Northparkes Mines
A century of mining together

# 2019 Annual Review

CMOC | Northparkes

| Document Details | |
|---|---|
| Name of Operation | CMOC-Northparkes Mines |
| Name of Operator | CMOC Mining Pty Ltd operating as CMOC Mining Services Pty Ltd |
| Development Consent/Project Approval Number | DC11_0060, as modified |
| Name of holder of development consent/Project Approval | CMOC Mining Pty Ltd |
| Mining Leases | ML1247, ML1367 ML1641, ML1743 |
| Name of holder of mining lease | CMOC Mining Pty Ltd |
| Water Licence # | Refer to Table 5 |
| Name of holder of water licence | CMOC Mining Pty Ltd |
| MOP Commencement Date | 1st January 2020 |
| MOP Completion Date | 1st January 2022 |
| Annual Review Commencement Date | 1st January 2019 |
| Annual Review Completion Date | 31st December 2019 |
| I, Hubert Lehman, certify that this audit report is a true and accurate record of the compliance status of CMOC-Northparkes Mines for the period 1st January 2019 to 31st December 2019 and that I am authorised to make this statement on behalf of CMOC Mining Pty Ltd. | |
| Name of authorised reporting officer | Hubert Lehman |
| Title of authorised reporting officer | Managing Director |
| Signature of authorised reporting officer | |
| Date | 27 March 2020 |

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# 1. STATEMENT OF COMPLIANCE

In accordance with the *Post-approval requirements for State significant mining developments – Annual Review Guideline* (NSW Government, 2015) a statement of compliance has been prepared to document the status of compliance with Development Consent 11_0060 (as modified), mining leases and other relevant approvals at the end of the 2019 reporting period. Table 1 identifies any non-compliances that occurred during the reporting period for each statutory approval. Where non-compliances have been identified, these are further detailed in Table 2. Non-compliances have been colour-coded in accordance with the descriptions provided in the *Annual Review Guideline, 2015*.

**Table 1 Statement of Compliance**

| Were all conditions of the relevant approvals complied with? | |
|---|---|
| PA 11_0060 | No |
| ML 1247 | Yes |
| ML 1367 | Yes |
| ML 1641 | Yes |
| ML 1743 | Yes |
| EPL 4784 | No |
| EPBC 2013/6788 | Yes |
| WAL9995, WAL8241, WAL7866, WAL34955, WAL32138, WAL32120, WAL32004, WAL31969, WAL31963, WAL31930, WAL31863, WAL31850, WAL21471, WAL21466, WAL1698, WAL13108, WAL10082 | Yes |

**Table 2 Non-Compliances**

| Relevant Approval | Condition No. | Condition Description | Compliance Status | Comment | Annual Review Section |
|---|---|---|---|---|---|
| Development Consent/ Project Approval 11_0060 | Schedule 6 Condition 5 | Revision of Strategies, Plans and Programs | Administrative | Management Plan reviews were not within 3 months of annual review submission | Section 11.1.1 |
| EPL 4784 | L1.1 | Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997 | Non-compliant | Slurry spill into the Goonumbla Creek clean water catchment area. | Section 11.1.2 |

# 2. INTRODUCTION

## 2.1 Mine Contacts

**Table 3 CMOC-Northparkes Mines Contacts**

| Position | Contact Name | Contact Number |
|---|---|---|
| Northparkes Hotline | Ali Standen | 02 6861 3000 |
| Mill Control (24 Hrs) | - | 02 6861 3167 |
| Access Control | - | 02 6861 3211 |
| Environment and Farm Superintendent | Chris Higgins | 02 6861 3265 |
| People, Safety and Environment Manager | Stacey Kelly | 02 6861 3495 |

## 2.2 Mine Operation Introduction and History

### *2.2.1 Location, History and Process Overview*

CMOC-Northparkes Mines (Northparkes) is a copper-gold mine located 27 kilometres north-west of the town of Parkes in central west New South Wales, Australia (Figure 1). The Northparkes business continues to run under a joint venture arrangement with 80% interest with China Molybdenum Pty Ltd and the remaining 20 percent share owned by the Sumitomo Group.

The majority of Northparkes employees reside in the Parkes Shire, which has a population of approximately 15,000 residents. Parkes Shire is a diverse municipality centred in the town of Parkes. The largest industry is the retail industry, closely followed by the agricultural industry.

North Mining Limited originally received development consent for Northparkes operations in 1992, 15 years after the first onsite resource discovery. This approval was based on open cut mining of E22 and E27 and underground mining of E26 within the 'Mining Reserve' of 64.1 million tonnes (Mt).

Underground block cave mining commenced at Northparkes in October 1993 with the construction of the E26 underground block cave mine through the granting of development consent DA504/90. Northparkes commissioned its second block cave mine, E26 Lift 2 in 2004. In 2008, North Mining Limited commissioned an extension to the second block cave mine, E26 Lift 2 North (E26 Lift 2N). Mining operations at Northparkes focus on the extraction of a range of ore bodies based on a set of target mineral concentration limits.

Open cut mining commenced with the E27 pit in December 1993 and the E22 pit in January 1994. The gold-enriched oxide ore was processed through a separate carbon-in-pulp (CIP) gold circuit, including the use of cyanide for gold extraction, prior to the construction of the copper-gold sulphide processing circuits in 1995. Ore was then stockpiled for blending with E26 underground material. Open cut mining at Northparkes operated on a campaign basis determined by economic and environmental viability. Open cut mining ceased in October 2010 with the completion of the E22 open cut campaign. The CIP processing plant has been decommissioned from site, with cyanide no longer used in process circuits on site.

In February 2007, the NSW Minister for Planning granted PA06_0026 under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). This approval provided for the ongoing operation of the previously approved mining operations and facilities and the extension of underground block cave mining into the E48 ore body. This project was known as the E48 Project. After approval in 2007, North Mining Limited commenced construction of E48 Lift 1, its third major block cave mine. Initial production of E48 Lift 1 began in 2010 and forms part of the approved underground mining operations in conjunction with E26 Lift 2 and E26 Lift 2N.

In October 2009, approval was granted for two modifications to PA06_0026 under Section 75W of the EP&A Act. Section 75W modification 1 (Mod 1) provided for the construction of the Estcourt Tailings Storage Facility (TSF), a mine and mill upgrade to increase processing up to 8.5Mtpa and extension of mine life until 2025. Section 75W modification two (Mod 2) provided for the development of a 1200m$^2$ warehouse within the approved mine infrastructure area.

In 2012 North Mining Limited was granted approval for development of a block cave knowledge centre under Part 4 of the EP&A Act (DA 11092) from Parkes Shire Council (PSC).

In 2013, CMOC Mining Pty Ltd acquired Northparkes.

In July 2014, Project Approval was granted for PA11_0600 under section 75J of the EP&A Act for the Northparkes Extension Project (the Project). This approval PA11_0060 surrendered the Project Approval PA06_0026 and DA11092 in accordance with section 104A of the EP&A Act. This requirement does not extend to the Forbes Water Pipeline Development Consent DA2009/0057.

In 2019, Project Approval 11_0060 was gazetted as a State Significant Development under section 4 of the EP&A Act and is now referred to as Development Consent 11_0060.

A copy of the 2019 Northparkes Value Chain is provided as Figure 2. The value chain is a high-level model used to describe the process by which Northparkes receive raw materials, add value to the raw materials through various processes to create a finished product, and then sell that end product to customers. Northparkes conducts annual value-chain analysis by looking at every production step required to create a product and identifying ways to increase the efficiency of the chain. The overall goal is to deliver maximum value for the least possible total cost and impact, and create a competitive advantage.

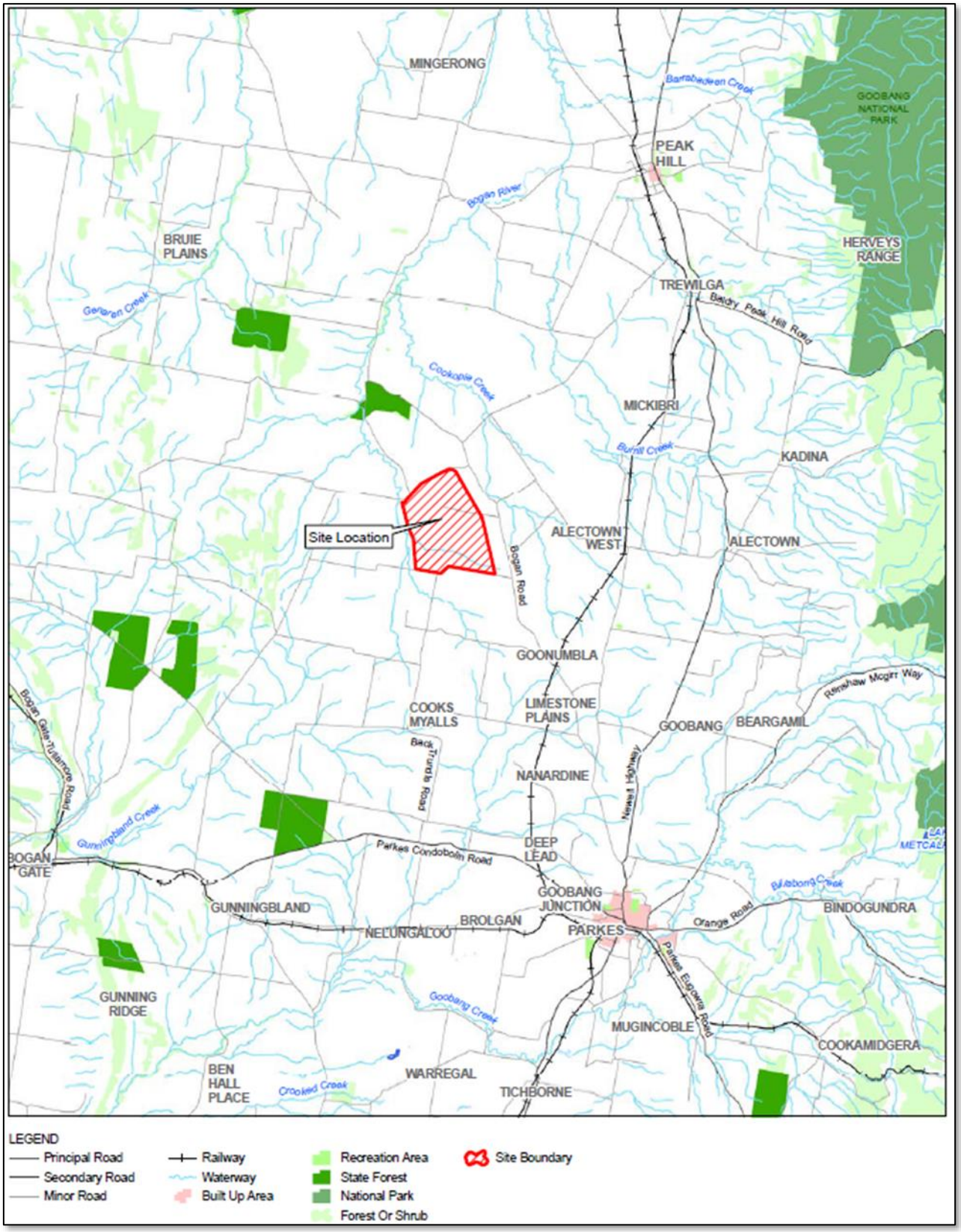



**Figure 1 Project Locality Plan**

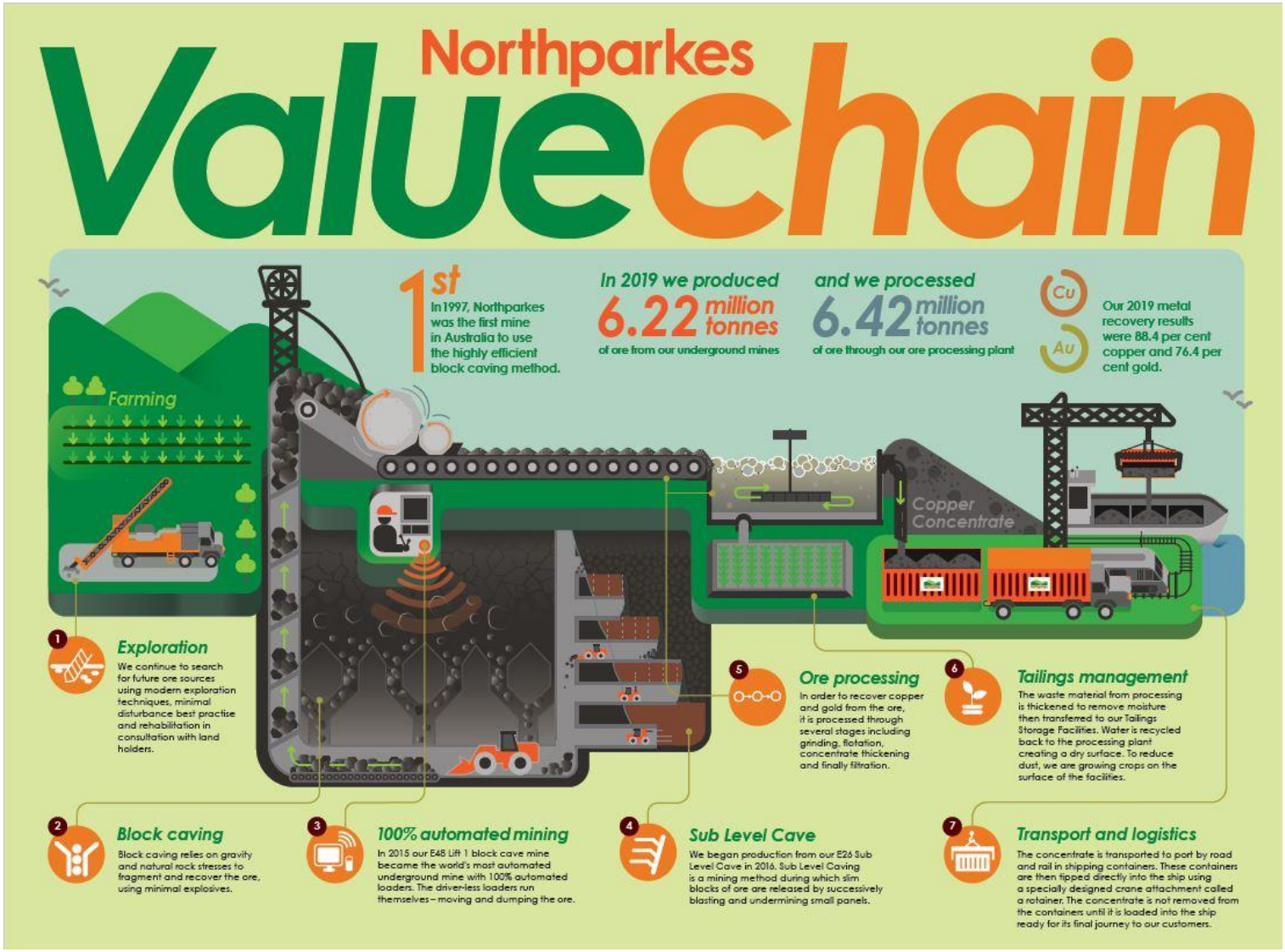



**Figure 2 Northparkes 2019 Value Chain**

### *2.2.2 Site Layout and Infrastructure*

Surface infrastructure and operation layout is shown in Figure 3.

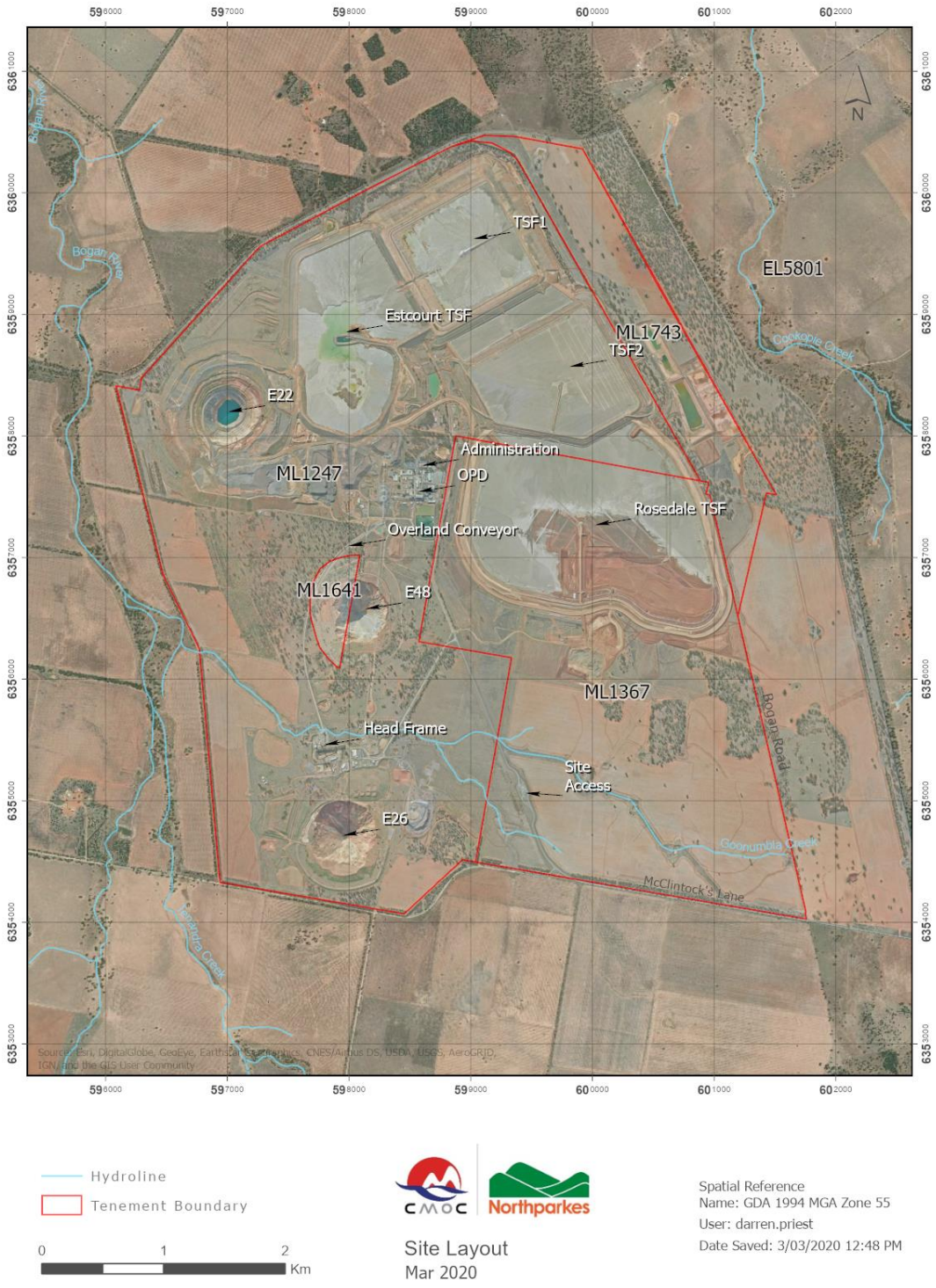



**Figure 3 Surface Infrastructure and Operational Layout**

The major components of the Northparkes and onsite infrastructure and operations includes:

- Continuation of approved underground block cave mining in the E48 and E26 ore bodies, and associated underground infrastructure;
- Development of underground block caving in the E22 resource beneath the E22 open cut void;
- Campaign open cut mining through development of five open cut resources including:
  - development of four small open cut pits E31, E31N, E28, E28N;
  - E26 open cut which is located in an area of previous underground block cave subsidence (existing vertical extent of subsidence void is approximately 200 metres);
- Ongoing TSF disposal and raises including:
  - continuation of tailings disposal to TSF1, TSF2, Infill TSF and Estcourt TSF to an approved height of 28 metres;
  - provision for additional raises on Estcourt TSF and Rosedale TSF to provide for an increased height up to approximately 28 metres above ground surface;
  - the extension of the Infill TSF west to adjoin the Estcourt TSF;
- Development of new waste dumps (overburden emplacement areas) for the management of open cut waste rock. Waste rock from open cut mining areas can be utilized in the development of TSF raises such as Rosedale TSF;
- Continuation of approved ore processing infrastructure up to 8.5 Mtpa capacity, and road haulage of copper concentrate to local rail sidings;
- Continued use of existing site infrastructure including administration buildings, workshop, internal access roads and service infrastructure;
- Continued use of surface mining infrastructure including ventilation shafts, hoisting shaft and ore conveyors;
- Continuation of existing approved water supply and management processes;
- Continuation of approved mining operations until end of 2032; and
- Rehabilitation and closure of the mine site will be carried out after the end of the operational life of the Project in accordance with relevant approvals.

## 2.3 Scope

This Annual Review provides a summary of actual operational and environmental management activities undertaken at Northparkes during the reporting period and provides a review against planned works, as described in the Mining Operations Plan (MOP), and predicted impacts documented in the Northparkes Mines Expansion Project Environmental Assessment (EA) (Umwelt, 2013). The Annual Review also covers community relations and addresses mine development and rehabilitation undertaken during the reporting period.

The report has been prepared to satisfy the conditions of the Development Consent 11_0060 (DC11_0060) (in particular Schedule 6, Condition 4) and Mining Leases (ML) 1247, 1367, 1641, 1743. Key requirements of these approvals are described in Table 4.

The report has been prepared generally in accordance with the NSW Governments "Annual Review Guideline" October 2015 where practicable, as well as the relevant Northparkes reporting framework.

Northparkes recognises and respects the importance of stakeholders and considers positive relationships important to aid in continual improvement of its environmental management practice. This report is therefore provided to the following stakeholders:

- Department of Planning and Industry and Environment;
- Natural Resources Access Regulator, Department of Primary Industries;
- Forestry Corporation of NSW;
- NSW Office of Environment and Heritage (OEH);
- NSW Environment Protection Agency (EPA);

- Peak Hill Local Aboriginal Land Council (PHLALC);
- Wiradjuri Council of Elders (WCE);
- Parkes Shire Council (PSC);
- Forbes Shire Council (FSC);
- Northparkes Community Consultative Committee; and
- General public (available at http://www.northparkes.com/).

## 2.4 Annual Review Requirements

**Table 4 Annual Review Requirements**

| Licence Approval or Guideline | Section Reference | Requirement | Reference in this Report |
|---|---|---|---|
| Development Consent 11_0060 | Schedule 6, Condition 4 | By the end of March each year, or as otherwise agreed by the Secretary, the Proponent shall review the Environmental performance of the project to the satisfaction of the Secretary. This review must:<br>(a) describe the development that was carried out in the previous calendar year, and the development that is proposed to be carried out over the next year; | Whole document |
| | | (b) include a comprehensive review of the monitoring results and complaints records of the project over the previous calendar year, which includes a comparison of these results against the<br>• the relevant statutory requirements, limits or performance measures/criteria;<br>• the monitoring results of previous years; and<br>• the relevant predictions in the EA; | Section 4, Section 6, Section 7, Section 8. |
| | | (c) identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance; | Section 1, Section 11 |
| | | (d) identify any trends in the monitoring data over the life of the project; | Section 4, Section 6, Section 7, Section 8. |
| | | (e) identify any discrepancies between the predicted and actual impacts of the project, and analyse the potential cause of any significant discrepancies; and | Section 4, Section 6, Section 7, Section 8. |
| | | (f) describe what measures will be implemented over the next year to improve the environmental performance of the project. | Section 12 |
| | Schedule 3, Condition 38 | The Proponent shall:<br>(a) implement all reasonable and feasible measures to minimise the waste (including waste rock) generated by the project)<br>(b) ensure that the waste generated by the project is appropriately stored, handled and disposed of; and<br>(c) monitor and report on effectiveness of the waste minimisation and management measures in the Annual Review | Section 4 |
| ML 1247<br>ML 1367<br>ML 1641<br>ML1742 | Condition 3 (f) | The lease holder must prepare a Rehabilitation Report to the satisfaction of the Minister. The report must:<br>i. provide a detailed review of the progress of rehabilitation against the performance measures and criteria established in the approved MOP;<br>ii. be submitted annually on the grant anniversary date (or at such times as agreed by the Minister); and<br>iii. be prepared in accordance with any relevant annual reporting guidelines published on the Department's website. | Whole document |

# 3. APPROVALS

## 3.1 Approvals, Leases and Licences

Table 5 summarises the key mining leases and approvals currently held by Northparkes which are relevant to the operations.

**Table 5 Summary of Licences**

| Approval | Description | Issue Date |
|---|---|---|
| **Project Approvals** | | |
| DC11_0060 | Project Approval – Step Change Project (Mine Extension) | 16/07/2014 |
| DC11_0060 Mod 1 | Modification to include Sub Level Cave Mining | 16/5/2015 |
| DC11_0060 Mod 2 | Correct error in project boundary | 31/3/2016 |
| DC11_0060 Mod 3 | Development and operation of E26 Lift 1 North | 22/8/2017 |
| DC11_0060 Mod 4 | Changes to Ore Processing Infrastructure | 06/09/2018 |
| DC11_0060 Mod 5 | Alternate road haulage route and new secondary crusher | 30/09/2019 |
| EPBC 2013/6788 | EPBC Approval | 13/02/2014 |
| **Council Approvals** | | |
| | PSC Approval for Road Train Access on Bogan Road | 19/11/1999 |
| DA2009/0057 | Development Consent (Forbes Water Pipeline) | 19/03/2009 |
| **Mining Leases** | | |
| ML 1247 | Mining Lease (1629.6 Ha) | 27/11/1991 |
| ML1367 | Mining Lease (826.2 Ha) | 21/03/1995 |
| ML1641 | Mining Lease (24.4 Ha) | 25/03/2010 |
| ML1743 | Mining Lease (193.3 Ha) | 01/09/2016 |
| **Exploration Leases** | | |
| EL 5800 | Exploration Lease (12,130Ha) | 08/01/2001 |
| EL 5801 | Exploration Lease (49,550 Ha) | 08/01/2001 |
| EL 5323 | Exploration Lease (21,840 Ha) | 18/07/1997 |
| EL 8377 | Exploration Lease (25,950 Ha) | 12/06/2015 |
| **Environmental Protection Licences** | | |
| EPL 4784 | Environmental Protection Licence | 30/05/2001 |
| **Dangerous Good and Explosives** | | |
| 35/02983 | Dangerous Goods Notification | 09/04/2015 |
| XSTR200036 | Licence to Store Explosives | 03/12/2018 |
| XMNF200011 | Licence to Manufacture Explosives | 28/07/2019 |
| 5060895 | Radiation Management Licence | 10/11/2017 |
| **Water Licences** | | |
| WAL9995 | Water Access Entitlement | 08/03/2005 |
| WAL8241 | Water Access Entitlement | 01/07/2012 |
| WAL7866 | Water Access Entitlement | 01/07/2004 |
| WAL34955 | Water Access Entitlement | 04/10/2012 |

| | | |
|---|---|---|
| WAL32138 | Water Access Entitlement | 14/09/2012 |
| WAL32120 | Water Access Entitlement | 14/09/2012 |
| WAL32004 | Water Access Entitlement | 14/09/2012 |
| WAL31969 | Water Access Entitlement | 14/09/2012 |
| WAL31963 | Water Access Entitlement | 14/09/2012 |
| WAL31930 | Water Access Entitlement | 14/09/2012 |
| WAL31863 | Water Access Entitlement | 14/09/2012 |
| WAL31850 | Water Access Entitlement | 14/09/2012 |
| WAL21471 | Water Access Entitlement | 03/12/2010 |
| WAL21466 | Water Access Entitlement | 03/12/2010 |
| WAL1698 | Water Access Entitlement | 01/07/2004 |
| WAL13108 | Water Access Entitlement | 20/12/2006 |
| WAL10082 | Water Access Entitlement | 18/10/2005 |
| **Forestry Occupation Permits** | | |
| 847 | Limestone State Forest Occupation Permit | 12/03/2019 |
| **Mining Operations Plan** | | |
| Current MOP | 01/01/2020 – 01/01/2022 MOP Period | 09/12/2019 |

### *3.1.1 Amendments during the Reporting Period*

### *3.1.2 Development Consent*

Development Consent 11_0060 (the Consent) was granted on 16 July 2014. Five modifications to the Consent have been granted since 2014 (dated 16/5/2015, 31/3/2016, 22/9/2017, 6/9/18 and 30/8/2019 respectively). The latest modification (Mod 5) was lodged for assessment under the Environmental Planning and Assessment Act 1979 (EP&A Act) in June 2019 and approval granted in August 2019. The modification proposed the use of an alternative road haulage route between the Northparkes Mine and the Parkes National Logistics Terminal and the construction of a new secondary crushing building in a different location to the previous approval.

The Department of Planning, Industry and Environment was satisfied that the modification is of minimal environmental impact and that the development to which the consent as modified relates is substantially the same development as the development authorised by the consent (as last modified under Section 75W).

### *3.1.3 Environmental Protection Licence*

An Annual Return for the reporting period was submitted to the EPA on 23 July 2019 in accordance with requirements under Environment Protection Licence (EPL) 4784 Condition R1.5.

# 4. OPERATIONS SUMMARY

## 4.1 Production Statistics

A summary of production figures for the 2018 and 2019 calendar years is provided in Table 6 below. Also shown are the predicted production figures for the 2020 reporting period.

**Table 6 Production and Waste Rock Summary**

| Material | Approved Limit | 2018 Reporting Period | This Reporting Period | 2020 Reporting Period (forecast) |
|---|---|---|---|---|
| Waste Rock/Overburden (t) | N/A | 80,329 | 158,661 | 115,000 |
| Ore Mined (Mt) | 8.5 | 6.53 | 6.22 | 6.33 |
| Fine Reject (tailings) (Mt) | N/A | 6.35 | 6.27 | 6.39 |
| Saleable Product (t) | N/A | 125,438 | 120,832 | 108,848 |

Mining operations within the 2019 reporting period remained below the limits specified in the Consent. Specific conditions from Schedule 2 of the Consent are presented in Table 7 with responses on the compliance of each also provided.

**Table 7 Compliance with Development Consent Conditions**

| Development Consent Condition No. and Description | Compliance Response |
|---|---|
| 5. The Proponent may carry out mining operations on site until 31 December 2032. | Compliant |
| 6. The Proponent must not process more than 8.5 million tonnes of ore onsite in any calendar year. | Compliant, see Table 8. |
| 7. The Proponent shall ensure that all ore concentrate produced on the site is transported to the Goonumbla Rail Siding via haulage on Bogan Road | Compliant. Condition 32A of Schedule 3 of the Consent permits the transport of copper concentrate to the Parkes National Logistics Terminal for a period of 12 months or when the Goonumbla rail siding is re-opened, whichever comes first. |

## 4.2 Mining and development

### *4.2.1 Open cut*

Active open cut mining ceased in 2010. There were no open cut mining activities in the current reporting period.

### *4.2.2 Underground Operations*

Underground mining activities are currently undertaken in ore body E48 using block caving methods and E26 using Sub Level Cave (SLC) methods. Block Caving is an underground hard rock mining method that involves undermining an ore body, allowing it to progressively collapse under its own weight (see Figure 4). It is the underground version of open pit mining. SLC methods rely on the undercutting of an area of rock, and then gradual failure of the overlying rock due to gravity and stress, to minimise mining risk and supply production.

The operations at E26 orebody ceased in 2008 due to ingress of clay in the draw points. The E26 SLC was commissioned in 2016. The construction of E48 block cave mine was completed in 2010, with the first ore extracted from E48 Lift 1 block cave mine, and is currently in production.

The E26 SLC project commenced construction in April 2015. The mine design aims to extract a remnant wedge of high-grade material adjacent to the E26 Lift 2 Block Cave. The SLC mining method involves construction of the sub level horizon followed by retreat drill and blast of that horizon. The broken material from blasting is recovered as the main source of production. The second sub level horizon is then constructed, as the top down process continues. The E26 SLC Mine consists of three sublevels approximately 20m apart. The first production ring in the E26 SLC was extracted in July 2016.

Automation (remote operation of underground load, haul and dump machinery) continued in the reporting period to maintain full automation of underground mine loaders. In mid-October 2015, Northparkes confirmed its position as the most automated underground mine in the world and achieved 100 percent automation of underground mine loaders.

Currently Northparkes is developing a new block cave (E26 Lift 1 North). Construction started in January 2019 and during 2019 approximately 3,689 metres of new tunnels were developed. This new block cave is scheduled to start full production in 2023.

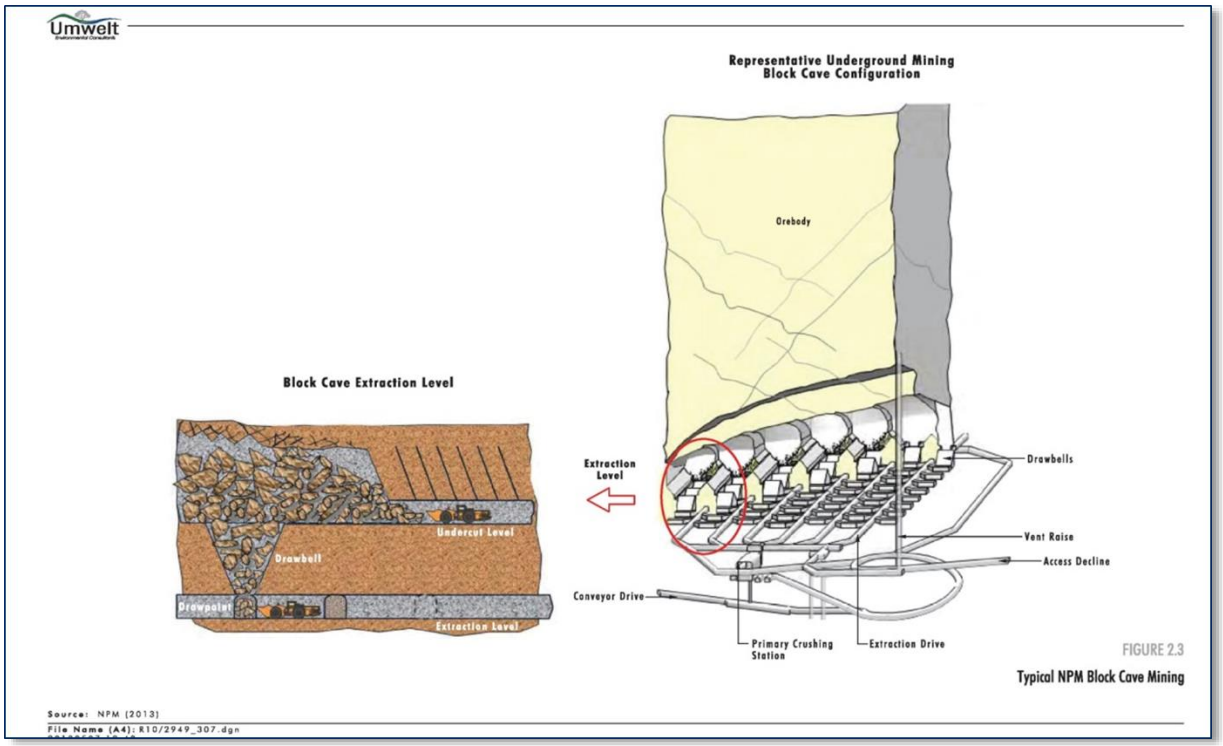



**Figure 4 Block Cave Mining Method**

### *4.2.3 Waste Rock*

A total of 158,661 tonnes of waste rock from underground development and raise boring was placed on the Lift 1 Mullock Dump during the reporting period. The underground waste was primarily from the E48 Ventilation Upgrade Project and some from the E26 Sub-Level Cave development.

The waste movement for this reporting period increased from the previous reporting period due to the development of the new block cave, E26 Lift 1 North. Approximately 3,689 metres of tunnels were developed during the 2019 reporting period.

No issues were identified from the inspections of waste rock dumps across site in the current reporting period.

## 4.3 Exploration and Resource Utilisation

Exploration and evaluation programs continued across ML1247 and ML1367 in the 2019 reporting period shown within Figure 5. No exploration activities were undertaken on ML1647 or ML1743 during the year. No non-compliances have been noted within the mining leases related to exploration or evaluation activities.

A total of 77 drill holes for 17,537.2m were completed for exploration and evaluation purposes during the reporting period. The drilling program comprised 32 Reverse Circulation holes for a total of 3,594.0m, and 45 Diamond drill holes (including 8 wedged holes at E22), for a total of 13,943.2m of core. The majority of this core was drilled testing the deeper extensions to mineralisation at E22 and infilling the Lift 1 mineralisation at GRP Project and for pre-conditioning purposes at the E26 Lift1 North Block Cave Project. Northparkes Mines is committed to identifying and evaluating new ore bodies with the intention of extending mine life.

Mining lease evaluation involved the following works:

- Diamond drill testing of the deeper extensions of the E22 mineralisation to inform extraction options for mining studies of that deposit;
- Diamond drilling of pre-conditioning holes to enable cave propagation for the E26 Lift 1 Nth Project;
- Diamond drilling to infill the drill spacing in the GRP314 Lift 1 resource block;
- Diamond and percussion drilling to define potential surface extractive mineralisation at the E31 Deposit and to characterise mining conditions of that deposit; and,
- Diamond and percussion drilling to define potential surface extractive mineralisation at the E28 Deposit.

In addition to new drilling, final assay results were received from thirteen holes drilled in the previous reporting period, which were either part of an ongoing project, or had assays pending. These holes were:

- Eight holes from the previously completed underground drilling at E26 L2E (MJH);
- Three holes from the previously completed surface RC/Diamond drill program at Nerrad; and
- Two holes from the previously completed surface diamond drill program at Hendrix.

In addition, thirteen previously completed holes drilled for geotechnical purposes in the E26 SLC resource area were assayed to inform the E26 block model and SLC mining forecasts.

In addition, two geophysical surveys were conducted in 2019. A close-spaced Ground Gravity survey covering areas of the mine leases and a high resolution airborne hyperspectral survey was flown over all the Northparkes tenements during late 2019, including the Mine Leases.

Exploration and evaluation activities will continue in the next reporting period (1/1/2020 to 31/12/2020 inclusive). The focus of these activities will be diamond drilling to evaluate near mine extensions as well as the drill testing of new and established targets derived from project generation onsite.

