Mount Thorley Warkworth

2017 Annual Review

MARCH 2018

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YANCOAL
兖煤澳大利亚有限公司
MT THORLEY WARKWORTH

Name of operation	Mount Thorley Warkworth
Name of operator	Yancoal Australia Ltd
Development consent/ project approval#	SSD-6464 & SSD-6465
Name of holder of development consent / project approval	Yancoal Australia Ltd
Mining lease #	Contained in Section 1.3 of this report
Name of holder of mining lease	Mount Thorley Operations Pty Ltd Warkworth Mining Limited
Water License #	Contained in Section 1.4 of this report
Name of holder of water licence	Contained in Section 1.4 of this report
MOP/RMP start date	05/02/2016
MOP/RMP end date	30/11/2021
Annual Review start date	01/01/2017
Annual Review end date	31/12/2017

I, Jason McCallum, certify that this audit report is a true and accurate record of the compliance status of Mount Thorley Warkworth for the period 01 January 2017 to 31 December 2017 and that I am authorised to make this statement on behalf of Yancoal Australia Ltd.

Note.

a) The Annual Review is an 'environmental audit' for the purposes of section 122B(2) of the Environmental Planning and Assessment Act 1979. Section 122E provides that a person must not include false or misleading information (or provide information for inclusion in) an audit report produced to the Minister in connection with an environmental audit if the person knows that the information is false or misleading in a material respect. The maximum penalty is, in the case of a corporation, $1 million and for an individual, $250,000.

b) The Crimes Act 1900 contains other offences relating to false and misleading information: section 192G (Intention to defraud by false or misleading statement—maximum penalty 5 years imprisonment); sections 307A, 307B and 307C (False or misleading applications/information/documents—maximum penalty 2 years imprisonment or $22,000, or both).

Name of the authorised reporting officer	Mr Jason McCallum
Title or the authorised reporting officer	General Manager Operations
Signature of Authorised Reporting Officer	
Date	27-3-18

Executive Summary

Mount Thorley Warkworth (MTW) is an integrated operation of two open cut coal mines, Warkworth Mining Limited (WML) and Mount Thorley Operations (MTO). This Annual Review reports on the environmental performance of Mount Thorley Warkworth (MTW) for the period 1 January 2017 to 31 December 2017.

This report has been prepared in accordance with conditions of the development consents and Mining Leases (ML) held by MTW which require a report of the operation's environmental performance to be provided on an annual basis. The structure of the 2017 Annual Review intends to align with the NSW Government *Post-approval requirements for State significant mining developments – Annual Review Guideline (October 2015).*

MTW produced 17.0 million tonnes of run-of-mine (ROM) coal during 2017, and 11.82million tonnes of saleable coal, against an approved ROM coal production rate of 28 million tonnes per annum (mtpa).

Noise

There were no non-compliances recorded against MTW's consented noise limits. A total of 857 hours of mine stoppage were recorded due to proactive and reactive measures to minimise noise. There was a 78.6% reduction (from 84 to 18) in the number of supplementary attended noise measurements which exceeded the internal trigger levels for corrective action compared to 2016.

Blasting

During the reporting period 308 blast events were initiated at MTW. There were no non-compliances against the airblast overpressure or ground vibration criteria listed in MTW's Environment Protection Licences or Planning Approvals. One (level 4) blast event was reported to the Department of Planning and Environment during the reporting period on 27-April-2017. W29-WHE-PR1 (the Blast) was initiated as per approved MTW Blast Management Plan from WML West Pit where it was observed to travel south east through maintained road closure dissipating at height over MTO (SSD-6465).

Air Quality

During 2017, MTW complied with all short term and annual average air quality criteria. A total of 8,030 hours of mine stoppage was recorded following implementation of proactive and reactive measures to minimise dust. A total of 145.3 ha of land was aerially seeded during autumn to minimise wind eroded dust from overburden areas not yet available for rehabilitation.

Heritage

Two Aboriginal cultural heritage salvage programs were conducted at MTW in 2017, in accordance with the MTW *Aboriginal Cultural Heritage Management Plan*. An ACHMP compliance inspection was also conducted during the reporting period. The compliance inspection was conducted by representatives of the Aboriginal community and were assisted by internal mine site personnel. A total of 20 Aboriginal cultural heritage sites were inspected during this program. There were no incidents or any unauthorised disturbance to historic heritage sites at MTW during 2017.

Surface Water

2017 was another dry year with a substantial reduction in water inputs from rainfall runoff compared to 2016. The amount of water imported from the Hunter River and neighbouring mines has increased to offset this deficit. Improvements to water management in 2017 have focused on reducing the risk of unauthorised water releases from site. A diversion channel at the base of the Abbey Green (MTO) rehabilitation area was constructed in 2017 to segregate clean and dirty water. Other works completed in 2017 include construction of Dam 48N, and SSD-05 dam for sediment control in Warkworth Pit.

Following rainfall on 4 December 2017, approximately 20 kL of stormwater overtopped a contour drain and flowed underneath Wallaby Scrub Road into a dam on land owned by MTW. Regulators were immediately notified. No environmental harm occurred as a result of the incident, it is currently under investigation by the EPA.

Warkworth Mine was convicted by the NSW Land and Environment Court for overflow of stormwater from a dam in 2016.

Groundwater

Groundwater monitoring activities were undertaken in 2017 in accordance with the MTW Water Management Plan and groundwater monitoring programme. The monitoring results are used to establish and monitor trends in physical and geochemical parameters of surrounding groundwater potentially influenced by mining.

Groundwater monitoring data is reviewed on a quarterly basis. There were no non-compliances related to groundwater in 2017.

Visual Amenity

The second stage of Warkworth's West Pit visual bund (adjacent to Putty Road) was constructed in 2017.

Rehabilitation and Land Management

A total of 124 ha rehabilitation was completed during 2017 against a MOP target of 107.1 ha. Total disturbance undertaken was 74.9 ha, slightly higher than the 2017 MOP projection of 72.8 ha. Capping of Tailings Dam 2, at the north of the operations, began in 2017. The net rehabilitation progress (i.e. rehabilitation minus rehabilitation disturbance) for the current MOP period (2015 to 2017) is 218.8ha, which is 10.5ha lower than the MOP target of 229.3ha. This is due to more rehabilitation disturbance being undertaken than planned. Cumulative new disturbance over the MOP period is approximately 40ha below the MOP forecast for the same period due mainly to a delay in clearing for the Rural Fire Service track.

Biodiversity and Offset Management

Restoration of the Warkworth Sands Woodland vegetation community continued in the Northern Biodiversity Area, with over 10,000 seedlings planted. Restoration activities for the Ironbark woodland continued in the Southern Biodiversity Area, with over 13,000 seedlings planted. Weed control, vertebrate pest management activities, fence repairs and waste removal were conducted during 2017 in the Regional Biodiversity Areas in accordance with the Offset Management Plans.

Contents page

List of Tables

List of Figures

List of Appendices

1. STATEMENT OF COMPLIANCE

Table 1 is a Statement of Compliance against the relevant approvals. Table 2 provides a brief summary of the non-compliances and a reference to where these are addressed within this Annual Review.

TABLE 1: REFERENCE TABLE

Were all conditions of the relevant approval(s) complied with?

DA SSD-6465 (MTO)	Yes
DA SSD-6464 (WML)	No

TABLE 2: NON-COMPLIANCES

Relevant approval	Condition number	Condition description (summary)	Compliance status	Where addressed in Annual Review
DA SSD-6464 (WML)	Schedule 3 Condition 24	Water Discharges / Pollution of Waters	Non-Compliant (Low)	11.1

COMPLIANCE STATUS KEY FOR TABLE 2

Risk level	Colour Code	Description
High	Non-compliant	Non-compliance with potential for significant environmental consequences, regardless of the likelihood of occurrence
Medium	Non-compliant	Non-compliance with : • Potential for serious environmental consequences, but is unlikely to occur; or • Potential for moderate environmental consequences, but is unlikely to occur
Low	Non-compliant	Non-compliance with : • Potential for moderate environmental consequences, but is unlikely to occur; or • Potential for low environmental consequences, but is unlikely to occur

Administrative non-compliance	Non-compliant	Only to be applied where the non-compliance does not result in any risk of environmental harm (e.g. submitting a report to government later than required under approval conditions)

Source: NSW Government *Post-approval requirements for State significant mining developments – Annual Review Guideline (October 2015).*

2. INTRODUCTION

Mount Thorley Warkworth Coal Mine (MTW), is an integrated operation consisting of Warkworth Mining Limited (WML) and Mount Thorley Operations (MTO) (Figure 1), situated 14 km southwest of Singleton, in the Upper Hunter Valley region of NSW. MTW is managed and operated by Yancoal Australia Limted (YAL)[1].

2.1 DOCUMENT PURPOSE

This report summarises the environmental performance of MTW in accordance with conditions of the development consents and Mining Leases (ML) held by site. The structure of the 2017 Annual Review intends to align with the NSW Government Post-approval requirements for State significant mining developments – Annual Review Guideline (October 2015).

[1] *On 1 September 2017, Yancoal Australia Limited acquired Rio Tinto's interest in Coal & Allied Industries Limited, including 80% of Mount Thorley mine and 55.6% of Warkworth mine. Yancoal also exercised a call option to further acquire Mitsubishi Development's 28.9% interest in the Warkworth mine.*

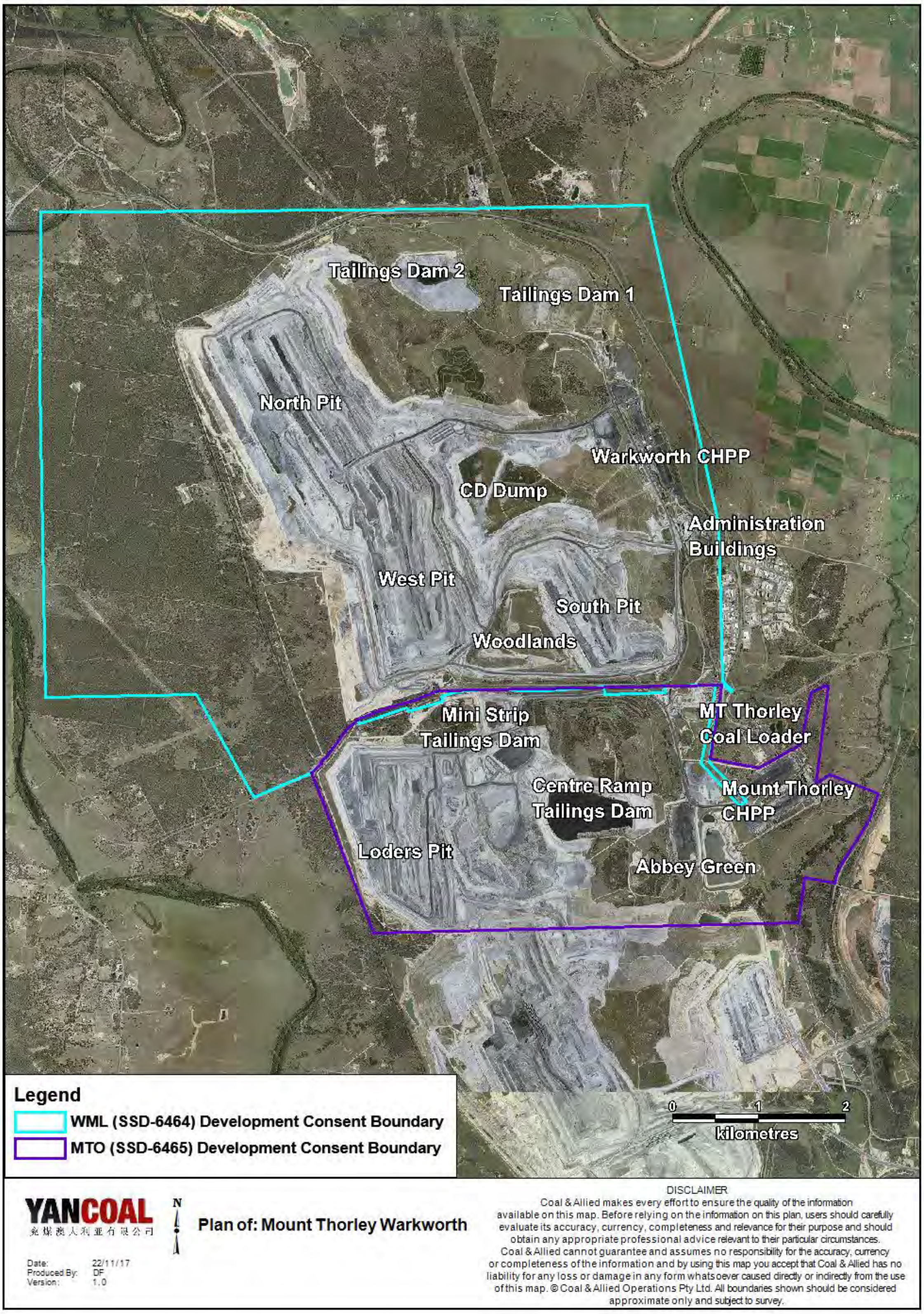

FIGURE 1: MTW SITE LAYOUT AND LOCALITY PLAN

2.2 MINE CONTACTS

Jason McCallum	General Manager - MTW
	Phone (02) 6570 1501
	Email: jason.mccallum@yancoal.com.au
Andrew Speechly	Manager – Environment and Community
	Phone (02) 6570 0497
	Email: andrew.speechly@yancoal.com.au

3. APPROVALS

3.1 APPROVALS, LEASES AND LICENSES

3.1.1 Current Approvals

The status of MTO and WML development consents, licenses and relevant approvals at 31December 2017 are summarised in Table 3 to Table 9.

TABLE 3: OPERATIONS APPROVALS- WARKWORTH

Approval Number	Description	Authority	Dates
EPBC 2009/5081	Approval under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) to extend the existing Warkworth Coal Mine over an additional 705 hectares of land at Warkworth NSW including associated modifications to existing mine infrastructure	DSEWPaC	9/8/2012 – 31/3/2033
EPBC 2002/629	Approval under the EPBC Act to construct and operate an open cut coal mine extension at the Warkworth Coal Mine	DSEWPaC	18/2/2004 (varied on 6/4/2004, 24/5/2004, 19/11/2004 and 13/7/2012) – 25/2/2039
SSD-6464	Warkworth Continuation Project	DP&E	26/11/2015

TABLE 4: OPERATIONS APPROVALS - MOUNT THORLEY

Approval Number	Description	Authority	Dates
SSD-6465	Mount Thorley Continuation Project	DP&E	26/11/2015

TABLE 5: LICENCES AND PERMITS

Licence Number	Description	Authority	Expiry Date
Warkworth			
EPL1376	Environment Protection Licence	EPA	N/A
50661122	Radiation Licence	EPA	02 May 2018
XSTR100160	Licence to Store – Explosives Act	WorkCover NSW	13 November 2018

Mount Thorley			
EPL24	Environment Protection Licence	EPA	N/A
EPL1976	Environment Protection Licence	EPA	N/A
5061110	Radiation Licence	EPA	31 July 2018

Note: Environment Protection Licences remain in force until the licence is surrendered by the licence holder or until it is suspended or revoked by the EPA or the Minister. A licence may only be surrendered with the written approval of the EPA.

TABLE 6: MINING TENEMENTS

Mining Tenement	Type	Purpose	Status	Dates
Warkworth				
CCL 753	Consolidated Coal Lease	Prospecting and Mining Coal	Granted	23/05/1990 - 17/02/2023
ML 1412	Mining Lease	Prospecting and Mining Coal	Renewal Pending	11/01/1997 - 10/01/2018
ML 1590	Mining Lease	Prospecting and Mining Coal	Granted	27/02/2007 - 26/02/2028
ML 1751	Mining Lease	Prospecting, Mining Coal and Purposes	Granted	17/03/2017 16/03/2038
Mount Thorley				
CL 219	Coal Lease	Prospecting and Mining Coal	Granted	23/09/1981 - 22/09/2023
(Part) ML 1547	Sub-Lease	Mining Purposes	Registered	The part sublease area known as the "Dam 22 Long Term Mining Sublease" was registered on 10th January 2018 for a term until 3 April 2025.
EL 7712	Exploration Licence	Prospecting Coal	Granted	23/2/2011 - 22/02/2016
ML 1752	Mining Lease	Prospecting, Mining Coal and Purposes	Granted	17/03/2017 16/03/2038
Mount Thorley Coal Limited				
MLA 548	Mining Lease Application	Mining Purposes	Application Pending	Mining Lease Application Lodged 13/11/2017

Note: The authority for all mining

TABLE 7: OTHER APPROVALS

Approval	Authority	Dates (current as of)
Emplacement Areas		
Warkworth		
Tailings Dam 2	DPI	22/10/2002
Tailings Dam 2 –130RL	DPI	9/12/2003
Tailings Dam 2 – High Risk Notification (Capping)	DPI	08/06/2016
Mount Thorley		
Section 126 Variation to Reject Emplacement Area	DPI	20/3/2001
Section 126 Construction of Reject Emplacement Area Centre Ramp Tailings Dam	DPI	9/4/2001
Mini Strip 24 Tailings Storage Facility	DPI	8/9/2004
Dam Safety Committee Centre Ramp Tailings Storage Facility Stage 2	DPI	12/2/2004
Section 126 Centre Ramp Tailings Dam – Raising height of embankment	DPI	10/5/2006
Section 126 Abbey Green South Tailings Dam	DPI	10/5/2006
Other Approvals		
Installation of a single 500mm water pipeline under Putty Road	RMS	31/10/2007
Installation of two 600mm tailings pipelines under Putty Road	RMS	1/2/2007
Resource Recovery Exemption for coal washery rejects at Mount Thorley Warkworth	DECC	1/2/2010

TABLE 8: WATER LICENCES

Licence Number	Type	Purpose	Legislation	Description	Renewal Date
20BL168821	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: MTAGP1, MTAGP2, ABGOH07, ABGOH43, ABGOH44, ABGOH45	Perpetuity
20BL171729	Bore	Monitoring Bore	Part 5 Water Act 1912	G3	Perpetuity

Licence Number	Type	Purpose	Legislation	Description	Renewal Date
20BL171841	Bore	Monitoring Bore	Part 5 Water Act 1912	OH1126	Perpetuity
20BL171842	Bore	Monitoring Bore	Part 5 Water Act 1912	OH944	Perpetuity
20BL171843	Bore	Monitoring Bore	Part 5 Water Act 1912	OH1137	Perpetuity
20BL171844	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: OH1123 (E), OH1123 (W)	Perpetuity
20BL171845	Bore	Monitoring Bore	Part 5 Water Act 1912	OH1124	Perpetuity
20BL171846	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: OH786, OH942	Perpetuity
20BL171847	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: OH1127, OH787	Perpetuity
20BL171848	Bore	Monitoring Bore	Part 5 Water Act 1912	OH1125	Perpetuity
20BL171849	Bore	Monitoring Bore	Part 5 Water Act 1912	OH1122	Perpetuity
20BL171850	Bore	Monitoring Bore	Part 5 Water Act 1912	OH1138	Perpetuity
20BL171891	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: OH1121, OH788, OH943	Perpetuity
20BL171892	Bore	Monitoring Bore	Part 5 Water Act 1914	Bores: WOH2153 (PZ2), WOH2154 (PZ1), WOH2155 (PZ4), WOH2156 (PZ3)	Perpetuity
20BL171893	Bore	Monitoring Bore	Part 5 Water Act 1918	Bores: WOH2141 (PZ6), Ground Water Alluvial Modelling	Perpetuity
20BL171894	Bore	Monitoring Bore	Part 5 Water Act 1913	WOH2139 (PZ5)	Perpetuity
20BL172272	Bore	Monitoring Bore	Part 5 Water Act 1912	PZ9S, PZ9D	Perpetuity
20BL172273	Bore	Monitoring Bore	Part 5 Water Act 1912	PZ8S, PZ8D	Perpetuity
20BL172439	Bore	Monitoring Bore	Part 5 Water Act 1912	Windermere	Perpetuity

Licence Number	Type	Purpose	Legislation	Description	Renewal Date
20BL172518	Bore	Monitoring Bore	Part 5 Water Act 1912	Windermere: MBW01, MBW02, MBW03, MBW04	Perpetuity
20BL173276	Bore	Monitoring Bore	Part 5 Water Act 1912	Windermere	Perpetuity
20BL173065	Bore	Monitoring Bore	Part 5 Water Act 1912	SR012	Perpetuity
20FW213276 (formerly 20CW802601)	Flood Work Approval	Block Dam	Water Management Act 2000	Charlton Rd Levee	23 August 2020
20WA209905 (Formerly 20SL051292)	Stream Diversion	Bywash Dams	Water Management Act 2000	Doctors Creek Bywash	31 July 2022
20CA209904 WAL - 19022	Stream Diversion	Bywash Dams	Water Management Act 2000	Sandy Hollow Creek	25 February 2023

TABLE 9: WATER ACCESS LICENCES

Licence Number	Description	Water Source	Water Sharing Plan	Water Source – Management Zone	Approved Extraction (ML)*	Actual Extraction 2017 (ML)
WAL963	Warkworth Mining Limited Hunter River Pump (General Security)	Hunter River	Hunter Regulated River WSP	Zone 2b (Hunter River From Wollombi Brook Junction To Oakhampton Rail Bridge)	243	0
WAL10543	Mount Thorley Joint Venture (MTJV) water supply scheme, held by Singleton Shire Council (our share 1,012 units + 1000 units from temporary transfer)	Hunter River	Hunter Regulated River WSP	Zone 2b (Hunter River From Wollombi Brook Junction To Oakhampton Rail Bridge)	2,012	1025
WAL10544	(Hunter Regulated River –	Hunter River	Hunter Regulated River WSP	Zone 2b (Hunter River From Wollombi Brook Junction To	5	0

Licence Number	Description	Water Source	Water Sharing Plan	Water Source – Management Zone	Approved Extraction (ML)*	Actual Extraction 2017 (ML)
	Domestic and Stock)			Oakhampton Rail Bridge)		
WAL18233	Old Farm	Hunter River Alluvium	Hunter Unregulated and Alluvial Water Sources WSP	Hunter Regulated River Alluvial Water Source – Downstream Glennies Creek Management Zone	5	3#
WAL18558	Hawkes	Wollombi Brook	Hunter Unregulated and Alluvial Water Sources WSP	Lower Wollombi Brook Water Source	50	9#
WAL19022	Sandy Hollow Creek	Unregulated River	Hunter Unregulated and Alluvial Water Sources WSP	Singleton Water Source	60	0
WAL40464 (previously 20BL170011)	Mt Thorley Pit Excavation	Permian Coal Seams	North Coast Fractured and Porous Rock Groundwater Sources WSP (commenced 1/7/16) Previously Water Act 1912	Sydney Basin – North Coast Groundwater Source	180	110#
WAL40465 (previously 20BL170012)	Warkworth Pit Excavation	Permian Coal Seams	North Coast Fractured and Porous Rock Groundwater Sources WSP (commenced 1/7/16) Previously Water Act 1912	Sydney Basin – North Coast Groundwater Source	750	140#

* Approved extraction limits are for a financial year.

Passive take / groundwater inflows to pit.

3.1.2 Management Plans, Programmes and Strategies

Table 10 details the Management Plans and strategies which are required under the Warkworth (SSD-6464) and Mount Thorley (SSD-6465) Development Consent instruments.

A Mining Operations Plan (MOP) was developed to replace the previous MOP and cover the existing MTW operations, as well as the approved operations outlined in the Environmental Impact Statements for the Warkworth Continuation 2014 and Mt Thorley Operations 2014. The MOP outlines the proposed operational and environmental management activities planned for MTW. Details regarding the submission and approval dates for the current MOP are shown in Table 11.

TABLE 10: STATUS OF MANAGEMENT PLANS REQUIRED UNDER WARKWORTH CONTINUATION (SSD-6464) AND MOUNT THORLEY OPERATIONS (SSD-6465) PROJECT APPROVALS

Plan / Program / Strategy	Status (approval date)
Air Quality Management Plan	07/02/2018
Noise Management Plan	07/02/2018
Blast Management Plan	07/02/2018
Water Management Plan	12/02/2018
WML Biodiversity Management Plan	03/02/2016
Rehabilitation Management Plan (addressed in MOP)	05/02/2016
Environmental Management Strategy	03/02/2016
MTW Historic Heritage Management Plan - Draft	11/10/2017
MTW Aboriginal Heritage Management Plan	07/02/2018
Wollombi Brook Aboriginal Cultural Heritage Conservation Area Conservation Management Plan - draft	11/10/2017
Management Plan for Goulburn River Biodiversity Area	26/06/2017 (DP&E)
Management Plan for Bowditch Biodiversity Area	26/06/2017 (DP&E)
Management Plan for Southern Biodiversity Area	26/06/2017 (DP&E)
Management Plan for Northern Biodiversity Area	26/06/2017 (DP&E)
Management Plan for Norther Rothbury Biodiversity Area	26/06/2017 (DP&E)
Warkworth Sands Woodland Integrated Management Plan (Condition 34)	Pending (Submitted 15/02/2017)

Plan / Program / Strategy	Status (approval date)
Warkworth Sands Woodland Performance Criteria (Condition 32a)	Pending (Submitted 15/02/2017)

TABLE 11: MOP APPROVAL STATUS FOR MOUNT THORLEY WARKWORTH

Mining Operations Plan	Date Submitted	Date Approved
Mount Thorley Warkworth MOP 2016	30/11/2015	05/02/2016

4. OPERATIONS SUMMARY

4.1 SUMMARY OF MINING ACTIVITIES

Areas to be mined are geologically modelled, a mine plan is formed and the relevant mining locations are surveyed prior to mining. Figure 2 illustrates the mining process. MTW have no active underground workings.

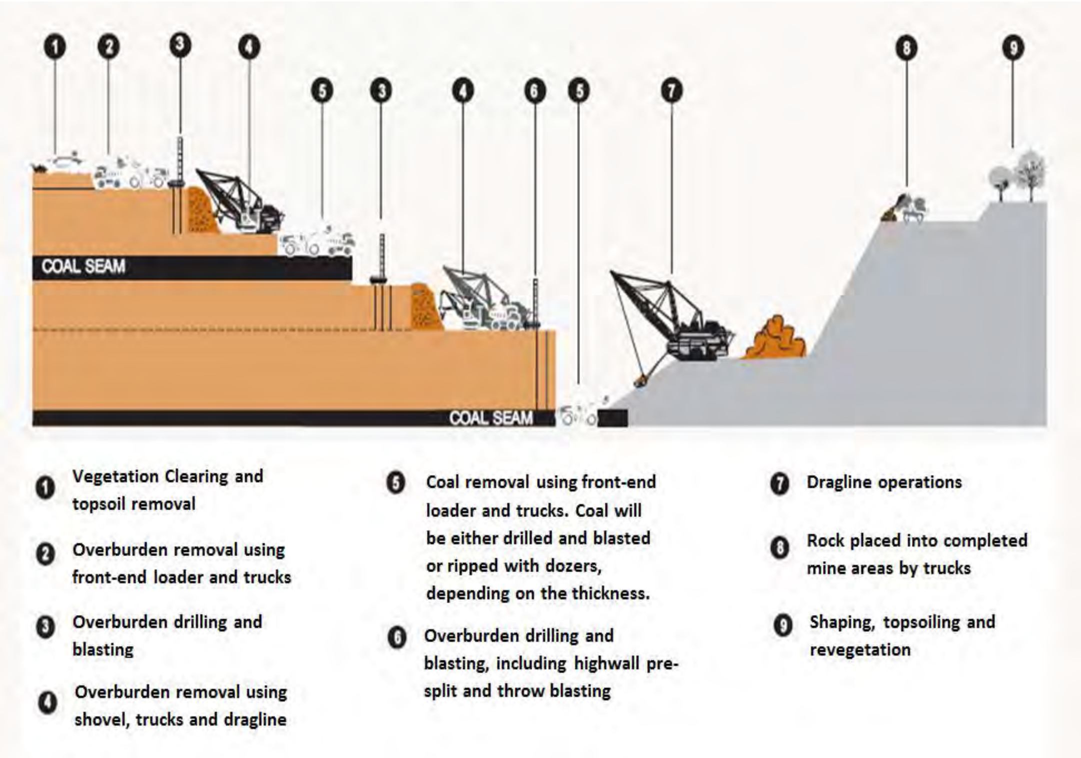

FIGURE 2: MINING PROCESS

Within the Warkworth lease, mining activities will continue to advance in a westerly direction in both North and West Pits. South Pit has reached its final limit with regard excavation. This area is currently being utilised for dumping activity. Within the Mount Thorley lease, mining has reached the western limit with remaining reserves to be mined to depth over the coming two years. All mining related activity is in line with the current MOP.

The planned 2018 production and waste schedule for MTW is summarised below:

- 17.0 Mt ROM coal;
- 11.8 Mt Product coal;
- 124 Mbcm overburden (including rehandle); and
- 5.2 Mt Tailings and reject

The Planned ROM coal production represents approximately 61% of the approved maximum ROM coal production for MTW.

Coal will continue to be transported via conveyer to the Mount Thorley Coal Loader and railed to the port.

4.2 MINERAL PROCESSING

All processing and rejects/tailings disposal activities undertaken in 2017 were consistent with the approved MOP and no changes were made to the processing and rejects/tailings disposal methods.

The currently active tailing emplacements are the Centre Ramp Tailings Storage Facility and Abbey Green South Tailings Storage Facility. During 2017 capping works on Tailings Dam 2 commenced.

4.3 PRODUCTION STATISTICS

Under the Project approvals in place during the reporting period, extraction of up to 28 million tonnes of ROM coal from MTW is permitted in a calendar year, comprising up to 18 million tonnes from ROM coal from the Warkworth Mine and 10 million tonnes from the Mount Thorley Mine. MTW Production Statistics for the previous, current and future reporting period are summarised in Table 12.

TABLE 12: SUMMARY OF PRODUCTION AT MTW IN 2017

Material	Approved Limits	Reporting Period 2016	Reporting Period 2017	Forecast for 2018
Prime Waste (kbcm)	N/A	96,938	101,669	101,834
MTO ROM Coal (Mtpa)	10 (SSD-6465)	3.96	4.08	2.32
WML ROM Coal (Mtpa)	18 (SSD-6464)	14.09	13.59	14.66
ROM Coal (Mtpa)	28 (Combined)	18.05	17.69	16.98
Coarse Reject (kt)	N/A	3,791	3,504	3,021
Fine Reject – Tailings (kt)	N/A	1,588	2,435	2,178
Product (kt)	N/A	12,396	11,817	11,831

4.4 SUMMARY OF CHANGES (DEVELOPMENTS AND EQUIPMENT UPGRADES)

- Some additional and replacement heavy equipment was purchased in 2017, including 5 new 320t haul trucks, one 36ot replacement Excavator and a new 500t Excavator.
- Mining activity during the reporting period with regard to volumes, location and equipment was consistent with 2016
- South Pit accelerated rehabilitation plan has progressed in line with the consent condition
- Construction Putty Road underpass commenced in 2017 with planned project completion in May 2018. The underpass will service as the main linkage of the Mount Thorley and

Warkworth operations reducing hauling length of Prime Waste (overburden) as the Warkworth Pit progresses west. Update of project progress in figures

FIGURE 3: PUTTY ROAD COMPLETED ROAD SURFACE OVERPASSING THIRD CROSSING – LOOKING WEST BOUND TOWARDS BULGA

FIGURE 4: PUTTY ROAD THIRD CROSSING - MINE VIEW LOOKING SOUTH

5. ACTIONS REQUIRED FROM PREVIOUS ANNUAL ENVIRONMENTAL MANAGEMENT REVIEW

An annual environmental inspection was not undertaken by DP&E. DRG issued a notice of satisfactory AEMR on 08 August 2017 with the below terms (to be included in the 2017 AEMR).

TABLE 13: RESPONSE TO ACTIONS ARISING FROM DGE REVIEW OF 2016 AR

Recommended Action	Annual Review section
Include monitoring results exceeding TARP trigger levels, the actions undertaken in response are included in the report.	6.2, 6.4, 7.3, 7.4
Report rehabilitation progress against commitments in the MOP, with an explanation/justification for any identified variance to the commitments. Variance may include the area rehabilitated or the location(s)	8.1, 8.3

6. ENVIRONMENTAL PERFORMANCE

6.1 METEOROLOGICAL DATA

Meteorological data is collected to assist in day to day operational decisions, planning, and environmental management and to meet Project Approval requirements. MTW operates a real time meteorological (weather) station which is located on Charlton Ridge. The meteorological station measures wind speed, wind direction, temperature, humidity, solar radiation, rainfall, and sigma theta. The meteorological station instruments are installed, calibrated, and maintained according to the relevant Australian Standard AS 3580.14 (2011). Meteorological data is available to employees and contractors via an intranet page. This service provides the mining operations with the trend assessment details required for informed operational decisions aimed at minimising impacts from the operation. Daily Meteorological data summaries are presented in the Monthly Environmental Monitoring reports, available via the website: http://insite.yancoal.com.au.

6.2 NOISE

6.2.1 Management

MTW manages noise to ensure compliance with permissible noise limits at nearby private residences. A combination of both proactive and reactive control mechanisms are employed on a continuous basis to ensure effective management of noise emissions is maintained. Noise management strategies and processes employed at MTW are detailed in the MTW Noise Management Plan available for viewing via the website: http://insite.yancoal.com.au.

MTW's noise performance improved significantly in 2017, demonstrated across a number of key metrics:

- Community noise complaints received – reduced by 42% from 2016
- Number of Community Response Officer (CRO) (supplementary) noise measurements which exceed the internal trigger level for action – reduced by 79% from 2016; and
- Number of equipment downtime hours logged in response to noise management triggers – reduced by ~52% from 2016.

A range of projects and processes were undertaken during 2017 to deliver this improved performance. These are described herein.

6.2.2 Real Time Noise Management

MTW's Real-Time noise management framework provides an effective tool for managing instances of elevated noise, ensuring compliance is maintained, and responding to community concerns.

MTW utilise CROs to provide an interface between the mine and community. They are effective in implementing the management framework, validating real-time alerts through supplementary handheld noise measurements and audible observations, driving operational change as required, and responding to community complaints. A summary of supplementary handheld noise measurements conducted by the CROs in 2017 is presented in Table 14.

MTW's "InSite" website allows members of the general public to access noise, meteorological, air quality data as well as any operational changes made during shift via an interactive website. Viewer access: http://insite.yancoal.com.au

TABLE 14: SUMMARY OF SUPPLEMENTARY ATTENDED NOISE MONITORING CONDUCTED BY COMMUNITY RESPONSE OFFICERS 2017

Monitoring Location	Number of Assessments	Number of measurements >WML trigger^	Number of measurements > MTO trigger^	Average WML noise level ($L_{Aeq\ 5min}$ dB(A))*	Average MTO noise level ($L_{Aeq\ 5min}$ dB(A))*
Wollemi Peak Road (Bulga RFS)	1,293	7	8	32.4	32.3
Bulga Village	542	1	-	31.4	31.7
Inlet Road	229	2	-	32.5	31.6
Inlet Road West	318	-	-	27.1	27.6
Long Point	751	-	-	30.4	30.5
Other	26	-	-	-	-
South Bulga	0	-	-	-	-
Wambo Road	80	-	-	34.0	32.8
Total	3,239	10	8	-	-

^Triggers are internally set thresholds for operational response and are specified in the MTW Noise Management Plan. The number of measurements greater than the trigger cannot be used an assessment or interpretation of compliance. Compliance assessment is provided in 6.2.3 and 6.2.4.

*Average noise levels do not take account of measurements taken where the noise source of interest was recorded as inaudible.

In response to the events listed in Table 14 which exceeded the trigger, up to 841 hours of equipment downtime were recorded to manage noise during 2017. This is a significant decrease (approximately 52%) in the number of downtime hours recorded in 2016 and resembles the reduction in number of supplementary noise measurements completed which exceed the trigger for management action.

6.2.3 Performance

A total of 96 compliance measurements were undertaking by an independent acoustic specialist in accordance with the MTW Noise Monitoring Programme during the reporting period. Each measurement involves an assessment of mine noise against the various L_{Aeq} and $L_{A1,1min}$ noise criteria in place under the Warkworth and Mount Thorley Approvals. Noise monitoring results are presented in the monthly Environmental Monitoring Reports, available via the website http://insite.yancoal.com.au

In accordance with Section 4 of the NSW Industrial Noise Policy, MTW has assessed measured noise levels collected during the attended compliance programme for low frequency content, and applied the modifying factor adjustment where applicable. The application of the modifying factor results in 7 exceedances of the WML L_{Aeq} Impact Assessment Criteria and four exceedances of the MTO L_{Aeq} Impact Assessment Criteria (refer to Table 15). The Department of Planning and Environment was notified in writing of each measurement.

MTW reports these measurements so as to ensure full disclosure, however it remains MTW's position that the prescribed methodology is unsuitable when applied to receptors at large distances from mine noise sources due to the nature of noise attenuation. Excess attenuation of noise with distance is greater for high frequency noise than it is for low frequency noise. At significant distance from a noise source (such as private residences from the MTW complex) this often results in large differentials between L_{Aeq} and L_{Ceq}. The NSW Industrial Noise Policy requires the penalty to be applied in these instances, irrespective of actual low frequency affectation. As such, MTW does not consider these instances to constitute non-compliance with the conditions of approval.

In October 2017, NSW EPA released the Noise Policy for industry. The guideline sets out a new framework for the assessment of low frequency noise emissions from industrial premises. MTW has adopted the new methodology for assessing low frequency affectation as of November 2017.

TABLE 15: ATTENDED NOISE MEASUREMENTS EXCEEDING CONSENT CONDITIONS FOLLOWING APPLICATION OF INP LOW FREQUENCY PENALTY

Location	Date/Time	Relevant Criteria	Criterion (dB)*	L_{Aeq}(dB)	Revised L_{Aeq} (dB)	Exceeds by (dB)
Inlet Road	09/01/2017	MTO L_{Aeq} impact assessment criteria	37	33	38	1
Bulga RFS	19/05/2017	MTO L_{Aeq} impact assessment criteria	37	36	41	4
Bulga RFS	06/07/2017	MTO L_{Aeq} impact assessment criteria	37	34	39	2
South Bulga	02/08/2017	MTO L_{Aeq} impact assessment criteria	36	32	37	1
Inlet Road	09/01/2017	WML L_{Aeq} impact assessment criteria	37	33	38	1
Inlet Road	09/02/2017	WML L_{Aeq} impact assessment criteria	37	33	38	1
Bulga RFS	19/05/2017	WML L_{Aeq} impact assessment criteria	37	34	39	2

Location	Date/Time	Relevant Criteria	Criterion (dB)*	L_{Aeq}(dB)	Revised L_{Aeq} (dB)	Exceeds by (dB)
Bulga RFS	15/06/2017	WML L_{Aeq} impact assessment criteria	37	35	40	3
South Bulga	15/06/2017	WML L_{Aeq} acquisition criteria	35	32	37	2
Bulga Village	16/10/2017	WML L_{Aeq} impact assessment criteria	38	38	43	5
Wambo Road	16/10/2017	WML L_{Aeq} impact assessment criteria	37	35	40	3

6.2.4 Comparison against Last Years' Results

A comparison of non-compliances and exceedances between years is used as a measure of the effectiveness of noise management measures employed on site. Non-compliance is determined with reference to the applicable conditions of consent and the *NSW Industrial Noise Policy*.

Details of this comparison are provided in Table 16, which demonstrates a continuation of the effective management delivered in 2016.

TABLE 16: COMPARISON OF 2017 NOISE MONITORING RESULTS AGAINST PREVIOUS YEARS'

Year	Number of assessments	Number of measurements greater than allowable noise limits (under applicable met conditions)	Number of non-compliances
2017	576	0	0
2016	576	0	0
2015	665	0	0
2014	700	0	0
2013	456	11	7
2012	562	13	3
2011	572	11	4
2010	561	3	3
2009	569	10	4

Given the large dataset available, a comparison between the results collected through the supplementary noise monitoring regime from year to year is also considered valuable. Improved noise performance is demonstrated through this data, with reductions in the number of measurements which exceed the noise management trigger at all monitoring locations. Further, reductions in the average noise levels measured across the reporting period are evident at the majority of monitoring locations with the exception of the Long Point and Wambo Road monitoring locations which have largely remained the same. There has been a slight increase in the number of assessments undertaken in 2017 compared to 2016, despite coinciding with a general reduction in measured average noise levels and a ~ 42% reduction in noise complaints.

Table 17: Comparison of CRO (supplementary) noise measurement performance

Monitoring Location	Number of Assessments		Number of measurements >WML trigger^		Number of measurements > MTO trigger^		Average WML noise level ($L_{Aeq\ 5min}$ dB(A))*		Average MTO noise level ($L_{Aeq\ 5min}$ dB(A))*	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Wollemi Peak Road (Bulga RFS)	1,284	1293	46	7	27	8	32.8	32.4	33.5	32.3
Bulga Village	309	542	0	1	1	-	32.4	31.4	32.4	31.7
Inlet Road	-	229	-	2	-	-	-	32.5	-	31.6
Inlet Road West	278	318	0	-	0	-	29.0	27.1	28.4	27.6
Long Point	506	751	2	-	0	-	31.3	30.4	28.0	30.5
South Bulga	4	0	0		0		32.0	-	33.3	-
Wambo Road	471	80	8	-	1	-	33.3	34.0	32.5	32.8
Total	2852	3239	56	10	29	8	NA	NA	NA	NA

^Triggers are internally set thresholds for operational response and are specified in the MTW Noise Management Plan. The number of measurements greater than the trigger cannot be used an assessment or interpretation of compliance. Compliance assessment is provided in 6.2.3 and 6.2.4.

*Average noise levels do not take account of measurements taken where the noise source of interest was recorded as inaudible.

6.2.5 Comparison against EA Predictions

Table 18 provides a comparison of 2017 attended monitoring data and the predicted noise levels modelled in the 2014 Warkworth Continuation EIS. Comparison has been made against the modelled worst case noise levels for Year 3 of the development (nominally 2017). The comparison data has been sourced from the modelled noise levels at the nearest residential receivers to the current monitoring locations. Reported 2017 data is the calculated quarterly average of WML contribution to measured $L_{Aeq\ (15\ minute)}$ results obtained through compliance assessment (irrespective of applicability of noise criteria due to meteorological conditions).

Where a monitoring event has been assessed as being "inaudible" or "not measurable", a conservative value of 25dB has been used to calculate the L_{Aeq} average for the quarter. The comparison shows that measured noise is lower than that predicted.

TABLE 18: PREDICTED NIGHT TIME WML (EIS 2014) $L_{AEQ\ (15\ MINUTE)}$ NOISE LEVELS AND AVERAGED 2017 MONITORING RESULTS

Monitoring Location	Year 3 Modelled Noise	Quarter 1 2016 average	Quarter 2 2016 average	Quarter 3 2016 average	Quarter 4 2016 average
	$L_{Aeq\ (15\ minute)}$ (dB)	$L_{Aeq\ (15\ minute)}$ (dB)	$L_{Aeq\ (15\ minute)}$ (dB)	$L_{Aeq\ (15\ minute)}$ (dB)	$L_{Aeq\ (15\ minute)}$ (dB)
Wollemi Peak Road*/Bulga RFS	≤38	26.3	31.3	25	27
Bulga Village	≤38	27.3	33.3	26.7	29.3
Gouldsville Road	≤35	28.3	27	30	28.3
Inlet Road	≤37	30.3	31	27.7	28.3
Inlet Road West*	≤35	26	26.7	26.7	26.7
Long Point*	≤35	26.7	24	26.7	25
South Bulga	≤38	25	28.7	25	25
Wambo Road	≤38	30[1]	30.3	26.7	29.3
Wollemi Peak Road*/Bulga RFS	≤38	26.3	31.3	25	27

*Denotes – No nearby receiver location modelled

[1] – No attended monitoring occurred at this location in January due to security concerns

6.3 BLASTING

6.3.1 Blasting Management

The objective of blasting operations at MTW is to ensure that optimal fragmentation is obtained whilst minimising dust and fume generation, adhering to safety standards and conforming to approvals criteria for ground vibration and airblast overpressure.

During the reporting period, MTW blast monitoring network operated in accordance with AS2187.2-2006 to measure ground vibration and airblast overpressure of each event at a high sampling frequency. Monitors function as regulatory compliance instruments in accordance with the MTW Blast Monitoring Programme (appended to Blast Management Plan) and are located on (or in locations representative of) privately owned land. During 2017 monitors were situated at the following locations (Figure 5):

- Abbey Green (Abbey Green Station, Putty Road, Glenridding);
- Bulga Village (Wambo Road, Bulga);
- Putty Road, Mount Thorley (known as MTIE -)
- Wambo Road (Wambo Road, Bulga);
- Warkworth Village (former Warkworth Public School, Warkworth); and
- Wollemi Peak Road (intersection of Putty & Wollemi Peak Roads, Bulga).

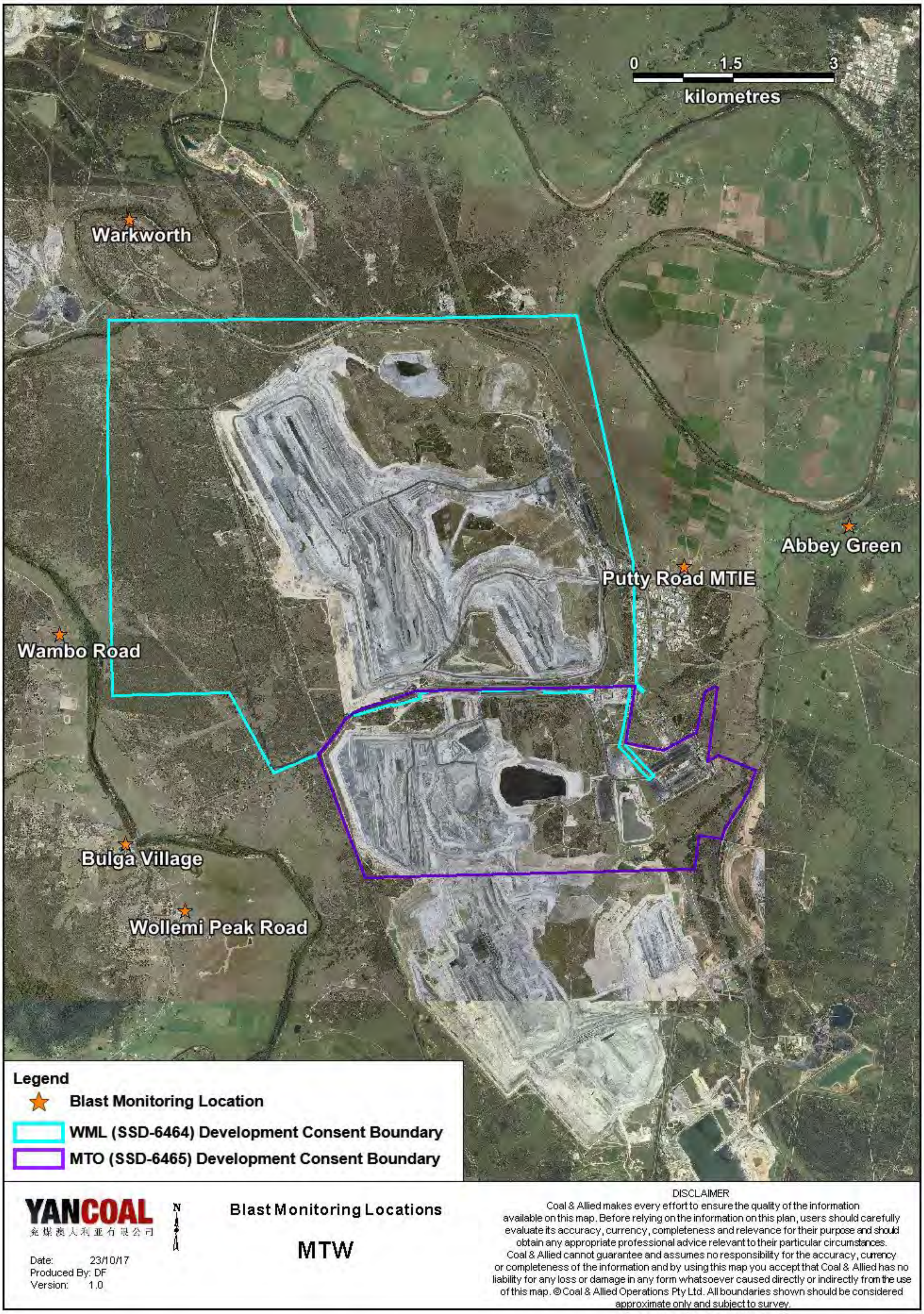

FIGURE 5: BLAST MONITORING LOCATIONS

6.3.2 Performance

During the reporting period MTW detonated 311 blast events. Results of ground vibration and airblast overpressure recorded during 2017 are presented in Figure 6 to Figure 11. All blasts returned results below the relevant airblast overpressure / ground vibration criteria for all monitoring locations.

Road closures occurred for all blasts within 500 metres of a public road. Public roads were also closed on occasions to mitigate potential impact upon road users from dust or when blast fume management zones encompassed public roads.

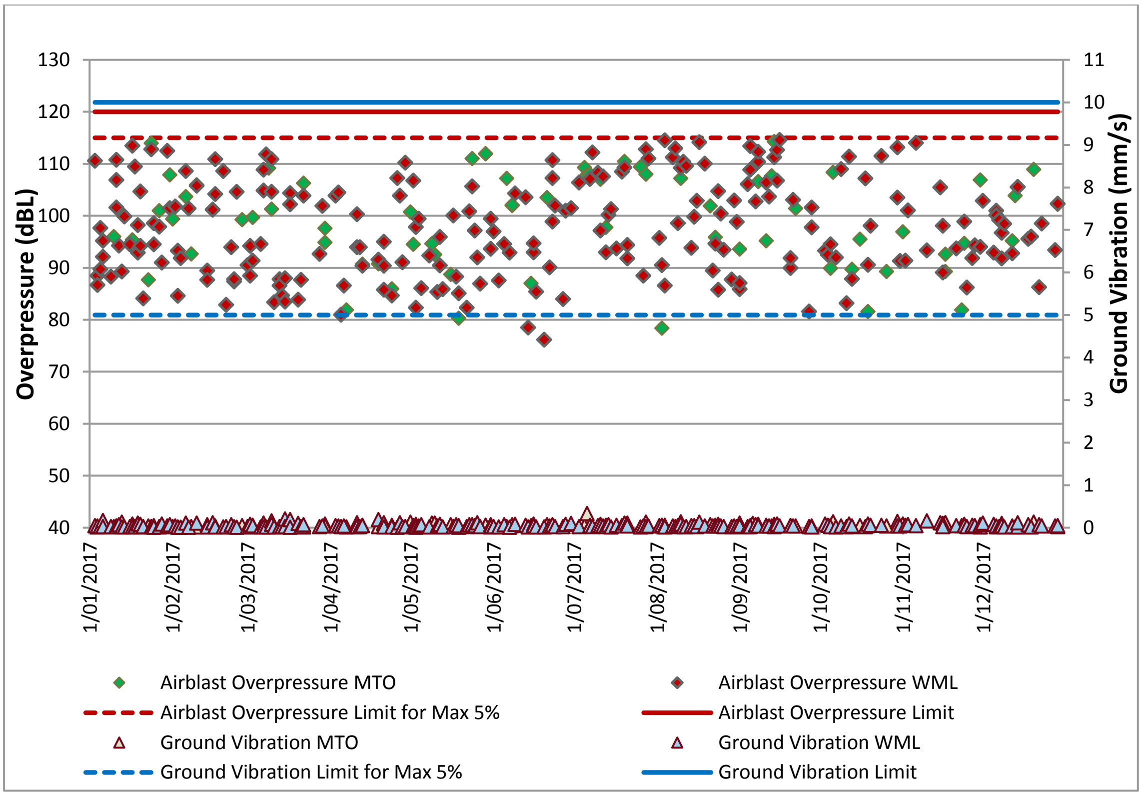

FIGURE 6: ABBEY GREEN BLASTING RESULTS

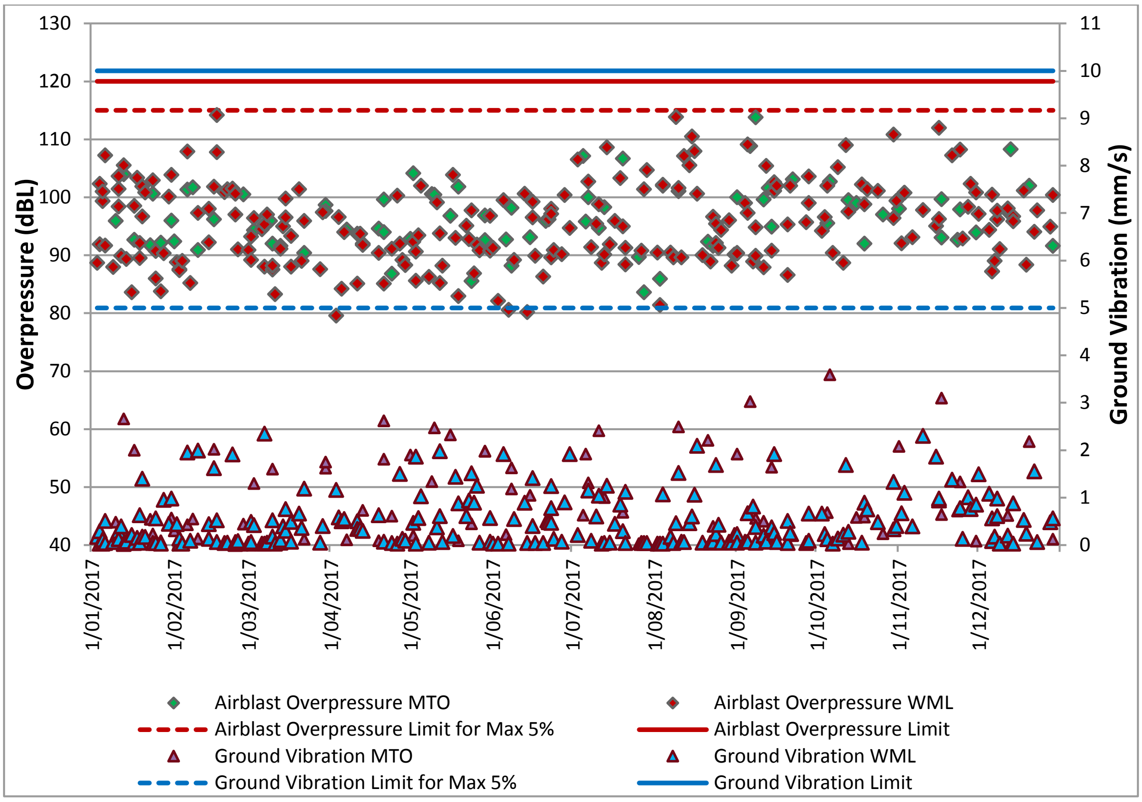

FIGURE 7: BULGA VILLAGE BLAST RESULTS

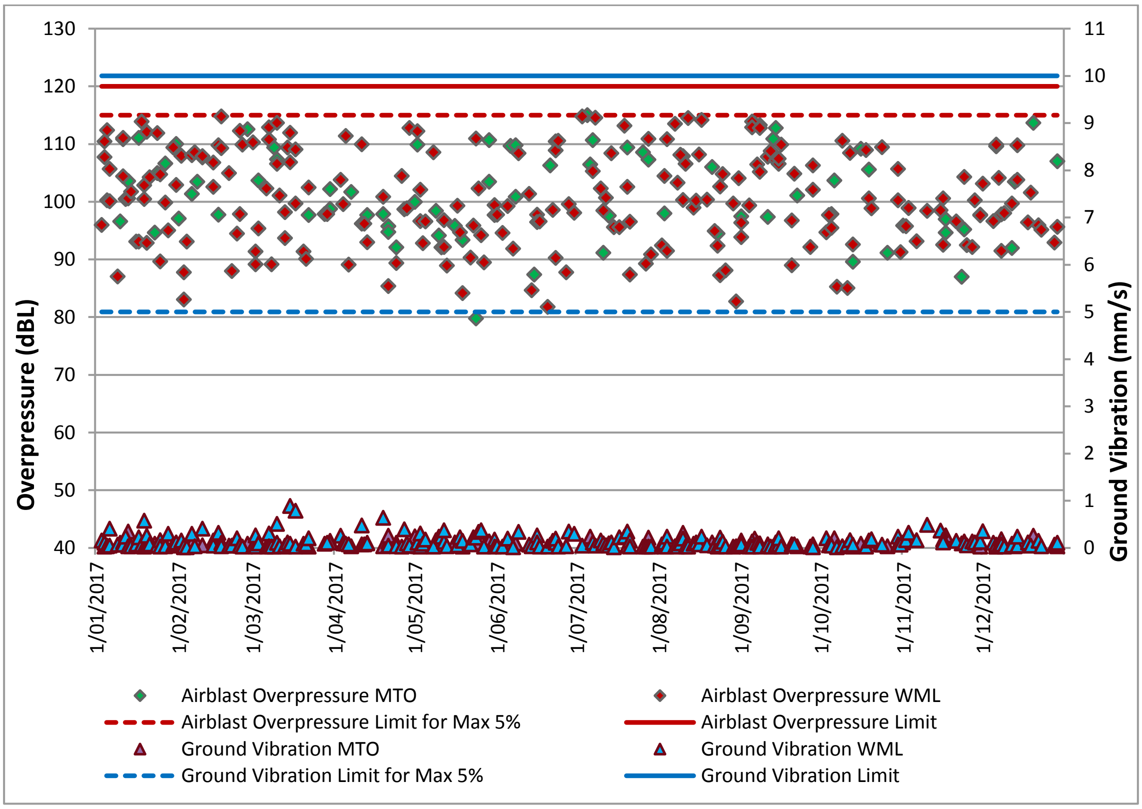

FIGURE 8: MTIE BLAST RESULTS

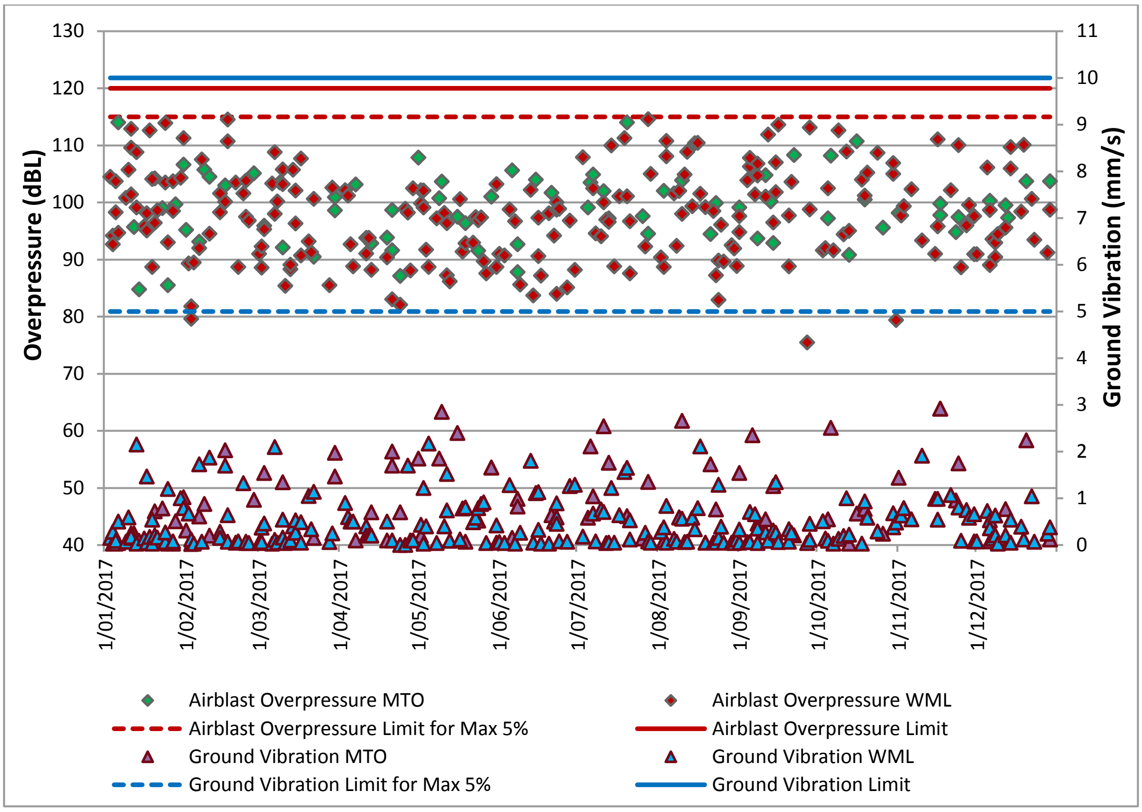

FIGURE 9: WOLLEMI PEAK ROAD BULGA BLAST RESULTS

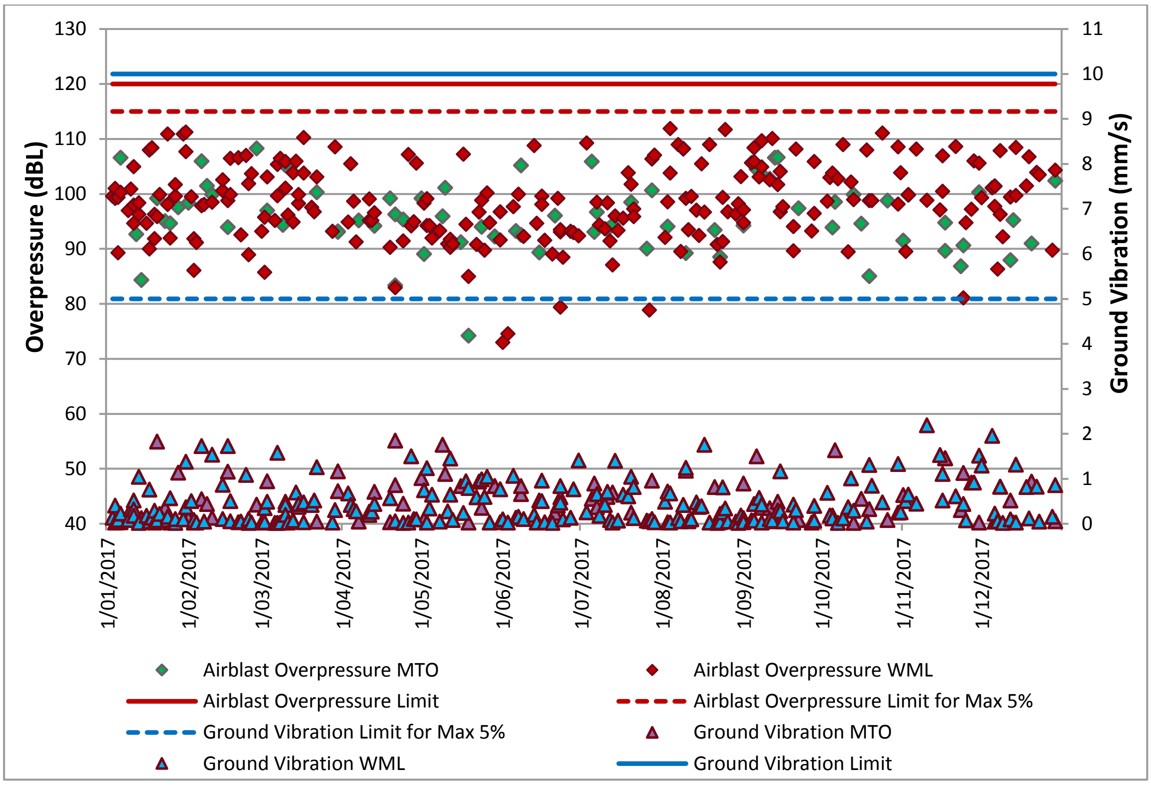

FIGURE 10: WAMBO ROAD BLAST RESULTS

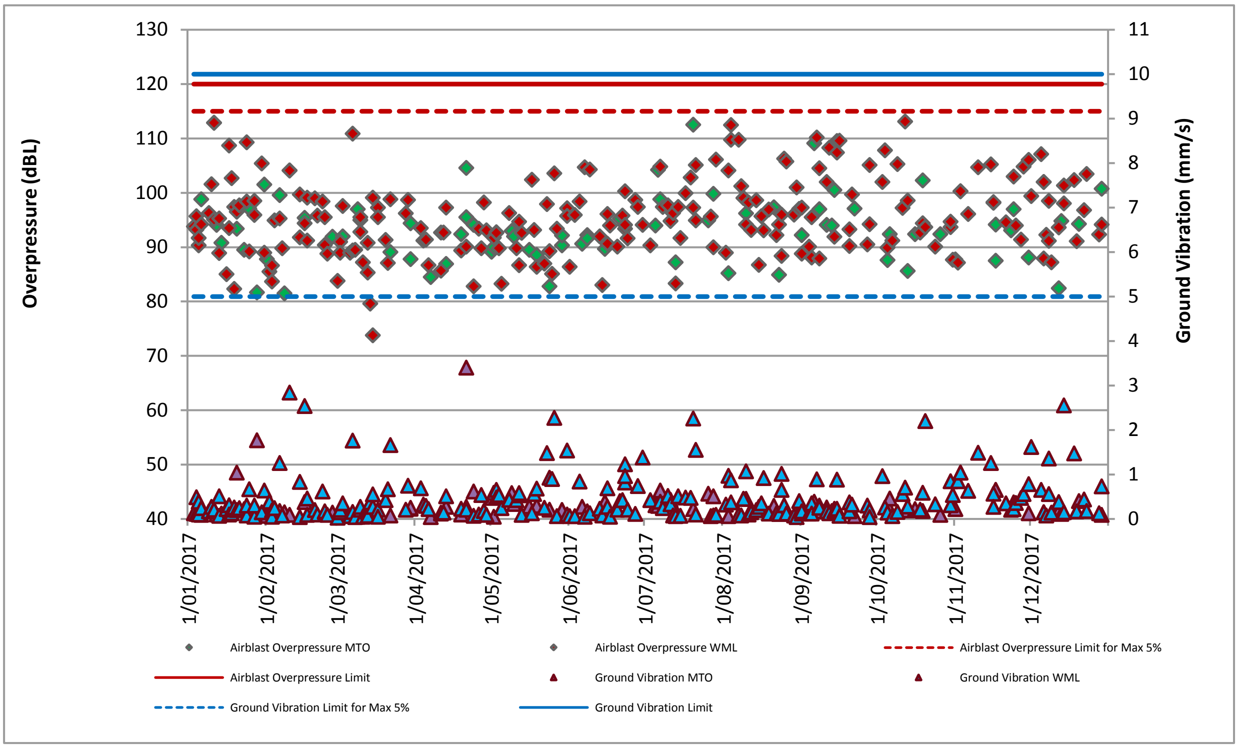

FIGURE 11: WARKWORTH BLAST RESULTS

6.3.3 Blast fume management

MTW operates a Post Blast Fume Generation Mitigation and Management Plan. This document outlines the practices to be utilised to reduce generation of post blast fume, and reduce potential offsite impact from any fume which may be produced. This includes risk assessment of the likelihood of fume production, specialised blasting design, appropriate product selection, on-bench water management, implementation of fume management zones and use of blasting permissions to identify likely path of any fume which may be produced.

All blasts are observed for fume and any fume produced is ranked according to the Australian Explosive Industry & Safety Group (AEISG) Scale.

During 2017, one blast produced visible post-blast fume with a post-blast ranking Level 4 according to the AEISG Scale.

A category four (4) blast fume event was notified to the DP&E on 27 April 2017, in accordance with notification requirements specified in the MTW Blast Management Plan which states:

> *"Notify the Department of Planning and Environment compliance office in Singleton of any blast producing post-blast fume that rates 3 at its highest extent and leaves the site (see definition below), and any blast that rates 4 or 5".*

A report was subsequently provided to DP&E for the event on 11 May 2017. The blast fume originated from a blast fired in the West Pit of the Warkworth premises. The plume left the MTW premises, crossing the Putty Road and re-entering the Mount Thorley lease where it dissipated at height.

Rankings for visible blast fume according to the AEISG scale for shots fired during 2017 and comparison to rankings distribution during previous years is provided in Table 19.

TABLE 19: VISIBLE BLAST FUME RANKINGS ACCORDING TO THE AEISG COLOUR SCALE

AEISG Ranking	2017	2016	2015
0	329	294	374
1	31	43	56
2	25	27	27
3	2	14	9
4	1	0	0
5	0	0	0
Total*	378	378	442

* Where a number of individual blasts were fired as a blast event, fume was assessed for each individual blast pattern rather than for the event as a whole.

6.3.4 Comparison of Monitoring Results Against Previous Years' Performance and EA Predictions

Blasting results recorded in 2017 are similar to results recorded in previous years and are consistent with EA predictions.

6.4 AIR QUALITY

6.4.1 Management

Air quality management at MTW is prescribed by the Air Quality Management Plan (available at http://insite.yancoal.com.au), the management plan;

- Describes procedures required to ensure compliance with the approval conditions relating to air quality including the measures that MTW will use to manage air quality.
- Details the management framework and mitigation actions to be taken while operating
- Provides a mechanism for assessing air quality monitoring results against the relevant impact assessment criteria.

6.4.2 Air Quality Performance

6.4.2.1 Real-Time Air Quality Management

MTW's real-time air quality monitoring stations continuously log information and transmit data to a central database, generating alarms when particulate matter levels exceed internal trigger limits.

1,603 real-time alarms for air quality and wind conditions were received and acknowledged during 2017. In response, 8,030 hours of equipment downtime was recorded due to air quality management. A detailed breakdown of air quality related equipment stoppages (per month, per equipment type) is presented in Figure 12.

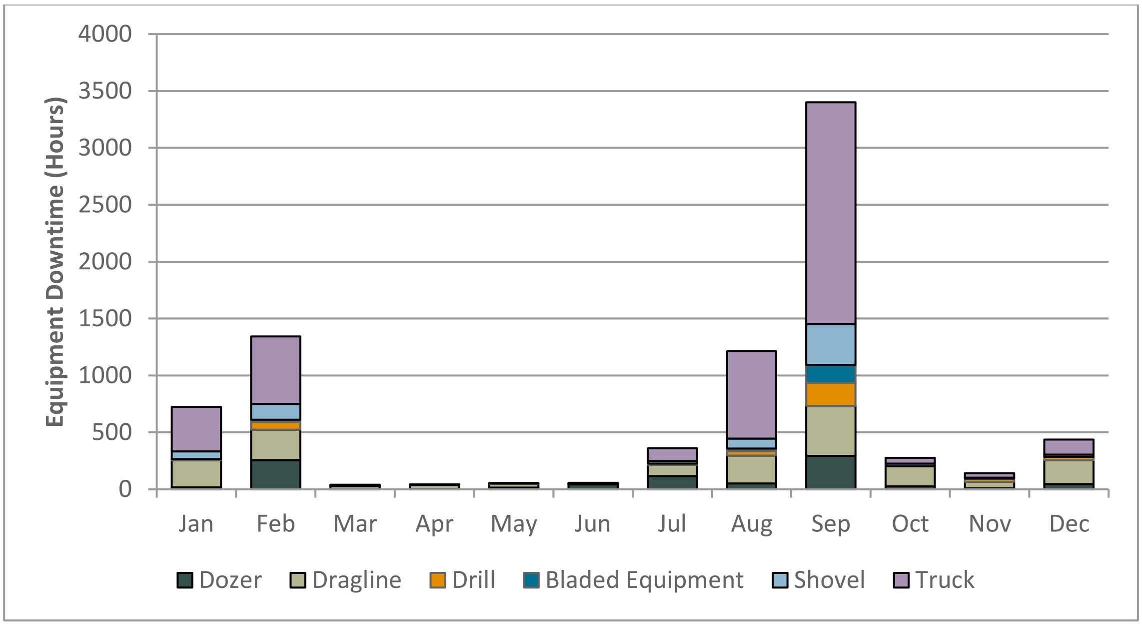

FIGURE 12: EQUIPMENT DOWNTIME FOR DUST MANAGEMENT BY MONTH

6.4.2.2 Temporary Stabilisation

The aerial seeding programme was undertaken in 2017 to reduce airborne dust from inactive waste dumps and ahead of mining areas. 145.3 hectares of area seeded (see Figure 13) using an exotic pasture grass and legume mix suitable for autumn sowing. A starter fertiliser was mixed with the seed prior to loading to provide sufficient nutrients for plant growth.

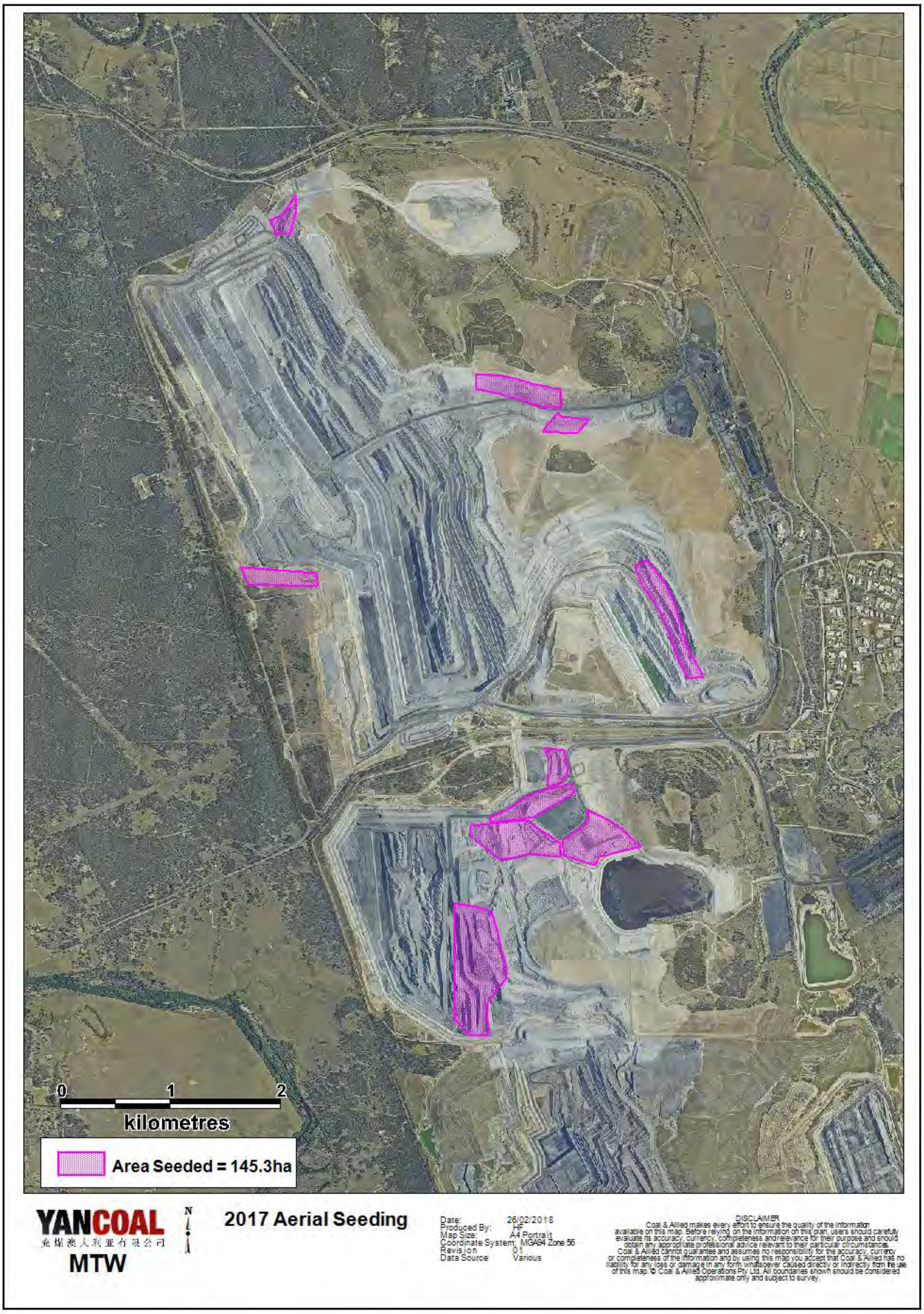

FIGURE 13: 2017 AERIAL SEEDING AREAS

6.4.3 Air Quality Monitoring

Air quality monitoring at MTW is undertaken in accordance with the MTW Air Quality Monitoring Programme and protocol for evaluating non-compliances. The monitoring network comprises an extensive array of monitoring equipment which is utilised to assess performance against the relevant conditions of MTW's approvals and Environment Protection Licences. Air quality monitoring locations are shown in Figure 14. During 2017, MTW complied with all short term and annual average air quality criteria.

Air quality compliance criteria are shown in Table 20, along with a summary of MTW's performance against the criteria. Whilst MTW operates under two separate planning approvals the following compliance assessment has been undertaken on a 'whole of MTW site' basis, rather than individually assessing the contribution of each approval area to the measured results.

Air quality monitoring data is made publically available through the MTW Monthly Environmental Monitoring Report and daily data can be accessed on http://insite.yancoal.com.au

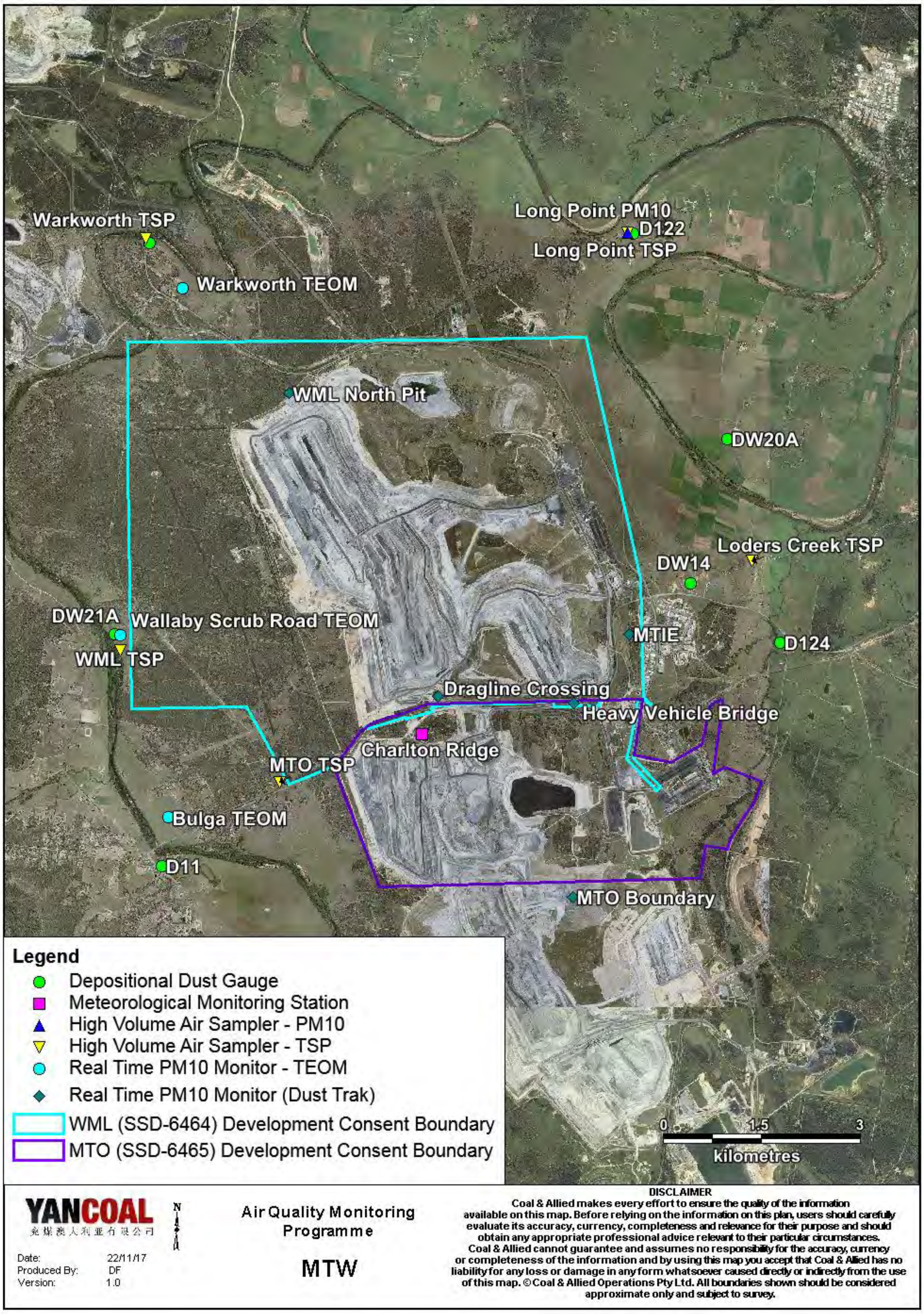

FIGURE 14: AIR AND METEOROLOGICAL MONITORING LOCATIONS MTW 2016

TABLE 20: AIR QUALITY IMPACT ASSESSMENT CRITERIA AND 2017 COMPLIANCE ASSESSMENT

Pollutant	Criterion	Averaging Period	Compliance
Deposited Dust	4 g/m^2/month	Maximum total deposited dust level	100%
	2 g/m^2/month	Maximum increase in deposited dust level	100%
Total Suspended Particulate matter (TSP)	90 $\mu g/m^3$	Long Term (Annual)	100%
Particulate matter <10µm (PM_{10})	30 $\mu g/m^3$	Long Term (Annual)	100%
	50 $\mu g/m^3$	Short Term (24 hour)	100%

6.4.3.1 Deposited Dust

Deposited dust is monitored at nine locations situated on, or representative of privately-owned land, in accordance with AS3580.10.1 (2003). The annual average insoluble matter deposition rates in 2017 compared with the impact assessment criterion and previous years' data is shown in Figure 13.

During 2017, all annual average insoluble matter deposition rates recorded on privately owned land were compliant with the long-term impact assessment criteria. All monitoring locations also demonstrated compliance with the maximum allowable insoluble solids increase criteria of 2g/m2/month (Figure 16).

There were two exceedances of the long-term impact assessment criteria, for maximum total deposited dust level, recorded at DW20A and Warkworth monitoring locations. An external consultant was engaged to conduct an investigation which determined maximum MTW contribution to be not more than 1.2g/m2/month, or 41% of the total level of 4.1g/m2/month at DW20A and also not more than 1.05g/m2/month or 25% of the total level of 4.2g/m2/month at Warkworth. As per MTW's approved Air Quality Management Plan, this does not constitute non-compliance and no further action is required. There was also one exceedance of the long-term impact assessment criteria of 2g/m2/month (Maximum increase in deposited dust level) recorded at DW20A. The increase in deposited dust level at DW20A was 2.2 g/m2/month in 2017, however the criteria relates to incremental increase in concentrations due to the development on its own. Investigation determined that maximum total deposited dust level due to activities at MTW was 1.2g/m2/month, which brings the increase in deposited dust level down below criteria. As such, the exceedance does not constitute non-compliance. During 2017 monthly dust deposition rates equal to or greater than the long-term impact assessment criteria of 4g/m2/month were recorded at a number of sites. Where field observations denote a sample as contaminated (typically with insects, bird droppings or vegetation), the results are excluded from Annual Average compliance assessment. Meteorological conditions and the results of nearby monitors for the sampling period are also considered when determining MTW's level of contribution to any elevated result. Details of excluded results are presented in the relevant MTW Monthly Environmental Monitoring Report. The graphs below illustrate a general trend in increased Depositional Dust across the board compared to previous year's. This is consistent with adverse meteorological conditions of low rain fall and consistent wind days.

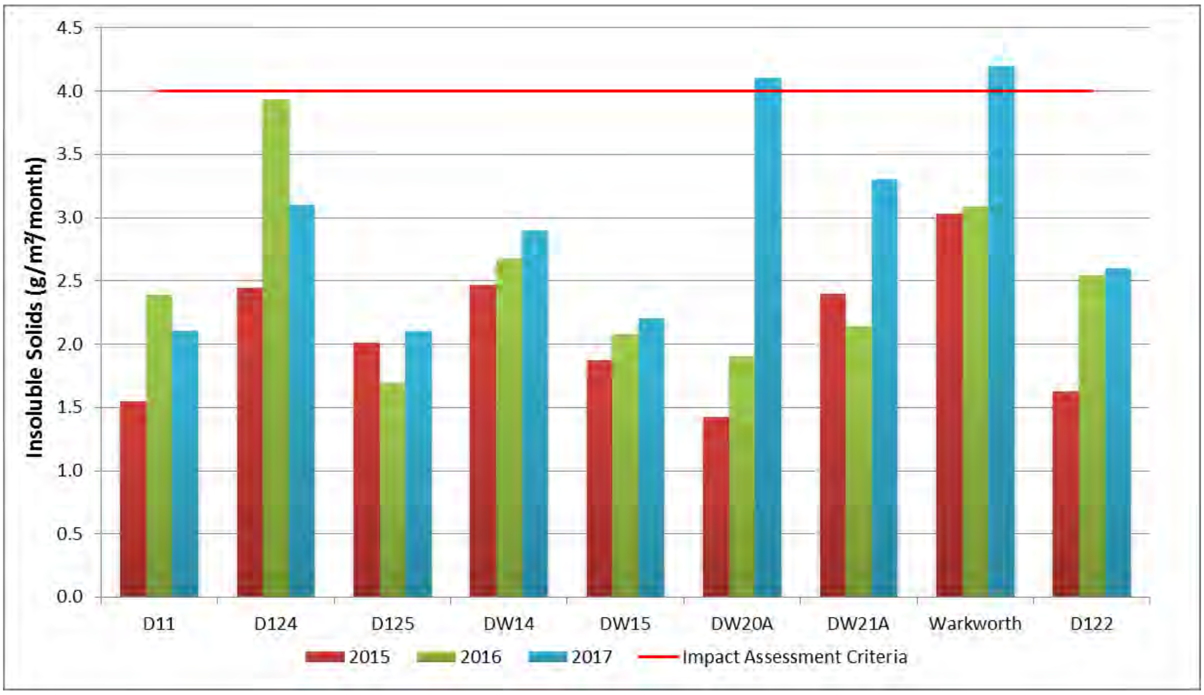

FIGURE 15: 2017 DEPOSITIONAL DUST RESULTS COMPARED AGAINST THE IMPACT ASSESSMENT CRITERIA AND PREVIOUS YEARS' RESULTS

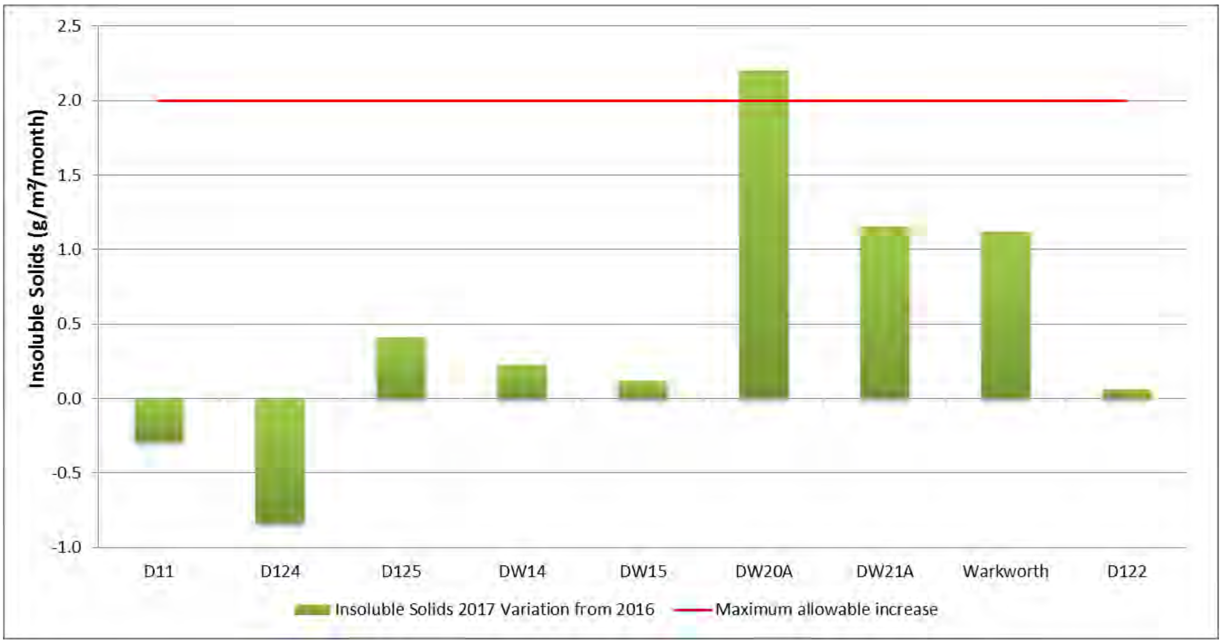

FIGURE 16: VARIATION IN INSOLUBLE SOLIDS DEPOSITION RATE FROM 2016 TO 2017 COMPARED AGAINST THE IMPACT ASSESSMENT CRITERIA

6.4.3.2 Total Suspended Particulates (TSP)

Total Suspended Particulates (TSP) are measured at five locations situated on or representative of privately owned land in accordance with AS3580.9.3 (2003). Annual average TSP concentrations recorded in 2017 compared against the long term impact assessment criterion and previous years' data, are shown Figure 17. During 2017 all annual average results were compliant with the impact assessment and land acquisition criteria.

One high volume air sample exceeded the annual TSP impact assessment criteria during the reporting period. This was investigated to determine the level of contribution from MTW activities in accordance with the compliance protocol outlined in the MTW Air Quality Management Plan. The recorded exceedance was determined to be compliant with the relevant criteria.

A summary of the investigation undertaken for the annual TSP exceedance is provided in Table 21

TABLE 21 : ANNUAL TSP INVESTIGATION - 2017

Date	Site	Annual Average PM_{10} result ($\mu g/m^3$)	Calculated Annual TSP ($\mu g/m^3$)	Discussion
2017	Long Point HVAS PM10	95.3	86.9	An external consultant was engaged to investigate the exceedance, which determined that the result, excluding extraneous livestock dust impacted days (from livestock "immediately" adjacent to the monitor), is below the criterion of 90μg/m3. As the measured result is not solely attributable to MTW, it does not constitute non-compliance, as per MTW's approved Air Quality Management Plan and so no further action is required. A horse round yard and a chicken coop, which were "immediately" adjacent to the monitor creating exposed soil, were relocated further away in response to the elevated conditions.

During the reporting period, 10 out of 300 TSP measurements were not able to be collected on the scheduled sampling date (based on a sampling frequency of every six days) due to power failures and technical issues with the monitors.

The annual average TSP concentrations recorded in 2017 are higher than those recorded in previous years, which is likely related to well below average rainfall for the year (Figure 17).

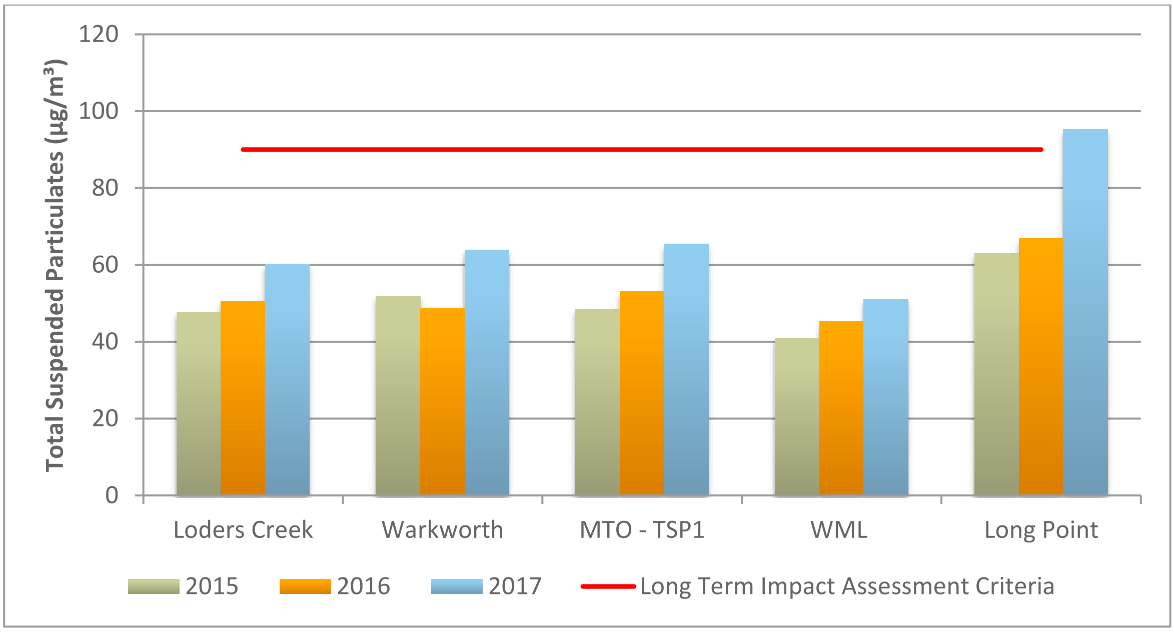

FIGURE 17: 2017 TSP ANNUAL AVERAGE COMPARED AGAINST THE IMPACT ASSESSMENT CRITERIA AND PREVIOUS YEARS' RESULTS

6.4.3.3 Particulate Matter <10µm (PM10)

Compliance assessment for Particulate Matter <10µm (PM_{10}) is measured at five locations on privately owned land in accordance with AS3580.9.6 (2003). During 2017, all short term and annual average results were compliant with the impact assessment criteria.

6.4.3.4 Short term PM10 impact assessment criteria

Monitoring results for PM_{10} (24 hour) collected through the High-Volume Air Sampler monitoring network are compared against the short-term impact assessment criteria (Figure 18). All 24hr average results recorded by MTW's surrounding network of TEOM monitors are presented on a quarterly basis in Figure 19 to Figure 22.

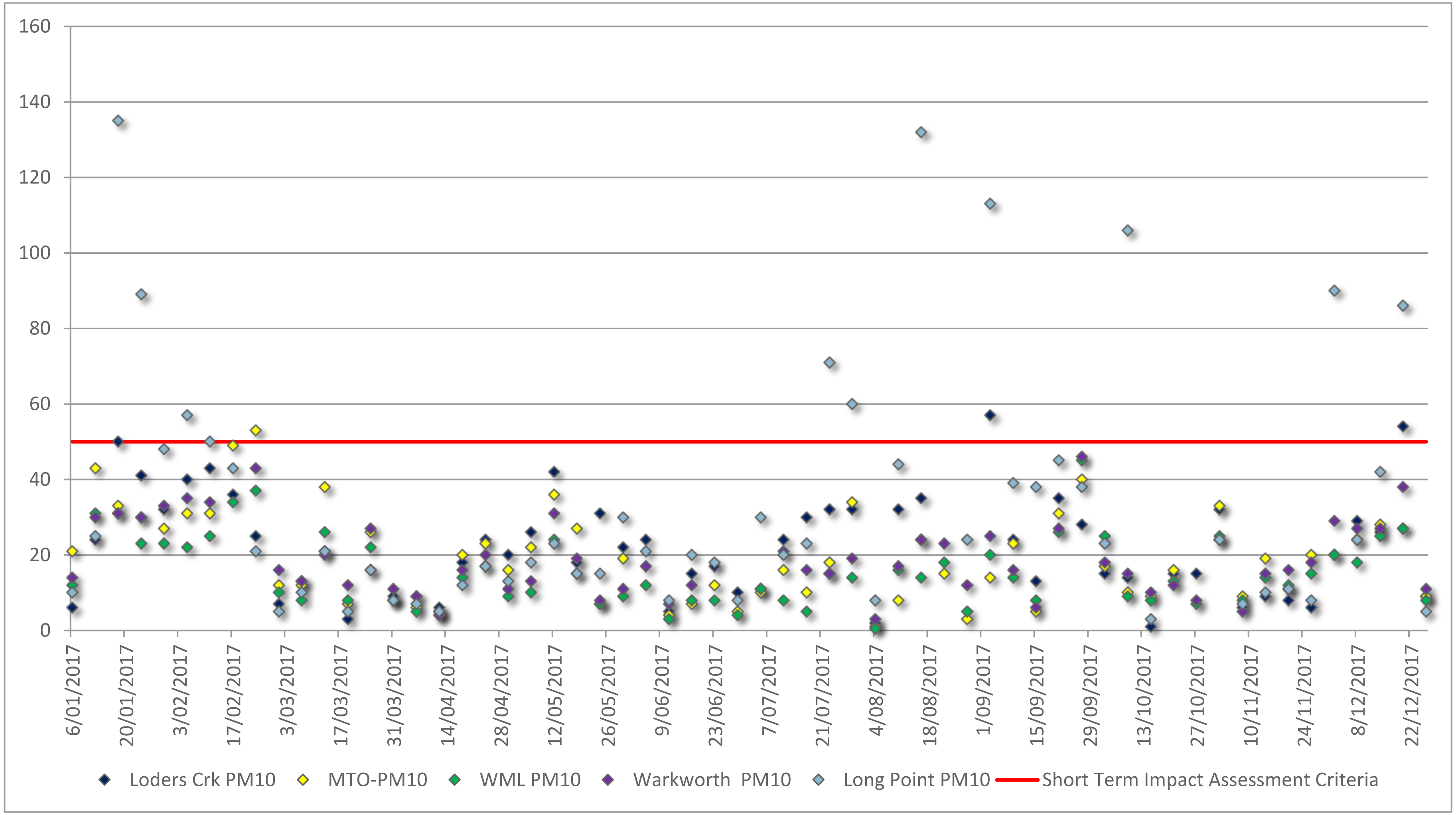

FIGURE 18: PM_{10} 24HR MONITORING RESULTS (MEASURED BY MTW PM_{10} HVAS NETWORK)

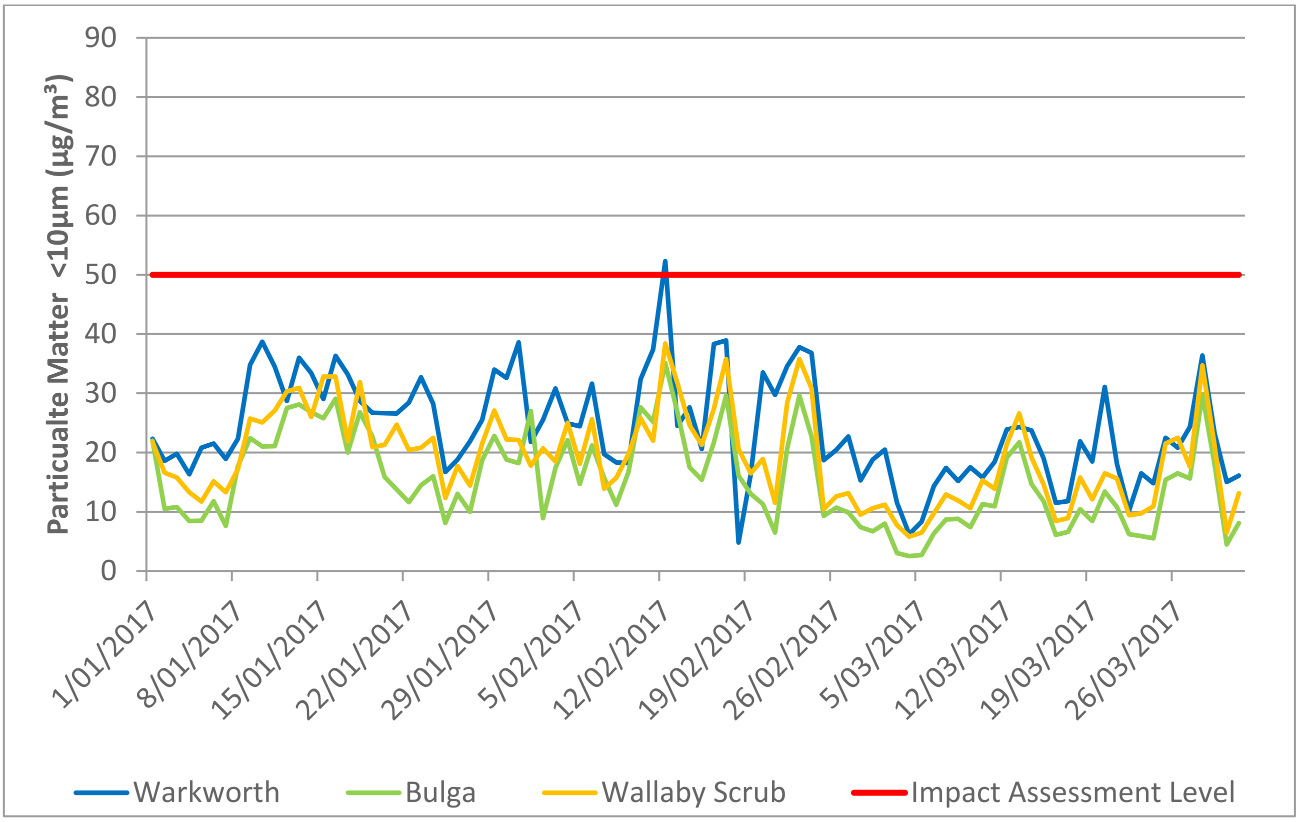

FIGURE 19: 24HR AVERAGE PM_{10} MEASURED AT TEOM MONITORS SURROUNDING MTW - QUARTER ONE 2017

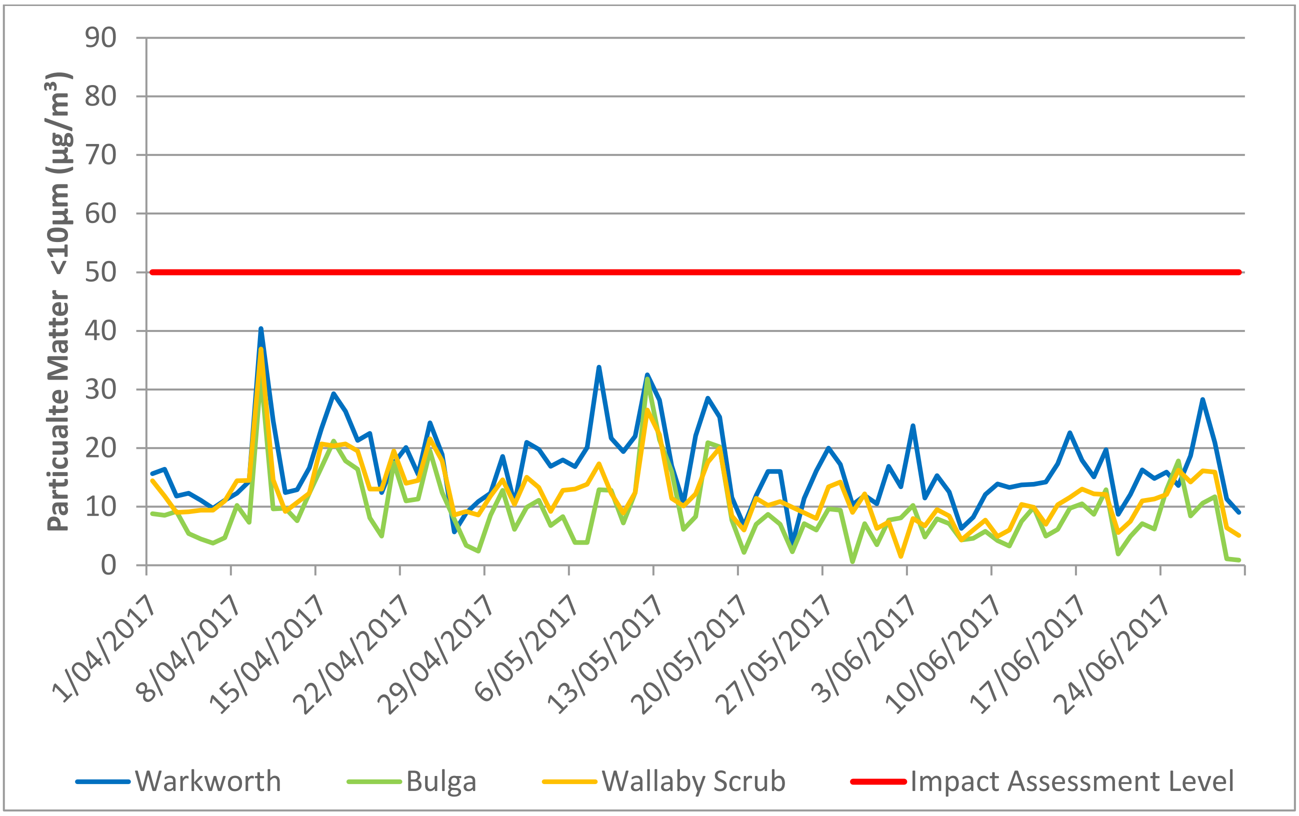

FIGURE 20: 24HR AVERAGE PM_{10} MEASURED AT TEOM MONITORS SURROUNDING MTW - QUARTER TWO 2017

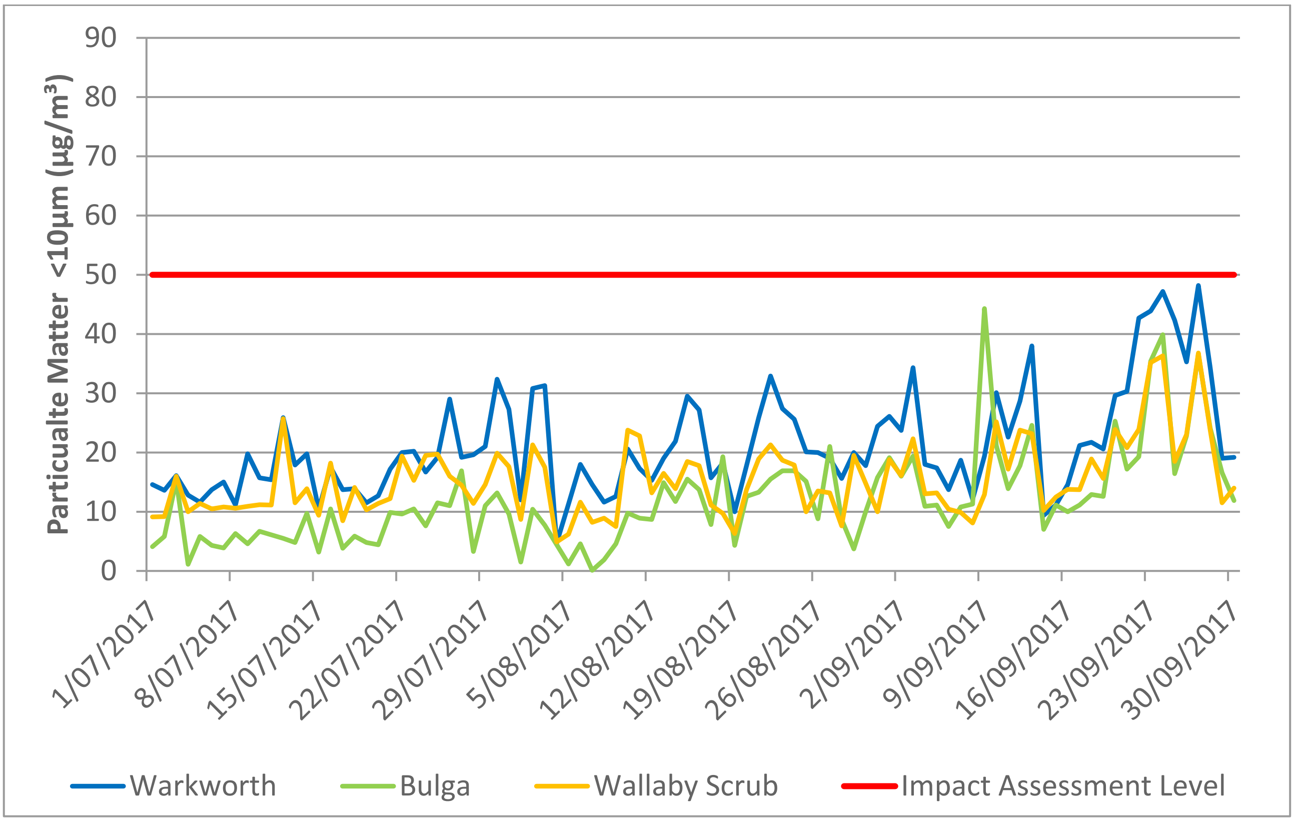

FIGURE 21: 24HR AVERAGE PM_{10} MEASURED AT TEOM MONITORS SURROUNDING MTW - QUARTER THREE 2017

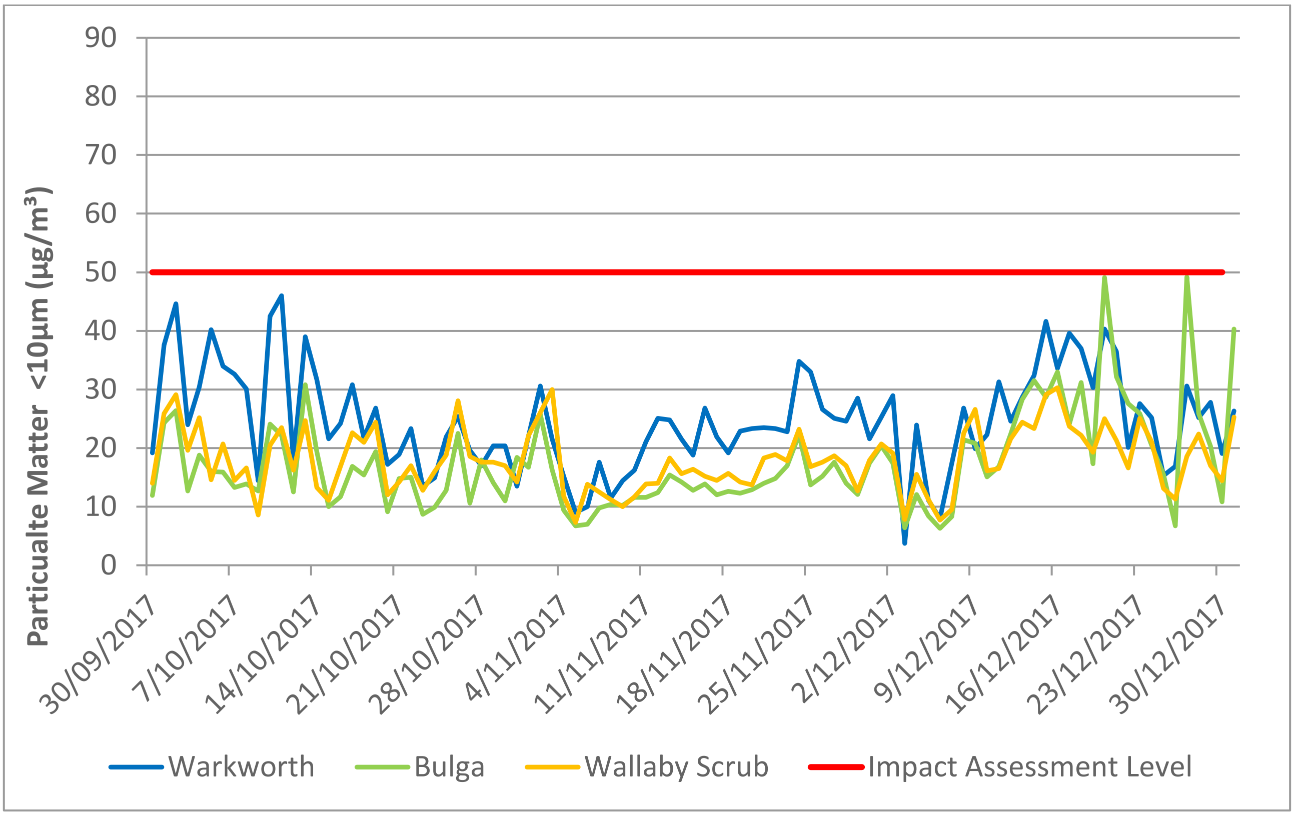

Figure 22: 24hr average PM_{10} measured at TEOM monitors surrounding MTW - Quarter Four 2017

11 high volume air samples and one TEOM PM_{10} measurement exceeded the 24 hour short term impact assessment criteria during the reporting period. Each was investigated to determine the level of contribution from MTW activities in accordance with the compliance protocol outlined in the MTW Air Quality Management Plan. All recorded exceedances were determined to be compliant with the relevant criterion.

A summary of the investigations undertaken for each short term PM_{10} exceedance are provided in Table 22.

TABLE 22 : 24 HOUR PM_{10} INVESTIGATIONS - 2017

Date	**Site**	**24hr PM_{10} result (μg/m^3)**	**Estimated contribution from MTW (μg/m^3)**	**Discussion**
12/02/2017	Warkworth OEH TEOM	52.3	27.8	Analysis of meteorological Data has determined the maximum potential MTW contribution to the result to be in the order of 27.8µg/m3 or ~53% of the measured result, determined by assessing contribution due to meteorological conditions.
05/02/2017	Long Point HVAS PM10	57	-	An analysis of meteorological data has determined that the Long Point monitoring location was predominantly upwind of MTW throughout the day. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
23/02/2017	MTO HVAS PM10	53	28	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 28µg/m3 or ~53% of the measured result. As the calculated contribution was less than 75% of the measured result MTW operations are not considered to be a significant contributor to the result as described in the MTW Air Quality Management Plan.
23/07/2017	Long Point HVAS PM10	71	-	An analysis of meteorological data has determined that the Long Point monitoring location was predominantly upwind of MTW throughout the day. Therefore, it is unlikely that MTW operations was significant contributor to the result and thus an estimation of contribution has not been calculated.
29/07/2017	Long Point HVAS PM10	60	-	An analysis of meteorological data has determined that the Long Point monitoring location was generally upwind of MTW throughout the day. Therefore, it is unlikely that MTW operations was significant

				contributor to the result and thus, an estimation of contribution has not been calculated.
16/08/2017	Long Point HVAS PM10	132	-	An analysis of meteorological data has determined that the Long Point monitoring location was generally upwind of MTW throughout the day. Therefore, it is unlikely that MTW operations was significant contributor to the result and thus an estimation of contribution has not been calculated.
03/09/2017	Long Point HVAS PM10	113	23	An analysis of meteorological data has determined that the Long Point monitoring location was generally upwind of MTW throughout the day. Therefore, it is unlikely that MTW operations was significant contributor to the result.
03/09/2017	Loders Creek HVAS PM10	57	34.5	An analysis of Meteorological data combined with up wind analysis has determined the maximum potential MTW contribution to the result to be in the order of 35µg/m3 or ~61% of the measured result. As the calculated contribution was less than 75% of the measured result MTW operations are not considered to be a significant contributor to the result as described in the MTW Air Quality Management Plan.
09/10/2017	Long Point HVAS PM10	106	-	An analysis of meteorological data has determined that the Long Point monitoring location was predominantly upwind of MTW throughout the day. Therefore, it is unlikely that MTW operations was significant contributor to the result and thus an estimation of contribution has not been calculated.
02/12/2017	Long Point HVAS PM10	90	-	An analysis of meteorological data has determined that the Long Point monitoring location was predominantly upwind of MTW throughout the day. Therefore, it is unlikely that MTW operations was significant contributor to the result and thus an estimation of contribution has not been calculated.
20/12/2017	Long Point HVAS PM10	86	-	An analysis of meteorological data has determined that the Long Point monitoring location was Predominantly up upwind of MTW throughout the day. Therefore, it is

				unlikely that MTW operations was significant contributor to the result and thus an estimation of contribution has not been calculated.
20/12/2017	Loders Creek HVAS PM10	54	23	An analysis of Meteorological data combined with up wind analysis has determined the maximum potential MTW contribution to the result to be in the order of 23µg/m3 or ~43% of the measured result. As the calculated contribution was less than 75% of the measured result MTW operations are not considered to be a significant contributor to the result as described in the MTW Air Quality Management Plan.

6.4.3.5 Long term PM10 impact assessment criteria

Annual average PM_{10} concentrations have been compared with the long term PM_{10} impact assessment criterion and previous years' data (Figure 23). All annual average PM_{10} concentrations recorded on privately owned land were compliant with the assessment criterion.

One high volume air sample exceeded the annual PM_{10} impact assessment criteria during the reporting period. The result was investigated by external consultant to determine the level of contribution from MTW activities in accordance with the compliance protocol outlined in the MTW Air Quality Management Plan. The exceedance was determined to be compliant with the relevant criteria.

A summary of the investigation undertaken for the annual PM_{10} exceedance is provided in Table 22

TABLE 23 : ANNUAL PM_{10} INVESTIGATION - 2017

Date	Site	Annual Average PM_{10} result ($\mu g/m^3$)	Calculated Annual PM_{10} ($\mu g/m^3$)	Discussion
2017	Long Point HVAS PM10	33.3	29.2	An external consultant was engaged to investigate the exceedance, which determined that the result, excluding extraneous livestock dust impacted days (from livestock "immediately" adjacent to the monitor), is below the criterion of 90µg/m3. As the measured result is not solely attributable to MTW, it does not constitute non-compliance, as per MTW's approved Air Quality Management Plan and so no further action is required.

				A horse round yard and a chicken coop, which were "immediately" adjacent to the monitor creating exposed soil, were relocated further away in response to the elevated conditions.

During the reporting period, 12 out of 300 PM_{10} measurements were not able to be collected on the scheduled sampling date (based on a sampling frequency of every six days) due to power failures and technical issues with the monitors.

All monitoring locations recorded increases in PM_{10} compared to 2016. This is likely related to below average rainfall for the year, substantially lower than the 2016 total.

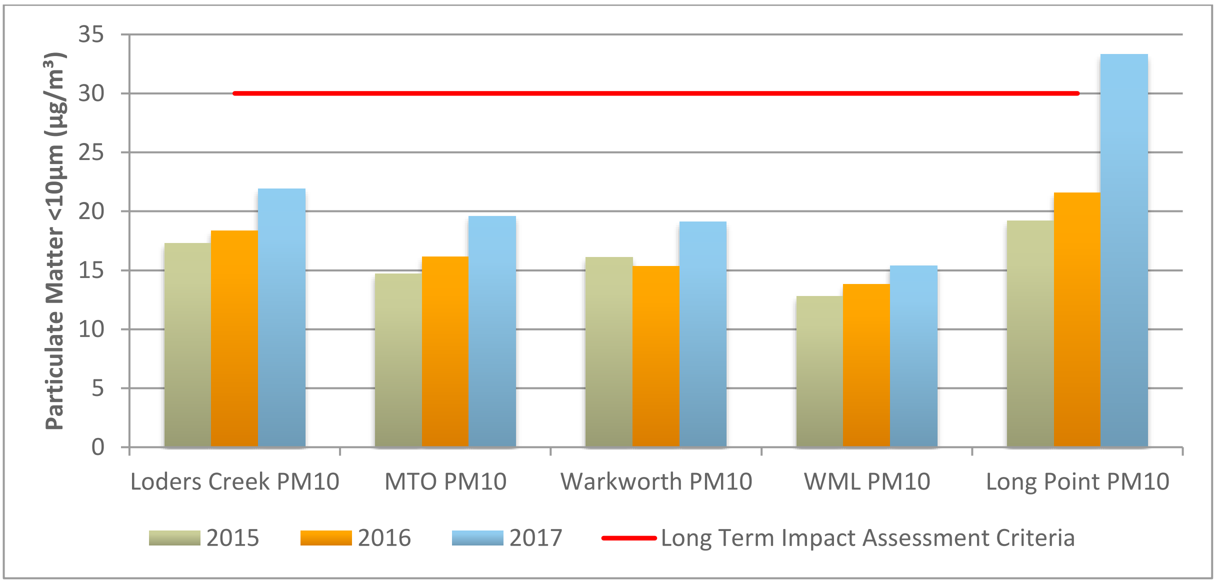

FIGURE 23: ANNUAL AVERAGE HVAS PM_{10} RESULTS 2015 TO 2017

6.4.3.6 *Comparison of 2017 Air Quality data against EA predictions*

Table 24 and Table 25 show a comparison between 2017 air quality data and the predictions made in the 2014 Warkworth Continuation Environmental Impact Statement (EIS). Comparisons have been made against the predictions listed in the EIS for Year 3 (2017) for the nearest private residence to each monitoring location.

Annual average PM_{10}, with the exception of Long Point, were consistent or below the modelled range for Year 3 of the development (nominally 2017). Long Point PM_{10} recorded an annual average result of 33.3µg/m³, exceeding the predicted annual average (16µg/m³). Given prevailing winds in the Hunter Valley and the location of the monitor relative to MTW operations it is unlikely that the measured increases are primarily a direct result of MTW activity.

TABLE 24: 2017 PM_{10} ANNUAL AVERAGE RESULTS COMPARED AGAINST CUMULATIVE PREDICTIONS FOR YEARS 3 - WARKWORTH CONTINUATION EIS (2014).

Monitoring Location	Long Term (annual average) PM_{10} criteria	
	Year 3 (μg/m^3)	2017 Annual Average (μg/m^3)
MTO PM_{10}	23	19.6
Loders Creek PM_{10}	19	21.9
WML PM_{10}	16	15.4
Warkworth PM_{10}	30	19.1
Long Point PM_{10}	16	33.3

TSP annual averages at all monitoring locations except Warkworth TSP were higher than modelled predictions for the Year 3 scenario. The difference between modelled predictions and the measured result can be explained as a function of model inputs which do not account for TSP contribution from regional particulate events such as bushfires, stock movement, dust from local roads and driveways and agricultural activity.

TABLE 25: 2017 TSP ANNUAL AVERAGE RESULTS COMPARED AGAINST CUMULATIVE PREDICTIONS FOR YEAR 3 – WARKWORTH CONTINUATION EIS (2014).

Monitoring Location	Long Term (annual average) TSP criteria	
	Year 3 (μg/m^3)	2017 Annual Average (μg/m^3)
MTO TSP1	52	65.5
Loders Creek TSP	43	60.1
WML- HV2a	39	51.1
Warkworth	65	63.9
Long Point	38	95.3

6.5 HERITAGE SUMMARY

6.5.1 Aboriginal Heritage

6.5.1.1 Aboriginal Archaeological and Cultural Heritage Investigations

Two Aboriginal cultural heritage salvage programs were conducted at MTW in 2017, in accordance with the MTW *Aboriginal Cultural Heritage Management Plan.* A salvage mitigation program was conducted on 22/23 July 2017 covering 25 isolated artefact sites to the west of the existing West Pit. Also, in December, a work program commenced to remove the Site M grinding grooves & relocate these features to, ultimately, the Wollombi Brook Aboriginal Cultural Heritage Conservation Area. This program will continue & conclude in 2018.

In addition to these programs, an ACHMP compliance inspection was conducted between 18-23 December. This compliance inspection was conducted by representatives of the Aboriginal community selected by MTW and were assisted by internal personnel. A total of 20 Aboriginal cultural heritage sites were inspected during this program. Five new Aboriginal cultural heritage sites was identified and recorded into the internal CH database during this audit.

The Coal & Allied Upper Hunter Valley Aboriginal Cultural Heritage Working Group (CHWG) is the primary forum for Aboriginal community consultation on matters pertaining to cultural heritage. The CHWG is comprised of representatives from MTW and Registered Aboriginal Parties (RAPs) from Upper Hunter Valley Aboriginal native title and community groups, corporations and individuals. The CHWG met and discussed cultural heritage management matters associated with MTW on six occasions during 2017: on 14 February, 23 February, 4 May, 8 June, 24 August & 9 November.

6.5.1.2 Audits and Incidents

During the reporting period there were 28 GDPs assessed for cultural heritage management considerations at MTW. Ground disturbance works were conducted on an Aboriginal cultural heritage sites avoidance basis so that no unsalvaged sites were impacted by these activities. There were no incidents nor any unauthorised disturbance caused to Aboriginal cultural heritage sites at MTW during 2017.

An independent MTW Environmental audit was conducted in 2017. One administrative non-compliance was identified in relation to Cultural Heritage Awareness Training materials not meeting the requirements of consents SSD-6464 and SSD-6465 and associated Aboriginal Heritage Management Plan (see attached Appendix 4).

6.5.2 Historic Heritage

6.5.2.1 Historic Heritage Activities

In 2012 the Community Heritage Advisory Group (CHAG) was established as a community consultation forum for all matters pertaining to management of historic (non-Indigenous) heritage located on MTW lands. The CHAG is comprised of community representatives with particular knowledge and interests in the historic heritage of the region such as historical groups, individuals and local government. The CHAG met four times over 2017 to discuss the results and recommendations arising from historic heritage surveys conducted over the entirety of MTW mining leases.

There were no incidents nor any unauthorised disturbance caused to historic heritage sites at MTW during 2016.

6.6 VISUAL AMENITY AND LIGHTING

6.6.1 Management

MTW aims to minimise visual amenity impacts from its operations. Two of the main controls used are lighting management and visual screening

Lighting

MTW aims to provide sufficient lighting for work to be undertaken safely, whilst minimising disturbance to neighbouring residents and public roads, particularly nearby residents in Bulga Village, Mount Thorley, Warkworth Village, Long Point, and Milbrodale; and vehicular traffic on the Putty Road and Golden Highway.

Actions undertaken in 2017 to manage lighting impacts include:

- Routine night shift inspections conducted by Community Response Officers to observe operating practices and to ensure lights are not shining towards nearby residential areas or affecting public roads.
- Yellow lights are used in preference to white lights in areas based on risk and external exposure.
- Alternate sheltered dumps are operated or work areas are shut down if lighting or visual amenity issues arise and cannot be sufficiently managed.
- MTW continue to modify the lighting plant plan in the Tipping and Dumping strategy to reflect changes in the operating area

Visual Screening

Visual screening of MTW operations uses various methods to best suit the terrain and infrastructure constraints around the boundary of the mine.

Bunding has an immediate screening effect, providing complete screening in areas where vegetation would be inadequate to filter views or where additional height is required. Bunds will be vegetated for visual amenity and to mitigate erosion.

Built screens (i.e. solid fences or walls) will be used as an alternative when bunds and tree screens are not practicable. Temporary screens (i.e. fencing and shade mesh) will be used as required for interim screening. Stage two of the Putty Road visual bund was completed in 2017. The bund will be vegetated with native seed mix in 2018.

Further rehabilitation of the eastern side of Warkworth in 2017 continues to improve the visual amenity when looking from the east.

7. WATER MANAGEMENT

7.1 WATER BALANCE

7.1.1 Water Management

An adaptive management approach is implemented at MTW to achieve the following objectives for water management:

- Fresh water usage is minimised;
- Impacts on the environment and MTW neighbours are minimised; and
- Interference to mining production is minimal.

This is achieved by:

- Preferentially using mine water for coal preparation and dust suppression where feasible;
- An emphasis on control of water quality and quantity at the source;
- Segregating waters of different quality where practical;
- Recycling on-site water;
- Ongoing maintenance and review of the water management system; and
- Releasing water to the environment in accordance with statutory requirements.

Plans showing the layout of all water management structures and key pipelines are shown in Figure 24The MTW Water Management Plan contains further detail on management practices and is available on the webpage https://insite.yancoal.com.au.

Improvements to water management in 2017 have focused on reducing the risk of unauthorised water releases from site. A diversion channel at the base of the Abbey Green rehabilitation area was constructed in 2017. Revegetation of the construction area for the diversion channel is in progress. Other works completed in 2017 include construction of the Dam 48N, and SSD-05 dam to contain runoff from disturbance areas as mining progresses west in Warkworth Pit. MTW gained operational control of Dam 10S sediment dam (Ramp 22 Dam) following its construction by Bulga mine and the relinquishment of its "Dam Mining Sublease" (sublease part of CL 219). MTW is now responsible for ongoing management of the dam as rehabilitation works progress along the common boundary shared with Bulga mine. Dam 10S receives rehabilitation runoff from both Bulga and MTW mine.

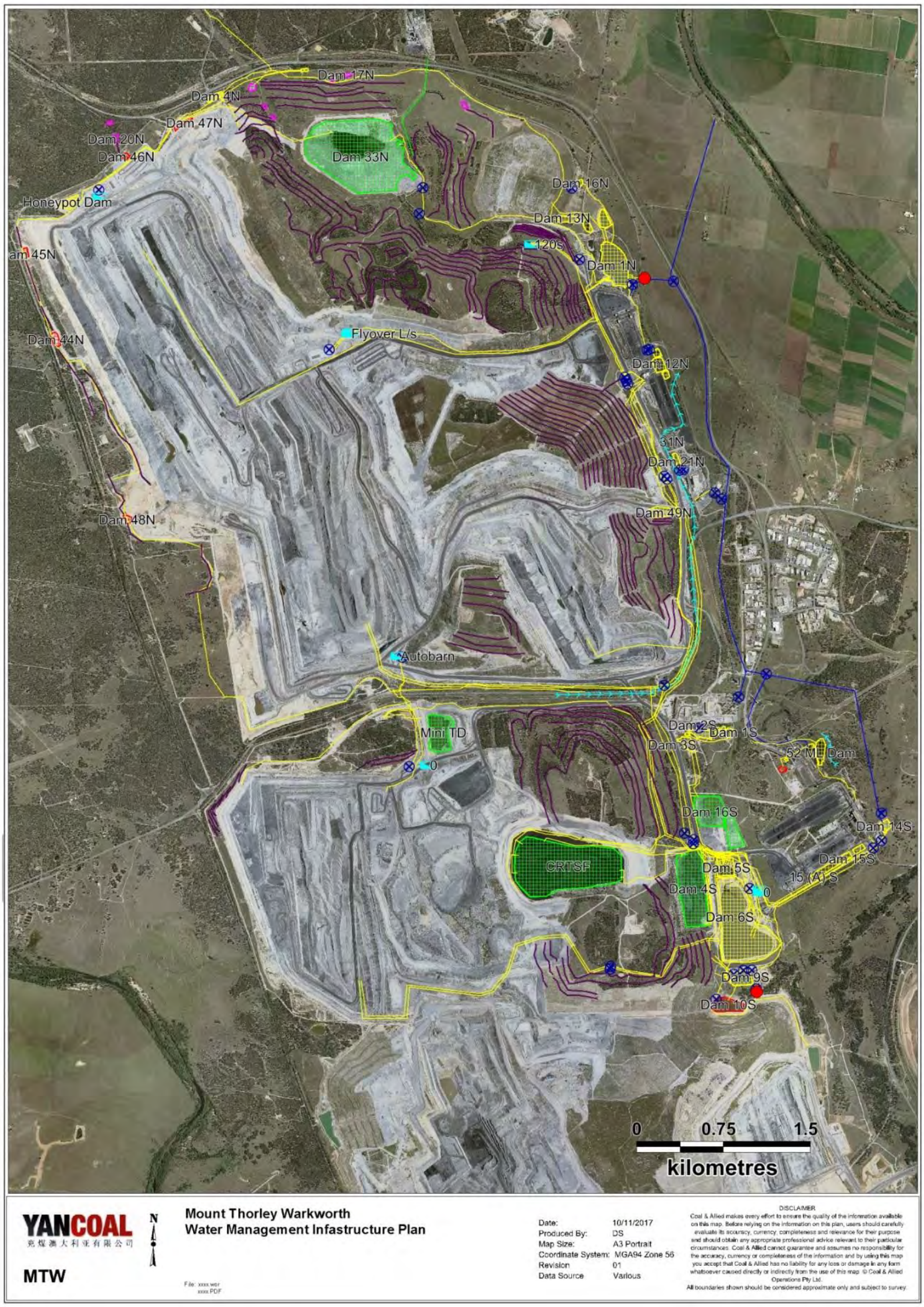

FIGURE 24: WATER MANAGEMENT INFRASTRUCTURE PLAN

7.2 WATER PERFORMANCE

7.2.1 Water Balance

MTW uses a water balance to record and assess water flux, but also to forecast and plan water management needs. These annual site water balances are then compared to previous results. A 2017 static water balance for MTW is presented in Table 26 and a simplified schematic of this balance is included Figure 25. A salt flux schematic is shown in Figure 26.

