Mount Thorley Warkworth

2018 Annual Review

Name of Operations	Mount Thorley Warkworth
Name of Operator	Coal & Allied (NSW) Pty Ltd (wholly owned subsidiary of Yancoal Australia Ltd)
Development consent /project approval	SSD-6464 & SSD-6465
Name of holder of development consent/project approval	Warkworth Mining Ltd Mt Thorley Operations Pty Ltd
Mining Lease #	Contained within Section 3.1 of this report
Name of holder of mining lease	Warkworth Mining Ltd Mount Thorley Operations Pty Ltd
Water Licence #	Contained within Section 3.1 of this report
Name of holder of water licence	Contained within Section 3.1 of this report
MOP/RMP start date	14/12/2018
MOP/RMP end date	30/11/2021
Annual Review Start Date	01/01/2018
Annual Review End Date	31/12/2018

I, Gary Mulhearn, certify that this audit report is a true and accurate record of the compliance status of Mount Thorley Warkworth for the period 1 January 2018 to 31 December 2018 and that I am authorised to make this statement on behalf of Coal & Allied (NSW) Pty 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 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 the 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 Authorised Reporting Officer	Mr Gary Mulhearn
Title of Authorised Reporting Officer	Environment and Community Manager
Signature of Authorised Reporting Officer	[signature]
Date	13 Sep 2019

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 2018 to 31 December 2018.

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 2018 Annual Review aligns with the NSW Department of Planning and Environment (DP&E) Post-approval requirements for State significant mining developments – Annual Review Guideline (October 2015).

MTW produced 17.6 million tonnes of run-of-mine (ROM) coal during 2018, and 12.1million tonnes of saleable coal, against an approved ROM coal production rate of 28 million tonnes per annum (mtpa).

A key milestone to MTW, reached during the reporting period, was the closure of Wallaby Scrub Road. A portion of Wallaby Scrub Road was gazetted as closed by the Minister for Lands and Forestry on 7 September 2018, and subsequently purchased from Singleton Council by Yancoal associated companies. The Warkworth Continuation Project development consent SSD-6464 approves open cut mining through the alignment of Wallaby Scrub Road, and the closure of the road is a key step for successful progression of the Warkworth Continuation Project.

Noise

There were no non-compliances recorded against MTW's consented noise limits. There was an increase (from 18 to 38) in the number of supplementary attended noise measurements which exceeded the internal trigger levels for corrective action compared to 2017. A total of 1,079 hours of mine stoppages were recorded due to proactive and reactive measures to minimise noise.

Blasting

During the reporting period 282 blast events were initiated at MTW. There were no non- compliances against airblast overpressure or ground vibration criteria listed in MTW's Environment Protection Licences or Planning Approvals.

On 28 December 2018, one blast exceeded the 120dB(L) threshold for airblast overpressure at the Bulga Village blast monitor. The exceedance was reported to the Department of Planning and Environment (DP&E) and to the NSW Environment Protection Authority (EPA) on 28 December 2018. A written report was provided to the DP&E and EPA for this blast which noted that wind gusts produced substantial air pressure peaks both before and during the blast which increased air pressure levels recorded at the Bulga Village monitor. It is probable that a wind gust during the period of airblast arrival increased the air pressure level recorded by the monitor. As such, the exceedance is not considered to be a non-compliance.

Air Quality

During 2018, MTW complied with all short term and annual average air quality criteria. A total of 7,728 hours of mine stoppage was recorded following implementation of proactive and reactive measures to minimise dust. A total of 80.0 ha of land was aerially seeded during autumn to minimise wind eroded dust from overburden areas not yet available for rehabilitation.

Heritage

Aboriginal cultural heritage inspections and two salvage programs were conducted at MTW in 2018, in accordance with the MTW Aboriginal Cultural Heritage Management Plan (ACHMP).

An ACHMP inspection of known Aboriginal cultural heritage sites (48 in total), was also conducted during the reporting period. The inspection was conducted by representatives of the Aboriginal community and were assisted by internal mine site personnel and a consultant archaeologist. There were no incidents or any unauthorised disturbance to historic heritage sites at MTW during 2018.

Surface Water

2018 was a drier than average year with a total of 456.6 mm rainfall recorded at MTW's Charlton Ridge Meteorological station.

Three new sediment basins (Dam 51N, Dam 52N and Dam 53N) and associated diversion drains were constructed during the reporting period in order to capture runoff originating from disturbed areas being prepared for mining.

WML received a Penalty Notice from the EPA in May 2018 in relation to an incident reported to the EPA and DP&E on 4 December 2017, details of that incident were provided in the 2017 Annual Review. The Penalty Notice was in relation to Environment Protection Licence 1376 (EPL 1376) *Condition O1.1* which requires operations to be carried out in a competent manner. New water management structures have been constructed since this incident, and the premises boundary changed to include the former Wallaby Scrub Road corridor within the licenced premises.

Groundwater

Groundwater monitoring activities were undertaken in 2018 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 2018.

Visual Amenity

The Putty Road visual bund was vegetated with native seed mix in 2018. Further rehabilitation of the eastern side of the Warkworth mine site in 2018 continued to improve the visual amenity when looking from the east. Parts of the northern end of Warkworth were rehabilitated in 2018, improving visual amenity particularly for motorists travelling east.

Rehabilitation and Land Management

A total of 102 ha rehabilitation was completed during 2018 against a MOP target of 112.6 ha. Total disturbance undertaken was 171.8 ha, slightly lower than the 2018 MOP projection of 177.2 ha. Tailings Dam 2 (Dam 33N) continued with closure activities by capping a portion of the southern area of the tailings beach with suitable weathered material.

The net rehabilitation progress (i.e. rehabilitation minus rehabilitation disturbance) for the current MOP period (2015 to 2018) is 301.1ha, which is 5.6ha lower than the MOP target of 306.7ha.
Cumulative new disturbance over the MOP period is 314.2ha which is in line with the MOP forecast of 314.7ha for the same period.

Biodiversity and Offset Management

Restoration of the Warkworth Sands Woodland vegetation community continued in the Northern Biodiversity Area, with over 8,000 seedlings planted. Restoration activities for the Central Hunter Grey Box – Ironbark Woodland and River Oak Forest continued in the Southern Biodiversity Area, with over 22,000 seedlings planted. Weed control, vertebrate pest management activities, seed collection, and fence repairs were conducted during 2018 in the Local and Regional Biodiversity Areas in accordance with the Offset Management Plans.

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1 STATEMENT OF COMPLIANCE

A Statement of Compliance against the relevant approvals is provided in **Table 1.1**. **Table 1.2** provides a brief summary of the non-compliances and a reference to where these are addressed within this Annual Review.

TABLE 1.1 STATEMENT OF COMPLIANCE

Approval	Were all conditions complied with?
DA SSD-6465 (MTO)	Yes
DA SSD-6464 (WML)	No

TABLE 1.2 NON COMPLIANCES

Relevant approval	Condition number	Condition description (summary)	Compliance status	Section in this Annual Review it is addressed.
SSD-6464 (WML)	Schedule 3 Condition 16	Blast Management Plan	Non-Compliant (Administrative non-compliance)	6.3

TABLE 1.3 COMPLIANCE STATUS KEY FOR TABLE 1.2

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 Limited (YAL). A summary of MTW tenements is shown in **Figure 2.**

2.1 Scope

This Annual Environmental Review (AER) covers the twelve-month reporting period from **1 January 2018 to 31 December 2018.**

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 2018 Annual Review aligns with the *DP&E Post-approval requirements for State significant mining developments – Annual Review Guideline* (October 2015).

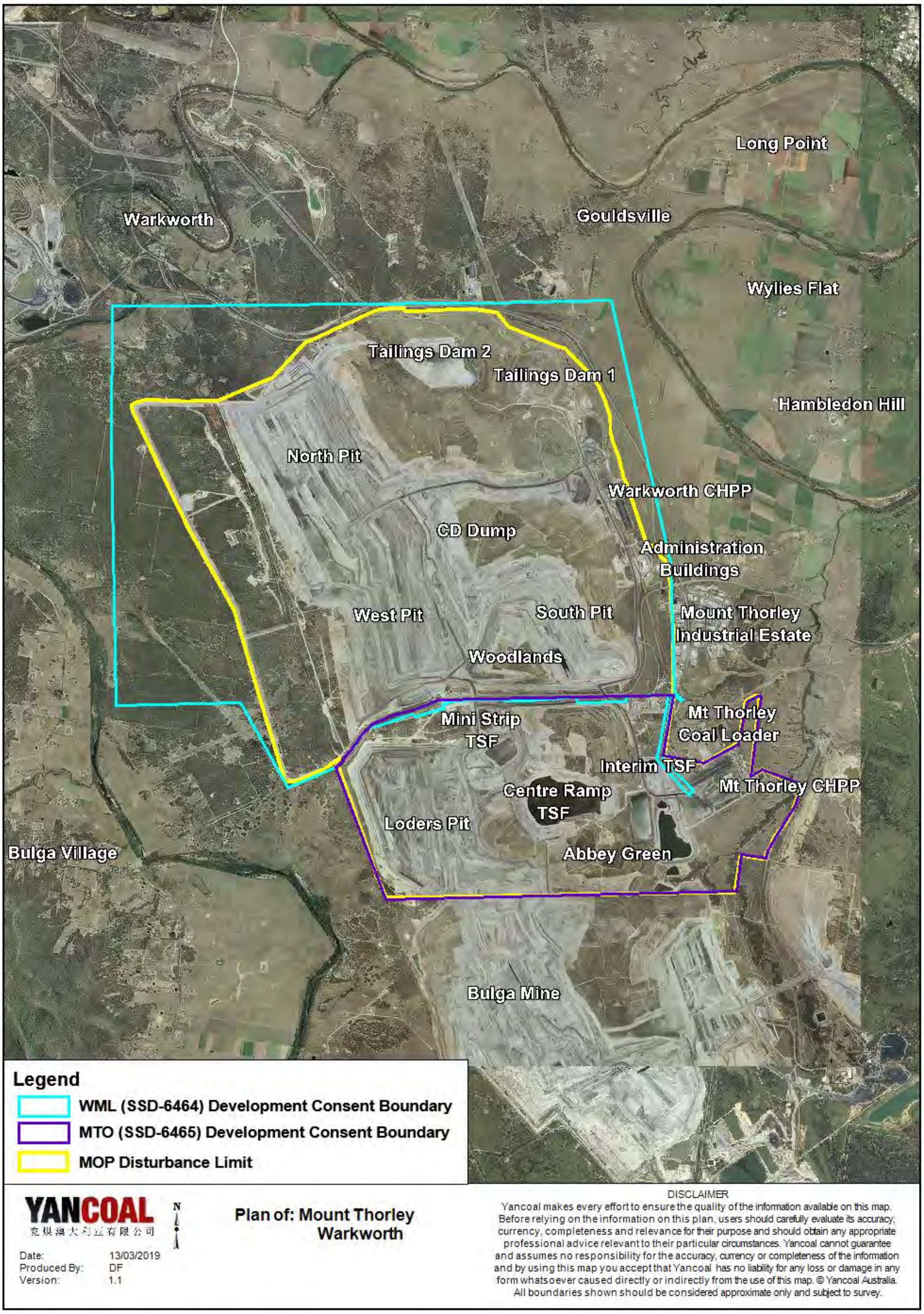


FIGURE 1: MTW SITE LAYOUT AND LOCALITY PLAN

FIGURE 2: MTW TENEMENT SUMMARY

2.2 Mine Contacts

Table 2.1 outlines the contact details for site personnel responsible at Mount Thorley Warkworth.

TABLE 2.1 SITE PERSONNEL

Position	Name	Contact Number
General Manager – MTW	Jason McCallum	(02) 6570 1501
Environment & Community Manager - MTW	Gary Mulhearn	(02) 6570 1734

3 APPROVALS

3.1 Approvals, Leases and Licences

3.1.1 Current Approvals

The status of MTO and WML development consents, licenses and relevant approvals at 31 December 2018 are summarised in **Table 3.1** to **Table 3.7**.

TABLE 3.1 OPERATIONS APPROVALS- WARKWORTH

Approval Number	Description	Authority	Date of Approval / Variations
SSD-6464	Warkworth Continuation Project development consent	DP&E	26/11/2015
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	Commonwealth Department of the Environment and Energy	9/8/2012 – 31/3/2033 (varied on 14/10/2018)
EPBC 2002/629	Approval under the EPBC Act to construct and operate an open cut coal mine extension at the Warkworth Coal Mine	Commonwealth Department of the Environment and Energy	18/2/2004 (varied on 6/4/2004, 24/5/2004, 19/11/2004, 13/7/2012, 14/10/2018) – 25/2/2039

TABLE 3.2 OPERATIONS APPROVALS - MOUNT THORLEY

Approval Number	Description	Authority	Date of Approval / Variations
SSD-6465	Mount Thorley Continuation Project development consent	DP&E	26/11/2015

TABLE 3.3 LICENCES AND PERMITS

Licence No	Description	Authority	Date of Approval / Variations
Warkworth			
EPL 1376	Environment Protection Licence	EPA	7/2/2019
50661122	Radiation Licence	EPA	2/05/2020
XSTR100160	Licence to Store – Explosives Act	WorkCover NSW	TBA (pending)
Mount Thorley			
EPL 24	Environment Protection Licence	EPA	24/11/2016
EPL 1976	Environment Protection Licence	EPA	18/10/2018
5061110	Radiation Licence	EPA	31/7/2019

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.

A variation to the Warkworth Environment Protection Licence (EPL 1376), was lodged with the EPA on 17 September 2018, to vary the premises boundary to include the section of the former Wallaby Scrub Road that was gazetted as closed on 7 September 2018, and subsequently purchased by Yancoal associated companies. This variation was approved on the 6 February 2019.

TABLE 3.4 MINING TENEMENTS

Mining tenement	Type	Purpose	Status	Date of Approval / Variations
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

Mining tenement	Type	Purpose	Status	Date of Approval / Variations
ML 1751	Mining Lease	Prospecting, Mining Coal and Purposes	Granted	17/03/2017 – 17/03/2023
Mount Thorley				
CL 219	Coal Lease	Prospecting and Mining Coal	Granted	23/09/1981 - 23/09/2023
(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 - 23/02/2020
ML 1752	Mining Lease	Prospecting, Mining Coal and Purposes	Granted	17/03/2017- 17/03/2038
EL 8824	Exploration Licence	Prospecting Coal	Granted	15/02/2019- 15/02/2025
Mount Thorley Coal Loading Limited				
MLA 548	Mining Lease Application	Mining Purposes	Application Pending	Mining Lease Application Lodged 13/11/2017

TABLE 3.5 OTHER APPROVALS

Approval	Authority	Dates (current as of)
Emplacement Areas **Warkworth**		
Tailings Dam 2 (TD2) - Establish Emplacement Area – Section 126(1) CMRA 1982	DPI	22/10/2002
Tailings Dam 2 (TD2) RL130 - Establish Emplacement Area – Section 126(1) CMRA 1982	DPI	09/12/2003
Tailings Dam 2 (TD2) – High Risk Notification - Capping	DPI	08/06/2016
Mount Thorley		
Section 126 Variation to Reject Emplacement Area	DPI	20/03/2001

Approval	Authority	Dates (current as of)
Centre Ramp Tailings Facility (CRTSF) RL92.5 – Establish Emplacement Area – Section 126(1) CMRA 1982	DPI	09/04/2001
Centre Ramp Tailings Facility (CRTSF) RL97.5 – Establish Emplacement Area – Section 126(1) CMRA 1982	DPI	08/09/2004
Centre Ramp Tailings Facility (CRTSF) RL120 – Establish Emplacement Area – Section 126(1) CMRA 1982	DPI	10/05/2006
Centre Ramp Tailings Facility (CRTSF) RL130 – High Risk Notification – Embankment Raise	DPI	01/09/2015
Mini Strip 24 Tailings Storage Facility – Establish Emplacement Area – Section 126(1) CMRA 1982	DPI	08/09/2004
Mini Strip 24 Tailings Storage Facility – Deprescription	DSC	20/06/2013
Abbey Green South Tailings Dam – Establish Emplacement Area – Section 126(1) CMRA 1982	DPI	10/5/2006
Interim Tailings Storage Facilities – High Risk Notification – Capping	DPI	16/02/2015
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	01/02/2007
Resource Recovery Exemption for coal washery rejects at Mount Thorley Warkworth	DECC	01/02/2010

TABLE 3.6 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
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

Licence Number	Type	Purpose	Legislation	Description	Renewal Date
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
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 3.7 WATER ACCESS LICENCES

Licence Number	Description	Water Source	Water Sharing Plan	Water Source – Management Zone	Approved Extraction (ML)*	Actual Extraction 2018 (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	1,768
WAL10544	(Hunter Regulated River – Domestic and Stock)	Hunter River	Hunter Regulated River WSP	Zone 2b (Hunter River From Wollombi Brook Junction To Oakhampton Rail Bridge)	5	0
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	3.5#
WAL18558	Hawkes	Wollombi Brook	Hunter Unregulated and Alluvial Water Sources WSP	Lower Wollombi Brook Water Source	50	9.5#
WAL19022	Sandy Hollow Creek	Unregulated River	Hunter Unregulated and Alluvial Water Sources WSP	Singleton Water Source	60	0

Licence Number	Description	Water Source	Water Sharing Plan	Water Source – Management Zone	Approved Extraction (ML)*	Actual Extraction 2018 (ML)
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	140#
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	275#

** Approved extraction limits are for a financial year.*

 # Passive take / groundwater inflows to pit.

3.1.2 Management Plans, Programmes and Strategies

Table 3.8 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 applicable environmental management activities planned for MTW. Details regarding the submission and approval dates for the current MOP are shown in **Table 3.9**.

TABLE 3.8 STATUS OF MANAGEMENT PLANS REQUIRED UNDER WARKWORTH CONTINUATION (SSD-6464) AND MOUNT THORLEY OPERATIONS (SSD-6465) DEVELOPMENT CONSENTS

Plan / Program / Strategy	Status (approval date)
Air Quality Management Plan	20/09/2018
Noise Management Plan	20/09/2018
Blast Management Plan	15/01/2019
Water Management Plan	20/09/2018
WML Biodiversity Management Plan	20/09/2018
Rehabilitation Management Plan (addressed in MOP)	14/12/2018
Environmental Management Strategy	24/08/2018
MTW Historic Heritage Management Plan	11/10/2017
MTW Aboriginal Heritage Management Plan	07/02/2018
Wollombi Brook Aboriginal Cultural Heritage Conservation Area Conservation Management Plan	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 North Rothbury Biodiversity Area	26/06/2017 (DP&E)
Warkworth Sands Woodland Integrated Management Plan	Pending (Submitted to OEH 15/02/2017)
Warkworth Sands Woodland Performance Criteria	Pending (Submitted to OEH 15/02/2017)

TABLE 3.9 MOP APPROVAL STATUS FOR MOUNT THORLEY WARKWORTH

Mining Operations Plan	Date Submitted	Date Approved
Mount Thorley Warkworth MOP Amendment A 2018 - 2021	11/10/2018	14/12/2018

4 OPERATIONS DURING THE REPORTING PERIOD

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 3** illustrates the mining process. MTW have no active underground workings.

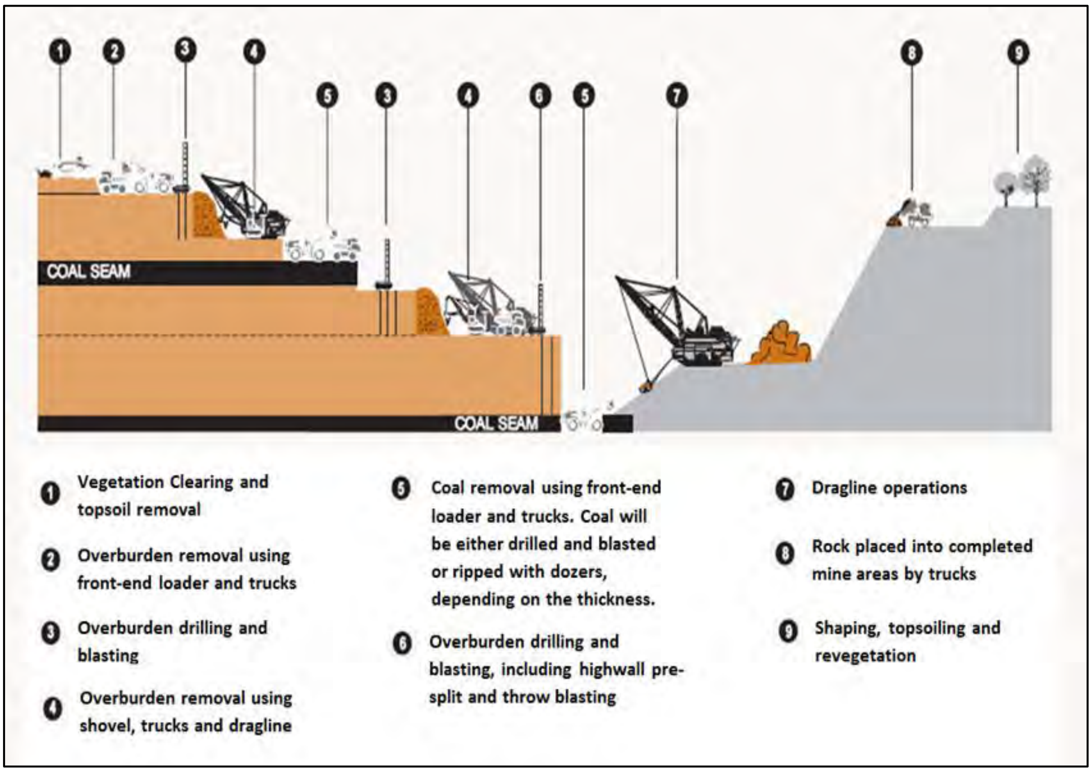


FIGURE 3: MINING PROCESS

Within Warkworth, mining activities will continue to advance in a westerly direction in both North and West Pits. South Pit has reached its final limit with regards to excavation. This area is currently being utilised for dumping activity. Within Mount Thorley, a small area in the southwestern extent of the mining lease will reach the western limit during 2019 with remaining reserves to be mined to depth during 2019. Exploration drilling was conducted within the relevant mining leases ahead of mining and within the pit to gain further information on the resource. All mining related activity is in line with the current MOP.

The planned 2019 production and waste schedule for MTW is summarised below:

- 17.5 Mt ROM coal;
- 12.0 Mt Product coal;
- 125 Mbcm overburden (including rehandle); and
- 5.5 Mt Tailings and reject

The forecasted ROM coal production represents approximately 63% 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 2018 were consistent with the approved MOP and no changes were made to the processing and rejects/tailings disposal methods.

Currently active tailing emplacements include the Centre Ramp Tailings Storage Facility and Abbey Green South Tailings Storage Facility. Tailings Dam 2 was previously used to receive ash from Redbank Power Station but ceased in July 2014 following the cessation of operations at Redbank Power Station. During 2018 capping works on Tailings Dam 2 continued.

4.3 Production Statistics

Approved extraction of up to 28 million tonnes of ROM coal from MTW is permitted in a calendar year, comprising up to 18 million tonnes of 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 4.1.**

TABLE 4.1 SUMMARY OF PRODUCTION AT MTW IN 2018

Material	Approved Limits	Reporting Period 2017	Reporting Period 2018	Forecast for 2019
Prime Overburden Waste (kbcm)	N/A	101,669	98,568	101,834
MTO ROM Coal (Mtpa)	10 (SSD-6465)	4.08	3.02	2.32
WML ROM Coal (Mtpa)	18 (SSD-6464)	13.59	14.59	14.66
ROM Coal (Mtpa)	28 (Combined)	17.69	17.61	16.98
Coarse Reject (kt)	N/A	3,504	4,306	4,393
Fine Reject – Tailings (kt)	N/A	2,435	1,070	1,098
Product (kt)	N/A	11,817	12,121	11,831

4.4 Summary of Changes (Developments and Equipment Upgrades)

A key milestone for MTW reached during the reporting period, was the closure of Wallaby Scrub Road. A portion of Wallaby Scrub Road was gazetted as closed by the Minister for Lands and Forestry on **7 September 2018**, and subsequently purchased from Singleton Council by Yancoal associated companies on the same date.

Construction activities completed in support of operations during 2018 have included:

- the Rural Fire Service Emergency Access Track/Fire Trail prior to the closure of Wallaby Scrub Road, as required by SSD-6464 Schedule 3 Condition 50;
- Putty Road third crossing as approved by SSD-6464 Schedule 3 Condition 49;
- water management structures ahead of mining; and
- mine ancillary infrastructure (e.g. powerline relocations, pipeline relocations).

No additional mining equipment was purchased in 2018.

5 ACTIONS REQUIRED FROM PREVIOUS ENVIRONMENTAL MANAGEMENT REVIEW

An annual environmental inspection was not undertaken by DP&E. **Table 5.1** below summarises the actions required by DP&E to be addressed in the 2018 AER.

TABLE 5.1 ACTIONS FROM/FOLLOWING THE PREVIOUS ANNUAL REVIEW

Action Required	Requested by	Section of Annual Review
Administrative – include a map showing the regional context of the project and mining lease and Environmental Protection Licence boundaries in accordance with the Departments AR guidelines.	DP&E	2.1
Groundwater – include the key findings from the independent groundwater consultant's report including any recommendations for improvement.	DP&E	6.7.5
Rehabilitation – describe key issues that may affect successful rehabilitation.	DP&E	7
Non-compliances – please include details on measures that will be implemented to prevent the recurrence of identified non-compliances.	DP&E	10

6 ENVIRONMENTAL MANAGEMENT AND PERFORMANCE

6.1 Meteorological Data

Meteorological data is collected to assist in day to day operational decisions, planning, and environmental management and to meet development consent requirements. MTW operates a real time meteorological (weather) station located on Charlton Ridge. The meteorological station measures wind speed, wind direction, temperature, humidity, solar radiation, rainfall, and sigma theta. Instruments are installed, calibrated, and maintained according to the relevant Australian Standard AS 3580.14 (2011). Meteorological data is available to site personnel and provides mining operations with trend assessment details to inform operational decisions aimed at minimising impacts. Daily Meteorological data summaries are presented in the Monthly Environmental Monitoring reports, available via the MTW website: http://insite.yancoal.com.au.

6.2 Noise

6.2.1 Noise Management

MTW manages noise to ensure compliance with permissible noise limits at nearby private residences. A combination of both proactive and reactive control mechanisms is 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 MTW website: http://insite.yancoal.com.au.

MTW's 2018 noise performance metrics are shown below:

- Community noise complaints received – reduced by ~10% from 2017
- Number of Community Response Officer (CRO) (supplementary) noise measurements which exceed the internal trigger level for action – increased to 38 from 18 in 2017; and
- Number of equipment downtime hours logged in response to noise management triggers – increased by ~28% from 2017.

A range of noise management projects and processes were undertaken during 2018. These are described herein.

6.2.1.1 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 2018 is presented in **Table 6.1**.

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 MTW's interactive website. Viewer access: http://insite.yancoal.com.au

TABLE 6.1 SUMMARY OF SUPPLEMENTARY ATTENDED NOISE MONITORING CONDUCTED BY COMMUNITY RESPONSE OFFICERS 2018

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)	1075	13	3	32.6	32.1
Bulga Village	609	1	-	31.8	30.9
Inlet Road	499	13	-	33.3	31.9
Inlet Road West	290	1	-	29.7	28.5
Long Point	1000	1	-	30.1	30.9
Other	9	-	-	-	-
South Bulga	0	-		-	-
Wambo Road	112	6	-	35.2	32.3
Total	3594	35	3	-	-

^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. A compliance assessment is provided in Sections 6.2.2 and 6.2.2.1.

**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 6.1** which exceeded the trigger, up to 1,079 hours of equipment downtime were recorded to manage noise during 2018. This is an increase (approximately 28%) to the number of downtime hours recorded in 2017 coinciding with an increase in the number of supplementary noise measurements completed which exceed the trigger for management action.

6.2.2 Noise Performance

A total of 99 compliance measurements were undertaken 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 LAeq and LA1, 1min noise criteria. Noise monitoring results are presented in the Monthly Environmental Monitoring Reports, available via the MTW website http://insite.yancoal.com.au.

In accordance with Fact Sheet C of the Noise Policy for Industry (NPfI), MTW has assessed measured noise levels collected during the attended compliance programme for low frequency content, and applied the modifying factor correction where applicable.

The application of the modifying factor resulted in one (1) exceedance of the WML LAeq Impact Assessment Criteria (refer to **Table 6.2)** during the reporting period**.** A subsequent measurement was taken on 10 August 2018 at 00:23. The re-measure confirmed compliance was achieved with the L_{Aeq},15minute criteria. Follow up monitoring was conducted at Bulga Village on the night of 13 August 2018. MTW complied with the L_{Aeq},15minute criteria and no further action was required. As both the re-measure and follow up monitoring were compliant, the initial exceedance does not constitute a non-compliance, as per MTW's approved Noise Management Plan. DP&E were notified in writing of the exceedance on 10 August 2018.

TABLE 6.2 ATTENDED NOISE MEASUREMENTS EXCEEDING CONSENT CONDITIONS FOLLOWING APPLICATION OF NPFI LOW FREQUENCY MODIFYING FACTOR

Location	Date/Time	Relevant Criteria	Criterion (dB)*	L_{Aeq}(dB)	Revised L_{Aeq} (dB)	Exceeds by (dB)
Bulga Village	09/08/2018	WML L_{Aeq} impact assessment criteria	38	39	41	3

6.2.2.1 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 Noise Policy for Industry.

Details of this comparison are provided in **Table 6.3** which demonstrates a continuation of the effective management delivered in 2017.

TABLE 6.3 COMPARISON OF 2018 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
2018	594	1	0
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. The data shows increases in the number of assessments made, coinciding with an increase in the number of measurements exceeding the WML noise management triggers (shown in **Table 6.4** below) and a general increase in the average WML noise levels. This also coincided with a 28% increase in equipment stoppages due to noise delays.

TABLE 6.4 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))*	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Wollemi Peak Road (Bulga RFS)	1293	1075	7	13	8	3	32.4	32.6	32.3	32.1
Bulga Village	542	609	1	1	-	-	31.4	31.8	31.7	30.9
Inlet Road	229	499	2	13	-	-	32.5	33.3	31.6	31.9
Inlet Road West	318	290	-	1	-	-	27.1	29.7	27.6	28.5
Long Point	751	1000	-	1	-	-	30.4	30.1	30.5	30.9
South Bulga	0	0	-	-	-	-	-	-	-	-
Wambo Road	80	112	-	6	-	-	34.0	35.2	32.8	32.3
Total	3239	3594	10	35	8	3	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.*

6.2.2.2 Comparison against EA Predictions

Table 6.5 provides a comparison of 2018 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 2018 data is the calculated quarterly average of WML contribution to measured LAeq (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 LAeq average for the quarter. The comparison shows that measured noise is lower than that predicted.

TABLE 6.5 PREDICTED NIGHT TIME WML (EIS 2014) LAEQ (15 MINUTE) NOISE LEVELS AND AVERAGED 2018 MONITORING RESULTS

Monitoring Location	Year 3 Modelled Noise	Quarter 1 2018 average	Quarter 2 2018 average	Quarter 3 2018 average	Quarter 4 2018 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	25.0	29.0	33.0	31.3
Bulga Village	≤38	23.3	29.7	37.0	27.3
Gouldsville Road	≤35	28.3	28.0	27.0	25.0
Inlet Road	≤37	25.0	32.3	34.7	33.3
Inlet Road West*	≤35	25.0	29.7	31.0	29.7
Long Point*	≤35	25.0	25.0	25.0	25.0
South Bulga	≤38	25.0	26.7	27.7	28.0
Wambo Road	≤38	25.0	29.3	33.3	30.3

**Denotes – No nearby receiver location modelled*

6.3 Blasting

6.3.1 Blast Management

During the reporting period, the MTW blast monitoring network operated in accordance with AS2187.2-2006 to measure ground vibration and air blast 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 2018 monitors were located at:

- 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).

These locations are shown on **Figure 4** below.

FIGURE 4: BLAST MONITORING LOCATIONS

6.3.2 Blast Performance

During the reporting period 282 blast events were initiated at MTW. One (**1**) blast event on **28 December 2018** recorded an air blast overpressure result of **120.1 dB(L),** exceeding the 120 dB(L) threshold for air blast overpressure at the Bulga Village blast monitor.

The event was reported to the DP&E and to the EPA on 28 December 2018 as a precautionary measure based on the monitored results at this monitor. A written report was subsequently provided to DP&E and to the EPA for this blast which noted that wind gusts produced substantial air pressure peaks both before and during the blast. The investigation determined that it is probable that a wind gust during the period of air blast arrival increased the air pressure level recorded by the Bulga Village monitor.

On 5 July 2018 an administrative non-compliance was recorded when a blast monitor failed to capture blast data from a small magnitude blast event. The data was unavailable as the peak vibration level was below the trigger threshold of 0.2mm/sec which triggers the automated capture of blast results. Blast results were also not manually captured within 20 days of the blast event, which is the storage limit of the blast monitors. MTW complied with all other blast related consent and licence conditions during the reporting period. Results of ground vibration and air blast overpressure recorded during 2018 are presented in **Figure 5** to **Figure 10**.

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.

In accordance with Schedule 3, Conditions 9 and 10 of SSD-6464, Warkworth Mining Limited carried out blasting on site between 7am and 5pm Monday to Saturday inclusive. No blasts occurred on Sundays or on public holidays. Warkworth Mining Limited carried out not more than 3 blasts per day and not more than 12 blasts per week (averaged over a calendar year).

In accordance with Schedule 3, Conditions 7 and 8 of SSD-6465, Mt Thorley Operations Limited carried out blasting on site between 7am and 5pm Monday to Saturday inclusive. No blasts occurred on Sundays or on public holidays. Mt Thorley Operations carried out not more than 2 blasts per day and not more than 6 blasts per week (averaged over a calendar year).

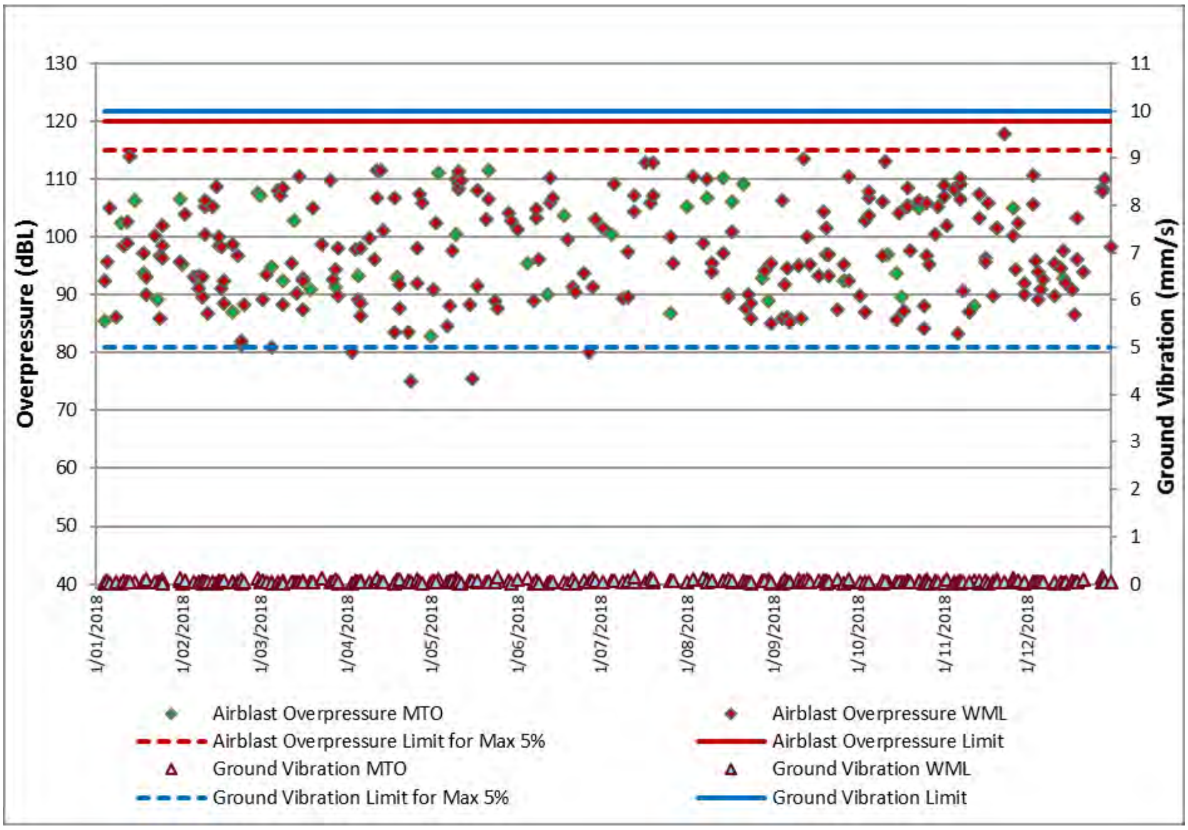


FIGURE 5: ABBEY GREEN BLAST RESULTS

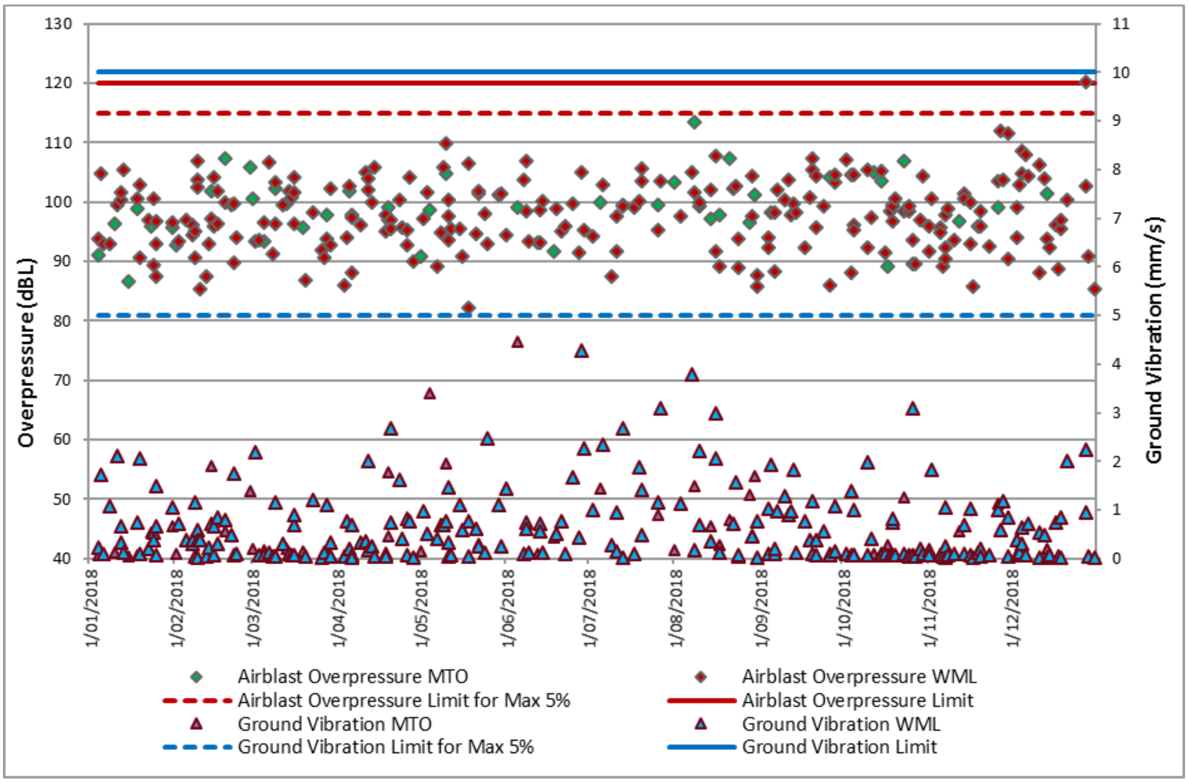


FIGURE 6: BULGA VILLAGE BLAST RESULTS

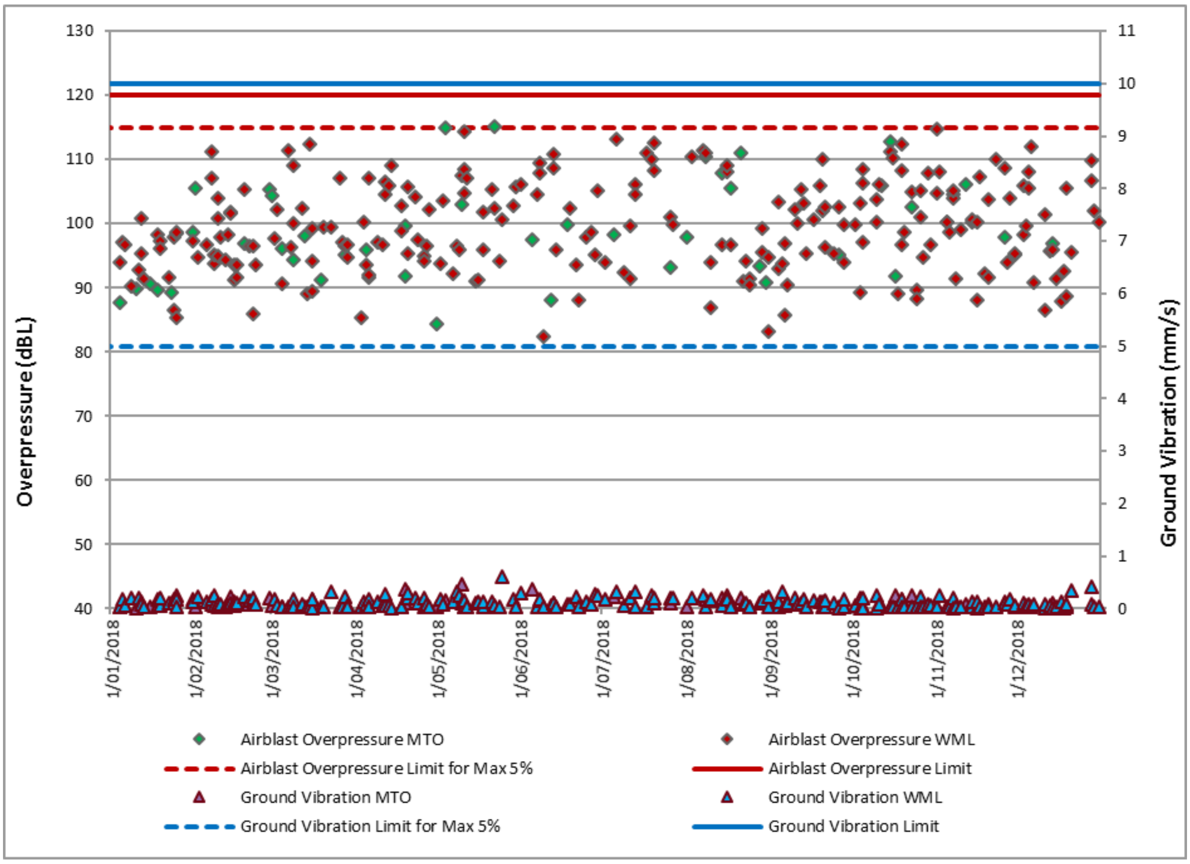


FIGURE 7: MTIE BLAST RESULTS

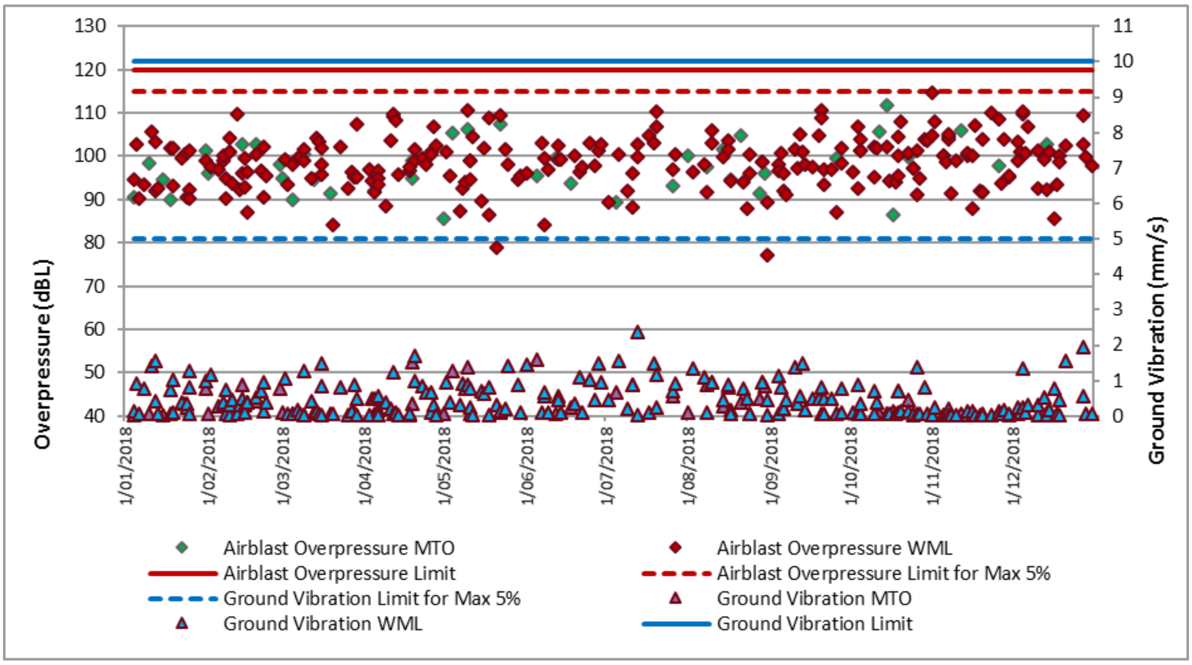


FIGURE 8: WOLLEMI PEAK ROAD BULGA BLAST RESULTS

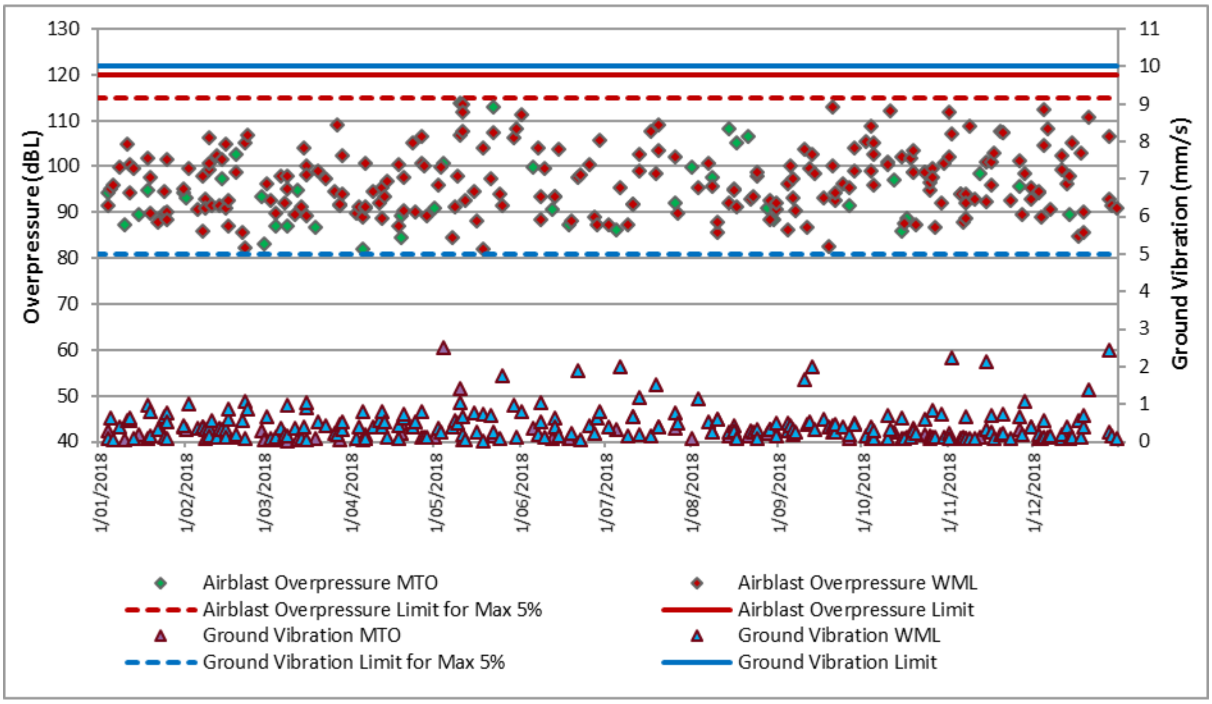


FIGURE 9: WAMBO ROAD BLAST RESULTS

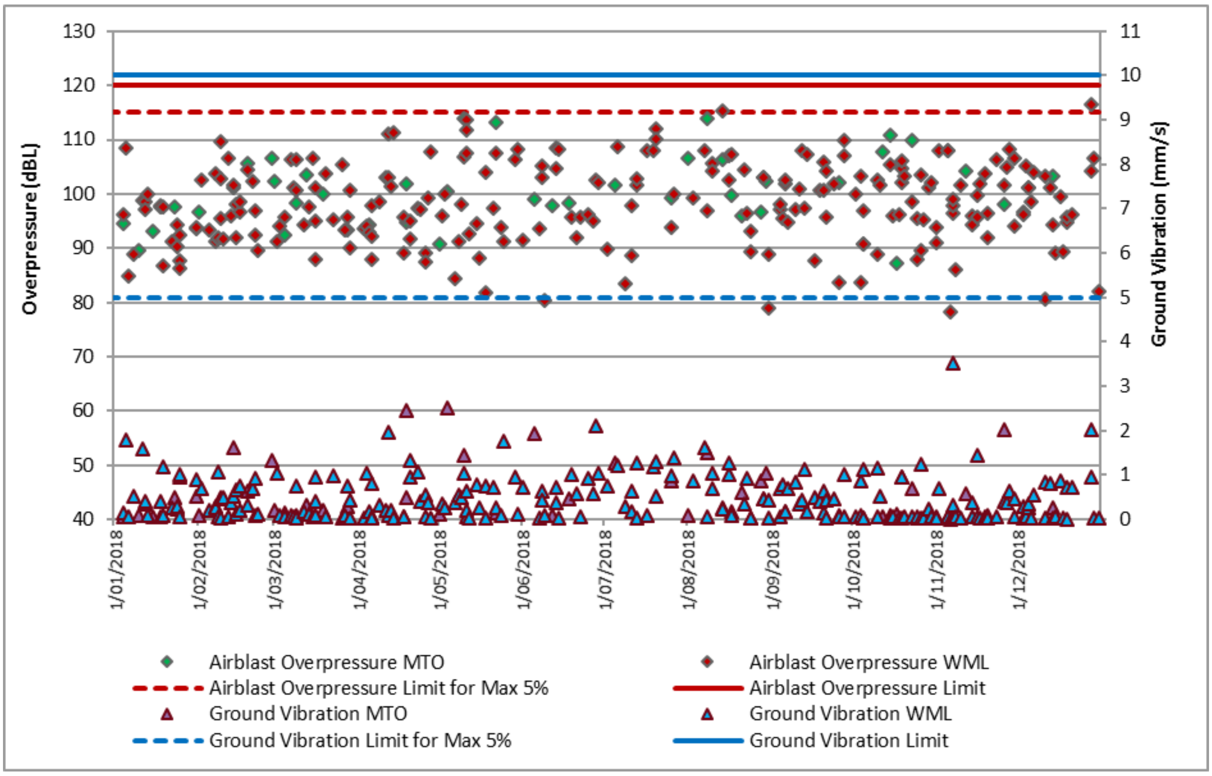


FIGURE 10: WARKWORTH BLAST RESULTS

6.3.2.1 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 2018, no blasts produced visible post-blast fume with a post-blast ranking Level 4 or higher according to the AEISG Scale.

Rankings for visible blast fume according to the AEISG scale for shots fired during 2018 and comparison to rankings distribution during previous years is provided in **Table 6.6.**

TABLE 6.6 VISIBLE BLAST FUME RANKINGS ACCORDING TO THE AEISG COLOUR SCALE

AEISG Ranking	2018	2017	2016
0	280	329	294
1	26	31	43
2	15	25	27
3	2	2	14
4	0	1	0
5	0	0	0
Total*	323	378	378

** 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.*

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

Blasting results recorded in 2018 are similar to results recorded in previous years and are consistent with EA predictions.

6.4 Air Quality

6.4.1 Air Quality 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; and
- Provides a mechanism for assessing air quality monitoring results against the relevant impact assessment criteria.

6.4.1.1 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.

1,358 real-time alarms for air quality and wind conditions were received and acknowledged during 2018. In response, **7,728** 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 11**.

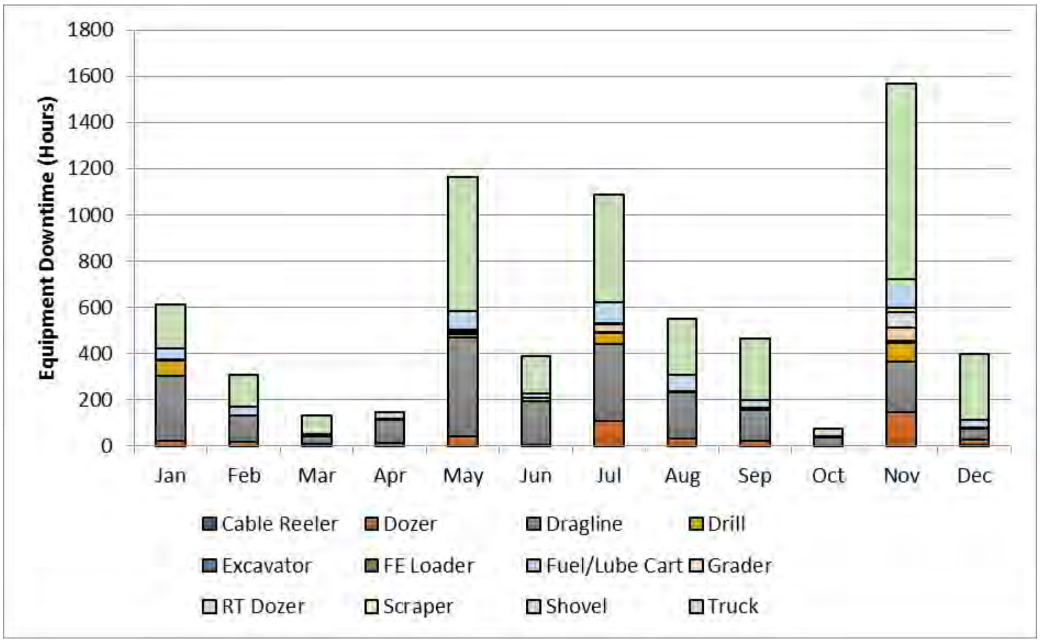


FIGURE 11: EQUIPMENT DOWNTIME FOR DUST MANAGEMENT BY MONTH (2018)

6.4.1.2 Temporary Stabilisation

An aerial seeding programme was undertaken in 2018 to reduce airborne dust from inactive waste dumps and ahead of mining areas. 80 hectares of area was seeded (see **Figure 12**) 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 12: AERIAL SEEDING AREAS

6.4.2 Air Quality Performance

6.4.2.1 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 EPL's. Air quality monitoring locations are shown in **Figure 13**. During 2018, MTW complied with all short term and annual average air quality criteria.

Air quality compliance criteria are shown in **Table 6.7,** 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 publicly available through the MTW Monthly Environmental Monitoring Report and daily data can be accessed on http://insite.yancoal.com.au

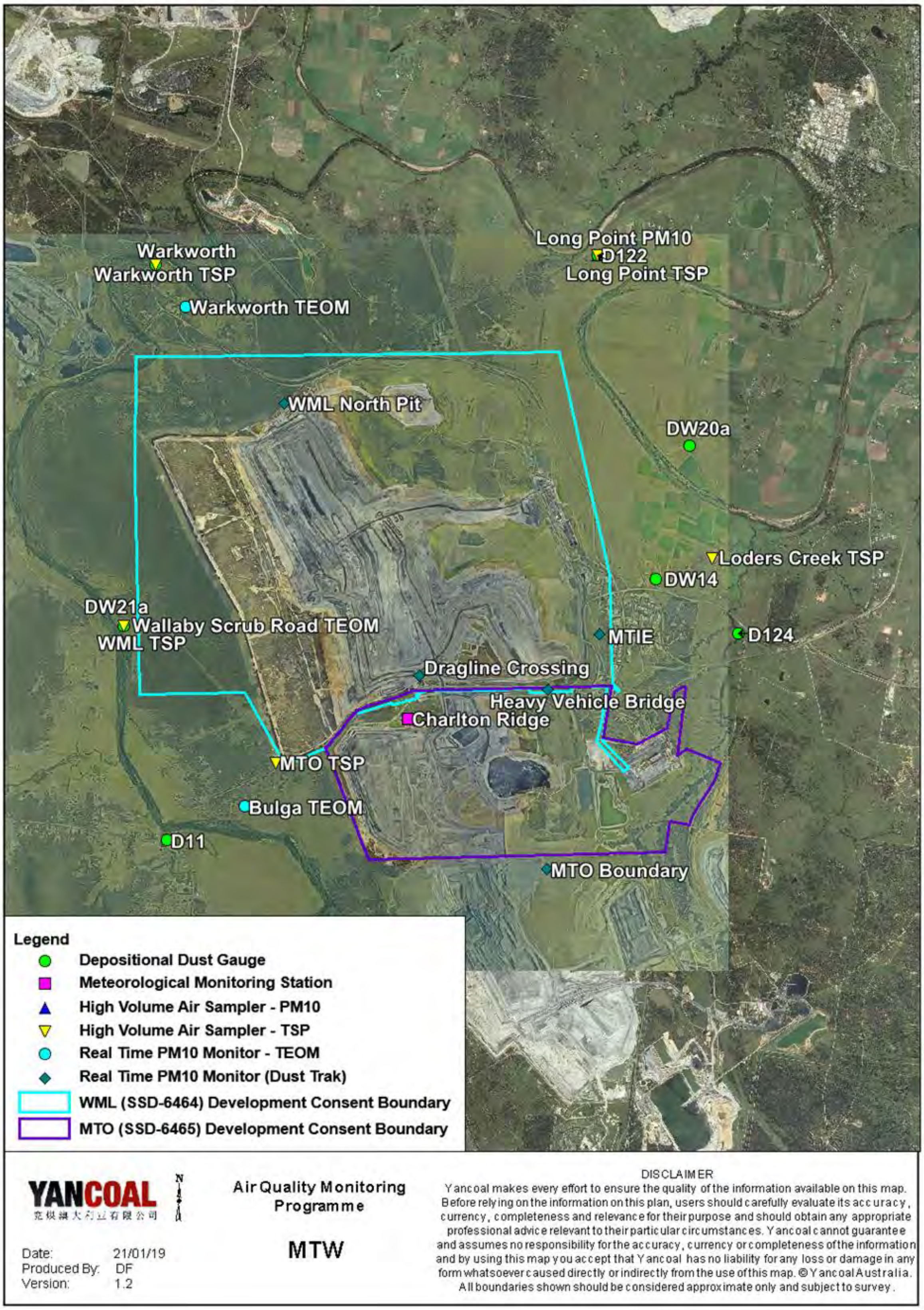


FIGURE 13: AIR AND METEOROLOGICAL MONITORING LOCATIONS MTW 2018

TABLE 6.7 AIR QUALITY IMPACT ASSESSMENT CRITERIA AND 2018 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%

6.4.2.2 Deposited Dust

Deposited dust is monitored at nine (9) locations situated on, or representative of privately-owned land in accordance with AS3580.10.1 (2003). The annual average insoluble matter deposition rates in 2018 compared with the impact assessment criterion and previous years' data is shown in **Figure 14.**

During 2018, 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 15**).

There was one exceedance of the long-term impact assessment criteria, for maximum total deposited dust level, recorded at the Warkworth monitoring location. An external consultant was engaged to conduct an investigation which determined maximum MTW contribution to be not more than 1.6g/m2/month, or 39% of the total level of 4.1g/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. During 2018 monthly dust deposition rates equal to or greater than the long-term impact assessment criteria of 4g/m2/month were recorded at multiple 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 in 2017 and 2018 compared to 2016. This is consistent with well below average rainfall totals recorded in 2017 and 2018.

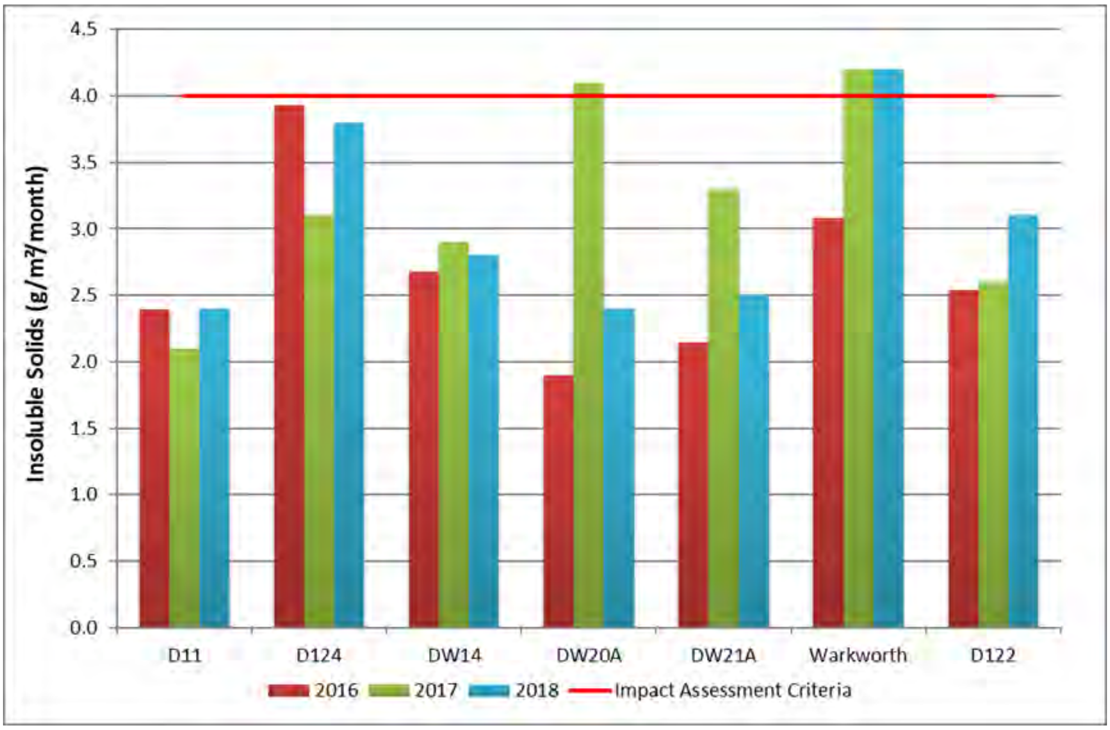


FIGURE 14: 2018 DEPOSITIONAL DUST RESULTS COMPARED AGAINST THE IMPACT ASSESSMENT CRITERIA AND PREVIOUS YEARS' RESULTS

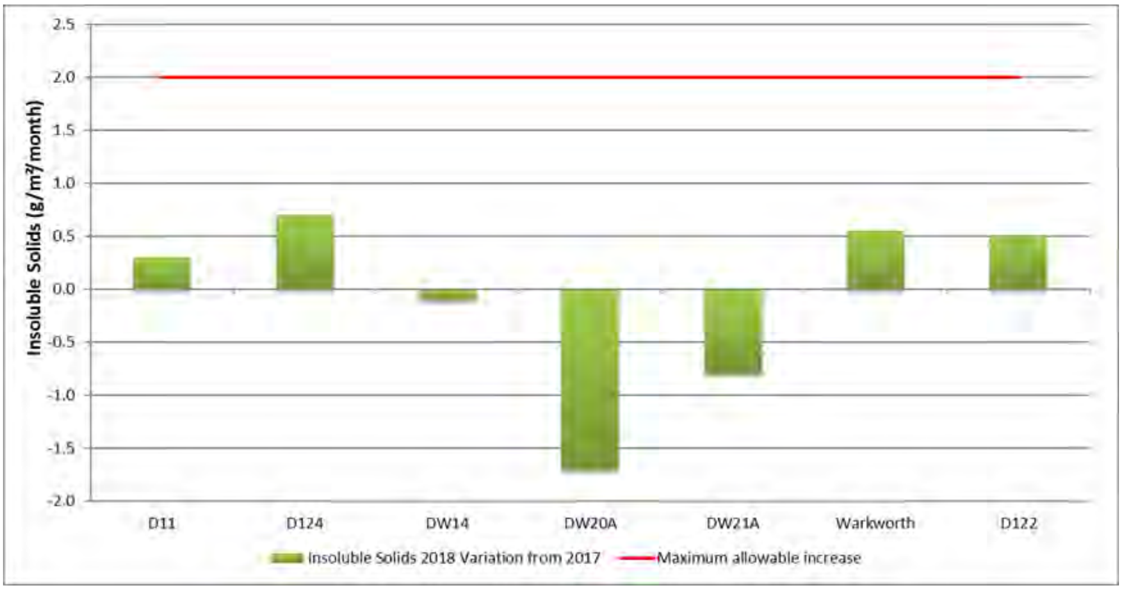


FIGURE 15: VARIATION IN INSOLUBLE SOLIDS DEPOSITION RATE FROM 2017 TO 2018 COMPARED AGAINST THE IMPACT ASSESSMENT CRITERIA

6.4.2.3 Total Suspended Particulates (TSP)

Total Suspended Particulates (TSP) are measured at five (5) locations situated on or representative of privately owned land in accordance with AS3580.9.3 (2003). Annual average TSP concentrations recorded in 2018 compared against the long-term impact assessment criterion and previous years' data, are shown **Figure 16**. During 2018 all annual average results were compliant with the impact assessment and land acquisition criteria.

One high volume air sampler 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 **6.8**

TABLE 6.8 ANNUAL TSP INVESTIGATION - 2018

Date	Site	Annual Average PM_{10} result (µg/m³)	Calculated Annual TSP (µg/m3)	Discussion
2018	Long Point HVAS TSP	106.3	18.6	An external consultant was engaged to investigate the exceedance. The investigation determined that contribution from MTW at the Long Point monitor during the review period was relatively low. This was based on an analysis of meteorological data and position of the site in relation to MTW. As the measured result is not primarily attributable to MTW, it does not constitute non-compliance, as per MTW's approved Air Quality Management Plan. No further action is required.

During the reporting period, four (4) out of the 305 TSP measurements required 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 equipment issues with the monitors.

The annual average TSP concentrations recorded in 2018 are higher than those recorded in previous years, which is likely related to well below average rainfall for the year.

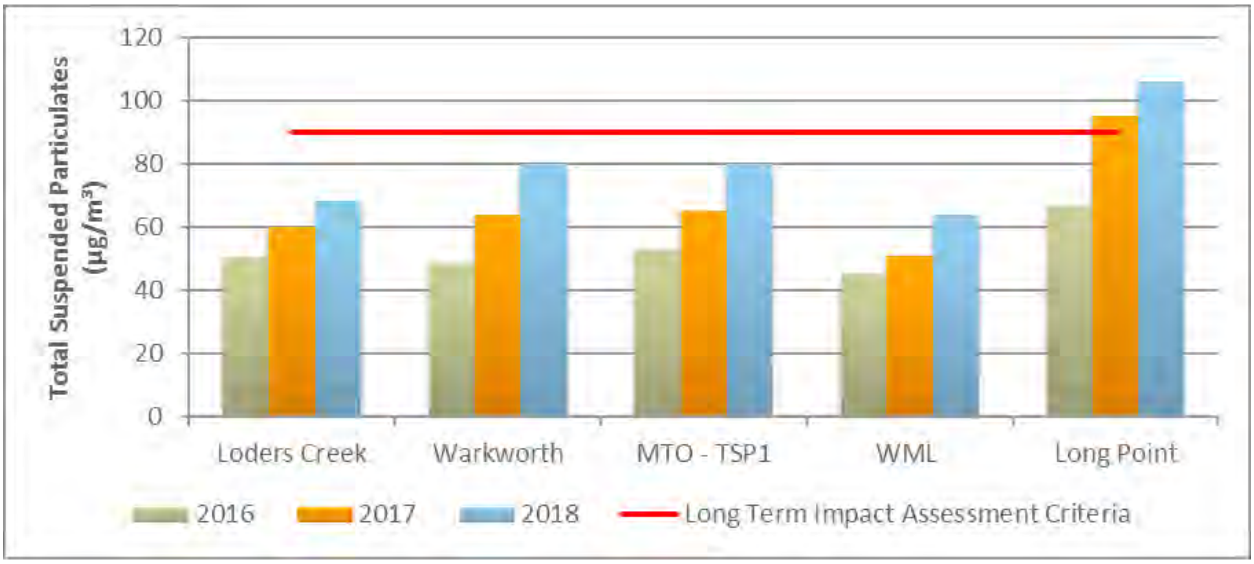


FIGURE 16: 2018 TSP ANNUAL AVERAGE COMPARED AGAINST THE IMPACT ASSESSMENT CRITERIA AND PREVIOUS YEARS' RESULTS

6.4.2.4 Particulate Matter <10µm (PM10)

Compliance assessment for Particulate Matter <10µm (PM_{10}) is measured at five (5) locations on privately owned land in accordance with AS3580.9.6 (2003). During 2018, all short term and annual average results were compliant with the impact assessment criteria.

6.4.2.5 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 17**). All 24hr average results recorded by MTW's surrounding network of TEOM monitors are presented on a quarterly basis in **Figure 17** to **Figure 21**

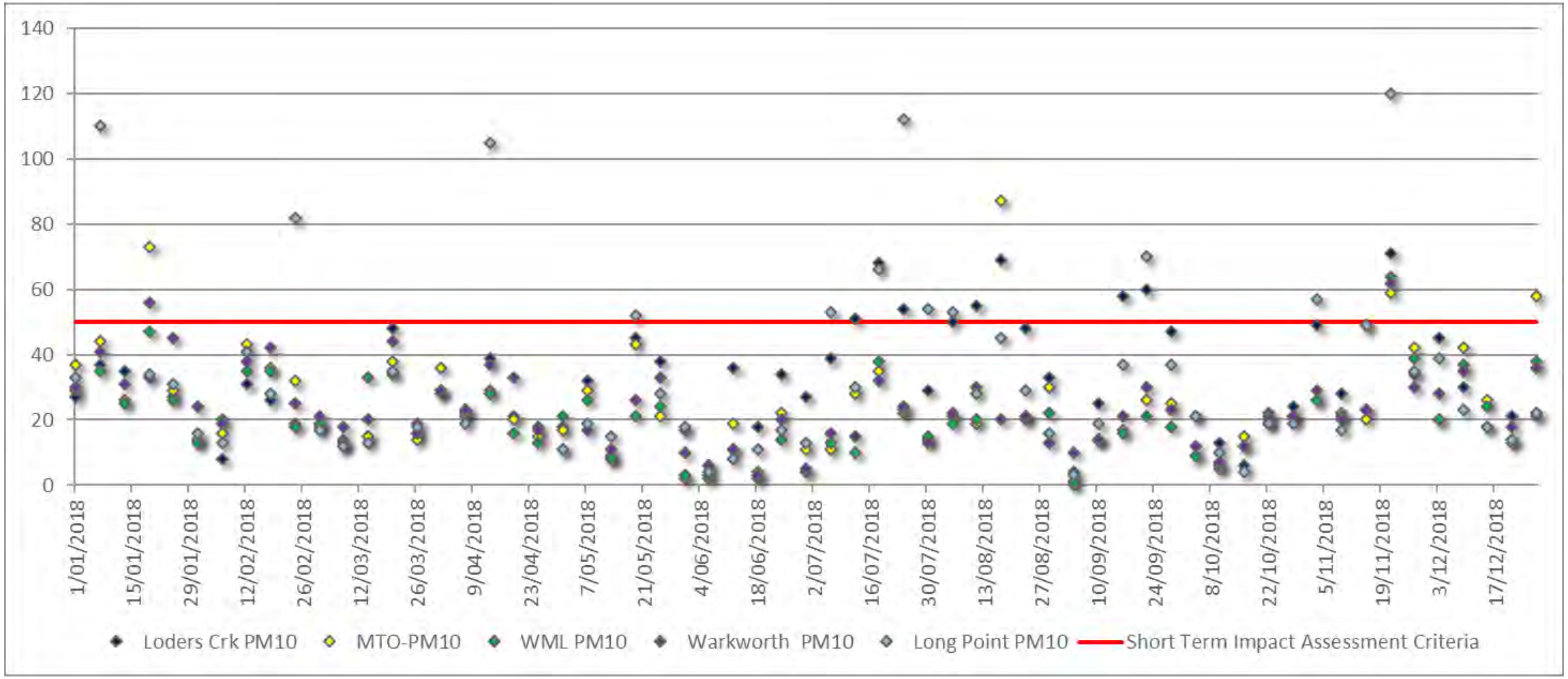


FIGURE 17: PM10 24HR MONITORING RESULTS (MEASURED BY MTW PM10 HVAS NETWORK)

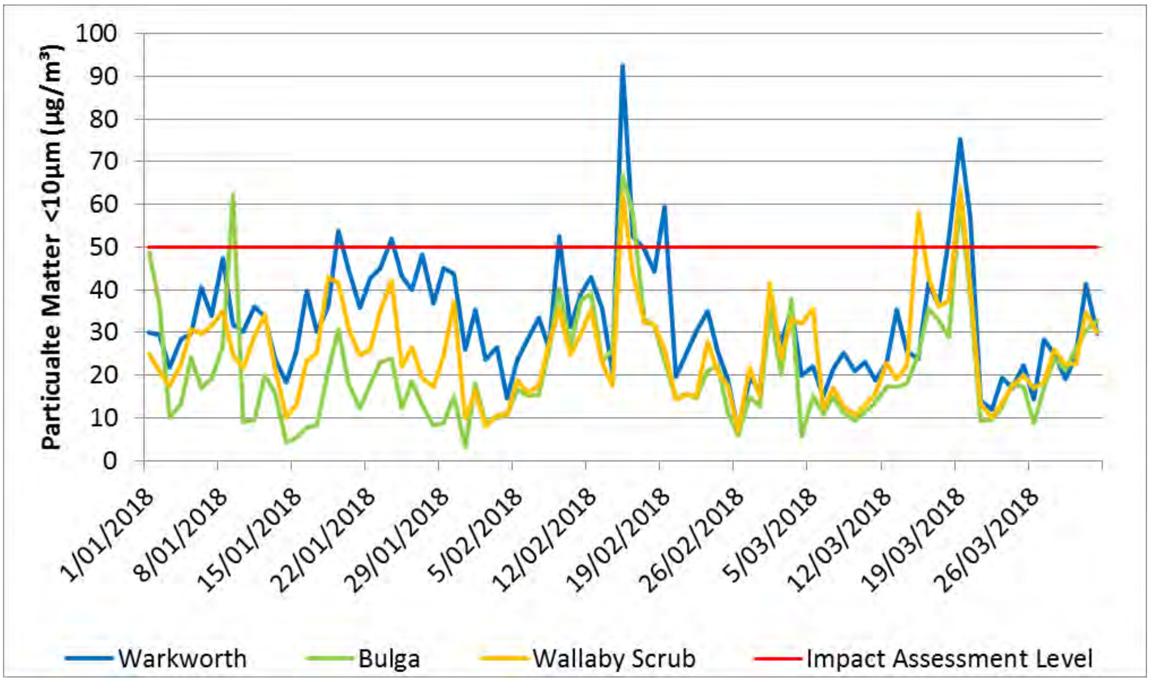


FIGURE 18: 24HR AVERAGE PM10 MEASURED AT TEOM MONITORS SURROUNDING MTW - QUARTER ONE 2018

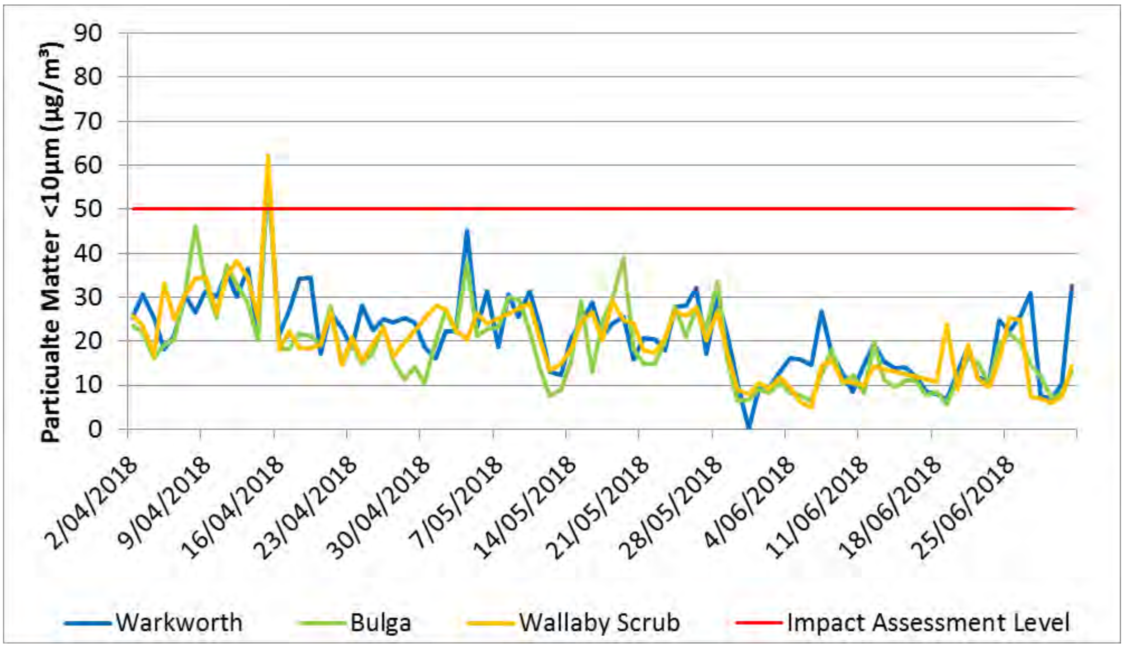


FIGURE 19: 24HR AVERAGE PM10 MEASURED AT TEOM MONITORS SURROUNDING MTW - QUARTER TWO 2018

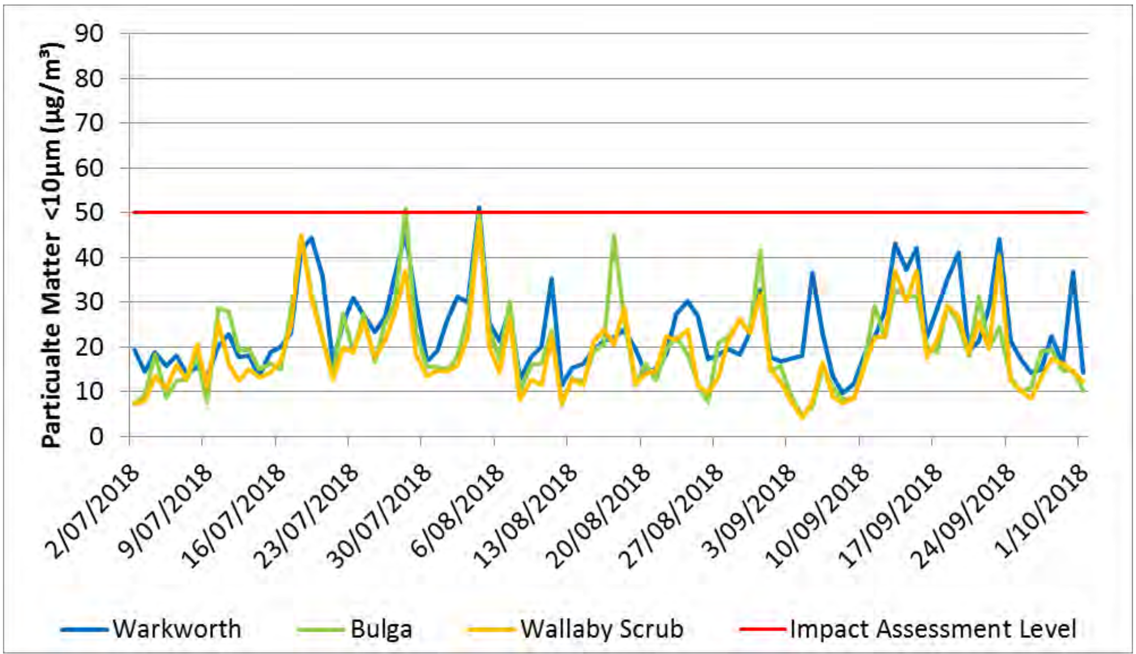


FIGURE 20: 24HR AVERAGE PM10 MEASURED AT TEOM MONITORS SURROUNDING MTW - QUARTER THREE 2018

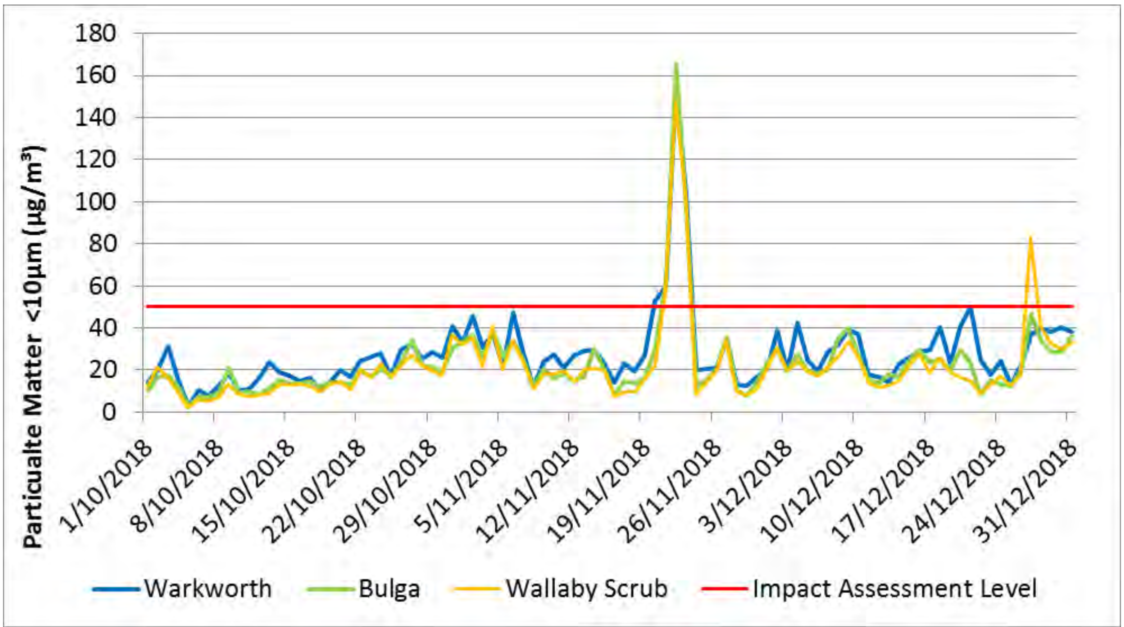


FIGURE 21: 24HR AVERAGE PM_{10} MEASURED AT TEOM MONITORS SURROUNDING MTW - QUARTER FOUR 2018

27 high volume air samples and 32 TEOM PM_{10} measurement results potentially 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 events were determined to be compliant with the relevant criterion.

A summary of the investigations undertaken for each short term PM10 exceedance are provided in **Table 6.9**

TABLE 6.9 24 HOUR PM_{10} INVESTIGATIONS - 2018

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
07/01/2018	Long Point HVAS PM_{10}	110.0	19.8	An analysis of meteorological data has determined the MTW contribution to the result to be in the order of 19.8µg/m3 or ~18% 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.
09/01/2018	Bulga TEOM	62.4	7.5	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 7.5µg/m3 or ~12% 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.
19/01/2018	MTO HVAS PM_{10}	73.0	39.5	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 39.5µg/m3 or ~54% 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.

Date	Site	24hr PM_{10} result ($\mu g/m^3$)	Estimated contribution from MTW ($\mu g/m^3$)	Discussion
19/01/2018	Warkworth HVAS PM_{10}	56.0	23.0	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 23.0µg/m3 or ~41% 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.
19/01/2018	Warkworth TEOM	53.8	27.6	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 27.6µg/m3 or ~51% 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.
24/01/2018	Warkworth TEOM	52.0	28.4	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 28.4µg/m3 or ~54% 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.
09/02/2018	Warkworth TEOM	52.5	16.7	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 16.7µg/m3 or ~32% 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.

Date	Site	24hr PM_{10} result (µg/m^3)	Estimated contribution from MTW (µg/m^3)	Discussion
15/02/2018	Warkworth TEOM	92.6	29.8	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 29.8µg/m3 or ~32% 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.
15/02/2018	Bulga OEH TEOM	66.7	3.9	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 3.9µg/m3 or ~5.8% 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.
15/02/2018	Wallaby Scrub Road TEOM	62.3	40.8	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 40.8µg/m3 or ~65.5% 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.
16/02/2018	Warkworth TEOM	52.4	23.3	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 23.3µg/m3 or ~45% 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.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
16/02/2018	Bulga OEH TEOM	57.9	1.6	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 1.6µg/m3 or ~2.8% 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.
19/02/2018	Warkworth TEOM	59.3	34.8	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 34.8µg/m3 or ~60% 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.
24/02/2018	Long Point HVAS PM_{10}	82.0	-	An analysis of meteorological data has determined that the Long Point monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
15/03/2018	Wallaby Scrub Road TEOM	58.2	4.6	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 4.6µg/m3 or ~8% 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.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
18/03/2018	Warkworth TEOM	52.1	8.8	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 8.8µg/m3 or ~17% 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.
19/03/2018	Warkworth TEOM	75.4	34.9	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 34.9µg/m3 or ~46% 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.
19/03/2018	Bulga OEH TEOM	61.1	-	An analysis of meteorological data has determined that the Bulga OEH monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
19/03/2018	Wallaby Scrub Road TEOM	63.8	23.0	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 23µg/m3 or ~36% 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.

Date	Site	24hr PM_{10} result (µg/m^3)	Estimated contribution from MTW (µg/m^3)	Discussion
20/03/2018	Warkworth TEOM	56.8	30.6	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 30.6µg/m3 or ~54% 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.
13/04/2018	Long Point HVAS PM_{10}	105.0	-	An analysis of meteorological data has determined that the Long Point monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
15/04/2018	Warkworth TEOM	57.3	-	An analysis of meteorological data has determined that the Warkworth monitoring location was not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
15/04/2018	Bulga OEH TEOM	58.9	-	An analysis of meteorological data has determined that the Bulga OEH monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.

Date	Site	24hr PM_{10} result (µg/m^3)	Estimated contribution from MTW (µg/m^3)	Discussion
15/04/2018	Wallaby Scrub Road TEOM	62.3	-	An analysis of meteorological data has determined that the Wallaby Scrub Road monitoring location was not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
19/05/2018	Long Point HVAS PM_{10}	52.0	20.0	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 20.0µg/m3 or ~38.5% 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.
06/07/2018	Long Point HVAS PM_{10}	53.0	-	An analysis of meteorological data has determined that the Long Point monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
12/07/2018	Loders Creek HVAS PM_{10}	51.0	33.3	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 33.3µg/m3 or ~65.4% 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.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
18/07/2018	Loders Creek HVAS PM_{10}	68.0	36.0	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 36.0µg/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.
18/07/2018	Long Point HVAS PM_{10}	66.0	-	An analysis of meteorological data has determined that the Long Point monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
24/07/2018	Loders Creek HVAS PM_{10}	54.0	30.0	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 30.0µg/m3 or ~56% 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.
24/07/2018	Long Point HVAS PM_{10}	112.0	-	An analysis of meteorological data has determined that the Long Point monitoring location was not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
28/07/2018	Bulga OEH TEOM	51.0	12.4	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 12.4µg/m3 or ~24% 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.
30/07/2018	Long Point HVAS PM_{10}	54.0	-	An analysis of meteorological data has determined that the Long Point monitoring location was not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
04/08/2018	Warkworth TEOM	51.3	2.0	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 2.0µg/m3 or ~3.9% 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.
05/08/2018	Long Point HVAS PM_{10}	53.0	32.3	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 32.3µg/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.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
11/08/2018	Loders Creek HVAS PM_{10}	55.0	25.0	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 25µg/m3 or ~45% 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.
17/08/2018	Loders Creek HVAS PM_{10}	69.0	36.3	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 36.3µg/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.
17/08/2018	MTO HVAS PM_{10}	87.0	43.0	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 43.0µg/m3 or ~49% 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.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
16/09/2018	Loders Creek HVAS PM_{10}	58.0	39.5	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 39.5µg/m3 or ~68% 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.
22/09/2018	Loders Creek HVAS PM_{10}	60.0	37.1	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 37.1µg/m3 or ~62% 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.
22/09/2018	Long Point HVAS PM_{10}	70.0	46.7	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 46.7µg/m3 or ~67% 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.
03/11/2018	Long Point HVAS PM_{10}	57.0	-	An analysis of meteorological data has determined that the Long Point monitoring location was not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
20/11/2018	Warkworth TEOM	52.5	36.4	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 36.4µg/m3 or ~69% 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.
21/11/2018	Loders Creek HVAS PM_{10}	71.0	8.0	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 8µg/m3 or ~11% 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.
21/11/2018	MTO HVAS PM_{10}	59.0	-	There was a regional dust event on this day. Investigation determined that the likely MTW contribution to the results is less than 75%. Accordingly, no further action is required (as per approved Air Quality Monitoring Programme).
21/11/2018	WML HVAS PM_{10}	64.0	-	There was a regional dust event on this day. An analysis of meteorological data has determined that the WML monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
21/11/2018	Warkworth HVAS PM_{10}	62.0	-	There was a regional dust event on this day. An analysis of meteorological data has determined that the Warkworth monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
21/11/2018	Long Point HVAS PM_{10}	120.0	-	There was a regional dust event on this day. An analysis of meteorological data has determined that the Long Point monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
21/11/2018	Warkworth TEOM	60.1	2.6	There was a regional dust event on this day. An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 2.6µg/m3 or ~4% 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.
21/11/2018	Bulga OEH TEOM	61.4	7.1	There was a regional dust event on this day. An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 7.1µg/m3 or ~12% 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.

Date	Site	24hr PM_{10} result (µg/m³)	Estimated contribution from MTW (µg/m³)	Discussion
21/11/2018	Wallaby Scrub Road TEOM	57.2	-	An analysis of meteorological data has determined that the Wallaby Scrub Road monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
22/11/2018	Warkworth TEOM	156.7	-	An analysis of meteorological data has determined that the Warkworth monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
22/11/2018	Bulga OEH TEOM	165.1	6.6	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 6.6µg/m3 or ~4% 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.
22/11/2018	Wallaby Scrub Road TEOM	147.2	-	An analysis of meteorological data has determined that the Wallaby Scrub Road monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
23/11/2018	Warkworth TEOM	102.7	-	An analysis of meteorological data has determined that the Warkworth monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.

Date	Site	24hr PM_{10} result (µg/m^3)	Estimated contribution from MTW (µg/m^3)	Discussion
23/11/2018	Bulga OEH TEOM	96.5	35.8	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 35.8µg/m3 or ~37% 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.
23/11/2018	Wallaby Scrub Road TEOM	103.3	-	An analysis of meteorological data has determined that the Wallaby Scrub Road monitoring location was generally not from MTW's angle of influence. Therefore, it is unlikely that MTW operations was a significant contributor to the result and thus an estimation of contribution has not been calculated.
27/12/2018	MTO HVAS PM_{10}	58.0	37.5	An analysis of meteorological data and background PM10 levels has determined the maximum potential MTW contribution to the result to be in the order of 37.5µg/m3 or ~65% 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.
27/12/2018	Wallaby Scrub Road TEOM	82.7	26.6	An analysis of meteorological data has determined the maximum potential MTW contribution to the result to be in the order of 26.6µg/m3 or ~32% 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.

6.4.2.6 Long term PM_{10} 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 22**). All annual average PM_{10} concentrations recorded on privately owned land were compliant with the assessment criterion.

Two high volume air samplers recorded results above the annual PM_{10} impact assessment criteria during the reporting period. The results were investigated by an external consultant to determine the levels of contribution from MTW activities in accordance with the compliance protocol outlined in the MTW Air Quality Management Plan. The results were determined to be compliant with the relevant criteria.

A summary of the investigations undertaken for each short term PM_{10} exceedance are provided in **Table 6.10**. 27 high volume air samples and 32 TEOM PM_{10} measurements exceeded the 24 hour short term impact assessment criteria during the reporting period. Each was investigated in accordance with the compliance protocol outlined in the MTW. Air Quality Management to determine the level of contribution from MTW activities. All recorded results were determined to be compliant with the relevant criterion.

TABLE 6.10 ANNUAL PM_{10} INVESTIGATION - 2018

Date	Site	Annual Average PM_{10} result (µg/m³)	Calculated Annual PM_{10} (µg/m³)	Discussion
2018	Long Point HVAS PM_{10}	33.3	5.8	An external consultant was engaged to investigate the exceedance. The investigation determined that contribution from MTW at the Long Point monitor during the review period was relatively low. This was based on an analysis of meteorological data and position of the site in relation to MTW. As the measured result is not primarily 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.
2018	Loders Creek HVAS PM_{10}	31.5	<9.5	An external consultant was engaged to investigate the exceedance. The investigation determined that contribution from MTW at the Loders Creek monitor during the review period was relatively low. This was based on an analysis of the meteorological data and background PM10

Date	Site	Annual Average PM_{10} result ($\mu g/m^3$)	Calculated Annual PM_{10} ($\mu g/m^3$)	Discussion
				levels. As the measured result is not primarily 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.

During the reporting period, 6 out of 305 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. This equates to a capture rate of 98%.

All monitoring locations recorded increases in PM10 compared to 2018. This is likely related to below average rainfall for the year.

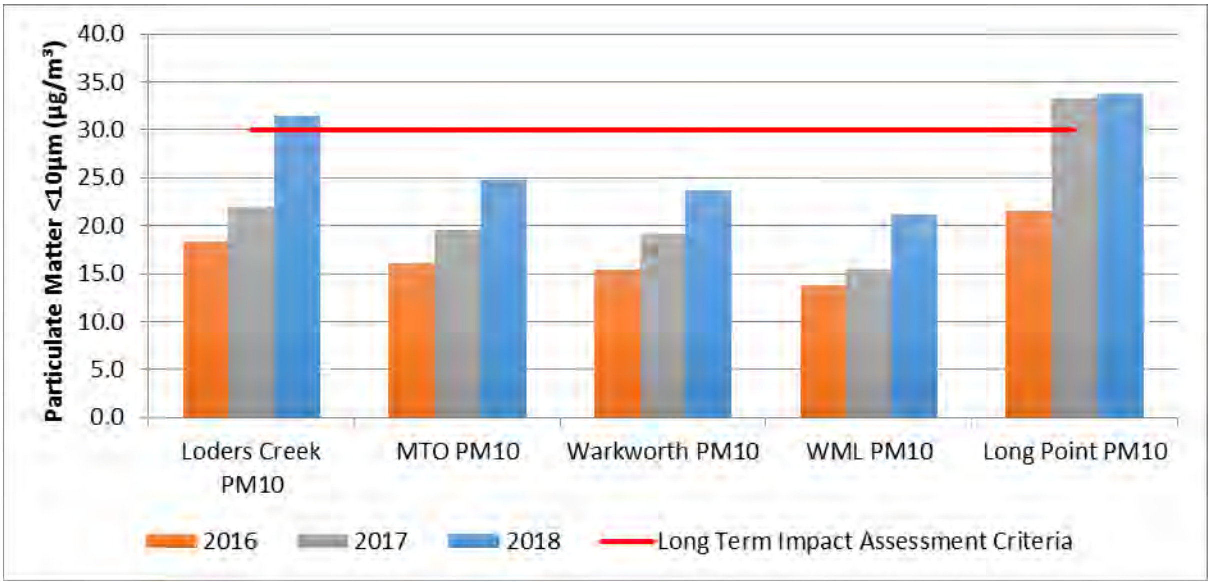


FIGURE 22: ANNUAL AVERAGE HVAS PM10 RESULTS 2016 TO 2018

6.4.2.7 Comparison of 2018 Air Quality data against EA predictions

Annual average PM_{10} results were generally above the modelled range for Year 3 of the development (nominally 2017). Long Point PM_{10} recorded an annual average result of 33.7µg/m3 and Loders Creek PM_{10} recorded an annual average result of 31.5 µg/m3 which is greater than the predicted annual averages of 16µg/m3 and 19 µg/m3 respectively. Given prevailing winds in the Hunter Valley and the location of the Long Point monitor relative to MTW operations it is unlikely that the measured increase at Long Point is primarily a direct result of MTW activity. An analysis of 2018 meteorological and PM_{10} monitoring data was undertaken by an external consultant, which identified that the measured increase at Loders Creek is largely related to elevated background levels and not primarily a direct result of MTW activity. Refer to **Table 6.11**

TSP annual averages at all monitoring locations 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 6.11 and **Table 6.12** show a comparison between 2018 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} results were generally above the modelled range for Year 3 of the development (nominally 2017). Long Point PM_{10} recorded an annual average result of 33.7µg/m3 and Loders Creek PM_{10} recorded an annual average result of 31.5 µg/m3 which is greater than the predicted annual averages of 16µg/m3 and 19 µg/m3 respectively. Given prevailing winds in the Hunter Valley and the location of the Long Point monitor relative to MTW operations it is unlikely that the measured increase at Long Point is primarily a direct result of MTW activity. An analysis of 2018 meteorological and PM_{10} monitoring data was undertaken by an external consultant, which identified that the measured increase at Loders Creek is largely related to elevated background levels and not primarily a direct result of MTW activity.

TABLE 6.11 2018 PM10 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 EIS Prediction (µg/m^3)	2018 Annual Average (µg/m^3)
MTO PM_{10}	23	24.8
Loders Creek PM_{10}	19	31.5
WML PM_{10}	16	21.1
Warkworth PM_{10}	30	23.7
Long Point PM_{10}	16	33.7

TSP annual averages at all monitoring locations were higher than modelled predictions for the EIS 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 6.12 2018 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 EIS Prediction (µg/m³)	2018 Annual Average (µg/m³)
MTO TSP1	52	80.2
Loders Creek TSP	43	68.3
WML- HV2a	39	64.1
Warkworth	65	79.9
Long Point	38	106.3

6.5 Heritage Summary

6.5.1 Heritage Management

During the reporting period, Aboriginal Cultural Heritage and Historic Heritage was managed in accordance with the sites approved Aboriginal Heritage and Historic Heritage Management Plans. A summary of the performance in each of these areas is outlined below.

6.5.2 Heritage Performance

6.5.2.1 Aboriginal Heritage

6.5.2.1.1 Aboriginal Archaeological and Cultural Heritage Investigations

Two (2) Aboriginal cultural heritage inspections and two (2) salvage programs were conducted at MTW in 2018 in accordance with the MTW Aboriginal Cultural Heritage Management Plan (ACHMP).

A salvage mitigation program was conducted on 26 February - 1 March 2018 covering 37 isolated artefact sites to the west of Wallaby Scrub Road along with the removal and relocation of the Site M grinding grooves to the Putty Road cultural heritage storage facility for future transfer to the Wollombi Brook Aboriginal Cultural Heritage Conservation Area (WBACHCA).

On 18-19 September 2018, an Aboriginal cultural heritage inspection of a 6km portion of the recently closed former Wallaby Scrub Road (WSR) corridor was conducted, which identified one isolated stone artefact. A further salvage and sub-surface investigation program was conducted on 9-12 October 2018 covering 14 isolated artefact sites, including that identified within the former WSR corridor during the September inspection. The remaining salvage sites were in the area west of the former WSR.

In addition to these programs, an ACHMP inspection was conducted on 28-29 November 2018. This inspection was conducted by representatives of the Aboriginal community and were assisted by internal personnel and a consultant archaeologist. A total of 48 Aboriginal cultural heritage sites were inspected during this program. The Aboriginal Heritage Management Plan Inspection report is shown in **Appendix 3.**

The 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 once in 2018, on 24 May.

6.5.2.1.2 Audits and Incidents

During the reporting period there were 15 Ground Disturbance Permits (GDP's) assessed for cultural heritage management considerations at MTW. Ground disturbance works were conducted based upon an Aboriginal cultural heritage sites avoidance policy so that no un-salvaged sites were impacted by these activities. There were no known incidents nor any unauthorised disturbance caused to Aboriginal cultural heritage sites at MTW during 2018.

6.5.2.2 Historic Heritage

6.5.2.2.1 Historic Heritage Activities

One historic heritage survey and investigation was conducted at MTW in 2018, in accordance with the MTW Historic Heritage Management Plan (HHMP).

Following the closure of Wallaby Scrub Road an archaeological survey of the road corridor was conducted followed by a sub-surface investigation of an area identified as having high archaeological potential. This investigation was carried out in accordance with Schedule 14 of the MTW HHMP and occurred on 17-22 October 2018. The work was led by consultant archaeologists, assisted by members of the Community Heritage Advisory Group (CHAG) and internal personnel.

In addition to this, a HHMP inspection was conducted on 30 November 2018. This inspection was conducted by a consultant archaeologist, assisted by representatives of the CHAG and internal personnel. A total of 3 historic heritage sites were inspected during this program. The Historic Heritage Management Plan Inspection Report is shown in **Appendix 4.**

In 2012 the CHAG was established as a community consultation forum for 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 was involved in two programs of work at MTW in 2018, as outlined above.

The MTW Historic Heritage Conservation Fund was launched by Singleton Council in December 2018, in accordance with Schedule 17 of the HHMP.

There were no incidents nor any unauthorised disturbance caused to historic heritage sites at MTW during 2018.

6.6 Visual Amenity and Lighting

6.6.1 Visual Amenity and Lighting Management

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

6.6.2 Visual Amenity and Lighting Performance

6.6.2.1 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, Milbrodale and vehicular traffic on the Putty Road and Golden Highway.

Actions undertaken in 2018 to manage lighting impacts at MTW included:

- 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; and
- MTW continue to modify the lighting plant plan in the Tipping and Dumping strategy to reflect changes in the operating area.

6.6.2.2 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 may be vegetated where practicable and feasible for visual amenity and to mitigate erosion.

Built screens (i.e. solid fences or walls), may be used as an alternative when bunds and tree screens are not practicable. Temporary screens (i.e. fencing and shade mesh) may also be used as required for interim screening.

The Putty Road visual bund was vegetated with native seed mix in 2018. Further rehabilitation of the eastern side of the Warkworth mine in 2018 continued to improve the visual amenity when looking from the east. The Putty Road visual bund will be extended to the west during the 2019 AR period. Part of the northern end of the Warkworth mine was also rehabilitated in 2018, improving visual amenity particularly for motorists travelling east.

6.7 Water

6.7.1 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 23**. The 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 2018 have focused on mitigating the risk of unauthorised water releases from site. Three new sediment basins (Dam 51N, Dam 52N and Dam 53N), and associated diversion drains were constructed during the reporting period in order to capture runoff from disturbed areas being prepared for mining. In addition, Tailings Dam 2 (Dam 33N), continued with closure activities by capping a portion of the southern area of the tailings beach with suitable weathered material.

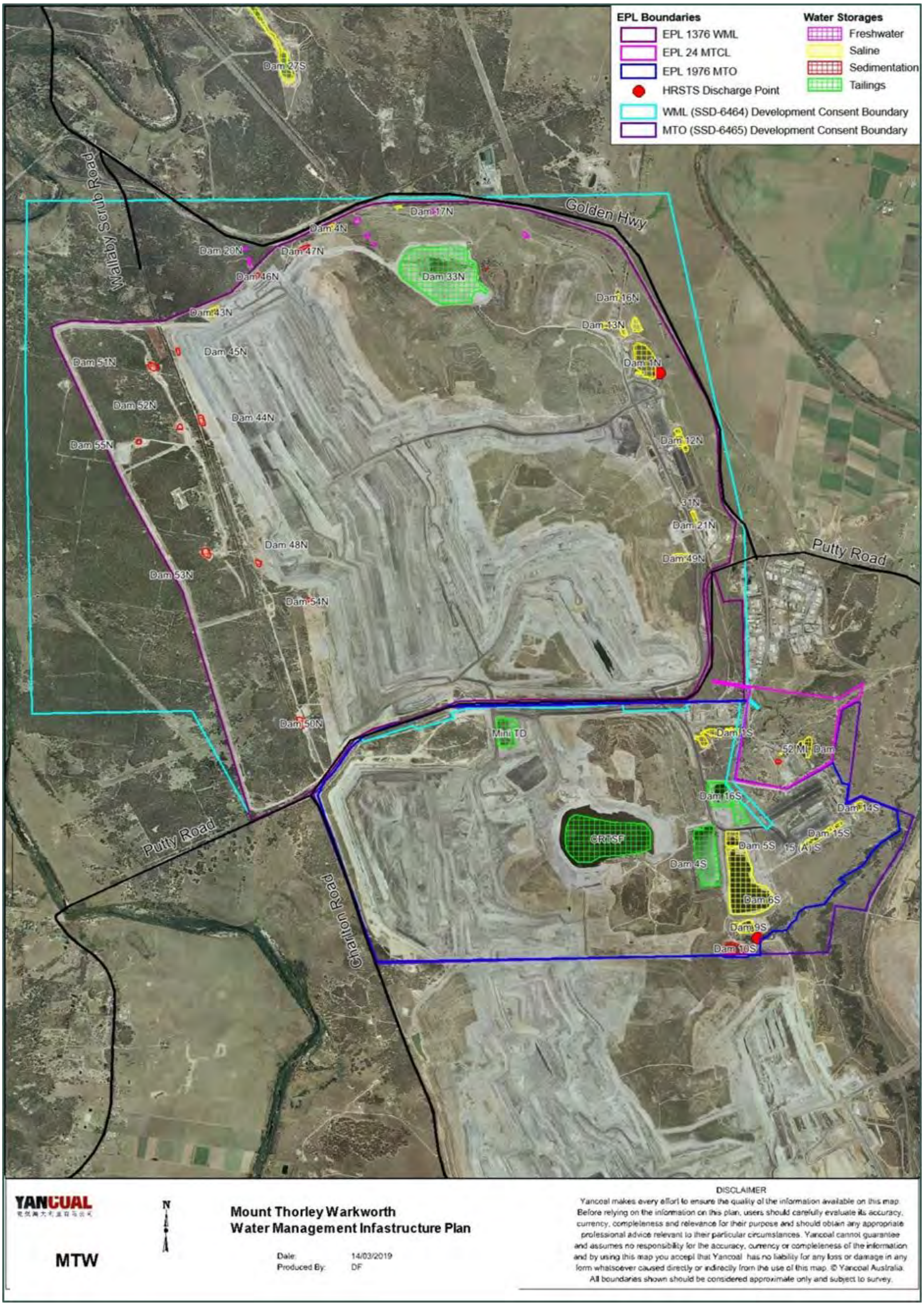


FIGURE 23: WATER MANAGEMENT INFRASTRUCTURE PLAN

6.7.2 Water Balance Performance

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 2018 static water balance for MTW is presented in **Table 6.13** and a simplified schematic of this balance is included in **Figure 24**. A salt flux schematic is shown in **Figure 25**.