The proposed exploration comprises 9,600m of drilling (8,400m diamond drilling and 1,200m reverse circulation drilling) and will be focussed on three programs testing known mineralisation, being:

- Further drill testing of the depth extensions at E22 deposit to provide input to conceptual mining proposals;
- Continuation of drill testing to infill the resource zone and define higher grades at the GRP314 deposit allowing an update of the Block Model; and

Testing of the boundaries and extents of mineralisation at MJH (E26L2 East) from underground drill positions.

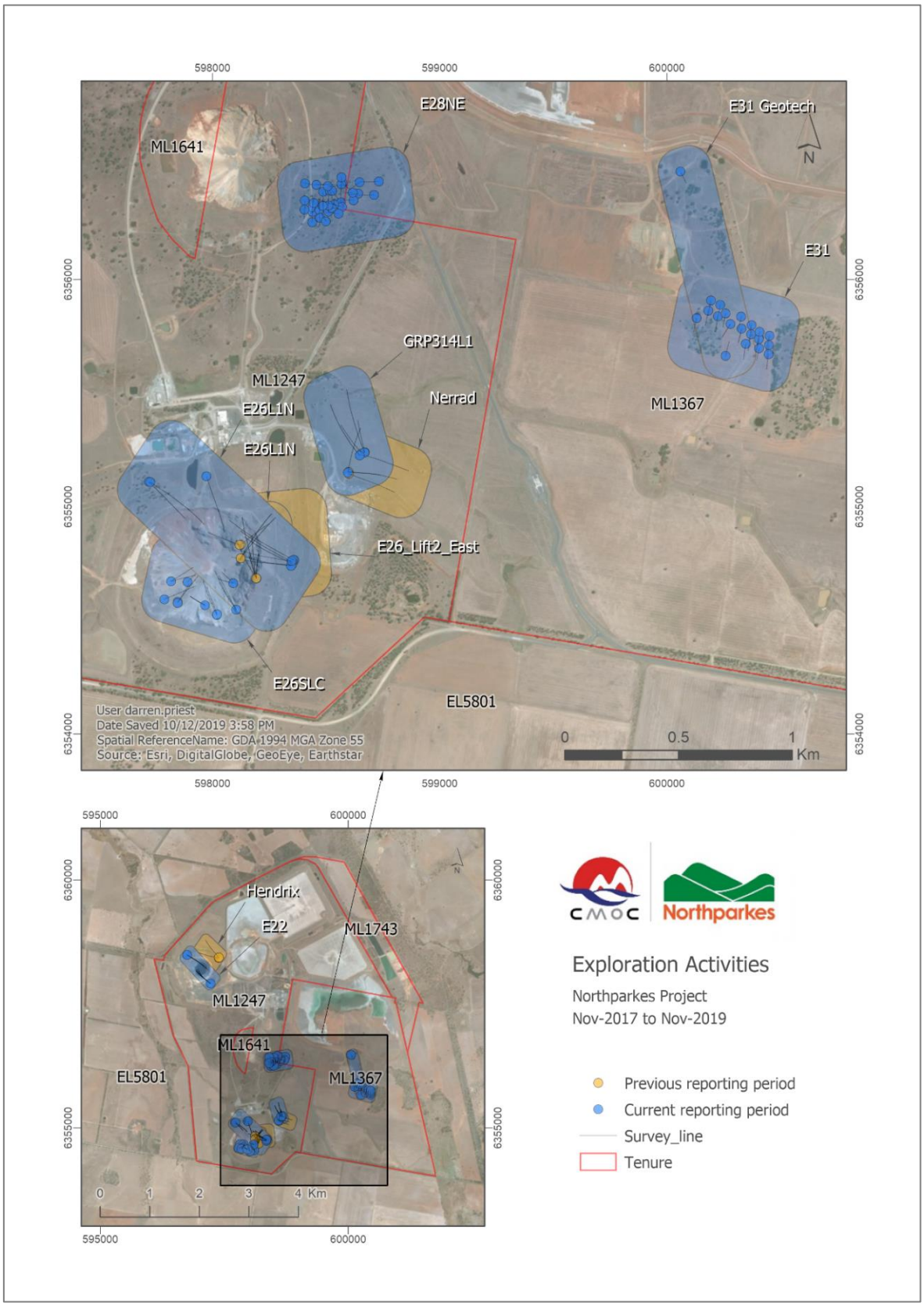



**Figure 5 Exploration and Evaluation Drilling Activities for 2018 and 2019 - Mining Leases**

## 4.4 Ore processing

In 2019, a total of 6.42 Mt of sulphide ore was processed from the underground ore body and existing surface stockpiles. Copper-gold concentrate production totalled 120,832 tonnes (dry) and this product was predominantly sold to customers in China and Japan. Production for the past five years is presented in Table 8.

Ore processing includes several defined stages including grinding, floatation and thickening. The grinding circuit comprises two separate modules (Mod 1 and Mod 2), each incorporating a Semi Autogenous Grinding (SAG) mill, oversize crushing technology, two stages of ball milling and froth floatation.

The floatation process floats a sulphide concentrate to recover copper and gold bearing minerals. From the floatation, the concentrate is processed through the concentrate thickener and transferred to the storage shed.

The tailings component is pumped from the floatation stage to a tails thickener and then to the Tailings Storage Facility (TSF).

**Table 8 Ore Processing Production**

| Year | Ore Milled (Mt) | Production Copper Concentrate (t) |
|---|---|---|
| 2015 | 6.04 | 151,518 |
| 2016 | 6.07 | 137,445 |
| 2017 | 6.51 | 132,063 |
| 2018 | 6.48 | 125,438 |
| 2019 | 6.42 | 120,832 |

## 4.5 Tailings

In the reporting period, 6.27 million tonnes of tailings were deposited between Estcourt TSF, TSF Infill, TSF 1 Closure and Rosedale TSF. A summary of the reporting period tailings distribution and TSF capacity consumed is provided in Table 9 below.

**Table 9 Distribution and Capacity Consumed of Tailings Storage Facilities**

| Tailings Storage Facility | Distribution (%) | Capacity Consumed (Mt) |
|---|---|---|
| TSF1 Closure | 30.6 | 1.92 |
| TSF2 | 0.0 | 0.00 |
| TSF Infill | 0.1 | 0.01 |
| Estcourt Stage 2 | 45.6 | 2.86 |
| Rosedale Stage 2 | 23.7 | 1.48 |

A total of 112.9 Mt of tailings has been deposited at Northparkes operations to date. All tailings have been deposited within TSF1, TSF2, Estcourt, Rosedale TSF and the Infill TSF located approximately 2km from the processing plant. The tailings are sub-aerially deposited into the active TSF and tailings liquid and runoff are contained and directed to the internal central decant tower.

All TSFs at Northparkes have been designed by an Engineer of Record to provide;

- Safe and permanent containment of all tailing's solids;
- The recovery of free water for reuse within the processing plant;
- Containment of all water under extreme rainfall conditions;
- Maximised structural strength through the deposited tailings; and
- Containment of all chemical residues.

Northparkes control measures for the management of tailings during construction and operation are implemented as per the Tailings Operators Manual and Tailings Management Plan.

The site tailings strategy is regularly reviewed, with the most optimal disposal strategy utilised. The future tailings deposition strategy involves alternating deposition between the Estcourt TSF, Rosedale TSF, Infill TSF, TSF2 and TSF1 Closure.

During the reporting period barley was sown onto the TSF2 surface (80ha) to continue to mitigate dust lift off. However, the success of the sowing was severely reduced due to the ongoing drought conditions experienced throughout 2019, with plant germination only occurring across approx. 20% of the TSF. One positive that did arise from the sowing operation was that the process of sowing provided newly ripped lines across the surface which actively minimised dust lift-off.

In 2019, construction of Stage 2 of the Rosedale TSF was completed, adding a projected 13.8Mt of storage capacity. Construction of the facility also included the completion of topsoil and subsoil removal in the basin in accordance to the Mining Operation Plan (MOP) prior to commencement of deposition. Dust mitigation measures were enacted throughout the construction program, including the ripping of approximately 100ha of desiccated tailings surface in the Rosedale TSF impoundment to reduce surface wind velocities and dust uplift.

### *4.5.1 Next Reporting Period*

Tailings deposition for 2020 is forecast to be 6.39 Mt. The tailings will be deposited between TSF 1 Closure, Estcourt Stage 2 and Rosedale Stage 2.

Water conservation will continue to be a focus in 2020. The continuing drought conditions are contributing to further investigations into water conservation initiatives in the space of water recovery. As in 2019, utilisation of water from the E22 Open Pit will continue.

Dust mitigation strategies will continue to be investigated and implemented across the business, with possibilities such as re-sowing a suitable crop onto TSF2 and chisel ploughing exposed areas of Rosedale considered.

## 4.6 Construction Activities during 2019

A summary of construction activities undertaken during the reporting period and their completion status is provided in Table 10.

**Table 10 Summary of construction activities during the reporting period**

| Infrastructure | Commencement Date | Completion Date |
|---|---|---|
| Mine Infrastructure Area (MIA) | | |
| E48 Ventilation Fan Upgrade Project | December 2017 | August 2020 |
| E26L1N Block Cave | January 2019 | July 2022 |
| Expansion Project | May 2019 | Q4 2021 |
| Tailings Storage Facilities (TSF) | | |
| Rosedale Stage 2 | May 2018 | October 2019 |

### *4.6.1 Underground Ventilation Upgrade Project*

In December 2017, Northparkes commenced a program to upgrade the underground ventilation infrastructure. The ventilation upgrade consists of two additional shafts, one intake and one exhaust. These shafts are approximately 5m in diameter and connect with the E48 underground block cave mine. The exhaust shaft vent consists of two surface ventilation fans, with the intake shaft not requiring any fans.

In 2019 the raise bore shafts were completed but due to rock falls damaging the integrity of part of the exhaust shaft a development incline was started to bypass the damaged region of the shaft. 828m of the 1702m incline was completed in 2019. Construction of the new vent fans are approximately 90% complete at the end of 2019.

### *4.6.2 E26L1N*

E26L1N is a block cave extension, mining the porphyries to the north of the E26L1 and E26L2 caves. The E26L1N mine will produce ore from 2021 until 2033 adding to the life of mine plan. The project will include over 10,000m of lateral development, a new jaw gyratory crusher as well as two new conveying systems. Production is expected to begin in 2021 with project completion in July 2022. As at end of 2019, 3,689m have been developed and the preconditioning drill program is complete.

### *4.6.3 7.6Mtpa Expansion Project*

The project scope considers a range of modifications and upgrades to each of the operating facilities to achieve a throughput rate of nominal 7.6Mtpa.

Generally, primary crushed product is delivered from underground via a hoist to the surface and conveyed to an existing secondary crushing & screening building. The secondary crushing circuit is to be fed onto existing overland conveyor 123-CV006, which delivers ore to a new product feed conveyor to New Secondary Crushing & Screening Circuit (Commissioning to be complete October-2020). The outcome of implementation of secondary crushing and screening facility is to present a P80 of 22mm to the OPD Stockpiles via 123-CV008. (Previous P80 of 40mm).

The Ore Processing Facility was originally designed for 5Mtpa. Over a 24-year period, incremental improvements have increased production to a record level of 6.5Mtpa in 2017 and 2018 which has resulted in most equipment operating at maximum capacity.

In 2018, a Feasibility Study was completed to assess the option of increasing the production rate of the existing underground and surface material handling systems and ore processing equipment to achieve a nominal throughput rate of 7.6Mtpa.

In 2019 the Expansion project was approved in April with the team was fully resourced over the next 5 months. The processing increased throughput is planned to be completed in Q4 2020 and the hoisting system upgrade to be completed in Q4 2021.

Construction activities completed in 2019 included;

- DO600 Refurbishment
- Installation of new TC200 Flotation tank
- FT57 & FT50 Civil construction
- Secondary Crusher bulk earthworks
- Secondary Crusher civil mobilisation

### *4.6.4 Rosedale Stage 2*

Bulk earthworks commenced in late January to perform a Stage 2 raise on the Rosedale TSF to provide Northparkes with an additional 12.5Mt (or 2 years at current mill rates) of tailings storage capacity. This was to include modification and upgrades to all infrastructure required to operate the facility. This broadly consisted of;

- Downstream Embankment widening;
- Upstream embankment raise (3.65m);
- Installation of a new drain network;
- Upgrade pumping infrastructure to boost water recoveries;
- Completion of topsoil and subsoil stripping to meet Environmental Licence conditions;
- Completion of haul roads to facilitate construction;
- Increase facility structural resilience.

The project was completed and commissioned for tailings deposition in September.

### *4.6.5 Next Reporting Period*

The major capital works to be undertaken during the next reporting period are:

- E26 L1N Block Cave Mine Development;
- 7.6Mtpa Expansion Project
  - FT57/50/51 construction works
  - Install new SV09 screen and infrastructure
  - New Thickener Feedwell
  - Upgrade CY05 & CY06 Cyclones
  - Pump upgrades throughout OPD
  - Install new HV Infrastructure – Switchroom, Transformer, Conductors and Power Factor Correction Unit
  - Construction of new screen and crushing buildings, including bulk earthworks and civil works
  - Installation of new crushers
  - Dust Scrubber unit installation
  - Extension and construction of new conveyor infrastructure – Steel work, electrical, conveyor belt, conveyor drives and pulley installations
  - Completion of tie in works around new and current equipment.
- Underground Ventilation Improvement Project
- Various sustaining capital works projects to support the mining and ore processing operations including infrastructure upgrades and mobile equipment rebuilds or purchases.
- Mining operations will focus on the development of the E26 L1N block cave whilst continuing to produce from both the E48 block cave and E26 sub-level cave.

# 5. ACTIONS REQUIRED FROM 2019 ANNUAL REVIEW

Each year, Northparkes hosts an Annual Review meeting for the relevant stakeholders, where the report for the previous reporting period is discussed in detail. The purpose of this meeting is to document any actions required as an outcome of the previous Annual Review, including any actions that have been undertaken and when those actions were complete. The meeting was attended by representatives from the following stakeholder groups: Environmental Protection Authority, Forbes Shire Council and Wiradjuri Executive Committee. A formal apology was made from the following stakeholder groups who were unable to attend: Department of Planning, Industry and Environment – Compliance, Department of Planning, Industry and Environment – Resources Regulator, NSW Department of Primary Industries – Water, Forestry Corporation of NSW and CCC Independent Chair.

The 2018 Annual Review meeting was held on 20 August 2019 with no actions raised.

# 6. ENVIRONMENTAL MANAGEMENT AND PERFORMANCE

## 6.1 Environmental Management System

Northparkes has developed and implemented a Health, Safety and Environment Management System (HSEMS). The environmental related system components and policy are compliant with ISO14001. This system acts as a framework document to provide an overview of the environmental components of the HSEMS.

The Environment Management System (EMS) at Northparkes provides the strategic framework for environmental management and is managed by the onsite Environmental Team. The EMS:

- Outlines all relevant statutory leases, licences and approvals that apply to the Northparkes operations;
- Details key plans, procedures, management plans and other documents that will be implemented to ensure compliance with all relevant leases, licences and approvals;
- Describes the key processes that will be implemented to:
    - Communicate with community and government stakeholders;
    - Manage community complaints;
    - Resolve disputes; and
    - Respond to non-compliance incidents and emergencies.
- Outlines Northparkes monitoring, reporting and auditing requirements;
- Outlines relevant roles, responsibilities and accountabilities relevant to environment management for all Northparkes employees and contractors.
- During the reporting period, Northparkes maintained the EMS to the ISO14001:2015 standard. Northparkes also maintained its A1 risk rating under the EPA's risk based licencing scheme, the highest possible standard.

Northparkes has developed a suite of environmental management plans (EMP) to guide environmental management at Northparkes. The plans have been developed in accordance with the EMS, the Consent and other statutory requirements. The revision status of approved key EMPs, as required by Schedule 6, Condition 3 of the Consent, is summarised in Table 11.

**Table 11 Key Environmental Management Plans**

| Management Plan | Status |
|---|---|
| Biodiversity Offset Management Plan | Revision 6-Revised 25 February 2020 |
| Water Management Plan<br>Surface Water Management Plan<br>Groundwater Management Plan | Revision 10- Currently under third party review<br>Revision 5- Currently under third party review<br>Revision 5- Currently under third party review |
| Pollution Incident Response Management Plan (PIRMP) | Revision 9-Revised 12 December 2019 |
| Air Quality Management Plan | Revision 17-Currently under third party review |
| Noise Management Plan | Revision 14-Revised 28 February 2019 |
| Waste Management Plan | Revision 15-Revised 30 November 2019 |
| Environmental Management Strategy | Revision 10-Revised 25 February 2020 |
| Blast Management Plan | Revision 4-Revised 20 October 2018 |
| Cultural Heritage Management Plan | Revision 6-Revised 28 February 2019 |
| Rehabilitation Management Plan | Revision 12-Revised 25 February 2020 |

The PIRMP listed in Table 11 applies to all activities that have the potential to generate pollution incidents. These include, but are not limited to, water discharge events, and hazardous spills resulting in land or water contamination and fire hazards.

The PIRMP provides an overarching procedure to respond to pollution incidents at Northparkes; the aims therefore comprise:

- Outlining the response and notification requirements in the event of a pollution incident;
- Provide clear definition of the roles and responsibilities for pollution incident responses; and
- Facilitate compliance with the requirements of the Protection of the Environment Operations Act *1997* (POEO Act) and associated regulations.

The PIRMP was implemented throughout the reporting period, tested in December 2019, and revised accordingly.

## 6.2 Meteorology

The Consent (Schedule 3, Condition 18) requires a permanent meteorological station to be installed and maintained for the life of the Project. The station must comply with the requirements in the *Approved Methods for Sampling of Air Pollutants in New South Wales* guideline and be capable of continuous real-time measurement of stability class in accordance with the NSW Industrial Noise Policy, unless a suitable alternative is approved by the Secretary following consultation with the EPA.

As such, a meteorological monitoring station (MET) has been established to continuously measure and record wind speed, wind direction, temperature, solar radiation and rainfall at Northparkes.

The MET station provides real-time data to Northparkes employees and contractors. Meteorological data is used for assessing compliance, proactive dust and noise management, and for investigative and reporting requirements. The parameters recorded by the MET monitoring station and the method are outlined in Table 12.

**Table 12 MET Monitoring Parameters**

| Parameter | Units | Frequency | Averaging period |
|---|---|---|---|
| Temperature at 2m | °C | Continuous | 15 minute |
| Temperature at 10m | °C | Continuous | 15 minute |
| Wind direction at 10m | ° | Continuous | 15 minute |
| Relative Humidity | ° | Continuous | 15 minute |
| Rainfall | mm/hr. | Continuous | 1 hour |
| Solar radiation | W/m2 | Continuous | 15 minute |

### *6.2.1 Temperature*

Maximum, minimum and average temperatures are calculated daily from the 15 min intervals. Figure 6 shows average monthly temperature records for the reporting period (10m MET recordings). Compared to the previous reporting period, the average maximum temperature is notably higher in the months of January (+2.7°C) and lower during March and April (-2.3°C and -2.4°C, respectively). Average minimum temperatures were distinctly higher than the previous reporting period during the months of January (+2.8°C) and July (+2.5°C). All other periods are generally consistent with the previous reporting period.

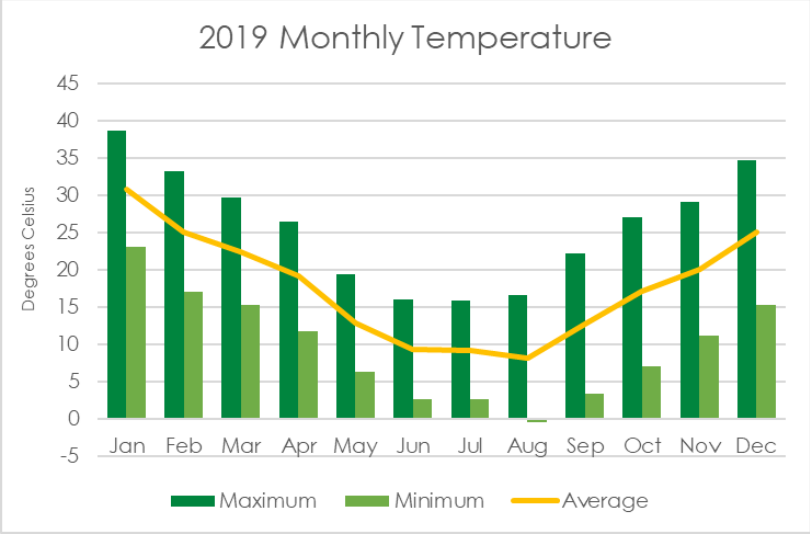



**Figure 6 Monthly temperature records**

### 6.2.2 *Rainfall*

A total rainfall of 206.6 mm was recorded at the weather station during the reporting period. This represents a 46.4mm (18%) decrease from the previous reporting period. The rainfall received during the reporting period was 403.4mm below the long-term average for the region (610mm).

Evaporation followed expected seasonal trends observed in previous climatic conditions for the region. A comparison of 2018 and 2019 rainfall is shown in Figure 7.

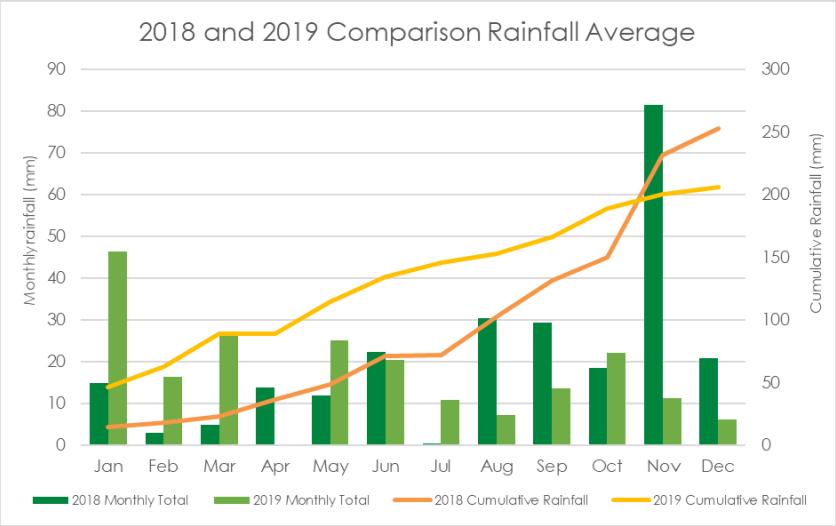



**Figure 7 Comparison of 2018 and 2019 rainfall**

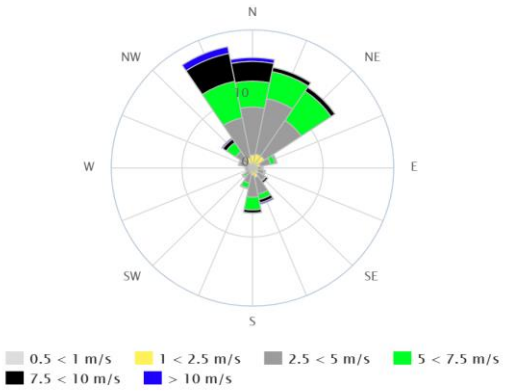
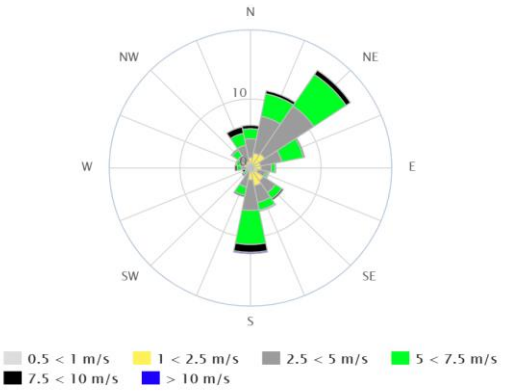
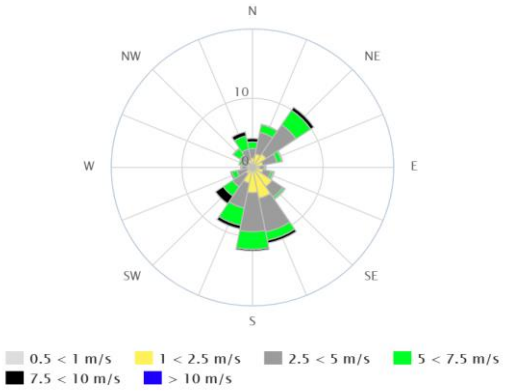
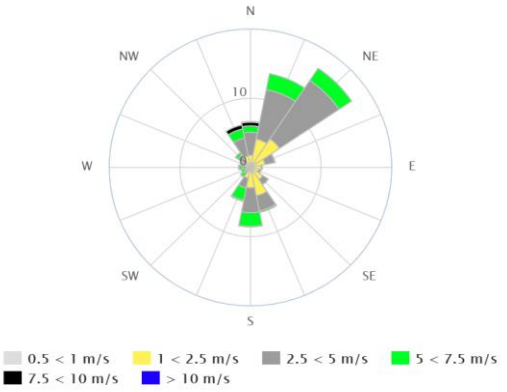
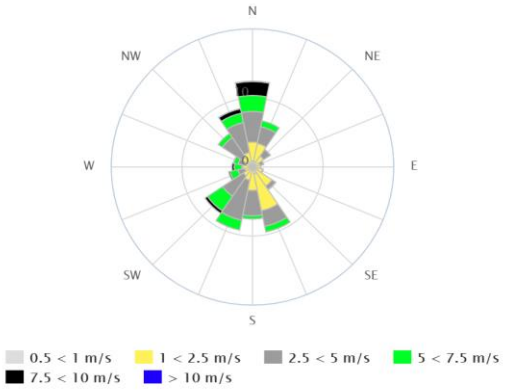
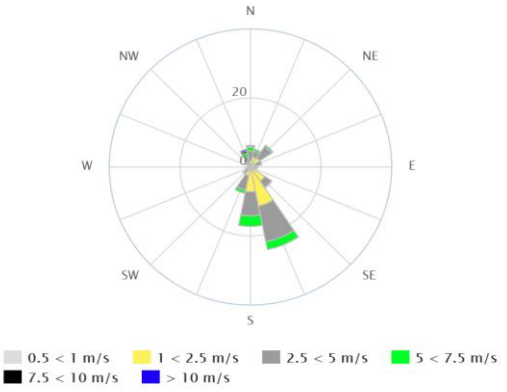
### 6.2.3 *Wind*

Wind speed and direction are important parameters for the preparation of blasting activities, investigating noise and dust events, and assessing cumulative impacts as a result of other operations in the region. Wind data for the 2019 reporting period are presented in Table 13 and the wind roses provided in Figure 8. Wind speed values are displayed as metres per second.

**Table 13 Monthly wind direction percentages for 2019**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **N (337.6° - 22.5°)** | 33 | 16 | 17 | 26 | 27 | 12 | 19 | 15 | 14 | 17 | 16 | 16 |
| **NE (22.6° - 67.5°)** | 23 | 30 | 19 | 31 | 7 | 14 | 11 | 3 | 6 | 16 | 5 | 10 |
| **E (67.6° - 112.5°)** | 4 | 8 | 5 | 4 | 4 | 6 | 4 | 3 | 3 | 6 | 1 | 2 |
| **SE (112.6° - 157.5°)** | 6 | 12 | 13 | 8 | 11 | 20 | 15 | 18 | 13 | 11 | 7 | 7 |
| **S (157.6° - 202.5°)** | 12 | 20 | 22 | 16 | 18 | 35 | 23 | 28 | 31 | 21 | 27 | 25 |
| **SW (202.6° - 247.5°)** | 4 | 4 | 12 | 5 | 16 | 6 | 17 | 19 | 20 | 12 | 24 | 20 |
| **W (247.6° - 292.5°)** | 3 | 4 | 4 | 3 | 6 | 2 | 5 | 6 | 6 | 7 | 7 | 7 |
| **NW (292.6° - 337.5°)** | 15 | 7 | 7 | 6 | 11 | 5 | 8 | 7 | 6 | 11 | 11 | 14 |

Analysis of data reveals that prevailing winds during the 2019 reporting period were predominantly from the north east during summer and autumn whilst southerly winds were experienced during the winter and spring. The prevailing wind conditions during this reporting period were consistent with the historical data as presented in the Step Change Environmental Assessment (EA), Umwelt 2013. Average wind speeds were generally consistent through the year recording 12.5km/h in H1 and 12.8km/h in H2.

| January 2019 | February 2019 |
|---|---|
|  |  |
| **March 2019** | **April 2019** |
|  |  |
| **May 2019** | **June 2019** |
|  |  |

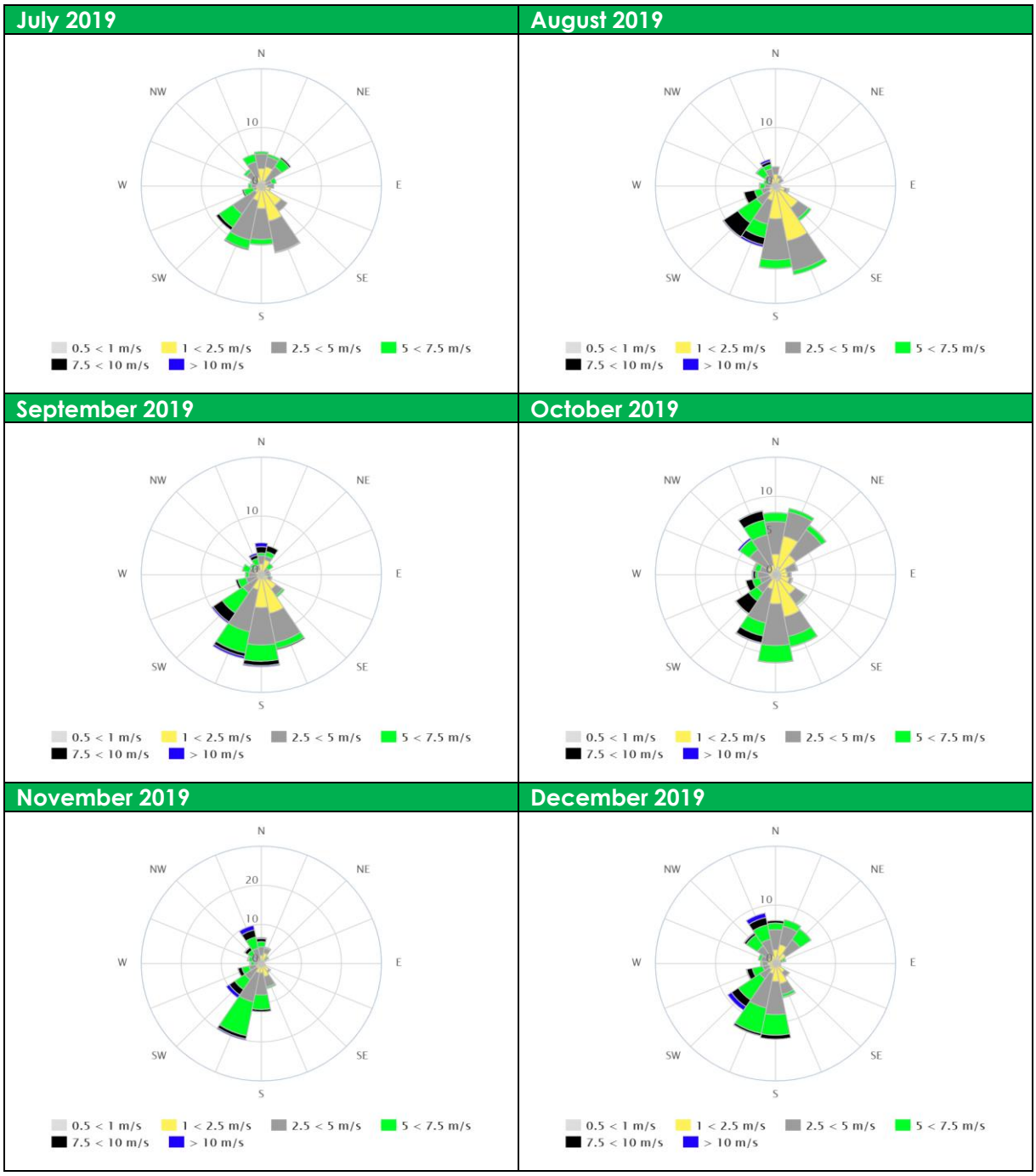



**Figure 8 Monthly wind rose summary for 2019**

### *6.2.4 Meteorology Improvements and Initiatives*

During the 2019 reporting period a new environmental monitoring database was implemented. The database will be used within the next reporting period to improve how real time metrological is displayed and utilised with other key environmental data, such as air quality.

## 6.3 Air Quality

### *6.3.1 Air Quality Management*

Air quality management is undertaken in accordance with the approved Air Quality Management Plan (AQMP). The AQMP outlines mitigation measures, required monitoring and provides clear definitions of the roles and responsibilities related to air quality and greenhouse gas management.

Through implementation of the AQMP, Northparkes executes a range of mitigation measures for air quality that have proved to be effective at managing dust impacts, demonstrated by maintaining compliance with criteria specified in the Consent. These will continue to be implemented throughout 2020. During the 2019 reporting period, mitigation measures included, but were not limited to, the following:

- Major works scheduled to undergo a risk assessment prior to commencing work;
- Environmental inductions and training to ensure workforce awareness;
- Purchase of equipment that meets relevant air emission standards;
- Maintaining plant and machinery in good working order;
- Maintaining haul roads in good condition;
- Regular contact with local residents;
- Weekly internal weather assessment;
- Sealing high traffic roads, where possible;
- Use of water carts on construction haul roads;
- Scheduling of work with attention paid to adverse weather conditions and modifications made to the work program where necessary;
- Implementation of best management practice to minimise the construction, operational and road air quality impacts of the operations;
- Northparkes has a private agreement in place with the owners of "Avondale" for the property to remain unoccupied over the life of the mine;
- An air quality management system that uses a combination of predictive meteorological forecasting and real-time weather monitoring data to guide the day-to-day planning of construction and mining operations, and the implementation of both proactive and reactive air quality mitigation measures to ensure compliance with the relevant conditions and approvals; and
- A program of regular air quality monitoring of site operations to determine whether the operations are complying with the criteria set out in the Consent.

Northparkes implements a dust monitoring program to measure concentrations of depositional dust, Total Suspended Particulates (TSP) and Particulate Matter (PM10) in the vicinity of the Northparkes operations. Depositional dust monitoring provides an indication of levels of dust in the atmosphere measured in g/m²/month of insoluble matter. TSP monitoring measures the total of all particles suspended in air, utilising a High-Volume Air Sampler (HVAS). PM10 measures the concentration of particulate matter less than 10 microns in diameter, utilising real-time Beta-Attenuation Monitoring (BAM). Results from monitoring are discussed in Section 6.3.2.

The current dust monitoring program includes 11 depositional dust gauges, three HVAS's and three BAM's, details of which are provided in Table 14. A figure showing the location of each air quality monitoring site is provided in Appendix 2.

**Table 14 Air Quality Monitoring Sites**

| Site ID | Type | Units | Frequency |
|---|---|---|---|
| Milpose | PM10 (BAM) and TSP (HVAS) | µg/m3 | Continuously and Every 6 days |
| Hubberstone | PM10 (BAM) and TSP (HVAS) | µg/m3 | Continuously and Every 6 days |
| Hillview | PM10 (BAM) and TSP (HVAS) | µg/m3 | Continuously and Every 6 days |
| ND19 | Deposited dust gauge | g/m2/month | Monthly |
| ND20 | Deposited dust gauge | g/m2/month | Monthly |
| ND21 | Deposited dust gauge | g/m2/month | Monthly |
| ND22 | Deposited dust gauge | g/m2/month | Monthly |
| TDE | Deposited dust gauge | g/m2/month | Monthly |
| TDE5 | Deposited dust gauge | g/m2/month | Monthly |
| TDN5 | Deposited dust gauge | g/m2/month | Monthly |
| TDNE | Deposited dust gauge | g/m2/month | Monthly |
| TDS5 | Deposited dust gauge | g/m2/month | Monthly |
| TDSW | Deposited dust gauge | g/m2/month | Monthly |
| TDW | Deposited dust gauge | g/m2/month | Monthly |

### 6.3.2 *Air Quality Performance*

All dust samples are collected by trained staff and analysed by NATA certified laboratories. This work is carried out in accordance with relevant statutory and industry code standards. Monitoring equipment is maintained in accordance with manufacturer's specifications.

During the reporting period dust lift-off from the TSF's was managed through the implementation of a variety of different strategies. These strategies included deposition of wet tailings on Estcourt, Infill, Rosedale and the central deposition closure works undertaken on TSF1. The sowing of TSF2 continued in 2019 and although the germination was greatly impacted by the ongoing drought, the strategy continued to be proven to be successful in reducing dust lift-off.

Northparkes aim to implement these same proven strategies, including the re-sowing of TSF 2, throughout 2020 to help reduce the risk of dust lift-off from the tailings storage facilities.

#### 6.3.2.1 $PM_{10}$

PM10 monitoring results for the 'Hubberstone'(Figure 9 and Figure 10), 'Milpose' (Figure 11 and Figure 12)and 'Hillview' (Figure 13 and Figure 14) monitoring locations, for the reporting period are displayed below. The criteria for exceedances (as nominated in the Consent) is >30 µg/$m^3$ for the annual average and >50 µg/$m^3$ for a 24-hour monitoring period.

Monitoring results for the three locations were under the air quality criteria stated in the Consent, with all outliers removed. During the reporting period, there were a total of seventy-three 24hr periods at Milpose, one hundred and twenty-one 24hr periods at Hubberstone and thirty-three 24hr periods at Hillview that recorded elevated particulate matter above the criteria stated in the Consent. Each of these readings triggered an internal investigation which determined that all elevated results were the result of non-mining influences. These included localised agricultural activities (sowing, harvesting and livestock management), bushfire smoke and the ongoing drought conditions resulting in reduced vegetation cover promoting dust lift off across the local district. The NSW Governments Regional Air Quality Monitoring Network (RAQMN) report outlines that combinations of little rainfall, minimal vegetation cover and strong winds have resulted in increased levels of dust haze throughout the region for the 2019 reporting period. Hubberstone was the location most affected by localised agricultural activity as the monitor is adjacent to a bare paddock containing livestock.

The annual average PM10 levels recorded at Milpose and Hillview monitoring locations are within the predicted levels of the EA (20 µg/m$^3$), with Hubberstone slightly above at 23.9 µg/m$^3$.