TABLE 26: STATIC MODEL RESULTS, ANNUAL WATER BALANCE

Water Stream	Volume (ML) (% Total)
Inputs	
Rainfall Runoff	3, 368 (39%)
Hunter River (MTJV supply scheme)	1,790 (21%)
Potable (Singleton Shire Council / trucked)	18 (<1%)
Groundwater	517 (6%)
Recycled to CHPP from tailings (not included in total)	4,097
Imported (LUG bore)	1,533 (18%)
Imported (Hunter Valley Operations)	300 (4%)
Water from ROM Coal	1,044 (12%)
Total Inputs	**8,570**
Outputs	
Dust Suppression	3,131 (40%)
Evaporation – mine water dams	987 (13%)
Entrained in process waste	1,876 (24%)
Discharged (HRSTS)	0 (0%)
Water in coarse reject	704 (9%)
Water in product coal	1,028 (13%)
Miscellaneous use (wash-down etc.)	110 (1%)
Total Outputs	**7,836**
Change in storage (increased)	**733**

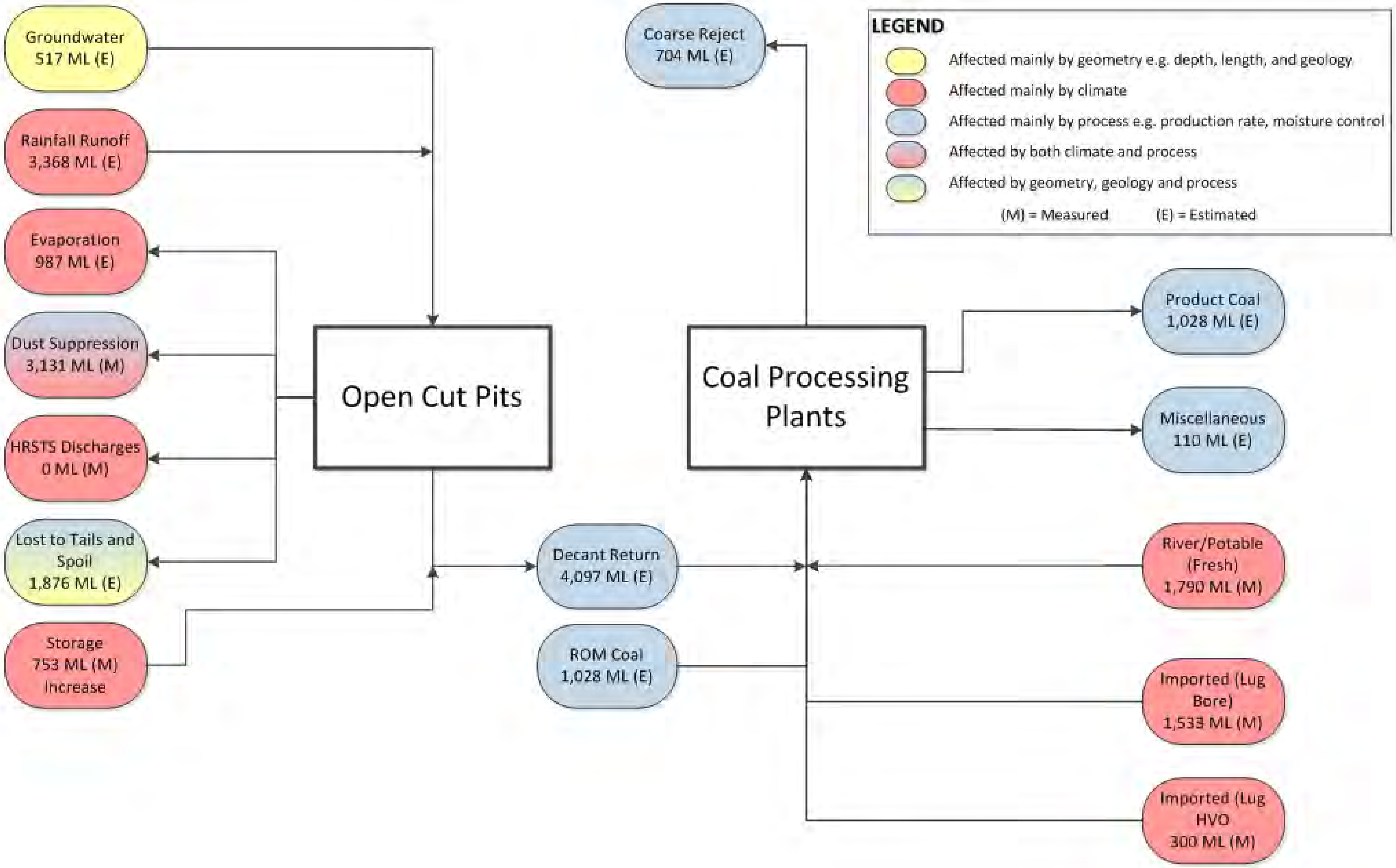

Figure 25: Schematic Diagram MTW Water Flux

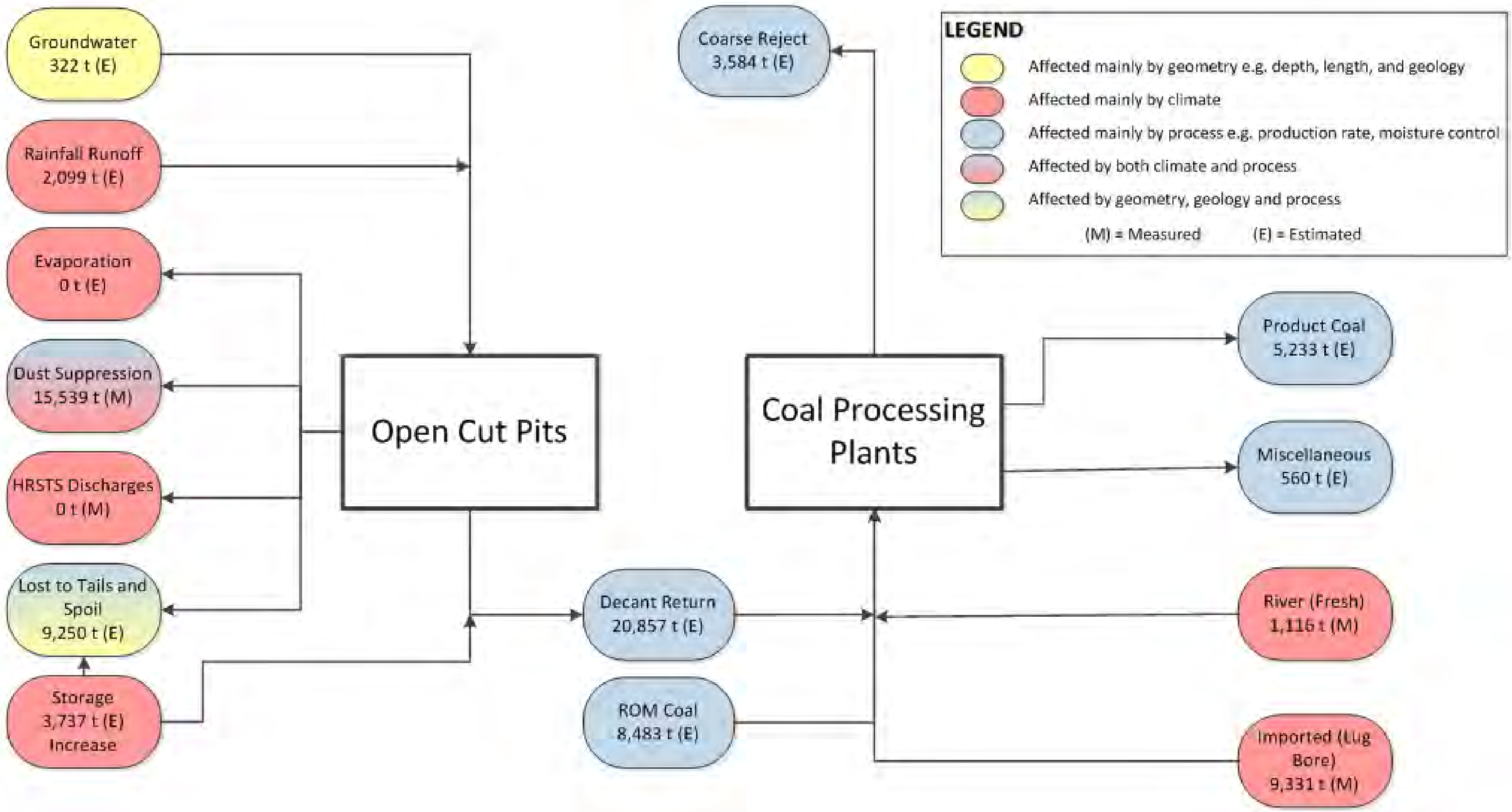

Figure 26: Schematic Diagram MTW Salt Flux

7.2.2 Water Inputs

A total of 444.4 mm of rainfall was recorded at MTW in 2017 producing a calculated 3,368 ML of runoff from developed, disturbed and mining catchments. Water falling on clean water catchments is diverted off site into natural systems where possible. Rainfall runoff was the largest input to the site mine water balance in 2017, however it is significantly less than the runoff captured in the 2016 reporting period (5,028 ML). where the site recorded an annual rainfall depth of 664.2 mm.

As the site water inventory is drawn down, water is imported to meet site demand. During the reporting period 1533 ML was imported from the LUG bore and another 300ML was imported from the Hunter Valley Operations Mine via the inter-site transfer pipeline. The site experienced a significant increase to imported water compared to the 2016 reporting period where the total imported water was 339 ML via the LUG bore.

MTW is able to source water from the Hunter River via the Mount Thorley Joint Venture (MTJV) water supply scheme. Singleton Shire Council holds the high security water licence on behalf of the scheme members. Singleton Shire Council maintains and operates the scheme to supply raw water to MTW, Glencore's Bulga-Beltana complex, and to meet Council's own needs. MTW's share of the MTJV allocation is 1,012 ML per financial year. During the reporting period an additional 1000 ML of high security water licenses were secured by MTW and were transferred to the MTJV license to further supplement the operations water supply. A total of 1790 ML of water was abstracted from the Hunter River during the reporting period.

Abstraction of water from the Hunter River in 2017 increased by 1,383 ML compared to 2016. The increase in abstraction can be attributed to a lack of local rainfall, with many rain events not overcoming the surface saturation threshold to generate runoff to replenish the site's water inventory. Lack of local rainfall is also the underlying cause of the increased volume of imported water from the LUG bore and neighbouring mines when comparing to the 2016 reporting period. A summary of water take by source is listed in Table 9.

Groundwater Licences under Part 5 of the *Water Act 1912* are held for each mining excavation area, to account for passive take via seepage inflows. Water Licences held by MTW are detailed in Table 8 and Table 9.

Licence conditions require the volume and quality of water taken by the works to be measured and reported on an annual basis. Groundwater inflows via pit wall seepage are at low rates, with a significant proportion evaporating at the coal face. The remainder reports to the pit floor, where it may accumulate along with direct rainfall, rainfall runoff and leakage from spoils. As a result it is not possible to physically measure the volume of water taken by these groundwater licences, nor the quality of waters extracted via seepage to the pits. In line with the Statement of Commitments listed in the 2014 Warkworth Continuation Environmental Impact Statement, a formal annual review of depressurisation of coal measures and alluvium is currently being undertaken.

7.2.3 Water Outputs

Significant water uses at MTW in 2017 were for dust suppression on haul roads, mining areas and coal stockpiles (3,131ML), evaporation from Dams (987ML) and water entrained in Process Waste (1,876ML). Water usage for dust suppression on haul roads slightly increased compared to the 2016 reporting period which can likely be attributed to drier conditions experienced in the current reporting period.

MTW participates in the Hunter River Salinity Trading Scheme (HRSTS) allowing it to discharge from licensed discharge points during declared discharge events associated with increased flow in the Hunter River. HRSTS discharges are undertaken in accordance with HRSTS regulations, EPL 1376 and EPL 1976. MTW maintains two licensed HRSTS discharge monitoring locations:

- Dam 1N, located at WML North, which discharges to Doctor's Creek
- Dam 9S, located at MTO South, which discharges to Loders Creek.

During the reporting period MTW did not discharge under the HRSTS.

7.3 SURFACE WATER

7.3.1 Water Management

Surface water monitoring activities continued in 2017 in accordance with the MTW Water Management Plan and MTW Surface Water Monitoring Programme. MTW maintains a network of surface water monitoring sites located at selected site dams and surrounding natural watercourses as shown in Figure 27.Water quality monitoring is undertaken to verify the effectiveness of the water management system onsite, and to identify the emergence of potentially adverse effects on surrounding watercourses. Primary water storage dams are monitored routinely to verify the quality of mine water, used in coal processing, dust suppression, and other day to day activities around the mine.

Surface water monitoring data review involves a comparison of measured pH, EC and TSS results against internal trigger values which have been derived from the historical data set. The response to measured excursions outside the trigger limits is detailed in the MTW Water Management Plan.

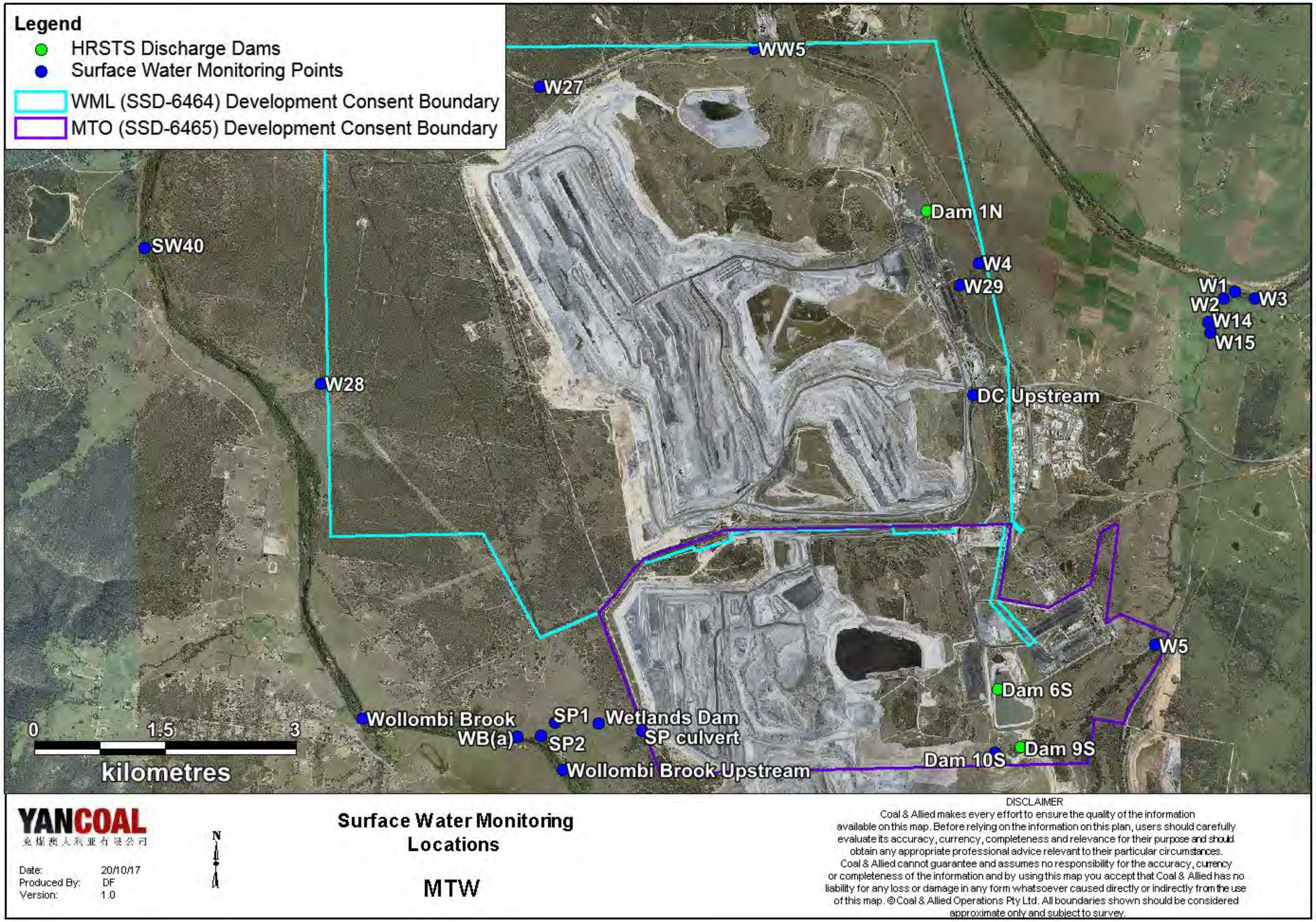

FIGURE 27: SURFACE WATER MONITORING POINTS

7.3.2 Surface Water Monitoring

Routine surface water monitoring was undertaken from 21 sites. Sampling of surface waters was carried out in accordance with AS/NZS 5667.6 (1998). Analysis of surface water was carried out in accordance with approved methods by a NATA accredited laboratory.

Water quality is evaluated through the assessment of pH, Electrical Conductivity (EC) and Total Suspended Solids (TSS). All surface water sites were also sampled for comprehensive analysis annually. The sampling frequency for ephemeral water sites was modified in 2016, from quarterly to a rain-event trigger system, in an effort to ensure samples taken were more representative of typical water quality for those streams (up to eight sampling events per annum can now be taken under the revised sampling protocol). Due to dry conditions during the reporting period fewer sampling runs were completed than in 2016 (two instead of four), however there was a marked improvement in data recovery as sites were not recorded as dry during the monitoring event. All required sampling and analysis was undertaken, except as detailed in Table 27. Trigger tracking results are described in Table 28.

TABLE 27: MTW WATER MONITORING DATA RECOVERY FOR 2017 (BY EXCEPTION)

Location	Data Recovery (%)	Comment
W28	50%	No safe access to site in January
WW5	50%	Site recorded as dry in March and December

A summary of all surface water monitoring results is provided in the MTW Monthly Environmental Monitoring Reports, and can be viewed via the Yancoal Australia website.

Figure 28 to Figure 33 show long term water quality trends for the Hunter River, Wollombi Brook, other surrounding tributaries and site dams. Measurements of EC and pH were generally stable during the reporting period and consistent with historical seasonal trends. Electrical conductivity shows an increasing trend during 2017 in site Dams 6S and 9S; drier weather conditions resulted in evapo-concentration of salts in mine water, combined with reduced fresh-water inputs from rainfall runoff.

A number of TSS trigger limits were exceeded in January, June and September, following significant runoff associated with rainfall events; these are outlined below in Table 28. Trigger tracking results are provided where three consecutive measurements of EC or pH are recorded; there were no instances of repeated exceedances of these measures during the reporting period. These are provided in the Monthly reports given on the Yancoal Australia website (https://insite.yancoal.com.au/).

TABLE 28: SURFACE WATER MONITORING - TRIGGER TRACKING RESULTS

Location	Date	Trigger Limit	Action taken in response
W5	15/08/2017 13/09/2017 08/12/2017	EC –95th Percentile	Watching Brief* Watching Brief* Dry weather conditions and lack of surface flow in preceding months likely to have resulted in elevated EC reading, unlikely to be anthropogenic impact. Continue to watch and monitor.
W1	28/03/2017 08/06/2017	EC –5th Percentile	Watching Brief* Watching Brief*
W1	13/09/2017	pH –95th Percentile	Natural Variability, watching brief
W2	28/03/2017	pH –5th Percentile	Watching Brief*
W3	13/09/2017	pH –95th Percentile	Watching Brief*
W4	31/03/2017	pH –5th Percentile	Watching Brief*
W5	28/03/2017 10/04/2017 11/05/2017 08/06/2017 10/07/2017 08/12/2017	pH –5th Percentile	Watching Brief* Watching Brief* Watching Brief* Low flow conditions in Loders Creek; pH low but within historical range. Continue to watch and monitor. Site observations concluded no mining related impact, results within natural variability. Continue to watch and monitor. Watching Brief*
W15	31/03/2017	pH –5th Percentile	Watching Brief*
W27	31/03/2017	pH –5th Percentile	Watching Brief*
W28	31/03/2017	pH –5th Percentile	Watching Brief*
Wollombi Brook	28/03/2017	pH –5th Percentile	Watching Brief* Watching Brief*

	10/04/2017		
Wollombi Brook Upstream	28/03/2017 10/04/2017 11/05/2017	**pH –5th Percentile**	Watching Brief* Watching Brief* Low flow conditions in Wollombi Brook; pH low but within historical range. Continue to watch and monitor.
W4	31/03/2017	**TSS – 50mg/L (ANZECC criteria)**	Field investigation did not identify any mining-related sources of sediment. Elevated TSS associated with high-intensity rainfall event. No further action.
W14	31/03/2017	**TSS – 50mg/L (ANZECC criteria)**	Field investigation did not identify any mining-related sources of sediment. Elevated TSS associated with high-intensity rainfall event. No further action.
W15	31/03/2017	**TSS – 50mg/L (ANZECC criteria)**	Investigation did not identify any mining-related sources of sediment. Elevated TSS associated with high-intensity rainfall event. No further action.
W27	31/03/2017	**TSS – 50mg/L (ANZECC criteria)**	Investigation did not identify any mining-related sources of sediment. Elevated TSS associated with high-intensity rainfall event; data consistent with historical range. No further action.
W28	31/03/2017	**TSS – 50mg/L (ANZECC criteria)**	Investigation did not identify any mining-related sources of sediment. Elevated TSS associated with high-intensity rainfall event; data consistent with historical range. No further action.
W29	31/03/2017	**TSS – 50mg/L (ANZECC criteria)**	Field investigation did not identify any mining-related sources of sediment. Elevated TSS associated with high-intensity rainfall event. No further action7.

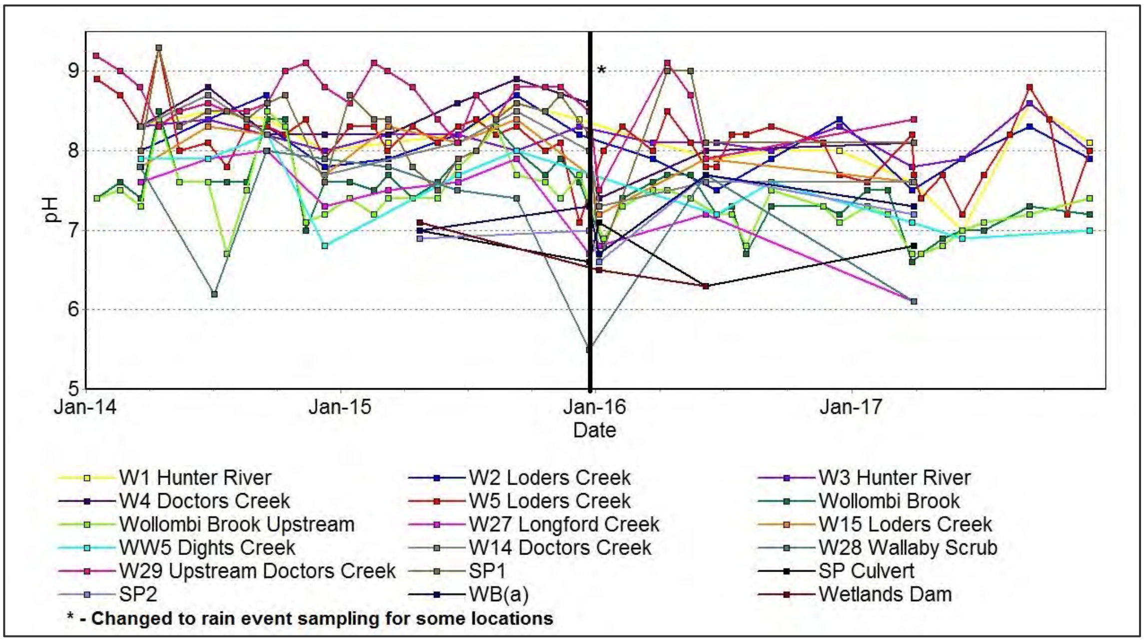

FIGURE 28: WATERCOURSE pH TRENDS 2014 TO 2017

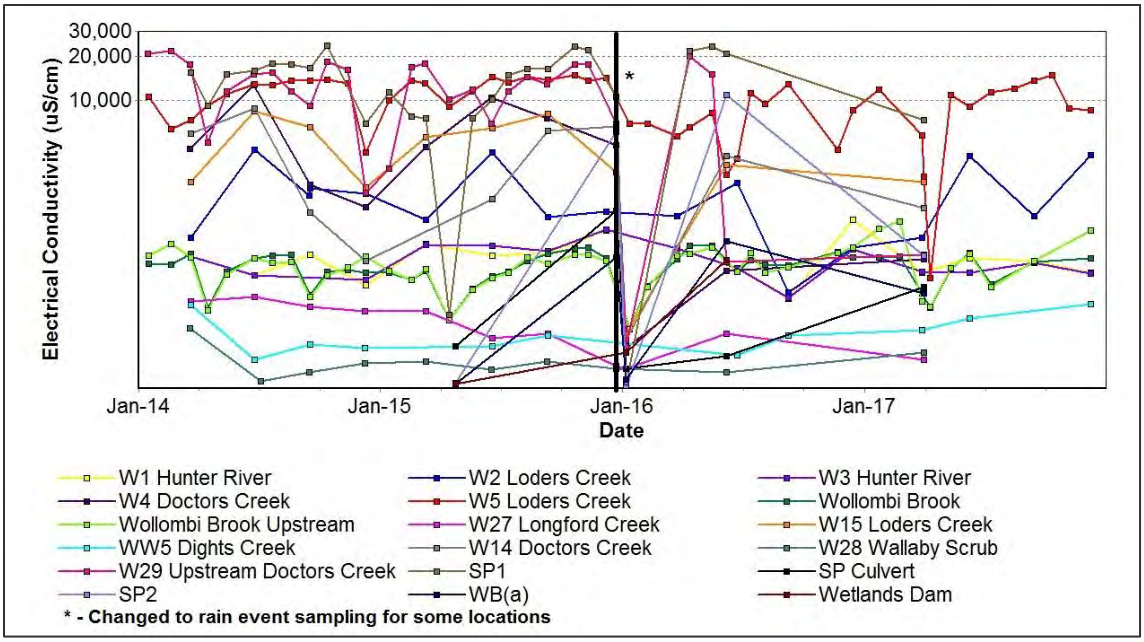

FIGURE 29: WATERCOURSE EC TRENDS 2014 TO 2017

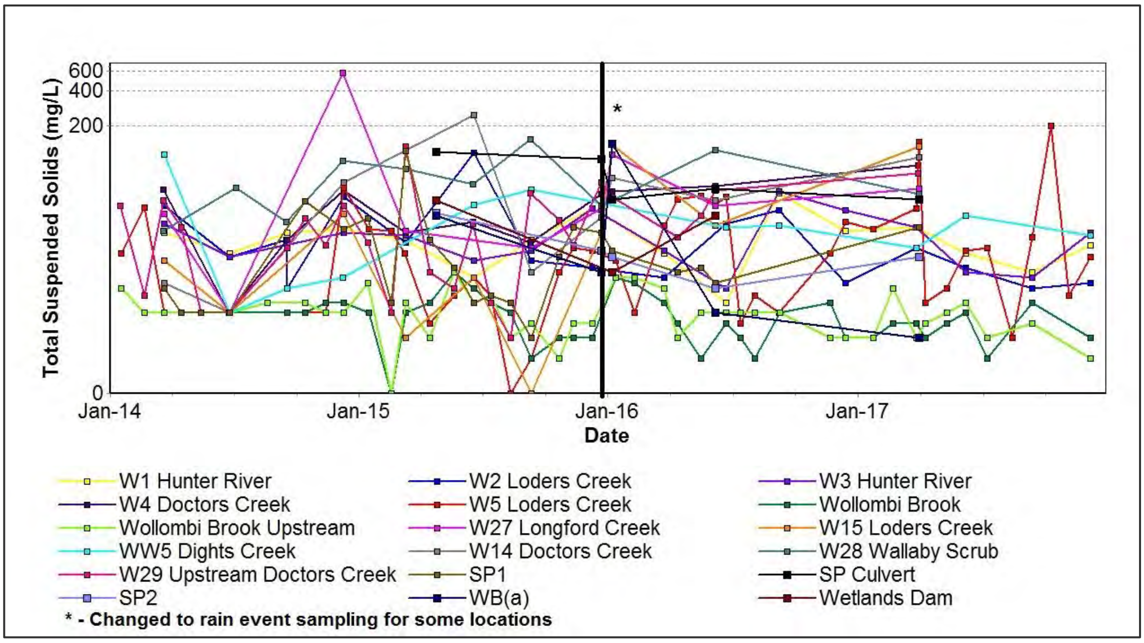

FIGURE 30: WATERCOURSE TSS TRENDS 2014 TO 2017

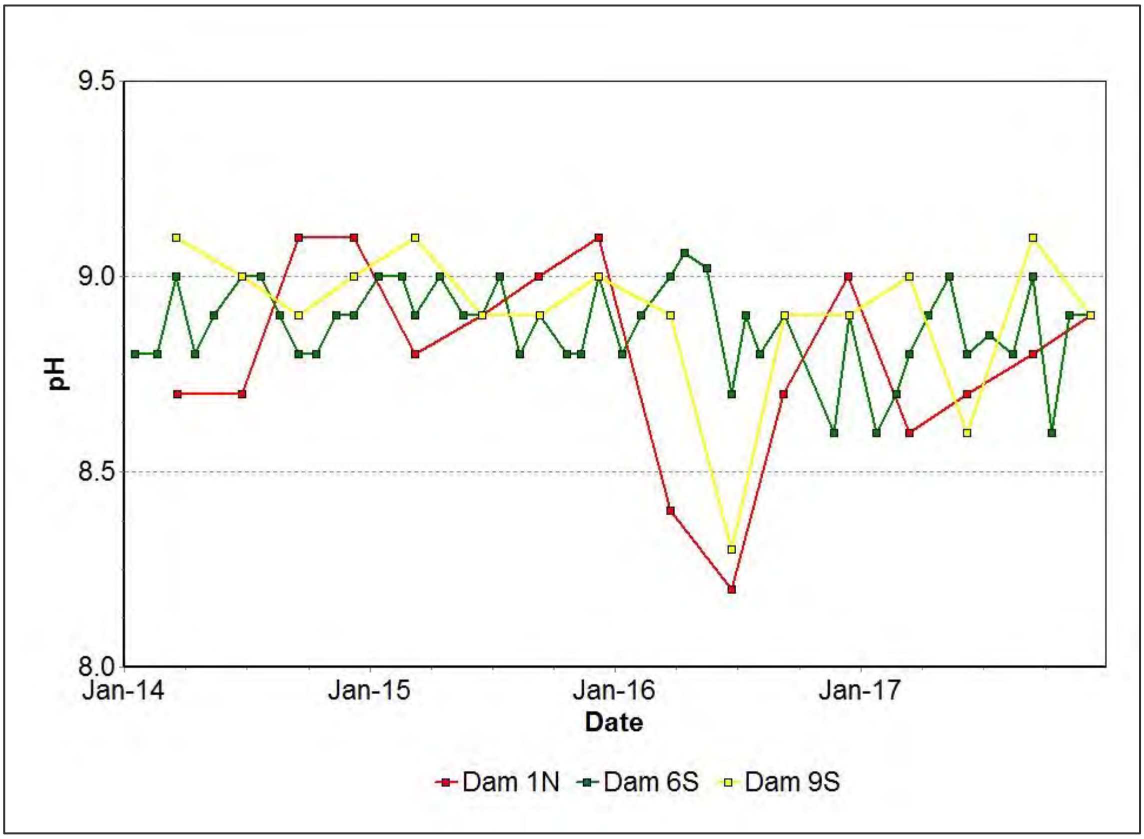

FIGURE 31: SITE DAMS PH TRENDS 2014 TO 2017

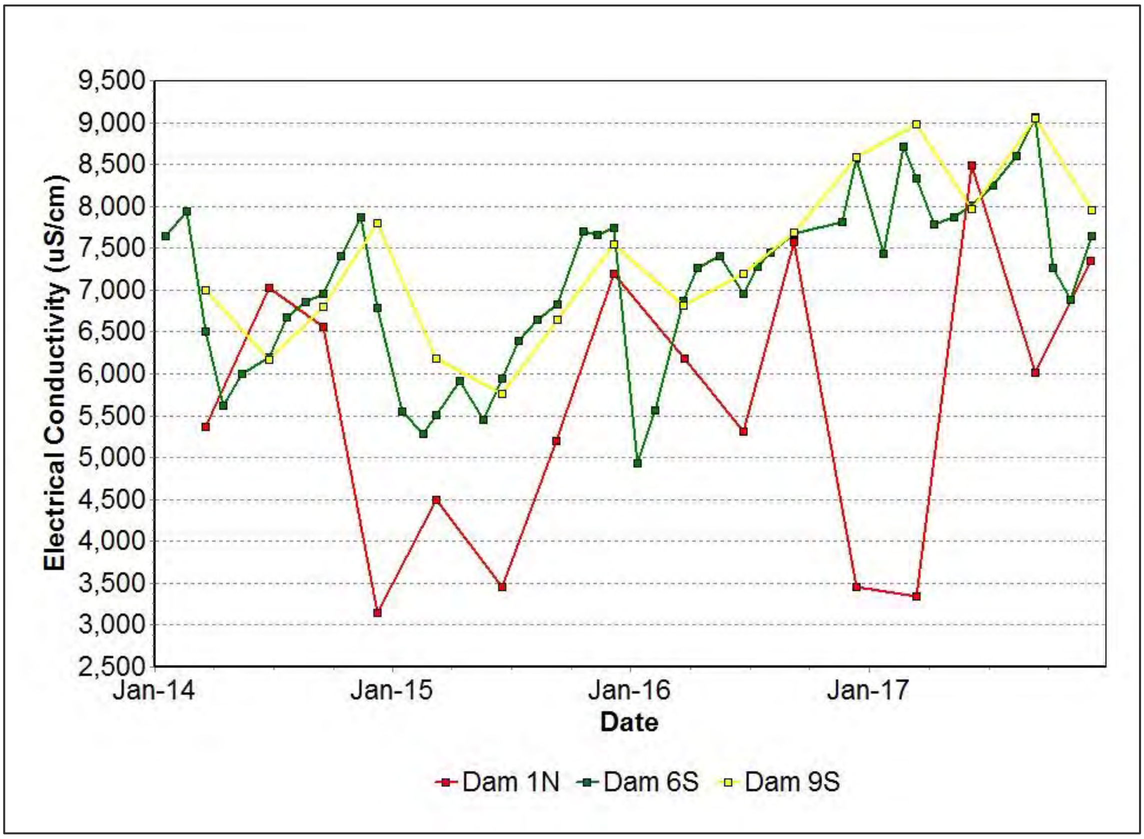

FIGURE 32: SITE DAMS EC TRENDS 2014 TO 2017

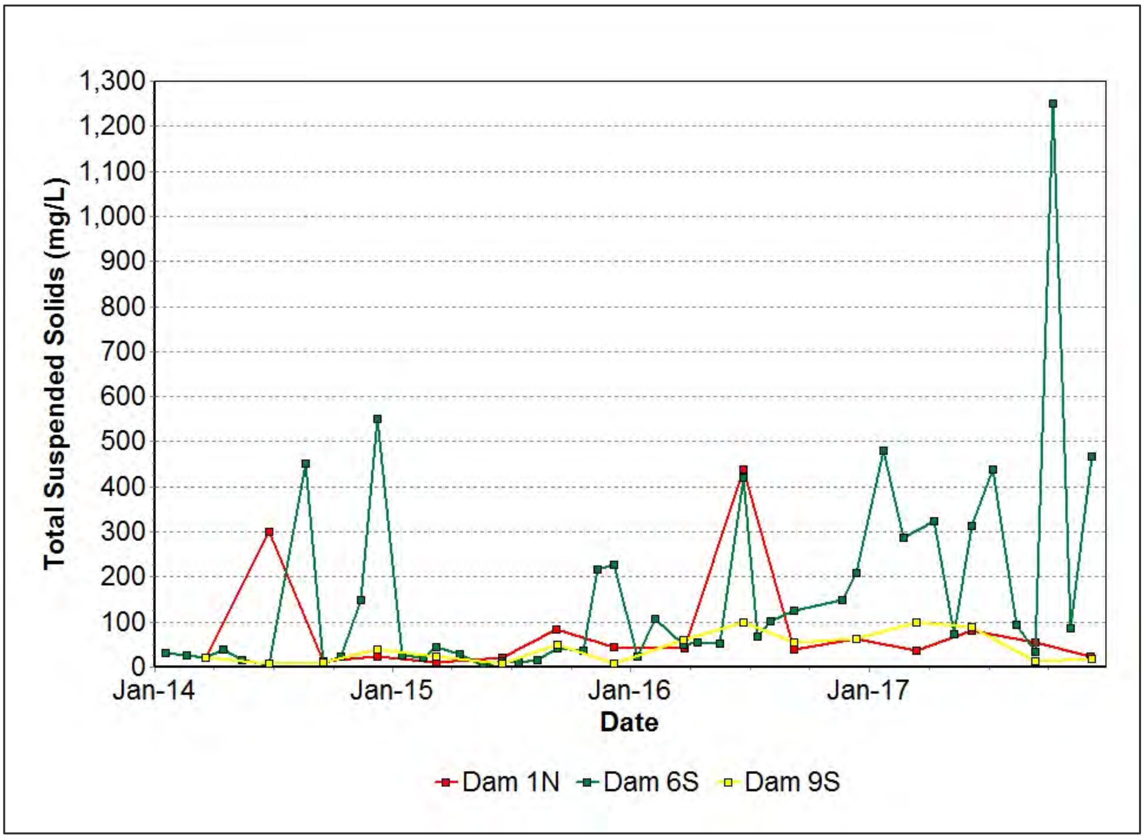

FIGURE 33: SITE DAMS TSS TRENDS 2014 TO 2017

7.3.3 Stream Health and Channel Stability

A programme to monitor and report on the stream and riparian vegetation health in Loders Creek and Wollombi Brook potentially affected by the development commenced in 2016, with baseline surveys completed.

Monitoring includes the following:

- Documenting locations and dimensions of significant erosive or depositional features;
- Photographs upstream, downstream, at both the left and right banks;
- Rating the site with the Ephemeral Stream Assessment protocol developed by the CSIRO to assess the erosional state of the creek at the monitoring location (a measure of channel stability);
- Rating the site with the Rapid Appraisal of Riparian Condition protocol developed by Land & Water Australia. This assesses the ecological condition of riparian habitats using indicators that reflect functional aspects of the physical, community and landscape features of the riparian zone (a measure of stream health); and
- Taking measurements of the channel cross-sections (transects) for comparison purposes for any future monitoring.

Stream health and channel stability monitoring results in 2017 indicated that channel stability in Loders Creek and Wollombi Brook had improved slightly whilst the health of riparian vegetation had slightly declined due to minor changes to habitat features such as leaf litter accumulations etc. The recommendations from the monitoring report suggested continuing the monitoring program on an annual basis and where possible utilising a risk based approach to installation of mitigation measures.

7.3.4 Audits and Reviews

An independent environmental audit of the Mount Thorley Operations and Warkworth Mining Operations was undertaken in May 2017. One non-compliance and one recommendation in relation to surface water management at MTW was identified in the 2017 audit.

The non-compliance was in relation to uncontrolled discharge of sediment water from site on 6th January 2016. A regulatory investigation into unauthorised release of water from a failure in a dam wall located at MTW on 6th January 2016 was also concluded in the Land and Environment Court during the 2017 reporting period. MTW was ordered to pay a penalty of $50,000 plus investigation costs for the breach of license conditions. Resulting actions in response to the incident indicated no further action necessary to satisfy the finding.

A recommendation was also given to MTW to review the Wollombi Brook Probable Maximum Flood (PMF) RL at the Charlton levee and ensure there is 500mm of freeboard (from PMF to levee top RL) to satisfy of the consents (SSD-6465 and SSD-6464) outlined in Schedule 3, Condition 27 (b).

7.4 GROUNDWATER

7.4.1 Groundwater Management

Groundwater monitoring activities were undertaken in 2017 in accordance with the MTW Water Management Plan and groundwater monitoring programme. The monitoring results are used to establish and monitor trends in physical and geochemical parameters of surrounding groundwater potentially influenced by mining.

The groundwater monitoring programme at MTW measures the quality of groundwater against background data, EIS predictions and historical trends. Ground water quality is evaluated through the parameters of pH, EC, and standing water level. A comprehensive suite of analytes are measured on an annual basis, including major anions, cations and metals. Prior to sampling for comprehensive analysis, bore purging is undertaken to ensure a representative sample is collected.

Groundwater monitoring data is reviewed on a quarterly basis. The review involves a comparison of measured pH and EC results against internal trigger values (5th and 95th percentile) which have been derived from the historical data set. The response to measured excursions outside the trigger limits is detailed in the MTW Water Management Plan.

The monitoring locations are shown in Figure 34, and the annual Ground Water Impacts Review can be found in Appendix 5.

FIGURE 34: GROUNDWATER MONITORING NETWORK AT MTW IN 2017

7.4.2 Groundwater Performance

Sampling of ground waters was carried out on 142 occasions from 39 bores across Mount Thorley Warkworth in accordance with AS/NZS 5667.6 (1998). Where laboratory analysis was undertaken, this was performed by a NATA accredited laboratory. Groundwater sampling and analysis was undertaken as required with the following exceptions detailed in Table 29.

TABLE 29: MTW WATER MONITORING DATA RECOVERY FOR 2017 (BY EXCEPTION)

Location	Data Recovery (%)	Comment
OH 944	0%	Insufficient water for sampling throughout 2017.
OH1122 (1)	75%	Standpipe damaged and subsequently repaired
G3	50%	Removed from Monitoring Programme
MB15MTW04	0%	Insufficient water for sampling since added to Monitoring Programme in 2017
MB15MTW05	0%	Insufficient water for sampling since added to Monitoring Programme in 2017
MB15MTW07	0%	Insufficient water for sampling since added to Monitoring Programme in 2017
MB15MTW08	0%	Insufficient water for sampling since added to Monitoring Programme in 2017
MB15MTW9	0%	Insufficient water for sampling since added to Monitoring Programme in 2017
MB15MTW10	0%	Insufficient water for sampling since added to Monitoring Programme in 2017
MB15MTW11	0%	Insufficient water for sampling since added to Monitoring Programme in 2017

A summary of the monitoring results for MTW Groundwater Sites is provided in the Monthly Environmental Monitoring Reports, available via the Yancoal Australia website (https://insite.yancoal.com.au).

7.4.3 Groundwater Monitoring Summary

The following section presents groundwater monitoring data in relation to the geographic locations and target stratigraphy for groundwater monitoring bores. Each location is discussed below, and a summary of monitoring data presented. Where monitoring results were recorded outside the internal trigger limit, these results are summarised in tables for each location.

7.4.3.1 Bayswater Seam Bores

Groundwater monitoring in the Bayswater seam was undertaken from seven sites during 2017. A total of 28 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 for Bayswater groundwater bores are shown in Figure 35, Figure 36 and Figure 37 respectively. Trigger tracking results are given in Table 30. Results were generally stable and consistent with historical trends.

TABLE 30: BAYSWATER SEAM GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
GW9709	10/03/2017	**pH – 5th percentile**	Watching Brief *
	11/12/2017		Watching Brief *
GW98MTCL2	10/03/2017	**pH – 5th percentile**	Watching Brief *
	23/07/2017		Watching Brief *
	14/09/2017		Results in line with historical data, continue to watch and monitor.
GW9709	14/09/2017	**EC – 95th percentile**	Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

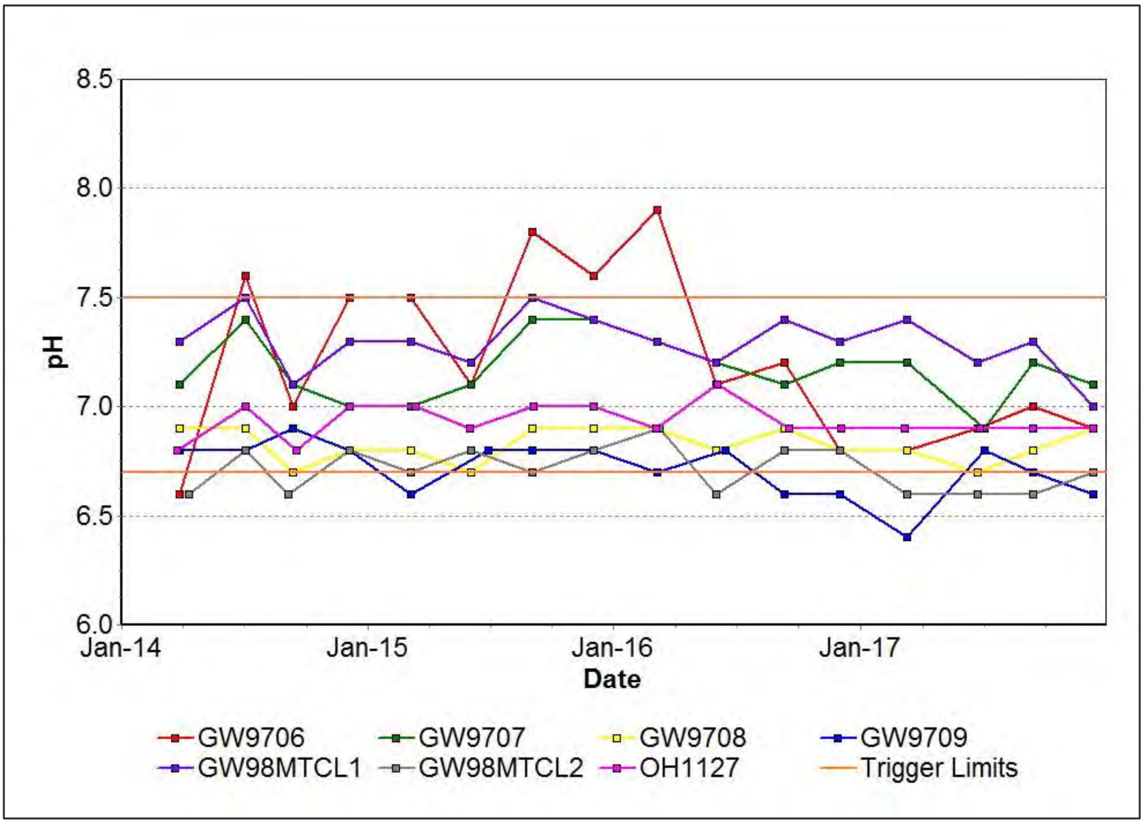

FIGURE 35: BAYSWATER SEAM PH TRENDS 2014TO 2017

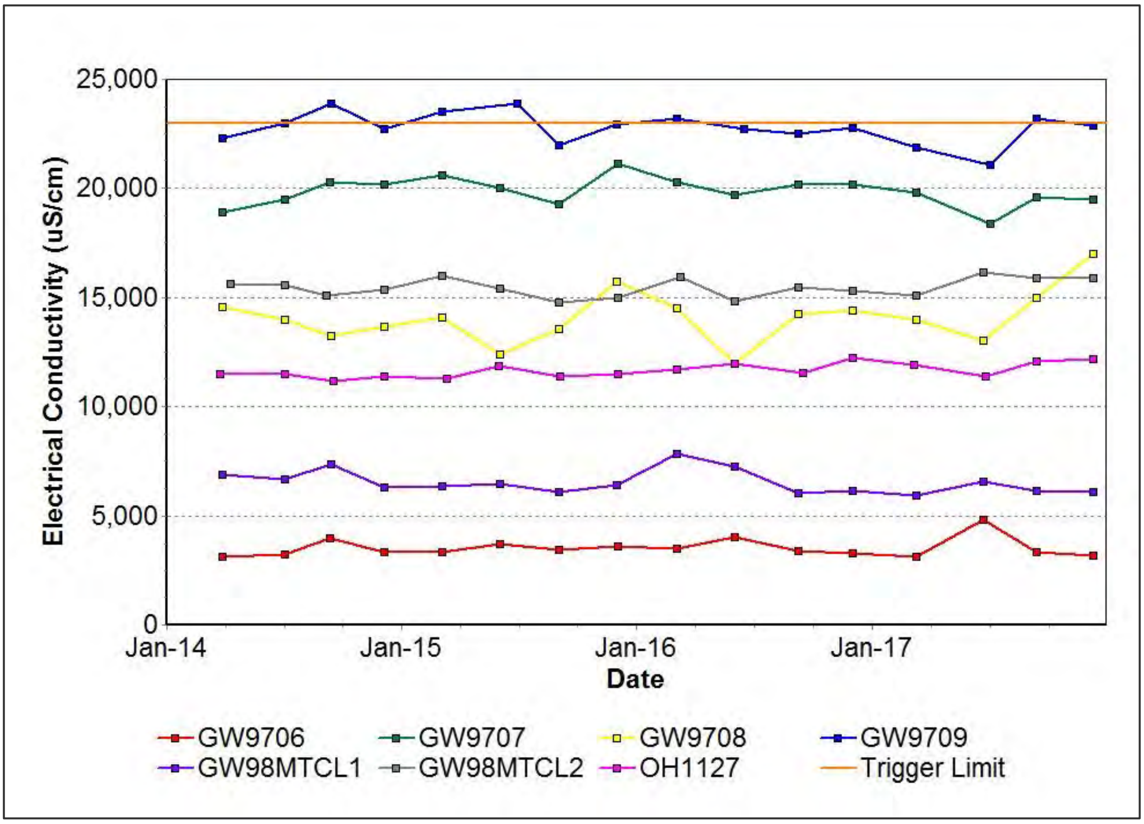

FIGURE 36: BAYSWATER SEAM EC TRENDS 2014 TO 2017

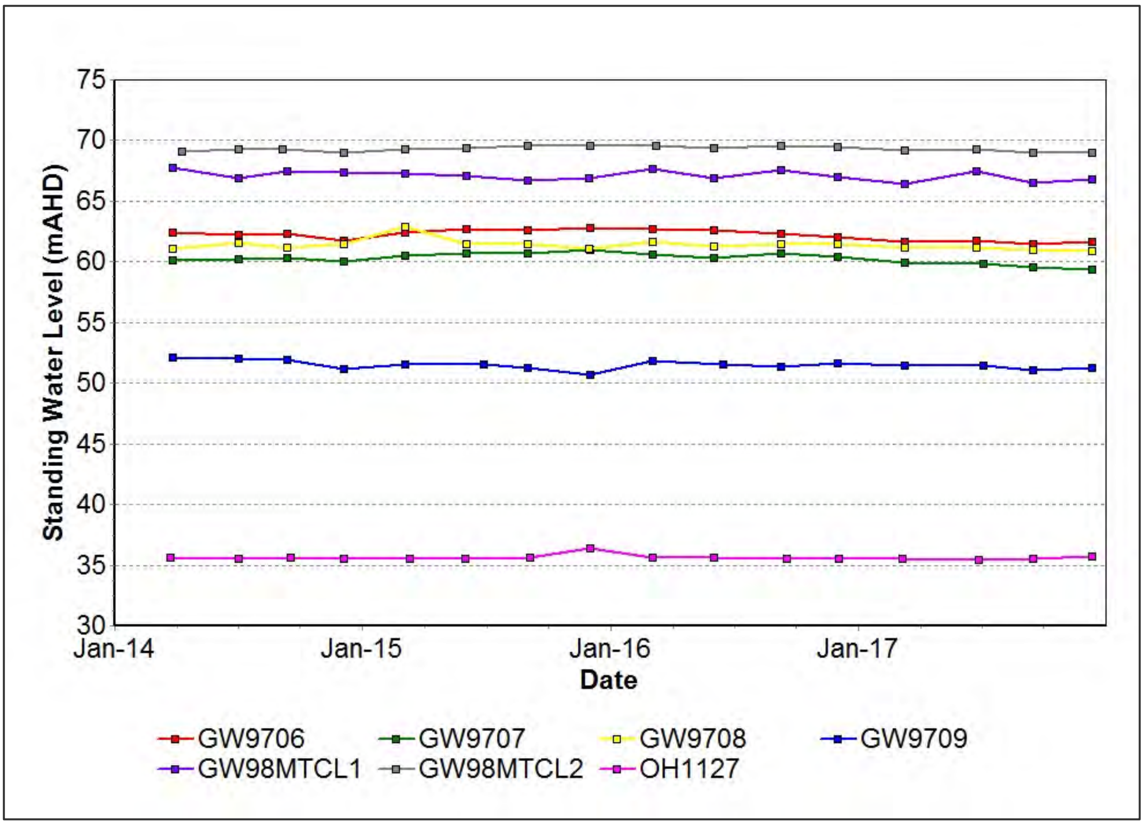

FIGURE 37: BAYSWATER SWL TRENDS 2014 TO 2017

7.4.3.2 Bowfield Seam Bores

Groundwater monitoring in the Bowfield seam was undertaken at one site during 2017. A total of 4 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 38, Figure 39 and Figure 40 respectively. Water quality results were similar to historical data.

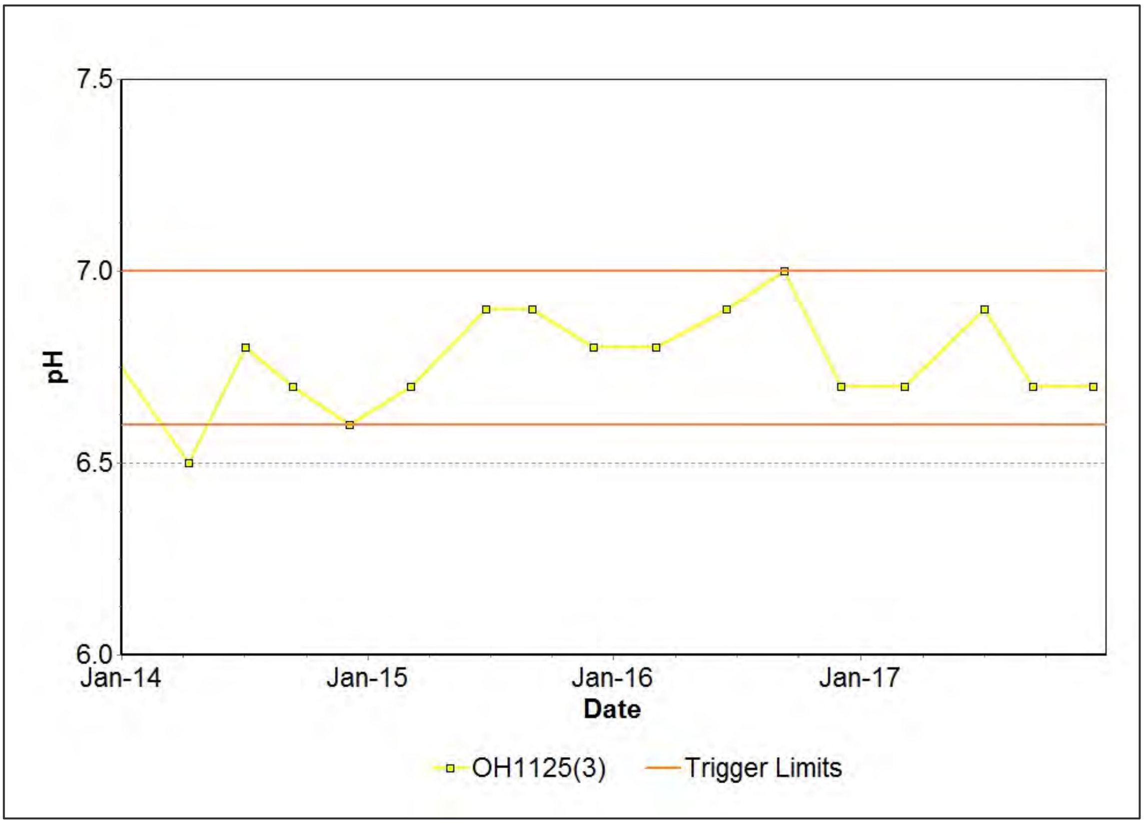

FIGURE 38 : BOWFIELD SEAM pH TREND 2014 TO 2017

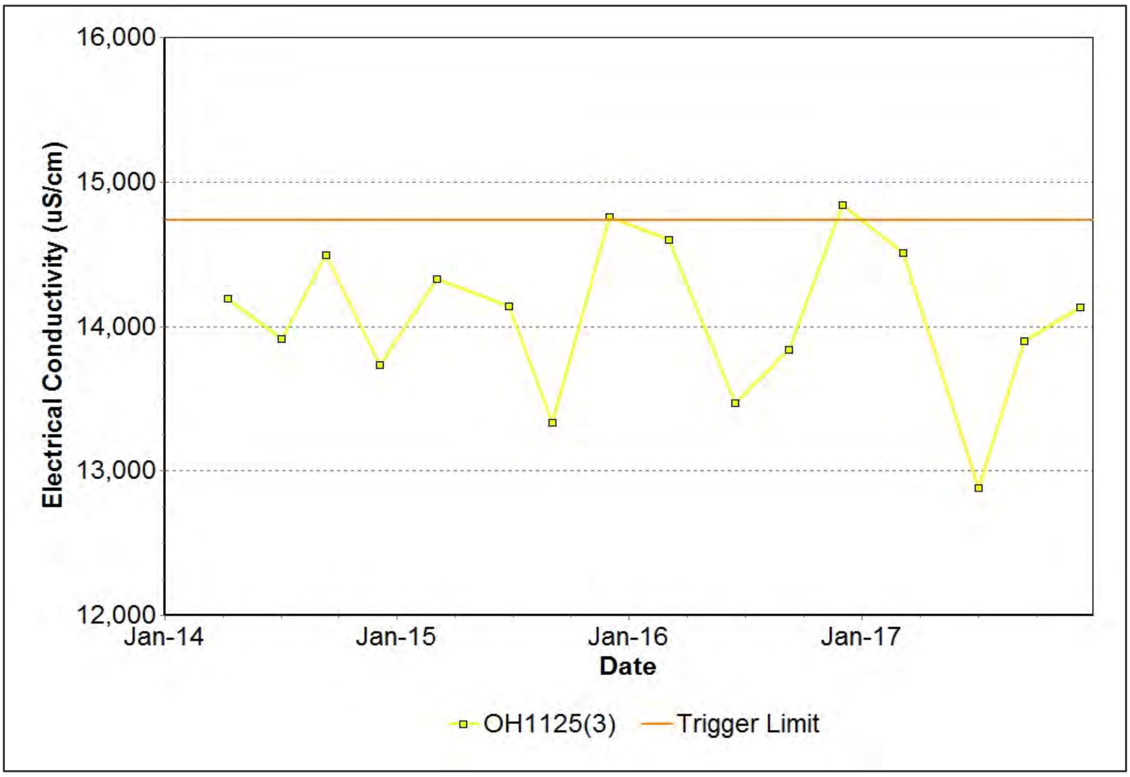

FIGURE 39: BOWFIELD SEAM EC TRENDS 2014 TO 2017

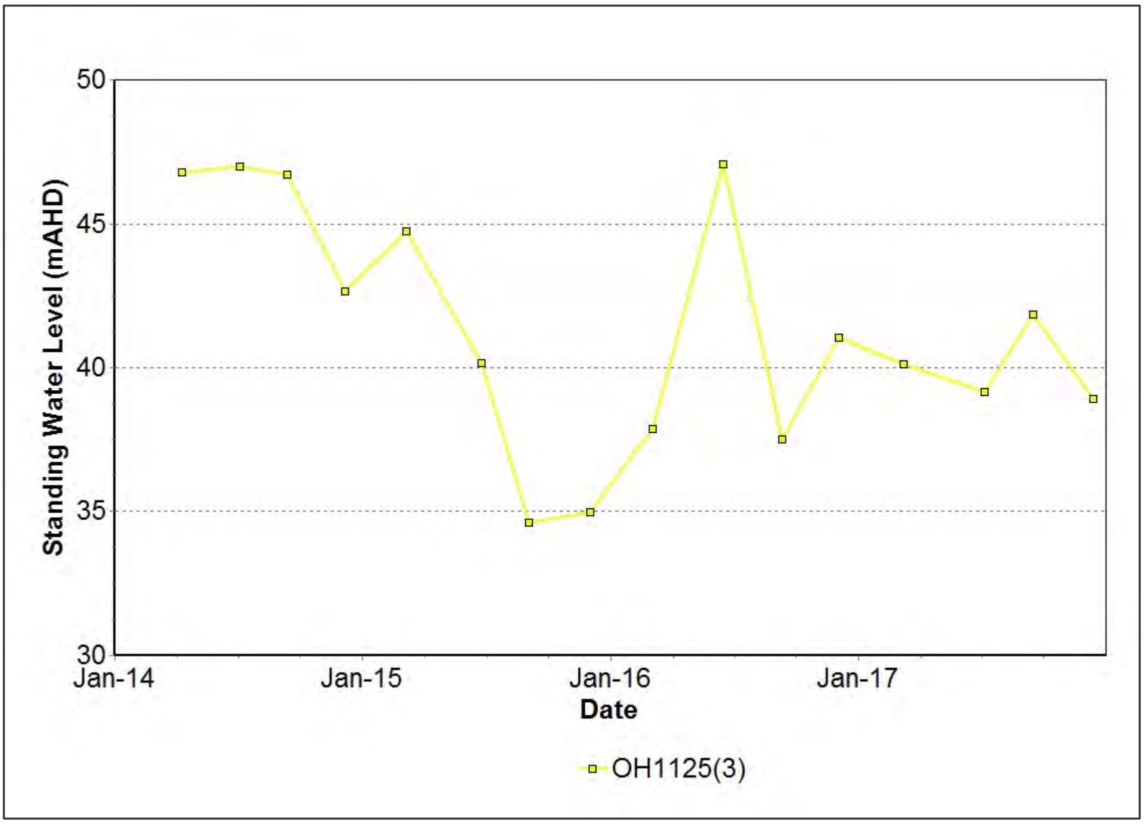

FIGURE 40: BOWFIELD SEAM SWL TREND 2014 TO 2017

7.4.3.3 Blakefield Seam Bores

Groundwater monitoring in the Blakefield seam was undertaken from three sites during 2017. A total of 11 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 41, Figure 42 and Figure 43 respectively. Water quality trends were generally steady, however an increasing pH trend was observed in WOH2139A, likely due to coal seam depressurisation as mining advances West, in the direction of the bore (supported by the water trend). Trigger tracking results are given in Table 31.

TABLE 31: BLAKEFIELD SEAM GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
WOH2139A	25/08/2017	**pH - 95th percentile**	Watching Brief *
	23/11/2017		Watching Brief *
OH1125 (1)	07/03/2017	**EC – 95th percentile**	Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

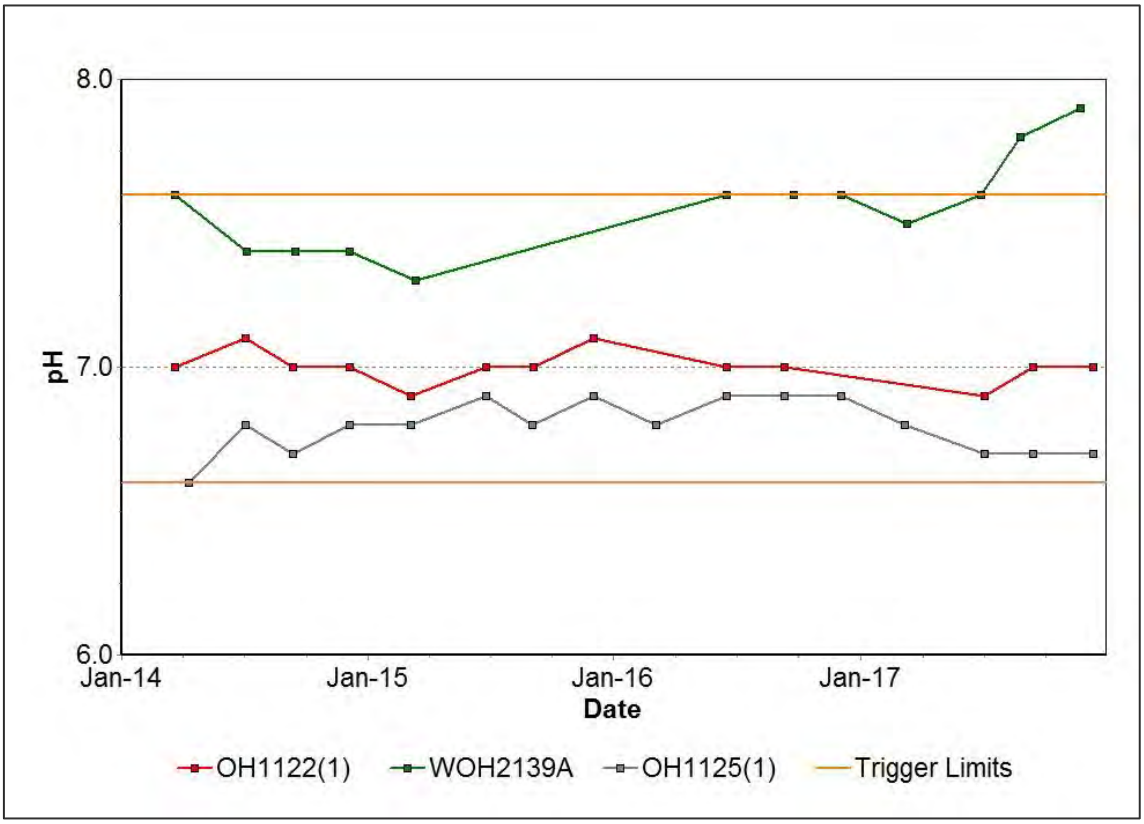

FIGURE 41: BLAKEFIELD SEAM GROUNDWATER PH TRENDS 2014 TO 2017

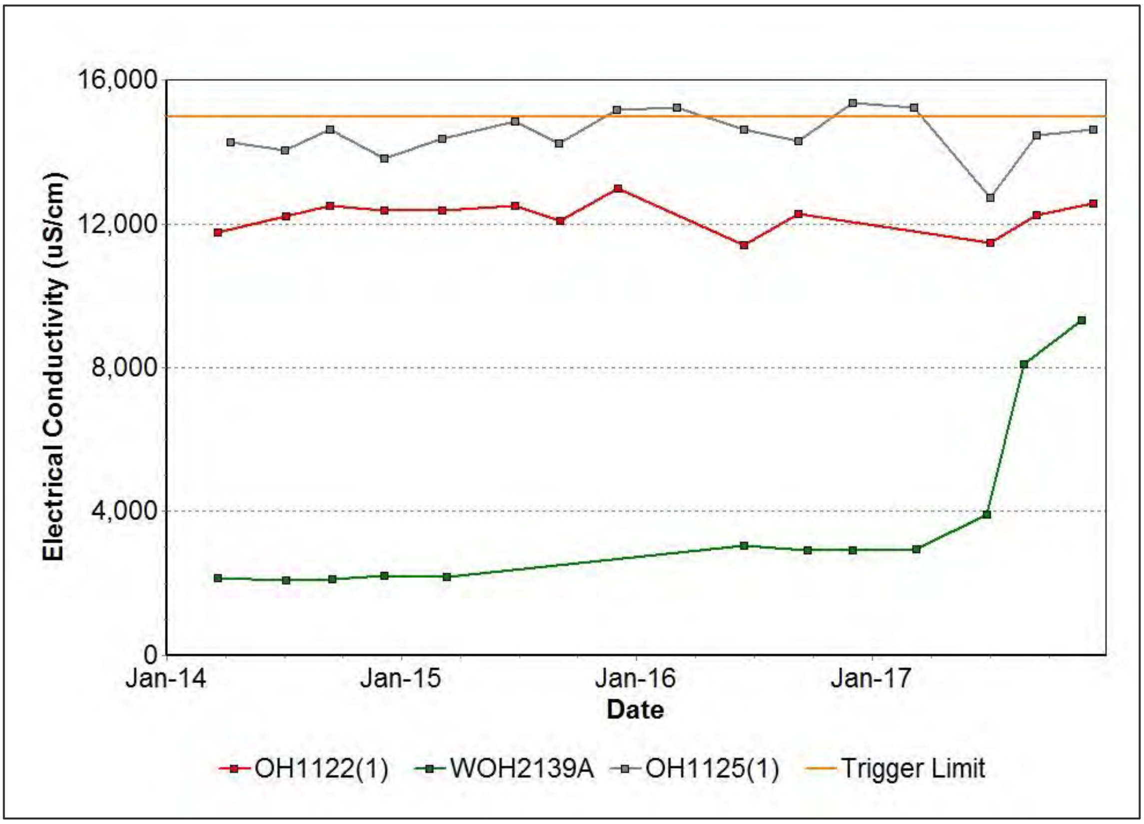

FIGURE 42: BLAKEFIELD SEAM GROUNDWATER EC TRENDS 2014 TO 2017

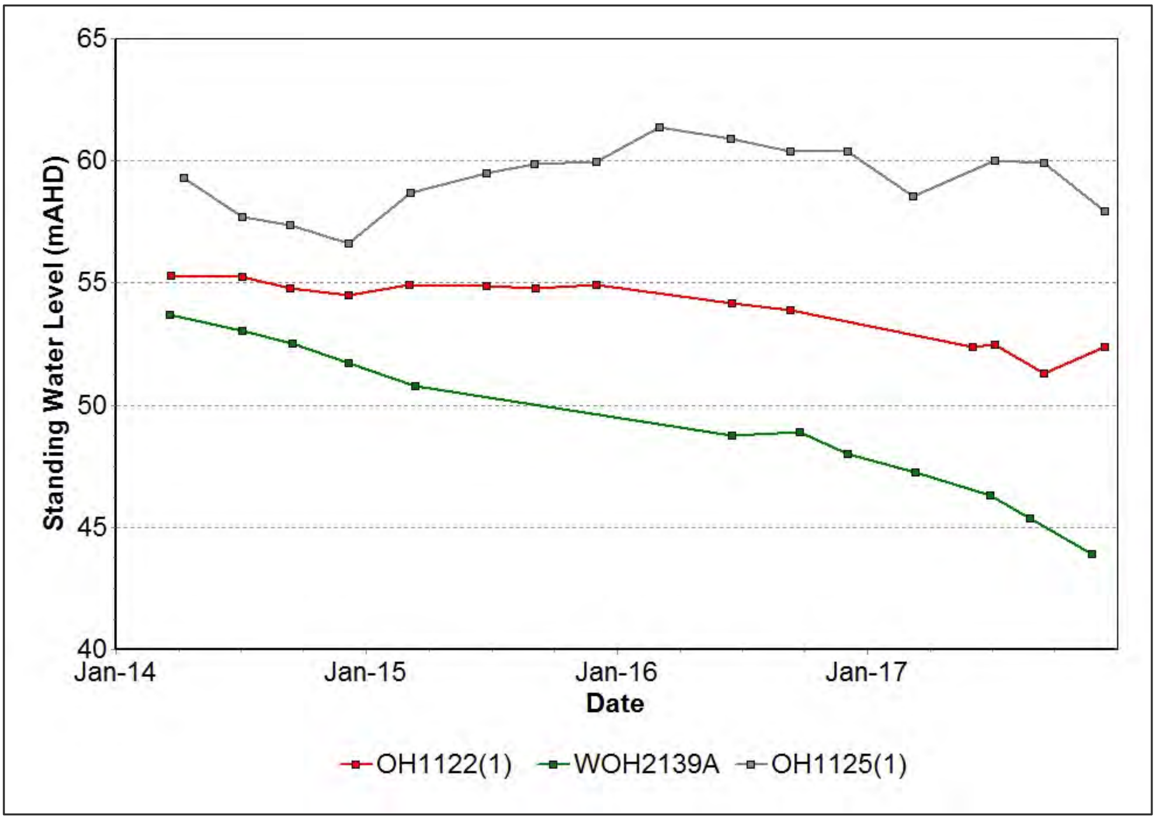

FIGURE 43: BLAKEFIELD SEAM GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.4 Hunter River Alluvium Bores

Groundwater monitoring in the Hunter River Alluvium was undertaken from six sites during 2017. A total of 20 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 for Hunter River Alluvium groundwater bores are shown in Figure 44 to Figure 56. Results were generally stable and consistent with historical trends. Monitoring of trends in these bores will continue.

TABLE 32:HUNTER RIVER ALLUVIUM GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
OH786	07/03/2017 11/12/2017	**pH - 5th percentile**	Watching Brief * Watching Brief *
OH786	14/09/2017	**EC – 95th percentile**	Watching Brief *
OH787	/03/2017	**pH – 5th percentile**	Watching Brief *
OH787	07/03/2017 14/09/2017 11/12/2017	**EC – 95th percentile**	Watching Brief * Watching Brief * Watching Brief *
OH942	07/03/2017 14/09/2017 11/12/2017	**EC 95th percentile**	Watching Brief * Watching Brief * Watching Brief *
OH788	14/09/2017 11/12/2017	**pH – 5th percentile**	Watching Brief * Watching Brief *

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

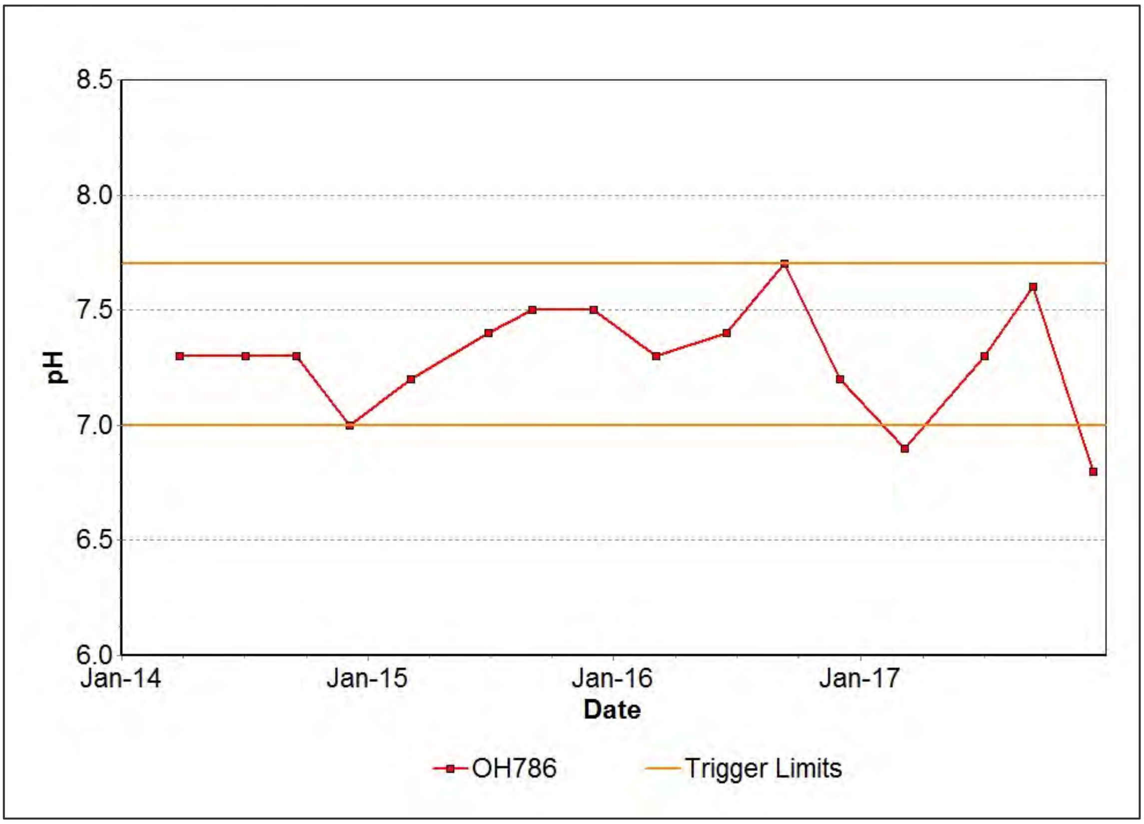

FIGURE 44: HUNTER RIVER ALLUVIUM BORE OH786 PH TREND 2014 TO 2017

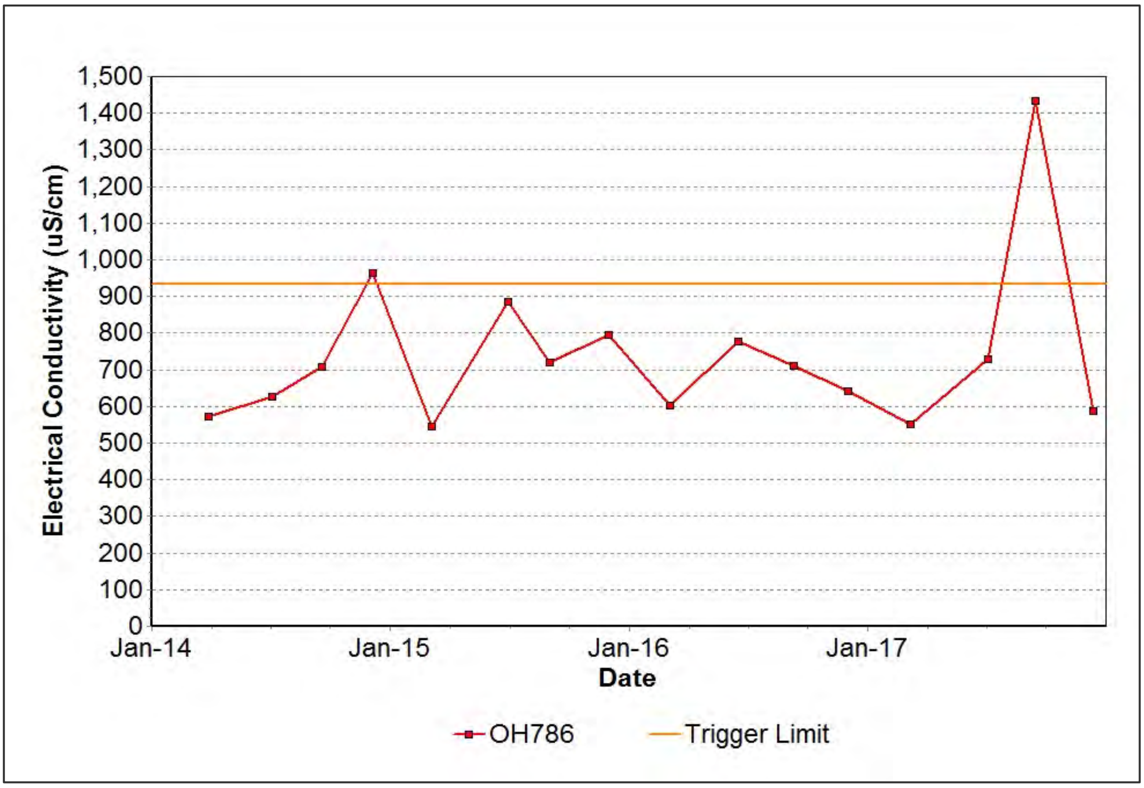

FIGURE 45: HUNTER RIVER ALLUVIUM BORE OH786 EC TREND 2014 TO 2017

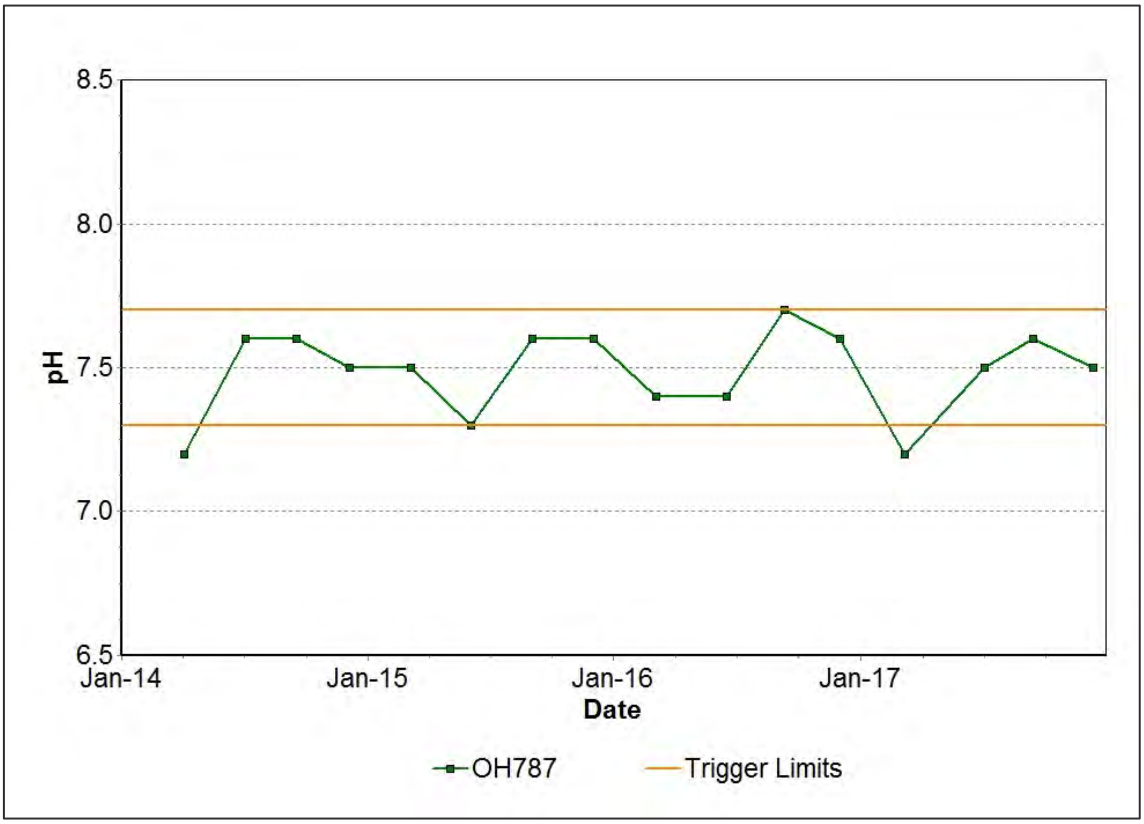

FIGURE 46: HUNTER RIVER ALLUVIUM BORE OH787 PH TREND 2014 TO 2017

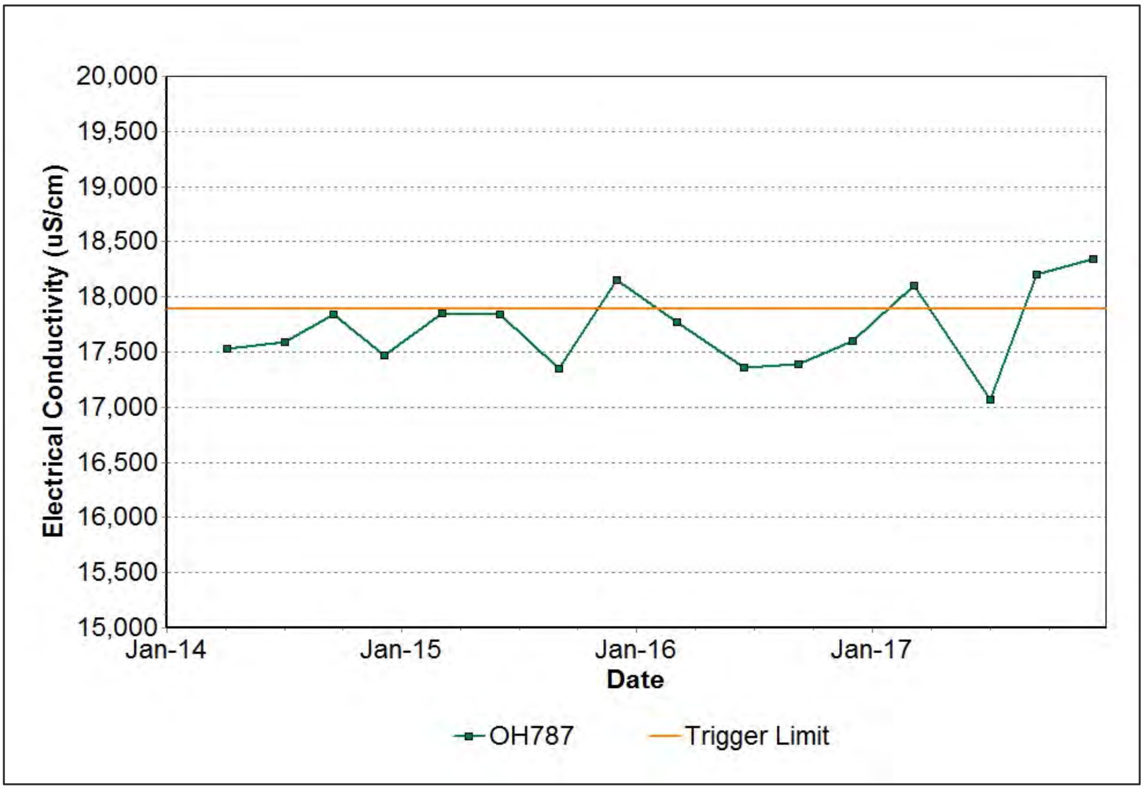

FIGURE 47: HUNTER RIVER ALLUVIUM BORE OH787 EC TREND 2014 TO 2017

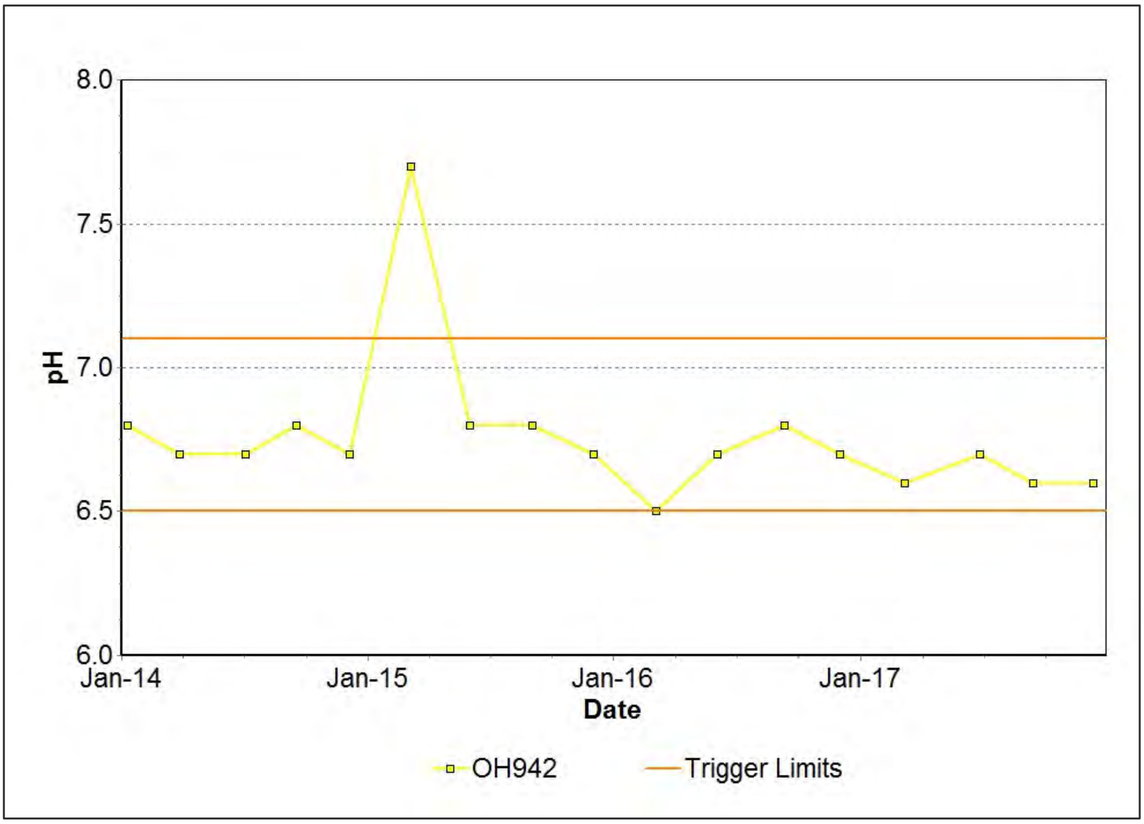

FIGURE 48: HUNTER RIVER ALLUVIUM BORE OH942 PH TREND 2014 TO 2017

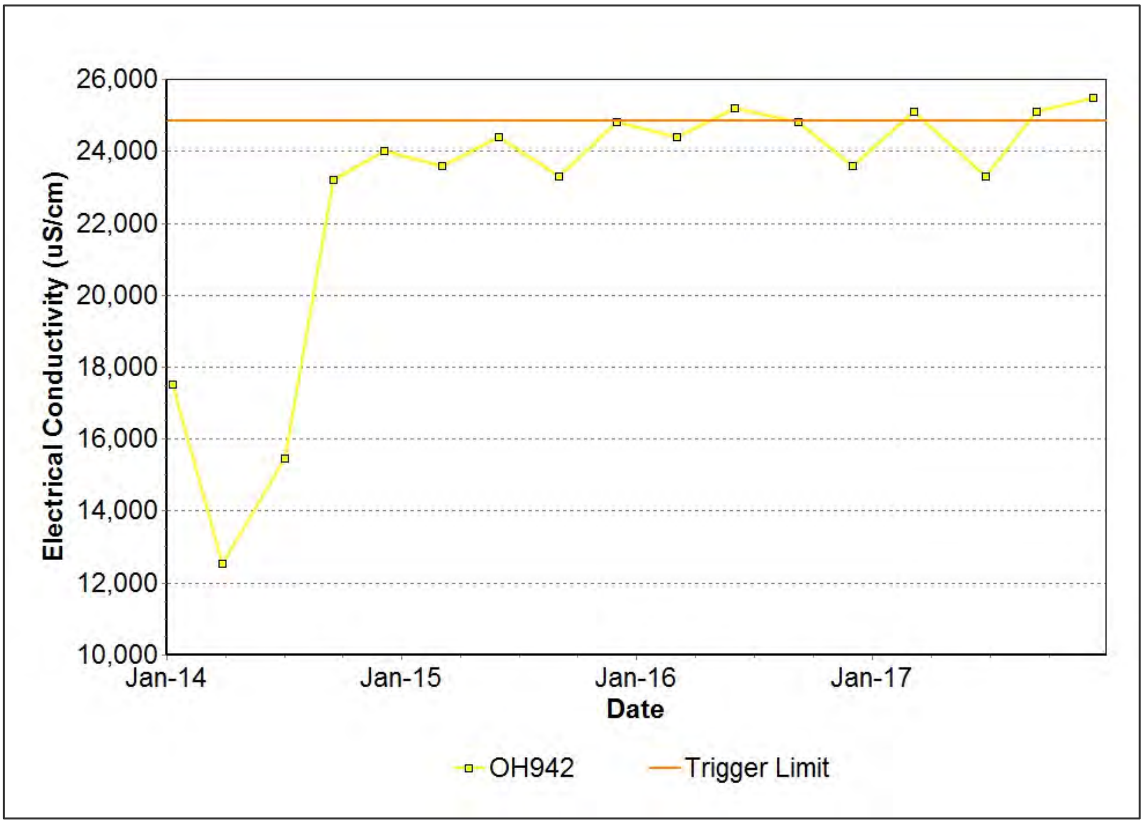

FIGURE 49: HUNTER RIVER ALLUVIUM BORE OH942 EC TREND 2014 TO 2017

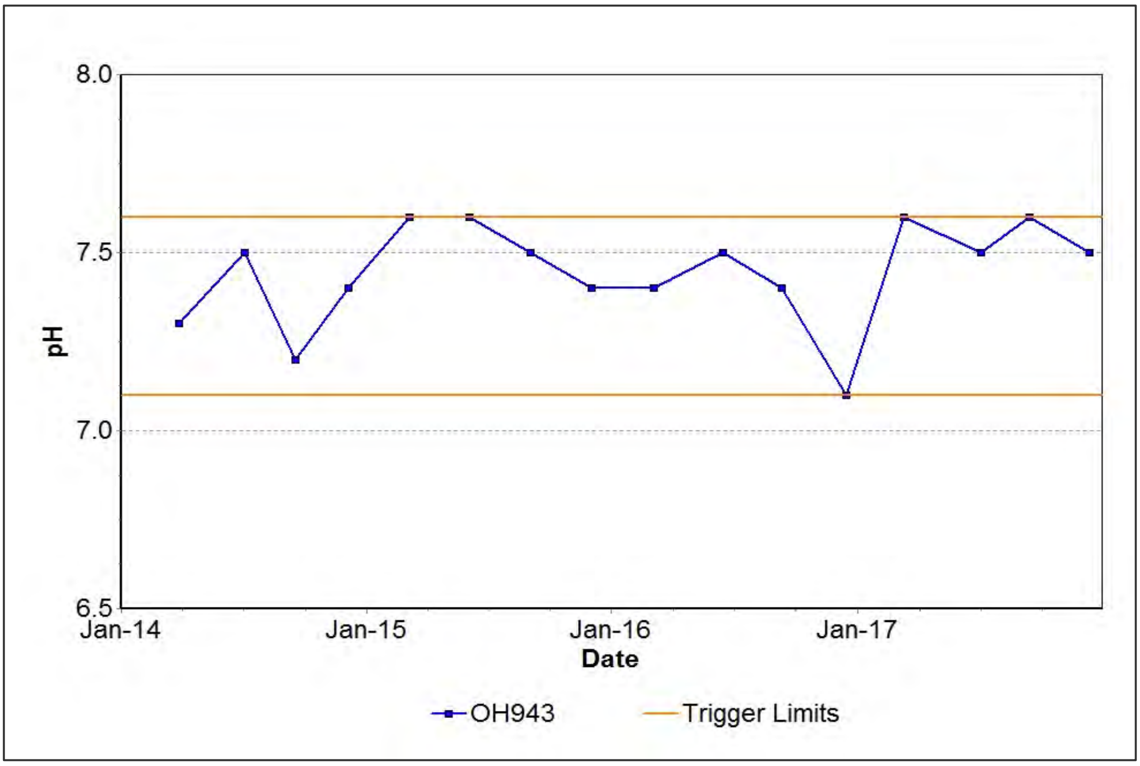

FIGURE 50: HUNTER RIVER ALLUVIUM BORE OH943 PH TREND 2014 TO 2017

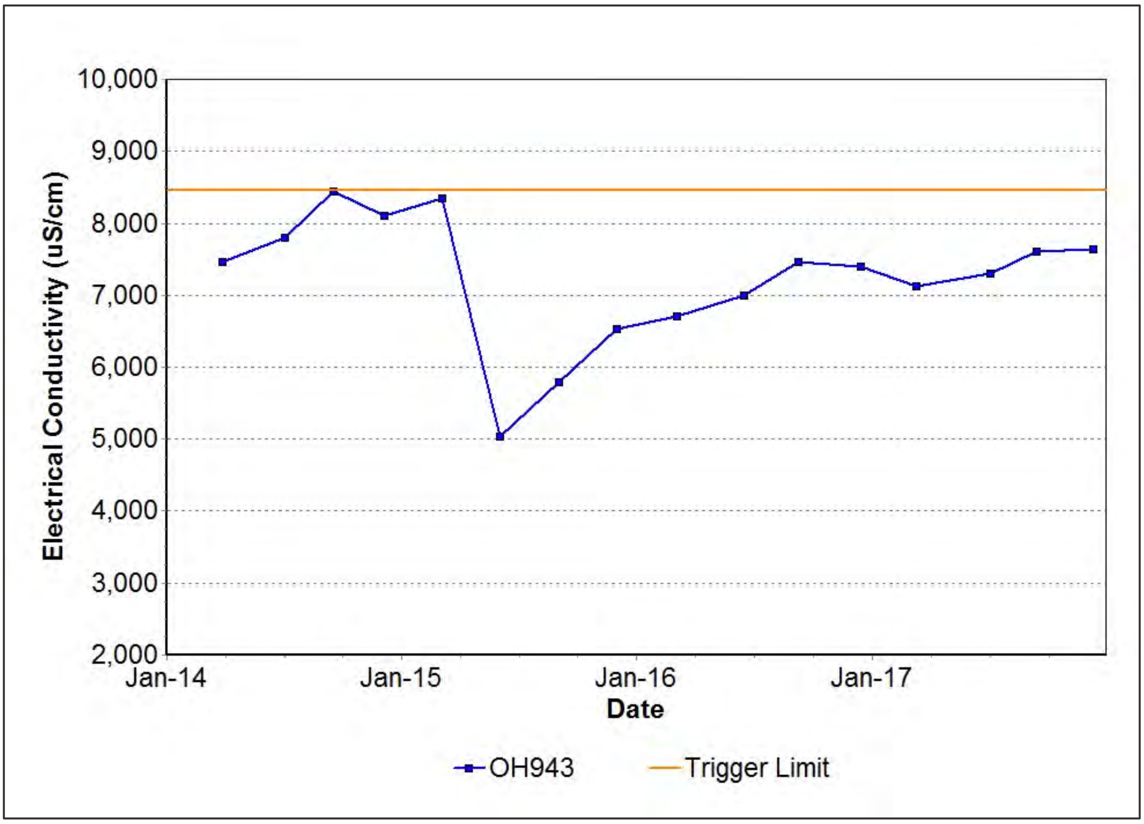

FIGURE 51: HUNTER RIVER ALLUVIUM BORE OH943 EC TREND 2014 TO 2017

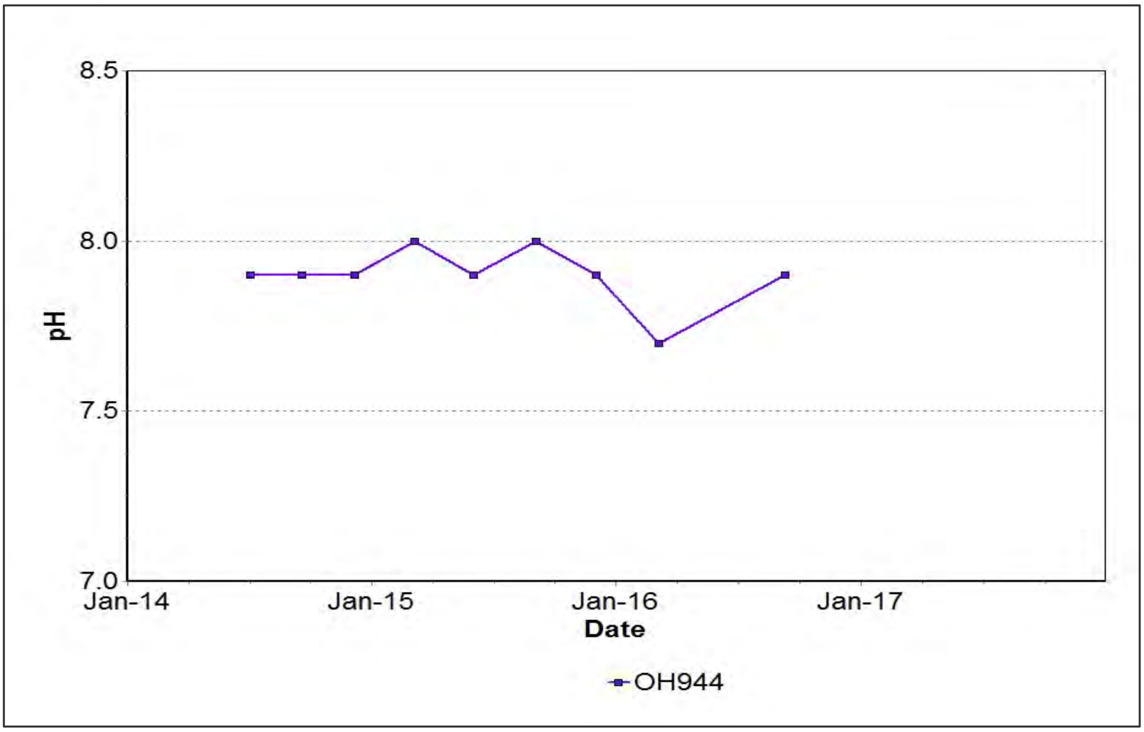

FIGURE 52: HUNTER RIVER ALLUVIUM BORE OH944 PH TREND 2014 TO 2017

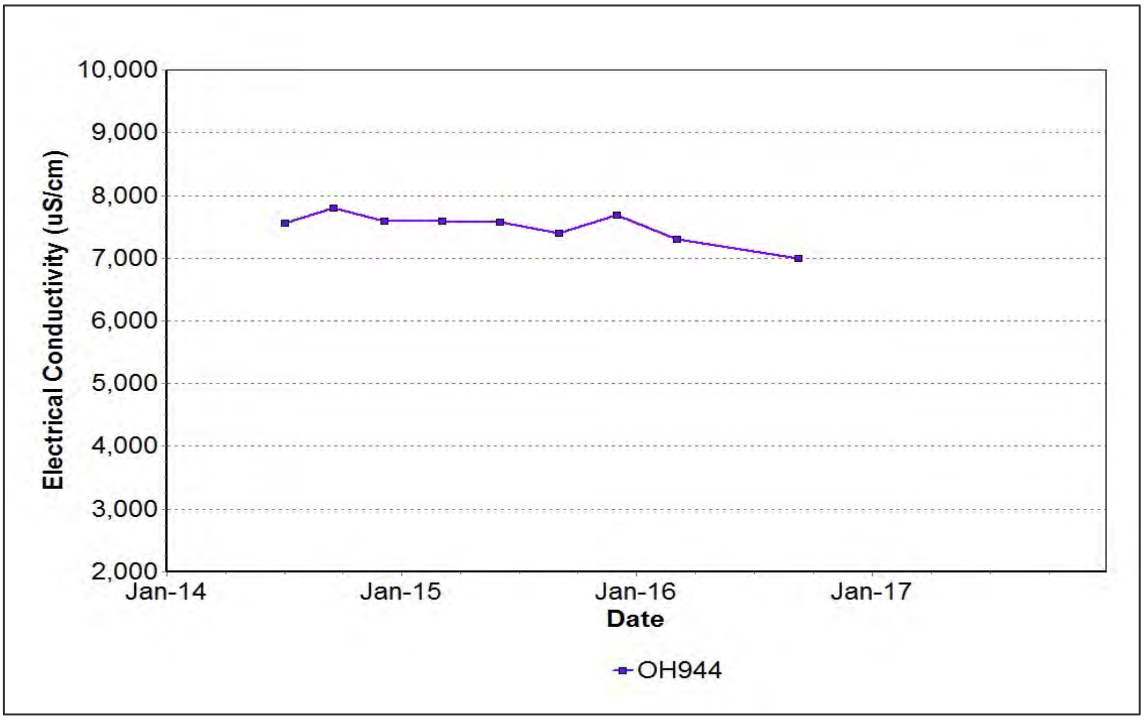

FIGURE 53: HUNTER RIVER ALLUVIUM BORE OH944 EC TREND 2014 TO 2017

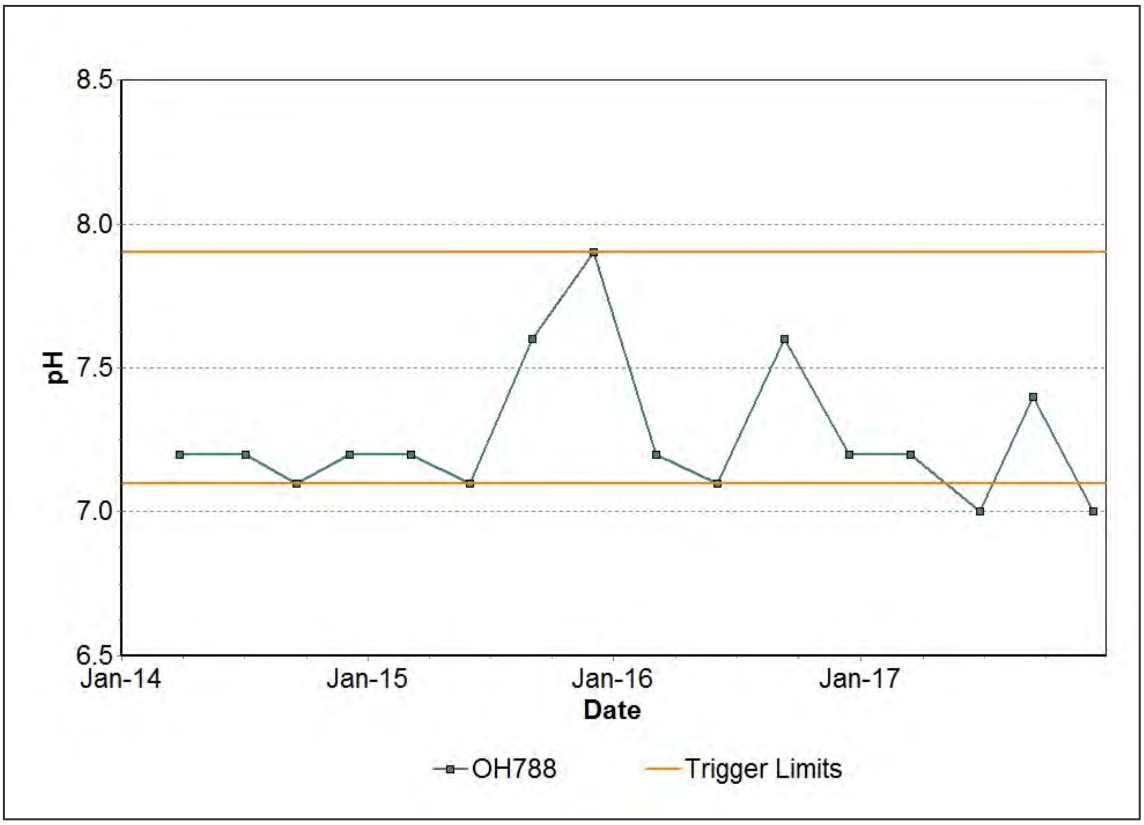

FIGURE 54: HUNTER RIVER ALLUVIUM BORE OH788 PH TREND 2014 TO 2017

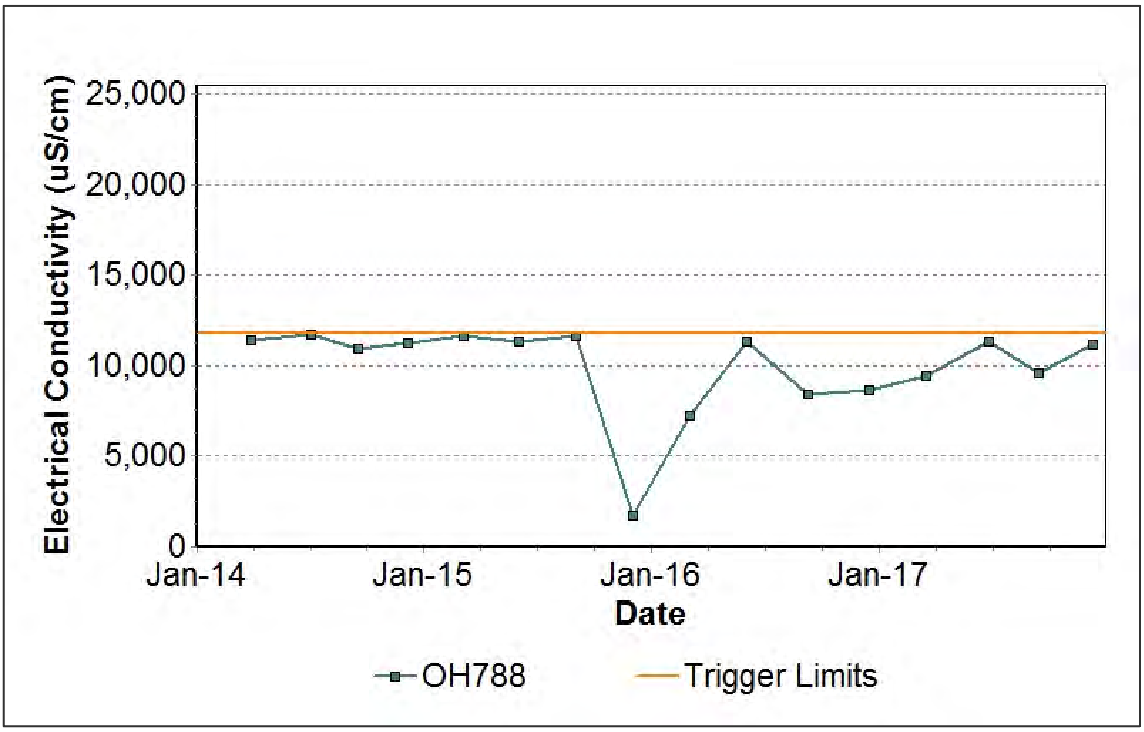

FIGURE 55: HUNTER RIVER ALLUVIUM BORE OH788 EC TREND 2014 TO 2017

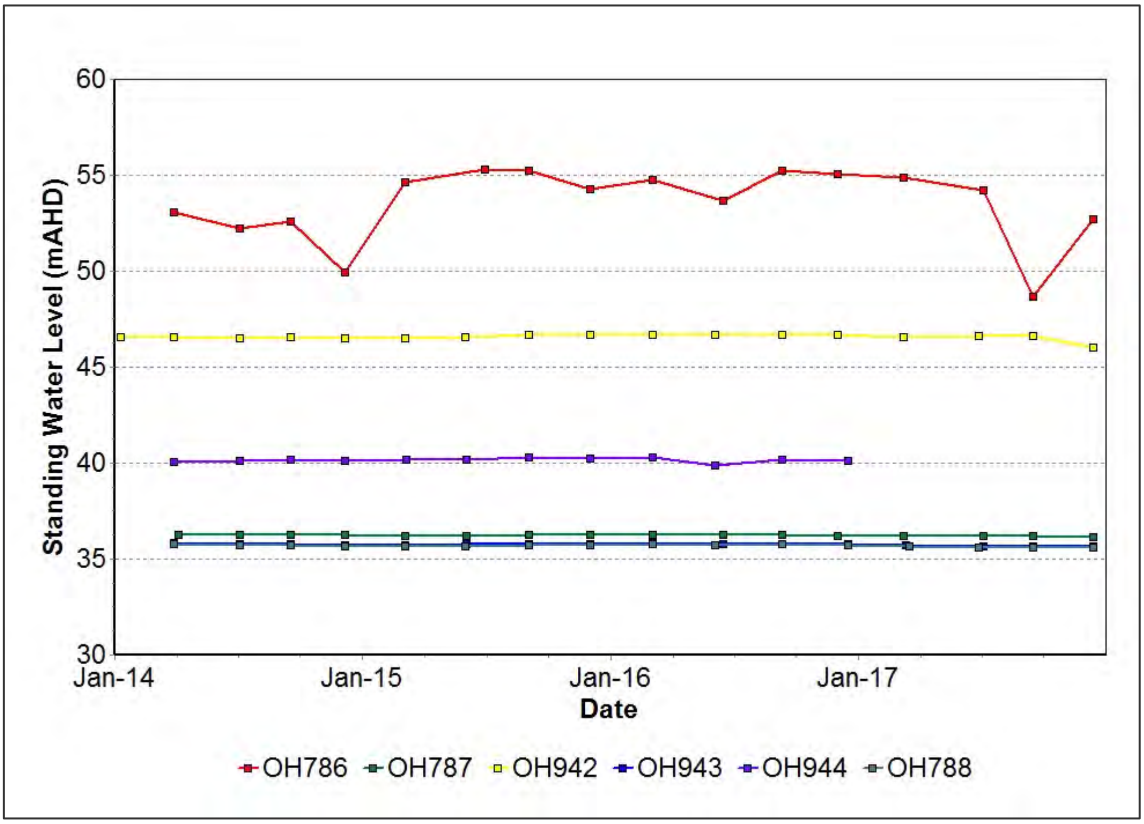

FIGURE 56: HUNTER RIVER ALLUVIUM GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.5 Redbank Bores

Groundwater monitoring in the Redbank seam was undertaken from four sites during 2017. A total of 16 samples were collected during the reporting period. The pH, EC and SWL trends for 2013 to 2017 for Redbank seam groundwater bores are shown in Figure 57, Figure 58 and Figure 59 respectively. Trigger tracking results are detailed in Table 33. A steady declining trend in water levels at all monitoring sites continued during the reporting period which is likely to be a result of coal seam depressurisation due to mining.

TABLE 33 : MTW REDBANK SEAM GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
WOH2153A	10/03/2017	**pH – 95th percentile**	Watching brief *

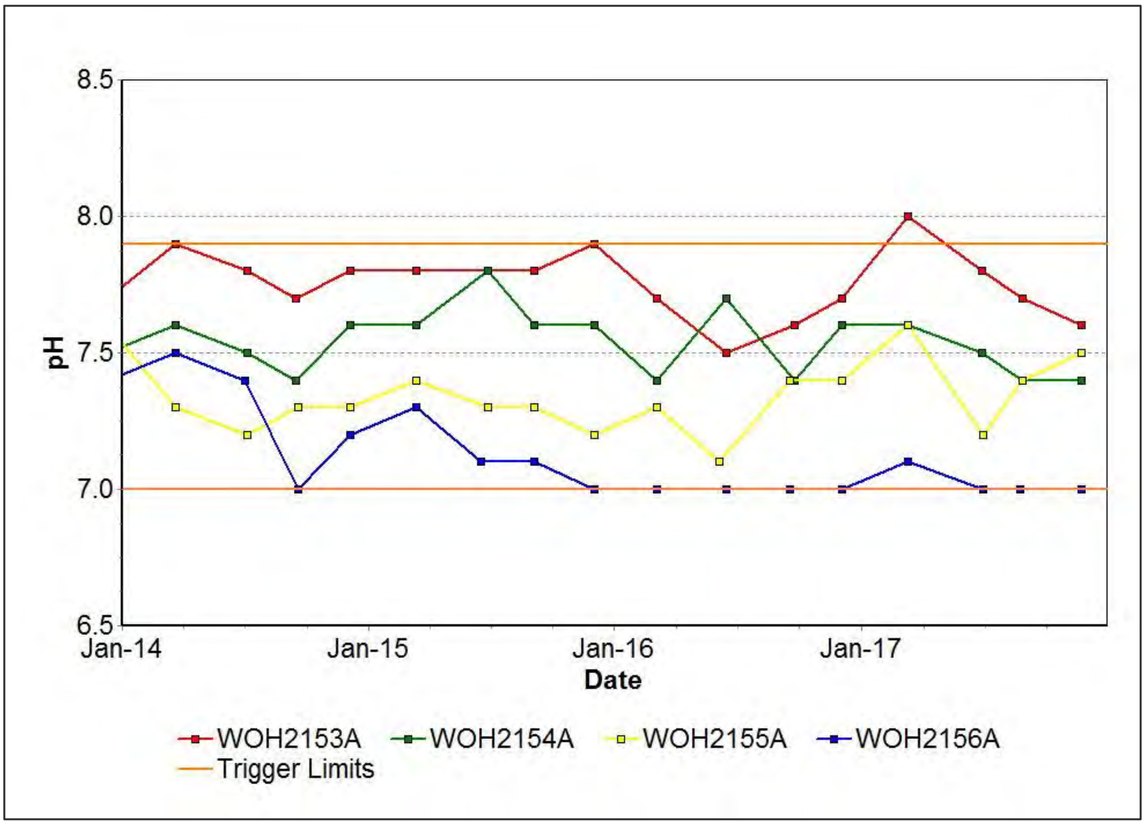

FIGURE 57: REDBANK SEAM GROUNDWATER PH TRENDS 2014 TO 2017

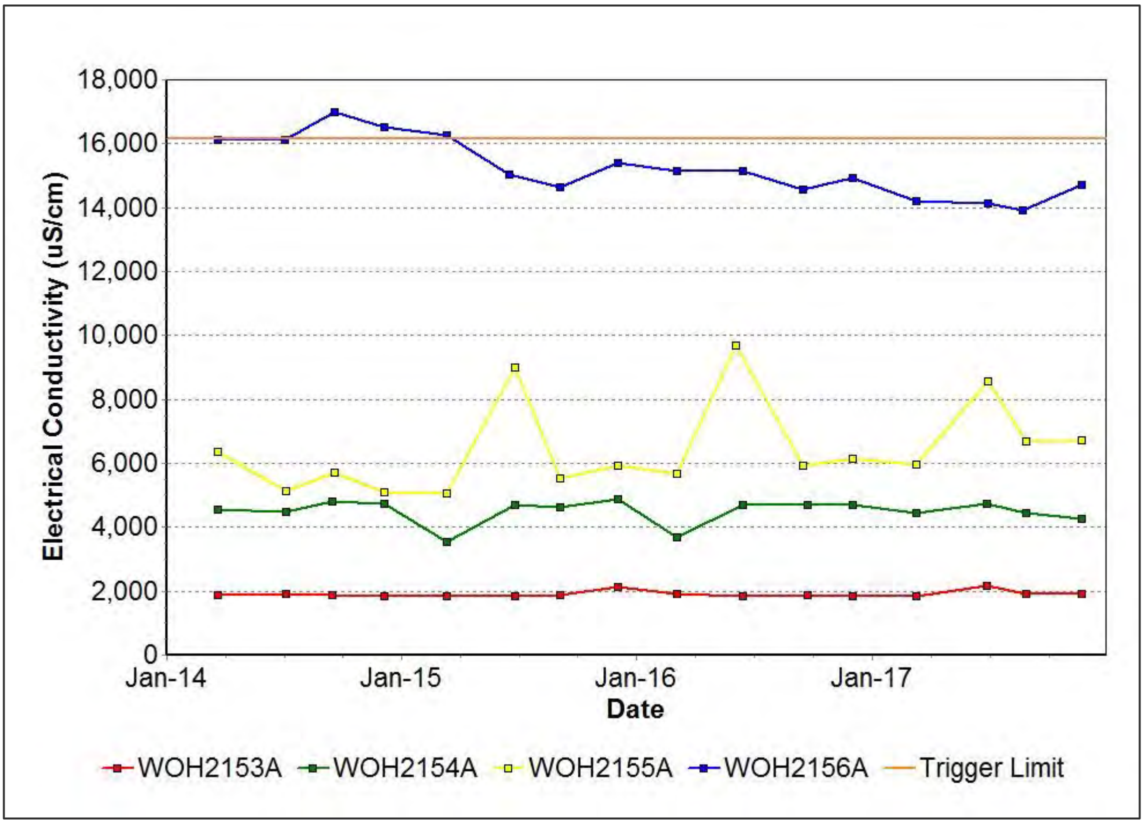

FIGURE 58: REDBANK SEAM GROUNDWATER EC TRENDS 2014 TO 2017

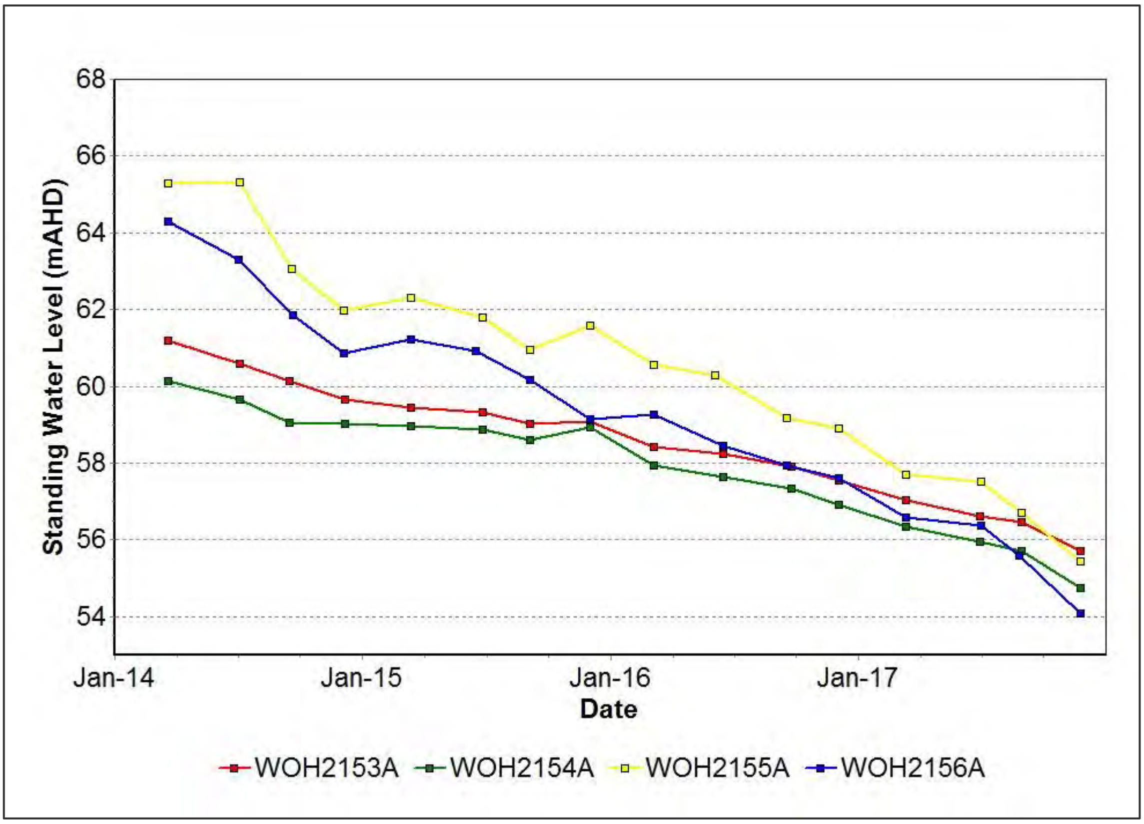

FIGURE 59: REDBANK SEAM GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.6 Shallow Overburden Bores

Groundwater monitoring in the Shallow Overburden was undertaken from three sites during 2017. A total of 12 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 for Shallow Overburden groundwater bores are shown in Figure 60, Figure 61 and Figure 62 respectively. Water levels and water quality were steady in all bores during the reporting period.

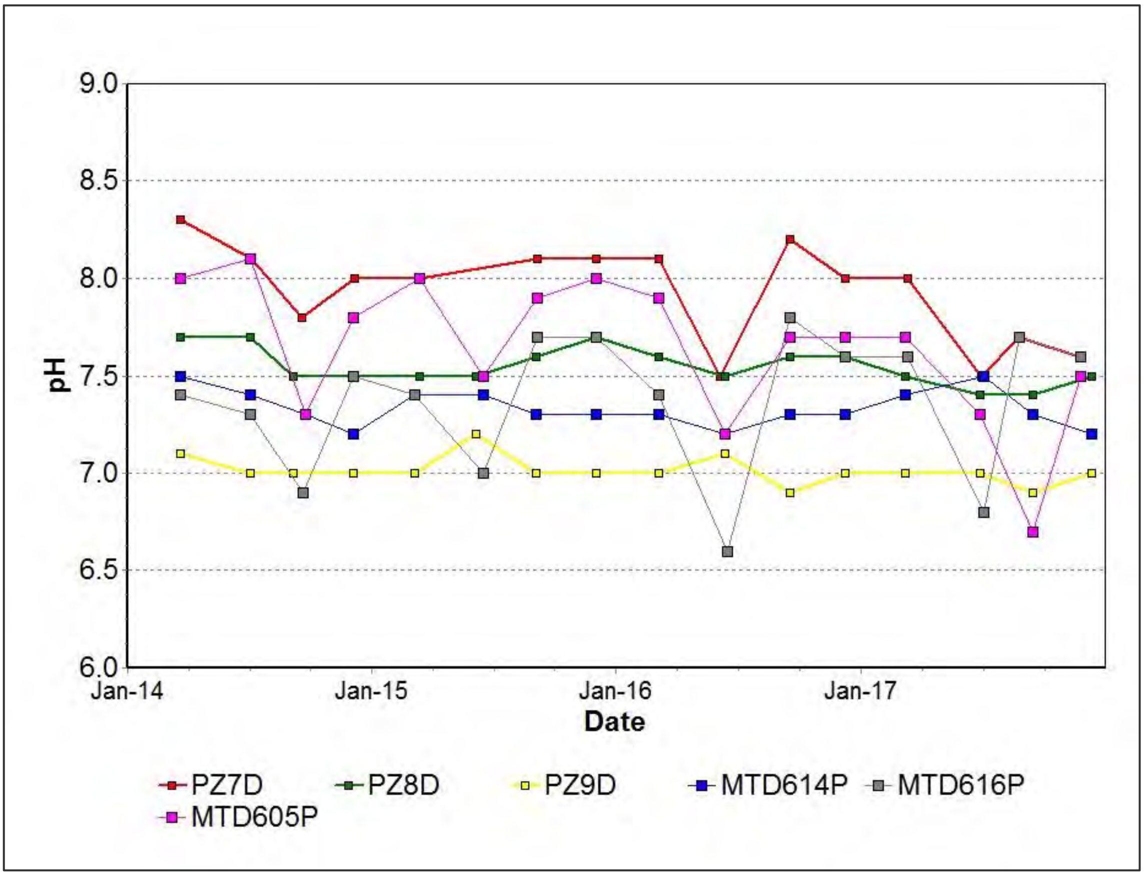

FIGURE 60 : SHALLOW OVERBURDEN SEAM GROUNDWATER PH TRENDS 2014 TO 2017

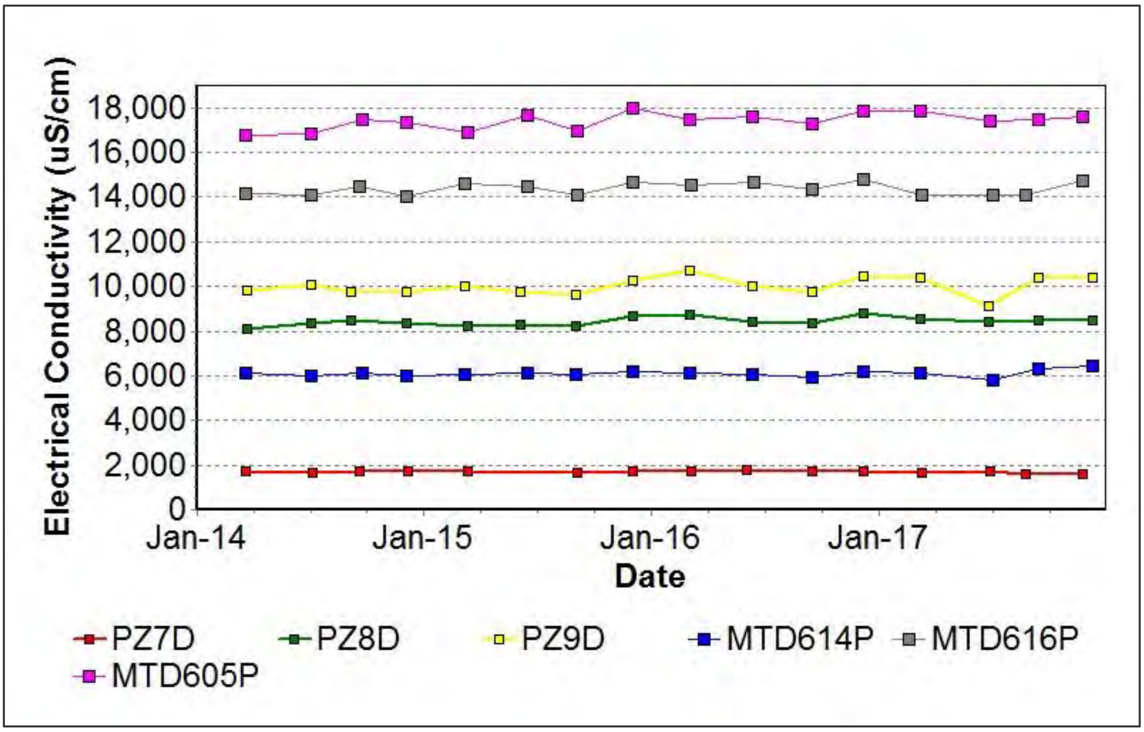

FIGURE 61: SHALLOW OVERBURDEN SEAM GROUNDWATER EC TRENDS 2014 TO 2017

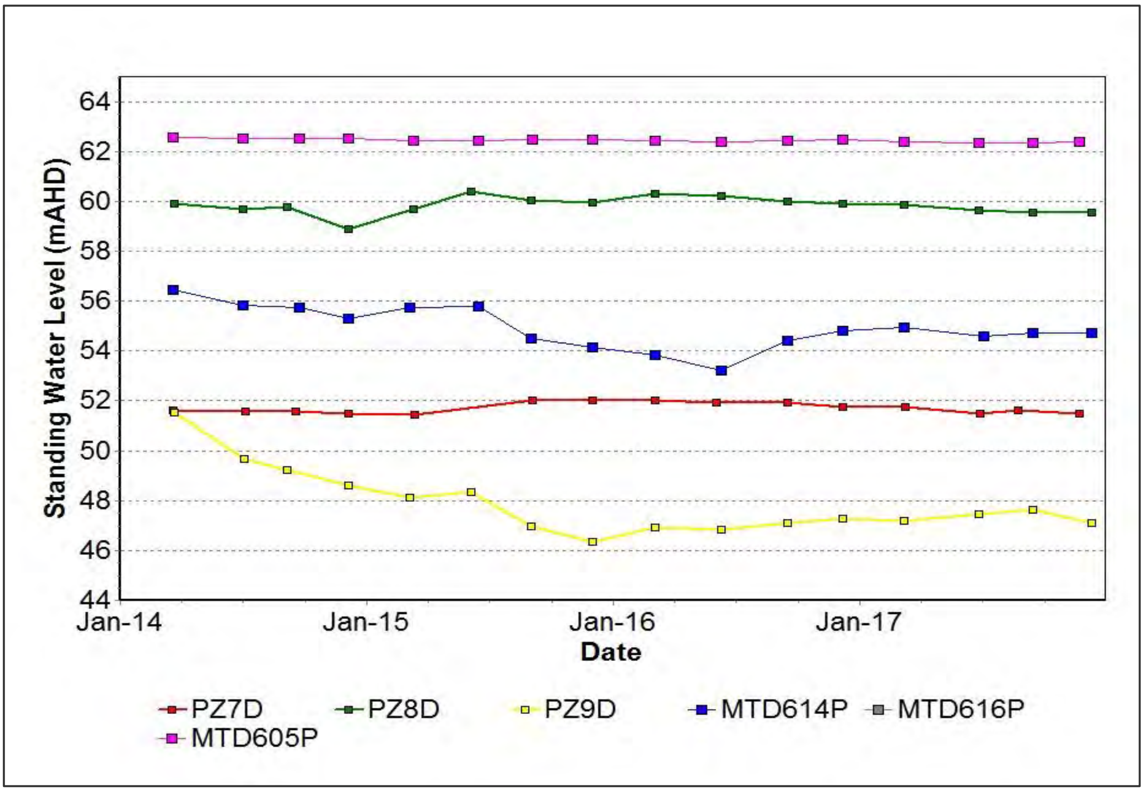

FIGURE 62: SHALLOW OVERBURDEN SEAM GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.7 Vaux Seam Bores

Groundwater monitoring in the Vaux seam was undertaken from three sites during 2017; a total of 12 samples were collected. The pH, EC and SWL trends for 2014 to 2017 for Vaux groundwater bores are shown in Figure 63, Figure 64 and Figure 65 respectively; results are consistent with historical trends.