TABLE 6.13 STATIC MODEL RESULTS, ANNUAL WATER BALANCE

Water Stream	Volume (ML) (% Total)
Inputs	
Rainfall Runoff	3, 698 (47%)
Hunter River (MTJV supply scheme)	1,768 (22%)
Potable (Singleton Shire Council / trucked)	20 (<1%)
Groundwater	428 (5%)
Recycled to CHPP from tailings (not included in total)	6,368
Imported (LUG bore)	875 (11%)
Imported (Hunter Valley Operations)	0 (0%)
Water from ROM Coal	1,089 (14%)
Total Inputs	**7,878**
Outputs	
Dust Suppression	3,249 (41%)
Evaporation – mine water dams	836 (11%)
Entrained in process waste	1,733 (22%)
Sharing with other mines	215 (3%)
Discharged (HRSTS)	0 (0%)
Water in coarse reject	667 (8%)
Water in product coal	1,147 (14%)
Miscellaneous use (wash-down etc.)	110 (1%)
Total Outputs	**7,957**
Change in storage	**(79)**

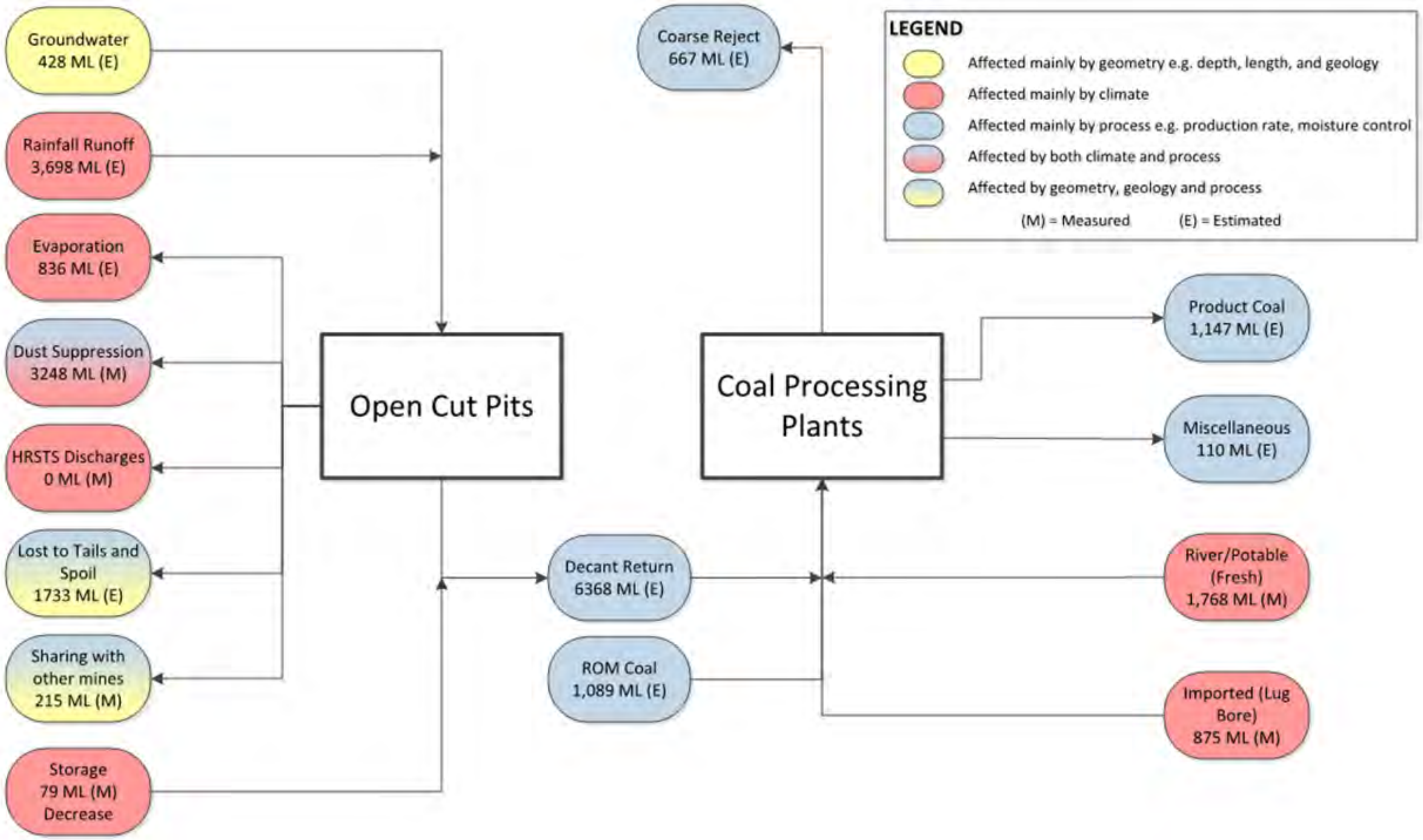


FIGURE 24: SCHEMATIC DIAGRAM MTW WATER FLUX

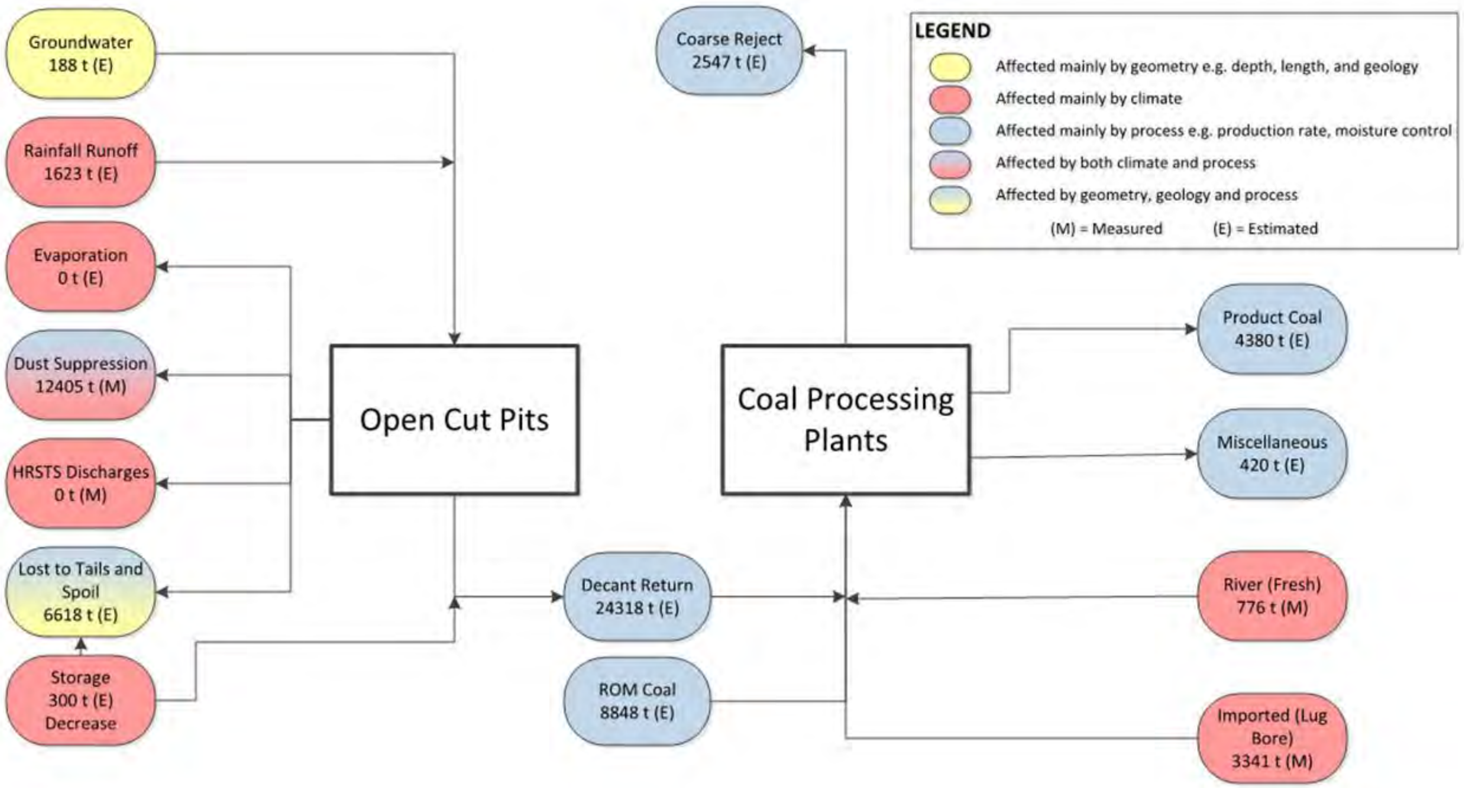


FIGURE 25: SCHEMATIC DIAGRAM MTW SALT FLUX

6.7.2.1 Water Inputs

A total of 456.2mm of rainfall was recorded at MTW in 2018 producing a calculated 3,698 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 2018 and comparable to the estimated runoff captured in the 2017 reporting period (3,368 ML) where the site recorded an annual rainfall depth of 444.4 mm.

As the site water inventory is drawn down, water is imported to meet site demand. During the reporting period 875 ML was imported from the LUG bore, which was significantly less than the previous reporting period (1,533ML extracted), due to operational changes to the way the pipeline infrastructure was utilised.

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 1,000 ML of high security water licenses were secured by MTW and were transferred to the MTJV license to further supplement the operations water supply. It should be noted that due to the nature of the Water NSW reporting period, some temporary allocation assignments were executed in the 2017 AER reporting period, however, water was abstracted in the 2018 reporting period. A total of 1,768 ML of water was abstracted from the Hunter River during the reporting period.

Abstraction of 1,768 ML of water from the Hunter River in 2018 was comparable to the volume of water extracted in the previous reporting period. (1,790 ML extracted in 2017). Similar rainfall trends during this reporting period compared to the previous reporting period, indicate that rain events did not overcome the surface saturation threshold to generate runoff to replenish the site's water inventory. A summary of water take by source is listed in **Table 6.13**

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 3.6**

Licence conditions require the volume and quality of water taken by the works to be measured and reported on an annual water calendar year basis (i.e. financial year). 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.

6.7.2.2 Water Outputs

Significant water uses at MTW in 2018 were for dust suppression on haul roads, mining areas and coal stockpiles (3,248ML), evaporation from Dams (836ML) and water entrained in process waste (1,733ML). Water usage for dust suppression on haul roads slightly increased compared to the 2017 reporting period which may be attributed to dry climatic conditions during the reporting period and increased utilisation of contractor water carts for ancillary mining areas.

MTW participates in the Hunter River Salinity Trading Scheme (HRSTS), allowing 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; and
- Dam 9S, located at MTO South, which discharges to Loders Creek.

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

6.7.3 Surface Water Management

Surface water monitoring activities continued in 2018 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 26**. 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.

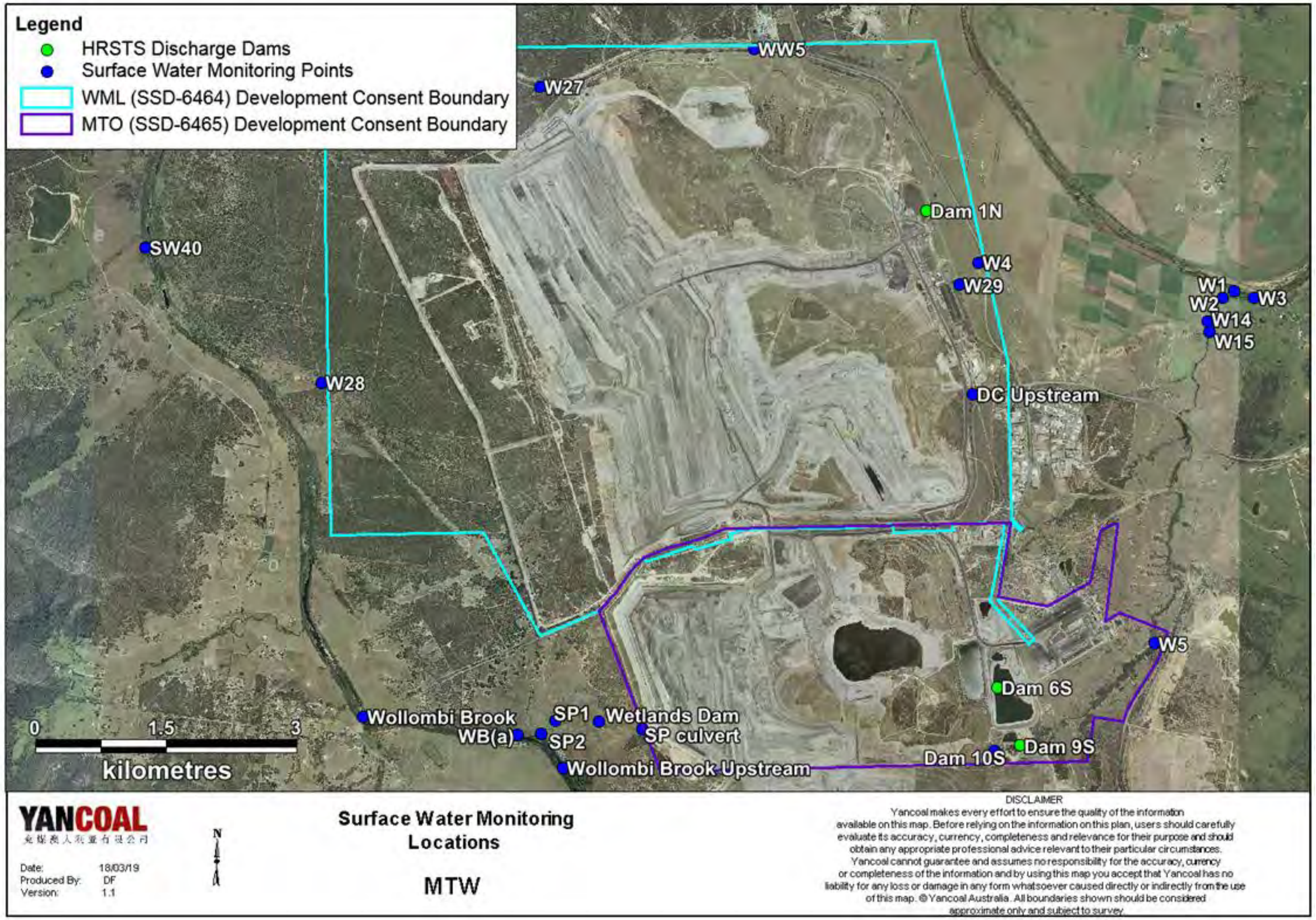


Figure 26: Surface Water Monitoring Points

6.7.4 Surface Water Performance

Routine surface water monitoring was undertaken from twelve (12) sites and rain event sampling was undertaken from thirteen (13) sites (See **Table 6.14** below). 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 well below average rainfall during the reporting period, only two sampling runs were completed in 2018. Low annual rainfall also resulted in lower data recovery in 2018 as multiple sites were recorded as dry during the monitoring event. All required sampling and analysis was undertaken, except as detailed in **Table 6.14**. Trigger tracking results are described in **Table 6.15**.

TABLE 6.14 MTW WATER MONITORING DATA RECOVERY FOR 2018 (BY EXCEPTION)

Location	Data Recovery (%)	Comment
SP1	0%	Site recorded as dry in February and November
W4	0%	Site recorded as dry (insufficient water) in February and November
W5	50%	Site recorded as dry/insufficient water in June, July, August, September, October and December
W27	0%	Site recorded as dry in February and November
W28	50%	No safe access in February
WW5	50%	Site recorded as dry in June and September
SP2	0%	Site recorded as dry in February and November
Wetlands Dam	0%	Site recorded as dry in February and November

Note: Missing data indicates that there was insufficient water to take a sample, or that there was no safe access.

A summary of all surface water monitoring results is provided in the MTW Monthly Environmental Monitoring Reports and can be viewed via MTW's Insite website (https://insite.yancoal.com.au/).

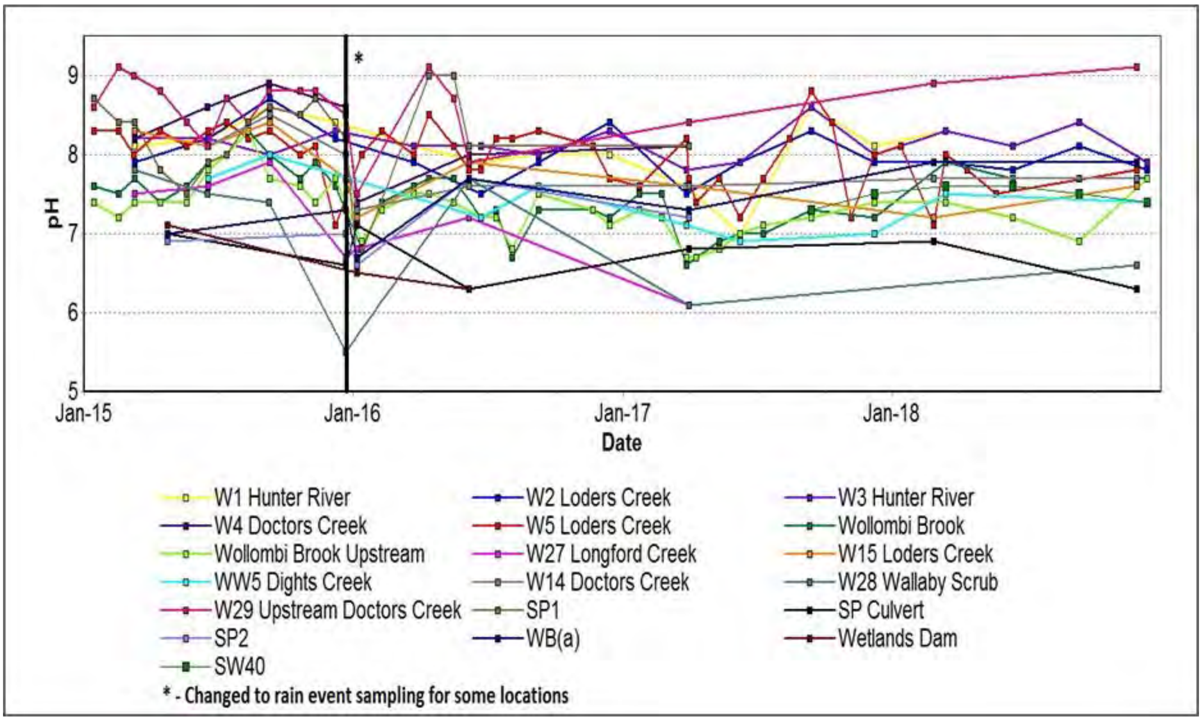
Figure 27 to **Figure 32** show long term water quality trends for the Hunter River, Wollombi Brook, other surrounding tributaries and site dams. Measurements of EC and pH were generally stable during the reporting period and consistent with historical seasonal trends.

A number of TSS limits were triggered in February and November, following significant runoff associated with rainfall events; these are outlined below in **Table 6.15.** Trigger tracking results are provided where three consecutive measurements of EC or pH are recorded. These are also provided in the Monthly reports given on the MTW Insite website (https://insite.yancoal.com.au/).

TABLE 6.15 SURFACE WATER MONITORING - TRIGGER TRACKING RESULTS

Site	Date	Trigger Limit	Action Taken in Response
W14	26/02/2018	EC –95th Percentile	Watching Brief*
W14	29/11/2018	EC –95th Percentile	Watching Brief*
W28	29/11/2018	EC –95th Percentile	Watching Brief*
Wollombi Brook	14/03/2018	EC –95th Percentile	Watching Brief*
Wollombi Brook	13/06/2018	EC –95th Percentile	Watching Brief*
Wollombi Brook	11/09/2018	EC –95th Percentile	Elevated EC is considered attributable to prolonged dry climatic conditions, and not related to mining related impacts. Continue to watch and monitor.
Wollombi Brook	13/12/2018	EC –95th Percentile	Elevated EC is considered attributable to prolonged dry climatic conditions, and not related to mining related impacts. Continue to watch and monitor.
Wollombi Brook Upstream	14/03/2018	EC –95th Percentile	Watching Brief*
Wollombi Brook Upstream	13/06/2018	EC –95th Percentile	Elevated EC is considered attributable to prolonged dry climatic conditions, and not related to mining related impacts. Continue to watch and monitor.
Wollombi Brook Upstream	13/12/2018	EC –95th Percentile	Elevated EC is considered attributable to prolonged dry climatic conditions, and not related to mining related impacts. Continue to watch and monitor.
SW40	11/09/2018	EC –95th Percentile	Watching Brief*
W5	14/02/2018	pH –5th Percentile	Watching Brief*
W5	22/05/2018	pH –5th Percentile	Watching Brief*
W15	26/02/2018	pH –5th Percentile	Watching Brief*

Site	Date	Trigger Limit	Action Taken in Response
W5	12/01/2018	TSS – 50mg/L (ANZECC criteria)	Field investigation did not identify any mining related sources of sediment. Field notes indicate that sample taken from water with no flow i.e. "pool" of water. No further action taken
W5	29/11/2018	TSS – 50mg/L (ANZECC criteria)	Field investigation did not identify any mining related sources of sediment. Elevated TSS associated with high intensity rainfall event after prolonged dry period. No further action taken
W14	26/02/2018	TSS – 50mg/L (ANZECC criteria)	Field investigation did not identify any mining related sources of sediment. Elevated TSS associated with high intensity rainfall event after prolonged dry period. No further action taken
W28	29/11/2018	TSS – 50mg/L (ANZECC criteria)	Field notes indicate that sample taken from water with no flow. Elevated TSS associated with high intensity rainfall event after prolonged dry period. No further action taken
W29	26/02/2018	TSS – 50mg/L (ANZECC criteria)	Field investigation did not identify any mining related sources of sediment. Elevated TSS associated with high intensity rainfall event after prolonged dry period. No further action taken
W29	29/11/2018	TSS – 50mg/L (ANZECC criteria)	Field notes indicate that sample taken from water with no flow (Pool). Elevated TSS associated with high intensity rainfall event after prolonged dry period. No further action taken



Note: Missing data indicates that there was insufficient water to take a sample, or that there was no safe access.

FIGURE 27: WATERCOURSE pH TRENDS 2015 TO 2018

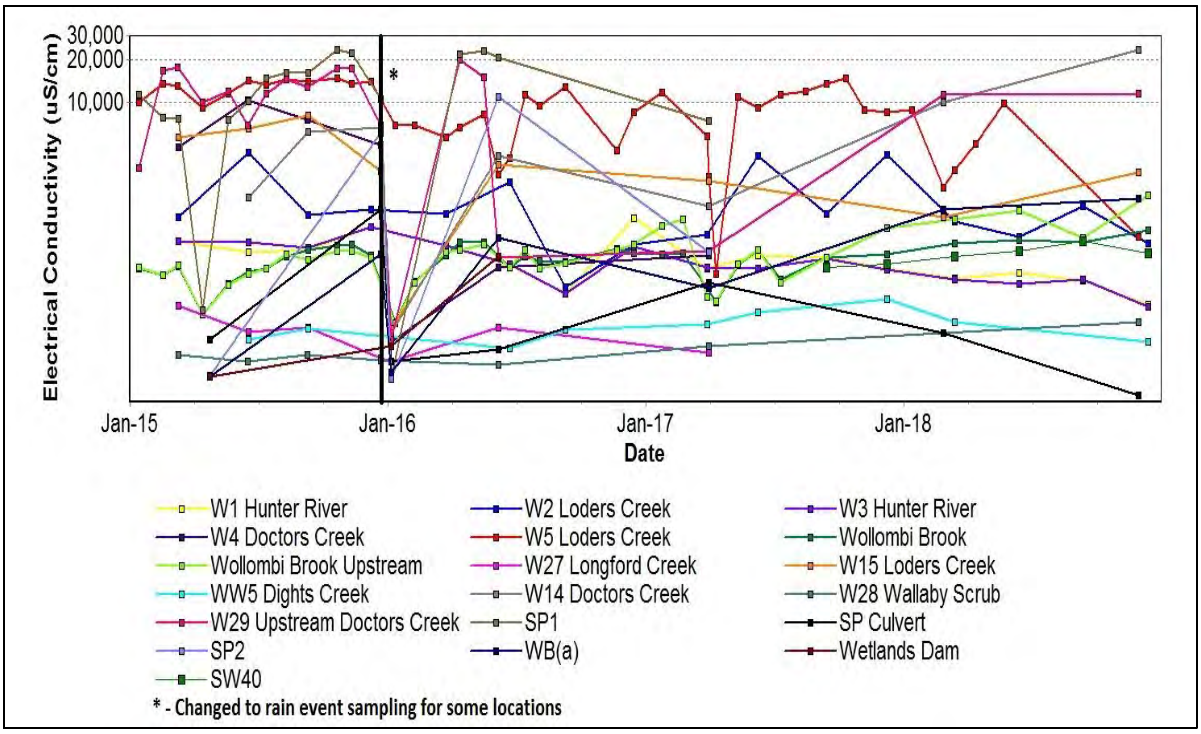


FIGURE 28: WATERCOURSE EC TRENDS 2015 TO 2018

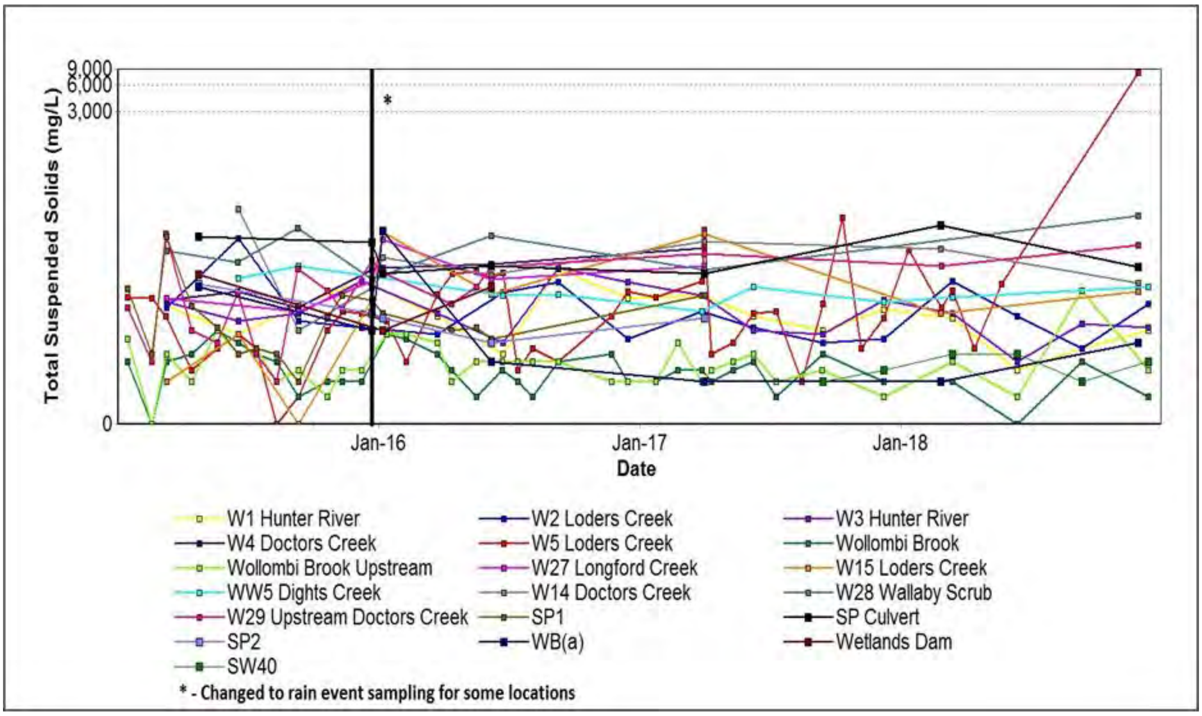


FIGURE 29: WATERCOURSE TSS TRENDS 2015 TO 2018

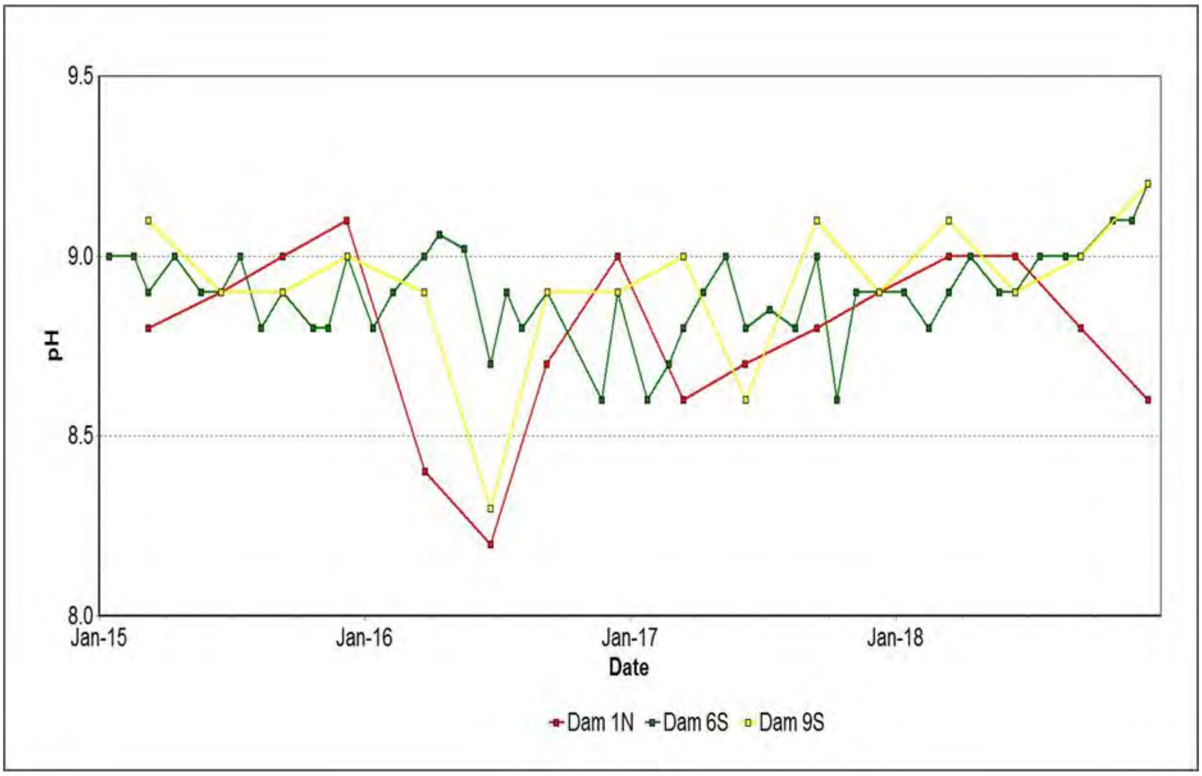


FIGURE 30: SITE DAMS PH TRENDS 2015 TO 2018

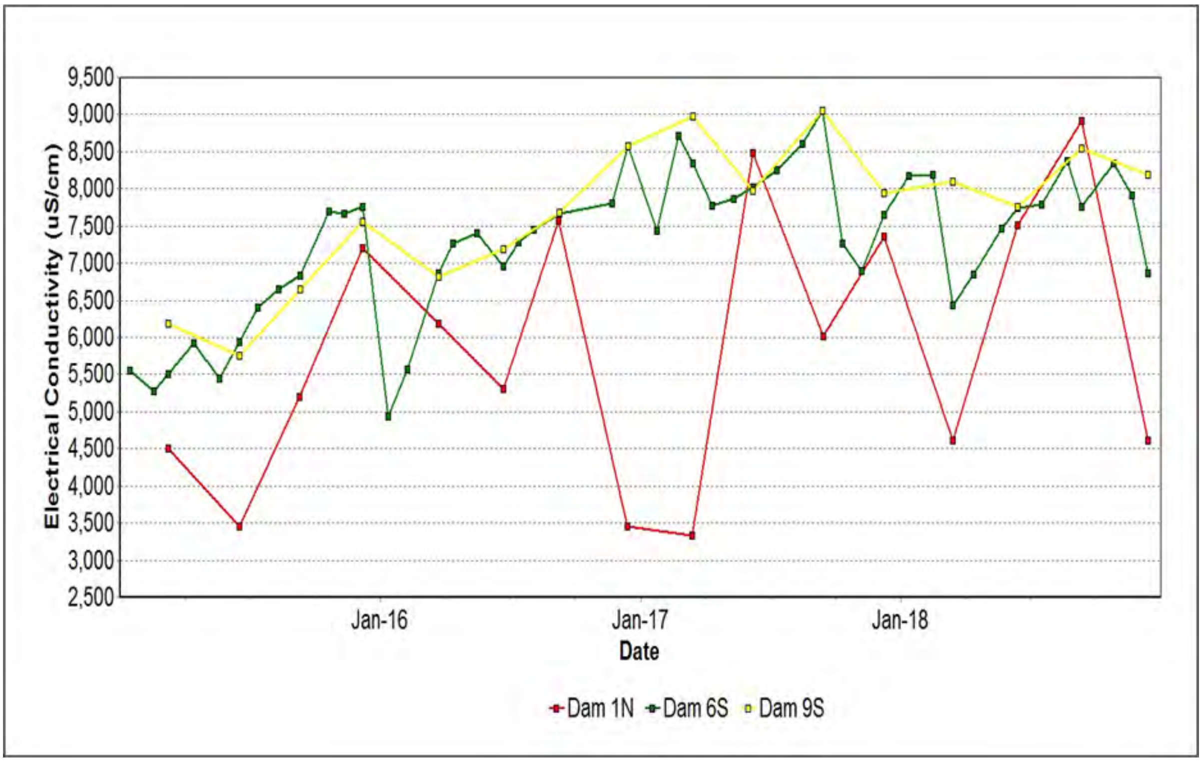


FIGURE 31: SITE DAMS EC TRENDS 2015 TO 2018

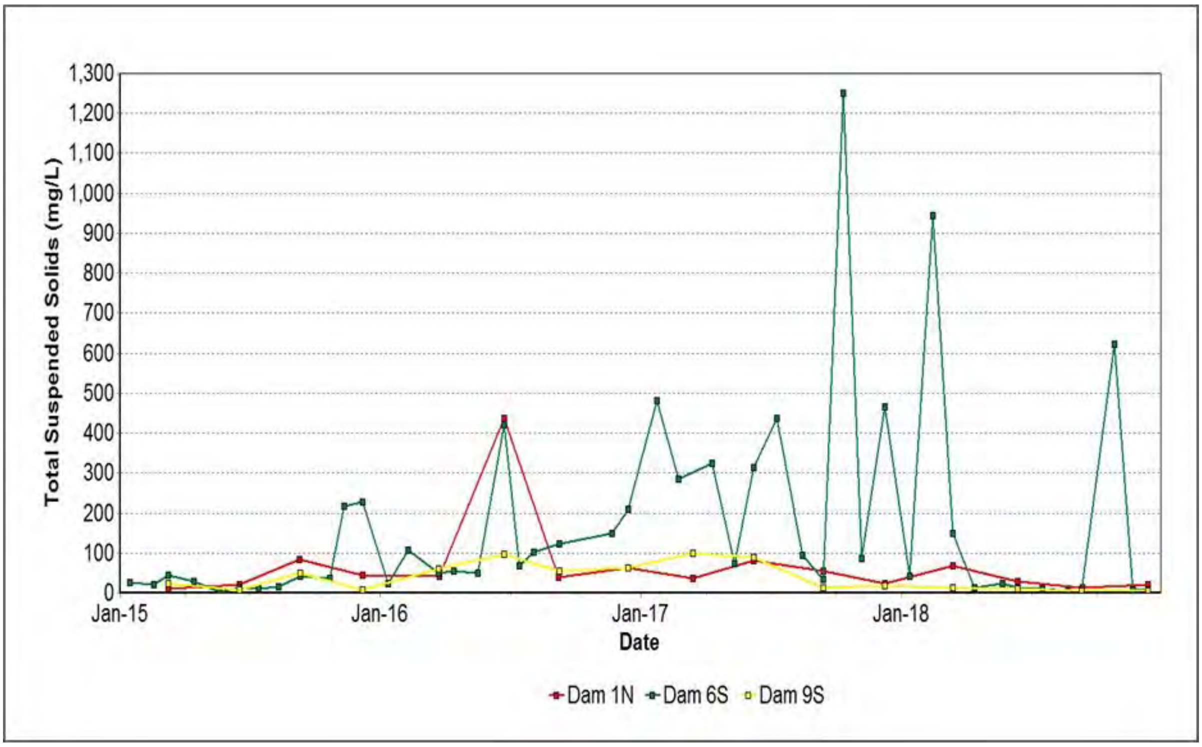


FIGURE 32: SITE DAMS TSS TRENDS 2015 TO 2018

6.7.4.1 Stream Health and Channel Stability

A programme to monitor and report on the stream and riparian vegetation health in Loders Creek and Wollombi Brook which may be potentially affected by the development commenced in 2016. The monitoring programme is conducted in conjunction with a similar programme managed by Bulga Surface Operations.

The annual monitoring program 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 (RARC) 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.

A copy of the stream health and stability monitoring report is provided as **Appendix 5.** As outlined in the report, stream health and channel stability monitoring results in 2018 indicated that channel stability in Wollombi Brook had remained the same as the previous year's monitoring cycle conditions and that the majority of Loders Creek displayed stable environments. Generally, the monitoring identified that both creeks have not significantly changed from what was observed during the 2017 baseline survey. However, some evidence of minor erosion progression was observed at some of the monitoring points. Many sections of the local creeks experience active erosion as a result of natural influences and are not related to the development. This is exacerbated by past land clearing and land use practices exposing dispersive sub-soils. Improvements were also identified during the 2018 survey, resulting from both natural occurrences as well as man-made upgrade works. The RARC stream health assessment identified that the monitoring points on Loders Creek were classified as poor, due predominantly a result of the long history of mining and grazing practices in the area.

The single monitoring point on Wollombi Brook was classed as poor. The recommendations from the monitoring report suggest utilising a risk-based approach to the installation of mitigation measures and/or improvement works.

During the reporting period MTW undertook creek stability improvement works at its Mount Thorley Operations HRSTS discharge location to improve the stream health and channel stability in this location. This site had a classification of poor before the remediation works were completed. During the 2018 assessment, the site was classified as stabilising. Before and after photos are provided below for reference.

MTO HRSTS Discharge Location – Before Stability Improvement Works

MTO HRSTS Discharge Location - After Stability Improvement Works

The 2018 stream health and stability assessment did not identify any direct impacts from MTW's current operations as contributing to a decline in stream health or channel stability. Despite this, MTW will review the LC3 stream monitoring location in the Loders Creek Cultural Heritage Conservation Area to assess whether improvement works are achievable in this zone, as this location was identified as having active erosion requiring priority attention. MTW will continue to undertake the annual stream health and stability monitoring it accordance with the requirements of its approved Water Management Plan.

6.7.5 Groundwater Management

Groundwater monitoring activities were undertaken in 2018 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 results outside the trigger limits is detailed in the MTW Water Management Plan.

The monitoring locations are shown in **Figure 33** and the annual Ground Water Impacts Review can be found in **Appendix 6.**

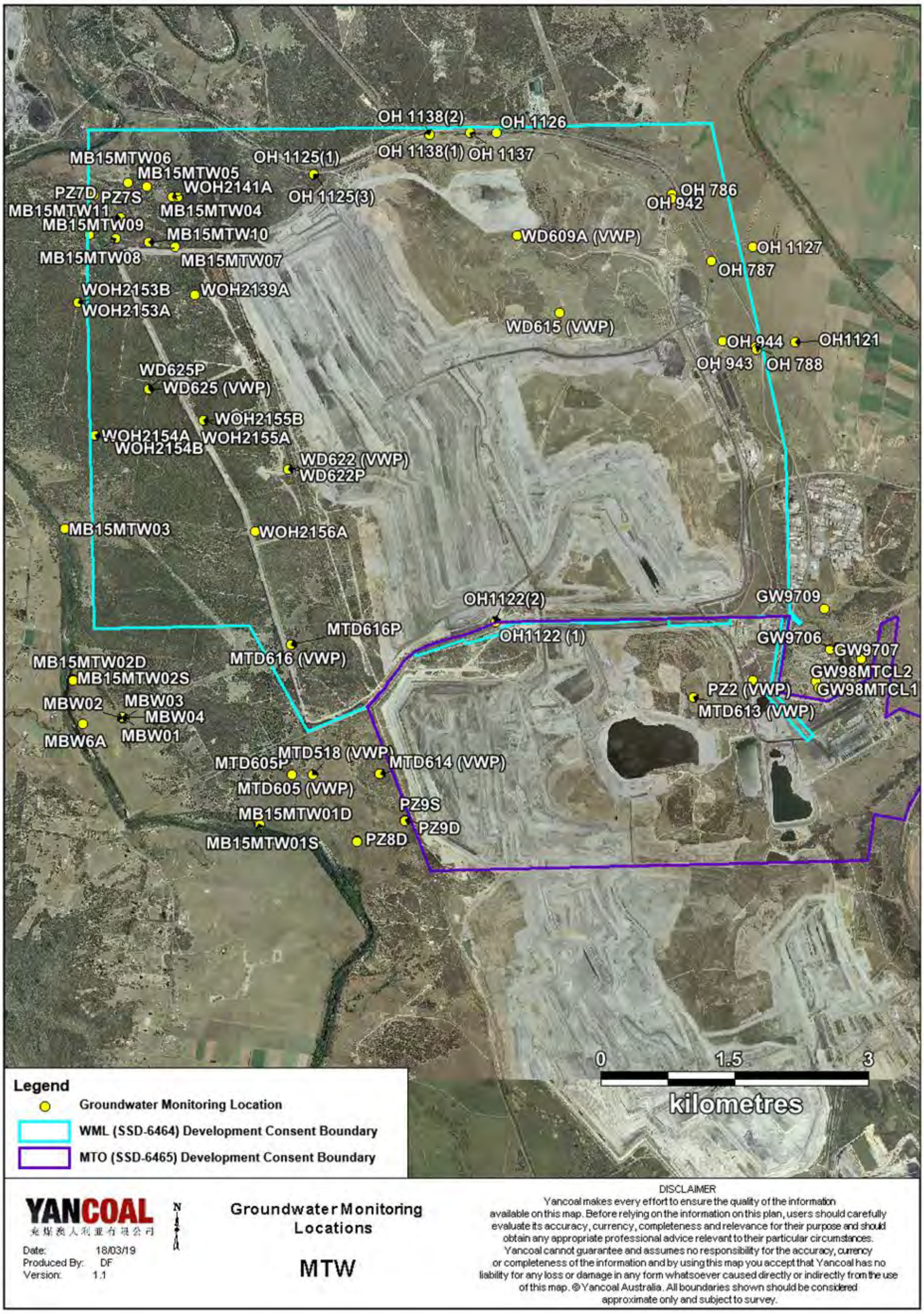


FIGURE 33: GROUNDWATER MONITORING NETWORK AT MTW IN 2018

6.7.6 Groundwater Performance

Sampling of ground waters was carried out on 259 occasions from 60 bores across MTW 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 6.16**.

Table 6.16 MTW Water Monitoring Data Recovery for 2018 (by exception)

Location	Data Recovery (%)	Comment
OH 786	50%	Insufficient water for sampling in September and December
OH943	75%	Insufficient water for sampling in March
OH944	0%	Insufficient water for sampling in 2018
MTD614P	75%	No access in June to fallen tree
WOH2155B	75%	No access possible in May
WOH2156B	75%	Insufficient water for sampling in August
MB15MTW04	0%	Insufficient water for sampling in 2018
MB15MTW05	0%	Insufficient water for sampling in 2018
MB15MTW06	25%	Insufficient water for sampling in July, August and November
MB15MTW07	0%	Insufficient water for sampling in 2018
MB15MTW08	0%	Insufficient water for sampling in 2018
MB15MTW9	0%	Insufficient water for sampling in 2018
MB15MTW10	0%	Insufficient water for sampling in 2018
MB15MTW11	0%	Insufficient water for sampling in 2018

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

The following sections present 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.

6.7.6.1 Bayswater Seam Bores

Groundwater monitoring in the Bayswater seam was undertaken from seven sites during 2018. A total of 28 samples were collected during the reporting period. The pH, EC and SWL trends for 2015 to 2018 for Bayswater groundwater bores are shown in **Figure 34** to **Figure 36** respectively. Trigger tracking results are given in **Table 6.17**. Results were generally stable and consistent with historical trends.

TABLE 6.17 BAYSWATER SEAM GROUNDWATER 2018 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
GW9709	02/03/2018	**pH – 5th percentile**	Watching Brief *
GW98MTCL2	02/03/2018	**pH – 5th percentile**	Watching Brief *
GW9709	13/12/2018	**EC – 95th percentile**	Watching Brief *

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

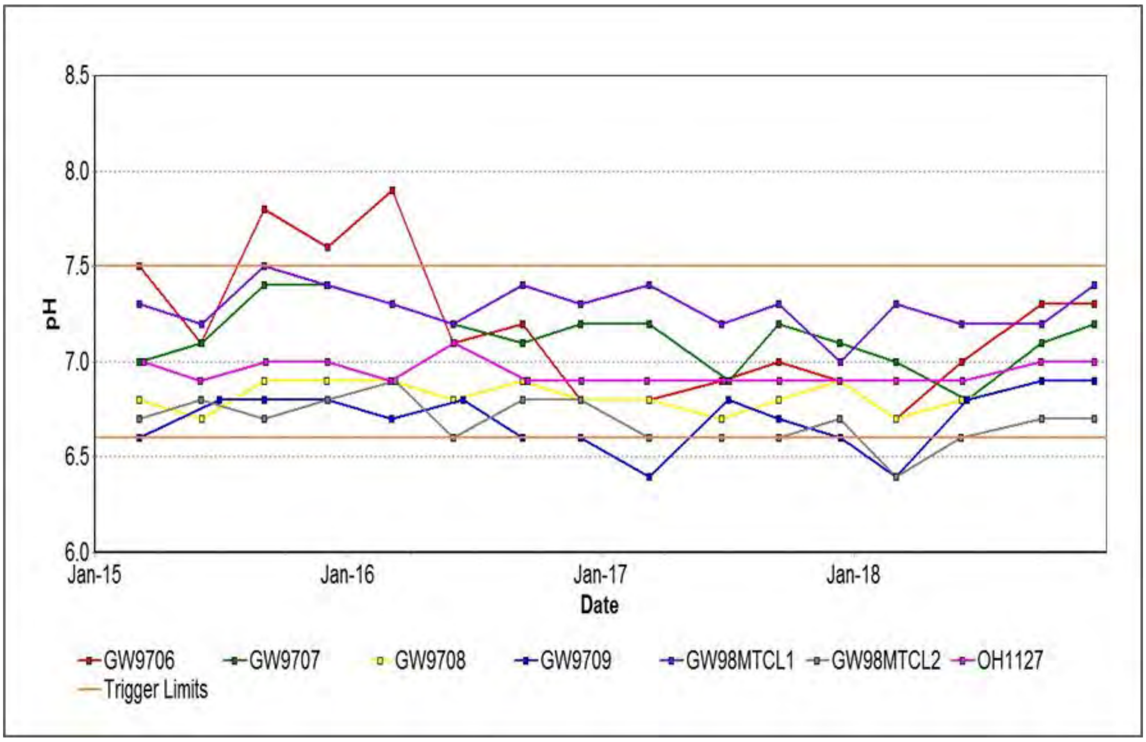


FIGURE 34: BAYSWATER SEAM pH TRENDS 2015 TO 2018

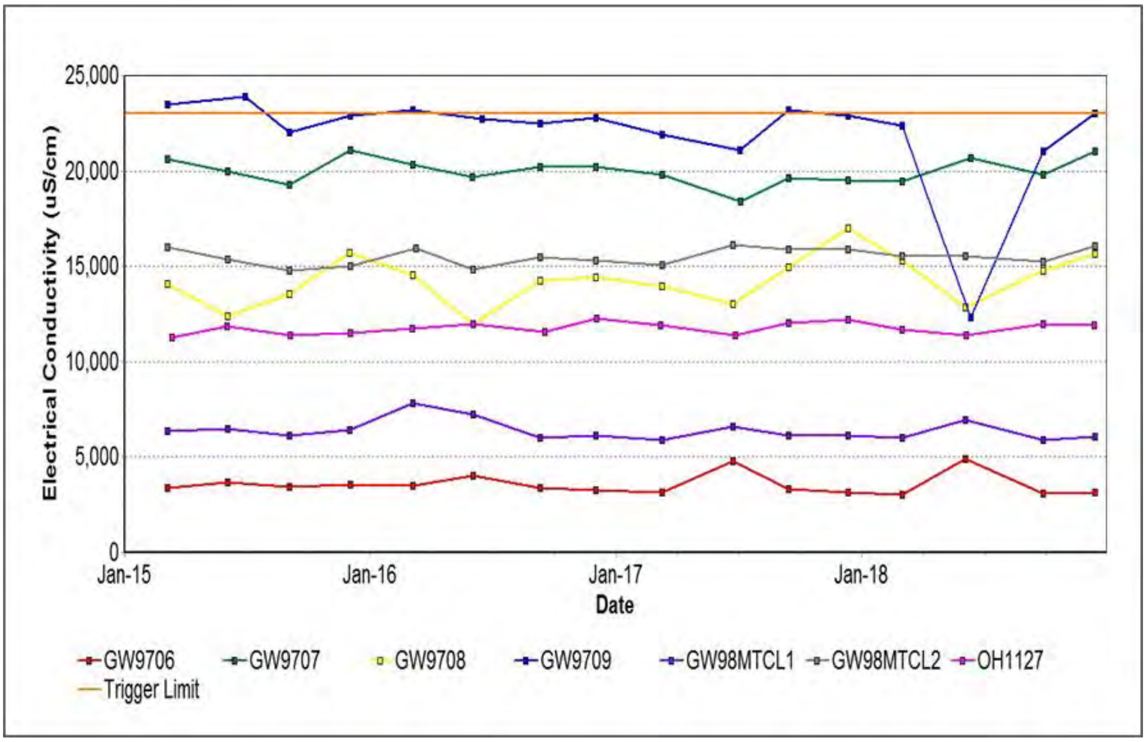


FIGURE 35: BAYSWATER SEAM EC TRENDS 2015 TO 2018

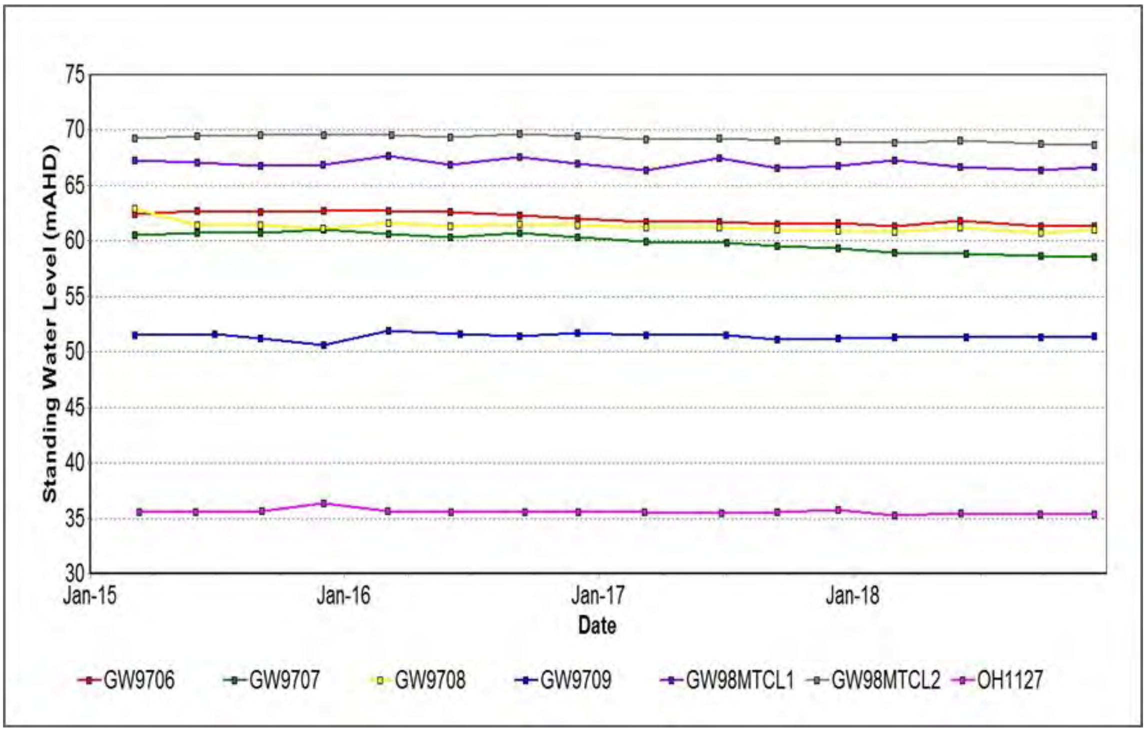


FIGURE 36: BAYSWATER SWL TRENDS 2015 TO 2018

6.7.6.2 Bowfield Seam Bores

Groundwater monitoring in the Bowfield seam was undertaken at one site during 2018. A total of 4 samples were collected during the reporting period. The pH, EC and SWL trends for 2015 to 2018 are shown in **Figure 37, Figure 38, Figure 39** respectively. Water quality results were similar to historical data.

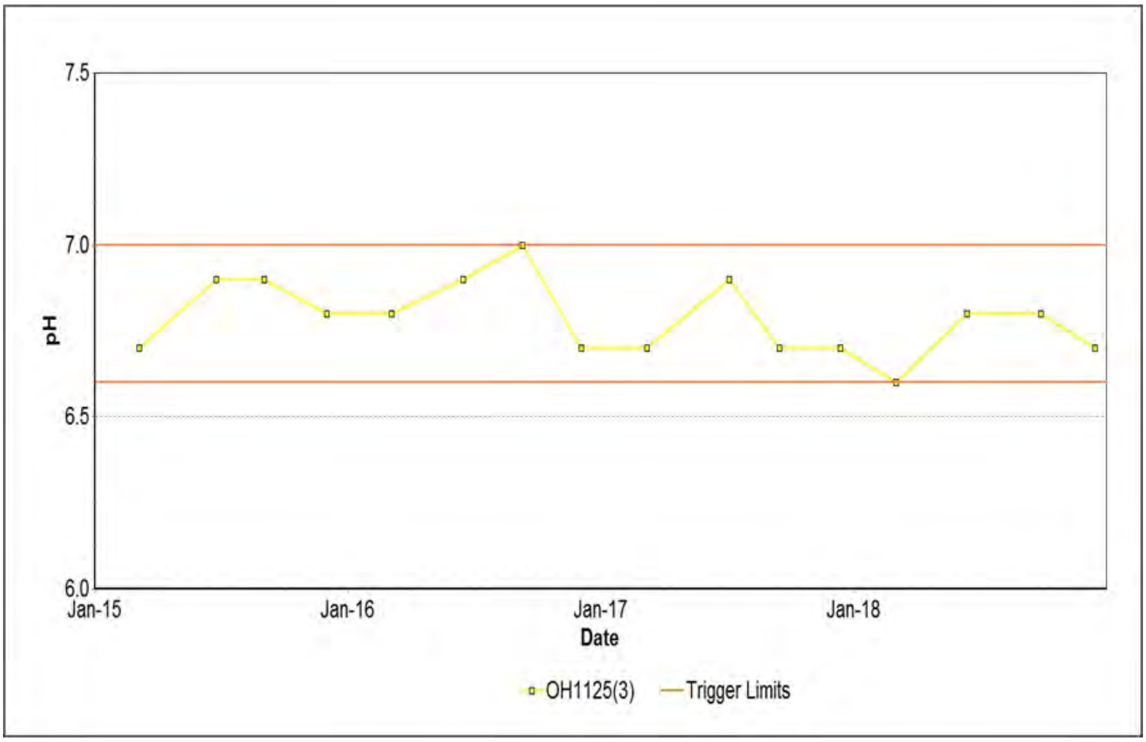


Figure 37: Bowfield Seam pH Trend 2015 to 2018

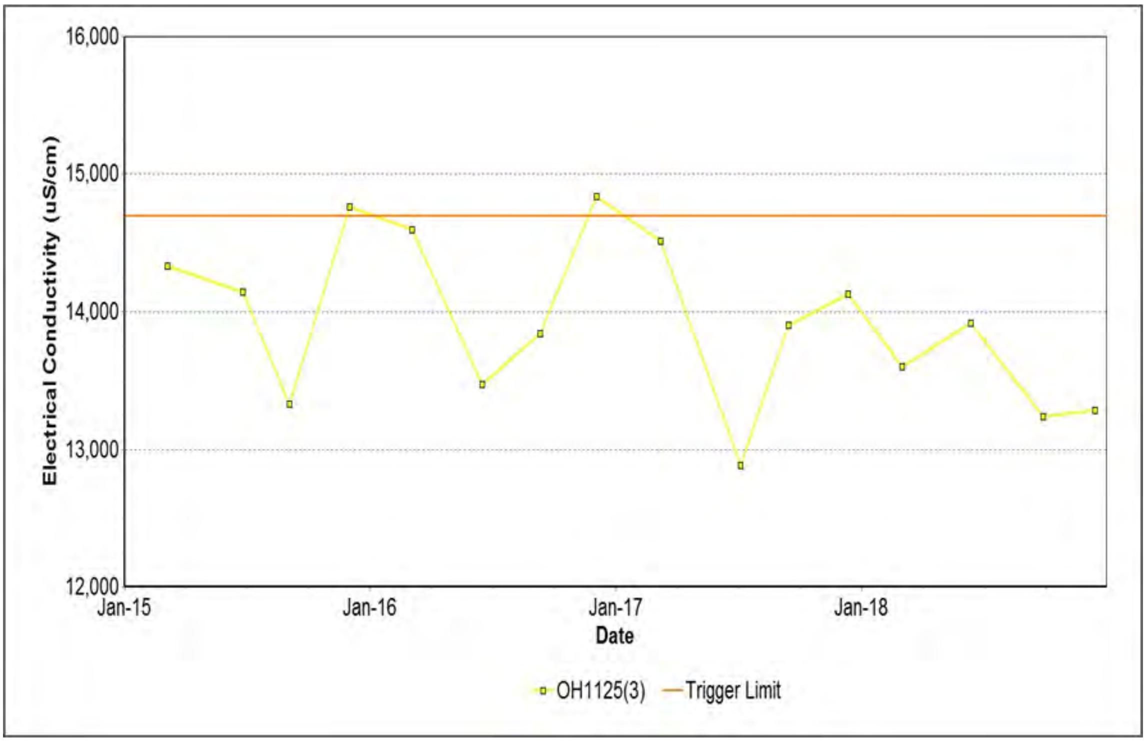


Figure 38: Bowfield Seam EC Trends 2015 to 2018

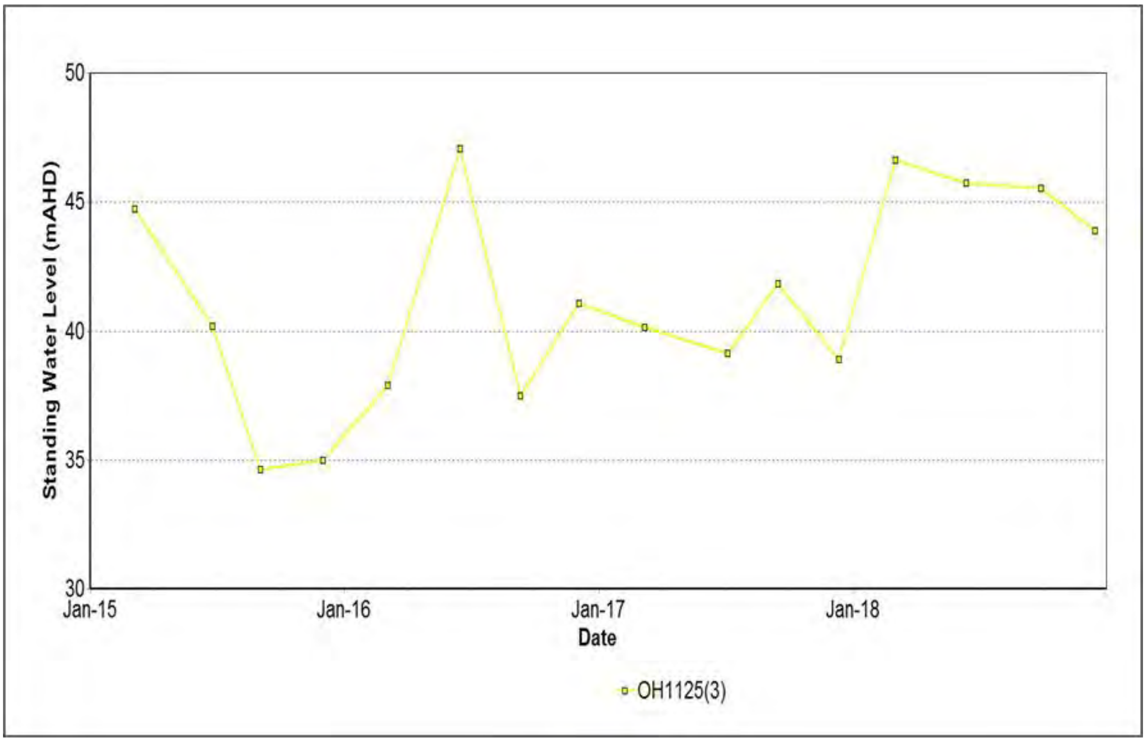


FIGURE 39: BAYSWATER SWL TRENDS 2015 TO 2018

6.7.6.3 Blakefield Seam Bores

Groundwater monitoring in the Blakefield seam was undertaken from three sites during 2018. A total of 12 samples were collected during the reporting period. The pH, EC and SWL trends for 2015 to 2018 are shown in **Figure 40, Figure 41** and **Figure 42** respectively. Water quality trends were generally steady with an increasing pH and EC trend observed in WOH2139A. Trigger tracking results are given in **Table 6.18**.

TABLE 6.18 BLAKEFIELD SEAM GROUNDWATER 2018 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
WOH2139A	06/02/2018	**pH - 95th percentile**	Data is stable and consistent with historical trend; no further action
	23/05/2018		Data is stable and consistent with historical trend. Other bores within the Blakefield seam are stable; no further action required
	06/08/2018		Increasing trend identified. Undertake additional monitoring on increased frequency.
	13/12/2018		Increasing trend identified. Undertake additional monitoring on increased frequency.
OH1125 (1)	02/03/2018	**pH - 5th percentile**	Watching Brief *
	14/12/2018		Watching Brief *

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

1 = No access possible until December sampling run

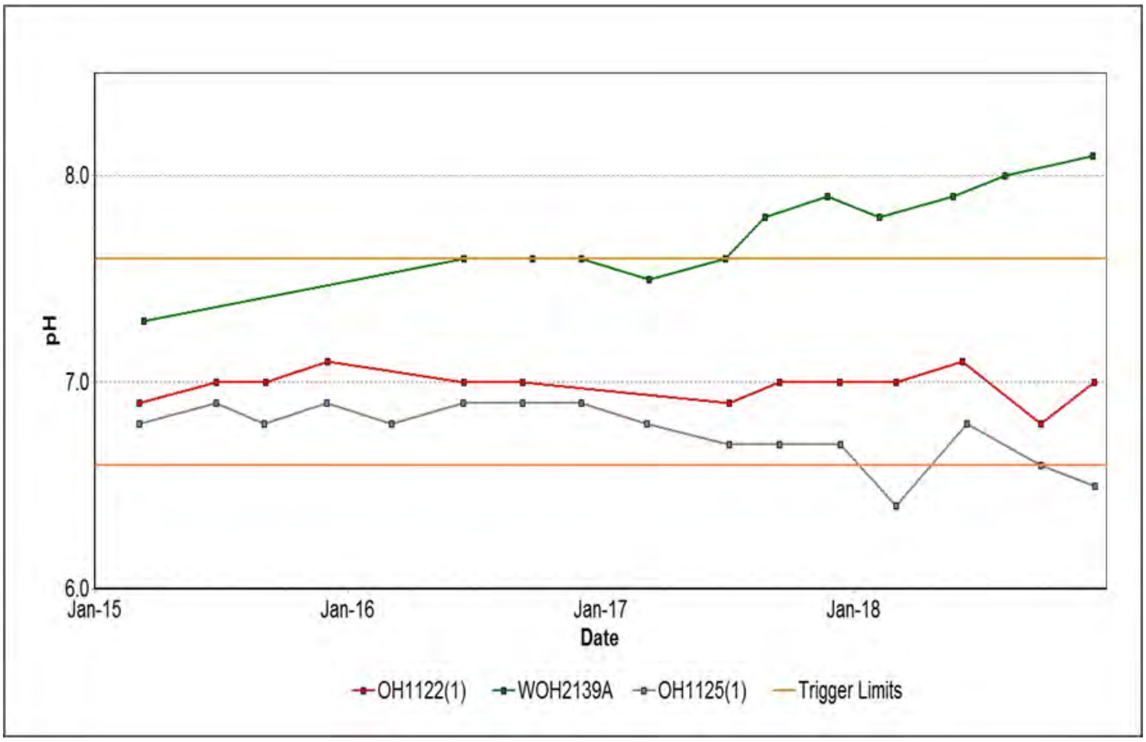


FIGURE 40: BLAKEFIELD SEAM GROUNDWATER PH TRENDS 2015 TO 2018

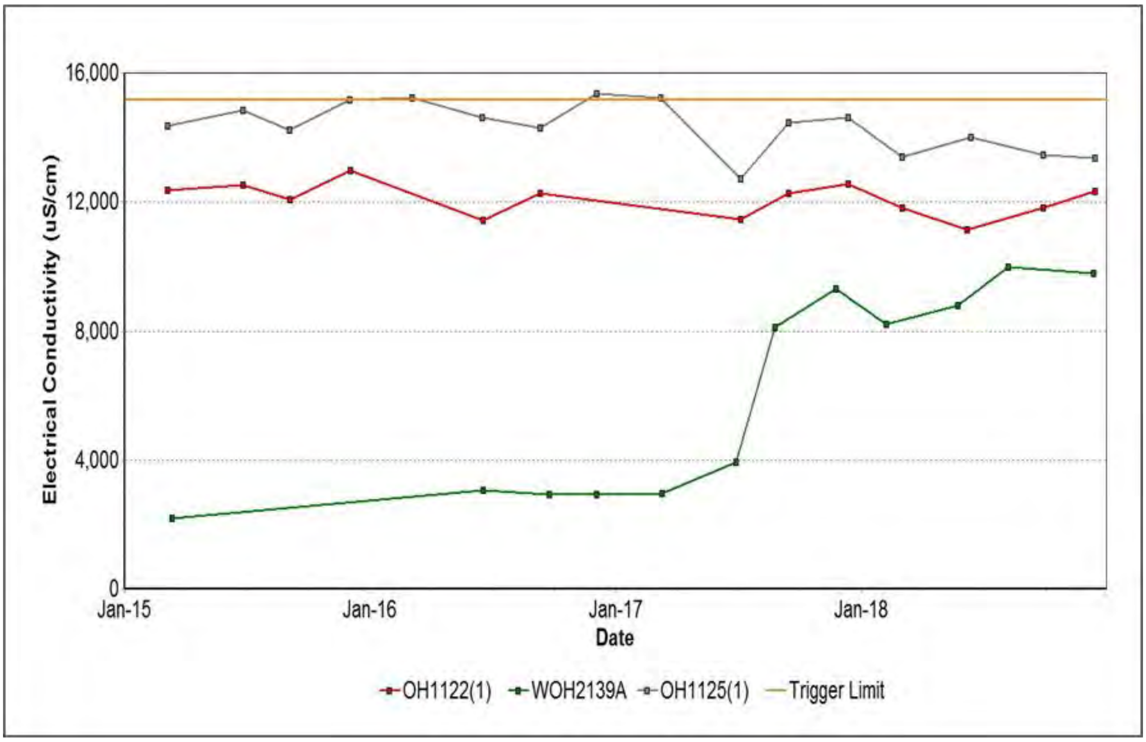


FIGURE 41: BLAKEFIELD SEAM GROUNDWATER EC TRENDS 2015 TO 2018

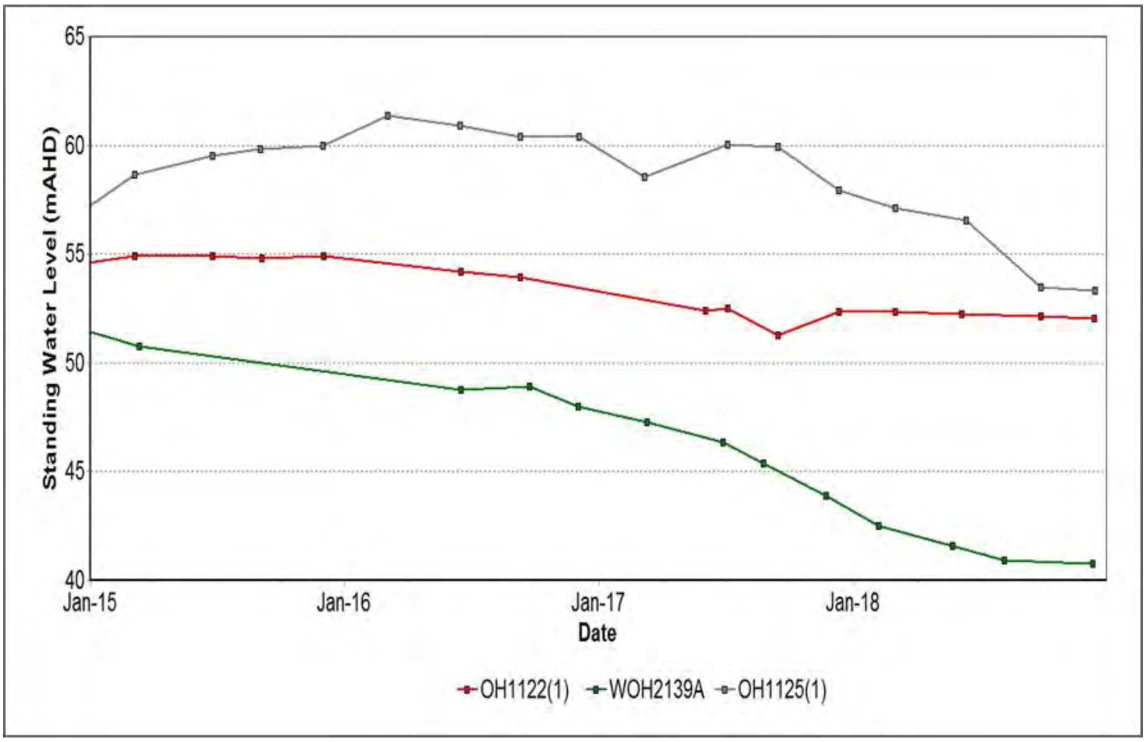


FIGURE 42: BLAKEFIELD SEAM GROUNDWATER SWL TRENDS 2015 TO 2018

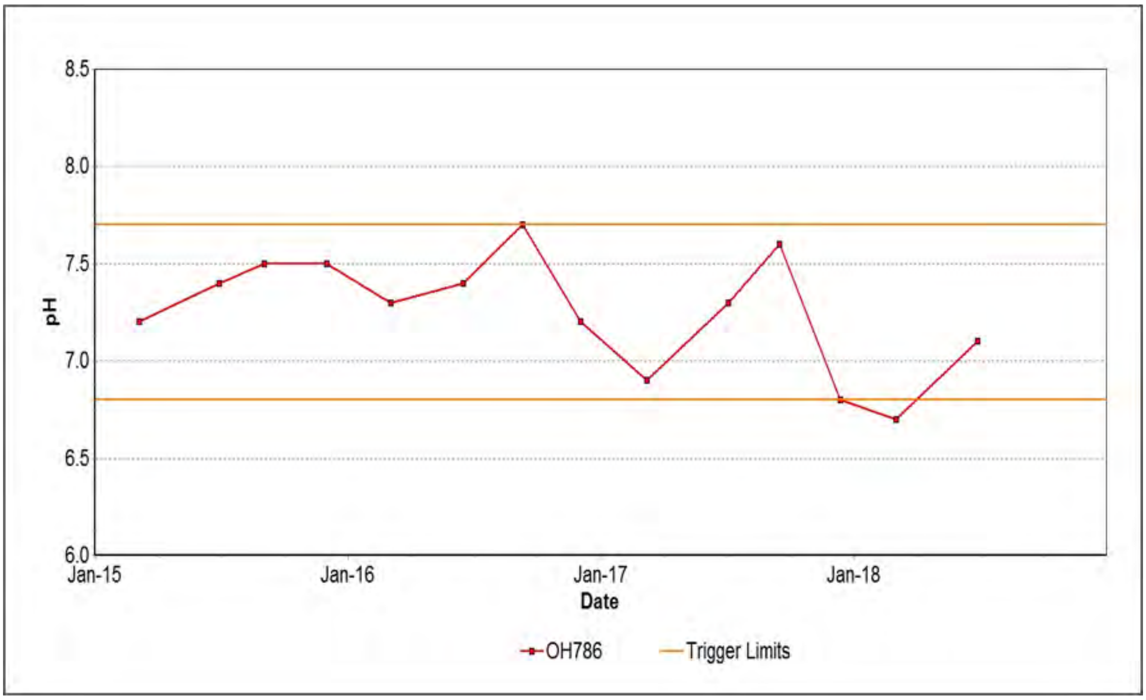
6.7.6.4 Hunter River Alluvium Bores

Groundwater monitoring in the Hunter River Alluvium was undertaken from five sites during 2018. A total of 17 samples were collected during the reporting period. The pH, EC and SWL trends for 2015 to 2018 for Hunter River Alluvium groundwater bores are shown in **Figure 43** to **Figure 55**. Results were generally stable and consistent with historical trends. Monitoring of trends in these bores will continue in the next reporting period.

TABLE 6.19 HUNTER RIVER ALLUVIUM GROUNDWATER 2018 INTERNAL TRIGGER TRACKING

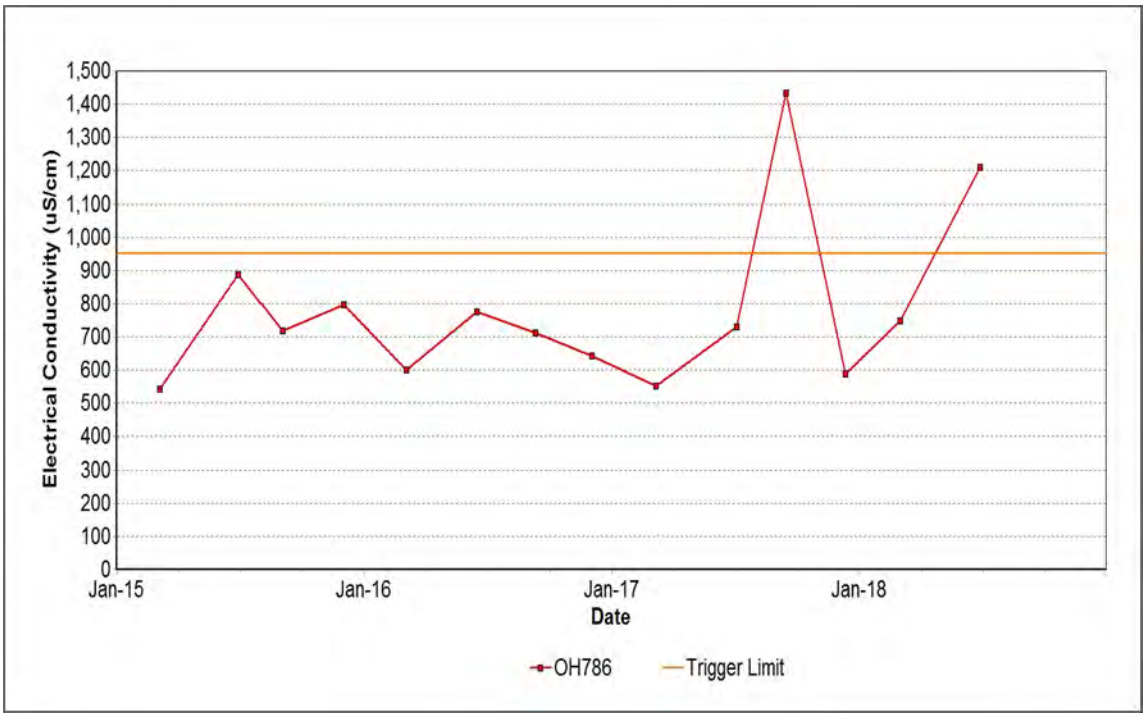
Location	Date	Trigger limit	Action taken in response
OH786	02/03/2018	**pH – 5th percentile**	Watching Brief *
OH786	28/06/2018	**EC – 95th percentile**	Watching Brief *
OH787	12/06/2018 27/09/2018	**EC – 95th percentile**	Watching Brief * Watching Brief *

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



Note: There has been insufficient water to sample since June 2018.

FIGURE 43: HUNTER RIVER ALLUVIUM BORE OH786 PH TREND 2015 TO 2018



Note: There has been insufficient water to sample since June 2018.

FIGURE 44: HUNTER RIVER ALLUVIUM BORE OH786 EC TREND 2015 TO 2018

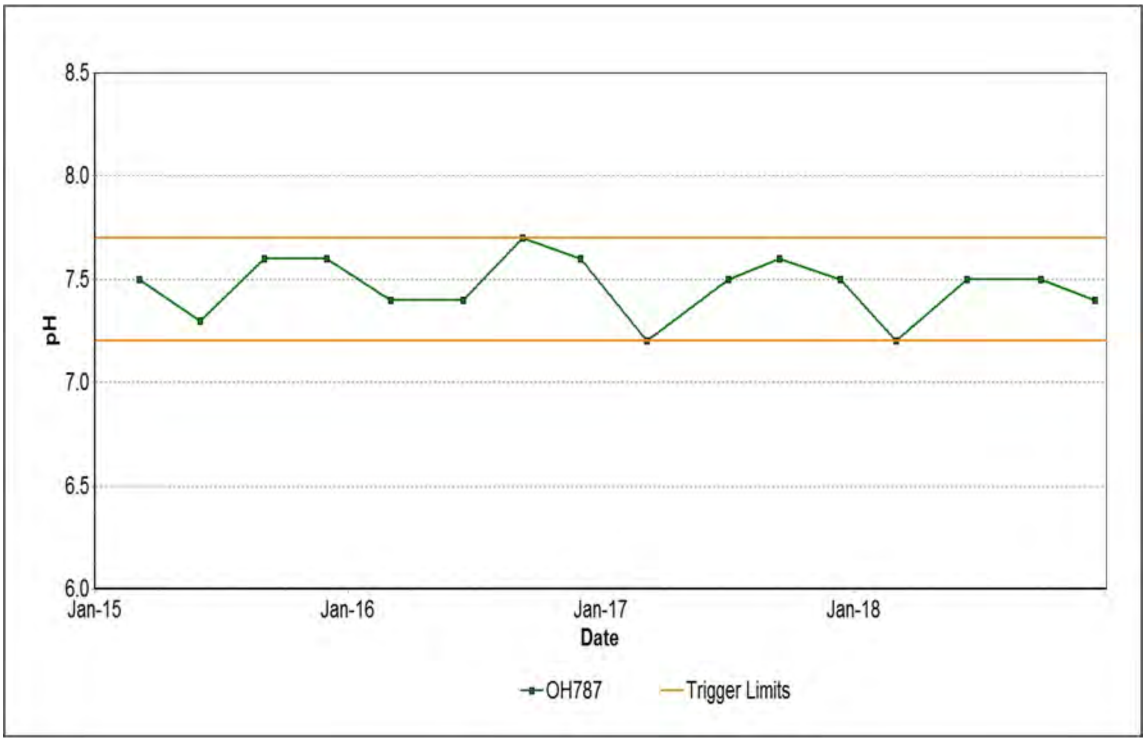


FIGURE 45: HUNTER RIVER ALLUVIUM BORE OH787 PH TREND 2015 TO 2018

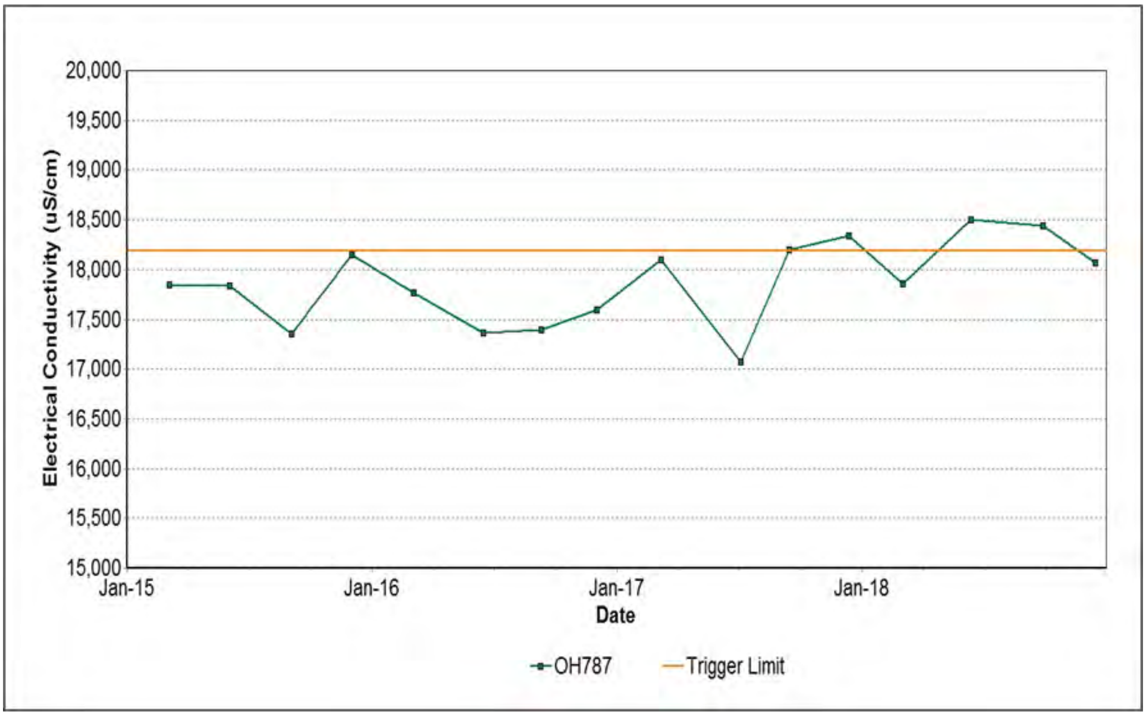


FIGURE 46: HUNTER RIVER ALLUVIUM BORE OH787 EC TREND 2015 TO 2018

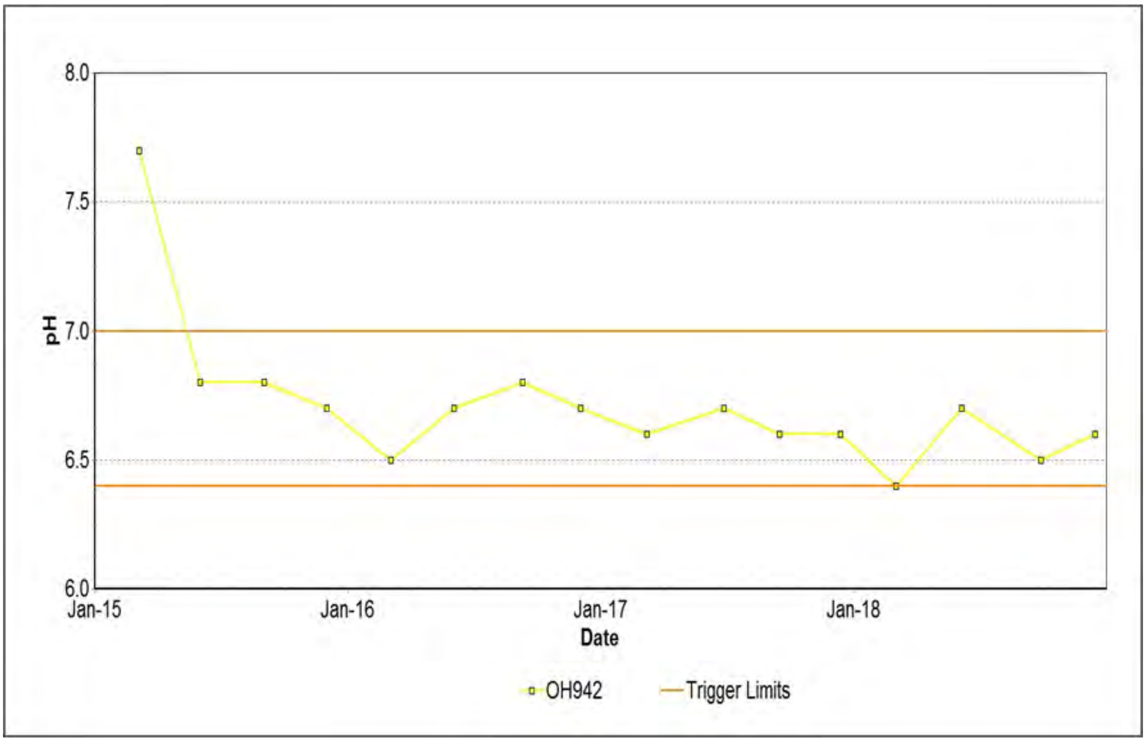


FIGURE 47: HUNTER RIVER ALLUVIUM BORE OH942 PH TREND 2015 TO 2018

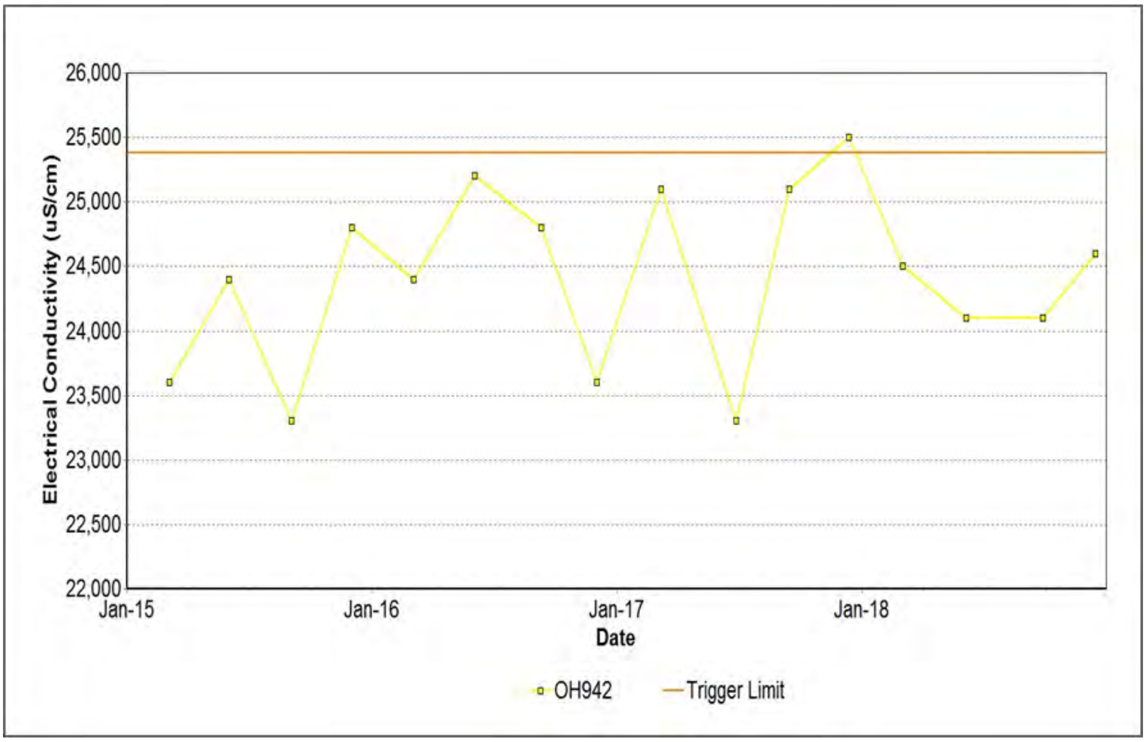


FIGURE 48: HUNTER RIVER ALLUVIUM BORE OH942 EC TREND 2015 TO 2018

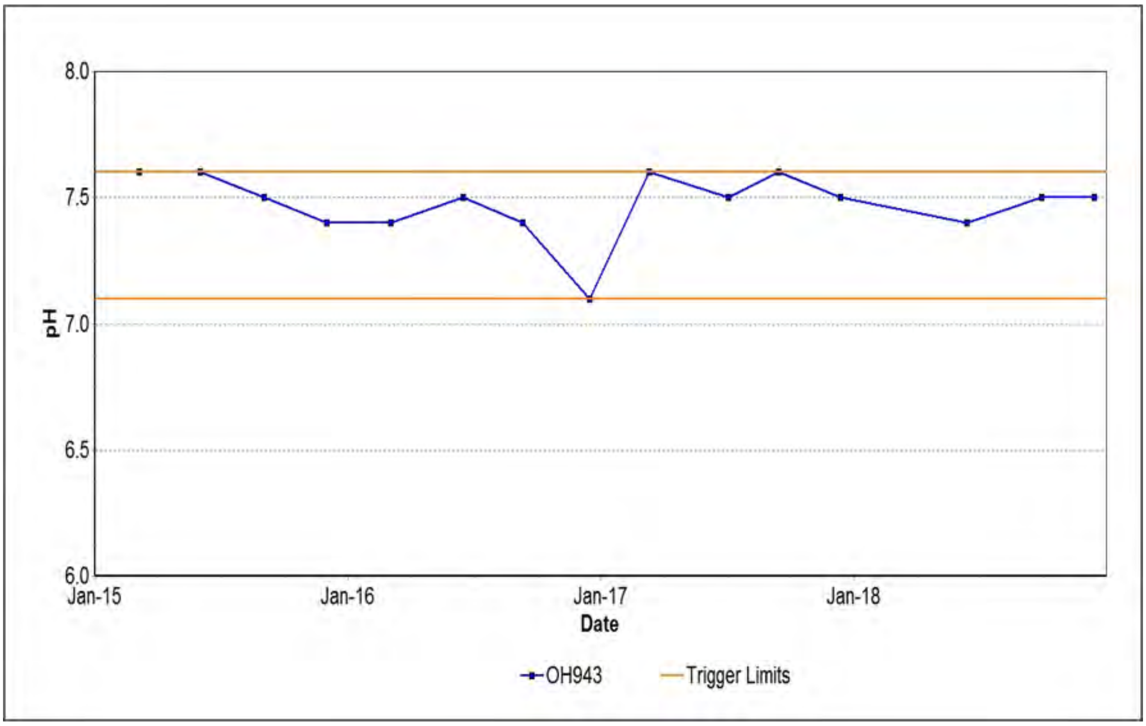


FIGURE 49: HUNTER RIVER ALLUVIUM BORE OH943 pH TREND 2015 TO 2018

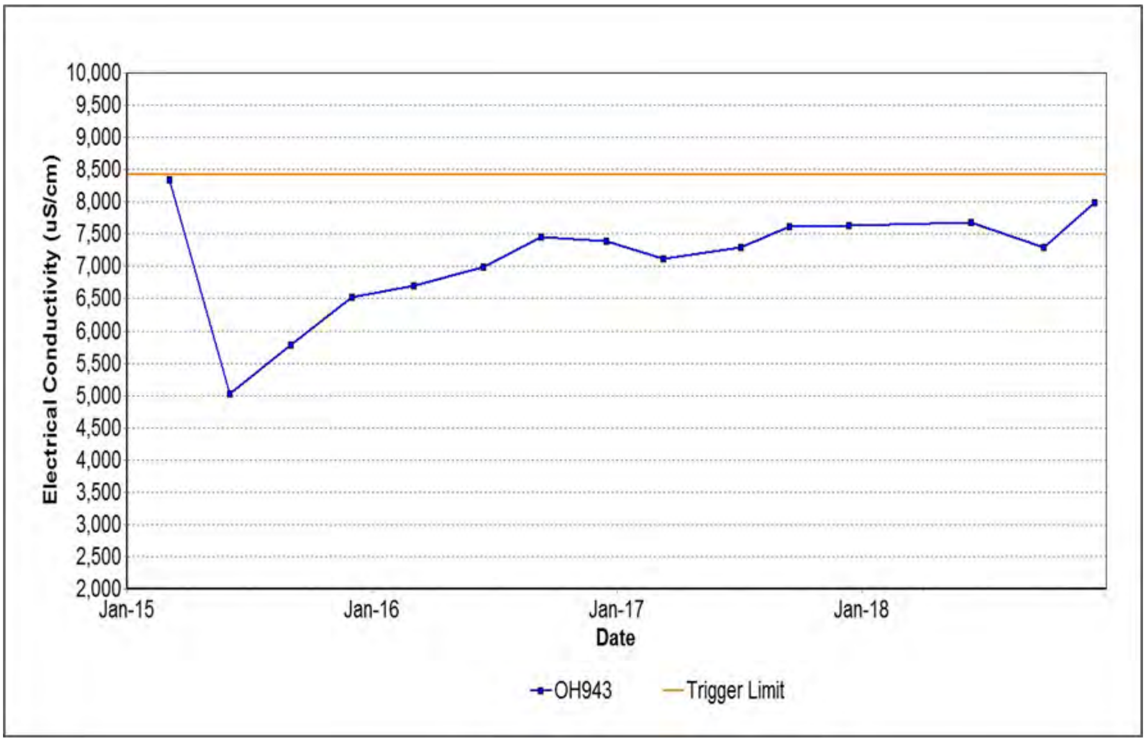
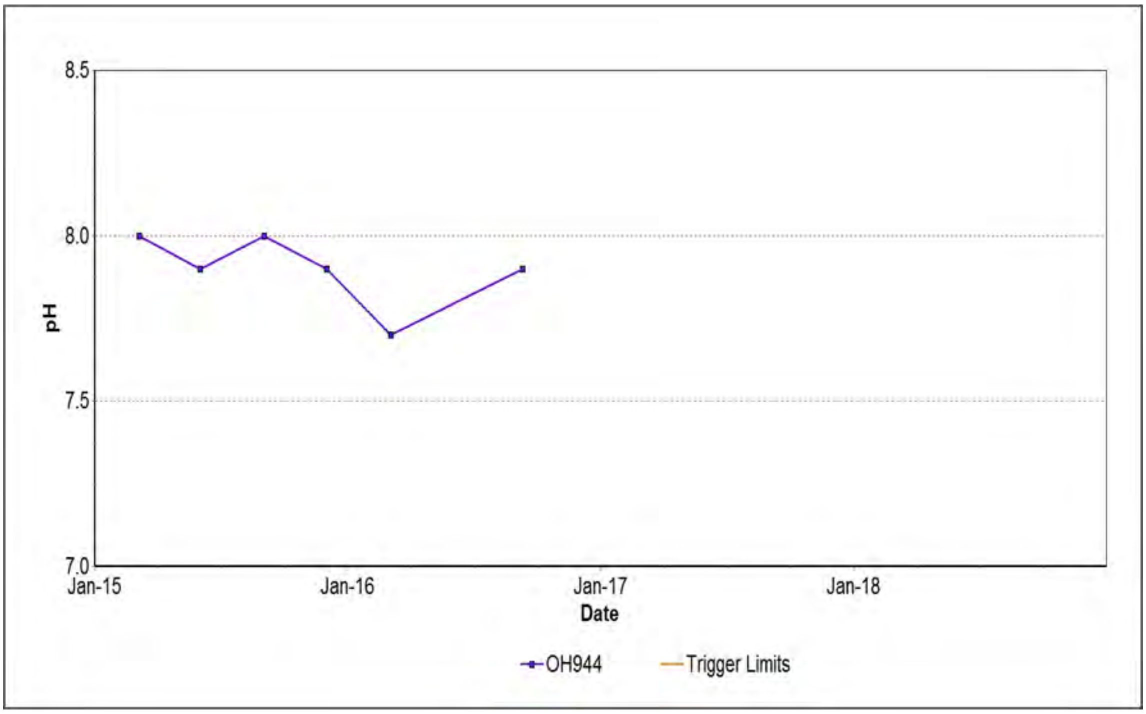
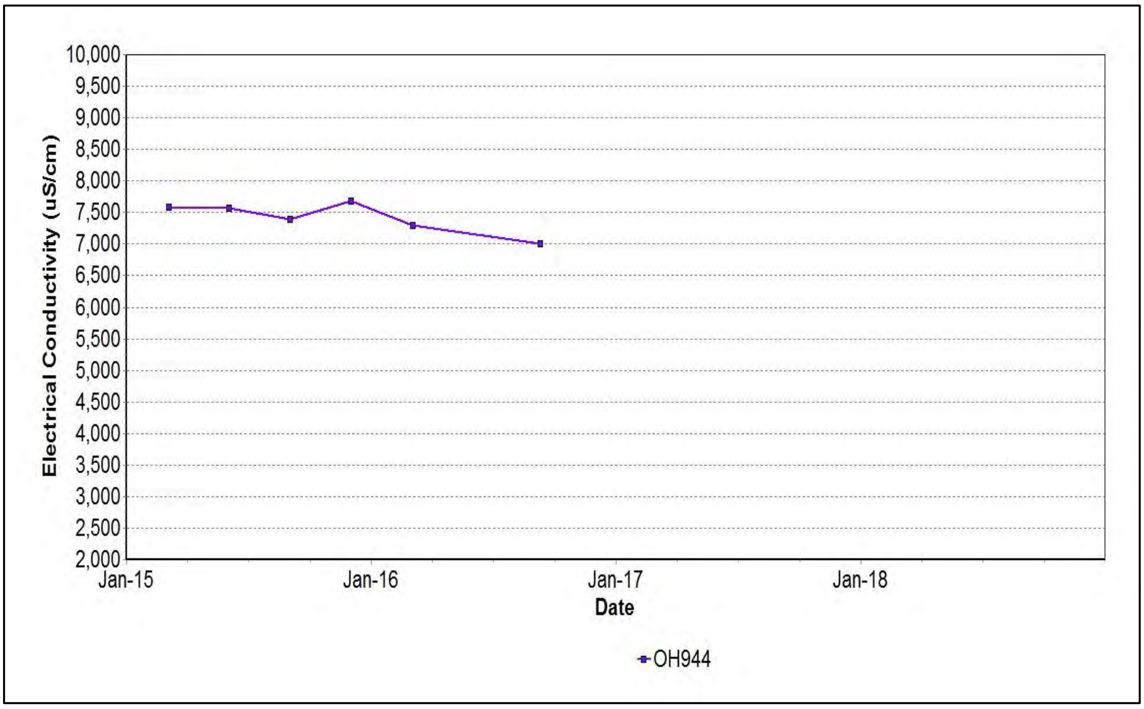


FIGURE 50: HUNTER RIVER ALLUVIUM BORE OH943 EC TREND 2015 TO 2018



Note: There has been insufficient water to sample since December 2016.

FIGURE 51: HUNTER RIVER ALLUVIUM BORE OH944 pH TREND 2015 TO 2018



Note: There has been insufficient water to sample since December 2016.

FIGURE 52: HUNTER RIVER ALLUVIUM BORE OH944 EC TREND 2015 TO 2018

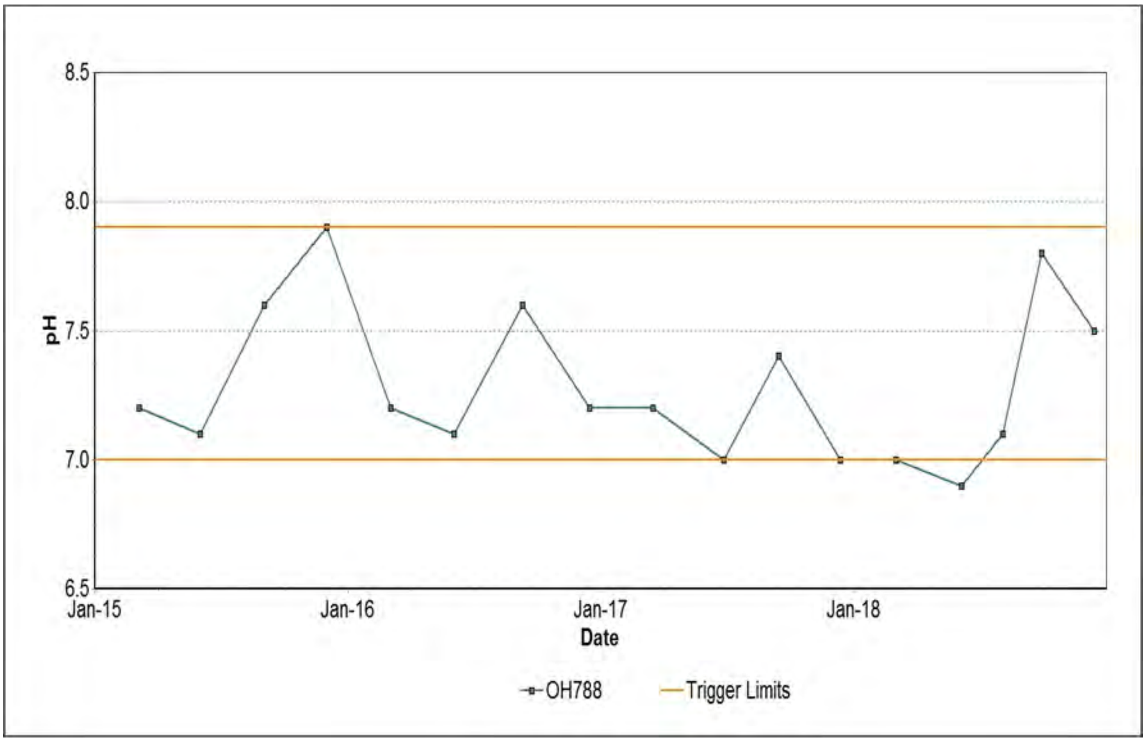


FIGURE 53: HUNTER RIVER ALLUVIUM BORE OH788 pH TREND 2015 TO 2018

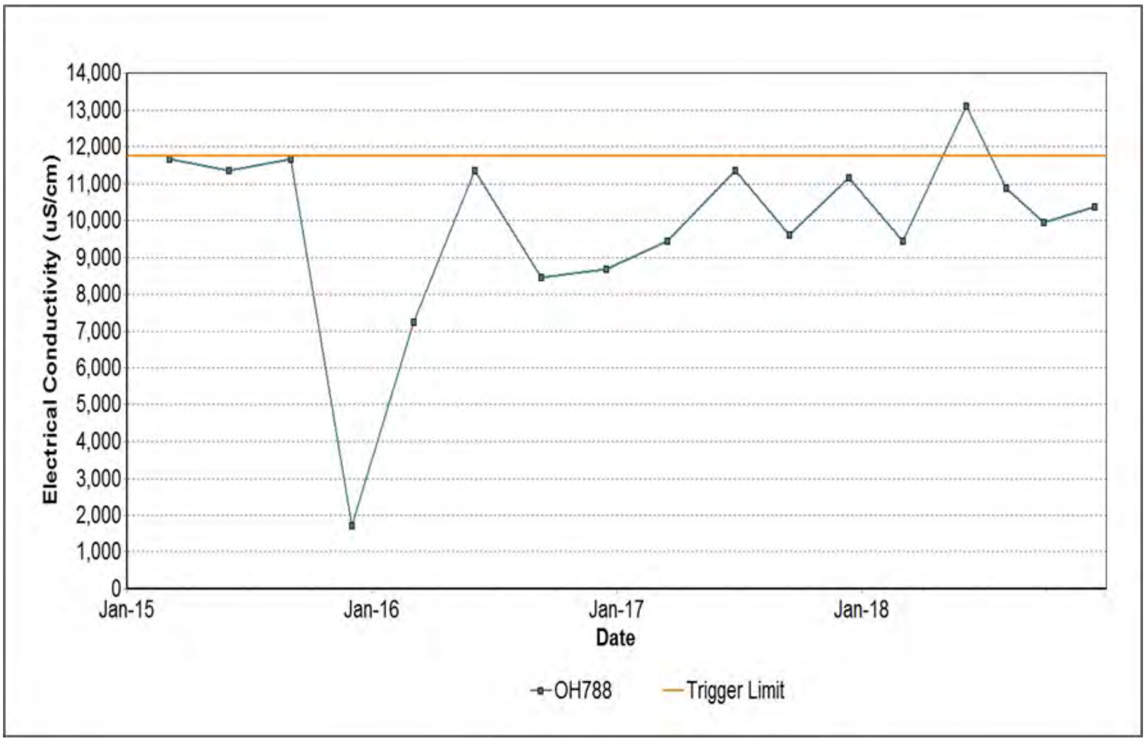


FIGURE 54: HUNTER RIVER ALLUVIUM BORE OH788 EC TREND 2015 TO 2018

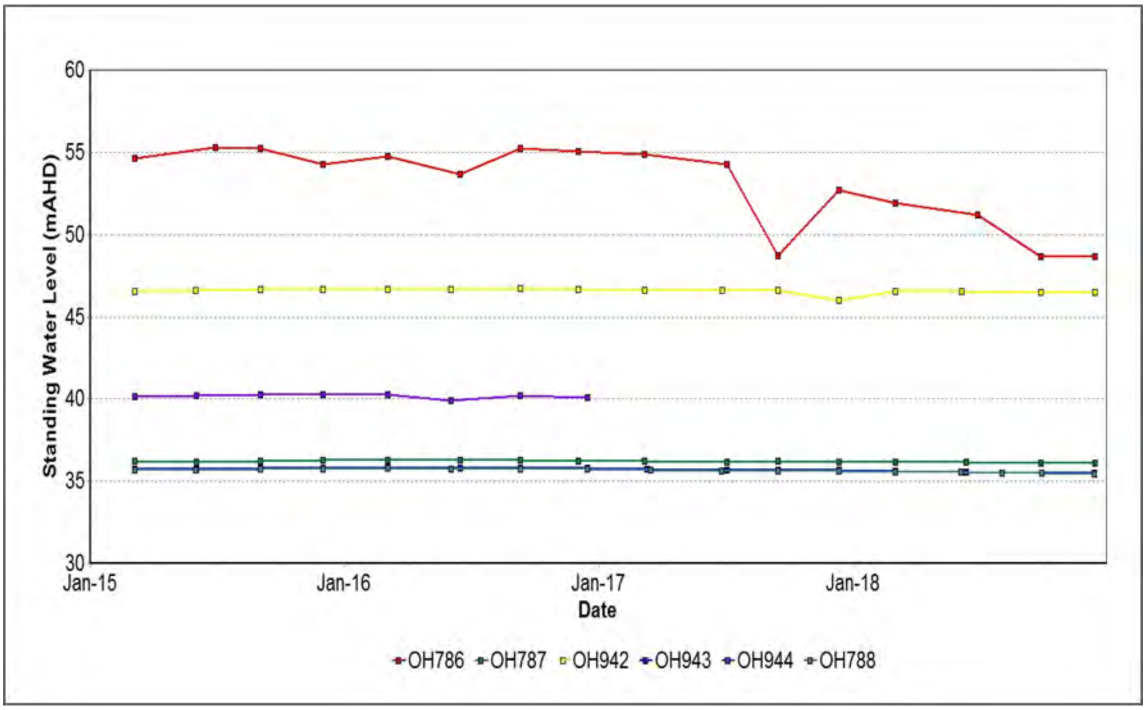


FIGURE 55: HUNTER RIVER ALLUVIUM GROUNDWATER SWL TRENDS 2015 TO 2018

6.7.6.5 Redbank Bores

Groundwater monitoring in the Redbank seam was undertaken from four sites during 2018. A total of 16 samples were collected during the reporting period. The pH, EC and SWL trends for 2015 to 2018 for Redbank seam groundwater bores are shown in **Figure 56**, **Figure 57** and **Figure 58** respectively.

