine landforms.

The Rehabilitation Management Plan focusses on the period 2018 – 2020 and describes the revegetation of the McArthur River Diversion Channel. The document outlines a series of performance indicators and completion criteria which MRM must achieve to complete the rehabilitation program.

MRM's objectives for the rehabilitation of the McArthur River Diversion Channel are to:

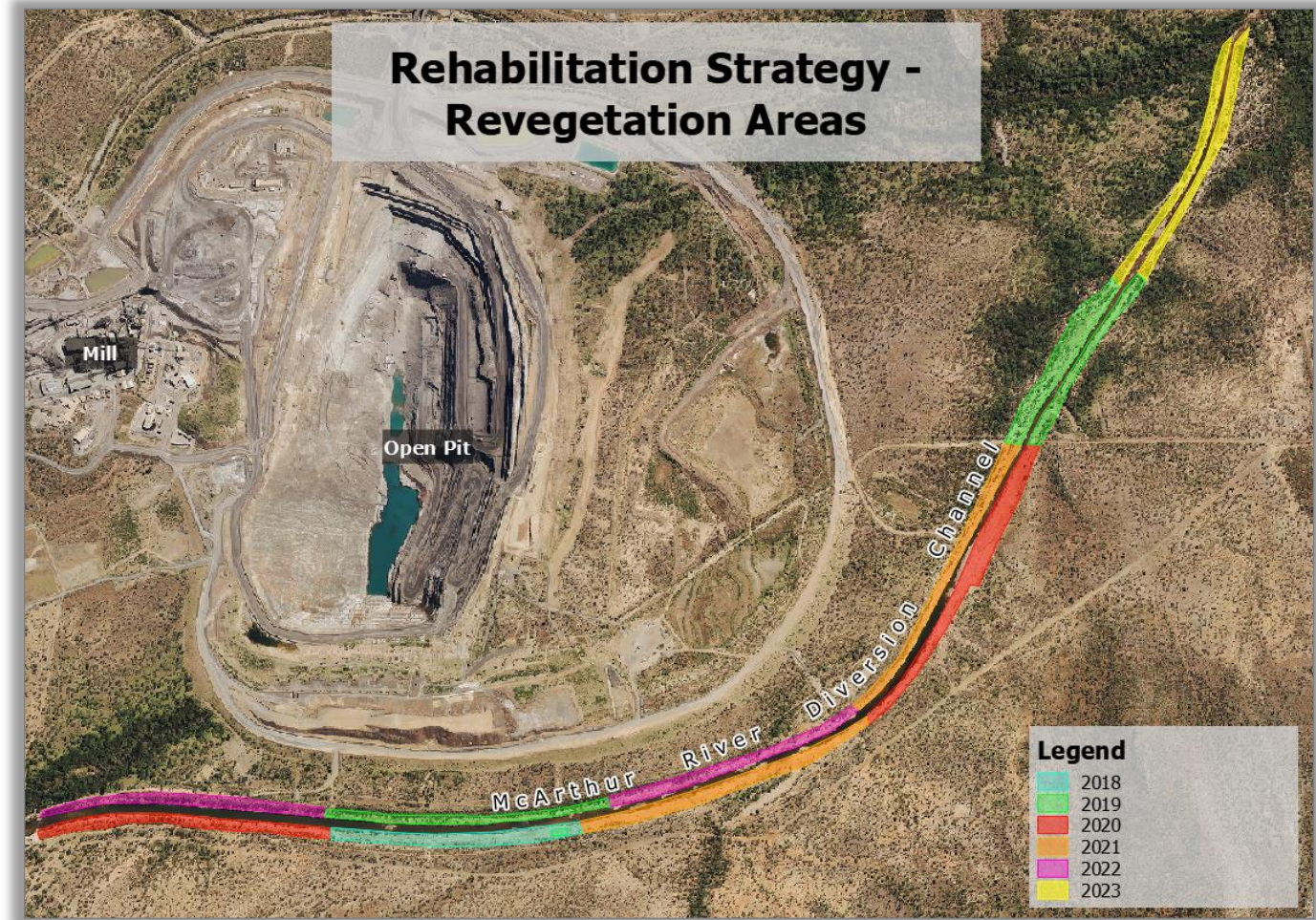
1. *Facilitate the development of the ecosystem and its functions along the channels for terrestrial and aquatic flora and fauna.*
2. *Minimise impacts on the surrounding terrestrial and aquatic environments.*
3. *Manage the geomorphological status of the channels (e.g. reduce erosion and improve stability).*
4. *Improve visual amenity.*

Annual Rehabilitation Strategy

To achieve the objectives, MRM developed a revegetation schedule for the Diversion Channel from 2018 – 2023.