TABLE 34: SHALLOW OVERBURDEN GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
OH1137	14/09/2017 11/12/2017	**EC – 95th percentile**	Watching brief * Watching brief *

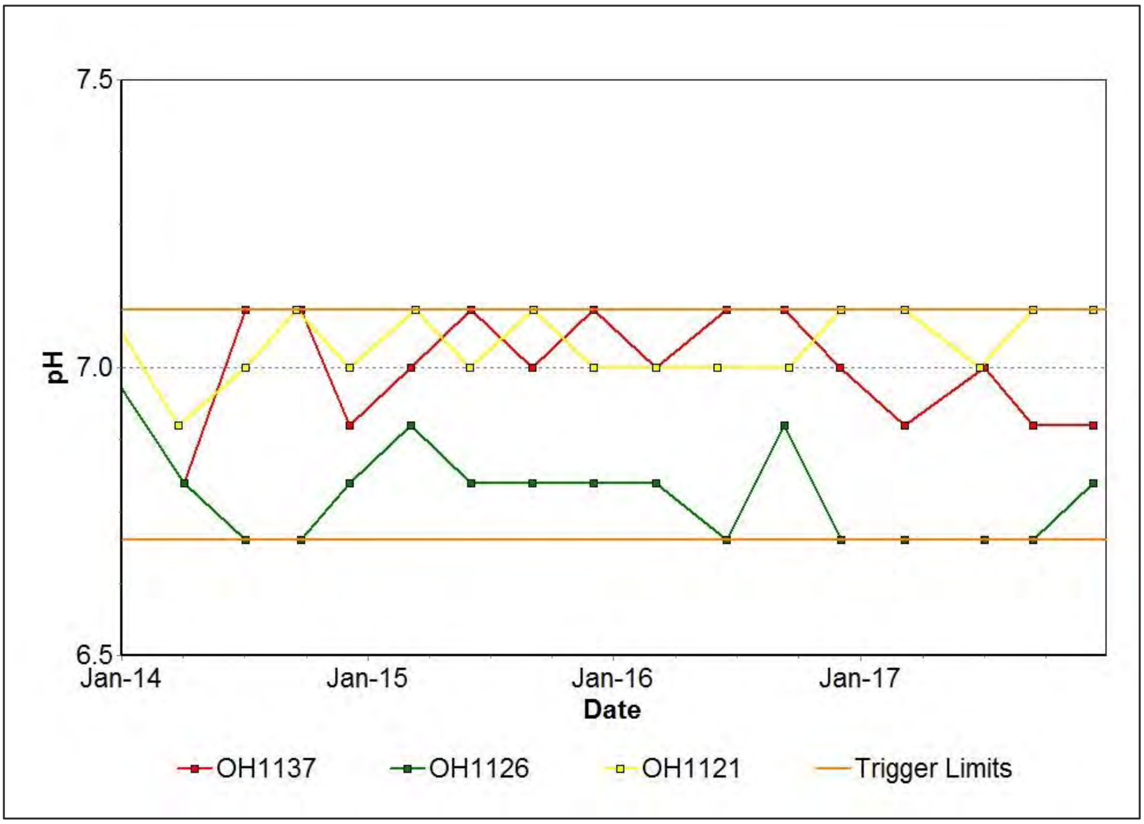

FIGURE 63: VAUX SEAM GROUNDWATER pH TRENDS 2014 TO 2017

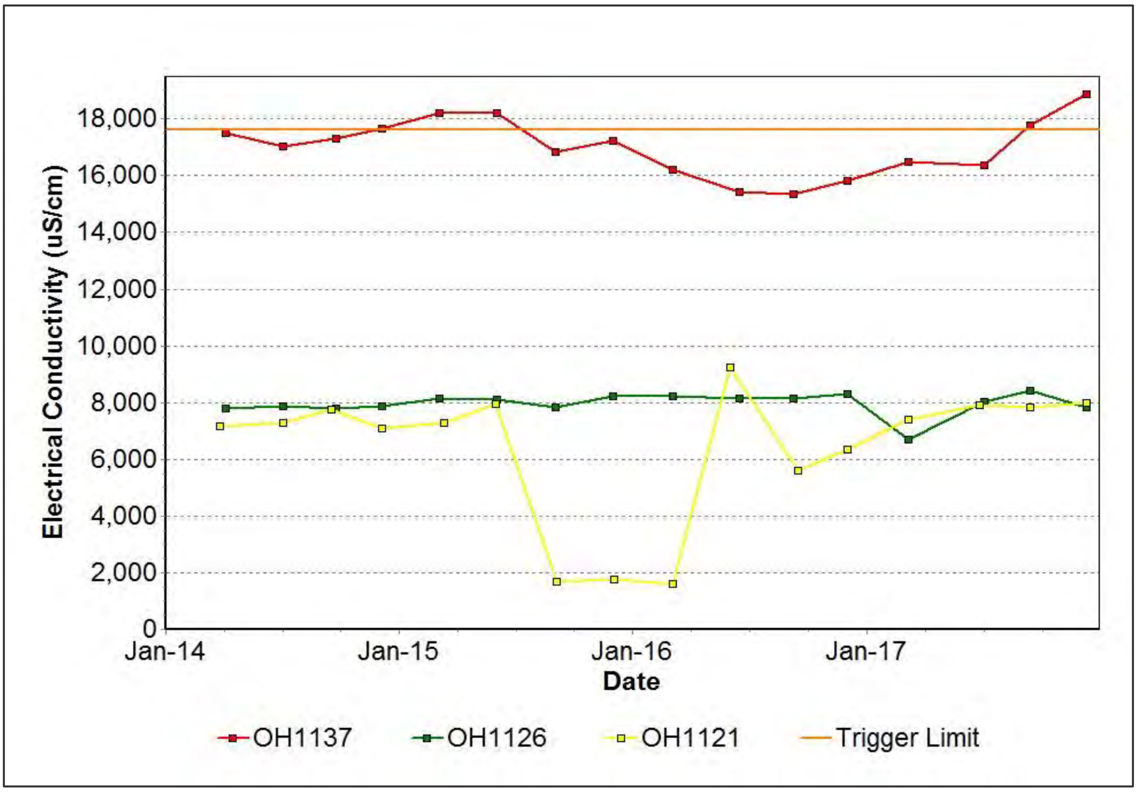

FIGURE 64: VAUX SEAM GROUNDWATER EC TRENDS 2014 TO 2017

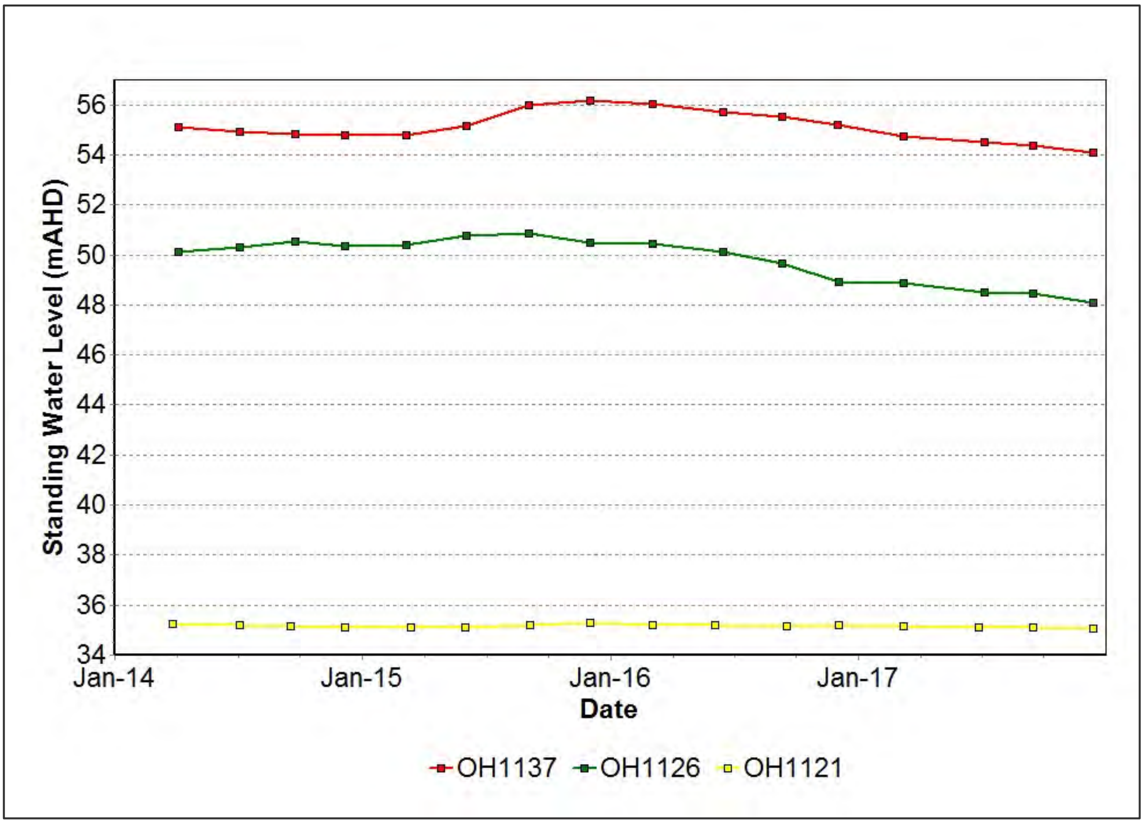

FIGURE 65: VAUX SEAM GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.8 Wambo Seam Bores

Groundwater monitoring in the Wambo seam bores were undertaken from five sites during 2017. A total of 19 samples were collected during the reporting period. The pH, EC and SWL trends for 2014 to 2017 for Wambo groundwater bores are shown in Figure 66, Figure 67 and Figure 68 respectively. Trigger tracking results are detailed in Table 35. Bore G3 collapsed during and was removed from the monitoring programme. Trends in all remaining bores were stable and consistent with historical data.

TABLE 35: MTW WAMBO SEAM GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
G3	15/12/2016	**pH – 5th percentile**	Bore partially collapsed in early 2016 so data may not be representative of aquifer. Removal from monitoring programme has been recommended following review of data from nearby bores.
	07/03/2017		Watching brief *
WOH2156B	10/03/2017	**EC – 95th percentile**	Elevated EC is likely the result of coal seam depressurisation, as evidenced by falling water level. This trend is consistent with effects of nearby mining. No further action required.
	30/06/2017		
	24/08/2017		
	23/11/2017		
WD622P	30/06/2017	**EC – 95th percentile**	Watching brief *

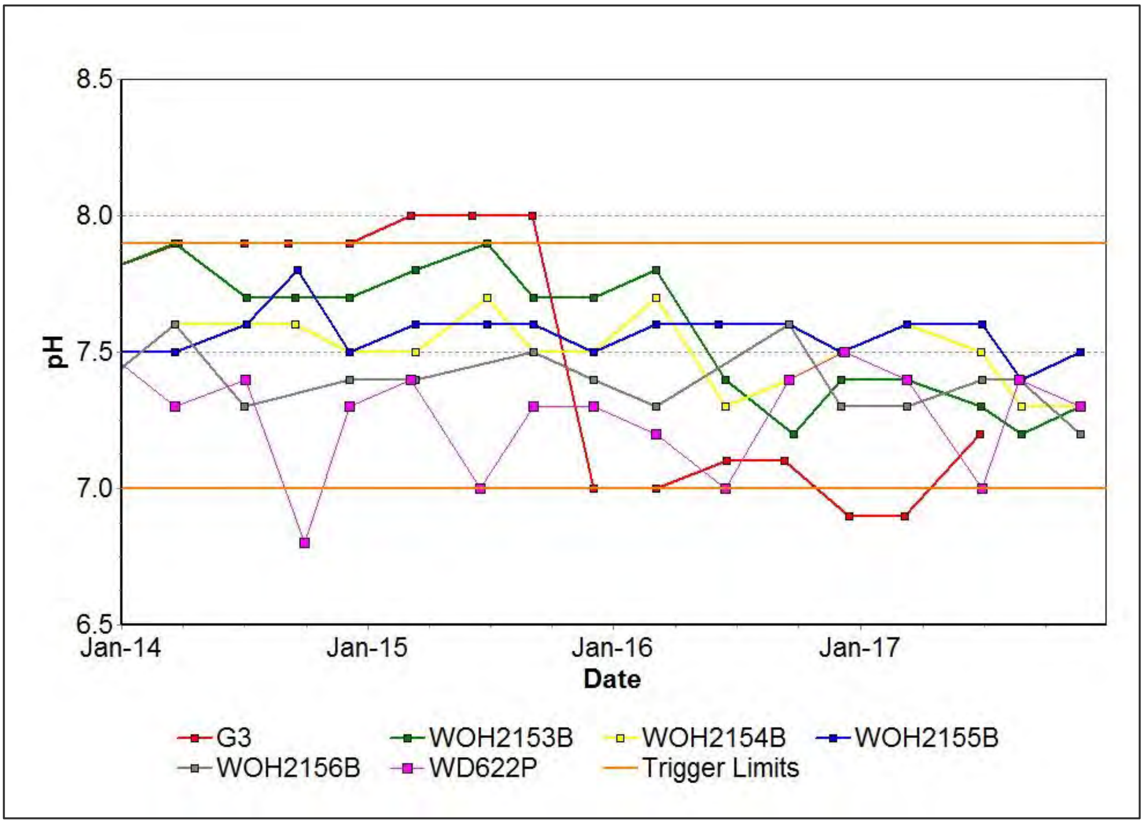

FIGURE 66: WAMBO SEAM GROUNDWATER PH TRENDS 2014 TO 2017

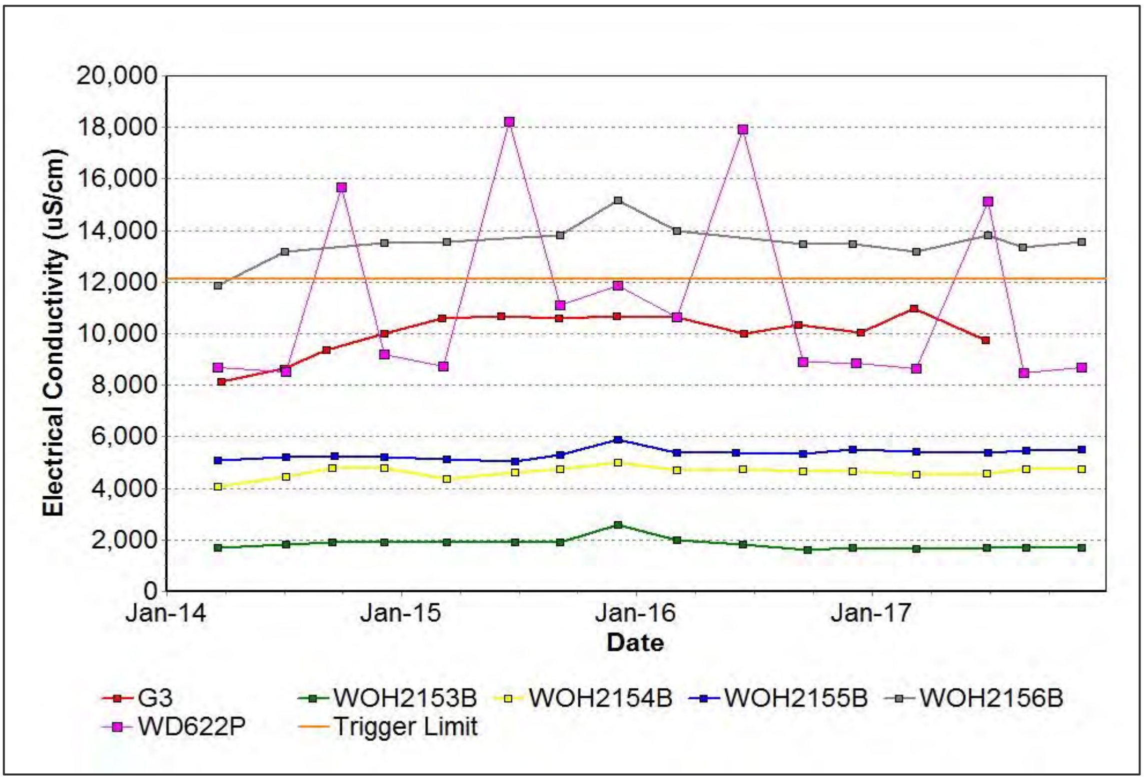

FIGURE 67: WAMBO SEAM GROUNDWATER EC TRENDS 2014 TO 2017

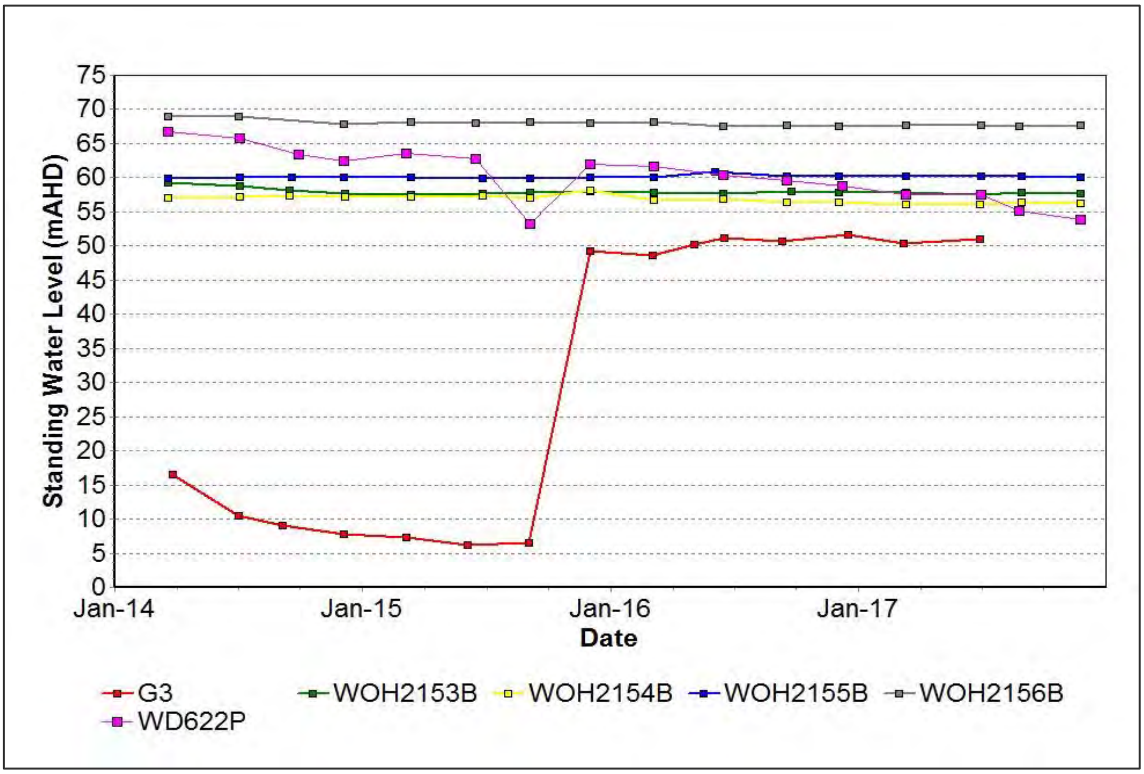

FIGURE 68: WAMBO SEAM GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.9 Warkworth Seam Bores

Groundwater monitoring in the Warkworth seam area was undertaken from two sites during 2017; eight samples were collected. The pH, EC and SWL trends for 2014 to 2017 for Warkworth seam bores are shown in Figure 69, Figure 70 and Figure 71 respectively.

TABLE 36: WARKWORTH SEAM GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
OH1138(1)	04/07/2017	pH – 5th percentile	Watching brief *
	14/09/2017		Watching brief *
	11/12/2017		Under investigation.
OH1138(1)	14/09/2017	EC – 95th percentile	Watching brief *
	11/12/2017		Watching brief *

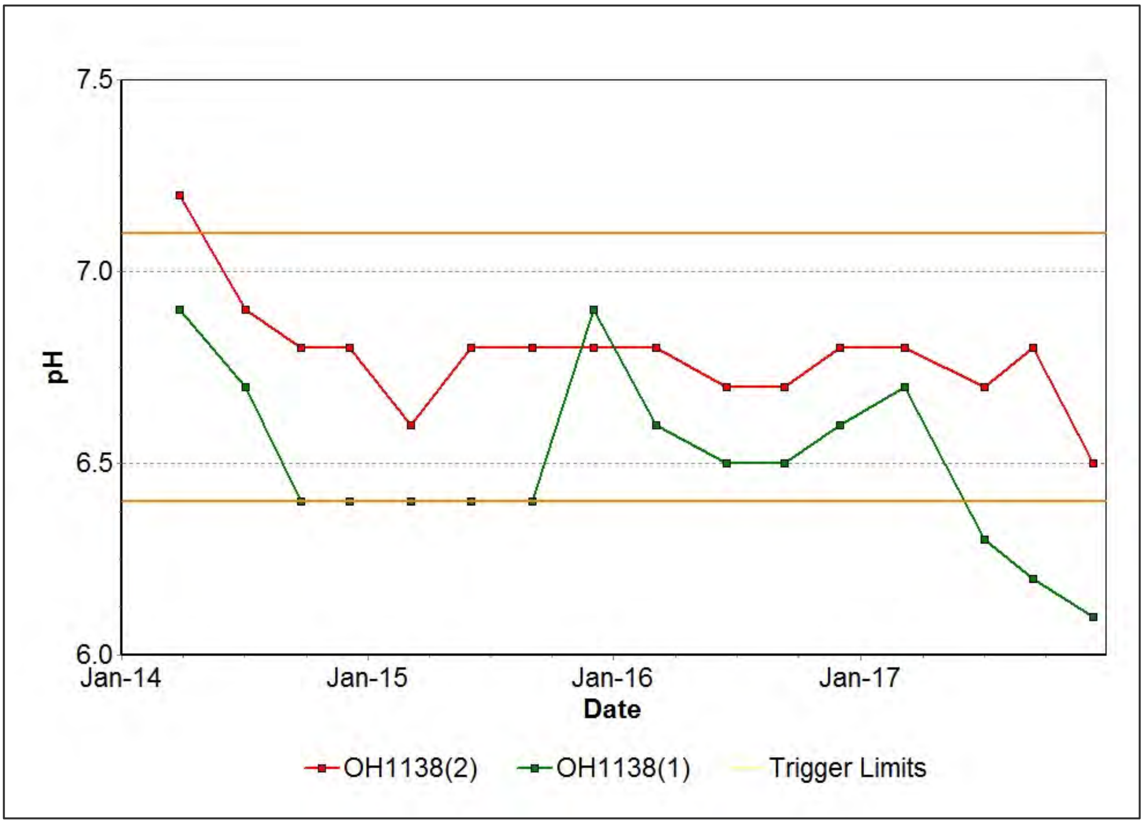

FIGURE 69: WARKWORTH SEAM GROUNDWATER PH TRENDS 2014 TO 2017

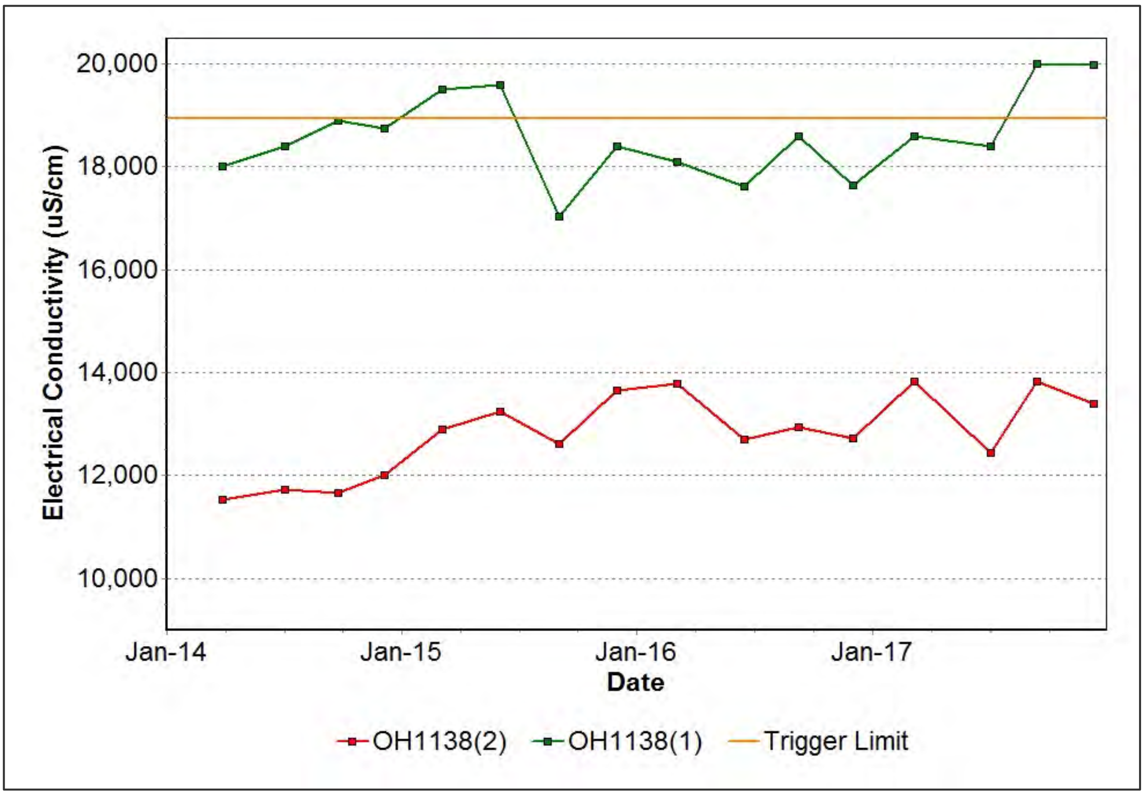

FIGURE 70: WARKWORTH SEAM GROUNDWATER EC TRENDS 2014 TO 2017

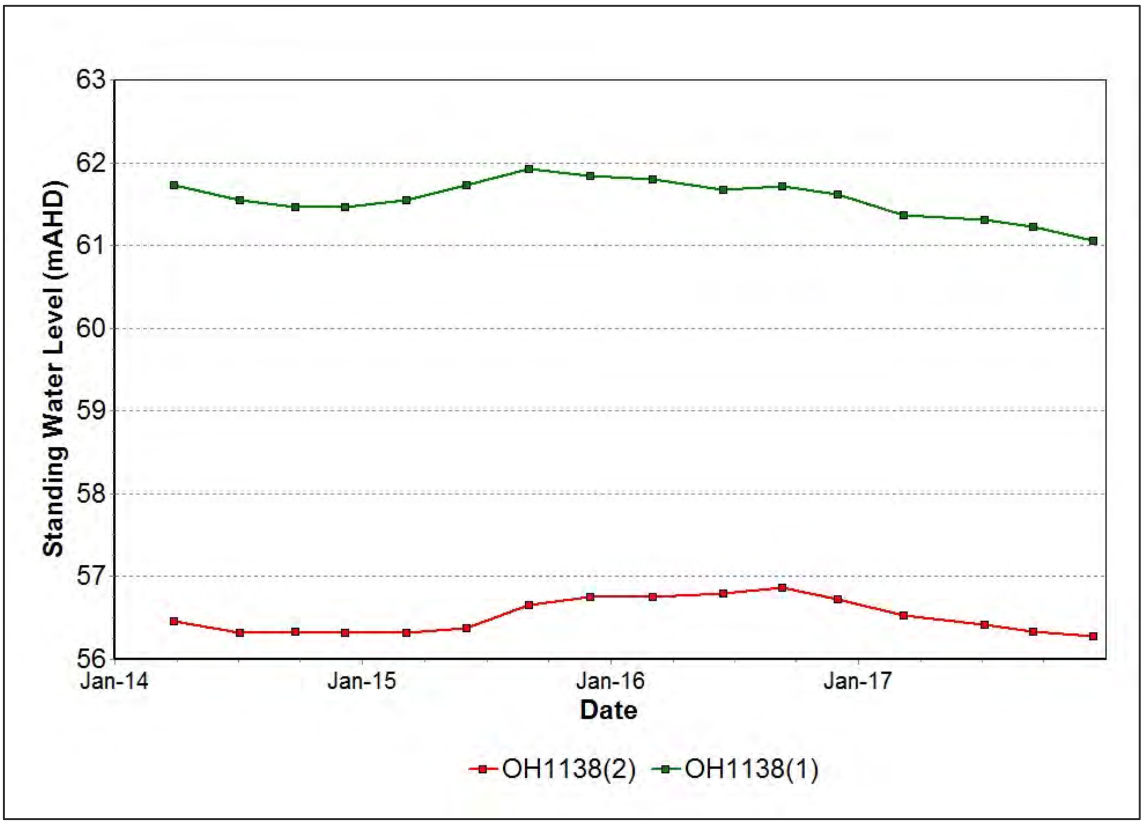

FIGURE 71: WARKWORTH SEAM GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.10 Wollombi Brook Alluvium Seam Bores

Groundwater monitoring in the Wollombi Brook Alluvium was undertaken from two sites during 2017; eight samples were collected. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 72, Figure 73 and Figure 74 respectively.

TABLE 37: WOLLOMBI BROOK ALLUVIUM SEAM GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
PZ9S	07/03/2017	**EC – 95th percentile**	Watching brief *

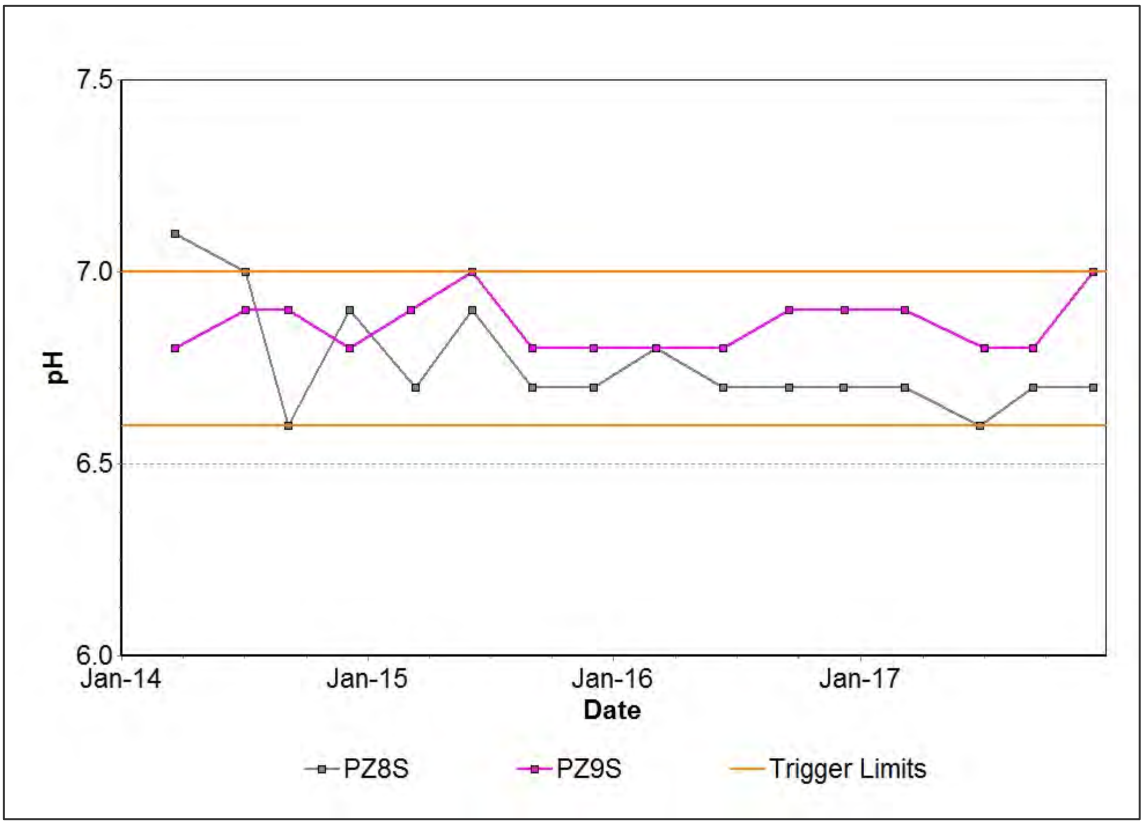

FIGURE 72: WOLLOMBI BROOK ALLUVIUM SEAM GROUNDWATER PH TRENDS 2014 TO 2017

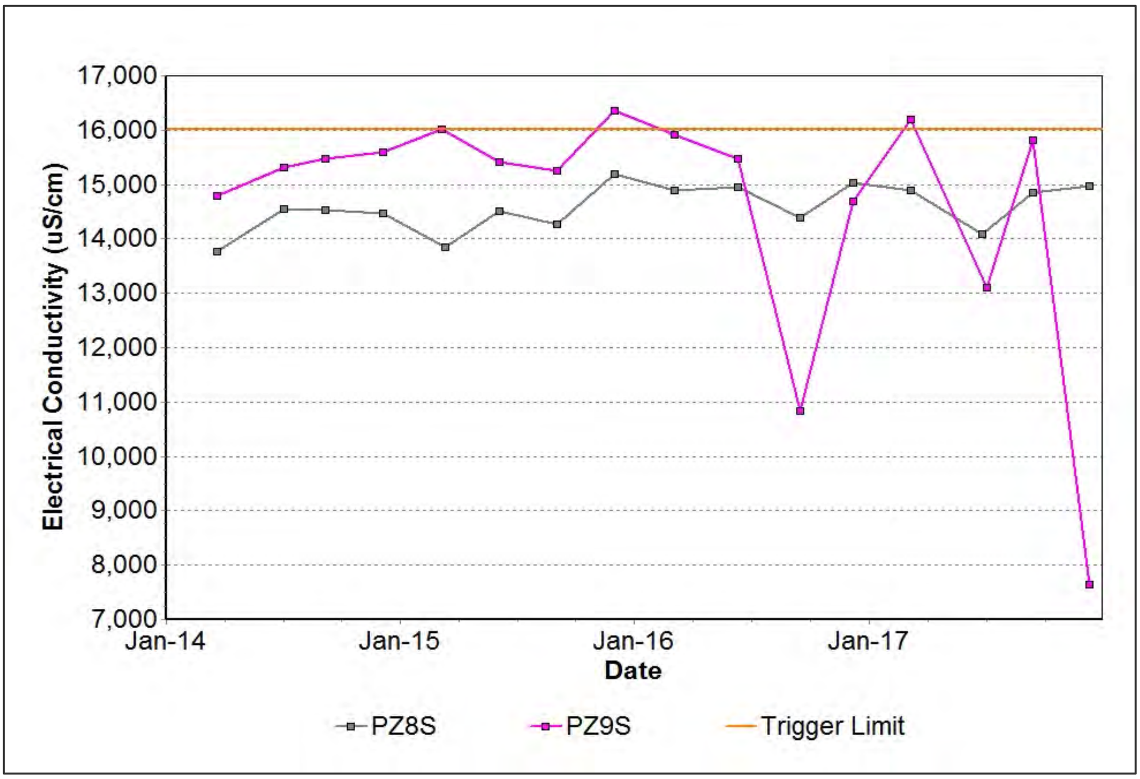

FIGURE 73: WOLLOMBI BROOK ALLUVIUM SEAM GROUNDWATER EC TRENDS 2014 TO 2017

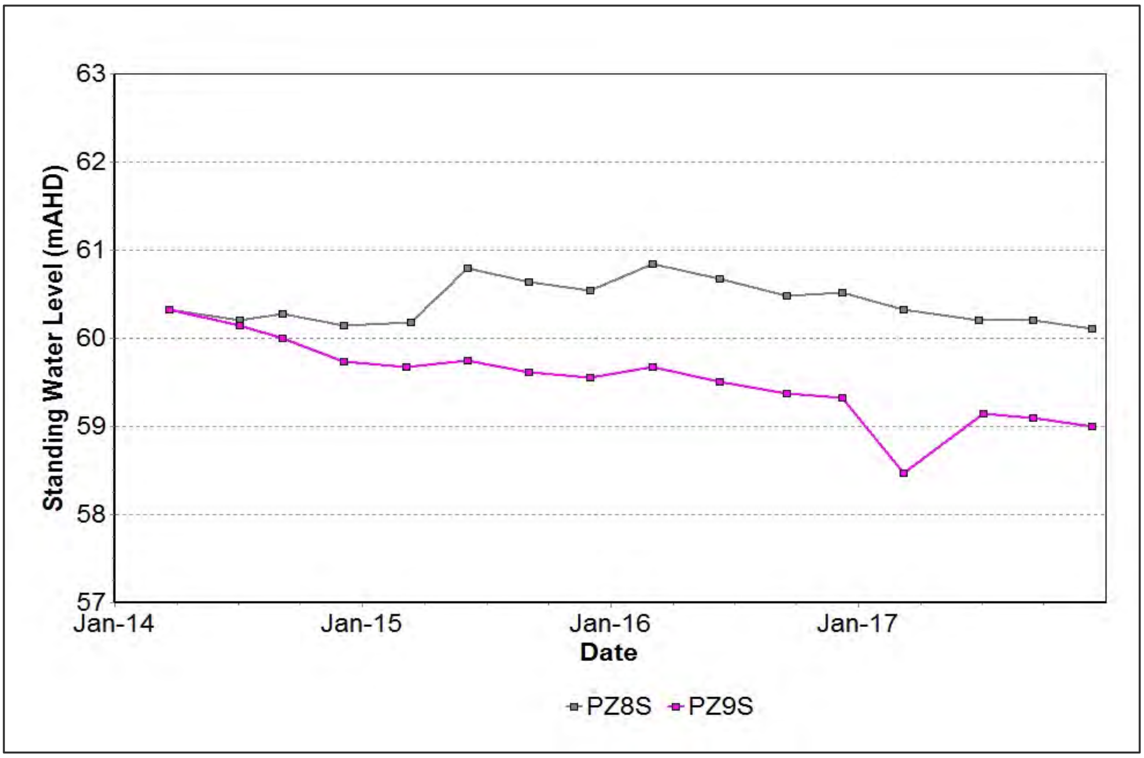

FIGURE 74: WOLLOMBI BROOK ALLUVIUM SEAM GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.11 Aeolian Warkworth Sands

Groundwater monitoring in the Aeolian Warkworth Sands was undertaken from one site during 2017; a total of four samples were collected. The pH, EC and SWL trends for 2014 to 2017 are shown in Figure 75, Figure 76 and Figure 77 respectively. Monitoring results were consistent with historical data.

TABLE 38: AEOLIAN WARKWORTH SANDS GROUNDWATER 2017 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
PZ7S	23/11/2017	**EC – 95th percentile**	Watching brief *

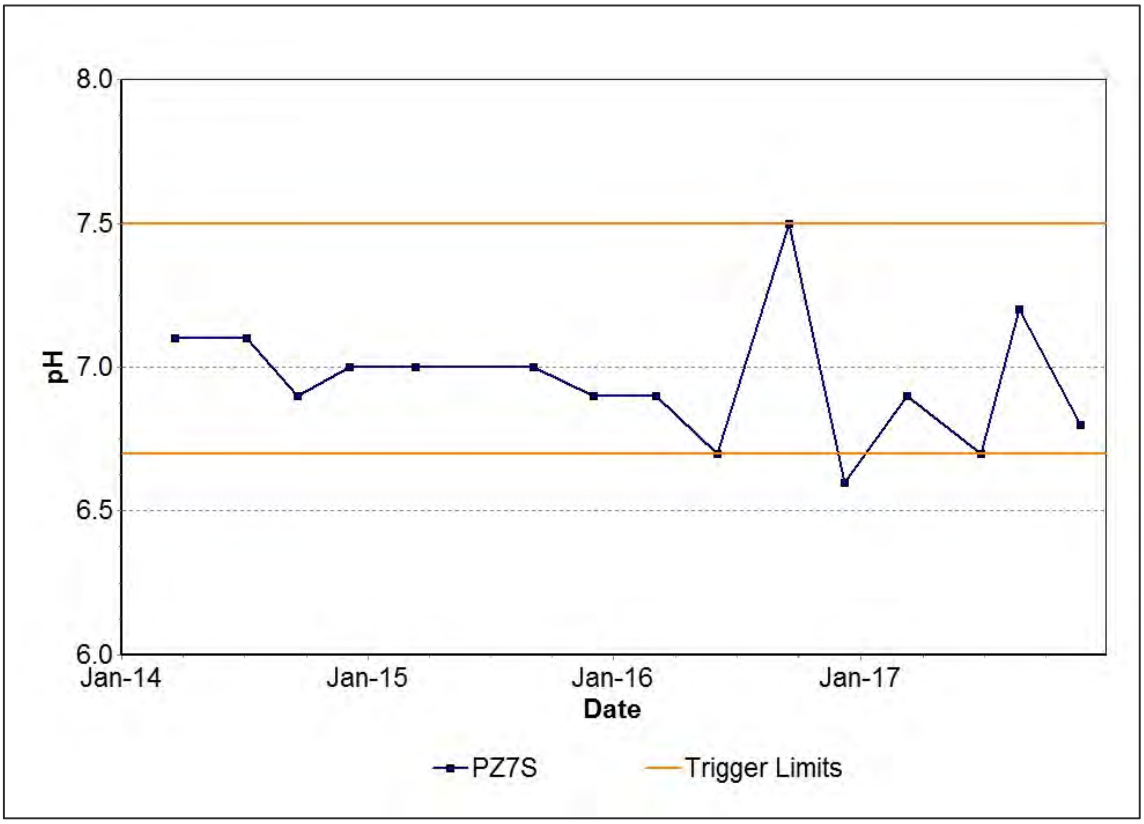

FIGURE 75 : AEOLIAN WARKWORTH SANDS GROUNDWATER pH TRENDS 2014 TO 2017

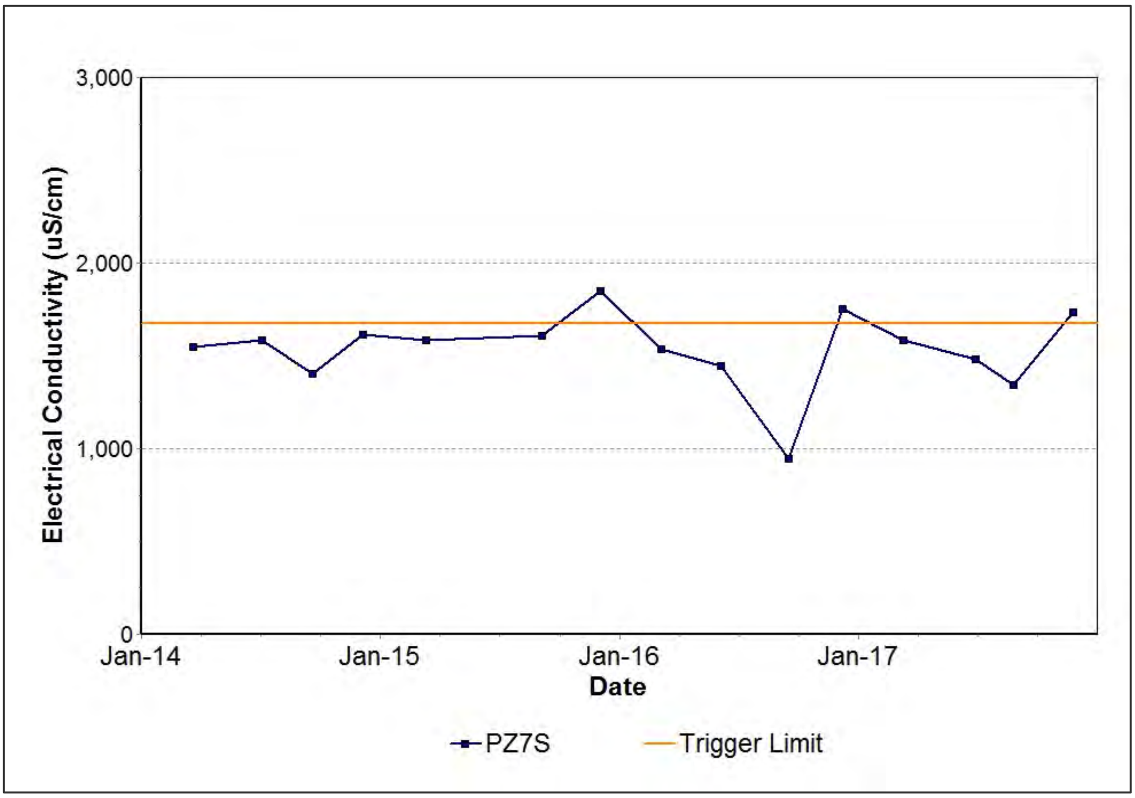

FIGURE 76: AEOLIAN WARKWORTH SANDS GROUNDWATER EC TRENDS 2014 TO 2017

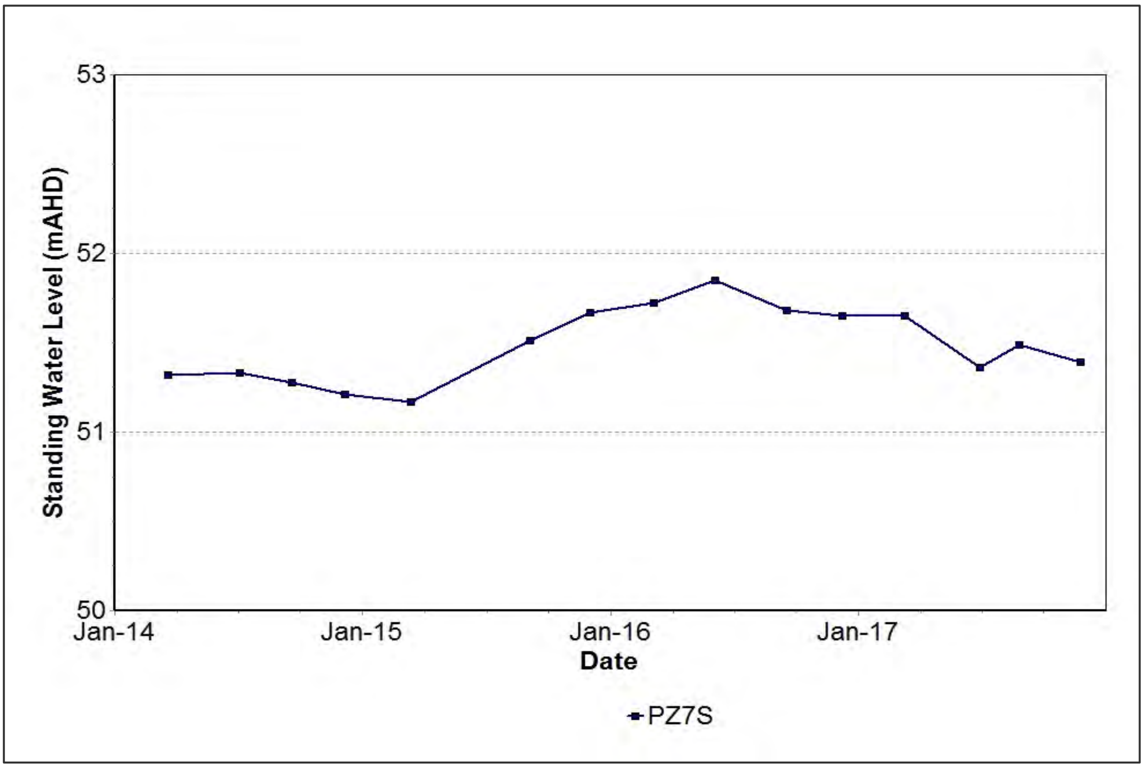

FIGURE 77: AEOLIAN WARKWORTH SANDS GROUNDWATER SWL TRENDS 2014 TO 2017

7.4.3.12 Audits and Reviews

An independent environmental audit of the Mount Thorley Operations and Warkworth Mining Operations was undertaken in May 2017. There were two findings related to water flow devices. A summary detailing the findings of this audit can be found on Yancoal's public website (https://insite.yancoal.com.au/document-library/audits-mtw).

8. REHABILITATION

Rehabilitation progress has been compared to the MOP that was current at the end of the reporting period (MTW MOP 2015-2021 approved 5th February 2016).

8.1 SUMMARY OF REHABILITATION

A total of 124 ha rehabilitation was undertaken during 2017 against a MOP target of 107.1 ha. Total disturbance undertaken during 2017 was 74.9 ha, slightly higher than the MOP projection of 72.8 ha. The disturbance during 2017 was made up of 40.4 ha of new disturbance and 34.5 ha of disturbance of previously rehabilitated area.

TABLE 39: KEY REHABILITATION PERFORMANCE INDICATORS

Mine Area Type	Previous Reporting Period (Actual) Year 2016 (ha)	This Reporting Period (Actual) 2017 (ha)	Next Reporting Period (Forecast) Year 2018 (ha)
A. Total mine footprint[2]	3,608.7	3,659.7	3,749.6
B. Total Active Disturbance[3]	2,499.5	2,468	2,499.7
C. Land being prepared for rehabilitation[4]	41.9	35.7	21.9
D. Land under active rehabilitation[5]	1,067.3	1,156	1,228
E. Completed rehabilitation[6]	0	0	0

[2] **Total mine footprint** includes all areas within a mining lease that either have at some point in time or continue to pose a rehabilitation liability due to mining and associated activities. As such it is the sum of total active disturbance, decommissioning, landform establishment, growth medium development, ecosystem establishment, ecosystem development and relinquished lands (as defined in DRE MOP/RMP Guidelines). Please note that subsidence remediation areas are excluded.

[3] **Total active disturbance** includes all areas ultimately requiring rehabilitation such as: on-lease exploration areas, stripped areas ahead of mining, infrastructure areas, water management infrastructure, sewage treatment facilities, topsoil stockpiles areas, access tracks and haul road, active mining areas, waste emplacements (active/unshaped/in or out-of-pit), and tailings dams (active/unshaped/uncapped).

[4] **Land being prepared for rehabilitation** – includes the sum of mine disturbed land that is under the following rehabilitation phases – decommissioning, landform establishment and growth medium development (as defined in DRE MOP/RMP Guidelines).

[5] **Land under active rehabilitation** – includes areas under rehabilitation and being managed to achieve relinquishment – includes the following rehabilitation phases as described in the DRE MOP/RMP Guidelines – "ecosystem and land use sustainability" (revegetation assessed as showing signs of trending towards relinquishment OR infrastructure development).

[6] **Completed rehabilitation** – requires formal sign off by DRE that the area has successfully met the rehabilitation land use objectives and completion criteria.

8.1.1 Management

Performance criteria for each rehabilitation phase have been detailed in the Mining Operations Plan (MOP) for MTW. These criteria have been developed so that the rehabilitation success can be quantitatively tracked as it progresses through the phases outlined below:

- Stage 1 – Decommissioning
- Stage 2 – Landform Establishment
- Stage 3 – Growing Media Development
- Stage 4 – Ecosystem and Land use Establishment
- Stage 5 – Ecosystem and Land use Sustainability
- Stage 6 – Rehabilitation Complete

The performance criteria are objective target levels or values that can be measured to quantitatively demonstrate the progress and ultimate success of a biophysical process. A monitoring methodology has been developed to measure the performance criteria outlined in the MOPs utilising a combination of tools that provide quantitative data to assess changes occurring over time.

The target levels or values have been based on monitoring results from reference sites and were detailed in a Mining Operations Plan (MOP) Amendment submitted to Division of Resources and Geoscience (DRG) in October 2017. The results of the rehabilitation monitoring programme for native vegetation areas (presented in Appendix 5) have been compared against the target levels to determine if rehabilitation has been successful or if additional intervention is needed.

Ecologists from Niche Environment and Heritage commenced monitoring of rehabilitated land returned to native vegetation in 2015. The results of monitoring conducted in early and mid 2017 are presented in Appendix 4. Monitoring was conducted across 12 reference sites within the two target vegetation communities Central Hunter Grey Box-Ironbark Woodland EEC, and Ironbark-Spotted Gum-Grey Box Forest EEC. The 2017 monitoring program revisited 16 of the 17 sites monitored in 2016 to check the consistency of the monitoring results from successive years. The 2017 monitoring program also established 8 new monitoring sites at MTW. Additional monitoring methods were incorporated into the 2017 program to measure the density, health and growth of canopy species. Sites were selected to include rehabilitation of varying ages and different rehabilitation methods.

8.2 DECOMMISSIONING

Capping of the Interim Tailings Storage Facility continued during 2017 using breaker rock from the South CHPP. A capping of inert spoil will be placed over the breaker rock before rehabilitating the area.

During 2017, capping of Tailings Dam 2 commenced using small contractor-owned equipment to place selected mine spoil in layers across the tailings dam surface. Capping work was suspended during 2017 due to settlement cracking occurring in an area where the tailings surface had low strength. Further geotechnical studies have been undertaken by Australian Tailings Consultants in order to design an alternative capping method that will allow capping work to safely recommence in 2018.

8.3 REHABILITATION PERFORMANCE

Table 40 summarises actual rehabilitation and disturbance completed compared with the rehabilitation commitments in the MTW MOP. Appendix 3 provides the Annual Rehabilitation Report Form, including rehabilitation progress for each domain through the rehabilitation phases.

The area of rehabilitation that was sown during the reporting period exceeded the combined MOP target for Mt Thorley and Warkworth by 16.9ha. The area of rehabilitation disturbance however exceeded the MOP target for MTW by 10.9ha, leading to a net rehabilitation result for 2017 that was 6ha in front of the MOP commitment. The net rehabilitation result over the MOP period (2015 to 2017) is 218.8ha versus a MOP commitment of 229.3ha, lagging by 10.5ha.

The amount of new disturbance undertaken in 2017 was approximately 20ha higher than the MOP projections. However, the cumulative new disturbance over the period of the current MOP is still approximately 40ha lower than the projected disturbance, mainly due to the clearing for the Rural Fire Service Road being delayed. This road will be used for emergency access by the RFS when Wallaby Scrub Road is closed. Clearing for the RFS road construction is scheduled to occur in 2018 after approval is gained to close Wallaby Scrub Road.

The 2017 rehabilitation areas for MTW are shown in Appendix 2.

TABLE 40: REHABILITATION AND DISTURBANCE COMPLETED IN 2017

MOP	Pit Area	2017 Totals (ha)		Cumulative Totals During MOP Period* (ha)	
		Actual	MOP Commitment	Actual	MOP Commitment
Rehabilitation					
MTW	Mt Thorley	55.1	44.9	91.6	63.2

	Warkworth	68.9	62.2	193	202.2
	MTW Total	**124.0**	**107.1**	**284.6**	**265.4**
Rehabilitation Disturbance					
MTW	Mt Thorley	14.0	19.4	19.0	23.9
	Warkworth	20.5	4.2	46.8	12.2
	MTW Total	**34.5**	**23.6**	**65.8**	**36.1**
New Disturbance					
MTW	Mt Thorley	5.0	0	6.6	0.4
	Warkworth	35.3	20.1	155.5	202.2
	MTW Total	**40.3**	**20.1**	**162.1**	**202.6**
Net Rehabilitation (Rehabilitation minus Rehabilitation Disturbance)					
MTW	Mt Thorley	41.1	25.5	72.6	39.3
	Warkworth	48.4	58	146.2	190
	MTW Total	**89.5**	**83.5**	**218.8**	**229.3**

Note: Rehabilitation areas relate to areas at or past the phase of Ecosystem and Landuse Establishment.
*** MOP Period is 2015 - 2021**

Progressive rehabilitation commitments are outlined in the Warkworth Continuation 2014 and Mt Thorley Operations 2014 Environmental Impact Statements. These documents modelled a total of 767 ha of rehabilitation would be complete by 2014, and a further 336 ha would be completed in the period 2015 to 2017, making a modelled total at the end of 2017 of 1,103ha. At the end of the reporting period there had been 1,156 hectares of rehabilitation completed across MTW, 53ha ahead of the EIS forecasts.

The South Pit South Accelerated Rehabilitation Plan was prepared in 2014 to address lagging rehabilitation in the South pit area of Warkworth. The Plan details how rehabilitation in this area will progress between 2014 and 2018. For the period 2014 to 2017 the Plan committed to 124.7 ha of rehabilitation being completed. The actual rehabilitation amounts to 158.8 ha, which is 34.1 ha ahead of the planned progress.

8.3.1 Rehabilitation Programme Variations

There were no variations to the rehabilitation programme during the reporting period.

8.4 REHABILITATION TRIALS

A trial was undertaken in the South Pit South area of MTW to investigate methods that could potentially improve the germination and establishment of native plants, particularly in areas that have been previously stabilised with exotic cover crops. The trial investigated various combinations of the following methods:

Compost application: secondary application of composted green waste;

Soil amelioration and seed bed preparation: ripping, aerating and application of Cal-S;

Inoculant and growth promotant application: bacteria and fungi dominated inoculants, germination and growth promotants.

The dry end to 2017 has meant that little germination has occurred on this trial area to date, however monitoring of this trial site will be conducted following rain in 2018.

8.4.1 Rehabilitation Maintenance

Management of rehabilitated areas is undertaken when required or when issues are identified through monitoring, auditing or inspections. Rehabilitation maintenance activities are described further in the sections below.

A licence agreement is in place for grazing 90 ha of Warkworth North Pit North rehabilitation area.

Post rehabilitation broadacre weed control

Broadacre weed treatment within rehabilitation areas is undertaken using agricultural methods comprising boom sprays and wick wipers. In existing rehabilitation areas boom spraying is primarily used to manage cover crop and fallow areas prior to sowing to final native seed mixes. Pre-emergent application of herbicide is occasionally necessary to control emerging weeds in the period between sowing and germination of the desired plants. Wick wiping targets rapidly growing exotic grasses and other erect growing weeds in the period following native germination but while desirable species remain below the wiper target zone. During 2017 areas totalling 312.3ha of existing rehabilitation received boom and/or wick wiper treatment (Figure 78).

Hand spraying and manual removal of weeds is also undertaken in rehabilitation areas with establishing native vegetation. These activities are described in Section 8.7 Weed Control.

Stem Thinning

Thinning of tree stems is undertaken in developing stands of native vegetation to reduce stem densities, manage species compositions and control over-shading. Where monitoring indicates that the density of overstory species is excessive, thinning is used as an intervention to maintain rehabilitation areas on the desired trajectory. The following herbicide application methods are utilised at MTW for stem thinning: cut and paint (using brushcutters and chainsaws), basal bark and splatter gun. During 2017, areas totalling 10.3ha of existing rehabilitation received stem thinning maintenance (Figure 78).

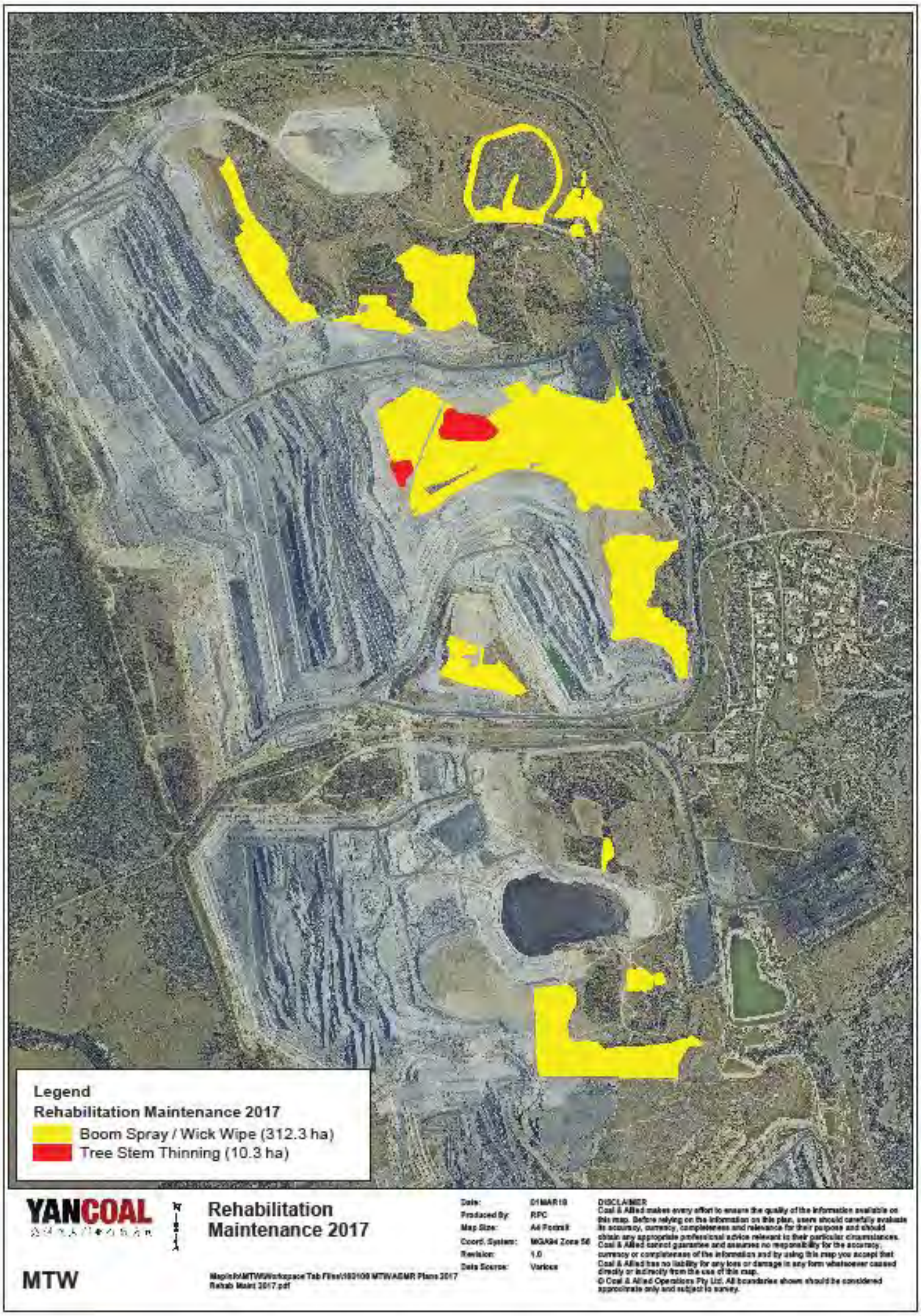

FIGURE 78: 2017 REHABILITATION MAINTENANCE LOCATIONS

8.5 TOPSOIL MANAGEMENT

Topsoil is managed according to Coal & Allied Ground Disturbance Permit and land management procedures outline the topsoil used and stockpiled during 2017. There were 110.6 ha of rehabilitation top soiled during 2017, using stockpiled and pre-stripped soil resources.

TABLE 41: SOIL MANAGEMENT

Soil Used This Period (m^3)	Soil Prestripped This Period (m^3)	Stockpile Inventory to Date (m^3)	Stockpile Inventory Last Report (m^3)
110,600	**74,900**	**639,824**	**675,524**

8.6 TAILINGS MANAGEMENT

Detail of capping activities on tailings storage facilities at MTW is covered in Appendix 1. Minimising the amount of standing water on tailings storage facilities, by managing the decant water, is important during and post tailings deposition to assist with closure of these facilities. Effective removal of decant water enables better consolidation of the tailings material, which in turn facilitates earlier capping and rehabilitation of the storage facility. Table 42 below outlines the current state of decant water pumping infrastructure across the active and inactive TSF's at MTW.

TABLE 42: TAILINGS MANAGEMENT

Facility	Status	Decant System
Centre Ramp TSF	Active	Decant pumps in place, regular pumping
Abbey Green South	Active	Decant pumps installed as required due to infrequent filling regime.
TD2	Inactive	Diesel Pump in place
Interim TSF	Inactive	Floating solar pump installed
Ministrip TSF	Inactive	Diesel Pump in place, pumping as required

8.7 WEED CONTROL

8.7.1 Weed Treatment

The weeds identified at MTW occur primarily in areas that have been disturbed such as post mining rehabilitation areas, previous civil works areas, soil stockpiles, water management structure surrounds, and general areas of minor ground disturbance. A total of 78 days of weed management work was undertaken on site at MTW during 2017, with 430 ha of land treated, including maintenance of access tracks and environmental monitoring points. The weeds targeted during the 2017 weed management programme were based on the results of the 2016 weed survey. Figure 79 illustrates the target species and weed treatment areas across MTW.

Weed treatment areas are assessed following the completion of periods of work to determine the effectiveness of control works.

The species focussed on during treatment included:

- African Boxthorn *(Lycium ferocissimum)*
- Galenia *(Galenia pubescens)*
- Lantana *(Lantana Camara)*
- Mother of Millions *(Bryophyllum delagoense)*
- Opuntia *(Pear) species (Tiger, Prickly and Creeping Pear)*
- St John's Wort *(Hypericum perforatum)*

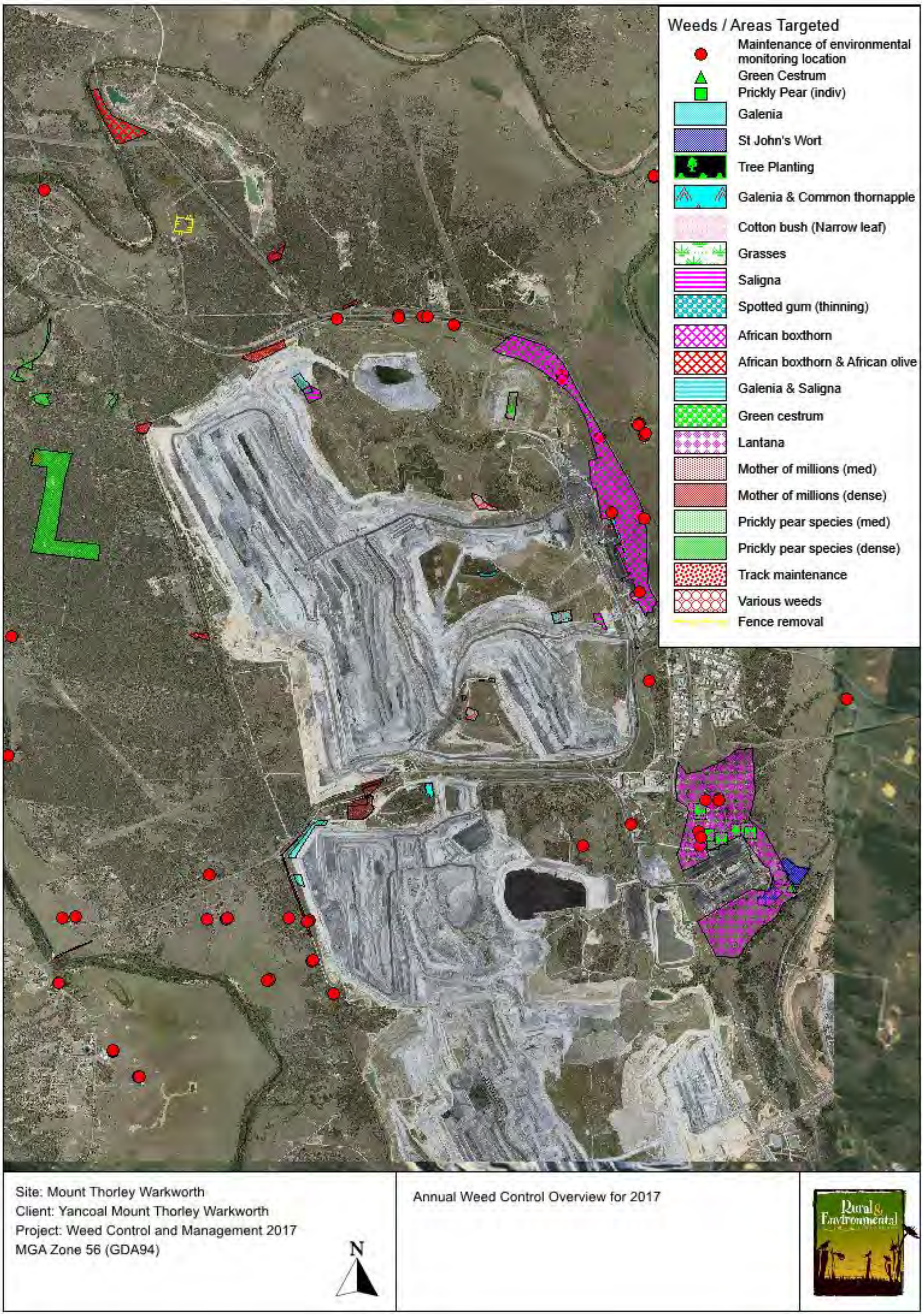

FIGURE 79: ANNUAL WEED CONTROL OVERVIEW FOR 2017

8.7.2 Annual Weed Survey

The management and control of weeds at MTW is governed by the Annual Weed Survey (AWS). The AWS lists Weeds of National Significance (WONS), noxious, environmental and other non-declared weed species identified across MTW, and provides a framework to allow for structured weed management and control across operational and non-operational areas of MTW.

The following summarises the results of the weed survey undertaken during December 2017, from 2018 all reports and surveys will be based upon the NSW Biosecurity Act 2015 which came into force from 1 July 2017 and repealed 14 Acts including the Noxious Weeds Act 1993. The new legislation has resulted in the development of the Hunter Regional Strategic Weed Management Plan 2017-2022 which covers the area occupied by MTW.

Seven WONS were identified during the survey, they included:

- African Boxthorn (*Lycium ferocissimum)*
- Bitou bush (*Chrysanthemoides monilifera subspecies rotundata)*
- Fireweed *(Scenecio madagascariensis)* – very sparse
- Lantana (*Lantana camara*)
- Pear Species,
    - Creeping Pear (Opuntia humifusa)
    - Prickly Pear Opuntia stricta)
    - Tiger Pear (Optunia aurantiaca)

Four other noxious weeds were identified at MTW during the survey, including:

- Mother of Millions *(Bryophyllum delagonese)*
- St Johns Wort *(Hypericum perforatum)*
- Xanthium species including
    - Bathurst burr (*Xanthium spinosum*)
    - Noogoora burr (*Xanthium occidentale*)

Seven environmental weed species were identified at MTW during the survey, they included:

- African Olive *(Olea europea subspecies cuspidae)*
- African lovegrass *(Eragrostis curvulva)*
- Blue heliotrope (*Heliotropium amplexicaule*)
- Castor Oil Plant *(Ricinus communis)*
- Common thornapple *(Datura stromonium)*
- Galenia (*Galenia pubescens)*
- Scotch Thistle (*Onopordum acanthium),*

Fourteen weeds that are not officially declared or listed were also recorded at MTW including:

- Aloe Vera (*Aloe vera*)
- Blackberry nightshade (*Solanum nigram)*
- Century plant (*Agave americana*)
- Farmers friends (*Bidens pilosa)*
- Golden wreath wattle or Saligna (*Acacia saligna)*
- Inkweed (Phytolacca octandra)
- Mustard weed (*Sisymbrium sp)*
- Narrow Leaved cotton bush (Gomphocarpus fructicosus)
- Spiny Rush (Juncas acutus)
- Tree Tobacco (Nicotiana glauca), and
- Wild Rose (Rosa species)
- Redroot pigweed (*Amaranthus retroflexus*)
- Rhodes grass (*Chloris gayana Kunth)*
- Stinking Roger (*Tagetes minuta)*

Species identified during the 2017 survey will form the basis of ongoing weed management works during 2018.

8.8 VERTEBRATE PEST MANAGEMENT

As part of MTW's Vertebrate Pest Action Plan a baiting programme is carried out on a seasonal basis. Three 1080 ground baiting programmes consisting of 60 bait sites utilising meat baits and ejector baits were undertaken during summer, winter and spring, to target wild dogs and foxes. Baits were checked over a three week period and replaced each week when taken.

Table 43 summarises the results from the programmes carried out at MTW during 2017 with baiting locations and results for the programmes are illustrated in Figure *80*.

TABLE 43: VERTEBRATE PEST CONTROL SUMMARY

Season	1080 Baiting			Trapping	Shooting			
	Total Lethal Baits Laid	Takes by Wild Dog	Takes by Fox	Wild Dog	Feral Pigs	Hares	Foxes	Rabbits
Summer	120	61	5	-	-	-	-	-
Autumn - Winter	120	63	3	1	2	25	-	5

Spring	120	64	5	-	3	15	6	6
Total	**360**	**188**	**13**	**1**	**5**	**40**	**6**	**11**

Additional pest management programmes included:

- Soft Jaw trapping across MTW: one wild dog trapped and euthanized.
- Opportunistic shooting of vertebrate pests: five pigs, 40 hares, six foxes and 11 rabbits were euthanized.

MTW will continue to carry out quarterly vertebrate pest control programmes during 2018 to limit feral pest impacts on landholdings and surrounding neighbours.

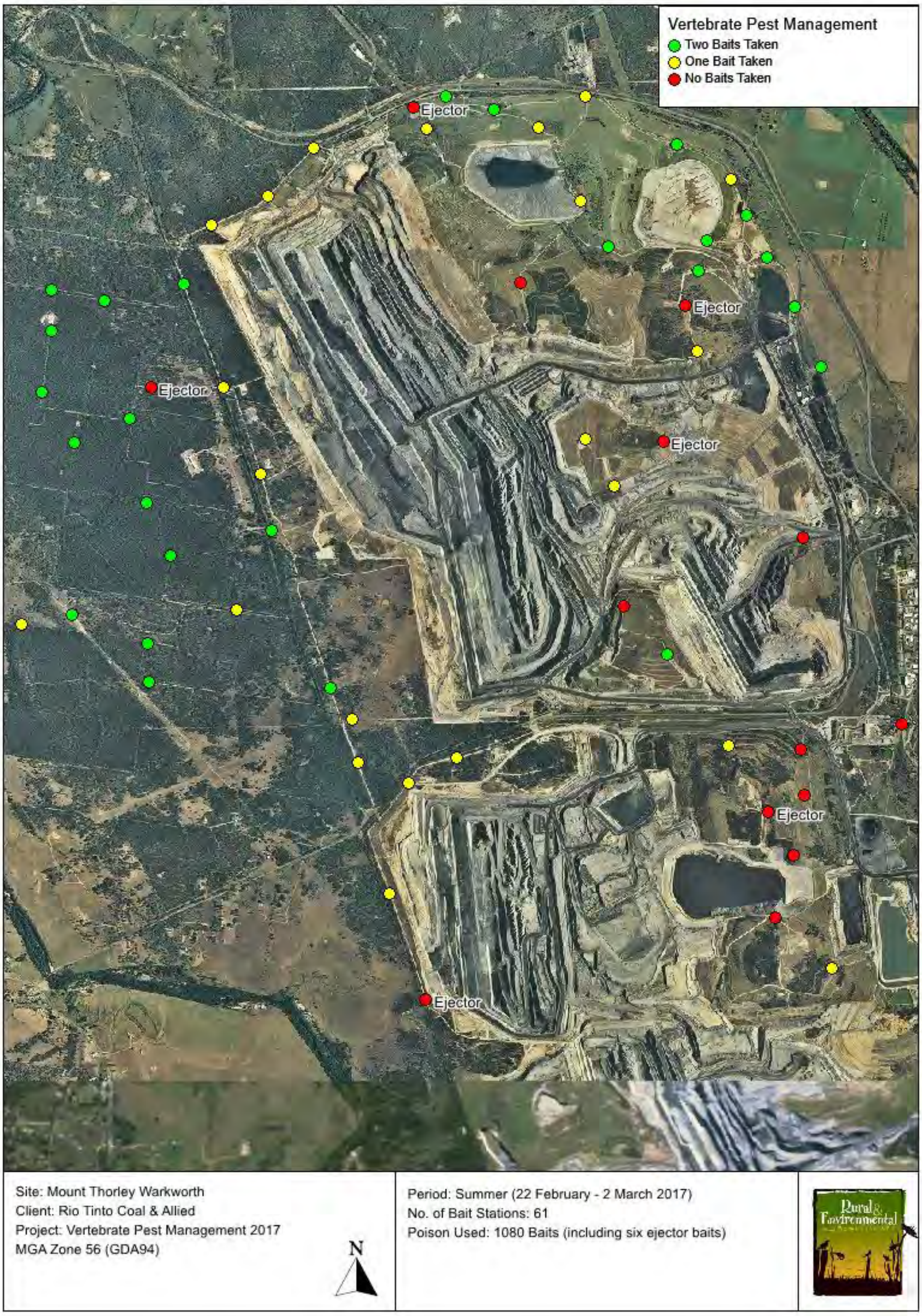

FIGURE 80: BAITING STATION LOCATIONS AND RESULTS AT MTW DURING THE SUMMER 2017 VERTEBRATE PEST MANAGEMENT PROGRAMME

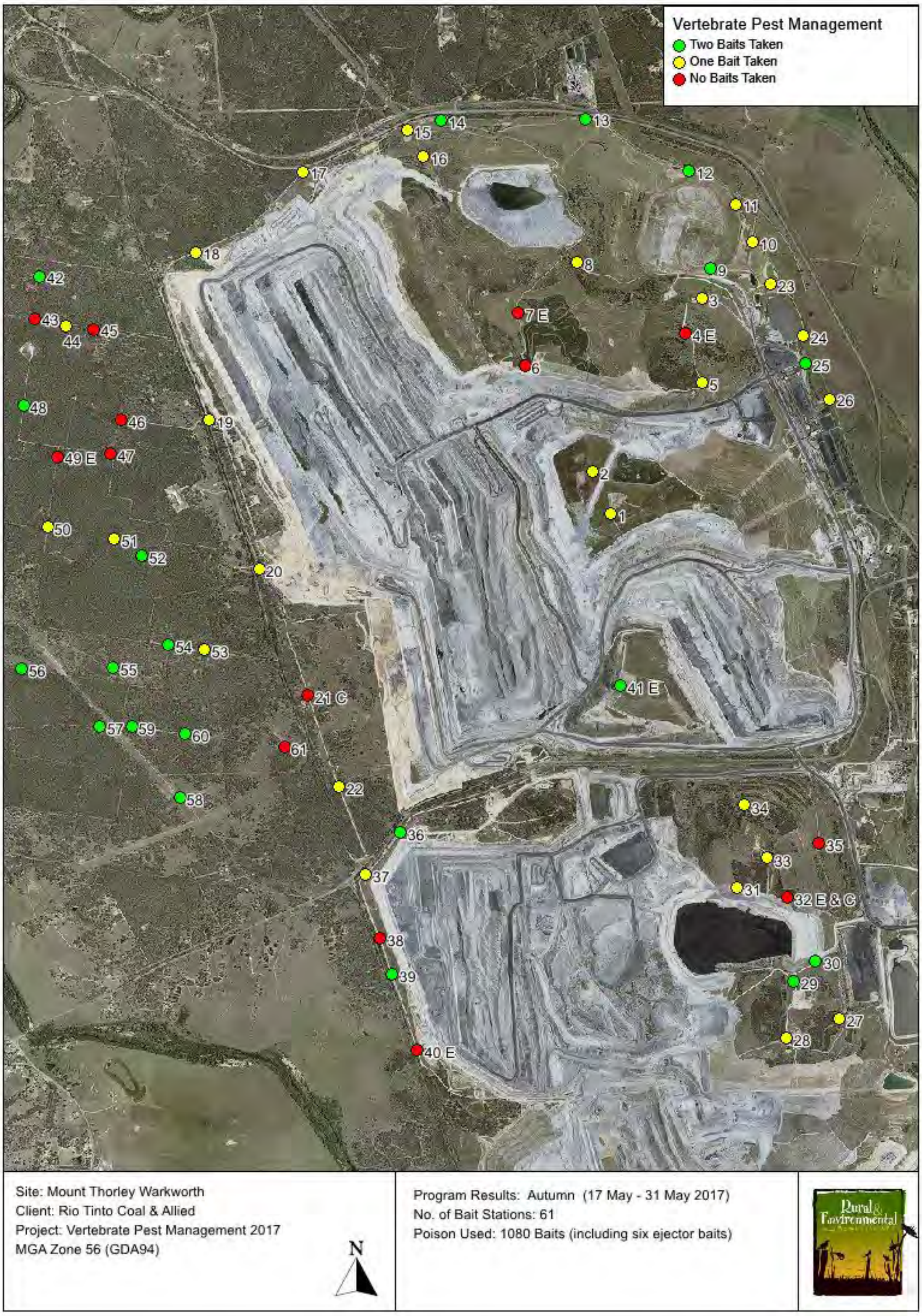

FIGURE 81: BAITING STATION LOCATIONS AND RESULTS AT MTW DURING THE AUTUMN 2017 VERTEBRATE PEST MANAGEMENT PROGRAMME

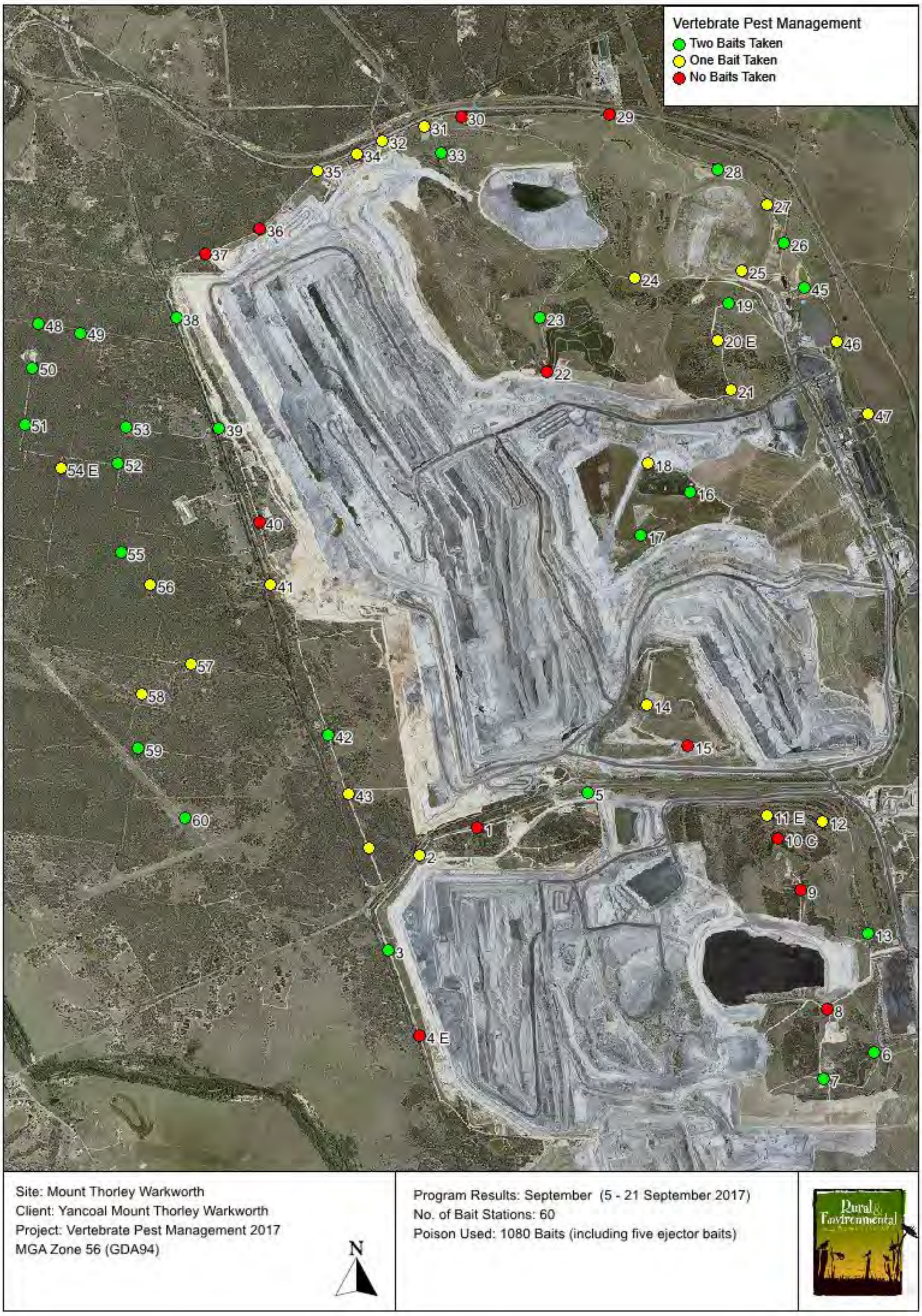

FIGURE 82: BAITING STATION LOCATIONS AND RESULTS AT MTW DURING THE SPRING 2017 VERTEBRATE PEST MANAGEMENT PROGRAMME

8.9 BIODIVERSITY OFFSETS

8.9.1 Management

The Warkworth Mine's impacts on biodiversity values are offset through the protection and management of Biodiversity Areas (BAs). The BA's that are related to MTW illustrated in Figure 83 and also listed in Table 46 below:

TABLE 44: MTW BIODIVERSITY AREAS

Biodiversity Area	Offset Area (ha)	Environmental Approvals				Offset Feature/s
		State Govt.		Federal Govt.		
		NSW 2013	NSW 2014	EPBC 2002/629	EPBC 2009/5081	
Southern	986	211	775		94	Warkworth Sands Woodland; Central Hunter Grey Box – Ironbark Woodland; Habitat for Swift Parrot, Regent Honeyeater, Southern Myotis and Large-eared Pied Bat.
Northern	341	39	302		341	Warkworth Sands Woodland; Central Hunter Grey Box – Ironbark Woodland; Habitat for Swift Parrot, Regent Honeyeater, Southern Myotis and Large-eared Pied Bat.
North Rothbury	41		41		41	North Rothbury Persoonia
Goulburn River (MTW Portion)	1,066		1,066	1,066		Central Hunter Valley Eucalypt Forest (CHVEF); Ironbark/Strinybark Communities; Box shrubby/grassy Woodlands; Habitat for Swift Parrot and Regent Honeyeater
Bowditch	602		602	520	82	CHVEF; Ironbark/Strinybark Communities; Habitat for Swift Parrot and Regent Honeyeater

Putty	383				383	CHVEF; Habitat for Swift Parrot and Regent Honeyeater
Seven oaks	519				519	CHVEF; Habitat for Swift Parrot and Regent Honeyeater
Condon View (MTW Portion)	345				345	CHVEF; Habitat for Swift Parrot and Regent Honeyeater

The MTW BA's are managed in accordance with the Local, Putty Road, and Regional Offset Management Plans (OMPs). These Offset Management Plans were superseded with new site specific plans in 2017.

The OMPs provides the management framework for the entire BAs and their Offset Areas, as in some cases the entire BA is not an Offset Area, to enhance the biodiversity values through the implementation of conservation management strategies. All of the OMPs are available on the Yancoal Portal.

FIGURE 83: MTW BIODIVERSITY OFFSET LOCALITY MAP

8.9.2 Biodiversity Area Management Activities

The OMPs describe the Conservation Management Strategies. The following are the key actions completed throughout 2017 across all the BAs:

Weed Control

Weed control at the Local BAs targeted Turkey Rhubarb *(Acetosa sagittata),* Tree of Heaven *(Ailanthus altissima*), Balloon Vine *(Cardiospermum grandiflora),* Mother of Millions *(Bryophyllum delagonese),* Green Cestrum *(Cestrum parqui)*, Lantana *(Lantana camara),* and African Boxthorn *(Lycium ferocissimum).*

Weed control at the Regional BAs targeted African Boxthorn *(Lycium ferocissimum),* Prickly Pear *(Opuntia species)*, Narrow leaf cotton bush *(Gomphocarpus fruticosus),* Blackberry *(Rubus fruticosus)*, Scotch thistle *(Onopordum acanthium),* Stinging nettles *(Urtica dioica),* Blackberry *(Rubus fruticosus),* Blackberry *(Rubus fruticosus),* Green cestrum *(cestrum parqui),* St John's wort *(Hypericum perforatum),* Tree of heaven *(Ailanthus altissima),* Caltrop or cat heads *(Tribulus terrestris)*, Mallow *(Malva parviflora),* African Olive *(Olea europaea subspecies cuspidate)*, Lantana *(Lantana camara),* Sweet briar *(Rosa rubiginosa),* and Nagoora Burr *(*Xanthium strumarium*)*.

Infrastructure Management and Improvement

Fence repairs and new sections of boundary fence were constructed at the Southern BA, Goulburn River BA and North Rothbury BA. Internal fences and waste were removed from the Southern BA areas to be planted in 2018. A farm dump site was cleaned up and asbestos and building waste from a derelict house and sheds were removed from the Goulburn River BA. New Biodiversity Area signs were installed and monthly property inspections were undertaken on all MTW BAs.

Incidents

Trespassing and illegal tree clearing and timber getting within the Southern Biodiversity Area resulted in felling approximately 40 full sized trees and 100 small trees. This unauthorised activity was reported to both Department of Environment and Energy and Department of Planning and Environment in October 2017.

Fire Management

The Regional Offset Bushfire Management Plan and the Warkworth Bushfire Management Plan were reviewed and updated. Slashing of fire breaks was undertaken on the Southern BA and Goulburn River BA.

Strategic Grazing

No strategic grazing was undertaken in the BAs in 2017.

Vertebrate Pest Management

Three 1080 ground baiting programmes were undertaken across the Biodiversity Areas targeting wild dogs and foxes. Baits were checked over a three week period and replaced each week when taken. Baiting in the Local BAs was undertaken in conjunction with baiting on site and occurred seasonally. Additional baiting programmes included Condon View and Putty BA in autumn and all Regional BAs in spring. Table 46 summarises the results from the programmes carried out on the BA's during 2017.

TABLE 45: SUMMARY OF VERTEBRATE PEST MANAGEMENT 2017

Season	1080 Baiting			Trapping		Shooting					
	Total Lethal Baits Laid	Takes by Wild Dog	Takes by Fox	Wild Dog	Fox	Feral Pig	Feral Cat	Fox	Deer	Hares	Rabbit
Summer	108	44	2	-	-	-	1	2	-	6	7
Autumn - Winter	162	59	2	6	2	8	-	1	-	-	-
Spring	260	101	24	-		1	-	-	4	4	-
Total	**530**	**204**	**28**	**6**	**2**	**9**	**1**	**3**	**4**	**10**	**7**

ADDITIONAL PEST MANAGEMENT PROGRAMMES INCLUDED:

- Soft Jaw trapping across Wandewoi and Goulburn River BA: six wild dogs and two foxes trapped and euthanised.
- Sixty Five feral cattle were mustered and removed from the Goulburn River BA.
- Noisy Miner ground shoot at the Goulburn River BA to assist the survivability of the Regent Honeyeater: 350 Noisy Miners controlled under NPWS Section 120/121.
- Opportunistic shooting of other vertebrate pests.
- Rabbit poisoning, 5850g out of 8000g of 1080 poison carrot was consumed at the Southern and Northern BA

Vertebrate pest management programmes will continue to be carried out during 2018 to limit feral pest impacts on landholdings and surrounding neighbours.

Seed Collection

Seed collection was undertaken by contractors in the Northern and Southern BAs during 2017, focussing on the WSW and Ironbark vegetation community. Tube stock for future plantings is currently being propagated from the seed collected. Seed collection was also undertaken on the Goulburn River BA for Yellow Box – Grey Box – Red Gum grassy woodland and River Oak riparian woodland with planting scheduled for 2019.

Revegetation

MTW has committed to restoring the Endangered Ecological Communities of Warkworth Sands Woodland and Central Hunter Grey Box – Ironbark Woodland in the Southern and Northern Biodiversity Areas. Work commenced in 2014 to restore over 80 hectares of Warkworth Sands Woodland, this involved the planting of seedlings and the relocation of sand salvaged ahead of mining activities.

In 2017, planting works continued in the Northern Biodiversity Area, with over 10,800 seedlings planted. Topsoil from ahead of mining operations at MTW was salvaged and hauled to the Biodiversity Area prior to planting commencing. In total there were 44 patches established, ten received 50mm of topsoil over the patch, two received 50mm of topsoil over half the patch, 12 received 25mm of topsoil over the patch and ten received no topsoil.

The team dug holes for each seedling, either by hand or auger, into 50x50m patches. All plants were watered, fertilised and protected with a tree guard. Within these patches the seedlings were planted at a close spacing to create "stepping stones" between existing remnant vegetation. When these patches grow they will create shelter to support natural regeneration in surrounding areas and over time all of these areas will connect together and create a better habitat for native plants and animals.

Restoration activities also included planting Central Hunter Grey Box – Ironbark Woodland in a small area of the Northern BA and 89 ha of the Southern BA with over 13,000 seedlings planted into rip lines. The site preparation for these sites included ripping by dozer and weed control. The team planted the seedlings into rip lines. To mimic nature the tree species were planted at a spacing of 5 -10m and shrubs species planted in clumps as commonly found with understory species within this vegetation type. All plants were watered, fertilised and protected with a tree guard.

The next round of planting is planned for Autumn 2018. Overall there is more than 500 hectares of grassland area to be planted and managed over 15 years to restore these Endangered Ecological Communities.

FIGURE 84: TUBE STOCK PLANTED INTO ONE OF THE PLOTS IN THE NORTHERN BIODIVERSITY AREA

FIGURE 85: TUBE STOCK PLANTED INTO RIP LINES AT THE SOUTHERN BIODIVERSITY AREA

8.9.3 Audits and Reviews

An Independent Environmental Audit was conducted during 2017 to fulfil the requirements of the Mt Thorley and Warkworth Development Consents (SSD-6464 and SSD-6465). The audit focused on the site's compliance with licences, approvals and management plans (including those associated with biodiversity offsets). The audit team from Jacobs were approved by DP&E and OEH prior to conducting the audit. A total of 1,512 conditions and commitments were assessed as part of this audit which identified 7 issues resulting in 14 non-compliances (3 of the non-compliances were administrative).

The next MTW Independent audit is due is 2020.

9. COMMUNITY

9.1 COMPLAINTS

A total of 382 complaints were recorded during the reporting period, down 17.5% compared to 2016. The 382 complaints were registered by 51 people, 53% were received from 6 individuals. Most complaints were received from Bulga residents, making up 88% of the complaints record, 22 Complainants remained anonymous and therefore no location could be assigned. A breakdown of complaints by type is shown in Noise remains of key concern for near neighbours. There has been a trending decrease (overall 39%) in noise complaints from 2015. The decrease experienced in 2017 is primarily attributed to full noise attenuation of the truck fleet. MTW continues to comprehensive noise monitoring programme and, noise Trigger Action Response Plan.

TABLE 46.

Noise remains of key concern for near neighbours. There has been a trending decrease (overall 39%) in noise complaints from 2015. The decrease experienced in 2017 is primarily attributed to full noise attenuation of the truck fleet. MTW continues to comprehensive noise monitoring programme and, noise Trigger Action Response Plan.

In summary:

- 42% reduction in noise complaints;
- Lighting and Dust related complaints have doubled in 2017 compared to 2016. 53% of lighting complaints from 2 individual complainants;
- Complaints in the "Other" category decreased from 2016 by 47%, however were still significantly higher than the 2015 statistics. Complaints in this category were primarily in regard to road closures for blasting.

The level of complaints received from Bulga residents remains elevated (despite improvements in noise management and a demonstrated high level of compliance in this area). Noise remains of key concern for near neighbours. There has been a trending decrease (overall 39%) in noise complaints from 2015. The decrease experienced in 2017 is primarily attributed to full noise attenuation of the truck fleet. MTW continues to comprehensive noise monitoring programme and, noise Trigger Action Response Plan.

TABLE 46: SUMMARY OF COMPLAINTS BY TYPE FOR 2015 TO 2017

Complaint type	2017	2016	2015
Noise	191	325	492
Blasting	68	65	54
Dust	80	38	62

Lighting	33	16	44
Water	0	0	0
Other	10	19	3
Total	**382**	**463**	**655**

9.2 REVIEW OF COMMUNITY ENGAGEMENT

9.2.1 Communication

Quarterly letters are sent to MTW's near neighbours to provide an overview of mining operations and other relevant activities, as well as inform residents about how impacts are being managed. In addition, Coal & Allied issues correspondence to specific near neighbours who may be affected by certain changes, to inform of upcoming consultation activities and as a feedback mechanism. In 2017, this included communication relating to:

- Social Impact Management Plan community consultation and feedback
- Third Crossing of Putty Road project
- MTW rehabilitation tour
- Company ownership changes

During September, MTW hosted a number of residents on a tour of Warkworth Rehabilitation and Warkworth Sands Woodlands restoration project areas. In July MTW held a community consultation session for members of the Bulga, Milbrodale and surrounding communities to consider the draft MTW Social Impact Management Plan.

A range of consultation and engagement activities were also completed, including:

- Engagement and consultation with near neighbours to provide project updates at key project milestones and activities, and in response to concerns/queries raised by individual near neighbours
- Local Council briefings
- Participation in the Upper Hunter Mining Dialogue – a programme co-ordinated by the NSW Minerals Council to engage the community across the Hunter Valley

Yancoal also maintained a community shopfront in Singleton and were involved in various community events through sponsorship and participation.

9.2.2 Community Consultation Committee

The MTW CCC met on a quarterly basis to provide updates on operations and environmental performance. The Committee is comprised of MTW representatives, community members and other key external stakeholders, including Council. The MTW CCC minutes are made available on the Yancoal website (www. insite.yancoal.com.au).

Following CCC meetings a letter is mailed to near neighbours to update them about what was discussed at the meeting and to provide any additional information about MTW's operations. In 2017 CCC members were:

- Dr Col Gellatly
- Cr Hollee Jenkins
- Mr Adrian Gallagher
- Mrs Christina Metlikovec
- Mr Graeme O'Brien
- Mr Ian Hedley
- Mr Stewart Mitchell
- MTW General Manager – Mr Jason McCallum (from 1st September)
- Manager Environment & Community – Mr Andrew Speechly

9.3 COMMUNITY DEVELOPMENT

In 2017, Coal & Allied continued its focus on ensuring the long term sustainability of the communities in which it operates, through the facilitation of community development programmes such as:

- Coal & Allied Community Development Fund (CDF)
- Mount Thorley Warkworth Site Donations Committee
- Community partnership with Westpac Rescue Helicopter Service

9.3.1 Community Development Fund

The year 2017 marked 19 years of operation of the CDF, which has invested over $15 million to support over 120 community projects in the Hunter Valley since its establishment in 1999, across the areas of health, education, environment and economic development.

In 2014, Coal & Allied announced that a further $3 million[7] would be made available to the CDF over a three year period (2015 – 2017) for projects in the Singleton, Muswellbrook and Upper Hunter LGAs. Strategic priority areas were refined for the 2015-2017 funding cycle to enable a more targeted approach to addressing identified community need and to leverage other resources Coal and Allied may be able to offer to strengthen community partnerships.

Priority areas for the 2015-2017 funding cycle include (See figure 82 for allocations):

- Economic Development: encouraging the diversity and competitiveness of the Upper Hunter economy
- Community Health: Supporting projects which target health, safety and social wellbeing of the community
- Education: Promoting the value of education and building skills within our community

[7] With the sale of Bengalla Mine and the Mount Pleasant project the total available funding was revised to reflect the reduced footprint. The revised allocation was $2,166,000

- Environment and Land Management: Supporting projects that can make a difference on a greater scale. i.e. beyond C&A mining operations

In 2017, the CDF contributed more than $800,000 to 14 programmes (Table 47) aimed at delivering long term benefits for communities in the CDF catchment, which include the Singleton, Muswellbrook and Upper Hunter LGAs. Across the 2015 – 2017 funding cycle the CDF contributed more than $2.1 million to community development programmes.

TABLE 47: COAL & ALLIED COMMUNITY DEVELOPMENT FUND PROJECTS SUPPORTED IN 2017

Partner	Programme	Value
Sirolli Institute	Enterprise Facilitation	$45,000
Upper Hunter Where There's A Will Foundation	Positive Education Programme	$80,000
University of Newcastle	Science and Engineering Challenge, and SMART Programme (2015-2019)	$138,493
Upper Hunter Education Fund	HSC Study Camps and Upper Hunter Education Fund Scholarships (2015-2017)	$84,000
Singleton Business Chamber	Business Development Officer	$72,000
University of Newcastle	University of Newcastle Scholarships	$80,000
Outward Bound Australia	Youth Leadership Programme (2015-2017)	$245,332
Singleton Council	Singleton Economic Development and Funding Coordinator (2015-2017)	$100,000
Ungooroo Aboriginal Corporation	Health Services Programme (2017-2018)	$110,000
Bulga Rural Fire Service	Electronic Datasign	$24,500
Australian Christian College Singleton	STEM Lego Robotics Programme	$10,420
Jerrys Plains Public School	Ready 4 School Programme (2017-2018)	$58,000

Tocal College	Tocal Steers Challenge (2015-2017)	$25,725
Milbrodale Public School	Early Learning Programme (2017-2018)	$64,000

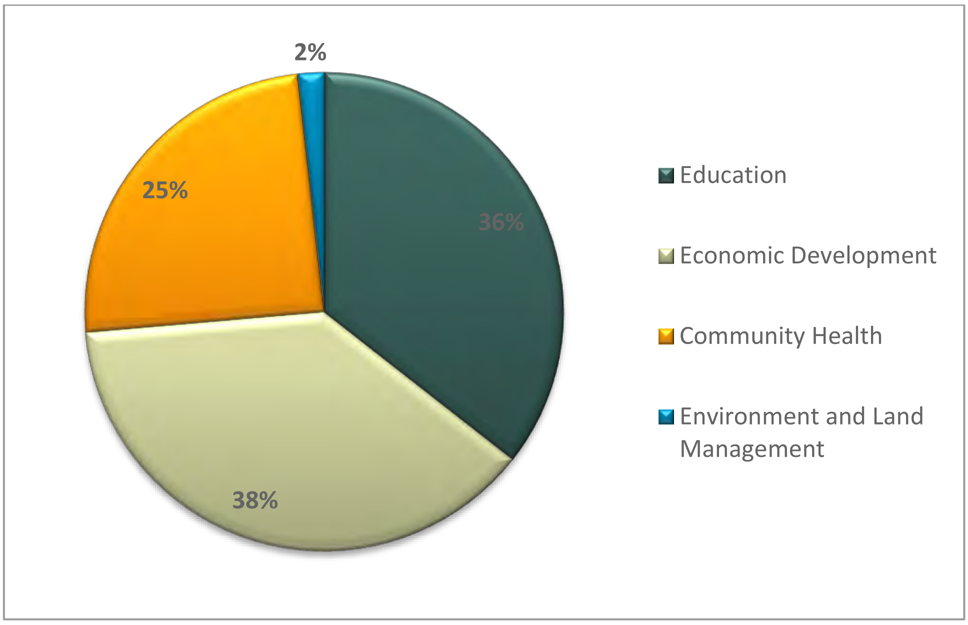

FIGURE 86: DISTRIBUTION OF COMMUNITY DEVELOPMENT FUND BY CATEGORY (2015 – 2017)

9.3.2 Site Donations

Coal & Allied considers applications for local donations and sponsorships that have a clear community benefit. In 2017, MTW provided $54,000 to 30 local projects and initiatives, including:

- Rotary Club of Singleton on Hunter - Singleton Art Prize
- Australian Families of the Military – Mental Health Retreat
- Wildlife Aid Inc.
- Singleton Business Chamber – International Women's Day event
- NSW Cancer Council – Singleton Relay for Life
- Singleton Junior Rugby League – Sporting equipment
- Singleton Junior Rugby League – 2017 season sponsorship
- Northern Agricultural Association Inc – 2017 Singleton Show
- Glendonbrook Hall Inc – Safety fencing for children's play area
- Singleton Pony Club – Repairs/upgrades to clubrooms
- Singleton Theatrical Society – 2017 production of 'Oliver Twist'
- Broke Fordwich Wine and Tourism Association – Little Bit of Italy festival
- Singleton Historical Society and Museum – Copier and printing consumables
- Singleton Hospital Community Trust – Holes 4 Hospital Charity Golf Day 2017

- Singleton Council – Christmas on John Street Fireworks
- Greta Branxton Wildcats Football Club – Jerseys for junior football teams
- Milbrodale Public School P&C Association – Family Fun Day 2017
- Singleton Golf Club Lady Members – Annual Open Day 2017
- NSW Cancer Council – Transport for Treatment program
- Salvation Army Singleton – Children's Christmas Party
- Singleton Fire Brigade Social Club – Santa's Lolly Run
- Singleton Australian Football Club – Strapping Ta

10. INDEPENDENT AUDIT

An Independent Environmental Audit (IEA) of MTW was conducted in 2017 to satisfy Schedule 5, Condition 9 of both the Warkworth (SSD-6464) and Mount Thorley (SSD-6465) Operations, which require an IEA to be undertaken *"within 1 year of the commencement of development under this consent, and every 3 years thereafter"*, and submitted *"within 6 weeks of the completion of this audit."*. In January 2016 MTW conducted an Independent Environmental Audit to satisfy the relevant conditions of MTW's previous Planning Approvals. In addition to the Planning Approvals and Statement of Commitments, the audit included an assessment of performance against the conditions of MTW's Mining Leases, Water Licences and EPL's, and a review of the adequacy of the Groundwater model. Due to this, the focus of the IEA for 2017 was on the new planning approvals. The Independent Environmental Audit reviewed all relevant approvals and environmental management documents with a total of 1,512 conditions and commitments being assessed as part of this audit; 7 issues resulted in 11 non-compliances, 3 of the non-compliances were administrative. No High-risk findings were identified in the audit.

The 7 issues identified in the IEA are generally in the fields of

- Water discharges
- Compliance to water license conditions
- Mining Method- Overburden Management
- Cultural Heritage management inductions
- Blast management controls
- Noise management- mitigation measures

A more detailed summary can be found in Appendix 4 of this report.

The initial audit report was submitted to DP&E in July 2017. Following review the DP&E requested additional information be provided. The amended audit report was submitted in March 2018 and is currently pending approval.

Once approved, reports for the environmental audit and MTW's response to recommendations will be available on the company website (https://insite.yancoal.com.au).

11. INCIDENTS AND NON-COMPLIANCE

11.1 WATER

4 December 2017

Following a rainfall event over the weekend of 2nd and 3rd December 2017, stormwater had pooled across a light vehicle gravel road (known as the Geo Road) which is aligned parallel to Wallaby Scrub Road approximately 300-400 metres east of the road corridor.

A Dozer operator undertook maintenance the road and opened a hole in the windrow to relieve water from the working surface, intending for the water to report to a sediment dam via a contour drain.

On inspection, it was observed that the contour drain intending to capture the released water had been overtopped as a result of the concentrated flow entering the contour at a singular point. The water then preceded downslope towards the mine boundary.

The water passed through a culvert under Wallaby Scrub Road and was contained in a farm dam and gully on mine-owned land within the boundary of EPL 1376 and Development Consent SSD-6464.

All of the water (approximately 23 kL) was recovered from the farm dam. MTW reported the incident to the NSW EPA, DP&E and DRG. The EPA inspected the site and are undertaking an investigation into the incident.

25 August 2017 (2016 Incident)

Warkworth Mining Ltd was convicted and fined $50,000 by the Land and Environment Court of New South Wales of an offence against s 64 of the Protection of the Environment Operations Act 1997. Warkworth was prosecuted by the NSW EPA for breaching a condition of its EPL which required Warkworth to carry out its licensed activities in a competent manner. The conviction related to an incident which occurred at the Warkworth Mine on January 6 2016 when a stormwater retention dam was breached after the dam's embankment wall partially failed. Up to 4 ML of sediment laden water escaped from the dam to land owned by MTW and to a lesser extent the nearby Wallaby Scrub Road reserve.

12. ACTIVITIES TO BE COMPLETED IN THE NEXT REPORTING PERIOD

12.1 NOISE

Noise management improvements identified for implementation in 2017 include:

- Maintain and continue sound power level testing of attenuated fleet;
- Continuation of daily public reporting, including information on noise management for the previous night shift (reporting undertaken on business days only); and
- Progressively upgrade BarnOwl noise monitors with lastest hardware/software packages; and
- Review MTW Noise Management Plan

12.2 BLASTING

Blasting management improvements identified for implementation in 2017 include:

- Review and if necessary the revision of the MTW Blast Management Plan; and
- Hardware upgrades to ground units to allow for longer storage of blast data.
- Providing SMS notifications to advice of planned road closure times and changes to road closures (February 2018).

12.3 Air Quality

Air Quality management improvements identified for implementation in 2018 includes:

- Review the MTW Air Quality Management Plan; and
- Upgrade Dusttrak PM10 monitors with heated inlets for improved monitoring results.

12.4 CULTURAL HERITAGE

Aboriginal Cultural Heritage

Ongoing Aboriginal archaeological and cultural heritage management activities will occur in 2018 at MTW in accordance with current AHMPs, to inform ongoing land management and development planning. This will include the removal of the Site M grinding grooves & the salvage of those Aboriginal artefact sites located within the ACHMP Area in areas required for 2018 mined development. Condition monitoring of those sites peripheral to authorised disturbance areas will be conducted at regular intervals to ensure operational compliance with the ACHMPs.

The Hunter Valley Sands Bodies research study will also commence, as will proactive management within the Wollombi Brook Aboriginal Cultural Heritage Conservation Area in accordance with the Plan of Management for that area. This will commence with the establishment of the Plan of Management Implementation Group.

Historic Heritage

Conservation Management Plans (CMPs) have been prepared for a number of historic sites at MTW. Protective maintenance and stabilisation of these sites, in line with the recommendations within the CMPs & the Project Approvals, will continue to be conducted throughout 2018. An MTW complex-wide Historic HMP has been developed in accordance with the conditions of the Warkworth & Mount Thorley Project Approvals, which will guide the management of historic heritage. Archaeological investigations into the Great North Road alignment will commence when Wallaby Scrub Road is closed to public access.

12.5 WATER

Improvements to water management in 2018 will focus on the following main activities:

- Construction of dams and drains for containment of sediment laden runoff ahead of mining.
- Separation and diversion of clean water runoff from mature rehabilitation areas at Warwkorth.
- Introduction of secondary flocculation process to tailings deposition to improve water recovery

12.6 REHABILITATION

Performance Criteria and Rehabilitation Monitoring

The rehabilitation monitoring programme will continue in 2018 for both grazing and native vegetation rehabilitation areas.

Rehabilitation and Rehabilitation Maintenance

During 2018, maintenance activities are planned to result in approximately 99ha of rehabilitation, currently in the initial stage of cover cropping, being seeded with the full native seed mixes. Weed spraying (boom and spot spraying) and weed wiping will be conducted in establishing rehabilitation areas as required to control both noxious and environmental weeds that are likely to impact on successful rehabilitation being achieved.

It is planned that 100ha of new rehabilitation will be undertaken at MTW during 2018.

Habitat Augmentation

Habitat augmentation measures, such as the construction of habitat ponds and the placement of salvaged logs in rehabilitation areas, will be undertaken during 2018.

Tailings Storage Facility Capping

Capping of Tailings Dam 2 will be progressed during 2018 in accordance with the revised capping methodology developed by Australian Tailings Consultants. The capping method being utilised on TD2 was reviewed and updated following settlement cracking of the capping layer in an area of TD2 in 2017.

Capping of the Interim TSF will continue during 2018 using breaker rock from the South CHPP as the initial capping layer.

12.7 BIODIVERSITY MANAGEMENT

In 2018, planting works to restore Warkworth Sands Woodland will continue in the Southern BA, with 14ha to be planted. Restoration activities will also include planting 118ha of Central Hunter Grey Box – Ironbark Woodland and 11ha of River Oak Forest in the Southern BA. Conservation management actions will be undertaken across the BAs in 2018 in accordance with the Offset Management Plans, these will include weed management across all the BAs in autumn and spring. Vertebrate pest management including 1080 ground baiting programmes scheduled for autumn and spring to target wild dogs and foxes across all BAs and a noisy miner control in the regent honeyeater breeding area at the Goulburn River BA. Waste removal and bushfire management are scheduled for later in the year at the Seven Oaks, Goulburn River and Condon View BA. Monitoring scheduled for all BAs in 2018 include Habitat Restoration, Bird Assemblage, Rapid Condition Assessment and property inspections. Infrastructure improvement including fence repairs and track maintenance will be undertaken as required.

12.8 COMMUNITY ENGAGEMENT

In 2018 Mount Thorley Warkworth will continue the implementation of the MTW Social Impact Management Plan.

One of the initiatives identified in the Social Impact Assessment for the Warkworth Continuation project was contribution towards a Near Neighbour Amenity Resource, with particular reference made to assisting with the cost of routine maintenance of water quality in rainwater tanks. Following community consultation regarding this initiative MTW provided a tank cleaning service to all near neighbours throughout 2017.

For the 2018 reporting period the MTW Near Neighbour Amenity Resource will continue with all MTW near Neighbours being offered under-sink water filtration systems with 12 months' supply of filter cartridges. The decision to supply filtration systems was made in response to community consultation conducted throughout 2017.

Amenity Resource project types/offers will be reviewed annually; therefore 2018 will also involve consultation on types of projects to be considered in 2018 and beyond.

12.9 COMMUNITY DEVELOPMENT

Priority areas for community development in 2017 included education, economic development, community health, environment and land management. MTW will continue to operate a site donations program in 2018 and the local community will also have access to a Yancoal corporate sponsorship program (to be launched mid-2018).

Appendix 1: Annual Rehabilitation Report Summary Table

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Annual Rehabilitation Report Form, Rehabilitation Maps and Rehabilitation Summary

Annual Rehabilitation Report Form – Mines
Year Ending: 2017
Mine: Mt Thorley Warkworth
Company: Rio Tinto Coal Australia – Coal and Allied
Plans Attached:
Mt Thorley Warkworth – AER 2017
Approved Mining Operations Plan:
MTW MOP (2015 – 2021) – Approval Date 05/02/2016
Total Area Covered by Mining Operations Plan:
MTW MOP – 6,185ha
Total Area Covered by Mining Lease for This Mine: 6,185ha

Table 1: Rehabilitation Progress 2017

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
1.1 Active mining and infrastructure area, facilities, including roads and tracks	1A	Final Void	Final Void	189.1	227.8
	1C	Final Void	Rehabilitation Area - Grassland	0.0	0.0
	2A	Water Management Areas	Final Void	0.0	0.0
	2B	Water Management Areas	Water Management Areas	0.0	0.0
	2C	Water Management Areas	Rehabilitation Area - Grassland	35.0	39.8
	2D	Water Management Areas	Rehabilitation Area - Woodland	0.0	0.0
	2E	Water Management Areas	Rehabilitation Area - Woodland EEC	26.2	22.8
	3B	Infrastructure Area	Water Management Areas	0.0	0.0
	3C	Infrastructure Area	Rehabilitation Area - Grassland	100.7	100.7
	3D	Infrastructure Area	Rehabilitation Area - Woodland	0.0	0.0

	3E	Infrastructure Area	Rehabilitation Area - Woodland EEC	69.0	68.5
	4C	Tailings Storage Facility	Rehabilitation Area - Grassland	75.7	75.6
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	11.7	11.7
	4E	Tailings Storage Facility	Rehabilitation Area - Woodland EEC	88.3	88.2
	5A	Overburden Emplacement Area	Final Void	0.0	0.0
	5B	Overburden Emplacement Area	Water Management Areas	0.0	0.0
	5C	Overburden Emplacement Area	Rehabilitation Area - Grassland	328.9	320.3
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	278.7	267.3
	5E	Overburden Emplacement Area	Rehabilitation Area - Woodland EEC	1323.7	1275.3
	Bulga Sublease Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	12.8	0.9
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	1.7	2.1
	Total Active			2541.4	2501.0
1.2 Decommissioning	Total - Decommissioning			0.0	0.0
1.3 Landform Establishment	Total - Landform Establishment			14.2 (Included in 1.1)	13.6 (Included in 1.1)
1.4 Growth Medium Development	Total - Growth Medium Development			14.5 (Included in 1.1)	24.5 (Included in 1.1)
1.5 Ecosystem and Land Use Establishment	2C	Water Management Areas	Rehabilitation Area - Grassland	0.0	3.5
	2E	Water Management Areas	Rehabilitation Area - Woodland EEC	2.9	2.9
	4E	Tailings Storage Facility	Rehabilitation Area - Woodland EEC	4.0	4.0
	5C	Overburden Emplacement	Rehabilitation Area - Grassland	37.4	34.8

		Area			
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	36.7	52.4
	5E	Overburden Emplacement Area	Rehabilitation Area - Woodland EEC	169.5	96.8
	Total - Ecosystem and Land Use Establishment			250.3	194.4
1.6 Ecosystem and Land Use Development	1A	Final Void	Final Void	1.1	0.0
	2C	Water Management Areas	Rehabilitation Area - Grassland	1.7	1.7
	2E	Water Management Areas	Rehabilitation Area - Woodland EEC	3.3	3.3
	3C	Infrastructure Area	Rehabilitation Area - Grassland	5.4	5.4
	3E	Infrastructure Area	Rehabilitation Area - Woodland EEC	0.0	0.5
	4C	Tailings Storage Facility	Rehabilitation Area - Grassland	27.3	27.3
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	1.4	1.4
	4E	Tailings Storage Facility	Rehabilitation Area - Woodland EEC	35.5	35.4
	5C	Overburden Emplacement Area	Rehabilitation Area - Grassland	507.9	536.1
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	11.6	10.2
	5E	Overburden Emplacement Area	Rehabilitation Area - Woodland EEC	221.9	339.8
	Total - Ecosystem and Land Use Development			817.0	961.1

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area Last Reported (ha)	Total Area to date (ha)
1.7 Rehabilitation Complete	Total - Rehabilitation Complete			0.0	0.0
1.8 Total Area Disturbed (items 1.1 to 1.7)	1A	Final Void	Final Void	190.2	227.8
	2A	Water Management Areas	Final Void	0.0	0.0
	2B	Water Management Areas	Water Management Areas	0.0	0.0

2C	Water Management Areas	Rehabilitation Area - Grassland	36.6	45.0
2D	Water Management Areas	Rehabilitation Area - Woodland	0.0	0.0
2E	Water Management Areas	Rehabilitation Area - Woodland EEC	32.3	29.0
3B	Infrastructure Area	Water Management Areas	0.0	0.0
3C	Infrastructure Area	Rehabilitation Area - Grassland	106.0	106.1
3D	Infrastructure Area	Rehabilitation Area - Woodland	0.0	0.0
3E	Infrastructure Area	Rehabilitation Area - Woodland EEC	69.0	69.0
4C	Tailings Storage Facility	Rehabilitation Area - Grassland	103.0	102.9
4D	Tailings Storage Facility	Rehabilitation Area - Woodland	13.1	13.1
4E	Tailings Storage Facility	Rehabilitation Area - Woodland EEC	127.7	127.6
5A	Overburden Emplacement Area	Final Void	0.0	0.0
5B	Overburden Emplacement Area	Water Management Areas	0.0	0.0
5C	Overburden Emplacement Area	Rehabilitation Area - Grassland	874.2	891.2
5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	327.0	329.9
5E	Overburden Emplacement Area	Rehabilitation Area - Woodland EEC	1715.1	1711.9
Bulga Sublease Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	12.8	0.9
Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	1.7	2.1
Total Footprint			3608.7	3656.5

Table 2: Soil Management and Erosion, 2017

Soil Stockpiling/ Use	Soil Used This Period (m3)	Soil Pre-stripped This Period (m3)	Stockpile Inventory to Date (m3)	Soil Stockpiled Last Report (m3)
	110,600	74,900	639,824	675,524
2.2 Erosion Treatment	Total Area to Date (ha)	Total Area Last Report (ha)	Total Area This Report (ha)	Area Retreated This Period (ha)
	Not Available	5.0	69.9	0
Approx. area of sheet or gully erosion requiring reshaping topdressing and/or resowing	Not Available			

Table 3: Weed Control

	Area (ha)
3.1 Approx. area adversely affected by weeds as of the date of this report	Not Available
3.2 Area treated for weed control during the period covered by the report	312.3
3.3 Give summary of control strategies used and verification by approval agency(s)	
Species targeted in rehabilitation areas during 2017 included: galenia, Rhodes grass, green panic, couch grass, *Acacia saligna*, mustard weed (Brassica), farmers friend (*Bidens pilosa*) and paddys lucerne (*Sida rhombifolia*).	

Table 4: Management of Rehabilitation Areas

4.1 Area treated with maintenance fertiliser	0ha

4.2 Area treated by rotational grazing, cropping or slashing	90ha
Give Summary	90ha Warkworth rehabilitation area licence agreement in place for grazing.

Table: 5 Variations to Rehabilitation Program

Has rehabilitation work proceeded generally in accordance with the conditions of an accepted Mining Operations Plan?	Yes
If not please cite any approval granted for variations, or briefly describe the seasonal conditions or other reasons for any changes and the nature of any changes which have been made.	NA

Table 6: Planned Operations During the Next Repot Period

6.1 Area estimated to be disturbed	117.9ha
6.2 Area estimated to be rehabilitated	100ha

Appendix 2: Rehabilitation and Disturbance Summary

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Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
North Pit North Slope	Woodland	317,340.5 E 6,392,658.1 N	10.5	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a primarily northerly aspect. ▪ Drainage is via easterly draining contours reporting to adjacent existing contour drainage and then to an engineered rock-line chute. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam/sandy clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required, and the area was sprayed with herbicide prior to sowing ▪ Diverse Native Woodland Mix was drilled into an aerated pattern at 14.7kg/ha.
North Pit North Topsoils	Native Grass	317,423.8 E 6,392,331.8 N	6.3	▪ Topsoil stockpile overlies the landform surface. The underlying landform was constructed from a waste emplacement. ▪ Typical slope of the landform is flat (0-2 degrees) and without dominant aspect. Topsoil stockpiles ~3 metres high with gently sloping sides (5-8 degrees) are constructed on the landform. ▪ Drainage is via overland flow to adjacent flat and gently undulating rehabilitation areas, and associated landscape drainage structures such as swales, shallow drainage channels, and basin impoundments. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. Placed topsoils were shaped to a flat mound with gently sloping sides. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ The area was sprayed with herbicide prior to preparation of the sandy clay loam soil from the topsoil stockpile surface by chisel ploughing and

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				removal of discrete oversize surface rock and timber. ▪ Native Grass Seed Mix was spread to the disturbed surface 22kg/ha.
Swan Lake Spoil Compost	Woodland	319,126.6 E 6,391,131.4 N	4.7	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief undulations (0-2 degrees) and without dominant aspect. ▪ Drainage is via overland flow to adjacent existing Swan Lake rehabilitation areas to the north and east. Existing area drainage is managed by a mix of swales and drainage depressions, drainage channels and contours, and a series of basins and engineered rock-lined chutes. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of rock material as necessary. ▪ Substrate material comprised weathered mine spoil. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation comprised aerating following ameliorant application, herbicide spraying following a fallow period, and re-aeration prior to sowing. ▪ Diverse Native Woodland Mix was drilled into an aerated pattern at 14.7kg/ha.
Swan Lake Topsoils	Native Grass	318,894.7 E 6,391,166.4 N	1.1	▪ Topsoil stockpile overlies the landform surface. The underlying landform was constructed from a waste emplacement. ▪ The area is flat (0-2 degrees) and without dominant aspect. Topsoil stockpiles ~3 metres high with gently sloping sides (5-8 degrees) are constructed on the landform. ▪ Drainage is via overland flow to adjacent flat and gently undulating rehabilitation areas, or to the mine. Adjacent rehabilitation areas report to the wider Swan Lake drainage network. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. Placed topsoils

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				were shaped to a flat mound with gently sloping sides. ▪ Mixed waste compost soil ameliorant was applied at 100t/ha. ▪ Discrete oversize surface rock and timber was removed from the stockpiles and the clay loam/sandy clay loam soils were aerated to prepare the seed bed. ▪ Native Grass Seed Mix was spread to the disturbed surface 20kg/ha.
CD RL160	Woodland	319,171.0 E 6,390,161.9 N	10.1	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief (0-2 degrees) and without dominant aspect. ▪ Primary drainage is overland to the localised drainage depressions and habitat ponds. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoil from existing stockpiles was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required. Discrete areas were sprayed with herbicide prior to sowing as required. ▪ Diverse Native Woodland Mix was drilled into an aerated pattern at 14.7kg/ha.
South Pit North Orica	Woodland	319,799.4 E 6,390,592.9 N	7.8	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is generally 10 degrees with a primarily easterly aspect. A portion of the lower slope has slopes to 14 degrees and will be reshaped at closure (above explosives reload facility). ▪ Drainage is via easterly draining contours to an engineered rock-line chute which reports to a basal dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Sandy clay loam topsoils from a combination of West Pit South pre-strip and local topsoil stockpiles were spread to the area at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required. ▪ Seasonal cover crop (oats) was sown to an initial 2.4ha area prior to final sowing of the complete area with Diverse Native Woodland Mix which was spread into an aerated pattern at 14.7kg/ha.
South Pit North	Exotic Pasture (cover crop)	320,849.6 E 6,390,446.7 N	1.6	▪ The landform was constructed from a waste emplacement. ▪ The area comprises the base of the wider rehab slope with sloping western areas (10 degrees) grading to flat areas (0-2 degrees) along the eastern portion. ▪ Drainage is via overland flow to drainage basins along the eastern edge of the area. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ A combination of sandy clay loam topsoils from local and Woodlands topsoil reclamation was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included rock removal and aerating as required. ▪ Summer cereal (millet) was spread to an aerated pattern at 25kg/ha.
CD RL170	Woodland	320,849.6 E 6,390,446.7 N	6.2	▪ The landform was constructed from a waste emplacement. ▪ The area has predominantly Northern aspect although with eastern areas of the landform orientated to the NE. The area is generally sloping (10 degrees) with the northern areas grading to flat areas at

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	***Rehabilitation Summary***
				base of slope with localised micro-relief (0-2 degrees). ▪ Sloping areas are drained by contours which report to a mid-slope engineered rock-line chute and a series of east flowing drain lines and surge basins prior to spilling to the primary South Pit North engineered rock-line chute. Base of slope areas flow overland to local drainage depressions and habitat ponds on the RL160 level plateau. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoils from existing local stockpiles was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking and aerating as required. ▪ Seasonal cover crop was sown to an initial 2.4ha area prior to final sowing of the complete area with Diverse Native Woodland Mix which was spread into an aerated pattern at 17kg/ha.
South Pit Centre	Woodland	320,690.4 E 6,389,367.4 N	10.8	▪ The landform was constructed from a waste emplacement. ▪ The area is sloping (10 degrees) with an easterly aspect. A portion of the lower slope has slopes to 14 degrees and will be reshaped at closure (above shut pad). ▪ The area is drained by contours which report via engineered rock-lined chutes to a basal storage dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy loam, sand clay loam and clay loam topsoils from ahead of pre-strip areas in North Pit and West Pit South in combination with stockpiled topsoils were spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				respectively. ▪ Growth medium preparation included herbicide application, rock picking and aerating as required. ▪ Diverse Native Woodland Mix was spread into an aerated pattern at 17kg/ha.
South Pit South Area A	Exotic Pasture (cover crop)	321,234.1 E 6,388,626.6 N	5.8	▪ The landform was constructed from a waste emplacement. ▪ The area is sloping (10 degrees) with an easterly aspect. ▪ The area is drained by contours which report via engineered rock-lined chutes to a basal storage dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoils from existing stockpiles were spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required, and was sprayed prior to sowing. ▪ Seasonal cereal (oats) was air seeded to an aerated pattern at 45kg/ha.
South Pit South Area B	Exotic Pasture (cover crop)	320,726.6 E 6,389,056.5 N	3.7	▪ The landform was constructed from a waste emplacement. ▪ The area is sloping (10 degrees) with an easterly aspect. ▪ The area is drained by contours which report via engineered rock-lined chutes to a drainage channel and then via lower slope drainage structures to a base of slope dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoils from existing stockpiles were spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Growth medium preparation included windrowing, rock picking, and aerating as required. ▪ Autumn Winter Rehab Blend (cereal/legumes/herbs) was air seeded to an aerated pattern at 30kg/ha.
Boral Shed	Woodland	318,339.7 E 6,387,539.0 N	2.7	▪ The landform was constructed from excavated natural topography and waste rock emplaced during construction of a relict haul road. ▪ The area is generally sloping (6-12 degrees) depending upon exact location upon the topography of the Charlton Ridge, although with smaller level or near level areas (1-2 degrees). Aspect of the area is generally to the north east. ▪ The area drainage is mixed with sloping areas drained by contours and flatter areas drained by overland flow. All areas drain to dams located on the lower slope. ▪ Landform surface preparation comprised bulk shaping, selective deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoil from pre-strip areas was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required, and was sprayed with herbicide prior to sowing. ▪ Diverse Native Woodland Mix was drilled into an aerated pattern at 17kg/ha.
Charlton Ridge Sub Site	Woodland	318,937.0 E 6,387,694.7 N	1.1	▪ The landform was constructed from excavated natural topography following rehabilitation of a relict cut-fill pad. ▪ The area is generally sloping (6-12 degrees) with a north-easterly aspect. The north-eastern potion of the area is relatively flat (0-2 degrees). ▪ Drainage is via contours on the sloping areas and overland flow on the flat sections.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Landform surface preparation comprised bulk shaping, selective deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoil from pre-strip areas was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required, and was sprayed with herbicide prior to sowing. ▪ Diverse Native Woodland Mix was spread into an aerated pattern at 17kg/ha.
MTO Bulga Flats	Woodland (flats) Native Grass (drain)	320,088.0 E 6,385,521.4 N	15.6	▪ The landform was constructed from a waste emplacement. ▪ The substantive northern area is flat with localised micro-relief (0-2 degrees) and without dominant aspect. The elongate southern area is an engineered channel draining the adjacent northern rehab areas. ▪ Drainage is via overland flow to adjacent flat and gently undulating rehabilitation areas, local drainage depressions and habitat ponds, and to the engineered earth and rock-lined drainage channel. The drainage channel reports to the Ramp 22 Dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. The drainage channel was constructed by excavation, compaction, rock-lining (lower reach) and topsoil placement (upper reach). ▪ Sandy clay loam topsoil from existing stockpiles was spread at a nominal thickness of 100mm in the upper reach and surrounds. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively were applied to the upper reach and surrounds. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required. Discrete areas were sprayed with herbicide prior to sowing.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Northern flat areas were sown to autumn cereal (oats) cover crop at 45kg/ha. Rehab edges and wider drain surrounds and rehab were sown to summer cereal (millet) cover crop at 35kg/ha. Earth lined drain sections and immediate surrounds were sown to custom Native Grass Seed Mix at 22kg/ha.
MTO RL137 Slope	Woodland	319,983.1 E 6,385,719.7 N	4.4	▪ The landform was constructed from a waste emplacement. ▪ The area is sloping (10 degrees) with an easterly aspect. ▪ Drainage is via north flowing contours to engineered rock-line chute (to be constructed), basal basin and engineered drain on the Bulga Flats. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoil from existing stockpiles was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required, and was sprayed prior to sowing. ▪ Diverse Native Woodland Mix was spread into an aerated pattern at 14.7kg/ha.
MTO RL155 Topsoils	Woodland	319,641.8 E 6,385,895.4 N	16.6	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief (0-2 degrees) and without dominant aspect. ▪ Drainage is via overland flow to adjacent flat and gently undulating rehabilitation areas, or to adjacent mine areas. Eastern elements will also drain to contours on the eastern slope and the associated engineered rock-line chute (to be constructed) and downstream structures. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoil from existing stockpiles was spread at a

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required, and was sprayed prior to sowing. ▪ Diverse Native Woodland Mix was drilled into an aerated pattern at 14.7kg/ha.
MTO RL155 Cover Crop	Exotic Cover Crop	319,611.7 E 6,386,022.2 N	3.6	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief (0-2 degrees) and without dominant aspect. ▪ Drainage is via overland flow to adjacent flat and gently undulating rehabilitation areas, or to adjacent mine areas. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Sandy clay loam topsoil from existing stockpiles was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included windrowing, rock picking, and aerating as required, and was sprayed prior to sowing. Summer cereal (millet) cover crop was drilled to an aerated pattern at 30kg/ha.
MTO RL155 Spoil Compost	Woodland	319,448.3 E 6,386,078.0 N	6.2	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief (0-2 degrees) and without dominant aspect. ▪ Drainage is via overland flow to adjacent flat and gently undulating rehabilitation areas, or to adjacent mine areas. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Substrate material comprised weathered mine spoil.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 10t/ha and 100t/ha respectively. ▪ Growth medium preparation included rock picking and aerating, as required. ▪ Diverse Native Woodland Mix was spread into an aerated pattern at 14.7kg/ha.
Ramp 22 Dam	Infrastructure (water management)	321,690.5 E 6,385,319.2 N	4.8	▪ This area has been handed back to Mount Thorley Warkworth following completion of a sub-lease agreement with Bulga Surface Operations. ▪ During the period of sub lease the final landform was completed comprising construction of an engineered dam and rehabilitation of areas immediately adjacent the dam. ▪ The landform was constructed from a waste emplacement. ▪ The wider area is flat or sloping consistent with the dam infrastructure and with a generally north easterly aspect. ▪ Surface preparation of vegetated areas comprised topsoil spreading, shallow ripping, and sowing.