A steady declining trend in water levels at all monitoring sites continued during the reporting period. This is expected given the close proximity of the bore to MTW's operations at Warkworth which are progressing West. The depressurisation of the groundwater in this area is a predicted outcome in the EIS as mining progresses.

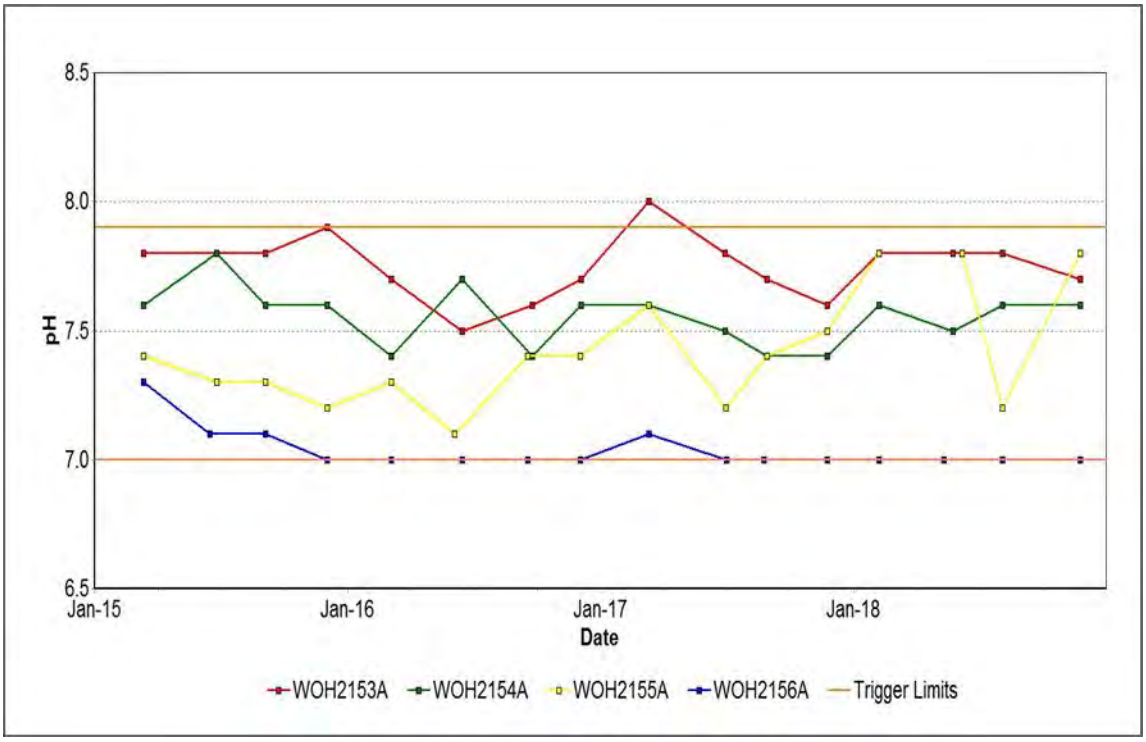


FIGURE 56: REDBANK SEAM GROUNDWATER PH TRENDS 2015 TO 2018

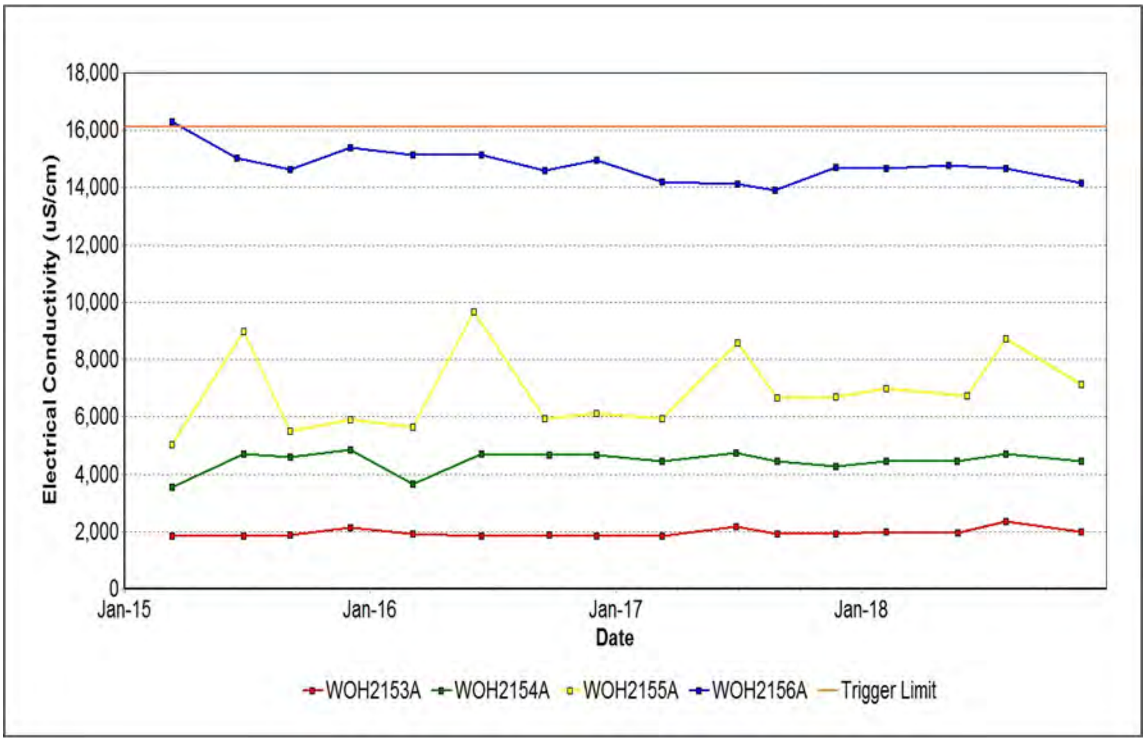


FIGURE 57: REDBANK SEAM GROUNDWATER EC TRENDS 2015 TO 2018

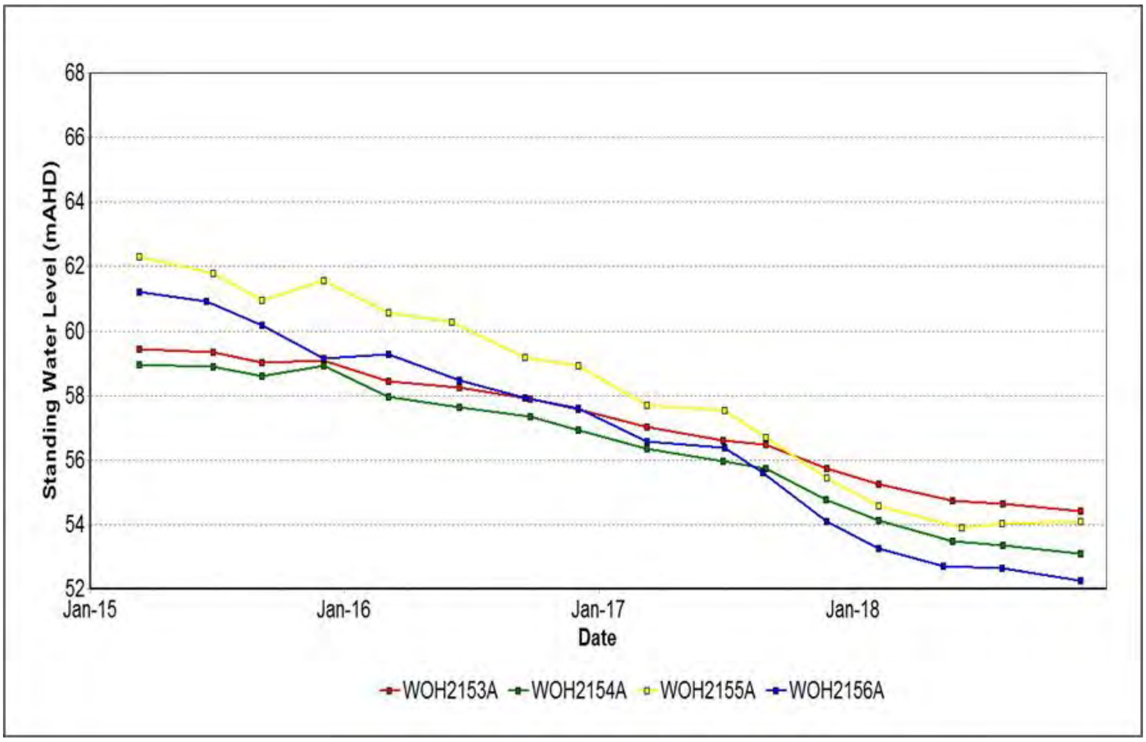


FIGURE 58: REDBANK SEAM GROUNDWATER SWL TRENDS 2015 TO 2018

6.7.6.6 Shallow Overburden Bores

Groundwater monitoring in the Shallow Overburden bores was undertaken from ten sites during 2018. A total of 39 samples were collected during the reporting period. The pH, EC and SWL trends for 2015 to 2018 for Shallow Overburden groundwater bores are shown in **Figure 59**, **Figure 60** and **Figure 61** respectively. Water levels and water quality were steady in all bores during the reporting period. Note: Sampling at MB15MTW01D, MB15MTW02D, MB15MTW03 and MBW02 began in late 2017. Due to insufficient data for meaningful trending analysis, the data has not been included in the 2015 to 2018 Figures below. The data from these sites will be shown in 2019 report groundwater Figures.

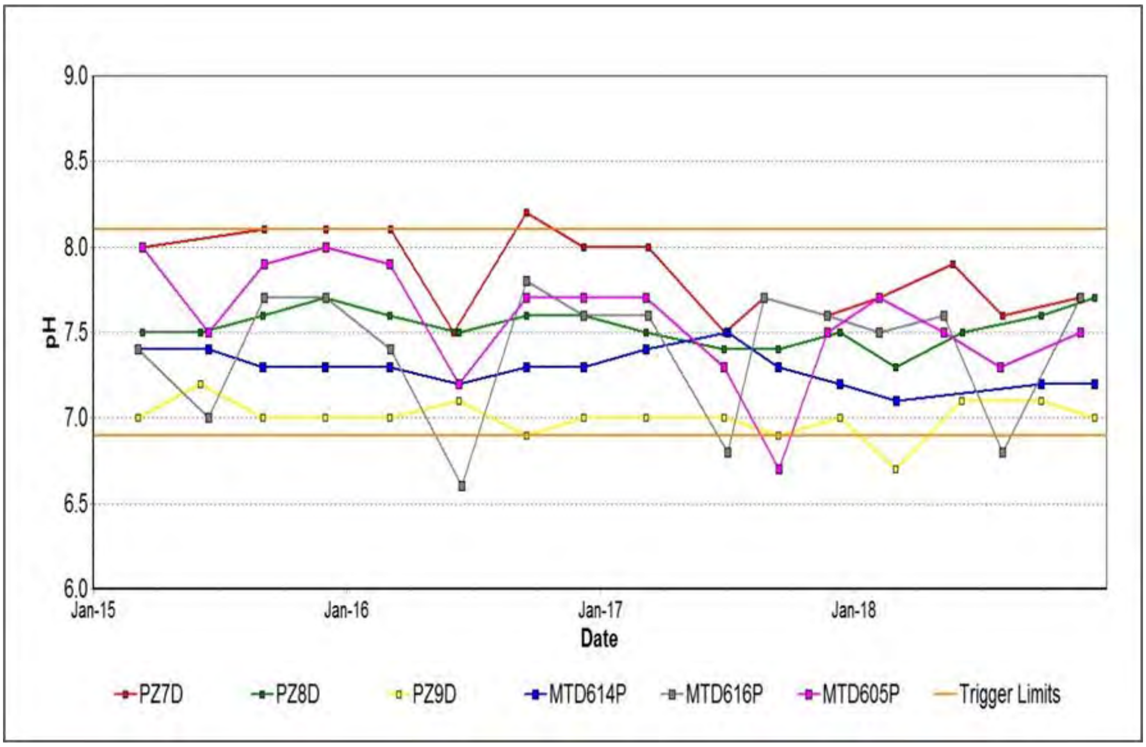


FIGURE 59: SHALLOW OVERBURDEN SEAM GROUNDWATER PH TRENDS 2015 TO 2018

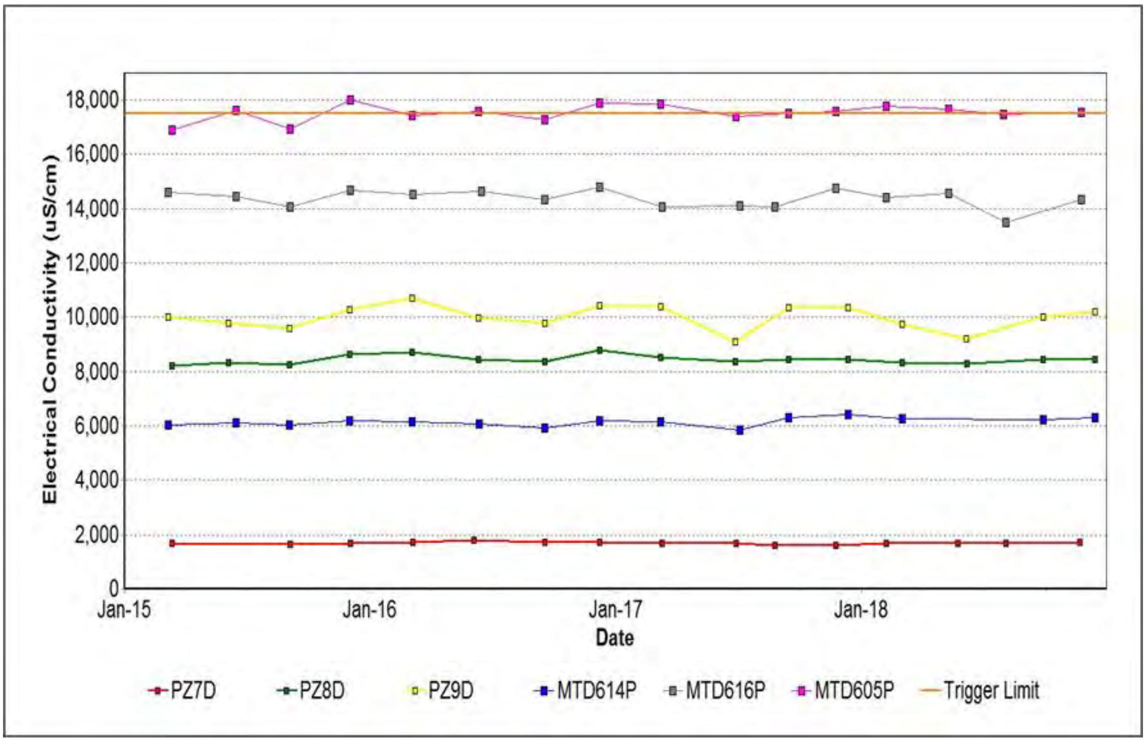


FIGURE 60: SHALLOW OVERBURDEN SEAM GROUNDWATER EC TRENDS 2015 TO 2018

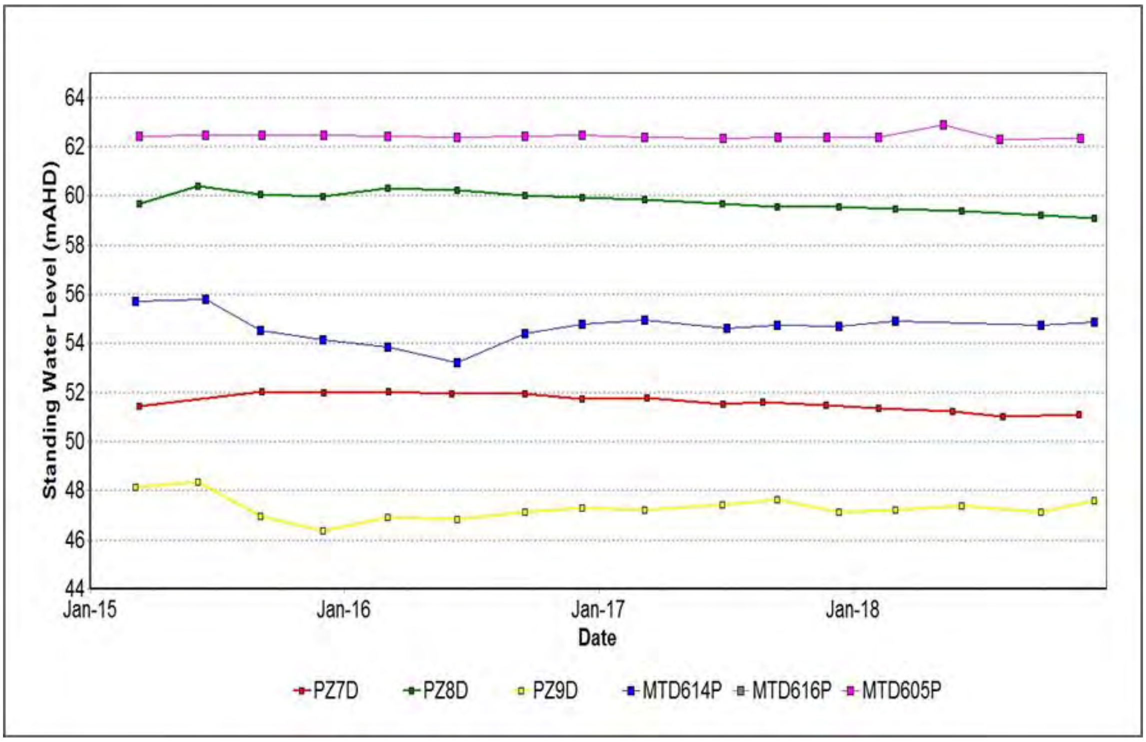


FIGURE 61: SHALLOW OVERBURDEN SEAM GROUNDWATER SWL TRENDS 2015 TO 2018

6.7.6.7 Vaux Seam Bores

Groundwater monitoring in the Vaux Seam was undertaken from three sites during 2018; a total of 12 samples were collected. The pH, EC and SWL trends for 2015 to 2018 for Vaux groundwater bores are shown in **Figure 62**, **Figure 63** and **Figure 64** respectively; results are consistent with historical trends.

TABLE 6.20 VAUX SEAM GROUNDWATER 2018 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
OH1137	Dec	**pH – 95th percentile**	Watching brief *
OH1121	Dec	**pH – 95th percentile**	Watching brief *

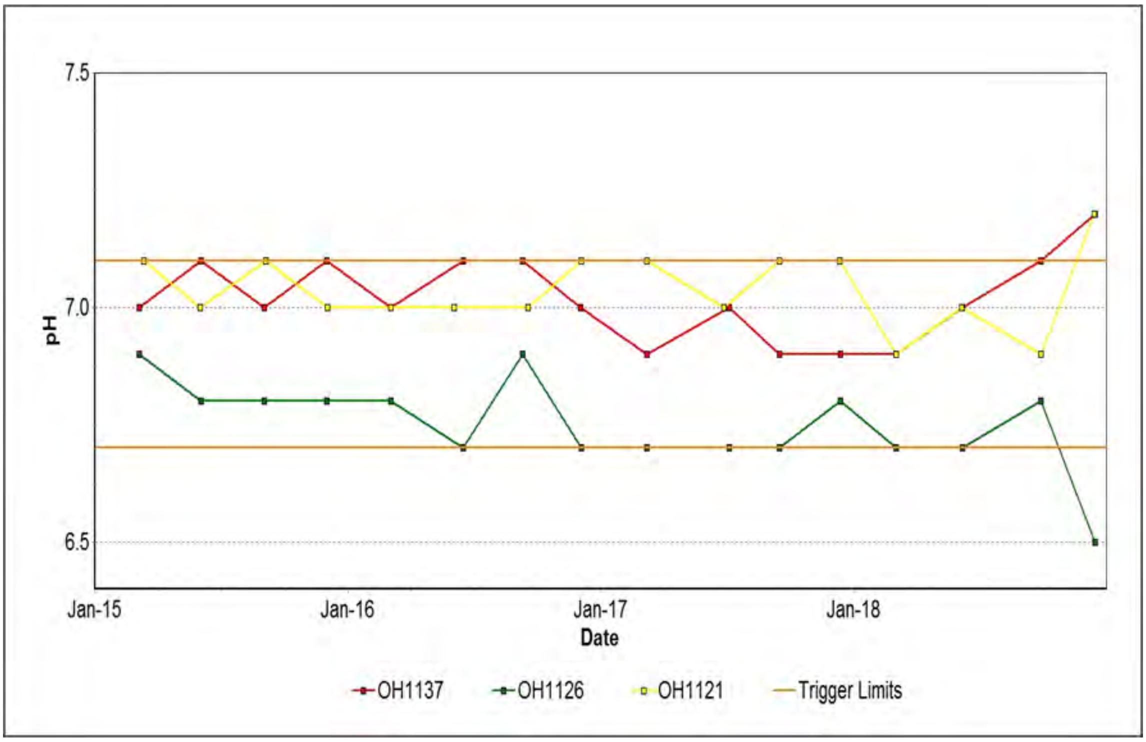


FIGURE 62: VAUX SEAM GROUNDWATER PH TRENDS 2015 TO 2018

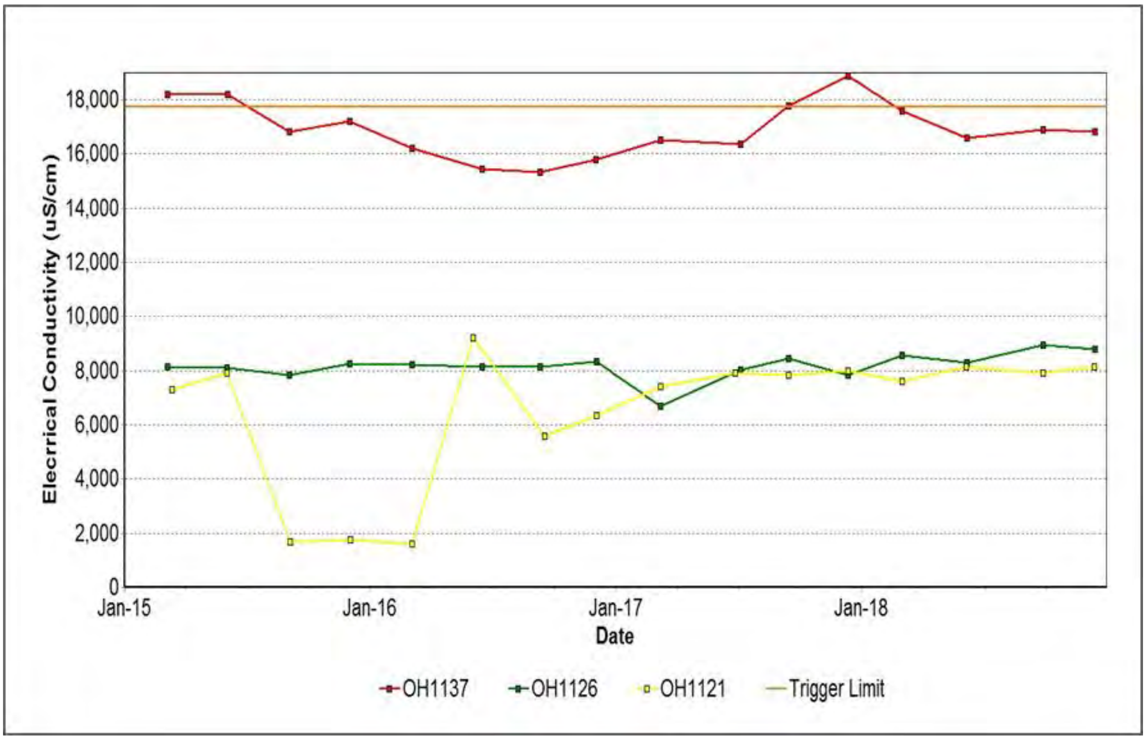


FIGURE 63: VAUX SEAM GROUNDWATER EC TRENDS 2015 TO 2018

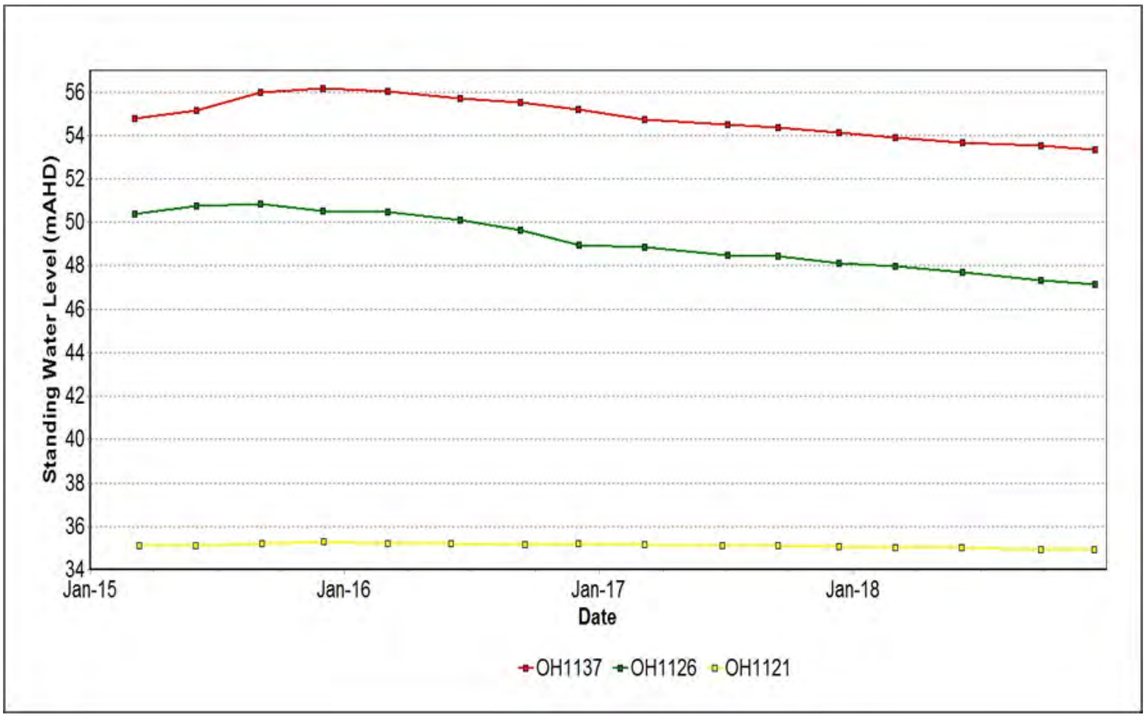


FIGURE 64: VAUX SEAM GROUNDWATER SWL TRENDS 2015 TO 2018

6.7.6.8 Wambo Seam Bores

Groundwater monitoring in the Wambo Seam was undertaken from six sites during 2018. A total of 22 samples were collected during the reporting period. The pH, EC and SWL trends for 2015 to 2018 for Wambo groundwater bores are shown in **Figure 65, Figure 66** and **Figure 67** respectively. Trends in all bores, except for WD662P (refer to Table 34), were generally stable and consistent with historical data.

TABLE 6.21 MTW WAMBO SEAM GROUNDWATER 2018 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
WD622P	Aug Nov	**pH – 5th percentile** **pH – 95th percentile**	Fluctuating pH is considered to be partly a result of coal seam depressurisation, as evidenced by historical trending of falling water level. This trend is consistent with the effects of nearby mining. Fluctuations also coincide with changes to the sampling methodology, from quarterly grab sampling to low flow pumping/purging prior to annual comprehensive sampling and analysis. Watching Brief.
WD622P	Aug	**EC – 95th percentile**	Fluctuation in EC coincides with changes to the sampling methodology, from quarterly grab sampling to low flow pumping/purging prior to annual comprehensive sampling and analysis. Watching Brief.

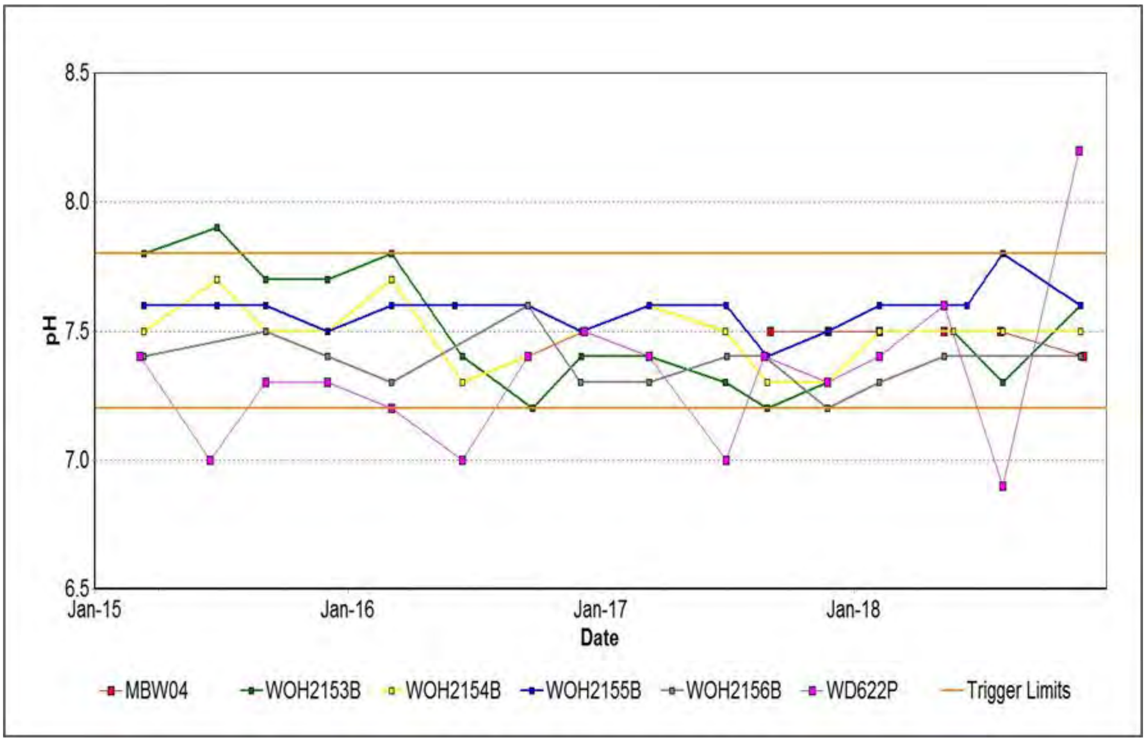


FIGURE 65: WAMBO SEAM GROUNDWATER pH TRENDS 2015 TO 2018

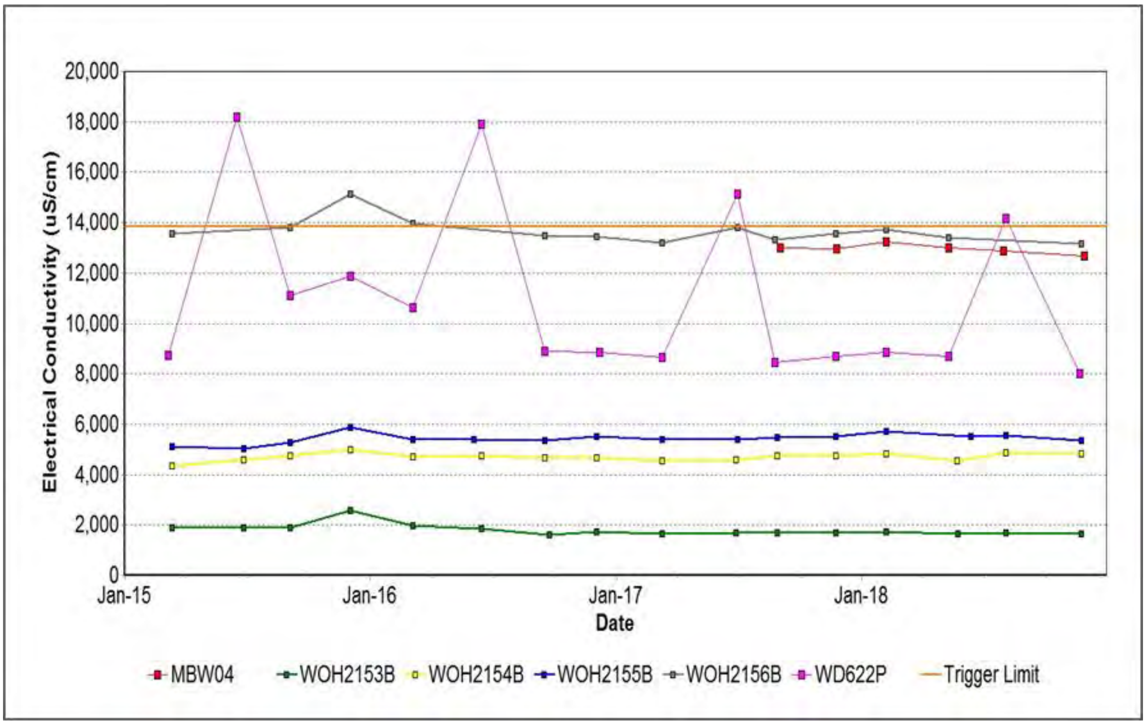


FIGURE 66: WAMBO SEAM GROUNDWATER EC TRENDS 2015 TO 2018

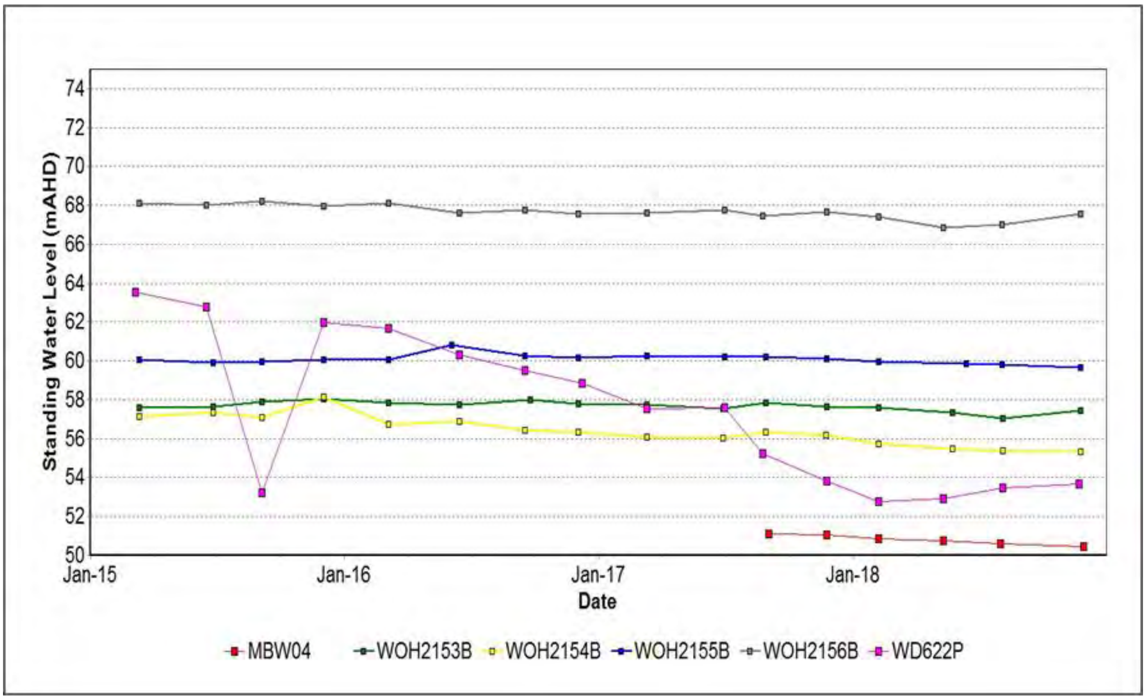


FIGURE 67: WAMBO SEAM GROUNDWATER SWL TRENDS 2015 TO 2018

6.7.6.9 Warkworth Seam Bores

Groundwater monitoring in the Warkworth Seam was undertaken from two sites during 2018; 15 samples were collected. The pH, EC and SWL trends for 2015 to 2018 for Warkworth seam bores are shown in **Figure 68**, **Figure 69** and **Figure 70** respectively. During the reporting period OH1138(1) exceeded trigger limits for declining pH and increasing EC. As outlined in **Appendix 6** it is expected that these results were most likely attributable to ongoing dry conditions, the water quality sampling methodology and potential influences from the licenced abstraction of water from the Lemington Underground Bore.

TABLE 6.22 WARKWORTH SEAM GROUNDWATER 2018 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
OH1138(1)	06/02/2018	**pH – 5th percentile**	Investigation commenced
	06/06/2018		pH beginning to recover to historic levels. Continue to monitor on increased frequency
	13/07/2018		Watching brief *
	22/08/2018		Watching brief *
	26/10/2018		Continue to monitor on increased frequency
	21/11/2018		Continue to monitor on increased frequency
	11/12/2018		pH beginning to recover to historic levels. Continue to monitor on increased frequency.
OH1138(1)	02/03/2018	**EC – 95th percentile**	Watching brief *
	21/11/2018		Watching brief *
	11/12/2018		Watching brief *

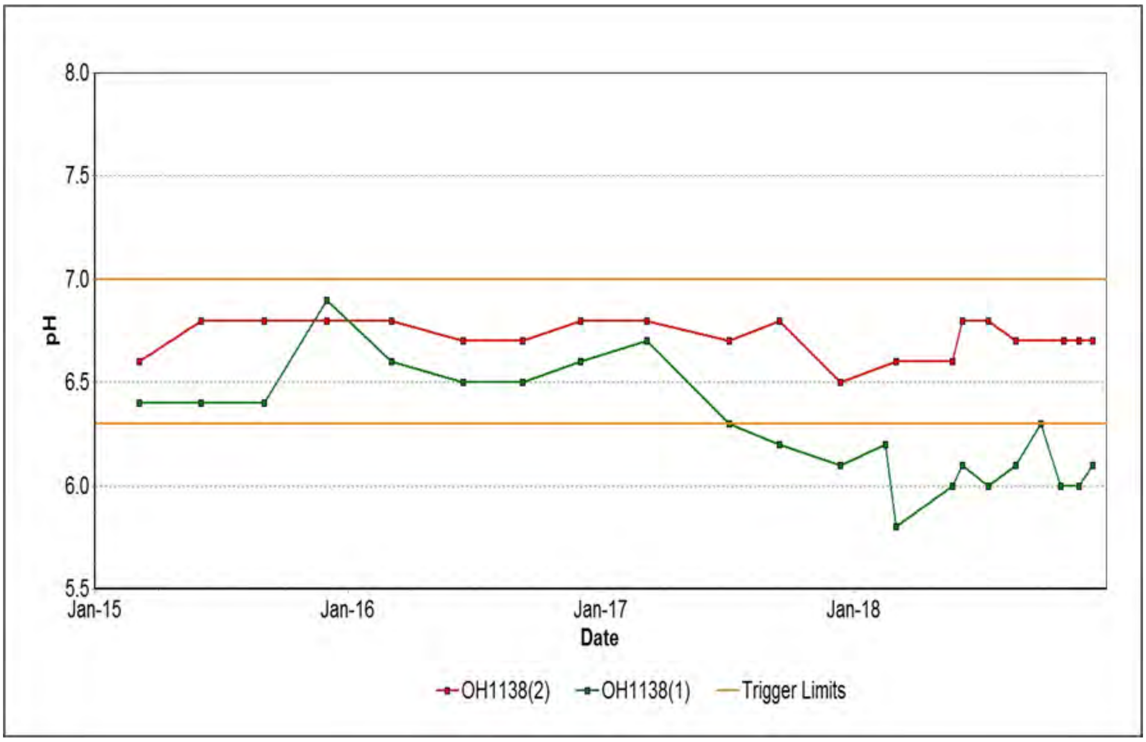


Figure 68: Warkworth Seam Groundwater pH Trends 2015 to 2018

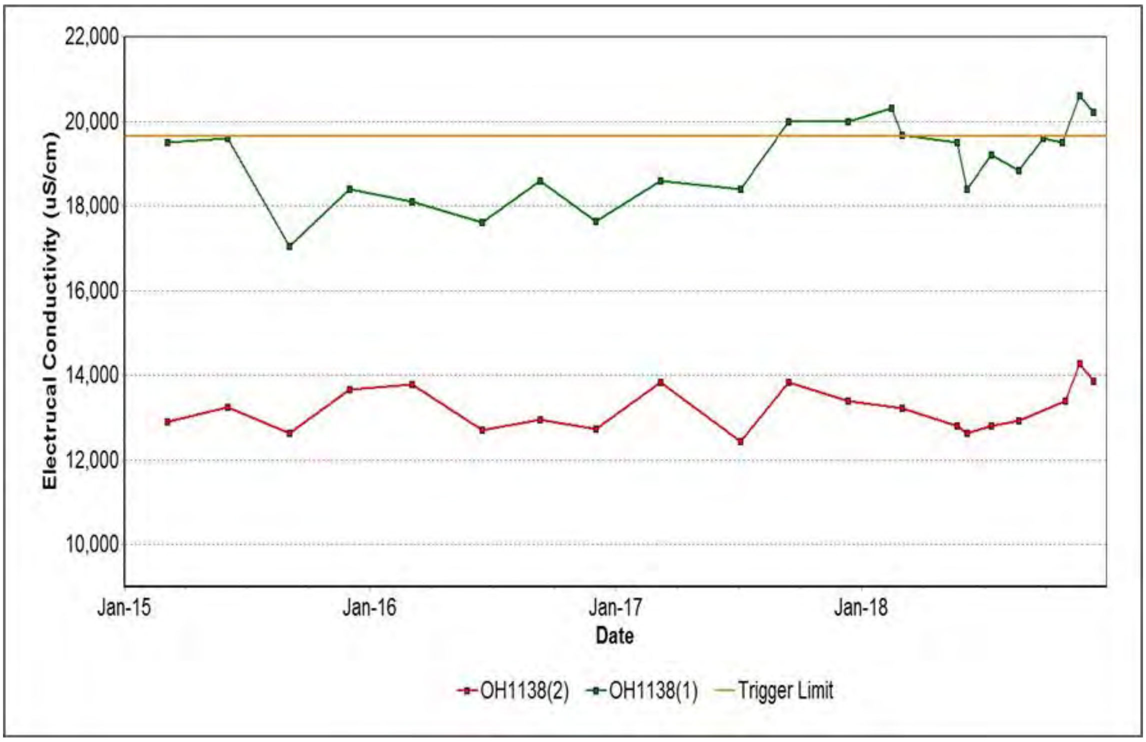


Figure 69: Warkworth Seam Groundwater EC Trends 2015 to 2018

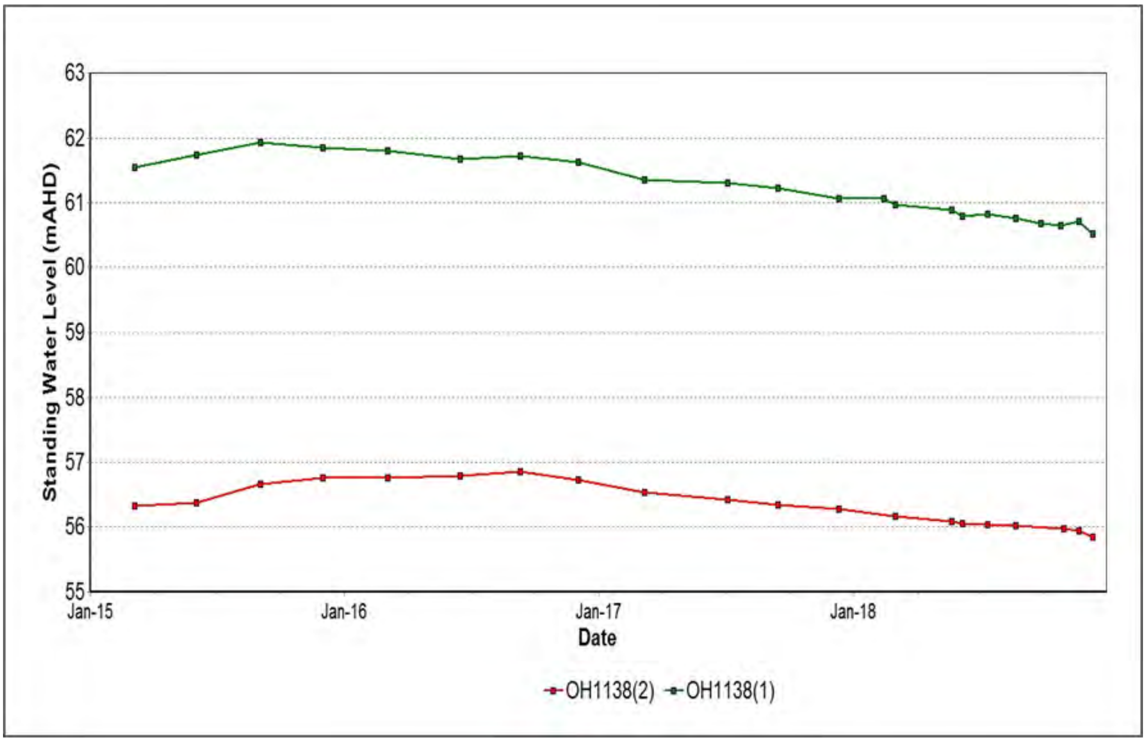


FIGURE 70: WARKWORTH SEAM GROUNDWATER SWL TRENDS 2015 TO 2018

6.7.6.10 Wollombi Brook Alluvium Seam Bores

Groundwater monitoring in the Wollombi Brook Alluvium was undertaken from two sites during 2018; eight samples were collected. The pH, EC and SWL trends for 2015 to 2018 are shown in **Figure 71** to **Figure 75** respectively. **Table 6.23** shows the Trigger Point summary.

TABLE 6.23 WOLLOMBI BROOK ALLUVIUM SEAM GROUNDWATER 2018 INTERNAL TRIGGER TRACKING

Location	Date	Trigger limit	Action taken in response
PZ9S	06/06/2018	**pH – 95th percentile**	Watching brief *
	27/09/2018		Watching brief *

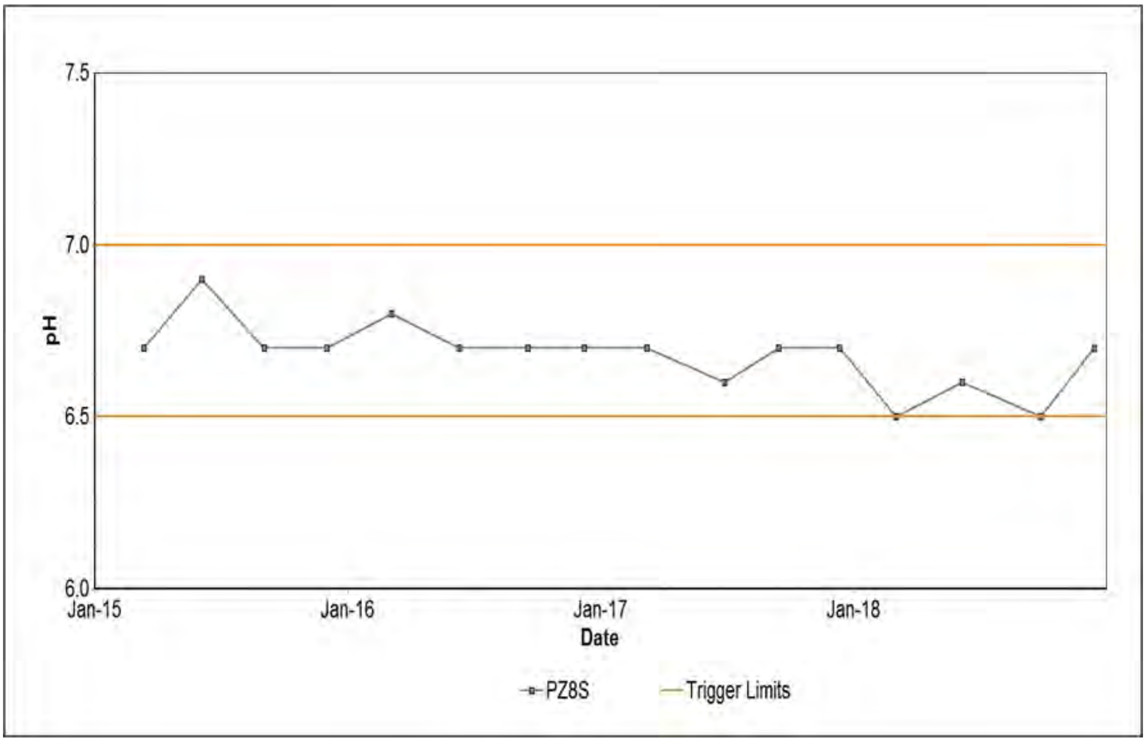


FIGURE 71: WOLLOMBI BROOK ALLUVIUM 1 SEAM GROUNDWATER PH TRENDS 2015 TO 2018

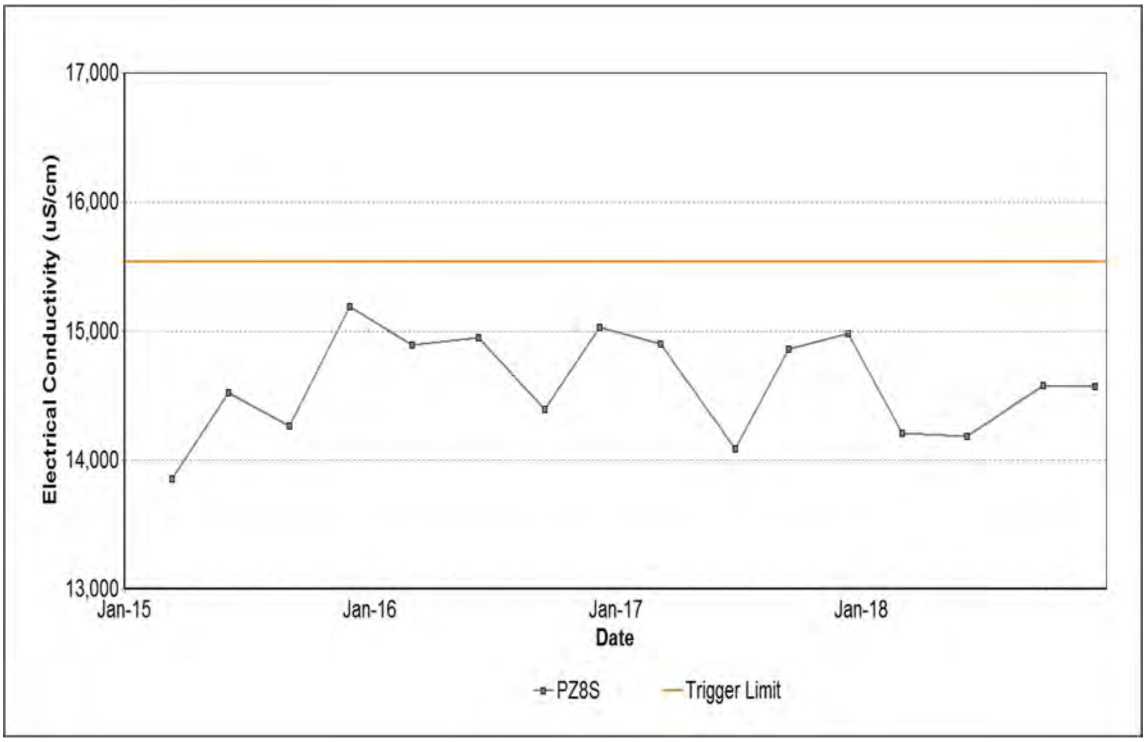


FIGURE 72: WOLLOMBI BROOK ALLUVIUM 1 SEAM GROUNDWATER EC TRENDS 2015 TO 2018

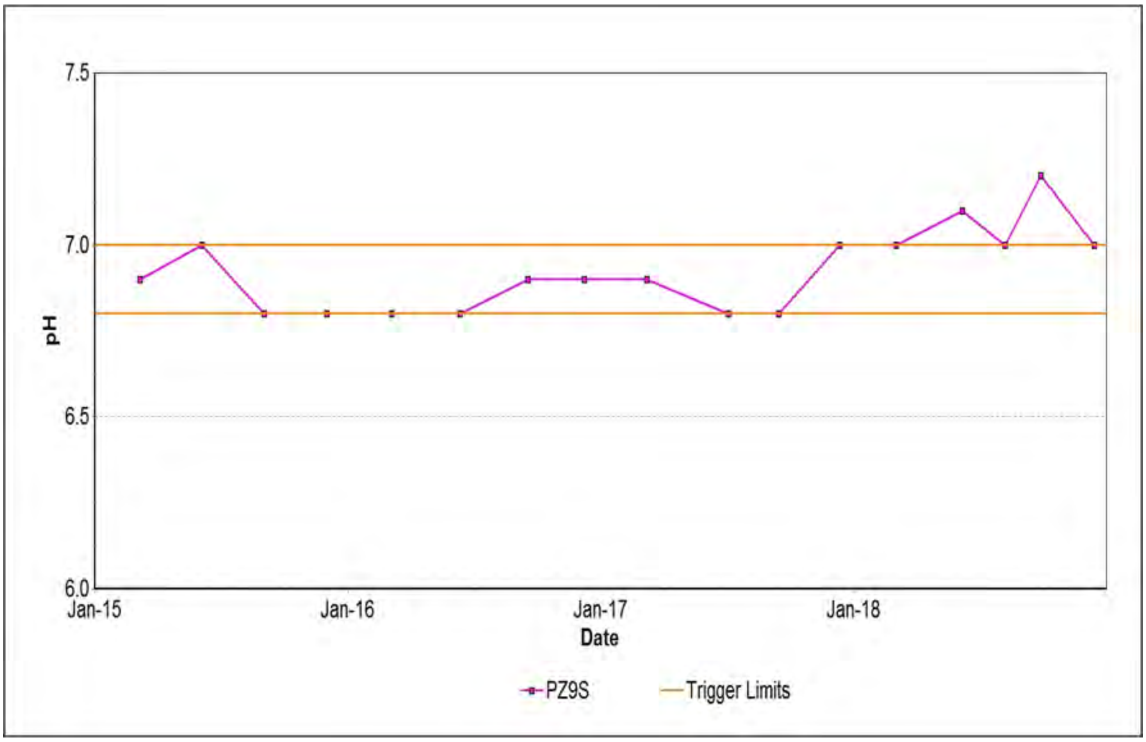


FIGURE 73: WOLLOMBI BROOK ALLUVIUM 2 SEAM GROUNDWATER PH TRENDS 2015 TO 2018

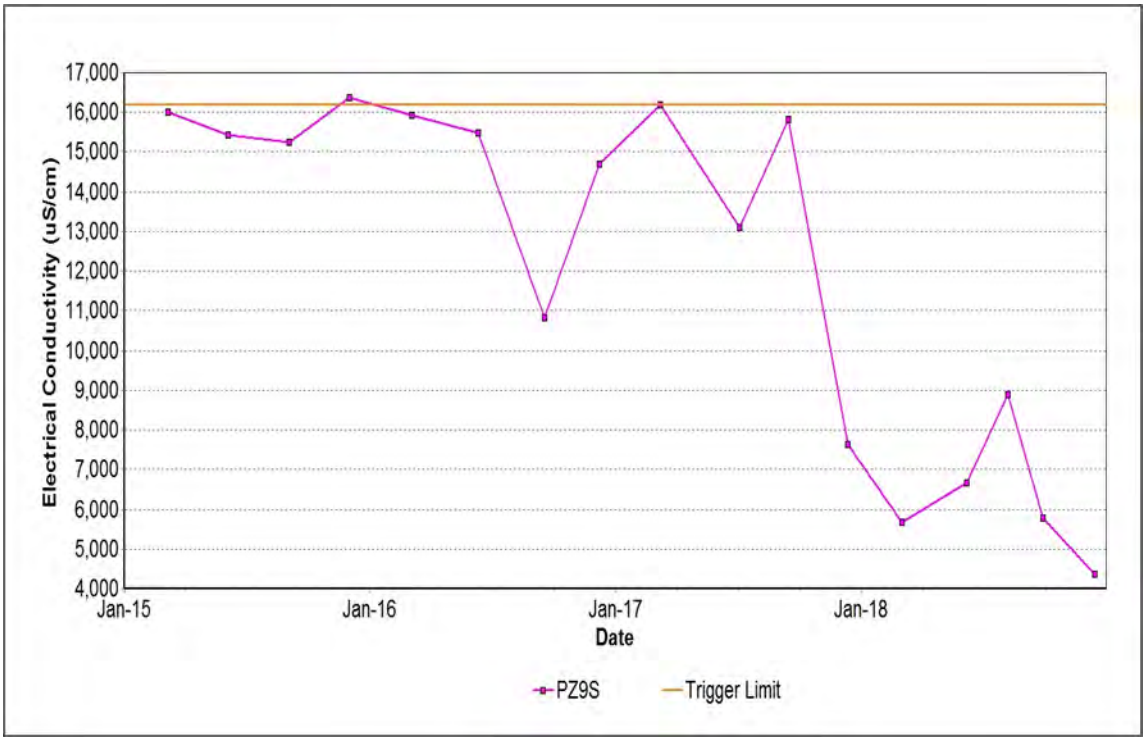


FIGURE 74: WOLLOMBI BROOK ALLUVIUM GROUNDWATER EC TRENDS 2015 TO 2018

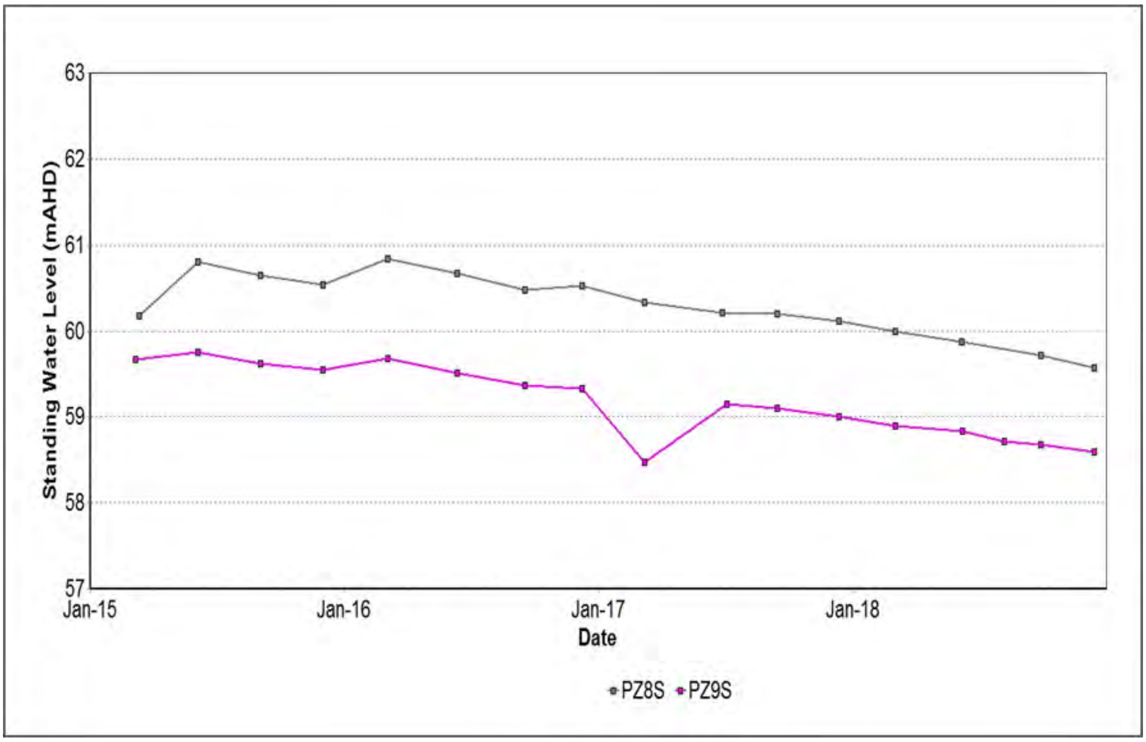


FIGURE 75: WOLLOMBI BROOK ALLUVIUM SEAM GROUNDWATER SWL TRENDS 2015 TO 2018

6.7.6.11 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 2015 to 2018 are shown in **Figure 76**, **Figure 77** and **Figure 78** respectively. Monitoring results were consistent with historical data.

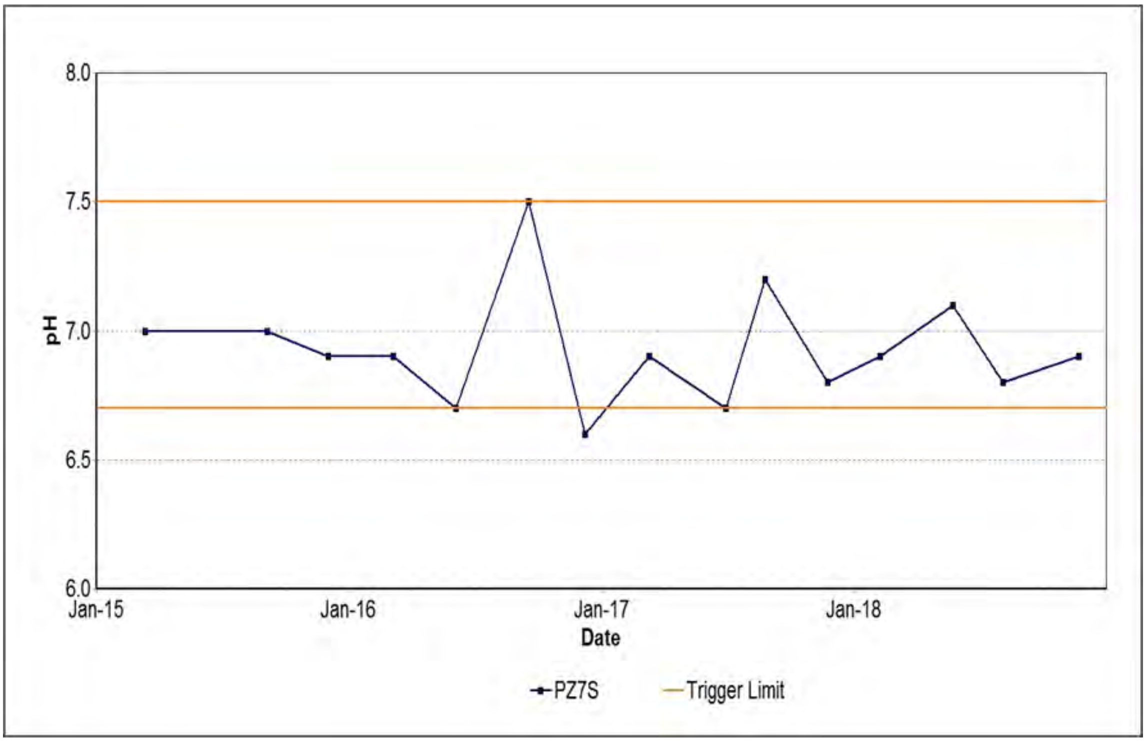


FIGURE 76: AEOLIAN WARKWORTH SANDS GROUNDWATER pH TRENDS 2015 TO 2018

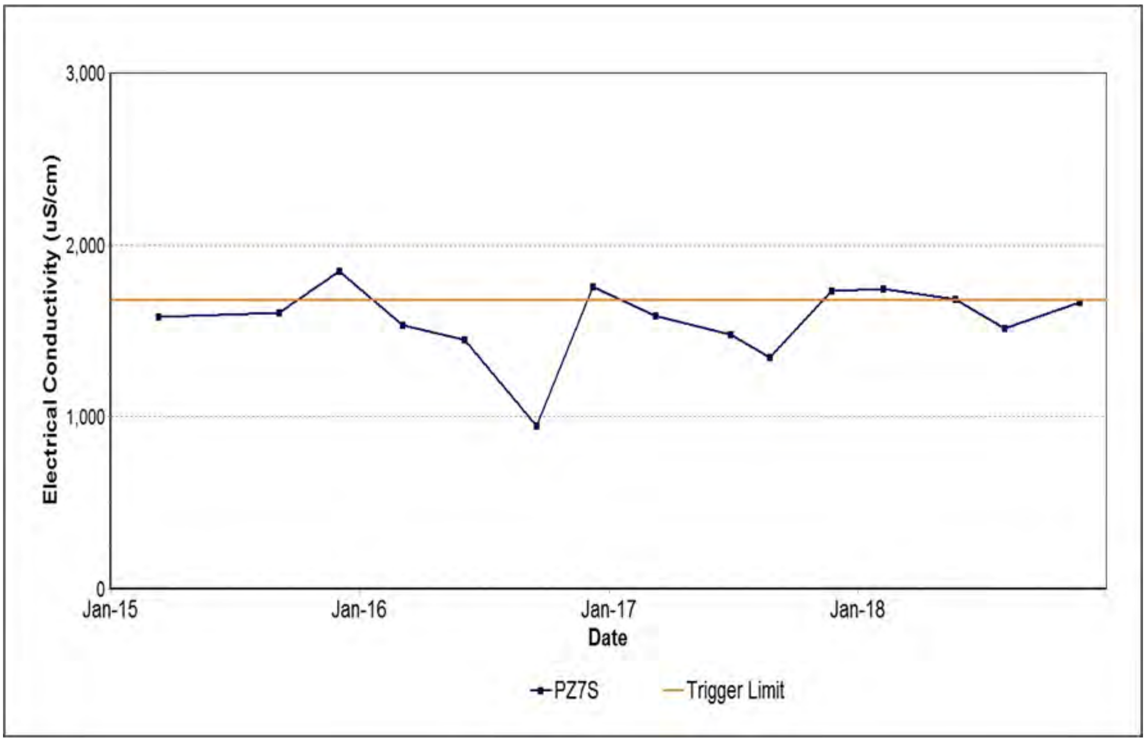


FIGURE 77: AEOLIAN WARKWORTH SANDS GROUNDWATER EC TRENDS 2015 TO 2018

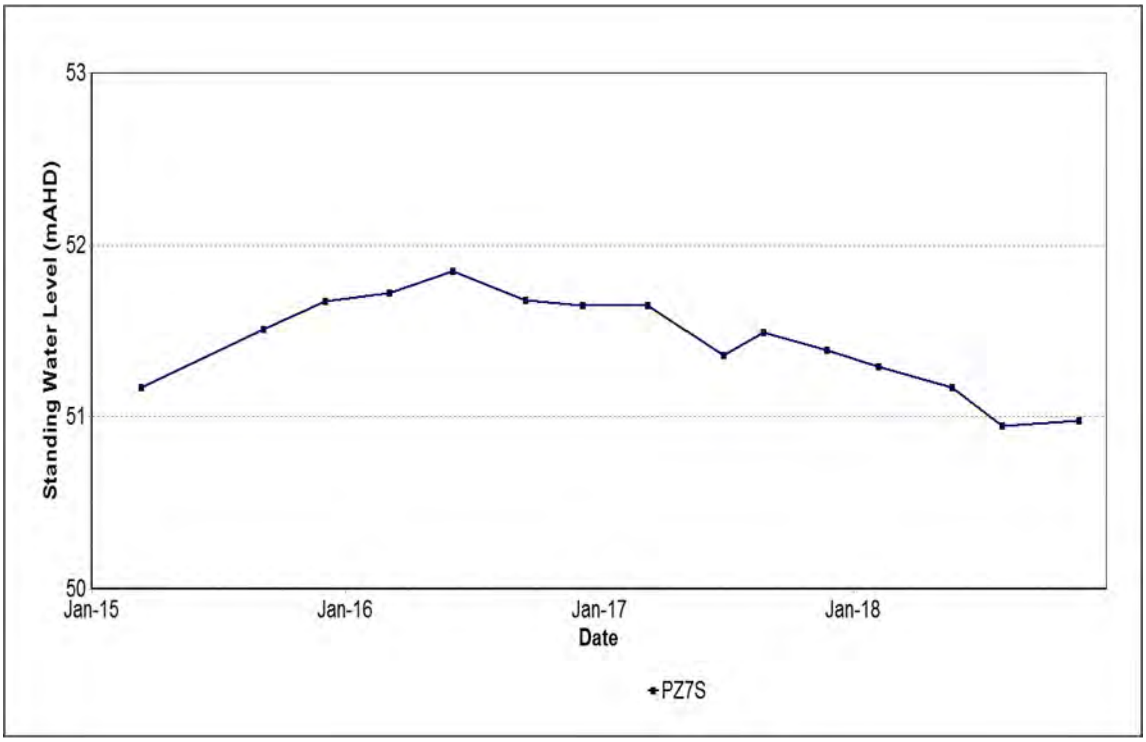


FIGURE 78: AEOLIAN WARKWORTH SANDS GROUNDWATER SWL TRENDS 2015 TO 2018

6.7.7 Audits and Reviews

Groundwater monitoring results are reviewed against the approved trigger limits within MTW's approved Water Management Plan on a quarterly basis by MTW. A comparison of the water quality information across MTW's monitoring bore network is provided graphically in **Figures 34** to **78.** The approved trigger limits are based on the historical water quality data as shown in the relevant site Environmental Impact Assessments. These trigger limits are updated annually based on collected site data as described in the MTW Water Management Plan. A summary of the management actions taken in response to any exceedances of the trigger limits during the period is provided in **Tables 6.17** to **6.23.**

An annual groundwater review was undertaken by an independent groundwater consultant. The scope of the review included an assessment of the water quality and groundwater levels recorded during the 2018 reporting period as well as a review of the historical results against the predictions in the site groundwater model. A copy of the report is included in **Appendix 6.**

Key findings from the independent groundwater consultant's report were:

- Groundwater monitoring data indicates that, where saturated, water within the alluvium declined slightly, generally in line with climate and stream flow trends. Groundwater within the Permian coal measures remained relatively stable to slightly declining over 2018. Where observed, the decreasing elevations are believed to be attributed to depressurisation of the coal seams in relation to mining activities as well as below average rainfall. The groundwater drawdown appears to be generally in line with the predicted drawdown with the coal measures around active mine areas.

- The review of the sites groundwater model predictions against the historical site data generally showed that the model appeared to adequately replicate observed changes in groundwater levels during the 2018 reporting period. The review did however highlight some areas for improvement to further validate the current groundwater model, these items are included in the groundwater report in **Appendix 6**.
- Review of water quality results and comparison to trigger levels for EC and pH identified several trigger exceedances over 2018. It was identified that several bores exceeded trigger limits for EC and pH. However, 2018 readings were generally in line with historical trends for these bores. The trigger limits established for each of the monitoring bores is detailed within MTW's approved Water Management Plan. Groundwater quality trends outside of historical trends were observed for bore OH1138, which likely relates to declining groundwater levels. The decline in levels may relate to the licenced abstraction of groundwater from the Lemington Underground bore at Hunter Valley Operations to the north.
- Over 2018 monitoring of the groundwater bore network was generally conducted in accordance with the Groundwater Monitoring Program outlined within the WMP. Annual samples were collected in general accordance with relevant standards except for cases where the condition of the bores (i.e. 32 mm casing) inhibited the ability to collect representative samples.

Key recommendations from the independent groundwater consultant's report include:

- A 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 of groundwater quality triggers to ensure they are reasonable and adequately capture historical trends for bores; and
- Incorporate findings from the groundwater model verification and additional site fieldwork into the next review of the MTW groundwater model.

MTW has modified the ground water quality sampling methodology for the 2019 reporting period as a direct result of the findings/recommendations outlined in the annual groundwater review. MTW now utilises a purging technique for the water quality sampling rather than grab samples each quarter. Results from the changed sampling methodology will be provided in the 2019 Annual Review.

In addition, MTW proposes to undertaking a review of the trigger limits associated with MTW's groundwater monitoring bore network to better reflect individual bore trends.

7 REHABILITATION

7.1 Summary of Rehabilitation

A total of 102 ha of rehabilitation was undertaken during 2018 against a MOP target of 112.6 ha.

Total disturbance undertaken during 2018 was 171.8 ha, which was slightly lower than the MOP projection of 177.2 ha. The disturbance during 2018 was made up of 152.1 ha of new disturbance and 19.7 ha of disturbance of previously rehabilitated area.

TABLE 7.1 KEY REHABILITATION PERFORMANCE INDICATORS

Mine Area Type	Previous Reporting Period (Actual) Year 2017 (ha)	This Reporting Period (Actual) Year 2018 (ha)	Next Reporting Period (Forecast) Year 2019 (ha)
A. Total mine footprint[1]	3,659.7	3,879.6	3,909.1
B. Total Active Disturbance[2]	2,468	2,546.5	2,496.2
C. Land being prepared for rehabilitation[3]	35.7	97.4	97.2
D. Land under active rehabilitation[4]	1,156	1,235.69	1,315.7
E. Completed rehabilitation[5]	0	0	0

[1] ***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.*

[2] ***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).*

[3] ***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).*

[4] ***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 establishment" and "ecosystem and land use sustainability" (revegetation assessed as showing signs of trending towards relinquishment OR infrastructure development).*

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

7.1.1 Management of Rehabilitation

Performance criteria for each rehabilitation phase is provided in detail in the MOP for MTW. The criteria has 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 the MOP Amendment A approved by Resources Regulator in December 2018. The results of the rehabilitation monitoring programme for native vegetation areas are 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 have been presented in previous MTW Annual Environmental Reviews (AER’s). Monitoring has been 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. Previous monitoring programs have established 26 permanent monitoring transects across MTW rehabilitation areas with the majority of these sites having been revisited in successive years to provide information on the progression of sites over time.

The rehabilitation monitoring that was to be conducted in the 2018/19 summer period has been delayed to Autumn 2019, therefore, no additional rehabilitation monitoring results are available to present in this 2018 AER. The move to Autumn monitoring is to coincide with the flowering time for the bulk of the native grasses to make it easier to identify the native understorey species and therefore provide a more accurate and transparent assessment of the rehabilitation program. The planned 2019 monitoring program will establish 24 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 have been selected to include rehabilitation of varying ages and different rehabilitation methods.

The key issues affecting successful rehabilitation at MTW and the control measures implemented to address these issues are listed below:

Issue 1 – Weed competition affecting native vegetation establishment.

Control Measures.

Use of mine spoil as growth medium to avoid use of weedy topsoils in rehabilitation. This technique has proven successful in establishing diverse native vegetation when combined with the use of composts and other ameliorants to improve the physical, chemical and nutritional quality of the mine spoil. The recent revocation of the ability to use Mixed Waste Organic Material (Mixed Waste Compost) has delayed further use of this technique however suitable alternative compost products will be trialled in 2019.

Weed control on topsoil stockpiles.

Topsoil stockpiles established prior to 2011 were seeded with exotic pasture species to provide a suitable cover for erosion protection. These competitive exotic species are causing weed problems in rehabilitation areas when the soil from these stockpiles is used on areas being returned to native vegetation. MTW has a topsoil stockpile maintenance program in place to spray out the exotic pasture species and sow native species on these old stockpiles. Stockpiles may require a number of weed control passes to adequately reduce weed levels before sowing to native species. New topsoil stockpiles are being treated in much the same way as new rehabilitation areas, in terms of weed control and soil amelioration, before being sown to native species. Establishment of native species on topsoil stockpiles will reduce the presence of weeds and provide a soil seed bank in rehabilitation areas that contains seeds from desirable native species.

Pre- and post-sowing weed control in rehabilitation.

MTW has implemented an extensive weed control program in rehabilitation areas to reduce the amount of weeds and assist the establishment of native vegetation. This program involves the use of boom sprays for both pre-sowing and pre-emergent spray passes to control weeds volunteering from the topsoil. After the native species have germinated, a weed-wiper can be used to control weeds that are taller than the native species. Herbicide can be wiped onto the taller weeds without affecting the emerging native species. Crews using backpack sprays and Quikspray units are also used to selectively control weeds that are growing amongst desirable native species.

Issue 2 – Topsoil/spoils prone to dispersion leading to surface crusting, erosion and poor vegetation establishment.

Control Measures.

Addition of ameliorants to topsoil/spoil. MTW conducts soil testing on the topsoil/spoil material that is used in rehabilitation areas. Based on the results of the soil testing, ameliorants such as compost, gypsum, lime and fertilisers are then used to address the physical, chemical and nutritional deficiencies of the topsoil/spoil. Subsequent applications of ameliorants are undertaken as required to address poor performing rehabilitation areas with continuing soil quality issues.

Issue 3 – Lack of native seed in topsoil seed bank leading to poor vegetation establishment.

Control Measures.

Sourcing of diverse native seed mixes. MTW has generally found that the soil seed bank in topsoils from both stripping areas and topsoil stockpiles cannot be relied on to contain sufficient native seed propagules for successful native vegetation establishment in rehabilitation. MTW has established medium term contracts with seed suppliers to provide some security of supply to suppliers who are then able to collect and store sufficient quantities of seed to meet MTW's future demands. The seed supply contracts include quality assurance controls to ensure the seed being purchased is of suitable quality i.e. satisfactory provenance, correct species, high seed count and viability.

7.2 Decommissioning

Capping of the Interim Tailings Storage Facility continued during 2018 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. Capping work has not been able to recommence during 2018 as geotechnical studies undertaken by Australian Tailings Consultants have determined that the tailings strength has not increased sufficiently to support the capping process. The main focus of activity during 2018 has been on pumping activities to keep the surface of the tailings storage facility dry. The aim of this work is to increase the strength of the top layer of the tailings to allow capping work to recommence.

7.3 Rehabilitation Performance

Table 7.2 summarises actual rehabilitation and disturbance completed compared with the rehabilitation commitments in the MTW MOP. **Appendix 1** 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 was 10.5ha below the MOP target for MTW. The area of rehabilitation disturbance however was less than the MOP target for MTW by 4.8ha, leading to a net rehabilitation result for 2018 that was 5.7ha behind the MOP commitment. The net rehabilitation result over the MOP period (2015 to 2018) is 301.1ha versus a MOP commitment of 306.7ha, lagging by 5.6ha.

The amount of new disturbance undertaken in 2018 was 0.5ha lower than the MOP projections. The cumulative new disturbance over the period of the current MOP is also 0.5ha lower than the projected disturbance.

The 2018 rehabilitation areas for MTW are shown in **Appendix 2.**

TABLE 7.2 REHABILITATION AND DISTURBANCE COMPLETED IN 2018

MOP	Pit Area	2018 Totals (ha)		Cumulative Totals During MOP Period* (ha)	
		Actual	MOP Commitment	Actual	MOP Commitment
Rehabilitation					
MTW	Mt Thorley	24.3	23.9	115.9	115.5
	Warkworth	77.8	88.7	270.8	281.7
	MTW Total	**102.1**	**112.6**	**386.7**	**397.2**
Rehabilitation Disturbance					
MTW	Mt Thorley	19.1	17.3	38.1	36.3
	Warkworth	0.7	7.3	47.5	54.2
	MTW Total	**19.8**	**24.6**	**85.6**	**90.5**
New Disturbance					
MTW	Mt Thorley	14.4	31.0	21.0	54.2
	Warkworth	137.7	121.6	293.2	260.5
	MTW Total	**152.1**	**152.6**	**314.2**	**314.7**
Net Rehabilitation (Rehabilitation minus Rehabilitation Disturbance)					
MTW	Mt Thorley	5.2	6.6	77.8	79.2
	Warkworth	77.1	81.4	223.3	227.5
	MTW Total	**82.3**	**88.0**	**301.1**	**306.7**

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 1,103 ha of rehabilitation to be completed by the end of 2017, and a further 505.8ha to be completed by the end of 2023. At the end of the reporting period there had been 1,235 hectares of rehabilitation completed across MTW, 212ha ahead of the EIS forecast for the end of 2017 and tracking well to achieve the forecast total rehabilitation area at the end of 2023.

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 2018 the Plan committed to 164.6 ha of rehabilitation being completed. The actual rehabilitation amounts to 200.6 ha, which is 36.0 ha ahead of the planned progress and completes our reporting requirements against the South Pit South Accelerated Rehabilitation Plan.

7.4 Rehabilitation Programme Variations

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

7.5 Rehabilitation Trials

During 2017, 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; and

Inoculant and growth promotant application: bacteria and fungi dominated inoculants, germination and growth promotants. Initial monitoring of the trial plots was conducted during autumn 2018 following germination of both native and exotic species. Further monitoring will be required to establish if the effects of the soil ameliorants have had a positive or negative impact overall, as the ameliorants have promoted both the growth of native and exotic (weed) species.

Initial results indicate that all treatments performed better than the control in measures of density and diversity of native species. The most beneficial treatments appear to be those involving ripping as the soil preparation and those using a fungal dominated inoculant with germination and growth promotants.

During 2018, a trial was undertaken on the CD Dump rehabilitation area of MTW to mainly compare the performance of an inoculated mineral fertiliser against that of Mixed Waste Compost as a soil ameliorant. The trial was conducted on plots that used both topsoil and mine spoil as the growth medium with the various treatments shown in the table below.

Monitoring of this trial will be undertaken during 2019 to determine the relative effects of the various soil ameliorants.

TABLE 7.3 SOIL AMELIORATION TREATMENTS USED FOR 2018 CD DUMP REHABILITATION TRIAL

Plot	Area ha	Growth Medium	Gypsum t/ha	Compost t/ha	Lime kg/ha	Fertiliser kg/ha
A1	0.95	Topsoil	0	50	300	300
A2	0.36	Topsoil	0	50	300	0
A3	0.28	Topsoil	0	50	0	400
A4	0.2	Spoil	0	50	300	0
A5	0.14	Spoil	0	50	300	300
B1	0.46	Topsoil	0	0	0	400
B2	0.29	Topsoil	0	0	300	300
B3	0.23	Topsoil	0	0	300	0
B4	0.2	Spoil	0	0	300	300
B5	0.2	Spoil	0	0	0	400
B6	0.18	Spoil	0	0	300	0
C1	4.31	Topsoil	10	100	0	0
C2	1.01	Spoil	10	100	0	0
Trial Total	**8.81**					

7.6 Rehabilitation Maintenance

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

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 2018 areas totalling 319.9ha of existing rehabilitation received boom and/or wick wiper treatment.

Hand spraying and manual removal of weeds is also undertaken in rehabilitation areas with establishing native vegetation. During 2018 areas totalling 37ha were treated using selective weed control methods (i.e. backpack spray, Quikspray).

Rehabilitation areas receiving weed control during 2018 are shown in **Figure 79** below. Note some areas may have received a combination of treatments during the reporting period.

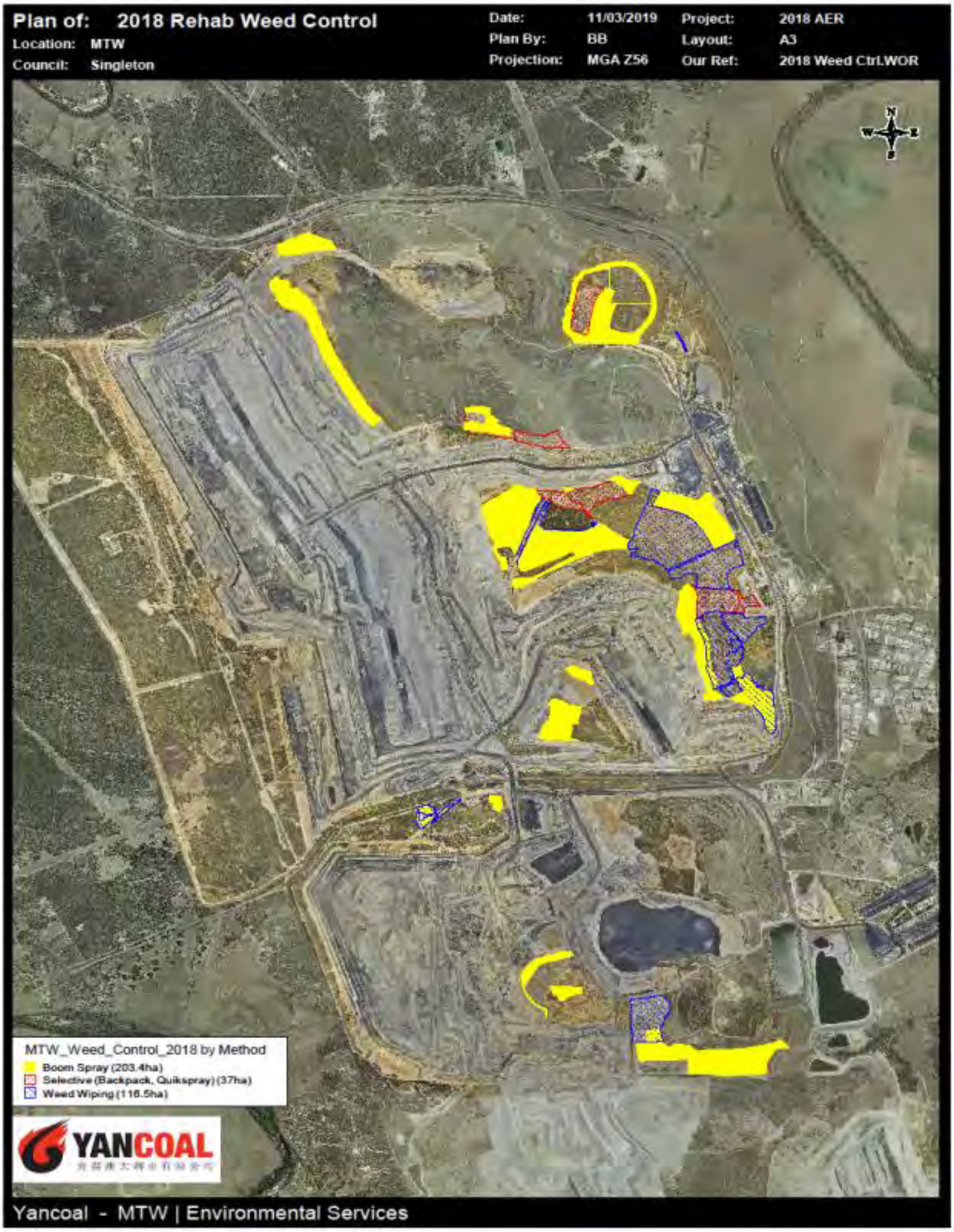


FIGURE 79: 2018 REHABILITATION WEED CONTROL LOCATIONS

7.7 Topsoil Management

Topsoil is managed according to MTW's Disturbance and Rehabilitation procedures. **Table 7.4** outlines the topsoil used and stockpiled during 2018. There were 63.7 ha of rehabilitation top soiled during 2018, using stockpiled and pre-stripped soil resources.

TABLE 7.4 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)
50,180	171,800	688,826	639,824

7.8 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 7.5** below outlines the current state of decant water pumping infrastructure across the active and inactive TSF's at MTW.

TABLE 7.5 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

7.9 Weed Control

7.9.1 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 69 days of weed management work was undertaken on site at MTW during 2018, with 505 ha of land treated, including maintenance of access tracks and 48 environmental monitoring points. The weeds targeted during the 2018 weed management programme were based on the results of the 2017 weed survey. **Figure 80** 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)
- Green cestrum (Cestrum parqui)
- Lantana (Lantana Camara)
- Mother of Millions (Bryophyllum delagoense)
- Opuntia (Pear) species (Tiger, Prickly and Creeping Pear)
- Pampas grass (Cortaderia celloana)
- Rhodes grass (Chloris gayana Kunth)
- Saligna (Acacia saligna)
- Tree of heaven (Ailanthus altissima)
- St John’s Wort (Hypericum perforatum)

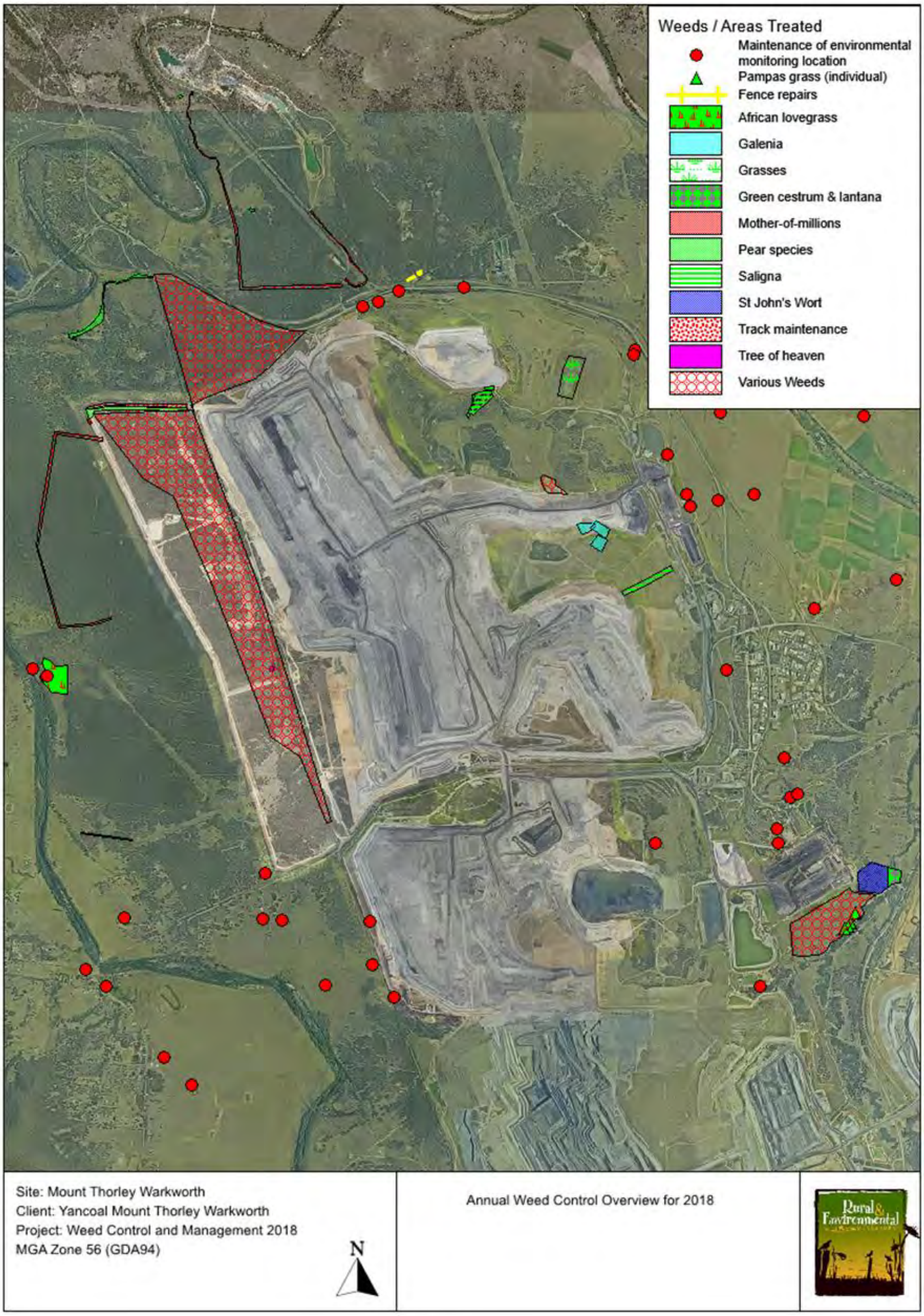


FIGURE 80: ANNUAL WEED CONTROL OVERVIEW FOR 2018

7.9.2 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 November 2018, and is 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.

Eight WONS were identified during the survey, they included:

- African Boxthorn (Lycium ferocissimum) State – Asset protection
- Bitou bush (Chrysanthemoides monilifera subspecies rotundata) State – Containment
- Fireweed (Scenecio madagascariensis) State – Asset protection/ Regional – additional species of concern
- Lantana (Lantana camara) State – Asset protection

Pear Species:

- Creeping Pear (Opuntia humifusa) State – Asset protection
- Prickly Pear (Opuntia stricta) State – Asset protection/ Additional species of concern
- Tiger Pear (Optunia aurantiaca) State – Asset protection
- Velvety Pear Tree (Opuntia tomentosa) State – Asset protection

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

- Green cestrum (Cestrum parqui) Regional - Asset protection
- Mother of Millions (Bryophyllum delagonese) Regional - Asset protection
- Bathurst burr (Xanthium spinosum) Additional species of concern
- Noogoora burr (Xanthium occidentale) Additional species of concern

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

- African Olive (Olea europea subspecies cuspidae) Regional – Asset protection
- African lovegrass (Eragrostis curvulva) Regional – Additional species of concern
- Blue heliotrope (Heliotropium amplexicaule) Regional – Additional species of concern
- Castor Oil Plant (Ricinus communis)
- Galenia (Galenia pubescens) Regional – Additional species of concern
- Passionflower (Passiflora spp)
- Scotch Thistle (Onopordum acanthium)
- Saffron thistle (Cartharmus lanatus)

Thirteen 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)
- Fennel (Foeniculum vulgare)
- Golden wreath wattle or Saligna (Acacia saligna)
- Inkweed (Phytolacca octandra)
- Mustard weed (Sisymbrium sp)
- Narrow Leaved cotton bush (Gomphocarpus fructicosus)
- Panic Veltgrass (Ehrhata erecta Lam)
- Spiny Rush (Juncas acutus)
- Tree Tobacco (Nicotiana glauca)
- Wild Rose (Rosa species)
- Rhodes grass (Chloris gayana Kunth)

Species identified during the 2018 survey will form the basis of ongoing weed management works during 2019.

7.10 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 approximately 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 7.6 summarises the results from the programmes carried out at MTW during 2018 with baiting locations and results for the programmes are illustrated in **Figure 81** to **Figure 83**.

TABLE 7.6 VERTEBRATE PEST CONTROL SUMMARY

Season	1080 Baiting				Trapping	Shooting			
	Total Lethal Baits Laid	Takes by Wild Dog	Takes by Fox	Takes by Feral Pigs	Wild Dog	Feral Pigs	Hares	Foxes	Rabbits
Summer - Autumn	120	60	4	-	-	-	13	-	-
Autumn - Winter	120	65	2	-	1	8	12	-	-
Spring	122	59	6	8	-	3	2	3	6
Total	**362**	**184**	**12**	**8**	**1**	**11**	**27**	**3**	**6**

Additional pest management programmes included:

- Wild dog and fox soft-jaw trapping across MTW in autumn: one wild dog trapped and euthanized.
- Feral pig 1080 baiting program carried out across MTW in spring: 8 feral pigs poisoned.
- Opportunistic shooting of vertebrate pests.

MTW will continue to carry out quarterly vertebrate pest control programmes during 2019 to limit feral pest impacts on landholdings and surrounding neighbours.

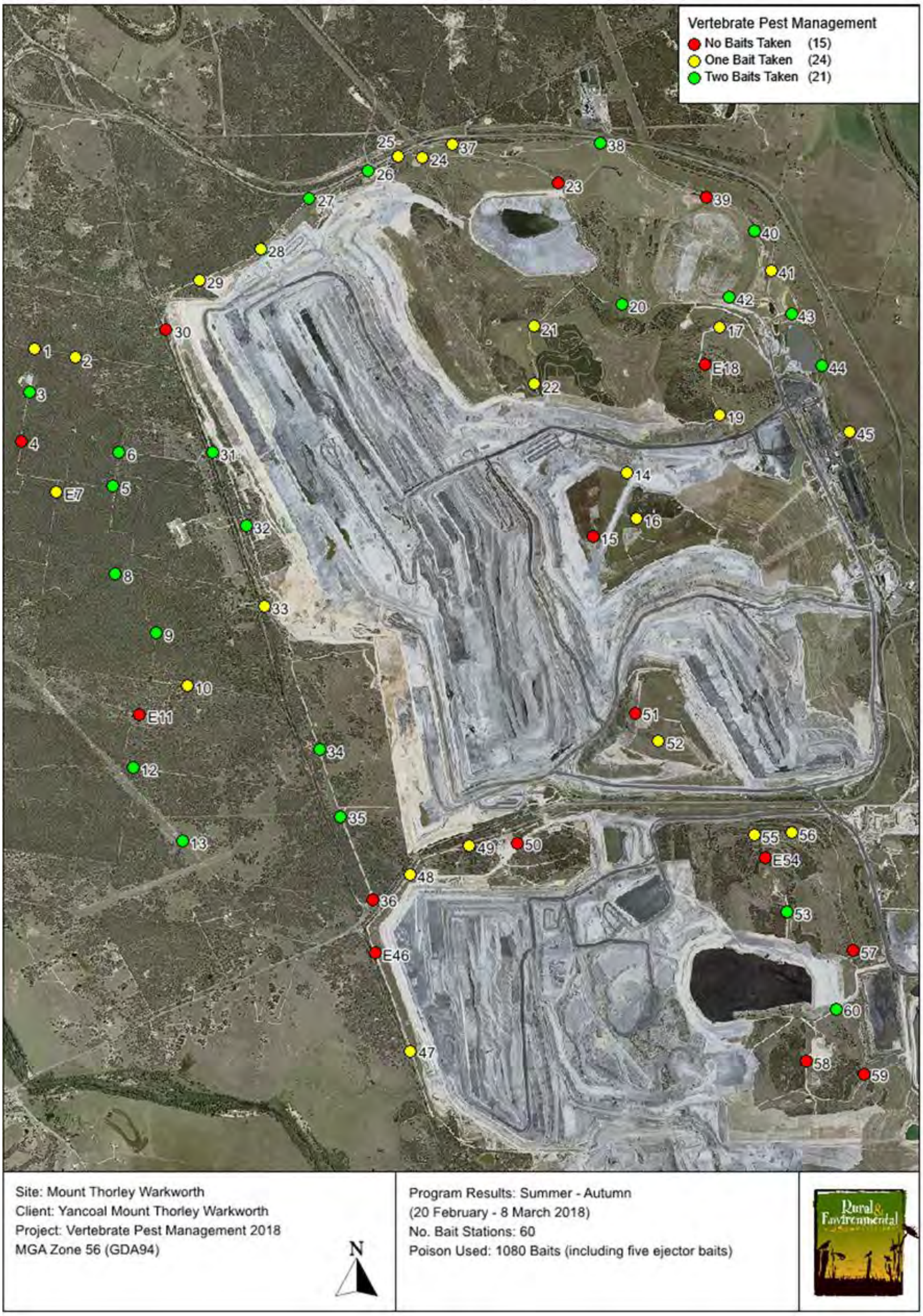


FIGURE 81: BAITING STATION LOCATIONS AND RESULTS AT MTW DURING THE SUMMER – AUTUMN 2018 VERTEBRATE PEST MANAGEMENT PROGRAMME

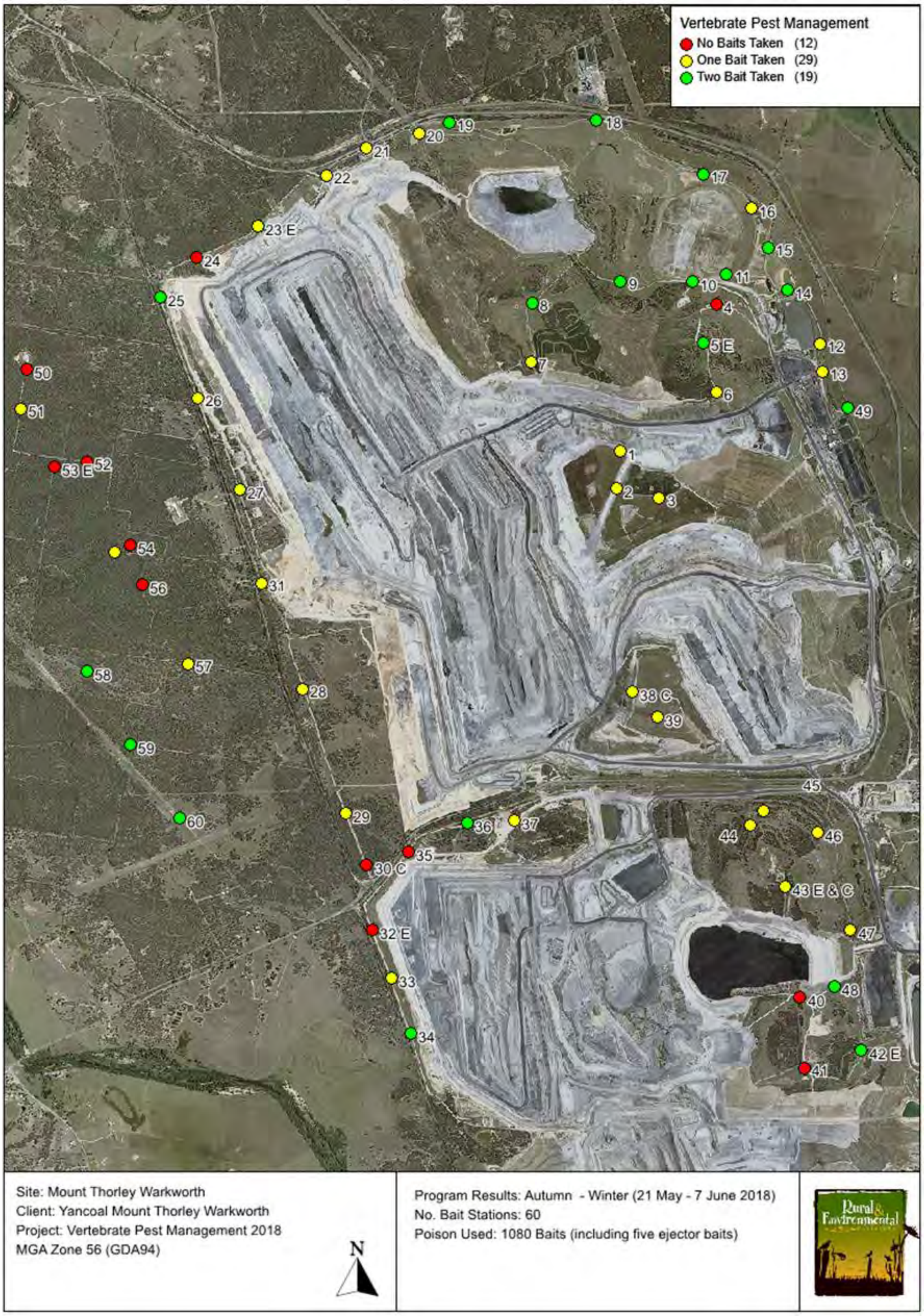


FIGURE 82: BAITING STATION LOCATIONS AND RESULTS AT MTW DURING THE AUTUMN - WINTER 2018 VERTEBRATE PEST MANAGEMENT PROGRAMME

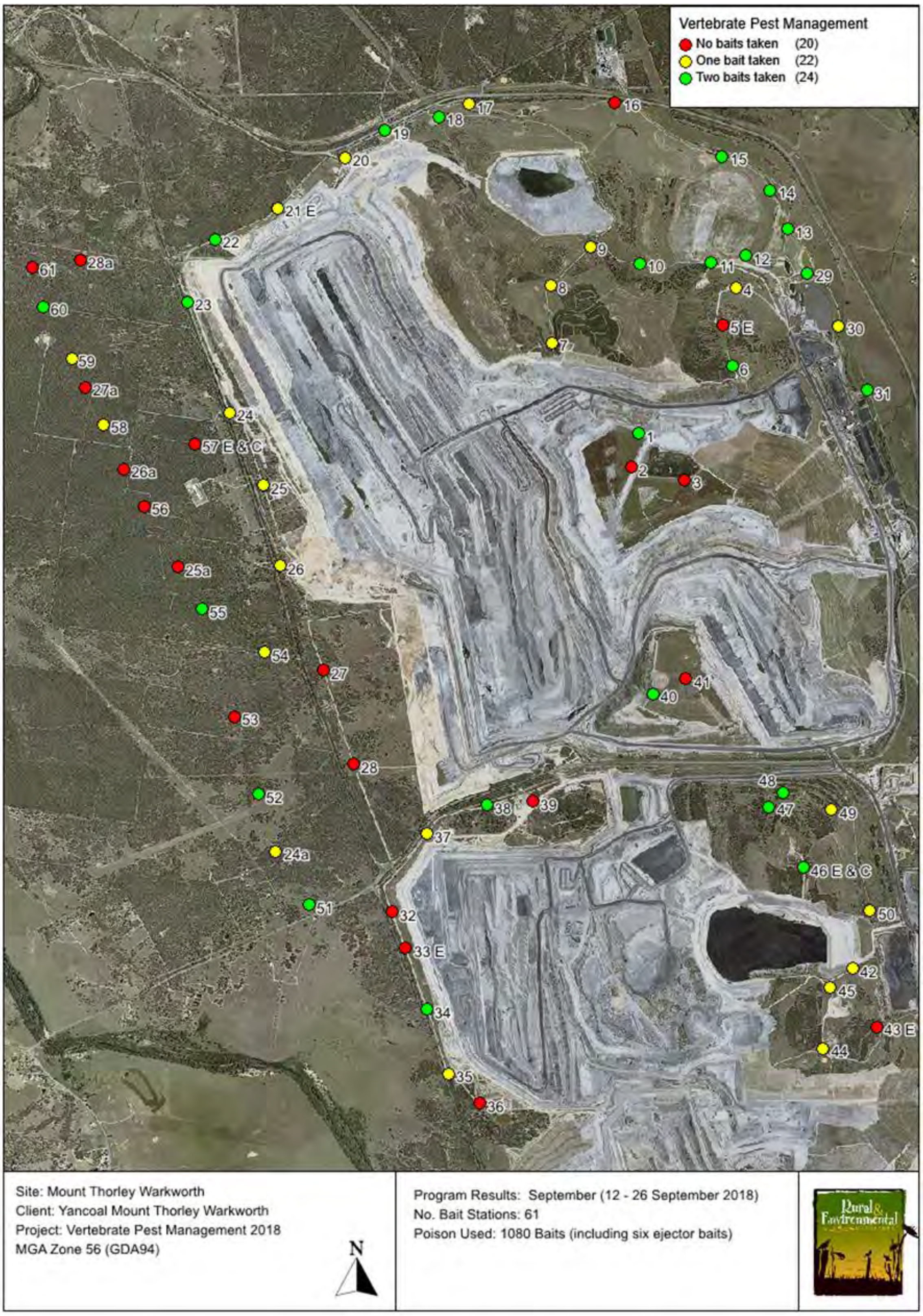


FIGURE 83: BAITING STATION LOCATIONS AND RESULTS AT MTW DURING THE SPRING 2018 VERTEBRATE PEST MANAGEMENT PROGRAMME

7.11 Biodiversity Offsets

7.11.1 Management

MTW'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 84** and also listed in **Table 7.7** below:

TABLE 7.7 MTW BIODIVERSITY AREAS

Biodiversity Areas	Area (ha)	Environmental Approvals				Offset Feature/s
		State		Federal		
		NSW 2014	NSW 2015	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/Stringybark Communities; Box shrubby/grassy Woodlands; Habitat for Swift Parrot and Regent Honeyeater
Bowditch	602		602	520	82	CHVEF; Ironbark/Stringybark 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 site specific Offset Management Plans (OMPs). All of the OMPs are available on MTW's Insite website.