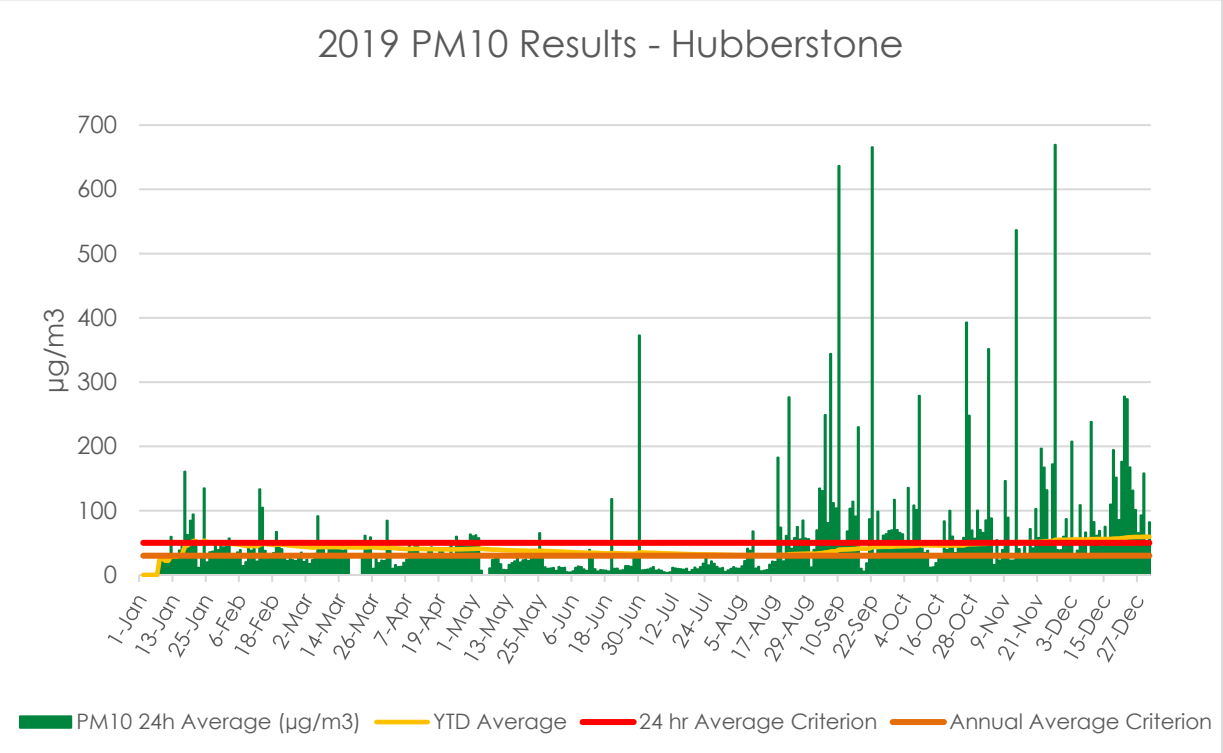



**Figure 9 PM10 Monitoring results - Hubberstone**

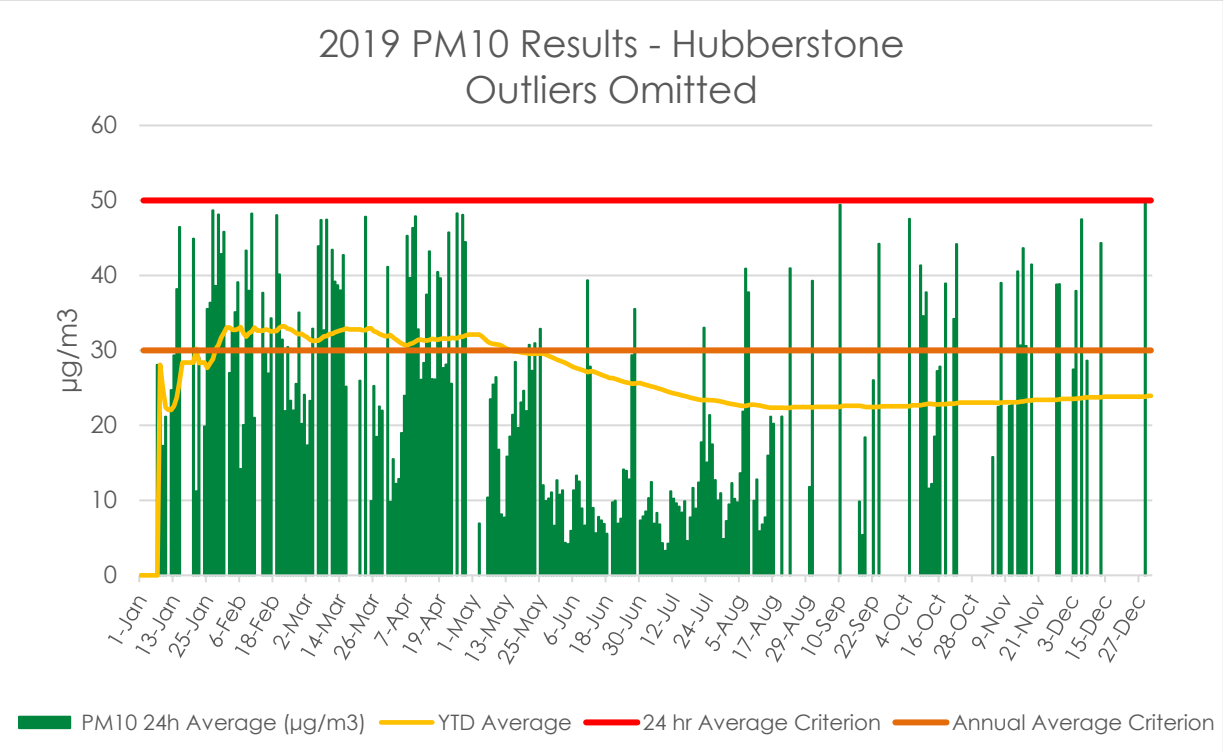



**Figure 10 PM10 Monitoring results with outliers omitted - Hubberstone**

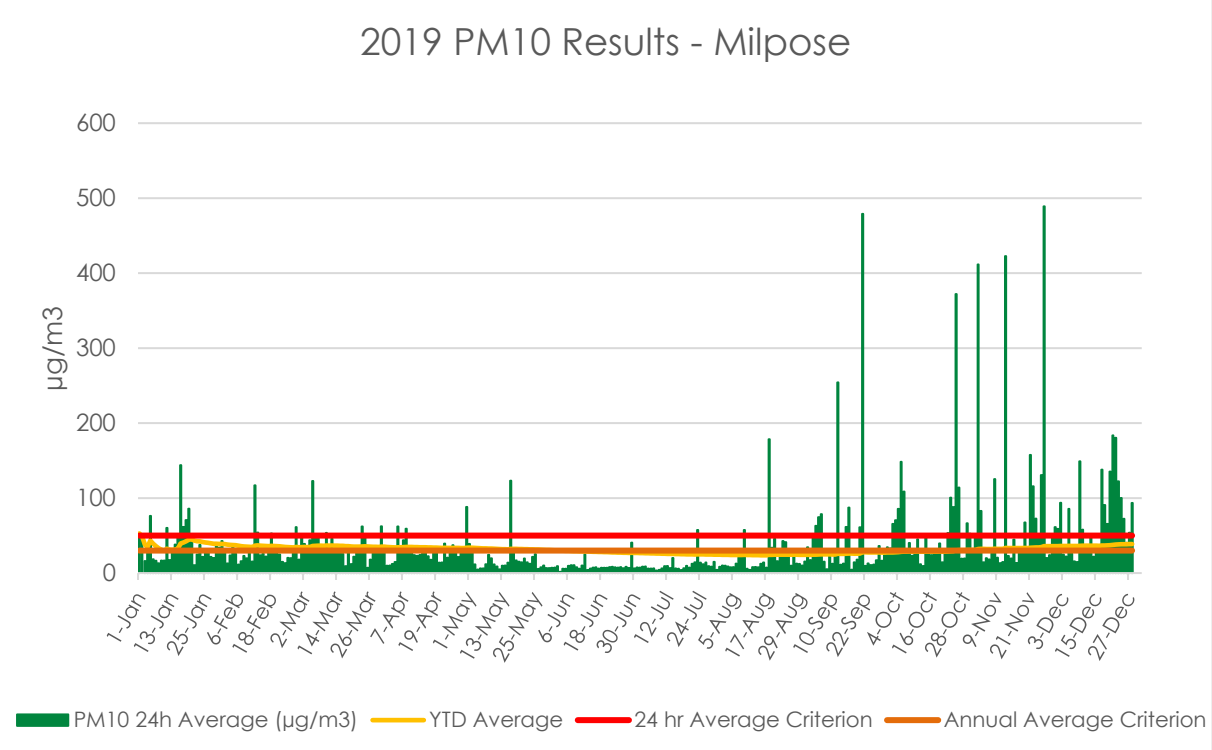



**Figure 11 PM10 Monitoring Results - Milpose**

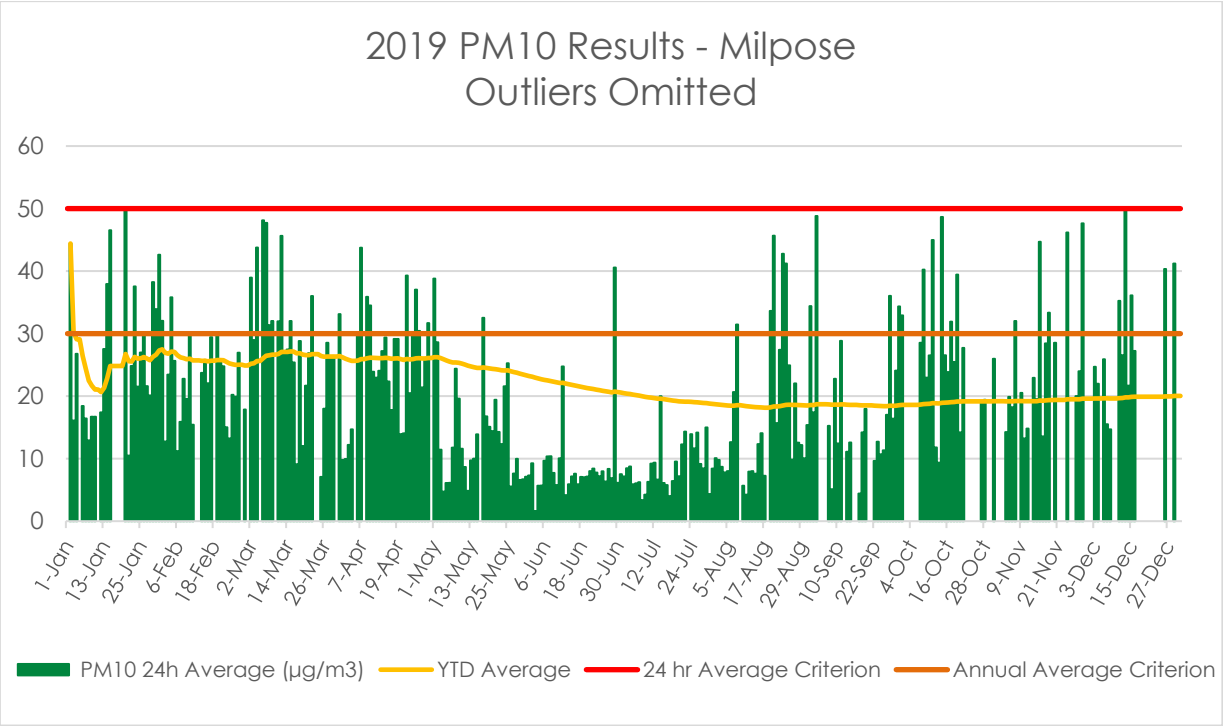



**Figure 12 PM10 Monitoring results with outliers omitted – Milpose**

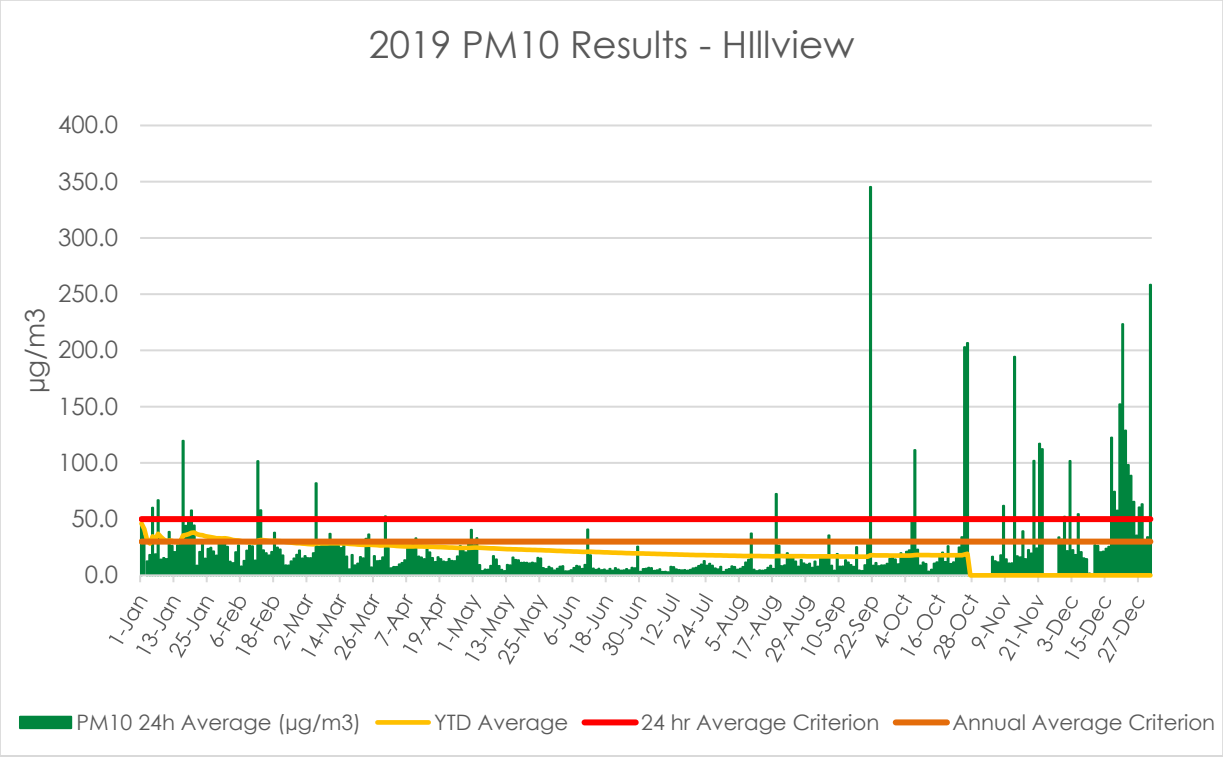



**Figure 13 Figure 14 PM10 Monitoring Results - Hillview**

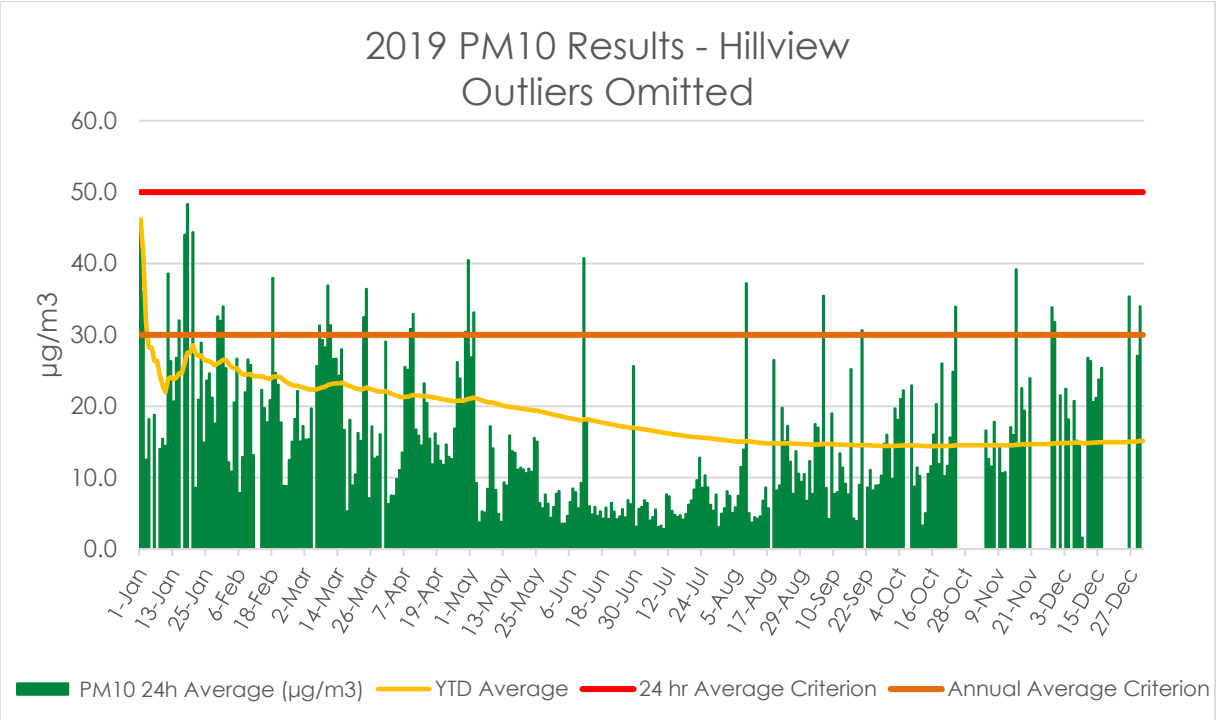



**Figure 14 PM10 Monitoring results with outliers omitted – Hillview**

### *6.3.2.2 Total Suspended Particulates (TSP)*

TSP monitoring results for the 'Hubberstone' (Figure 15 and Figure 16), 'Milpose' (Figure 17 and Figure 18) and 'Hillview' (Figure 19 and Figure 20) monitoring locations for the reporting period are displayed below. All recorded dust levels were under the required criteria set by the Consent (90 µg/m$^3$) for the 2019 monitoring period with outliers omitted. The annual average TSP dust levels recorded at all TSP monitoring locations are in line with the predicted levels within the EA (50 µg/m$^3$). The combinations of little rainfall, minimal vegetation cover and strong winds have resulted in increased dust events throughout the region for the 2019 reporting period.

The missing data for Hubberstone on 3 January, 3 May and 14 July, Hillview on 8 July and Milpose on 29 December, was the result of power supply issues.

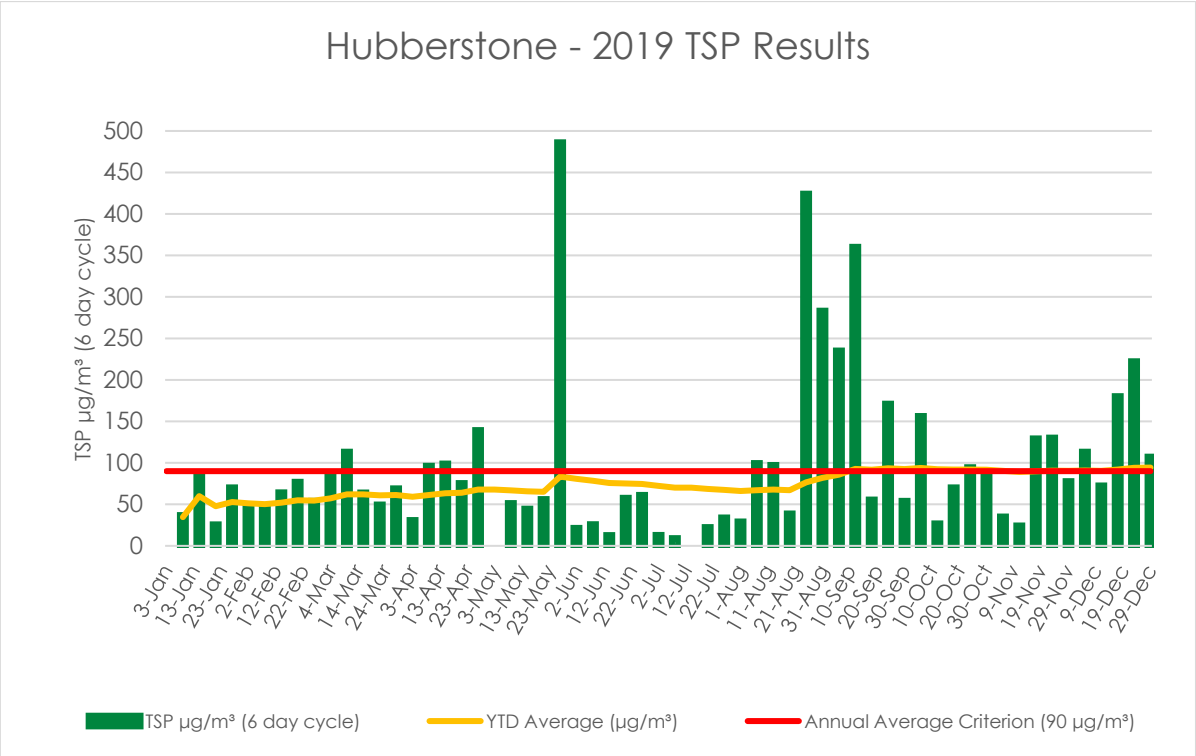



**Figure 15 TSP Results for Hubberstone**

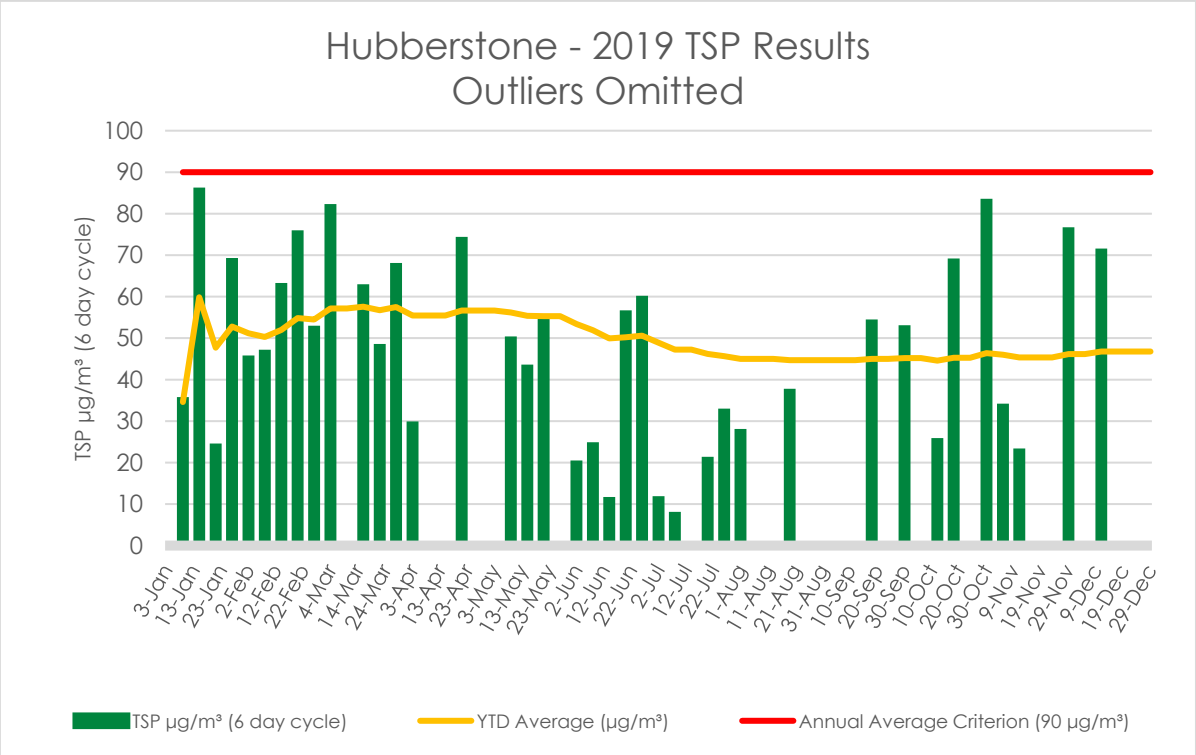



**Figure 16 TSP Results for Hubberstone with outliers omitted**

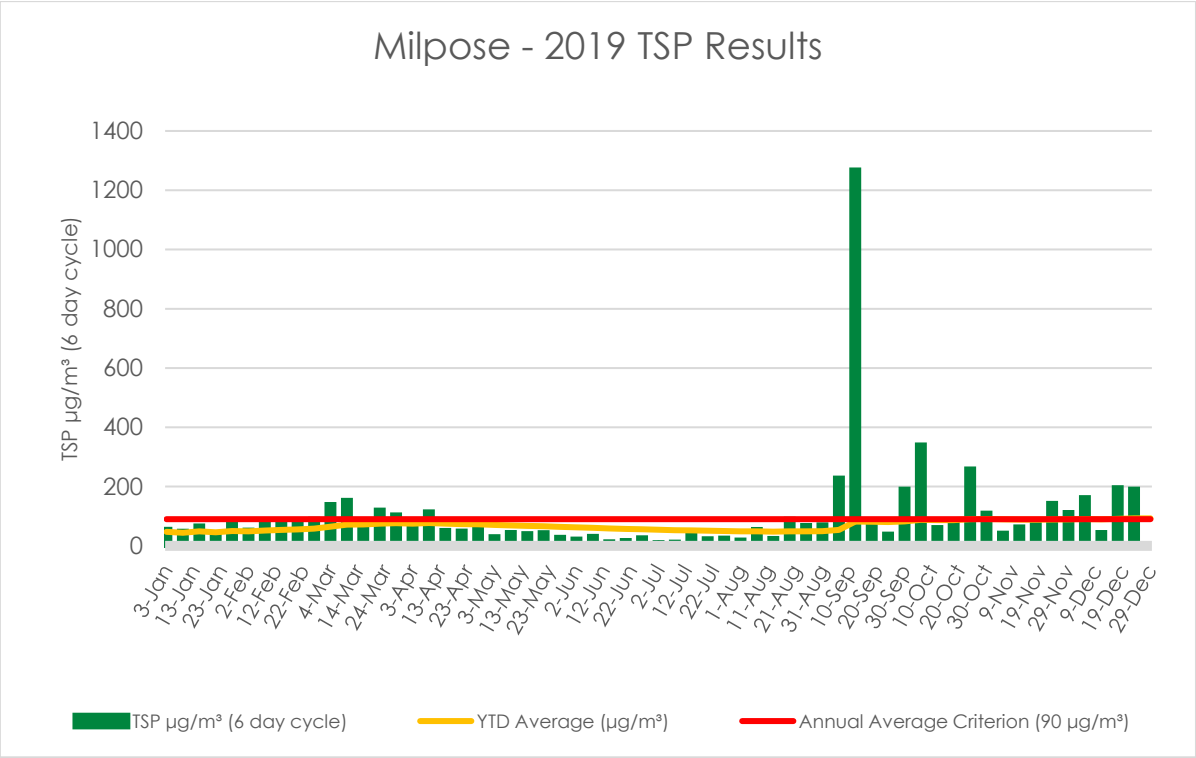



**Figure 17 TSP Results for Milpose**

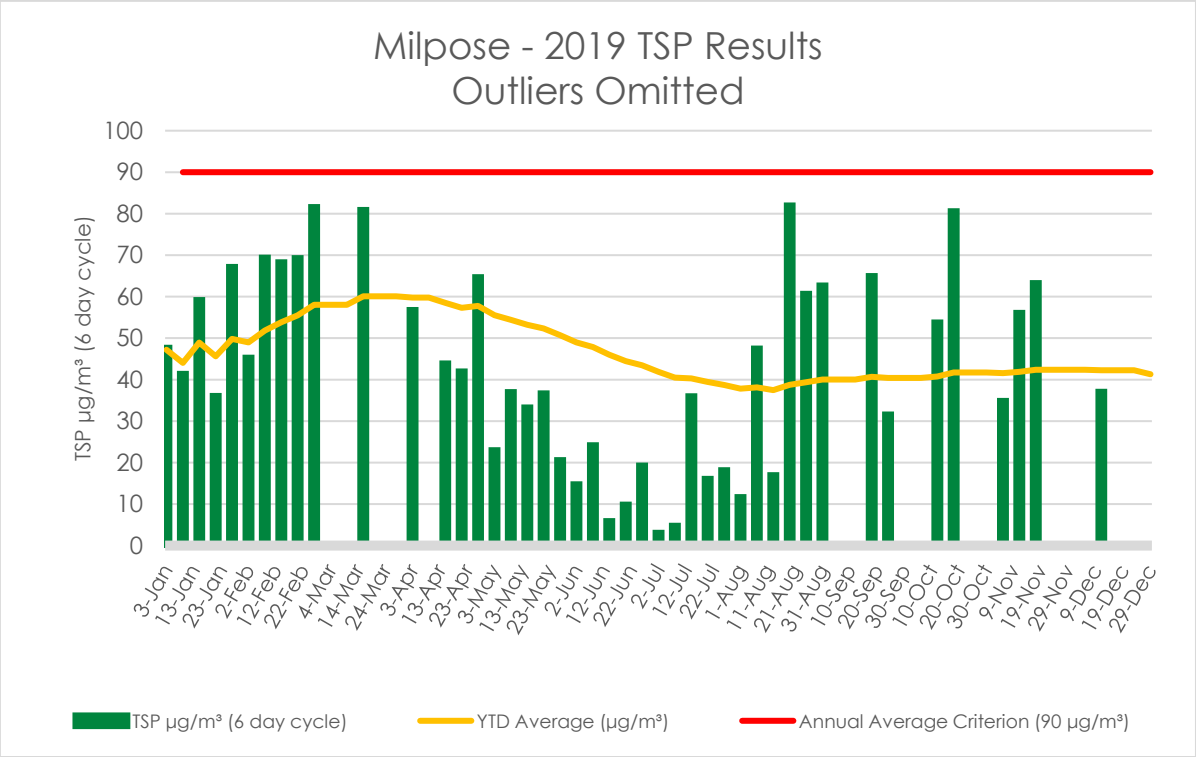



**Figure 18 TSP Results for Milpose with outliers omitted**

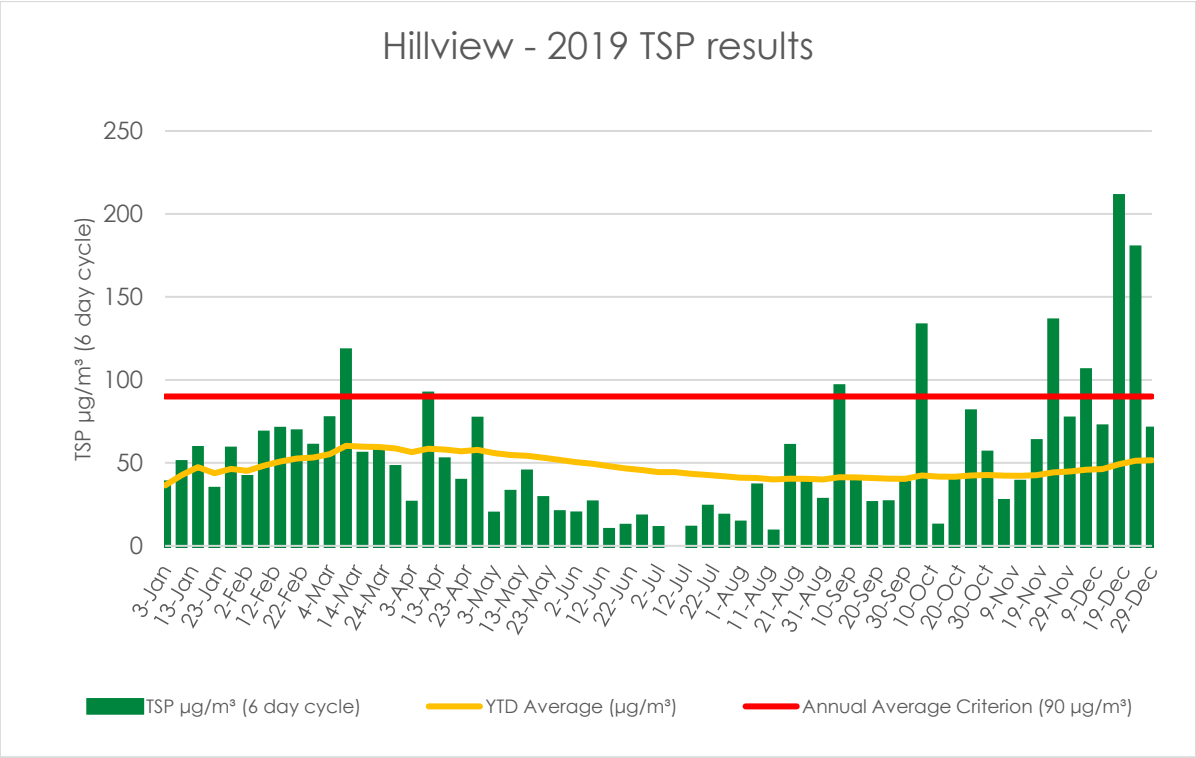



**Figure 19 TSP Results for Hillview**

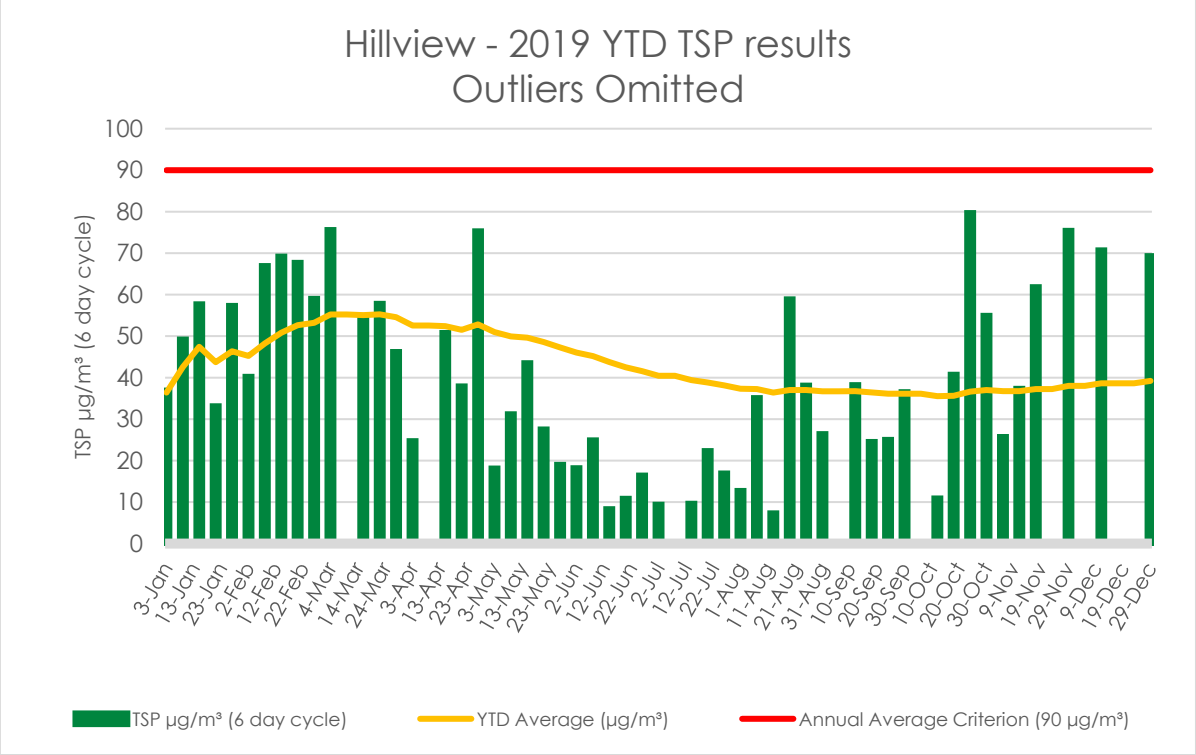



**Figure 20 TSP Results for Hillview with outliers omitted**

### *6.3.2.3 Depositional Dust*

Depositional dust samples were analysed by a NATA accredited laboratory to determine sample contamination by naturally occurring impurities. Figure 21 presents the annual average results following laboratory analysis of all eleven dust gauges. The results indicate that all reportable depositional dust gauges remained below the annual average criterion of 4.0 g/m2 /month for the 2019 period.

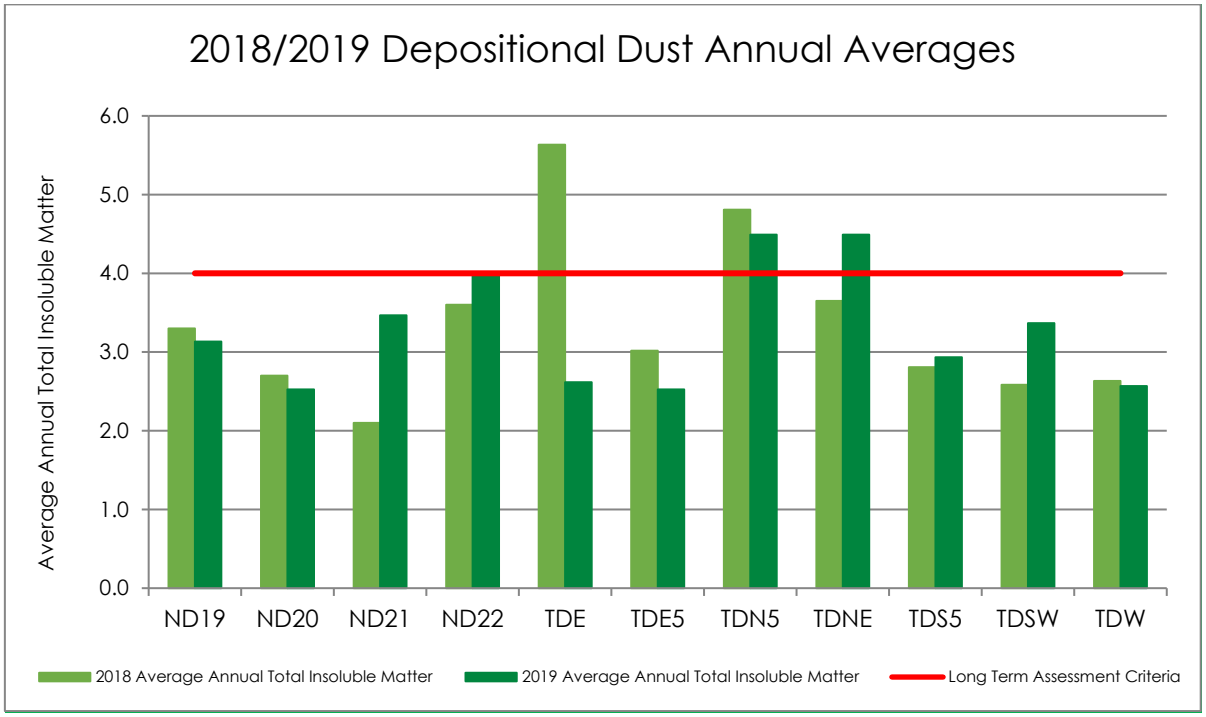



**Figure 21 Depositional Dust Annual Averages**

Depositional dust systems are often subject to contamination by naturally occurring impurities such as bird droppings, insects and vegetation or regularly impacted by local extraneous sources (such as farming activities, local dirt roads or large dust storms following lengthy drought periods). On fifty-two separate occasions over the reporting period, samples were deemed contaminated and removed from the data as outliers. Each elevated result exceeded internal trigger levels which were then subject to an investigation. These investigations determined that all high readings were the result of localised agricultural activities (sowing, harvesting and livestock management) or the ongoing drought conditions promoting dust lift off across the local district.