Revegetation involves progressively planting a number of key species along the length of the Diversion Channel.

- ~120,000 tubestock planted each year.
- 625,310 planted since 2009.
- Approximately 1.15 million trees will have been planted on the Diversion Channel by its completion in 2023.





Rehabilitation Methodology

Rehabilitation Methodology

Revegetation Species

- The species of grasses, trees and shrubs selected for planting is based on the revegetation area (waterline, mid-bank, upper-bank).
- A list of key species has been identified within the Rehabilitation Management Plan to ensure that ecosystem development reflects the natural riparian system.

Planting

- Seedlings propagated as tubestock have proven to be the most successful method of plant establishment and survival.
- Planting densities vary based on revegetation area (waterline, mid-bank, upper-bank).

Maintenance and Management Activities

- Infill planting (or planting of specific species)
- Weed management
- Pest management
- Cattle management
- Bushfire management
- Access control





Rehabilitation Programs

MRM Nursery

- 80% of tubestock planted on the McArthur River Diversion Channel is sourced from seed collected from the local area and grown in MRM's dedicated onsite Nursery.
 - Exemplary of Glencore's leading industry approach to environmental management.
 - 3 shade houses and large hardening off area.
 - >120,000 tubestock capacity.



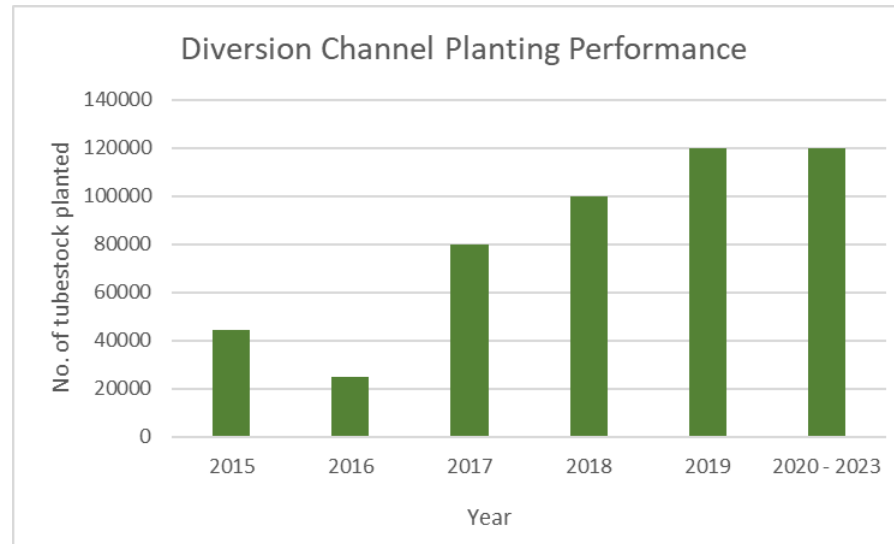
Seed propagation nursery (75% UV shade cloth)



Tubestock propagation nursery (30% UV shade cloth)

Dedicated Revegetation Team

- MRM increased revegetation efforts considerably in 2017 to reduce the time required to achieve rehabilitation objectives.
- MRM now has a dedicated team of eleven workers that carry out revegetation works on the Diversion Channel annually during the dry season.
- MRM has exceeded the target of 120,000 tubestock planted in 2019.



Large Woody Debris



The effective placement of large woody debris (sourced from approved clearing) within the Diversion Channel has been the single most effective action in providing fish habitat, with many other related benefits:

- Higher numbers of fish and increased diversity recorded at sites with large woody debris
- Aids in fish migration via 'stepping stones', to provide respite from stream flow
- Alleviates scouring of the Diversion Channel
- Acts as a source of carbon
- Creates variation in flow and micro-habitat
- Improves stream bank stability

Revegetation Irrigation System

- A dedicated irrigation system supplies water to plants within the Diversion Channel during the dry season, improving survival rates and guiding revegetation success.
- Water is sourced from a licensed extraction bore to supply the two irrigation sleds and water tanks on the Diversion Channel.
- A total of 6km of irrigation pipework has been installed in 2018 - 2019.