Figure 84: MTW Biodiversity Offset Locality Map

7.11.2 Biodiversity Area Management Activities

The OMPs describe the Conservation Management Strategies. The following are the key actions completed throughout 2018 across all the BAs:

7.11.2.1 Weed Control

Weed control at the Local BAs targeted the following species:

- African boxthorn (Lycium ferocissimum)
- African lovegrass (Eragrostis curvula)
- African olive (Olea europaea subsp. Cuspidate)
- Balloon vine (Cardiospermum grandiflora)
- Blue heliotrope (Heliotropium amplexicaule)
- Castor oil plant (Ricinus communis)
- Couch grass (Cynodon dactylon)
- Fireweed (Scenecio madagascariensis) Galenia (Galenia pubescens)
- Green cestrum (Cestrum parqui)
- Lantana (Lantana camara)
- Moth vine (Arujuia sericifera)
- Mother of millions (Bryophyllum delagonese)
- Natal grass (Melinis repens)
- Paterson's curse (Echium plantagineum)
- Prickly pear (Opuntia stricta)
- Tree of heaven (Ailanthus altissima)
- Tiger pear (Optunia aurantiaca)
- Tree pear (Optunia tomentose)
- Turkey rhubarb (Acetosa sagittata)
- Twiggy mullein (Verbascum virgatum

Weed control at the Regional BAs targeted the following species:

- Blackberry (Rubus fruticosus)
- Bridal creeper (Asparagus asparagoides)
- Caltrop or cat heads (Tribulus terrestris)
- Fireweed (Scenecio madagascariensis)
- Green cestrum (Cestrum parqui)
- Lamb's ear (Stachys byzantine)
- Lamb's tongue or Mullein (Verbascum thapsus)
- Lavender scallops (Bryophyllum fedtschenkoi)
- Narrow leaf cotton bush (Gomphocarpus fructicosus)
- Prickly pear (Opuntia stricta)
- Scotch thistle (Onopordum acanthium)
- Stinging nettle (Urtica dioica)
- Tiger pear (Optunia aurantiaca)
- Variegated thistle (Silybum marianum)Willow (Salix spp).

7.11.2.2 Infrastructure Management and Improvement

Fence repairs were undertaken on the Southern BA and on North Rothbury BA. All tracks were maintained to reduce encroaching vegetation and improve access. Regular property inspections were undertaken on all BAs.

7.11.2.3 Fire Management

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

7.11.2.4 Strategic Grazing

No strategic grazing was undertaken in the BAs in 2018.

7.11.2.5 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. Baiting in all Regional BAs was undertaken in autumn and spring. **Table 7.8** summarises the results from the programmes carried out on the BA's during 2018.

TABLE 7.8 SUMMARY OF VERTEBRATE PEST MANAGEMENT 2018

Season	1080 Ground Baiting				Ground Shooting					
	Total Lethal Baits Laid	Takes by Wild Dog	Takes by Fox	Takes by Feral Pig	Feral Pig	Feral Cat	Fox	Deer	Hares	Rabbit
Summer	120	77	2	-	8	-	3	-	6	-
Autumn - Winter	304	140	14	-	-	-	-	-	-	-
Spring	307	136	24	31	6	1	5	1	4	14
Total	**731**	**353**	**40**	**31**	**14**	**1**	**8**	**1**	**10**	**14**

Additional pest management programmes included:

- Feral pig 1080 baiting programme carried out across Northern and Southern BA in spring: 31 pigs poisoned.
- Noisy Miner ground shoot at the Goulburn River BA to assist the survivability of the Regent Honeyeater: 365 Noisy Miners controlled under NPWS Section 120/121.
- Aerial Baiting undertaken by LLS/ Hunter valley combined wild dog association over the Goulburn River BA in November to support the ground baiting programme.
- Aerial pest control (shoot) undertaken by LLS over the Goulburn River BA in November targeting feral Pigs, wild dogs, wild deer and goats.
- Opportunistic shooting of other vertebrate pests.

Vertebrate pest management programmes will continue to be carried out during 2019 to limit feral pest impacts on landholdings and surrounding neighbours.

7.11.2.6 Seed Collection

Seed collection was undertaken by contractors in the Northern and Southern BAs during 2018, focussing on the WSW and Ironbark vegetation community. Seed collection was also undertaken on the Goulburn River BA for Yellow Box – Grey Box – Red Gum grassy woodland and River Oak riparian woodland. Tube stock for 2019 plantings is currently being propagated from the seed collected.

7.11.2.7 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 and overall there is more than 500 hectares of grassland area to be planted and managed over 15 years to restore these Endangered Ecological Communities.

In 2018, restoration work include planting 129 ha of Central Hunter Grey Box – Ironbark Woodland and River Oak Forest in the Southern BA with over 22,000 tube stock 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 planting period saw well below average rainfall so additional watering was undertaken to assist plant establishment.

14ha of Warkworth Sands Woodland was planted in the reshaped sand quarry and old orchard areas of the Southern BA. Infill planting continued in the Warkworth Sands Woodland and Central Hunter Grey Box – Ironbark Woodland areas that were planted in 2017 at the Southern and Northern BAs with over 8,000 tube stock planted into these areas in 2018.

The next round of planting is planned for autumn 2019 and will include 7ha of Warkworth Sands Woodland in the Northern BA, infill of the 2018 planting areas at the Southern BA and 50ha of

Supplementary planting of Yellow Box – Grey Box – Red Gum grassy woodland and River Oak riparian woodland at the Goulburn River BA.

FIGURE 85: TUBE STOCK PLANTED INTO THE SAND QUARRY IN THE SOUTHERN BIODIVERSITY AREA

FIGURE 86: TUBE STOCK PLANTED INTO RIP LINES AT THE SOUTHERN BIODIVERSITY AREA

7.12 Audits and Reviews

The NSW Resources Regulator undertook an inspection at MTW on 30 May 2018, focussing on topsoil management practices and compliance with commitments in the approved MOP, dated 15 January 2016.

The inspection resulted in the following general observations:

- The mine operators were unable to produce records that document how topsoil has been stripped, handled, stockpiled, monitored and maintained;
- The mine operators do not maintain records of topsoil monitoring and TARP intervention; and the
- Stripping, stockpiling, maintenance and utilisation of topsoil is generally in accordance with the MOP.

As a result of the above observations the following corrective action was required:

- Develop and implement a strategy for developing procedures for topsoil stripping, management, monitoring, TARP intervention and record keeping of topsoil activities at Mt Thorley Warkworth Operations.

Response to corrective action:

- Topsoil stockpile inventory records are now being maintained to provide the following information for MTW stockpiles:
  - topsoil source (including description of stripping area i.e. weed loads etc.); and
  - stockpile establishment date, stockpile location, quantity, maintenance activities (i.e. soil amelioration, weed control etc.).
- Rehabilitation records are now being maintained to track the source of topsoil being applied to rehabilitation areas. This information is used to inform decisions about the timing of sowing of native seed mixes (i.e. delayed sowing of native seed mixes in weedy topsoils to allow for pre-sowing weed control).

The next MTW Independent Environmental Audit is due in **2020.**

8 COMMUNITY

8.1 Complaints

A total of 351 complaints were recorded during the reporting period, down approximately 8% compared to 2017. The 351 complaints were registered by approximately 62 people (some complainants remained anonymous), with just over 50% of complaints received from 9 individuals. Most complaints were received from Bulga residents. A breakdown of complaints by type is shown in **Table 8.1.**

Noise remains of key concern for near neighbours. There has been a trending decrease (overall 47%) in noise complaints from 2016. The decrease experienced from 2016 is primarily attributed to full noise attenuation of the truck fleet, as completed by the end of 2016.

In summary:

- 10% reduction in noise complaints;
- Blast, dust and lighting related complaint numbers have remained fairly consistent from 2017, although dust and lighting related complaints were higher than in 2016. An increase in dust complaints from 2016 is considered related to well below average rainfall in 2017 and 2018;
- Complaints in the "Other" category decreased from 2017. Complaints in this category were in regard to pest management signage, rubbish on road and site vehicle use.

TABLE 8.1 SUMMARY OF COMPLAINTS BY TYPE FOR 2016 TO 2018

Complaint type	2018	2017	2016
Noise	171	191	325
Blasting	69	68	65
Dust	76	80	38
Lighting	32	33	16
Water	0	0	0
Other	3	10	19
Total	**351**	**382**	**463**

8.2 Review of Community Engagement

8.2.1 Communication

Members of the community are encouraged to contact MTW and engage in a way that suits them. Communication avenues in place to support MTW include:

- MTW free call Community Information Line (1800 727 745), which is advertised regularly in local newspapers and community newsletters;
- Online, via Insite website (www. insite.yancoal.com.au) with information about MTW including approvals documents, public reports, environmental monitoring results, blasting and road closures, and information about the MTW Community Consultative Committee (CCC);
- MTW provide several avenues for community members to register enquiries or complaints, including via community information hotline and Environment and Community personnel;
- MTW maintains a 24 hour freecall environmental hotline (1800 656 892), which allows community members to register a concern or complaint at any time of the day or night, 365 days a year. The hotline is advertised in telephone directories, on the InSite website, regularly in local newspapers, and in MTW publications;
- MTW maintains a Blast Information Line (1800 099 669) which provides information on blasts and road closures;
- Near neighbour engagement, including proactive visits to neighbours surrounding MTW; and
- MTW also issues correspondence to specific community members who may be affected by certain changes, to inform of upcoming consultation activities and as a feedback mechanism.

MTW hosted four (4) mine tours during 2018. The first, in April, was during the Hunter Coal Festival and was open to all community members. Further tours in May and November enabled primary school children from St Catherine's Catholic College to tour the operation. Finally, MTW hosted the Clontarf Academy students for a mine tour and career information day in November.

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

- Near Neighbour Amenity Resource: Through this project MTW provided and installed undersink water filters in the homes of 45 of MTW's neighbours (residents of Bulga, Milbrodale and Long Point);
- 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;
- Hosting the Bulga Rural Fire Service (RFS) for a tour of the new RFS access road (Watts Track) to enable emergency service access to the area following the closure of Wallaby Scrub Road. The access road and entry protocol was approved by the RFS prior to road closure; and the

- 2018 Hunter Coal Festival (April 2018): MTW exhibited general environmental, rehabilitation, dust and noise management and community investment information along with a haul truck simulator at the Singleton Community Day on 7 April. MTW also operated mine tours on the day.

Yancoal also maintained a community shopfront in Singleton prior to it's closure in Q1 2018 and were involved in various community events through sponsorship and participation.

8.2.2 Community Consultation Committee

The MTW CCC met on a quarterly basis to discuss our operations. The Committee is comprised of Yancoal representatives, community members and other key external stakeholders, including Singleton Council. The MTW CCC minutes were made available on the MTW Insite website (www. insite.yancoal.com.au). The community is invited to visit the MTW website to learn more about the MTW CCC, as well as other aspects of MTW operations and projects.

During the reporting period the CCC members were:

- Dr Col Gellatly - Independent Chair
- Cr Hollee Jenkins - Singleton Council Representative
- Mr Adrian Gallagher – Community Representative
- Mrs Christina Metlikovec – Community Representative
- Mr Graeme O'Brien – Community Representative
- Mr Ian Hedley – Community Representative
- Mr Stewart Mitchell – Community Representative

Company representatives attending the CCC included:

- Mr Jason McCallum - MTW General Manager
- Mr Gary Mulhearn – MTW Environment & Community Manager
- Mr Travis Bates – MTW Community Relations Specialist
- Ms Hayley Frazer – MTW Environmental Advisor

8.2.3 Community Support and Development

In 2018, MTW 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:

- Community Development Fund (CDF)
- Mount Thorley Warkworth Site Donations Committee

In December 2018 Yancoal launched the new Yancoal Community Support Program (CSP) which replaces the former CDF. The CSP intends to make a genuine positive difference to the communities in which Yancoal operates. The CSP is intended to operate to develop longer term (2-3 year) partnerships to develop longer term commitments within the community and permit community programs to mature. Applications for CSP partnerships will be received once per year, with the first offer closing 31 January 2019.

8.2.3.1 Community Development Fund

In 2018, MTW continued to support several CDF programs valuing almost $500,000 across a range of focus areas, from mental health through to education and business development. These programs are listed in **Table 8.2**.

TABLE 8.2 COMMUNITY DEVELOPMENT FUND PROJECTS SUPPORTED IN 2018

Partner	Programme	Value
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)	$54,541
University of Newcastle	University of Newcastle Scholarships	$60,000
Ungooroo Aboriginal Corporation	Health Services Programme (2017-2018)	$110,000
Jerrys Plains Public School	Ready 4 School Programme	$30,000
Milbrodale Public School	Early Learning Programme (2017-2018)	$64,000
Sirolli Institute	Enterprise Facilitator program	$75,000

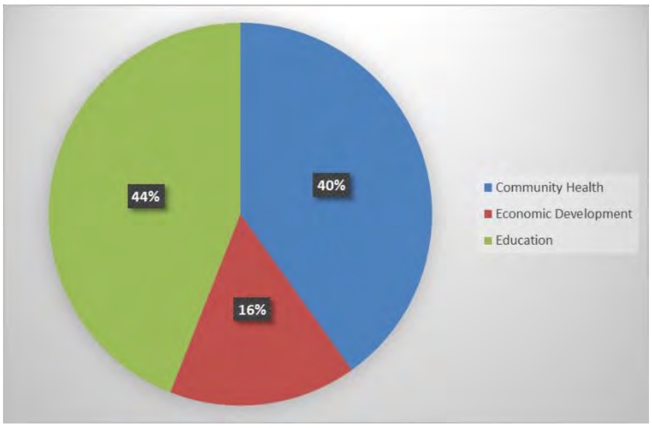


FIGURE 87: DISTRIBUTION OF COMMUNITY DEVELOPMENT FUND BY CATEGORY (2018)

8.2.3.2 MTW Site Donations

MTW considers and supports applications for local donations and sponsorships that have a clear community benefit.

In 2018, MTW provided $65,000 to 24 local projects and initiatives, including:

- Singleton Business Chamber – 2018 Hunter Coal Festival;
- Singleton Business Chamber – 2018 Outstanding Business Awards;
- Newcastle Combined Schools – 2018 Combined Schools Anzac Service;
- Wildlife Aid;
- Singleton Golf Lady Members – 2018 Annual Open Golf Day;
- Wanaruah Local Aboriginal Land Council – Naidoc Week Awards;
- Singleton Theatrical Society – 2018 Production of 'Mary Poppins';
- Rotary Club of Singleton on Hunter – 2018 Singleton Art Prize;
- Mindaribba Warriors – Gold Sponsor (Rugby League);
- Singleton Womens's Bowling Club – 2018 Kookaburra Carnival;
- Bulga Rural Fire Service – CCTV installation at station;
- Milbrodale Public School – Family Fun Day;
- Broke Public School – K-6 Robotics Program;
- Northern Agricultural Association Inc. - 2018 Singleton Show;
- Merriwa Rotary Club – Bugger the Drought fundraising picnic day;
- Country Women's Association (CWA) – CWA Friendship Day at Baiame Cave;
- Singleton Neighbourhood Centre – Breakfast Program (12 months);
- Witmore Enterprises Inc – Diamond Dance Event 60 years celebration;
- NSW Cancer Council – Transport for Treatment;
- Branxton Public School P&C – Home readers program;
- Singleton Council – Pass the Hat Drought relief fundraiser;
- Singleton Australian Football Club – Strapping for 2019 season;
- Australian Christian College Singleton – 3D Printer; and the
- Samaritans Foundation – Samaritans Christmas Lunch Singleton.

9 INDEPENDENT ENVIRONMENTAL AUDIT

There was no Independent Environmental Audit completed during the reporting period. An update of progress against the Action Plan developed in response to the 2017 Independent Environmental Audit is included in **Appendix 7**. The next MTW Independent Environmental Audit is due in 2020.

10 INCIDENTS AND NON-COMPLIANCE

A summary of the environmental incidents reported during 2018 is provided in **Table 10.1** below

TABLE 10.1 ENVIRONMENTAL INCIDENT SUMMARY 2018

Date	Incident Details	Follow up Actions
5 July 2018	An administrative non-compliance was recorded when the blast monitoring system failed to capture blast data from a small magnitude blast event. The data was unavailable as the peak vibration level was below the trigger threshold of 0.2mm/sec, which triggers the automated capture of blast results.	To reduce the possibility of reoccurrence, the blast monitor data storage capacity is to be increased to 40 days. The data within the blast monitoring system is regularly reviewed and checked for completeness by MTW's Drill and Blast Engineer and is also reconciled each month for monthly environmental reporting.
28 December 2018	A West Pit blast, W36-WYC-PR5 fired at ~ 12:03pm on 28 December 2018 recorded an airblast overpressure measurement of 120.1 dB(L) at the Bulga Village monitoring location.	An external investigation was undertaken to determine the validity of the result and subsequent cause. The investigation indicated no evidence that the higher than expected air pressure level recorded at the Bulga Village monitoring station was due to the blast design used or the implementation of the blast. The investigation also determined that at the time of the blast, wind gusts produced substantial air pressure peaks both before and during the blast and that it is probable that a wind gust during the period of airblast arrival increased the air pressure level recorded by the Bulga Village monitor The exceedance was reported to the Department of Planning and Environment and the EPA.

WML received a Penalty Notice from the EPA in May 2018 in relation to an incident reported to the EPA and DP&E on 4 December 2017, details of that incident were provided in the 2017 Annual Review. The Penalty Notice was in relation to EPL 1376 Condition O1.1 which requires operations to be carried out in a competent manner. The EPA noted that there was no actual environmental harm from the incident. New water management structures have been constructed since this incident, and the premises boundary changed to include the former Wallaby Scrub Road corridor within the licenced premises.

11 ACTIVITIES TO BE COMPLETED IN THE NEXT REPORTING PERIOD

Yancoal will endeavour to carry out the following activities during the 2019 reporting period at Mount Thorley Warkworth, as outlined in **Table 11.1**.

Table 11.1 Proposed Activities for 2019 Reporting Period

ID	Performance Area	Activities Proposed
1	Noise	• Maintain and continue sound power level testing of attenuated fleet; • Continue undertaking noise management and monitoring actions in accordance with the MTW Noise Management Plan
2	Blasting	• Firmware and hardware upgrades to blast monitors to increase data storage capacity and reduce the possibility of data mis-capture; • Review and revise the MTW Blast Management Plan for operational changes at MTW
3	Air Quality	• Upgrades to the meteorological station and dust monitor hardware.
4	Aboriginal Cultural Heritage	• Ongoing Aboriginal archaeological and cultural heritage management activities will occur in 2019 at MTW in accordance with current management plans, to inform ongoing land management and development planning. This will include the relocation of the Site M grinding grooves from the Putty Road Storage facility to the WBACHCA & the salvage of those Aboriginal artefact sites located within the ACHMP Area in areas required for mine development. Condition monitoring of those sites peripheral to authorised disturbance areas will be conducted at regular intervals to ensure operational compliance with the ACHMP. • The Hunter Valley Sands Bodies research study will also commence, as will proactive management within the Wollombi Brook and Loders Creek Aboriginal Cultural Heritage Conservation Areas in accordance with the management plans for those areas. • Conservation Agreements for the Wollombi Brook and Loders Creek Aboriginal Cultural Heritage Conservation Areas will be progressed in 2019.

ID	Performance Area	Activities Proposed
5	Historic Heritage	• Implementing the MTW complex-wide HHMP developed in accordance with the conditions of the Warkworth & Mount Thorley Development Consents, which will guide the management of historic heritage.
6	Water	• Improving the general capacity of the site's water resources via construction and/or upgrades of approved tailings storage and water storage facilities. • Implementation of actions/recommendations from the annual groundwater review • Develop an action plan to address the findings of the annual stream health assessment for Loders Creek.
7	Rehabilitation	• The rehabilitation monitoring programme will continue in 2019 for native vegetation rehabilitation areas. 24 new permanent transects will be established in rehabilitation as part of the 2019 program. • Maintenance activities are planned to result in approximately 51ha 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 80ha of new rehabilitation will be undertaken at MTW during 2019. • Habitat augmentation measures, such as the construction of habitat ponds and the placement of salvaged logs in rehabilitation areas. • Capping of Tailings Dam 2 will be progressed during 2019 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 2019 using breaker rock from the South CHPP as the initial capping layer.

ID	Performance Area	Activities Proposed
8	Biodiversity Management	• Planting works will continue to restore Warkworth Sands Woodland and Central Hunter Grey Box – Ironbark Woodland in the Northern and Southern BAs. Supplementary planting to re-establish the cleared land in the Yellow Box – Grey Box – Red Gum Grassy Woodland to a Box Gum Grassy Woodland community and increase the suitability of habitat for the Regent Honeyeater in the River Oak riparian woodland will commence at the Goulburn River Biodiversity Area. • Conservation management actions will be undertaken across the BAs in 2019 in accordance with the Offset Management Plans, these will include weed management in autumn and spring. Vertebrate pest management including 1080 ground baiting programmes to target wild dogs and foxes scheduled for autumn and spring 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. Rapid Condition Assessment and property Inspections will be undertaken across all BAs. Infrastructure improvement including fence repairs and track maintenance will be undertaken as required. • Progress the securing of biodiversity offset areas using the methods detailed in the relevant state and federal biodiversity approvals.
9	Community Engagement	• Continued operation of the Community Consultation Committee. • Implementation of the MTW Social Impact Management Plan (which outlines specific and general stakeholder engagement and consultation requirements).
10	Community Development	• Implementation of the Yancoal Community Support Program (CSP) after closing date of 31 January 2019, and seeking applications from the local community for 2019 funding. The CSP program will provide an opportunity for multiple site or group-wide investment in larger, long-term, capacity building projects that make a positive difference. Focus areas include health, social and community, environment, education and training.

Appendix 1:

Annual Rehabilitation Report Summary Table

Annual Rehabilitation Report Form, Rehabilitation Maps and Rehabilitation Summary

Annual Rehabilitation Report Form – Mines
Year Ending: 2018
Mine: Mt Thorley Warkworth
Company: Yancoal Australia
Plans Attached:
Mt Thorley Warkworth – AER 2018
Approved Mining Operations Plan:
MTW MOP Amendment A (2015 – 2021) – Approval Date 14/12/2018
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 2018

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	227.8	312.8
	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	39.8	42.0
	2D	Water Management Areas	Rehabilitation Area - Woodland	0.0	0.0
	2E	Water Management Areas	Rehabilitation Area - Woodland EEC	22.8	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	68.5	68.6
	4C	Tailings Storage Facility	Rehabilitation Area - Grassland	75.6	75.7
	4D	Tailings Storage Facility	Rehabilitation Area - Woodland	11.7	11.7
	4E	Tailings Storage Facility	Rehabilitation Area - Woodland EEC	88.2	88.3
	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	320.3	364.4
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	267.3	256.1
	5E	Overburden Emplacement Area	Rehabilitation Area - Woodland EEC	1275.3	1241.7
	Bulga Sublease Area	N/A	N/A	0.9	0.2
	Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	2.1	6.2
	Total Active			2501.0	2591.2
1.2 Decommissioning	Total - Decommissioning			0.0	0.0
1.3 Landform Establishment	Total - Landform Establishment			13.6 (Included in 1.1)	93.1 (Included in 1.1)
1.4 Growth Medium Development	Total - Growth Medium Development			24.5 (Included in 1.1)	4.3 (Included in 1.1)
1.5 Ecosystem and Land Use Establishment	2C	Water Management Areas	Rehabilitation Area - Grassland	3.5	1.2
	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 Area	Rehabilitation Area - Grassland	34.8	35.9
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	52.4	28.4
	5E	Overburden Emplacement Area	Rehabilitation Area - Woodland EEC	96.8	95.5
	Total - Ecosystem and Land Use Establishment			194.4	167.9
	1A	Final Void	Final Void	0.0	1.8

1.6 Ecosystem and Land Use Development	2C	Water Management Areas	Rehabilitation Area - Grassland	1.7	1.8
	2E	Water Management Areas	Rehabilitation Area - Woodland EEC	3.3	3.3
	3C	Infrastructure Area	Rehabilitation Area - Grassland	5.4	5.4
	3D	Infrastructure Area	Rehabilitation Area - Woodland	0.0	1.5
	3E	Infrastructure Area	Rehabilitation Area - Woodland EEC	0.5	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	35.4	35.5
	5C	Overburden Emplacement Area	Rehabilitation Area - Grassland	536.1	550.4
	5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	10.2	43.7
	5E	Overburden Emplacement Area	Rehabilitation Area - Woodland EEC	339.8	394.9
	Bulga Sublease Area	N/A	N/A	0.0	0.4
	Total - Ecosystem and Land Use Development			961.1	1067.9

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	227.8	314.6
	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	45.0	45.0
	2D	Water Management Areas	Rehabilitation Area - Woodland	0.0	0.0
	2E	Water Management Areas	Rehabilitation Area - Woodland EEC	29.0	29.0
	3B	Infrastructure Area	Water Management Areas	0.0	0.0
	3C	Infrastructure Area	Rehabilitation Area - Grassland	106.1	106.1
	3D	Infrastructure Area	Rehabilitation Area - Woodland	0.0	1.5
	3E	Infrastructure Area	Rehabilitation Area - Woodland EEC	69.0	69.1

4C	Tailings Storage Facility	Rehabilitation Area - Grassland	102.9	103.0
4D	Tailings Storage Facility	Rehabilitation Area - Woodland	13.1	13.1
4E	Tailings Storage Facility	Rehabilitation Area - Woodland EEC	127.6	127.8
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	891.2	950.7
5D	Overburden Emplacement Area	Rehabilitation Area - Woodland	329.9	328.2
5E	Overburden Emplacement Area	Rehabilitation Area - Woodland EEC	1711.9	1732.1
Bulga Sublease Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	0.9	0.6
Outside Domain Area	N/A - Outside Domain Boundary	N/A - Outside Domain Boundary	2.1	6.2
Total Footprint			3656.5	3827.0

Table 2: Soil Management and Erosion, 2018

Soil Stockpiling/ Use	Soil Used This Period (m3)	Soil Pre-stripped This Period (m3)	Stockpile Inventory to Date (m3)	Soil Stockpiled Last Report (m3)
	50,180	171,800	688,826	639,824
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	69.9	21.7	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	356.9
3.3 Give summary of control strategies used and verification by approval agency(s)	
Species targeted in rehabilitation areas during 2018 included: galenia, Rhodes grass, green panic, couch grass, *Acacia saligna*, mustard weed (Brassica), farmers friend (*Bidens pilosa*) and paddys lucerne (*Sida rhombifolia*). 319.9ha treated for weed control using boom spray or wick wiper treatment; 37ha treated for weed control using Quikspray units or backpack sprays.	

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 Report Period

6.1 Area estimated to be disturbed	64ha

6.2 Area estimated to be rehabilitated	80ha

Appendix 2:

Rehabilitation and Disturbance Summary

MTW Annual Review Appendix 2 – Rehabilitation Summary

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
North Pit North RL100	Woodland	317,440.1 E 6,392,963.1 N	2.4	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 14 degrees with a primarily northerly aspect. ▪ Drainage is via easterly draining contours reporting to adjacent existing contour drainage and then to an engineered rock-lined 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 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sprayed with herbicide in April (primarily targeting *Galenia pubescens)* prior to sowing the area in June with an Autumn Winter Rehab Blend cover crop at 50kg/ha using an air-seeder mounted on an aerator implement. ▪ The area was sprayed with herbicide again in November (targeting Galenia pubescens and cover crop species) prior to sowing in November with Diverse Native Woodland Mix drilled into an aerated pattern at 14.7kg/ha.
North Pit North RL100 Geofluv	Woodland	317,202.0 E 6,392,942.1 N	3.8	▪ The landform was constructed from a waste emplacement. ▪ The landform has been designed using a geomorphological landform approach based on alluvial analogues. Typical slope of the landform is 10 to 14 degrees with limited areas at 16 to 18 degrees. The slope has a primarily northerly aspect. ▪ Drainage is via rock-lined drainage lines, directing run-off to a sediment control structure to the west. ▪ 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 5t/ha and 100t/ha respectively.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in June with an Autumn Winter Rehab Blend cover crop at 50kg/ha using an air-seeder mounted on an aerator implement. ▪ The area was sprayed with herbicide in November (targeting *Galenia pubescens* and cover crop species) prior to sowing in November with Diverse Native Woodland Mix drilled into an aerated pattern at 14.7kg/ha.
North Pit North Crib Hut	Woodland	316,433.4 E 6,392,514.9 N	0.5	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a primarily northerly aspect. ▪ Run-off from the slope is directed to a sediment control structure to the east. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ 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 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sprayed with herbicide in November (targeting *Galenia pubescens*) prior to sowing in November with Diverse Native Woodland Mix at 14.7kg/ha using a two stage seeding method: 1) non-flowable component was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
North Pit North RL180 Geofluv	Woodland	317,216.0 E 6,392,430.9 N	7.4	▪ The landform was constructed from a waste emplacement. ▪ The landform has been designed using a geomorphological landform approach based on alluvial analogues. Typical slope of the landform is 8 to 14 degrees with limited areas at 16 to 18 degrees. The slope has a primarily northerly aspect. ▪ Drainage is via rock-lined drainage lines, directing run-off to a sediment control structure to the north. The current water management arrangement is a temporary measure as the position of the Tailings Dam 2 haul road is

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				preventing the installation of the long term water management arrangement. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Two topsoil types were spread on different sections: 1) Clay loam topsoil from existing topsoil stockpiles; and 2) Sandy loam from stripping areas in NPN, both soil types were spread at a nominal thickness of 100mm. ▪ Mixed waste compost was applied as a soil ameliorant to both soil types at a rate of 100t/ha; and recycled gypsum was applied to the stockpiled clay loam soil only at a rate of 5t/ha. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sprayed with herbicide in November (targeting exotic grasses) prior to sowing in November with Diverse Native Woodland Mix at 14.7kg/ha using a two-stage seeding method: 1) non-flowable component was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
North Pit North RL175	Woodland	317,592.4 E 6,391,734.1 N	10.0	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 14 degrees with an easterly aspect. ▪ Drainage on the southern half of the slope is via southerly draining contours reporting to an engineered rock-lined chute (still to be constructed). The northern half of the slope was set up as a trial area with no contours installed on the slope to test the stability of a nominal 14 degree slope with and without contours. Drainage from the northern half of the slope reports to flatter areas at the base of the slope and eventually flow to a sediment control structure to the south. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ 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 5t/ha and 100t/ha respectively.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	***Rehabilitation Summary***
				▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in June with an Autumn Winter Rehab Blend cover crop at 50kg/ha using an air-seeder mounted on an aerator implement. ▪ The area was sprayed with herbicide in November (targeting *Galenia pubescens* and cover crop species) prior to sowing in November with Diverse Native Woodland Mix at 14.7kg/ha using a two-stage seeding method: 1) non-flowable component was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
Swanlake RL160	Woodland	318,597.4 E 6,391,135.3 N	7.1	▪ The landform was constructed from a waste emplacement. ▪ The landform is flat in this area, no aspect. ▪ Area is flat and hence not requiring drainage controls. ▪ Landform surface preparation comprised minor shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ No topsoil was added, spoil was used as the growth medium. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in June with Diverse Native Woodland Mix drilled into an aerated pattern at 14.7kg/ha.
CD RL160 Spoil/Compost	Woodland	319,103.4 E 6,390,722.1 N	4.6	▪ The landform was constructed from a waste emplacement. ▪ The landform is flat in this area, no aspect. ▪ Area is flat and hence not requiring drainage controls. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ No topsoil was added, spoil has been used as the growth medium. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in August with Diverse Native Woodland Mix at 14.7kg/ha using a two-stage seeding method: 1) non-flowable component

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
CD RL160 Topsoil	Woodland	318,987.8 E 6,390,655.6 N	2.3	▪ The landform was constructed from a waste emplacement. ▪ The landform is flat in this area, no aspect. ▪ Area is flat and hence not requiring drainage controls. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ 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 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in August with Diverse Native Woodland Mix at 14.7kg/ha using a two-stage seeding method: 1) non-flowable component was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
South Pit North Orica Slope	Woodland	320,042.7 E 6,390,690.6 N	1.8	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 to 14 degrees with a primarily easterly aspect. ▪ Drainage is via southerly draining contours reporting to adjacent existing contour drainage and then to an engineered rock-lined chute. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ 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 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sprayed with herbicide in November (primarily targeting *Galenia pubescens* and exotic grasses) prior to sowing the area in November

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				with Diverse Native Woodland Mix at 14.7kg/ha using a two-stage seeding method: 1) non-flowable component was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
CD RL170 Topsoil A	Woodland	319,956.9 E 6,389,902.7 N	5.1	▪ 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 and westerly draining contours reporting to a central engineered rock-lined chute leading to a sediment control dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ A trial of various soil ameliorants was installed comprising plots with various combinations of mixed waste compost at 50-100t/ha, inoculated mineral waste fertiliser at 300-400kg/ha, lime at 300kg/ha and recycled gypsum at 10t/ha. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in late August and early September with Diverse Native Woodland Mix at 14.7kg/ha using a two-stage seeding method: 1) non-flowable component was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
CD RL170 Topsoil B	Woodland	319,988.4 E 6,389,874.7 N	2.2	▪ 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 and westerly draining contours reporting to a central engineered rock-lined chute leading to a sediment control dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Cal S was applied as a soil ameliorant at a rate of 300kg/ha. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ The area was sown in December with millet seed at a rate of 25kg/ha.
CD RL170 Spoil/Compost	Woodland	319,516.0 E 6,389,857.0 N	1.6	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a northerly aspect. ▪ Drainage is via easterly draining contours reporting to adjacent existing contour drainage and then to an engineered rock-lined chute. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ No topsoil was added, spoil is therefore the growth medium. ▪ A trial of various soil ameliorants was installed comprising plots with various combinations of mixed waste compost at 50t/ha, inoculated mineral waste fertiliser at 300-400kg/ha and lime at 300kg/ha. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in August with Diverse Native Woodland Mix at 14.7kg/ha using a two-stage seeding method: 1) non-flowable component was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
South Pit South RL160 A	Woodland	320,572.7 E 6,389,433.6 N	9.3	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with an easterly aspect. ▪ Drainage is via southerly draining contours reporting to an engineered rock-lined chute. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ 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 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in January with Spring Summer Rehab Blend cover crop seed which was spread into an aerated pattern at 25kg/ha. ▪ The area was sprayed with herbicide in April (primarily targeting *Galenia pubescens,* exotic grasses and cover crop species*)*. The area was sprayed

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				with herbicide again in June (primarily targeting remaining *Galenia pubescens*) prior to sowing the area in July with Diverse Native Woodland Mix at 14.7kg/ha using the direct drill into an aerated pattern.
South Pit South RL160 B	Woodland	320,464.2 E 6,389,596.4 N	0.8	▪ The landform was constructed from a waste emplacement. ▪ Typical slope of the landform is 10 degrees with a primarily easterly aspect. ▪ Drainage is via easterly and westerly draining contours reporting to a central engineered rock-lined chute leading to a sediment control dam. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Cal S was applied as a soil ameliorant at a rate of 300kg/ha. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in December with millet seed at a rate of 20kg/ha using a belt spreader sowing into an aerator pattern.
South Pit South RL160 C	Woodland	320,616.1 E 6,389,156.9 N	0.4	▪ The landform was constructed from a waste emplacement. ▪ The area is largely flat. ▪ No water management structures required. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Growth medium preparation included aerating as required ▪ The area was sown in December with millet seed at a rate of 20kg/ha using a belt spreader sowing into an aerator pattern.
Woodlands RL130	Woodland	319,641.4 E 6,389,926.8 N	1.9	▪ The landform was constructed from a waste emplacement. ▪ The landform has been designed using a geomorphological landform approach based on alluvial analogues. Typical slope of the landform is 10 to 14 degrees. The slope has a north-easterly aspect. ▪ Drainage from the slope currently reports to the South Pit void. ▪ 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*
				▪ Two topsoil types were spread on different sections: 1) Clay loam topsoil from existing topsoil stockpiles; and 2) Clay loam from adjacent rehab stripping areas at Woodlands, both soil types were spread at a nominal thickness of 100mm. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 5t/ha and 100t/ha respectively to both soil types. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sprayed with herbicide in November (targeting *Galenia pubescens* and exotic grasses) prior to sowing in November with Diverse Native Woodland Mix at 14.7kg/ha using a two-stage seeding method: 1) non-flowable component was broadcast onto the surface using the direct drill; and 2) the flowable components were broadcast by an air-seeder mounted on an aerator implement.
Rural Fire Service Road	Woodland	315,464.4 E 6,389,675.7 N	18.1	▪ Disturbance of this area involved mulching of vegetation only, no landform construction or growth medium establishment was required as soil profile had not been altered. ▪ Drainage is via sediment control structures that were built as part of the RFS Road construction. Run-off is captured in sediment basins before flowing into existing drainage lines to the west. ▪ Growth medium preparation included aerating to provide a favourable seed bed ▪ The area was split into three soil/vegetation types: lighter (sandy) soil, standard Ironbark/Grey Box soil, and poorly drained Melaleuca soil. These three areas were sown with seed from different shrub species suited to the soil type at 1kg/ha. These areas will be managed as seed production areas for rehabilitation seed mixes.
Mt Thorley Dragline Crossing	Woodland	318,705.7 E 6,387,798.1 N	1.0	▪ The area is an old dragline crossing area so only minor re-shaping was required, subsoil profile was still intact. ▪ Typical slope of the area is 10 degrees with a primarily northerly aspect. ▪ Drainage from the slope reports to two sediment control dams to the north. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Recycled gypsum was applied as a soil ameliorant at a rate of 5t/ha.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Growth medium preparation included aerating as required ▪ The area was sown in December with millet seed at a rate of 20kg/ha using an air-seeder fitted to an aerator implement.
Mt Thorley Green Mile Geofluv	Woodland	319,872.6 E 6,387,641.5 N	10.0	▪ The landform was constructed from a waste emplacement. ▪ The landform has been designed using a geomorphological landform approach based on alluvial analogues. Typical slope of the landform is 10 to 14 degrees with limited areas 18 to 24 degrees. The slope has a predominantly north-easterly aspect. ▪ Drainage is via rock-lined drainage lines, directing run-off to a sediment control structure to the north. The current water management arrangement is a temporary measure as the position of the Green Mile haul road is preventing the installation of the long term water management arrangement. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ Two topsoil types were spread on different sections: 1) Clay loam topsoil from existing topsoil stockpiles; and 2) Clay loam from adjacent rehab stripping areas at West Pit South, both soil types were spread at a nominal thickness of 100mm. ▪ The stockpiled soil spread on the Western half would have benefited from the application of compost to assist with water infiltration however the EPA ban on the use of Mixed Waste Compost meant that compost application was not possible until alternative compost products could be sourced in early 2019. Soil ameliorants comprising recycled gypsum at 2.5t/ha, lime at 300kg/ha and Cal S at 300kg/ha were applied to different areas. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in December with millet seed at a rate of 20kg/ha using an air-seeder fitted to an aerator implement.
Mt Thorley RL155 Topsoil A	Woodland	319,203.8 E 6,386,125.8 N	1.9	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief undulations (0-2 degrees) and without dominant aspect. ▪ No water management structures required.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
				▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of rock material as necessary. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sprayed with herbicide in May (primarily targeting *Galenia pubescens*) before sowing with Autumn Winter Rehab Blend cover crop using an air-seeder mounted to an aerator implement at a seeding rate of 30kg/ha. The area was sprayed with herbicide again in November (targeting *Galenia pubescens* and cover crop species).
Mt Thorley RL155 Topsoil B	Woodland	319,406.6 E 6,386,438.9 N	2.8	▪ The landform was constructed from a waste emplacement. ▪ The landform has been designed using a geomorphological landform approach based on alluvial analogues. Typical slope of the landform is 0 to 5 degrees. The slope has a predominantly northerly aspect. ▪ A constructed drainage line running to the west will be extended as future geofluv landform is constructed. This drainage line will eventually report to a sediment control basin. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of rock material as necessary. ▪ Clay loam topsoil from existing topsoil stockpiles was spread at a nominal thickness of 100mm. ▪ Growth medium ameliorant recycled gypsum was applied at a rate of 2.5t/ha. Fertiliser will be applied in 2019 at the time of sowing the area with native seed. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in December with cereal Millet at 20kg/ha using a belt-spreader to broadcast the seed into an aerated pattern.

Rehabilitation Site Name	Type	Coordinates (GDA94)	Area (ha)	*Rehabilitation Summary*
Mt Thorley RL155 Spoil/Compost	Woodland	319,285.6 E 6,386,001.3 N	7.0	▪ The landform was constructed from a waste emplacement. ▪ The area is flat with localised micro-relief undulations (0-2 degrees) and without dominant aspect. ▪ No water management structures required. ▪ Landform surface preparation comprised bulk shaping, deep ripping, rock raking, and removal of oversize rock material. ▪ No topsoil was added, spoil is therefore the growth medium. ▪ Soil ameliorants comprising recycled gypsum and mixed waste compost were applied at rates of 5t/ha and 100t/ha respectively. ▪ Growth medium preparation included ameliorant incorporation, rock windrowing, rock picking, and aerating as required ▪ The area was sown in April with Diverse Native Woodland Mix at 14.7kg/ha using a direct drill sowing into an aerated pattern.

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

Appendix 3:

Aboriginal Heritage Management Plan Compliance Inspection Report

Mount Thorley Warkworth Aboriginal Heritage Management Plan Compliance Audit Inspection

Report prepared for

Yancoal Australia, Mount Thorley Warkworth

December 2018

Joel Deacon

ARROW HERITAGE SOLUTIONS

Introduction

Yancoal Australia (Yancoal) manage the Mount Thorley Warkworth (MTW) mining complex located in the Hunter Valley, approximately 8km south-west of Singleton. Approval for the continuation & expansion of the mine, which will allow the mine to extract a further 230 million tonnes over 21 years, was granted on 26th November 2015 under two separate project approvals: the Warkworth Continuation Project Approval (SSD-6464) & the Mount Thorley Operations Project Approval (SSD-6465).

Pursuant to Condition 43 of the Warkworth Continuation Project Approval, & condition 28 of the Mount Thorley Operations Project Approval, Yancoal have developed a MTW Aboriginal Heritage Management Plan (AHMP) to cover both mining operations, which was approved by the Department of Planning & Environment on 29th May 2017. This AHMP sets out the principles, processes & measures through which Aboriginal cultural heritage will be managed within the AHMP Area. This includes a commitment (Provision 24) to conduct annual AHMP compliance inspections with members of the Aboriginal community, through the auspices of the MTW Aboriginal Cultural Heritage Working Group (CHWG), throughout the life of operations. The purpose of the compliance inspections is to afford the Aboriginal stakeholders & MTW:

- the opportunity to visit mine operations and mine areas to inspect the operational compliance with AHMP provisions & Ground Disturbance Permit procedures;
- to inspect and monitor the condition and management of various sites; and
- to review the effectiveness and performance of AHMP provisions in the management of cultural heritage at the mine.

These compliance inspections are to be conducted at least annually. Due to the number of Aboriginal cultural heritage sites within the AHMP area & the time foreseen to inspect all sites, it is not feasible to inspect every site during the same field trip. Therefore, a regular, rolling program of compliance inspections has been implemented that will visit all sites at each location periodically. A record will be kept of each compliance inspection against each Aboriginal cultural heritage site, so that it can be ensured that each site is inspected regularly.

Proposed Activity and Project Brief

The compliance inspections involved the following elements:

- An AHMP compliance inspection report pro-forma will be completed for the nominated inspection areas and Aboriginal cultural heritage sites visited;
- Photographs of the inspected Aboriginal cultural heritage sites will also be taken;
- The pro-forma will note the outcomes of the inspections including evidence of compliance and non-compliance with AHMP provisions, recommendations on modifications and improvements to management provisions, recommendations on corrective actions, and other comments associated with AHMP provisions;
- Specific inspection with an arborist of three Aboriginal scarred trees to develop a preliminary removal methodology.

Timing & Personnel

The MTW AHMP compliance inspection program was conducted on Wednesday 28th and Thursday 29th November 2018. The personnel involved in these inspections were:

Name	Organisation	Wed 28 Nov	Thu 29 Nov
Joel Deacon	Arrow Heritage Solutions	X	X
Travis Bates	MTW	X	X
Donna Swan	Wallangan	X	X
David Horton	Wanaruah Local Aboriginal Land Council	X	
Natasha Kellett	Wanaruah Local Aboriginal Land Council		X
Jason Schutz	Strikeforce		X
Daniel	Strikeforce/D & C Trees		X

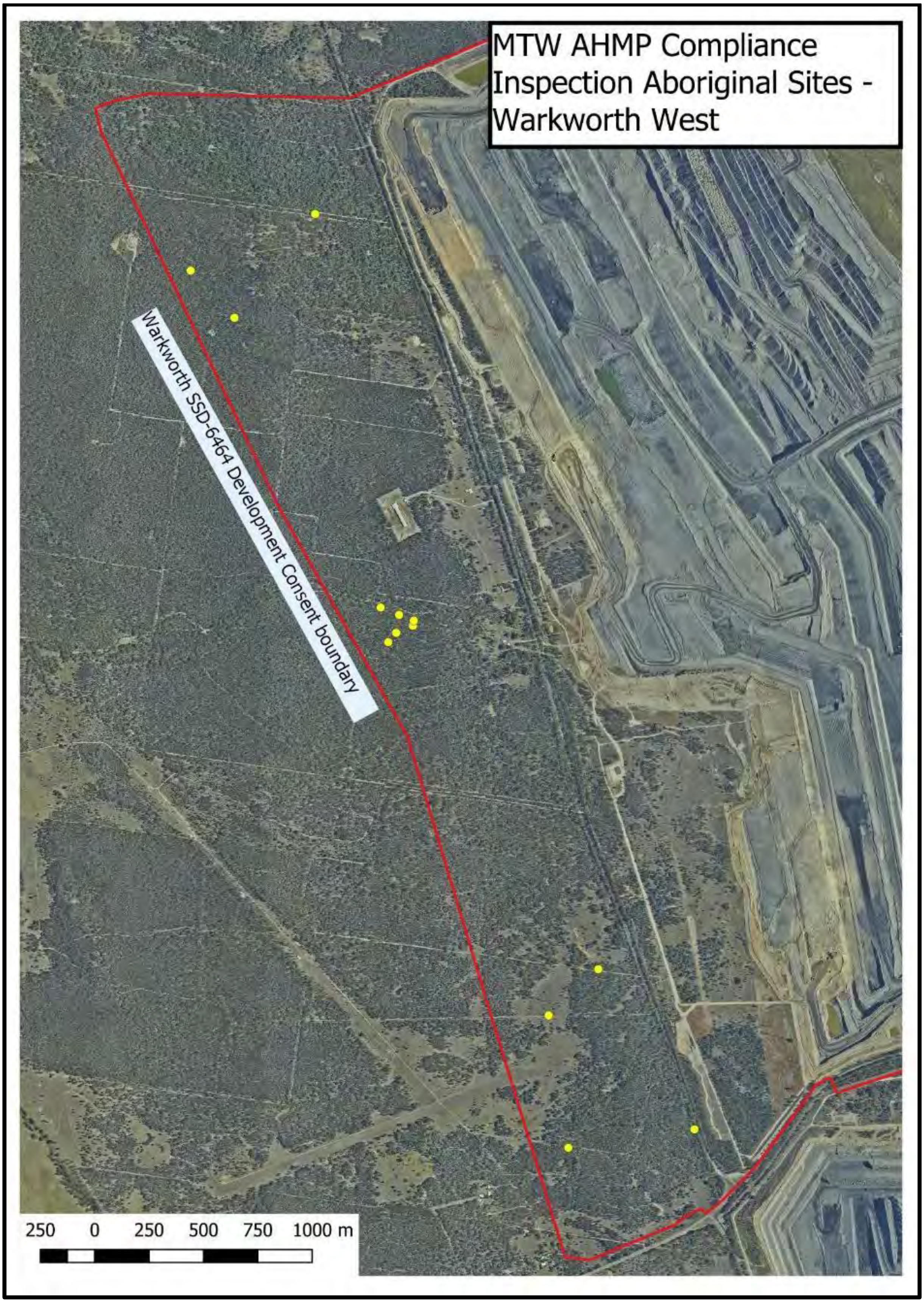
Arrow Heritage Solutions were engaged as independent heritage consultants to conduct the AHMP compliance inspections, and Joel Deacon acted as technical advisor and author of this report. MTW's Environment and Communities Specialist Travis Bates arranged the compliance inspection programs and escorted the field team. Representatives of the Wanaruah Local Aboriginal Lands Council and Wallangan participated in the field work program, and Jason Schutz and Daniel attended on the Thursday morning to provide technical arborist advice on three scarred trees.

MTW AHMP Compliance Inspection

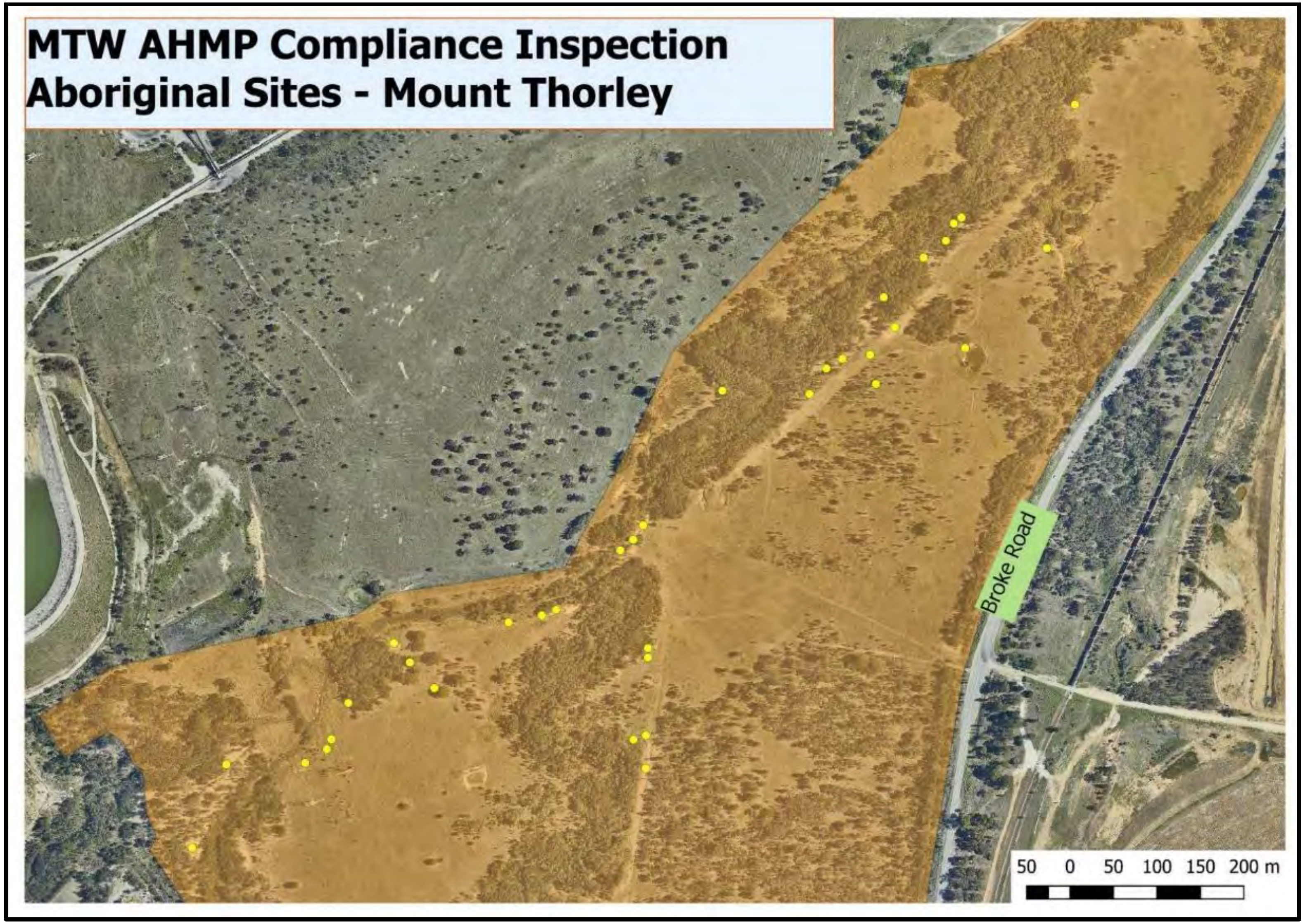
A total of 48 Aboriginal heritage sites were inspected across both the Warkworth and the Mount Thorley mining sites (see Map 1 and 2). The area at Warkworth was selected for inspection as this is adjacent to current development areas and is being frequently accessed for a variety of activities. The sites inspected at Mount Thorley are located within the Loder Creek Aboriginal Cultural Heritage Conservation Area and, although protected from any possible ground disturbing activities, do have the potential to be affected by erosion and other environmental factors

Results

The following table summarises the results of the MTW compliance inspection and summarises the information recorded on the individual pro-forma inspection sheets. Using a mobile mapper pre-loaded with the GIS co-ordinates for each Aboriginal heritage site, the field team travelled to each location and attempted to re-locate each site. Sometimes this was not possible due to poor ground surface visibility, a result which in itself was not overly significant as long as it was determined that the vicinity had not been inadvertently disturbed. The presence and condition of barricading or fencing was noted, as well as the presence and nature of various potential site disturbing factors (e.g. erosion, animal, human). General observations of each site were made if necessary, and, based on information provided for all the above factors, management recommendations were discussed and agreed by the field team for each site.



Map 1: Location of Aboriginal heritage sites inspected at Warkworth Mine during the MTW AHMP compliance inspection program



Map 2: Location of Aboriginal heritage sites inspected at Mount Thorley during the MTW AHMP compliance inspection program (Loder Creek Aboriginal Cultural Heritage Conservation Area shaded orange)

Site Name	Date	Mine	Site re-identified?	Site intact?	Site fenced/ barricaded?	Fencing/ barricading intact?	Natural erosion	Livestock damage	Human disturbance	Animal disturbance	Pests & weeds	General observations	Management recommendations
MTW-222	28/11/2018	WML	Yes	Yes	Yes	Yes	eroded track	No	on old track	No	ant nest	site intact despite nearby erosion	Nil
MTW-4	28/11/2018	WML	No	Yes	Yes	Yes	No	No	No	No	No	not found due to poor GSV	Place on 2019 audit schedule
MTW-523*	29/11/2018	WML	Yes	No	Yes	Yes	No	No	No	No	termites	high deterioration	Use fork lift to place on long pallet or flat bed truck; strap down, wrap in carpet & move once only; potentially move to WBACHCA
MTW-606	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	under powerline	No	No	-	Fix erosion
MTW-612	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	longer than first recorded	Nil
MTW-613	29/11/2018	MTO	Yes	Yes	No	-	No	No	under powerline	No	St Johns wort	artefacts' made from ceramic transformers	Nil
MTW-614	29/11/2018	MTO	Yes	Yes	No	-	eroding dam wall	No	on dam wall	No	No	-	May need barricading/monitoring if dam removed
MTW-615	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	-	Nil
MTW-616	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	not all found	Nil
MTW-617	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	four artefacts found	Nil
MTW-618	29/11/2018	MTO	No	Yes	No	-	severe	No	No	No	green cestrum	-	Fix erosion; remove weeds
MTW-619	29/11/2018	MTO	Yes	Yes	No	-	slight	No	No	No	No	-	Nil
MTW-620	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	quartzite noted	Nil
MTW-621	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	on track	No	ant nest	-	Barricade site as on access track
MTW-622	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	-	Nil
MTW-623	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	hammerstone also noted	Nil
MTW-624	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	four extra artefacts noted	Nil
MTW-625	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	-	Nil
MTW-626	29/11/2018	MTO	Yes	Yes	No	-	No	No	under powerline	No	No	-	Barricade site as on access track
MTW-627	29/11/2018	MTO	Yes	Yes	No	-	No	No	under powerline	No	No	-	Barricade site as on access track
MTW-628	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	high leaf litter but eight more flakes noted; potential knapping area	Nil
MTW-629	29/11/2018	MTO	Yes	Yes	No	-	No	No	No	No	No	-	Nil
MTW-630	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Nil
MTW-631	28/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Fix erosion; build a creek remediation plan into the LCACHCA PoM, which includes temporary removal of artefacts & replacement when revegetated
MTW-632	28/11/2018	MTO	Yes	Yes	No	-	severe bank erosion	No	No	No	No	many more artefacts exposed than before; recent rain demonstrates effect of sheet wash	Fix erosion; build a creek remediation plan into the LCACHCA PoM, which includes temporary removal of artefacts & replacement when revegetated
MTW-636	28/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Fix erosion; build a creek remediation plan into the LCACHCA PoM, which includes temporary removal of artefacts & replacement when revegetated

MTW-637	28/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Fix erosion; build a creek remediation plan into the LCACHCA PoM, which includes temporary removal of artefacts & replacement when revegetated
MTW-638	28/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Fix erosion; build a creek remediation plan into the LCACHCA PoM, which includes temporary removal of artefacts & replacement when revegetated
MTW-639	29/11/2018	MTO	Yes	Yes	No	-	severe	No	No	No	prickly pear, spiny rush	-	Remove weeds; fix erosion
MTW-640	29/11/2018	MTO	Yes	Yes	No	-	sheet wash	No	No	No	prickly pear	more silcrete artefacts observed	Remove weeds; fix erosion
MTW-641	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	boxthorn	-	Remove weeds; fix erosion
MTW-642	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Fix erosion
MTW-643	28/11/2018	MTO	Yes	Yes	No	-	No	No	No	rabbits	galenia	-	Include rabbit eradication plan in LCACHCA PoM
MTW-646	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	lantana	-	Remove weeds; fix erosion
MTW-648	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	under powerline	No	fireweed	-	Remove weeds; fix erosion
MTW-655	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Erosion control would be very difficult considering multitude of artefacts – discuss with MTW
MTW-659	29/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Fix erosion
MTW-665	28/11/2018	MTO	Yes	Yes	No	-	Yes	No	No	No	No	-	Fix erosion; build a creek remediation plan into the LCACHCA PoM, which includes temporary removal of artefacts & replacement when revegetated
MTW-69	28/11/2018	WML	No	Yes	No	-	No	No	No	No	No	-	Place on 2019 audit schedule; barricade site
MTW-70	28/11/2018	WML	Yes	Yes	Yes	Yes	No	No	No	No	termites	dead, burnt scarred tree	Nil
MTW-71	28/11/2018	WML	Yes	Yes	Yes	Yes	No	No	No	No	No	-	Nil
MTW-72	28/11/2018	WML	Yes	Yes	No	-	No	No	on old track	No	No	found one flake	Block off track
MTW-8*	29/11/2018	WML	Yes	Yes	Yes	Yes	No	No	No	No	No	very fragile scarred tree	Potential to trim & support through middle; split trunk & just remove scar; very poor structural condition; lots of bracing & propping required
MTW-80*	29/11/2018	WML	Yes	Yes	Yes	Yes	No	No	No	No	No	tree in good health	Remove crown, cut trunk at base then lift; not hollow; talk to CHWG about where to store; date tree through tree rings; distribute wood to CHWG members; monitor for artefacts during removal
MTW-86	28/11/2018	WML	No	Yes	Yes	Yes	No	No	No	No	prickly pear	not found due to poor GSV	Place on 2019 audit schedule; remove weeds
MTW-89	28/11/2018	WML	Yes	Yes	No	-	No	No	on old track	No	No	artefacts found	Block track off
MTW-90	28/11/2018	WML	No	Yes	No	-	sheet wash	No	on old track	No	No	not found due to poor GSV	Place on 2019 audit schedule; barricade site
WS7	28/11/2018	WML	No	Yes	Yes	Yes	No	No	on old track	No	prickly pear	not found	Place on 2019 audit schedule; remove weeds

Table 1: Results of HVO North Aboriginal Sites Compliance Inspection

* See specific section below for scarred trees.

Aboriginal Site Management Recommendations

Management recommendations were provided for almost all Aboriginal heritage sites visited. At some sites, more than one management action was recommended. The nature of these recommendations are described below.

Install barricade, wire and/or signage

Sites: MTW-614, MTW-621, MTW-626, MTW-627, MTW-69, MTW-90

These are located in areas that are subject to moderate levels of activity or are in close proximity to access ways. It is recommended that barricading, fencing and signage at these sites be installed to prevent inadvertent disturbance.

Audit in 2019

Sites: MTW-4, MTW-69, MTW-86, MTW-90, WS7

Due to poor GSV at some locations as a result of sheet-wash erosion, heavy leaf litter or ground covering vegetation, some Aboriginal heritage sites were unable to be relocated. It is recommended that further attempts are made to relocate these sites during the 2019 AHMP compliance audit inspection.

Remediate erosion

Sites: MTW-606, MTW-618, MTW-631, MTW-632, MTW-636, MTW-637, MTW-638, MTW-639, MTW-640, MTW-641, MTW-642, MTW-646, MTW-648, MTW-659, MTW-665

There are a number of Aboriginal heritage sites located on the banks of Loder Creek, or other ephemeral watercourses leading to it, that are being impacted by erosion, which is quite severe in some areas (see photographs below). Rather than a site by site approach, it is recommended that a holistic environmental remediation plan be developed and implemented for the LCACHCA, with input from the MTW CHWG and their assistance sought in its implementation. As part of this plan, approval should be sought from the Office of Environment and Heritage (OEH) to allow the temporary removal of artefacts from remediation areas and their replacement once revegetation has been established and erosion has ceased.

Erosion at MTW-632

Erosion at MTW-639

Discuss options to protect with MTW

Sites: MTW-655

This is an extremely dense Aboriginal heritage site containing hundreds if not thousands of artefacts. It is located in a short, bowl-shaped eroded gully that seems to attract the run-off from the evident sheet-wash in the area. Due to the very large number of artefacts present, the erosion control methods recommended above may not be suitable, however, it is vital that measures are implemented to prevent further possible loss of artefacts through washing into the nearby creek. It is suggested that other rehabilitation methods are explored at this site, in consultation with the MTW CHWG, rather than a collection of artefacts. Such other methods may involve erosion control around the site rather than on the site itself, and efforts to divert run off around the gully rather than through it. Being located within an Aboriginal cultural heritage conservation area, it is important that sites such as this remain in situ for the education and appreciation of future generations.

MTW-655 located around and across eroding gully

Rabbit eradication plan

Sites: MTW-643

There was evidence at this site of rabbit burrowing and disturbance, which is commonplace throughout the LCACHCA. Such activity, as well as damaging Aboriginal heritage site integrity, also impacts on an aesthetic and environmental level, both of which are of value to the area. Rather than a site by site approach, it is recommended that a widespread rabbit eradication program be developed alongside the environmental remediation plan for the whole LCACHCA, with input from the MTW CHWG and their assistance sought in its implementation.

Block old access track off

Sites: MTW-72, MTW-89

These sites are located on and immediately adjacent to a now disused vehicle track, which, although naturally revegetating, can still be accessed. As this track appears to have no current value as an accessway, it is recommended that this track be physically blocked at either end (either with an earthen bund or tree fall) to prevent inadvertent access and subsequent potential damage to these Aboriginal heritage sites.

MTW-89 located on disused access track

Remove weeds

Sites: MTW-618, MTW-639, MTW-640, MTW-641, MTW-646, MTW-648, MTW-86, WS7

Introduced weeds or noxious plants were identified at eight specific Aboriginal heritage sites, but were also noted throughout the LCACHCA. These species included green cestrum (MTW-618), prickly pear (MTW-639, 640, 86, WS7), spiny rush (MTW-639), boxthorn (MTW-641), galenia (MTW-643), lantana (MTW-646) and fireweed (MTW-648). Although the presence of such species is not specifically detrimental to the Aboriginal heritage sites, their presence is noted so that these areas can be included in MTW's regular weed eradication programs. Eradication of weeds within the LCACHCA would also fit well within the environmental remediation program suggested above. If these areas are to be treated, then access for any poisoning or plant removal must be on foot, with no unnecessary ground disturbance to be conducted.

Lantana identified at MTW-646

Prickly pear (centre-left) at WS7

Aboriginal Scarred Trees

A specific inspection was also conducted with an arborist of three Aboriginal scarred trees located west of Wallaby Scrub Road at Warkworth Mine (see Map 3 below). The aim of these inspections was to explore options for the removal and relocation of these trees in the near future. A preliminary removal methodology is presented for each tree below, which will be finalised by a suitably qualified and experienced arborist prior to the removal program.


MTW AHMP Compliance Inspection
Aboriginal Scarred Trees
MTW-80
Warkworth SSD-6464 Development Consent boundary
MTW-8
MTW-523
250 0 250 500 750 1000 m

MTW-8

Aboriginal scarred tree MTW-8 was recorded in March 2008, with the site in much the same condition as present – a dead, brittle stump. The scar measures 110 x 40cm, and was verified as being of cultural origin in October 2008.

Despite the hollow, fragile nature of the tree, advice from the arborist suggests that there is some potential to salvage the scarred portion of the trunk. Due to the tree's very poor structural condition, it is suggested that the top of the trunk is trimmed and bracing applied inside the hollow trunk to support the scarred section. When the stump is sufficiently braced, the trunk can be cut at the base and the scarred section removed, with the internal bracing to remain installed. It should be noted that, despite best endeavours, there is a low likelihood of a successful salvage operation.

Once successfully removed, the tree can be transported to the Wollombi Brook Aboriginal Cultural Heritage Conservation Area (WBACHCA) and appropriately displayed and conserved, in consultation with the MTW CHWG.

Aboriginal Scarred Tree MTW-8

MTW-80

Aboriginal scarred tree MTW-80 is a live standing blue-gum, recorded in March 2008, with the site in much the same condition as present. The small oval scar measures 50 x 35cm and was verified as being of cultural origin in October 2008.

The tree is in good health, with an intact (non-hollow) trunk, and advice from the arborist suggests that there is good potential to salvage the scarred portion of the trunk. It is suggested that the crown of the tree is removed and, while the scarred portion of the trunk is supported by a crane, the tree trunk then cut at the base. Consideration should be given to using dendrochronology to date the tree to add to our knowledge database. In addition, one of the RAPs has asked that the lopped wood from the crown be distributed to interested MTW CHWG members.

Once successfully removed, the tree can be transported to the WBACHCA and appropriately displayed and conserved, in consultation with the MTW CHWG. Two stone artefacts (a flake of mudstone and a flake of silcrete) were originally recorded at the site but have not been re-identified during subsequent site visits. CHWG representatives should be present to monitor the removal and remove any artefacts that may be uncovered.


Aboriginal Scarred Tree MTW-80

MTW-523

Aboriginal scarred tree MTW-523 was recorded during an historic heritage survey in May 2012. The site is a dead ironbark trunk, which has been deliberately felled some time ago from the road reserve. The scar may have been from a canoe, but the tree has deteriorated a great deal since recording, with the structure of the trunk collapsing onto the ground facing scar.

Despite the hollow, fragile nature of the tree, advice from the arborist suggests that there is some potential to salvage the scarred portion of the trunk. Due to the tree's very poor structural condition, it is suggested that the trunk is wrapped in carpet (or similar) and strapped together to stabilise. It could then be moved onto the forks of a forklift and placed onto a pallet, and then a flat-bed truck. It is recommended that the trunk be moved only once.

Once successfully removed, the tree can be transported to the WBACHCA and appropriately displayed and conserved, in consultation with the MTW CHWG. It should be noted that, despite best endeavours, there is a low likelihood of a successful salvage operation.

Aboriginal Scarred Tree MTW-523 (scar facing ground)

Appendix 4:

Historic Heritage Management Plan Compliance Inspection Report

Mount Thorley Warkworth
Historic Heritage Management Plan
Compliance Audit Inspection

Report prepared for

Yancoal Australia, Mount Thorley Warkworth

December 2018

Joel Deacon

ARROW
HERITAGE SOLUTIONS

Introduction

Yancoal Australia (Yancoal) manage the Mount Thorley Warkworth (MTW) mining complex located in the Hunter Valley, approximately 8km south-west of Singleton. Approval for the continuation & expansion of the mine, which will allow the mine to extract a further 230 million tonnes over 21 years, was granted on 26th November 2015 under two separate project approvals: the Warkworth Continuation Project Approval (SSD-6464) & the Mount Thorley Operations Project Approval (SSD-6465).

Pursuant to Condition 46 of the Warkworth Continuation Project Approval, Yancoal have developed a MTW Historic Heritage Management Plan (HHMP) that covers the whole MTW mining complex. The MTW HHMP was approved by the Department of Planning & Environment on 11th October 2017 and sets out the principles, processes & measures through which historic heritage will be managed within the HHMP Area. This includes the commitment (Provision 19) to conduct annual HHMP compliance inspections with members of the community through the auspices of the Community Heritage Advisory Group (CHAG). The purpose of the HHMP compliance inspections is to:

a. inspect areas and sites to assess compliance with the provisions of the HHMP;
b. inspect and monitor the condition and management of various sites; and
c. review the effectiveness and performance of the HHMP provisions in the management of historic heritage at MTW.

Proposed Activity and Project Brief

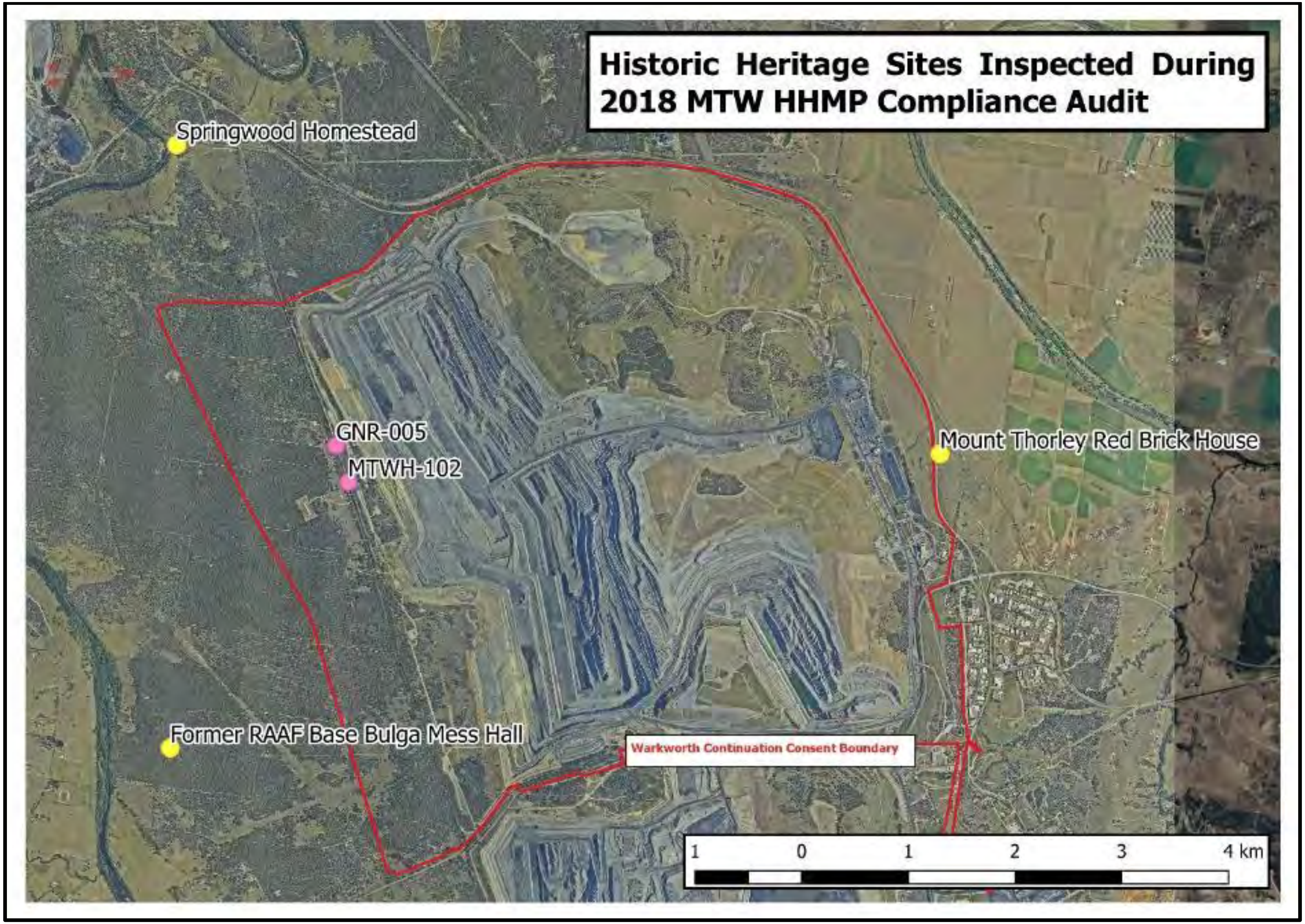
The Terms of Reference provided to the consultant on 17 September 2018 outlined the historic sites to visit and the tasks to be completed during the HHMP compliance audit inspection:

- Re-locate the two historic blaze trees within the Wallaby Scrub Road corridor with an arborist to discuss method of removal;
- Inspect the following historic sites within the MTW HHMP area to assess compliance with actions listed in the HHMP and specific Conservation Management Plans (CMP), and also collate a detailed photographic record for each site as a baseline for future inspections:
    - Former RAAF Base Bulga Mess Hall
    - Springwood Homestead
    - Mount Thorley Brick Farm House

Timing & Personnel

The MTW HHMP compliance inspection was conducted on Friday 30th November 2018. The personnel involved in this inspection were:

Name	**Position/Organisation**
Joel Deacon	Archaeologist, Arrow Heritage Solutions
Travis Bates	Specialist Environment and Communities, MTW
Neville Hodkinson	CHAG representative


Historic Heritage Sites Inspected During 2018 MTW HHMP Compliance Audit
Springwood Homestead
GNR-005
MTWH-102
Mount Thorley Red Brick House
Former RAAF Base Bulga Mess Hall
Warkworth Continuation Consent Boundary
1 0 1 2 3 4 km

Arrow Heritage Solutions were engaged as independent heritage consultants to conduct the HHMP compliance inspection, and Joel Deacon acted as technical advisor and author of this report. MTW's Environment and Communities Specialist Travis Bates arranged the compliance inspection program and escorted the field team. Neville Hodkinson responded to an invitation sent to CHAG members and participated as a representative of that forum. An arborist had earlier visited the historic blazed trees with the consultant to provide technical arborist advice on their management.

Historic Blaze Trees

Two historic blaze trees are located within the Wallaby Scrub Road corridor, likely associated with delineating the easement of road. GNR-005 is located on the western side of Wallaby Scrub Road, c.5m east of the current road. The scar faces east, c.90cm from the base of the tree, and measures 550 x 200mm. The scar has previously been painted white, bears an axe mark and nail, but has no other discernible numbers or arrows. MTWH-102 is also located c.5m east of Wallaby Scrub Road and the blaze is of a similar size, though closer to the base of the tree. This scar also contains a nail, but the tree, an ironbark, has been affected by fire.

Blazed Tree GNR-005

Blazed Tree MTWH-102

HHMP Requirements

With regards to actions required within the MTW HHMP, these only apply to site GNR-005. There are no historic heritage management actions required for MTWH-102. The management actions required for GNR-005 are to:

- Photographically record the tree; and
- Remove the scarred portion of the tree and deposit with the Singleton Historical Society and Museum (SHSM) or at the Hunter Valley Services Cultural Heritage Storage Facility.

The archival recording and photographing of the tree has been conducted by Veritas Archaeology and History Services, with copies of this work stored at MTW. The arborist who inspected the tree has advised that the blaze would be able to be easily removed from the trunk by removing the tree crown above the scar and cutting below the scar to detach the section from the trunk. It should be noted that since the approval of the MTW HHMP, MTW no longer has access to the Hunter Valley Services Cultural Heritage Storage Facility. Rather, the Cultural Heritage Storage Facility managed by MTW at 1916 Putty Rd should be used as a repository if the SHSM decline the offer of accepting the blazed tree portion.

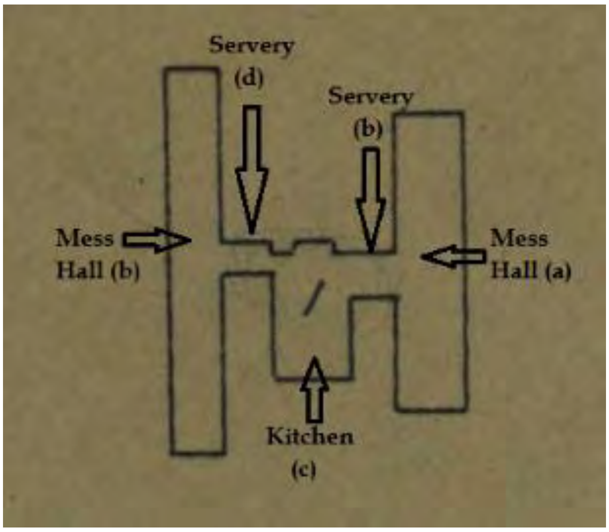
Recommendations

1. As the two trees are very similar in age, condition and purpose, MTW should consider applying the below recommendations to both trees, despite only having obligations for GNR-005;
2. A suitably experienced tree-lopper (or similar professional) should be engaged to extract the blazed portion of the trunk from the tree with chainsaw by first removing the top part of the trunk and crown, followed by cutting the trunk below the blazed section;
3. Offer the blaze sections, with relevant contextual information, to the SHSM for display. If the SHSM decline the offer, suitably store the trees at the 1916 Putty Rd Cultural Heritage Storage Facility.

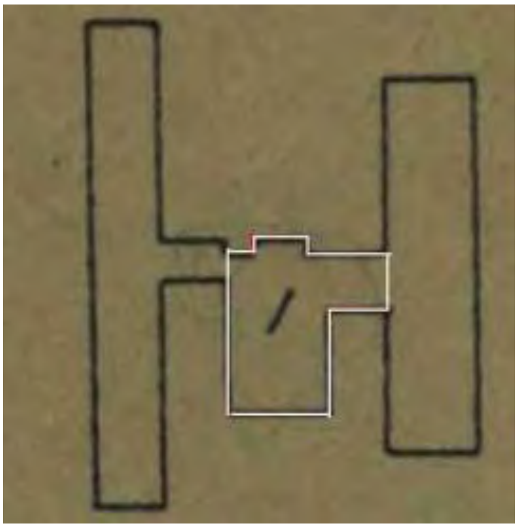
Former RAAF Base Bulga Mess Hall

Following the Japanese attack on Pearl Harbour in December 1941, plans were approved to expand existing RAAF bases and establish new ones, including a number of sites in the Hunter Valley. Bulga was identified as a potential site for an operational base and the area was officially taken over by the RAAF on 12 June 1942 for use as a relief landing strip. By July 1943 the site was completed, including the kitchen and mess hall, however, by January 1944 the use of the site was limited due to the decreasing threat of attack. A 1946 condition report noted this building as deteriorating. In January 1953, the building was noted as missing a few sheets of iron and windows.

The building sits in the former camp area west of the north-south runway. It was originally irregular in plan comprising a central kitchen area measuring 13.4 x 8.8m, with long rectangular mess halls to the east and west, connected by a servery on either side. The remnant structure today comprises the kitchen building and the foundation of one of the serveries (see below).



Original layout of building



Remaining structure

The remnant building is "L" shaped in plan with brick and concrete footings. During the original assessment conducted by ERM in November 2012 the building was noted as being in poor condition with trees physically impacting on the building fabric, and some minor settlement issues resulting in cracking and failing brickwork. The western section of the building was the most intact part, retaining the original timber frame, corrugated asbestos cement roof sheeting and walls clad with corrugated iron sheeting.

View to mess from south-east (2012)

Remnant kitchen area (2012)

The building is currently structurally unsound, with a large tree impacting on the roof and a number of timber elements either missing or in a deteriorated state. Corrugated asbestos roof sheeting is also missing in some places, and damaged and in poor condition where it remains. Much of the corrugated iron sheeting is corroded. Brickwork is also cracking in a number of locations resulting in significant movement outward, loss of mortar and loss of bricks along the southern and eastern elevations.

As a result, a number of structural recommendations were outlined by ERM in a CMP developed for the site in 2012. These recommendations were not intended to return the building to a serviceable state, rather they seek to do the minimum required to allow safe access to the building to prevent significant damage, and also allow safe access for asbestos removal and internal inspection of the building in the short to medium term.

CMP Requirements

Short to medium term structural recommendations include:

a) **Remove fallen tree branch.** The tree branch impacting on the roof of the building should be removed, using an external mobile elevated platform or boom lift;
b) **Temporary propping.** The building should be temporarily propped and supported as per Bligh Tanner plans SK 1.0 A and SK 2.0 A (contained within the CMP) to allow for safe access into the building and more detailed inspection of the structure.
c) **Asbestos Removal.** Asbestos removal should be completed by a licensed asbestos removal specialist, include the roof sheeting, all asbestos dust and fibres, and loose fragments that are known to exist in the remaining area.
d) **Stabilise framework and replace roof.** Any structural roof members that are destabilized once the roof sheeting is removed are to be secured as required. Side walls which lose stiffness once the roof sheeting has been removed are to be propped temporarily until the new roof has been replaced.
e) **Archaeological clean-up.** Asbestos removal and clean-up should be supervised by a historical archaeologist to ensure any identified items of significance are retained.

f) **Further building inspection.** A structural engineer should complete a building inspection to identify structural repairs and stability requirements with four weeks of the building being cleaned up and decontaminated from asbestos.

Following the internal inspection of the building noted in (f) above, further advice may be provided regarding medium to long term recommendations. Due to the lack of integrity of the building, recommendations are unlikely to be directed at restoration of the building, but more towards retaining the remnant structure in a safe environment and reducing further deterioration. Repair drawings have been provided in the CMP to remedy any major cracking in the brickwork or where sections of brickwork have either partially collapsed or broken away from the wall.

Photographic Comparison 2012 - 2018

During the inspection of the Former RAAF Base Bulga Mess Hall for this report, a number of photographs were taken from the same angles and of the same features as were taken during the ERM 2012 assessment and archival recording. These photographs provide a visual baseline condition assessment of the building, and also allow a comparative analysis of the deterioration levels over the last six years. These photographs are set out below, along with comments pertinent to management recommendations.

2012	2018
	
East elevation: no discernible change – note fallen branch from tree on western side.	
	
View to north-east elevation: roof over open kitchen area has deteriorated, causing severe lean on far wall.	


South-east elevation: evidence of increased bow to southern wall.


South elevation: evidence of increased bow to southern wall and missing panel above entry.


West elevation: shows deterioration of roofing members above open kitchen area and leaning north wall, and further collapse of asbestos roof due to fallen dead tree.


North elevation: no discernible change.


North-east elevation: difficult to discern change.


Concrete and brick foundation at east side of building: difficult to discern change.


View to building interior from north-east: shows collapse of remnant roofing members above open kitchen area.


Grease trap at south end of building: shows bow to south wall.


Storage area at south end of building: further slight collapse of storage area.

	
Windows and entry at west elevation: shows large trunk/branch portions of tree collapsed on roof, which has destroyed roof ventilator.	
	
Timber window detail, west elevation: no discernible change.	
	
Showing cylindrical ventilator and damage to roof, view from west: shows significant roof damage from fallen dead tree, including to ventilator.	

	
Detail of north-west elevation: shows increased collapse over open kitchen area, as well as new damage to brick foundation at north-west corner.	
	
Showing interior damage at kitchen at north end of building: shows increased collapse over and accumulation of debris within open kitchen area. Note also severe lean to north wall.	
	
Showing interior damage at kitchen at north end of building: shows increased collapse over and accumulation of debris within open kitchen area. Note also severe lean to north wall.	

	
View to interior of south end of building, view from east: shows increased collapse over open kitchen area.	
	
Showing stove at kitchen at north end: note the remaining two stove doors have become unhinged and build up of debris from collapsed roof.	


View to interior, showing west entry to building: no discernible change.


Showing west interior space: no discernible change.


Damaged brick foundation at south-east corner: no discernible increase to cracked brick foundation.


Detail of damaged brick foundation: some further collapse of concrete/cement above brick foundation.


View to interior of building, looking north from south entry: no discernible change.


View to interior of building from entry at west: no discernible change.

Showing interior of building, viewed from north-west corner: shows collapsed roofing members above open kitchen area and accumulation of debris.

Showing interior of building, viewed from north-west corner: shows collapsed roofing members above open kitchen area and accumulation of debris.

The comparative photographs above show the changes at the building over the past six years. Apart from the general deterioration of the panelling and timber within the 75 year old mess hall, the major negative changes can be summarised as:

- Collapse of dead tree onto western side of asbestos roofing causing damage to sheeting and roofing members, as well reducing structural stability of southern wall;
- Complete collapse of remaining roofing members over open kitchen area causing increased debris and severely reducing the structural stability of the northern wall; and
- New damage to brick foundation in north-west corner.

The following recommendations are based on those presented in the 2012 ERM CMP and also take into account the condition of the mess hall building in 2018.

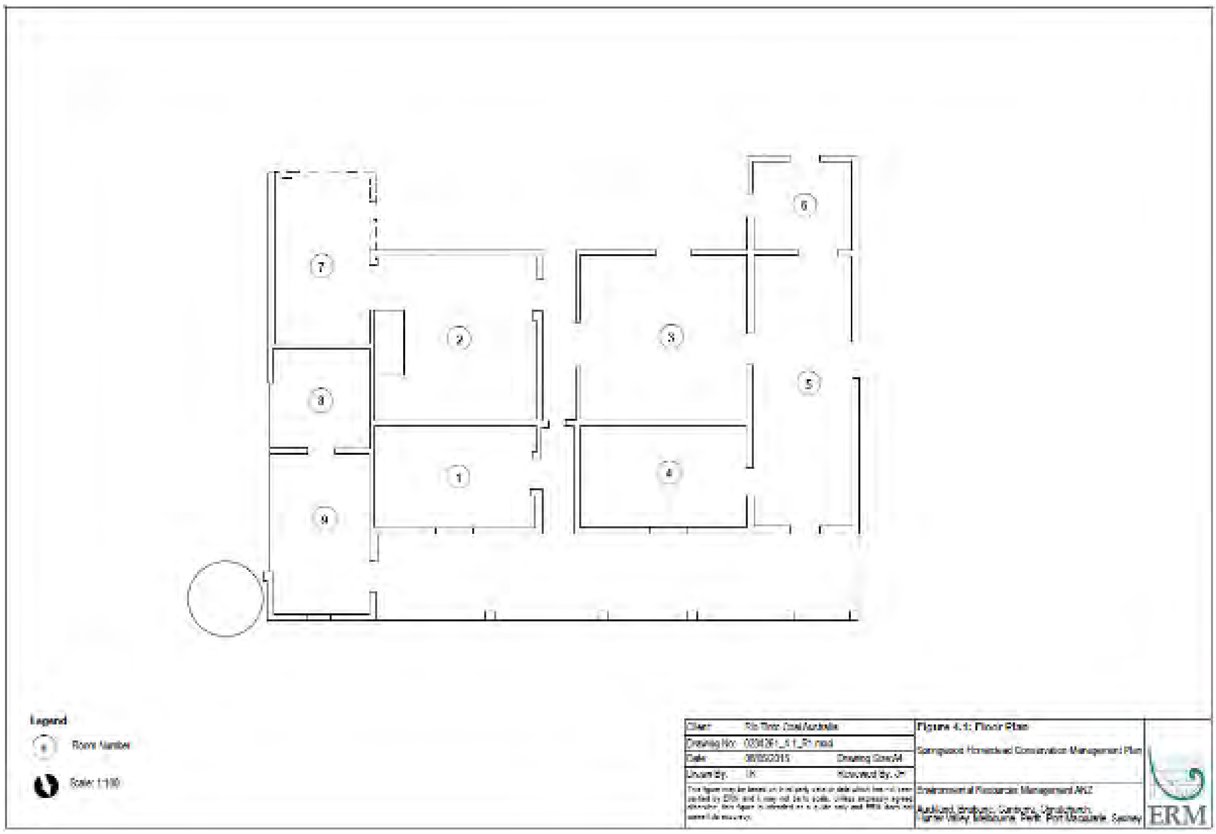
Recommendations

1. Remove the fallen dead tree from the roof. In addition, to prevent similar damage in the future, serious consideration should be given to removing or lopping those trees that are located close enough to the building that they may cause damage if they fall or drop large branches;

2. The building and surrounds should be thoroughly cleaned of asbestos and other rubbish material. An archaeologist should be present to collect any items of historic importance or that relate to the original fabric of the building. These can be stored inside the building and potentially re-used during further stabilization programs;
3. Any parts of the building framework, such as roofing members of walls should be stabilized and propped, using the Bligh Tanner plans as a guide;
4. A structural engineer should then inspect the building before any further works are commenced to make further recommendations on stability requirements and structural repairs; and
5. Future condition inspections should photograph the building using the photograph views and locations above so that any changes to the building can be documented.

Springwood Homestead

Based on historical research, Springwood Homestead is likely to have been constructed c.1860, and displays many characteristics of late Old Colonial Georgian and Victorian Georgian architecture, including an original shingle broken-backed roof, fanlights or transom lights, panelled doors and under-roof verandahs. The homestead is low-set, constructed in vertical timber slabs and built around a four room square core, as shown in the plan below (taken from ERM's 2015 CMP).



Given that Springwood Homestead is timber framed and in direct contact with the ground, it is remarkable that it is still standing and in a stable condition, with most roof rafters appearing to be still in place. Although the building fabric is generally intact there are a number of areas where the level of structural damage to the roof, wall and flooring members is high. The majority of the damage has occurred from white ants and fungal decay, resulting in localised collapse of outer external walls and roof structures. Within the CMP developed for the site by ERM in 2015, a number of stabilisation measures have been recommended that will assist to reduce the extent of damage, however a return to a habitable state is not planned.

Springwood Homestead in 2012

CMP Recommendations

Although many recommendations are made within the CMP, the more important management measures have been incorporated within a conservation works schedule that covers the following issues:

- Drainage and weatherproofing;
- Asbestos;
- Vegetation;
- Termites and vermin;
- Building fabric; and
- Structural capacity and wind loads.

The works schedule prioritises the required conservation works and are presented with technical specifications from a structural engineer. Those measures that attend to the buildings structural integrity are the focus of the schedule.

High Priority

a) Remove debris from roof using a cherry picker or similar;
b) Remove tree from eastern elevation and stabilize building in this location;
c) Remove vine from eastern wall using combination of pruning and herbicide;
d) Remove tree from south-west corner and stabilize building in this location;
e) Prune all overhanging branches and maintain regular maintenance program; and
f) Reinstate southern verandah and roof to match northern elevation.

Moderate to Low Priority

g) Place treated plywood sheeting over door openings;
h) Prune trees, spray weeds and slash grass;

i) Clean up of site surrounds, overseen by archaeologist;
j) Clean up of building interior, overseen by archaeologist;
k) Refix loose ceiling boards, retaining evidence of fabric if unable to fix;
l) Refix loose and dislodged slabs and plates; and
m) Place treated plywood sheeting over openings and undertake repairs to windows.

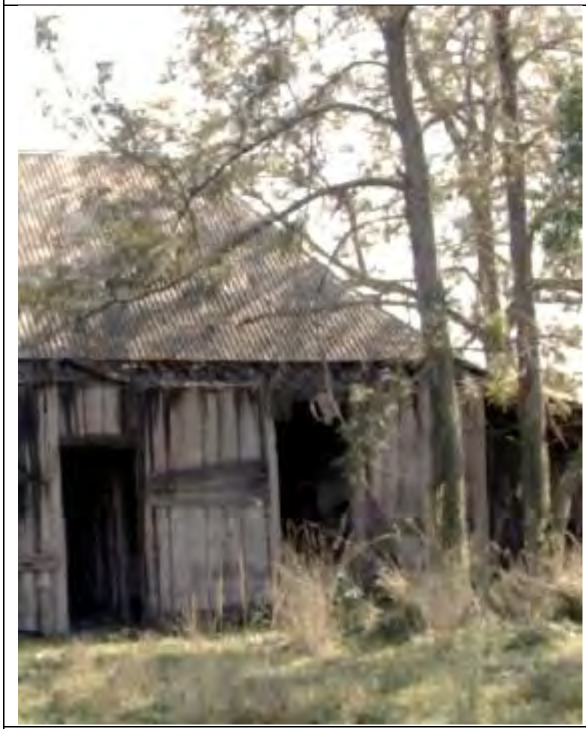
Photographic Comparison 2014 - 2018

During the inspection of Springwood Homestead for this report, a number of photographs were taken from the same angles and of the same features as were taken during the ERM 2014 assessment that informed the 2015 CMP. These photographs provide a visual baseline condition assessment of the building, and also allow a comparative analysis of the deterioration levels over the last three years. These photographs are set out below, along with comments pertinent to management recommendations.

2014	2018
	
Northern entrance: further deterioration of overlaid weatherboard.	

	
Eastern elevation: no discernible change.	
	
Looking towards south-west corner from east: no discernible change to tree impact, but note missing vertical slabs from southern wall.	

	
Looking towards south-west corner from south-west: no discernible change to tree impact, but note missing vertical slabs from southern wall.	
	
Southern elevation: vertical timber slabs have been removed from southern wall.	

	
Southern elevation: vertical timber slabs have been removed from southern wall.	
	
Southern elevation: vertical timber slabs have been removed from southern wall.	

	
Southern elevation: vertical timber slabs have been removed from southern wall.	
	
Southern elevation doorway: door has been removed.	
	
South-eastern corner: vertical slabs have been removed causing further collapse of roof.	

	
Eastern side: debris has been cleaned and stored and a weed removal program conducted. The house area has also been fenced.	
	
Room 2 interior: increased debris caused by removal of southern wall.	

	
Room 4 ceiling: no discernible change.	
	
South-west corner: shows removal of vertical slabs from southern wall.	

	
Northern elevation: further deterioration of weatherboard panelling.	
	
South-east corner: shows removal of vertical slabs from southern wall and further collapse of roof.	

	
Eastern elevation: possible further collapse of crossbeam and guttering.	
	
Northern elevation: slumping of verandah along edge beam.	

View of south-west corner from south: shows removal of vertical slabs from southern wall as well as some increase in vegetation growth.

The comparative photographs above show the changes at the building over the past four years. Some of the deterioration has been severe, making the implementation of the management recommendations below imperative to halt rapid decline to the building's integrity and stability. These major negative changes are:

- The removal of all of the vertical timber slabs from the southern wall, not only reducing the structural integrity of this side of the building but also now allowing weather and its associated adverse impacts into the building; and
- Continued growth of trees and vines and their localised impacts on structural stability.

It was noted during the inspection that some positive management measures had been implemented, including the removal of weeds and vegetation from around the homestead, the clean up of debris from around the exterior of the building, and the erection of fencing. The following recommendations are based on those presented in the 2015 ERM CMP and also take into account the condition of the homestead in 2018.

Recommendations

Management recommendations can be prioritised as of high or moderate importance, and high priority recommendations should be actioned as soon as possible and prior to the 2019 compliance inspection of the building, at which time these recommendations and the conservation works schedule within the CMP can be re-evaluated and amended by a structural engineer prior to further works being commenced.

High Priority

1. Remove the trees and vines currently impacting the building at the eastern elevation and south-west corner, and treat to prevent regrowth. Coincident with this removal, acrow props should be installed where appropriate, i.e. where the trees themselves have supporting the building structure, and as per the structural engineer's instructions at Annex B of the CMP;
2. Once vegetation has been removed, clean all debris from roof and prune (or consider the removal of) all other trees in close vicinity of the building with potential to drop leaf/branch litter on roof;
3. Clear the surroundings of the building of rubbish, overgrowth and weeds in the accompaniment of an archaeologist to ensure any items of historical relevance are salvaged and stored within the homestead;
4. Due to the damage caused by the removal of the vertical slabs, once the items above are complete, a structural engineer should then re-inspect the building before any further works are commenced to make further recommendations on stability requirements and structural repairs; and
5. Due to the vandalism caused to the homestead by unauthorized removal of historically significant and structurally important vertical timber slabs, a security regime including the deployment of video cameras should be implemented to deter and prevent future similar episodes.

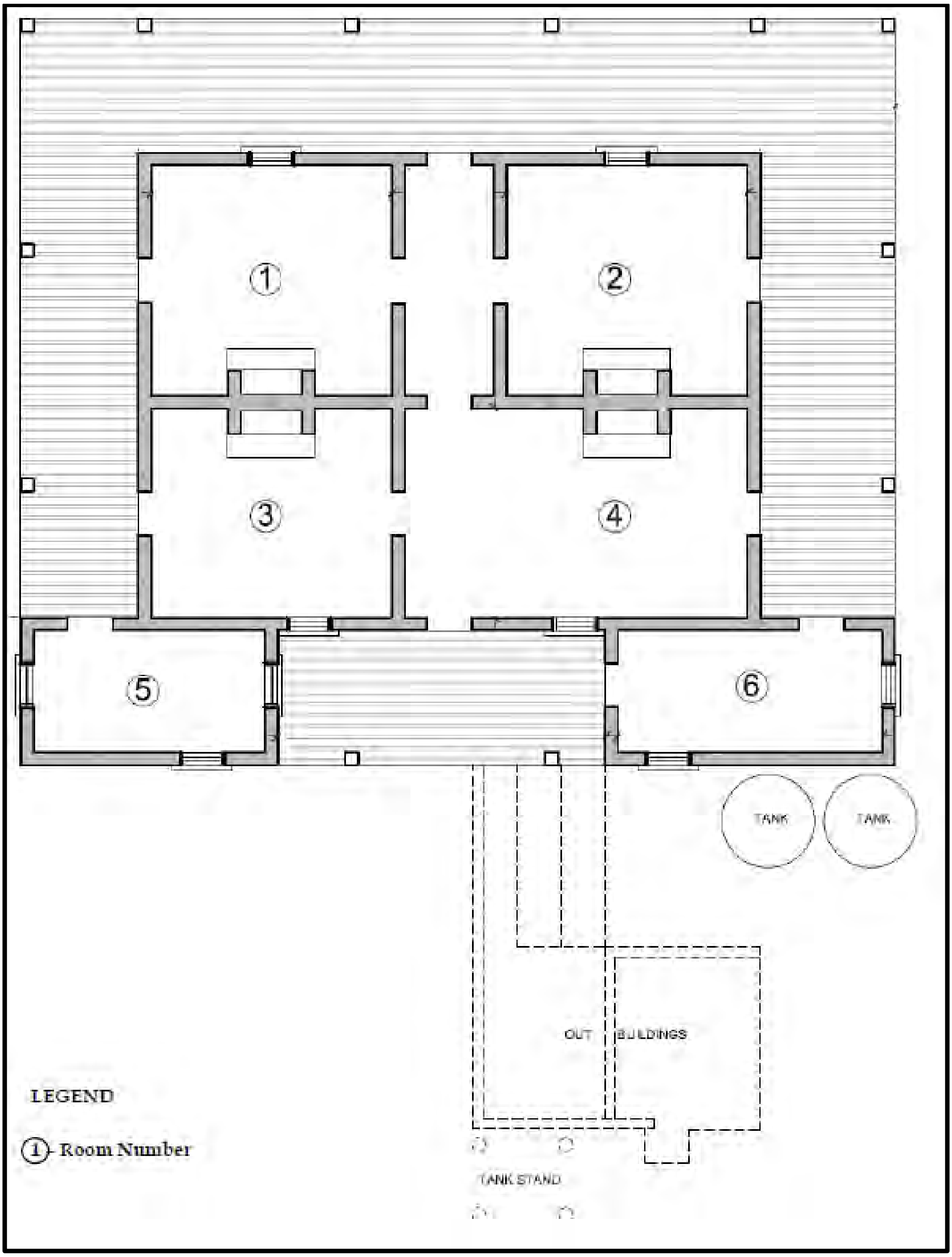
Moderate Priority

Once the high priority recommendations have been attended to, the structural engineer may recommend different or additional measures than originally put forward. Notwithstanding these, the following moderate priority measures are recommended to attain compliance with the CMP and enhance the condition of the homestead:

1. Due to their propensity to harbour termites and transfer infestation to the building, remove all peppercorn trees from around the building;
2. Future condition inspections should photograph the building using the photograph views and locations presented above so that any changes to the building can be documented in subsequent inspections;
3. Implement and maintain regular vegetation maintenance and termite control program;
4. Pending structural engineer's advice, reinstate southern wall, verandah and roof to match northern elevation.
5. Pending reconstruction of southern wall, place treated plywood sheeting over door and window openings;
6. Clean up of building interior, overseen by archaeologist;
7. Pending structural engineer's advice, refix loose ceiling boards and loose and dislodged wall slabs and plates, retaining evidence of fabric if unable to fix;
8. Ensure the minor recommendations and 'policies' listed throughout Section 7 of the CMP are considered in the future management of the homestead; and
9. Give consideration to an archaeological excavation and research program at the site, with possible community involvement, to explore the areas of archaeological potential identified in the CMP.