Autumn Winter Rehab Blend	Composition (%)
Oats	68
Ryegrass	22
Lucerne	5
Arrowleaf Clover	5

Spring Summer Rehab Blend	Composition (%)
Rebound Millet	57
Chicory	7
Red Clover	7
Lucerne	29

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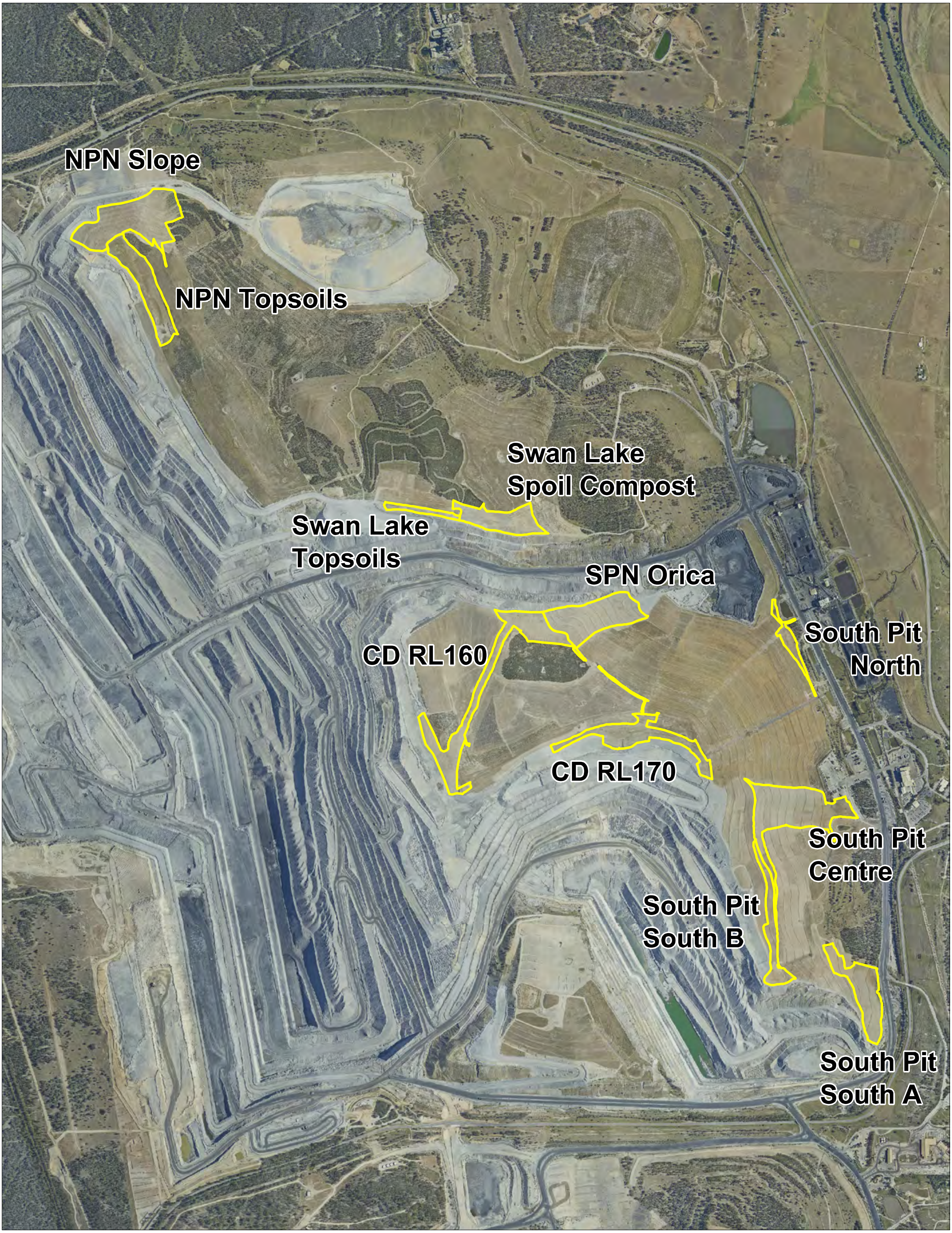
MTW (Mount Thorley) Rehabilitation Areas 2017

Date:	20FEB18
Produced By:	RPC
Map Size:	A4 Portrait
Coord. System:	MGA94 Zone 56
Revision:	1.0
Data Source:	Various

MTW

MapInfo\MTW\Workspace Tab Files\180108 MTW AEMR Plans 2017
MTW MTO Rehab Areas 2017.pdf



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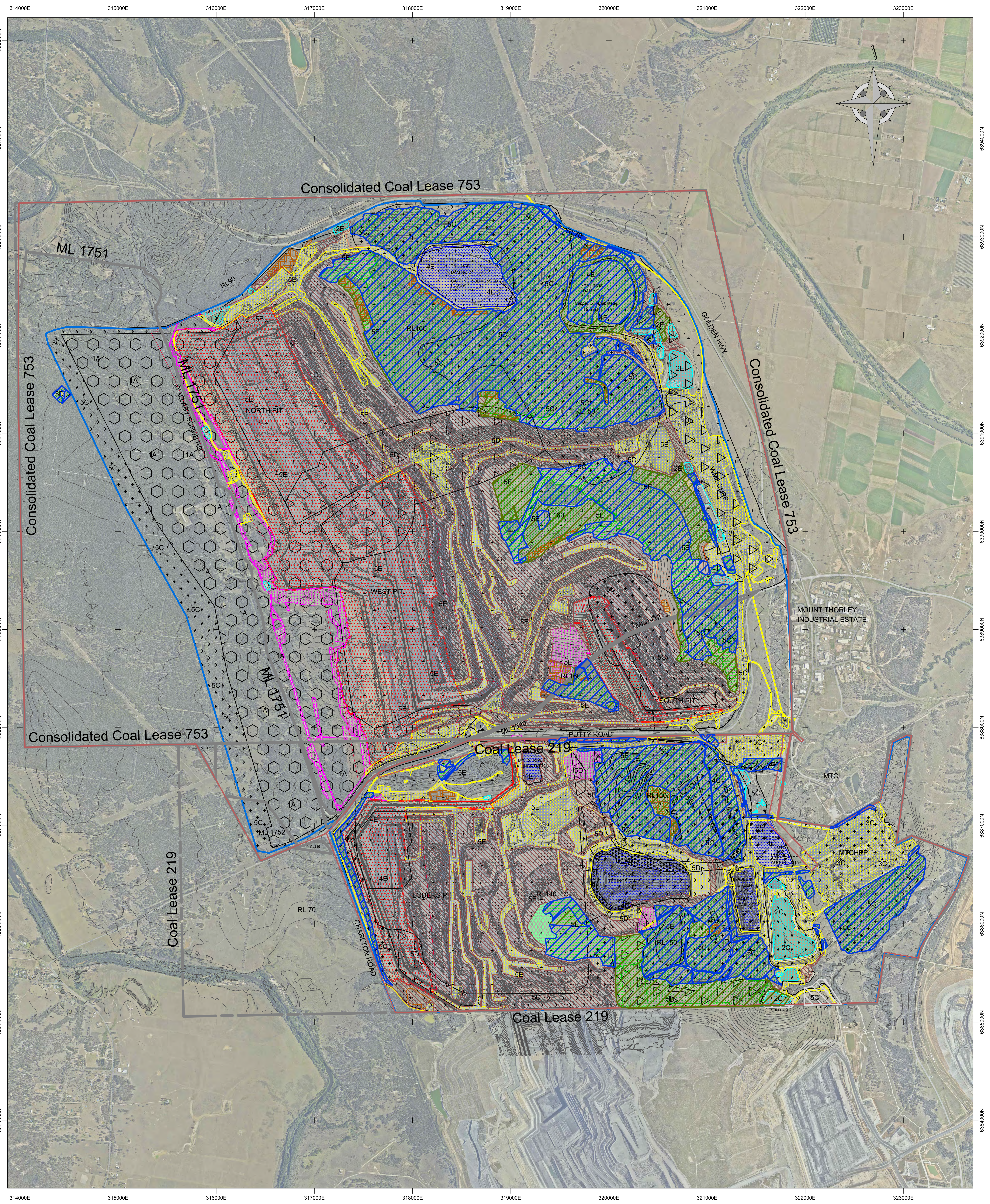
MTW

**MTW (Warkworth)
Rehabilitation Areas 2017**

MapInfo\MTW\Workspace Tab Files\180108 MTW AEMR Plans 2017
MTW WML Rehab Areas 2017.pdf

Date:	20FEB18
Produced By:	RPC
Map Size:	A4 Portrait
Coord. System:	MGA94 Zone 56
Revision:	1.0
Data Source:	Various



Mining Tenement
- Project Approval Area
- Sublease Boundary
- Area of disturbance
- Expected mining area - 2017

Rehabilitation Phases
- Ecosystem and Land Use Establishment
- Ecosystem and Land Use Sustainability
- Lease Boundary
- 2017- 5m Contours (AHD)

Primary Domains
- 1 - Final Void
- 2 - Water Management Area
- 3 - Infrastructure Area
- 4 - Tailings Storage Facility
- 5 - Overburden Emplacement

Secondary Domains
- A - Final Void
- B - Water Management Area
- C - Rehabilitation Area- Grassland
- D - Rehabilitation Area- Woodland Other
- E - Rehabilitation Area- Woodland EEC

Note: For plan clarity only, black polygons have been used for primary & secondary domains. Plan has been labeled with text.

Aerial photo date: 5th January 2018
Co-ordinate grid datum: MGA Zone 56 (GDA 94)
Height datum: Australian Height Datum (AHD71)

AEMR 2017 Areas
- Active Mining
- Shaped Spoils
- Shaped Spoils >10°
- Unshaped Spoils
- Topsoil Stripped
- Topsoil Spread > 18°
- Topsoil Spread
- New Rehabilitation
- Rehabilitation
- Infrastructure
- Infrastructure Tailings
- Water Structures
- Topsoil Stockpile
- Compost Spread

SCHEDULE OF ENDORSEMENTS

REF	DATE	DESCRIPTION/REFERENCES	SIGNED
Full Plan	28-02-2018	Mine surveying content depicted on the plan is sourced from RT 769	J.SHERRITT
Full Plan	28-02-2018	Domain boundaries supplied by others.	J.SHERRITT
Full Plan	28-02-2018	Disturbance limits supplied by others.	J.SHERRITT
Full Plan	28-02-2018	Mining tenement & lease boundaries supplied by others.	J.SHERRITT
Full Plan	28-02-2018	Expected mining areas supplied by others.	J.SHERRITT
Full Plan	28-02-2018	Rehabilitation data & phases supplied by others.	J.SHERRITT

UNCONTROLLED IF PRINTED

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0m 100m 250m 500m 1000m 1500m 2000m
SCALE 1:12500

I, James Sherritt, Registered Mining Surveyor, No. 8626, certify that to the best of my knowledge and belief the survey information on this plan conforms to the accuracy and standards required by the Department of Trade & Investment Resources & Energy, NSW.

Registered Mining Surveyor
28/02/2018
Date

MOUNT THORLEY OPERATIONS / WARKWORTH MINING Ltd.

Annual Environmental Review Plan 2017

REDUCTION RATIO: 1 : 12,500
A0
DRAWN BY: J.SHERRITT
DATE: 28/02/2018
APPROVED BY: B BAXTER
PLAN No. MTW-1061

Appendix 3: Rehabilitation Monitoring Report

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niche
Environment and Heritage

Native Vegetation Rehabilitation Monitoring 2017 – New Sites

Mount Thorley Warkworth and Hunter Valley Operations

Prepared for Coal & Allied

13 March 2018

Document control

Project no.:	3417
Project client:	Coal & Allied Operations Pty Ltd
Project office:	Mudgee
Document description:	Monitoring of new native vegetation within rehabilitation areas at Mt Thorley Warkworth Operations (MTW) and Hunter Valley Operations (HVO) as part of the annual Rehabilitation Monitoring Program.
Project Director:	Rhidian Harrington
Project Manager:	Vivien Howard
Authors:	Vivien Howard and Alex Christie
Internal review:	Rhidian Harrington
Document status:	Rev1
Document address:	P:\Projects\3000s\3400s\3417 RTCA Rehabilitation Monitoring\Report\Final\New Sites 2017

Author	Revision number	Internal review	Date issued
Vivien Howard Alex Christie	Rev 0	R. Harrington	27/07/17
Alex Christie	Rev 1	L. Carter	14/03/18

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box W36
Parramatta NSW 2150
Email: info@niche-eh.com
All mail correspondence should be through our Head Office.

Sydney
0488 224 888

Central Coast
0488 224 999

Illawarra
0488 224 777

Armidale
0488 224 094

Newcastle
0488 224 160

Mudgee
0488 224 025

Port Macquarie
0488 774 081

Brisbane
0488 224 036

Cairns
0488 284 743

Cover photograph: Native rehabilitation at monitoring site

Executive summary

Context

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Coal & Allied Operations Pty Ltd (C&A) to undertake monitoring of native rehabilitation post-mining at the Mt Thorley Warkworth (MTW) and Hunter Valley Operations (HVO) mine sites. The monitoring forms part of the MTW and HVO monitoring program, which aims to assess the recovery of native rehabilitation within the HVO and MTW rehabilitation areas. The monitoring follows on from the first round monitoring undertaken by Niche in February and March 2016 at the same sites (Niche 2016), but also inludes a number of new sites. This report presents the findings from monitoring undertaken at 25 MTW sites and 29 HVO sites.

Methods

This monitoring report provides the results of the progress of the native vegetation rehabilitation and was undertaken largely in accordance with the methodology detailed in AECOM (2012) *Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites*. Two notable amendments to the methodology were employed, based on lessons learnt during the 2016 monitoring period. These amendments include:

- Removal of the 1 x 1 metre pasture/groundcover monitoring and replacement with a BioBanking plot, including a nested 20 x 20 metre plot at each site.
- Introduction of stem density counts along two, 2 metre strips along the length of the 50 metre centre tape.
- Introduction of tree tagging, where endemic trees with a Diametre at Breast Height (DBH) larger than 5 centimetres were marked and numbered, and specific details of each tree was recorded.

These surveys also included the set-up of monitoing plots at 12 reference sites established at Belford National Park and within biodiversity offset areas owned by Rio Tinto and Peabody Energy. The reference sites have been selected to target Biometric Vegetation Types (BVTs) specified in the respective Mining Operations Plans (MOP) for MTW and HVO, these being:

1. HU701 Central Hunter Grey Box-Ironbark Woodland.
2. HU632 Central Hunter Ironbark-Spotted Gum-Grey Box Forest.

The data obtained during the monitoring has been presented in this report and compared with baseline data collected during the 2016 monitoring period and the reference sites established.

Aims

The aim of the monitoring program is to monitor vegetation attributes at rehabilitation sites established in 2016 and reference sites to determine the success of the rehabilitation within the HVO and MTW post-mine areas.

Results

This report compares the data from 2016 with the data collected at the 12 reference sites and 54 monitoring sites in 2017.

Key findings include:

- There is significant variation in the types and ages of the rehabilitation sites that were part of the monitoring project, and therefore there is a high degree of variability in monitoring results including native plant species richness, exotic cover, percentage cover, and projected cover of all strata.
- Rehabilitation sites fall within the reference site soil property ranges and therefore meet the MOP performance criteria.
- Generally the Landscape Organisation Index (LOI) at the reference and rehabilitation sites was high, with an average LOI of 0.98 for the reference sites and 0.9, 0.7 and 0.8 for HVO and MTW woodland – other and MTW woodland – EEC sites respectivly.
- The average infiltration scores for rehabilitation sites overall has increased from 42.4 to 51.1 for HVO sites and 37.4 to 41.6 for MTW woodland – other sites. MTW woodland – EEC has dropped slightly from 47.8 to 43.7. This is likely due to the addition of new sites to this domain type.
- All rehabilitation sites fall below benchmark in at least one attribute.
- Due to the density of regenerating shrub species, a number of sites exceed the upper benchmark for Native Ground Cover – Shrubs (NGCS). This is likely a result of the combination of exceptional germination and juvenile canopy and mid-storey species contributing towards NGCS.
- Only one MTW woodland – EEC site is meeting the MOP performance criteria target for Native Overstorey Cover (NOS).
- All other MTW woodland – EEC sites have very low to no NOS. This is due to juvenile trees not occurring in the canopy stratum.
- Eight MTW woodland – EEC rehabilitation sites were within the reference site range values for native mid-storey cover (NMS). Part of the contribution to mid-storey cover however might be due to the presence of juvenile overstorey species which are not yet mature enough to be included in the overstorey and are included as mid-storey.
- Results for woodland – other rehabilitation sites are indicating that the current target for Exotic Plant Cover (EPC) of 0% will be very difficult to achieve. Only two woodland – other rehabilitation sites across HVO and MTW sites met this reference site benchmark level and in both cases these sites had no vegetative cover at all due to a recent knockdown herbicide spray.
- In comparison, the MOP performance criteria target for exotic plant cover for woodland – EEC rehabilitation sites has been set at a more realistic level of 5-33%. Nine of the MTW woodland – EEC rehabilitation sites met this target level. High exotic plant cover scores that exceed the benchmark at new rehabilitation sites are primarily due to the use of cover crops early during the rehabilitation works.
- Most MTW Woodland – EEC rehabilitation sites were not meeting the target levels for total native plant species richness (NPS). Although sites were generally meeting species richness targets for native trees, shrubs and grasses, they were achieving low results for species richness of 'other species' (i.e. herbs, forbs and monocots other than grasses etc.). The category of 'other species' is where most of the native plant species diversity is found in the reference sites, with results from reference sites showing they contain 10-20 species in this category.
- In relation to NPS, there is not necessarily a correlation between age of the rehabilitation and species richness. Older rehabilitation sites do not necessarily have a greater number of plant species. This is likely to reflect that seed mixes being used since 2011 have had a much higher diversity of species than earlier seed mixes.

- Due to the age of the rehabilitation sites, only eight of the 54 rehabilitation sites had trees with a DBH greater than five centimetres. However, the canopy species diversity at these sites were generally good, with all of these sites falling within the benchmark range.
- No fallen logs or large rocks were recorded at any of the rehabilitation sites.
- The 2017 reference site benchmarks vary from 2016, likely due to seasonal differences. While field surveys were conducted during the same time of the year as the 2016 surveys, many benchmark values are lower. This is likely a result of extended periods of extremely hot weather prior to the 2017 surveys, which is likely to have killed sensitive herbs and forbs compared to the previous year.

Table of Contents

List of Figures

List of Tables

List of Appendices

Abbreviations

Acronym	Term/Definition
BBAM	BioBanking Assessment Methodology
BVT	Biometric Vegetation Type
C&A	Coal & Allied Operations
Dbh	Diameter at breast height
EEC	Endangered Ecological Community
EPC	Exotic Plant Cover
FL	Fallen logs
ha	Hectare/s
HVO	Hunter Valley Operations
Km	Kilometre
LFA	Landscape Function Analysis
LFI	Landscape Function Index
LOI	Land Organisation Index
MOP	Mining Operations Plan
MTW	Mount Thorley Warkworth
NGCG	Native ground cover grasses
NGCO	Native ground cover other
NGCS	Native ground cover shrubs
NMS	Native midstorey
NOS	Native overstorey
NPS	Native plant species
NTH	Number of trees with hollows
NPWS	National Parks and Wildlife Service
OEH	NSW Office of Environment and Heritage (formerly DECCW, DECC, DEC)
OR	Overstorey regeneration
PCT	Plant Community Type
SSCI	Soil Surface Condition Indicators
TSC Act	*Threatened Species Conservation Act 1995* (NSW)

1. Introduction

1.1 Overview

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Coal & Allied Operations Pty Ltd (C&A) to undertake the first year of native rehabilitation post-mining monitoring at the Mt Thorley Warkworth (MTW) and Hunter Valley Operations (HVO) mine sites (Figure 1Figure 12). The monitoring forms part of the MTW and HVO monitoring program, which aims to assess the recovery of native rehabilitation across all 29 HVO and 25 MTW sites. This includes an additional 13 new HVO rehabilitation monitoring sites and 8 new MTW rehabilitation monitoring sites. This document outlines the 2017 monitoring results in isolation, but also compares these results with the data collected during the baseline surveys undertaken during 2016 (Niche 2016).

The monitoring methods implemented were largely consistent with the methodology detailed in Monitoring Methodology - Post-mined Lands MTW and HVO North Mine Sites (AECOM 2012).

Information available from the relevant BioBanking benchmark sites and monitoring data from the reference sites have been used to inform the performance criteria targets for native vegetation rehabilitation in the Mining Operations Plan (MOP) for MTW, HVO North and HVO South. The results of monitoring in these new rehabilitation areas have been assessed against the MOP performance criteria in this report.

It should be noted, that monitoring of native vegetation rehabilitation was generally not undertaken prior to 2015 and was first undertaken in 2016 and then subsequently in 2017. The results of these other monitoring periods are presented in a separate report, Native Vegetation Rehabilitation Monitoring 2016 – Mount Thorley Warkworth and Hunter Valley Operations (Niche 2016).

1.2 Background to the rehabilitation monitoring

Rehabilitation monitoring at MTW and HVO is undertaken to satisfy the following regulatory obligations:

- Schedule 3 – Condition 58(i) of Development Consent SSD-6464 (Warkworth Mine)
- Schedule 3 – Condition 36(h) of Development Consent SSD-6465 (Mt Thorley Mine)
- Schedule 4 – Condition 62C(j) of Development Consent DA 450-10-2003 (HVO North)
- Schedule 3 – Condition 36(e) of Project Application PA 06_0261 (HVO South)
- Commitments made in respective Mining Operations Plans (MOPs) for MTW, HVO North and HVO South.

Rehabilitation activities at MTW and HVO involve areas of post-mined lands being returned to either a native ecosystem or a grazing pasture (or grassland). C&A has committed to recreating Endangered Ecological Communities (EEC) to a standard comparable to similar reference EECs. The EECs include Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest, which are both listed as EECs under the NSW *Threatened Species Conservation Act 1995* (TSC Act). The area of rehabilitation that is proposed to be returned to EEC communities is 2,114 hectares at MTW and 4 hectares at HVO.

1.3 Project scope and objectives

This rehabilitation monitoring report documents the 2017 monitoring survey results and provides comparisons with reference site data and published OEH benchmark data. Further to the existing rehabilitation sites, this report includes new monitoring data for an additional 21 new rehabilitation sites that had not been surveyed prior to 2017.

The monitoring involved the following key objectives:

- Establish permanent monitoring sites within each of the new rehabilitation areas (13 at HVO and eight at MTW)
- Complete Landscape Function Analysis (LFA) at all monitoring sites
- Complete visual monitoring at all monitoring sites
- Complete soil analysis at all monitoring sites
- Complete photographic monitoring at all monitoring sites
- Complete tree health characteristic at all monitoring sites
- Provide an analysis of results against reference sites
- Provide recommendations to assist with the improvement of future monitoring and performance indicators.

Based on learnings from monitoring in 2016 at older monitoring sites, the methodology outlined in AECOM (2012) was amended in the following ways:

- Removal of the 1 x 1 metre pasture/groundcover monitoring and replacement with a BioBanking plot, including a nested 20 x 20 metre plot at each site.
- Introduction of stem density counts along two, 2 metre strips along the length of the 50 metre centre tape. The data from these will be compared separately to gauge consistency and determine if this level of collection is required in the future. Sensitivity analysis will aslo be undertaken to determine if this level of data collection is adequate for this purpose.
- The methodology for the collection of information pertaining to endemic canopy was made a little more prescriptive, where each canopy tree (endemic) with a Diametre at Breast Height (DBH) larger than 5 centimetres was marked with a metal tree tag or similar. Each tree was given a unique number and details including canopy health and reproductive status (flowers/fruit) was recorded.

Given the young age of the rehabilitation monitored as part of these works, some details of the health of the endemic canopy were not collected because individuals that may make up the canopy in the future were not currently developed enough (i.e. they all have a DBH less than 5 centimetres).

1.4 Monitoring team

Data collection for the 2017 monitoring period was undertaken between the 7th and 15th February 2017 with addional monitoring of new sites between the 1st and 3rd May 2017. Ecologists involved with the completion of field monitoring tasks and reporting are listed as follows:

Vivien Howard	Senior Ecologist (Field survey and reporting)
Alex Christie	Ecologist (Field survey and reporting)

2. Monitoring Sites

2.1 HVO rehabilitation areas

Monitoring has been conducted within 29 individual rehabilitation areas across HVO (see Figure 2 to Figure 6), comprised of different rehabilitation establishment conditions. The desired outcome of the rehabilitation is to achieve a native woodland community. Details regarding the establishment and treatment for each site, including the target domain type are provided in Table 1. It is worthwhile to note that two monitoring sites established during the 2016 monitoring period were not revisited as the native seed mixes had not been sown. Locations of the monitoring sites are provided in Appendix 3.

Table 1. HVO rehabilitation areas, establishment conditions and size – Woodland - other domain type

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
HVOWES200801	3.4	2008	Topsoil, native seed broadcasted in 2008	Woodland - other
HVOWES201101	4.4	2011	Compost (with spoil), native seed hydroseeded in 2011	Woodland - other
HVOWES201301	3.7	2013	Compost (with spoil), native seed drilled in 2013	Woodland - other
HVOWES201302	12.7	2013	Topsoil/Compost, native seed drilled in 2016	Woodland - other
HVOCAR200901	14.2	2009	Topsoil, native seed broadcast in 2009	Woodland - other
HVOCAR200902	7.7	2009	Topsoil, native seed broadcast in 2009	Woodland - other
HVOCAR201401	25.6	2014	Compost (with topsoil), natives not sown	Woodland - other
HVORIV201406	3.1	2014	Topsoil/Compost, native seed drilled in 2016	Woodland - other
HVORIV201405	14.3	2014	Compost (with subsoil), native seed drilled in 2014	Woodland - other
HVORIV201404	8.4	2014	Compost (with subsoil), native seed drilled in 2014	Woodland - other
HVORIV201403	4.8	2014	Compost (with subsoil), native seed drilled in 2015	Woodland - other
HVORIV201402	10	2014	Compost (with subsoil), native seed drilled in 2014	Woodland - other
HVORIV201401	5.8	2014	Compost (with spoil), native seed drilled in 2014	Woodland - other
HVOCHE201201	20.8	2012	Compost (with topsoil), native seed drilled in 2013	Woodland - other
HVOCHE201203	26.6	2012	Compost (with topsoil), natives not sown	Woodland - other
HVOCHE201401	9.8	2014	Compost (with topsoil), natives not sown	Woodland - other
HVORIV201502	6.8	2015	Topsoil/compost, natives not	Woodland - other

[1] Soil and seeding information provided by Bill Baxter (C&A)

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
			sown	
HVORIV201503	6.2	2015	Topsoil/compost, second application of gypsum and compost, natives drilled 2016	Woodland - other
HVORIV201501	2.4	2015	Topsoil/compost, natives drilled 2016	Woodland - other
HVOLEM201501	13.4	2015	Topsoil/compost, natives sown first	Woodland - other
HVOCHE201501	24.4	2015	Topsoil/compost, natives not sown	Woodland - other
HVORIV201601	7.9	2016	Topsoil/compost, natives not sown	Woodland - other
HVOWES201602	4.0	2016	Topsoil/compost, natives sown first	Woodland - other
HVOWES201601	6.2	2016	Topsoil/compost, natives sown first	Woodland - other
HVOWES201603	8.1	2016	Topsoil/Composted green waste trial, native sown first	Woodland - other
HVOWES201604	5.0	2016	Topsoil/Composted green waste trial, native sown first.	Woodland - other
HVOCHE201601	21.5	2016	Topsoil/compost, natives not sown	Woodland - other
HVOCHE201602	10.2	2016	Topsoil/compost, natives not sown	Woodland - other
HVOLEM201601	5.0	2016	Topsoil/Composted green waste trial, native sown first (after delay)	Woodland - other

2.2 MTW rehabilitation areas

Monitoring has been conducted within 25 individual rehabilitation areas across MTW (see Figure 10 to Figure 15), comprised of different rehabilitation establishment conditions. These are listed in Table 2 and Table 3 below.

Table 2. MTW rehabilitation areas, establishment conditions, and size – Woodland – EEC domain type

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
MTWNPN201301	23.1	2013	Compost (with topsoil), natives drilled Winter 2015	Woodland -EEC
MTWNPN201401	7.1	2014	Topsoil/compost, natives drilled in 2014	Woodland -EEC
MTWNPN201402	1.9	2014	Compost (with fresh sand topsoil), natives drilled 2014	Woodland -EEC
MTWNPN201403	5.5	2014	Compost (with subsoil), natives drilled 2014	Woodland -EEC
MTWNPN201101	43.3	2011	Topsoil, natives hydroseeded 2011	Woodland -EEC

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
MTWNPN200901	21.8	2009	Topsoil, native seed broadcasted in 2009	Woodland -EEC
MTWCDD201101	8.1	2011	Topsoil, native seed hydroseeded	Woodland -EEC
MTWCDD201301	9.1	2013	Compost (with topsoil), natives not sown	Woodland -EEC
MTWCDD201501	6.4	2015	Compost (with spoil), natives drilled	Woodland -EEC
MTWSPN201401	37.7	2014	Compost (with topsoil), natives not sown	Woodland -EEC
MTWWDL201401	4.7	2014	Compost (with topsoil), natives drilled 2015	Woodland -EEC
MTWWDL201402	8.9	2014	Topsoil/compost, natives drilled in 2016	Woodland -EEC
MTWTD1201501	20.6	2015	Compost (with spoil), native seed drilled 2015	Woodland -EEC
MTWMTO200503	11.7	2005	Topsoil, native seed broadcasted in 2005	Woodland -EEC
MTWSPS201601	5	2016	Topsoil/compost, natives not sown	Woodland -EEC
MTWSPN201602	1.4	2016	Topsoil/compost, natives hydroseeded 1st	Woodland -EEC
MTWSPN201601	8.1	2016	Topsoil/compost, natives not sown	Woodland -EEC
MTWSPN201501	12.2	2015	Topsoil/compost, natives not sown	Woodland -EEC
MTWSPS201602	13	2016	Topsoil/compost, natives not sown	Woodland -EEC
MTWNOO201501	3.7	2015	Topsoil/compost, natives drilled 2016	Woodland -EEC

Table 3. MTW rehabilitation areas, establishment conditions and size - Woodland - EEC domain type

Rehabilitation area name	Area (ha)	Establishment date	Soil and seeding information[1]	Target domain type
MTWMTO200001	6.3	2000	Topsoil, native seed broadcasted in 2000	Woodland - other
MTWNPN200501	13.2	2005	Topsoil, native seed broadcasted in 2005	Woodland - other
MTWNPN200502	4.8	2005	Topsoil, native seed broadcasted in 2005	Woodland - other
MTWMTO201501	8.1	2015	Topsoil, natives not sown	Woodland - other
MTWMTO201601	28.4	2016	Topsoil/compost, natives not sown	Woodland - other

2.3 Native rehabilitation performance criteria, measures and associated indicators

As previously discussed in Section 1.2, performance criteria for the native rehabilitation areas have been detailed in the MOP's (Coal & Allied 2015, 2016a and 2016b), and target values for the criteria have been developed based on reference site monitoring data and information available from OEH BioBanking benchmarks. This monitoring report provides a comparison of results for rehabilitation sites against reference sites, BioBanking benchmark values (where available) and the relevant performance criteria. The results section of this report has been divided based on the MOP performance criteria, with the relevant criteria displayed above the relevant results.

3. Monitoring methodology

3.1 Monitoring dates

Monitoring was undertaken during two distinct periods, including seven days between 7th and 15th February 2017 and three days between 1st and 3rd May 2017. Details regarding the dates, personnel and sites completed for each day during the monitoring is provided in Appendix 2.

3.2 Design

Monitoring was undertaken in accordance with AECOM's (2012) Monitoring Methodology. Niche has summarised the techniques used from AECOM's Monitoring Methodology below.

3.2.1 Rehabilitation monitoring sites

A total of 54 rehabilitation monitoring sites have been established in rehabilitation areas being returned to woodland/forest vegetation, including:

- 29 monitoring sites at HVO (Figure 2, and Figure 3Figure 9)
- 25 monitoring sites at MTW (Figure 2, and Figure 10Figure 15).

For each monitoring site, a marker-post was placed at the start and end point, with the end point established downslope. Waypoints were taken at the start and end point for each monitoring site location (Appendix 3).

Monitoring at each rehabilitation site included the collection of the following data: photo points, visual assessment, Landscape Function Analysis (LFA), soil analysis, and the collection of BioBanking data.

The locations of the monitoring sites, along with their associated descriptions and coordinates have been provided in Appendix 3.

3.2.2 Reference monitoring sites

As part of the monitoring undertaken during 2016, 12 reference monitoring sites were established. These aimed at capturing data around two BVTs specified in the MOP. Six sites were established at each of two vegetation communities:

1. HU701 Central Hunter Grey Box-Ironbark Woodland
2. HU632 Central Hunter Ironbark-Spotted Gum-Grey Box Forest.

Two of the Central Hunter Grey Box-Ironbark Woodland reference sites were established within land managed by Wambo Coal Mine (Figure 18), with another four established in land managed by C&A (Figure 16 and Figure 17).

The coordinates for the location of each reference site is provided in Appendix 3.

BioBanking data collected at each of the reference sites was input into the OEH BioBanking Benchmark Calculator to provide the lower and upper benchmark ranges for each attribute. The reference site ranges were then compared to the OEH benchmarks for both BVTs.

Follow-up monitoring at these reference sites was undertaken during February 2017.

3.3 Sampling techniques

3.3.3 Landscape Function Analysis (LFA)

LFA is a monitoring procedure developed by the CSIRO (Tongway and Hindley, 1997, last revised in 2004) that uses rapidly acquired field-assessed indicators to assess the biogeochemical functioning of landscapes at the hillslope scale. It provides a rapid, reliable, and easily applied method for assessing and monitoring landscape restoration or rehabilitation projects. LFA examines the way physical and biological resources are acquired, used, cycled and lost from a landscape.

Eleven Soil Surface Condition Indicators (SSCIs) (Table 4), each focusing on the measurement of specific biological and/or physical processes, are used to calculate three LFA indices; soil stability, soil infiltration and nutrient cycling. The three indices have scores of 0 to 100, which represent the ecosystem function of the area. These scores provide quantitative measures that may be used to compare rehabilitated areas with reference sites throughout the course of a monitoring program.

An LFA plot and transect was completed at each rehabilitation and reference site.

Table 4. Soil Surface Condition Indicators (SSCI) used to assess the effect of biological and physical processes on ecosystem function

Indicator	Related process
Rainsplash Protection	Rainsplash erosion
Perennial Vegetation Cover	Below ground biomass
Litter	Nutrient cycling of organic matter
Cryptogam Cover	Indication of soil stability and presence of nutrients
Crust Brokenness	Potential for wind and water erosion
Soil Erosion Type and Severity	Type and severity of existing soil erosion
Deposited Materials	Soil stability upslope
Soil Surface Roughness	Water infiltration and retention
Surface Resistance to Disturbance	Effect of mechanical disturbance
Slake Test	Soil stability when wet
Texture	Soil permeability and water storage

3.3.4 BioBanking – site value scores

The NSW Biodiversity Banking and Offsets Scheme – known as ‘BioBanking’, was introduced by the NSW government in 2008. The BioBanking Assessment Methodology (BBAM) assesses biodiversity values as defined by the TSC Act. These values include the composition, structure and function of ecosystems. They also include (but are not limited to) threatened species, threatened populations and threatened ecological communities, and their habitats.

AECOM (2012) refers to the use of ‘site value’ to provide a quantitative measure of the condition of the vegetation within each rehabilitation area. The site value for a particular zone is calculated based on quantitative measures of ten site attributes which are measured along a transect and within a survey plot, and assessed against benchmarks values (Table 5). A minimum number of plots are required based on the area of the site being assessed. It was thought to be more valuable to present results for each of the BioBanking criteria rather than just the site value score. In accordance with the relevant MOP performance criteria, the results for the Woodland - Other rehabilitation areas have been compared to the reference site benchmarks.

BioBanking plots were undertaken at all reference sites and all rehabilitation sites as identified in Appendix 4.

Table 5. The ten site value scores recorded as part the BioBanking assessment

Attribute	Explanation
Native plant species richness (NPS)	Number of native species recorded within a nested 20 x 20 m quadrat.
Native over-storey % cover (NOS)	Recorded at 5 m intervals along a 50 m tape
Native mid-storey % cover NMS)	Recorded at 5 m intervals along a 50 m tape
Native ground cover (grass) % cover (NGCG)	Recorded at 1 m intervals along a 50 m tape
Native ground cover (other) % cover (NGCO)	Recorded at 1 m intervals along a 50 m tape
Native ground cover (shrubs) % cover NGCS)	Recorded at 1 m intervals along a 50 m tape
Exotic plant cover % cover (EPC)	Recorded at 1 m intervals along a 50 m tap
Overstorey regeneration	Regeneration is measured as the proportion of over-storey species present in the zone that are regenerating (i.e. with diameter at breast height < 5 cm). For example, if there are three tree species present in the zone but only one of these species is regenerating, then the value is 0.33. The maximum value for this measure is 1.
Fallen logs (m) Length of logs (m) (FL)	Total length of logs recorded within the 20 x 50 m quadrat. To be eligible for inclusion, logs must be >10 cm diameter and longer than 50 cm.
Number of trees with hollows (NTH)	Number of trees with hollows within the 20 x 50 m quadrat.

3.3.5 Visual monitoring

Species composition

The dominant species present in the monitoring area were identified to obtain a 'picture' of the species composition. In rehabilitation areas, this allowed confirmation that the species establishing conformed to the target vegetation types being re-established.

Additionally, notes were made on the general health and sustainability of vegetation as indicated by presence/absence of flowering/fruiting adult plants. The presence of plants at reproductive stage is an indication that the ecosystem is recruiting and, as such, capable of self-regeneration. Given the young age of the rehabilitation sites where monitoring was undertaken, minimal details around canopy health and maturity were collected during the 2017 monitoring period.

Habitat and fauna monitoring

Artificial habitat features installed throughout the site as part of the rehabilitation activities (e.g. stag trees) were recorded.

Notes were also made on the presence and extent of habitat features such as free standing water, coarse woody debris, rocks, mistletoes and whether plants were flowering or fruiting.

Disturbance monitoring

Disturbance monitoring was undertaken using the visual monitoring tool developed by AECOM (2012). This technique is a field-based, rapid assessment tool to visually assess and award a score to various contributors. The objective of this monitoring is to identify factors and processes that occur at the landscape/catchment scale and have the potential to impact on the monitoring site. The disturbance monitoring aims to cover those aspects that are not adequately covered in the BioBanking and LFA monitoring tools. The following disturbance categories (and associated disturbance factors) were monitored and assessed at each site:

- Disturbance related to mining activities, including:
  - Evidence of wheeled vehicles, tracked vehicles and foot disturbance
  - Excavation
  - Presence of mine rubbish
- Disturbance related to non-mining activities, including:
  - Evidence of grazing
  - Presence of animal pads
- Presence of exotic weeds and feral animal species
- Presence of domestic litter / rubbish
- Fire disturbance
- Evidence of nearby maintenance activities (i.e. chemical treatments, fencing, earthworks)
- Surface stability and erosion issues, including:
  - Eroding factor (i.e. wind, water).
  - Erosion type (i.e. sheet, rill/gully, pedestal, terracette, scalding (Tongway & Hindley 2004)).

3.3.6 Canopy development and over-storey regeneration

In order to understand the adequacy of canopy development at rehabilitation sites in terms of species diversity, stem density, size and habitat values, two additional assessment techniques were introduced. One captures the adequacy of canopy recruitment, whilst the other captures canopy development and maturity:

- Introduction of stem density counts along two, 2 metre strips along the length of the 50 metre centre tape. The number and species of each individual canopy tree was counted. Where individuals could not be identified to species level, they were identified to genus.
- Information pertaining to canopy development; diversity and density, average trunk diameter, condition of the tree population, and percent of the endemic canopy with reproductive structures. This was undertaken in the nested 20 x 20 metre plot and each tree labelled with a metal tree tag or flagging tape with an ID number to allow for follow-up monitoring. Trees with a DBH less than five centimetres were not included in the count.

3.3.7 Soil analyses

Soil characterisation and analyses were performed to determine the physical and chemical properties of the growing media. Soil samples were collected from all monitoring sites (rehabilitation and reference sites). A composite sample, consisting of a minimum of nine sub-samples collected 10 to 15 metres apart, was collected within a 20 metre radius. The radius was based on a central point five metres in from the 20 metre quadrat tape. All samples were placed in a bucket, and were mixed. The sample was then placed in a plastic bag, labelled, and sent to the Environmental Analysis Laboratory (EAL) and Sydney Environmental & Soil Laboratory (SESL) Australia for analysis.

The following soil parameters were determined:

- pH
- Electrical conductivity (EC)
- Cation balance
- Sodicity
- Soil organic matter content
- Soil texture including clay content.

3.3.8 Photographic monitoring

Photographic monitoring is a simple and useful tool that allows for direct visual comparison of a specific site between monitoring events. Digital photographs were taken at the start and finish transect points at each monitoring site. This included:

- A photograph with the tape (and star picket) in the centre of the frame
- Photograph to the left and right of the centre tape.

3.3.9 Rill survey

In accordance with the LFA methodology (Tongway and Hindley 2004), rill surveys are to be carried out where rills are observed at less than 30 metre spacing across the slope.

None of the monitoring sites were impacted by rill erosion at the time of the 2017 monitoring survey, and therefore no rill surveys were undertaken.

3.3.10 Weather

Temperatures and rainfall in the months preceding the field monitoring period during both 2017 and 2016 are listed below in Table 6 and Table 7.

Conditions during the first round of the 2017 field surveys were dry and hot, with low rainfall recorded. When comparing results between 2016 and 2017 it should be noted that the weather preceding the 2017 surveys had considerably higher temperatures and lower rainfall than historical averages, with the rainfall being notably less than the rainfall which preceded the 2016 surveys. Daily maximum temperatures ranged from 29°C to 45°C.

Table 6. Weather conditions preceding and during the 2017 monitoring period (BoM Station # 061397)

	Monthly mean and total			Historical average (2002-2016)		
Month	**Min Temp (°C)**	**Max Temp (°C)**	**Rainfall (mm)**	**Min Temp (°C)**	**Max Temp (°C)**	**Rainfall (mm)**
October 2016	10.4	25.1	52.2	14.1	26.4	44.7
November 2016	12.7	30.7	52.2	17.8	28.8	83.6
December 2016	17.2	33.0	75	19.4	29.9	70.5
January 2017	19.1	34.4	48.4	20.2	31.5	69.9
February 2017	19.4	36.2	8.1	18.6	32.7	91.9
March 2017	17.7	28.5	129.7	15.1	28.2	64.2
April 2017	10.8	24.1	37.6	11.1	24.7	60.8
May 2017	7.3	21.7	24.6	6.9	21.5	29.3

Table 7. Weather conditions preceding and during the 2016 monitoring period (BOM Station #061397)

	Monthly mean and total			Historical average (2002-2016)		
Month	**Min Temp (°C)**	**Max Temp (°C)**	**Rainfall (mm)**	**Min Temp (°C)**	**Max Temp (°C)**	**Rainfall (mm)**
October 2015	10.0	26.8	42.6	14.1	26.4	44.7
November 2015	14.0	28.8	83.9	17.8	28.8	83.6
December 2015	15.8	29.9	73.9	19.4	29.9	70.5
January 2016	17.7	29.3	208.8	20.2	31.5	69.9
February 2016	17.6	29.0	10.0	18.6	32.7	91.9

3.4 Limitations

Many of the flora recorded in the rehabilitation monitoring sites were in a juvenile or seedling state and could not always be identified confidently. As such, identification may need to be updated in later monitoring years and analyses corrected.

Whilst the reference sites were located within BVTs that were in good condition and within the general region of the study area, they had been impacted by historic clearing, and thus old growth forms of these BVTs were not able to be sampled as reference sites. Considering this disturbance history, the reference sites represent recovering vegetation communities and therefore are useful to compare with the rehabilitation sites during the establishment phase.

Data analysis was limited to a comparison of rehabilitation site, (split by domain type) and reference sites, and to areas of different soil treatment. Details regarding weed management history and seeding rates were not available so data analysis based on these parameters was not undertaken. It was evident during the field visits in January that weather had created sub-optimal conditions for plant growth with the hot dry conditions resulting in stress to many individual plants, including individuals within mature rehabilitation areas and at reference sites in remnant vegetation. This was particularly evident for groundcovers species.

As some of the assessment methods changed between the 2016 baseline and 2017 monitoring periods, not all the key parameters were directly comparable. The ground-cover assessment was not replicated during 2017, therefore this data is not available for comparison. Similarly, new data collected, including details around canopy maturity and overstorey regeneration cannot be compared at this stage as baseline data is not available.

3.1 Compliance with the performance criteria outlined in the Mining Operations Plan.

The MOP provides a range of performance criteria to assess the native rehabilitation, in terms of establishment and sustainability. Due to the number of sites and the breadth and number of performance criteria, it is difficult to assess the performance of sites against the criteria in one Table. Table 8 provides a list of each of the criteria and provides the table number where it's addressed for each of the sites.

Table 8. MOP Performance Criteria – MTW and HVO rehabilitation sites

Performance Criteria – Growth Medium Development		Subheading	Domain Type	Table Number
1	pH >5.5 and <8.5	Soil Analysis	All Woodland	Table 10 to Table 13
2	Electrical Conductivity <2 dS/m	Soil Analysis	All Woodland	Table 10 to Table 13
3	Phosphorous within levels in analogue sites by Year 5	Soil Analysis	All Woodland	Table 10 to Table 13
4	Organic Carbon within levels in analogue sites by Year 5	Soil Analysis	All Woodland	Table 10 to Table 13
5	Cation Exchange Capacity within levels in analogue sites by Year 2	Soil Analysis	All Woodland	Table 10 to Table 13
6	Exchangeable Sodium Percentage within levels in analogue sites by Year 2	Soil Analysis	All Woodland	Table 10 to Table 13
7	Calcium/magnesium ratio within levels in analogue sites by Year 2	Soil Analysis	All Woodland	Table 10 to Table 13
Performance Criteria – Ecosystem and Landuse Establishment		**Subheading**	**Domain Type**	**Table Number**
1	Based on key physical, biological and chemical characteristics the LFA Stability Index provides an indication of the site's stability and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
2	Based on key physical, biological and chemical characteristics the LFA Infiltration Index provides an indication of the site's infiltration capacity and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
3	Based on key physical, biological and chemical characteristics the LFA Nutrient Recycling Index provides an indication of the site's ability to recycle nutrients and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
4	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
5	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Canopy Development	Woodland - Other	Table 29 and Table 31
6	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland - Other	Table 24 and Table 26
7	The density of trees is comparable to that of analogue sites (no./area)	Canopy Development	Woodland - Other	Table 29 and Table 31
8	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Canopy Development	Woodland EEC	Table 30

9	The number of shrub species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland EEC	Table 25
10	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland EEC	Table 25
11	The number of subshrub species and understorey species (other than grasses) comprising the vegetation community is comparable to that of analogue sites (no. species/area).	Species Richness	Woodland EEC	Table 25
12	The native plant species richness is within 50-100% or exceeds that of analogue sites (no. species/area). (Use OEH benchmark values)	Species Richness	Woodland EEC	Table 25
13	The density of trees is comparable to that of analogue sites (no./area)	Canopy Development	Woodland EEC	Table 30
Performance Criteria – Ecosystem and Landuse Sustainability		**Subheading**	**Domain Type**	**Table Number**
1	Weed plant cover (calculated as a percentage of total ground cover) is comparable to that of analogue sites. (% Cover)	Vegetation Structure and Species Richness	Woodland - Other	Table 37 and Table 38
2	Total groundcover is the sum of protective ground cover components (dead and live plant material, rocks and logs) and is comparable to that of analogue sites (% Cover)	Habitat Features	Woodland - Other	Table 16 and Table 17
3	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no./area).	Vegetation Health	Woodland - Other	Table 42
4	The percentage of maturing trees and shrubs with a stem diameter greater than 5cm that are local endemic species is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
5	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no./area).	Vegetation Health	Woodland - Other	Table 42
6	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Vegetation Health	Woodland - Other	Table 42
7	The percentage of the tree population which are in healthy condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
8	The percentage of the tree population which are in a medium health condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
9	The percentage of the tree population which are in a state of advance dieback and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
10	The presence of reproductive structures such as buds, flowers or fruit on trees and shrubs provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources and that the % population is comparable to that of analogue sites.	Vegetation Health	Woodland - Other	Table 42
11	The proportion of over-storey species occurring as regeneration is within 50-100% or exceeds that of analogue sites.	Vegetation Structure and Species Richness	Woodland - Other	Table 37 and Table 38
12	The percentage of native over storey cover is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
13	The percentage of native mid storey cover is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39

14	The percentage of native ground cover (grasses) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
15	The percentage of native ground cover (shrubs) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
16	The percentage of native ground cover (other) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
17	Exotic plant cover (calculated as a percentage of total ground cover and mid storey cover) is within 5-33% or less than that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
18	Total groundcover is the sum of protective ground cover components (dead and live plant material, rocks and logs) and is comparable to that of analogue sites (% Cover).	Habitat Features	Woodland - EEC	Table 18
19	The abundance of native understorey species per square metre, averaged across the site, provides an indication of the heterogeneity of the site and that the number of native species is comparable to analogue sites (no. species/m^2).	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
20	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no. /area).	Vegetation Health	Woodland - EEC	Table 42
21	The percentage of maturing trees and shrubs with a stem diameter greater than 5cm that are local endemic species is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
22	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no./area).	Vegetation Health	Woodland - EEC	Table 42
23	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Vegetation Health	Woodland - EEC	Table 42
24	The percentage of the tree population which are in healthy condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
25	The percentage of the tree population which are in a medium health condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
26	The percentage of the tree population which are in a state of advance dieback and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
27	The presence of reproductive structures such as buds, flowers or fruit on trees and shrubs provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources and that the % population is comparable to that of analogue sites.	Vegetation Health	Woodland - EEC	Table 42
28	The proportion of over-storey species occurring as regeneration is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
29	The total length of fallen logs is within 50- <100% or exceeds that of analogue sites. (Use OEH benchmark values)	Habitat Features	Woodland - EEC	Table 39
30	The number of hollows / nesting sites is within 50- <100% or exceeds that of analogue sites. (Use OEH benchmark values)	Habitat Features	Woodland - EEC	Table 39

4. Results

4.1 Growth Medium Development

Table 9 outlines the MOP performance criteria that are relevant to growth medium development. They are applicable to all the rehabilitation sites, regardless of the domain type.

Table 9. Growth Medium Development MOP Performance Criteria

Performance Criteria – Growth Medium Development		Subheading	Domain Type
1	pH >5.5 and <8.5	Soil Analysis	All Woodland
2	Electrical Conductivity <2 dS/m	Soil Analysis	All Woodland
3	Phosphorous within levels in analogue sites by Year 5	Soil Analysis	All Woodland
4	Organic Carbon within levels in analogue sites by Year 5	Soil Analysis	All Woodland
5	Cation Exchange Capacity within levels in analogue sites by Year 2	Soil Analysis	All Woodland
6	Exchangeable Sodium Percentage within levels in analogue sites by Year 2	Soil Analysis	All Woodland
7	Calcium/magnesium ratio within levels in analogue sites by Year 2	Soil Analysis	All Woodland

4.1.1 Soil Analysis

The results of the soil analyses by EAL Australia for key soil chemistry parameters for the HVO and MTW sites are detailed in Appendix 7.

Some of the results for soil properties outlined in the MOP Performance criteria have been compared with data from the reference sites. Data from the reference sites is provided in Table 10. The comparison of rehabilitation site data against the reference site ranges can be seen in Table 11, Table 12 and Table 13.

Table 10. Reference site soil results 2017

Site Name	pH >5.5 and <8.5	EC (dS/m) <2 dS/m	Phosphorus - Exchangeable (Mg/Kg)	Organic Carbon (% OM)	CEC (cmol+/Kg)	Sodium - ESP (%)	Calcium / Magnesium Ratio
WamboSpot1	6.28	0.06	4.73	5.02	8.26	1.16	2.14
WamboSpot2	6.41	0.05	5.94	6.23	14.88	1.53	1.94
WamboSpot3	6.19	0.06	5.28	4.74	8.59	2.17	1.87
WamboGB01	5.76	0.06	9.01	5.87	12.07	3.64	0.8
WamboGB02	6.69	0.1	7.73	7.67	20.44	1.74	2.02
WARKGB01	5.42	0.05	3.36	3.43	7.97	3.27	1.56
WARKGB02	6.03	0.06	5.41	4.97	8.16	2.63	1.99
WARKGB04	5.71	0.09	9.44	8.72	8.25	5.54	1
BEL1	5.44	0.05	5.19	7.05	7.44	4.18	0.65
BEL2	5.93	0.05	3.2	3.69	7.66	2.84	1.66
BEL3	5.69	0.1	5.19	8.17	11.26	4.43	1.28
Range	**5.42-6.69**	**0.05-0.10**	**3.19-9.44**	**3.43-8.72**	**7.44-20.44**	**1.16-5.54**	**0.65-2.14**
Average	**5.96**	**0.07**	**5.86**	**5.96**	**10.45**	**3.01**	**1.54**

Table 11. HVO Rehabilitation site soil results compared to MOP target/reference site range values (woodland – other domain type)

Site Name	pH >5.5 and <8.5	Electrical Conductivity (EC) (dS/m) <2 dS/m	Phosphorus - Exchangeable (Mg/Kg)	Organic Carbon (% OM)	Cation Exchange Capacity (CEC) (cmol+/Kg)	Sodium - ESP (%)	Calcium / Magnesium Ratio
Reference Site Average	**5.96**	**0.07**	**5.86**	**5.96**	**10.45**	**3.01**	**1.54**
Reference Site Range	**5.42-6.69**	**0.05-0.10**	**3.19-9.44**	**3.43-8.72**	**7.44-20.44**	**1.16-5.54**	**0.65-2.14**
HVO WES200801	7.24	0.11	17.17	4.43	13.76	2.02	1.10
HVO WES201101	8.44	0.16	87.55	5.64	20.09	2.05	1.48
HVO WES201301	8.37	0.18	146.20	4.36	18.96	1.27	2.24
HVO WES201302	7.81	0.54	186.15	8.84	23.81	1.65	2.74
HVO CAR200901	7.60	0.12	14.96	4.06	17.46	5.53	0.75
HVO CAR200902	7.70	0.08	11.65	2.73	23.27	3.01	1.16
HVO CAR201401	8.03	0.15	48.37	4.80	23.68	3.03	1.85
HVO RIV201406	7.78	0.17	55.85	6.41	22.01	4.98	1.20
HVO RIV201405	8.46	0.12	149.60	3.48	13.50	3.65	2.67
HVO RIV201404	8.80	0.20	101.15	5.29	20.66	6.02	2.30
HVO RIV201403	8.51	0.17	64.77	3.82	21.87	5.43	0.91
HVO RIV201402	8.72	0.48	215.05	8.28	30.22	9.32	1.58
HVO RIV201401	8.80	0.45	243.95	7.67	30.27	9.96	1.07
HVO CHE201201	8.13	0.16	249.90	9.57	23.32	4.04	2.69
HVO CHE201401 - A	7.69	0.13	77.18	4.97	18.25	2.53	1.71
HVO CHE201401 - B	8.14	0.17	244.80	6.27	16.47	3.44	3.95
HVO CHE201203	5.53	0.05	9.52	2.84	4.32	7.06	1.25
HVOCHE201601	8.07	0.52	43.30	6.69	17.75	4.20	1.74
HVOCHE201602	7.77	0.73	71.11	5.58	25.00	4.22	2.15
HVOLEM201501	6.98	0.06	50.64	3.62	7.19	1.70	3.41
HVOLEM201601	6.16	0.07	11.28	1.08	3.55	4.19	1.65
HVORIV201501	8.36	0.15	54.84	3.78	16.59	5.41	1.98
HVORIV201502	8.21	0.14	49.59	4.97	18.85	3.93	1.38
HVORIV201503	7.54	1.69	212.54	7.70	27.52	3.94	5.44
HVORIV201601	7.75	0.55	80.29	7.30	20.22	3.76	1.16
HVOWES201601	7.58	0.75	117.82	6.88	19.48	3.26	4.07
HVOWES201602	7.48	0.40	57.73	7.18	17.53	3.29	3.30
HVOWES201603	7.24	0.44	58.78	5.79	15.50	6.19	1.33
HVOWES201604	7.76	0.44	32.54	3.64	17.68	1.85	2.67

(light grey)	outside reference site range values
(green)	within reference site range values

Notes: pH and EC are compared against the target set within the MOP performance criteria rather than compared to reference site range values.

Table 12. MTW Rehabilitation site soil results compared to MOP target/reference site range values (woodland – EEC domain type)

Site Name	pH >5.5 and <8.5	Electrical Conductivity (EC) (dS/m) <2 dS/m	Phosphorus - Exchangeable (Mg/Kg)	Organic Carbon (% OM)	Cation Exchange Capacity (CEC) (cmol+/Kg)	Sodium - ESP (%)	Calcium / Magnesium Ratio
Reference Site Average	**5.96**	**0.07**	**5.86**	**5.96**	**10.45**	**3.01**	**1.54**
Reference Site Range	**5.42-6.69**	**0.05-0.10**	**3.19-9.44**	**3.43-8.72**	**7.44-20.44**	**1.16-5.54**	**0.65-2.14**
MTWNPN201301	6.87	0.08	24.57	2.64	8.04	1.37	2.43
MTWNPN201401	6.84	0.1	36.3	5.32	13.33	3.61	1.43
MTWNPN201403	8.28	0.2	121.55	4.94	17.27	6.1	1.54
MTWNPN201101	8.14	0.07	25.67	3.4	14.09	0.84	1.92
MTWNPN200901 - A	6.41	0.15	7.89	4.87	14.24	1.85	1.15
MTWNPN200901-B	8.02	0.16	81.43	5.2	18.25	1.23	2.4
MTWCDD201101	6.95	0.1	8.84	3.82	13.86	6.31	1.27
MTWCDD201301	8.31	0.14	133.45	5.99	16.31	4.44	2.64
MTWCDD201501	8.81	0.19	147.05	5.25	13.02	6.13	1.82
MTWWDL201401	7.41	0.17	86.7	6.74	15.17	8.68	1.53
MTWWDL201402	8.11	0.35	119.85	5.81	20.08	7.59	1.56
MTWTDI201501	9.19	0.8	89.25	10.94	19.61	36.74	1.14
MTWMTO200503	7.71	0.19	11.14	4.94	13.69	4.78	1.11
MTWSPN201401	8.32	0.16	38.42	5.29	15.49	4.04	2.04
MTWNOO201501	7.62	0.13	48.02	4.97	16.96	3.02	1.68
MTWNPN201402	6.32	0.03	30.96	4.4625	4.76	0.86	6.78
MTWSPN201501	8.07	0.32	186.04	7.2625	19.72	1.72	4.24
MTWSPN201601	7.04	0.68	112.83	8.085	20.84	4.31	2.85
MTWSPN201602	7.06	0.39	93.94	5.1625	13.59	7.4	1.92
MTWSPS201601	8.23	0.53	103.91	7.6825	20.42	4.88	2.65
MTWSPS201602	7.89	0.67	81.34	4.9525	20.07	4.68	2.24

(light grey)	outside reference site range values
(green)	within reference site range values

Notes: pH and EC are compared against the targets set within the MOP performance criteria rather than compared to reference site range values.

Table 13. MTW Rehabilitation site soil results compared to MOP target/reference site range values (woodland – other domain type)

Site Name	pH >5.5 and <8.5	Electrical Conductivity (EC) (dS/m) <2 dS/m	Phosphorus - Exchangeable (Mg/Kg)	Organic Carbon (% OM)	Cation Exchange Capacity (CEC) (cmol+/Kg)	Sodium - ESP (%)	Calcium / Magnesium Ratio
Reference Site Average	5.96	0.07	5.86	5.96	10.45	3.01	1.54
Reference Site Range	5.42-6.69	0.05-0.10	3.19-9.44	3.43-8.72	7.44-20.44	1.16-5.54	0.65-2.14
MTWMTO200001	7.55	0.15	15.64	2.47	12.43	13.55	0.73
MTWNPN200501	7.48	0.09	19.98	3.89	11.66	2.83	1.08
MTWNPN200502	7.31	0.09	22.44	5.97	13.07	1.43	1
MTWMTO201501	9.07	0.23	10.5	3.7625	12.69	9.71	1.62
MTWMTO201601	8.49	0.63	53.53	5.215	15.99	10.9	2.01

outside reference site range values

within reference site range values

Notes: pH and EC are compared against the target set within the MOP performance criteria rather than compared to reference site range values.

The above soil analysis shows results from HVO and MTW monitoring sites broken into domain type. The key results include:

- All sites, apart from HVO RIV201404, HVO RIV201403, HVO RIV201402, HVO RIV201401, MTWCDD201501, MTWTD1201501 and MTWMTO201501, fell within the MOP target levels for soil pH. The listed sites that did not fall within the target levels exhibited high alkalinity.
- Only two sites MTWNPN200901 – A, and MTWCDD201101 fell within the reference site range for Phosphorous levels. All other rehabilitation sites had higher Phosphorous levels than the reference sites.
- All sites, excluding HVOCAR200902 and HVOCHE201203 meet reference site levels for organic carbon.

4.2 Ecosystem and Landuse Establishment

4.2.1 Landscape Function Analysis

The following MOP performance criteria are relevant to LFA. The results are provided in Table 15 - Table 21. The relevant MOP performance criteria are provided in Table 14. These criteria relate to all sites, regardless of the domain type.

Table 14. Landscape Function Analysis MOP performance criteria

Performance Criteria – Ecosystem and Landuse Establishment		Subheading	Domain Type	Table Number
1	Based on key physical, biological and chemical characteristics the LFA Stability Index provides an indication of the site's stability and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
2	Based on key physical, biological and chemical characteristics the LFA Infiltration Index provides an indication of the site's infiltration capacity and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21
3	Based on key physical, biological and chemical characteristics the LFA Nutrient Recycling Index provides an indication of the site's ability to recycle nutrients and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21

4	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to or trending towards that of analogue sites (%)	LFA	All Woodland	Table 15 to Table 21

Reference Sites

The LFA scores for the Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest reference sites were tabulated and are provided in Table 15. It also provides the results and data from the 2016 baseline. Key results include the following:

- Most sites scored an Landscape Organisation Index (LOI) of 1.0
- Most LOI scores were largely consistent, with only minor variation between 2016 and 2017
- WAMBOSPOT2 had the lowest LOI (0.95) across all reference sites
- The average LOI for Ironbark-Spotted Gum-Grey Box Forest was similar to the average for Grey Box-Ironbark Woodland
- The stability scores achieved at many sites reduced overall between 2016 and 2017
- Stability ranged from 53.9 to 68.9 for Grey Box-Ironbark Woodland with WAMBOSPOT2 having the highest stability score of 68.9
- There has been some variation in the LFA scores between 2016 and 2017 at reference sites.

Table 15. LFA data for Reference sites

	Landscape Organisation Index		**Stability**		**Infiltration**		**Nutrient cycling**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Central Hunter Grey Box-Ironbark Woodland								
WARKGB01	1	1	69.8	53.9	49.7	65.2	43.2	42.9
WARKGB02	1	0.98	70	59.8	57.6	59	52.1	51.6
WARKGB03	0.84	0.99	57.9	55	49.8	55	38.7	38.5
WARKGB04	0.97	0.98	72.5	58.9	48.4	52.1	48.4	60.6
WAMBOGB1	1	1	58.3	63.5	56.2	57.4	46.3	56.9
WAMBOGB2	1	1	72.5	61.1	48.4	55.5	48.4	50.8
Range	**0.84 - 1**	**0.98 - 1**	**57.9- 72.5**	**53.9 - 63.5**	**48.4 - 57.6**	**52.1 - 65.2**	**38.7 - 52.1**	**38.5 - 60.6**
Average	**1.0**	**1.0**	**66.8**	**58.7**	**51.7**	**57.4**	**46.2**	**50.2**
Central Hunter Ironbark-Spotted Gum-Grey Box Forest								
BELLSPOT1	1	1	66.7	56.9	51.6	70.4	43.6	41.4
BELLSPOT2	0.94	0.98	81.8	66.7	69.9	61.1	54.2	70.3
BELLSPOT3	1	1	63.9	55.2	65.3	61.8	54.9	64.4
WAMBOSPOT1	1	1	62.5	66.9	74	60.4	65.6	55.6
WAMBOSPOT2	0.96	0.95	72.7	68.9	64.2	58.1	62.1	79.8
WAMBOSPOT3	1	1	69.7	62.2	67.2	73.9	59.7	53.8
Range	**0.94 - 1**	**0.98 - 1**	**62.5- 81.8**	**55.2 - 68.9**	**51.6 - 74**	**58.1 - 73.9**	**43.6 - 65.6**	**41.4 - 79.8**
Average	**1.0**	**1.0**	**69.6**	**62.8**	**65.4**	**64.3**	**56.7**	**60.9**
Total Range	**0.84 - 1**	**0.98 - 1**	**57.9-81.8**	**53.9 - 68.9**	**48.4 - 74**	**52.1 - 73.9**	**38.7 - 65.6**	**38.5 - 79.8**
Total Average	**1.0**	**1.0**	**68.2**	**60.8**	**58.5**	**60.8**	**51.4**	**55.6**

The 2016 and 2017 raw data, ranges and average LFA scores for all the HVO and MTW sites broken by domain type is provided in Table 16-Table 21. A summary of the key outcome is provided below.

HVO rehabilitation sites – Woodland other

The raw data, ranges and average LFA scores for HVO - woodland other sites from 2016 and 2017 is provided in Table 16 and Table 19. The comparison columns for each of the four indices are based on the reference site range values for each of these indices.

Based on the data, LFA scores across all indices were fairly consistent for all sites, with no conspicuous outliers. The average LOI score was 0.9 across all sites. High LOI scores, particularly at younger rehabilitation sites, were generally driven by extensive grass cover, rather than development of leaf litter or shrub species.

MTW rehabilitation sites – woodland other

The raw data, ranges and average LFA scores for MTW - woodland other sites from 2016 and 2017 is provided in Table 17 and Table 20. The comparison columns for each of the four indices are based on the reference site range values for each of these indices.

Key results are as follows:

- LOI ranged from 0.41 to 0.96
- Stability ranged from 39.5 to 56.1
- Infiltration was variable and ranged from 28.7 to 56.4
- Nutrient cycling was variable and ranged from 10.3 to 77.8
- MTWCDD201501 had the lowest LFA score.

MTW rehabilitation sites – woodland EEC

The raw data, ranges and average LFA scores for MTW – woodland EEC sites from 2016 and 2017 is provided in Table 18 and Table 21. The comparison columns for each of the four indices is based on the reference site range values for each of these indices.

Key results are as follows:

- LOI ranged from 0.21 to 1.0
- Stability ranged from 44.2 to 73.2
- Infiltration was highly variable and ranged from 8.2 to 65.4
- Nutrient cycling was variable and ranged from 12.3 to 43.1.

Table 16. Landscape Function Analysis scores HVO- woodland other domain type (2017 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**0.98**	**60.75**	**60.75**	**55.5**
Reference Site Range	**0.98 - 1**	**53.9 - 68.9**	**52.1 - 73.9**	**38.5 - 79.8**
HVOCAR200901	0.59	59.4	35.8	39.7
HVOCAR200902	0.93	63	75	61.5
HVOCAR201401	0.75	50.9	59.6	49.9
HVOCHE201201	0.84	56.1	54	47.7
HVOCHE201203	0.96	62.8	58.4	47.7
HVOCHE201401	0.99	51.1	47.9	36.2
HVORIV201401	0.94	67.1	60.5	58.3
HVORIV201402	0.84	53.5	51.6	43.4
HVORIV201403	0.91	53.4	33.1	36.3
HVORIV201404	0.87	55.6	43.2	32.1
HVORIV201405	1	56.7	46.9	32.3
HVORIV201406	0.95	51.6	70.5	15.3
HVOWES200801	0.84	69.6	43.5	72.1
HVOWES201101	0.73	63.8	53.2	54.4
HVOWES201301	0.67	61.9	50	42.9
HVOWES201302	0.96	62	58	47
HVOCHE201501	1	59	57	44.6
HVOCHE201601	1	45	27.6	13
HVOCHE201602	1	44.4	30.9	11.6
HVOLEM201501	1	57.9	75.7	69.2
HVOLEM201601	0.98	59.5	56.7	47.7
HVORIV201501	1	51.1	65.9	47.7
HVORIV201502	1	69	43	47
HVORIV201503	1	61.5	61.9	64.6
HVORIV201601	0.92	67.4	57.4	42.8
HVOWES201601	1	53.3	35.8	23.8
HVOWES201602	0.92	55.1	26.2	17.9
HVOWES201603	0.96	56.1	53.4	49.1
HVOWES201604	0.89	54.6	40.7	30.7
Rehabilitation Site Average	**0.9**	**57.8**	**51.1**	**42.7**

(light grey)	lower than reference site range values
(light green)	within reference site range values
(dark green)	exceeds reference site range values

Table 17. Landscape Function Analysis scores for MTW - woodland other domain type (2017 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**0.98**	**60.75**	**60.75**	**55.5**
Reference Site Range	**0.98 - 1**	**53.9 - 68.9**	**52.1 - 73.9**	**38.5 - 79.8**
MTWMTO200001	0.96	56.1	56.4	41.5
MTWNPN200501	0.58	51.3	50.1	43.1
MTWNPN200502	0.67	39.5	41.1	34
MTWMTO201501	0.41	54.4	31.6	31.5
MTWMTO201601	0.69	50.7	28.7	12.3
Rehabilitation Site Average	**0.7**	**50.4**	**41.6**	**32.5**

lower than reference site range values

within reference site range values

exceeds reference site range values

Table 18. Landscape Function Analysis results for MTW - woodland EEC domain type (2017 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**0.98**	**60.75**	**60.75**	**55.5**
Reference Site Range	**0.98 - 1**	**53.9 - 68.9**	**52.1 - 73.9**	**38.5 - 79.8**
MTWCDD201101	0.71	69.3	49.6	61.5
MTWCDD201301	0.97	60	48	49
MTWCDD201501	0.28	13.3	8.2	5.7
MTWMTO200503	0.35	56.1	45.3	33.5
MTWNPN200901	0.89	73.2	54.1	58.5
MTWNPN201101	0.21	69.3	49.6	61.5
MTWNPN201301	0.61	49.9	29.4	30.8
MTWNPN201402	0.55	53	51.6	44.8
MTWNPN201403	0.95	51.5	39	38.3
MTWSPN201401	0.94	45.2	65.4	49.5
MTWTD1201501	0.64	58.9	22.8	18.6
MTWWDL201401	0.68	44.2	32.5	35.9
MTWWDL201402	0.94	64.5	43.7	46.4
MTWNOO201501	1	52.8	27.5	20.9
MTWNPN201402	1	54.5	53.6	40.2
MTWSPN201501	0.01	57.5	53	38.5
MTWSPN201601	0	55.6	33.4	20.1
MTWSPN201602	0.85	57.6	66	60.1
MTWSPS201601	0.79	50.2	53.2	44.6
MTWSPS201602	0.75	53.9	31.8	20.8
Rehabilitation Site Average	**0.8**	**54.8**	**43.7**	**39.7**

lower than reference site range values

within reference site range values

exceeds reference site range values

Table 19. Landscape Function Analysis scores HVO- woodland other domain type (2016 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**1.0**	**68.2**	**58.5**	**51.4**
Reference Site Range	**0.84 - 1**	**57.9 - 81.8**	**48.4 - 74**	**38.7 - 65.6**
HVO CAR200901	0.83	66.5	47.4	44.2
HVO CAR200902	0.99	68	46.2	40.1
HVO CAR201401	0.86	61.4	43.3	50.2
HVO CHE201201	0.98	65.4	56.1	76.5
HVO CHE201203	0.91	64.3	57.3	57.5
HVO CHE201301	1	64.2	46.3	67
HVO CHE201401	0.82	55.6	40.2	34.1
HVO RIV201301	0.94	73.1	48.7	52.4
HVO RIV201401	0.69	49	33.2	22.6
HVO RIV201402	0.77	53.9	22.1	13.5
HVO RIV201403	0.86	50.8	22	16
HVO RIV201404	0.96	56	21.3	15.9
HVO RIV201405	1	73.1	64.1	77.8
HVO RIV201406	1	74.4	63.3	75.6
HVO WES200801	0.61	58.8	47.1	46
HVO WES201101	0.95	61.4	35.9	25.7
HVO WES201301	0.88	50.4	27	18.8
Rehabilitation Site Average	**0.9**	**61.5**	**42.4**	**43.2**

lower than reference site range values

within reference site range values

exceeds reference site range values

Table 20. Landscape Function Analysis scores for MTW - woodland other domain type (2016 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**1.0**	**68.2**	**58.5**	**51.4**
Reference Site Range	**0.84 - 1**	**57.9 - 81.8**	**48.4 - 74**	**38.7 - 65.6**
MTWMTO200001	0.89	58.2	31.8	33.9
MTWNPN200501	0.92	63.3	43.3	39.9
MTWNPN200502	0.95	61.3	37	32.4
Rehabilitation Site Average	**0.9**	**60.9**	**37.4**	**35.4**

	lower than reference site range values
	within reference site range values
	exceeds reference site range values

Table 21. Landscape Function Analysis scores for MTW - woodland EEC domain type (2016 data)

Site name	LOI	Stability	Infiltration	Nutrient cycling
Reference Site Average	**1.0**	**68.2**	**58.5**	**51.4**
Reference Site Range	**0.84 - 1**	**57.9 - 81.8**	**48.4 - 74**	**38.7 - 65.6**
MTWCDD201101	0.98	85.4	65.2	72.1
MTWCDD201301	1	78.7	77.8	64.6
MTWCDD201501	0.14	47.8	10.3	10.3
MTWMTO200503	0.54	54	28.5	21.4
MTWNPN200901	0.93	66.2	40.5	45.8
MTWNPN201101	1	58.7	57.1	53.5
MTWNPN201301	1	63.5	57.1	53.3
MTWNPN201401	0.67	61.9	32.8	21.4
MTWNPN201402	0.96	59.8	39.5	47
MTWNPN201403	0.98	74.6	66.8	65.5
MTWSPN201401	1	73.7	40.7	37.2
MTWTD1201501	0.61	54.4	24	22
MTWWDL201401	0.97	63.7	40.6	36.8
MTWWDL201401	0.97	63.7	40.6	36.8
MTWWDL201402	0.98	66.5	71.4	67.2
MTWWDL201402	0.98	66.5	71.4	67.2
Rehabilitation Site Average	**0.9**	**64.9**	**47.8**	**45.1**

	lower than reference site range values
	within reference site range values
	exceeds reference site range values

4.2.2 Species Richness

Table 23 to Table 26 below provide species counts of the reference and rehabilitation sites. These tables also highlight the rehabilitation sites that have achieved species richness comparable to the reference sites.

The following MOP performance criteria in Table 22 show performance criteria relevant to species richness. Some of these performance criteria only apply to particular domain types. A comparison of total native plant species richness for rehabilitation and reference sites is presented in Table 24 to Table 26 for information purposes. This measure is only a MOP performance criteria for Woodland – EEC domains and the target relates to species richness in OEH benchmark sites for Central Hunter Grey Box-Ironbark Woodland. A comparison of total native species richness for Woodland – EEC rehabilitation sites against the OEH benchmarks is presented in the Native Plant Species (NPS) column of Table 39.

Table 22. Species richness MOP performance criteria

Performance Criteria – Ecosystem and Landuse Establishment		Subheading	Domain Type	Table Number
6	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland - Other	Table 24 and Table 26
9	The number of shrub species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland EEC	Table 25
10	The number of grass species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Species Richness	Woodland EEC	Table 25
11	The number of subshrub species and understorey species (other than grasses) comprising the vegetation community is comparable to that of analogue sites (no. species/area).	Species Richness	Woodland EEC	Table 25
12	The native plant species richness is within 50-100% or exceeds that of analogue sites (no. species/area). (Use benchmark values)	Species Richness	Woodland EEC	Table 39

Table 23. 2017 Reference site native species count

Site Name	Number of Tree Species	Number of Shrub Species	Number of Grass Species	Number of Other Species	Total Native Plant Species Richness
Reference Sites					
BEL1	2	6	4	12	24
BEL2	2	4	4	12	22
BEL3	4	4	6	12	26
WAMBOG1	2	4	5	12	23
WAMBOGB2	1	6	9	12	28
WAMBOSPOT1	4	9	4	13	30
WAMBOSPOT2	4	7	8	12	31
WAMBOSPOT3	3	7	6	13	29
WARKGB01	2	5	5	14	26
WARKGB02	2	6	7	20	35
WARKGB03	3	6	6	11	26
WARKGB04	2	5	6	10	23
Reference Site Average	**3**	**6**	**6**	**13**	**28**
Reference Site Range	**1 - 4**	**4 - 9**	**4 - 9**	**10 - 20**	**22 - 35**

Table 24. 2017 HVO Rehabilitation sites native species count (Woodland – other domain type)

Site Name	Number of Tree Species	Number of Shrub Species	Number of Grass Species	Number of Other Species	Total Native Plant Species Richness
Reference Site Average	3	6	6	13	28
Reference Site Range	1 - 4	4 - 9	4 - 9	10 - 20	22 - 35
HVOCAR200901	3	4	1	0	8
HVOCAR200902	3	3	2	0	8
HVOCAR201401*	0	0	2	2	4
HVOCHE201201	0	0	2	3	5
HVOCHE201203*	0	0	2	1	3
HVOCHE201401*	0	0	3	0	3
HVORIV201401	3	5	6	6	20
HVORIV201402	1	1	4	2	8
HVORIV201403	0	2	5	3	10
HVORIV201404	0	2	3	4	9
HVORIV201405	0	0	1	0	1
HVORIV201406	0	0	5	4	9
HVOWES200801	4	6	7	2	19
HVOWES201101	6	7	5	3	21
HVOWES201301	4	2	6	2	14
HVOWES201302*	0	0	4	2	6
HVOCHE201501	0	0	0	3	3
HVOCHE201601	0	0	2	1	3
HVOCHE201602	0	0	1	1	2
HVOLEM201501	1	2	7	3	13
HVOLEM201601	1	5	3	5	14
HVORIV201501	0	0	11	2	13
HVORIV201502	0	0	2	5	7
HVORIV201503	4	4	10	4	22
HVORIV201601	0	0	1	1	2
HVOWES201601	0	3	5	4	12
HVOWES201602	3	11	12	11	37
HVOWES201603	4	6	11	5	26
HVOWES201604	0	6	8	6	20
HVO Average	1.3	2.5	4.6	3.3	11.7

	lower than reference site range values
	within reference site range values
	exceeds reference site range values
	not a MOP performance criteria for this domain type

Notes: * = sites that have not yet been sown with native seed mixes and therefore excluded from site averages.

Table 25. 2017 MTW Rehabilitation sites native species count (Woodland EEC domain type)

Site Name	Number of Tree Species	Number of Shrub Species	Number of Grass Species	Number of Other Species	Total Native Plant Species Richness
Reference Site Average	**3**	**6**	**6**	**13**	**28**
Reference Site Range	**1 - 4**	**4 - 9**	**4 - 9**	**10 - 20**	**22 - 35**
MTWCDD201101	4	10	5	6	25
MTWCDD201301*	0	0	0	0	0
MTWCDD201501	3	7	13	3	26
MTWMTO200503	2	0	6	12	20
MTWNPN200901	4	6	2	1	13
MTWNPN201101	2	9	2	3	16
MTWNPN201301	0	7	5	3	15
MTWNPN201401	0	12	9	3	24
MTWNPN201403	1	3	3	2	9
MTWSPN201401*	0	0	4	0	4
MTWTDI201501	1	2	8	1	12
MTWWDL201401	3	8	6	6	23
MTWWDL201402*	0	0	5	2	7
MTWNOO201501	0	3	7	3	13
MTWSPN201501	0	0	1	0	1
MTWSPN201601	0	0	0	0	0
MTWSPN201602	0	2	6	5	13
MTWSPS201601	0	0	2	4	6
MTWSPS201602	0	0	0	0	0
MTWNPN201402	0	10	5	7	22
MTW Average	**1.1**	**3.6**	**4.4**	**2.8**	**11.9**

(light grey)	lower than reference site range values
(light green)	within reference site range values
(dark green)	exceeds reference site range values
(pink)	MOP performance criteria for this domain relates to comparison with OEH benchmark (see Table 39)

Notes: * = sites that have not yet been sown with native seed mixes and therefore excluded from site averages.

Table 26. 2017 MTW rehabilitation sites native species count (Woodland – other domain type)

Site Name	Number of Tree Species	Number of Shrub Species	Number of Grass Species	Number of Other Species	Total Native Plant Species Richness
Reference Site Average	**3**	**6**	**6**	**13**	**28**
Reference Site Range	**1 - 4**	**4 - 9**	**4 - 9**	**10 - 20**	**22 - 35**
MTWMTO200001	2	2	0	9	13
MTWNPN200501	1	2	4	6	13
MTWNPN200502	2	4	2	2	10
MTWMTO201501	0	0	0	0	0

MTWMTO201601	0	0	2	1	3
MTW Average	**1.0**	**1.6**	**1.6**	**3.6**	**7.8**

	lower than reference site range values
	within reference site range values
	exceeds reference site range values
	not a MOP performance criteria for this domain type

Notes: * = sites that have not yet been sown with native seed mixes and therefore excluded from site averages

4.2.3 Canopy Development

Table 27. Tree species and canopy development MOP performance criteria

Performance Criteria – Ecosystem and Landuse Establishment		Subheading	Domain Type	Table Number
5	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Canopy Development	Woodland - Other	Table 29 and Table 31
7	The density of trees is comparable to that of analogue sites (no./area)	Canopy Development	Woodland - Other	Table 29 and Table 31
8	The number of tree species comprising the vegetation community is comparable to that of analogue sites (no. species/area)	Canopy Development	Woodland EEC	Table 30
13	The density of trees is comparable to that of analogue sites (no./area)	Canopy Development	Woodland EEC	Table 30

Reference site stem density counts

At each rehabilitation and reference site the stem density of canopy species was recorded within two 50 metre x 2 metre quadrats, running along either side of the 50 metre tape. The number of each different kind of over-storey species was recorded and the results are summarised in Table 28 - Table 31, with full results provided in Appendix 6.

Table 28. Details of canopy regeneration at reference sites

Site	Number of species	Stems per hectare (ha)
WAMBOGB1	2	950
WAMBOGB2	1	250
WARKGB01	2	3150
WARKGB02	2	1050
WARKGB03	3	2750
WARKGB04	2	500
Average	**2**	**1442**
BELLSPOT1	2	300
BELLSPOT2	2	850
BELLSPOT3	4	1000
WAMBOSPOT1	4	1650
WAMBOSPOT2	4	950
WAMBOSPOT3	3	800
Average	**3.2**	**925**
Total Average	**3**	**1183**
Range	**1 - 4**	**250 - 3150**

Table 29. Details of canopy regeneration at HVO rehabilitation sites 2017 (Woodland – other)

Site	Number of species	Stems per hectare (ha)	Natives sown (Y/N)
Reference Site Range	**1 - 4**	**250 - 3150**	
HVOCAR200901	3	1900	Y
HVOCAR200902	3	2400	Y
HVOCAR201401	0	0	N
HVOCHE201201	0	0	Y
HVOCHE201203	0	0	N
HVOCHE201401	0	0	N
HVORIV201401	3	350	Y
HVORIV201402	1	50	Y
HVORIV201403	0	0	Y
HVORIV201404	0	0	Y
HVORIV201405	0	0	Y
HVORIV201406	0	0	Y
HVOWES200801	4	4250	Y
HVOWES201101	6	4650	Y
HVOWES201301	4	600	Y
HVOWES201302	0	0	N
HVOLEM201501	1	100	Y
HVORIV201501	1	50	Y
HVORIV201503	1	50	Y

HVOWES201602	4	1000	Y
HVOWES201603	1	50	Y
HVOCHE201501	0	0	N
HVOCHE201601	0	0	N
HVOCHE201602	0	0	N
HVOLEM201601	0	0	N
HVORIV201502	0	0	N
HVORIV201601	0	0	N
HVOWES201601	0	0	N
HVOWES201604	0	0	N
Average	**1.9**	**908.8**	

	lower than reference site range values
	within reference site range values
	exceeds reference site range values

Notes: Sites which have not yet been sown with native seed mixes have been excluded from site averages.

Table 30. Details of canopy regeneration at MTW rehabilitation sites 2017 (Woodland – EEC)

Site	Number of species	Stems per hectare (ha)	Natives sown (Y/N)
Reference Site Range	**1 - 4**	**250 - 3150**	
MTWCDD201101	4	1750	Y
MTWCDD201301	0	0	N
MTWCDD201501	3	4850	Y
MTWMTO200503	2	1150	Y
MTWNPN200901	4	3500	Y
MTWNPN201101	2	600	Y
MTWNPN201301	0	0	Y
MTWNPN201401	0	0	Y
MTWNPN201402	0	0	Y
MTWNPN201403	1	100	Y
MTWSPN201401	0	0	N
MTWTDI201501	1	50	Y
MTWWDL201401	3	750	Y
MTWWDL201402	0	0	N
MTWNOO201501	0	0	N
MTWSPN201501	0	0	N
MTWSPN201601	0	0	N
MTWSPN201602	0	0	N
MTWSPS201601	0	0	N
MTWSPS201602	0	0	N
Average	**2.0**	**1159.1**	

	lower than reference site range values
	within reference site range values
	exceeds reference site range values

Notes: Sites which have not yet been sown with native seed mixes have been excluded from site averages.

Table 31. Details of canopy regeneration at MTW rehab sites 2017 (Woodland – other)

Site	Number of species	Stems per hectare (ha)	Natives sown (Y/N)
Reference Site Range	**1 - 4**	**250 - 3150**	
MTWMTO200001	2	850	Y
MTWNPN200501	1	100	Y
MTWNPN200502	2	1500	Y
MTWMTO201501	0	0	N
MTWMTO201601	0	0	N
Average	**1.7**	**816.7**	

	lower than reference site range values
	within reference site range values

exceeds reference site range values

Notes: Sites which have not yet been sown with native seed mixes have been excluded from site averages.

4.3 Ecosystem and Landuse Sustainability

4.3.1 Vegetation Structure and Species Richness

Results for vegetation structure and species richness for both reference and rehabilitation sites are displayed in Table 37 to Table 41 below. Both OEH and the calculated reference site benchmark values are also shown.

Table 32. Vegetation Structure and Species Richness MOP performance criteria

Performance Criteria – Ecosystem and Landuse Sustainability		Subheading	Domain Type	Table Number
1	Weed plant cover (calculated as a percentage of total ground cover) is comparable to that of analogue sites. (% Cover)	Vegetation Structure and Species Richness	Woodland - Other	Table 37 and Table 38
11	The proportion of over-storey species occurring as regeneration is within 50-100% or exceeds that of analogue sites.	Vegetation Structure and Species Richness	Woodland - Other	Table 37 and Table 38
12	The percentage of native over storey cover is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
13	The percentage of native mid storey cover is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
14	The percentage of native ground cover (grasses) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
15	The percentage of native ground cover (shrubs) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
16	The percentage of native ground cover (other) is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
17	Exotic plant cover (calculated as a percentage of total ground cover and mid storey cover) is within 5-33% or less than that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
19	The abundance of native understorey species per square metre, averaged across the site, provides an indication of the heterogeneity of the site and that the number of native species is comparable to analogue sites (no. species/m^2).	Vegetation Structure and Species Richness	Woodland - EEC	Table 39
28	The proportion of over-storey species occurring as regeneration is within 50-100% or exceeds that of analogue sites. (Use OEH benchmark values)	Vegetation Structure and Species Richness	Woodland - EEC	Table 39

Reference sites

OEH Benchmark values

The OEH Benchmark Values for both Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest are provided in Table 33.

Based on a comparison of the OEH benchmark values for the two communities the following can be concluded:

- Grey-Box Ironbark Woodland has a higher NPS compared to Ironbark Spotted Gum-Grey Box Forest
- Spotted Gum – Grey Box Forest has a greater NOS range compared to Grey-Box Ironbark Woodland
- Spotted Gum – Grey Box Forest has a greater NMS range compared to Grey-Box Ironbark Woodland
- Ironbark Spotted Gum-Grey Box Forest has a greater NGCG and a greater NGCG range compared to Grey-Box Ironbark Woodland
- Grey-Box Ironbark Woodland has the same NGCS range as Ironbark Spotted Gum – Grey Box Forest
- Grey-Box Ironbark Woodland has a greater NGCO compared to Ironbark Spotted Gum-Grey Box Forest
- NTH is greater in Grey-Box Ironbark Woodland
- FL is far greater within Ironbark Spotted Gum – Grey Box Forest.

Table 33. OEH Benchmark values for Central Hunter Grey Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest

Plot name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Grey-Box Ironbark Woodland OEH Benchmark Upper and Lower Limits	≥41	15	40	5	20	30	50	5	10	20	40	0	3	1	≥5
Spotted Gum – Grey Box Forest OEH Benchmark Upper and Lower Limits	≥25	20	50	10	60	5	16	5	10	5	15	0	1	1	≥66

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.

4.3.2 Reference sites against OEH Benchmark values

BioBanking data collected at each of the reference sites was input into the OEH BioBanking Benchmark Calculator to provide the lower and upper benchmark ranges for each attribute. The OEH benchmarks values have been compared to the reference site benchmark values below in Table 34 and Table 35.

Table 34. OEH benchmarks and 2017 reference site benchmarks

Reference site name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Central Hunter Grey Box-Ironbark Woodland															
WamboGB01	25	9.5		0.5		40		2		2		0	0	1	11
WamboGB02	28	13.5		0		32		6		6		0	0	1	22
WARKGB01	25	11.5		8		20		8		2		2	1	1	26
WARKGB02	37	21.5		1		66		0		8		0	0	1	60
WarkGB03	25	7.5		1		32		0		2		0	0	1	15
WarkGB04	22	6		0		26		10		14		0	1	1	10
Reference Site Benchmark Upper and Lower Limits	≥27	13.3	22.8	0.0	10.0	18.0	33.0	1.0	11.0	3.0	26.0	0	≥1	1	≥21
OEH Benchmark Upper and Lower Limits	≥41	15	40	5	20	30	50	5	10	20	40	0	3	1	≥5
Central Hunter Ironbark-Spotted Gum-Grey Box Forest															
BEL1	25	13		0		38		0		14		0	0	1	17
BEL2	22	19.5		0		22		2		36		6	0	1	24
BEL3	25	17		0		14		4		16		4	0	1	27
WamboSpot1	28	14		14.5		28		8		2		0	4	1	82
WamboSpot2	29	13.5		0		24		12		4		0	1	1	15
WamboSpot3	29	26		5.5		22		10		4		0	2	1	12
Reference Site Benchmark Upper and Lower Limits	≥25	6.8	17.5	0.0	4.5	23.0	53.0	0.0	9.0	2.0	11.0	0	≥0	1	≥19
OEH Benchmark Upper and Lower Limits	≥25	20	50	10	60	5	16	5	10	5	15	0	≥1	1	≥66

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.

Table 35. OEH benchmarks and 2016 reference site benchmarks

Reference site name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Central Hunter Grey Box-Ironbark Woodland															
WamboGB01	34	13		7		50		6		32		0	0	1	7
WamboGB02	35	19		0		62		12		12		0	0	1	23
WARKGB01	28	15		23		38		0		38		2	0	1	4.5
WARKGB02	31	14.5		1		70		0		62		0	0	1	22
WarkGB03	31	18.5		0		54		0		16		0	0	1	27
WarkGB04	29	2		0		64		28		16		4	1	1	3
Reference Site Benchmark Upper and Lower Limits	≥31	7.5	18.8	0	15.0	44.0	67.0	0	20.0	14.0	50.0	0	≥0	1	≥15
OEH Benchmark Upper and Lower Limits	≥41	15	40	5	20	30	50	5	10	20	40	0	3	1	≥5
Central Hunter Ironbark-Spotted Gum-Grey Box Forest															
BEL1	34	10.5		0		56		2		22		0	0	1	60
BEL2	35	38		2		56		6		50		0	0	1	13.5
BEL3	33	26.5		0		36		2		50		0	0	1	64
WamboSpot1	32	27		14		38		4		12		0	4	1	74
WamboSpot2	27	21		7.5		40		6		12		0	0	1	12
WamboSpot3	34	29		15		30		8		16		0	4	1	13
Reference Site Benchmark Upper and Lower Limits	≥34	15.8	33.5	0.0	14.5	33.0	56.0	2.0	7.0	12.0	50.0	0	≥0	1	≥37
OEH Benchmark Upper and Lower Limits	≥25	20	50	10	60	5	16	5	10	5	15	0	1	1	≥66

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.

Table 36. Combined reference site benchmarks using combined data from all reference sites and from both 2016 and 2017 monitoring

Reference site name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Reference Site Benchmark Upper and Lower Limits	≥28	7.4	26.6	0.0	14.6	21.8	64.2	0	10.2	2.0	39.2	0	≥1	1	≥20

Based on a comparison of the reference site benchmarks to the OEH benchmarks of Central Hunter Grey Box-Ironbark Woodland, the following conclusions can be made:

- Reference sites have a lower limit for most attributes, except NGCG and FL
- NPS for the reference site benchmark had a total of 14 species less than the OEH benchmark
- NOS for reference site benchmark has a smaller range than the OEH benchmark and this may be attributed to the historic clearing of the reference sites
- NMS for the reference site benchmark has a lower value of zero, whilst the OEH benchmark has a lower value of five percent
- NGCG for the reference site benchmark has a small range compared to the OEH benchmark
- NGCS for the reference site benchmark has a lower value of one and a higher upper value compared to the OEH benchmark
- NGCO for the reference site benchmark has a lower value of three, whilst the OEH benchmark has a lower value of 20 percent
- FL is higher for the reference site benchmark than the OEH benchmark.

Based on a comparison of the local benchmarks to the OEH benchmarks of Central Hunter Ironbark-Spotted Gum-Grey Box Forest, the following conclusions can be made:

- NPS was the same for the local benchmark and OEH benchmark
- NOS for reference site benchmark has a smaller range than the OEH benchmark and this may be attributed to the historic clearing of the reference sites
- NMS for the reference site benchmark has a lower benchmark value of zero compared to a lower OEH benchmark of ten and the reference site benchmark also has a significantly lower upper value compared to the OEH benchmark
- NGCG for the reference site benchmark is significantly higher compared to the the OEH benchmark
- NGCS for the reference site benchmark has a greater range compared to OEH benchmark
- NGCO for the reference site benchmark has a slightly lower range compared to OEH benchmark
- FL has a lower reference site benchmark than the OEH benchmark.

Considerable variation can be seen between the 2016 and 2017 local benchmark data (Table 34 and Table 35):

- NPS, NMS and NGCG decreased in both vegetation types in 2017 compared with 2016
- NOS has increased slightly in Central Hunter Grey Box-Ironbark Woodland, although it has decreased in Central Hunter Ironbark-Spotted Gum-Grey Box Forest in 2017
- NGCS has decreased for Central Hunter Grey Box-Ironbark Woodland while the range for Central Hunter Ironbark-Spotted Gum-Grey Box Forest in 2017 has increased
- NGCO has reduced substantially over both vegetation from 2016 to 2017
- Another hollow was recorded in Central Hunter Grey Box-Ironbark Woodland bringing the benchmark up to ≥1 from ≥0 the previous year
- FL has decreased substantially for Central Hunter Ironbark-Spotted Gum-Grey Box Forest in 2017, while the range for Central Hunter Grey Box-Ironbark Woodland has increased slightly.

A combined reference site benchmark has been established utilising data from both Central Hunter Ironbark-Spotted Gum-Grey Box Forest and Central Hunter Grey Box-Ironbark Woodland (Table 36). This benchmark calculation includes data from both 2016 and 2017 and aims to provide a representative benchmark of general vegetation within the region.

4.3.3 Biobanking values for rehabilitation sites against OEH benchmarks and reference site benchmarks.

The MOP performance criteria for Woodland – Other domains require analysis of biometric data against reference sites benchmark values (see Table 37 - Table 38). The MOP performance criteria for Woodland – EEC domains require analysis of biometric data against OEH benchmark values (see Table 39). The data has been tabulated based on site and domain type.

Table 37. HVO Woodland – other rehabilitation sites compared to the combined reference site benchmarks

Plot name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Combined Benchmark	≥28	7.4	26.6	0.0	14.6	21.8	64.2	0	10.2	2.0	39.2	0	≥1	1	≥20
HVOCAR200901	9	0		13		0		4		2		30	0	0	0
HVOCAR200902	10	8		0		0		0		0		74	0	0	0
HVOCAR201401*	4	0		0		0		0		0		74	0	0	0
HVOCHE201201	5	0		0		0		0		18		14	0	0	0
HVOCHE201203*	3	0		0		20		0		0		64	0	0	0
HVOCHE201401*	3	0		0		28		0		0		42	0	0	0
HVORIV201401	18	0		0		4		4		20		50	0	0	0
HVORIV201402	7	0		0		14		0		4		38	0	0	0
HVORIV201403	11	0		0		24		0		2		52	0	0	0
HVORIV201404	10	0		0		16		4		10		10	0	0	0
HVORIV201405	1	0		0		0		0		0		60	0	0	0
HVORIV201406	9	0		0		0		2		4		34	0	0	0
HVOWES200801	16	11		2		16		0		2		10	0	0	0
HVOWES201101	21	8		0		12		2		24		10	0	0	0
HVOWES201301	14	0		0		30		0		8		30	0	0	0
HVOWES201302*	0	0		0		50		0		8		30	0	0	0
HVOCHE201501	0	0		0		0		0		0		80	0	0	0
HVOCHE201601	0	0		0		0		0		0		0	0	0	0
HVOCHE201602	0	0		0		2		0		0		0	0	0	0
HVOLEM201501	0	0		0		94		0		0		18	0	0	0
HVOLEM201601	0	0		0		14		4		2		52	0	0	0
HVORIV201501	13	0		0		52		0		0		76	0	0	0
HVORIV201502	7	0		0		0		0		16		100	0	0	0
HVORIV201503	22	0		0		32		4		10		66	0	0	0
HVORIV201601	2	0		0		0		0		0		92	0	0	0
HVOWES201601	12	0		0		64		0		0		88	0	0	0
HVOWES201602	37	0		0		62		24		4		18	0	0	0
HVOWES201603	26	0		0		40		0		0		74	0	0	0
HVOWES201604	20	0		0		42		0		4		38	0	0	0

lower than reference site benchmark

within reference site benchmark

exceeds reference site benchmark

not a MOP performance criteria for this domain type

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.
Notes: 1. * = Sites which have not yet been sown with native seed mixes; 2. A low value for Exotic Plant Cover (EPC) is the desired result.

Table 38. MTW Woodland – other rehabilitation sites compared to the combined reference site benchmarks

Plot name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Combined Benchmark	≥28	7.4	26.6	0.0	14.6	21.8	64.2	0	10.2	2.0	39.2	0	≥1	1	≥20
MTWMTO200001	12	0.5		0		0		0		40		18	0	0	0
MTWNPN200501	12	0		3.5		12		0		0		22	0	0	0
MTWNPN200502	11	16.5		12		0		4		0		34	0	0	0
MTWMTO201501	4	0		0		0		0		2		72	0	0	0
MTWMTO201601	0	0		0		10		0		0		34	0	0	0

lower than reference site benchmark
within reference site benchmark
exceeds reference site benchmark
not a MOP performance criteria for this domain type

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.
Notes: 1. * = Sites which have not yet been sown with native seed mixes; 2. A low value for Exotic Plant Cover (EPC) is the desired result.

Table 39. MTW Woodland – EEC rehabilitation sites compared to the Central Hunter Grey Box – Ironbark Woodland OEH benchmarks

Plot name	NPS	NOS		NMS		NGCG		NGCS		NGCO		EPC	NTH	OR	FL
Central Hunter Grey Box-Ironbark Woodland OEH benchmark	≥41	15	40	5	20	30	50	5	10	20	40	5-33%	3	1	≥5
MTWCDD201101	24	3		6		18		48		12		2	0	0	0
MTWCDD201301*	0	0		0		0		0		0		90	0	0	0
MTWCDD201501	24	0		5		26		24		10		16	0	0	0
MTWMTO200503	19	0.5		0		10		0		6		78	0	0	0
MTWNPN200901	13	17		2.5		2		18		2		2	0	0	0
MTWNPN201101	16	0		5.5		12		26		0		46	0	0	0
MTWNPN201301	16	0		0		12		6		16		28	0	0	0
MTWNPN201401	24	0		8.3		30		22		4		26	0	0	0
MTWNPN201403	10	0		0		6		2		10		66	0	0	0
MTWSPN201401*	4	0		0		16		0		0		10	0	0	0
MTWTDI201501	13	0		0		34		0		50		20	0	0	0
MTWWDL201401	23	0		1.5		20		26		16		16	0	0	0
MTWWDL201402*	7	0		0		10		0		0		80	0	0	0
MTWNOO201501	0	0		0		40		0		2		56	0	0	0
MTWSPN201501	1	0		0		0		0		0		0	0	0	0
MTWSPN201601	0	0		0		0		0		0		0	0	0	0
MTWSPN201602	13	0		0		32		0		0		38	0	0	0
MTWSPS201601	6	0		0		0		0		4		58	0	0	0
MTWSPS201602	0	0		0		0		0		0		34	0	0	0
MTWNPN201402	22	4.9		11.6		54		46		8		8	0	0	0

	lower than 50% of OEH benchmark
	within 50 – 100% of OEH benchmark
	exceeds OEH benchmark

NPS: Native Plant Species, NOS: Native overstorey, NMS: Native midstorey, NGCG: Native ground cover grasses, NGCS: Native ground cover shrubs, NGCO: Native ground cover other, EPC: Exotic Plant Cover, NTH: Number trees with hollows, OR: Overstorey Regeneration, FL: Fallen Logs.
Notes: 1. * = Sites which have not yet been sown with native seed mixes; 2. A low value for Exotic Plant Cover (EPC) is the desired result; 3. MOP Performance Criteria target of 5-33% used for comparison for EPC.

4.3.4 Vegetation Health

Results of vegetation health for reference and rehabilitation sites can be seen in Table 41 and Table 42 below.

Table 40. Vegetation Health MOP performance criteria

Performance Criteria – Ecosystem and Landuse Sustainability		Subheading	Domain Type	Table Number
3	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no. /area).	Vegetation Health	Woodland - Other	Table 42
4	The percentage of maturing trees and shrubs with a stem diameter greater than 5cm that are local endemic species is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
5	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no. /area).	Vegetation Health	Woodland - Other	Table 42
6	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Vegetation Health	Woodland - Other	Table 42
7	The percentage of the tree population which are in healthy condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
8	The percentage of the tree population which are in a medium health condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
9	The percentage of the tree population which are in a state of advance dieback and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - Other	Table 42
10	The presence of reproductive structures such as buds, flowers or fruit on trees and shrubs provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources and that the % population is comparable to that of analogue sites.	Vegetation Health	Woodland - Other	Table 42
20	The diversity of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to that of analogue sites (no. /area).	Vegetation Health	Woodland - EEC	Table 42
21	The percentage of maturing trees and shrubs with a stem diameter greater than 5cm that are local endemic species is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
22	The density of maturing trees and shrubs with a stem diameter greater than 5cm is comparable to analogue sites (no. /area).	Vegetation Health	Woodland - EEC	Table 42
23	Average trunk diameter (dbh) of the tree population provides a measure of age and growth rate and that it is trending towards that of analogue sites (cm).	Vegetation Health	Woodland - EEC	Table 42
24	The percentage of the tree population which are in healthy condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
25	The percentage of the tree population which are in a medium health condition and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
26	The percentage of the tree population which are in a state of advance dieback and that the percentage is comparable to analogue sites.	Vegetation Health	Woodland - EEC	Table 42
27	The presence of reproductive structures such as buds, flowers or fruit on trees and shrubs provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources and that the % population is comparable to that of analogue sites.	Vegetation Health	Woodland - EEC	Table 42

Reference site canopy maturity and habitat values

At each reference site, individual canopy tree species with a DBH greater than five centimetres were marked with a metal tree tag or flagging tape and were numbered. This will allow future monitoring to identify trees that were included in counts and DBH measurements. Whether an individual had flowers or fruit was determined by whether there was evidence of these structures on the tree at the time of survey. Therefore, this is likely to under-estimate the maturity of the tree canopy. The results are provided below in Table 41. Full data is provided in Appendix 6.

Table 41. Details of canopy maturity at reference sites

Site name	Average tree width (cm)	Native trees >5cm DBH (20x20 plot)	Native trees >5cm DBH per hectare	Native tree species >5cm DBH	Native trees with fruit/flowers
WAMBOGB1	11.5	22	550	4	0
WAMBOGB2	22	4	100	2	0
WARKGB1	14.8	25	625	2	0
WARKGB2	14	24	600	2	0
WARKGB3	14.5	28	700	3	0
WARKGB4	65	2	50	1	0
BELLSPOT1	18.7	20	500	2	0
BELLSPOT2	19	13	325	2	0
BELLSPOT3	15	21	525	3	0
WAMBOSPOT1	22.5	8	200	3	0
WAMBOSPOT2	10.75	29	725	2	2
WAMBOSPOT3	22	9	225	3	0
Total Average	**20.8**	**17**	**427.1**	**2.4**	**0.16**
Reference Site Range	**11.5 - 65**	**2 - 29**	**50 - 725**	**1 - 4**	**0 - 2**

Rehabilitation site canopy maturity and habitat values

As for reference sites, each individual canopy tree at rehabilitation sites with a DBH greater than five centimetres were marked with a metal tree tag or flagging tape and numbered. Only a limited number of rehabilitation sites had canopy trees with a DBH greater than five centimetres. Whether an individual had flowers or fruit was determined by whether there was evidence of these structures on the tree at the time of survey. This technique is also likely to under-estimate the maturity of the tree canopy for rehabilitation sites but the same method has been applied at reference sites to provide an equal comparison. The canopy maturity results are provided in Table 42. Full data is provided in Appendix 6.

Table 42. Details of canopy maturity at all rehabilitation sites – split by location and domain type

Site name	Average tree width (cm)	Native trees >5cm DBH (20x20 plot)	Native trees >5cm DBH per hectare	Native tree species >5cm DBH	Native trees with fruit/flowers
Reference Site Range	**11.5 - 65**	**2 - 29**	**50 - 725**	**1 - 4**	**0 - 2**
HVOCAR200901	10.5	25	625	3	0
HVOCAR200902	6.5	4	100	3	0
HVOWES200801	6.1	38	950	2	0
HVOWES201101	6.2	17	425	2	0
Average	**7.3**	**21**	**525**	**2.5**	**0**
MTWCDD201101	5.8	17	425	2	2
Average	**5.8**	**17.0**	**425.0**	**2.0**	**2.0**
MTWMTO200001	7.1	6	150	1	0
MTWNPN200501	15	2	50	1	0
MTWNPN200502	9.1	30	750	3	0
Average	**10.4**	**12.7**	**316.7**	**1.7**	**0.0**
Total Average	**8.2**	**17.37**	**434.4**	**2.13**	**0.16**

	lower than reference site range values
	within reference site range values
	exceeds reference site range values

4.3.5 Habitat Features

Habitat features such as fallen logs and number of hollow bearing trees were recorded using the BioBanking methodology. The results for these performance criteria are presented in Table 39 of the BioBanking data. The total groundcover components (dead and live plant material, rocks and logs) can be seen in the Stability column of the LFA results in Table 16 to Table 18.

Table 43. Habitat Features MOP performance criteria

Performance Criteria – Ecosystem and Landuse Sustainability		Subheading	Domain Type	Table Number
2	Total groundcover is the sum of protective ground cover components (dead and live plant material, rocks and logs) and is comparable to that of analogue sites (% Cover)	Habitat Features	Woodland - Other	Table 16 and Table 17
18	Total groundcover is the sum of protective ground cover components (dead and live plant material, rocks and logs) and is comparable to that of analogue sites (% Cover).	Habitat Features	Woodland - EEC	Table 18
29	The total length of fallen logs is within 50-100% or exceeds that of analogue sites. (Use benchmark values)	Habitat Features	Woodland - EEC	Table 39
30	The number of hollows / nesting sites is within 50-100% or exceeds that of analogue sites. (Use benchmark values)	Habitat Features	Woodland - EEC	Table 39

All rehabilitation sites were recorded as having no fallen logs, therefore, not within the 2017 reference site range values (for Woodland – Other domains) or within 50-100% of OEH benchmark levels (for Woodland – EEC domains).

The results in Table 39 of the BioBanking data show zero hollow bearing trees recoded across all rehabilitation sites.

Total groundcover at the rehabilitation sites, including protective ground cover components such as dead and live plant material, rocks and logs, has been compared to the reference sites using the LFA data. This can be seen in Table 16, Table 17, and Table 18 of Section 4.2.1 within the LOI column of the LFA results where total groundcover percentage for rehabilitation sites from the 2017 monitoring is compared with the reference site range values.

4.3.6 Visual and Photo Monitoring (Appendix)

The results of the visual monitoring, and photo monitoring are provided in Appendix 5.

5. Discussion

5.1 Growth Medium Development

5.1.1 Soil Analysis

Overall, many of the rehabilitation sites fall within the MOP performance criteria targets or reference site soil property range values and therefore meet the MOP performance criteria. The following conclusions can be made from comparing rehabilitation sites against reference site range values (where applicable) or the target specified in the MOP performance criteria:

- pH falls between the target values specified in the MOP at all sites except HVORIV201404, HVORIV201403, HVORIV201402, HVORIV201401, MTWCDD201501, MTWTDI201501 and MTWMTO201501. These sites have only recently been established and it may take some time for the pH to reduce and become less alkaline, as is seen in older sites. While most sites fall between the values specified in the MOP, many rehabilitation sites show higher levels of pH than that of the reference sites.
- Electrical Conductivity (EC) falls within the required target of <2dS/m as outlined in the MOP for all sites, however the rehabilitation sites are generally higher than the reference site range.
- Phosphorous levels only meet benchmark at two sites, MTWNPN200901-A and MTWCDD201101. Levels of phosphorus at rehabilitation sites were markedly higher than those recorded at reference sites. Many of the older sites do not meet the performance criteria of being within analogue levels within five years of establishment.
- Organic Carbon has met benchmark for all sites excluding HVOCAR200902 and HVOCHE201203. This is likely due to compost being added and the organic matter from short-lived annuals. Sites with a higher number of exotic cover tended to have higher Organic Carbon. These higher Organic Carbon levels may also make it difficult for native species to compete on sites with higher densities of exotic species.
- Cation Exchange Capacity (CEC) falls between benchmark for approximately 70 percent of sites.
- Approximatly 46 percent of rehabilitation sites did not meet benchmark for sodium levels.
- Half of the HVO rehabilitation sites and the MTW woodland – other domain sites did not meet the reference site benchmark for Calcium / Magnesium Ratio. MTW woodland – EEC rehabilitation sites all fell within benchmark levels for Calcium / Magnesium Ratio.

5.2 Ecosystem and Landuse Establishment

5.2.1 Landscape Function Analysis (LFA)

LFA data was used to help understand landscapes stability, infiltration and Nutrient cycling capacity. These characteristics are discussed seperatly below.

5.2.2 Landscape Organisation Index (LOI)

In general the LOI at the reference and rehabilitation sites was high, with an average LOI of 0.98 for the reference sites and 0.9, 0.8 and 0.7 for the rehabilitation sites for HVO – woodland other, MTW – woodland other and MTW – woodland EEC respectively (see Table 15 - Table 21). The variability in the range of scores however, was greater at the rehabilitation sites than the reference sites. The variability in values at the rehabilitation sites is likely to be influenced by the seed treatments applied to those sites and the age of the rehabilitation. For example, many of the rehabilitation sites with a LOI of 1 achieved this result due to the high density of grass species (whether native or exotic). An example of one of these sites with a high density of exotic grasses is HVORIV201405, which is similar to that observed in 2016. This result highlights that LOI does not determine native cover per se, rather it's a determination of site stability. Conversely, sites that achieved relatively low LOI indices were typically spoil/compost sites that had only recently been established and exhibited little grass or plant cover (i.e. MTWSPN201501 and MTWSPN201601). Changes in the LOI between 2016 and 2017 can be seen in Table 16 - Table 21.

5.2.3 Soil surface condition

Stability

There's some level of consistency between the average stability index for reference and rehabilitation sites, with the reference sites obtaining an average index of 60.75 and the rehabilitation sites obtaining an average scores of 57.8 for HVO woodland – other, 50.4 MTW woodland – other, and 54.8 MTW woodland – EEC sites. As with the results from the LOI (above), stability indicators across the reference sites show greater consistency than the stability indicators for the rehabilitation sites. One of the indicators of stability is vegetation cover, which due to weed treatment (herbicide spray) at some rehabilitation sites, had reduced. This may have contributed to a reduction in the average score at rehabilitation sites. Changes in scores for stability between 2016 and 2017 for reference sites at HVO and MTW can be found in Table 16 - Table 21.

Infiltration

The average infiltration scores for rehabilitation sites overall from 2016 to 2017 has increased from 42.4 to 51.1 for HVO for woodland - other and 37.4 to 41.6 for MTW woodland – other sites. MTW woodland – EEC has dropped slightly from 47.8 to 43.7. This is likely due to the addition of new sites to this domain type. The range of scores was greater for the rehabilitation scores than for the reference sites. This may be due to an increase in the litter component at most rehabilitation sites. Under the methodology, dead and decaying vegetation forms litter and this probably contributed to the higher infiltration scores.

Nutrient cycling

Nutrient enrichment values between 2016 and 2017 showed no obvious trend with the average difference for the reference sites increasing from 51.43 to 55.5, while the average for the rehabilitation sites has decreased from 43.2 to 42.7 for HVO for woodland - other, 35.4 to 32.5 for MTW woodland – other and 45.1 to 39.7 for MTW woodland – EEC site in 2016 to 2017. This is likely due to the addition of new monitoring sites.

5.2.4 Species Richness

Tree species

The results of the native species counts for tree species are discussed in Section 5.2.5 Canopy Development.

Grass species

The reference sites recorded a range between 4 and 9, averaging six grass species overall. Rehabilitation sites were lower recording averages of 4.6 for HVO woodland – other, 4.4 for MTW woodland – EEC and 1.6 for woodland – other sites. At HVO, eleven sites met benchmark for this criteria with four exceeding the benchmark range. Eleven MTW woodland – EEC sites met the benchmark, with one exceeding the benchmark range. Only one of the woodland other domain types at MTW met benchmark for this criteria.

Shrub Species

MTW woodland – EEC domain contained sixteen sites that fell within or exceeded the reference site range, with an average of 3.6 shrub species for MTW woodland - EEC. This average was bought down by the inclusion of the younger sites, none of which meet the local benchmark for number of shrub species.

Other Species

MTW woodland – EEC domain contained only one site each that met the reference site range The average for these sites was 2.8 which is low in comparison with the reference sites average of 13 species. This may indicate that rehabilitation sites require a greater diversity or higher rate of herbs and forbs added to the seeding mix.

Native plant species richness

MTW woodland – EEC had five sites that were within the MOP target of 50-100% of the OEH benchmark value for native plant species richness. Most sites contain adequate numbers of tree, shrub and grass species, however, they lacked other species such as herbs and forbs which has reduced the overall number of native plant species per site.

The current diversity targets that are in place to guide seed mix formulation require 10 species of herbs and forbs to be included in each seed mix for planting of MTW Woodland – EEC areas. Given the low rates of establishment of herbs and forbs in rehabilitation areas, further investigation of the suitability of the species being included in seed mixes to rehabilitation areas may be warranted. If species currently being used in seed mixes are found to be problematic to germinate or establish in rehabilitation areas then other species that are more suited to rehabilitation areas should be investigated. To achieve higher diversity of herbs and forbs in rehabilitation areas it may also be necessary to increase the sowing rate of herbs and forbes that are added to seed mixes. Low rates of herb and forb establishment may also be due to these species not having enough over-storey protection which may require enrichment planting of herbs and forbs into established rehabilitation areas to address this issue.

5.2.5 Canopy Development

Number of tree species

HVO woodland – other sites contained 12 sites that was within or exceeded the reference site range of 1 to 4 species. These sites recorded an average score of 1.9. MTW woodland – other sites contained three sites that were within the reference site range, with an average score of 1.7.

MTW woodland – EEC contained eight sites that fell within the reference site range. The average value recorded for these sites was 2. Many of the rehabilitation sites had not been broadcast with native seed at time of recording, and as such have not been included in the average.

Many of the tree species recorded over the sites were still at a juvenile stage which made it difficult to correctly identify all individuals to a species level. Furthermore, some seeds may not have germinated at this early stage. Overstorey species richness should continue to be monitored and dependant on the results some site may require additional seeding or enrichment planting in the future to promote the number of overstorey species.

Canopy density

Six HVO woodland – other domain type sites met the reference site range of 250 to 3150 stems per hectare. Two sites HVOWES200801 and HVOWES201101 exceeded the benchmark range. These eight sites recorded an average score of 908.8 stems per hectare. Of the HVO woodland - other sites HVOCHE201201, HVORIV201403, HVORIV201404, HVORIV201405 and HVORIV201406 have previously been sown to natives but have no overstorey species recoded.

The MTW woodland – other sites contained two sites that met the benchmark range, with sites recording an average score of 816.7. All sites that had been sown to natives had overstorey species germinate.

MTW woodland – EEC sites contained four sites that fell within the local benchmark. Two sites MTWCDD201501 and MTWNPN200901 exceeded this benchmark. The average value recorded for these sites was 1,159.1 stems per hectare. MTWNPN201301, MTWNPN201401 and MTWNPN201402 had been previously sown to natives, however, showed no sign of overstorey species germinating.

All the domain types show a large range of variation between sites, in particular MTW woodland – EEC, has sites ranging from 0 to a density up to 4,850 stems per hectare which exceeded the benchmark. Some sites may require tree thinning in the future to more closely align with reference site range values. Thinning will allow understory species to compete for light and help them establish. It will also increase the number of fallen logs on the ground, helping to improve performance criteria for length of fallen logs with that of the reference sites.

The new method of monitoring the stem density of canopy species by counting individuals along the transect, within 2 meters either side of the 50 metre tape and extrapolating to stems per hectare worked well. This method of collecting stem density should continue to be used in future monitoring.

5.3 Ecosystem and Landuse Sustainability

5.3.6 Vegetation Structure and Species Richness

Exotic plant cover

At HVO, two sites fell within benchmark for exotic plant cover HVOCHE201601 and HVOCHE201602. However, these sites actually contained no vegetative cover at all. HVORIV201502 had 100 percent exotic plant cover. The high percentage of exotic cover at some of the rehabilitation sites is due to the use of cover crops which were seeded to stabilise and add nitrogen to the soil.

The MTW woodland – other domain type, did not have any sites which met benchmark levels. The site which contained the highest percentage of exotic cover in this domain was MTWMTO201501 with 72 percent cover.

MTW woodland – EEC contained two sites which fell within benchmark, these were MTWSPN201501 and MTWSPN201601. Again these sites also contained no vegetative cover. The site that contained the highest percentage of exotic cover was MTWCDD201301 with 90 percent cover.

It will be difficult to lower exotic plant cover to a level similar to that of the reference sites, as most of these exotic species have established a large seed bank which may last for many years before germinating. The best way to reduce exotic cover is to establish the native overstorey species, allowing them to shade out the exotic understory species.

Native over-storey cover (NOS)

Only one MTW Woodland – EEC rehabilitation site was within the 50-100% of the OEH benchmark target for this criteria. This is due to the young age of the rehabilitation sites, meaning that establishing overstorey trees are not yet large enough to contribute to the measured overstorey cover. The generally adequate overstorey stem densities in rehabilitation areas, as seen in Table 30, provide confidence that the rehabilitation sites will achieve the target levels for NOS when the trees grow to a sufficient height.

Native mid-storey cover

Six of the MTW Woodland – EEC rehabilitation sites were within the 50-100% of the OEH benchmark target for this criteria. Due to the young nature of the rehabilitation sites, this mid-storey cover may consist of over-storey species that haven't reached maturity and are still growing within the mid-storey stratum.

Native ground cover (grasses)

Nine of the MTW woodland – EEC rehabilitation sites were within the 50-100% of the OEH benchmark target for this criteria, with one site MTWNPN201402 exceeding the OEH upper benchmark. Two of the sites that did not achieve the benchmark levels were established pre-2011 prior to the use of native grass seed in the rehabilitation seed mixes. One of these sites MTWNPN200901 also has a very high overstorey stem density (3,500 stems/ha) which would be causing shading and competition for grass species. The remaining MTW woodland – EEC rehabilitation sites that have been sown to native seed mixes but are not yet achieving the benchmark level for native grass cover are mainly new sites experiencing delayed germination due to dry weather.

Native ground cover (shrubs)

MTW woodland – EEC contains eight sites which met MOP performance criteria target levels, of which seven sites exceeded the OEH upper benchmark. This is likely a result of the combination of exceptional germination combined with juvenile canopy and mid-storey species contributing towards NGCS.

Native ground cover (other)

MTW woodland- EEC had six sites meet benchmark and one site exceed the OEH benchmark range for Central Hunter Grey Box-Ironbark Woodland. The low results for native plant species richness for 'other species' in MTW woodland – EEC rehabilitation sites (Table 25) indicate that a small number of herbs and forbs are contributing to the measured cover for 'other species'.

5.3.7 Vegetation Health

Tree Diversity (DBH >5cm)

Rehabilitation sites containing tree species with a DBH >5 cm fell between the benchmark range of 1 to 4 species of maturing trees. HVO had an average of 2.5 species of maturing trees at sites which contained trees >5cm DBH, and this was slightly above the reference site average of 2.4 species per site. MTW woodland – other had a single site which contained two species of trees with a >5cm DBH. MTW woodland – EEC supported three sites of mature trees, which produced an average of 1.7 tree species per site. Overall these sites had an average of 2.13 species of tree per site containing trees >5cm DBH (Table 42). While this is a reasonable number of species per site, only eight of the 54 rehabilitation sites recorded trees with a DBH >5cm. No new rehabilitation sites contained trees >5cm DBH which was to be expected. This performance criteria will only improve with time once trees on younger sites have matured and have a larger DBH.

Tree Density (DBH >5cm)

All rehabilitation sites containing tree species with a DBH >5 cm fell between or exceeded the benchmark range of 50 – 725 stems per hectare. HVO sites recorded an average of 525 trees per hectare which was moderately denser than the reference site average of 427.1 trees per hectare. HVO site HVOWES200801 also exceeded the benchmark range with 950 trees per hectare. The MTW woodland – other site produced a score of 425 trees per hectare, which is slightly lower than the reference site average. MTW woodland – EEC produced a score of 316.7 trees per hectare with one site (MTWNPN200502) exceeding the benchmark range. Together all sites containing trees averaged an above benchmark score of 434.4 trees per hectare (Table 42).

These sites would also contain trees that fell below the 5 centimetre DBH cut off, meaning many of these sites may produce higher densities of trees >5 centimetre DBH in the future, as smaller trees mature. If this is the case, management of tree densities will be required into the future to bring numbers down to within benchmark levels. As mentioned previously, thinning may also be required to improve light penetration in order to improve growth and establishment of ground-storey species.

Tree Health

No quantitative data was collected for tree health, however, visual analysis of sites in the field allowed us tree health at rehabilitation sites to be noted. All trees appeared to be in a healthy to moderate condition, even in the dry conditions in which the rehabilitation sites were recoded. No trees were viewed as being in a state of advanced dieback.

Reproductive Structures

All sites meet benchmark range, however, it should be noted the range begins at zero automatically qualifying sites as reaching the benchmark. Table 42 shows one site within the MTW woodland – other domain containing two trees that had buds or were flowering. This has brought the average for all rehabilitation site domain types up to be comparable to the average achieved by the reference sites. This shows that some of the rehabilitation sites are possibly becoming capable of recruitment.

5.3.8 Habitat Features

Percentage Groundcover (dead and live plant material, rocks and logs)

Total groundcover including protective ground cover components such as dead and live plant material, rocks, and logs at the rehabilitation sites have been compared to the reference sites in Table 15 of the LFA data. LOI represents percentage cover (dead and live plant material, rocks and logs) along the transect. As mentioned above in Section 5.2.2 LOI, was relatively high for both reference and rehabilitation sites. This was a result of the high density of dead or live vegetation, mostly in the form of cover crops.

Rehabilitation sites did not contain any logs or large rocks. Sites contained uniform sized rocks from overburden, but lacked larger boulders and flat habitat rocks that would otherwise naturally occur, and can been seen at some of the reference sites.

