



Appendix E

Flood Assessment





Memorandum

20 September 2016

To TNG Limited

Copy to

From Loong Hey Yoong
Wayne Schäfer

Tel 08 6222 8385
08 6222 8403

Subject 100-year ARI Flood Assessment

Job no. 61/29057/39

1 Introduction and Background

A flood assessment undertaken to support environmental approval for the Mount Peake Project identified that the pit may be susceptible to flooding from Murray Creek and that flood protection works may be required. The assessment was based on relatively coarse LIDAR elevation data that had not been corrected for vegetation influences.

Submissions received on the draft Environmental Impact Statement (EIS) by the Northern Territory Environment Protection Authority (NT EPA) requested that further assessment of flood extents should be undertaken and for the assessment to include the 100-year Average Recurrence Interval (ARI), 72-hour storm event.

To support this additional assessment, TNG acquired more definitive and accurate elevation data. A review of the flood hydrology was also undertaken with data from more remote streamflow gauges being included.

This memorandum documents the outcomes of the revised flood assessment.

2 Digital Elevation Model

Digital Elevation Models (DEMs) were developed from the WorldView-3 Stereo Imagery captured on July 2016 by GeoImage, details of which are provided at **Appendix A**. The spatial extents of the DEMs included the proposed mine site and the proposed road crossings at Murray Creek and Hanson River.

3 Flood Hydrology

A revision of the previous flood hydrology documented in the Mount Peake Project Groundwater and Surface Water Assessment Report No. 61/29057/150062 (hereafter referred to as the 'Assessment Report') was undertaken to define the 100-year ARI storm event. Previous work only focused on storm events up to the 50-year ARI. The same approach and methodology that was previously employed was applied, but with the inclusion of data from three additional streamflow gauging stations (i.e. Stations G0010005, G0050115 and G0290004). The locations of these additional stations are shown on **Figure 1**.

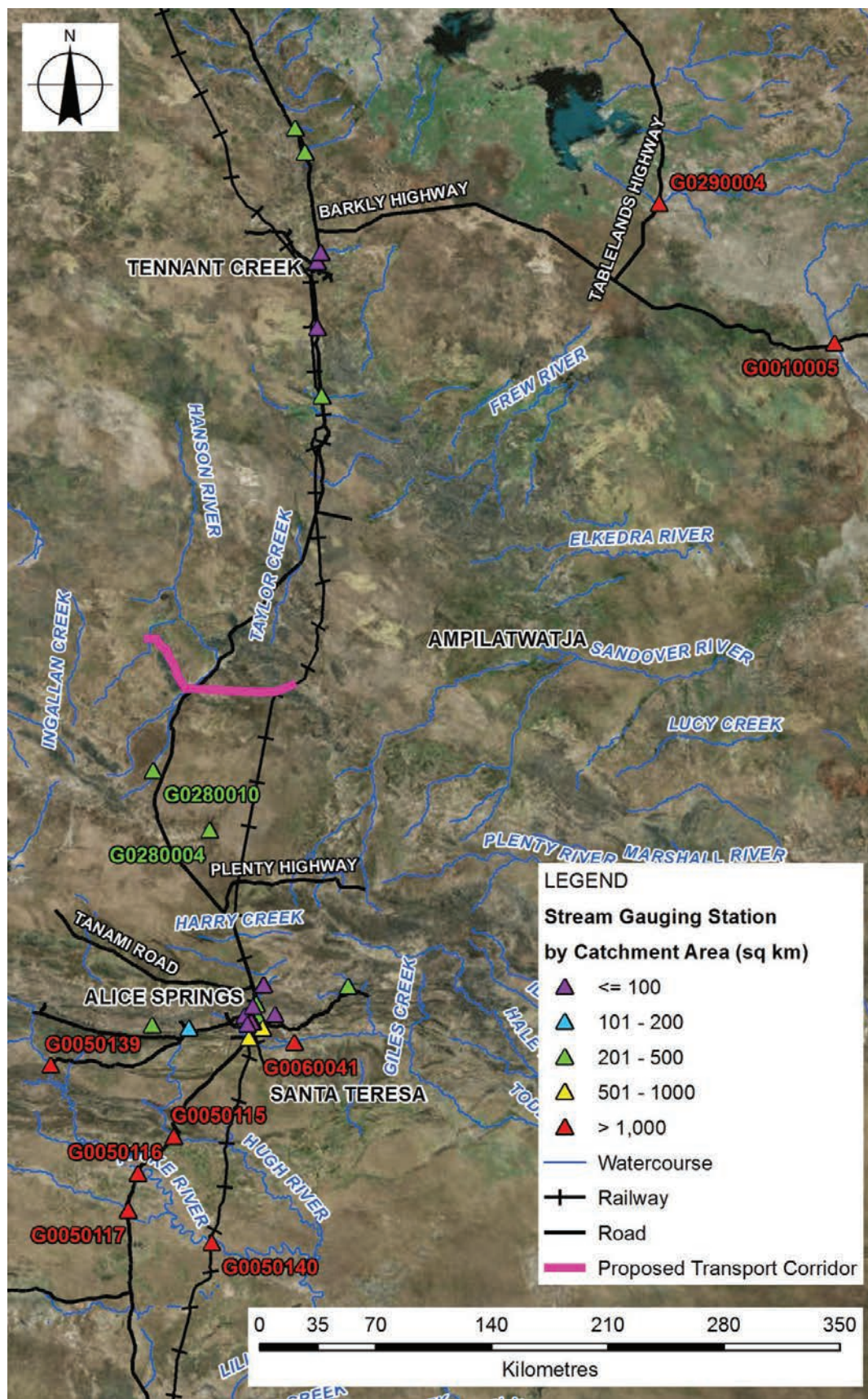


Figure 1: Locations of Streamflow Gauging Stations

In comparison to the original stations selected in the Assessment Report, the three new stations were noted to produce runoff more frequently and with higher runoff volumes relative to their catchment sizes. The inclusion of these additional streamflow data (with more frequent and higher discharges) influenced the flood frequency analysis outcomes and resulted in larger calculated peak discharges.

The Rational Method was employed for the estimation of peak discharges from the catchments (as for the Assessment Report). This method is currently the recommended flood estimation approach in the *Australian Rainfall and Runoff* (Institution of Engineers, Australia 1987), which is the national guideline for the estimation of design flood characteristics in Australia. The revised 100-year ARI peak discharges are summarised in **Table 1**.

Table 1: Estimated 100-year ARI peak discharges

Target Catchment	Runoff Coefficient	Peak Discharge (m ³ /s)
Murray Creek	0.57	1,341
Hanson River	0.57	2,574

The flood assessment also attempted to validate the peak discharges against those estimated using the newly released (draft) Regional Flood Frequency Estimation (RFFE) Model¹, which will be adopted in the forthcoming release of the 4th edition of *Australian Rainfall and Runoff* (Engineers Australia 2016). However, as of time of writing, model results (i.e. Model 2016 v1) for the study area (and greater arid region) have been disabled due to anomalies. Consequently, a comparison against the RFFE Model results could not be undertaken.

4 Flood Modelling

Flood modelling was undertaken for Murray Creek and Hanson River for the 100-year ARI storm event using TUFLOW Classic (Build 2016-03-AA), which is a two-dimensional fixed grid based program for simulating flood flow. The DEMs of the two watercourses and mine site were used as inputs into modelling. Modelling was undertaken using a 10 m cell size and 2 second time step interval.

The 100-year ARI peak discharge (summarised in **Table 1**) was applied as a constant inflow boundary condition just upstream of the proposed road crossings. The flows were subsequently routed through the topography itself, with the surface roughness and slope dictating the flow hydraulics. A free discharge boundary condition was assumed at the downstream end as backwater effects due to downstream surface water features were unlikely (refer to **Section 5.2** of the Assessment Report). This approach is considered to be relatively conservative compared to applying a varying hydrograph inflow boundary condition.

The predicted flood extents for the 100-year ARI storm event along the Murray Creek and Hanson River are depicted in **Figure 2** and **Figure 3** respectively. The flood extents indicate shallow breakouts and overland flow along the lengths of both watercourses. It is important to note that localised flooding as a result of direct rainfall onto the terrain is beyond the scope of this flood modelling exercise and not simulated. Ponding and/or flooding of surface depressions adjacent to the watercourses are likely to occur in the 100-year ARI storm event and should be assessed during infrastructure design.

¹ <http://rffe.arr.org.au/>

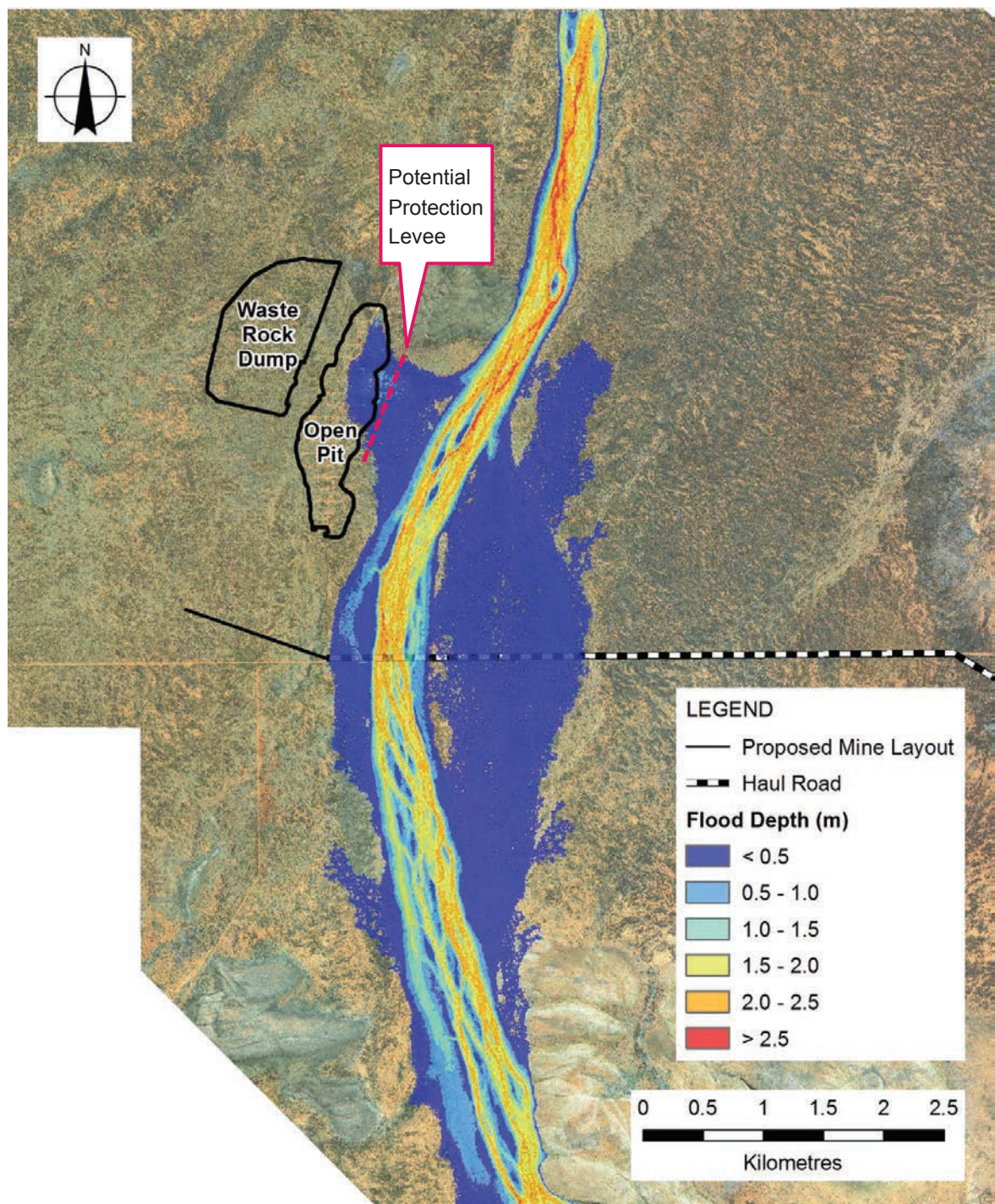


Figure 2: Simulated flood extents along Murray Creek for the 100-year ARI storm event

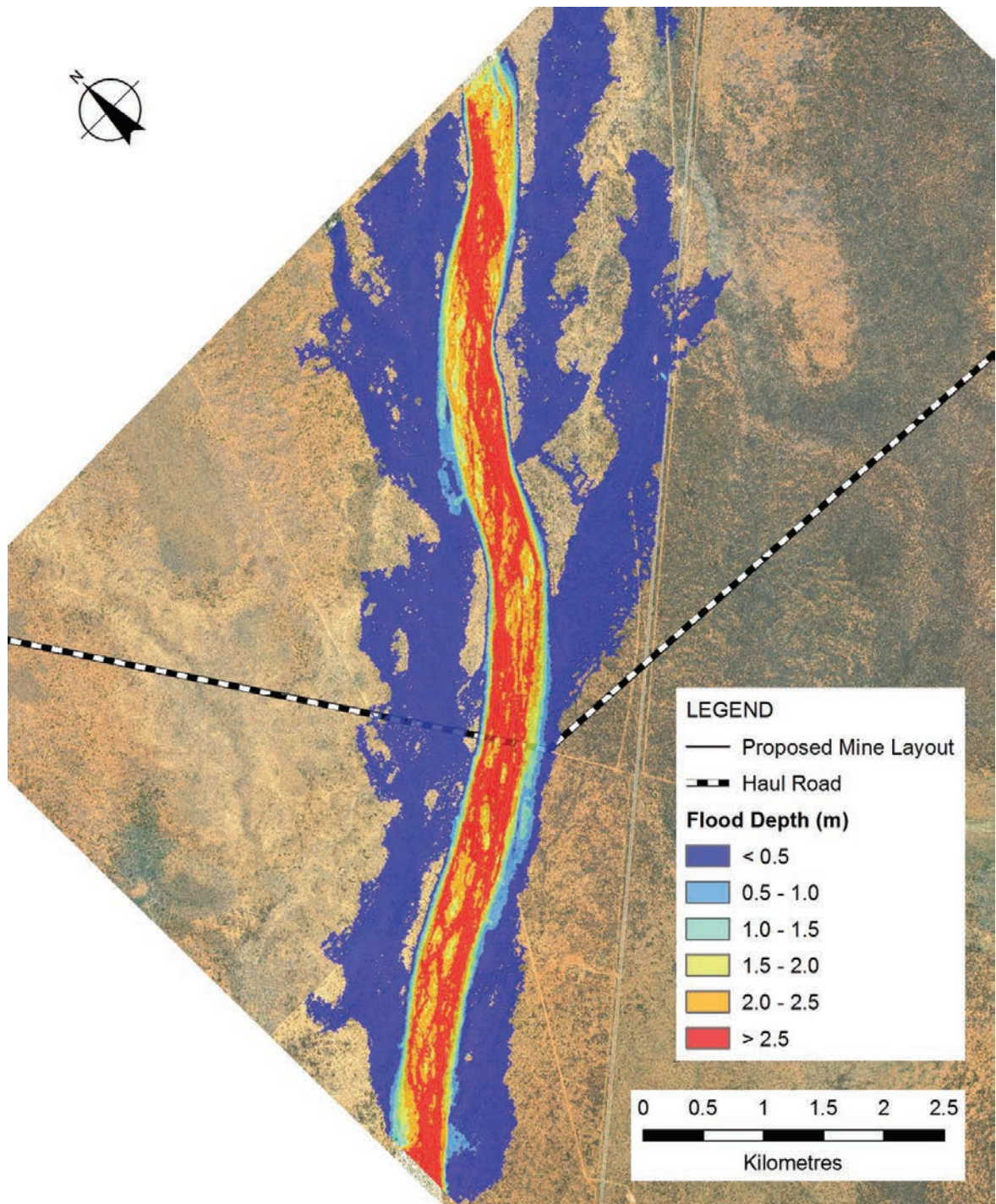


Figure 3: Simulated flood extents along Hanson River for the 100-year ARI storm event

Of particular interest is the proposed mine pit adjacent to Murray Creek, where modelling indicates that there is the potential for flooding. Accordingly, construction of a protection levee along the lower lying areas is recommended to avoid flooding of the pit. An indicative alignment of the protection levee is depicted on **Figure 2**.

It is understood that floodways are proposed for road crossings. The approaches to both proposed road crossings are likely to be inundated during the 100-year ARI storm event, which needs to be considered in the road crossing designs. **Table 2** lists the predicted worst-case flood depths at the

road crossings for varying storm event ARIs. It should be noted that the reported depths assume the natural ground surface and reflect the depth at the lowest point along the road crossing.

Table 2: Predicted worst-case flood depths

Storm Event	Maximum Water Depth (m)	
	Murray Creek	Hanson River
10-year ARI	1.17	1.58
20-year ARI	1.63	2.05
50-year ARI	2.25	2.69
100-year ARI	2.47	3.58

5 Flood Inundation Durations

The determination of the flood inundation durations was based on the updated hydrology detailed in **Section 2** and following the same methodology as described in **Section 5.3.6** of the Assessment Report. **Figure 4** to **Figure 7** depict the estimated durations of flood inundation in Murray Creek and the Hanson River for the 10-year to 100-year ARI, 72-hour storm events respectively.

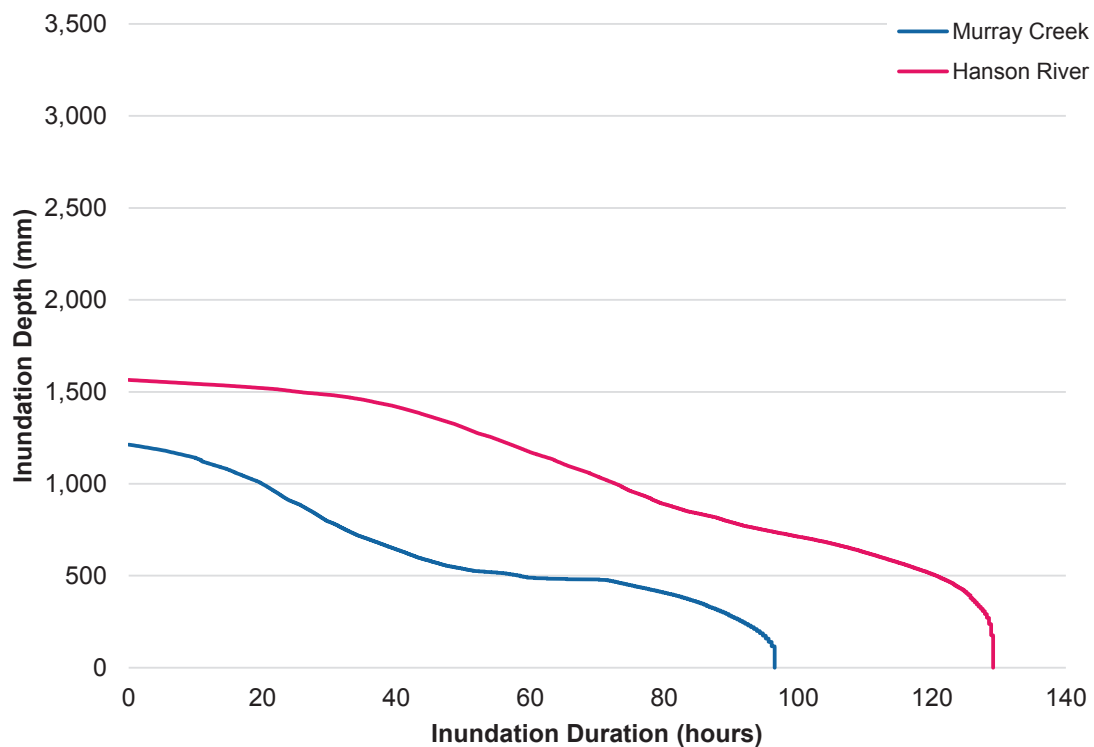


Figure 4: Simulated flood inundation duration in the 10-year ARI, 72-hour storm event

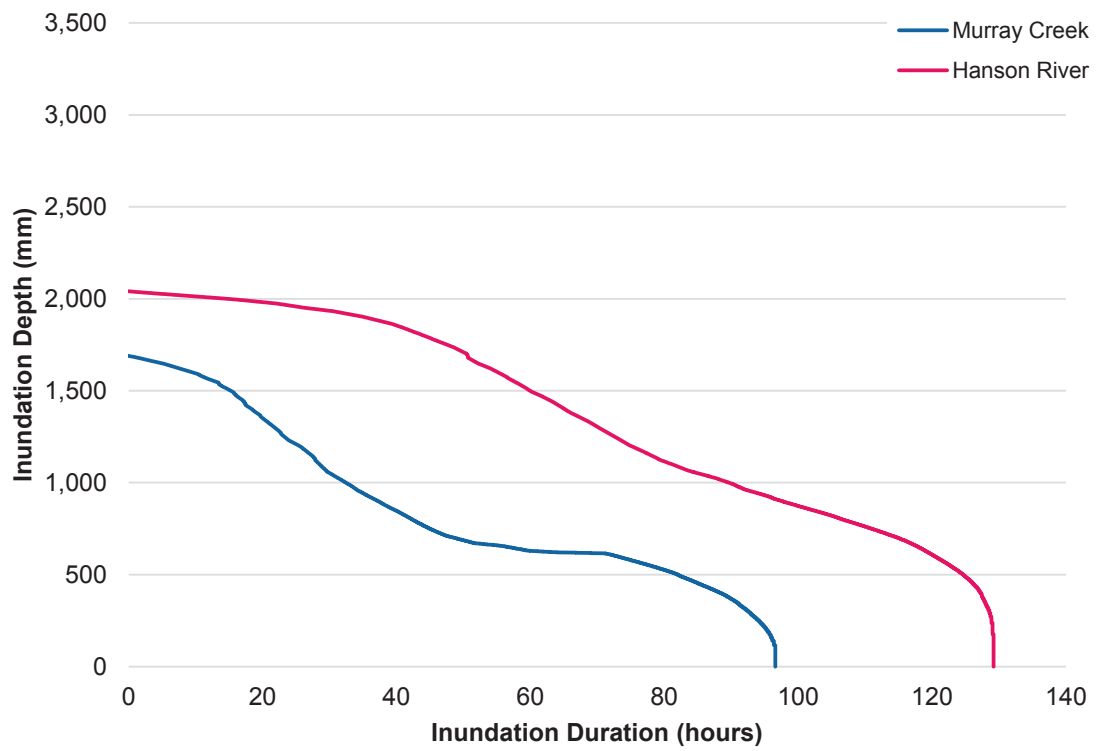


Figure 5: Simulated flood inundation duration in the 20-year ARI, 72-hour storm event

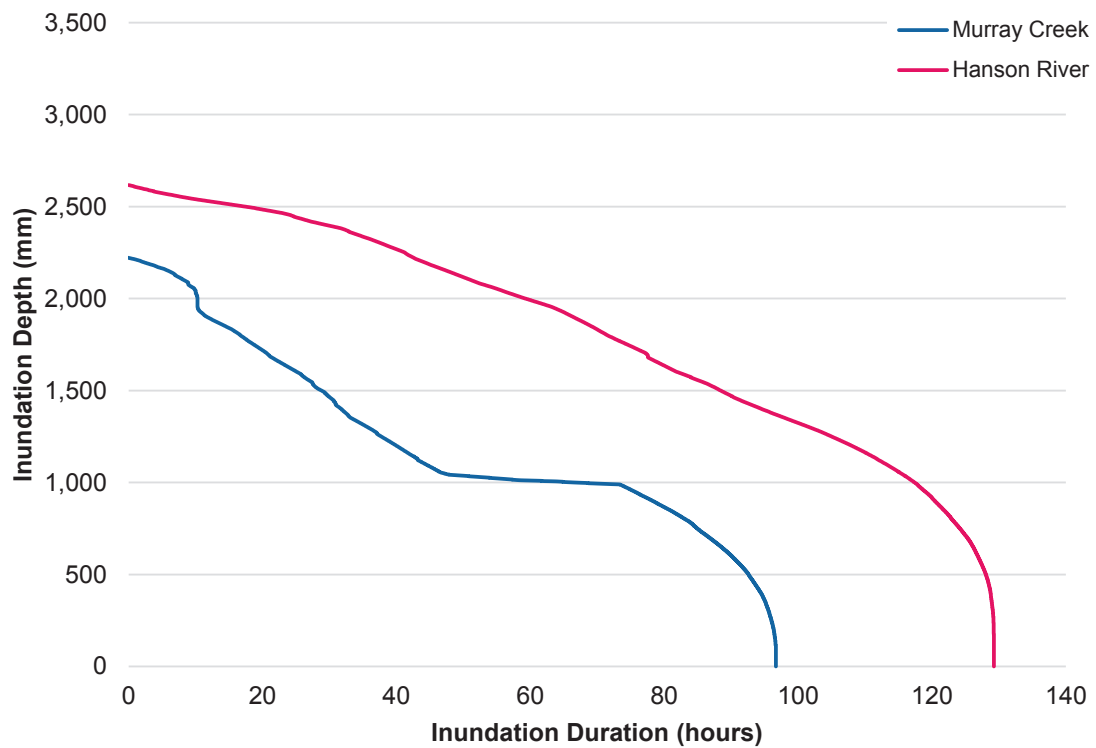


Figure 6: Simulated flood inundation duration in the 50-year ARI, 72-hour storm event

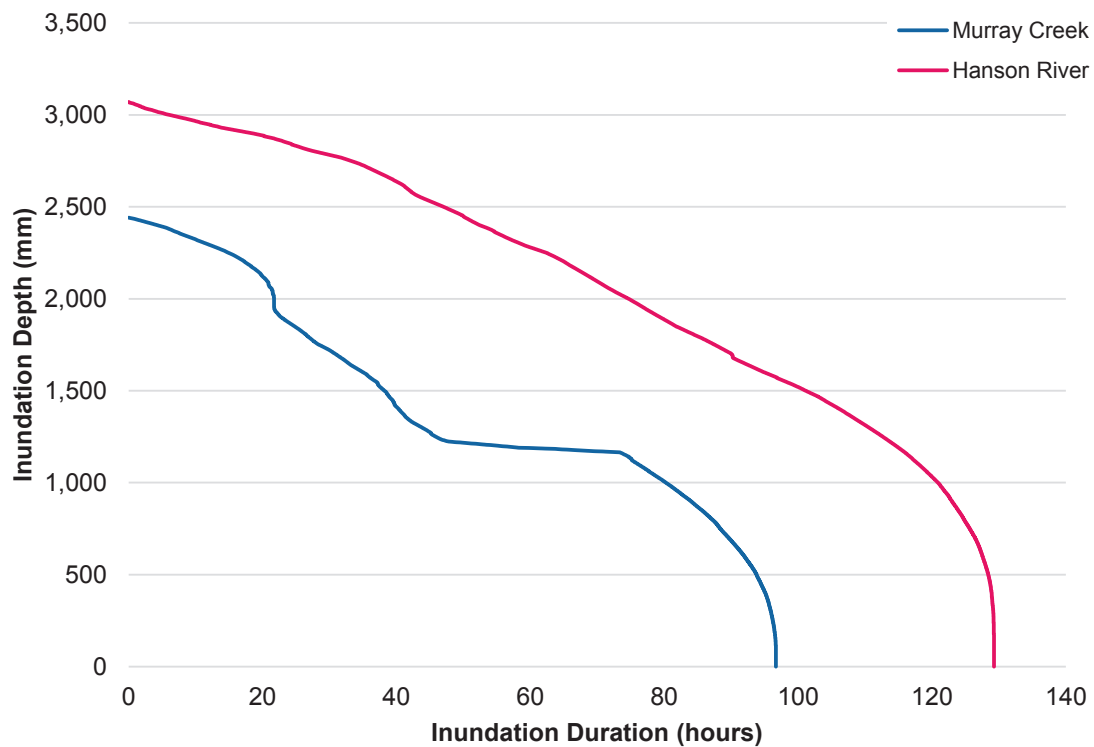


Figure 7: Simulated flood inundation duration in the 100-year ARI, 72-hour storm event

The curves shown on **Figure 7** indicate significantly deeper flows across the Hanson River crossing over a longer period of inundation. This is characteristic of large catchments, which typically generate higher runoff volumes and have longer hydrological response times. A distinct step reduction in inundation duration was predicted at the Murray Creek crossing as the inundation depth decreases from around 1.25 m to 1.15 m. This drop is the result of the rapid reduction of catchment discharge towards the end of the storm event. This was especially noticeable at the Murray Creek crossing due to its small catchment size and, in turn, relatively quick hydrological response.