Mount Thorley Brick Farm House

The Mount Thorley Brick Farm House is located off the Golden Highway opposite the MTW coal handling and preparation plant, c.10km south-west of Singleton. The portion of land on which the house sits was purchased by Eliza Glass in 1870 and the physical attributes of the house, which display characteristics of Victorian Georgian architecture, suggest that it was constructed during the following decade. The building is roughly square in plan, with four principal rooms flanking a central hallway.



Floor plan of Mount Thorley Brick Farm House, north up (from ERM 2015 CMP)

The masonry structure of the building is sound, however, it was noted as being in poor physical condition in 2015 (when a CMP was developed for the site by ERM), with a collapsed verandah roof, missing or loose roof sheeting, missing or collapsed verandah posts, and floorboards and areas affected by termites. Recommendations are made within the CMP's conservation works schedule to arrest the deterioration of the building, a number of which appear to have been completed by the proponent.

Mount Thorley Brick Farm House (2012)

CMP Recommendations and Photographic Comparisons

The conservation works schedule within the CMP considered the following issues at Mount Thorley Brick Farm House:

- Drainage and weather-proofing;
- Asbestos;
- Vegetation;
- Termites and vermin;
- Building fabric; and
- Structural capacity and wind loads.

The following CMP recommendations were prioritised in order to stabilise the building to ensure it may be able to be adaptively reused in future. It is noted below where these works have been completed. "Before and after" photographs compare the specific locations and issues from 2015 to the 2018 inspection. Photographs from 2015 are shown on the left below each recommendation, with 2018 photographs on the right.

High Priority

1. Remove partially collapsed verandah entirely to prevent further stress and damage to the building where it remains connected. Store verandah elements on site so they are protected from the weather and off the ground away from the threat of termites **(complete)**;

2. Ensure that vegetation is cut back and away from structures on a regular basis **(has been completed in the past)**;

3. Place 12mm painted maritime grade plywood sheeting over all window and door openings and ensure all openings are weather tight and vermin proof **(complete, however some panels require maintenance)**.

Moderate Priority

1. Have an asbestos removalist take samples of broken fibrous cement sheeting to test for the presence of asbestos, and remove as required **(possibly complete as clean-up of debris appears to have occurred)**;

2. Implement an annual termite inspection regime and treat as required **(unsure if has occurred)**;

3. Remove all debris, ensuring an archaeologist is on hand to identify and catalogue any early architectural fittings or rare pieces of joinery that should be retained for future restoration purposes **(appears to have occurred, however overgrowth will need removing to confirm)**;

4. Assess any damage to rafters/joists/battens where roof sheeting is missing on main roof, and replace to match existing. Replace any damaged soffit or fascia boards at the same time **(as roof has been repaired this may have occurred)**;

   Undertake patch repairs to roof and replace missing roof sheeting to match existing. Refix loose sheets and flashings. Replace roof screws with new galvanized screws **(complete)**;

5. After completely detaching verandah from the building, restore verandah roof frame by re-using original fabric where possible including wall plate, battens and rafters **(not complete)**;

   Repair verandah posts with damaged lower sections by removing these sections and splicing new pieces of timber to match existing **(not complete)**;


   Re-install verandah roof with corrugated galvanized iron to match existing bull-nosed profile **(not complete)**;

6. Remove all debris from verandah and assess extent of damage to verandah boards and joists. Replace to match existing **(clean-up complete only)**;


7. Replace damaged timber members and install new roof sheeting on southern skillion roof to match existing **(not complete)**;


8. Rebuild northern brick wall of room 6 and repoint mortar joints **(not complete – wall element has collapsed)**;


9. Replace timber members of roof framing above Room 6 to match existing **(not complete – roof has collapsed)**;


10. Replace gutters to match existing materials and ogee profile. Install new down-pipes and ensure they are discharging away from the building **(not complete)**;

11. Repoint mortar joints with lime based mortar on brickwork below Room 6 eastern elevation window sill **(not complete)**;

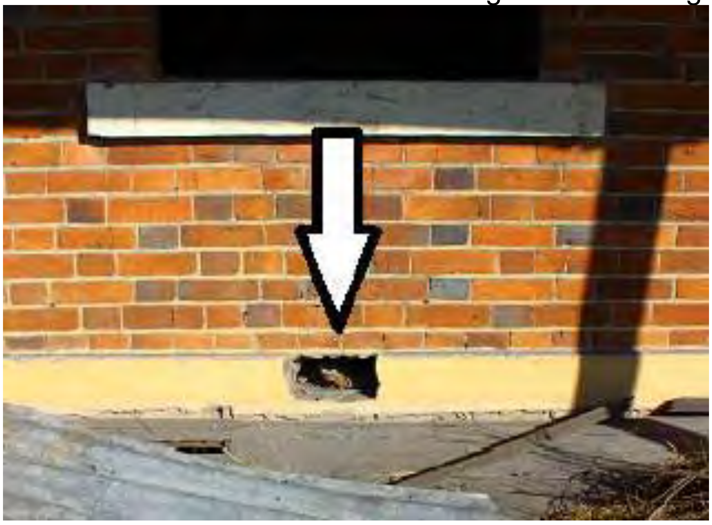
12. Monitor northern wall of Room 5, and if cracking or leaning worsens rebuild brick wall and repoint mortar joints **(no discernible worsening)**;

13. Clean up debris against eastern elevation to below ventilation opening **(not complete)**.

Low Priority

1. Reconstruct cement rendered brick dwarf wall on northern elevation verandah and undertake patch repairs to cement render **(not complete)**;

2. Install new ventilation grilles to existing openings **(not complete)**;



3. Repoint mortar joints on northern wall of Room 5 **(not complete)**; and


4. Repoint chimney mortar joints **(not complete)**.


Recommendations

The high priority and many of the moderate priority recommended actions within the CMP conservation works schedule have been implemented. The recommendations outlined below will complete this works schedule and include a regular maintenance regime to ensure the building continues to be monitored and remediation works conducted when required.

1. Implement a regular vegetation slashing and maintenance schedule for the building surrounds, ensuring all debris is clear from ground-level ventilation openings;
2. Replace any damaged plywood door/window coverings and ensure all coverings are tightly attached;
3. If any asbestos or fibrous cement sheeting remains at the property, engage an asbestos removalist to take samples and remove as required;
4. Implement an annual termite inspection regime and treat as required, giving consideration to removing the peppercorn trees surrounding the building;
5. After next vegetation slashing, check that all debris surrounding the house has been removed. If this has not occurred, remove all debris, ensuring an archaeologist is on hand to identify and catalogue any early architectural fittings or rare pieces of joinery that should be retained for future restoration purposes;
6. Reinstall verandah, including verandah decking and northern brick dwarf wall, re-using original material where possible, as per recommendations M5, M6 and L1 in the CMP conservation works schedule;
7. As the roof above Room 6 has collapsed, salvage any reusable masonry or timber and set aside within room. Engage a structural engineer to advise on feasibility of reconstructing the roof. (NB. Recommendation M9 in the CMP conservation works schedule erroneously refers to Room 5 rather than Room 6 as shown in the photograph);
8. Replace gutters around the house to match existing materials and ogee profile. Install new down-pipes and ensure they are discharging away from the building.
9. Repoint mortar joints with lime based mortar on brickwork below Room 6 eastern elevation window sill, on northern wall of room 5 and all chimneys;
10. Install new ventilation grilles to existing ground level openings; and
11. Future condition inspections should photograph the building using the photograph views and locations presented above so that any changes to the building can be documented in subsequent inspections.

Appendix 5:

Annual Stream Health and Stability Report

2018 STREAM HEALTH AND STABILITY REPORT

Mount Thorley Warkworth

SLR Ref: 630.12636-R01
Version No: -v0.2
March 2019

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
630.12636-R01-v0.2	8 March 2019	Emily Curtis / Stephane Peignelin / Matt Doherty	Duncan Barnes	Paul Delaney

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DOCUMENT REFERENCES

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APPENDICES

1 Introduction

SLR Consulting Australia Pty Ltd (SLR) were previously engaged in December 2017 by Bulga Surface Operations (BSO) and Mount Thorley Warkworth (MTW) to conduct channel stability and stream health monitoring of creeks adjacent to the mine sites. An integrated channel monitoring program was developed as both mines discharge into the same drainage lines (e.g. Loder Creek). The monitoring program includes channel stability and stream health assessments at six specific monitoring points (two of which are only specific to BSO and one point which is only specific to MTW). In addition it also includes a visual inspection of Loder Creek from the Hunter River to the MTW discharge point to identify any areas of increased erosion.

SLR were subsequently engaged to undertake the 2018 annual channel stability and stream health monitoring to identify any changes to the creeks including any new erosion features in accordance with regulatory requirements. This report has been specifically prepared for the MTW monitoring points and should be read in conjunction with the baseline report titled *'2017 MTW Annual Stream Health and Stability Report FINAL'* issued on the 21th December 2017.

MTW advise there have been nil discharge events from the MTW discharge point between the 2017 stream health monitoring event and the 2018 monitoring event. There has been 362 mm of rainfall recorded within the on-site rainfall gauge for the period 22nd November 2017 to 7th November 2018. In comparison, the Bureau of Meteorology shows an annual average of 653mm at Singleton (Singleton STP 61397). This indicates that this round of monitoring was subjected to a significantly drier year than what occurs on average within the region.

2 METHODOLOGY

In accordance with the accepted scope of works the following procedure was undertaken at each monitoring site:

1. Documenting locations and dimensions of significant erosive or depositional features;
2. Photographs upstream, downstream and at both banks;
3. 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);
4. 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
5. Taking measurements of the channel cross-sections (transects) for comparison purposes for any future monitoring.

2.1 Rapid Appraisal of Riparian Condition (RARC)

The RARC is an assessment method incorporating indicators of geophysical and biological properties and processes which are likely to provide reliable estimates of ecological condition in riverine ecosystems (Land & Water Australia, 2005). The RARC index is made up of five sub-indices, each with a number of indicator variables which can be seen in **Table 1** below.

Table 1 Summary table of indicators, functions and components assessed in the RARC (Land and Water Australia, 2005)

Functions of the riparian zone at different levels of organisation	Components of the riparian ecosystem that perform those functions	Indicators of the functions used in the RARC
Physical:		
Reduction of erosion of banks	Roots, ground cover	Vegetation cover*
Sediment trapping	Roots, fallen logs, ground cover	Canopy cover, fallen logs, ground cover vegetation, leaf litter cover
Controlling stream microclimate/ discharge/water temperatures	Riparian forest	Canopy cover
Filtering of nutrients from upslope	Vegetation, leaf litter	Ground cover vegetation, leaf litter cover
Community:		
Provision of organic matter to aquatic food chains	Vegetation	Vegetation cover*, leaf litter cover
Retention of plant propagules	Fallen logs, leaf litter	Fallen logs, leaf litter cover
Maintenance of plant diversity	Regeneration of dominant species, presence of important species, dominance of natives *versus* exotics	Native canopy and shrub regeneration, grazing damage to regeneration, reeds, native vegetation cover*
Provision of habitat for aquatic and terrestrial fauna	Fallen logs, leaf litter, standing dead trees/hollows, riparian forest, habitat complexity	Fallen logs, leaf litter cover, standing dead trees, hollows, vegetation cover*, number of vegetation layers
Landscape:		
Provision of biological connections in the landscape	Riparian forest (cover, width, connectedness)	Vegetation cover*, width of riparian vegetation, longitudinal continuity of riparian vegetation, proximity to other habitat
Provision of refuge in droughts	Riparian forest	Vegetation cover*

* Vegetation cover = canopy, understorey and ground cover

In accordance with previous annual stream health surveys undertaken at the site classifications have been assigned based on the total score as assessed by the RARC methodology. It is useful to compare this total score over time to see how the biodiversity and functionality of the riparian zone is progressing at each of the monitoring points. **Table 2** below outlines these classifications.

Table 2 Summary RARC Classification System

RARC Total Score	Classification
40-50	Excellent
35-39	Good

RARC Total Score	Classification
30-34	Average
25-29	Poor
<25	Very Poor

2.2 CSIRO Ephemeral Stream Assessment

The CSIRO *Ephemeral Stream Assessment* procedures (CSIRO, date unknown) were used to assess the channel stability of the creeks in the vicinity of the MTW Mine. The assessment uses four main classes of indicators to evaluate the degree of stream-bed condition:

1. The type and condition of the vegetation present, if any;
2. The shape and profile of the drainage line and type of materials on the drainage line floor;
3. The nature of the drainage line wall materials; and
4. The nature of the stream bank bordering flats and/or slopes and regulation of lateral flow into the drainage line.

The indicators produce a rating based on a scoring system, and the combined total of the indicators rank each location from very actively eroding through to very stable as shown in **Table 3.** This enables an assessment to be made as to whether the section of creek has changed since previous rounds of annual monitoring.

Table 3 Classification of different drainage line states (CSIRO)

Activity Rating (%)	Classification	Discussion of Classification
80 +	Very Stable	Drainage line is very stable and likely to be in original form. It is able to withstand all flow velocities that have previously occurred in this area and only minimal monitoring is required, predominantly after high flow events, to ensure condition does not deteriorate.
70-80	Stable	Drainage line is stable. It is important to assess this zone in relation to the other classifications and define whether this zone is moving from potentially stabilising to a more stable form, or if it is deteriorating from a very stable form. The nature of this relationship will identify the type of monitoring required.

Activity Rating (%)	Classification	Discussion of Classification
60-69	Potentially Stabilising	Drainage line is potentially stabilising. Ongoing monitoring is required while rehabilitation works are not needed in the immediate future.
50-59	Active	Drainage line is actively eroding and remedial actions are required. It is important to classify if erosion is caused primarily by upstream flows, lateral flows or unstable wall materials so that appropriate rehabilitation can be carried out.
< 50	Very Active	Drainage line is very actively eroding and immediate remedial actions are required. It is important to classify if erosion is caused primarily by upstream flows, lateral flows or unstable wall materials so that appropriate rehabilitation can be carried out.

Table Source: CSIRO Ephemeral Stream Assessment (CSIRO, date unknown)

2.3 Transects at Monitoring Points

Transect data is collected at the monitoring points to provide a representation of the drainage line profile. The transect assessment allows for simple identification of any deposition of sediments within the channel bed or scouring of the banks by comparison with profile measurements on a yearly basis.

The transect assessment is undertaken by extending a tape measure laterally across the drainage line to two permanently fixed posts which are located within the riparian zone. A survey staff is then used to measure the height relative elevation difference between the tape and the ground surface at approximately 0.5 m increments or at points which capture any sudden changes in channel geometry (e.g. steep channel banks).

2.4 Visual Assessment of Loder Creek

A visual inspection of Loder Creek from the Hunter River to the MTW discharge point was undertaken to identify any areas of increased erosion. Where erosion was observed within this reach of Loder Creek the following were recorded:

- Documented locations and dimensions of notable erosive or depositional features;
- Photos so that comparisons could be made in future surveys; and
- 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.

Any visible changes that occurred since the preceding inspection will be documented by comparison to the photos taken during the previous surveys.

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MTW Channel Stability Monitoring Points - 2018

FIGURE 1

3 Results

3.1 Channel Stability / Stream Health Monitoring Site Results

3.1.1 MTW Dis (321966 E 6385379 N)

This monitoring point is located at the Mount Thorley discharge point. This section of creek has been upgraded and now includes rock armouring of the creek bed as well as jute mesh and seeding of both banks. Overall, the creek stability at this location has improved from the previous monitoring cycle and is now stabilising.

The banks are characterised by patches of Bull Oak (*Allocasuarina luehmannii*), Swamp Oak (*Casuarina glauca*) and scattered eucalypts. The understorey is sparse with occasional small Acacia shrubs and the groundcover is bare in most areas (with evidence of soil erosion). Both banks of the creek contain an almost continuous band of riparian vegetation in widths less than 40m wide with the exception of the cleared area where constructions works have occurred. Exotic grass areas and bare soil (mine workings and vehicle tracks) surround riparian vegetation. Linkage to larger areas of native vegetation is absent. Regeneration of native canopy species is evident across the site. The channel of the creek line contained dense native *Juncus* spp.

RARC Stream Health Assessment Classification – **Poor**

CSIRO Ephemeral Stream Assessment Classification – **Potentially Stabilising**

Photos taken at the established photo points for this monitoring point are shown in Plate 1 to Plate 4.

Plate 1 Right Bank

Plate 2 Upstream

Plate 3 Downstream

Plate 4 Left Bank

For the purpose of monitoring any changes to the creek, a creek line transect was established. The transect is shown in **Figure 2** and was taken from left to right looking downstream. It can see from this transect that the channel has changed significantly since the previous monitoring cycle. This is a result of the upgrade work done at this monitoring point including rock armouring of the creek bed explaining the elevation changes on the below graph. It should also be noted that as part of the upgrade works, the peg on the left bank was removed which explains why this round of monitoring shows a shorter length of transect.

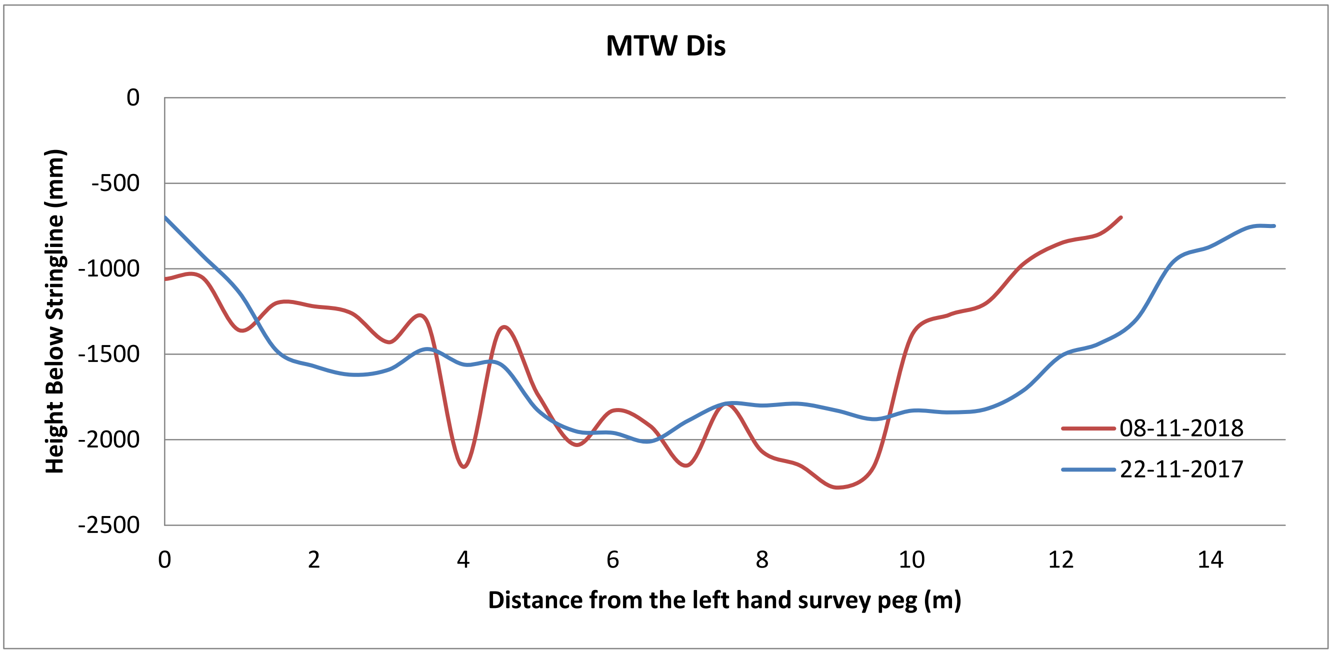

Figure 2 MTW Dis Transect Results

3.1.2 BM35 (322746 E 6385819 N)

The channel at this location was observed to have long grass coverage across the bed. The left bank also appears stable with good grass coverage. The right bank contains some lateral erosion (approximately 0.5m high) at the top of the bank. The lateral erosion is forming some rill/gully erosion down this bank, however the rest of the right bank appears to be stable with good grass coverage. The lateral erosion observed on the right bank is a result of the poor vegetation cover and the upslope reporting catchment. Overall, this location shows similar conditions to the previous monitoring cycle with minor expansion of the lateral erosion.

The creek banks are characterised by Swamp Oak (*Casuarina glauca*) with scattered eucalypts upslope. Both banks of the creek contained an almost continuous band of riparian vegetation in widths mostly around 15m wide with one patch downstream extending to 40m wide. The understory contained moderate levels of weed infestation including Lantana, Paddy's Lucerne and Rhodes Grass. Exotic pastures surrounded riparian vegetation and linkage to other areas of native vegetation was absent. The channel of the creek line contained dense native *Typha* spp. with exotic grasses. Regenerating canopy tree (mostly *Casuarina glauca*) species were abundant.

RARC Stream Health Assessment Classification – **Poor**

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 5 to 9.

Plate 5 Right Bank

Plate 6 Upstream

Plate 7 Downstream

Plate 8 Left Bank

Plate 9 Erosion (top of right bank)

For the purpose of monitoring any changes of the creek, a creek line transect was established. The transect is shown in **Figure 3** and was taken from left to right looking downstream. It suggests that some scouring has occurred on the left bank and creek bed since the previous monitoring cycle.

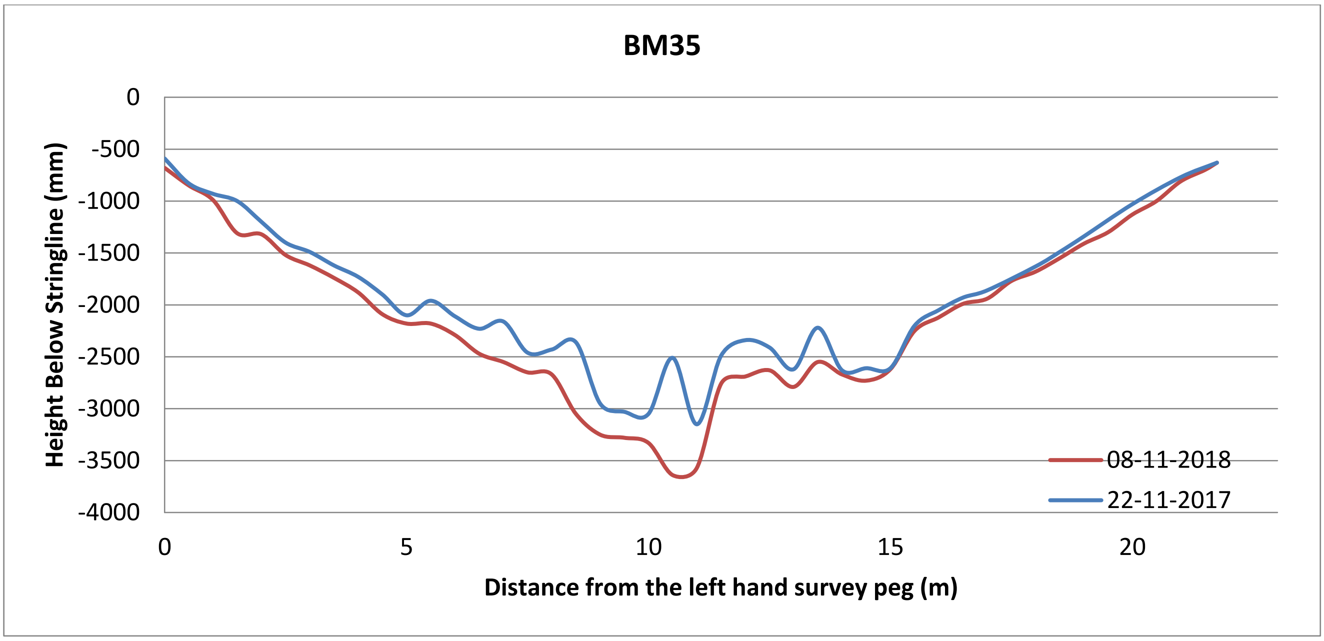

Figure 3 BM35 Transect Results

3.1.3 BM34 (323779 E 6388119 N)

The creek bed at this monitoring point is covered by reeds and is stable. Both the left and right banks have good grass coverage and appear to be stable with gentle-moderate slopes. The creek upstream and downstream of the monitoring point also appears to be stable. The creek has a very slight meander at this monitoring point. Overall this location has remained the same as the previous monitoring cycle conditions.

Note that the downgraded channel stability rating at this monitoring point is related to the subjectivity in the CSIRO methodology as this cycle of monitoring has been undertaken by a different person.

Lantana, Paddy's Lucerne and African Boxthorn were abundant below the canopy. Native Weeping Grass (*Microlaena stipoides*) was present in small patches beneath the denser canopy areas. Both banks of the creek contained an almost continuous band of riparian vegetation in widths less than 30m wide. Exotic pastures surrounded riparian vegetation and linkage to other areas of native vegetation was absent. The channel of the creek line contained dense native *Juncus* spp and *Phragmites australis* with sparse aquatic weeds. Regenerating canopy tree (mostly *Casuarina glauca*) species were abundant.

RARC Stream Health Assessment Classification – **Poor**

CSIRO Ephemeral Stream Assessment Classification – **Stable**

Photos taken at the established photo points for this monitoring point are shown in Plates 10 to 13.

Plate 10 Right Bank

Plate 11 Upstream

Plate 12 Downstream

Plate 13 Left Bank

For the purpose of monitoring any changes of the creek, a creek line transect was established. The transect is shown in **Figure 4** and was taken from left to right looking downstream. It suggests that some scouring has occurred on the entire cross section of the creek since the previous monitoring cycle although this monitoring site didn't appear to have changed significantly since the December 2017 monitoring cycle.

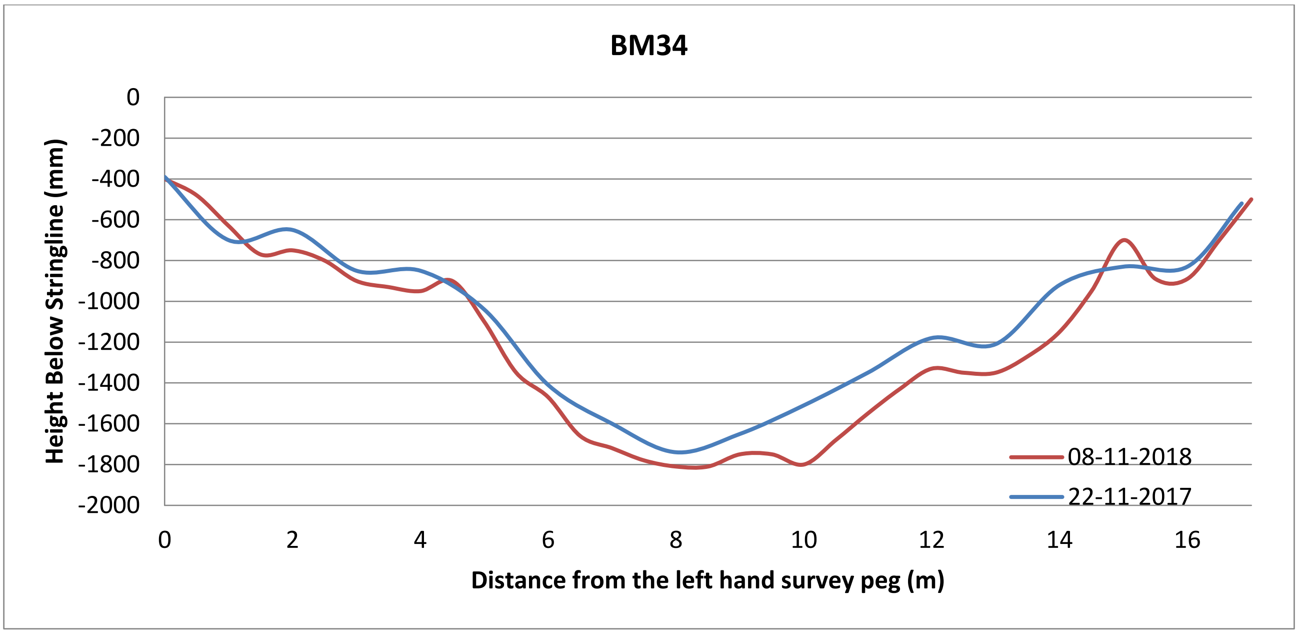

Figure 4 BM34 Transect Results

3.1.4 BM37 (313709 E 6388933 N)

Monitoring point BM37 is the only monitoring point that is located on Wollombi Brook Wollombi Brook is a large tributary of the Hunter River, with channel widths ranging from 10m to 60m. Generally Wollombi Brook has flowing water in it except during extreme drought periods. Water was observed to be ponding but not flowing at the time of the inspection. Both the left and right banks appeared to be generally stable with both banks containing trees. The right bank is steeper than the left bank with a moderate slope and a height of approximately 2m. A pipe outlet exists immediately downstream of the monitoring point on the eastern bank and has scoured out the bank slightly with some exposed moderately dispersive soils (approximately 0.3m high). Some wombat holes were also observed on the eastern bank. Overall this location has remained the same as the previous monitoring cycle conditions.

At sample site BM37, only the eastern side of Wollombi Brook was surveyed, as the width and depth of the stream prevented transects being extending across the full width of the stream. Riparian vegetation along a 280 meter reach of the stream was surveyed, with four parallel transects established across the riparian zone upstream and downstream of the sample site (marker point). Generally only a thin band (of between 5m to 15m in width) of native riparian forest exists along the banks of the stream. The innermost parts of the riparian zone, extending over a series of steep terraced banks, comprise of a narrow band of modified open forest of mainly Swamp Oak (*Casuarina glauca*), River Oak (*Casuarina cunninghamiana*) and occasional Cabbage Gum *Eucalyptus amplifolia*. The lower bank edges contain patches of dense reeds, including *Typha orientalis*, *Phragmites australis* and the exotic *Juncus acutus*. Patches of Parramatta Green Wattle *Acacia parramattensis*, as well as juvenile (or early mature) eucalypts and casuarinas, form a mid-canopy in places; however, generally the vegetation lacks a shrub layer. Leaf litter, as well as exotic grasses and herbs, dominates the ground layer, with common species being Paddy’s Lucerne *Sida rhombifolia*, Panic Veldt Grass *Ehrharta erecta* and Common Sowthistle *Sonchus oleraceus*. The native Weeping Grass (*Microlaena stipoides*) occurs occasionally in shaded bank areas.

Upslope of this vegetation, extending to the outer parts of the riparian zone, the forest canopy gives way to cleared land comprising with exotic pasture grass, supporting a range of common exotic grasses and herbs, including African Lovegrass *Eragrostis curvula*, Narrow-leafed Carpet Grass *Axonopus fissifolius*, Couch *Cynodon dactylon* and several other species.

RARC Stream Health Assessment Classification – **Poor**

CSIRO Ephemeral Stream Assessment Classification – **Stable**

Photos taken at the established photo points for this monitoring point are shown in Plates 14 to 19.

Plate 14 Right Bank

Plate 15 Upstream

Plate 16 Downstream

Plate 17 Left Bank

Plate 18 Erosion

Plate 19 Erosion

3.2 Loder Creek Erosion Visual Assessment

3.2.1 LC1 (321974 E 6385382 N)

The erosion at LC1 has been remediated as part of upgrade work on the Mount Thorley discharge point. The works undertaken at this erosion site included rock armouring of the creek bed as well as jute mesh and seeding of both banks. Overall, this location has improved greatly from the previous monitoring cycle and is now considered stable.

CSIRO Ephemeral Stream Assessment Classification – **Stable**

Photos taken at the established photo points for this monitoring point are shown in Plates 20 to 23.

Plate 20 Right Bank

Plate 21 Upstream

Plate 22 Downstream

Plate 23 Left Bank

3.2.2 LC2 (322019 E 6385367 N)

The erosion observed at LC2 included a steep near vertical section of exposed dispersive material (approximately 2m high) on the right bank. This area appeared to be actively eroding including some areas immediately downstream. However, this monitoring location appears to be similar to what was observed in the December 2017 survey. A tree was observed to have fallen over at this section of the exposed creek bank. The creek bed and left bank appear to be stable at this location.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 24 to 26.

Plate 24 Upstream

Plate 25 Downstream

Plate 26 Erosion

3.2.3 LC3 (322087 E 6385446 N)

This location is positioned at a small channel entry point to Loder Creek (on the left bank). The channel appears to be stable, however the confluence point has some significant erosion with some slight undercutting and tunnelling of the dispersive soil. Overall, this monitoring location appears very similar to the previous monitoring cycle.

CSIRO Ephemeral Stream Assessment Classification – **Very Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 27 to 30.

Plate 27 Upstream

Plate 28 Downstream

Plate 29 Erosion

Plate 30 Tunnel Erosion

3.2.4 LC4 (322367 E 6385647 N)

LC4 is located under a powerline in an area where it appears that vegetation has been maintained within the powerline easement. The near vertical left bank on the outside of the creek meander is about 4-5m high and has some exposed dispersive material (approximately 1m high) near the top of the bank however this erosion has shown signs of potentially stabilising. The right bank is much flatter and appears to be stable, as does the creek bed. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

CSIRO Ephemeral Stream Assessment Classification – **Potentially Stabilising**

Photos taken at the established photo points for this monitoring point are shown in Plates 31 to 34.

Plate 31 Right Bank

Plate 32 Upstream

Plate 33 Downstream

Plate 34 Left Bank

3.2.5 LC5 (322484 E 6385655 N)

LC5 is located in a historic diversion of Loder Creek. The erosion observed at LC5 included erosion extending up the right bank approximately 20-30m. The area has 0.5-1.0m steep exposed walls surrounding 5m of exposed soil. The creek bed and left bank appear to be stable. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

Note that the downgraded channel stability rating at this monitoring point is related to the subjectivity in the CSIRO methodology as this cycle of monitoring has been undertaken by a different person.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 35 to 39.

Plate 35 Right Bank

Plate 36 Upstream

Plate 37 Downstream

Plate 38 Left Bank

Plate 39 Erosion (top of right bank)

3.2.6 LC6 (322670 E 6385697 N)

The erosion observed at LC6 included significant lateral erosion near the top of the right bank. This erosion was approximately 1m high with an alluvial fan extending approximately 2m from the near vertical bank. The rest of the right bank appears to stable as does the creek bed and the left bank. Overall, this monitoring location appears similar to the previous monitoring cycle. The active erosion appears to be primarily the result of a historic disturbance of the top of the right bank which has exposed the highly dispersive soils at this location.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 40 to 45.

Plate 40 Right Bank

Plate 41 Upstream

Plate 42 Downstream

Plate 43 Left Bank

Plate 44 Erosion

Plate 45 Erosion

3.2.7 LC7 (322759 E 6385778 N)

The erosion observed at LC7 included an area of active erosion of a steep comprising exposed dispersive clay material (approximately 0.8m high) on the right bank, however this erosion is not laterally extensive. The erosion appears to have been caused by lateral flow across the bare banks in the area. The right bank appears to be stable downslope of the eroded area, as does the creek bed and the left bank. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 46 to 50.

Plate 46 Right Bank

Plate 47 Upstream

Plate 48 Downstream

Plate 49 Left Bank

Plate 50 Erosion

3.2.8 LC8 (323948 E 6389351 N)

The erosion observed at LC8 included significant erosion of the left bank (approximately 0.8m high with the overall bank at approximately 2.5m high) at a location with a slight meander in the creek as shown on Plate 54. The erosion has some minor undercutting with a section of vertical banks partly stabilised by tree roots. The soil appears be alluvial and not particularly dispersive. Trees at this location are at risk of falling over due to loss of support. The creek bed and right bank appear to be stable. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

CSIRO Ephemeral Stream Assessment Classification – **Potentially Stabilising**

Photos taken at the established photo points for this monitoring point are shown in Plates 51 to 54.

Plate 51 Right Bank

Plate 52 Upstream

Plate 53 Downstream

Plate 54 Left Bank

3.2.9 LC9 (323996 E 6389540 N)

The erosion observed at LC9 included some loss of exposed slightly dispersive material on the right bank which may have been caused by livestock in the area. This bank is about 2m high and has about 0.8m of exposed soil. The area appears to be stabilising. The creek bed and the left bank appear to be stable. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

CSIRO Ephemeral Stream Assessment Classification – **Potentially Stabilising**

Photos taken at the established photo points for this monitoring point are shown in Plates 55 to 58.

Plate 55 Right Bank

Plate 56 Upstream

Plate 57 Downstream

Plate 58 Left Bank

3.2.10 LC10 (324131 E 6390142 N)

The erosion observed at LC10 is located immediately downstream of a concrete lined chute. The soil is alluvial and non-dispersive. The erosion has been created from scouring of the right bank during large flow events with the upstream chute increasing the velocity of the water to this downstream section of channel. This scouring has over a period of time exposed some tree roots of some of the trees that line the creek bank. The creek has steep slopes on both banks (approximately 4-5m high). The creek is generally stable upstream and downstream except for some cattle tracks immediately upstream on the right bank. Limited vegetation exists in the creek bed. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

Note that the downgraded channel stability rating at this monitoring point is related to the subjectivity in the CSIRO methodology as this cycle of monitoring has been undertaken by a different person.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 59 to 62.

Plate 59 Right Bank

Plate 60 Upstream

Plate 61 Downstream

Plate 62 Left Bank

3.2.11 LC11 (322881 E 6386043 N)

The erosion observed at LC11 includes some significant tunnelling and active erosion on the left bank with exposed vertical dispersive soil. Potential causes for this erosion include wombat holes as well as the presence of a contour bank overflow (which is located immediately upslope of the erosion). Trees were observed on both banks and creek bed. The creek bed and the right bank both show stable conditions. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 63 to 68.

Plate 63 Right Bank

Plate 64 Upstream

Plate 65 Downstream

Plate 66 Left Bank

Plate 67 Erosion

Plate 68 Erosion (Top)

3.2.12 LC12 (323802 E 6388650 N)

The erosion observed at LC12 includes some erosion (approximately 2m high) on the left bank with exposed vertical dispersive soil. It is likely that this erosion was at least partially caused by a fallen tree at the monitoring point location. The left bank at the monitoring point is significantly higher than the right bank. The creek bed and the right bank both show stable conditions. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 69 to 72.

Plate 69 Right Bank

Plate 70 Upstream

Plate 71 Downstream

Plate 72 Left Bank

3.2.13 LC13 (324160 E 6390408 N)

LC13 includes some erosion extending for approximately 5m on the steep left bank with exposed soil which doesn't appear to be highly dispersive. This erosion was most likely caused by livestock tracks observed upstream and downstream of the monitoring location or a localised slope failure. The creek and the right bank both show stable conditions. Overall, this monitoring location has shown similar conditions to the previous monitoring cycle.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 72 to 75.

Plate 72 Right Bank

Plate 73 Upstream

Plate 74 Downstream

Plate 75 Left Bank

4 Summary of Results

Monitoring Site	RARC Stream Heath Assessment Classification		CSIRO Ephemeral Stream Assessment Classification		Primary Cause of Erosion
	2017	2018	2017	2018	
MTW Dis	Poor	Poor	Active	Potentially Stabilising	Lateral Inflows
BM35	Poor	Poor	Active	Active	Unstable Wall Materials
BM34	Poor	Poor	Very Stable	Stable	NA
BM37	Average	Poor	Stable	Stable	NA
LC1	NA	NA	Active	Stable	NA
LC2	NA	NA	Active	Active	Unstable Wall Materials
LC3	NA	NA	Very Active	Very Active	Upstream Flows
LC4	NA	NA	Potentially Stabilising	Potentially Stabilising	Unstable Wall Materials
LC5	NA	NA	Potentially Stabilising	Active	Unstable Wall Materials
LC6	NA	NA	Active	Active	Unstable Wall Materials
LC7	NA	NA	Active	Active	Lateral Inflows
LC8	NA	NA	Potentially Stabilising	Potentially Stabilising	Upstream Flows
LC9	NA	NA	Potentially Stabilising	Potentially Stabilising	Unstable Wall Materials
LC10	NA	NA	Potentially Stabilising	Active	Upstream Flows
LC11	NA	NA	Active	Active	Wombat Activity, Contour Bank Overflows
LC12	NA	NA	Active	Active	Fallen Tree
LC13	NA	NA	Active	Active	Livestock Tracks

5 Conclusion and Recommendations

MTW advise there have been nil discharge events from the MTW discharge point between the 2017 stream health monitoring event and the 2018 monitoring event. There has been 362 mm of rainfall recorded within the on-site rainfall gauge for the period 22nd November 2017 to 7th November 2018. In comparison, the Bureau of Meteorology shows an annual average of 653mm at Singleton (Singleton STP 61397). This indicates that this round of monitoring was subjected to a significantly drier year than what occurs on average within the region.

The results of this monitoring survey indicate that both stream health and channel stability fluctuate over different sections of Loder Creek. The survey identified that some sections of Loder Creek are currently eroding and are vulnerable to further erosion with areas of significant erosion observed. These areas are generally associated with exposed dispersive sub-soils, which hamper vegetation establishment by the development of a hard surface crust when the soil is dry, and the 'melting' nature of the soil when wet.

The survey identified that the majority of Loder Creek displayed stable environments. Generally the monitoring identified that the creeks have not significantly changed from what was observed during the 2017 baseline survey, however some evidence of minor erosion progression were observed at some of the monitoring points. Many sections of the creek experience active erosion as a result of natural influences. This is exacerbated by past land clearing and mining/agricultural practices exposing dispersive sub-soils. Improvements were also identified during the 2018 survey, resulting from both natural occurrences as well as man-made upgrade works.

In a few occasions, CSIRO ratings have downgraded from what was observed during the 2017 inspection although the observed conditions were similar. This is largely related to the subjectivity using the methodology proposed by CSIRO and therefore is subjected to change where there is a change in assessor.

The RARC stream health assessment identified that the monitoring points on Loder Creek were classified as poor. Similar to the stability rating of the creeks, this is predominantly a result of the long history of mining and grazing practices in the area. The single monitoring point on Wollombi Brook was classed as poor.

It is recommended that MTW adopt a risk based approach to determine whether mitigation measures and/or improvement works are required at the monitoring points where erosion was observed. Different remediation measures may be utilised depending on the type of erosion that has occurred (as listed in **Section 4**).

For example, erosion caused by lateral flows and unstable wall materials may be remediated by re-grading the batter slope (as required) to a maximum gradient of 3(H):1(V), ripping the soil and then seeding with a suitable vegetation species. Gypsum may also be used as a soil ameliorant and applied at a rate of 1kg/m^2. Bunding may also be used to control upslope lateral flows. Creek erosion caused by the shear stresses associated with the upstream flows may be remediated by armouring of the creek bed / banks (i.e. rock, jute mesh, erosion blanket etc), as was observed to have been implemented by MTW at location MTW Dis during the 2018 survey.

In addition, it is also recommended that MTW adopt a risk based approach associated with areas where poor riparian health of the creek exists where this is coincident with an area that would benefit from remediation works from observed erosion. Opportunities to improve riparian health should be considered including the planting of suitable native vegetation within the riparian zone of the creeks, including areas beyond the immediate creek bed and banks.

6 References

Land & Water Australia (2005), Rapid Appraisal Of Riparian Condition – Version Two (River and Riparian Technical Guideline No. 4a)

Commonwealth Scientific and Research Organisation (CSIRO) (date unknown) - Ephemeral Stream Assessment, date accessed 14/09/09,

http://www.cse.csiro.au/research/ras/efa/resources/ephemeraldrainagelineassessment.pdf

APPENDIX A

Rapid Appraisal of Riparian Conditions

Rapid Appraisal of Riparian Condition

Site Number: MTW DIS

Site: Mount Thorley Discharge
GPS start: See figure
Date: 08-11-2018
Observer: MD
GPS end:

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	2

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = >95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	3	75	4
2	3	15	2
3	5	45	4
4	7	55	4
Average			3.5

Channel <10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW >40m
Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW >4

Proximity

Score
1

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	3	3	2	1	2	1	3
2	2	2	0	0	2	1	3
3	2	2	2	1	2	1	3
4	2	2	2	1	2	1	3
Average	2.25	2.25	1.5	0.75	2	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%
Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	2	2	1	0	1
2	1	1	0	0	1
3	1	1	0	0	0
4	1	1	0	0	0
Average	1.25	1.25	0.25	0	0.5

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%
Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present
Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	0	1	1
2	1	0	0	2
3	1	0	0	2
4	1	0	0	2
Average	1	0	0.25	1.75

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage
Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	MTO DIS

Longitudinal continuity of riparian canopy vegetation

Score
2

Width of riparian canopy vegetation

Average	3.5

Proximity

Score
1

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	2.25	2.25	1.5	0.75	2	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1.25	1.25	0.25	0	0.5

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1	0	0.25	1.75

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)	11	12	9	10	8	50
	6.5	8.75	4	3.25	3	25.5

Rapid Appraisal of Riparian Condition

Site Number: BM35

Site:	Loaders Creek	**GPS start:**	See figure
Date:	08-11-2018 **Observer:** MD	**GPS end:**	

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	3

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = >95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	5	18	2
2	5	25	3
3	5	30	3
4	5	60	4
Average			3

Channel <10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW >40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW >4

Proximity

Score
1

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	2	2	2	1	3	1	3
2	2	2	2	1	2	1	3
3	2	2	2	1	2	1	3
4	3	3	2	1	1	1	3
Average	2.25	2.25	2	1	2	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	2	2	0	0	1
2	2	2	0	0	1
3	2	2	0	0	0
4	2	2	0	0	1
Average	2	2	0	0	0.75

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	1	0	1	2
2	1	0	1	2
3	1	0	1	2
4	1	0	1	2
Average	1	0	1	2

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	BCC01

Longitudinal continuity of riparian canopy vegetation

Score
3

Width of riparian canopy vegetation

Average	3

Proximity

Score
1

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	2.25	2.25	2	1	2	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	2	2	0	0	0.75

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1	0	1	2

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)	11	12	9	10	8	50
	7	9.25	4.25	4.75	4	29.25

Rapid Appraisal of Riparian Condition

Site Number: BM34

Site:	Loaders Creek			**GPS start:**	see figure
Date:	08-11-2018	**Observer:**	MD	**GPS end:**	

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	4

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	6	25	3
2	6	20	3
3	6	15	2
4	6	15	2
Average			2.5

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
2

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	2	2	2	0	2	2	3
2	2	2	2	0	2	2	3
3	1	1	1	0	3	2	3
4	1	1	1	0	3	2	3
Average	1.5	1.5	1.5	0	2.5	2	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	1	1	1	1	1
2	1	1	1	0	1
3	1	1	1	0	1
4	1	1	1	0	0
Average	1	1	1	0.25	0.75

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	2	0	1	2
2	2	0	1	2
3	1	0	1	2
4	2	0	1	2
Average	1.75	0	1	2

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	BM34

Longitudinal continuity of riparian canopy vegetation

Score
4

Width of riparian canopy vegetation

Average	2.5

Proximity

Score
2

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	1.5	1.5	1.5	0	2.5	2	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1	1	1	0.25	0.75

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	1.75	0	1	2

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	**Total**
(out of)	11	12	9	10	8	50
	8.5	8.5	3.5	4	4.75	29.25

Rapid Appraisal of Riparian Condition

Site Number: **BM37**

Site:	Wollomi Brool			**GPS start:**	See figure
Date:	08-11-2018	**Observer:**	MD	**GPS end:**	

Longitudinal continuity of riparian canopy vegetation (>5m wide)

Map	Score
	3

0 = <50%, 1 = 50-64%, 2 = 65-79%, 3 = 80-94%, 4 = ≥95% vegetated bank;

with ½ point subtracted for each significant discontinuity (>50m long)

Width of riparian canopy vegetation

Transect	Channel Width (CW)	Vegetation Width (VW)	Score
1	20	15	1
2	10	17	2
3	20	20	4
4	10	35	3
Average			2.5

Channel ≤10m wide: 0 = VW <5m, 1 = VW 5-9m , 2 = VW 10-19m, 3 = VW 20-39m, 4 = VW ≥40m

Channel >10m wide: 0 = VW/CW <0.5, 1 = VW/CW 0.5-0.9, 2 = VW/CW 1-1.9, 3 = VW/CW 2-3.9, 4 = VW/CW ≥4

Proximity

Score
2

Nearest patch of native vegetation >10ha:

0 = >1km, 1 = 200m-1km, 2 = contiguous,

3 = contiguous with patch >50ha

Vegetation cover: Canopy >5m, Understorey 1-5m, Ground cover <1m

Transect	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
1	2	2	2	1	3	1	3
2	2	2	2	1	3	1	3
3	2	2	2	1	3	1	3
4	2	2	2	1	3	1	3
Average	2	2	2	1	3	1	3

Canopy and ground cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Understorey cover: 0 = none, 1 = 1-5%, 2 = 6-30%, 3 = >30%

Debris

Transect	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
1	2	2	0	0	0
2	2	2	0	0	1
3	2	2	0	0	0
4	2	2	0	0	1
Average	2	2	0	0	0.5

Leaf litter & native leaf litter cover: 0 = none, 1 = 1-30%, 2 = 31-60%, 3 = >60%

Standing dead trees (>20cm dbh) & hollow-bearing trees: 0 = absent, 1 = present

Fallen logs (>10cm diameter): 0 = none, 1 = small quantities, 2 = abundant

Features

Transect	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
1	0	0	1	2
2	0	0	1	2
3	0	0	1	2
4	0	0	1	2
Average	0	0	1	2

Regeneration <1m tall: 0 = none, 1 = scattered, and 2 = abundant, with ½ point subtracted for grazing damage

Reeds & large tussock grasses: 0 = none, 1 = scattered, and 2 = abundant

Calculation of scores

Site Number:	BM37

Longitudinal continuity of riparian canopy vegetation

Score
3

Width of riparian canopy vegetation

Average	2.5

Proximity

Score
2

Vegetation cover

	Canopy	Native canopy	Understorey	Native understorey	Ground cover	Native ground cover	# layers
Average	2	2	2	1	3	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	2	2	0	0	0.5

Features

	Native canopy species regeneration	Native understorey regeneration	Large native tussock grasses	Reeds
Average	0	0	1	2

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)	11	12	9	10	8	50
	7.5	10	4	4.5	3	29

APPENDIX B

CSIRO Ephemeral Stream Assessment Database

BSO MTW CSIRO Ephemeral Stream Assessment Database

-

Site Number	Distance US/DS from Survey Peg (m)	Date of Monitoring Assessor Channel Characteristic	Nov-18 SLR Rating
LC1		Vegetation on D/L Floor	3
		Vegetation on D/L Walls	3
		Shape of D/L Cross-Section	3
		Longitudinal Morphology	3
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	3
		Nature and Shape of Bank Edge	4
		Nature of Lateral Flow Regulation	3
		Sum of Ratings	**23**
		Activity Rating	**72**
		Classification	**Stable**
LC2	0m (At Survey Peg)	Vegetation on D/L Floor	3
		Vegetation on D/L Walls	1
		Shape of D/L Cross-Section	2
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	1
		Nature and Shape of Bank Edge	4
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**18**
		Activity Rating	**56**
		Classification	**Active**
LC3	0m (At Survey Peg)	Vegetation on D/L Floor	3
		Vegetation on D/L Walls	1
		Shape of D/L Cross-Section	2
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	1
		Nature and Shape of Bank Edge	3
		Nature of Lateral Flow Regulation	2
		Sum of Ratings	**15**
		Activity Rating	**47**
		Classification	**Very Active**
LC4	0m (At Survey Peg)	Vegetation on D/L Floor	3
		Vegetation on D/L Walls	3
		Shape of D/L Cross-Section	3
		Longitudinal Morphology	3
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	1

		Nature and Shape of Bank Edge	4
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**22**
		Activity Rating	**69**
		Classification	**Potentially Stabilising**
LC5		Vegetation on D/L Floor	3
		Vegetation on D/L Walls	2
		Shape of D/L Cross-Section	2
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	2
		Nature and Shape of Bank Edge	3
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**19**
		Activity Rating	**59**
		Classification	**Active**
LC6		Vegetation on D/L Floor	3
		Vegetation on D/L Walls	2
		Shape of D/L Cross-Section	2
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	1
		Nature and Shape of Bank Edge	3
		Nature of Lateral Flow Regulation	3
		Sum of Ratings	**17**
		Activity Rating	**53**
		Classification	**Active**
LC7		Vegetation on D/L Floor	3
		Vegetation on D/L Walls	1
		Shape of D/L Cross-Section	2
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	2
		Nature and Shape of Bank Edge	4
		Nature of Lateral Flow Regulation	2
		Sum of Ratings	**17**
		Activity Rating	**53**
		Classification	**Active**
LC8		Vegetation on D/L Floor	2
		Vegetation on D/L Walls	1
		Shape of D/L Cross-Section	3
		Longitudinal Morphology	3
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	2
		Nature and Shape of Bank Edge	4

		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**20**
		Activity Rating	**63**
		Classification	**Potentially Stabilising**
LC9		Vegetation on D/L Floor	3
		Vegetation on D/L Walls	3
		Shape of D/L Cross-Section	3
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	3
		Nature and Shape of Bank Edge	3
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**22**
		Activity Rating	**69**
		Classification	**Potentially Stabilising**
LC10		Vegetation on D/L Floor	1
		Vegetation on D/L Walls	1
		Shape of D/L Cross-Section	2
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	4
		Nature and Shape of Bank Edge	4
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**19**
		Activity Rating	**59**
		Classification	**Active**
LC11		Vegetation on D/L Floor	3
		Vegetation on D/L Walls	1
		Shape of D/L Cross-Section	2
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	1
		Nature and Shape of Bank Edge	3
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**17**
		Activity Rating	**53**
		Classification	**Active**
LC12		Vegetation on D/L Floor	2
		Vegetation on D/L Walls	2
		Shape of D/L Cross-Section	3
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	2
		Nature and Shape of Bank Edge	3
		Nature of Lateral Flow Regulation	4

		Sum of Ratings	**19**
		Activity Rating	**59**
		Classification	**Active**
LC13		Vegetation on D/L Floor	1
		Vegetation on D/L Walls	2
		Shape of D/L Cross-Section	3
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	2
		Nature and Shape of Bank Edge	4
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**19**
		Activity Rating	**59**
		Classification	**Active**
MTW Dis		Vegetation on D/L Floor	1
		Vegetation on D/L Walls	2
		Shape of D/L Cross-Section	3
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	3
		Nature of D/L Wall Materials	3
		Nature and Shape of Bank Edge	4
		Nature of Lateral Flow Regulation	2
		Sum of Ratings	**20**
		Activity Rating	**63**
		Classification	**Potentially Stabilising**
BM34		Vegetation on D/L Floor	3
		Vegetation on D/L Walls	3
		Shape of D/L Cross-Section	5
		Longitudinal Morphology	3
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	3
		Nature and Shape of Bank Edge	3
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**25**
		Activity Rating	**78**
		Classification	**Stable**
BM35		Vegetation on D/L Floor	3
		Vegetation on D/L Walls	2
		Shape of D/L Cross-Section	2
		Longitudinal Morphology	2
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	2
		Nature and Shape of Bank Edge	3
		Nature of Lateral Flow Regulation	3
		Sum of Ratings	**18**

		Activity Rating	**56**
		Classification	**Active**
BM37		Vegetation on D/L Floor	1
		Vegetation on D/L Walls	3
		Shape of D/L Cross-Section	4
		Longitudinal Morphology	3
		Particle Size of Materials on Floor	1
		Nature of D/L Wall Materials	3
		Nature and Shape of Bank Edge	4
		Nature of Lateral Flow Regulation	4
		Sum of Ratings	**23**
		Activity Rating	**72**
		Classification	**Stable**

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Appendix 6:

Annual Ground Water Impacts Review

MT THORLEY WARKWORTH

2018 Annual Groundwater Review

Prepared for:

Yancoal

SLR Ref: 620.12289-R06
Version No: v3.0
August 2019

PREPARED BY

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BASIS OF REPORT

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.12289-R04-v3.0	29 August 2019	Duncan Dawson, Tony Johnson	Claire Stephenson	Claire Stephenson
620.12289-R04-v2.0	27 March 2019	Duncan Dawson	Claire Stephenson	Claire Stephenson
620.12289-R04-v1.0	13 March 2019	Duncan Dawson	Claire Stephenson	Claire Stephenson

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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 2018 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).

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 2018.

Table 2-1 Summary of MTW Activities

Mine Area	Site	2018 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	No mining active, rehabilitation works in place.
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 in 2017 and rehabilitation undertaken. Capping works commenced
Centre Ramp Tailings Dam (Dam 17S)	Loders Pit – Mt Thorley. Tailings dam located overlying spoil, within backfilled pit.	Active – secondary flocculant added
Abbey Green Tailings Dam (Dam 4S)	Abbey Green – Mt Thorley. Tailings dam located overlying spoil, within backfilled pit.	Active
Mini-strip 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.

Figure 2-1 Locality Map

2.2 Groundwater Impacts

Groundwater impacts associated with the approved operations are presented within the:

- Warkworth Mine Modification Groundwater Impact Assessment (AGE 2013);
- 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 hard rock 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), which was updated in September 2018. Further discussion on the monitoring and management requirements is included within **Section 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 River Regulated 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 2018 WMP. The table identifies where the conditions relating to routine groundwater monitoring for 2018 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
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 2018. As per WMP, no privately-owned bores identified as potentially impacted. See ecology review for discussion on ecosystems and vegetation.

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 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**. Comparison between observed and modelled groundwater levels undertaken as part of 2017 groundwater review.
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 monitoring 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.
	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.	Model predictions last assessed in 2017 Groundwater Review.
	Licensing: • retain and obtain appropriate water licences, as required, to account for modelled take.	**Section 2.3** and **Section 5.4**

Condition	Details	Where Addressed
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 2018 monthly data.

Table 3-1 Long Term Average and 2018 Climate Data

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Historical	77	73	59	47	39	47	40	36	41	52	62	69	**641**
2018 Rainfall	2	68	57	19	13	36	5	18	21	82	59	49	**428**

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.

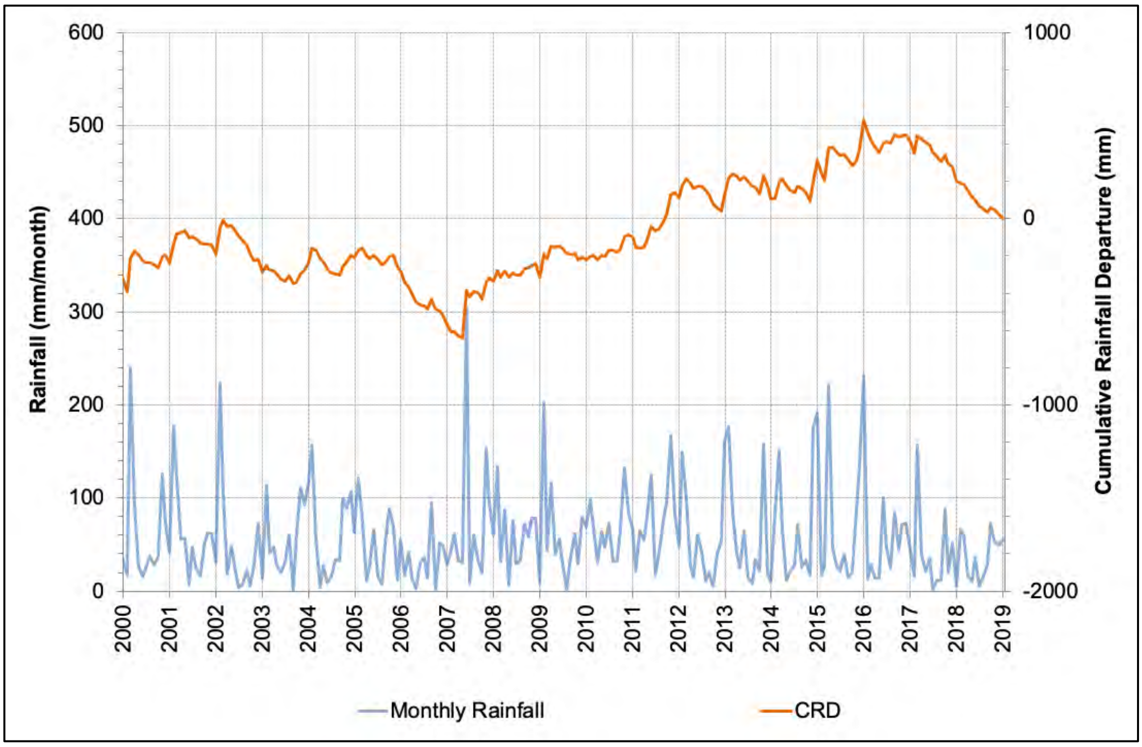


Figure 3-1 Cumulative Rainfall Departure and Monthly Rainfall

As shown in **Figure 3-1**, the region has generally experienced below average rainfall from 2016. Over 2018 there were generally no above average rainfall events, except for October where 82 mm of rain was recorded.

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).

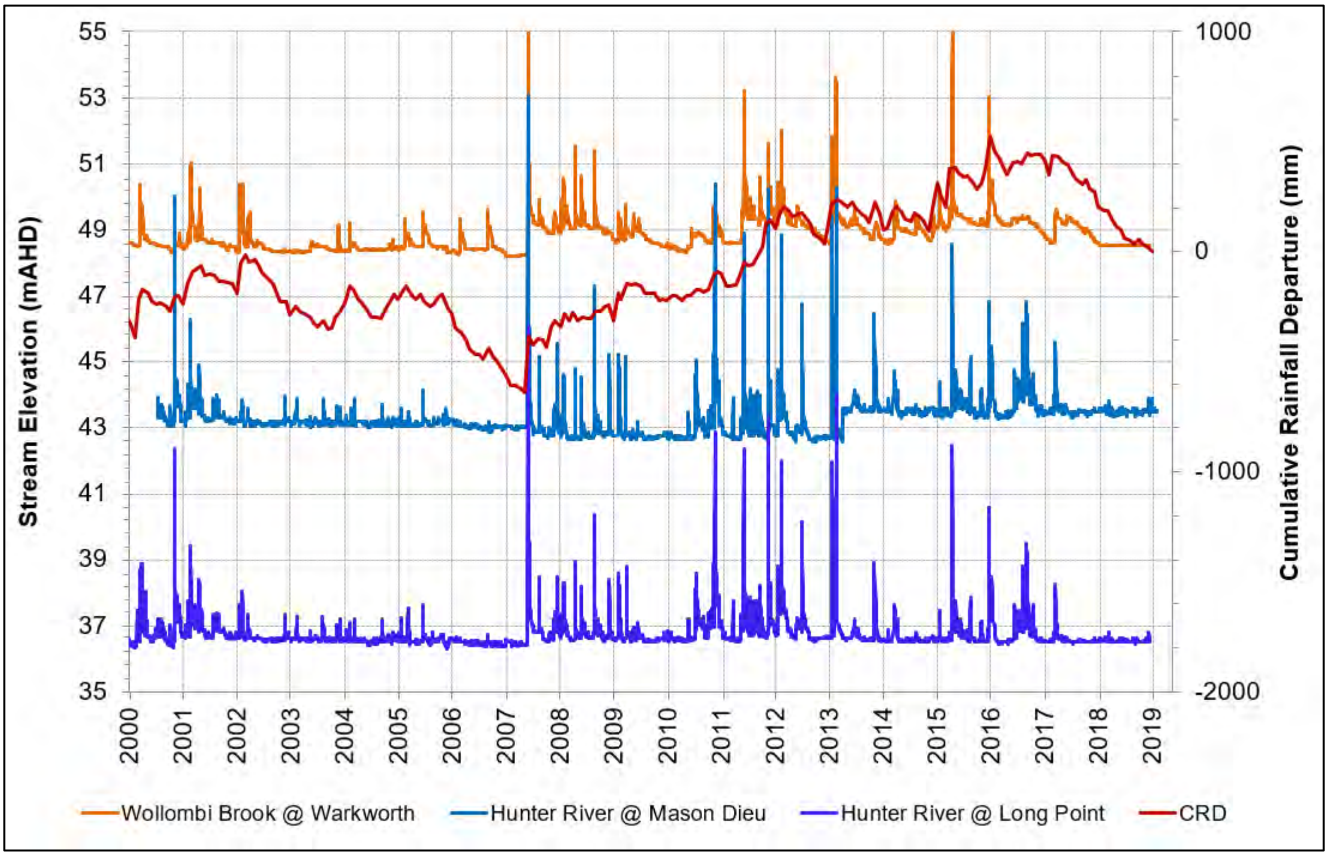


Figure 3-2 Surface Water Levels

As shown in **Figure 3-2**, over 2018 stream elevations within the Hunter River remained stable ranging between 36.44 mAHD and 36.80 mAHD at Long Point and between 43.35 mAHD and 43.91 mAHD at Mason Dieu. Glenbawn Dam is located approximately 135 km upstream of the project area. Daily regulated releases of the dam storage are undertaken to maintain flow and environmental quality of the Hunter River. Given the low rainfall recorded over 2018, the consistent elevations observed at both gauging stations are likely to be largely due to these storage releases.

Figure 3-2 shows that over 2018, stream elevations within Wollombi Brook were recorded between 48.5 mAHD and 48.7 mAHD. The zero gauge for Warkworth station (Station 210004) is 47.755 mAHD, meaning that water levels recorded above zero gauge over 2018 ranged between 0.75 m and 0.95m, but this may reflect pooled water. Time series data of total rainfall against discharge volumes for Wollombi Brook is presented in **Figure 3-3**. The graph shows that since August 2017 no discharge volumes have been recorded within the brook, suggesting that that over 2018 Wollombi Brook did not flow.

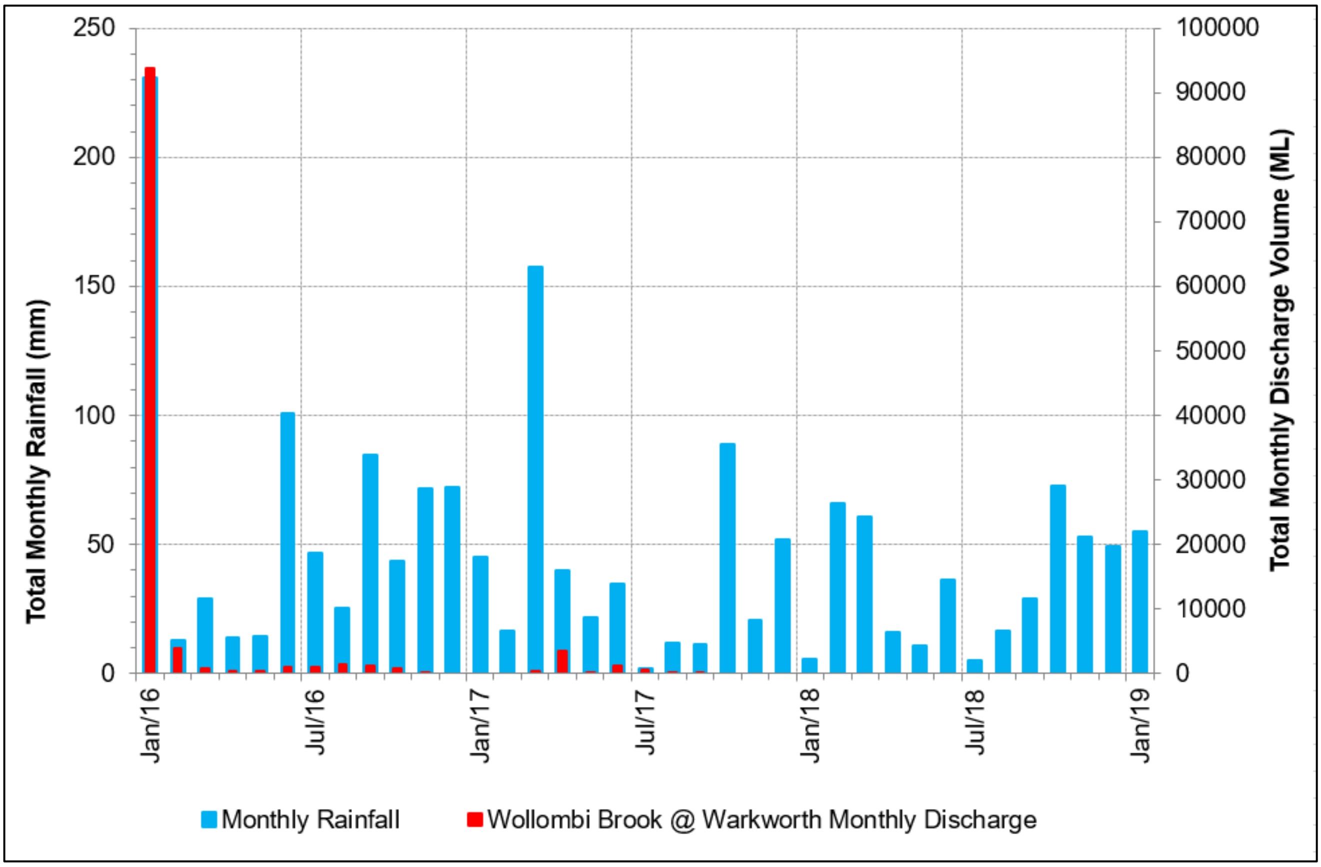


Figure 3-3 Surface Water Flow Volumes

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 Vane 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 3-4** 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.

Figure 3-4 Surface Geology

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, the Permian coal seams of the Whittingham Coal Measures and associated regolith material. Description of the groundwater units was derived from historical groundwater assessment reports, discussed in **Section 2.2**.

3.3.1 Regolith

Regolith material has been identified in the east of the project area overlying the Permian coal measures. The material is clay rich comprising clays, sandy clays and minor clay sands. The material has previously been categorised as alluvium. The regolith is recharged by rainfall infiltration and potential seepage from mine infrastructure.

3.3.2 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).

3.3.3 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 is 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 has been installed progressively over the life of the operations at MTW and acquired through land purchase. In relation to the WMP the groundwater monitoring network at MTW comprises 60 open standpipe bores installed into various geologic units. As outlined within the WMP, bores are grouped based on geology, as summarised below:

- Regolith;
- 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.
- Shallow Overburden

In addition, 10 vibrating wire piezometers (VWP's) with a total of 36 sensors are present across the site. However, based on discussion with site personnel and review of the data it is understood some of the VWP sensors may not be fully operational due to a range of factors (i.e. batteries). Details of each of the MTW monitoring bores as well as each bore's 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 60 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.

Six of the 60 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 5**.

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.

The WMP documents that sampling is to be undertaken in accordance 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*. Groundwater bores are purged prior to sample extraction for all samples requiring comprehensive laboratory analysis.

From review of the field contractors sampling field sheets, it is understood that for annual groundwater sampling the bores with 50 mm casing are purged either by using a Solinist low flow pump or bailer (3x casing volumes where possible) and water levels and field parameters (i.e. EC and pH) monitored. This approach is considered consistent with *AS 5667.1:-1998.* For bores with 25 mm and 32 mm casing, it is understood that the sample is collected following the purging using a bailer with a one-way check valve at the bottom of the bailer. Bores are purged until the field parameters stabilise and then they are sampled.

It is understood that all quarterly monitoring grab samples are collected using a disposable bailer. 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.

Figure 4-1 Groundwater Monitoring Network

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 2018 WMP and summarized in **Table 4-1**. EC and pH trigger levels for several bores have been updated since the 2017 WMP and these are denoted in the summary table.

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	Regolith*	950^	6.8^	7.7
OH787	Regolith*	18,185^	7.2^	7.7
OH788	Hunter River Alluvium	11,742	7.0	7.9
OH942	Regolith*	25,380^	6.4^	7.0^
OH943	Hunter River Alluvium	8,415^	7.1	7.6
PZ7S	Aeolian Warkworth Sands	1,752^	6.7	7.5
PZ8S	Wollombi Brook Alluvium	15,126^	6.5^	7.0
PZ9S	Wollombi Brook Alluvium	16,202^	6.8^	7.0^
PZ7D	Shallow Overburden	17,490^	6.9	8.1
PZ8D	Shallow Overburden	17,490^	6.9	8.1
PZ9D	Shallow Overburden	17,490^	6.9	8.1
MTD616P	Shallow Overburden	17,490^	6.9	8.1
MTD614P	Shallow Overburden	17,490^	6.9	8.1
MBW02	Shallow Overburden	17,490^	6.9	8.1
MB15MTW01D	Shallow Overburden	17,490^	6.9	8.1
MTD605P	Shallow Overburden	17,490^	6.9	8.1
MB15MTW02D	Shallow Overburden	17,490^	6.9	8.1
MB15MTW03	Shallow Overburden	17,490^	6.9	8.1
WD625P	Woodlands Hill / Whybrow	11,996^	7.1	7.3
WOH2153A	Redbank	16,123^	7.0	7.9
WOH2154A	Redbank	16,123^	7.0	7.9
WOH2155A	Redbank	16,123^	7.0	7.9
WOH2156A	Redbank	16,123^	7.0	7.9
WOH2153B	Wambo	13,843^	7.2^	7.8^
WOH2154B	Wambo	13,843^	7.2^	7.8^
WOH2155B	Wambo	13,843^	7.2^	7.8^

Location	Target Seam/ Stratigraphy	EC (95th) µS/cm	pH (5th)	pH (95th)
WOH2156B	Wambo	13,843^	7.2^	7.8^
WD622P	Wambo	13,843^	7.2^	7.8^
MBW04	Wambo	13,843^	7.2^	7.8^
WOH2139A	Blakefield	15,161^	6.6	7.6
OH1122 (1)	Blakefield	15,161^	6.6	7.6
OH1125 (1)	Blakefield	15,161^	6.6	7.6
OH1125 (3)	Bowfield	14,696^	6.6	7.0
OH1138 (1)	Warkworth	19,657^	6.3^	7.0^
OH1138 (2)	Warkworth	19,657^	6.3^	7.0^
OH1121	Vane Subgroup†	17,745^	6.7	7.1
OH1126	Vaux	17,745^	6.7	7.1
OH1137	Vaux	17,745^	6.7	7.1
OH1127	Vane Subgroup†	22,991^	6.6^	7.5
GW 9706	Bayswater	22,991^	6.6^	7.5
GW 9707	Bayswater	22,991^	6.6^	7.5
GW 9708	Bayswater	22,991^	6.6^	7.5
GW 9709	Bayswater	22,991^	6.6^	7.5
GW98MTCL1	Bayswater	22,991^	6.6^	7.5
GW98MTCL2	Bayswater	22,991^	6.6^	7.5

Note: ** Bore located outside extent of mapped alluvium and bore logs and site geology shows the bore actually intersects regolith material not Hunter River Alluvium as categorised within WMP*

† Bore located outside extent of mapped Jerry's Plains Subgroup and likely intersects underlying Vane Subgroup as per 1:25k geological mapping

^ Trigger level changed from previous WMP value

5 Monitoring Results

5.1 Data Recovery

Over 2018, groundwater monitoring was carried out at 60 monitoring bores across MTW. No water level or quality data was collected from eight of the monitoring bores over 2018 due to them being dry. The bores and 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
WOH2156B	WQ	75%	Insufficient water for lab sample – August 2018
WOH2139A	WL and WQ	100%	No access – November 2018, point sample December 2018
OH943	WQ	50%	Insufficient water for lab sample – March & June 2018
OH944	WL and WQ	0%	Bore dry over 2018
OH786	WQ	75%	Insufficient water for lab sample – June, September & November 2018
PZ9S	WQ	50%	Insufficient water for lab sample – June & August 2018
MTD614P	WL and WQ	75%	No access – June 2018
MB15MTW04	WL and WQ	0%	Bore dry over 2018
MB15MTW05	WL and WQ	0%	Bore dry over 2018
MB15MTW06	WL and WQ	25%	Bore dry from May to November 2018
MB15MTW07	WL and WQ	0%	Bore dry over 2018
MB15MTW08	WL and WQ	0%	Bore dry over 2018
MB15MTW09	WL and WQ	0%	Bore dry over 2018
MB15MTW10	WL and WQ	0%	Bore dry over 2018
MB15MTW11	WL and WQ	0%	Bore dry over 2018

Groundwater levels are recorded by site VWP's. Level data was successfully downloaded from eight of the VWP sites. Sites where data collection issues have been encountered are outlined in **Table 5-2.** Further work to check the VWP's are working correctly (i.e. check / replacing batteries) is ongoing.

Table 5-2 VWP Data Recovery

Location	Sensor (s)	Comments
WD622	1 to 5	Data erroneous – potential sensor failure
MTD518	1 to 3	Unable to process data – no sensor details available
PZ2	1 & 2	No longer exists
MTD605	3	Data potentially erroneous – calculated SWL elevation above VWP surface elevation.
MTD613	1	No data provided – sensor noted as 'out of service'
MTD614	3 to 5	Data erroneous – potential sensor failure

5.2 Water Levels

A summary of the water level results is provided for each of the main water bearing units (regolith, alluvium and Permian coal measures) below. Routine water level readings for 2018 are presented in **Appendix B**.

5.2.1 Regolith

Review of the construction depths of bores previously identified as intersecting the Hunter River Alluvium found three bores (OH786, OH787 and OH942) are in fact screened within regolith material meaning surficial clays and shallow deeply weathered Permian Coal Measures.

Over 2018, groundwater within the regolith bores occurred at depths of between 3.71 m and 13.87 m below surface. **Figure 5-4** presents the historical groundwater levels for all three regolith 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 which intersects the shallow regolith east of TD1. Flunctuations in groundwater levels within OH786 appear to follow changes in rainfall suggesting that they are influenced by climatic conditions. The adjacent bore OH942 is installed approximatley 6 m deeper into the weatherd Permian Coal Measures and recorded stable groundwater levels, indicating reduced rainfall recharge with depth.

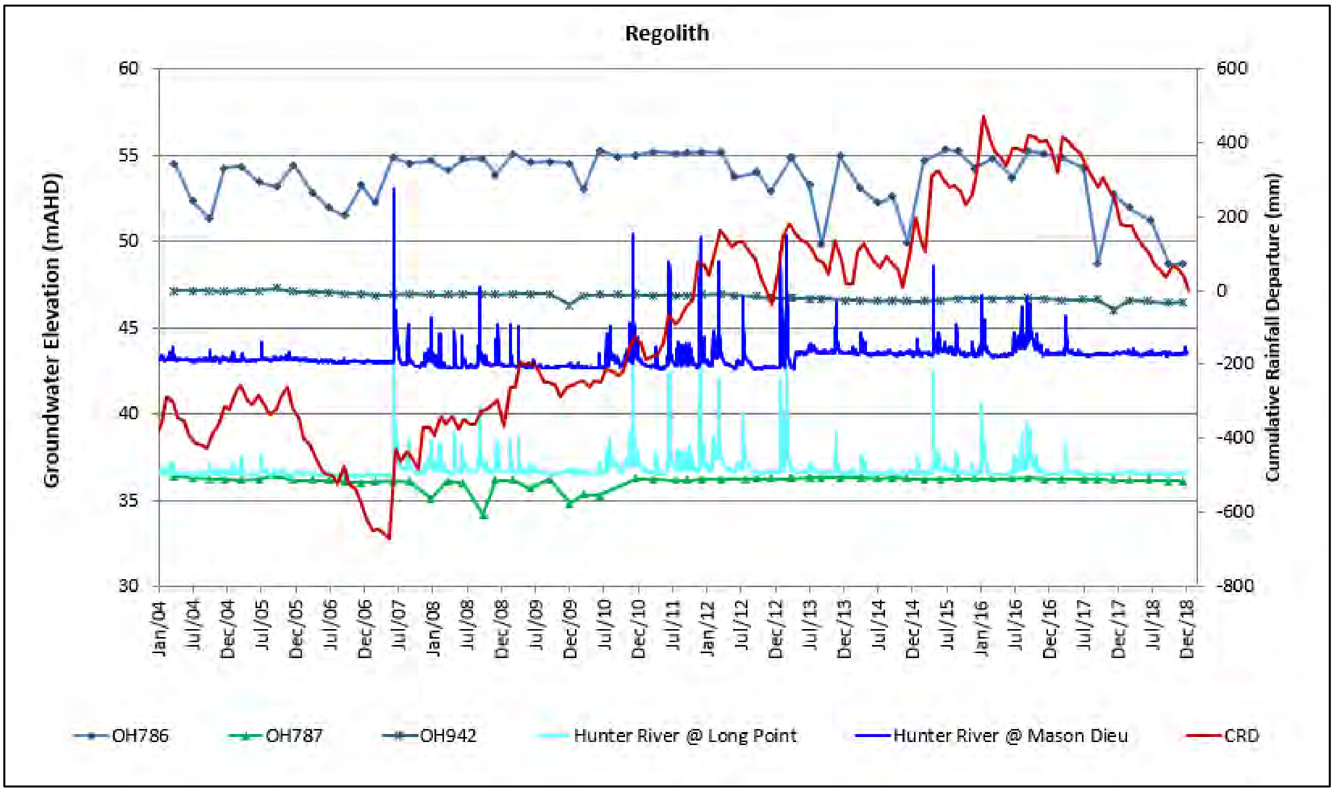


Figure 5-1 Groundwater Levels – Regolith

5.2.2 Alluvium

Groundwater level trends are discussed below for the Warkworth Sands, alluvium along the Hunter River and alluvium along Wollombi Brook.

5.2.2.1 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. Levels have been compensated using barometric levels recorded at the neighbouring Bulga Mine. As the barometric levels have not been recorded on site there is a degree of 'noise' in the readings however general trends in levels can still be inferred.

Bore PZ7 is a nested bore with screen within the Warkworth Sands to 11.1 m depth, and screen within the shallow overburden material at 30.5 m depth. Historical water level data for the bore is presented in **Figure 5-2**. **Figure 5-2** shows a general decline in groundwater levels within the Warkworth Sands and shallow overburden material at PZ7 over 2018. This trend appears to correspond with the general decline in rainfall over this period.

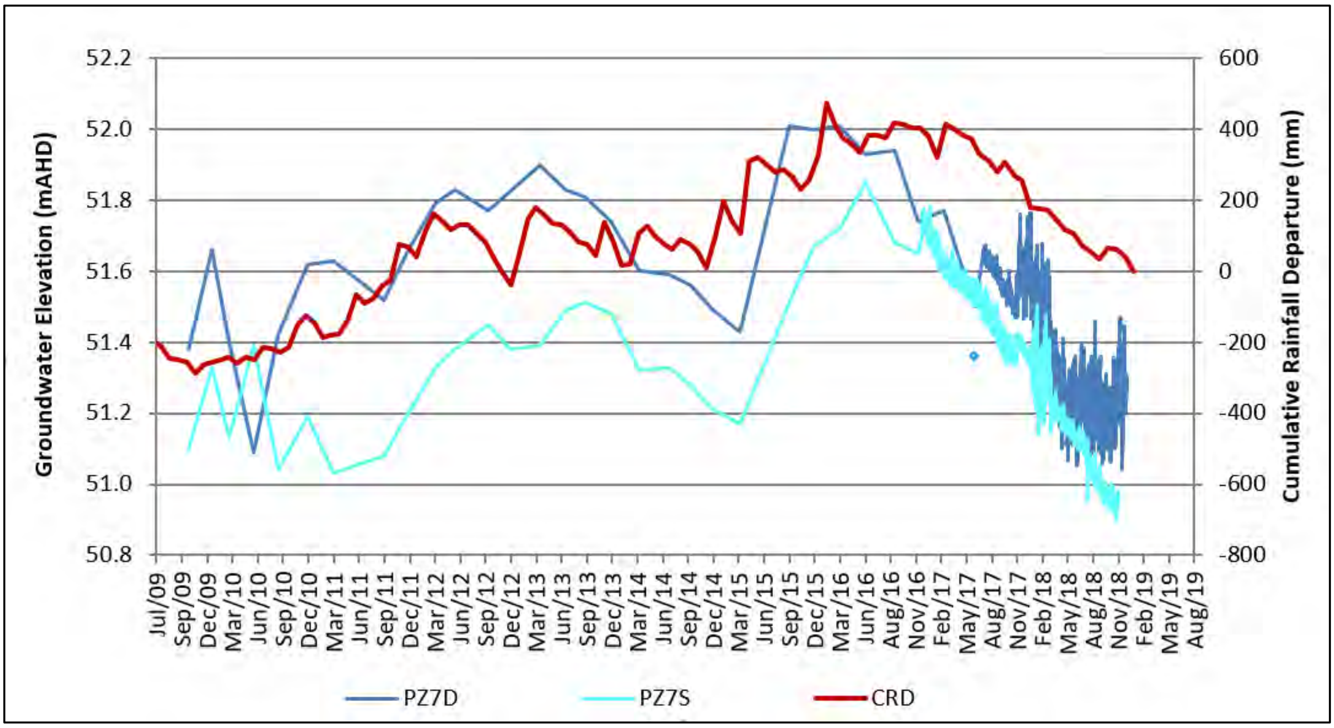


Figure 5-2 Groundwater Levels – Warkworth Sands Bore PZ7S and PZ7D

Bores MB15MTW04 to MB15MTW11 were generally recorded as dry since construction in 2016. An exception to this was bore MB15MTW06, which shows groundwater levels that respond to rainfall events (**Figure 5-3)**. Over Q2 and Q3 2018 bore MB15MTW06 was recorded as dry, which corresponds with a period of below average rainfall during this period (**Figure 5-3**).

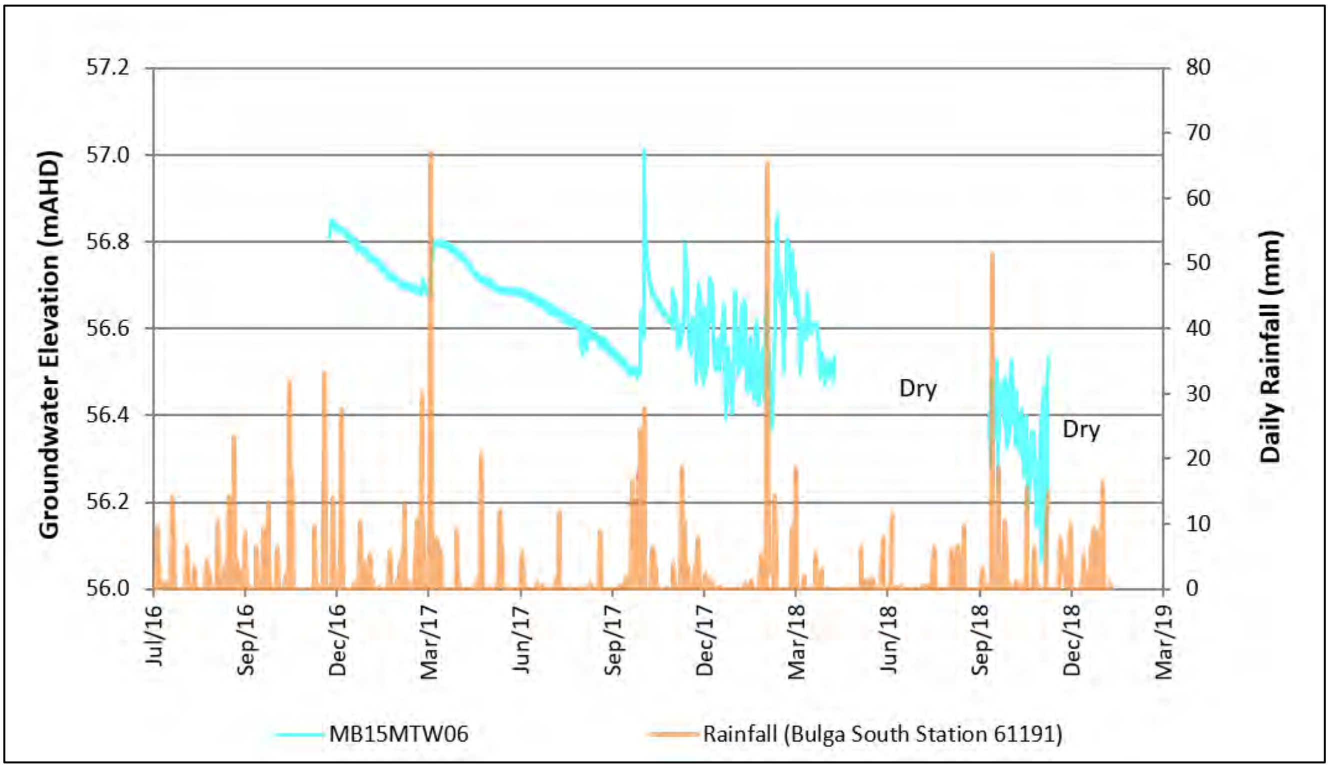


Figure 5-3 Groundwater Levels – Warkworth Sands Bore MB15MTW06

5.2.2.2 Hunter River Alluvium

Three bores within the monitoring network intersect alluvium along the Hunter River, these are OH788, OH943 to OH944. Over 2018, bore OH944 was dry, with water levels recorded at or below the base of the bore. According to available bore construction details, 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 9.5 m and 9.9 m below surface over 2018. **Figure 5-4** presents the historical groundwater levels for all three 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. As shown in **Figure 5-4** over 2018, groundwater levels in all Hunter River alluvium bores were relatively stable.

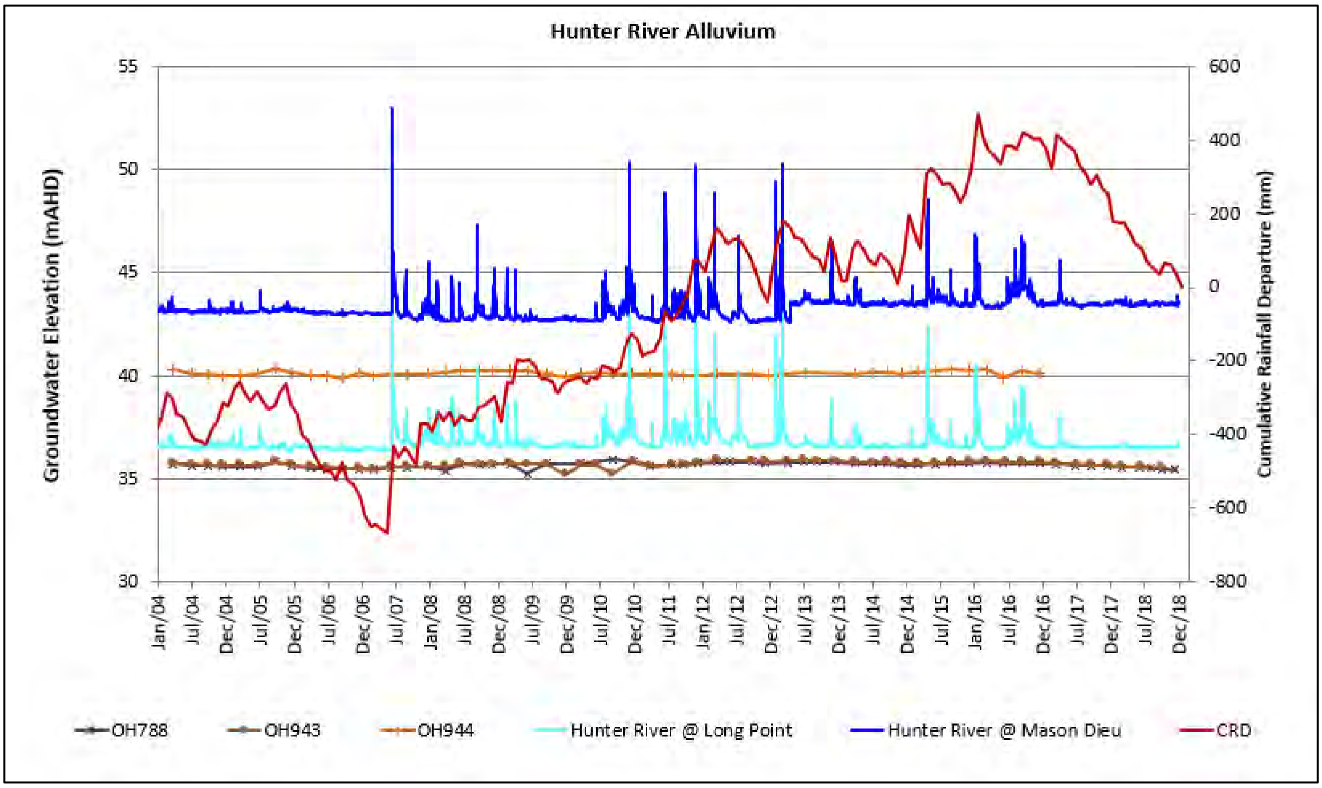


Figure 5-4 Groundwater Levels – Hunter River Alluvium

5.2.2.3 Wollombi Brook Alluvium

Five bores intersect the alluvium along the Wollombi Brook, G3, 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 5-5,** 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. It should be noted that due to data logger failure groundwater level data for MB15MTW02D is only accurate up to June 2018. Any data recorded after June 2018 has not been included within this review.

Bores MB15MTW01 and MB15MTW02 are located adjacent to Wollombi Brook. **Figure 5-5** shows that over 2018 alluvial groundwater elevations along Wollombi Brook were below stream elevations, indicating losing conditions. Groundwater levels within the alluvium and shallow overburden steadily declined over 2018. 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.

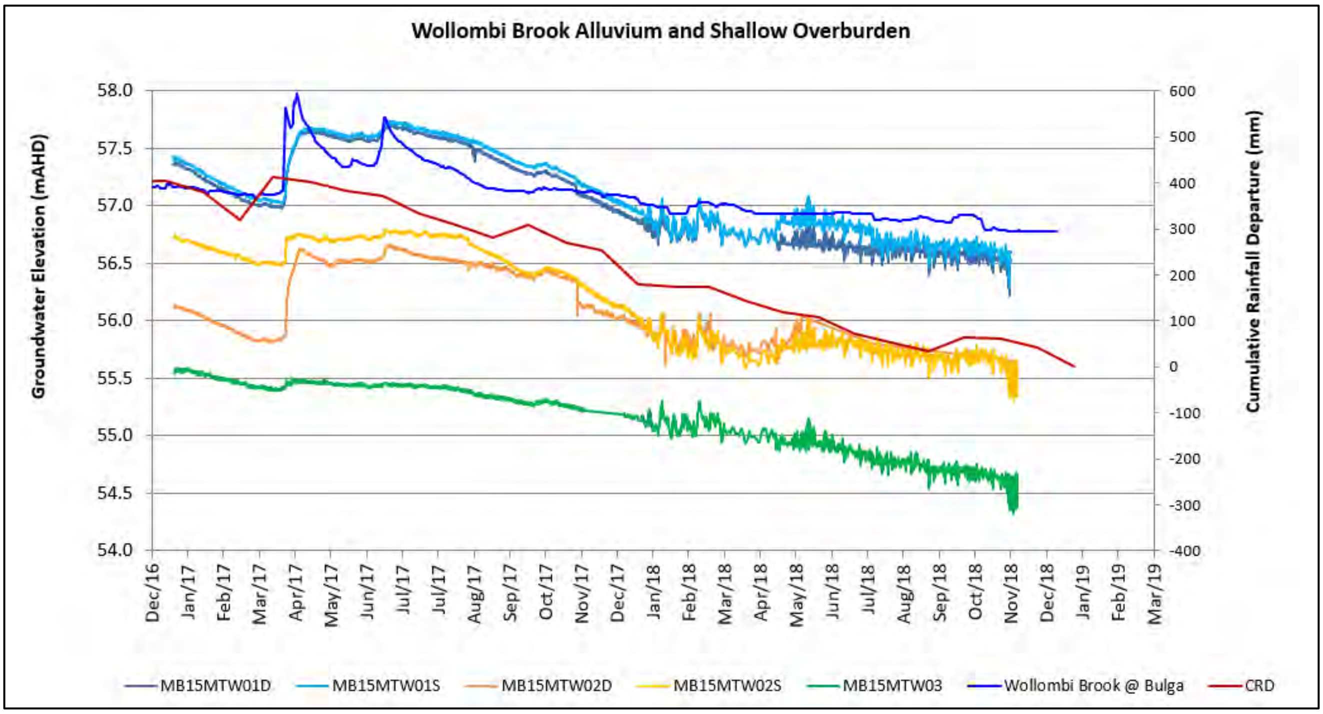


Figure 5-5 Groundwater Levels – Wollombi Brook Alluvium MB15MTW01 and MB15MTW02

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 5-6**. 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 5-6** shows a general decline in groundwater levels within the alluvium over time.

Figure 5-6 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. Between 2016 and 2017 groundwater levels gradually rose before becoming more stable over 2018. 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.

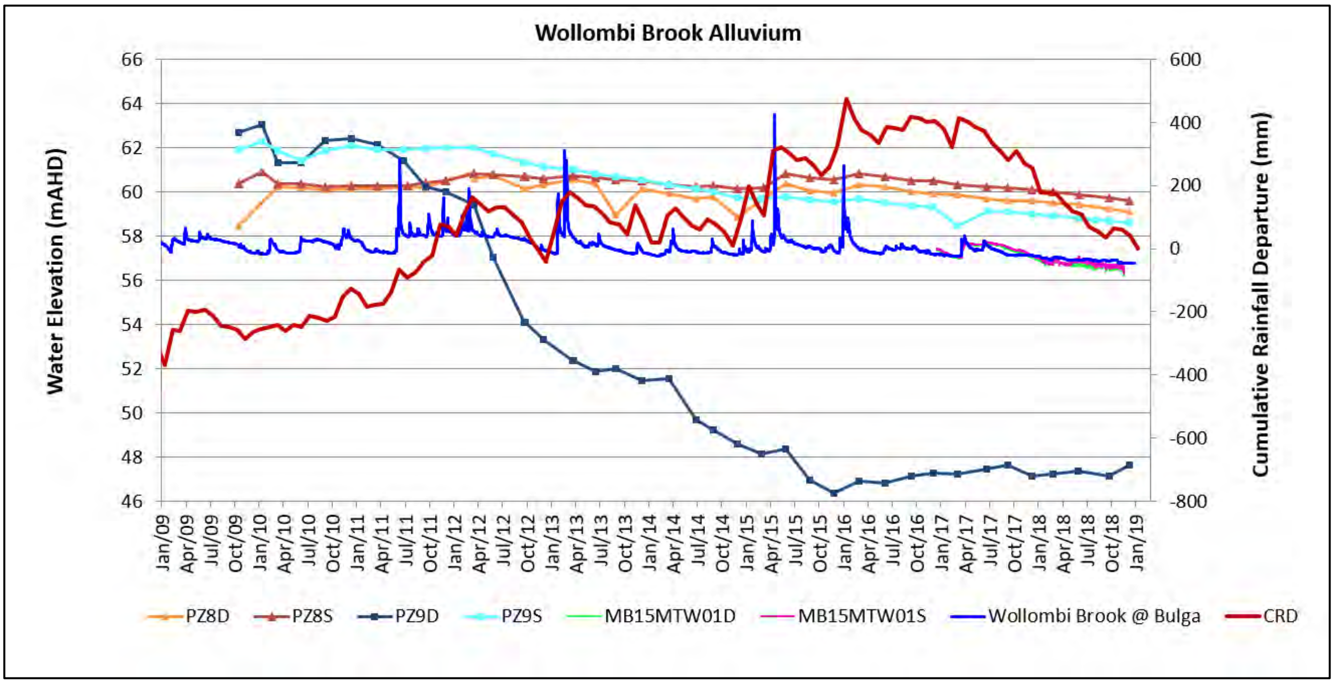


Figure 5-6 Groundwater Levels – Wollombi Brook Alluvium Bores PZ8, PZ9, MB15MTW01 and MB15MTW02

5.2.3 Permian Coal Measures

Groundwater level trends for the Permian coal measures are discussed in stratigraphic order in **Section 5.2.3.1** to **Section 5.2.3.9** 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.

5.2.3.1 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 5-5** of **Section 5.2.1**, as the bore is located along Wollombi Brook. **Figure 5-5** showed a general decline in groundwater levels at MB15MTW03 over 2018. 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 5-7**. **Figure 5-7** shows stable to slightly declining groundwater levels within the shallow overburden material.

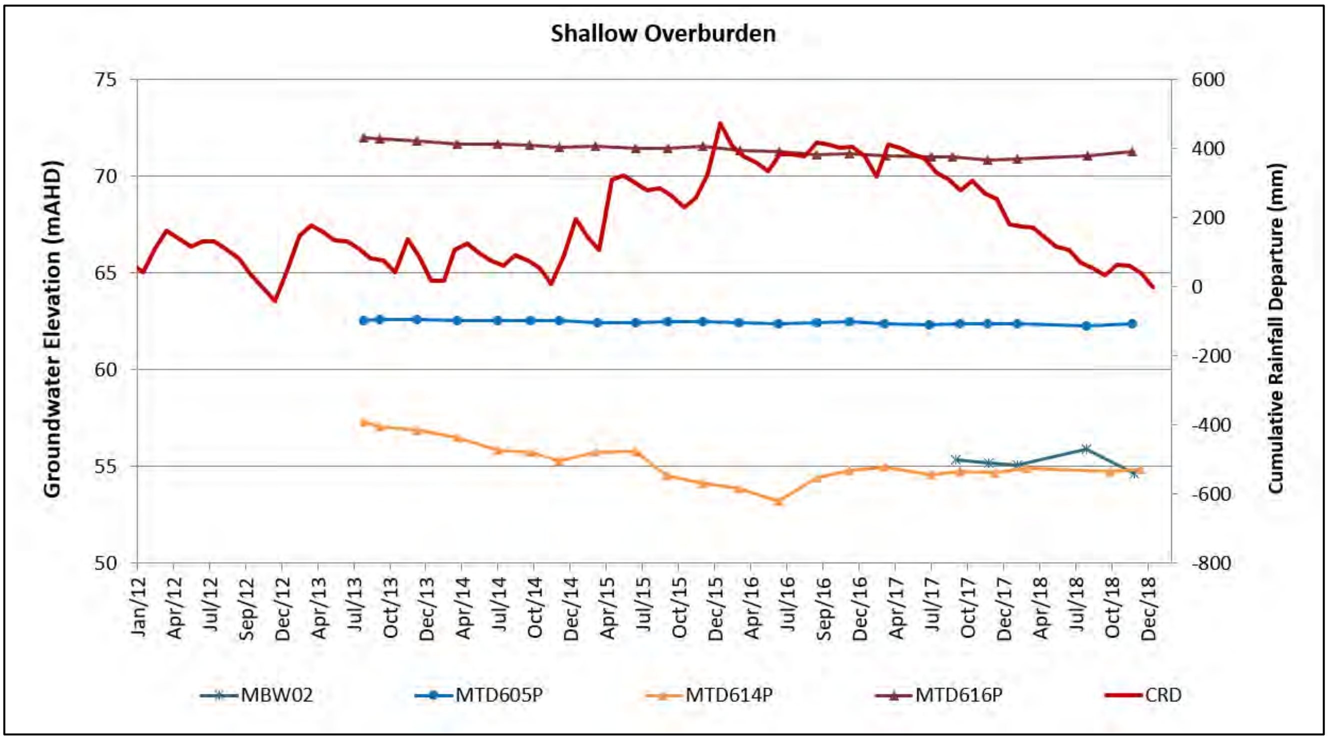


Figure 5-7 Hydrograph of Shallow Permian Coal Measures

5.2.3.2 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 5-8**. **The graph** shows that over 2018 groundwater elevations ranged between 52.3 mAHD and 67.4 mAHD. Over 2018 groundwater levels generally declined in bores WOH2154B, WOH2153A, WOH2154A and WOH2156A. Over 2018 groundwater elevation in WD622P increased from 52.8 m AHD to 53.7 m AHD. WD622P, is located within 300 m of the highwall at West Pit. Groundwater elevations were also found to slightly increase after June 2018 in bores WOH2155A and WOH2156B. Groundwater levels remained relatively stable at bores WOH2153B, WOH2155B and WD625P, which are all located approximately 1 km west of Warkworth operations.

Groundwater level trends for VWP sensors installed within the Whybrow and Wambo seams are presented in **Figure 5-9** and **Figure 5-10** respectively. The graphs show that over 2018 groundwater elevations within both seams slightly declined. This corresponds with the monitoring bore data and is likely due to depressurisation of the seams from mining of West Pit and Loders Pit to the east. The exception to this was seen in the MTD614 sensor installed within the Whybrow Seam (sensor 1) where groundwater elevations were found to increase. MTD614 is located directly to the west of Loders Pit which is actively mined down to the deeper Woodlands Hill Seam. The active mining should in theory result in lowering of groundwater levels through depressurisation, continued monitoring of the sensor should be maintained to ensure it is working correctly and verify this data.