Length of fallen logs

No fallen logs where recorded at any of the rehabilitation sites. This performance criteria is something that will develop with time. However, improvement against this criteria could be fast-tracked with the introduction of such features as ‘habitat furniture’. As mentioned above in Sections 5.2.5 and 5.3.7 trees will require thinning in the future and this should be done at such a time and in such a way so that it contributes towards improving performance levels for rehabilitation sites with regard to fallen logs.

No hollow trees were recorded at any of the rehabilitation sites. Hollows would not be expected to develop in any of the rehabilitation sites for many years. Habitat for hollow dependant birds may be improved by the installation of next boxes in the future.

5.3.9 Visual and Photo Monitoring (Appendix)

The results of the visual monitoring and photo monitoring are provided in Appendix 5.

6. Conclusions

6.1 Conclusions

There is significant variation in the types and ages of the rehabilitation sites which formed part of this monitoring project and thus there is a high degree of variability in the results, particularly for native plant species richness, exotic cover, percentage cover, LOI and projected cover of all strata. Weather conditions varied greatly between the 2016 and 2017 monitoring seasons, which affected the degree of native cover and diversity at both the rehabilitation sites and at the reference sites. Provided below are some of the core outcomes of the BioBanking assessment, LFA, the assessment of tree canopy and over-storey regeneration.

6.2 Growth Medium Development

Generally speaking, many of the rehabilitation sites fall within the MOP performance criteria targets or reference site soil property range values and therefore meet the MOP performance criteria. Most rehabilitation sites met the MOP performance criteria targets for pH, EC, Organic Carbon and Cation Exchange Capacity. Phosphorous levels in rehabilitation sites were generally significantly higher than the reference site range values. High levels of available major nutrients such as Phosphorous will be useful for the re-establishment of vegetation communities in rehabilitation areas. However, there is a risk that high nutrient levels may stimulate weed growth that can compete with the native plants and prevent establishment of the desired vegetation communities. Weed management will therefore be an important intervention to ensure rehabilitation areas continue on the desired trajectory.

6.3 Ecosystem and Landuse Establishment

6.3.1 Landscape Function Analysis

Landscape Function Analysis was undertaken at all rehabilitation sites and reference sites. Generally the LOI at the reference and rehabilitation sites was high, with an average LOI of 0.98 for the reference sites and 0.9, 0.8 and 0.7 for the rehabilitation sites (see Table 16 to Table 21). However, the variability in the range of scores was greater at the rehabilitation sites than at the reference sites. This variability is likely to be influenced by rehabilitation management, with sites with a high degree of herbaceous cover returning a high LOI score and sites that had recently been sprayed and had limited live cover returning a low LOI score.

Three other attributes are measured through LFA, including stability, infiltration and nutrient cycling. Like with the LOI score, there was some consistency between the stability score achieved at the rehabilitation sites and the reference sites. The reference sites obtained an average index of 60.75 and the rehabilitation sites obtaining average scores of 57.8 for HVO sites, 50.4 for MTW woodland – other, 54.8 for MTW woodland – EEC. As vegetation cover is a core component of the stability score, individual site management practises (including high herbaceous cover or conversely herbicide spraying) can dictate this indicator.

The average infiltration scores for rehabilitation sites overall has increased from 42.4 for HVO sites, 37.4 for MTW woodland – other and 47.8 for MTW woodland – EEC to 51.1, 41.6, and 43.7 respectively. MTW woodland – EEC has dropped slightly from 47.8 to 43.7. This is likely due to the addition of new sites to this domain type.

Nutrient enrichment values between 2016 and 2017 showed no obvious trend with average differences for the reference sites increasing from 51.43 to 55.5 and the average for the rehabilitation sites having decreased from 43.2 for HVO sites, 35.4 for MTW woodland - other and 45.1 for MTW woodland – EEC in 2016 to 42.7, 32.5 and 39.7 in 2017 respectively. This is likely due to the addition of new monitoring sites.

6.3.2 Species Richness

Measures of species richness for trees and grasses are used as MOP performance criteria for all Woodland domain types. Of the rehabilitation sites that had been planted with native seed mixes, 48% of the HVO woodland – other; 60% of the MTW woodland – other; and 47% of the MTW woodland – EEC sites were within or exceeded the reference site range values for native tree species richness. Similarly, 60% of the HVO woodland – other; 20% of the MTW woodland – other; and 71% of the MTW woodland – EEC rehabilitation sites that had been sown with native seed mixes met or exceeded the reference site range values for native grass species richness. These results are expected to improve with future monitoring because many of the sites that didn't achieve the reference site range values were new sites that were experiencing delayed germination due to dry weather conditions.

Additional MOP performance criteria for species richness related to shrubs, other groundcover (i.e. not grasses) and total native plant species apply to woodland – EEC domains. The reference site range for shrub species richness was 4 to 9, and a total of eight MTW woodland – EEC rehabilitation sites met or exceeded the reference site range values for this criteria. Species richness data collected for 'other species' (including herbs and forbs) indicated that in comparison to reference site range values, MTW woodland – EEC rehabilitation sites do not score as well for this attribute. The reference site range is 10 to 20 species, and only one of the MTW woodland – EEC rehabilitation sites fell within this range.

The relatively poor species richness result for 'other species' also impacted on the performance of MTW woodland – EEC rehabilitation sites in terms of total native plant species richness. Only five of the 17 MTW woodland – EEC rehabilitation sites that had been sown to native seed mixes achieved the total native plant species target of 50-100% of the OEH Benchmark for Central Hunter Grey Box – Ironbark Woodland. While many sites meet the canopy, grass and shrub targets, the comparative number of species of herbs and forbs is often too low. This may be due to such species germinating later than other species or not having enough overstorey protection to establish.

6.4 Ecosystem and Landuse Sustainability

6.4.3 Vegetation structure and species richness

Results were generally positive when comparing rehabilitation sites with benchmark ranges, with some sites falling within the reference site benchmark for some of the ten attributes. Given the relatively young age of some of the rehabilitation sites, it is inherent that these sites would not meet benchmark for these attributes. Core outcomes include:

- All rehabilitation sites fall below benchmark in at least one attribute.
- Due to the density of regenerating shrub species, a number of sites exceed the upper benchmark for NGCS. This is likely a result of the combination of exceptional germination and juvenile canopy and mid-storey species contributing towards NGCS.
- Only one MTW woodland – EEC site is meeting the MOP performance criteria target for NOS.
- All other MTW woodland – EEC sites have very low to no NOS. This is due to juvenile trees not occurring in the canopy stratum.
- The 2017 reference site benchmarks vary from 2016, likely due to seasonal differences. While field surveys were conducted during the same time of the year as the 2016 surveys, many benchmark values are lower. This is likely a result of extended periods of extremely hot weather prior to the 2017 surveys, which is likely to have killed sensitive herbs and forbs compared to the previous year.

- The MOP performance criteria for exotic plant cover for woodland – other rehabilitation sites has a target level of 'comparable to reference site values'. As all of the reference sites had exotic plant cover levels of 0-6%, the reference site benchmark value was calculated to be 0%. Only two woodland – other rehabilitation sites across HVO and MTW sites met this reference site benchmark level and in both cases these sites had no vegetative cover at all due to a recent knockdown herbicide spray. A target level of 0% exotic plant cover is going to be very difficult to achieve in rehabilitation areas due to high weed seed loads present in topsoil.
- In comparison, the MOP performance criteria target for exotic plant cover for woodland – EEC rehabilitation sites has been set at 5-33%. Nine of the MTW woodland – EEC rehabilitation sites met this target level. High exotic plant cover scores that exceed the benchmark at new rehabilitation sites are primarily due to the use of cover crops early during the rehabilitation works.
- MTW Woodland – EEC rehabilitation sites were generally not meeting the target levels for total native plant species richness (NPS). Although sites were generally meeting species richness targets for native trees, shrubs and grasses, they were achieving low results for species richness of 'other species' (i.e. herbs, forbs and monocots other than grasses etc.). The category of 'other species' is where most of the native plant species diversity is found in the reference sites, with results from reference sites showing they contain 10-20 species in this category.
- In relation to NPS, there is not necessarily a correlation between age of the rehabilitation and species richness. Older rehabilitation sites do not necessarily have a greater number of plant species. This is likely to reflect that seed mixes being used since 2011 have had a much higher diversity of species than earlier seed mixes.
- Eight MTW woodland – EEC rehabilitation sites were within the reference site range values for native mid-storey cover. Part of the contribution to mid-storey cover however might be due to the presence of juvenile overstorey species which are not yet mature enough to be included in the overstorey and are included as mid-storey.
- Due to the age of the rehabilitation sites, only eight of the 54 rehabilitation sites had trees with a DBH greater than five centimetres. However, the canopy species diversity at these sites were generally good, with all of these sites falling within the benchmark range.
- No fallen logs or large rocks were recorded at any of the rehabilitation sites.

7. References

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Coal and Allied (2016a) Mining Operations Plan – HVO North.

Coal and Allied (2016b) Mining Operations Plan - Mount Thorley Warkworth.

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Niche (2016) Native Vegetation Rehabilitation Monitoring 2016 - Mount Thorley Warkworth and Hunter Valley Operations. Prepared for Coal & Allied.

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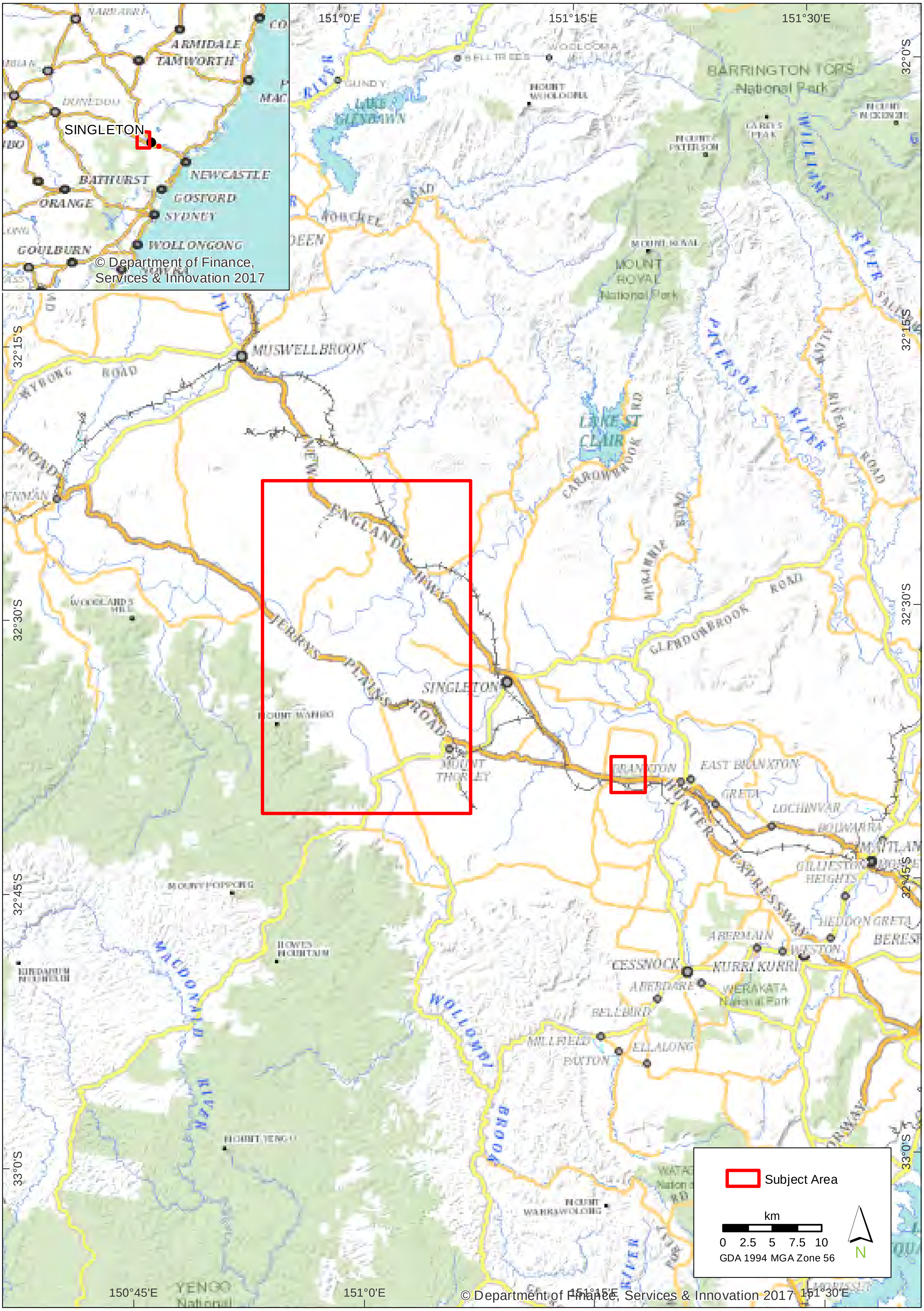
Tongway, D. and Hindley, N. (2004) Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes with Special References to Mine sites and Rangelands. CSIRO Sustainable Ecosystems, Canberra.

Appendix 1 – Figures

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_1_Location.mxd



Location map

Native Vegetation Rehabilitation Monitoring

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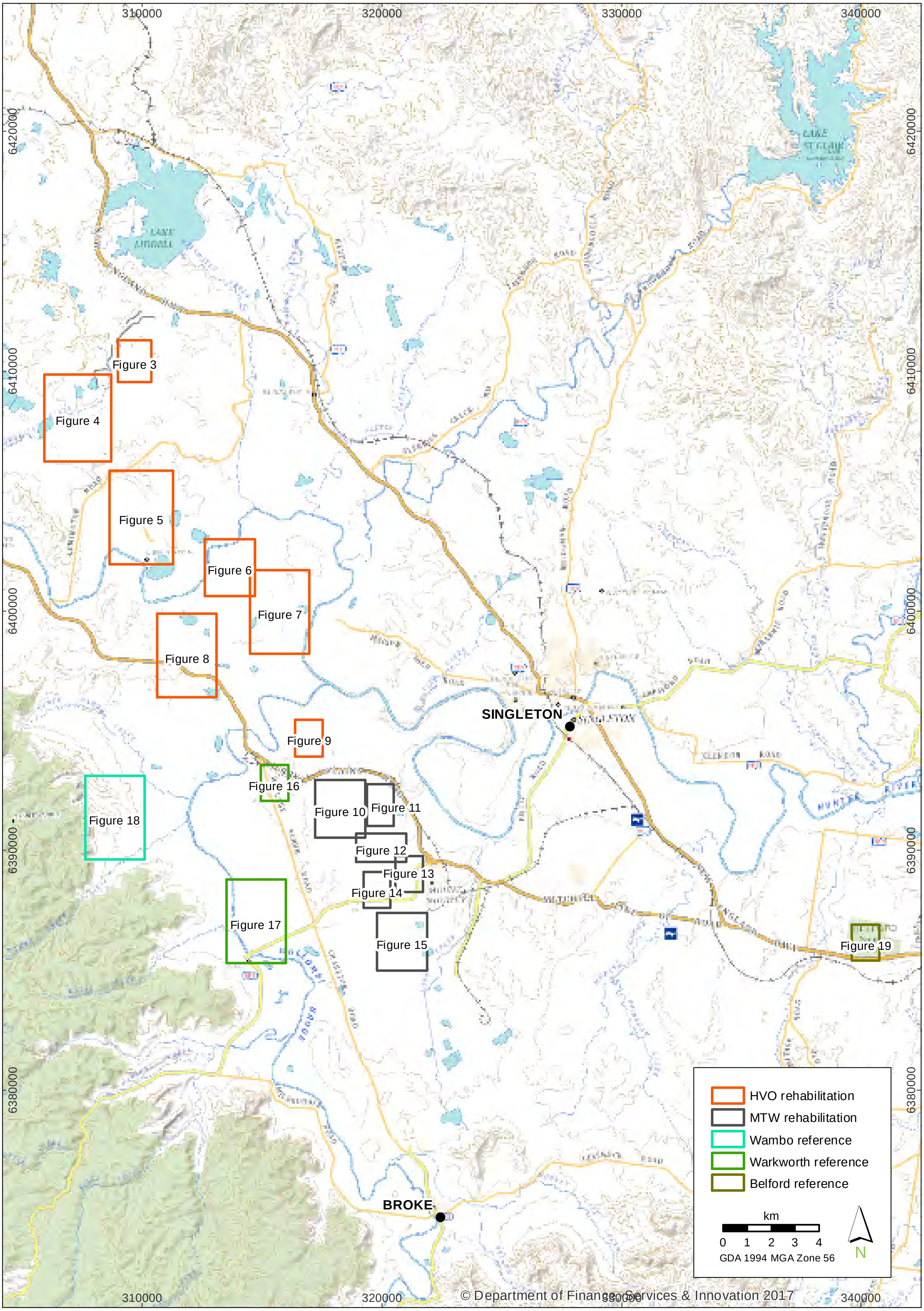
FIGURE 1



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Site locations overview

Native Vegetation Rehabilitation Monitoring

FIGURE 2

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Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_3_HVOWES.mxd

HVO survey locations - map 1 (HVOWES)

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FIGURE 3

Imagery: (c) Nearmap 2018-02-07

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HVO survey locations - map 2 (HVOWES)

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FIGURE 4

Imagery: (c) Nearmap 2015-03-06

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HVO survey locations - map 3 (HVOCAR)

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FIGURE 5

Imagery: (c) Nearmap 2015 - 2018

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HVO survey locations - map 4 (HVOCHE)

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FIGURE 6

Imagery: (c) Nearmap 2017-11-03

HVO survey locations - map 5 (HVOCHE)

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FIGURE 7

Imagery: (c) Nearmap 2017-11-03

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_8_HVORIV.mxd

HVO survey locations - map 6 (HVORIV)

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FIGURE 8

Imagery: (c) Nearmap 2017-11-03

HVO survey locations - map 7 (HVOLEM)

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FIGURE 9

Imagery: (c) Nearmap 2017-11-03

MTW survey locations - map 1 (MTWNPN)

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FIGURE 10

Imagery: (c) Nearmap 2017-11-03

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Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_11_MTWNPN_NOO.mxd

MTW survey locations - map 2 (MTWNPN-NOO)

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FIGURE 11

Imagery: (c) Nearmap 2017-11-03

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_12_MTW_NPN_SPN.mxd

MTW survey location - map 3 (MTWCDD-SPN)

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FIGURE 12

Imagery: (c) Nearmap 2018-01-05

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Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018

MTW survey location - map 4 (MTWSPS)

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FIGURE 13

Imagery: (c) Nearmap 2018-01-05

T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_14_MTWWDL.mxd Date: 08/03/2018 Project Number: 3417 Project Manager: VH Drawn by: RJ

MTW survey location - map 5 (MTWWDL)

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FIGURE 14

Imagery: (c) Nearmap 2018-01-05

MTW survey location - map 6 (MTWMTO)

Native Vegetation Rehabilitation Monitoring

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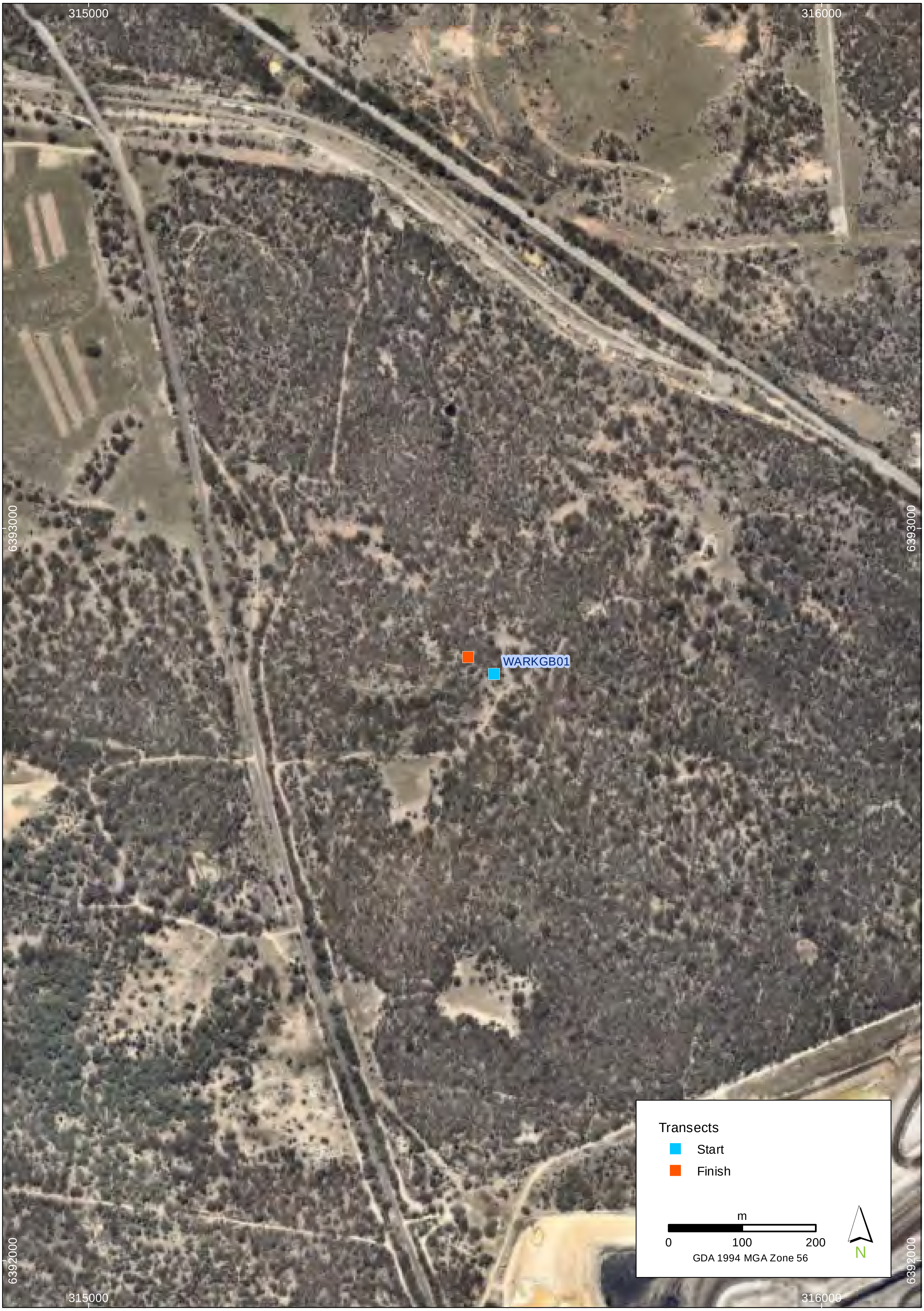
FIGURE 15

Imagery: (c) Nearmap 2018-01-05



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Warkworth reference sites (WARKGB01)

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FIGURE 16

Imagery: (c) Nearmap 2017-11-03

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Warkworth reference sites (WARKGB02-03-04

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FIGURE 17

Imagery: (c) Nearmap 2018-01-05

Drawn by: RJ Project Manager: VH Project Number: 3417 Date: 08/03/2018 T:\spatial\projects\a3400\a3417_RTCA\Maps\report_20170712\3417_Figure_18_Wambo GB01-GB02-Spot1-Spot2-Spot3.mxd

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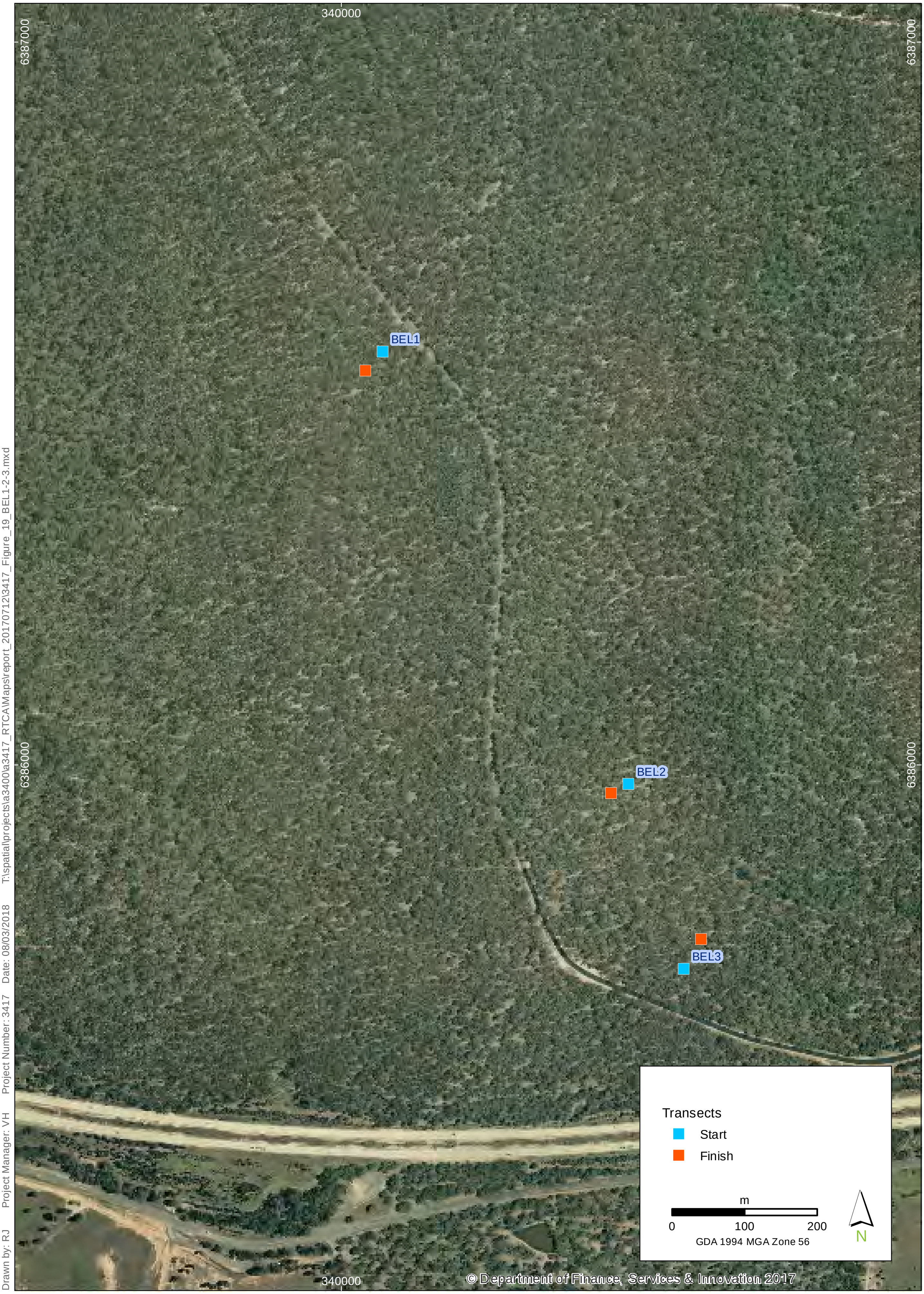
Wambo reference sites

Native Vegetation Rehabilitation Monitoring

FIGURE 18

Imagery: (c) LPI 2008-12-17



Belford reference sites

Native Vegetation Rehabilitation Monitoring

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FIGURE 19

Imagery: (c) LPI 2008-12-17

Appendix 2 – Monitoring dates

Location	Survey personnel	Date
HVO CAR200901	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	13/02/2017
HVO CAR200902	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	13/02/2017
HVO CAR201401	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	13/02/2017
HVO CHE201201	Alex Christie, Vivien Howard and Jess Blair	09/02/2017
HVO CHE201203	Alex Christie, Vivien Howard and Jess Blair	09/02/2017
HVO CHE201401	Alex Christie, Vivien Howard and Jess Blair	09/02/2017
HVO RIV201401	Alex Christie, Vivien Howard and Bill Baxter	13/02/2017
HVO RIV201402	Alex Christie, Vivien Howard and Bill Baxter	13/02/2017
HVO RIV201403	Alex Christie, Vivien Howard and Bill Baxter	13/02/2017
HVO RIV201404	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
HVO RIV201405	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
HVO RIV201406	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
HVO WES200801	Alex Christie, Vivien Howard and Bill Baxter	14/02/2017
HVO WES201101	Alex Christie, Vivien Howard and Bill Baxter	14/02/2017
HVO WES201301	Alex Christie, Vivien Howard and Bill Baxter	14/02/2017
HVO WES201302	Alex Christie, Vivien Howard and Bill Baxter	14/02/2017
HVOCHE201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOCHE201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOCHE201602	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOLEM201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOLEM201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVORIV201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVORIV201502	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVORIV201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOWES201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOWES201602	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
HVOWES201603	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWCDD201101	Alex Christie, Vivien Howard and Jess Blair	08/02/2017
MTWCDD201301	Alex Christie, Vivien Howard and Jess Blair	08/02/2017
MTWCDD201501	Alex Christie, Vivien Howard and Jess Blair	08/02/2017
MTWMTO200001	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
MTWMTO200503	Alex Christie, Vivien Howard and Bill Baxter	09/02/2017
MTWMTO201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWMTO201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWNOO201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWNPN200501	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017

Location	Survey personnel	Date
MTWNPN200502	Alex Christie, Vivien Howard and Bill Baxter	08/02/2017
MTWNPN200901	Alex Christie, Vivien Howard and Jess Blair	15/02/2017
MTWNPN201101	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017
MTWNPN201301	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017
MTWNPN201402	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017
MTWNPN201403	Alex Christie, Vivien Howard and Bill Baxter	07/02/2017
MTWSPN201401	Alex Christie, Vivien Howard and Bill Baxter	08/02/2017
MTWSPN201501	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWSPN201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWSPN201602	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWSPS201601	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWSPS201602	Alex Christie, Vivien Howard, Robert Carter and Bill Baxter	1/05/2017
MTWTD1201501	Luke Baker, Vivien Howard and Bill Baxter	08/02/2017
MTWWDL201401	Alex Christie, Vivien Howard and Bill Baxter	08/02/2017
MTWWDL201402	Alex Christie, Vivien Howard and Bill Baxter	15/02/2017
BELLSPOT1	Alex Christie and Vivien Howard	06/02/2017
BELSPOT2	Alex Christie and Vivien Howard	14/02/2017
BELSPOT3	Alex Christie and Vivien Howard	14/02/2017
WAMBOGB1	Alex Christie and Vivien Howard	16/02/2017
WAMBOGB2	Alex Christie and Vivien Howard	16/02/2017
WAMBOSPOT1	Alex Christie and Vivien Howard	16/02/2017
WAMBOSPOT2	Alex Christie and Vivien Howard	16/02/2017
WAMBOSPOT3	Alex Christie and Vivien Howard	16/02/2017
WARKGB1	Alex Christie and Vivien Howard	15/02/2017
WARKGB2	Alex Christie and Vivien Howard	10/02/2017
WARKGB3	Alex Christie and Vivien Howard	10/02/2017
WARKGB4	Alex Christie and Vivien Howard	10/02/2017

Appendix 3 – Monitoring locations

Hunter Valley Operations monitoring sites and locations

Monitoring site	Position on transection	Northing	Easting
HVO CAR200901	Start	6405168	310358
HVO CAR200901	Finish	6405171	310311
HVO CAR200902	Start	6403453	309114
HVO CAR200902	Finish	6403430	309076
HVO CAR201401	Start	6403057	309832
HVO CAR201401	Finish	6403083	309872
HVO CHE201201	Start	6400898	315694
HVO CHE201201	Finish	6400937	315660
HVO CHE201301	Start	6400040	315617
HVO CHE201301	Finish	6400044	315667
HVO CHE201401	Start	6399065	315541
HVO CHE201401	Finish	6399040	315582
HVO RIV201401	Start	6398663	311033
HVO RIV201401	Finish	6398633	310994
HVO RIV201402	Start	6398476	311320
HVO RIV201402	Finish	6398516	311293
HVO RIV201403	Start	6398539	311901
HVO RIV201403	Finish	6398558	311854
HVO RIV201404	Start	6398524	312023
HVO RIV201404	Finish	6398476	312029
HVO RIV201405	Start	6398089	312243
HVO RIV201405	Finish	6398114	312269
HVO RIV201406	Start	6397946	312522
HVO RIV201406	Finish	6397895	312522
HVO WES200801	Start	6406920	306340
HVO WES200801	Finish	6406877	306364
HVO WES201101	Start	6409164	308265

Monitoring site	Position on transection	Northing	Easting
HVO WES201101	Finish	6409172	308223
HVO WES201301	Start	6407223	306899
HVO WES201301	Finish	6407251	306859
HVO WES201302	Start	6407365	306889
HVO WES201302	Finish	6407409	306878
HVORIV201502	Start	6398308	311543
HVORIV201502	Finish	6398260	311526
HVORIV201501	Start	6398020	312211
HVORIV201501	Finish	6397998	312256
HVOLEM201501	Start	6394462	316910
HVOLEM201501	Finish	Not recorded	Not recorded
HVOCHE201501	Start	6402006	313968
HVOCHE201501	Finish	6402056	313952
HVORIV201601	Start	6398284	311284
HVORIV201601	Finish	6398245	311314
HVOWES201602	Start	6408560	308357
HVOWES201602	Finish	6408597	308323
HVOWES201601	Start	6410903	309820
HVOWES201601	Finish	Not recorded	Not recorded
HVOWES201603	Start	6409944	309354
HVOWES201603	Finish	6409903	309385
HVOCHE201601	Start	6401634	313555
HVOCHE201601	Finish	6401683	313541
HVOCHE201602	Start	6401299	313072
HVOCHE201602	Finish	6401346	313057
HVOLEM201601	Start	6394768	317039
HVOLEM201601	Finish	6394760	316990
HVORIV201503	Start	311249	6398378
HVORIV201503	Finish	311216	6398340
HVOWES201604	Start	307372	6407327

Monitoring site	Position on transection	Northing	Easting
HVOWES201604	Finish	307394	6407374

Mount Thorley Warkworth monitoring sites and locations

Monitoring site	Position on transection	Northing	Easting
MTWCDC201101	Start	6390304	319599
MTWCDC201101	Finish	6390312	319552
MTWCDD201301	Start	6390165	319516
MTWCDD201301	Finish	6390212	319535
MTWCDD201501	Start	6390074	319049
MTWCDD201501	Finish	6390034	319081
MTWNPN201401	Start	6392128	317619
MTWNPN201401	Finish	Not recorded	Not recorded
MTWMTO200001	Start	6386940	320551
MTWMTO200001	Finish	6386982	320531
MTWMTO200503	Start	6385782	320678
MTWMTO200503	Finish	6385756	320640
MTWNPN200501	Start	6391225	319816
MTWNPN200501	Finish	6391183	319842
MTWNPN200502	Start	6391981	319682
MTWNPN200502	Finish	Not recorded	Not recorded
MTWNPN200901	Start	6391524	319069
MTWNPN200901	Finish	6391535	319027
MTWNPN201101	Start	6392138	318166
MTWNPN201301	Finish	6391519	317995
MTWNPN201301	Start	6391551	318047
MTWNPN201402	Start	6392086	317658
MTWNPN201402	Finish	6392120	317620
MTWNPN201403	Start	6391271	318089
MTWNPN201403	Finish	6391236	318060
MTWSPN201401	Start	6390161	320170

Monitoring site	Position on transection	Northing	Easting
MTWSPN201401	Finish	Not recorded	Not recorded
MTWTDI201501	Start	6392186	319688
MTWTDI201501	Finish	6392236	319692
MTWWDL201401	Start	6388508	319805
MTWWDL201401	Finish	6388526	319849
MTWWDL201402	Start	6388357	319636
MTWWDL201402	Finish	6388309	319624
MTWMTO201501	Start	6385357	321386
MTWMTO201501	Finish	6385331	321427
MTWSPS201601	Start	6389384	320910
MTWSPS201601	Finish	6389413	320949
MTWSPN201602	Start	6389769	320444
MTWSPN201602	Finish	6389775	320494
MTWSPN201601	Start	6390589	320130
MTWSPN201601	Finish	6390630	320158
MTWSPN201501	Start	6390291	319956
MTWSPN201501	Finish	6390332	319984
MTWSPS201602	Start	6388963	320830
MTWSPS201602	Finish	6388975	320879
MTWMTO201601	Start	6385308	320667
MTWMTO201601	Finish	6385305	320718
MTWNOO201501	Start	6391940	320406
MTWNOO201501	Finish	6391979	320438

Reference monitoring sites and locations

Monitoring site	Position on transection	Northing	Easting
BEL1	Start	6386547	340083
BEL1	Finish	6386546	340033
BEL2	Start	6386551	340072
BEL2	Finish	6385962	340373

Monitoring site	Position on transection	Northing	Easting
BEL3	Start	6385719	340474
BEL3	Finish	6385760	340498
WamboGB01	Start	6392661	309215
WamboGB01	Finish	6392618	309194
WamboGB02	Start	6391965	309539
WamboGB02	Finish	6392010	309561
WamboSpot1	Start	6390324	308275
WamboSpot1	Finish	6390355	308311
WamboSpot2	Start	6390550	308504
WamboSpot2	Finish	6390593	308522
WamboSpot3	Start	6390200	308276
WamboSpot3	Finish	6390185	308238
WARKGB01	Start	6392801	315553
WARKGB01	Finish	6392824	315517
WARKGB02	Start	6387985	314002
WARKGB02	Finish	6387939	313998
WARKGB03	Start	6386859	314917
WARKGB03	Finish	6386864	314960
WARKGB04	Start	6386046	315336
WARKGB04	Finish	6386087	315316

Appendix 4 – Flora species list

Flora two-way table: MTW Sites

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Aizoaceae	*Galenia pubescens*	Galenia	X	2			3	2		2	3	2		2
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X	1				2			2	1		2
Asteraceae	*Arctotheca calendula*	Capeweed	X						3					
Asteraceae	*Aster* spp.		X	2	3					2				
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	X	1				2	2					2
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy						2			2			1
Asteraceae	*Centaurea solstitialis*	St Barnabys Thistle	X		1									
Asteraceae	*Cichorium intybus*	Chicory	X						2					
Asteraceae	*Cirsium vulgare*	Spear Thistle	X						2					
Asteraceae	*Conyza* spp.	A Fleabane	X	2	3	2	1	2			2			2
Asteraceae	Gnaphalium spp.	Cudweed						2						
Asteraceae	*Senecio madagascariensis*	Fireweed	X	2		2			2			1	1	
Asteraceae	*Sonchus* spp.	Sowthistle	X		1				2					

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Asteraceae	*Tagetes minuta*	Stinking Roger	X								1			
Asteraceae	*Vittadinia cuneata*	A Fuzzweed					2	2			2			
Asteraceae	*Vittadinia sulcata*						2	1				2		
Boraginaceae	*Echium* spp.		X				5	5				2		
Brassicaceae	*Brassica rapa*		X							2		1		
Brassicaceae	*Lepidium campestre*	Field Cress	X			1	1							
Brassicaceae	*Lepidium spp.*	A Peppercress	X		2									
Cactaceae	*Opuntia aurantiaca*	Tiger Pear	X				2	1						
Caryophyllaceae	*Petrorhagia prolifera*	Proliferous Pink	X	1	1	2								
Chenopodiaceae	*Atriplex semibaccata*	Creeping Saltbush		2		2	2	2						
Chenopodiaceae	*Chenopodium album*	Fat Hen	X						2					1
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush						3			1			
Chenopodiaceae	*Einadia trigonos*	Fishweed				2	2							
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush		2			3	3			1			2
Commelinaceae	*Commelina cyanea*	Native Wandering					2							

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
		Jew												
Convolvulaceae	*Dichondra repens*	Kidney Weed						1		2				
Cyperaceae	*Carex appressa*	Tall Sedge						1						
Fabaceae (Faboideae)	*Daviesia genistifolia*	Broom Bitter Pea												2
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine		2			2	2		2	1		1	
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla												1
Fabaceae (Faboideae)	*Macroptilium atropurpureum*	Siratro	X						1					
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X						2					
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle		3		2					2	2	3	4
Fabaceae (Mimosoideae)	*Acacia binervata*	Two-veined Hickory				2								
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle		2		2				3				4
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle		2		2				2			2	3
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle		2									3	
Fabaceae (Mimosoideae)	*Acacia falcata*			3									1	3

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Fabaceae (Mimosoideae)	*Acacia filicifolia*	Fern-leaved Wattle								1				
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle		2		2					2	1	2	3
Fabaceae (Mimosoideae)	*Acacia longifolia*			2								2		
Fabaceae (Mimosoideae)	*Acacia mearnsii*	Black Wattle												2
Fabaceae (Mimosoideae)	*Acacia parvipinnula*	Silver-stemmed Wattle										4		
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba		2		2							2	
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	X					2			4	1		3
Fabaceae (Mimosoideae)	*Acacia spectabilis*	Mudgee Wattle		2		2								
Fabaceae (Mimosoideae)	*Acacia* spp.	Wattle					2							
Gentianaceae	*Centaurium spicatum*	Spike Centaury				2								
Geraniaceae	*Geranium* spp.		X							2				
Malvaceae	*Malva* spp.	Mallow	X						2					
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X							2				

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Malvaceae	*Sida corrugata*	Corrugated Sida		2			2							1
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X	2				2	2	3	3		2	
Myoporaceae	*Eremophila debilis*	Amulla		2			2	1			2	2		
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X							2				
Myrtaceae	*Corymbia citriodora*	Lemon-scented Gum	X								4			
Myrtaceae	*Corymbia maculata*	Spotted Gum		3		3						5	6	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark		2									3	2
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark										3	3	1
Myrtaceae	*Eucalyptus moluccana*	Grey Box		3			3	1				3	3	
Oxalidaceae	*Oxalis perennans*									2				
Phyllanthaceae	*Phyllanthus hirtellus*	Thyme Spurge						2						
Phytolaccaceae	*Phytolacca octandra*	Inkweed	X			1								
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X			2		1	2	2			1	2
Poaceae	*Austrostipa aristiglumis*	Plains Grass				1								

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Poaceae	*Austrostipa scabra*	Speargrass				2								
Poaceae	*Bothriochloa macra*	Red Grass		2		2		2		4	1			1
Poaceae	*Capillipedium spicigerum*	Scented-top Grass				1								
Poaceae	*Chloris gayana*	Rhodes Grass	X	2	5	1					4	1	3	4
Poaceae	*Chloris truncata*	Windmill Grass				2		2		3	1			
Poaceae	*Chloris ventricosa*	Tall Chloris		2		3					1			
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass				2		4			3		2	
Poaceae	*Cynodon dactylon*	Common Couch		1		2		2	3			1		
Poaceae	*Digitaria divaricatissima*	Umbrella Grass				1								
Poaceae	*Entolasia marginata*	Bordered Panic										1		
Poaceae	*Entolasia stricta*	Wiry Panic								2				
Poaceae	*Eragrostis brownii*	Brown's Lovegrass				1				3				
Poaceae	*Eragrostis curvula*	African Lovegrass	X					2			2	2		1
Poaceae	*Eriochloa* spp.	A Cupgrass							2	2				
Poaceae	*Panicum effusum*	Hairy Panic				2				2				

Family	Species	Common Name	Exotic	MTWCDD 201101	MTWCDD 201301	MTWCDD 201501	MTWMTO 200001	MTWMTO 200503	MTWMTO 201601	MTWNOO 201501	MTWNPN 200501	MTWNPN 200502	MTWNPN 200901	MTWNPN 201101
Poaceae	*Panicum maximum*	Guinea Grass	X							4				
Poaceae	Paspalum dilatatum	Paspalum	X	2								2		
Poaceae	Pennisetum clandestinum	Kikuyu Grass	X											2
Poaceae	Pennisetum glaucum	Pearl Millet	X						4					
Poaceae	Rytidosperma spp.			2		2		2					2	
Poaceae	Setaria gracilis	Slender Pigeon Grass	X	1							1			
Poaceae	Setaria parviflora		X							2		2		
Poaceae	Sporobolus creber	Slender Rat's Tail Grass				2		2		2				
Poaceae	Themeda triandra			2										2
Poaceae	Urochloa spp.		X							2				
Portulacaceae	Portulaca spp.		X						3					
Sapindaceae	Dodonaea viscosa	Sticky Hop-bush												2
Solanaceae	Solanum nigrum	Black-berry Nightshade	X			1								
Solanaceae	Solanum prinophyllum	Forest Nightshade					1		1					
Verbenaceae	Verbena bonariensis	Purpletop	X	2			1				2	1		2

Flora two-way table: MTW Sites

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
Aizoaceae	*Galenia pubescens*	Galenia	X	2	1		1	2	2			1	1	1	3
Aizoaceae	*Galenia* spp.		X			4									
Amaranthaceae	*Alternanthera* spp.	Joyweed						1							
Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily				1									
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X		1					1		1			1
Asteraceae	*Aster* spp.		X	2	2						2				
Asteraceae	*Aster subulatus*	Wild Aster	X												2
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	X	4	3	3				1				1	2
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy		2								2		2	
Asteraceae	*Centaurea solstitialis*	St Barnabys Thistle	X								1	1	1		
Asteraceae	*Chrysocephalum apiculatum*	Common Everlasting						1							
Asteraceae	*Cichorium intybus*	Chicory	X						3	3					
Asteraceae	*Cirsium vulgare*	Spear Thistle	X	2	2	1				1	1		1		1
Asteraceae	*Conyza* spp.	A Fleabane	X	2	3	1			2		1		2		
Asteraceae	*Hypochaeris radicata*	Catsear	X											2	
Asteraceae	*Senecio madagascariensis*	Fireweed	X		2			1	2	2	1		2	1	2
Asteraceae	*Sonchus oleraceus*	Common Sowthistle	X							3					2
Asteraceae	*Sonchus* spp.	Sowthistle	X	2		2		1	2		1		2		

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
Asteraceae	*Tagetes minuta*	Stinking Roger	X											1	
Asteraceae	*Vittadinia cuneata*	A Fuzzweed			2									2	
Brassicaceae	*Brassica rapa*		X	4		3		2	3	4			5	1	
Brassicaceae	*Lepidium spp.*	A Peppercress	X	2		1					1				2
Cactaceae	*Opuntia stricta*	Common Prickly Pear, Smooth Pest Pear	X	2											
Chenopodiaceae	*Atriplex semibaccata*	Creeping Saltbush		2								2	2		
Chenopodiaceae	*Atriplex* spp.	A Saltbush						1							
Chenopodiaceae	*Chenopodium album*	Fat Hen	X									1			
Chenopodiaceae	*Chenopodium pumilio*	Small Crumbweed												1	
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush				2						2			
Chenopodiaceae	*Einadia trigonos*	Fishweed										3			
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush									2	1			1
Commelinaceae	*Commelina cyanea*	Native Wandering Jew												1	
Convolvulaceae	*Dichondra repens*	Kidney Weed						1							1
Euphorbiaceae	*Euphorbia* spp.		X					2							
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea			2									1	
Fabaceae (Faboideae)	*Desmodium brachypodum*	Large Tick-trefoil												1	

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine						1	2						
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla			3							2		2	
Fabaceae (Faboideae)	*Indigofera australis*	Australian Indigo		2	2			1				1		2	
Fabaceae (Faboideae)	*Macroptilium atropurpureum*	Siratro	X						1	4					
Fabaceae (Faboideae)	*Medicago polymorpha*	Burr Medic	X												2
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X						2	4		1			
Fabaceae (Faboideae)	*Swainsona galegifolia*	Smooth Darling Pea			1										
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle		3	4							3			
Fabaceae (Mimosoideae)	*Acacia binervata*	Two-veined Hickory			4										
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle		3	4	2		1						2	
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle		3	3	2						2		3	
Fabaceae (Mimosoideae)	*Acacia falcata*			3	2							3		3	
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle				2						3			
Fabaceae (Mimosoidea	*Acacia leiocalyx*													5	

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
e)															
Fabaceae (Mimosoideae)	*Acacia longifolia*			2	3							1		3	
Fabaceae (Mimosoideae)	*Acacia paradoxa*	Kangaroo Thorn		3	2							1		2	
Fabaceae (Mimosoideae)	*Acacia parvipinnula*	Silver-stemmed Wattle			2									2	
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba									1	2			
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	X	2		1							1	1	
Fabaceae (Mimosoideae)	*Acacia spectabilis*	Mudgee Wattle									1				
Fumariaceae	*Fumaria* spp.	Fumitory	X												1
Gentianaceae	*Centaurium* spp.		X										3		
Geraniaceae	*Geranium homeanum*								1						
Lycopodiaceae	*Phylloglossum drummondii*	Pigmy Clubmoss							2						
Malvaceae	*Malva* spp.	Mallow	X												
Malvaceae	*Malva sylvestris*	Tall Mallow	X				1								
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X	2				2							
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X	4	1	3		2		2		2		1	2
Myoporaceae	*Eremophila*	Amulla											2		

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
	debilis														
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X					1	2	2				1	
Myrtaceae	*Corymbia maculata*	Spotted Gum		1							2	2			
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark										2			
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark				1									
Myrtaceae	*Eucalyptus moluccana*	Grey Box				1									
Myrtaceae	*Eucalyptus spp.*										1	2			
Phyllanthaceae	*Breynia* spp.													2	
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X									1	2		2
Poaceae	*Austrostipa scabra*	Speargrass			3						2			2	
Poaceae	*Bothriochloa macra*	Red Grass		2	2			2			1		3	1	
Poaceae	*Chloris gayana*	Rhodes Grass	X	3	2	5	2		2		4	2	2		3
Poaceae	*Chloris truncata*	Windmill Grass		2				6			4	3	2		
Poaceae	*Chloris ventricosa*	Tall Chloris			3		2				2	3	2		
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass			2										
Poaceae	*Cynodon dactylon*	Common Couch		3	4	2		2	3			2	3	2	2
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass		2							2				
Poaceae	*Eragrostis brownii*	Brown's Lovegrass						4						1	

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
Poaceae	*Eragrostis curvula*	African Lovegrass	X		2	1								1	
Poaceae	*Eriochloa procera*	Spring Grass													2
Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass		3	2	2						3	5		
Poaceae	*Eriochloa* spp.	A Cupgrass							2						
Poaceae	*Heteropogon contortus*	Bunch Speargrass			3										
Poaceae	*Lolium perenne*	Perennial Ryegrass	X										3		
Poaceae	*Melinis repens*	Red Natal Grass	X											2	
Poaceae	*Panicum effusum*	Hairy Panic				1		2			2	1			
Poaceae	*Panicum maximum*	Guinea Grass	X						2	4	1		2		2
Poaceae	Paspalidium spp.							1			2				
Poaceae	Paspalum dilatatum	Paspalum	X	2											2
Poaceae	Pennisetum clandestinum	Kikuyu Grass	X		1										1
Poaceae	Pennisetum glaucum	Pearl Millet	X										5		
Poaceae	Rytidosperma spp.				2							2			
Poaceae	Setaria gracilis	Slender Pigeon Grass	X	2								3	2		
Poaceae	Setaria italica	Foxtail Millet	X							2					
Poaceae	Setaria parviflora		X					3							
Poaceae	Sporobolus	Slender Rat's Tail									2				

Family	Species	Common Name	Exotic	MTWNP N201301	MTWNP N201401	MTWNP N201403	MTWSPN 201501	MTWSPN 201602	MTWSPS 201601	MTWSPS 201602	MTWTDI 201501	MTWWD L201401	MTWWD L201402	MTWNP N201402	MTWMT O201501
	creber	Grass													
Poaceae	Themeda australis	Kangaroo Grass												1	
Poaceae	Themeda triandra				3										
Poaceae	Urochloa panicoides	Urochloa Grass	X										2		
Portulacacea e	Portulaca spp.		X				1	2		1					
Rubiaceae	Cyclophyllum longipetalum	Coast Canthium		2											
Sapindaceae	Dodonaea viscosa	Sticky Hop-bush			2										
Solanaceae	Solanum nigrum	Black-berry Nightshade	X					2	2	3		1		1	
Thymelaeace ae	Pimelea linifolia	Slender Rice Flower			2									1	
Verbenaceae	Verbena bonariensis	Purpletop	X		2							2			2
Zygophyllace ae	Tribulus spp.	Cat-head, Caltrop							1						

Flora two-way table: HVO Sites

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Aizoaceae	*Galenia pubescens*	Galenia	X	3		3	2	2	2		1	1			3
Apiaceae	*Cyclospermum leptophyllum*	Slender Celery	X								1				
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X	2		2		1							2
Apocynaceae	*Gomphocarpus spp.*		X									1			
Asteraceae	*Arctotheca calendula*	Capeweed	X								1				
Asteraceae	*Aster spp.*		X										2		4
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy											2		
Asteraceae	*Cassinia arcuata*	Sifton Bush					1								
Asteraceae	*Chrysocephalum apiculatum*	Common Everlasting											2		
Asteraceae	*Cichorium intybus*	Chicory	X									2			
Asteraceae	*Cirsium vulgare*	Spear Thistle	X			2								2	2
Asteraceae	*Conyza spp.*	A Fleabane	X		2	2		2					3	2	3
Asteraceae	*Hypochaeris radicata*	Catsear	X							2	1		2	2	
Asteraceae	*Senecio madagascariensis*	Fireweed	X	2	3	2				2	1		2	4	3
Asteraceae	*Senecio spp.*	Groundsel, Fireweed	X						1						

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Asteraceae	*Silybum marianum*	Variegated Thistle	X							1	1			2	
Asteraceae	*Sonchus oleraceus*	Common Sowthistle	X								1				
Asteraceae	*Sonchus spp.*	Sowthistle	X									1	2	4	2
Asteraceae	*Tagetes minuta*	Stinking Roger	X											2	
Asteraceae	*Vittadinia sulcata*						1								
Brassicaceae	*Brassica rapa*		X			4			3						2
Brassicaceae	*Lepidium spp.*	A Peppercress	X					2	1						
Cactaceae	*Opuntia aurantiaca*	Tiger Pear	X				1								
Campanulaceae	*Wahlenbergia spp.*	Bluebell												2	
Chenopodiaceae	*Atriplex semibaccata*	Creeping Saltbush					2								3
Chenopodiaceae	*Chenopodium album*	Fat Hen	X											4	
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush													4
Chenopodiaceae	*Salsola spp.*														4
Convolvulaceae	*Dichondra repens*	Kidney Weed										1			
Cucurbitaceae	*Citrullus lanatus*	Camel Melon	X											3	
Cyperaceae	*Carex inversa*	Knob Sedge			2										
Cyperaceae	*Cyperus spp.*									2				2	
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine				1									
Fabaceae	*Hardenbergia*	False												2	2

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
(Faboideae)	*violacea*	Sarsaparilla													
Fabaceae (Faboideae)	*Macroptilium atropurpureum*	Siratro	X								1	1			
Fabaceae (Faboideae)	*Medicago polymorpha*	Burr Medic	X								1				
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X								1				
Fabaceae (Faboideae)	*Medicago spp.*	A Medic	X									1			
Fabaceae (Faboideae)	*Trifolium spp.*	A Clover	X			2					1				
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle		3										2	
Fabaceae (Mimosoideae)	*Acacia binervata*	Two-veined Hickory												2	2
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle		4	4										3
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle											2	2	3
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle		4	4										
Fabaceae (Mimosoideae)	*Acacia falcata*												1		3
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle		4	3										
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba			5									2	3
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	X	4		3					1		1		3
Gentianaceae	*Centaurium spp.*		X		3	2									

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Geraniaceae	*Erodium cicutarium*	Common Crowfoot	X									1			
Geraniaceae	*Geranium solanderi*	Native Geranium								1					
Geraniaceae	*Geranium spp.*		X								1	1			
Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort									1				
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X			2						1			
Malvaceae	*Sida corrugata*	Corrugated Sida		1											
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X			2	1				1	1		2	
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X							2	1	1	2	5	
Myrtaceae	*Corymbia maculata*	Spotted Gum		5	5									1	
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark		2	1										
Myrtaceae	*Eucalyptus moluccana*	Grey Box		5	2								2		4
Oxalidaceae	*Oxalis perennans*									2				2	
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X		3	2			1		1				3
Poaceae	*Austrostipa scabra*	Speargrass													3
Poaceae	*Avena spp.*	Oats	X						1						
Poaceae	*Bothriochloa macra*	Red Grass											2		
Poaceae	*Capillipedium spicigerum*	Scented-top Grass											2		

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Poaceae	*Chloris gayana*	Rhodes Grass	X	5	5	5	2	4	2						5
Poaceae	*Chloris truncata*	Windmill Grass				3							3		4
Poaceae	*Chloris ventricosa*	Tall Chloris							2						
Poaceae	*Cynodon dactylon*	Common Couch		3		3		3			1	1	6	2	3
Poaceae	*Dichanthium sericeum*	Queensland Bluegrass												2	
Poaceae	*Dichanthium setosum*	Bluegrass											2		
Poaceae	*Eragrostis brownii*	Brown's Lovegrass											2		
Poaceae	*Eragrostis spp.*	A Lovegrass	X						1						
Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass					2	4	5						
Poaceae	*Melinus repens*	Red Natal Grass	X											3	
Poaceae	*Panicum capillare*	Witchgrass	X								1				
Poaceae	*Panicum effusum*	Hairy Panic			2		1				1			2	4
Poaceae	*Panicum maximum*	Guinea Grass	X	2	2	3								3	
Poaceae	*Pennisetum glaucum*	Pearl Millet	X							2	1	2		2	
Poaceae	*Rytidosperma spp.*								1						3
Poaceae	*Setaria gracilis*	Slender Pigeon Grass	X						3						3

Family	Species	Common Name	Exotic	HVOCAR2 00901	HVOCAR2 00902	HVOCAR2 01401	HVOCHE2 01201	HVOCHE2 01301	HVOCHE2 01401	HVOCHE2 01501	HVOCHE2 01601	HVOCHE2 01602	HVOLEM2 01501	HVOLEM2 01601	HVORIV2 01401
Poaceae	*Setaria parviflora*		X										2	4	
Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass			2								3		
Poaceae	*Themeda triandra*														2
Poaceae	*Urochloa panicoides*	Urochloa Grass	X						2						
Portulacaceae	*Portulaca oleracea*	Pigweed						2							
Portulacaceae	*Portulaca spp.*		X				2				1			2	
Rubiaceae	*Pomax umbellata*	Pomax											2		
Sapindaceae	*Dodonaea viscosa*	Sticky Hop-bush												2	
Solanaceae	*Solanum nigrum*	Black-berry Nightshade	X			1								2	
Solanaceae	*Solanum prinophyllum*	Forest Nightshade				2									2
Solanaceae	*Solanum spp.*		X									1			
Thymelaeaceae	*Pimelea linifolia*	Slender Rice Flower												3	
Verbenaceae	*Verbena bonariensis*	Purpletop	X			2		2							

Flora two-way table: HVO Sites

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
Aizoaceae	*Galenia pubescens*	Galenia	X		3	2	2	3	2			2	3	3	3
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X		2				2	2	2				
Asteraceae	*Aster spp.*		X	2	2		2		2	3	2				3
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	X					1	2	5	3	2			
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy						1							
Asteraceae	*Carthamus lanatus*	Saffron Thistle	X	2											2
Asteraceae	*Centaurea solstitialis*	St Barnabys Thistle	X		3	2									2
Asteraceae	*Cichorium intybus*	Chicory	X						3		3	2			
Asteraceae	*Cirsium vulgare*	Spear Thistle	X	3	3						2	1			1
Asteraceae	*Conyza spp.*	A Fleabane	X	3	2		2	4	2	2	2		1		
Asteraceae	*Senecio madagascariensis*	Fireweed	X	3	3	1	2	2	2	2	2	2			2
Asteraceae	*Silybum marianum*	Variegated Thistle	X								2	1			
Asteraceae	*Sonchus oleraceus*	Common Sowthistle	X						2						
Asteraceae	*Sonchus spp.*	Sowthistle	X	3	2						3	2			
Asteraceae	*Tagetes minuta*	Stinking Roger	X						2			1			
Asteraceae	*Taraxacum officinale*	Dandelion	X									1			
Asteraceae	*Vittadinia*	A Fuzzweed													1

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
	muelleri														
Brassicaceae	*Brassica rapa*		X	2	2				2	2	2	3			4
Brassicaceae	*Hirschfeldia incana*	Buchan Weed	X												1
Brassicaceae	*Lepidium spp.*	A Peppercress	X									2			
Cactaceae	*Opuntia stricta*	Common Prickly Pear, Smooth Pest Pear	X				2								
Campanulaceae	*Wahlenbergia spp.*	Bluebell						1		2					
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak												3	
Chenopodiaceae	*Atriplex semibaccata*	Creeping Saltbush				2									
Chenopodiaceae	*Chenopodium album*	Fat Hen	X			2	3		2						
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush				2				2	3				
Chenopodiaceae	*Einadia trigonos*	Fishweed			3						2			4	
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush		4	4									4	4
Chenopodiaceae	*Salsola spp.*			3	3	2			2	2	2				
Chenopodiaceae	*Sclerolaena spp.*	Copperburr, Poverty-bush						2							
Commelinaceae	*Commelina cyanea*	Native Wandering Jew				1		1		3					
Convolvulaceae	*Dichondra repens*	Kidney Weed								2					
Fabaceae	*Glycine*	Twining									1				

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
(Faboideae)	*clandestina*	glycine													
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla												1	
Fabaceae (Faboideae)	*Indigofera australis*	Australian Indigo												4	
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X								3	5			
Fabaceae (Faboideae)	*Trifolium spp.*	A Clover	X								2				
Fabaceae (Faboideae)	*Vicia spp.*	Vetch	X									2			
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle									2		4		
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle			3										
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle				1					2		3		3
Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle											5	3	
Fabaceae (Mimosoideae)	*Acacia falcata*		X								2			2	
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle									3			3	3
Fabaceae (Mimosoideae)	*Acacia longifolia*													3	
Fabaceae (Mimosoideae	*Acacia paradoxa*	Kangaroo Thorn											1		

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
)															
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba		1	2	1					3		4	4	1
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	X	3	3	1			1		2	1			
Geraniaceae	*Geranium spp.*		X									1			
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush											2		
Malvaceae	*Malva spp.*	Mallow	X				2								
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X		2										
Malvaceae	*Modiola spp.*		X						1						
Malvaceae	*Sida corrugata*	Corrugated Sida											2		
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X						2		1		3		
Malvaceae	*Sida spp.*		X						2						
Myoporaceae	*Eremophila debilis*	Amulla											3		
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X								2	1			
Myrtaceae	*Corymbia maculata*	Spotted Gum									2		5	5	3
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark									1			4	
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark												3	3
Myrtaceae	*Eucalyptus moluccana*	Grey Box			4	2					1			3	3

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
Oleaceae	*Notelaea microcarpa*	Native Olive												1	
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X		2				2	2	2	2	1		2
Poaceae	*Aristida spp.*	A Wiregrass							1						
Poaceae	*Aristida vagans*	Threeawn Speargrass											2		
Poaceae	*Austrostipa bigeniculata*	Yanganbil									3				
Poaceae	*Austrostipa spp.*	A Speargrass							2						
Poaceae	*Austrostipa verticillata*	Slender Bamboo Grass									2		4	3	3
Poaceae	*Avena spp.*	Oats	X				1		2						
Poaceae	*Bothriochloa macra*	Red Grass		2					3		4			2	4
Poaceae	*Bromus spp.*	A Brome	X												2
Poaceae	*Capillipedium spicigerum*	Scented-top Grass									3				
Poaceae	*Chloris gayana*	Rhodes Grass	X	3	5				2		3	1	3	2	3
Poaceae	*Chloris truncata*	Windmill Grass		2				2	2		3				2
Poaceae	*Chloris ventricosa*	Tall Chloris							2						
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass							2				2	2	
Poaceae	*Cynodon dactylon*	Common Couch		2	3	2					3				
Poaceae	*Digitaria brownii*	Cotton Panic Grass							2						
Poaceae	*Digitaria*	Umbrella					4								

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
	divaricatissima	Grass													
Poaceae	*Digitaria spp.*	A Finger Grass	X						2						
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass						3		2					
Poaceae	*Echinochloa spp.*		X	2			2				2				
Poaceae	*Eragrostis curvula*	African Lovegrass	X											3	2
Poaceae	*Eragrostis leptostachya*	Paddock Lovegrass			2								1		
Poaceae	*Eragrostis spp.*	A Lovegrass	X						2						
Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass				2		2							
Poaceae	*Eriochloa spp.*	A Cupgrass							2	2	2	2			
Poaceae	*Lachnagrostis spp.*							2							
Poaceae	*Lolium perenne*	Perennial Ryegrass	X				1								
Poaceae	*Lolium spp.*	A Ryegrass	X						2						
Poaceae	*Panicum effusum*	Hairy Panic		4	4	2		2	2		2		1		2
Poaceae	*Panicum maximum*	Guinea Grass	X									2			
Poaceae	*Paspalidium spp.*								2		1				
Poaceae	*Paspalum dilatatum*	Paspalum	X						2						
Poaceae	*Pennisetum glaucum*	Pearl Millet	X	2				2		2	3				
Poaceae	*Rytidosperma*				3				2		2		2	3	4

Family	Species	Common Name	Exotic	HVORIV2 01402	HVORIV2 01403	HVORIV2 01404	HVORIV2 01405	HVORIV2 01406	HVORIV2 01501	HVORIV2 01502	HVORIV2 01503	HVORIV2 01601	HVOWES 200801	HVOWES 201101	HVOWES 201301
	spp.														
Poaceae	*Setaria parviflora*		X					2	2	4	4				
Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass											1		3
Poaceae	*Themeda triandra*													3	
Poaceae	*Triticum spp.*		X									3			
Poaceae	*Urochloa panicoides*	Urochloa Grass	X					1							
Poaceae	*Urochloa spp.*		X						2						
Polygonaceae	*Rumex crispus*	Curled Dock	X		1										
Portulacaceae	*Portulaca spp.*		X			1									
Proteaceae	*Hakea sericea*	Needlebush												2	
Rosaceae	*Rubus fruticosus*	Blackberry complex	X						2						
Rubiaceae	*Pomax umbellata*	Pomax							2						
Solanaceae	*Solanum nigrum*	Black-berry Nightshade	X		2				2	3	3	1			2
Solanaceae	*Solanum prinophyllum*	Forest Nightshade										1			
Verbenaceae	*Verbena bonariensis*	Purpletop	X	1		2			2						2

Flora two-way table: HVO Sites

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Aizoaceae	*Galenia pubescens*	Galenia	X	2	2	2	5	2
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	X		1	2	1	3
Asteraceae	*Aster* spp.		X	2			2	
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	X		2	2	5	
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy				1		
Asteraceae	*Carthamus lanatus*	Saffron Thistle	X					2
Asteraceae	*Cichorium intybus*	Chicory	X		2			
Asteraceae	*Cirsium vulgare*	Spear Thistle	X			2	1	1
Asteraceae	*Conyza* spp.	A Fleabane	X	3		2	2	
Asteraceae	*Senecio madagascariensis*	Fireweed	X1		2		1	
Asteraceae	*Sonchus* spp.	Sowthistle	X					2
Asteraceae	*Tagetes minuta*	Stinking Roger	X		2	1	1	
Asteraceae	*Taraxacum officinale*	Dandelion	X			1		
Asteraceae	*Vittadinia cuneata*	A Fuzzweed				1		
Asteraceae	*Xanthium occidentale*	Noogoora Burr	X		2	3		
Asteraceae	*Xanthium spinosum*	Bathurst Burr	X				1	
Boraginaceae	*Heliotropium amplexicaule*	Blue Heliotrope	X					3
Brassicaceae	*Brassica rapa*		X	4	1			4

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell				2		
Chenopodiaceae	*Atriplex* spp.	A Saltbush			1	2		
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush		2			3	2
Chenopodiaceae	*Einadia trigonos*	Fishweed		2	1			
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush		4				
Chenopodiaceae	*Salsola* spp.					2		2
Convolvulaceae	*Dichondra repens*	Kidney Weed				1		2
Euphorbiaceae	*Ricinus communis*	Castor Oil Plant	X					2
Fabaceae (Faboideae)	*Daviesia genistifolia*	Broom Bitter Pea				2		
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea				1		
Fabaceae (Faboideae)	*Desmodium brachypodum*	Large Tick-trefoil				1		
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine				1		
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla				1	1	1
Fabaceae (Faboideae)	*Indigofera australis*	Australian Indigo				2	2	
Fabaceae (Faboideae)	*Medicago sativa*	Lucerne	X					1
Fabaceae (Faboideae)	*Trifolium repens*	White Clover	X				2	1
Fabaceae	*Acacia*	Fan Wattle			1	2	2	2

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
(Mimosoideae)	*amblygona*							
Fabaceae (Mimosoideae)	*Acacia cultriformis*	Knife-leaved Wattle				2		
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle			1	2	3	2
Fabaceae (Mimosoideae)	*Acacia falcata*					2	2	
Fabaceae (Mimosoideae)	*Acacia filicifolia*	Fern-leaved Wattle					2	3
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle					1	
Fabaceae (Mimosoideae)	*Acacia longifolia*					1		
Fabaceae (Mimosoideae)	*Acacia paradoxa*	Kangaroo Thorn				2		
Fabaceae (Mimosoideae)	*Acacia parvipinnula*	Silver-stemmed Wattle				2		
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba						1
Fabaceae (Mimosoideae)	*Acacia spectabilis*	Mudgee Wattle			2	2	2	3
Gentianaceae	*Centaurium* spp.		X	2				
Geraniaceae	*Erodium cicutarium*	Common Crowfoot	X			2		

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Geraniaceae	*Erodium crinitum*	Blue Crowfoot						4
Geraniaceae	*Erodium spp.*	Crowfoot	X		1			
Geraniaceae	*Geranium solanderi*	Native Geranium					1	
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	X		1		2	2
Malvaceae	*Sida cardiophylla*							1
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	X		2		2	4
Myoporaceae	*Eremophila debilis*	Amulla				1		
Myrsinaceae	*Anagallis arvensis*	Scarlet Pimpernel	X		2	2	2	3
Myrtaceae	*Angophora floribunda*	Rough-barked Apple				1		
Myrtaceae	*Corymbia maculata*	Spotted Gum				2	2	
Myrtaceae	*Eucalyptus moluccana*	Grey Box				2	1	
Myrtaceae	*Eucalyptus spp.*						1	
Oxalidaceae	*Oxalis perennans*				1		1	
Phytolaccaceae	*Phytolacca octandra*	Inkweed	X				1	1
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	X	3	1	2	2	2
Poaceae	*Aira cupaniana*	Silvery Hairgrass	X		2			
Poaceae	*Aristida ramosa*	Purple Wiregrass					1	

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Poaceae	*Austrostipa bigeniculata*	Yanganbil				2	2	
Poaceae	*Austrostipa scabra*	Speargrass				2	3	
Poaceae	*Bothriochloa macra*	Red Grass				2	2	2
Poaceae	*Capillipedium spicigerum*	Scented-top Grass			2	3	2	
Poaceae	*Chloris gayana*	Rhodes Grass	X	4	3	2	2	2
Poaceae	*Chloris truncata*	Windmill Grass		4	2	2	3	2
Poaceae	*Chloris ventricosa*	Tall Chloris		3		2		
Poaceae	*Chloris virgata*	Feathertop Rhodes Grass	X		2		2	
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass				2		1
Poaceae	*Cynodon dactylon*	Common Couch				1	3	
Poaceae	*Dichanthium sericeum*	Queensland Bluegrass			3		4	
Poaceae	*Dichanthium setosum*	Bluegrass						4
Poaceae	*Digitaria* spp.	A Finger Grass	X		2			
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass			2			
Poaceae	*Eleusine* spp.		X				1	
Poaceae	*Eragrostis brownii*	Brown's Lovegrass						2
Poaceae	*Eragrostis* spp.	A Lovegrass	X			2		
Poaceae	*Eriochloa*	Early Spring		6				

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
	pseudoacrotricha	Grass						
Poaceae	*Eriochloa* spp.	A Cupgrass			2	2		2
Poaceae	*Melinis repens*	Red Natal Grass	X			1		
Poaceae	*Panicum capillare*	Witchgrass	X			2		
Poaceae	*Panicum effusum*	Hairy Panic					2	2
Poaceae	*Panicum maximum*	Guinea Grass		2	3		1	4
Poaceae	*Paspalidium distans*					2		
Poaceae	Paspalidium spp.							2
Poaceae	Paspalum dilatatum	Paspalum				1	2	2
Poaceae	Paspalum quadrifarium	Tussock Paspalum			2			
Poaceae	Pennisetum clandestinum	Kikuyu Grass			2		2	2
Poaceae	Pennisetum glaucum	Pearl Millet	X			1	2	
Poaceae	Rytidosperma spp.					2	3	
Poaceae	Setaria parviflora		X		3		5	
Poaceae	Sporobolus creber	Slender Rat's Tail Grass		4				
Poaceae	Themeda avenacea	Native Oatgrass				1	1	
Poaceae	Urochloa spp.		X				2	2

Family	Species	Common Name	Exotic	HVOWES2 01302	HVOWES2 01601	HVOWES2 01602	HVOWES2 01603	HVOWES2 01604
Solanaceae	Solanum nigrum	Black-berry Nightshade	X			2	2	2
Solanaceae	Solanum prinophyllum	Forest Nightshade			2	2	3	3
Verbenaceae	Verbena bonariensis	Purpletop	X	2		2	2	

Flora two-way table: Reference sites

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower		1			2								
Adiantaceae	*Cheilanthes sieberi*	Rock Fern			1	1	2						2		
Aizoaceae	*Galenia pubescens*	Galenia	*												3
Amaranthaceae	*Alternanthera spp.*	Joyweed											1		3
Anthericaceae	*Dichopogon spp.*	Chocolate Lily					2			1			3		
Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily		2										3	
Asteraceae	*Calotis cuneifolia*	Purple Burr-Daisy				2						2			
Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy			3								2		
Asteraceae	*Cassinia uncata*	Sticky Cassinia										2	1		
Asteraceae	*Chrysocephalum apiculatum*	Common Everlasting						2					1		
Asteraceae	*Olearia elliptica*	Sticky Daisy-bush		4			4	1	3	5	3		1		
Asteraceae	*Ozothamnus diosmifolius*	White Dogwood													1
Asteraceae	*Senecio madagascariensis*	Fireweed	*		1		2	2				2	2	2	3
Asteraceae	*Senecio sp. E*				2							2			
Asteraceae	*Vittadinia cuneata*	A Fuzzweed		2			2					2	2		
Asteraceae	*Vittadinia sulcata*				3										2
Bignoniaceae	*Pandorea pandorana*	Wonga Vine								1					
Cactaceae	*Opuntia aurantiaca*	Tiger Pear	*										2	2	2
Cactaceae	*Opuntia stricta*	Common Prickly Pear, Smooth Pest Pear	*				2	2	2			4	1		
Campanulaceae	*Wahlenbergia spp.*	Bluebell					2	2			1		2		
Casuarinaceae	*Allocasuarina luehmannii*	Bulloak					5					4	5	5	3
Chenopodiaceae	*Einadia hastata*	Berry Saltbush										1			
Chenopodiaceae	*Einadia nutans*	Climbing Saltbush											1		
Chenopodiaceae	*Einadia trigonos*	Fishweed										2			

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
Chenopodiaceae	*Enchylaena tomentosa*	Ruby Saltbush													1
Clusiaceae	*Hypericum gramineum*	Small St John's Wort											1		
Commelinaceae	*Commelina cyanea*	Native Wandering Jew								2	1		3	3	3
Convolvulaceae	*Dichondra repens*	Kidney Weed											1		
Cyperaceae	*Carex inversa*	Knob Sedge					2						2		
Cyperaceae	*Cyperus gracilis*	Slender Flat-sedge												1	
Cyperaceae	*Gahnia aspera*	Rough Saw-sedge		2	3	3		2	2		2		1		
Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge		3	4										
Dilleniaceae	*Hibbertia spp.*								2						
Ericaceae	*Lissanthe strigosa*	Peach Heath		3	3	2									
Euphorbiaceae	*Amperea xiphoclada*										3	4			
Fabaceae (Faboideae)	*Daviesia genistifolia*	Broom Bitter Pea												2	
Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea												2	3
Fabaceae (Faboideae)	*Desmodium brachypodum*	Large Tick-trefoil					2	2	2	3					
Fabaceae (Faboideae)	*Desmodium varians*	Slender Tick-trefoil		2		3	2	2	2	3	2	2	2	3	
Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine									2	1	3		
Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine		2	3	3			2			2	3	3	
Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla		3											
Fabaceae (Faboideae)	*Hovea linearis*								1						
Fabaceae (Faboideae)	*Pultenaea spinosa*	A Bush Pea		3	3										
Fabaceae (Mimosoideae)	*Acacia amblygona*	Fan Wattle		3				3		3				3	5
Fabaceae (Mimosoideae)	*Acacia bulgaensis*	Bulga Wattle							4						
Fabaceae (Mimosoideae)	*Acacia decora*	Western Silver Wattle						2							
Fabaceae	*Acacia decurrens*	Black Wattle											1		

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
(Mimosoideae)															
Fabaceae (Mimosoideae)	*Acacia falcata*			3	4	2		3							2
Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle					2		3		4	3			
Fabaceae (Mimosoideae)	*Acacia mearnsii*	Black Wattle		3	4	2									
Fabaceae (Mimosoideae)	*Acacia salicina*	Cooba													1
Fabaceae (Mimosoideae)	*Acacia saligna*	Golden Wreath Wattle	*				2	2				1			
Goodeniaceae	*Goodenia rotundifolia*			1											
Juncaceae	*Juncus prismatocarpus*						1	2							
Lauraceae	*Cassytha pubescens*	Downy Dodder-laurel									2				
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush			4	5	2	2		2			2		2
Lomandraceae	*Lomandra filiformis subsp. filiformis*							2	2	2					
Lomandraceae	*Lomandra glauca*	Pale Mat-rush												2	3
Lomandraceae	*Lomandra multiflora*	Many-flowered Mat-rush			2			2	2		2	2			
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily								2					
Malvaceae	*Sida corrugata*	Corrugated Sida					3	2	2	2		3	2		
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	*												2
Myoporaceae	*Eremophila debilis*	Amulla				1						3	2		2
Myrsinaceae	*Rapanea howittiana*	Brush Muttonwood									2				
Myrtaceae	*Corymbia maculata*	Spotted Gum		5	5	5				5	4				
Myrtaceae	*Eucalyptus amplifolia*	Cabbage Gum												5	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark		4			2		4		4	5	5	4	4
Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark				4	4								
Myrtaceae	*Eucalyptus moluccana*	Grey Box		3	4	5	3	5		5					
Myrtaceae	*Eucalyptus punctata*	Grey Gum							5		3				

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
Myrtaceae	*Melaleuca decora*													4	
Oleaceae	*Notelaea longifolia*	Large Mock-olive						2	3	2	2	3			
Oleaceae	*Notelaea microcarpa*	Native Olive						4							
Oleaceae	*Olea europaea*	Common Olive	*	3	3	5									
Oxalidaceae	*Oxalis perennans*													1	
Phormiaceae	*Dianella longifolia*	Blueberry Lily			1										
Phormiaceae	*Dianella longifolia var. longifolia*	A Blue Flax Lily				2	2			2			1		
Phormiaceae	*Dianella revoluta*	Blueberry Lily		3	3	4	2				2			2	3
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush			4	3			2		2	3	2	2	
Phyllanthaceae	*Phyllanthus gunnii*														1
Phyllanthaceae	*Phyllanthus hirtellus*	Thyme Spurge											1	1	
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn		4		3			4	4	4		3	3	
Plantaginaceae	*Veronica plebeia*	Trailing Speedwell					2							2	
Poaceae	*Aristida ramosa*	Purple Wiregrass			2	3	4	3		2			4		
Poaceae	*Aristida vagans*	Threeawn Speargrass		3	1	2		2	3	3	3	4	4	5	4
Poaceae	*Austrostipa scabra*	Speargrass		2			4	2		2		3	3		
Poaceae	*Austrostipa verticillata*	Slender Bamboo Grass						2	4		4				
Poaceae	*Chloris truncata*	Windmill Grass								2					3
Poaceae	*Chloris ventricosa*	Tall Chloris						2		2					
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass		3	4	3	4	3	4	4	3	4	3	5	5
Poaceae	*Cynodon dactylon*	Common Couch												3	
Poaceae	*Entolasia marginata*	Bordered Panic		2											
Poaceae	*Entolasia stricta*	Wiry Panic			4	4	2				2		5	4	
Poaceae	*Eragrostis brownii*	Brown's Lovegrass						2						3	3
Poaceae	*Microlaena stipoides*	Weeping Grass				2									
Poaceae	*Oplismenus aemulus*										1				
Poaceae	*Panicum effusum*	Hairy Panic						2		2					

Family	Species	Common Name	Exotic *	BEL1	BEL2	BEL3	WAMBO G1	WAMBO GB2	WAMBO SPOT1	WAMBO SPOT2	WAMBO SPOT3	WARK GB01	WARK GB02	WARK GB03	WARK GB04
Poaceae	*Rytidosperma spp.*					2	4	3	2	4	2	3	4	3	3
Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass													3
Poaceae	*Themeda triandra*											2	4		
Proteaceae	*Grevillea mucronulata*									2					
Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung							3		3				
Ranunculaceae	*Clematis aristata*	Old Man's Beard									1				
Rubiaceae	*Pomax umbellata*	Pomax		2		2									
Rutaceae	*Boronia pinnata*									1					
Santalaceae	*Exocarpos cupressiformis*	Cherry Ballart							4			3	1		
Sapindaceae	*Dodonaea viscosa*	Sticky Hop-bush						2	3	2	4				
Solanaceae	*Solanum prinophyllum*	Forest Nightshade				1			2			2	1		
Sterculiaceae	*Brachychiton populneus*	Kurrajong						1	1	1	1				
Sterculiaceae	*Lasiopetalum spp.*								1						
Verbenaceae	*Lantana camara*	Lantana	*									1			
Zamiaceae	*Macrozamia flexuosa*								3	3	4				

Appendix 5 – Visual and Photo Monitoring

HVORIV201503

HVORIV201503	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	311249	6398378
End transect:	311216	6398340

Description:

The HVORIV201503 rehabilitation area occurs on imported topsoil and compost with a second application of gypsum and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Aster sp., Chloris gayana, Pennisetum glaucum, Sonchus spp., Setaria parviflora, Cichorium intybus, Solanum nigrum* and *Bidens pilosa.*

Table. Dominant species and structure at HVORIV201503

Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia amblygona, Acacia decora, Corymbia maculata, Acacia implexa, Acacia falcata*
Ground layer	1	30	*Bothriochloa macra, Rytidosperma spp., Chloris truncata, Austrostipa bigeniculata, Einadia nutans, Cynodon dactylon, Capillipedium spicigerum*

*Projected foliage cover

Site photographs at HVORIV201503

Start position 2017

End position 2017

HVORIV201502

HVORIV201502	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	311543	6398308
End transect:	311526	6398260

Description:

The HVORIV201502 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been weed wiped to kill weeds and reduce competition with natives sown in 2016.

Common weeds recorded at the site included *Aster sp., Solanum nigrum, Plantago lanceolata, Conyza bonariensis* and *Bidens pilosa.*

Table. Dominant species and structure at HVORIV201502

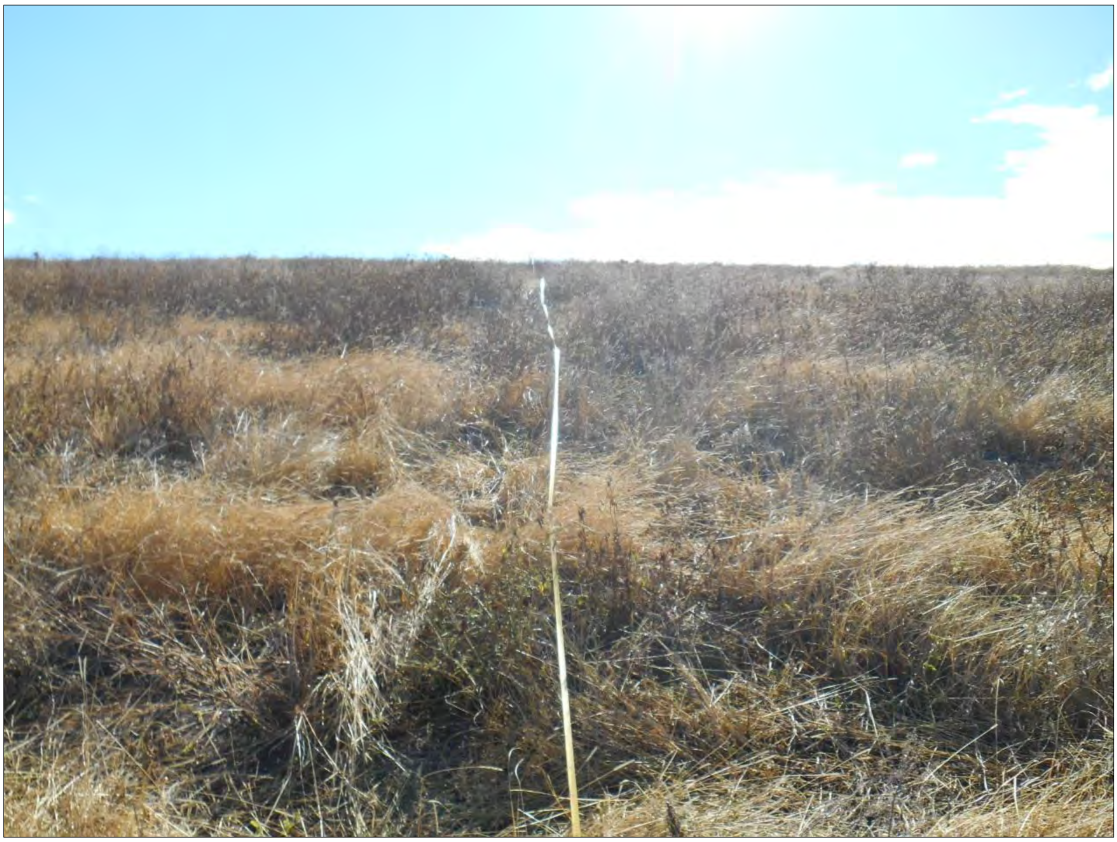
Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	1	15	*Commelina cyanea, Dichondra repens, Einadia nutans*

*Projected foliage cover

Site photographs at HVORIV201502

Start position 2017

End position 2017



HVORIV201501

HVORIV201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	312211	6398020
End transect:	312256	6397998

Description:

HVORIV201501 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the rehabilitation site consists mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Acacia saligna*, *Galenia pubescens, Plantago lanceolata, Conyza bonariensis, Senecio madagascariensis* and *Chloris gayana*.

Table. Dominant species and structure at HVORIV201501

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	1	40	*Bothriochloa macra, Panicum effusum*, *Austrostipa sp.*

*Projected foliage cover

Site photographs at HVORIV201501

Start position 2017

End position 2017

HVOLEM201501

HVOLEM201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	6394462	316910
End transect:	-	-

Description:

HVOLEM201501 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOLEM201501 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Senecio madagascariensis, Conyza bonariensis* and *Aster spp*.

Table. Dominant species and structure at HVOLEM201501

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Eucalyptus moluccana*
Ground layer	1	75	*Cynodon dactylon, Bothriochloa macra, Capillipedium spicigerum, Dichanthium sericeum, Sporobolus creber, Chloris truncata*

*Projected foliage cover

Site photographs at HVOLEM201501

Start position 2017

End position 2017

HVOCHE201501

HVOCHE201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	313968	6402006
End transect:	313952	6402056

Description:

HVOCHE201501rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOCHE201501consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been sprayed to kill weeds and cover crop to prepare for natives to be sown.

Common weeds recorded at the site included *Senecio madagascariensis, Anagallis arvensis* and *Hypochaeris radicata.*

Table. Dominant species and structure at HVOCHE201501

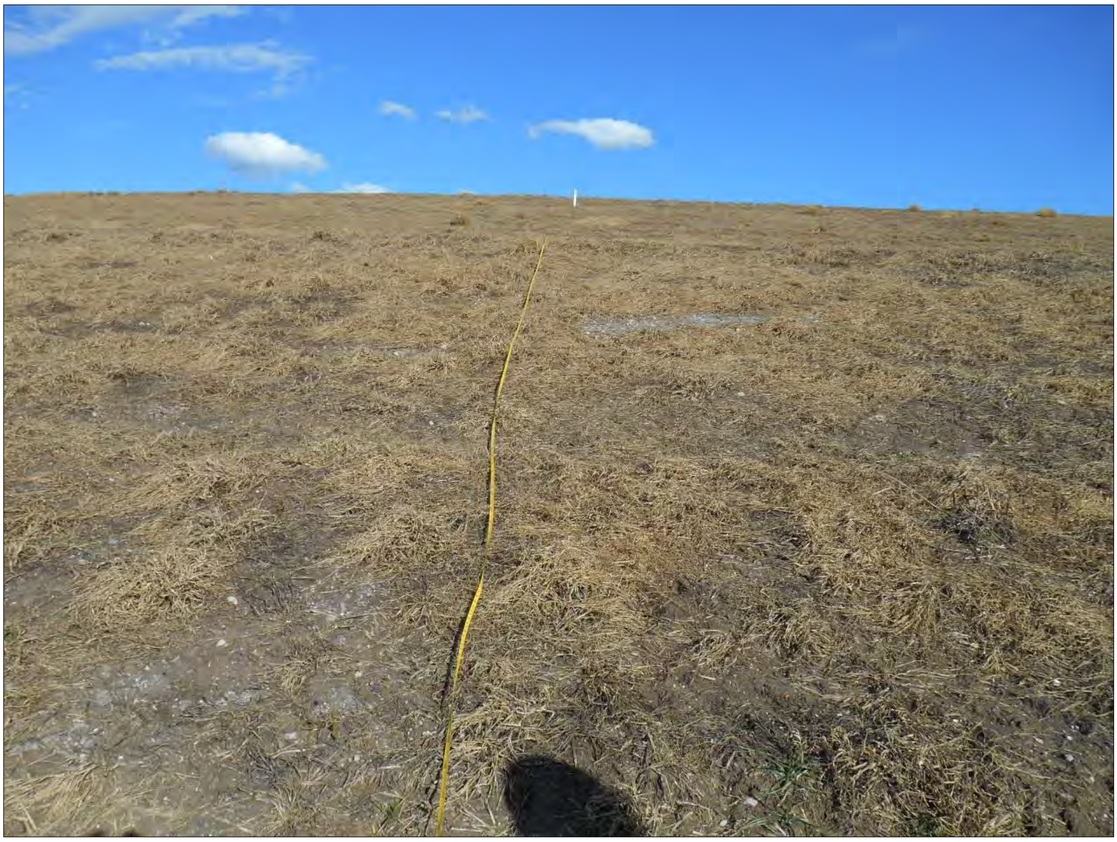
Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	
Ground layer	0.5	<5	*Oxalis perennans*, *Geranium solanderi*

*Projected foliage cover

Site photographs at HVOCHE201501

Start position 2017

End position 2017



HVORIV201601

HVORIV201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	311284	6398284
End transect:	311314	6398245

Description:

HVORIV201601 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVORIV201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Medicago sativa, Bidens pilosa, Senecio madagascariensis, Sonchus sp.* and *Brassica spp*..

Table. Dominant species and structure at HVORIV201601

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	1	<5	*Solanum prinophyllum, Echinochloa colona, Geranium solanderi*

*Projected foliage cover

Site photographs at HVORIV201601

Start position 2017

End position 2017

HVOWES201602

HVOWES201602	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	308357	6408560
End transect:	308323	6408597

Description:

HVOWES201602 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

It should be noted that a number of regenerating eucalypts and small acacias were recorded in the plot.

Disturbance:

Disturbance present at rehabilitation site HVOWES201602 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Galenia pubescens, Plantago lanceolata, Senecio mada gascariensis, Gomphocarpous fruiticosis, Melinis repens, Pennisetum glaucum* and *Solanum nigrum.*

Table. Dominant species and structure at HVOWES201602

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	30	*Acacia falcata, acacia cultriformis, Acacia paradoxa, Eucalyptus moluccana, Corymbia maculate, Acacia decora*
Ground layer	1	50	*Capillipedium spicigerum, Dichondra repens, Wahlenbergia communis, Austrostipa scabra, Themeda avenacea*

*Projected foliage cover

Site photographs at HVOWES201602

Start position 2017

End position 2017

HVOWES201601

HVOWES201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	309820	6410903
End transect:	-	-

Description:

HVOWES201601 rehabilitation area occurs on a combination of spoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

It should be noted that a number of acacias were also recorded regenerating in the plot.

Disturbance:

Disturbance present at rehabilitation site HVOWES201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Chloris gayana*, *Galenia pubescens, Bidens pilosa, Senecio mada gascariensis, Gomphocarpous fruiticosis, Panicum maximum, Sida rhombifolia* and *Solanum nigrum.*

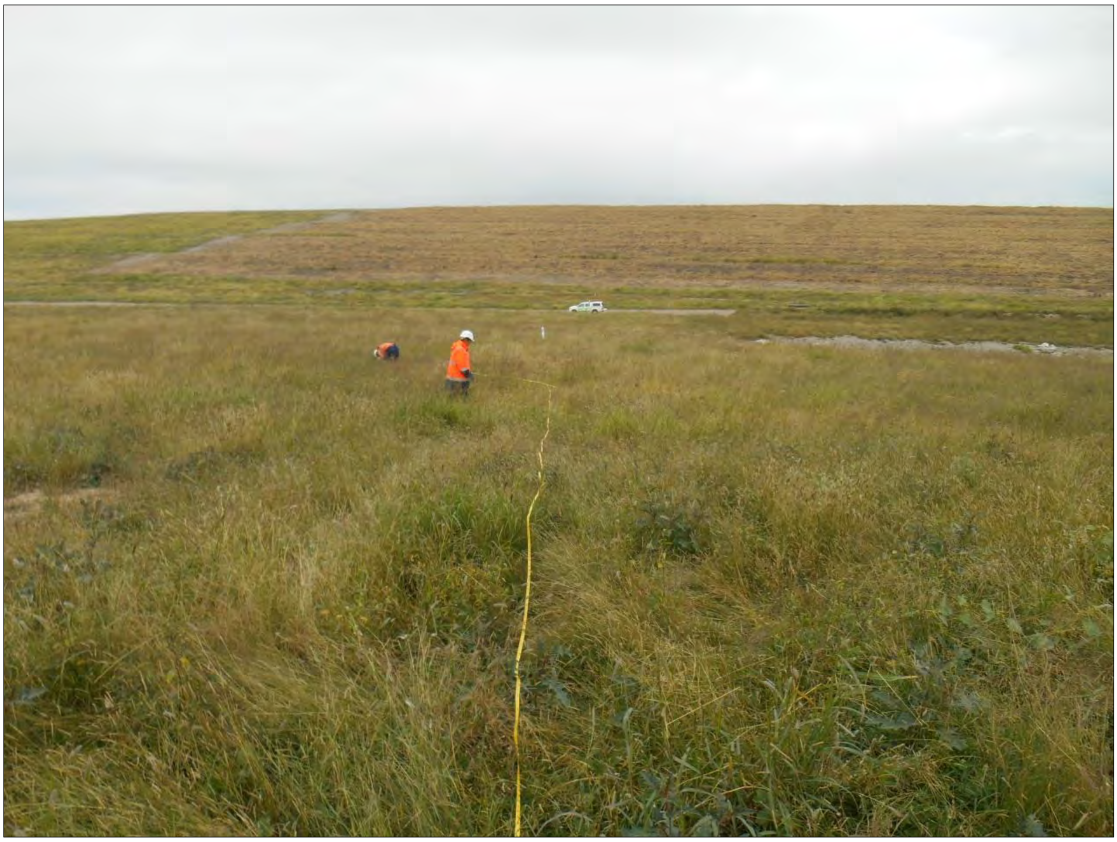
Table. Dominant species and structure at HVOWES201601

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia spectabilis, Acacia decora, Acacia amblygona*
Ground layer	1	25	*Capillipedium spicigerum, Solanum prinophyllum, Chloris truncata, Eriochloa pseudoacrotricha, Atriplex semibaccata*

*Projected foliage cover

Site photographs at HVOWES201601

Start position 2017



End position 2017

HVOWES201603

HVOWES201603	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	309354	6409944
End transect:	309385	6409903

Description:

HVOWES201603 rehabilitation area occurs on a combination of topsoil and compost. The compost that was applied to this area is a composted green waste rather than the mixed source compost typically used in rehabilitation at HVO.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOWES201603 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Conyza bonariensis, Chloris gayana, Setaria parviflora, Verbena bonariensis, Galenia pubescens, Bidens pilosa, Senecio mada gascariensis, Gomphocarpous fruiticosis, Panicum maximum, Plantago lanceolata, Sida rhombifolia* and *Solanum nigrum.*

Table. Dominant species and structure at HVOWES201603

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia decora, Acacia falcata, Acacia filicifolia, Acacia amblygona*
Ground layer	1	30	*Einadia nutans, Austrostipa bigeniculata, Austrostipa scabra Chloris truncata, Rytidosperma spp., Cynodon dactylon, Dichanthium sericeum*

*Projected foliage cover

Site photographs at HVOWES201603

Start position 2017

End position 2017

HVOWES201604

HVOWES201604	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	307372	6407327
End transect:	307394	6407374

Description:

HVOWES201604 rehabilitation area occurs on a combination of topsoil, compost and trail of composted green waste.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOWES201604 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Chloris gayana, Anagallis arvensis, Galenia pubescens, Gomphocarpous fruiticosis, Panicum maximum, Heliotropium amplexicaule, Sida rhombifolia, Brassica rapa* and *Erodium cicutarium.*

Table. Dominant species and structure at HVOWES201604

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia decora, Acacia filicifolia, Acacia amblygona, Acacia spectabilis*
Ground layer	1	30	*Solanum prinophyllum, Einadia nutans, Dichondra repens, Chloris truncata, Dichanthium sericeum*

*Projected foliage cover

Site photographs at HVOWES201604

Start position 2017

End position 2017

HVOCHE201601

HVOCHE201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	313555	6401634
End transect:	313541	6401683

Description:

HVOCHE201601 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOCHE201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been sprayed to kill weeds and cover crop to prepare for natives to be sown.

Common weeds recorded at the site included *Conyza bonariensis, Galenia pubescens, Senecio madagascariensis* and *Sida rhombifolia.*

Table. Dominant species and structure at HVOCHE201601

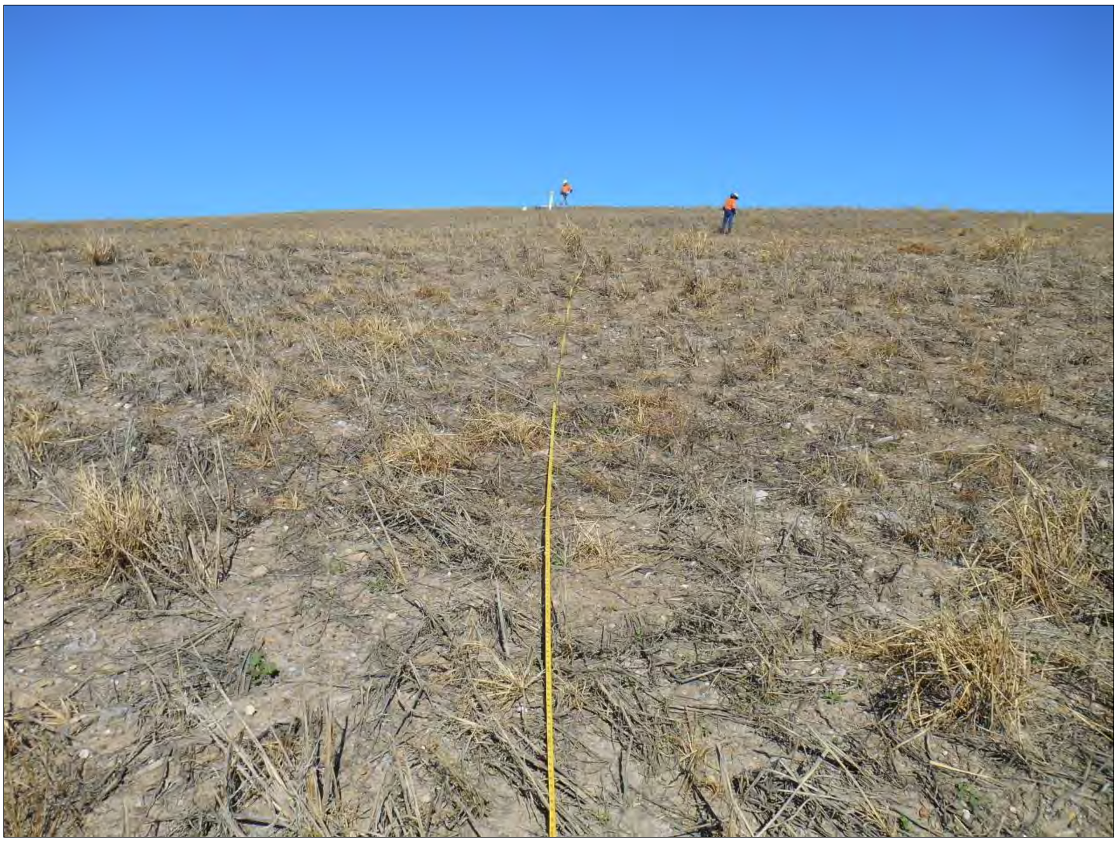
Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	1	<5	*Panicum effusum, Cynodon dactylon*

*Projected foliage cover

Site photographs at HVOCHE201601

Start position 2017

End position 2017



HVOCHE201602

HVOCHE201602	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	313072	6401299
End transect:	313057	6401346

Description:

HVOCHE201602 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOCHE201602 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been sprayed to kill weeds and cover crop to prepare for natives to be sown.

Common weeds recorded at the site included *Pennisetum glaucum, Macroptilium atropurpureum* and *Galenia pubescens.*

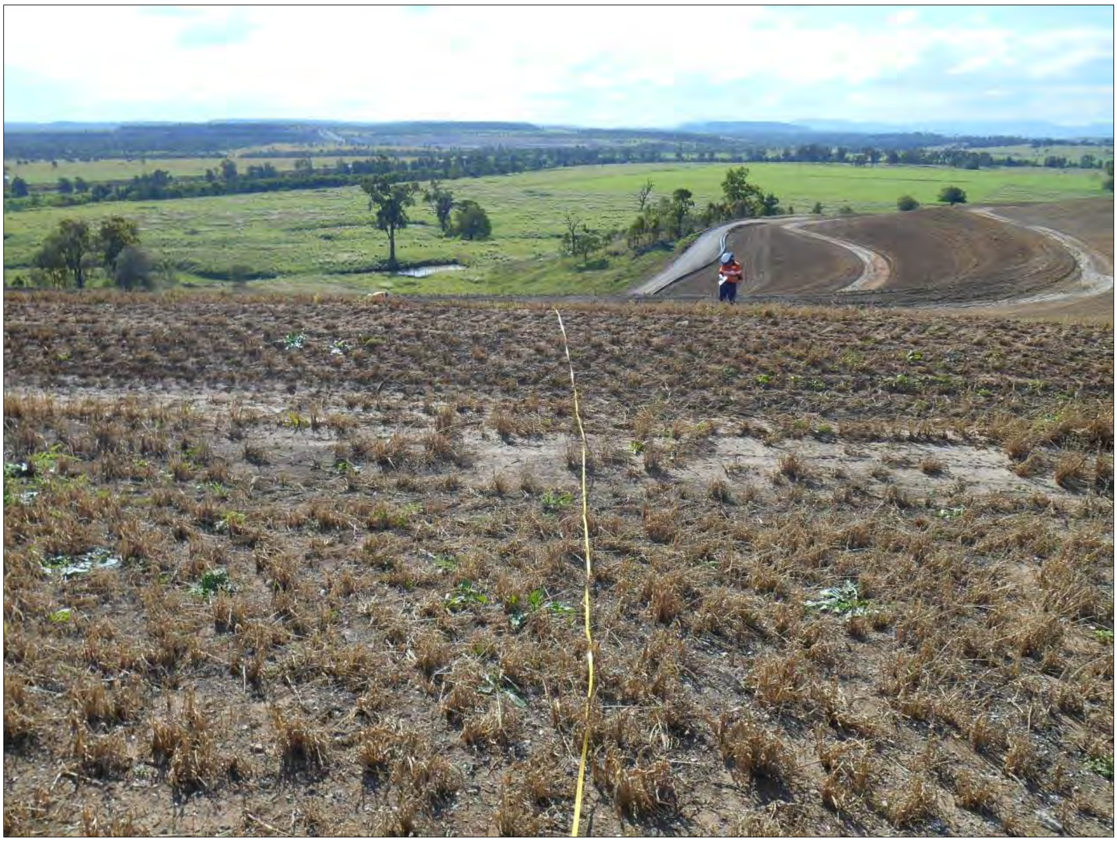
Table. Dominant species and structure at HVOCHE201602

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	0.5	<5	*Dichondra repens, Cynodon dactylon*

*Projected foliage cover

Site photographs at HVOCHE201602

Start position 2017



End position 2017

HVOLEM201601

HVOLEM201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	317039	6394768
End transect:	316990	6394760

Description:

HVOLEM201601 is rehabilitation area occurs on a combination of topsoil, compost and trial of composted green waste.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site HVOLEM201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Conyza bonariensis, Setaria parviflora, Galenia pubescens, Senecio mada gascariensis, Panicum maximum* and *Anagallis arvensis.*

Table. Dominant species and structure at HVOLEM201601

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1	<5	*Corymbia maculata, Acacia binervata, Dodonaea viscosa, Acacia salicina, Acacia amblygona*
Ground layer	0.5	10	*Dysphania pumilio, Pimelea linifolia, Dichanthium sericeum, wahlenbergia communis, Hardenbergia violacea*

*Projected foliage cover

Site photographs at HVOLEM201601

Start position 2017

End position 2017

MTWSPS201601

MTWSPS201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320910	6389384
End transect:	320949	6389413

Description:

MTWSPS201601 rehabilitation area occurs on topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site MTWSPS201601 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Chloris gayana, Cichorium intybus* and *Conyza spp.*.

Table. Dominant species and structure at MTWSPS201601

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	0.5	10	*Cynodon dactylon, Glycine tabacina, Phylon sp., Eriochloa pseudoacrotricha*

*Projected foliage cover

Site photographs at MTWSPS201601

Start position 2017

End position 2017

MTWSPN201602

MTWSPN201602	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320444	6389769
End transect:	320494	6389775

Description:

MTWSPN201602 rehabilitation area occurs on a combination of topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at rehabilitation site MTWSPN201602 consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Setaria parviflora, Cichorium intybus, Brassica rapa* and *Solanum nigrum.*

Table. Dominant species and structure at MTWSPN201602

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	0.5	30	*Chloris truncata, Panicum effusum, Bothriochloa macra, Eragrostis brownii*

*Projected foliage cover

Site photographs at MTWSPN201602

Start position 2017

End position 2017

MTWSPN201601

MTWSPN201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320130	6390589
End transect:	320158	6390630

Description:

The MTWSPN201601 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

It should be noted no natives or exotic species were recorded at MTWSPN201601.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Site has been sprayed to kill weeds and cover crop to prepare for natives to be sown.

Table. Dominant species and structure at MTWSPN201601

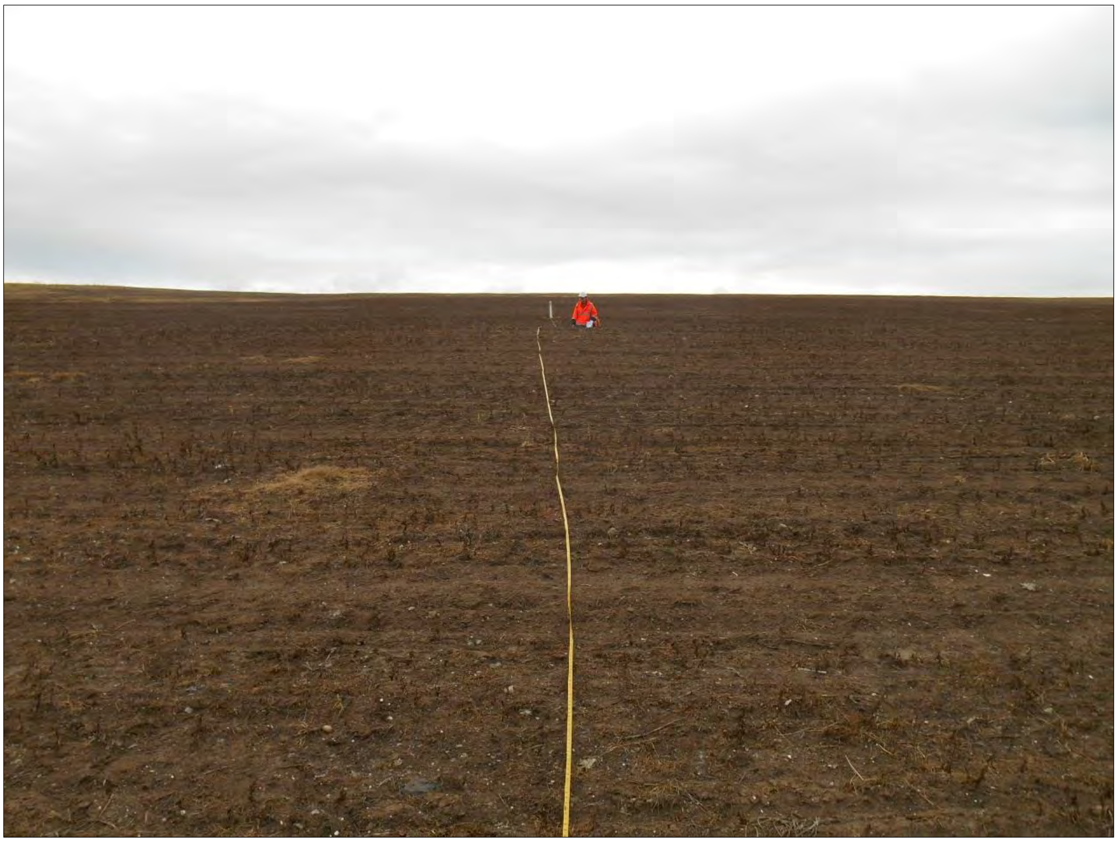
Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	-	-	-

*Projected foliage cover

Site photographs at MTWSPN201601

Start position 2017

End position 2017



MTWSPN201501

MTWSPN201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	319956	6390291
End transect:	319984	6390332

Description:

The MTWSPN201501 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

It should be noted no native species were recorded at MTWSPN201501. One native species, *Chloris ventricosa,* was recorded which had been sprayed and was dead.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Portulaca spp., Galenia pubescens* and *Chloris gayana.*

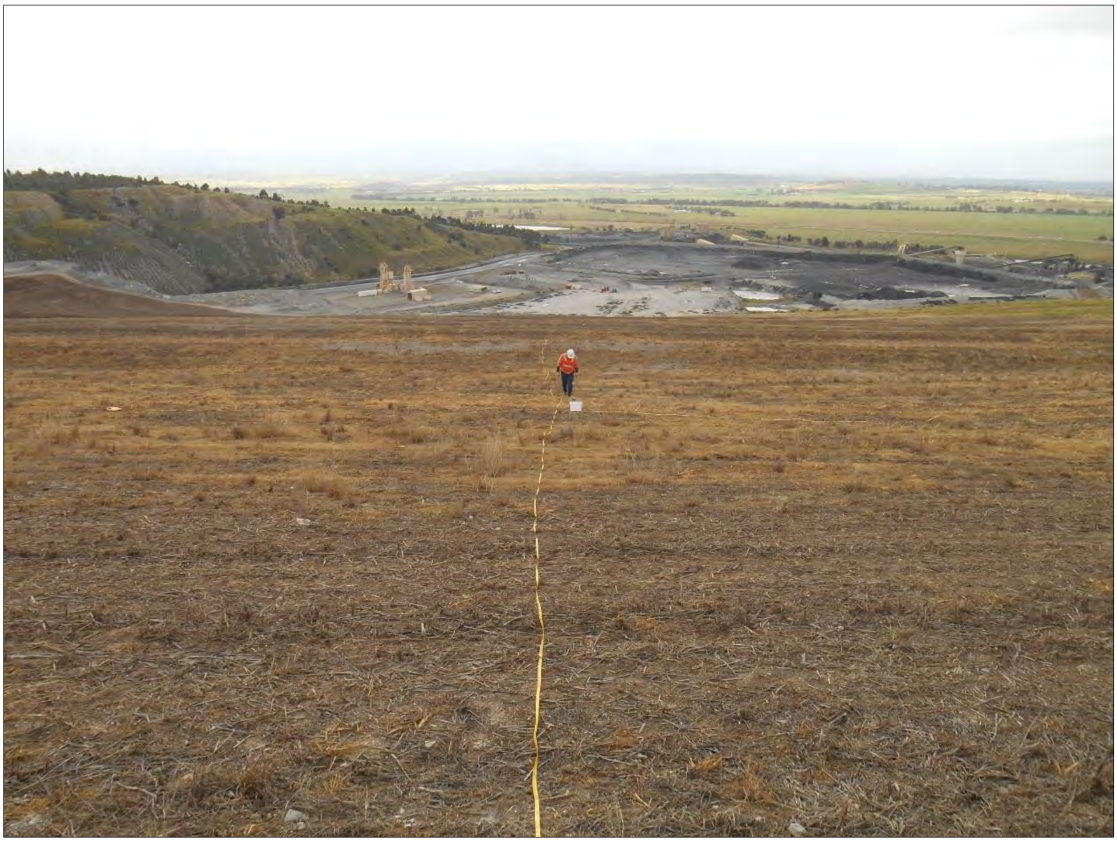
Table. Dominant species and structure at MTWSPN201501

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	-	-	-

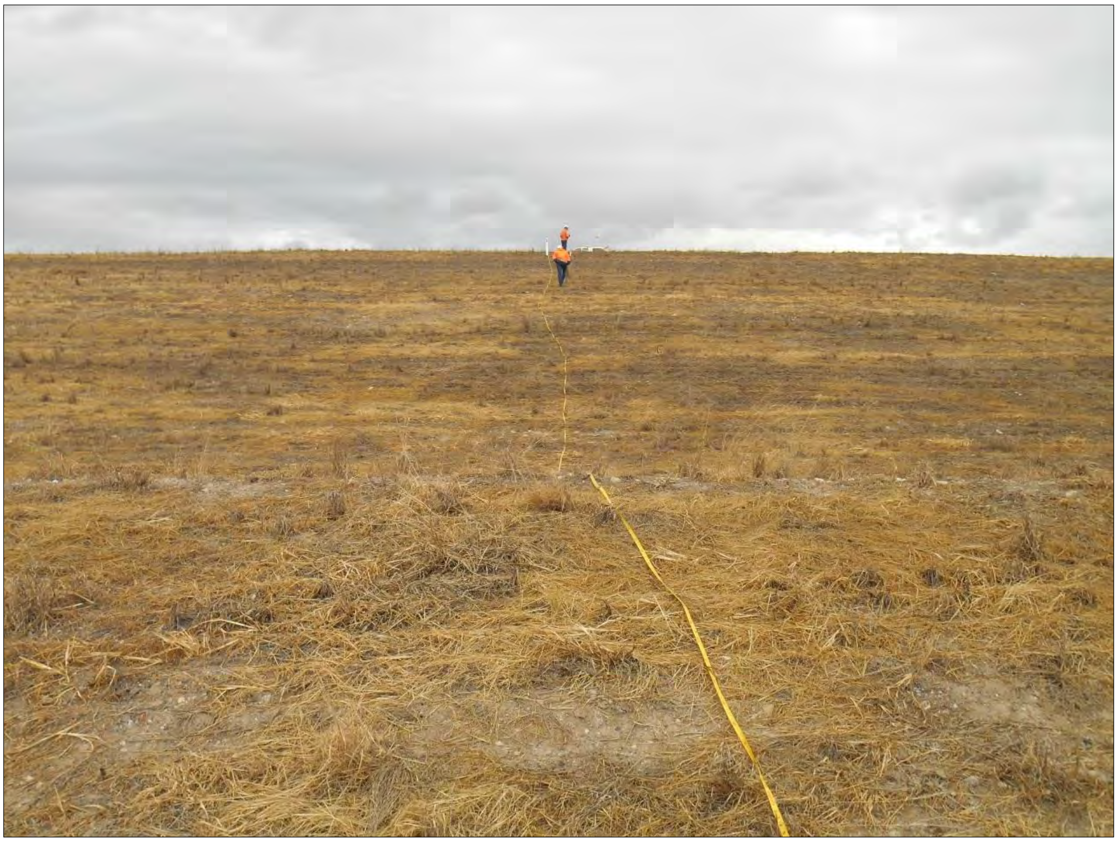
*Projected foliage cover

Site photographs at MTWSPN201501

Start position 2017



End position 2017



MTWSPS201602

MTWSPS201602	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320830	6388963
End transect:	320879	6388975

Description:

The MTWSPS201602 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Macroptilium bracteatum* , *Medicago sativa, Brassica rapa* and *Panicum maximum.*

Table. Dominant species and structure at MTWSPS201602

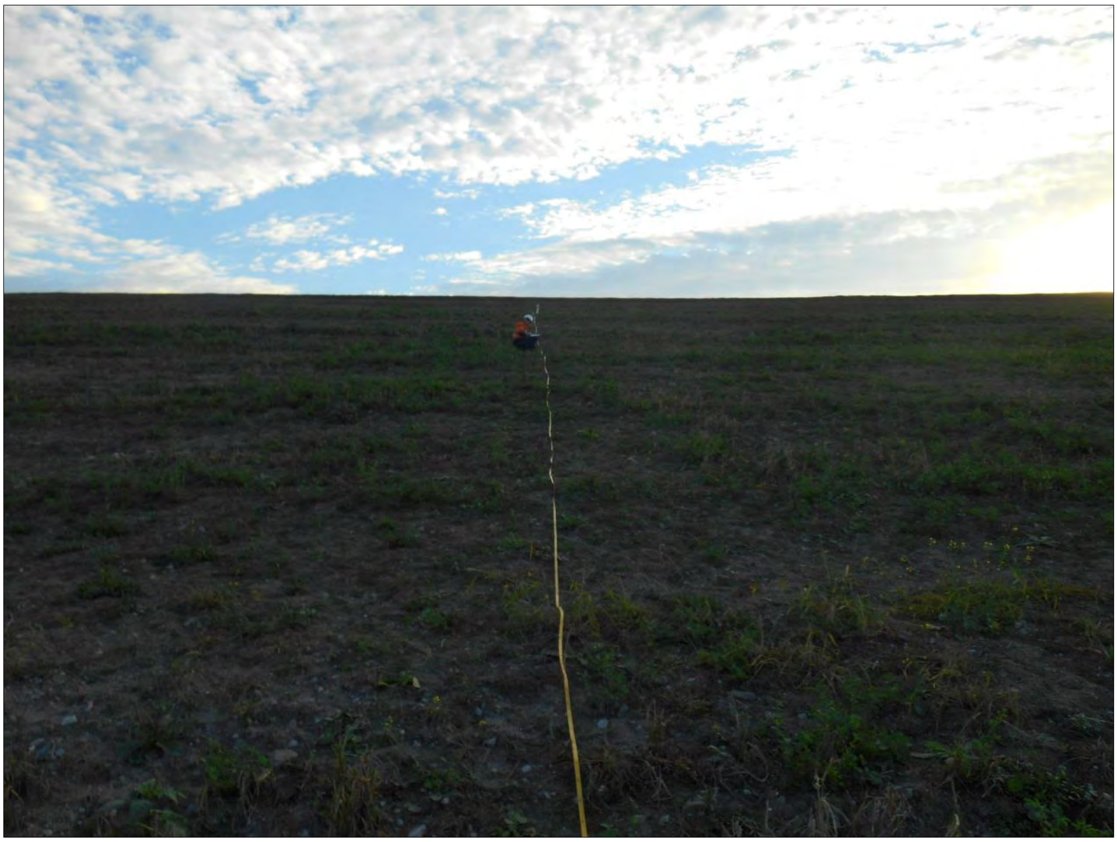
Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	-	-	-

*Projected foliage cover

Site photographs at MTWSPS201602

Start position 2017

End position 2017



MTWNOO201501

MTWNOO201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320406	6391940
End transect:	320438	6391979

Description:

The MTWNOO201501 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the rehabilitation site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Panicum maximum, Plantago lanceolata, Chloris gayana, Sida rhombifolia* and *Brassica rapa.*

Table. Dominant species and structure at MTWNOO201501

Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	1.5	<5	*Acacia cultriformis, Acacia decora*
Ground layer	1	40	*Sporobolus creber, Chloris truncata, Bothriochloa macra, Dichondra repens, Oxalis perennans, Eragrostis brownii, Panicum effusum, Glycine tabacina, Geranium solanderi, Entolasia stricta*

*Projected foliage cover

Site photographs at MTWNOO201501

Start position 2016

End position 2017

MTWMTO201501

MTWMTO201501	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	321386	6385357
End transect:	321427	6385331

Description:

The MTWMTO201501 rehabilitation area occurs on imported topsoil.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Bidens pilosa, Setaria italica, Galea pubescens, Plantago lanceolata, Chloris gayana, Sida rhombifolia* and *Verbena bonariensis.*

Table. Dominant species and structure at MTWMTO201501

Stratum	Height (m)	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	0.5	<5	*Dichondra repens, Enchylaena tomentosa, Cynodon dactylon, Eriochloa pseudoacrotricha*

*Projected foliage cover

Site photographs at MTWMTO201501

Start position 2017

End position 2017

MTWMTO201601

MTWMTO201601	MGA 84 Zone 56	
Position	**Easting**	**Northing**
Start transect:	320667	6385308
End transect:	320718	6385305

Description:

The MTWMTO201601 rehabilitation area occurs on imported topsoil and compost.

The dominant species, including the structure of the site, is provided in the table below.

Disturbance:

Disturbance present at the site consisted mainly of weeds, and grazing by macropods. No evidence of fire was observed in the rehabilitation area. No areas containing rubbish were observed.

