Mt Rawdon Operations

Application to Amend the Environmental Authority to Facilitate a Revision to the Groundwater Monitoring Program

November 2015

prepared for

Mt Rawdon Operations Pty Ltd

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Limitations of this Report

Client: Mt Rawdon Operations

Prepared by Northern Resource Consultants (NRC)

This disclaimer brings the limitations of the investigations to the attention of the reader.

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This report has been formulated in the context of published guidelines, field observations, discussions with site personnel, and results of laboratory analyses.

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Project Description

1. About the Mt Rawdon Operation

1.1 Background

The Mount Rawdon gold deposit is a large tonnage, volcanic-hosted, low-grade gold deposit, with gold occurring as either fine-grained free gold or closely associated with sulfide minerals. Mount Rawdon Operation (MRO) is located 36km southwest of Gin Gin in southeast Queensland. The location of the site is shown on a map included in Appendix A of this report.

Site-specific exploration at Mount Rawdon Operations (MRO) began in 1969 with rock chip sampling undertaken by Noranda Ltd identifying a significant +0.7g/t Au surface anomaly (Placer Pacific 1996). An in-depth feasibility study was conducted in the mid-1990s. Equigold NL acquired the project, and construction on MRO commenced, in early 2000. MRO was commissioned in January 2001. During operations in 2001, Equigold completed a targeted drilling program immediately below and adjacent to the existing pit. The result of this program was an increase in the reserve from 22.8Mt to 45.85Mt of ore.

In 2005, a redesign of the open pit was completed based on the increased cut-off grade and steeper pit wall angles. In 2008 Equigold merged with Lihir Gold Limited. In 2010 Lihir Gold Limited merged with Newcrest Mining.

In 2011 the project reached a milestone – one million ounces of gold produced in the 10 years since commissioning. Later in that same year, Evolution Mining was created through a merger between Catalpa Resources and Conquest Mining, and acquired 100% of MRO via a concurrent acquisition of Newcrest Mining's Cracow and Mount Rawdon gold mines. In July 2014 another milestone was reached: 40t of gold produced.

1.2 Current Operations

MRO is an active open pit gold mine that operates using conventional open pit mining methods. The associated processing plant incorporates primary and secondary crushing, semi-autogenous grinding (SAG) and ball milling, followed by conventional cyanide leaching. As of 2014, mill throughput is maintained at 3.5 million tonnes per annum of ore with a gold recovery of approximately 90%, and the pit is currently over 300m deep below the original mountain outcrop.

The current life of the mine estimates production continuing until 2022, which is eight years from the date of this application to amend the Environmental Authority (EA) EPML00712113. Processing is undertaken adjacent to the open cut pit, via conventional cyanide leach extraction. Tailings are stored in the site's tailings storage facility (TSF), which has a disturbance footprint of approximately 160ha, located 400m north of the open pit. The Process

Water Dam and the TSF operate in a closed circuit by recycling water back to the processing operation.

2. Purpose of this EA Amendment Application

Mt Rawdon Operation (MRO) currently implements a groundwater monitoring program in accordance with the requirements of the site's Environmental Authority (EA) EPML00712113 dated 13 August 2015. During 2015, RPS was commissioned to produce a review of the regional bore monitoring program and a review of the seepage bore monitoring program. The regional groundwater review formed part of an action plan to address regional groundwater quality at MRO and was commissioned at the behest of the Department of Environment and Heritage Protection (EHP). An additional review of seepage monitoring bores was also commissioned by MRO to ensure all aspects of groundwater quality and monitoring at site were considered. The reviews were presented to EHP in Maryborough, resulting in a short addendum to the memorandum reviewing the regional bore monitoring program.

Based on the reviews conducted by RPS, MRO has elected to amend its groundwater monitoring program in order to more effectively track the evolution of groundwater quality at the MRO site. Under the definitions provided by EHP in their guideline EM959 *Major and minor amendments* (Version 3) (2014), this application to amend the EA qualifies as a minor amendment as it:

- Is not a change to a standard condition identified in the EA as a standard condition,
- Does not significantly increase the level of environmental harm caused by any ERA,
- Does not change rehabilitation objectives in the EA,
- Does not significantly increase the scale or intensity of any ERA,
- Does not relate to a new relevant resource tenure, and
- Does not increase the existing disturbance area for any ERA

3. Objective of this Report

The objective of this report is to demonstrate that the amendments to the groundwater monitoring program planned under this EA amendment application do not adversely impact the environmental values relating to groundwater and surface water in the receiving environment. This report will also prove that the revised groundwater monitoring program is more suitable for the appropriate management of groundwater quality at MRO.

This report has been prepared according to the requirements of EHP's guideline EM963, *Application Requirements for Activities with Impacts to Water.*

4. Project Location

The MRO gold deposit is located in South East Queensland, approximately 80km southwest of the city of Bundaberg, and 300km north-northwest of Brisbane. Access to the deposit from Gin Gin on the Bruce Highway is via a sealed road for 52km southwest to the township of Mount

Perry, and then southeast by gazetted road, which is unsealed for most of the 18km length. Mount Perry is the closest township to MRO, located approximately 15km northwest of the operation.

The gold deposit lies beneath the southern side of a hill known as Mount Rawdon, located between Mingham Creek and the Perry River, both of which drain to the Burnett River. The mining lease is located within the North Burnett Regional Council region. For a map of the project location, please refer to Appendix A of this report.

5. Proponent

Mount Rawdon Operations Pty Ltd is a subsidiary of Evolution Mining Ltd. The proponent for this project and this application to amend the current EA EPML00712113 dated 13 August 2015 is:

Mount Rawdon Operations Pty Ltd
PO Box 1168
Bundaberg
Queensland 4670

6. Tenement and Property Description

MRO comprises nine mining leases (MLs), totalling just over 2,015 hectares. Table 1 shows details of the leases and existing and proposed mining and mineral processing activities for each lease. Mining tenure at Mount Rawdon overlies background land tenure described by three lots on plan units: Lot 3 BN37400, Lot 2 SP138073 and Lot 38 BON559. Evolution Mining Pty Ltd owns the background land tenure for MRO. For a map displaying cadastre boundaries and the proposed site infrastructure, please see Appendix A of this report.

Table 1: Mining lease details at Mt Rawdon Operation

MINING LEASE NUMBER	AREA (HA)	EXPIRY DATE	CADASTRE	CURRENT ACTIVITY
ML1206	41.88	30 Sept 2022	Lot 3 BN37400	Open pit, waste rock storage
ML1210	16.09	30 Apr 2023	Lot 3 BN37400	Open pit
ML1259	593.93	31 May 2028 (Under renewal)	Lot 3 BN37400; Lot 2 SP138073; Lot 38 BON559	Tailings dam, waste rock storage, infrastructure, open pit
ML1231	8	31 Aug 2022	Lot 3 BN37400	Crushed ore stockpile
ML1203	0.4	31 Jan 2020	Lot 3 BN37400	Open pit
ML1192	1.80	31 May 2028	Lot 3 BN37400	Open pit

MINING LEASE NUMBER	AREA (HA)	EXPIRY DATE	CADASTRE	CURRENT ACTIVITY
ML1204	2	31 Jan 2020	Lot 3 BN37400	Open pit
ML50119	485.5	31 Jan 2029 (Under renewal)	Lot 3 BN37400	Power transmission line
ML80095	865.82	31 May 2028	Lot 3 BN37400; Lot 2 SP138073; Lot 38 BON559	Topsoil stockpiles, access and infrastructure associated with open pit, waste rock storage

7. Environmentally Relevant Activities and Notifiable Activities

7.1 Groundwater Monitoring, ERAs and Notifiable Activities

The proposed revision to the groundwater monitoring will not involve any alterations to the ERAs or notifiable activities conducted at MRO. The proposed revision will also not reduce the effectiveness with which the groundwater monitoring program provides information on any potential environmental harm caused by ERAs or notifiable activities conducted on site. The ERAs and Notifiable Activities conducted at site are listed below.

7.2 Environmentally Relevant Activities

MRO is currently authorised to conduct the following Environmentally Relevant Activities (ERAs) as per Schedule 2 of the *Environmental Protection Regulation (2008)* pp.167-:

- ERA 8 Chemical Storage (formerly ERA 7, 11),
- ERA 17 Abrasive blasting (formerly ERA 23),
- ERA 21 Motor vehicle workshop operation (formerly ERA 28)
- ERA 30 Metal smelting and refining (formerly ERA 41)
- ERA 31 Mineral processing (formerly ERA 42),
- ERA 63 Sewage treatment (formerly ERA 15),
- ERA 64 Water treatment (formerly ERA 16).

These ERAs are described below in some detail, but this application to revise the EA does not involve any change to any of the currently approved ERAs or notifiable activities at MRO.

Chemical Storage

Chemical storage—storing more than 10t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code. Table 2 identifies each of the chemicals stored on site.

Table 2: MRO chemicals stored under notifiable activities as per schedule 3 of the EPA.

SUBSTANCE NAME	USED FOR	TYPICAL LOCATION	APPROX. QUANTITY	D. G. CLASS
Ammonium Nitrate	To produce explosives	Orica yard	20,000kg	5.1
Caustic soda-liquid (46%-50%)	Gold dissolution	Cyanide facility	50,000L @ 50%	8
Composol (dilute ammonium nitrate)	To produce explosives	Orica yard	1,000L	N/A
EP Advantage	To produce explosives	Orica yard	60,000kg	5.1
EP Eclipse	To produce explosives	Orica yard	20,000kg	5.1
"Gasser"	To produce explosives	Orica yard	1,000L	N/A
Hydrochloric Acid 32%	Stripping & assaying	Gold room & lab	32,000L	8
Sodium cyanide solution 30%w/w	Gold dissolution	Cyanide facility	160,000L @ 28%	6.1
EP Vistis	To produce explosives	Orica yard	85,000kg	5.1
XP additive	To produce explosives	Orica yard	40,000kg	N/A

7.3 Notifiable Activities

Notifiable activities are activities that have the potential to cause land contamination. MRO already conduct a number of notifiable activities as per schedule 3 of the EPA. This application to revise the EA does not involve any change to any of the currently approved notifiable activities at MRO.

Full details of the activities are listed in this section. The following Notifiable Activities are being conducted on the project site (as per Schedule 3 of the Environment Protection Act):

- 1 Abrasive Blasting,
- 7 Chemical Storage
- 24 Mine Wastes,
- 25 Mineral Processing,
- 29 Petroleum Product or Oil Storage,
- 35 Smelting or Refining.

Abrasive Blasting

Abrasive blasting – carrying out abrasive blast cleaning (other than cleaning carried out in fully enclosed booths) or disposing of abrasive blasting material.

Chemical Storage

Chemical storage (other than petroleum products or oil) is defined as storage of more than 10t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code.

Mine Wastes

Mine wastes – storing hazardous mine or exploration wastes, including, for example, tailings, overburden or waste rock containing hazardous contaminants.

A single TSF is operational at the Mount Rawdon site. All mineral processing wastes are stored in the TSF in addition to high risk potentially acid forming (PAF) waste rock from the pit. The total structural tailings dam disturbance footprint is approximately 160 hectares.

Two waste rock dumps are currently operational at the Mount Rawdon site. Waste rock that has been characterised as non-acid forming (NAF) or medium risk PAF is disposed of in the northern waste rock dump. All medium risk PAF waste rock is deposited in the core of the dump and encapsulated by NAF rock. Waste rock deposited in the western waste rock dump is NAF material only.

Mineral Processing

Ore is processed using conventional cyanide leaching technology. The ore processing facilities include the crushing, milling, leaching, and gold recovery units along with associated reagents and the tailing storage facility. The main equipment components of each process are listed below:

- Crushing: Primary and Secondary gyratory crushers
- Milling: SAG mill / pebble crusher / ball mill circuit
- Leaching: CIL circuit containing six leach tanks
- Gold recovery: AARL stripping circuit

Petroleum Product or Oil Storage

Petroleum product or oil storage is defined as storing petroleum products or oil

(a) in underground tanks with more than 200L capacity; or

(b) in above ground tanks with

(i) for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code—more than 2500L capacity; or

(ii) for petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code—more than 5000L capacity; or

(iii) for petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS 1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia—more than 25,000L capacity.

There is a 140,000L above-ground diesel fuel tank in the Mining Operations. The fuel is used for earthmoving machinery. There is a 13,000L diesel tank adjacent to the processing area which is predominantly used for refuelling of light vehicles and is also bunded.

Smelting or Refining

Smelting or refining is defined as fusing or melting metalliferous metal or refining the metal. Processing at MRO incorporates primary and secondary crushing, semi-autogenous grinding (SAG) and ball milling, followed by conventional cyanide leaching.

Amendments Sought

1. Groundwater Categories and Required Information

MRO is seeking to amend the site's requirements for groundwater monitoring as detailed within the EA. The groundwater monitoring program at MRO consists of two sets of monitoring bores for:

1. TSF seepage monitoring
2. Regional groundwater monitoring.

A complete list of all of the monitoring bores drilled at MRO, their status in the current EA if applicable, their intended use going forward and the explanation behind that use is included in Table 16 of this report. The following sections of this report go through the information included in Table 16 in more accessible detail.

This proposed groundwater monitoring program is based on memoranda and recommendations provided by Jon Hall, Principal Hydrogeologist and Technical Director – Mine Water Management at specialist water management company RPS, who has over 35 years' experience in hydrogeology. The three memoranda are included in the appendices of this report.

The current EA included 53 monitoring bores in total, plus two more required bores under the regional monitoring program where the EA lists details to be confirmed. This adds to a total of 55 monitoring bores. The revised groundwater monitoring program proposes a total of 47 individual monitoring bores, some serving a dual purpose as both seepage and regional bores. These bores are broken down as follows:

- There will be 16 regional groundwater monitoring bores, including six dual status bores, used for both seepage monitoring and regional groundwater quality monitoring.
- There will be 30 seepage monitoring bores, including the same six dual status bores used for both seepage monitoring and regional groundwater quality monitoring.
- There will be seven investigation bores.

In terms of individual bore count, this equates to 10 regional bores, 24 seepage bores, six dual purpose bores and seven investigation bores, for a total of 47 individual bores, but including the additional functions of dual purpose bores this actually provides for 53 bore monitoring functions, which is identical to the identified monitoring effort of named bores included in the current EA.

This application includes representative groundwater data from aquifers in the region, with both seepage data and regional groundwater quality data interrogated as part of the design of this monitoring program. Years of sampling data are available from MRO and this comprehensive dataset assisted in the design of an effective monitoring program that will provide an early indication of any first arrival of seepage. The revised sampling program includes measures that allow for identification of any instance where a seepage front may bypass the primary seepage monitoring bores.

The revised program also includes both trigger and compliance limits with a targeted trigger allowing for specific investigation of potential encroaching seepage. Bore construction data is available for all of the new bores that are already drilled and are to be added to the EA and these bore logs are provided in the appendices of this report.

The revised groundwater monitoring program includes monitoring of parameters—cations and anions—that allows for identification of 'water type' which in turn will allow discrimination between groundwater influence and other potential factors in investigations.

2. Summary

2.1 Aims of the Proposed Program

The key aims of the proposed groundwater monitoring program at MRO as outlined by RPS (2015a, 2015b) are:

- Protection of the environment from harm due to groundwater seepage from the mine,
- Synoptic mapping of the overall groundwater quality to provide:
  - Snapshots of the distribution of groundwater quality and risk to the environment,
  - Snapshots at time intervals over which no significant change to environmental risk is expected.
- Synoptic mapping of groundwater levels to provide:
  - Confirmation of broad groundwater and seepage flow directions,
  - Confirmation of any water table mounding as a result of seepage,
- Identification of the first arrival of seepage from contaminant sources,
- Tracking of seepage migration through the aquifer system,
- Prediction of future migration of seepage towards groundwater discharge zones,
  - Baseflow to creeks,
  - Groundwater flow from the mine lease area,
- Validation and recalibration of conceptual and predictive models and validation of seepage predictions,
- Compliance with regulatory conditions.

2.2 Changes to the Existing Program

In terms of changes to the existing groundwater monitoring program, MRO is seeking:

- An amendment to the number of bores used for both seepage and regional groundwater monitoring,
- An amendment to the frequency of monitoring in some of those bores (but not a reduction in effectiveness),

- An amendment to the classification of bores, e.g. instead of just regional bores and seepage bores, this proposal is for a more complex and effective bore classification and monitoring structure,
- An amendment to the parameters monitored at each bore, to better reflect requirements for early detection of seepage and natural background conditions at MRO.

A comprehensive synopsis of the amendments sought is included in this section of this EA amendment, with full supporting details provided in the memoranda supplied by RPS on seepage monitoring and regional monitoring at MRO (RPS 2015a, RPS 2015b, RPS 2015c). A map representing all of the bores identified in this report is included in Appendix A of this document.

3. Seepage Monitoring Program

3.1 Existing Seepage Monitoring Program

There are 39 seepage monitoring bores presented in Schedule C, Table 7 on page 15 of the site's August 2015 EA. These bores are required to be monitored monthly. Of the 39 seepage monitoring bores in the EA, one lies within the footprint of the West Dam and three within the footprint of the Western Waste Rock Dump (WRD) and the EA contains a caveat that a replacement for each of these bores must be drilled before the existing bore can be decommissioned. (These replacements have been drilled and the bores highlighted in the EA have been decommissioned.)

Table 3: List of seepage monitoring bores at MRO, sourced from Schedule C, Table 7 of the August 2015 EA. Coordinates are in AMG.

MONITORING BORE ID		EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH
1	MRMB01	375163.748	7205924.195	118.85	48
2	MRMB02	375162.728	7205928. 136	118.92	12
3	MRMB03	375246.829	7206045.808	117.62	48
4	MRMB04	375249.880	7206045.473	117.72	12
5	MRMB05	375346.804	7206157. 718	117.22	48
6	MRMB06	375350.683	7206153.179	117.46	36
7	MRMB07	374973.603	7205952.933	125.08	24
8	MRMB08	374667.270	7205948.381	136.89	30
9	MRMB09	374508.358	7205939.547	140.79	24
10	MRMB10	374204.353	7205936.445	138.36	36

MONITORING BORE ID		EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH
11	MRMB12	374439.756	7206353.655	119.03	30
12	MRMB13	374058.462	7206062.631	125.11	24
13	**MRMB17**[1]	**37447.620**	**7204296.352**	**141.14**	**44**
14	**MRMB18**[1]	**374512.887**	**7204039.905**	**122.317**	**36**
15	**MRMB19**[1]	**374516.366**	**7204514.137**	**137.56**	**48**
16	MRMB21	375512.207	7206192.208	116.34	35
17	MRMB22	375275.585	7206074.918	116.19	13
18	MRMB23	375052.75	7205969.020	121.08	42
19	MRMB29	375145.369	7206102.638	121.14	19
20	MRMB30	374786.312	7206225.700	127.89	30
21	MRMB31	374607.15	7206084.70	134.02	19
22	MRMB32	375004.574	7206007.565	126.13	20
23	MRMB33	374738.341	7206016.675	133.40	27
24	MRMB34	374900.370	7206005.569	131.25	22
25	**MRMB35**[1]	**374588.922**	**7203741.845**	**113.40**	**49**
26	MRMB36	374694.189	7203392.750	108.73	49
27	MRMB39	375750.545	7206350.068	112.42	41
28	MRMB40	375029.465	7206420.507	121.72	43
29	MRMB41	374703.194	7206711.419	113.04	40
30	MRMB42	374698.059	7206707.176	113.06	16
31	MRMB43	373774.742	7205555.134	137.70	37
32	MRMB44	373772.732	7205550.396	138.00	13
33	MRMB45	374953.007	7204516.478	152.6	39
34	MRMB46	375360.122	7205779.237	151.34	39
35	MRMB48	375360.122	7205779.237	130.735	39
36	MRMB50	374143.591	7204593.28	169.89	31
37	MRMB52	374997.087	7207002.726	112.511	31
38	MRMB53	375296.998	7206820.456	111.88	25
39	MRPB2	373462.130	7205469.936	146.92	49

MONITORING BORE ID	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH

[1]Bores included in the EA and located within the footprint of the Western WRD or West Dam and indicated for replacement before decommissioning in Schedule C, Table 7 of the EA.

3.2 Proposed Revision to the Seepage Monitoring Program

RPS produced a memorandum on 18 August 2015, entitled *Seepage Monitoring Program – Review and Rationalisation*, which recommends a number of actions to revise the seepage monitoring program (RPS 2015a). A copy of the full memorandum is included as Appendix B of this document. The key features of the upgraded monitoring program synopsised from the RPS memorandum include a three tiered network of seepage monitoring bores that cover the main seepage pathways from the TSF and plant areas. A total of 30 bores will be used to monitor seepage from the TSF and plant areas:

- Nineteen of the existing 39 seepage monitoring bores will continue to be used for seepage monitoring.
- Fourteen of the 39 seepage bores in the existing EA are recommended for decommissioning.
- A further six of the 39 seepage bores in the existing EA have already been decommissioned (MRMB08, MRMB09, MRMB17, MRMB18, MRMB19 and MRMB35)

A map of decommissioned bores and bores recommended for decommissioning is included in Appendix A of this report. On top of the 19 bores from the existing EA, a further 11 will be added to the revised seepage monitoring program. These additional 11 bores are made up as follows:

- Three new bores will be drilled.
  - New Bore B will have dual status and be included in both the seepage monitoring program and the regional monitoring program.
  - New Bore C will have dual status and be included in both the seepage monitoring program and the regional monitoring program.
  - New Bore D will be drilled as a seepage monitoring bore intended to replace MRMB21.
- Five existing bores already drilled but not in the EA will be included in the revised seepage monitoring program as seepage monitoring bores only: MRMB65, MRMB66, MRMB67, MRMB68 and MRMB69.
- Two bores listed as regional monitoring bores in the August 2015 EA are being repurposed for inclusion in the revised seepage program: MRMB20 and MRMB49.
- The final of the 11 bores is MRMB72. This is an already constructed bore that is not currently in the EA but will be introduced as a dual status bore, included in both the revised seepage monitoring program and the revised regional compliance monitoring program.
  - There are six dual status bores in total – of these dual status bores, three are in the existing EA (MRMB36, MRMB52 and MRMB53). There is one drilled bore that is not

in the EA that will have dual status (MRMB72), and two of the new bores, New Bore B and New Bore C brings the number of dual status bores to six.

The 30 bores described above that make up the revised seepage monitoring bore network will be used to undertake a three-tiered program of monitoring, including:

- Compliance monitoring for parameters similar to the existing monitoring program,
- Trigger monitoring for key indicators of the first arrival of seepage from the TSF,
- Investigation monitoring for key indicators and other parameters on an as required basis, usually prompted by an exceedance in trigger level parameters.

A full list of bores to be included in the revised seepage monitoring program is included in Table 4. A map of the proposed seepage monitoring bores is included in Appendix A of this report.

Table 4: Proposed bore list for the revised seepage monitoring program. Includes dual status bores that are also part of the revised regional compliance monitoring program. Coordinates are in GDA94 Zone 56K.

BORE NAME	CLASSIFICATION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH
MRMB10	Seepage Bore	Revised Seepage Program	374310	7206121	138.36	36
MRMB13	Seepage Bore	Revised Seepage Program	374164	7206247	125.11	24
MRMB20	Regional Bore	Revised Seepage Program	374999	7204451	154.82	36
MRMB22	Seepage Bore	Revised Seepage Program	375381	7206260	116.19	13
MRMB30	Seepage Bore	Revised Seepage Program	374892	7206410	127.89	30
MRMB32	Seepage Bore	Revised Seepage Program	375110	7206192	126.13	20
MRMB36	Seepage Bore	Dual Status: Seepage and Regional	374800	7203578	108.73	49
MRMB39	Seepage Bore	Revised Seepage Program	375856	7206535	112.42	41

BORE NAME	CLASSIFICATION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH
MRMB40	Seepage Bore	Revised Seepage Program	375135	7206605	121.72	43
MRMB41	Seepage Bore	Revised Seepage Program	374809	7206896	113.04	40
MRMB42	Seepage Bore	Revised Seepage Program	374804	7206892	113.06	16
MRMB43	Seepage Bore	Revised Seepage Program	373880	7205740	137.7	37
MRMB44	Seepage Bore	Revised Seepage Program	373878	7205736	138	13
MRMB45	Seepage Bore	Revised Seepage Program	375060	7204704	152.6	39
MRMB46	Seepage Bore	Revised Seepage Program	375348	7205133	151.34	39
MRMB48	Seepage Bore	Revised Seepage Program	375466	7205964	130.735	39
MRMB49	Regional Bore	Revised Seepage Program	375650	7205571	145.36	32
MRMB50	Seepage Bore	Revised Seepage Program	374249	7204778	169.89	31
MRMB52	Seepage Bore	Dual Status: Seepage and Regional	375103	7207188	112.51	31
MRMB53	Seepage Bore	Dual Status: Seepage and Regional	375403	7207005	111.88	25

BORE NAME	CLASSIFICATION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH
MRPB2	Seepage Bore	Revised Seepage Program	373568	7205655	146.92	49
MRMB65	Not included in the August 2015 EA	Revised Seepage Program	374926	7206745	122.7	30
MRMB66	Not included in the August 2015 EA	Revised Seepage Program	375834	7206885	127.34	30
MRMB67	Not included in the August 2015 EA	Revised Seepage Program	376399	7206366	127.1	30
MRMB68	Not included in the August 2015 EA	Revised Seepage Program	376140	7205997	134.9	30
MRMB69	Not included in the August 2015 EA	Revised Seepage Program	374430	7204749	135.5	36
MRMB72	Not included in the August 2015 EA	Dual Status: Seepage and Regional	374799	7203590	127.5	22
New Bore B	Not included in the August 2015 EA	Dual Status: Seepage and Regional	To be installed	To be installed	To be installed	To be installed
New Bore C	Not included in the August 2015 EA	Dual Status: Seepage and Regional	To be installed	To be installed	To be installed	To be installed
New Bore D	Not included in the August 2015 EA	Revised Seepage Program	To be installed	To be installed	To be installed	To be installed

3.3 Proposed Seepage Monitoring Frequencies

Full details of the proposed monitoring frequency for the seepage monitoring bores is included in Table 5 of the RPS memorandum on seepage monitoring (RPS 2015a). The key points of the proposed monitoring frequency are as follows:

- Monthly monitoring of key indicator parameters at primary bores,
- Monthly investigation monitoring if the first arrival of seepage is indicated at any of the primary or secondary bores by exceedance of trigger levels.
- Six monthly monitoring of compliance parameters and general parameters at primary and secondary bores to provide biannual snapshots of the water quality ahead of seepage fronts and check if any seepage fronts appear to be bypassing primary bores.
- Annual monitoring of tertiary bores to provide an annual snapshot of the general distribution of water quality across the entire site.
- Once seepage is detected at a bore and confirmed through investigation monitoring, that bore will be downgraded to tertiary monitoring and the next downstream bore elevated to primary status.

This monitoring program differentiates between compliance monitoring and indicator parameter monitoring. Compliance monitoring tests for parameters included in the EA. Indicator parameter monitoring tests for indicators known to provide the first indication of the arrival of a seepage front. A full description of the different monitoring approaches is covered in the next section of this report, entitled ‘Seepage Monitoring Parameters’.

Proposed primary seepage monitoring bores are presented in Table 5 of this report. Proposed secondary seepage monitoring bores are presented in Table 6 of this report. Proposed tertiary seepage monitoring bores are presented in Table 7 of this report. A map indicating primary, secondary and tertiary seepage monitoring bores is included in Appendix A of this report. Dual status bores that are used for regional groundwater quality monitoring and also included as investigation bores in the event of an exceedance of compliance parameters or indicator parameters in primary bores are included in Table 8 of this report.

Table 5: Proposed primary seepage monitoring bores with sampling frequency as per RPS (2015b). Coordinates are in GDA94, Zone 56K.

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
1	MRMB13	374164	7206247	Monthly measurement of standing water levels. Monthly monitoring for indicator parameters. Biannual monitoring for parameters listed in Table 6 of the RPS memorandum (RPS 2015a) and reproduced in this document in Table 9. In the case where investigation monitoring is triggered by an exceedance of trigger levels in compliance monitoring results or indicator parameters, primary bores should be monitored monthly for both compliance parameters and
2	MRMB32	375110	7206192	
3	MRMB40	375135	7206605	
4	MRMB43	373880	7205740	
5	MRMB44	373878	7205736	

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
6	MRMB48	375466	7205964	indicator parameters. An investigation must be conducted into the exceedance. If the arrival of seepage at a primary bore is confirmed through that investigation monitoring, that bore is downgraded to tertiary status and the next downstream bore elevated to primary status. Biannual monitoring should also be carried out for general parameters to provide a snapshot of water quality across the site (this monitoring applies to all bores except tertiary bores).
7	MRMB49	375650	7205571	
8	MRMB50	374249	7204778	
9	MRMB69	374430	7204749	
10	New Bore D	To be constructed	To be constructed	

Table 6: Proposed secondary seepage monitoring bores with sampling frequency as per RPS (2015b). Coordinates are in GDA94, Zone 56K.

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
1	MRMB36	374800	7203578	Monthly measurement of standing water levels. Biannual monitoring for indicator parameters, sulfate and salinity. This provides a check on whether there has been seepage bypass of primary monitoring bores. Biannual monitoring for parameters listed in Table 6 of the RPS memorandum (RPS 2015a) and reproduced in this document in Table 9. Biannual monitoring should also be carried out for general parameters to provide a snapshot of water quality across the site (this monitoring applies to all bores except tertiary bores).
2	MRMB39	375856	7206535	
3	MRMB41	374809	7206896	
4	MRMB42	374804	7206892	
5	MRPB2	373568	7205655	
6	MRMB65	374926	7206745	
7	MRMB66	375834	7206885	
8	MRMB67	376399	7206366	
9	MRMB68	376140	7205997	

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
10	MRMB72	374799	7203590	

The secondary seepage monitoring network is not designed for inclusion in investigations triggered by exceedances of compliance parameters or indicator parameters at primary seepage monitoring bores.

Table 7: Proposed tertiary seepage monitoring bores with sampling frequency as per RPS (2015b). Coordinates are in GDA94, Zone 56K.

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
1	MRMB10	374310	7206121	Monthly measurement of standing water levels. Annual monitoring for indicator parameters, sulfate and salinity. This provides a check on whether there has been seepage bypass of primary and secondary monitoring bores. Annual monitoring for parameters listed in Table 6 of the RPS memorandum (RPS 2015a) and reproduced in this document in Table 9. Not to be included in monitoring for general parameters.
2	MRMB20	374999	7204451	
3	MRMB22	375381	7206260	
4	MRMB30	374892	7206410	
5	MRMB45	375060	7204704	
6	MRMB46	375348	7205133	

Table 8: Proposed dual status bores to be used for both regional monitoring and included as seepage monitoring investigation bores in the case of a compliance parameter or indicator parameter exceedance in the primary monitoring bore network (RPS 2015b, RPS 2015a). Coordinates are in GDA94, Zone 56K.

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
1	MRMB52	375103	7207188	Will be sampled as part of the regional monitoring bore sampling program (RPS 2015b).

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
2	MRMB53	375403	7207005	In the case where investigation monitoring is triggered by an exceedance of trigger levels in compliance monitoring results or indicator parameters, dual status bores should be monitored as follows: – Every two months for SWLs. – Every two months for indicator parameters. – Every two months for other parameters indicated by the nature of the investigation taking place.
3	New Bore B	To be installed	To be installed	
4	New Bore C	To be installed	To be installed	These bores do not need to be monitored for compliance parameters in case of an investigation, and are not included in general parameters monitoring.

*Bores MRMB36 and MRMB72 are additional dual status bores that are part of the regional monitoring network and also act as secondary monitoring bores for Mingham Creek. The monitoring frequency on those bores is outlined in Table 6 of this report and is more rigorous than that required of dual status bores that are only sampled as part of the seepage program in case of investigation. Subsequently this shallow/deep pair of dual status bores has been omitted from this table.

3.4 Proposed Revision to Seepage Monitoring Parameters

The proposed seepage monitoring program has three distinct purposes:

- Compliance monitoring, to test for parameters included in the EA,
- Indicator parameter monitoring, to test for key parameters known as first indicators of the arrival of a seepage front, and
- Synoptic or snapshot monitoring, which provides a clear picture of the distribution of groundwater quality across the site.

RPS analysed monitoring data from MRO to derive a pattern in analysis to extrapolate what parameters indicate the first arrival of seepage. It is evident that an increase in sulfate and salinity indicate the first arrival of seepage (or the mixing front ahead of seepage) at MRO (RPS 2015a). The proposed compliance parameters and tolerable levels suggested for the revised EA are largely the same as the current program, with the following exceptions (RPS 2015a). This list is sourced directly from section 5.4 Monitoring Parameters of the RPS memorandum (2015b):

- The tolerable level for salinity (TDS) has been increased to 12,000mg/L. This is consistent with the tolerable level for EC in the current program. TDS is also an indicator parameter.
- EC has been removed from the compliance parameters as it is redundant. It will be measured but reported as calculated TDS.
- Sulfate has been added to the parameter list, but as an indicator parameter only.

- Trigger levels for compliance parameters are the same as tolerable levels.
- No set trigger levels have been set for sulfate or salinity. Rather, it is recommended that the trigger for further investigation should be any reported single value that exceeds the historical median of the dataset of that particular bore by more than 50%.
- Sodium, magnesium, calcium, potassium, chloride, carbonate and bicarbonate have been added to the normal monitoring program. Together with sulfate, these will allow for the characterisation of water types based on distributions of general anions and cations.

The recommended monitoring parameters and tolerable limits in mg/L are presented in Table 6 of the RPS memorandum (2015b) and reproduced here in Table 9 on page 21 of this report**.**

Table 9: Recommended monitoring parameters and tolerable limits for seepage monitoring bores (RPS 2015a).

PARAMETER	COMPLIANCE PARAMETERS		INDICATOR PARAMETERS	GENERAL PARAMETERS	COMMENTS
	Tolerable Level	**Trigger Level**	**Trigger Level**		
Groundwater Levels (SWL)			<0.5 below ground level		As warning of potential baseflow to local creeks.
TDS (by calc)	12,000mg/L	150% of the median			The trigger is the value which exceeds the historical median of that particular bore by more than 50%. The compliance level is determined by calculation from EC of 18,000µS/cm (as per the current program)
pH	5.0 to 9.0	5.0 to 9.0			
Cu	1mg/L	1mg/L			
SO_4			150% of the median		The trigger is the value which exceeds the historical median of that particular bore by more than 50%
Total CN	0.5mg/L	0.5mg/L			
WAD CN	0.05mg/L	0.05mg/L			
Na, K, Mg				No limit	Included to allow for characterisation of water type.
Cl, CO_3, HCO_3				No limit	Included to allow for characterisation of water type.

4. Regional Groundwater Quality Monitoring

4.1 Existing Regional Compliance Monitoring Program

In addition to the seepage monitoring bores in the EA, there are 14 listed existing regional groundwater monitoring bores to be monitored every six months. These bores are presented in Schedule C, Table 10 on page 17 of the site's EA. That table requires two additional regional monitoring bores be installed and the detailed provided to EHP by 13 February 2016.

Table 10: Regional monitoring bores from Schedule C, Table 10 of the August 2015 EA. Coordinates are in AMG.

MONITORING BORE ID		EASTING	NORTHING	RLTO TOP OF CAP (M)	DEPTH (M)
1	MRMB11	374268	7206233	124.437	24.56
2	MRMB20	374901	7204246	154.818	36.07
3	MRMB24	375661	7205123	128.207	33.93
4	MRMB25	376062	7205495	115.819	48.10
5	MRMB26	376174	7205497	114.341	12.00
6	MRMB27	376397	7205230	111.621	46.05
7	MRMB28	376845	7204634	113.679	11.90
8	MRPB1	376537	7204846	114394	34.67
9	MRMB37	377385	7203929	122.735	50
10	MRMB38	376989	7206448	104.198	41
11	MRMB49	375542	7205384	145.357	32
12	MRMB51	3758864	7205178	125.259	37
13	MRMB54	374366	7206967	125.12	31
14	MRMB55	375849	7205752	127.595	31
*Plus two additional bores TBA when installed					

4.2 Proposed Revision to the Regional Compliance Monitoring Program

Compliance and Investigation Bores

The proposed changes to the regional groundwater monitoring program include a two-tiered regional network of monitoring bores, composed of compliance bores and investigation bores. Some of the compliance bores will have dual purpose in both the regional and seepage monitoring programs. There is no proposed reduction in the number of regional compliance monitoring bores, with the revised program including 16 bores. That number is achieved as follows:

- Four of the original 14 regional monitoring bores in the EA remain in their original capacity as regional compliance monitoring bores (MRMB28, MRMB37, MRMB38 and MRMB54).
- Five bores that are currently drilled but not in the existing EA will be included in the regional compliance monitoring program (MRMB61, MRMB62, MRMB63, MRMB64 and MRMB70).
- One newly drilled bore will be included as a regional compliance bore – New Bore A will be drilled to replace MRMB25 as a compliance bore (with MRMB25 being repurposed as a regional investigation bore).
- The remaining six bores to be included in the regional compliance monitoring bores are the dual status bores already described in the seepage monitoring program. To reiterate, three of those bores are in the existing EA (MRMB36, MRMB52 and MRMB53). There is one drilled bore that is not in the EA that will have dual status (MRMB72), and two of the new bores, New Bore B and New Bore C brings the number of dual status bores to six.

A map of the proposed regional monitoring bores is included in Appendix A of this report.

Bores Excluded from the Revised Program

Of the original regional monitoring bores included in the EA, the 10 not being included in the revised regional monitoring program are accounted for as follows:

- MRPB1 is to be repurposed as an investigation bore.
- MRMB11 is recommended for decommissioning.
- MRMB20 is to be repurposed as a seepage monitoring bore.
- MRMB24 has been decommissioned.
- MRMB25 is to be repurposed as an investigation bore.
- MRMB26 is to be repurposed as an investigation bore.
- MRMB27 is to be repurposed as an investigation bore.
- MRMB49 is to be repurposed as a seepage monitoring bore.
- MRMB51 has been decommissioned.
- MRMB55 was recently reclassified from regional monitoring to act as a seepage monitoring bore, and is now recommended for decommissioning and replacement with MRMB68 as a seepage monitoring bore.

The proposed revised regional compliance monitoring bores are presented in Table 11 of this report.

Monitoring Approach

The proposed regional compliance monitoring program involves a three-tiered program of monitoring: compliance, trigger and investigation monitoring, including:

- Compliance monitoring for a comprehensive list of parameters similar to the current program,
- Trigger monitoring for key indicators of the first arrival of seepage from the TSF or WRDs,
- Investigation monitoring for key indicators and other parameters as required.

The regional compliance monitoring bores and the investigation monitoring bores are presented separately in this document in Table 11 and Table 12 and should be listed separately in the EA.

Table 11: Proposed regional compliance monitoring bores (includes dual purpose bores that will also be included in the revised seepage monitoring program). Coordinates are in GDA94, Zone 56K.

BORE NAME	FUNCTION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH
MRMB28	Regional Bore	Revised Regional Compliance Bore	376953	7204821	113.7	12
MRMB36	Seepage Bore	Dual Status: Seepage and Regional	374800	7203578	108.73	49
MRMB37	Regional Bore	Revised Regional Compliance Bore	377492	7204116	122.74	50
MRMB38	Regional Bore	Revised Regional Compliance Bore	377096	7206635	104.2	41
MRMB52	Seepage Bore	Dual Status: Seepage and Regional	375103	7207188	112.51	31
MRMB53	Seepage Bore	Dual Status: Seepage and Regional	375403	7207005	111.88	25

BORE NAME	FUNCTION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH
MRMB54	Regional Bore	Revised Regional Compliance Bore	374473	7207154	125.12	31
MRMB61	Not included in the August 2015 EA	Revised Regional Compliance Bore	376731	7204473	128	31
MRMB62	Not included in the August 2015 EA	Revised Regional Compliance Bore	376572	7203977	148	37
MRMB63	Not included in the August 2015 EA	Revised Regional Compliance Bore	376558	7205270	128	25
MRMB64	Not included in the August 2015 EA	Revised Regional Compliance Bore	376325	7205993	125	43
MRMB70	Not included in the August 2015 EA	Revised Regional Compliance Bore	374482	7203728	147.5	42
MRMB72	Not included in the August 2015 EA	Dual Status: Seepage and Regional	374799	7203590	127.5	22
New Bore A	Not included in the August 2015 EA	Revised Regional Compliance Bore	To be installed	To be installed	To be installed	To be installed
New Bore B	Not included in the August 2015 EA	Dual Status: Seepage and Regional	To be installed	To be installed	To be installed	To be installed
New Bore C	Not included in the August 2015 EA	Dual Status: Seepage and Regional	To be installed	To be installed	To be installed	To be installed

4.3 Inclusion of Investigation Bores in the Regional Program

There are seven intended investigation bores which will be used to monitor key indicators and other parameters as required. These bores are MRMB25, MRMB26, MRMB27, MRPB1, MRMB59, MRMB60 and MRMB71 and their details are presented in Table 12. A map of the investigation bores at MRO is included in Appendix A of this report.

Table 12: Proposed investigation bores for inclusion in the EA. Coordinates are in GDA94, Zone 56K.

BORE NAME	FUNCTION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH
MRMB25	Regional Bore	Investigation Bore	376169	7205682	115.82	48
MRMB26	Regional Bore	Investigation Bore	376281	7205684	114.34	12
MRMB27	Regional Bore	Investigation Bore	376504	7205417	111.62	46
MRPB1	Regional Bore	Investigation Bore	376644	7205033	114.39	35
MRMB59	Not included in the August 2015 EA	Investigation Bore	376199	7203734	176	31
MRMB60	Not included in the August 2015 EA	Investigation Bore	376577	7204529	131	36
MRMB71	Not included in the August 2015 EA	Investigation Bore	374632	7203643	133.5	39

These investigation bores are distinct from the bores to be utilised for investigations in the seepage monitoring program. The regional investigation bore network can be monitored for key indicators and other parameters as required and there is a provision to add additional monitoring bores to the regional investigation network. The number of bores to be investigated and the parameters for investigation will be decided on an as-needed basis, depending on the nature and extent of the investigation.

Exceedance of compliance parameters or indicator parameters in regional compliance bores will trigger sampling of investigation bores. The regional investigation bores will not be included in general parameter sampling.

4.4 Proposed Regional and Investigation Monitoring Frequencies

The frequency of monitoring for the regional compliance bores is similar to the existing EA, which requires they be monitored every six months. Should an investigation be triggered by monitoring results, two-monthly investigation monitoring will take place on both the regional compliance bores and the investigation bores.

- Routine monitoring on regional compliance bores will take place:
  - Every three months for standing water levels,
  - Every six months for compliance parameters,
- Investigation monitoring will be conducted when triggered:
  - Every two months on the regional compliance bores for SWL,
  - Every two months on the investigation bores for SWL,
  - Every six months on the compliance bores for compliance parameters (not to be carried out on the investigation bores),
  - Every two months on both regional compliance bores and investigation bores for indicator parameters,
  - Every two months on both regional compliance bores and investigation bores for general parameters.

Full details of the proposed monitoring frequencies are included in Table 5, page 10 of the RPS memorandum on regional bore monitoring (RPS 2015b). A map of the proposed regional monitoring program that indicates regional, dual status and investigation bores is included in Appendix A of this report.

Table 13: Proposed regional compliance monitoring bores with sampling frequency as per RPS (2015a). Coordinates are in GDA94, Zone 56K.

<table>
<tr><th colspan="2">BORE NAME</th><th>EASTING</th><th>NORTHING</th><th>SAMPLING FREQUENCY</th></tr>
<tr><td>1</td><td>MRMB28</td><td>376953</td><td>7204821</td><td rowspan="6">Quarterly measurement of standing water levels.
Biannual monitoring for indicator parameters, sulfate and salinity.
Biannual monitoring for parameters listed in Table 6 of the RPS memorandum (RPS 2015b) and reproduced in this document in Table 15.
Biannual monitoring for general parameters.
In the situation where an investigation is triggered by exceedance of compliance or indicator parameters in any of these bores, monitoring will be amended as follows and an investigation will be undertaken:</td></tr>
<tr><td>2</td><td>MRMB37</td><td>377492</td><td>7204116</td></tr>
<tr><td>3</td><td>MRMB38</td><td>377096</td><td>7206635</td></tr>
<tr><td>4</td><td>MRMB54</td><td>374473</td><td>7207154</td></tr>
<tr><td>5</td><td>MRMB61</td><td>376731</td><td>7204473</td></tr>
<tr><td>6</td><td>MRMB62</td><td>376572</td><td>7203977</td></tr>
</table>

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
7	MRMB63	376558	7205270	– Two-monthly measurement of standing water levels. – Biannual monitoring for compliance parameters. – Two-monthly monitoring for indicator parameters. – Two-monthly monitoring for other parameters. – Biannual monitoring for general parameters.
8	MRMB64	376325	7205993	
9	MRMB70	374482	7203728	
10	New Bore A	To be installed	To be installed	

Table 14: Proposed regional investigation monitoring bores with sampling frequency as per RPS (2015a). Coordinates are in GDA94, Zone 56K.

BORE NAME		EASTING	NORTHING	SAMPLING FREQUENCY
1	MRMB25	376169	7205682	These bores are to be monitored **only** in the case of a triggered investigation. When an investigation is triggered, selected bores from this list will be nominated for monitoring for indicator parameters and other selected parameters. In the instance where an investigation has been triggered, they should be monitored as follows: – Two-monthly measurement of standing water levels. – Two-monthly monitoring for indicator parameters. – Two-monthly monitoring for other parameters. These bores are not for inclusion in monitoring for general parameters.
2	MRMB26	376281	7205684	
3	MRMB27	376504	7205417	
4	MRPB1	376644	7205033	
5	MRMB59	376199	7203734	
6	MRMB60	376577	7204529	
7	MRMB71	374632	7203643	

4.5 Proposed Revision to the Regional Monitoring Parameters

Monitoring Purpose

Monitoring in the proposed regional groundwater quality monitoring program has three distinct purposes:

- Compliance monitoring, to test for parameters included in the EA,

- Trigger monitoring for the key indicators of the first arrival of seepage from the TSF or WRDs,
- Investigation monitoring for key indicators and other parameters as required.

Compliance Parameters and Tolerable Levels

The proposed compliance parameters and tolerable levels suggested for the revised EA are largely the same as the current program, with the following exceptions (RPS 2015b). This list is sourced directly from section 5.4, 'Monitoring Parameters', of the RPS memorandum (2015a):

- The compliance levels listed in the current monitoring program have been adopted as trigger levels for further investigation. Exceedance of these levels will trigger an investigation but will not constitute non-compliance.
- Sulfate and nitrate have been removed as compliance parameters, but remain in the program as trigger parameters.
- No set trigger levels have been established for sulfate or salinity. Rather, it is recommended that the trigger for further investigation should be any single reported value which exceeds the historical median at that particular bore by more than 50%.
- The trigger level for nitrate has been set as the revised ANZECC guideline for aquatic ecosystems, to cover the potential impact on waterways if there is baseflow to creeks. Investigation would initially focus on groundwater levels – if there is no potential for baseflow (i.e. the water table is too deep) then no further investigation would be required.
- Contaminant limit compliance levels have been based on the ANZECC guidelines for stock watering.
- Aluminium, boron, chromium and fluoride, none of which are significant elements present in the ore and waste rock at MRO, have been removed from the parameter list.
- Selenium, which is present in measurable quantities in the ore and waste rock, has been added to the parameter list.
- Sodium and chloride have been removed from the compliance parameters list but added to the general parameter list. Magnesium, potassium, carbonate and bi-carbonate have been added to the general parameter list to allow for the characterisation of water types based on distributions of general anions and cations.

The recommended monitoring parameters and tolerable limits in mg/L are presented in Table 6 of the RPS memorandum (2015a) and reproduced here in Table 15 on page 30. The applicability of monitoring parameters for regional bores are further discussed in this report under the Possible Impacts to Environmental Values in section 4, Groundwater Interaction with Surface Water, on page 69.

Table 15: Recommended monitoring parameters and tolerable limits for regional monitoring bores (RPS 2015b).

PARAMETER	COMPLIANCE PARAMETERS		INDICATOR PARAMETERS	GENERAL PARAMETERS	COMMENTS
	Tolerable Level	**Trigger Level**	**Trigger Level**		
Groundwater Levels (SWL)			<0.5 below ground level		To cover potential for baseflow to creeks.
TDS (by calc)	10,000mg/L	150% of the median	150% of the median		The trigger is the value which exceeds the historical median of that particular bore by 50%.
pH	6.0 to 9.0	6.0 to 9.0			
Cu	1mg/L	0.24mg/L			
Zn	20mg/L	0.1mg/L			
Cd	0.035mg/L	0.01mg/L			
As	0.5mg/L	0.12mg/L			
Pb	0.1mg/L	0.012mg/L			
Mn	10mg/L	1.8mg/L			
Se	0.05mg/L	0.02mg/L			
Fe	No limit	10mg/L			No ANZECC upper limit is specific for stock watering.
SO_4	N/A		150% of the median		The trigger is the value which exceeds the historical median of that particular bore by 50%.
NO_3 - N	NA	1.4mg/L			Based on the recently revised ANZECC guideline for aquatic ecosystems where algal blooms are a concern (NRC 2015). Covers the possibility of groundwater baseflow to creeks.

PARAMETER	COMPLIANCE PARAMETERS		INDICATOR PARAMETERS	GENERAL PARAMETERS	COMMENTS
	Tolerable Level	**Trigger Level**	**Trigger Level**		
Total CN	0.5mg/L	0.03mg/L			
WAD CN	0.05mg/L	0.024mg/L			
Na, K, Mg				No limit	Included to allow for characterisation of water type.
Cl, CO_3, HCO_3				No limit	Included to allow for characterisation of water type.

5. Bore Summary

A complete list of all monitoring bores at MRO, their status in the August 2015 EA and their intended destiny under this proposed revision to the groundwater monitoring program at MRO is included in Table 16 of this report on page 33.

This application proposes to add 18 bores to the EA, 14 of which are already drilled. These bores were constructed in accordance with the requirements of Australian Standard AS/NZS 5667.11:1998 *Water Quality Sampling: Guidance on Sampling Groundwaters.* The four new bores to be drilled and included in the EA will also be constructed in accordance with this standard. The bore logs for those 14 bores already drilled are included as Appendix E of this report.

Table 16: A complete list of all bores at MRO, both listed in the August 2015 EA and not yet included, their current status in the EA if applicable and their intended use as described in this EA amendment. Coordinates are in GDA94 Zone 56K.

BORE NAME	FUNCTION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH	SPECIFIC INTENDED USE
MRMB01	Seepage Bore	Recommended for Decommissioning	375269	7206109	118.85	48	To be decommissioned: some down slope migration of surficial seepage is suspected due to bore's proximity to SD1 (RPS 2015a).
MRMB02	Seepage Bore	Recommended for Decommissioning	375268	7206113	118.92	12	To be decommissioned: some down slope migration of surficial seepage is suspected due to bore's proximity to SD1 (RPS 2015a).
MRMB03	Seepage Bore	Recommended for Decommissioning	375353	7206232	117.62	48	To be decommissioned (RPS 2015a).
MRMB04	Seepage Bore	Recommended for Decommissioning	375356	7206230	117.72	12	To be decommissioned (RPS 2015a).
MRMB05	Seepage Bore	Recommended for Decommissioning	375452	7206342	117.22	48	To be decommissioned (RPS 2015a).
MRMB06	Seepage Bore	Recommended for Decommissioning	375456	7206338	117.46	36	To be decommissioned (RPS 2015a).
MRMB07	Seepage Bore	Recommended for Decommissioning	375079	7206138	125.08	24	To be decommissioned (RPS 2015a).
MRMB08	Seepage Bore	Decommissioned	374774	7206135	136.89	30	Subject to an investigation into total cyanide levels in 2012, further investigation revealed this bore lay within a seepage interception trench downstream of the TSF and had inadequate construction. It was recommended for decommissioning in September 2014 (NRC, 2014) and subsequently decommissioned.
MRMB09	Seepage Bore	Decommissioned	374615	7206126	140.79	24	Subject to an investigation into total cyanide levels in 2012, further investigation revealed this bore lay within a seepage interception trench downstream of the TSF and had inadequate construction. It was recommended for decommissioning in September 2014 (NRC, 2014) and subsequently decommissioned.
MRMB10	Seepage Bore	Revised Seepage Program	374310	7206121	138.36	36	Tertiary monitoring bore for Swindon Creek (TSF North) (RPS 2015a).
MRMB11	Regional Bore	Recommended for Decommissioning	374375	7206420	124.44	25	Bore construction records do not indicate the presence of a concrete seal above the water bearing zone. Recommended for removal from the regional monitoring program, with MRMB52 acting as a replacement. (RPS 2015b).
MRMB12	Seepage Bore	Recommended for Decommissioning	374545	7206538	119.03	30	Recommended for decommissioning, with bores MRMB41, MRMB42 and MRMB65 providing adequate secondary monitoring for Swindon Creek (TSF North) (RPS 2015a).
MRMB13	Seepage Bore	Revised Seepage Program	374164	7206247	125.11	24	Primary monitoring bore for Swindon Creek (TSF North) (RPS 2015a).
MRMB17	Seepage Bore	Decommissioned	374555	7204483	141.14	44	Bore was situated within the footprint of the Western WRD / West Dam. Decommissioned (NRC, 2015). Bores MRMB17, MRMB18 and MRMB35 were replaced by bores MRMB70, MRMB71 and MRMB72.
MRMB18	Seepage Bore	Decommissioned	374619	7204226	122.317	36	Bore was situated within the footprint of the Western WRD / West Dam. Decommissioned (NRC, 2015). Bores MRMB17, MRMB18 and MRMB35 were replaced by bores MRMB70, MRMB71 and MRMB72.
MRMB19	Seepage Bore	Decommissioned	374623	7204701	137.56	48	Bore was situated within the footprint of the Western WRD / West Dam. Decommissioned (NRC, 2015). Replaced with MRMB69 (RPS 2015a).
MRMB20	Regional Bore	Revised Seepage Program	374999	7204451	154.82	36	Former regional monitoring bore, now a tertiary seepage monitoring bore for the Plant Area between the TSF and Pit/WRD (RPS 2015a). Recommended for removal from the regional program (RPS 2015b)..
MRMB21	Seepage Bore	Recommended for Decommissioning	375618	7206377	116.34	35	To be decommissioned and replaced by New Bore D (RPS 2015a).
MRMB22	Seepage Bore	Revised Seepage Program	375381	7206260	116.19	13	Tertiary monitoring bore for Swindon Creek (RPS 2015a).