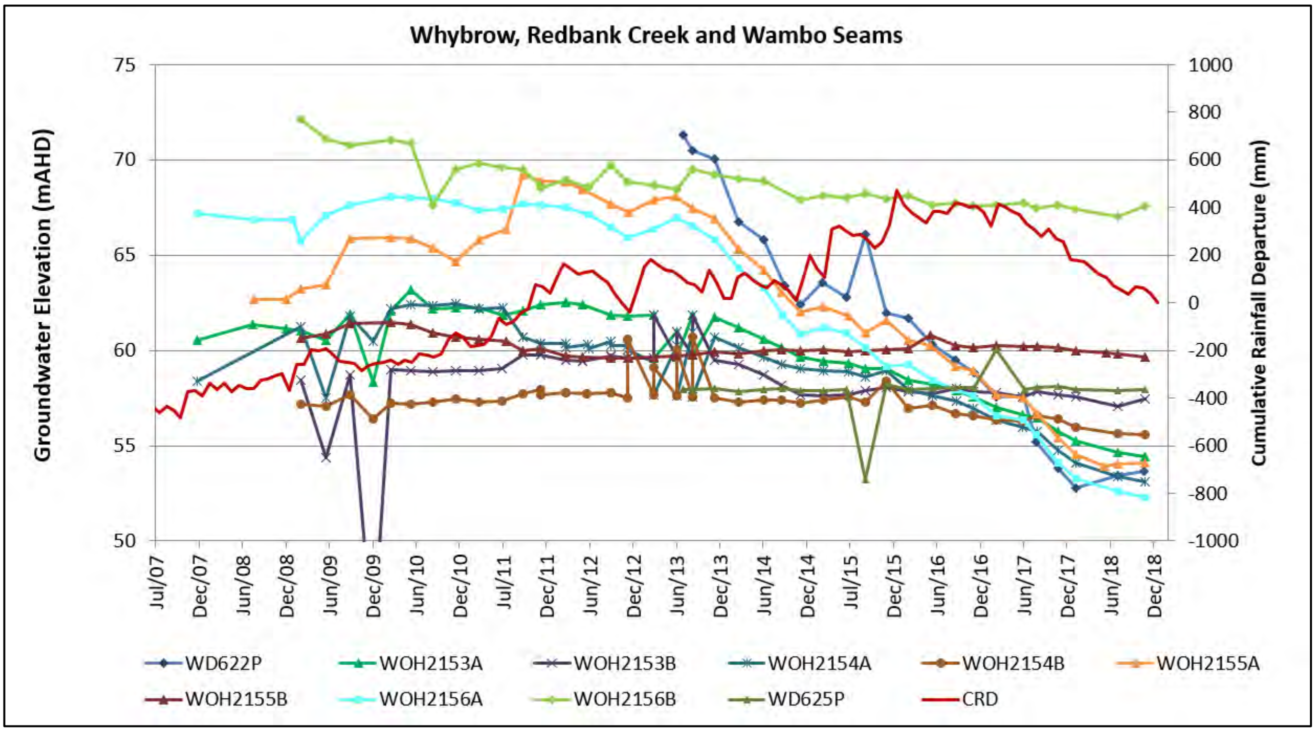


Figure 5-8 Hydrograph of Whybrow, Wambo and Redbank Creek Seams

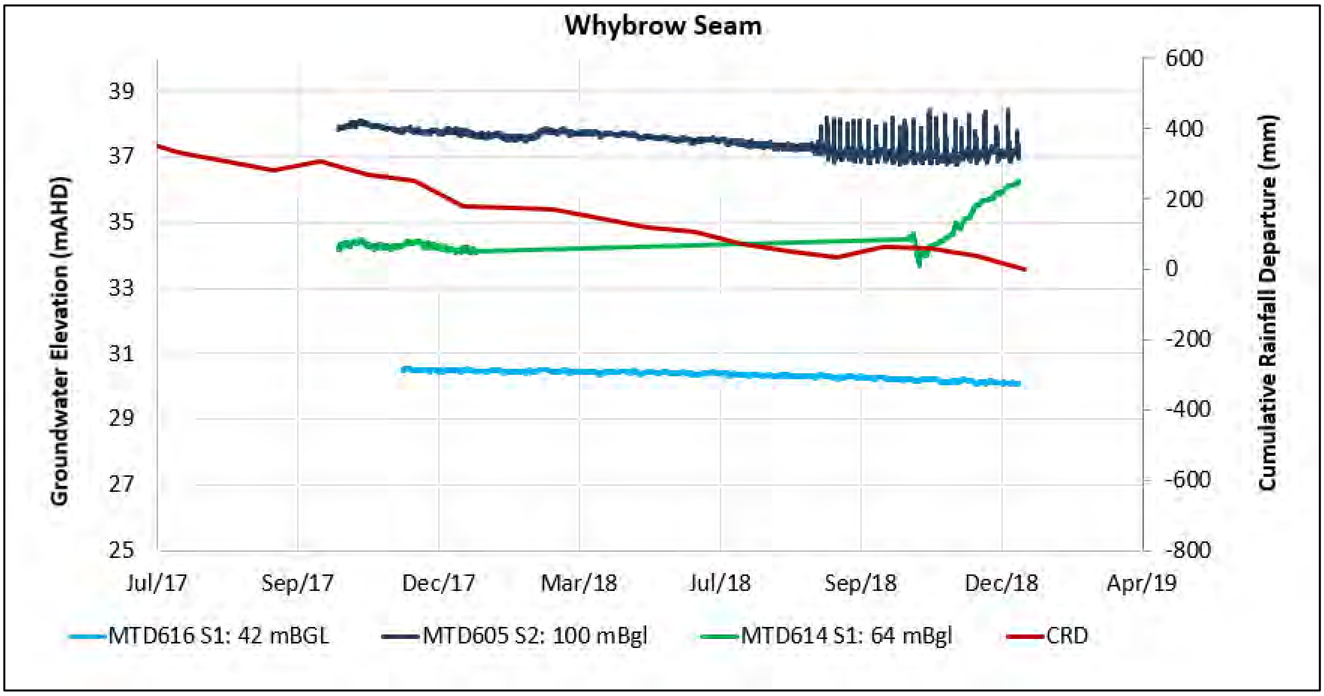


Figure 5-9 VWP Hydrograph of Whybrow Seam

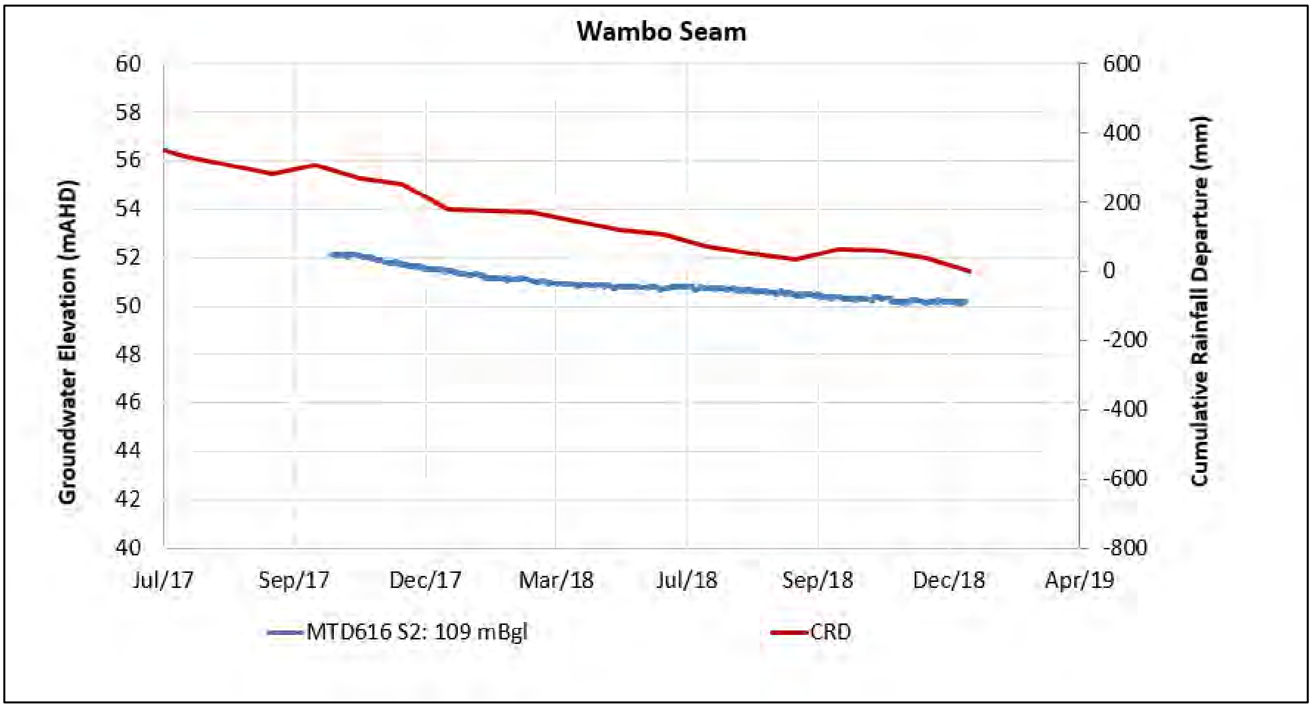


Figure 5-10 VWP Hydrograph of Wambo Seam

5.2.3.3 Blakefield Seam

Historical groundwater level trends for bores intersecting the Blakefield Seam are presented in **Figure 5-11**. The graph shows that over 2018 groundwater elevations ranged between 40.8 mAHD and 57.1 mAHD. Groundwater levels generally declined within the Blakefield Seam around site over Q1 to Q3 2018. In Q4 2018 groundwater levels still declined but became more stable. In response to mine progression Bore OH1125(1) recorded a 3.8 m decline, Bore WOH2139A recorded a 1.7 m decline and Bore OH1122(1) recorded a 0.3 m decline over 2018.

Groundwater level trends for VWP sensors installed within the Blakefield Seam are presented in **Figure 5-12**. The graph shows that over 2018 groundwater elevations within the seam slightly declined. This corresponds with the monitoring bore data and is likely due to depressurisation of the seams from expansion of West Pit and Loders Pit to the east.

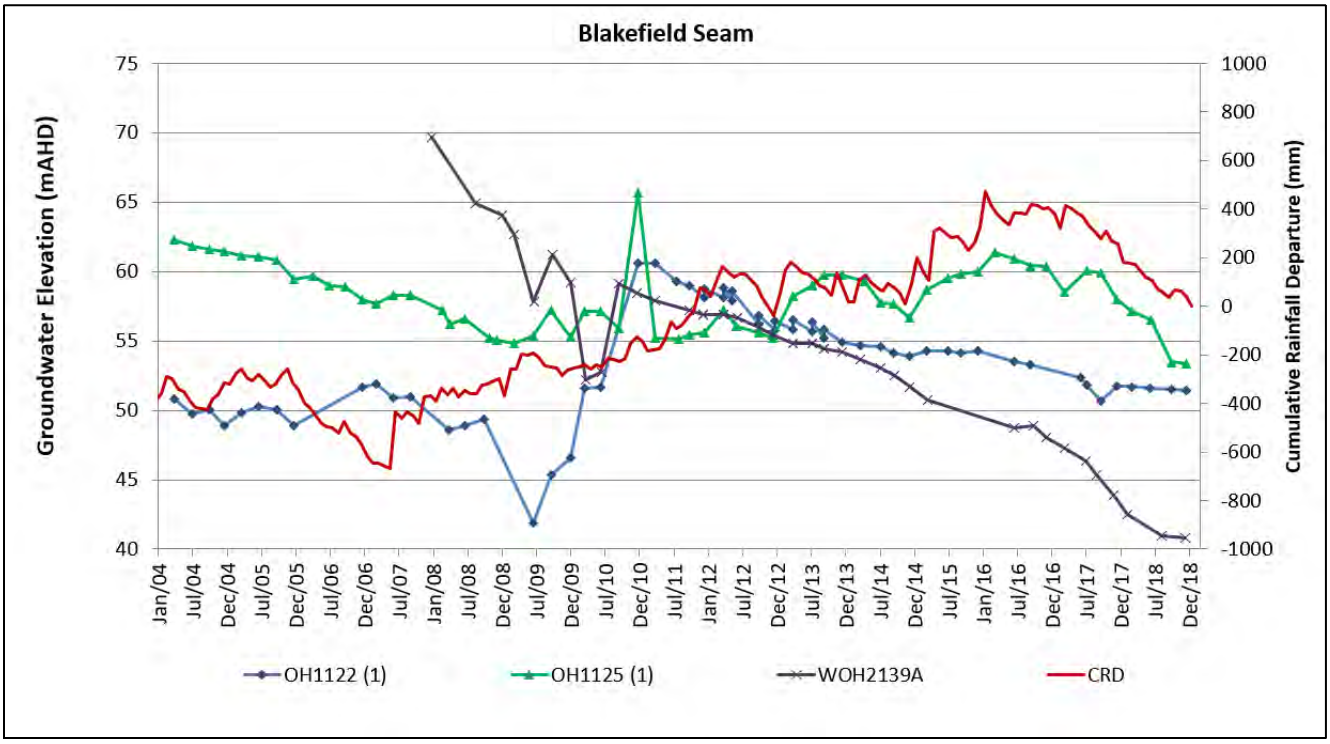


Figure 5-11 Hydrograph of Blakefield Seam

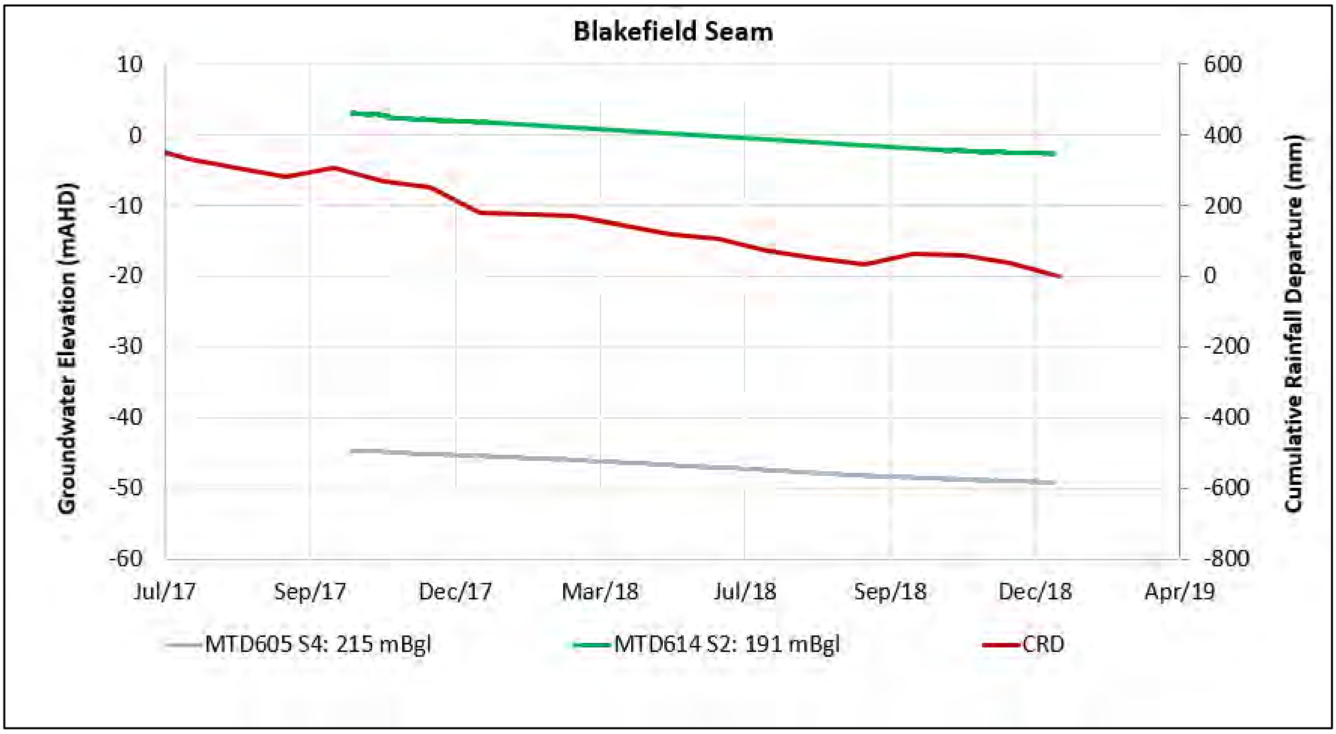


Figure 5-12 VWP Hydrograph of Blakefield Seam

5.2.3.4 Woodlands Hill Seam

Groundwater level trends for VWP sensors installed within the Woodlands Hill Seam are presented in **Figure 5-13**. The graph shows that over 2018 groundwater elevations within the seam at VWP WD625 were variable, whereas at VWP MTD616 groundwater elevations slightly declined. MTD616 is located to the north west of Loders Pit and west of West Pit. The decreasing groundwater elevations are likely due to dewatering of the coal seam from mining of these pits.

WD625 is located to the west of North Pit and recorded variable groundwater elevations over 2018. The cause of these fluctuations is unclear but may relate to underground mine and water storage activities at Wambo.

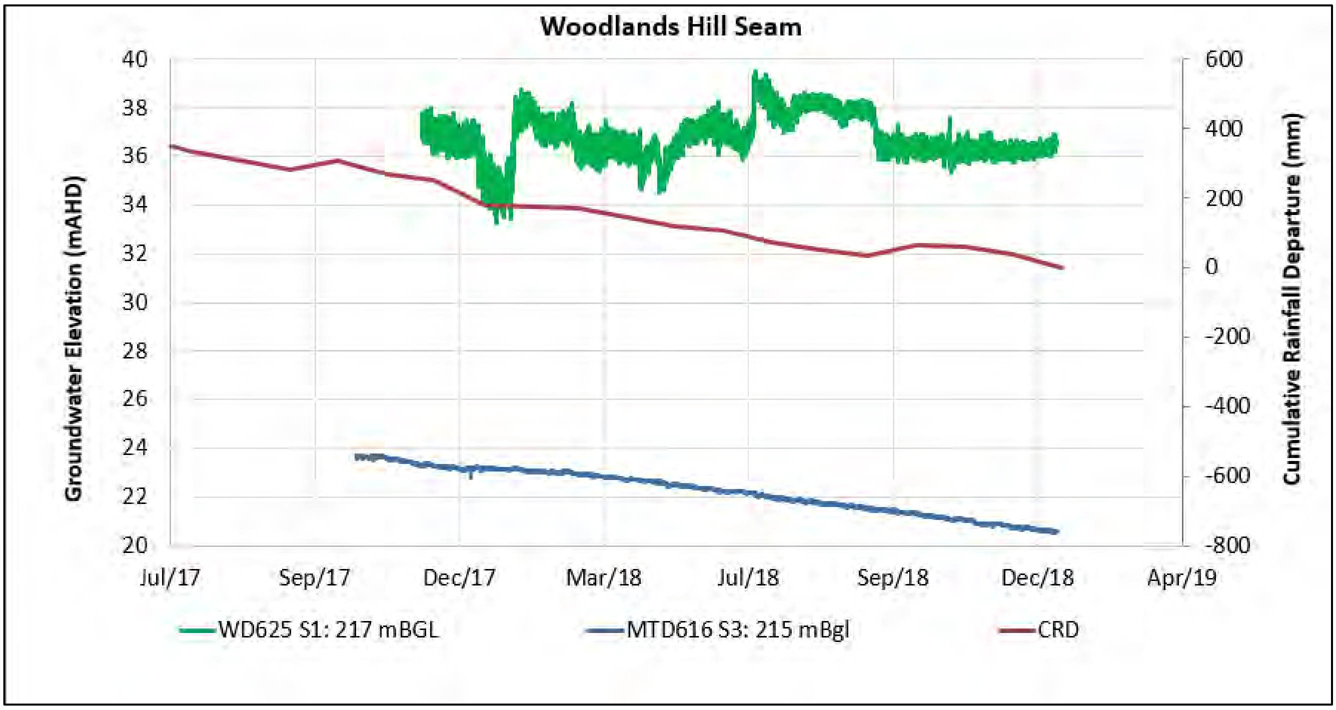


Figure 5-13 VWP Hydrograph of Woodlands Hill Seam

5.2.3.5 Bowfield Seam

Historical groundwater level trends for bores intersecting the Bowfield Seam are presented in **Figure 5-14**. The graph shows that between December 2017 and March 2018 groundwater elevations in Bore OH1125(3) increased by 7.7 m. Over 2018 groundwater elevations in Bore OH1125(3) decreased from 46.6 mAHD to 43.93 mAHD, corresponding to the decrease in rainfall over this period. Bore OH1125(3) is located directly to the north of North Pit. The increase in groundwater elevation noted between 2017 and 2018 may correspond to recovery with progressive mine rehabilitation or potentially in response to site water storage activities associated in dewatering TD2. 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.

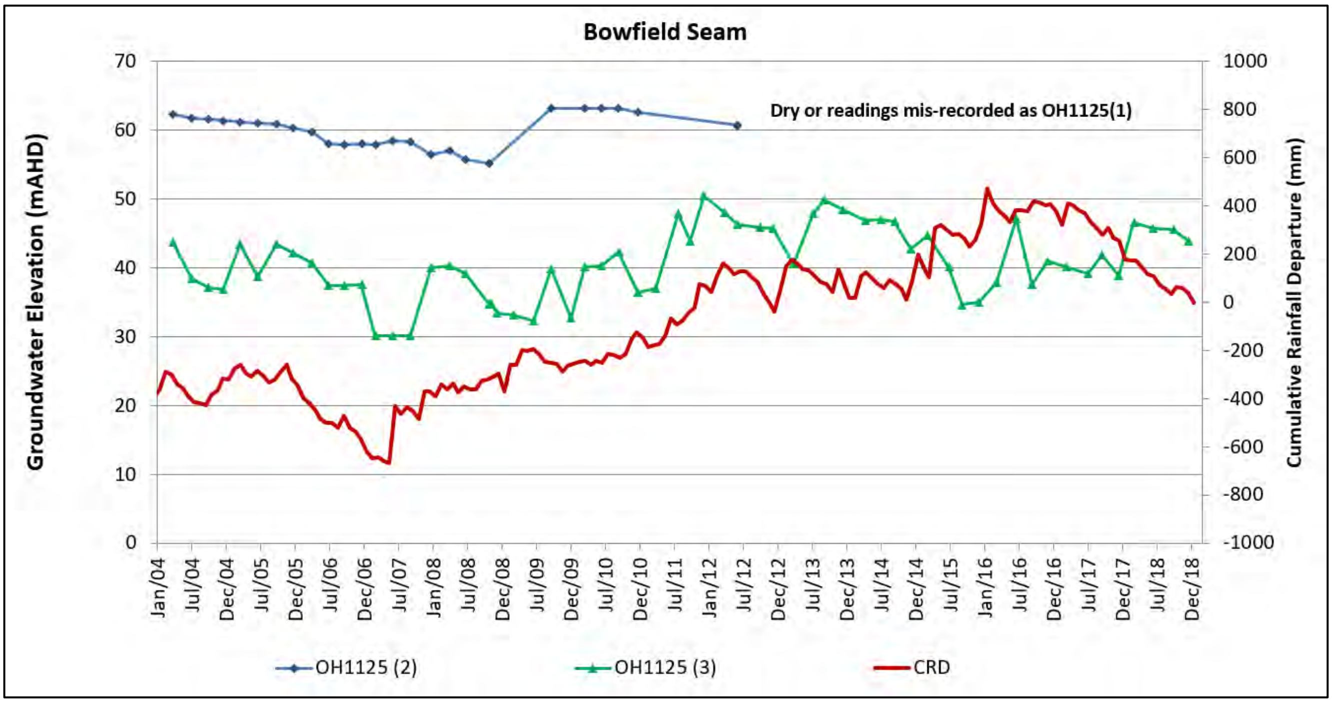


Figure 5-14 Hydrograph of Bowfield Seam

5.2.3.6 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 5-15**. The graph shows that over 2018 groundwater elevations ranged between 55.85 mAHD and 61.06 mAHD and level declined by up to 0.54 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.

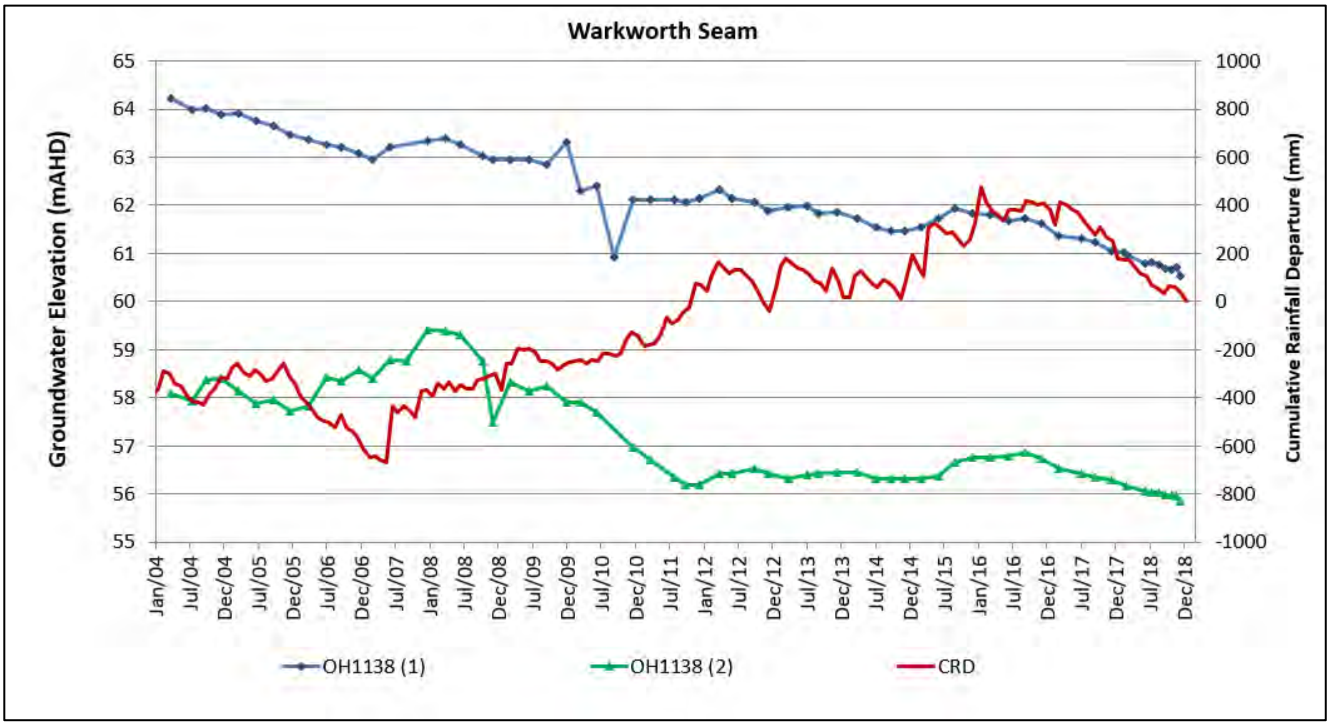


Figure 5-15 Hydrograph of Warkworth Seam

5.2.3.7 Mt Arthur and Piercefield Seams

Historical groundwater level trends for VWP sensors intersecting the Mt Arthur and Piercefield coal seams are presented **Figure 5-16** and **Figure 5-17** respectively.

Figure 5-16 shows that over 2018 groundwater elevations within the Mt Arthur Seam ranged between 2.59 mAHD and 34.35 mAHD and level declined by up to 1.61 m. The large difference in groundwater elevations is related to the difference in sensor elevations across the VWPs. The sensor elevations and construction details for VWP MTD605 should be reviewed to verify the accuracy of the groundwater elevations presented. The decreasing elevations within VWP MTD605 and MTD616 are likely to be due to the depressurisation of coal seams related to West Pit and Loders Pit. The stable elevations observed in WD625 suggest that depressurisation of the coal seams associated with North Pit are not influencing groundwater levels within the Mt Arthur seam at this location.

Figure 5-17 shows that over 2018 groundwater elevations within the Piercefield Seam declined from 27.22 mAHD to 25.38 mAHD (1.84 m). VWP WD615 is located along the southern boundary of North Pit. The decrease in groundwater elevation within the Piercefield Seam is likely to be associated with the depressurisation of coal seams related to the western excavation of North Pit.

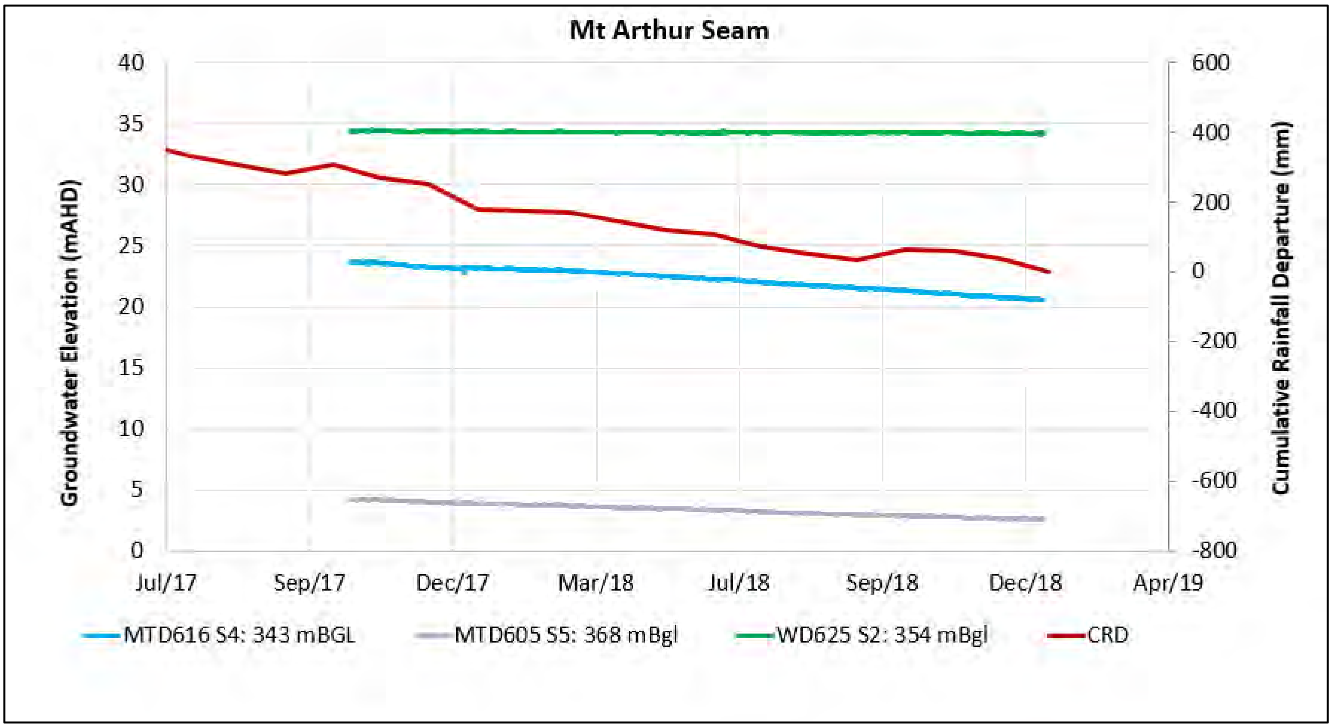


Figure 5-16 VWP hydrograph of Mt Arthur Seam

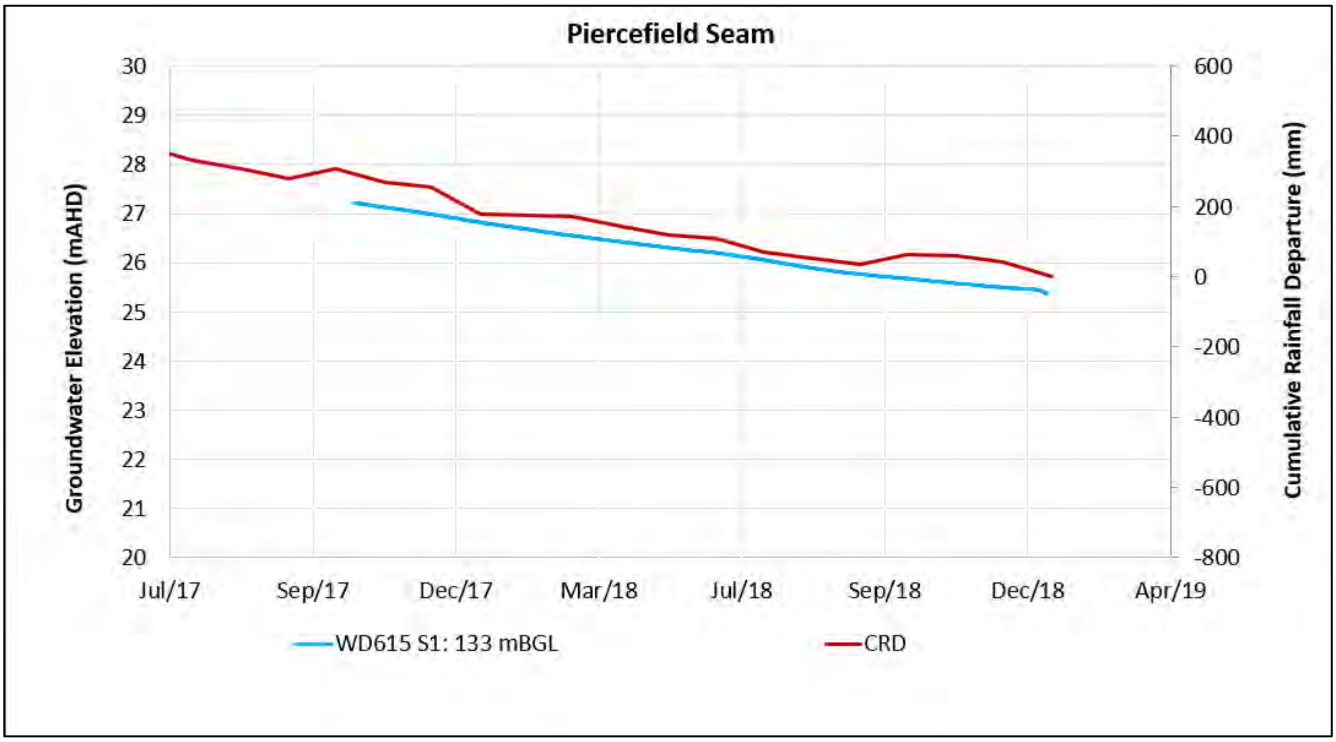


Figure 5-17 VWP hydrograph of Piercefield Seam

5.2.3.8 Vaux Seam

Historical groundwater level trends for bores intersecting the Vaux Seam around MTW are presented in **Figure 5-18**. The graph shows that over 2018 groundwater elevations within the Vaux Seam, north of North Pit, (OH1126 and OH1137) ranged between 47.12 mAHD and 53.89 mAHD and levels declined by up to 0.87 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 2018. 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 3-4**) 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.

Groundwater level trends for VWP sensors installed within the Vaux seam are presented in **Figure 5-19**. The graph shows that over 2018 groundwater elevations were relatively stable. WD625 is located to the west of North Pit, MT605 is located to the west of Loders Pit and MTD616 is located to the south west of West Pit. The VWP data therefore suggests that over 2018 groundwater levels within the Vaux Seam were not influenced by mine operations at these locations.

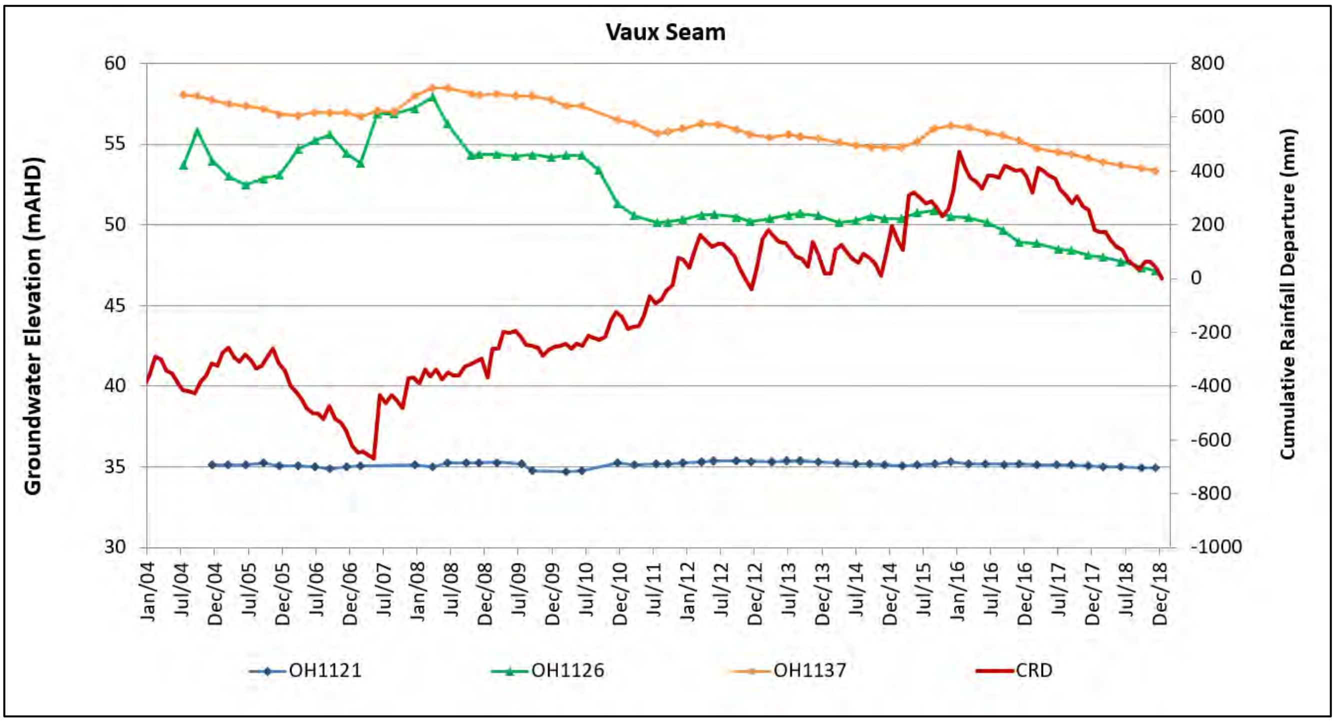


Figure 5-18 Hydrograph of Vaux Seam

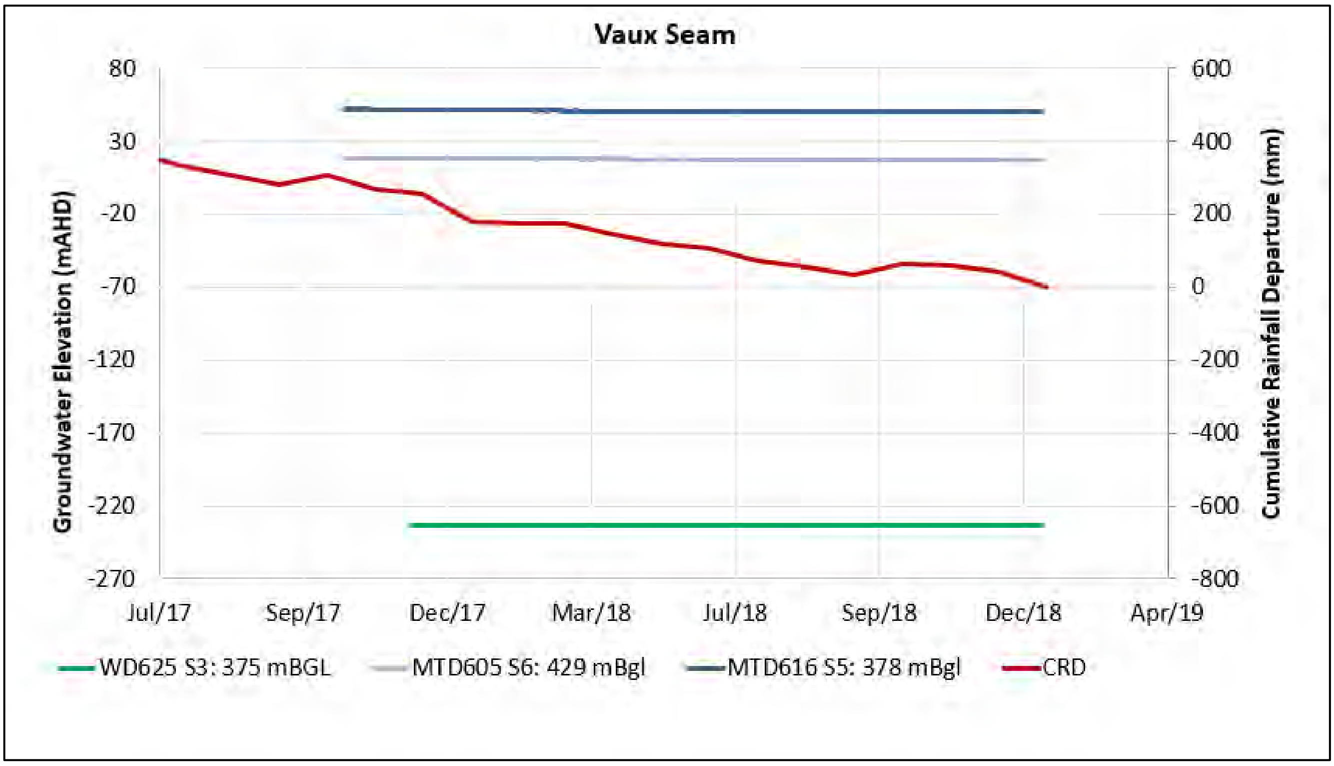


Figure 5-19 VWP hydrograph of Vaux Seam

5.2.3.9 Bayswater Seam

Historical groundwater level trends for bores intersecting the Bayswater Seam around MTW are presented in **Figure 5-20**. The graph shows that over 2018 groundwater levels remained relatively stable, with elevations ranging between 35.24 mAHD and 69.07 mAHD. All bores presented in **Figure 5-20** are located to the south east of South Pit.

Groundwater level trends for VWP sensors installed within the Bayswater Seam are presented in **Figure 5-21**. The graph shows that over 2018 groundwater elevations were relatively stable. All VWP locations are located to the west of the main mine pits (North Pit, West Pit and Loders Pit). As observed within the Vaux Seam, the groundwater levels reported suggest that mine operations are not impacting groundwater levels within the Bayswater seam at the VWP monitoring locations.

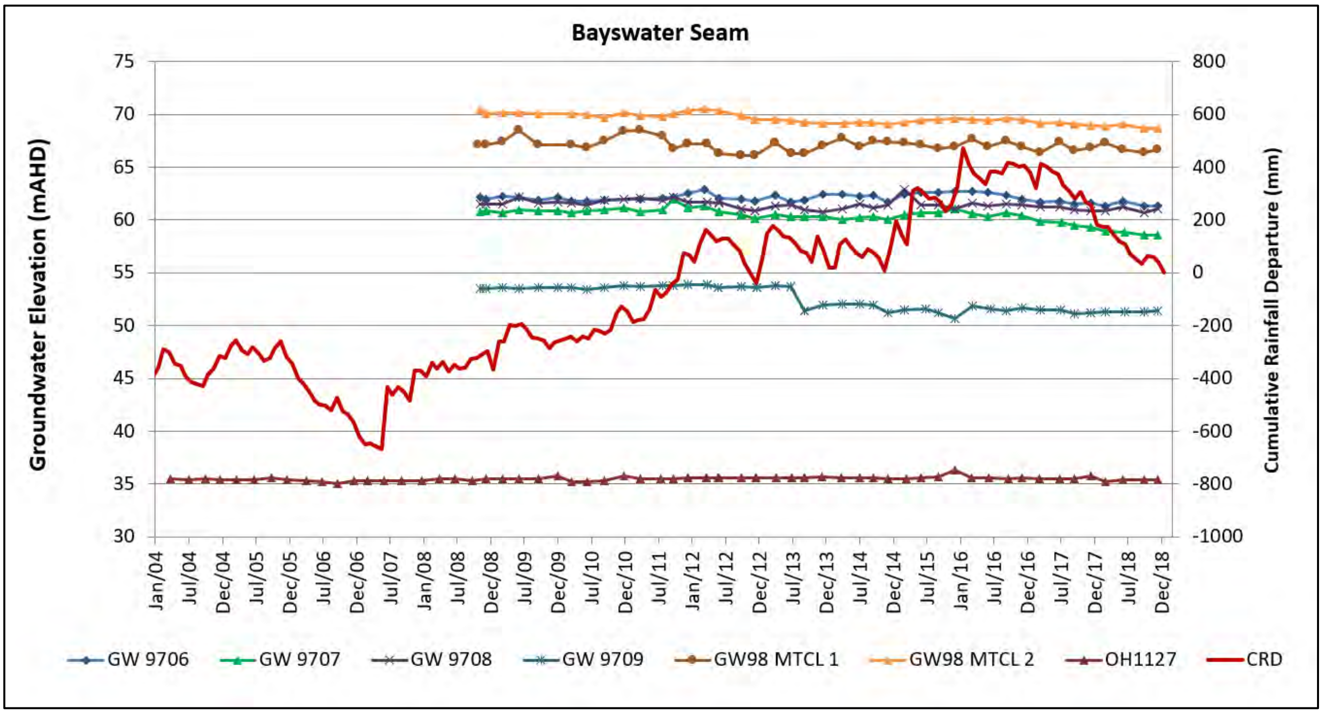


Figure 5-20 Hydrograph of Bayswater Seam

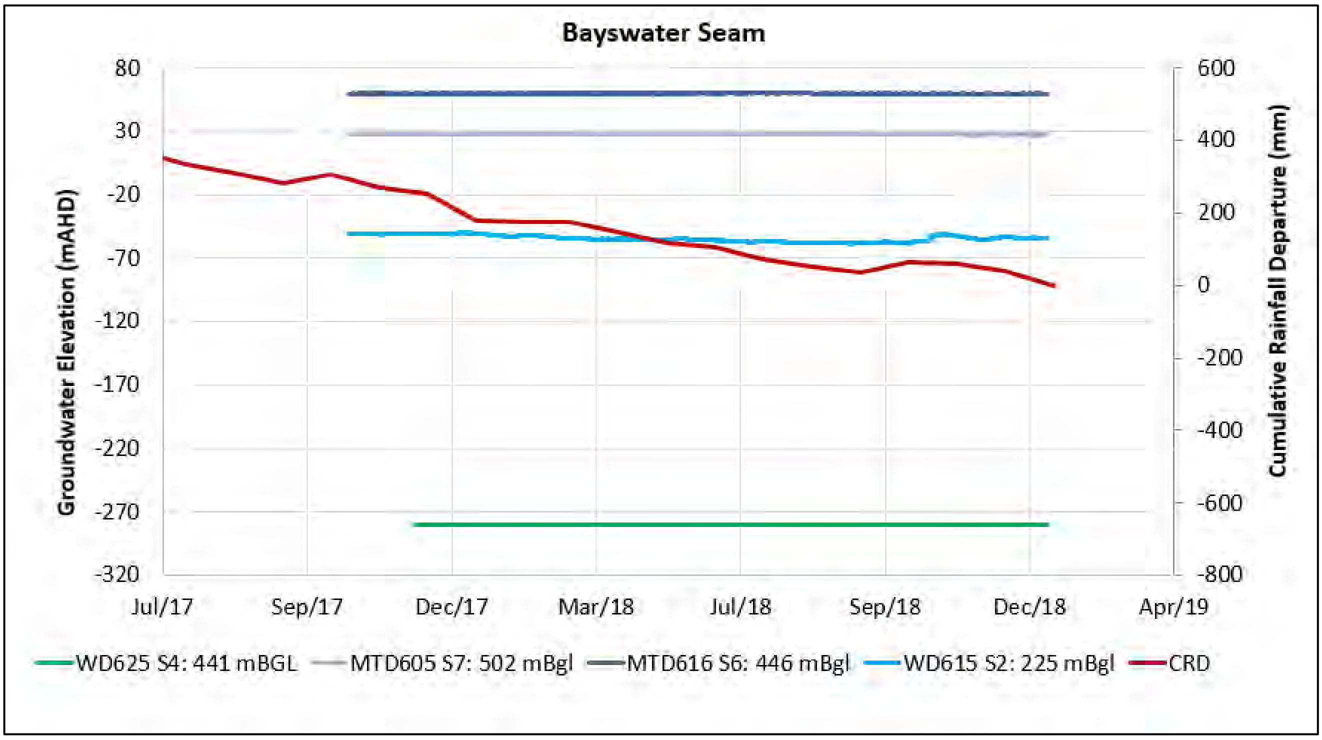


Figure 5-21 VWP hydrograph of Bayswater Seam

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.

5.3.1.1 Regolith

Over the 2018 monitoring period, the following triggers were exceeded for the bores within the regolith:

- Bore OH786 recorded EC above the trigger level of 950 µS/cm in Q2; however, this appears to be a spike result, with the Q1 reading within the trigger range (as stated samples were not collected in Q3 and Q4 due to insufficient water); and
- Bore OH787 recorded EC levels at and above the trigger level of 18,185 µS/cm in Q2 and Q3.

Historical EC readings for OH787 since 2015 show regular fluctuations of between 17,070 µS/cm and 18,150 µS/cm. The 2018 readings of up to 18,500 µS/cm are therefore slightly above historical levels. This trend may relate to the area having received below average rainfall over most of 2018. Bore OH787 recorded groundwater levels of between 13.79 m and 13.86 m depth, which are above the reported base of the bore (15.05 m depth). Available construction details indicate the screen extends to 12.1m. This difference in reported bore depths may suggest that a sump exists, potentially influencing results. A review of the bore condition and construction is required to verify the bore depth. A review of the sampling methodology is also recommended as the practice of collecting grab samples is likely to influence the quarterly results.

5.3.2 Alluvium

Over 2018, 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 2018; and
- Bores targeting the Warkworth Sands, MB15MTW04 to MB15MTW11, were recorded as dry over 2018

Alluvial groundwater quality over 2018 ranges between the different units, as discussed below:

- Warkworth Sands: EC ranges between 1,515 µS/cm and 1,746 µS/cm and pH ranges between 6.8 and 7.1 for bore PZ7S.
- Hunter River: EC ranges between 7,300 µS/cm and 13,090 µS/cm and pH ranges between 6.9 and 7.8.
- Regolith: EC ranges between 747 µS/cm and 24,600 µS/cm and pH ranges between 6.4 and 7.5.
- Wollombi Brook: EC ranges between 4,360 µS/cm and 14,580 µS/cm and pH ranges between 6.5 and 7.7;

Discussion in water quality trends and triggers is included for each alluvial unit from **Section 5.3.2.1** to **Section 5.3.2.3**.

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 2018 (MB15MTW04 to MB15MTW07 to MB15MTW11). Full water quality data is presented in **Appendix D** and summarised below:

- Total aluminium: variable readings ranging from 0.008 mg/L (PZ7D) to 0.16 mg/L (MB15MTW02D) with the exception of bore MB15MTW01D that recorded a total aluminium concentration of 61 mg/L;
- Total arsenic: variable readings from below the limit of reporting or less than 0.001 mg/L to 0.024 mg/L (MB15MTW01D);
- Total cadmium: concentrations generally below the limit of reporting or less than 0.0001 mg/L. Bores OH787 and PZ8D recorded a total cadmium concentration of 0.0002 mg/L and bore MB15MTW01D recorded a total cadmium concentration of 0.0004 mg/L;
- Total lead: concentrations below the limit of reporting of less than 0.01 mg/L, except for bore MB15MTW01D that recorded total lead of 0.079 mg/L;
- Total selenium: concentrations below the limit of reporting or less than 0.01 mg/L, except for bores OH787 and MB15MTW01D that recorded total selenium concentrations of 0.011 mg/L and 0.03 mg/L respectively; and
- Total zinc: concentrations generally below the limit of reporting or less than 0.1 mg/L, except for bores OH787 and MB15MTW01D that recorded total selenium concentrations of 0.42 mg/L and 0.74 mg/L respectively;

5.3.2.1 Warkworth Sands

Over the 2018 monitoring period no exceedances of the pH and EC triggers were reported for bore PZ7S.

5.3.2.2 Hunter River Alluvium

Over the 2018 monitoring period, the following triggers were exceeded for the bores within the Hunter River alluvium:

- Bore OH788 recorded pH levels below the lower trigger level of 7.0 in Q2.

5.3.2.3 Wollombi Brook Alluvium

Over the 2018 monitoring period, the following triggers were exceeded for the bores within the Woollombi Brook alluvium:

- Bore PZ9S recorded pH levels above the upper trigger level limit of 7.0 in Q2 and Q3; in Q1 and Q4 pH was recorded at the trigger level value.

Over 2018 SWL in bore PZ9S decreased from 6.53 m to 6.84 m, and the depth of PZ9S is reported as 6.9 m. Based on this it is anticipated that the bore may be dry and the results 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.

5.3.3 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 2018.

Bores MB15MTW04, MB15MTW05, MB15MTW11 and OH1125(2) were not sampled as they were dry throughout 2018. Bores MB15MTW07 to MB15MTW10 were not sampled in Q1, Q2 and Q4 as they were dry and in Q3 due to access restrictions. Access restrictions also prevented the sampling of bores MTD614P (in Q2), WOH2155A (in Q3), WOH2155B (in Q3) and WOH2139A (in Q4).

Over 2018 groundwater within the shallow overburden material of the Permian coal measures recorded EC of between 1,049 µS/cm and 17,770 µS/cm and pH ranges between 6.1 and 8.0. Over 2018 groundwater within the Permian coal measures recorded EC of between 1,658 µS/cm and 23,000 µS/cm and pH ranges between 5.8 and 8.2.

In accordance with the WMP full water quality analysis was conducted for the bores targeting the Permian coal measures, except for WOH2155A, WOH2155A and WOH2139A due to no access and WOH2156B due to insufficient water present. Full water quality data is presented in **Appendix D** and summarised below:

- Total aluminium: variable readings from 0.02 mg/L (GW 9706) to 4.9 mg/L (OH1226) over 2018. Exceptions to this were reported in bores MBW6A and OH1138 (1)) where respective concentrations of were recorded 7.5 mg/L and 26 mg/L;
- Total arsenic: concentrations generally below the limit of reporting or less than or equal to 0.005 mg/L, except for bore OH1138 (1) that recorded a concentration of 0.021 mg/L;
- Total cadmium: concentrations generally below the limit of reporting or less than or equal to 0.0012 mg/L;
- Total lead and selenium: concentrations below the limit of reporting or less than or equal to 0.022 mg/L, except for bores OH1138 (1) and OH1126 that recorded a lead concentration of 0.057mg/L and 0.039mg/L respectively; and
- Total zinc: concentrations from below the limit of reporting to 0.67 mg/L (WOH2155B).

Over the 2018 monitoring period, the following triggers were exceeded for bores within the Permian coal measures.

- Bore WOH2139A recorded a pH of over 7.6 in throughout 2018, these readings are consistent with 2017 results but are higher than historical trends;
- Bore OH1125 (1) recorded pH below the lower trigger value of 6.6 in Q1 and Q4;
- Bore OH1126 (1) recorded pH below the lower trigger value of 6.6 in Q4;
- Bore OH1138 (1) recorded pH below the lower trigger value of 6.3 from Q1 to Q4, and EC of above 19,657 µS/cm in Q1 and Q4. Trends for this bore are discussed below;
- Bore OH1137 recorded pH above the upper trigger value of 7.1 in Q4;
- Bore GW 9709 recorded pH below the lower trigger value of 6.6 in Q1 and above the EC trigger value of 22,991 µS/cm in Q4. The isolated pH reading of 6.4 is below historical trends. The remaining pH results (Q2 to Q4) and EC readings are in line with historical trends.
- Bore GW98MTCL2 recorded pH below 6.6 in Q1. The isolated pH reading of 6.4 is below historical trends. The remaining pH results are in line with historical readings for the bore that have ranged from 6.6 to 7.1 since 2011.

Further discussion of EC and pH trends for bore OH1138(1) is included below.

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.

Additional to the quarterly monitoring events bore OH1138(1) was monitored in May 2018, July 2018, August 2018, October 2018 and November 2018. pH over 2018 was variable and generally outside of the trigger threshold, with readings ranging between 5.8 (March 2018) to 6.1 (December 2018). A single reading equal to the pH lower trigger value of 6.3 was reported in September 2018. Except for monitoring results from February 2018, March 2018, November 2018 and December 2018 EC concentrations were within trigger levels. pH and EC concentrations for bore OH1138 (2) were within trigger limits throughout 2018.

Trends in water quality for the two bores are presented in **Figure 5-22**. The graph shows that over 2018 pH readings in bore OH1138 (1) were variable, decreasing in Q1 and then generally increasing to Q3 after which they again decrease. pH within OH1138 (1) generally remained stable throughout 2018 Overall pH was lower than historic trends in bore OH1138 (1) and similar to historic trends in bore OH1138 (2). The graph includes available water quality data for adjacent surface water dam 27N, which shows no clear correlation to trends in OH1138.

Figure 5-22 shows that between January and June 2018, EC concentrations in bore OH1138 (2) generally decreased and EC concentrations in bore OH1138 (1) remained stable. After June 2018 EC concentrations in both bores steadily increased until November 2018. Over 2018, the trigger level of 19,657 µS/cm was exceeded in bore OH1138 (1) in February, March, November and December. The graph includes available water quality data for adjacent surface water dam 27N, which shows no clear correlation to trends in OH1138. Comparison of EC to groundwater levels in **Figure 5-23** shows the rise in EC coincides in a decline in groundwater levels. This decline in groundwater levels may relate to drawdown associated to abstraction from the Lemington Underground (LUG) bore to the north.

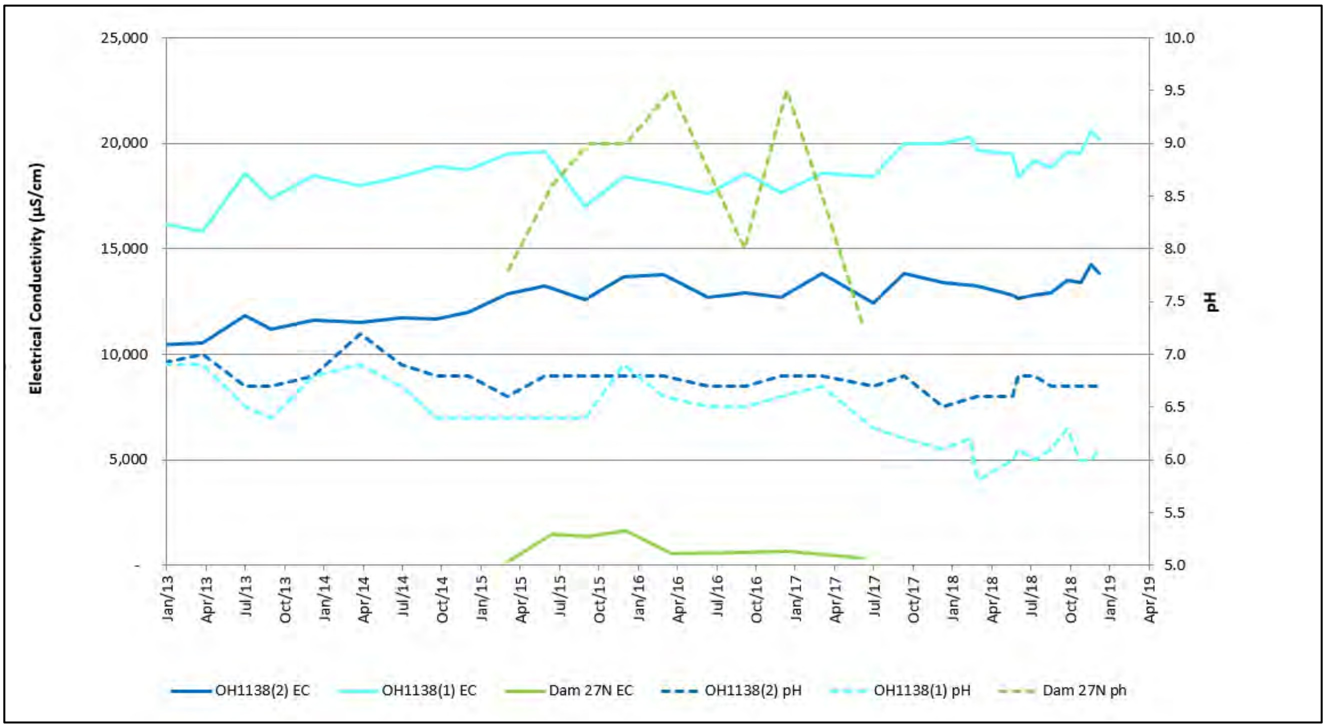


Figure 5-22 Water Quality Trends at OH1138(1) and OH1138(2)

Figure 5-23 Electrical Conductivity and SWL Trends at OH1138(1)

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 and the estimated groundwater take for the various water sources. is discussed below. 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 updated by AGE (2015). The model was calibrated up to 2014 conditions 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 2018 was approximately:

- 31 ML from the Hunter River Regulated Water Source;
- 19 ML from the Hunter Unregulated and Alluvial Water Sources; and
- 573 ML from the North Coast Fractured and Porous Rock water source.

5.4.2 Surface Water Abstraction

Over 2018, surface water was abstracted from the Hunter River in accordance with licence conditions. Metered volumes recorded by Yancoal show 1,768 ML of water was pumped from the Hunter River over the 2018 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 (July to June). The licenses are 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 2017 to June 2018 a total of 1,127 ML of water was abstracted from the Lemington Underground bore, which is within the licensed allocation of 1,800 ML/year. Further details on the groundwater related impacts from abstraction is presented within the HVO annual review.

5.4.4 Summary of Water Take For 2018

Water take from the various groundwater and surface water sources associated with MTW are presented in **Table 5-3** for the 2018 calendar year. Abstraction volumes from the Lemington Underground bore are not presented within **Table 5-3** as they are captured within the HVO annual groundwater review.

Table 5-3 Predicted Groundwater Take for 2018

	Hunter Regulated	Hunter Unregulated	North Coast Fractured and Porous Rock
Mt Thorley Pit Excavation	~0.5	~4.0	~298
Warkworth Pit Excavation	~3.0	~6.0	~275
Surface Water Abstraction	1,768	0	-
Total	**1,771.5**	**10**	**573**

As shown in **Table 5-3**, over the 2018 reporting year the total take under the Hunter River Regulated water source was estimated at 1,771.5 ML, total take from Hunter Unregulated water source was estimated at 10 ML and 573 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 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.
- The CRD plot indicates that the less than average rainfall has occurred since June 2017, which may result in a lowering of regional groundwater levels depending on recharge mechanisms. The predictive modelling generally estimates recharge rates based on historical averages that are higher than currently observed. This is likely the cause for deviation between observed and predicted water levels at bores GW9707 and PZ7S.
- Recent trends in observed data vary from modelled at VWP’s WD615_P2, MTD605_P2, MTD605_P3 and MTD605_P6, WD609. The observed data appears inconsistent with historical trends and may reflect errors in data conversion.
- Groundwater level drawdown is observed in bores WOH2153A, WOH2154A, WOH2155A and WOH2156A above predictive results. In contrast bore PZ9D was predicted to have higher drawdown than observed. The cause for discrepancy may relate to changes in mine scheduling and how pre-stripping and backfilling was captured within the model.

Overall, the numerical model appears to adequately replicate observed changes in groundwater levels for 2018. 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;
- Review the model structure and compare to the site geological model and available drill data; and
- Review data collected from VWPs.

6 Conclusions and Recommendations

6.1 Conclusions

This annual groundwater review covers data collected over 2018 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 2018 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.

Review of climate data indicates that, with the exception of October (82 mm), over 2018 the region generally experienced below average rainfall. (428 mm). Similar trends of below average stream flow was recorded for the Wollombi Brook from the HITS stations.

The groundwater bore network at MTW has been installed progressively over the life of the operations and acquired through land purchase. In accordance with the WMP 60 open standpipe bores require routine SWL and quality. The WMP also requires routine SWL monitoring of 10 VWPs, however based on discussion with site personnel and review of the data it is understood some of the VWP sensors may not be fully operational due to a range of factors (i.e. batteries)

Available VWP and monitoring bore logger data was reviewed to assess trends in groundwater levels over 2018. The data indicates that where saturated, water within the alluvium declined slightly, generally in line with climate and stream flow trends. Groundwater within the Permian coal measures remained relatively stable to slightly declining over 2018. Where observed, the decreasing elevations are believed to be attributed to depressurisation of the coal seams in relation to mining activities. The groundwater drawdown appears in line with the predicted drawdown with the coal measures around active mine areas.

As per the WMP, pH and EC concentrations are monitored within compliance bores on a quarterly basis, with a larger suite of analytes reviewed annually. Review of water quality results and comparison to trigger levels for EC and pH identified several trigger exceedances over 2018. It was identified that several bores exceeded triggers for EC and pH; however, 2018 readings were in line with historical trends for these bores. Groundwater quality trends outside of historical trends were observed for bore OH1138, which likely relates to declining groundwater levels. The decline in levels may relate to abstraction from Lemington Underground bore at Hunter Valley Operations to the north.

Over 2018 monitoring of the groundwater bore network was generally conducted in accordance with the Groundwater Monitoring Program outlined within the WMP. Annual samples were collected in general accordance with relevant standards except for cases where the condition of the bores (i.e. 32 mm casing) inhibited the ability to collect representative samples. Review of the quarterly monitoring methodology found that bailers were utilised to collect grab samples from each location. This approach is not in line with industry standards and may not provide a representative water quality sample. Over 2018 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.

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 2018 reporting year the total take under the Hunter Regulated water source was estimated at 1,771.5 ML. Total take from Hunter Unregulated water source was estimated at 10 ML and 573 ML from the North Coast Fractured and Porous Rock water source.

Review of groundwater level trends with reference to groundwater impact predictions for the approved operations was conducted. The observed depressurisation in the Permian coal measures appears in line with predictions around active mine areas. Some exceptions were noted due to observed climate trends, differences in mine progression and influence from surrounding operations. It was also noted that some of the observation points within the model do not match model layering. Additional works are being conducted at site to check the bores and install additional monitoring points across the site.

6.2 Recommendations

Based on review of the available data for 2018, 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 standards.
- Review of groundwater quality triggers to ensure they are reasonable and adequately capture historical trends for bores.
- Incorporate findings from the model verification and additional site fieldwork for future interactions of the 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
OH786a	320542	6392674	55.7	7.1	Regolith	Q	Q	Q	A
OH787	320982	6391921	50.0	12.1	Regolith	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	Regolith	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 Elevation (mAHD)	Bore Depth (mbTOC)	Geology	Groundwater Monitoring Program			
						Water Level	EC	pH	Full WQ
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	Vane Subgroup	Q	Q	Q	A
OH1126	318586	6393387	64.5	52.5	Vaux	Q	Q	Q	A
OH1137	318266	6393377	67.9	17.8	Vaux	Q	Q	Q	A
OH1127	321444	6392097	51.2	29.0	Vane Subgroup	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
GW98MTCL1	322188	6387032	77.8	19.7	Bayswater	Q	Q	Q	A
GW98MTCL2	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			

ID	Easting	Northing	Top of Casing Elevation (mAHD)	Bore Depth (mbTOC)	Geology	Groundwater Monitoring Program			
						Water Level	EC	pH	Full WQ
MTD614_P5	317265	6386174	72.4	453.0	Bowfield Seam	Q			
WD456 (VWP)			100.6		Bayswater Seam	Q			
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 2018

Bore ID	Target Geology	EC Trigger 95th	pH Trigger 5^{th} – 95^{th}		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	Regolith	950	6.8	7.7	3.7	51.9	**6.7**	747	4.5	51.2	7.1	**1209**	7.0	48.7			7.0	48.7		
OH787	Regolith	18185	7.2	7.7	13.8	36.2	7.2	17860	13.8	36.1	7.5	**18500**	13.9	36.1	7.5	**18440**	13.9	36.1	7.4	18070
OH788	Hunter River Alluvium	11742	7.1	7.9	9.8	35.6	**7.0**	9450	9.9	35.5	**6.9**	**13090**	9.9	35.5	7.1	10870	9.9	35.4	7.5	10370
OH942	Regolith	25380	6.4	7	9.2	46.6	6.4	24500	9.2	46.5	6.7	24100	9.3	46.5	6.5	24100	9.3	46.5	6.6	24600
OH943	Hunter River Alluvium	8415	7.1	7.6	9.5	35.6			9.5	35.6	7.4	7680	9.5	35.5	7.5	7300	9.6	35.5	7.5	7980
OH944	Hunter River Alluvium				Dry				Dry				Dry				Dry			
G3(2)	Wollombi Brook Alluvium																			
PZ8S	Wollombi Brook Alluvium	15200	6.5	7	5.8	60.0	6.5	14210	5.9	59.9	6.6	14180	6.0	59.7	6.5	14580	6.2	59.6	6.7	14570
PZ9S	Wollombi Brook Alluvium	16140	6.8	7	6.5	58.9	7.0	5680	6.6	58.8	**7.1**	6670	6.7	58.7	7.0	8900	6.8	58.6	7.0	4360
MB15MTW01S	Wollombi Brook Alluvium				6.4	56.9	**8.4**	**1474**	6.6	56.7	**6.8**	**2430**					6.7	56.6	**6.5**	**1411**
MB15MTW02S	Wollombi Brook Alluvium				6.2	55.9	**7.6**	**1960**	6.6	55.5	**7.1**	**2780**					6.6	55.5	**7.5**	**2720**
PZ7S	Aeolian Warkworth Sands				5.4	57.0	**7.3**	**18300**	5.6	56.8	**7.5**	**17290**					5.8	56.6	**7.2**	**17660**
MBW01	Alluvium	1752	6.7	7.5	7.2	51.3	6.9	1746	7.3	51.2	7.1	1687	7.5	51.0	6.8	1515	7.5	51.0	6.9	1669
MB15MTW04	Warkworth Sands				Dry				Dry				Dry				Dry			
MB15MTW05	Warkworth Sands				Dry				Dry				Dry				Dry			
MB15MTW06	Warkworth Sands				3.6	56.4	**5.5**	**77**	Dry				Dry				Dry			
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	17490	6.9	8.1	7.1	51.4	7.7	1668	7.2	51.2	7.9	1668	7.4	51.0	7.6	1667	7.3	51.1	7.7	1708
PZ8D	Shallow Overburden	17490	6.9	8.1	6.3	59.5	7.3	8340	6.4	59.4	7.5	8290	6.6	59.2	7.6	8460	6.7	59.1	7.7	8460

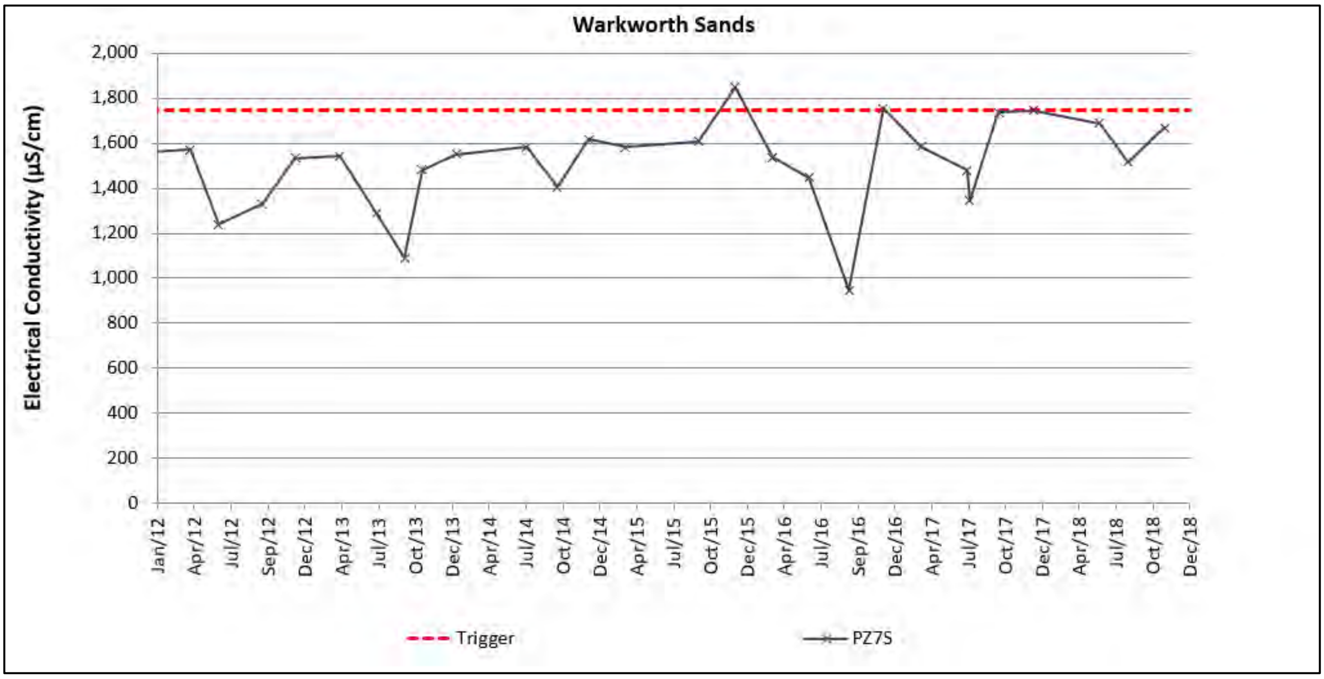
Bore ID	Target Geology	EC Trigger 95th	pH Trigger 5^{th} – 95^{th}		Q1				Q2				Q3				Q4			
					SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC
PZ9D	Shallow Overburden	17490	6.9	8.1	18.3	47.2	**6.7**	9740	18.2	47.4	7.1	9220	18.4	47.1	7.1	10000	17.9	47.6	7.0	10210
MTD616P	Shallow Overburden	17490	6.9	8.1	6.9	70.9	7.5	14420	6.9	71.0	7.6	14560	6.7	71.1	**6.8**	13480	6.6	71.3	7.7	14350
MTD614P	Shallow Overburden - Conglomerate	17490	6.9	8.1	17.7	54.9	7.1	6270					17.9	54.7	7.2	6230	17.8	54.8	7.2	6320
MBW02	Shallow Overburden	17490	6.9	8.1	7.6	55.1	7.0	1078	6.7	55.9	7.3	11680					8.0	54.6	7.4	1650
MB15MTW01D	Shallow Overburden?	17490	6.9	8.1	6.5	56.8	**6.3**	2660	6.7	56.6	7.1	3440					6.8	56.5	**6.1**	3380
MTD605P	Shallow Overburden - sandstone	17490	6.9	8.1	15.0	62.4	7.7	**17770**	15.1	62.3	7.3	17460					15.0	62.4	7.5	**17530**
MB15MTW02D	Shallow Overburden?	17490	6.9	8.1	6.0	56.0	7.7	10970	6.2	55.8	7.8	9910					6.4	55.7	7.9	9020
MB15MTW03	Shallow Overburden?	17490	6.9	8.1	5.8	55.1	7.2	12450	6.1	54.8	7.0	11810					6.3	54.7	6.9	12100
WD625P	Whybrow Seam	11996	7.1	7.3	18.5	58.0	7.2	11750	18.5	57.9	7.2	11600	18.5	57.9	7.2	11800	18.4	58.0	7.3	11550
MBW03	Whybrow Seam				7.4	55.0	7.2	7930	7.7	54.7	7.4	9040					7.8	54.6	6.9	5730
WOH2153A	Redbank Crk Seam	16123	7	7.9	13.0	55.3	7.8	1980	13.5	54.8	7.8	1970	13.6	54.6	7.8	2370	13.8	54.4	7.7	2000
WOH2154A	Redbank Crk Seam	16123	7	7.9	14.8	54.1	7.6	4460	15.4	53.5	7.5	4450	15.5	53.4	7.6	4720	15.8	53.1	7.6	4450
WOH2155A	Redbank Crk Seam	16123	7	7.9	20.0	54.6	7.8	6980	20.6	53.9	7.8	6750	20.5	54.0	7.2	8730	20.5	54.1	7.8	7120
WOH2156A	Redbank Crk Seam	16123	7	7.9	27.1	53.3	7.0	14670	27.7	52.7	7.0	14780	27.8	52.6	7.0	14670	28.1	52.3	7.0	14170
WOH2153B	Wambo Seam	13843	7.2	7.8	10.7	57.6	7.5	1746	10.9	57.4	7.5	1670	11.2	57.0	7.3	1692	10.8	57.4	7.6	1658
WOH2154B	Wambo Seam	13843	7.2	7.8	12.9	56.0	7.5	4830	13.2	55.7	7.5	4530	13.3	55.6	7.5	4850	13.3	55.6	7.5	4830
WOH2155B	Wambo Seam	13843	7.2	7.8	14.6	60.0	7.6	5700	14.7	59.9	7.6	5530	14.8	59.8	7.8	5550	14.9	59.7	7.6	5370
WOH2156B	Wambo Seam	13843	7.2	7.8	13.0	67.4	7.3	13720	13.5	66.9	7.4	13420	13.4	67.0			12.8	67.6	7.4	13170
WD622P	Wambo Seam	13843	7.2	7.8	31.7	52.8	7.4	8860	31.5	52.9	7.6	8690	31.0	53.5	**6.9**	**14170**	30.8	53.7	**8.2**	8000
MBW04	Wambo	13843	7.2	7.8	11.6	50.9	7.5	13220	11.9	50.6	7.5	12860					12.0	50.5	7.4	12690
WOH2139A	Blakefield	15161	6.6	7.6	49.2	42.5	**7.8**	8200	50.1	41.6	**7.9**	8780	50.8	40.9	**8.0**	9980				
OH1122 (1)	Blakefield Seam	15161	6.6	7.6	48.9	51.7	7.0	11810	49.0	51.6	7.1	11150	49.0	51.5	6.8	11820	49.1	51.4	7.0	12320
OH1125 (1)	Blakefield	15161	6.6	7.6	29.1	57.1	**6.4**	13380	29.7	56.5	6.8	13990	32.7	53.5	6.6	13450	32.9	53.3	**6.5**	13370
OH1125 (2)	Unknown	14696	6.6	7																
OH1125 (3)	Bowfield Seam	14696	6.6	7	39.6	46.6	6.6	13600	40.5	45.8	6.8	13920	40.7	45.6	6.8	13240	42.3	43.9	6.7	13280

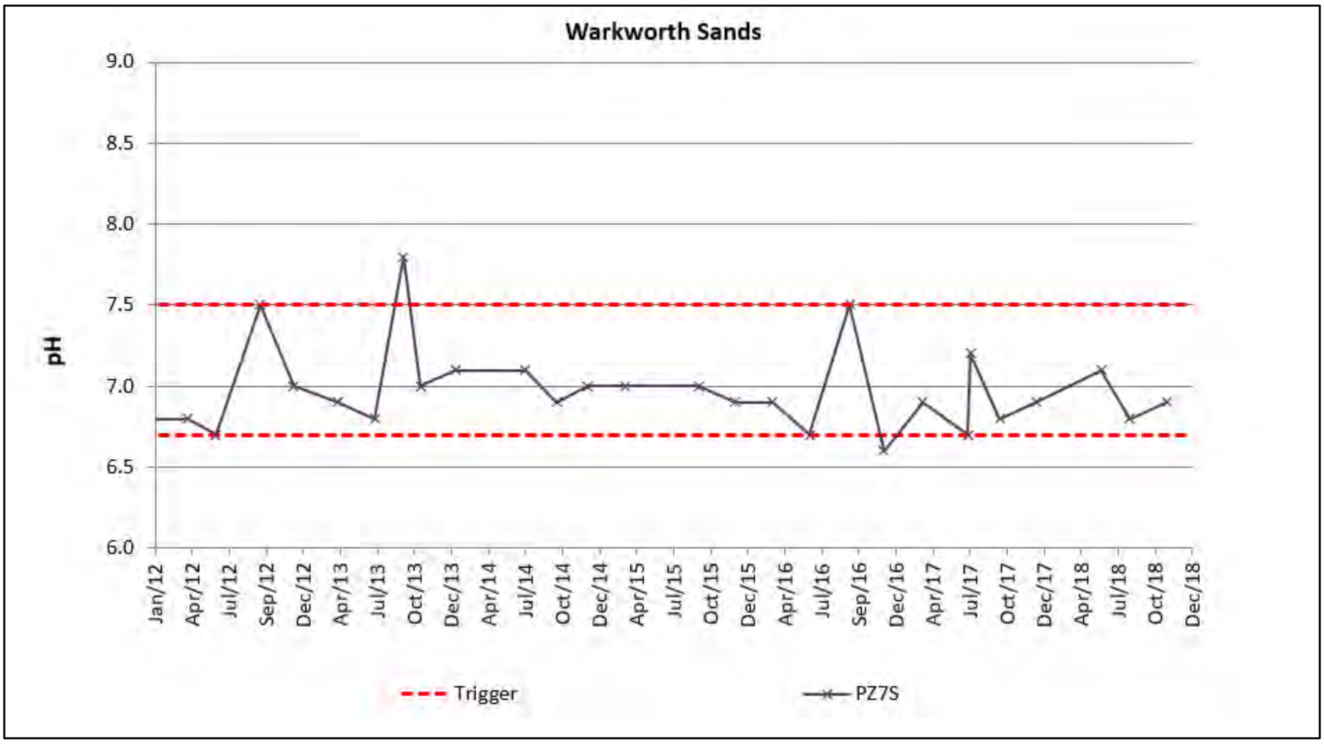
Bore ID	Target Geology	EC Trigger 95th	pH Trigger 5th –95th		Q1				Q2				Q3				Q4			
					SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC
OH1138 (1)	Warkworth	19657	6.3	7	9.8	61.0	**5.8**	**19670**	9.9	60.8	**6.1**	18400	10.0	60.8	**6.1**	18830	10.0	60.7	**6.0**	**20600**
OH1138 (2)	Warkworth	19657	6.3	7	14.6	56.2	6.6	13230	14.7	56.1	6.8	12640	14.7	56.0	6.7	12920	14.8	56.0	6.7	14270
OH1121	Vane Subgroup	17745	6.7	7.1	10.6	35.0	6.9	7620	10.6	35.0	7.0	8150	10.7	34.9	6.9	7920	10.7	34.9	**7.2**	8140
OH1126	Vaux	17745	6.7	7.1	16.5	48.0	6.7	8570	16.8	47.7	6.7	8310	17.2	47.4	6.8	8940	17.4	47.1	**6.5**	8780
OH1137	Vaux	17745	6.7	7.1	14.0	53.9	6.9	17600	14.2	53.7	7.0	16610	14.4	53.5	7.1	16900	14.5	53.4	**7.2**	16810
OH1127	Vane Subgroup	22991	6.6	7.5	16.0	35.2	6.9	11670	15.8	35.4	6.9	11410	15.9	35.4	7.0	11990	15.9	35.4	7.0	11930
GW 9706	Bayswater	22991	6.6	7.5	2.9	61.3	6.7	3020	2.5	61.8	7.0	4890	2.9	61.3	7.3	3070	2.9	61.3	7.3	3130
GW 9707	Bayswater	22991	6.6	7.5	5.0	59.0	7.0	19440	5.0	58.9	6.8	20700	5.3	58.6	7.1	19800	5.4	58.5	7.2	21000
GW 9708	Bayswater	22991	6.6	7.5	12.3	60.9	6.7	15300	11.9	61.2	6.8	12870	12.5	60.7	6.9	14780	12.1	61.0	6.9	15650
GW 9709	Bayswater	22991	6.6	7.5	9.0	51.3	6.4	22400	9.0	51.3	6.8	22300	9.0	51.3	6.9	21000	8.9	51.4	6.9	**23000**
GW98MTCL1	Bayswater	22991	6.6	7.5	10.5	67.3	7.3	6020	11.1	66.7	7.2	6950	11.4	66.4	7.2	5890	11.1	66.7	7.4	6060
GW98MTCL2	Bayswater	22991	6.6	7.5	10.6	68.9	6.4	15540	10.4	69.1	6.6	15540	10.8	68.7	6.7	15220	10.8	68.7	6.7	16070
WOH2141A	Whynot Seam				42.9	48.7	7.7	10500	43.2	48.4	7.7	10390	43.4	48.2	7.8	10220	43.7	47.9	7.7	10460
MBW6A					7.5		6.7	1050	7.9		6.4	9040					8.0		6.3	1027

***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
Apr/18
Jul/18
Oct/18
Dec/18
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
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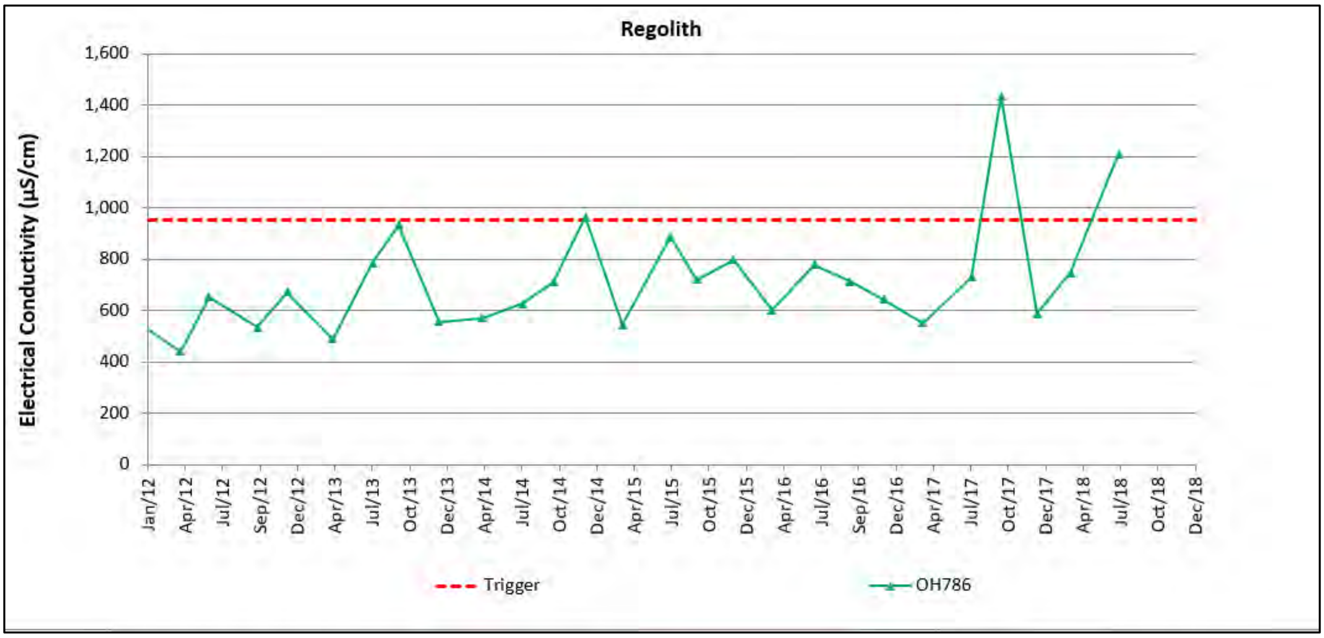
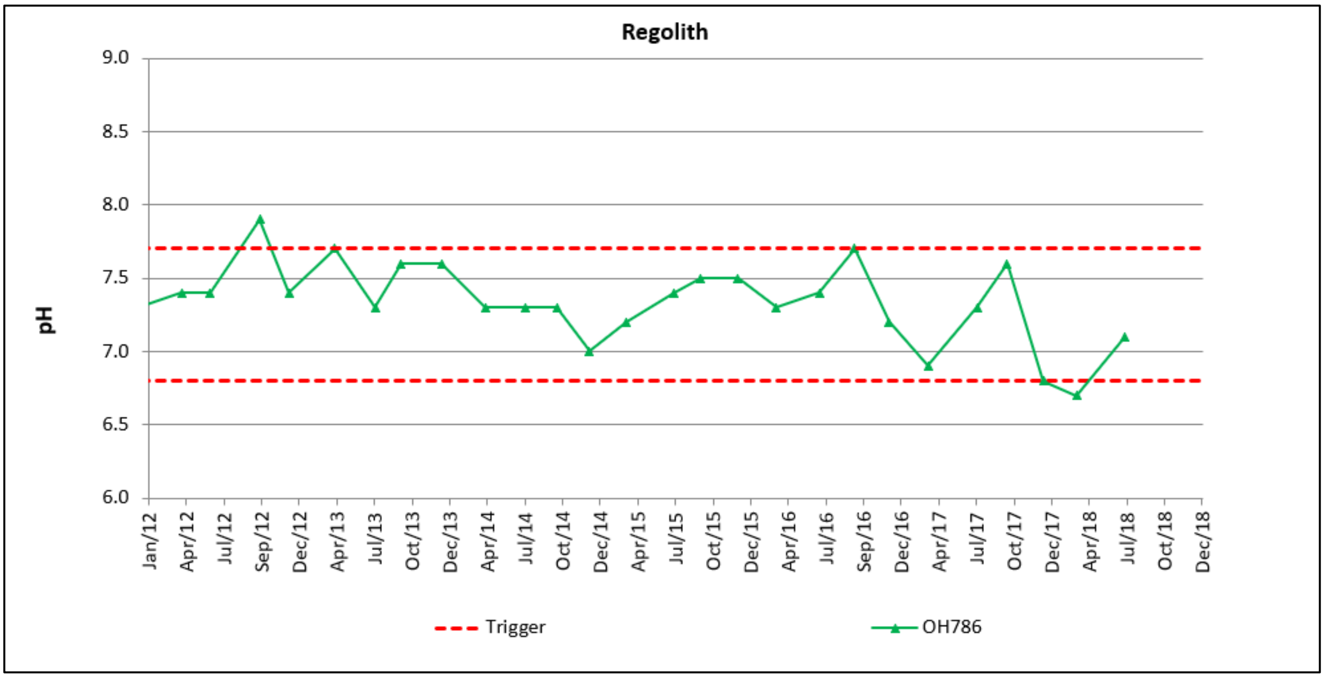
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
PZ7S


Regolith
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
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH786


Regolith
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
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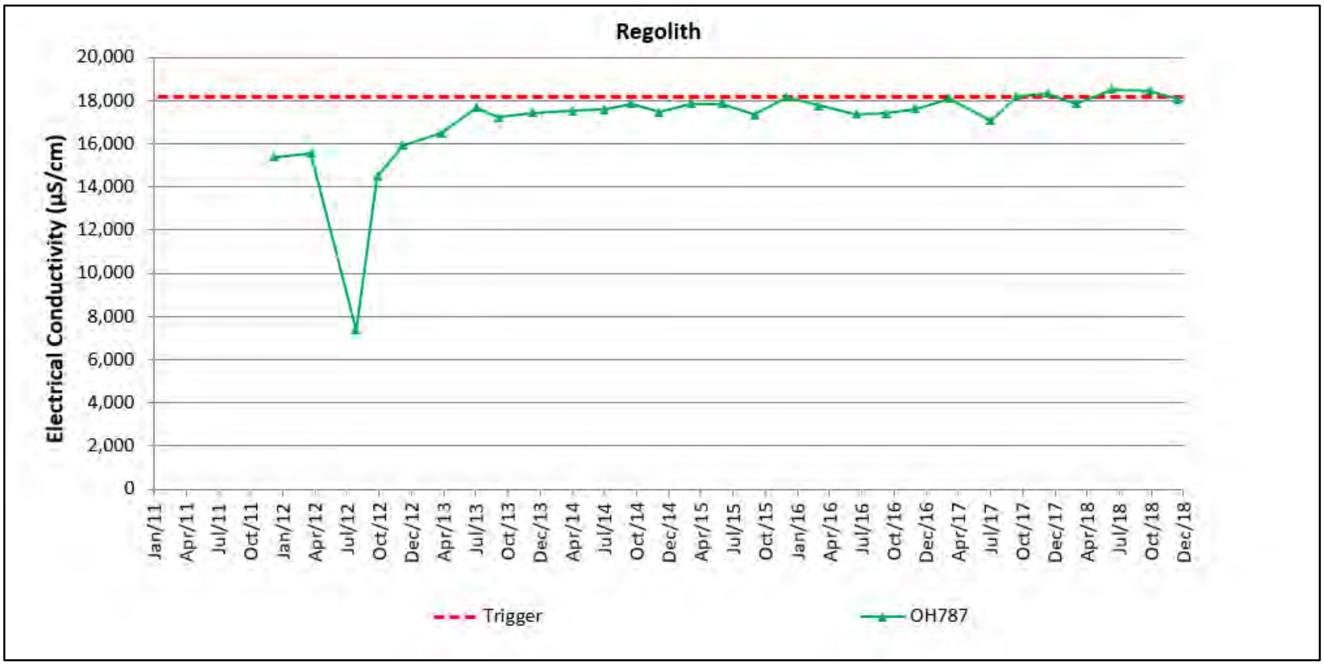
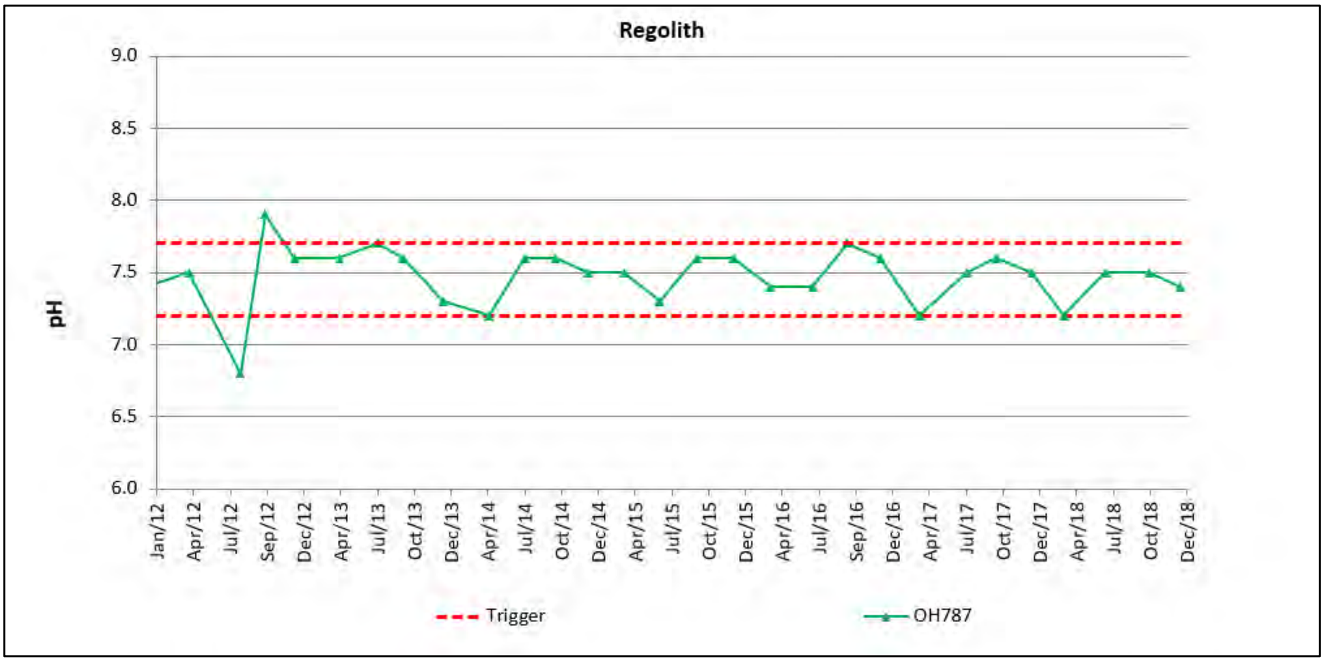
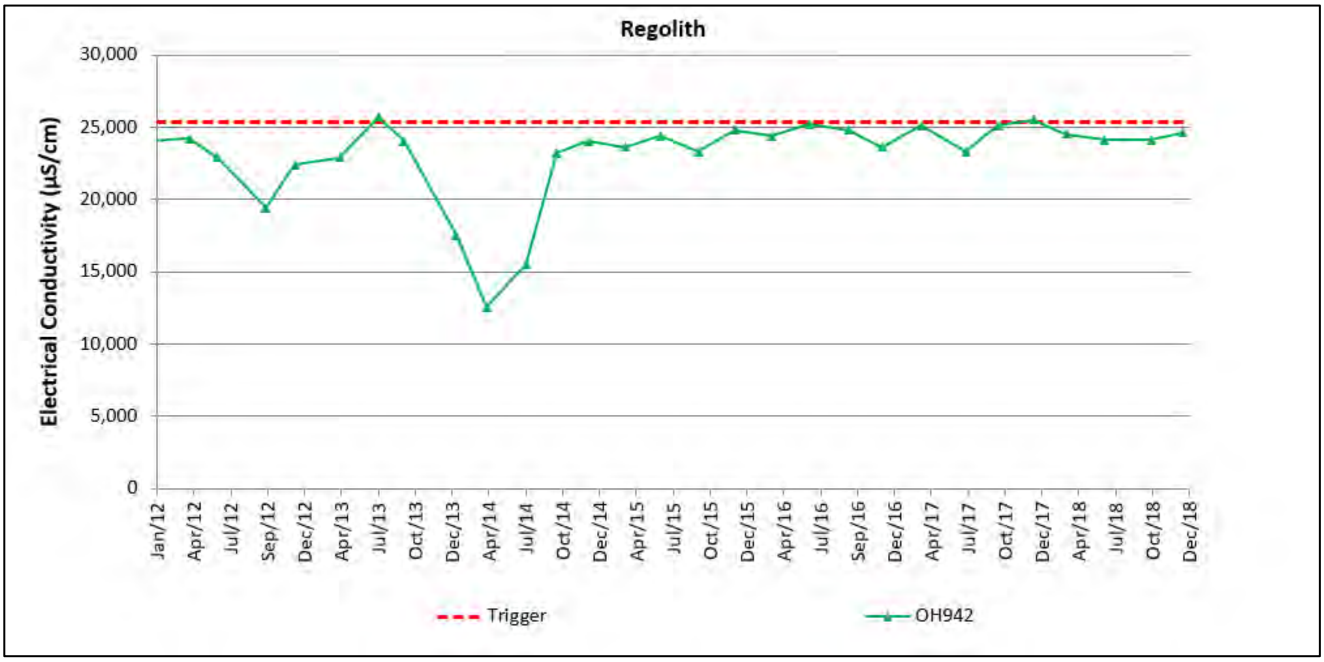
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH786

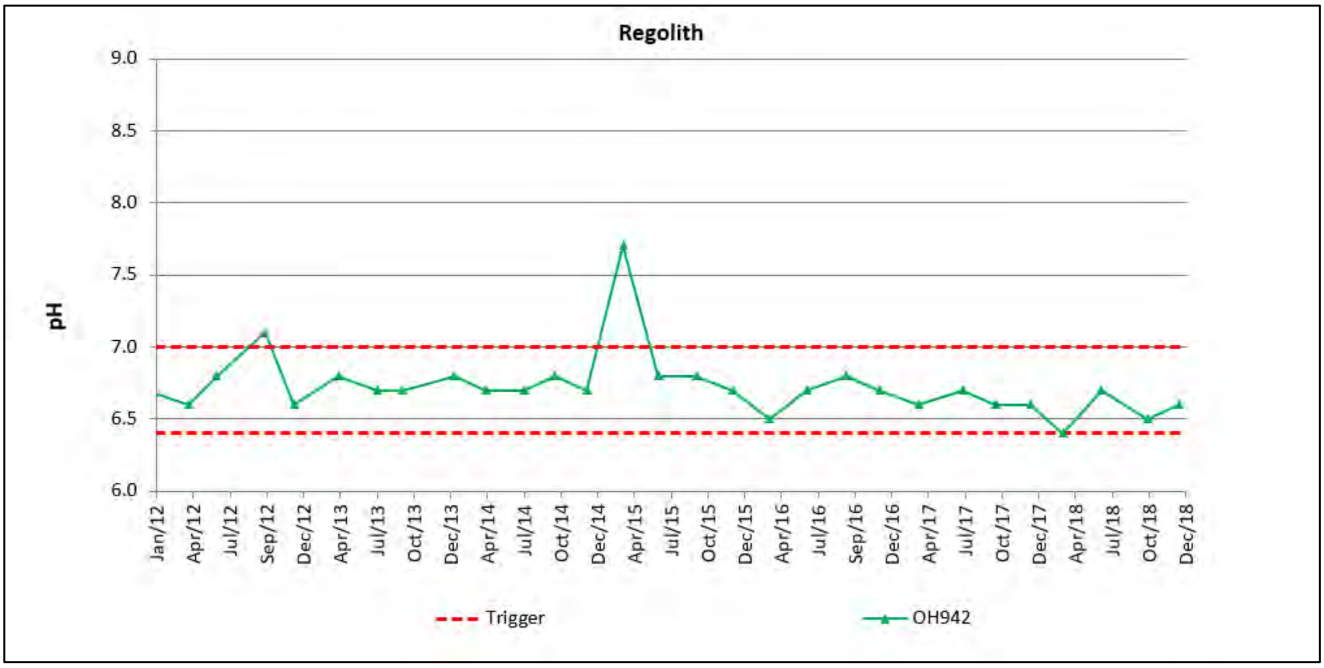


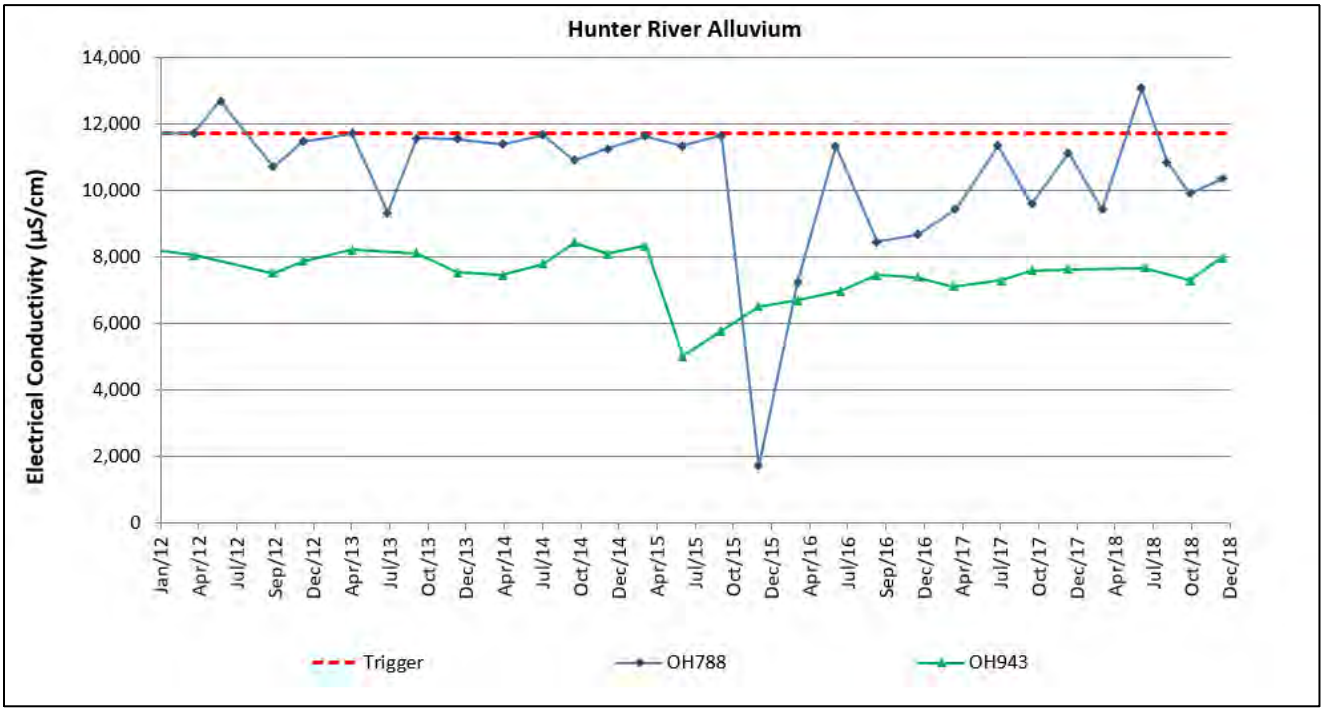
Regolith
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/11
Apr/11
Jul/11
Oct/11
Jan/12
Apr/12
Jul/12
Oct/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Jan/16
Apr/16
Jul/16
Oct/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH787