All dust gauge results, with outliers removed, remain below the criteria specified in the Consent. Between 2013 and 2015 the rolling annual average of all gauges was on an upward trend. During 2015, the trend stabilised and then began trending downwards during 2016. Depositional dust levels recorded during the 2018 period reported upward trending as a result of increasing drought conditions. In 2019, this trend continued with six of the eleven dust gauges recording annual averages above the previous reporting period.

Northparkes are undertaking a review of the current depositional dust monitoring program to determine if any efficiencies can be made during 2020.

### 6.3.3 *Air Quality Improvements and Initiatives*

During 2020, Northparkes will look to employ a number of additional strategies for managing potential air quality impacts, these include:

- Sow a crop on the TSF2 surface to provide ground cover and to reduce risk of dust lift off from the TSF's;
- Alternate tailings material deposition between the active TSF's, reducing exposed areas; and

In addition to these strategies, Northparkes is continuing to review the regional air quality monitoring network to ensure any monitoring locations that are consistently impacted by extraneous sources nearby, are removed or relocated. This initiative was discussed at the 2018 neighbours' meetings and Community Consultative Committee meetings as well as with the EPA during the 2019 Annual Review meeting.

## 6.4 Noise

### 6.4.1 *Noise Management*

Operational noise is managed by Northparkes in accordance with the approved Noise Management Plan (NMP). The NMP covers all operational activities with the potential to generate noise at Northparkes. It details specific noise management and mitigation measures, outlines monitoring and reporting requirements and provides clear definition of the roles and responsibilities for noise management.

Control measures for the management of noise during construction, operation and decommissioning are essential in minimising noise impacts. The three main strategies used to identify reasonable and feasible noise control/mitigation strategies are:

- Controlling noise at the source - There are three approaches to controlling noise generated by the source: source elimination; Best Management Practice (BMP) and Best Available Technology Economically Achievable (BATEA).
- Controlling the transmission of noise - There are two approaches: the use of barriers and land-use controls which attenuate noise by increasing the distance between sources and receiver; and
- Controlling noise at the receiver - There are two approaches: negotiating an agreement with the landholder or acoustic treatment of dwellings to control noise.

Noise control measures at Northparkes are designed to comply with the Consent and the requirements of the *NSW Noise Policy for Industry (2017)*.

Operational control measures include:

- Northparkes has a private agreement in place with the owners of "Avondale" for the property to remain unoccupied over the life of mine;
- Major works scheduled undergo a risk assessment prior to commencing work;
- Environmental inductions and training to ensure workforce awareness;
- Purchase of equipment that meets relevant noise emission standards;
- Maintaining plant and machinery in good working order;
- Maintaining haul roads in good condition;
- Operating equipment in a manner that will minimise noise emissions;
- Avoiding the unnecessary clustering of earth moving equipment;
- Regular contact with local residents;
- Modifications to surface ventilation fans;
- Scheduling of work with attention paid to adverse weather conditions, particularly at night, and modifications made to the work program where necessary;
- Implementation of best management practice to minimise the construction, operational and road noise of the operations;

- A program of regular noise monitoring of site operations to determine whether the operations are complying with the criteria set out in the Consent. This monitoring will be undertaken as attended and real-time noise monitoring at surrounding receivers over the life of the mine; and
- Additional targeted noise monitoring during construction periods for TSFs, and whilst campaign open cut mining operations occur during winter night time operations if required. This targeted monitoring program will include the use of real time monitoring and be undertaken to identify situations when meteorological conditions have the potential to exacerbate noise impact on neighboring receivers. Appropriate noise mitigation measures will be implemented as required.

### *6.4.2 Noise Performance*

Northparkes undertakes a noise monitoring program at four locations on privately owned properties outside the mining leases. The program consists of both operator-attended and unattended surveys at the four nearest occupied residences 'Hubberstone', 'Milpose', 'Lone Pine' and 'Hillview' (see Appendix 1).

Noise measurements are undertaken in accordance with the requirements of the Consent, *AS 1055*, and the *NSW Noise Policy for Industry, 2017*. Northparkes engaged acoustic specialists to undertake attended noise monitoring on a quarterly basis at locations defined in the NMP to adequately assess the noise impacts related to Northparkes operations. All acoustic instrumentation is designed to comply with the requirements of *AS 1259.2* and carries current NATA or manufacturer calibration certificates.

A total of 144 attended noise surveys were undertaken during the reporting period, of which 114 (79%) were during favourable meteorological conditions, as stipulated in the Consent. The surveys undertaken during unfavourable meteorological conditions were excluded from assessment. The reasons for this included the wind speed exceeding 5 m/s and constant traffic.

Unattended noise monitoring was conducted continuously over the year at each monitoring location. This data was used to assess background ambient noise levels and do not have an applicable exceedance criterion.

A summary of the attended noise monitoring results is provided in Table 15. This includes all quarterly monitoring conducted in 2019.

**Table 15 Summary of Attended Noise Monitoring Results**

| Location | | Day | Evening | Night | |
|---|---|---|---|---|---|
| | | $L_{Aeq}$(15min) | $L_{Aeq}$(15min) | $L_{Aeq}$(15min) | $L_{A1}$(1min) |
| | **Criteria dB (A)** | **35** | **35** | **35** | **45** |
| **Hubberstone** | 6-8 Mar | ≠ | ≠ | ≠ | ≠ |
| | 8-9 May | ^ | ^ | ~<25 | <25 |
| | 27-28 Aug | ^ | 23-28 | ^ | <20 |
| | 5-6 Nov | ^ | ^ | 20-26 | <35 |
| **Lone Pine** | 6-8 Mar | ^ | ≠ | ≠ | ≠ |
| | 8-9 May | ^ | ^ | ~<26 | <25 |
| | 27-28 Aug | ^ | 21-25 | <20 | <25 |
| | 5-6 Nov | ^ | ^ | <20 | <40 |
| **Milpose** | 6-8 Mar | ^ | ≠ | ≠ | ≠ |
| | 8-9 May | ^ | <25 | ^ | <25 |
| | 27-28 Aug | ^ | ^ | ^ | <20 |
| | 5-6 Nov | ^ | <24 | ^ | <40 |

| | | | | | |
|---|---|---|---|---|---|
| Hillview | 6-8 Mar | ^ | ≠ | ≠ | ≠ |
| | 8-9 May | ^ | <25 | ^ | <20 |
| | 27-28 Aug | ^ | ^ | ^ | <20 |
| | 5-6 Nov | ^ | ^ | ^ | <35 |

* Note: This measurement was impacted by extraneous noise not related to the mine (such as wind noise and fauna). As LA[1] results are not adjustable, this measurement is not representative of noise produced by the mine and should be disregarded.
^ Northparkes Inaudible.
~ Northparkes Slightly Audible
≠ Not measurable

Noise levels assessed as part of the monitoring program were within all operational noise criteria. They were also lower than the noise levels predicted in the EA (Umwelt, 2013), and did not exceed the sleep disturbance limit at night. Northparkes was successful in achieving the long-term intrusive noise goals during the 2019 reporting period.

All attended monitoring reports for the reporting period are available on the Northparkes webpage at: http://www.northparkes.com/news/#publications

### *6.4.3 Noise Improvements and Initiatives*

Northparkes will continue to implement the operational controls in the approved NMP including its quarterly attended noise monitoring. If operations remain the same, Northparkes propose no new initiatives as the project continues to comply with the Consent noise criteria.

## 6.5 Blasting

### *6.5.1 Blasting Management*

Northparkes does not currently undertake surface blasting activities. Therefore, all associated management activities are not currently applicable. If surface mining activities resume, management and monitoring practices will be re-established.

### *6.5.2 Blasting Performance*

Blast monitoring did not occur in 2019 due to there being no surface blasting activities in 2019.

### *6.5.3 Blasting Improvements and Initiatives*

The vibration monitoring program will be reviewed if operational changes occur.

## 6.6 Biodiversity and Ecology

### *6.6.1 Biodiversity and Ecology Management*

Biodiversity impacts at Northparkes are managed in accordance with the approved Biodiversity Offset Management Plan (BOMP). The BOMP provides a framework for managing biodiversity values within the project boundary, Biodiversity Offset Areas (BOAs), and wider locality.

The BOMP guides the management of potential risks to biodiversity as a result of operations at Northparkes. Specifically, the BOMP aims to:

- Provide details of the parties responsible for monitoring, reviewing, and implementing the BOMP;
- Ensure compliance with all legislative requirements, statutory approvals/licences and corporate responsibilities of Northparkes;

- Describe the measures (short, medium and long-term) to be implemented to manage remnant vegetation and habitat within the Project boundary and BOAs, including detailed performance and completion criteria;
- Describe the practical management strategies (including procedures) to be implemented to manage impacts on flora and fauna, maximising salvage and beneficial use of resources in areas to be impacted for habitat enhancement, rehabilitate creeks, drainage lines and disturbed areas, control weeds and pests; and
- Describe biodiversity monitoring and reporting requirements.

No impacts outside those predicted in the EA have occurred during the reporting period indicating the management strategies specified by the BOMP and implemented across the site are adequate to address potential impacts.

Northparkes has implemented a range of biodiversity monitoring activities since the commencement of operations, in addition to those studies completed for the EA. Biodiversity monitoring has included the following programs or studies:

- Rehabilitation monitoring for both the mine site and the offset areas;
- Flora and fauna monitoring at the Kokoda Biodiversity Offset Site (Kokoda); and
- Annual pine donkey orchid population monitoring survey.

The following sections summarise activities related to biodiversity management, provide updates on key biodiversity studies undertaken during the reporting period, and summarises the performance of Northparkes in meeting requirements of the Consent and internal management plans.

### *6.6.2 Biodiversity and Ecology Performance*

#### *6.6.2.1 Ecological Monitoring*

Northparkes engage external consultants to undertake rehabilitation monitoring at the Kokoda Biodiversity Offset Site (Kokoda). This program is guided by clearly defined, repeatable and consistent methodologies for monitoring changes in various aspects of ecosystem function, succession and long-term sustainability. The adopted monitoring methodology is a standard and simple procedure that can be easily replicated over any vegetation community or revegetation area. It includes a combination of Landscape Function Analysis (LFA) and flora diversity. For more details on rehabilitation monitoring undertaken in 2019 at Kokoda, refer to the 2019 Kokoda Offset Monitoring Report, available via the Northparkes website at http://www.northparkes.com/news/#publications .

#### *6.6.2.2 Kokoda Ecological Monitoring*

A range of ecological field surveys were undertaken across Kokoda in 2019. These included:

- Floristic data using plot-based surveys;
- Landscape Function Analysis (LFA) monitoring;
- Targeted bird surveys in winter and spring;
- Monitoring of kangaroo numbers;
- Biometric vegetation surveys; and
- Qualitative biannual inspections for weeds, pests and maintenance.

##### *6.6.2.2.1 Floristic Data Using Plot-Based Surveys*

A total of seventeen 20 x 20 metre permanent flora sampling sites (plots) were undertaken at Kokoda in 2019. The location of survey sites was selected to represent the different vegetation communities mapped by Umwelt in 2013 and were marked for ease of relocating for subsequent monitoring surveys (using a handheld global positioning system (GPS) and star pickets). Photographs were also taken at each site to help monitor changes over time.

During surveys, total floristic diversity was recorded in systematic increments within the monitoring plots, beginning at the start of the LFA vegetation transect in the 1 x 1 m sub-plot. Total shrub counts were made within the shaded 10 x 20 m subplots and mature tree counts and condition variables were made within the entire 20 x 20 m quadrat. For more information on the methodologies used to conduct the flora surveys, refer to the 2019 Kokoda Offset Monitoring Report.

Floristic plot-based survey at Kokoda in 2019 recorded 106 plant species; including 20 non-native (exotic) species and 86 native species. No threatened flora species were detected in the flora plots during field surveys. Refer to the 2019 Kokoda Offset Monitoring Report for full information and data.

A range of Key Performance Indicators (KPI's) were quantified by data obtained from replicated reference sites which were representative of the Grey Box Woodland CEEC and Dwyer's Red Gum woodland. All ecological performance indicators are quantified by range values measured from these reference sites which form both *upper* and *lower* KPI targets. The same ecological performance indicators are also measured in the revegetation/rehabilitation sites and these should equal or exceed these values, or at least demonstrate an increasing trend.

Table 16 below indicates the performance of the woodland revegetation monitoring sites against the proposed Primary Completion Performance Indicators. The selection of criteria has been presented in order of rehabilitation phases according to the ESG3 MOP guidelines. The range values of the ecological performance targets are amended annually. Revegetation sites meeting or exceeding the range values of their representative community type have been identified with a coloured box and have therefore been deemed to meet these primary completion performance targets this year. Hashed coloured boxes indicate they may be outside of the reference target ranges, but within acceptable agricultural limits.

The reference sites at Kokoda are typically degraded and of low quality which subsequently have provided low performance targets. In the Grey Box woodlands, there was limited abundance and diversity of the grassy understorey and there were limited shrubs. Subsequently the revegetation activities proposed should include a range of species known to occur within these communities and not just restricted to those occurring within the existing reference sites.

**Table 16 Performance of the Grey Box, Ironbark and Dwyers Red Gum woodland revegetation sites against primary completion performance indicators in 2019.**

| Rehabilitation Phase | Aspect or ecosystem component | Completion criteria | Performance Indicators | Unit of measure | GBReveg 1 | GBReveg 2 | GBReveg 3 | GBReveg 4 | GBReveg 5 | WBWood 1 | IronWood 1 | DReveg 1 | DReveg 2 | DReveg 3 | DWoodLQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Performance indicators are quantified by the range of values obtained from replicated reference sites* | | | | | 2018 | | | | | | | | | | |
| **Phase 2: Landform establishment and stability** | **Landform slope, gradient** | Landform suitable for final land use and generally compatible with surrounding topography | Slope | < Degrees (18°) | 5 | 4 | 3 | 4 | 3 | 3 | 4 | 4 | 3 | 4 | 3 |
| | **Active erosion** | Areas of active erosion are limited | No. Rills/Gullies | No. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phase 3: Growth medium development** | **Soil chemical, physical properties and amelioration** | Soil properties are suitable for the establishment and maintenance of selected vegetation species | pH | pH (5.6 - 7.3) | 6.7 | 5.3 | 6.0 | 5.7 | 6.1 | 6.2 | 4.8 | 5.4 | 5.2 | 5.4 | 5.0 |
| | | | Organic Matter | % (>4.5) | 3.4 | 5.5 | 3.1 | 2.8 | 2.5 | 3.1 | 4.8 | 3.5 | 4.3 | 2.9 | 4.8 |
| | | | Phosphorous | ppm (50) | 7.9 | 9.8 | 9.2 | 8.2 | 7.2 | 7.9 | 5.9 | 9.2 | 10.8 | 6.9 | 8.5 |
| **Phase 4: Ecosystem & Land use Establishment** | | | LFA Stability | % | 73.6 | 61.0 | 73.1 | 67.5 | 73.9 | 62.7 | 62.5 | 73.2 | 66.5 | 64.5 | 65.0 |

| Rehabilitation Phase | Aspect or ecosystem component | Completion criteria | Performance Indicators | Unit of measure | GBReveg 1 | GBReveg 2 | GBReveg 3 | GBReveg 4 | GBReveg 5 | WBWood 1 | IronWood 1 | DReveg 1 | DReveg 2 | DReveg 3 | DWoodLQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Landscape Function Analysis (LFA): Landform stability and organisation** | Landform is stable and performing as it was designed to do | LFA Landscape organisation | % | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 89 | 86 | 100 | 100 |
| | **Vegetation diversity** | Vegetation contains a diversity of species comparable to that of the local remnant vegetation | Diversity of shrubs and juvenile trees | species/area | 1 | 0 | 0 | 0 | 0 | 5 | 6 | 2 | 3 | 1 | 1 |
| | | | | % population | 100 | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 100 | 100 | 100 |
| | | | Exotic species richness | <No./area | 14 | 4 | 15 | 10 | 13 | 1 | 1 | 6 | 1 | 12 | 0 |
| | **Vegetation density** | Vegetation contains a density of species comparable to that of the local remnant vegetation | Density of shrubs and juvenile trees | No./area | 1 | 0 | 0 | 0 | 0 | 8 | 129 | 11 | 3 | 1 | 8 |
| | **Ecosystem composition** | | Trees | No./area | 1 | 0 | 0 | 0 | 0 | 4 | 6 | 1 | 1 | 1 | 2 |
| | | | Shrubs | No./area | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 2 | 0 | 0 |

| Rehabilitation Phase | Aspect or ecosystem component | Completion criteria | Performance Indicators | Unit of measure | GBReveg 1 | GBReveg 2 | GBReveg 3 | GBReveg 4 | GBReveg 5 | WBWood 1 | IronWood 1 | DReveg 1 | DReveg 2 | DReveg 3 | DWoodLQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | The vegetation is comprised by a range of growth forms comparable to that of the local remnant vegetation | Herbs | No./area | 15 | 16 | 17 | 15 | 21 | 11 | 4 | 10 | 2 | 20 | 3 |
| **Phase 5: Ecosystem & Land use Sustainability** | **Landscape Function Analysis (LFA): Landform function and ecological performance** | Landform is ecologically functional and performing as it was designed to do | LFA Infiltration | % | 45.5 | 33.6 | 47 | 42.6 | 45.2 | 52.7 | 48.4 | 43 | 37.8 | 41.2 | 55.9 |
| | | | LFA Nutrient recycling | % | 44.1 | 31.1 | 42.1 | 37.6 | 43.9 | 53.2 | 44.3 | 39.7 | 37.8 | 35.8 | 54.9 |
| | **Protective ground cover** | Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation | Perennial plant cover (< 0.5m) | % | 9.5 | 6.5 | 20.5 | 5.5 | 6 | 4.5 | 2.5 | 10 | 5 | 16.5 | 1.5 |
| | | | Total Ground Cover | % | 96 | 72.5 | 89.5 | 83 | 96.5 | 99 | 80.5 | 76 | 72 | 87.5 | 87.5 |

| Rehabilitation Phase | Aspect or ecosystem component | Completion criteria | Performance Indicators | Unit of measure | GBReveg 1 | GBReveg 2 | GBReveg 3 | GBReveg 4 | GBReveg 5 | WBWood 1 | IronWood 1 | DReveg 1 | DReveg 2 | DReveg 3 | DWoodLQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Native ground cover abundance** | Native ground cover abundance is comparable to that of the local remnant vegetation | Percent ground cover provided by native vegetation <0.5m tall | % | 47.8 | 73 | 37.3 | 59.6 | 58.7 | 96.7 | 100 | 96 | 97 | 66 | 100 |
| | **Ecosystem growth and natural recruitment** | The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant vegetation | shrubs and juvenile trees 0 - 0.5m in height | No./area | 1 | 0 | 0 | 0 | 0 | 6 | 94 | 1 | 2 | 1 | 8 |
| | | | shrubs and juvenile trees 1.5 - 2m in height | No./area | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 |
| | **Ecosystem structure** | The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation | Foliage cover 0.5 - 2 m | % cover | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | | | Foliage cover >6m | % cover | 0 | 0 | 0 | 0 | 0 | 48 | 45 | 0 | 0 | 0 | 40 |

| Rehabilitation Phase | Aspect or ecosystem component | Completion criteria | Performance Indicators | Unit of measure | GBReveg 1 | GBReveg 2 | GBReveg 3 | GBReveg 4 | GBReveg 5 | WBWood 1 | IronWood 1 | DReveg 1 | DReveg 2 | DReveg 3 | DWoodLQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Tree diversity** | Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation | Tree diversity | % | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 0 | 0 | 100 |
| | **Tree density** | Vegetation contains a density of maturing tree and shrubs species comparable to that of the local remnant vegetation | Tree density | No./area | 0 | 0 | 0 | 0 | 0 | 8 | 40 | 1 | 0 | 0 | 9 |
| | **Ecosystem health** | The vegetation is in a condition comparable to that of the local remnant vegetation. | Live trees | % population | 0 | 0 | 0 | 0 | 0 | 88 | 70 | 100 | 0 | 0 | 100 |
| | | | Healthy trees | % population | 0 | 0 | 0 | 0 | 0 | 0 | 2.5 | 100 | 0 | 0 | 0 |
| | | | Flowers/fruit: Trees | % population | 0 | 0 | 0 | 0 | 0 | 62.5 | 20 | | | | 66.7 |

#### 6.6.2.2.2 *Landscape Function Analysis Monitoring*

Landscape Function Analysis (LFA) monitoring was also undertaken at the seventeen permanent plots. LFA is a methodology used to assess key indicators of ecosystem function including landscape organisation and soil surface condition as measure of how well the landscape retains and uses vital resources. The indicators used quantify the utilisation of the vital landscape resources of water, topsoil, organic matter and perennial vegetation in space and time. Soil sampling was also undertaken at the plots.

For information on LFA monitoring undertaken at Kokoda during 2019, refer to Table 16 and the 2019 Kokoda Offset Monitoring Report.

#### 6.6.2.2.3 *Targeted Bird Surveys*

Targeted bird surveys were carried out at Kokoda in winter and spring 2019. Bird surveys were conducted at six sites across two days in winter and eleven sites across two days in spring. Surveys consisted of a 2 ha area search for 20 minutes in suitable habitat within Kokoda on each day.

All bird surveys undertaken at Kokoda in 2019 were undertaken by an ecologist. Winter bird surveys targeted the Regent Honeyeater and Swift Parrot, and spring bird surveys targeted the Superb Parrot and eastern subspecies of the Grey-crowned Babbler. During targeted bird surveys, all birds seen (using binoculars) or heard (using diagnostic calls) were recorded. Targeted bird surveys were undertaken twice at each survey site each time in the early morning when birds are most active and vocal to maximise detectability. Any opportunistic bird species identified during surveys were also recorded.

During targeted bird surveys at Kokoda in 2019, a total of 55 bird species were recorded during winter and a total of 66 bird species during spring. Five of those species were identified as threatened and/or migratory under the *Biodiversity Conservation Act 2016* and *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). These include:

- Superb parrot (Polytelis swainsonii) (EPBC: V/ BC: V) - observed during winter and spring surveys (Figure 22);
- Grey-crowned babbler (eastern sub-species) (Pomatostomus temporalis) (BC-V) - observed during winter and spring surveys (Figure 22);
- Diamond Firetail (*Stagonopleura guttata*) (BC-V) observed during winter and spring surveys;
- Dusky Woodswallow *(Artamus cyanopterus)* (BC-V) observed during winter survey (Figure 22); and
- Speckled Warbler (*Chthonicola sagittata*) (BC-V) observed during winter and spring.

The threatened species list was less than previous years in comparison. The Dusky Woodswallow (right) was recorded for the first time at Kokoda.

The grey-crowned babbler (centre) is a sedentary species; therefore, these records are likely to indicate that populations of this species occur within Kokoda. However, the superb parrot (left) is a nomadic species and likely to only use the site for foraging during eucalypt flowering.

Figure 22 Superb Parrot, Grey-crowned babbler (eastern sub-species) & dusky woodswallow

#### 6.6.2.2.4 *Biometric Vegetation Surveys*

Biometric vegetation surveys were undertaken at the Kokoda Biodiversity Offset Site in 2019 between the 8th and 10th of October to support Northparkes Voluntary Conservation Agreement (VCA). Results were found to be consistent with previous monitoring years. The VCA for Kokoda was submitted in 2017, as per the Northparkes project approvals and was signed by Northparkes and the Office of Environment and Heritage (OEH) Executives in February 2018.

#### 6.6.2.2.5 *Qualitative Biannual Inspections*

Biannual inspections of the Kokoda Biodiversity Offset Site were undertaken on 30 April 2019 and 26 November 2019 and recorded the presence and locations of pests and weeds as well as outlined any maintenance activities that may require action.

During the May inspection, Northparkes personnel noted the previously recorded patch of Tree-of-Heaven had significantly deteriorated in condition as a result of actioned spraying from the previous inspection. No feral pest species or weeds of concern were observed during the visit. As the drought pressure increased, natural regeneration across the conservation area maintained its condition. Significant macropod grazing had caused groundcover to reduce though still sufficient enough to provide erosion and runoff control.

During the November inspection, Northparkes were undertaking major civil works as per conditions of the VCA. Works included but not limited to the construction of firebreaks, installation of exclusion fencing and maintenance of internal tracks. No pest species were observed at time of inspection. The Tree-of-Heaven population was still present though in poor condition. Further spraying will be actioned if required.

No actions were assigned during the 2019 period though opportunities for improvement are continuously investigated.

#### 6.6.2.2.6 *Opportunistic Flora and Fauna Monitoring*

Prior to the erection of exclusion fencing around the boundary of the Kokoda Offset Area, a number of trial cameras were set up across Kokoda to opportunistically observe the range of potential feral animal species. The cameras were then again set up after the completion of the fencing to assess what species required ongoing management. Table 17 details the current presence of feral animal species from the trail cameras. Although the presence of cats and pigs have not been captured post fencing, it is possible they exist within offset area, but are yet to be photographed. Programs for the management of these feral pest species, mainly pigs and goats, will be investigated during 2020.

**Table 17 Presence of feral pest species**

| Feral Animal Species | Prior to Fencing | Post Fencing |
|---|---|---|
| Cats | Yes | No |
| Dogs | No | No |
| Foxes | Yes | Yes |
| Pigs | Yes | No |
| Goats | Yes | Yes |

#### *6.6.2.3 Pine Donkey Orchid Population Monitoring*

Field inspections of the two populations of the pine donkey orchid (*Diuris tricolour*) (Figure 23) found within the Northparkes mining lease were carried out from mid-September through to early October. Targeted inspections for emerging and effloresced plants were undertaken to coincide with the species flowering period. The density of *Diuris tricolor* individuals recorded at the two populations have varied significantly over the years, with the seasonal conditions and survey timing having a significant impact on the orchid populations, ground cover abundance and ease of identification. In 2017, exceptionally dry conditions resulted in individuals being stunted with most being 10-15cm in height. Some individuals had finished flowering, while others were in bud. In 2018, very dry conditions persisted throughout the year. There was however 31 mm and 29 mm of rain falling during August and September which has promoted the emergence of the Pine Donkey Orchids. The combination of dry conditions and slightly earlier surveying resulted in individuals that were also very small, and many were still in bud. This year, no individuals were recorded at all as a result of the continued dry conditions and increased grazing pressure by macropods.

**Table 18 Number of Pine Donkey Orchids observed during surveys.**

| Population | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| Limestone Forest | N/A | 69 | 143 | 485 | 37 | 494 | 0 |
| Adavale Lane | N/A | 130 | 38 | 603 | 37 | 52 | 0 |
| **Total** | **947** | **199** | **181** | **1,088** | **74** | **546** | **0** |

Figure 23 Pine Donkey Orchid (*Diurus tricolour*)

### 6.6.3 *Biodiversity and Ecology Improvements and Initiatives*

Northparkes has implemented a comprehensive biodiversity monitoring program, which will continue through the next reporting period to consistently track and inform Northparkes' performance in meeting biodiversity objectives.

Revegetation works within Kokoda will target the optimal planting times during 2020. They will be undertaken in accordance with the commitments outlined in the approved BOMP and the VCA. The 2020 revegetation works will involve the planting of approximately 18,000 native species throughout a total area of 37 ha within the habitat restoration zones of the Kokoda. The individual areas subject to revegetation are planted with species aimed at restoring the following ecological communities:

- Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest; and
- Grey Box Grassy Woodlands.

## 6.7 Waste

### 6.7.1 *Waste Management*

The Consent, specifically Schedule 3 Condition 38, requires the following with regards to waste:

- Implement all reasonable and feasible measures to minimise waste generated by the Project;
- Ensure waste generated by the Project is appropriately stored, handled and disposed of; and
- Monitor and report on the effectiveness of waste minimisation and management measures in the Annual Review.

Northparkes Waste Management Plan covers aspects of waste management peripheral to mining activities, i.e. does not include production waste, such as coarse or fine reject. The Waste Management Plan was prepared in accordance with the objectives of the *Waste Avoidance and Resource Recovery Act 2007* and is based on the waste management hierarchy of avoid, reduce, reuse, recycle and dispose.

Waste management measures employed on site include:

- Green putrescible waste will be collected on site and disposed of at an appropriate licensed waste management facility;
- General waste from operations is disposed of at an appropriate licensed waste management facility;
- Recyclable wastes are collected for recycling at an appropriate facility;
- Contaminated soil is collected and transported to the on-site bioremediation area for treatment and eventual on-site disposal;
- Scrap metal materials are separated onsite and collected by a recycling contractor for off-site recycling;
- All waste oils and greases are segregated and stored appropriately until collection by a licensed waste contractor for appropriate offsite recycling/disposal;
- Waste chemicals (including solvents) are segregated, stored appropriately and transported offsite by a licensed waste contractor for appropriate disposal;
- Contaminated areas are bunded and water is reused within the process water circuit; and
- Clean water surface water/runoff is diverted around mine facilities (where feasible).

### 6.7.2 Waste Performance

Northparkes tracks operational waste disposal for all key waste streams. All waste streams are stored in appropriate containers prior to disposal at licenced facilities.

This reporting period has seen an increase in many waste streams compared to the 2018 reporting period. This can be attributed to the increased amount of consumables required for various projects being undertaken by Northparkes. Operational waste collection statistics for the 2019 reporting period is summarised in Table 19.

**Table 19 Summary of Waste Disposal**

| Waste Stream | 2019 (tonnes) |
|---|---|
| **Hazardous recycled**: empty drums; oil filters; oily water; waste grease; waste oil; dust suppressant/resin/glue; and fluorescent tubes. | 195.67 |
| **Hazardous disposal**: hydraulic hose; medical/sanitary waste; oily rags; and used absorbent | 24.35 |
| **Non-Hazardous recycled**: co-mingled; poly pipe | 20.94 |
| **Non-Hazardous disposal**: mixed solid waste | 213.40 |
| **Contained onsite**: timber and effluent | 3.16 |
| **Recycled metal** | 995.90 |
| **TOTAL** | **1,453.42** |

Northparkes and its contractors have continued to implement the waste management hierarchy. Wherever possible, waste materials are re-used on site in preference to direct disposal. Recycling of materials is also undertaken where possible to minimise waste. An example of reuse is the integration of an oil water separator at the wash bay, which minimises waste water and returns water to the water management system for re-use.

Site induction packages include waste awareness components and Northparkes has included waste best practice in employee and contractor HSE sessions. Environmental surveillance was undertaken by Northparkes throughout the reporting period with observations and non-conformances communicated as necessary to relevant contractors.

### 6.7.3 Bioremediation Areas

The bioremediation area was maintained and monitored during the reporting period, as listed in Table 20. Successful management of this bioremediation area has allowed for onsite treatment of contaminated material and subsequently reduced the need to transfer contaminated waste material offsite. The bioremediation area was active during the 2019 reporting period (refer to Table 20).

The materials retained in the bioremediation area are aerated and watered as required. A bioremediation agent was also applied to the material as necessary.

During the reporting period, sampling of the surge dam (eastern cell) material was undertaken and analysed for residual hydrocarbons and contaminants. Further testing will be undertaken, as required, during the 2020 period to deem it suitable for disposal.

**Table 20 Summary of Bioremediation Activities**

| Initiated | Origin of Material | Description | Completion |
|---|---|---|---|
| 2016 | - | Construction of bioremediation area | 2016 |
| 2016 | Surge Dam (western cell) | The treatment of approximately 15,000m³ of material from the western dam with Micro-Blaze formulation | 2017 |
| 2019 | Surge Dam (eastern cell) | The treatment of approximately 21,000m³ of material from the eastern dam with Micro-Blaze formulation | Ongoing |

### *6.7.4 Waste Improvements and Initiatives*

Consistent with the implementation of the waste management hierarchy, Northparkes and its waste contractor continue to look for ways to re-use waste materials onsite in preference of direct disposal. Overall waste disposal volumes are predicted to increase in 2020 due to increased focus on site clean-up.

## 6.8 Cultural Heritage

### *6.8.1 Cultural Heritage Management*

The management, including identification, assessment and monitoring, of cultural heritage at Northparkes is undertaken in accordance with the Cultural Heritage Management Plan (CHMP).

The CHMP prescribes:

- The policies and practices for the preservation of sites during construction and operations;
- Other facets of cultural heritage practices and conservation measures including salvage of sites as required and the practice of due diligence inspections;
- Management of unanticipated Aboriginal objects; and
- Other relevant cultural heritage considerations including consultation with the Aboriginal community.

Northparkes utilises a Site Disturbance Permit (SDP) approval system to manage the protection of heritage sites on the mining lease. This approval process applies to activities planned in undisturbed areas or previously rehabilitated areas. The area to be disturbed is compared to the Aboriginal cultural heritage sensitivity zones to determine the need for additional survey work or salvage work prior to starting the project.

### 6.8.2 Cultural Heritage Performance

In accordance with the CHMP, the Wiradjuri Executive Committee (WEC) met on a regular basis throughout the reporting period, with meetings held in February, April, June and December. The WEC is a consultation forum to enable appropriate review of the aboriginal heritage management practices at Northparkes and identify potential improvement opportunities from the community. The WEC reviews all SDP's at their quarterly meetings.

Works and initiatives undertaken by the WEC in the reporting period included:

- Review of all site disturbance permits issued by Northparkes during the reporting period;
- Feedback on selection of Northparkes Indigenous Scholarship recipients and encouragement of Indigenous employment;
- Maintained the Indigenous workforce participation rates at 6% as part of the School2Work program which actively engages the community; and
- Commitments outlined in the 2019 work plans included: education, community engagement, business development and employment and training.

A total area of 356ha were surveyed for archaeological assessments during the reporting period to assess the risk of possible impacts to heritage items/values around the possible disturbance areas, such as future tailings storage facilities or exploration drilling programs. Across the 356ha there were 317 artefacts identified, of which approximately 250 were within an area adjacent to lower reaches of Goonumbla Creek. The two photos within (Figure 24) were identified during the reporting period and were left in-situ. The photo to the left shows a fine-grained quartzite that is estimated to have had at least 5 flakes struck from it. The photo to the right shows a ground-edge axe.

**Figure 24 Core with flakes removed and ground-edge axe**

### 6.8.3 Cultural Heritage Improvements and Initiatives

Work and initiatives planned for the WEC in the next reporting period include:

- Develop and complete 2020 work plans in the three identified areas: education, employment and community engagement;
- Support school to work programs including training and apprenticeships;
- Develop initiatives to increase the percentage of Indigenous employees within the workforce to 10%, within 5 years;
- Raise employee awareness and knowledge of Cultural Heritage through induction programs and sessions with leadership teams;
- Improve community engagement through volunteer opportunities including the Local Aboriginal Land Council project and Meet You Up The Street program; and
- Undertake a review of the current CHMP and implement an ongoing monitoring program for known registered sites.

# 7. WATER MANAGEMENT

Water management at Northparkes is undertaken in accordance with approved management plans, prepared generally in accordance with Consent. The Water Management Plan (WMP) acts as the overarching document to governing water management at Northparkes. Approved subordinate plans supporting the WMP include:

- Surface Water Management Plan (SWMP);
- Groundwater Management Plan (GWMP); and
- Site Water Balance (SWB) report.

## 7.1 Surface Water

### *7.1.1 Surface Water Management*

Surface water is managed in accordance with the SWMP and associated water management plans which conform to the Consent, licenses and other regulatory requirements of Northparkes.

The primary objectives of water management at Northparkes is to manage dirty and contaminated catchment runoff, divert clean water around operational areas of the mine and to collect and store water for use on site to minimise the dependence on external water supplies. A critical component of the water management system is to maintain zero discharge of contaminated water into the surrounding environment.

The water management strategy includes the separation of clean, dirty and contaminated water, categorised as follows:

- **Clean water** includes surface runoff from areas not affected by mining operations and includes runoff from undisturbed areas and rehabilitated areas and water supplied by external sources. The clean water system includes diversion drains and farm dams (FD) surrounding active mining areas in order to capture and divert clean water away from areas disturbed by mining operations.
- **Dirty water** includes sediment-laden runoff from disturbed areas, including waste rock stockpile areas, TSF embankments and surface infrastructure areas that are not associated with mineralized ore. Runoff from these areas is collected in sediment dams (SD) to allow sediment to fall out of suspension.
- **Contaminated water** includes water associated with mining, ore processing and tailings storage. Any potentially contaminated water is managed within retention ponds (RP), the Caloola Dams, E22 pit, surge dams and the process water dam to avoid uncontrolled discharge into surrounding watercourses and to maximise water reuse.