Measuring Performance

Measuring Performance

- Success of revegetation is assessed against the completion criteria outlined in the Rehabilitation Management Plan.
- Specialist consultants carry out a number of monitoring programs annually to assess rehabilitation success:
 - Revegetation Monitoring Program (revegetation establishment)
 - Diversity and Abundance of Aquatic Fauna Monitoring Program (aquatic fauna)
 - Acoustic Monitoring of Freshwater Sawfish and Barramundi
 - Riparian Birds Monitoring Program (terrestrial fauna)



Measuring Performance

Revegetation Monitoring

- Revegetation monitoring along the McArthur River and Barney Creek Diversion Channels completed annually since 2012.
- Revegetation success is assessed against the completion criteria outlined in the Rehabilitation Management Plan.
- Results from the 2018-2019 study indicate:
 - Vegetation along the McArthur River Diversion Channel has an established canopy and diverse shrub and ground layer in the upstream stretches
 - Barney Creek Diversion Channel batter revegetation sites are progressing towards completion criteria with Native species richness criteria met a 100% of sites.
 - Ongoing monitoring and management plan development is required to ensure successful rehabilitation



Measuring Performance



Aquatic Fauna – Diversity and Abundance

- Since its open cut operations, MRM has been committed to monitoring aquatic fauna of the McArthur River Diversion Channel.
- Monitoring undertaken biannually during the early dry and late dry seasonal periods includes:
 - Fish populations in permanent and ephemeral pools
 - Freshwater sawfish populations
 - Habitat connectivity and fish passage
- Results indicate:
 - Fish assemblages are strongly influenced by wet season rainfall
 - The Diversion Channel is showing strong signs of recovery
 - Diversity is generally comparable to naturally vegetated areas with extensive large woody debris
 - The Diversion Channel provides adequate habitat connectivity for Sawfish passage and is conducive to their survivorship

Measuring Performance

Aquatic Fauna - Acoustic Monitoring of Freshwater Sawfish and Barramundi

- MRM is required to ensure the McArthur River remains a suitable habitat for Freshwater Sawfish, as defined in EPBC Approval 2003/954
- The Acoustic Monitoring Program was implemented in 2016 to monitor the movement of Freshwater Sawfish and Barramundi
- 14 receivers are located upstream, within and downstream of the Diversion Channel
- To date, 18 Freshwater Sawfish and 26 Barramundi have been fitted with acoustic tags
- Results of the study have indicated that both Freshwater Sawfish and Barramundi are able to move freely throughout the Diversion Channel



Measuring Performance

Riparian Bird Monitoring

- The Riparian Birds Monitoring Program was established in 2006 with consultation from the NT Government.
- The Riparian Birds Monitoring program is designed to determine the success of rehabilitation works along the Barney Creek and McArthur River Diversion Channels.
- Results from the study indicate:
 - Riparian bird assemblages, particularly in the upper and lower ends of the McArthur River Diversion Channel, have increased in similarity to reference riparian forest
 - All revegetation sites on the Barney Creek Diversion Channel are supporting increasingly similar bird assemblages to open woodland and riparian reference sites



Success to date

- Comprehensive array of ecological monitoring programs
- No observed adverse impacts in the McArthur River – ‘fish are safe to eat’
- Demonstrated continued fish passage in the Diversion Channel
- Aquatic habitat in the Diversion Channel is trending towards reference sites
- No significant difference in fish species diversity in the Diversion Channel compared to upstream and downstream
- Significant increase in riparian bird assemblage on the upper sections – trending towards reference sites
- Monitoring demonstrates to the NT EPA ‘the good condition’ of the McArthur River







MRM is committed to the successful rehabilitation of the McArthur River Mine.

With an adaptive approach to environmental monitoring and management, MRM can ensure the ongoing development and maintenance of the ecosystem and its functions.