BORE NAME	FUNCTION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH	SPECIFIC INTENDED USE
MRMB23	Seepage Bore	Recommended for Decommissioning	375158	7206154	121.08	42	To be decommissioned (RPS 2015a).
MRMB24	Regional Bore	Decommissioned	375767	7205309	128.21	34	An investigation conducted in 2012/2013 indicated a potential breach of the bentonite seal on this bore and decommissioning was recommended. This was decommissioned and replaced by MRMB63 (NRC, 2013).
MRMB25	Regional Bore	Investigation Bore	376169	7205682	115.82	48	To be retained as a regional investigation bore. Currently a regional compliance bore, but to be replaced in this regard by New Bore A (RPS 2015b).
MRMB26	Regional Bore	Investigation Bore	376281	7205684	114.34	12	To be retained as a regional investigation bore. Currently a regional compliance bore, but to be replaced in this regard by New Bore A (RPS 2015b).
MRMB27	Regional Bore	Investigation Bore	376504	7205417	111.62	46	To be retained as a regional investigation bore. Currently a regional compliance bore, but to be replaced in this regard by recently constructed MRMB63 (RPS 2015b).
MRMB28	Regional Bore	Revised Regional Compliance Bore	376953	7204821	113.70	12	To be retained as a regional compliance bore, downstream of WRD North (downstream of WD3 and WD4 at the confluence of tributaries of Twelve Mile Creek) (RPS 2015b).
MRMB29	Seepage Bore	Recommended for Decommissioning	375251	7206287	121.14	19	To be decommissioned at MRO's request – extraneous to the proposed groundwater regional and seepage monitoring programs (*Pers comms.* S. Sewell, 23 Sept 2015).
MRMB30	Seepage Bore	Revised Seepage Program	374892	7206410	127.89	30	Tertiary monitoring bore for Unnamed Creek (TSF North) (RPS 2015a)
MRMB31	Seepage Bore	Recommended for Decommissioning	374713	7206269	134.02	19	There are no available records on the construction of this bore. Recommended for decommissioning, with sufficient tertiary monitoring of Unnamed Creek provided by MRMB30 (RPS 2015a).
MRMB32	Seepage Bore	Revised Seepage Program	375110	7206192	126.13	20	Primary monitoring bore for Rawdon Creek (TSF Northeast) (RPS 2015a).
MRMB33	Seepage Bore	Recommended for Decommissioning	374844	7206201	133.4	27	There are no available records on the construction of this bore. Recommended for decommissioning, with sufficient tertiary monitoring of Unnamed Creek provided by MRMB30 (RPS 2015a).
MRMB34	Seepage Bore	Recommended for Decommissioning	375006	7206190	131.25	No construction record, but EA states a depth of 21.71	There are no available records on the construction of this bore. Recommended for decommissioning, with sufficient tertiary monitoring of Unnamed Creek provided by MRMB30 (RPS 2015a). This bore has been recently decommissioned.
MRMB35	Seepage Bore	Decommissioned	374696	7203929	113.4	49	Bore was situated within the footprint of the Western WRD / West Dam. Decommissioned (NRC, 2015). Bores MRMB17, MRMB18 and MRMB35 were replaced by bores MRMB70, MRMB71 and MRMB72.
MRMB36	Seepage Bore	Dual Status: Seepage and Regional	374800	7203578	108.73	49	Dual status: to be included as a part of the revised seepage program as a secondary monitoring bore for Mingham Creek (TSF South and WRD West) (RPS 2015a) and also as a regional compliance bore (RPS 2015b). Part of a shallow/deep pairing with MRMB72.
MRMB37	Regional Bore	Revised Regional Compliance Bore	377492	7204116	122.74	50	To be retained as a regional compliance monitoring bore – not downstream of WRD North but on an upstream tributary of Twelve Mile Creek and not on an interpreted seepage flow path (RPS 2015b).
MRMB38	Regional Bore	Revised Regional Compliance Bore	377096	7206635	104.2	41	To be retained as a regional compliance monitoring bore – the most downstream bore on Twelve Mile Creek, close to the mine lease boundary (RPS 2015b).
MRMB39	Seepage Bore	Revised Seepage Program	375856	7206535	112.42	41	Secondary monitoring bore for Rawdon Creek (TSF Northeast) (RPS 2015a).
MRMB40	Seepage Bore	Revised Seepage Program	375135	7206605	121.72	43	Primary monitoring bore for Unnamed Creek (TSF North) (RPS 2015a).
MRMB41	Seepage Bore	Revised Seepage Program	374809	7206896	113.04	40	Secondary monitoring bore for Swindon Creek (TSF North) (RPS 2015a).
MRMB42	Seepage Bore	Revised Seepage Program	374804	7206892	113.06	16	Secondary monitoring bore for Swindon Creek (TSF North) (RPS 2015a).

BORE NAME	FUNCTION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH	SPECIFIC INTENDED USE
MRMB43	Seepage Bore	Revised Seepage Program	373880	7205740	137.7	37	Primary seepage monitoring bore for Swindon Creek (TSF West) (RPS 2015a).
MRMB44	Seepage Bore	Revised Seepage Program	373878	7205736	138	13	Primary seepage monitoring bore for Swindon Creek (TSF West) (RPS 2015a).
MRMB45	Seepage Bore	Revised Seepage Program	375060	7204704	152.6	39	Former regional bore, status changed to a seepage bore in the August 2015 EA as per NRC recommendation. Repurposed as a tertiary monitoring bore for the Plant and area between the Pit/WRD (RPS 2015a).
MRMB46	Seepage Bore	Revised Seepage Program	375348	7205133	151.34	39	Former regional bore, status changed to a seepage bore in the August 2015 EA as per NRC recommendation. Repurposed as a tertiary monitoring bore for the Plant and area between the Pit/WRD (RPS 2015a).
MRMB48	Seepage Bore	Revised Seepage Program	375466	7205964	130.735	39	Primary monitoring bore for Rawdon Creek (TSF Northeast) (RPS 2015a).
MRMB49	Regional Bore	Revised Seepage Program	375650	7205571	145.36	32	Former regional monitoring bore, repurposed as a primary monitoring bore for Rawdon Creek (TSF Northeast) (RPS 2015a).
MRMB50	Seepage Bore	Revised Seepage Program	374249	7204778	169.89	31	Primary monitoring bore for Mingham Creek (TSF South and WRD West) (RPS 2015a).
MRMB51	Regional Bore	Decommissioned	375971	7205365	131	37	The annular seal on this bore has been breached and the bore was subject to a joint investigation into exceedances with MRMB24 in 2012/2013. This bore has subsequently been decommissioned and nominally replaced by MRMB63 and MRMB64. This location is also covered by New Bore A and investigation bores MRMB25 and MRMB26. (RPS 2015b).
MRMB52	Seepage Bore	Dual Status: Seepage and Regional	375103	7207188	112.51	31	Dual status: to be included as a part of the revised seepage program as a regional monitoring bore for Swindon Creek (TSF North) (RPS 2015a) and also as a regional compliance bore (RPS 2015b).
MRMB53	Seepage Bore	Dual Status: Seepage and Regional	375403	7207005	111.88	25	Dual status: to be included as a part of the revised seepage program as a regional monitoring bore for Unnamed Creek (TSF North) (RPS 2015a) and also as a regional compliance bore (RPS 2015b).
MRMB54	Regional Bore	Revised Regional Compliance Bore	374473	7207154	125.12	31	To be retained as a regional compliance monitoring bore. Not downstream of the TSF, but adjacent to Perry Creek upstream of Swindon Creek (RPS 2015b).
MRMB55	Regional Bore	Recommended for Decommissioning	375956	7205939	127.60	31	To be decommissioned and replaced with MRMB68 (RPS 2015a).
MRPB1	Regional Bore	Investigation Bore	376644	7205033	114.39	35	To be repurposed as a regional investigation bore downstream of WRD near WD2. Currently a compliance bore, but being replaced as a seepage monitoring bore by MRMB63 (RPS 2015b).
MRPB2	Seepage Bore	Revised Seepage Program	373568	7205655	146.92	49	Secondary monitoring bore for Swindon Creek (TSF West) (RPS 2015a).
MRMB59	Not included in the August 2015 EA	Investigation Bore	376199	7203734	176	31	To be introduced into the EA monitoring program as a regional investigation bore (RPS 2015b).
MRMB60	Not included in the August 2015 EA	Investigation Bore	376577	7204529	131	36	To be introduced into the EA monitoring program as a regional investigation bore (RPS 2015b).
MRMB61	Not included in the August 2015 EA	Revised Regional Compliance Bore	376731	7204473	128	31	To be introduced to the EA as a regional compliance monitoring bore downstream of WRD North (on Twelve Mile Creek downstream of WD3 and WD4 (RPS 2015b).
MRMB62	Not included in the August 2015 EA	Revised Regional Compliance Bore	376572	7203977	148	37	To be introduced to the EA as a regional compliance monitoring bore downstream of WRD North (on Twelve Mile Creek upstream of WD4) (RPS 2015b).
MRMB63	Not included in the August 2015 EA	Revised Regional Compliance Bore	376558	7205270	128	25	Regional compliance bore downstream of WRD North. Replacing compliance bore MRMB27, which is to be retained as a regional investigation bore (RPS 2015b).
MRMB64	Not included in the August 2015 EA	Revised Regional Compliance Bore	376325	7205993	125	43	To be introduced to the EA as a regional compliance monitoring bore downstream of WRD North (on the catchment boundary between groundwater flow / seepage from the WRD and the TSF) (RPS 2015b).
MRMB65	Not included in the August 2015 EA	Revised Seepage Program	374926	7206745	122.7	30	New bore converted from TSF2 investigation bore BH01. Secondary monitoring bore for Swindon Creek (TSF North) (RPS 2015a).

BORE NAME	FUNCTION IN THE AUGUST 2015 EA	DESTINY	EASTING	NORTHING	RL TO TOP OF CAP (M)	TOTAL DEPTH	SPECIFIC INTENDED USE
MRMB66	Not included in the August 2015 EA	Revised Seepage Program	375834	7206885	127.34	30	New bore converted from TSF2 investigation bore BH02. Secondary monitoring bore for Unnamed Creek (TSF North) (RPS 2015a).
MRMB67	Not included in the August 2015 EA	Revised Seepage Program	376399	7206366	127.1	30	New bore converted from TSF2 investigation bore BH03. Secondary monitoring bore for Rawdon Creek (TSF Northeast) (RPS 2015a).
MRMB68	Not included in the August 2015 EA	Revised Seepage Program	376140	7205997	134.9	30	New bore converted from TSF2 investigation bore BH04, replacing ex regional bore MRMB55, which is to be decommissioned. Secondary monitoring bore for Rawdon Creek (TSF Northeast) (RPS 2015a).
MRMB69	Not included in the August 2015 EA	Revised Seepage Program	374430	7204749	135.5	36	Replacement for MRMB19. Primary monitoring bore for Mingham Creek (TSF South and WRD West) (RPS 2015a).
MRMB70	Not included in the August 2015 EA	Revised Regional Compliance Bore	374482	7203728	147.5	42	To be introduced to the EA as a regional compliance monitoring bore immediately downstream of WRD West (RPS 2015b).
MRMB71	Not included in the August 2015 EA	Investigation Bore	374632	7203643	133.5	39	Currently in use as a regional compliance bore (though not listed in the EA). To be introduced into the EA monitoring program as a regional investigation bore because nearby bores MRMB70, MRMB36 and MRMB72 adequately manage compliance monitoring (RPS 2015b).
MRMB72	Not included in the August 2015 EA	Dual Status: Seepage and Regional	374799	7203590	127.5	22	Dual status: to be included as a part of the revised seepage program as a secondary monitoring bore for Mingham Creek (TSF South and WRD West) (RPS 2015a) and also as a regional compliance bore (RPS 2015b). Part of a shallow/deep pairing with MRMB36.
New Bore A	Not included in the August 2015 EA	Revised Regional Compliance Bore	To be installed	To be installed	To be installed	To be installed	To be included as a regional compliance bore. Will replace bore MRMB25 for compliance, with MRMB25 retained as a regional investigation bore (RPS 2015b).
New Bore B	Not included in the August 2015 EA	Dual Status: Seepage and Regional	To be installed	To be installed	To be installed	To be installed	Dual status: to be included as a part of the revised seepage program as a regional monitoring bore for Mingham Creek (TSF South and WRD West) (RPS 2015a) and also as a regional compliance bore (RPS 2015b).
New Bore C	Not included in the August 2015 EA	Dual Status: Seepage and Regional	To be installed	To be installed	To be installed	To be installed	Dual status: to be included as a part of the revised seepage program as a regional monitoring bore for Rawdon Creek (TSF Northeast) (RPS 2015a) and also as a regional compliance bore (RPS 2015b).
New Bore D	Not included in the August 2015 EA	Revised Seepage Program	To be installed	To be installed	To be installed	To be installed	Primary monitoring bore for Rawdon Creek (TSF Northeast). Replacement for MRMB21. (RPS 2015a).

Site Overview

1. Guidelines and Legislation

1.1 Guideline EM963

This section of this EA amendment application report has been prepared in accordance with EHP's *Guideline EM963, Application Requirements for Activities with Impacts to Water,* (Version 2). This guideline details the information to be provided to support an environmental authority application involving activities with impacts to water. For the purposes of EHP's guideline EM963, 'water' can include all, or any part of, a river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water in natural or artificial watercourses, bed and banks of a watercourse, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and groundwater.

For the purpose of this EA amendment application, this report will address the aspects of the guideline concerned with groundwater.

1.2 Applicable State Legislation

Key pieces of legislation application to this report are:

- *The Environmental Protection Act 1994* (Queensland) (the EP Act),
- *The Environmental Protection Regulation 2008* (Queensland) (the EP Regulation),
- *The Water Act 2000* (Queensland) (the Water Act).

1.3 Applicable Plans and Policies

The regional plans and policies applicable to this report are:

- *The Environmental Protection (Water) Policy 2009* (the EPP Water),
- *The Water Resource (Burnett Basin) Plan 2014*,
- *The Burnett Baffle Water Quality Improvement Plan*,
- *The Wide Bay Burnett Regional Plan 2011.*

2. Climate

2.1 Weather Stations

MRO is located in the subtropical region of southeast Queensland, characterised by hot summers and mild winters. Rainfall in this area is characterised by short, intense rainfall events occurring primarily in the wet season from November to April. Historical meteorological data exists for the area surrounding MRO and a list of Bureau of Meteorology (BOM) weather stations in close proximity and with comprehensive rainfall and temperature data is included in Table 17 of this report.

Table 17: BOM weather stations in proximity to MRO.

STATION NUMBER	STATION NAME	LATITUDE	LONGITUDE	YEARS OF GOOD DATA*	DISTANCE FROM MRO
039070	Mount Perry The Pines	25.17° S	151.64° E	123	14.4km
039096	Wateranga	25.36° S	151.82° E	80	13.5km
039256	Dingle Dell	25.15° S	151.63° E	22	16.6km
039218	Moolboolaman	25.01° S	151.81° E	72	27.3km
039040	Gin Gin Post Office	24.99° S	151.96° E	108	35.4km
040428	Brian Pastures	25.66° S	151.75° E	33	44.8km
039039	Gayndah Post Office	25.63° S	151.61° E	117	43.9km

*Years of good data refers to the number of years the weather station has consistently recorded comprehensive rainfall and/or temperature data

2.2 Rainfall

Annual Rainfall

Rainfall data for this report is sourced from Mount Perry the Pines (BOM station 039070), which is less than 15km from MRO and has over a century of available rainfall data. The annual rainfall as recorded at this station since 1889 is presented in Figure 1. Full dry season data is not yet available for 2015; however, given there are approximately 6 weeks left in the 2015 dry season, the figures are not likely to change much. Since 2000, MRO has operated an onsite rainfall gauge, and an automatic gauge has been in use on the site since 1 January 2012. Where appropriate, onsite rainfall data is compared to data from Mount Perry the Pines to ensure rainfall in the vicinity of the site is accurately represented.

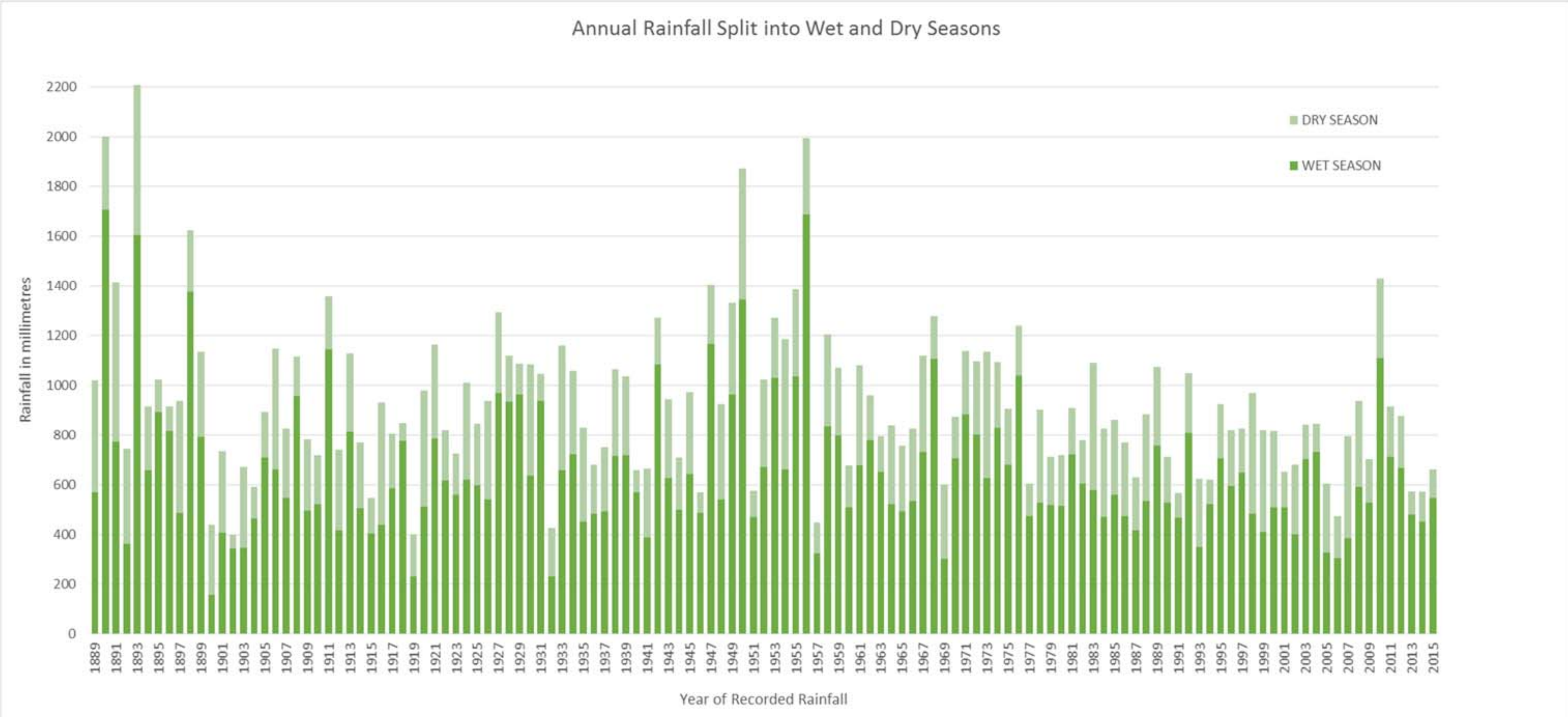


Figure 1: Annual rainfall from BOM station Mt Perry the Pines from 1889 to 2015, split into wet and dry seasons with 2015 dry season figures included up to mid-September.

The rainfall statistics from Mount Perry the Pines demonstrate the high variability of annual rainfall in the region around MRO. The maximum annual rainfall in the last 126 years was 2207.2mm, which fell in 1893. The minimum annual rainfall of just 397.4mm fell in 1902. The mean annual rainfall is 939.9mm (BOM, 2015). It is clearly evident from Figure 1 that rain does not fall evenly through the year in the region around MRO, with most precipitation (over 70% each year) falling in the wet season from November to April.

Onsite Rainfall versus BOM Station Data

Comparing annual rainfall data collected using the gauges at MRO to the results from Mount Perry the Pines reveals some variation in rainfall between the two sites, which are just under 15km apart.

A more detailed examination of the last 12 months of complete data from September 2014 to August 2015 reveals trend where the onsite data at MRO can be far in excess of falls recorded at Mt Perry the Pines, as shown in Figure 2. While overall the rainfall intensity tracks similarly, the MRO site is prone to intense, local rainfall events not experienced at the Mt Perry the Pines station.

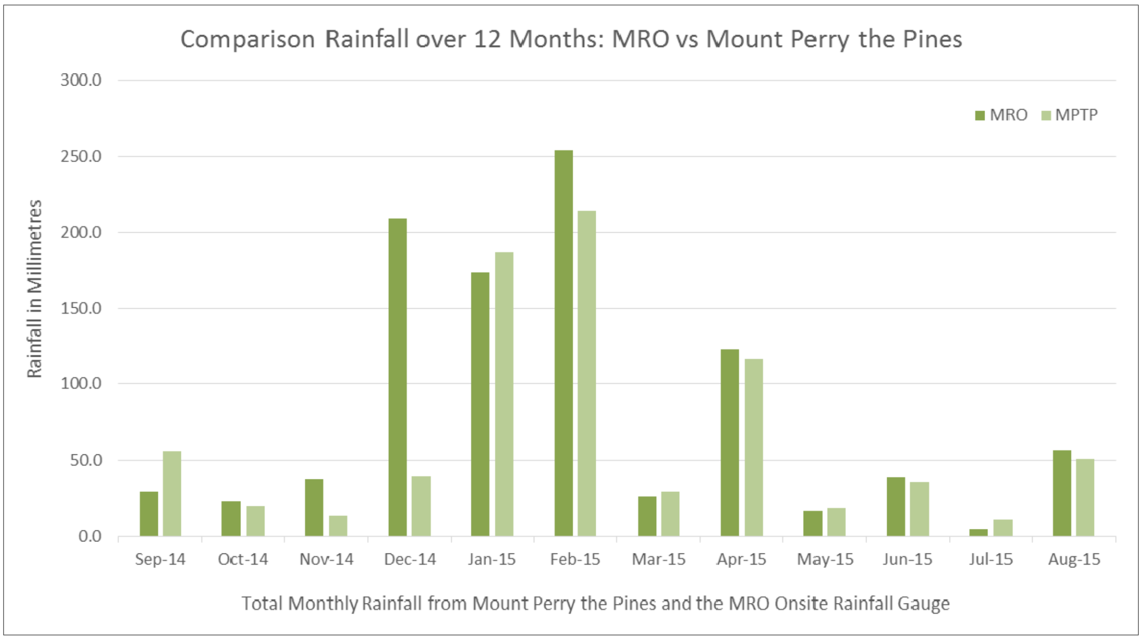


Figure 2: The last 12 months of rainfall data from both Mount Perry the Pines and the onsite rainfall gauge at MRO.

This correlation is borne out through interrogation of data over a longer period. The rainfall data from the onsite rainfall gauge at MRO is compared to the BOM data from Mount Perry the Pines for a 15 year period from 2001 to 2015 year to date in Figure 3.

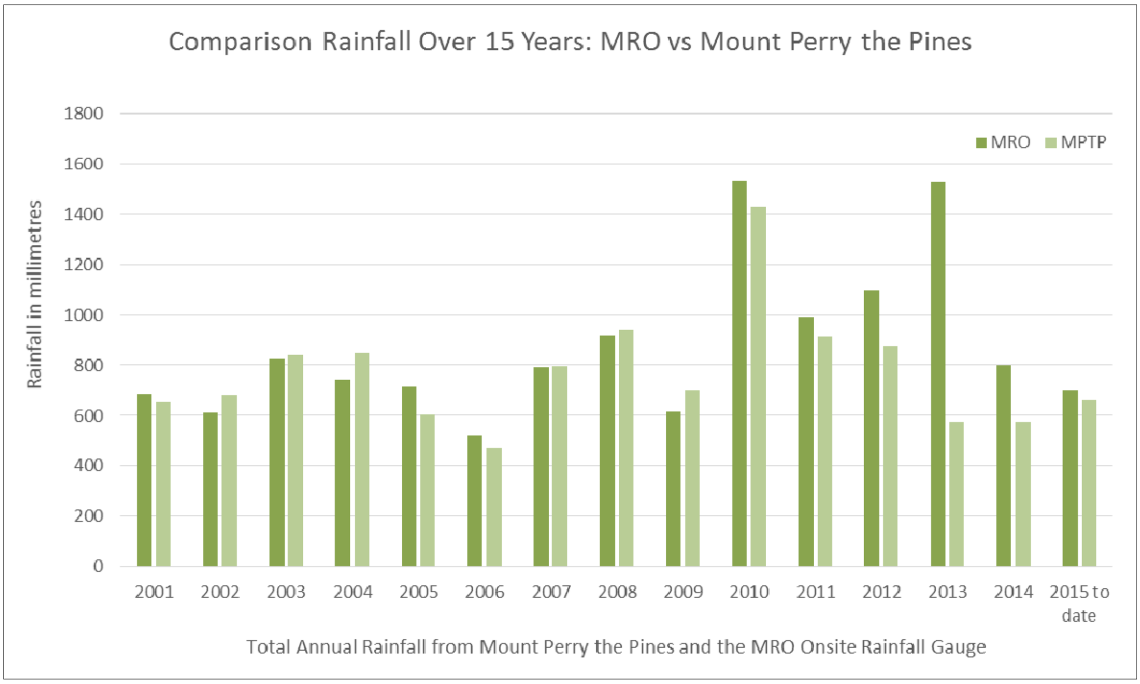


Figure 3: Comparison rainfall from 2001 to 2015 (year to date) from MRO onsite and Mount Perry the Pines.

Rainfall Intensity

While total rainfall between the two sites tracked at a similar intensity in the early part of the last 15 years, from 2010 onwards MRO has consistently recorded heavier rainfall across the year than that recorded at Mount Perry the Pines. That difference has ranged from 38mm year to date in 2015 to 954.8mm more rain at MRO than Mount Perry the Pines in 2013. It is important to note that a considerable proportion of the rainfall variation between the two sites in 2013 is down to a single intensive 72 hour rainfall event in early 2013 from a low pressure system caused by ex-tropical cyclone Oswald. The BOM holds rainfall data from Mount Perry the Pines for the equivalent dates and the difference is stark. The rainfall contrast across the three days of 24-26 January 2013 is presented in Table 18.

Table 18: Contrasting rainfall between Mount Perry the Pines and MRO recorded during an extreme 72-hour rainfall event in January 2013

DATE	MOUNT PERRY THE PINES	MT RAWDON ONSITE
	Rainfall in Millimetres	
24 January 2014	11.0	112.0
25 January 2014	88.6	120.2
26 January 2014	111.8	479.0

The 1:100 average recurrence interval (ARI) flood event is inherently linked to the 1:100 ARI rainfall intensity. This is measured as rainfall intensity that has a 0.01% chance of occurring in any given year. This value is commonly referred to as the Q100 ARI, or the 0.01 annual exceedance probability (AEP) rainfall. For the purpose of this report, rainfall intensity will be referred to as AEP.

There can be many 0.01 AEP events because there can be multiple storms of varying duration or intensity (mm/hr). In catchment studies, the duration of the 0.01 AEP event is calculated based on the peak discharge of the catchment under study. The peak discharge corresponds to the maximum rate of water leaving the catchment under a certain sized rainfall event. The time that it takes for the hydrograph of the catchment to reach its peak is the duration chosen to represent various AEP events.

The highest historical rainfall events at Mount Perry the Pines are presented in Table 19.

Table 19: Highest historical rainfall events recorded at Mount Perry the Pines (BOM, 2015)

24 HOUR EVENTS		48 HOUR EVENTS		72 HOUR EVENTS	
Date	Rainfall	Date	Rainfall	Date	Rainfall
27/01/2013	345.0mm	26/01/2013	456.8mm	25/01/2013	545.4mm
23/1/1890	339.1mm	1/03/1950	393.7mm	1/03/1950	452.4mm
1/03/1947	303.3mm	23/1/1890	387.4mm	1/2/1893	423.5mm
28/02/1950	296.7mm	24/1/1890	365.0mm	23/1/1890	413.3mm
6/3/1898	247.9mm	6/3/1898	364.0mm	24/1/1890	413.3mm
17/05/1926	240.8mm	28/02/1950	355.4mm	7/3/1898	399.3mm
16/03/1992	230.0mm	1/03/1947	341.7mm	2/03/1950	398.0mm

The four highest 24-hour rainfall events from Mount Perry the Pines are classified as more intense than the 0.01 AEP 24-hour duration events. These four high rainfall events also form part of the highest 48-hour and 72-hour events on record. The most significant event on record occurred on 27 January, 2013, where 345mm of rain fall in just 24 hours, rising to 456.8mm at 48 hours and 545.4mm in 72 hours. Prior to this, the most significant 24-hour rainfall event in the last 24 years took place on 16 March, 1992, where 230mm of rain fell in one day.

Figure 4 illustrates the rainfall Intensity Frequency Duration (IFD) using data from Mount Perry the Pines. It shows the likelihood of a rainfall event occurring at a given intensity and duration, e.g. a 1:100 ARI rainfall event with an 0.01 AEP would result in just over 165mm of rain falling in 24 hours.

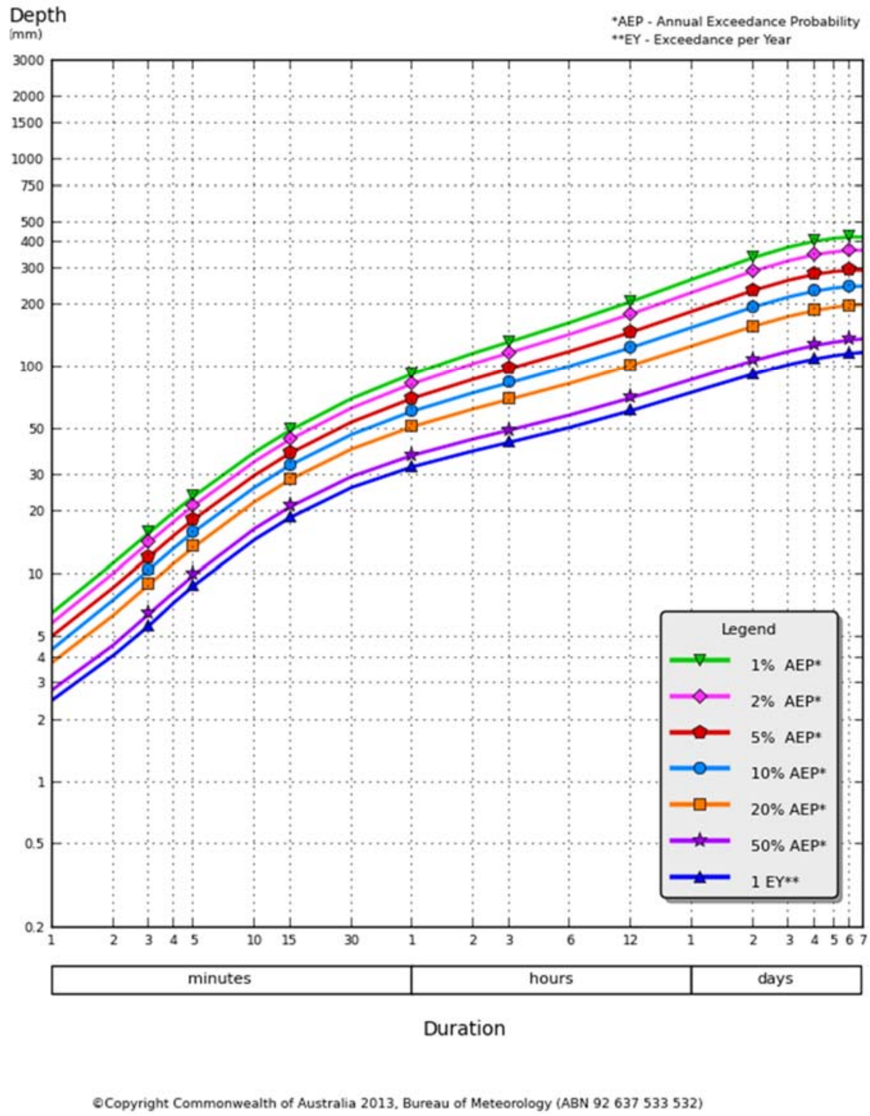


Figure 4: Return period of different rainfall events using data from Mount Perry the Pines (BOM, 2015).

2.3 Temperature and Evaporation

Temperature data is sourced from the Gayndah Post Office station 039039, which is the closest BPM station to have comprehensive temperature records (ranging from 1894). Mean maximum temperatures are approximately 32°C during the summer months (December to February) and 22°C during the winter months (June to August). Mean minimum temperatures are approximately 20°C during summer and 6°C during winter. Mean minimum and maximum temperature data is presented in Figure 5 (BoM 2015).

Annual pan evaporation has been sourced from Brian Pastures station 040428, approximately 44km from MRO. Annual average of daily evaporation is 5.3mm, with significantly higher evaporation during the hotter summer months.

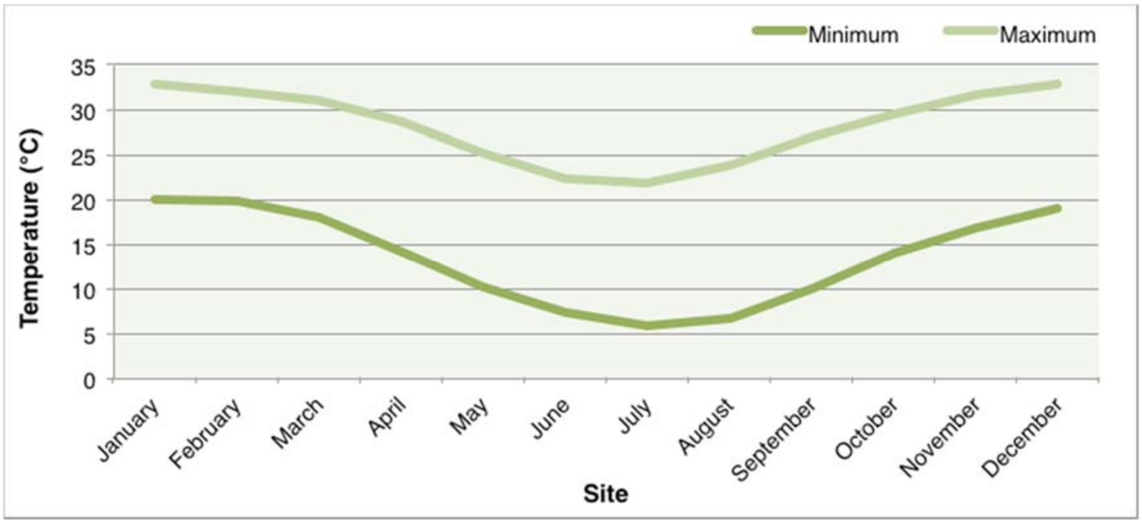


Figure 5: Mean minimum and maximum temperature from the Gaydah Post Office (BoM 2015)

Environmental Values

1. Identifying Environmental Values

This section identifying the environmental values for water at MRO adheres to the requirements of EHP guideline EM963. For the most part this report will focus on the environmental values of groundwater at MRO, to prove that an amendment to the groundwater monitoring program will have no detrimental effects on the environmental value of groundwater in the region. However, some attention will also be given to the environmental value of surface water at the site, insomuch as groundwater is known to contribute baseflow to creeks around MRO.

2. Site Plan

2.1 Topography

MRO is located in the North Burnett region of southeast Queensland, situated in the moderate relief slopes of the Burnett Range, which comprises part of the Great Dividing Range. MRO is approximately 170m above mean sea level (AMSL) and is surrounded by rolling to steep hills, up to 440m AMSL in elevation (a map entitled Topography and Hydrology is available in Appendix A of this document). The most prominent landform in the local area is Mount Perry, which peaks 750m AMSL and lies approximately 10km northwest of the mine site. The highest relief landforms lie to the north and west of the mine site. This topographic influence may influence high levels of orographic rainfall at the mine site due to the predominant south-easterly wind direction. Evidence provided in section 2.2 Rainfall in this report would appear to support that theory. The land slopes gently to the northeast from the mine site, over a distance of approximately 2km until reaching the Perry River.

2.2 Hydrology

Regional Hydrology

MRO is situated in the Lower Burnett sub-catchment of the Burnett Basin catchment. The Burnett catchment is the third largest river basin on the east coast of Queensland, with a catchment area of approximately 34,500 square kilometres (Van Manen 1999). The Lower Burnett sub-catchment comprises an area of 3,874.9 square kilometres. Surface runoff from MRO drains into the Burnett River towards the South and into the Perry River towards the north.

Swindon Creek, Rawdon Creek and Twelve Mile Creek are ephemeral creeks that course to the northeast and discharge into the Perry River. The Perry River flows in an easterly direction and merges with the Burnett River near Morganville, approximately 35km downstream of MRO and 25km directly to the northeast of the site. The catchment area of the Perry River at MRO is approximately 156 square kilometres (DNRM 2013). The southern boundary of the mine site is adjacent to the crest of a hill. The southern area of the mine site drains to the southeast via Mingham Creek into the Burnett River. The Burnett River flows into the Coral Sea east of the town of Bundaberg.

The Burnett River flows for 420km from its source in the Burnett Ranges to its mouth at Burnett Heads. The main tributaries of the Burnett River are Three Moon Creek (the northern tributary), the Nogo River (the north-western tributary), the Auburn River (the south-western tributary), the Boyne and Sturt Rivers (the southern tributaries), Barker and Barambah Creeks (the south-eastern tributaries) and the Perry River (the eastern tributary) (Nguyen 1998).

There are a number of weirs and water storage dams constructed along the Burnett River in this sub-catchment that regulate the river's flow. The largest storage infrastructure is the Paradise Dam, which as a design storage capacity of 300,000 megalitres (ML). Rainfall in the catchment is variable with both tropical and temperate weather patterns. Cattle grazing and crop production dominate the land use in this catchment (Howell *et al.* 2010).

Site Hydrology

The topography of MRO falls away steeply from the top of Mount Rawdon to the northwest of the site, leading to undulating hills at the base of the mountain. The land slopes gently over a distance of 3km to alluvial flats along the Perry River. Runoff from the mining lease travels overland rapidly, and surface flow in ephemeral creeks is sustained for a number of days following rainfall. For most of the year there is no flow in the Perry River and water pools in a series of low volume waterholes (Angus and Lewis 1996).

A network of drainage lines within site feed Swindon Creek, Rawdon Creek, Twelve Mile Creek and Mingham Creek after rainfall. The northern area of the site drains into the Perry River via Twelve Mile Creek, Rawdon Creek, Swindon Creek and Unnamed Creek. The southern area of the site drains via a number of drainage lines into Mingham Creek, an ephemeral system that during heavy rainfall will flow to the Burnett River approximately 8km south of the site.

The primary source of surface water at MRO is runoff subsequent to a rainfall event. Within MRO, a network of diversion drains channel clean water runoff away from operational areas and prohibits mixing of potentially mine affected runoff with clean stormwater. Potentially mine impacted water from within operational areas is diverted to four containment dams (WD1, WD2, WD3 and WD4) around the WRD, two sediment dams (SD1 and SD2) downstream of the TSF and West Dam located to the south of the Western WRD.

2.3 Wetlands

The state-wide wetlands map obtained from the Queensland Government Information Service (QGIS) website (DEHP, 2015) shows all wetlands of significance in Queensland. No natural wetlands are present at or in close vicinity to MRO. The nearest wetlands of high ecological significance (HES) are approximately 20km east of MRO and will not be impacted by a change to the groundwater monitoring program at MRO.

2.4 Existing and Proposed Groundwater Bores

The existing and proposed groundwater bores that are the subject of this application are described at length in the Amendments Sought section starting on page 8 of this report. To summarise the proposed breakdown of bores as listed in the current EA, and detailed in the RPS memoranda (2015a, 2015b and 2015c):

Current Bores

- There are 39 seepage monitoring bores in the EA,
- There are 14 regional monitoring bores in the EA, plus two more to be installed by 2016 with details to be confirmed on installation.

Decommissioned Bores and Bores to be Decommissioned

- Six of the 39 seepage monitoring bores in the EA have been decommissioned,
- Two of the regional monitoring bores in the EA have been decommissioned,
- A further 14 of the seepage monitoring bores in the EA are recommended for decommissioning.
- Another two of the regional monitoring bores from the EA are recommended for decommissioning.

Bores to be Added to the EA

A total of 18 additional bores are to be added to the EA. Fourteen of these are already drilled and have been assessed for their suitability for inclusion in the revised monitoring program by RPS (2015a, 2015b, 2015c) and four more are to be installed. Bore logs for the 14 bores already drilled are included in Appendix E of this report.

- Of 14 bores already drilled at MRO to be added to the EA:
  - One will be a dual status bores for monitoring of both seepage and regional groundwater quality,
  - Three will be investigation bores,
  - Five bores will be added to the EA as regional compliance monitoring bores,
  - The remaining five bores will be added to the EA as seepage monitoring bores.
- Of the four new bores are to be drilled and added to the EA,
  - One will be a new regional compliance monitoring bore,
  - Two will be dual status bores monitoring both seepage and regional compliance,
  - The last will be a seepage monitoring bore.

Total Number of Bores in the Revised Groundwater Monitoring Program

The current EA has 53 monitoring bores in total, plus two more bores under regional monitoring with details to be confirmed. This adds to a total of 55 monitoring bores.

The revised groundwater monitoring program proposes a total of 47 monitoring bores. These bores are broken down as follows:

- There will be 16 regional groundwater monitoring bores, including six dual status bores, used for both seepage monitoring and regional groundwater quality monitoring.
- There will be 30 seepage monitoring bores, including the same six dual status bores used for both seepage monitoring and regional groundwater quality monitoring.
- There will be seven investigation bores.

In terms of individual bore count, this equates to 10 regional bores, 24 seepage bores, six dual purpose bores and seven investigation bores, for a total of 47 individual bores.

2.5 Movement of Groundwater at MRO

Directional Flow

The EHP Guideline EM963 under section 3, page 8, requires *'…a conceptual model showing the movement (including direction and rate of flow) of groundwater in the area. This requirement is essential for activities which have a high risk of contaminating groundwater to determine appropriate locations for compliance monitoring'.*

This proposed revision to the EA at MRO is not an application to introduce or increase the scale of any activity which has a high risk of contaminating groundwater. However, this application does propose a change to how compliance monitoring at site is conducted and as such, this requirement on the movement of groundwater is important to address in this application.

Groundwater at MRO occurs in fractured or fissured aquifers of low to moderate productivity (Brodie and Kilgour, 1998). Angus and Lewis (1996) reported that aquifers at MRO have limited areal occurrence and groundwater flow is fracture controlled with a yield of up to 0.8 L/s. Based on airlift yields reported from 17 monitoring bores during drilling, K H Morgan and associates (2006) reported that most had yields of less than 0.1 L/s. Four bores had airlift yields between 0.1 L/s and 1 L/s whereas only 3 had a yield of more than 1 L/s. The highest yield reported was nearly 2 L/s (for MRPB1).

Depth to the water table is highly variable across the site, representing low interconnectivity between groundwater bearing zones.

The yield from aquifers beyond the mining lease is also low. Figure 6 shows the air lift yields recorded from 29 groundwater bores on the mining lease and within a 15 km radius of MRO (based on data provided by the State of Queensland, Department of Natural Resources and Mines, 2013). Nearly two thirds of the bores have yields less than 0.5 L/s while about 10% of the bores yield more than 2 L/s. Generally low yield from the bores in this area indicates lack of connectivity of local aquifers to the regional groundwater aquifer systems of significant yield.

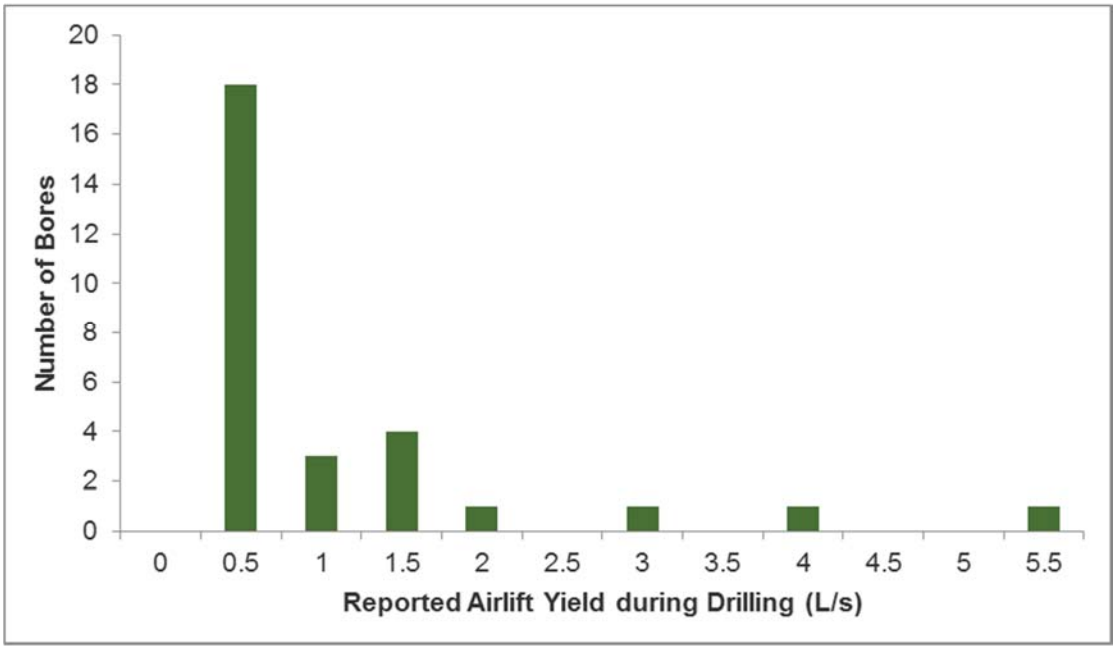


Figure 6: Distribution of airlift yields from bores within a 15 km radius of MRO

The RPS seepage memorandum (RPS 2015a) identifies that pre-mining groundwater flows were largely controlled by topography and drainage, with groundwater flow from elevated areas toward the major creek lines and then following the major drainage systems (through alluvium and underlying weathered and fractured basement rocks). The memorandum states there will have been some groundwater baseflow to the local creeks (springs) at topographic breakaways. Most of the pre-mining groundwater flow was to the northeast, parallel with Swindon, Rawdon and Twelve Mile Creeks, towards the Perry River with some minor groundwater flows to the south toward Mingham Creek (RPS 2015a).

Since the commencement of mining, local groundwater flow patterns have been influenced by site activities and RPS identifies that the TSF has become a source of recharge/seepage to groundwater, while the pit has become a groundwater sink (RPS 2015a). RPS further identifies the WRD and runoff containment dams downstream of the WRD have become sources of groundwater recharge.

Groundwater Flow Velocities

The RPS seepage memorandum (2015b) cites an NRC report from October 2014 where the predicted average groundwater particle velocities were calculated, travelling from the area beneath the region that lies between the northern wall of the TSF and the Perry River to the Perry River itself. This was the site of the proposed TSF2. The particle velocities were calculated at around 0.02m/d (around 7m/yr) (RPS 2015a citing NRC 2014b).

The NRC model adopted average permeability conditions for the fractured basement of 0.1m/d and regolith of 0.05m/d and was calibrated against observed long-term groundwater levels. The model predicted a travel time of 50 years for groundwater particles travelling along the shortest route toward the Perry River, which was a distance of 300m, but it is worth noting that this modelling was conducted as part of studies investigating the potential environmental impacts of the proposed TSF2. The actual distance from the toe of the existing TSF at MRO to the Perry River is 1,100m.

While it is possible that some parts of the fractured rock aquifer between the existing TSF and the Perry River may have higher permeability, a recent bore census conducted by NRC in 2015 and cited by RPS (2015b) indicated bore yields in excess of 1L/s at only five of 53 bores reviewed.

RPS (2015b) describes an assessment of average groundwater flow velocities across the mine site undertaken using a flow model using Darcy's Law and applied to groundwater flows from the existing TSF and WRD. The measured hydraulic gradients downstream of the TSF were around 0.15%. Assuming an average permeability of 0.1m/d (as per the numerical groundwater flow model) and an effective porosity of 5% (typical value for aquifers of this nature). The indicated average groundwater velocity is around 0.03m/d or 10m/yr (RPS 2015a).

RPS (2015b) states downstream of the WRD, the measured hydraulic gradient is marginally higher at 0.02%, indicating an average groundwater velocity of 0.04m/d (or 15m/yr) (RPS 2015a).

RPS summarises these data overall to estimate a groundwater particle velocity range from around 7m/yr to 15m/yr.

2.6 Flooding Potential

Given that this is an application to make changes to the groundwater monitoring program and does not involve additional disturbance at MRO, flooding potential at the site represents no potential impact to the revised monitoring program.

2.7 Waste Storage, Processing, Treatment and Disposal

The proposed amendment to the groundwater monitoring program will have no impact on the generation, storage, processing, treatment or disposal of waste.

2.8 Environmentally Sensitive Places

The proposed change to the groundwater monitoring program does not represent a change to any ERA at the site, so the proximity of environmentally sensitive places to MRO is not relevant to this application.

2.9 Hydrogeological Features of the Site

Hydrogeology encompasses the interrelationships of geological materials and processes with water. More specifically, the presence of groundwater, its movement, response to extraction or contribution of water and the fate and transport of contaminants is governed by the hydrogeological features of the proposed site (Fetter 1994).

Structural features and hydrogeology of the region is shown in the map titled Hydrogeology in Appendix A of this document. This map indicates that groundwater is predominantly present in fractured rock aquifers within the MRO mining lease boundary and its vicinity. It is also apparent from this map that the porous alluvial aquifer zone is approximately 10km southeast of the mine lease. Angus and Lewis (1996) reported that aquifers at MRO have limited areal occurrence and groundwater flow is fracture controlled with yield up to 0.8L/s.

The RPS memorandum on the seepage monitoring program (RPS 2015a) identifies that the local and sub-regional aquifer system at Mt Rawdon comprises:

- Variably fractured basement rocks with low to moderate permeability depending on the physical nature of and hydraulic interconnection between faults, shears and joint sets,
- Weathered basement, largely comprising low permeability clay rich regolith,
- Shallow creek alluvium comprising moderately permeable alluvial sediments which are mostly dry over the mine area or which form intermittent, perched aquifers after rainfall recharge. These aquifers are more permanent in lower topographical areas downstream of the mine site (e.g. at or near the Perry River Dam.)

The RPS memorandum also identifies a prominent set of northeast to southwest trending faults identified in a number of hydrogeological studies, with local drainages tending to follow these broad fault lines (RPS 2015a). The memorandum confirms no major aquifers have been identified, although some isolated bore yields of up to 3L/s have been reported during monitoring bore drilling (RPS 2015a).