Erosion and sediment control is guided by the WMP and the SWMP, and is consistent with the "Blue Book" - *Managing Urban Stormwater, Soils and Construction, Volume 1* (Landcom, 2004) and *Managing Urban Stormwater, Volume 2E: Mines and Quarries* (DECC, 2008). Erosion and sediment control measures implemented include but are not limited to:

- Minimising ground disturbance where possible;
- Amelioration of dispersive soil to minimise the risk of rill, gully and tunnel erosion and to allow the infiltration of surface water;
- Contour scarification of compacted surfaces to encourage infiltration and surface roughness;
- Placing removed soils in areas where they are less likely to be affected by surface water run-off;
- Stockpiling in a stable manner by ensuring that topsoil is not dispersed and the height of stockpiles is restricted to 2m;
- Long term (greater than six months) stockpiles are stabilised by appropriate seeding or mulched vegetation where possible;

- Disturbed areas are rehabilitated as soon as possible following disturbance, including regrading where required;
- Where feasible, understory and ground cover vegetation are retained in and around drainage lines;
- Preventing vehicles from entering top soiled rehabilitation areas to prevent damage to vegetation and soil structure;
- Erosion and sediment control measures are installed before commencement of any works;
- All erosion control measures are maintained until all earthworks and mining activities are completed and site rehabilitation is complete; and
- All erosion and sediment control measures employed are appropriately designed, sized, located and installed. Erosion and sediment control measures include the use of:
    - Silt fencing;
    - Channel bed and bank protection;
    - Earth bunds and diversion drains;
    - Geotextile sediment fencing; and
    - Sediment retention basins.

In accordance with the Consent, Northparkes maintains a Surface Water Balance (SWB) for effective management of water resources. The SWB details water use, water demand and water management, as well as the sources and security of water supply, including contingency for future reporting periods. The SWB revision started in 2019 and will continue into 2020 in order to better reflect modifications to the mine plan and ongoing updates to the water model.

The following subsections describe surface water monitoring and environmental performance.

#### *7.1.1.1 Surface Water Quality Monitoring*

Water quality monitoring is undertaken at Northparkes specifically within the three defined water management systems of;

- Clean water management system, which includes farm dams and watercourses;
- Dirty water management system, which includes sediment dams; and
- Contaminated water management system, which includes all aspects of ore processing, and retention ponds.

Table 21 lists each monitoring location and their corresponding water management system.

**Table 21 Surface Water Quality Monitoring Location Catchments**

| Clean water management system | Dirty water management system | Contaminated water management system |
|---|---|---|
| **Upstream**<br>WC4. WC6, WC 7, WC13, W14<br><br>**Downstream**<br>WC1, WC2, WC3, WC5, WC11 WC12,WC15, WC16<br><br>**Farm Dams**<br>FD04, FD05, FD06, FD07, FD11, FD12, FD16, FD18, FD21, FD25, FD26, FD27 | SD03, SD10, SD15, SD16 | RP01, RP02, RP03, RP04, RP05, RP06, RP07, RP08, RP09, RP10, RP12 RP13, RP15, RP16, RP19, RP20, RP21, RP22, RP23, RP24, RP25, RP26, RP27, RP29, RP32, RP33<br><br>Grease Trap 1, Grease Trap 2, Process Water Dam, Surge Dam 1 and 2, Caloola Dams. |

The monitoring locations of watercourses and surface water storages are provided Appendix 2. Table 22 identifies surface water monitoring locations assessed for each of the above listed water management systems. There were some dams within the water management system that are typically dry. These monitoring locations were identified to have insufficient or no water quality data available for assessment.

The monitoring of watercourse stability is required to manage the potential impact on the watercourse from instabilities formed as a result to changes in the watercourses hydraulic operation. As part of the water quality monitoring in the watercourse locations, visual assessments are conducted to determine any visible instabilities. Records are made including comments regarding bed and bank condition as well as presence of riparian vegetation. Photographs may also be taken to provide further information on the status of the watercourse.

Table 23 provides information on the watercourse stability monitoring program.

**Table 22 Surface water monitoring program**

| Monitoring Locations | Frequency | Analytical Suite |
|---|---|---|
| Watercourses (clean water systems) | Quarterly | pH, EC, TSS, TDS, Cu, Na, K, Ca, Mg, Cl, $SO_4$, $HCO_3$, $CO_3$ |
| Farm Dams (clean water systems) | Quarterly | pH, EC, TSS, TDS, Cu, NA, K, Ca, Mg, Cl, $SO_4$, $HCO_3$, $CO_3$ |
| Sediment Ponds (dirty water management system) | Quarterly | pH, EC, TSS, TDS, Cu, NA, K, Ca, Mg, Cl, $SO_4$, $HCO_3$, $CO_3$ |
| Retention Ponds and Process water system (contaminated water management system) | Quarterly | pH, EC, Cu |
| | Annual | pH, EC, TSS, TDS, Na, K, Ca, Mg, Cl, $SO_4$, $HCO_3$, $CO_3$, Al, As, Ba, Be, Cd, Co, Cu, Cr, Mo, Mn, Ni, Pb, Se, Th, U, Zn |

**Table 23 Watercourse stability monitoring program**

| Location | Frequency | Assessment Requirements |
|---|---|---|
| WC01, WC02, WC03, WC04, WC05, WC06, WC07, WC11, WC12, WC13, WC14, WC15, WC16 | Quarterly, additional sampling following heavy rainfall events. | Visual assessment of channel form, presence of instabilities in watercourse banks or in crossing structure (bridge/culvert). |

Northparkes uses a handheld multi-parameter water quality probe (pH, EC, temperature). All water quality samples requiring lab analysis are collected by a suitably qualified employee and sent to a NATA accredited laboratory for processing.

The existing monitoring program is subject to periodic review and as such will evolve with the continual development of Northparkes water management system.

### *7.1.1.2 Water Storage and Usage Monitoring*

Water storage levels of all active sediment ponds, retention ponds and process water dams are monitored and recorded periodically. This allows for effective management of stored supplies in terms of consumption, avoidance of potential discharges and infrastructure planning.

### *7.1.1.3 Surface Water Quality Criteria*

Surface water quality criteria based on a two-stage water quality trigger system based on the statistical analysis of the existing available water quality data is being reviewed in 2020.

Previous water management plan Stage 1 and Stage 2 trigger values as well as livestock water quality guidelines were taken into consideration when developing the updated site relevant water quality trigger levels. The trigger levels for surface water quality sites are detailed in Appendix C of the approved WMP.

### 7.1.2 Surface Water Performance

#### 7.1.2.1 Results of Ambient and Events Based Monitoring

No samples were collected at WC1, WC2, WC3, WC4, WC5, WC6, WC7, WC11, WC13, WC14, WC15, WC16, FD6, FD12, FD18, FD27, RP05, RP06, RP07, RP08, RP10, RP12, RP16, RP19, RP23, RP24, RP26, RP28, SP03, SP10, SP15 and SP16 for the reporting period as they were dry or <10% volume throughout the monitoring period. Only one sampling event occurred at monitoring locations FD11, FD26, RP04, RP22, RP25 and RP32 due to locations also being dry or <10% volume during the monitoring period.

Copper levels were at or below the long-term averages for all retention and process water monitoring locations. The concentrations of copper throughout the reporting period is in line with or below the previous year and were in-line with long term averages. Electrical conductivity levels for retention ponds and process water monitoring locations were consistent with long term averages, apart from site RP32, SD1 and Caloola Dam, which triggered Northparkes Stage 2 trigger levels. As these locations contain processed operational water, fluctuations in chemical parameters are expected. These locations will however be monitored closely during the next sampling period for any further variations. Monitoring results for pH indicated that retention ponds and process water monitoring locations predominantly stayed below internal trigger levels and were consistent with the long-term averages.

The farm dams are located outside the mining lease within neighbouring properties, or adjacent to Northparkes's farming operations. The copper concentrations and electrical conductivity levels for farm dams generally remained stable and in-line with or below the long-term averages. The electrical conductivity for the reporting period was generally in-line with the long-term averages, except for FD11 and FD26 which increased above the long-term average. These sites will be monitored closely during the next sampling period for any fluctuations. pH generally remained consistent with the previous reporting period and long-term data.

All water courses remained dry for the entire year except for WC12, which is the Bogan River. All monitoring results were in-line with the long-term averages for all parameters.

Northparkes will continue to monitor and assess local water courses to ensure there are no detrimental mine related impacts to the local environment.

The monitoring results were predominantly in line with or below historical data and representative of the regional freshwater quality characteristics. The monitoring results are available in Appendix 2.

#### 7.1.2.2 Surface Water Storage

Water is essential in the processing of ore through the concentrator to produce copper concentrate. Effective water management is therefore crucial to the long-term success of Northparkes operations. A summary of the major water storages at the beginning 2018, 2019 and 2020 are provided in Table 24.

**Table 24 Major Water Storages**

| Major Storage Volumes (ML) | 01/01/2018 | 01/01/2019 | 01/01/2020 |
|---|---|---|---|
| Caloola North | 76 | 118 | 0 |
| Caloola South | 163 | 124 | 0 |
| E22 Void | 1,800 | 1,464 | 533 |
| Process Water Dam (PWD) | 130 | 172 | 132 |
| RP09 | 50 | 50 | 10 |

### *7.1.2.3 Water Supply*

Northparkes sources water from numerous locations including imported water from various licences (see Table 5). Water recycled from the on-site ore processing facility and tailings dam reclamation system is collected through existing on-site infrastructure.

Effective water management is crucial to the long-term success of Northparkes operations as it is essential in the processing of ore through the concentrator to produce copper concentrate. The operations water management system aims to efficiently and economically collect, store and re-use water onsite to minimise external water supply inputs and supplement supply during periods of high consumption.

In accordance with its licences and Consent, Northparkes accesses groundwater from the Lachlan Alluvial Water Sources. Northparkes also holds water entitlements for surface water extraction from the Lachlan River. Furthermore, Northparkes can trade additional water to make up shortfalls or sell any excess water in a reporting period. Where necessary, Northparkes uses existing water entitlements to supplement demand. The water supplied by Northparkes licenses for mining activities during the 2018/2019 water reporting period is detailed in Table 25.

**Table 25 Northparkes 2018/2019 Mine Water Entitlements and Use**

| Water Licence | Water sharing plan, source and management zone | Licenced Volume (ML) | Temporary Transfer (ML) | Passive take/ inflows | Active Pumping | Total |
|---|---|---|---|---|---|---|
| WAL9995 | Lachlan River, Water Sharing Plan; Lachlan River Regulated River Water Source | 260 | 0 | 0 | No | 0 |
| WAL8241 | | 2976 | 0 | 0 | No | 0 |
| WAL7866 | | 495 | 0 | 0 | No | 0 |
| WAL21471 | | 200 | 0 | 0 | No | 0 |
| WAL21466 | | 50 | 0 | 0 | No | 0 |
| WAL1698 | | 486 | 0 | 0 | No | 0 |
| WAL13108 | | 300 | 0 | 0 | No | 0 |
| WAL34955 | Lachlan River, Water Sharing Plan; NSW Murray Darling Basin Fractured Rock Groundwater Sources | 232 | 0 | <10 | No | <10 |
| WAL32138 | Lachlan River, Water Sharing Plan; Lachlan Unregulated and Alluvial Water Sources | 1110 | 0 | 0 | No | 0 |
| WAL32120 | | 1050 | 0 | 0 | Yes | 546.05 |
| WAL32004 | | 1600 | 0 | 0 | Yes | 1,189.03 |
| WAL31969 | | 1728 | 0 | 0 | No | 0 |
| WAL31963 | | 700 | 0 | 0 | No | 0 |
| WAL31930 | | 600 | 0 | 0 | No | 0 |
| WAL31863 | | 534 | 0 | 0 | No | 0 |
| WAL31850 | | 500 | 0 | 0 | No | 0 |
| WAL10082 | Lachlan River, Water Sharing Plan; | 1 | 0 | 0 | No | 0 |

Core water demands during the 2019 reporting period were for ore processing and dust suppression. Small quantities of water were also required for vehicle wash down and potable water uses. Table 26 outlines future estimated water volumes for Northparkes as described in the EA (Umwelt, 2013). Water demand predictions were initially provided in the EA; and have remained unchanged through subsequent project modifications.

**Table 26 Predicted Water Demand**

| Water Source | Current Approved Operations (ML) |
|---|---|
| External | 4,350 |
| Recycled | 2,091 |
| Surface Water Runoff | 523 |
| Groundwater | 290 |
| Total | 7,254 |

### *7.1.3 Surface Water Improvements and Initiatives*

Within the next reporting period there will be several initiatives regarding water management. Northparkes will work to streamline monitoring requirements and refine the site water model to reflect current and future operations.

## 7.2 Groundwater

### *7.2.1 Groundwater Management*

Groundwater is managed in accordance with the approved GWMP. The GWMP provides a framework defining how Northparkes will assess, manage and mitigate impacts to the groundwater system. This particularly focuses on impacts to the shallow alluvial aquifer as a result of mining activities such as dewatering the open pit void and underground operations. The GWMP specifies impact assessment criteria and trigger levels to identify groundwater level and quality changes, and outlines Northparkes monitoring and reporting requirements for groundwater management.

#### *7.2.1.1 Groundwater Monitoring Program*

Northparkes groundwater monitoring program aims to identify any changes to the natural groundwater system as a result of mining operations and ensure compliance with the Consent. It focuses on potential impacts to environmental assets and groundwater users in the area surrounding Northparkes.

The monitoring program undertaken during the reporting period included:

- Quarterly monitoring of groundwater levels; and
- Quarterly laboratory groundwater quality analysis.

During the reporting period the active groundwater monitoring network comprised 42 monitoring bores screened across different geographical areas, including 14 surrounding the open cut voids, 12 surrounding the tailing storage facilities, 11 associated with the underground operations and five regional bores on neighbouring properties. Monitoring details for these bores are listed in Table 27 and their respective locations are shown in Appendix 2.

**Table 27 Groundwater monitoring program**

| Monitoring Locations | Frequency | Analytical Suite |
|---|---|---|
| TSF Bores, Open cut Bores, Underground Bores, Regional Bores | Quarterly | Water level, pH, EC, total dissolved solids, hydroxide alkalinity, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, sulphate, chloride, calcium, magnesium, sodium, potassium, aluminium, antimony, arsenic, beryllium, barium, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, zinc, nitrate, strontium, thallium, thorium, uranium, iron and mercury. |

#### *7.2.1.2 Groundwater Quality Criteria*

Northparkes engaged an independent consultant to conduct a review of trigger levels for groundwater levels and quality. The review was conducted to assist in providing more relevant trigger levels for the groundwater monitoring network. The trigger levels were developed to assist in identifying and appropriately managing potential groundwater impacts based on historical monitoring data available from the groundwater monitoring network. Northparkes has developed groundwater levels and quality criteria for each bore where there is sufficient data available.

Each bore has been set with Stage 1 and 2 trigger levels which correspond to Appendix D of the WMP. Applying individual trigger levels to bores provides Northparkes with a more accurate and representative range of the groundwater levels and quality of the bores. This enables more accurate interpretation of the monitoring data with respects to the Northparkes operation.

The trigger values for water level and quality for the groundwater monitoring sites are detailed in Appendix D of the WMP.

### *7.2.2 Groundwater Performance*

There were no non-compliances related to groundwater management recorded during the reporting period. All bores show trends that are generally within historical ranges of all parameters. All quarterly monitoring events were carried out successfully and within the scheduled period.

#### *7.2.2.1 Groundwater Levels*

Quarterly monitoring of groundwater levels are undertaken by suitably qualified Northparkes personnel in accordance with the approved GWMP. Throughout 2019 and over the last 10 years, groundwater levels have displayed a consistent upward trend at all monitoring bores (Figure 25, Figure 26, Figure 27 & Figure 28), the cause of which is currently under independent review as part of the water monitoring network review undertaken by a suitably qualified consultant. Annual rainfall over the past decade has been following a decreasing trend (Figure 29). Changes in rainfall over the past decade may also have effects on local water quality variability, which is further discussed in Section 7.2.2.2. Groundwater levels remained below internal trigger values set in the WMP.

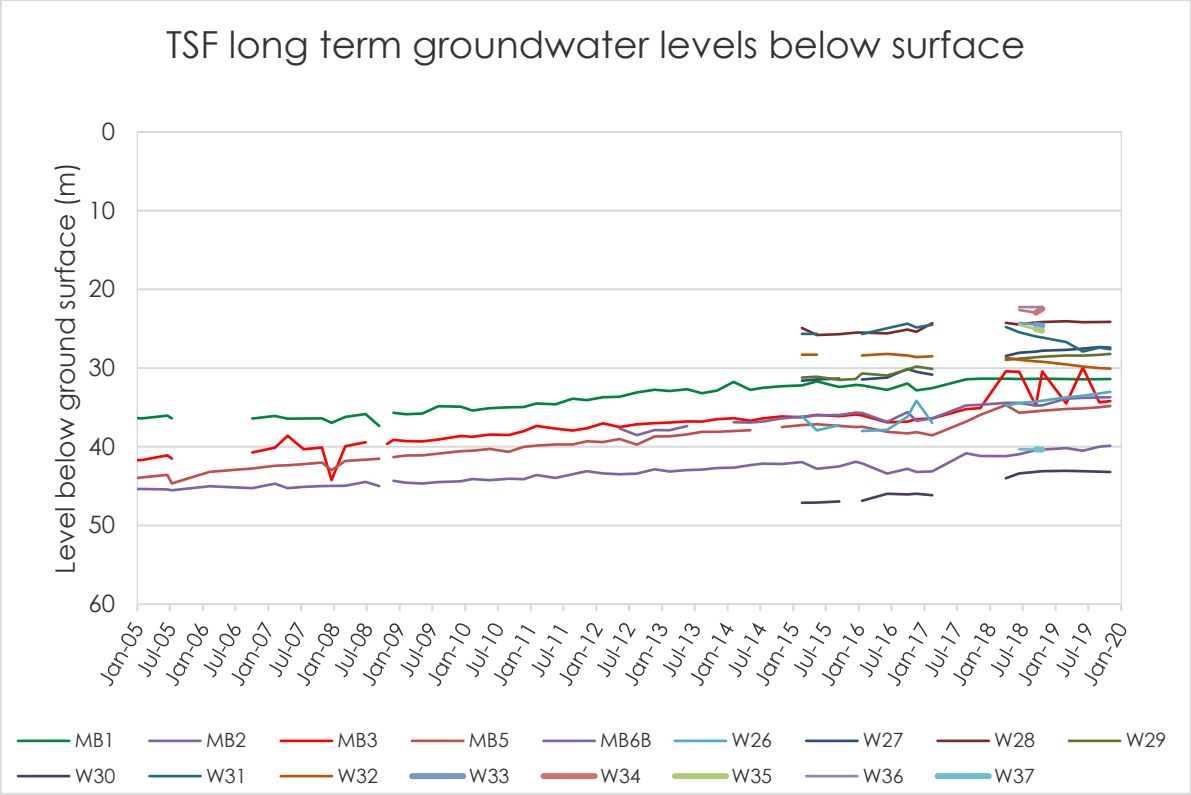



**Figure 25 Long term groundwater levels for TSF bores**

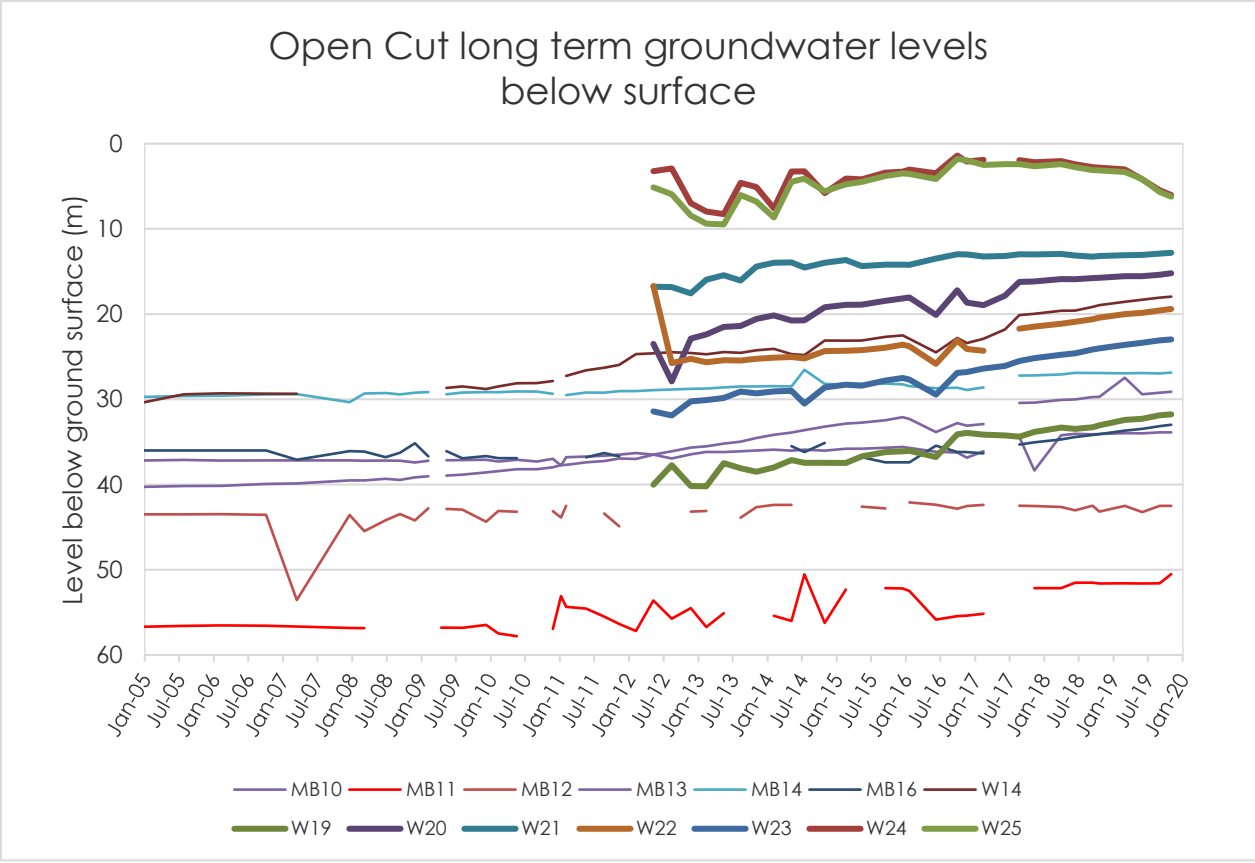



**Figure 26 Long term groundwater levels for Open-cut bores**

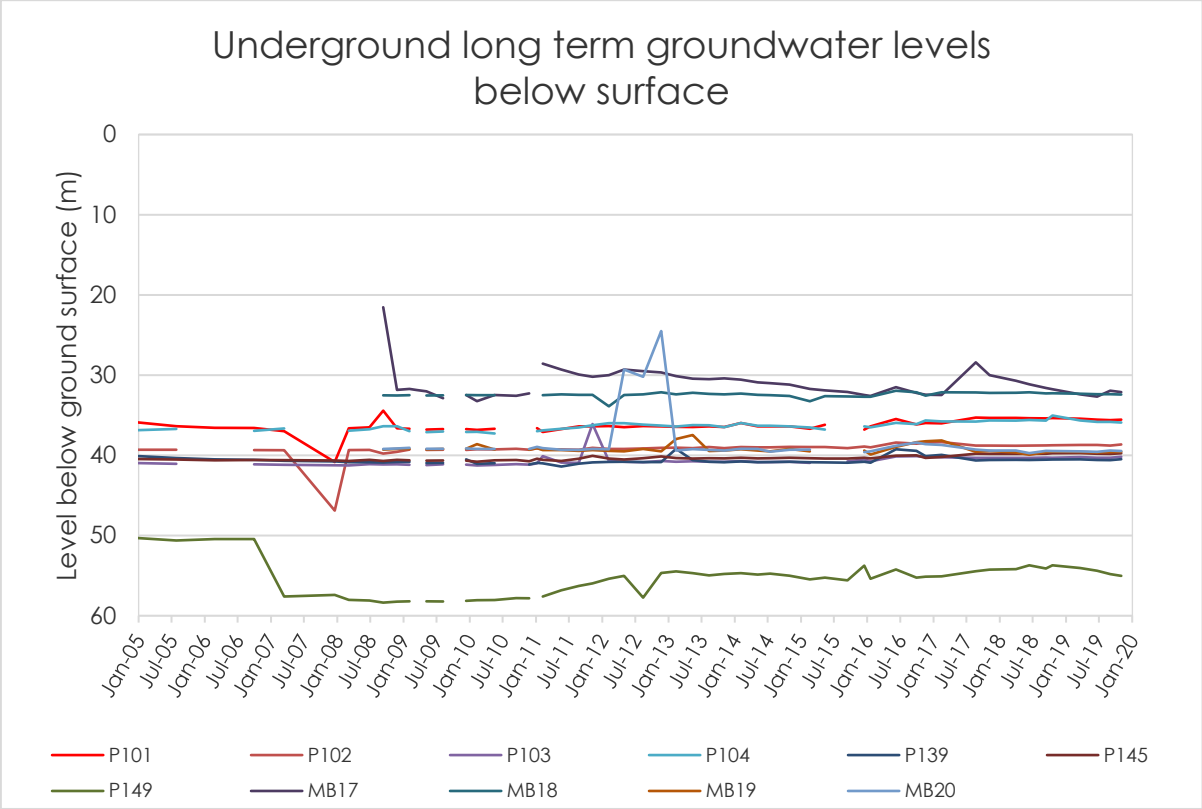



**Figure 27 Long term groundwater levels for Underground bores**

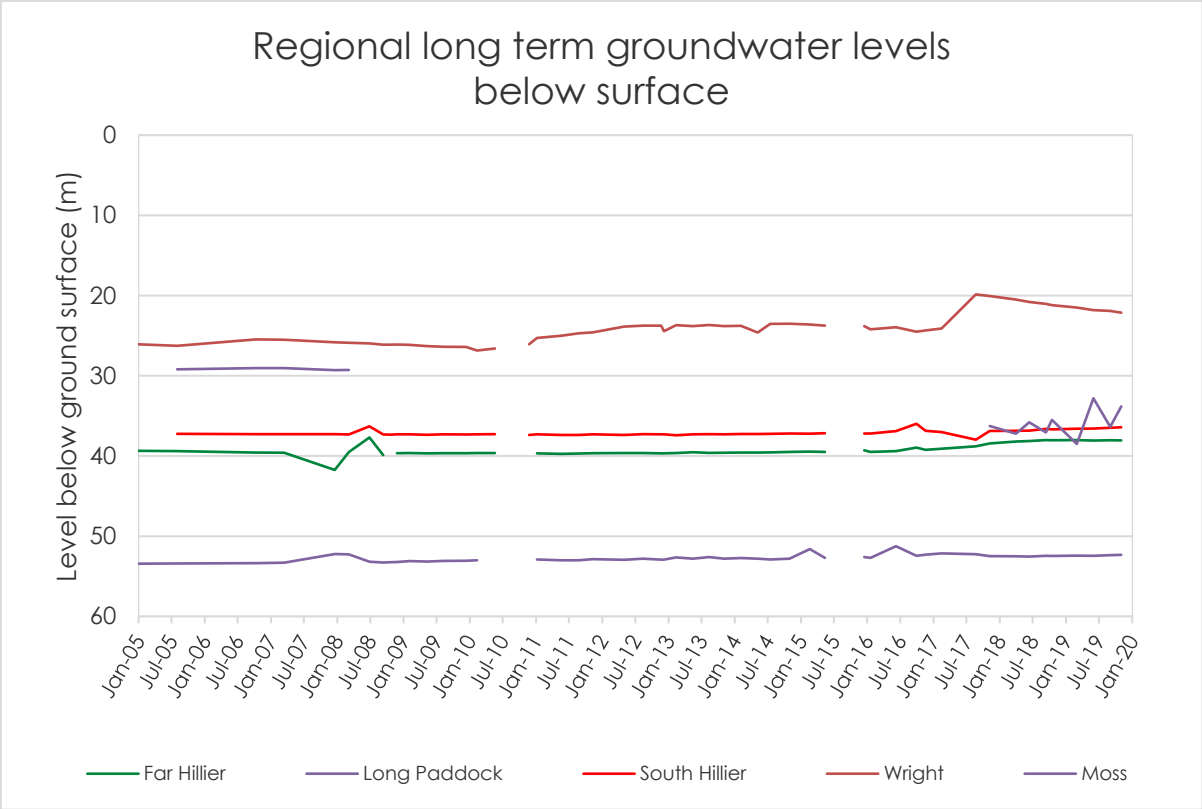



**Figure 28 Long term groundwater levels for Regional bores**

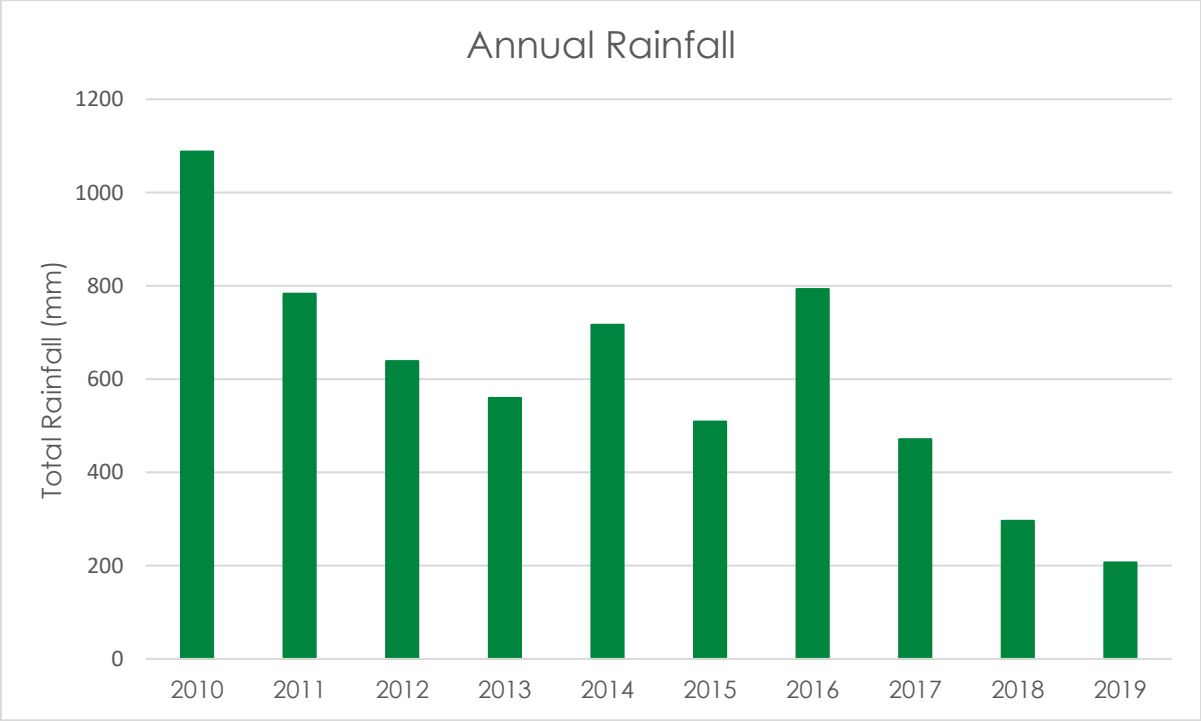



**Figure 29 Annual rainfall at Northparkes mines (Note: Parkes airport rainfall data 2010 - 2015)**

### *7.2.2.2 Groundwater Quality*

**TSF Bores**

For the TSF bores pH, copper and electrical conductivity have remained in line with the historical average, except for MB5 during the second quarter of the reporting period. Copper concentrations were recorded at 0.782mg/L, an increase from the previous quarter which recorded 0.008mg/L. Sampling results for the location returned within the long-term average for the following two periods, deeming the elevated result an anomaly.

**Open Cut Bores**

Open cut monitoring bore MB11 was not sampled during the reporting period and hasn't been sampled since Q2 2016 due to it being dry. The copper concentrations for all open cut bores were in line with the last reporting period and long-term averages. The pH concentrations and electrical conductivity levels remained consistent with previous years.

**Underground Bores**

The electrical conductivity and copper concentration results for all underground bores were in-line with long term averages and are all below the relevant internal investigation trigger levels. The pH results for underground bores were also in-line with the long-term average, except MB18 which showed elevated results slightly above the trigger level. This site will be monitored closely during the next sampling period for any fluctuations and investigated if required.

**Regional Bores**

Regional ground water quality remained similar to the previous reporting period and in-line with the long-term averages. Groundwater pH, copper concentration and electrical conductivity at each regional bore were generally consistent with previous monitoring periods.

The groundwater monitoring results were predominantly in-line with historical long-term average data, and consistent with the EA predictions. The monitoring results are presented in Appendix 2.

### 7.2.3 *Improvements and Initiatives*

A review is planned of the groundwater quality monitoring requirements as long-term trends continue to show no significant change since the inception of the project. Northparkes is proposing to revise the frequency of groundwater quality monitoring as quarterly monitoring is not showing any significant trends.

## 7.3 Water Balance

Northparkes has implemented a water model to capture water inputs, outputs and throughputs. The GoldSim model was updated in 2018 to incorporate the latest production data and demands.

Results of the model are incorporated in internal management decisions and are communicated internally to the leadership team on an annual basis.

In reviewing the mine water balance for the reporting period, the following is of note:

- In 2019, a total of 206.6 mm rainfall was recorded onsite which was 35 per cent of the annual average rainfall for Parkes;
- The volume of freshwater imported to site increased (1913 ML in 2015, 2221 ML in 2016, 1926 ML in 2017 and 2725 in 2018) from the previous reporting period. All water imported to site was from two groundwater licence allocations owned by Northparkes or through a commercial arrangement with Parkes Shire Council. No allocations of Northparkes river water was imported to site in the reporting period, as shown in Table 25;
- Total water use during the reporting period was significantly more compared to the previous reporting period with an increase of approximately 27% from 4,645 ML in 2018 to 5,881 ML in 2019. Improved water recovery from the tailings thickener reduced the requirement for fresh/recycled water return to the plant;
- Recycled water use increased during this reporting period from 41% in the 2018 reporting period to 49% (1920 ML in 2018 and 2872 ML in 2019);
- Details of Northparkes water balance for the reporting period are outlined in Table 28.

**Table 28 Reporting period water balance**

| Water Balance | Total (ML) |
|---|---|
| Total Water Input | 3,009 |
| Recycled | 2,872 |
| **Water Use** | **5,881** |

# 8. REHABILITATION

Northparkes owns and manages approximately 10,500 ha of land within and surrounding the mine leases. This area supports a range of land uses including mining, exploration, crop production and habitat re-establishment.

Rehabilitation activities at Northparkes incorporate the entire landholding in order to enhance the regional landscape and native habitat values. The Rehabilitation Strategy is described in Sections 2.0 and 3.0 of Appendix 4 of the EA. The State and Federal approvals both state that the rehabilitation of Northparkes must be consistent with the Rehabilitation Strategy (i.e. Schedule 3, Condition 39 of DC11_0060). The MOP summarises the key elements of the Rehabilitation Strategy as well as providing a description of activities and mine landform. As discussed within the 2015 to 2020 MOP, there are limited opportunities for progressive rehabilitation, however activities were carried out in accordance with the MOP.

The Rehabilitation Management Plan (RMP) was prepared to guide the ongoing management of the sites progressive rehabilitation as to ensure that it is integrated with the surrounding Northparkes owned land and is managed with a view to enhancing the regional landscape and native habitats.

## 8.1 Post Mining Land Use

Northparkes is committed to developing a stable landform that is capable of supporting sustainable ecosystems and enables sustainable land use after the completion of mining operations at Northparkes.

The agreed final land use as stated in the project Consent includes the following:

- Agricultural land use;
- Native vegetation re-establishment and conservation;
- Restricted land use; and
- Limestone Sate Forest.

## 8.2 Northparkes Farms and Adjacent Vegetation

Agricultural land around the mine site is used primarily for crop farming in combination with native vegetation communities. Since acquiring the agricultural holdings, Northparkes has placed considerable emphasis upon sustainable agricultural practices to minimise off-site impacts including:

- Removal of stock to minimise impacts to soil and vegetation;
- Conservation tillage practices; and
- Soil conservation works (including stubble retention).

Wherever possible, Northparkes has maintained remnant vegetation within its landholdings. An important component of the rehabilitation strategy is the development and implementation of revegetation plans that link the significant areas of remnant vegetation with wildlife corridors and enhance ecological value.

Land management aspects are monitored on a continuous basis across the mining lease and farms through inspections conducted by the Environment and Farms team. These aspects include vegetation clearing activities, top soil management and invasive weed and animal pest mitigation.

Scheduled inspections (known as Zero Harm Operations Walks (ZHOWs)) of areas within and surrounding the Northparkes mining lease, including the farms, are undertaken either on a quarterly or biannual basis. ZHOWs assess aspects of land management, soils, water and dust.

## 8.3 TSF1 Final Landform

During 2019 discharge of tailings recommenced using the central discharge method. This method creates a self-draining final landform that assists with closure of the facility. The central discharge requires the discharged of tailings in thin layers to enable drying. As such, the tailings discharge will continue to occur over several years.

## 8.4 Research and Rehabilitation Trials

### *8.4.1 TSF1 Trial Plots*

Since 2008, the Centre for Mined Land Rehabilitation (CMLR) has carried out a range of rehabilitation studies in association with the TSFs. The field trials, involving four trial plots of 20m X 20m within the southeast corner of TSF1, have different levels and layers of cover over the tailings, have continued through 2019.

**Table 29 TSF1 Capping trial design specifications**

| Design | Plot A | Plot B | Plot C | Plot D |
|---|---|---|---|---|
| | No specific cover | Shallow cover | Shallow cover with capillary break | Standard cover |
| Topsoil [m] | 0.1 | 0.1 | 0.1 | 0.1 |
| Waste rock [m] | -- | 0.4 | 0.4 | 0.9 |
| Capillary break [m] | -- | -- | 0.3 | -- |
| Total trial depth [m] | 0.1 | 0.5 | 0.8 | 1 |

The research trials demonstrated that the tailings at Northparkes generally contain low concentrations of sulphide bearing minerals and some residual metals from processing such as copper. Physically, they are characterised by relatively low hydraulic conductivity and small percentage of continuous macro-pores, which has limited free drainage but shows crack development close to the surface.

The following criteria for an optimal cover design informed the decision for the field trial plots:

- Avoidance of deep drainage;
- Sufficient depth of soil for plant growth;
- Storage of precipitation; and
- Prevention of upward salt movement.