Common weeds recorded at the site included *Pennisetum glaucum, Solanum nigrum, Portulaca spp.* and *Arctotheca calendula.*

Table. Dominant species and structure at MTWMTO201601

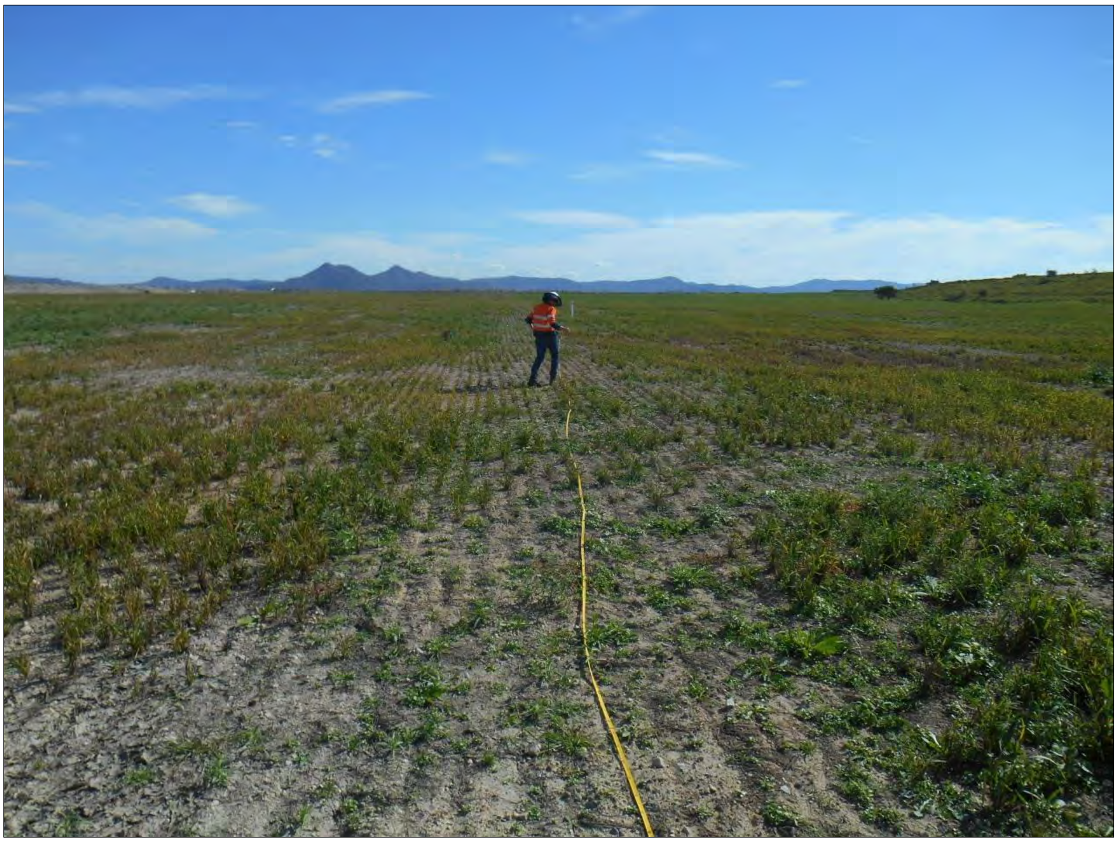
Stratum	Height	% cover*	Dominant native species
Tree layer	-	-	-
Midstorey layer	-	-	-
Shrub layer	-	-	-
Ground layer	-	-	-

*Projected foliage cover

Site photographs at MTWMTO201601

Start position 2017

End position 2017



Appendix 6 – Tree and canopy data

Bell 1				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		20	
2	*E. crebra*		30	
3	*C. maculata*		13	
4	*C. maculata*		16	
5	*E. crebra*		15	
6	*E. crebra*		30	
7	*C. maculata*		12	
8	*C. maculata*		20	
9	*C. maculata*		18	
10	*E. crebra*		28	
11	*C. maculata*		15	
12	*E. crebra*		25	
13	*E. crebra*		12	
14	*E. crebra*		10	
15	*E. crebra*		10	
16	*E. crebra*		10	
17	*E. crebra*		25	
18	*E. crebra*		25	
19	*E. crebra*		30	
20	*E. crebra*		10	

Bell 2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		20	
2	*E. moluccana*		16	
3	*C. maculata*		22	
4	*C. maculata*		21	
5	*C. maculata*		20	1
6	*C. maculata*		12	
7	*C. maculata*		18	
8	*C. maculata*		8	
9	*C. maculata*		13	
10	*C. maculata*		20	
11	*C. maculata*		13	

Bell 2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
12	*C. maculata*		43	
13	*E. moluccana*		18	
			244	

Bell 3				
Tree Number	**Tree Species**	**Fruit/Flowers**	**Width range (cm)**	**Hollows**
1	*C. maculata*		26	
2	*C. maculata*		25	
3	*C. maculata*		12	
4	*E. moluccana*		15	
5	*C. maculata*		11	
6	*C. maculata*		28	
7	*C. maculata*		24	
8	*C. maculata*		11	
9	*C. maculata*		17	
10	*C. maculata*		12	
11	*E. moluccana*		15	
12	*C. maculata*		11	
13	*E. moluccana*		15	
14	*C. maculata*		10	
15	*E. fibrosa*		12	
16	*C. maculata*		8	
17	*C. maculata*		18	
18	*C. maculata*		18	
19	*C. maculata*		12	
20	*C. maculata*		15	
21	*C. maculata*		11	

HVOCAR200901				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		7	
2	*C. maculata*		7	
3	*C. maculata*		7	
4	*C. maculata*		7	
5	*C. maculata*		6	
6	*C. maculata*		12	
7	*E. moluccana*		13	

HVOCAR200901				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
8	*E. moluccana*		10	
9	*C. maculata*		15	
10	*C. maculata*		11	
11	*C. maculata*		15	
12	*C. maculata*		9	
13	*C. maculata*		5	
14	*C. maculata*		7	
15	*A. implexa*		13	
16	*E. moluccana*		11	
17	*C. maculata*		13	
18	*C. maculata*		12	
19	*E. moluccana*		6	
20	*C. maculata*		10	
21	*C. maculata*		5	
22	*E. moluccana*		7	
23	*C. maculata*		8	
24	*C. maculata*		7	
25	*E. moluccana*		12	
26	*C. maculata*		9	
27	*C. maculata*		10	
28	*E. moluccana*		5	

HVOCAR200902				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		6	
2	*C. maculata*		7	
3	*A. implexa*		7	
4	*C. maculata*		6	

HVOWES200801				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		5	
2	*C. maculata*		6	
3	*C. maculata*		5	
4	*C. maculata*		5	
5	*C. maculata*		6	
6	*C. maculata*		6	

HVOWES200801				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
7	*C. maculata*		5	
8	*C. maculata*		6	
9	*C. maculata*		9	
10	*C. maculata*		5	
11	*C. maculata*		5	
12	*E. moluccana*		5	
13	*C. maculata*		5	
14	*C. maculata*		6	
15	*C. maculata*		6	
16	*C. maculata*		5	
17	*C. maculata*		9	
18	*C. maculata*		5	
19	*C. maculata*		6	
20	*C. maculata*		7	
21	*E. moluccana*		7	
22	*C. maculata*		6	
23	*C. maculata*		8	
24	*C. maculata*		11	
25	*C. maculata*		6	
26	*C. maculata*		6	
27	*C. maculata*		6	
28	*C. maculata*		6	
29	*C. maculata*		7	
30	*C. maculata*		10	
31	*C. maculata*		8	
32	*C. maculata*		6	
33	*C. maculata*		6	
34	*C. maculata*		5	
35	*C. maculata*		6	
36	*C. maculata*		7	
37	*C. maculata*		6	

HVOWES201101				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		6	
2	*E. moluccana*		7	
3	*C. maculata*		5	
4	*C. maculata*		5	

HVOWES201101				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
5	*C. maculata*		6	
6	*C. maculata*		7	
7	*C. maculata*		6	
8	*C. maculata*		7	
9	*C. maculata*		8	
10	*C. maculata*		6	
11	*C. maculata*		6	
12	*C. maculata*		7	
13	*E. moluccana*		7	
14	*E. moluccana*		6	
15	*C. maculata*		6	
16	*C. maculata*		6	
17	*E. moluccana*		6	

MTWCDD201101				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		8	
2	*C. maculata*		5	
3	*C. maculata*		4	
4	*C. maculata*		5	
5	*C. maculata*		5	
6	*C. maculata*	flowers	7	
7	*E. moluccana*		6	
8	*E. moluccana*		5	
9	*C. maculata*		5	
10	*C. maculata*		5	
11	*E. moluccana*		4	
12	*C. maculata*		8	
13	*C. maculata*		5	
14	*C. maculata*		7	
15	*C. maculata*		6	
16	*C. maculata*		6	
17	*C. maculata*	heavy flower	9	

MTWMTO200001				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		11	

MTWMTO200001				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
2	*E. moluccana*		10	
3	*E. moluccana*		7	
4	*E. moluccana*		9	
5	*E. moluccana*		6	

MTWNPN200501				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	A. implexa	flowers	15	
2	A. implexa	flowers	15	

MTWNPN200502				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*C. maculata*		5	
2	*Unknown*		7	
3	*C. maculata*		10	
4	*C. maculata*		9.5	
5	*C. maculata*		13	
6	*C. maculata*		11	
7	*C. maculata*		9	
8	*C. maculata*		9	
9	*C. maculata*		14	
10	*Unknown*		8.5	
11	*C. maculata*		15	
12	*Unknown*		9.5	
13	*Unknown*		7	
14	*C. maculata*		15	
15	*C. maculata*		8	
16	*Oposite leaves*		5	
17	*C. maculata*		8	
18	*C. maculata*		5.5	
19	*C. maculata*		11.5	
20	*C. maculata*		7.5	
21	*C. maculata*		7.5	
22	*Oposite leaves*		9	
24	*C. maculata*		10	
25	*C. maculata*		11	
26	*C. maculata*		10	

MTWNPN200502				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
27	*C. maculata*		11	
28	*C. maculata*		7	
29	*C. maculata*		9	
30	*E. moluccana*		9.5	

WAMBOGB1				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*A. luehmannii*		10	
2	*A. luehmannii*		7	
3	*A. luehmannii*		12	
4	*A. luehmannii*		9	
5	*A. luehmannii*		8	
6	*A. luehmannii*		9	
7	*A. luehmannii*		9	
8	*E. fibrosa*		21	
9	*E. fibrosa*		9	
10	*E. fibrosa*		12	
11	*E. fibrosa*		18	
12	*E. fibrosa*		10	
13	*E. fibrosa*		13	
14	*E. fibrosa*		6	
15	*E. fibrosa*		11	
16	*E. fibrosa*		10	
17	*E. fibrosa*		17	
18	*E. crebra*		18	
19	*E. moluccana*		12	
20	*A. luehmannii*		11	
21	*A. luehmannii*		15	
22	*A. luehmannii*		10	

WAMBOGB2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*		13	
2	*E. moluccana*		13	
3	*E. moluccana*		55	
4	*E. moluccana*		7	

WAMBOSPOT1				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	E. crebra		17	
2	E. punctata		35	1
3	E. crebra		17	
4	E. crebra		22	
5	E. crebra		21	
6	E. punctata		26	2
7	C. maculata		6	
8	E. punctata		35	2

WAMBOSPOT2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. moluccana*	fruit	23	
2	*E. moluccana*		16	
3	*C. maculata*	fruit	9	
4	*C. maculata*		10	
5	*C. maculata*		12	
6	*C. maculata*		9, 7.5	
7	*E. moluccana*		23	
8	*E. moluccana*		14	
9	*C. maculata*		11	
10	*C. maculata*		9	
11	*E. moluccana*		11	
12	*E. moluccana*		20	
13	*E. moluccana*		8	
14	*E. moluccana*		7.5	
15	*E. moluccana*		7	
16	*E. moluccana*		9	
17	*C. maculata*		48	
18	*E. moluccana*		13	
19	*E. moluccana*		13	
20	*E. moluccana*		15	
21	*E. moluccana*		14	
22	*E. moluccana*		9	
23	*E. moluccana*		13	
24	*E. moluccana*		8	
25	*E. moluccana*		18	
26	*E. moluccana*		12	
27	*C. maculata*		8	

WAMBOSPOT2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
28	*C. maculata*		9	
29	*E. moluccana*		13	

WAMBOSPOT3				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. crebra*		24	
2	*E. crebra*		17	
3	*E. punctata*		28	
4	*E. crebra*		16	
5	*C. maculata*		24	
6	*C. maculata*		17	
7	*C. maculata*		32	
8	*E. crebra*		22	
9	*E. crebra*		18	

WARKGB1				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. crebra*		29	
2	*E. crebra*		16.5	
3	*E. crebra*		15	
4	*E. crebra*		21	
5	*E. crebra*		17	
6	*E. crebra*		9	
7	*E. crebra*		14	
8	*E. crebra*		16	
9	*A. leuhmannii*		10	
10	*E. crebra*		8	
11	*E. crebra*		16	
12	*E. crebra*		11.5	
13	*E. crebra*		14	
14	*E. crebra*		20	
15	*E. crebra*		12	
16	*E. crebra*		10	
17	*E. crebra*		9	
18	*E. crebra*		17	
19	*E. crebra*		12	
20	*E. crebra*		12	
21	*E. crebra*		14	

WARKGB1				
22	*E. crebra*		13	
23	*E. crebra*		23	
24	*A. leuhmannii*		18	
25	*E. crebra*		13	

WARKGB2				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*A. leuhmannii*		8	
2	*E. crebra*		26	
3	*A. leuhmannii*		7	
4	*A. leuhmannii*		7	
5	*E. crebra*		14	
6	*E. crebra*		22	
7	*E. crebra*		16	
8	*A. leuhmannii*		8	
9	*A. leuhmannii*		11	
10	*A. leuhmannii*		11	
11	*E. crebra*		14	
12	*A. leuhmannii*		11	
13	*E. crebra*		8	
14	*E. crebra*		9	
15	*E. crebra*		9	
16	*E. crebra*		35	
17	*E. crebra*		18	
18	*E. crebra*		21	
19	*A. leuhmannii*		8	
20	*E. crebra*		18	
21	*E. crebra*		8	
22	*E. crebra*		13	
23	*A. leuhmannii*		8	
24	*E. crebra*		26	

WARKGB3				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*A. leuhmannii*		9	
2	*A. leuhmannii*		11	
3	*E. crebra*		28	
4	*E. amplifolia*		9.5	
5	*E. amplifolia*		9	

WARKGB3				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
6	*A. leuhmannii*		11	
7	*A. leuhmannii*		11	
8	*E. amplifolia*		18	
9	*A. leuhmannii*		18	
10	*E. amplifolia*		26	
11	*A. leuhmannii*		11	
12	*1B*		17	
13	*A. leuhmannii*		14	
14	*E. amplifolia*		19	
15	*E. amplifolia*		7	
16	*E. amplifolia*		17	
17	*E. crebra*		25	
18	*A. leuhmannii*		14	
19	*E. amplifolia*		19	
20	*E. amplifolia*		15	
21	*E. amplifolia*		9.5	
22	*A. leuhmannii*		12	
23	*A. leuhmannii*		13	
24	*E. crebra*		15	
25	*E. amplifolia*		21	
26	*E. amplifolia*		13	
27	*E. amplifolia*		6	
28	*A. leuhmannii*		8	

WARKGB4				
Tree Number	Tree Species	Fruit/Flowers	Width range (cm)	Hollows
1	*E. crebra*		110	3
2	*E. crebra*		20	

BELL1						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	2	*E. moluccana*	1			
				3	2	0.03

BELL2						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	3	*C. maculata*	8			
E. moluccana	4	*E. moluccana*	2			
				17	4	0.085

BELL3						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	3	*C. maculata*	7			
E. moluccana	1	*E. moluccana*	4			
E. crebra	4	*E. crebra*				
A. leuhmannii	1			20	4	0.1

HVOCAR200901						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. moluccana	1	*E. moluccana*	2			
C. maculata	17	*C. maculata*	12			
A. implexa	4	*A. implexa*	2			
				38	4	0.19

HVOCAR200902						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	19	*C. maculata*	24			
E. moluccana	2	*E. moluccana*	1			
Unknown	2					
				48	4	0.24

HVORIV201401						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. moluccana	1	*E. moluccana*	3			
		Unknown	2			
		E. crebra	1	7	4	0.035

HVORIV201402						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. crebra	1					
				1	4	0.005

HVOWES200801						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	20	*C. maculata*	43			
E. moluccana	4	*E. moluccana*	4			
Eucalypt sp.	4	*Eucalypt sp.*	8			
		A. implexa	2	85	4	0.425
HVOWES201101						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	21	*C. maculata*	30			
E. moluccana	10	*E. moluccana*	11			
E. fibrosa	1	*E. fibrosa*				
E. crebra	2	*E. crebra*	4			
A. implexa	6	*A. implexa*	4			
Eucalypt sp.	2	*Eucalypt sp.*	2	93	4	0.465
HVOWES201301						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. crebra	3	*E. crebra*	2			
A. implexa	2	*A. implexa*				
Eucalypt sp.	1	*C. maculata*	2			
		E. moluccana	2	12	4	0.06
MTWCDD201101						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
Eucalypt sp. 1	4	*Eucalypt sp. 1*	3			
Eucalypt sp. 2	2	*Eucalypt sp. 2*				
C. maculata	5	*C. maculata*	16			
A. implexa	3	*A. implexa*	2	35	4	0.175
MTWCDD2015						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. fibrosa	1	*E. fibrosa*	1			
C. maculata	33	*C. maculata*	37			
E. moluccana	11	*E. moluccana*	14			
				97	4	0.485
MTWMTO200001						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. cladocalyx	10	*E. cladocalyx*	4	17	4	0.085

E. moluccana	1	*E. moluccana*	2			
MTWMTO200503						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. cladocalyx	14	*E. cladocalyx*	8			
E. moluccana	1					
				23	4	0.115
MTWNPN200501						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
A. implexa	2					
				2	4	0.01
MTWNPN200502						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
C. maculata	13	*C. maculata*	12			
A. mearnsii	3	*A. mearnsii*	2			
				30	4	0.15
MTWNPN200901						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
		C. maculata	43			
		E. crebra	12			
		E. moluccana	14			
		A. implexa	1	70	4	0.35
MTWNPN201101						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
Eucalypt sp. 1	6	*Eucalypt sp. 1*	1			
		Eucalypt sp. 2	5			
				12	4	0.06
MTWNPN201403						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2

		Eucalypt sp. 1	2			
				2	4	0.01
MTWTDI201501						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
Eucalypt sp. 1	1					
				1	4	0.005
MTWWDL201401						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
C. maculata	3	*C. maculata*	5			
A. implexa	1	*A. implexa*	5			
E. moluccana	1	*E. moluccana*				
				15	4	0.075
WAMBOGB1						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
A. leuhmannii	8	*A. leuhmannii*	7			
E. crebra		*E. crebra*	4			
				19	4	0.095
WAMBOGB2						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. moluccana	3	*E. moluccana*	2			
				5	4	0.025
WAMBOSPOT1						
LHS		RHS		Total trees	Width	Trees per m2
Genus	Number	Genus	Number			
E. punctata	1	*E. punctata*				
E. crebra	3	*E. crebra*				
C. maculata	2	*C. maculata*	3			
A. bulgaensis	13	*A. bulgaensis*	11	33	4	0.165
WAMBOSPOT2						
LHS		RHS		Total trees	Width	Trees per m2

Genus	Number	Genus	Number			
E. moluccana	7	*E. moluccana*	5			
C. maculata	3	*C. maculata*	2			
		E. crebra	1			
		A. leuhmannii	1	19	4	0.095
WAMBOSPOT3						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	3	*E. crebra*	3			
C. maculata	2	*C. maculata*	3			
A. implexa	4	*A. implexa*	1			
				16	4	0.08
WARKGB01						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
A. leuhmannii	23	*A. leuhmannii*	26			
E. crebra	4	*E. crebra*	10			
				63	4	0.315
WARKGB02						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	14	*A. leuhmannii*	2			
		E. crebra	5			
				21	4	0.105
WARKGB03						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
A. leuhmannii	27	*A. leuhmannii*	16			
E. crebra	1	*E. crebra*	1			
E. amplifolia	5	*E. amplifolia*	5			
				55	4	0.275
WARKGB04						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	3	*E. crebra*	5			
		A. leuhmannii	2			
				10	4	0.05
HVOLEM2015						

LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. crebra	1					
				1	2	0.01
HVORIV201501						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
		E. fibrosa	1			
				1	4	0.005
HVORIV201503						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
C. maculata	1					
				1	4	0.005
HVOWES201602						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
E. moluccana	2	*E. moluccana*	2			
C. maculata	9	*C. maculata*	5			
				20	4	0.1
HVOWES201603						
LHS		RHS				
Genus	Number	Genus	Number	Total trees	Width	Trees per m2
		E. fibrosa	1			
				1	4	0.005

Appendix 7 – Agricultural soil analysis results

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 1	Sample 2	Sample 3	Sample 4
	Sample ID:			HVOCHE201501	HVORIV201601	MTWSPN201501	HVOWES201601
	Crop:			N/G	N/G	N/G	N/G
	Client:			RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/1*	*F9706/2*	*F9706/3*	*F9706/4*
Morgan 1	Calcium	Ca	mg/kg	1749	1280	2555	2212
	Magnesium	Mg		684	699	364	354
	Potassium	K		169	251	270	183
	Phosphorus	P		14	17	20	10
Bray1	Phosphorus	P	mg/kg	30	27	73	28
Colwell				131	80	186	118
Bray2				238	141	397	177
KCl	Nitrate Nitrogen	N	mg/kg	23	8.5	48	4.1
	Ammonium Nitrogen			5.0	3.5	2.7	2.9
	Sulfur	S		23	370	110	605
1:5 Water	pH		units	8.15	7.75	8.07	7.58
	Conductivity		dS/m	0.164	0.551	0.318	0.755
Calculation	Estimated Organic Matter		% OM	4.3	7.3	7.3	6.9
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	16.84	9.81	14.70	14.42
			kg/ha	7558	4402	6598	6473
			mg/kg	3374	1965	2946	2890
	Magnesium	Mg	$cmol^+/Kg$	9.63	8.46	3.46	3.54
			kg/ha	2621	2302	943	964
			mg/kg	1170	1028	421	430
	Potassium	K	$cmol^+/Kg$	1.15	1.19	1.20	0.87
			kg/ha	1010	1038	1055	765
			mg/kg	451	463	471	341
	Sodium	Na	$cmol^+/Kg$	0.88	0.76	0.34	0.64
			kg/ha	452	391	174	327
			mg/kg	202	175	78	146
KCl	Aluminium	Al	$cmol^+/Kg$	0.01	0.01	0.02	0.02
			kg/ha	3	2	3	3
			mg/kg	1	1	1	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.00	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	28.51	20.22	19.72	19.48
Base Saturation Calculations	Calcium	Ca	%	59.1	48.5	74.5	74.0
	Magnesium	Mg		33.8	41.8	17.6	18.2
	Potassium	K		4.0	5.9	6.1	4.5
	Sodium - ESP	Na		3.1	3.8	1.7	3.3
	Aluminium	Al		0.0	0.1	0.1	0.1
	Hydrogen	H^+		0.0	0.0	0.0	0.0
Calculation	Calcium / Magnesium Ratio		ratio	1.7	1.2	4.2	4.1
DTPA	Zinc	Zn	mg/kg	12	13	33	20
	Manganese	Mn		6.6	5.2	5.3	9.0
	Iron	Fe		32	32	40	71
	Copper	Cu		3.2	2.0	4.2	2.9
$CaCl_2$	Boron	B	mg/kg	0.74	0.74	0.95	0.94
	Silicon	Si		33	27	25	24
LECO IR Analyser	Total Carbon	C	%	2.46	4.17	4.15	3.93
	Total Nitrogen	N	%	0.19	0.26	0.29	0.29
Calculation	Carbon/ Nitrogen Ratio		ratio	13.3	15.8	14.2	13.7
	Basic Texture			Loam	Loam	Loam	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	105	353	203	483

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eal Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 1	Sample 2	Sample 3	Sample 4
			Sample ID:	HVOCHE201501	HVORIV201601	MTWSPN201501	HVOWES201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
				F9706/1	F9706/2	F9706/3	F9706/4
Total Acid Extractable	Calcium	Ca	mg/kg	7,508	5,464	10,000	6,464
	Magnesium	Mg		5,993	3,106	1,938	1,309
	Potassium	K		2,087	1,645	1,550	1,405
	Sodium	Na		555	561	238	323
	Sulfur	S		242	633	506	914
Total Acid Extractable	Phosphorus	P	mg/kg	985	434	938	587
Total Acid Extractable	Zinc	Zn	mg/kg	98	80	152	96
	Manganese	Mn		830	257	222	308
	Iron	Fe		40,739	23,036	20,660	25,849
	Copper	Cu		40	23	49	28
	Boron	B		2.6	<2	2.1	<2
	Silicon	Si		1,161	1,804	1,785	2,015
	Aluminium	Al		18,952	7,206	5,720	6,805
Total Acid Extractable	Molybdenum	Mo	mg/kg	0.7	0.9	1.0	0.9
	Cobalt	Co		22	9.3	6.3	8.8
	Selenium	Se		0.6	0.7	0.6	0.7
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	0.8	<0.5
	Lead	Pb		19	17	39	24
	Arsenic	As		5.5	6.7	7.7	8.2
	Chromium	Cr		40	12	9.4	11
	Nickel	Ni		46	14	12	10
	Mercury	Hg		<0.1	<0.1	0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 cmol$^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg Calcium
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations cmol$^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable cmol$^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 5	Sample 6	Sample 7	Sample 8
	Sample ID:			HVOCHE201602	HVORIV201503	HVOLEM201601	MTWMTO201501
	Crop:			N/G	N/G	N/G	N/G
	Client:			RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/5*	*F9706/6*	*F9706/7*	*F9706/8*
Morgan 1	Calcium	Ca	mg/kg	1824	3829	249	1129
	Magnesium	Mg	mg/kg	613	474	109	392
	Potassium	K	mg/kg	209	236	60	111
	Phosphorus	P	mg/kg	7.3	16	1.4	1.2
Bray1	Phosphorus	P	mg/kg	20	52	4.8	2.8
Colwell	Phosphorus	P	mg/kg	71	213	11	10
Bray2	Phosphorus	P	mg/kg	136	325	12	8
KCl	Nitrate Nitrogen	N	mg/kg	69	7.5	0.8	3.0
	Ammonium Nitrogen	N	mg/kg	2.8	2.6	1.3	0.9
	Sulfur	S	mg/kg	412	1585	80	98
1:5 Water	pH		units	7.77	7.54	6.16	9.07
	Conductivity		dS/m	0.728	1.685	0.066	0.233
Calculation	Estimated Organic Matter		% OM	5.6	7.7	1.1	3.8
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	15.51	21.41	1.95	6.77
			kg/ha	6961	9610	875	3040
			mg/kg	3107	4290	391	1357
	Magnesium	Mg	$cmol^+/Kg$	7.21	3.94	1.18	4.17
			kg/ha	1962	1072	322	1136
			mg/kg	876	479	144	507
	Potassium	K	$cmol^+/Kg$	1.22	1.08	0.24	0.50
			kg/ha	1071	944	208	434
			mg/kg	478	421	93	194
	Sodium	Na	$cmol^+/Kg$	1.05	1.08	0.15	1.23
			kg/ha	543	558	77	635
			mg/kg	242	249	34	283
KCl	Aluminium	Al	$cmol^+/Kg$	0.02	0.02	0.02	0.02
			kg/ha	3	3	4	3
			mg/kg	1	1	2	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.01	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	25.00	27.52	3.55	12.69
Base Saturation Calculations	Calcium	Ca	%	62.0	77.8	55.0	53.4
	Magnesium	Mg	%	28.8	14.3	33.4	32.9
	Potassium	K	%	4.9	3.9	6.7	3.9
	Sodium - ESP	Na	%	4.2	3.9	4.2	9.7
	Aluminium	Al	%	0.1	0.1	0.6	0.1
	Hydrogen	H^+	%	0.0	0.0	0.2	0.0
Calculation	Calcium / Magnesium Ratio		ratio	2.2	5.4	1.6	1.6
DTPA	Zinc	Zn	mg/kg	11	27	1.0	2.3
	Manganese	Mn	mg/kg	8.2	9.2	2.4	0.9
	Iron	Fe	mg/kg	38	48	221	14
	Copper	Cu	mg/kg	1.5	3.5	0.2	1.0
$CaCl_2$	Boron	B	mg/kg	0.79	1.21	0.37	0.19
	Silicon	Si	mg/kg	24	22	30	3
LECO IR Analyser	Total Carbon	C	%	3.19	4.40	0.62	2.15
	Total Nitrogen	N	%	0.25	0.32	0.05	0.09
Calculation	Carbon/ Nitrogen Ratio		ratio	12.6	13.7	12.1	23.4
	Basic Texture			Loam	Loam	Sandy Soil	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	466	1079	42	149

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Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 5	Sample 6	Sample 7	Sample 8
	Sample ID:			HVOCHE201602	HVORIV201503	HVOLEM201601	MTWMTO201501
	Crop:			N/G	N/G	N/G	N/G
	Client:			RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/5*	*F9706/6*	*F9706/7*	*F9706/8*
Total Acid Extractable	Calcium	Ca	mg/kg	5,195	9,557	432	4,600
	Magnesium	Mg		2,125	1,710	253	3,079
	Potassium	K		1,804	1,460	274	1,241
	Sodium	Na		435	565	81	1,481
	Sulfur	S		615	1,926	82	224
Total Acid Extractable	Phosphorus	P	mg/kg	424	903	72	88
Total Acid Extractable	Zinc	Zn	mg/kg	74	133	5.5	60
	Manganese	Mn		476	351	38	244
	Iron	Fe		39,870	27,802	10,758	17,315
	Copper	Cu		21	44	1.7	12
	Boron	B		<2	3.5	<2	<2
	Silicon	Si		2,072	1,977	1,992	1,654
	Aluminium	Al		10,814	9,637	2,980	4,657
Total Acid Extractable	Molybdenum	Mo	mg/kg	0.9	0.9	0.3	0.6
	Cobalt	Co		11	9.3	3.0	7.1
	Selenium	Se		0.7	0.9	<0.5	<0.5
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	0.6	<0.5	<0.5
	Lead	Pb		20	36	5.1	13
	Arsenic	As		6.7	6.0	2.6	5.8
	Chromium	Cr		20	31	5.2	4.8
	Nickel	Ni		18	16	2.1	9.4
	Mercury	Hg		<0.1	<0.1	<0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
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2. 1 $cmol^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+$/Kg results

Quality Checked: Kris Saville
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Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 9	Sample 10	Sample 11	Sample 12
	Sample ID:			HVOWES201602	MTWSPN201601	MTWSPN201602	MTWMTO201601
	Crop:			N/G	N/G	N/G	N/G
	Client:			RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/9*	*F9706/10*	*F9706/11*	*F9706/12*
Morgan 1	Calcium	Ca	mg/kg	1435	1595	906	1441
	Magnesium	Mg		323	400	335	434
	Potassium	K		161	327	210	186
	Phosphorus	P		4.8	15	12	6.5
Bray1	Phosphorus	P	mg/kg	13	40	41	25
Colwell				58	113	94	54
Bray2				88	196	149	104
KCl	Nitrate Nitrogen	N	mg/kg	1.5	123	14	45
	Ammonium Nitrogen			2.6	12	2.3	2.0
	Sulfur	S		262	250	189	329
1:5 Water	pH		units	7.48	7.04	7.06	8.49
	Conductivity		dS/m	0.403	0.683	0.391	0.626
Calculation	Estimated Organic Matter		% OM	7.2	8.1	5.2	5.2
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	12.32	13.50	7.65	8.98
			kg/ha	5532	6061	3432	4030
			mg/kg	2470	2706	1532	1799
	Magnesium	Mg	$cmol^+/Kg$	3.73	4.74	3.97	4.46
			kg/ha	1017	1291	1082	1213
			mg/kg	454	576	483	542
	Potassium	K	$cmol^+/Kg$	0.88	1.69	0.95	0.80
			kg/ha	771	1480	833	703
			mg/kg	344	661	372	314
	Sodium	Na	$cmol^+/Kg$	0.58	0.90	1.01	1.74
			kg/ha	297	463	518	897
			mg/kg	133	207	231	401
KCl	Aluminium	Al	$cmol^+/Kg$	0.01	0.01	0.02	0.01
			kg/ha	3	2	4	3
			mg/kg	1	1	2	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.00	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	17.53	20.84	13.59	15.99
Base Saturation Calculations	Calcium	Ca	%	70.3	64.8	56.2	56.1
	Magnesium	Mg		21.3	22.8	29.2	27.9
	Potassium	K		5.0	8.1	7.0	5.0
	Sodium - ESP	Na		3.3	4.3	7.4	10.9
	Aluminium	Al		0.1	0.1	0.1	0.1
	Hydrogen	H^+		0.0	0.0	0.0	0.0
Calculation	Calcium / Magnesium Ratio		ratio	3.3	2.8	1.9	2.0
DTPA	Zinc	Zn	mg/kg	18	16	12	7.3
	Manganese	Mn		10	23	13	4.6
	Iron	Fe		36	55	97	27
	Copper	Cu		3.2	1.7	1.2	1.1
$CaCl_2$	Boron	B	mg/kg	0.52	0.74	0.83	0.33
	Silicon	Si		23	43	39	12
LECO IR Analyser	Total Carbon	C	%	4.10	4.62	2.95	2.98
	Total Nitrogen	N	%	0.25	0.35	0.20	0.15
Calculation	Carbon/ Nitrogen Ratio		ratio	16.5	13.1	15.1	19.5
	Basic Texture			Loam	Loam	Loam	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	258	437	250	401

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 9	**Sample 10**	**Sample 11**	**Sample 12**
			Sample ID:	HVOWES201602	MTWSPN201601	MTWSPN201602	MTWMTO201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/9*	*F9706/10*	*F9706/11*	*F9706/12*
Total Acid Extractable	Calcium	Ca	mg/kg	4,194	5,144	2,809	4,234
	Magnesium	Mg		1,411	1,806	1,160	1,773
	Potassium	K		1,538	2,261	1,229	1,278
	Sodium	Na		260	431	489	1,069
	Sulfur	S		490	529	375	408
Total Acid Extractable	Phosphorus	P	mg/kg	373	624	356	237
Total Acid Extractable	Zinc	Zn	mg/kg	130	94	50	55
	Manganese	Mn		625	380	142	203
	Iron	Fe		62,088	21,776	15,024	25,814
	Copper	Cu		48	25	13	13
	Boron	B		<2	2.1	<2	<2
	Silicon	Si		2,877	2,063	1,866	1,597
	Aluminium	Al		8,204	9,895	6,625	5,124
Total Acid Extractable	Molybdenum	Mo	mg/kg	4.5	0.9	0.8	0.9
	Cobalt	Co		10	8.4	3.9	5.1
	Selenium	Se		0.7	0.9	<0.5	<0.5
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	<0.5	<0.5
	Lead	Pb		30	23	16	16
	Arsenic	As		13	5.8	4.8	7.2
	Chromium	Cr		13	11	6.5	6.1
	Nickel	Ni		12	12	5.4	6.7
	Mercury	Hg		<0.1	<0.1	<0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 cmol$^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations cmol$^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable cmol$^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 13	**Sample 14**	**Sample 15**	**Sample 16**
			Sample ID:	MTWNOO201501	HVORIV201501	HVOWES201603	HVOCHE201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/13*	*F9706/14*	*F9706/15*	*F9706/16*
Morgan 1	Calcium	Ca	mg/kg	1074	1242	872	1580
	Magnesium	Mg		457	430	492	585
	Potassium	K		192	154	173	186
	Phosphorus	P		6.7	4.5	5.5	5.0
Bray1	Phosphorus	P	mg/kg	13	13	15	14
Colwell				48	55	59	43
Bray2				65	70	58	51
KCl	Nitrate Nitrogen	N	mg/kg	1.3	3.9	0.9	11
	Ammonium Nitrogen			2.1	1.8	1.5	1.5
	Sulfur	S		33	27	293	381
1:5 Water	pH		units	7.62	8.36	7.24	8.07
	Conductivity		dS/m	0.134	0.154	0.440	0.523
Calculation	Estimated Organic Matter		% OM	5.0	3.8	5.8	6.7
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	9.65	9.84	7.81	10.28
			kg/ha	4332	4416	3507	4615
			mg/kg	1934	1972	1566	2060
	Magnesium	Mg	$cmol^+/Kg$	5.75	4.97	5.85	5.92
			kg/ha	1565	1353	1593	1611
			mg/kg	699	604	711	719
	Potassium	K	$cmol^+/Kg$	1.04	0.87	0.86	0.79
			kg/ha	910	766	755	692
			mg/kg	406	342	337	309
	Sodium	Na	$cmol^+/Kg$	0.51	0.90	0.96	0.75
			kg/ha	264	462	494	384
			mg/kg	118	206	220	171
KCl	Aluminium	Al	$cmol^+/Kg$	0.01	0.01	0.01	0.01
			kg/ha	3	2	2	2
			mg/kg	1	1	1	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.00	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	16.96	16.59	15.50	17.75
Base Saturation Calculations	Calcium	Ca	%	56.9	59.3	50.4	57.9
	Magnesium	Mg		33.9	30.0	37.8	33.3
	Potassium	K		6.1	5.3	5.6	4.5
	Sodium - ESP	Na		3.0	5.4	6.2	4.2
	Aluminium	Al		0.1	0.1	0.1	0.1
	Hydrogen	H^+		0.0	0.0	0.0	0.0
Calculation	Calcium / Magnesium Ratio		ratio	1.7	2.0	1.3	1.7
DTPA	Zinc	Zn	mg/kg	9.2	14	9.0	6.9
	Manganese	Mn		6.4	7.5	6.0	4.9
	Iron	Fe		62	32	62	18
	Copper	Cu		1.1	2.6	1.4	1.8
$CaCl_2$	Boron	B	mg/kg	0.58	0.49	0.89	0.45
	Silicon	Si		32	25	35	19
LECO IR Analyser	Total Carbon	C	%	2.84	2.16	3.31	3.82
	Total Nitrogen	N	%	0.18	0.15	0.18	0.17
Calculation	Carbon/ Nitrogen Ratio		ratio	15.6	14.6	18.6	22.5
	Basic Texture			Loam	Loam	Loam	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	86	98	282	335

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

				Sample 13	**Sample 14**	**Sample 15**	**Sample 16**
			Sample ID:	MTWNOO201501	HVORIV201501	HVOWES201603	HVOCHE201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/13*	*F9706/14*	*F9706/15*	*F9706/16*
Total Acid Extractable	Calcium	Ca	mg/kg	4,273	5,515	3,637	6,742
	Magnesium	Mg		2,009	2,546	1,924	3,382
	Potassium	K		1,609	1,577	1,532	1,471
	Sodium	Na		287	422	439	541
	Sulfur	S		266	201	494	584
Total Acid Extractable	Phosphorus	P	mg/kg	350	331	324	360
Total Acid Extractable	Zinc	Zn	mg/kg	59	80	70	67
	Manganese	Mn		259	632	398	520
	Iron	Fe		31,403	35,570	54,331	26,314
	Copper	Cu		13	23	16	22
	Boron	B		<2	<2	2.3	<2
	Silicon	Si		2,059	1,882	2,960	2,166
	Aluminium	Al		9,212	9,874	7,417	5,769
Total Acid Extractable	Molybdenum	Mo	mg/kg	1.0	1.1	1.2	0.7
	Cobalt	Co		6.9	11	8.0	12
	Selenium	Se		0.8	0.8	1.1	<0.5
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	<0.5	<0.5
	Lead	Pb		17	21	17	15
	Arsenic	As		7.4	6.0	12	5.7
	Chromium	Cr		9.0	21	10	16
	Nickel	Ni		8.5	16	11	18
	Mercury	Hg		<0.1	<0.1	<0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 17	Sample 18	Sample 19	Sample 20
			Sample ID:	HVOWES201604	MTWSPS201602	HVORIV201502	MTWSPS201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
Method	*Nutrient*		*Units*	*F9706/17*	*F9706/18*	*F9706/19*	*F9706/20*
Morgan 1	Calcium	Ca	mg/kg	1542	1519	1225	1984
	Magnesium	Mg		414	487	629	514
	Potassium	K		139	178	203	207
	Phosphorus	P		3.5	3.9	4.0	6.1
Bray1	Phosphorus	P	mg/kg	6.1	15	10	26
Colwell				33	81	50	104
Bray2				25	76	69	149
KCl	Nitrate Nitrogen	N	mg/kg	5.0	19	13	16
	Ammonium Nitrogen			1.7	1.8	1.9	2.6
	Sulfur	S		398	457	20	320
1:5 Water	pH		units	7.76	7.89	8.21	8.23
	Conductivity		dS/m	0.443	0.666	0.141	0.532
Calculation	Estimated Organic Matter		% OM	3.6	5.0	5.0	7.7
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	12.05	12.61	9.82	13.45
			kg/ha	5408	5659	4407	6035
			mg/kg	2414	2526	1968	2694
	Magnesium	Mg	$cmol^+/Kg$	4.51	5.63	7.14	5.07
			kg/ha	1228	1532	1944	1381
			mg/kg	548	684	868	617
	Potassium	K	$cmol^+/Kg$	0.79	0.88	1.14	0.88
			kg/ha	691	771	998	774
			mg/kg	308	344	446	346
	Sodium	Na	$cmol^+/Kg$	0.33	0.94	0.74	1.00
			kg/ha	169	484	382	513
			mg/kg	75	216	171	229
KCl	Aluminium	Al	$cmol^+/Kg$	0.01	0.02	0.01	0.02
			kg/ha	2	3	2	3
			mg/kg	1	1	1	1
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.00	0.00	0.00
			kg/ha	0	0	0	0
			mg/kg	0	0	0	0
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	17.68	20.07	18.85	20.42
Base Saturation Calculations	Calcium	Ca	%	68.1	62.8	52.1	65.9
	Magnesium	Mg		25.5	28.0	37.9	24.9
	Potassium	K		4.5	4.4	6.0	4.3
	Sodium - ESP	Na		1.9	4.7	3.9	4.9
	Aluminium	Al		0.0	0.1	0.1	0.1
	Hydrogen	H^+		0.0	0.0	0.0	0.0
Calculation	Calcium / Magnesium Ratio		ratio	2.7	2.2	1.4	2.6
DTPA	Zinc	Zn	mg/kg	4.7	13	8.9	23
	Manganese	Mn		7.4	4.6	5.0	4.2
	Iron	Fe		38	46	25	39
	Copper	Cu		1.3	2.1	1.6	3.9
$CaCl_2$	Boron	B	mg/kg	0.64	0.56	0.41	0.67
	Silicon	Si		27	18	8	12
LECO IR Analyser	Total Carbon	C	%	2.08	2.83	2.84	4.39
	Total Nitrogen	N	%	0.15	0.17	0.18	0.24
Calculation	Carbon/ Nitrogen Ratio		ratio	14.3	16.6	15.4	18.4
	Basic Texture			Loam	Loam	Loam	Loam
	Basic Colour			Brownish	Brownish	Brownish	Brownish
Calculation	Chloride Estimate		equiv. ppm	284	426	90	340

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Southern Cross University
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T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 17	Sample 18	Sample 19	Sample 20
			Sample ID:	HVOWES201604	MTWSPS201602	HVORIV201502	MTWSPS201601
			Crop:	N/G	N/G	N/G	N/G
			Client:	RTCA	RTCA	RTCA	RTCA
				F9706/17	F9706/18	F9706/19	F9706/20
Total Acid Extractable	Calcium	Ca	mg/kg	4,212	4,410	5,773	7,892
	Magnesium	Mg		1,594	1,808	3,256	3,088
	Potassium	K		1,478	1,370	1,790	1,611
	Sodium	Na		193	458	1,665	557
	Sulfur	S		494	594	210	684
Total Acid Extractable	Phosphorus	P	mg/kg	247	291	380	492
Total Acid Extractable	Zinc	Zn	mg/kg	56	75	79	131
	Manganese	Mn		474	188	567	262
	Iron	Fe		31,840	22,614	40,004	19,427
	Copper	Cu		15	22	22	42
	Boron	B		3.2	2.2	2.5	3.0
	Silicon	Si		1,962	2,025	1,822	1,558
	Aluminium	Al		8,002	7,590	11,780	6,710
Total Acid Extractable	Molybdenum	Mo	mg/kg	0.7	0.9	0.9	0.8
	Cobalt	Co		10	6.3	16	8.4
	Selenium	Se		<0.5	<0.5	<0.5	<0.5
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	<0.5	<0.5
	Lead	Pb		14	23	18	32
	Arsenic	As		8.1	4.8	8.0	5.1
	Chromium	Cr		8.6	8.0	20	9.3
	Nickel	Ni		9.0	8.7	23	13
	Mercury	Hg		<0.1	<0.1	<0.1	<0.1
	Silver	Ag		<1	<1	<1	<1

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 $cmol^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations $cmol^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable $cmol^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

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Southern Cross University

Southern Cross University
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T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 21	Sample 22	Heavy Soil	Medium Soil	Light Soil	Sandy Soil
	Sample ID:			HVOLEM201501	MTWNPN20140 2				
	Crop:			N/G	N/G				
	Client:			RTCA	RTCA	*e.g Clay*	*e.g Clay Loam*	*e.g Loam*	*e.g Loamy Sand*
Method	*Nutrient*		*Units*	*F9706/21*	*F9706/22*	***Indicative guidelines only- refer Note 6***			
Morgan 1	Calcium	Ca	mg/kg	602	449	*1150*	*750*	*375*	*175*
	Magnesium	Mg		143	57	*160*	*105*	*60*	*25*
	Potassium	K		137	49	*113*	*75*	*60*	*50*
	Phosphorus	P		6.1	5.1	*15*	*12*	*10*	*5.0*
Bray1	Phosphorus	P	mg/kg	24	19	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
Colwell				51	31	*80*	*50*	*45*	*35*
Bray2				41	41	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
KCl	Nitrate Nitrogen	N	mg/kg	2.4	1.0	*15*	*13*	*10*	*10*
	Ammonium Nitrogen			1.8	2.0	*20*	*18*	*15*	*12*
	Sulfur	S		17	3.7	*10.0*	*8.0*	*8.0*	*7.0*
1:5 Water	pH		units	6.98	6.32	*6.5*	*6.5*	*6.3*	*6.3*
	Conductivity		dS/m	0.059	0.032	*0.200*	*0.150*	*0.120*	*0.100*
Calculation	Estimated Organic Matter		% OM	3.6	4.5	*>5.5*	*>4.5*	*>3.5*	*>2.5*
Ammonium Acetate + Calculations	Calcium	Ca	$cmol^+/Kg$	5.00	3.92	*15.6*	*10.8*	*5.0*	*1.9*
			kg/ha	2247	1758	*6250*	*4300*	*2000*	*750*
			mg/kg	1003	785	*3125*	*2150*	*1000*	*375*
	Magnesium	Mg	$cmol^+/Kg$	1.47	0.58	*2.4*	*1.7*	*1.2*	*0.60*
			kg/ha	400	157	*580*	*400*	*290*	*150*
			mg/kg	179	70	*290*	*200*	*145*	*75*
	Potassium	K	$cmol^+/Kg$	0.57	0.16	*0.60*	*0.50*	*0.40*	*0.30*
			kg/ha	500	143	*470*	*380*	*300*	*200*
			mg/kg	223	64	*235*	*190*	*150*	*100*
	Sodium	Na	$cmol^+/Kg$	0.12	0.04	*0.3*	*0.26*	*0.22*	*0.11*
			kg/ha	63	21	*138*	*120*	*101*	*51*
			mg/kg	28	9	*69*	*60*	*51*	*25*
KCl	Aluminium	Al	$cmol^+/Kg$	0.02	0.04	*0.6*	*0.5*	*0.4*	*0.2*
			kg/ha	3	8	*108*	*90*	*64.8*	*27*
			mg/kg	2	4	*54*	*45*	*32*	*14*
Acidity Titration	Hydrogen	H^+	$cmol^+/Kg$	0.00	0.02	*0.6*	*0.5*	*0.4*	*0.2*
			kg/ha	0	0	*12*	*10*	*22.5*	*3*
			mg/kg	0	0	*6*	*5*	*4*	*2*
Calculation	Effective Cation Exchange Capacity (ECEC)		$cmol^+/Kg$	7.19	4.76	*20.1*	*14.3*	*7.8*	*3.3*
Base Saturation Calculations	Calcium	Ca	%	69.7	82.3	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium	Mg		20.5	12.1	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium	K		8.0	3.4	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP	Na		1.7	0.9	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium	Al		0.2	0.9	*6.0*	*7.0*	*10.4*	*12*
	Hydrogen	H^+		0.0	0.4				
Calculation	Calcium / Magnesium Ratio		ratio	3.4	6.8	*6.5*	*6.4*	*4.2*	*3.2*
DTPA	Zinc	Zn	mg/kg	5.3	6.2	*6.0*	*5.0*	*4.0*	*3.0*
	Manganese	Mn		26	7.1	*25*	*22*	*18*	*15*
	Iron	Fe		423	91	*25*	*22*	*18*	*15*
	Copper	Cu		0.4	0.7	*2.4*	*2.0*	*1.6*	*1.2*
$CaCl_2$	Boron	B	mg/kg	0.55	0.31	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon	Si		29	24	*50*	*45*	*40*	*35*
LECO IR Analyser	Total Carbon	C	%	2.07	2.55	*>3.1*	*>2.6*	*>2.0*	*>1.4*
	Total Nitrogen	N	%	0.11	0.11	*>0.30*	*>0.25*	*>0.20*	*>0.15*
Calculation	Carbon/ Nitrogen Ratio		ratio	18.3	23.8	*10-12*	*10-12*	*10-12*	*10-12*
	Basic Texture			Sandy Soil	Sandy Soil	..	..	..	..
	Basic Colour			Brownish	Brownish	..	..	..	..
Calculation	Chloride Estimate		equiv. ppm	38	21	..	..	..	..

Environmental Analysis Laboratory
Southern Cross University

Southern Cross University
PO Box 157 Lismore NSW 2480

T: (02) 6620 3678
F: (02) 6620 3957
E: eal@scu.edu.au
W: scu.edu.au/eal
ABN: 41 995 651 524

Job No:	F9706
No of Samples:	22
Date Supplied:	24th May 2017
Supplied by:	Niche-eh

Method	Nutrient		Units	Sample 21	Sample 22	Heavy Soil	Medium Soil	Light Soil	Sandy Soil
			Sample ID:	HVOLEM201501	MTWNPN201402				
			Crop:	N/G	N/G				
			Client:	RTCA	RTCA	*e.g Clay*	*e.g Clay Loam*	*e.g Loam*	*e.g Loamy Sand*
Method	Nutrient		Units	F9706/21	F9706/22	***Indicative guidelines only- refer Note 6***			
Total Acid Extractable	Calcium	Ca	mg/kg	1,622	1,232	*1,000 - 10,000 Ca*			
	Magnesium	Mg		329	193	*500 - 5,000 Mg*			
	Potassium	K		417	297	*200 - 2,000 K*			
	Sodium	Na		63	<50	*100 - 500 Na*			
	Sulfur	S		121	91	*100 - 1,000 S*			
Total Acid Extractable	Phosphorus	P	mg/kg	163	128	*400 - 1,500 P*			
Total Acid Extractable	Zinc	Zn	mg/kg	17	19	*20 - 50 Zn*			
	Manganese	Mn		108	63	*200 - 2,000 Mn*			
	Iron	Fe		5,762	2,238	*1,000 - 50,000 Fe*			
	Copper	Cu		3.6	5.4	*20 - 50 Cu*			
	Boron	B		2.3	<2	*2 - 50 B*			
	Silicon	Si		1,976	1,346	*1,000 - 3,000 Si*			
	Aluminium	Al		2,869	1,440	*2,000 - 50,000 Al*			
Total Acid Extractable	Molybdenum	Mo	mg/kg	0.3	<0.2	*0.5 - 3 Mo*			
	Cobalt	Co		2	2.2	*5 - 50 Co*			
	Selenium	Se		<0.5	<0.5	*0.1 - 2.0 Se*			
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	*< 5 Cd*			
	Lead	Pb		6.5	5.5	*< 75 Pb*			
	Arsenic	As		<2	<2	*< 25 As*			
	Chromium	Cr		5.7	2.6	*<25 Cr*			
	Nickel	Ni		2.1	2.2	*<150 Ni*			
	Mercury	Hg		<0.1	<0.1	*< 3.75 Hg*			
	Silver	Ag		<1	<1	*.. Ag*			

EAL Soil Testing Notes

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to <2 mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts
7. Total Acid Extractable Nutrients indicate a store of nutrients
8. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centre preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

Calculations

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 cmol$^+$/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol+/Kg = 230 mg/Kg Sodium, 390 mg/Kg Potassium, 122 mg/Kg Magnesium, 200 mg/Kg
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations cmol$^+$/Kg
7. Base saturation calculations = (cation cmol+/Kg) /ECEC x 100
8. Ca / Mg ratio from the exchangeable cmol$^+$/Kg results

Quality Checked: Kris Saville
Manager, Agricultural testing division

Appendix 8 – Microbial soil analysis results

Niche Environment and Heritage

A specialist environmental and heritage consultancy.

Head Office

Niche Environment and Heritage
PO Box W36 Parramatta NSW 2150
Email: info@niche-eh.com

All mail correspondence should be through our Head Office

Appendix 4: 2017 Independent Audit Review – response to recommendations

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Response to Non-Compliances and Recommendations MTW IEA 2017

Table 1 Response to the recommendations contained in the audit report.

Reference	Non Compliance	Response	Timing
SSD6464 Sch. 3, C24(a) WMP 7.4.3.1	On the 6th January 2016, a sediment dam overtopped resulting in an uncontrolled discharge.	An internal investigation was undertaken in response to this incident. The investigation and subsequent action plan has been completed to rectify the issues at this dam and to prevent reoccurrence not only at this dam but other dams being constructed or modified. No further action is required in response to this finding.	Complete
MT EIS 2.4.4 (iii)	No ongoing characterisation of overburden materials was conducted.	Mt Thorley mining area has reached the extent of its progression and hence there will be no further requirement for ongoing characterisation of overburden materials.	Complete
AHMP 9	There was no written or electronic record of which personnel had completed site specific environmental training for Cultural Heritage.	The AHMP and the C&A induction require closer alignment to ensure training materials cover all specific Cultural Heritage awareness requirements.	31/12/2017
BMP 5.2.3	On the 8-06-16 a blast was not monitored by the Bulga Village blast monitor due to a software malfunction.	An internal investigation identified the cause of the data loss to be isolated to a GPS fault on a single blast monitoring unit. This fault has since been corrected and no further action is required in response to this finding.	Complete
NMP 6.2	There was no substantive evidence of car-pooling encouragement programs at the time of the audit.	Car-pooling occurs however MTW do not run programs to specifically encourage car-pooling nor is it deemed to be necessary to do so. The Noise Management Plan will be revised to reflect this.	Next management plan review.
20BL170012 C.9 20BL170011 C.9 20BL171930 C.8 20BL171932 C.8	Water flow devices used to measure the volume of water extracted were not approved by NOW (DPI – Water). Three bore licences were found to be non-compliant with this condition, however two were decommissioned and are not in use and one related to the bore licence associated with groundwater inflow to the Warkworth Pit.	Following commencement of the North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan on 1/7/2016, Licences 20BL170011 and 20BL170012 have been converted to Water Access Licences (WALs 40464 and 40465 respectively). Revised licence conditions are yet to be issued by DPI Water for review; when draft conditions are issued changes will be sought to reflect that groundwater inflows to a pit excavation cannot be measured using a flow meter. Licences 20BL171930 and 20BL171932 are related to a historical methane extraction project; the bores are not in use. An investigation will be undertaken to determine if the bores	TBA; timing for issue of draft conditions by DPI Water not known at this time. 30/11/2017

Reference	Non Compliance	Response	Timing
		should be formally abandoned and the licences relinquished, or if used for monitoring, an application sought to modify the licence purpose and conditions to reflect no water is to be abstracted.	
20BL170011 C.8 and C.10 20BL170012 C.8 and C.10	Water flow devices used to measure the volume of water extracted were not calibrated. This related to the aforementioned bore licences that did not have flow devices attached and as such are not able to be calibrated.	Following commencement of the North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan on 1/7/2016, Licences 20BL170011 and 20BL170012 have been converted to Water Access Licences (WALs 40464 and 40465 respectively). Revised licence conditions are yet to be issued by DPI Water for review; when draft conditions are issued changes will be sought to reflect that groundwater inflows to a pit excavation cannot be measured using a flow meter and thus a flowmeter cannot be calibrated.	TBA; timing for issue of draft conditions by DPI Water not known at this time.
Recommendations			
1.	Complete the Salvage report for salvage work conducted in 2016.	A final report will be compiled to bring together the results and completed compliance actions relating to the MTW 2016 ACH salvage	31/12/2017
2.	Review findings in this audit report that were found “Not Able to be Verified” to determine whether further documentation may be able to be generated to make these items compliant.	C&A will undertake a review to verify the audit components that were listed as “Not Able to be Verified”, and action as appropriate to ensure future compliance with these conditions.	31/10/2017

Appendix 5: Annual Ground Water Impacts Review

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MT THORLEY WARKWORTH

2017 Annual Groundwater Review

Prepared for:

Yancoal

SLR Ref: 620.12289-R01
Version No: v1.0
March 2018

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 2, 15 Astor Terrace
Spring Hill QLD 4000 Australia
(PO Box 26 Spring Hill QLD 4004)
T: +61 7 3858 4800   F: +61 7 3858 4801
E: brisbane@slrconsulting.com   www.slrconsulting.com

BASIS OF REPORT

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.12289-R01-v2.0	23 March 2018	Claire Stephenson	Brian Rask	Brian Rask
620.12289-R01-v1.0	22 March 2018	Claire Stephenson	Brian Rask	Brian Rask

CONTENTS

CONTENTS

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

1 Introduction

1.1 Overview

The Mt Thorley and Warkworth (MTW) mining complex is located approximately 15 km south-west of Singleton, NSW. As part of compliance with mine approval conditions, routine groundwater monitoring is conducted across MTW, and the data reviewed and analysed on an annual basis. The annual groundwater review is required for:

- Warkworth Mine in accordance with Condition 25 of the Warkworth Consent (SSD6464) Statement of Commitments; and
- Mt Thorley Mine in accordance with Condition 27 of Development Consent (SSD 6465)

Yancoal commissioned SLR Consulting? Pty Ltd (SLR) to review the groundwater monitoring data for the 2017 calendar year. This report presents groundwater monitoring data collected at the MTW complex and discusses the impact of mining on the groundwater regime.

1.2 Scope

The scope of work for this review included analysis of monitoring data and reporting. This report presents:

- Site background:
  - Legislative requirements and conditions relevant to groundwater;
  - Mine activities over reporting period;
  - Hydrogeological regime; and
  - Groundwater monitoring network and program.
- Data review:
  - Review and illustration (i.e. hydrographs) of groundwater level trends;
  - Review and illustration (i.e. hydrographs) of groundwater quality trends; and
  - Comparison of water level and quality trends to relevant trigger levels and natural trends (i.e. surface water levels and rainfall).
- Discussion of groundwater impacts and compliance over the reporting period and provision of recommendations (where required).

SLR also compared modelled groundwater levels against observed groundwater levels for a high level assessment of the validity of the existing numerical groundwater model.

2 MTW Complex

The following section provides a summary of known activities conducted across the complex that relate to the annual groundwater review. The general site layout is presented in **Figure 2-1**.

2.1 Mine Operations

Table 2-1 presents a summary of mine areas across MTW and activities conducted over 2017.

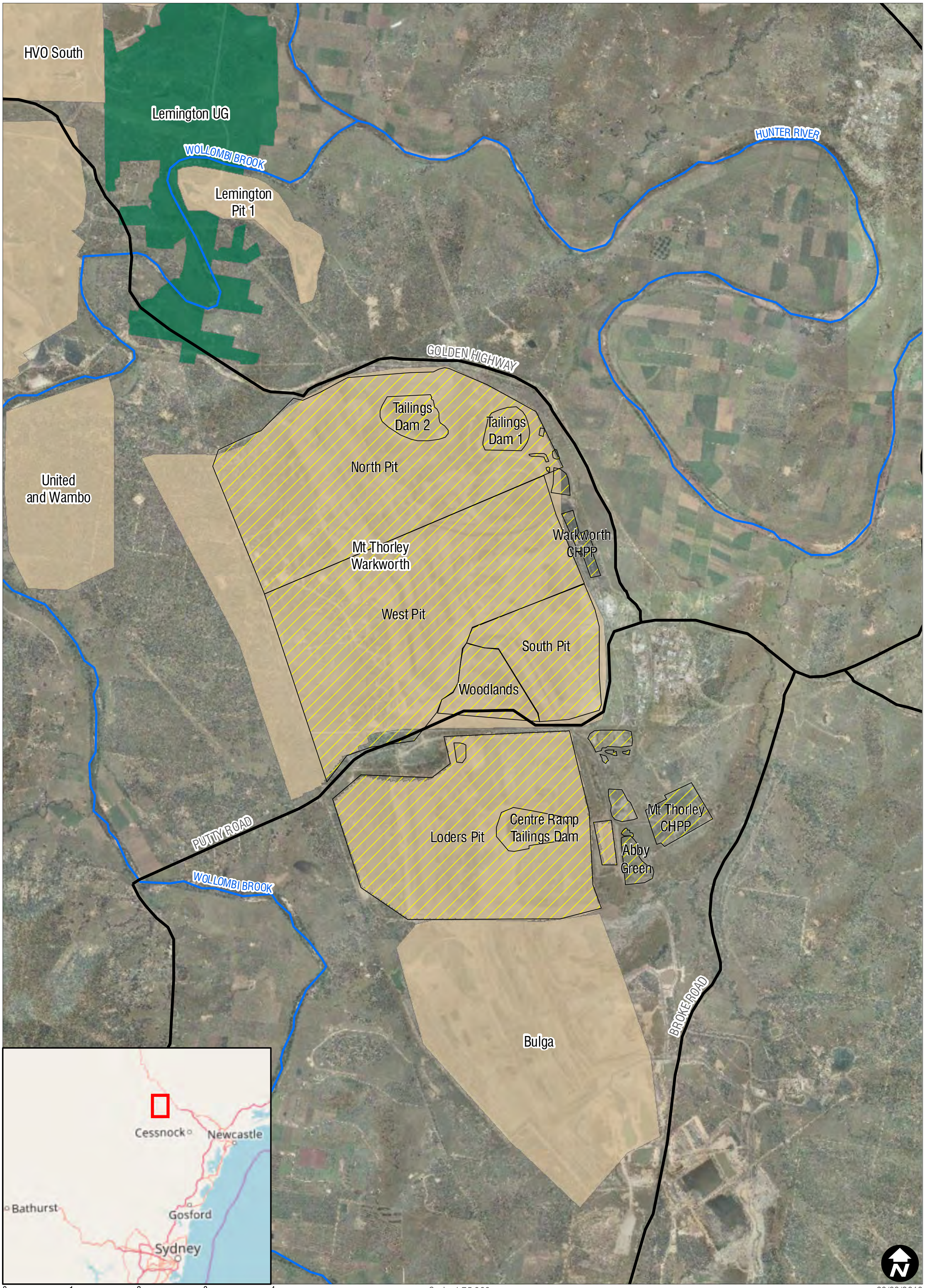
Table 2-1 Summary of MTW Activities

Mine Area	Site	2017 Activities
North Pit	Warkworth	Mining progressed to the west, mining down to the Mt Arthur Seam.
West Pit	Warkworth	Mining progressed to the west, mining down to the Mt Arthur Seam.
South Pit	Warkworth	Mining within current pit extent, mining down to the Mt Arthur Seam.
Loders Pit	Mt Thorley	Mining within current pit extent, down to the Woodlands Hill Seam.
Abby Green Pit	Mt Thorley	No mining active, rehabilitation works in place.

A range of tailings storage facilities (TSF) are present across MTW, as summarised in **Table 2-2**.

Table 2-2 Summary of approved tailings storage facilitates at MTW

Area	Location	Status
Tailings Dam 1 (Dam 32N)	North Pit – Warkworth. Tailings dam located overlying spoil, within backfilled pit.	Inactive, tailings dam rehabilitated.
Tailings Dam 2 (Dam 33N)	North Pit – Warkworth. Tailings dam located overlying spoil, within backfilled pit.	Inactive, excess standing water actively decanted. Rehabilitation works commenced
Centre Ramp Tailings Dam (Dam 17S)	Loders Pit – Mt Thorley Tailings dam located overlying spoil, within backfilled pit.	Active
Mini Tailings Dam	Loders Pit – Mt Thorley Tailings dam located overlying spoil, within backfilled pit.	Inactive, Excess standing water actively decanted. Rehabilitation works planned
Loders Pit North	Loders Pit- Mount Thorley Tailings dam located in-pit.	Approved TSF not yet developed.



0 1 2 3 4 Kilometres

Scale: 1:75,000
GDA 1994 MGA Zone 56

20/03/2018

H:\Projects-SLR\620-BNE\620-BNE\620.12289 Warkworth GW\06 SLR Data\01 CADGIS\ArcGIS\SLR 62012289_F02_1_Locality_001.mxd

Main road
Major watercourses
MTW Infrastructure
Mine Areas
Open Cut
Underground

Sheet Size : A4

SLR
www.slrconsulting.com.au

Mt Thorley Warkworth
2017 Annual Groundwater Review
Locality Map

Figure 2-1

2.2 Groundwater Impacts

Groundwater impacts associated with the approved operations are presented within the:

- Warkworth Mine Modification Groundwater Impact Assessment (AGE 0213);
- Warkworth Continuation 2014 Groundwater Assessment (AGE 2014a);
- Mount Thorley Operations 2014 Groundwater Assessment (AGE 2014b);
- Mount Thorley and Warkworth Mines, Long Term Approvals Model Update (AGE 2015).

The most recent groundwater assessment that captures operations across MTW was the Long Term Approvals Model Update (AGE 2015). The groundwater assessment involved updating the numerical groundwater model developed in 2014 as part of the continuation projects. Updates included recalibration of the model to site observations and updating the mine plans. AGE (2015) reported on predicted impacts associated with approved operations. The approved operations included mining at North Pit, West Pit and Loders Pit until 2035, as well as surrounding non-MTW mining operations (i.e. Wambo). Groundwater conditions and groundwater response to approved mining, as reported by AGE (2015), indicated:

- Groundwater within the hardrock units (i.e. Whittingham Coal Measures) is directly intercepted by approved operations at MTW, with a peak take of 275 ML/year predicted for Warkworth and 298 ML/year predicted for Mt Thorley;
- Groundwater within the confined to semi-confined Permian coal measures became depressurised around the area of active mining;
- There is no direct interception of groundwater within the ‘highly productive’ alluvium for active mine operations at MTW;
- With depressurisation of the coal measures, the model predicted a reduction in upward seepage to the ‘highly productive’ alluvium along the Hunter River and Wollombi Brook, referred to as ‘indirect take’. Peak indirect take:
  - From the Wollombi Brook alluvium (Hunter Unregulated) was predicted to be 16.7 ML/year for Warkworth and 11.3 ML/year for Mt Thorley;
  - From the Hunter River alluvium (Hunter Regulated) was predicted to be 3.5 ML/year for Warkworth and 0.6 ML/year for Mt Thorley;

Groundwater licenses have been obtained for the approved operations, as discussed in **Section 2.3**. Management and monitoring requirements of potential groundwater related impacts from approved operations are captured within the development consent conditions. These conditions are addressed within the site Water Management Plan (WMP). Further discussion on the monitoring and management requirements is included within **Section 2.4**.

2.3 Groundwater Licensing

Under the *Water Act 1912* and *Water Management Act 2000*, adequate water licences are required for approval of the mine developments. Groundwater licenses held for MTW are outlined in **Table 2-3**. Water licence details have been obtained from the WMP.

Table 2-3 MTW Groundwater Licenses

License Number	Description	WSP	Water Source - Management Zone	Approved Extraction (ML)
40464 20AL218784	Mt Thorley Excavations	North Coast Fractured and Porous Rock	Permian Coal Seams	180
40465 20AL218785	Warkworth Excavations			750
18558 20AL208627	-	Hunter Unregulated and Alluvial Water Sources	Lower Wollombi Brook Water Source	50
19022 20AL209903	Sandy Hollow Creek		Singleton Water Source	60
10543 20AL201239	To Oakhampton Rail Bridge	Hunter Regulated River Water Source	Zone 2b Hunter River from Wollombi Brook Junction to downstream extent of the Hunter Regulated River	1,012
963 20AL201242	Warkworth Farm – Hunter River Pump			243
971 20AL201258				270
1008 20AL201341				243
995 20AL201302	Anndale Farm – Hunter River Pump			243
1009 20AL201343				435
969 20AL201254	-		Zone 1b Hunter River from Goulburn River Junction to Glennies Creek Junction	39

2.4 Groundwater Conditions

In accordance with the development consent approval conditions and statement of commitments (SOC) to the 2014 continuation project approval, Yancoal are required to prepare and implement a WMP to the satisfaction of the Director-General. **Table 2-4** presents a summary of the relevant groundwater conditions and SOC's from the WMP. The table identifies where the conditions relating to routine groundwater monitoring for 2017 have been addressed.

Table 2-4 Groundwater Conditions within WMP

Condition	Details	Where Addressed
Sch. 3, Cond. 24 for Mt Thorley (SSD-6465) Sch. 3, Cond. 26 for Warkworth (SSD-6464)	Design, install and maintain emplacements to prevent offsite migration of saline groundwater seepage	See **Section 5** for discussion of groundwater quality. WMP and surface water review

Condition	Details	Where Addressed
Sch. 3, Cond. 25(b) for Mt Thorley (SSD-6465) Sch. 3, Cond. 27(b) for Warkworth (SSD-6464)	Groundwater Management Plan, which includes detailed baseline data on groundwater levels, yield and quality in the region, and privately-owned groundwater bores, that could be affected by the development	See WMP. As per WMP, no privately-owned groundwater bores on non-mine owned land were identified as having groundwater levels decline by over 2 m due to the approved operations.
Sch. 3, Cond. 25(b) for Mt Thorley (SSD-6465) Sch. 3, Cond. 27(b) for Warkworth (SSD-6464)	Groundwater Management Plan, which includes groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts	See **Section 4.3** for triggers and **Section 5.3** for discussion on site water quality results against trigger levels.
Sch. 3, Cond. 25(b) for Mt Thorley (SSD-6465) Sch. 3, Cond. 27(b) for Warkworth (SSD-6464)	Groundwater Management Plan which includes a program to monitor and report on:	
	Groundwater inflows to the open cut pits;	See WMP
	The seepage/leachate from water storages, emplacements, backfilled voids and final voids;	See WMP and surface water review and see **Section 5** for discussion of groundwater quality.
	The impacts of the development on: • regional and local (including alluvial) aquifers; • groundwater supply of potentially affected landowners; • groundwater dependent ecosystems and riparian vegetation; • base flows to Loders Creek (Mt Thorley) and Wollombi Brook (Warkworth);	See **Section 5** for discussion on groundwater monitoring results for 2017. As per WMP, no privately-owned bores identified as potentially impacted. See ecology review for discussion on ecosystems and vegetation.
Sch. 3, Cond. 25(b) for Mt Thorley (SSD-6465) Sch. 3, Cond. 27(b) for Warkworth (SSD-6464)	Groundwater Management Plan which includes a plan to respond to any exceedances of the groundwater assessment criteria;	Trigger exceedances are discussed in **Section 5.**
Sch. 3, Cond. 25(b) for Mt Thorley (SSD-6465) Sch. 3, Cond. 27(b) for Warkworth (SSD-6464)	Groundwater Management Plan which includes a program to validate the groundwater model for the development, including an independent review of the model with every independent environmental audit, and compare the monitoring results with modelled predictions.	Numerical model last updated in 2015 as discussed in **Section 2.2**. **Section 5.5** presents comparison between observed and modelled groundwater levels.
SOC Warkworth Continuation 2014 EIS Table 22.1 Groundwater	Updates to current groundwater monitoring programme: • installation of nested monitoring bores along the Wollombi Brook (PZ10, PZ11, PZ12); and • installation of monitors bores with the Warkworth Sands system as part of an update to the existing Warkworth Sands Ephemeral Perched Aquifer Management Plan within the MTW WMP.	Bores installed in 2016, see **Section 4** for details on the monitoring program.

Condition	Details	Where Addressed
	Mine seepage monitoring programme: • recording of the time, location and estimated volume of any unexpected increased groundwater outflow from the highwall and endwall; • measurement of water pumped from the mine, preferably using flow meters or other suitable gauging apparatus; • correlation of rainfall records with mine seepage records so groundwater and surface water can be separated;	See mine water balance and surface water review.
	Data management and reporting: • establishment of trigger levels; • quarterly review of groundwater levels and field water quality against trigger levels, with site-specific investigations initiated; • formal review of depressurisation of coal measures and alluvium would be undertaken annually by a suitably qualified hydrogeologist; • annual reporting (including all water level and water quality data); and • all groundwater data being stored in a database customised for MTW with suitable QA/QC controls.	Quarterly reviews conducted as part of routine groundwater monitoring by external contractors AECOM. Review of groundwater level and quality changes presented in **Section 5**. Data stored within database held by Yancoal.
	Future model iterations: • assess the validity of the model predictions every three years; and • incorporate into the model and revise predictions, if required.	**Section 5.5**
	Licensing: • retain and obtain appropriate water licences, as required, to account for modelled take.	**Section 2.3** and **Section 5.4**
SOC Mount Thorley Operations 2014 EIS Table 21.1 Groundwater	A site specific investigation into trigger level exceedance would be undertaken if: • professional judgement determines that the single deviation or a developing trend could result in environmental harm; or • three consecutive measurements exceed trigger values.	See **Section 5.3** for discussion on site water quality results against trigger levels.
	Data management and reporting: • establishment of trigger levels; • quarterly review of groundwater levels and field water quality against trigger levels, with site specific investigations initiated; and • all groundwater data being stored in a database customised for MTW with suitable QA/QC controls.	Trigger levels presented in **Section 4.3**. Quarterly reviews conducted as part of routine groundwater monitoring by external contractors AECOM. Data stored within database held by Yancoal.
	Licensing: • retain and obtain appropriate water licences, as required, to account for modelled take.	**Section 2.3**

Groundwater monitoring is conducted in accordance with the Groundwater Monitoring Program outlined within Appendix C of the WMP. The program outlines groundwater monitoring frequency, parameters to be tested and groundwater triggers for electrical conductivity (EC) and pH. Further discussion on the groundwater monitoring program and triggers is included in **Section 4**.

3 Hydrogeological Setting

This section presents a brief summary of the hydrogeological setting for MTW. This includes discussion on climate, terrain, drainage, geology and groundwater bearing units.

3.1 Climate, Terrain and Drainage

3.1.1 Climate

The climate of the MTW region can be classed as temperate and is characterised by hot summers and mild dry winters. Rainfall data is available from Bureau of Meteorology (BoM) Station 61086 (Jerrys Plains) from 1900 to 2014, Station 61191 (Bulga South) from 1959 to present and Station 61397 from 1900 to present. **Table 3-1** provides the average monthly rainfall data, as well as the 2017 monthly data.

Table 3-1 Long Term Average and 2017 Climate Data

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Historical	78	73	59	47	39	47	41	36	41	51	62	69	**643**
2017 Rainfall	51	14	151	37	21	35	2	12	12	79	24	54	**490**

A cumulative rainfall departure (CRD) plot is provided as **Figure 3-1** to illustrate long term climate trends in the MTW area, based on the average rainfall across the three BoM stations. The CRD graphically shows trends in recorded rainfall compared to long-term averages (1900 to present) and provides a historical record of relatively wet and dry periods. A rising trend in slope in the CRD graph indicates periods of above average rainfall, whilst a declining slope indicates periods when rainfall is below average. A level slope indicates average rainfall conditions.

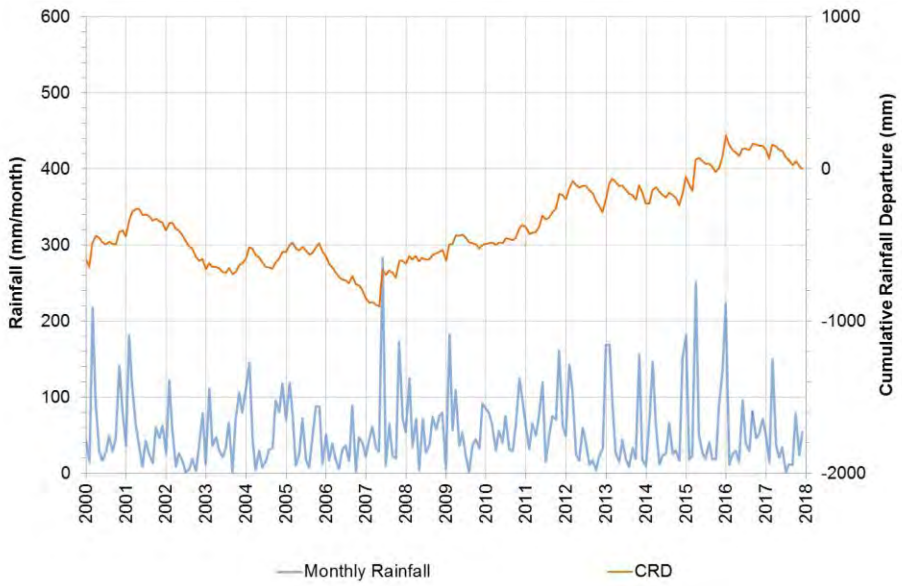


Figure 3-1 Cumulative Rainfall Departure and Monthly Rainfall

As shown in **Figure 3-1**, the region has generally experienced below average rainfall from 2016. However, an above average rainfall event occurred in March 2017, with 151 mm of rainfall over the month.

3.1.2 Terrain and Drainage

Ground elevations at MTW range between 35 m Australian Height Datum (mAHD) along the Hunter River alluvial plains to 100 mAHD west of MTW. Minor ephemeral drainage features are also present around MTW (i.e. Loders Creek, Sandy Hollow Creek, Doctors Creek), draining into the Hunter River.

Real time stream flow data is monitored along the Hunter River and Wollombi Brook at DPI Water gauging stations via the Hunter Integrated Telemetry System (HITS). Time series river water elevations (mean level above zero gauge elevation) is presented in **Figure 3-2** for three HITS stations (Hunter River @ Mason Dieu, Hunter River @ Long Point and Wollombi Brook @ Warkworth).

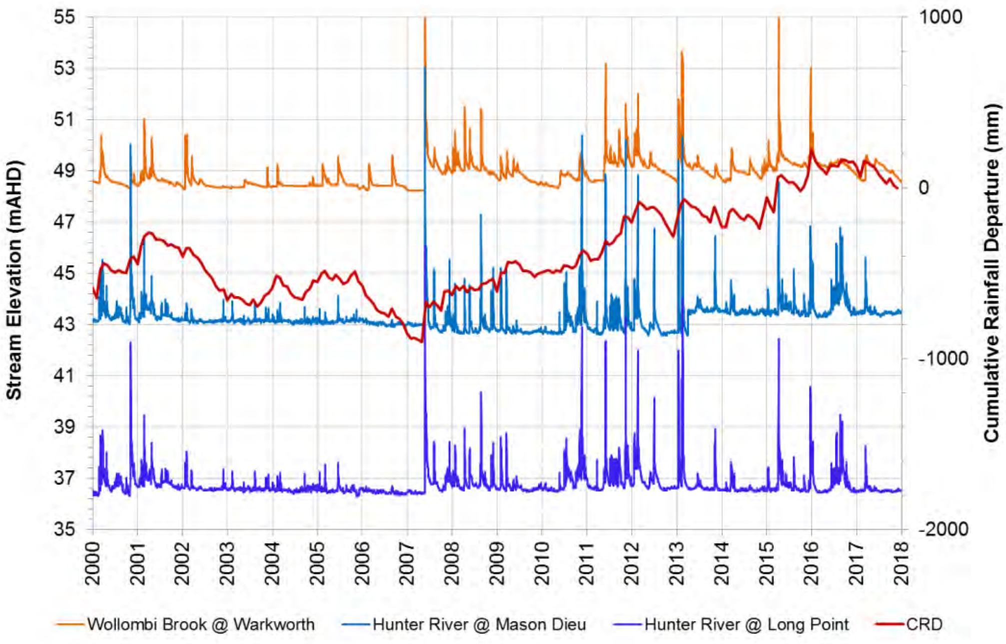


Figure 3-2 Surface Water Levels

As shown in **Figure 3-2**, over 2017 stream elevations within the Hunter River ranged from 36 mAHD and 40 mAHD at Long Point. Over 2017, stream elevations within Wollombi Brook ranged between 48 mAHD and 50 mAHD. In both the Hunter River and Wollombi Brook, stream levels rapidly rose at the end of March, in line with the peak rainfall event.

3.2 Geology

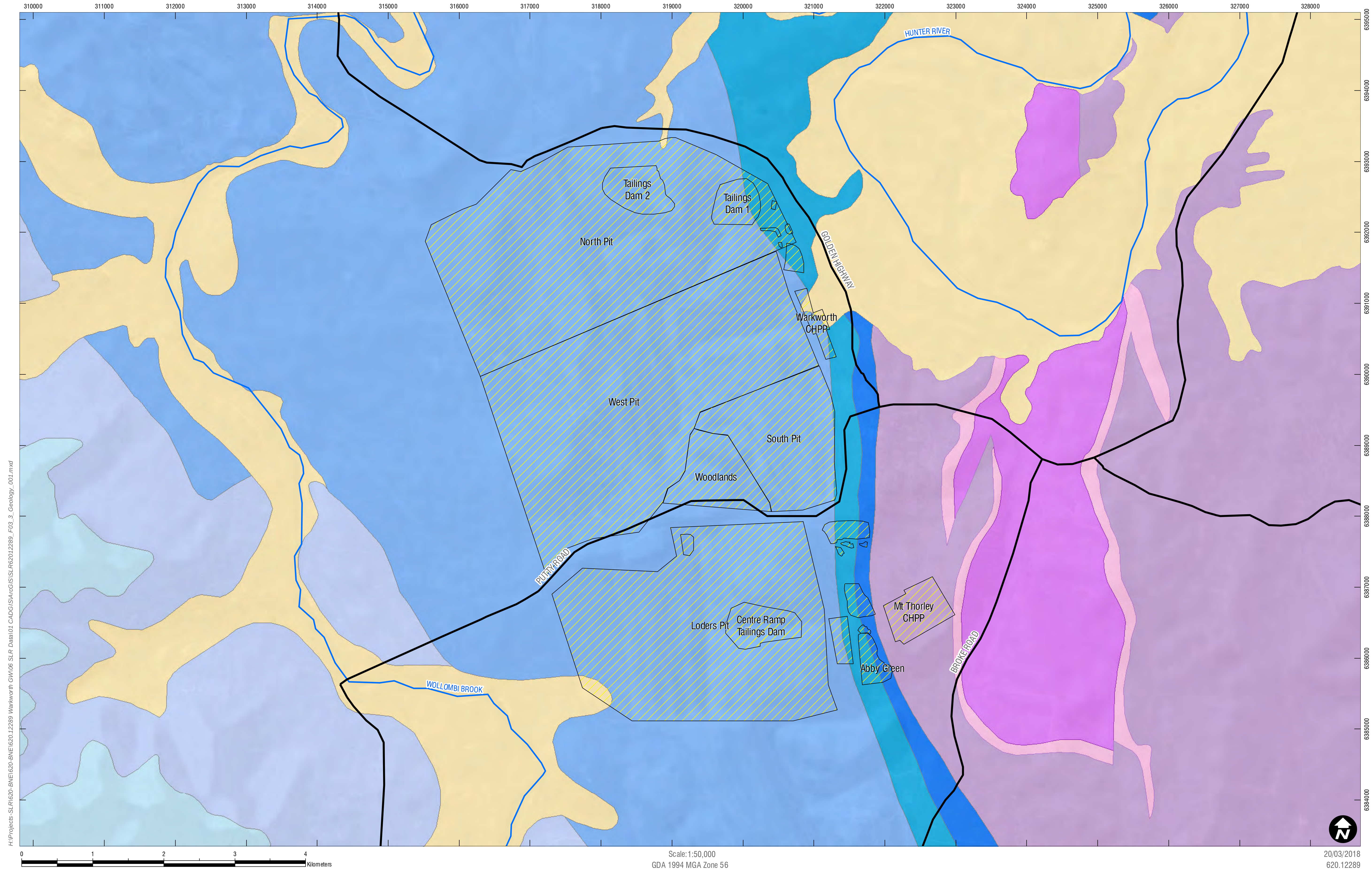
MTW lies within the Hunter Coalfields, which are dominated by the Permian aged Whittingham Coal Measures of the Sydney Basin. The Whittingham Coal Measures are made up of the Jerrys Plains Sub-group and Van Sub-group. These units comprise economic coal seams along with overburden and interburden consisting of sandstone, siltstone, tuffaceous mudstone and conglomerate. The Whittingham Coal Measures are truncated to the east by the Hunter-Mooki Thrust Fault and occur at MTW as stratified (layered) sequences that dip at a shallow angle (2^0 to 5^0) to the south-west. The coal seams subcrop to the east of MTW.

Along the Hunter River and Wollombi Brook thin Quaternary alluvial deposits unconformably overlie the Permian strata. The alluvial deposits comprise surficial fine grained sediments (i.e. silts and clays). Along major watercourses (i.e. Hunter River and Wollombi Brook) the surficial sediments overlie basal sands and gravels.

Table 3-2 presents a summary of site geology and **Figure 3-3** presents a map of the geology of the MTW site and surrounds.

Table 3-2 MTW Generalized Stratigraphy

Age	Stratigraphic Unit		Description
Cainozoic	Quaternary sediments - alluvium (Qa)	Surficial alluvium (Qhb)	Shallow sequences of clay, silty sand and sand.
		Productive basal sands/gravel (Qha)	Basal sands and gravels along major watercourses (i.e. Hunter River).
	Silicified weathering profile (Czas)		Silcrete
	Alluvial terraces (Cza)		Silt, sand and gravel
Jurassic	Volcanics (Jv)		Flows, sills and dykes
Permian	Whittingham Coal Measures	Jerrys Plains Sub-group (Pswj)	Coal bearing sequences interbedded with sandstone and siltstone. Coal seams (youngest to oldest) include Whybrow Seam, Redbank Creek Seam, Wambo Seam, Whynot Seam, Blakefield Seam, Glen Munro Seam, Woodlands Hill Seam, Arrowfield Seam, Bowfield Seam, Warkworth Seam, Mt Arthur Seam, Piercefield Seam, Vaux Seam, Broonie Seam and Bayswater Seam.
		Archerfield Sandstone	Lithic sandstone marker bed.
		Vane Sub-group (Pswv)	Coal bearing sequences interbedded with sandstone and siltstone. Coal seams (youngest to oldest) include Lemington Seam, Pikes Gully Seam, Arties Seam, Liddell Seam, Barrett Seam and Hebden Seam.



MTW Infrastructure	**Hunter Coalfields 100k Geology**	Pms - Muree Sandstone
Main road	Qa - Quaternary Alluvium	Pswv - Archerfield Ss. Vane Subgroup
Major watercourses	Rn - Narrabean Group	Pswc - Saltwater Creek Formation
	Psl - Newcastle Coal Measures	Pmm - Mulbring Siltstone
	Pswj - Jerrys Plains Subgroup	Pmb - Branxton Formation

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2017 Annual Groundwater Review
Surface Geology

Figure 3-3

3.3 Groundwater Units

The principal groundwater units at MTW and its immediate surrounds are the productive alluvium associated with the Hunter River and Wollombi Brook, and the Permian coal seams of the Whittingham Coal Measures. Description of the groundwater units was derived from historical groundwater assessment reports, discussed in **Section 2.2**.

3.3.1 Alluvium

The Quaternary alluvium is an unconfined groundwater system that is recharged by rainfall infiltration, streamflow and upward leakage from the underlying stratigraphy, particularly in undisturbed areas (i.e. away from active mining). The potentiometric surface and flow direction within the alluvium is a subdued reflection of topography. Groundwater within the Hunter River alluvium flows in a southerly direction, while water within the Wollombi Brook alluvium flows in a north to north-easterly direction towards the Hunter River.

Regionally, the Hunter River and Wollombi Brook are predominantly gaining water from the surrounding alluvium, as well as from rainfall and regulated flow (i.e. dam releases). However, there are also areas where the rivers recharge the underlying alluvium. These losing conditions can occur around areas of active mining, where the hydraulic gradient is increased due to depressurisation of the underlying coal measures. Losing conditions also occur within the more topographically elevated tributaries of the main water courses, where the water table is deeper and not connected directly to the streams.

While “less productive” groundwater within the surficial alluvium (Qhb **Table 3-2**) does not meet the ANZECC (2000) water quality guidelines for stock water supply, the “highly productive” alluvium (basal sands and gravels (Qha **Table 3-2**)) is considered suitable for stock water supply from a water quality perspective. However, most agricultural producers (crop and cattle) utilise surface water resources (Hunter River and Wollombi Brook) in preference to alluvial groundwater.

Aeolian sands referred to as the Warkworth Sands are present north to north-west of North Pit, and within a small area to the south-west of Loders Pit. The Warkworth Sands comprise fine grained sands to a thickness of approximately 3 m. The unit overlies clay rich regolith material, which apparently forms a perched aquifer recharged from rainfall infiltration (AGE 2014a). The Warkworth Sands supports woodland (Warkworth Sands Woodland), which is classified as an Endangered Ecological Community (EEC) under the *Threatened Species Conservation Act* 1995 and Critically Endangered (CE) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

3.3.2 Permian Coal Measures

The Whittingham Coal Measures outcrop across the north to east of MTW. The coal measures form unconfined groundwater systems at outcrop, becoming semi-confined to confined as they dip towards the south-west.

Recharge occurs from direct rainfall to the ground surface, infiltrating into the formations through the thin soil cover and weathered profile. The coal measures also occur at subcrop in localised zones beneath alluvium associated with the Hunter River and Wollombi Brook, where the unit is recharged by downward seepage where gradients promote this flow.

The coal seams are typically moderately to slightly permeable, whilst the hydraulic conductivity of the interburden material is generally less than coal seams but is more variable, depending on the predominance of fractures in the rock mass. The hydraulic conductivity of the coal seams generally decreases with depth due to the closure of the cleats with increasing stratigraphic pressure.

The direction of groundwater flow for the Whittingham Coal Measures is influenced by the local geomorphology and structural geology, as well as the long history of mining within the region which has significantly altered groundwater flow paths within the Permian units. Groundwater flow in the Permian aquifers on a regional scale follows the regional topography, flowing in a north-easterly direction. However, on a local scale groundwater levels show drawdown impacts associated with the extensive active mining areas. Groundwater discharge from the Whittingham Coal Measures currently occurs as discharge to active mining and abstraction bores, as well as upward seepage to the Quaternary alluvium where hydraulic gradients promote this flow.

There is no significant usage of groundwater from the Permian coal measures, likely due to the poor quality that generally exceeds ANZECC (2000) water quality guidelines for stock supply, and presence of perennial surface water flows (Hunter River and Wollombi Brook) and the more productive alluvial aquifer.

4 Groundwater Monitoring

4.1 Groundwater Monitoring Program

Groundwater monitoring is conducted at MTW in accordance with the MTW WMP. The monitoring results are used to establish and monitor trends in physical and geochemical parameters of surrounding groundwater potentially influenced by mining.

The monitoring program at MTW measures the Standing Water Level (SWL) in monitoring bores, reported as elevation (mAHD). The data is compared against background data, EIS predictions and historical trends as a means of assessing MTW related impacts to the quantity of groundwater in the various aquifers. The monitoring program at MTW also assesses the quality of groundwater against background data and historical trends. Groundwater quality is evaluated through the parameters of pH and EC. On a periodic basis (nominally once per annum) a comprehensive suite of analytes are measured, including major anions, cations and metals. Prior to sampling for comprehensive analysis, bore purging is undertaken to ensure a representative sample is collected.

Groundwater quality monitoring data is reviewed on a quarterly basis. The review involves a comparison of measured pH and EC results against internal trigger values which have been derived from the historical data set. Trigger limits are calculated as the 95th percentile maximum value (EC and pH) and the 5th percentile minimum value (pH only) from data collected since 2011. Trigger levels have been set based on target stratigraphy. A site specific investigation will be initiated where three consecutive measurements of EC or pH exceed trigger values or where professional judgement determines that a single deviation or a developing trend could result in environmental harm.

The groundwater monitoring network at MTW comprises 72 open standpipe bores installed into various geologic units. As outlined within the WMP, bores are grouped based on geology, as summarised below:

- Hunter River alluvium;
- Wollombi Brook alluvium;
- Aeolian Warkworth Sands;
- Whittingham Coal Measures:
    - Redbank Seam;
    - Wambo Seam;
    - Blakefield Seam;
    - Woodlands Hill Seam;
    - Bowfield Seam;
    - Warkworth Seam;
    - Vaux Seam; and
    - Bayswater Seam.

In addition, 14 vibrating wire piezometers (VWP's) with a total of 45 sensors are present across the site. However, it is understood several of the VWP's are not operational due to equipment failure (i.e. batteries) and calibration details to convert raw output data is pending.

Details of each of the MTW monitoring bores as well as each bores respective monitoring program are provided in **Appendix A** and the location of the bores are presented in **Figure 4-1**.

As outlined in **Appendix A**, full laboratory water quality analysis is required to be conducted for 61 of bores, on an annual basis. The full water quality analysis includes:

- Total dissolved solids (TDS);
- Major ions (Ca, Cl, K, Na, SO_4 (or S), CO_3);
- Total alkalinity, bicarbonate alkalinity, carbonate alkalinity, hydroxide alkalinity; and
- Total metals (Al, As, B, Cd, Cu, Hg, Mg, Ni, Pb, Se, and Zn.

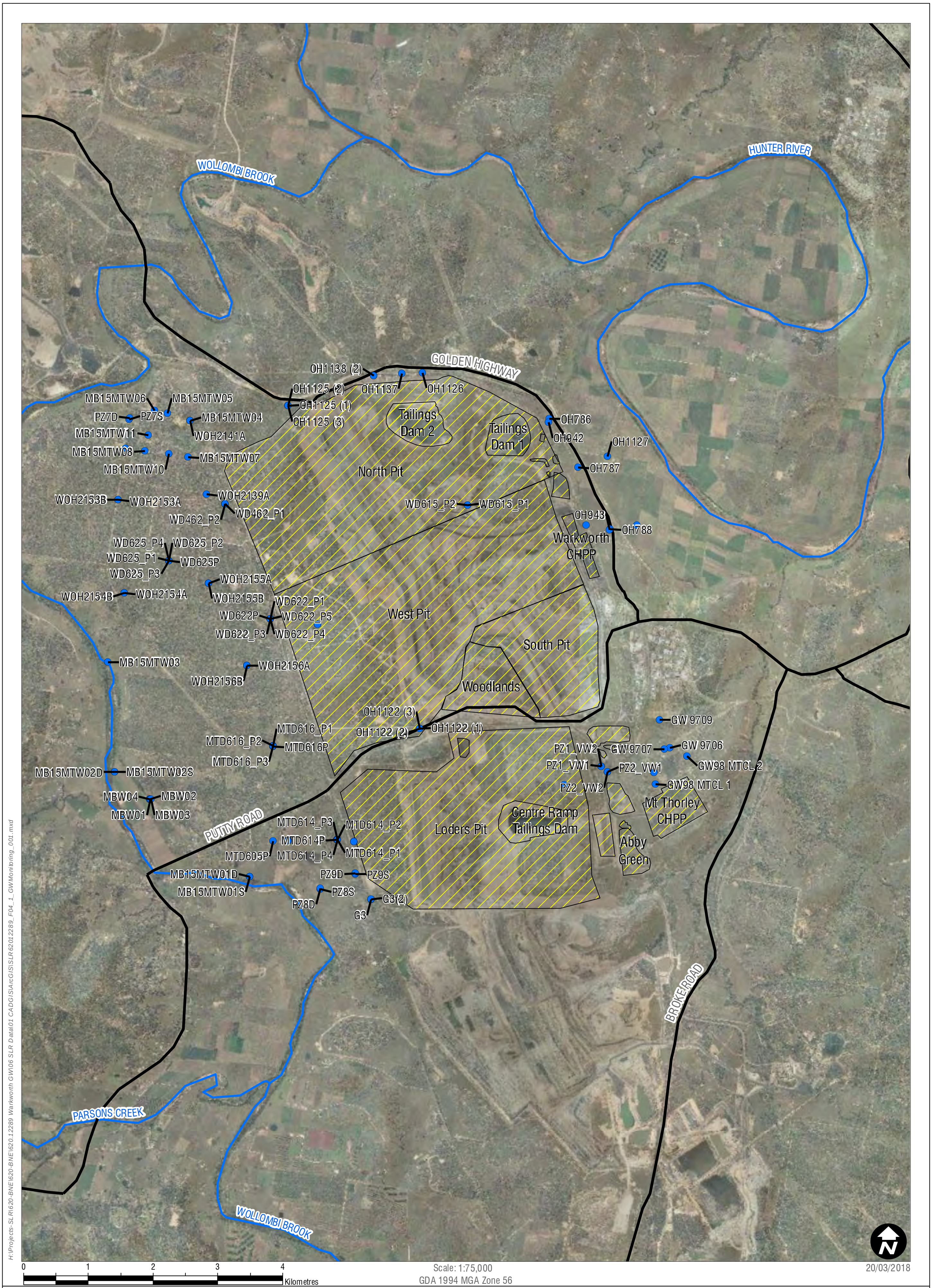
Seven of the 61 bores are also analysed for total metals Mo, V and Cr, as shown in **Appendix A.** Discussion on the groundwater monitoring network is presented in **Section 4.4**.

4.2 Groundwater Monitoring Methodology

MTW engages suitably experienced contractors to carry out sampling and analysis. Sampling is required to be undertaken in accordance with relevant Australian Standards and other regulatory guidelines. Samples are analysed by laboratories that are National Association of Testing Authorities (NATA) accredited or equivalent for the parameters being analysed.

According to the WMP, sampling is undertaken via bailer method for all samples requiring only pH and EC. Groundwater bores are purged (3x casing volumes where possible) prior to sample extraction for all samples requiring comprehensive laboratory analysis.

Discussion on the groundwater monitoring methodology is presented in **Section 4.4**.



Main road

Major watercourses

Groundwater Monitoring Points

MTW Infrastructure

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2017 Annual Groundwater Review
Groundwater Monitoring Network

Figure 4-1

4.3 Groundwater Triggers

The WMP includes groundwater assessment criteria, including water quality trigger levels for investigating potentially adverse groundwater impacts. Trigger levels were established for EC based on the 95th percentile of baseline data, and the trigger levels for pH based on the 5th and 95th percentiles, as presented in the WMP and summarized **Table 4-1**. Groundwater quality readings from the site monitoring bores have been compared to the relevant trigger levels in **Section 5.3**.

Table 4-1 Groundwater Quality Triggers by Location

Location	Target Seam/ Stratigraphy	EC (95th) µS/cm	pH (5th)	pH (95th)
OH786	Hunter River Alluvium	924	7.0	7.7
OH787	Hunter River Alluvium	17,850	7.3	7.7
OH788	Hunter River Alluvium	11,747	7.1	7.9
OH942	Hunter River Alluvium	25,140	6.5	7.1
OH943	Hunter River Alluvium	8,435	7.1	7.6
PZ7S	Aeolian Warkworth Sands	1,749	6.7	7.5
PZ8S	Wollombi Brook Alluvium	15,200	6.6	7.0
PZ9S	Wollombi Brook Alluvium	16,140	6.7	6.9
PZ7D	Shallow Overburden	17,444	6.9	8.1
PZ8D	Shallow Overburden	17,444	6.9	8.1
PZ9D	Shallow Overburden	17,444	6.9	8.1
MTD616P	Shallow Overburden	17,444	6.9	8.1
MTD614P	Shallow Overburden	17,444	6.9	8.1
MBW02	Shallow Overburden	17,444	6.9	8.1
MB15MTW01D	Shallow Overburden	17,444	6.9	8.1
MTD605P	Shallow Overburden	17,444	6.9	8.1
MB15MTW02D	Shallow Overburden	17,444	6.9	8.1
MB15MTW03	Shallow Overburden	17,444	6.9	8.1
WD625P	Woodlands Hill / Whybrow	12,026	7.1	7.3
WOH2153A	Redbank	16,168	7.0	7.9
WOH2154A	Redbank	16,168	7.0	7.9
WOH2155A	Redbank	16,168	7.0	7.9
WOH2156A	Redbank	16,168	7.0	7.9
WOH2153B	Wambo	13,658	7.0	7.9
WOH2154B	Wambo	13,658	7.0	7.9
WOH2155B	Wambo	13,658	7.0	7.9
WOH2156B	Wambo	13,658	7.0	7.9
WD622P	Wambo	13,658	7.0	7.9
MBW04	Wambo	13,658	7.0	7.9
WOH2139A	Blakefield	15,148	6.6	7.6

Location	Target Seam/ Stratigraphy	EC (95th) µS/cm	pH (5th)	pH (95th)
OH1122 (1)	Blakefield	15,148	6.6	7.6
OH1125 (1)	Blakefield	15,148	6.6	7.6
OH1125 (3)	Bowfield	14,736	6.6	7.0
OH1138 (1)	Warkworth	18,844	6.4	7.1
OH1138 (2)	Warkworth	18,844	6.4	7.1
OH1121	Vaux	17,624	6.7	7.1
OH1126	Vaux	17,624	6.7	7.1
OH1137	Vaux	17,624	6.7	7.1
OH1127	Bayswater	23,000	6.7	7.5
GW 9706	Bayswater	23,000	6.7	7.5
GW 9707	Bayswater	23,000	6.7	7.5
GW 9708	Bayswater	23,000	6.7	7.5
GW 9709	Bayswater	23,000	6.7	7.5
GW98 MTCL 1	Bayswater	23,000	6.7	7.5
GW98 MTCL 2	Bayswater	23,000	6.7	7.5

4.4 Network Review

SLR visited MTW on 2nd March 2017 and observed some of the site monitoring bores and discussed groundwater monitoring methodology with the sampling contractors (AECOM). Of the bores visited, it was observed that:

- Bores are reasonably secure, with a steel riser cemented into the ground;
- The ground around the observed bores was reasonably clear;
- Tracks to bores were generally accessible, with any observed obstacles to access promptly dealt with by site; and
- Nested bores are within the one hole and constructed with 25 mm to 50 mm PVC pipe. Labels were attached to the outer casing to distinguish which bore was which.

From discussion with the field contractors, it is understood that for annual groundwater sampling the bores with 50 mm casing are purged using a Solinist low flow pump and water levels and field parameters (i.e. EC and pH) monitored. This approach is considered consistent with *AS 5667.1:-1998, Guidance on the Design of Sampling Programs, Sampling Techniques and the Preservation and Handling of Samples* and *AS 5667.11-1998 Guidance on Sampling of Groundwaters*.

For bores with 25 mm and 32 mm casing, it is understood samples are collected from a bailer with a one-way check valve at the bottom of the bailer, with no prior purging. It is understood this method is also used for quarterly groundwater monitoring. As outlined within *AS 5667.11-1998*, mineral material can accumulate within boreholes. Therefore, to collect representative groundwater samples the bore should be purged (4 to 6 times the well volume) and water quality parameters stabilised before sampling. It is recommended that the groundwater monitoring methodology be further reviewed to ensure all water quality samples (quarterly and annual) are representative and in accordance with industry standards.

5 Monitoring Results

5.1 Data Recovery

Over 2017, groundwater monitoring was carried out at 52 monitoring bores across MTW. Sites with a data capture rate of less than 100 per cent are outlined in **Table 5-1**.

Table 5-1 Groundwater Monitoring Data Recovery

Location	Type	Data Recovery	Comments
OH944	WL and WQ	0%	Bore dry over 2017
MB15MTW01S	WQ	50%	Recently installed bore, not monitored until Q3 2017
MB15MTW01D	WQ	50%	Recently installed bore, not monitored until Q3 2017
MB15MTW02S	WQ	50%	Recently installed bore, not monitored until Q3 2017
MB15MTW02D	WQ	50%	Recently installed bore, not monitored until Q3 2017
MB15MTW03	WL and WQ	50%	Recently installed bore, not monitored until Q3 2017
MB15MTW04	WL and WQ	100%	Recently installed bore, recorded as dry over 2017
MB15MTW05	WL and WQ	0%	Recently installed bore, recorded as dry over 2017
MB15MTW06	WQ	50%	Recently installed bore, not monitored until Q3 2017
MB15MTW07	WL and WQ	0%	Recently installed bore, recorded as dry over 2017
MB15MTW08	WL and WQ	0%	Recently installed bore, recorded as dry over 2017
MB15MTW09	WL and WQ	0%	Recently installed bore, recorded as dry over 2017
MB15MTW10	WL and WQ	0%	Recently installed bore, recorded as dry over 2017
MB15MTW11	WL and WQ	0%	Recently installed bore, recorded as dry over 2017
MBW02	WL and WQ	50%	Recently acquired bore, not monitored until Q3 2017
MBW03	WL and WQ	50%	Recently acquired bore, not monitored until Q3 2017
MBW04	WL and WQ	50%	Recently acquired bore, not monitored until Q3 2017
OH1125 (2)	WL and WQ	0%	Bore dry over 2017
MBW6A	WL and WQ	0%	No available details on bore

Groundwater levels as recorded at site VWP's was not provided for inclusion within the annual groundwater review. Further work to compile the VWP data and check the VWP's are working correctly (i.e. check batteries) is ongoing.

5.2 Water Levels

A summary of the water level results is provided for each of the main water bearing units (alluvium and Permian coal measures) below. Routine water level readings for 2017 are presented in **Appendix B**.

5.2.1 Alluvium

Groundwater level trends are discussed below for the Warkworth Sands, alluvium along the Hunter River and alluvium along Wollombi Brook.

5.2.1.1 Warkworth Sands

Bores within the Warkworth Sands include PZ7S, MB15MTW04 to MB15MTW11. All bores within the Warkworth Sands are equipped with dataloggers that are set to record groundwater levels on a six hourly basis. Install depths of the dataloggers have not been provided, but have been estimated based on manual dipped water levels. Ground elevations at the MB15MTW bores have not been surveyed, so a nominal elevation of 60 mAHD has been used.

Bore PZ7 is a nested bore with screen within the Warkworth Sands to 11.1 m depth, and screen within the shallow overburden material with at 30.5 m depth. Historical water level data for the bore is presented in **Figure 5-1**. **Figure 5-1** shows a general decline in groundwater levels within the Warkworth Sands and shallow overburden material at PZ7 over 2017. This trend appears to correspond with the general decline in rainfall over this period.

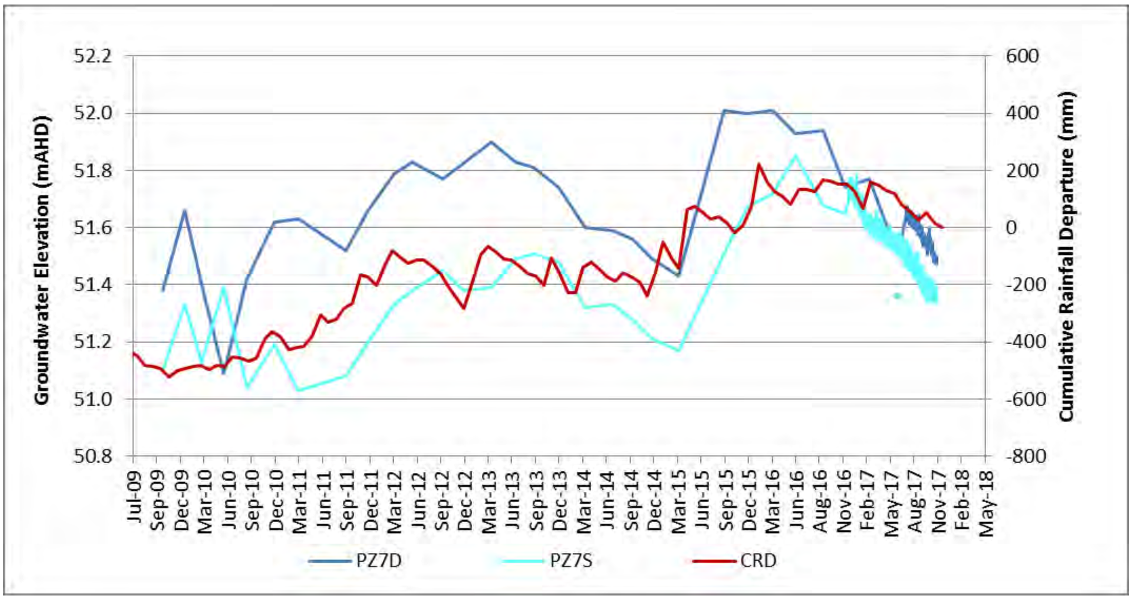


Figure 5-1 Groundwater Levels – Warkworth Sands Bore Bore PZ7S and PZ7D

Bores MB15MTW04 to MB15MTW11 were generally recorded as dry over 2017. An exception to this was bore MB15MTW06, which is presented in **Figure 5-2**. **Figure 5-2** shows a general decline in groundwater levels within the Warkworth Sands over 2017. Spikes in levels are visible in March and October that appear to correspond with periods of increased daily rainfall.

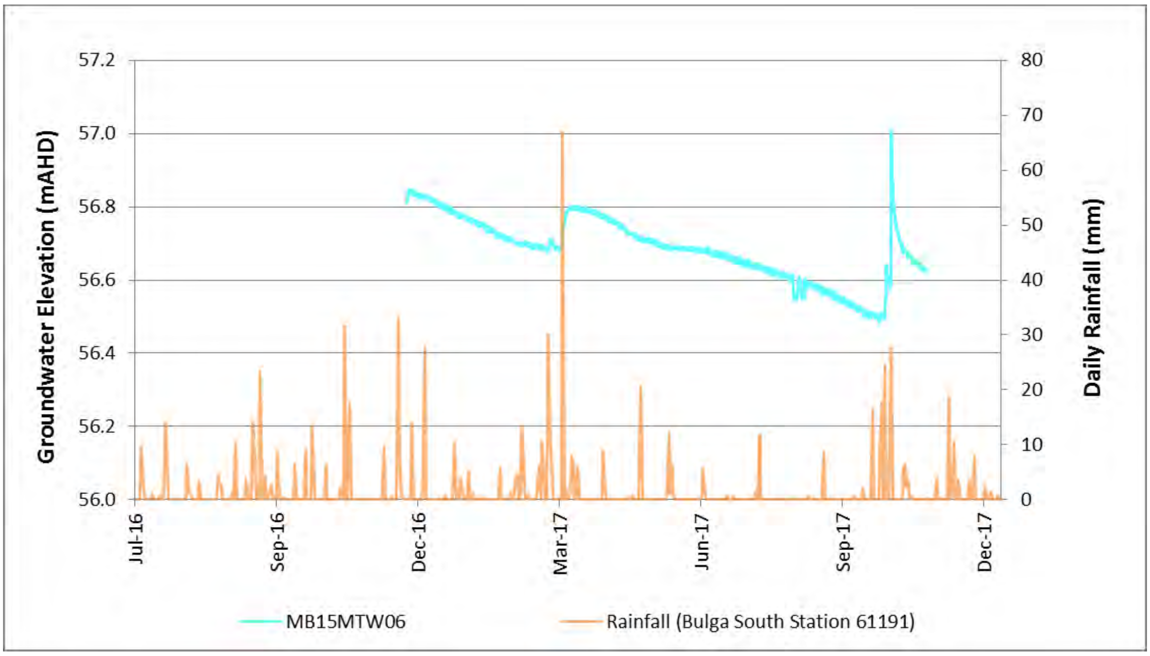


Figure 5-2 Groundwater Levels – Warkworth Sands Bore MB15MTW06

5.2.1.2 Hunter River Alluvium

Six bores within the monitoring network intersect alluvium along the Hunter River, these are OH786 to OH788 and OH942 to OH944. Over 2017, two of the bores (OH787 and OH944) were dry, with water levels recorded at or below the base of the bore. According to available bore construction details, bore OH787 12.1 m, but has recorded groundwater levels of between 13.6 m and 15.8 m depth since monitoring commenced in 2004. These readings may therefore relate to measurement with a bore sump. Bore OH944 is apparently 8.2 m deep and historical monitoring records detail the bore has often been dry or had insufficient water present to sample since 2011.

Of the bores with water present, alluvial groundwater occurred at depths of between 1 m and 10 m below surface over 2017. **Figure 5-3** presents the historical groundwater levels for all six Hunter River alluvium bores, along with rainfall trends (CRD) and stream elevations recorded at the Hunter River stream gauges at Mason Dieu and Long Point.

The greatest fluctuations in water level were recorded for bore OH786, while adjacent bore (OH942) recorded relatively stable groundwater levels. Review of construction details indicates bore OH786 may intersect the more permeable sequences of the Hunter River alluvium, while bore OH942 may intersect the underlying weathered overburden material. Further review of the bore construction details is recommended to better understand water level and quality trends.

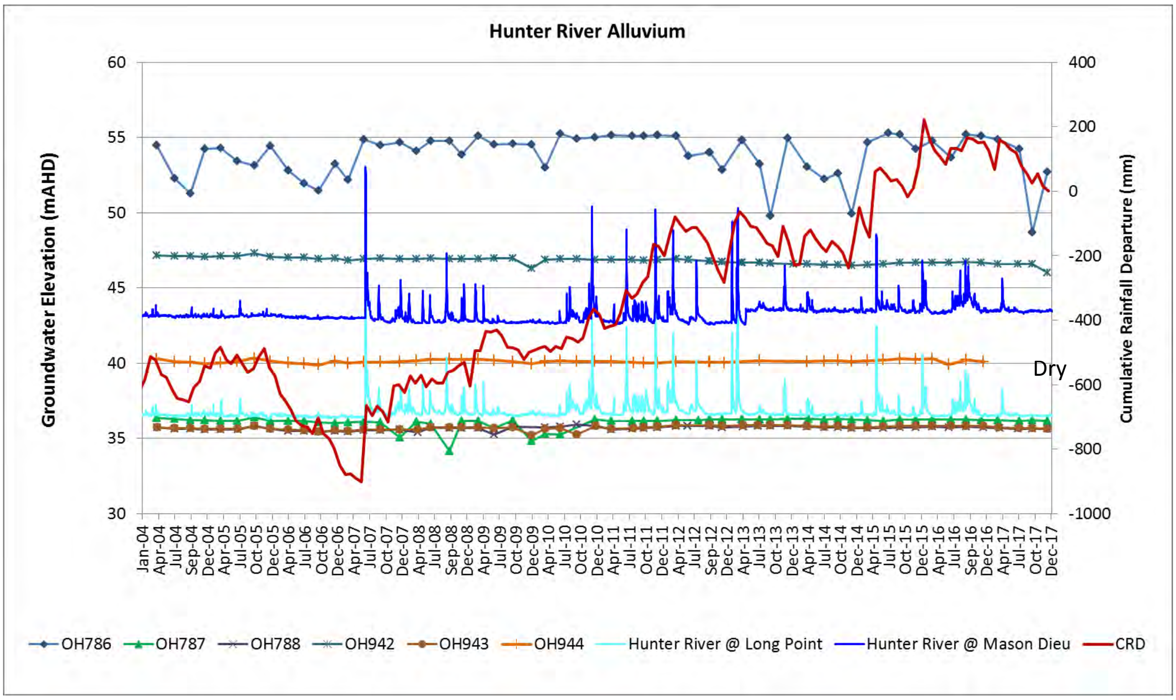


Figure 5-3 Groundwater Levels – Hunter River Alluvium

5.2.1.3 Wollombi Brook Alluvium

Four bores intersect the alluvium along the Wollombi Brook, PZ8S, PZ9S and MB15MTW01S and MB15MTW02S. Each of the bores is nested with a deeper bore screened within the underlying overburden material of the Permian coal measures.

Groundwater level trends for bores west of MTW (MB15MTW01 and MB15MTW02) are presented in **Figure** 5-4, which includes rainfall trends (CRD) and stream elevations for Wollombi Brook as recorded at Bulga. Groundwater levels at the two locations are recorded with data loggers and manual dip readings. The ground elevation at the bores was not available at the time of reporting, so was estimated to be 60 mAHD.

Bores MB15MTW01 and MB15MTW02 are located adjacent to Wollombi Brook. **Figure 5-4** shows that alluvial groundwater elevations along Wollombi Brook are likely to be below stream elevations, indicating losing conditions. Groundwater levels within the alluvium and shallow overburden generally declined over 2017. Exceptions to this were in March 2017 and to a lesser extent in June 2017, when groundwater elevations rose following peak rainfall and streamflow events. Trends between the alluvium and underlying shallow overburden material follow similar trends along Wollombi Brook. This contrasts with observations further away from the Wollombi Brook, as discussed below.

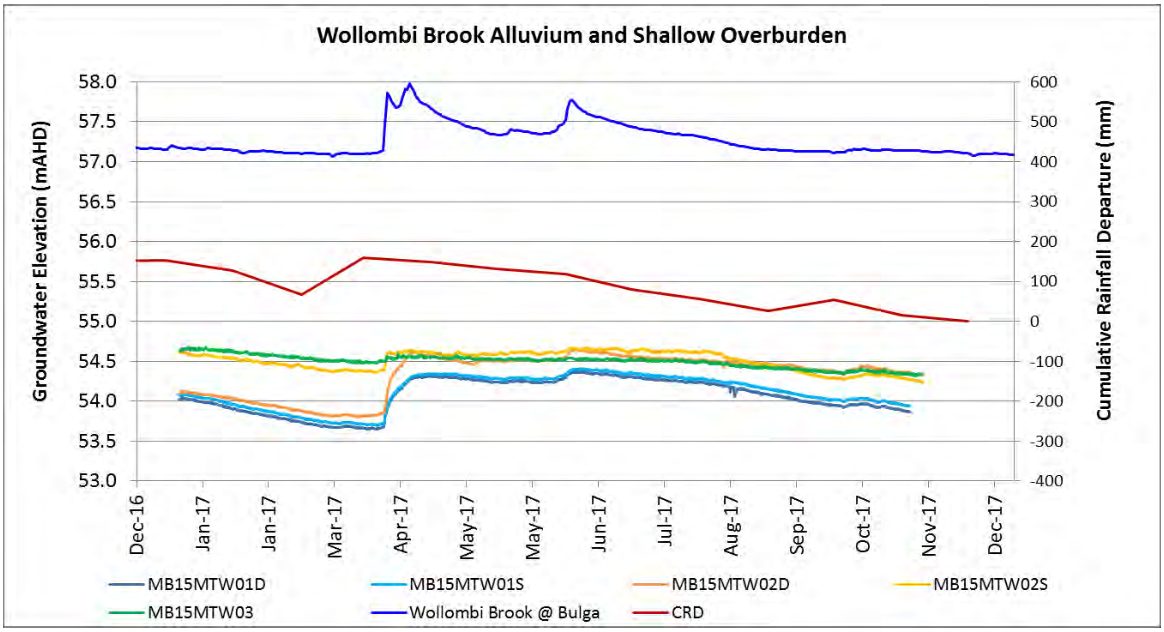


Figure 5-4 Groundwater Levels – Wollombi Brook Alluvium MB15MTW01 and MB15MTW02

Groundwater level trends for bores over 600 m from Wollombi Brook, at the south-western end of site (PZ8 and PZ9), are presented in **Figure 5-5**. Trends for the MB15MTW alluvial bores are also included for comparison. The graph also includes rainfall trends (CRD) and stream elevations for Wollombi Brook as recorded at Bulga. As with the bores adjacent to Wollombi Brook, **Figure 5-5** shows a general decline in groundwater levels within the alluvium over time.

Figure 5-5 shows that alluvial groundwater elevations are higher than the underlying overburden material, indicating a downward flow gradient. It is also noted that groundwater levels within shallow overburden bore PZ9D declined from commencement of monitoring in 2009 to 2016. Since 2016 groundwater levels have gradually risen. Bore PZ9D is positioned closest to the active operations at Loders Pit. Therefore the decline in groundwater levels within the shallow overburden material likely reflects depressurisation from mining, as predicted as part of the mine approvals (AGE 2014b). Both PZ9S and PZ9D are shallow, at 7 m and 24 m depth, respectively. Therefore, the difference in groundwater trends highlights limited vertical hydraulic connection between the Permian coal measures and surficial sediments at this location.

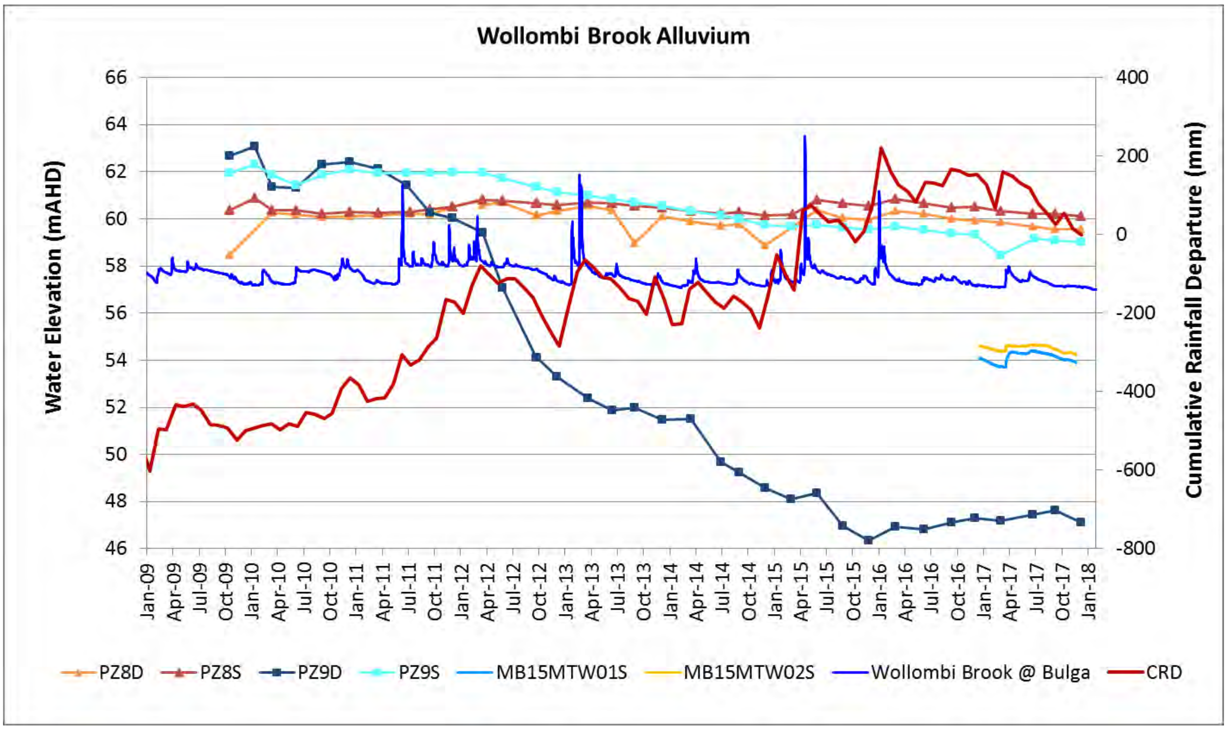


Figure 5-5 Groundwater Levels – Wollombi Brook Alluvium Bores PZ7, PZ8, MB15MTW01 and MB15MTW02

5.2.2 Permian Coal Measures

Groundwater level trends for the Permian coal measures are discussed in stratigraphic order in **Section 5.2.2.1** to **Section 5.2.2.7** below. This includes further discussion on the shallow overburden, shallow coal seams (Whybrow, Redbank Creek and Wambo seams), Blakefield Seam, Bowfield Seam, Warkworth Seam, Vaux Seam and Bayswater Seam.

5.2.2.1 Shallow Overburden

Ten monitoring bores intersect the shallow overburden material, PZ7D, PZ8D, PZ9D, MTD605P, MTD614P, MTD616P, MBW02, MB15MTW01D, MB15MTW02D and MB15MTW03. Groundwater level trends for bores nested with alluvial bores (PZ7D, PZ8D, PZ9D, MB15MTW01D and MB15MTW02D) are discussed in **Section 5.2.1**. Trends for bore MB15MTW03 are also presented in **Figure 5-4** of **Section 5.2.1**, as the bore is located along Wollombi Brook. **Figure 5-4** showed a general decline in groundwater levels at MB15MTW03 over 2017. The trends were similar to what was observed within the upstream alluvial bores, but with a more muted response to streamflow changes.

Groundwater level trends for bores MTD605P, MTD614P, MTD616P and MBW02 are presented in **Figure 5-6**. **Figure 5-6** shows stable to slightly declining groundwater levels within the shallow overburden material.

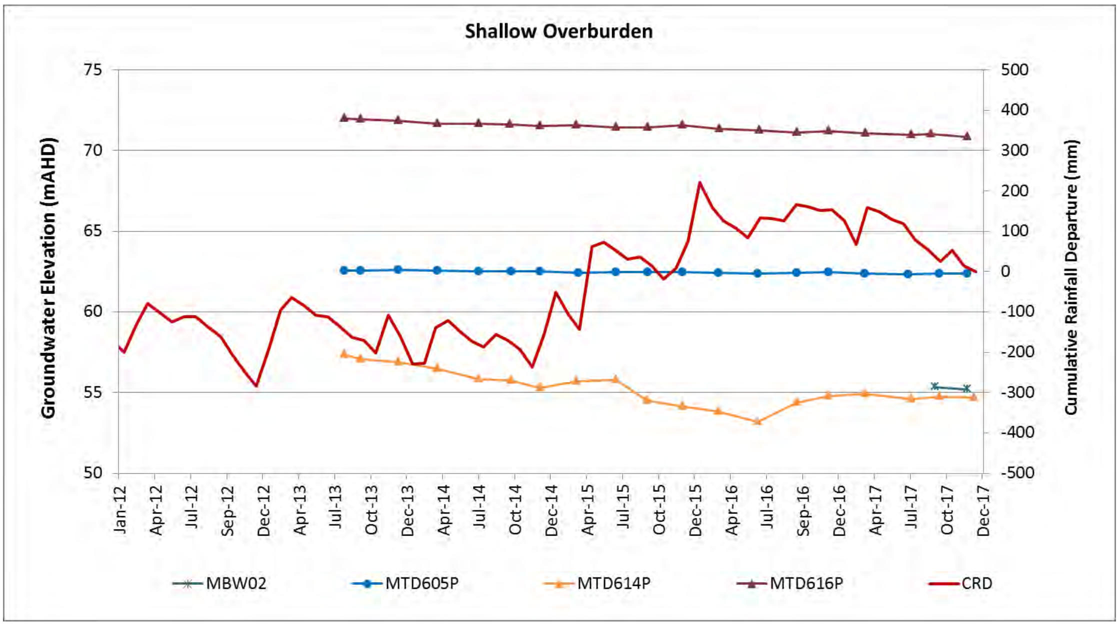


Figure 5-6 Hydrograph of Shallow Permian Coal Measures

5.2.2.2 Whybrow, Redbank Creek and Wambo Seams

Historical groundwater level trends for bores intersecting the shallow coal seams (Whybrow, Redbank Creek and Wambo seams) are presented in **Figure 5-7**. The graph shows that over 2017 groundwater elevations ranged between 53.8 mAHD and 67.8 mAHD and generally declined. The greatest decline (3.9 m) was observed at bore WD622P, which is located within 300 m of the highwall at West Pit. Groundwater levels also remained relatively stable at bores WOH2153B to WOH2156B and WD625P, which are all located approximately 1 km west of Warkworth operations.

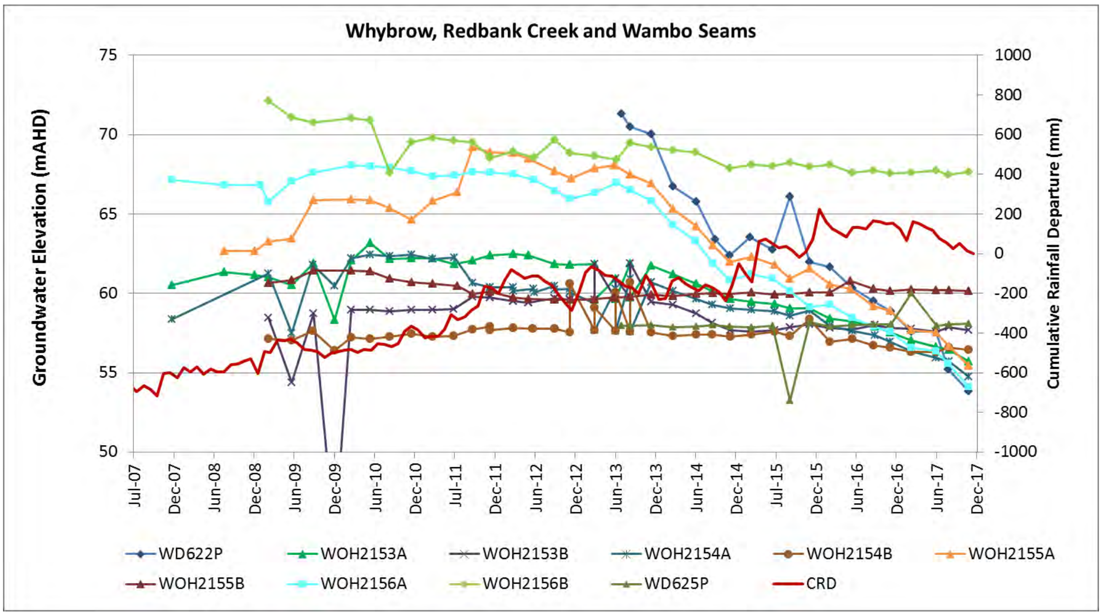


Figure 5-7 Hydrograph of Whybrow, Wambo and Redbank Creek Seams

5.2.2.3 Blakefield Seam

Historical groundwater level trends for bores intersecting the Blakefield Seam are presented in **Figure 5-8**. The graph shows that over 2017 groundwater elevations ranged between 43.9 mAHD and 60.0 mAHD. Groundwater levels generally declined within the Blakefield Seam around site. In response to mine progression Bore WOH2139A recorded a 3.4 m decline and OH1122(1) recorded a 0.7 m decline over 2017. In September 2017 bore OH1122(1) recorded a 1.3 m decline and recovery in groundwater levels compared to readings in June and December. The cause for this change is unclear, but may relate to localised site activities or reading error.

Over 2017, groundwater levels were variable at bore OH1125(1), which is located north of North Pit. Bore OH1125 is a nested bore with three screened sections. Review of available construction details indicates the bore is 12 m deep and groundwater elevation? readings exceed the total depth. It is likely that the readings relate to OH1125(2), which has been recorded as dry since 2012.

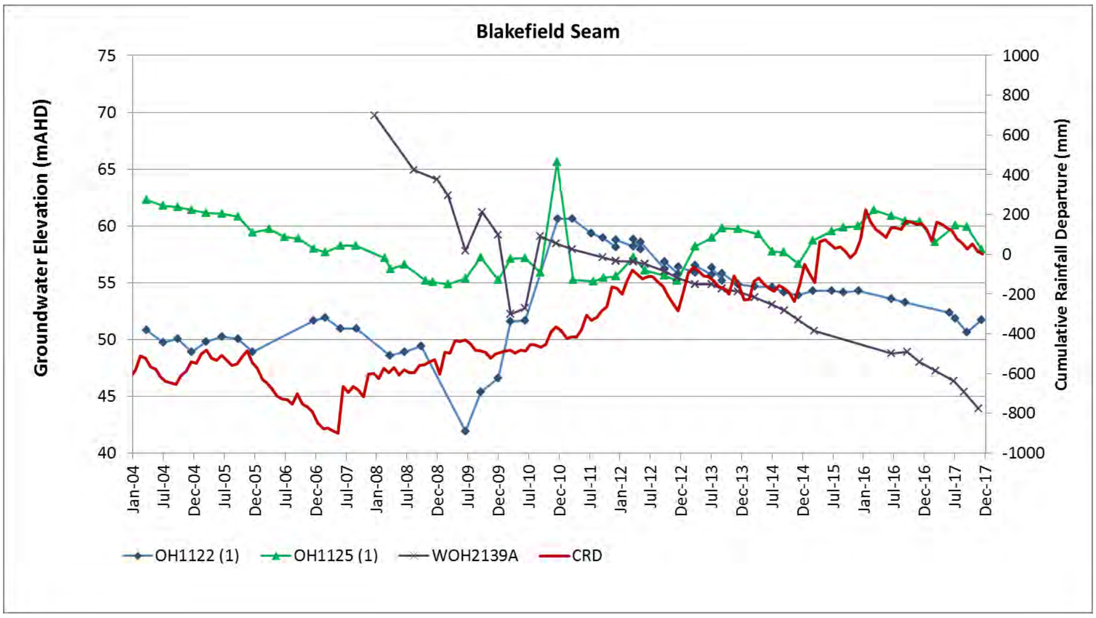


Figure 5-8 Hydrograph of Blakefield Seam

5.2.2.4 Bowfield Seam

Historical groundwater level trends for bores intersecting the Bowfield Seam are presented in **Figure 5-9**. The graph shows that over 2017 groundwater elevations ranged between 38.9 mAHD and 41.9 mAHD at bore OH1125(3). Review of available bore details indicates the total depth of the bore is 62.7 m; however, some records indicate the bore was constructed to over 80 m depth. Review of the condition of the bore is recommended.

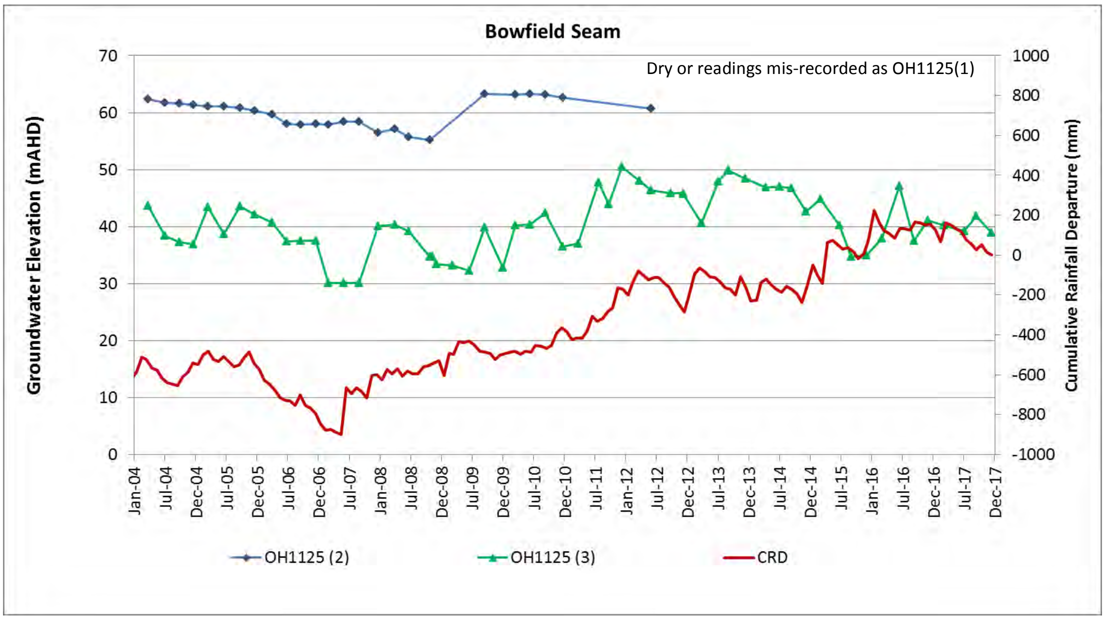


Figure 5-9 Hydrograph of Bowfield Seam

5.2.2.5 Warkworth Seam

Historical groundwater level trends for bores intersecting the Warkworth Seam at bore OH1138 at two intervals (1 and 2) are presented in **Figure 5-10**. The graph shows that over 2017 groundwater elevations ranged between 56.3 mAHD and 61.4 mAHD and level declined by 0.3 m. The bore is located north of North Pit and the decline may relate to drawdown towards active mining within the pit to the south-west. The trend may also be influenced by abstraction from Lemington Underground Bore to the north-west.

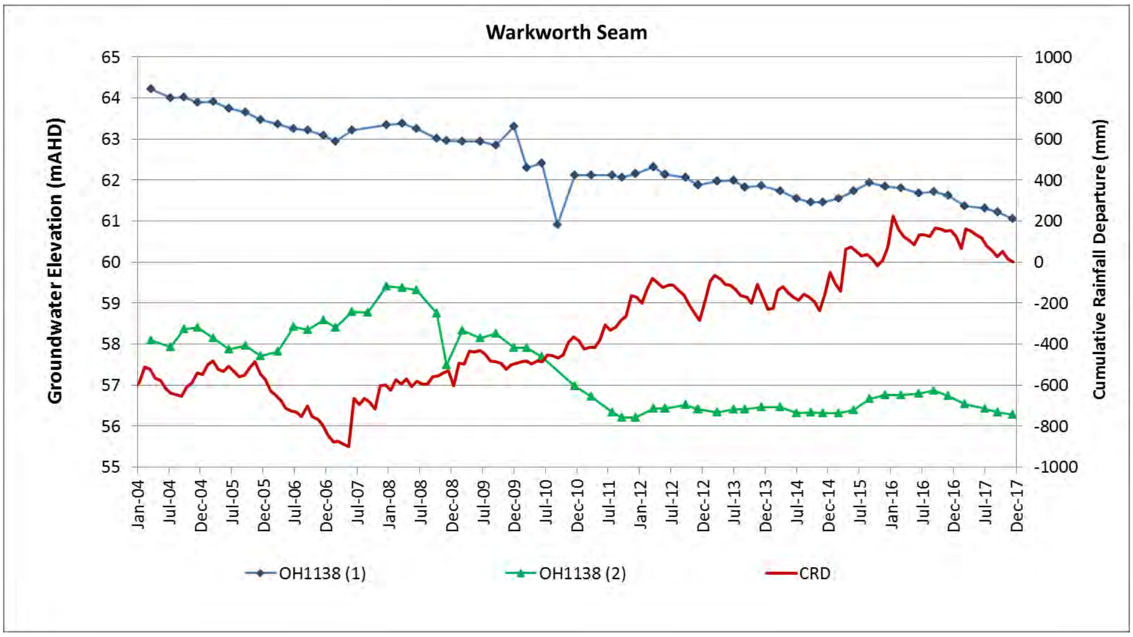


Figure 5-10 Hydrograph of Warkworth Seam

5.2.2.6 Vaux Seam

Historical groundwater level trends for bores intersecting the Vaux Seam around MTW are presented in **Figure 5-11**. The graph shows that over 2017 groundwater elevations within the Vaux Seam, north of North Pit, (OH1126 and OH1137) ranged between 48.1 mAHD and 54.8 mAHD and levels declined by up to 0.8 m. These trends are similar to trends observed within the Warkworth Seam, which may relate to depressurisation of the coal seams below the actively mined seams at MTW, or due to surrounding mine operations that target the Vaux Seam.