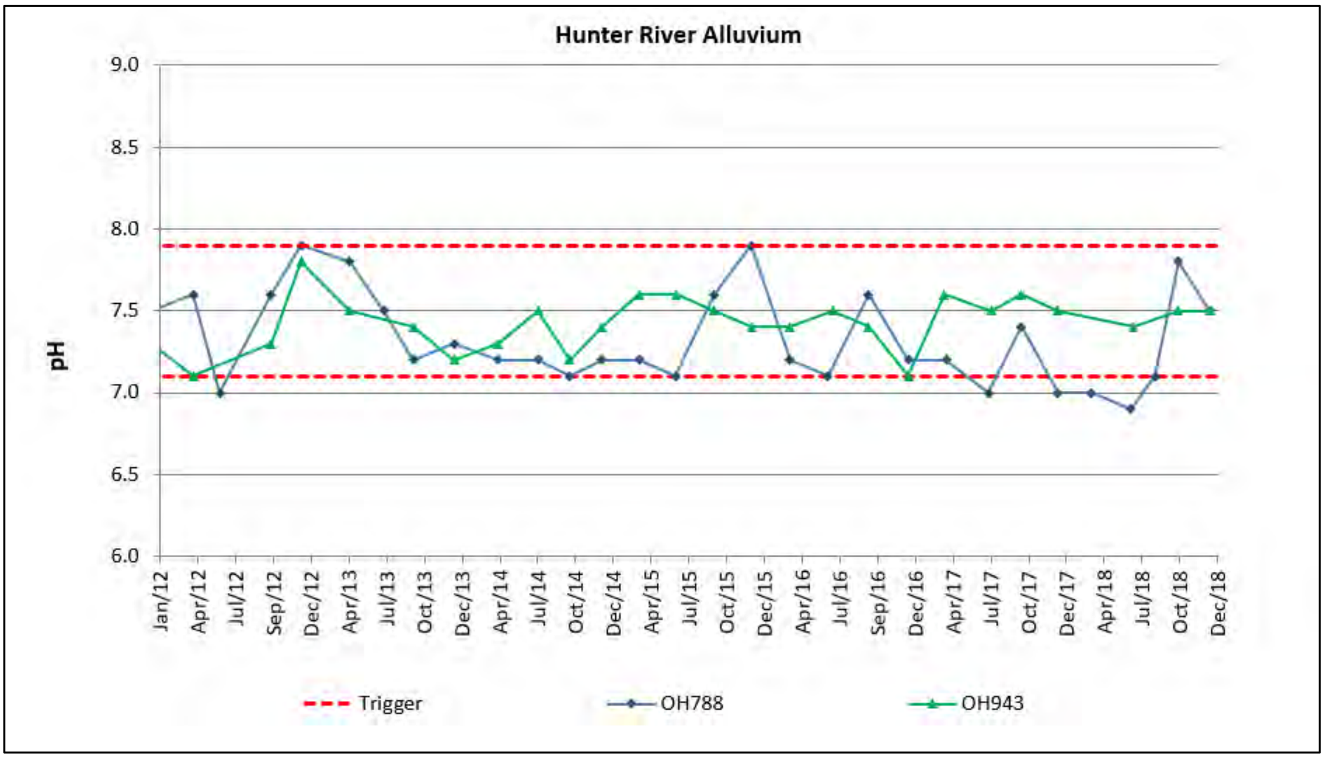


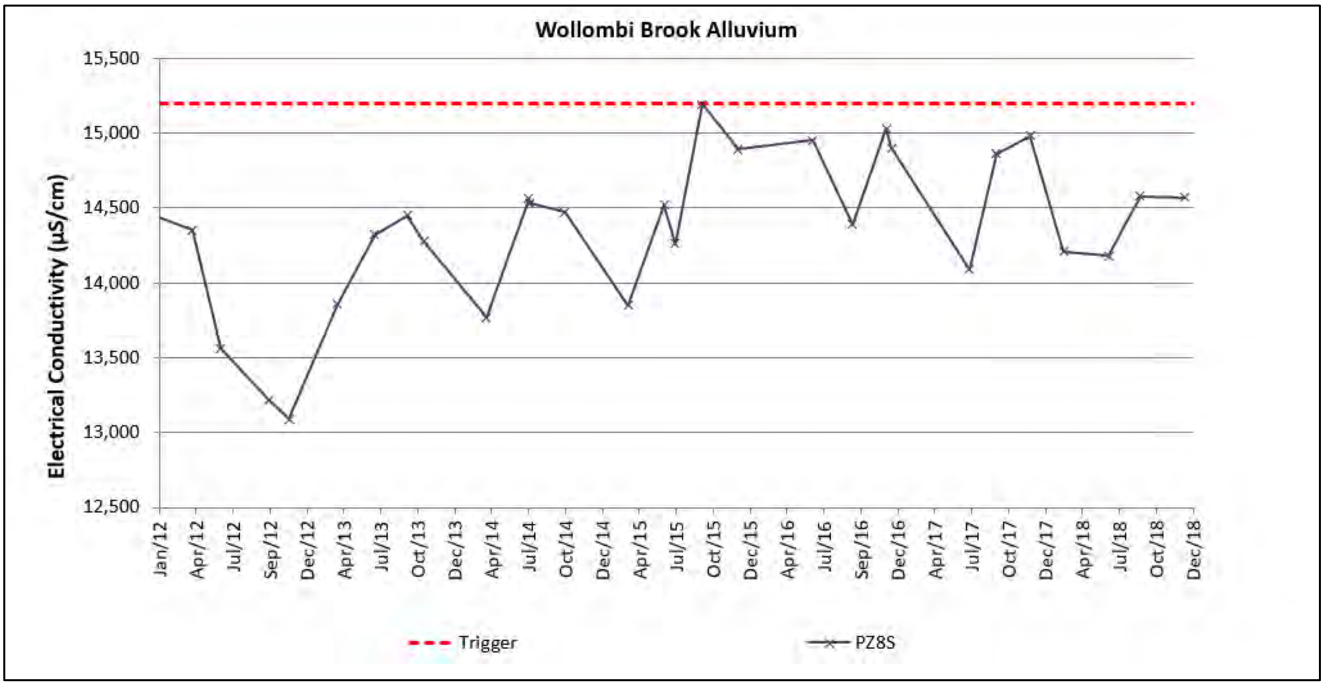
Regolith
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH787

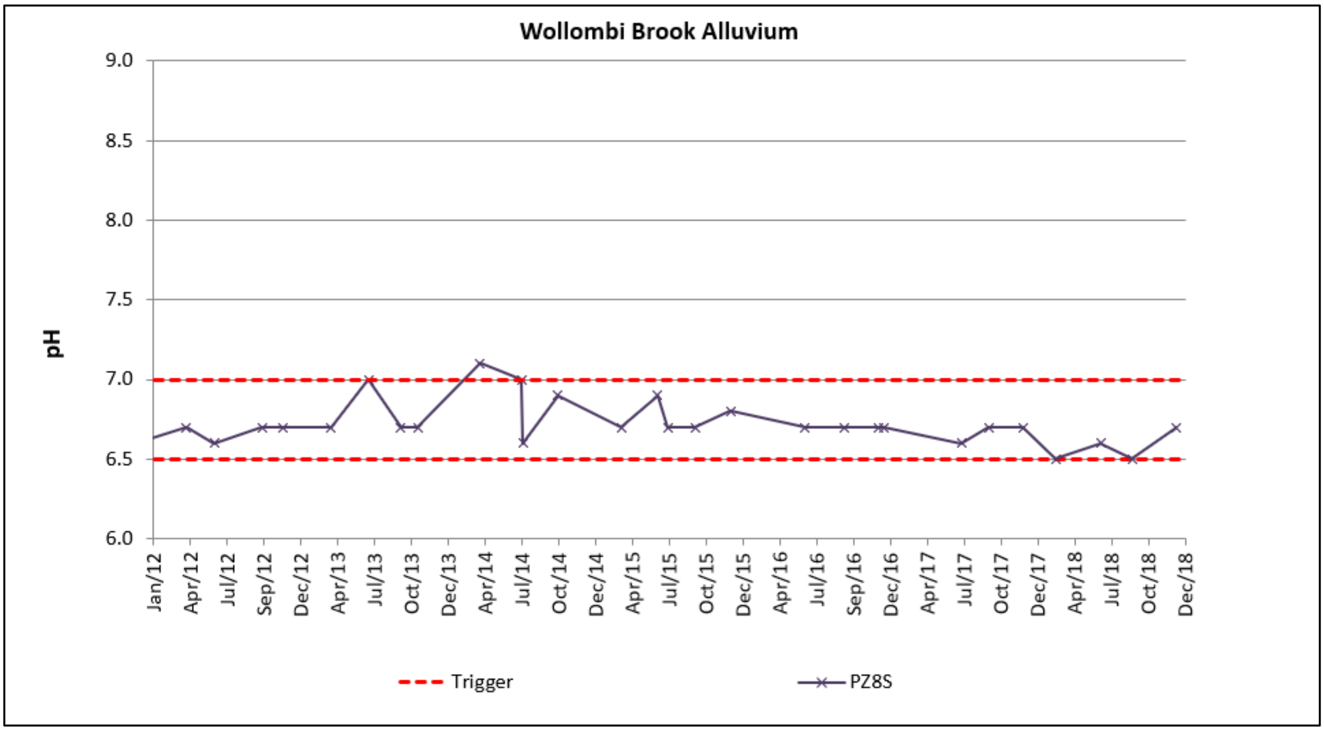

Regolith
Electrical Conductivity (µS/cm)
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH942


Regolith
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
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH942


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
Apr/18
Jul/18
Oct/18
Dec/18
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
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH788
OH943


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
Apr/18
Jul/18
Oct/18
Dec/18
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
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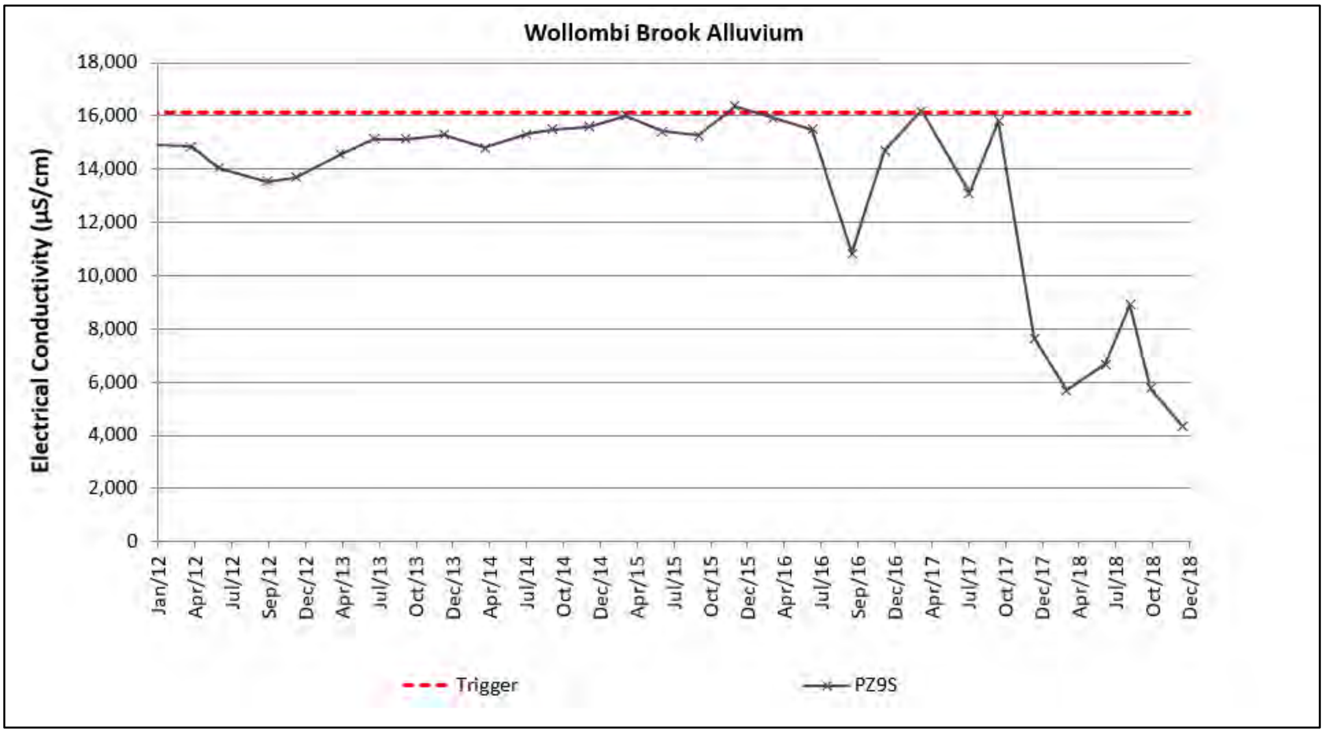
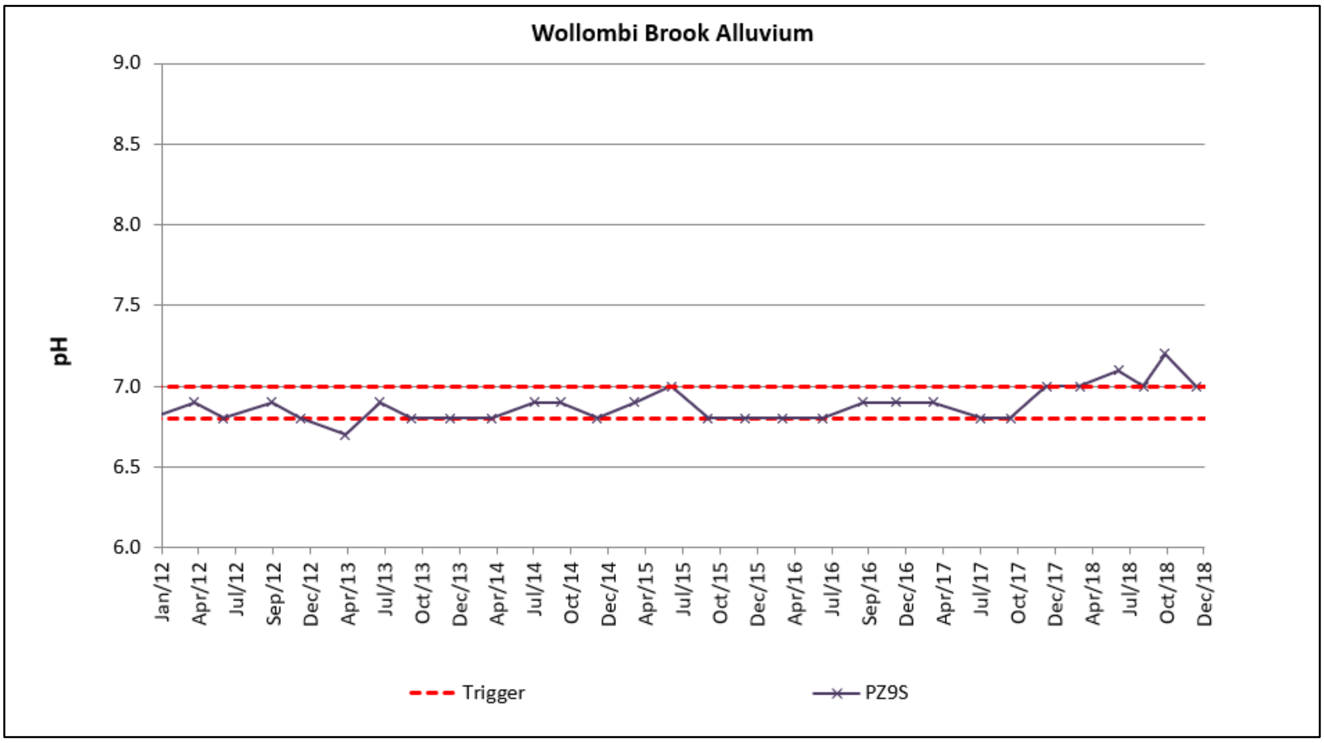
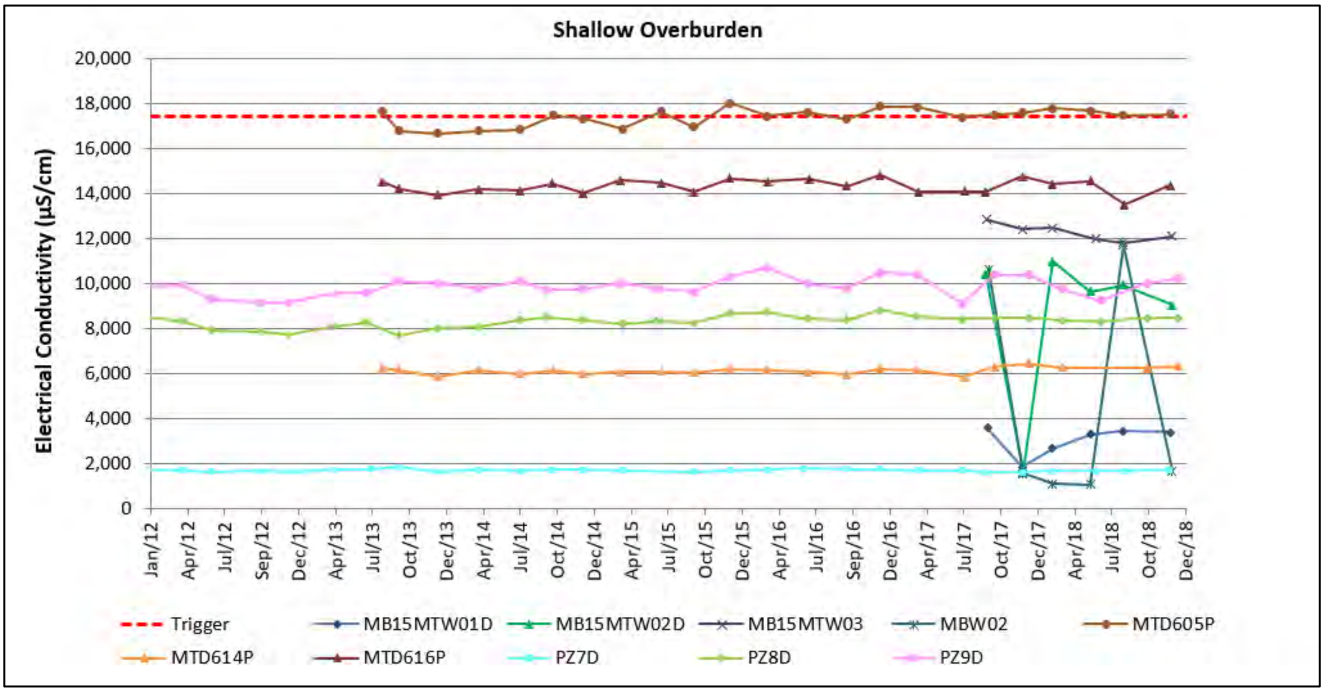
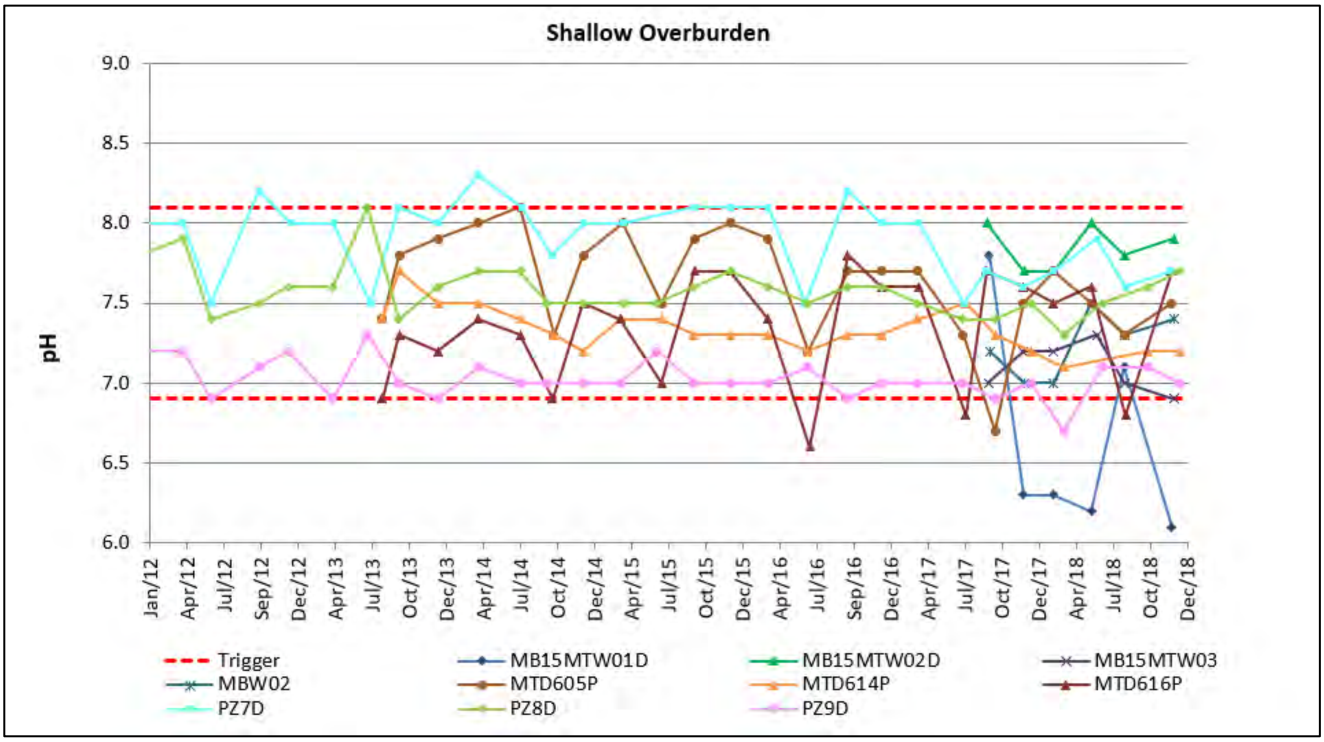
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
PZ8S


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 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
PZ9S

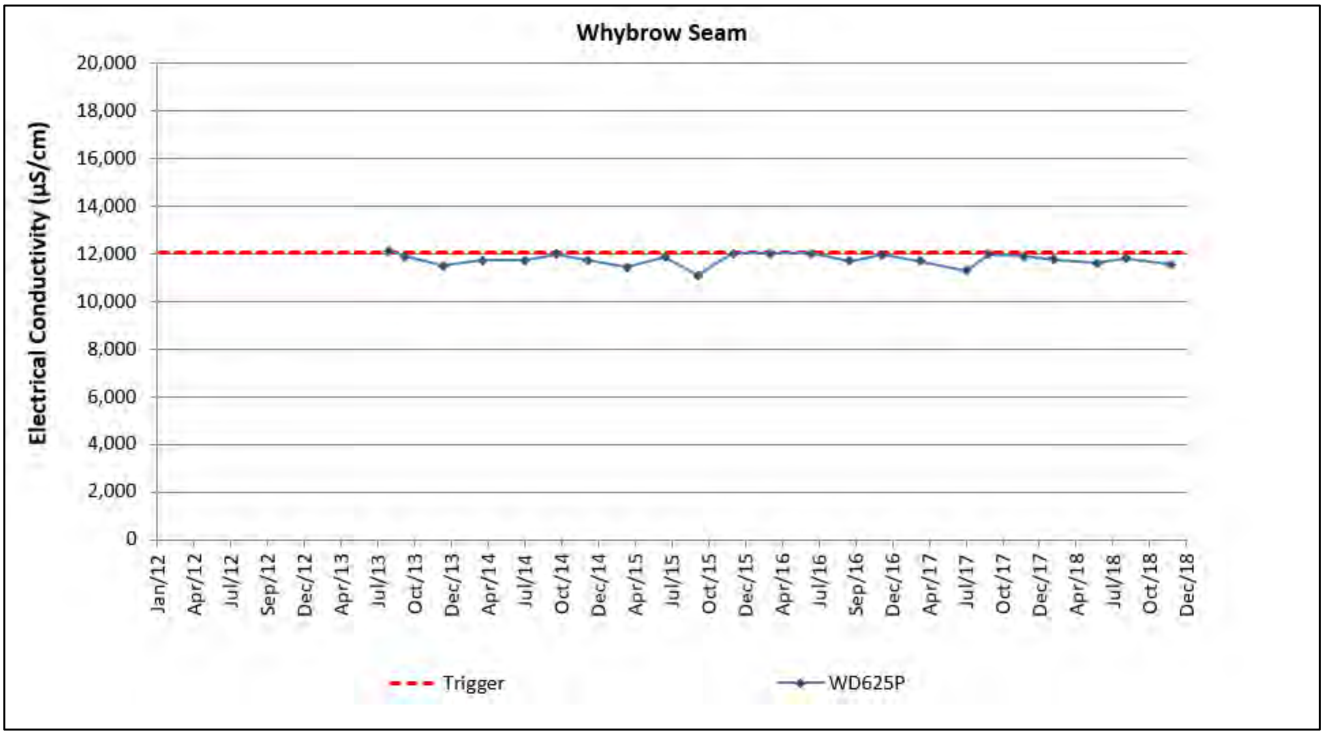

Wollombi Brook Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
PZ9S



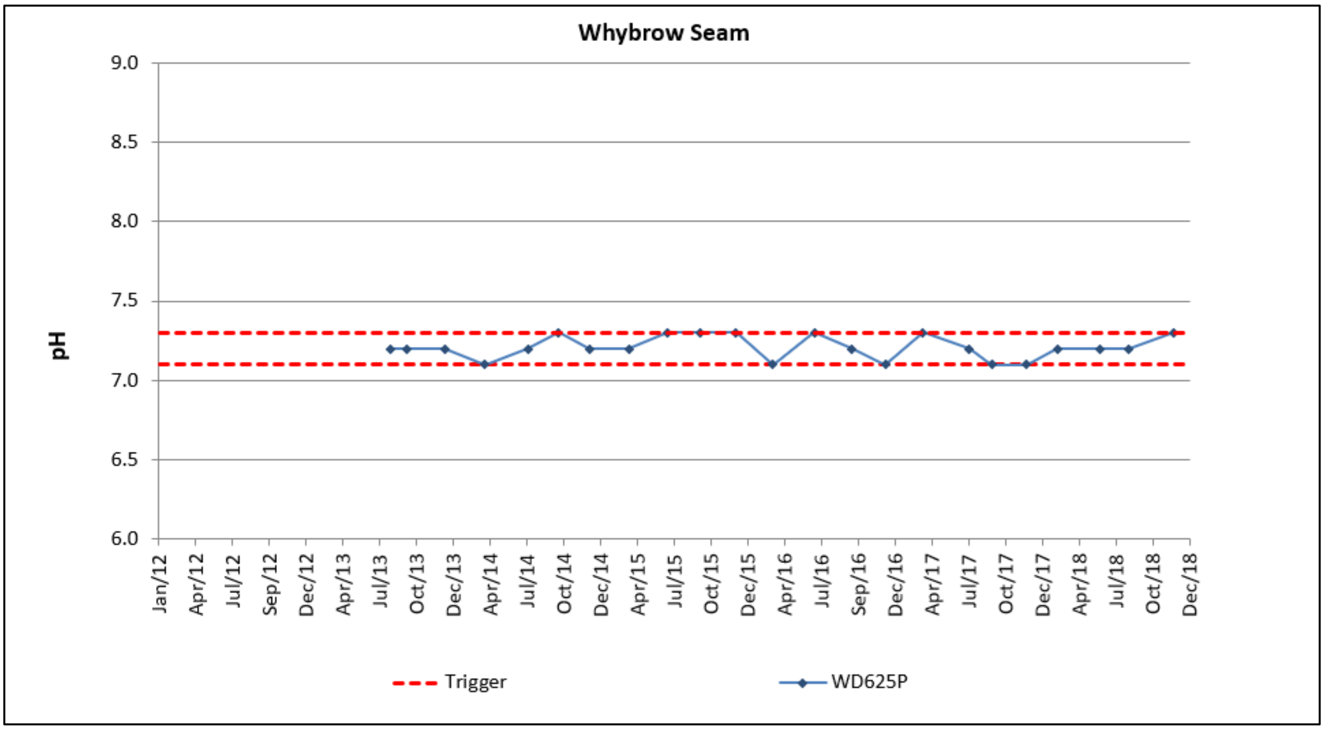
Shallow Overburden
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
MB15MTW01D
MB15MTW02D
MB15MTW03
MBW02
MTD605P
MTD614P
MTD616P
PZ7D
PZ8D
PZ9D



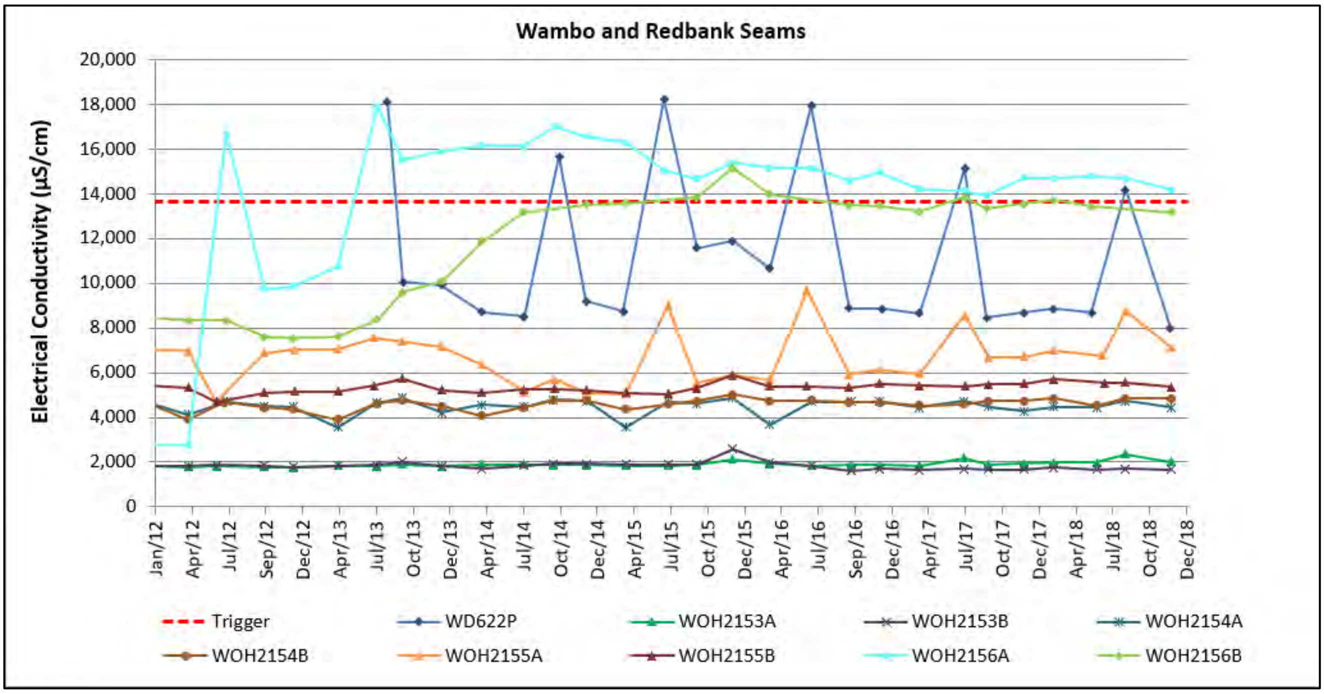
Shallow Overburden
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
MB15MTW01D
MB15MTW02D
MB15MTW03
MBW02
MTD605P
MTD614P
MTD616P
PZ7D
PZ8D
PZ9D

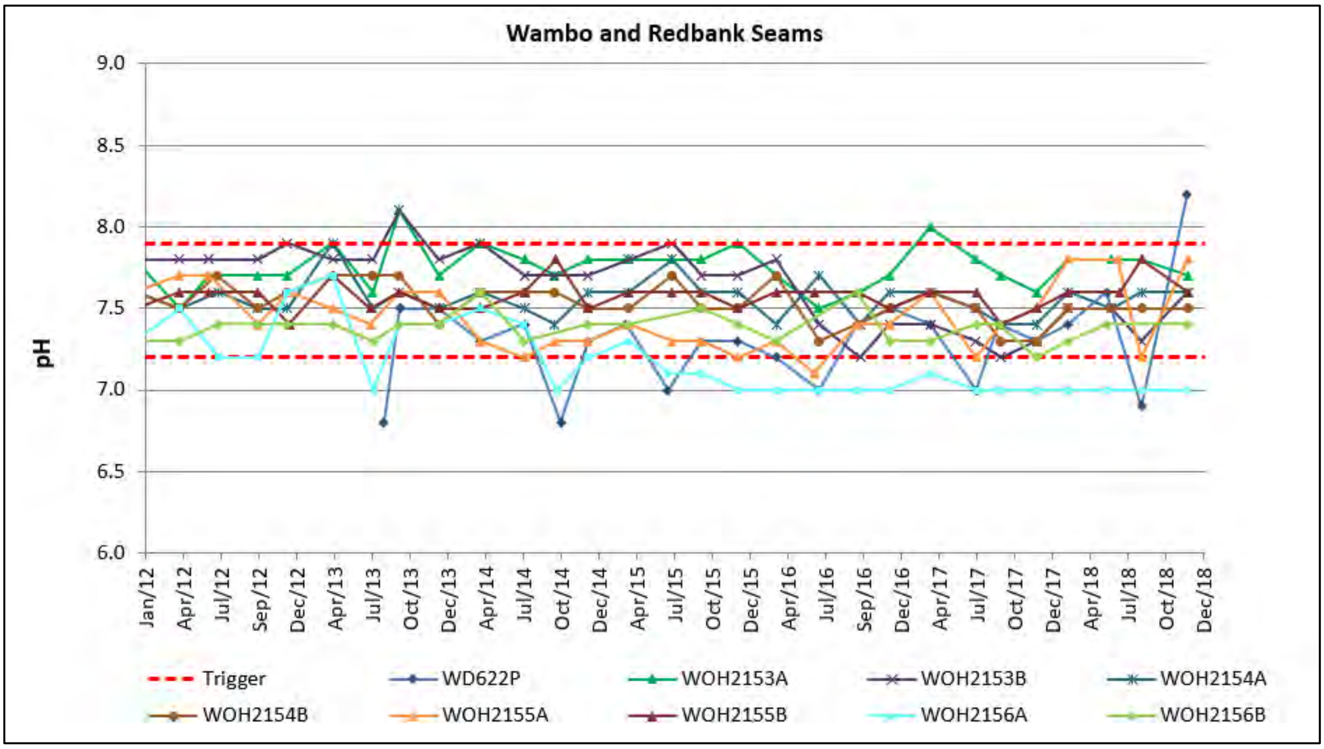


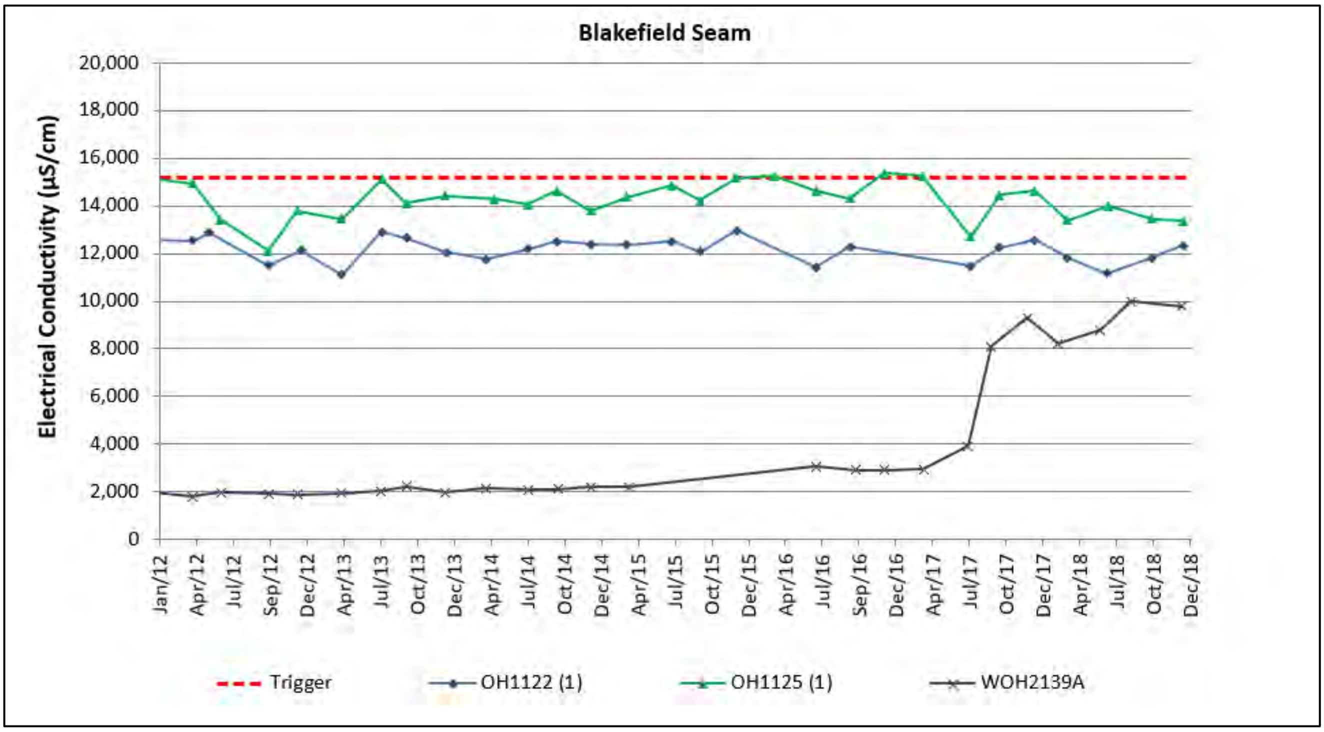
Whybrow Seam
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
WD625P

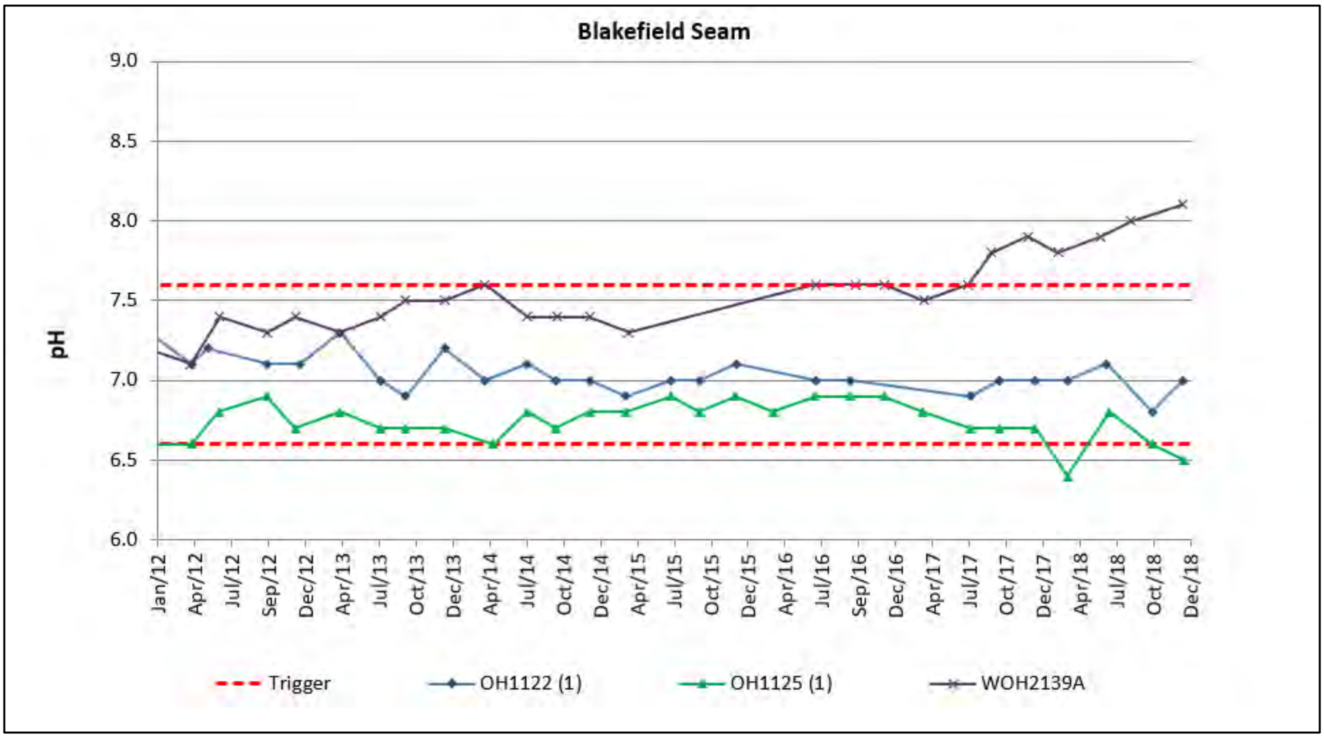


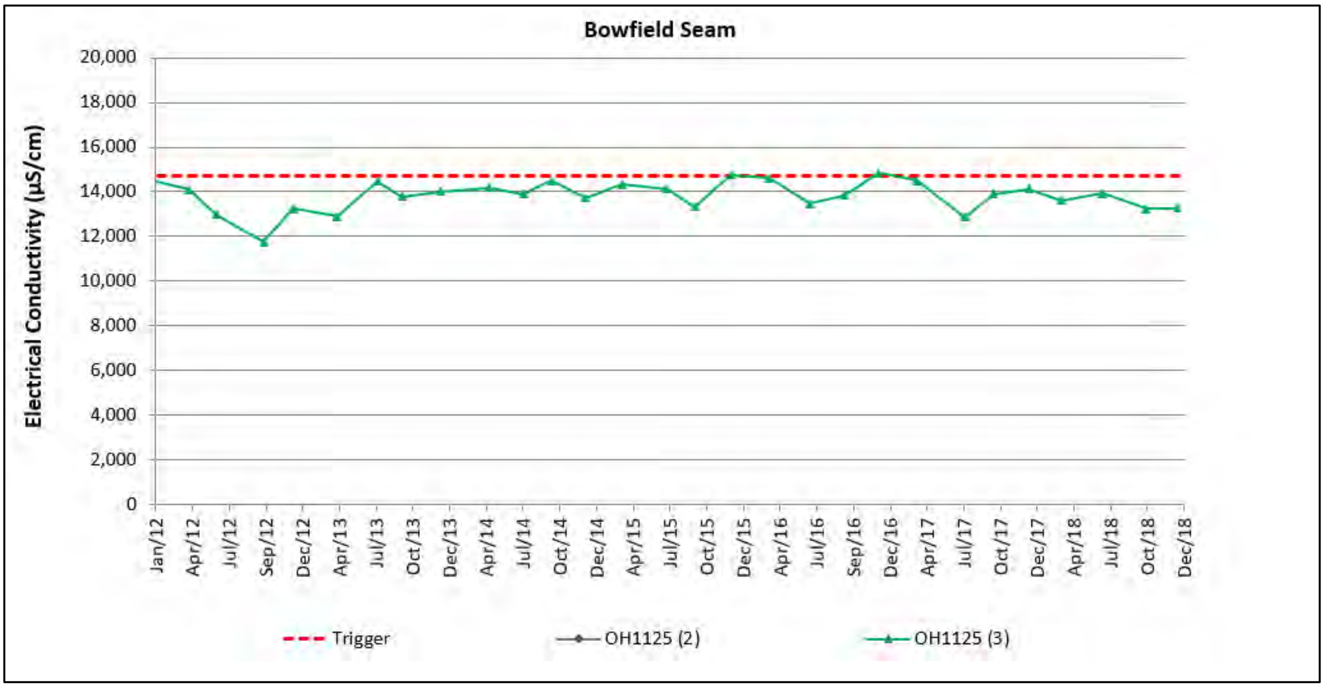
Whybrow Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
WD625P

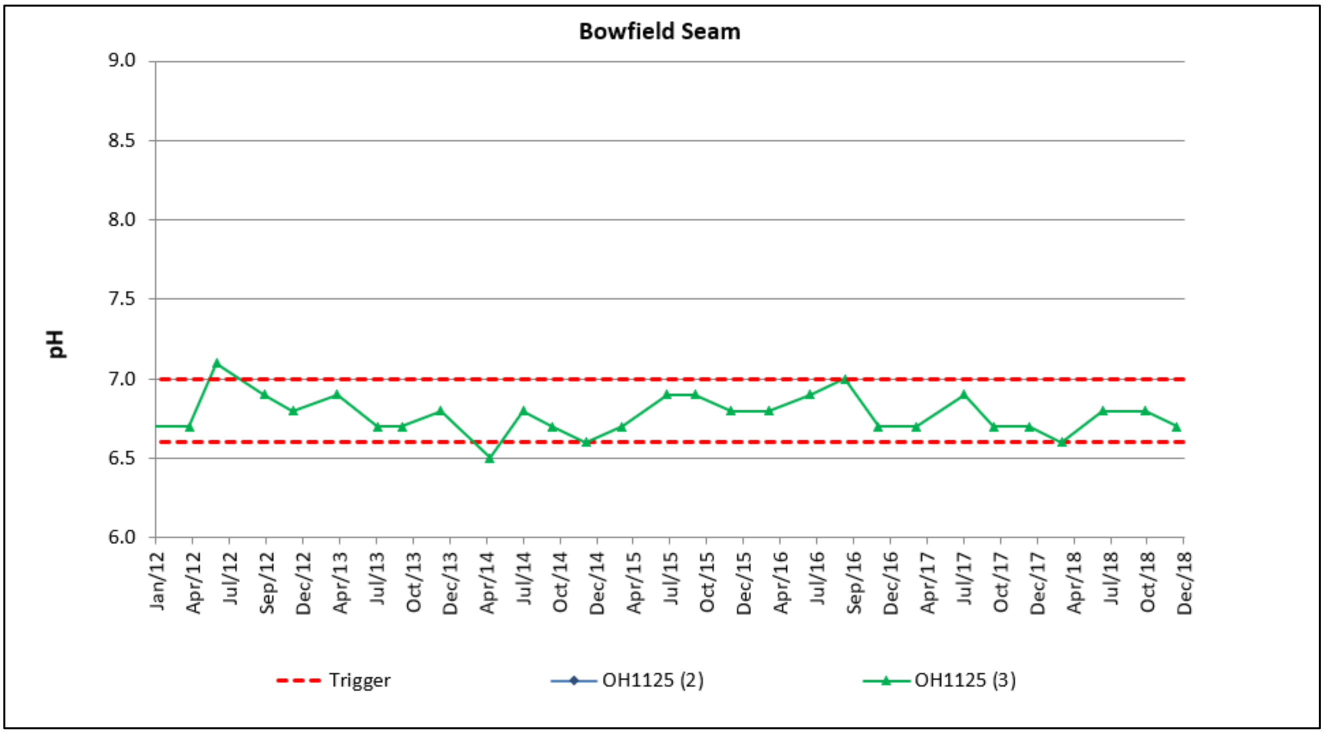

Wambo and Redbank Seams
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
WD622P
WOH2153A
WOH2153B
WOH2154A
WOH2154B
WOH2155A
WOH2155B
WOH2156A
WOH2156B

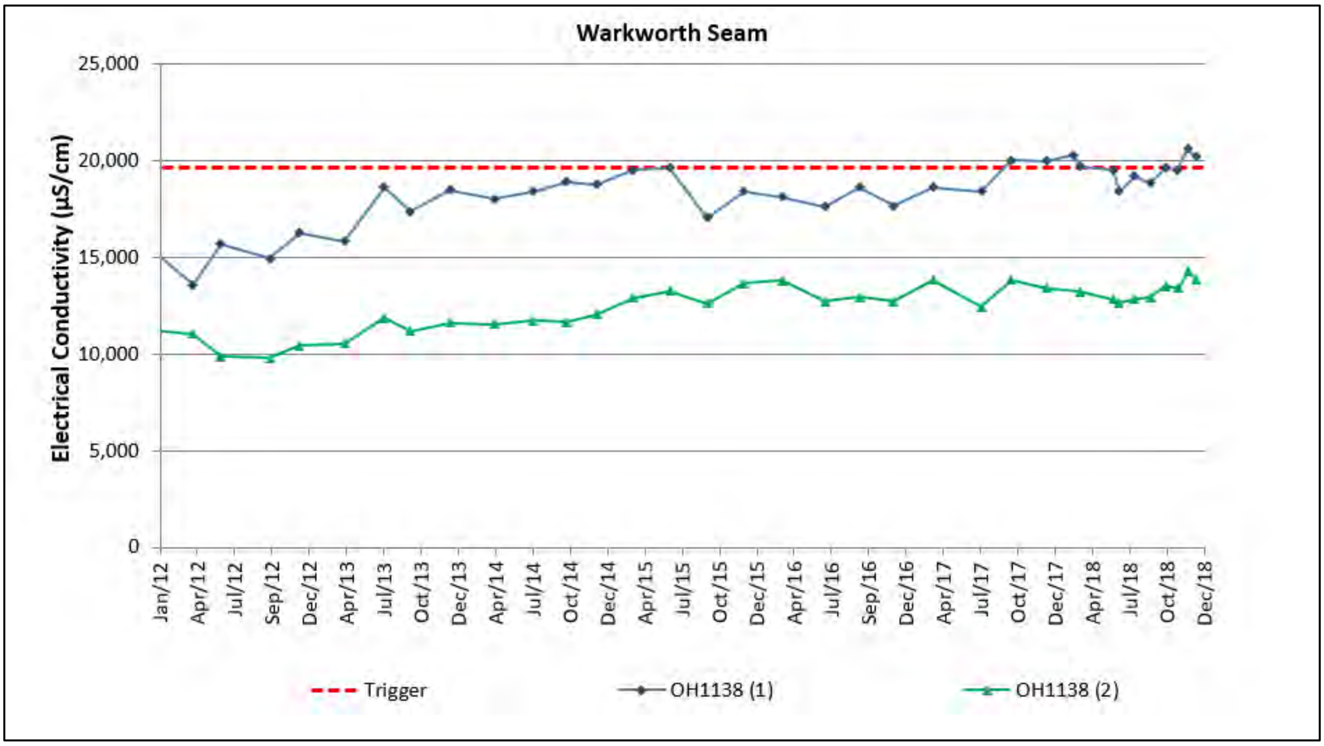

Wambo and Redbank Seams
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
WD622P
WOH2153A
WOH2153B
WOH2154A
WOH2154B
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 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
OH1122 (1)
OH1125 (1)
WOH2139A

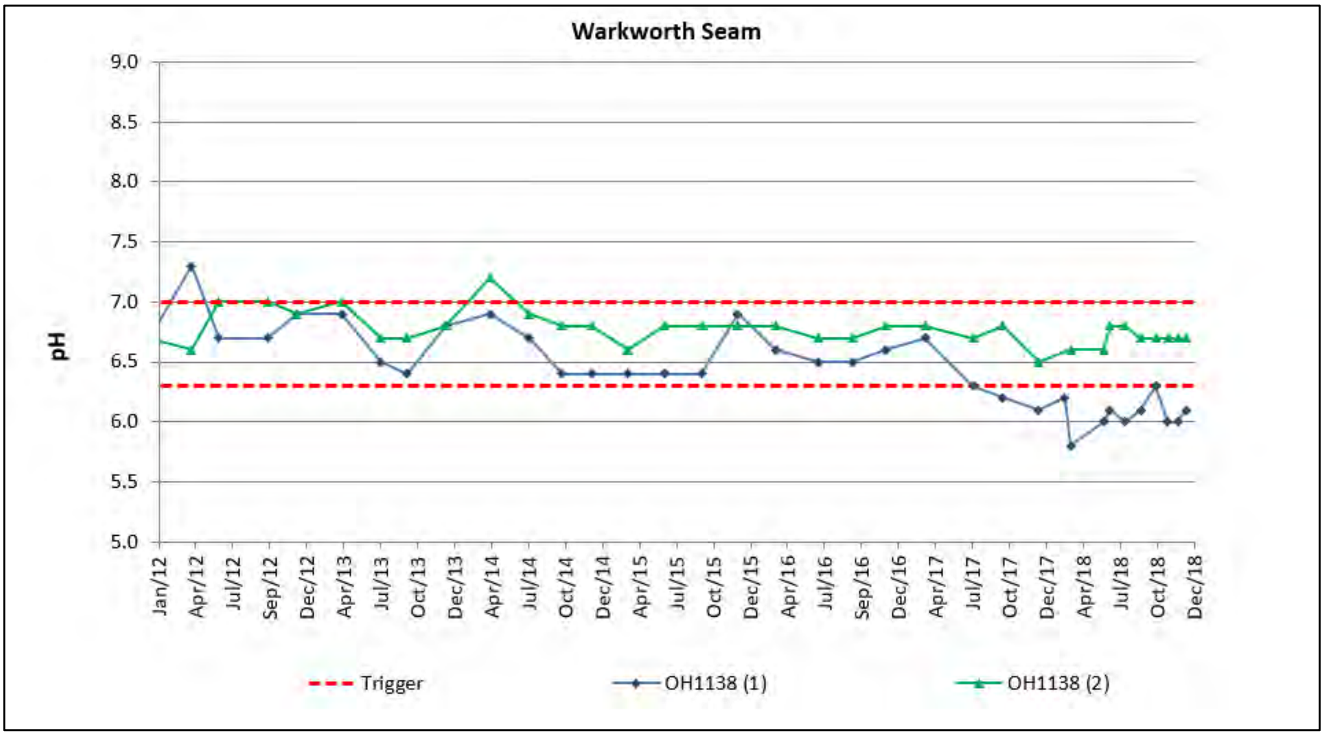

Blakefield Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
OH1122 (1)
OH1125 (1)
WOH2139A


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
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH1125 (2)
OH1125 (3)

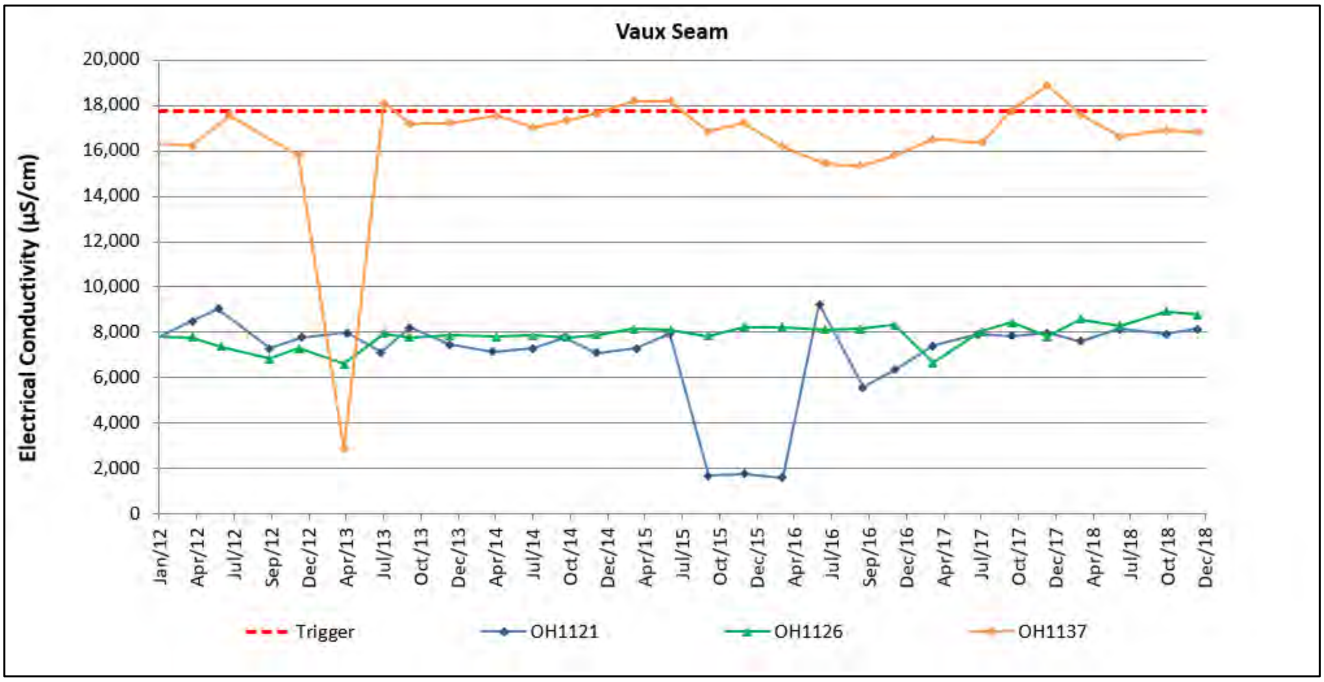

Bowfield Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
OH1125 (2)
OH1125 (3)

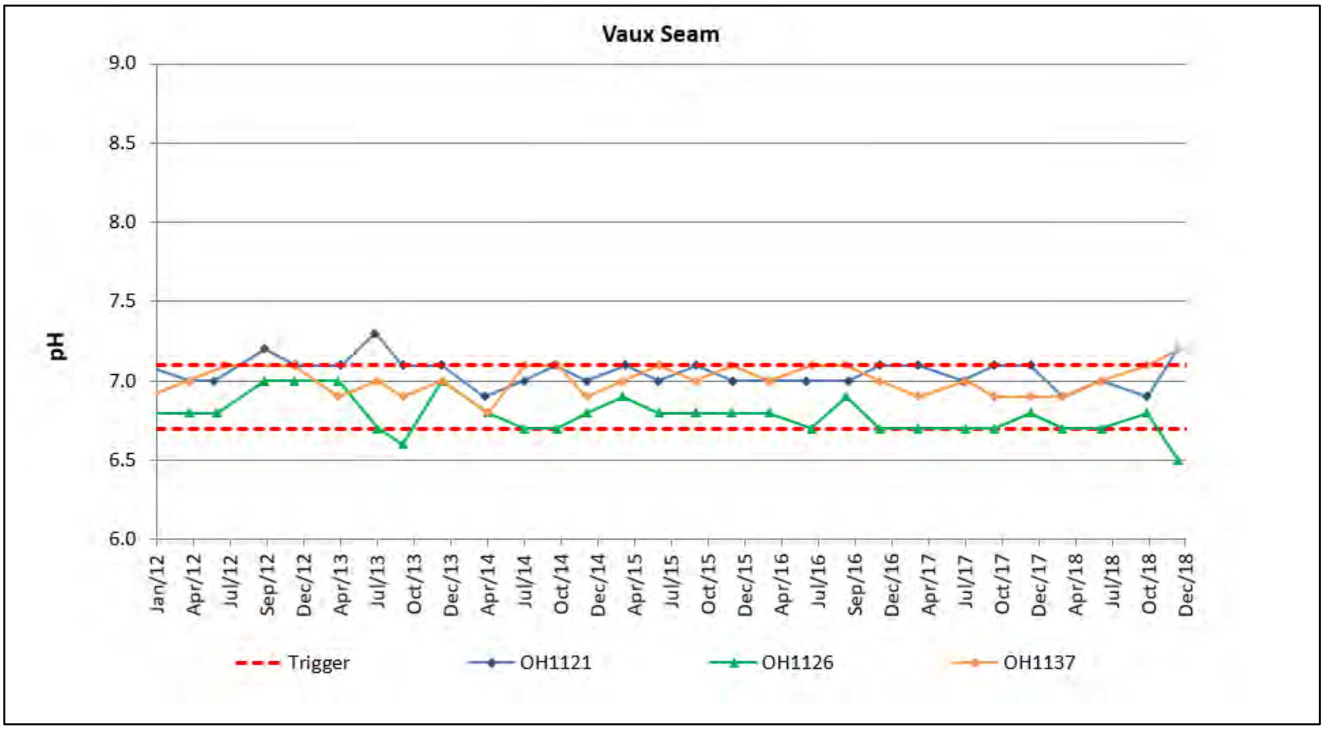


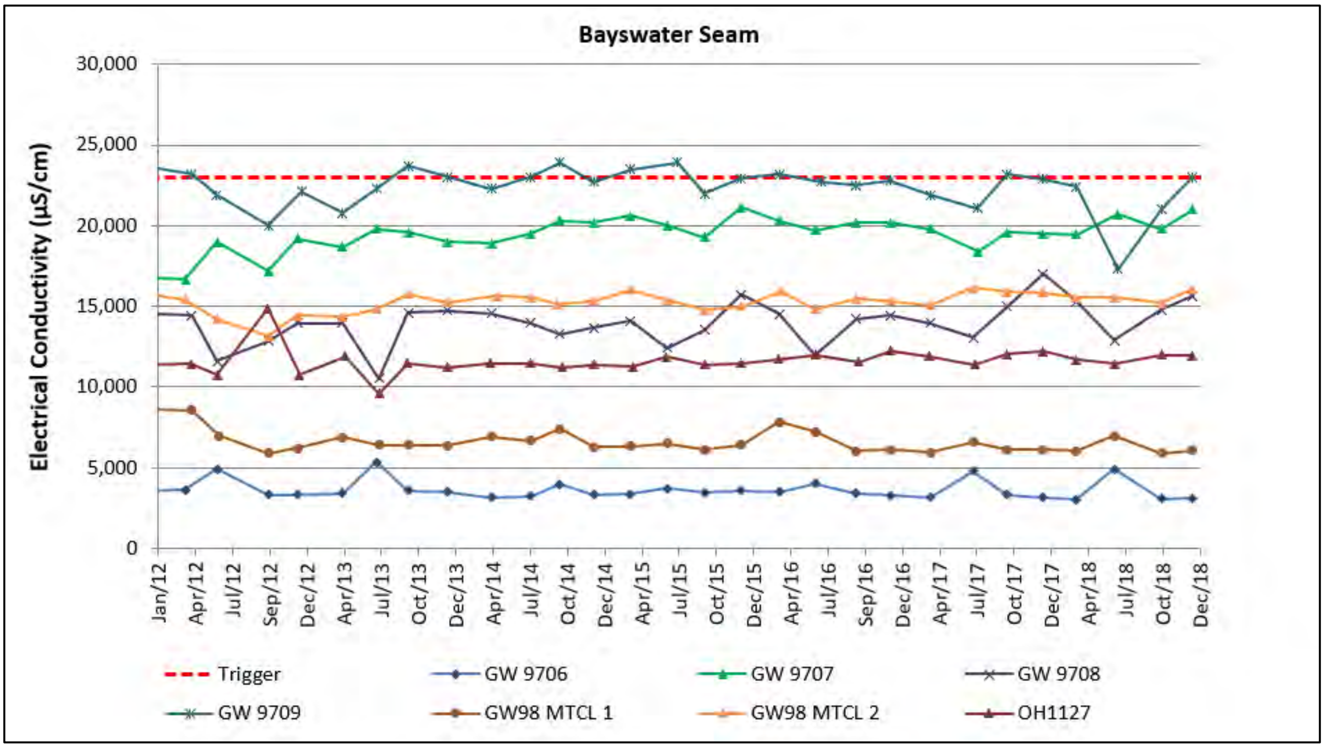
Warkworth Seam
Electrical Conductivity (µS/cm)
25,000
20,000
15,000
10,000
5,000
0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
OH1138 (1)
OH1138 (2)

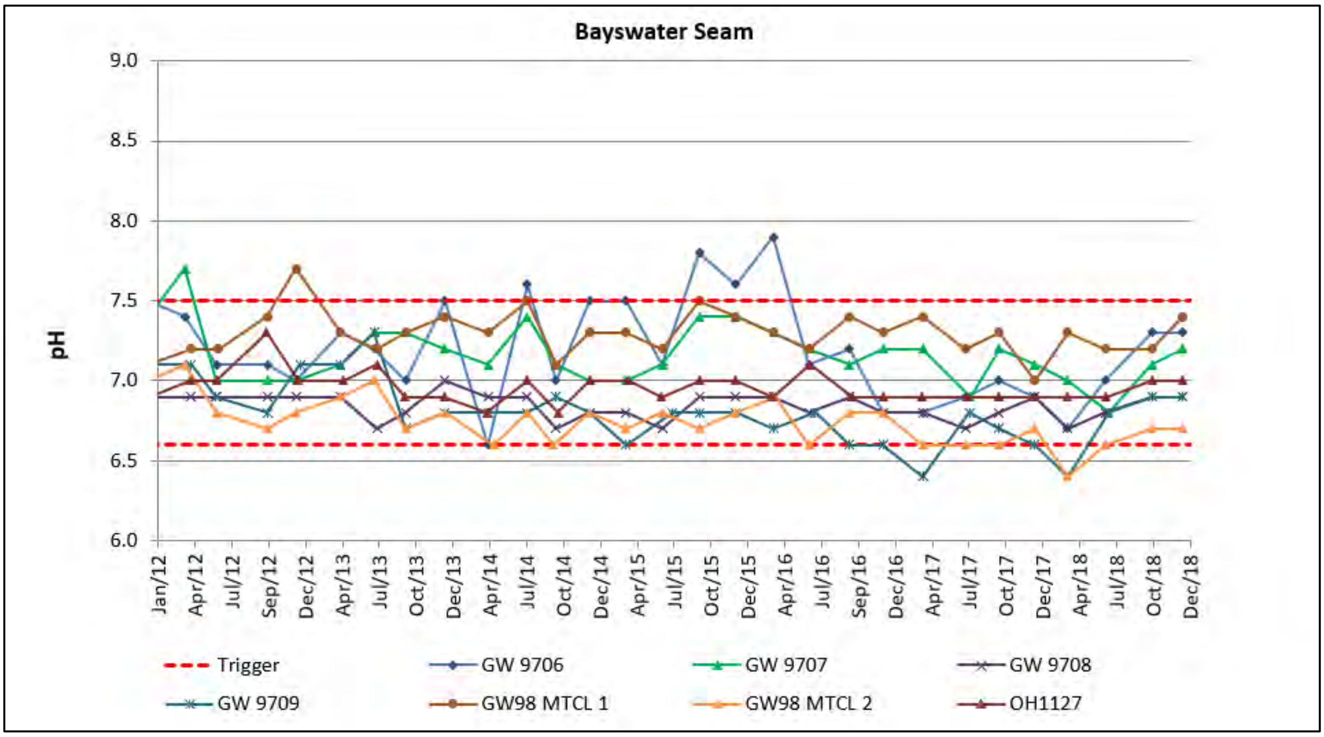


Warkworth Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18
Trigger
OH1138 (1)
OH1138 (2)


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
Apr/18
Jul/18
Oct/18
Dec/18
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
Apr/18
Jul/18
Oct/18
Dec/18
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
Apr/18
Jul/18
Oct/18
Dec/18
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
Apr/18
Jul/18
Oct/18
Dec/18
Trigger
GW 9706
GW 9707
GW 9708
GW 9709
GW98 MTCL 1
GW98 MTCL 2
OH1127

APPENDIX D

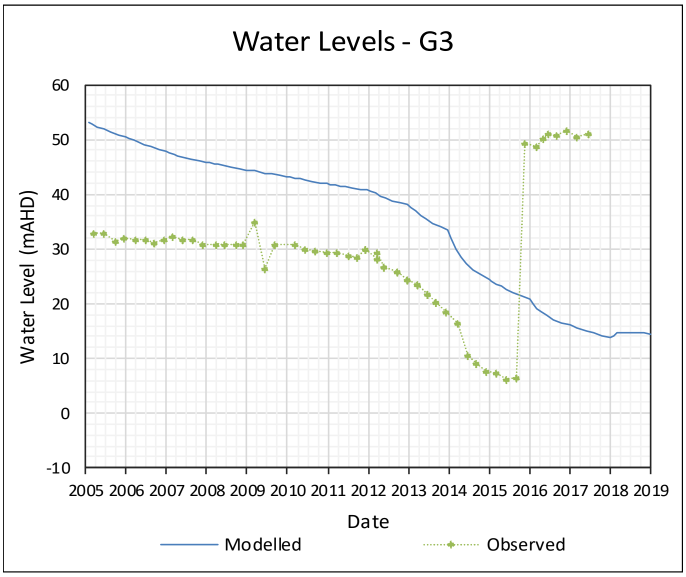
Full Water Quality Data 2018

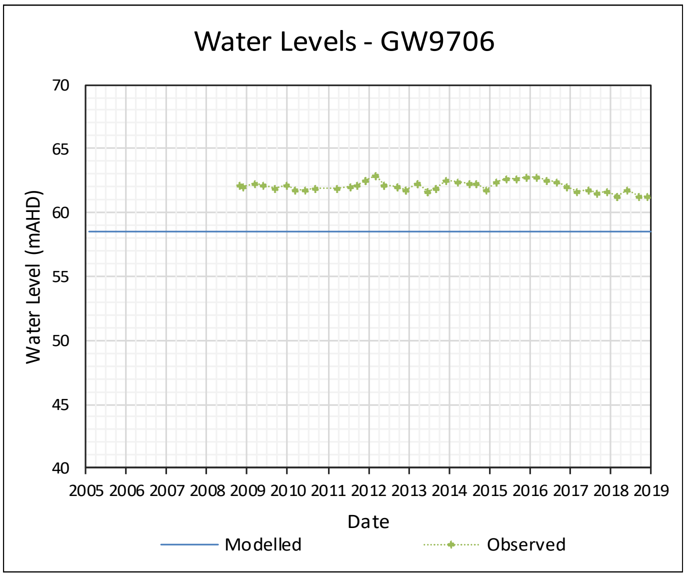
Station	Geology	Time	Date	SWL RL Calc	pH Field	EC Field (uS/cm (25TRef))	Water Temp (Deg C)	Comment	TDS - Total (mg/l)	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Acidity as CaCO3	SO4 - Total (mg/l)	Cl- (mg/l)	Ca - Total (mg/l)
PZ7S	Aeolian Warkworth Sands	13:00	03-08-18	50.95	6.8	1,515	22.8		847	0	0	440	440		20	238	54
OH786	Regolith	8:50	28-06-18	51.18	7.1	1,209	19.3	Purged 5/6/18. Insufficient Sample for lab analysis									
OH787	Regolith	11:25	12-06-18	36.13	7.5	18,500	19.6	Purged 5/6/18	10660	0	0	1542	1542	108	270	5948	74
OH942	Regolith	9:05	05-06-18	46.51	6.7	24,100	20.3		17180	0	0	715	715		970	8647	160
OH788	Hunter River Alluvium	13:30	04-06-18	35.53	6.9	13,090	20.7		10110	0	0	1531	1531		240	3999	97
OH943	Hunter River Alluvium	8:05	12-06-18	35.58	7.4	7,680	19.3	Purged 4/6/18. Insufficient Sample for lab analysis									
OH944	Hunter River Alluvium	14:25	04-06-18					Dry									
MB15MTW01S	Wollombi Brook Alluvium	10:20	30-07-18	56.69	6.8	2,430	20.0		1140	0	0	46	46		79	690	55
MB15MTW02S	Wollombi Brook Alluvium	13:30	30-07-18	55.48	7.1	2,780	21.1		1510	0	0	351	351		36	690	47
PZ8S	Wollombi Brook Alluvium	8:30	06-06-18	59.87	6.6	14,180	19.6		8350	0	0	681	681		520	4798	120
PZ9S	Wollombi Brook Alluvium	13:35	06-06-18	58.83	7.1	6,670	18.4	Purged 5/6/18. Insufficient Sample for lab analysis									
MBW01	Alluvium	10:30	31-07-18	56.76	7.5	17,290	19.7		10890	0	0	1395	1395		520	5750	45
MB15MTW01D	Shallow Overburden? Alluvium?	8:40	30-07-18	56.60	7.1	3,440	19.5		1730	0	0	209	209		78	940	46
MB15MTW02D	Shallow Overburden? Alluvium?	12:30	30-07-18	55.80	7.8	9,910	23.2		6030	0	0	2282	2282		25	2150	21
MB15MTW03	Shallow Overburden - Wollombi alluvium?	14:05	30-07-18	54.83	7.0	11,810	18.7		7300	0	0	1044	1044		330	3800	190
MBW02	Shallow Overburden	10:05	31-07-18	55.88	7.3	11,680	19.8		4010	0	0	1161	1161		<1	1900	21
MTD605P	Shallow Overburden - sandstone	11:00	30-07-18	62.28	7.3	17,460	21.7		10540	0	0	2217	2217		910	4710	27
MTD614P	Shallow Overburden - Conglomerate	10:40	06-06-18					No Access (Fallen Tree)									
MTD616P	Shallow Overburden	10:40	03-08-18	71.09	6.8	13,480	20.4		8530	0	0	1380	1380		470	4468	100
PZ7D	Shallow Overburden	12:00	03-08-18	51.02	7.6	1,667	22.0		995	0	0	480	480		31	248	18
PZ8D	Shallow Overburden	9:00	06-06-18	59.39	7.5	8,290	18.9		5040	0	0	1914	1914		18	1949	31
PZ9D	Shallow Overburden	13:25	05-06-18	47.36	7.1	9,220	19.5		5960	0	0	1055	1055		410	2749	160
GW 9706	Bayswater	9:55	04-06-18	61.77	7.0	4,890	19.7		3420	0	0	512	512		1100	800	130
GW 9707	Bayswater	8:30	12-06-18	58.89	6.8	20,700	19.4	Purged 4/6/18	14690	0	0	732	732		4900	5248	370
GW 9708	Bayswater	11:05	04-06-18	61.21	6.8	12,870	21.5		10060	0	0	709	709		5100	2149	450
GW 9709	Bayswater	8:40	12-06-18	51.31	6.8	22,300	18.3	Purged 4/6/18	17410	0	0	832	832		6000	5298	530
GW98 MTCL 1	Bayswater	11:50	04-06-18	66.67	7.2	6,950	23.8		4720	0	0	975	975		930	1425	67
GW98 MTCL 2	Bayswater	8:50	04-06-18	69.07	6.6	15,540	20.9		12320	0	0	652	652		4600	3699	570
OH1127	Vane Subgroup	12:30	05-06-18	35.41	6.9	11,410	20.0		7170	0	0	2093	2093		<2	3149	150
OH1122 (1)	Blakefield Seam	10:30	06-06-18	51.58	7.1	11,150	19.7		8240	0	0	1486	1486		610	3299	100
OH1125 (1)	Blakefield	10:00	12-06-18	56.53	6.8	13,990	19.5	Suspended Solids (Orange)	7760	0	0	938	938	225	830	4499	270
OH1125 (2)	Unknown - Blakefield?	10:05	12-06-18					Dry									
WOH2139A	Blakefield	10:20	06-08-18	40.94	8.0	9,980	21.0	EC Checked	3730	0	0	890	890		4.9	1846	8.8
OH1125 (3)	Bowfield Seam	10:10	12-06-18	45.75	6.8	13,920	19.4		7050	0	0	954	954	181	820	4449	270
WOH2153A	Redbank Crk Seam	13:50	03-08-18	54.63	7.8	2,370	20.5	EC Checked	1340	0	0	970	970		21	204	2.5
WOH2154A	Redbank Crk Seam	12:45	03-08-18	53.36	7.6	4,720	20.7		2730	0	0	1030	1030		130	864	4.7
WOH2155A	Redbank Crk Seam	11:10	03-08-18	54.02	7.2	8,730	19.9	EC Checked	5260	0	0	960	960		790	2186	35
WOH2156A	Redbank Crk Seam	9:45	03-08-18	52.63	7.0	14,670	18.7		9350	0	0	1230	1230		1200	4104	110
OH1121	Vane Subgroup	11:40	05-06-18	35.00	7.0	8,150	19.5		5350	0	0	680	680		210	2399	150
OH1126	Vaux	12:30	06-06-18	47.72	6.7	8,310	19.8		5550	0	0	632	632	49	670	2499	77
OH1137	Vaux?	13:00	06-06-18	53.68	7.0	16,610	20.1		10880	0	0	1194	1194		700	5748	130
MBW04	Wambo Seam	9:40	31-07-18	50.58	7.5	12,860	19.8		7330	0	0	1850	1850		250	3500	75
WD622P	Wambo Seam	13:30	03-08-18	53.45	6.9	14,170	22.3		9530	0	0	1070	1070		940	4857	120
WOH2153B	Wambo Seam	13:55	03-08-18	57.04	7.3	1,692	19.6		1590	0	0	620	620		21	199	5.1
WOH2154B	Wambo Seam	12:48	03-08-18	55.64	7.5	4,850	19.4		2750	0	0	1060	1060		120	903	6.9
WOH2155B	Wambo Seam	11:18	03-08-18	59.79	7.8	5,550	18.8		3030	0	0	1120	1120		230	1044	21
WOH2156B	Wambo Seam	9:48	03-08-18	67.01				Insufficient Water to Sample									
OH1138 (1)	Warkworth Seam	13:30	06-06-18	60.79	6.1	18,400	17.4		12190	0	0	252	252		450	7348	150
OH1138 (2)	Warkworth Seam	14:00	06-06-18	56.05	6.8	12,640	18.4		8130	0	0	801	801		700	4399	530
MBW03	Whybrow Seam	11:45	31-07-18	54.67	7.4	9,040	21.2		5600	0	0	2238	2238		<5	1950	26
WD625P	Whybrow Seam	13:10	03-08-18	57.87	7.2	11,800	19.7	Purged 31/07/2018	6840	0	0	1320	1320		230	3545	62
WOH2141A	Whynot Seam	9:30	06-08-18	48.18	7.8	10,220	19.4		5670	0	0	1240	1240		<1	2914	14
MBW6A		8:40	31-07-18		6.4	9,040	16.8		533	0	0	132	132		32	180	9.9

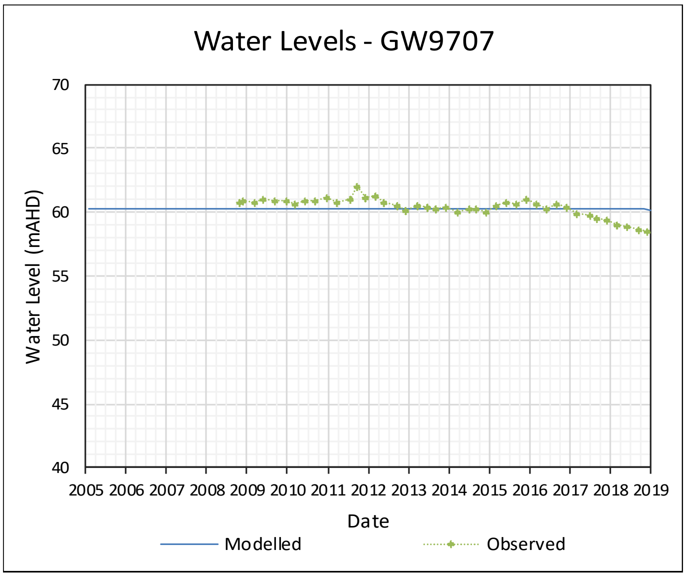
Station	Geology	Time	Date	Mg – Total (mg/l)	Na – Total (mg/l)	K – Total (mg/l)	Al – Total (mg/l)	As – Total (mg/l)	Cd – Total (mg/l)	Cu – Total (mg/l)	Pb – Total (mg/l)	Ni – Total (mg/l)	Se (mg/l)	Zn – Total (mg/l)	B (mg/l)	Hg – Total (mg/l)	Mo (mg/l)	V (mg/l)	Cr (mg/l)	F (mg/l)	Nitrogen Ammonia (mg/l)	Nitrite (mg/l)
PZ7S	Aeolian Warkworth Sands	13:00	03-08-18	0.002	<0.0001	0.007	0.004	0.005	0.002	0.022	0.06	<0.0001				0.0003						
OH786	Regolith	8:50	28-06-18													<0.0001						
OH787	Regolith	11:25	12-06-18	0.009	0.0002	0.047	0.04	0.031	0.011	0.42	0.14	<0.0001	0.005	0.081	0.045	<0.0001						
OH942	Regolith	9:05	05-06-18	0.005	<0.0001	0.02	0.012	0.029	0.009	0.048	0.1	0.0025	0.003	0.068	0.055	<0.0001						
OH788	Hunter River Alluvium	13:30	04-06-18	0.002	<0.0001	<0.001	<0.001	<0.001	0.001	0.005	0.13	<0.0001				<0.0001						
OH943	Hunter River Alluvium	8:05	12-06-18													<0.0001						
OH944	Hunter River Alluvium	14:25	04-06-18													0.0002						
MB15MTW01S	Wollombi Brook Alluvium	10:20	30-07-18	0.003	<0.0001	0.005	<0.001	0.006	<0.001	0.012	0.14	<0.0001				<0.0001						
MB15MTW02S	Wollombi Brook Alluvium	13:30	30-07-18	0.004	<0.0001	<0.001	<0.001	0.004	<0.001	<0.005	0.11	<0.0001				<0.0001						
PZ8S	Wollombi Brook Alluvium	8:30	06-06-18	<0.001	<0.0001	0.008	<0.001	0.005	0.005	0.019	0.06	<0.0001				<0.0001						
PZ9S	Wollombi Brook Alluvium	13:35	06-06-18													<0.0001						
MBW01	Alluvium	10:30	31-07-18	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	0.011	0.17	<0.0001										
MB15MTW01D	Shallow Overburden? Alluvium?	8:40	30-07-18	0.024	0.0004	0.18	0.079	0.51	0.03	0.74	0.14	0.0002				<0.0001						
MB15MTW02D	Shallow Overburden? Alluvium?	12:30	30-07-18	0.003	<0.0001	0.001	<0.001	0.009	<0.001	0.026	0.37	<0.0001				<0.0001						
MB15MTW03	Shallow Overburden - Wollombi alluvium	14:05	30-07-18	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.006	0.19	<0.0001				<0.0001						
MBW02	Shallow Overburden	10:05	31-07-18	0.004	0.0001	0.044	0.002	0.008	<0.001	0.048	0.05	<0.0001										
MTD605P	Shallow Overburden - sandstone	11:00	30-07-18	0.002	<0.0001	<0.001	<0.001	0.002	<0.001	0.007	0.49	<0.0001				0.0002						
MTD614P	Shallow Overburden - Conglomerate	10:40	06-06-18													0.0003						
MTD616P	Shallow Overburden	10:40	03-08-18	<0.001	<0.0001	<0.001	<0.001	0.012	<0.001	0.014	0.19	<0.0001				<0.0001						
PZ7D	Shallow Overburden	12:00	03-08-18	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	0.005	0.12	<0.0001				<0.0001						
PZ8D	Shallow Overburden	9:00	06-06-18	0.009	0.0002	0.026	0.001	0.015	0.003	0.017	0.27	<0.0001				0.0003						
PZ9D	Shallow Overburden	13:25	05-06-18	0.001	<0.0001	0.003	0.001	0.003	0.002	0.027	0.12	<0.0001				<0.0001						
GW 9706	Bayswater	9:55	04-06-18	<0.001	<0.0001	<0.001	<0.001	<0.001	0.002	0.009	0.19	<0.0001				<0.0001						
GW 9707	Bayswater	8:30	12-06-18	<0.001	0.0001	<0.001	0.001	0.006	0.004	0.023	0.56	<0.0001				<0.0001						
GW 9708	Bayswater	11:05	04-06-18	<0.001	<0.0001	0.001	<0.001	<0.001	0.003	0.01	0.35	<0.0001				<0.0001						
GW 9709	Bayswater	8:40	12-06-18	<0.001	0.0002	<0.001	0.001	0.01	0.003	0.015	0.43	<0.0001				<0.0001						
GW98 MTCL 1	Bayswater	11:50	04-06-18	<0.001	<0.0001	0.001	<0.001	0.002	0.009	0.016	0.28	<0.0001				<0.0001						
GW98 MTCL 2	Bayswater	8:50	04-06-18	<0.001	0.0001	0.002	<0.001	0.002	<0.001	0.016	0.3	<0.0001				<0.0001						
OH1127	Vane Subgroup	12:30	05-06-18	<0.001	<0.0001	<0.001	<0.001	0.002	0.002	0.029	0.17	<0.0001				<0.0001						
OH1122 (1)	Blakefield Seam	10:30	06-06-18	0.003	0.0002	0.038	0.022	0.01	<0.001	0.32	0.17	<0.0001	0.002	0.011	0.007	<0.0001						
OH1125 (1)	Blakefield	10:00	12-06-18	0.001	<0.0001	<0.001	0.002	0.008	0.001	0.041	0.1	<0.0001	0.002	0.002	<0.001	<0.0001						
OH1125 (2)	Unknown - Blakefield?	10:05	12-06-18													<0.0001						
WOH2139A	Blakefield	10:20	06-08-18	0.002	<0.0001	0.004	0.002	0.002	<0.001	0.076	0.17	<0.0001				<0.0001	0.001	0.002	<0.001			
OH1125 (3)	Bowfield Seam	10:10	12-06-18	0.002	<0.0001	0.012	0.016	0.013	0.001	0.49	0.1	<0.0001	0.001	0.009	0.005	<0.0001						
WOH2153A	Redbank Crk Seam	13:50	03-08-18	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.016	0.17	<0.0001				<0.0001						
WOH2154A	Redbank Crk Seam	12:45	03-08-18	<0.001	<0.0001	0.004	0.003	0.002	<0.001	0.12	0.16	<0.0001				<0.0001	0.001	0.008	0.005			
WOH2155A	Redbank Crk Seam	11:10	03-08-18	0.001	<0.0001	0.004	0.005	0.002	<0.001	0.18	0.15	<0.0001				<0.0001						
WOH2156A	Redbank Crk Seam	9:45	03-08-18	0.001	<0.0001	0.001	0.001	0.001	<0.001	0.048	0.18	<0.0001				<0.0001						
OH1121	Vane Subgroup	11:40	05-06-18	<0.001	<0.0001	<0.001	<0.001	0.001	0.003	0.014	0.13	<0.0001				<0.0001						
OH1126	Vaux	12:30	06-06-18	0.004	0.0003	0.03	0.057	0.015	0.002	0.67	0.14	<0.0001				0.0007	<0.001	0.006	0.006			
OH1137	Vaux?	13:00	06-06-18	0.003	0.0001	0.005	0.007	0.007	0.013	0.072	0.058	0.0006				<0.0001						
MBW04	Wambo Seam	9:40	31-07-18	0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	0.17	<0.0001										
WD622P	Wambo Seam	13:30	03-08-18	0.005	<0.0001	0.007	0.005	0.14	<0.001	0.025	0.15	<0.0001				<0.0001						
WOH2153B	Wambo Seam	13:55	03-08-18	0.002	0.0002	0.007	0.008	0.005	<0.001	0.57	0.15	<0.0001				<0.0001				<0.001	0.003	0.003
WOH2154B	Wambo Seam	12:48	03-08-18	0.001	<0.0001	0.009	0.006	0.004	<0.001	0.43	0.16	<0.0001				<0.0001						
WOH2155B	Wambo Seam	11:18	03-08-18	0.002	<0.0001	0.019	0.011	0.005	0.001	0.67	0.28	<0.0001				<0.0001						
WOH2156B	Wambo Seam	9:48	03-08-18													<0.0001						
OH1138 (1)	Warkworth Seam	13:30	06-06-18	0.021	0.0011	0.027	0.039	0.044	0.039	0.11	0.035	0.0085				<0.0001						
OH1138 (2)	Warkworth Seam	14:00	06-06-18	0.001	0.0002	0.007	0.003	<0.001	0.003	0.017	0.033	<0.0001				<0.0001						
MBW03	Whybrow Seam	11:45	31-07-18	<0.001	<0.0001	0.007	<0.001	0.001	<0.001	0.011	0.25	<0.0001										
WD625P	Whybrow Seam	13:10	03-08-18	0.003	<0.0001	0.01	0.022	0.008	<0.001	0.11	0.21	<0.0001				<0.0001						
WOH2141A	Whynot Seam	9:30	06-08-18	0.002	<0.0001	0.025	0.005	0.004	0.001	0.064	0.18	<0.0001				<0.0001	0.005	0.003	0.003	0.005	0.003	0.003
MBW6A		8:40	31-07-18	0.002	<0.0001	0.009	0.004	0.008	0.002	0.027	0.13	<0.0001										

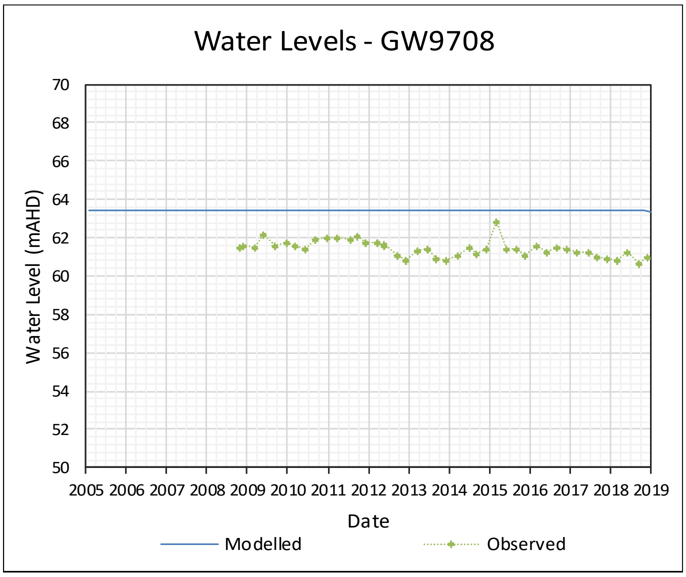
APPENDIX E

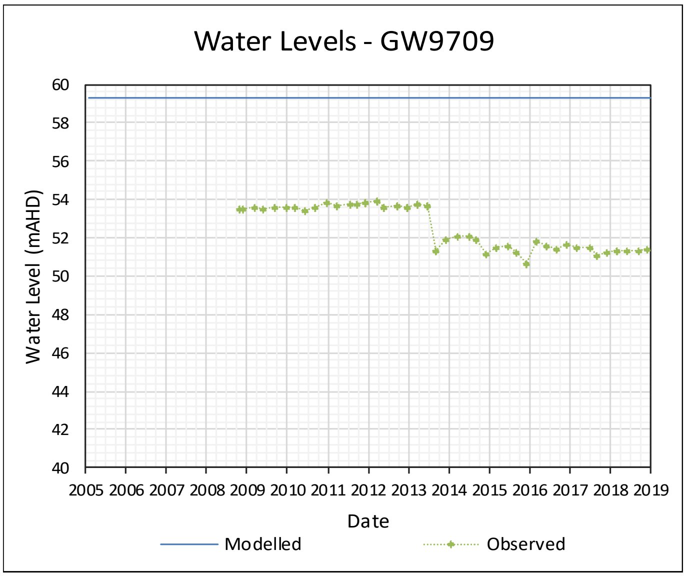
Modelled vs Observed Groundwater Levels

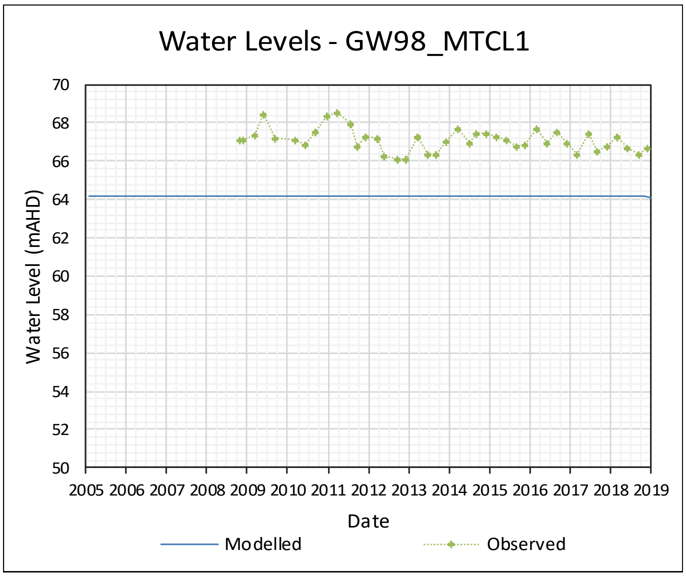

Water Levels - G3
Water Level (mAHD)
60
50
40
30
20
10
0
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

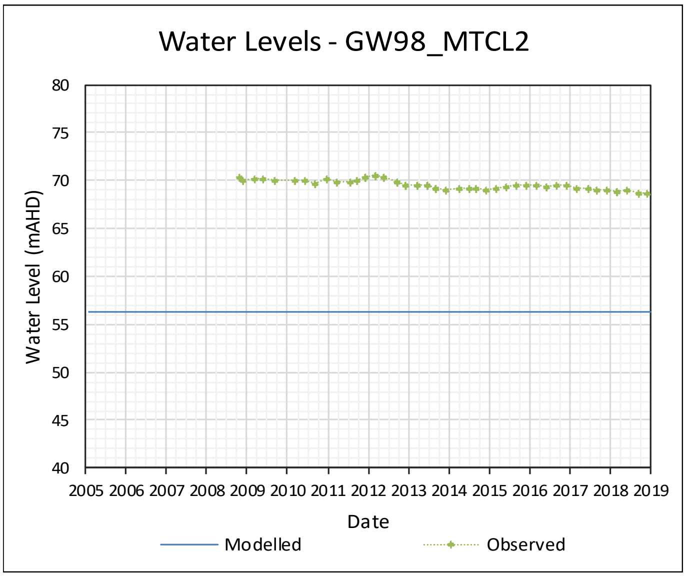

Water Levels - GW9706
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

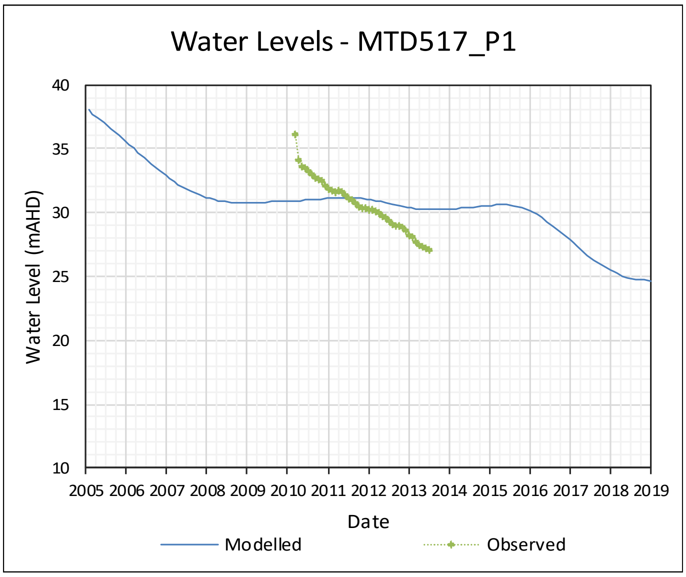

Water Levels - GW9707
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

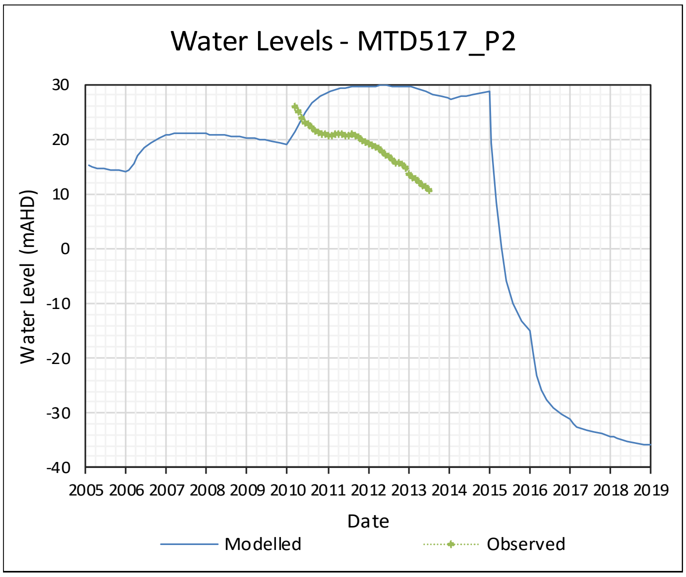

Water Levels - GW9708
Water Level (mAHD)
70
68
66
64
62
60
58
56
54
52
50
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

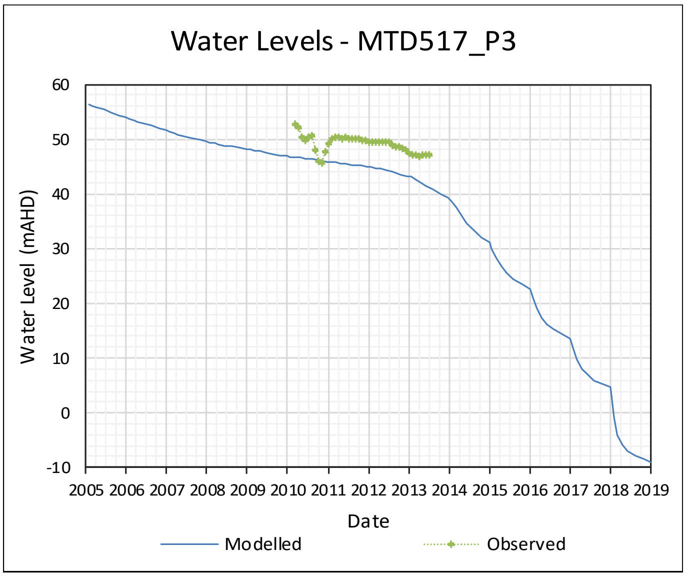

Water Levels - GW9709
Water Level (mAHD)
60
58
56
54
52
50
48
46
44
42
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

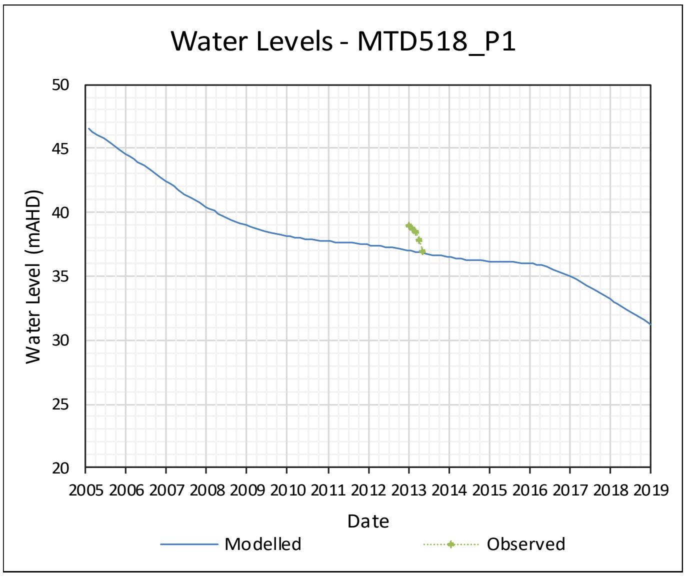

Water Levels - GW98_MTCL1
Water Level (mAHD)
70
68
66
64
62
60
58
56
54
52
50
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

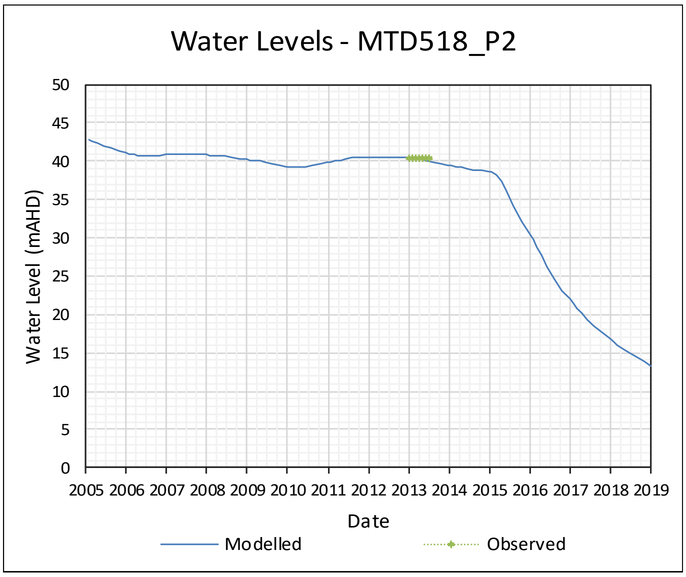

Water Levels - GW98_MTCL2
Water Level (mAHD)
80
75
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

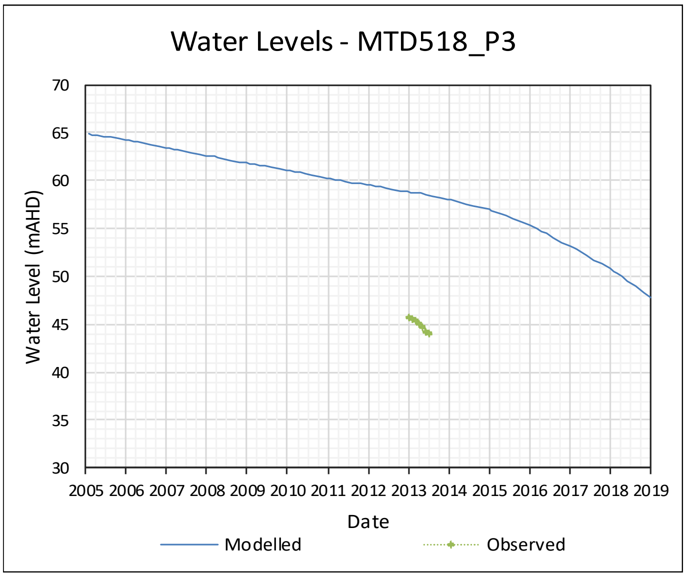

Water Levels - MTD517_P1
Water Level (mAHD)
40
35
30
25
20
15
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

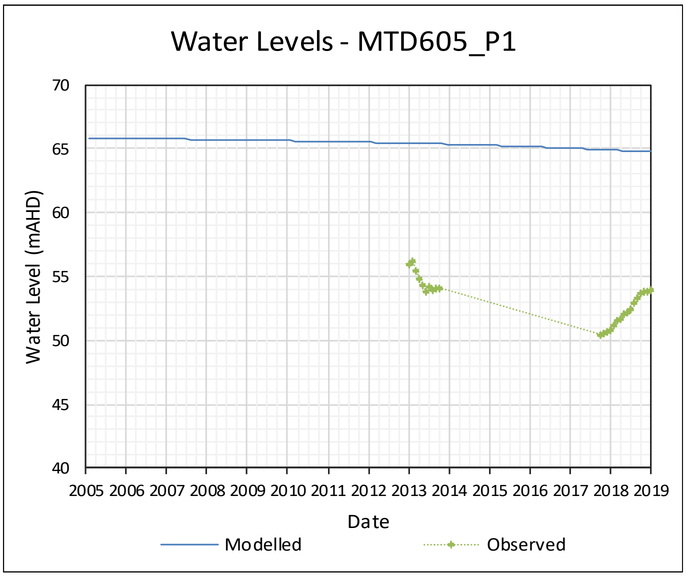

Water Levels - MTD517_P2
Water Level (mAHD)
30
20
10
0
-10
-20
-30
-40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

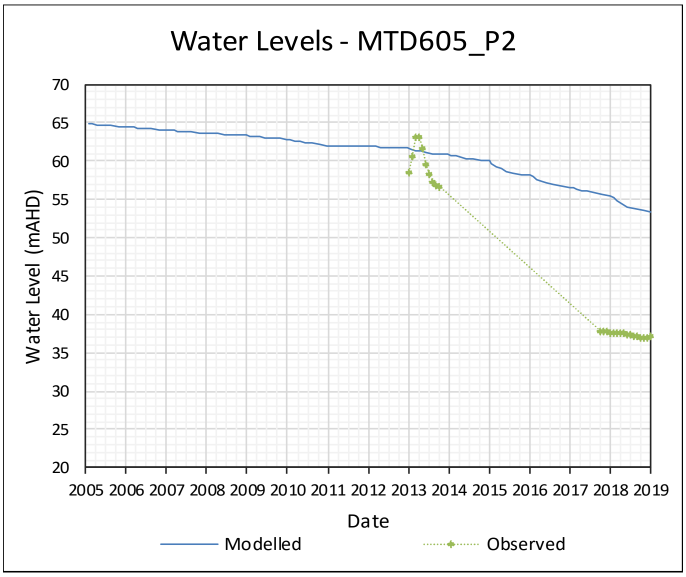

Water Levels - MTD517_P3
Water Level (mAHD)
60
50
40
30
20
10
0
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

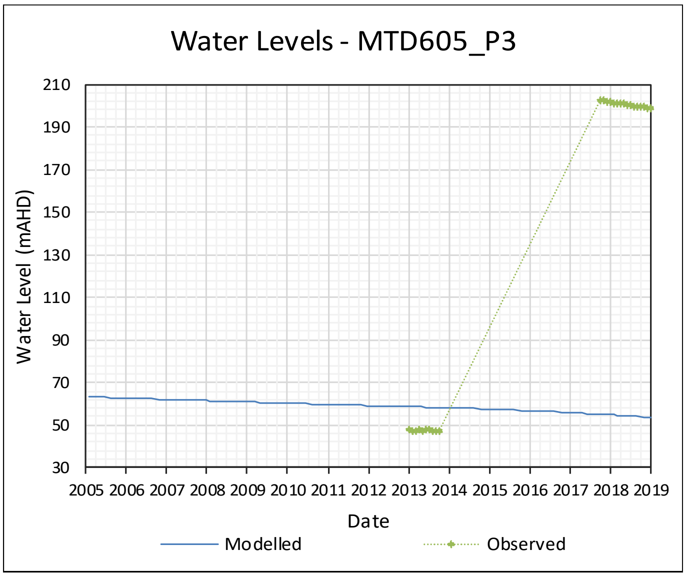

Water Levels - MTD518_P1
Water Level (mAHD)
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

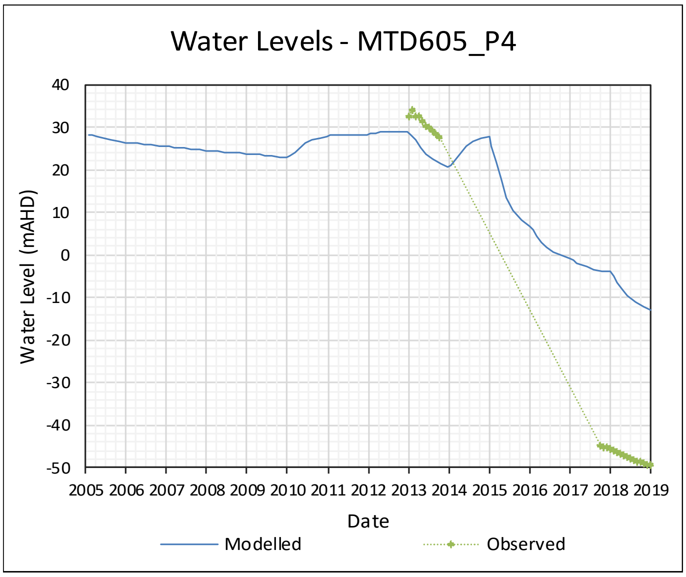

Water Levels - MTD518_P2
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
5
0
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

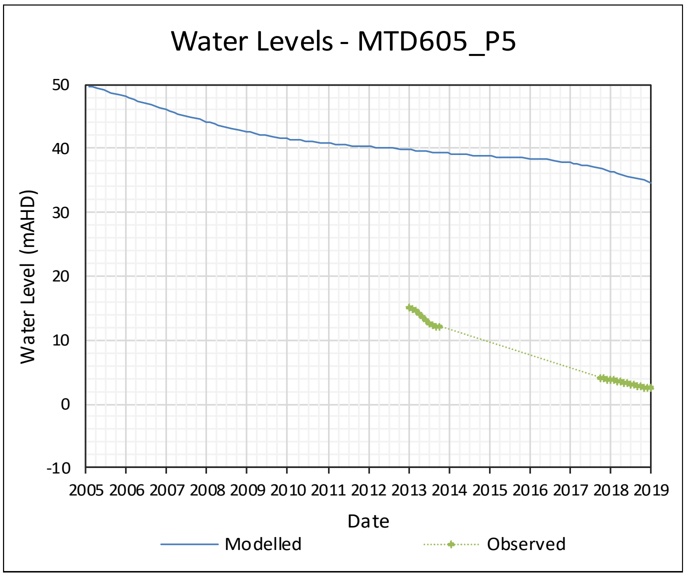

Water Levels - MTD518_P3
70
65
60
55
50
45
40
35
30
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