The critical design criteria based on the findings of the previous studies were summarised as depth of cover and depth of topsoil. Modelling of the water balance for various cover design scenarios showed that for the climatic conditions of Northparkes, the contribution of vegetation to extract moisture from the cover could greatly improve the performance (i.e. reduces the risk of deep drainage). The maximum depth from which upward water flow caused by evaporation has been derived from modelling is approximately 1.8 to 2m. This depth would ensure avoidance of surface salt accumulation. In case of shortcomings of topsoil or other fine textured material, upward flow from a saline subsurface layer can be interrupted by a capillary break layer, consisting of coarse competent rock, which would allow a reduction of the cover thickness.

During 2019, the trial plots were assessed by Federation University Australia and the Sustainable Mineral Institute. The focus of the assessment was on the success of vegetation assessment, with the report attached within Appendix 3. The 2019 review is seen as a critical time in the assessment of vegetation maintenance due to the prolonged drought creating an unfavourable extreme situation.

The assessment of the trial plots showed the following key points:

- The proportion of revegetative plant cover is highest in the Plot A with the most direct revegetation. One conclusion is that this plot provides the highest access to soil moisture.
- Groundcover was greater than 40% for all plots, which assists in erosion reduction
- Salt enrichment at the soil surface or in the soil profile (Plot A) has increased compared to initial conditions
- Considering extreme drought conditions, salinity does not appear to have become a constraining factor for plant growth as long as plant species or seed mix matches conditions
- Despite the salinity of the tailings, the topsoil and possibly the hydrological conditions created by the plants by using soil moisture have reduce potential risk of salinity capillary rise
- A thickness of less than 0.5m of growth medium of vegetation will sustain plant growth and vegetation cover during periods of extensive drought
- Ongoing monitoring of the trials though out the drought and into future wet period is of high value, in particularly the dynamic of leaching of salts
- Future research into direct revegetation into tailings using salt tolerant species including a range of variables should be carried out

During the reporting period a review of the range of species established within the trial plots was also carried out. The most common ground cover across the four plots was Yanga Bush (*Maireana brevifolia*). The Plants of Western NSW state that this bluebush species can be found on a wide range of soils in many vegetation communities, often in saline situations and is drought resistant.

### *8.4.2 TSF2 Direct Revegetation*

Since 2015, Northparkes has engaged in a range of projects on the existing TSFs to reduce potential dust lift off. Direct seeding has proven to be a successful mitigation strategy to reduce dust lift off through vegetation cover on the existing TSF's.

The establishment of vegetation directly into tailings has not only proven to be an effective dust control strategy, but has proven vegetation establishment directly within the saline tailings surface is possible.

As TSF1 is currently receiving central discharge tailings to create and closure landform, the direct vegetation seeding was limited to TSF2 in 2019. During May 2019, the tailings beach of TSF2 was sown to barley. Due to prolonged drought conditions in 2019, there was limited barley growth. However, the bluebush and saltbush species continued to provide groundcover throughout the ongoing drought.

The ongoing success of these vegetation species directly in the TSF2 tailings has initiated a study into the potential long-term rehabilitation outcomes. The study will be initiated in 2020 and is planned to be carried out over several years to ensure vegetation performance is also measured in non-drought periods. The study will assess the benefits and risks of direct revegetation into tailings profiles at Northparkes.

**Figure 30 Bluebush and saltbush established directly within the TSF2 tailings (Oct 2019)**

## 8.5 Rehabilitation Status

The areas rehabilitated to date includes the E26 Oxide Dump, E26 Lift 1 Mullock Dump, waste rock dumps surrounding the E22 pit and the Northern and Eastern buttressed walls of TSF1. None of these rehabilitation areas on site have been signed-off by the appropriate regulatory authority to date.

In 2009 DnA Environmental established a total of 21 monitoring sites which included four mixed woodland and three native grassland reference sites. These monitoring sites are assessed on a three-year basis, with the next monitoring year being 2020. The previous monitoring results from 2017 were included in previous Annual Reviews.

All reference sites have been subjected to some prior form of disturbance, in particular clearing, logging and grazing and some sites were likely to be older regrowth. Exotic annual grasses and a range of other agricultural weeds such were also common.

The 14 rehabilitation monitoring sites were a combination of mixed native woodland and grasslands communities which occurred on various waste emplacements (E22, E26, E27) and on the sides of the Northern and Southern TSF's (TSF1, TSF2). Some sites were also established in revegetation areas located around the farming properties (Kundibah, Beechmore, Altona and Estcourt) as well in the Limestone Forest Offset (LFO) areas. Separate monitoring reports have been prepared to record ecological changes occurring in the Estcourt and Kokoda Offset Areas. The monitoring sites were chosen based on their final land use/vegetation community type and year of establishment and were considered to be representative of the rehabilitation area as a whole.

The mine sites rehabilitation status at the end of the 2019 reporting period are in line with the 2015-2020 MOP schedule. The 2015-2020 MOP forecast that a total of 99ha of ecosystem development to have been completed by the end of the MOP term, 2020. The detail within Table 30 aligns with the details within the 2020-2022 MOP.

The TSF1 external batters and tailings beach landform represent the 102ha of land being prepared for rehabilitation within Table 30. Northparkes currently has 54ha of operational areas and an additional 109ha within the Limestone State Forest within the ecosystem establishment phase. The reduction in the operational area within ecosystem establishment phase in 2019 is due to the removal of the E26 Clay Dump from emplacements to stockpiles. The 2019 increase in total area under rehabilitation is due to the TSF1 landform establishment works and addition of the Limestone State Forest.

There are no current or foreseeable issues that may affect the ability to successfully rehabilitate the site. Table 30 and Figure 31 provides the status of disturbance and rehabilitation as per '*Table 8*' of the guidelines.

**Table 30 Rehabilitation Status**

| Mine Area Type | 2018 Reporting Period (actual) | 2019 Reporting Period (Actual) | 2020 Reporting Period (forecast |
|---|---|---|---|
| Total Mine Footprint | 1251.04 | 1,144.88 | 1,191.59 |
| Total active disturbance | 1143.04 | 876 | 922.71 |
| Land being prepared for rehabilitation | 25 | 102.28 | 102.28 |
| Land under active rehabilitation | 84 | 162.6 | 162.6 |
| Completed Rehabilitation | 0 | 0 | 0 |

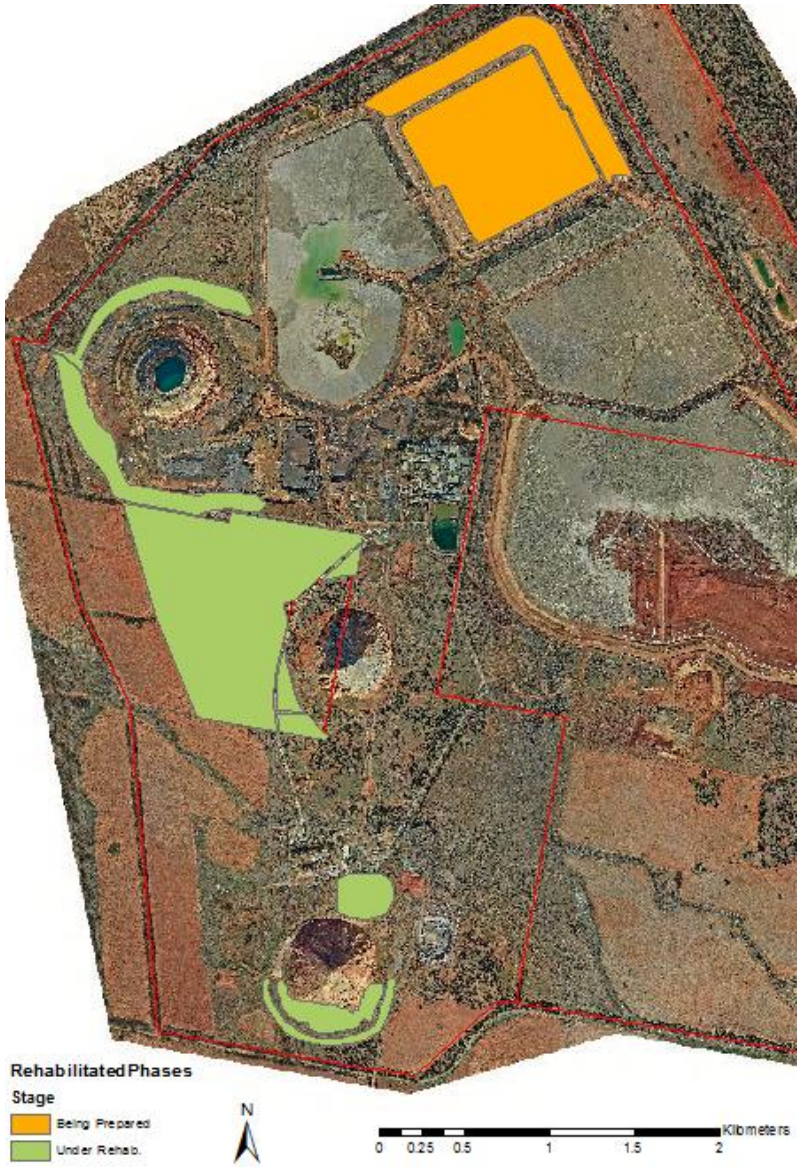



**Figure 31 Current status of mining and rehabilitation at the end of the reporting period.**

## 8.6 Rehabilitation Actions for the next Reporting Period

As per the commitments within the current MOP period, the following rehabilitation activities will be carried out:

- Rehabilitation Monitoring of Analogue Sites, which is detailed within Section 8.5;
- The ongoing monitoring of the established tailings cover trial plots on TSF1 will continue, which is detailed within Section 8.4.1;
- Research into the vegetation established directly into the tailings will be carried out in the next reporting period, which is detailed within Section 8.4.2; and
- An assessment of topsoil, subsoil and waste rock stockpiles will be initiated during the next reporting period. The study will assess the quality and quantity of the materials to assist in confirming the growth medium aspects of closure.

# 9. COMMUNITY RELATIONS

## 9.1 Reporting Period Summary

The Northparkes Stakeholder Communications Management Plan (the Plan) guides Northparkes relationship with the community in which it is licensed to operate. The Plan aims to address the various and, at times, diverse needs of Northparkes stakeholders: employees, community and government.

During 2019, Northparkes:

- Expanded stakeholder relationships;
- Worked closely with the community and proactively participated in community initiatives such as the Parkes Elvis Festival, Trundle Bush Tucker Day, various White Ribbon events and the Parkes Show;
- Invested in the future of the community through community contributions strategic partnerships in excess of $358,040.16; and
- Provided in-kind support to community groups throughout the Central West via its award-winning Volunteer Leave Program (Figure 32) - Northparkes employees volunteered 474 hours in the reporting period.
- Northparkes recognises the importance of positive relations with its community and takes this into account in the operation of its business and the decisions made.

**Figure 32 Employees participating in the Parkes White Ribbon March**

## 9.2 Community Engagement

Northparkes engages directly and regularly with the local community to both understand community issues and to keep the community updated about activities relating to the operations at Northparkes.

The Northparkes Community Consultative Committee (CCC) was established in 2006. The CCC provides an open forum to discuss any issues relating to Northparkes and its impact on the local community. The CCC comprises approximately seven community members and three Northparkes personnel. Two meetings were held in the reporting period in March and November 2019. No significant issues were raised during the meetings held with the community during the reporting period.

Northparkes respects the need for regular communication with its nearby neighbours. Neighbours meetings are typically held with Northparkes closest neighbours biannually to provide consultation and feedback in regard to mining activities.

We held one neighbours meeting during the reporting period in December.

In June, Northparkes distributed its annual Northparkes Report (previously known as the Sustainable Development Report) to key stakeholders. This report was also shared on the website, our social platforms and made available to all employees.

The Source community newsletter was distributed once during the reporting period with positive feedback from community members on the content, design and intent of the newsletter. The newsletter was published in January via insertion in the Parkes Champion Post and Forbes Advocate.

The Northparkes Facebook page was used actively as a two-way communication channel by both Northparkes and the community in 2019. The page now has over 3,000 followers.

**Figure 33 Employees engaging with our neighbours during a neighbours meeting.**

## 9.3 Contributions and Achievements

In line with its commitment to support a sustainable community, Northparkes has an investment program to manage financial support for local community events, committees and schools. This program encompasses a small number of carefully considered donations, the Northparkes Community Investment Program and the partnership programs. An independent sub-committee helps Northparkes make decisions regarding sponsorship requests from the local community, as part of the Northparkes Community Investment Program.

In 2019, Northparkes continued to provide financial assistance to local organisations that deliver benefits to the community. In excess of $350,000 was invested in various sporting, educational, cultural, industry, environmental and agricultural programs.

This funding was complemented by the nationally recognised Northparkes Volunteer Leave Program. This program allows Northparkes employees to volunteer for two days each year to help community groups throughout the Central West. Employees receive time in lieu if volunteering takes place outside of work hours. During the reporting period employees donated 474 hours to groups and projects throughout the Central West.

**Figure 34 A sample of photographs collected at Northparkes supported events**

The major initiatives in the current reporting period included:

- Over 90 employees participated in 15 volunteering initiatives, which included helping prepare for The Parkes agricultural show, supporting various White Ribbon events, the Parke Elvis Festival and assisting with the Trundle Bush Tucker day;
- Funding a Grants Officer Program in conjunction with Parkes Shire Council;
- Funding for an Aboriginal project officer in conjunction with Parkes Shire Council;
- A Sports Grant Program with the Parkes Shire Council;
- Sponsorship of the Parkes, Peak Hill and Trundle agricultural shows;

- Supporting education through the Parkes Life Education Program;
- A community equipment pool scheme which provides community groups access to equipment such as marquees, a blow-up TV screen, a PA system, eskies etc. for use free of charge; and
- Sponsorship of the Parkes Elvis Festival Street Parade.

## 9.4 Complaints

### *9.4.1 Management of Complaints*

Northparkes has a process for receiving, investigating, responding and reporting complaints received from community members. 24-hour external telephone lines are in place to allow the public to raise community concerns. These contact numbers are advertised on the Northparkes website (www.northparkes.com).

Registered neighbours of Northparkes also received via post an updated magnetised contact list including all relevant contact numbers of Northparkes personnel.

The website provides information about all aspects of Northparkes operations, and has the capacity for the community to submit enquiries, concerns or complaints via e-mail direct to the Community and External Relations Advisor.

All complaints received across site are referred to the Community and External Relations Advisor, and are then responded to in a professional and timely manner. All complaints are recorded, with the outcomes of investigation findings and corrective actions communicated to the relevant personnel and reported in the Annual Review and the annual Northparkes Report.

Northparkes maintained its dust risk notification communication strategy in 2019. The Northparkes Environment team distributes a weekly weather report, internally. If there is a high-risk dust day, the Community and External Relations Advisor sends an advance text message to any neighbour who may be affected. The message includes information about the expected high-risk day and any mitigating actions Northparkes plans to take, as well as the invitation to call the Community and External Relations Advisor if people have concerns or questions.

### *9.4.2 Registered Community Complaints*

During the reporting period, Northparkes received one complaint from a community member. The complaint is related to a Northparkes employee and their driving behaviours on local roads. This is the first complaint related to Northparkes Mines in over 2 years. The last complaint in 2017 was also related to driving behaviours.

The complainant was very happy with the timeliness and response to the matter by Northparkes. Monthly summaries of complaints are made publicly available on Northparkes website at: http://www.northparkes.com/news/#community-reports

Northparkes was not advised of any complaints to a regulator during the reporting period.

## 9.5 Workforce Profile at Northparkes Mines

Wherever possible, local personnel are employed by Northparkes and its contractors. The Northparkes team consists of 428 staff, with majority locally based. A breakdown of the local government areas where Northparkes employees reside is presented in Table 31.

**Table 31 Residential Locality of Northparkes Employees**

| Locality | Northparkes Employee Residency (%) |
|---|---|
| Parkes | 77% |
| Forbes | 11% |
| Dubbo | 2% |
| Orange | 2% |
| Peak Hill | 2% |
| Other | 6% |

# 10. INDEPENDENT AUDIT

As required by Schedule 6, Condition 9 and 10 of DC11_0060, Northparkes are required to undertake an independent environmental audit every three years. The last independent audit was carried out within the 2018 reporting period. The next independent audit is scheduled for 2021.

# 11. INCIDENTS AND NON-COMPLIANCES

## 11.1 Non-compliances during the reporting period

As stated within Section 1, there were two non-compliances recorded for the 2019 reporting period. The non-compliances are considered administrative or of low environmental risk. Details of the non-compliances are provided within the following sections.

### *11.1.1 Management Plan Reviews*

Schedule 6, condition 5 of the DC11_0060 states that the strategies, plans and programs required under the Consent are to be revised within three months of submitting the Annual Review. Not all management plans were revised between the 1st of April and June 30th as they were placed within an internal document review process.

The review timing for the Management Plans required under the DC11_0060 have had their annual review date altered to the 30th June.

### *11.1.2 Goonumbla Creek Incident*

In April 2019 Northparkes self-reported that slurry material from near the secondary crusher had been placed within the Goonumbla Creek clean water management area. All material was removed, and the site rehabilitated under consultation with a Wiradjuri Elder, an Archaeologist and under the supervision of the Environmental Team. Post clean up samples indicated that there were no traces of contamination.

Northparkes received an Official Warning from the Environmental Protection Authority under Section 120 and Section 64 of the Protection of Environment Operations Act, by breaching EPL 4784 condition L1.1.

## 11.2 Summary Environmental Incidents

During 2019 there were 26 internal environmental incidents reported across different event types and event outcomes, excluding the two events listed within Section 11.1. The details of incidents, likely causes, actions to date and additional proposed measures were uploaded into the site software package (known as NED) in accordance with reporting procedures. The break down between near misses and incidents is detailed within Table 32.

**Table 32 Environmental Hazards and Incidents in 2019**

| Event Type | Number |
|---|---|
| Hazards | 1 |
| Incident Near Miss | 9 |
| Incident Actual | 18 |
| **Total** | **28** |

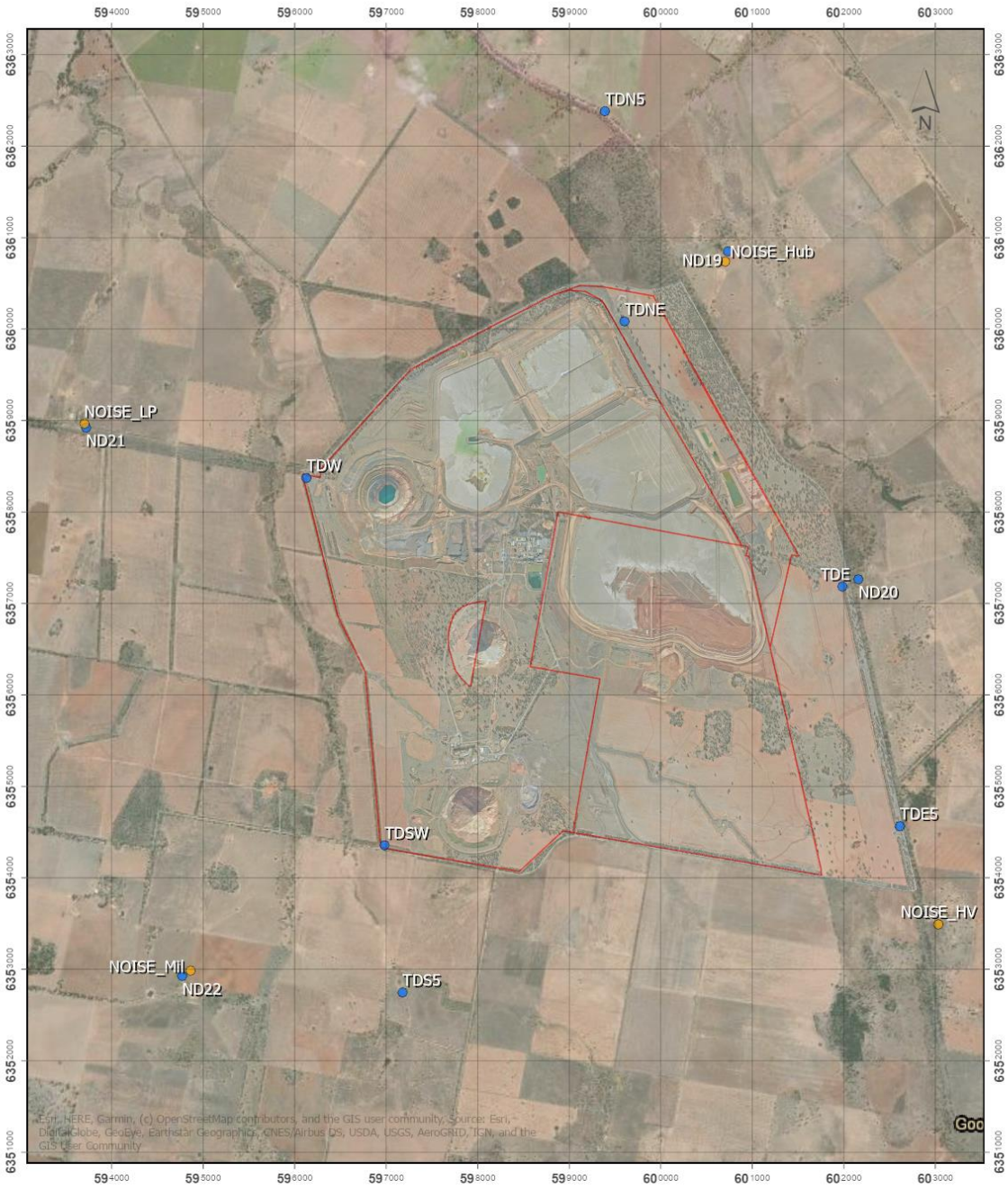
# 12. ACTIVITIES TO BE COMPLETED IN THE NEXT REPORTING PERIOD

Activities proposed for the next reporting period include:

- Review and revision of various Environmental Management Plans;
- Continue E26L1N development;
- A stakeholder information day and identification of community support initiatives;
- Year 1 Management Actions, including planting in the Kokoda Offset;
- Implementation of the software data management program to increase the efficiency of data transfer and management from field monitoring;
- TSF2 re-seeding;
- Water monitoring assessment aimed to improve the efficiency of field monitoring and removing unnecessary monitoring sites from the monitoring schedule; and
- Review of the regional air quality monitoring network, to remove those monitoring locations that are impacted by extraneous sources.

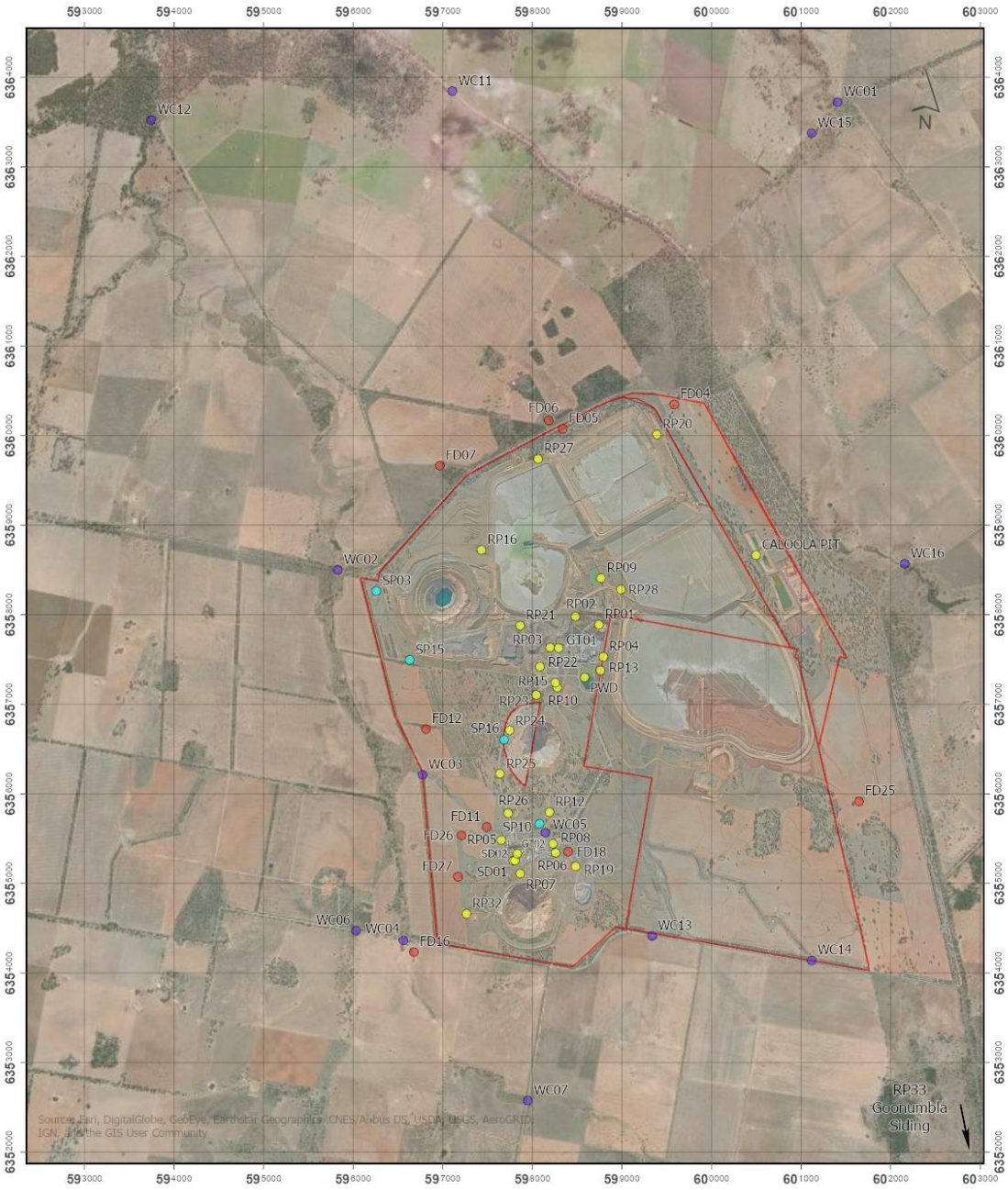
# APPENDIX 1

## Dust and Noise monitoring locations

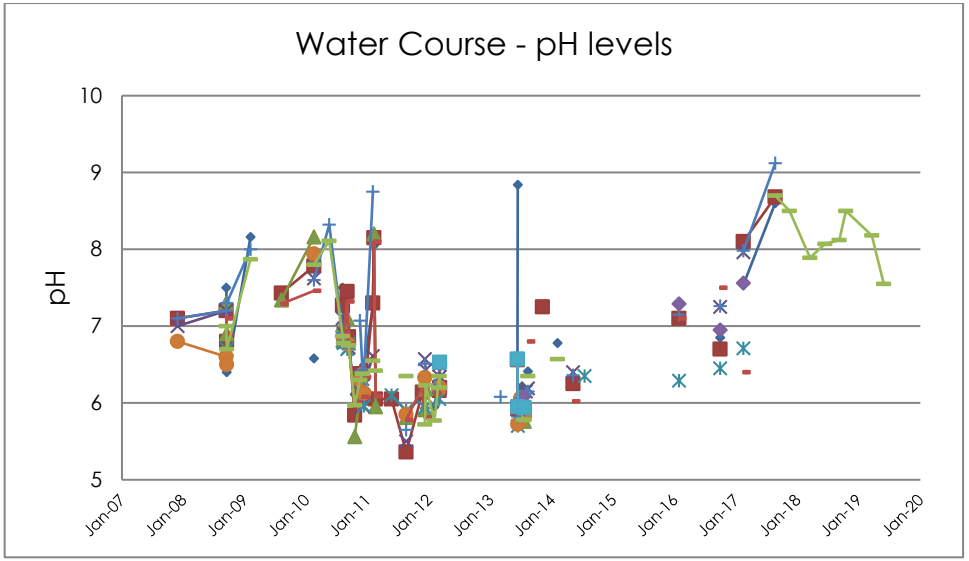


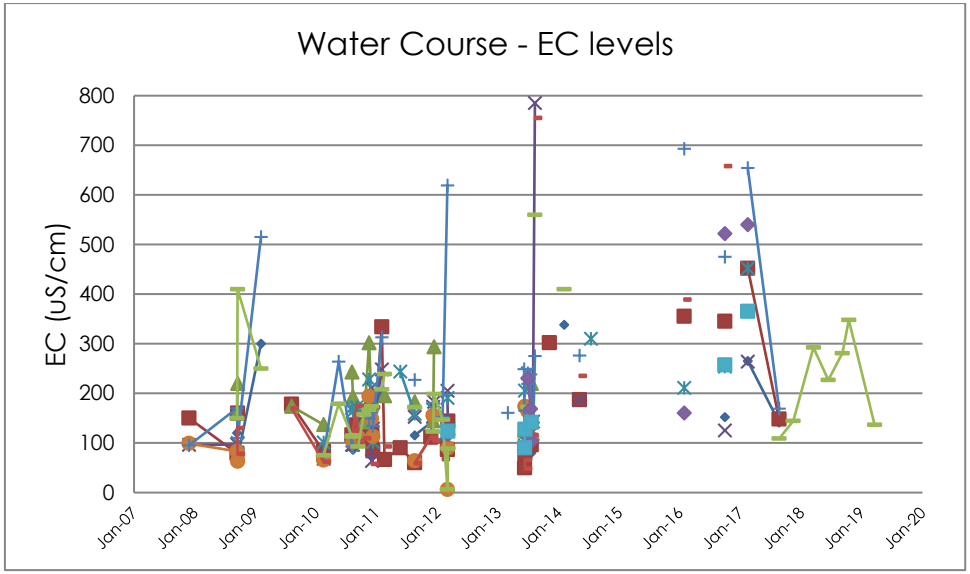
# APPENDIX 2

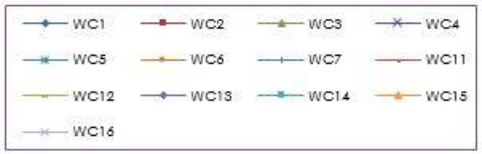
## Water monitoring: Surface water monitoring locations

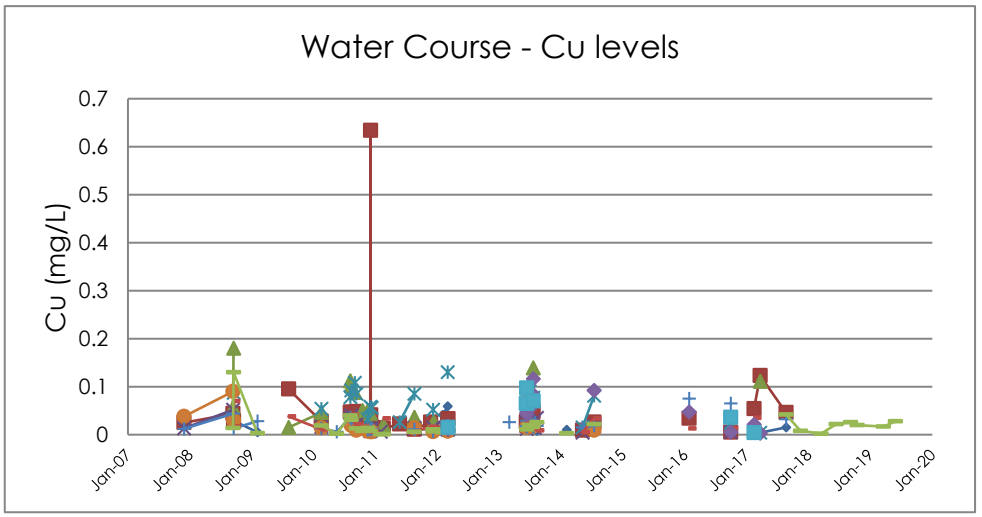


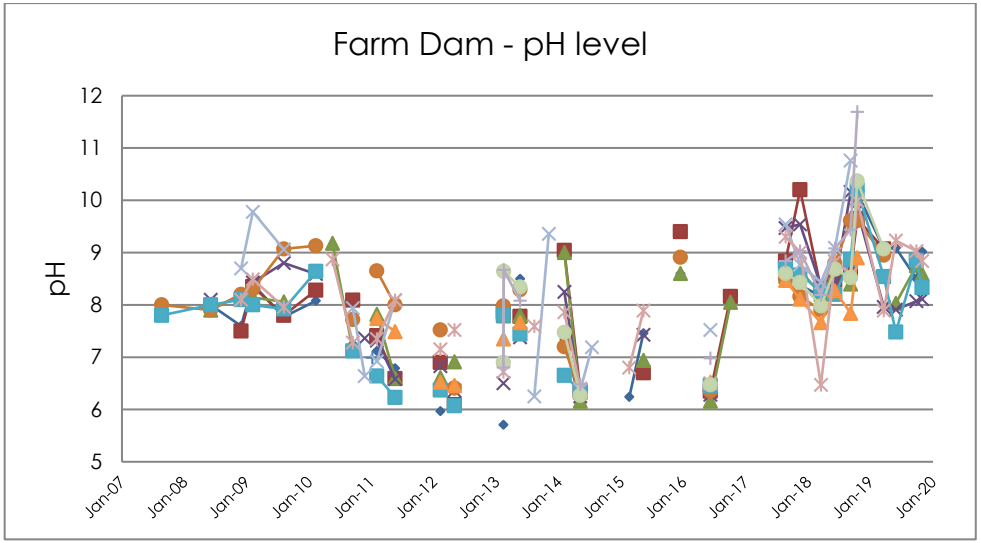
***Surface water monitoring results***

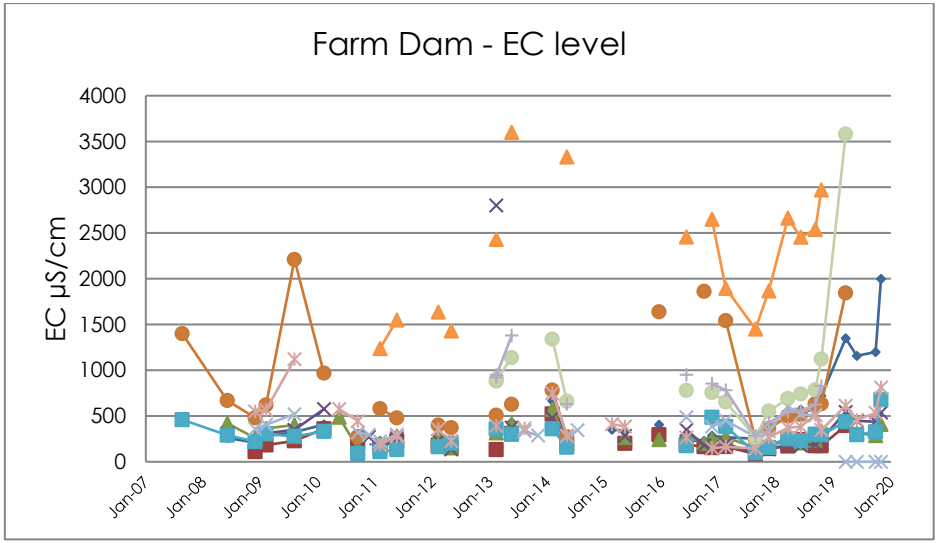


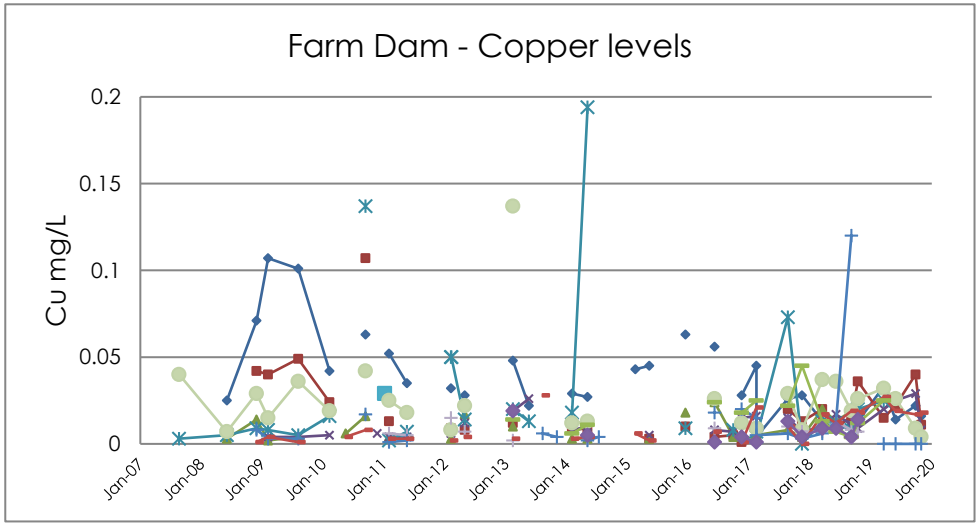



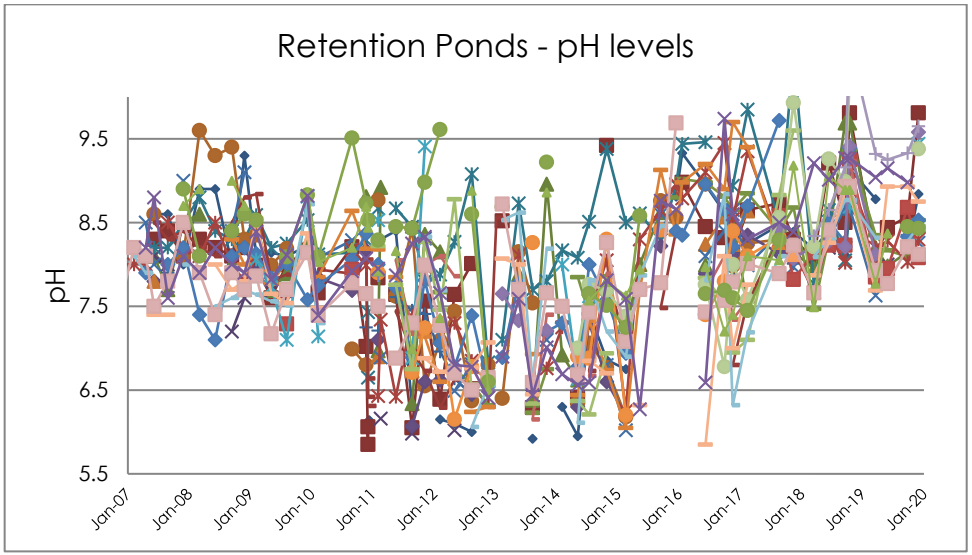



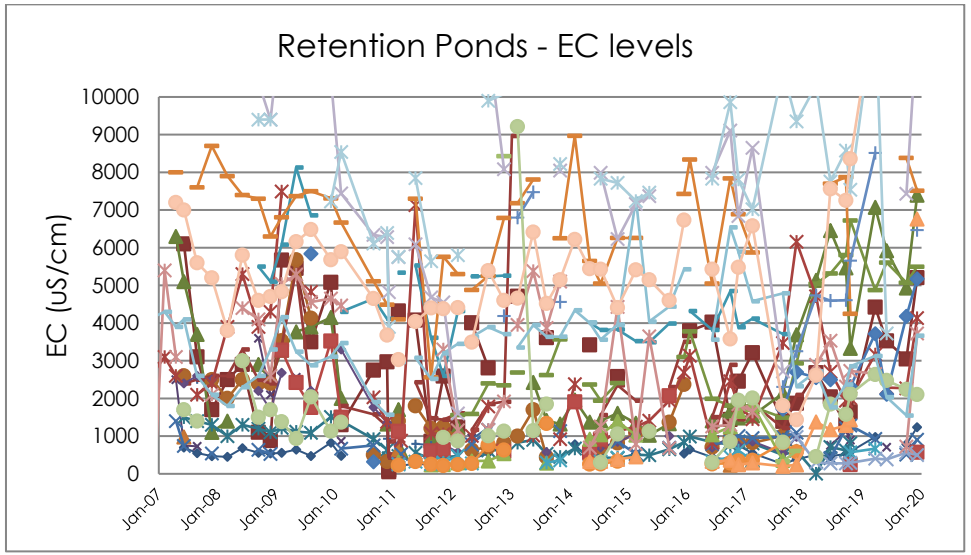

Farm Dam - pH level
pH
12
11
10
9
8
7
6
5
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