Data from groundwater monitoring indicates that the northeast-southwest trending fault located between the TSF and the pit forms a hydraulic barrier to groundwater flow across the fault (e.g. northwest to southeast flow across the fault) (RPS 2015a).

RPS concludes that other than local influences on groundwater flow already identified here, overall groundwater flow in the area remains similar to pre-mining conditions. Figure 1 of the RPS seepage memorandum shows the interpreted current main groundwater flow pathways from the mine site (RPS 2015a).

Hydrogeological Units

Drilling records for monitoring bores (KCB 2012; NRC 2014a) indicate the presence of three main hydrogeological units:

1. Regolith.

   The regolith consists of an organics-rich topsoil layer less than a metre thick. This is followed by gravel, sand or clay layer of thickness varying from 1-4m and highly decomposed/weathered igneous rocks up to a thickness of 15m. Groundwater levels from the monitoring bores suggest that the regolith is usually permanently saturated near mine water storages such as the TSF1 and runoff containment dams. Elsewhere, the regolith contains water predominantly in the form of soil moisture and is generally unsaturated. Nearly all recharge occurs due to rainfall infiltrating through the regolith within the catchment. The weathering zone becomes saturated during rainfall events and is expected to be a significant source of groundwater recharge. No continuous aquifer system is present up to the depth of 20m below ground surface (Allan Watson Associates 2012).

2. Fractured Rock Aquifer.

   Groundwater monitoring bores at MRO are less than 40m deep. Saturated zones in these bores lie either in the mudstone, chert, minor mafic volcanics or metasediments of the Curtis Island Group (CIG) and dacite or dacite rich volcanics of the Arabanga Volcanic Group (AVG). The upper beds of the AVG and CIG form the fractured rock aquifer. This hydrogeological unit is responsible for most of the groundwater present at MRO.

3. Basement units.

   Basement units consist of fresh granite, dacite, rhyolite or granodiorite occurring at depths below 30m below ground level. Fracturing intensity in this unit is very low and therefore it accounts for little groundwater flow.

2.10 Barriers Overlying and Underlying Aquifers

The main water bearing zones at MRO are the fractures in hard rock belonging to the AVG or CIG. Aquifers are underlain by basement rocks with very low permeability due to reduced fracture intensity. Drilling records of monitoring bores at MRO also show that some of the water bearing fracture zones are overlain by localised clayey layers of decomposed rocks.

3. Surface Water

3.1 EPP Water – Schedule 1: Water Quality Objectives

The Environmental Protection (Water) Policy 2009 (EPP (Water)) provides a framework for defining the environmental value of all inland water bodies (surface water, groundwater and coastal water bodies) in Queensland and sets guidelines for their water quality. Environmental values of several water bodies to be protected or enhanced are defined in Schedule 1 of the EPP (Water). This schedule (last updated November 2014) does not include any water body on or around MRO so there are no specific environmental values or water quality objectives for the water bodies at MRO defined in this legislation.

3.2 Potentially Affected Surface Waters

This EA application does not propose any change to mining activities that would increase or otherwise alter the risk of environmental harm to surface water. While the application encompasses a change to the groundwater monitoring program, the revised program is still highly comprehensive.

Points to note are:

- The revised groundwater monitoring program is highly comprehensive, comprising 47 monitoring bores,

- The revised program includes a focus on early detection of potential seepage fronts with trigger limits for sulfate and salinity,
- The revised program includes a SWL-based trigger limit for rising SWLs within bores indicating the potential for groundwater to have a greater baseflow contribution,
- Groundwater is relatively slow-moving at MRO, with RPS estimating the groundwater particle velocity range from around 7m/yr to 15m/yr.

Considering these mitigating factors, this EA amendment application is not considered to pose a risk to the environmental values of surface water at MRO.

3.3 Environmental Values of Surface Water at MRO

Detailed independent assessment of the environmental values of water in the Burnett-Baffle catchment was undertaken for the *Burnett-Baffle Water Quality Improvement Plan* (WQIP) (BMRG 2010). Environmental values were identified by the community through public meetings conducted throughout the catchments. While the activities comprised in this EA amendment application do not pose a risk to the environmental values of surface water at MRO, those environmental values are identified herein. The environmental values identified for the Perry River at Placer Dam (now known as Perry River Dam) are listed in Table 21. The management goals for the Perry River are also specified in Table 21. These environmental values are relevant to the Perry River catchment and apply to tributaries of the Perry River such as Twelve Mile Creek, Rawdon Creek, Swindon Creek and the Unnamed Creek.

ANZECC 2000 guideline values for monitored parameters at MRO (as listed in Schedule C, Table 4 of the EA) are shown in Table 20. Median values of all monitored parameters at upstream reference sites meet ANZECC freshwater aquatic ecosystem (95% protection) trigger limits. However, on a number of occasions, pH, copper and zinc concentrations have exceeded the ANZECC aquatic ecosystem protection trigger values for the 95% protection level in upstream sites.

In terms of livestock drinking water quality, water quality in all streams at MRO is suitable for livestock watering according to the ANZECC guidelines. Based on upstream water quality, water in the streams at MRO is unsuitable for human consumption according to the ANZECC guidelines, due to occasional low pH recorded.

Table 20: ANZECC 2000 guideline values for contaminants of concern in the receiving environment at MRO

ANZECC 2000 GUIDELINES							
ANZECC LIMITS	**pH**	**TDS**	**Sulfate**	**Arsenic**	**Cadmium**	**Copper**	**Zinc**
Aquatic Ecosystem (95% species protection)	6.5 – 8.0	n/a*	n/a	0.013 mg/L	0.0002 mg/L	0.0014 mg/L	0.008 mg/L

ANZECC 2000 GUIDELINES							
ANZECC LIMITS	**pH**	**TDS**	**Sulfate**	**Arsenic**	**Cadmium**	**Copper**	**Zinc**
Livestock Drinking	ne*	4000mg/L	1000 mg/L	0.5 mg/L	0.01 mg/L	1 mg/L	20 mg/L
Drinking Water	6.5 – 8.5	1000mg/L (aesthetic)	500 mg/L	0.007 mg/L	0.002 mg/L	2 mg/L	3mg/L (aesthetic)
*n/a denotes no set guideline value							

3.4 Water Quality Objectives

Water quality objectives are the quantitative measures established to protect the environmental values of waters. The purpose of water quality objectives is to act as a general tool for assessing water quality (ANZECC 2000). Where appropriate, water quality objectives are based on Australian (ANZECC 2000) and Queensland Water Quality Guidelines (QWQG; EHP 2009); however, some may be modified by social and economic inputs (EPP Water 2009). While water quality guidelines are often used as *de facto* objectives, guidelines are conceptually distinct from water quality objectives.

MRO proposes the water quality objective for surface water at MRO be the maintenance of upstream water quality in each downstream water body in the receiving environment. Contaminants of concern for surface water should remain as those in the current EA (Schedule C, Table 4, 'Receiving water monitoring requirements'), as MRO is not proposing any changes to its current processing operations and subsequently the management approaches already in place should be sufficient to maintain upstream water quality in each downstream water body in the receiving environment.

Table 21: Environmental Values of the Perry River at Perry River Dam (Placer Dam) as set out by the Burnett Mary Regional Group (BMRG 2010) and the applicability and relevance of these environmental values to the receiving waters of MRO

ENVIRONMENTAL VALUE	MANAGEMENT GOALS	APPLICABILITY	RELEVANCE	APPLICABLE GUIDELINES
Aquatic ecosystems	Protection/enhancement of aquatic ecosystem values, habitat and wildlife	Yes	Local watercourses provide a water source and are of environmental value to native flora and fauna.	Current EA requirements, Burnett-Baffle WQIP and ANZECC 2000 guidelines for 95% level of protection.
Irrigation	Suitability of water supply for irrigation.	No	Water from the creeks at MRO or from Perry River Dam is not used for irrigation.	
Farm supply	Suitability of domestic farm water supply, other than drinking water.	No	Water from the creeks at MRO or from Perry River Dam is not used for farm supply.	
Stock watering	Suitability of water supply for production of healthy livestock.	Yes	Pastoral land use is predominant around MRO. Cattle drink from watercourses.	Burnett-Baffle WQIP, ANZECC 2000 Guidelines –Livestock Drinking water for all surface waters.
Aquaculture, human consumption of aquatic foods	Health of aquaculture species and humans consuming aquatic foods	Yes	Recreational fishing could be an environmental value at Perry River Dam. There is no evidence of industrial aquaculture around MRO.	Burnett-Baffle WQIP and ANZECC 2000 Guidelines. Although the applicability of this environmental value at MRO is not evident, it will be protected with aquatic ecosystem protection.
Primary recreation	Health of humans during recreation involving direct contact and high probability of water swallowed.	No	The Perry River Dam or other creeks at MRO are not used for swimming or any other contact water sport.	
Secondary recreation	Health of humans during recreation that involves indirect contact and low probability of water swallowed (e.g. boating).	No	The Perry River Dam and other creeks at MRO are not used for secondary recreation e.g. boating. Rare chances of contact for secondary recreational purposes ensure this environmental value at MRO is not applicable.	

ENVIRONMENTAL VALUE	MANAGEMENT GOALS	APPLICABILITY	RELEVANCE	APPLICABLE GUIDELINES
Visual appreciation	Amenity of waterways for recreation that does not involve any contact with water.	Yes	While the visual amenity of the Perry River is an environmental value, the MLs are not open to the public so creeks on the ML are not accessed for their aesthetics.	Burnett-Baffle WQIP and ANZECC 2000 recreation guidelines –Visual use - no contact
Drinking water	Suitability of raw drinking water supply.	No	This surface water is not used as a raw drinking water supply	
Industrial use	Suitability of water supply for industrial use.	Yes	While the water is suitable for industrial use, there is no significant industry present within 10 km of MRO.	
Cultural and spiritual values (indigenous or non-indigenous)	Aesthetic, historical, scientific, social or other significance, to past, present or future generations	No	There is no aesthetic, historical, scientific, social or other significance, to past, present or future generations	

4. Groundwater

4.1 Location and Depth of Groundwater

Groundwater aquifers at MRO are believed to be highly localised and discontinuous (Angus and Lewis 1996). Depth to groundwater varies widely. Groundwater bores within 10km of the site are shown in the map titled 'Hydrogeology' in Appendix A of this document. There are only five registered bores within a 10km radius of the MRO mining leases apart from monitoring bores onsite, indicating relatively limited use of groundwater in the region.

An assessment of the median standing water levels (SWLs) for seepage and regional monitoring bores included in the EA is represented in Figure 7. The median groundwater level varies greatly, ranging from 0m to 32.16m across the site. These levels vary seasonally due to rainfall recharge during the wet season.

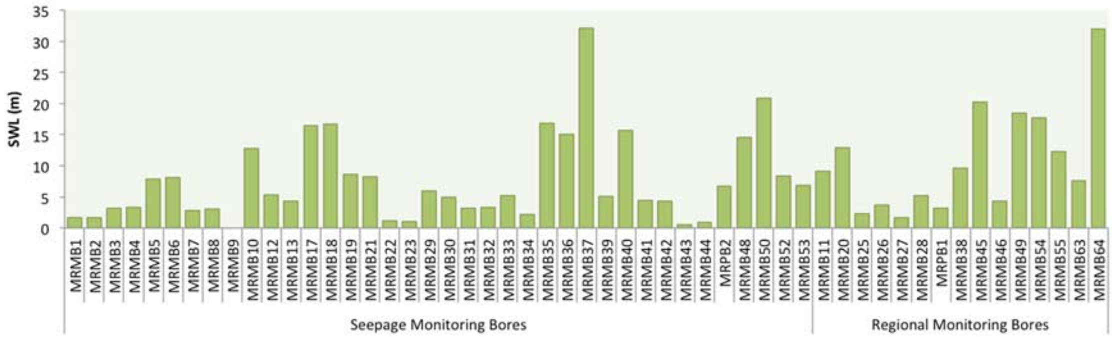


Figure 7: Median standing water levels (SWL) for all seepage monitoring bores and regional monitoring bores. Data sourced from MRO's SWL database.

4.2 Existing Groundwater Quality

There are no reference bores for groundwater monitoring at MRO. Accurate characterisation of background water quality is not possible. However, the monitoring information from the TSF seepage monitoring bores and regional groundwater bores can be used to provide an overview of water quality across the site. An exhaustive review of groundwater quality at MRO was presented in an annual water quality review report submitted to EHP as part of MRO's annual return (NRC 2014). This EA amendment application does not involve any change in mining or processing activity that would result in a change in the level risk of environmental harm posed to groundwater at MRO.

The revised groundwater monitoring program utilises the comprehensive historical dataset from monitoring bores at MRO to the site's advantage, allowing for early identification of seepage through monitoring for elevated levels of sulfate and salinity, known to be key indicators of seepage arrival (RPS 2015a). A synopsis of historical water quality at MRO based on site's own monitoring records is presented here.

Water Quality in Seepage Bores

Major ion chemistry of the seepage bores at MRO is shown along with that of the TSF decant in the piper diagrams shown in Figure 8, Figure 9 and Figure 10. Major ion composition in some seepage bores located very close to the northern wall of the TSF show evidence of impacts from the TSF. However, such impacts stabilised in the reporting period 2013-2014 due to a range of measures undertaken by MRO to more efficiently manage the seepage from the TSF. The low permeability of tailings combined with the compartmental nature of aquifers around the TSF ensure that seepage from the TSF is not transported regionally, even under the high hydraulic gradient that exists in this area.

The TSF decant has a very distinct Na-SO_4 signature. MRMB1, MRMB2, MRMB9, MRMB19 and MRMB23 appear to show some degree of mixing with the TSF decant as evident from their position on the piper diagram in Figure 8 and Figure 10.

As part of the proposed groundwater monitoring program, MRMB1, MRMB2 and MRMB23 are recommended for decommissioning (RPS 2015a). At the time of this application, MRMB09 has been decommissioned after an investigation into total cyanide levels in 2012, and MRMB19 has been decommissioned due to its location in the footprint of the Western WRD / West Dam region. MRMB19 has been replaced by MRMB69 (RPS 2015a).

Excluding MRMB23, all seepage bores shown in Figure 9 and Figure 10 exhibit a much lower degree of mixing with TSF decant. The natural groundwater around the TSF shows Na-Cl type signature as evident from bores MRMB30, MRMB33 and MRMB34 in Figure 9. Of these three bores, MRMB33 and MRMB34 are both recommended for decommissioning (RPS 2015a). MRMB30 has a role in the revised seepage program as a tertiary monitoring bore for the Unnamed Creek.

Based on the analysis of major ion chemistry of the seepage bores, the extent of impact from TSF appears to be limited to seepage monitoring bores in the immediate vicinity of Northern wall of the TSF. There is no evidence of an increase in the extent of impact of TSF seepage when compared with that in the previous reporting period.

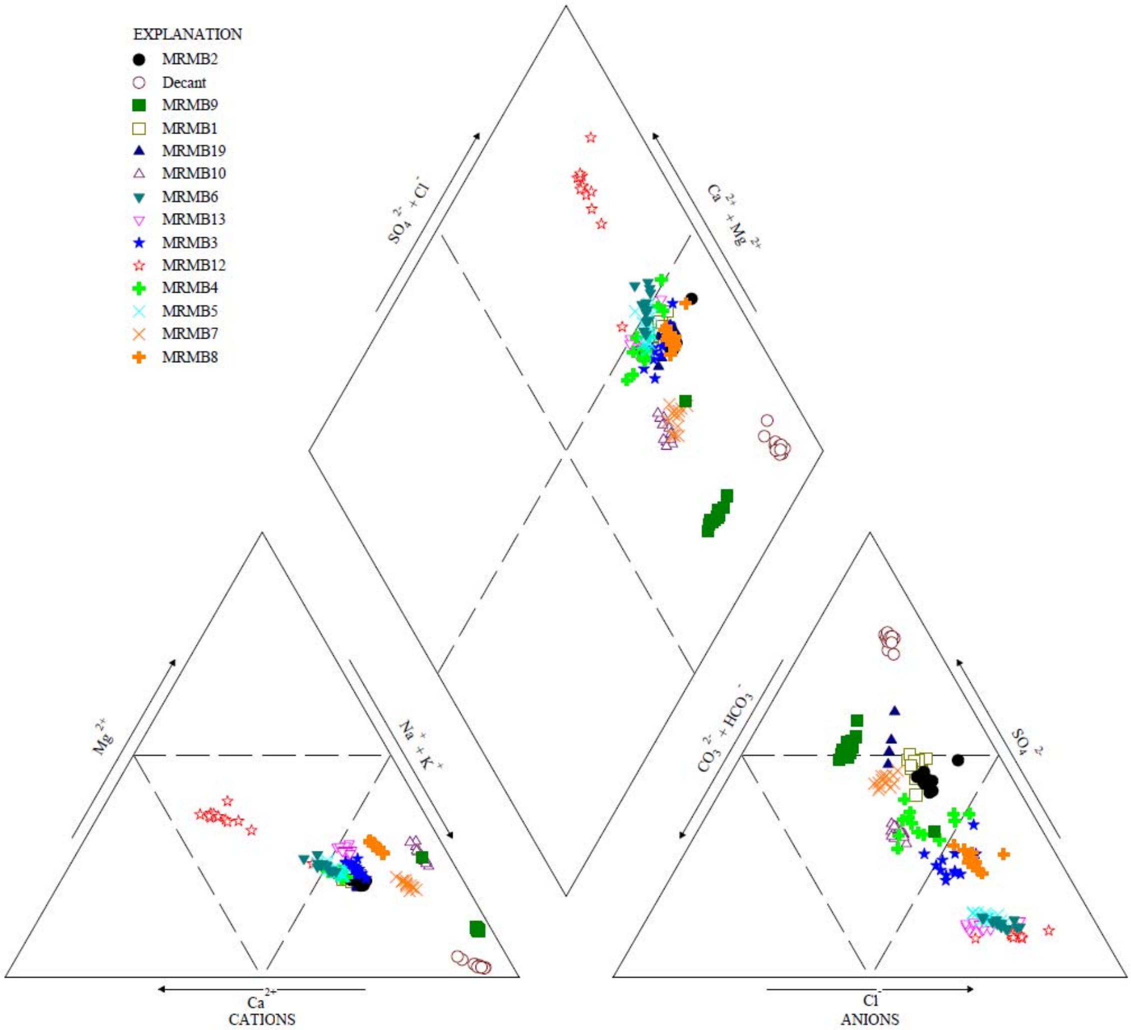


Figure 8: Major ion composition of seepage bores at MRO (Part 1 of 3)

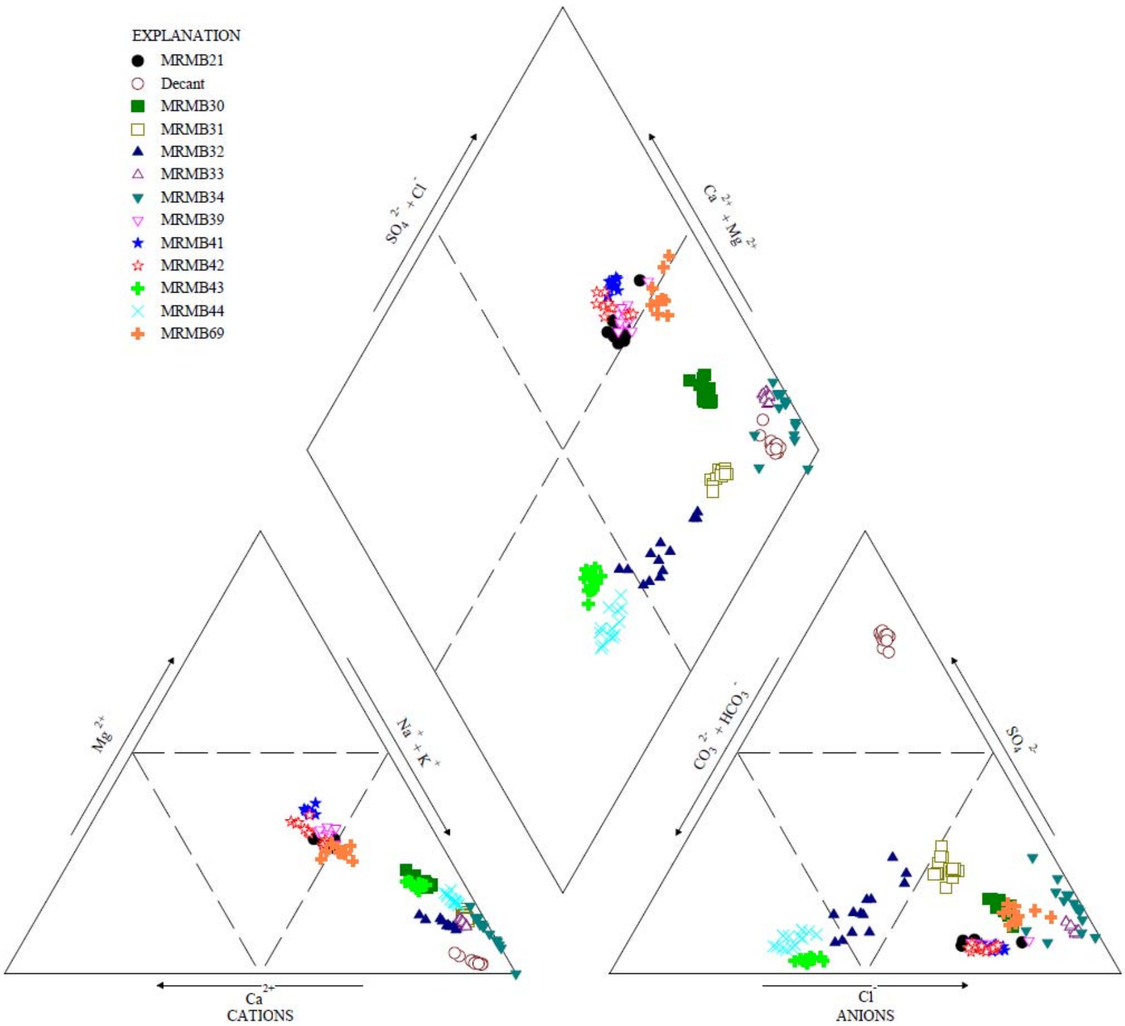


Figure 9: Major ion composition of seepage bores at MRO (Part 2 of 3)

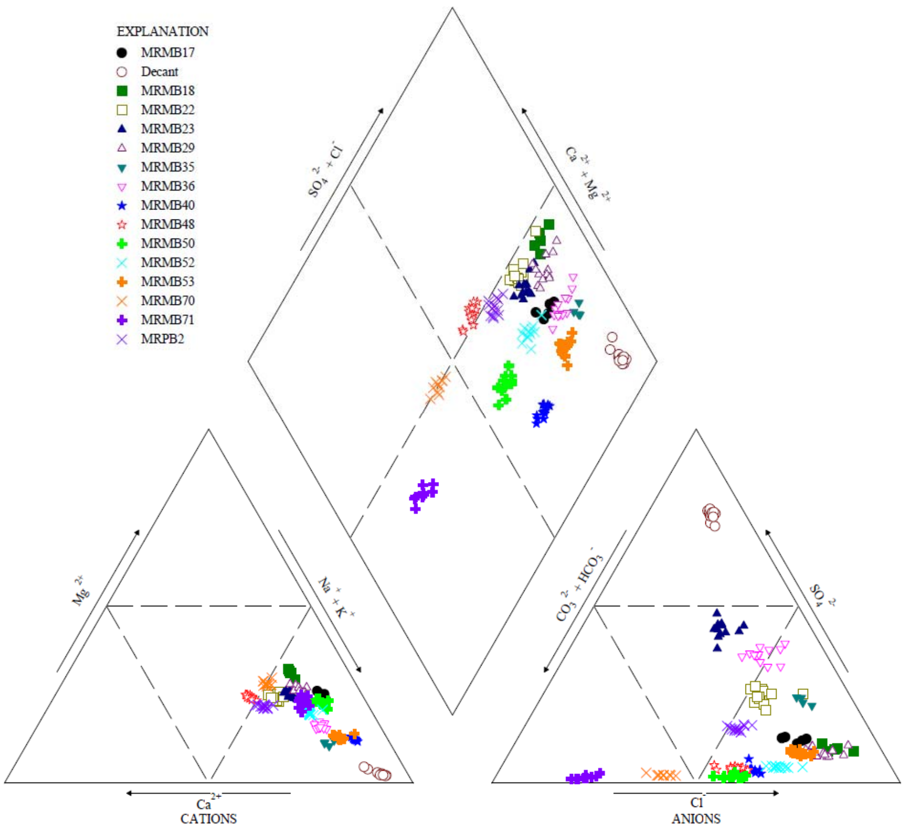


Figure 10: Major ion composition of seepage bores at MRO (part 3 of 3)

Most groundwater parameters in the seepage monitoring bores remained within the EA contaminant limits. The exception to this is pH on four occasions in seepage bore MRMB34, which is now recommended for decommissioning (RPS 2015a). The occurrence of low pH in this bore prompted an investigation (RGS 2014) and a report was submitted to EHP. The investigation concluded that:

> *"…the seepage and salt precipitate near MRMB34 had a different chemical signature to tailing water extracts, TSF decant, and TSF seepage; and was likely to be derived from groundwater interaction with naturally occurring rock materials, rather than from any seepage from the tailings materials in the TSF."* (RGS 2014)

No visual and/or chemical evidence of acidic mine drainage (AMD) was found near MRMB34 (RGS 2014).

Water Quality in Regional Groundwater Bores

As defined in the EA, 'regional groundwater' at MRO is the groundwater potentially impacted by mining activities on or around the site beyond the capture systems implemented for the existing TSF. Regulated water quality parameters for regional groundwater bores and the contaminant limits are listed in Table 22.

Table 22: Regional groundwater contaminant limits as listed in Schedule C, Table 11 of the August 2015 EA.

PARAMETER	UNITS	LIMIT TYPE	CONTAMINANT LIMITS
Piezometric Head	mAHD	N/A	N/A
Total Dissolved Solids	mg/L	Maximum	10000
pH*	pH units	Range	6.0 – 9.0
Sodium	mg/L	Maximum	1620
Chloride	mg/L	Maximum	3120
Copper*	mg/L	Maximum	0.24
Zinc*	mg/L	Maximum	0.9
Cadmium*	mg/L	Maximum	0.035
Arsenic*	mg/L	Maximum	0.12
WAD Cyanide	mg/L	Maximum	0.024
Total Cyanide	mg/L	Maximum	0.030
Electrical Conductivity	µS/cm	Maximum	15000
Sulfate	mg/L	Maximum	744
Lead*	mg/L	Maximum	0.012
Aluminium	mg/L	Maximum	3.42
Iron*	mg/L	Maximum	10
Boron*	mg/L	Maximum	0.60
Chromium*	mg/L	Maximum	0.024
Manganese*	mg/L	Maximum	1.8
Fluoride	mg/L	Maximum	7.6
Nitrate	mg/L	Maximum	0.6
* Monitoring bore MRMB20 is exempt from these limits			

While MRMB20 is exempt from a number of parameter limits in the EA, this bore has a role in the revised seepage monitoring program as a tertiary monitoring bore for the plant area between the TSF and the Pit/WRD (RPS 2015a). MRO propose that MRMB20 remain exempt from the parameters limits in the EA as the bore is in proximity to the crushed ore stockpile and the ROM pad and is expected to show some impact from these facilities. In its role as a tertiary monitoring bore, MRMB20 can assist in monitoring water levels and water quality behind the known seepage front (RPS 2015a).

Most of the regional groundwater bores included in the August 2015 EA meet the EA limits with the following exceptions:

- Sulfate or nitrate concentrations above the EA limits have been reported in a number of bores surrounding the North WRD (MRMB20, MRMB24, MRMB25, MRMB26, MRMB27, MRMB46, MRMB49 and MRPB1). The revised groundwater monitoring program proposes the following fate for those bores:
  - MRMB20 to be retained as a tertiary seepage monitoring bore and to remain exempt from indicated parameter limits in the EA,
  - MRMB24 has been decommissioned,
  - MRMB25 is to be repurposed as an investigation bore,
  - MRMB26 is to be repurposed as an investigation bore,
  - MRMB27 is to be repurposed as an investigation bore,
  - MRMB46 will be utilised as a tertiary monitoring bore for the plant and area between the pit and WRD,
  - MRMB49 is to form part of the revised seepage monitoring program as a primary monitoring bore for Rawdon Creek,
  - MRPB1 is to be repurposed as an investigation bore.
- Total cyanide exceeded the EA limit at MRMB46 in November 2014.
  - In its role as a tertiary monitoring bore, MRMB46 will provide low frequency snapshot monitoring to confirm water quality and water levels behind the seepage front (RPS 2015a).

The parameters described in this report in Table 22 and reproduced from the August 2015 EA are proposed to change slightly in the revised groundwater monitoring program. That change is covered in this report in section 4.5, Proposed Revision to the Regional Monitoring Parameters on page 28. The proposed revised parameters are included in that section as Table 15 of this report.

4.3 Testing to Confirm Aquifer Properties

While this EA amendment application does not include a revision to extractive activities that would present a greater risk of environmental harm to groundwater, the proposed groundwater monitoring program was informed by available data on aquifer properties. The results of recent hydrogeological testing at site is presented here for reference.

Hydrogeological studies conducted at MRO in October 2013 included field measurements of hydraulic conductivity in a number of sterilisation bores installed under an exploration drilling program. Groundwater monitoring bores installed in the vicinity of the existing TSF were also studied. A total of nine bores were installed and tested. Falling head slug tests were carried out in all investigative bores except BH01, where a low-flow pump test was conducted. The results of these investigations are shown in Table 23. The data obtained from the falling head slug tests was analysed using the Bouwer and Rice (1976) method. The data obtained from the pumping tests was analysed using the Papadopulos and Cooper (1967) method. The range of observed hydraulic conductivity values demonstrated through this testing is typical of fractured igneous and metamorphic rocks (Heath 1983).

Two monitoring bores (BH01 and BH02) and a sterilisation bore (MRO_RC_82) intersected saturated water bearing zones (aquifers). All other boreholes encountered unsaturated water bearing zones with very little yield. A pumping test was conducted on BH01 using a low flow pump (18 L/min). It dried out within four hours of the beginning of the test.

Falling head slug tests were carried out on all the other bores. During the test, water was quickly introduced into each bore using a high volume pump, while a digital pressure transducer continuously logged the hydraulic head in the bore at one second intervals.

Monitoring bore BH01 seems to intersect a confined aquifer with a transmissivity of 1.454×10^{-5} m^2/s. The transmissivity (T) value was converted to permeability (K) based on the saturated thickness of the aquifer. All calculated values of permeability fall roughly within the typical range for fractured igneous and metamorphic rock (8×10^{-9} to 3×10^{-4} m/s (Heath 1983)). This equates to a very low yield and permeability of the aquifers investigated.

Table 23: Calculated permeability (K) of bores at MRO from testing conducted in October 2013

BORE NAME	SCREENED INTERVAL	TOTAL DEPTH (M)	PERMEABILITY (K IN M/SEC)
MRMB65 (BH01)	24-30m	30	4.15E-06
MRMB66 (BH02)	27-30m	30	2.81E-06
MRMB67 (BH03)	27-30m	30	3.02E-09
MRMB68 (BH04)	27-30m	30	3.01E-07
MRO_RC_70	27-30m	30	2.01E-08
MRO_RC_71	27-30m	30	1.78E-08
MRO_RC_80	27-30m	30	2.75E-07
MRO_RC_81	27-30m	30	4.08E-09
MRO_RC_82	27-30m	30	8.87E-06

4.4 Other Groundwater Features at MRO

Given this proposed EA amendment does not involve any activity likely to increase the risk of environmental harm to groundwater at MRO, a brief snapshot is provided here of other groundwater features at the site in accordance with Guideline EM963 (EHP 2015b).

Groundwater Dependent Ecosystems and Underground Ecosystems

Groundwater plays an integral role in sustaining ecosystems. Vegetation is classified as groundwater dependent when groundwater is relied on for plant growth and photosynthesis throughout the year (Eamus 2009). A national atlas of groundwater dependent ecosystems (GDEs) has been developed by the Bureau of Meteorology. A search into this database indicates the vegetation in the area surrounding MRO has low to moderate potential for groundwater dependency. It also suggests that there are no significant inflow dependent ecosystems at this site.

Historical Impacts

Mining at Mount Rawdon dates back to 1946 when alluvial gold was discovered. This led to the establishment of a ten-head stamp battery in 1950 that treated ore from small shallow pits, shafts and open cuts predominantly on the southern slopes of Mount Rawdon. Mining was discontinued in 1953. Approximately 6kg of gold was extracted from 758 tonnes of ore during this time (Angus and Lewis 1996). Environmental regulations and monitoring requirements of groundwater during the initial phases of mining at Mount Rawdon was considerably less stringent. Disposal of chemicals used in the gold processing during this period is expected to have modified the quality of waters around the MRO.

Agricultural activities including cattle grazing are also known to modify surface and ground water quality particularly through the introduction and mobilisation of nutrients, salts and agrochemicals (Bolger and Stevens 1999). The hydrologic system and associated aquatic ecosystems in the area surrounding MRO had been modified by anthropogenic activities prior to commencement of present operations.

4.5 Environmental Values for Groundwater

Environmental values for groundwater are not set out in the BMRG WQIP (2010).
ANZECC 2000 guidelines indicate that all water resources should be subject to at least one of the assigned environmental values, noting environmental values are often interdependent. Each of the default environmental values provide in ANZECC 2000 have been considered with respect to groundwater at MRO. The environmental values for groundwater at MRO are set out in Table 24.

This EA amendment application does not propose any alteration to extractive or processing activities at MRO that would increase the risk of impact to the environmental values of groundwater in the region.

Table 24: Environmental values associated with groundwater at MRO

ENVIRONMENTAL VALUE	MANAGEMENT GOALS	APPLICABILITY	RELEVANCE	APPLICABLE GUIDELINE
Livestock groundwater use	Ensure groundwater is sufficient as a supplementary source of water for livestock	Yes	Commercial activities in the region include mining and cattle grazing for beef production. Groundwater is used for livestock watering in the region as a supplementary source along with the use of surface water, however groundwater is not used extensively in the areas adjacent to MRO	ANZECC Guidelines –Livestock Drinking water for all surface waters
Historic/cultural value	Aesthetic, historical, scientific, social or other significance, to past, present or future generations	Yes	Disposal of chemicals used in historic gold processing is expected to have modified the quality of waters at MRO site. Agricultural activities including cattle grazing are also known to modify ground water quality particularly through the introduction and mobilisation of nutrients, salts and agrochemicals (Bolger and Stevens 1999)	
Aquatic ecosystems	Protection/enhancement of aquatic ecosystem values, habitat and wildlife	No	There are no groundwater dependent ecosystems associated with groundwater with the TSF. No significant inflow dependent ecosystems are present. The hydrologic system and associated aquatic ecosystems in the area surrounding MRO had been modified by anthropogenic activities prior to commencement of present operations	Current EA requirements and ANZECC guidelines for 95% level of protection
Drinking water	Suitability of raw drinking water supply	No	The groundwater system underlying MRO has a water quality that is unsuitable for human consumption as it is above the drinking water guideline for aesthetics. Groundwater is not used for drinking purposes due to the ease of obtaining mains water and rainwater.	
Recreational use	Health of humans during recreation involving direct and indirect contact	No	Not applicable because recreational use, whether by means of full body contact or visual aesthetics, is not possible.	ANZECC recreation guidelines – Visual use – no interaction

4.6 Groundwater Quality Objectives

The QWQG (EHP 2009) does not specifically address groundwater. The ANZECC (2000) guideline maintains applicability to groundwater in the context of its interaction with surface water and above ground uses of groundwater. For the purpose of this report, QWQG is assumed to have the same applicability. In summary, the applicability of ANZECC (2000) and the QWQG (2009) guidelines to groundwater relates to above ground uses of groundwater only. Comments related to groundwater management in the ANZECC (2000) have been reproduced below.

> *"Groundwater should be managed in such a way that when it comes to the surface, whether from natural seepages or from bores, it will not cause the established water quality objectives for these waters to be exceeded, nor compromise their designated environmental values."* (ANZECC 2000).

Based on the aboveground uses and environmental values of groundwater discussed earlier and summarised in Table 24, the water quality objective for groundwater at MRO should be to meet the ANZECC (2000) stock watering guideline values at regional groundwater monitoring locations.

Possible Impacts to Environmental Values

1. Changing the Groundwater Monitoring Program

This EA amendment application does not include any proposed changes to the spatial extent, duration or volume of extractive or processing activities at MRO. There is no proposed additional surface disturbance. This EA amendment application does not include a direct increased risk of environmental harm to the environmental values of groundwater on site.

Arguably the groundwater monitoring program assists in the prevention of environmental harm through providing environmental managers at MRO with information on the quality of groundwater at the site and detecting changes in that groundwater quality. The possible impacts to environmental values will be treated in this report in terms of a risk posed to the environmental values of groundwater by a change in monitoring of that groundwater.

2. Unplanned and Uncontrolled Releases

While this EA amendment does not propose changes in mining activities that would lead to unplanned and/or uncontrolled releases, Guideline EM963 identifies seepage through the floor or walls of waste water and contaminant treatment or storage lagoons as a common source of contaminants. The current seepage monitoring program at MRO is designed to identify seepage infiltration to groundwater at the site.

The proposed monitoring program takes seepage monitoring a step further, utilising historical dataset evidence that sulfate and salinity are early indicators to design a monitoring system that offers early warning of the first arrival of seepage at a bore. The proposed program adopts the compliance levels listed in the current program as trigger levels for further investigation (RPS 2015a). This approach to seepage monitoring at MRO should allow for a more focused approach to early identification of seepage, allowing rapid response and mitigation.

3. Water Infrastructure

This EA amendment does not include any changes to water storage infrastructure at MRO. Existing water infrastructure at MRO is detailed in Table 25. The revised groundwater monitoring program continues to monitor potential impacts from water storages on site on the groundwater at MRO.

Table 25: Location and storage capacities of water storage facilities at MRO

DAM	LOCATION	RELEASE DESTINATION	MAXIMUM CAPACITY (ML)	REGULATED
TSF	Northwest of west waste rock dump		3,207.4	Yes
WD1	North of North Dump base	Twelve Mile Creek	220.8	Yes
WD2	Northeast of North Dump base	Twelve Mile Creek	101.6	Yes
WD3	East of North Dump base	Twelve Mile Creek	35.8	Yes
WD4	South east of North Dump base	Twelve Mile Creek	72.2	Yes
Sediment Dam 1 (SD1)	Northeast of TSF base	SD2	15.7	Yes
West Dam	Southeast of West WRD	Mingham Creek	397.7	Yes
Process Water Ponds	Adjacent to Processing Plant	South Dam	11.1	Yes
South Dam	South of the TSF southern wall	West Dam	327.8	Yes

4. Groundwater Interaction with Surface Water

4.1 Seepage at MRO

Aquifers at MRO are mostly low yielding, fracture controlled and limited in their extent. There are no permanent surface water bodies that are directly fed by groundwater at MRO, though it is recognised there is potential for groundwater (and seepage-infiltrated groundwater) to enter local creeks as baseflow and be conveyed downstream to aquatic ecosystems (RPS 2015b). Swindon Creek, Rawdon Creek and the Unnamed Creek may form preferential seepage pathways downstream of the TSF. For this reason the revised groundwater seepage monitoring program includes primary, secondary and tertiary seepage monitoring bores on each creek line and the regional monitoring program will use exceedance of trigger values as a prompt to commence an investigation.

The intention behind the use of sulfate and salinity as early indicators of the arrival of a seepage front is to trigger an investigation that will confirm if a bore has been impacted by seepage. When a regional monitoring bore is confirmed as seepage impacted, its status will change to an investigation bore. Depending on the location and distribution of other bores in proximity to the impacted bore, a new regional monitoring bore may be installed downstream of the impacted bore to provide adequate regional monitoring coverage (RPS 2015a).

In an addendum to the regional monitoring bore program memorandum, RPS (2015c) pointed out that the process of re-categorising regional bores to investigation bores and the installation of new downstream bores is not intended as a never-ending process ahead of an ever expanding seepage front.

RPS (2015c) describes the following driving principles in overall seepage management and monitoring:

- Seepage should not be permitted to egress the site and impact on the regional environment (defined as just downstream of the lease boundaries or the effective hydrologic boundaries of the site),
- Bores closest to and immediately downstream of the WRDs and TSF are designed to detect and track seepage.
- If seepage is detected in these bores through monitoring of the key indicators, sulfate and salinity, this will trigger an investigation.
- If the investigation confirms the arrival of seepage, the following would occur:
  - Implementation of a seepage recovery/mitigation plan,
  - Re-categorisation of monitoring bores and installation of new regional bores as required,
  - Monitoring to confirm the performance of the seepage recovery/mitigation plan.
- Regional monitoring bores at groundwater egress points are intended to quantify the water quality of groundwater leaving the site and confirm the absence of seepage that might impact the receiving environment.

4.2 Monitoring Parameters

The proposed monitoring parameters for the regional monitoring bores identifies that in practice the specified contaminant limits in the EA act as both compliance and trigger levels. RPS (2015b) recommends:

- The list of metals and trace elements to be monitored be revised to include elements that are characteristic of waste rock/ore at MRO. This includes copper, zinc, cadmium, lead, arsenic and selenium.
- Sulfate and nitrate should be removed as compliance parameters but continue to be monitored for trigger levels and data used for interpretation only.
- Salinity as TDS is calculated from electrical conductivity and so both parameters do not need to be reported.
- General anions and cations (i.e. sodium, magnesium, potassium, chloride, carbonate and bicarbonate) should be included in monitoring as these parameters allow for the characterisation of water types, but no trigger or compliance levels should be applied to these parameters.

The environmental value for groundwater at MRO is as livestock watering and no other environmental values apply. This recognises the value of groundwater at site as it comes to the surface and is used at the surface, in accordance with ANZECC recommendations. On this basis, RPS (2015b) proposes the current contaminant limits in the EA (with some modifications as described above) should be adopted as trigger levels for investigation and the compliance levels should be based on ANZECC guidelines for stock watering.

4.3 Receiving Environment Monitoring

Also recognising the potential for groundwater to contribute to baseflow in the creeks at MRO, the compliance limits for parameters with the potential to have a greater impact on aquatic ecosystems should be set at the ANZECC guideline for aquatic ecosystem protection. The proposed parameters for the regional groundwater monitoring program at MRO are included in Table 15 on page 30 of this report.

Aquatic ecology surveys have previously been completed at MRO for receiving environment sites in the wet and dry seasons, providing a good indication of the background habitat quality present at site, and the range and quality of the macroinvertebrate assemblage present at surveyed sites. Macroinvertebrate assemblages present in Rawdon Creek and the Perry River following the wet season of 2013 showed impacts from the extreme rainfall event and subsequent flooding that took place in January 2013 (please refer to section 2, Climate in this report, and within that section refer to Rainfall Intensity on page 41). A large percentage of tolerant taxa were present at that time. Results from these streams in the following dry season (nearly 11 months after the flood events) concluded that the macroinvertebrate assemblages were recovering from these flooding impacts, but still consisted of tolerant taxa indicative of ephemeral streams that are undergoing evapotranspiration during the dry season.

It is unlikely sensitive macroinvertebrate taxa are present within receiving environment streams at MRO due to the highly ephemeral nature of these streams, and the anthropogenic impacts these stream have already experienced through livestock grazing and historical mining in the region.

Conclusion

The groundwater monitoring program at MRO is comprehensive but would benefit from a greater focus and efficiency. A revision of the regional groundwater monitoring program was conducted at the request of EHP and included in an action plan to address regional groundwater quality. The seepage monitoring program revision was conducted to ensure the entire groundwater monitoring program at MRO was thoroughly reviewed and understood. This EA amendment draws on those reviews to increase the effectiveness of seepage monitoring and regional groundwater quality monitoring across the site.

As per the monitoring program reviews (RPS 2015a, 2015b), the existing program is recognised as providing a good monitoring coverage of the potential impacts of the TSF on regional and local groundwater, and of the potential impacts of non-TSF related site activities on regional groundwater at MRO.

Some of the monitoring requirements in the EA conditions for both regional and seepage monitoring are considered to be superfluous and do not add any real value to the effectiveness of the existing monitoring program. The RPS memoranda identify that significant improvement to both the regional and seepage monitoring programs could be achieved using the minor refinements detailed in this EA amendment application.

The modifications to the groundwater monitoring program at MRO detailed in this EA amendment result in no net reduction in the number of compliance bores to be monitored. The recommended modifications will result in a broader and more effective monitoring of potential impacts on groundwater at MRO from all site activities. The proposed program is consistent with the monitoring aims defined in the EA and allows both regional and seepage monitoring to provide a more meaningful understanding of the evolution of groundwater quality at MRO.

References

Alan Watson Associates. (2012). Tailings storage facility Stage 3d lift construction (RL163.0m) design report. Prepared for Mount Rawdon Pty. Ltd.

Angus, M. and Lewis, R. W. (1996). Mt Rawdon Project Feasibility Study. Placer Pacific Limited, Sydney, Australia.

Bolger, P. F., & Stevens, M. A. (1999). Contamination of Australian groundwater systems with nitrate. Land & Water Resources Research & Development Corporation.

Bouwer, H., & Rice, R. C. (1976). A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research, 12(3), 423-428.

Brodie, R. Kilgour, B. (1998). Principal Hydrogeological Divisions of Australia (National Geoscience Dataset). Geosciences Australia. ANZLIC unique identifier: ANZCW0703002666

Bureau of Meteorology (2015). List of weather stations in proximity to MRO as presented in Table 17 of this document.

Burnett Mary Regional Group (BMRG) (2010) Burnett-Baffle Water Quality Improvement Plan.

Department of Environment and Heritage Protection (EHP) (2009). Queensland Water Quality Guidelines.

Department of Environment and Heritage Protection (EHP) (2015a). Guideline EM944: Model mining conditions (Version 5).

Department of Environment and Heritage Protection (EHP) (2015b). Guideline EM963: Application requirements for activities with impacts to water (Version 2).

Department of Natural Resources and Mines (DNRM). (2013). HYSITREP - Site Summary Report. 136019A - Perry River at Mt Rawdon. Government of Queensland. Available online: http://watermonitoring.derm.qld.gov.au/host.htm

Eamus, D. (2009). Identifying Groundwater Dependent Ecosystems. Australian Government – Land & Water Australia. Product ID PN30129.

Fetter, C. W. (1994). Applied hydrogeology (Vol. 691). Upper Saddle River: Prentice Hall.

Heath, R.C. (1983). Basic ground-water hydrology, U.S. Geological Survey Water-Supply Paper 2220, 86p.

Howell, S., Zann, M. and Rollason, S. (2010). Aquatic conservation assessments (ACA) using AquaBAMM for the riverine and non-riverine wetlands of the Wide Bay-Burnett catchments. Department of Environment and Resource Management, Queensland Government.

KH Morgan Geological Consultants Pty Ltd (2006). “Review of groundwater chemistry Mt Rawdon Gold Mine”, prepared for Equigold, Project No. 917.

Klohn Crippen Berger (KCB). (2012). Drilling and Bore Completion Report Tier 1 Groundwater Monitoring Bores. Prepared for Mount Rawdon Operations Pty. Ltd.

Nguyen (1998). Lower Burnett River dam sites initial engineering appraisal study: Hydrologic and hydraulic investigations. Surface water assessment group, Department of Natural Resources, Government of Queensland.

NRC (2013). Memorandum on the Rationale for Relocation of Bores MRMB24 and MRMB51.

NRC (2014). Investigation into Elevated Cyanide at MRMB8 and MRMB9 and Discussion Regarding the Suitability of these Bores as Tailings Seepage Monitoring Bores – Technical Note.

Northern Resource Consultants. (2014b). Numerical Modelling Report: Groundwater Flow. Report submitted to Mount Rawdon Operation Pty. Ltd.

NRC (2015). Mount Rawdon Operations Groundwater Monitoring Bore Census.

Papadopulos, I. S., & Cooper, H. H. (1967). Drawdown in a well of large diameter. Water Resources Research, 3(1), 241-244.

RGS (2014). Investigation of potential seepage issue and non-compliance below Mt Rawdon TSF. Project Number 201417.

RPS (2015a). Memorandum: Seepage Monitoring Programme – Review and Rationalisation.

RPS (2015b). Memorandum: Regional Bore Monitoring Programme – Review and Rationalisation.

RPS (2015c). Regional Bore Monitoring Programme – Addendum.

Van Manen (1999). An Ecological and Physical Assessment of the Condition of Streams in the Burnett, Kolan and Burrum River Catchments. Department of Natural Resources Management. Brisbane.

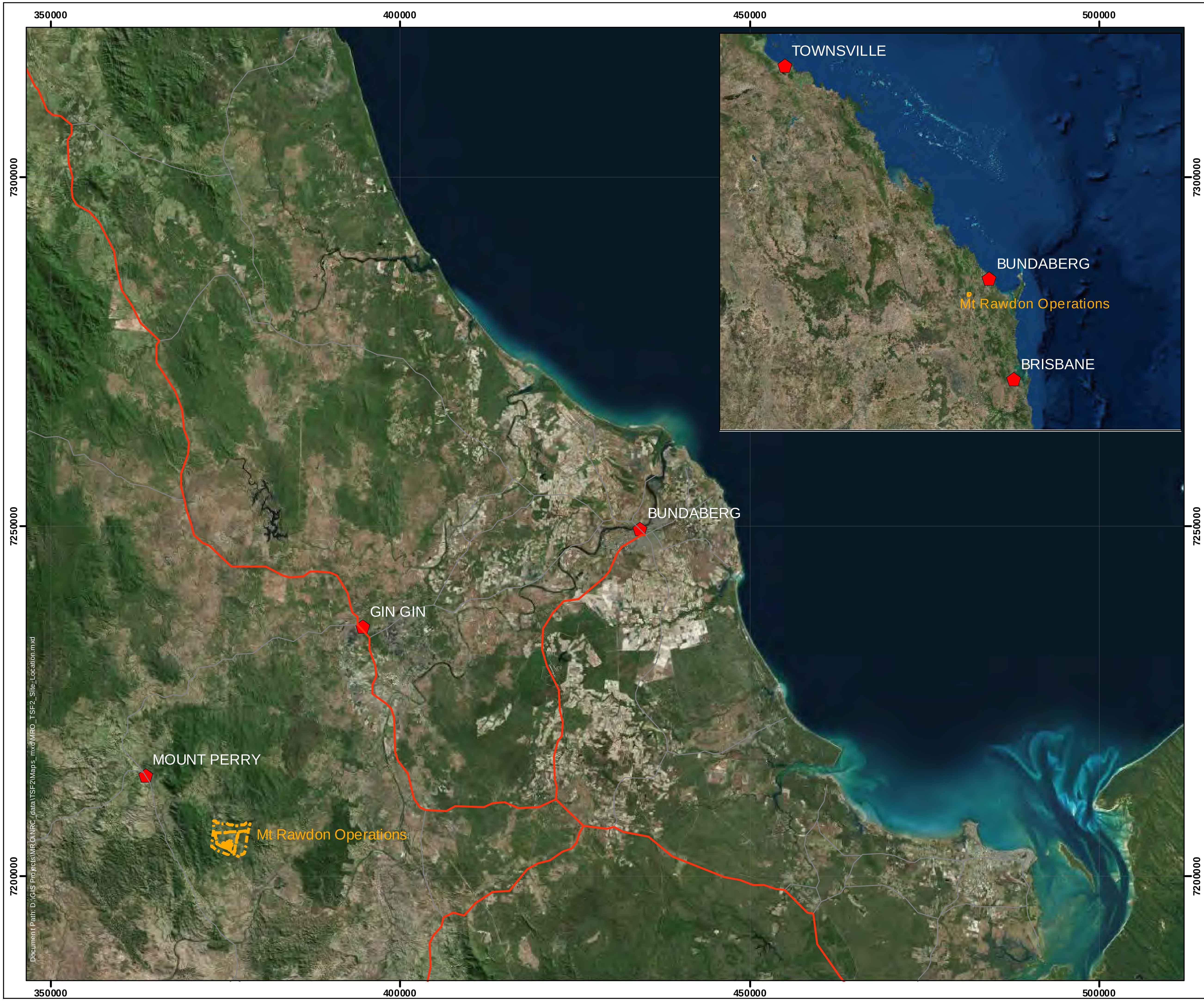
Appendix summary

Appendix A

Maps

The following maps are included in this appendix:

1. Site location
2. Cadastral boundaries and land tenure
3. All bores referenced in this report
4. Bores included in the August 2015 EA
5. Decommissioned bores and bores recommended for decommissioning
6. Proposed seepage monitoring bores including dual status bores
7. Detailed revised seepage program indicating primary, secondary and tertiary bores
8. Proposed regional monitoring bores including dual status bores
9. Proposed investigation bores
10. Detailed revised regional program indicating regional, dual status and investigation bores
11. Topography and hydrology



MOUNT RAWDON OPERATIONS

SITE LOCATION

Legend

- Towns
- Highways
- Roads
- Mine Lease

Notes:
Mine Lease boundary extracted from ml.shp, State of Queensland.
Highways and roads sourced from Physical Road Network, State of Queensland.
Towns sourced through Place Names Gazetteer, State of Queensland.
Imagery sourced through ArcGIS Basemaps.