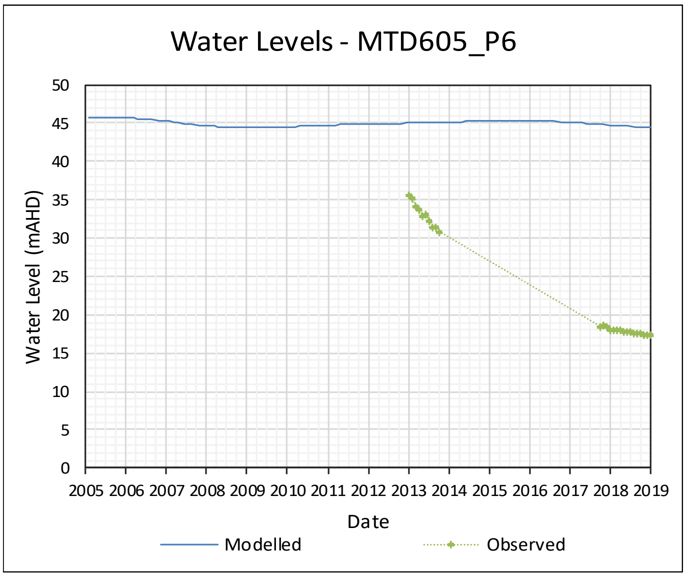

Water Levels - MTD605_P1
70
65
60
55
50
45
40
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

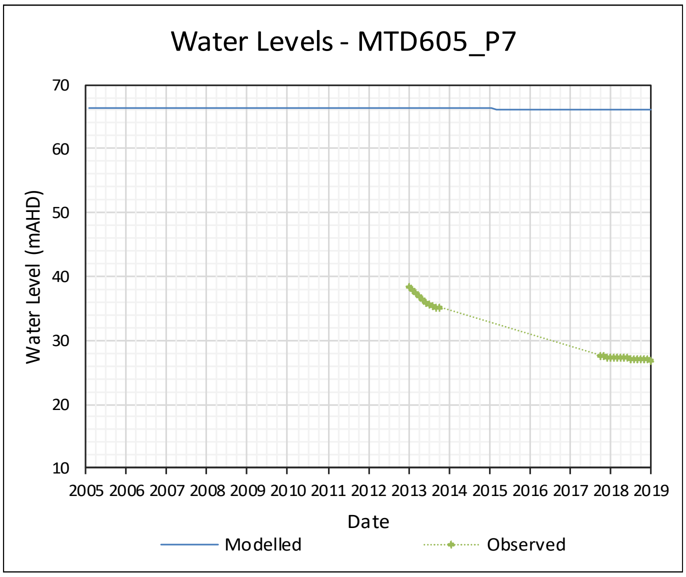

Water Levels - MTD605_P2
70
65
60
55
50
45
40
35
30
25
20
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

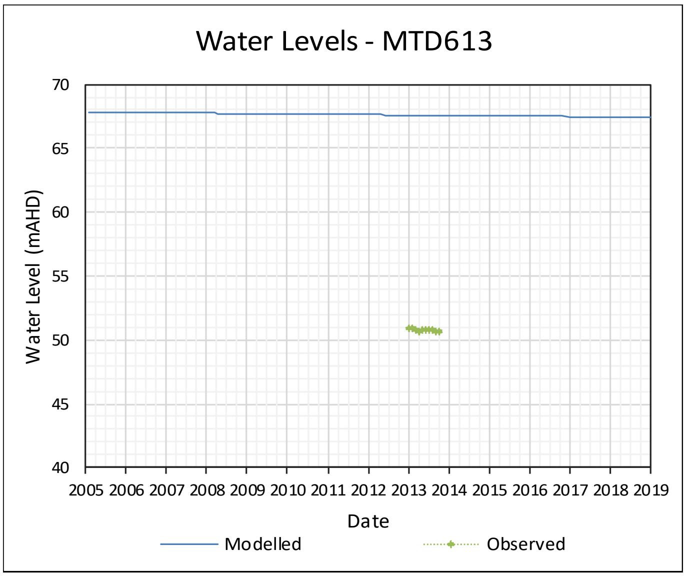

Water Levels - MTD605_P3
210
190
170
150
130
110
90
70
50
30
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

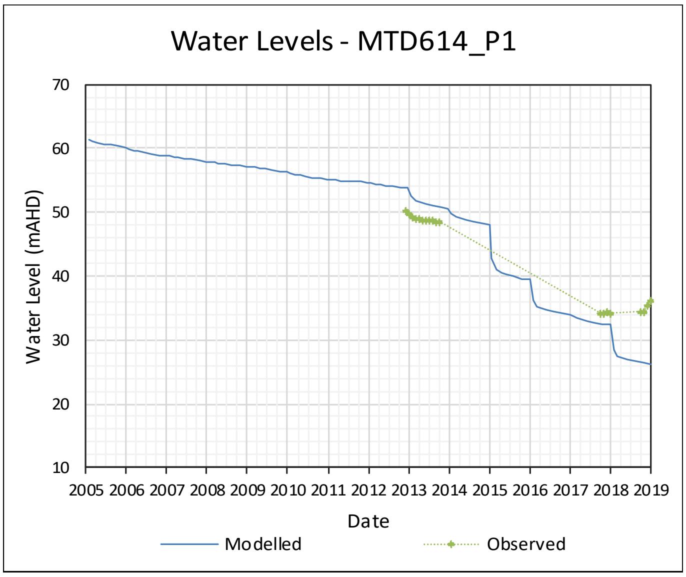

Water Levels - MTD605_P4
40
30
20
10
0
-10
-20
-30
-40
-50
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

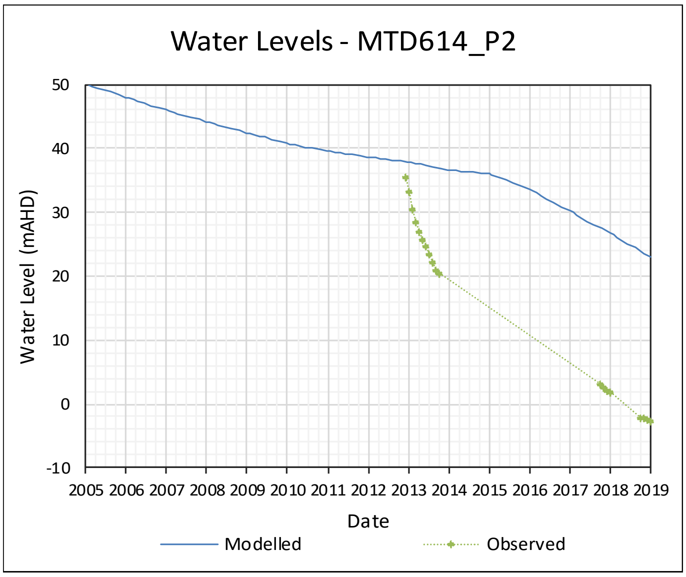

Water Levels - MTD605_P5
50
40
30
20
10
0
-10
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

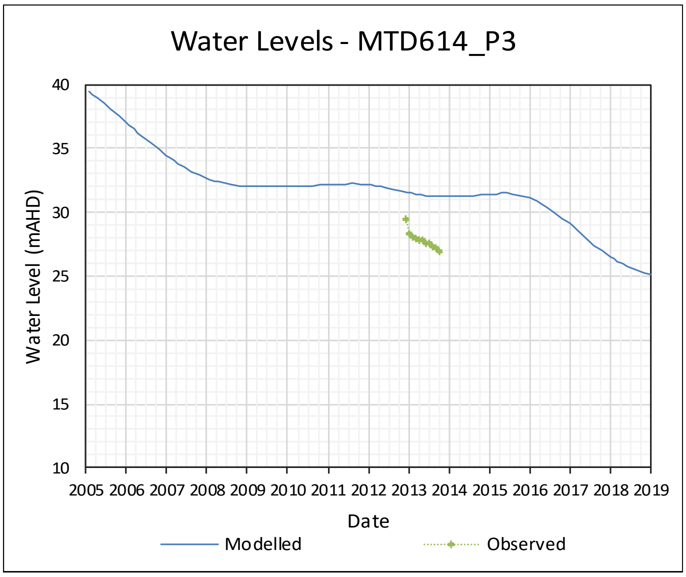

Water Levels - MTD605_P6
Water Level (mAHD)
Date
Modelled
Observed

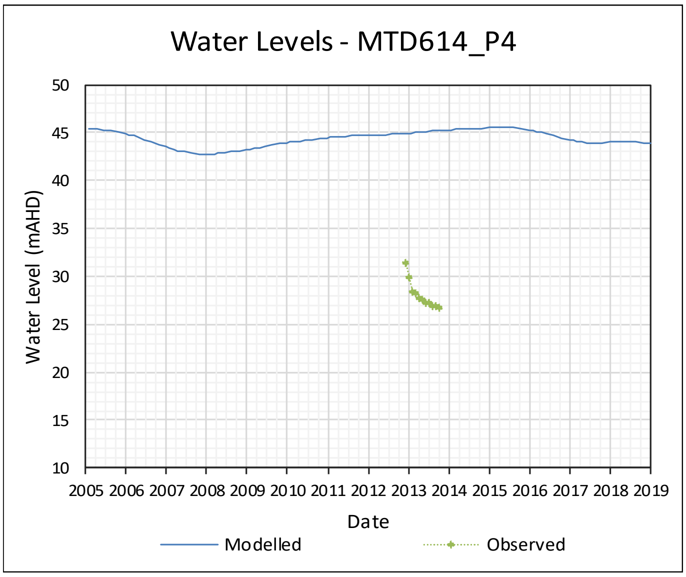

Water Levels - MTD605_P7
Water Level (mAHD)
Date
Modelled
Observed

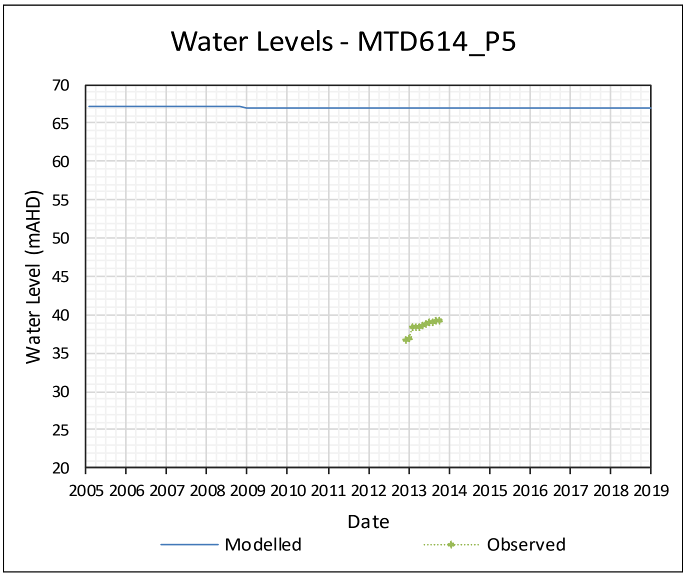

Water Levels - MTD613
Water Level (mAHD)
Date
Modelled
Observed

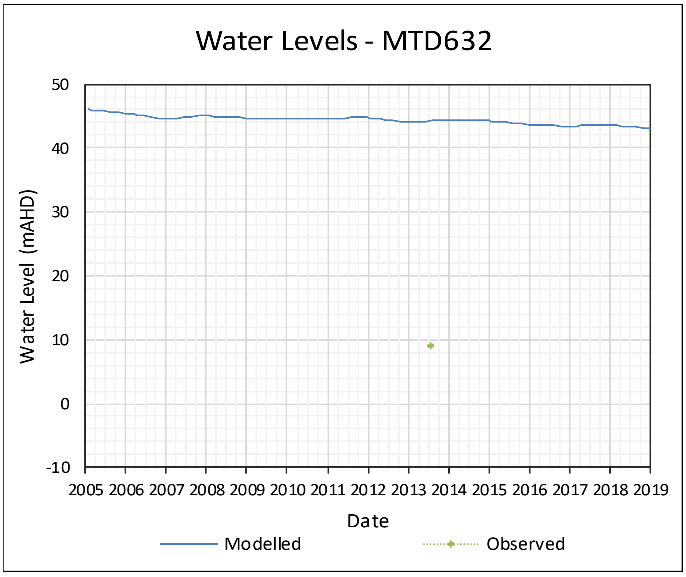

Water Levels - MTD614_P1
Water Level (mAHD)
Date
Modelled
Observed

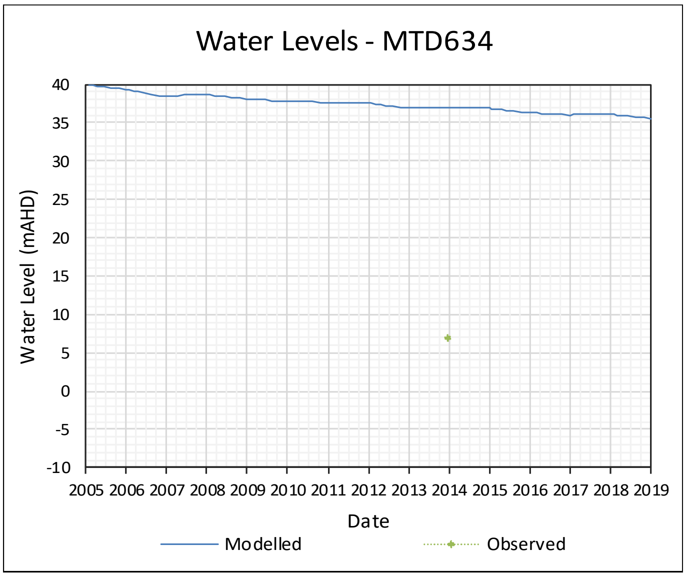

Water Levels - MTD614_P2
Water Level (mAHD)
Date
Modelled
Observed

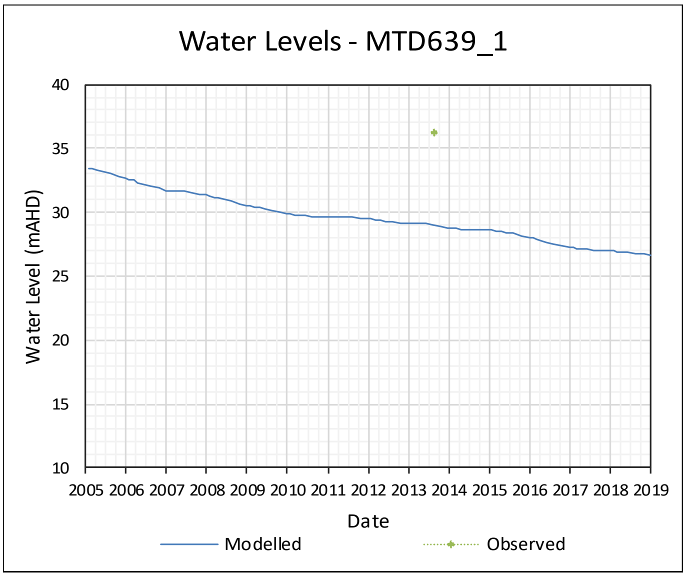

Water Levels - MTD614_P3
Water Level (mAHD)
Date
Modelled
Observed

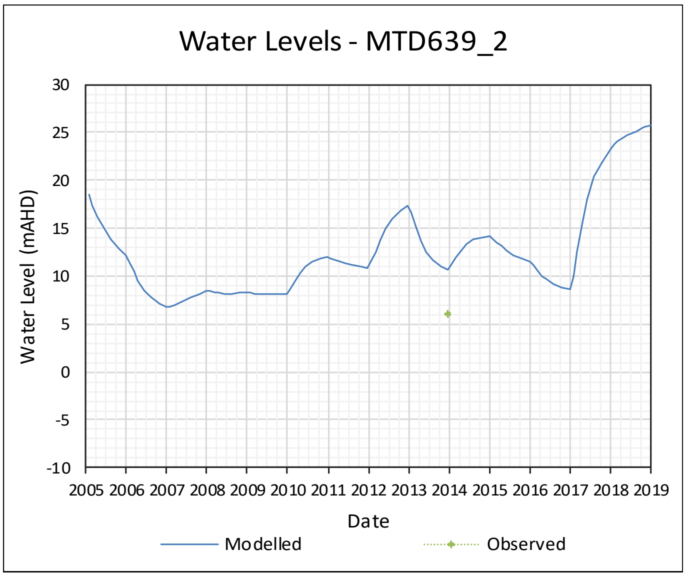

Water Levels - MTD614_P4
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

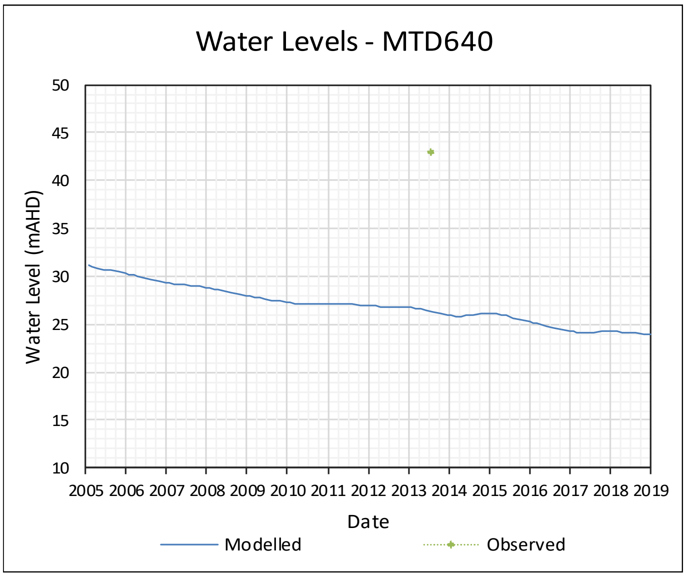

Water Levels - MTD614_P5
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed


Water Levels - MTD632
Water Level (mAHD)
50
40
30
20
10
0
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

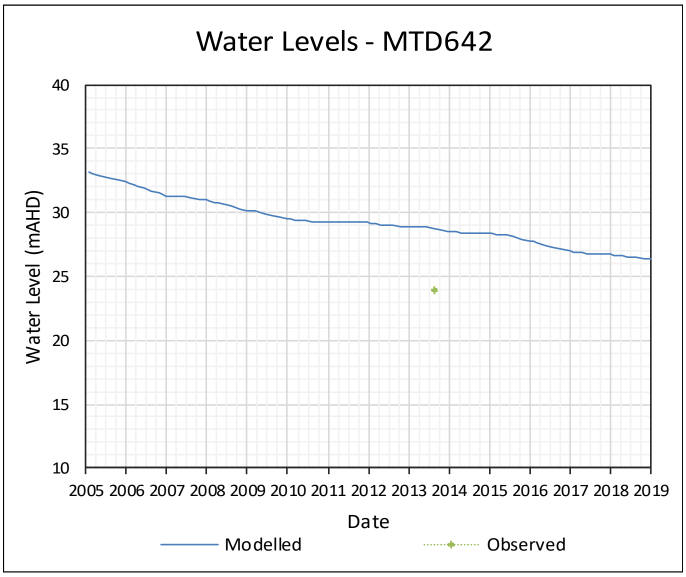

Water Levels - MTD634
Water Level (mAHD)
40
35
30
25
20
15
10
5
0
-5
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed


Water Levels - MTD639_1
Water Level (mAHD)
40
35
30
25
20
15
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

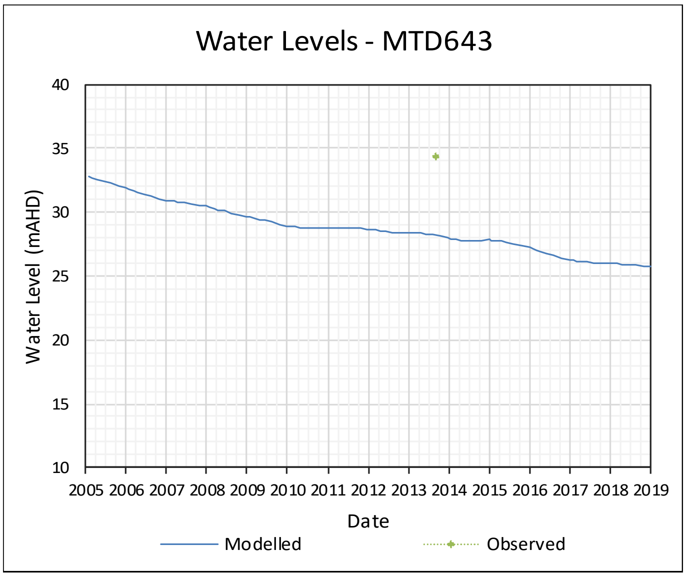

Water Levels - MTD639_2
Water Level (mAHD)
30
25
20
15
10
5
0
-5
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



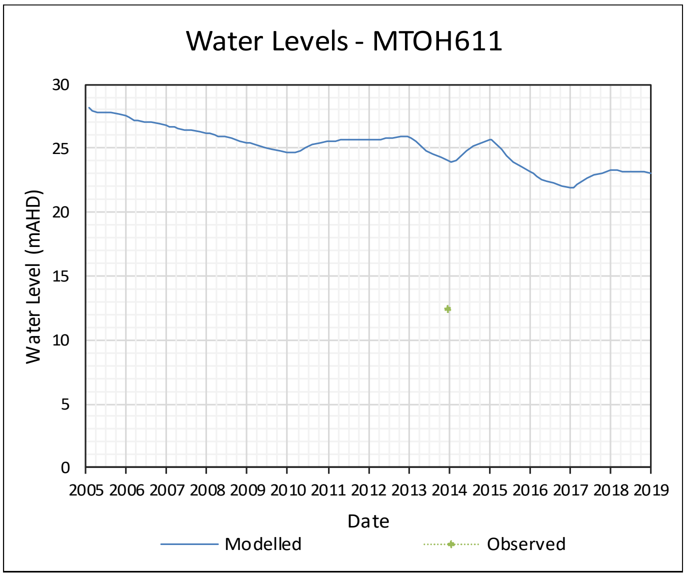
Water Levels - MTD640
Water Level (mAHD)
Date
Modelled
Observed



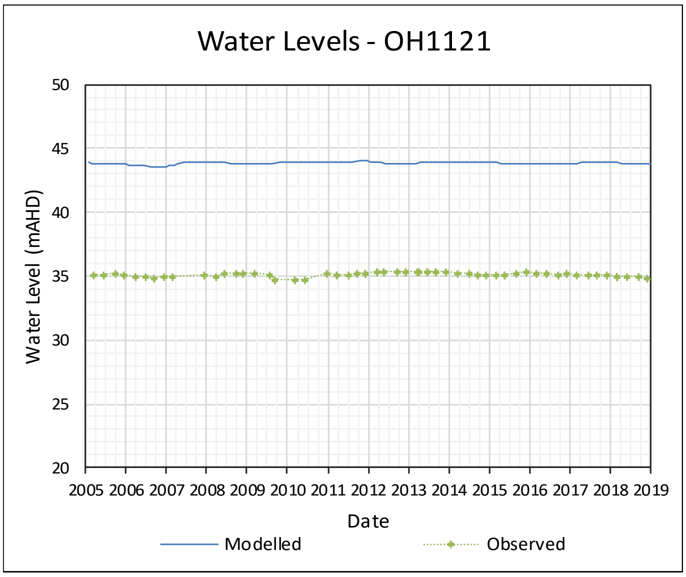
Water Levels - MTD642
Water Level (mAHD)
Date
Modelled
Observed



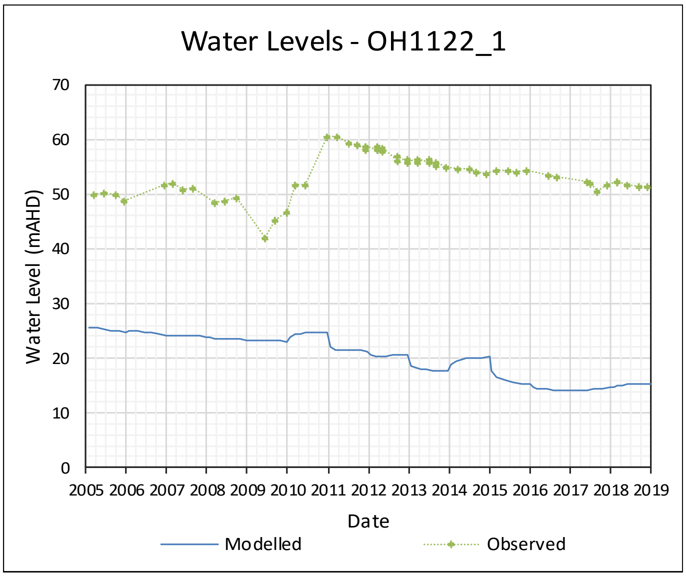
Water Levels - MTD643
Water Level (mAHD)
Date
Modelled
Observed



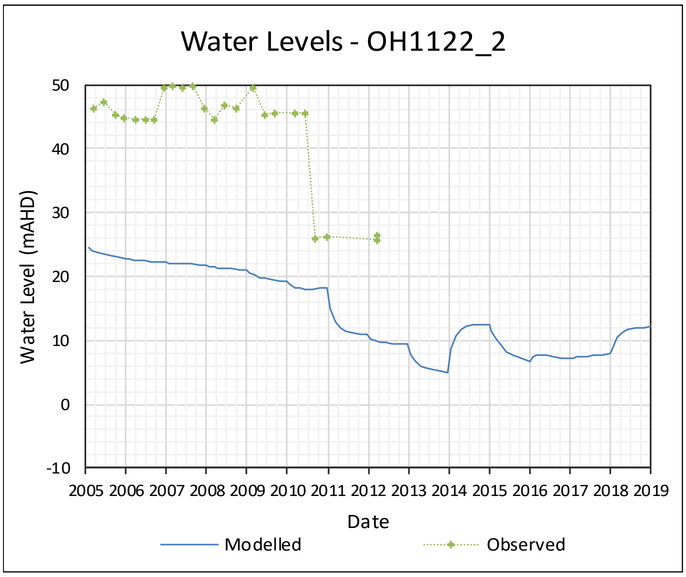
Water Levels - MTOH611
Water Level (mAHD)
Date
Modelled
Observed

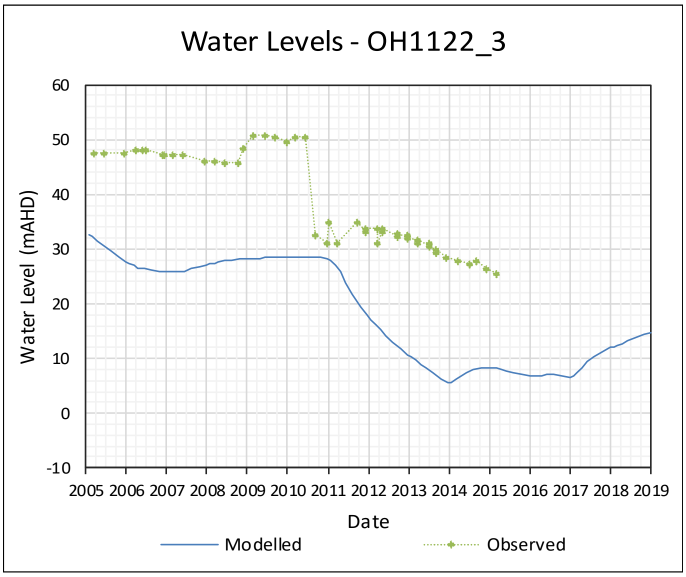


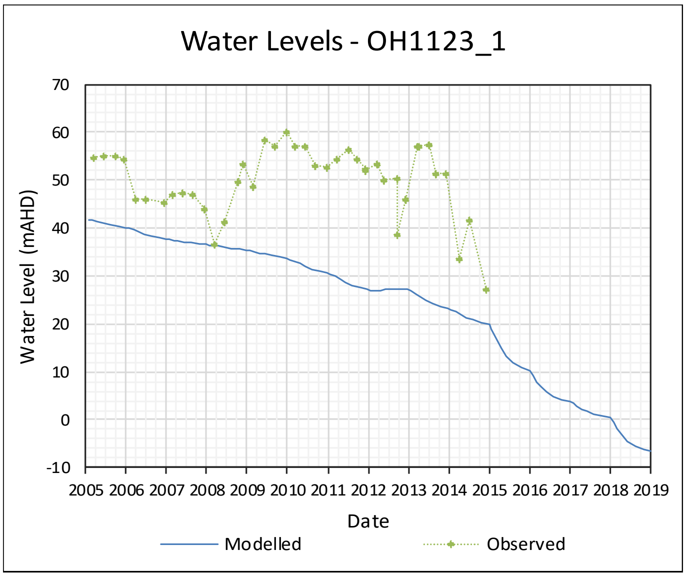
Water Levels - OH1121
Water Level (mAHD)
Date
Modelled
Observed

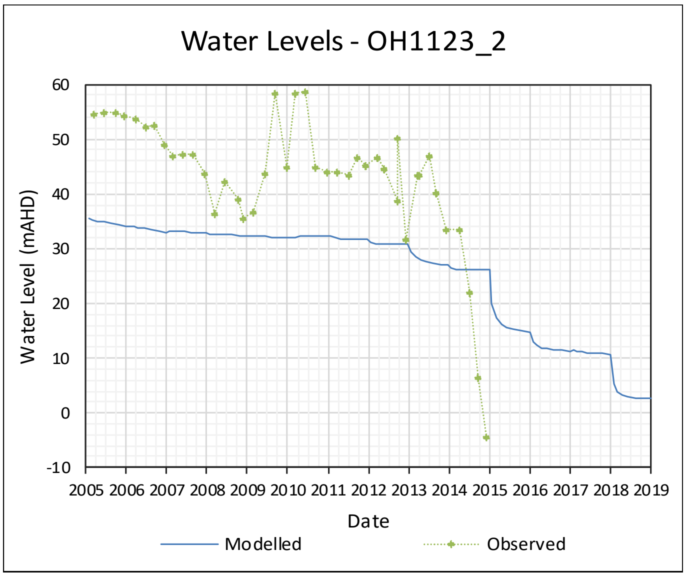


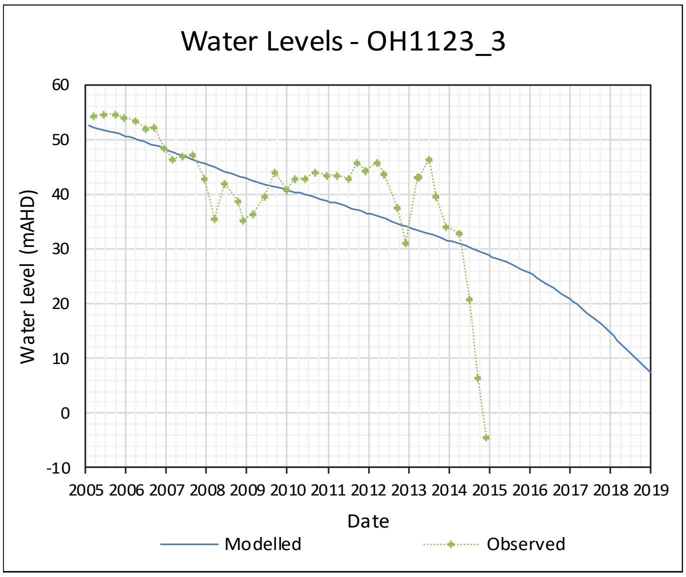
Water Levels - OH1122_1
Water Level (mAHD)
Date
Modelled
Observed

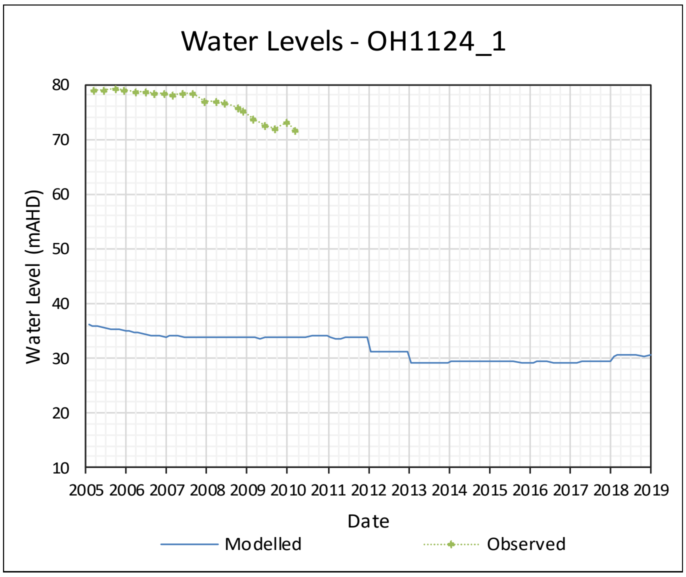

Water Levels - OH1122_2
Water Level (mAHD)
Date
Modelled
Observed

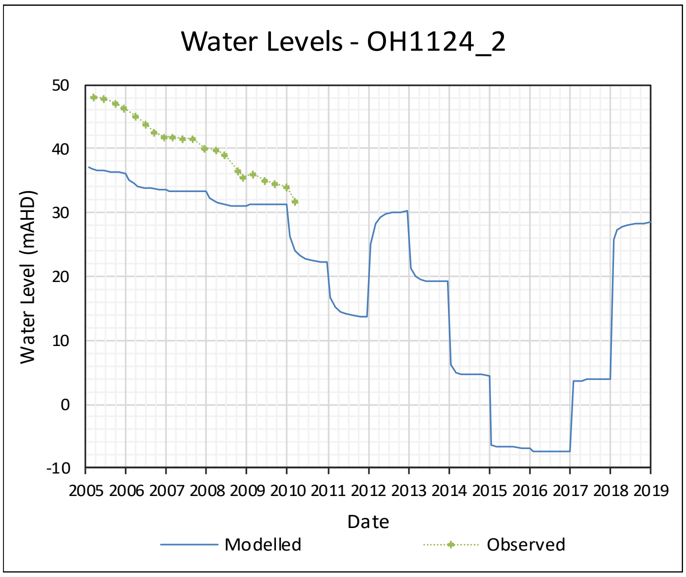

Water Levels - OH1122_3
Water Level (mAHD)
Date
Modelled
Observed

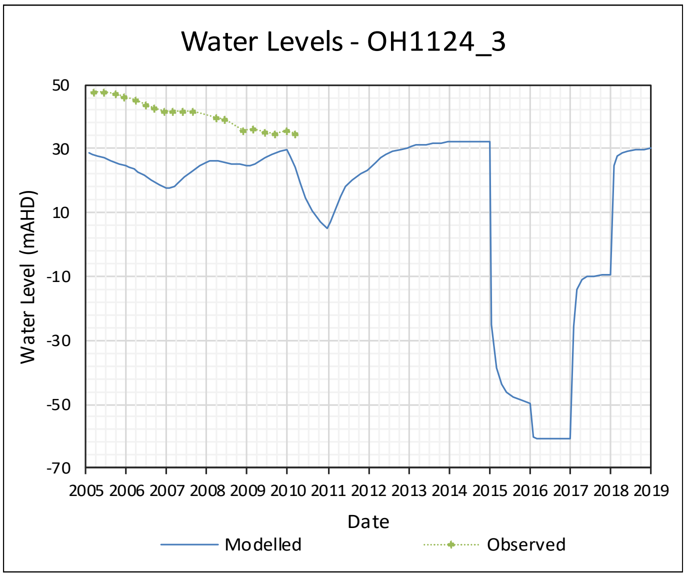

Water Levels - OH1123_1
Water Level (mAHD)
Date
Modelled
Observed

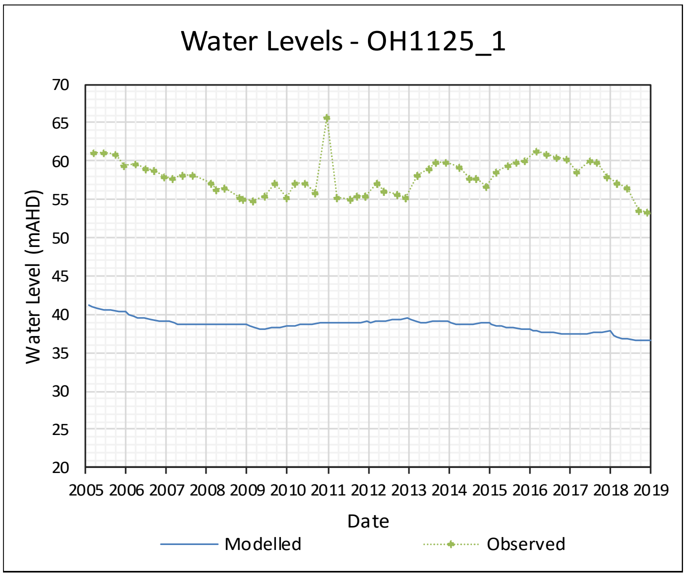

Water Levels - OH1123_2
Water Level (mAHD)
Date
Modelled
Observed

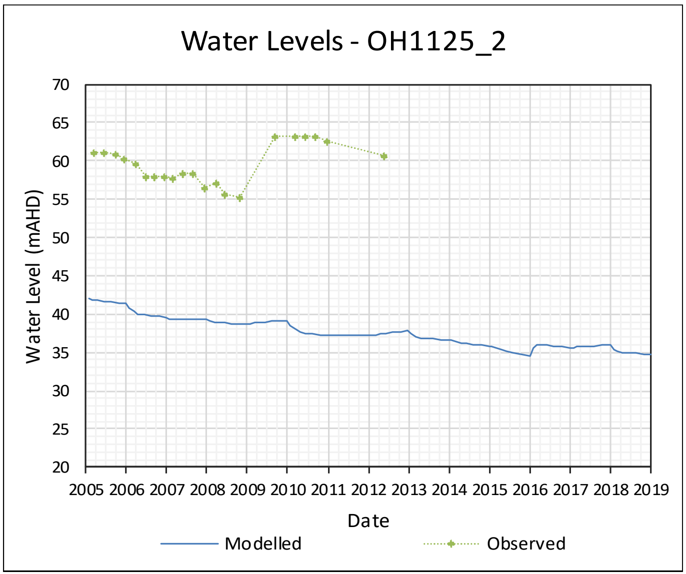

Water Levels - OH1123_3
Water Level (mAHD)
Date
Modelled
Observed

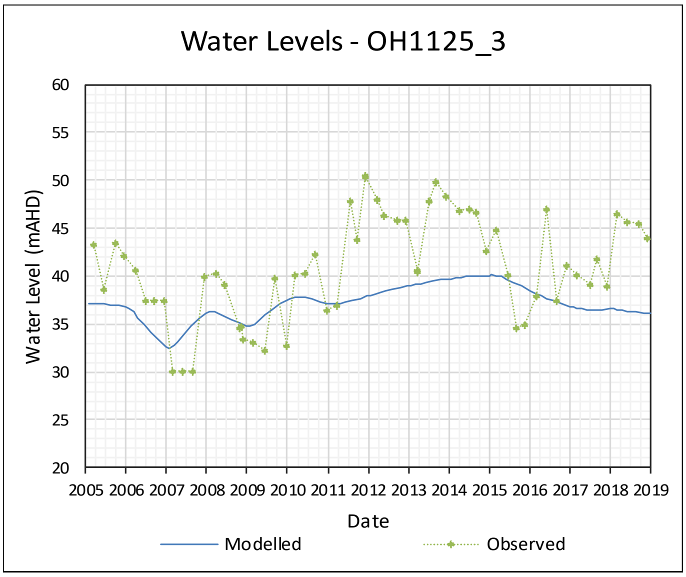

Water Levels - OH1124_1
Water Level (mAHD)
Date
Modelled
Observed

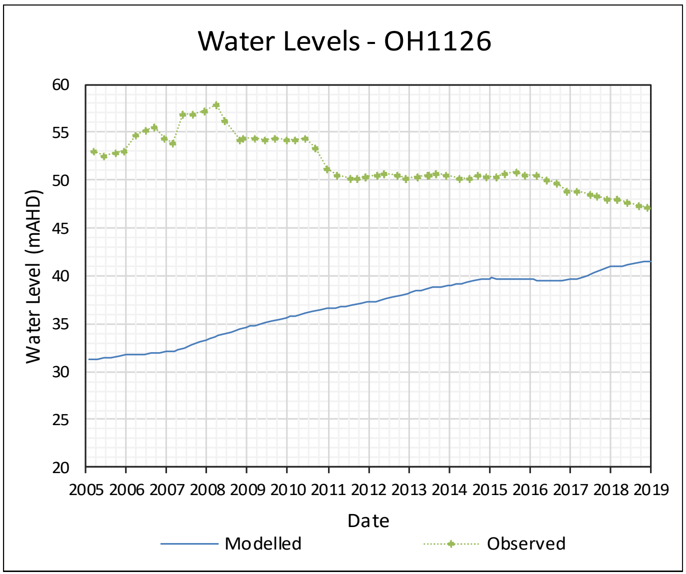

Water Levels - OH1124_2
Water Level (mAHD)
50
40
30
20
10
0
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

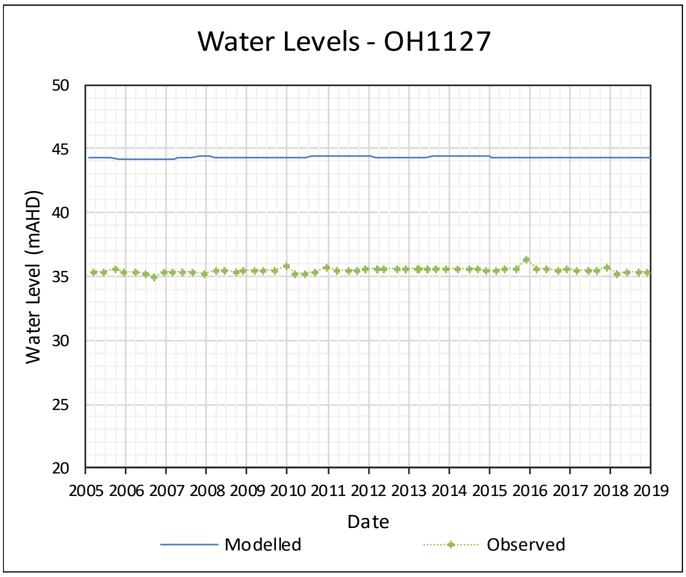

Water Levels - OH1124_3
Water Level (mAHD)
50
30
10
-10
-30
-50
-70
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

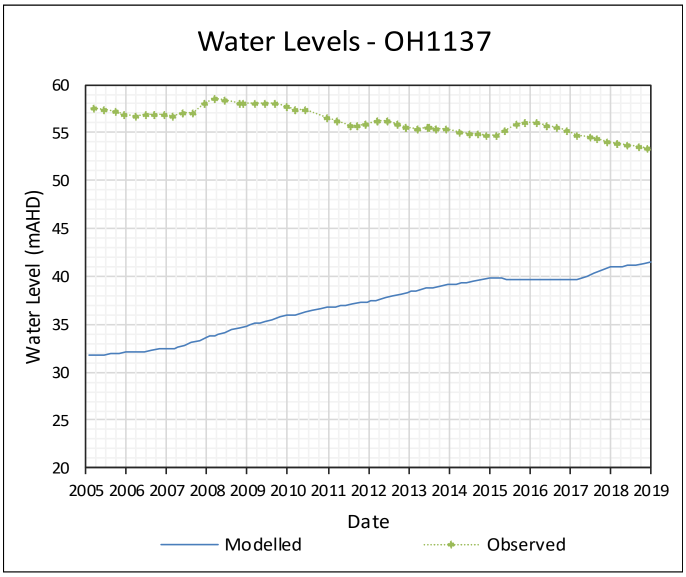

Water Levels - OH1125_1
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

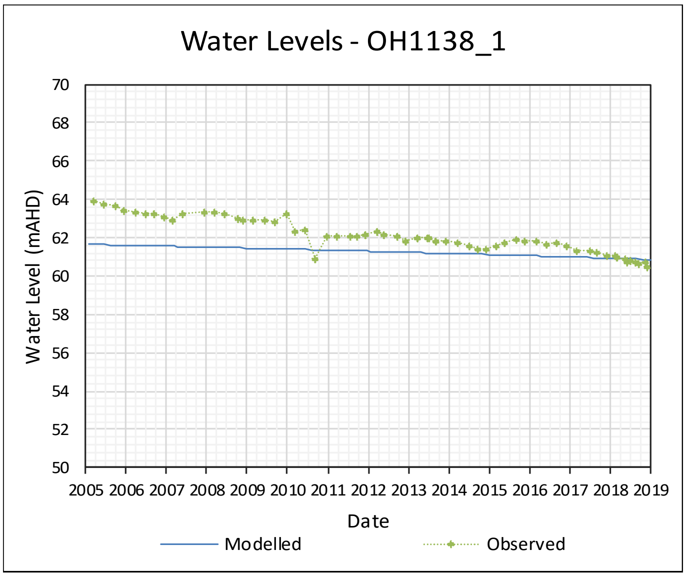

Water Levels - OH1125_2
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

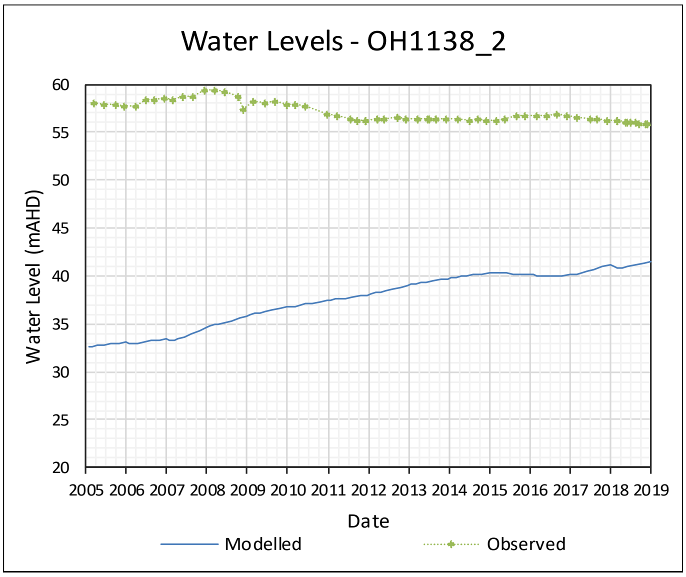

Water Levels - OH1125_3
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

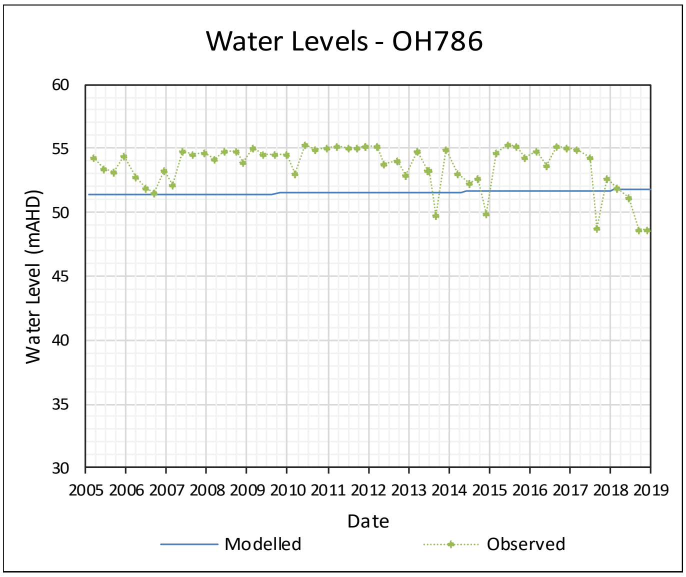

Water Levels - OH1126
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

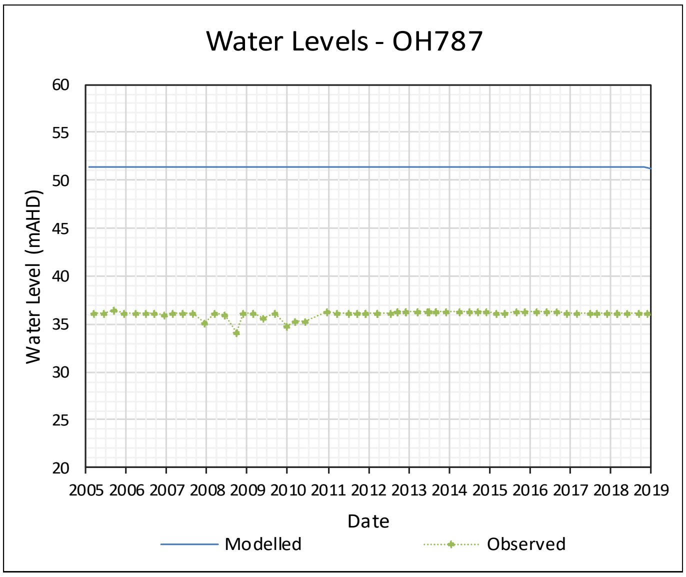

Water Levels - OH1127
Water Level (mAHD)
Date
Modelled
Observed

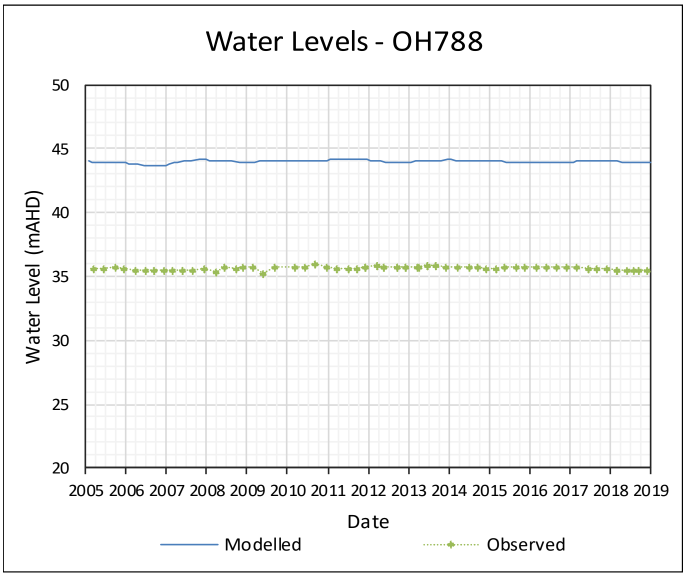

Water Levels - OH1137
Water Level (mAHD)
Date
Modelled
Observed

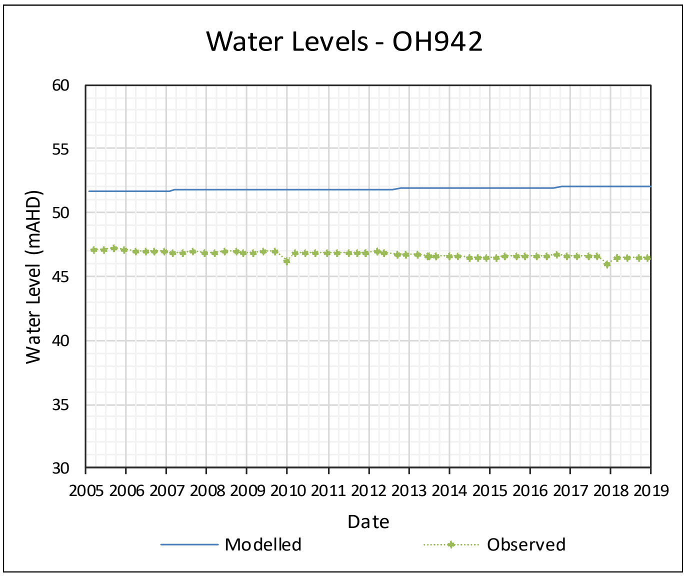

Water Levels - OH1138_1
Water Level (mAHD)
Date
Modelled
Observed

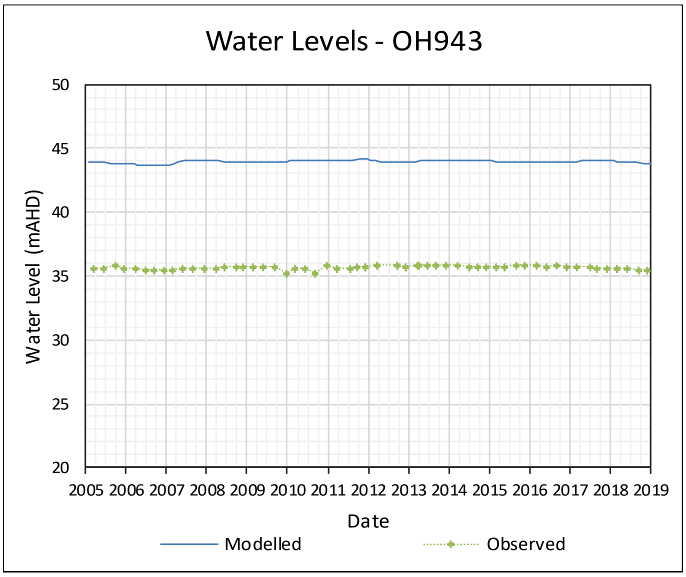

Water Levels - OH1138_2
Water Level (mAHD)
Date
Modelled
Observed

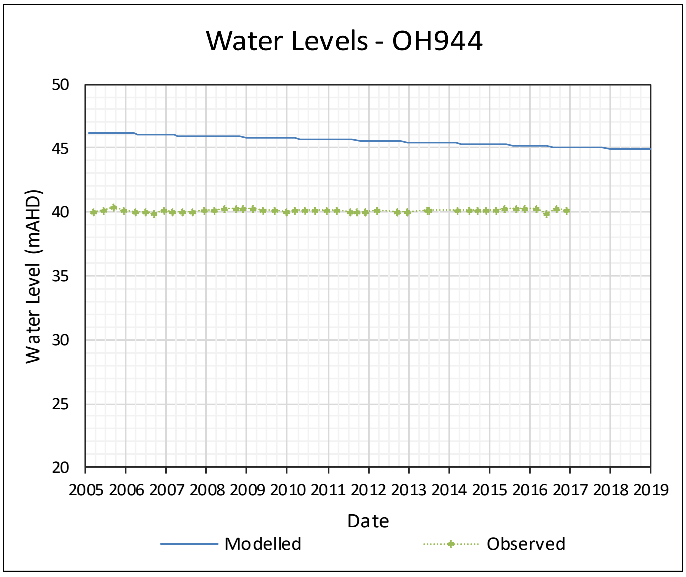

Water Levels - OH786
Water Level (mAHD)
Date
Modelled
Observed

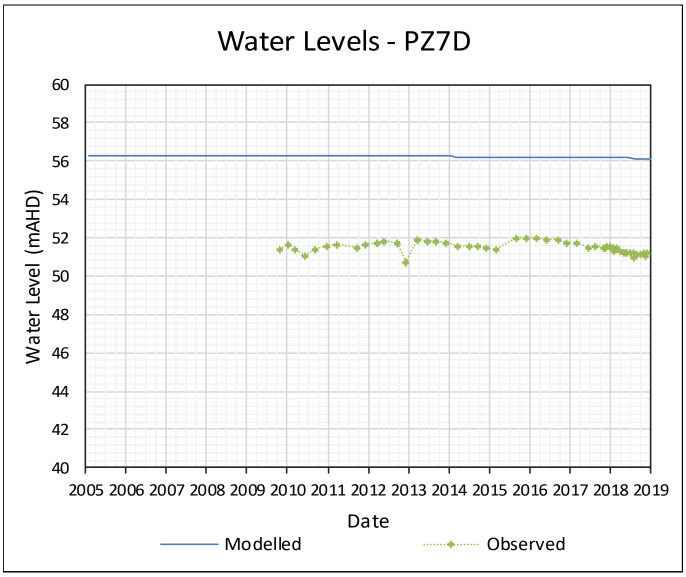

Water Levels - OH787
Water Level (mAHD)
Date
Modelled
Observed

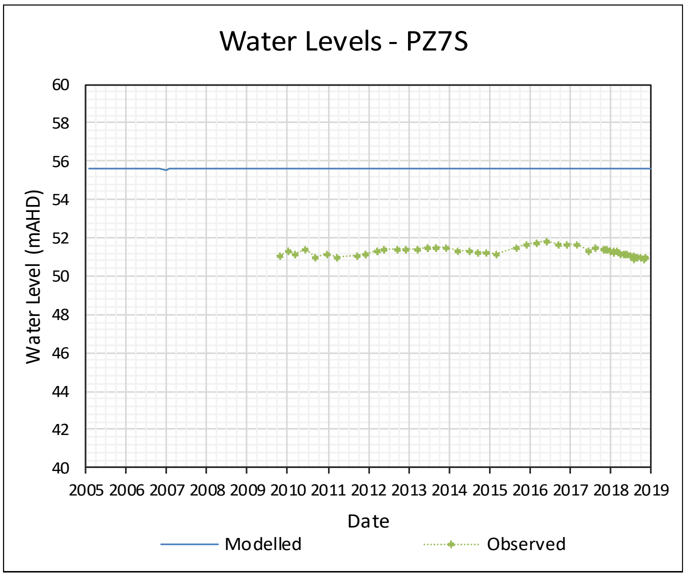

Water Levels - OH788
Water Level (mAHD)
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

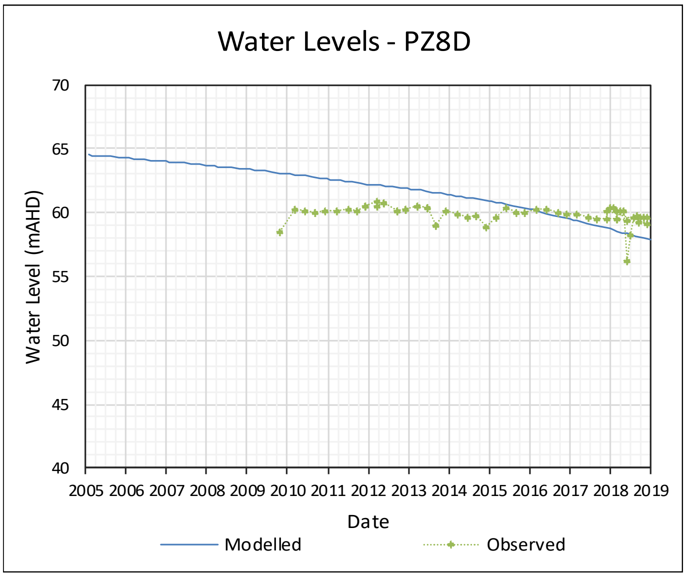

Water Levels - OH942
Water Level (mAHD)
60
55
50
45
40
35
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

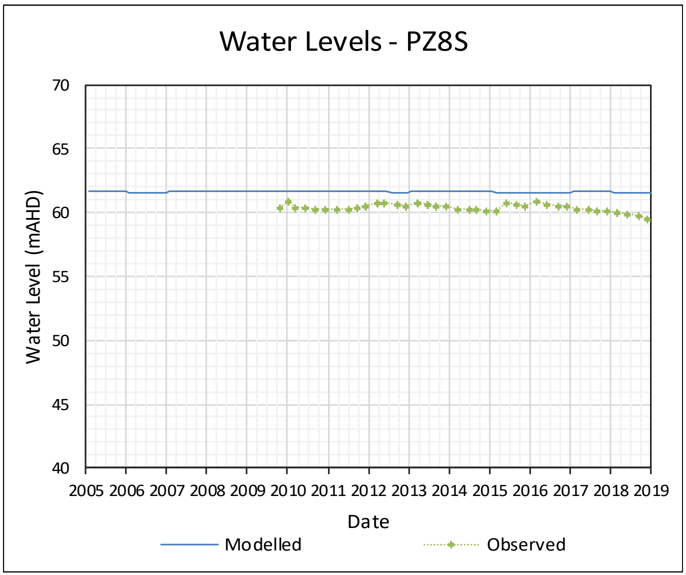

Water Levels - OH943
Water Level (mAHD)
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

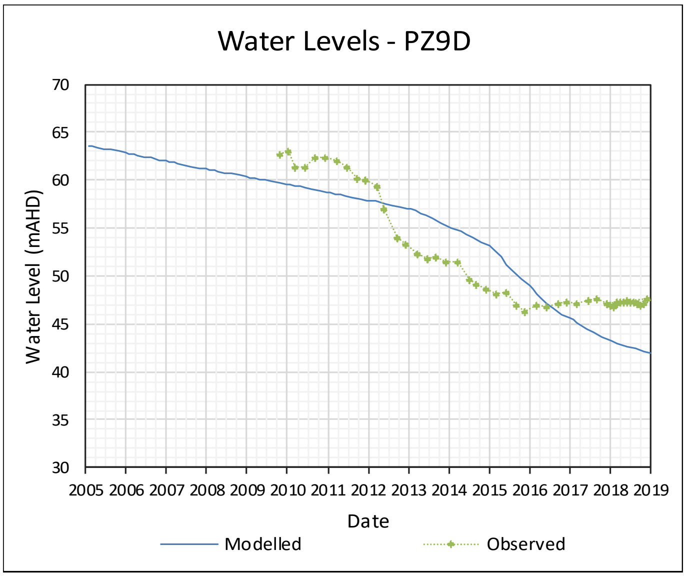

Water Levels - OH944
Water Level (mAHD)
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

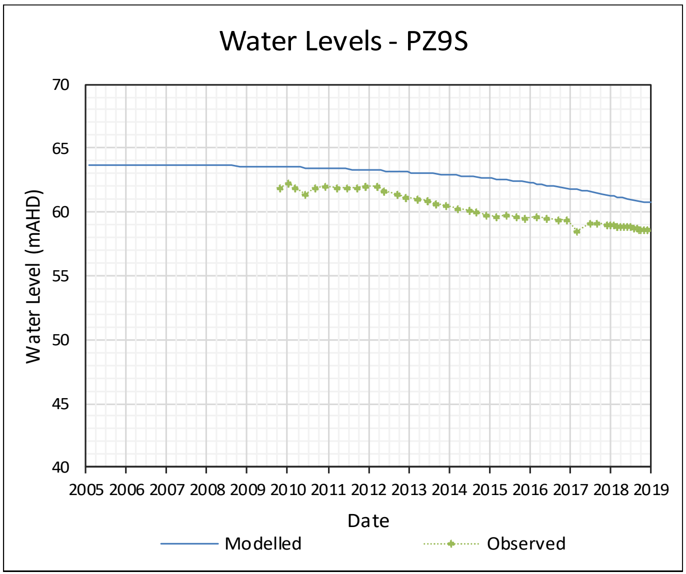

Water Levels - PZ7D
Water Level (mAHD)
60
58
56
54
52
50
48
46
44
42
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

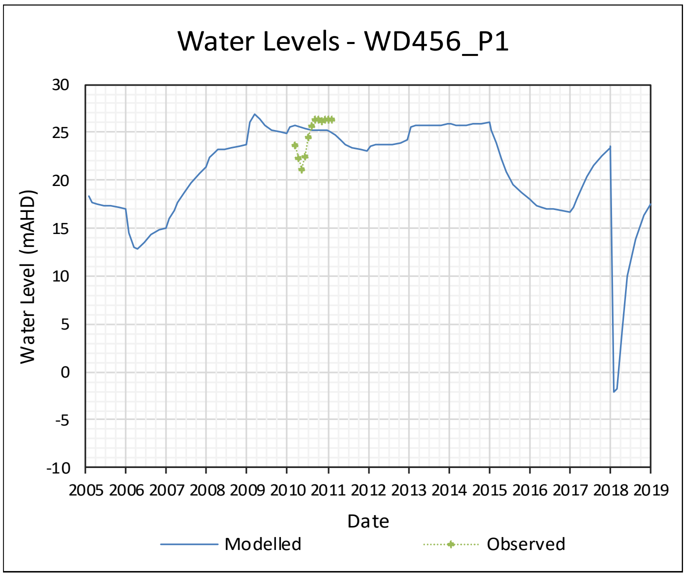

Water Levels - PZ7S
Water Level (mAHD)
60
58
56
54
52
50
48
46
44
42
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

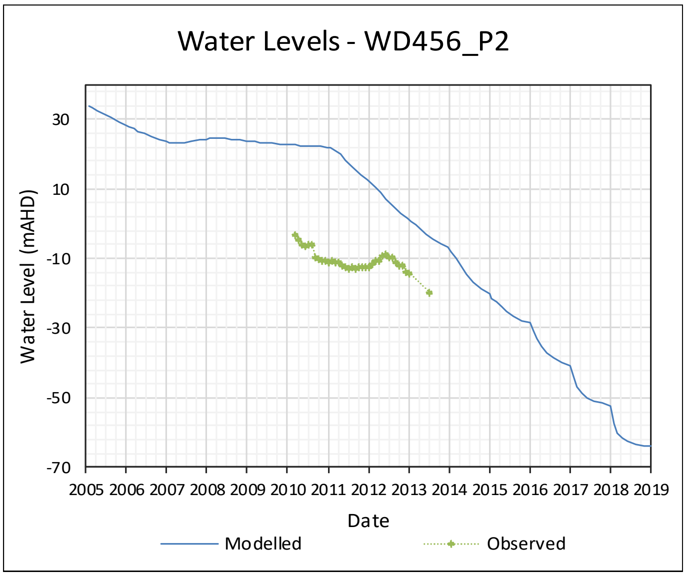

Water Levels - PZ8D
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

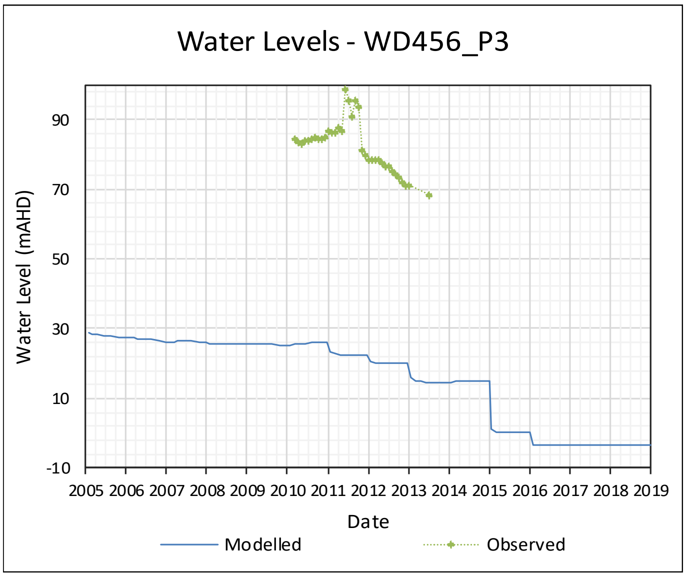

Water Levels - PZ8S
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

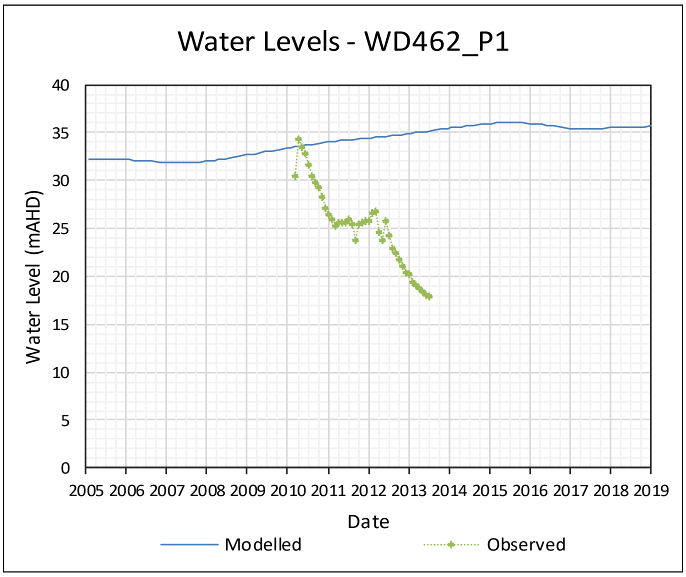

Water Levels - PZ9D
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

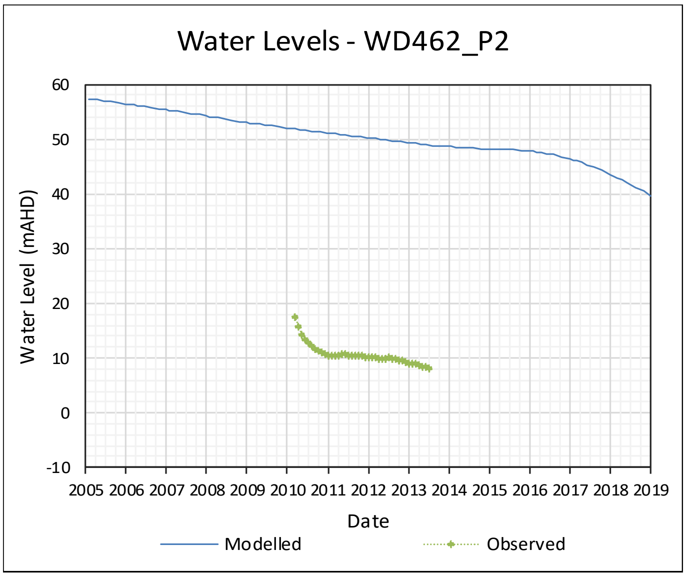

Water Levels - PZ9S
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

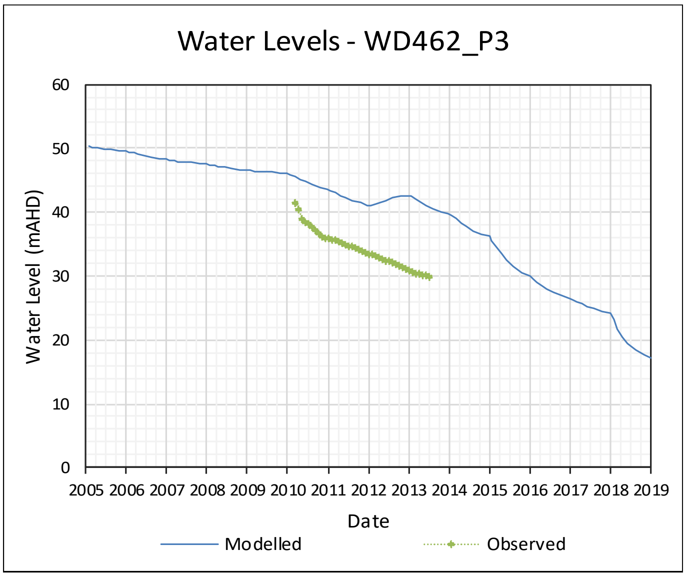

Water Levels - WD456_P1
Water Level (mAHD)
30
25
20
15
10
5
0
-5
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

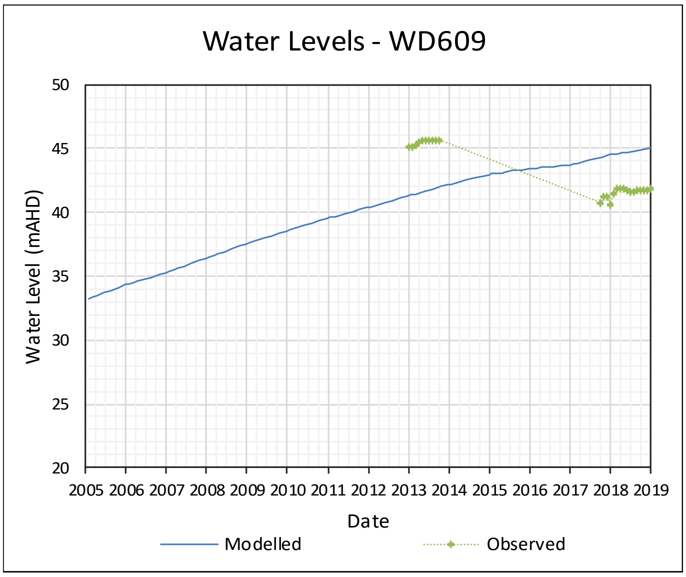

Water Levels - WD456_P2
Water Level (mAHD)
30
10
-10
-30
-50
-70
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

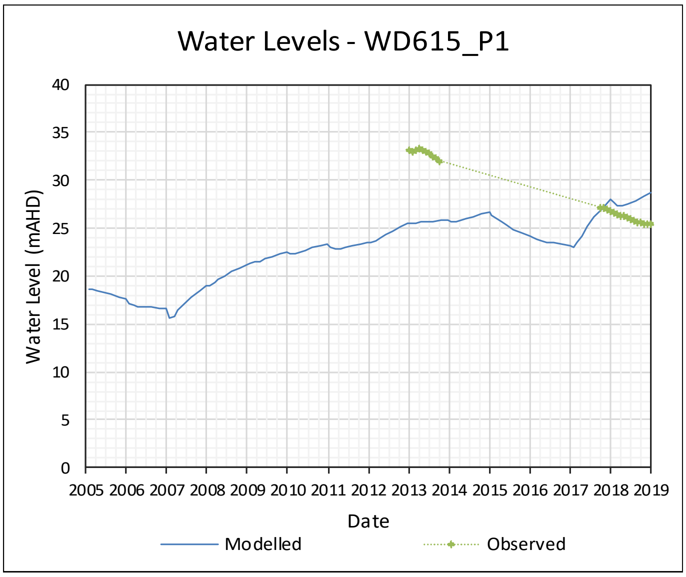

Water Levels - WD456_P3
Water Level (mAHD)
90
70
50
30
10
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

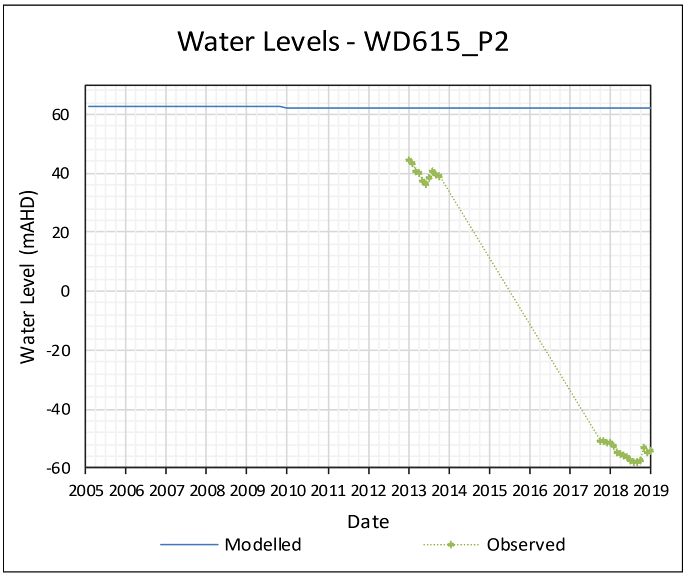

Water Levels - WD462_P1
Water Level (mAHD)
40
35
30
25
20
15
10
5
0
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed


Water Levels - WD462_P2
Water Level (mAHD)
60
50
40
30
20
10
0
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

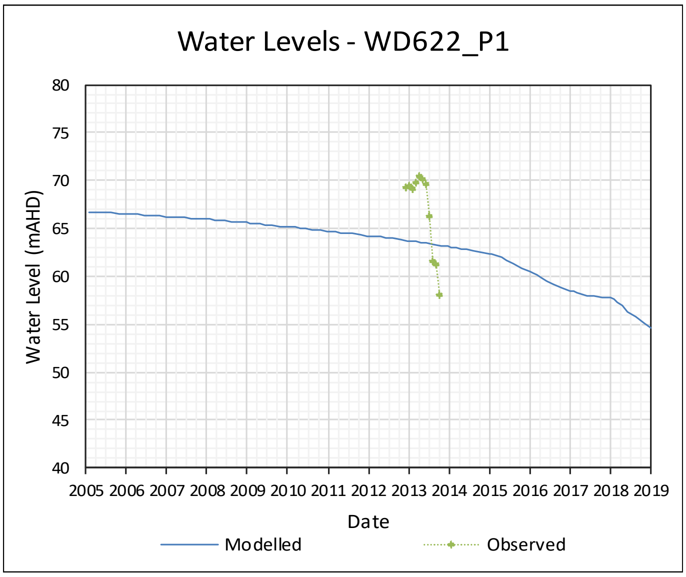

Water Levels - WD462_P3
Water Level (mAHD)
60
50
40
30
20
10
0
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed


Water Levels - WD609
Water Level (mAHD)
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

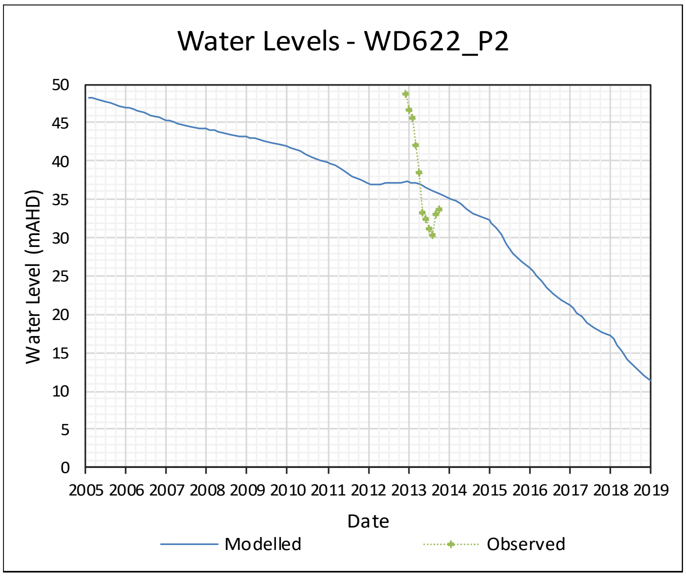

Water Levels - WD615_P1
Water Level (mAHD)
40
35
30
25
20
15
10
5
0
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



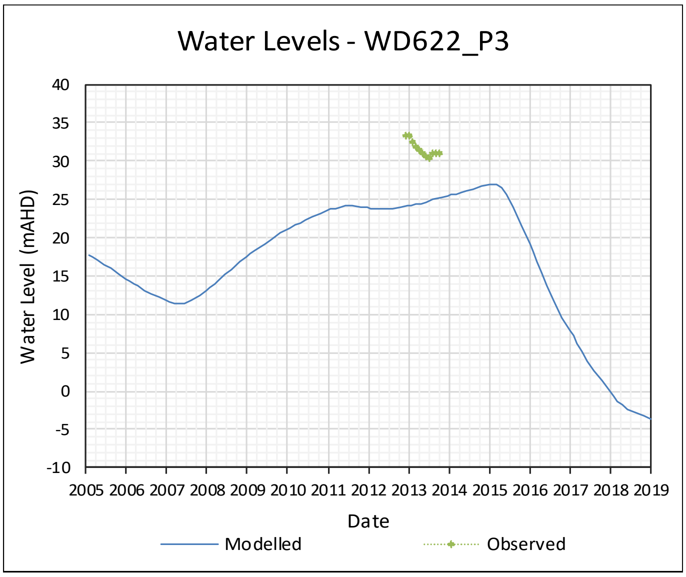
Water Levels - WD615_P2
Water Level (mAHD)
60
40
20
0
-20
-40
-60
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



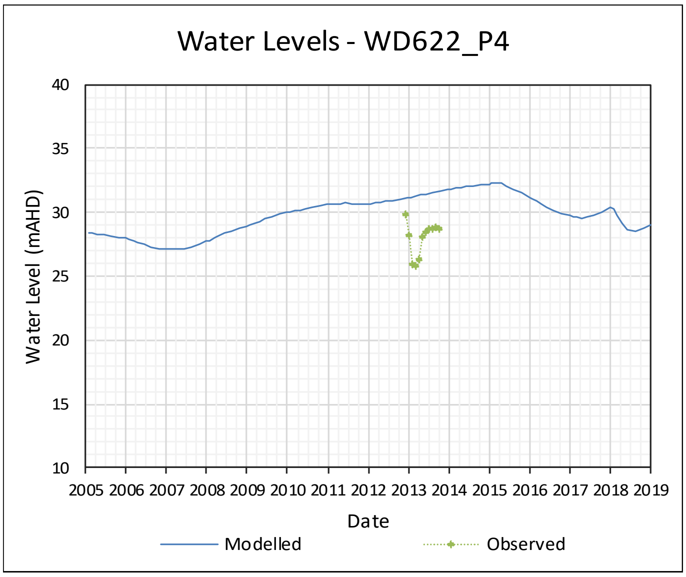
Water Levels - WD622_P1
Water Level (mAHD)
80
75
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



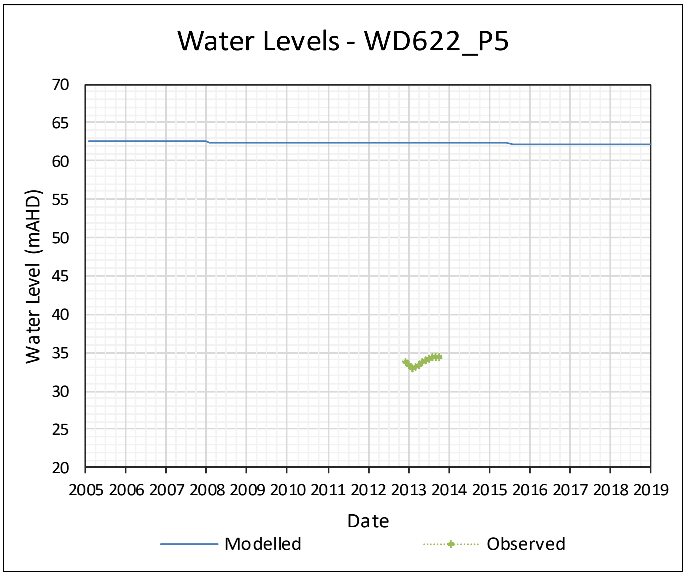
Water Levels - WD622_P2
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
5
0
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



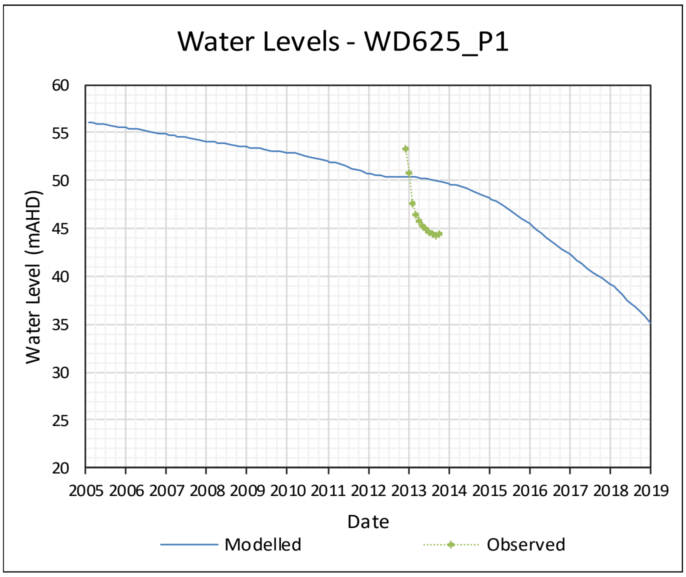
Water Levels - WD622_P3
Water Level (mAHD)
40
35
30
25
20
15
10
5
0
-5
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



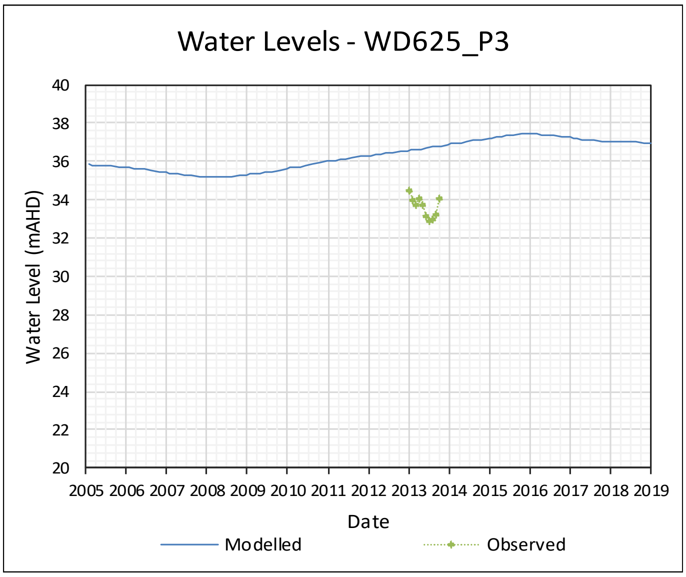
Water Levels - WD622_P4
Water Level (mAHD)
40
35
30
25
20
15
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



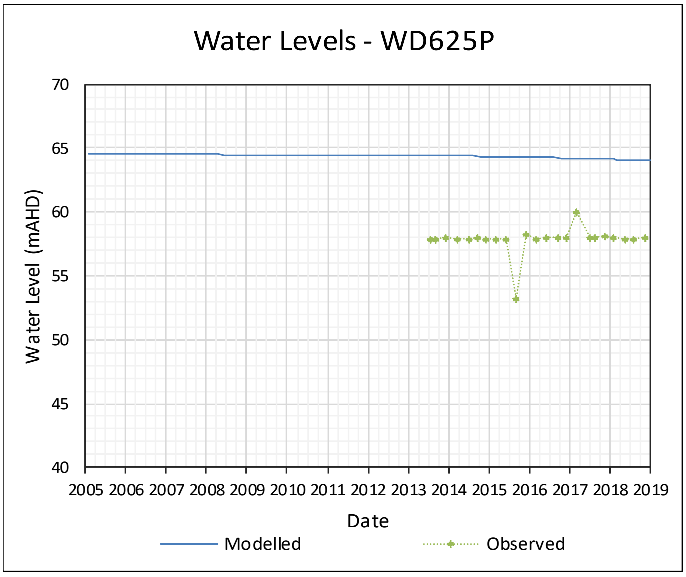
Water Levels - WD622_P5
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



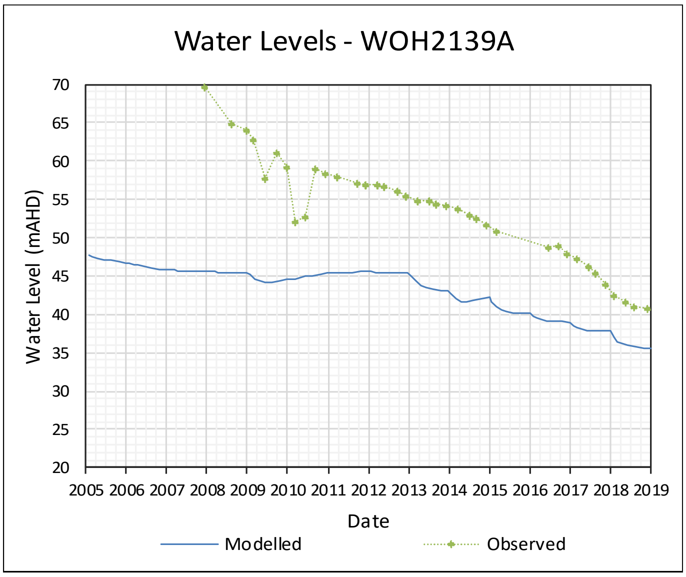
Water Levels - WD625_P1
Water Level (mAHD)
Date
Modelled
Observed



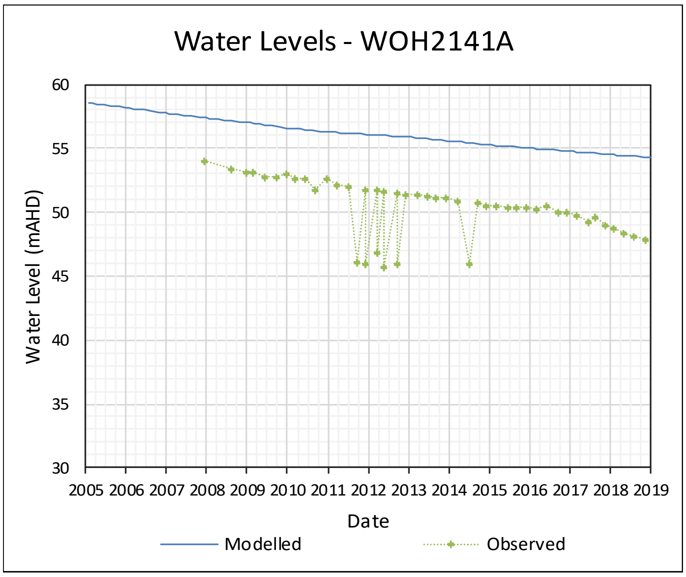
Water Levels - WD625_P3
Water Level (mAHD)
Date
Modelled
Observed



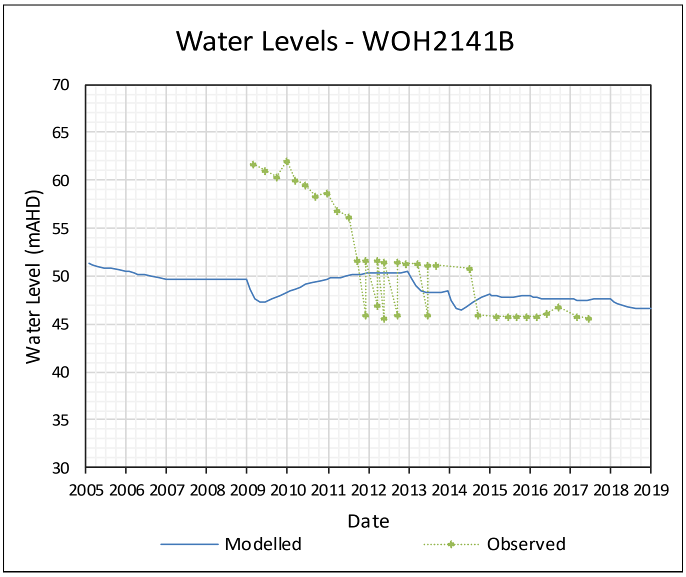
Water Levels - WD625P
Water Level (mAHD)
Date
Modelled
Observed



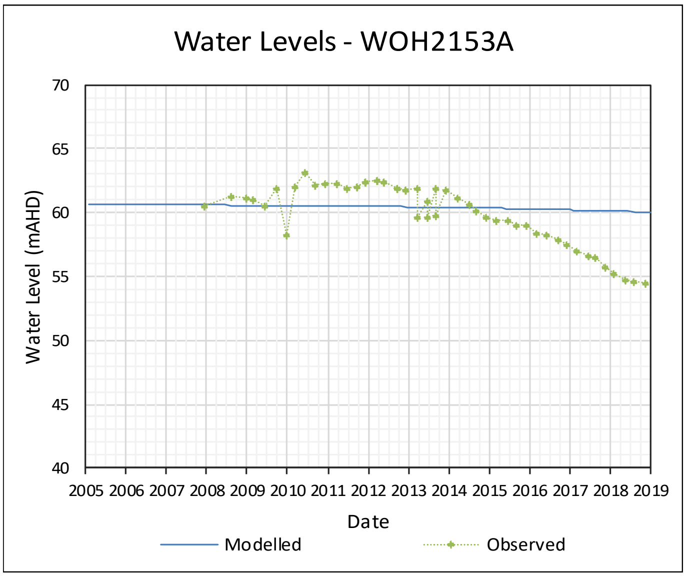
Water Levels - WOH2139A
Water Level (mAHD)
Date
Modelled
Observed

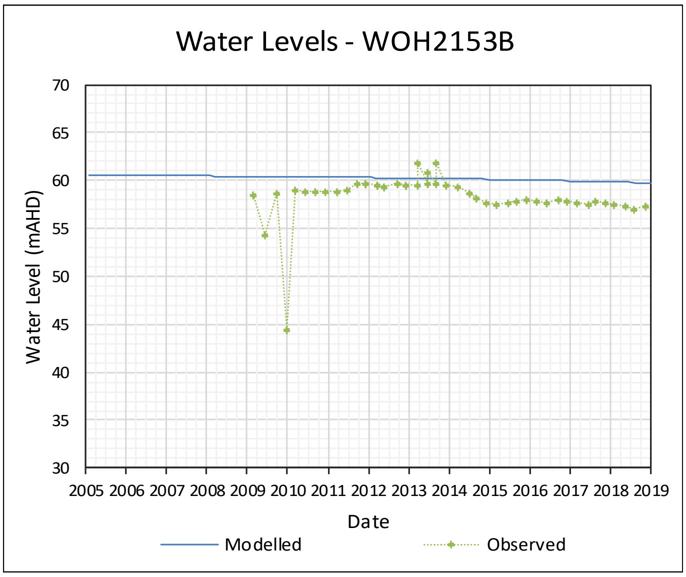


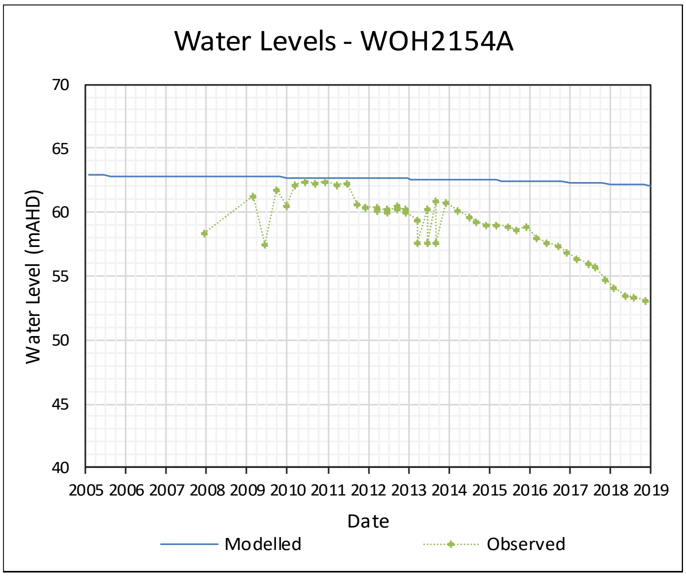
Water Levels - WOH2141A
Water Level (mAHD)
Date
Modelled
Observed

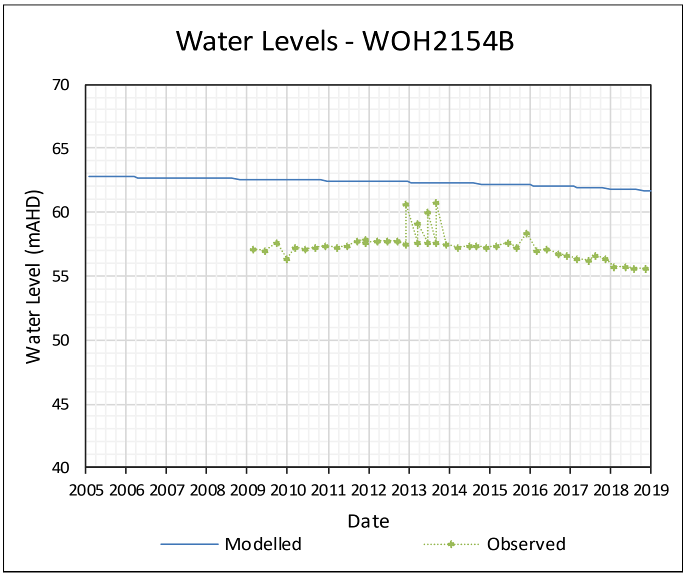


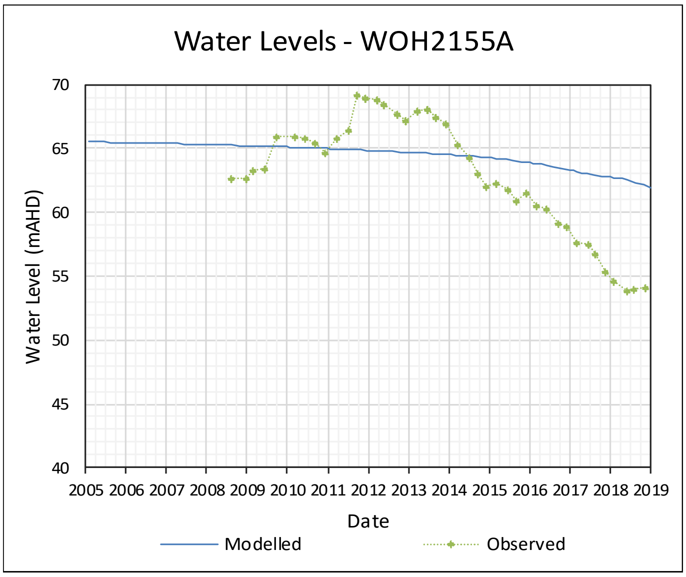
Water Levels - WOH2141B
Water Level (mAHD)
Date
Modelled
Observed

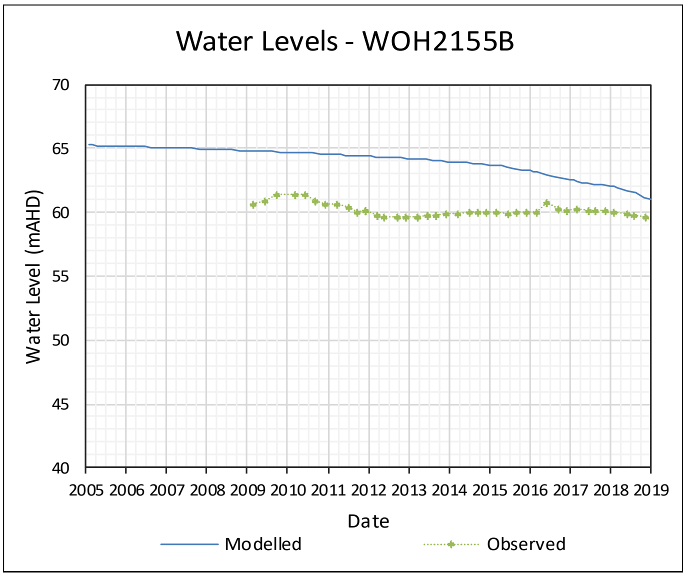

Water Levels - WOH2153A
Water Level (mAHD)
Date
Modelled
Observed

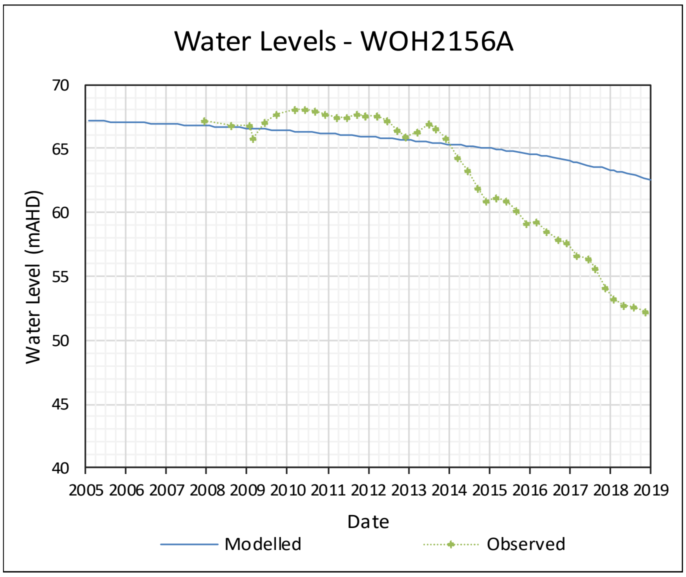

Water Levels - WOH2153B
Water Level (mAHD)
Date
Modelled
Observed


Water Levels - WOH2154A
Water Level (mAHD)
Date
Modelled
Observed

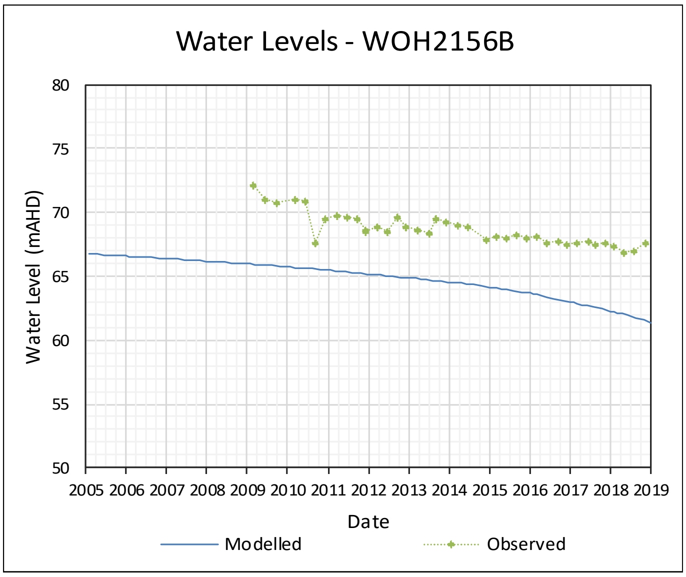

Water Levels - WOH2154B
Water Level (mAHD)
Date
Modelled
Observed


Water Levels - WOH2155A
Water Level (mAHD)
Date
Modelled
Observed


Water Levels - WOH2155B
Water Level (mAHD)
Date
Modelled
Observed



Water Levels - WOH2156A
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed



Water Levels - WOH2156B
Water Level (mAHD)
80
75
70
65
60
55
50
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date
Modelled
Observed

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Appendix 7:

IEA Action Status Table

Audit Action Plan Status from MTW IEA 2017 (Rev C)

Reference	Non Compliance / MTW Response	Action Status Update	Target Date for Completion
SSD6464 Sch. 3, C24(a) WMP 7.4.3.1	On the 6th January 2016, a sediment dam overtopped resulting in an uncontrolled discharge. **Response/Action Description** 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.	N/A
SSD 6464 Sch.3 C.27(b)(ii) SSD 6465 Sch.3 C.25(b)(ii)	The Surface Water Management Plan does not include detailed performance indicators of management objectives for Final Voids **Response/Action Description** MTW to update the WMP to include further detail on the performance objectives and management objectives for Final Voids, as indicated in the development consents and the EIS commitments.	Complete. The MTW Mining Operations Plan includes detailed plans and rehabilitation objectives for the site, including for final voids. To address this item, a link to the Mining Operations Plan was included in an update to the Water Management Plan approved by DP&E on 20 September 2018	30/7/2019 (or at next WMP triggered update, whichever is sooner)

Reference	Non Compliance / MTW Response	Action Status Update	Target Date for Completion
MT EIS 2.4.4 (iii)	No ongoing characterisation of overburden materials was conducted. **Response/Action Description** Extensive geochemical testing of overburden has been carried out across MTW with results showing very low risk of Acid Rock Drainage (ARD) in the overburden material being mined at MTW. The results of sampling conducted to date will be presented to DP&E to justify why ongoing characterisation of overburden materials across MTW is not required.	Complete. Presentation made to DP&E Compliance Team on 09/10/2018 to present results of overburden and interburden ARD assessments and testing conducted at MTW to illustrate why ongoing characterisation of overburden materials across MTW is not required. No further action required.	N/A
AHMP 9	There was no written or electronic record of which personnel had completed site specific environmental training for Cultural Heritage. **Response/Action Description** MTW to ensure that the AHMP and the MTW induction will cover all specific Cultural Heritage awareness requirements and that suitable training records are maintained	Complete. MTW induction has been updated and now covers all specific Cultural Heritage awareness requirements as prescribed by the AHMP. Training records are maintained by H&S Department.	N/A
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. **Response/Action Description** 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.	N/A

Reference	Non Compliance / MTW Response	Action Status Update	Target Date for Completion
BMP 5.2.2	Blasting Controls Training was not documented **Response/Action Description** MTW to review process for documenting training records for training required by BMP to ensure that suitable training records are maintained.	In Progress. Action item is included on MTW's action tracking system.	18/06/2019
NMP 6.2	There was no substantive evidence of car-pooling encouragement programs at the time of the audit. **Response/Action Description** 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.	Complete.	N/A

Reference	Non Compliance / MTW Response	Action Status Update	Target Date for Completion
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. **Response/Action Description** 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 issued by DPI Water are to be reviewed; 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 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.	Complete. At this point in time there are no mandatory or discretionary conditions on the works approval 20MW065009 for licenses WAL 40464 or WAL 40465 as advised by the Natural Resource Access Regulator (NRAR) during phone conversation 23/9/2018. NRAR has advised the only WAL with license conditions at this time is WAL 18233.	N/A

Reference	Non Compliance / MTW Response	Action Status Update	Target Date for Completion
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. **Response/Action Description** 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 issued by DPI Water are to be reviewed; to reflect that groundwater inflows to a pit excavation cannot be measured using a flow meter.	Complete. At this point in time there are no mandatory or discretionary conditions on the works approval 20MW065009 for licenses WAL 40464 or WAL 40465 as advised by the Natural Resource Access Regulator (NRAR) during phone conversation 23/9/2018. NRAR has advised the only WAL with license conditions at this time is WAL 18233.	N/A
Recommendations			
1.	Complete the Salvage report for salvage work conducted in 2016. **Response/Action Description** A final report will be compiled to bring together the results and completed compliance actions relating to the MTW 2016 ACH salvage	Complete. 2016 Compliance and Salvage Report (19 CH sites within the Stage 1 AHMP area) updated and finalised on 21/8/18.	N/A

Reference	Non Compliance / MTW Response	Action Status Update	Target Date for Completion
2.	MTW will determine 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). **Response/Action Description** Determine 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).	Complete. A review of the 2016 flood mapping by WBM BMT for Singleton Council indicates that the PMF flood level around the salt pan creek (tributary of Wollombi Brook) is approx 70.0m AHD. A review of MTW survey data indicates that the Charlton levee crest is maintained above RL 70.5 or higher throughout the levee length as at 17/10/2018.	N/A
3.	All training required by the SSD 6464 and 6465 approvals or as required by the Management Plans required by the approvals should be documented. **Response/Action Description** Review process for documenting training records for training required by approvals, Implement process for documenting these training records as required.	In Progress. Action item is included on MTW's action tracking system.	18/06/2019