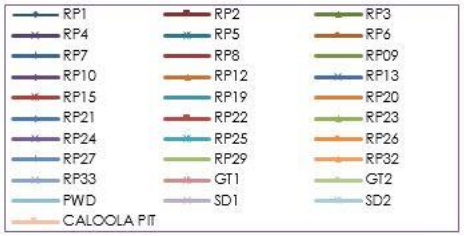

Farm Dam - EC level
EC µS/cm
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

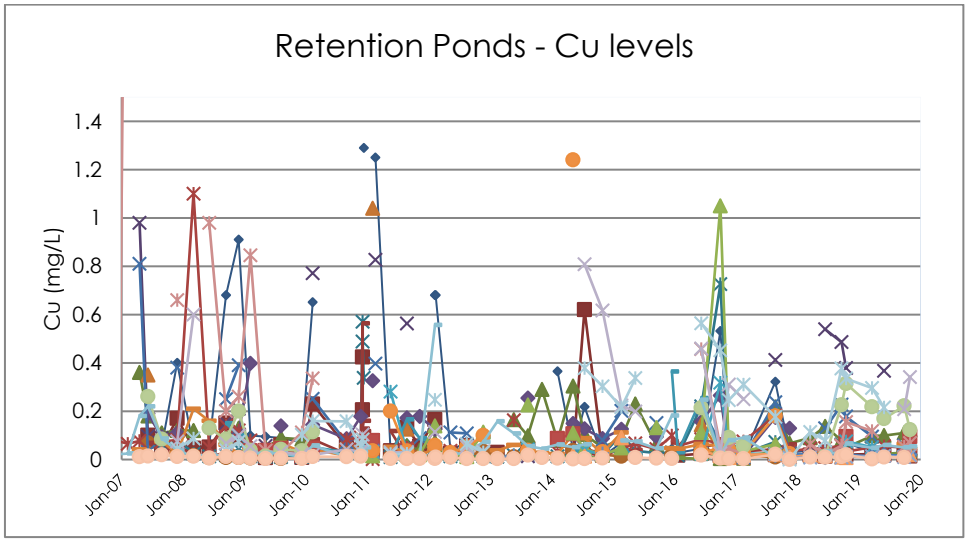
FD4
FD5
FD6
FD7
FD11
FD12
FD16
FD18
FD21
FD25
FD26
FD27

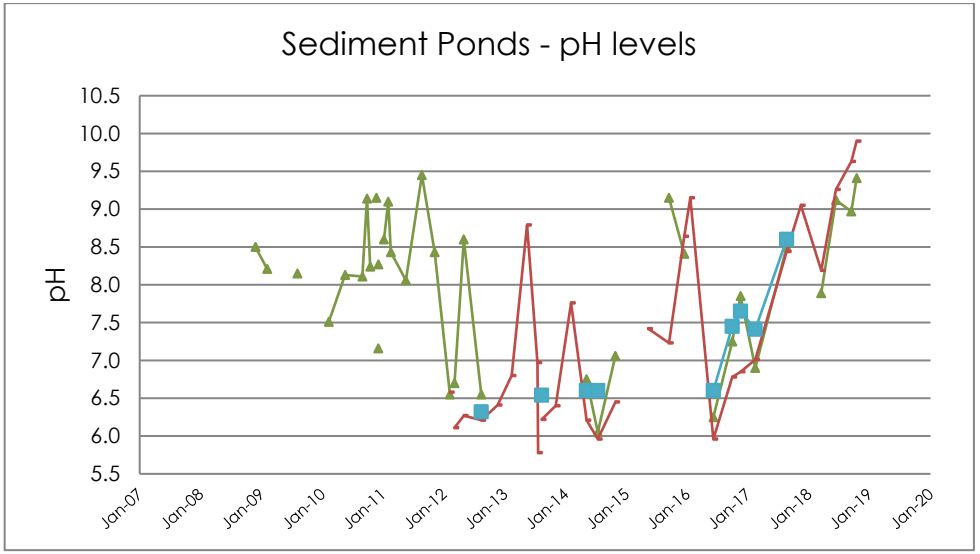

Farm Dam - Copper levels
Cu mg/L
0.2
0.15
0.1
0.05
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

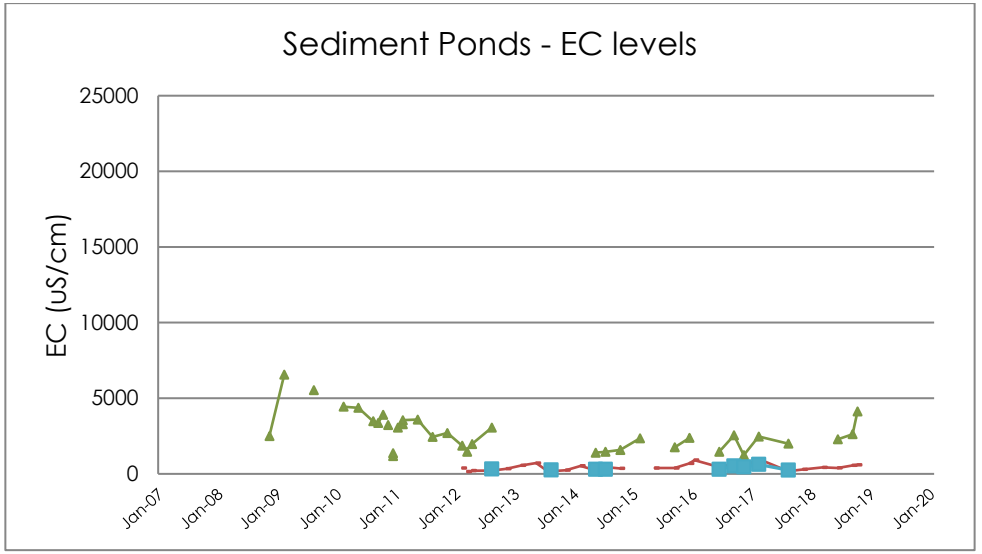

Retention Ponds - pH levels
pH
9.5
8.5
7.5
6.5
5.5
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

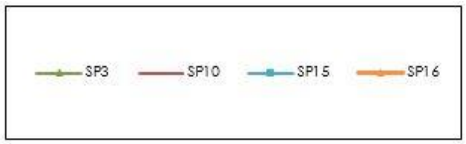

Retention Ponds - EC levels
EC (uS/cm)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

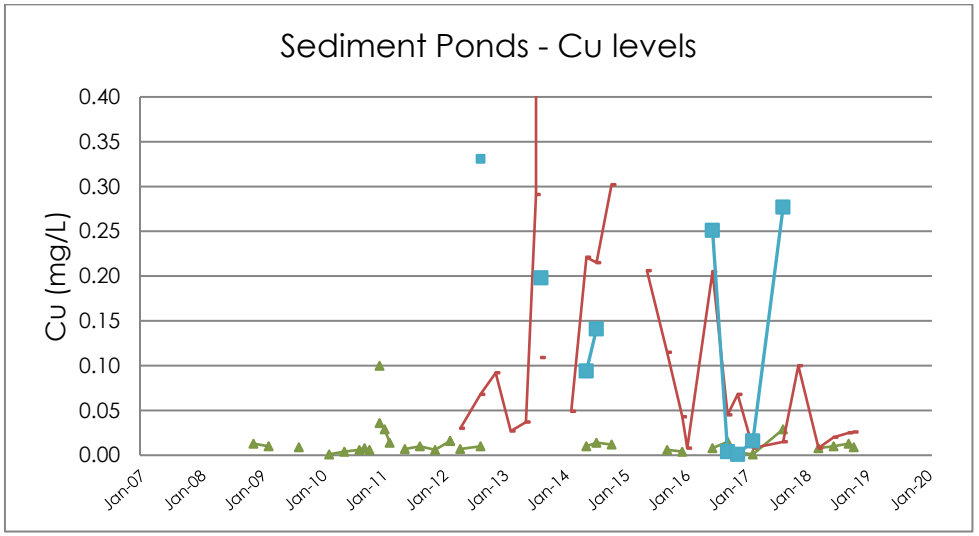

RP1
RP2
RP3
RP4
RP5
RP6
RP7
RP8
RP09
RP10
RP12
RP13
RP15
RP19
RP20
RP21
RP22
RP23
RP24
RP25
RP26
RP27
RP29
RP32
RP33
GT1
GT2
PWD
SD1
SD2
CALOOLA PIT


Retention Ponds - Cu levels
Cu (mg/L)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

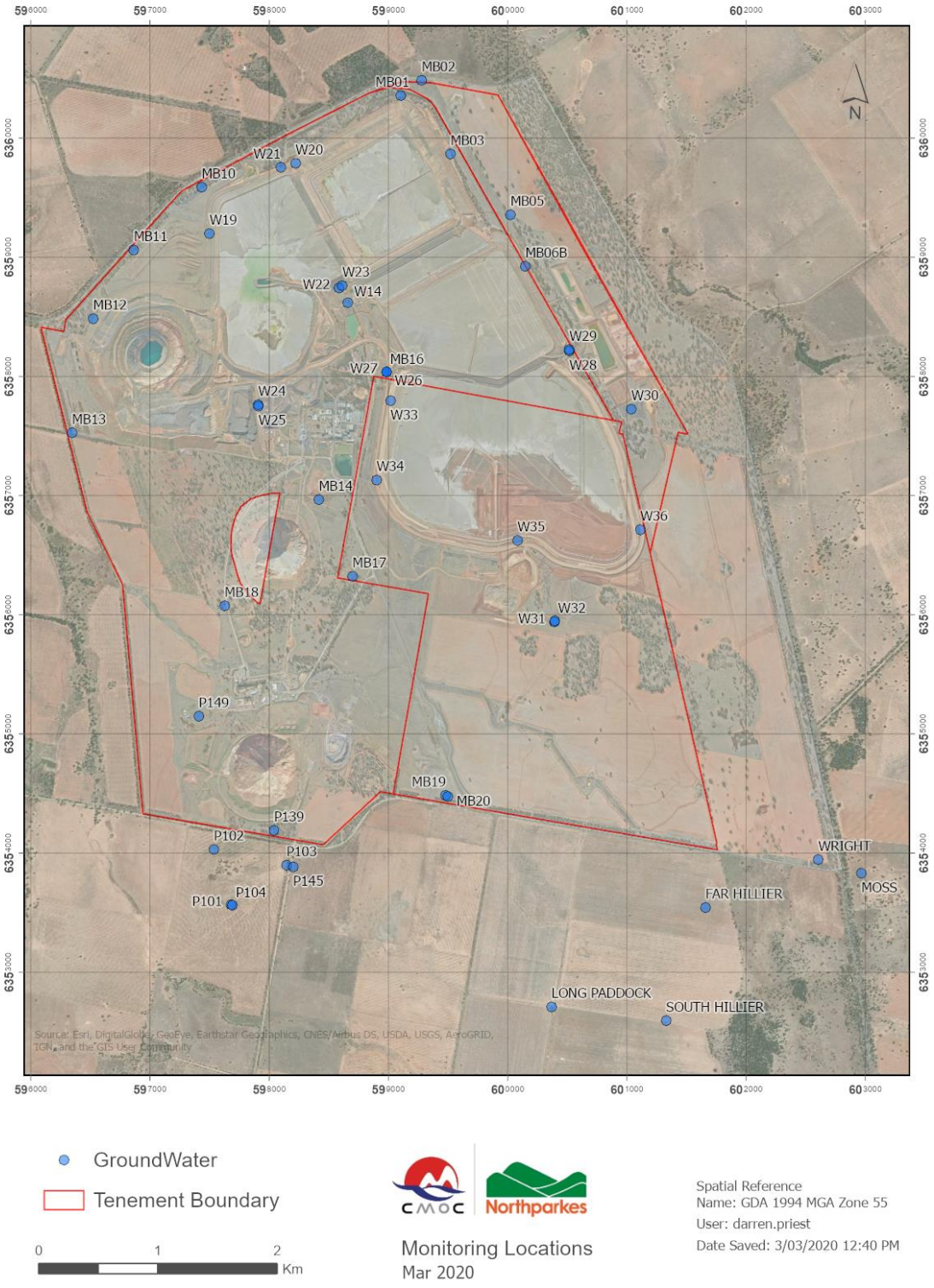

Sediment Ponds - pH levels
pH
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20


Sediment Ponds - EC levels
EC (uS/cm)
25000
20000
15000
10000
5000
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

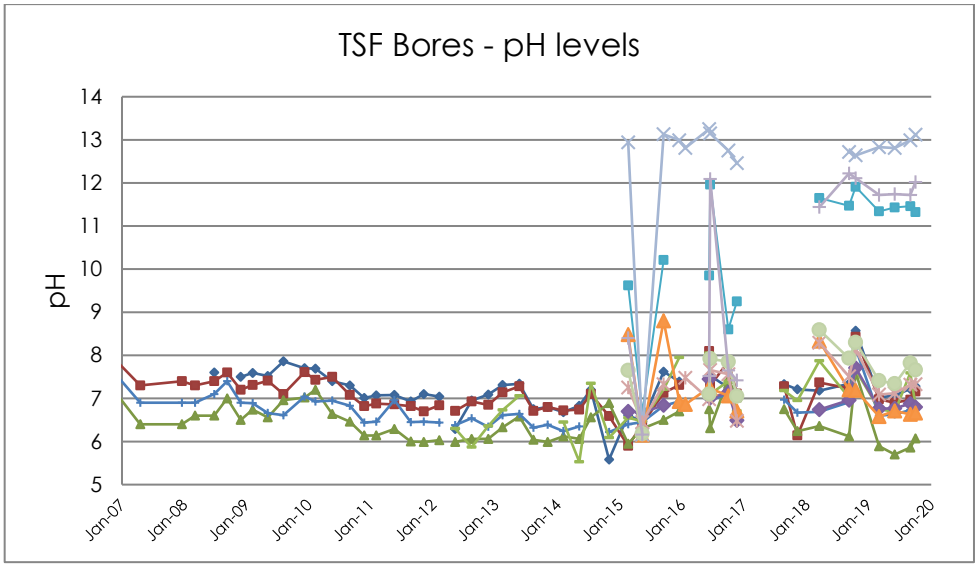

SP3
SP10
SP15
SP16

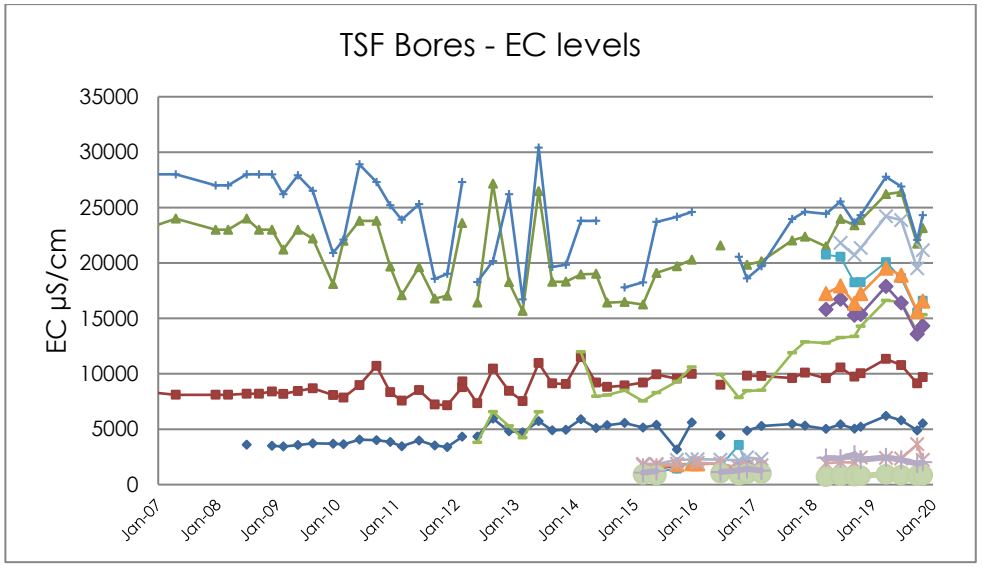

Sediment Ponds - Cu levels
Cu (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

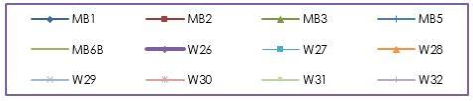
## *Ground water monitoring locations*

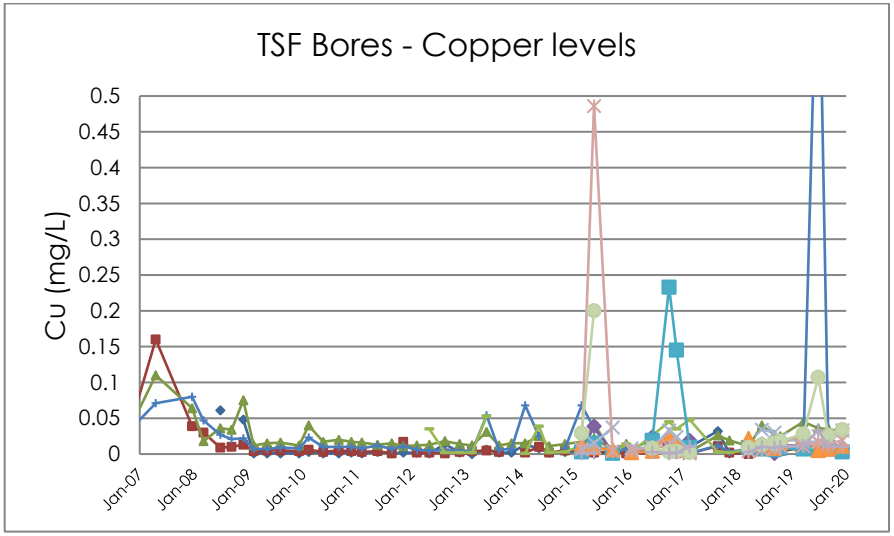


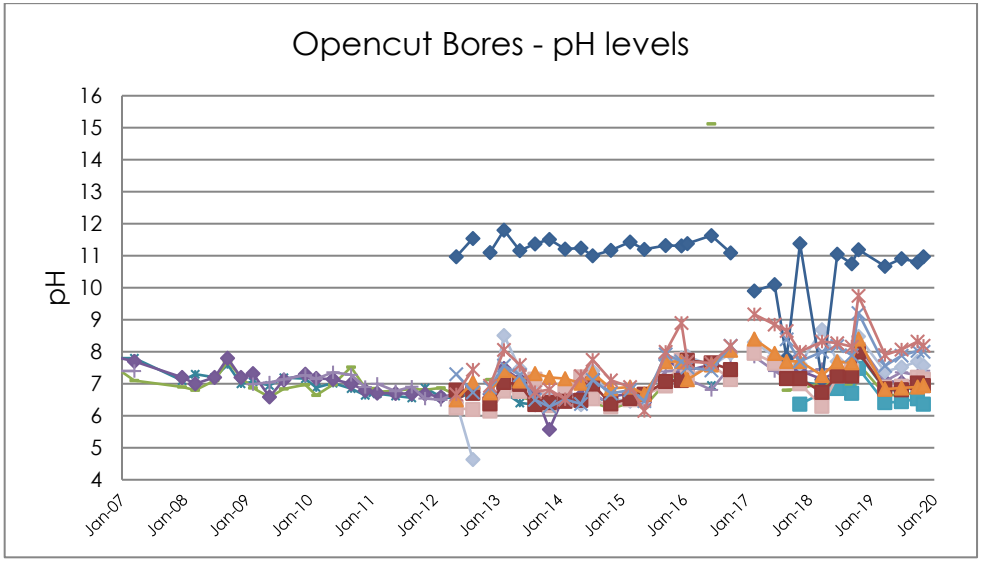
***Ground water monitoring results***

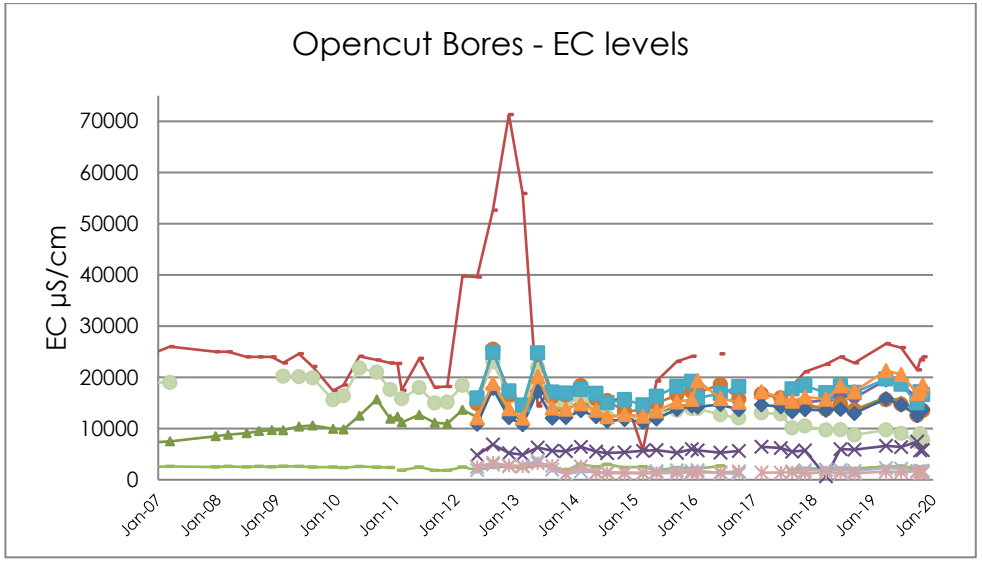


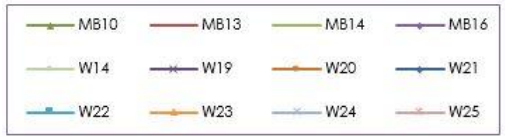



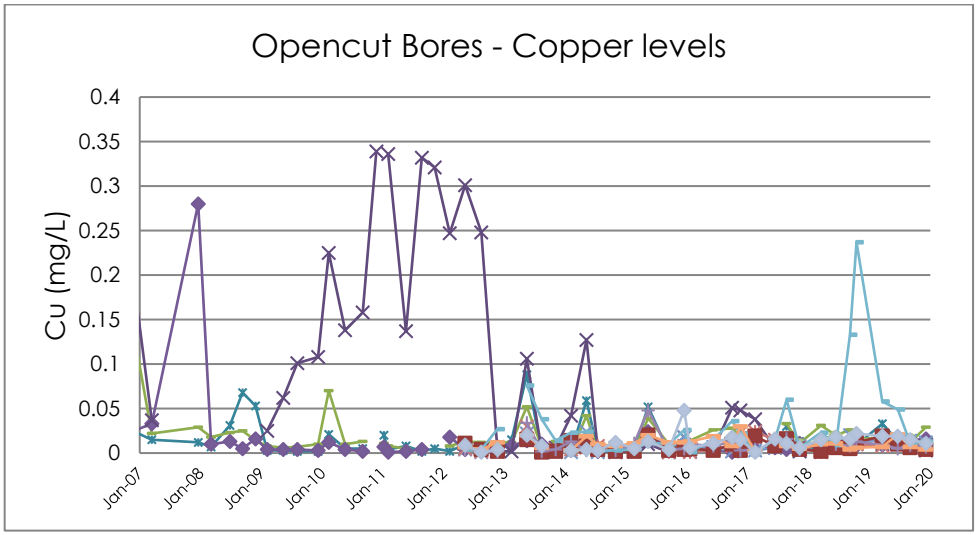



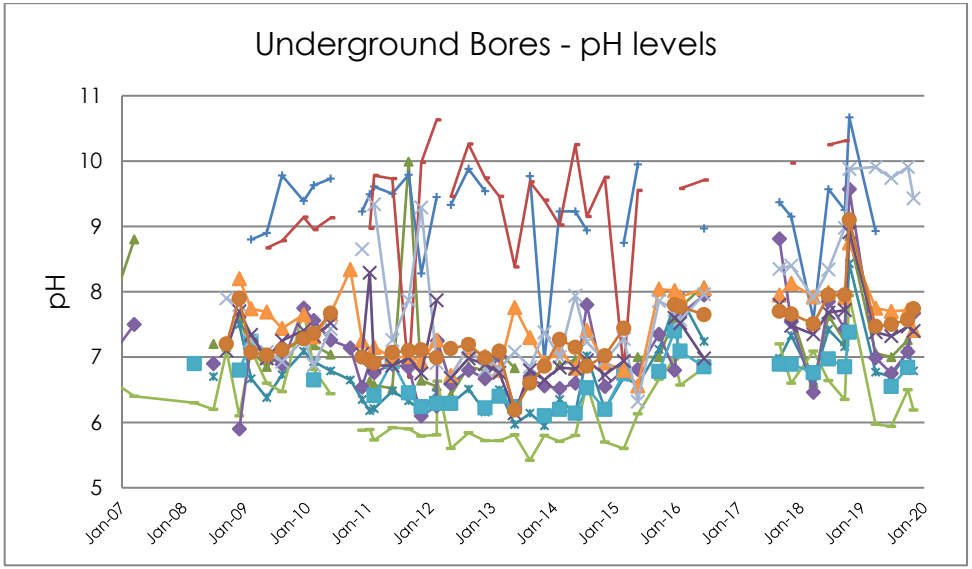



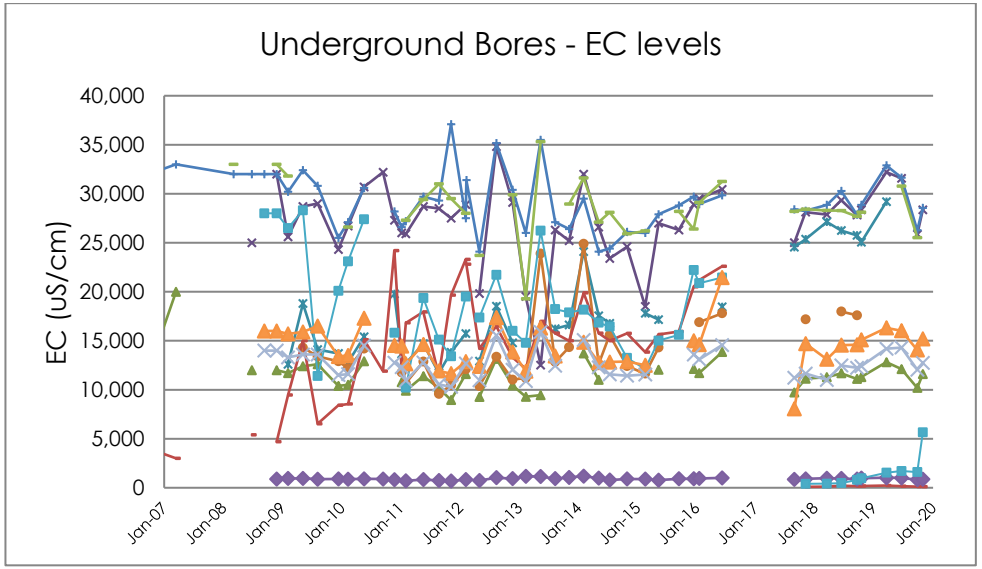

Opencut Bores - pH levels
pH
16
15
14
13
12
11
10
9
8
7
6
5
4
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

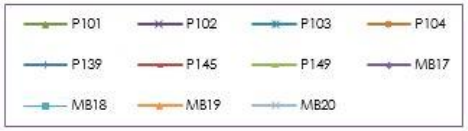

Opencut Bores - EC levels
EC µS/cm
70000
60000
50000
40000
30000
20000
10000
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

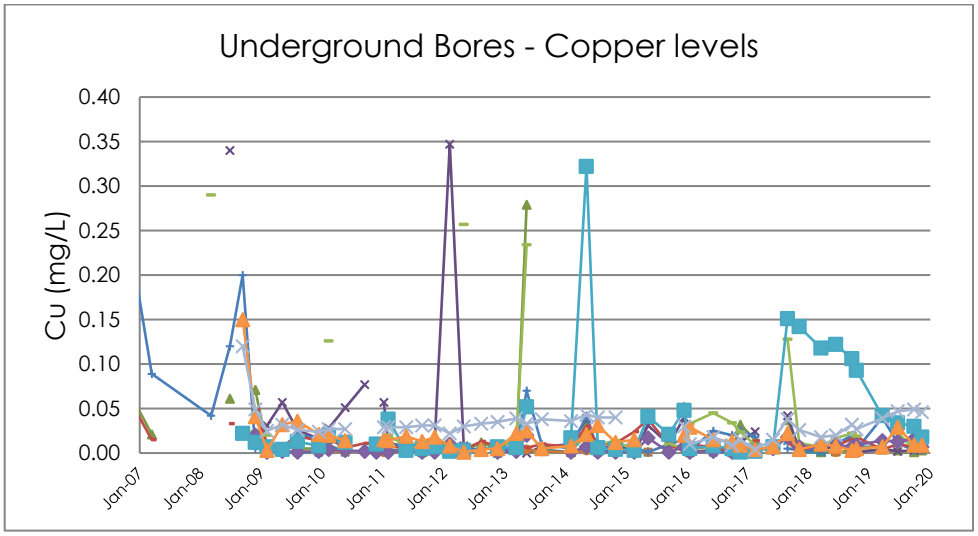

MB10
MB13
MB14
MB16
W14
W19
W20
W21
W22
W23
W24
W25

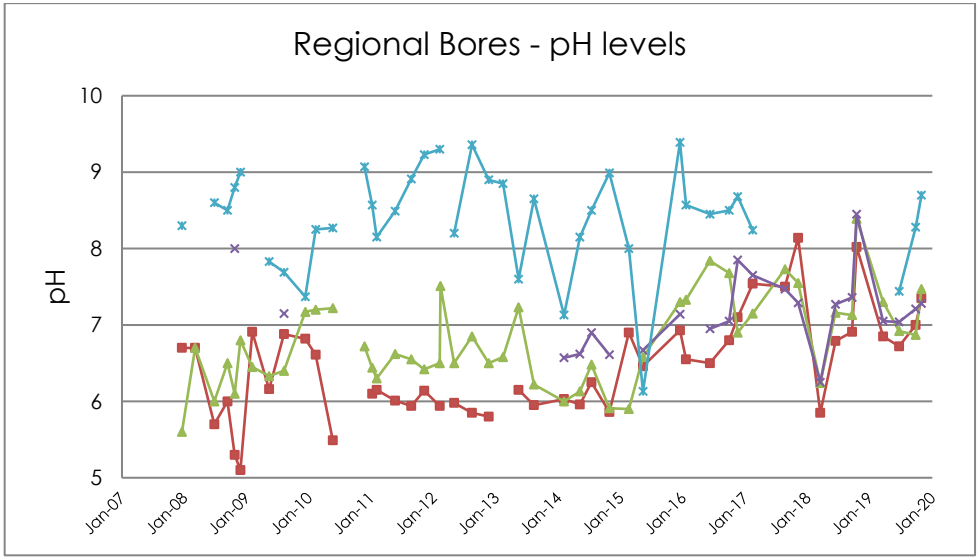

Opencut Bores - Copper levels
Cu (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

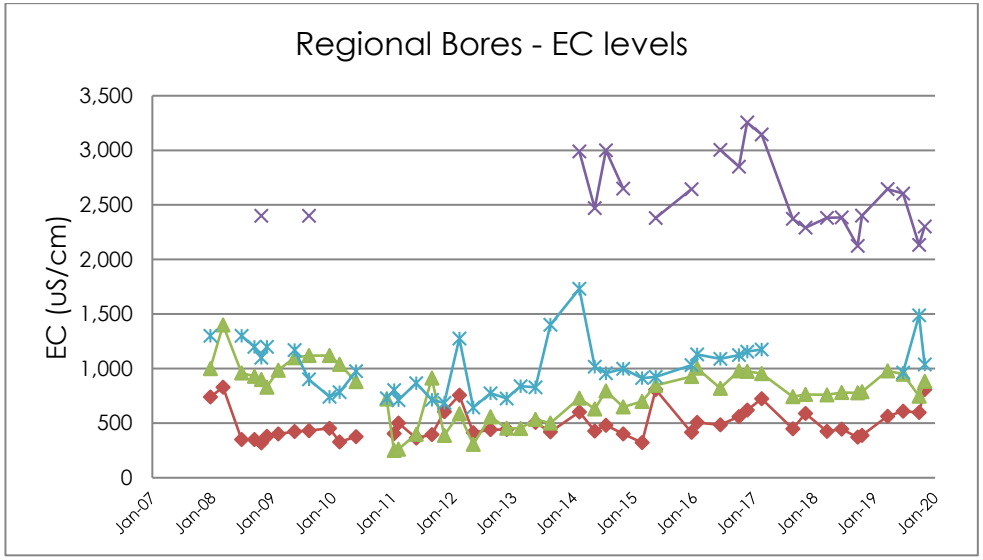

Underground Bores - pH levels
pH
11
10
9
8
7
6
5
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20


Underground Bores - EC levels
EC (uS/cm)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

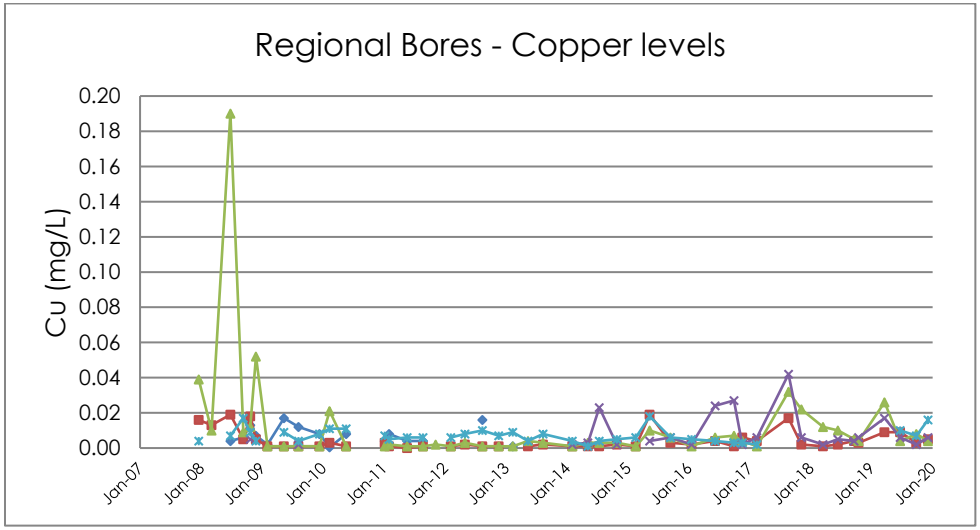

P101
P102
P103
P104
P139
P145
P149
MB17
MB18
MB19
MB20


Underground Bores - Copper levels
Cu (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20


Regional Bores - pH levels
pH
10
9
8
7
6
5
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20


Regional Bores - EC levels
EC (uS/cm)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

Far Hillier
Wright
Mass
Long Paddock


Regional Bores - Copper levels
Cu (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

# APPENDIX 3: TSF1 REHABILITATION TRIAL PLOT 2019 ASSESSMENT

# Assessment of the NPM cover trials for the determination of the establishment of a stable vegetation cover

T Baumgartl[1,2], M Edraki[2]

[1]Geotechnical and Hydrogeological Engineering Research Group; Federation University Australia;

[2]Sustainable Minerals Institute (SMI), The University of Queensland

November 2019

## 1. Executive summary

Four trials of different cover designs were constructed in 2014 with the objective to investigate the water balance of each of the designs and in parallel the performance of soils as growth medium for plant growth. Three of the designs incorporated a waste rock layer as subsoil material with reduced water holding capacity, one design applied topsoil directly on tailings. After five years of development and consolidation of processes the success of vegetation establishment has been assessed. The time of assessment follows a severe drought since 2018 and presents an extreme situation in the development of a stable revegetated landform on tailings.

The success of plant establishment and vegetation cover determines the success and suitability of a cover design. From the results to date it appears, that vegetation established directly on tailings with support of topsoil depicts the most successful cover design. While this appears in the first instance surprising, it confirms that vegetation establishment in the climatic conditions and variability of NPM is primarily dependent on the availability (or access) to water. In case of direct revegetation into tailings following some amending strategies like ripping and applying of topsoil plants were given the opportunity to extract water from the tailings. Water availability was limited in the other trials. Unexpectedly, despite the high salt content of the tailings and to be expected upward movement of salts, it appears that the vegetation has impacted the hydrology of the surface soil such that water flow and movement of salt to the surface is limited or even prevented. Direct revegetation in combination with a to be determined optimized application of amendment strategies appears to have a high potential to produce a successful rehabilitation outcome.

## 2. Background

Literature and substrate studies on the properties and behavior of NPM tailings by the Sustainable Minerals Institute, The University of Queensland, and reported in 2010 (Sustainable Minerals Institute-University of Queensland; *Rehabilitation Strategies for Tailings Storage Facilities - Planning for Closure - Stage 3 Report*) evidenced that the tailings at NPM generally contain low concentrations of sulphide bearing minerals and some residual metals from processing like copper. Physically, they are characterised by relatively

low hydraulic conductivity and small percentage of continuous macro-pores and have limited free drainage but show crack development close to the surface.

Vegetation establishment is critical for the stabilisation of the TSF surface against water or wind erosion, to positively support the reduction of moisture in the cover and to improve the buffer capacity for rainfall. Based on the results from previous studies numerical modeling on the hydrology of various scenarios of cover designs led to the selection of four different designs which were implemented in a field trial constructed in 2014 (Sustainable Minerals Institute-University of Queensland; *Rehabilitation Strategies for Tailings Storage Facilities - Planning for Closure – Stage 4: Field trial for testing of cover systems - Construction report*)

The following criteria for an optimal cover design guided the decision for the field trial plots:

- Avoidance of deep drainage
- Sufficient depth of soil for plant growth
- Storage of precipitation
- Prevention of upward salt movement

The critical design criteria based on the findings of the previous studies were summarised as depth of cover and depth of topsoil.

Four test plots (plot A, B, C, D; locations see Fig. 1) of different cover design were constructed in July 2014.

Tab. 1 summarises the cover designs.

From previous observations and work on dried tailings, it was recognized that plant roots are restricted mechanically to grow deep and the root depth for some excavated species was found to be around 0.1m. To improve the potential accessibility of tailings to plant roots for water and/or nutrient uptake, the tailings of all plots was ripped prior to cover construction. All trial plots had a topsoil of 0.1m topsoil layer enriched with organic matter (hay).

*Tab. 1: Design of trial plots*

| **Design** | A | B | C | D |
|---|---|---|---|---|
| Topsoil [m] | 0.1 | 0.1 | 0.1 | 0.1 |
| Waste rock [m] | -- | 0.4 | 0.4 | 0.9 |
| Capillary break [m] | -- | -- | 0.3 | -- |
| **Total trial depth [m]** | **'0.1'** | **0.5** | **0.8** | **1** |

This layer was placed either directly on tailings or on waste rock as subsurface material of 0.4 and 0.9m thickness respectively. A further design contained a capillary break layer of 0.3m of coarse waste rock underneath the topsoil/0.4m submaterial layer. At the time of construction emphasis was laid on the availability of benign substrate and coarse waste rock

containing only small quantities of fines has been chosen. Due to availability and accessibility this decision deviated from the original choice of weathered, fines dominated subsoil as substrate overlying tailings.

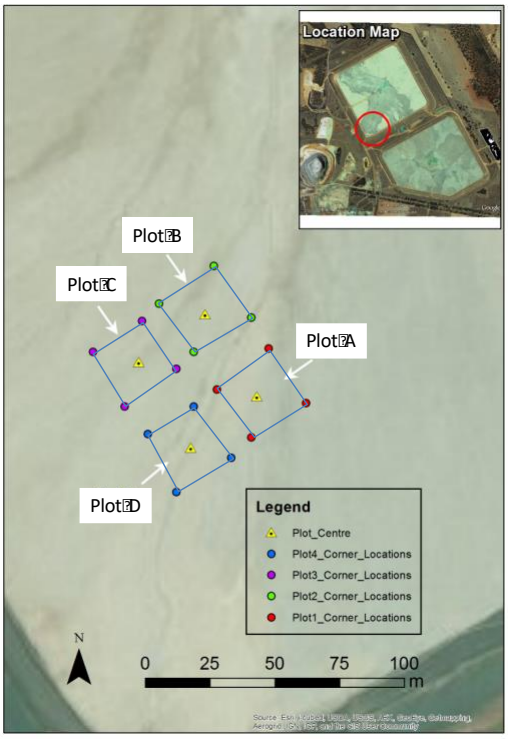



*Fig. 1. Position of trial plots on TSF*

All plots were seeded with a grass seed mix of local species and irrigated. It could not be established to what extent saltbush/salt tolerant species have been included in the seed mix and on which plots they were sown.

Objective of this report is the assessment of the performance of the vegetation cover as an outcome of the design of the trial plots. The extent of success measured as vegetation cover will be used as an indicative measure for the development of a rehabilitation strategy of the NPM TSF surface.

# 3. Methodology

## Soil analysis

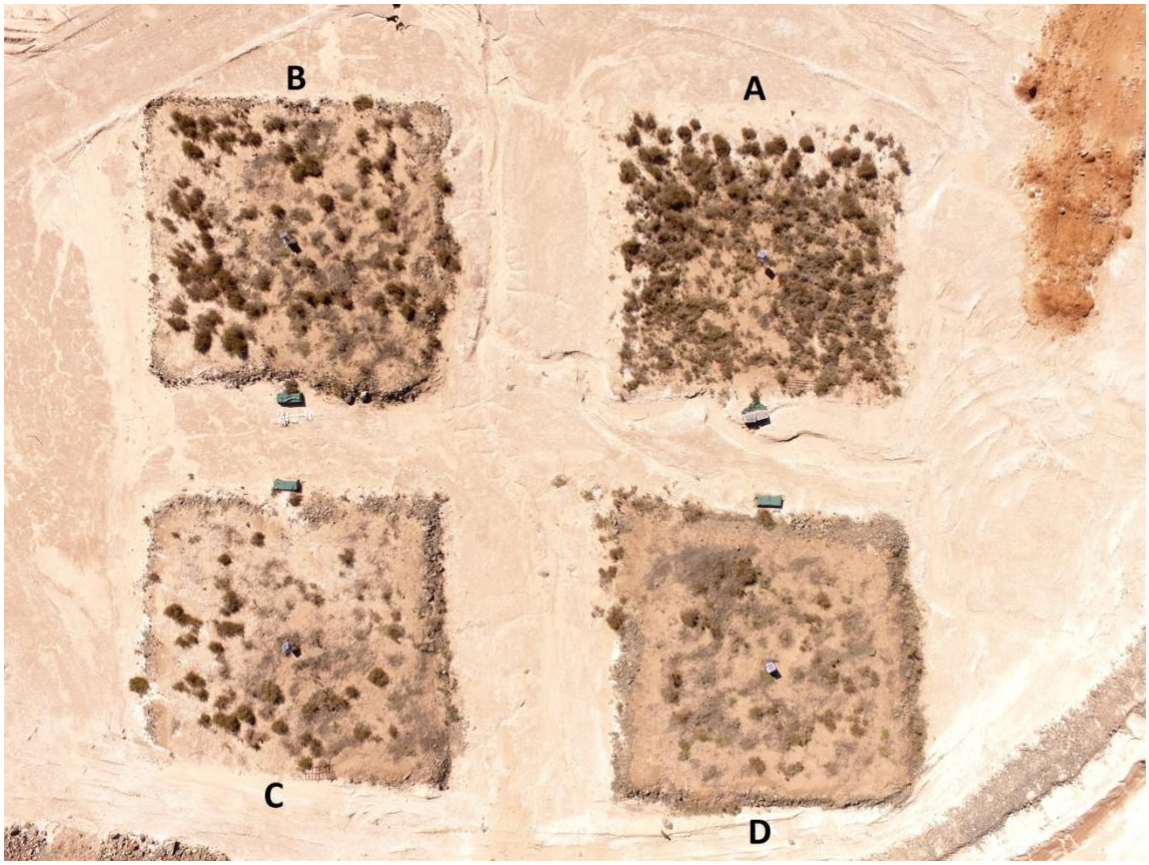
At various dates following commissioning of the trials between July 2014 and August 2019, topsoil was sampled from up to three depths (0-2, 2-5 and 5-10cm) of the cover trial and bulk chemical parameters pH and electrical conductivity were measured. Subsequently, samples were taken directly from the surface of the tailings to the east of Plot A. In August 2019 samples from plot A were taken from bare and in addition from under vegetation locations (the latter are labelled ‘Plot A-veg’ in Table 2).

Samples taken in August 2019 were analysed in addition for the major cations (Ca, Na, Mg, K), total and plant available Nitrogen and total organic carbon (TOC). Two replicate samples were taken and average values are summarised in Table A1 in the appendix.

## Vegetation cover analysis

Aerial photos were taken on 15 August 2019 by NPM and provided for further analysis from the four trial plots with the intention to derive the proportional vegetation cover (Plate 1)

*Plate 1: Aerial photo of cover NPM trial (15 August 2019)*

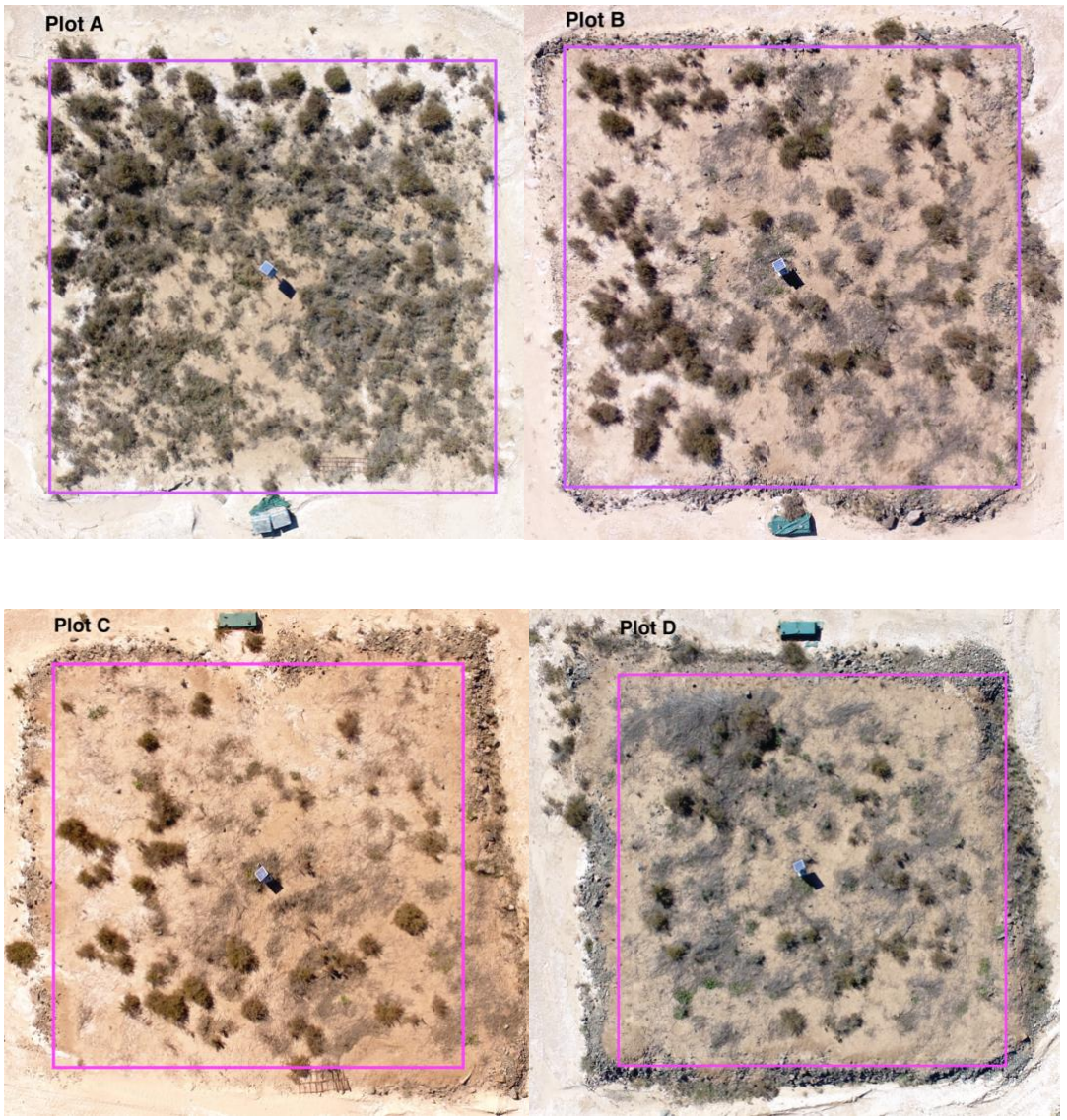



For each plot a rectangular boundary was defined for further analysis (Plate 2a-d).

The focus for the vegetation cover analysis was on vegetation, which appeared from the aerial image as being able to regenerate, dead vegetation or litter was excluded for the plots B-D and only for Plot A an additional analysis including litter has been carried out.

It should be noted that preceding the sampling and aerial photo taken in August 2019 are severe dry conditions which resulted in a major rainfall deficit over a period of at least 1.5 years. Fig. 2 compares average and actual rainfall for the period January 2018 - July 2019 (data from Bureau of Meteorology; station 065100 - Alectown; accessed 15 Sep 2019). During this period 50% of the monthly rainfall was below 50% of the average rainfall for that month and only one month exceeded the average rainfall.

*Plate 2a-d: Defined boundaries for analysis of vegetation cover for Plot A-D*



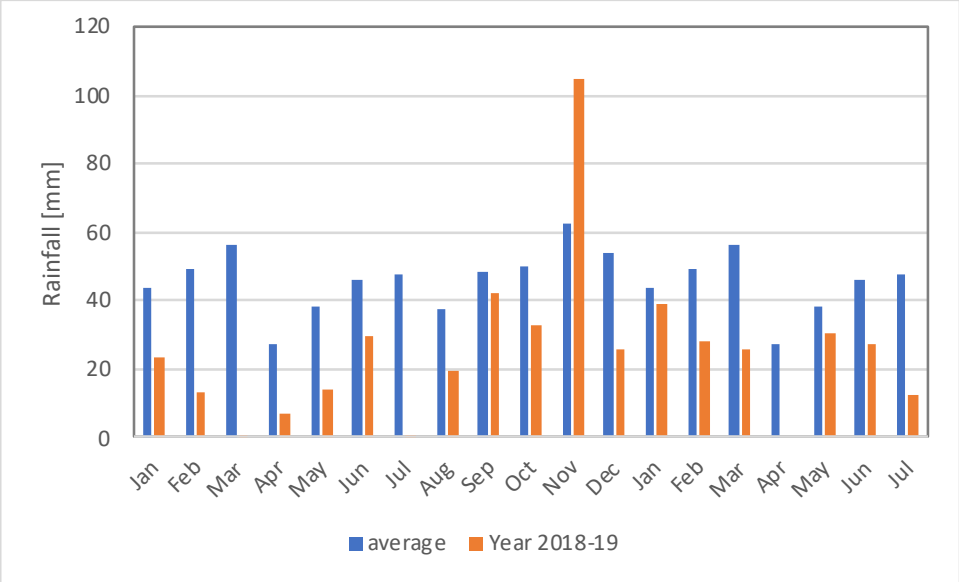



Figure 2: Comparison of average monthly rainfall and actual monthly rainfall 2018-19

# 4. Results

## Soil analysis

The bulk soil parameter pH and EC show for all plots for the surface depth 0-2cm as a trend initially a decrease in salinity, which was most pronounced for the sampling date June 2016 (following a substantial wet period) and has increased thereafter at the last sampling date. Plots B-D show in general lower values of EC than Plot A and the variability between sampling dates is relatively small, with the exception of one sampled location of Plot C which had very high values. The high values have to probably be considered as an outlier caused by e.g. tailings translocation onto the trial plot through wind. From the vicinity of the trial plot. Capillary rise and precipitation of salts can be excluded as the second location of plot C and plots B and D indicate and which was shown previously through the soil moisture measurements at these plots.

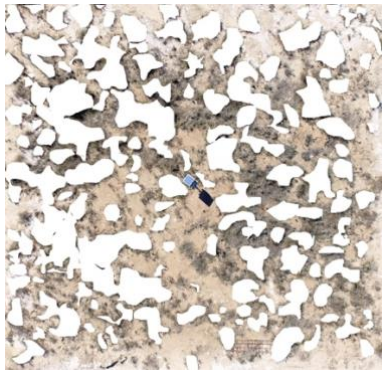
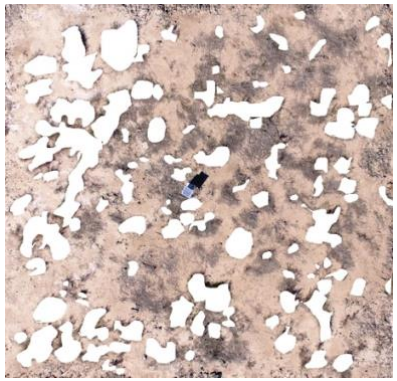
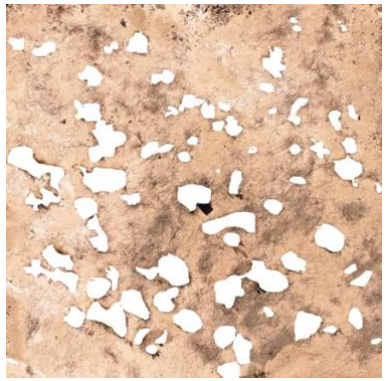
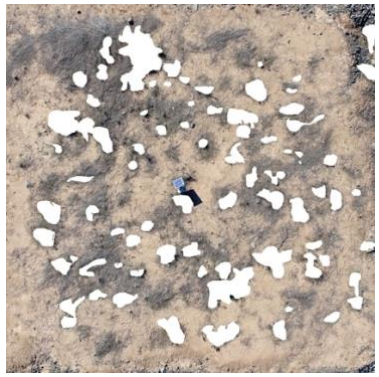
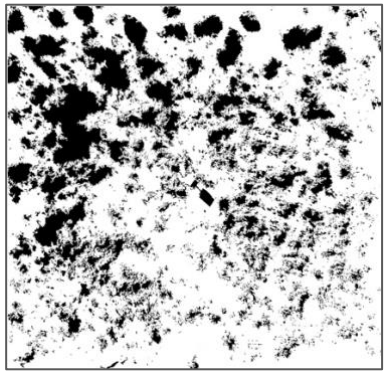
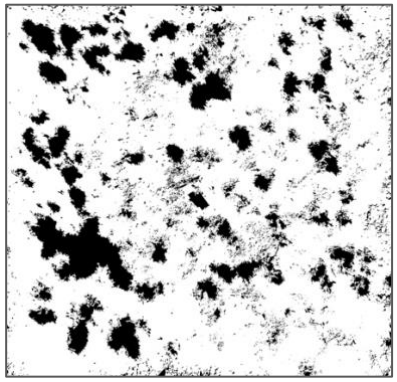
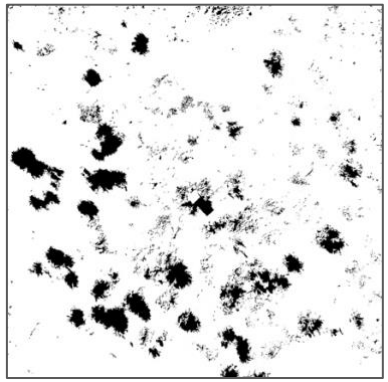
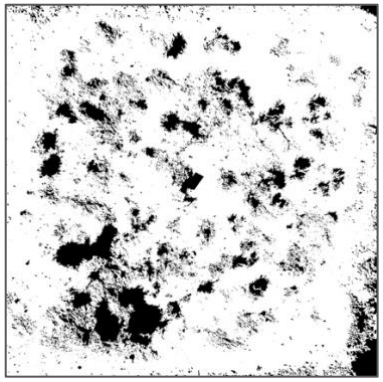
However, plot A shows higher values of EC which are increasing with depth towards the unaffected tailings substrate. This trend has been seen throughout the monitoring period and despite the very dry conditions, it appears that no accumulation of salts towards the soil surface and development of a salt crust has occurred. Additional samples were taken at Plot A at vegetated locations. EC values here are strongly reduced to at least the depth of 0.1m. This appears to be a phenomenon which has been observed elsewhere. In conditions where plant roots are actively removing water from the soil, they interrupt the capillary flow and connection towards the surface. Capillary flow and upward transport of salts is only possible at sufficiently moist conditions. Even shallow rooting depths appear to sufficiently influence the soil moisture conditions that a deterioration of the conditions is avoided. Natural colonisation with vegetation on the NPM tailings is an indicator to confirm this process (see Plate P1,2 in appendix). It should be added, that a sufficiently permeable soil surface should prevail over time to allow salts to be transported downward during rainfall events.

*Table 2: Time series of bulk chemical and physical properties of soils of cover trials plots*

| | sampling date: | Jun-15 | Dec-15 | Jun-16 | Aug-19 | Jun-15 | Dec-15 | Jun-16 | Aug-19 |
|---|---|---|---|---|---|---|---|---|---|
| | depth [cm] | pH | pH | pH | pH | EC [µS/cm] | EC [µS/cm] | EC [µS/cm] | EC [µS/cm] |
| A | 0 - 2 | 6.3 | 8.2 | 6.6 | 7.1 | 820 | 112 | 62 | 870 |
| | 2 - 5 | 5.9 | 5.9 | 6.0 | 6.3 | 1969 | 1745 | 384 | 2835 |
| | 5 - 10 | 6.5 | 6.1 | 5.9 | 7.4 | 2410 | 3800 | 613 | 4150 |
| A-veg | 0 - 2 | nv | nv | nv | 7.3 | nv | nv | nv | 195 |
| | 2 - 5 | nv | nv | nv | 6.4 | nv | nv | nv | 259 |
| | 5 - 10 | nv | nv | nv | 6.0 | nv | nv | nv | 339 |
| B | 0 - 2 | 7.2 | 6.9 | 6.5 | 7.1 | 252 | 135 | 54 | 658 |
| | 2 - 5 | 6.3 | 6.1 | 6.0 | 6.2 | 1095 | 1093 | 239 | 1148 |
| | 5 - 10 | 6.6 | 6.3 | 6.1 | 6.1 | 549 | 768 | 449 | 766 |
| C | 0 - 2 | 7.1 | 7.1 | 6.4 | 7.5 | 180 | 81 | 45 | *2034 |
| | 2 - 5 | 6.3 | 6.3 | 6.1 | 7.0 | 1015 | 935 | 135 | *1498 |
| | 5 - 10 | 6.3 | 6.8 | 5.7 | 6.8 | 665 | 548 | 478 | 511 |
| D | 0 - 2 | 6.7 | 7.4 | 6.1 | 7.6 | 298 | 78 | 137 | 160 |
| | 2 - 5 | 6.5 | 6.5 | 5.9 | 7.3 | 385 | 770 | 266 | 527 |
| | 5 - 10 | 6.6 | 6.5 | 5.6 | 6.7 | 316 | 650 | 418 | 411 |
| Tailings | 0 - 2 | nv | 7.1 | 5.1 | 8.3 | nv | 19980 | 2230 | 3870 |
| | 2 - 5 | nv | 7.5 | 5.6 | 8.3 | nv | 3730 | 950 | 1870 |

nv: no value; * very high standard deviation between parallel samples

*Plate 3: Comparison of visual (top row) and image analysis (bottom row) of regenerative vegetation (quantified as white in top row and black in bottom row)*

| Plot A | Plot B | Plot C | Plot D |
|---|---|---|---|
|  |  |  |  |
|  |  |  |  |

The chemical analysis of the major cations and anions (data in table A of the appendix) depict the contribution of tailings to the ion concentrations. The values for plot A for sulfate and chloride are significantly higher than for e.g. plot D (Figure 3). The latter trial plot is elevated highest above the tailings baseline elevation. Plot B and C show signs of blow-on effect of tailings and in particular plot C shows a high standard deviation (not shown) of the replicate samples for the anions and sodium concentrations. Plot A shows a pronounced decline of the anion concentrations towards the surface. This is quite noteworthy as the surface elevation of plot A is in line with the surrounding tailings. The control tailings element concentrations of samples taken next to plot A in comparison show an increase of the anion and sodium concentration towards the surface and document an evaporative concentration of salts at the surface. Very opposite to this trend, samples taken from underneath vegetation of plot A show very low anion and cation concentrations and are very similar to plot D. Copper concentrations are slightly higher in profile A1 (Figure 3).

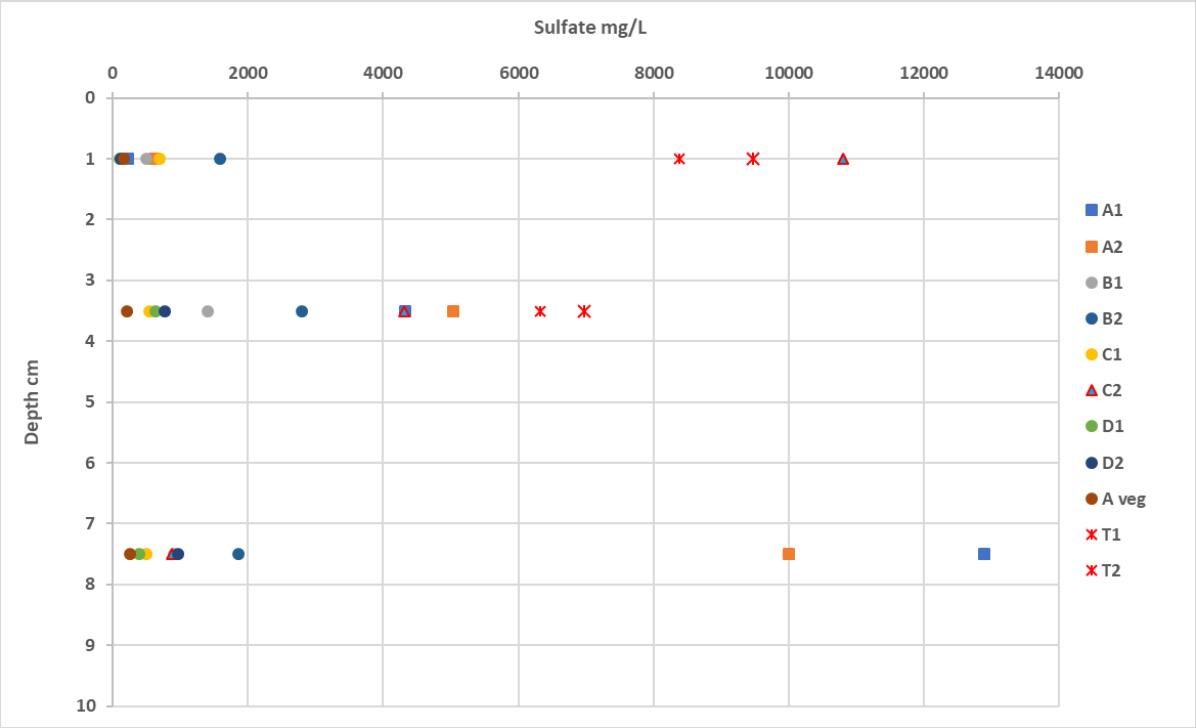



Figure 3: Soil profile concentrations of sulfate

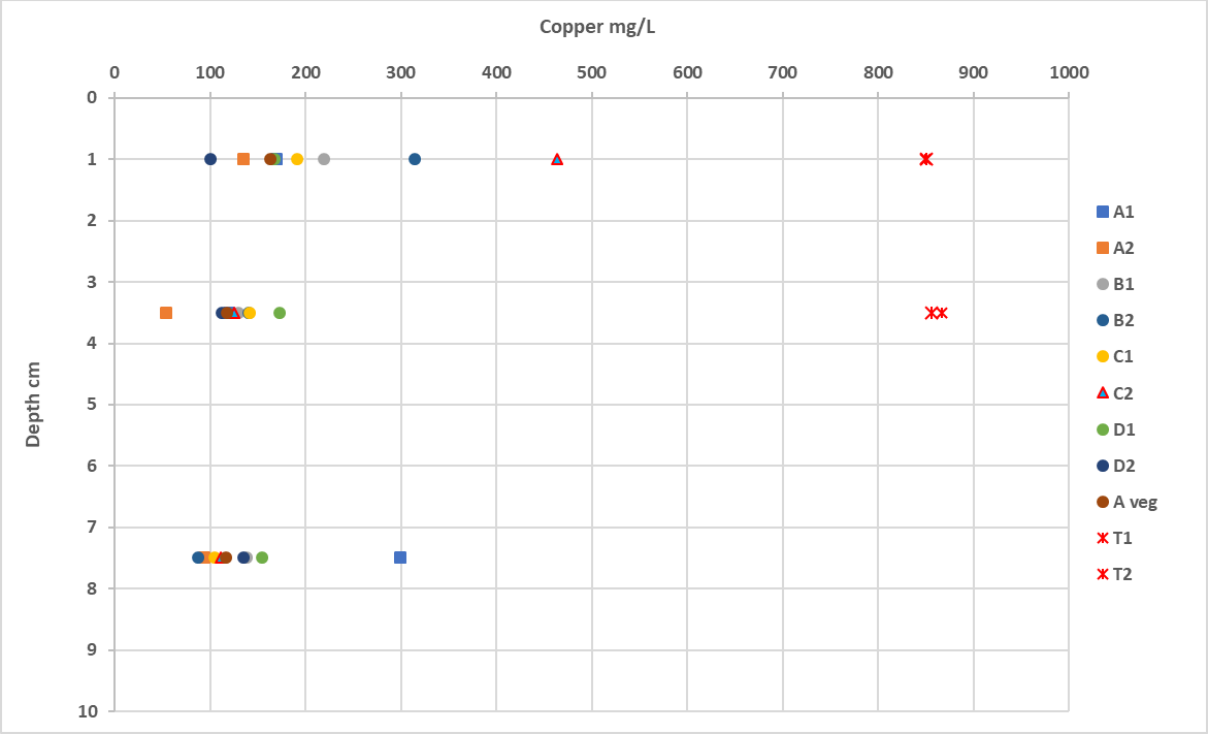



Figure 4: Soil profile concentrations of copper

Samples were also analysed for nitrogen and soil organic carbon as an indicator for the development state of the soils as plant growth medium. The nitrogen and total organic carbon (TOC) results are quite similar between all samples, excluding the location 'tailings' and plot A-veg. Comparing the TOC of plot A-veg with the concentrations of plot A-D, there is a significant increase of the TOC concentration from 0.97% to 1.23% under vegetation. This increase in concentration can be found across all three depth samples. While this result requires statistical validation, in combination with the results from the analysis of anion and cation concentrations, it confirms the observation of improved soil chemical conditions which can be found under the vegetated soil and is a indicator of a self-ameliorating effect vegetation seems to have.

The values of the water content at the time of sampling reflect the design conditions. The soils of plots B-D overlying the waste rock material are dry throughout and water contents are very low at the depth 5-10cm with 4-8%(-weight) while Plot A shows an increase of moisture at 5-10cm depth between 11-13% (-weight). Despite the preceding very dry period, the soil moisture conditions in plot A for these shallow depths is significantly better for plant growth/survival than for plots B-D.

## Vegetation cover analysis

The aerial images of the four trial plots have been analysed two-fold. From the colour image a b&w image was generated excluding bare soil and grey litter, i.e. only green appearing vegetation was considered in the analysis. For validation of this approach, visually green and as alive assessed vegetation was excluded. Plate 3 is showing the results of both types of

analysis, i.e. image analysis and visual analysis. The percentage of regenerative vegetation has been calculated for all plots and is tabled in Table 3.

The results show that from the image analysis Plot A has the highest vegetation cover with 25% and Plot C the lowest with 9%. The visual analysis results in a more pronounced differentiation between Plot A and Plots B-D. The general trend is however very similar and confirms both analytical approaches.

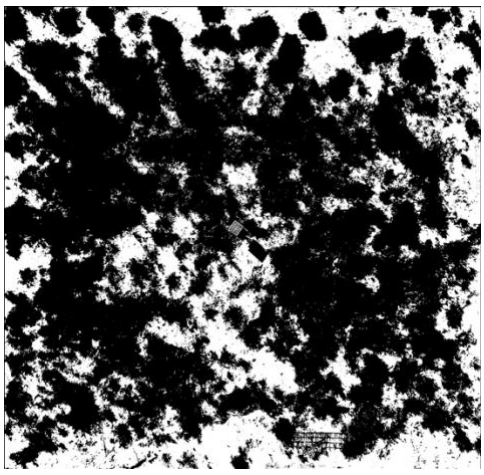
As litter will remain on the surface beyond a season, it can be viewed as beneficial mulch component but also as a means to prevent or limit erosion by wind. An additional analysis has been carried out to also include dead organic matter for the quantification of the overall cover by plant matter, i.e. including both dead and alive biomass.

Plate 4 shows exemplary a colour enhanced original image of the aerial photo and the cover analysis. The percentage of plant cover (vegetative and litter) has been calculated for all four plots (Table 3; 'plus litter').

*Table 3: Vegetation cover-% quantified by image and visual analysis*

| Plot | image analysis | visual | plus litter |
|---|---|---|---|
| **A** | 25% | 31% | 68% |
| **B** | 18% | 18% | 58% |
| **C** | 9% | 12% | 43% |
| **D** | 15% | 12% | 69% |

*Plate 4: Enhanced image (left) and result from image analysis (right)*



## 5. Conclusions

The assessment of the cover trials in regard to success of development of an ideally stable and dense plant cover has demonstrated that access to water determines the extent of the vegetation cover. The proportion of revegetative plant cover is highest in the direct revegetation plot (Plot A), which provides the highest amount of soil moisture in the root zone, and varies in the other plots. Including plant litter in the quantification of plant cover, which represents growth and cover conditions at times with higher water availability for plant growth, the cover reaches values > 40% for all plots and is highest for Plot A and D.

The investigations have shown that after five years there is enrichment with salts at the soil surface or in the soil profile (Plot A) compared to the initial conditions. From the vegetation coverage analysis and being cognisant of the partially extreme drought conditions since trial construction, it appears that salinity has not become a constraining factor, neither for the trial designs incorporating waste rock as subsoil substrate nor for the design of direct seeding into amended tailings, as long as the plant species can adapt or seed mix has been selected to the local growth conditions. Despite the fact that salinity of tailings is high, it appears that the salt concentration has been sufficiently reduced by the topsoil amendment and upward movement of salts may be prevented due to altered hydrological conditions created by the plant, i.e. drying of the topsoil and reducing the possibility of capillary rise of saline water to the soil surface. Based on the experiences from the trial and data analysis, it can be postulated, that a thickness of less than 0.5m of a growth medium for vegetation would well be sufficient to sustain plant growth and vegetation cover during periods of extensive drought.

Following the current severe drought, it will be of high value to continue to monitor the trials and assess whether the dynamic of leaching of salts, as has been determined initially after construction of the trials and following wet conditions, is still occurring in the future.

Direct revegetation into tailings in combination with an optimisation of remediation measures may be an environmentally and economically attractive option for rehabilitation of the TSF. Adapting the selection of plant species covering tailings to potentially saline conditions by incorporating salt tolerant species can provide certainty for successful rehabilitation in the long term. Critical variables to be considered in the planning and provision of optimal conditions will include rooting depth for vegetation, the amendment of tailings to improve and maintain in the long term soil system services and to limit upward salt movement within the profile. In-line mixing of benign soil substrate to the tailings stream and application as a final landform layer may provide an option to create optimised conditions for rehabilitation.

# 6. Appendix

**A1: Soil chemical analysis for three depth increments, four trial plots, tailings and under a vegetated location of plot A**

| | sampling depth | Moisture Content weight-% | Sulfate as SO4 2- mg/kg | Chloride mg/kg | Calcium mg/kg | Magnesium mg/kg | Sodium mg/kg | Potassium mg/kg | Nitrite + Nitrate as N (Sol.) mg/kg | Total Kjeldahl mg/kg | Total Nitrogen as N mg/kg | Total Organic Carbon % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot A | 0-2 | 3.2 | 425 | 1085 | 65 | 45 | 520 | 60 | 16.8 | 720 | 735 | 0.95 |
| | 2-5 | 7.2 | 4680 | 2645 | 485 | 500 | 1955 | 180 | 17.7 | 715 | 735 | 1.02 |
| | 5-10 | 12.5 | 11450 | 2955 | 2395 | 870 | 2590 | 435 | 1.0 | 840 | 840 | 0.97 |
| Plot B | 0-2 | 3.1 | 1040 | 140 | 110 | 50 | 340 | 70 | 33.4 | 690 | 720 | 0.85 |
| | 2-5 | 5.7 | 2105 | 335 | 305 | 180 | 575 | 90 | 81.8 | 795 | 875 | 1.04 |
| | 5-10 | 7.9 | 1385 | 305 | 185 | 130 | 405 | 70 | 59.9 | 885 | 945 | 1.15 |
| Plot C | 0-2 | 2.6 | 5750 | 975 | 1040 | 280 | 1585 | 260 | 13.5 | 590 | 605 | 0.82 |
| | 2-5 | 6.5 | 2425 | 1015 | 270 | 180 | 1030 | 130 | 38.9 | 800 | 835 | 1.03 |
| | 5-10 | 7.2 | 680 | 230 | 75 | 55 | 250 | 50 | 22.5 | 730 | 755 | 1.02 |
| Plot D | 0-2 | 3.1 | 115 | 35 | 15 | 10 | 80 | 30 | 19.3 | 610 | 630 | 0.83 |
| | 2-5 | 4.9 | 700 | 125 | 105 | 55 | 225 | 40 | 51.6 | 690 | 745 | 0.96 |
| | 5-10 | 4.2 | 675 | 110 | 105 | 60 | 165 | 35 | 23.8 | 785 | 805 | 1.03 |
| Plot A-Veg | 0-2 | 4.7 | 170 | 90 | 40 | 40 | 80 | 90 | 0.8 | 920 | 920 | 1.28 |
| | 2-5 | 7.8 | 210 | 230 | 50 | 50 | 110 | 80 | <0.1 | 1050 | 1050 | 1.18 |
| | 5-10 | 10.7 | 260 | 300 | 40 | 40 | 150 | 60 | <0.1 | 930 | 930 | 1.24 |
| Tailings | 0-2 | 6.4 | 8930 | 2760 | 2400 | 560 | 1810 | 485 | 7.9 | 30 | 40 | 0.11 |
| | 2-5 | 12.8 | 6650 | 610 | 2365 | 255 | 595 | 305 | 1.7 | | | 0.14 |

**A2: Observations of natural establishment of vegetation on tailings and examples of associated processes**

A2-P1: Natural colonisation on tailings; established plant grows above tailings surface due to wind-blown tailings, which is captured by the plant. The elevated position presumably allows salts to be leached from the higher position and produces favourable conditions for plant growth

A2-P2: Natural colonisation on tailings; view towards centre of TSF

Photos provided by NPM; photos were taken on 30 September 2019