10 5 0 10
Kilometers
Scale: 1:500,000 at A3

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 23/02/2015
Document Name: MRO_TSF2_Site_Location

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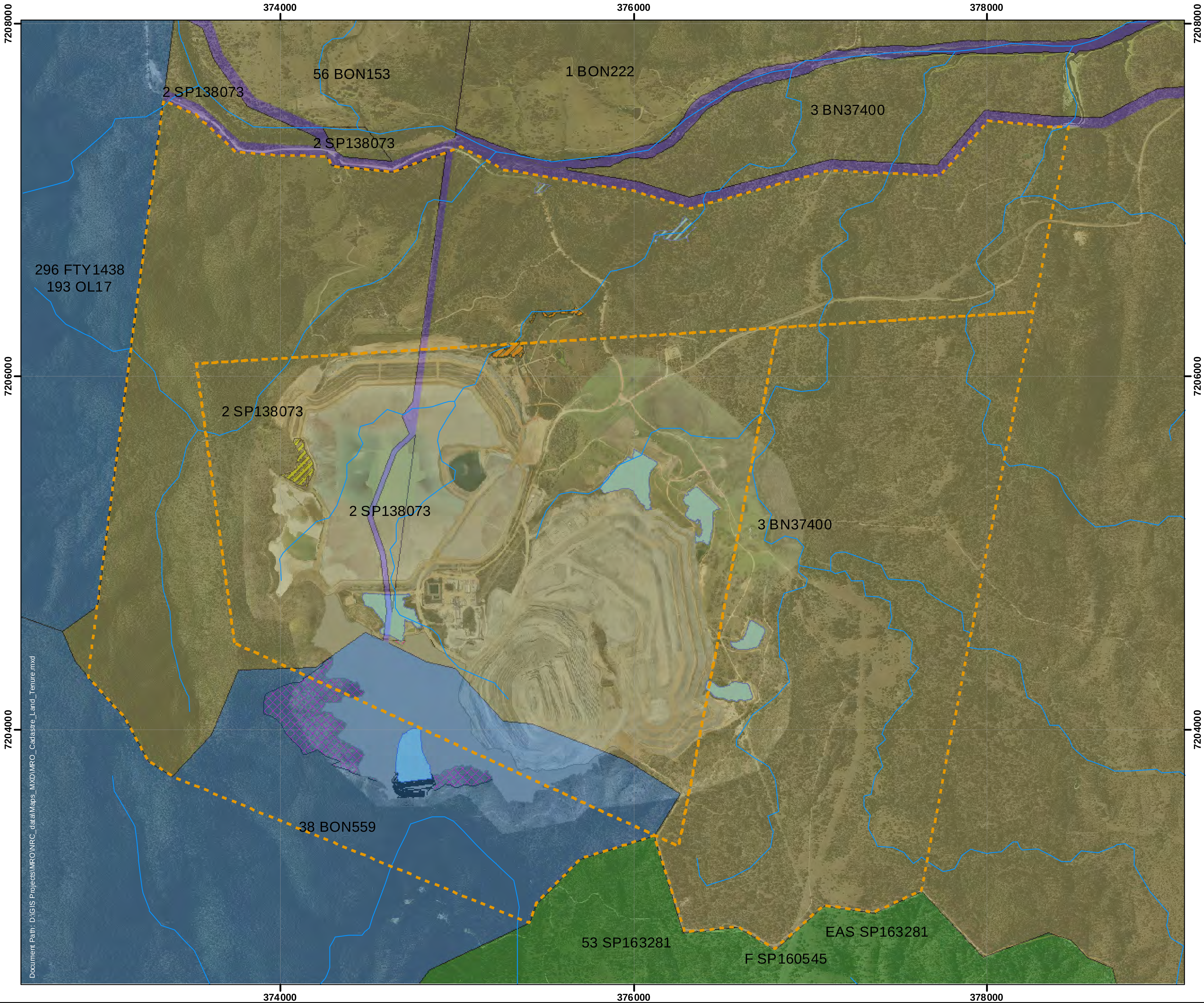

MOUNT RAWDON OPERATIONS

CADASTRAL BOUNDARIES AND LAND TENURE

Legend

- Mine Lease
- Watercourse

Land Tenure and Cadastral Boundaries

- No Classification
- Easement
- Freehold
- Lands Lease
- Timber Reserve

Dams

- Existing Dam
- Proposed Dam
- Replaced Dam
- West Dam Embankment
- Cleared area associated with Stage 4 Expansion
- Approved area associated with Stage 4 Expansion (not yet cleared)
- Approved Area associated with Stage 4 (175m)

Notes:
Proposed infrastructure layers sourced from client.
Mine Lease boundary provided by client
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Cadastre and Land Tenure from: IQ_QLD_CADASTRETENURE_DCDB_CUR.shp (North Burnett Regional Council, 2013)
Imagery supplied by client : Evolution_Mining_overall_15cm.ecw (2013), supplemented with E016_MRO_Master_150927_25cm_Moasic.ecw

400 200 0 400
Meters
N

Scale: 1:20,000 at A3

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015

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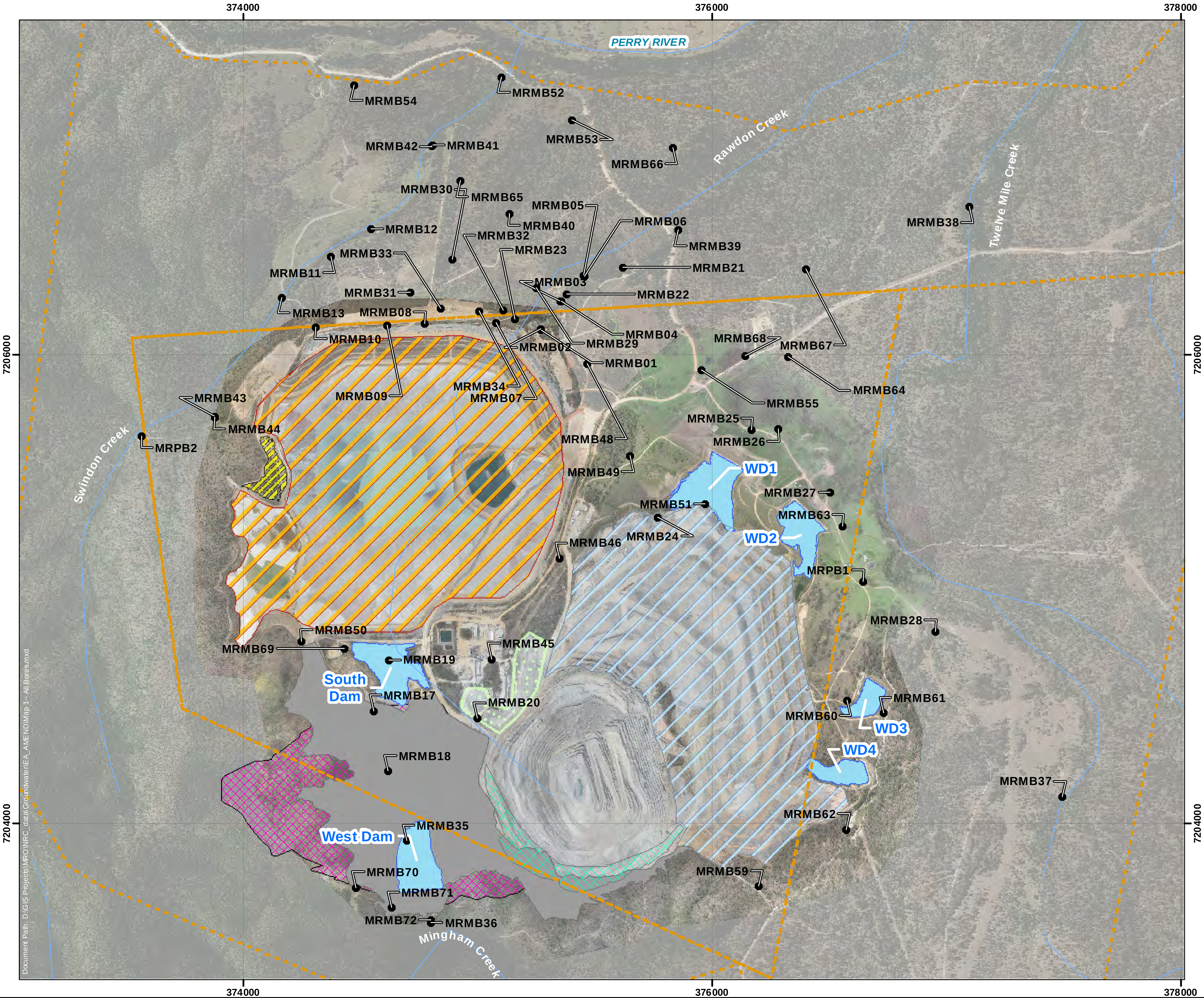

MOUNT RAWDON OPERATIONS

ALL BORES

Legend

Bores

- Bores
- Mine Lease
- Major Watercourse
- Minor Watercourse

Site Infrastructure

- North WRD
- ROM
- TSF 1
- Pit Cutback
- Existing Dam
- Cleared area associated with Stage 4 Expansion
- Approved area associated with Stage 4 Expansion (not yet cleared)
- Approved Area associated with Stage 4 (175m)

Notes:
Mine Lease boundary provided by client
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client: Evolution_mining_overall_15cm.ecw (2013).
Mining areas supplemented with E016_MRO_Master_150927_25cm_Moasic.ecw

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Meters
Scale: 1:15,000 at A3

N

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015
Document Name: Map 1 - All Bores

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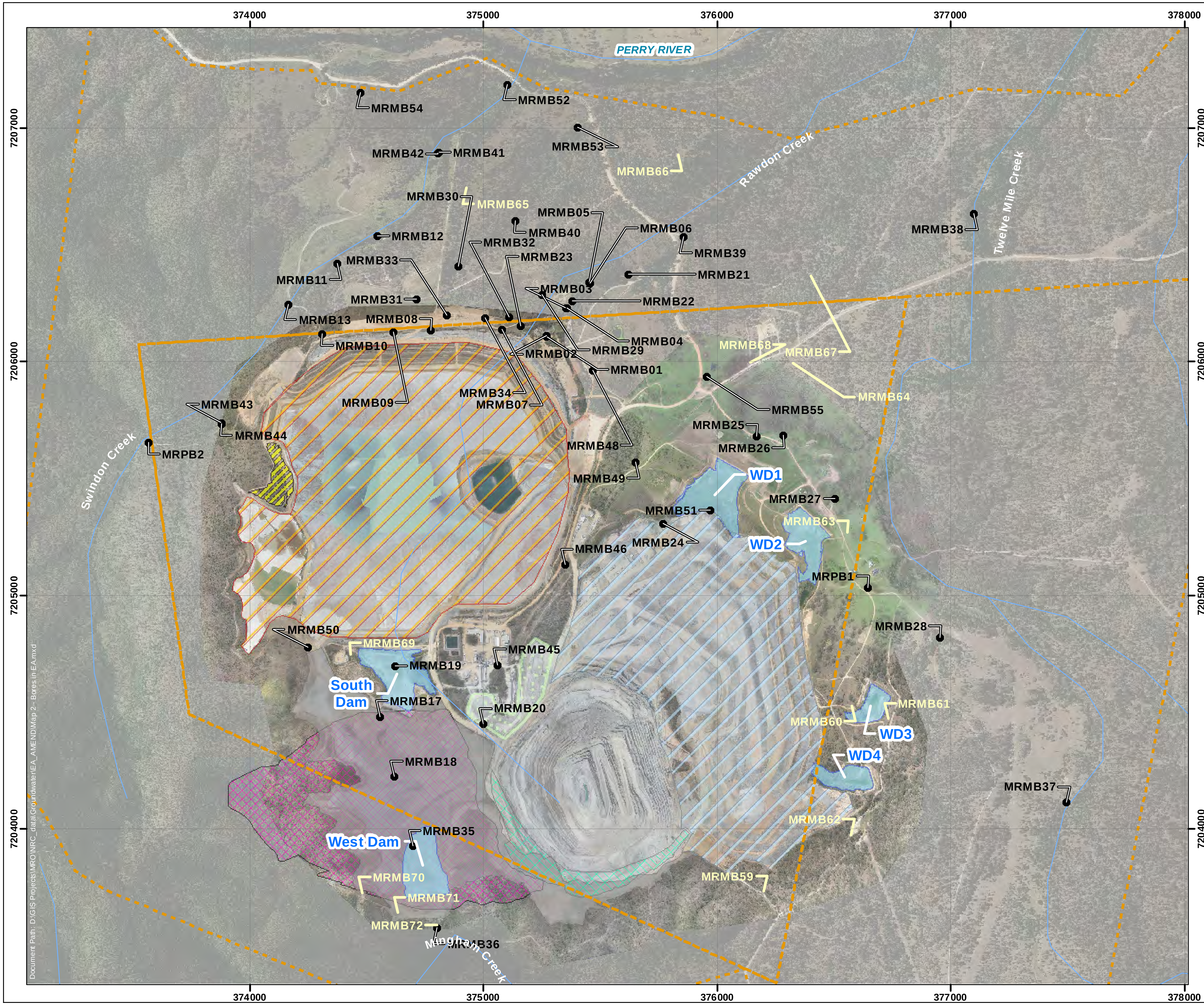

MOUNT RAWDON OPERATIONS

BORES INCLUDED IN AUGUST 2015 EA

Legend

Bores

- Bores not in EA
- Bores in EA
- Mine Lease
- Major Watercourse
- Minor Watercourse

Site Infrastructure

- North WRD
- ROM
- TSF 1
- Pit Cutback
- Existing Dam
- Cleared area associated with Stage 4 Expansion
- Approved area associated with Stage 4 Expansion (not yet cleared)
- Approved Area associated with Stage 4 (175m)

Notes:
Mine Lease boundary provided by client
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client: Evolution_mining_overall_15cm.ecw (2013), E016_MRO_Master_150927_25cm_Moasic.ecw

300 150 0 300
Meters
N

Scale: 1:15,000 at A3

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994

Date: 4/11/2015
Document Name: Map 2 - Bores in EA

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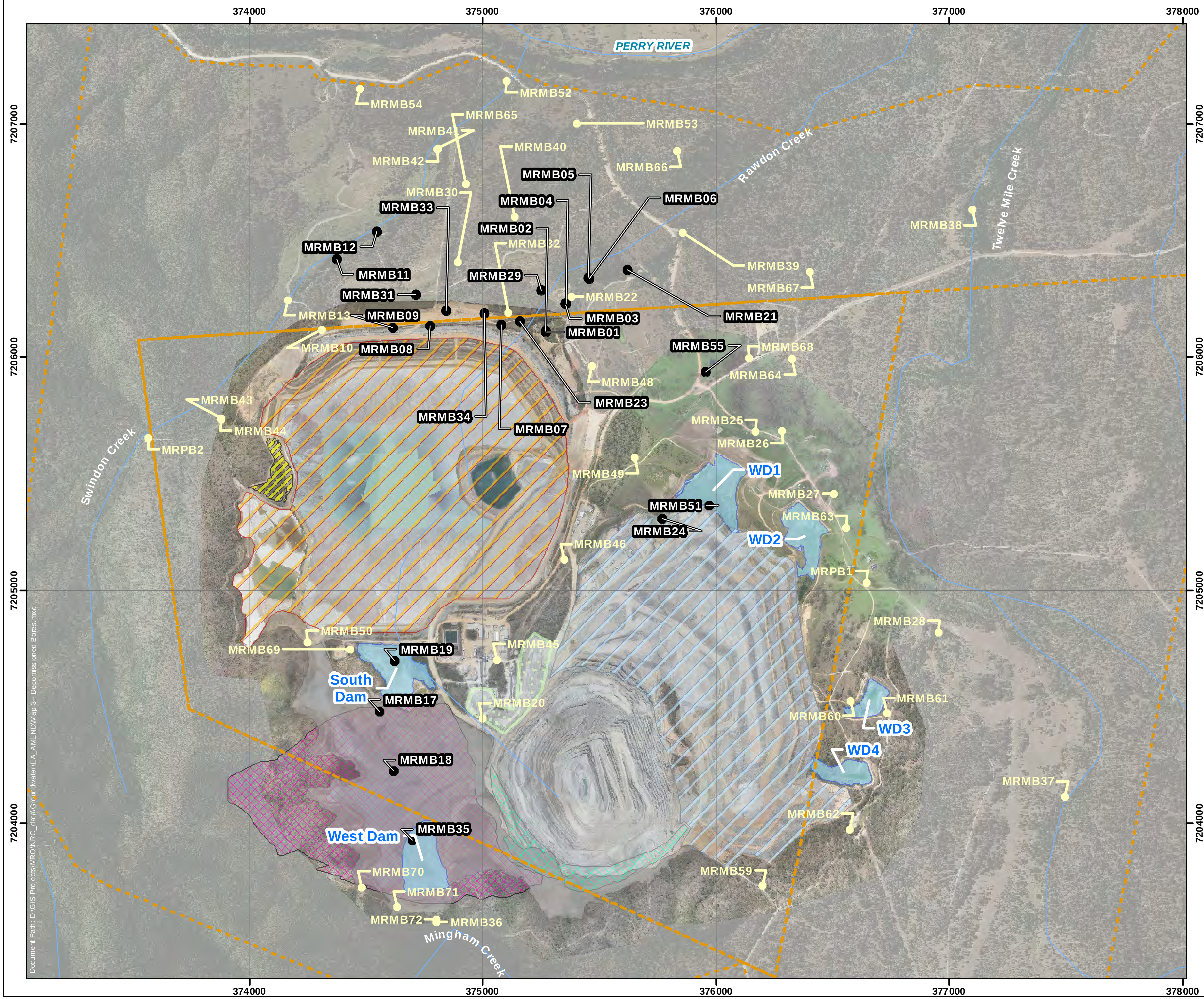

MOUNT RAWDON OPERATIONS

DECOMISSIONED BORES AND BORES TO BE DECOMISSIONED

Legend

- All Other Bores
- Decomissioned and to be Decomissioned
- Major Watercourse
- Minor Watercourse
- Mine Lease

Site Infrastructure

- North WRD
- ROM
- TSF 1
- Pit Cutback
- Existing Dam
- Cleared area associated with Stage 4 Expansion
- Approved area associated with Stage 4 Expansion (not yet cleared)
- Approved Area associated with Stage 4 (175m)

Notes:
Mine Lease boundary provided by client State of Queensland.
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client: Evolution_mining_overall_15cm.ecw (2013), supplemented with E016_MRO_Master_150927_25cm_Moasic.ecw

300 150 0 300
Meters

Scale: 1:15,000 at A3

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015
Document Name: Map 3 - Decomissioned Bores

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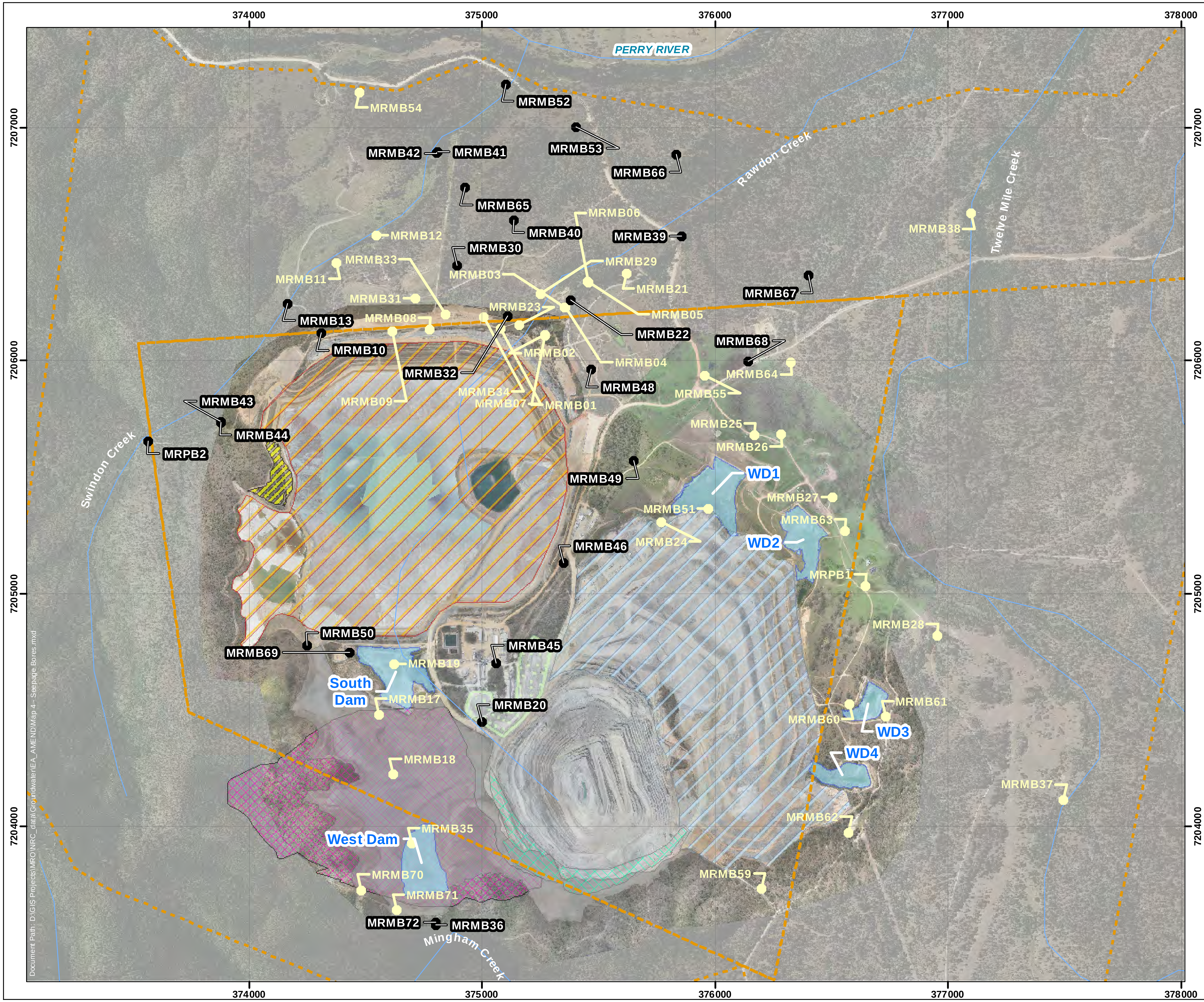

MOUNT RAWDON OPERATIONS

SEEPAGE BORES

Legend

- All Other Bores
- Seepage Bore
- Mine Lease
- Major Watercourse
- Minor Watercourse

Site Infrastructure

- North WRD
- ROM
- TSF 1
- Pit Cutback
- Existing Dam
- Cleared area associated with Stage 4 Expansion
- Approved area associated with Stage 4 Expansion (not yet cleared)
- Approved Area associated with Stage 4 (175m)

Notes:
Mine Lease boundary provided by client
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client: Evolution_mining_overall_15cm.ecw (2013), supplemented with E016_MRO_Master_150927_25cm_Moasic.ecw

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Meters
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Scale: 1:15,000 at A3

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015
Document Name: Map 4 - Seepage Bores

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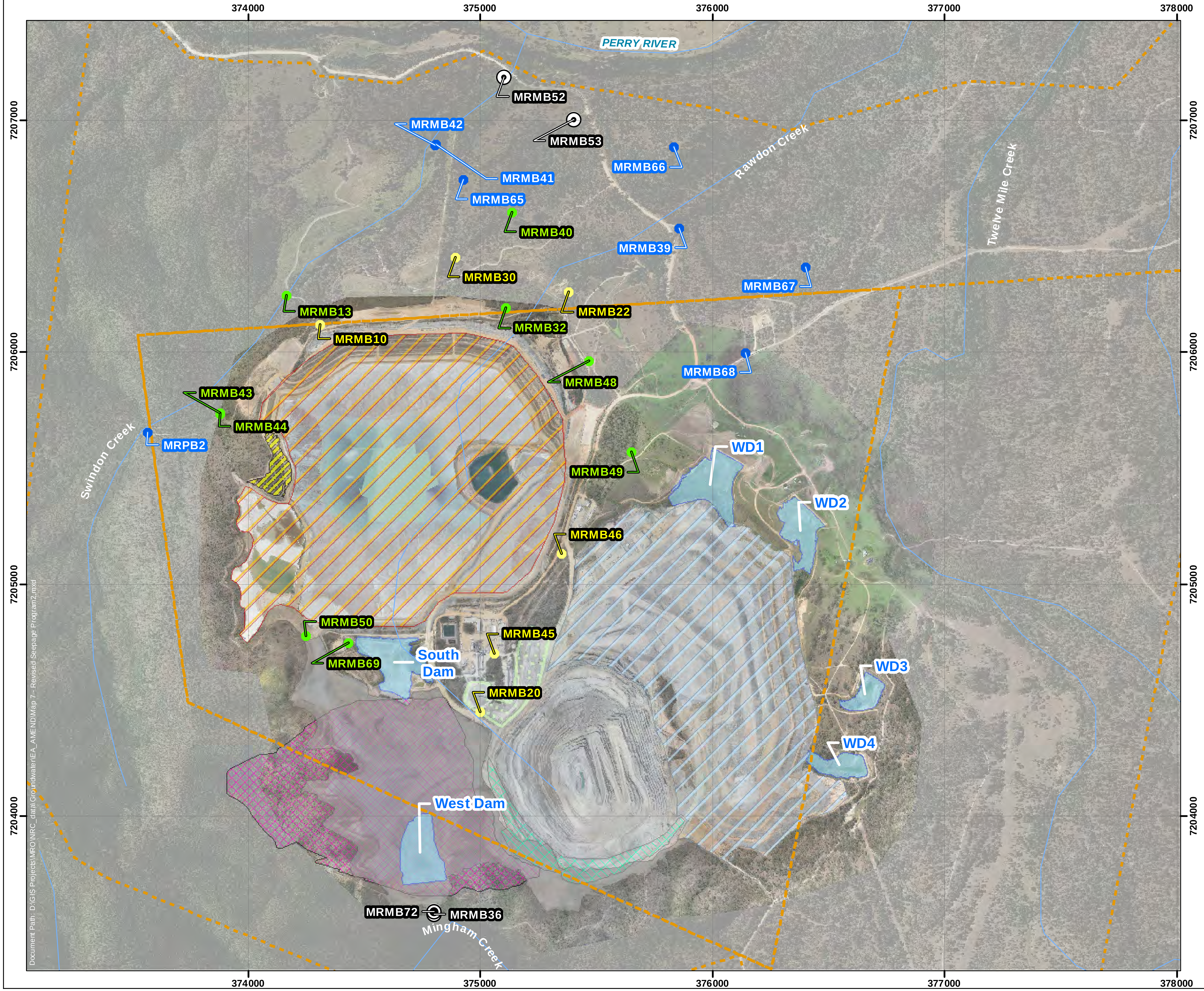
northern resource consultants



MOUNT RAWDON OPERATIONS

REVISED SEEPAGE PROGRAM

Legend

- Regional and Seepage
- Regional and Secondary Seepage
- Primary Seepage
- Secondary Seepage
- Tertiary Seepage
- Mine Lease
- Major Watercourse
- Minor Watercourse

Site Infrastructure

- North WRD
- ROM
- TSF 1
- Pit Cutback
- Existing Dam
- Cleared area associated with Stage 4 Expansion
- Approved area associated with Stage 4 Expansion (not yet cleared)
- Approved Area associated with Stage 4 (175m)

Notes:
Mine Lease boundary provided by client
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client: Evolution_mining_overall_15cm.ecw (2013), supplemented with E016_MRO_Master_150927_25cm_Moasic.ecw

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Meters
Scale: 1:15,000 at A3

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015
Document Name: Map 7 - Revised Seepage Program

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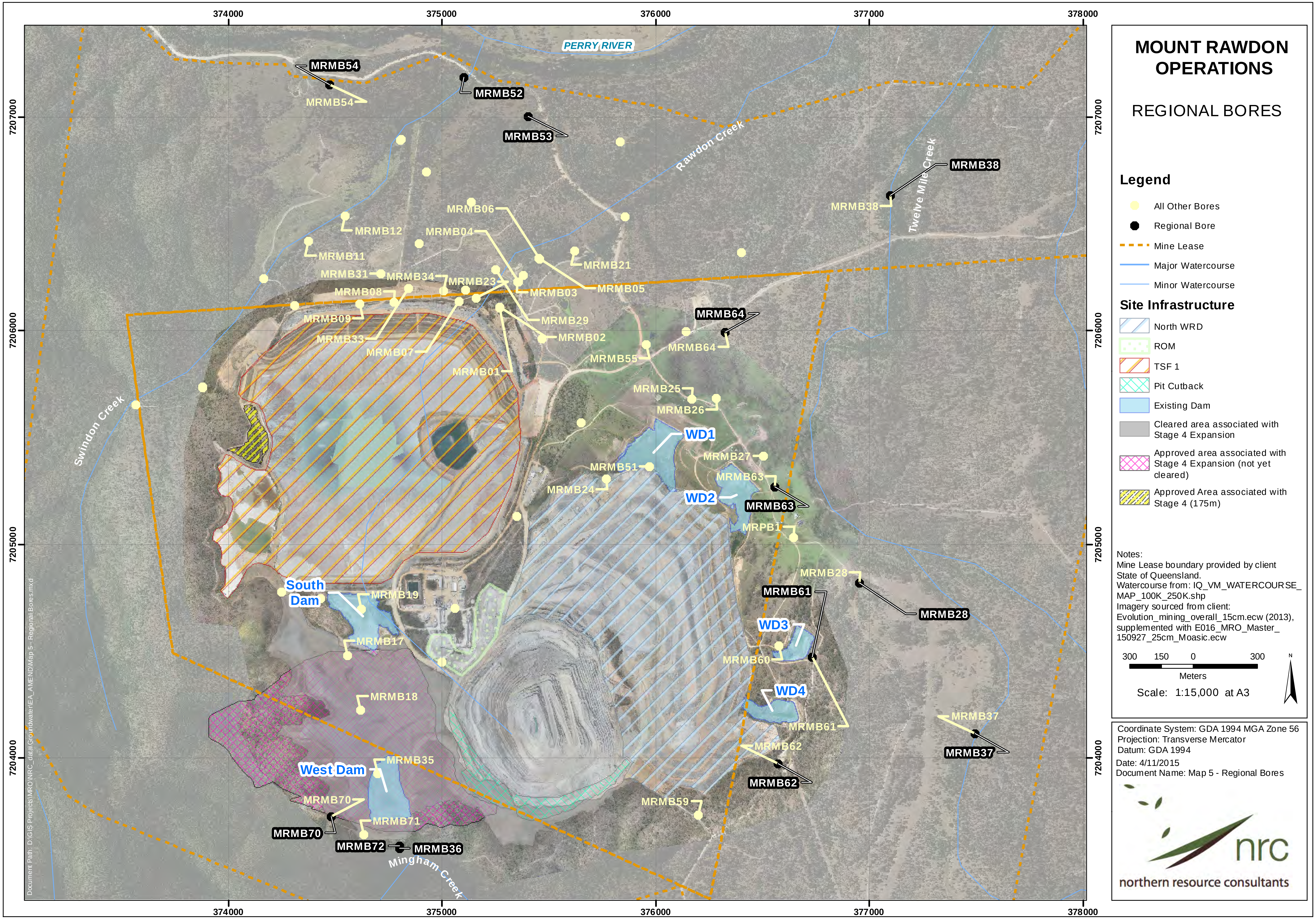
northern resource consultants


MOUNT RAWDON OPERATIONS
REGIONAL BORES
Legend
All Other Bores
Regional Bore
Mine Lease
Major Watercourse
Minor Watercourse
Site Infrastructure
North WRD
ROM
TSF 1
Pit Cutback
Existing Dam
Cleared area associated with Stage 4 Expansion
Approved area associated with Stage 4 Expansion (not yet cleared)
Approved Area associated with Stage 4 (175m)
Notes:
Mine Lease boundary provided by client State of Queensland.
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client: Evolution_mining_overall_15cm.ecw (2013), supplemented with E016_MRO_Master_150927_25cm_Moasic.ecw
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Meters
Scale: 1:15,000 at A3
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015
Document Name: Map 5 - Regional Bores
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PERRY RIVER
Rawdon Creek
Twelve Mile Creek
Swindon Creek
Mingham Creek
South Dam
West Dam
WD1
WD2
WD3
WD4
MRMB54
MRMB52
MRMB53
MRMB38
MRMB06
MRMB12
MRMB04
MRMB11
MRMB21
MRMB31
MRMB34
MRMB23
MRMB05
MRMB08
MRMB03
MRMB64
MRMB09
MRMB29
MRMB33
MRMB02
MRMB07
MRMB55
MRMB01
MRMB25
MRMB26
MRMB27
MRMB51
MRMB63
MRMB24
MRPB1
MRMB28
MRMB61
MRMB19
MRMB17
MRMB60
MRMB18
MRMB37
MRMB62
MRMB35
MRMB70
MRMB59
MRMB71
MRMB72
MRMB36
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375000
376000
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7204000
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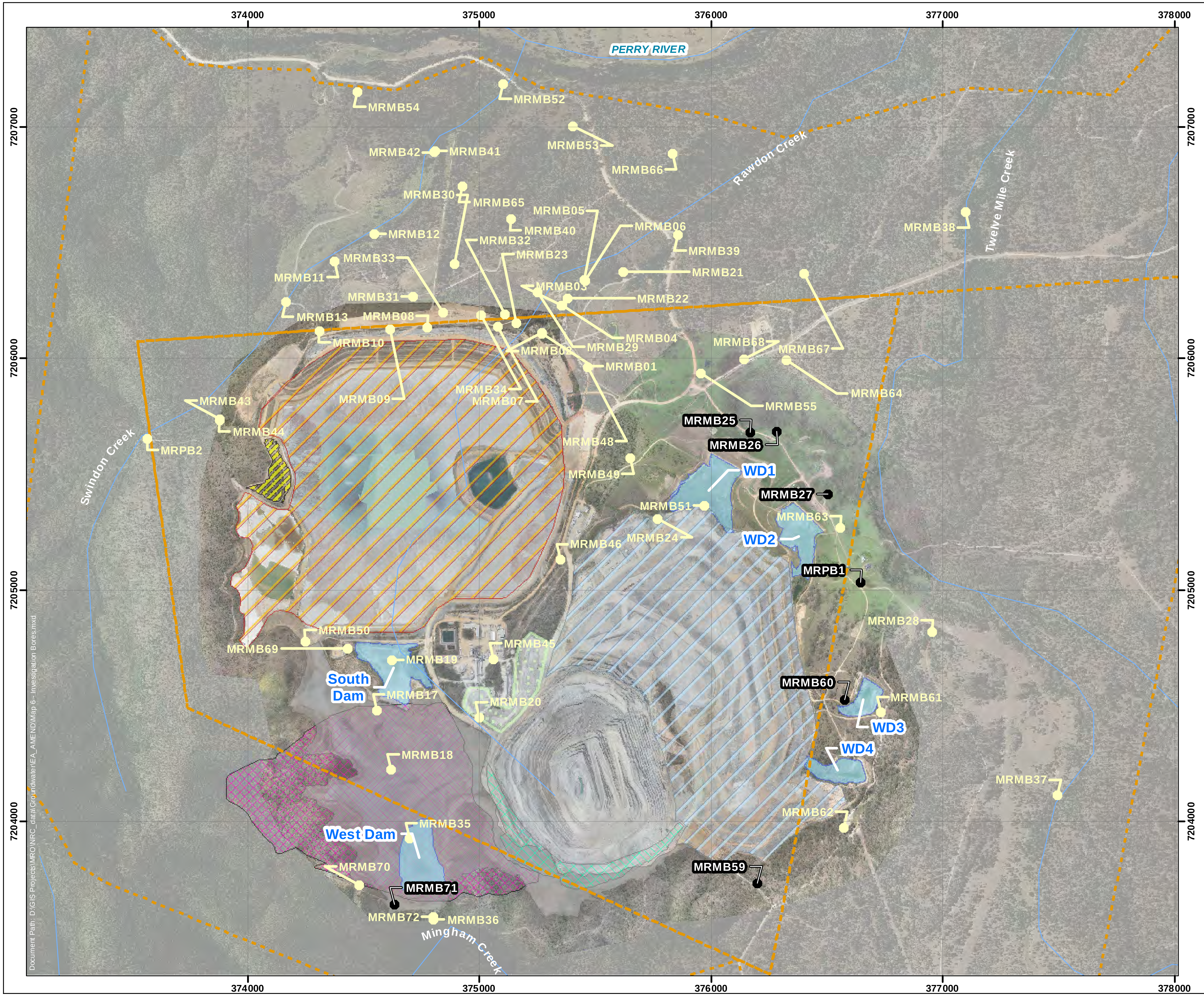

MOUNT RAWDON OPERATIONS

INVESTIGATION BORES

Legend

- All Other Bores
- Investigation Bore
- Mine Lease
- Major Watercourse
- Minor Watercourse

Site Infrastructure

- North WRD
- ROM
- TSF 1
- Pit Cutback
- Existing Dam
- Cleared area associated with Stage 4 Expansion
- Approved area associated with Stage 4 Expansion (not yet cleared)
- Approved Area associated with Stage 4 (175m)

Notes:
Mine Lease boundary provided by client
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client: Evolution_mining_overall_15cm.ecw (2013), supplemented with E016_MRO_Master_150927_25cm_Moasic.ecw

300 150 0 300
Meters
N

Scale: 1:15,000 at A3

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015
Document Name: Map 6 - Investigation Bores

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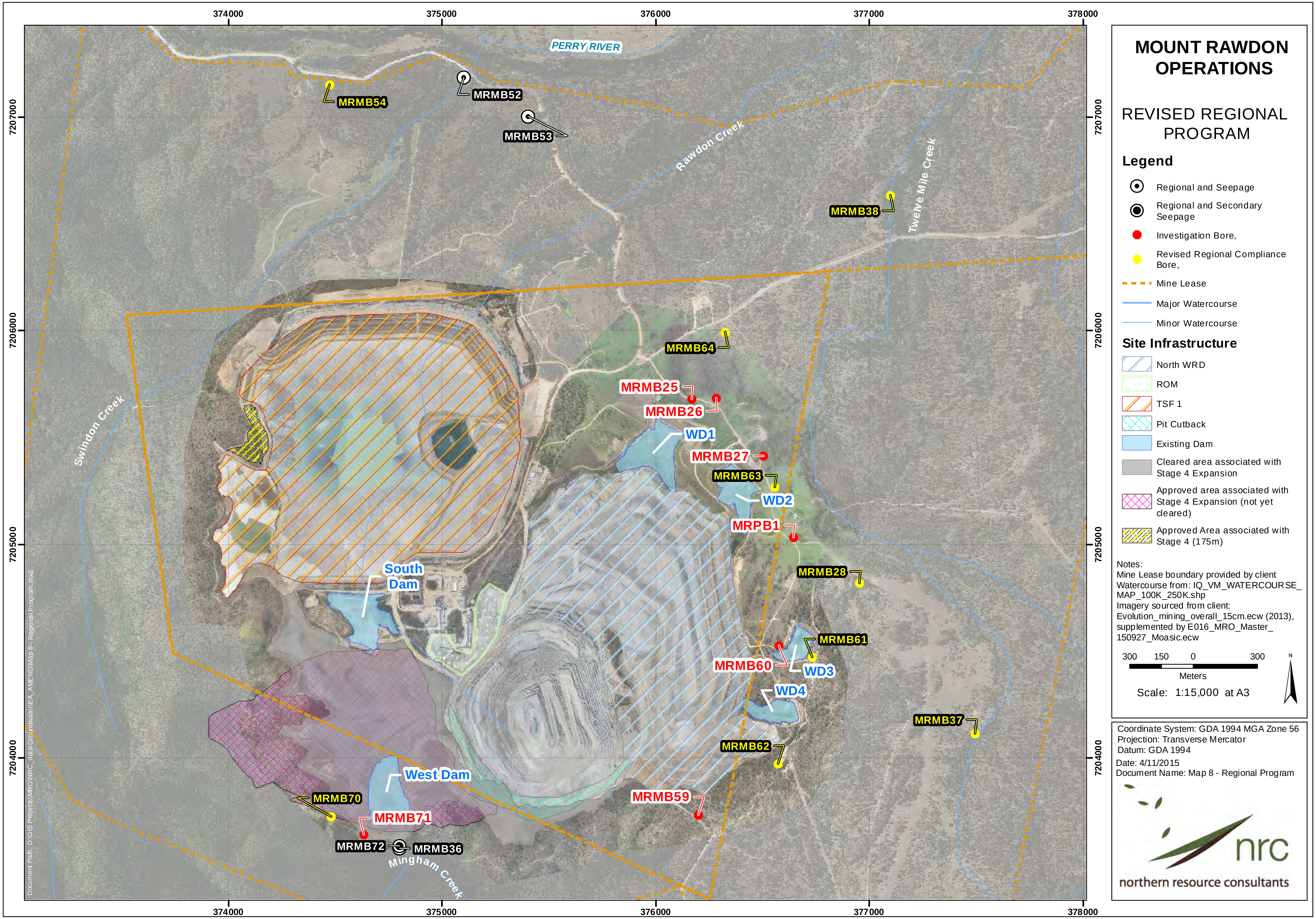

MOUNT RAWDON OPERATIONS
REVISED REGIONAL PROGRAM
Legend
Regional and Seepage
Regional and Secondary Seepage
Investigation Bore,
Revised Regional Compliance Bore,
Mine Lease
Major Watercourse
Minor Watercourse
Site Infrastructure
North WRD
ROM
TSF 1
Pit Cutback
Existing Dam
Cleared area associated with Stage 4 Expansion
Approved area associated with Stage 4 Expansion (not yet cleared)
Approved Area associated with Stage 4 (175m)
Notes:
Mine Lease boundary provided by client
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client: Evolution_mining_overall_15cm.ecw (2013), supplemented by E016_MRO_Master_150927_Moasic.ecw
300 150 0 300
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Scale: 1:15,000 at A3
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Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015
Document Name: Map 8 - Regional Program
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374000
375000
376000
377000
378000
7207000
7206000
7205000
7204000
PERRY RIVER
Rawdon Creek
Twelve Mile Creek
Swindon Creek
Mingham Creek
MRMB54
MRMB52
MRMB53
MRMB38
MRMB64
MRMB25
MRMB26
WD1
MRMB27
MRMB63
WD2
MRPB1
MRMB28
South Dam
MRMB61
MRMB60
WD3
WD4
MRMB37
MRMB62
West Dam
MRMB70
MRMB71
MRMB59
MRMB72
MRMB36
Document Path: D:\GIS Projects\MRO\NRC_data\Groundwater\EA_AMEND\Map 8 - Regional Program.mxd

MOUNT RAWDON OPERATIONS

TOPOGRAPHY AND HYDROLOGY

Legend

- Mine Lease
- Watercourse

Elevation Contours (10m interval)

- Index Contour
- Intermediate Contour
- West Dam Embankment
- Existing Dam
- Cleared area associated with Stage 4 Expansion
- Approved area associated with Stage 4 Expansion (not yet cleared)
- Approved Area associated with Stage 4 (175m)

Notes:
Proposed infrastructure layers sourced from client.
Mine Lease boundary supplied by client
Elevation Contours from: IQ_DEM_10MCONT_50K_NTHBURNETT.shp
Watercourse from: IQ_VM_WATERCOURSE_MAP_100K_250K.shp
Imagery sourced from client:
Evolution_mining_overall_15cm.ecw (2013).
Supplemented with E016_MRO_Master_150927_25cm_Moasic.ecw

400 200 0 400
Meters

Scale: 1:20,000 at A3

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/11/2015
Document Name: MRO_Topography

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Appendix B

RPS Memorandum *Seepage Monitoring Programme – Review and Rationalisation* 18 August 2015 (RPS 2015a)

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MEMORANDUM

COMPANY:	Evolution Mining Ltd - Mt Rawdon Operations				
ATTENTION:	Sven Sewell				
FROM:	Jon Hall				
DATE:	18 August 2015	JOB NO:	1725-D1	DOC NO:	016b
SUBJECT:	Seepage Monitoring Programme – Review and Rationalisation				

Sven,

Further to my recent site visit to Mt Rawdon Gold Mine, and review of background information and monitoring records, we present the following report on, and recommendations for, the groundwater seepage monitoring programme. This report follows on from our earlier report on the regional groundwater monitoring programme.

The key findings of this review are that:

- In general, the existing programme provides a good monitoring coverage of the potential impacts of the TSF and plant site on local and regional groundwater.
- However, some of the specific monitoring requirements in the current EA conditions are considered to be superfluous, given the nature and current distribution of seepage, and do not add any real value to the effectiveness of the programme.
- Significant improvement to the monitoring programme to provide more efficient and site-wide coverage of the potential impacts of TSF and plant site on local and regional groundwater could be achieved with some refinements to the programme.
- Recommended refinements, include:
    - A change in monitoring status for some bores.
    - Removal of some bores from the monitoring programme.
    - Installation of one new bore.
    - Minor changes to monitoring parameters and introduction of trigger monitoring.

It should be noted that the recommended modifications to the regional monitoring programme result in only a minimal net reduction in the number of compliance bores to be monitored. However, the recommended modifications result in much more effective monitoring of potential impacts on groundwater from site activities. The recommended programme also meets the monitoring aims specified in the environmental authority permit (EA EPML00712113).

Details on the approach to the review and the development of specific monitoring recommendations are presented below. It should also be noted that the recommended seepage monitoring programme is designed to be consistent with and integrate with the refined regional monitoring programme recommended in our earlier report.

1. APPROACH TO ASSESSMENT

The approach to the review and assessment of the seepage monitoring programme, was similar to that adopted in the recent review of the regional monitoring programme, and was as follows:

- Define the conceptual approach to monitoring:
    - Define what the monitoring programme needs to achieve.
    - Determine (conceptually) how best to meet requirements.
    - Develop broad levels/degrees of monitoring based on risk.
- Define the conceptual groundwater flow and seepage models:
    - Develop hydrogeological understanding and historical data.

RPS

  - Confirm sources of seepage and potential rates of seepage migration.
  - Confirm chemical nature (and signature) of seepage.
- Confirm the specific monitoring approach:
  - Define levels of required monitoring (eg trigger and compliance monitoring) based on risk.
  - Define monitoring requirements for each monitoring level.
- Recommend the specific monitoring programme:
  - Define specific schedules of bores and monitoring requirements.

2. CONCEPTUAL APPROACH TO MONITORING

2.1 Key Aims of Monitoring

The key aims of any groundwater monitoring programme are as follows (from the highest context level to specific operation compliance):

- Protection of the environment from harm due to groundwater seepage from the mine.
- Synoptic mapping of the overall groundwater quality to provide:
  - Snapshots of the distribution of groundwater quality and risk to the environment.
  - Snapshots at time intervals over which no significant change to environmental risk expected.
- Synoptic mapping of groundwater levels to provide:
  - Confirmation of broad groundwater (and seepage) flow directions.
  - Confirmation of any water table mounding as a result of seepage.
- Identification of the first arrival of seepage from contaminant sources (TSF/WRD etc).
- Tracking of seepage migration through the aquifer system.
- Prediction of future migration of seepage towards groundwater discharge zones:
  - Baseflow to creeks.
  - Groundwater flow from the mine lease area.
- Validation (and re-calibration) of conceptual and predictive models and validation of seepage predictions.
- Compliance with regulatory conditions.

In terms of the Mt Rawdon seepage monitoring programme, Section C5-8 of the environmental authority permit (EA EPML00712113) states that *"Seepage from the Tailings Storage Facility must be monitored at the locations and frequencies specified in Schedule C – Table 7 and Indicated on Map Schedule 1 – Map 1"*. Section C5-11 states that *"Seepage water containing contaminants from the Tailings Storage Facility must be prevented from entering surface waters"*.

In a practical sense, this is interpreted to mean that the seepage monitoring programme should be targeted at the identification and tracking of seepage from the TSF (and plant site) and the prevention of groundwater seepage expressing as surface water flow. It is also noted that the potential impacts of seepage on regional groundwater are covered by the regional monitoring programme.

2.2 Meeting Monitoring Aims

The keys to meeting monitoring aims are to develop a clear understanding of seepage flow processes (flow pathways, seepage velocities and seepage characteristics) and understanding the potential risks of seepage to the environment, and then to develop a monitoring programme that provides adequate identification and assessment of the distribution and migration of seepage and potential environmental risk.

The former (seepage flow processes and risks) are covered in Chapter 3 of this report. The remainder of this chapter deals with the conceptual approach to meeting the broad aims of monitoring.

At the commencement of any mining project, monitoring programmes (developed during the environmental impact assessment and approvals stage) typically tend to focus on high frequency and comprehensive monitoring. This is as a result of a limited understanding of the groundwater flow processes occurring on site (including realistic groundwater/seepage velocities) and also applying a degree of conservatism in light of many residual unknowns.

However, once operational performance data are available (as is clearly the case at Mt Rawdon with over 15 years of operation and comprehensive monitoring data) it is possible to refine the groundwater monitoring programme to cost effectively meet the monitoring objectives.

In general, the key components of an effective operational monitoring programme are:

- A primary set of monitoring bores - these are those bores immediately downstream of known seepage fronts (from various site sources of contamination - TSF, plant, WRD). These bores are designed to detect the first arrival of potential seepage and should be monitored for "trigger" parameters (see below) at a frequency such that there is minimal risk of a seepage front advancing too far beyond the bore between monitoring.
- A secondary set of monitoring bores – these are down-hydraulic gradient of the primary bores. These provide coverage of "regional" groundwater. The bores also provide a back-up in case seepage bypasses the primary bores, and would be elevated to primary status once seepage has been detected and confirmed in the relevant up-gradient bore. In terms of seepage detection, these bores only need to be monitored for trigger parameters at much less frequency than the primary bores. Secondary bores are typically also used as regional monitoring bores.
- A tertiary set of monitoring bores – once seepage has been detected and confirmed at primary or secondary bores, and the next down-gradient bore has been elevated to primary status, these bores are reclassified as tertiary bores and can be dropped from the regular seepage detection programme (trigger parameters) although monitoring might continue for investigation purposes.
- Indicator parameter monitoring – there will be one or two key parameters that provide the first indication of the arrival of a seepage front. These should be the target parameters for seepage detection monitoring. If monitoring of these parameters indicates the presence of seepage, then more comprehensive monitoring should be undertaken to confirm this.
- Synoptic (or snapshot) monitoring – it will be necessary to provide a clear picture of the distribution of groundwater quality on a semi-regular basis, to provide a more detailed understanding of the nature and spread of seepage and to meet internal environmental standards and regulatory compliance requirements. This monitoring would involve the comprehensive analysis of samples from all bores and would typically be undertaken once or twice a year.

As outlined previously, a specific monitoring approach based on the above concepts and the understanding of groundwater flow and seepage processes (outlined in Chapter 3 below), is presented in Chapter 4.

3. CONCEPTUAL GROUNDWATER FLOW AND SEEPAGE MODELS

3.1 Local Hydrogeology

The local and sub-regional aquifer system at Mt Rawdon comprises:

- Variably fractured basement rocks with low to moderate permeability depending on the physical nature of and hydraulic interconnection between faults, shears and joint sets.
- Weathered basement, largely comprising low permeability clay rich regolith.
- Shallow creek alluvium comprising moderately permeable alluvial sediments which are mostly dry over the mine area or which form intermittent, perched aquifers after rainfall recharge. These aquifers are more permanent in lower topographical areas downstream of the mine site (eg at/near Perry River Dam).

A prominent set of NE-SW trending faults has been identified in a number of hydrogeological studies, and local drainages tend to follow these broad fault lines. No major aquifers have been identified, although some isolated bore yields (of up to 3L/s) have been reported during the drilling of some monitoring bores.

3.2 Groundwater Flows

3.2.1 Groundwater Flow Paths

Pre-mining groundwater flows were largely controlled by topography and drainage, with groundwater flow from elevated areas towards the major creek lines and then following the major drainage systems (though alluvium and underlying weathered and fractured basement rocks). There will have been some groundwater baseflow to the local creeks (springs) at topographic breakaways. Most of the pre-mining groundwater flow was to the northeast, parallel with Swindon, Rawdon and Twelve Mile Creeks, towards the Perry River with some minor groundwater flows to the south towards Mingham Creek.