Groundwater levels within bore OH1121 remained stable over 2017. This bore is located upgradient (east) of MTW and is reported in the WMP to intersect the shallow Vaux Seam (20 m depth). However, upon review of the geology map (**Figure 3-3**) the Jerry's Plains Subgroup that the Vaux Seam is within is not present at this location. Therefore, the condition and construction details of the bore should be further reviewed.

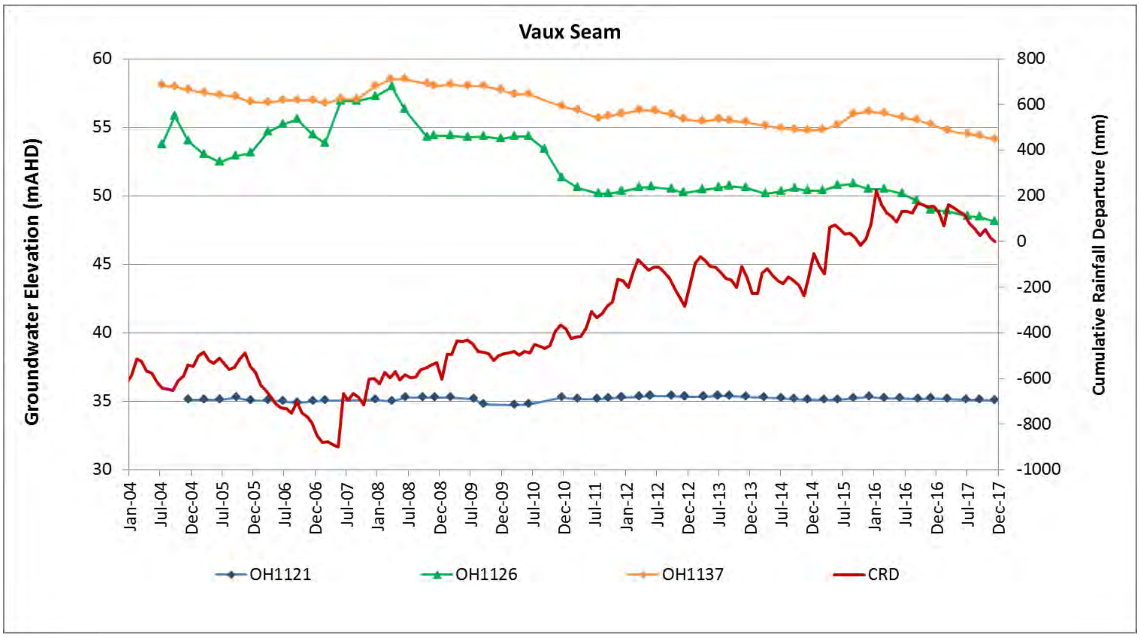


Figure 5-11 Hydrograph of Vaux Seam

5.2.2.7 Bayswater Seam

Historical groundwater level trends for bores intersecting the Bayswater Seam around MTW are presented in **Figure 5-12**. The graph shows that over 2017 groundwater levels remained relatively stable, with elevations ranging between 35.5 mAHD and 69.2 mAHD.

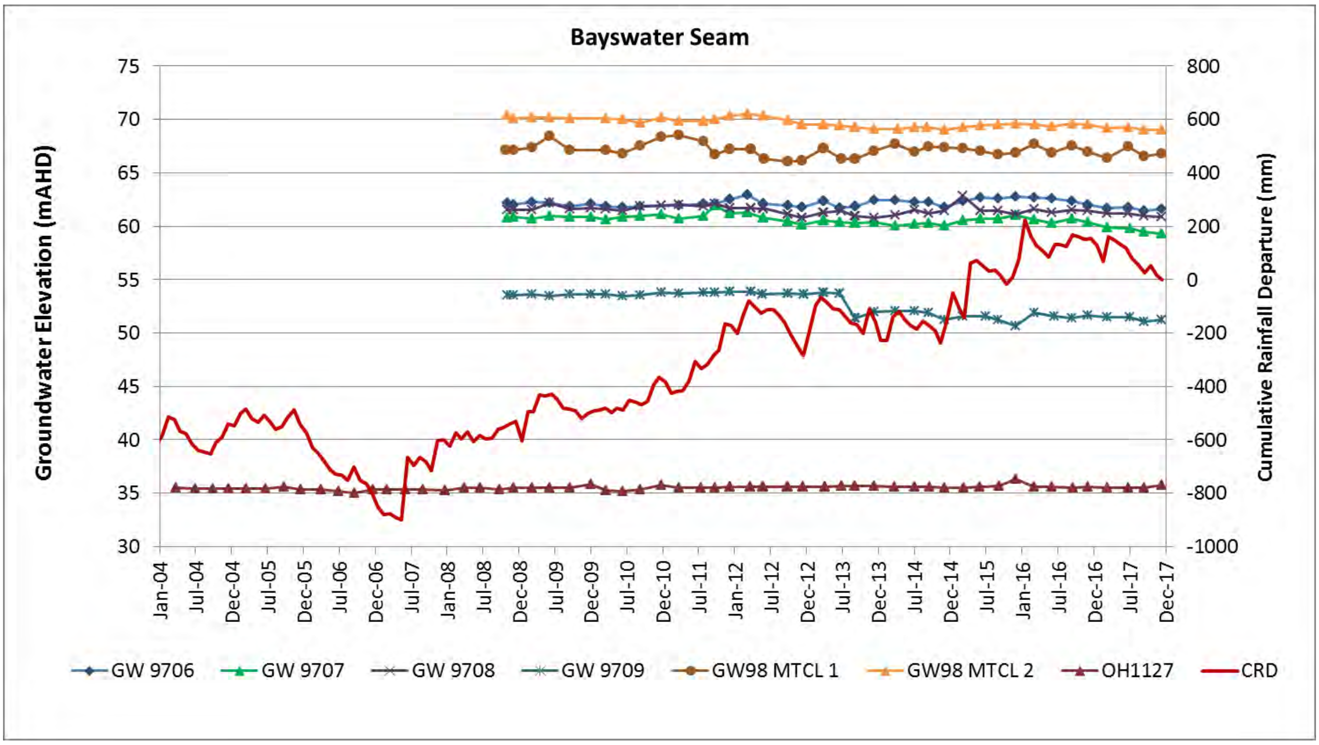


Figure 5-12 **Hydrograph of Bayswater Seam**

5.3 Water Quality

A summary of the water quality results is provided for each of the main water bearing units (alluvium and Permian coal measures) below. Routine EC and pH readings and historical trends are presented in **Appendix B** and **Appendix C**, respectively.

5.3.1 Alluvium

Over 2017, routine monitoring of EC and pH was conducted for most alluvial monitoring bores on a quarterly basis. Exceptions to this were:

- OH944 was recorded as dry throughout 2017; and
- Bores targeting the Wollombi Brook alluvium, MB15MTW01S and MB15MTW02S, were monitored from Q3 in 2017.
- Bores targeting the Warkworth Sands, MB15MTW04, MB15MTW05, MB15MTW07 to MB15MTW11, were recorded as dry over 2017, with the exception of MB15MTW06 that was sampled from Q3.

Alluvial groundwater quality over 2017 ranges between the different units, as discussed below:

- Warkworth Sands: EC ranges between 1,344 µS/cm and 1,735 µS/cm and pH ranges between 6.7 and 7.2 for bore PZ7S.
- Hunter River: EC ranges between 551 µS/cm and 25,500 µS/cm and pH ranges between 6.6 and 7.6.

- Wollombi Brook: EC ranges between 7,640 µS/cm and 18,160 µS/cm and pH ranges between 6.6 and 7.4.

Discussion in water quality trends and triggers is included for each alluvial unit from **Section 5.3.1.1** to **Section 5.3.1.3**.

Full water quality analysis was conducted for the site alluvial bores in accordance with the WMP. Exceptions to this include bore OH786 and OH944 due to insufficient water to sample, and recently installed bores within the Warkworth Sands that were dry over 20217 (MB15MTW04, MB15MTW05, MB15MTW07 to MB15MTW11). Full water quality data is presented in **Appendix D** and summarised below:

- Total aluminium: variable readings from 0.01 mg/L (MB15MTW01S) to 41 mg/L (OH943) over 2017;
- Total arsenic: concentrations generally below the limit of reporting or less than 0.01 mg/L. One reading of 0.02 mg/L was recorded for bore OH943;
- Total cadmium: concentrations generally below the limit of reporting or less than 0.001 mg/L. Bores OH788 and OH942 recorded total cadmium concentrations of 0.0024 mg/L and 0.0011 mg/L, respectively;
- Total lead and selenium: concentrations below the limit of reporting or less than 0.02 mg/L, with the exception of bore OH943 that recorded total lead of 0.11 mg/L;
- Total zinc: concentrations generally below the limit of reporting or less than 0.1 mg/L, with the exception of bore OH943 that recorded total zinc of 1.4 mg/L;

5.3.1.1 Warkworth Sands

Over the 2017 monitoring period bore PZ7S recorded one reading at the pH lower trigger of 6.7 in Q2, but pH remained within the trigger range for the remainder of the year.

5.3.1.2 Hunter River Alluvium

Over the 2017 monitoring period, the following triggers were exceeded for the bores within the Hunter River alluvium:

- Bore OH786 recorded EC above the trigger level of 924 µS/cm in Q3; however this appears to be a spike result, with the Q4 reading within the trigger range.
- Bore OH787 recorded EC levels at and above the trigger level of 17,850 µS/cm in Q1, Q3 and Q4.
- Bore OH942recorded EC levels at and above the trigger level of 25,140 µS/cm in Q3 and Q4.

Bores OH787 and OH942 intersect the 'less productive alluvium' along the Hunter River. Over 2017, bore OH787 recorded groundwater levels between 13.2 m and 13.8 m depth, which exceed the recorded total depth of the bore. Based on this information, the bore is anticipated to be dry and the readings over 2017 likely reflect sediment at the base of the bore or potentially water within a sump at the base of the bore. The practice of collecting grab samples also likely influences these results.

Bore OH942 recorded groundwater levels of between 9.2 m and 9.8 m depth, which are above the base of the bore (13.15 m depth). Historical EC readings for OH942 since 2011 show regular fluctuations of between 7,370 µS/cm and 18,100 µS/cm. The 2017 readings of up to 18,340 µS/cm are therefore slightly above historical levels. This trend may relate to the area having received below average rainfall over most of 2017. Further review of the condition and construction of the bore as well as sampling methodology is recommended.

5.3.1.3 Wollombi Brook Alluvium

Over the 2017 monitoring period, no EC or pH triggers were exceeded for the bores within the Wollombi Brook alluvium (PZ8S and PZ9S).

5.3.2 Permian Coal Measures

Routine monitoring of EC and pH was conducted for all monitoring bores intersecting the Permian coal measures and overburden material on a quarterly basis over 2017. Exceptions to this are bores MBW02, MBW04, MB15MTW01D, MB15MTW02D and MB15MTW03 that were added to the monitoring program from Q3 2017. Bore OH1122(1) was not monitored in Q1 due to access restrictions, and bore OH1125(2) was dry throughout 2017.

Over 2017 groundwater within the shallow overburden material of the Permian coal measures recorded EC of between 5,830 µS/cm and 17,850 µS/cm and pH ranges between 7.2 and 8.0. Over 2017 groundwater within the Permian coal measures recorded EC of between 771 µS/cm and 23,200 µS/cm and pH ranges between 6.1 and 8.0.

In accordance with the WMP full water quality analysis was conducted for the bores targeting the Permian coal measures, with the exception of WOH2156B and OH1125(2) due to insufficient water/dry conditions present. Bore OH1122(1) was also not sampled for full water quality analysis over 2017. Full water quality data is presented in **Appendix D** and summarised below:

- Total aluminium: variable readings from below laboratory limit of reporting to 5.7 mg/L (WOH2141A) over 2017;
- Total arsenic: concentrations generally below the limit of reporting or less than or equal to 0.006 mg/L, with the exception of bore GW98 MTCL 1 that recorded a concentration of 0.017 mg/L;
- Total cadmium: concentrations generally below the limit of reporting or less than 0.001 mg/L;
- Total lead and selenium: concentrations below the limit of reporting or less than or equal to 0.02 mg/L, , with the exception of bore GW98 MTCL 1 that recorded a lead concentration of 0.066 mg/L; and
- Total zinc: concentrations from below the limit of reporting to 0.62 mg/L (WOH2155B).

Over the 2017 monitoring period, the following triggers were exceeded for bores within the Permian coal measures:

- Bore WOH2153A recorded pH of 8 in Q1; however pH remained within the trigger range for the remainder of the year;
- Bores WOH2156B and WD622P recorded EC above the trigger value of 13,658 µS/cm in Q2; however their EC remained within the trigger range for the remainder of the year;

- Bore WOH2139A recorded a pH of over 7.6 in Q3 and Q4, these readings are higher than historical trends;
- Bore OH1125 (1) recorded EC above the trigger value of 15,148 µS/cm in Q1; however EC for the bore remained within the trigger range for the remainder of the year;
- Bore OH1138 (1) recorded pH below 6.4 from Q2 to Q4, and EC of above 18,844 µS/cm from Q3 to Q4. Trends for this bore are discussed below;
- Bore OH1137 recorded EC above the trigger value of 17,624 µS/cm in Q3 and Q4. Trends for this bore are discussed below;
- Bore GW 9709 recorded pH below 6.4 in Q1 and Q4, and EC of above 23,000 µS/cm in Q3. The isolated pH reading of 6.4 is below historical trends, but remained in line with historical trends for the remainder of the year. The EC readings were within historical trends.
- Bore GW98 MTCL 2 recorded pH of 6.6 to 6.7 throughout 2017. These results are in line with historical readings for the bore that have ranged from 6.6 to 7.1 since 2011.

Bore WOH2139A intersects the Blakefield Seam with a bore depth of approximately 96 m and is located approximately 500 m west of North Pit. The bore recorded a rise pH from 7.5 in March 2017 up to 7.9 in November 2017. Also, while within the EC trigger range, the bore did record a rise in EC from 2,960 µS/cm in March 2017 up to 9,310 µS/cm in November 2017. **Figure 5-13** compares EC to groundwater levels recorded at bore WOH2139A since 2007. Groundwater levels have continued to decline with progression of the mine; however EC remained below 4,000 µS/cm prior to 2017.

Review of the database indicates that grab samples were collected in August and November 2017 and may not be fully representative of the groundwater unit. However, the trend in pH and EC is prominent compared to other bores on site, and indicates potential groundwater quality change in this area. Over this same period groundwater levels declined by 3.9 m at bore WOH2139A. Further review of the groundwater trends at WOH2139A are required, including collection of representative water quality samples and water quality testing of water stored within North Pit.

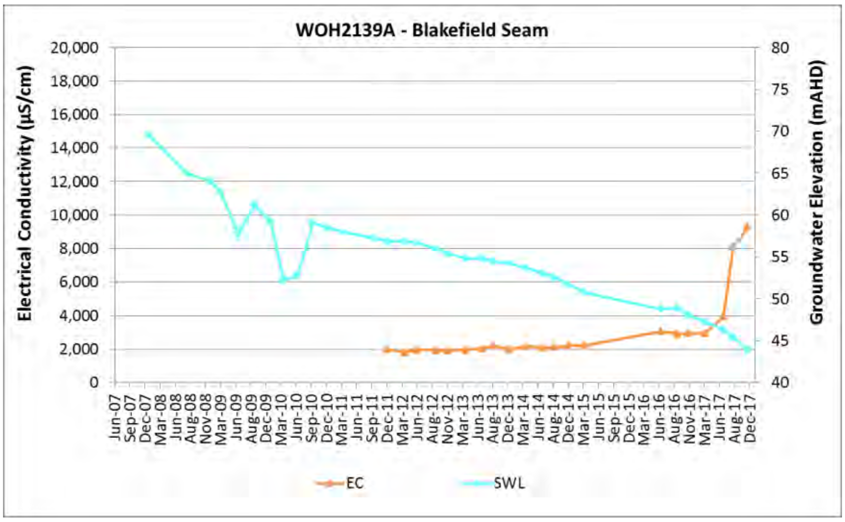


Figure 5-13 Water Quality Trends at WOH2139A

Bore OH1138 is constructed as a nested bore with two sections of 32 mm PVC casing within the one hole, both of which target the shallow Warkworth Seam. OH1138(1) is apparently screened from 20.8 m to 24.8 m depth and OH1138(2) is apparently screened from 38.8 m to 42.8 m depth. The bores are located on the north side of North Pit.

Bore OH1138(1) recorded declining trend in pH over 2017 outside of the trigger range, with readings of 6.7 (March 2017) down to 6.1 (December 2017). A slight decline in pH was also observed for bore OH1138(1), but readings remained within the trigger range. Both bores record a slight rise in EC since monitoring commenced in 2012. Over 2017, EC for OH1138(2) fluctuated slightly but generally remained consistent with historic trends. Over 2017, EC for OH1138(1) increased between July and September, with the Q3 and Q4 readings above the trigger level of 18,844 µS/cm. Trends in water quality for the two bores are presented in **Figure** 5-14. The graph includes available water quality data for adjacent surface water dam 27N, which shows no clear correlation to trends in OH1138. Further assessment of trends and identification of potential sources is recommended.

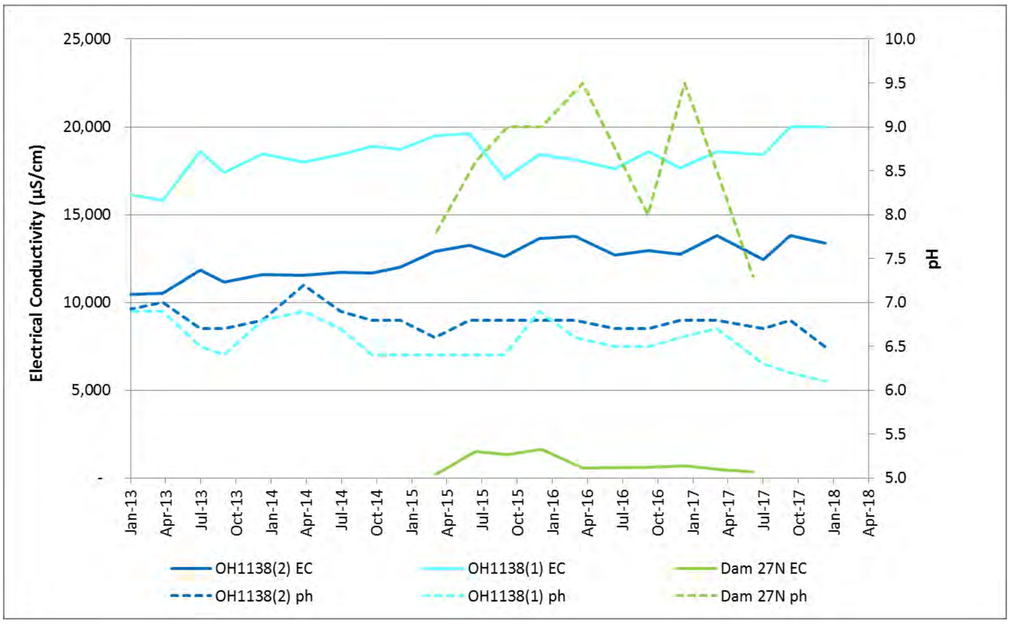


Figure 5-14 Water Quality Trends at OH1138(1) and (OH1138(2)

5.4 Groundwater Take

Interception of groundwater occurs at site due to a range of activities, including direct interception of groundwater with mining activities, and indirect interception via induced inter-formation flows due to depressurisation of the Permian coal measures. Each activity is discussed below and the estimated groundwater take for the various water sources. Note, the information presented does not capture the full mine water balance but only a summary of available information provided to SLR.

5.4.1 Groundwater Inflows to Mine Operations

A numerical groundwater model was developed for MTW and recently updated by AGE (2015). The model was calibrated to 2014 and replicates mine progression to year 2035. As discussed in **Section 2.2**, AGE (2015) present predicted groundwater take (direct and indirect) from the various groundwater sources. AGE (2015) report that MTW operations were predicted to intercept up to approximately 500 ML of water from the North Coast Fractured and Porous Rock water source. AGE (2015) report that the predicted indirect interception of water, via inter-formational flows due to depressurisation of the Permian coal measures, for 2017 was approximately:

- 3.5 ML from the Hunter River Regulated Water Source; and
- 9.5 ML from the Hunter Unregulated and Alluvial Water Sources.

5.4.2 Surface Water Abstraction

Over 2017, surface water was abstracted from the Hunter River in accordance with licence conditions. Metered volumes recorded by Yancoal show 1,625 ML of water was pumped from the Hunter River over the 2017 calendar year.

5.4.3 Groundwater abstraction

Lemington Underground bore is an abstraction bore at the Hunter Valley Operations. The bore is constructed into the abandoned LUG mine void underlying HVO and is licensed to take up to 1,800 ML of water from the North Coast Fractured and Porous Rock aquifer (20BL173392) per water year. The licenses is held by HVO, but utilised by MTW as part of a water sharing agreement.

The bore is equipped with a flow meter, with total monthly abstraction documented. Based on the flow volumes recorded from July 2016 to June 2017, 901 ML of water was abstracted from the Lemington Underground bore, which is within the licensed allocation of 1,800 ML/year. From June 2017 to December 2017 826 ML of water was abstracted. Further details on the groundwater related impacts from abstraction is presented within the HVO annual review.

5.4.4 Summary of Water Take For 2017

Water take from the various groundwater and surface water sources associated with MTW are presented in **Table 5-2** for the 2017 calendar year. Abstraction volumes from the Lemington Underground bore are not presented within **Table 5-2** as they are captured within the HVO annual groundwater review.

Table 5-2 Predicted Groundwater Take for 2017

	Hunter Regulated	Hunter Unregulated	North Coast Fractured and Porous Rock
Mt Thorley Pit Excavation	~3.0	~5.5	~250
Warkworth Pit Excavation	~0.5	~4.0	~250
Surface Water Abstraction	1,621	0	-
Total	**1,625**	**9.5**	**500**

As shown in **Table 5-2**, over the 2017 reporting year the total take under the Hunter Regulated water source was estimated at 1,625 ML, total take from Hunter Unregulated water source was estimated at 9.5 ML and 500 ML from the North Coast Fractured and Porous Rock water source. These volumes are within the licensed volumes (see **Section 2.3**) for each water source.

5.5 Verification of Model Predictions

In accordance with Schedule 3 Condition 26(b) (Mount Thorley SSD 6465) and Condition 27 (b) (Warkworth SSD 6464), the WMP includes requirements to review the numerical groundwater model every 3 years, comparing monitoring results with modelled predictions. The original numerical groundwater model for MTW was developed in 2014 as part of the Continuation Project (AGE 2014a and AGE2014b). The model was developed using MODFLOW-SURFACT code to simulate groundwater response to mining over time. The model comprises 16 layers with 98,644 cells (76,089 active) per model layer. The numerical groundwater model was updated in 2015 by AGE (2015), with changes made to the model design (i.e. mine progress, extent of alluvium, flood levee and final void) and the hydraulic parameters recalibrated.

SLR were provided with the AGE (2015) numerical groundwater model predictions, which have been graphed against observed groundwater levels at the site in **Appendix E**. Review of the trends has identified that the predicted groundwater level trends generally correspond to trends within observed data. However, at a few of the bores and VWP sensors the model predicted less drawdown than observed, as discussed below:

- GW9707, GW9708 and GW9709 – groundwater observations recorded a slight decline over 2017 compared to stable levels within the model. The model replicated the bores as being within layer 16 (basement) but construction details indicate the bores are within the shallow (<30 m deep) weathered Bayswater Seam.
- OH1123 – groundwater observations indicate a rapid decline in groundwater levels from 2014, while the model predicted a more gradual decline in groundwater levels. The difference appears to relate to actual mine progression and model cell discretisation. Bore OH1123 was mined through around 2015; however the modelled drain cells do not immediately intersect the bore.
- OH1126, OH1137 and OH1138 – the bores intersect shallow (13 m to 53 m depth) Permian coal measures (Warkworth Seam and Vaux Seam) to the north of North Pit. The bores record a general decline in groundwater levels since 2008, while the model predicted a rise in groundwater levels. This difference may relate to how the model replicates recovery within the rehabilitated spoil at North Pit. The difference may also relate to influence of groundwater abstraction from the Lemington Underground Bore that is not replicated within the model.

- WDH462_P1 – is a VWP sensor that targets the Vaux Seam to the west of North Pit, which is mined down to the shallow Mt Arthur Seam. The bore recorded a decline in groundwater levels since 2011, while the model predicted a rise in groundwater levels. As outlined within the AGE (2014a) groundwater assessment report, this likely relates to depressurisation of the seams below the base of the pit as well as cumulative impacts from surrounding operations.
- WOH2153A, WOH2154A, WOH2155A and WOH2156A – all four bores are reported to intersect the Redbank Creek Seam at depths of between 30 m and 70 m. This seam is not present within the numerical groundwater model; therefore, the bores are represented in the model as intersecting the lower permeability interburden material in Layer 4.

Overall, the numerical model appears to adequately replicate observed changes in groundwater levels for 2017. For future consideration, work could be conducted to further refine the model predictions, as follows:

- Better match between actual mine progression and predicted mine progression (including spoil emplacement) for operations at MTW and surrounding mine operations;
- Include groundwater abstraction from Lemington Underground bore within the model;
- Include current climate and streamflow trends, as well as incorporate data from recently installed bores (i.e. MB15MTW bores);
- Review calibrated parameters for spoil and vertical hydraulic conductivity within the Permian coal measures;
- Review monitoring bore construction details and confirm water bearing zones being monitored, and
- Review the model structure and compare to the site geological model and available drill data.

6 Conclusions and Recommendations

6.1 Conclusions

This annual groundwater review covers data collected over 2017 and was completed in compliance with:

- Warkworth Mine in accordance with Condition 25 of the Warkworth Consent (SSD6464) Statement of Commitments; and
- Mt Thorley Mine in accordance with Condition 27 of Development Consent (SSD 6465)

Over 2017 operations across MTW included active mining at North Pit, West Pit, South Pit and Loders Pit. Tailings Dam 1 has been rehabilitated, and Tailings Dam 2 undergoing rehabilitation, with excess water being actively dewatered.

Review of climate data indicates the region generally experienced below average rainfall over 2017 (490 mm), with the exception of above average rainfall in March (151 mm). Similar trends are reflected in stream levels for the Hunter River and Wollombi Brook from the HITS stations.

The groundwater bore network at MTW comprises 75 bores that were installed progressively over the life of the operations and acquired through land purchase. According to the WMP, sampling is undertaken via bailer method for all samples requiring only pH and EC. It is unclear if this planned approach utilises industry guideline compliant point source sampling equipment and\or methodologies to obtain representative samples. Over 2017 monitoring of the groundwater bore network was generally conducted in accordance with the Groundwater Monitoring Program outlined within the WMP. However, the WMP monitoring approach may not meet industry standards and the condition of the bores (i.e. 32 mm casing) may inhibit the ability to collect representative water quality samples. In addition, water level and water quality readings were not taken for 19 bores due to a range of factors such as dry or blocked bore conditions and access restrictions. VWP data has also not been reviewed due to correction details not being available and issues with the condition of VWPs (i.e. battery failure).

Review of groundwater level trends indicates that where saturated, water within the alluvium declined slightly over 2017, generally in line with climate and stream flow trends. Groundwater within the Permian coal measures remained relatively stable to slightly declining over 2017.

Review of water quality results and comparison to trigger levels for EC and pH identified several trigger exceedances over 2017. It was identified that several bores exceeded triggers for EC and pH; however 2017 readings were in line with historical trends for these bores. Groundwater quality trends outside of historical trends were observed for bores WOH2139A and OH1138, the cause of which will require further review.

A numerical groundwater model was developed in 2014 as part of the continuation project (AGE 2014a and AGE2014b) and recalibrated in 2015 (AGE 2015). Modelled groundwater levels (AGE 2015) were compared to recent observed groundwater levels. Overall, the model generally replicates observed groundwater trends and therefore provides a reasonable representation of 2017 groundwater conditions. To further refine the predictions into the future, additional updates to the model have been identified.

Quantification of groundwater take was undertaken based on reported volumes estimated for approved operations by AGE (2015) and metered abstraction volumes from bores and surface water pumps. Based on this, over the 2017 reporting year the total take under the Hunter Regulated water source was estimated at 1,625 ML. Total take from Hunter Unregulated water source was estimated at 9.5 ML and 500 ML from the North Coast Fractured and Porous Rock water source.

6.2 Recommendations

Based on review of the available data for 2017, the following recommendations have been made:

- Review of the groundwater monitoring network should be conducted to clearly outline the purpose and applicability of each bore for assessing potential groundwater related impacts. This includes assessing bore depth and construction.
- Check surveyed ground and casing elevations for bores, particularly the MB15MTW bores.
- Review of monitoring techniques should be undertaken to ensure a representative groundwater quality sample is collected for all monitoring events, consistent with industry best practice guidelines and procedures.
- Review groundwater quality triggers to ensure they are reasonable and adequately capture historical trends for bores.
- Further assess the potential sources of groundwater trends at bore OH1138 and WOH2139A.
- Consider updating model input files and verifying model structure in future iterations of the numerical groundwater model.

7 References

Australasian Groundwater and Environmental Consultants 2013, *Warkworth Mine Modification Groundwater Impact Assessment*, Appendix C in Warkworth Modification 6 Environmental Assessment, prepared for EMGA Mitchell McLennan, August 2013.

Australasian Groundwater and Environmental Consultants 2014a, *Warkworth Continuation 2014 Groundwater Assessment*, prepared for EMGA Mitchell McLennan, May 2014.

Australasian Groundwater and Environmental Consultants 2014b, *Mount Thorley 2014 Groundwater Assessment*, prepared for EMGA Mitchell McLennan, May 2014.

Australasian Groundwater and Environmental Consultants 2015, *Mount Thorley and Warkworth Mines, Long Term Approvals Model Update*, February 2015.

APPENDIX A

Groundwater Monitoring Program

ID	Easting	Northing	Top of Casing Elevation (mAHD)	Bore Depth (mbTOC)	Geology	Groundwater Monitoring Program			
						Water Level	EC	pH	Full WQ
OH786	320542	6392674	55.7	7.1	Hunter River Alluvium	Q	Q	Q	A
OH787	320982	6391921	50.0	12.1	Hunter River Alluvium	Q	Q	Q	A*
OH788	321482	6390967	45.4	22.1	Hunter River Alluvium	Q	Q	Q	A
OH942	320536	6392622	55.8	13.2	Hunter River Alluvium	Q	Q	Q	A*
OH943	321476	6390963	45.0	9.9	Hunter River Alluvium	Q	Q	Q	A
OH944	321113	6391035	47.9	8.2	Hunter River Alluvium	Q	Q	Q	A
G3(2)	317787	6385253	73.0	4.1	Wollombi Brook Alluvium				
PZ8S	317002	6385411	65.8		Wollombi Brook Alluvium	Q	Q	Q	A
PZ9S	317542	6385642	65.4	6.9	Wollombi Brook Alluvium	Q	Q	Q	A
MB15MTW01S	315909	6385605			Wollombi Brook Alluvium	Q	Q	Q	A
MB15MTW02S	313823	6387224			Wollombi Brook Alluvium	Q	Q	Q	A
MBW01	314379	6386796	62.4	11.0	Alluvium	Q	Q	Q	A
PZ7S	314055	6392671	58.4	11.1	Aeolian Warkworth Sands	Q	Q	Q	A
MB15MTW04	314993	6392645		6.5	Warkworth Sands	Q	Q	Q	A
MB15MTW05	314645	6392758		6.9	Warkworth Sands	Q	Q	Q	A
MB15MTW06	314438	6392801		6.9	Warkworth Sands	Q	Q	Q	A
MB15MTW07	314965	6392085		6.8	Warkworth Sands	Q	Q	Q	A
MB15MTW08	314296	6392182		6.8	Warkworth Sands	Q	Q	Q	A
MB15MTW09	313995	6392219		3.1	Warkworth Sands	Q	Q	Q	A
MB15MTW10	314667	6392134		3.7	Warkworth Sands	Q	Q	Q	A
MB15MTW11	314352	6392417		6.9	Warkworth Sands	Q	Q	Q	A
PZ7D	314057	6392684	58.4	30.5	Shallow Overburden	Q	Q	Q	A
PZ8D	317001	6385418	65.8	37.0	Shallow Overburden	Q	Q	Q	A
PZ9D	317541	6385652	65.5	24.0	Shallow Overburden	Q	Q	Q	A
MTD616P	316269	6387618	77.8	29.0	Shallow Overburden	Q	Q	Q	A
MTD614P	317259	6386175	72.6	30.0	Shallow Overburden - Conglomerate	Q	Q	Q	A
MBW02	314373	6386798	62.6	60.4	Shallow Overburden	Q	Q	Q	A
MB15MTW01D	315910	6385604			Shallow Overburden? Alluvium?	Q	Q	Q	A
MTD605P	316279	6386156	77.4	42.0	Shallow Overburden - sandstone	Q	Q	Q	A
MB15MTW02D	313823	6387219			Shallow Overburden? Alluvium?	Q	Q	Q	A
MB15MTW03	313722	6388917		22.7	Shallow Overburden - Wollombi alluvium?	Q	Q	Q	A
WD625P	314669	6390487	76.4	31.0	Whybrow Seam	Q	Q	Q	A
WOH2153A	313881	6391429	68.3	42.6	Redbank Crk Seam	Q	Q	Q	A
WOH2154A	313976	6389990	68.9	69.4	Redbank Crk Seam	Q	Q	Q	A
WOH2155A	315278	6390138	74.6	46.0	Redbank Crk Seam	Q	Q	Q	A
WOH2156A	315874	6388866	80.4	31.5	Redbank Crk Seam	Q	Q	Q	A
WOH2153B	313881	6391429	68.3	62.4	Wambo Seam	Q	Q	Q	A
WOH2154B	313976	6389990	68.9	98.0	Wambo Seam	Q	Q	Q	A
WOH2155B	315278	6390138	74.6	73.1	Wambo Seam	Q	Q	Q	A
WOH2156B	315874	6388866	80.4	80.1	Wambo Seam	Q	Q	Q	A
WD622P	316229	6389585	84.5	55.0	Wambo Seam	Q	Q	Q	A
MBW04	314368	6386800	62.4	162.0	Wambo	Q	Q	Q	A
WOH2139A	315249	6391511	91.7	96.0	Blakefield	Q	Q	Q	A*
OH1122 (1)	318545	6387886	100.6	49.6	Blakefield Seam	Q	Q	Q	A*
OH1122 (2)	318545	6387886	100.6	112.6	Woodlands Hill Seam				
OH1122 (3)	318545	6387886	100.6	152.6	Bowfield Seam				
OH1125 (1)	316511	6392875	86.2	40.0	Blakefield	Q	Q	Q	A*

ID	Easting	Northing	Top of Casing	Bore Depth (mbTOC)	Geology	Groundwater Monitoring Program			
OH1125 (2)	316511	6392875	86.2	25.3	Unknown - Blakefield?	Q	Q	Q	A*
OH1125 (3)	316511	6392875	86.2	62.7	Bowfield Seam	Q	Q	Q	A*
OH1138 (1)	317835	6393346	70.7	24.8	Warkworth Seam	Q	Q	Q	A
OH1138 (2)	317835	6393346	70.7	42.8	Warkworth Seam	Q	Q	Q	A
OH1121	321902	6391030	45.6	20.3	Vaux	Q	Q	Q	A
OH1126	318586	6393387	64.5	52.5	Vaux	Q	Q	Q	A
OH1137	318266	6393377	67.9	17.8	Alluvium? WMP has Vaux?	Q	Q	Q	A
OH1127	321444	6392097	51.2	29.0	Bayswater	Q	Q	Q	A
GW 9706	322404	6387589	64.2	21.2	Bayswater	Q	Q	Q	A
GW 9707	322319	6387569	63.9	21.0	Bayswater	Q	Q	Q	A
GW 9708	322158	6387209	73.1	29.6	Bayswater	Q	Q	Q	A
GW 9709	322251	6388026	60.3	21.0	Bayswater	Q	Q	Q	A
GW98 MTCL 1	322188	6387032	77.8	19.7	Bayswater	Q	Q	Q	A
GW98 MTCL 2	322669	6387462	79.5	27.6	Bayswater	Q	Q	Q	A
WOH2141A	314989	6392647	91.6	45.6	Whynot Seam	Q	Q	Q	A
PZ1_VW1	321350	6387310	72.1	41.0	Mt Arthur Seam (Shallow)	Q			
PZ1_VW2	321350	6387310	72.1	42.0	Mt Arthur Seam (Deep)	Q			
PZ2_VW1	321445	6387218	68.1	48.6	Mt Arthur Seam (Shallow)	Q			
PZ2_VW2	321445	6387218	68.1	49.6	Mt Arthur Seam (Deep)	Q			
WD609A	318803	63922	129.9	110.0	Spoil	Q			
WD615_P1	319281	6391347	160.0	133.0	Piercefield Seam	Q			
WD615_P2	319281	6391347	160.0	225.0	Bayswater Seam	Q			
WD625_P1	314663	6390483	76.4	217.0	Woodlands Hill	Q			
WD625_P2	314663	6390483	76.4	354.0	Mt Arthur Seam	Q			
WD625_P3	314663	6390483	76.4	375.0	Vaux Seam	Q			
WD625_P4	314663	6390483	76.4	441.0	Bayswater Seam	Q			
WD622_P1	316236	6389588	84.5	54.0	Wambo Seam	Q			
WD622_P2	316236	6389588	84.5	165.0	Woodlands Hill Seam	Q			
WD622_P3	316236	6389588	84.5	314.0	Mt Arthur Seam	Q			
WD622_P4	316236	6389588	84.5	334.0	Vaux Seam	Q			
WD622_P5	316236	6389588	84.5	408.0	Bayswater Seam	Q			
MTD616_P1	316274	6387621	77.7	42.0	Whybrow Seam	Q			
MTD616_P2	316274	6387621	77.7	109.0	Wambo Seam	Q			
MTD616_P3	316274	6387621	77.7	215.0	Woodlands Hill Seam	Q			
MTD616_P4	316274	6387621	77.7	343.0	Mt Arthur Seam	Q			
MTD616_P5	316274	6387621	77.7	378.0	Vaux Seam	Q			
MTD616_P6	316274	6387621	77.7	446.0	Bayswater Seam	Q			
MTD613 (VWP)	320778	6387025	150.5	384.0	Broonie/Bayswater Seam?	Q			
MTD605_P1	316512	6386159	77.1	58.0	Weathered OB over Whybrow	Q			
MTD605_P2	316512	6386159	77.1	100.0	Whybrow Seam	Q			
MTD605_P3	316512	6386159	77.1	149.0	IB btw Wambo and Whynot	Q			
MTD605_P4	316512	6386159	77.1	215.0	Blakefield Seam	Q			
MTD605_P5	316512	6386159	77.1	368.0	Mt Arthur Seam	Q			
MTD605_P6	316512	6386159	77.1	429.0	Vaux Seam	Q			
MTD605_P7	316512	6386159	77.1	502.0	Bayswater Seam	Q			
MTD614_P1	317265	6386174	72.4	64.0	Whybrow Seam	Q			
MTD614_P2	317265	6386174	72.4	191.0	Glen Munro Seam	Q			
MTD614_P3	317265	6386174	72.4	342.0	Mt Arthur Seam	Q			
MTD614_P4	317265	6386174	72.4	383.0	Vaux Seam	Q			
MTD614_P5	317265	6386174	72.4	453.0	Bowfield Seam	Q			
WD456 (VWP)			100.6		Bayswater Seam	Q			

ID	Easting	Northing	Top of Casing	Bore Depth (mbTOC)	Geology	Groundwater Monitoring Program			
WD462_P1	315529	6391358	101.7	354.6	Vaux Seam	Q			
WD462_P2	315529	6391358	101.7	354.6	Bowfield Seam	Q			
WD462_P3	315529	6391358	101.7	354.6	Woodlands Hill Seam	Q			
MTD517_P1	317521	6386147	77.3		Mt Arthur Seam	Q			
MTD517_P2	317521	6386147	77.3		Woodlands Hill Seam	Q			
MTD517_P3	317521	6386147	77.3		Wambo Seam	Q			
MTD518_P1	316512	6386156	80.0		Mt Arthur Seam	Q			
MTD518_P2	316512	6386156	80.0		Blakefield/Woodlands Hill Seam	Q			
MTD518_P3	316512	6386156	80.0		Wambo Seam	Q			
MBW03	314387	6386794	62.4	84.2	Whybrow Seam	Q	Q	Q	A
MBW6A						Q	Q	Q	A

Notes:

TOC – top of casing

Q – Quarterly

A – Annual

 # Comprehensive analysis includes metals Mo, V and Cr

APPENDIX B

Groundwater Level and Quality Readings 2017

Bore ID	Target Geology	EC Trigger 95th	pH Trigger 5th–95th		Q1				Q2				Q3				Q4			
					SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC
OH786	Hunter River Alluvium	924	7	7.7	0.8	54.9	**6.9**	551	1.4	54.2	7.3	730	7.0	48.7	7.6	**1435**	3.0	52.7	**6.8**	588
OH787	Hunter River Alluvium	17850	7.3	7.7	13.8	36.2	**7.2**	**18100**	13.8	36.2	7.5	17070	13.8	36.2	7.6	**18200**	13.8	36.2	7.5	**18340**
OH788	Hunter River Alluvium	11747	7.1	7.9	9.7	35.7	7.2	9440	9.8	35.6	**7.0**	11360	9.8	35.6	7.4	9600	9.8	35.6	**7.0**	11150
OH942	Hunter River Alluvium	25140	6.5	7.1	9.2	46.6	6.6	25100	9.2	46.6	6.7	23300	9.1	46.6	6.6	25100	9.7	46.0	6.6	**25500**
OH943	Hunter River Alluvium	8435	7.1	7.6	9.3	35.7	7.6	7120	9.4	35.7	7.5	7300	9.4	35.7	7.6	7610	9.4	35.7	7.5	7640
OH944	Hunter River Alluvium				Dry				Dry				Dry				Dry			
G3(2)	Wollombi Brook Alluvium																			
PZ8S	Wollombi Brook Alluvium	15200	6.6	7	5.4	60.3	6.7	14900	5.5	60.2	6.6	14090	5.6	60.2	6.7	14860	5.6	60.1	6.7	14980
PZ9S	Wollombi Brook Alluvium	16140	6.7	6.9	7.0	58.5	6.9	**16190**	6.3	59.2	6.8	13100	6.3	59.1	6.8	15810	6.4	59.0	**7.0**	7640
MB15MTW01S	Wollombi Brook Alluvium												5.8	54.2	6.8	1850	6.1	53.9	7.2	1419
MB15MTW02S	Wollombi Brook Alluvium												5.4	54.6	7.3	2240	5.8	54.2	7.2	2360
PZ7S	Aeolian Warkworth Sands	1749	6.7	7.5	6.8	51.7	6.9	1585	7.1	51.4	6.7	1480	7.0	51.5	7.2	1344	7.1	51.4	6.8	1735
MBW01	Alluvium												5.3	57.1	7.3	18160	5.3	57.1	7.4	18100
MB15MTW04	Warkworth Sands				Dry				Dry				Dry				Dry			
MB15MTW05	Warkworth Sands				Dry				Dry				Dry				Dry			
MB15MTW06	Warkworth Sands				3.3	56.7			3.3	56.7			3.4	56.6	5.6	48	3.4	56.6	6.3	100
MB15MTW07	Warkworth Sands				Dry				Dry				Dry				Dry			
MB15MTW08	Warkworth Sands				Dry				Dry				Dry				Dry			
MB15MTW09	Warkworth Sands				Dry				Dry				Dry				Dry			
MB15MTW10	Warkworth Sands				Dry				Dry				Dry				Dry			
MB15MTW11	Warkworth Sands				Dry				Dry				Dry				Dry			
PZ7D	Shallow Overburden	17444	6.9	8.1	6.7	51.8	8.0	1675	6.9	51.5	7.5	1694	6.8	51.6	7.7	1600	6.9	51.5	7.6	1604
PZ8D	Shallow Overburden	17444	6.9	8.1	5.9	59.9	7.5	8520	6.1	59.7	7.4	8390	6.2	59.6	7.4	8460	6.2	59.6	7.5	8460

Bore ID	Target Geology	EC	pH Trigger		Q1				Q2				Q3				Q4			
PZ9D	Shallow Overburden	17444	6.9	8.1	18.3	47.2	7.0	10400	18.1	47.4	7.0	9100	17.9	47.6	6.9	10370	18.4	47.1	7.0	10370
MTD616P	Shallow Overburden	17444	6.9	8.1	6.7	71.1	7.6	14080	6.8	71.0	**6.8**	14100	6.8	71.0	7.7	14080	7.0	70.8	7.6	14750
MTD614P	Shallow Overburden - Conglomerate	17444	6.9	8.1	17.7	54.9	7.4	6150	18.0	54.6	7.5	5830	17.9	54.7	7.3	6290	17.9	54.7	7.2	6430
MBW02	Shallow Overburden	17444	6.9	8.1									7.3	55.3	7.2	10630	7.4	52.2	7.0	1533
MB15MTW01D	Shallow Overburden?	17444	6.9	8.1	6.3	53.7			5.6	54.4			5.9	54.1	7.8	3580	6.2	53.8	**6.3**	1814
MTD605P	Shallow Overburden - sandstone	17444	6.9	8.1	15.0	62.4	7.7	**17850**	15.0	62.3	7.3	17390	15.0	62.4	**6.7**	**17490**	15.0	62.4	7.5	**17580**
MB15MTW02D	Shallow Overburden?	17444	6.9	8.1	6.2	53.8			5.4	54.6			5.5	54.5	8.0	10400	6.0	54.0	7.7	1610
MB15MTW03	Shallow Overburden?	17444	6.9	8.1	5.5	54.5			5.5	54.5			**5.6**	54.5	7.0	**12830**	**5.7**	54.3	7.2	**12420**
WD625P	Whybrow Seam	12026	7.1	7.3	16.4	60.0	7.3	11690	18.5	58.0	7.2	11290	18.4	58.0	7.1	11960	18.3	58.1	7.1	11880
MBW03	Whybrow Seam												7.1	55.3	7.3	9760	7.2	55.1	7.3	9720
WOH2153A	Redbank Crk Seam	16168	7	7.9	11.2	57.0	**8.0**	1850	11.7	56.6	7.8	2180	11.8	56.5	7.7	1904	12.5	55.7	7.6	1929
WOH2154A	Redbank Crk Seam	16168	7	7.9	12.5	56.4	7.6	4440	12.9	56.0	7.5	4740	13.2	55.7	7.4	4460	14.1	54.8	7.4	4270
WOH2155A	Redbank Crk Seam	16168	7	7.9	16.9	57.7	7.6	5950	17.0	57.5	7.2	8570	17.9	56.7	7.4	6680	19.1	55.4	7.5	6710
WOH2156A	Redbank Crk Seam	16168	7	7.9	23.8	56.6	7.1	14190	24.0	56.4	7.0	14140	24.8	55.6	7.0	13900	26.3	54.1	7.0	14700
WOH2153B	Wambo Seam	13658	7	7.9	10.5	57.8	7.4	1633	10.7	57.6	7.3	1694	10.4	57.9	7.2	1680	10.6	57.7	7.3	1683
WOH2154B	Wambo Seam	13658	7	7.9	12.6	56.3	7.6	4540	12.6	56.3	7.5	4580	12.3	56.6	7.3	4740	12.5	56.4	7.3	4730
WOH2155B	Wambo Seam	13658	7	7.9	14.3	60.3	7.6	5410	14.4	60.2	7.6	5390	14.4	60.2	7.4	5470	14.4	60.1	7.5	5510
WOH2156B	Wambo Seam	13658	7	7.9	12.8	67.6	7.3	13190	12.6	67.8	7.4	**13810**	12.9	67.5	7.4	13330	12.7	67.7	7.2	13550
WD622P	Wambo Seam	13658	7	7.9	26.9	57.6	7.4	8650	26.9	57.6	7.0	**15120**	29.3	55.2	7.4	8460	30.6	53.8	7.3	8690
MBW04	Wambo	13658	7	7.9									11.3	51.1	7.5	13010	11.4	51.1	7.5	12940
WOH2139A	Blakefield	15148	6.6	7.6	44.5	47.3	7.5	2960	45.4	46.3	7.6	3930	46.3	45.4	**7.8**	8110	47.8	43.9	**7.9**	9310
OH1122 (1)	Blakefield Seam	15148	6.6	7.6					48.2	52.4			49.9	50.7	7.0	12250	48.8	51.7	7.0	12560
OH1125 (1)	Blakefield	15148	6.6	7.6	27.7	58.5	6.8	**15240**	26.2	60.0	6.7	12710	26.3	59.9	6.7	14450	28.3	57.9	6.7	14630
OH1125 (2)	Unknown	14736	6.6	7																
OH1125 (3)	Bowfield Seam	14736	6.6	7	46.0	40.2	6.7	14510	47.0	39.2	6.9	12880	44.3	41.9	6.7	13900	47.3	38.9	6.7	14130
OH1138 (1)	Warkworth	18844	6.4	7.1	9.4	61.4	6.7	18600	9.4	61.3	**6.3**	18400	9.5	61.2	**6.2**	**20000**	9.7	61.1	**6.1**	**19980**
OH1138 (2)	Warkworth	18844	6.4	7.1	14.2	56.5	6.8	13820	14.3	56.4	6.7	12440	14.4	56.3	6.8	13820	14.4	56.3	6.5	13390

Bore ID	Target Geology	EC	pH Trigger		Q1				Q2				Q3				Q4			
OH1121	Vaux	17624	6.7	7.1	10.5	35.1	7.1	7410	10.5	35.1	7.0	7920	10.5	35.1	7.1	7830	10.6	35.1	7.1	7980
OH1126	Vaux	17624	6.7	7.1	15.7	48.9	6.7	6680	16.0	48.5	6.7	8030	16.1	48.4	6.7	8430	16.4	48.1	6.8	7820
OH1137	Vaux	17624	6.7	7.1	13.1	54.8	6.9	16500	13.4	54.5	7.0	16370	13.5	54.4	6.9	**17760**	13.8	54.1	6.9	**18880**
OH1127	Bayswater	23000	6.7	7.5	15.7	35.5	6.9	11920	15.7	35.5	6.9	11400	15.7	35.5	6.9	12050	15.5	35.8	6.9	12190
GW 9706	Bayswater	23000	6.7	7.5	2.6	61.7	6.8	3140	2.5	61.8	6.9	4800	2.8	61.5	7.0	3320	2.6	61.6	6.9	3170
GW 9707	Bayswater	23000	6.7	7.5	4.0	59.9	7.2	19800	4.1	59.8	6.9	18400	4.4	59.5	7.2	19600	4.6	59.3	7.1	19500
GW 9708	Bayswater	23000	6.7	7.5	11.9	61.2	6.8	13970	11.9	61.2	6.7	13050	12.2	61.0	6.8	14980	12.3	60.9	6.9	16990
GW 9709	Bayswater	23000	6.7	7.5	8.9	51.5	**6.4**	21900	8.9	51.5	6.8	21100	9.2	51.1	6.7	**23200**	9.1	51.3	**6.6**	22900
GW98 MTCL 1	Bayswater	23000	6.7	7.5	11.4	66.4	7.4	5920	10.3	67.4	7.2	6580	11.2	66.6	7.3	6120	10.9	66.8	7.0	6110
GW98 MTCL 2	Bayswater	23000	6.7	7.5	10.3	69.2	**6.6**	15070	10.2	69.2	**6.6**	16150	10.4	69.0	**6.6**	15890	10.5	69.0	6.7	15870
WOH2141A	Whynot Seam	-	-	-	41.9	49.7	7.7	10130	42.3	49.3	7.8	10240	42.0	49.6	7.6	10390	42.6	49.0	7.6	10310
MBW6A		-	-	-									6.9	NS	6.4	771	7.1	NS	6.7	1000
G3	Wambo Seam	-	-	-	22.7	50.4	6.9	10960	22.1	51.0	7.2	9760								

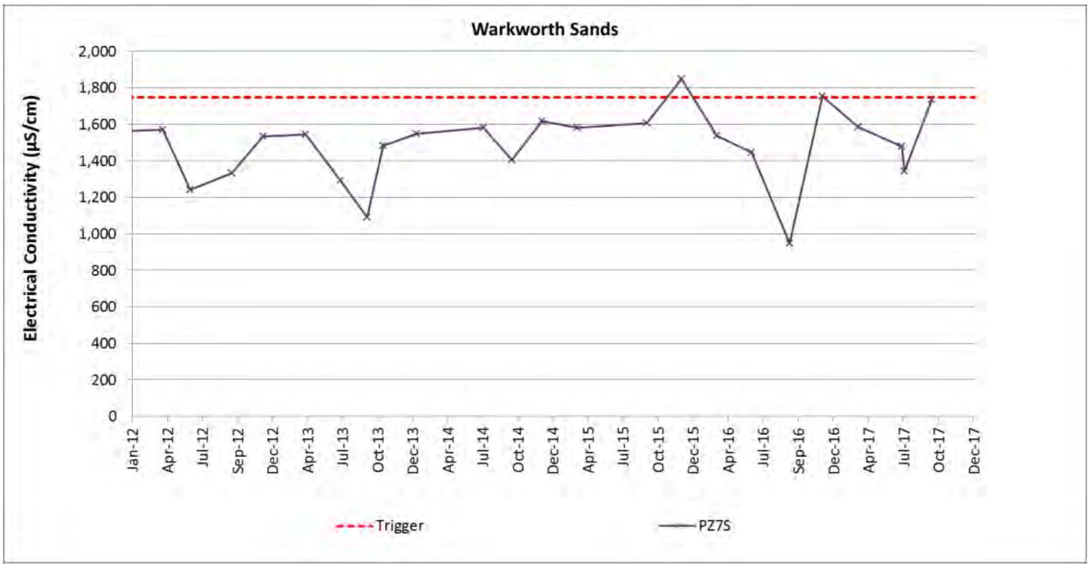
***Note**: SWL – standing water level*

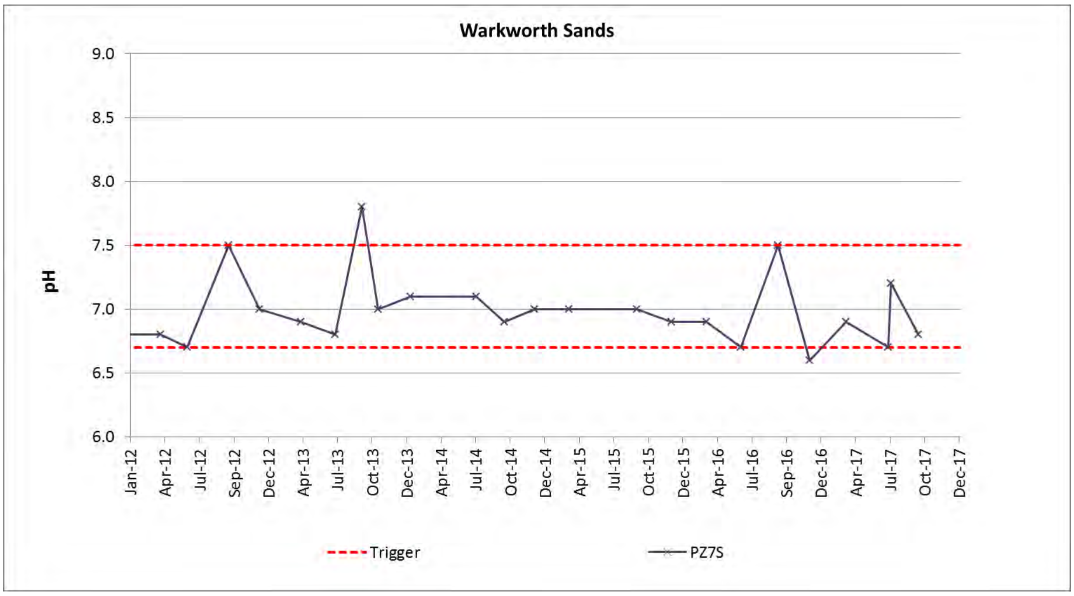
mbTOC – meters below top of casing

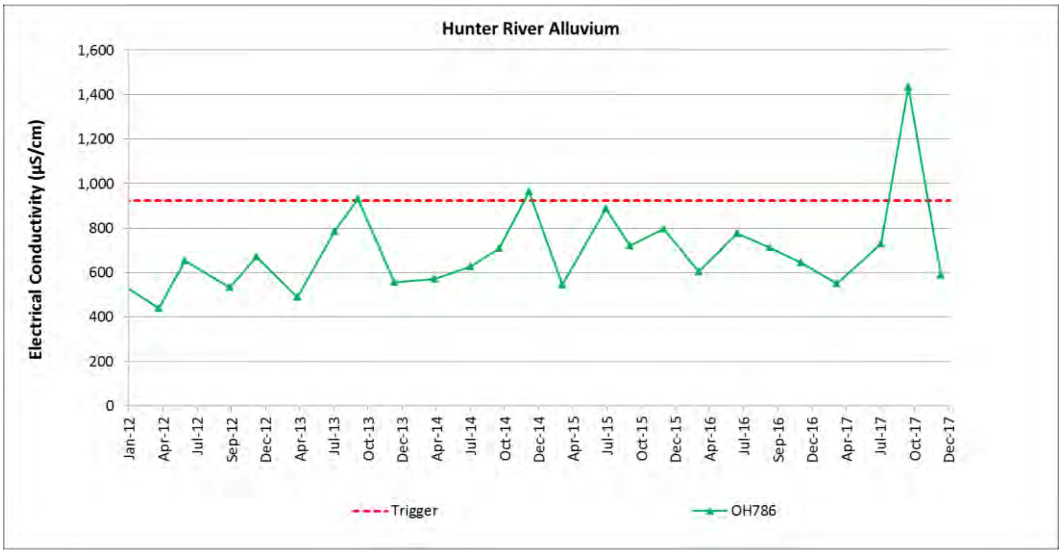
NS – Casing elevation not surveyed

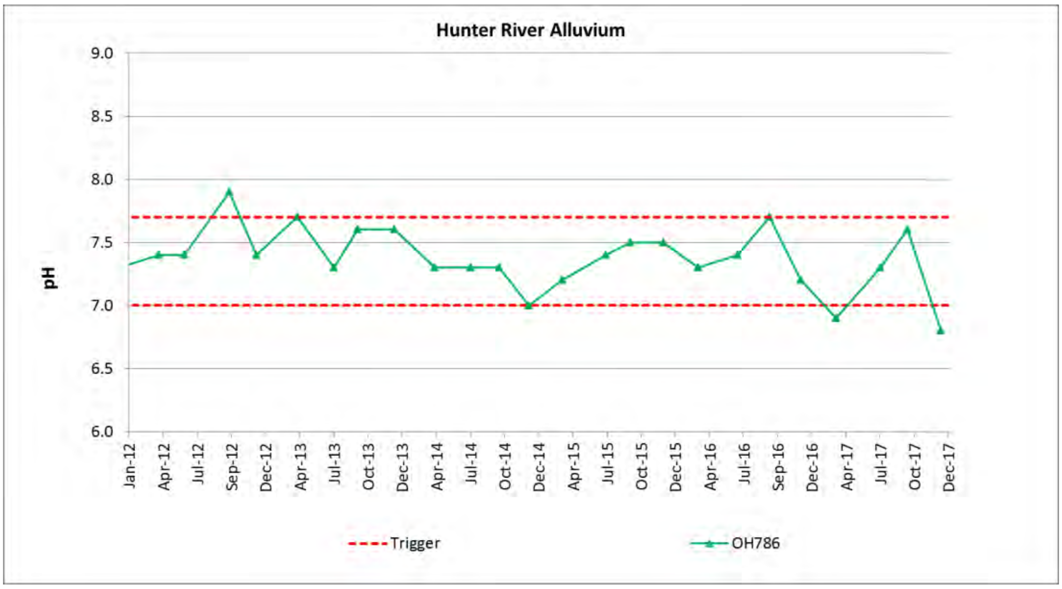
APPENDIX C

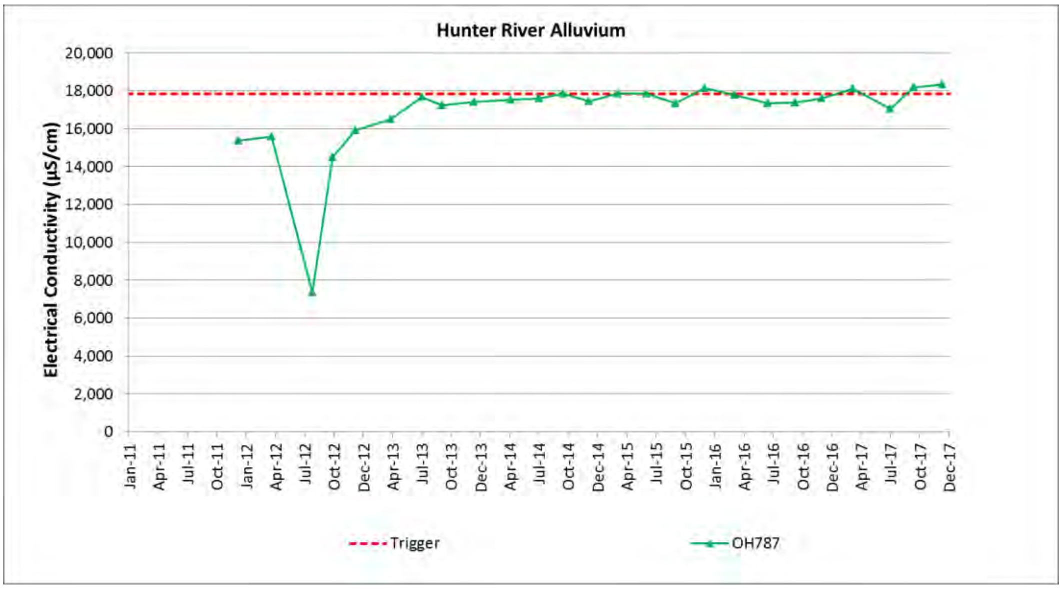
Groundwater Quality Graphs

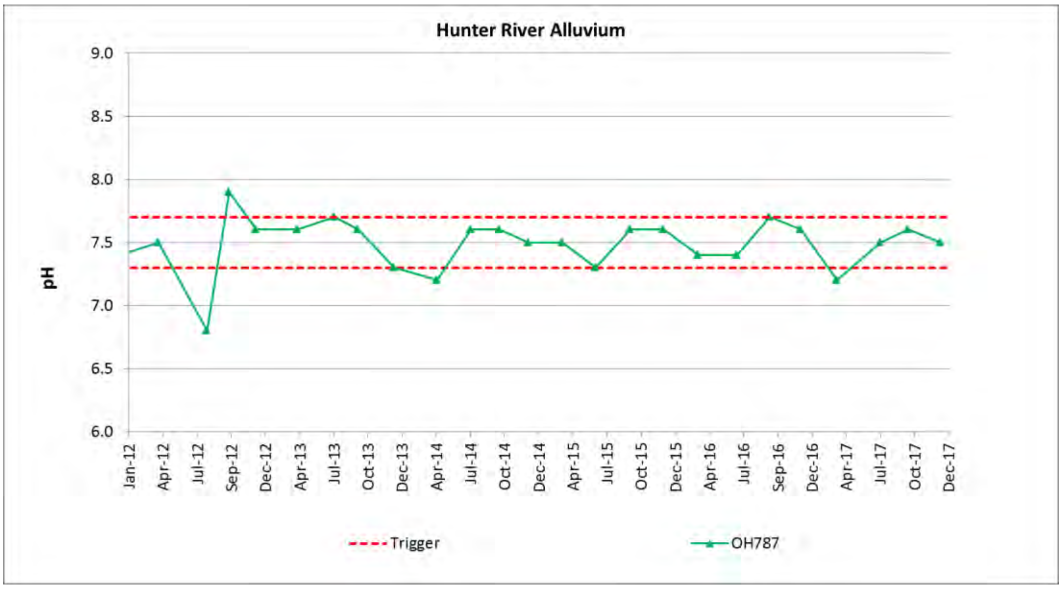

Warkworth Sands
Electrical Conductivity (µS/cm)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
PZ7S

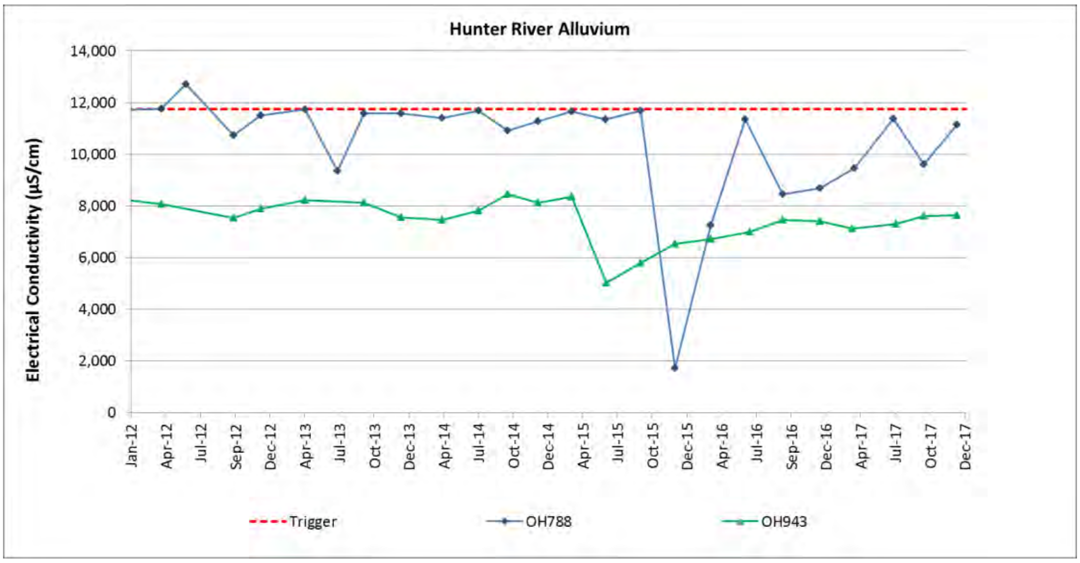

Warkworth Sands
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
PZ7S

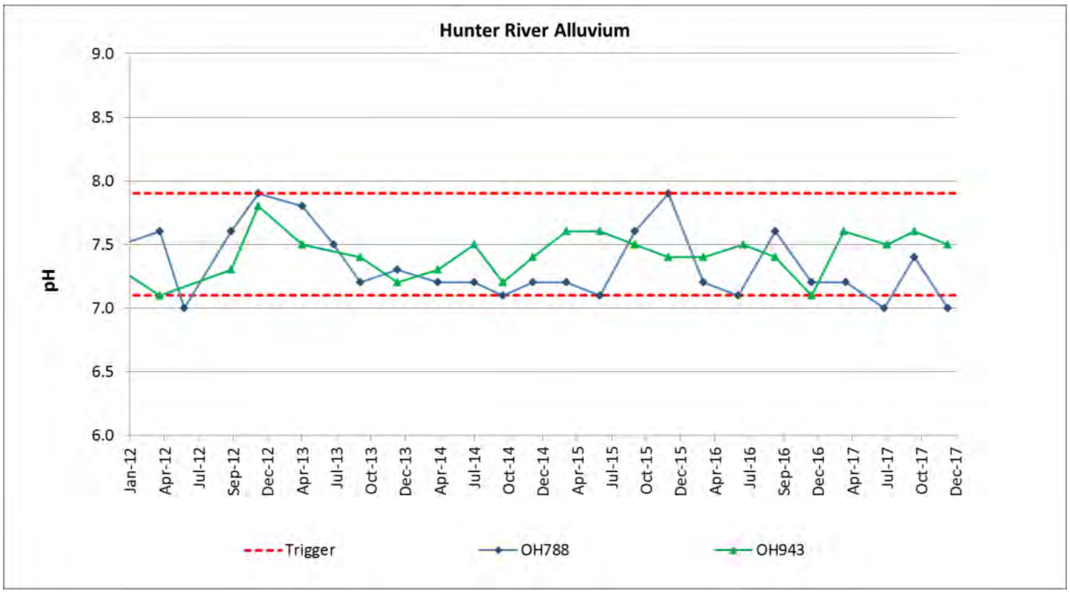

Hunter River Alluvium
Electrical Conductivity (µS/cm)
1,600
1,400
1,200
1,000
800
600
400
200
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH786

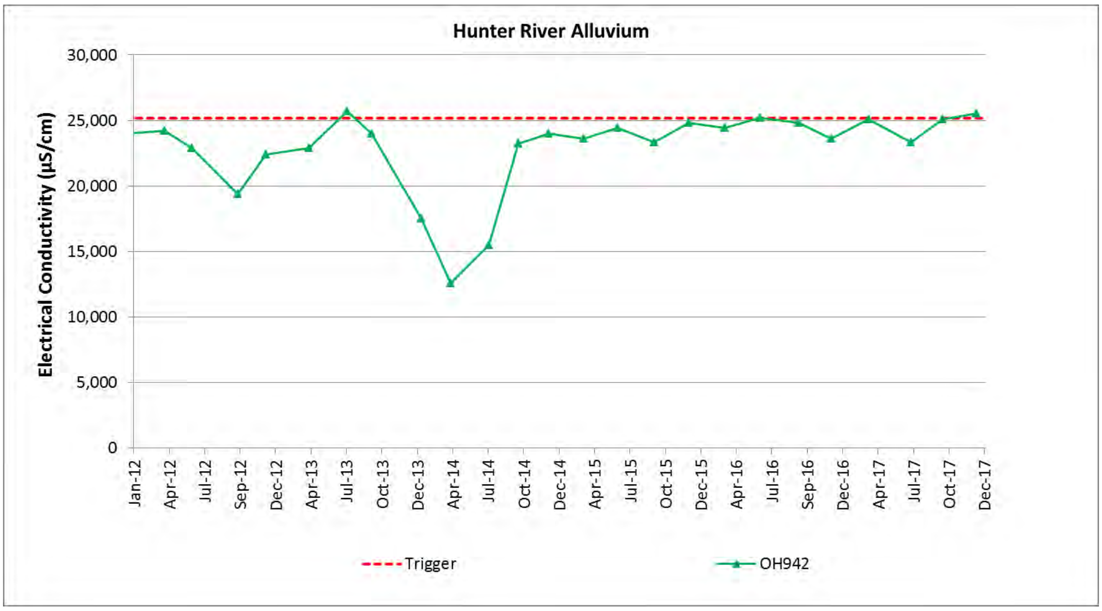

Hunter River Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH786

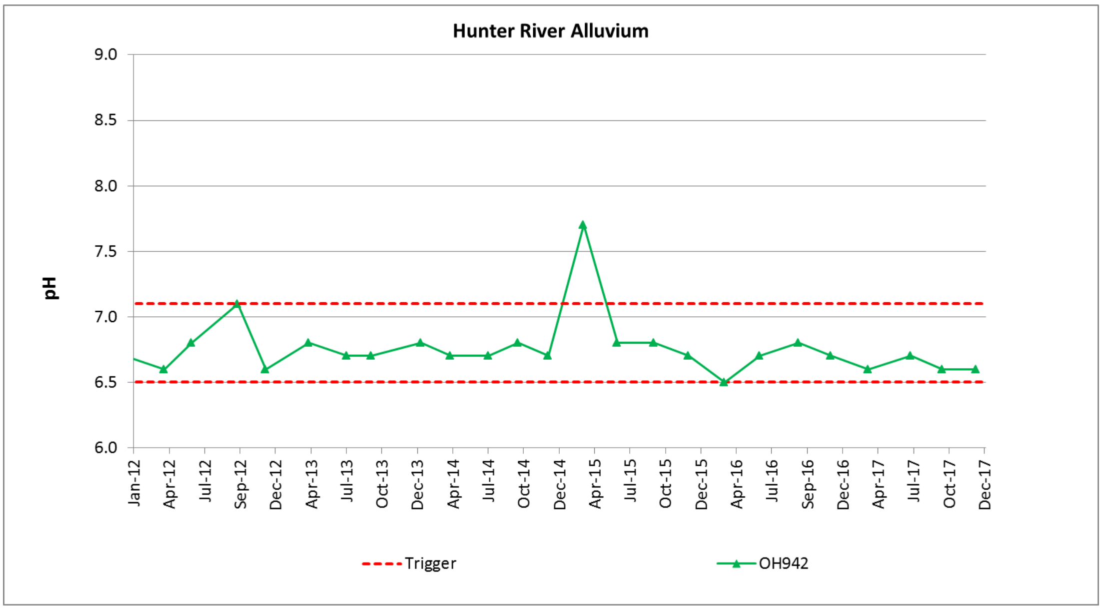

Hunter River Alluvium
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
Oct-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Jan-16
Apr-16
Jul-16
Oct-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH787

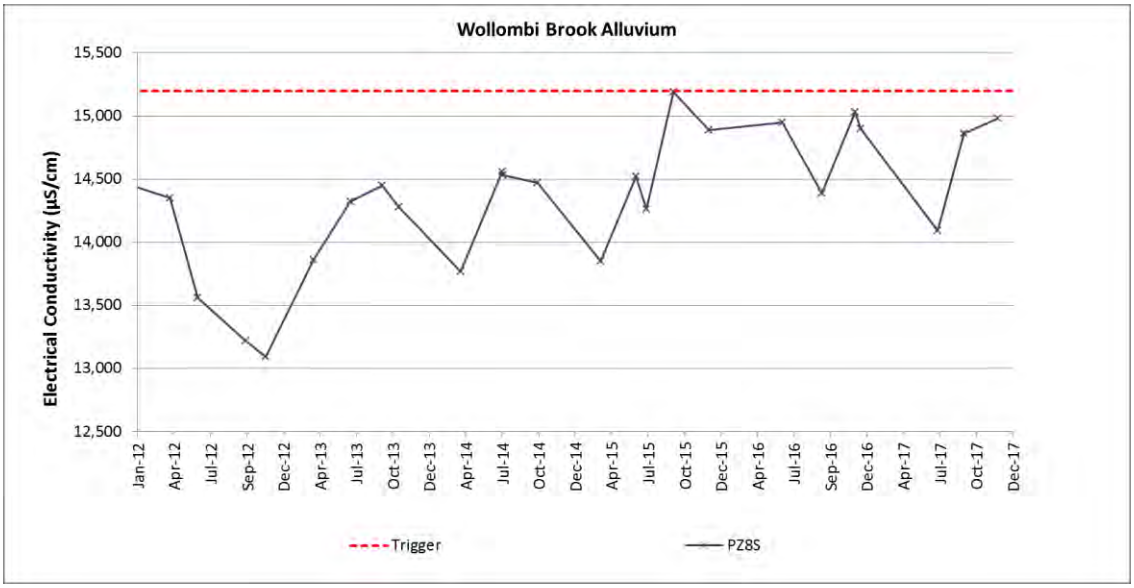

Hunter River Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH787

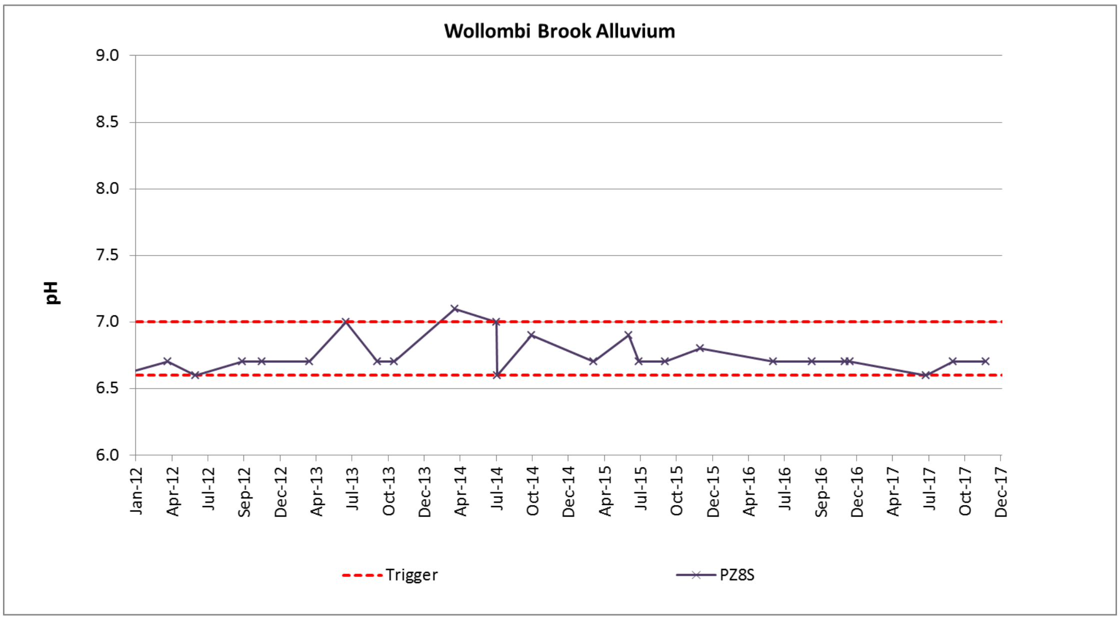

Hunter River Alluvium
Electrical Conductivity (µS/cm)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH788
OH943

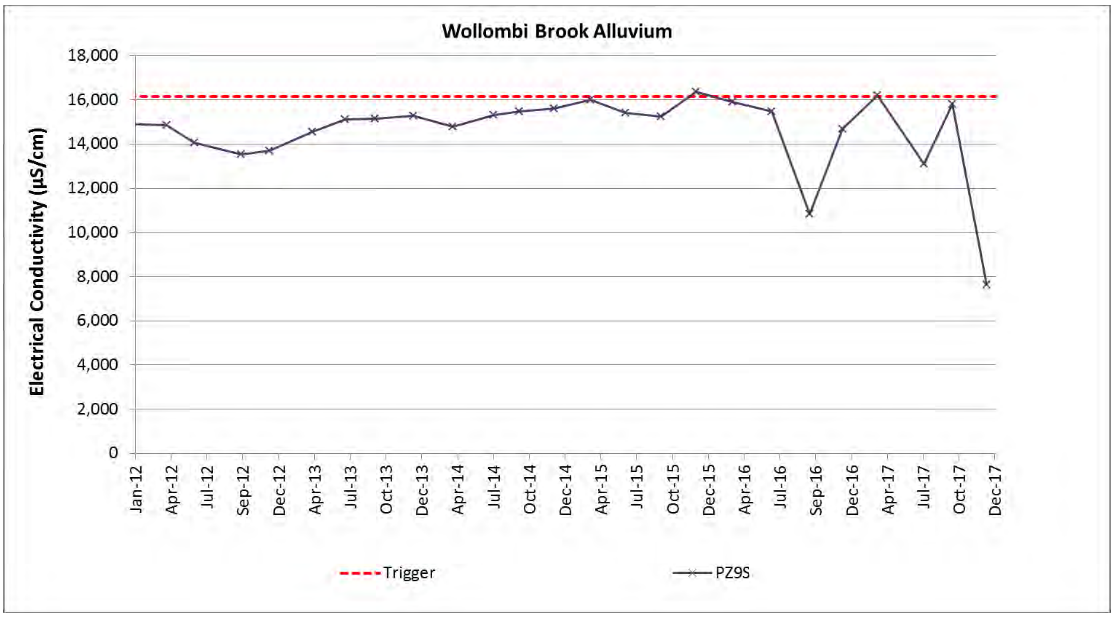

Hunter River Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH788
OH943


Hunter River Alluvium
Electrical Conductivity (µS/cm)
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH942

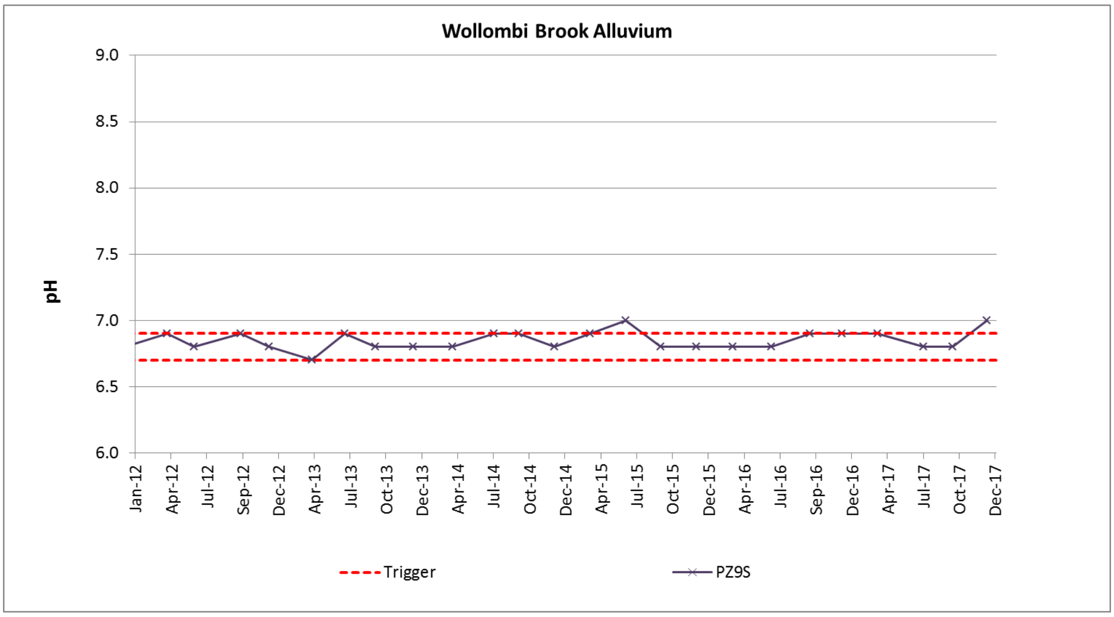

Hunter River Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH942


Wollombi Brook Alluvium
Electrical Conductivity (µS/cm)
15,500
15,000
14,500
14,000
13,500
13,000
12,500
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
PZ8S

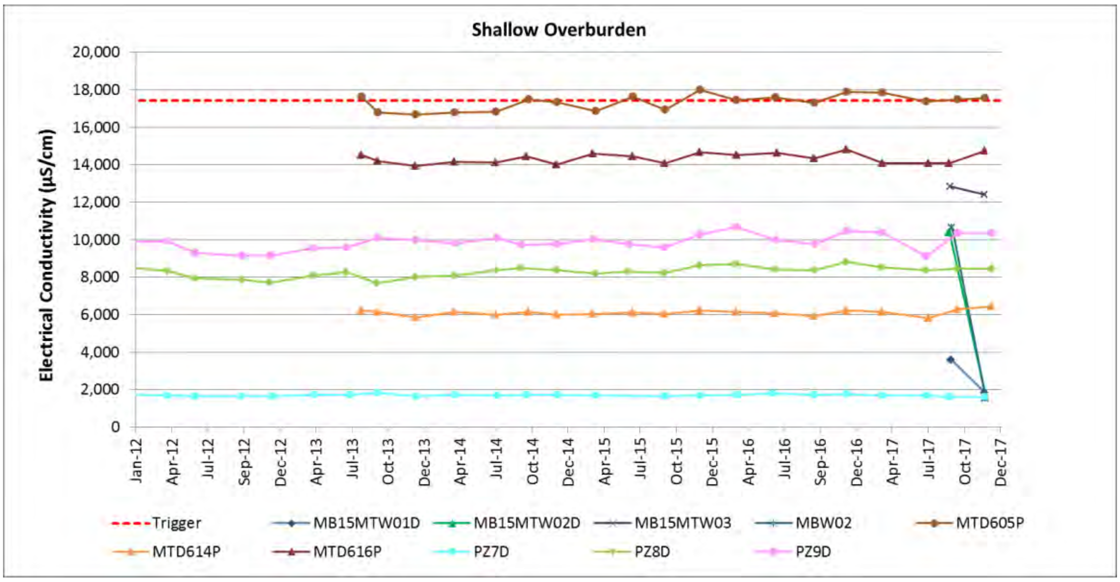

Wollombi Brook Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
PZ8S

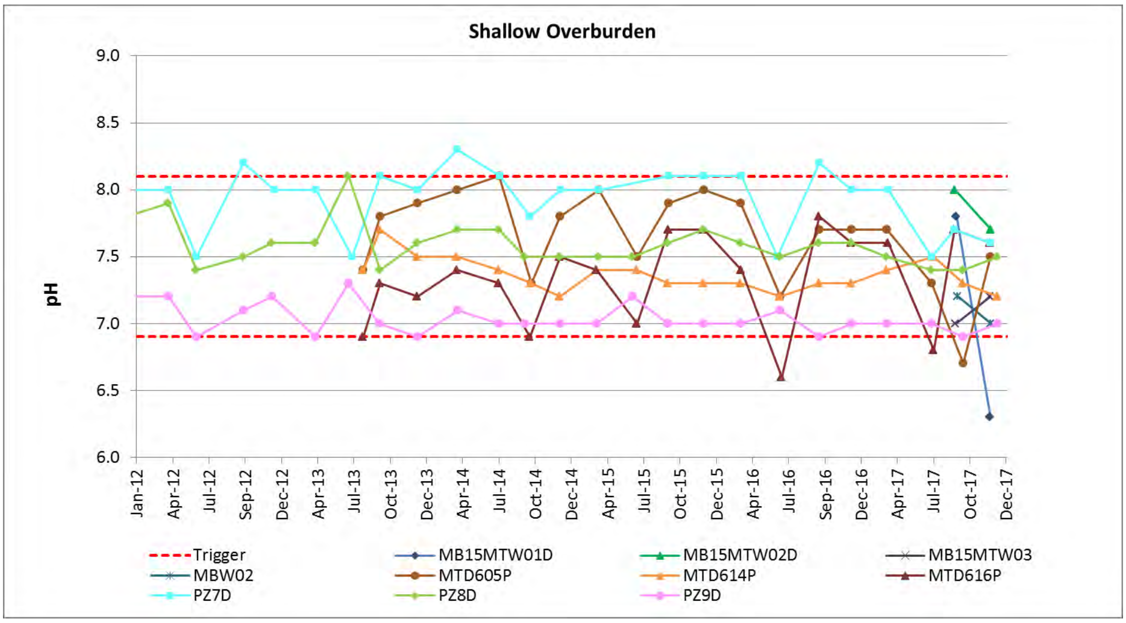


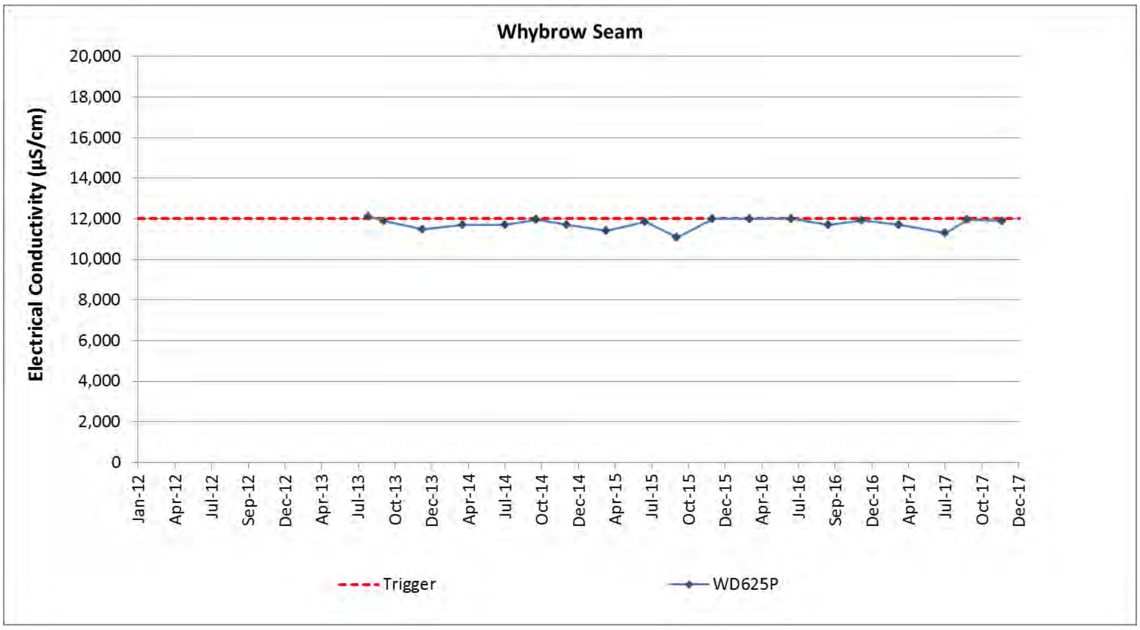
Wollombi Brook Alluvium
Electrical Conductivity (µS/cm)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
PZ9S



Wollombi Brook Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
PZ9S


Shallow Overburden
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
MB15MTW01D
MB15MTW02D
MB15MTW03
MBW02
MTD605P
MTD614P
MTD616P
PZ7D
PZ8D
PZ9D


Shallow Overburden
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
MB15MTW01D
MB15MTW02D
MB15MTW03
MBW02
MTD605P
MTD614P
MTD616P
PZ7D
PZ8D
PZ9D


Whybrow Seam
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
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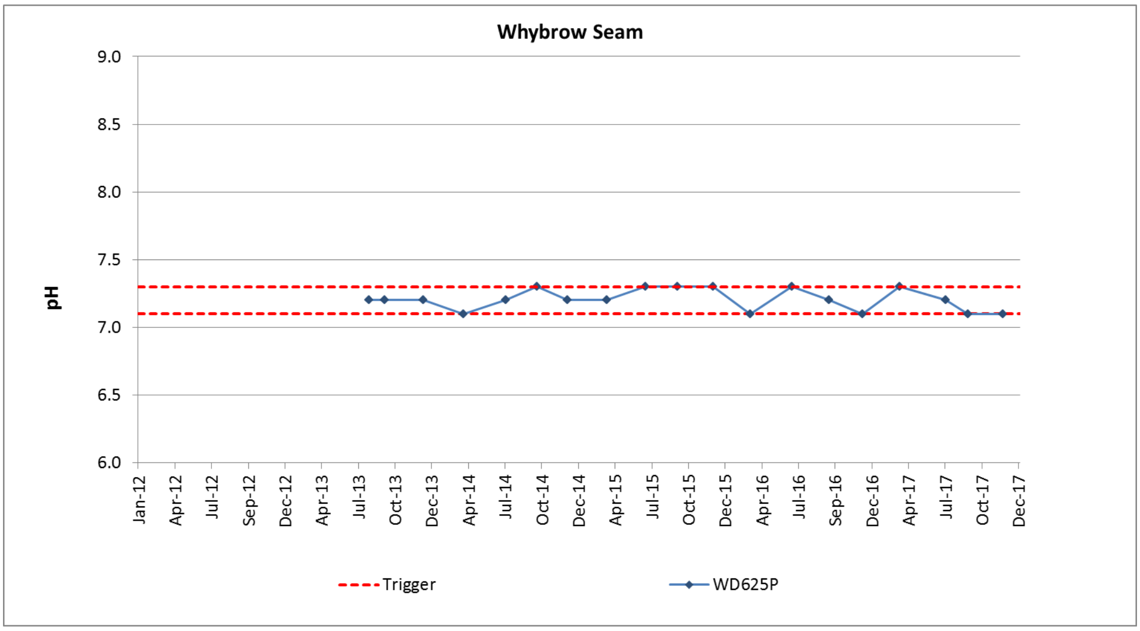
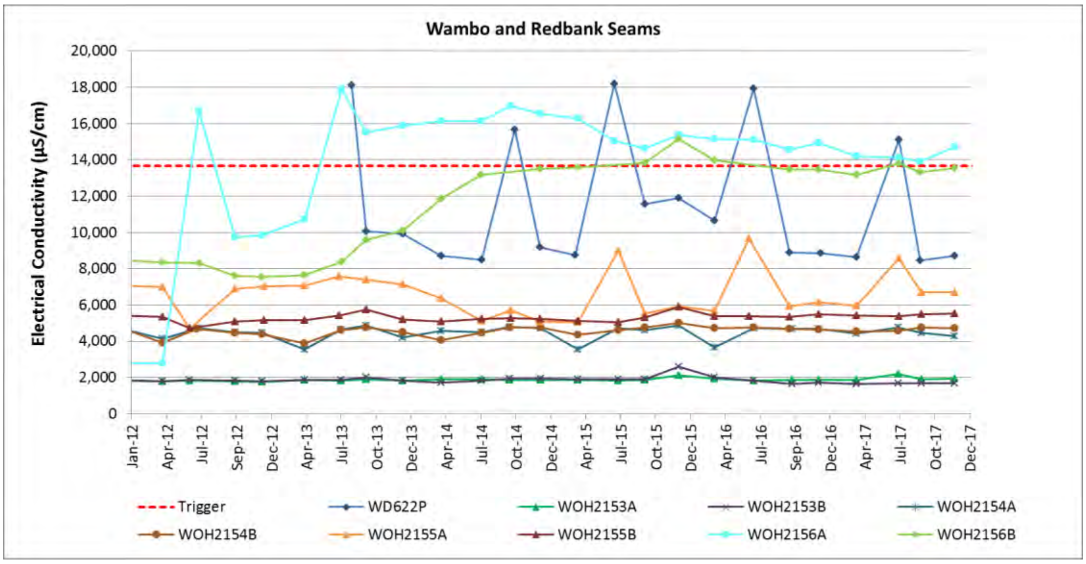
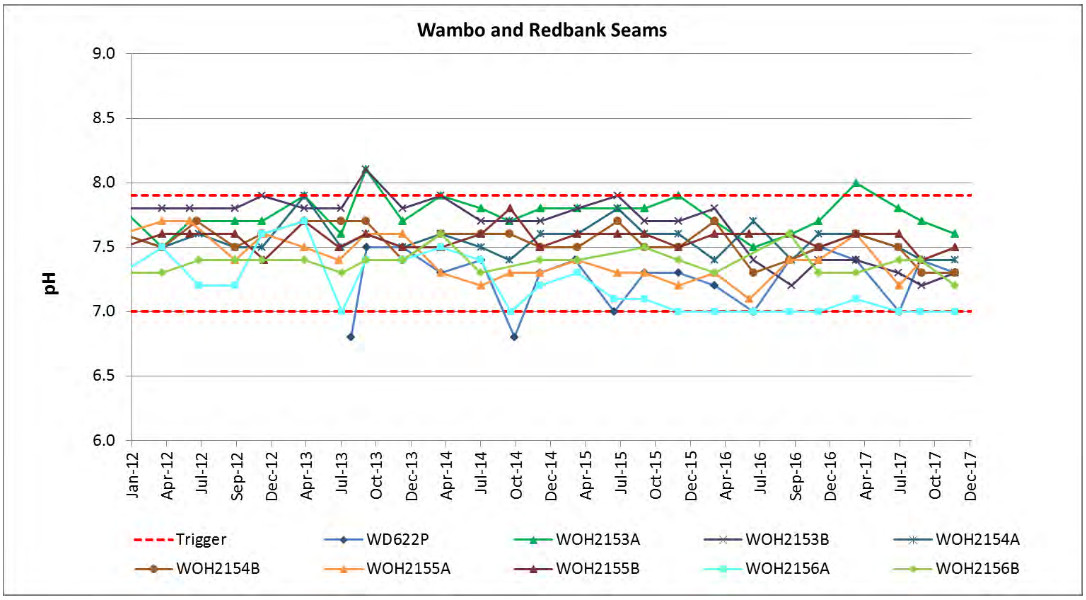
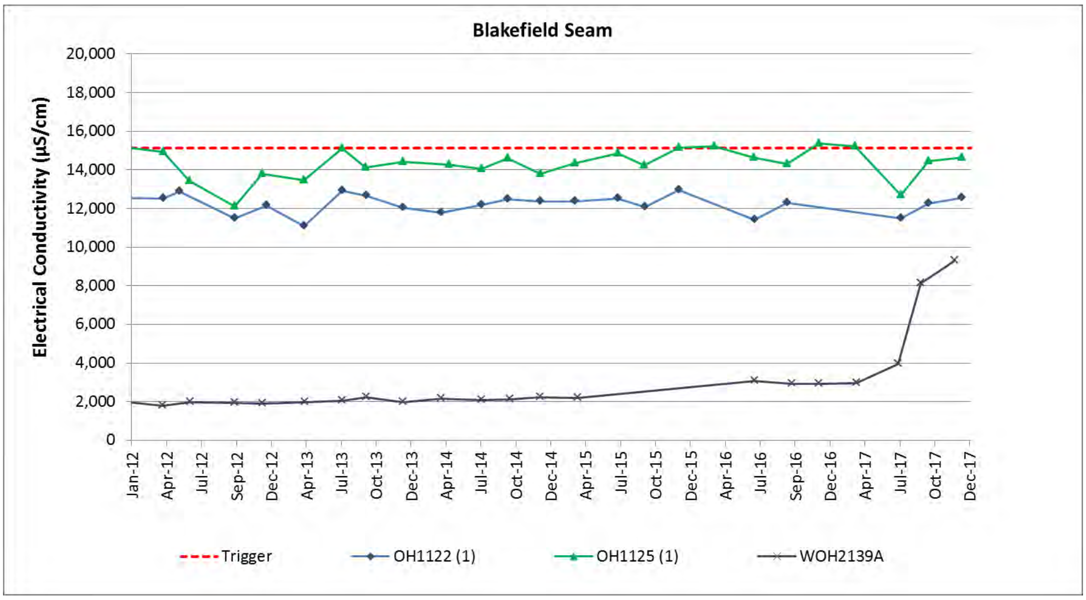
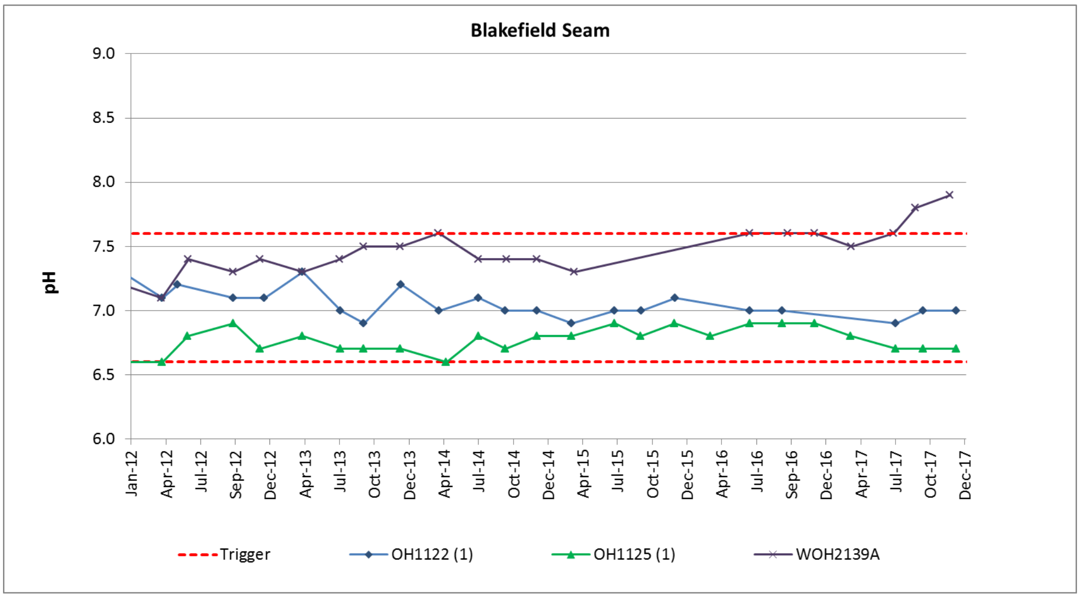
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
WD625P


Whybrow Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
WD625P


Wambo and Redbank Seams
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
WD622P
WOH2153A
WOH2153B
WOH2154A
WOH2154B
WOH2155A
WOH2155B
WOH2156A
WOH2156B


Wambo and Redbank Seams
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
WD622P
WOH2153A
WOH2153B
WOH2154A
WOH2154B
WOH2155A
WOH2155B
WOH2156A
WOH2156B


Blakefield Seam
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH1122 (1)
OH1125 (1)
WOH2139A


Blakefield Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
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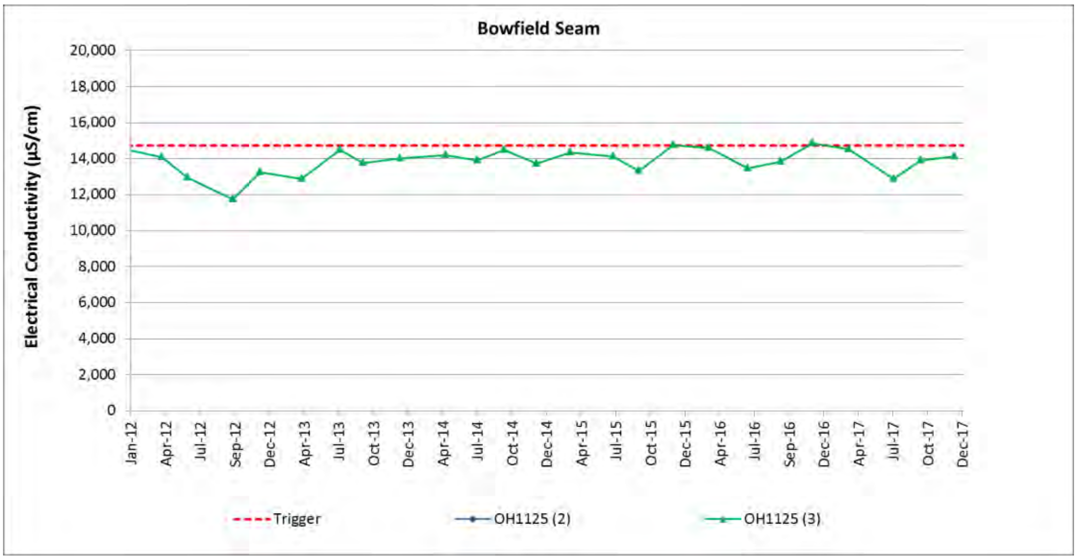
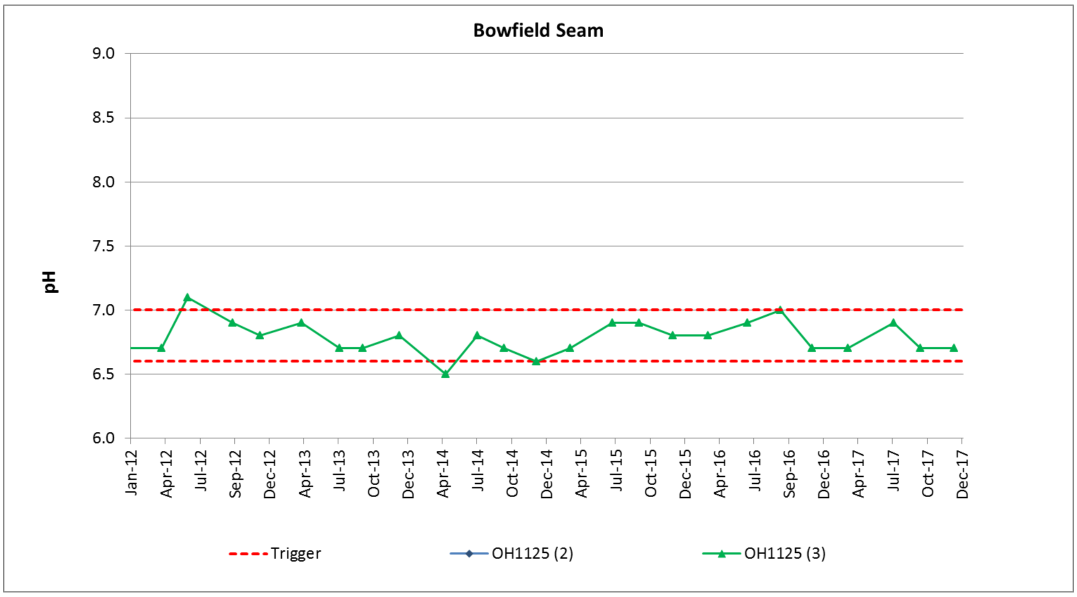
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH1122 (1)
OH1125 (1)
WOH2139A


Bowfield Seam
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH1125 (2)
OH1125 (3)


Bowfield Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
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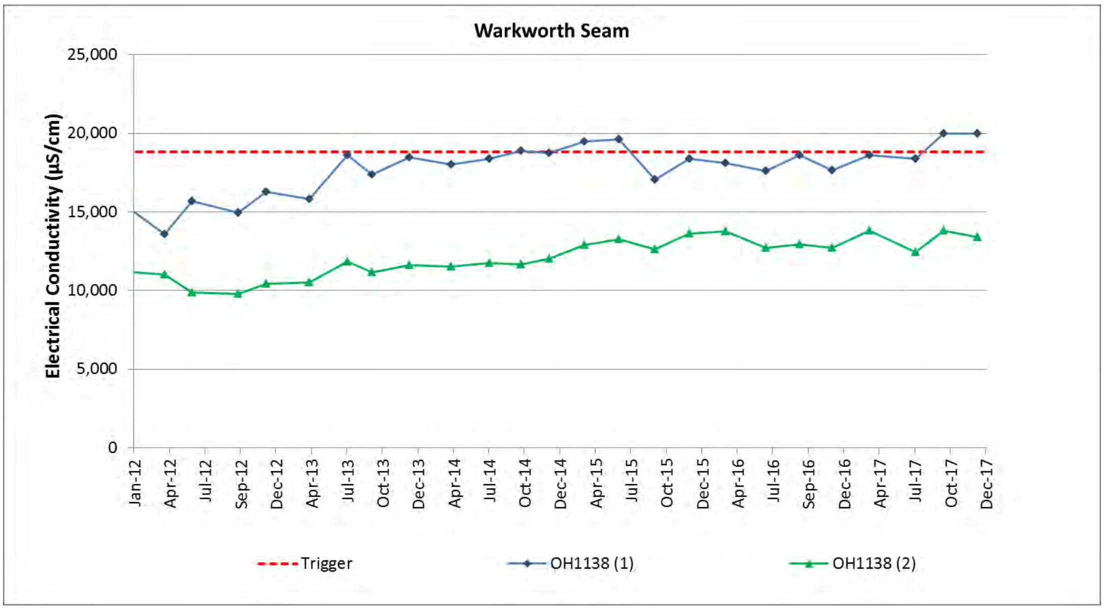
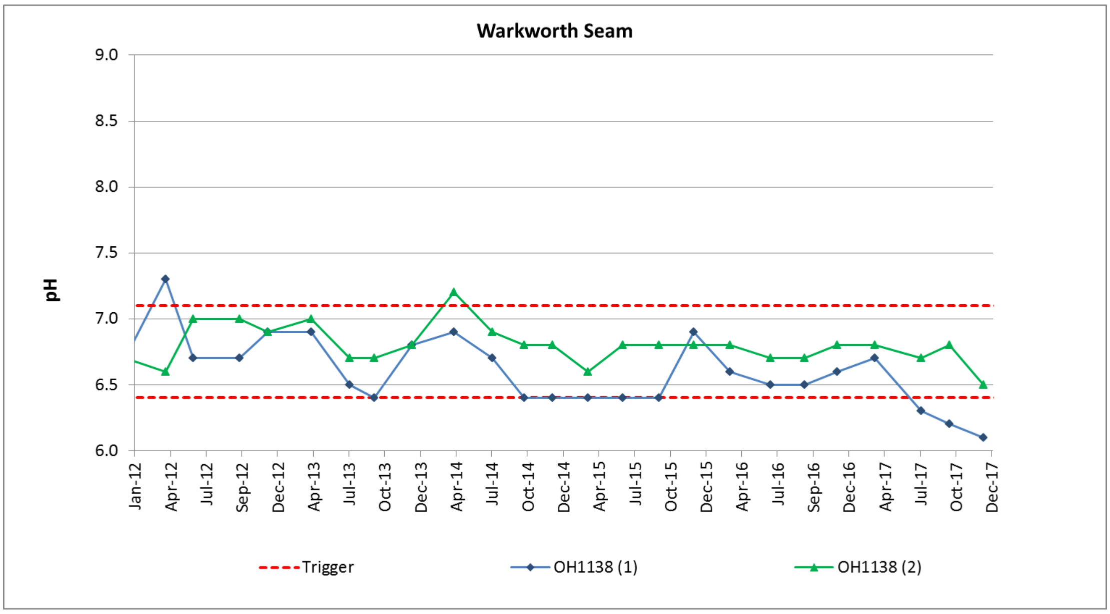
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH1125 (2)
OH1125 (3)


Warkworth Seam
Electrical Conductivity (µS/cm)
25,000
20,000
15,000
10,000
5,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH1138 (1)
OH1138 (2)


Warkworth Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
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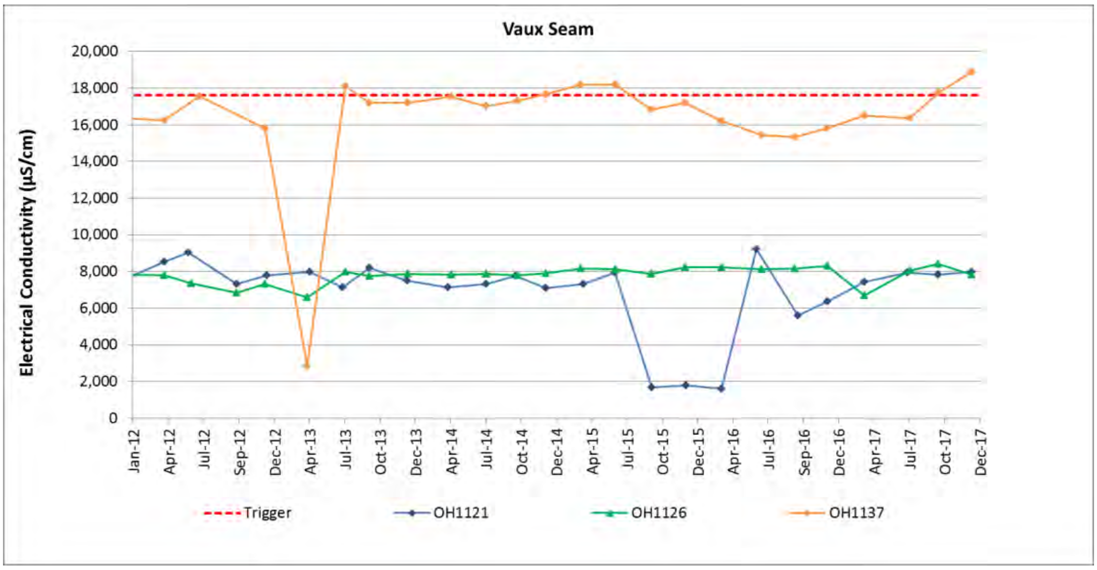
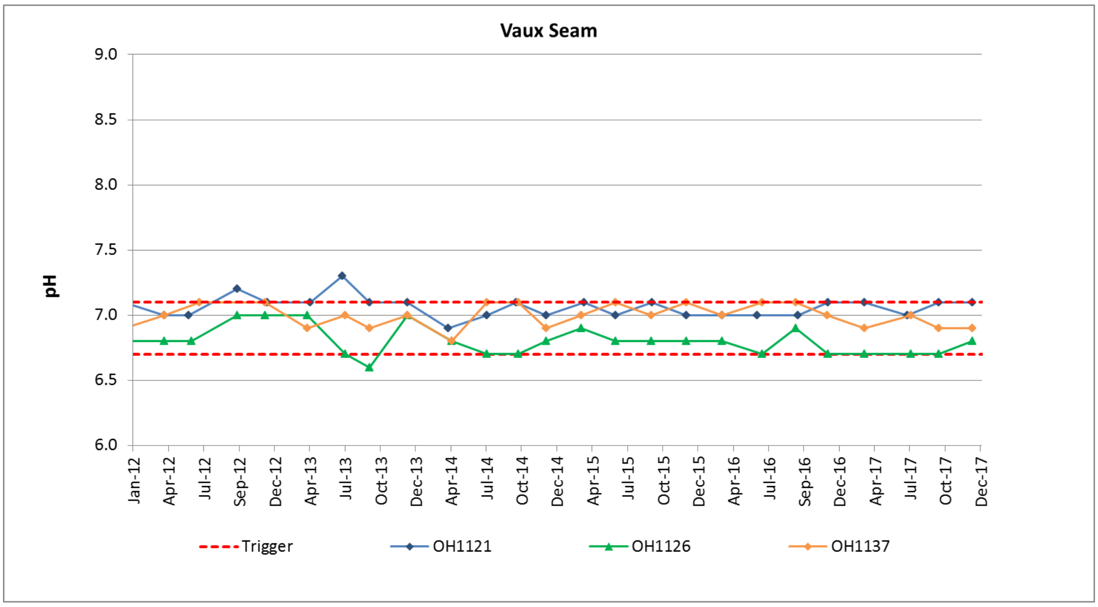
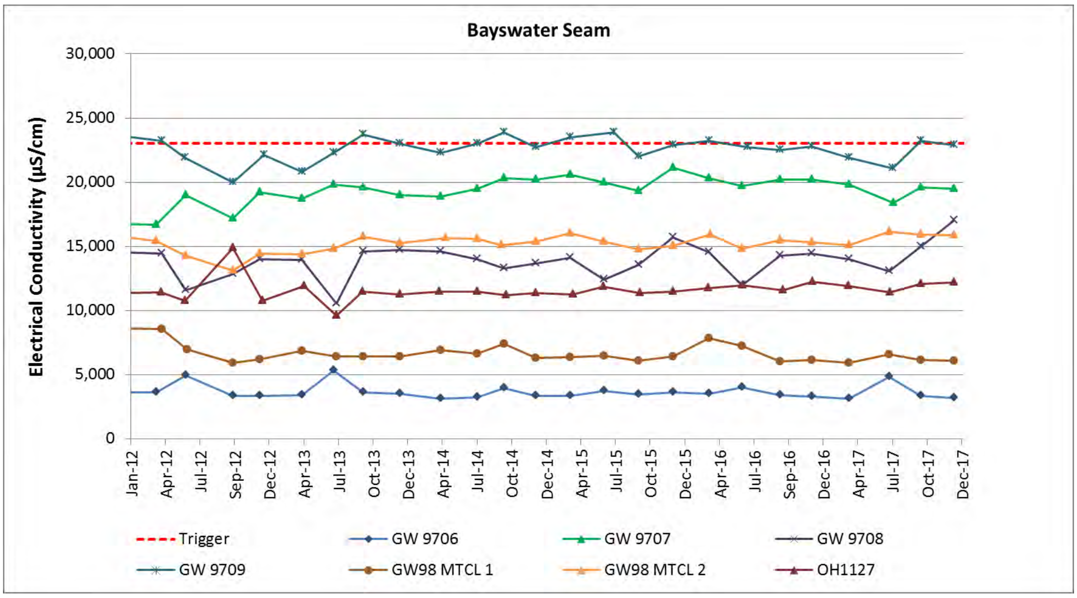
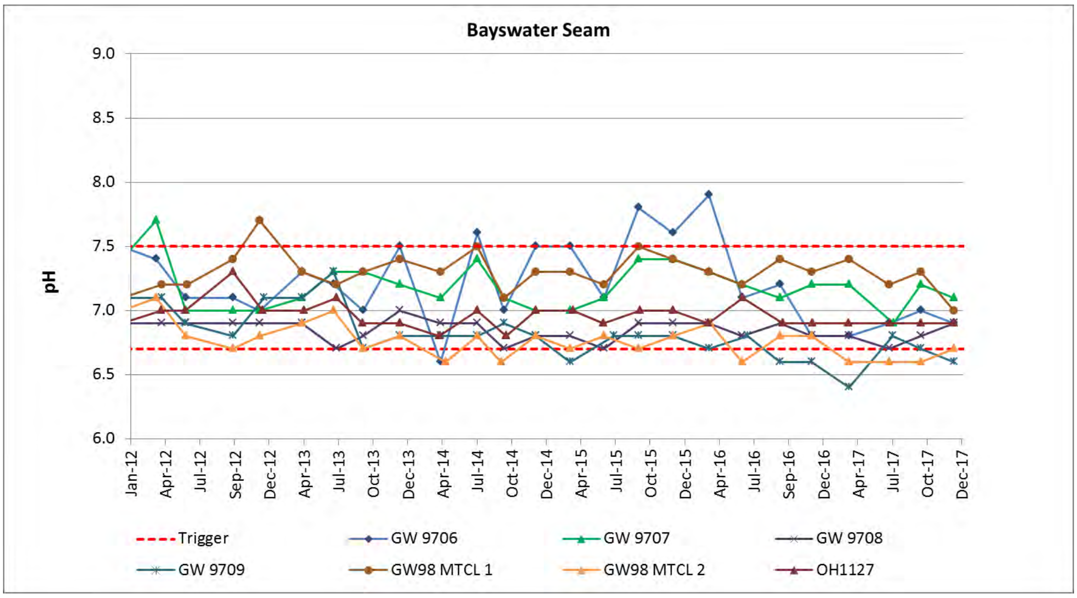
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH1138 (1)
OH1138 (2)


Vaux Seam
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH1121
OH1126
OH1137


Vaux Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
OH1121
OH1126
OH1137


Bayswater Seam
Electrical Conductivity (µS/cm)
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
GW 9706
GW 9707
GW 9708
GW 9709
GW98 MTCL 1
GW98 MTCL 2
OH1127


Bayswater Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-12
Apr-12
Jul-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Dec-13
Apr-14
Jul-14
Oct-14
Dec-14
Apr-15
Jul-15
Oct-15
Dec-15
Apr-16
Jul-16
Sep-16
Dec-16
Apr-17
Jul-17
Oct-17
Dec-17
Trigger
GW 9706
GW 9707
GW 9708
GW 9709
GW98 MTCL 1
GW98 MTCL 2
OH1127

APPENDIX D

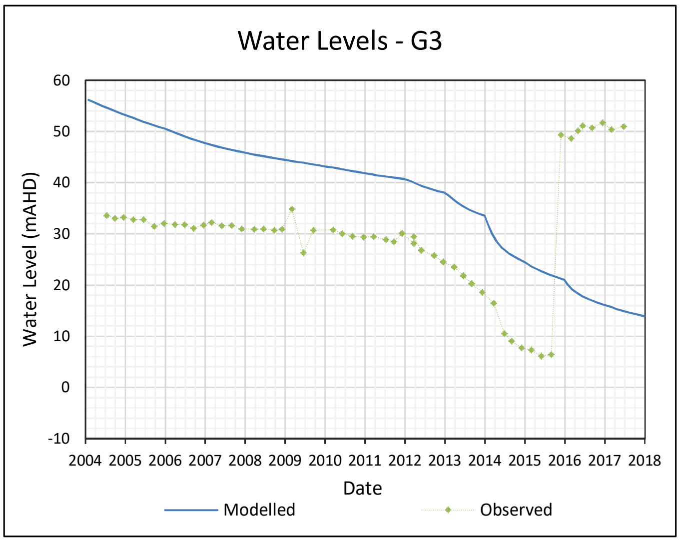
Full Water Quality Data 2017

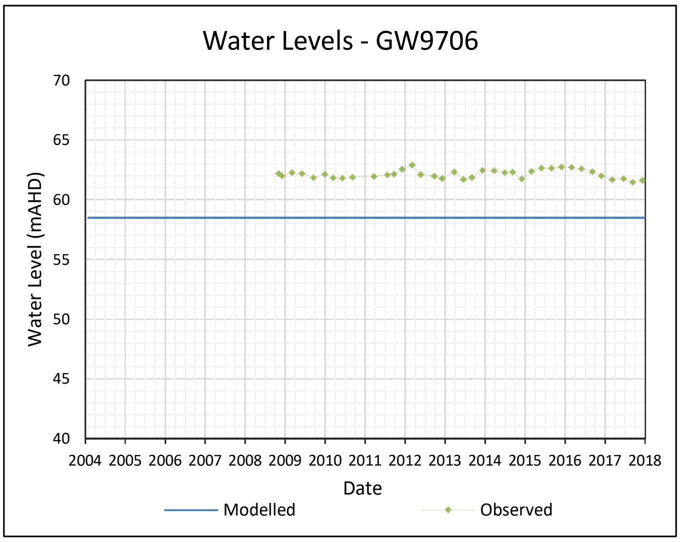
Station	Geology	Time	Date	SWL RL Calc	pH Field	EC Field (uS/cm (25TRef))	Water Temp (Deg C)	Comment	TDS - Total (mg/l)	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Acidity as CaCO3	SO4 - Total (mg/l)	Cl- (mg/l)	Ca - Total (mg/l)
PZ7S	Aeolian Warkworth Sands	9:40	28-06-2017	51.36	6.7	1,480	18.8		804	0	0	419	419		23	217	58
MB15MTW06	Warkworth Sands	12:45	01-09-2017		5.6	48	19.5	d 5 times over 7 days. Low EC che	96	0	0	7	7		6	<10	0.6
OH787	Hunter River Alluvium	12:45	03-07-2017	36.18	7.5	17,070	19.2	purged 26/6/17	10500	0	0	1618	1618		280	6500	72
OH788	Hunter River Alluvium	8:15	26-06-2017	35.62	7.0	11,360	19.8		7070	0	0	1365	1365		310	3433	80
OH942	Hunter River Alluvium	11:20	26-06-2017	46.60	6.7	23,300	21.1		14260	0	0	709	709		1000	9032	150
OH943	Hunter River Alluvium	13:10	03-07-2017	35.69	7.5	7,300	18.9	purged 26/6/17	4020	0	0	999	999		390	1800	70
MB15MTW01S	Wollombi Brook Alluvium	13:00	28-08-2017		6.8	1,850	20.8		922	0	0	99	99		83	454	44
MB15MTW02S	Wollombi Brook Alluvium	11:50	25-08-2017		7.3	2,240	19.8		1280	0	0	327	327		57	507	45
PZ8S	Wollombi Brook Alluvium	10:25	27-06-2017	60.21	6.6	14,090	20.3		8020	0	0	668	668		550	4965	120
PZ9S	Wollombi Brook Alluvium	10:05	03-07-2017	59.15	6.8	13,100	18.3	purged 27/6/17	8700	0	0	873	873		740	4960	100
MBW01	Alluvium	8:30	01-09-2017		7.3	18,160	19.3		10380	0	0	1365	1365		550	5969	45
MBW02	Shallow Overburden	8:25	01-09-2017		7.2	10,630	20.5	pumped	5770	0	0	1883	1883		2.5	2800	43
MTD616P	Shallow Overburden	11:00	03-07-2017	71.00	6.8	14,100	19.7		8410	0	0	1382	1382		520	4750	110
PZ7D	Shallow Overburden	8:50	28-06-2017	51.50	7.5	1,694	19.7		958	0	0	477	477		37	254	19
PZ8D	Shallow Overburden	8:20	27-06-2017	59.66	7.4	8,390	21.7		4760	0	0	1896	1896		68	1849	31
PZ9D	Shallow Overburden	11:10	27-06-2017	47.44	7.0	9,100	20.8		5430	0	0	1061	1061		390	2747	160
MTD614P	Shallow Overburden - Conglomerate	10:25	03-07-2017	54.59	7.5	5,830	18.2	purged 27/6/17	3510	0	0	1722	1722		110	1190	42
MTD605P	Shallow Overburden - sandstone	14:40	27-06-2017	62.33	7.3	17,390	20.9		12490	0	0	2208	2208		920	4754	26
MB15MTW03	Shallow Overburden - Wollombi alluvium?	10:25	28-08-2017		7.0	12,830	19.5		7200	0	0	1054	1054		360	4067	190
MB15MTW01D	Shallow Overburden? Alluvium?	10:20	30-08-2017		7.8	3,580	22.2		1930	0	0	212	212		88	1060	53
MB15MTW02D	Shallow Overburden? Alluvium?	12:00	25-08-2017		8.0	10,400	20.5		6360	0	0	2040	2040		69	2747	20
GW9706	Bayswater	12:55	23-06-2017	61.76	6.9	4,800	19.1		3150	0	0	496	496		1100	697	130
GW9707	Bayswater	12:15	04-07-2017	59.81	6.9	18,400	20.2	purged 3/7/17	14730	0	0	700	700		5500	4750	420
GW9708	Bayswater	8:45	23-06-2017	61.22	6.7	13,050	20.5		10450	0	0	682	682		4900	1954	460
GW9709	Bayswater	9:30	03-07-2017	51.48	6.8	21,100	18.4	purged 23/6/17	17620	0	0	830	830		6500	6230	570
GW98MTCL1	Bayswater	9:55	23-06-2017	67.43	7.2	6,580	21.0		3980	0	0	910	910		950	1188	63
GW98MTCL2	Bayswater	12:00	23-06-2017	69.24	6.6	16,150	20.1		11890	0	0	653	653		4500	3645	570
OH1127	Bayswater	12:50	26-06-2017	35.48	6.9	11,400	20.0		6880	0	0	2101	2101		<1	3064	140
OH1125 (1)	Blakefield	11:10	04-07-2017	60.03	6.7	12,710	20.3		7970	0	0	1040	1040	225	1000	4700	250
WOH2139A	Blakefield	10:25	28-06-2017	46.33	7.6	3,930	21.2		4190	0	0	1000	1000		19	2345	17
WOH2139A	Blakefield	8:45	25-08-2017	45.38	7.8	8,110	21.6	Point sampler	4840	0	0	1063	1063		10	2324	12
OH1122 (1)	Blakefield Seam	8:25	04-07-2017	51.85	6.9	11,470	19.8		6910	0	0	1458	1458		680	3430	96
OH1125 (3)	Bowfield Seam	11:15	04-07-2017	39.18	6.9	12,880	19.9		7860	0	0	966	966	250	860	4700	270
WOH2153A	Redbank Crk Seam	12:05	28-06-2017	56.61	7.8	2,180	19.6		1170	0	0	850	850		26	185	2.6
WOH2154A	Redbank Crk Seam	13:10	28-06-2017	55.95	7.5	4,740	18.0		2540	0	0	1018	1018		140	887	4.8
WOH2155A	Redbank Crk Seam	9:30	30-06-2017	57.53	7.2	8,570	19.2		5340	0	0	932	932		960	2007	30
WOH2156A	Redbank Crk Seam	13:00	30-06-2017	56.37	7.0	14,140	20.4		9180	0	0	1207	1207		1300	4014	120
OH1121	Vaux	13:45	26-06-2017	35.10	7.0	7,920	20.4		4640	0	0	672	672		200	2509	150
OH1126	Vaux	9:25	04-07-2017	48.49	6.7	8,030	19.5		4720	0	0	594	594	191	720	2380	64
OH1137	Vaux?	9:50	04-07-2017	54.50	7.0	16,370	19.7		10200	0	0	1186	1186		790	6130	120
MBW04	Wambo	8:20	01-09-2017		7.5	13,010	21.1		7080	0	0	1680	1680		330	3803	78
G3	Wambo Seam	13:40	27-06-2017	50.98	7.2	9,760	19.4		6030	0	0	1332	1332	78	360	2852	120
WD622P	Wambo Seam	11:00	30-06-2017	57.59	7.0	15,120	22.5		9290	0	0	1018	1018		1000	4701	130
WOH2153B	Wambo Seam	12:10	28-06-2017	57.57	7.3	1,694	19.2		995	0	0	565	565		40	195	3.4
WOH2154B	Wambo Seam	13:20	28-06-2017	56.29	7.5	4,580	18.4		2520	0	0	1049	1049		130	951	7.3
WOH2155B	Wambo Seam	9:35	30-06-2017	60.20	7.6	5,390	17.6		2820	0	0	1098	1098		260	1078	24
OH1138 (1)	Warkworth Seam	10:20	04-07-2017	61.31	6.3	18,400	18.9		10700	0	0	325	325		510	7610	150
OH1138 (2)	Warkworth Seam	10:25	04-07-2017	56.42	6.7	12,440	19.2		7620	0	0	772	772		750	4810	540
WD625P	Whybrow Seam	12:05	03-07-2017	57.95	7.2	11,290	18.5	purged 30/6/17	6600	0	0	1323	1323		250	3700	68
MBW03	Whybrow Seam	8:35	01-09-2017		7.3	9,760	21.1		4690	0	0	2071	2071		1.1	2113	25
WOH2141A	Whynot Seam	8:15	28-06-2017	49.32	7.8	10,240	20.8		5530	0	0	1257	1257		13	2984	15
MBW6A		10:50	01-09-2017		6.4	771	20.8		411	0	0	131	131		33	148	12