Key simulation findings for the 100-year ARI, 72-hour storm event (refer to **Figure 7**) are:

- The maximum depths of flow in the Hanson River and Murray Creek are ~3.1 m and ~2.4 m respectively; and
- The duration of inundation of 0.5 m or greater in the Hanson River and Murray Creek are ~130 hours (i.e. ~5.5 days) and ~95 hours (i.e. ~4 days) respectively.

It should be noted that the maximum depths shown on **Figure 7** reflect the worst-case during the 100-year ARI, 72-hour storm event only. The flood depths within the watercourses could still be higher depending on the storm duration (as demonstrated in **Table 2**).

6 Conclusions and Recommendations

Simulation of the predicted flood extents for the 100-year ARI indicate that:

- Shallow breakouts and overland flow is simulated along the lengths of both Murray Creek and the Hanson River;
- There is the potential for flooding of the mine pit, which will require a protection levee;
- The approaches to the road crossings are likely to be inundated, which will need to be addressed in the road designs;
- The maximum depths of flow in the Hanson River and Murray Creek are likely to be 3.58 m and 2.47 m respectively; and
- The durations of inundation of 0.5 m or greater in the Hanson River and Murray Creek during the 72-hour storm event are ~130 hours (i.e. ~5.5 days) and ~95 hours (i.e. ~4 days) respectively.

Regards,



Loong Hey Yoong
Environmental Engineer



Wayne Schäfer
Principal Water Resources Engineer

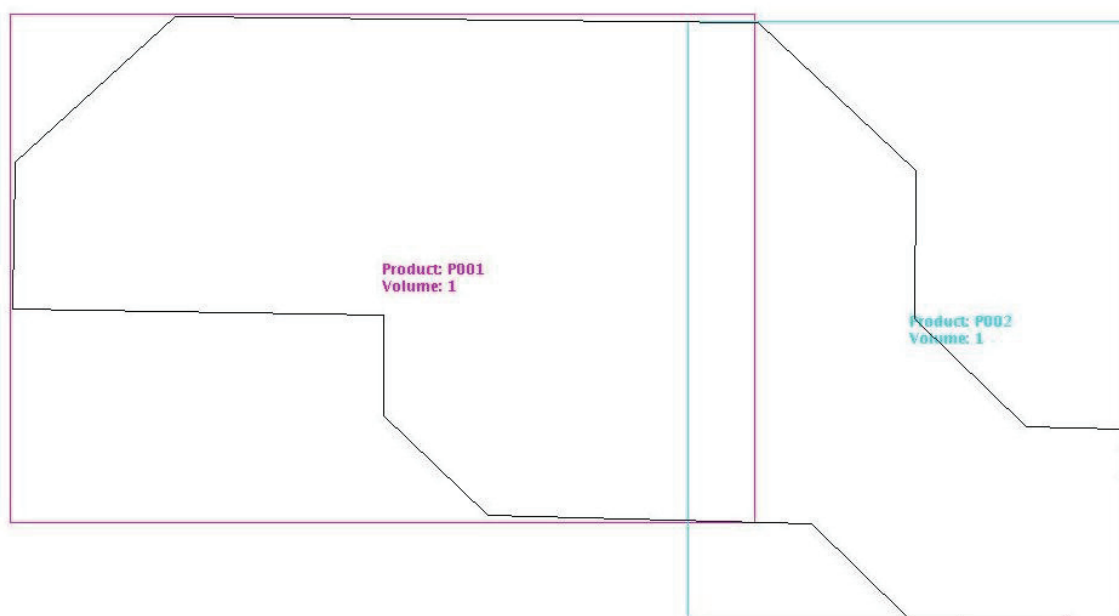
Appendix A: Digital Elevation Model Details

Job No.	17969
Client	TNG Limited
Area of interest	Mount Peake (West Mine), NT
Data type	WorldView-3 Stereo
Datum	GDA84
Projection	MGA53

Digital Elevation Model and Imagery Processing of WorldView-3 Stereo Imagery Mount Peake (West Mine), NT

Raw Data:

- Fresh Stereo Ortho-Ready Standard Level 2A WorldView-3 stereo imagery
- 30cm resolution panchromatic, 120cm resolution 4-band multispectral
- 2 swaths (P001 and P002), 151sqkm
- Both swaths captured on 04 July 2016

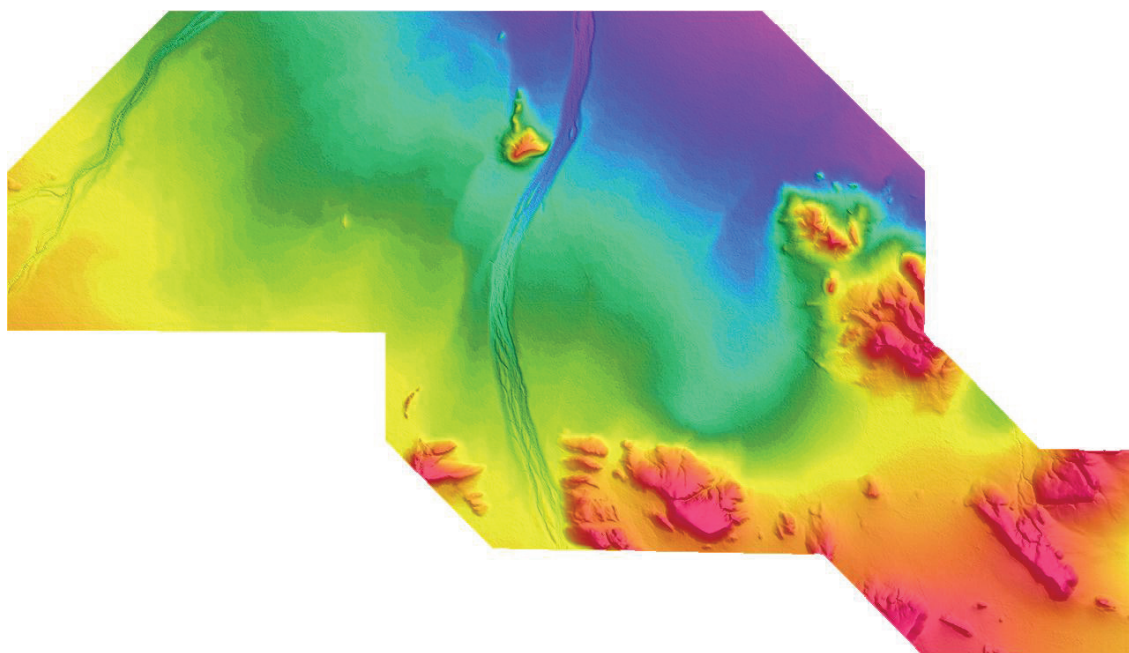


DSM and DTM Generation:

- Imagery triangulated using least squares block adjustment in SOCET GXP software for generation of 50cm gridded Digital Surface Model (DSM)
- Interpolated any poorly correlated pixels and/or null cells using proprietary Geoimage techniques; any anomalous values e.g. spikes were manually edited using PCI Geomatica
- Final 50cm resolution DSM exported to ER Mapper BIL and GeoTIFF formats
- Translated the noise free DSM to a bare earth model DTM (Digital Terrain Model) removing surface features using semi-automatic algorithms in PCI Geomatica
- Final 50cm resolution DTM exported to ER Mapper BIL and GeoTIFF formats
- Both 50cm and 1m tagged contours generated from the DTM using Intrepid and provided in tagged ESRI Shape format

Please Note:

The digital elevation data is not adjusted to ground control points and some correlation artefacts (banding) is noticeable in flat terrain with a height offset of around 10cm to true ground elevation.



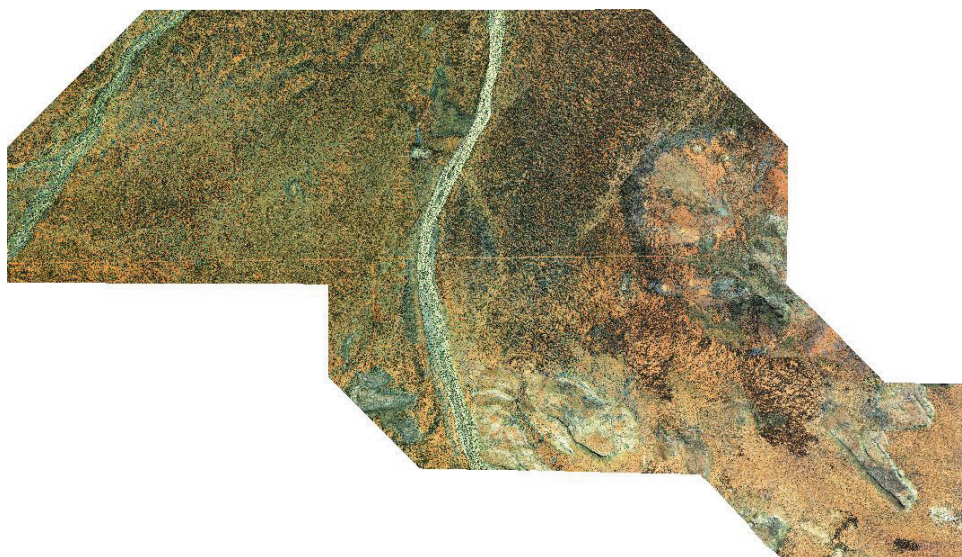
*50cm-resolution DTM generated from WorldView-3 stereo pairs
Captured 04 July 2016*

Imagery Generation:

- Raw GeoTIFF tiles of most nadir imagery compiled in PCI Geomatica
- Systematically orthorectified the panchromatic swaths using rational polynomial coefficients (RPCs) and the generated DTM resampled to 10m for Z control; tie points also collected on the overlap region
- Mosaicked the orthorectified panchromatic swaths using PCI Geomatica
- Orthorectified the multispectral swaths using RPCs with XY control from the panchromatic mosaic and the generated DTM resampled to 10m for Z control; tie points also collected on the overlap region
- Mosaicked the orthorectified multispectral swaths using PCI Geomatica
- Pan-sharpened the multispectral mosaic using the panchromatic mosaic in PCI Geomatica
- Re-projected the multispectral, panchromatic and pan-sharpened multispectral data from WGS84/SUTM53 to GDA94/MGA53
- Multispectral, panchromatic, and pan-sharpened data exported to GeoTIFF format with ESRI world files
- Contrast enhanced, GeoTIFF format images of the pan-sharpened data prepared in ER Mapper
 - Natural Colour (NC) – visible red, visible green, and visible blue in RGB
 - False Colour (FC) – NIR, visible red, and visible green in RGB
 - Enhanced Natural Colour (ENC) – visible red, visible green + NIR, and visible blue in RGB

Please Note:

GeoTIFF files over 4GB in size are divided into tiles with a 100 pixel overlap, name suffix indicates row and column number.



*30cm WorldView-3 mosaic acquired 04 July 2016
Enhanced Natural Colour*

Products Supplied:

/DEM/DTM/Contours

- 50cm tagged contours in ESRI Shapefile format
([MtPeake_WestMine_WV3_04Jul2016_50cmDTM_Contours_MGA53_polyline.shp](#))
- 1m tagged contours in ESRI Shapefile format
([MtPeake_WestMine_WV3_04Jul2016_1mDTM_Contours_MGA53_polyline.shp](#))

/DEM/DTM

- ER Mapper BIL format, IEEE4ByteReal, 50cm resolution raster grid
([MtPeake_WestMine_WV3_04Jul2016_50cmDTM_MGA53.ers](#))
- GeoTIFF format, IEEE4ByteReal, 50cm resolution raster grid with ESRI world file
([MtPeake_WestMine_WV3_04Jul2016_50cmDTM_MGA53_R1C1.tif](#))

/DEM/DSM

- ER Mapper BIL format, IEEE4ByteReal, 50cm resolution raster grid
([MtPeake_WestMine_WV3_04Jul2016_50cmDSM_MGA53.ers](#))
- GeoTIFF format, IEEE4ByteReal, 50cm resolution raster grid with ESRI world file
([MtPeake_WestMine_WV3_04Jul2016_50cmDSM_MGA53_R1C1.tif](#))

/Unenhanced_GeoTIFF

- Un-enhanced Unsigned16BitInteger 4-band multispectral single swath imagery in GeoTIFF format with ESRI world file
([MtPeake_WestMine_WV3_120cm_04Jul2016_BGRN_MGA53_P001.tif etc.](#))
- Un-enhanced Unsigned16BitInteger 4-band multispectral mosaic imagery in GeoTIFF format with ESRI world file
([MtPeake_WestMine_WV3_120cm_04Jul2016_BGRN_Mosaic_MGA53.tif](#))
- Un-enhanced Unsigned16BitInteger panchromatic single swath imagery in GeoTIFF format with ESRI world file
([MtPeake_WestMine_WV3_30cm_04Jul2016_Pan_MGA53_P001.tif etc.](#))
- Un-enhanced Unsigned16BitInteger panchromatic mosaic imagery in GeoTIFF format with ESRI world file
([MtPeake_WestMine_WV3_30cm_04Jul2016_Pan_Mosaic_MGA53_R1C1.tif](#))
- Un-enhanced Unsigned16BitInteger pan-sharpened multispectral imagery in GeoTIFF format with ESRI world file, as single band files
([MtPeake_WestMine_WV3_30cm_04Jul2016_psBlue_Mosaic_MGA53_R1C1.tif etc.](#))

/Enhancements_GeoTIFF

- Unsigned8BitInteger GeoTIFF format enhancements with ESRI world file
([MtPeake_WestMine_WV3_30cm_04Jul2016_Mosaic_ENC_MGA53_R1C1.tif etc.](#))

/Metadata

- 17969_Readme_WestMine.pdf
- DigitalGlobe EULA ([WW0023A_Internal_Use_License_Ver2-24-15.pdf](#))
- Metadata for these captures ([16JUL04015136-M2AS-055422679040_01_P001.IMD etc.](#))

Dataset Details:

WorldView-3 Multispectral Swath P001 captured 04 July 2016:

Top Left Coordinate = 313984.80mE, 7609992.00mN
Cell Size = 120cm
Number of Lines = 8405
Number of Pixels = 11619
Projection = MGA53
Datum = GDA94

WorldView-3 Multispectral Swath P002 captured 04 July 2016:

Top Left Coordinate = 326760.00mE, 7609996.80mN
Cell Size = 120cm
Number of Lines = 9998
Number of Pixels = 6898
Projection = MGA53
Datum = GDA94

WorldView-3 Multispectral Mosaic captured 04 July 2016:

Top Left Coordinate = 313984.80mE, 7609996.80mN
Cell Size = 120cm
Number of Lines = 9998
Number of Pixels = 17544
Projection = MGA53
Datum = GDA94

WorldView-3 Panchromatic Swath P001 captured 04 July 2016:

Top Left Coordinate = 313985.10mE, 7609991.40mN
Cell Size = 30cm
Number of Lines = 33621
Number of Pixels = 46474
Projection = MGA53
Datum = GDA94

WorldView-3 Panchromatic Swath P002 captured 04 July 2016:

Top Left Coordinate = 326760.30mE, 7609995.90mN
Cell Size = 30cm
Number of Lines = 39994
Number of Pixels = 27590
Projection = MGA53
Datum = GDA94

WorldView-3 Panchromatic Mosaic captured 04 July 2016:

Top Left Coordinate = 313985.10mE, 7609995.90mN

Cell Size = 30cm

Number of Lines = 39994

Number of Pixels = 70174

Projection = MGA53

Datum = GDA94

WorldView-3 Pan-sharpened Multispectral Mosaic captured 04 July 2016:

Top Left Coordinate = 313985.10mE, 7609995.90mN

Cell Size = 30cm

Number of Lines = 39989

Number of Pixels = 70174

Projection = MGA53

Datum = GDA94

WorldView-3 generated 50cm DSM and DTM captured 04 July 2016:

Top Left Coordinate = 313993.72mE, 7609990.22mN

Cell Size = 50cm

Number of Lines = 23968

Number of Pixels = 42052

Projection = MGA53

Datum = GDA94

Job No.	17969
Client	TNG Limited
Area of interest	Mount Peake (South Highway), NT
Data type	WorldView-3 Stereo
Datum	GDA84
Projection	MGA53

Digital Elevation Model and Imagery Processing of WorldView-3 Stereo Imagery Mount Peake (South Highway), NT

Raw Data:

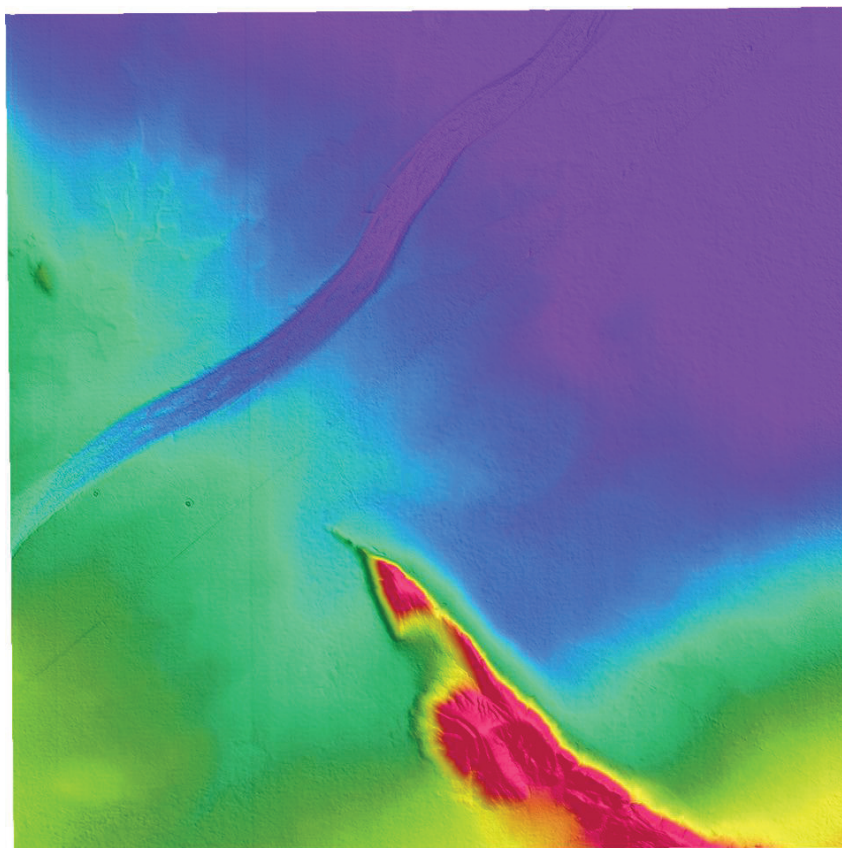
- Fresh Stereo Ortho-Ready Standard Level 2A WorldView-3 stereo imagery
- 30cm resolution panchromatic, 120cm resolution 4-band multispectral
- 1 swath, 100sqkm
- Data captured on 09 July 2016

DSM and DTM Generation:

- Imagery triangulated using least squares block adjustment in SOCET GXP software for generation of 50cm gridded Digital Surface Model (DSM)
- Interpolated any poorly correlated pixels and/or null cells using proprietary Geoimage techniques; any anomalous values e.g. spikes, were manually edited using PCI Geomatica
- Final 50cm resolution DSM exported to ER Mapper BIL and GeoTIFF formats
- Translated the noise free DSM to a bare earth model DTM (Digital Terrain Model) removing surface features using semi-automatic algorithms in PCI Geomatica
- Final 50cm resolution DTM exported to ER Mapper BIL and GeoTIFF formats
- Both 50cm and 1m tagged contours generated from the DTM using Intrepid and provided in tagged ESRI Shape format

Please Note:

The digital elevation data is not adjusted to ground control points and some correlation artefacts (banding) is noticeable in flat terrain with a height offset of around 10cm to true ground elevation.



*50cm-resolution DTM generated from WorldView-3 stereo pairs
Captured 09 July 2016*

Imagery Generation:

- Raw GeoTIFF tiles of most nadir imagery compiled in PCI Geomatica
- Systematically orthorectified the panchromatic and multispectral swaths separately using rational polynomial coefficients (RPCs) and the generated DTM resampled to 5m for Z control
- Pan-sharpened the multispectral swath using the panchromatic swath in PCI Geomatica
- Re-projected the multispectral, panchromatic and pan-sharpened multispectral data from WGS84/SUTM53 to GDA94/MGA53
- Multispectral, panchromatic, and pan-sharpened data exported to GeoTIFF format with ESRI world files
- Contrast enhanced, GeoTIFF format images of the pan-sharpened data prepared in ER Mapper
 - Natural Colour (NC) – visible red, visible green, and visible blue in RGB
 - False Colour (FC) – NIR, visible red, and visible green in RGB
 - Enhanced Natural Colour (ENC) – visible red, visible green + NIR, and visible blue in RGB



30cm WorldView-3 image acquired 09 July 2016
Enhanced Natural Colour

Products Supplied:

/DEM/DTM/Contours

- 50cm tagged contours in ESRI Arc Shapefile format
([MtPeake_SouthHwy_WV3_09Jul2016_50cmDTM_Contours_MGA53_polyline.shp](#))
- 1m tagged contours in ESRI Arc Shapefile format
([MtPeake_SouthHwy_WV3_09Jul2016_1mDTM_Contours_MGA53_polyline.shp](#))

/DEM/DTM

- ER Mapper BIL format, IEEE4ByteReal, 50cm resolution raster grid
([MtPeake_SouthHwy_WV3_09Jul2016_50cmDTM_MGA53.ers](#))
- GeoTIFF format, IEEE4ByteReal, 50cm resolution raster grid with ESRI world file
([MtPeake_SouthHwy_WV3_09Jul2016_50cmDTM_MGA53.tif](#))

/DEM/DSM

- ER Mapper BIL format, IEEE4ByteReal, 50cm resolution raster grid
([MtPeake_SouthHwy_WV3_09Jul2016_50cmDSM_MGA53.ers](#))
- GeoTIFF format, IEEE4ByteReal, 50cm resolution raster grid with ESRI world file
([MtPeake_SouthHwy_WV3_09Jul2016_50cmDSM_MGA53.tif](#))

/Unenhanced_GeoTIFF

- Un-enhanced Unsigned16BitInteger 4-band multispectral imagery in GeoTIFF format with ESRI world file
([MtPeake_SouthHwy_WV3_120cm_09Jul2016_BGRN_MGA53.tif](#))
- Un-enhanced Unsigned16BitInteger panchromatic imagery in GeoTIFF format with ESRI world file
([MtPeake_SouthHwy_WV3_30cm_09Jul2016_Pan_MGA53.tif](#))
- Un-enhanced Unsigned16BitInteger pan-sharpened multispectral imagery in GeoTIFF format with ESRI world file, as single band files
([MtPeake_SouthHwy_WV3_30cm_09Jul2016_psBlue_MGA53.tif](#) etc.)

/Enhancements_GeoTIFF

- Unsigned8BitInteger GeoTIFF format enhancements with ESRI world file
([MtPeake_SouthHwy_WV3_30cm_09Jul2016_ENC_MGA53.tif](#) etc.)

/Metadata

- 17969_Readme_SouthHwy.pdf
- DigitalGlobe EULA ([WW0023A_Internal_Use_License_Ver2-24-15.pdf](#))
- Metadata for these captures ([16JUL09013331-M2AS-055422679030_01_P001.IMD](#) etc.)