Since mining has commenced, local groundwater flow patterns have been influenced by site activities. The TSF has become a source of recharge/seepage and the pit has become a groundwater sink. The WRD and/or the runoff containment dams downstream of the WRD have also become sources of groundwater recharge. Monitoring data also indicates that the NE-SW trending fault that is located between the TSF and the pit forms a hydraulic barrier to groundwater across the fault (ie a barrier to NW-SE flow). Other than these local influences on groundwater flow, overall groundwater flow remains similar to pre-mining conditions.

Figure 1 shows the interpreted current main groundwater flow pathways from the mine site.

3.2.2 Groundwater Flow Velocities

Numerical groundwater flow modelling, recently undertaken to support the TSF2 Application (Numerical Modelling Report - Groundwater Flow (NRC, Oct 2014)), predicted average groundwater particle velocities from beneath the toe of TSF2 towards Perry River of around 0.02m/d (around 7m/yr).

The model adopted average permeability conditions for the fractured basement (0.1m/d) and regolith (0.05m/d) and was calibrated against observed long term groundwater levels. The model predicted a travel time of 50 years for groundwater particles travelling the shortest route towards Perry River (around 300m). It is possible that some parts of the fractured rock aquifer might have a higher permeability. However, a recent bore census (MRO Groundwater Monitoring Bore Census (NRC, Jan 2015)) indicated bore yields in excess of 1L/s at only five of the 53 bores reviewed. Given this, and the fact that good model calibration was achieved with the average permeability adopted, it is concluded that any elevated permeability would be localised and will not affect average groundwater flow velocities.

A further assessment of average groundwater flow velocities across the mine site was undertaken using a simple Darcy flow model applied to groundwater flows from the existing TSF and WRD. Measured hydraulic gradients (from groundwater level data) downstream of the TSF were around 0.15%. Assuming an average permeability of 0.1m/d (as per the numerical groundwater flow model) and an effective porosity of 5% (typical value for aquifers of this nature), the indicated average groundwater velocity is around 0.03m/d (or 10m/yr).

Downstream of the WRD, the measured hydraulic gradient is marginally higher at 0.2%, indicating an average groundwater velocity of around 0.04m/d (or 15m/yr).

In summary, estimations of groundwater (particle) velocity range from around 7 to 15m/yr. As an extreme case, if permeability along a flow path was consistently one order of magnitude higher (at around 1m/d) over the whole length of the flow path, then local groundwater velocities could be similarly one order of magnitude higher (at around 70 to 150m/yr). However, as outlined above, the distribution of historical bore yields suggest that it is highly unlikely that such conditions persist over any extended distance.

3.3 Seepage Flows

3.3.1 Seepage Flow Paths

Seepage from the various sources on site will follow the groundwater flow pathways shown on Figure 1.

3.3.2 Sources of Seepage Contaminants

The main potential sources of seepage to groundwater are the TSF, plant area and WRD and the following elements/compounds (which could be mobilised in seepage) are present:

- Mined ore/waste contains Au, Ag, Cu, Zn, Cd, Pb, Se, As, Fe, Mn, S.
- The process plant uses Na, CN (from sodium cyanide in gold leaching solution).
- Waste dumps contain all of the elements listed in the first dot point above plus NO_3 (from explosives residue).

3.3.3 Seepage Characteristics

A significant amount of water quality assessment and hydrochemical evaluation has been undertaken as part of the annual water quality reporting process and more specific investigations of particular water quality characteristics triggered by some monitoring results. Relevant reports include:

- Mt Rawdon EA Amendment Application for TSF2 – Response to Guideline EM963 Application Requirements for Activities with Impacts to Water (NRC, Mar 2015).
- 2014 Annual Water Quality Review Report (NRC, Dec 2014).
- Groundwater Investigation – Total Cyanide Tot CN Exceedance in MRMB45 and 46 (NRC, Apr 2015).
- Investigation into Nitrate and Sulphate Concentrations in Groundwater at MRO (NRC, Feb 2015).
- Groundwater Quality Investigation – Bores MRMB25, 27 and 49 at MRO (NRC, Apr 2103).
- Rationale for Relocation or Bores MRMB24 and 51 (NRC, Dec 2013).

Key findings in relation to the hydrochemical nature of groundwater on site are that natural groundwater has a sodium-chloride signature but that groundwater affected by mixing with seepage from both the TSF and WRD has a sodium-sulphate signature. The sulphate in seepage is derived from the oxidation of sulphides in the ore and waste. The sodium is natural but also could be derived from sodium hydroxide, used as a buffering agent in the gold processing circuit.

Seepage can also be characterized by elevated levels of some of the metals listed in Chapter 3.3.2, salinity (as TDS), nitrate (from the WRD) and cyanide (from the TSF and plant area). Table 1 (following page) shows the interpreted times when the concentrations of various contaminants started to (and continued to) clearly increase from background levels at bores where the arrival of seepage has been confirmed by assessment of overall water quality. These include bores downstream of the TSF and WRD. Appendix A presents plots of sulphate and salinity for these bores.

These data clearly show that, in all cases, the first arrival of seepage was characterized by a steady increase in sulphate concentrations (from background levels). In all but one case, the increase in sulphate was accompanied by a corresponding increase in salinity. In one bore (MRMB25 downstream of the WRD) the increase in sulphate was also accompanied by an increase in nitrate and in two bores (MRMB1 and 2 immediately downstream of the TSF) by total cyanide.

In many of the bores, increases in the concentration of cyanide, nitrate, zinc, cadmium and lead have been observed at some time (ranging from months to years) after the first arrivals of elevated sulphate and salinity.

Table 1: First Arrival of Seepage (derived from MRO monitoring data).

Bore	Source	First Arrival Parameters	Following Parameters
MRMB24	WRD	SO_4, TDS (Dec 04)	Zn, Cd (mid 07), Pb (Jan 08), NO_3 (<Aug 08)
MRMB25	WRD	SO_4, NO_3 (Jul 12)	Nil
MRMB26	WRD	SO_4, TDS (Nov 07)	NO_3 (Jul 13)
MRMB27	WRD	SO_4, TDS (Apr 06)	Nil
MRPB1	WRD	SO_4, (Jul10)	Nil
MRMB1	TSF	SO_4, TDS, CN (Aug 01)	Cu (Nov 06), Zn (Apr 07), Cd (Feb 10)
MRMB2	TSF	SO_4, TDS CN..(Aug 01)	Cu (Jul 06)
MRMB9	TSF	SO_4, TDS (Jul 02)	Cu, Zn, Cd (Nov 05), CN (Mar10)
MRMB19	TSF	SO_4, TDS (Feb 03)	Zn, Cd (Mar 03)
MRMB23	TSF	SO_4, TDS (Sep 07)	CN (Aug 12)

It is concluded that the clear site wide "indicator parameters" of the first arrival of seepage (or the mixing front ahead of seepage) are sulphate and salinity.

3.3.4 Seepage Migration Velocity

Interpreted first arrival times of seepage were used to calculate average seepage velocities towards each bore. Key assumptions used in this assessment were:

- The main source of seepage towards bores downstream of the TSF was the downstream toe of the current TSF embankment.
- The main sources of seepage towards bores downstream of the WRD were the WRDs themselves and the runoff collection dams WD1 and WD2.
- Seepage first entered the groundwater system (by vertical leakage from the above sources) in the first year of mining (2001).
- The first arrival of seepage is as indicated in Table 1.
- Note that bores MRMB1, 2 and 9 were not used in this assessment. Seepage was observed in these bores almost immediately after commissioning of the original (much smaller TSF) and the mechanism for seepage arrival at these bores is not clear (although some down slope migration in surface seepage is suspected particularly at MRMB1 and 2 which are adjacent to seepage dam SD1), thus introducing large potential errors in such calculations.
- Seepage velocity downstream of the TSF was estimated from the travel times of seepage from immediately downstream of the current toe of the TSF (as indicated by first arrival at bore MRMB9) towards bore MRMB23.

The results for one bore downstream of the TSF (MRMB23) indicate a seepage velocity of around 0.03m/d (around 11m/yr). The results for four bores downstream of the WRD (MRMB25, 26, 27, MRPB1 indicate an average seepage velocity of around 0.05m/d (around 18m/yr).

These results are of a similar order to those estimated for groundwater particle velocity (refer Chapter 3.2.2).

4. SPECIFIC MONITORING APPROACH

The generic key components and levels of monitoring outlined in Chapter 2.2 largely apply to an integrated site-wide monitoring programme. This current review is focussed on the seepage monitoring programme to satisfy the aims of seepage monitoring and the requirements under the EA.

As such, only the seepage monitoring focussed components of the overall monitoring approach (outlined in Section 2) have been adopted in developing the refined seepage monitoring programme. However, the monitoring approach developed for the seepage monitoring programme (subject of this report) is designed to be compatible with the parallel regional monitoring programme, which has recently been reviewed by MRO.

4.1 Categories of Required Monitoring

The primary aims of the seepage monitoring is to detect and monitor the migration of seepage in groundwater downstream of the TSF (and plant site) and the potential for seepage to express in surface water.

With reference to the generic key components of a monitoring programme, the seepage monitoring programme would comprise primary, secondary and tertiary bores, but integrate with the regional monitoring programme in terms of monitoring the impact on regional groundwater. There are four clear preferred groundwater flow pathways from the TSF (and plant site): three to north along Swindon Creek, Rawdon Creek and the unnamed creek between the two; and one to the south towards Mingham Creek (beneath the new Western WRD).

Seepage has been detected (close to the TSF) at bores along each of these flow pathways. These can now be classified as tertiary bores, requiring only periodic monitoring to confirm contaminant concentrations behind the seepage front. There are also three bores in and around the plant site that have detected seepage that will eventually flow southwards to Mingham Creek or into the pit. These can also now be classified as tertiary bores.

Along each of the groundwater flow pathways, there are existing bores that can be used as primary and secondary bores. In some cases, secondary monitoring can also be provided by bores in the regional monitoring programme.

It should be noted that there are a number of existing bores where the bore construction details cannot be confirmed and/or where it has been confirmed that the bore construction does not meet appropriate monitoring bore standards. It has previously been recommended that these bores either be decommissioned or replaced (NRC, Feb 2015). Where these bores are not in critical locations (ie primary or secondary bores) and not adequately covered by other bores, these bores should be replaced. Where these bores are in non-critical locations (ie behind the seepage front) or where they are covered by other bores, they can be used for low priority monitoring (tertiary monitoring) or decommissioned.

4.2 Monitoring Frequencies

As outlined in Chapters 3.2 and 3.3, groundwater and seepage velocities are very slow, less than 20m/yr. As such, in terms of monitoring the actual impact on regional groundwater, it is considered that monitoring frequencies could be significantly relaxed and that two monthly monitoring of indicator parameters in primary bores and annual monitoring of compliance parameters in the primary bores (and all monitoring in secondary bores) would be more than adequate. However, it is recognised that this would be a significant departure from historical monitoring practices in Queensland and that the adequacy of such a monitoring frequency for primary and secondary seepage monitoring bores would need to be demonstrated by further operational monitoring history. For now, then, it is recommended that the primary bores should be monitored monthly and the secondary bores monitored six-monthly.

For tertiary bores, annual water quality monitoring would be more than sufficient for snapshot monitoring of the distribution of groundwater quality. However, monthly groundwater level monitoring should be maintained at tertiary bores (as for the other bores) as emergence of groundwater seepage at the surface would have implications for surface water quality.

It is also recommended that the frequency of investigation monitoring (monitoring triggered by exceedances of trigger levels in indicator or compliance parameters) should be at monthly intervals.

4.3 Monitoring Parameters

The current seepage monitoring programme lists a single set of parameters, with specified tolerable contaminant limits set as the compliance levels. However it is recommended that trigger levels should be set for indicator parameters and that some general parameters should also be monitored.

In terms of the list of parameters to be monitored, it is recommended that:

- Salinity (as TDS) is calculated from electrical conductivity and so both parameters do not need to be reported.
- TDS, sulphate and groundwater levels should be monitored as indicator parameters and trigger levels set.
- General anions and cations (ie sodium, magnesium, potassium, chloride, carbonate and bi-carbonate) should be included in monitoring as these parameters allow for the characterisation of "water types" based on distributions of general anions and cations (using Piper/Durov/Expanded Durov data plots). However, there should be no trigger or compliance levels applied to these.

In terms of compliance levels (tolerable limits), it is recommended that these remain as is, with the exception of removing EC as a compliance parameter.

In terms of trigger level monitoring, it is recommended that the trigger levels for sulphate and salinity (which have been confirmed as the clear indicator parameters for the first arrival of seepage) should not be set as specific concentration limits, but rather they should be set as deviations from historical trend. This could be done in two ways:

- Clear trend of increasing levels above historical background variations (ie graphical trend analysis).
- A spot level that exceeds some statistical feature of historical data (eg median value).

As shown in the plots of sulphate and salinity for selected bores in Appendix A (where the arrival of seepage has been confirmed by broader water quality assessment), both methods would work. However, trend analysis can take some time to confirm first arrival of seepage. To provide a more timely means of assessing the need for further investigation, it is recommended that the trigger should be any single reported value (for concentration) that exceeds the historical median by more than 50%.

It is also recommended that there should be trigger levels for depth to groundwater, where a shallow water table could indicate the potential for baseflow of groundwater to local creeks. The recommended trigger level is a recorded depth to water less than 0.5m below ground.

Once an investigation has been triggered, the higher frequency investigation monitoring would include all indicator and compliance parameters. There is no need to monitor for general parameters during investigation monitoring.

5. RECOMMENDED SEEPAGE MONITORING PROGRAMME

5.1 Overview

The recommended seepage monitoring programme focuses on monitoring and managing the potential impacts of seepage (from the TSF and plant area), but fits together with recommended upgraded regional monitoring programme to provide integrated monitoring of the impacts of all site activities on local and regional groundwater). Key features of the seepage monitoring programme include:

- A three tiered network of seepage monitoring bores covering the five main seepage pathways from the TSF and plant and the plant area itself, including:
    - Ten primary monitoring bores (including one new bore);
    - Ten secondary monitoring bores; and
    - Six tertiary monitoring bores.
- Coupled with the six regional bores located downstream of the above bores along the main seepage pathways, overall monitoring of seepage will be covered by 30 bores. The current seepage monitoring programme specified in the EA conditions comprises 35 bores, not including six bores (MRMB8, MRMB9, MRMB17, MRMB18, MRMB19, and MRMB34) which have been recently decommissioned, but including four replacement bores (MRMB69, MRMB70, MRMB71, and MRMB72).
- Other features of the recommended seepage monitoring programme are:
    - Two bores have been transferred to the upgraded Regional monitoring system.
    - Seven recently installed new bores have been included in the Seepage monitoring programme.
    - Four existing regional bores have been transferred into the Seepage monitoring programme.
    - Fifteen bores are to be decommissioned, including two bores that were removed from the Regional programme and considered to be not suitable for inclusion into the Seepage monitoring programme.

  - One new bore is to be drilled/installed.

- A three tiered programme of monitoring, including:
  - Compliance monitoring for parameters (similar to the current programme).
  - Trigger monitoring for the key indicators of the first arrival of seepage from the TSF.
  - Investigation monitoring for key indicators (and other parameters) as required, if trigger levels of specific parameters are exceeded.

The recommended bores to be included in the seepage monitoring programme (together with selected bores in the regional monitoring programme are shown on Figure 2.

5.2 Monitoring Bores

It is recommended that the monitoring bores listed in Table 2 should be designated with status as shown. These Primary, Secondary and Tertiary bores should be monitored at the intervals specified in Chapter 5.3 and for the parameters specified in Chapter 5.4.

Table 2: Recommended Seepage Monitoring Bores and Bore Status

Bore Status	Bore	Comments
Swindon Creek (TSF West)		
Primary	MRMB43	Shallow and deep pair of bores. No seepage arrival indicated in data. Appropriate bore construction.
	MRMB44	
Secondary	MRPB2	No seepage arrival indicated in data. Appropriate bore construction.
Swindon Creek (TSF North)		
Primary	MRMB13	Has elevated NO_3, but no seepage arrival indicated in data. Appropriate bore construction.
Secondary	MRMB41	Shallow and deep bore pair. No seepage arrival indicated in data. Appropriate bore construction.
	MRMB42	
	MRMB65	New bore (converted from TSF2 investigation bore BH01). Would become Primary bore if TSF2 proceeds. Secondary monitoring will provide baseline data. Appropriate bore construction.
Regional	MRMB52 (R)	Status changed to regional monitoring bore as part of recommended new regional monitoring programme. At downstream end of potential seepage flow path. Appropriate bore construction.
Tertiary	MRMB10	First arrival of seepage confirmed in 2005. Recommended for decommissioning and replacement (NRC, Feb 2105). Suggest no action other than Tertiary monitoring.
Decommission	MRMB11 (ex-R)	Recently recommended to be removed and/or transferred from regional monitoring programme. Uncertain bore construction recommended for decommissioning and possible replacement (NRC, Feb 2105). Seepage path adequately monitored by MRMB10 and MRMB12 and suggest no action other than decommissioning.
	MRMB12	Has elevated NO3, but no seepage arrival indicated in data. Recommended for decommissioning and replacement (NRC, Feb 2105). Secondary monitoring adequately provided by MRMB41/42 and MRMB65.
Un-named Creek (TSF North)		
Primary	MRMB40	No seepage arrival indicated in data. Appropriate bore construction.
Secondary	MRMB66	No Secondary monitoring along main seepage path (but Secondary monitoring provided by Regional bore MRMB53). MRMB66 (converted from TSF2 investigation bore BH02) would become Primary bore if TSF2 proceeds. Secondary monitoring will provide baseline data. Appropriate bore construction.
Regional	MRMB53 (R)	Status changed to regional monitoring bore as part of recommended new regional monitoring programme. At downstream end of potential seepage flow path. Appropriate bore construction.
Tertiary	MRMB30	First arrival of seepage confirmed in 2006. Recommended for decommissioning and possible replacement (NRC, Feb 2105). Within TSF2 footprint and suggest no action other than Tertiary monitoring.
Decommission	MRMB31	First arrival of seepage confirmed in 2006/2007. Recommended for decommissioning and possible replacement (NRC, Feb 2105). Within TSF2 footprint and suggest no action other than decommissioning. Tertiary monitoring provided by MRMB30.
	MRMB33	
	MRMB34	
Rawdon Creek (TSF Northeast)		
Primary	New Bore D	Replacement for MRMB21, which is on main seepage path, but no seepage arrival indicated in data. Recommended for decommissioning and possible replacement (NRC, Feb 2105). Within TSF2 footprint, but new bore is required to provide Primary monitoring.

Bore Status	Bore	Comments
	MRMB32	Off main seepage path, but no seepage arrival indicated in data. Appropriate bore construction.
	MRMB48	Off main seepage path, but provides for additional monitoring of seepage front. No seepage arrival indicated in data. Appropriate bore construction.
	MRMB49 (ex-R)	Recently recommended to be removed and/or transferred from regional monitoring programme. Off main seepage path, but provides for additional monitoring of seepage front to east of TSF. Elevated NO_3 but no seepage arrival indicated in data. Appropriate bore construction.
Secondary	MRMB39	No seepage arrival indicated in data. Appropriate bore construction.
	MRMB68	New bore (converted from TSF2 investigation bore BH04). Would become Primary bore if TSF2 proceeds. Secondary monitoring will provide baseline data. Appropriate bore construction.
	MRMB67	New bore (converted from TSF2 investigation bore BH03). Would become Primary bore if TSF2 proceeds. Secondary monitoring will provide baseline data. Appropriate bore construction.
Regional	New Bore C (R)	New regional bore defined in recommended new regional monitoring programme at downstream end of potential seepage flow path.
Tertiary	MRMB22	First arrival of seepage confirmed in 2003/2004. Recommended for decommissioning and possible replacement (NRC, Feb 2105). Within TSF2 footprint and suggest no action other than Tertiary monitoring.
Decommission	MRMB3, 4	First arrival of seepage confirmed in all bores prior to 2004. Recommended for decommissioning and possible replacement (NRC, Feb 2105). Within TSF2 footprint and suggest no action other than decommissioning.
	MRMB7	
	MRMB23	
	MRMB1, 2	
	MRMB5,6	
	MRMB21	Recommended for decommissioning and possible replacement (NRC, Feb 2105). To be replaced by New Bore D
	MRMB55 (ex-R)	Recently recommended to be removed and/or transferred from regional monitoring programme. Within footprint of TSF2. Recommend replacement by MRMB68.
Mingham Creek (TSF South and WRD West)		
Primary	MRMB50	No seepage arrival indicated in data. Appropriate bore construction. MRMB69 is a recent replacement bore for MRMB19.
	MRMB69	
Secondary	MRMB36 (R)	Secondary monitoring provided by these Regional bores (shallow/deep pair). Appropriate bore construction.
	MRMB72 (R)	
Regional	New Bore B (R)	New regional bore defined in recommended new regional monitoring programme at downstream end of potential seepage flow path.
Plant and Area between TSF and Pit/WRD		
Tertiary	MRMB20 (ex-R)	First arrival of seepage confirmed in 2008 (although elevated levels of some parameters prior to this). Recommended for decommissioning and replacement (NRC, Feb 2105). Suggest no action other than Tertiary monitoring.
	MRMB45 (ex-R)	Elevated CN but no seepage arrival indicated in other data. Bores impacted by TSF seepage (NRC, Apr 2015). Downstream (Primary and Secondary) monitoring covered by other bores.
	MRMB46 (ex-R)	

(R) –Bores to be monitored as part of the recommended upgraded regional monitoring programme.

(ex-R) - Bores transferred from regional monitoring programme)to be monitored or not, as required)..

5.3 Monitoring Frequency

It is recommended that the bores should be monitored at the frequencies listed in Table 5. Key features of the programme are as follows:

- High frequency (monthly) monitoring of key indicator parameters at Primary bores (ie those bores immediately downstream of the known/interpreted seepage front(s). This monitoring is designed to detect first arrival of seepage.
- High frequency investigation monitoring if the first arrival of seepage is indicated at any of the Primary (or Secondary) bores by exceedance of trigger levels.

- Moderate frequency (6 monthly) monitoring of compliance parameters and general parameters at Primary and Secondary bores (ie those bores downstream of the Primary bores). This monitoring is designed to provide biannual snapshots of the general distribution of water quality ahead of any seepage fronts and also to provide check monitoring of any seepage by-pass of the Primary bores.
- Low frequency (annual) monitoring of the Tertiary bores to provide annual snapshots of the general distribution of water quality over the whole mine site and to assess hydrochemical changes behind the seepage fronts.
- Once seepage has been detected at any bore and confirmed by investigation monitoring, that bore will be downgraded to tertiary status and the next downstream bore elevated to Primary status.

It should be noted that additional moderate frequency monitoring coverage is provided by the Regional bores.

Table 5: Recommended Monitoring Frequencies

Bore Designation	Groundwater Levels	Compliance Parameters	Indicator Parameters	General Parameters	Comments
Normal Monitoring					
Primary Bores	Monthly	6 monthly	Monthly	6 monthly	High frequency monitoring of key indicators to detect seepage arrival and moderate frequency snapshot monitoring to map distribution of water downstream of seepage front.
Secondary Bores	Monthly	6 monthly	6 monthly	6 monthly	Moderate frequency snapshot monitoring to map distribution of water downstream of seepage front. Also check monitoring for any seepage by-pass of Primary bores.
Tertiary Bores	Monthly	Annually	Annually	Annually	Low frequency snapshot monitoring only to confirm water quality and water levels behind seepage front.
Investigation Monitoring (following exceedance of trigger levels)					
Primary Bores	Monthly	Monthly	Monthly	Nil	Investigation monitoring following excceedance of trigger levels. Once arrival of seepage has been confirmed, bore status changed to Secondary and next downstream bore elevated to Primary status.

5.4 Monitoring Parameters

It is recommended that the bores should be monitored for the parameters listed in Table 6.

Table 6: Recommended Monitoring Parameters and Tolerable Limits (mg/L)

Parameter	Compliance Parameters		Indicator Parameters	General Parameters	Comments
	Tolerable Level	Trigger Level	Trigger Level		
Groundwater Levels			<0.5m bgl		As warning of potential baseflow to local creeks.
TDS (by calc)	12,000	150% of median	150% of median		Trigger is value which exceeds historical median by more than 50%. Compliance level determined by calculation from EC of 18,000uS/cm (as per current programme)
pH	5.0 to 9.0	5.0 to 9.0			
Cu	1	1			
SO_4			150% of median		Trigger is value which exceeds historical median by more than 50%.
Total CN	0.5	0.5			
WAD CN	0.05	0.05			
Na, K, Mg				No limit	Included to allow for characterisation of "water type"
Cl, CO_3, HCO_3,				No limit	

The compliance parameters and (tolerable levels) are largely the same as in the current programme, with the following exceptions:

- The tolerable level for salinity (TDS) has been increased to 12,000mg/L. This is consistent with the tolerable level for EC in the current programme. TDS is also an indicator parameter.
- EC has been removed from the compliance parameters as it is redundant. It will be measured, but reported as calculated TDS.
- Sulphate has been added to the parameter list, but as an indicator parameter only.
- Trigger levels for compliance parameters are the same as tolerable levels.
- No set trigger levels have been set for sulphate or salinity. Rather, it is recommended that the trigger for further investigation should be any reported spot value that exceeds the historical median by more than 50%.istorical median.
- Sodium, magnesium, calcium, potassium, chloride, carbonate and bicarbonate have been added to the normal monitoring programme. Together with sulphate, these will allow for the characterisation of “water types” based on distributions of general anions and cations.

6. SUMMARY

The key findings of this review are that:

- In general, the existing programme provides a good monitoring coverage of the potential impacts of the TSF on local and regional groundwater.
- However, some of the specific monitoring requirements in the EA conditions are considered to be superfluous and do not add any real value to the effectiveness of the programme.
- Significant improvement to the monitoring programme to provide more efficient and site-wide coverage of the potential impacts of all site activities on local and regional groundwater could be achieved with some minor refinements to the programme.
- Recommended refinements, include:
    - A change in monitoring status for some bores.
    - Removal of some bores from the monitoring programme.
    - Installation of one new bore.
    - Minor changes to monitoring parameters and introduction of trigger monitoring.

It should be noted that the recommended modifications to the regional monitoring programme result in only a minimal net reduction in the number of compliance bores to be monitored. However, the recommended modifications result in much more effective monitoring of potential impacts on groundwater from site activities.

The recommended seepage monitoring programme is completely consistent with the monitoring aims defined in the environmental authority permit (EA EPML00712113). The recommended programme is also consistent with the existing and potential future seepage monitoring programme.

We thank you for the opportunity of working with you on this review and we look forward to continuing to work with you on the rationalisation of monitoring programmes at Mt Rawdon.

Yours sincerely,
RPS Water

Jon Hall

Jon Hall

Senior Principal Hydrogeologist

Emma Bolton

Emma Bolton

Principal Hydrogeologist

N

0 500
Metres
Scale: 1:25,000 @A3
GDA 1994 Zone 56

AUTHOR:	JH	REPORT NO:	016
DRAWN:	MR	REVISION:	b
DATE:	18/08/2015	JOB NO:	1725D

Location: F:\Jobs\1725D\Spatial_Data\MapInfo\Workspaces\016b Figure 1 - Groundwater and Seepage flow paths

LEGEND

- Major Seepage Flow Path
- Minor Seepage Flow Path
- Watercourse
- Lease Boundary
- Existing Dam
- Western Waste Dump

DATA SOURCES:
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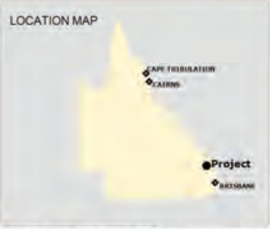
FIGURE 1
GROUNDWATER AND SEEPAGE FLOW PATHS



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0 500
Metres
Scale: 1:25,000 @A3
GDA 1994 Zone 56

AUTHOR:	JH	REPORT NO:	016
DRAWN:	MR	REVISION:	b
DATE:	18/08/2015	JOB NO:	1725D

Location: F:\Jobs\1725D\Spatial_Data\MapInfo\Workspaces\016b Figure 2 - Recommended regional GW Monitoring

LEGEND

- Regional Monitoring Bore (MRMB)
- Primary Seepage Bore (MRMB)
- Secondary Monitoring Bore (MRMB)
- Tertiary Monitoring Bore (MRMB)
- Watercourse
- Lease Boundary
- Existing Dam
- Western Waste Dump

DATA SOURCES:
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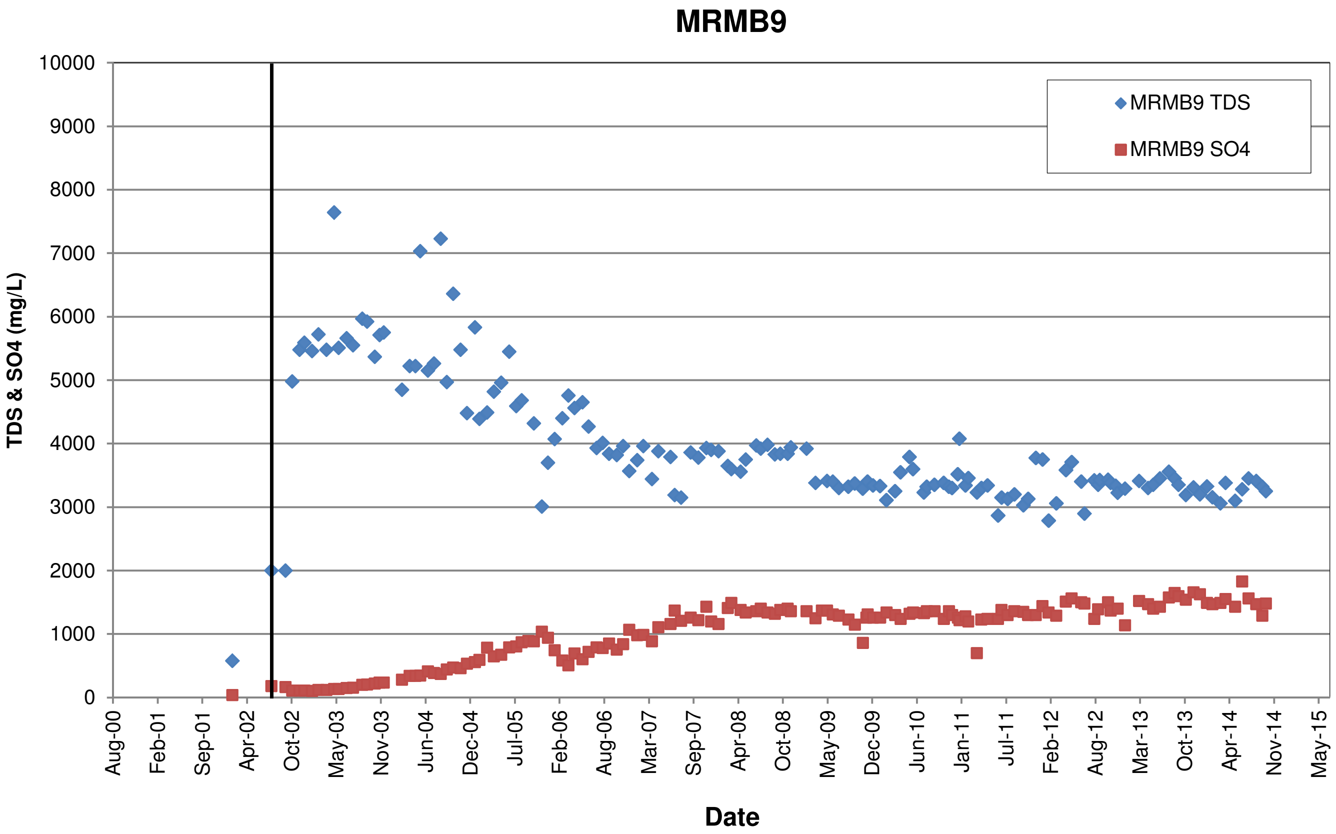
FIGURE 2

RECOMMENDED GROUNDWATER MONITORING PROGRAM - SEEPAGE

APPENDIX A: PLOTS OF SULPHATE AND SALINITY IN SELECTED BORES


MRMB9
TDS & SO4 (mg/L)
Date
MRMB9 TDS
MRMB9 SO4
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Aug-00
Feb-01
Sep-01
Apr-02
Oct-02
May-03
Nov-03
Jun-04
Dec-04
Jul-05
Feb-06
Aug-06
Mar-07
Sep-07
Apr-08
Oct-08
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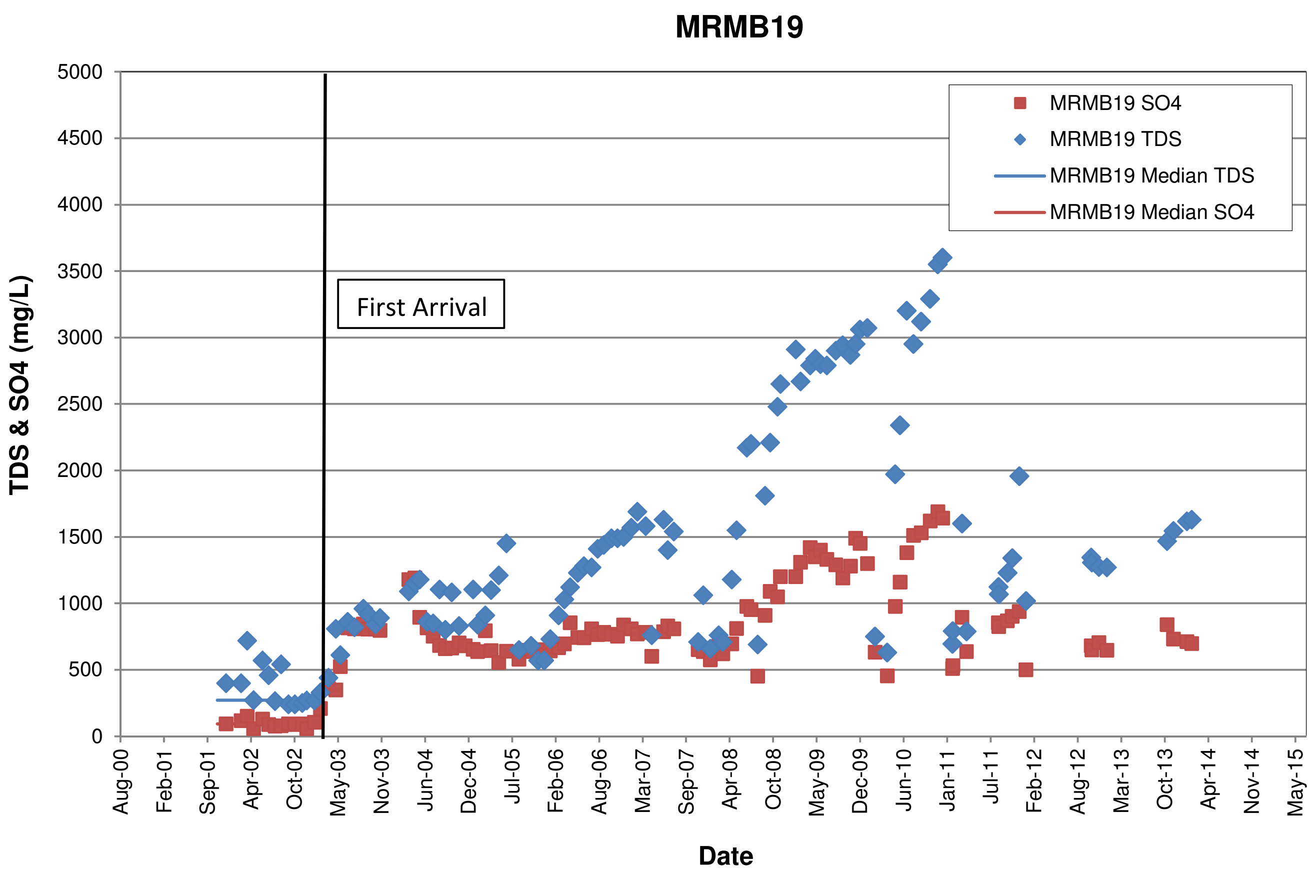
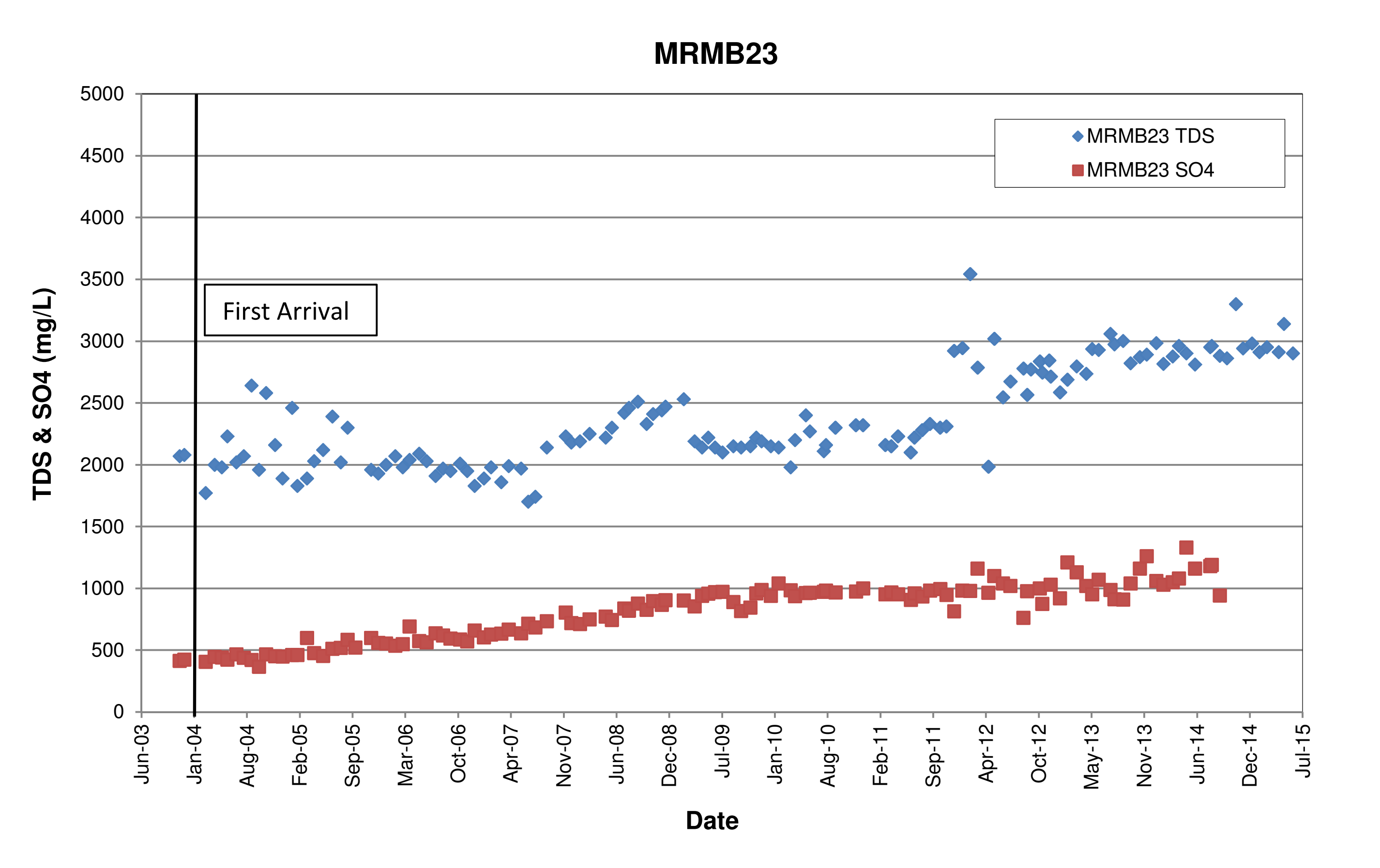
Apr-14
Nov-14
May-15


MRMB19
TDS & SO4 (mg/L)
Date
First Arrival
MRMB19 SO4
MRMB19 TDS
MRMB19 Median TDS
MRMB19 Median SO4
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Aug-00
Feb-01
Sep-01
Apr-02
Oct-02
May-03
Nov-03
Jun-04
Dec-04
Jul-05
Feb-06
Aug-06
Mar-07
Sep-07
Apr-08
Oct-08
May-09
Dec-09
Jun-10
Jan-11
Jul-11
Feb-12
Aug-12
Mar-13
Oct-13
Apr-14
Nov-14
May-15


MRMB23
First Arrival
MRMB23 TDS
MRMB23 SO4
TDS & SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06
Oct-06
Apr-07
Nov-07
Jun-08
Dec-08
Jul-09
Jan-10
Aug-10
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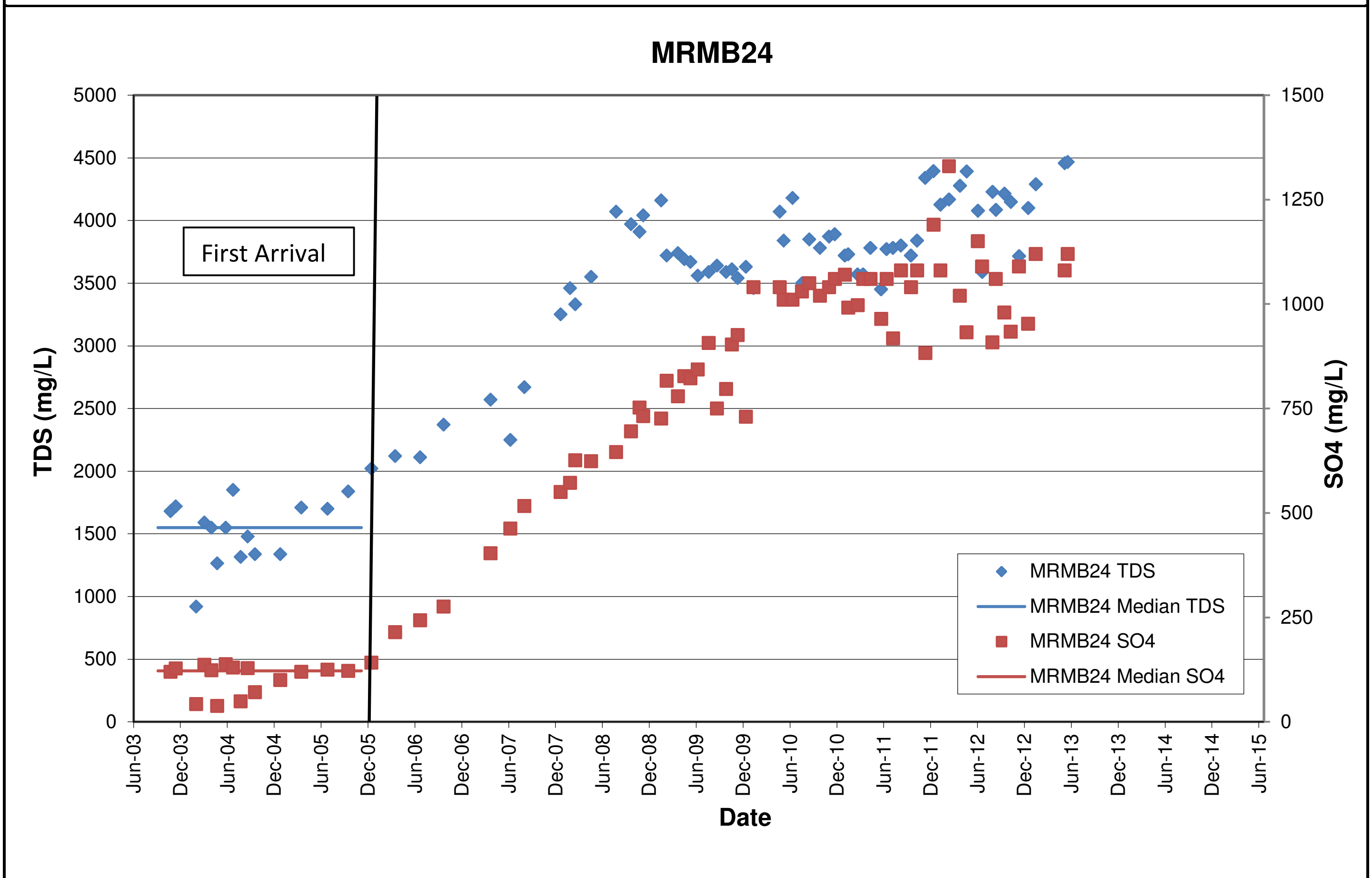
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Jul-15
Date


MRMB24
First Arrival
MRMB24 TDS
MRMB24 Median TDS
MRMB24 SO4
MRMB24 Median SO4
TDS (mg/L)
SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1500
1250
1000
750
500
250
0
Jun-03
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08
Dec-08
Jun-09
Dec-09
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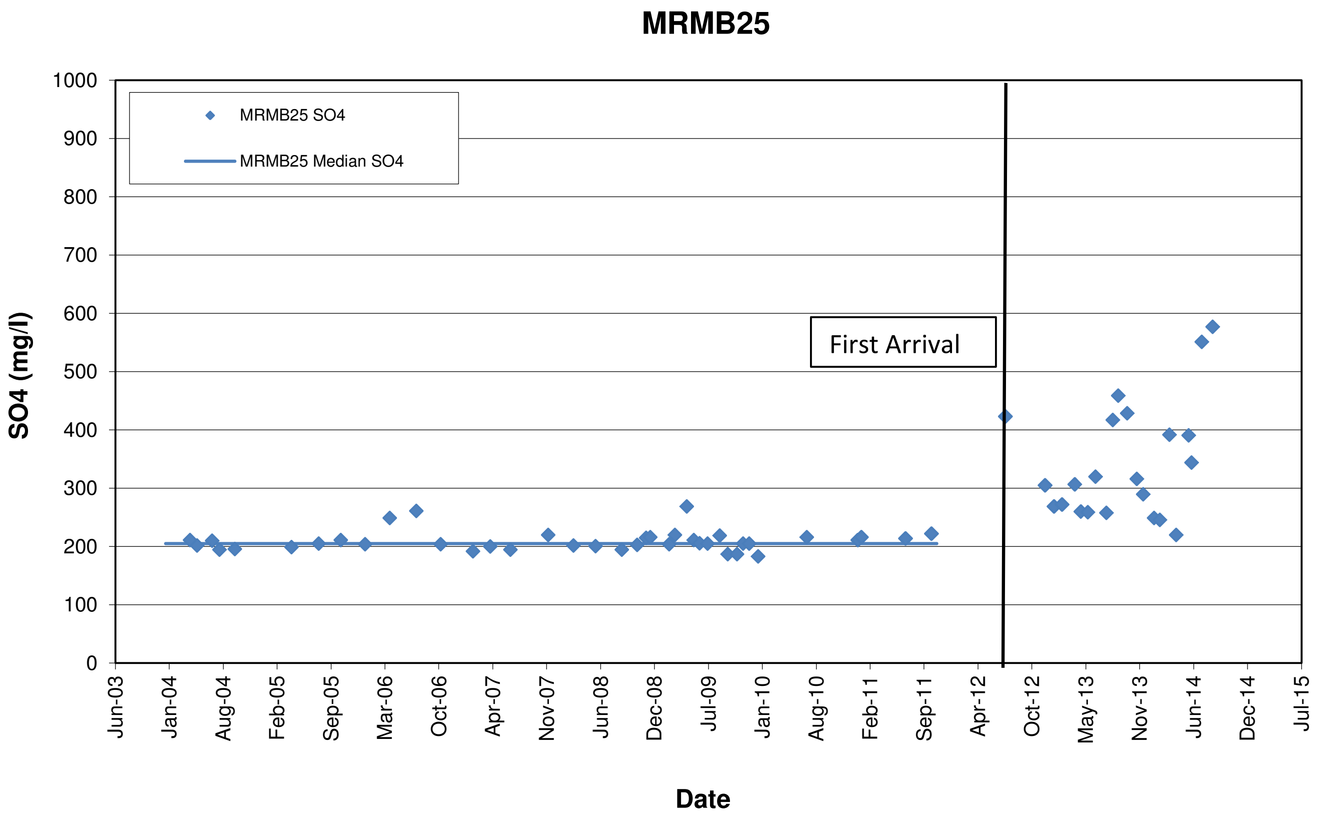
Jun-14
Dec-14
Jun-15
Date



MRMB25
MRMB25 SO4
MRMB25 Median SO4
First Arrival
SO4 (mg/l)
1000
900
800
700
600
500
400
300
200
100
0
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06
Oct-06
Apr-07
Nov-07
Jun-08
Dec-08
Jul-09
Jan-10
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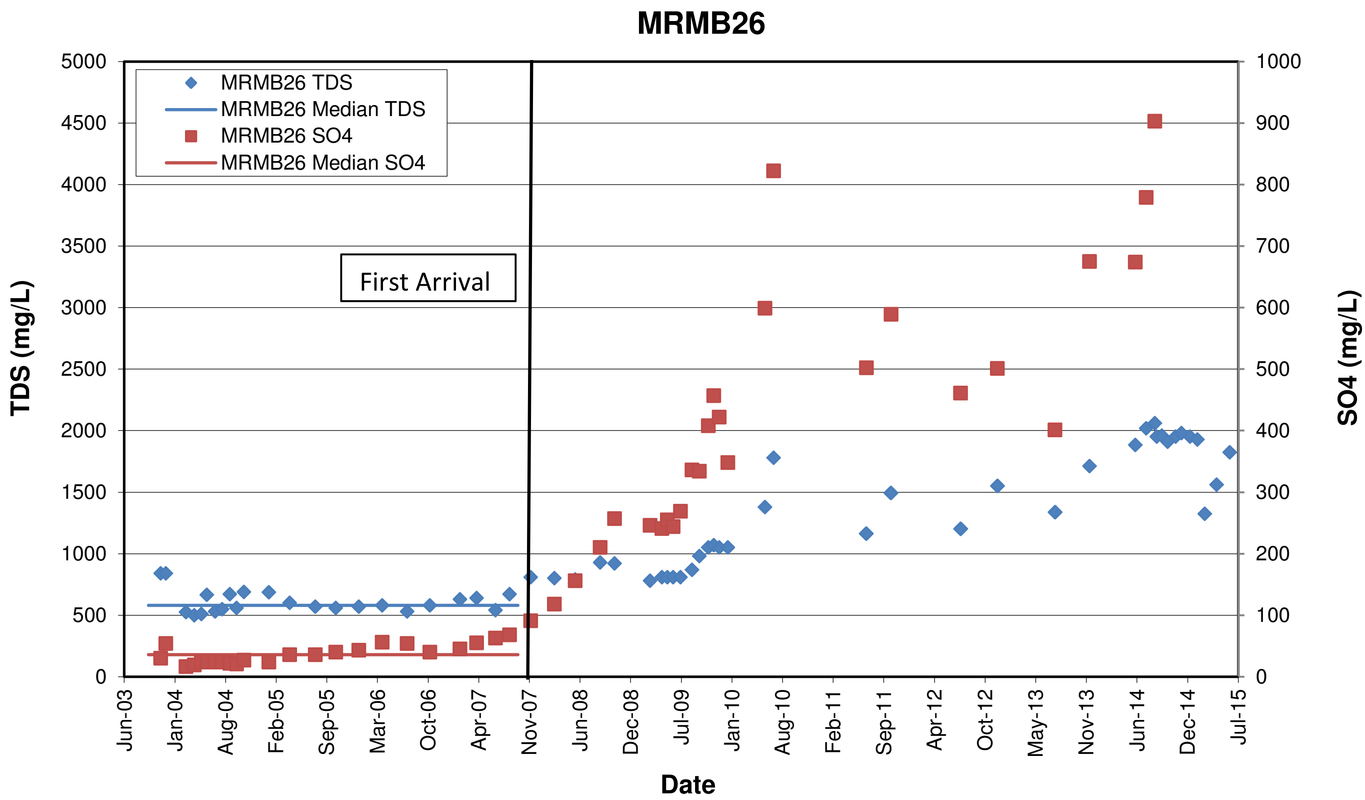
Dec-14
Jul-15
Date