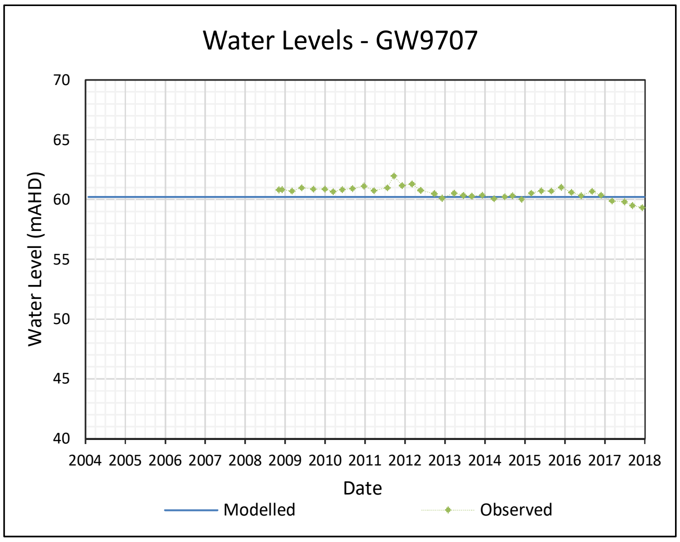
Station	Geology	Time	Date	Mg - Total (mg/l)	Na - Total (mg/l)	K - Total (mg/l)	Al - Total (mg/l)	As - Total (mg/l)	Cd - Total (mg/l)	Cu - Total (mg/l)	Pb - Total (mg/l)	Ni - Total (mg/l)	Se (mg/l)	Zn - Total (mg/l)	B (mg/l)	Hg - Total (mg/l)	Mo (mg/l)	V (mg/l)	Cr (mg/l)	F (mg/l)	Nitrogen Ammonia (mg/l)	Nitrite (mg/l)
PZ7S	Aeolian Warkworth Sands	9:40	28-06-2017	41	200	8.4	7.3	0.005	<0.0001	0.022	0.012	0.012	0.006	0.04	0.078	<0.0001						
MB15MTW06	Warkworth Sands	12:45	01-09-2017	0.5	3.4	1.1	5.6	<0.001	<0.0001	0.005	0.005	0.004	0.003	0.03	<0.005	0.0003						
OH787	Hunter River Alluvium	12:45	03-07-2017	260	3700	49	0.42	0.001	<0.0001	0.003	0.001	0.004	0.002	0.055	0.15	<0.0001						
OH788	Hunter River Alluvium	8:15	26-06-2017	230	2400	59	0.12	<0.001	0.0024	<0.001	0.002	0.002	<0.001	0.011	0.13	<0.0001						
OH942	Hunter River Alluvium	11:20	26-06-2017	850	4600	71	3.3	0.004	0.0011	0.002	<0.001	0.006	0.004	0.01	0.098	0.0007	<0.001	0.006	0.006			
OH943	Hunter River Alluvium	13:10	03-07-2017	130	1400	23	41	0.019	0.0006	0.088	0.11	0.086	0.016	1.4	0.13	<0.0001						
MB15MTW01S	Wollombi Brook Alluvium	13:00	28-08-2017	37	230	9.3	0.01	0.003	<0.0001	<0.001	<0.001	0.005	<0.001	0.013	0.048	<0.0001						
MB15MTW02S	Wollombi Brook Alluvium	11:50	25-08-2017	28	380	10	0.11	0.003	<0.0001	0.002	<0.001	0.015	<0.001	0.011	0.059	<0.0001						
PZ8S	Wollombi Brook Alluvium	10:25	27-06-2017	310	2600	17	0.15	0.002	0.0007	0.022	<0.001	0.005	0.002	0.018	0.071	<0.0001						
PZ9S	Wollombi Brook Alluvium	10:05	03-07-2017	500	2400	90	25	0.008	<0.0001	0.5	0.019	0.013	0.004	0.06	0.096	<0.0001						
MBW01	Alluvium	8:30	01-09-2017	250	3300	45	0.071	<0.001	<0.0001	0.001	<0.001	0.001	<0.001	0.01	0.096	0.0002						
MBW02	Shallow Overburden	8:25	01-09-2017	39	2200	24	0.051	0.002	<0.0001	<0.001	<0.001	0.001	<0.001	0.006	0.19	0.0003						
MTD616P	Shallow Overburden	11:00	03-07-2017	380	2700	78	0.021	<0.001	<0.0001	0.001	<0.001	0.002	<0.001	<0.005	0.26	<0.0001						
PZ7D	Shallow Overburden	8:50	28-06-2017	19	330	5.1	0.06	<0.001	<0.0001	0.001	<0.001	0.001	<0.001	0.007	0.17	<0.0001						
PZ8D	Shallow Overburden	8:20	27-06-2017	40	1900	14	2.8	0.004	0.0062	0.013	0.006	0.022	0.004	0.029	0.27	<0.0001						
PZ9D	Shallow Overburden	11:10	27-06-2017	280	1600	33	0.046	<0.001	0.0003	<0.001	<0.001	0.002	<0.001	0.008	0.14	<0.0001						
MTD614P	Shallow Overburden - Conglomerate	10:25	03-07-2017	130	1100	14	0.28	0.008	<0.0001	0.006	0.004	0.005	<0.001	0.03	0.16	<0.0001						
MTD605P	Shallow Overburden - sandstone	14:40	27-06-2017	26	4200	18	0.37	<0.001	0.0011	0.002	<0.001	0.015	<0.001	0.013	0.44	<0.0001						
MB15MTW03	hallow Overburden - Wollombi alluvium	10:25	28-08-2017	220	2200	30	13	<0.001	<0.0001	<0.001	0.001	0.002	<0.001	0.01	0.13	<0.0001						
MB15MTW01D	Shallow Overburden? Alluvium?	10:20	30-08-2017	78	540	11	6.3	0.005	<0.0001	0.015	0.008	0.073	0.003	0.079	0.068	<0.0001						
MB15MTW02D	Shallow Overburden? Alluvium?	12:00	25-08-2017	30	2500	14	16	0.014	<0.0001	0.01	0.002	0.15	0.001	0.03	0.31	<0.0001						
GW9706	Bayswater	12:55	23-06-2017	110	860	16	<0.005	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	0.17	<0.0001						
GW9707	Bayswater	12:15	04-07-2017	690	3800	34	0.54	<0.001	0.0007	0.009	0.009	0.012	<0.001	0.056	0.66	<0.0001						
GW9708	Bayswater	8:45	23-06-2017	470	2300	32	0.097	<0.001	0.0002	<0.001	<0.001	0.001	<0.001	0.008	0.36	<0.0001						
GW9709	Bayswater	9:30	03-07-2017	880	4300	42	0.49	0.003	0.0003	0.01	0.009	0.015	0.002	0.056	0.52	<0.0001						
GW98MTCL1	Bayswater	9:55	23-06-2017	110	1300	21	0.023	**0.017**	0.0004	<0.001	<0.001	0.063	0.017	0.013	0.26	<0.0001						
GW98MTCL2	Bayswater	12:00	23-06-2017	570	2700	61	0.12	0.003	0.0006	0.001	<0.001	0.006	0.003	0.013	0.32	<0.0001						
OH1127	Bayswater	12:50	26-06-2017	130	2300	25	0.016	<0.001	0.0001	0.001	<0.001	<0.001	<0.001	0.009	0.2	<0.0001						
OH1125 (1)	Blakefield	11:10	04-07-2017	560	2200	40	0.15	0.001	<0.0001	0.003	0.002	0.018	<0.001	0.04	0.12	<0.0001	0.001	0.002	<0.001			
WOH2139A	Blakefield	10:25	28-06-2017	15	840	8.6	0.82	0.003	<0.0001	0.012	0.004	0.004	<0.001	0.26	0.14	<0.0001	0.005	0.003	0.003	0.005	0.003	0.003
WOH2139A	Blakefield	8:45	25-08-2017	11	1700	11	0.8	0.002	<0.0001	0.005	0.003	0.003	<0.001	0.12	0.16	<0.0001						
OH1122 (1)	Blakefield Seam	8:25	04-07-2017	360	2200	59	0.96	<0.001	<0.0001	0.013	0.011	0.003	<0.001	0.17	0.16	<0.0001				<0.001	0.003	0.003
OH1125 (3)	Bowfield Seam	11:15	04-07-2017	580	2000	40	2.6	0.002	<0.0001	0.012	0.017	0.009	0.001	0.38	0.11	<0.0001	0.001	0.008	0.005			
WOH2153A	Redbank Crk Seam	12:05	28-06-2017	2.8	480	4.1	3.8	<0.001	<0.0001	0.005	0.012	0.002	0.001	0.1	0.2	<0.0001						
WOH2154A	Redbank Crk Seam	13:10	28-06-2017	4.4	1000	8.2	0.079	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.013	0.21	<0.0001						
WOH2155A	Redbank Crk Seam	9:30	30-06-2017	64	1600	18	12	0.001	0.0002	0.008	0.008	0.004	<0.001	0.34	0.21	<0.0001						
WOH2156A	Redbank Crk Seam	13:00	30-06-2017	260	2800	39	2.7	0.002	<0.0001	0.003	0.002	0.002	<0.001	0.042	0.24	<0.0001						
OH1121	Vaux	13:45	26-06-2017	170	1500	16	0.014	<0.001	<0.0001	0.002	<0.001	<0.001	<0.001	0.005	0.12	<0.0001						
OH1126	Vaux	9:25	04-07-2017	170	1500	32	4.2	0.002	0.0002	0.015	0.018	0.007	0.002	0.36	0.14	<0.0001						
OH1137	Vaux?	9:50	04-07-2017	420	3300	59	3.9	0.005	0.0001	0.009	0.012	0.009	0.016	0.18	0.059	0.0003						
MBW04	Wambo	8:20	01-09-2017	120	2700	37	2.6	0.005	<0.0001	0.006	0.007	0.005	0.002	0.042	0.12	0.0002						
G3	Wambo Seam	13:40	27-06-2017	210	2100	33	3.2	0.001	0.0001	0.021	0.02	0.007	0.001	0.26	0.11	<0.0001						
WD622P	Wambo Seam	11:00	30-06-2017	360	2900	44	0.94	0.004	<0.0001	0.005	0.007	0.02	0.001	0.036	0.21	<0.0001						
WOH2153B	Wambo Seam	12:10	28-06-2017	3.3	360	3.3	1.3	<0.001	<0.0001	0.004	0.004	0.002	<0.001	0.13	0.18	<0.0001						
WOH2154B	Wambo Seam	13:20	28-06-2017	6.6	1100	8.6	2	<0.001	<0.0001	0.007	0.006	0.003	<0.001	0.24	0.21	<0.0001						
WOH2155B	Wambo Seam	9:35	30-06-2017	26	1200	12	4.1	0.002	0.0001	0.012	0.011	0.005	0.001	0.62	0.36	<0.0001						
OH1138 (1)	Warkworth Seam	10:20	04-07-2017	830	3100	120	15	0.001	0.0007	0.008	0.006	0.011	0.003	0.2	0.015	<0.0001						
OH1138 (2)	Warkworth Seam	10:25	04-07-2017	490	1800	34	0.61	<0.001	<0.0001	0.006	0.003	0.001	<0.001	0.11	0.032	<0.0001						
WD625P	Whybrow Seam	12:05	03-07-2017	210	2300	23	0.18	0.003	<0.0001	0.003	0.006	0.004	<0.001	0.05	0.28	<0.0001						
MBW03	Whybrow Seam	8:35	01-09-2017	16	2000	20	0.09	<0.001	<0.0001	0.005	<0.001	0.002	<0.001	0.013	0.19	0.0003						
WOH2141A	Whynot Seam	8:15	28-06-2017	20	2300	13	**5.7**	0.006	0.0004	0.18	**0.066**	0.027	0.003	0.16	0.27	<0.0001						
MBW6A		10:50	01-09-2017	13	130	2.9	0.58	<0.001	<0.0001	0.003	<0.001	0.01	<0.001	0.052	0.093	0.0002						

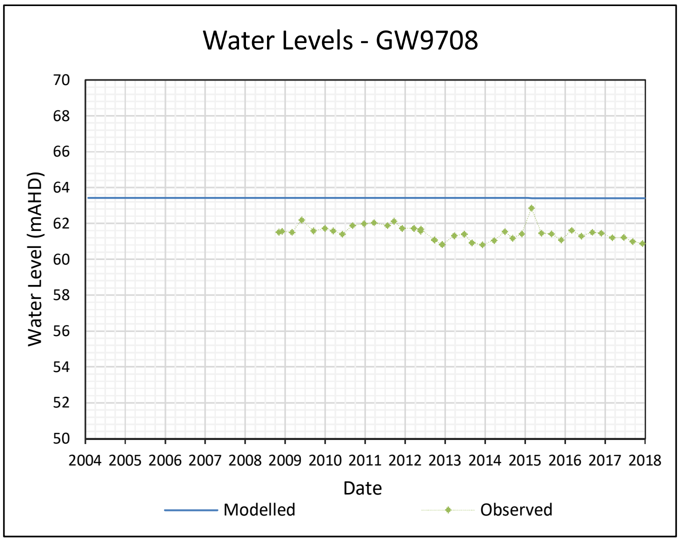
APPENDIX E

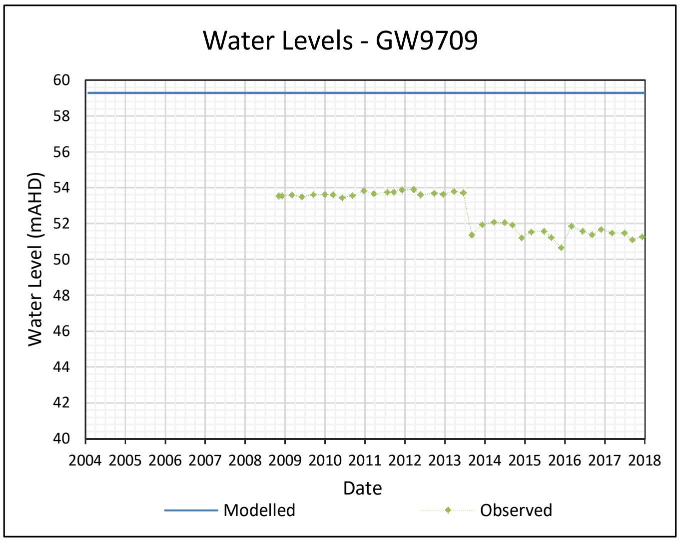
Modelled and Observed Groundwater Levels

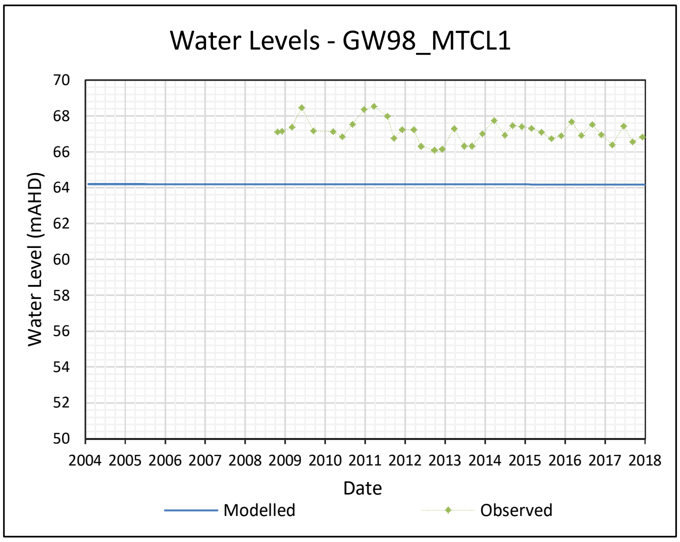

Water Levels - G3
Water Level (mAHD)
60
50
40
30
20
10
0
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

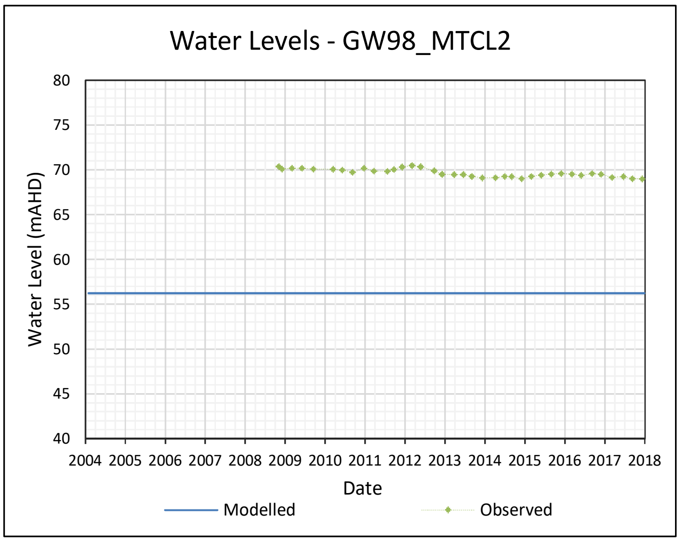

Water Levels - GW9706
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

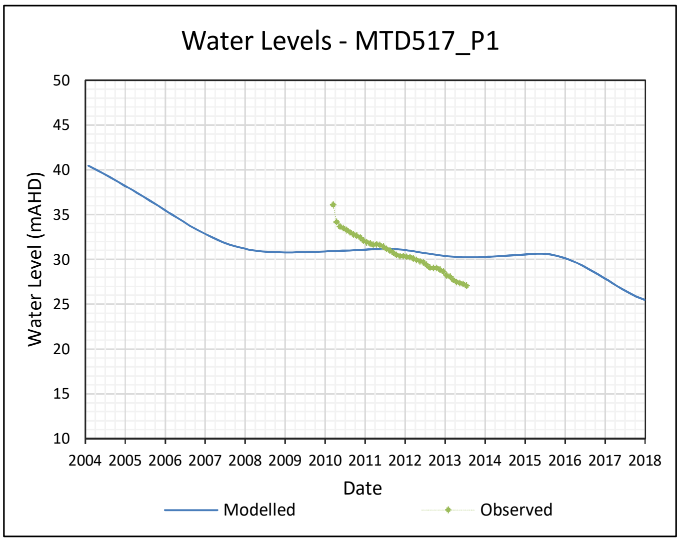

Water Levels - GW9707
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

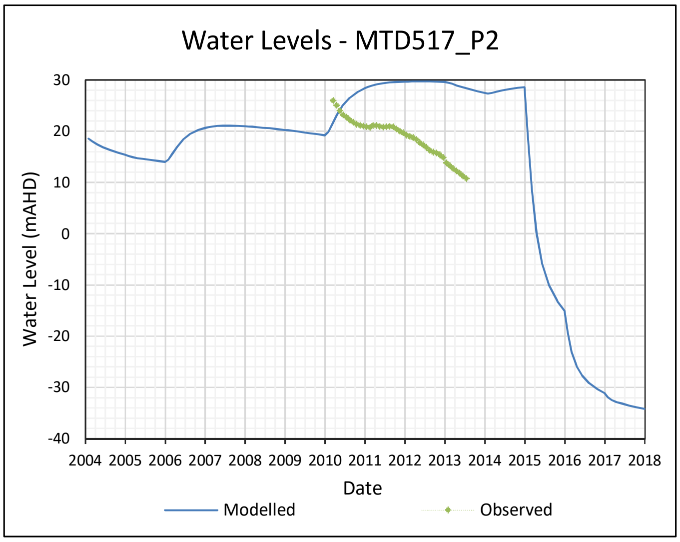

Water Levels - GW9708
Water Level (mAHD)
70
68
66
64
62
60
58
56
54
52
50
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

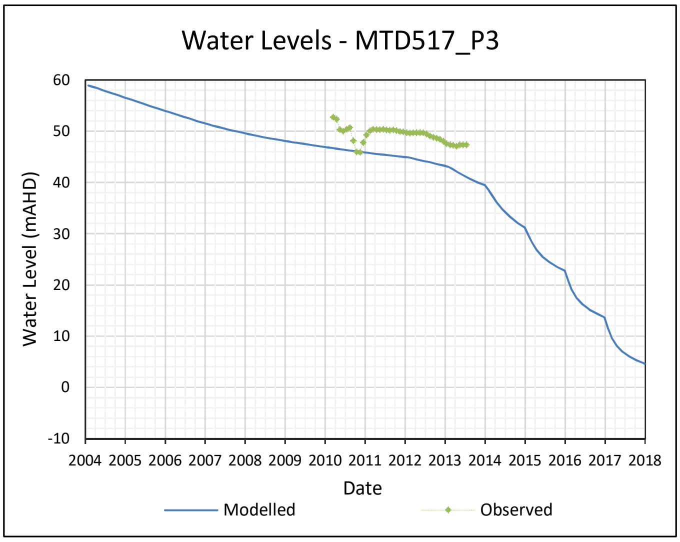

Water Levels - GW9709
Water Level (mAHD)
60
58
56
54
52
50
48
46
44
42
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

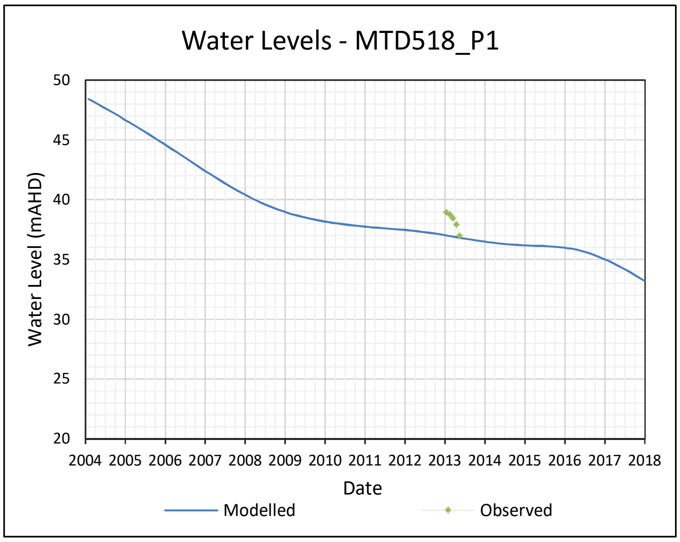

Water Levels - GW98_MTCL1
Water Level (mAHD)
70
68
66
64
62
60
58
56
54
52
50
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

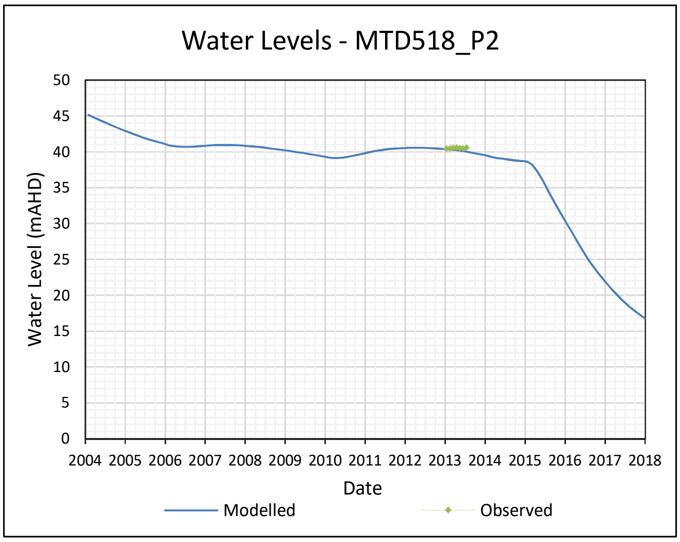

Water Levels - GW98_MTCL2
Water Level (mAHD)
80
75
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

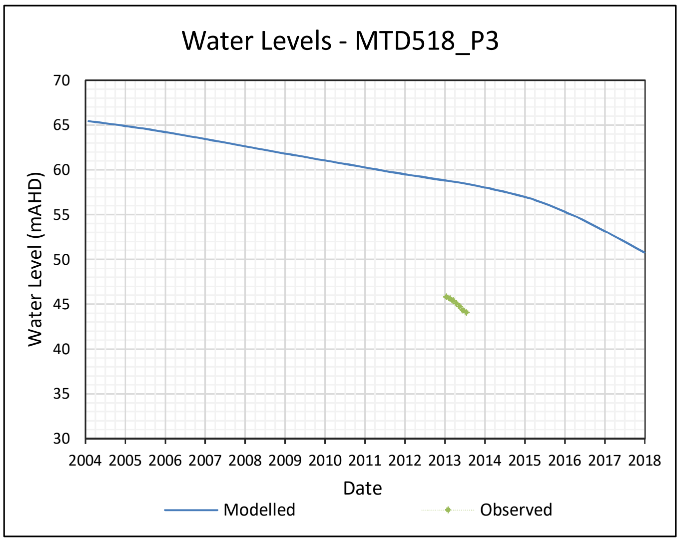

Water Levels - MTD517_P1
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

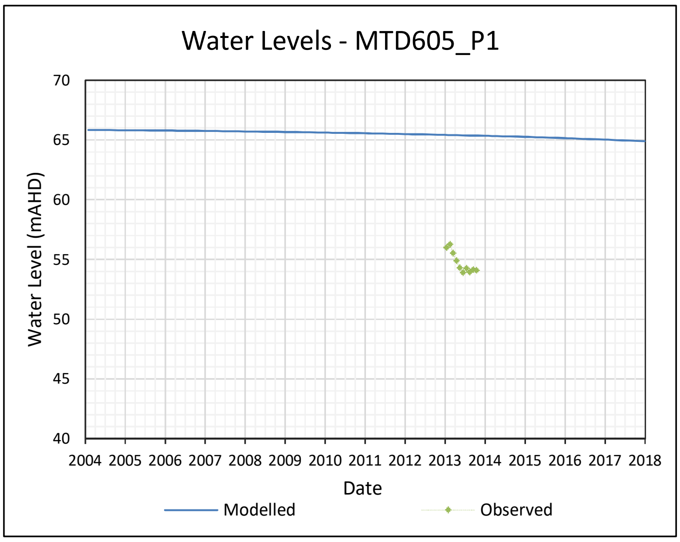

Water Levels - MTD517_P2
Water Level (mAHD)
30
20
10
0
-10
-20
-30
-40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

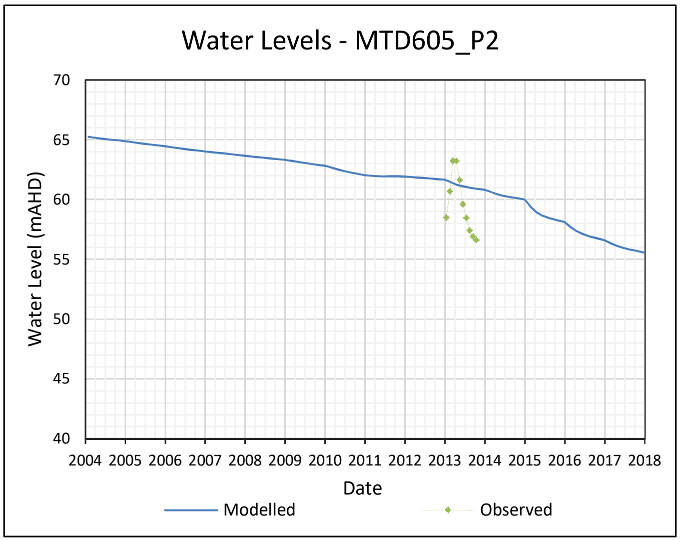

Water Levels - MTD517_P3
Water Level (mAHD)
60
50
40
30
20
10
0
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

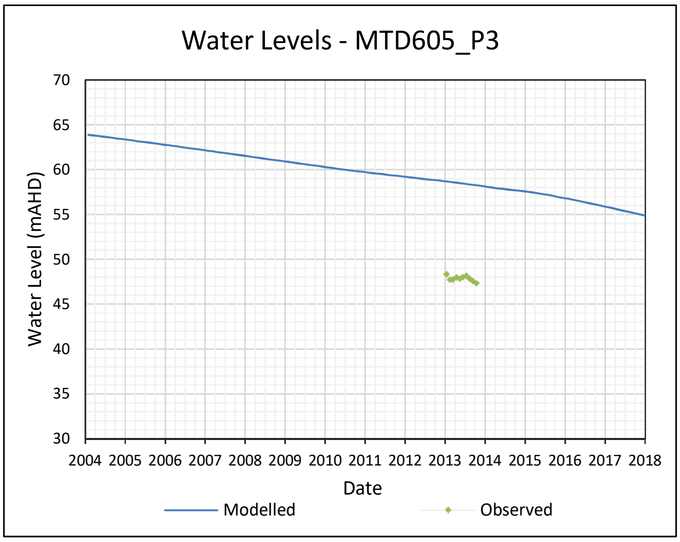

Water Levels - MTD518_P1
Water Level (mAHD)
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

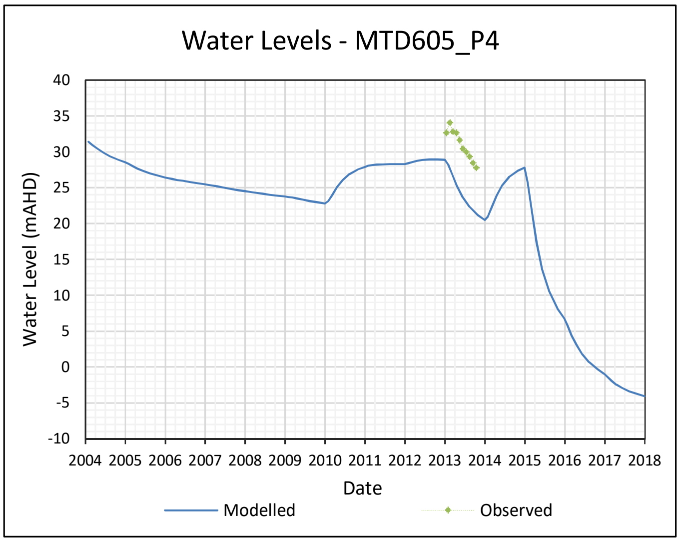

Water Levels - MTD518_P2
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
5
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

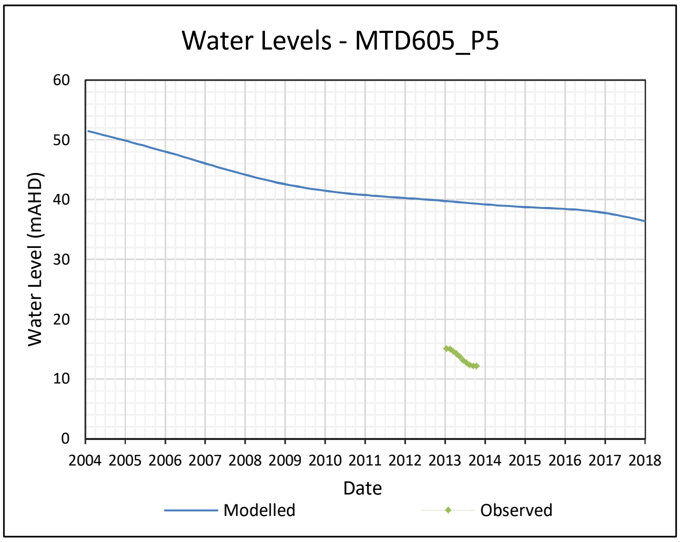

Water Levels - MTD518_P3
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

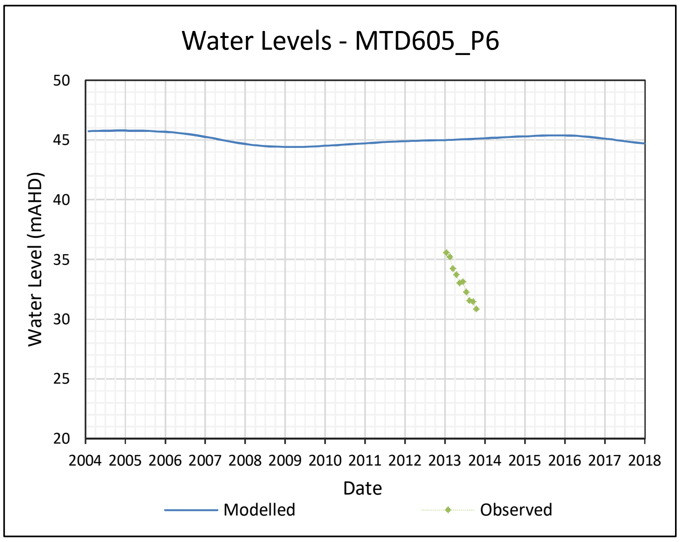

Water Levels - MTD605_P1
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

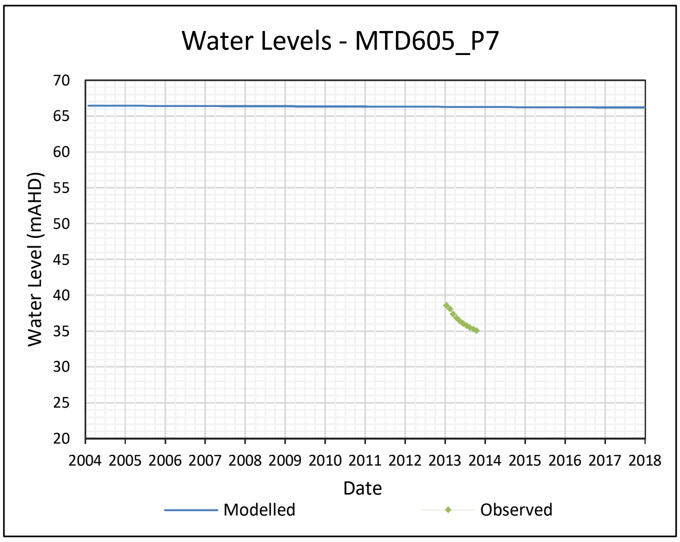

Water Levels - MTD605_P2
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

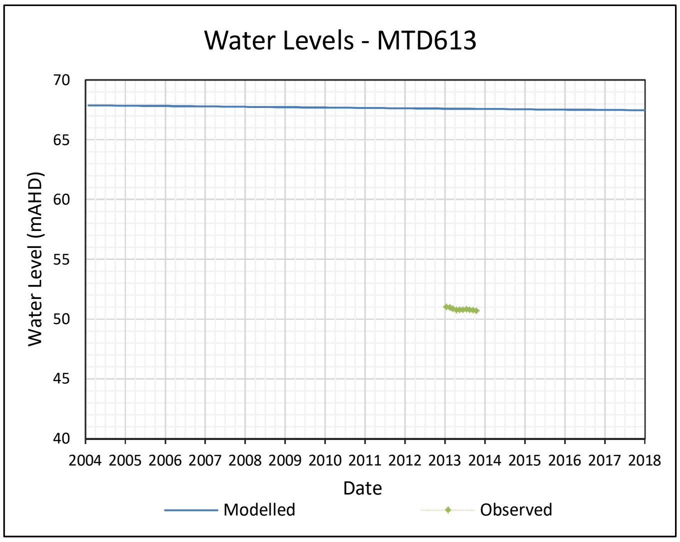

Water Levels - MTD605_P3
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

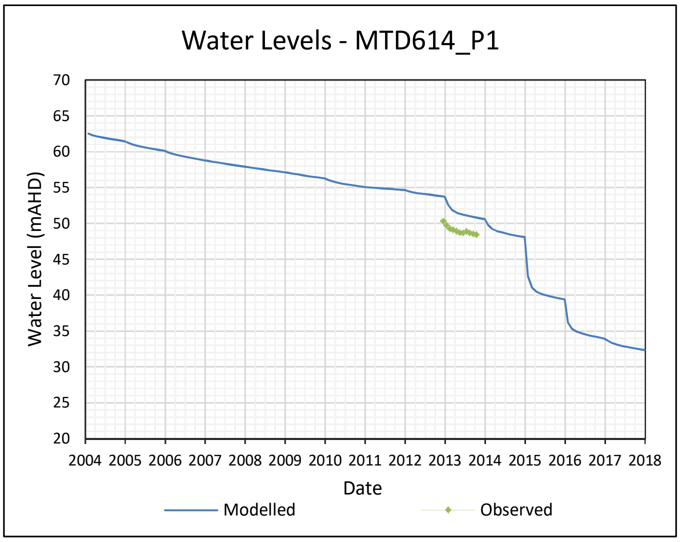

Water Levels - MTD605_P4
Water Level (mAHD)
40
35
30
25
20
15
10
5
0
-5
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

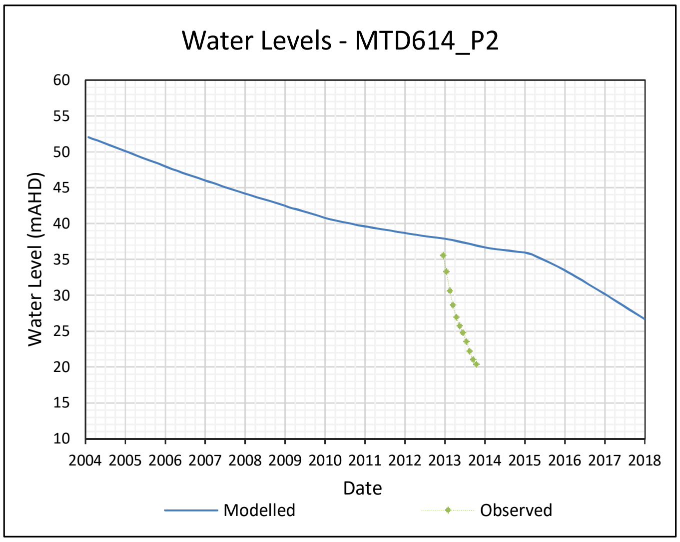

Water Levels - MTD605_P5
Water Level (mAHD)
60
50
40
30
20
10
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

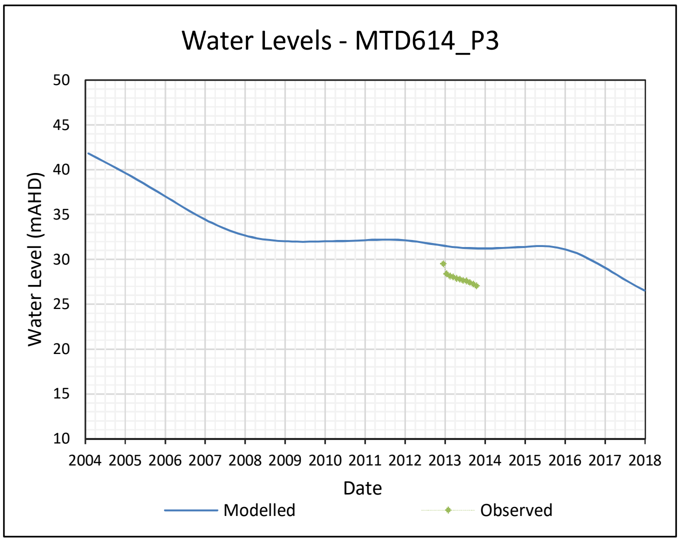

Water Levels - MTD605_P6
Water Level (mAHD)
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

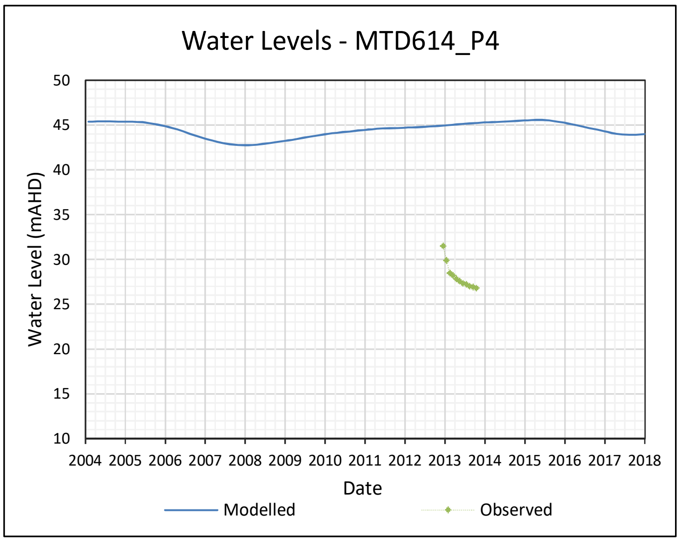

Water Levels - MTD605_P7
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

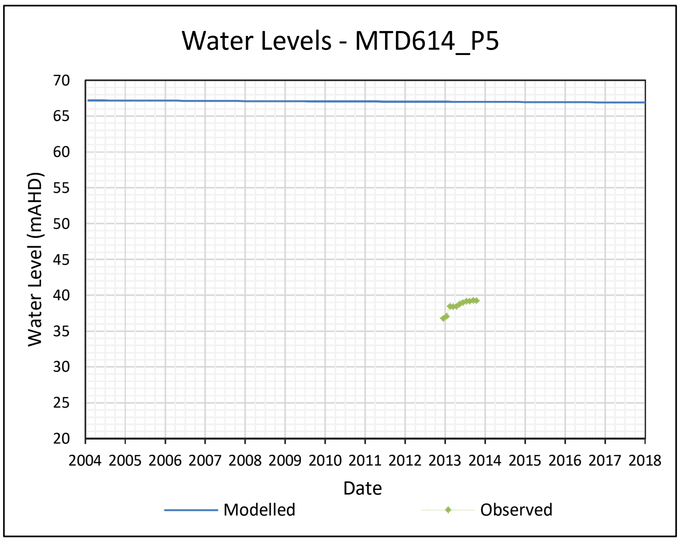

Water Levels - MTD613
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

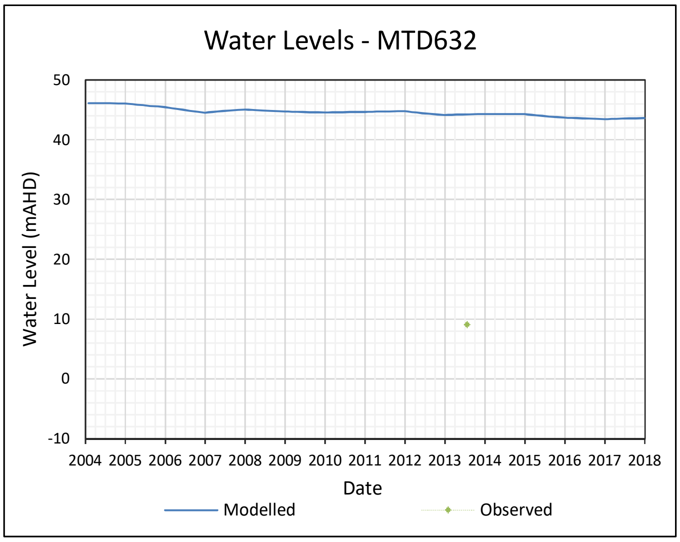

Water Levels - MTD614_P1
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

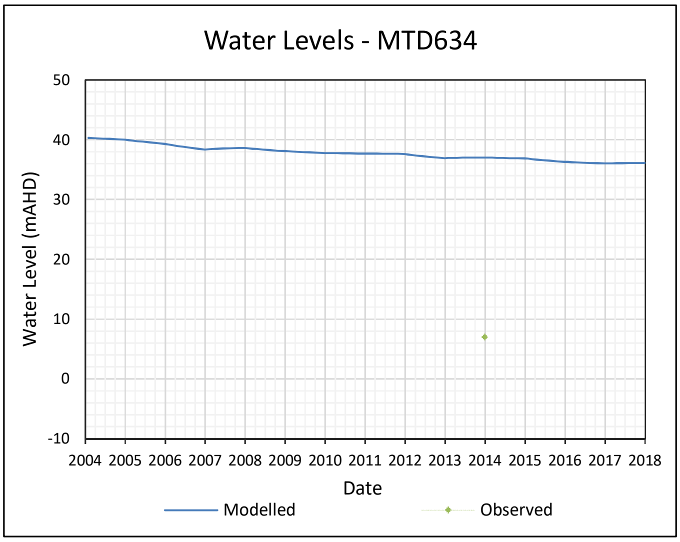

Water Levels - MTD614_P2
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

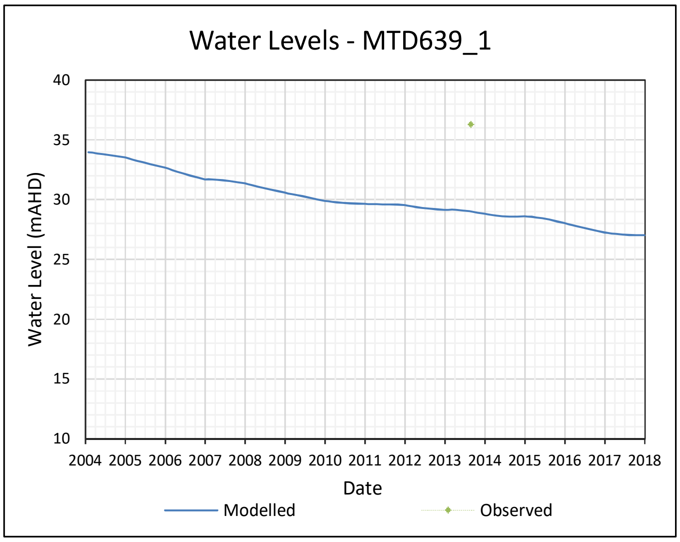

Water Levels - MTD614_P3
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

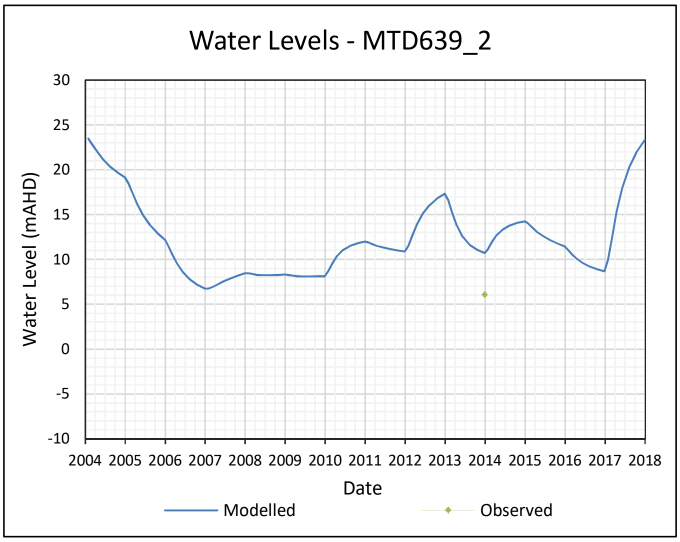

Water Levels - MTD614_P4
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

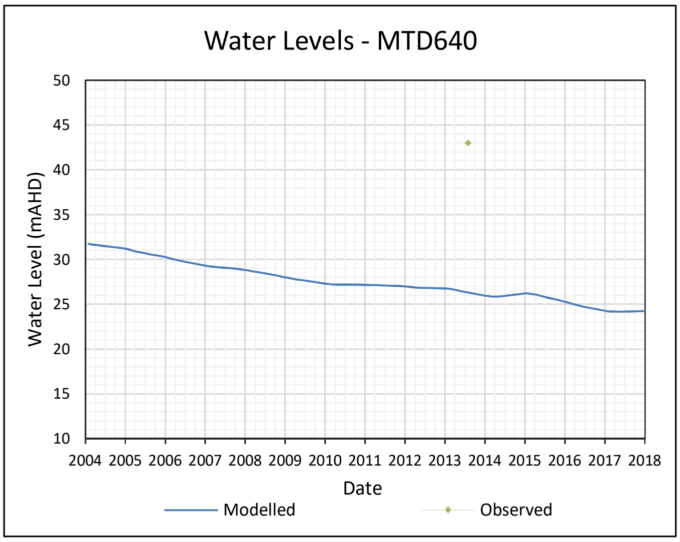

Water Levels - MTD614_P5
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

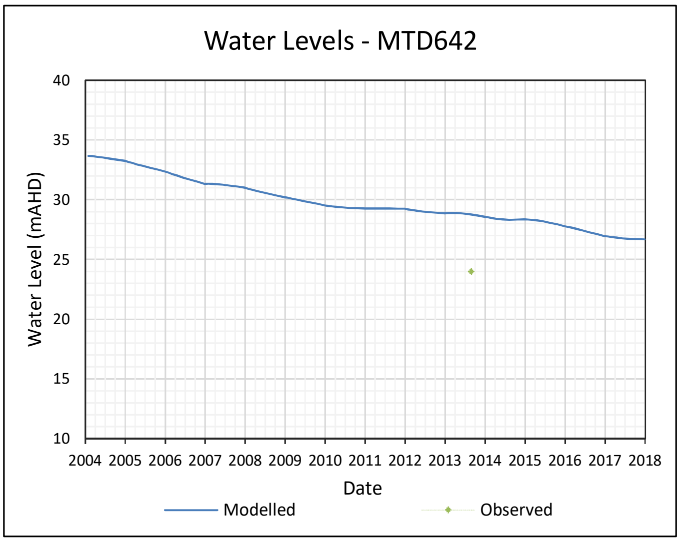

Water Levels - MTD632
Water Level (mAHD)
50
40
30
20
10
0
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

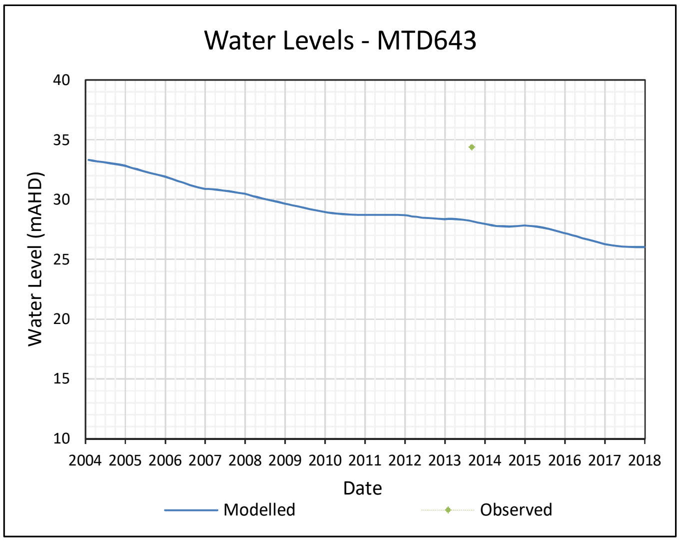

Water Levels - MTD634
Water Level (mAHD)
50
40
30
20
10
0
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

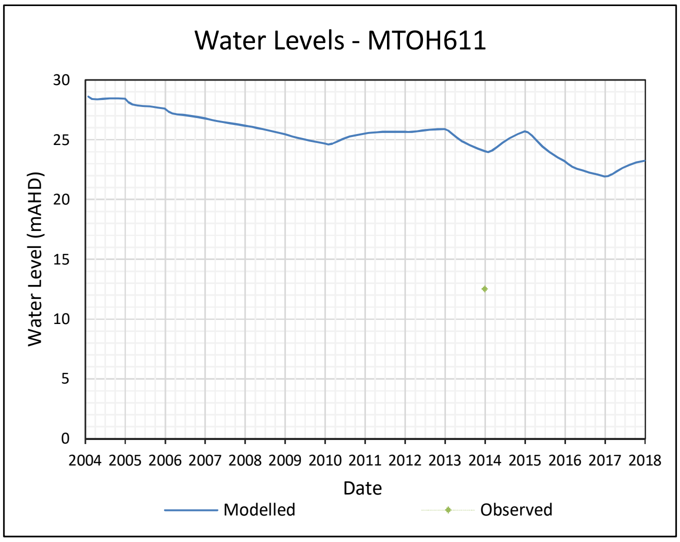

Water Levels - MTD639_1
Water Level (mAHD)
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

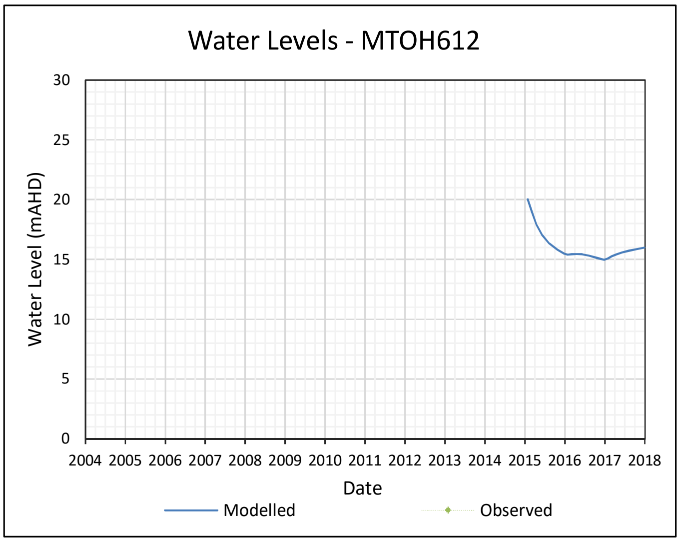

Water Levels - MTD639_2
Water Level (mAHD)
30
25
20
15
10
5
0
-5
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

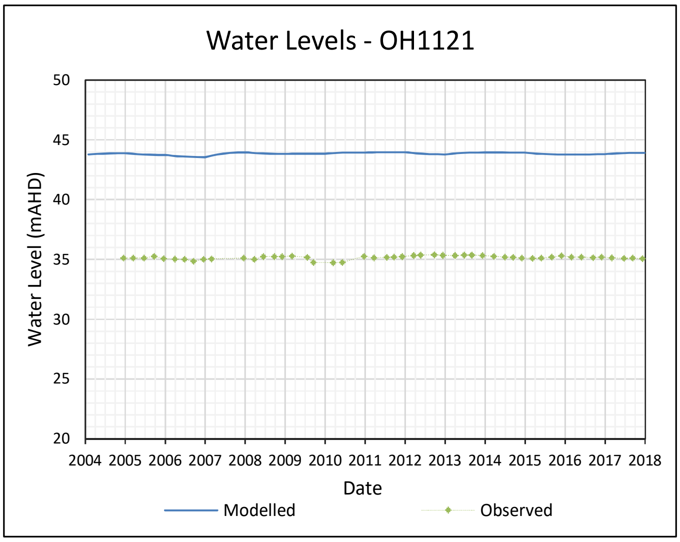

Water Levels - MTD640
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

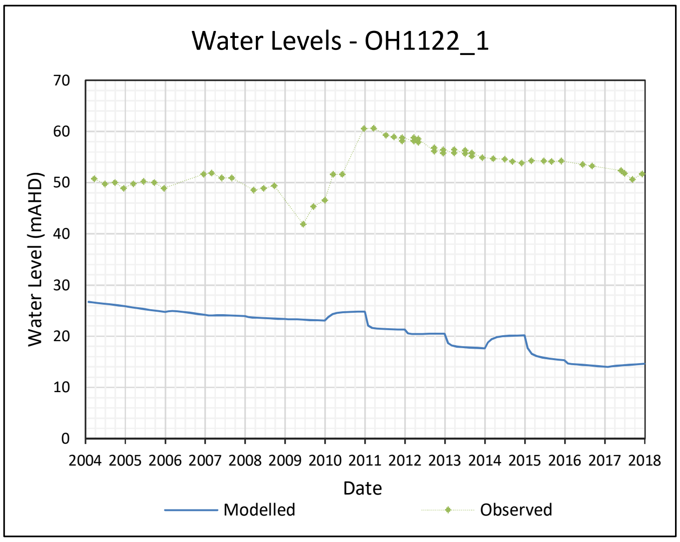

Water Levels - MTD642
Water Level (mAHD)
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

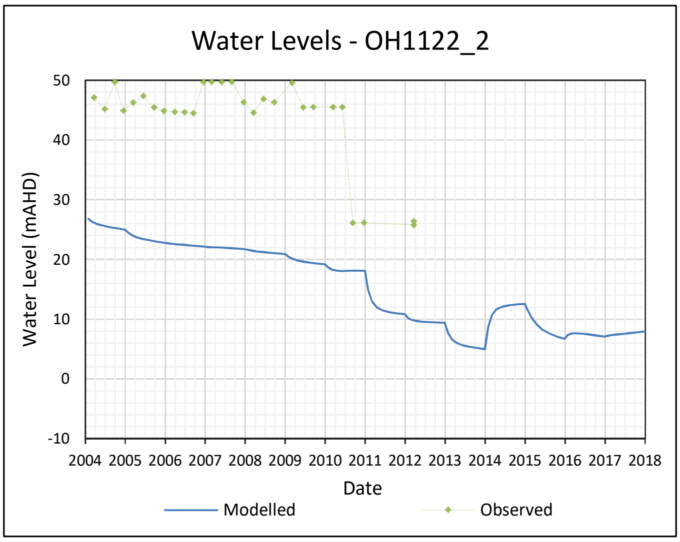

Water Levels - MTD643
Water Level (mAHD)
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

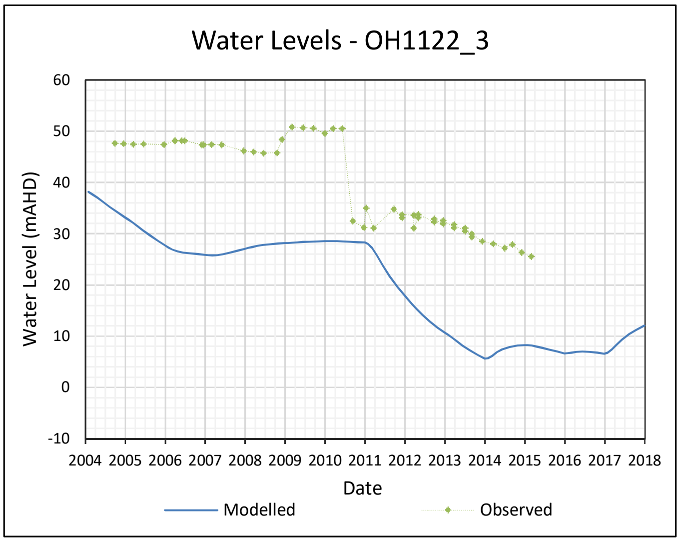

Water Levels - MTOH611
Water Level (mAHD)
30
25
20
15
10
5
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

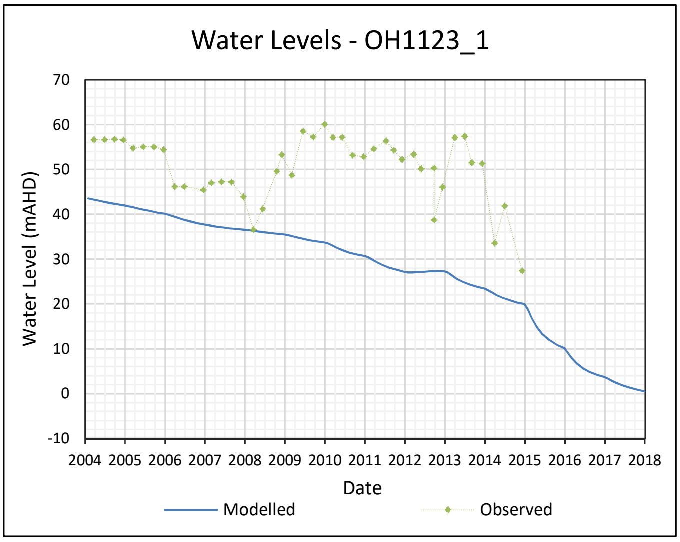

Water Levels - MTOH612
Water Level (mAHD)
30
25
20
15
10
5
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

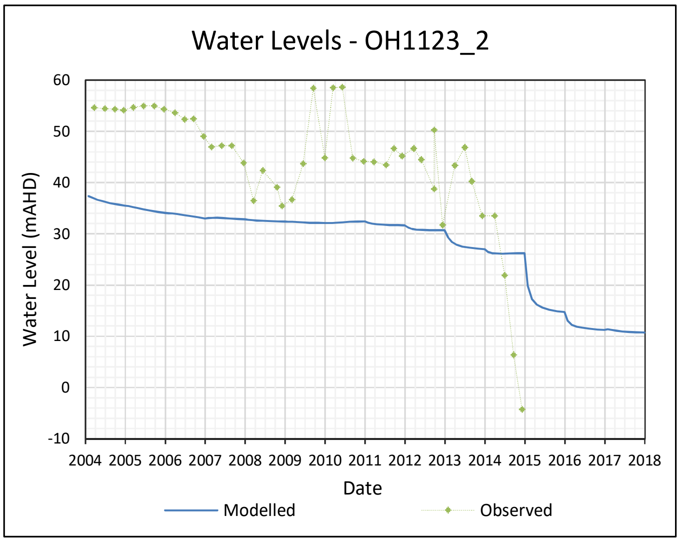

Water Levels - OH1121
Water Level (mAHD)
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

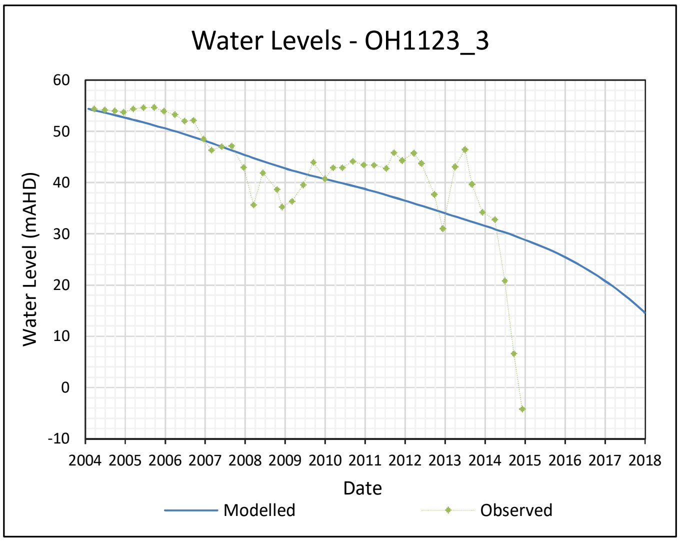

Water Levels - OH1122_1
Water Level (mAHD)
Date
Modelled
Observed

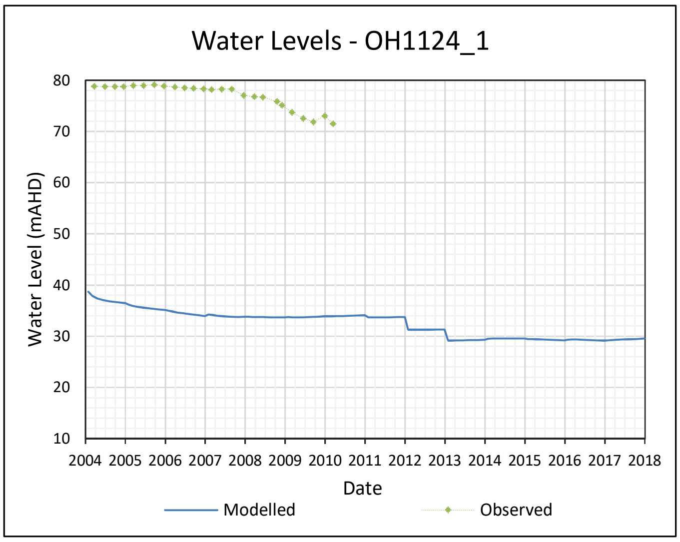

Water Levels - OH1122_2
Water Level (mAHD)
Date
Modelled
Observed

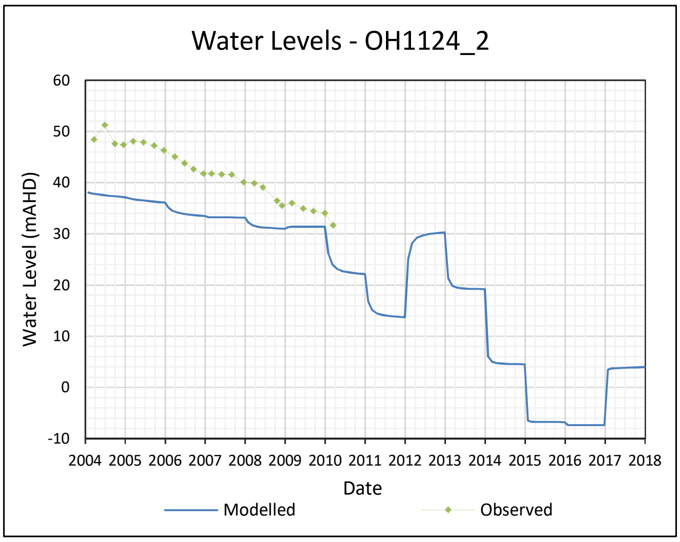

Water Levels - OH1122_3
Water Level (mAHD)
Date
Modelled
Observed

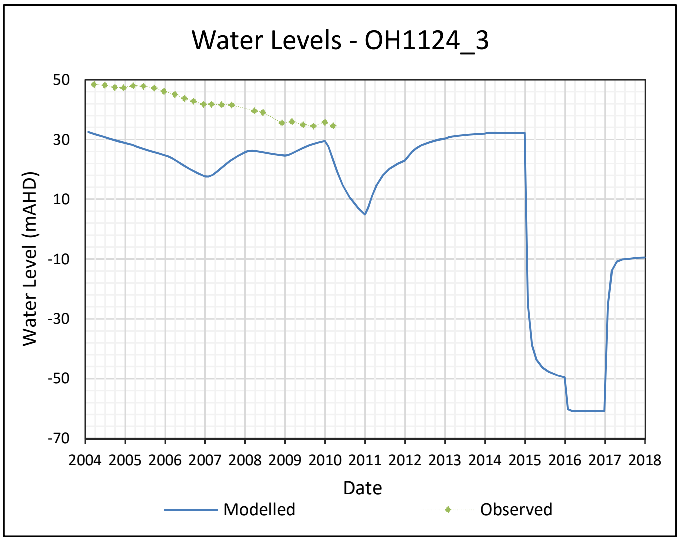

Water Levels - OH1123_1
Water Level (mAHD)
Date
Modelled
Observed

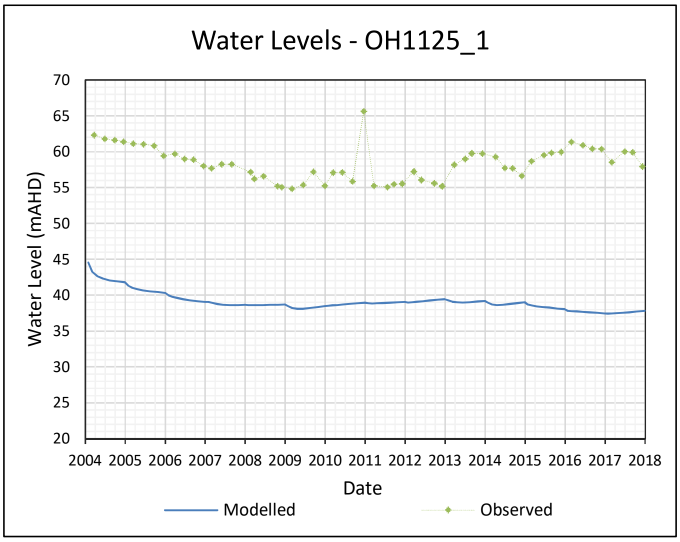

Water Levels - OH1123_2
Water Level (mAHD)
Date
Modelled
Observed

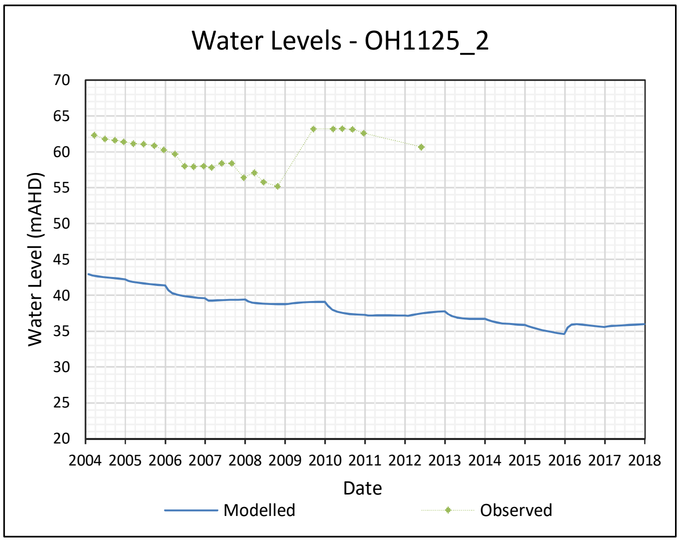

Water Levels - OH1123_3
Water Level (mAHD)
Date
Modelled
Observed

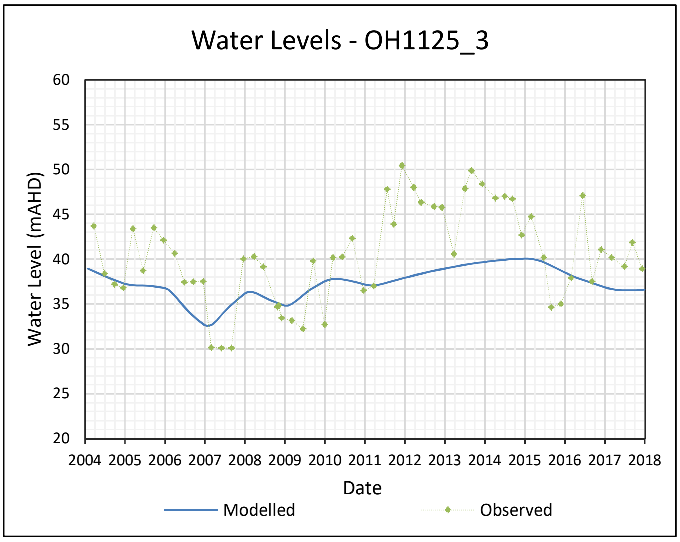

Water Levels - OH1124_1
Water Level (mAHD)
80
70
60
50
40
30
20
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

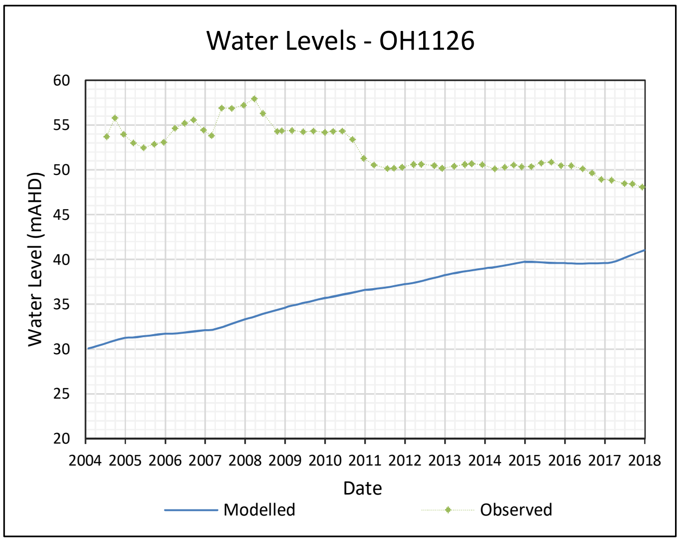

Water Levels - OH1124_2
Water Level (mAHD)
60
50
40
30
20
10
0
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

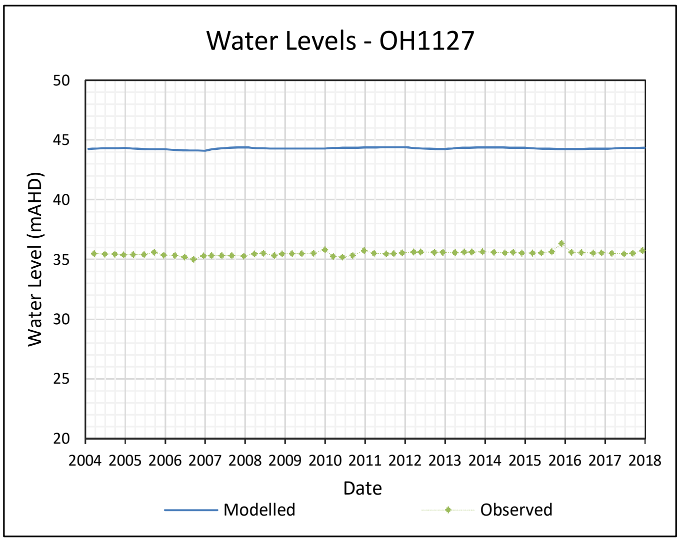

Water Levels - OH1124_3
Water Level (mAHD)
50
30
10
-10
-30
-50
-70
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

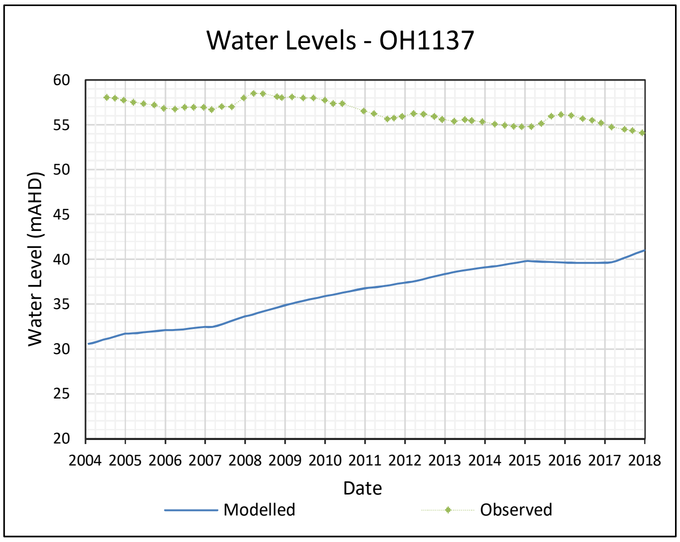

Water Levels - OH1125_1
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

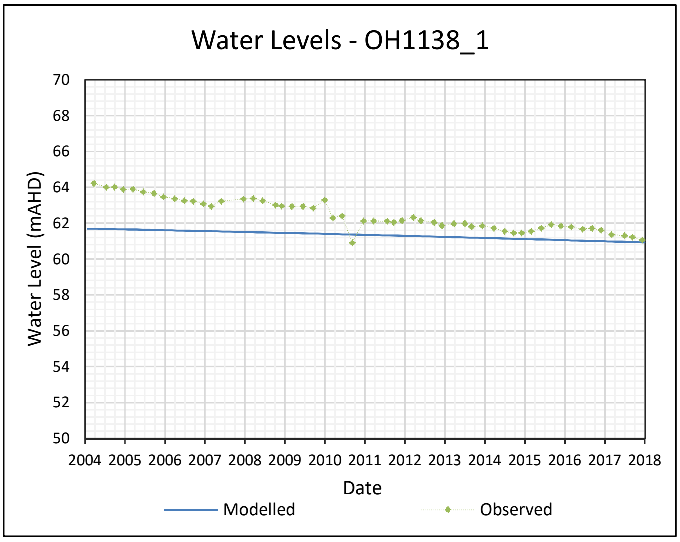

Water Levels - OH1125_2
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

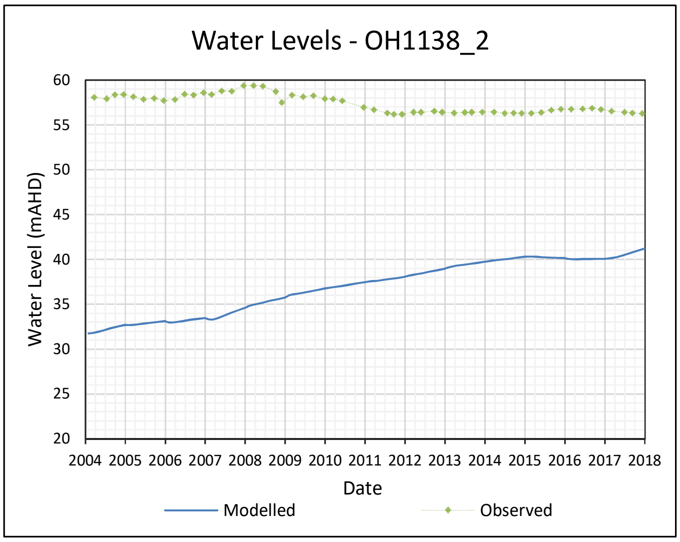

Water Levels - OH1125_3
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

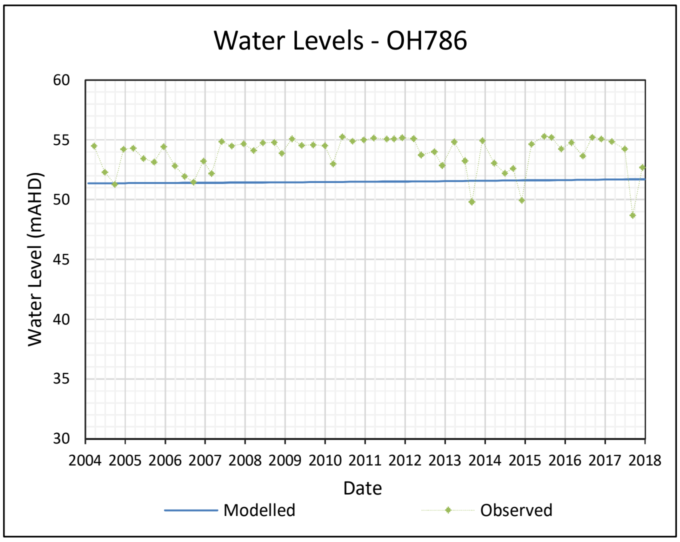

Water Levels - OH1126
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

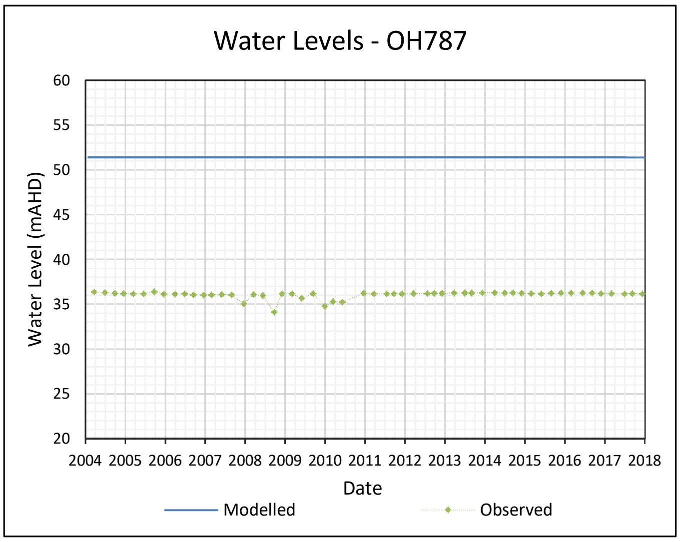

Water Levels - OH1127
Water Level (mAHD)
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

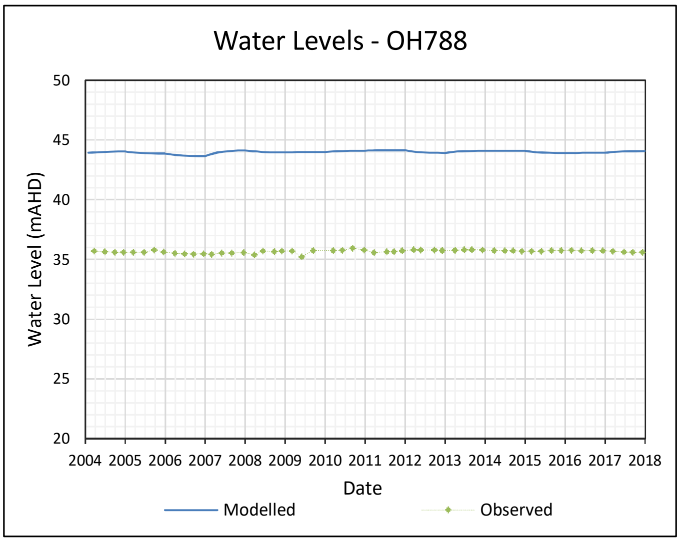

Water Levels - OH1137
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

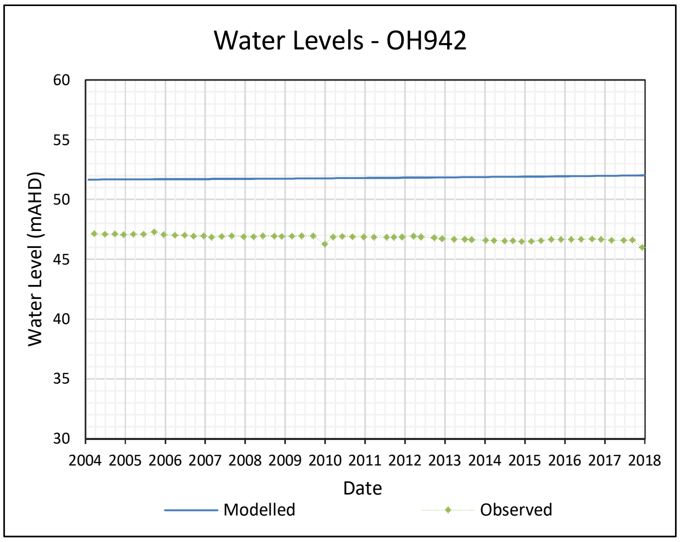

Water Levels - OH1138_1
Water Level (mAHD)
70
68
66
64
62
60
58
56
54
52
50
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

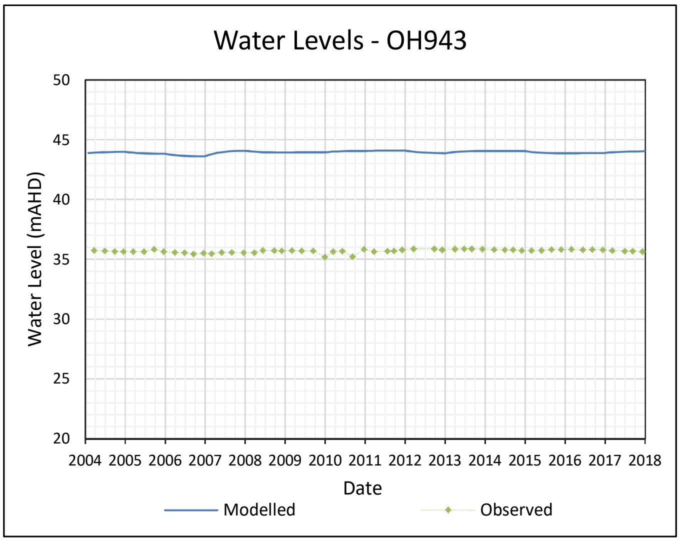

Water Levels - OH1138_2
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

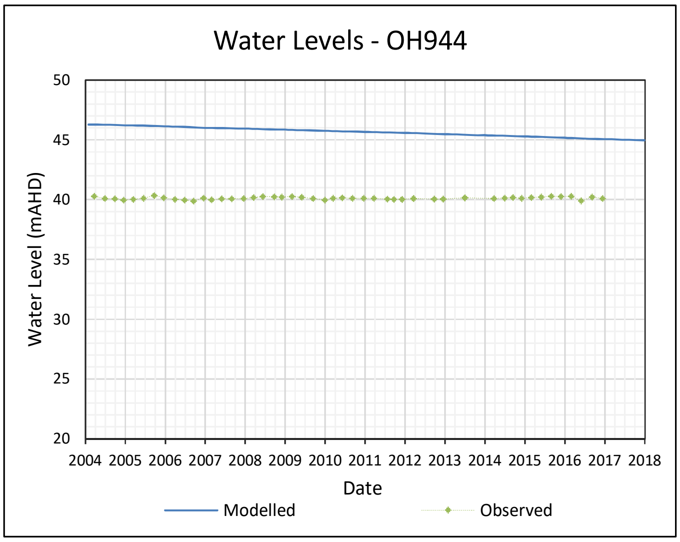

Water Levels - OH786
Water Level (mAHD)
60
55
50
45
40
35
30
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

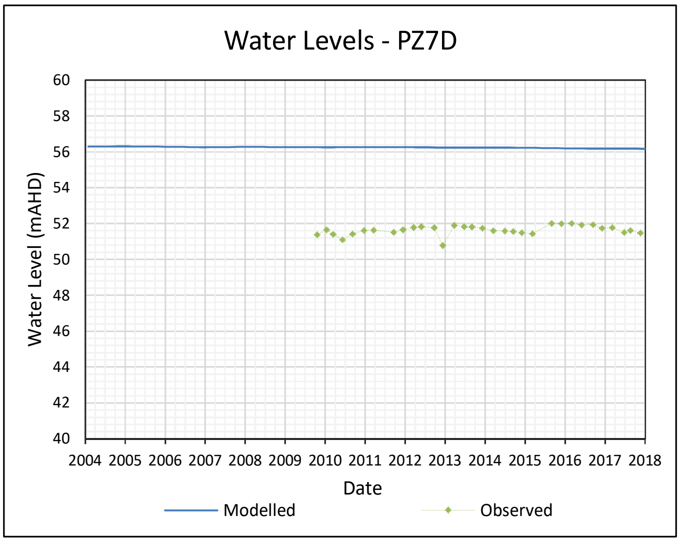

Water Levels - OH787
Water Level (mAHD)
Date
Modelled
Observed

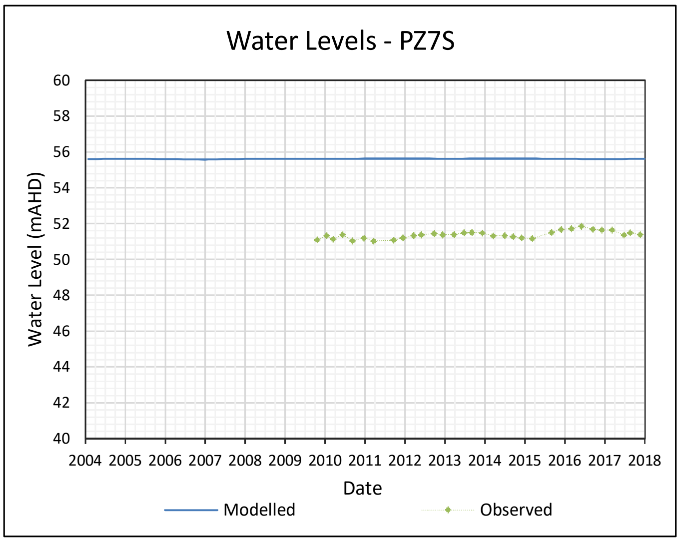

Water Levels - OH788
Water Level (mAHD)
Date
Modelled
Observed


Water Levels - OH942
Water Level (mAHD)
Date
Modelled
Observed

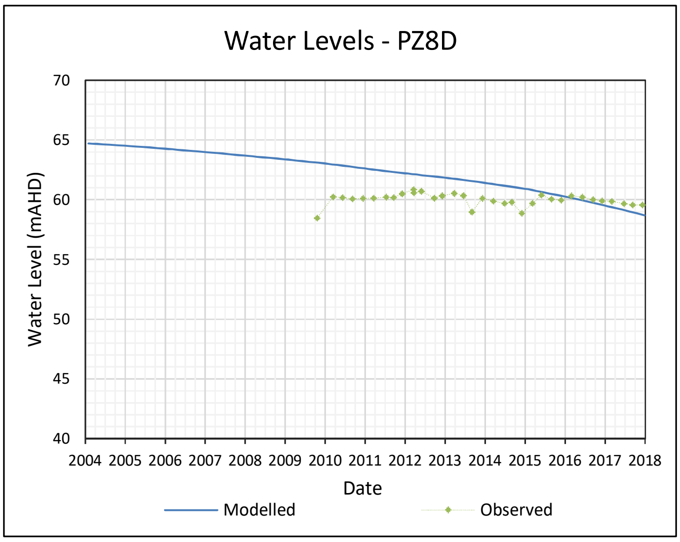

Water Levels - OH943
Water Level (mAHD)
Date
Modelled
Observed


Water Levels - OH944
Water Level (mAHD)
Date
Modelled
Observed

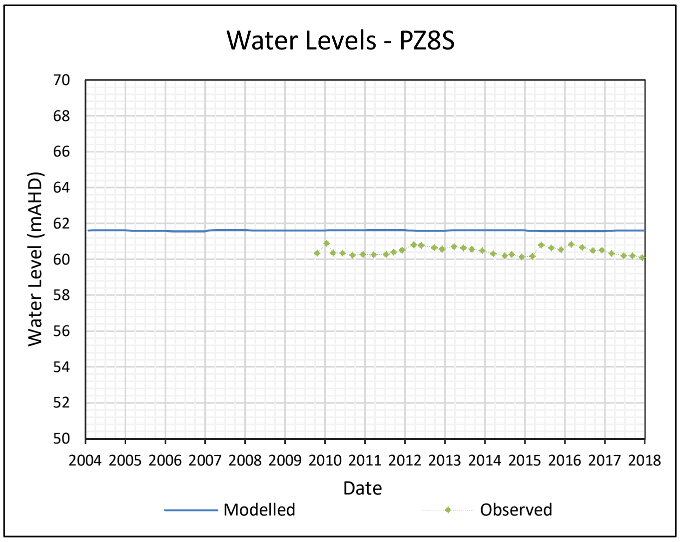

Water Levels - PZ7D
Water Level (mAHD)
Date
Modelled
Observed



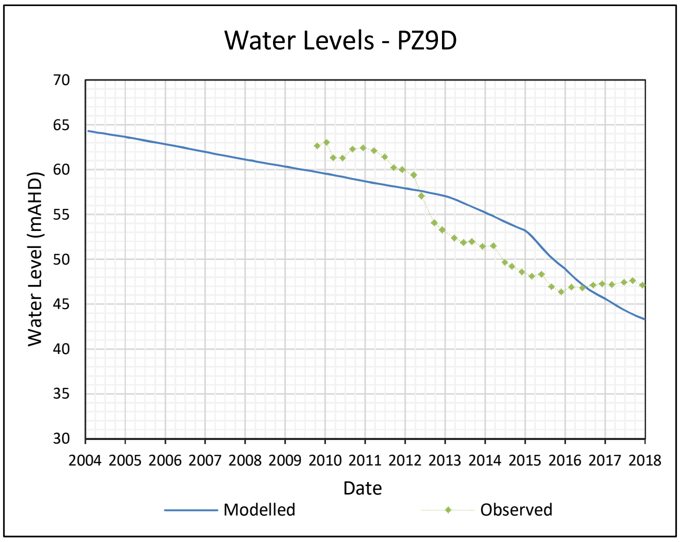
Water Levels - PZ7S
Water Level (mAHD)
Date
Modelled
Observed



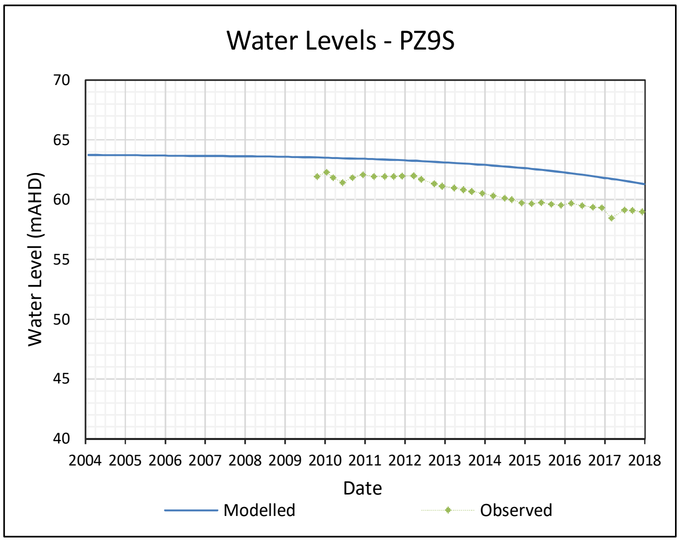
Water Levels - PZ8D
Water Level (mAHD)
Date
Modelled
Observed



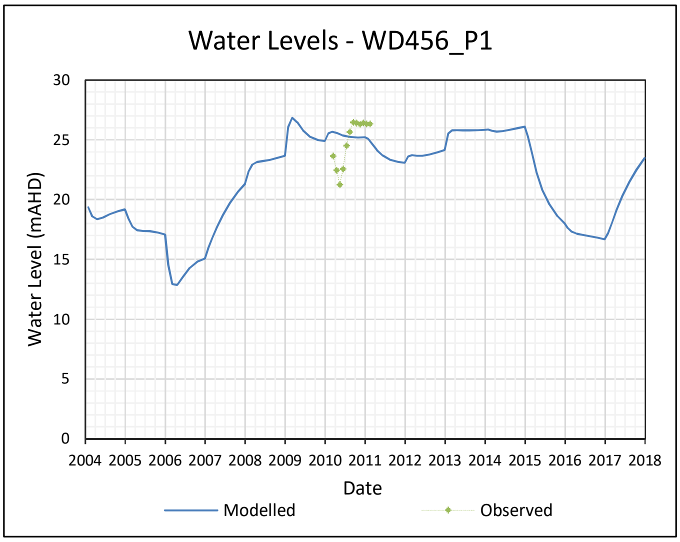
Water Levels - PZ8S
Water Level (mAHD)
Date
Modelled
Observed



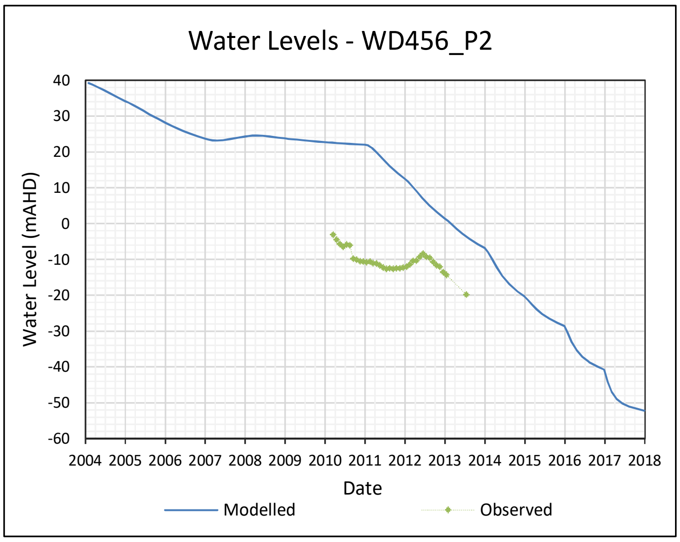
Water Levels - PZ9D
Water Level (mAHD)
Date
Modelled
Observed

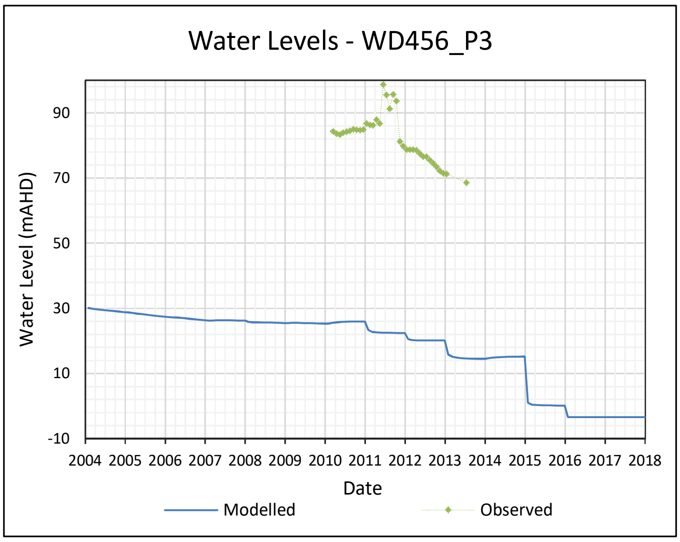


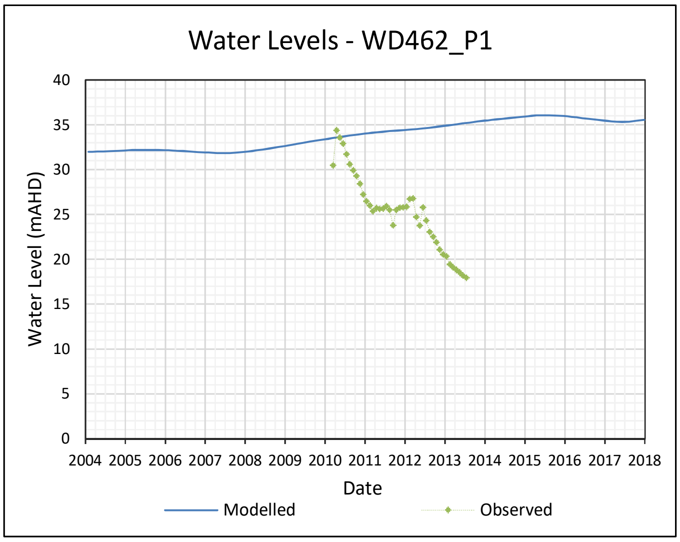
Water Levels - PZ9S
Water Level (mAHD)
Date
Modelled
Observed

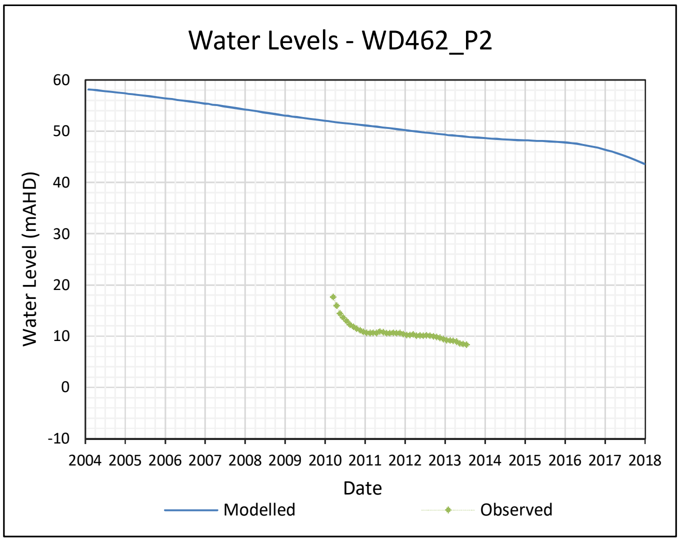


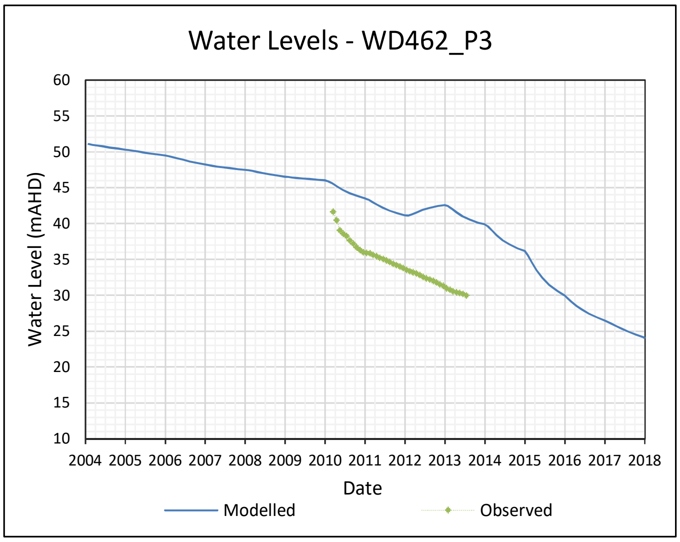
Water Levels - WD456_P1
Water Level (mAHD)
Date
Modelled
Observed

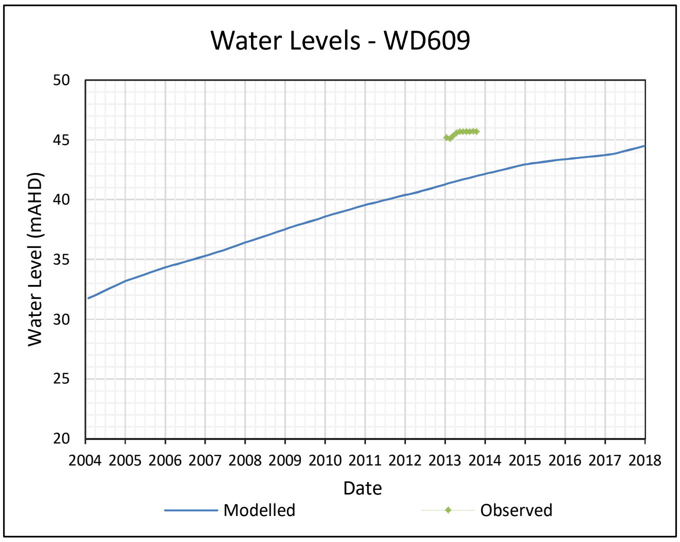

Water Levels - WD456_P2
Water Level (mAHD)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

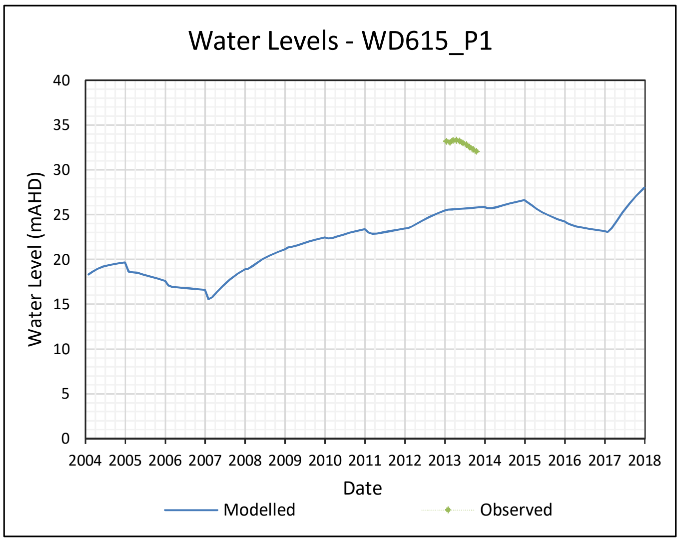

Water Levels - WD456_P3
Water Level (mAHD)
90
70
50
30
10
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed


Water Levels - WD462_P1
Water Level (mAHD)
40
35
30
25
20
15
10
5
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

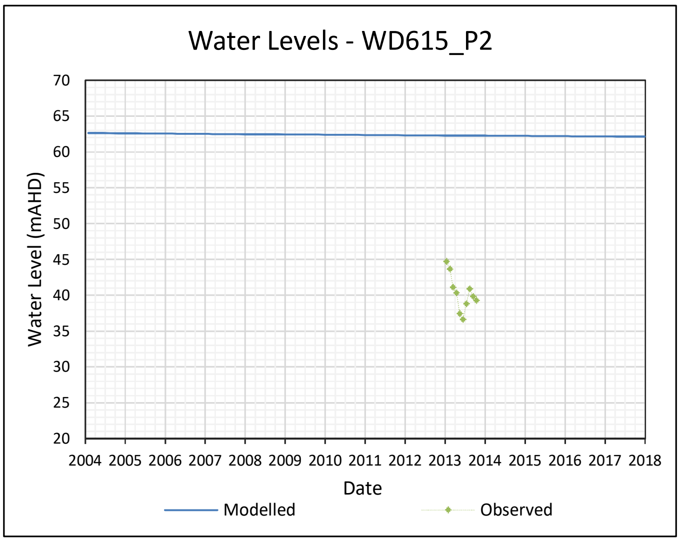

Water Levels - WD462_P2
Water Level (mAHD)
60
50
40
30
20
10
0
-10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed


Water Levels - WD462_P3
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

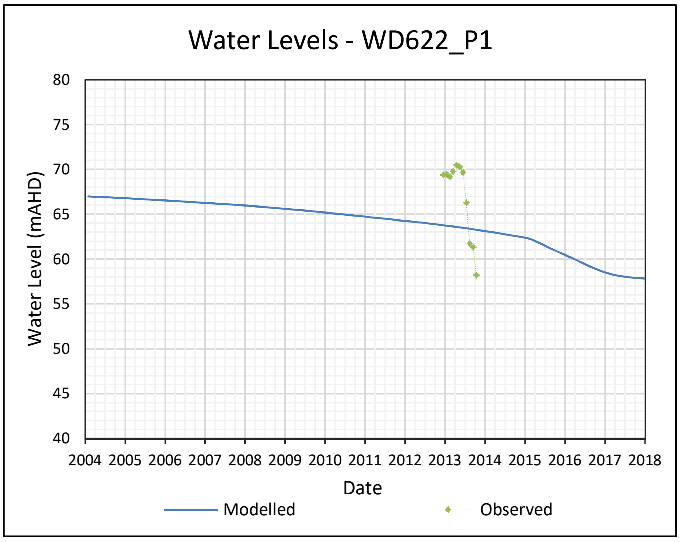

Water Levels - WD609
Water Level (mAHD)
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed



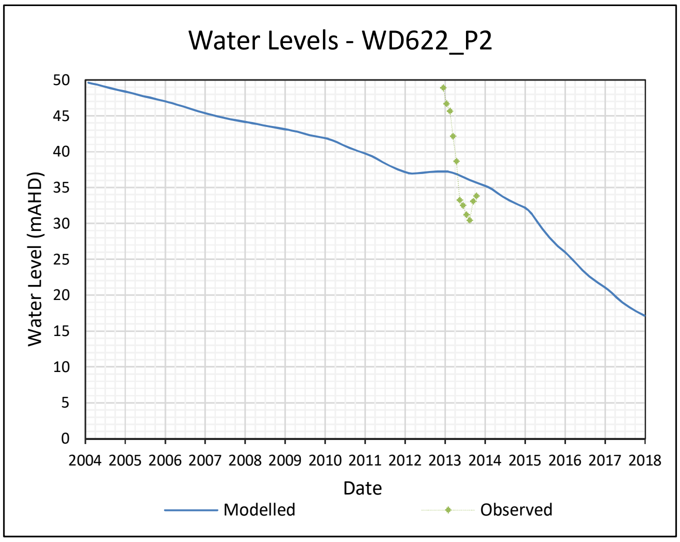
Water Levels - WD615_P1
Water Level (mAHD)
Date
Modelled
Observed



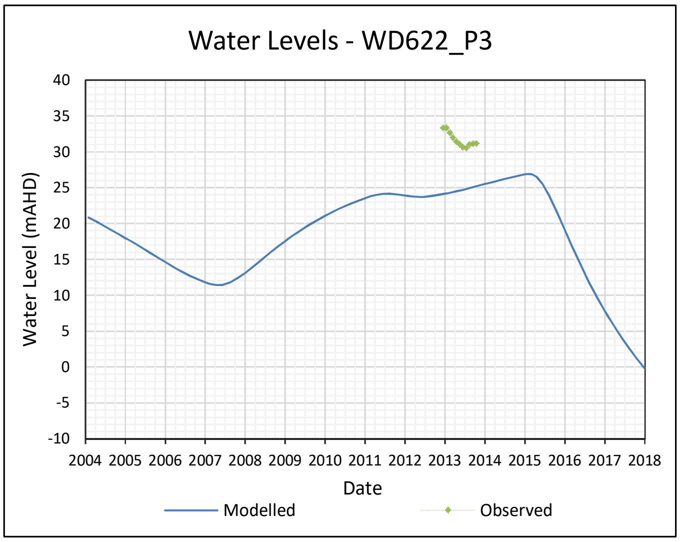
Water Levels - WD615_P2
Water Level (mAHD)
Date
Modelled
Observed



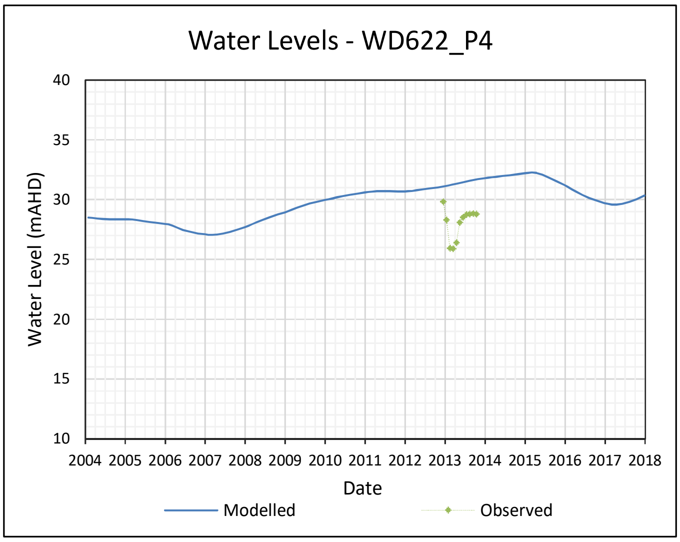
Water Levels - WD622_P1
Water Level (mAHD)
Date
Modelled
Observed



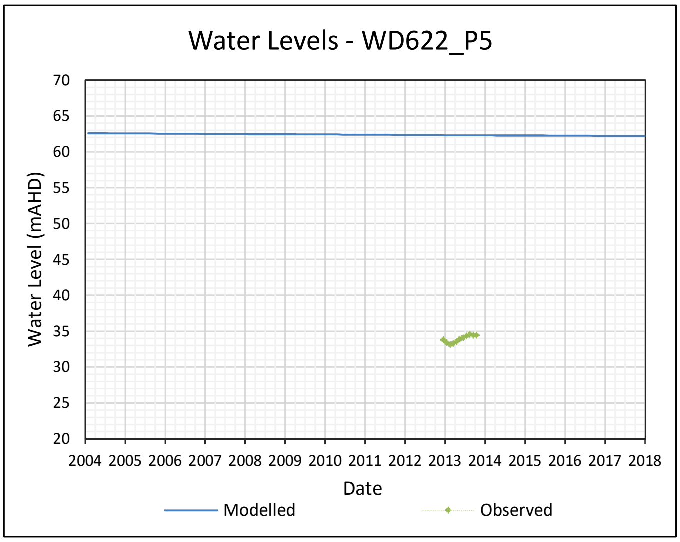
Water Levels - WD622_P2
Water Level (mAHD)
Date
Modelled
Observed



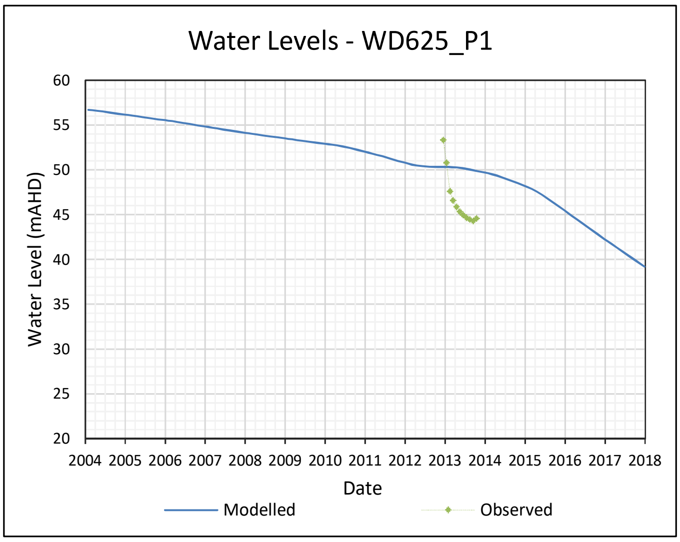
Water Levels - WD622_P3
Water Level (mAHD)
Date
Modelled
Observed



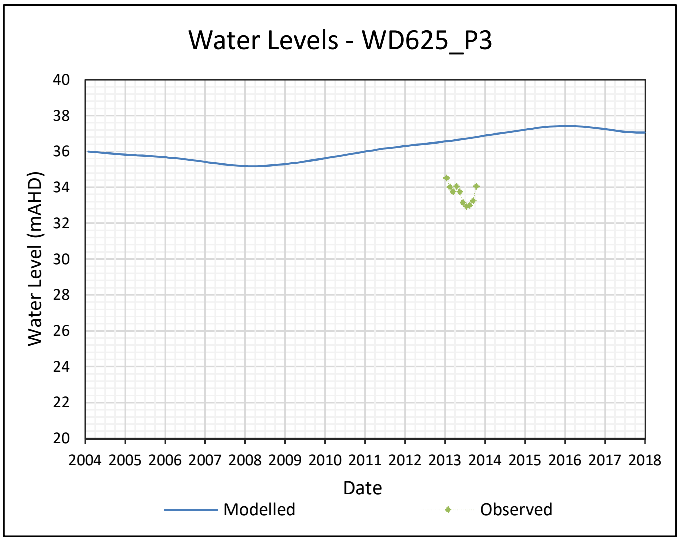
Water Levels - WD622_P4
Water Level (mAHD)
Date
Modelled
Observed



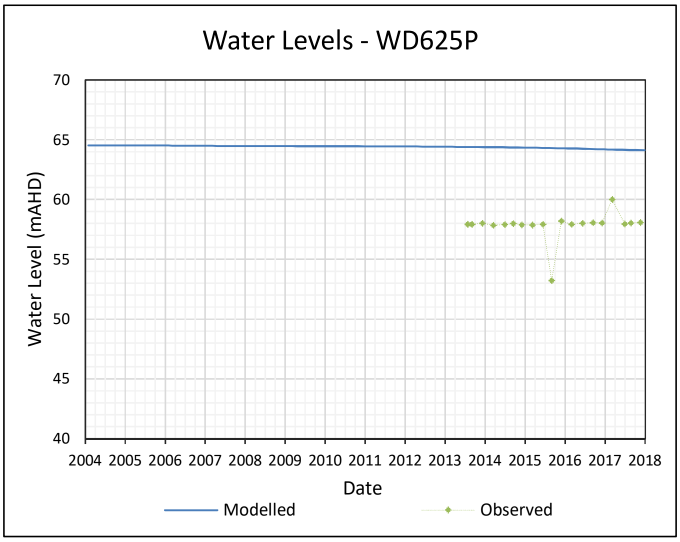
Water Levels - WD622_P5
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed



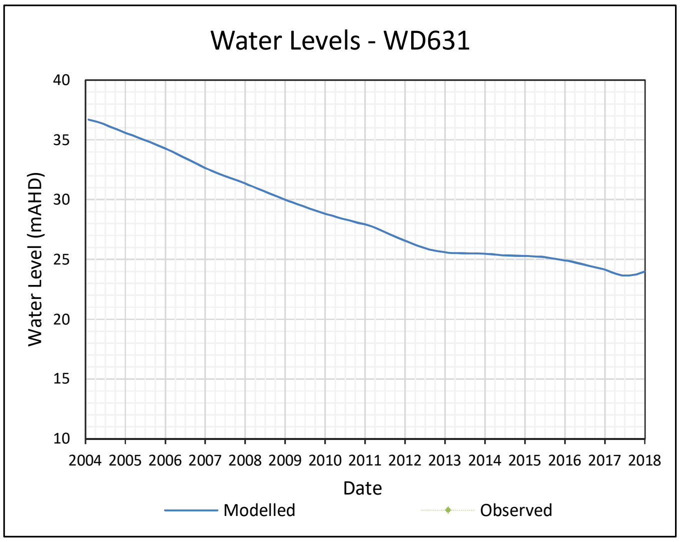
Water Levels - WD625_P1
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed



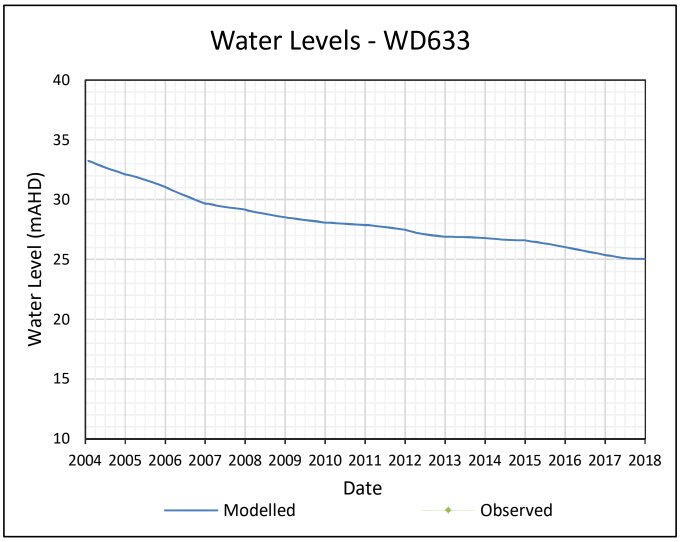
Water Levels - WD625_P3
Water Level (mAHD)
40
38
36
34
32
30
28
26
24
22
20
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed



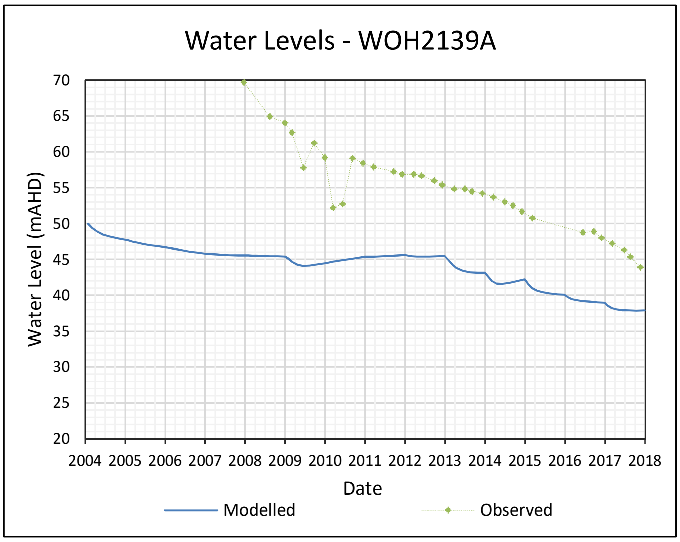
Water Levels - WD625P
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

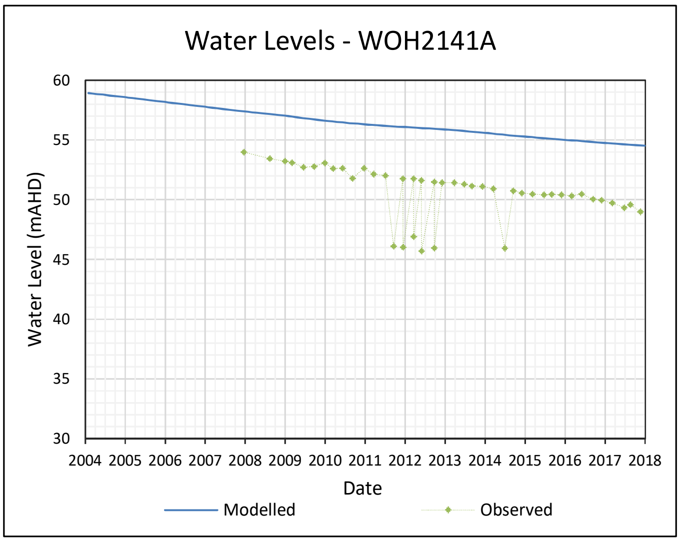


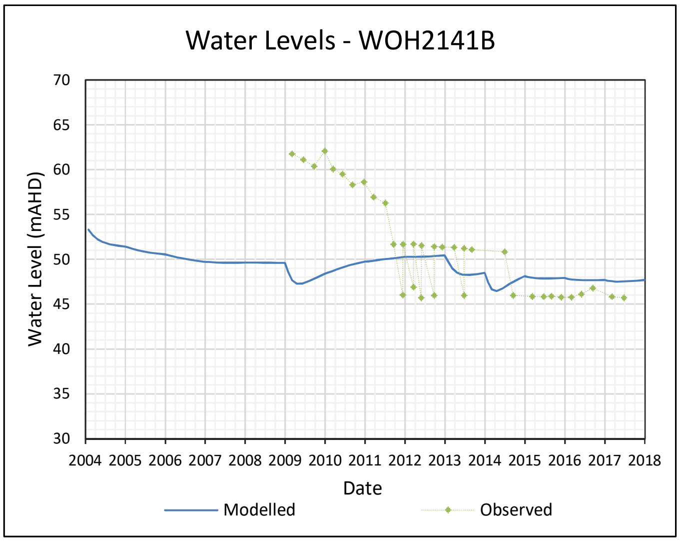
Water Levels - WD631
Water Level (mAHD)
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

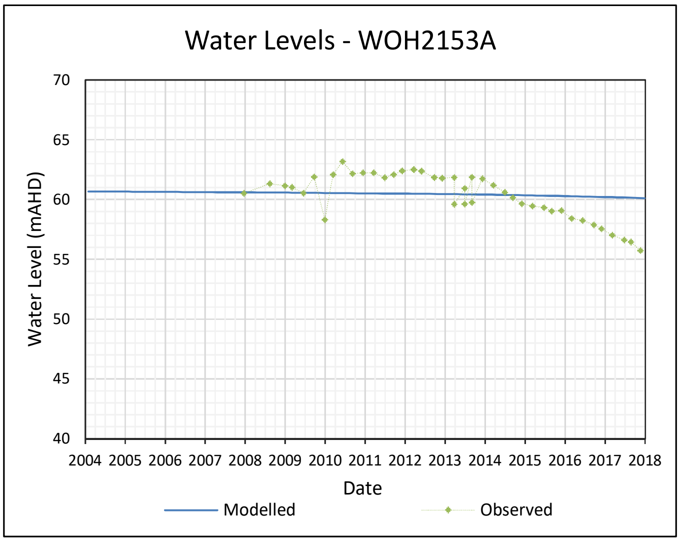


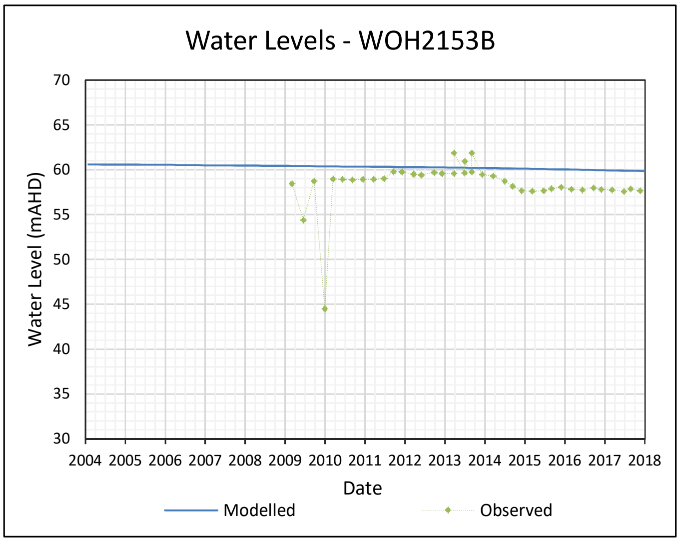
Water Levels - WD633
Water Level (mAHD)
40
35
30
25
20
15
10
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

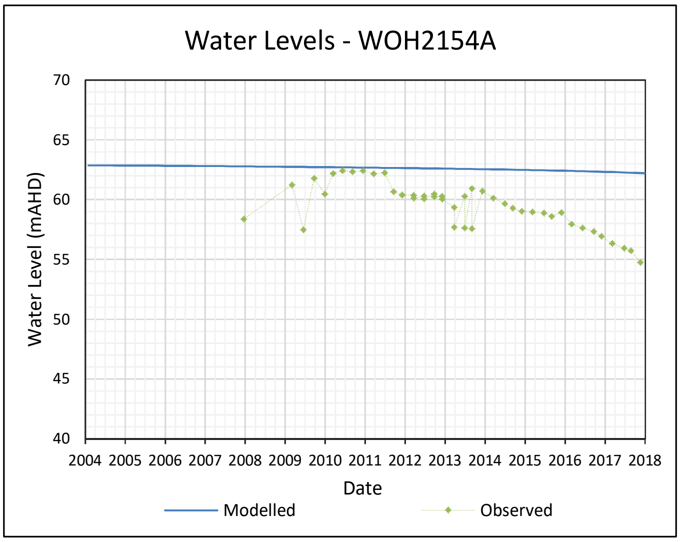

Water Levels - WOH2139A
Water Level (mAHD)
Date
Modelled
Observed

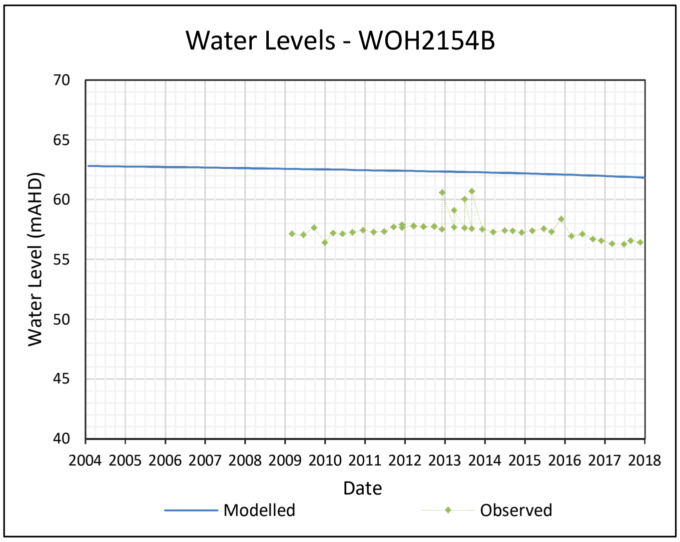

Water Levels - WOH2141A
Water Level (mAHD)
Date
Modelled
Observed

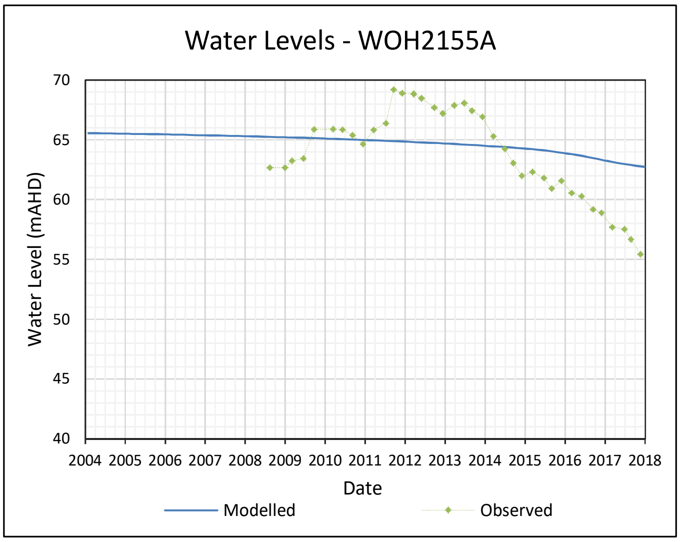

Water Levels - WOH2141B
Water Level (mAHD)
Date
Modelled
Observed

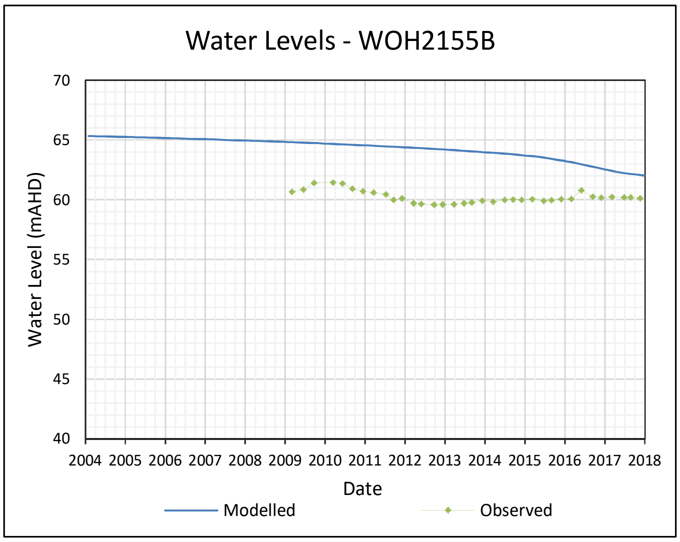

Water Levels - WOH2153A
Water Level (mAHD)
Date
Modelled
Observed

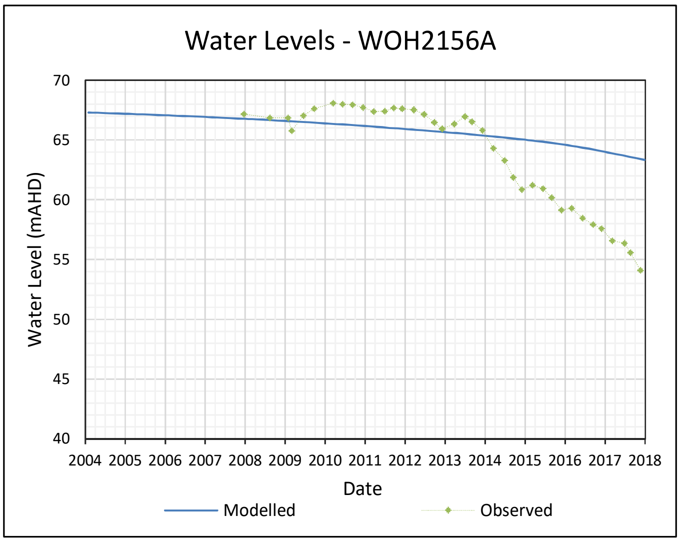

Water Levels - WOH2153B
Water Level (mAHD)
Date
Modelled
Observed

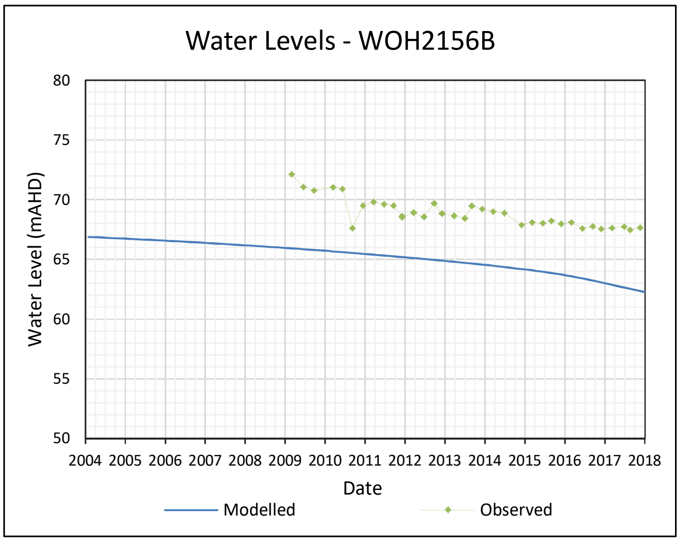

Water Levels - WOH2154A
Water Level (mAHD)
Date
Modelled
Observed


Water Levels - WOH2154B
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed


Water Levels - WOH2155A
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed


Water Levels - WOH2155B
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed


Water Levels - WOH2156A
Water Level (mAHD)
70
65
60
55
50
45
40
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed


Water Levels - WOH2156B
Water Level (mAHD)
80
75
70
65
60
55
50
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Date
Modelled
Observed

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

ROCKHAMPTON
rockhampton@slrconsulting.com
M: +61 407 810 417

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TAMWORTH
PO Box 11034
Tamworth NSW 2340
Australia
M: +61 408 474 248
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

NELSON
5 Duncan Street
Port Nelson 7010
New Zealand
T: +64 274 898 628

NEW PLYMOUTH
Level 2, 10 Devon Street East
New Plymouth 4310
New Zealand
T: +64 0800 757 695