Dataset Details:

WorldView-3 Multispectral Image captured 09 July 2016:

Top Left Coordinate = 345538.80mE, 7579686.00mN
 Cell Size = 120cm
 Number of Lines = 8443
 Number of Pixels = 8414
 Projection = MGA53
 Datum = GDA94

WorldView-3 Panchromatic Image captured 09 July 2016:

Top Left Coordinate = 345539.10mE, 7579685.40mN
 Cell Size = 30cm
 Number of Lines = 33774
 Number of Pixels = 33655
 Projection = MGA53
 Datum = GDA94

WorldView-3 Pan-sharpened Multispectral Image captured 09 July 2016:

Top Left Coordinate = 345539.10mE, 7579685.40mN
 Cell Size = 30cm
 Number of Lines = 33770
 Number of Pixels = 33655
 Projection = MGA53
 Datum = GDA94

WorldView-3 generated 50cm DSM and DTM captured 09 July 2016:

Top Left Coordinate = 345541.13mE, 7579681.17mN

Cell Size = 50cm

Number of Lines = 20233

Number of Pixels = 20182

Projection = MGA53

Datum = GDA94



Appendix F

AMD Assessment





TNG Limited

Mount Peake - Acid and Metalliferous Drainage Assessment
Assessment of laboratory results

November 2016

Executive summary

This report presents the findings of a laboratory assessment of geochemical data relating to the risk of development of acid, metalliferous or saline drainage at the Mount Peake site. The assessment was undertaken to provide further information on the potential risk of AMD following a desktop assessment undertaken as part of the Draft Environmental Impact Statement.

The previous assessment was based on extensive geochemical testing of ore and waste material using X-Ray Fluorescence analysis during various stages of drilling. The data found that in general the waste and ore was low in sulfur with 98.6% of the samples recording total sulfur less than 0.2%. Laboratory testing undertaken for the current assessment analysed ore and waste material for Static and Kinetic AMD parameters to test the validity of the previous assessment and further quantify the AMD risk.

The Stage 1 testing undertaken for this assessment analysed 409 samples (196 from waste rocks, 209 from ore and 4 from tailings material). The number of samples analysed exceeded the industry recommended number of samples. Stage 1 analysis was undertaken on all samples for Net Acid Producing Potential (NAPP), Net Acid Generation (NAG), metals and sulfur.

Stage 1 results broadly supported the preliminary assessment undertaken in 2015, with both datasets showing consistently low sulfur concentrations for waste and ore, indicating the material is unlikely to generate acid. The laboratory analysis demonstrated that the majority of samples were low in sulfides, with 85% of the waste samples being less than 0.05% sulfides, and 97% of the ore samples being less than 0.05% sulfides. Total sulfur was below Limits of Reporting (0.01%) for almost half of the waste samples.

Maximum Potential Acidity (MPA) for the samples analysed recorded median, mean and 99% Upper Confidence Limit values of 0.5, 0.7 and 0.8 kg/t H_2SO_4 respectively, demonstrating a general lack of sulfide material and a very low acid potential for the waste and ore.

Net Acid Producing Potential (NAPP) results demonstrated that all samples returned negative values, indicating that all the material can be classified as either acid-consuming material (ACM) or non-acid-forming (NAF).

Based on Stage 1 results, samples representing the highest sulfur and/or metal data were chosen for Stage 2 testing. Analysis included Kinetic NAG testing, acid buffering characteristic curve (ABCC) analyses and Australian standard leaching procedure (ASLP) testing.

The kinetic NAG and ABCC tests indicate that in the highest risk samples the ANC may be largely due to reactions of silicates such as micas and clays and hence overestimated. However, the various waste rock and ore material have adequate acid neutralising capacity and the risk of acid leachate generation is very low.

Leachate testing indicates that leachate from waste rock may be sodic and cause soil dispersion if irrigated on to local soils. This can be managed by capping waste rock dumps with non-dispersive soils on closure, diverting runoff to holding ponds via armoured drainage channels and by amending impacted soils or treating leachate with lime, if soil contact is likely.

It is concluded that the project does not pose a significant AMD risk to the environment.

In keeping with TNG's commitments to safeguarding the environment, further AMD monitoring will be undertaken pre-mining and during mining to provide feedback to confirm that concentrations of key AMD parameters are consistent with the existing testing. In the unlikely event that material with a greater AMD potential is identified, appropriate contingency measures will be taken.

Abbreviations

Abbreviation	Definition
ABCC	Acid buffering characteristic curves
ACM	Acid consuming material
AMD	Acid and metalliferous drainage
ANC	Acid neutralising capacity
APP	Acid producing potential
ASLP	Australian standard leaching procedure
CEC	Cation exchange capacity
EC	Electrical conductivity
ESP	Exchangeable sodium percentage
GAI	Geochemical abundance index
ICP-MS	Inductively coupled plasma mass spectrometry
KNAG	Kinetic net acid generation
LOM	Life of mine
LOR	Limits of reporting
MMP	Mine Management Plan
MPA	Maximum potential acidity
Mt	Million tonnes
Mtpa	Million tonnes per annum
NAF	Non-acid forming
NAG	Net acid generation
NAPP	Net acid production potential
NPR	Neutralising potential ratio
PAF	Potentially acid forming
SAR	Sodium adsorption ratio
TSF	Tailings Storage Facility
UC	Uncertain category
UCL	Upper confidence limit
WRD	Waste rock dump
XRF	X-ray fluorescence

Glossary

Definition
Acid and metalliferous drainage Acidic and metalliferous drainage includes acidic drainage, pH neutral metalliferous drainage (Neutral Mine Drainage), and saline drainage generally caused by the oxidation of sulfide minerals.
Acid forming Materials which will generate acidic water, soluble metals or salts.
Acid neutralising capacity Measures the capacity of a sample to neutralise any acid produced. Expressed as kg H ₂ SO ₄ per tonne of rock.
Acid producing potential Measures total acid producing potential irrespective of the presence of any acid neutralising capacity. Expressed as kg H ₂ SO ₄ per tonne of rock.
Cation exchange capacity The total capacity of a soil to hold exchangeable cations. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients and provides a buffer against soil acidification.
Electrical conductivity The level of soluble salts (salinity) readily leached from the material.
Geochemical abundance index A measure to compare the elemental concentration in a sample to the median abundance in the most relevant media (soils, crustal abundance etc.). The purpose is to provide a relative indication of any elemental enrichment that may be of environmental importance.
Kinetic net acid generation Measures net acid generation over time due to the effects of dynamic processes, including reaction rates (such as sulfide oxidation and acid generation), material alteration and drainage chemistry and loadings that result from weathering.
Maximum potential acidity The total amount of sulfur in a sample and is an estimate of the maximum acidity a rock can generate.
Metalliferous drainage A form of acid and metalliferous drainage characterised by near-neutral pH, elevated heavy metal concentrations and high sulfide salinity.
Net acid generation The residual acid generated from sulfide oxidation once any neutralising components in the sample are taken into account. Any remaining acidity is expressed as kg H ₂ SO ₄ per tonne of rock.

Net acid production potential

Calculated by subtracting acid neutralising capacity from acid producing potential. Expressed as kg H₂SO₄ per tonne of rock.

Neutralising potential ratio

The safety factor of acid neutralising capacity (ANC) divided by maximum potential acidity (MPR). An NPR of greater than 2 is considered to have adequate neutralising capacity with a good factor of safety, between 1 and 2 is usually classified as Uncertain as although it has more ANC than MPA, there is not a great enough factor of safety, and anything with an NPR of less than 1 is considered Potentially Acid Forming.

Non-acid forming

Materials which are chemically stable and will not generate any acidic water, soluble metals or salts that could impact the environment.

Potentially acid forming

Materials that when exposed to air and water, can generate acidic water, soluble metals or salts that could impact the environment.

Saline drainage

A product of acid and metalliferous drainage characterised by high sulfate salinity but near-neutral pH and low concentrations of heavy metals.

Sodicity

Sodicity is a term given to the amount of sodium held in a soil. A soil is considered sodic when the sodium reaches a concentration where it starts to affect soil structure. Sodic soils can be dispersive with reduced infiltration and drainage.

Sodium adsorption ratio

A measure of the suitability of water for use in agricultural irrigation, as determined by the concentrations of solids dissolved in the water. It is also a measure of the sodicity of soil, as determined from analysis of water extracted from the soil.

Table of contents

Abbreviations	ii
Glossary	iii
1. Introduction.....	1
1.1 Introduction	1
1.2 Scope and limitations.....	1
1.3 Data sources	2
1.4 Project summary	2
1.5 Ore and waste management	2
2. Geochemical assessment.....	4
2.1 Available data	4
2.2 Sample density, numbers and locations	5
2.3 Assay-based AMD Assessment	7
2.4 Stage 1 Static AMD testing	8
2.5 Stage 2 Kinetic AMD and leachate testing	15
2.6 Summary of key results	23
3. AMD Management Plan	24
3.1 AMD risk	24
3.2 Waste rock and ore management.....	24
3.3 AMD monitoring	24
4. Conclusions.....	27
5. References	28

Table index

Table 2-1	Size of geochemical data sets by type	6
Table 2-2	GAI summary	7
Table 2-3	MPA for each lithology / waste stream (kg/t H ₂ SO ₄).....	9
Table 2-4	ANC for each lithology / waste stream (kg/t H ₂ SO ₄).....	10
Table 2-5	NAPP for each lithology / waste stream (kg/t H ₂ SO ₄).....	11
Table 2-6	NPR for each lithology / waste stream.....	12
Table 2-7	ABCC derived neutralising capacity and static ANC values	18
Table 2-8	Leachate data – elements with exceedances.....	20
Table 2-9	Indicative mine waste salinity classification parameters.....	21

Figure index

Figure 1-1	Waste and ore volumes for each year of mining	3
Figure 2-1	Sample location summary	6
Figure 2-2	Sulfur data – Comparison of ICP-MS data (this study) and XRF data (GHD, 2015).....	8
Figure 2-3	Total sulfide for ore	9
Figure 2-4	Total sulfide for waste	9
Figure 2-5	MPA statistics for each lithology / waste stream (kg/t H ₂ SO ₄).....	10
Figure 2-6	ANC statistics for each lithology / waste stream (kg/t H ₂ SO ₄).....	11
Figure 2-7	NAPP statistics for each lithology / waste stream (kg/t H ₂ SO ₄).....	12
Figure 2-8	NPR statistics for each lithology / waste stream.....	13
Figure 2-9	NAG vs NAPP Plot – High (-50 to 50 kg/t H ₂ SO ₄) NAPP	14
Figure 2-10	NAG vs NAPP Plot - Full Range	14
Figure 2-11	NAG vs NPR plot	15
Figure 2-12	Collated KNAG plots - pH	16
Figure 2-13	Collated KNAG plots - temperature	16
Figure 2-14	NAG pH KNAG pH correlation plot.....	17
Figure 2-15	Sodium Adsorption Ratio (SAR) vs Electrical Conductivity (EC) soil classification.....	22

Appendices

Appendix A - Acid buffering characteristics curves

Appendix B - Leachate data

1. Introduction

1.1 Introduction

GHD Pty Ltd (GHD) carried out a preliminary Acid and Metalliferous Drainage (AMD) assessment for the proposed TNG Limited (TNG) Mount Peake mine, as part of the Draft Environmental Impact Statement (EIS). The preliminary assessment was based mainly on existing assay data that was collated during resource assessment. The assessment indicated that overall the site appears to pose a low risk of acid drainage with 98.6% of the samples analysed returning values of below 0.2% for total sulfur.

Following submission of the EIS, the NT government provided feedback that further AMD test work was required. In light of this, a laboratory program was scheduled to address the outstanding uncertainty regarding site AMD risks.

The following report provides an assessment of the laboratory results and makes recommendations for further assessment where required. In addition, the report also clarifies potential AMD issues of concern that were raised by submitters on the Draft EIS.

1.2 Scope and limitations

The scope of works for this study included:

- Specify a laboratory sampling plan for Primary Tests on targeted samples
- Collate and present laboratory data by lithological unit / waste stream and undertake geostatistical analysis
- Review data in view of the overall Project and associated environmental risks
- Develop a further sampling and analysis program to address any further uncertainty.

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1.3 Data sources

The following key data sources were used in this assessment:

- Assay data for elements, including Al (aluminium), As (arsenic), Ba (barium), Ca (calcium), Cl (chlorine), Co (cobalt), Cr (chromium), Cu (copper), Fe (iron), K (potassium), Mg (magnesium), Mn (manganese), Na (sodium), Ni (nickel), P (phosphorous), Pb (lead), S (sulfur), Si (silicon), Sn (tin), Se (selenium), Sr (strontium), Ti (titanium), V (vanadium), Zn (zinc) and Zr (zircon)
- Stage 1 Static AMD testing of potential ore and waste rock material for:
 - Total Metals by inductively coupled plasma mass spectrometry (ICP-MS)
 - Net Acid Producing Potential (NAPP)
 - Net Acid Generation (NAG); and
 - 1:5 EC and pH
- Stage 2 Kinetic and leachability testing comprising:
 - Kinetic NAG (KNAG)
 - Acid Buffering Characteristic Curves (ABCC)
 - Australian Standard Leaching Procedure (ASLP) deionised water leachate analyses
- Life of mine (LOM) plan and potential options relative to the above features
- Hydrogeological (including geological and geotechnical) documents, reports and borehole logs.

1.4 Project summary

The mine site is located approximately 235 km north-northwest of Alice Springs and approximately 50 km west of the Stuart Highway. The Mount Peake Project will comprise:

- The mining of a polymetallic ore body through an open-pit truck and shovel operation
- Processing of the ore to produce a magnetite concentrate
- Storage of tailings at an onsite Tailings Storage Facility (TSF)
- Road haulage of the concentrate to a new railway siding and loadout facility on the Alice Springs to Darwin railway near Adnera
- Rail transport of the concentrate to TNG's proposed process plant.

The Project will mine at a rate of up to 8.4 million tonnes per annum (Mtpa) and, following processing, will produce up to 1.8 Mtpa of magnetite concentrate for further offsite processing to produce vanadium pentoxide flake, pigment grade titanium dioxide and pig iron ingots.

The life of the project is expected to be 19 years inclusive of construction (2 years), mining and production (15 years), and closure and rehabilitation (2 years).

1.5 Ore and waste management

Detail of the waste rock management process will be further developed in the Mine Management Plan (MMP) which will be submitted at a later date.

The waste rock generated during pre-production mining would, in part, be used to construct pads for infrastructure, a run of mine (ROM) pad, and product stockpile pads. It is estimated that this volume would be up to 5 Mt. Waste rock generated by mining in subsequent years would be stored in the Waste Rock Dump (WRD) located to the west of the pit.

The waste rock can be categorised into four broad lithological units: Unmineralised gabbro (58% of waste material, granite (10% of waste material), alluvials (32% of waste material) and fault material (less than 1% of waste material).

Material to be excavated consists of between 2 to 16 m of overburden (waste) overlying the main ore body. The orebody is hosted by a mafic intrusive rock, a gabbro sill. The sill is up to 250 m thick with gabbro both below and above the ore zones. The orebody comprises the magnetite-rich portion of the sill, which forms a flat-lying body that is oriented north/south.

Mining will commence with a “starter pit” accessing high-grade and low strip ratio ore. Drilling and blasting, to loosen rock ahead of mining, will be undertaken to produce rock sizes that conform to processing requirements.

Extracted high-grade ore will be transported by haul truck from the pit to the ROM pad and directly fed into the process plant.

Four long-term stockpiles will be established according to grade. The higher-grade stockpile will be used to balance the mining and processing rates and will be of similar quality to the direct feed material. Medium- and low-grade stockpiles will be depleted towards the end of the mine life with the higher-grade material used first.

Waste material will be trucked to the WRD that will progressively develop to the west of the pit. Waste and ore volumes are presented in Figure 1-1. The waste rock total accounts for 61 Mt, representing 44% of the total of the pit volume.

The WRD will be surrounded with an engineered drainage channel, with dedicated monitoring points to gauge runoff volumes and assess water quality.

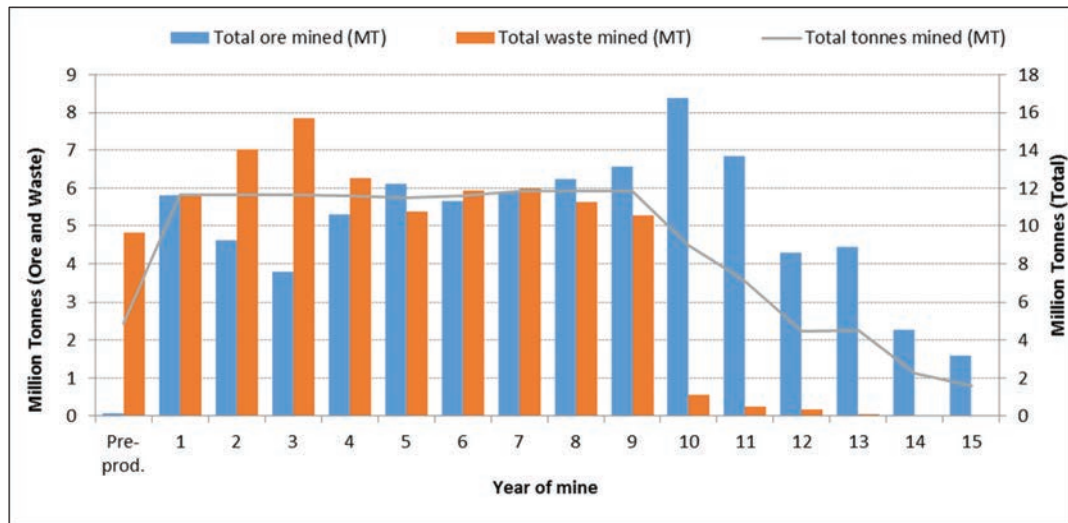


Figure 1-1 Waste and ore volumes for each year of mining

2. Geochemical assessment

2.1 Available data

2.1.1 Assay data

The previous report (GHD, 2015) presented the assay data assessment. This was based on the analysis of 6324 samples taken from the 2012 and 2015 drilling programs.

Laboratory X-Ray Fluorescence (XRF) (5301 samples) and XRF of select chip tray samples (1023 samples) was undertaken on up to 24 elements (Al, As, Ba, Ca, Cl, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, S, Si, Sn, Sr, Ti, V, Zn and Zr).

2.1.2 Stage 1 - Static AMD Tests

The sample material used for the Stage 1 dataset includes representative samples from ore and waste. The waste material can be grouped into distinctive geological/spatial units: alluvial waste, granite waste, gabbro waste and fault zone waste. Samples are also included to represent tailings samples; these have been taken from waste samples from experimental processing of the ore. Ore samples are also included in the assessment to represent risks posed by ore stockpiles.

For the Stage 1 laboratory assessment, a total of 409 samples were analysed, comprising 196 from the waste rocks, 209 from the ore and 4 (the total number of available samples) from experimental tailings.

Samples were chosen from core and drill cuttings for the waste and ore to provide a representative range of samples. In addition, four samples were obtained from trial process material that is representative of the tailings.

All samples were analysed for:

- NAPP
- NAG
- Total metals analysis (Ag, Al, As, B, Ba, Be, Bi, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, U, Zn, Li, V, Se, Sn, Sr, Th & Ti)
- Sulfate.

2.1.3 Stage 2 - Kinetic AMD tests

Following a review of the Primary sample results a selection of samples was scheduled for Secondary tests. Sample selection was based on selecting a combination of samples, preferentially selected from those primary results showing the highest sulfur, NAPP and metal values whilst also representing waste, tails and ore.

For the Stage 2 laboratory assessment, a total of 88 samples were analysed (42 from the Waste rocks, 42 from the Ore and 4 from Tailings).

All samples were analysed for:

- ASLP Leach (non-volatile) deionised water - selected based on the sulfide content
- Analysis of leachate for metals
- Analysis of leachate for General Water Suite: Ca, Mg, Na, K, EC, Cl, SO₄, alkalinity, fluoride, hardness & TDS
- Exchangeable cations.

In addition, a subset of 10 samples were selected for KNAG and ABCC. The subset was based on samples with the highest sulfur concentrations, with 8 chosen from waste material and 2 from ore material.

2.2 Sample density, numbers and locations

2.2.1 Sample density

Geochemical sample density is a critical parameter to ensure that a statistically significant data set has been captured, such that the AMD risk assessment is based on sound characterisation.

There is arguably no 'right' number of samples that should be collected for geochemical characterisation, rather, demonstrating a level of confidence for the stated purpose statistically is preferred. Several publications provide guidance toward obtaining a representative sampling density. For example, Price (1997), Miller (1997) and the (then) Queensland Department of Mines and Energy (DME) (1995) have provided guidance on geochemical sampling numbers / density. The correct number, however, relates to a level of statistical significance for which the AMD risk becomes acceptable based on the proposed development.

The above sources provide the following recommended sample number by lithological unit:

$$n = 25 \times \sqrt{x} \text{ (where } x = \text{million tonnes (Mt) of material per major lithological unit)}$$

Based on the above formula, a rule of thumb to be quasi-representative is around 250 samples per 100 Mt of waste material, per major geological unit. At Mount Peak, the waste rock comprises approximately 61 Mt, and the Ore around 78 Mt. Tailings is expected to be around 38 Mt (arising from the ore material).

For sampling density, DITR (2007) recommend that at pre-feasibility stage, "Several hundred representative samples of high and low grade ore, waste rock and tailings should be collected for geochemical test work. i.e. Sufficient samples to populate a block model with a reliable distribution of net acid production potential (NAPP) data on ore, waste and wall rock".

This has been completed at Mount Peake in the form of the original assay-based dataset and subsequent laboratory assessment data. Further, DITR (2007) recommend that at feasibility stage, the proponent should, 'Improve density of NAPP data for the block model if necessary, and conduct sufficient NAG test work to cross check NAPP data for key lithologies. If there are still insufficient data to assess AMD potential and provide a convincing management plan for approval, additional sampling, test work and refinement of block models will be required".

2.2.2 Sample numbers

The number of analyses from Mount Peake is shown in Table 2-1. The samples exceed the minimum numbers recommended, especially considering the low-risk presented by a low sulfur deposit.

2.2.3 Sample locations

Figure 2-1 shows the location of the geochemical-dataset, with sample location identified for the 2015 assay based assessment and subsequent Primary and Secondary sampling undertaken for this assessment. The figure illustrates the good spatial distribution of sampling locations, with Primary and Secondary samples being dispersed throughout the deposit. It should also be noted that the samples were taken from a variety of depths to best reflect the waste and ore.

2.2.4 Summary

Testing was undertaken from a sufficient number, depth and distribution of lithologies to determine the potential AMD risk posed by the project.

Table 2-1 Size of geochemical data sets by type

Data type	Waste samples	Ore samples	Tails samples	Total number of samples
XRF assay – up to 24 elements	3795	2529	NA	6324
Net Acid Producing Potential (NAPP)	196	209	4	409
Net Acid Generation (NAG)				
Metals analysis (Ag, Al, As, B, Ba, Be, Bi, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, U, Zn, Li, V, Se, Sn, Sr, Th & Ti)				
Sulfate				
ASLP Leach (non-volatile) deionised water - selected based on the sulfide content	42	42	4	88
Analysis of leachate for metals				
Analysis of leachate for General Water Suite: Ca, Mg, Na, K, pH, EC, Cl, SO ₄ , alkalinity, fluoride, hardness & TDS				
Exchangeable cations.				
KNAG and ABCC	8	2	0	10

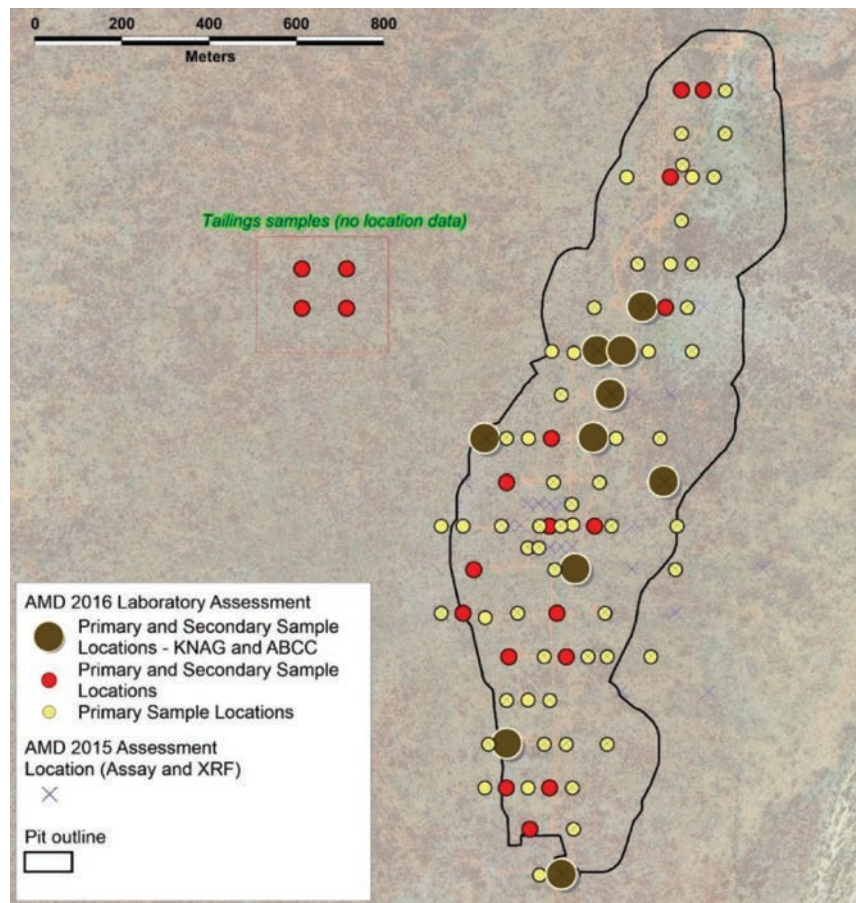


Figure 2-1 Sample location summary

2.3 Assay-based AMD Assessment

2.3.1 Relative elemental concentrations

Elemental concentrations (by ICP-MS) were assessed for a suite of 28 elements for 398 samples comprising 5-25 m composite samples from RC drilling coarse reject samples. From this data an assessment of the relative enrichment can be made. Results are compared to the average crustal abundance for each element. As the abundance of elements varies significantly, a log base 2 index has been historically developed to simplify comparison of measured values with average abundance. The index, called the global, or geochemical abundance index (GAI), and method, is documented in INAP (2009).

INAP (2009) describes the Geochemical Abundance Index (GAI) as a measure to compare the elemental concentration in a sample to the median abundance in the most relevant media (soils, crustal abundance etc.). The purpose is to provide a relative indication of any elemental enrichment that may be of environmental importance. The GAI for an element is calculated by:

$GAI = \log_2 [C / (1.5 * S)]$ Where *C* is the elemental concentration in a sample and *S* is the median content for that element in the reference material.

The GAI is measured on a scale of 0 to 6; whereby 0 indicates the element is present at a concentration equal to median global abundance, and 6 indicates an approximate 100 fold, or greater, enrichment above global abundance. As a general guide, a GAI of 3 or above is considered significant, and such enrichment may warrant further investigation.

It is important to note that the GAI only considers total concentration and does not take in to account solubility/mobility or bioavailability in the environment nor does it take in to account the toxicity of the element. Consequently, some elements that are highly elevated but immobile may not represent a risk of environmental harm, whereas other more soluble or toxic metals at much lower concentrations may present a risk. The GAI is only considered as an indicator of elements to be assessed in more detail (see leachate discussion in Section 2.5.3).

A GAI of 3, the level above which concentrations are considered elevated, was exceeded in at least one sample for eight elements (As, Bi, Bo, Co, Mn, Se, Ag & V), however of these, only selenium had a median GAI of greater than 3. A summary of the GAI data for those elements with enrichment is presented in Table 2-2.

Table 2-2 GAI summary

Element	No. of samples	Count of samples above GAI x 3	Min	Median	Mean	Max	99% UCL*
As	398	1	-3.8	-2.2	-2.0	3.6	-1.9
Bi	398	1	-1.4	-1.4	-0.8	4.8	-0.7
Bo	398	3	1.7	1.7	1.8	4.4	1.8
Co	398	1	-5.8	0.9	0.2	3.9	0.4
Mn	398	1	-5.6	-1.1	-1.2	4.4	-1.1
Se	398	77	3.7	3.7	4.1	6.7	4.2
Ag	398	4	-0.1	-0.1	0.5	5.4	0.6
V	398	4	-4.6	0.8	0.6	3.4	0.8

* The 99% upper confidence limit

It should be noted that elevated concentrations of the metals noted in Table 2-2 does not necessarily mean an environmental risk is present, but allows further investigations and risk assessments to target those metals that are shown to be naturally elevated.

2.4 Stage 1 Static AMD testing

2.4.1 Sulfur analysis - ICP-MS and XRF comparison

The laboratory assessment included assessment of all samples for total sulfur (as % S) and for sulfate (as SO₄ %) by ICP-MS. The limit of reporting (LOR) for total sulfur was 0.01%. Of the 398 samples analysed, 114 were below LOR, but for the purpose of this study were included as 0.01% sulfur (i.e. to reflect worst case). Out of the 398 samples, only 3 had a total sulfur greater than 0.2% meaning that just over 99% of the samples had a Maximum Potential Acidity (MPA) of less than 10 kg of H₂SO₄ per tonne. Total sulfide was calculated by subtracting the sulfate concentrations from the total sulfur.

A comparison of the 2015 XRF data and laboratory sulfur data is illustrated in Figure 2-2 as box and whisker plot. The box plots show the middle quartiles separated by the data median. The whiskers represent the minimum and maximum of values. The data show that in general the XRF and laboratory sulfur data are similar, however the XRF is generally more variable for each unit and in most cases slightly higher than the laboratory sulfur data. It should be noted that the XRF data is based on 6321 samples, whereas the laboratory data is based on 398 samples.

Sulfide concentrations, based on laboratory distributions for the ore and waste material, are presented in Figure 2-3 and Figure 2-4 respectively. As demonstrated by the figures, the majority of samples for both units are low in sulfides, with 85% of the waste samples being less than 0.05% sulfides, and 97% of the ore samples being less than 0.05% sulfides. Figure 2-4 highlights that total sulfur was below LOR for almost half of the waste samples (93 out of 204 – 45% of samples).

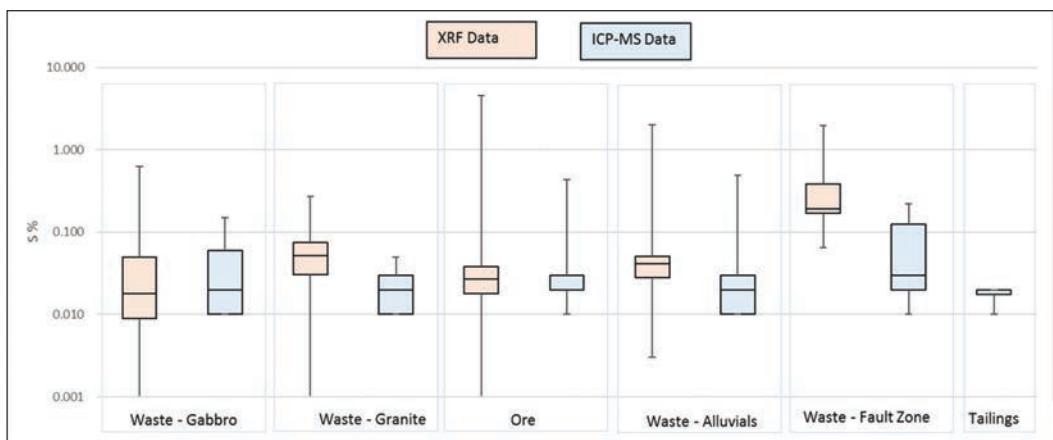


Figure 2-2 Sulfur data – Comparison of ICP-MS data (this study) and XRF data (GHD, 2015)

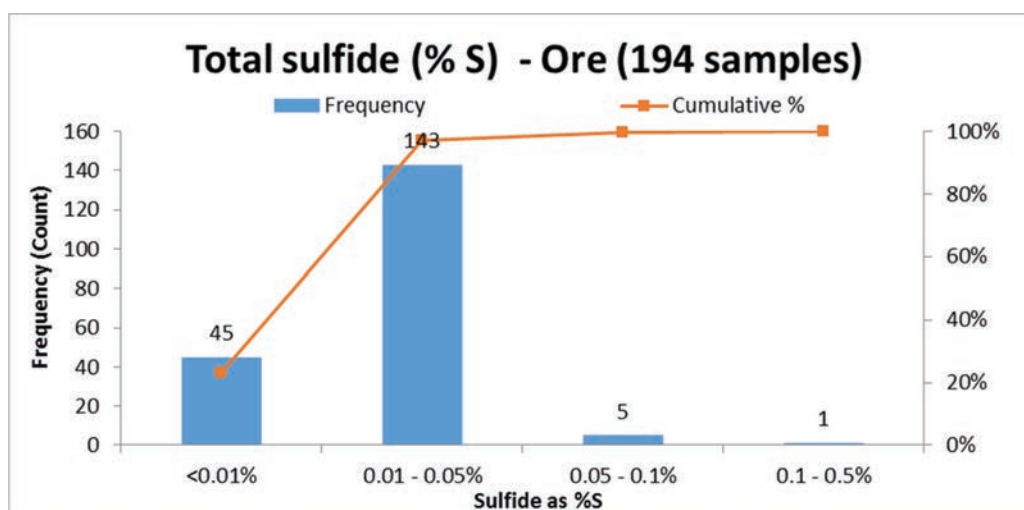


Figure 2-3 Total sulfide for ore

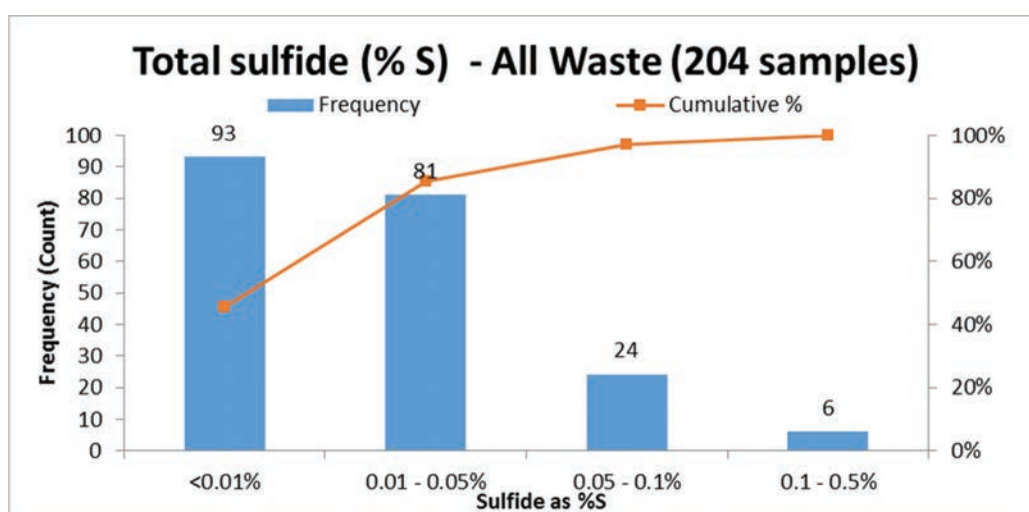


Figure 2-4 Total sulfide for waste

2.4.2 Maximum Potential Acidity (MPA)

Data from the laboratory sulfur analysis (Total Sulfur), was used to calculate the MPA for each of the selected Stage 1 samples. The MPA is the total amount of sulfur in a sample and is an estimate of the maximum acidity a rock can generate. It assumes that there is no neutralising capacity, therefore provides a worst-case estimate of the samples acidity. A summary of the data for each main lithology/waste type is presented in Table 2-3 and Figure 2-5.

Table 2-3 MPA for each lithology / waste stream (kg/t H₂SO₄)

	ALL	Ore	Tailings	Fault zone	Gabbro	Granite	Alluvial
Samples	398	194	4.00	3.00	120.0	22.0	55.0
Min	0.0	0.0	0.2	0.2	0.0	0.0	0.0
Median	0.5	0.5	0.5	0.4	0.4	0.3	0.3
Mean	0.7	0.7	0.4	2.3	0.9	0.4	0.5
Max	13.4	11.7	0.5	6.4	4.4	1.1	13.4
99% UCL	0.8	0.8	0.6	5.6	1.0	0.5	1.0

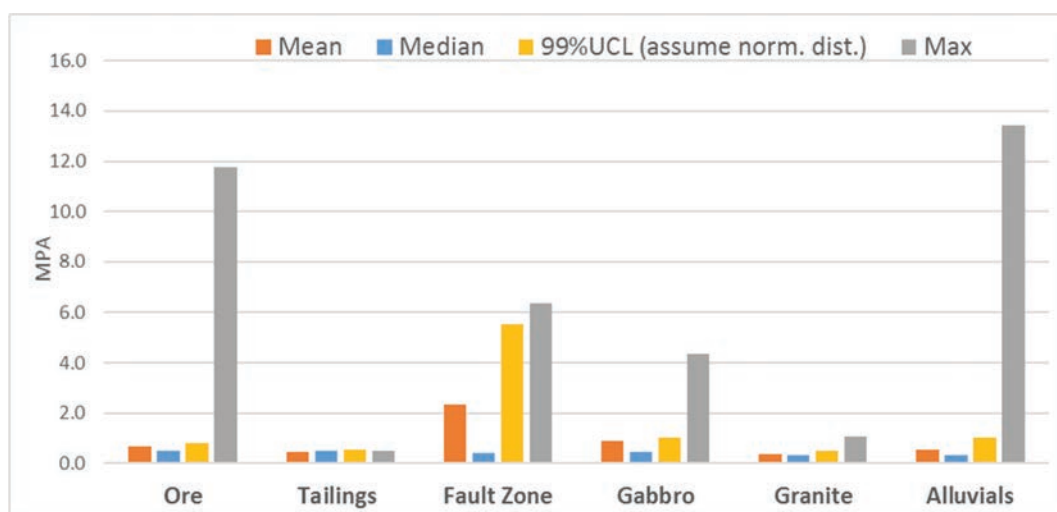


Figure 2-5 MPA statistics for each lithology / waste stream (kg/t H₂SO₄)

The highest sulfide sulfur and MPA was recorded in an alluvial sample (13.4 kg/t H₂SO₄) which is marginally higher than an ore sample (11.7 kg/t H₂SO₄). The alluvial sample is from a shallow oxidised sample collated from material between 0 to 15 m at 12MPRC044. This result is significantly different than all other alluvial samples (see difference between 99% UCL and maximum MPA values in Figure 2-5) and the elevated sulfide is inconsistent with the oxidised environment. It is possible that this sample was contaminated from the drill rig as this was the first hole drilled during the drilling campaign, therefore some residual drill cuttings may have been derived from a different site. The ore sample is from weathered Ore Zone Gabbro at 12MPRC084 from between 35 and 50 m. These are the only two samples than have an MPA of greater than 10 kg/t H₂SO₄. Both of these samples were retained in the analysis for completeness but did not impact the results or the conclusions drawn.

The full sample MPA dataset recorded median, mean and 99% upper confidence limit values of 0.5, 0.7 and 0.8 kg/t H₂SO₄ respectively. This demonstrates a very low acid potential for the resource (waste and ore).

2.4.3 Acid Neutralising Capacity (ANC)

Data from the laboratory ANC data for each main lithology/waste type is presented in Table 2-4 and Figure 2-6. Derivation of ANC values is used to determine if the sample has the capacity to neutralise potential acid. The higher the ANC value, the more neutralising capacity the sample has. The ANC becomes important for waste with potential high acidify, however given the low acidity demonstrated for the Project (see Section above), the ANC concentrations are less significant.

Table 2-4 ANC for each lithology / waste stream (kg/t H₂SO₄)

	ALL	Ore	Tailings	Fault zone	Gabbro	Granite	Alluvial
Samples	398	194.0	4.0	3.0	120.0	22.0	55.0
Min	3.7	15.1	106.0	4.6	8.7	3.7	5.8
Median	52.05	68.0	115.0	75.0	34.4	12.7	37.1
Mean	63.1	78.0	113.8	59.9	43.1	37.5	60.8
Max	399	216	119	100	164	399	241
99% UCL	67.7	83.6	118.4	105.6	48.7	72.2	76.3

Titrated ANC values ranged from 3.7 kg/t H₂SO₄ to 399 kg/t H₂SO₄ with a median of 52.1 kg/t H₂SO₄, a mean of 63.1 kg/t H₂SO₄ and a 99% UCL of 67.7 kg/t H₂SO₄. This indicates that most rock types have relatively high neutralising capacity, that is, if there was acid potential present in the rock, it has the ability to provide some neutralising capacity (i.e. it could lower its acid potential).

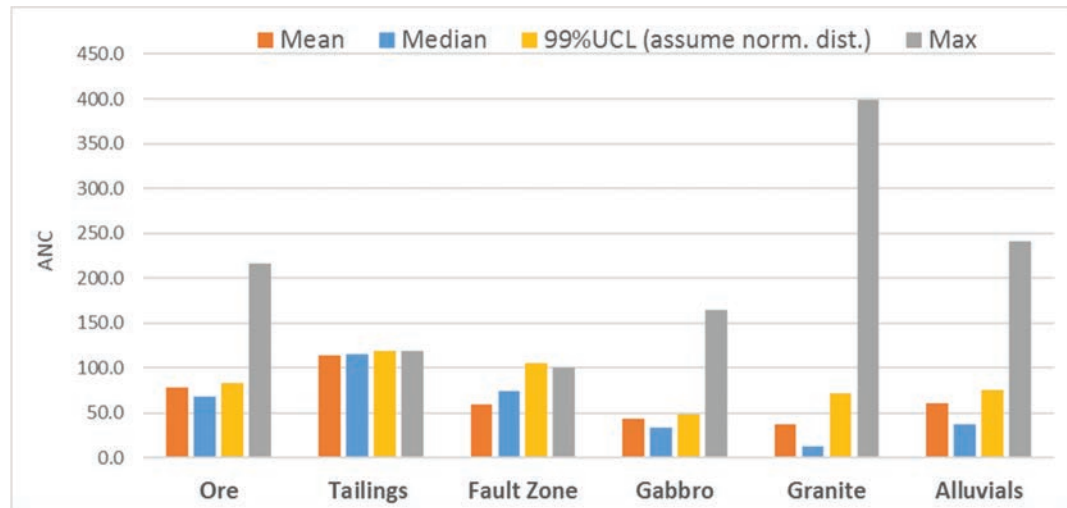


Figure 2-6 ANC statistics for each lithology / waste stream (kg/t H₂SO₄)

2.4.4 Net Acid Producing Potential (NAPP)

Laboratory NAPP data for each main lithology/waste type is presented in Table 2-5 and Figure 2-7. The NAPP is a qualitative measure of the difference between the capacity of a sample to generate acid and its capacity to neutralise acid. The NAPP is calculated by subtracting the neutralising capacity (ANC) from the maximum acidity (MPA). As such, where a negative NAPP result is found, this indicates that a sample has more neutralising capacity than acid potential.

All NAPP results were negative and were either acid consuming material (ACM) with a NAPP of less than -100 kg/t H₂SO₄, or non-acid-forming (NAF) with a NAPP between -100 and 0 kg/t H₂SO₄. The NAPP ranged from a minimum -398 kg/t H₂SO₄ in a sample of waste granite (11MPRC042, 10-20 m), to a maximum of -2.9 kg/t H₂SO₄ in a sample of waste granite (11MPRC041, 25-35 m).

The full sample dataset recorded median, mean and 99% UCL values of -51.65, -62.2 and -57.6 kg/t H₂SO₄ respectively. This therefore demonstrates that the overall resource (waste and ore) is acid consuming and not acid generating.

Table 2-5 NAPP for each lithology / waste stream (kg/t H₂SO₄)

	ALL	Ore	Tailings	Fault zone	Gabbro	Granite	Alluvial
Samples	398	194.0	4.0	3.0	120.0	22.0	55.0
Min	-398	-215.0	-118.0	-100.0	-163.0	-398.0	-239.0
Median	-51.65	-66.9	-114.5	-68.3	-33.3	-12.4	-37.1
Mean	-62.2	-77.2	-113.0	-57.3	-42.1	-37.0	-60.0
Max	-2.9	-14.5	-105.0	-3.7	-8.7	-2.9	-5.2
99% UCL	-57.6	-71.7	-108.2	-12.0	-36.6	-2.3	-44.7

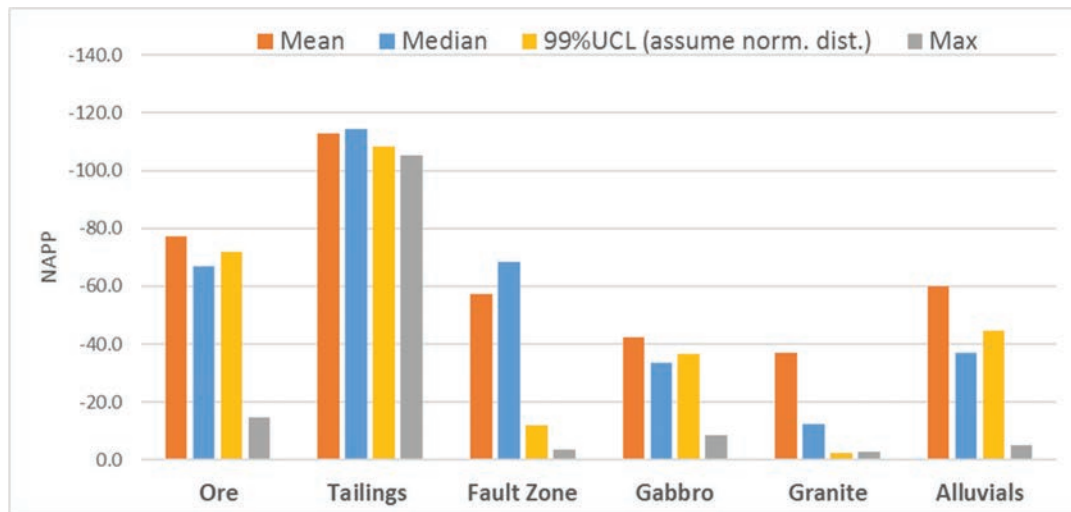


Figure 2-7 NAPP statistics for each lithology / waste stream (kg/t H₂SO₄)

2.4.5 Neutralising Potential Ratio (NPR)

Data from the laboratory ANC and MPA analysis has been used to calculate the Neutralising Potential Ratio or NPR (ANC/MPA) which is effectively the safety factor of neutralising capacity divided by acid generating capacity. An NPR of greater than 2 is considered to have adequate neutralising capacity with a good factor of safety, between 1 and 2 is usually classified as Uncertain (UC) as although it has more ANC then MPA, there is not a great enough factor of safety, and anything with an NPR of less than 1 is considered Potentially Acid Forming (PAF). The data for each main lithology/waste type is presented in Table 2-6 and Figure 2-8.

As summarised by Table 2-6 and Figure 2-8, the NPR ranged from 6.3 to 21600 with a median of 106 and a mean of 353. High NPR values (i.e. >5000) are indicative of very low sulfide values. All the rock types had strongly positive median and mean values, indicating that all waste types and ore are classified as Non Acid Forming (NAF) with a high neutralising capacity and a very low potential acidity.

Table 2-6 NPR for each lithology / waste stream

	ALL	Ore	Tailings	Fault zone	Gabbro	Granite	Alluvial
Samples	398	194	4.00	3.00	120.00	22.00	55.00
Min	6.3	9.5	207.8	11.0	6.3	6.3	10.9
Median	103.4	124.0	229.4	11.8	82.3	47.8	137.6
Mean	360.0	324.2	307.6	171.0	260.6	302.9	740.2
Max	21600	14000	563.7	490.2	7460.8	3700	21600
99% UCL	506.2	486.7	452.8	426.4	402.1	625.3	1556.3

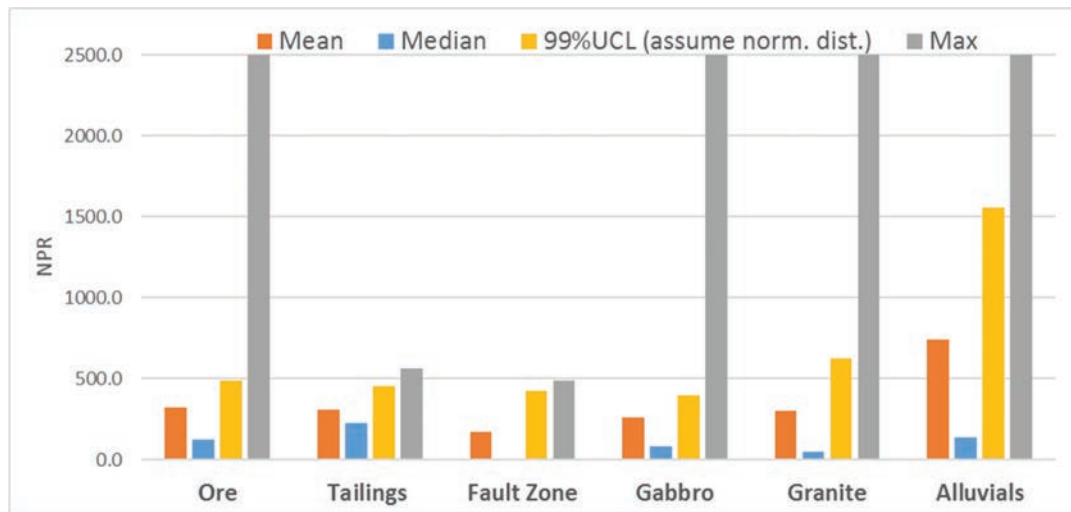


Figure 2-8 NPR statistics for each lithology / waste stream

2.4.6 Net Acid Generation - NAG

NAG vs NAPP plots (Figure 2-9 and Figure 2-10), combine direct post-oxidisation pH measurement of the NAG test with the acid-base accounting assessment of the NAPP test. The NAG pH laboratory test provides an estimate of the acid forming potential, with pH values more than 4.5 indicating that the sample is non-acid forming and values less than pH 4.5 indicating that the sample is potentially acid forming.

Data illustrate that all material, both waste (tailings, gabbro, fault zone, granite, alluvials) and ore are classed as NAF or ACM, with NAG pH values greater than 6 and NAPP values all negative (i.e. a sample has more neutralising capacity than acid potential). Figure 2-9 and Figure 2-10 show some grouping based on lithology and waste, with the alluvial material (QSP) tending to have the highest NAG, and waste gabbro tending to have the lowest NAG. The highest NAPP values (whilst still negative) are found in the granite waste.

When plotted against NPR (Figure 2-11) to further clarify the risk that a sample will generate acid, the plot shows that due to the strongly positive NPR, all samples are strongly NAF.

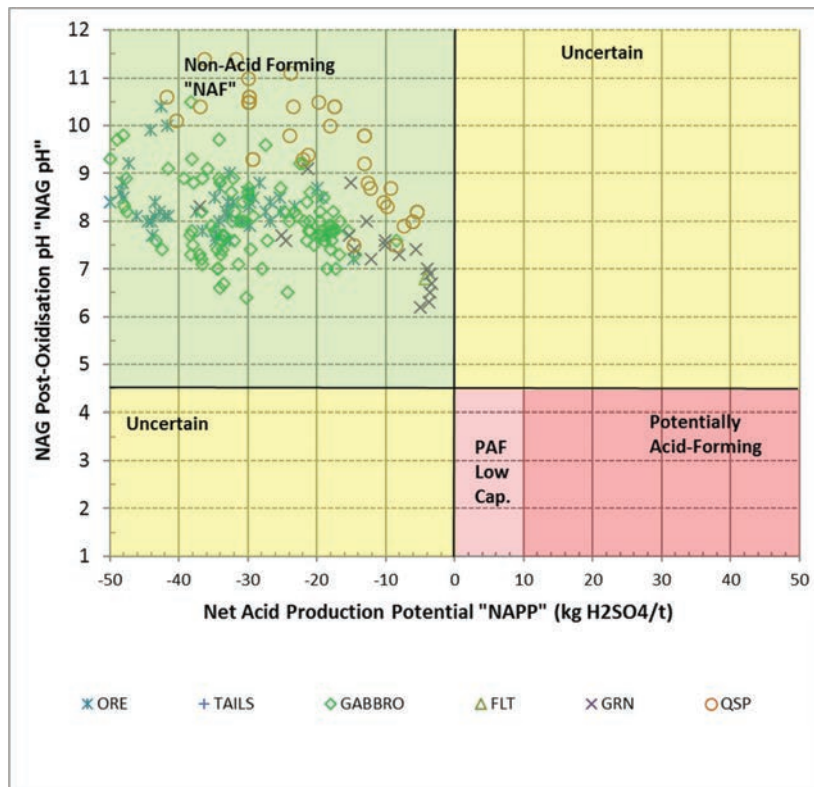


Figure 2-9 NAG vs NAPP Plot – High (-50 to 50 kg/t H₂SO₄) NAPP

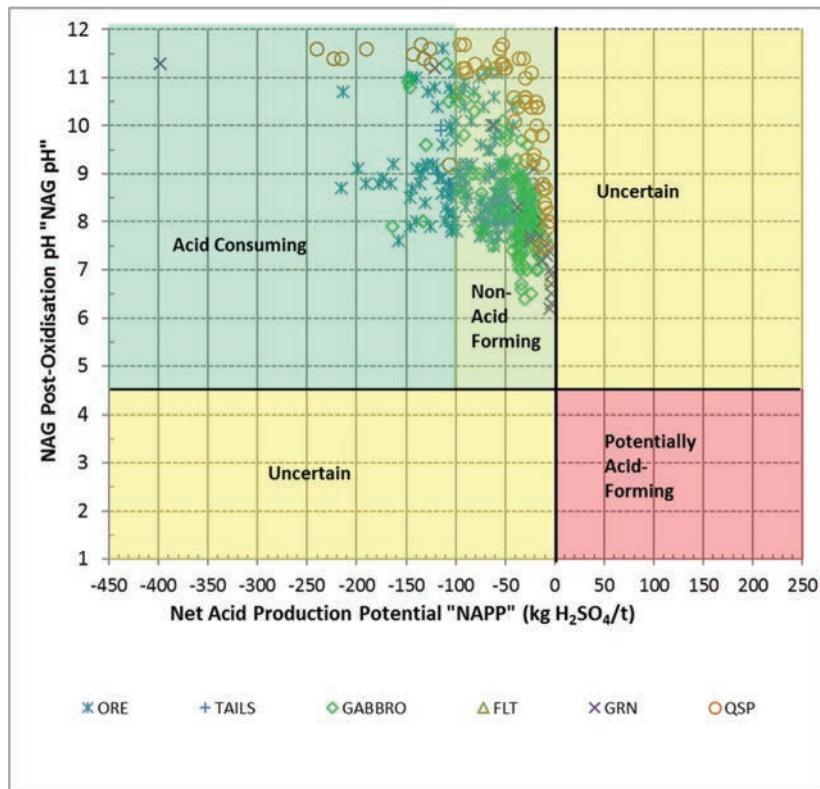


Figure 2-10 NAG vs NAPP Plot - Full Range

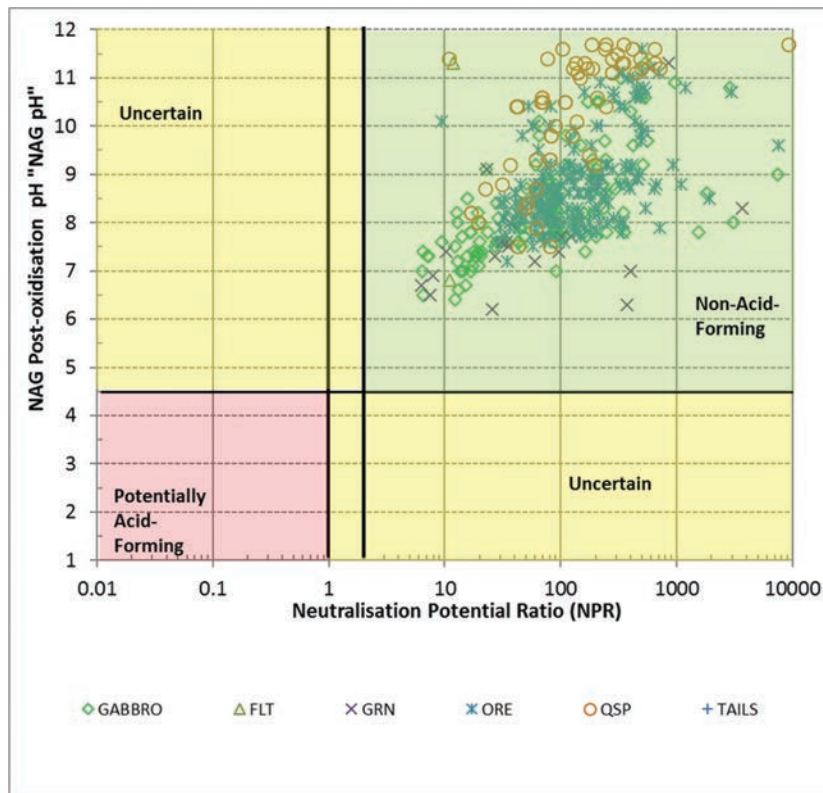


Figure 2-11 NAG vs NPR plot

2.5 Stage 2 Kinetic AMD and leachate testing

Selected samples of waste and ore were subjected to additional testing. Samples were chosen from the highest Stage 1 sulfur and/or elevated metals results. The Stage 2 testing included:

- Kinetic NAG (KNAG) testing to gain an indication of time available for temporary stockpiling before the material begins to oxidise and produce acid
- Acid buffering characteristic curve (ABCC) analyses to determine if the apparent ANC is fully available
- ASLP testing to assess the risk of metalliferous drainage.

Due to the samples being selected from the highest sulfur and metals results, they are considered to represent worst case examples. The results are summarised below.

2.5.1 Kinetic NAG testing

The KNAG testing tended to confirm the initial static test results that classified the samples as being NAF. Considering that samples were selected based on the highest sulfur and metal concentrations, this further demonstrates the non-acid forming nature of the ore and waste. As illustrated by the pH and temperature change plots (Figure 2-12 and Figure 2-13) most samples (7) were non-reactive to weekly reactive, showing flat temperature and pH. The most reactive sample was found to be from the waste gabbro unit (AMD1284) that showed some reaction in the first 200 minutes with pH reducing from 5.8 to 4.5.

Two samples AMD1284 and AMD1390 both from gabbro waste, showed a gradual decline in pH towards pH 4.5-5 at the end of the cycle possibly indicating reaction with metal oxides (probably magnetite) rather than sulfide oxidation.

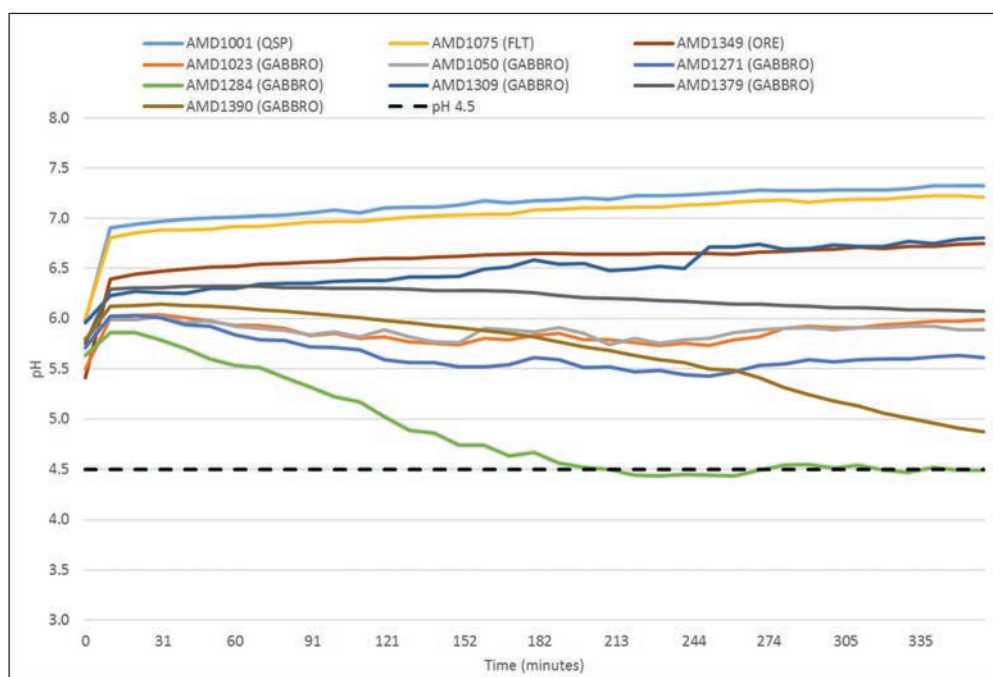


Figure 2-12 Collated KNAG plots - pH

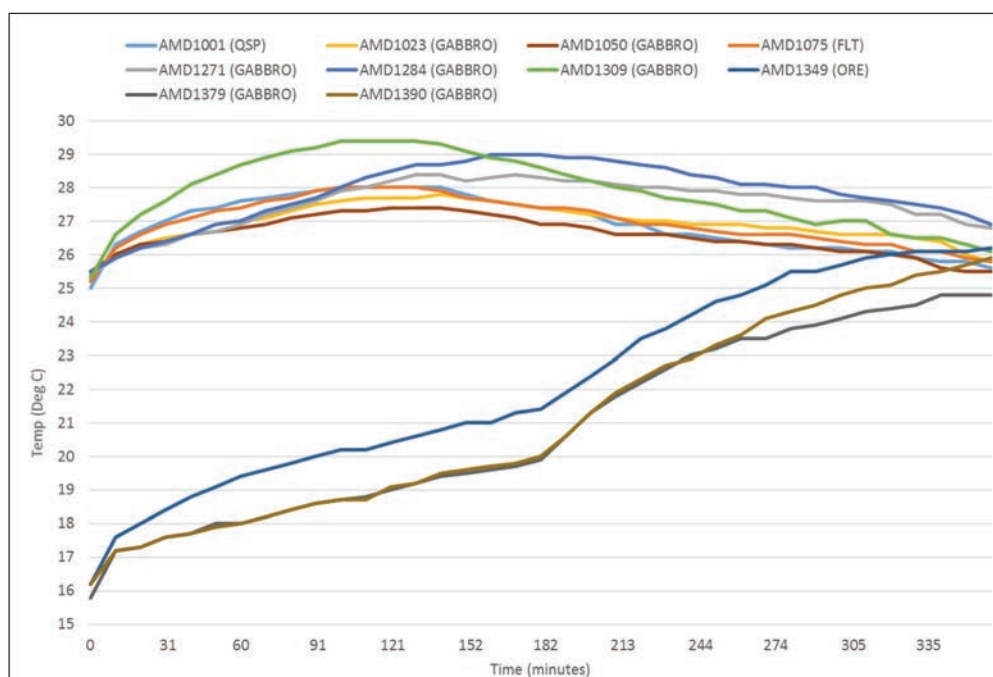


Figure 2-13 Collated KNAG plots - temperature

KNAG testing was undertaken on a selection of 10 samples based on samples that returned the highest sulfur data. The NAG pH and final KNAG pH show a moderate linear correlation to one another (Figure 2-14), although the single addition NAG was generally 1-2 pH units higher than the final KNAG suggesting that a static NAG test is broadly suitable for classifying material if this overestimation of pH is allowed for static NAG pH. However, it is possible that the lower KNAG pH is due to reaction of the peroxide with magnetite and oxidation of ferrous iron to ferric iron, rather than underestimation of acid generated by sulfide oxidation. As all final KNAG pH were above 4.5, the results do not change any of the NAG/NAPP-derived classifications.

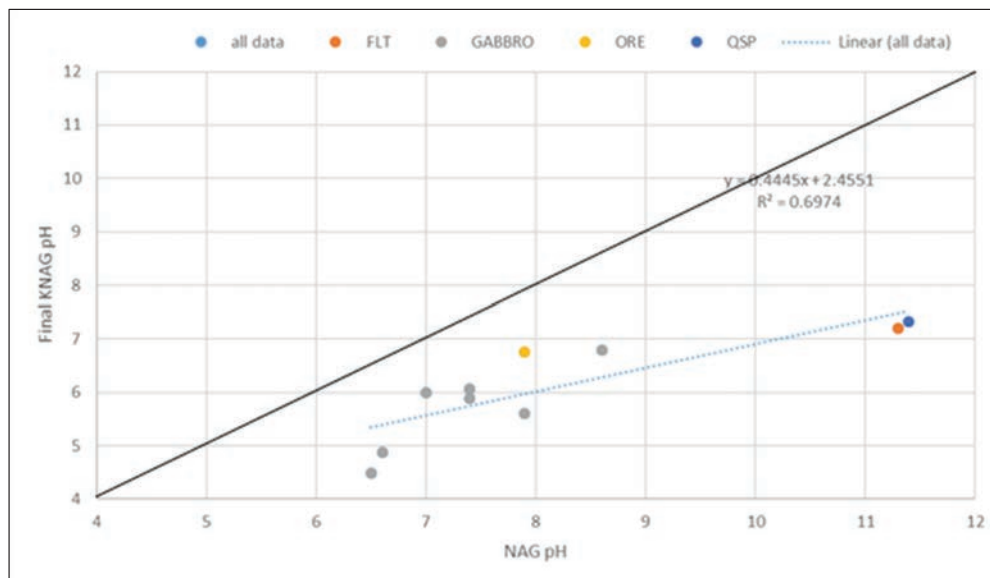


Figure 2-14 NAG pH KNAG pH correlation plot

All samples maintained a pH of greater than 4.3 after 360 minutes. This indicates that the risk of acid generation is low in all samples. Again, it should be noted that samples for KNAG were selected from samples with the highest potential acidity.

Based on general correlations between KNAG and column leach testing lags (Stewart *et al*, 2006) the times taken to produce acidic leachate is likely to be greater than 2 years although the static testing suggests none of the resampled material would generate acid at any stage.

Hongping *et al* (2015) assessed the reactivity of natural magnetites with a variety of elemental impurities for catalysing the decomposition of H_2O_2 to produce hydroxyl free radicals ($\bullet OH$), according to the equations below:



Note that the reaction releases H^+ (acid) ions and $\bullet OH$ and $\bullet OOH$ radicals (not to be confused with OH^- base ions) hence the catalytic breakdown of hydrogen peroxide solutions by magnetite can produce acidic solutions that can give a false positive for sulfide oxidation. Consequently, it is possible that rather than single NAG testing underestimating acidity, KNAG testing overestimates acid production.

Based on the above results, the material is unlikely to generate acid within the proposed areas of storage of site, namely the TSF, waste rock dump and ore stockpiles.

2.5.2 Acid Buffering Characteristic Curve (ABCC)

The ABCC test involves the slow titration of a sample with acid while continually monitoring pH. This test is helpful in determining if a sulfidic sample with a NAPP < 0 (all samples from the Stage 1 testing) and a NAG pH > 4.5 has enough readily available neutralising capacity to render it non-acid producing throughout the oxidation process.

ABCC curves and ANC results from Stage 1 testing are presented in Appendix A. The ABCC curves showed two neutralisation types. Two samples (AMD1001 from the alluvial material and AMD1075 from the faulted material) showed a typical calcite neutralisation curve, showing a relatively flat line until the carbonate was consumed at around the static ANC value.

The remaining curves showed a relatively rapid decline to pH 4.5 well before the ANC value, indicating neutralisation in the NAG and NAPP tests by silicates such as clays and micas rather than carbonates and that standard NAPP testing may overestimate ANC. Based on these data, a conservative estimate of ANC would be 5 kg/t H₂SO₄. The difference between the titrated ABCC value and the initial Static ANC values is shown below in Table 2-7. The ABCC-derived acid neutralising capacity shows that the Static ANC values have generally overestimated the acid neutralising capacity of the waste rock although they still have an excess of acid neutralising capacity). Given the KNAG results above, however, the KNAG and ABCC support the assumption of the material being either NAF or ACM.

Table 2-7 ABCC derived neutralising capacity and static ANC values

Sample	Waste / ore	ABCC @ pH 4.5 (kgH ₂ SO ₄)	ANC (kgH ₂ SO ₄)	ABCC - ANC (kgH ₂ SO ₄)
AMD1001	Waste - QSP	138	146	8
AMD1023	Waste - Gabbro	4	20	16
AMD1050	Waste - Gabbro	4	21	17
AMD1075	Waste - FLT	42	75	33
AMD1271	Waste - Gabbro	4	40	36
AMD1284	Waste - Gabbro	4	29	25
AMD1309	Waste - Gabbro	15	74	59
AMD1349	Ore	7	52	45
AMD1379	Waste - Gabbro	5	45	40
AMD1390	Waste - Gabbro	2	37	35

2.5.3 Leachate analysis

Australian Standard Leachate Procedure (ASLP) was performed to assess the potential of the NAF stockpiled material to produce saline or metalliferous leachate. The test was performed on the crushed samples using deionised water to simulate leaching by rainwater in the absence of significant sulfide-derived acid. The results were compared to a hierarchy of water quality guidelines (Appendix B) The hierarchy comprises:

- ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Guidelines for protection of 99% of freshwater aquatic ecosystem species (FAE99%)
- ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Guidelines for protection of livestock watering
- Australian Drinking Water Guidelines (ADWG) (NHMRC & NRMCC, 2011). Most composite-lined landfill guidelines, such as Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites In the Northern Territory (NT EPA, 2013) use an upper limit of 100 times ADWG, assuming a 100 times dilution between the waste storage and the receiving environment. Unlined burial guidelines such as ANZECC (1999) apply an upper limit of 10 times ADWG, therefore for conservative purposes a factor of 10 times ADWG has been adopted for this assessment
- Guidelines for incidental contact are based on Primary Recreational Contact guidelines (nominally 10 times the ADWG).

ASLP leaching of a finely pulverised sample is relatively aggressive in comparison to the natural leaching likely to occur in stockpiles. Unlike oxidisation and leaching of sulfidic rock which tends to gradually release contamination over time, a single addition ASLP represents initial leaching of relatively soluble material rather than representing long-term leaching behaviour. Leachate volumes are also generally small compared with large-scale receiving environments and surrounding runoff and surface water flows, with potential for dilution in the environment. As noted above, most waste burial and landfill guidelines use a dilution factor of 10 for unlined storage and 100 for clay composite single-lined storage when comparing ASLP concentrations with applicable trigger levels.

The metals Al, As, B, Cd, Cu, Fe, Pb, Ni, Se and Zn exceeded FAE99. Of these Al, As, Cu, Fe, Pb, Ni, and Zn exceeded the FAE99 level by a factor of more than 10 in some samples. Only Fe and Al exceeded more than 10 times ADWG, although as they are both relatively insoluble in circum-neutral oxidising conditions they are unlikely to be significantly elevated in actual waste rock leachate. Based on the above results, the waste rock is within the acceptable limits for unlined storage. The results for these elements are presented in Table 2-8.

Table 2-8 also separates the exceedances by waste/lithology type. As shown in the table, most of the samples were either from the ore or gabbro waste. There is some difference in leachate between units, for example Cu was more than 10 times the FAE99 in 53% of the gabbro waste samples, compared to only 7% of the ore samples. As was detected at more than 10 times the FAE99 in 7% of the ore samples but less than 10 times the FAE99 in all other units.

Based on the data presented in Appendix B and Table 2-8 critical leachate constituents in terms of aquatic ecosystems appear to be Al, Zn and to a lesser extent Cu, based on their consistent exceedance of FAE99.

Table 2-8 Leachate data – elements with exceedances

Element	Al	As	Cu	Fe	Pb	Ni	Zn
Count above detection limits	88	30	72	88	31	82	88
99%UCL (assume norm. dist.)	2.57	0.003	0.01	7.37	0.004	0.01	0.06
10 x ANZECC 2000 FW 99%	0.27	0.008	0.01	-	0.01	0.08	0.024
No. greater than 10 x FW 99%	82	1	21	0	1	3	82
% over x10 FW	93%	3%	29%	-	3%	4%	93%
10 x ADWG	2	0.1	20	3	0.1	0.2	30
No. greater than 10 x ADWG	41	0	0	74	0	0	0
% over x10 ADWG	47%	0%	0%	84%	0%	0%	0%
Ore							
Count	35	15	30	35	3	34	35
No. greater than 10 x FW 99%	34	1	2	0	0	0	33
% over x10 FW	97%	7%	7%	0%	0%	0%	94%
No. greater than 10 x ADWG	14	0	0	29	0	0	0
% over x10 ADWG	40%	0%	0%	83%	0%	0%	0%
Tailings							
Count	4	0	4	4	0	4	4
No. greater than 10 x FW 99%	4	0	0	0	0	3	4
% over x10 FW	100%	0%	0%	0%	0%	75%	100%
No. greater than 10 x ADWG	1	0	0	4	0	0	0
% over x10 ADWG	25%	0%	0%	100%	0%	0%	0%
Fault zone							
Count	3	3	1	3	2	2	3
No. greater than 10 x FW 99%	2	0	0	0	1	0	2
% over x10 FW	67%	0%	0%	0%	50%	0%	67%
No. greater than 10 x ADWG	1	0	0	1	0	0	0
% over x10 ADWG	33%	0%	0%	33%	0%	0%	0%
Gabbro							
Count	40	6	36	40	23	39	40
No. greater than 10 x FW 99%	39	0	19	0	0	0	40
% over x10 FW	98%	0%	53%	0%	0%	0%	100%
No. greater than 10 x ADWG	24	0	0	39	0	0	0
% over x10 ADWG	60%	0%	0%	98%	0%	0%	0%
Granite							
Count	1	1	0	1	1	1	1
No. greater than 10 x FW 99%	1	0	0	0	0	0	1
% over x10 FW	100%	0%	0%	0%	0%	0%	100%
No. greater than 10 x ADWG	0	0	0	0	0	0	0
% over x10 ADWG	0%	0%	0%	0%	0%	0%	0%
Alluvials							
Count	5	5	1	5	2	2	5
No. greater than 10 x FW 99%	2	0	0	0	0	0	2
% over x10 FW	40%	0%	0%	0%	0%	0%	40%
No. greater than 10 x ADWG	1	0	0	1	0	0	0
% over x10 ADWG	20%	0%	0%	20%	0%	0%	0%

2.5.4 Soil stability and salinity

A range of soil salinity and stability indicators are commonly assessed against the criteria developed by QLD DME (1995) and shown in Table 2-9.

Table 2-9 Indicative mine waste salinity classification parameters

Test	Units	Very Low	Low	Medium	High	Very High
pH (1:5)	pH units	<4.5	4.5-5.5	5.5-7.0	7.0-9.0	>9.0
Electrical Conductivity (1:5)	µS/cm	<150	150-450	450-900	900-2,000	>2,000
Exchangeable Sodium Percentage (ESP)	%	<2	2-6	6-12	12-20	>20
Exchangeable Ca/Mg	ratio	<1	1-2	2-5	>5	-

¹: Values become approx. 200, 200-400, 400-800, 800-1,600 and <1,600 if analysis undertaken by saturated extract/paste

Green is ideal range, yellow is marginal and pink is high risk.

The information presented in Table 2-9 is indicative and acts as a guideline only. Generally speaking, a soil may be considered sodic when sodium concentrations begin to affect soil structure. This is generally recognised in Australia when ESP >6 %; while strongly sodic soils have ESPs of >15 (Isbell *et al* 1983). When sodic soils become wet (as sodium is a monovalent cation as compared with the bivalent cations magnesium and calcium) the bonds weaken and the soils can become dispersive or slake. Therefore, a high level of exchangeable sodium is not desirable in soils for mine rehabilitation, as it can lead to dispersion, tunnel erosion and surface crusting; with individual clay particles going into suspension potentially leading to decreased surface water quality (Charman and Murphy, 2001).

Secondary consequences include surface hard-setting as soil structure breaks down, with decreased infiltration leading to difficulties in establishing vegetation and, therefore, ongoing erosion from bare surfaces.

Another indicator of dispersion potential in soils is the exchangeable Ca:Mg ratio. Soils that are high in sodium and magnesium tend to show more dispersion than soils that are high in sodium and calcium (Hazelton and Murphy, 2007). The potential for dispersion may be increased in soils with Ca:Mg ratios of below approximately 1-2. This is based on the fact that Ca²⁺ ions flocculate or open soils, while Mg²⁺ ions tend to coagulate or close soils. Low Ca:Mg ratio soils are sometimes known as high magnesium soils. A Ca:Mg ratio of approximately 4-6 is generally considered ideal although ultimately, it becomes a function of the crop/vegetation's tolerance.

At a broader level low cation exchange capacity (CEC) of, nominally, <5 meq/100g indicates that the soils have a low ability to hold nutrients.

The soil stability results are summarised as:

- The 1:5 leachate samples have electrical conductivity (EC) values ranged from 54 to 316 µS/cm placing them in the very low to low salinity risk category.
- 1:5 leachate pH are all between 6.73 and 9.44, ranging from medium to high pH
- ESP ranged from less than 0.2% to a maximum of 51.9% indicating a wide range of potential for dispersion from very low to very high. Only 16 of the 88 samples (AMD1063, AMD1301, AMD1311, AMD1312, AMD1320, AMD1354, AMD1355, AMD1356, AMD1376, AMD1395, AMD1397, AMD1398, AMD1399, AMD1400, AMD1401 and AMD1404) contained ESPs above 12% placing them in the high to very high range

- Generally, samples that had high ESPs also had Ca/Mg ratios of less than 2 indicating a risk of soil dispersion
- Total cation exchange capacities ranged from less than 0.1 to 20 meq/100g, with only 17 samples having a CEC greater than 5, most of which also had high ESP, indicating a generally low ability to hold nutrients
- The Sodium Adsorption Ratio (SAR) of the leachate ranges from 1 to 18. When compared with the relatively low EC, the samples plot in the “soil structural problems likely” (ANZECC & ARMCANZ 2000) indicating a high risk of leachate causing dispersion of clays and damaging soil structures if not managed appropriately (Figure 2-15). As noted elsewhere, management would include limiting contact with site soils or adding agricultural lime or gypsum to the soil or leachate, to reduce the sodium adsorption ratio, if disposal by irrigation is required.
- Overall the waste rock has a low risk of salinity but a moderate to high risk of soil erosion or sodicity in the highly weathered material if exposed. Most of the materials also had a poor capacity to hold nutrients although this is expected with non-soil materials. This will be managed by sediment and erosion control during deposition and capping with topsoil on completion, and control of leachate to minimise contact with sensitive soils. Alternatively, capping soils can be ameliorated by adding agricultural lime or gypsum, depending on soil pH, in accordance with standard agricultural practice.

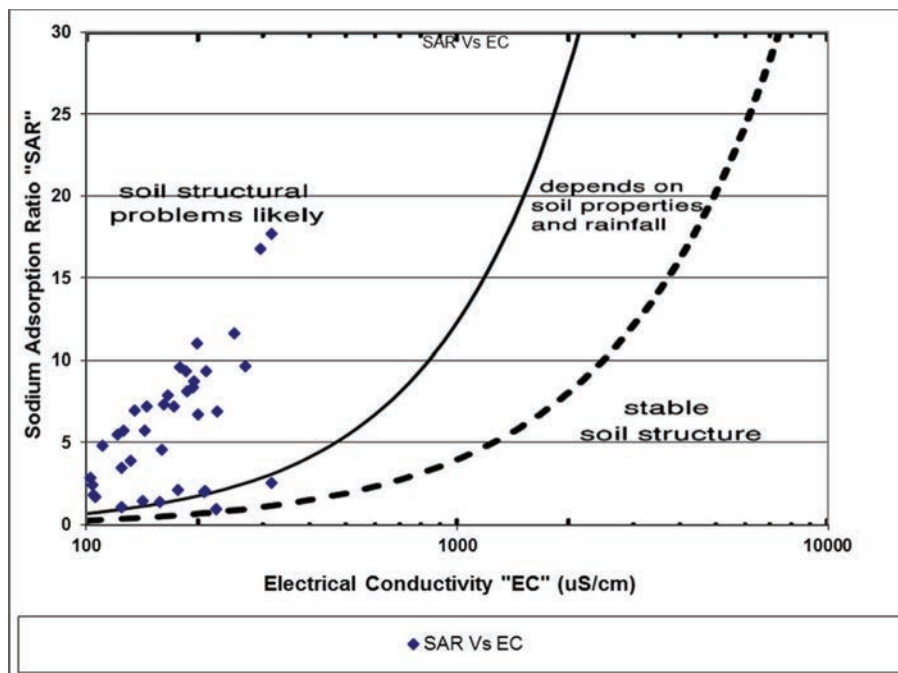


Figure 2-15 Sodium Adsorption Ratio (SAR) vs Electrical Conductivity (EC) soil classification

2.6 Summary of key results

The laboratory results have demonstrated that the overall risk of AMD is low. This is valid for the waste material (gabbro, granite, alluvials and fault zone) and the ore/tailings. The laboratory sulfur data has shown that out of the 398 samples, only 3 had a total sulfur greater than 0.2% (99% of the samples less than 0.2%) and only two samples had a calculated Maximum Potential Acidity (MPA) of more than 10 kg of H₂SO₄ per tonne (an alluvial sample at 13.4 kg/t H₂SO₄ and an ore sample at 11.7 kg/t H₂SO₄). This is broadly consistent with the XRF data presented in GHD (2015) where 98.6% of the samples analysed returning values of below 0.2% for total sulfur. It is noted that the elevated sulfur content of the alluvial sample may have been caused by contamination from the drill rig and is inconsistent with the oxidising environment.

Data on the Net Acid Producing Potential (NAPP) demonstrated that all samples returned negative values and all Neutralising Potential Ratios (NPR) were strongly positive indicating that the material is acid consuming or non-acid-forming. The combined NAG and NAPP data demonstrates that the material tested can all be classed as Non-Acid-Forming or Acid-Consuming.

Although the kinetic NAG and ABCC tests indicate that in the highest risk samples the ANC may be, to a large extent, due to reactions of silicates such as micas and clays and hence overestimated, the various waste rock and ore material have adequate acid neutralising capacity and the risk of acid leachate generation is very low.

The leachate testing indicates leachate from waste rock may be sodic and cause soil dispersion if irrigated on to local soils. This can be managed, however, by capping waste rock dumps by non-dispersive soils on closure, diverting runoff to holding ponds via armoured drainage channels and by amending impacted soils or treating leachate with agricultural lime or gypsum, depending on soil pH, if irrigation is used as a leachate management option or other long-term contact with soils is likely.

3. AMD Management Plan

3.1 AMD risk

The laboratory testing of waste and ore has indicated that the material has a low risk of generating AMD comprising acidic, metalliferous or saline leachate, providing leachate and runoff are not allowed to discharge undiluted in to nearby surface water environments. Leachate is likely to be relatively sodic and any irrigated soils will require treatment with agricultural lime. Although the AMD risk is considered low based on the data assessed, the management plan has taken the highest risk material in to account.

3.2 Waste rock and ore management

Details of the mining process, including waste rock management to confirm the minimal AMD risk will be further detailed in the Mine Management Plan (MMP) which has not yet been completed.

The key components of the waste rock management will include ongoing testing during mining to provide further delineation of any potential acidic, metalliferous or saline generating material.

At this stage, a conceptual design and allowance for a small PAF cell should be included in the MMP as a contingency, although it is currently not required as no significant PAF material has been identified. It should be designed to allow storage of separable blocks of PAF material if any are identified during production.

3.3 AMD monitoring

3.3.1 Introduction

AMD monitoring during the mining and closure stages provides critical feedback to confirm that the AMD controls are effective for their stated aim, even in the case of low-AMD risk materials. In that regard, the following would be monitored:

- In-situ material scheduled for mining
- Constructed landforms; being WRDs, the ROM Pad, ore stockpiles
- Water (surface water and groundwater).

An outcomes-based approach would be used as informed by adaptive management to meet site-specific trigger values that would be developed over time as data is gathered. Currently, the 99% species survival trigger values (ANZECC & ARMCANZ 2000) have been nominated.

The following section provides an overview of the monitoring requirements.

3.3.2 Geochemical monitoring

Additional geochemical data collection would be carried out as part of the pre-production phase of the project. The sampling plan is based on the assumption that, as a minimum, S, Ca, Mg and As will be analysed as part of the standard AMD suite during any additional infill drilling and sampling. Additional metals (Al, Pb, Zn, Cu, Cr, Cd) should also be included, especially those identified as elevated within the groundwater.

Blasthole geochemical analysis to determine whether any material is PAF will be undertaken by having XRF analysis run in an on-site laboratory or by hand-held XRF with the appropriate calibrated range of analytes, level of reporting and resolution.

Drum leach tests

In order to complement the laboratory testing already completed to date, drum leach tests will be undertaken. These complement environmental geochemical surveys of potential acid, metalliferous or saline leachate-generating waste rock, providing information such as sulfide reactivity, oxidation kinetics, metal solubility and the leaching behaviour of the test materials. They are designed to simulate the site-specific weathering processes of waste rock and ore piles in order to define parameters such as acid producing potential and metal mobility. In contrast to column leach testing, drum leach testing can be performed at the site under investigation thus accurately representing mine specific conditions.

The tests will be carried out on a number of waste, ore and tailings samples. It is the intention to duplicate the drums containing these materials to have one set left to receive natural rainfall, and the second set to receive simulated rainfall (deionised water) on a regular frequency to represent results over a longer time period. This will allow detection of any meaningful data at an early stage, thus allowing contingency plans to be developed/refined.

Effluent samples will be collected via a tap inserted in to the base of the drum. Effluent volumes will be measured and analysed for pH and electrical conductivity. Samples will be sent for laboratory analysis of total and dissolved metals, major ions and fluoride at intervals defined by the length of testing.

A rain gauge will be installed near the drums to allow for calculation of the amount of precipitation entering the drums, and provide a sample of rainwater for analysis. Rainwater will be collected at the same intervals as the effluent from the drums, and subjected to the same testing as effluent (pH, redox potential and electrical conductivity). Typical sampling intervals may be monthly for the first six months, every two months for the next six months then quarterly thereafter.

3.3.3 Surface and groundwater monitoring

The sampling locations, procedures, schedule and analytes for AMD surface and groundwater monitoring are consistent with the project Water Monitoring Plan and are therefore not reproduced herein. Monitoring will be targeted to include locations specific to, but not limited to, the pit, Waste Rock Dump, Tailings Storage Facility and Ore stockpiles.

Analytes with specific reference to AMD monitoring include pH, EC, acidity and alkalinity, sulfate and metals. Baseline water quality data is also included in the Water Monitoring Plan.

Decreasing alkalinity is generally a good early indicator of deteriorating conditions in leachate from a WRD containing PAF material, and can therefore be tracked as an 'early warning' mechanism. Metal concentrations and declining pH values generally lag behind declining alkalinity; therefore, corrective actions can be implemented early should alkalinity decline.

Other trends that highlight the onset of AMD include increasing sulfate, increasing sulfate / alkalinity and sulfate to chloride ratios, decreasing pH values and an increase in soluble metals as a result. An initial set of groundwater samples will be assessed for the full suite of metals by ICP-MS such that all metals elevated in the rock are covered by baseline sampling and to provide a comparison for ASLP results.

3.3.4 AMD management plan implementation and review

Implementation

The Plan is to be implemented throughout the pre-production and operational stages of the project. It will be updated as the project progresses.

Review

This plan will be revised annually until two years after the closure of the pit. Furthermore, any activity not previously authorised under the approved plan will be incorporated into a revised plan for review and approval by the appropriate authorities. Revised plans would not be approved unless they provided equivalent or improved environmental outcomes over time.

This Plan will also be used to inform future revisions of project's Closure Plan which also forms part of the Mine Management Plan.

3.3.5 Contingency planning

Contingency plans are developed for those failure modes where residual risk remains after the application of AMD prevention and control approaches. A contingency plan should include targeted monitoring, trigger levels for actions, and specific responses in case a certain event occurs. For example, if a failure mode is the potential for AMD seepage from a waste rock pile, then monitoring can be established for sulfate concentrations in waste rock seepage as an early indicator of potential AMD formation. If significant increases in sulfate concentrations are measured, then contingency measures such as covers or drainage collection amendment might be implemented.

Contingency plans specific to AMD management at the site would include an exceedance in the ground or surface water monitoring against site-specific trigger values. The approach would be to undertake a 'root cause' analysis whereby the causal link for the water quality exceedance would be determined. Adaptive management would then seek to implement an appropriate alternate management strategy to eliminate any future risk of a repeat, given the nature of the incident.

4. Conclusions

Based on the findings of this study, the following conclusions are made:

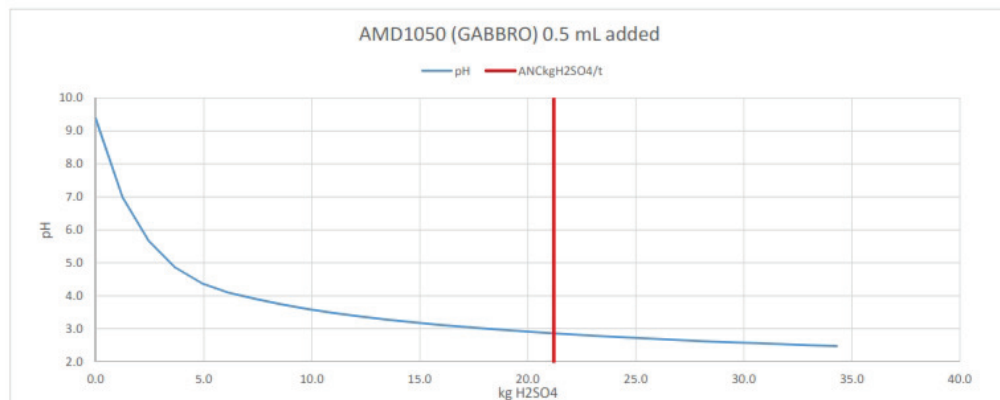
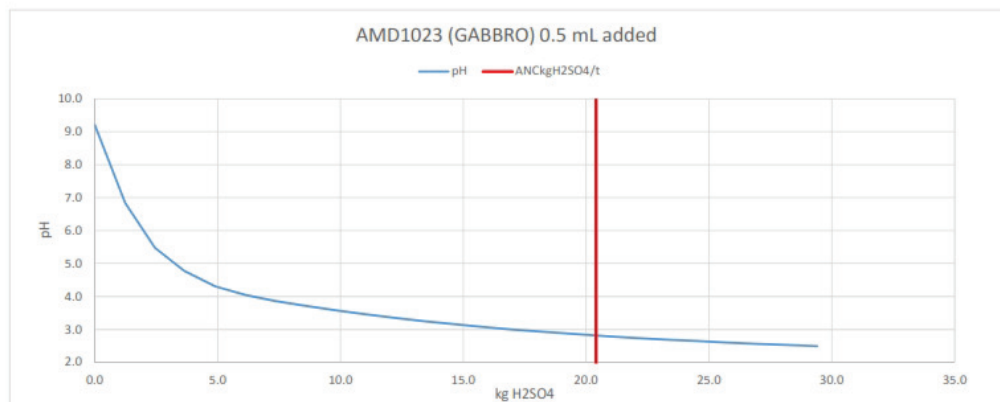
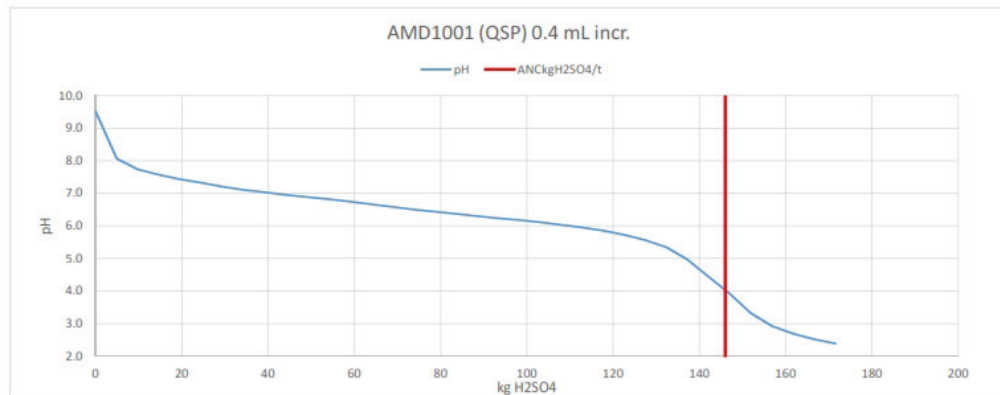
- The static AMD tests undertaken on a total of 409 samples were from a sufficient number, depths and distribution of lithologies to determine the potential AMD risk posed by the project.
- The laboratory data were broadly in support of the preliminary assessment undertaken in 2015, with both datasets showing consistently low sulfur concentrations for waste (including alluvial waste, granite waste, gabbro waste and fault zone waste) and ore. For the laboratory analysis undertaken for this investigation, the majority of samples for waste and ore recorded sulfides at such low levels that no acid related risk is likely. For example, 85% of the waste samples recorded less than 0.05% sulfides, and 97% of the ore samples were less than 0.05% sulfides. Total sulfur was below laboratory reporting limits (0.01%) for almost half of the waste samples.
- The highest sulfur and Maximum Potential Acidity (MPA) was recorded in an alluvial sample (13.4 kg/t H_2SO_4) which is marginally higher than an ore sample (11.7 kg/t H_2SO_4). These were the only two samples that had an MPA of greater than 10 kg/t H_2SO_4 (the third highest concentration was 6.4 kg/t H_2SO_4). It is noted that the elevated sulfur content of the alluvial sample may have been caused by contamination from the drill rig. The general distribution of MPA indicates recorded median, mean and 99% UCL values of 0.5, 0.7 and 0.8 kg/t H_2SO_4 respectively, demonstrating a general lack of sulfide material within the ore and wastes.
- Data on the Net Acid Producing Potential (NAPP) demonstrated that all samples returned negative values, indicating that the material is acid-consuming material (ACM) or non-acid-forming (NAF). Consequently, all Neutralising Potential Ratios (NPR) were strongly positive. The combined NAG and NAPP data demonstrate that all material tested can all be classed as NAF or ACM.
- Kinetic NAG and ABCC tests were undertaken on a selection of samples with the highest sulfide values. The data indicated that in the highest risk samples, the ANC may be to a large extent due to reactions of silicates such as micas and clays and hence overestimated, but that the various waste rock and ore material have adequate acid neutralising capacity and the risk of acid leachate generation is very low.
- The ASLP testing indicates leachate from waste rock may be sodic and cause soil dispersion if irrigated on to local soils. This can be managed, however by amending impacted soils or treating leachate with agricultural lime, if irrigation is used as a leachate management option or other long-term contact with soils is likely.
- As part of TNG's commitment to AMD assessment and management, drum leach and sequential batch leach tests will be undertaken on a number of waste, ore and tailings samples. These will complement environmental geochemical surveys of potential acid, metalliferous or saline leachate-generating waste rock, providing information such as sulfide reactivity, oxidation kinetics, metal solubility and the leaching behaviour of the test materials.
- Further AMD monitoring should be included in the Mine Management Plan and should occur during the mining and closure stages to provide critical feedback to confirm the concentrations of key AMD parameters are consistent with the existing testing. In the unlikely event that material with a greater AMD potential is identified, appropriate contingency measures should be taken.

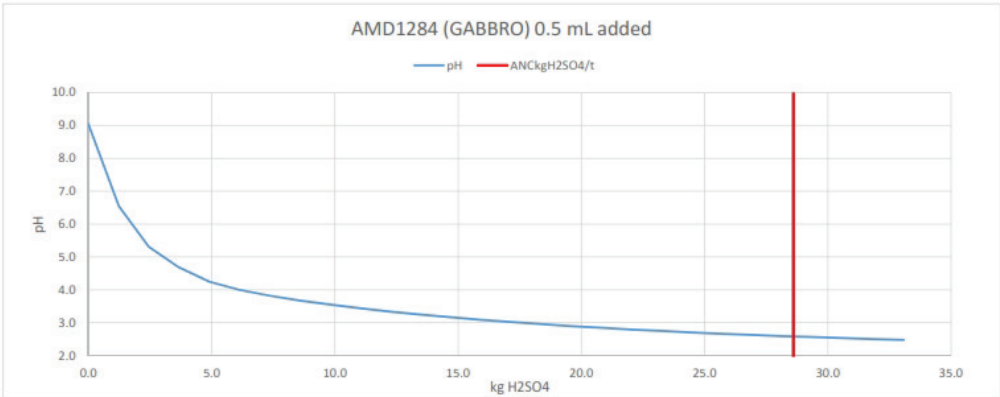
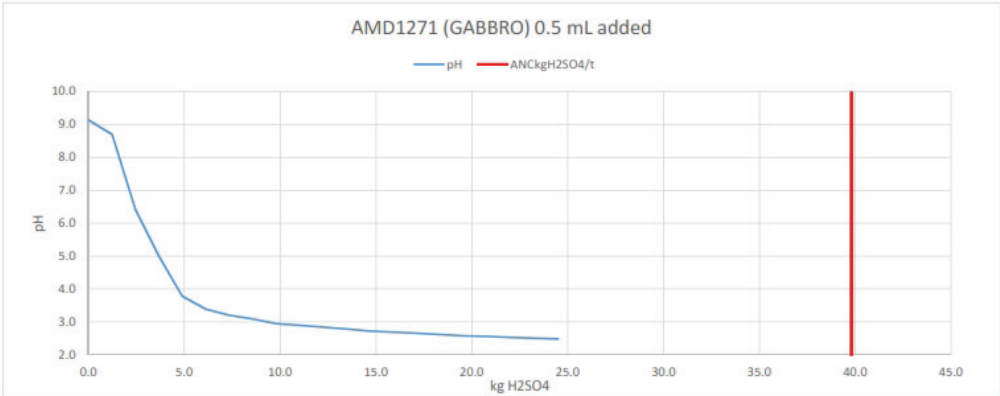
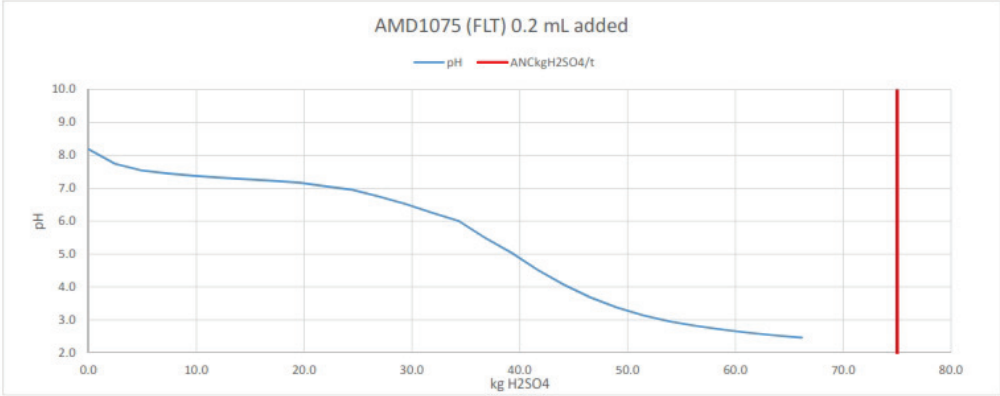
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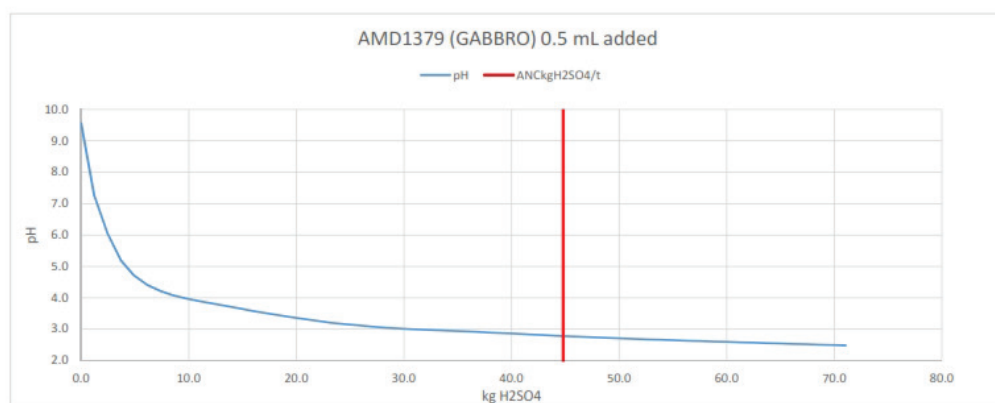
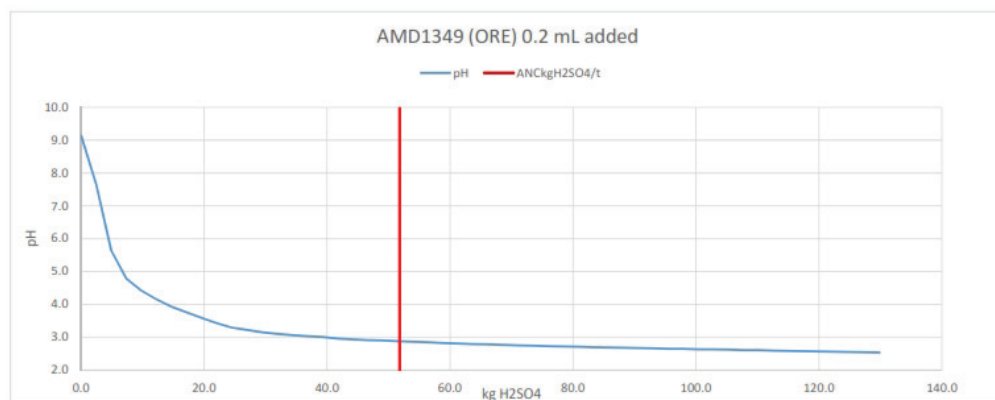
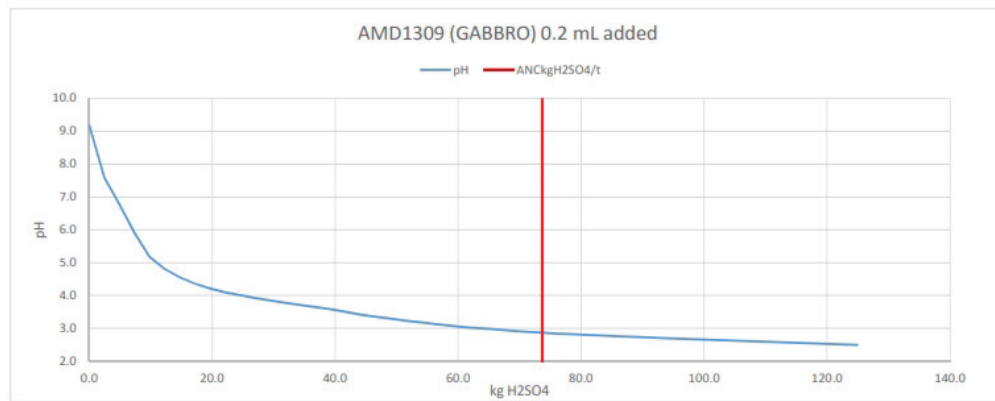
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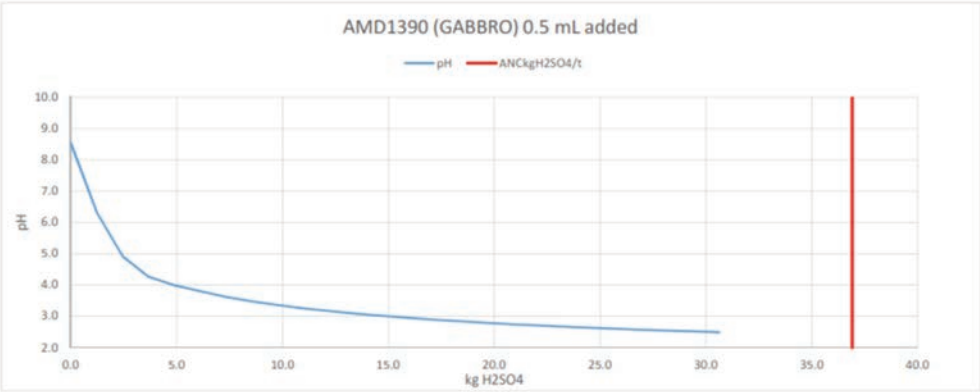
Appendices

Appendix A - Acid buffering characteristics curves









Appendix B - Leachate data

GHD

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Document Status

Rev	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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1	A Osbaldeston R Virtue	R Virtue		I McCardle		10//10/16
2	A Osbaldeston R Virtue	R Virtue		I McCardle		10/11/16

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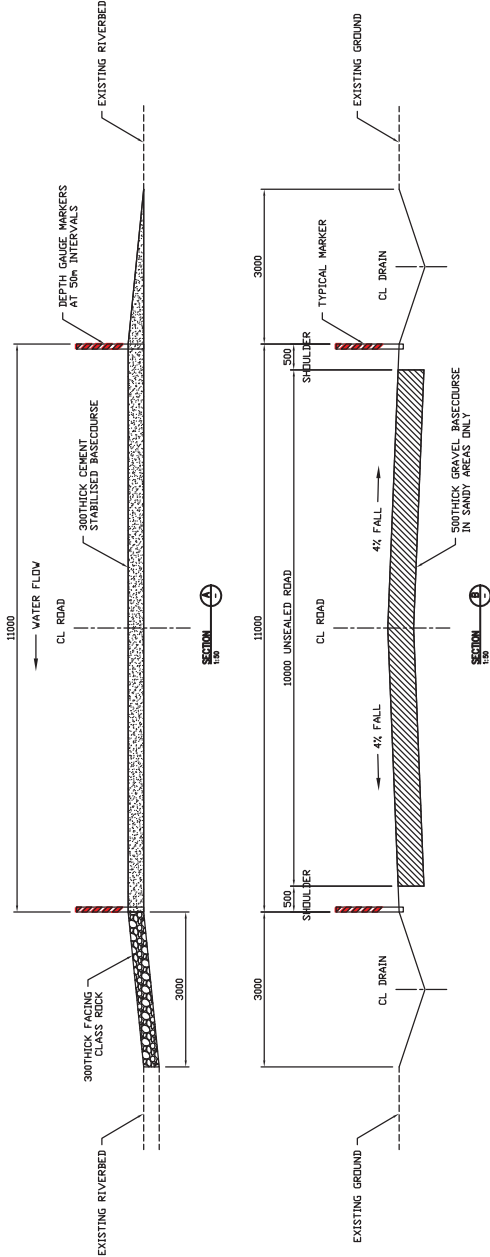


Appendix G

Floodway Concept



1. ALL DIMENSIONS ARE SHOWN IN MILLIMETRES
UNLESS NOTED OTHERWISE.

[illegible]



Appendix H

MSDS



Safety Data Sheet



1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product Name: **AMMONIUM NITRATE**

Other name(s): Nitric acid ammonium salt; Nitram; Nitropril; CPAN; Chemically Pure Ammonium Nitrate; Security Sensitive Ammonium Nitrate; SSAN.

Recommended Use of the Chemical and Restrictions on Use General chemical; explosives manufacture; fertilizer.

This material is classified as a Security Sensitive Ammonium Nitrate (SSAN). Various government controls may apply to this material.

Supplier: Ixom Operations Pty Ltd
ABN: 51 600 546 512
Street Address: Level 8, 1 Nicholson Street
East Melbourne Victoria 3002
Australia

Telephone Number: +61 3 9906 3000
Emergency Telephone: **AUSTRALIA: 1 800 033 111 (ALL HOURS)**
INTERNATIONAL AUSTRALIA: +61 3 9663 2130 (ALL HOURS)

Please ensure you refer to the limitations of this Safety Data Sheet as set out in the "Other Information" section at the end of this Data Sheet.

2. HAZARDS IDENTIFICATION

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.

This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:

Oxidising solids - Category 3

Eye Irritation - Category 2A

SIGNAL WORD: WARNING



Hazard Statement(s):

H272 May intensify fire; oxidizer.

H319 Causes serious eye irritation.

Precautionary Statement(s):

Prevention:

P210 Keep away from heat, sparks, open flames, hot surfaces. No smoking.

P220 Keep and store away from clothing, incompatible materials, combustible materials.

P221 Take any precaution to avoid mixing with combustibles / incompatible materials.

P264 Wash hands thoroughly after handling.

P280 Wear protective gloves / protective clothing / eye protection / face protection.

Safety Data Sheet

**Response:**

P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

P337+P313 If eye irritation persists: Get medical advice/attention.

P370+P378 In case of fire: Use extinguishing media as outlined in Section 5 of this Safety Data Sheet to extinguish.

Storage:

No storage statements.

Disposal:

P501 Dispose of contents and container in accordance with local, regional, national, international regulations.

Other Hazards:

AUH031 Contact with acids liberates toxic gas.

AUH044 Risk of explosion if heated under confinement.

Poisons Schedule (SUSMP): None allocated.

3. COMPOSITION AND INFORMATION ON INGREDIENTS

Components	CAS Number	Proportion	Hazard Codes
Ammonium nitrate	6484-52-2	>98% w/w	H272 H319
Other minor ingredients	-	<2% w/w	-

4. FIRST AID MEASURES

For advice, contact a Poisons Information Centre (e.g. phone Australia 131 126; New Zealand 0800 764 766) or a doctor.

Inhalation:

Remove victim from area of exposure - avoid becoming a casualty. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume most comfortable position and keep warm. Keep at rest until fully recovered. If patient finds breathing difficult and develops a bluish discolouration of the skin (which suggests a lack of oxygen in the blood - cyanosis), ensure airways are clear of any obstruction and have a qualified person give oxygen through a face mask. Apply artificial respiration if patient is not breathing. Seek immediate medical advice.

Skin Contact:

If skin contact occurs, remove contaminated clothing and wash skin with running water. If irritation occurs seek medical advice. Nitrates can be absorbed through cut, burnt or broken skin. Launder contaminated clothing before reuse.

Eye Contact:

If in eyes, hold eyelids apart and flush the eye continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre or a doctor, or for at least 15 minutes. Seek medical attention.

Ingestion:

Rinse mouth with water. If swallowed, do NOT induce vomiting. Give a glass of water. Seek medical advice.

Safety Data Sheet



Indication of immediate medical attention and special treatment needed:

Clinical findings: The smooth muscle relaxant effect of nitrate salts may lead to headache, dizziness and marked hypotension.

Cyanosis is clinically detectable when approximately 15% of the haemoglobin has been converted to methaemoglobin (ie. ferric iron).

Symptoms such as headache, dizziness, weakness and dyspnoea occur when methaemoglobin concentrations are 30% to 40%; at levels of about 60%, stupor, convulsions, coma and respiratory paralysis occur and the blood is a chocolate brown colour. At higher levels death may result. Spectrophotometric analysis can determine the presence and concentration of methaemoglobin in blood.

Treatment:

1. Give 100% oxygen.
2. In cases of (a) ingestion: use gastric lavage, (b) contamination of skin (unburnt or burnt): continue washing to remove salts.
3. Observe blood pressure and treat hypotension if necessary.
4. When methaemoglobin concentrations exceed 40% or when symptoms are present, give methylene blue 1 to 2 mg/kg body weight in a 1% solution by slow intravenous injection. If cyanosis has not resolved within one hour a second dose of 2 mg/kg body weight may be given. The total dose should not exceed 7 mg/kg body weight as unwanted effects such as dyspnoea, chest pain, vomiting, diarrhoea, mental confusion and cyanosis may occur. Without treatment methaemoglobin levels of 20-30% revert to normal within 3 days.
5. Bed rest is required for methaemoglobin levels in excess of 40%.
6. Continue to monitor and give oxygen for at least two hours after treatment with methylene blue.
7. Consider transfer to centre where haemoperfusion can be performed to remove the nitrates from the blood if the condition of the patient is unstable.
8. Following inhalation of oxides of nitrogen the patient should be observed in hospital for 24 hours for delayed onset of pulmonary oedema.

Further observation for 2-3 weeks may be required to detect the onset of the inflammatory changes of bronchiolitis fibrosa obliterans.

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media:

Coarse water spray. Water spray (large quantities).

Unsuitable Extinguishing Media:

Extinguishing methods based on smothering are ineffective in the case of oxidizing agents. DO NOT USE the following as extinguishing media: Carbon dioxide, dry chemical powder.

Hazchem or Emergency Action Code: 1Y

Specific hazards arising from the chemical:

WARNING:

Explosion risk in case of fire, especially if contaminated or confined. Molten product may explode from friction, shock or containment. In the case of an intense fire evacuate all personnel to at least 1000 m.

Oxidizing substance. Increases intensity of a fire, even in the absence of oxygen. Ammonium nitrate on its own is not combustible, however it supports the combustion of other materials. Contact with combustible material may cause fire. Decomposes on heating emitting irritating white fumes and/or brown fumes. Brown fumes indicate the presence of toxic oxides of nitrogen.

Safety Data Sheet



Special protective equipment and precautions for fire-fighters:

WARNING:

A major fire may involve a risk of explosion. Evacuate area immediately. Allow fire to burn out. An adjacent detonation may also involve the risk of explosion. Heating can cause decomposition of the material, which can lead to the containers exploding. Confinement of material may result in detonation.

In the case of an intense fire evacuate all personnel to a least 1000 metres. Police and emergency personnel should be notified immediately. If possible remove vehicles and further heat and ignition sources from area. Do not return to areas until the site has completely cooled down.

Decomposes on heating emitting irritating white fumes and/or brown fumes. Brown fumes indicate the presence of toxic oxides of nitrogen. On detection of fire the compartment(s) should be opened up to provide maximum ventilation. Fire-fighters to wear self-contained breathing apparatus and suitable protective clothing if there is a risk of exposure to products of combustion/decomposition. If safe to do so, remove containers from path of fire. If safe to do so, prevent molten material from being confined in drains, pipes etc.

6. ACCIDENTAL RELEASE MEASURES

Emergency procedures/Environmental precautions:

Shut off all possible sources of ignition. Clear area of all unprotected personnel. Do not allow the product to mix with combustible/organic materials.

Do not allow container or product to get into drains, sewers, streams or ponds. If contamination of sewers or waterways has occurred advise local emergency services.

Personal precautions/Protective equipment/Methods and materials for containment and cleaning up:

Clean up spillages immediately. Contain - prevent run off into drains and waterways. Wear protective equipment to prevent skin and eye contact and breathing in dust. Sweep up, but avoid generating dust. Collect in properly labelled containers, with loose fitting lids, for disposal. (Loose fitting lids). DO NOT return spilled material to original container for re-use. Ensure that contaminated material (clothing, pallets) is thoroughly washed.

This material is classified as a Security Sensitive Ammonium Nitrate (SSAN). Spillage recovery needs to be appropriately documented and material accurately accounted for.

In the case of a transport accident notify the Police, Regulatory Authorities and Ixom Operations Pty Ltd (Telephone: 1800 033 111 -- 24 hour service Australia) and/or (Telephone: 0800 734 607 -- 24 hour service New Zealand) or Ixom International Australia (Telephone: +61 3 9663 2130 -- 24 hour service Australia).

7. HANDLING AND STORAGE

Precautions for safe handling:

Avoid skin and eye contact and breathing in dust. Avoid handling which leads to dust formation. Handle with care. Keep out of reach of children.

Conditions for safe storage, including any incompatibilities:

Store in a cool, dry, well ventilated place. Store away from sources of heat or ignition. Ammonium Nitrate is incompatible with, and must be stored away from, tetranitromethane, dichloroisocyanuric acid, trichloroisocyanuric acid, any bromate, chlorate, chlorite, hypochlorite or chloroisocyanurate or any inorganic nitrite. Store away from incompatible materials described in Section 10. Keep containers closed when not in use - check regularly for spills.

If using wooden pallets, these must be hardwood and periodically washed down with large amounts of water to remove all traces of the material. Concrete floors are recommended for storage. If ammonium nitrate is to be stored in bulk, the surface must be treated so that it is resistant to attack. Bulk ammonium nitrate should not be stored on a bituminous floor.

Floors drains, recesses or other areas of possible confinement should be eliminated to prevent entrapment/confinement of molten (flowing) ammonium nitrate during a fire.

This product when stored in a confined, unventilated space/hold can give off ammonia or other odour and lead to the depletion of oxygen within this space and other confined spaces. It is therefore essential that ventilation is carried out prior to entry.

Ensure ammonium nitrate is stored securely and in accordance with regulations/controls issued by relevant authority. The secure storage of ammonium nitrate within Australia includes but is not limited to the use of site security plans, locking the facility/container with physical restraining items, validation and record keeping of all stock, and where deemed necessary through a risk management approach constant surveillance.

Within Australia all persons who have unsupervised access to Security Sensitive Ammonium Nitrate (SSAN), will require security clearances. The issuing of security clearances is controlled and issued through the local Government authorities. The checks include a criminal history check (CHC), and a politically motivated violence check (PMV).

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control Parameters: No value assigned for this specific material by Safe Work Australia. However, Workplace Exposure Standard(s) for particulates and decomposition products:

Dusts not otherwise classified: 8hr TWA = 10 mg/m³

Nitrogen dioxide: 8hr TWA = 5.6 mg/m³ (3 ppm), 15 min STEL = 9.4 mg/m³ (5 ppm)

As published by Safe Work Australia Workplace Exposure Standards for Airborne Contaminants.

TWA - The time-weighted average airborne concentration of a particular substance when calculated over an eight-hour working day, for a five-day working week.

STEL (Short Term Exposure Limit) - the airborne concentration of a particular substance calculated as a time-weighted average over 15 minutes, which should not be exceeded at any time during a normal eight hour work day. According to current knowledge this concentration should neither impair the health of, nor cause undue discomfort to, nearly all workers.

These Workplace Exposure Standards are guides to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. These workplace exposure standards should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity.

Safety Data Sheet



Appropriate engineering controls:

Ensure ventilation is adequate to maintain air concentrations below Workplace Exposure Standards. Keep containers closed when not in use.

If in the handling and application of this material, safe exposure levels could be exceeded, the use of engineering controls such as local exhaust ventilation must be considered and the results documented. If achieving safe exposure levels does not require engineering controls, then a detailed and documented risk assessment using the relevant Personal Protective Equipment (PPE) (refer to PPE section below) as a basis must be carried out to determine the minimum PPE requirements.

Individual protection measures, such as Personal Protective Equipment (PPE):

The selection of PPE is dependent on a detailed risk assessment. The risk assessment should consider the work situation, the physical form of the chemical, the handling methods, and environmental factors.

OVERALLS, SAFETY SHOES, CHEMICAL GOGGLES, GLOVES, DUST MASK.



Wear overalls, chemical goggles and impervious gloves. Avoid generating and inhaling dusts. If determined by a risk assessment an inhalation risk exists, wear a dust mask/respirator meeting the requirements of AS/NZS 1715 and AS/NZS 1716. Always wash hands before smoking, eating, drinking or using the toilet. Wash contaminated clothing and other protective equipment before storage or re-use.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Granular Solid / Prills
Colour:	White to Off-white
Odour:	Negligible
Molecular Formula:	NH ₄ NO ₃
Solubility:	Soluble in water.
Specific Gravity:	0.72 - 0.78 g/cm ³ (bulk density)
Relative Vapour Density (air=1):	Not available
Vapour Pressure (20 °C):	Negligible
Flash Point (°C):	Not applicable
Flammability Limits (%):	Not applicable
Autoignition Temperature (°C):	Not available
Melting Point/Range (°C):	160 - 169
Boiling Point/Range (°C):	Decomposes
Decomposition Point (°C):	ca. 210
pH:	4.5 - 5.2 (10% solution @20°C)

10. STABILITY AND REACTIVITY

Reactivity:	Powerful oxidizing agent. Oxidizing agents may cause vigorous reactions. Contact with acids liberates toxic gas. Hygroscopic: absorbs moisture or water from surrounding air.
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Safety Data Sheet



Chemical stability:	Stable under normal ambient and anticipated storage and handling conditions when free of contaminants including inorganic and organic materials. May explode under confinement and high temperature, but not readily detonated. May explode due to nearby detonations.
Possibility of hazardous reactions:	Oxidizing agent. Supports combustion of other materials and increases intensity of a fire. Will react with organic materials, and reducing agents. Reacts with nitrites, chlorides, chlorates, permanganates and metal powders. When mixed with strong acids, and occasionally during blasting, it produces an irritating toxic brown gas, mostly of nitrogen dioxide. When molten (such as in a fire situation) may decompose violently due to shock or pressure. Contamination with chlorine bleaches, pool chlorine and hypochlorites may result in the formation of explosive nitrogen trichloride. Heating can cause expansion or decomposition of the material, which can lead to the containers exploding.
Conditions to avoid:	Avoid exposure to heat, sources of ignition, and open flame. Will react with organic materials and reducing agents. Avoid contact with combustible chemicals. Avoid contact with other chemicals. Avoid dust generation. Avoid exposure to moisture.
Incompatible materials:	Ammonium nitrate is a powerful oxidizing agent; it is incompatible with tetranitromethane, dichloroisocyanuric acid, trichloroisocyanuric acid, bromates, chlorates, chlorites, hypochlorites, perchlorates, permanganates, chloroisocyanurate, nitrites, powdered metals. Incompatible with combustible materials. Incompatible with reducing agents. Incompatible with copper, zinc, brass and bronze.
Hazardous decomposition products:	Oxides of nitrogen. Ammonium nitrate fumes. Ammonia. Nitric acid.

11. TOXICOLOGICAL INFORMATION

No adverse health effects expected if the product is handled in accordance with this Safety Data Sheet and the product label. Symptoms or effects that may arise if the product is mishandled and overexposure occurs are:

Ingestion:	Swallowing can result in nausea, vomiting, diarrhoea, and abdominal pain. Swallowing large amounts may result in headaches, dizziness and a reduction in blood pressure (hypotension).
Eye contact:	An eye irritant.
Skin contact:	Repeated or prolonged skin contact may lead to irritation. Can be absorbed through cut, broken, or burnt skin with resultant adverse effects. Contact with molten material may cause skin burns. See effects as noted under 'Inhalation'.
Inhalation:	Breathing in dust may result in respiratory irritation. Blasting may produce a toxic brown gas of nitrogen dioxide. Inhalation of the gas may result in chest discomfort, shortness of breath and possible pulmonary oedema, the onset of which may be delayed. Absorption of ammonium nitrate by inhalation, ingestion or through burnt or broken skin may cause dilation of blood vessels by direct smooth muscle relaxation and may also cause methaemoglobinaemia. May cause dizziness, drowsiness, nausea and headache due to central nervous system effects.

Safety Data Sheet

**Acute toxicity:**

Oral LD50 (rat): 2217 mg/kg (for ammonium nitrate)

Respiratory or skin sensitisation:

Not known or reported to be a skin or respiratory sensitiser.

Chronic effects: No information available for the product.

NITRATES: Absorption of nitrates by ingestion, inhalation or through burnt or broken skin may cause dilation of the blood vessels by direct smooth muscle relaxation with a subsequent lowering of blood pressure and may also cause breathing difficulties, blueness of the skin (cyanosis) and methaemoglobinaemia. In humans and animals methaemoglobinaemia has occurred under untreated circumstances following the ingestion of nitrates.

12. ECOLOGICAL INFORMATION

Ecotoxicity

Avoid contaminating waterways. Ammonium nitrate is a plant nutrient. Large scale contamination may kill vegetation and cause poisoning in livestock and poultry.

Low toxicity to aquatic life. TLm 96: 10-100 ppm

Ammonia: 48hr LC50 (Cyprinus carpio): 1.15-1.72mg un-ionised NH₃/L; 95-102 mg total NH₃/L

Nitrates: 96hr LC50 (Chinook salmon, rainbow trout, bluegill): 420-1360 mg NO₃-/L

Persistence/degradability:

The material is biodegradable.

Bioaccumulative potential:

Not expected to bioconcentrate or bioaccumulate.

Mobility in soil:

The material is water soluble and may disperse in soil.

Aquatic toxicity:

Ammonium nitrate was evaluated at 5, 10, 25 and 50 mg (NH₄⁺)/L. The fertility of *Daphnia magna* was decreased at 50 mg/L. Post embryonic growth of crustacea was impaired at 10, 25 and 50 mg/L.

Can stimulate weed and algal growth in static surface waters.

13. DISPOSAL CONSIDERATIONS

Disposal methods:

Refer to Waste Management Authority. Dispose of contents and container in accordance with local regulations. Empty containers must be either rendered totally unusable, or if to be recycled for use, decontaminated by rinsing thoroughly with water. Rinsing water needs to be disposed of carefully.

Waste ammonium nitrate may be disposed of as a fertiliser, but this method of disposal must be agreed with the authorities.

As this material is classified as a Security Sensitive Ammonium Nitrate (SSAN) disposal of material needs to be appropriately documented and material accurately accounted for.

14. TRANSPORT INFORMATION

Safety Data Sheet



Road and Rail Transport

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.



UN No: 1942
Transport Hazard Class: 5.1 Oxidizing Agent
Packing Group: III
Proper Shipping Name or Technical Name: AMMONIUM NITRATE
Hazchem or Emergency Action Code: 1Y

Marine Transport

Classified as Dangerous Goods by the criteria of the International Maritime Dangerous Goods Code (IMDG Code) for transport by sea; DANGEROUS GOODS.

UN No: 1942
Transport Hazard Class: 5.1 Oxidizing Agent
Packing Group: III
Proper Shipping Name or Technical Name: AMMONIUM NITRATE

IMDG EMS Fire: F-H
IMDG EMS Spill: S-Q

Air Transport

Classified as Dangerous Goods by the criteria of the International Air Transport Association (IATA) Dangerous Goods Regulations for transport by air; DANGEROUS GOODS.

UN No: 1942
Transport Hazard Class: 5.1 Oxidizing Agent
Packing Group: III
Proper Shipping Name or Technical Name: AMMONIUM NITRATE

15. REGULATORY INFORMATION

Classification:

This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:

Oxidising solids - Category 3
Eye Irritation - Category 2A

Hazard Statement(s):

H272 May intensify fire; oxidizer.
H319 Causes serious eye irritation.

Poisons Schedule (SUSMP): None allocated.

All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

Product Name: AMMONIUM NITRATE
Substance No: 000032017701

Issued: 14/11/2016
Version: 6

Safety Data Sheet



Various regulations/controls/authorisations/licences may apply governing the manufacture, importation, exportation, use, handling, storage, sale/supply, transport and disposal of ammonium nitrate. Ammonium nitrate in Australia is considered a security sensitive material and loss, theft, attempted theft and unexplained discrepancies shall be reported to authorities. Record keeping and licensing of individuals shall be required and maintained.

16. OTHER INFORMATION

'Registry of Toxic Effects of Chemical Substances'. Ed. D. Sweet, US Dept. of Health & Human Services: Cincinnati, 2016.

In: 'The Dictionary of Substances and their Effects'. Ed. Gangolli S. Royal Society of Chemistry, 1999.

PACIA Code of Practice for Secure Distribution of High Analysis Ammonium Nitrate. 03/ 2004.

'Principles for the Regulation of Ammonium Nitrate COAG (Council of Australian Government)'.

This safety data sheet has been prepared by Ixom Operations Pty Ltd Toxicology & SDS Services.

Reason(s) for Issue:

Revised Primary SDS

Alignment to Safe Work Australia requirements

Change to Hazchem Code

This SDS summarises to our best knowledge at the date of issue, the chemical health and safety hazards of the material and general guidance on how to safely handle the material in the workplace. Since Ixom Operations Pty Ltd cannot anticipate or control the conditions under which the product may be used, each user must, prior to usage, assess and control the risks arising from its use of the material.

If clarification or further information is needed, the user should contact their Ixom representative or Ixom Operations Pty Ltd at the contact details on page 1.

Ixom Operations Pty Ltd's responsibility for the material as sold is subject to the terms and conditions of sale, a copy of which is available upon request.

Material Safety Data Sheet

Version 1.01

Revision Date: 19/12/2014

Magnetite (Fe_3O_4)

P₈₀ 90 Microns

1. Product Identification

Names: Magnetite, Iron Oxide (magnetite)

Molecular Weight: 231.54

Chemical Formula: Fe_3O_4

2. Product Composition

Key Components	CAS No.	Purity
Magnetite	1309-38-2	74.03%
Vanadium Pentoxide	1314-62-1	1.11%
TiO ₂	13463-67-7	16.58%
SiO ₂	7631-86-9	3.26%

3. Hazards Identification

Overview: High level of prolonged exposure to dust causes lung/airways irritation

Health Risk: Low

Flammability Risk: Low

Reactivity Risk: Low

Contact Risk: Low

Inhalation:

Inhalation of dust may cause irritation to airways and lungs. Symptoms include coughing / shortness of breath

Ingestion:

Oral consumption will cause gastric distress.

Skin Contact:

Should not cause any adverse effects.

Eye Contact:

May cause irritation if dust enters eyes.

Chronic Exposure:

Repeated and long term exposure via inhalation may cause siderosis. This is considered for this material to be fairly benign and should not cause physiological restrictions.

4. First Aid**Inhalation:**

Move victim to fresh air. Seek medical advice if victim is experiencing difficulty breathing.

Skin contact:

Wash affected area with soap and excess water. Seek medical if irritation arises.

Eye contact:

Wash eye with water (minimum 15 minutes), seek medical attention for continued irritation.

Ingested:

Administer water and seek medical advice for large amounts ingested.

5. Fire Fighting Measures**Fire Risk:**

Not deemed to be a fire hazard

Explosion Risk:

Slightly potential for dust explosion, not deemed to be a major hazard if proper operation used.

Fire Control:

No incompatibilities to standard fire control media or methods.

Other Information:

In event of fire, full protective clothing and self-contained breathing apparatus (SCBA) required.

6. Accidental Release

Follow PPE requirements (Section 8). Avoid dust formation and breathing dust. Ensure adequate ventilation.

Pick material for reclaiming / disposal, do not create dust. Sweep up and shovel spillage, collecting in suitable containers to await disposal.

Other:

See Section 13 for details on material disposal

7. Storage and Handling

Follow all local and statutory requirements for handling and storage of magnetite materials. Ensure dust generation is minimised during handling.

8. Exposure Control / PPE

Ensure all site PPE (clothing, eye wear and steel capped boots) are worn in areas where the product is stored, transported and handled. Exhaust and ventilation should be used to prevent dust exposure. In events of high dust, suitable respiratory protection should be used.

9. Physical and Chemical Properties

Appearance: Black-brown fine grained solid

Odour: none

Solubility: Insoluble

S.G: 5.24

pH: N/A

Volatiles: @ 21°C: 0%

Melting Point: 2849°C

Vapour Density: (Air=1): N/A

Vapour Pressure: 1mmHg @ 20°C

Chemical Stability: Stable

10. Stability and Reactivity

Stability: Stable under normal storage conditions

Incompatibles: Carbon monoxide, acids

Hazardous Decomposition: N/A

Avoid: Exposure to incompatible materials, dust formation

11. Toxicology Data

Carcinogen: No

Material is considered non-toxic.

12. Ecological Information

Non-toxic to flora and fauna, will cause visual effect upon distribution.

13. Disposal

Recover maximum amount of material. Material can be retreated or sent to downstream as determined by site management.

14. Transportation Information

Magnetite is not regulated for transport.

15. Regulatory Information

Magnetite is not regulated for transport.

16. Other Information

The data used for form the informations and recommendations in this MSDS are believed to be correct.

No guarantee or warranty of any kind, express or implied, is made with respect to the information contained in this document. It is the user's obligation to determine the conditions of safe use of this product.

Section: 1. PRODUCT AND COMPANY IDENTIFICATION

Product name : OPTIMER™ 83372

Other means of identification : Not applicable.

Recommended use : POWDER FLOCCULANT

Restrictions on use : Refer to available product literature or ask your local Sales Representative for restrictions on use and dose limits.

Company : ECOLAB PTY LTD
2 Drake Avenue
Macquarie Park NSW 2113
Australia
A.B.N. 59 000 449 990
TEL: 1300 654 224
FAX: +61 2 8870 8680

Emergency telephone number : 1800 205 506
International: +64 7 958 2372

Issuing date : 10.06.2016

Section: 2. HAZARDS IDENTIFICATION

GHS Classification

Not a hazardous substance or mixture.

Precautionary Statements : **Prevention:**
Wash hands thoroughly after handling.
Response:
Get medical advice/ attention if you feel unwell.
Storage:
Store in accordance with local regulations.
Disposal:
Dispose of contents/ container to an approved waste disposal plant.

Other hazards : None known.

Section: 3. COMPOSITION/INFORMATION ON INGREDIENTS

No hazardous ingredients

Section: 4. FIRST AID MEASURES

In case of eye contact : Rinse with plenty of water. Get medical attention if symptoms occur.

In case of skin contact : Wash off with soap and plenty of water. Get medical attention if symptoms occur.

If swallowed : Contact the Poison's Information Centre (eg Australia 13 1126; New Zealand 0800 764 766).
Rinse mouth. Get medical attention if symptoms occur.

If inhaled : Get medical attention if symptoms occur.

SAFETY DATA SHEET

OPTIMER™ 83372

- Protection of first-aiders : In event of emergency assess the danger before taking action. Do not put yourself at risk of injury. If in doubt, contact emergency responders. Use personal protective equipment as required.
- Notes to physician : Treat symptomatically.
- Most important symptoms and effects, both acute and delayed : See Section 11 for more detailed information on health effects and symptoms.

Section: 5. FIREFIGHTING MEASURES

- Suitable extinguishing media : Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
- Unsuitable extinguishing media : None known.
- Specific hazards during firefighting : Not flammable or combustible.
- Hazardous combustion products : Decomposition products may include the following materials: Carbon oxides
- Special protective equipment for firefighters : Use personal protective equipment.
- Specific extinguishing methods : Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations.

Section: 6. ACCIDENTAL RELEASE MEASURES

- Personal precautions, protective equipment and emergency procedures : Refer to protective measures listed in sections 7 and 8.
- Environmental precautions : No special environmental precautions required.
- Methods and materials for containment and cleaning up : Sweep up and shovel into suitable containers for disposal.

Section: 7. HANDLING AND STORAGE

- Advice on safe handling : For personal protection see section 8. Wash hands after handling.
- Conditions for safe storage : Keep out of reach of children. Keep container tightly closed. Store in suitable labeled containers.
- Suitable material : The following compatibility data is suggested based on similar product data and/or industry experience: Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use., HDPE (high density polyethylene)
- Unsuitable material : not determined

Section: 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

SAFETY DATA SHEET

OPTIMER™ 83372

Contains no substances with occupational exposure limit values.

Engineering measures : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Personal protective equipment

Eye protection : Safety glasses

Hand protection : Wear protective gloves.
Gloves should be discarded and replaced if there is any indication of degradation or chemical breakthrough.

Skin protection : Wear suitable protective clothing.

Respiratory protection : No personal respiratory protective equipment normally required.

Hygiene measures : Wash hands before breaks and immediately after handling the product.

Section: 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance : Granular

Colour : white

Odour : odourless

Flash point : does not flash

pH : 6.5, 0.5 %

Odour Threshold : no data available

Melting point/freezing point : no data available

Initial boiling point and boiling range : no data available

Evaporation rate : no data available

Flammability (solid, gas) : no data available

Upper explosion limit : no data available

Lower explosion limit : no data available

Vapour pressure : no data available

Relative vapour density : no data available

Relative density : no data available

Density : no data available

Water solubility : completely soluble

Solubility in other solvents : no data available

Partition coefficient: n-octanol/water : no data available

Auto-ignition temperature : no data available

Thermal decomposition temperature : no data available

Viscosity, dynamic : 1,600 mPa.s (20 °C), (@ 5.0 g/l aqueous solution)
650 mPa.s (20 °C), (@ 2.5 g/l aqueous solution)

SAFETY DATA SHEET

OPTIMER™ 83372

250 mPa.s (20 °C), (@ 1.0 g/l aqueous solution)

Viscosity, kinematic : no data available
Molecular weight : no data available
VOC : 0 %

Section: 10. STABILITY AND REACTIVITY

Chemical stability : Stable under normal conditions.

Possibility of hazardous reactions : No dangerous reaction known under conditions of normal use.

Conditions to avoid : None known.

Incompatible materials : Addition of water results in gelling.
Contact with strong oxidizers (e.g. chlorine, peroxides, chromates, nitric acid, perchlorate, concentrated oxygen, permanganate) may generate heat, fires, explosions and/or toxic vapors.
Acids

Hazardous decomposition products : Decomposition products may include the following materials:
Carbon oxides

Section: 11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure : Eye contact, Skin contact

Potential Health Effects

Eyes : Health injuries are not known or expected under normal use.

Skin : Health injuries are not known or expected under normal use.

Ingestion : Health injuries are not known or expected under normal use.

Inhalation : Health injuries are not known or expected under normal use.

Chronic Exposure : Health injuries are not known or expected under normal use.

Experience with human exposure

Eye contact : No symptoms known or expected.

Skin contact : No symptoms known or expected.

Ingestion : No symptoms known or expected.

Inhalation : No symptoms known or expected.

Toxicity

Product

Acute oral toxicity : LD50 rat: > 5,000 mg/kg
Test substance: Product

Acute inhalation toxicity : no data available

SAFETY DATA SHEET

OPTIMER™ 83372

Acute dermal toxicity	: no data available
Skin corrosion/irritation	: no data available
Serious eye damage/eye irritation	: no data available
Respiratory or skin sensitization	: no data available
Carcinogenicity	: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
Reproductive effects	: No toxicity to reproduction
Germ cell mutagenicity	: Contains no ingredient listed as a mutagen
Teratogenicity	: no data available
STOT - single exposure	: no data available
STOT - repeated exposure	: no data available
Aspiration toxicity	: No aspiration toxicity classification

Human Hazard Characterization

Based on our hazard characterization, the potential human hazard is: Low

Section: 12. ECOLOGICAL INFORMATION

Ecotoxicity

Environmental Effects : This product has no known ecotoxicological effects.

Product

Toxicity to fish : no data available

Toxicity to daphnia and other aquatic invertebrates : no data available

Toxicity to algae : no data available

Persistence and degradability

The product may be degraded via abiotic processes.

Chemical Oxygen Demand (COD): 1,100,000 mg/l

Biochemical Oxygen Demand (BOD): Biological degradation: Approx 20-30% (DIN EN 29888)

Mobility

The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.

If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air : <5%
Water : <5%

SAFETY DATA SHEET

OPTIMER™ 83372

Soil : > 90%

The portion in water is expected to be soluble or dispersible.

Bioaccumulative potential

Elimination from the aqueous phase via precipitation or flocculation is possible. No bioaccumulation will occur. The large size of the polymer is incompatible with transport across the cellular membranes.

Other information

no data available

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION

Based on our hazard characterization, the potential environmental hazard is: Low

Section: 13. DISPOSAL CONSIDERATIONS

- Disposal methods : Where possible recycling is preferred to disposal or incineration. If recycling is not practicable, dispose of in compliance with local regulations. Dispose of wastes in an approved waste disposal facility.
- Disposal considerations : Dispose of as unused product. Empty containers should be taken to an approved waste handling site for recycling or disposal. Do not re-use empty containers.

Section: 14. TRANSPORT INFORMATION

The shipper/consignor/sender is responsible to ensure that the packaging, labeling, and markings are in compliance with the selected mode of transport.

Land transport

Proper shipping name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

Air transport (IATA)

Proper shipping name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

Sea transport (IMDG/IMO)

Proper shipping name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

Section: 15. REGULATORY INFORMATION

Standard for the Uniform : No poison schedule number allocated
Scheduling of Medicines and
Poisons

INTERNATIONAL CHEMICAL CONTROL LAWS :

TOXIC SUBSTANCES CONTROL ACT (TSCA)

The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA)

The substances in this preparation are listed on the Domestic Substances List (DSL), are exempt, or have been reported in accordance with the New Substances Notification Regulations.

SAFETY DATA SHEET

OPTIMER™ 83372

AUSTRALIA

All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

CHINA

All substances in this product comply with the Provisions on the Environmental Administration of New Chemical Substances and are listed on or exempt from the Inventory of Existing Chemical Substances China (IECSC).

JAPAN

All substances in this product comply with the Law Regulating the Manufacture and Importation Of Chemical Substances and are listed on the Existing and New Chemical Substances list (ENCS).

KOREA

All substances in this product comply with the Chemical Control Act (CCA) and are listed on the Existing Chemicals List (ECL)

NEW ZEALAND

All substances in this product comply with the Hazardous Substances and New Organisms (HSNO) Act 1996, and are listed on or are exempt from the New Zealand Inventory of Chemicals.

PHILIPPINES

All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

Section: 16. OTHER INFORMATION

REFERENCES

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPS™ CD-ROM Version),
Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH,
(TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPS™ CD-ROM Version),
Micromedex, Inc., Englewood, CO.

Revision Date	: 10.06.2016
Date of first issue	: 10.06.2016
Version Number	: 1.0
Prepared By	: Regulatory Affairs

REVISED INFORMATION: Significant changes to regulatory or health information for this revision is indicated by a bar in the left-hand margin of the SDS.

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling,

SAFETY DATA SHEET

OPTIMER™ 83372

use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text. For additional copies of an SDS visit www.nalco.com and request access.

Safety Data Sheet



1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product Name: **SODIUM HYPOCHLORITE SOLUTION (10-15% AVAILABLE CHLORINE)**

Recommended Use of the Chemical and Restrictions on Use Water treatment: Sanitising agent.
Available chlorine = 10 - 15%.

Supplier: Ixom Operations Pty Ltd
ABN: 51 600 546 512
Street Address: Level 8, 1 Nicholson Street
Melbourne 3000
Australia

Telephone Number: +61 3 9665 7111
Facsimile: +61 3 9665 7937
Emergency Telephone: **1 800 033 111 (ALL HOURS)**

Please ensure you refer to the limitations of this Safety Data Sheet as set out in the "Other Information" section at the end of this Data Sheet.

2. HAZARDS IDENTIFICATION

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.

This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:

Skin Corrosion - Sub-category 1B
Eye Damage - Category 1

The following health/environmental hazard categories fall outside the scope of the Workplace Health and Safety Regulations:
Acute Aquatic Toxicity - Category 1

SIGNAL WORD: DANGER



Hazard Statement(s):

H314 Causes severe skin burns and eye damage.

Precautionary Statement(s):

Prevention:

P260 Do not breathe mist, vapours, spray.
P264 Wash hands thoroughly after handling.
P280 Wear protective gloves / protective clothing / eye protection / face protection.

Product Name: SODIUM HYPOCHLORITE SOLUTION (10-15% AVAILABLE CHLORINE)
Substance No: 000034421401

Issued: 10/11/2016

Version: 10

Safety Data Sheet

**Response:**

P301+P330+P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303+P361+P353 IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P321 Specific treatment (see First Aid Measures on Safety Data Sheet).
P363 Wash contaminated clothing before re-use.
P304+P340 IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P310 Immediately call a POISON CENTER or doctor/physician.
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

Storage:

P405 Store locked up.

Disposal:

P501 Dispose of contents and container in accordance with local, regional, national, international regulations.

Other Hazards:

AUH031 Contact with acids liberates toxic gas.

Poisons Schedule (SUSMP): S5 Caution.

3. COMPOSITION AND INFORMATION ON INGREDIENTS

Components	CAS Number	Proportion	Hazard Codes
Water	7732-18-5	>60%	-
Sodium hypochlorite	7681-52-9	10-<30%	H314 H400
Sodium hydroxide	1310-73-2	<1%	H290 H314 H318

4. FIRST AID MEASURES

For advice, contact a Poisons Information Centre (e.g. phone Australia 131 126; New Zealand 0800 764 766) or a doctor.

Inhalation:

Remove victim from area of exposure - avoid becoming a casualty. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume most comfortable position and keep warm. Keep at rest until fully recovered. If patient finds breathing difficult and develops a bluish discolouration of the skin (which suggests a lack of oxygen in the blood - cyanosis), ensure airways are clear of any obstruction and have a qualified person give oxygen through a face mask. Apply artificial respiration if patient is not breathing. Seek immediate medical advice.

Skin Contact:

If spilt on large areas of skin or hair, immediately drench with running water and remove clothing. Continue to wash skin and hair with plenty of water (and soap if material is insoluble) until advised to stop by the Poisons Information Centre or a doctor.

Eye Contact:

Immediately wash in and around the eye area with large amounts of water for at least 15 minutes. Eyelids to be held apart. Remove clothing if contaminated and wash skin. Urgently seek medical assistance. Transport promptly to hospital or medical centre. Continue to wash with large amounts of water until medical help is available.

Ingestion:

Immediately rinse mouth with water. If swallowed, do NOT induce vomiting. Give a glass of water. Seek immediate medical assistance.

Product Name: SODIUM HYPOCHLORITE SOLUTION (10-15% AVAILABLE CHLORINE)
Substance No: 000034421401

Issued: 10/11/2016

Version: 10

Safety Data Sheet

**Indication of immediate medical attention and special treatment needed:**

Treat symptomatically. Can cause corneal burns. Delayed pulmonary oedema may result.

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media:

Not combustible, however, if material is involved in a fire use: Fine water spray, normal foam, dry agent (carbon dioxide, dry chemical powder).

Hazchem or Emergency Action Code: 2X

Specific hazards arising from the chemical:

Non-combustible material.

Special protective equipment and precautions for fire-fighters:

Decomposes on heating emitting toxic fumes, including those of chlorine. Fire fighters to wear self-contained breathing apparatus and suitable protective clothing if risk of exposure to products of decomposition.

6. ACCIDENTAL RELEASE MEASURES

Emergency procedures/Environmental precautions:

Clear area of all unprotected personnel. If contamination of sewers or waterways has occurred advise local emergency services.

Personal precautions/Protective equipment/Methods and materials for containment and cleaning up:

Slippery when spilt. Avoid accidents, clean up immediately. Wear protective equipment to prevent skin and eye contact and breathing in vapours. Work up wind or increase ventilation. Contain - prevent run off into drains and waterways. Use absorbent (soil, sand or other inert material). Collect and seal in properly labelled containers or drums for disposal. For small amounts, in case of spillage flush with large quantities of water.

7. HANDLING AND STORAGE

This material is a Scheduled Poison S5 and must be stored, maintained and used in accordance with the relevant regulations.

Precautions for safe handling:

Avoid skin and eye contact and breathing in vapour, mists and aerosols. Keep out of reach of children.

Conditions for safe storage, including any incompatibilities:

Store in a cool, dry, well ventilated place. Store away from foodstuffs. Store away from acids. Store away from incompatible materials described in Section 10. Keep containers closed when not in use - check regularly for leaks.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control Parameters: No value assigned for this specific material by Safe Work Australia. However, Workplace Exposure Standard(s) for constituent(s) and decomposition product(s):

Sodium hydroxide: Peak Limitation = 2 mg/m³

Chlorine: Peak Limitation = 3 mg/m³ (1 ppm)

Safety Data Sheet



As published by Safe Work Australia Workplace Exposure Standards for Airborne Contaminants.

Peak Limitation - a maximum or peak airborne concentration of a particular substance determined over the shortest analytically practicable period of time which does not exceed 15 minutes.

These Workplace Exposure Standards are guides to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. These workplace exposure standards should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity.

Appropriate engineering controls:

Ensure ventilation is adequate and that air concentrations of components are controlled below quoted Workplace Exposure Standards. Keep containers closed when not in use.

If in the handling and application of this material, safe exposure levels could be exceeded, the use of engineering controls such as local exhaust ventilation must be considered and the results documented. If achieving safe exposure levels does not require engineering controls, then a detailed and documented risk assessment using the relevant Personal Protective Equipment (PPE) (refer to PPE section below) as a basis must be carried out to determine the minimum PPE requirements.

Individual protection measures, such as Personal Protective Equipment (PPE):

The selection of PPE is dependent on a detailed risk assessment. The risk assessment should consider the work situation, the physical form of the chemical, the handling methods, and environmental factors.

OVERALLS, CHEMICAL GOGGLES, FACE SHIELD, GLOVES (Long), APRON, RUBBER BOOTS.



Wear overalls, chemical goggles, face shield, elbow-length impervious gloves, splash apron or equivalent chemical impervious outer garment, and rubber boots. Always wash hands before smoking, eating, drinking or using the toilet. Wash contaminated clothing and other protective equipment before storage or re-use.

If determined by a risk assessment an inhalation risk exists, wear an air supplied respirator meeting the requirements of AS/NZS 1715 and AS/NZS 1716.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid
Colour:	Pale Yellow - Green
Odour:	Chlorine
Solubility:	Miscible in water.
Specific Gravity:	1.2 @20°C
Relative Vapour Density (air=1):	Not available
Vapour Pressure (20 °C):	Not available
Flash Point (°C):	Not applicable
Flammability Limits (%):	Not applicable
Autoignition Temperature (°C):	Not available
Boiling Point/Range (°C):	Not available

Product Name: SODIUM HYPOCHLORITE SOLUTION (10-15% AVAILABLE CHLORINE)
Substance No: 000034421401

Issued: 10/11/2016

Version: 10

Safety Data Sheet



pH: 12.5 (1% w/w)

10. STABILITY AND REACTIVITY

Reactivity:	Contact with acids liberates toxic gas.
Chemical stability:	Stable under normal ambient and anticipated storage and handling conditions of temperature and pressure. The amount of available chlorine diminishes over time.
Possibility of hazardous reactions:	Hazardous polymerisation will not occur. Reacts exothermically with acids . Reacts with ammonia, amines and ammonium salts to product chloramines. Decomposes on heating to produce chlorine gas.
Conditions to avoid:	Avoid contact with foodstuffs. Avoid exposure to heat, sources of ignition, and open flame. Avoid exposure to light. Avoid contact with other chemicals. Avoid contact with acids .
Incompatible materials:	Incompatible with acids , metals , metal salts , peroxides , reducing agents , and ethylene diamine tetraacetic acid . Incompatible with ammonia and ammonium compounds such as amines and ammonium salts.
Hazardous decomposition products:	Chlorine.

11. TOXICOLOGICAL INFORMATION

No adverse health effects expected if the product is handled in accordance with this Safety Data Sheet and the product label. Symptoms or effects that may arise if the product is mishandled and overexposure occurs are:

Ingestion:	Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.
Eye contact:	A severe eye irritant. Corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.
Skin contact:	Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.
Inhalation:	Breathing in mists or aerosols may produce respiratory irritation. Delayed (up to 48 hours) fluid build up in the lungs may occur.

Acute toxicity: No LD50 data available for the product. For the constituent SODIUM HYPOCHLORITE:
Oral LD50 (mice): 5800 mg/kg

Serious eye damage/irritation: Moderate irritant (rabbit). Standard Draize test

Chronic effects: No information available for the product.

12. ECOLOGICAL INFORMATION

Ecotoxicity	Avoid contaminating waterways.
Persistence/degradability:	This material is biodegradable.

Product Name: SODIUM HYPOCHLORITE SOLUTION (10-15% AVAILABLE CHLORINE)
Substance No: 000034421401

Issued: 10/11/2016

Version: 10

Safety Data Sheet



Bioaccumulative potential: Does not bioaccumulate.

Aquatic toxicity: Very toxic to aquatic organisms.

96hr LC50 (fish): 0.065 mg/L (for sodium hypochlorite)

13. DISPOSAL CONSIDERATIONS

Disposal methods:

Refer to Waste Management Authority. Dispose of material through a licensed waste contractor. Decontamination and destruction of containers should be considered.

14. TRANSPORT INFORMATION

Road and Rail Transport

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.



UN No: 1791
Transport Hazard Class: 8 Corrosive
Packing Group: II
Proper Shipping Name or Technical Name: HYPOCHLORITE SOLUTION
Hazchem or Emergency Action Code: 2X

Marine Transport

Classified as Dangerous Goods by the criteria of the International Maritime Dangerous Goods Code (IMDG Code) for transport by sea; DANGEROUS GOODS.

UN No: 1791
Transport Hazard Class: 8 Corrosive
Packing Group: II
Proper Shipping Name or Technical Name: HYPOCHLORITE SOLUTION

IMDG EMS Fire: F-A
IMDG EMS Spill: S-B

Air Transport

Classified as Dangerous Goods by the criteria of the International Air Transport Association (IATA) Dangerous Goods Regulations for transport by air; DANGEROUS GOODS.

UN No: 1791
Transport Hazard Class: 8 Corrosive
Packing Group: II
Proper Shipping Name or Technical Name: HYPOCHLORITE SOLUTION

Product Name: SODIUM HYPOCHLORITE SOLUTION (10-15% AVAILABLE CHLORINE)
Substance No: 000034421401

Issued: 10/11/2016

Version: 10

Safety Data Sheet



15. REGULATORY INFORMATION

Classification:

This material is hazardous according to Safe Work Australia; HAZARDOUS CHEMICAL.

Classification of the chemical:

Skin Corrosion - Sub-category 1B

Eye Damage - Category 1

The following health/environmental hazard categories fall outside the scope of the Workplace Health and Safety Regulations:

Acute Aquatic Toxicity - Category 1

Hazard Statement(s):

H314 Causes severe skin burns and eye damage.

Poisons Schedule (SUSMP): S5 Caution.

All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

'Registry of Toxic Effects of Chemical Substances'. Ed. D. Sweet, US Dept. of Health & Human Services: Cincinnati, 2016.

This safety data sheet has been prepared by Ixom Operations Pty Ltd Toxicology & SDS Services.

Reason(s) for Issue:

Revised Primary SDS

Change in Hazardous Chemical Classification

Change in Packing Group

This SDS summarises to our best knowledge at the date of issue, the chemical health and safety hazards of the material and general guidance on how to safely handle the material in the workplace. Since Ixom Operations Pty Ltd cannot anticipate or control the conditions under which the product may be used, each user must, prior to usage, assess and control the risks arising from its use of the material.

If clarification or further information is needed, the user should contact their Ixom representative or Ixom Operations Pty Ltd at the contact details on page 1.

Ixom Operations Pty Ltd's responsibility for the material as sold is subject to the terms and conditions of sale, a copy of which is available upon request.