MRMB26
MRMB26 TDS
MRMB26 Median TDS
MRMB26 SO4
MRMB26 Median SO4
First Arrival
TDS (mg/L)
SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1000
900
800
700
600
500
400
300
200
100
0
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06
Oct-06
Apr-07
Nov-07
Jun-08
Dec-08
Jul-09
Jan-10
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May-13
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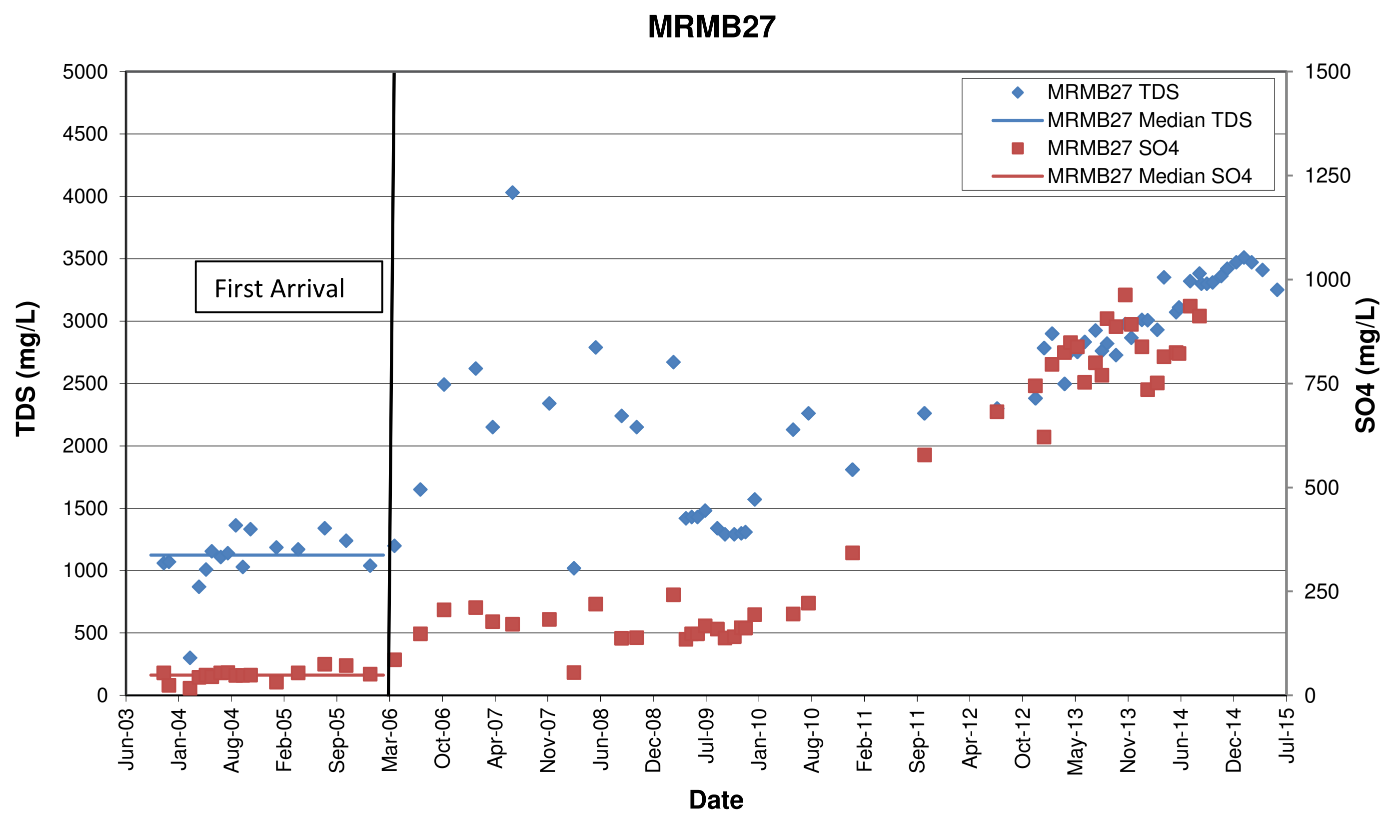
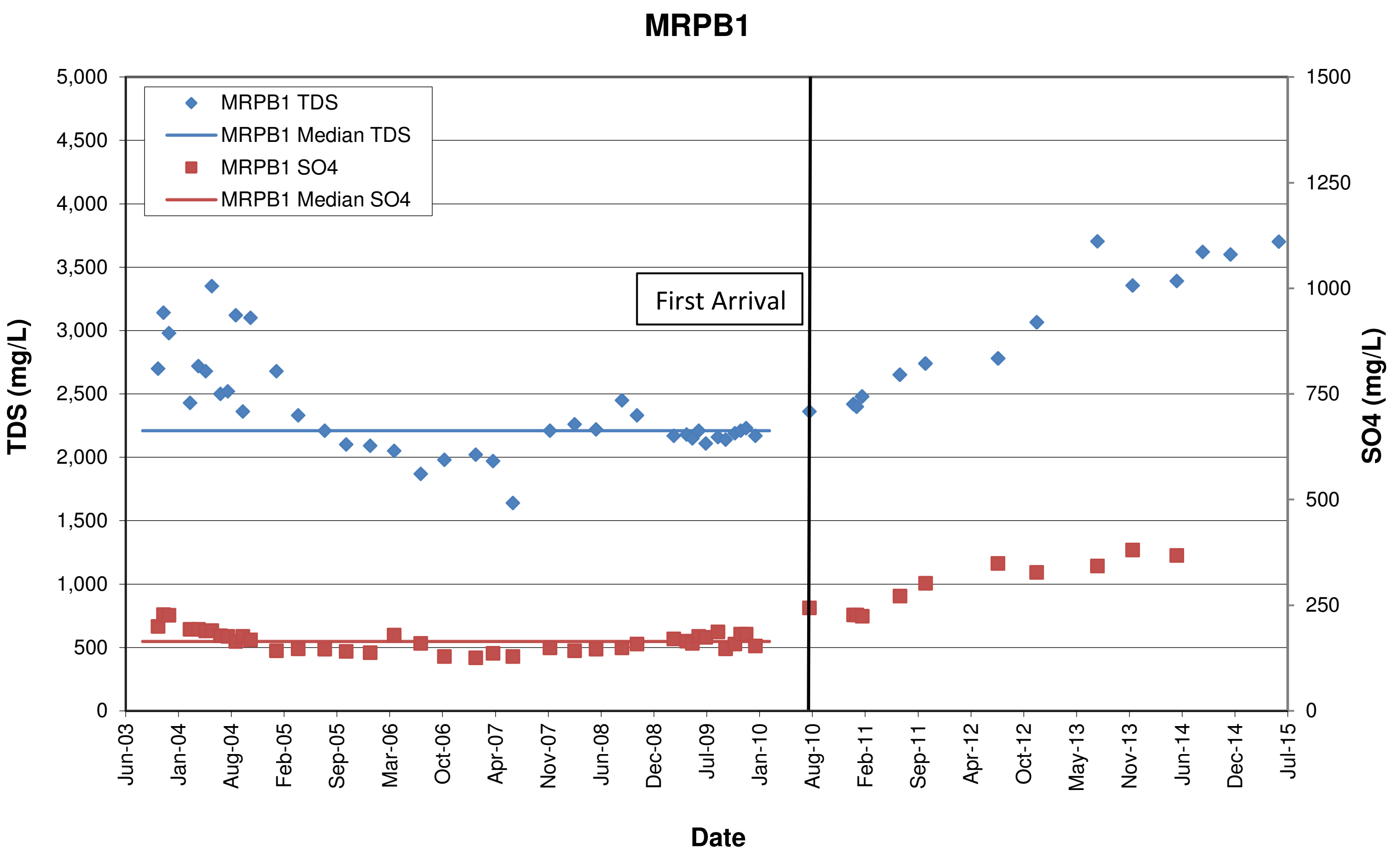
Jun-14
Dec-14
Jul-15
Date

RPS


MRMB27
TDS (mg/L)
SO4 (mg/L)
First Arrival
MRMB27 TDS
MRMB27 Median TDS
MRMB27 SO4
MRMB27 Median SO4
Date
Jun-03 Jan-04 Aug-04 Feb-05 Sep-05 Mar-06 Oct-06 Apr-07 Nov-07 Jun-08 Dec-08 Jul-09 Jan-10 Aug-10 Feb-11 Sep-11 Apr-12 Oct-12 May-13 Nov-13 Jun-14 Dec-14 Jul-15


MRPB1
TDS (mg/L)
SO4 (mg/L)
First Arrival
MRPB1 TDS
MRPB1 Median TDS
MRPB1 SO4
MRPB1 Median SO4
Date
Jun-03 Jan-04 Aug-04 Feb-05 Sep-05 Mar-06 Oct-06 Apr-07 Nov-07 Jun-08 Dec-08 Jul-09 Jan-10 Aug-10 Feb-11 Sep-11 Apr-12 Oct-12 May-13 Nov-13 Jun-14 Dec-14 Jul-15

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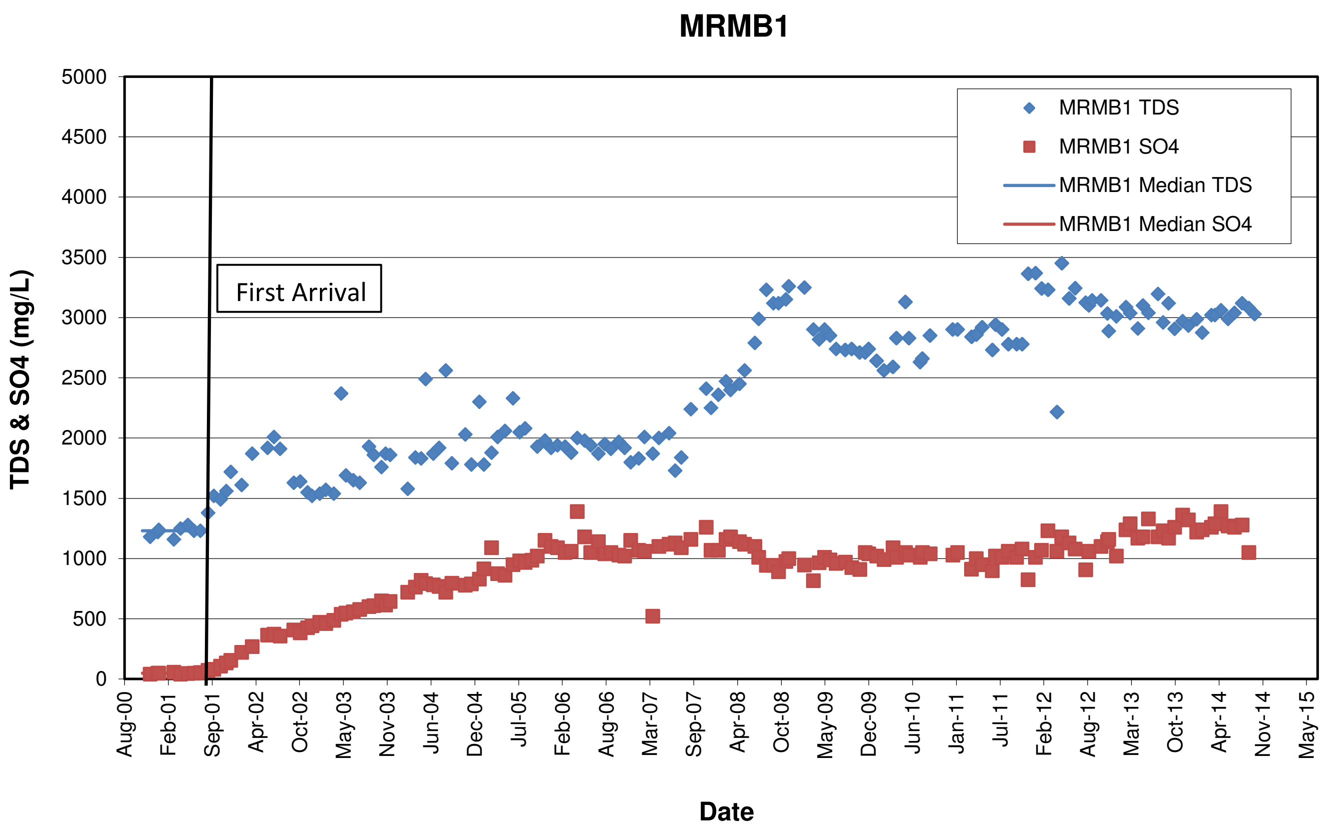
MRMB1
TDS & SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
First Arrival
MRMB1 TDS
MRMB1 SO4
MRMB1 Median TDS
MRMB1 Median SO4
Aug-00
Feb-01
Sep-01
Apr-02
Oct-02
May-03
Nov-03
Jun-04
Dec-04
Jul-05
Feb-06
Aug-06
Mar-07
Sep-07
Apr-08
Oct-08
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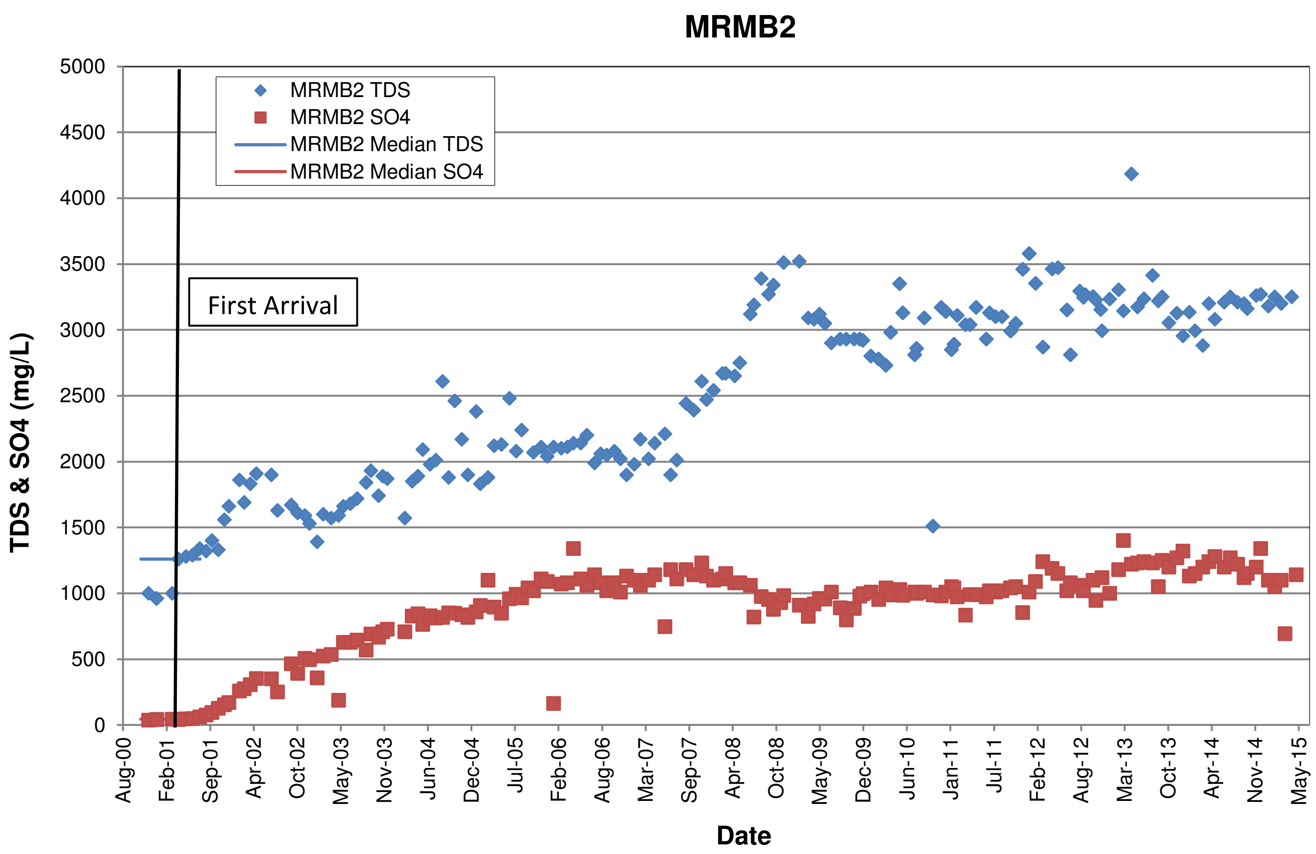
Nov-14
May-15
Date


MRMB2
TDS & SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
First Arrival
MRMB2 TDS
MRMB2 SO4
MRMB2 Median TDS
MRMB2 Median SO4
Aug-00
Feb-01
Sep-01
Apr-02
Oct-02
May-03
Nov-03
Jun-04
Dec-04
Jul-05
Feb-06
Aug-06
Mar-07
Sep-07
Apr-08
Oct-08
May-09
Dec-09
Jun-10
Jan-11
Jul-11
Feb-12
Aug-12
Mar-13
Oct-13
Apr-14
Nov-14
May-15
Date

Appendix C

RPS Memorandum *Regional Bore Monitoring Programme – Review and Rationalisation* 24 July 2015 (RPS 2015b)

38 Station Street, Subiaco Western Australia 6008, PO Box 465, Subiaco Western Australia 6904
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MEMORANDUM

COMPANY:	Evolution Mining Ltd - Mt Rawdon Operations		
ATTENTION:	Sven Sewell		
FROM:	Jon Hall		
DATE:	24th July 2015	JOB NO: 1725-D1	DOC NO: 015b
SUBJECT:	Regional Bore Monitoring Programme – Review and Rationalisation		

Sven,

Further to my recent site visit to Mt Rawdon Gold Mine, and review of background information and monitoring records, we present the following report on, and recommendations for, the regional groundwater monitoring programme.

The key findings of this review are that:

- In general, the existing programme provides a good monitoring coverage of the potential impacts of non-TSF related site activities on regional groundwater.
- However, some of the specific monitoring requirements in the EA conditions are considered to be superfluous and do not add any real value to the effectiveness of the programme.
- Significant improvement to the monitoring programme to provide more efficient and site-wide coverage of the potential impacts of all site activities on regional groundwater could be achieved with some minor refinements to the programme.
- Recommended refinements, include:
    - A change in monitoring status for some bores.
    - Removal of some bores from the regional programme (and transfer of some to other programmes).
    - Installation of some new bores in new locations.
    - Minor changes to monitoring parameters and introduction of trigger monitoring.

It should be noted that the recommended modifications to the regional monitoring programme result in no net reduction in the number of compliance bores to be monitored. Rather, the recommended modifications result in a much broader and more effective monitoring of potential impacts on regional groundwater from all site activities.

The recommended regional monitoring programme is completely consistent with the monitoring aims defined in Section C6-1 of the environmental authority permit (EA EPML00712113). The recommended regional monitoring programme is designed to be compatible with the parallel seepage monitoring programme, which is also undergoing a review by MRO.

Details on the approach to the review and the development of specific monitoring recommendations are presented below. It should also be noted that the recommended regional monitoring programme is designed to be consistent with an integrated site-wide monitoring programme that might be implemented following the planned upcoming review of the current seepage monitoring programme.

1. APPROACH TO ASSESSMENT

The approach to the review and assessment of the regional groundwater monitoring programme was as follows:

- Define the conceptual approach to monitoring:
    - Define what the monitoring programme needs to achieve.
    - Determine (conceptually) how best to meet requirements.
    - Develop broad levels/degrees of monitoring based on risk.
- Define the conceptual groundwater flow and seepage models:

  - Develop hydrogeological understanding and historical data.
  - Confirm sources of seepage and potential rates of seepage migration.
  - Confirm chemical nature (and signature) of seepage.
- Confirm the specific monitoring approach:
  - Define levels of required monitoring (eg trigger and compliance monitoring) based on risk.
  - Define monitoring requirements for each monitoring level.
- Recommend the specific monitoring programme:
  - Define specific schedules of bores and monitoring requirements.

2. CONCEPTUAL APPROACH TO MONITORING

2.1 Key Aims of Monitoring

The key aims of any groundwater monitoring programme are as follows (from the highest context level to specific operation compliance):

- Protection of the environment from harm due to groundwater seepage from the mine.
- Synoptic mapping of the overall groundwater quality to provide:
  - Snapshots of the distribution of groundwater quality and risk to the environment.
  - Snapshots at time intervals over which no significant change to environmental risk expected.
- Synoptic mapping of groundwater levels to provide:
  - Confirmation of broad groundwater (and seepage) flow directions.
  - Confirmation of any water table mounding as a result of seepage.
- Identification of the first arrival of seepage from contaminant sources (TSF/WRD etc).
- Tracking of seepage migration through the aquifer system.
- Prediction of future migration of seepage towards groundwater discharge zones:
  - Baseflow to creeks.
  - Groundwater flow from the mine lease area.
- Validation (and re-calibration) of conceptual and predictive models and validation of seepage predictions.
- Compliance with regulatory conditions.

In terms of the Mt Rawdon regional monitoring programme, Section C6-1 of the environmental authority permit (EA EPML00712113) clearly defines that the regional monitoring is targeted at "*Regional groundwater that may be potentially impacted by mining activities*". In a practical sense, this is interpreted to mean groundwater that is representative of groundwater flow away from the general mine site and into the broader regional groundwater system, as distinct from groundwater immediately adjacent to sources of contaminant seepage (TSF, WRD etc). That is, the regional monitoring programme is designed to assess the impact of mining activities on the regional environment.

2.2 Meeting Monitoring Aims

The keys to meeting monitoring aims are to develop a clear understanding of seepage flow processes (flow pathways, seepage velocities and seepage characteristics) and understanding the potential risks of seepage to the environment, and then to develop a monitoring programme that provides adequate identification and assessment of the distribution and migration of seepage and potential environmental risk.

The former (seepage flow processes and risks) are covered in Chapter 3 of this report. The remainder of this chapter deals with the conceptual approach to meeting the broad aims of monitoring.

At the commencement of any mining project, monitoring programmes (developed during the environmental impact assessment and approvals stage) typically tend to focus on high frequency and comprehensive monitoring. This is as a result of a limited understanding of the groundwater flow processes occurring on site (including realistic groundwater/seepage velocities) and also applying a degree of conservatism in light of many residual unknowns.

However, once operational performance data are available (as is clearly the case at Mt Rawdon with over 15 years of operation and comprehensive monitoring data) it is possible to refine the groundwater monitoring programme to cost effectively meet the monitoring objectives.

In general, the key components of an effective operational monitoring programme are:

- A primary set of monitoring bores - these are those bores immediately downstream of known seepage fronts (from various site sources of contamination - TSF, plant, WRD). These bores are designed to detect the first arrival of potential seepage and should be monitored for "trigger" parameters (see below) at a frequency such that there is minimal risk of a seepage front advancing too far beyond the bore between monitoring.
- A secondary set of monitoring bores – these are down-hydraulic gradient of the primary bores. These provide coverage of "regional" groundwater. The bores also provide a back-up in case seepage bypasses the primary bores, and would be elevated to primary status once seepage has been detected and confirmed in the relevant up-gradient bore. In terms of seepage detection, these bores only need to be monitored for trigger parameters at much less frequency than the primary bores. Secondary bores are typically also used as regional monitoring bores.
- A tertiary set of monitoring bores – once seepage has been detected and confirmed at primary or secondary bores, and the next down-gradient bore has been elevated to primary status, these bores are reclassified as tertiary bores and can be dropped from the regular seepage detection programme (trigger parameters) although monitoring might continue for investigation purposes.
- Indicator parameter monitoring – there will be one or two key parameters that provide the first indication of the arrival of a seepage front. These should be the target parameters for seepage detection monitoring. If monitoring of these parameters indicates the presence of seepage, then more comprehensive monitoring should be undertaken to confirm this.
- Synoptic (or snapshot) monitoring – it will be necessary to provide a clear picture of the distribution of groundwater quality on a semi-regular basis, to provide a more detailed understanding of the nature and spread of seepage and to meet internal environmental standards and regulatory compliance requirements. This monitoring would involve the comprehensive analysis of samples from all bores and would typically be undertaken once or twice a year.

As outlined previously, a specific monitoring approach based on the above concepts and the understanding of groundwater flow and seepage processes (outlined in Chapter 3 below), is presented in Chapter 4.

3. CONCEPTUAL GROUNDWATER FLOW AND SEEPAGE MODELS

3.1 Local Hydrogeology

The local and sub-regional aquifer system at Mt Rawdon comprises:

- Variably fractured basement rocks with low to moderate permeability depending on the physical nature of and hydraulic interconnection between faults, shears and joint sets.
- Weathered basement, largely comprising low permeability clay rich regolith.
- Shallow creek alluvium comprising moderately permeable alluvial sediments which are mostly dry over the mine area or which form intermittent, perched aquifers after rainfall recharge. These aquifers are more permanent in lower topographical areas downstream of the mine site (eg at/near Perry River Dam).

A prominent set of NE-SW trending faults has been identified in a number of hydrogeological studies, and local drainages tend to follow these broad fault lines. No major aquifers have been identified, although some isolated bore yields (of up to 3L/s) have been reported during the drilling of some monitoring bores.

3.2 Groundwater Flows

3.2.1 Groundwater Flow Paths

Pre-mining groundwater flows were largely controlled by topography and drainage, with groundwater flow from elevated areas towards the major creek lines and then following the major drainage systems (though alluvium and underlying weathered and fractured basement rocks). There will have been some groundwater baseflow to the local creeks (springs) at topographic breakaways. Most of the pre-mining groundwater flow was to the northeast, parallel with Swindon, Rawdon and Twelve Mile Creeks, towards the Perry River with some minor groundwater flows to the south towards Mingham Creek.

Since mining has commenced, local groundwater flow patterns have been influenced by site activities. The TSF has become a source of recharge/seepage and the pit has become a groundwater sink. The WRD and/or the runoff containment dams downstream of the WRD have also become sources of groundwater recharge. Monitoring data also indicates that the NE-SW trending fault that is located between the TSF and the pit forms a hydraulic barrier to groundwater across the fault (ie a barrier to NW-SE flow). Other than these local influences on groundwater flow, overall groundwater flow remains similar to pre-mining conditions.

Figure 1 shows the interpreted current main groundwater flow pathways from the mine site.

3.2.2 Groundwater Flow Velocities

Numerical groundwater flow modelling, recently undertaken to support the TSF2 Application (Numerical Modelling Report - Groundwater Flow (NRC, Oct 2014)), predicted average groundwater particle velocities from beneath the toe of TSF2 towards Perry River of around 0.02m/d (around 7m/yr).

The model adopted average permeability conditions for the fractured basement (0.1m/d) and regolith (0.05m/d) and was calibrated against observed long term groundwater levels. The model predicted a travel time of 50 years for groundwater particles travelling the shortest route towards Perry River (around 300m). It is possible that some parts of the fractured rock aquifer might have a higher permeability. However, a recent bore census (MRO Groundwater Monitoring Bore Census (NRC, Jan 2015)) indicated bore yields in excess of 1L/s at only five of the 53 bores reviewed. Given this, and the fact that good model calibration was achieved with the average permeability adopted, it is concluded that any elevated permeability would be localised and will not affect average groundwater flow velocities.

A further assessment of average groundwater flow velocities across the mine site was undertaken using a simple Darcy flow model applied to groundwater flows from the existing TSF and WRD. Measured hydraulic gradients (from groundwater level data) downstream of the TSF were around 0.15%. Assuming an average permeability of 0.1m/d (as per the numerical groundwater flow model) and an effective porosity of 5% (typical value for aquifers of this nature), the indicated average groundwater velocity is around 0.03m/d (or 10m/yr).

Downstream of the WRD, the measured hydraulic gradient is marginally higher at 0.2%, indicating an average groundwater velocity of around 0.04m/d (or 15m/yr).

In summary, estimations of groundwater (particle) velocity range from around 7 to 15m/yr. As an extreme case, if permeability along a flow path was consistently one order of magnitude higher (at around 1m/d) over the whole length of the flow path, then local groundwater velocities could be similarly one order of magnitude higher (at around 70 to 150m/yr). However, as outlined above, the distribution of historical bore yields suggest that it is highly unlikely that such conditions persist over any extended distance.

3.3 Seepage Flows

3.3.1 Seepage Flow Paths

Seepage from the various sources on site will follow the groundwater flow pathways shown on Figure 1.

3.3.2 Sources of Seepage Contaminants

The main potential sources of seepage to groundwater are the TSF, plant area and WRD and the following elements/compounds (which could be mobilised in seepage) are present:

- Mined ore/waste contains Au, Ag, Cu, Zn, Cd, Pb, Se, As, Fe, Mn, S.
- The process plant uses Na, CN (from sodium cyanide in gold leaching solution).
- Waste dumps contain all of the elements listed in the first dot point above plus NO_3 (from explosives residue).

3.3.3 Seepage Characteristics

A significant amount of water quality assessment and hydrochemical evaluation has been undertaken as part of the annual water quality reporting process and more specific investigations of particular water quality characteristics triggered by some monitoring results. Relevant reports include:

- Mt Rawdon EA Amendment Application for TSF2 – Response to Guideline EM963 Application Requirements for Activities with Impacts to Water (NRC, Mar 2015).
- 2014 Annual Water Quality Review Report (NRC, Dec 2014).
- Groundwater Investigation – Total Cyanide Tot CN Exceedance in MRMB45 and 46 (NRC, Apr 2015).
- Investigation into Nitrate and Sulphate Concentrations in Groundwater at MRO (NRC, Feb 2015).
- Groundwater Quality Investigation – Bores MRMB25, 27 and 49 at MRO (NRC, Apr 2103).
- Rationale for Relocation or Bores MRMB24 and 51 (NRC, Dec 2013).

Key findings in relation to the hydrochemical nature of groundwater on site are that natural groundwater has a sodium-chloride signature but that groundwater affected by mixing with seepage from both the TSF and WRD has a sodium-sulphate signature. The sulphate in seepage is derived from the oxidation of sulphides in the ore and waste. The sodium is natural but also could be derived from sodium hydroxide, used as a buffering agent in the gold processing circuit.

Seepage can also be characterized by elevated levels of some of the metals listed in Chapter 3.3.2, salinity (as TDS), nitrate (from the WRD) and cyanide (from the TSF and plant area). Table 1 (following page) shows the interpreted times when the concentrations of various contaminants started to (and continued to) clearly increase from background levels at bores where the arrival of seepage has been confirmed by assessment of overall water quality. These include bores downstream of the TSF and WRD. Appendix A presents plots of sulphate and salinity for these bores.

These data clearly show that, in all cases, the first arrival of seepage was characterized by a steady increase in sulphate concentrations (from background levels). In all but one case, the increase in sulphate was accompanied by a corresponding increase in salinity. In one bore (MRMB25 downstream of the WRD) the increase in sulphate was also accompanied by an increase in nitrate and in two bores (MRMB1 and 2 immediately downstream of the TSF) by total cyanide.

In many of the bores, increases in the concentration of cyanide, nitrate, zinc, cadmium and lead have been observed at some time (ranging from months to years) after the first arrivals of elevated sulphate and salinity.

Table 1: First Arrival of Seepage (derived from MRO monitoring data).

Bore	Source	First Arrival Parameters	Following Parameters
MRMB24	WRD	SO_4, TDS (Dec 04)	Zn, Cd (mid 07), Pb (Jan 08), NO_3 (<Aug 08)
MRMB25	WRD	SO_4, NO_3 (Jul 12)	Nil
MRMB26	WRD	SO_4, TDS (Nov 07)	NO_3 (Jul 13)
MRMB27	WRD	SO_4, TDS (Apr 06)	Nil
MRPB1	WRD	SO_4, (Jul10)	Nil
MRMB1	TSF	SO_4, TDS, CN (Aug 01)	Cu (Nov 06), Zn (Apr 07), Cd (Feb 10)
MRMB2	TSF	SO_4, TDS CN..(Aug 01)	Cu (Jul 06)
MRMB9	TSF	SO_4, TDS (Jul 02)	Cu, Zn, Cd (Nov 05), CN (Mar10)
MRMB19	TSF	SO_4, TDS (Feb 03)	Zn, Cd (Mar 03)
MRMB23	TSF	SO_4, TDS (Sep 07)	CN (Aug 12)

It is concluded that the clear site wide “indicator parameters” of the first arrival of seepage (or the mixing front ahead of seepage) are sulphate and salinity.

3.3.4 Seepage Migration Velocity

Interpreted first arrival times of seepage were used to calculate average seepage velocities towards each bore. Key assumptions used in this assessment were:

- The main source of seepage towards bores downstream of the TSF was the downstream toe of the current TSF embankment.
- The main sources of seepage towards bores downstream of the WRD were the WRDs themselves and the runoff collection dams WD1 and WD2.
- Seepage first entered the groundwater system (by vertical leakage from the above sources) in the first year of mining (2001).
- The first arrival of seepage is as indicated in Table 1.
- Note that bores MRMB1, 2 and 9 were not used in this assessment. Seepage was observed in these bores almost immediately after commissioning of the original (much smaller TSF) and the mechanism for seepage arrival at these bores is not clear (although some down slope migration in surface seepage is suspected particularly at MRMB1 and 2 which are adjacent to seepage dam SD1), thus introducing large potential errors in such calculations.
- Seepage velocity downstream of the TSF was estimated from the travel times of seepage from immediately downstream of the current toe of the TSF (as indicated by first arrival at bore MRMB9) towards bore MRMB23.

The results for one bore downstream of the TSF (MRMB23) indicate a seepage velocity of around 0.03m/d (around 11m/yr). The results for four bores downstream of the WRD (MRMB25, 26, 27, MRPB1 indicate an average seepage velocity of around 0.05m/d (around 18m/yr).

These results are of a similar order to those estimated for groundwater particle velocity (refer Chapter 3.2.2).

4. SPECIFIC MONITORING APPROACH

The generic key components and levels of monitoring outlined in Chapter 2.2 largely apply to an integrated site-wide monitoring programme. This current review is focussed on the regional monitoring programme to satisfy the aims of regional monitoring and the requirements under the EA.

As such, only the regionally focussed components of the overall monitoring approach (outlined in Section 2) have been adopted in developing the refined regional programme. However, the monitoring approach developed for the regional monitoring programme (subject of this report) is designed to be compatible with the parallel seepage monitoring programme, which is also undergoing a review by MRO.

4.1 Categories of Required Monitoring

The primary aim of the regional monitoring is to monitor the potential impacts on regional groundwater. As such, it is recommended that the regional monitoring programme covers the potential impacts of all site activities on regional groundwater.

With reference to the generic key elements of a monitoring programme, the regional monitoring bores would essentially be secondary bores. That is bores well downstream of any seepage front and downstream of any primary bores (which would be located immediately ahead of any seepage front). This concept works well downstream of the TSF where there are several known seepage pathways heading towards Perry River and where there is an extensive grid of TSF seepage monitoring bores, with numerous secondary bores downstream of known seepage fronts. The bores located furthest downstream are obvious choices for regional monitoring bores.

To the north, east and south of the WRDs, however, seepage has already been detected in a significant number of existing bores close to the WRDs. In practice, these bores should be classified as tertiary bores, and some of the new bores recently drilled as part of various investigations classified a primary bores. In the context of monitoring potential impacts on regional groundwater, these primary bores are considered to also fulfil the role of regional monitoring bores.

Also, it is considered that, at least in the near future, the tertiary bores can provide valuable information in terms of investigation of the nature and extent of seepage from the WRDs as well as measuring the remedial influence of the recently upgraded seepage recovery systems at WD1 and WD2. These upgraded seepage recovery systems comprise excavated trenches across the main seepage pathways from each of the two dams, with enhanced permeability zone beneath each trench created by a series of blast holes. These sub-trench permeable zones effectively increase the depth of seepage interception by each trench. The trenches are equipped with pumps which are controlled by water level switches.

In summary, it is recommended that the regional monitoring programme should comprise two categories of bores:

- Regional bores – which need to be in locations and monitored at sufficient frequency to effectively detect the first arrival of seepage and then track the migration of any seepage fronts, and to effectively monitor any impact or risk of impact to regional groundwater. Some of these bores should be located downstream of (and relatively close to) known and suspected seepage fronts, while others should be located further downstream along potential seepage pathways close to mine lease boundaries and regional groundwater discharge zones (ie Perry River).
- Investigation bores – which will be monitored as required to assist in the investigation of incidents where regular monitoring of the regional bores triggers any such investigation (ie exceedance of trigger or compliance levels of monitoring parameters). The number of bores to be monitored as part of any investigation would be confirmed based on the nature of the incident to be investigated. Once the investigation is completed, monitoring of these bores would be discontinued.

Bores that do not add any value to regional monitoring should be removed from the regional monitoring programme. Some might be decommissioned while others might be incorporated into other monitoring programmes on site.

4.2 Monitoring Frequencies

As outlined in Chapters 3.2 and 3.3, groundwater and seepage velocities are very slow, less than 20m/yr. In terms of monitoring the actual impact on regional groundwater, it is considered that annual monitoring would be more than adequate. This would also allow for adequate snapshot monitoring of the distribution of groundwater quality.

However, it is recognised that annual monitoring would be a significant departure from historical monitoring practices in Queensland and that the adequacy of such a monitoring frequency for regional bores would need to be demonstrated by further operational monitoring history. For now, then, it is recommended that the standard monitoring frequency for regional bores should be maintained at six monthly.

It is also recommended that the frequency of investigation monitoring (monitoring triggered by exceedances of trigger levels in indicator or compliance parameters) should be maintained at two monthly.

4.3 Monitoring Parameters

The current regional monitoring programme lists a single set of parameters, with specified contaminant limits set as the compliance levels. In practice, however, these specified limits fill the role of both trigger and compliance levels. The rationale behind the currently specified contaminant limits is unclear. Some appear to be based on some groundwater quality data collected early in the mine life and some (eg nitrate) appear to be based on ANZECC guidelines for surface aquatic systems. Also, it is unclear why some metals have been included, but not others.

In terms of the list of parameters to be monitored, it is recommended that:

- The list of metals (and trace elements) should be revised to include those elements that are characteristics of the ore/waste rock. That is copper, zinc, cadmium, lead, arsenic and selenium. Elemental sulphur would be covered by monitoring for sulphate. Metals for which there are no significant source on site (aluminium, boron, chromium and fluoride) should be removed from the parameter list.
- There has been some previous investigation of elevated sulphate and nitrate levels (NRC, Feb 2015) which resulted in a recommendation that both be removed as compliance parameters at the time. This recommendation is endorsed, however, it is recommended that both parameters continue to be monitored as trigger monitoring (refer below), as these are the key indicators of seepage arrival. That is, sulphate and nitrate data should be used for interpretation purposes only and not compliance.
- Salinity (as TDS) is calculated from electrical conductivity and so both parameters do not need to be reported.
- General anions and cations (ie sodium, magnesium, potassium, chloride, carbonate and bi-carbonate) should be included in monitoring as these parameters allow for the characterisation of “water types” based on distributions of general anions and cations (using Piper/Durov/Expanded Durov data plots). However, there should be no trigger or compliance levels applied to these.

In terms of compliance levels versus trigger levels, the EA Amendment Application for TSF2 (NRC, Mar 2015) states that the assessed environmental value of groundwater is livestock only, while the environmental value for surface water also includes aquatic ecosystems, aquaculture, visual appreciation and industrial use. As such we believe that the current contaminant limits (with some minor modification) should be adopted as trigger levels for investigation, and that the compliance levels should be based on ANZECC guidelines for stockwater. However, it is recognized that there is the potential for groundwater (and seepage) to enter local creeks as baseflow and be conveyed downstream to aquatic ecosystems. As such, it is recommended that trigger levels for key parameters in relation to potential impact on aquatic ecosystems (eg nitrate) should be set at ANZECC guidleins for aquatic ecosystems.

It is recommended that there should be trigger level monitoring for sulphate and nitrate. However, as has already been recommended (NRC, Feb 2015) compliance levels for these parameters are not considered necessary.

In terms of trigger level monitoring, it is recommended that the trigger levels for sulphate and salinity (which have been confirmed as the clear indicator parameters for the first arrival of seepage) should not be set as specific concentration limits, but rather they should be set as deviations from historical trend. This could be done in two ways:

- Clear trend of increasing levels above historical background variations (ie graphical trend analysis).
- A spot level that exceeds some statistical feature of historical data (eg median value).

As shown in the plots of sulphate and salinity for selected bores in Appendix A (where the arrival of seepage has been confirmed by broader water quality assessment), both methods would work. However, trend analysis can take some time to confirm first arrival of seepage. To provide a more timely means of assessing the need for futher investigation it is recommended that the trigger should be any single reported value (for concentration) that exceeds the historical median by more than 50%.

It is also recommended that there should be trigger levels for depth to groundwater, where a shallow water table could indicate the potential for baseflow of groundwater to local creeks. The recommended trigger level is a recorded depth to water less than 0.5m below ground.

Once an investigation has been triggered, the higher frequency investigation monitoring should focus on the key indicators of seepage (sulphate and salinity) and any other parameters that have exceeded trigger (or compliance levels). There is no need to monitor for all compliance or general parameters during investigation monitoring.

5. RECOMMENDED REGIONAL MONITORING PROGRAMME

5.1 Overview

The recommended specific regional monitoring programme focuses on monitoring and managing the potential impacts of all site activities on regional groundwater (and not just the potential impacts of the WRDs as does the current regional programme). Key features include:

- A two tiered regional network of monitoring bores - compliance bores and investigation bores, including:
  - 16 regional compliance monitoring bores (same number as current programme).
  - 7 investigation bores (with provision to add more as required).
- A three tiered programme of monitoring - compliance, trigger and investigation monitoring, including:
  - Compliance monitoring for a comprehensive list of parameters (similar to current programme).
  - Trigger monitoring for the key indicators of the first arrival of seepage from the TSF or WRDs.
  - Investigation monitoring for key indicators and other parameters as required.

It is recommended that some bores (8 bores) are removed from the current regional monitoring programme. The recommended bores to be included in the regional monitoring programme are shown on Figure 2.

5.2 Monitoring Bores

5.2.1 Compliance Bores

It is recommended that the monitoring bores listed in Table 2 should be designated as compliance bores. These bores should be monitored at the intervals specified in Chapter 5.3 and for the parameters specified in Chapter 5.4.

Table 2: Recommended Regional Compliance Bores

Bore	Comments
Downstream of WRD North	
MRMB28	Downstream of WD3 and WD4 at confluence of tributaries of Twelve Mile Creek. Bore construction uncertain, but adequate for monitoring at present. May need to be replaced in future if uncertainty in bore construction impedes interpretation of data (after first arrival of seepage is detected).
MRMB37	Not downstream of WRD North, but on upstream tributary of Twelve Mine Creek not on interpreted seepage flow path. Confirmed appropriate bore construction.
MRMB38	Most downstream bore on Twelve Mile Creek close to mine lease boundary. Confirmed appropriate bore construction.
MRMB61	On Twelve Mile Creek downstream of WD3 and WD4. Confirmed appropriate bore construction.
MRMB62	On Twelve Mine Creek upstream of WD4. Confirmed appropriate bore construction.
MRMB63	On Twelve Mile Creek downstream of WD2. Confirmed appropriate bore construction.
MRMB64	On catchment boundary between groundwater flow/seepage from WRD and TSF. Confirmed appropriate bore construction.
New Bore A	On Twelve Mile Creek downstream of WD1 and at confluence of seepage pathways from WD1 and all other WRD seepage sources. To have appropriate bore construction.
Downstream of WRD West	
MRMB36	Deep bore immediately downstream of WD5. Paired with MRMB72. Confirmed appropriate bore construction.
MRMB70	Immediately downstream of WRD West. Confirmed appropriate bore construction.
MRMB72	Shallow bore immediately downstream of WD5. Paired with MRMB36. Confirmed appropriate bore construction. This bore is currently dry but would be sampled if/when water table rises.
New Bore B	Downstream of WD5 on Mingham Creek at mine lease boundary. To have appropriate bore construction.
Downstream of TSF	
MRMB52	On Swindon Creek just upstream of Perry River and mine lease boundary. Confirmed appropriate bore construction.
MRMB53	On un-named creek just upstream of Perry River and mine lease boundary. Confirmed appropriate bore construction.
MRMB54	Not downstream of TSF, but adjacent to Perry Creek upstream of Swindon Creek. Confirmed appropriate bore construction.
New Bore C	On Rawdon Creek just upstream of Perry River and mine lease boundary. To have appropriate bore construction.

5.2.2 Investigation Bores

It is recommended that the bores listed in Table 3 should be designated as investigation bores. The number of bores to be monitored as part of any investigation would be confirmed based on the nature of the issue to be investigated. Monitoring frequencies and parameters to be measured are specified in Chapters 5.3 and 5.4.

Table 3: Recommended Regional Investigation Bores

Bore	Comments
MRPB1	Moderate yielding bore of uncertain construction downstream of WRD near WD2. First arrival of seepage in July 2010. Currently a compliance bore, but to be replaced (for compliance monitoring) by recently installed high yielding bore MRMB63.
MRMB25	Low yielding bore of uncertain construction downstream of WD1. First arrival of seepage in July 2012. Currently a compliance bore, but to be replaced (for compliance monitoring) by New Bore A.
MRMB26	Low yielding bore of uncertain construction downstream of WD1 and MRMB25. First arrival of seepage in May 2008. Currently a compliance bore, but to be replaced (for compliance monitoring) by New Bore A.
MRMB27	Low yielding bore of uncertain construction downstream of WD2. First arrival of seepage in April 2006. Currently a compliance bore, but to be replaced by (for compliance monitoring) recently installed high yielding bore MRMB63.
MRMB59	Recently installed bore with confirmed appropriate bore construction, adjacent to upstream end of WRD North.
MRMB60	Recently installed bore with confirmed appropriate bore construction, between WRD North and WD3.
MRMB71	Recently installed bore with confirmed appropriate bore construction, immediately downstream of WRD West and adjacent to WD5. Currently a compliance bore, but compliance monitoring can be adequately managed by three adjacent bores (MRMB70, MRMB36 and MRMB72)

5.2.3 Bores to be Removed from the Regional Programme

It is recommended that the bores listed below should be removed from the regional monitoring programme. Two of these bores have already been decommissioned (and replaced by new bores) and the others are in locations more impacted by TSF seepage and/or within the plant site. These latter bores will be considered for inclusion into a refined seepage monitoring programme.

Table 4: Recommended Bores to be Removed from Regional Monitoring Programme

Bore	Comments
MRMB11	Uncertain bore construction and very low yield. Location downstream of TSF covered by existing nearby seepage monitoring bores. Regional monitoring covered by MRMB52.
MRMB20	Uncertain bore construction and located close to the ROM pad and crusher stockpile. Has historically shown high levels of many contaminants. Has been recommended for decommissioning. This bore (or replacement bore) may be incorporated into refined seepage monitoring programme.
MRMB24	Uncertain bore construction and potentially influenced by surface water at the toe of the WRD. Has been decommissioned and nominally replaced by MRMB63 and 64. Also covered by proposed regional bore New Bore A and investigation bores MRMB25 and 26.
MRMB45	Low yielding bore in plant between TSF and pit. Should be incorporated into refined seepage monitoring programme.
MRMB46	Low yielding bore between TSF and pit/WRD. Should be incorporated into refined seepage monitoring programme.
MRMB49	Non-yielding bore located on TSF side of interpreted fault barrier. Historically has shown elevated NO_3. Should be incorporated into refined seepage monitoring programme.
MRMB51	Initially drilled to between WRD North and WD1, but annular seal has been breached. Potentially influenced by surface water at the toe of the WRD. Has been decommissioned and nominally replaced by MRMB63 and 64. Also covered by proposed regional bore New Bore A and investigation bores MRMB25 and 26.
MRMB55	Non-yielding bore located on catchment divide between TSF and WRD on the TSF side of interpreted fault barrier. May be incorporated into refined seepage monitoring programme.

5.3 Monitoring Frequency

It is recommended that the bores should be monitored at the frequencies listed in Table 5. The recommended programme for the compliance bores is largely the same as for the current EA requirements for the monitoring programme. The only difference is that two-monthly investigation monitoring (should an investigation be triggered by monitoring results) would be restricted to the indicator parameters (sulphate and salinity together with any other parameters which has exceeded trigger levels). The key difference between the recommended and current monitoring programmes is that any triggered investigation would also include selected investigation bores.

By way of example, under the recommended programme, bores MRMB25, 26 and 27 and MRPB1 (currently listed as compliance bores but recommended to re-designated as investigation bores) would continue to be monitored at two-monthly intervals for indicator parameters. These bores all show elevated sulphate (and salinity) and continued high frequency monitoring for indicator parameters (and other parameters as required) will provide key information on the influence of the recently upgraded groundwater seepage recovery systems at WD1 and WD2.

Table 5: Recommended Monitoring Frequencies

Bore Designation	Groundwater Levels	Compliance Parameters	Indicator Parameters	Other Parameters	General Parameters	Comments
Normal Monitoring						
Compliance Bores	3 monthly	6 monthly	6 monthly	Nil	6 monthly	Specified normal regional monitoring programme.
Investigation Monitoring (following exceedance of trigger levels)						
Compliance Bores	2 monthly	6 monthly	2 monthly	2 monthly	6 monthly	Required investigation monitoring at specific bore(s) if trigger levels in indicator parameters (or compliance levels in any parameters) are exceeded in that bore(s). Other parameters to be monitored as part of an investigation subject to which trigger levels are exceeded.
Investigation Bores	2 monthly	Nil	2 monthly	2 monthly	Nil	Required investigation monitoring at selected bores triggered by the above. Bores to be monitored as part of specific investigation to be determined at the time. Other parameters to be specified as required to assist investigation subject to which trigger levels are exceeded.

5.4 Monitoring Parameters

It is recommended that the bores should be monitored for the parameters listed in Table 6.

The key differences between the recommended monitoring parameters and the current programme are as follows:

- The contaminant limits (compliance levels) listed in the current programme have been adopted as trigger levels for further investigation. Exceedance of these levels will trigger further investigation (as is the case in the current programme) but will not constitute non-compliance.
- Sulphate and nitrate have been removed as compliance parameters, but remain in the programme as trigger paremeters.
- No set trigger levels have been set for sulphate or salinity. Rather, it is recommended that the trigger for further investigation should be any single reported value which exceeds the historical median by more than 50%.
- The trigger level for nitrate has been set as the revised ANZECC guideline for aquatic ecosystems, to cover the potential impact on water ways if there is also baseflow to creeks. Investigation would then initially focus on groundwater levels. If there is no potential for baseflow (ie deep water table) then no further investigation would be required.
- Compliance levels (contaminant limits) have been based on the ANZECC guidelines for stockwater.
- Aluminium, boron, chromium and fluoride, none of which are significant elements present in the ore and waste rock have been removed from the parameter list.
- Selenium, which is present in measurable quantities in the ore and waste rock has been added to the parameter list.
- Sodium and Chloride have been removed from the compliance parameters list but added to the general parameter list. Magnesium, potassium, carbonate and bi-carbonate have been added to the general parameter list to allow for the characterisation of "water types" based on distributions of general anions and cations.

Table 6: Recommended Monitoring Parameters and Contaminant Limits (mg/L)

Parameter	Compliance Parameters		Indicator Parameters	General Parameters	Comments
	Compliance Levels (mg/L)	Trigger Levels (mg/L)	Trigger Level		
Groundwater Level			<0.5m bgl		To cover potential for baseflow to creeks
TDS (by calc)	10,000	150% of median	150% of median		Trigger is value which exceeds historical median by 50%
pH	6.0 to 9.0	6.0 to 9.0			
Cu	1	0.24			
Zn	20	0.1			
Cd	0.035	0.01			
As	0.5	0.12			
Pb,	0.1	0.012			
Mn	10	1.8			
Se	0.05	0.02			
Fe	No limit	10			No ANZECC upper limit specified for stockwater
SO_4	NA		150% of median		Trigger is value which exceeds historical median by 50%
NO_3 - N	NA	1.4			Based on recently revised ANZECC guideline for aquatic ecosystem where algal blooms are a concern (NRC, Feb 2015). Covers possibility of groundwater baseflow to Creeks.
Total CN	0.5	0.03			
WAD CN	0.05	0.024			
Na, K, Mg				No limit	Included to allow for characterisation of "water type"
Cl, CO_3, HCO_3,				No limit	

6. SUMMARY

The key findings of this review are that:

- In general, the existing programme provides a good monitoring coverage of the potential impacts of non-TSF related site activities on regional groundwater.
- However, some of the specific monitoring requirements in the EA conditions are considered to be superfluous and do not add any real value to the effectiveness of the programme.
- Significant improvement to the monitoring programme to provide more efficient and site-wide coverage of the potential impacts of all site activities on regional groundwater could be achieved with some minor refinements to the programme.
- Recommended refinements, include:
    - A change in monitoring status for some bores;
    - Removal of some bores from the regional programme (and transfer to the seepage monitoring programme);
    - Installation of some new bores in new locations;
    - Minor changes to monitoring parameters and introduction of trigger monitoring.

It should be noted that the recommended modifications to the regional monitoring programme result in no net reduction in the number of compliance bores to be monitored. Rather, the recommended modifications result in a much broader and more effective monitoring of potential impacts on regional groundwater from all site activities.

The recommended regional monitoring programme is completely consistent with the monitoring aims defined in Section C6-1 of the environmental authority permit (EA EPML00712113). The recommended programme is also consistent with the parallel seepage monitoring programme, which is also undergoing a review by MRO.

We thank you for the opportunity of working with you on this review and we look forward to continuing to work with you on the rationalisation of monitoring programmes at Mt Rawdon.

Yours sincerely,
RPS Water

Jon Hall ***Emma Bolton***

Jon Hall
Senior Principal Hydrogeologist

Emma Bolton
Principal Hydrogeologist

N

0 500

Metres

Scale: 1:25,000 @A3

GDA 1994 Zone 56

AUTHOR: JH	REPORT NO: 015
DRAWN: MR	REVISION: b
DATE: 18/08/2015	JOB NO: 1725D

Location: F:\Jobs\1725D\Spatial_Data\MapInfo\Workspaces\015b Figure 1 - Groundwater and Seepage flow paths

LEGEND

- Major Seepage Flow Path
- Minor Seepage Flow Path
- Watercourse
- Lease Boundary
- Existing Dam
- Western Waste Dump

DATA SOURCES:
Input data source here

RPS

FIGURE 1
GROUNDWATER AND SEEPAGE FLOW PATHS

N

0 500

Metres

Scale: 1:25,000 @A3

GDA 1994 Zone 56

AUTHOR:	JH	REPORT NO:	015
DRAWN:	MR	REVISION:	b
DATE:	18/08/2015	JOB NO:	1725D

Location: F:\Jobs\1725D\Spatial_Data\MapInfo\Workspaces\000 Figure 2 - Recommended regional GW Monitoring

LEGEND

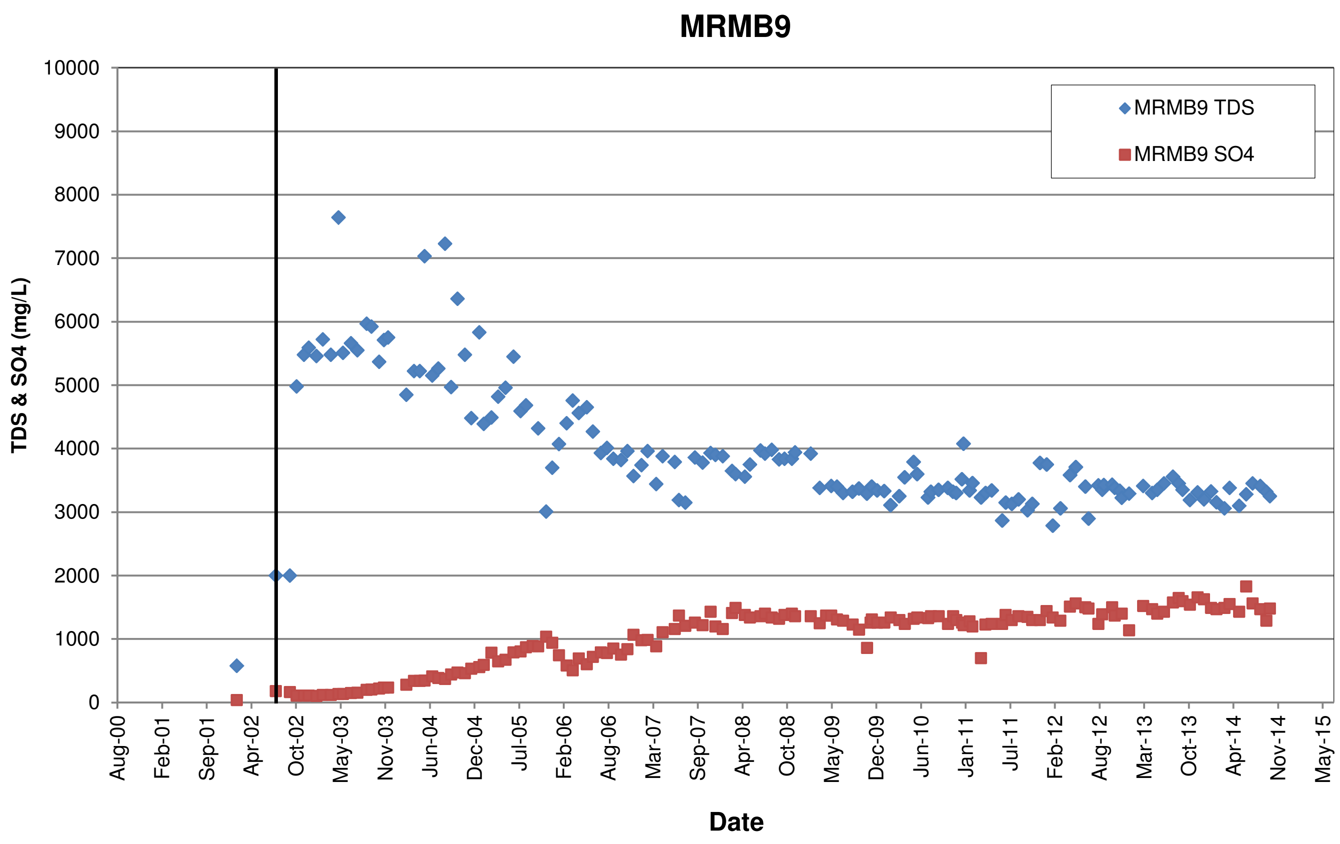
- Regional Monitoring Bore (MRMB)
- Investigation Bore (MRMB)
- Watercourse
- Lease Boundary
- Existing Dam
- Western Waste Dump

DATA SOURCES:
Input data source here

RPS

FIGURE 2
RECOMMENDED REGIONAL GROUNDWATER MONITORING PROGRAM

APPENDIX A: PLOTS OF SULPHATE AND SALINITY IN SELECTED BORES


MRMB9
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
TDS & SO4 (mg/L)
MRMB9 TDS
MRMB9 SO4
Aug-00
Feb-01
Sep-01
Apr-02
Oct-02
May-03
Nov-03
Jun-04
Dec-04
Jul-05
Feb-06
Aug-06
Mar-07
Sep-07
Apr-08
Oct-08
May-09
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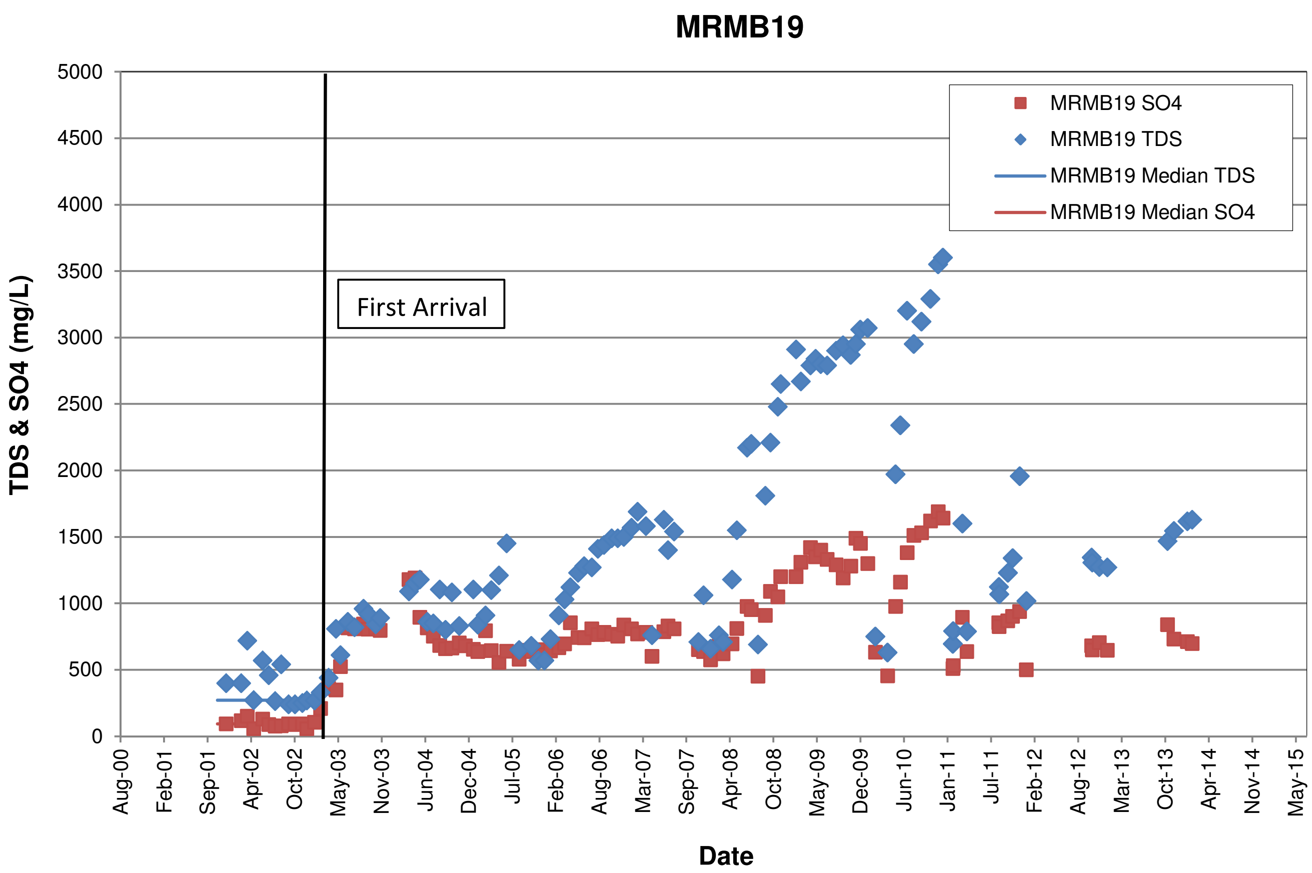
Apr-14
Nov-14
May-15
Date


MRMB19
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
TDS & SO4 (mg/L)
MRMB19 SO4
MRMB19 TDS
MRMB19 Median TDS
MRMB19 Median SO4
First Arrival
Aug-00
Feb-01
Sep-01
Apr-02
Oct-02
May-03
Nov-03
Jun-04
Dec-04
Jul-05
Feb-06
Aug-06
Mar-07
Sep-07
Apr-08
Oct-08
May-09
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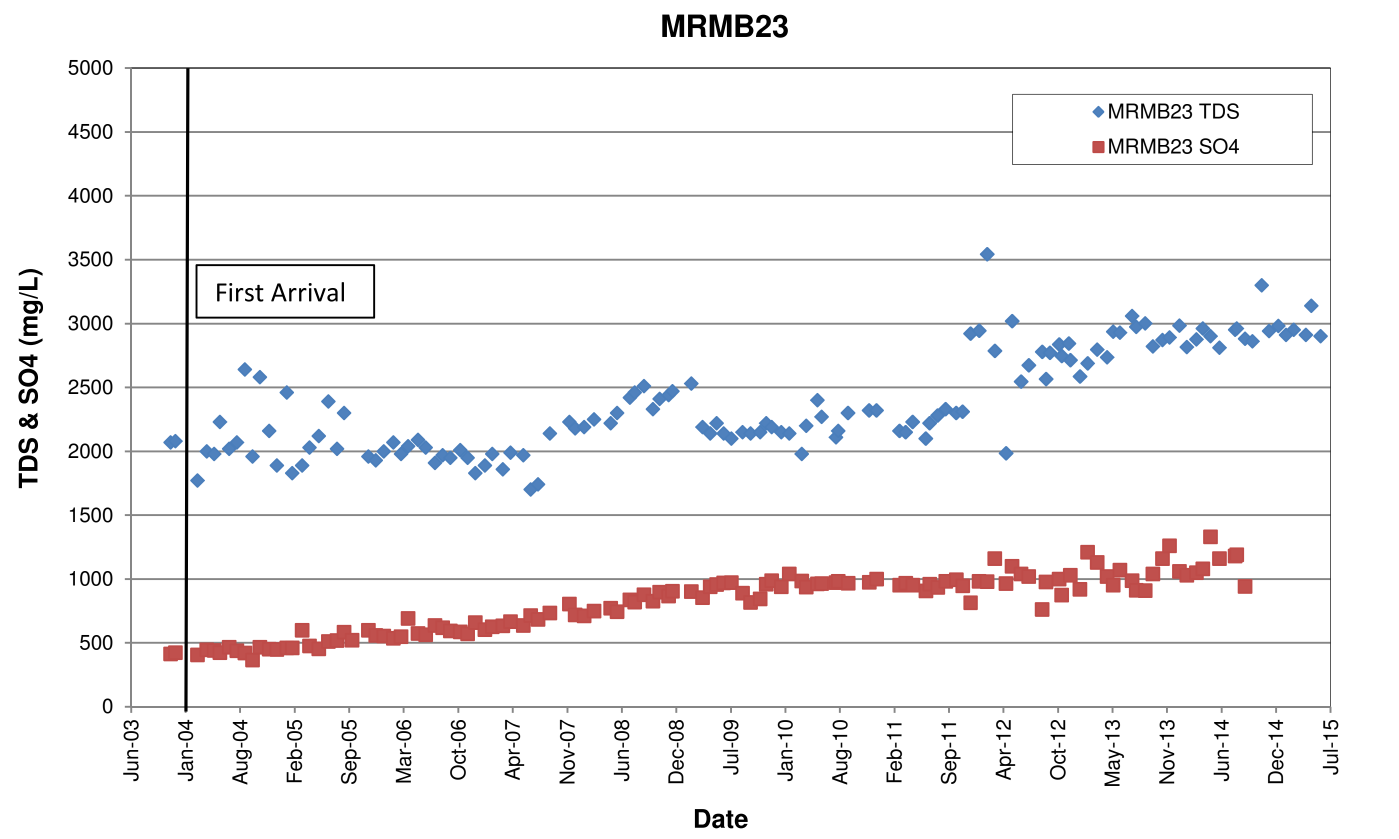
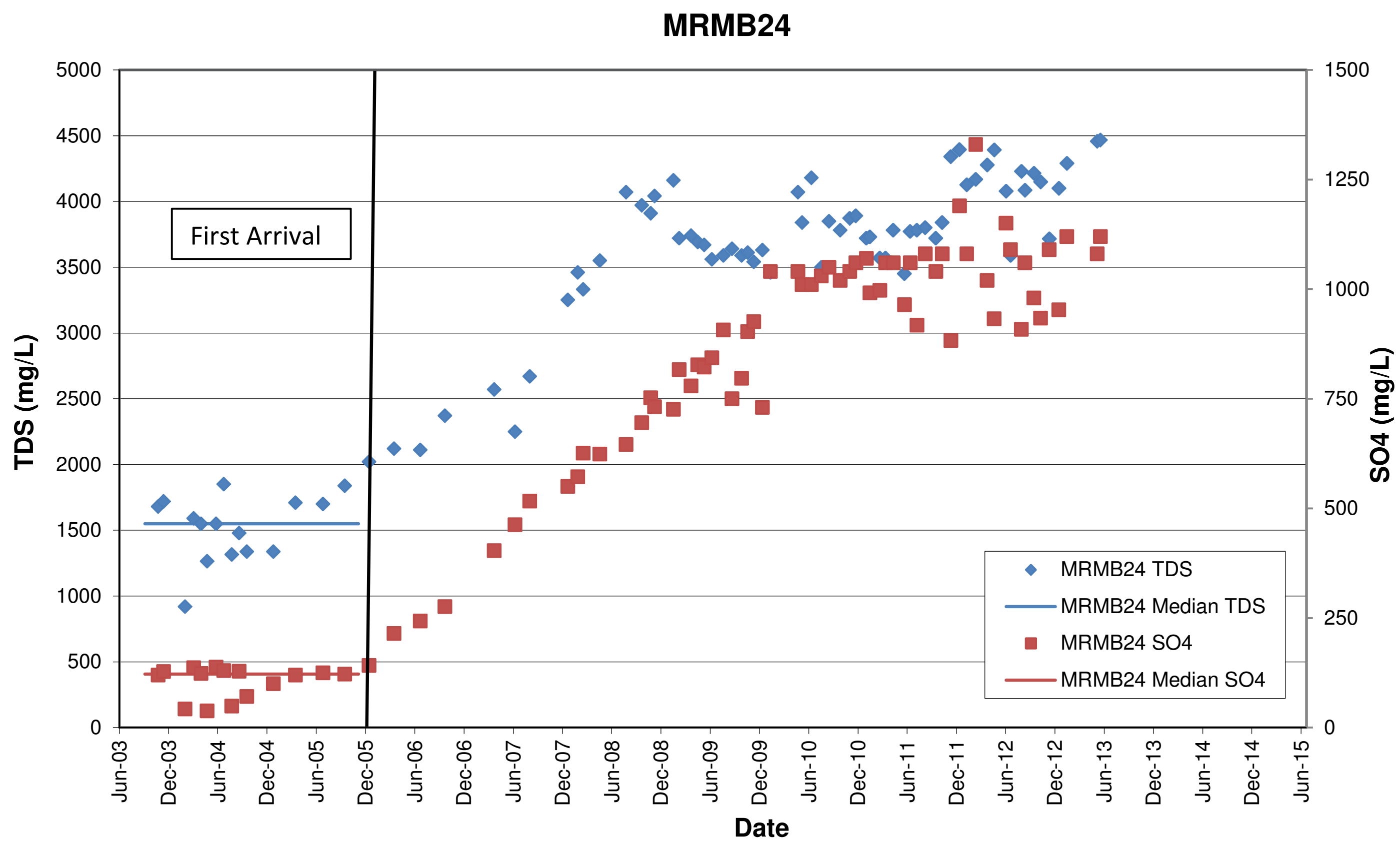
Nov-14
May-15
Date


MRMB23
TDS & SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
First Arrival
MRMB23 TDS
MRMB23 SO4
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06
Oct-06
Apr-07
Nov-07
Jun-08
Dec-08
Jul-09
Jan-10
Aug-10
Feb-11
Sep-11
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Jul-15
Date


MRMB24
TDS (mg/L)
SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1500
1250
1000
750
500
250
0
First Arrival
MRMB24 TDS
MRMB24 Median TDS
MRMB24 SO4
MRMB24 Median SO4
Jun-03
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08
Dec-08
Jun-09
Dec-09
Jun-10
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Jun-12
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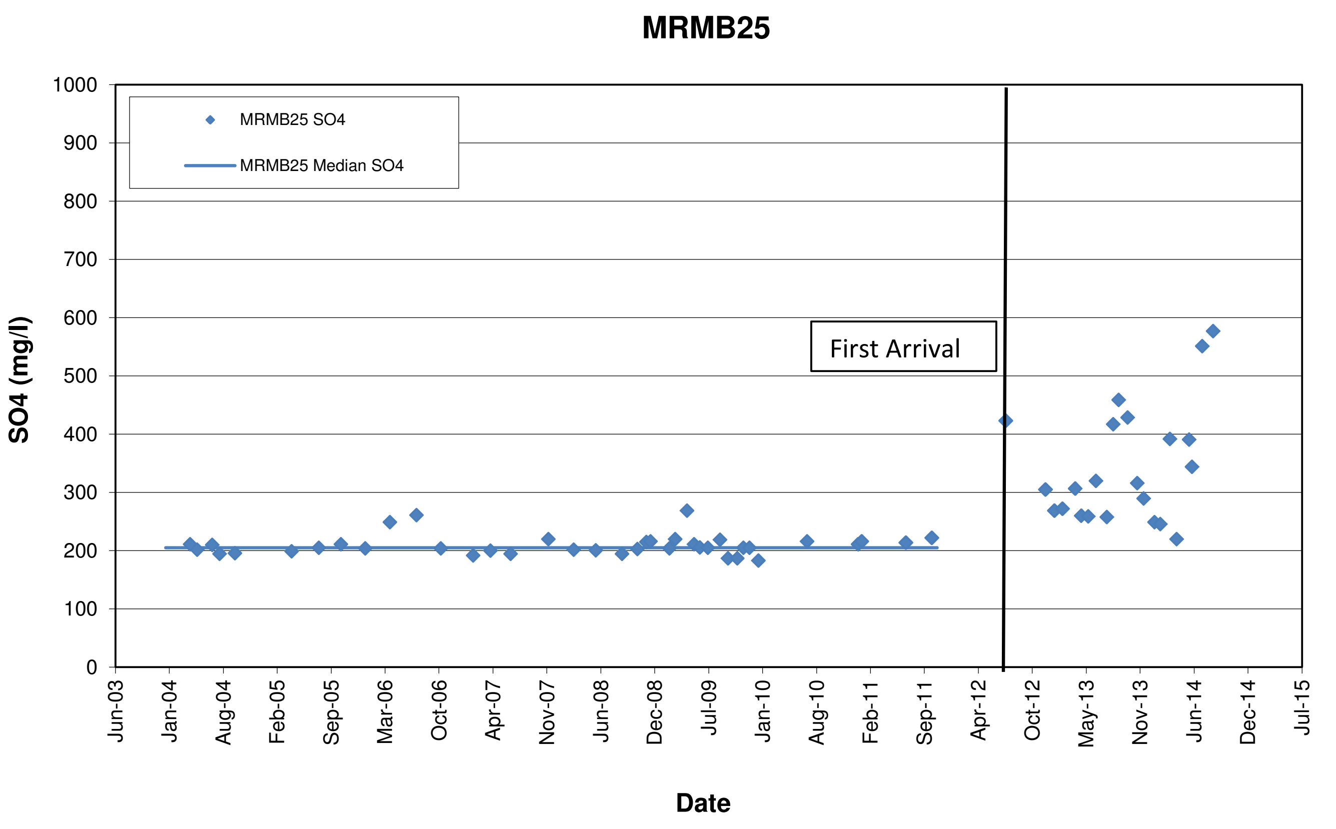
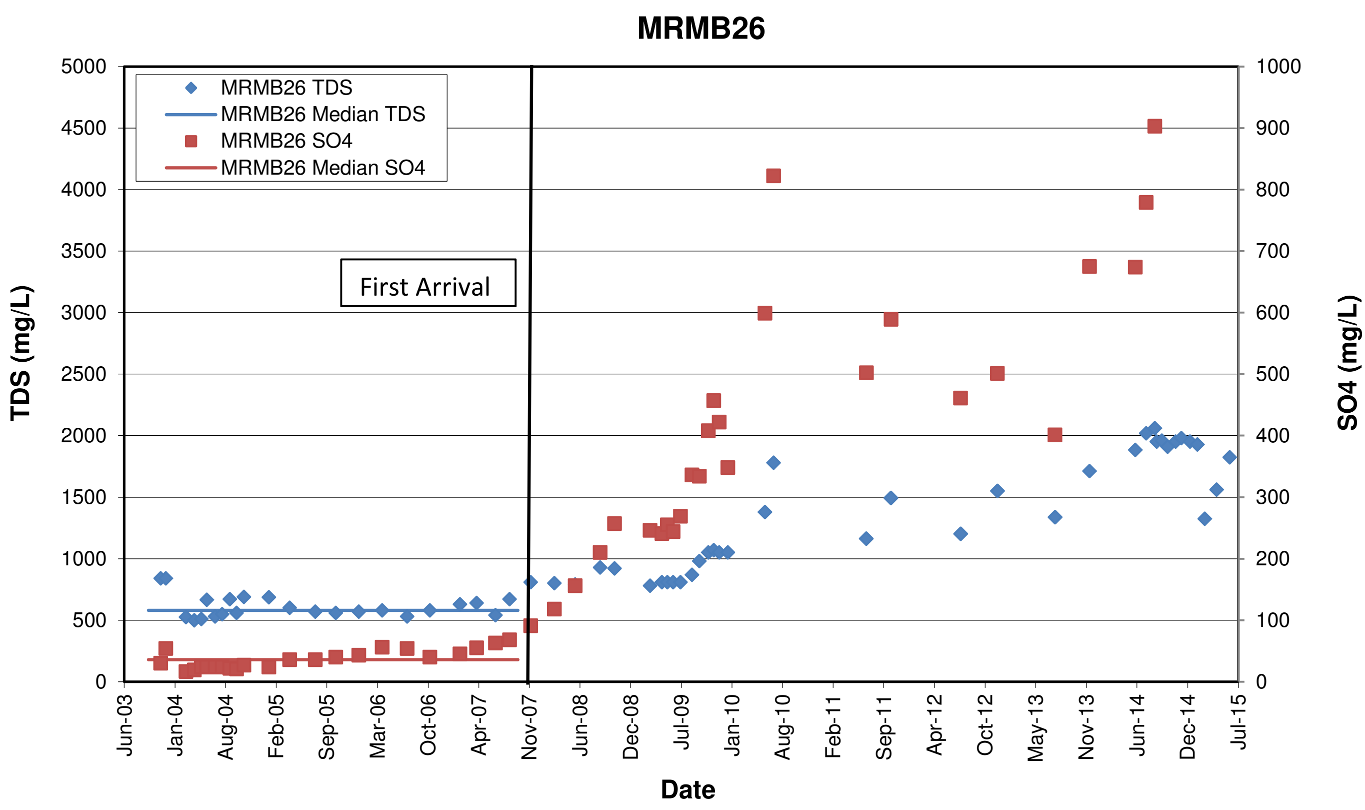
Dec-13
Jun-14
Dec-14
Jun-15
Date


MRMB25
MRMB25 SO4
MRMB25 Median SO4
First Arrival
SO4 (mg/l)
1000
900
800
700
600
500
400
300
200
100
0
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06
Oct-06
Apr-07
Nov-07
Jun-08
Dec-08
Jul-09
Jan-10
Aug-10
Feb-11
Sep-11
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Jul-15
Date


MRMB26
MRMB26 TDS
MRMB26 Median TDS
MRMB26 SO4
MRMB26 Median SO4
First Arrival
TDS (mg/L)
SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1000
900
800
700
600
500
400
300
200
100
0
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06
Oct-06
Apr-07
Nov-07
Jun-08
Dec-08
Jul-09
Jan-10
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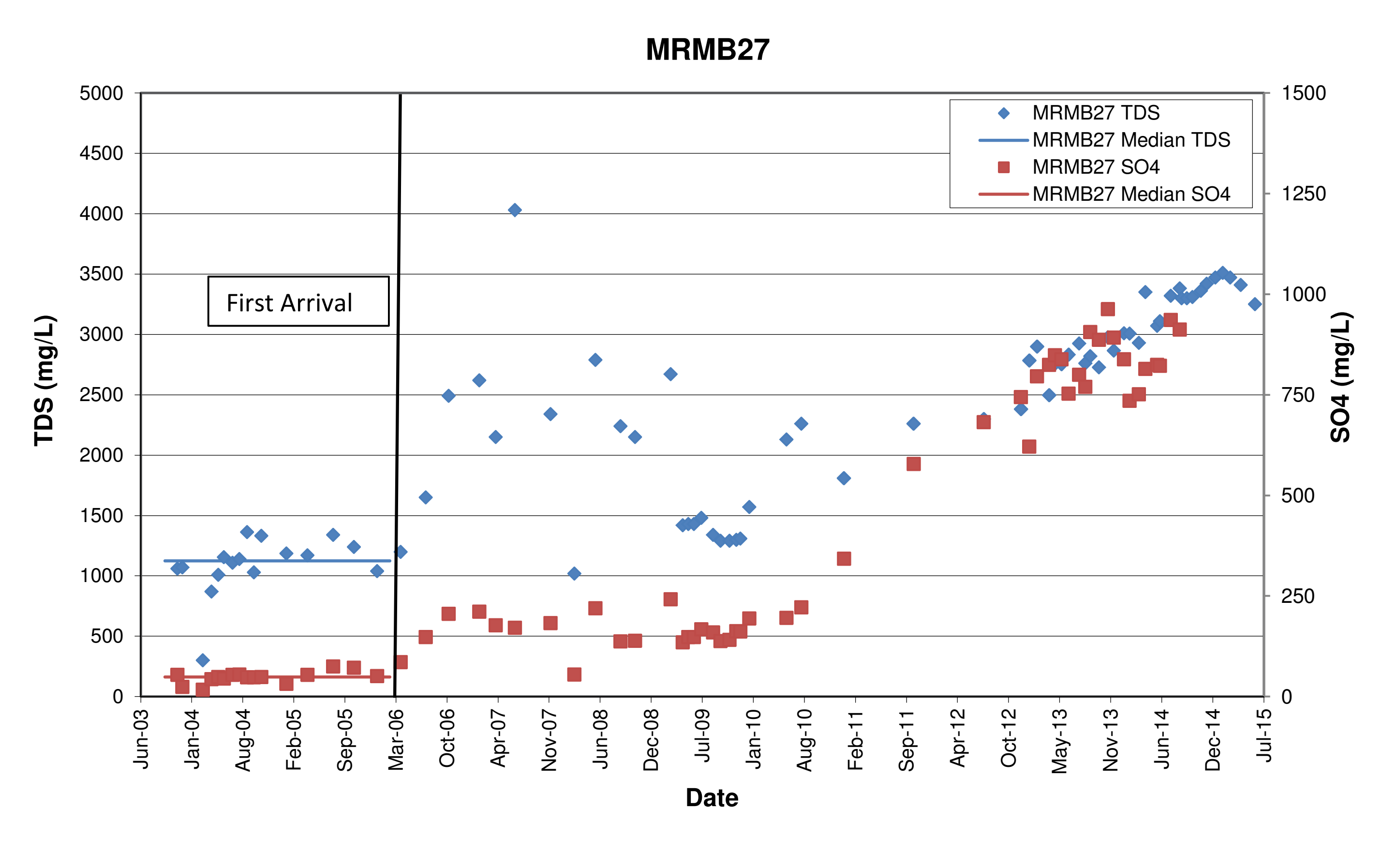
Dec-14
Jul-15
Date


MRMB27
First Arrival
MRMB27 TDS
MRMB27 Median TDS
MRMB27 SO4
MRMB27 Median SO4
TDS (mg/L)
SO4 (mg/L)
Date
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1500
1250
1000
750
500
250
0
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06
Oct-06
Apr-07
Nov-07
Jun-08
Dec-08
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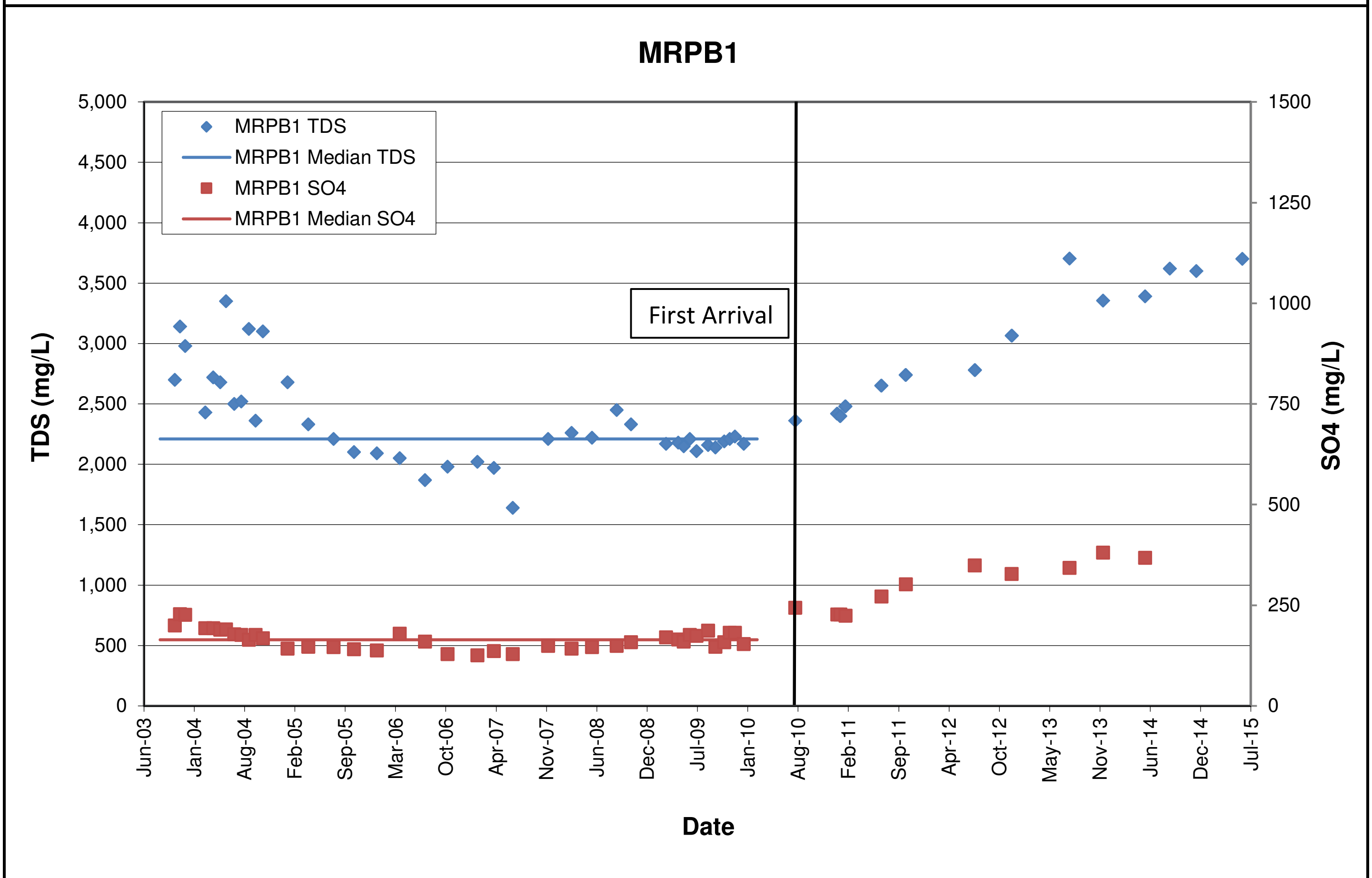
Jun-14
Dec-14
Jul-15


MRPB1
MRPB1 TDS
MRPB1 Median TDS
MRPB1 SO4
MRPB1 Median SO4
First Arrival
TDS (mg/L)
SO4 (mg/L)
Date
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1500
1250
1000
750
500
250
0
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06
Oct-06
Apr-07
Nov-07
Jun-08
Dec-08
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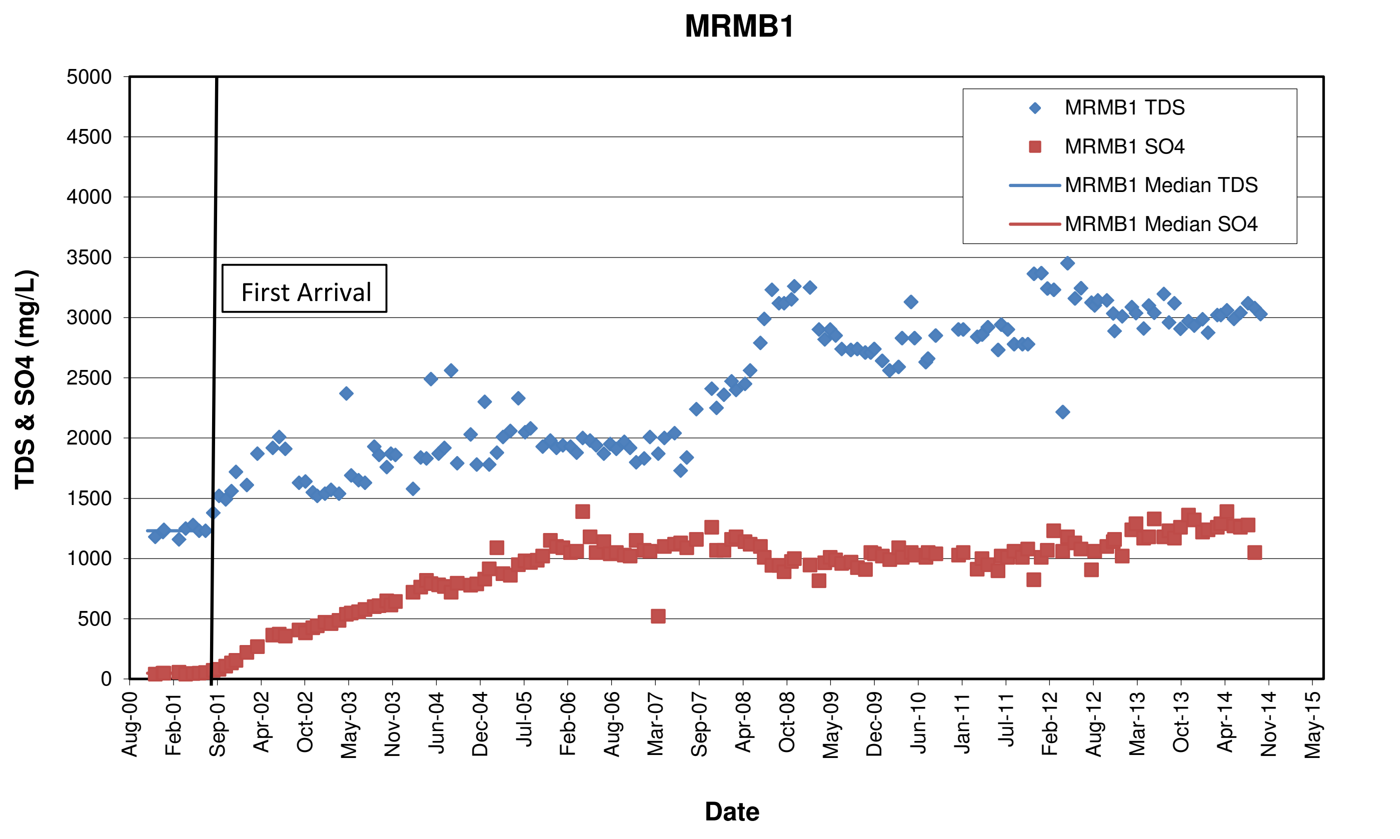
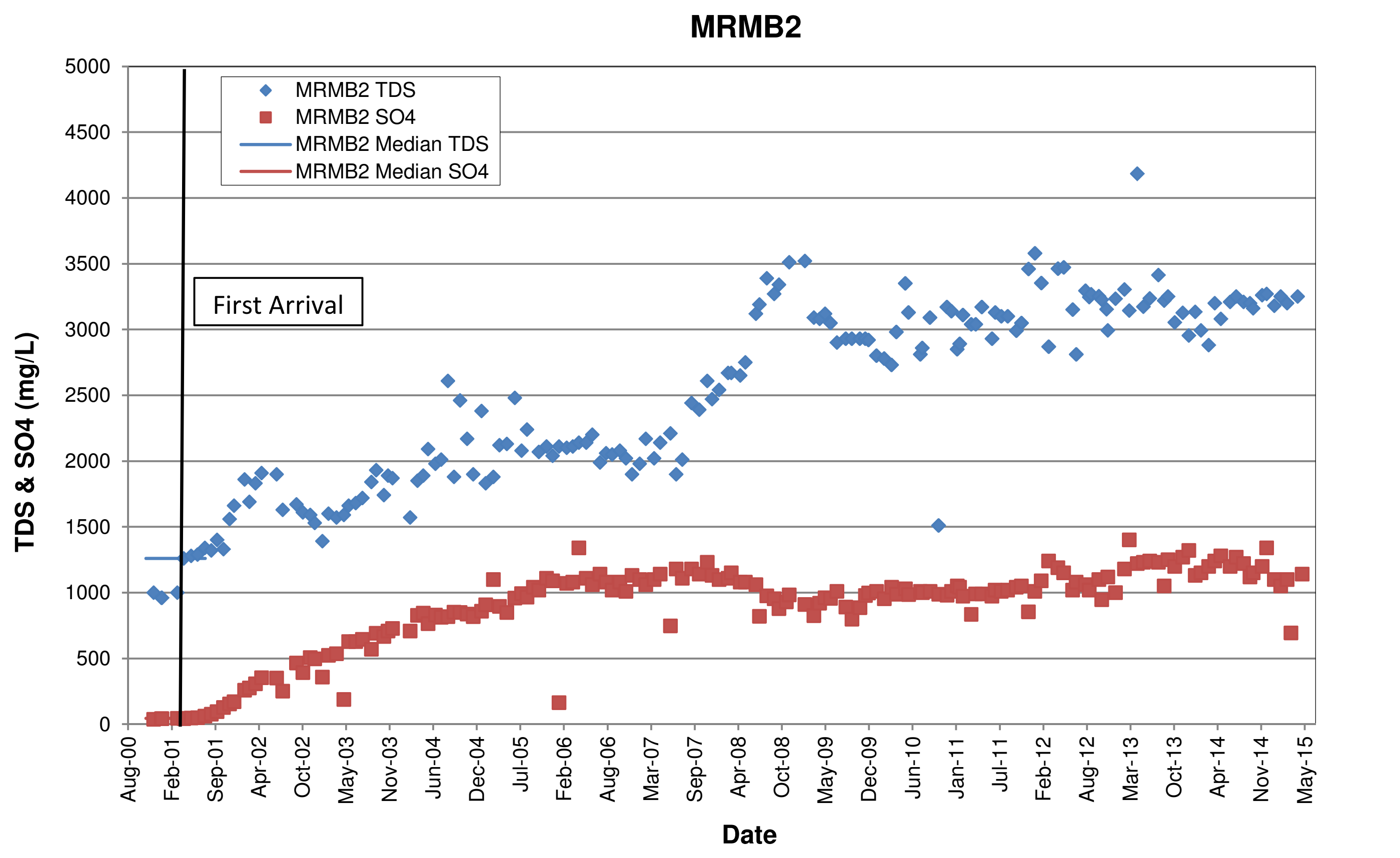
Jun-14
Dec-14
Jul-15


MRMB1
MRMB1 TDS
MRMB1 SO4
MRMB1 Median TDS
MRMB1 Median SO4
First Arrival
TDS & SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Aug-00 Feb-01 Sep-01 Apr-02 Oct-02 May-03 Nov-03 Jun-04 Dec-04 Jul-05 Feb-06 Aug-06 Mar-07 Sep-07 Apr-08 Oct-08 May-09 Dec-09 Jun-10 Jan-11 Jul-11 Feb-12 Aug-12 Mar-13 Oct-13 Apr-14 Nov-14 May-15
Date


MRMB2
MRMB2 TDS
MRMB2 SO4
MRMB2 Median TDS
MRMB2 Median SO4
First Arrival
TDS & SO4 (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Aug-00 Feb-01 Sep-01 Apr-02 Oct-02 May-03 Nov-03 Jun-04 Dec-04 Jul-05 Feb-06 Aug-06 Mar-07 Sep-07 Apr-08 Oct-08 May-09 Dec-09 Jun-10 Jan-11 Jul-11 Feb-12 Aug-12 Mar-13 Oct-13 Apr-14 Nov-14 May-15
Date

Appendix D

RPS Memorandum *Regional Bore Monitoring Program – Addendum* 1 September 2015 (RPS 2015c)

38 Station Street, Subiaco Western Australia 6008, PO Box 465, Subiaco Western Australia 6904
T +61 8 9211 1111 F +61 8 9211 1122 E water@rpsgroup.com.au W rpsgroup.com.au

MEMORANDUM

COMPANY:	Evolution Mining Ltd - Mt Rawdon Operations				
ATTENTION:	Sven Sewell				
FROM:	Jon Hall				
DATE:	1st September 2015	JOB NO:	1725-D2	DOC NO:	020a
SUBJECT:	Regional Bore Monitoring Programme – Addendum				

Sven,

Further to our recent meeting with DEHP (Maryborough) and presentation of the findings and recommendations from our review of the regional monitoring programme, we present the following addendum to report of 24th July 2015 (Doc1725D/6000/015b.docx). This addendum addresses concerns raised by DEHP officers about overall seepage management and how the proposed monitoring approach might be applied to an expanding seepage plume.

1. MONITORING BORE CATEGORISATION

As part of the monitoring approach developed for Mt Rawdon (Chapter 4 of our report) and the recommended changes to the specific monitoring programme (Chapter 5), we propose the following:

- Bores will be classified as regional or investigation bores based on their locations with regard to the known/suspected locations of any seepage fronts from the WRDs (and TSF).
- Regional bores are those located downstream of any seepage front with monitoring requirements (parameters, frequencies) to be specified in an amended EA. These bores are designed to:
  - Provide first detection of any seepage front.
  - Provide the distribution of groundwater quality and groundwater levels at nominated time intervals.
  - Provide for the definition of the water quality of any groundwater leaving the mine site.
  - Provide an assessment of any risk to the regional environment from seepage.
- The exceedance of trigger values on monitoring data in the regional bores (with trigger parameters and trigger levels to be defined in an amended EA) will result in the commencement of an investigation of the cause and potential impact of any such exceedance and the need for remedial measures to be implemented.
- Once the arrival of a seepage front has been confirmed at any regional bore (by the triggered investigations), the bore will be re-categorised as an investigation bore. As an investigation bore, the bore will be used to:
  - Provide information to any ongoing investigation into the arrival, location and migration of the seepage front.
  - Provide information on the progress of any seepage recovery/remediation actions that may have arisen from investigations.
- Depending on location and the distribution of other bores, a new regional bore may be drilled/installed downstream of the re-categorised investigation bore to provide adequate regional monitoring coverage.

However, it must be stressed that the process of re-categorising regional bores to investigation bores and installation of new, downstream regional bores is not intended to be a never-ending process following an ever expanding seepage front. Neither would such a process be the “solution” to the migration of seepage downstream of the mine. The recommended regional monitoring approach and monitoring programme solely relate to how the regional monitoring system should evolve over time to best provide adequate monitoring of the potential impacts to the regional environment. It is only one component of the overall seepage management process.

2. OVERALL SEEPAGE MANAGEMENT AND MONITORING

In terms of overall seepage management and protection of the regional environment (and where monitoring fits into the overall process), the following driving principles apply:

- The regional environment is defined as that existing just downstream of the lease boundaries or the effective hydrologic boundaries of the mine site.
- Seepage should not be permitted to egress the site and impact on the regional environment.
- In terms of groundwater flow (and potential seepage flow) the points of egress from the mine site are:
    - To the north of the TSF (in the area of Swindon Creek and the un-named creek to the east of Swindon Creek) – the Perry River where groundwater will egress the site as baseflow to the river.
    - To the northeast of the TSF and north of the Northern WRD (in the areas of Rawdon Creek and Twelve Mile Creek) – the northern mine lease boundary (some 200m upstream of the Perry River) where groundwater will egress the site as throughflow.
    - To the south of the TSF and the Western WRD – the mine lease boundary where groundwater can egress the site as throughflow and/or baseflow to Mingham Creek.
- The bores close to and immediately downstream of the WRDs (and TSF) are those designed to detect and track any seepage. If seepage is detected in these bores (key indicators), an investigation will be triggered. As detailed in Section 1, if the investigation confirms the arrival of seepage then the following would occur:
    - Implementation of a seepage recovery/mitigation plan.
    - Re-categorisation of monitoring bores and installation of new regional bores as required.
    - Monitoring to confirm the performance and progress of the seepage recovery/mitigation plan.
- The regional monitoring bores located at the groundwater egress points are designed to quantify the water quality of groundwater leaving the site and confirm the absence of any seepage that might impact the environment.

An example of how the seepage management process works now (and will continue to work) is the recently implemented seepage recovery system installed and operated downstream of dams WD1 and WD2. Following the detection of seepage from the Northern WRD in bores MRMB25, 26 and 27 and MRPB1, investigation monitoring was triggered and the presence and nature of the seepage confirmed. MRO implemented a seepage recovery scheme comprising two seepage recovery trenches downstream of WD1 and WD2 and have been pumping these trenches since. Ongoing investigation monitoring has shown that groundwater levels have declined and that contaminant levels downstream of the recovery trenches have, and continue to decline. That is, operation of the seepage recovery system is essentially “pulling back” seepage.

The only differences to the overall seepage management process that would result from the adoption of the proposed regional monitoring programme are:

- Bores MRMB25, 26 and 27 and MRPB1 would be re-categorised as investigation bores and continue to be monitored until the reversal of the seepage front has been confirmed.
- Incorporation of new regional bores downstream of the above bores.

We believe that the above overall approach, and the specific approach to monitoring, provides a practical and effective means of seepage management and the monitoring of and protection of the regional environment.

We trust that the above addendum will address the concerns raised by DEHP by clarifying where monitoring sits within the overall seepage management process.

Yours sincerely,
RPS Water

Jon Hall

Jon Hall
Technical Director - Mine Water Management

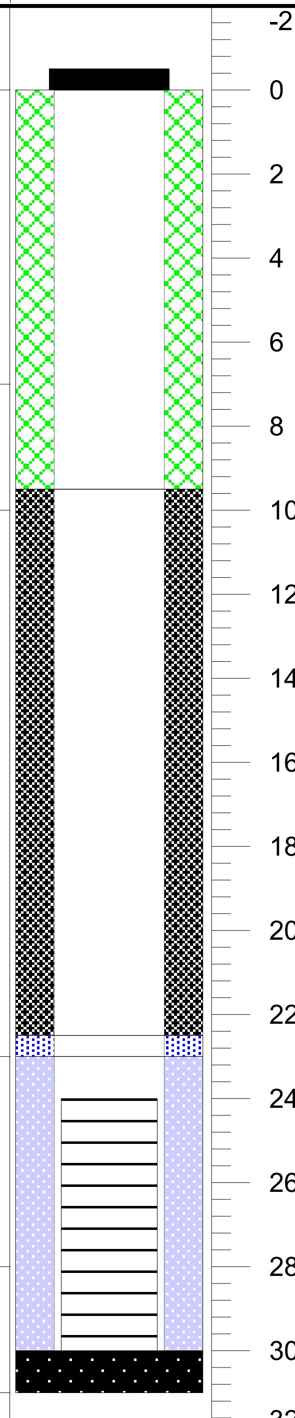
Appendix E

Bore Logs

northern resource consultants	PROJECT: MRO/121/2013	WELL ID: MRMB59	
	LOCATION: Mount Rawdon, QLD	DATE STARTED: 5/1/2013	DATE COMPLETED: 5/1/2013
	DRILLING CONTRACTOR: Associated Exploration Drillers	NORTHING: 7203751 mS	EASTING: 376209 mE
	DATUM: GDA94 ZONE 56	GROUND SURFACE ELEV.: 175.5 mAHD	TOC ELEVATION: 176 mAHD
LOGGED BY: MJ	DRILLING METHOD: DTH Rotary Air	TOTAL DEPTH: 31 m	DEPTH TO WATER: m

Depth (m)	Graphic Log	Lithological Description
0 – 7		TOPSOIL: Clay rich soil orange brown in colour.
7 – 10		QUARTZITE: silicified. Brown with minor oxidation.
10 – 23		QBS: Quartz biotite schist: grey brown in colour with weak chlorite alteration.
23 – 28		GRANODIORITE: fresh rock, grey in colour with weak chlorite alteration.
28 – 31		QBS: Fresh quartz biotite schist, dark grey in colour with weak chlorite alteration.

Well Construction



Top Cap

Cement Grout in annular space
Dry Bore.

Drilled Rock Chips

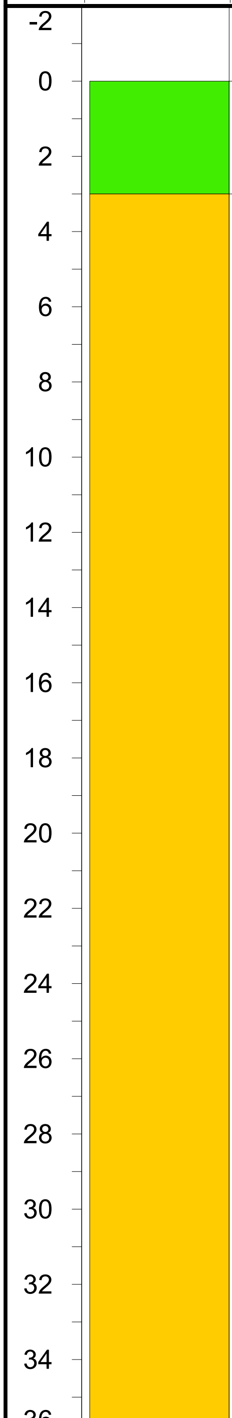
Bentonite Seal
Gravel Pack, 2-4mm washed gravel.
Slotted PVC pipe screen, 0.2mm wide annular slots.

Hole depth was 31m but was backfilled to 30m due to caving in.

NOTES:

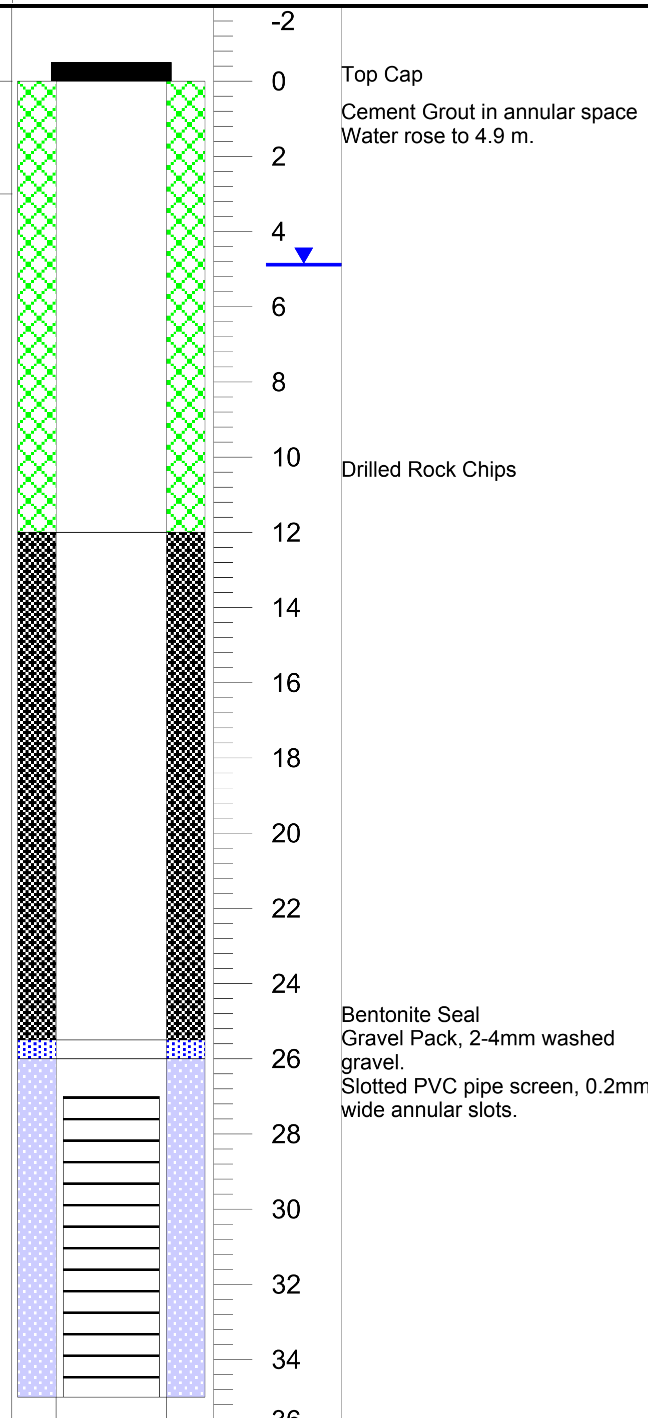
northern resource consultants	PROJECT: **MRO/121/2013**	WELL ID: **MRMB60**
	LOCATION: **Mount Rawdon, QLD**	DATE STARTED: **4/30/2013** / DATE COMPLETED: **5/1/2013**
	DRILLING CONTRACTOR: **Associated Exploration Drillers**	NORTHING: **7204540 mS** / EASTING: **376581 mE**
	DATUM: **GDA94 ZONE 56**	GROUND SURFACE ELEV.: **130.5 mAHD** / TOC ELEVATION: **131 mAHD**
LOGGED BY: **MJ**	DRILLING METHOD: **DTH Rotary Air**	TOTAL DEPTH: **36 m** / DEPTH TO WATER: **4.88 m**

Depth (m)	Graphic Log	Lithological Description	Well Construction



GRANITE: slightly weathered yellow orange in colour. (0 – 3 m)

QBS: Quartz biotite schist, dark grey in colour with weak chlorite alteration. (3 – 36 m)

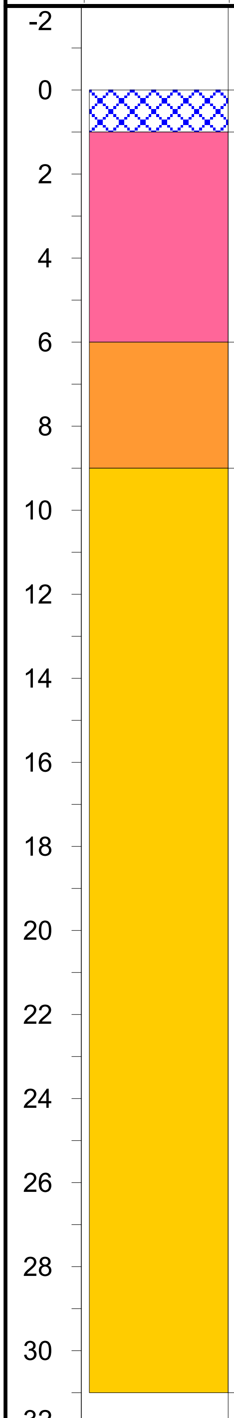


NOTES:

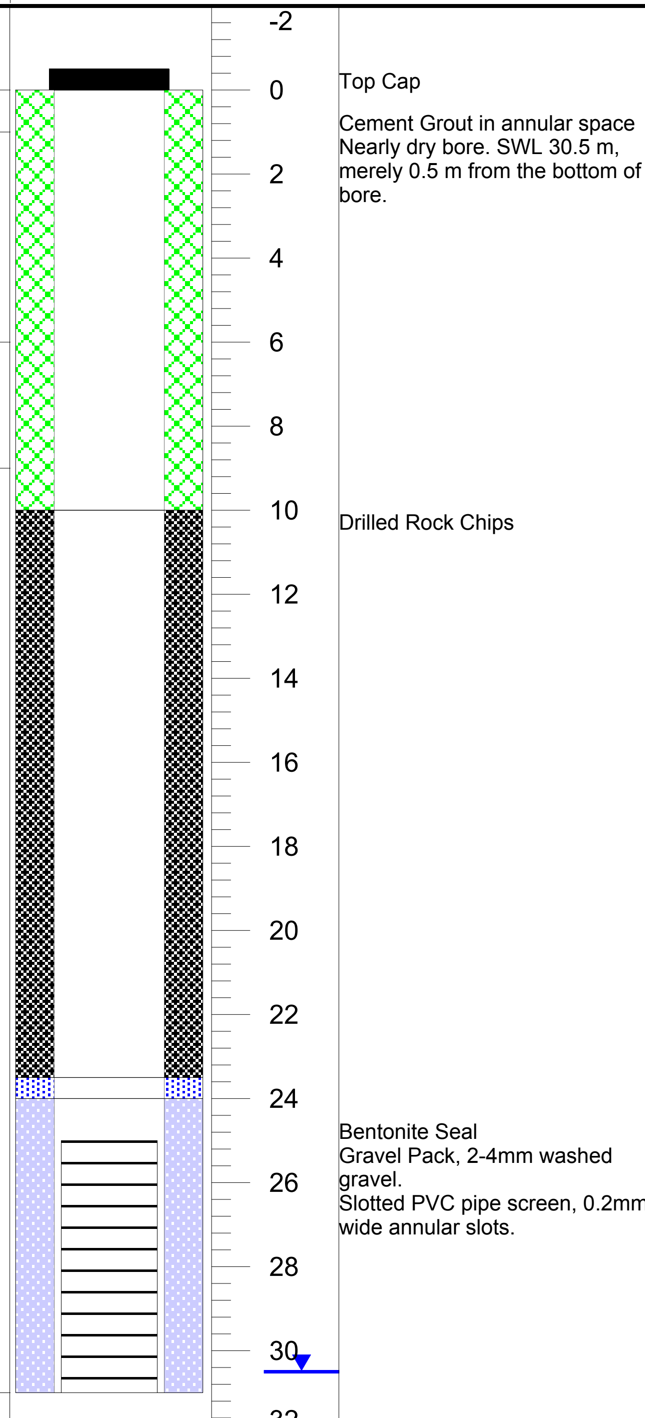
nrc
northern resource consultants

LOGGED BY: **MJ**	PROJECT: **MRO/121/2013**	WELL ID: **MRMB61**	
	LOCATION: **Mount Rawdon, QLD**	DATE STARTED: **4/30/2013**	DATE COMPLETED: **4/30/2013**
	DRILLING CONTRACTOR: **Associated Exploration Drillers**	NORTHING: **7204475 mS**	EASTING: **376724 mE**
	DATUM: **GDA94 ZONE 56**	GROUND SURFACE ELEV.: **127.5 mAHD**	TOC ELEVATION: **128 mAHD**
	DRILLING METHOD: **DTH Rotary Air**	TOTAL DEPTH: **31 m**	DEPTH TO WATER: **30.5 m**

Depth (m)	Graphic Log	Lithological Description
0		TOPSOIL: dark brown silty soil.
1		QUARTZ: yellow orange in colour with minor oxidation.
6		QUARTZITE: silicified. Yellow Orange with minor oxidation.
9		QBS: Fresh quartz biotite schist, dark grey in colour with weak chlorite alteration.



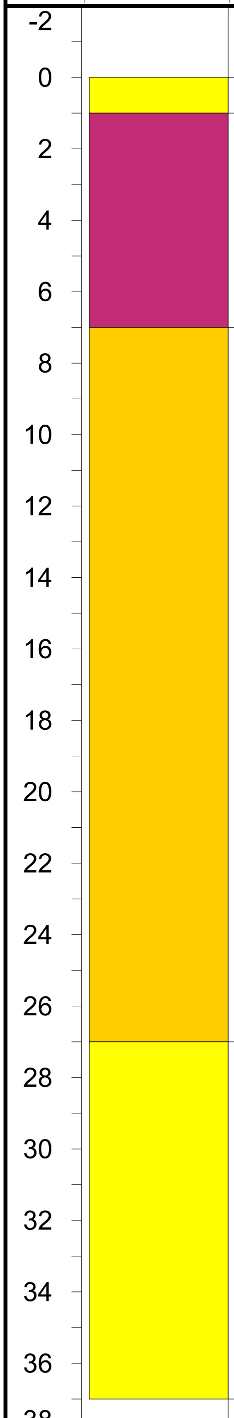
Well Construction



NOTES:

northern resource consultants	PROJECT: **MRO/121/2013**	WELL ID: **MRMB62**	
	LOCATION: **Mount Rawdon, QLD**	DATE STARTED: **5/1/2013**	DATE COMPLETED: **5/2/2013**
	DRILLING CONTRACTOR: **Associated Exploration Drillers**	NORTHING: **7203970 mS**	EASTING: **376574 mE**
	DATUM: **GDA94 ZONE 56**	GROUND SURFACE ELEV.: **147.5 mAHD**	TOC ELEVATION: **148 mAHD**
LOGGED BY: **MJ**	DRILLING METHOD: **DTH Rotary Air**	TOTAL DEPTH: **37 m**	DEPTH TO WATER: **8.5 m**

Depth (m)	Graphic Log	Lithological Description	Well Construction

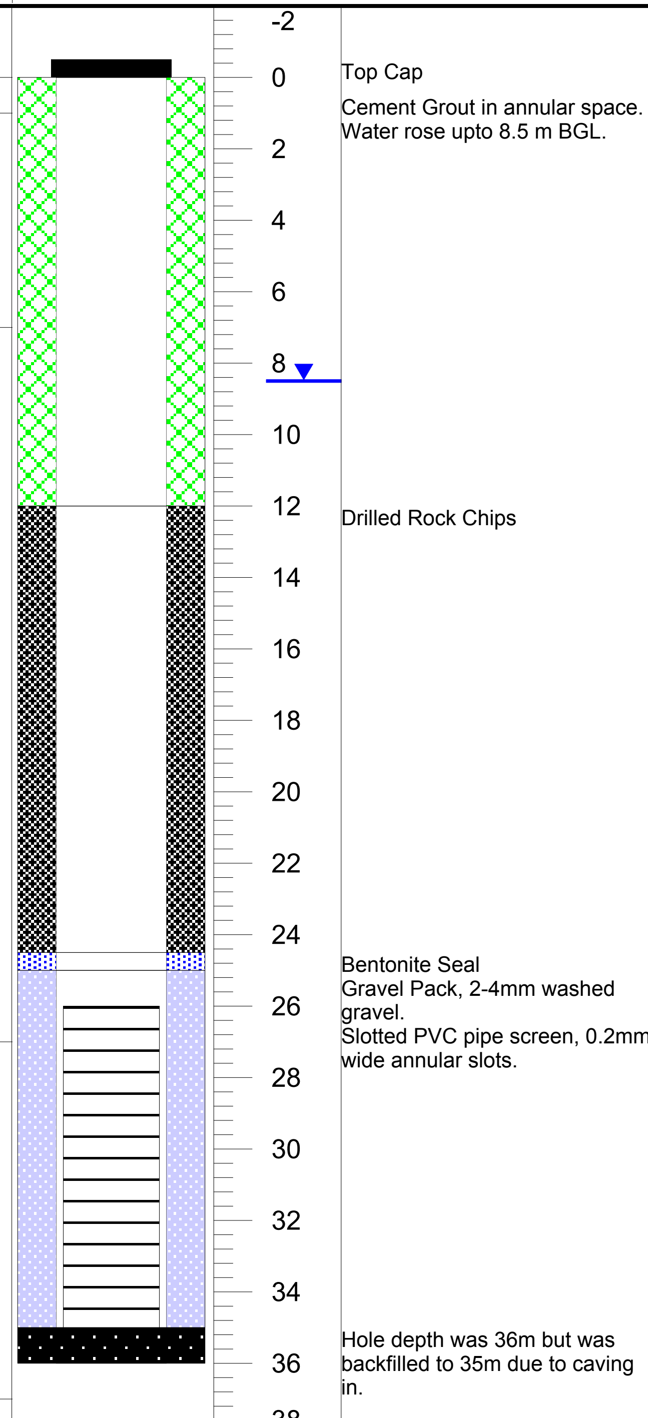


TRACHYTE: Pinkish orange, strongly oxidised.

GRANODIORITE: yellowish grey with minor oxidation.

QBS: Quartz biotite schist, grey brown in colour with weak chlorite alteration.

TRACHYTE: Grey orange in color with weak K-feldspar alteration.



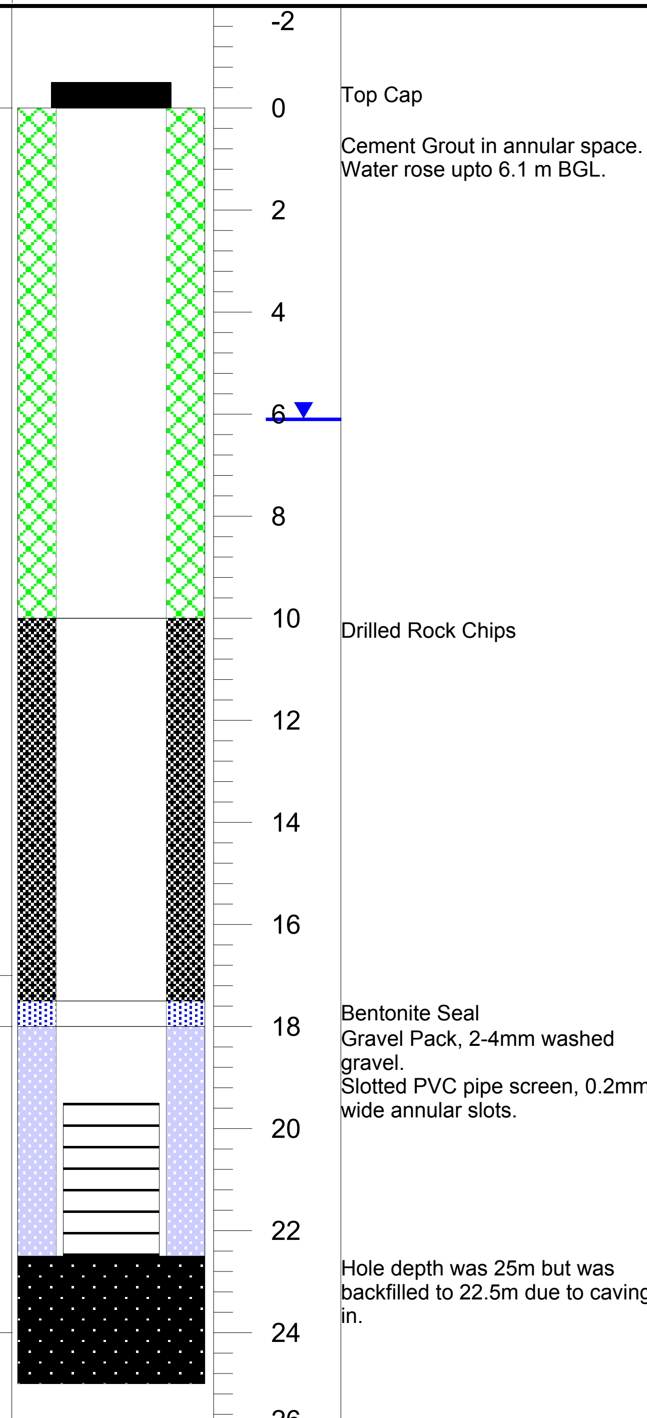
NOTES:

northern resource consultants

PROJECT:	MRO/121/2013
WELL ID:	MRMB63
LOCATION:	Mount Rawdon, QLD
DATE STARTED:	5/2/2013
DATE COMPLETED:	5/2/2013
DRILLING CONTRACTOR:	Associated Exploration Drillers
NORTHING:	7205278 mS
EASTING:	376537 mE
DATUM:	GDA94 ZONE 56
GROUND SURFACE ELEV.:	127.5 mAHD
TOC ELEVATION:	128 mAHD
LOGGED BY:	MJ
DRILLING METHOD:	DTH Rotary Air
TOTAL DEPTH:	25 m
DEPTH TO WATER:	6.1 m

Depth (m)	Graphic Log	Lithological Description
		MTPS: Metapsammite, grey orange in colour: minor oxidation.
		GRANODIORITE: fresh rock, grey in colour with weak chlorite alteration.
		MTPS: Fresh metapsammite, dark grey in colour with weak chlorite alteration.

Well Construction



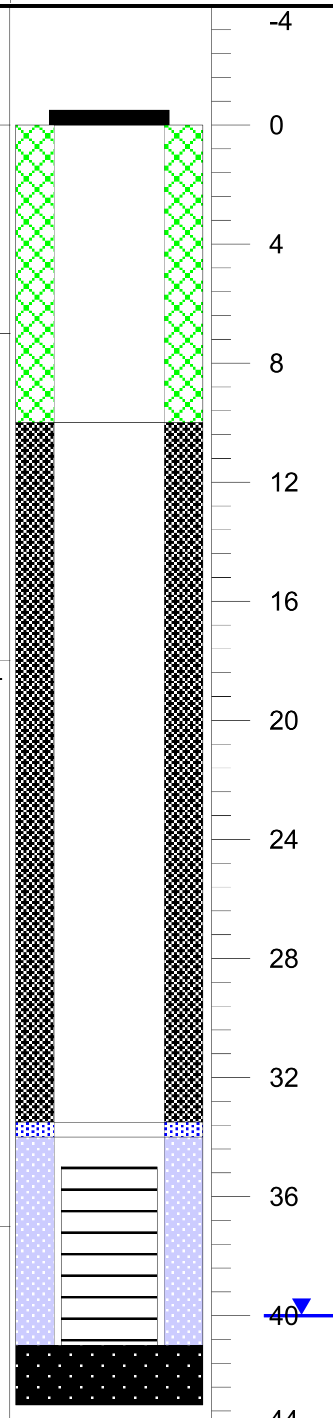
NOTES:

northern resource consultants

	PROJECT: MRO/121/2013	WELL ID: MRMB64	
	LOCATION: Mount Rawdon, QLD	DATE STARTED: 4/29/2013	DATE COMPLETED: 4/30/2013
	DRILLING CONTRACTOR: Associated Exploration Drillers	NORTHING: 7205995 mS	EASTING: 376329 mE
	DATUM: GDA94 ZONE 56	GROUND SURFACE ELEV.: 124.5 mAHD	TOC ELEVATION: 125 mAHD
LOGGED BY: MJ	DRILLING METHOD: DTH Rotary Air	TOTAL DEPTH: 43 m	DEPTH TO WATER: 40 m

Depth (m)	Graphic Log	Lithological Description
0 – 7		TOPSOIL: brown, silty soil.
7 – 18		QUARTZ: orange in colour with minor oxidation.
18 – 37		GRANITE: slightly weathered with chlorite alteration. Grey in colour.
37 – 44		QBS: Fresh quartz biotite schist, dark grey in colour with weak chlorite alteration.

Well Construction



Top Cap
Cement Grout in annular space. Nearly dry bore. Water rose up to 40.0 m BGL.

Drilled Rock Chips

Bentonite Seal
Gravel Pack, 2-4mm washed gravel.
Slotted PVC pipe screen, 0.2mm wide annular slots.

Hole depth was 43m but was backfilled to 41m due to caving in.

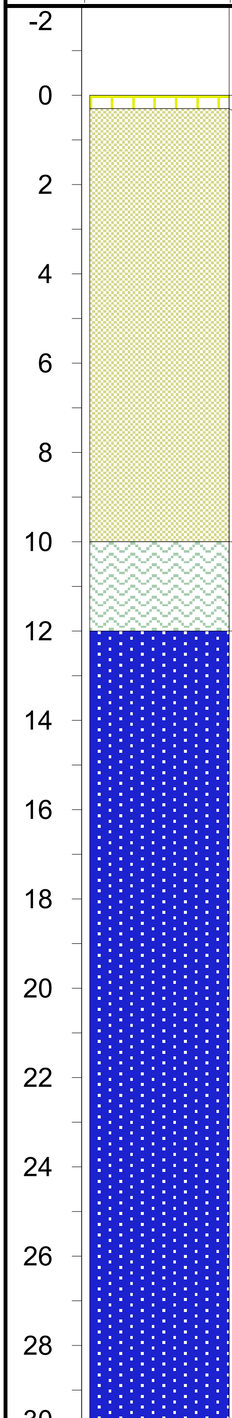
NOTES:

northern resource consultants

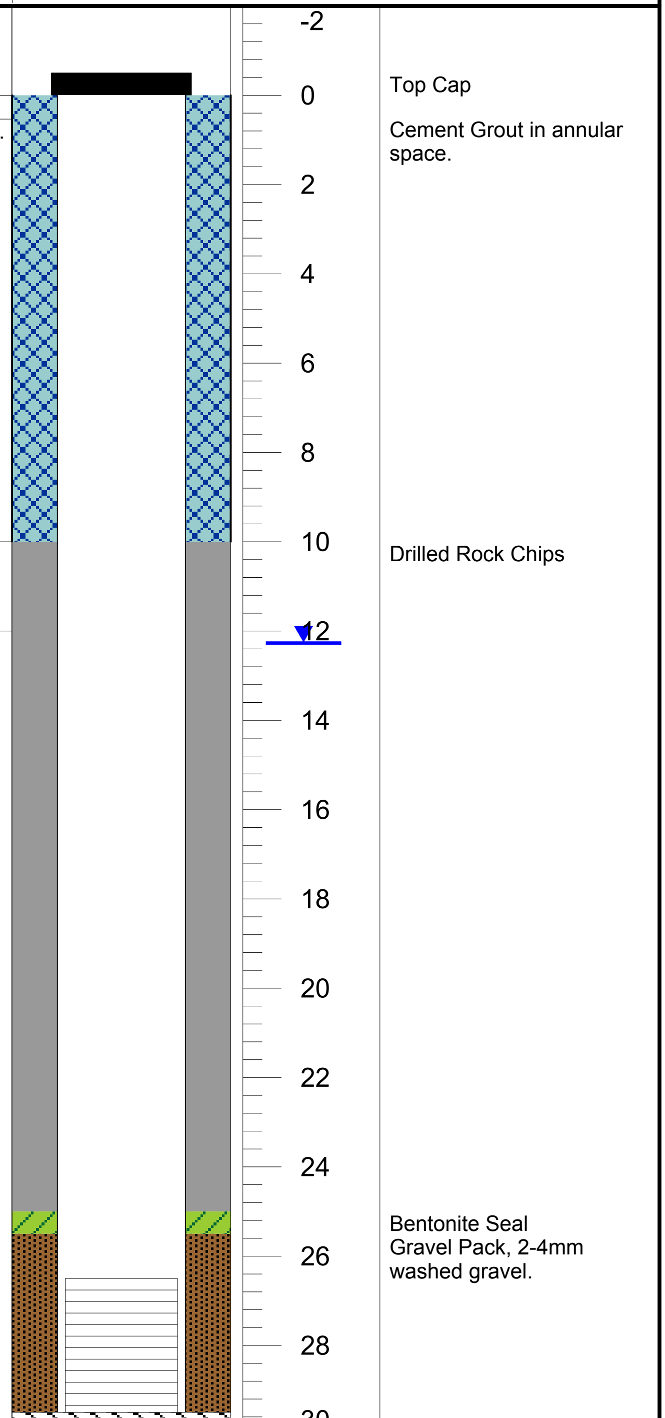
PROJECT:	WELL ID:	
MRO/121/2014	MRMB65	
LOCATION: Mount Rawdon, QLD	DATE STARTED:	DATE COMPLETED:
DRILLING CONTRACTOR: Associated Exploration Drillers	NORTHING: 7206743.106 mS	EASTING: 374925.496 mE
DATUM: GDA94 ZONE 56	GROUND SURFACE ELEV.: 122.702 mAHD	TOC ELEVATION: 123.202 mAHD
DRILLING METHOD: DTH Rotary Air	TOTAL DEPTH: 30 m	DEPTH TO WATER: 12.27 m

LOGGED BY: MJ

Depth (m)	Lithological Description
0	TOPSOIL: Brown Sandy Topsoil
0	QUARTZITE: silicified. White to Orange brown with minor oxidation.
10	WEATHERED GRANITE: Slightly weathered grey granite with iron stains.
12	FRESH GRANITE: Fresh massive granite. Light to dark grey with fresh CIG metasediment bands between 18 and 19 m and 27.3 to 30 m



Well Construction

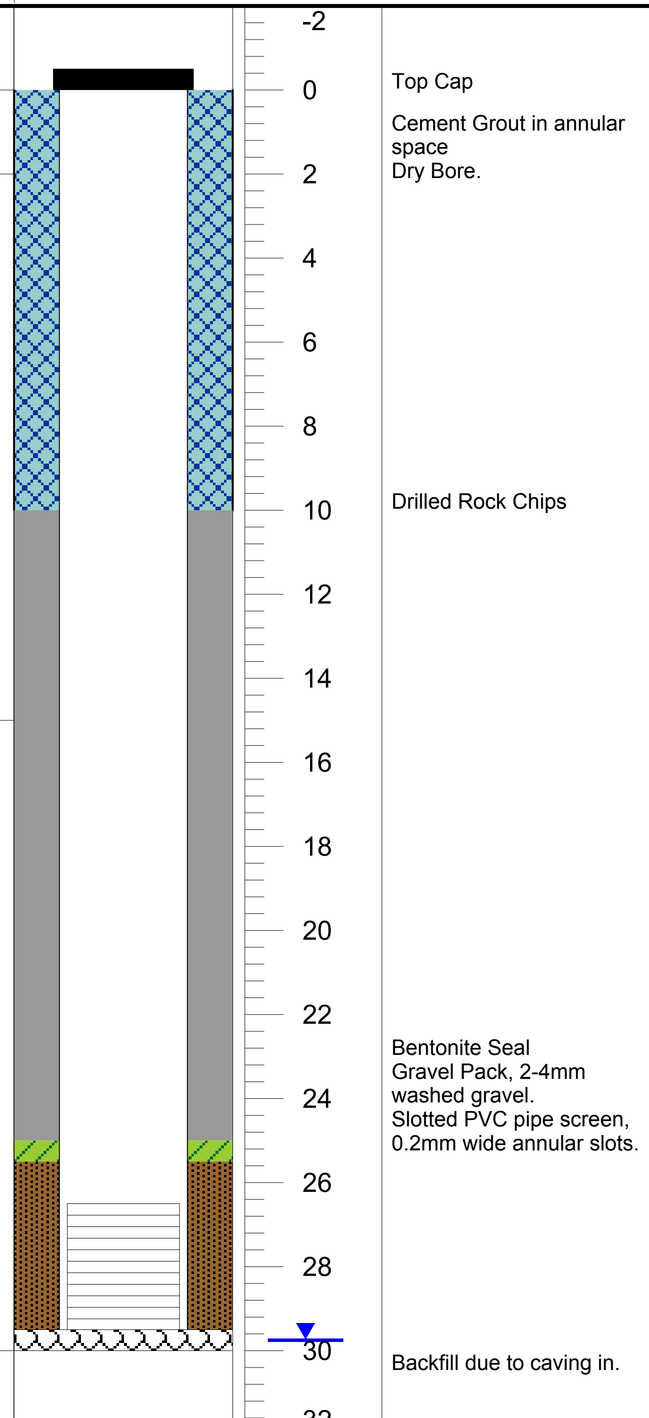


NOTES:

northern resource consultants (nrc)	PROJECT: **MRO/121/2014**	WELL ID: **MRMB66**	
	LOCATION: **Mount Rawdon, QLD**	DATE STARTED:	DATE COMPLETED:
	DRILLING CONTRACTOR: **Associated Exploration Drillers**	NORTHING: **7206882.864 mS**	EASTING: **375833.148 mE**
	DATUM: **GDA94 ZONE 56**	GROUND SURFACE ELEV.: **127.337 mAHD**	TOC ELEVATION: **127.837 mAHD**
LOGGED BY: **MJ**	DRILLING METHOD: **DTH Rotary Air**	TOTAL DEPTH: **30 m**	DEPTH TO WATER: **29.75 m**

Depth (m)	Graphic Log	Lithological Description
0 – 2		TOPSOIL: Brown Clayey topsoil with gravels.
2 – 15		CLAY: Brown silty clay.
15 – 30		GRANODIORITE: fresh rock, dark brown in colour with pink and green bits.

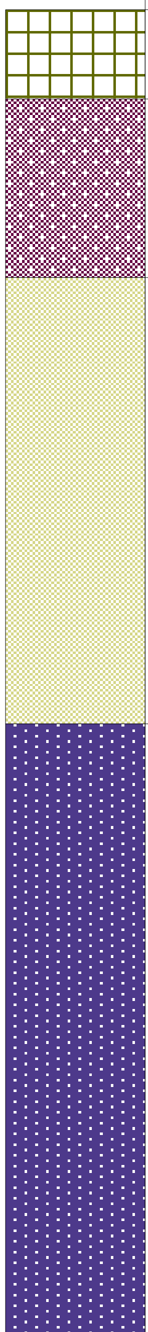
Well Construction



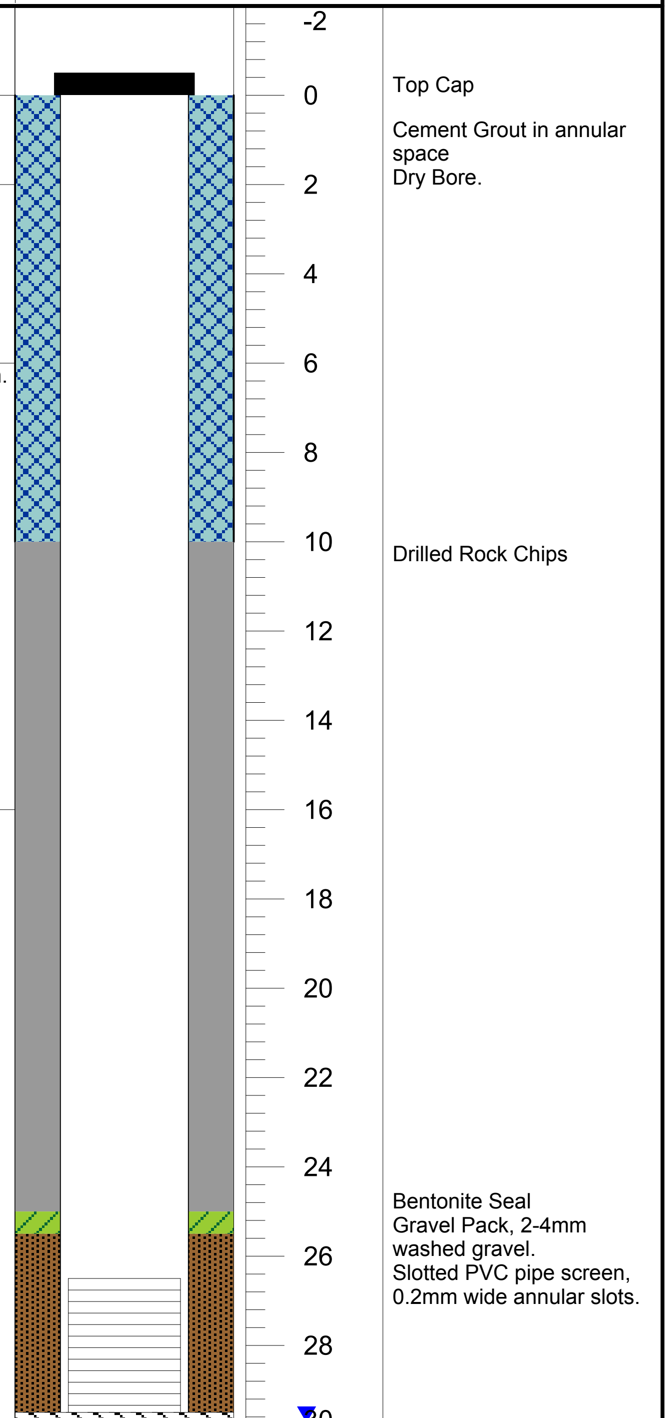
NOTES:

PROJECT: **MRO/121/2014**	WELL ID: **MRMB67**	
LOCATION: **Mount Rawdon, QLD**	DATE STARTED:	DATE COMPLETED:
DRILLING CONTRACTOR: **Associated Exploration Drillers**	NORTHING: **7206363.992 mS**	EASTING: **376398.366 mE**
DATUM: **GDA94 ZONE 56**	GROUND SURFACE ELEV.: **127.099 mAHD**	TOC ELEVATION: **127.599 mAHD**
LOGGED BY: **MJ**	DRILLING METHOD: **DTH Rotary Air**	TOTAL DEPTH: **30 m**
		DEPTH TO WATER: **29.75 m**

Depth (m)	Graphic Log	Lithological Description
0		TOPSOIL: Fine brown sand.
2		SAPROLITE: Decomposed metasediments. Light grey.
6		QUARTZITE: silicified. White to Orange brown with minor oxidation.
16		FRESH GRANITE: Fresh massive granite. Light grey.
30		



Well Construction

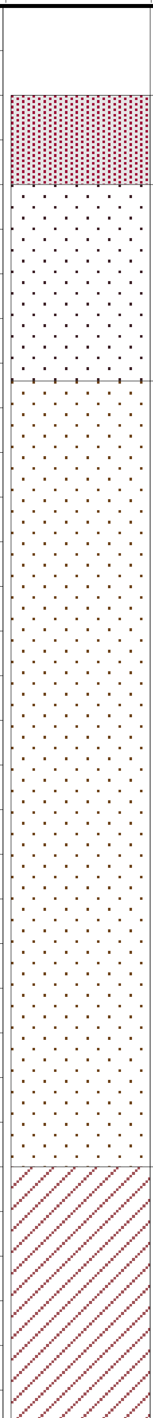


NOTES:

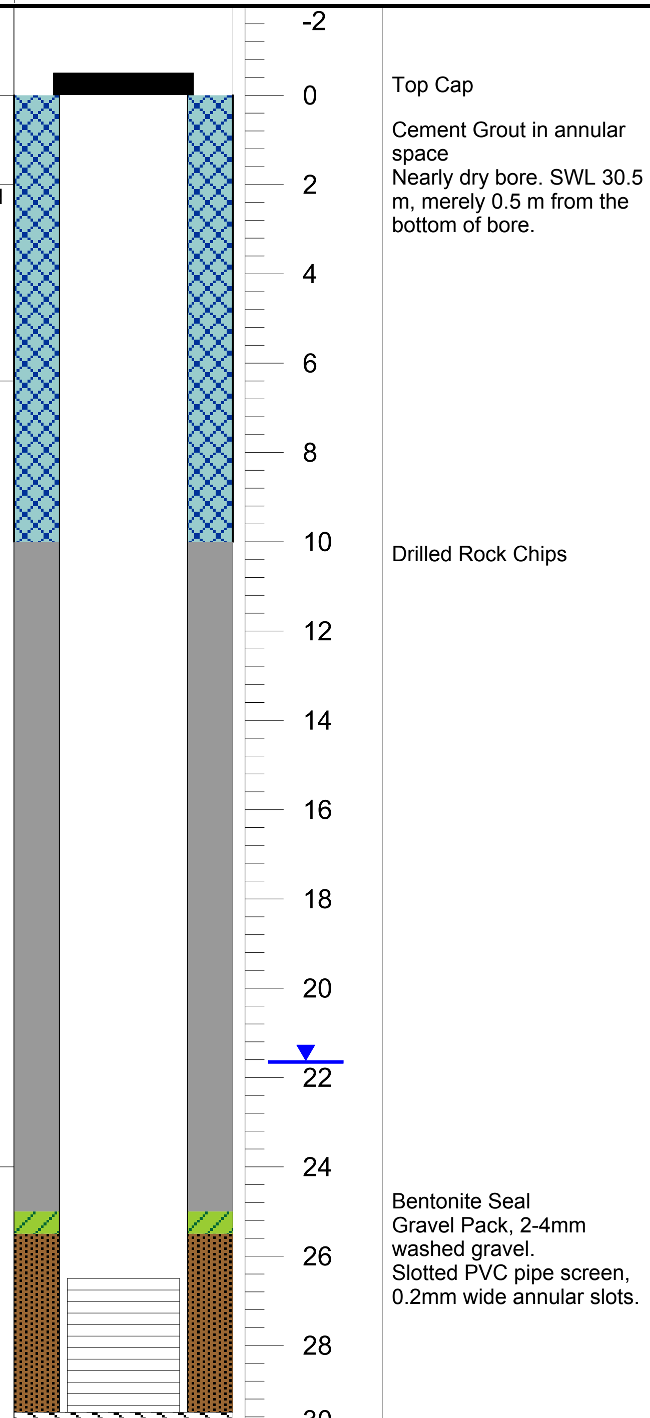
northern resource consultants

PROJECT: **MRO/121/2014**		WELL ID: **MRMB68**	
LOCATION: **Mount Rawdon, QLD**		DATE STARTED:	DATE COMPLETED:
DRILLING CONTRACTOR: **Associated Exploration Drillers**		NORTHING: **7205994.607 mS**	EASTING: **376139.161 mE**
DATUM: **GDA94 ZONE 56**		GROUND SURFACE ELEV.: **134.898 mAHD**	TOC ELEVATION: **135.398 mAHD**
LOGGED BY: **MJ**	DRILLING METHOD: **DTH Rotary Air**	TOTAL DEPTH: **30 m**	DEPTH TO WATER: **21.65 m**

Depth (m)	Graphic Log	Lithological Description
0 – 2		CLAY: Clayey top soil. Brown to dark brown in color.
2 – 6.4		MUDSTONE: Highly decomposed mudstone. Reddish, Orange and Grey colored pebbles associated with CIG metasediments.
6.4 – 24		MUDSTONE: Grey orange mudstone with horizontal bedding planes. Intense microfractures.
24 – 30		DACITE: Grey. Fine to medium grained.



Well Construction



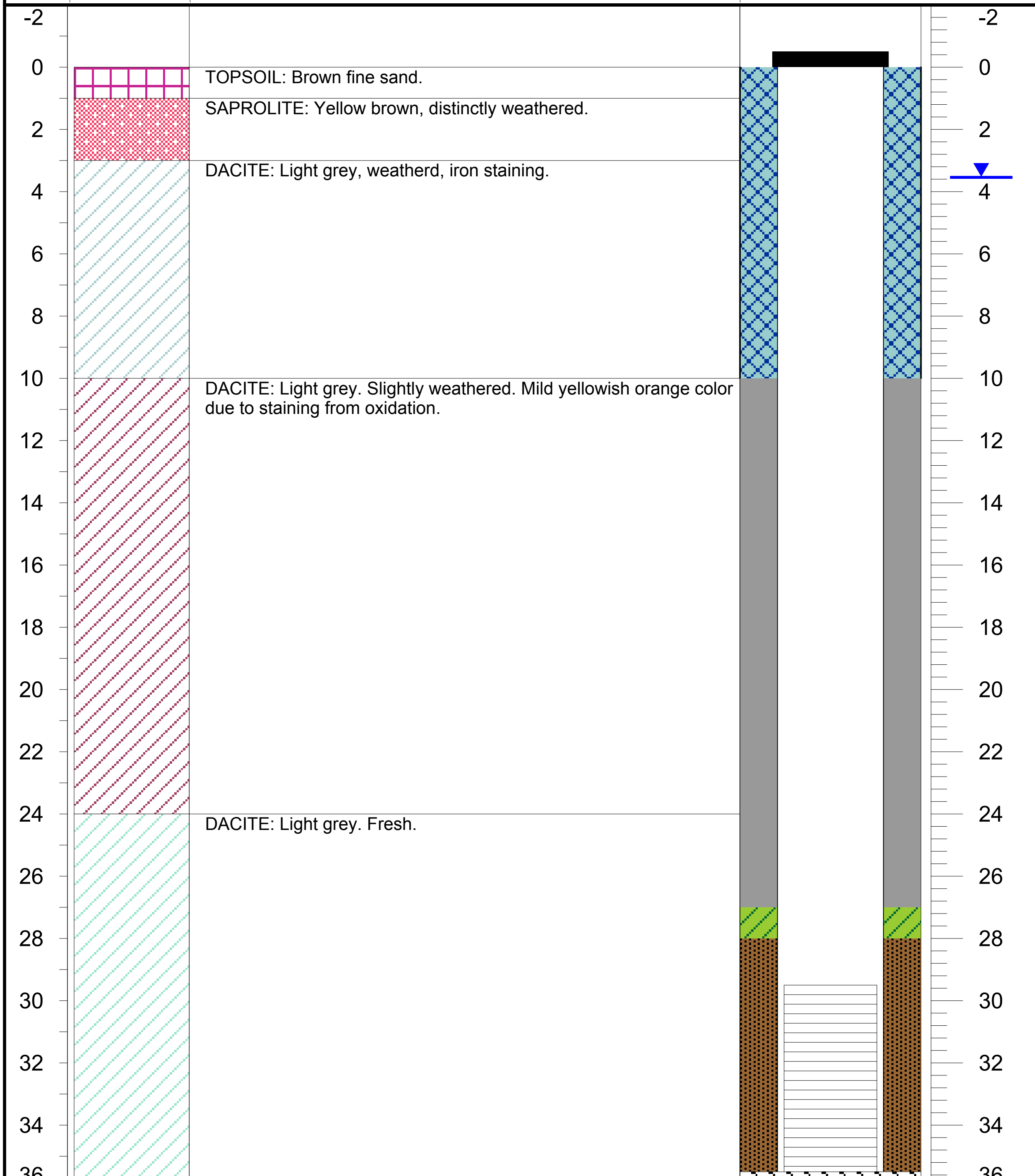
NOTES:

northern resource consultants

PROJECT: MRO/121/2014	WELL ID: MRMB69	
LOCATION: Mount Rawdon, QLD	DATE STARTED:	DATE COMPLETED:
DRILLING CONTRACTOR: Associated Exploration Drillers	NORTHING: 7204749 mS	EASTING: 374430 mE
DATUM: GDA94 ZONE 56	GROUND SURFACE ELEV.: 135 mAHD	TOC ELEVATION: 135.5 mAHD
DRILLING METHOD: DTH Rotary Air	TOTAL DEPTH: 36 m	DEPTH TO WATER: 3.54 m

LOGGED BY: MJ

Depth (m)	Graphic Log	Lithological Description	Well Construction



Lithological Description

TOPSOIL: Brown fine sand.

SAPROLITE: Yellow brown, distinctly weathered.

DACITE: Light grey, weatherd, iron staining.

DACITE: Light grey. Slightly weathered. Mild yellowish orange color due to staining from oxidation.

DACITE: Light grey. Fresh.

Well Construction

Top Cap

Cement Grout in annular space.

Drilled Rock Chips

Bentonite Seal

Gravel Pack, 2-4mm washed gravel.

Slotted PVC pipe screen, 0.2mm wide annular slots.

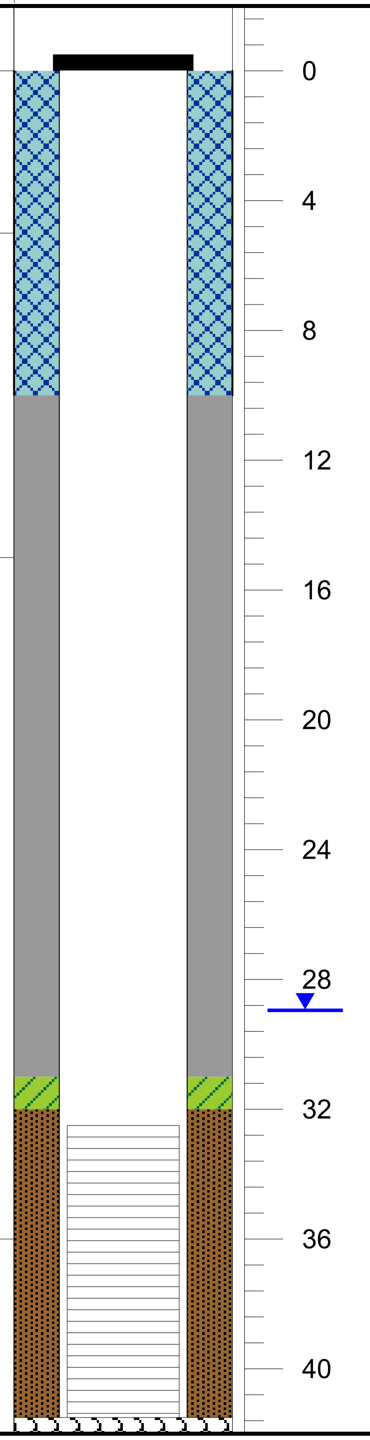
Backfill due to caving in.

NOTES:

northern resource consultants (nrc)	PROJECT: **MRO/121/2014**	WELL ID: **MRMB70**
	LOCATION: **Mount Rawdon, QLD**	DATE STARTED: / DATE COMPLETED:
	DRILLING CONTRACTOR: **Associated Exploration Drillers**	NORTHING: **7203728 mS** / EASTING: **374482 mE**
	DATUM: **GDA94 ZONE 56**	GROUND SURFACE ELEV.: **147 mAHD** / TOC ELEVATION: **147.5 mAHD**
LOGGED BY: **MJ**	DRILLING METHOD: **DTH Rotary Air**	TOTAL DEPTH: **42 m** / DEPTH TO WATER: **28.95 m**

Depth (m)	Graphic Log	Lithological Description
0–5		QBS: Quartz biotite schist. Dark grey. Weathered. Stained from oxidation.
5–15		DACITE: Light grey, weatherd, iron staining.
15–36		DACITE: Light grey. Fresh.
36–42		DACITE: Light grey. Water Bearing, iron oxidation stains, possible fracture zone/fault.

Well Construction



Top Cap

Cement Grout in annular space.
Water rose upto 28.55 m BGL. Measured yield was about 2.5 L/s. EC:1957 microS/cm and pH 7.89.

Drilled Rock Chips

Bentonite Seal

Gravel Pack, 2-4mm washed gravel.
Slotted PVC pipe screen, 0.2mm wide annular slots.

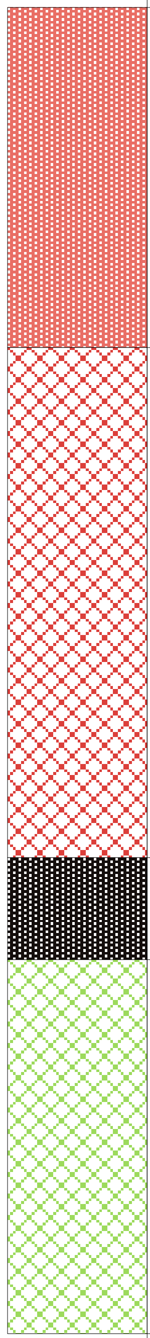
NOTES:

PROJECT:	WELL ID:	
MRO/121/2014	MRMB71	
LOCATION: Mount Rawdon, QLD	DATE STARTED:	DATE COMPLETED:
DRILLING CONTRACTOR: Associated Exploration Drillers	NORTHING: 7203643 mS	EASTING: 374632 mE
DATUM: GDA94 ZONE 56	GROUND SURFACE ELEV.: 133 mAHD	TOC ELEVATION: 133.5 mAHD
DRILLING METHOD: DTH Rotary Air	TOTAL DEPTH: 39 m	DEPTH TO WATER: 36 m

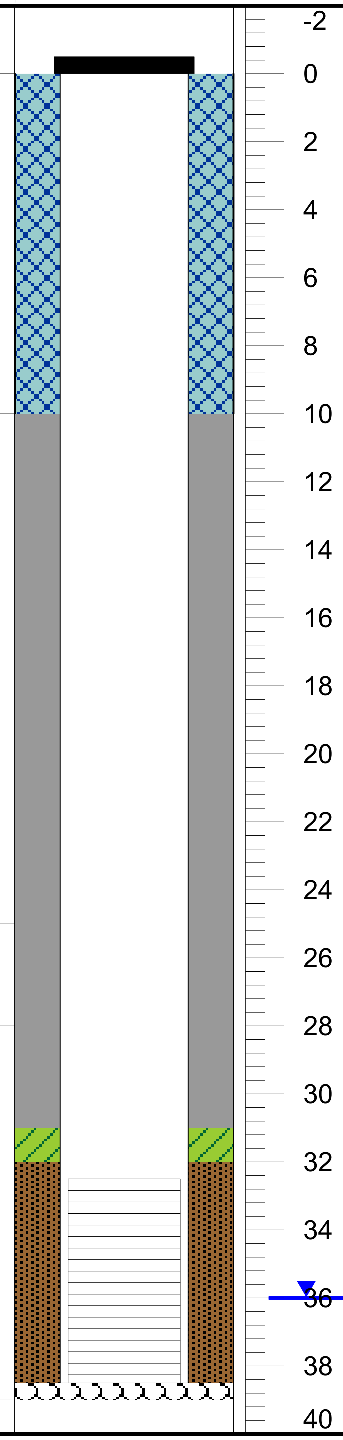
northern resource consultants

LOGGED BY: MJ

Depth (m)	Graphic Log	Lithological Description
0		QBS: Quartz biotite schist. Dark grey. Weathered. Stained from oxidation.
10		GRANODIORITE: fresh rock, black and white in colour.
25		QBS: Quartz biotite schist. Dark grey. Slightly Weathered.
28		GRANODIORITE: Fresh. Slight staining at 35 m.



Well Construction



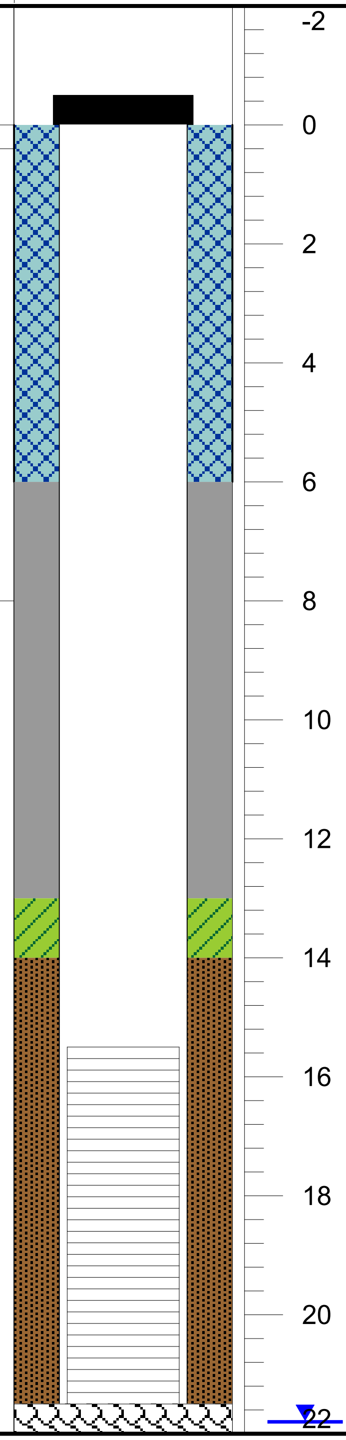
Depth (m)	Well Construction
0	Top Cap
0	Cement Grout in annular space.
10	Drilled Rock Chips
31	Bentonite Seal
32	Gravel Pack, 2-4mm washed gravel.
32.5	Slotted PVC pipe screen, 0.2mm wide annular slots.
39	Backfill due to caving in.

NOTES:

northern resource consultants	PROJECT: **MRO/121/2014**	WELL ID: **MRMB72**
	LOCATION: **Mount Rawdon, QLD**	DATE STARTED: / DATE COMPLETED:
	DRILLING CONTRACTOR: **Associated Exploration Drillers**	NORTHING: **7203590 mS** / EASTING: **374799 mE**
	DATUM: **GDA94 ZONE 56**	GROUND SURFACE ELEV.: **127 mAHD** / TOC ELEVATION: **127.5 mAHD**
LOGGED BY: **MJ**	DRILLING METHOD: **DTH Rotary Air**	TOTAL DEPTH: **22 m** / DEPTH TO WATER: **21.8 m**

Depth (m)	Graphic Log	Lithological Description
0		TOPSOIL: Sandy Brown Soil.
0.4		WEATHERED RHYOLITE: Light colored. Strongly weathered.
8		GRANITE: Fresh Granite. Light grey.

Well Construction



Depth (m)	Well Construction
-0.5	Top Cap
0	Cement Grout in annular space. Dry bore.
6	Drilled Rock Chips
13	Bentonite Seal
14	Gravel Pack, 2-4mm washed gravel. Slotted PVC pipe screen, 0.2mm wide annular slots.
21.8	Backfill due to caving in.

NOTES: