Appendix 3:

Annual Stream Health and Stability Report

2019 STREAM HEALTH AND STABILITY REPORT

Mount Thorley Warkworth

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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.

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) was 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 was subsequently engaged to undertake the 2018 and 2019 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 2017 and 2018 reports for better understanding.

MTW advise there have been nil discharge events from the MTW discharge point between the 2018 stream health monitoring event and the 2019 monitoring event. There has been 283 mm of rainfall recorded within the on-site rainfall gauge for the period November 2018 to October 2019. In comparison, the Bureau of Meteorology shows an average of 502 mm at Singleton (Singleton STP 61397) for the same period. 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.
60-69	Potentially Stabilising	Drainage line is potentially stabilising. Ongoing monitoring is required while rehabilitation works are not needed in the immediate future.

Activity Rating (%)	Classification	Discussion of Classification
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.

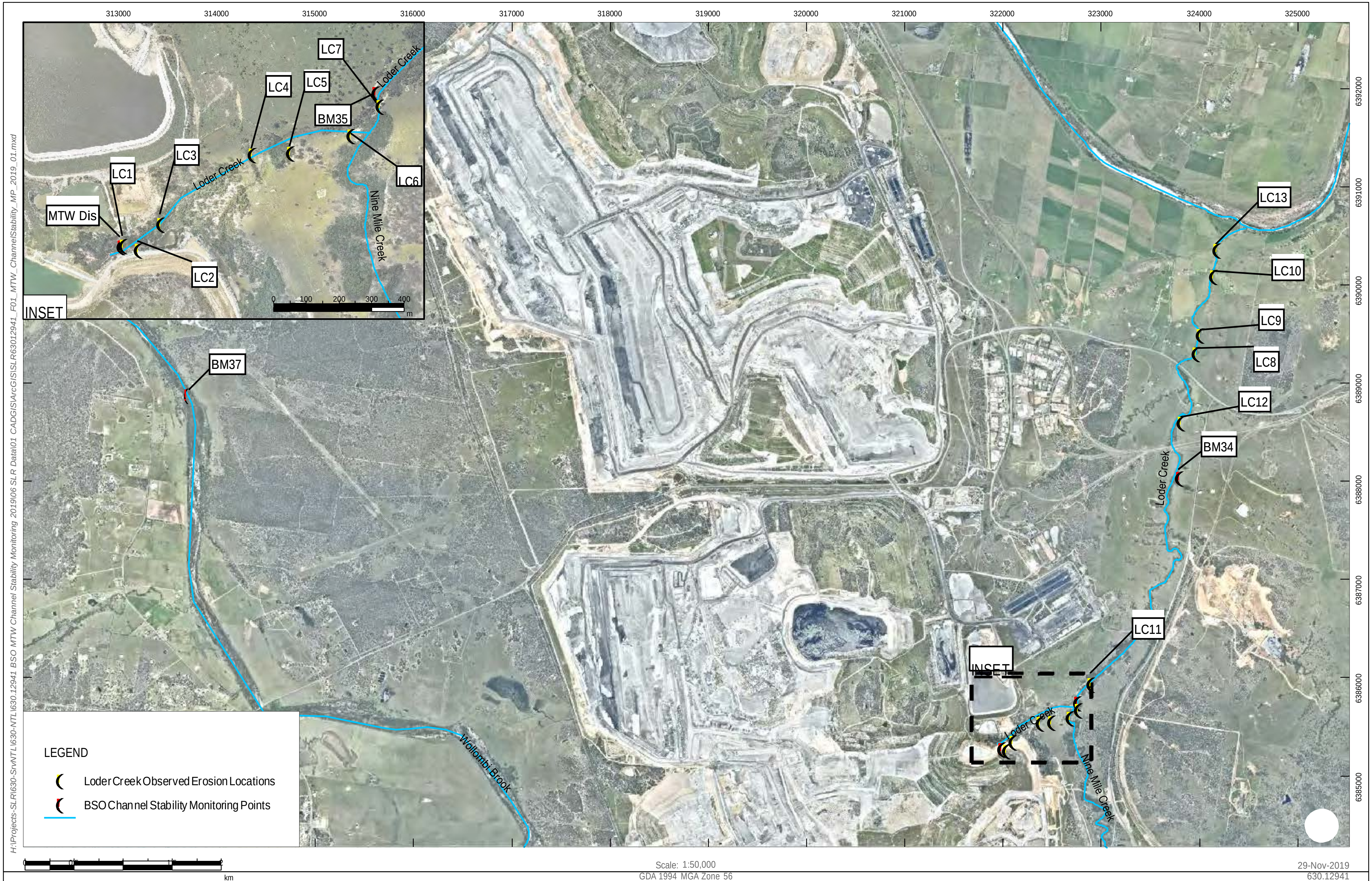
The transect assessment is undertaken by extending a tape measure laterally across the drainage line to two permanently fixed posts which are located within the riparian zone. A survey staff is then used to measure the vertical distance between the tape and the ground surface at approximately 0.5 m increments 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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630.12941

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MTW Channel Stability Monitoring Points - 2019

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 scattered eucalypts with Bull Oak (*Allocasuarina luehmannii*) and Swamp Oak (*Casuarina glauca*) dominating the canopy. The understorey is sparse consisting mainly of Acacia shrubs scattered on the bank. Very little groundcover was observed with most areas consisting of bare earth especially around jute mesh. It should be noted there is very little diversity in either canopy or groundcover species. 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 construction works have occurred. Exotic grass and bare soil (mine workings and vehicle tracks) surround riparian vegetation. Debris such as leaf litter and small numbers of fallen logs are evident. 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 hasn't changed significantly since the previous monitoring cycle. 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. Difference in the data appears to be within the expected transect accuracy tolerances, and it is not possible to discern if there has been bed erosion across at transect location.

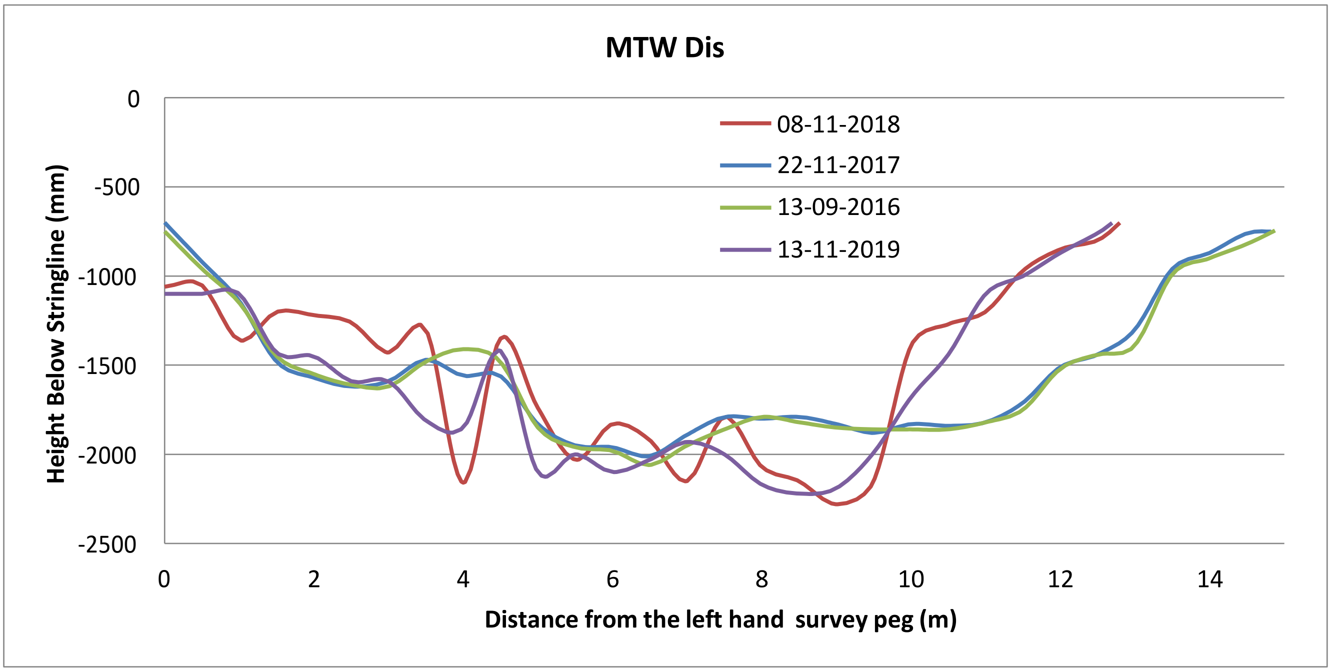

Figure 2 MTW Dis Transect Results

3.1.2 BM35 (322746 E 6385819 N)

The channel at this location was observed to have a good coverage of long grass 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. Overall, this location shows similar conditions to the previous monitoring cycle.

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 consisted of weeds 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 no significant scouring has occurred on the banks or creek bed since the previous monitoring cycles. Difference in the data appears to be within the expected transect accuracy tolerances.

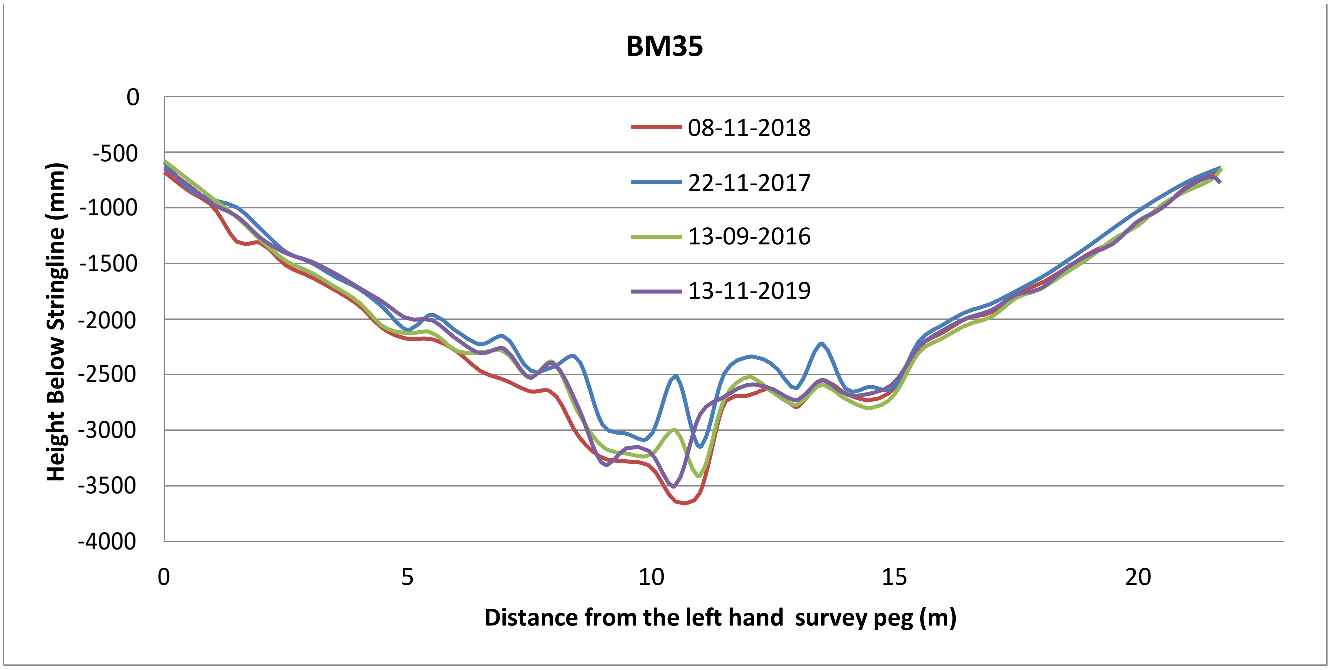

Figure 3 BM35 Transect Results

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.

The banks were characterised by dense Swamp Oak (*Casuarina glauca*), tall River Oak *(Casuarina cunninghamia)* with scattered eucalypts. The creek is congested with *Juncus spp* and *Phragmites australis.* The understory contained high levels of weed infestation. Lantana, Paddy's Lucerne and in particular African Boxthorn were abundant below the canopy particularly upstream of the monitoring point. It should be noted that there has been a slight increase in the density of African Boxthorn since the 2018 monitoring event. 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. Regenerating canopy tree (mostly *Casuarina glauca*) species were abundant. BM34 increased from the upper range of 'poor' to the lower range of 'average' due to an increase in canopy cover.

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 no significant scouring has occurred on the banks or creek bed since the previous monitoring cycles. Difference in the data appears to be within the expected transect accuracy tolerances at most locations. The data also suggests that across the bed and right hand bank it is likely that there has been erosion over the past 3 years.

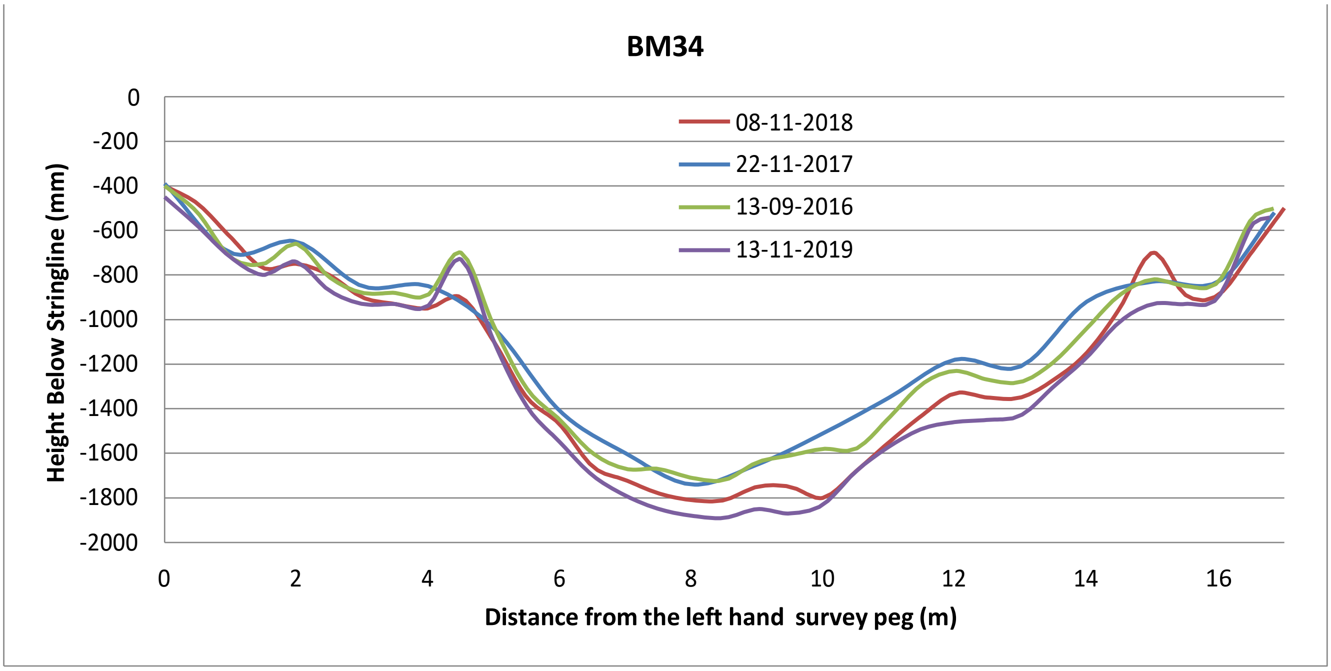

Figure 4 BM34 Transect Results

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. No significant change was noted.

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 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 Loders 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 2018 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

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Plate 26 Erosion

3.2.3 LC3 (322087 E 6385446 N)

This location is positioned at a small channel entry point to Loders 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 33.

Plate 31 Right Bank

Plate 32 Left Bank

Plate 33 Downstream

3.2.5 LC5 (322484 E 6385655 N)

LC5 is located in a historic diversion of Loders Creek. The erosion observed at LC5 included erosion extending up the right bank approximately 20-30m. The area has 0.5-1.0m high 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.

CSIRO Ephemeral Stream Assessment Classification – **Active**

Photos taken at the established photo points for this monitoring point are shown in Plates 34 to 37.

Plate 34 Right Bank

Plate 35 Upstream

Plate 36 Downstream

Plate 37 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 38 to 40.

Plate 38 Right Bank

Plate 39 Erosion

Plate 40 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 41 to 45.

Plate 41 Right Bank

Plate 42 Upstream

Plate 43 Downstream Plate 44 Left Bank

Plate 45 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 57. 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 46 to 49.

SLR

Plate 46 Right Bank

Plate 47 Upstream

Plate 48 Downstream

Plate 49 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 50 to 53.

Plate 50 Right Bank

Plate 51 Upstream

Plate 52 Downstream

Plate 53 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 exposed some tree roots of some of the trees that line the creek bank. The creek has steep slopes on both banks (approximately 4m 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.

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

Photos taken at the established photo points for this monitoring point are shown in Plates 54 to 57.


Plate 54 Right Bank

Plate 55 Upstream


Plate 56 Downstream

Plate 57 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 58 to 61.

Plate 58 Upstream

Plate 59 Downstream

Plate 60 Erosion

Plate 61 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 – **Potentially Stabilising**

Photos taken at the established photo points for this monitoring point are shown in Plates 62 to 65.

Plate 62 Right Bank

Plate 63 Upstream

Plate 64 Downstream

Plate 65 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 66 to 69.

Plate 66 Right Bank

Plate 67 Upstream

Plate 68 Downstream

Plate 69 Left Bank

4 Summary of Results

Monitoring Site	RARC Stream Heath Assessment Classification			CSIRO Ephemeral Stream Asses Classification			
	2017	2018	2019	2017	2018		
MTW Dis	Poor	Poor	Poor	Active	Potentially Stabilising	Potentially ilising	Lateral Inflows
BM35	Poor	Poor	Poor	Active	Active		
BM34	Poor	Poor	Average	Very Stable	Stable		
BM37	Average	Poor	Poor	Stable	Stable	Potentially Stabilising	NA
LC1	NA	NA	NA	Active	Stable		
LC2	NA	NA	NA	Active	Active		
LC3	NA	NA	NA	Very Active	Very Active	ery Active	Upstream Flows
LC4	NA	NA	NA	Potentially Stabilising	Potentially Stabilising	Potentially ilising	Unstable Wall Materials
LC5	NA	NA	NA	Potentially Stabilising	Active		
LC6	NA	NA	NA	Active	Active		
LC7	NA	NA	NA	Active	Active		

Monitoring Site	RARC Stream Heath Assessment Classification			CSIRO Ephemeral Stream Assessment Classification			Primary Cause of Erosion
	2017	2018	2019	2017	2018	2019	
LC8	NA	NA	NA	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Upstream Flows
LC9	NA	NA	NA	Potentially Stabilising	Potentially Stabilising	Potentially Stabilising	Unstable Wall Materials
LC10	NA	NA	NA	Potentially Stabilising	Active	Potentially Stabilising	Upstream Flows
LC11	NA	NA	NA	Active	Active	Active	Wombat Activity, Contour Bank Overflows
LC12	NA	NA	NA	Active	Active	Potentially Stabilising	Fallen Tree
LC13	NA	NA	NA	Active	Active	Active	Livestock Tracks

5 Conclusion and Recommendations

MTW advise there have been nil discharge events from the MTW discharge point between the 2018 stream health monitoring event and the 2019 monitoring event. There has been 283 mm of rainfall recorded within the on-site rainfall gauge for the period November 2018 to October 2019. In comparison, the Bureau of Meteorology shows an average of 502 mm at Singleton (Singleton STP 61397) for the same period. 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 2018 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. Improvements were also identified during the 2019 survey, resulting from both natural occurrences as well as man-made upgrade works.

In one instance, the CSIRO rating has downgraded from what was observed during the 2018 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 and average. It should be noted that BM34 situated on Loder Creek increased from the upper range of 'poor' to the lower range of 'average' due to an increase in canopy cover. The single monitoring point on Wollombi Brook was classed as poor with little change observed since monitoring in 2018.

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.

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:	13/11/2019	**Observer:** SM	**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	1	1	2	1	3
2	2	2	0	0	2	1	3
3	2	2	1	1	2	1	3
4	2	2	1	1	2	1	3
Average	2.25	2.25	0.75	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	3	3	0	0	1
2	3	3	1	0	1
3	3	3	0	0	0
4	3	3	0	0	0
Average	3	3	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	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:	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	0.75	0.75	2	1	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	3	3	0.25	0	0.5

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
	6.5	8	4	6.75	4	29.25

Rapid Appraisal of Riparian Condition

Site Number: BM34

Site:	Loaders Creek			**GPS start:**	see figure
Date:	14-11-2019	**Observer:**	SM	**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	3	3	2	0	3	2	3
2	2	2	2	0	3	2	3
3	3	3	2	0	3	2	3
4	3	3	2	0	3	2	3
Average	2.75	2.75	2	0	3	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	0	0	0
2	1	1	0	0	0
3	1	1	0	0	0
4	1	1	0	0	0
Average	1	1	0	0	0

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	1	1	2
2	1	1	1	2
3	1	1	1	2
4	1	1	1	2
Average	1	1	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	2.75	2.5	2	0	3	2	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	1	1	0	0	0

Features

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

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	Total
(out of)	11	12	9	10	8	50
	8.5	10.75	4.5	2	5	30.75

Rapid Appraisal of Riparian Condition

Site Number: BM35

Site:	Loaders Creek			**GPS start:**	See figure
Date:	13-11-2019	**Observer:**	SM	**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	0	2	0	3
2	2	2	2	0	2	0	3
3	3	3	2	0	2	0	3
4	3	3	2	0	1	0	3
Average	2.5	2.5	2	0	1.75	0	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	3	3	0	0	1
2	3	3	0	0	1
3	3	3	0	0	0
4	3	3	0	0	1
Average	3	3	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	1	1	2
2	1	1	1	2
3	1	1	1	2
4	1	1	1	2
Average	1	1	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	0	2	0	3

Debris

	Leaf litter	Native leaf litter	Standing dead trees	Hollow-bearing trees	Fallen logs
Average	3	3	0	0	0

Features

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

TOTALS

Site:	Habitat	Cover	Natives	Debris	Features	**Total**
(out of)	11	12	9	10	8	50
	7	9.25	2.25	6	5	29.5

Rapid Appraisal of Riparian Condition

Site Number: BM37

Site:	Wollomi Brook			**GPS start:**	See figure
Date:	13/11/2019	**Observer:**	SM	**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	Nov-18	Nov-19
		Assessor	SLR	SLR
		Channel Characteristic	Rating	Rating
LC1	0m (At Survey Peg)	Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	3	3
		Shape of D/L Cross-Section	3	3
		Longitudinal Morphology	3	3
		Particle Size of Materials on Floor	1	1
		Nature of D/L Wall Materials	3	3
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	3	3
		Sum of Ratings	**23**	**23**
		Activity Rating	**72**	**72**
		Classification	**Stable**	**Stable**
LC2	0m (At Survey Peg)	Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	1	1
		Shape of D/L Cross-Section	2	2
		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	1	1
		Nature of D/L Wall Materials	1	1
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**18**	**18**
		Activity Rating	**56**	**56**
		Classification	**Active**	**Active**
LC3	0m (At Survey Peg)	Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	1	1
		Shape of D/L Cross-Section	2	1
		Longitudinal Morphology	2	1
		Particle Size of Materials on Floor	1	1
		Nature of D/L Wall Materials	1	1
		Nature and Shape of Bank Edge	3	3
		Nature of Lateral Flow Regulation	2	2
		Sum of Ratings	**15**	**13**
		Activity Rating	**47**	**41**
		Classification	**Very Active**	**Very Active**
LC4	0m (At Survey Peg)	Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	3	3
		Shape of D/L Cross-Section	3	2
		Longitudinal Morphology	3	3
		Particle Size of Materials on Floor	1	1
		Nature of D/L Wall Materials	1	1
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**22**	**21**
		Activity Rating	**69**	**66**
		Classification	**Potentially Stabilising**	**Potentially Stabilising**
LC5	0m (At Survey Peg)	Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	2	2
		Shape of D/L Cross-Section	2	2
		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	1	1
		Nature of D/L Wall Materials	2	2
		Nature and Shape of Bank Edge	3	3
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**19**	**19**
		Activity Rating	**59**	**59**
		Classification	**Active**	**Active**
LC6	0m (At Survey Peg)	Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	2	2
		Shape of D/L Cross-Section	2	2
		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	1	1
		Nature of D/L Wall Materials	1	1
		Nature and Shape of Bank Edge	3	3
		Nature of Lateral Flow Regulation	3	3
		Sum of Ratings	**17**	**17**
		Activity Rating	**53**	**53**
		Classification	**Active**	**Active**
LC7	0m (At Survey Peg)	Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	1	1
		Shape of D/L Cross-Section	2	2
		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	1	1
		Nature of D/L Wall Materials	2	2
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	2	2
		Sum of Ratings	**17**	**17**
		Activity Rating	**53**	**53**
		Classification	**Active**	**Active**
LC8	0m (At Survey Peg)	Vegetation on D/L Floor	2	2
		Vegetation on D/L Walls	1	1
		Shape of D/L Cross-Section	3	3
		Longitudinal Morphology	3	3
		Particle Size of Materials on Floor	1	1
		Nature of D/L Wall Materials	2	2
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**20**	**20**
		Activity Rating	**63**	**63**
		Classification	**Potentially Stabilising**	**Potentially Stabilising**
		Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	3	3
		Shape of D/L Cross-Section	3	3

		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	1	1
LC9	0m (At Survey Peg)	Nature of D/L Wall Materials	3	2
		Nature and Shape of Bank Edge	3	4
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**22**	**22**
		Activity Rating	**69**	**69**
		Classification	**Potentially Stabilising**	**Potentially Stabilising**
		Vegetation on D/L Floor	1	1
		Vegetation on D/L Walls	1	1
		Shape of D/L Cross-Section	2	2
		Longitudinal Morphology	2	1
		Particle Size of Materials on Floor	1	3
LC10	0m (At Survey Peg)	Nature of D/L Wall Materials	4	4
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**19**	**20**
		Activity Rating	**59**	**63**
		Classification	**Active**	**Potentially Stabilising**
		Vegetation on D/L Floor	3	2
		Vegetation on D/L Walls	1	2
		Shape of D/L Cross-Section	2	3
		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	1	1
LC11	0m (At Survey Peg)	Nature of D/L Wall Materials	1	2
		Nature and Shape of Bank Edge	3	3
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**17**	**19**
		Activity Rating	**53**	**59**
		Classification	**Active**	**Active**
		Vegetation on D/L Floor	2	2
		Vegetation on D/L Walls	2	2
		Shape of D/L Cross-Section	3	3
		Longitudinal Morphology	2	3
		Particle Size of Materials on Floor	1	1
LC12	0m (At Survey Peg)	Nature of D/L Wall Materials	2	2
		Nature and Shape of Bank Edge	3	3
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**19**	**20**
		Activity Rating	**59**	**63**
		Classification	**Active**	**Potentially Stabilising**
		Vegetation on D/L Floor	1	1
		Vegetation on D/L Walls	2	1
		Shape of D/L Cross-Section	3	2
		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	1	1
LC13	0m (At Survey Peg)	Nature of D/L Wall Materials	2	3
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**19**	**18**
		Activity Rating	**59**	**56**
		Classification	**Active**	**Active**
		Vegetation on D/L Floor	1	1
		Vegetation on D/L Walls	2	2
		Shape of D/L Cross-Section	3	3
		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	3	3
MTW Dis	0m (At Survey Peg)	Nature of D/L Wall Materials	3	3
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	2	2
		Sum of Ratings	**20**	**20**
		Activity Rating	**63**	**63**
		Classification	**Potentially Stabilising**	**Potentially Stabilising**
		Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	3	3
		Shape of D/L Cross-Section	5	5
		Longitudinal Morphology	3	3
		Particle Size of Materials on Floor	1	1
BM34	0m (At Survey Peg)	Nature of D/L Wall Materials	3	3
		Nature and Shape of Bank Edge	3	3
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**25**	**25**
		Activity Rating	**78**	**78**
		Classification	**Stable**	**Stable**
		Vegetation on D/L Floor	3	3
		Vegetation on D/L Walls	2	2
		Shape of D/L Cross-Section	2	2
		Longitudinal Morphology	2	2
		Particle Size of Materials on Floor	1	1
BM35	0m (At Survey Peg)	Nature of D/L Wall Materials	2	2
		Nature and Shape of Bank Edge	3	3
		Nature of Lateral Flow Regulation	3	3
		Sum of Ratings	**18**	**18**
		Activity Rating	**56**	**56**
		Classification	**Active**	**Active**
		Vegetation on D/L Floor	1	1
		Vegetation on D/L Walls	3	3
		Shape of D/L Cross-Section	4	4
		Longitudinal Morphology	3	3
		Particle Size of Materials on Floor	1	1
BM37	0m (At Survey Peg)	Nature of D/L Wall Materials	3	2
		Nature and Shape of Bank Edge	4	4
		Nature of Lateral Flow Regulation	4	4
		Sum of Ratings	**23**	**22**
		Activity Rating	**72**	**69**
		Classification	**Stable**	**Potentially Stabilising**

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Appendix 4:

Annual Ground Water Review Report

MOUNT THORLEY WARKWORTH ANNUAL GROUNDWATER REVIEW 2019

2019 Annual Groundwater Review

Prepared for:

Yancoal Mount Thorley Warkworth Australia
PO Box 267
SINGLETON NSW 2330

SLR Ref: 620.12289.40000-R05
Version No: -v2.0
March 2020

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Yancoal Mount Thorley Warkworth Australia (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
620.12289.40000-R05-v2.0	26 March 2020	Duncan Dawson	Claire Stephenson	Claire Stephenson
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1 Introduction

1.1 Overview

The Mount Thorley 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 (SSD 6464) Statement of Commitments; and
- Mt Thorley Mine in accordance with Condition 27 of Development Consent (SSD 6465)

MTW commissioned SLR Consulting Pty Ltd (SLR) to review the groundwater monitoring data for the 2019 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).
- Review of numerical groundwater model predictions and comparison to observed groundwater levels.
- 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 2019.

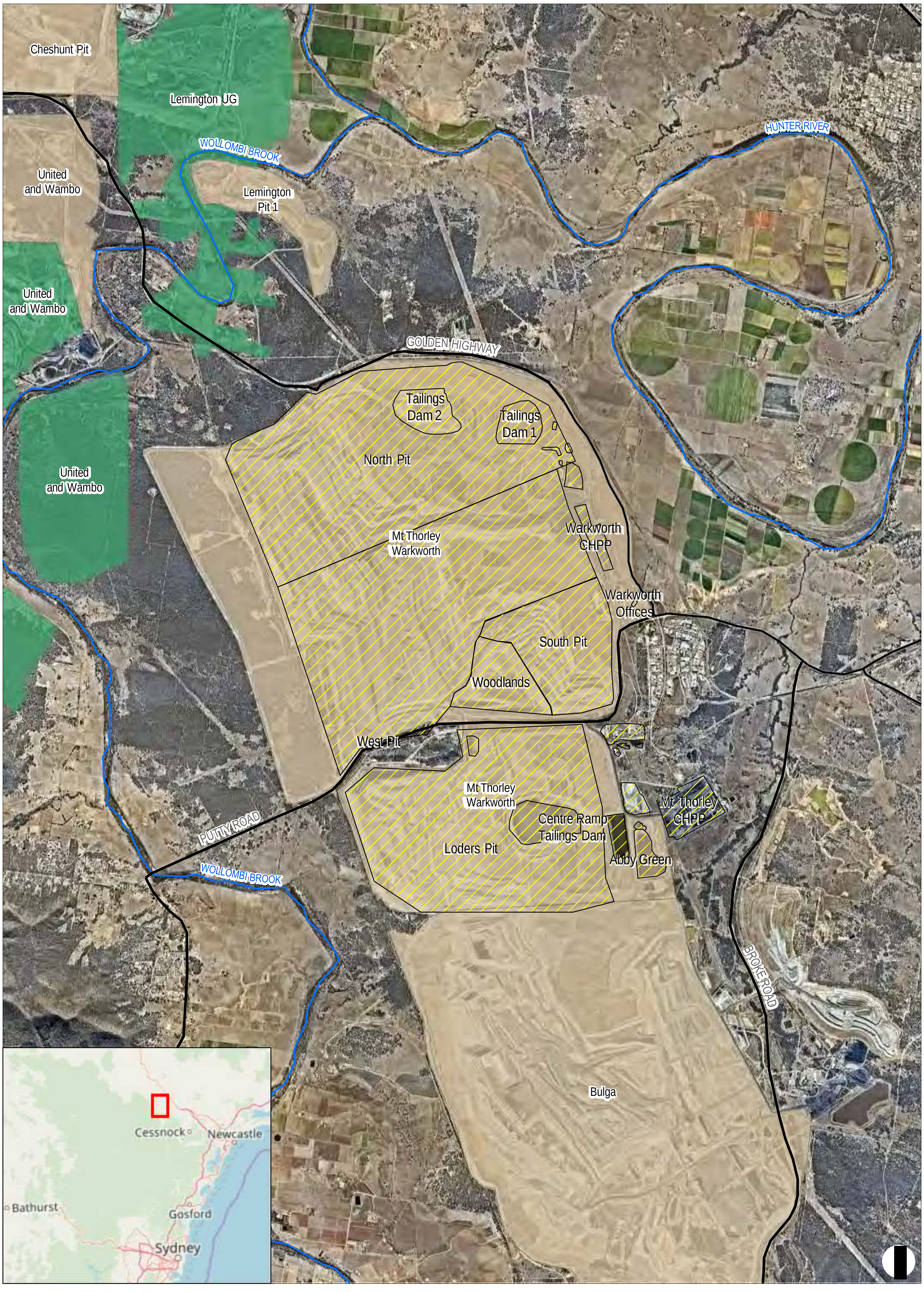
Table 2-1 Summary of MTW Activities

Mine Area	Site	2019 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 active mining, rehabilitation works in place.
Loders Pit	Mt Thorley	Mining continued within the existing footprint down to the Redbank 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 commenced. Capping of the tailings dam continued during the period.
Centre Ramp Tailings Dam (Dam 17S)	Loders Pit – Mt Thorley. Tailings dam located overlying spoil, within backfilled pit.	Active
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 in progress
Loders Pit North	Loders Pit- Mount Thorley. Tailings dam located in-pit.	Approved TSF not yet developed.



Main road
Major watercourses
MTW Infrastructure
Mine Areas
Open Cut
Underground

Sheet Size : A4

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Mt Thorley Warkworth
2019 Annual Groundwater Review
Locality Map

Figure 2-1

2.2 Groundwater Impacts

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

- Warkworth Mine Modification Groundwater Impact Assessment (AGE, 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 5.**

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
18469 20AL218784	-			245
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	1,009
963 20AL201242	Warkworth Farm – Hunter River Pump			243
971 20AL201258				270
1008 20AL201341				243
995 20AL201302	Appledale 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 2019 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 6** 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 5.3** for triggers and **Section 6.3** 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 6** 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 6** for discussion on groundwater monitoring results for 2019. 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 6.**
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 in **Section 6.5.**.
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 5** 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 6**. 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 assessed in **Section 6.5.**
	Licensing: • retain and obtain appropriate water licences, as required, to account for modelled take.	**Section 2.3** and **Section 6.4**

<table>
<tr><th>Condition</th><th>Details</th><th>Where Addressed</th></tr>
<tr><td rowspan="3">SOC Mount Thorley Operations
2014 EIS Table 21.1 Groundwater</td><td>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.</td><td>See Section 6.3 for discussion on site water quality results against trigger levels.</td></tr>
<tr><td>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.</td><td>Trigger levels presented in Section 5.3.

Quarterly reviews conducted as part of routine groundwater monitoring by external contractors AECOM.

Data stored within database held by Yancoal.</td></tr>
<tr><td>Licensing:
• retain and obtain appropriate water licences, as required, to account for modelled take.</td><td>Section 2.3</td></tr>
</table>

Groundwater monitoring is to be conducted in accordance with the Groundwater Monitoring Program (GMP) 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 GMP and triggers is included in **Section 5**.

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 from the Bureau of Meteorology (BoM) Station 61191 Bulga South was used as this provides the longest record of data in the area from 1959 to present. **Table 3-1** shows the average monthly rainfall calculated since 1959 and for the year 2019.

Table 3-1 Long Term Average and 2019 Climate Data

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Historical	86.6	84.2	66.7	45.9	40.3	44.1	30.0	34.2	38.5	54.3	61.8	71.5	**656.6**
2019 Rainfall	59.6	21.0	145.6	3.4	11.8	6.4	13.4	21.8	21.4	4.4	30.8	0.2	**339.8**

A cumulative rainfall departure (CRD) plot is provided as **Figure 3-1** to illustrate long term climate trends in the MTW area, based on average monthly rainfall data. The CRD graphically shows trends in recorded rainfall compared to long-term averages (1959 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.

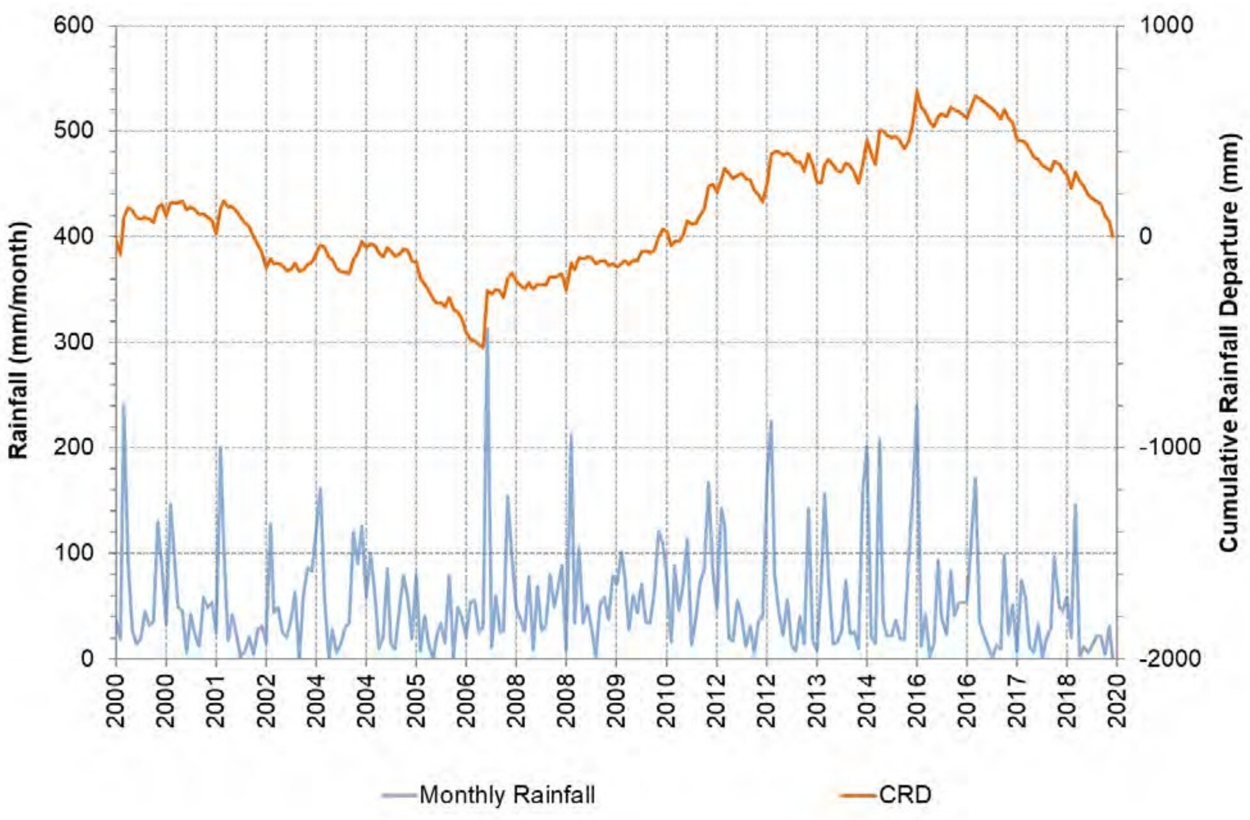


Figure 3-1 Cumulative Rainfall Departure and Monthly Rainfall

As shown in **Figure 3-1**, the region has generally experienced below average rainfall from 2016. Over 2019 rainfall was well below historical average for all months, except for March where 145.6 mm of rainfall was recorded, which was 78.9 mm above average.

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 NSW Department of Primary Industries (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).

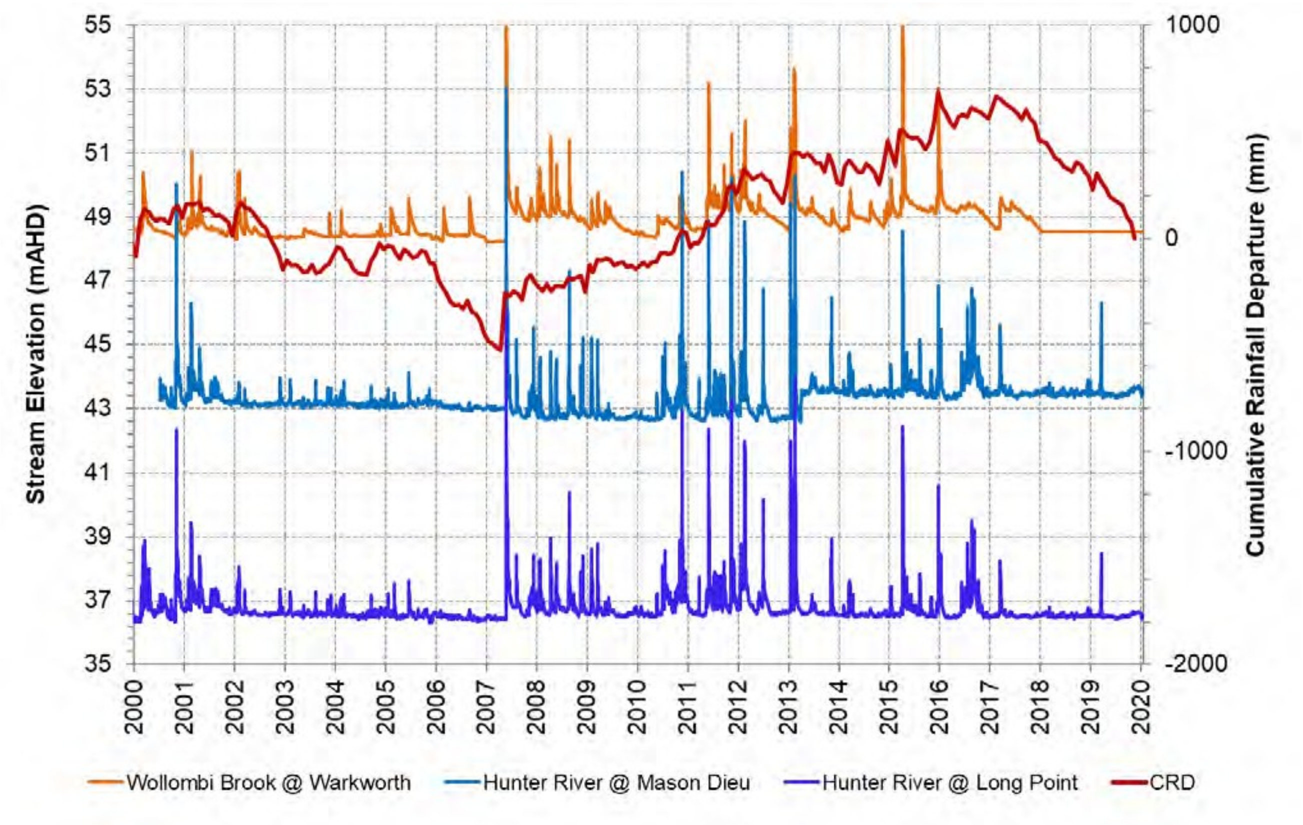


Figure 3-2 Surface Water Levels

As shown in **Figure 3-2**, over 2019 stream elevations within the Hunter River remained stable ranging between 36.43 mAHD and 38.49 mAHD at Long Point and between 43.32 mAHD and 46.32 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 2019, the consistent elevations observed at both gauging stations are likely to be largely due to these storage releases. This is supported by the spike in elevation seen in April 2019 in contrast to the negligible rainfall (3.4 mm) recorded over the same period.

Figure 3-2 shows that over 2019, stream elevations within Wollombi Brook were recorded consistently at 48.5 mAHD. The zero gauge for Warkworth station (Station 210004) is 47.755 mAHD, meaning that water levels were recorded above the zero gauge over 2019 at 0.78 m. The stability of the water level over 2019 suggests pooled water has been measured rather than changes in stream elevations. 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 2019 Wollombi Brook did not flow, which is consistent with the observed water levels.

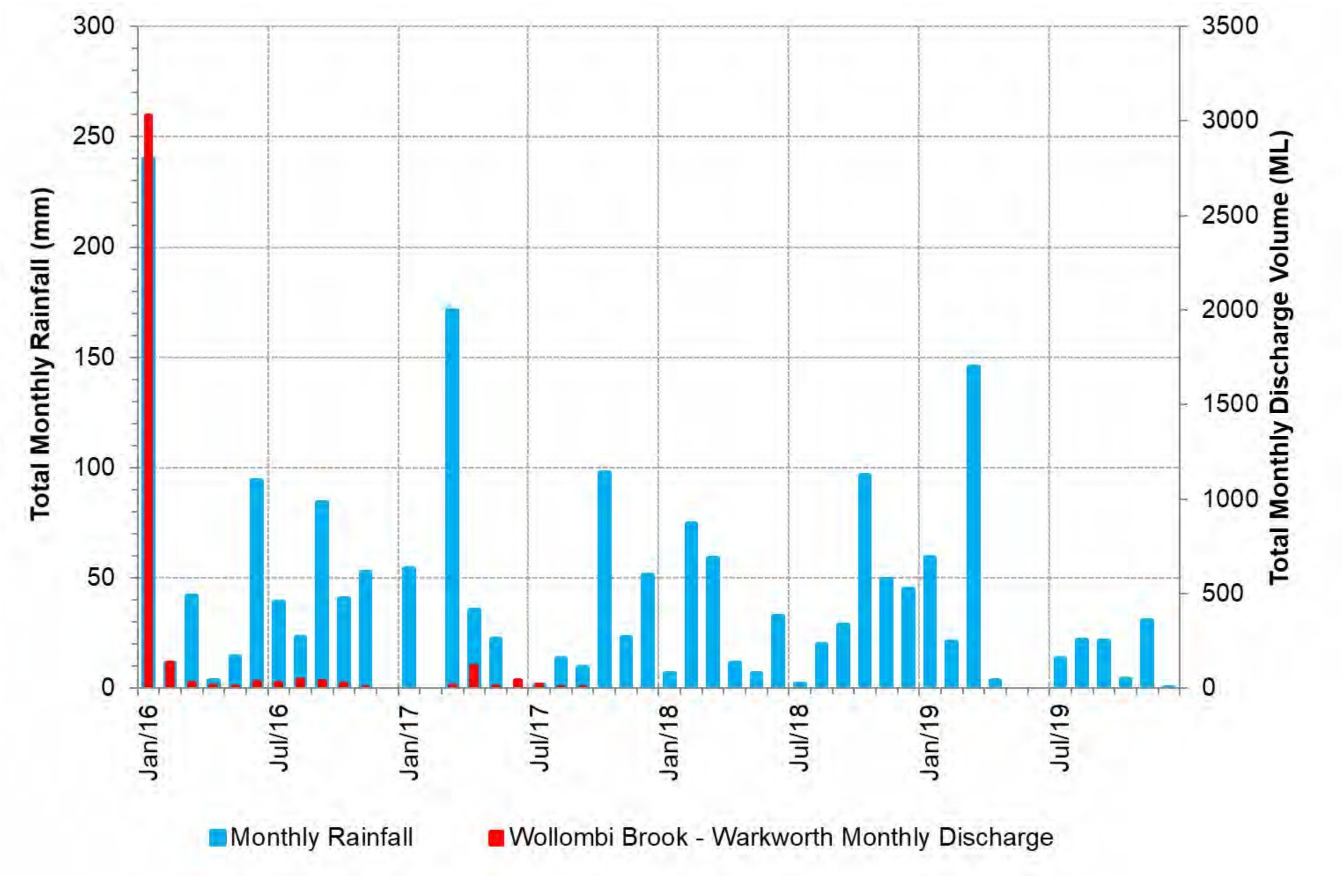


Figure 3-3 Wollombi Brook Monthly Surface Water Flow Volumes vs Monthly Rainfall

3.2 Geology

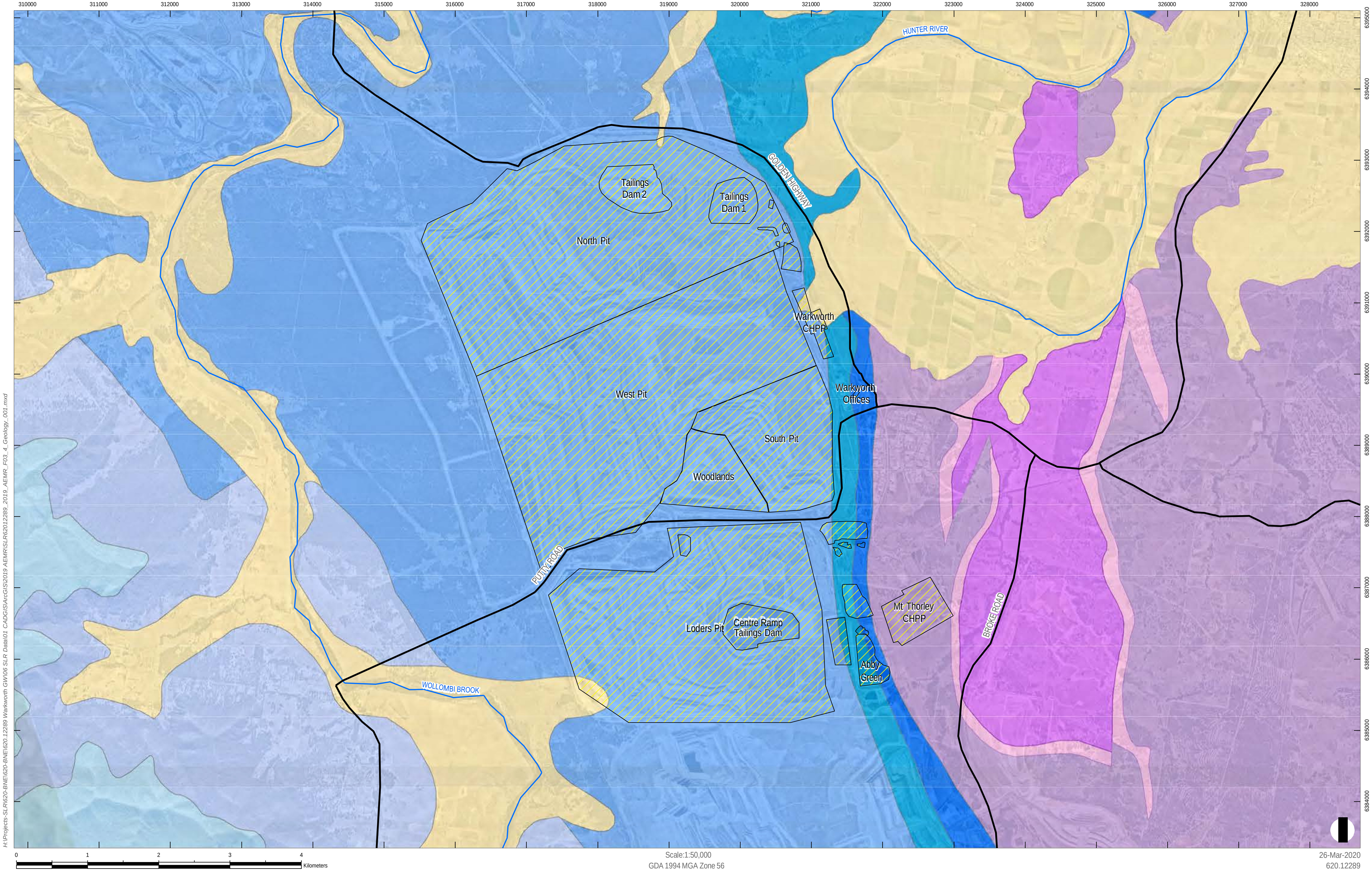
MTW lies within the Hunter Coalfields, which are dominated by the Permian aged Whittingham Coal Measures of the Sydney Basin. The Whittingham Coal Measures are made up of the Jerrys Plains Sub-group and Vane Sub-group. These units comprise economic coal seams along with overburden and interburden consisting 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.



MTW Infrastructure
Main road
Major watercourses

Hunter Coalfields 100k Geology

Qa - Quaternary Alluvium
Rn - Narrabean Group
Psl - Newcastle Coal Measures
Pswj - Jerrys Plains Subgroup
Pms - Muree Sandstone
Pswv - Archerfield Ss. Vane Subgroup
Pswc - Saltwater Creek Formation
Pmm - Mulbring Siltstone
Pmb - Branxton Formation

Sheet Size : A3

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2019 Annual Groundwater Review
Surface Geology

Figure 3-4

4 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**.

4.1 Regolith

Regolith material has been identified in the east of the project area overlying the Permian coal measures to depths of around 5 m. The material is clay rich comprising clays, sandy clays and minor clay sands with permeability of around 3.3 x 10^{-5} m/day to 9.5 x 10^{-3} m/day. The material has previously been categorised as alluvium. The regolith is recharged by rainfall infiltration and potential seepage from mine infrastructure.

4.2 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).

4.3 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. Conglomerates and weathered sandstone can be present to depths of around 16 m, and exhibit hydraulic conductivity of around 1.2×10^{-3} m/day to 9.5×10^{-2} m/day.

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.

5 Groundwater Monitoring

5.1 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 5-1**.

In Q1 and Q2 2019 an additional four VWPs were installed at MTW as part of ongoing site investigations. These bores are not included within the compliance network within the WMP, but details on the bores are presented in **Table 5-1** below for background reference.

Table 5-1 2019 VWP Construction Details Summary

Bore ID	Easting(s) GDA94 z56	Northing(s) GDA94 z56	Ground RL (m AHD)	Sensor Depth (m bTOC)	Target Aquifer	Comments
LD603_P1	321198	6386574	90.87	275.17	Below Bayswater	P1 - not currently connected
LD603_P2				268.29	Bayswater Seam	
LD603_P3				191.65	Vaux Seam	
LD603_P4				148.7	Mt Arthur Seam	
LD603_P5				79.95	Mt Arthur Seam Overburden	
LD603_P6				37.3	Spoil	
WD646R_P1	316795	6392767	99.590	359.53	Below Bayswater Seam	P1 - not currently connected. P2 - potential sensor failure following installation.
WD646R_P2				340.72	Bayswater Seam	
WD646R_P3				304.8	Bayswater/Vaux Interburden	
WD646R_P4				261.35	Vaux Seam	
WD646R_P5				181.76	Mt Arthur Seam	
WD646R_P6				72.97	Mt Arthur Overburden	
WD645_P1	319108	6390127	157.49	311.99	Below Bayswater Seam	
WD645_P2				295.52	Bayswater Seam	
WD645_P3				249.22	Bayswater/Vaux Interburden	
WD645_P4				219.85	Vaux Seam	
WD645_P5				205.36	Base of spoil	
MTD650_P1	317618	6385929	75.21	423.77	Below Bayswater Seam	
MTD650_P2				403.86	Bayswater Seam	
MTD650_P3				376.02	Bayswater/Vaux Interburden	
MTD650_P4				341.23	Vaux Seam	
MTD650_P5				297	Mt Arthur Seam	

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 6**.

5.2 Groundwater Monitoring Methodology

MTW engages field contractors AECOM 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 contractors sampling field sheets, it is understood that the quarterly and annual groundwater samples for the majority of bores are collected following purging 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.

For the remaining bores (WOH1239A, WOH2141A, WOH2153A, WOH1254A, WOH2155A, WOH2156A, WD622P, MBW02 and MBW03) it is understood that the quarterly and annual groundwater samples are collected as grab samples 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.

Scale: 1:75,000

GDA 1994 MGA Zone 56

26-Mar-2020

Kilometres

Main road

Major watercourses

Groundwater Monitoring Points

MTW Infrastructure

Sheet Size : A4

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Mt Thorley Warkworth
2019 Annual Groundwater Review
Groundwater Monitoring Network

Figure 4-1

5.3 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 5-2**.

Groundwater quality readings from the site monitoring bores have been compared to the relevant trigger levels in **Section 6.3**.

Table 5-2 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
WOH2156B	Wambo	13,843	7.2	7.8
WD622P	Wambo	13,843	7.2	7.8

Location	Target Seam/ Stratigraphy	EC (95th) µS/cm	pH (5th)	pH (95th)
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

5.4 Trigger Investigations

As part of the annual review of groundwater level and quality trends for 2018, SLR (2019) identified several readings outside of the trigger threshold range for water quality (EC and pH) and water levels where further investigation was required. A summary of these and works undertaken to investigate the trends is included below:

- Bore PZ9S recorded pH at or above the trigger threshold of 7.0. The pH readings coincided with a general decline in groundwater level and SLR (2019) indicated it may relate to sampling methodology and influence from sediment at the base of the bore. Review of sampling methodology to ensure representative samples were collected was recommended.
- Bore OH1138(1) recorded pH below the trigger threshold of 6.3 over 2018 and EC above 19,657 µS/cm. The bore is constructed as a nested monitoring point with 32 mm PVC to 42.8 m depth screened within the Warkworth Seam. The bore recorded a general rise in EC over time with a decline in groundwater levels. The decline in levels was identified as potentially relating to abstraction from the Lemington Underground (LUG) Bore 1.25 km to the north west, which abstracts from the abandoned Lemington Underground board and pillar workings that were mined into the Mt Arthur Seam.

6 Monitoring Results

6.1 Data Recovery and Network Review

Over 2019, groundwater monitoring was carried out at 60 monitoring bores across MTW. No water level or quality data was collected from ten of the monitoring bores over 2019 due to them being dry. The bores and sites with a data capture rate of less than 100 per cent are outlined in **Table 6-1**.

Table 6-1 Groundwater Monitoring Data Recovery

Location	Type	Data Recovery	Comments
OH943	WQ	0%	Insufficient water for field test and lab sample – March, June, September & December 2019
OH944	WL and WQ	0%	Bore dry over 2019
OH786	WQ	75%	Insufficient water for lab sample – June 2019 (field results only)
PZ9S	WQ	75%	Insufficient water for field test and lab sample – June, September & December 2019
MBW02	WL and WQ	75%	No access – February 2019
MB15MTW04	WL and WQ	0%	Bore dry over 2019
MB15MTW05	WL and WQ	0%	Bore dry over 2019
MB15MTW06	WL and WQ	0%	Bore dry over 2019
MB15MTW07	WL and WQ	0%	Bore dry over 2019
MB15MTW08	WL and WQ	0%	Bore dry over 2019
MB15MTW09	WL and WQ	0%	Bore dry over 2019
MB15MTW10	WL and WQ	0%	Bore dry over 2019
MB15MTW11	WL and WQ	0%	Bore dry over 2019
GW9709	WQ	75%	Insufficient water for field test – December 2019
OH1125 (2)	WL and WQ	0 %	Bore dry over 2019
OH1137	WL and WQ	75% (WL) / 25% (WQ)	Bore blocked – June 2019, Bore dry – September & December 2019
WHO2154B	WQ	0%	Bore blocked – March 2019, Insufficient Water for lab sample and field test – May, August and November 2019
WOH2156B	WQ	75%	Insufficient water for lab sample and field test – May, August & November 2019

Groundwater levels are recorded by site VWP's and data loggers installed in select monitoring bores. Level data was successfully downloaded from nine of the VWP sites and 18 of the loggers. Sites where data collection issues have been encountered are outlined in **Table 6-2.** Further work to check the VWP's and monitoring bore loggers are working correctly (i.e. check / replacing batteries and logger depths) is ongoing.

Table 6-2 Logger Data Recovery

Bore ID	Serial Number	Comments
PZ8S		No logger installed in bore
PZ8D	2053696	Data erroneous after February 2019 (data does not match manual dip measurements). It is suspected that the logger install depth may be different to the reported depth or that the logger has failed – further investigation required to confirm logger depth and status.
PZ9S	2053704	Water level below base of logger therefore the logger is only recording atmospheric pressure – recommend logger be lowered if sufficient water present above base of bore.
PZ7S	2016488	2019 data does not match manual dip measurements. It is suspected that the logger install depth may be different to the reported depth – further investigation required to confirm logger depth.
PZ7D	2053695	2019 data does not match manual dip measurements. It is suspected that the logger install depth may be different to the reported depth – further investigation required to confirm logger depth.
MB15MTW02S	2053694	2019 data does not match manual dip measurements. It is suspected that the logger install depth may be different to the reported depth – further investigation required to confirm logger depth.
MB15MTW02D	2039901	Erroneous data from June 2019. Logger to be replaced during next quarterly monitoring event.

Table 6-3 VWP Data Recovery

Location	Sensor (s)	Comments
WD622	1 to 5	Data erroneous – potential sensor failure
MTD518	1 to 3	Data gap between March and July 2019 following removal of logger. Logger replaced in July 2019 and all sensors appear to be recording correctly.
PZ2	1 & 2	No longer exists
MTD605	3, 5 & 6	Data potentially erroneous – calculated SWL elevation above VWP surface elevation. Sensor 5 data erroneous from 01/11/19 – potential sensor failure Sensor 6 data erroneous from 23/06/19 – potential sensor failure
MTD613	1	Erroneous data between June and August 2019, however sensor appears to be working correctly after this period.
MTD614	3 to 5	Data erroneous – potential sensor failure
WD462	1 to 3	Sensor data not collected.
PZ1	1 & 2	Sensor 2 logger replaced in June 2019. Sensor 1 and 2 depths and calibration details unknown

Overall, the current monitoring network and program is generally adequate for satisfying current monitoring requirements of the WMP. There is good spatial of coverage of monitoring locations across the site, with multiple bores and VWP sensors installed into each relevant aquifer unit when take into account the installation of additional VWP's in 2019. It is recommended that the Groundwater Management Plan be updated to incorporate these additional VWP's, remove destroyed/erroneous monitoring points and to more clearly identify the purpose of each bore based on its location and construction. Compliance conditions should also be updated to align with the revised network and identified purpose of bores.

6.2 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 2019 are presented in **Appendix B**.

6.2.1 Regolith

In the 2018 annual environmental monitoring report (SLR, 2019) a review of the construction depths for bores previously identified as intersecting the Hunter River Alluvium in the WMP was undertaken. The review found that three bores (OH786, OH787 and OH942) are in fact screened within regolith material meaning surficial clays and shallow deeply weathered Permian coal measures.

Over 2019, groundwater within the regolith bores occurred at depths of between 2.75 m and 13.96 m below surface. **Figure 6-4** 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 and Dam 1N. Flunctuations in groundwater levels within OH786 have fluctuated over time but generally show a decline since 2016. This may relate to climate trends and reduced rainfall recharge, or potentially relate to cessation of storage within TD1 from 2012 and water storage in Dam 1N. The adjacent bore OH942 is installed approximatley 6 m deeper into the weatherd Permian Coal Measures and recorded stable groundwater levels. This indicates the recharge source is largely restricted to the shallow regolith.

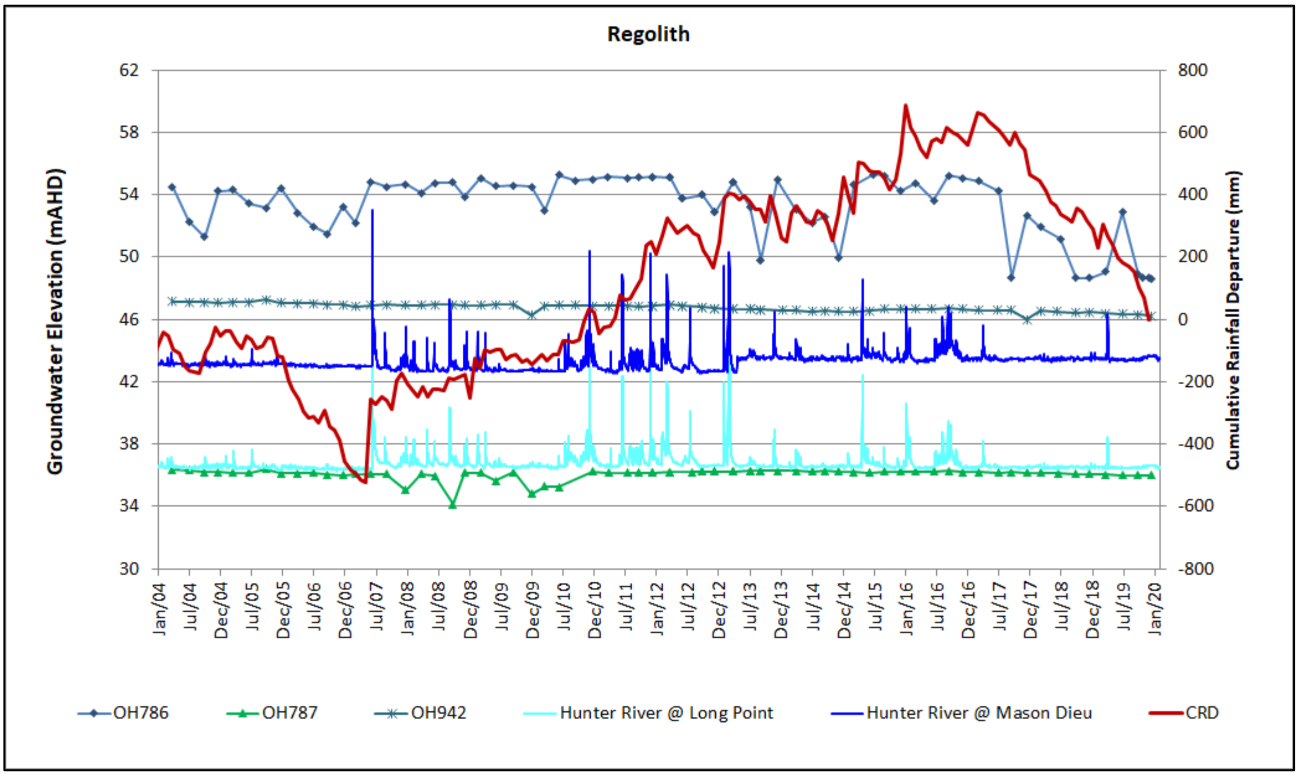


Figure 6-1 Groundwater Levels – Regolith

6.2.2 Alluvium

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

6.2.2.1 Warkworth Sands

Bores within the Warkworth Sands include PZ7S and 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. Levels have been compensated using barometric levels recorded at the MTW site. Barometric levels used to compensate the 2018 data was sourced from the neighbouring Bulga Mine which resulted in a degree of 'noise' in the readings.

Bore PZ7 is a nested bore with screen within the Warkworth Sands to 11.1 m depth (PZ7S), and screen within the shallow overburden material at 30.5 m depth (PZ7D). Historical water level data for the bores is presented in **Figure 6-2**. **Figure 6-2** shows that groundwater elevations within the coal measures at PZ7D have historically been slightly higher than levels in the overlying Warkworth Sands, indicating a potential upward gradient. Since 2016 this gradient has reduced, with levels within the Warkworth Sands and shallow overburden showing similar elevations and trends. **Figure 6-2** shows that over 2019 groundwater levels within the Warkworth Sands and shallow overburden material at PZ7S and PZ7D generally declined. This trend appears to correspond with the general decline in rainfall over this period; however, the logger data does not show a response to the above average rainfall experienced in March 2019. Further investigation into the local ground conditions, condition of the nested bore and functionality of the bore loggers should be undertaken, to understand the interaction between the two bore depths.

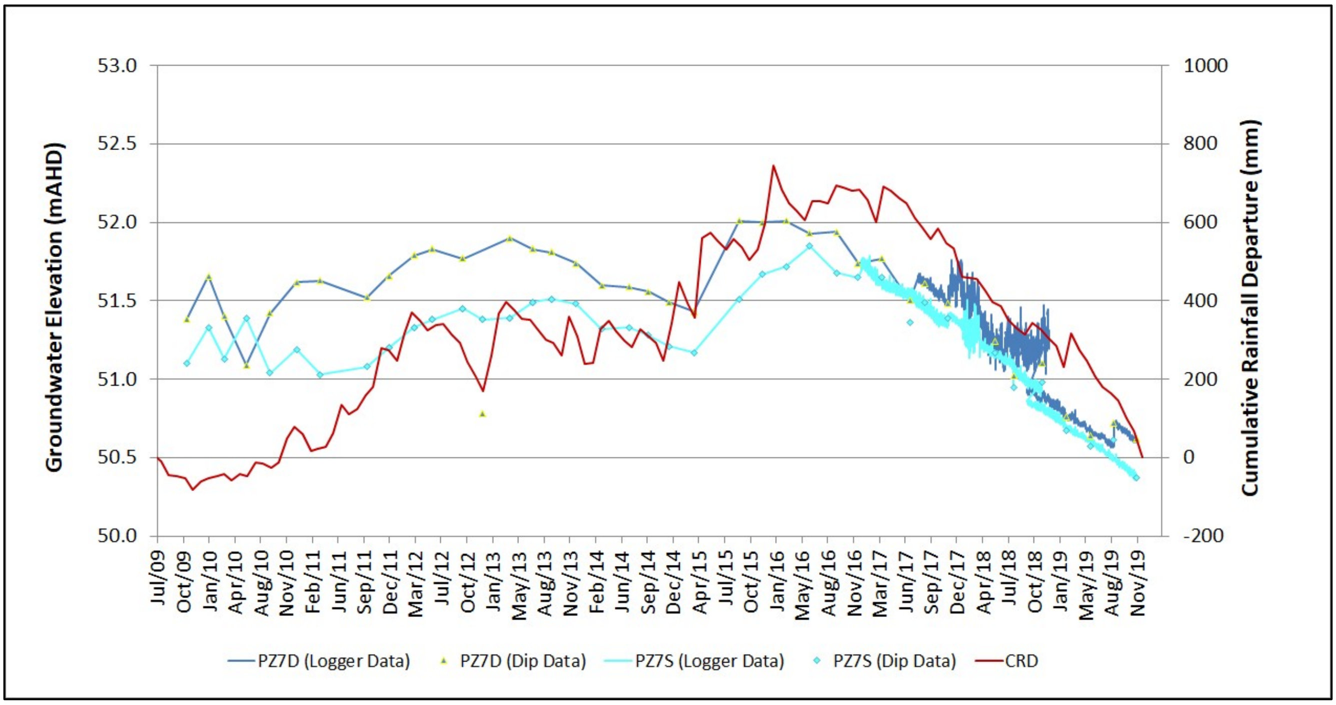


Figure 6-2 Groundwater Levels – Warkworth Sands Bore PZ7S and PZ7D

Bores MB15MTW04 to MB15MTW11 were generally recorded as dry since construction in 2016. An exception to this was bore MB15MTW06, which has historically shown a groundwater level response to rainfall events (**Figure 6-3**). Bore MB15MTW06 was generally recorded as dry throughout 2019, which generally corresponds with the below average rainfall recorded during this period, except for the above average rainfall in March 2019 (**Figure 6-3**). Further review into the groundwater conditions associated with the Warkworth Sands is recommended.

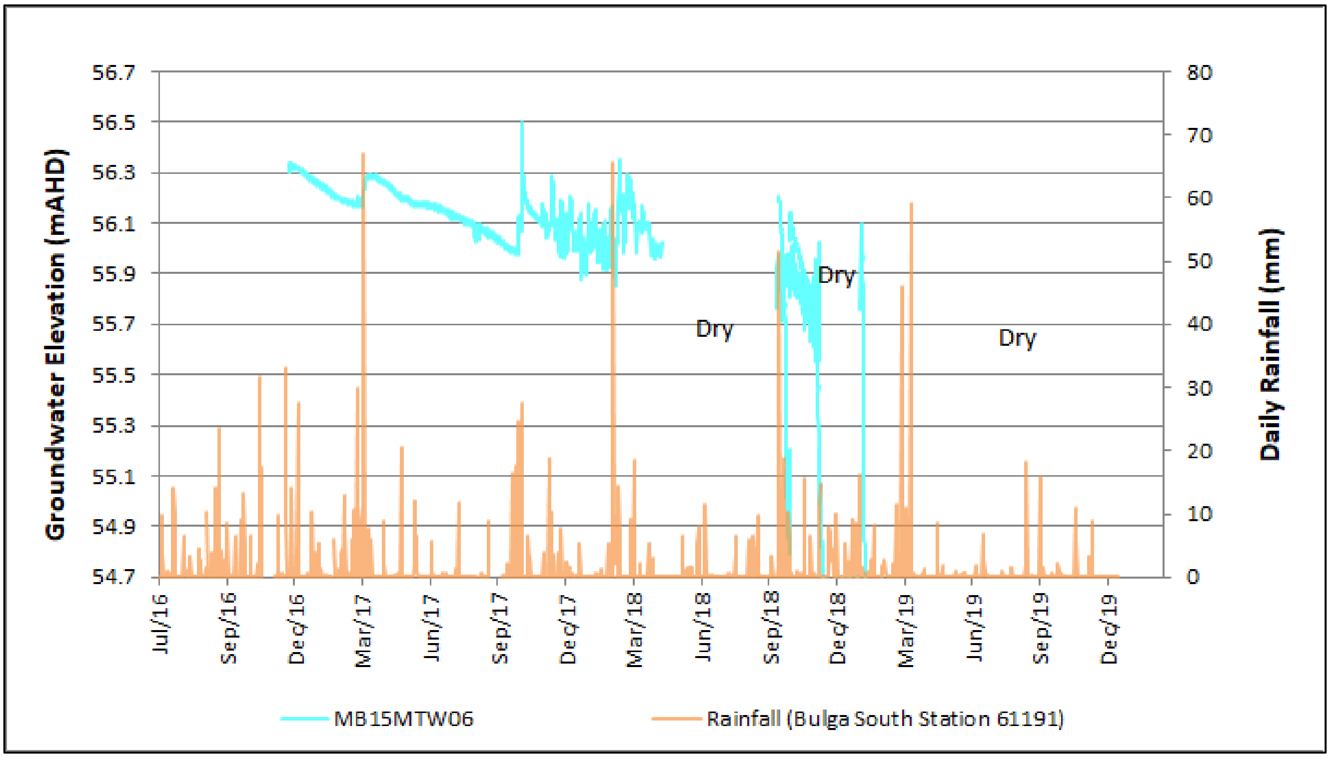


Figure 6-3 Groundwater Levels – Warkworth Sands Bore MB15MTW06

6.2.2.2 Hunter River Alluvium

Three bores within the monitoring network intersect alluvium along the Hunter River, these are OH788, OH943 to OH944. Over 2019, 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 9.47 m and 9.61 m below surface over 2019. **Figure 6-4** 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 6-4**, groundwater levels have remained relatively stable at bores OH788 and OH943 since monitoring commenced in 2004, with less than 0.5 m variation in levels recorded. There is a very slight decline since 2016 recorded for both bores that may relate to the below average rainfall period. However, historical readings show no correlation with rainfall trends and no response to peak rainfall periods. It is recommended that the construction and geology at the two bores be reviewed to verify they do intersect alluvium.

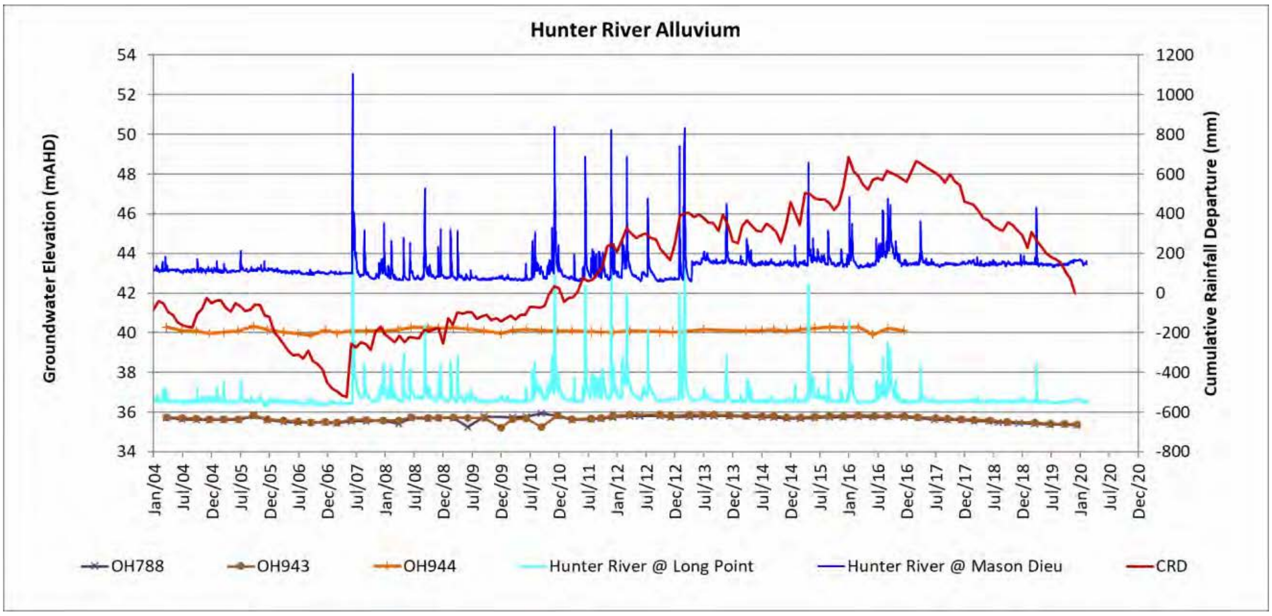


Figure 6-4 Groundwater Levels – Hunter River Alluvium

6.2.2.3 Wollombi Brook Alluvium

Five bores intersect the alluvium along the Wollombi Brook: G3, PZ8S, PZ9S, 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 6-5,** 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. Manual dip readings have therefore been used instead, to provide a basic indication of changes to groundwater levels. Manual dip readings have also been plotted alongside the logger data for MB1MTW02S. The reason for this is that following review of the logger data, the readings between March and May 2019 were found to be erroneous with record levels approximately 0.5m lower than recorded before and after this period. It is believed that this difference is likely to have been due to a change in the logger depth placement. The logger data has therefore been adjusted to account for the difference in logger depth over this period. Lastly, it should be noted that the 'noisy' data observed for all bores throughout 2018 is due to the use of barometric data from the neighbouring Bulga mine during this period.

Bores MB15MTW01 and MB15MTW02 are located adjacent to Wollombi Brook. **Figure 6-5** shows that over 2019 alluvial groundwater elevations along Wollombi Brook were below stream elevations, indicating losing conditions. Groundwater levels within the alluvium and shallow overburden steadily declined over 2019. 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.

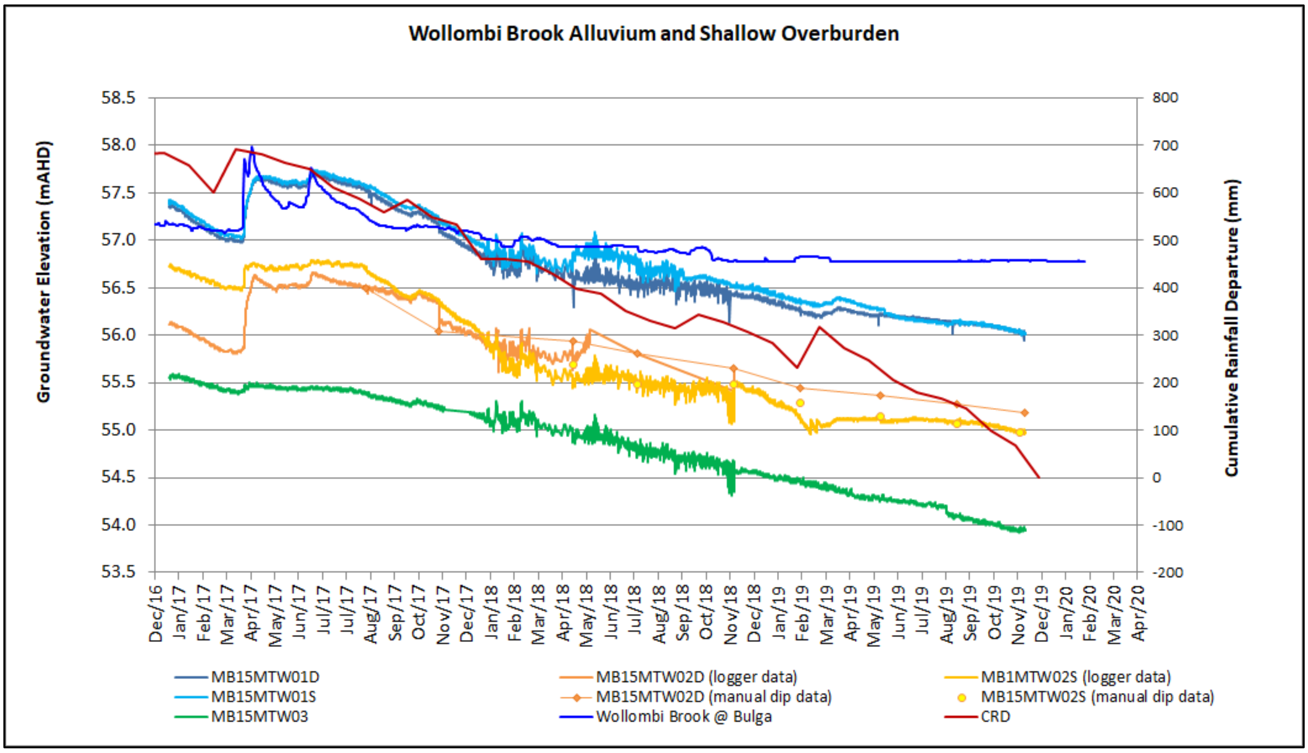


Figure 6-5 Groundwater Levels – Wollombi Brook Alluvium MB15MTW01 and MB15MTW02

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 6-6**. 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 6-6** shows a general decline in groundwater levels within the alluvium following rainfall trends, with a slight rise following the March 2019 above average rainfall event.

Figure 6-6 shows that alluvial groundwater elevations are higher than the underlying overburden material, indicating a downward flow gradient. The exception to this is bore site MB15MTW02 where the alluvial groundwater elevations are marginally lower than the underlying overburden material, indicating a potential upward 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 2019. 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. Overburden bore PZ8D also recorded a decline in levels between June and December 2019, which is not observed in PZ8S alluvial bore. The bores are located approximately 800 m from Loders Pit and the decline in the overburden likely reflects depressurisation from mining, as predicted by AGE (2014b).

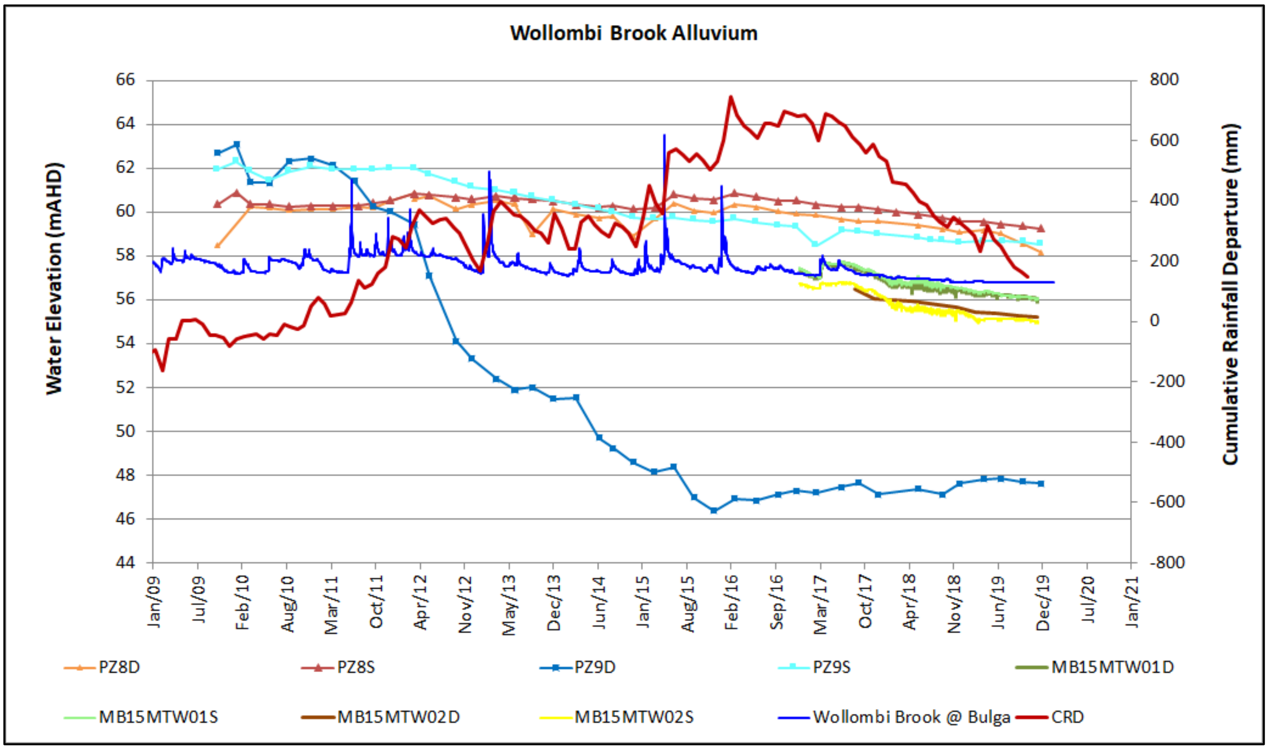


Figure 6-6 Groundwater Levels – Wollombi Brook Alluvium Bores PZ8, PZ9, MB15MTW01 and MB15MTW02

6.2.3 Permian Coal Measures

Groundwater level trends for the Permian coal measures are discussed in stratigraphic order in **Section 6.2.3.1** to **Section 6.2.3.9** 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.

6.2.3.1 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 6.2.1**. Trends for bore MB15MTW03 are also presented in **Figure 6-5** of **Section 6.2.1**, as the bore is located along Wollombi Brook. **Figure 6-5** showed a general decline in groundwater levels at MB15MTW03 over 2019. The trends were similar to what was observed within the upstream alluvial bores, but with a more muted response to streamflow changes and no visible response in groundwater levels to the March 2019 above average rainfall event.

Groundwater level trends for bores MTD605P, MTD614P, MTD616P, and MBW02 are presented in **Figure 6-7**. **Figure 6-7** shows stable to slightly declining groundwater levels within the shallow overburden material. The exception to this is bore MTD616P in which slightly increasing groundwater levels were recorded. No land use changes or activities are known to have occurred near the bore that may have caused this rising trend. Further investigation into site conditions around MTD616P should be undertaken to confirm this.

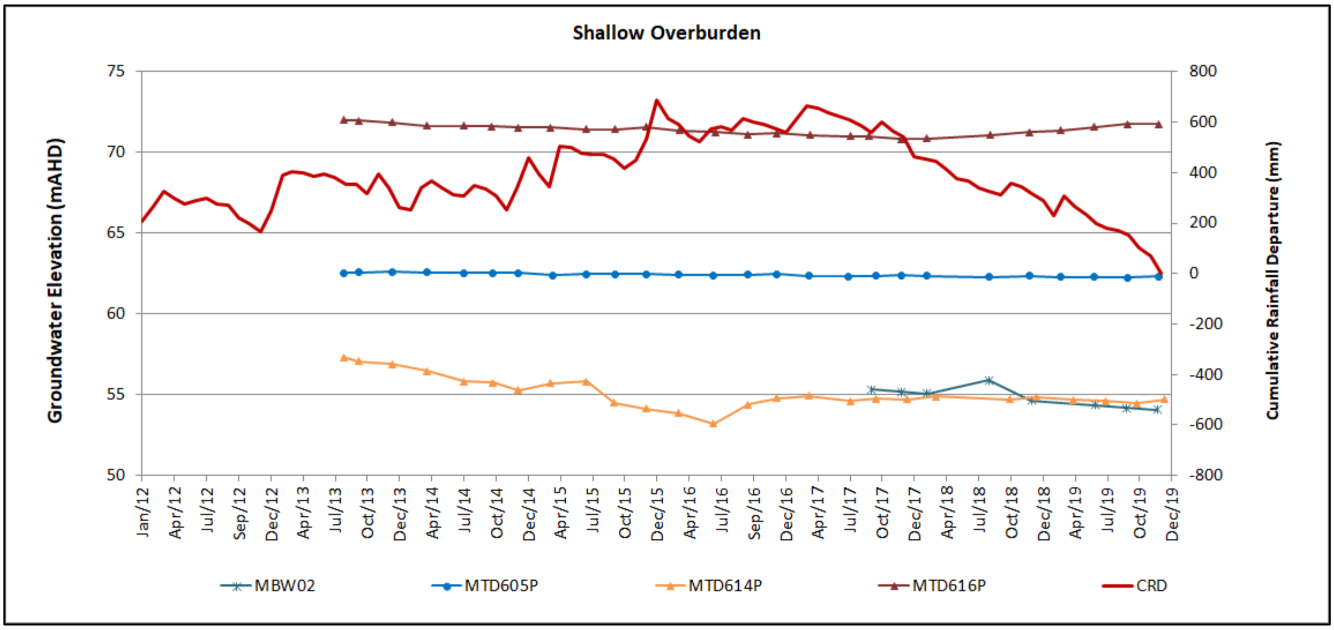


Figure 6-7 Hydrograph of Shallow Permian Coal Measures

6.2.3.2 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 6-8**. The graph shows that over 2019 groundwater elevations ranged between 46.6 mAHD and 67.7 mAHD. Over 2019 groundwater levels generally declined in bores WD622P, WOH2154B, WOH2155A, WOH2153A, WOH2154A, and WOH2156A. With the exception of bore WOH2153A, the rate of groundwater level decline increased from May 2019. Over 2019 groundwater elevations in WD622P, decreased from 52.96 m AHD to 46.56 m AHD; in WOH2154B decreased from 54.97 m AHD to 53.81 m AHD; in WOH2155A from 53.55 m AHD to 49.85 m AHD; and from WOH2156A from 51.63 m AHD to 47.75 m AHD. Bores WOH2154A, WOH2155A and WOH2156A all target the Redbank Creek Seam with WD622P and WOH2154B targeting the Wambo Seam. WD622P, is located within 300 m of the highwall at West Pit, with the remaining bores approximately 750m west of the North and West Pits. The increased decline in groundwater levels are therefore likely to be a response to the depressurisation of the coal seams as a result of mining operations. Groundwater levels remained relatively stable at bores WOH2153B, WOH2155B and WD625P, which are all located approximately 1 km west of Warkworth operations. Groundwater elevations were found to slightly increase throughout 2019 in WOH2156B.

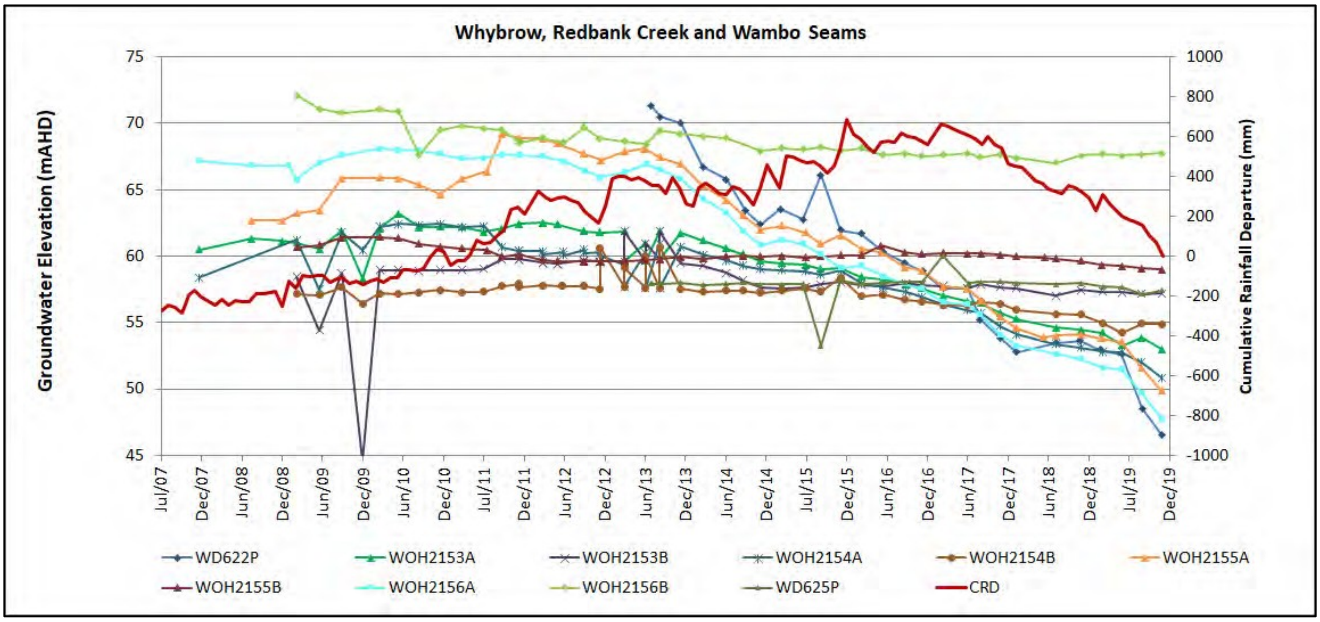


Figure 6-8 Hydrograph of Whybrow, Wambo and Redbank Creek Seams

Groundwater level trends for VWP sensors installed within the Whybrow and Wambo seams are presented in **Figure 6-9** and **Figure 6-10** respectively. The graphs show that over 2019 groundwater elevations within both seams declined, with a steeper decline again observed within the Wambo Seam from May 2019. 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.

In the 2018 annual environmental monitoring review it was found that the MTD614 sensor installed within the Whybrow Seam (sensor 1) recorded increasing groundwater elevations, this in contrast to the other Whybrow Seam sensors where declining elevations have been recorded. 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. It was suggested that the increase in groundwater elevations may indicate that the sensor is not working correctly. Review of the 2019 data found that groundwater elevations recorded MTD614 (sensor 1) continued to increase until August after which they began to decrease. Review of the raw sensor data suggests that the sensor and logger are working correctly, with pressure and temperature readings relatively consistent since installation. This trend is also consistent with trends for nearby shallow overburden bore MTD616P.

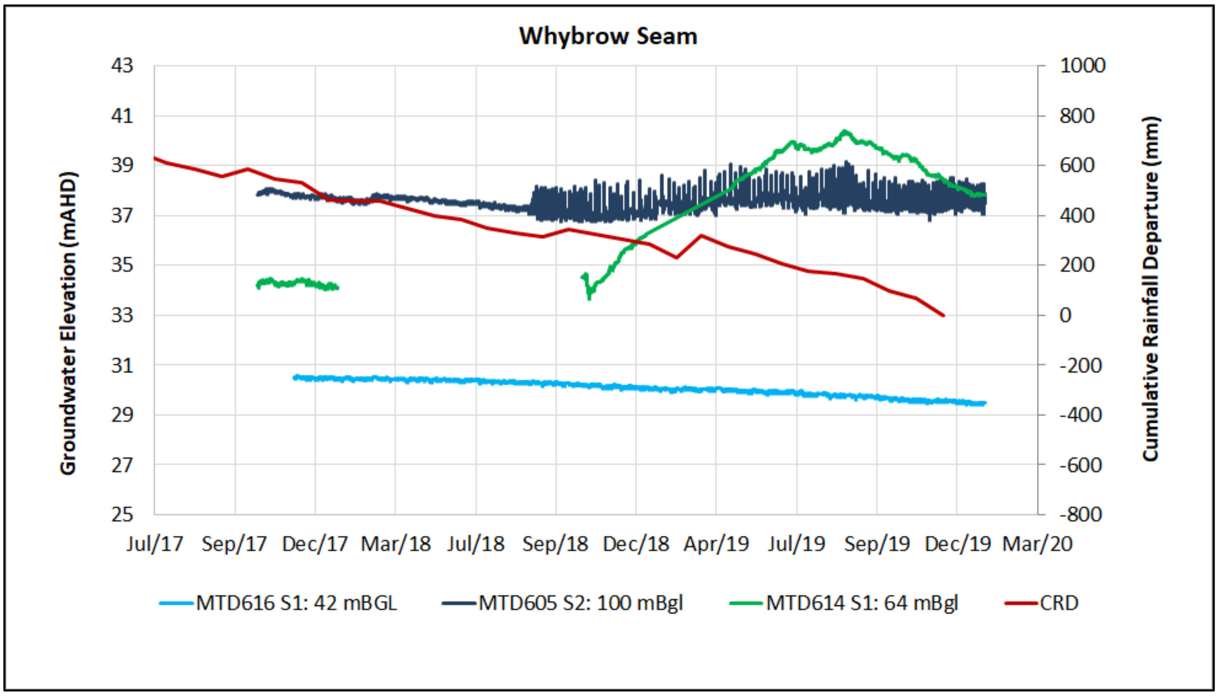


Figure 6-9 VWP Hydrograph of Whybrow Seam

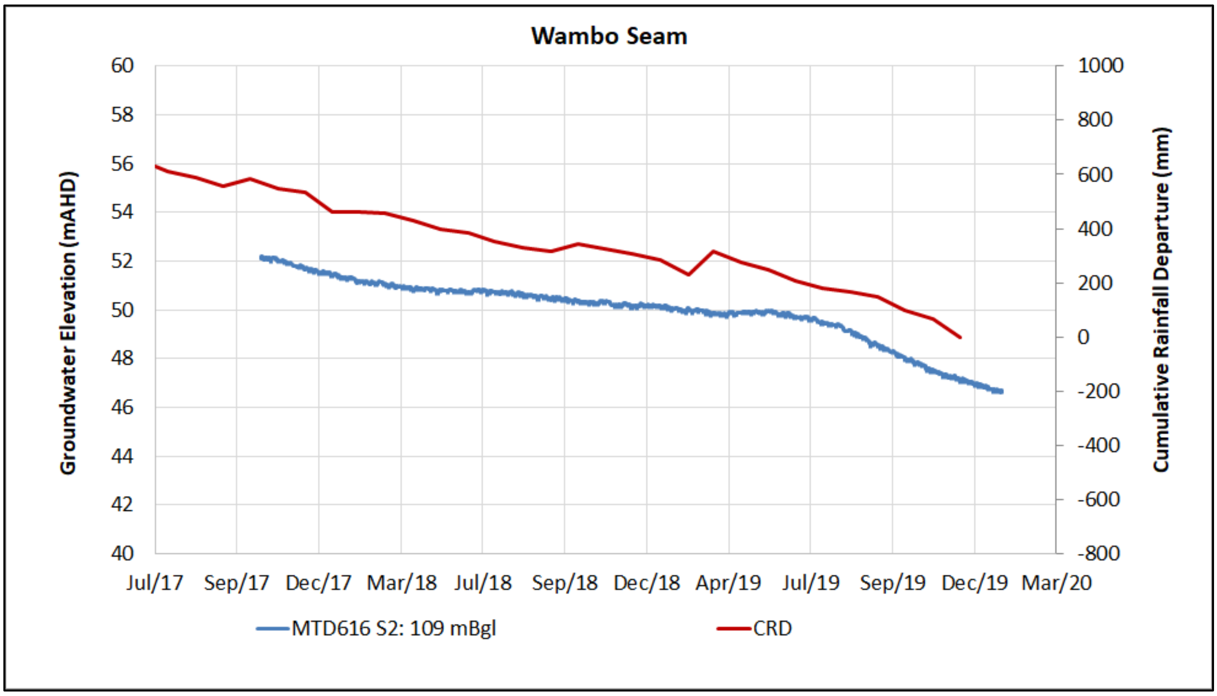


Figure 6-10 VWP Hydrograph of Wambo Seam

6.2.3.3 Blakefield Seam

Historical groundwater level trends for bores intersecting the Blakefield Seam are presented in **Figure 6-11**. The graph shows that over 2019 groundwater elevations ranged between 34.9 mAHD and 53.16 mAHD. Over 2019 groundwater levels generally declined within the Blakefield Seam in bores OH1125 (1) and WOH2139A. Groundwater levels within OH1122 remained relatively stable throughout 2019. In response to mine progression Bore OH1125(1) recorded a 3.5 m decline, Bore WOH2139A recorded a 5.7 m decline and Bore OH1122(1) recorded a 0.2 m decline over 2019.

Groundwater level trends for VWP sensors installed within the Blakefield Seam are presented in **Figure 6-12**. The graph shows that over 2019 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 to the east.

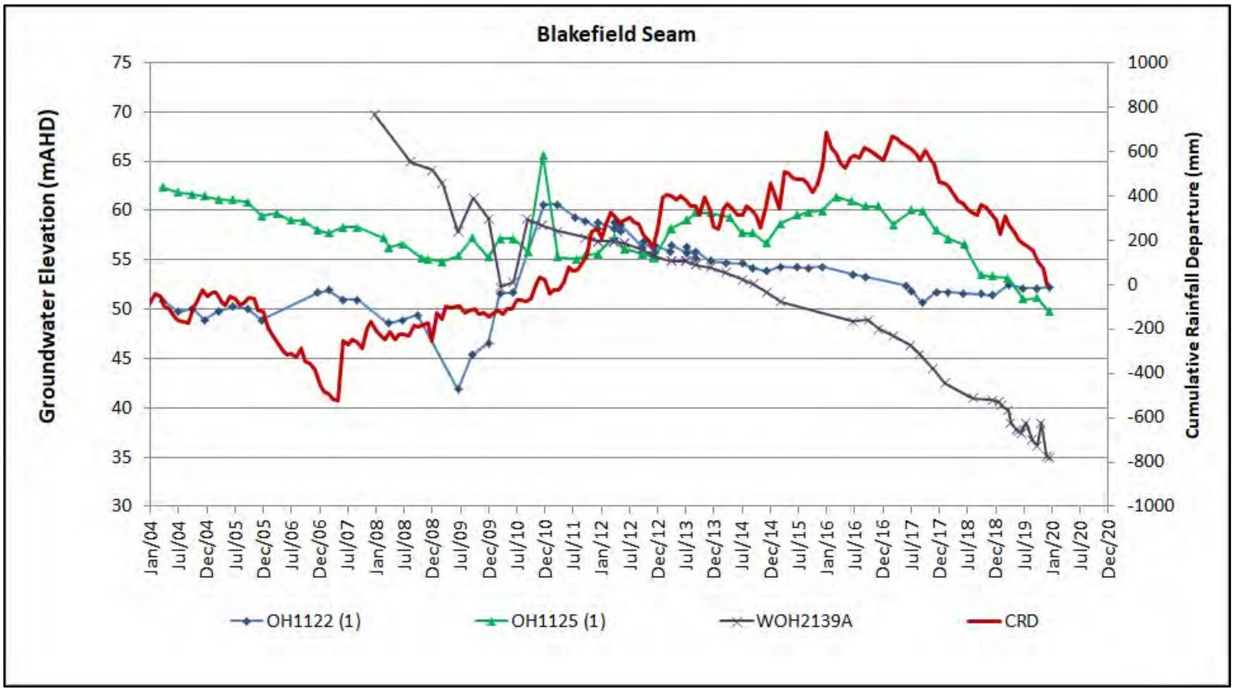


Figure 6-11 Hydrograph of Blakefield Seam

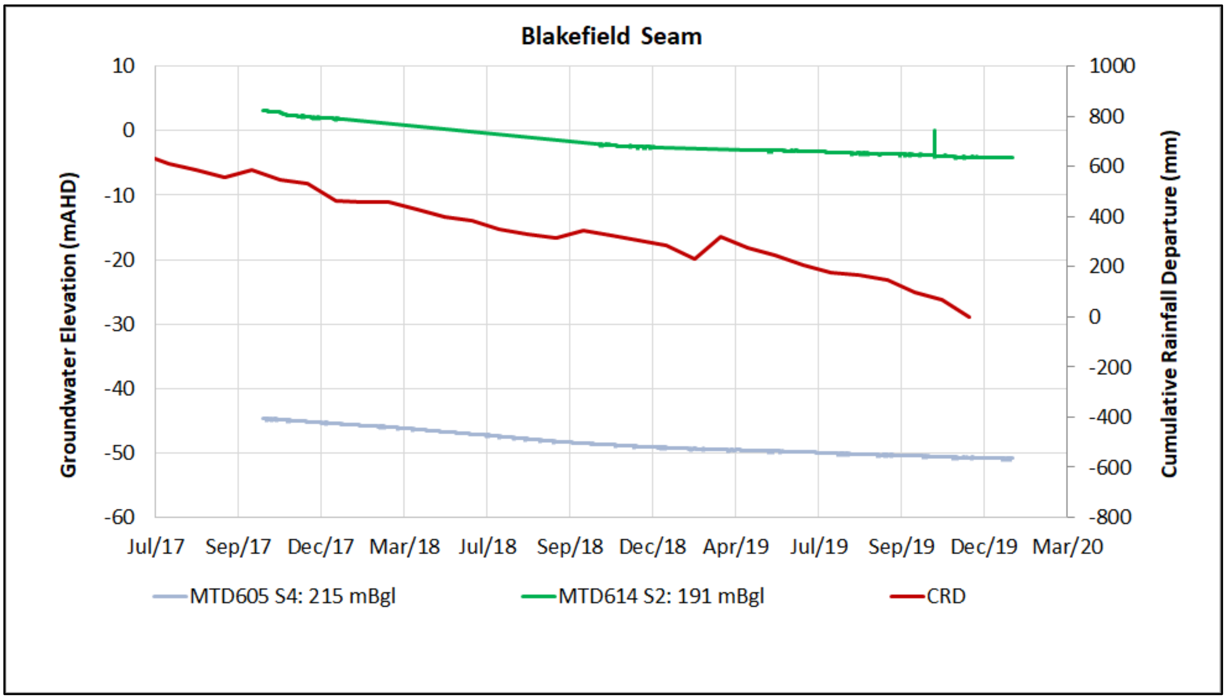


Figure 6-12 VWP Hydrograph of Blakefield Seam

6.2.3.4 Woodlands Hill Seam

Groundwater level trends for VWP sensors installed within the Woodlands Hill Seam are presented in **Figure 6-13**. The graph shows that over 2019 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 but generally decreasing groundwater elevations over 2019. The cause of these fluctuations is unclear but may relate to underground mine and water storage activities at Wambo.

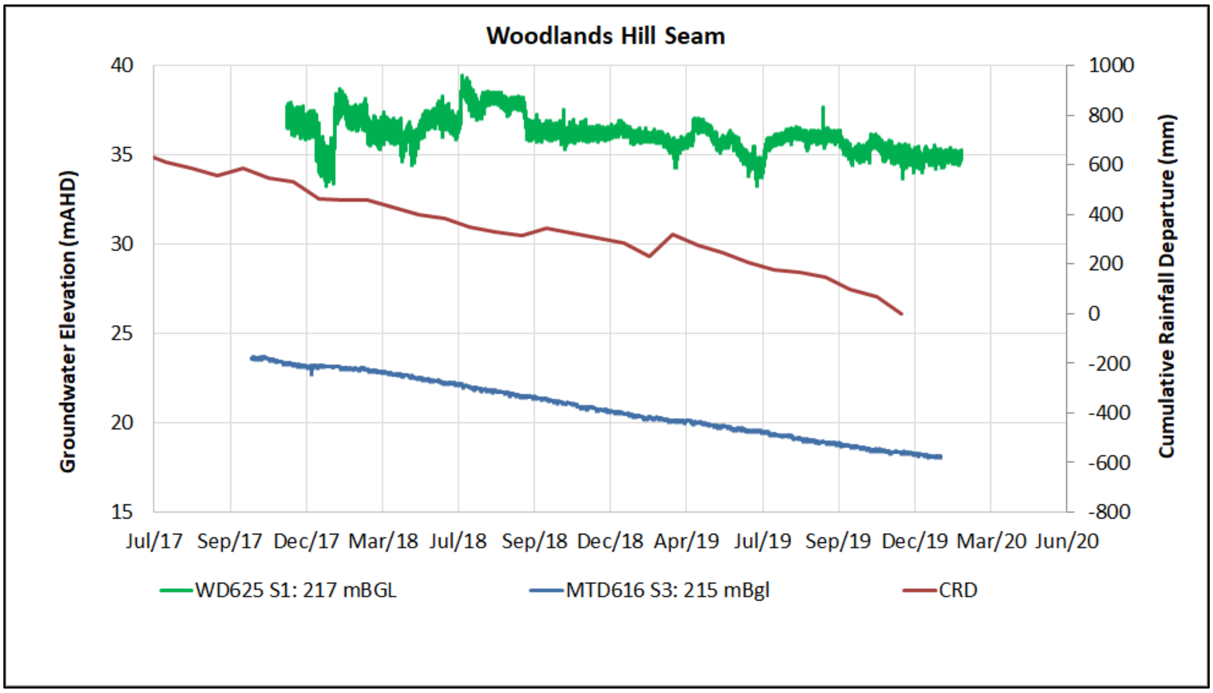


Figure 6-13 VWP Hydrograph of Woodlands Hill Seam

6.2.3.5 Bowfield Seam

Historical groundwater level trends for bores intersecting the Bowfield Seam are presented in **Figure 6-14**. The graph shows that over 2019 groundwater elevations in Bore OH1125(3) decreased from 47.19 mAHD to 29.71 mAHD, corresponding to the decrease in rainfall over this period. Bore OH1125(3) is located directly to the north of North Pit and the decline may relate to drawdown towards active mining within the pit to the south. The trend may also be influenced by abstraction from LUG Bore located approximately 1.25 km to the north west. The LUG bore intersects the historical Lemington Underground workings, which mined through the deeper Mt Arthur Seam. The increased groundwater level drawdown observed over 2019 may therefore be a combination of the effects of mining of the North Pit and licenced abstraction from the LUG bore.

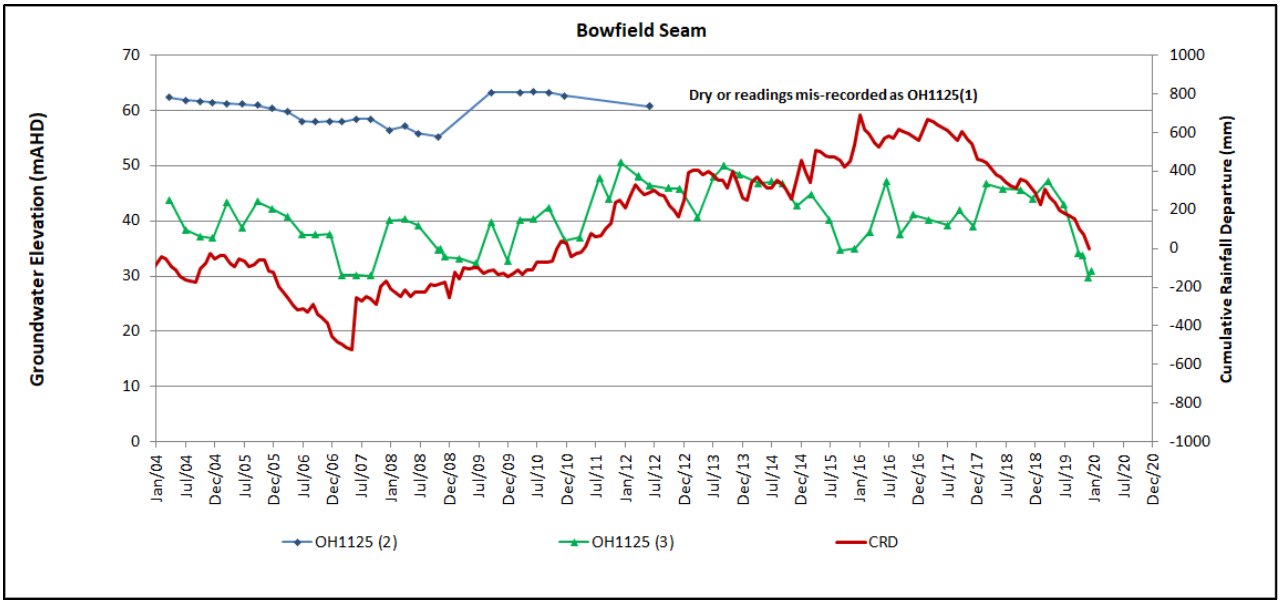


Figure 6-14 Hydrograph of Bowfield Seam

6.2.3.6 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 6-15**. The graph shows that over 2019 groundwater elevations ranged between 55.59 mAHD and 60.53 mAHD and level declined by up to 0.46 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 LUG Bore approximately 1.25 km to the north-west.

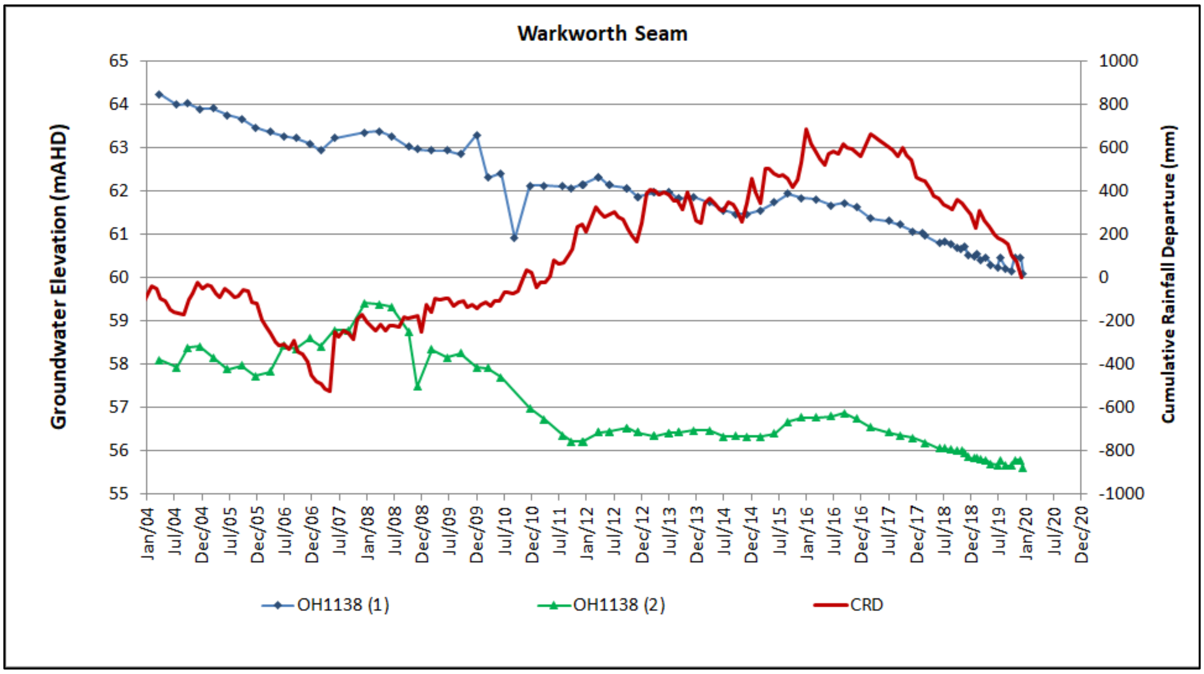


Figure 6-15 Hydrograph of Warkworth Seam

6.2.3.7 Mt Arthur and Piercefield Seams

Historical groundwater level trends for VWP sensors intersecting the Mt Arthur and Piercefield coal seams are presented in **Figure 6-16** and **Figure 6-17** respectively. At MTD605 water level data is only available up to November 2019. After this period the data is erroneous, suggesting that the sensor has failed.

Figure 6-16 shows that over 2019 groundwater elevations within the Mt Arthur Seam ranged between 1.84 mAHD and 34.59 mAHD with a groundwater level decline of up to 2.48 m observed. The large difference in groundwater elevations is related to the difference in sensor elevations across the VWPs. The accuracy of the MTD605 sensor data has previously been questioned due to the low elevations recorded. The sensor calibration details and reported construction depths have been confirmed which suggests a long term issue with the sensor prior to failure. Although the accuracy of the groundwater elevations for MT605 are questionable, the decreasing trend in water level corresponds with the MTD616 readings.

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 6-17 shows that over 2019 groundwater elevations within the Piercefield Seam increased from a low of 25.04 mAHD in February 2019 to 25.71 mAHD in December 2019 (0.67 m). VWP WD615 is located along the southern boundary of North Pit, within a rehabilitated area of the pit. The VWP sensor is located in the seam underlying the mined coal seam at this location. The increase in groundwater elevation within the Piercefield Seam is potentially an indication of recharge from the overlying spoil as groundwater recovery takes place in the rehabilitated areas.

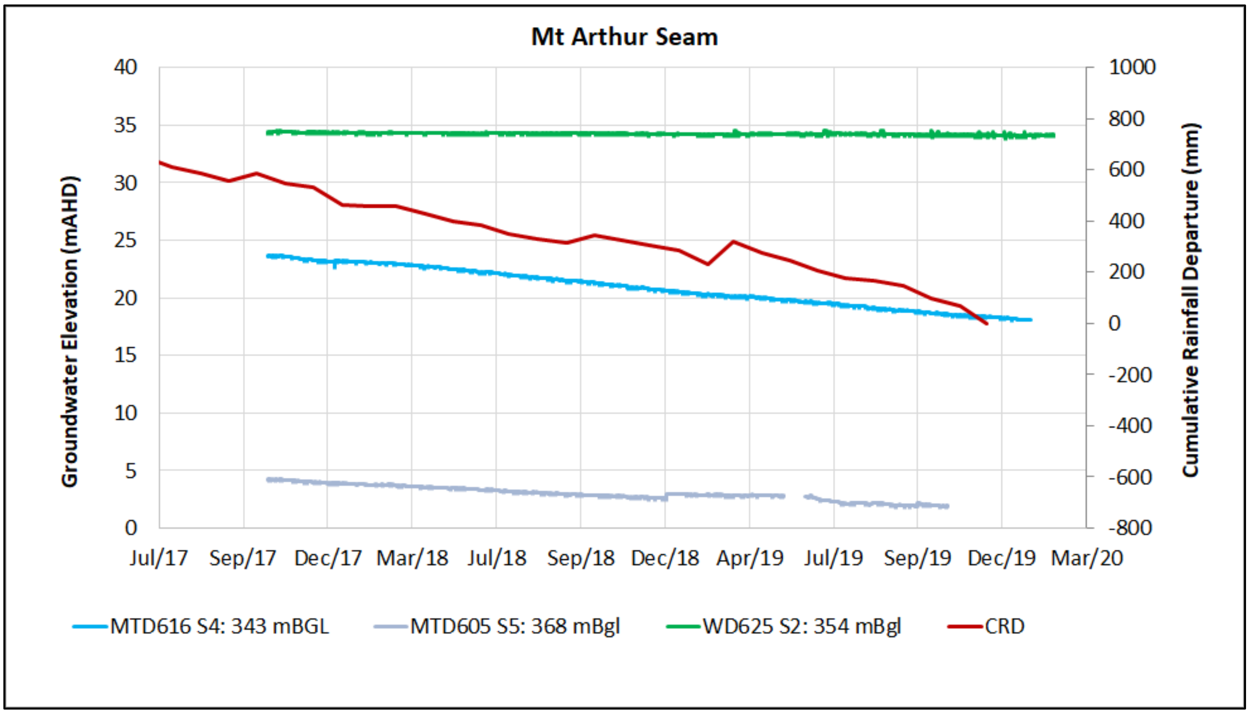


Figure 6-16 VWP hydrograph of Mt Arthur Seam

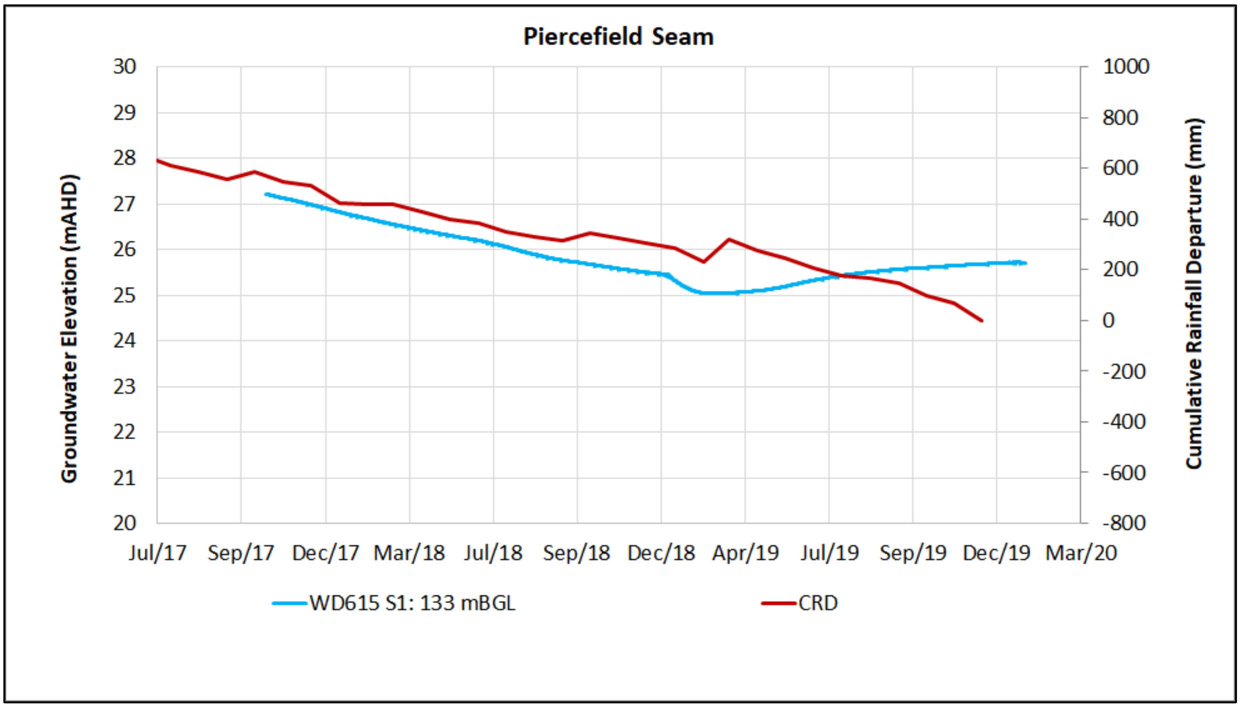


Figure 6-17 VWP hydrograph of Piercefield Seam

6.2.3.8 Vaux Seam

Historical groundwater level trends for bores intersecting the Vaux Seam around MTW are presented in **Figure 6-18**. The graph shows that over 2019 groundwater elevations within the Vaux Seam, north of North Pit, (OH1126 and OH1137) ranged between 46.18 mAHD and 53.08 mAHD. Levels declined by up to 0.55 m with OH1137 reported as dry from September 2019. 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 2019. 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 6-19**. Although the sensor for MTD605 appears to have failed in June 2019, the graph shows that over 2019 groundwater elevations were relatively stable. WD625 is located to the west of North Pit, MTD605 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 2019 groundwater levels within the Vaux Seam were not influenced by mine operations at these locations.

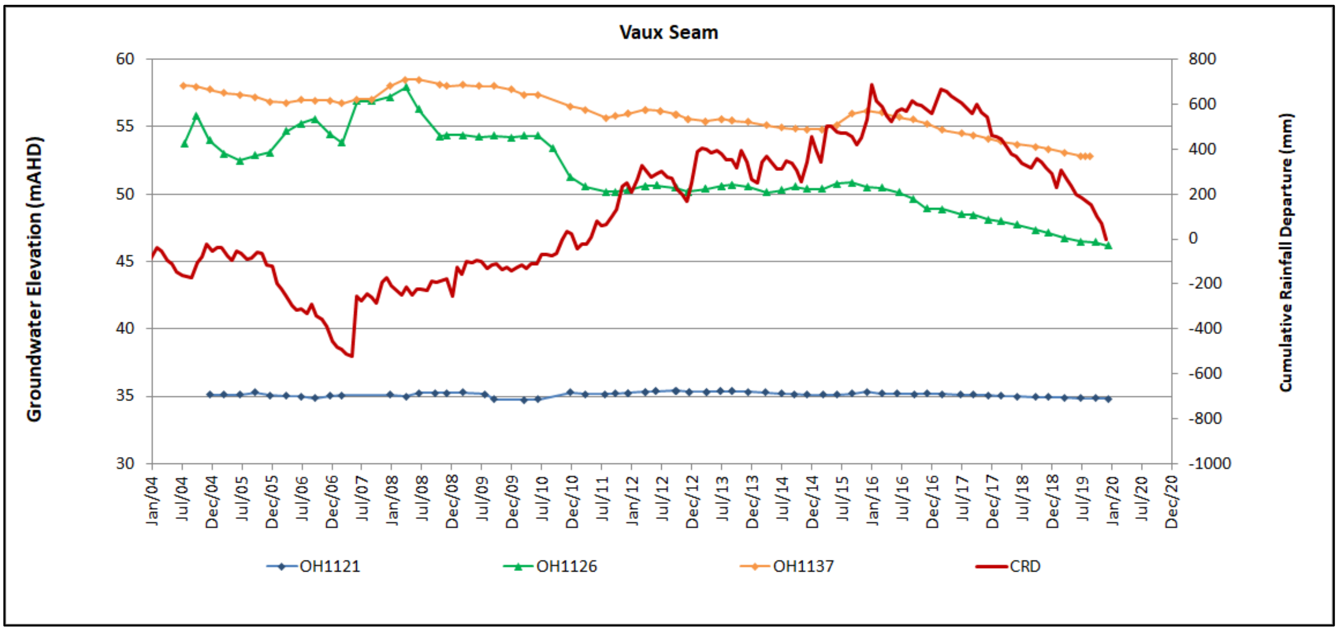


Figure 6-18 Hydrograph of Vaux Seam

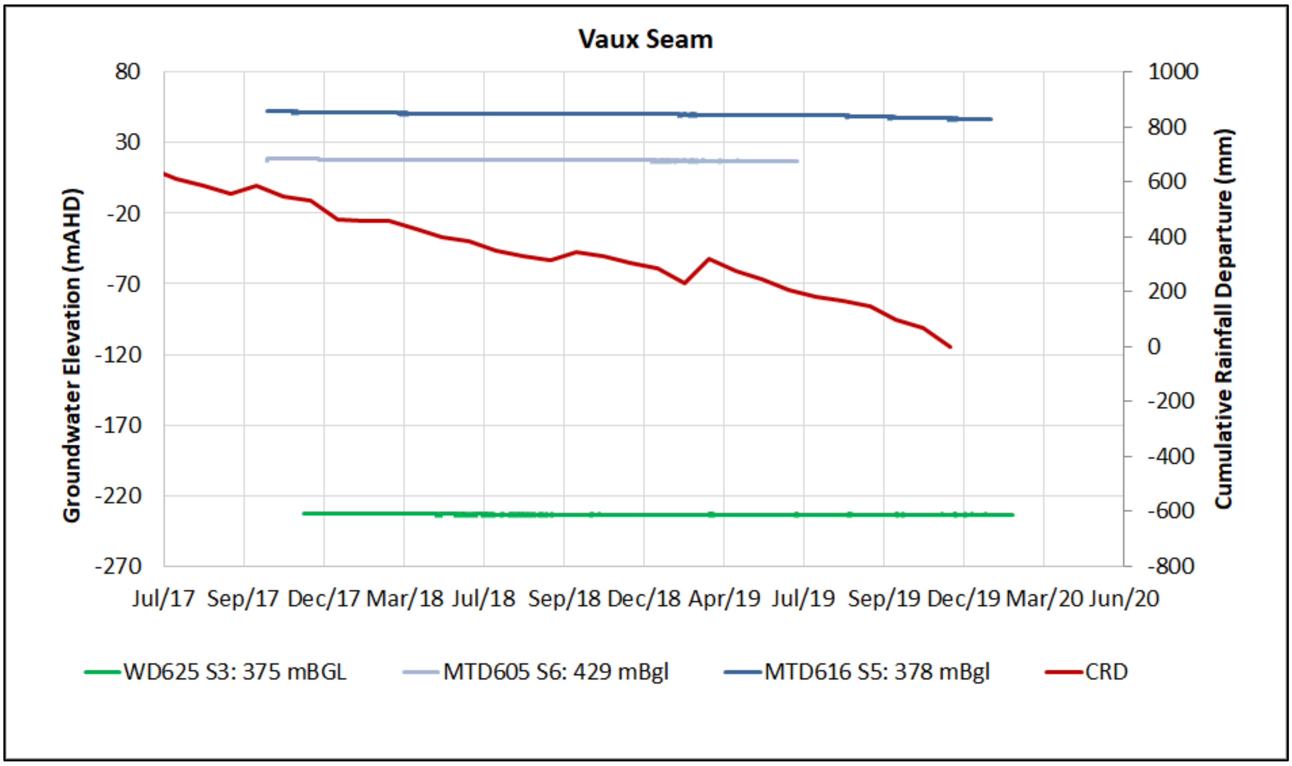


Figure 6-19 VWP hydrograph of Vaux Seam

6.2.3.9 Bayswater Seam

Historical groundwater level trends for bores intersecting the Bayswater Seam around MTW are presented in **Figure 6-20**. The graph shows that over 2019 groundwater levels remained relatively stable, with elevations ranging between 35.25 mAHD and 68.55 mAHD. All bores presented in **Figure 6-20** are located to the south east of South Pit.

Groundwater level trends for VWP sensors installed within the Bayswater Seam are presented in **Figure 6-21**. The graph shows that over 2019 groundwater elevations were relatively stable. The exception to this is WD615 where groundwater elevations increased. With the exception of WD615 all VWP locations are located to the west of the main mine pits (North Pit, West Pit and Loders Pit). WD615 is located in the east of the North 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. The increase in groundwater elevations observed in WD615 corresponds with the increasing elevations observed within the Piercefield Seam at the same location. The increase may again be an indication of recovering groundwater levels within rehabilitated areas of the North Pit resulting in recharge to the underlying coal seams

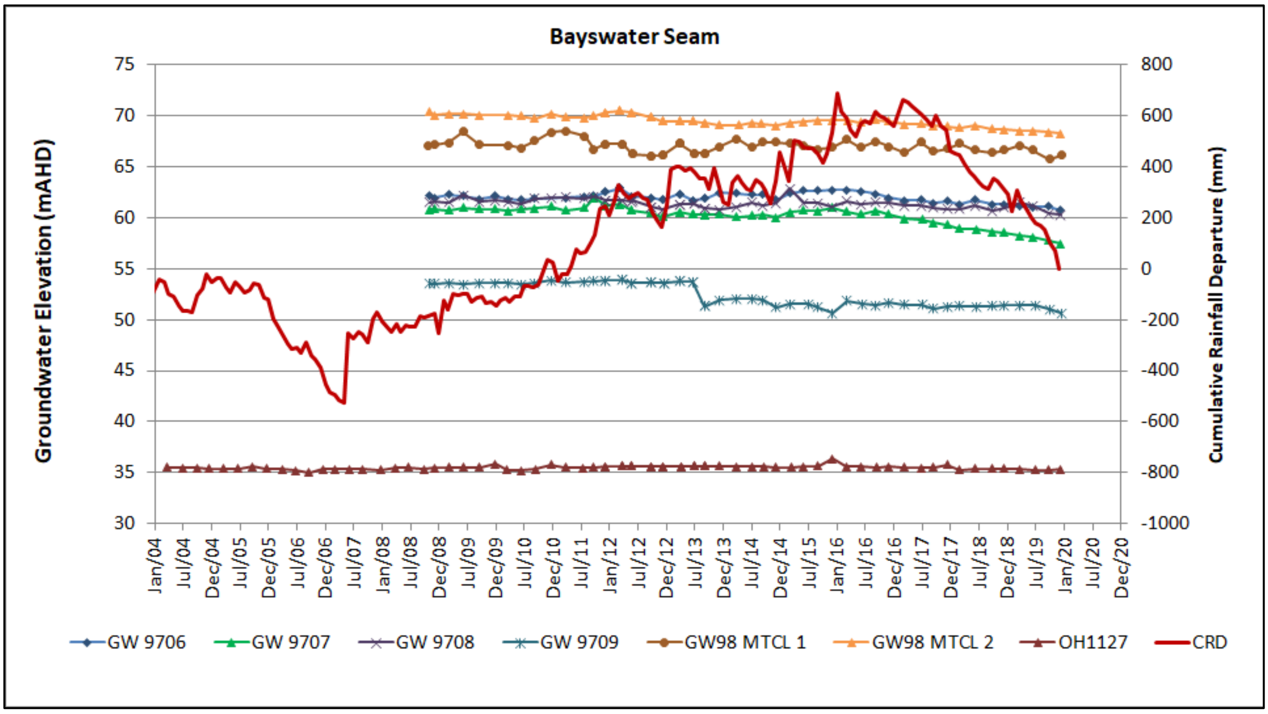


Figure 6-20 Hydrograph of Bayswater Seam

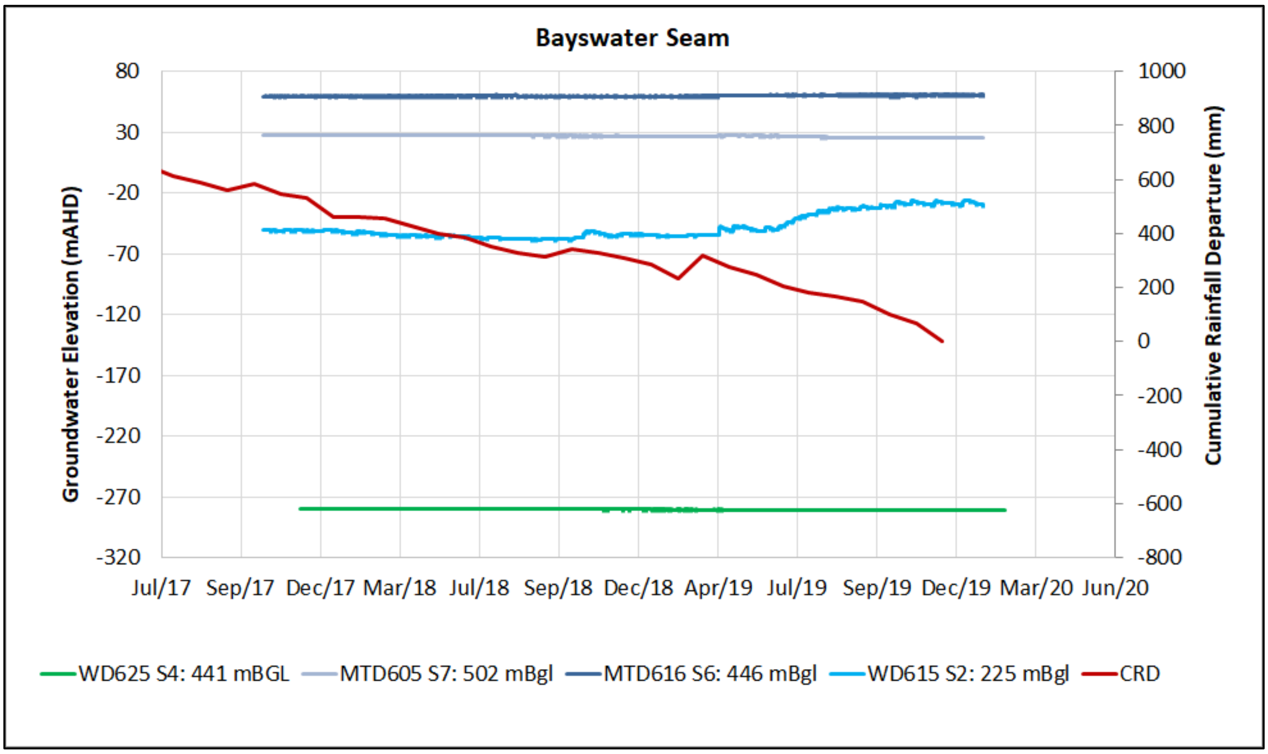


Figure 6-21 VWP hydrograph of Bayswater Seam

6.3 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.

6.3.1 Regolith

Over the 2019 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 Q1, Q3 and Q4;
- Bore OH787 recorded EC levels above the trigger level of 18,185 µS/cm in Q1 and Q4, and pH equal to the trigger level of 7.7 in Q2.
- Bore OH942 recorded EC levels marginally above the trigger level of 25,380 µS/cm in Q1 and Q2, with EC levels below the trigger level in Q3 and Q4. .

As discussed in **Section 5.3**, bores OH786 and OH787 recorded EC above the trigger threshold in 2018, and again in 2019. Previous investigations by AGE (2014b) indicates potential for seepage from TD1 and TD2.

Historical EC readings for OH787 since 2015 show regular fluctuations of between 17,070 µS/cm and 18,150 µS/cm. The 2019 readings of up to 19,160 µS/cm are therefore slightly above historical levels. This trend may relate to the area having received below average rainfall over most of 2019. Bore OH787 recorded groundwater levels of between 13.90 m and 13.96 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.

Historical EC readings for OH786 between 2012 and 2018 show regular fluctuations of between 440 µS/cm and 1,435 µS/cm. The 2019 readings of up to 2,760 µS/cm are therefore slightly above historical levels. This trend may relate to the area having received below average rainfall over most of 2019. Bore OH786 recorded groundwater levels of between 2.75 m and 7.02 m depth, which are above the reported base of the bore (7.1 m depth). Review of data shows that elevated EC concentrations correspond to events where water levels are reported close to the total bore depth. In addition review of sampling comments shows that during these events the presence of suspended solids in the purge water has been noted. It is therefore likely that the exceedances of the EC trigger level is a result of sediment within the collected sample influencing results rather than an indication of long term increasing trends.

6.3.2 Alluvium

Over 2019, 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 2019;
- OH943 and PZ9S were recorded as having insufficient water for sampling from March 2019; and
- Bores targeting the Warkworth Sands MB15MTW04 to MB15MTW11 were recorded as dry throughout 2019.

Alluvial groundwater quality over 2019 ranges between the different units, as discussed below:

- Warkworth Sands: EC ranges between 1,328 µS/cm and 1,641 µS/cm and pH ranges between 6.5 and 6.8 for bore PZ7S.
- Hunter River: EC ranges between 8,250 µS/cm and 13,850 µS/cm and pH ranges between 6.9 and 7.4;
- Regolith: EC ranges between 845 µS/cm and 25,400 µS/cm and pH ranges between 6.6 and 7.7; and
- Wollombi Brook: EC ranges between 715 µS/cm and 14,710 µS/cm and pH ranges between 6.2 and 7.6

Discussion in water quality trends and triggers is included for each alluvial unit from **Section 6.3.2.1** to **Section 6.3.2.3**.

Full water quality analysis was conducted for the site alluvial bores in accordance with the WMP. Exceptions to this include bores MB15MTW04 to MB15MTW10 and OH944 (dry throughout 2019), MB15MTW11 (could not be accessed) and OH786, OH943, and PZ9S (insufficient water available for sampling).

Full water quality data is presented in **Appendix D** and summarised below:

- Total aluminium: values ranged from below the limit of reporting (LOR) 0.01 mg/L to 0.85 mg/L (PZ7S);
- Total arsenic: values ranged from below the LOR of 0.001 mg/L to 0.004 mg/L (MB15MTW02S);
- Total cadmium: all values were recorded as below the LOR of 0.0001 mg/L;
- Total copper: values ranged from below the LOR of 0.001 mg/L to 0.02 mg/L (PZ8S);
- Total lead: concentrations below the limit of reporting of less than 0.001 mg/L, except for bores PZ7S and OH787 that recorded total lead concentrations of 0.01 mg/L and 0.003 mg/L respectively;
- Total nickel: values ranged from below the LOR of 0.001 mg/ to 0.087 mg/L (MB15MTW02S);
- Total selenium: all concentrations were below the LOR of 0.01 mg/L;
- Total zinc: concentrations generally below the limit of reporting or less than 0.01 mg/L, except for bores OH787, MB15MTW01S, and PZ8S that recorded total selenium concentrations of 0.087 mg/L, 0.01 mg/L and 0.013 mg/L respectively;
- Total boron: concentrations were variable ranging from below the LOR to 0.12 mg/L (OH787); and
- Total mercury: all concentrations were reported below the LOR of 0.001 mg/L with the exception of bore OH942 which recorded a total mercury concentration of 0.0007 mg/L.

6.3.2.1 Warkworth Sands

Over the 2019 monitoring period, the following triggers were exceeded for the bores within the Warkworth Sands alluvium:

- Bore PZ7S recorded a pH of 6.5 in Q3 which is marginally below the lower trigger level of 6.7.

Over 2019 the SWL in bore PZ7S decreased from 7.77 m to 8.07 m, and the depth of PZ7S is reported as 11.3 m. pH levels have fluctuated within PZ7S since 2012 and therefore the Q3 result is consistent with historic variations.

6.3.2.2 Hunter River Alluvium

Over the 2019 monitoring period, the following triggers were exceeded for the bores within the Hunter River alluvium:

- Bore OH788 recorded pH levels at and marginally below the lower trigger level of 7.1 throughout 2019. EC concentrations were also recorded above the trigger level of 11,742 µS/cm in Q2, Q3 and Q4.

Over 2019 SWL in bore OH788 was relatively stable ranging between 9.96 m to 10.03 m. The depth of bore OH788 is reported as 22.1 m with the screen depth reported as 21.6 m. Following recommendations made in the 2018 AEMR, the sampling methodology for the quarterly monitoring changed from a grab sample to low flow. The increase in EC concentrations observed over 2019 may be as a result of this change. Lower than average rainfall over 2019 may also contribute to an increase in EC concentrations within the Hunter River Alluvium with resulting in reduced recharge and therefore less fresh water entering the system.

6.3.2.3 Wollombi Brook Alluvium

Over the 2019 monitoring period, the following triggers were exceeded for the bores within the Woollombi Brook alluvium:

- Bore PZ9S recorded pH levels at the lower trigger limit of 6.8 in Q1; and.
- Bore PZ8S recorded pH levels below the trigger limit of 6.5 in Q4;

Over 2019 SWL in bore PZ9S decreased from 6.76 m to 6.91 m, and the depth of PZ9S is reported as 6.9 m. Through Q2 to Q4 insufficient water was available to undertake field testing. In addition, the Q1 sample recorded an EC concentration of 715 µS/cm which is significantly fresher than the EC concentration reported in the PZ8S bore. Based on this it is anticipated that the bore in Q1 may have been dry and the results likely reflect water within a sump at the base of the bore

6.3.3 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 2019. Exceptions to this include:

- OH1125(2) which could not be sampled as the bore was dry over 2019;
- OH1137 which was dry in Q2, Q3, and Q4;
- WOH2153B which was blocked in Q1 and had insufficient water for sampling in Q2 and Q3;
- WOH2156B which had insufficient water for sampling in Q2, Q3, and Q4;
- GW9709 had insufficient water for sampling in Q4; and
- MBW02 which could not be accessed in Q1.

Over 2019 groundwater within the shallow overburden material of the Permian coal measures recorded EC of between 1,664 µS/cm and 17,780 µS/cm and pH ranges between 6.3 and 8.0.

Over 2019 groundwater within the Permian coal measures recorded EC between 1,592 µS/cm and 23,300 µS/cm and pH ranges between 5.9 and 8.2.

In accordance with the WMP full water quality analysis was conducted for the bores targeting the Permian coal measures. Exceptions to this include OH1125(2) which could not be sampled as the bore was dry over 2019; OH1137 which was blocked; and WOH2153B and WOH2156B which had insufficient water for sampling. Full water quality data is presented in **Appendix D** and summarised below:

For bores within the shallow overburden:

- Total aluminium: concentrations ranged from 0.02 mg/L to 5.22 mg/L (MB15MTW01D);
- Total arsenic: concentrations ranged from below the LOR of 0.001 mg/L to 0.014 mg/L (PZ8D);
- Total cadmium: all bores reported concentrations which were below the LOR of 0.0001 mg/L;
- Total copper concentrations ranged from below the LOR of 0.001 mg/L to 0.012 mg/L (PZ8D);
- Total lead concentrations ranged from below the LOR of 0.001 mg/L to 0.034 mg/L (PZ8D);
- Total nickel concentrations ranged from below the LOR of 0.001 mg/L to 0.007 mg/L (MB15MTW02D);
- Total selenium: concentrations were below the LOR of 0.01 mg/L for all bores;
- Total zinc: concentrations ranged from below the LOR of 0.005 mg/L to 0.062 mg/L (MB15MTW02D);
- Total boron: concentrations ranged from 0.08 mg/L to 0.31 mg/L (MTD605P); and
- Total mercury: concentrations were below the LOR of 0.0001 mg/L for all bores.

For bores within the Permian Coal Measures:

- Total aluminium: concentrations ranged from 0.01 mg/L to 5.58 mg/L (WOH2154B);
- Total arsenic: concentrations ranged from below the LOR of 0.001 mg/L to 0.004 mg/L (OH1138(2));
- Total cadmium: concentrations ranged from below the LOR of 0.0001 mg/L to 0.0008 mg/L (OH1138(1));
- Total copper concentrations ranged from below the LOR of 0.001 mg/L to 0.04 mg/L (OH1138(2));
- Total lead concentrations ranged from below the LOR of 0.001 mg/L to 0.017 mg/L (OH1138(2) and OH1126);
- Total nickel concentrations ranged from below the LOR of 0.001 mg/L to 0.02 mg/L (OH1138(1));
- Total selenium: concentrations were below the LOR of 0.01 mg/L for all bores;
- Total zinc: concentrations ranged from below the LOR of 0.005 mg/L to 0.494 mg/L (WOH2154B);
- Total boron: concentrations ranged from below the LOR of 0.05 mg/L to 0.46 mg/L (GW9707); and
- Total mercury: concentrations were below the LOR of 0.0001 mg/L for all bores with the exception of (OH1138(1)) which recorded a concentration of 0.0018 mg/L.

6.3.3.1 Shallow Overburden Trigger Exceedances

Over the 2019 monitoring period, the following triggers were exceeded for bores within the shallow overburden.

- Bore MTD605P recorded an EC of above the trigger level of 17,490 in Q4;
- Bore MTD616P recorded a PH of below the lower trigger level of 6.9 in Q2, Q3, and Q4;
- Bore MB15MTW01D recorded a PH of below the lower trigger level of 6.9 throughout 2019.

6.3.3.2 Permian Coal Measures Trigger Exceedances

Over the 2019 monitoring period, the following triggers were exceeded for bores within the Permian coal measures.

- Bore WD625P recorded pH values at and below the lower trigger level of 7.1 in Q1 and Q2 and EC concentrations above the trigger level of 11,996 µS/cm in Q1 and Q3;
- Bore WOH2153A recorded pH values at and above the upper trigger level of 7.9 in Q2, Q3 and Q4;
- Bore WHO2154A recorded a pH value below the lower trigger level of 7.2 in Q1;
- Bore WHO2155A recorded a pH value at the upper trigger level of 7.9 in Q1;
- Bore WOH2153B recorded a pH value at the lower trigger level of 7.2 in Q4;
- Bore WHO2154B recorded a pH value below the lower trigger level of 7.2 in Q1;
- Bore WHO2155B recorded a pH value below the lower trigger level of 7.2 in Q1;
- Bore WOH2156B recorded an EC concentration above the trigger level of 13,843 µS/cm in Q1;
- Bore WD622P recorded pH values above the upper trigger level of 7.9 in Q1 and at and below the lower trigger level of 7.2 in Q2 and Q3. EC concentrations were also recorded above the trigger level of 13,843 µS/cm in Q2 and Q3;
- Bore WOH2139A recorded pH values at and above the upper trigger level of 7.6 from Q1 to Q4;
- Bore OH1138 (1) recorded pH values below the lower trigger value of 6.3 from Q1 to Q4;
- Bore OH1137 recorded a pH value at the trigger level of 7.1 and an EC concentration marginally above the trigger level of 17,745 µS/cm in Q1;
- Bore GW9709 recorded EC concentrations marginally above the trigger level of 22,991 µS/cm in Q1 and Q3;
- Bore GW98MCTL2 recorded pH at or below the lower trigger level of 6.6 throughout the whole of 2019;

Further discussion of EC and pH trends for bores WOH2139A and OH1138(1) is included below.

Bore WOH2139A is located directly west of North Pit and intersects the Blakefield Seam with a depth of 98 m. Additional to the quarterly monitoring events bore WOH2139A was monitored every month throughout 2019. All pH results were above the upper trigger limit throughout 2019. This is consistent with historical results since October 2017. EC concentrations for bore WOH2139A were within trigger limits throughout 2019; however, a significant increase in EC concentrations was also observed from October 2017. Comparison of the data shows that pH values and EC concentrations are generally inversely proportional to water levels, increasing as water levels decrease and vice versa. The trends for pH and EC in comparison to the SWL in the bore are presented in **Figure 6-22** and **Figure 6-23**. Given the proximity of WOH2139A to North Pit, the changes in water quality in relation to changes in water levels is expected.

The EC concentrations and pH values for bore WOH2139A are not consistent with those recorded in the other monitoring bores intersecting the Blakefield Seam (OH1122 (1) and OH1125 (1)). Within the monitoring network bore OH1125 (1) is located directly to the north of the North Pit, with bore OH1122 (1) located directly to the south of the West Pit. Review of historical and 2019 water quality data shows that the pH values and EC concentrations within these bores are similar and are therefore potential more representative of the Blakefield Seam. A review of the construction details and lithological logs for each bore should be undertaken to confirm that each bore is targeting the Blakefield Seam. In addition, review of sampling techniques shows that WOH2139A is a grab sample whereas bore OH1122 (1) is sampled using full purge techniques. The difference in techniques may therefore result in the variability in quality observed between the bores.

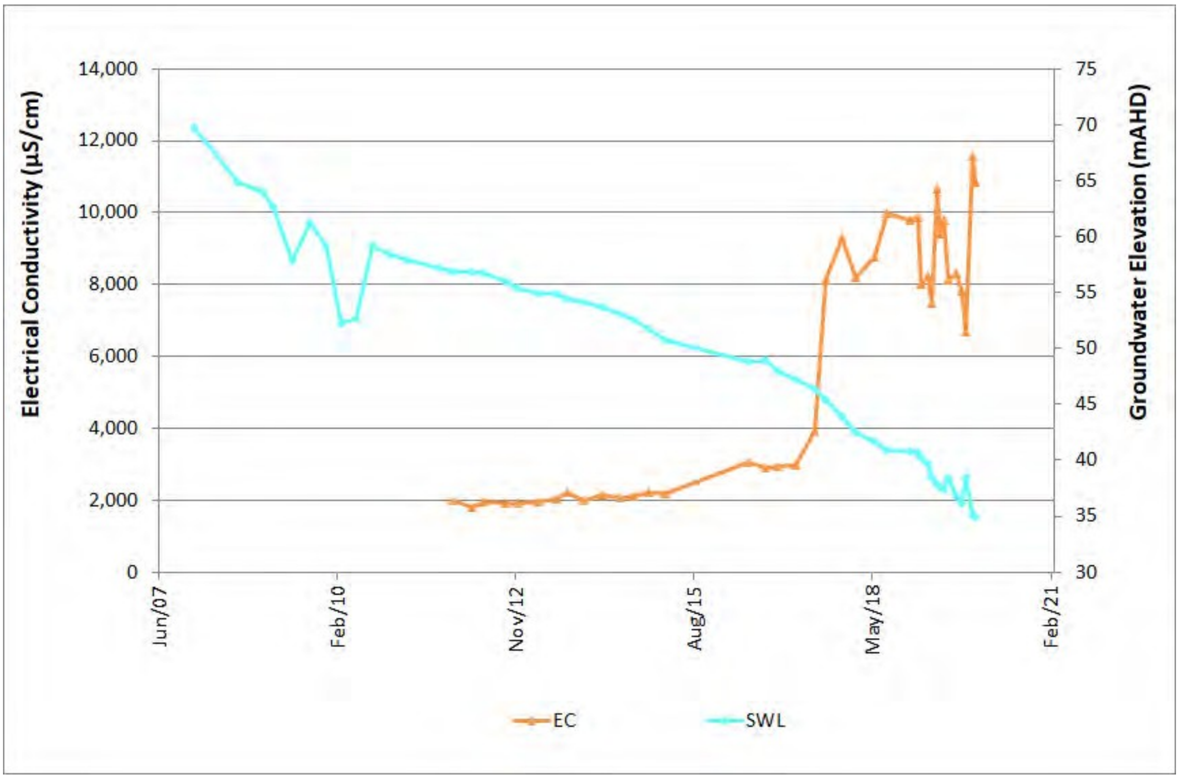


Figure 6-22 Electrical Conductivity and SWL Trends at WOH2139A

Figure 6-23 pH and SWL Trends at WOH2139A

Bore OH1138 is constructed as a nested bore with two sections of 32 mm PVC casing within the one hole, both of which target the shallow Warkworth Seam. OH1138(1) is apparently screened from 20.8 m to 24.8 m depth and OH1138(2) is apparently screened from 38.8 m to 42.8 m depth. The bores are located on the north side of North Pit.

Additional to the quarterly monitoring events bore OH1138(1) was monitored monthly throughout 2019. pH over 2019 was variable and consistently below the lower pH trigger threshold, with readings ranging between 5.9 (July 2019) to 6.2 (August 2019). Except for monitoring results from April 2019 and May 2019 EC concentrations were within trigger levels. pH and EC concentrations for bore OH1138 (2) were within trigger limits throughout 2019.

Trends in water quality for the two bores are presented in **Figure 6-24**. The graph shows that over 2019 pH readings in bore OH1138 (1) were generally stable with small variations from month to month. 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 6-24 shows that over 2019, trends in EC concentrations in both bore OH1138 (1) and OH1138 (2) were similar, with concentrations initially increasing until July 2019, decreasing until October 2019 and then increasing again across the rest of the year. Over 2019, the trigger level of 19,657 µS/cm was exceeded in bore OH1138 (1) in April and May. The graph includes available water quality data for adjacent surface water dam 27N, which shows no clear correlation to trends in OH1138. **Figure 6-25** shows that EC concentrations have fluctuated in OH1138 (1) since 2013, with no apparent correlation with the observed decline in groundwater levels.

Figure 6-24 Water Quality Trends at OH1138(1) and OH1138(2)

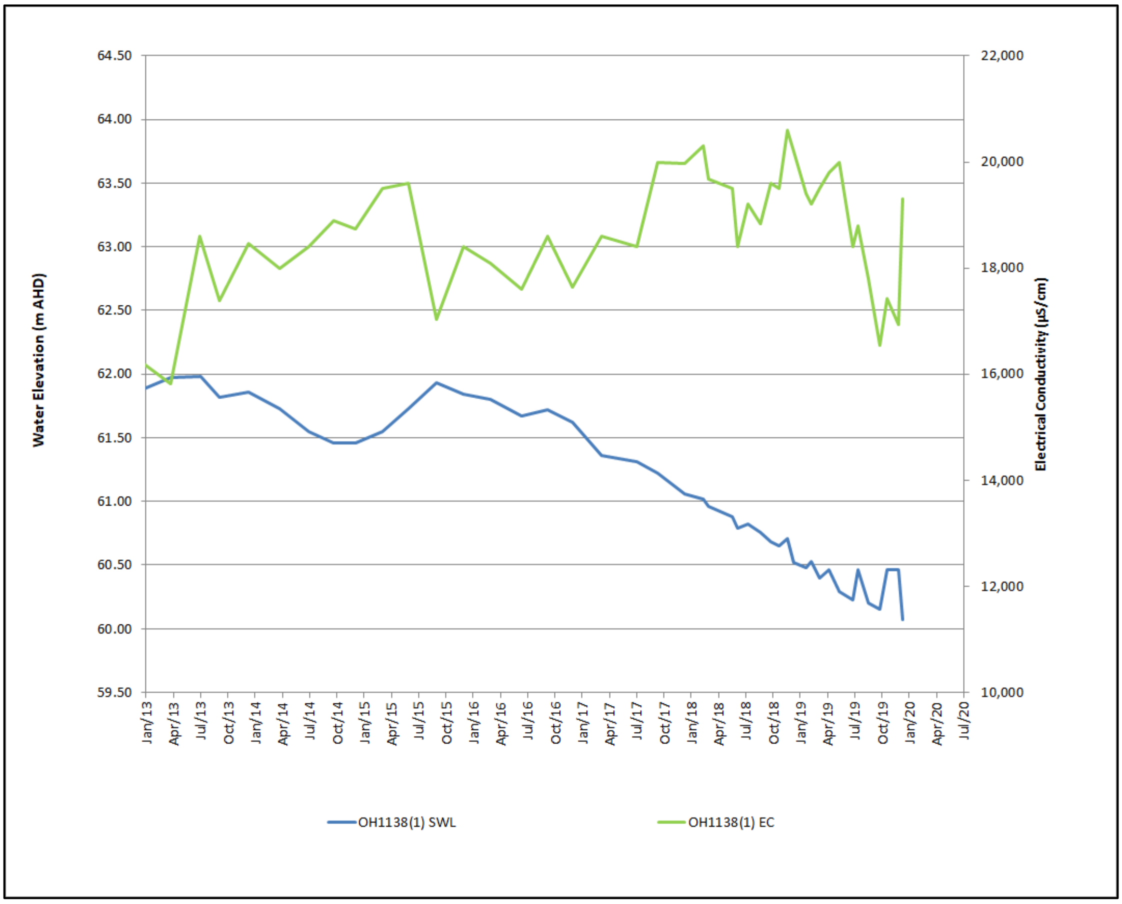


Figure 6-25 Electrical Conductivity and SWL Trends at OH1138(1)

6.4 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.

6.4.1 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 2019 was approximately:

- 3.5 ML from the Hunter River Regulated Water Source;
- 11 ML from the Hunter Unregulated and Alluvial Water Sources; and
- 270 ML from the North Coast Fractured and Porous Rock water source.

6.4.2 Surface Water Abstraction

Over 2019, surface water was abstracted from the Hunter River in accordance with licence conditions. Metered volumes recorded by Yancoal show 1,594 ML of water was pumped from the Hunter River over the 2019 calendar year.

6.4.3 Groundwater Abstraction

Lemington Underground (LUG) 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 (WAL 39798) 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 2018 to June 2019 a total of 1,315 ML of water was abstracted from the LUG bore, which is within the licensed allocation of 1,800 ML/year.

6.4.4 Summary of Water Take For 2019

Water take from the various groundwater and surface water sources associated with MTW are presented in **Table 6-4** for the 2019 calendar year. Abstraction volumes from the LUG bore are not presented within **Table 6-4** as they are reported through HVO's licencing and reporting processes.

Table 6-4 Predicted Groundwater Take (ML) for 2019

	Hunter Regulated	Hunter Unregulated	North Coast Fractured and Porous Rock
Mt Thorley Pit Excavation	~0.5	~5.0	~110
Warkworth Pit Excavation	~3.0	~6.0	~160
Surface Water Abstraction	1,594	0	-
Total	**1,597.5**	**11**	**~270**

As shown in **Table 6-4**, over the 2019 reporting year the total take under the Hunter River Regulated water source was estimated at 1,597.5 ML, total take from Hunter Unregulated water source was estimated at 11 ML and 270 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.

6.5 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 AGE, 2014b). 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 decline from 2017 and through 2019 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, model cell discretisation and influence from abstraction from LUG Bore not captured in the model.
- 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 licenced 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.
- Recent trends in observed data vary from modelled at VWP's WD625_P3, WD615_P2, MTD605_P2, MTD605_P3, MTD605_P6, MTD605_P7, MTD613, MTD518, and 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 2019 at most bores. However, work should 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 the licenced groundwater abstraction from LUG 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 including construction details and calibration certificates.

7 Conclusions and Recommendations

7.1 Conclusions

This annual groundwater review covers data collected over 2019 and was completed in compliance with:

- Warkworth Mine in accordance with Schedule 3 Condition 27 of the Warkworth Consent (SSD 6464); and
- Mt Thorley Mine in accordance with Schedule 3 Condition 25 of Development Consent (SSD 6465)

Over 2019 operations across MTW included active mining at North Pit, Loders Pit and West Pit. Tailings Dam 1 has been rehabilitated, and Tailings Dam 2 undergoing rehabilitation.

Review of climate data indicates that, with the exception of March (145.6mm), over 2019 the region generally experienced below average rainfall, and no flow has been recorded along Wollombi Brook.

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 monitoring. 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, pressurisation of sensors above their working limit). To ensure that water level data continues to be collected across all aquifer units a review of all bores and VWPs in which logger / sensor failures have been reported should be undertaken. The review should include an assessment into whether the faulty logger / sensor can be repaired or whether replacement / rectification works are required.

Available VWP and monitoring bore logger data was reviewed to assess trends in groundwater levels over 2019. 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 2019. 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 on a quarterly basis at nominated bores, 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 2019. It was identified that several bores exceeded triggers for EC and pH; however, 2019 readings were in line with historical trends for these bores. It is also noted that MTW changed its sampling methodology during the 2019 reporting period following recommendations in the 2018 review. It is recommended that a review of the trigger be undertaken in light of the revised sampling methodology. Groundwater quality trends outside of historical trends were observed for bore OH1138 and WOH2139A, which likely relate to declining groundwater levels. The decline in levels may relate to abstraction from the LUG Bore at Hunter Valley Operations to the north and the progression of mining activities associated with North Pit. Groundwater levels within the Warkworth Sands at PZ7S declined over the 2019, despite above average rainfall recorded in March 2019, similar to trends observed for bores in overburden. Further investigation into the ground conditions, bore construction and loggers at PZ7S and PZ7D is recommended.

Over 2019 monitoring of the groundwater bore network was generally conducted in accordance with the GMP outlined within the WMP. Following recommendations made in the previous Annual Review, quarterly sampling methodologies were changed in 2019 to be in general accordance with relevant standards. Annual samples were also collected in general accordance with relevant standards. The exception to this was generally for cases where the condition of the bores (i.e. 32 mm casing) inhibited the ability to collect representative samples. Grab samples have been taken for monitoring bores WOH1239A, WOH2141A, WOH2153A, WOH1254A, WOH2155A, WOH2156A, WD622P, MBW02 and MBW03 within the network. This approach is not in line with industry standards and may not provide a representative water quality sample. The justification for this methodology should be reviewed to determine if more suitable methods (i.e. full purge or low flow) can be applied. A review into the requirement of these bores for the collection of water quality data for the WMP should be undertaken. If it is found that the continued collection of water quality data is required from a bore and suitable sampling methods cannot be adopted, then bore rectification works should be considered.

Over 2019 water level and water quality readings were not taken at 19 bore locations 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 2019 reporting year the total take under the Hunter Regulated water source was estimated at 1,597.5 ML. Total take from Hunter Unregulated water source was estimated at 11 ML and 270 ML from the North Coast Fractured and Porous Rock water source.

Comparison of observed groundwater levels against predicted levels generated from the numerical groundwater model were made. Overall, the numerical model was found to have adequately replicated observed changes in groundwater levels for 2019. Where modelled and observed values were significantly different, it was largely found that the difference in values could be attributed to differences in actual and predicted site conditions (i.e. climatic conditions, changes to mine progression / activities etc). A number of recommendations are therefore related to updating the model including a review of VWP data and construction, better matching of actual mine progression, inclusion of the LUG bore abstraction and the inclusion of current climate and streamflow trends.

Overall, the current monitoring network and program is generally adequate for satisfying current monitoring requirements of the WMP. There is good spatial of coverage of monitoring locations across the site, with multiple bores and VWP sensors installed into each relevant aquifer unit. To ensure this is maintained a network review should be undertaken with the purpose of identifying existing monitoring infrastructure that may need rectification or replacement due to potential impacts from current and future mining.

7.2 Recommendations

Based on review of the available data for 2019, the following recommendations have been made:

- Review the groundwater monitoring network and program to more clearly identify the purpose of each bore based on its location and construction, and align the compliance conditions to this purpose. Including inclusion of newly installed monitoring points and removal of bores/sensors from the program that have been identified as destroyed/erroneous;
- Check surveyed ground and casing elevations for bores, particularly the MB15MTW bores;
- Check VWP's and monitoring bore loggers are working correctly (i.e. check/replace batteries and logger depths) and install a site barometric logger for atmospheric compensation;
- Installation of data loggers within bores MB15MTW02D and PZ8S;

- Review of logger installation depths for bores PZ8D, PZ9S, PZ7S, PZ7D and MB15MTW02S. Review required to confirm that the reported installation depths are correct and to ensure loggers are suitably placed below the standing water level;
- Investigate ground conditions, bore construction and logger data for nested bore PZ7S and PZ7D;
- Review geological and bore construction logs and geology for bores OH943, OH944, OH788, OH1121;
- Review site conditions around MTD616P and MTD614 to understand cause for rise in groundwater levels within shallow stratigraphy;
- Review of groundwater quality triggers to ensure they are reasonable and adequately capture historical trends for bores and account for changing climate conditions; and
- Continue to update the numerical groundwater model to more account for climate trends and actual mine progression activities that have evolved since the initial model development.

8 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.

SLR Consulting 2019, *Mt Thorley Warkworth Annual Groundwater Review*, prepared for Yancoal.

APPENDIX A

Groundwater Monitoring Program

ID	Easting	Northing	Top of Casing Elevation (mAHD)	Bore Depth (m bTOC)	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 (m bTOC)	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 (m bTOC)	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 2019

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	6.6	49.1	7.2	**1510**	2.8	52.9	7.1	845	6.7	48.9	7.1	**1920**	7.0	48.6	7.5	**2760**
OH787	Regolith	18185	7.2	7.7	13.9	36.1	7.6	**19100**	14.0	36.0	7.7	17310	14.0	36.0	7.6	17190	14.0	36.0	7.3	**19160**
OH788	Hunter River Alluvium	11742	7.1	7.9	1	35.4	7.1	11240	1	35.4	**7.0**	**12030**	1	35.4	**6.9**	**13850**	1	35.4	**7.0**	**13500**
OH942	Regolith	25380	6.4	7	9.3	46.4	6.6	**25400**	9.4	46.3	6.6	**25400**	9.5	46.3	6.6	25200	9.5	46.2	6.7	25300
OH943	Hunter River Alluvium	8415	7.1	7.6	9.6	35.5	7.4	8250	9.6	35.4			9.6	35.4			9.7	35.4		
OH944	Hunter River Alluvium																			
G3(2)	Wollombi Brook Alluvium																			
PZ8S	Wollombi Brook Alluvium	15200	6.5	7	6.2	59.5	6.6	14610	6.3	59.4	6.7	14580	6.4	59.4	6.8	13420	6.5	59.2	**6.2**	14710
PZ9S	Wollombi Brook Alluvium	16140	6.8	7	6.8	58.7	6.8	715	6.8	58.7		0	6.8	58.6			6.9	58.5		0
MB15MTW01S	Wollombi Brook Alluvium				6.9	56.4	**6.7**	**1533**	7.1	56.3	**6.9**	**3730**	7.1	56.3	**6.7**	**2160**	7.1	56.2	**6.6**	**2320**
MB15MTW02S	Wollombi Brook Alluvium				6.8	55.3	**7.6**	**2610**	7.0	55.2	**6.8**	**3840**	7.1	55.1	**6.8**	**3980**	7.1	55.0	**6.8**	**4000**
PZ7S	Aeolian Warkworth Sands				5.9	56.5	**7.5**	**16690**	5.9	56.5	**7.3**	**18200**	6.0	56.4	**7.4**	**15430**	6.1	56.3	**7.3**	**17580**
MBW01	Alluvium	1752	6.7	7.5	7.8	50.7	6.8	1407	7.9	50.6	6.7	1641	7.8	50.6	**6.5**	1328	8.1	50.4	6.8	1451
MB15MTW04	Warkworth Sands																			
MB15MTW05	Warkworth Sands																			
MB15MTW06	Warkworth Sands																			
MB15MTW07	Warkworth Sands																			
MB15MTW08	Warkworth Sands																			
MB15MTW09	Warkworth Sands																			
MB15MTW10	Warkworth Sands																			
MB15MTW11	Warkworth Sands																			

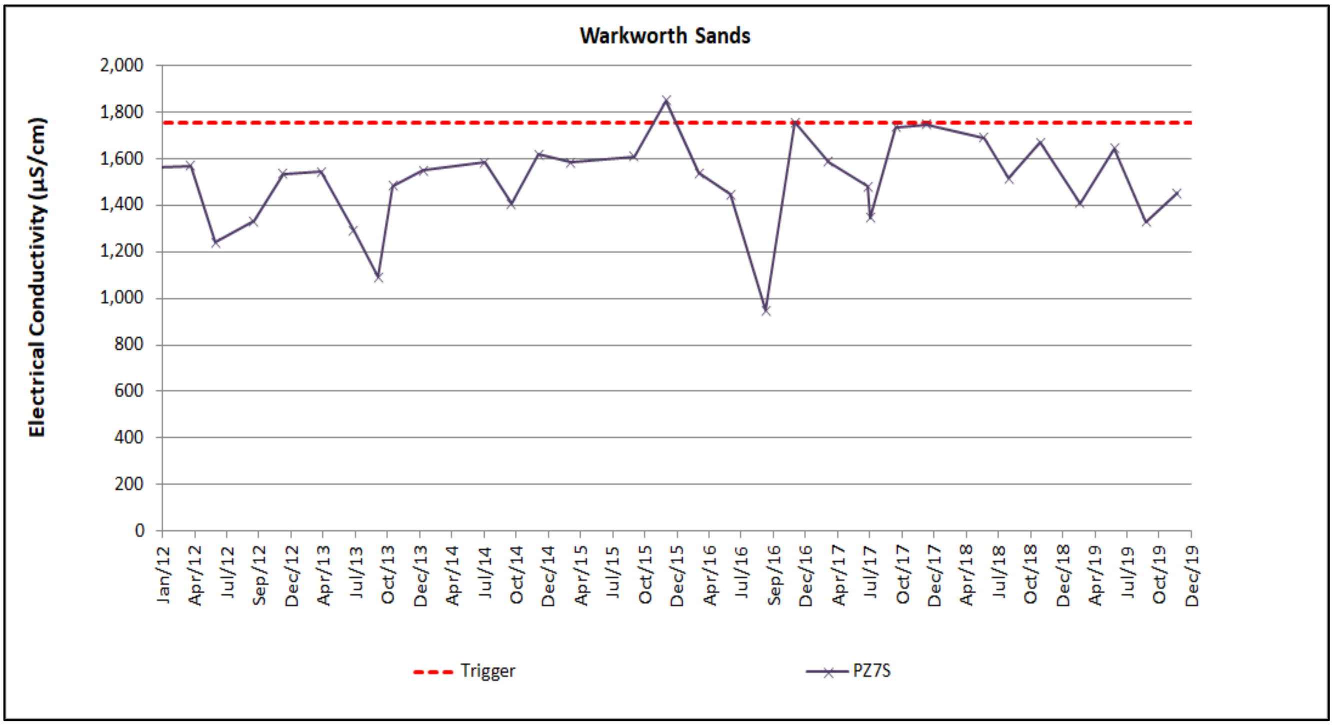
Bore ID	Target Geology	EC Trigger 95th	pH Trigger 5th–95th		Q1				Q2				Q3				Q4			
					SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC
PZ7D	Shallow Overburden	17490	6.9	8.1	7.7	50.8	7.8	1710	7.8	50.6	7.6	1686	7.7	50.7	7.6	1710	7.8	50.6	7.6	1664
PZ8D	Shallow Overburden	17490	6.9	8.1	6.6	59.2	7.5	8410	6.8	59.0	7.4	8500	7.2	58.5	7.5	8130	7.6	58.2	7.3	8670
PZ9D	Shallow Overburden	17490	6.9	8.1	17.7	47.8	7.1	10110	17.7	47.8	7.1	9970	17.8	47.7	7.1	8600	17.9	47.6	7.0	10330
MTD616P	Shallow Overburden	17490	6.9	8.1	6.5	71.4	7.6	14540	6.2	71.6	**6.8**	13880	6.1	71.8	**6.8**	14100	6.1	71.8	**6.7**	14600
MTD614P	Shallow Overburden - Conglomerate	17490	6.9	8.1	17.9	54.7	7.3	6160	18.0	54.6	7.5	5940	18.1	54.5	7.3	6840	17.9	54.7	7.2	9390
MBW02	Shallow Overburden	17490	6.9	8.1					8.3	54.3	7.3	7910	8.4	54.2	7.2	11150	8.6	54.1	7.2	12340
MB15MTW01D	Shallow Overburden?	17490	6.9	8.1	7.0	56.3	**6.3**	3330	7.0	56.4	**6.7**	2250	7.1	56.2	**6.3**	3900	7.4	55.9	**6.4**	3400
MTD605P	Shallow Overburden - sandstone	17490	6.9	8.1	15.1	62.3	7.7	17130	15.1	62.3	7.3	17130	15.1	62.3	7.7	16840	15.0	62.3	7.2	**17780**
MB15MTW02D	Shallow Overburden?	17490	6.9	8.1	6.6	55.4	8.0	9400	6.6	55.4	7.7	10200	6.7	55.3	7.6	9850	6.8	55.2	7.8	9400
MB15MTW03	Shallow Overburden?	17490	6.9	8.1	6.4	54.5	7.1	11860	6.6	54.4	7.0	12760	6.7	54.2	7.0	11030	6.8	54.1	6.9	12640
WD625P	Whybrow Seam	11996	7.1	7.3	18.7	57.7	**6.1**	**12520**	18.8	57.7	7.1	11200	19.3	57.1	7.2	**12180**	19.0	57.4	7.2	11910
MBW03	Whybrow Seam				8.0	54.4	**7.4**	**9680**	8.1	54.3	**7.3**	**9940**	8.2	54.2	**7.2**	**8980**	8.3	54.1	**7.3**	**9790**
WOH2153A	Redbank Crk Seam	16123	7	7.9	14.0	54.2	7.8	2080	15.0	53.3	7.9	2410	14.4	53.8	**8.0**	2260	15.3	53.0	**8.0**	2550
WOH2154A	Redbank Crk Seam	16123	7	7.9	16.1	52.8	**6.8**	4610	16.1	52.8	7.7	4730	16.9	52.0	7.7	4680	18.1	50.8	7.5	4750
WOH2155A	Redbank Crk Seam	16123	7	7.9	20.7	53.8	7.9	7200	21.0	53.6	7.2	9050	23.0	51.6	7.2	9350	24.7	49.9	7.2	9000
WOH2156A	Redbank Crk Seam	16123	7	7.9	28.8	51.6	7.1	15210	28.9	51.5	7.1	14860	30.7	49.7	7.1	14680	32.6	47.8	7.1	14960
WOH2153B	Wambo Seam	13843	7.2	7.8	10.9	57.3			11.0	57.3			11.1	57.2			11.1	57.2	7.2	1592
WOH2154B	Wambo Seam	13843	7.2	7.8	13.7	55.0	**6.9**	4910	14.4	54.2	7.5	5170	13.7	54.9	7.4	7620	13.8	54.9	7.3	8360
WOH2155B	Wambo Seam	13843	7.2	7.8	15.2	59.4	**6.7**	5490	15.3	59.3	7.7	5430	15.5	59.1	7.7	5390	15.6	59.0	7.6	5440
WOH2156B	Wambo Seam	13843	7.2	7.8	12.7	67.7	7.3	**14080**	12.8	67.6			12.7	67.7			12.7	67.7		
WD622P	Wambo Seam	13843	7.2	7.8	31.5	53.0	**8.0**	7560	31.9	52.6	**6.8**	**17830**	35.9	48.5	**6.9**	**14100**	37.9	46.6	7.4	8780

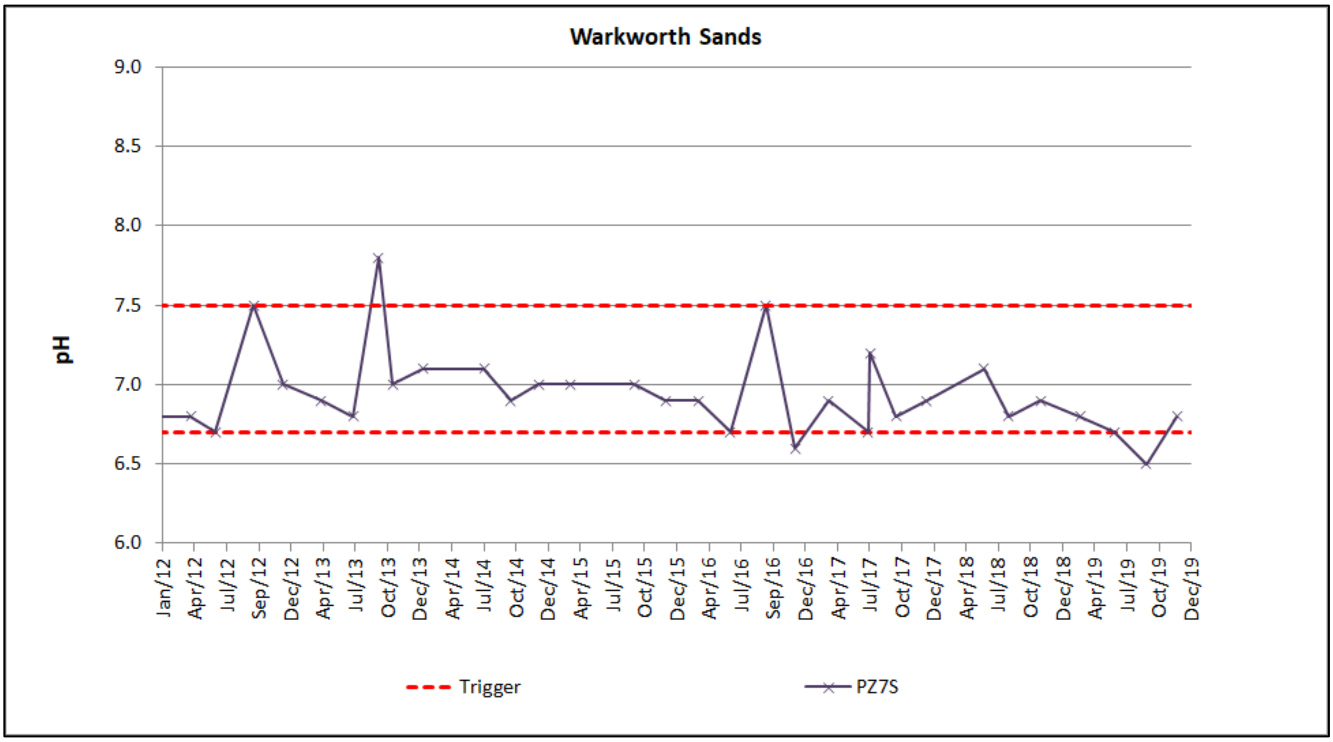
Bore ID	Target Geology	EC Trigger 95th	pH Trigger 5th –95th		Q1				Q2				Q3				Q4			
					SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC	SWL mbTOC	SWL mAHD	pH	EC
MBW04	Wambo	13843	7.2	7.8	12.2	50.2	7.6	12650	12.4	5	7.6	13190	12.6	49.8	7.5	11380	12.8	49.6	7.5	12930
WOH2139A	Blakefield	15161	6.6	7.6	52.0	39.7	**7.8**	8230	54.1	37.7	**8.0**	9420	55.0	36.8	**7.9**	8320	56.6	35.1	**8.2**	11550
OH1122 (1)	Blakefield Seam	15161	6.6	7.6	48.7	52.5	7.0	12090	49.1	52.1	7.1	12060	49.1	52.1	7.1	12130	48.9	52.3	7.1	12160
OH1125 (1)	Blakefield	15161	6.6	7.6	33.0	53.2	6.8	14230	35.2	51.0	6.8	12540	35.1	51.1	6.7	11410	36.5	49.7	6.7	13970
OH1125 (2)	Unknown	14696	6.6	7																
OH1125 (3)	Bowfield Seam	14696	6.6	7	39.0	47.2	6.8	14130	43.3	42.8	6.8	12440	52.0	34.2	6.7	11410	55.3	30.9	6.8	13980
OH1138 (1)	Warkworth	19657	6.3	7	10.3	60.4	**6.0**	19500	10.5	60.2	**6.2**	18400	10.6	60.2	**6.1**	16550	10.7	60.1	**6.0**	19300
OH1138 (2)	Warkworth	19657	6.3	7	14.9	55.8	6.7	13420	15.1	55.7	6.7	12730	15.1	55.6	6.7	11780	15.1	55.6	6.6	13920
OH1121	Vane Subgroup	17745	6.7	7.1	10.8	34.9	7.0	8100	10.8	34.9	7.0	8860	10.8	34.8	6.9	9150	10.8	34.8	6.9	9320
OH1126	Vaux	17745	6.7	7.1	17.8	46.7	6.8	9750	18.0	46.5	6.9	12280	18.1	46.4	6.9	10670	18.3	46.2	6.8	14360
OH1137	Vaux	17745	6.7	7.1	14.8	53.1	7.1	**17790**	15.0	52.8										
OH1127	Vane Subgroup	22991	6.6	7.5	15.9	35.3	6.7	12190	15.9	35.3	6.9	12080	16.0	35.3	6.8	12120	15.9	35.3	6.9	12170
GW 9706	Bayswater	22991	6.6	7.5	3.1	61.1	7.1	3160	3.2	61.1	7.1	4170	3.1	61.1	7.0	4790	3.5	60.7	6.8	4250
GW 9707	Bayswater	22991	6.6	7.5	5.7	58.2	7.0	21200	5.8	58.1	7.0	20800	6.1	57.8	7.1	20900	6.5	57.5	6.9	20600
GW 9708	Bayswater	22991	6.6	7.5	11.6	61.5	6.8	15990	11.9	61.2	6.8	13120	12.8	60.4	6.8	13600	12.9	60.3	6.6	13420
GW 9709	Bayswater	22991	6.6	7.5	8.9	51.4	6.8	**23300**	8.9	51.4	6.9	20000	9.3	51.1	6.9	**23000**	9.7	50.6		
GW98MTCL1	Bayswater	22991	6.6	7.5	10.7	67.1	7.3	6180	11.1	66.7	7.1	7560	12.0	65.7	7.0	6020	11.6	66.2	7.0	6010
GW98MTCL2	Bayswater	22991	6.6	7.5	10.9	68.6	6.6	16510	11.0	68.5	6.6	16300	11.1	68.4	6.6	16360	11.2	68.3	**6.5**	16540
WOH2141A	Whynot Seam				43.9	47.7	**7.7**	**10260**	44.2	47.4	**7.8**	**10220**	44.3	47.3	**7.8**	**10220**	44.4	47.2	**7.8**	**10390**
MBW6A					8.3		**6.6**	**990**	8.3		**6.7**	**968**	8.3		**6.3**	**924**	8.4		**6.4**	**953**

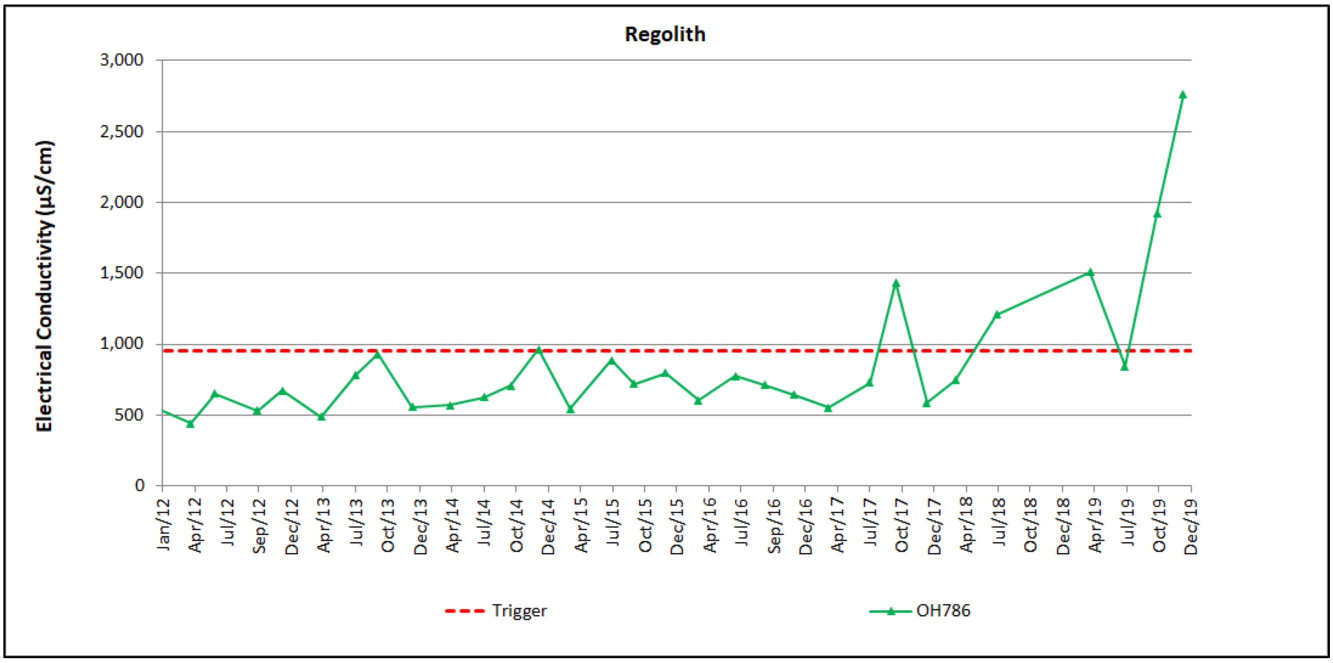
***Note**:* *SWL – standing water level*
mbTOC – meters below top of casing
NS – Casing elevation not surveyed

APPENDIX C

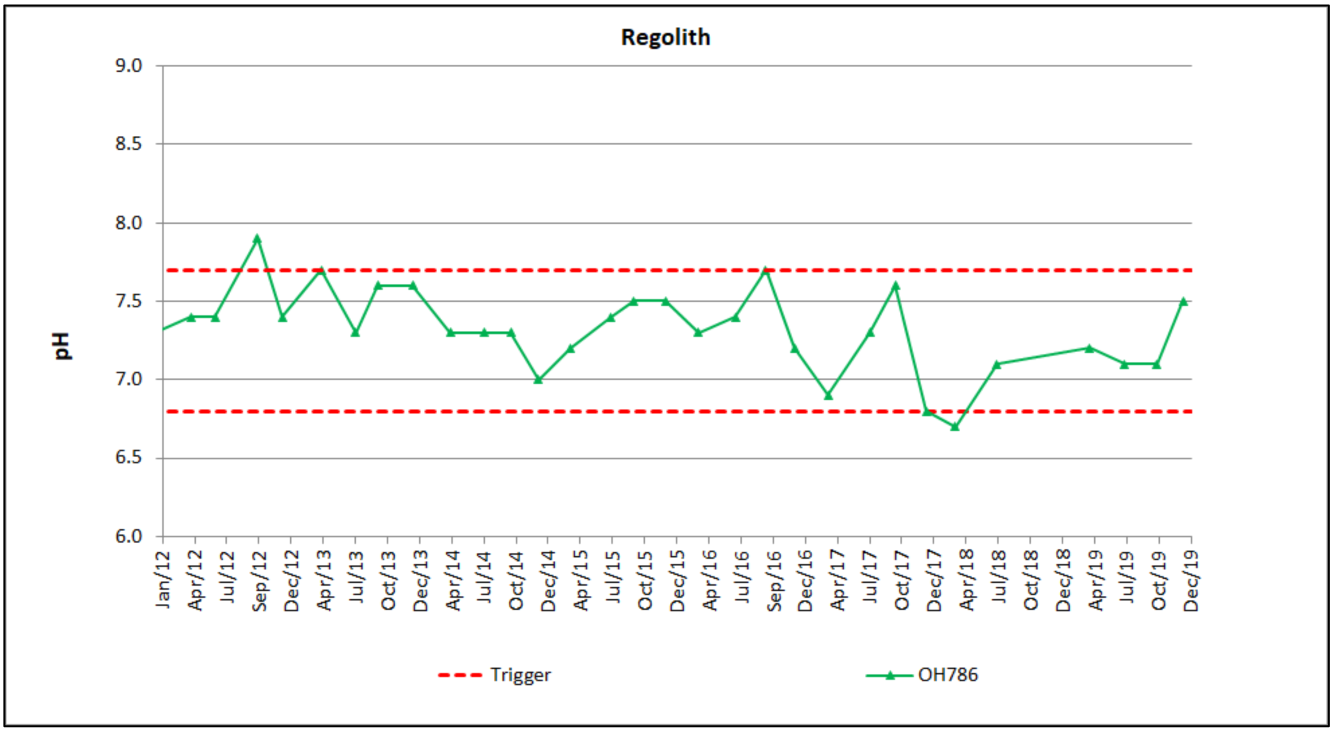
Groundwater Quality Graphs


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
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
PZ7S

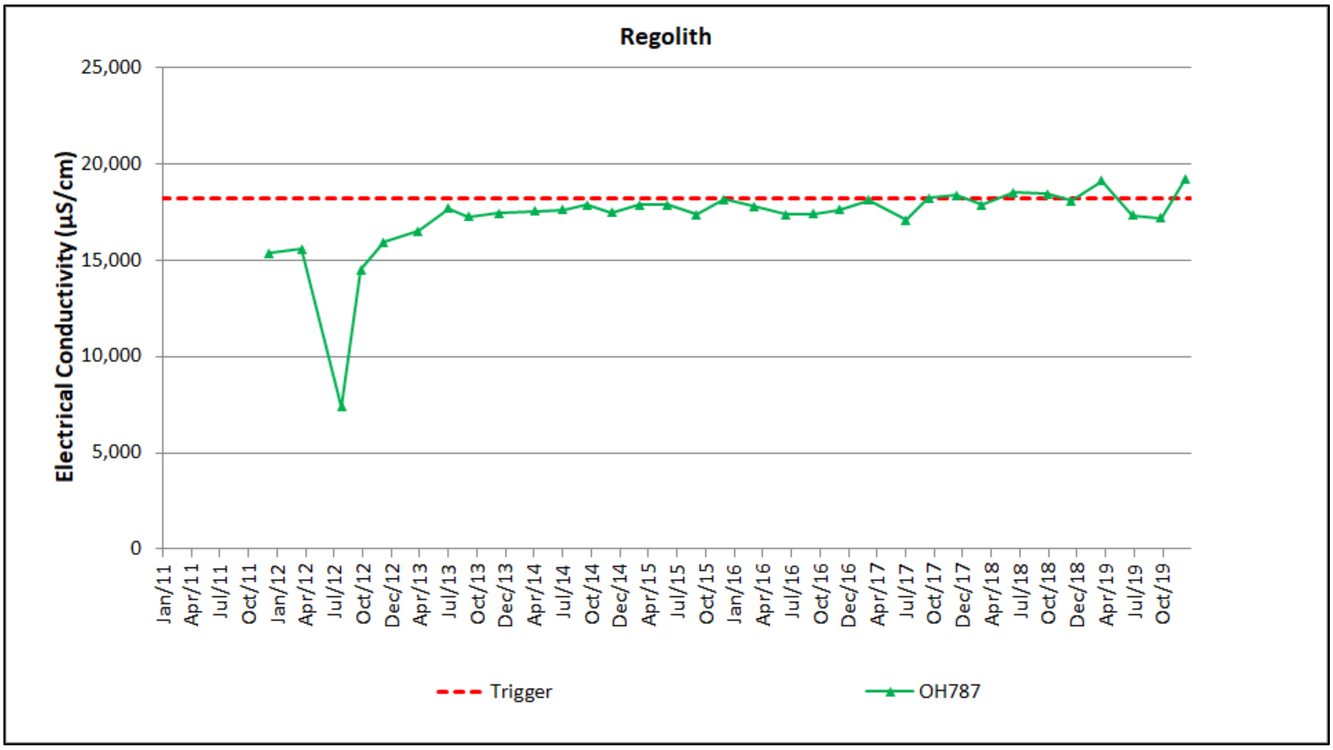

Warkworth Sands
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
PZ7S

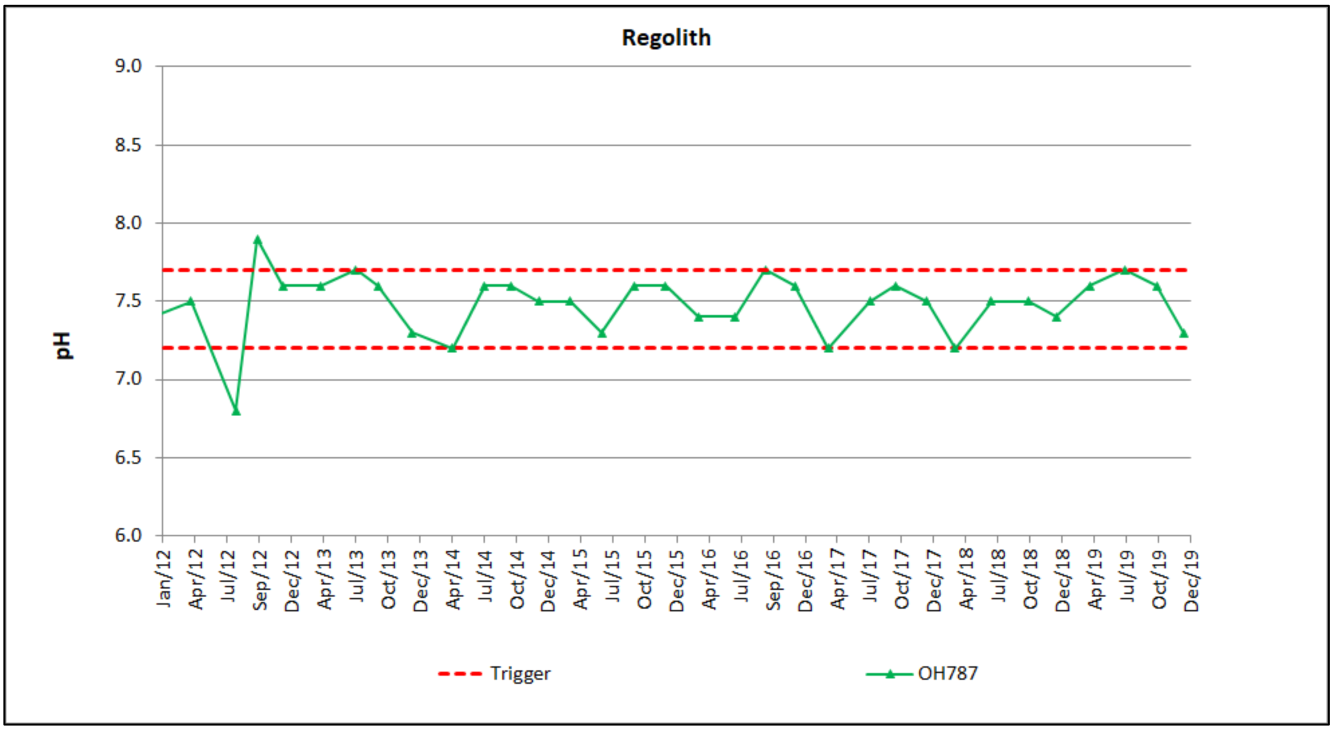


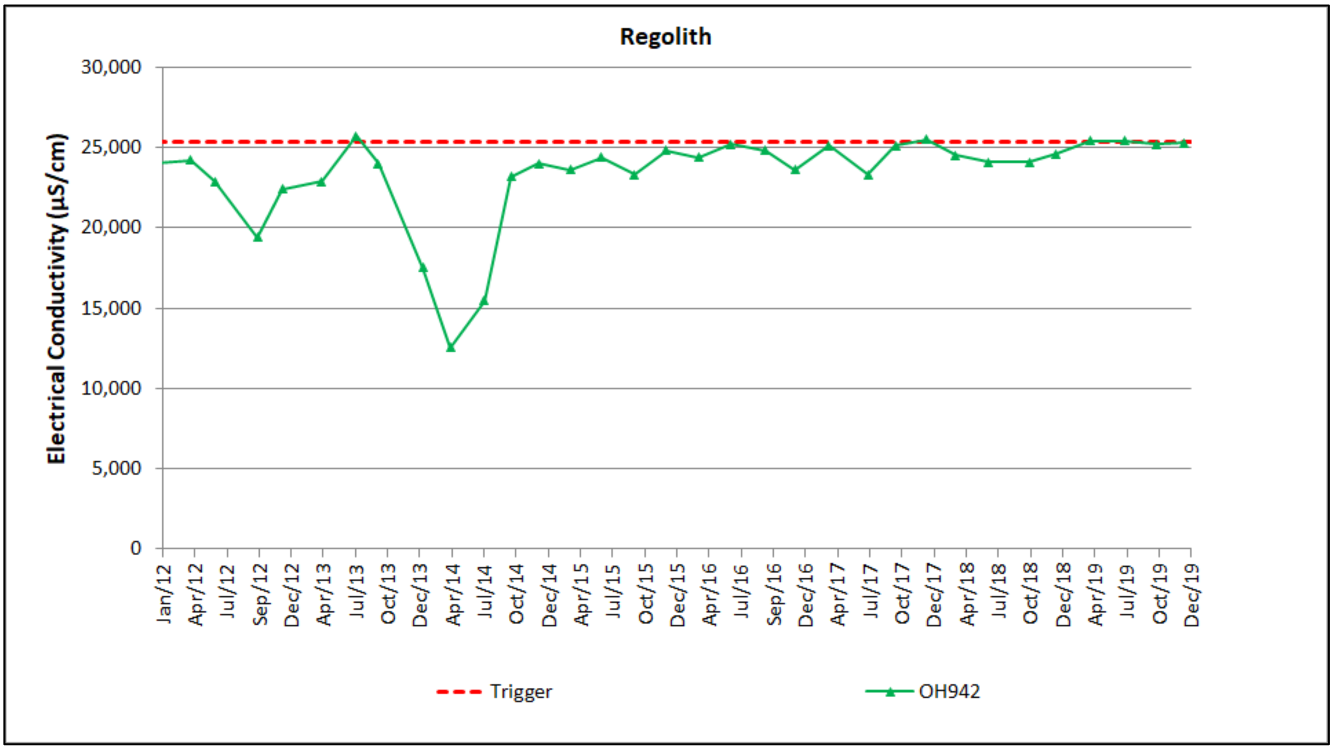
Regolith
Electrical Conductivity (µS/cm)
3,000
2,500
2,000
1,500
1,000
500
0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18 Apr/19 Jul/19 Oct/19 Dec/19
Trigger
OH786

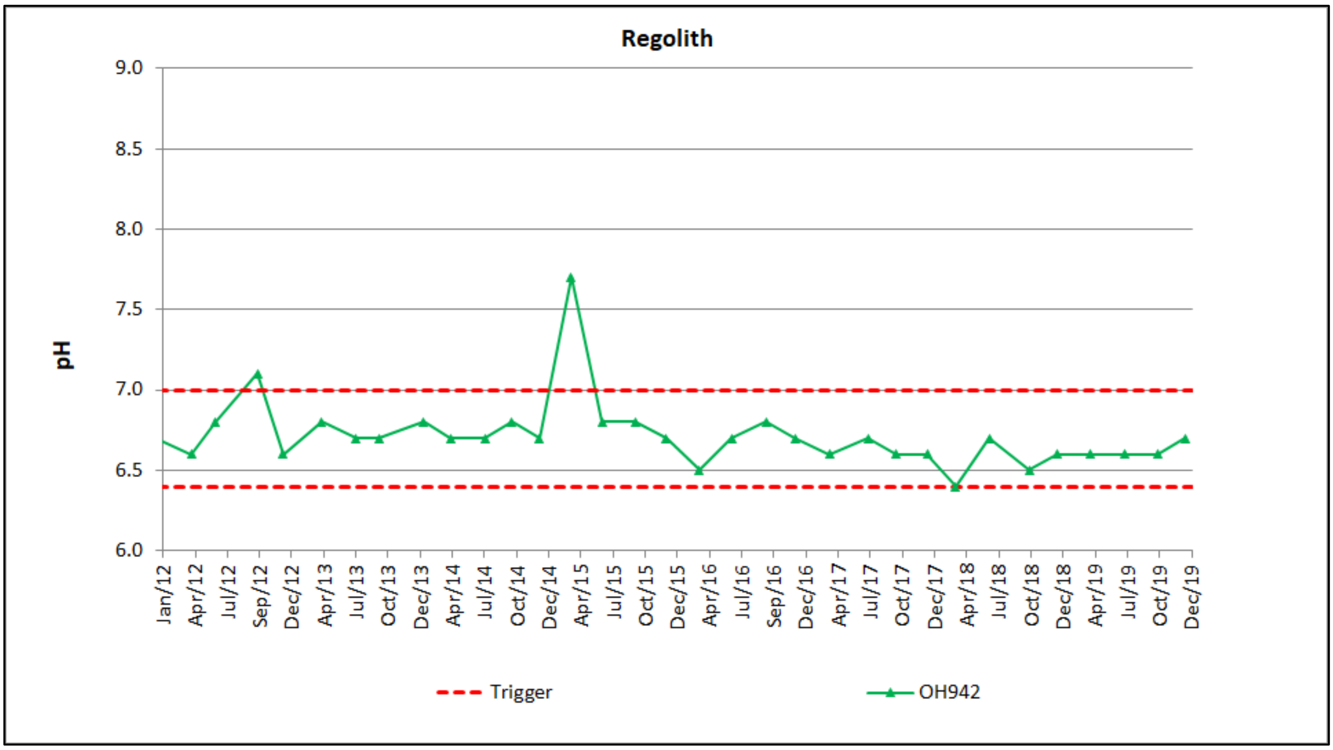


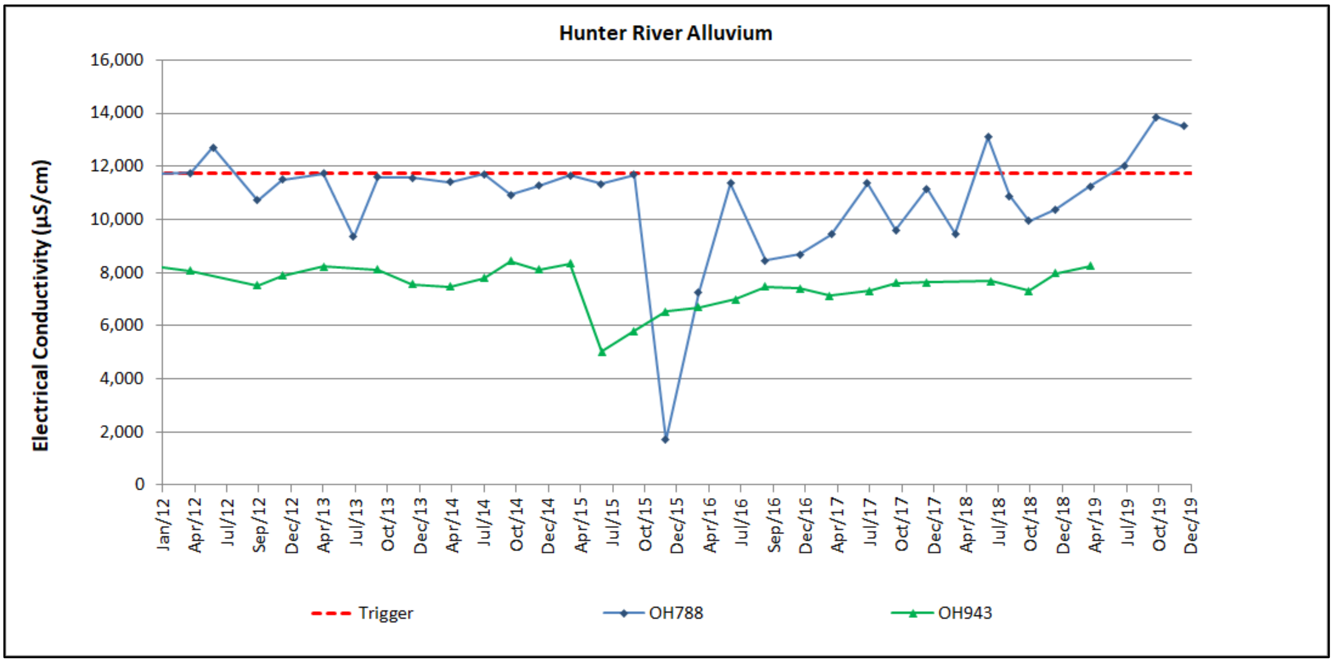
Regolith
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18 Apr/19 Jul/19 Oct/19 Dec/19
Trigger
OH786

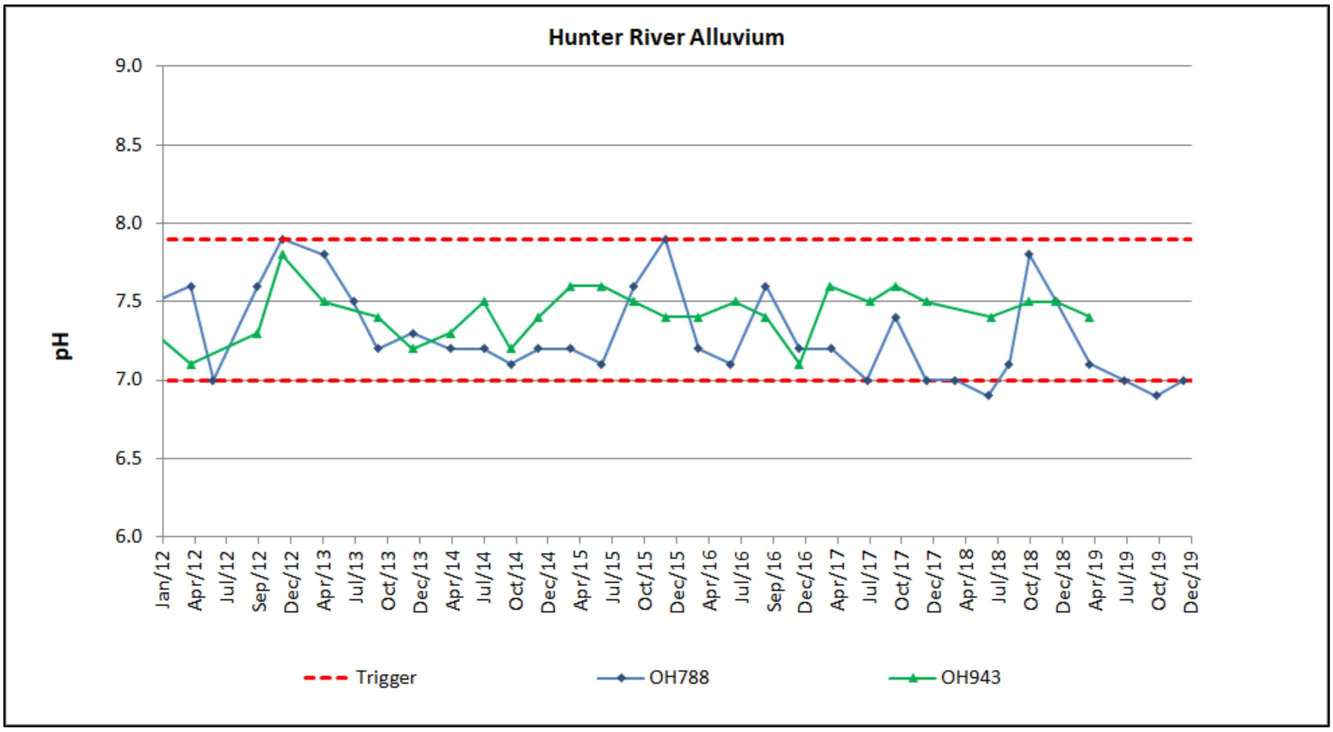

Regolith
Electrical Conductivity (µS/cm)
25,000
20,000
15,000
10,000
5,000
0
Jan/11
Apr/11
Jul/11
Oct/11
Jan/12
Apr/12
Jul/12
Oct/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Jan/16
Apr/16
Jul/16
Oct/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Trigger
OH787

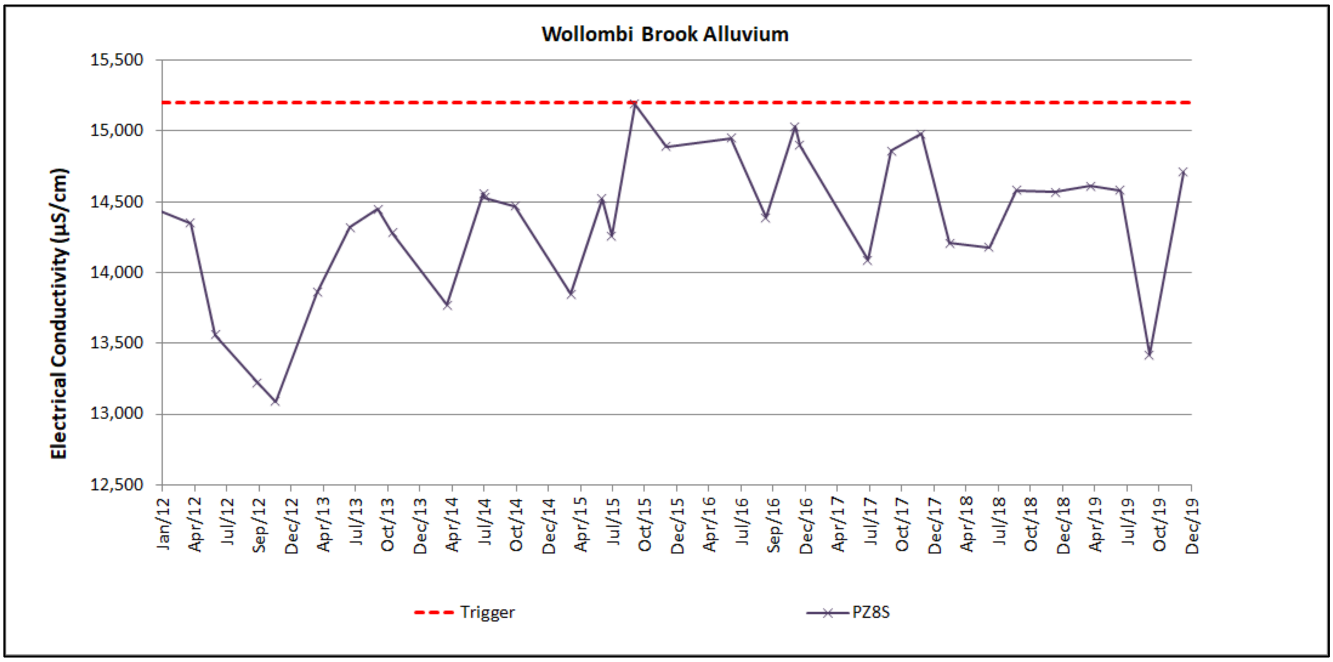

Regolith
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
OH787

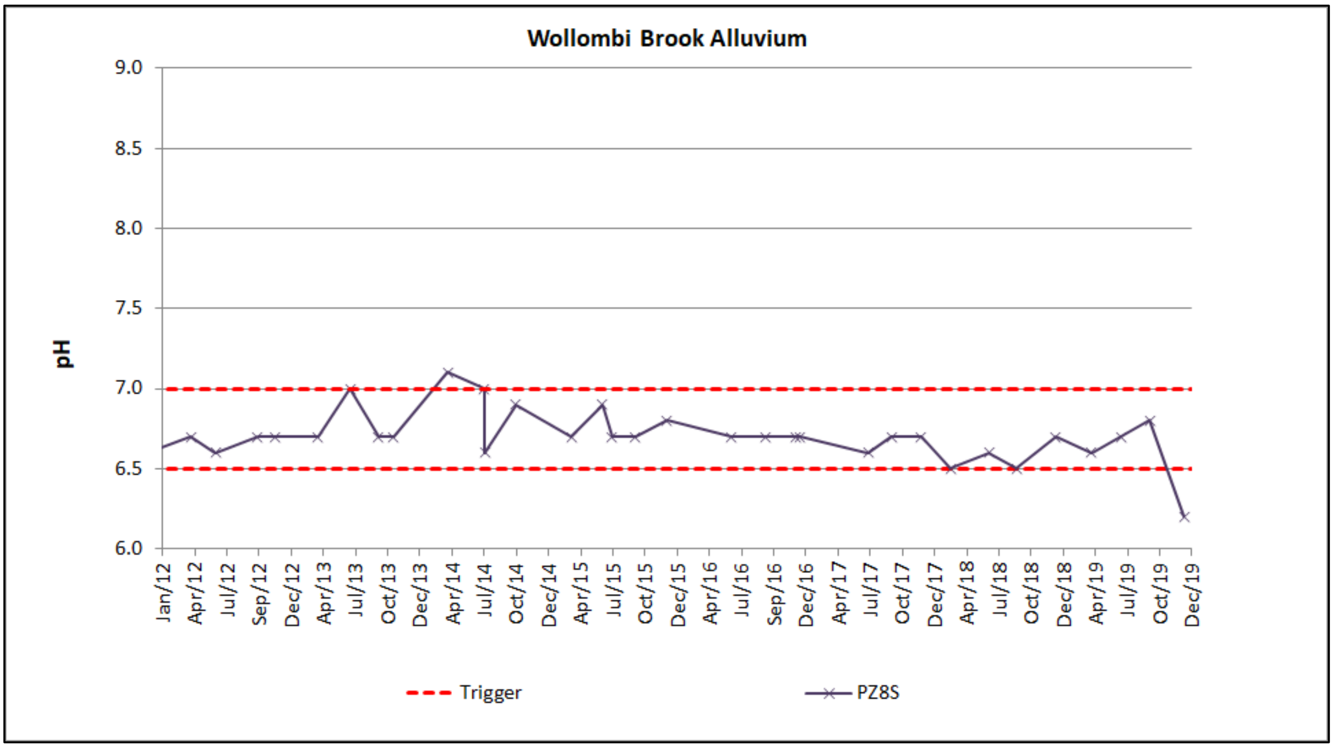

Regolith
Electrical Conductivity (µS/cm)
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
OH942

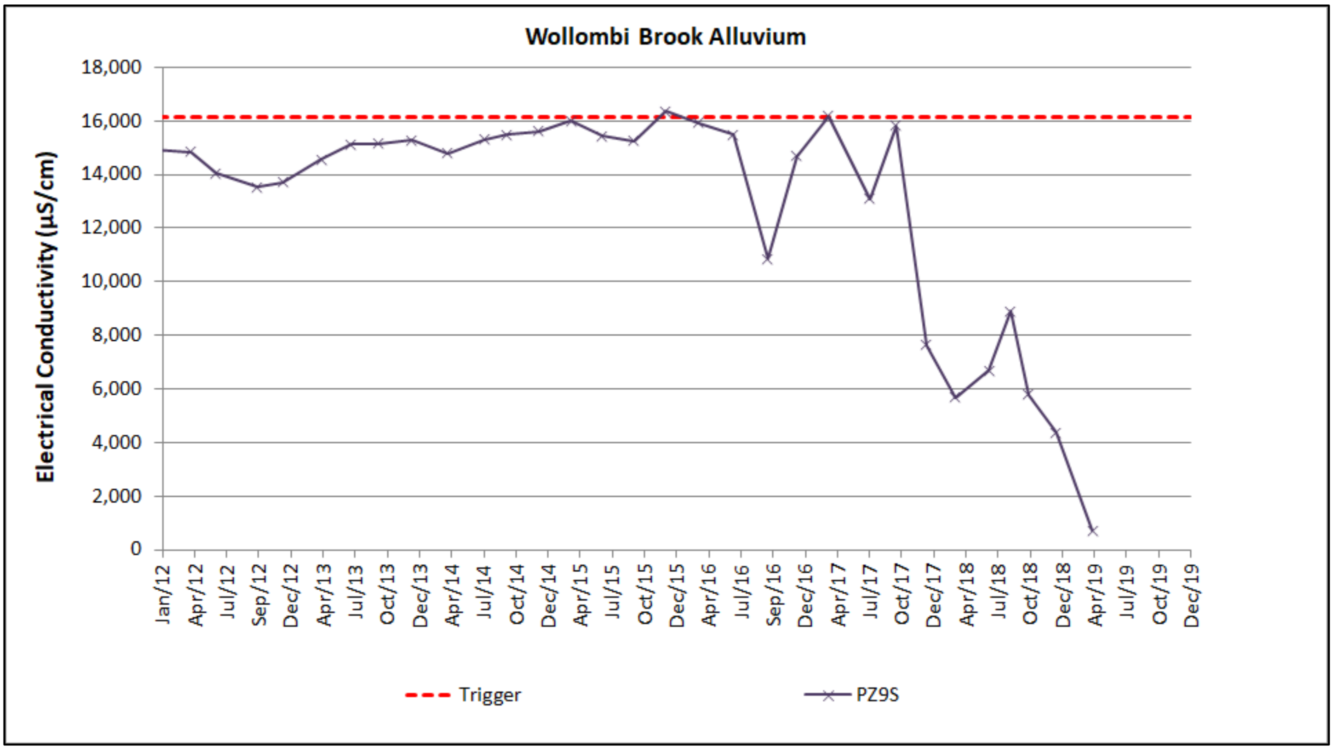

Regolith
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
OH942

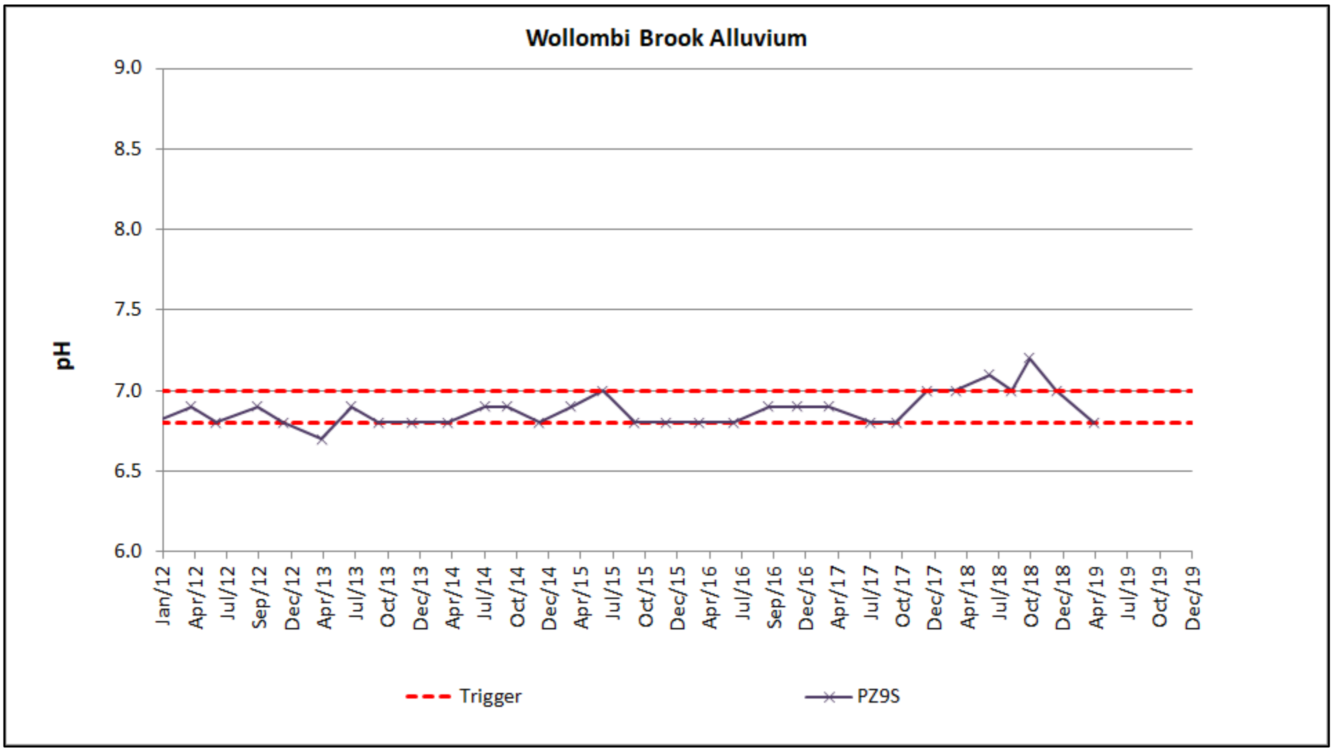

Hunter River Alluvium
Electrical Conductivity (µS/cm)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18 Apr/19 Jul/19 Oct/19 Dec/19
Trigger
OH788
OH943

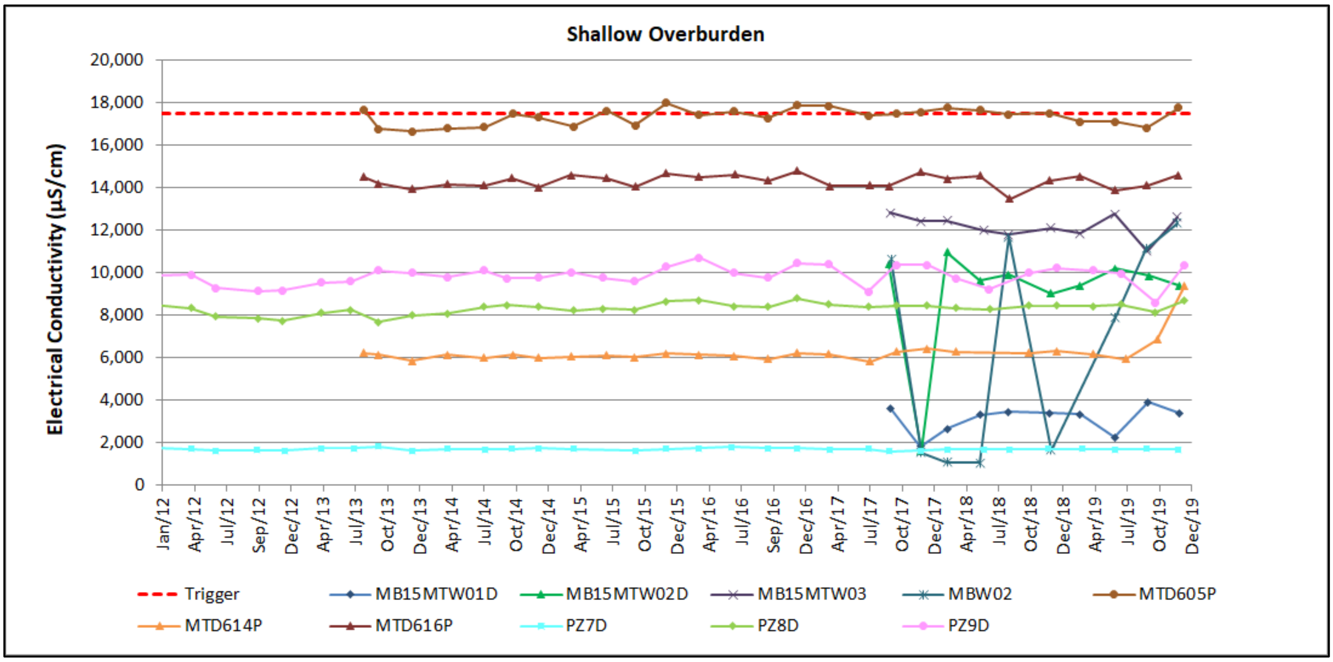

Hunter River Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18 Apr/19 Jul/19 Oct/19 Dec/19
Trigger
OH788
OH943

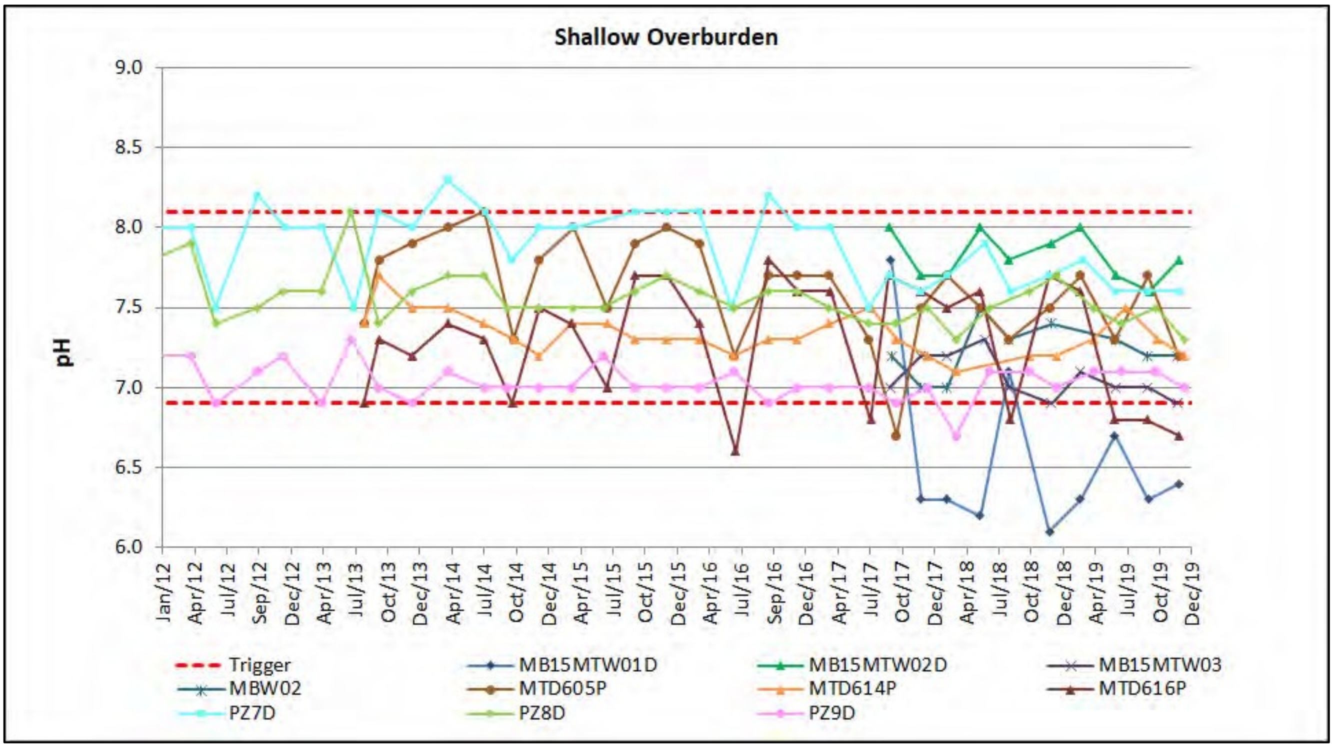

Wollombi Brook Alluvium
Electrical Conductivity (µS/cm)
15,500
15,000
14,500
14,000
13,500
13,000
12,500
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18 Apr/19 Jul/19 Oct/19 Dec/19
Trigger
PZ8S

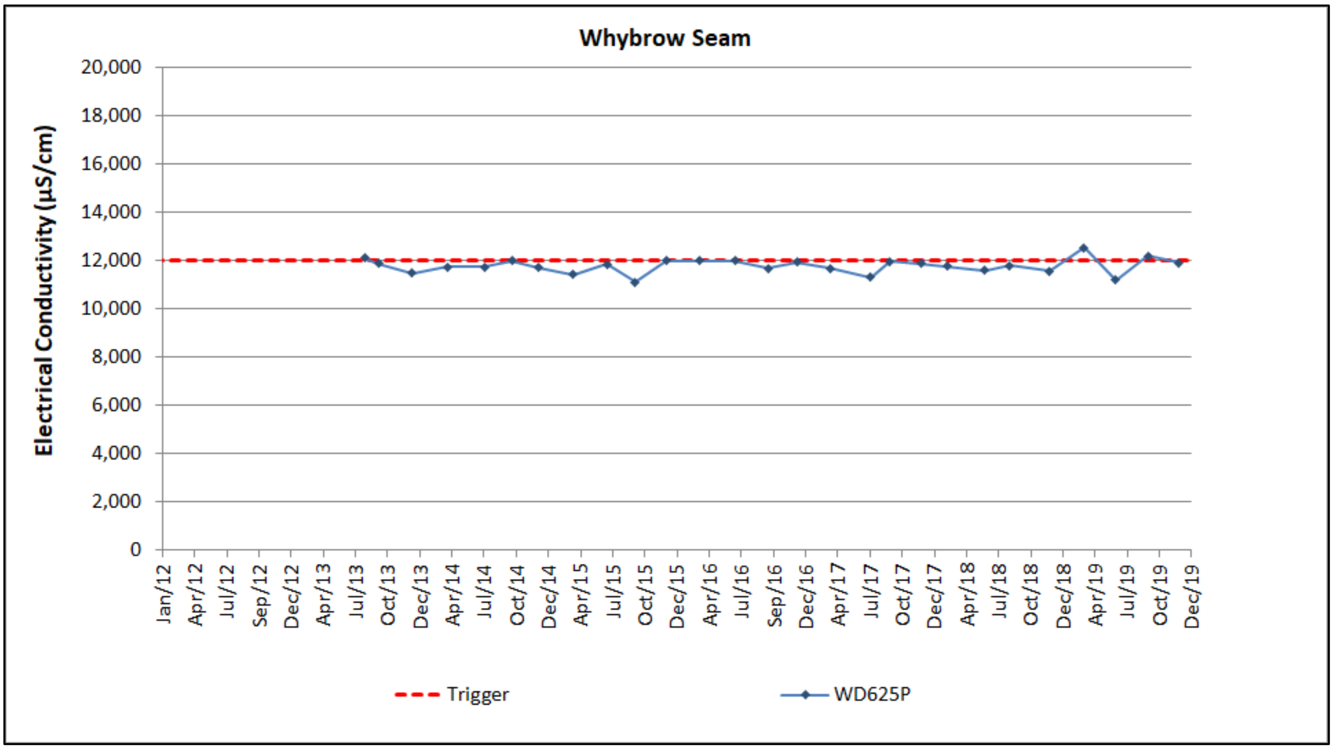

Wollombi Brook Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12 Apr/12 Jul/12 Sep/12 Dec/12 Apr/13 Jul/13 Oct/13 Dec/13 Apr/14 Jul/14 Oct/14 Dec/14 Apr/15 Jul/15 Oct/15 Dec/15 Apr/16 Jul/16 Sep/16 Dec/16 Apr/17 Jul/17 Oct/17 Dec/17 Apr/18 Jul/18 Oct/18 Dec/18 Apr/19 Jul/19 Oct/19 Dec/19
Trigger
PZ8S

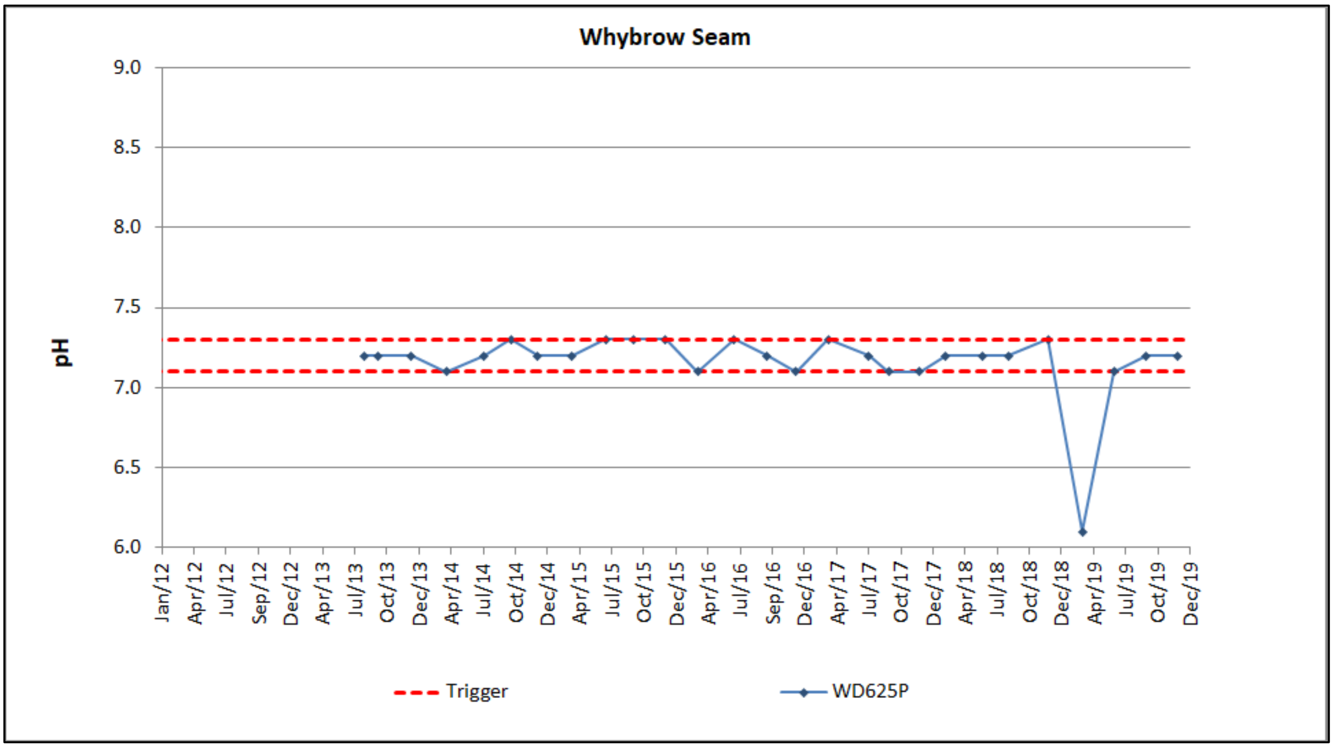

Wollombi Brook Alluvium
Electrical Conductivity (µS/cm)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
PZ9S

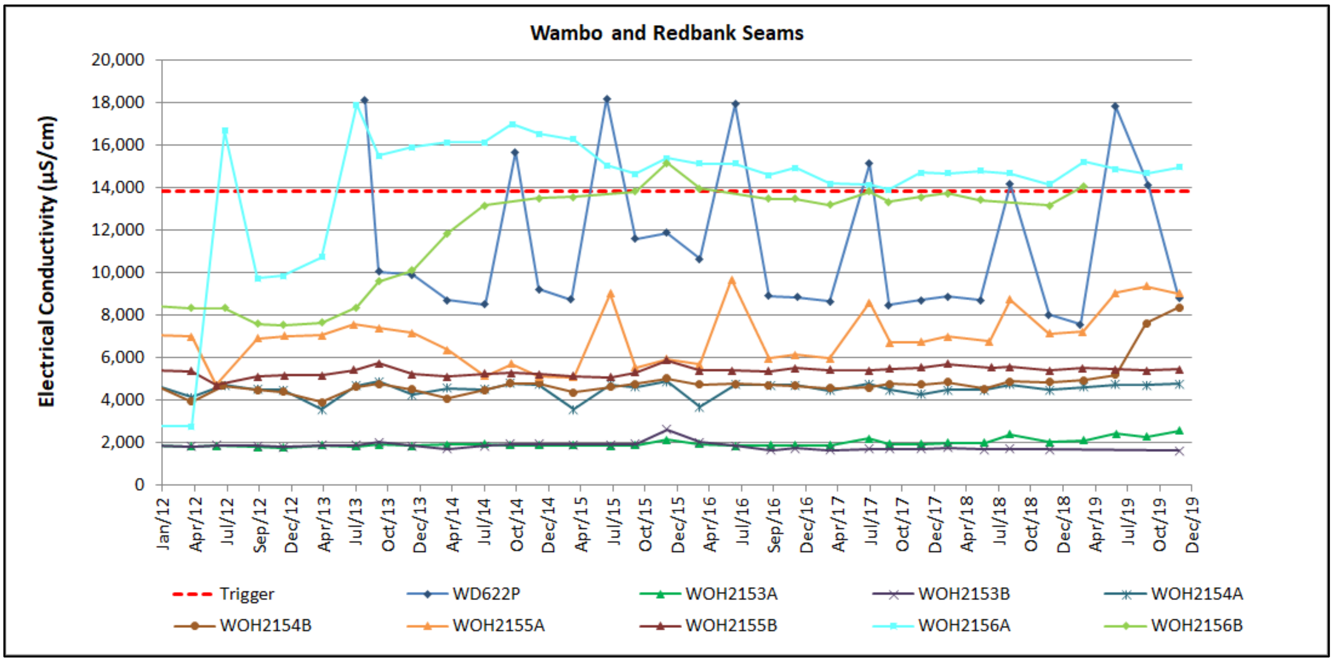

Wollombi Brook Alluvium
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
PZ9S

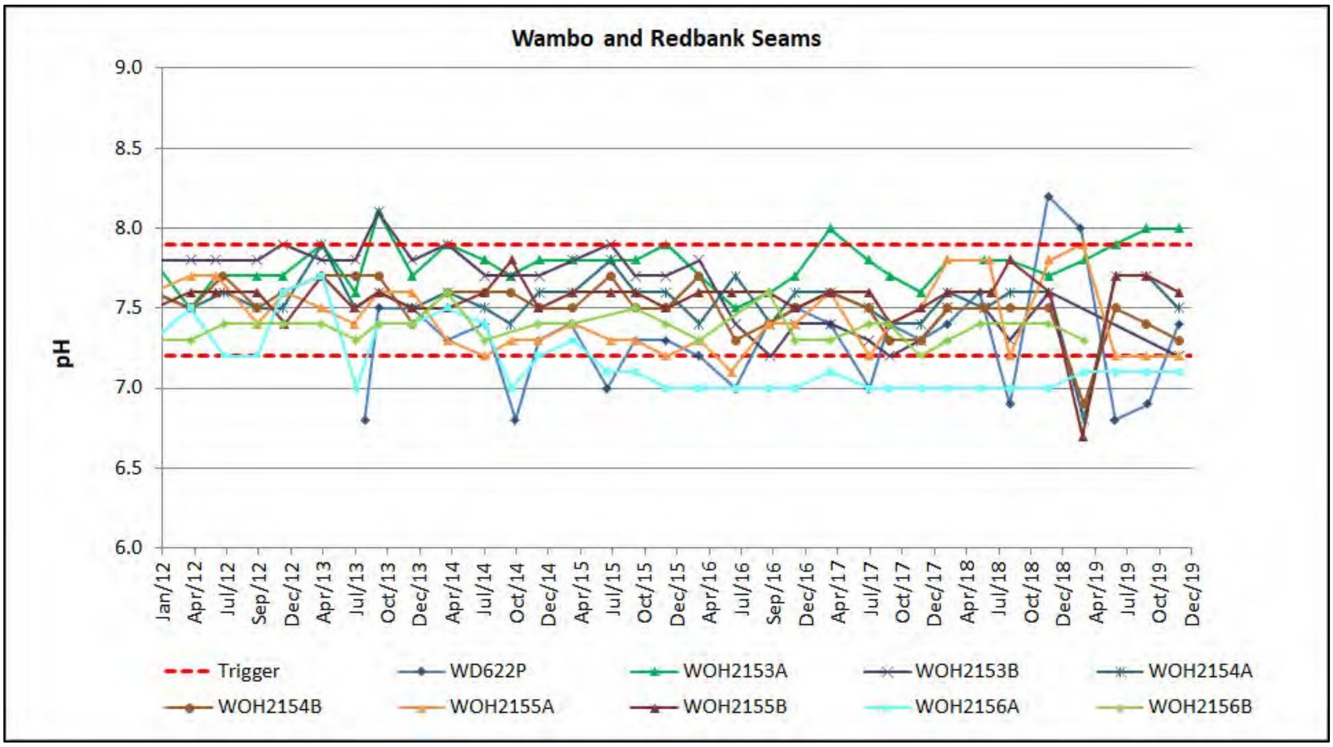

Shallow Overburden
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
MB15MTW01D
MB15MTW02D
MB15MTW03
MBW02
MTD605P
MTD614P
MTD616P
PZ7D
PZ8D
PZ9D

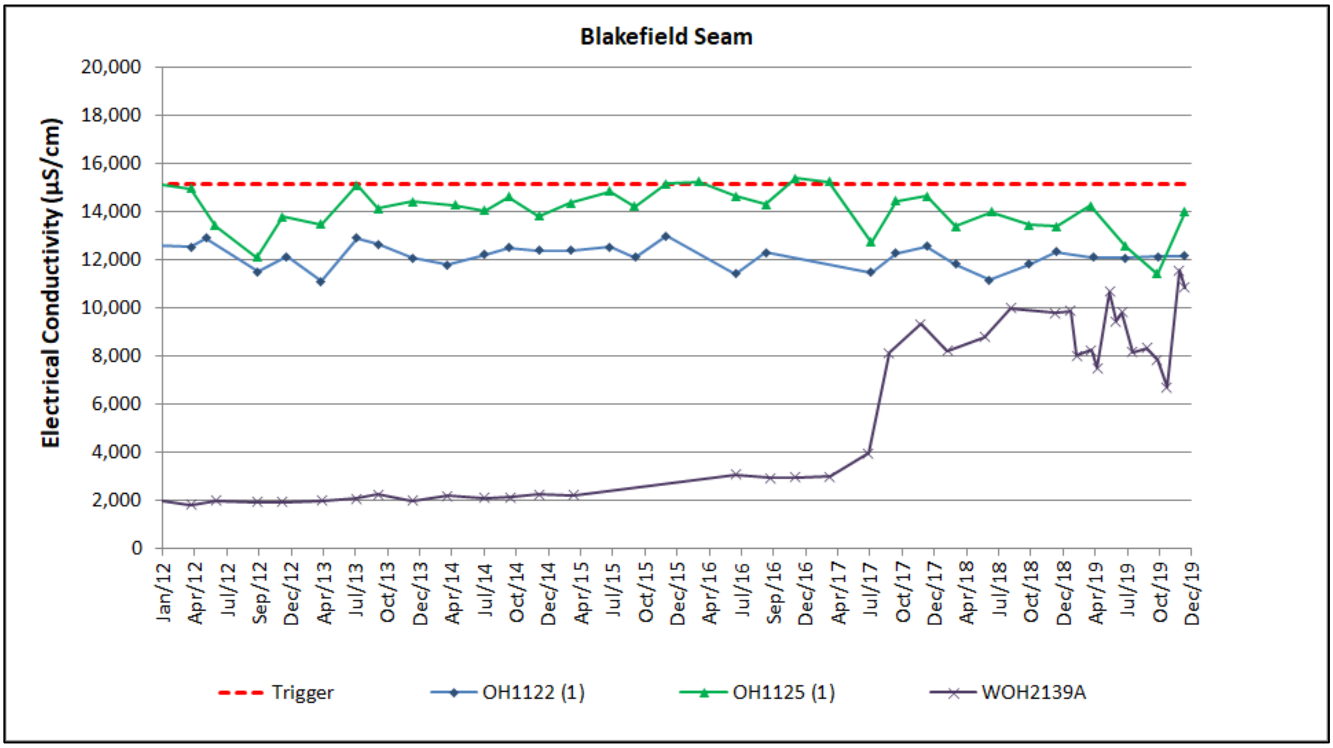

Shallow Overburden
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
MB15MTW01D
MB15MTW02D
MB15MTW03
MBW02
MTD605P
MTD614P
MTD616P
PZ7D
PZ8D
PZ9D

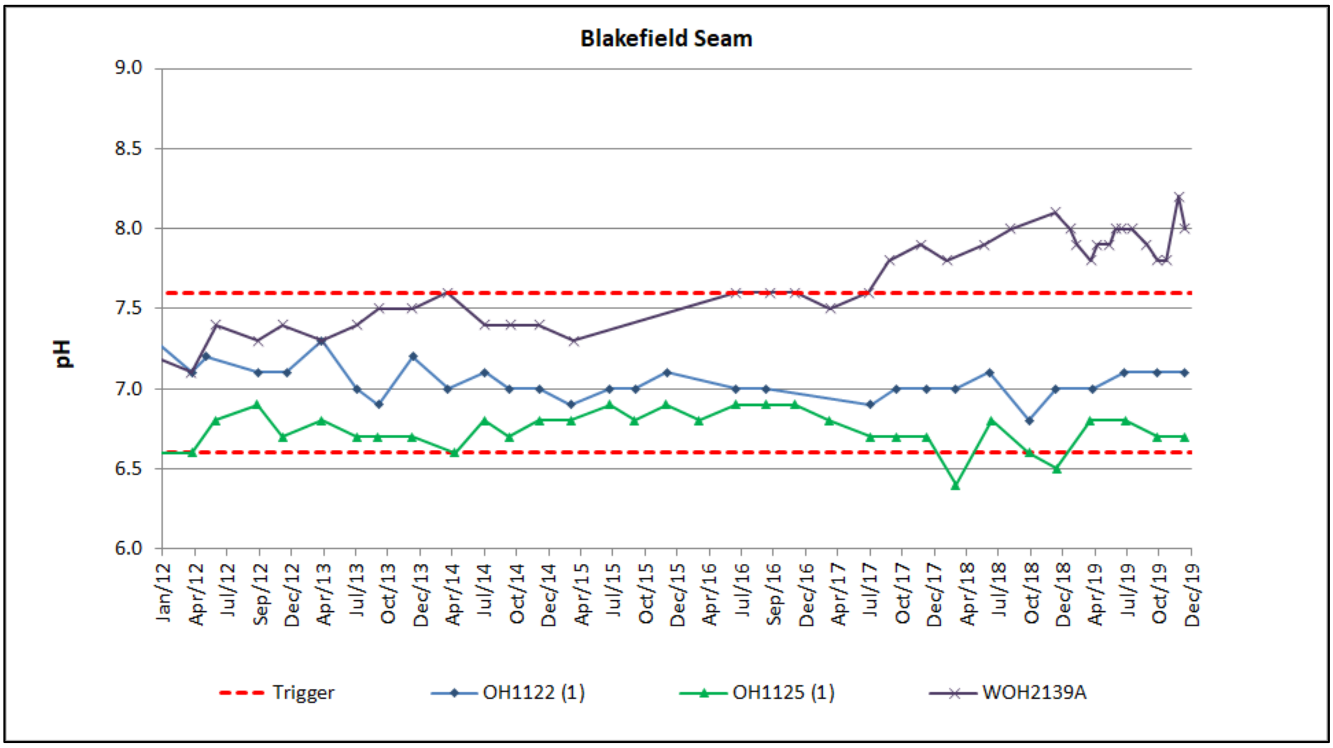

Whybrow Seam
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
WD625P

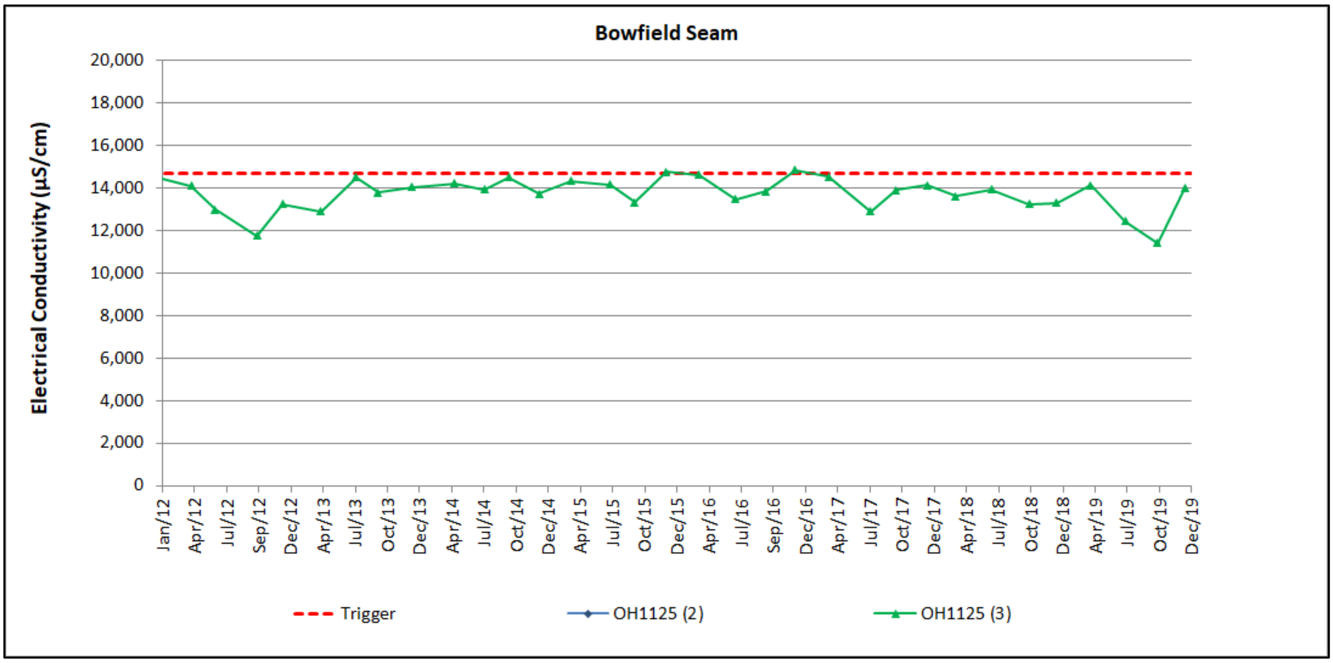

Whybrow Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
WD625P


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
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
WD622P
WOH2153A
WOH2153B
WOH2154A
WOH2154B
WOH2155A
WOH2155B
WOH2156A
WOH2156B

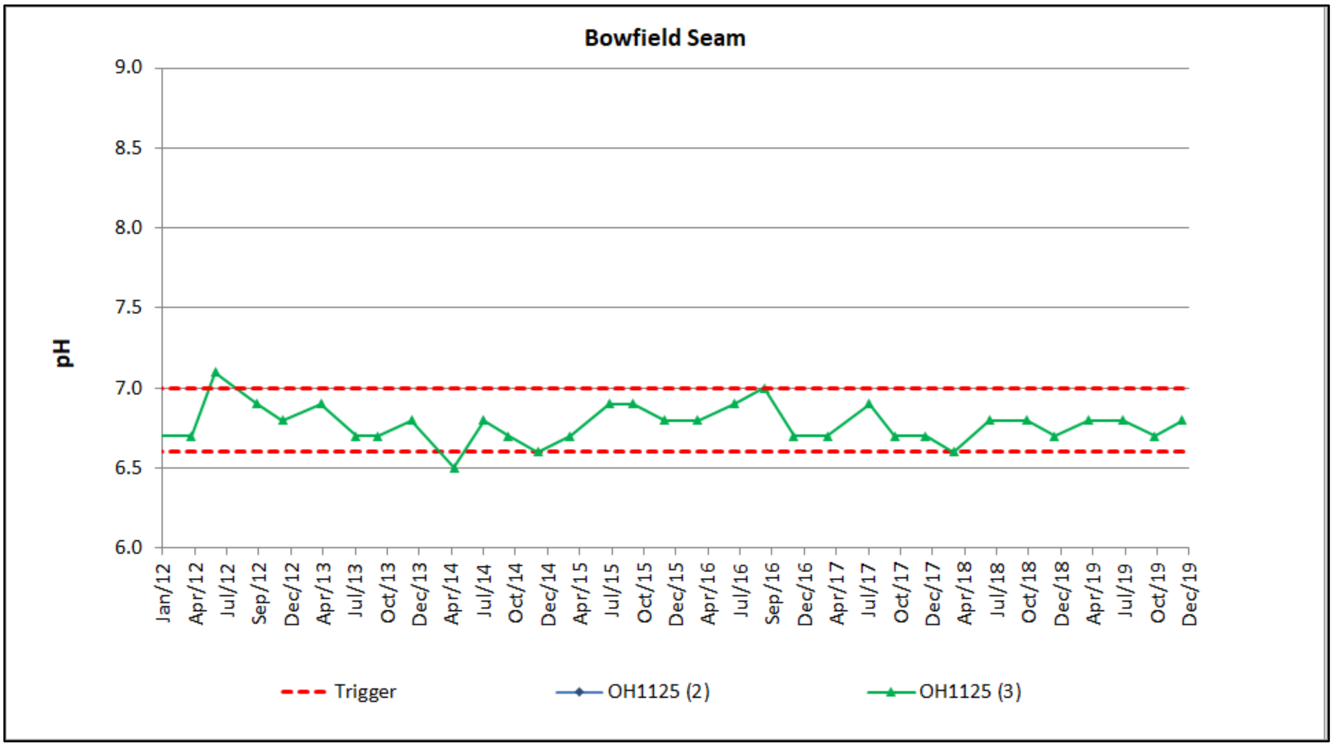

Wambo and Redbank Seams
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
WD622P
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
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
OH1122 (1)
OH1125 (1)
WOH2139A

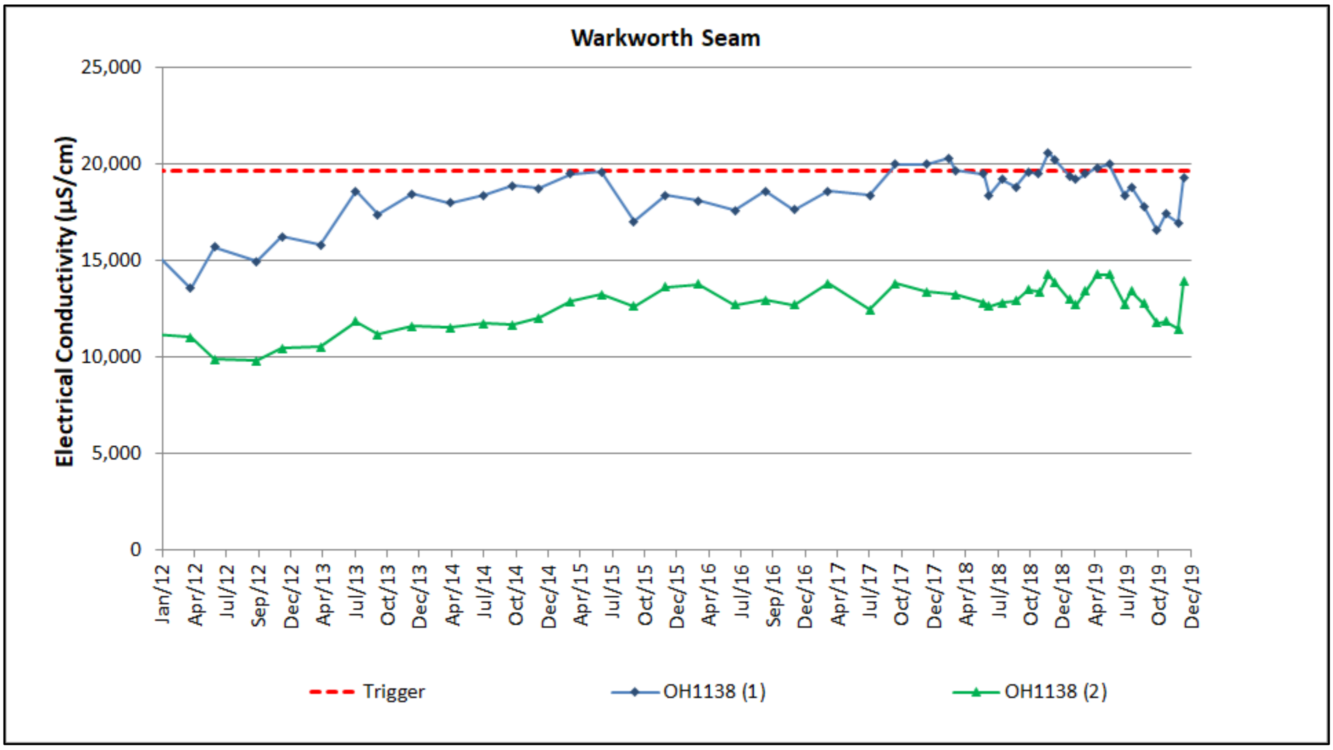

Blakefield Seam
pH
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
OH1122 (1)
OH1125 (1)
WOH2139A

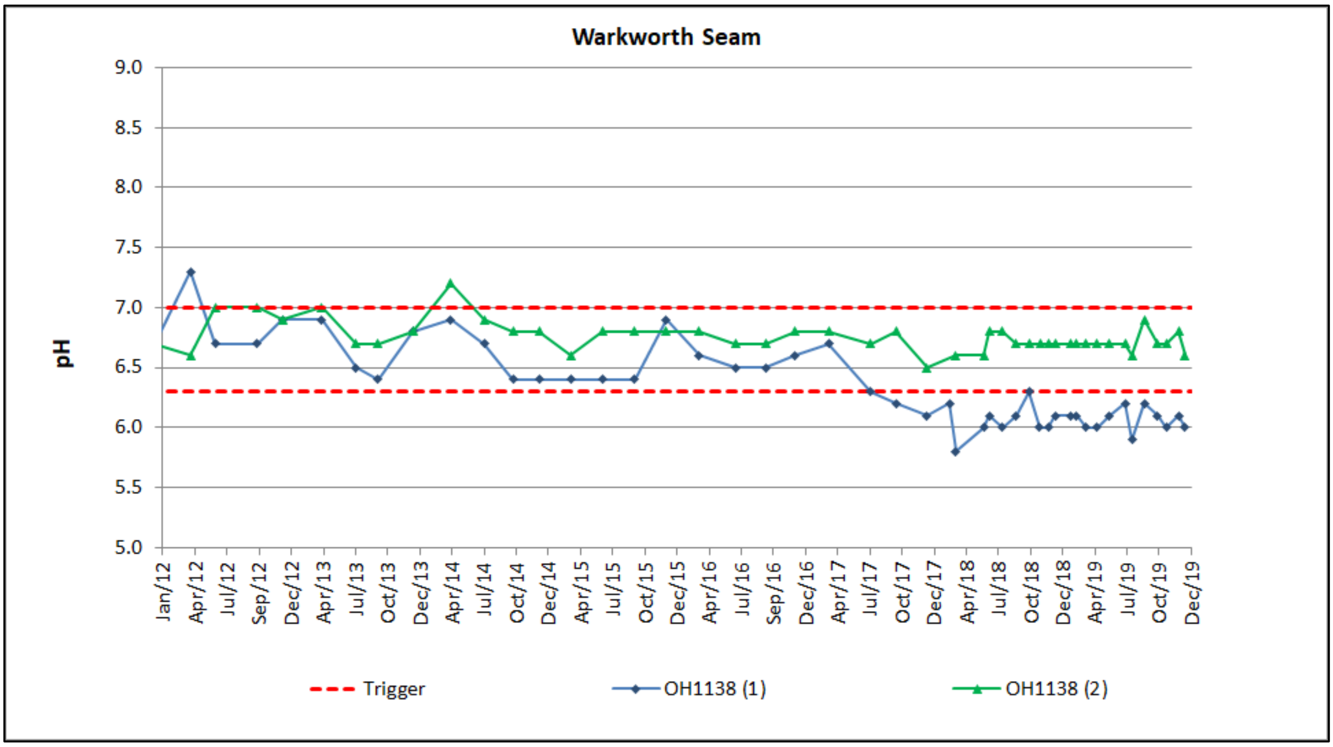


Bowfield Seam
Electrical Conductivity (µS/cm)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan/12
Apr/12
Jul/12
Sep/12
Dec/12
Apr/13
Jul/13
Oct/13
Dec/13
Apr/14
Jul/14
Oct/14
Dec/14
Apr/15
Jul/15
Oct/15
Dec/15
Apr/16
Jul/16
Sep/16
Dec/16
Apr/17
Jul/17
Oct/17
Dec/17
Apr/18
Jul/18
Oct/18
Dec/18
Apr/19
Jul/19
Oct/19
Dec/19
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
Apr/19
Jul/19
Oct/19
Dec/19
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
Apr/19
Jul/19
Oct/19
Dec/19
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
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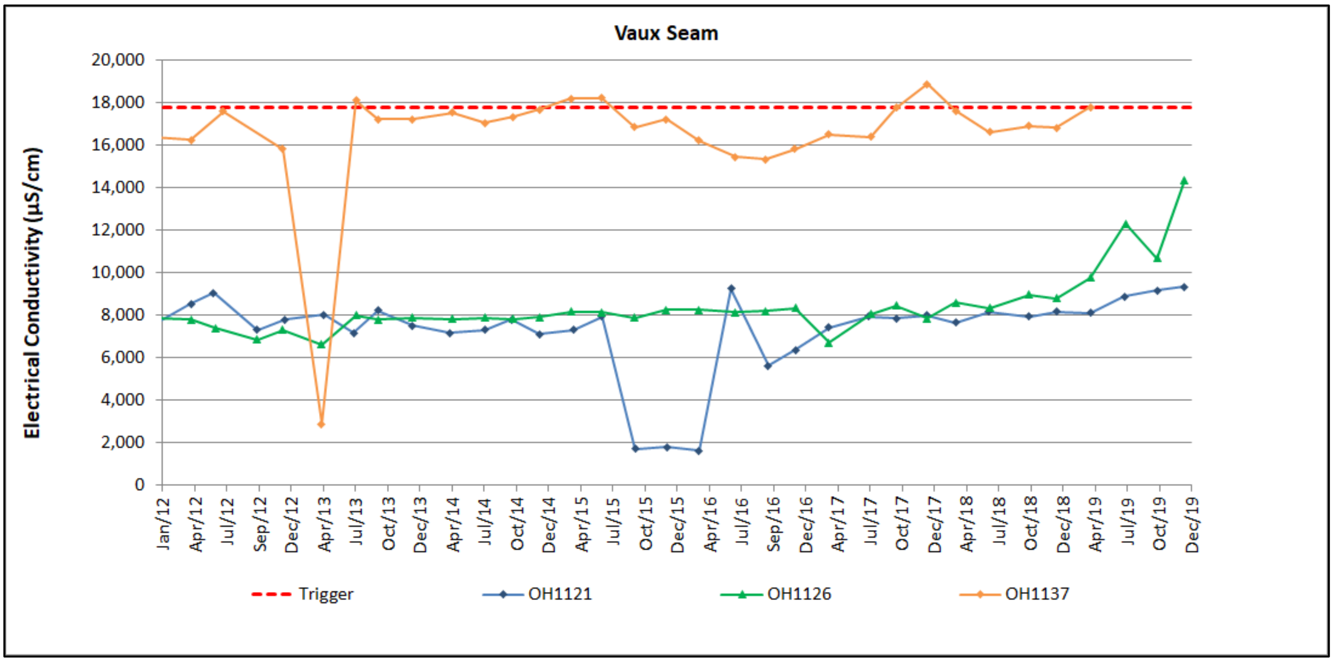
Jul/19
Oct/19
Dec/19
Trigger
OH1138 (1)
OH1138 (2)


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
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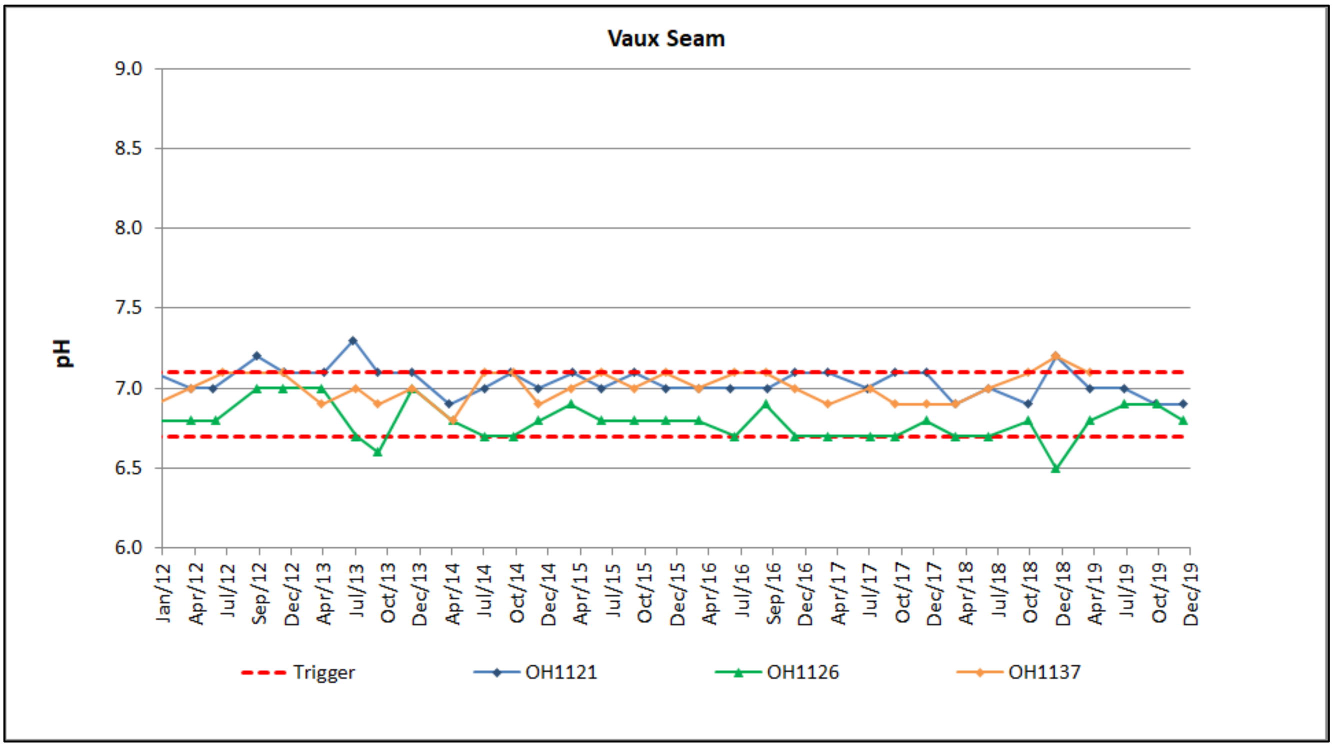
Jul/19
Oct/19
Dec/19
Trigger
OH1121
OH1126
OH1137


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
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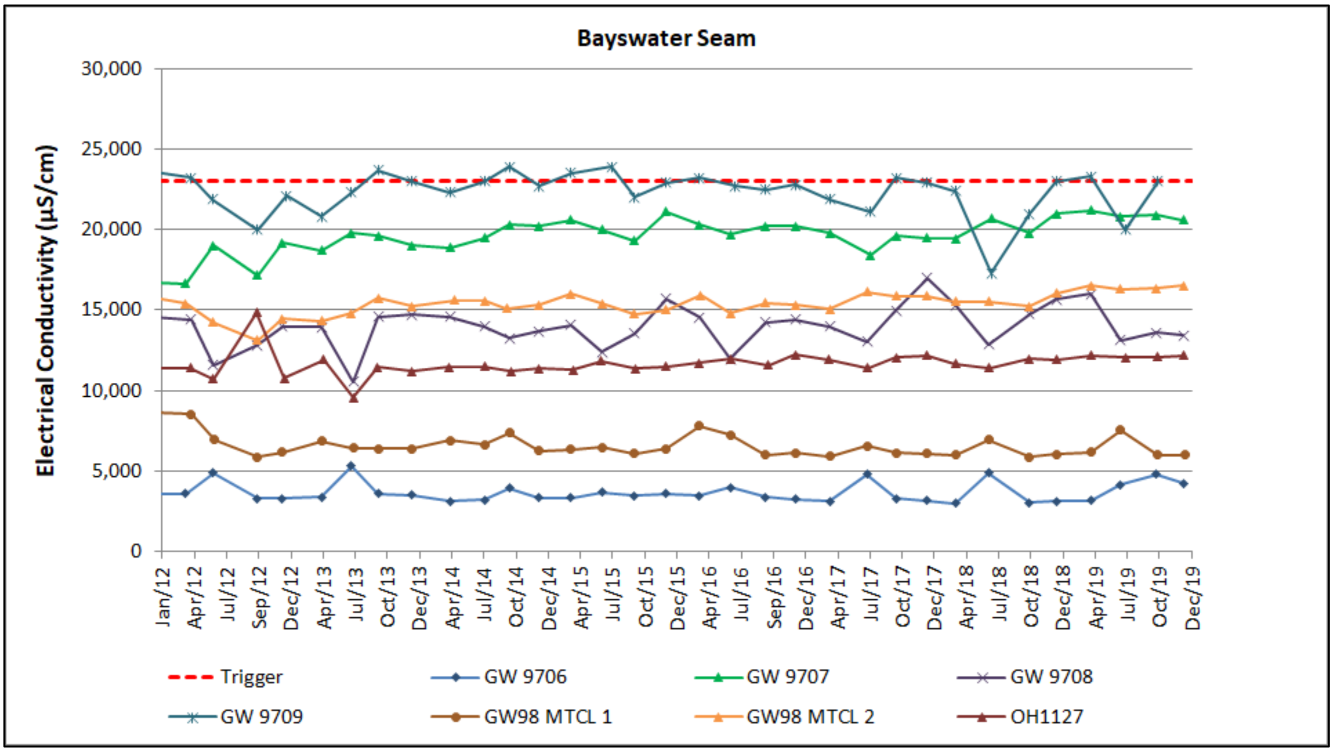
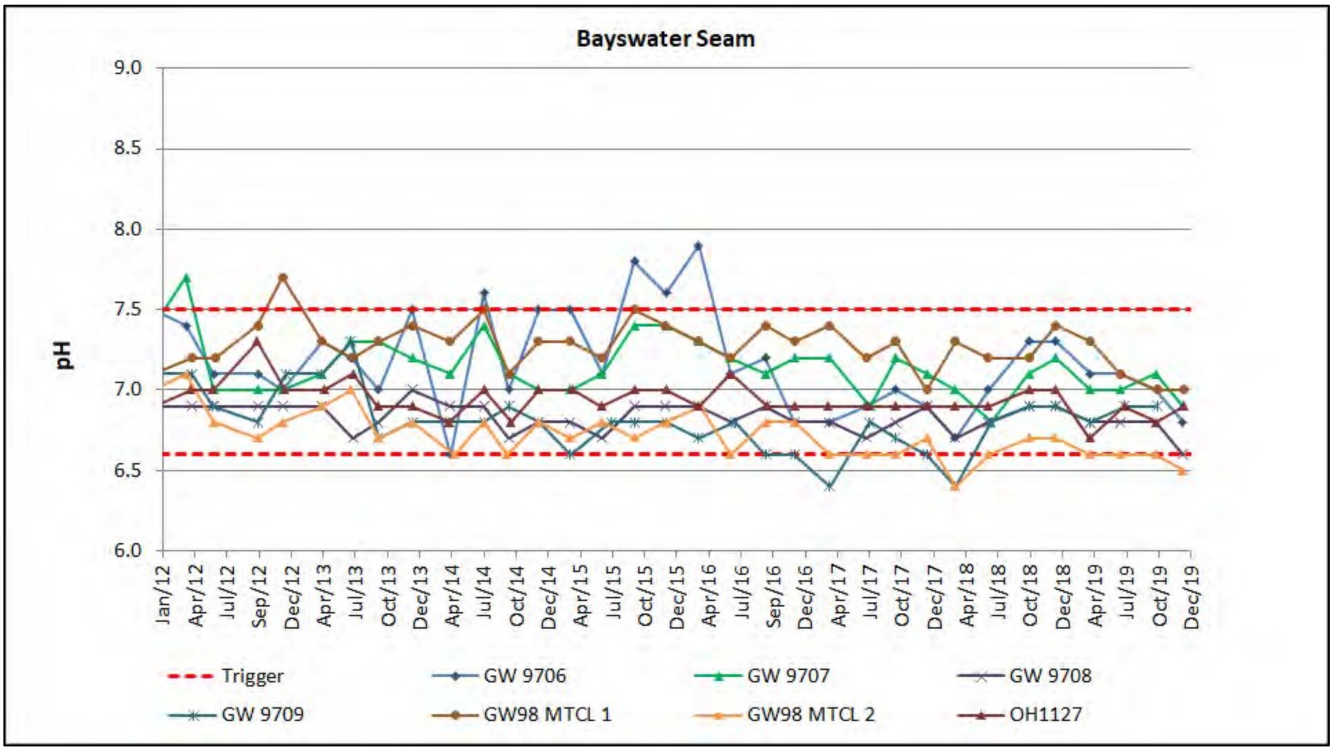
Jul/19
Oct/19
Dec/19
Trigger
OH1121
OH1126
OH1137


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
Apr/19
Jul/19
Oct/19
Dec/19
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
Apr/19
Jul/19
Oct/19
Dec/19
Trigger
GW 9706
GW 9707
GW 9708
GW 9709
GW98 MTCL 1
GW98 MTCL 2
OH1127

APPENDIX D

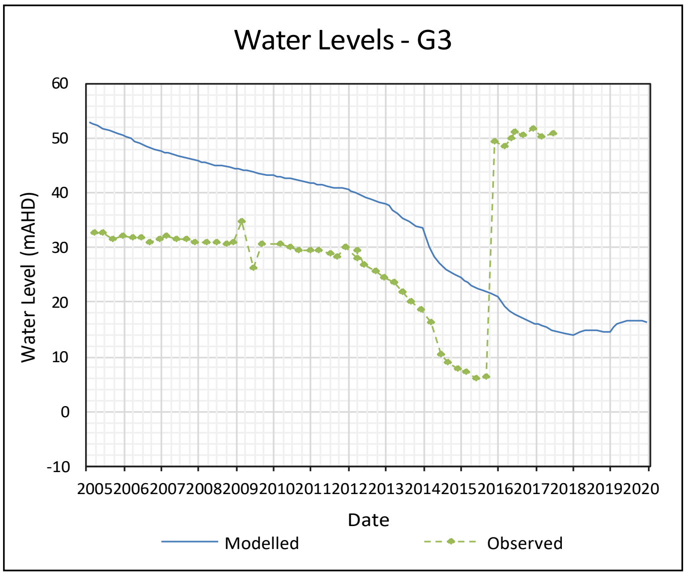
Full Water Quality Data 2019

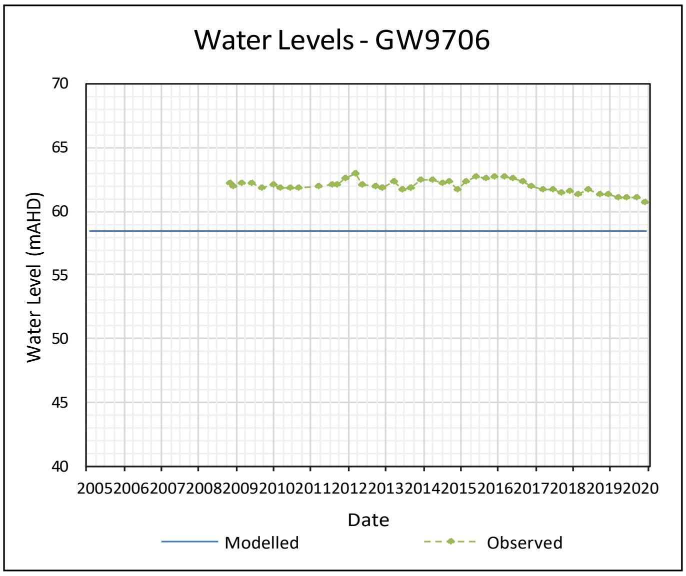
Station	Geology	Time	Date	SWL RL Calc	pH Field	EC Field (uS/cm (25TRef))	Water Temp (Deg C)	Comment	TDS - Total (mg/l)	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Acidity as CaCO3	SO4 - Total (mg/l)	Cl- (mg/l)	Ca - Total (mg/l)
PZ7S	Aeolian Warkworth Sands	8:25	28-05-19	50.57	6.7	1,641	17.2		838	<1	<1	415	415		22	269	59
MB15MTW04	Warkworth Sands	10:50	28-05-19					Dry									
MB15MTW05	Warkworth Sands	11:00	28-05-19					Dry									
MB15MTW06	Warkworth Sands	11:10	28-05-19					Dry									
MB15MTW07	Warkworth Sands	11:20	31-05-19					Dry									
MB15MTW08	Warkworth Sands	11:10	31-05-19					Dry									
MB15MTW09	Warkworth Sands	11:25	31-05-19					Dry									
MB15MTW10	Warkworth Sands	11:15	31-05-19					Dry									
MB15MTW11	Warkworth Sands	10:25	31-05-19					No Access - Fallen Tree									
OH786	Regolith	12:40	27-06-19	52.90	7.1	845	20.5	Purged 14/06/2019. Insufficent water- field results only									
OH787	Regolith	12:50	27-06-19	36.01	7.7	17,310	20.1	Purged 14/06/2019	11300	<1	<1	1180	1180	50	322	5530	87
OH788	Hunter River Alluvium	12:30	25-06-19	35.38	7.0	12,030	19.5		6810	<1	<1	1040	1040		362	3310	88
OH943	Hunter River Alluvium	12:40	25-06-19	35.40				Insufficient water									
OH944	Hunter River Alluvium	13:30	25-06-19					Dry									
MB15MTW01S	Wollombi Brook Alluvium	0.3611	43612	56.258	6.9	3730	21.4		1380	<1	<1	59	59		64	674	53
MB15MTW02S	Wollombi Brook Alluvium	0.4167	43615	55.15	6.8	3840	19.9		2120	<1	<1	290	290		17	1060	65
PZ8S	Wollombi Brook Alluvium	0.3576	43630	59.44	6.7	14580	20.1		8730	<1	<1	581	581		558	4940	110
PZ9S	Wollombi Brook Alluvium	0.5694	43643	58.65				Purged 14/06/2019. Insufficient water following purge									
MBW01	Alluvium	11:10	29-05-19	56.48	7.3	18,200	20.6		11000	<1	<1	1380	1380		510	5590	43
MB15MTW01D	Shallow Overburden? Alluvium?	9:50	27-05-19	56.35	6.7	2,250	20.4		2010	<1	<1	363	363		141	1010	31
MB15MTW02D	Shallow Overburden? Alluvium?	8:25	30-05-19	55.37	7.7	10,200	19.8		6280	<1	<1	2000	2000		9	2420	47
MB15MTW03	Shallow Overburden - Wollombi alluvium	13:00	28-05-19	54.37	7.0	12,760	19.3		7660	<1	<1	926	926		368	4010	196
MBW02	Shallow Overburden	11:15	29-05-19	54.34	7.3	7,910	17.5	DTW Checked	4770	<1	<1	1150	1150		<1	1940	42
MTD605P	Shallow Overburden - sandstone	10:30	27-05-19	62.27	7.3	17,130	20		11400	<1	<1	2050	2050		788	4820	45
MTD614P	Shallow Overburden - Conglomerate	13:50	27-06-19	54.59	7.5	5,940	19.7	Purged 14/06/2019	3630	<1	<1	1440	1440		100	991	52
MTD616P	Shallow Overburden	13:00	27-05-19	71.58	6.8	13,880	20.6		8980	<1	<1	1310	1310		472	4620	104
PZ7D	Shallow Overburden	9:10	28-05-19	50.64	7.6	1,686	19.3		901	<1	<1	440	440		30	282	20
PZ8D	Shallow Overburden	9:10	14-06-19	59.01	7.4	8,500	22.3		4610	<1	<1	1810	1810		47	1800	35
PZ9D	Shallow Overburden	10:35	14-06-19	47.84	7.1	9,970	21.4		5720	<1	<1	876	876		412	3060	167
GW 9706	Bayswater	10:25	13-06-19	61.06	7.1	4,170	21.4		2270	<1	<1	502	502		881	600	96
GW 9707	Bayswater	11:10	13-06-19	58.12	7.0	20,800	22.6		16100	<1	<1	758	758		5370	5400	429
GW 9708	Bayswater	12:20	13-06-19	61.21	6.8	13,120	22.9		11200	<1	<1	682	682		5020	1950	494
GW 9709	Bayswater	13:20	27-06-19	51.44	6.9	20,000	19.6	Purged 13/06/2019	18100	<1	<1	772	772		6960	5210	607
GW98 MTCL 1	Bayswater	13:20	13-06-19	66.68	7.1	7,560	22.9		4150	<1	<1	875	875		783	1460	67
GW98 MTCL 2	Bayswater	9:25	13-06-19	68.51	6.6	16,300	21.7		12600	<1	<1	653	653		4440	4060	646
OH1127	Vane Subgroup	10:05	26-06-19	35.28	6.9	12,080	20.3		7170	<1	<1	1900	1900		<1	3080	147
OH1122 (1)	Blakefield Seam	12:20	26-06-19	52.13	7.1	12,060	20.8		6610	<1	<1	1420	1420		532	3260	112
OH1125 (1)	Blakefield	11:10	27-06-19	51.02	6.8	12,540	20.4		8940	<1	<1	918	918	83	730	4160	320
OH1125 (3)	Bowfield Seam	11:30	27-06-19	42.84	6.8	12,440	20.9		9100	<1	<1	872	872	90	725	4050	323
WOH2139A	Blakefield	12:30	30-05-19	37.65	8.0	9,420	20.1		5280	<1	<1	954	954		<1	2750	9
WOH2153A	Redbank Crk Seam	9:30	31-05-19	53.29	7.9	2,410	18.5		1420	<1	<1	909	909		23	242	2
WOH2154A	Redbank Crk Seam	13:20	30-05-19	52.76	7.7	4,730	19.6		2760	<1	<1	958	958		144	937	4
WOH2155A	Redbank Crk Seam	11:50	30-05-19	53.55	7.2	9,050	19.8		5730	<1	<1	918	918		763	2280	42
WOH2156A	Redbank Crk Seam	11:15	30-05-19	51.47	7.1	14,860	19		9580	<1	<1	1160	1160		958	4280	113
OH942	Regolith	11:10	26-06-19	46.34	6.6	25,400	20.2		17500	<1	<1	605	605		954	7710	173
OH1125 (2)	Unknown - Blakefield?	11:20	27-06-19					Dry									
OH1121	Vane Subgroup	13:45	25-06-19	34.85	7.0	8,860	20.6		4600	<1	<1	673	673		240	2720	179
OH1126	Vaux	10:10	27-06-19	46.49	6.9	12,280	20.5		7110	<1	<1	799	799	66	757	3750	141
OH1137	Vaux?	10:00	27-06-19	52.84				Blocked									
OH1137	Vaux?	12:30	25-07-19	52.79				Results checked following annual sampling in June 2019. Foot valve sampling scheduled for further investigation.									
OH1137	Vaux?	12:05	20-08-19	52.77				DTB ammended. Foot valve and tubing installed									
MBW04	Wambo Seam	11:30	29-05-19	50.03	7.6	13,190	18.3	DTW Checked	7870	<1	<1	1710	1710		248	3620	67
WD622P	Wambo Seam	8:20	29-05-19	52.59	6.8	17,830	21.1		11300	<1	<1	1040	1040		1370	5430	152
WOH2153B	Wambo Seam	9:35	31-05-19	57.29				Insufficient Water									
WOH2154B	Wambo Seam	13:25	30-05-19	54.22	7.5	5,170	18.6		2910	<1	<1	974	974		157	1160	14
WOH2155B	Wambo Seam	11:45	30-05-19	59.25	7.7	5,430	18.6		2970	<1	<1	1040	1040		262	1050	21
WOH2156B	Wambo Seam	11:10	30-05-19	67.57				Insufficient Water	533	0	0	132	132		32	180	9.9
OH1138 (1)	Warkworth Seam	8:15	27-06-19	60.23	6.2	18,400	16.7		11800	<1	<1	231	231		407	6460	154
OH1138 (2)	Warkworth Seam	8:35	27-06-19	55.66	6.7	12,730	17.7		8790	<1	<1	683	683		639	4370	552
MBW03	Whybrow Seam	11:20	29-05-19	54.31	7.3	9,940	19.5	Suspended Solids	5730	<1	<1	2050	2050		<1	1980	37
WD625P	Whybrow Seam	10:10	31-05-19	57.65	7.1	11,200	17.9		6390	<1	<1	1220	1220		263	3640	67
WOH2141A	Whynot Seam	10:20	28-05-19	47.41	7.8	10,220	20.4		5920	<1	<1	1160	1160		<1	3030	15
MBW6A	0	10:15	29-05-19		6.7	968	19.4		475	<1	<1	120	120		31	226	10

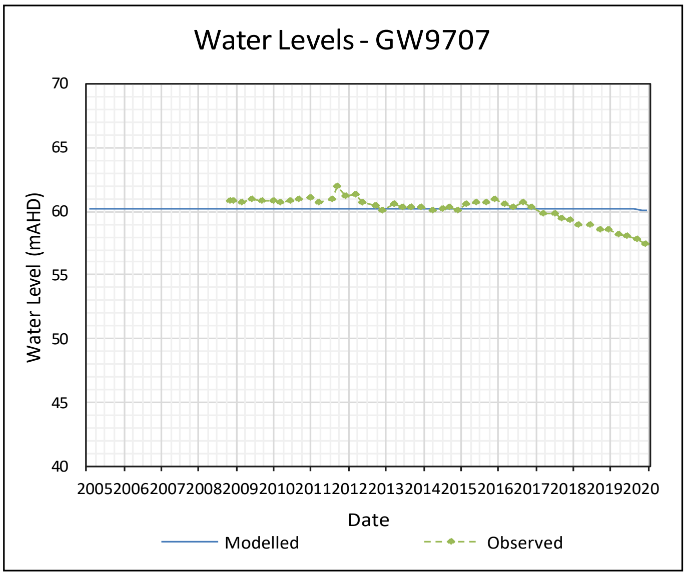
Station	Geology	Time	Date	SWL RL Calc	pH Field	EC Field (uS/cm (25TRef))	Water Temp (Deg C)	Comment	TDS - Total (mg/l)	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Acidity as CaCO3	SO4 - Total (mg/l)	Cl- (mg/l)	Ca - Total (mg/l)
PZ7S	Aeolian Warkworth Sands	8:25	28-05-19	50.57	6.7	1,641	17.2		838	<1	<1	415	415		22	269	59
MB15MTW04	Warkworth Sands	10:50	28-05-19					Dry									
MB15MTW05	Warkworth Sands	11:00	28-05-19					Dry									
MB15MTW06	Warkworth Sands	11:10	28-05-19					Dry									
MB15MTW07	Warkworth Sands	11:20	31-05-19					Dry									
MB15MTW08	Warkworth Sands	11:10	31-05-19					Dry									
MB15MTW09	Warkworth Sands	11:25	31-05-19					Dry									
MB15MTW10	Warkworth Sands	11:15	31-05-19					Dry									
MB15MTW11	Warkworth Sands	10:25	31-05-19					No Access - Fallen Tree									
OH786	Regolith	12:40	27-06-19	52.90	7.1	845	20.5	Purged 14/06/2019. Insufficent water- field results only									
OH787	Regolith	12:50	27-06-19	36.01	7.7	17,310	20.1	Purged 14/06/2019	11300	<1	<1	1180	1180	50	322	5530	87
OH788	Hunter River Alluvium	12:30	25-06-19	35.38	7.0	12,030	19.5		6810	<1	<1	1040	1040		362	3310	88
OH943	Hunter River Alluvium	12:40	25-06-19	35.40				Insufficient water									
OH944	Hunter River Alluvium	13:30	25-06-19					Dry									
MB15MTW01S	Wollombi Brook Alluvium	0.3611	43612	56.258	6.9	3730	21.4		1380	<1	<1	59	59		64	674	53
MB15MTW02S	Wollombi Brook Alluvium	0.4167	43615	55.15	6.8	3840	19.9		2120	<1	<1	290	290		17	1060	65
PZ8S	Wollombi Brook Alluvium	0.3576	43630	59.44	6.7	14580	20.1		8730	<1	<1	581	581		558	4940	110
PZ9S	Wollombi Brook Alluvium	0.5694	43643	58.65				Purged 14/06/2019. Insufficient water following purge									
MBW01	Alluvium	11:10	29-05-19	56.48	7.3	18,200	20.6		11000	<1	<1	1380	1380		510	5590	43
MB15MTW01D	Shallow Overburden? Alluvium?	9:50	27-05-19	56.35	6.7	2,250	20.4		2010	<1	<1	363	363		141	1010	31
MB15MTW02D	Shallow Overburden? Alluvium?	8:25	30-05-19	55.37	7.7	10,200	19.8		6280	<1	<1	2000	2000		9	2420	47
MB15MTW03	Shallow Overburden - Wollombi alluvium	13:00	28-05-19	54.37	7.0	12,760	19.3		7660	<1	<1	926	926		368	4010	196
MBW02	Shallow Overburden	11:15	29-05-19	54.34	7.3	7,910	17.5	DTW Checked	4770	<1	<1	1150	1150		<1	1940	42
MTD605P	Shallow Overburden - sandstone	10:30	27-05-19	62.27	7.3	17,130	20		11400	<1	<1	2050	2050		788	4820	45
MTD614P	Shallow Overburden - Conglomerate	13:50	27-06-19	54.59	7.5	5,940	19.7	Purged 14/06/2019	3630	<1	<1	1440	1440		100	991	52
MTD616P	Shallow Overburden	13:00	27-05-19	71.58	6.8	13,880	20.6		8980	<1	<1	1310	1310		472	4620	104
PZ7D	Shallow Overburden	9:10	28-05-19	50.64	7.6	1,686	19.3		901	<1	<1	440	440		30	282	20
PZ8D	Shallow Overburden	9:10	14-06-19	59.01	7.4	8,500	22.3		4610	<1	<1	1810	1810		47	1800	35
PZ9D	Shallow Overburden	10:35	14-06-19	47.84	7.1	9,970	21.4		5720	<1	<1	876	876		412	3060	167
GW 9706	Bayswater	10:25	13-06-19	61.06	7.1	4,170	21.4		2270	<1	<1	502	502		881	600	96
GW 9707	Bayswater	11:10	13-06-19	58.12	7.0	20,800	22.6		16100	<1	<1	758	758		5370	5400	429
GW 9708	Bayswater	12:20	13-06-19	61.21	6.8	13,120	22.9		11200	<1	<1	682	682		5020	1950	494
GW 9709	Bayswater	13:20	27-06-19	51.44	6.9	20,000	19.6	Purged 13/06/2019	18100	<1	<1	772	772		6960	5210	607
GW98 MTCL 1	Bayswater	13:20	13-06-19	66.68	7.1	7,560	22.9		4150	<1	<1	875	875		783	1460	67
GW98 MTCL 2	Bayswater	9:25	13-06-19	68.51	6.6	16,300	21.7		12600	<1	<1	653	653		4440	4060	646
OH1127	Vane Subgroup	10:05	26-06-19	35.28	6.9	12,080	20.3		7170	<1	<1	1900	1900		<1	3080	147
OH1122 (1)	Blakefield Seam	12:20	26-06-19	52.13	7.1	12,060	20.8		6610	<1	<1	1420	1420		532	3260	112
OH1125 (1)	Blakefield	11:10	27-06-19	51.02	6.8	12,540	20.4		8940	<1	<1	918	918	83	730	4160	320
OH1125 (3)	Bowfield Seam	11:30	27-06-19	42.84	6.8	12,440	20.9		9100	<1	<1	872	872	90	725	4050	323
WOH2139A	Blakefield	12:30	30-05-19	37.65	8.0	9,420	20.1		5280	<1	<1	954	954		<1	2750	9
WOH2153A	Redbank Crk Seam	9:30	31-05-19	53.29	7.9	2,410	18.5		1420	<1	<1	909	909		23	242	2
WOH2154A	Redbank Crk Seam	13:20	30-05-19	52.76	7.7	4,730	19.6		2760	<1	<1	958	958		144	937	4
WOH2155A	Redbank Crk Seam	11:50	30-05-19	53.55	7.2	9,050	19.8		5730	<1	<1	918	918		763	2280	42
WOH2156A	Redbank Crk Seam	11:15	30-05-19	51.47	7.1	14,860	19		9580	<1	<1	1160	1160		958	4280	113
OH942	Regolith	11:10	26-06-19	46.34	6.6	25,400	20.2		17500	<1	<1	605	605		954	7710	173
OH1125 (2)	Unknown - Blakefield?	11:20	27-06-19					Dry									
OH1121	Vane Subgroup	13:45	25-06-19	34.85	7.0	8,860	20.6		4600	<1	<1	673	673		240	2720	179
OH1126	Vaux	10:10	27-06-19	46.49	6.9	12,280	20.5		7110	<1	<1	799	799	66	757	3750	141
OH1137	Vaux?	10:00	27-06-19	52.84				Blocked									
OH1137	Vaux?	12:30	25-07-19	52.79				Results checked following annual sampling in June 2019. Foot valve sampling scheduled for further investigation.									
OH1137	Vaux?	12:05	20-08-19	52.77				DTB ammended. Foot valve and tubing installed									
MBW04	Wambo Seam	11:30	29-05-19	50.03	7.6	13,190	18.3	DTW Checked	7870	<1	<1	1710	1710		248	3620	67
WD622P	Wambo Seam	8:20	29-05-19	52.59	6.8	17,830	21.1		11300	<1	<1	1040	1040		1370	5430	152
WOH2153B	Wambo Seam	9:35	31-05-19	57.29				Insufficient Water									
WOH2154B	Wambo Seam	13:25	30-05-19	54.22	7.5	5,170	18.6		2910	<1	<1	974	974		157	1160	14
WOH2155B	Wambo Seam	11:45	30-05-19	59.25	7.7	5,430	18.6		2970	<1	<1	1040	1040		262	1050	21
WOH2156B	Wambo Seam	11:10	30-05-19	67.57				Insufficient Water	533	0	0	132	132		32	180	9.9
OH1138 (1)	Warkworth Seam	8:15	27-06-19	60.23	6.2	18,400	16.7		11800	<1	<1	231	231		407	6460	154
OH1138 (2)	Warkworth Seam	8:35	27-06-19	55.66	6.7	12,730	17.7		8790	<1	<1	683	683		639	4370	552
MBW03	Whybrow Seam	11:20	29-05-19	54.31	7.3	9,940	19.5	Suspended Solids	5730	<1	<1	2050	2050		<1	1980	37
WD625P	Whybrow Seam	10:10	31-05-19	57.65	7.1	11,200	17.9		6390	<1	<1	1220	1220		263	3640	67
WOH2141A	Whynot Seam	10:20	28-05-19	47.41	7.8	10,220	20.4		5920	<1	<1	1160	1160		<1	3030	15
MBW6A	0	10:15	29-05-19		6.7	968	19.4		475	<1	<1	120	120		31	226	10

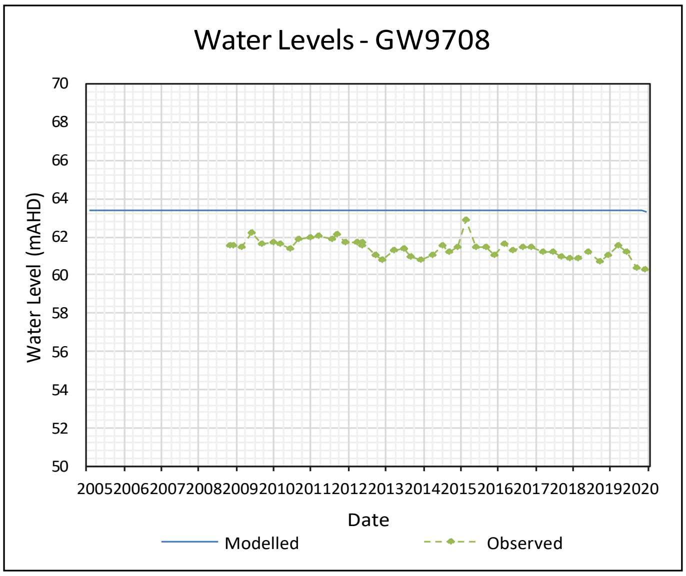
APPENDIX E

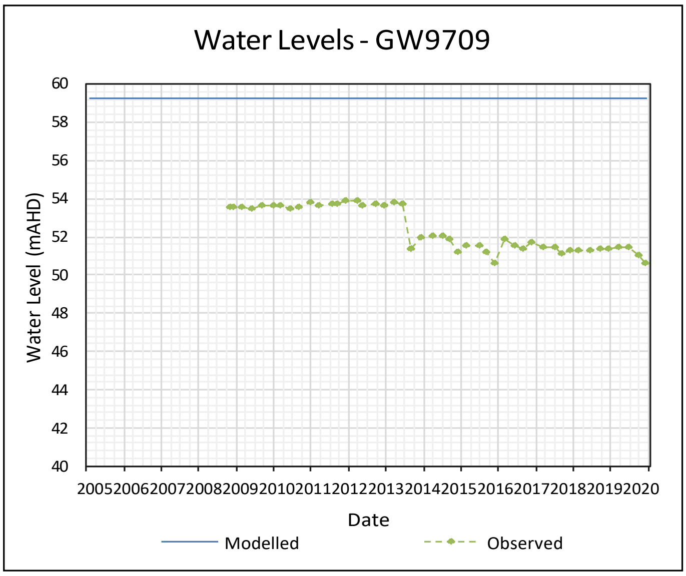
Model Verification Hydrographs

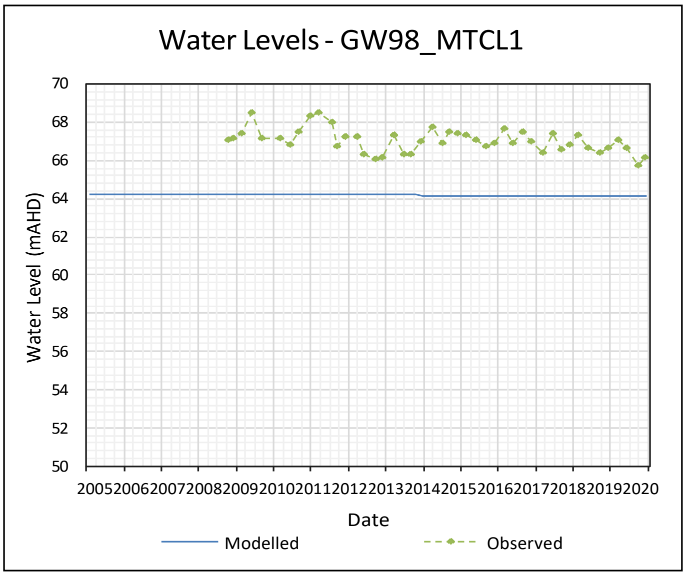

Water Levels - G3
Water Level (mAHD)
Date
Modelled
Observed

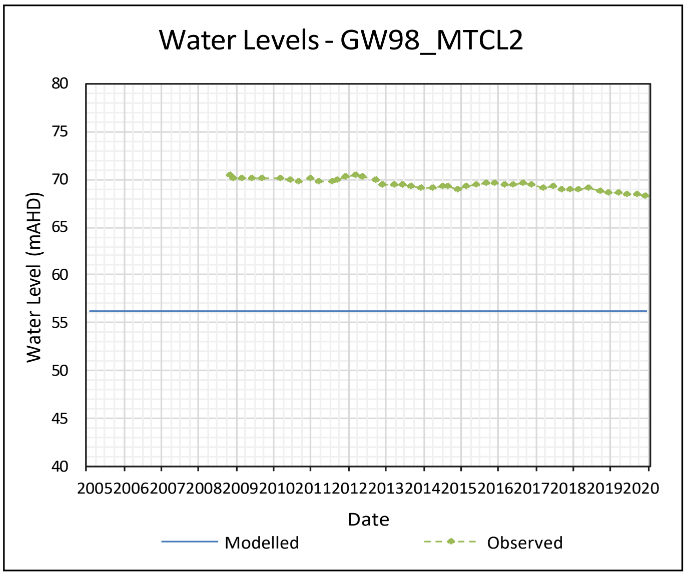

Water Levels - GW9706
Water Level (mAHD)
Date
Modelled
Observed

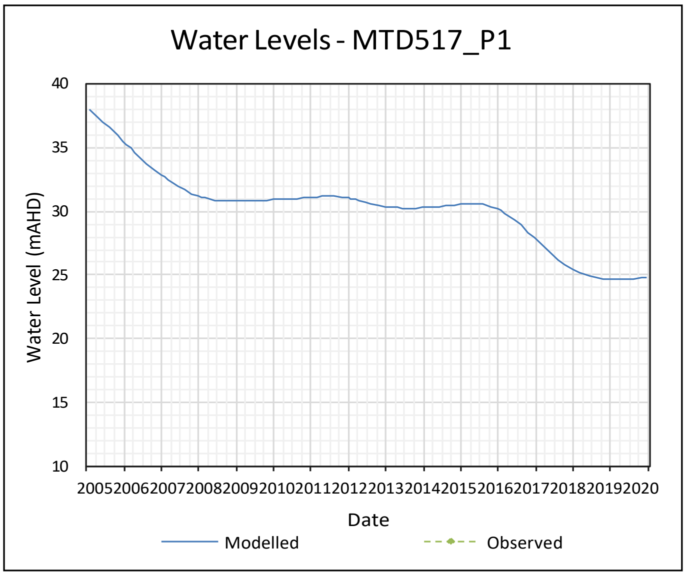

Water Levels - GW9707
Water Level (mAHD)
Date
Modelled
Observed

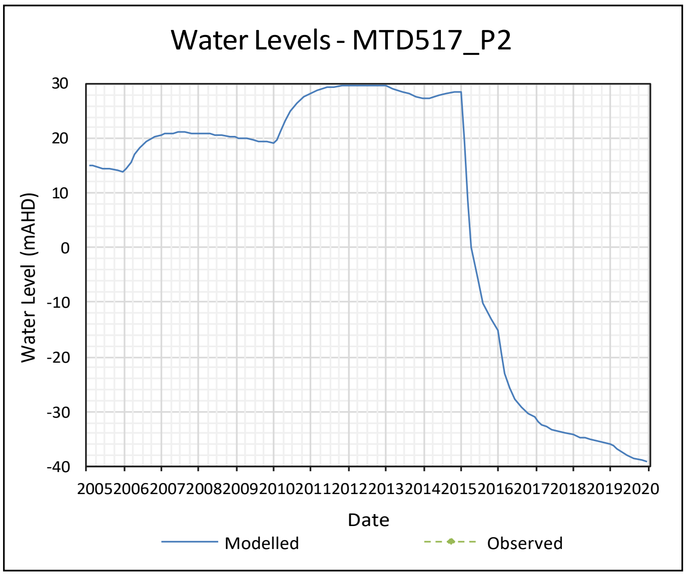

Water Levels - GW9708
Water Level (mAHD)
Date
Modelled
Observed

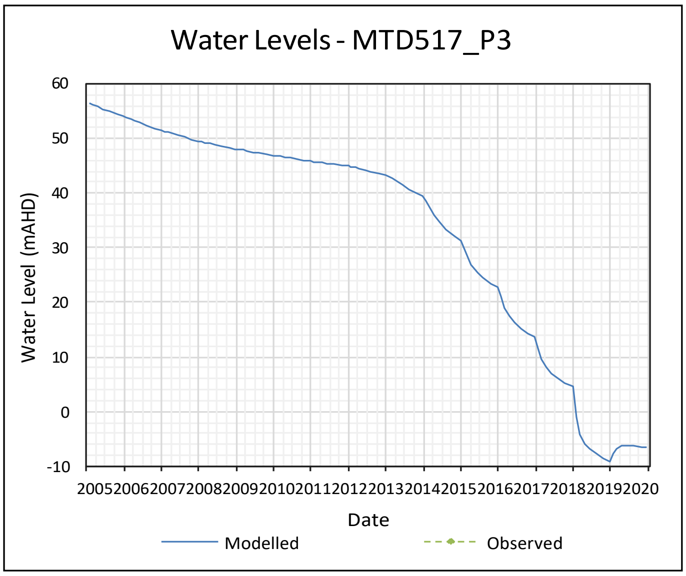

Water Levels - GW9709
Water Level (mAHD)
Date
Modelled
Observed

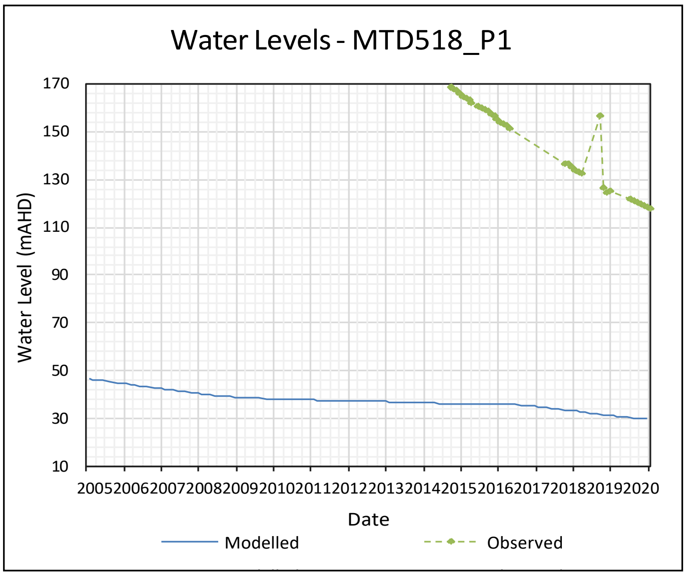

Water Levels - GW98_MTCL1
Water Level (mAHD)
Date
Modelled
Observed

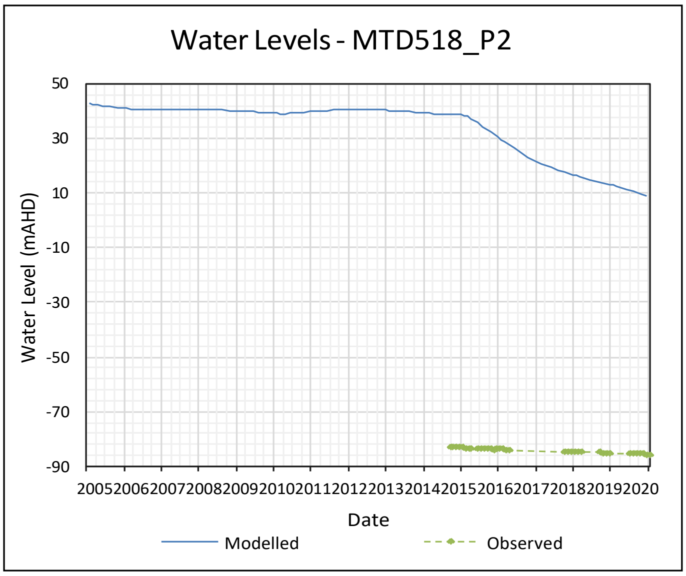

Water Levels - GW98_MTCL2
Water Level (mAHD)
Date
Modelled
Observed

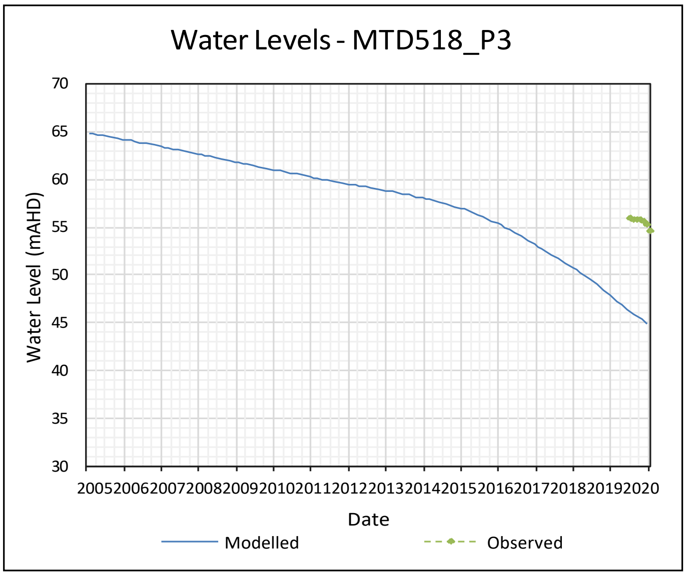

Water Levels - MTD517_P1
Water Level (mAHD)
Date
Modelled
Observed

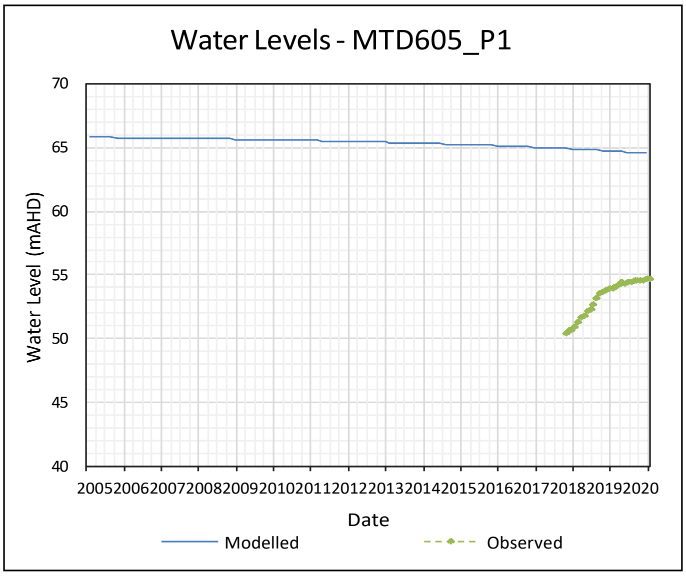

Water Levels - MTD517_P2
Water Level (mAHD)
Date
Modelled
Observed

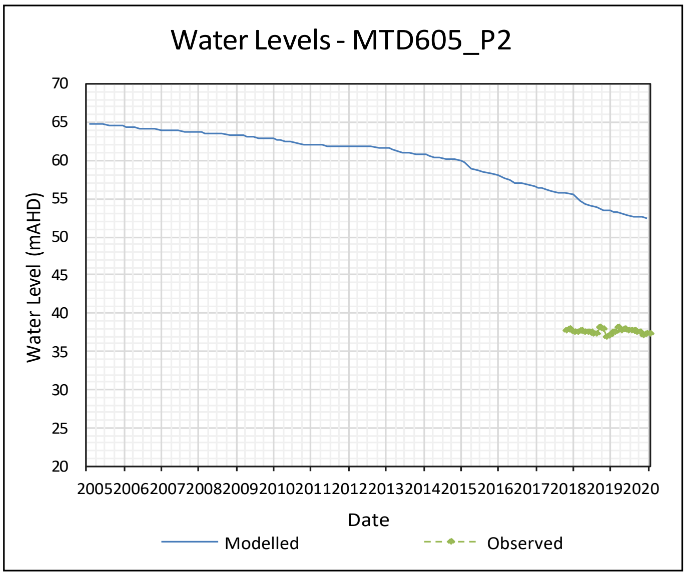

Water Levels - MTD517_P3
Water Level (mAHD)
Date
Modelled
Observed

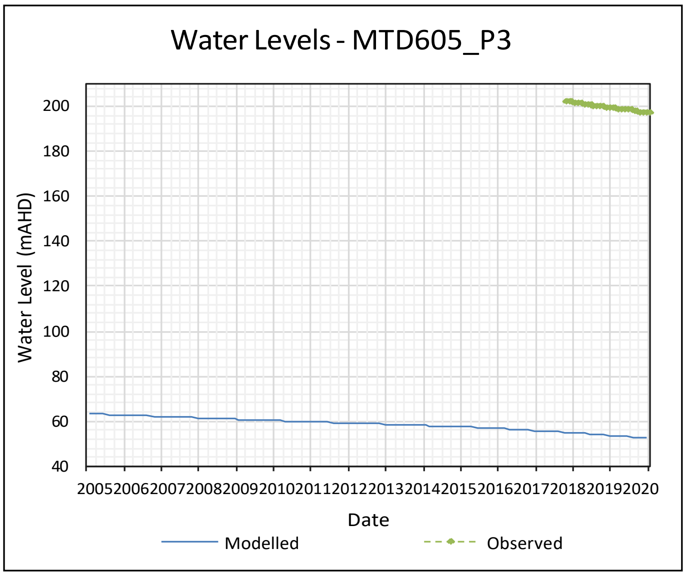

Water Levels - MTD518_P1
Water Level (mAHD)
Date
Modelled
Observed

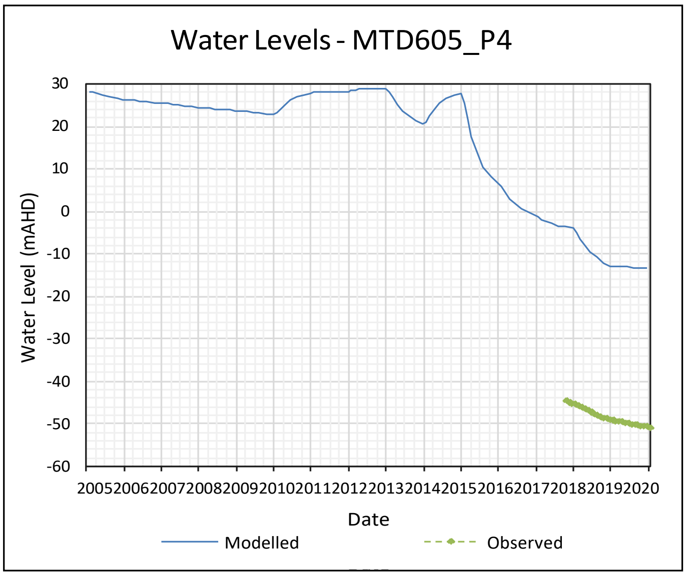

Water Levels - MTD518_P2
Water Level (mAHD)
Date
Modelled
Observed

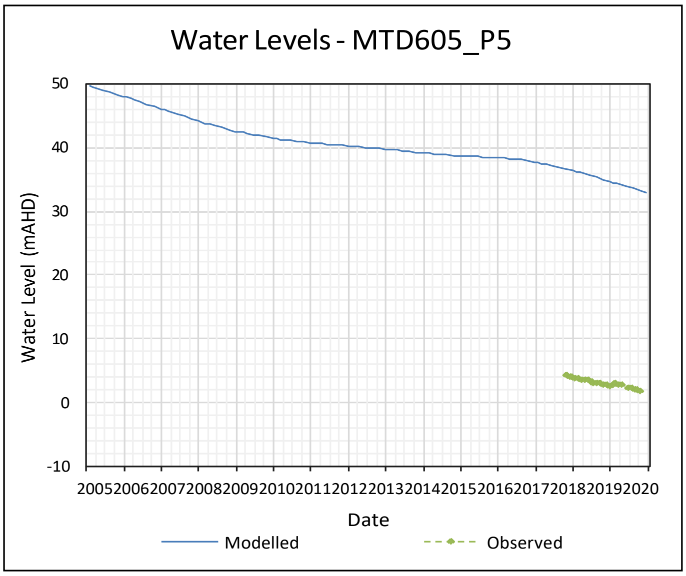

Water Levels - MTD518_P3
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

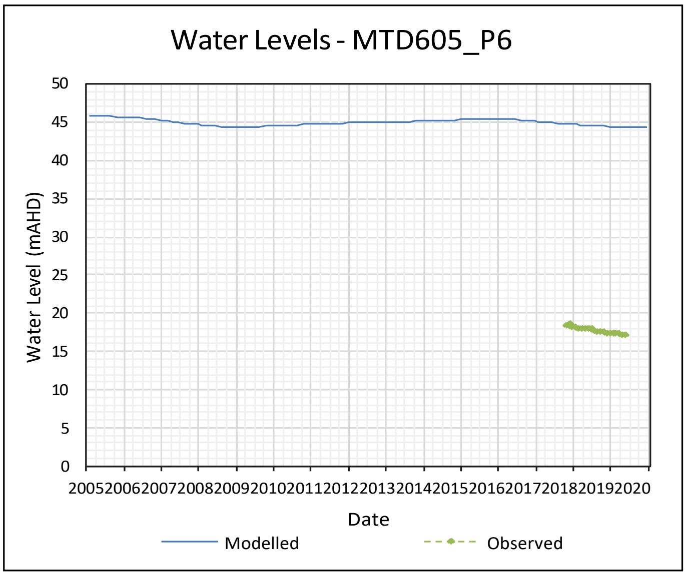

Water Levels - MTD605_P1
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

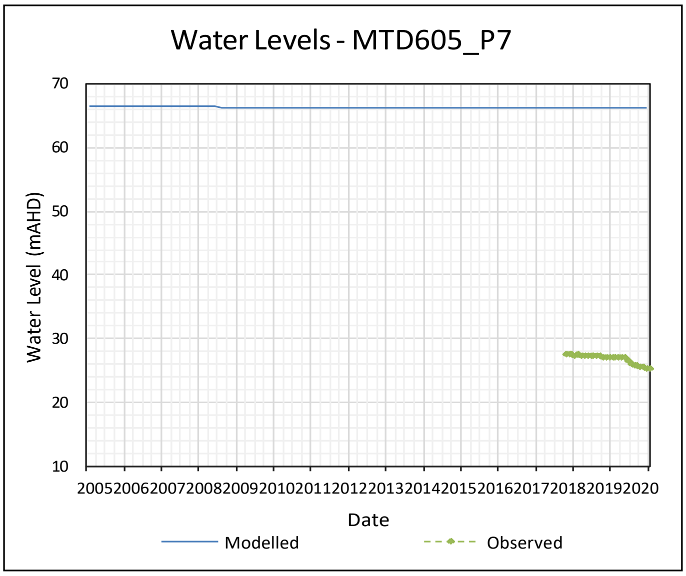

Water Levels - MTD605_P2
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

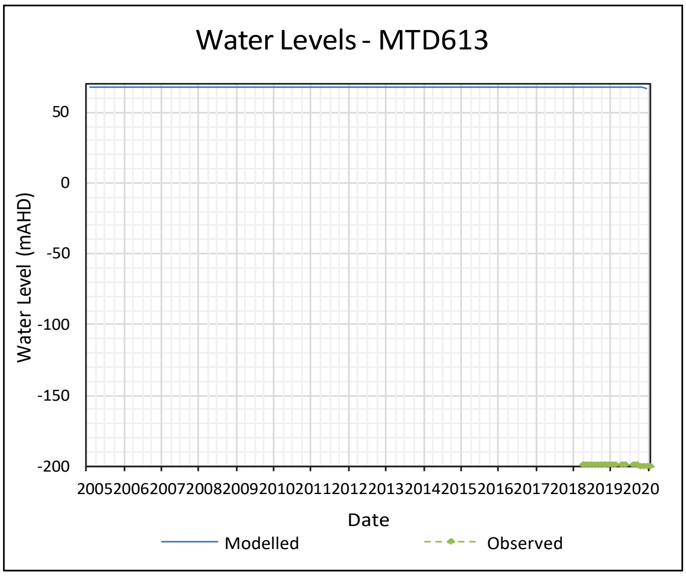

Water Levels - MTD605_P3
Water Level (mAHD)
200
180
160
140
120
100
80
60
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

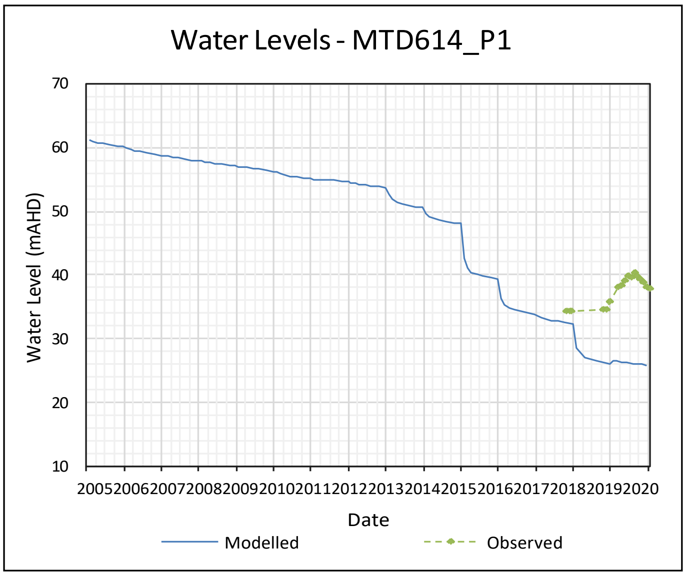

Water Levels - MTD605_P4
Water Level (mAHD)
30
20
10
0
-10
-20
-30
-40
-50
-60
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

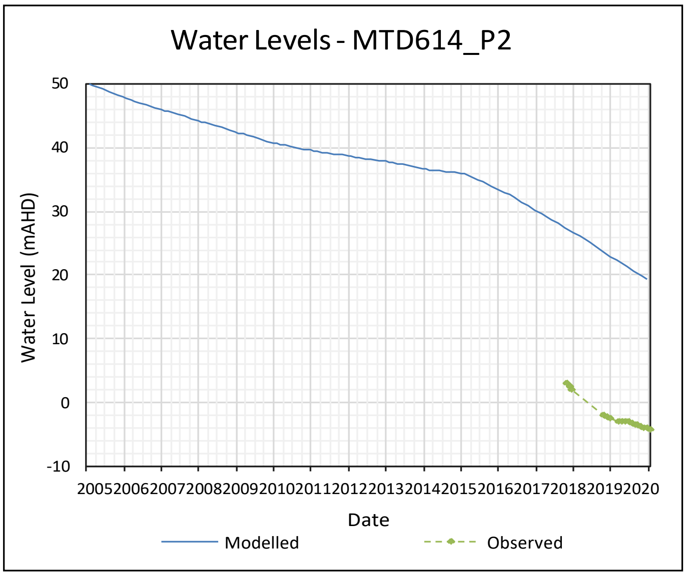

Water Levels - MTD605_P5
Water Level (mAHD)
50
40
30
20
10
0
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

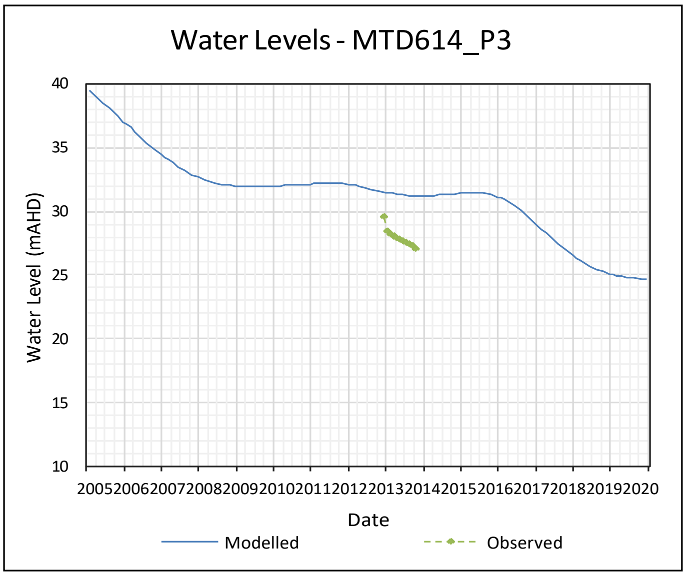

Water Levels - MTD605_P6
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
5
0
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

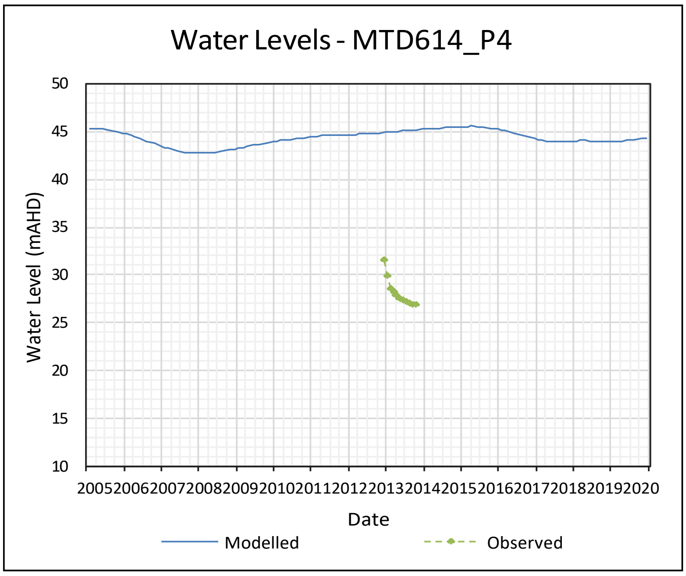

Water Levels - MTD605_P7
Water Level (mAHD)
70
60
50
40
30
20
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

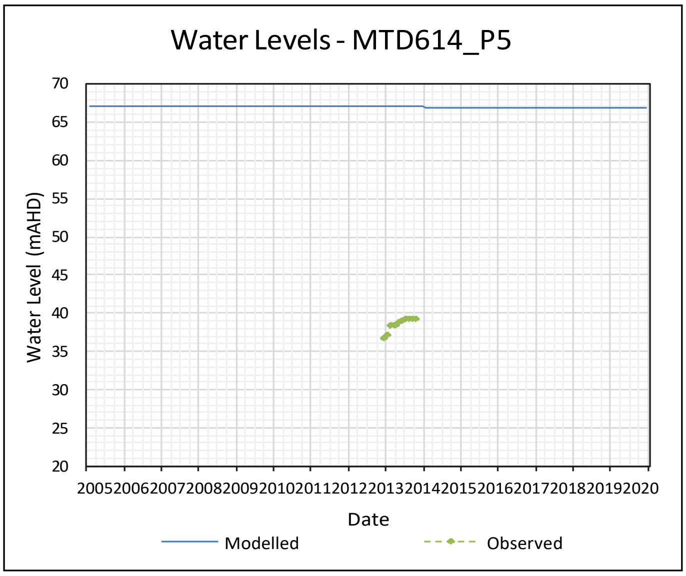

Water Levels - MTD613
Water Level (mAHD)
50
0
-50
-100
-150
-200
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

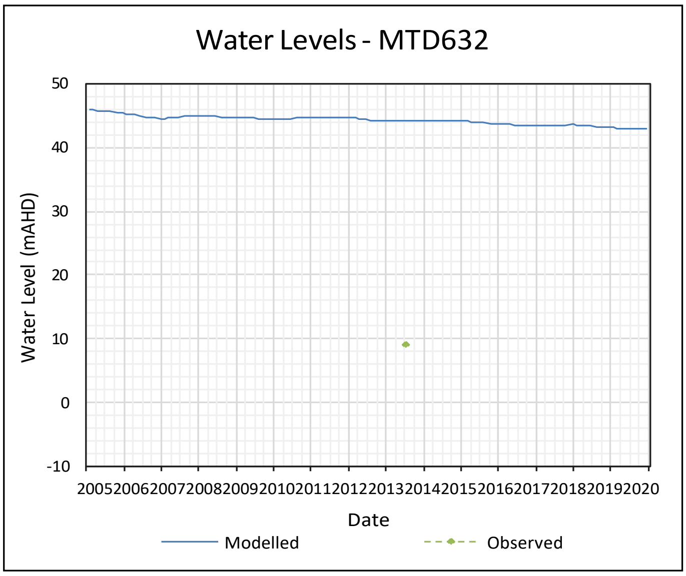

Water Levels - MTD614_P1
Water Level (mAHD)
70
60
50
40
30
20
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

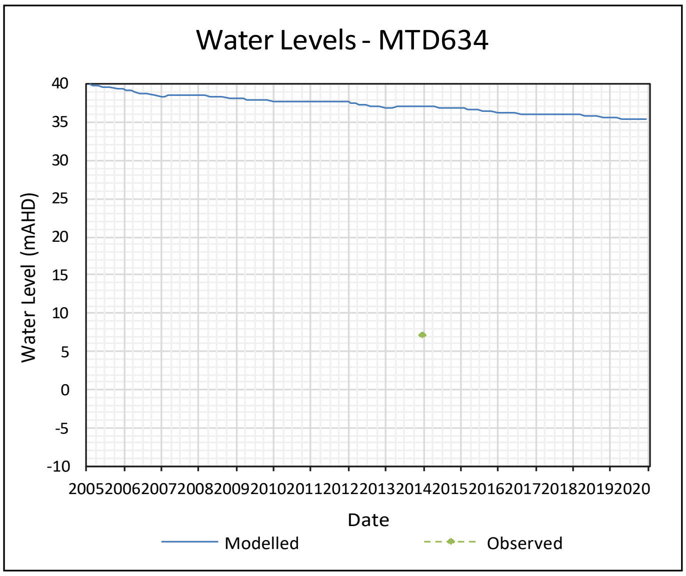

Water Levels - MTD614_P2
Water Level (mAHD)
50
40
30
20
10
0
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

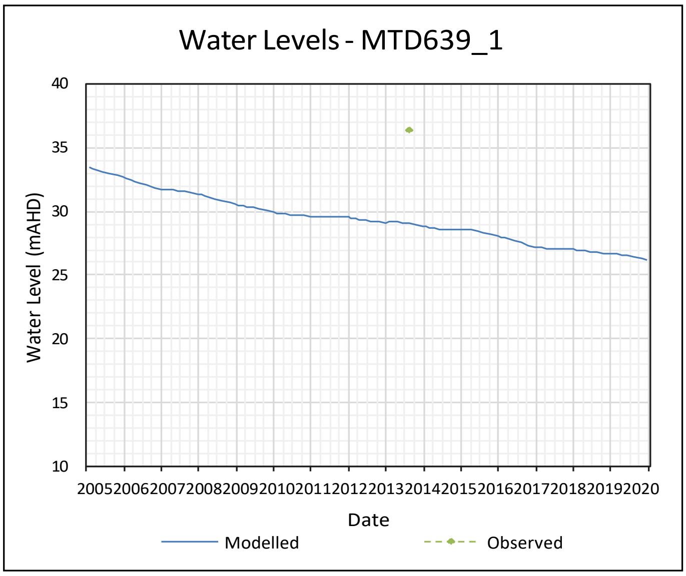

Water Levels - MTD614_P3
Water Level (mAHD)
40
35
30
25
20
15
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

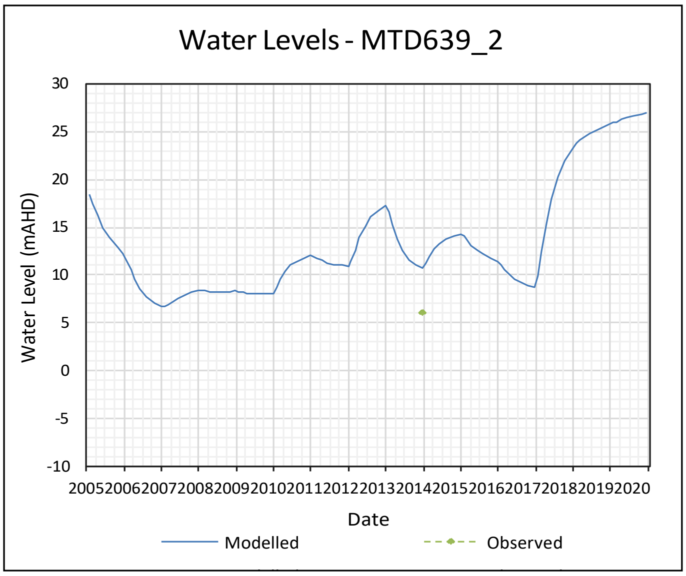

Water Levels - MTD614_P4
Water Level (mAHD)
Date
Modelled
Observed

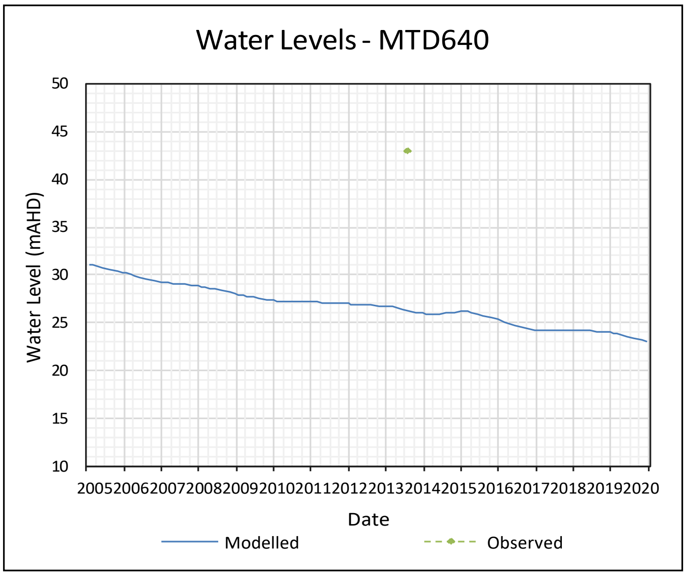

Water Levels - MTD614_P5
Water Level (mAHD)
Date
Modelled
Observed

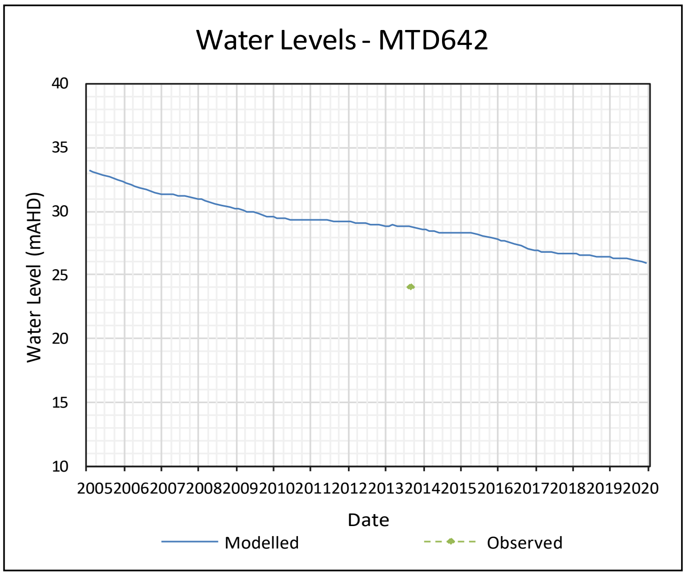

Water Levels - MTD632
Water Level (mAHD)
Date
Modelled
Observed

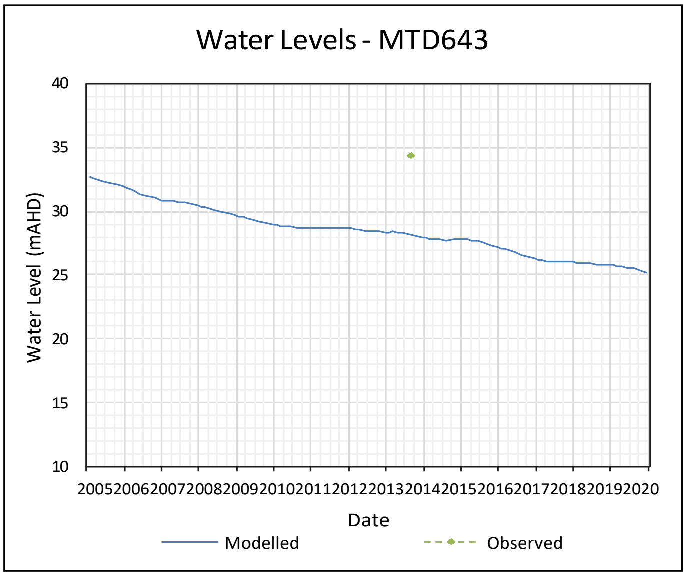

Water Levels - MTD634
Water Level (mAHD)
Date
Modelled
Observed

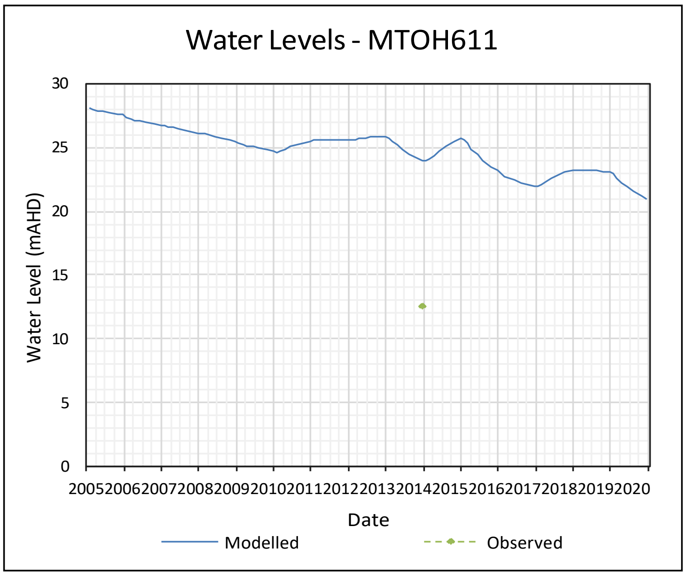

Water Levels - MTD639_1
Water Level (mAHD)
Date
Modelled
Observed

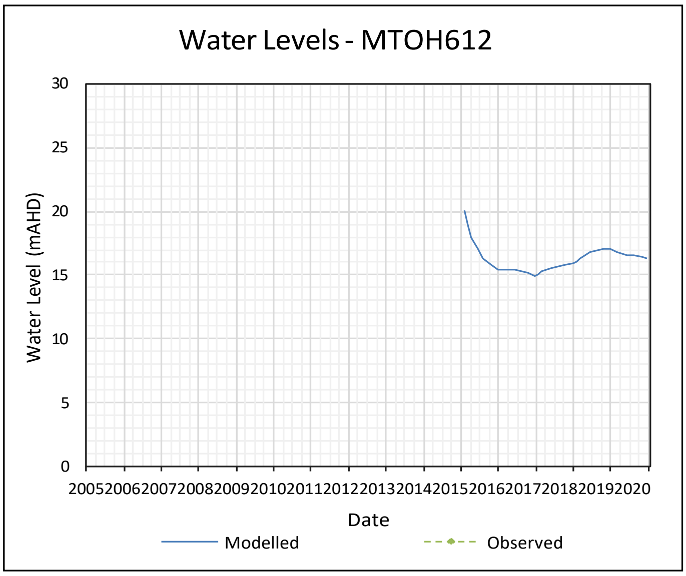

Water Levels - MTD639_2
Water Level (mAHD)
Date
Modelled
Observed

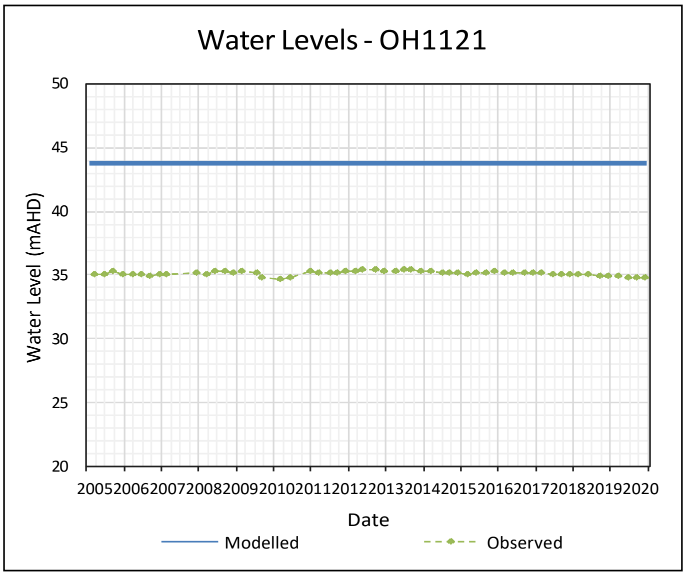

Water Levels - MTD640
Water Level (mAHD)
50
45
40
35
30
25
20
15
10
2005200620072008200920102011201220132014201520162017201820192020
Date
Modelled
Observed

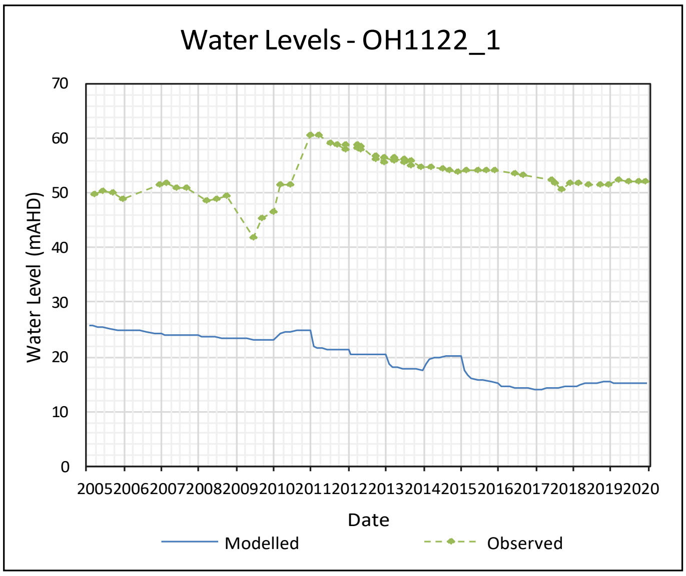

Water Levels - MTD642
Water Level (mAHD)
40
35
30
25
20
15
10
2005200620072008200920102011201220132014201520162017201820192020
Date
Modelled
Observed

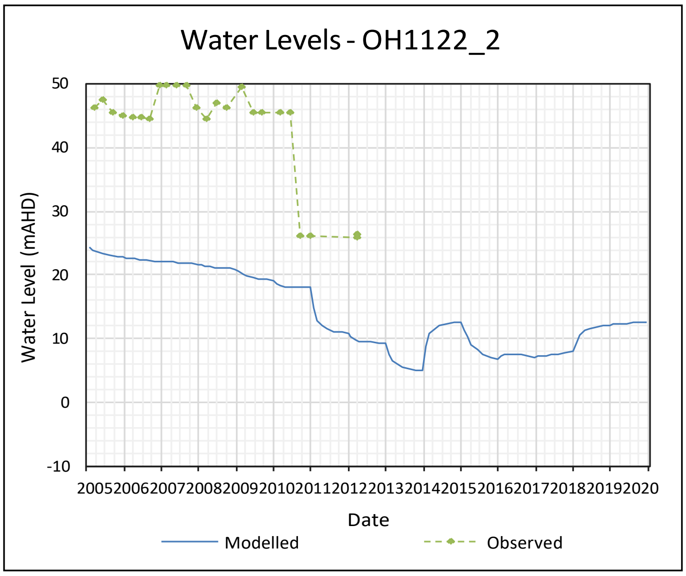

Water Levels - MTD643
Water Level (mAHD)
40
35
30
25
20
15
10
2005200620072008200920102011201220132014201520162017201820192020
Date
Modelled
Observed

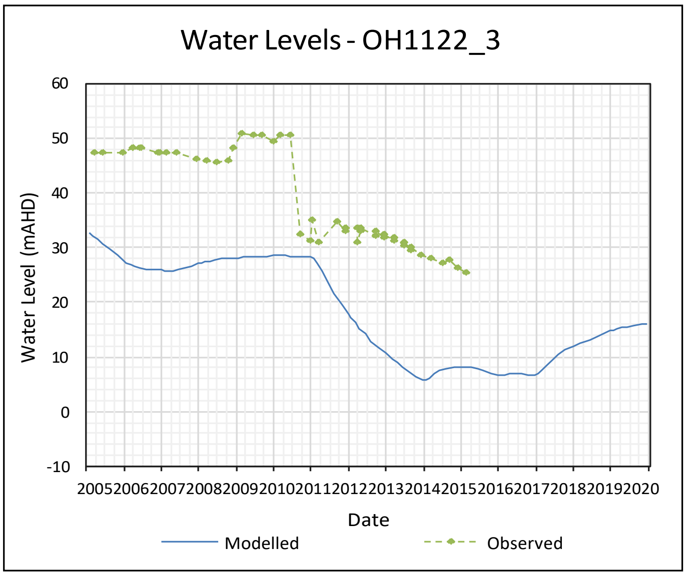

Water Levels - MTOH611
Water Level (mAHD)
30
25
20
15
10
5
0
2005200620072008200920102011201220132014201520162017201820192020
Date
Modelled
Observed

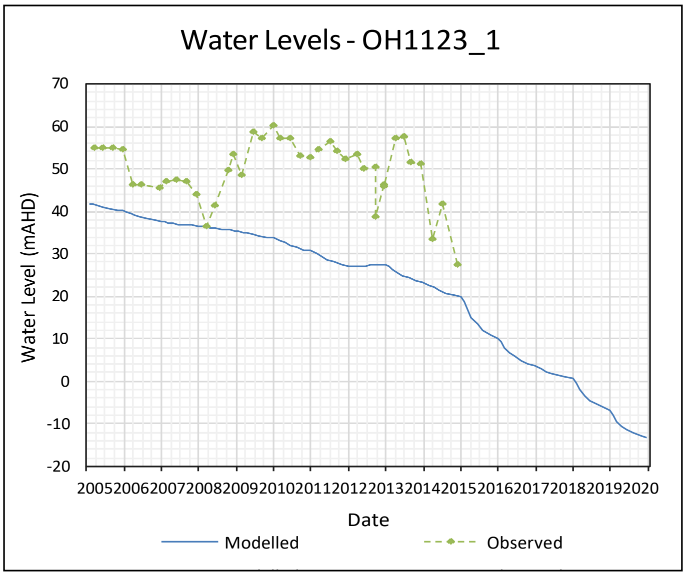

Water Levels - MTOH612
Water Level (mAHD)
30
25
20
15
10
5
0
2005200620072008200920102011201220132014201520162017201820192020
Date
Modelled
Observed

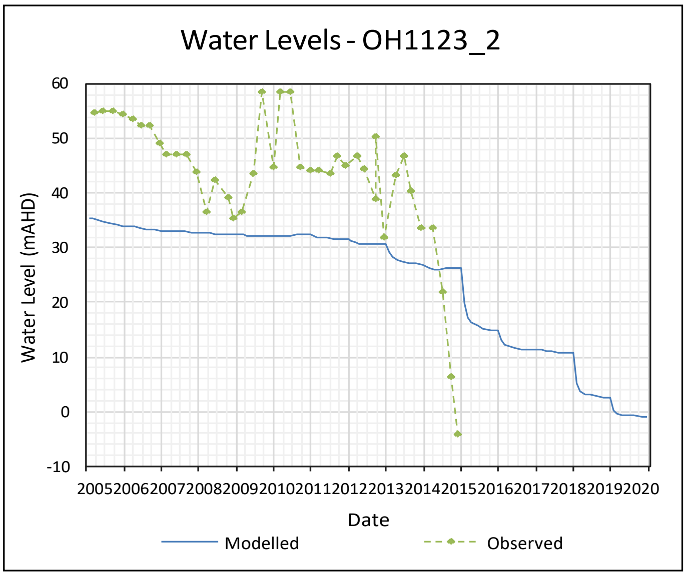

Water Levels - OH1121
Water Level (mAHD)
50
45
40
35
30
25
20
2005200620072008200920102011201220132014201520162017201820192020
Date
Modelled
Observed

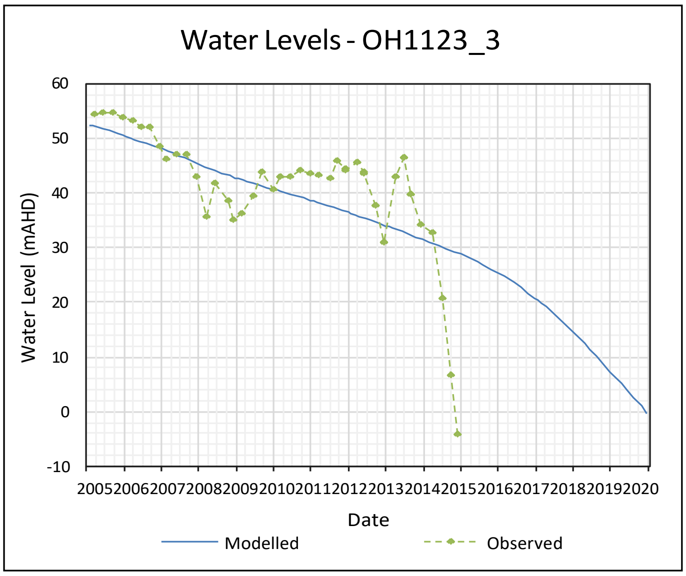

Water Levels - OH1122_1
Water Level (mAHD)
Date
Modelled
Observed

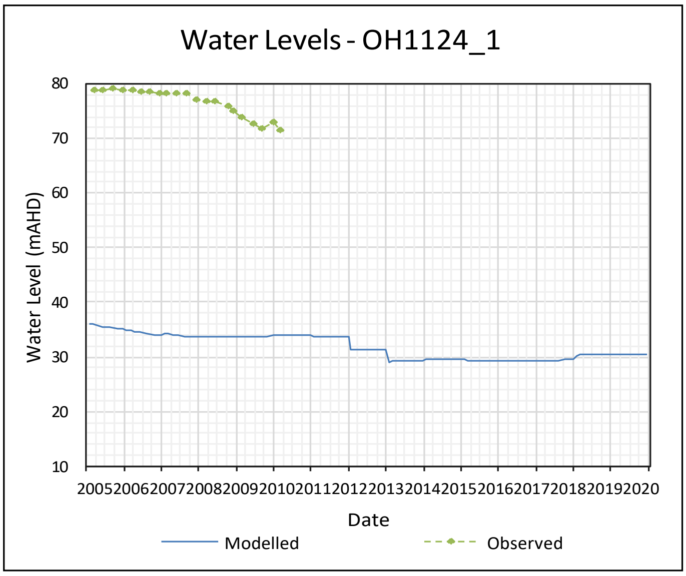

Water Levels - OH1122_2
Water Level (mAHD)
Date
Modelled
Observed

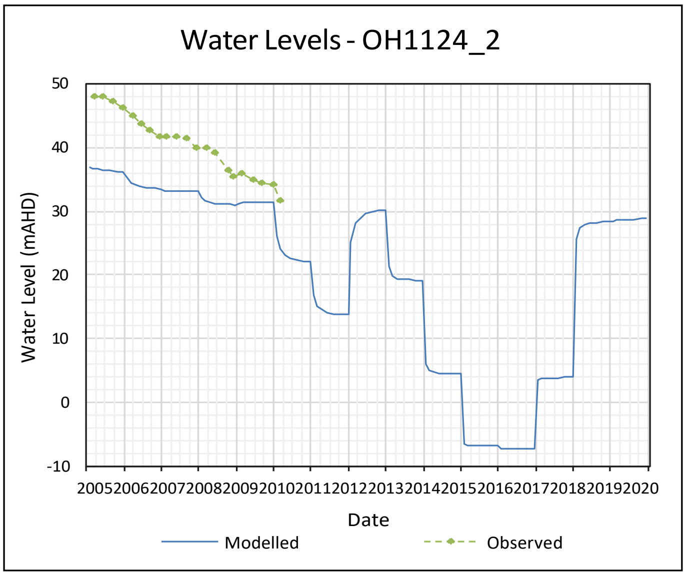

Water Levels - OH1122_3
Water Level (mAHD)
Date
Modelled
Observed

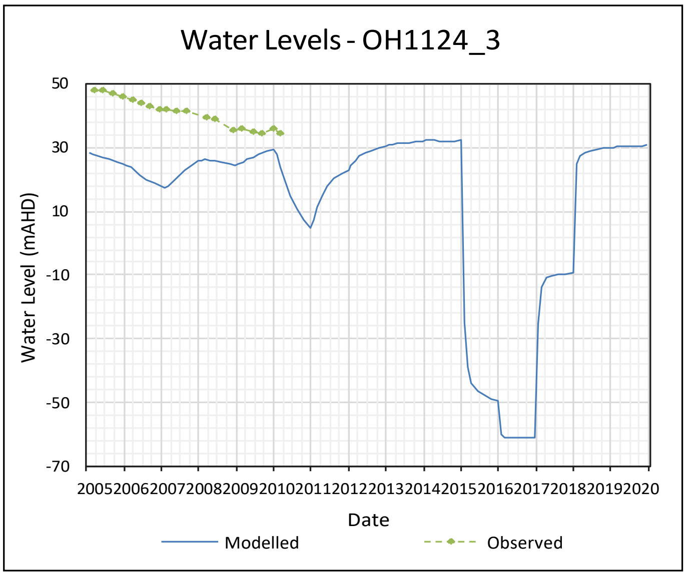

Water Levels - OH1123_1
Water Level (mAHD)
Date
Modelled
Observed

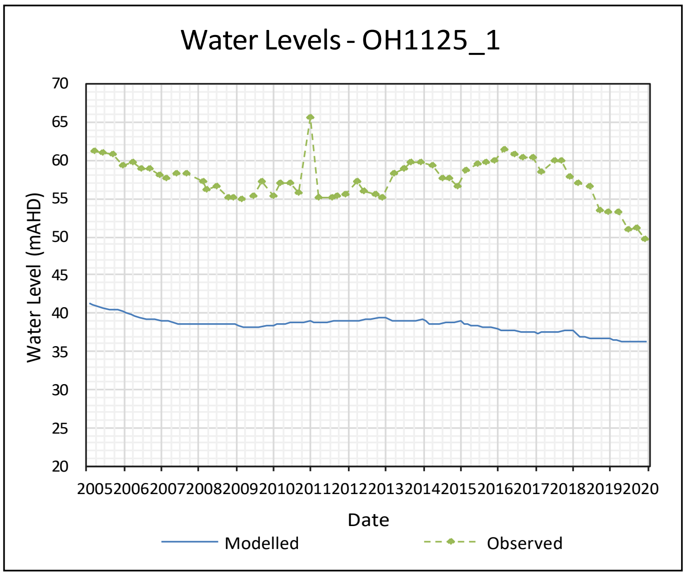

Water Levels - OH1123_2
Water Level (mAHD)
Date
Modelled
Observed

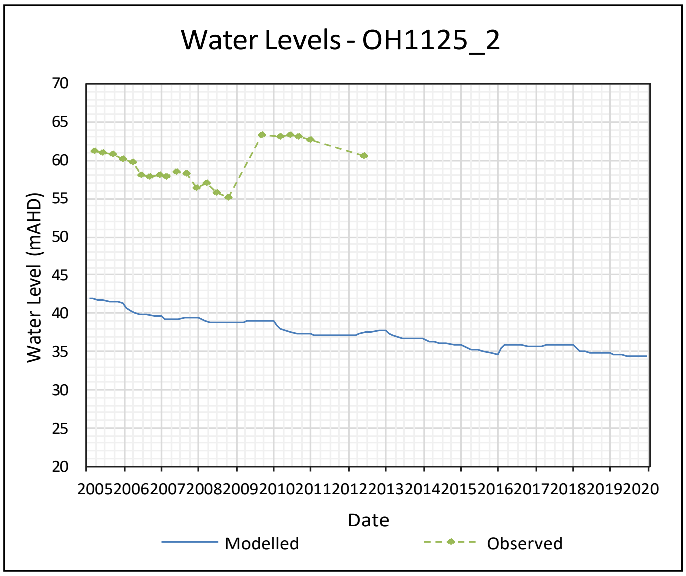

Water Levels - OH1123_3
Water Level (mAHD)
Date
Modelled
Observed

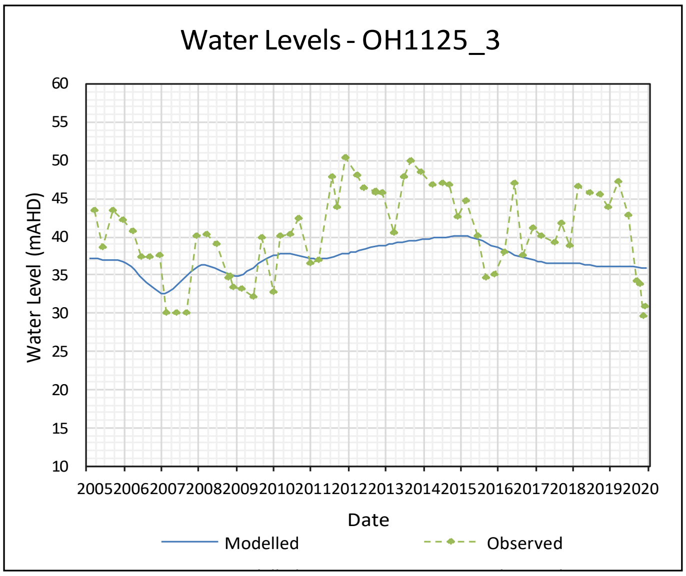

Water Levels - OH1124_1
Water Level (mAHD)
80
70
60
50
40
30
20
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

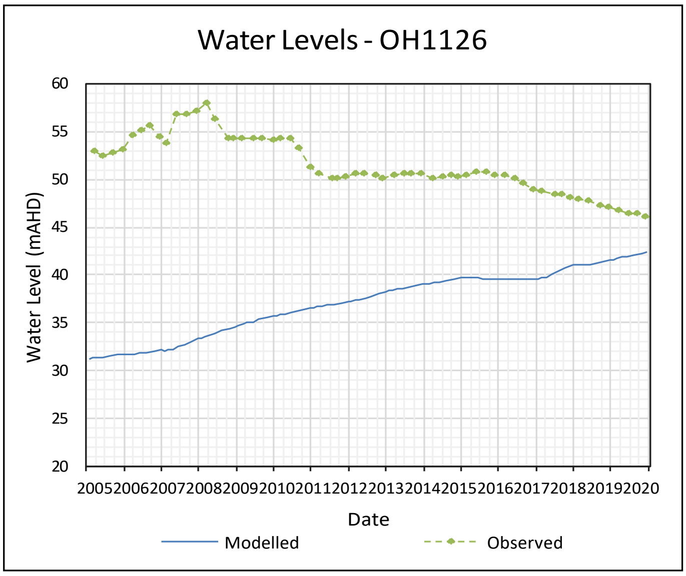

Water Levels - OH1124_2
Water Level (mAHD)
50
40
30
20
10
0
-10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

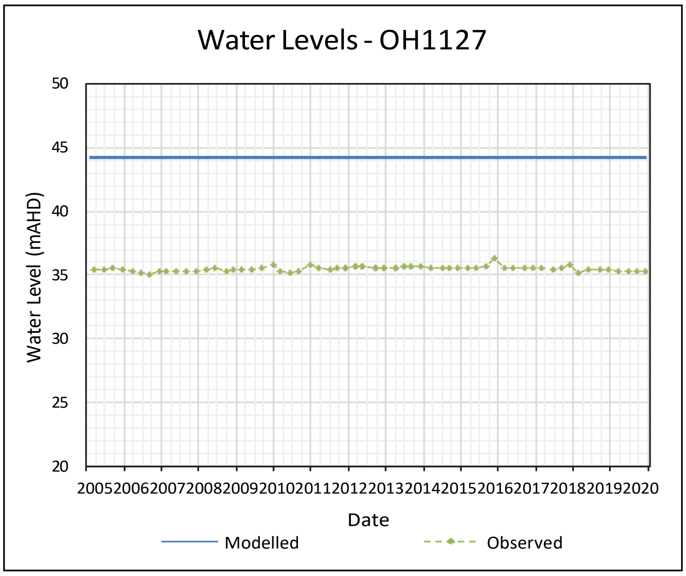

Water Levels - OH1124_3
Water Level (mAHD)
50
30
10
-10
-30
-50
-70
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

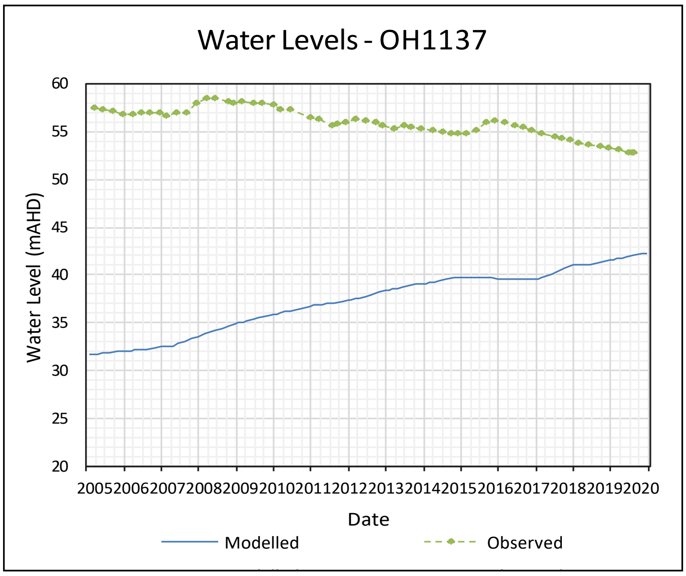

Water Levels - OH1125_1
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

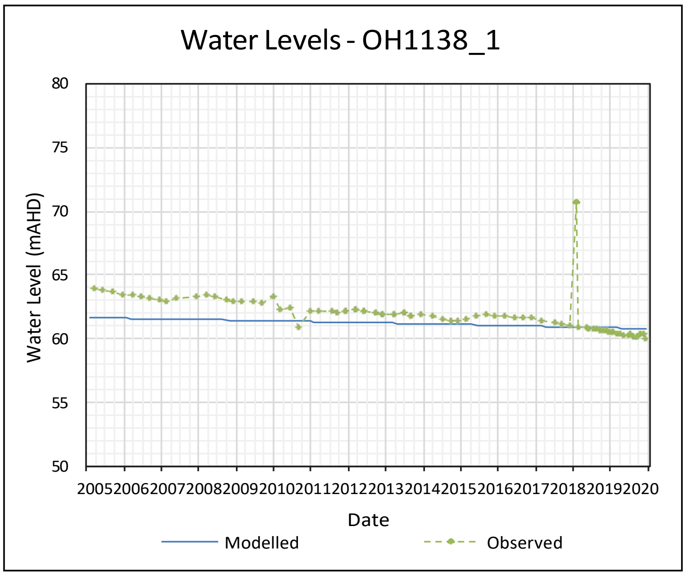

Water Levels - OH1125_2
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

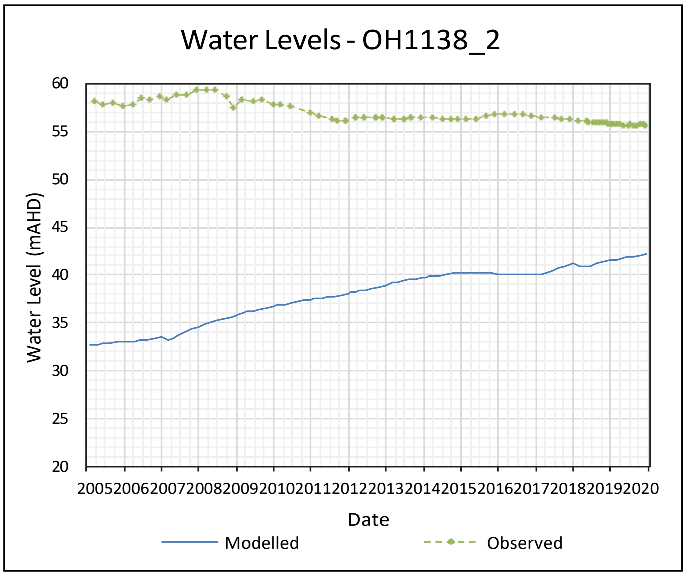

Water Levels - OH1125_3
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
15
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

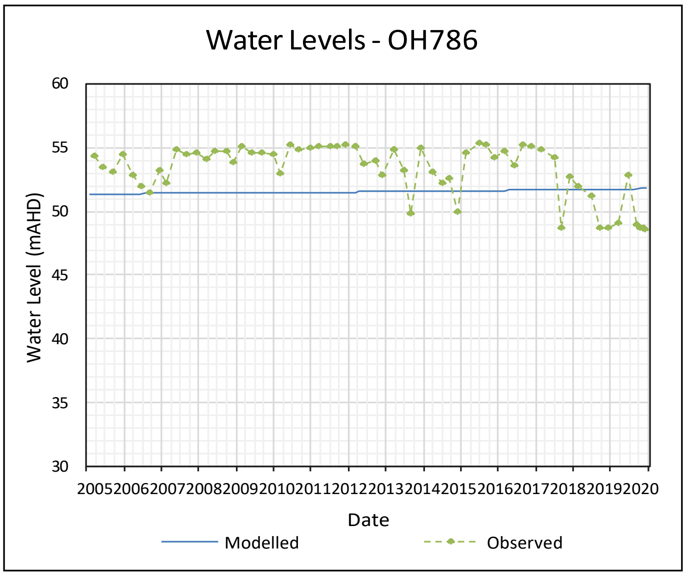

Water Levels - OH1126
60
55
50
45
40
35
30
25
20
Water Level (mAHD)
20052006200720082009201020112012201320142015201620172018201920 20
Date
Modelled
Observed

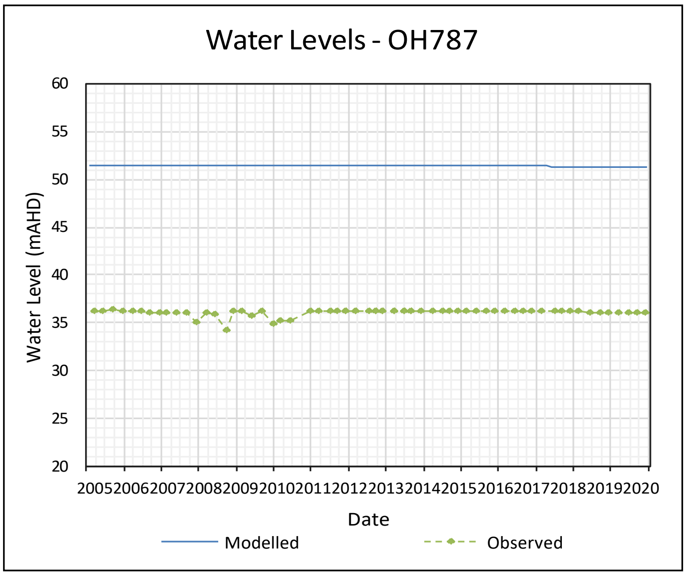

Water Levels - OH1127
50
45
40
35
30
25
20
Water Level (mAHD)
20052006200720082009201020112012201320142015201620172018201920 20
Date
Modelled
Observed

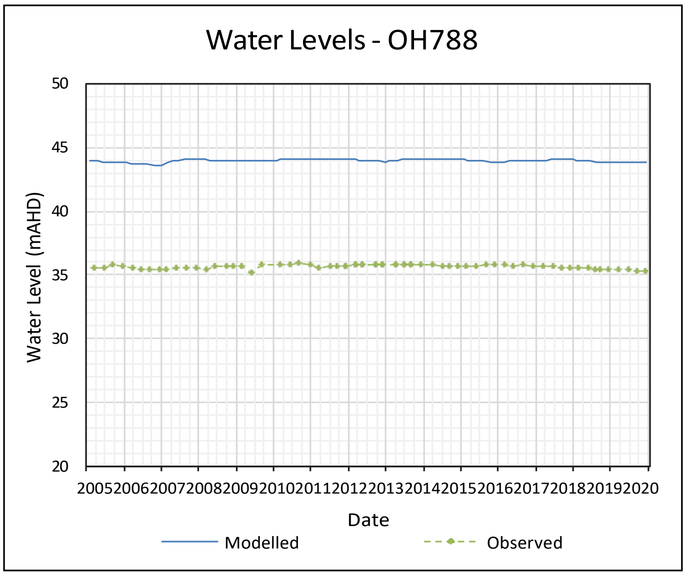

Water Levels - OH1137
60
55
50
45
40
35
30
25
20
Water Level (mAHD)
20052006200720082009201020112012201320142015201620172018201920 20
Date
Modelled
Observed

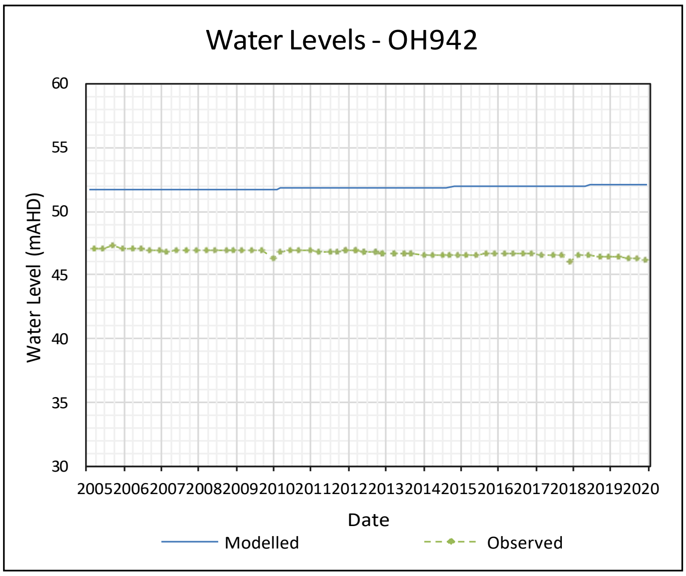

Water Levels - OH1138_1
80
75
70
65
60
55
50
Water Level (mAHD)
20052006200720082009201020112012201320142015201620172018201920 20
Date
Modelled
Observed

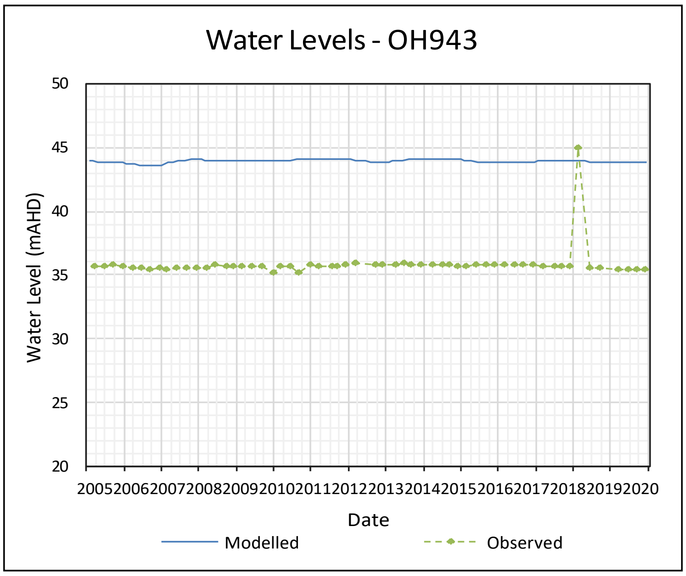

Water Levels - OH1138_2
60
55
50
45
40
35
30
25
20
Water Level (mAHD)
20052006200720082009201020112012201320142015201620172018201920 20
Date
Modelled
Observed

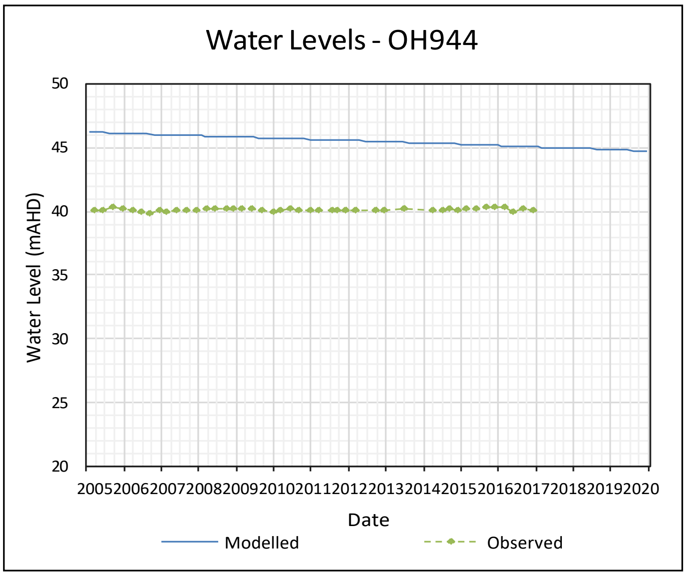

Water Levels - OH786
60
55
50
45
40
35
30
Water Level (mAHD)
20052006200720082009201020112012201320142015201620172018201920 20
Date
Modelled
Observed

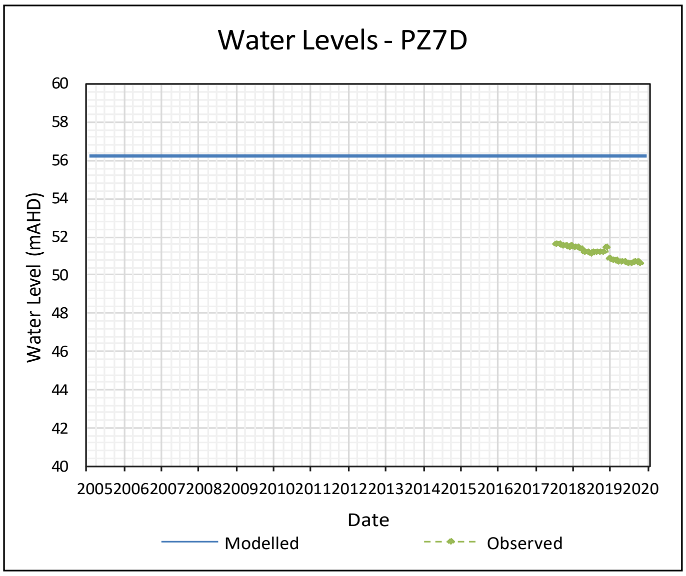

Water Levels - OH787
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

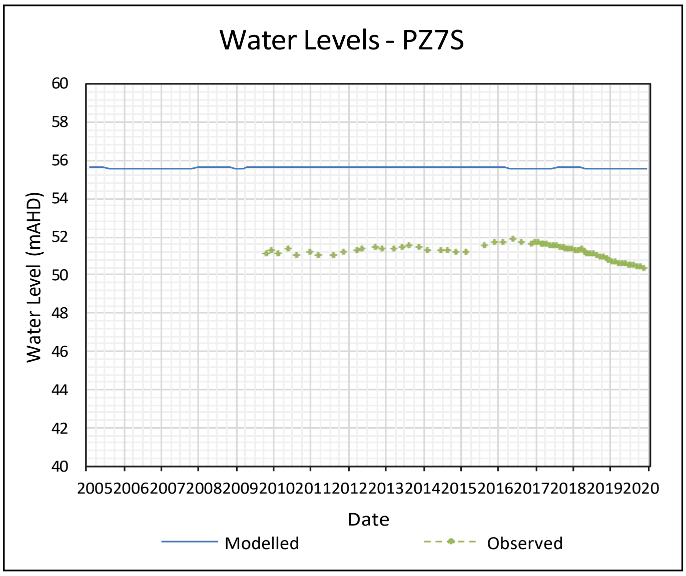

Water Levels - OH788
Water Level (mAHD)
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

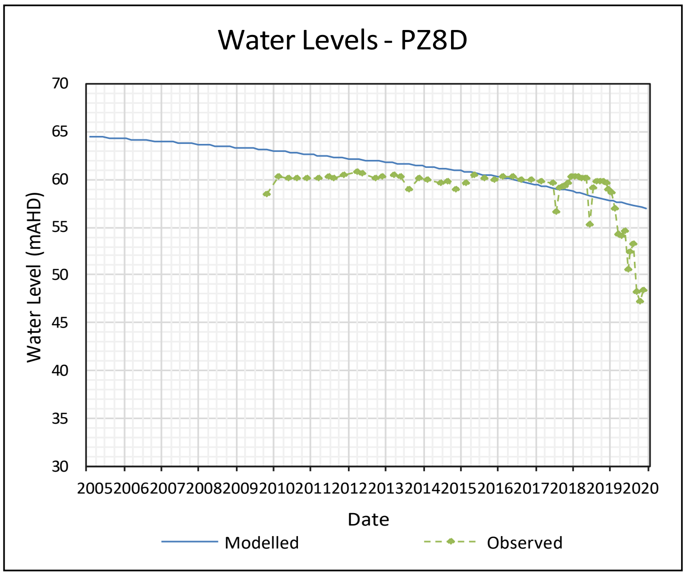

Water Levels - OH942
Water Level (mAHD)
60
55
50
45
40
35
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

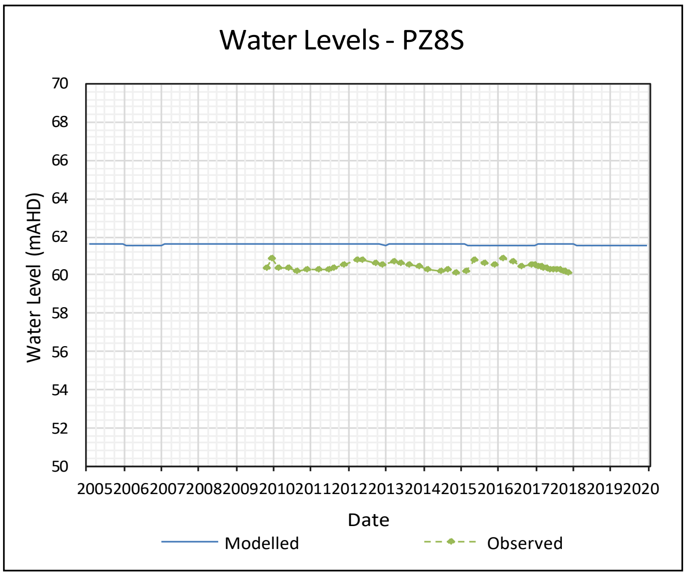

Water Levels - OH943
Water Level (mAHD)
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

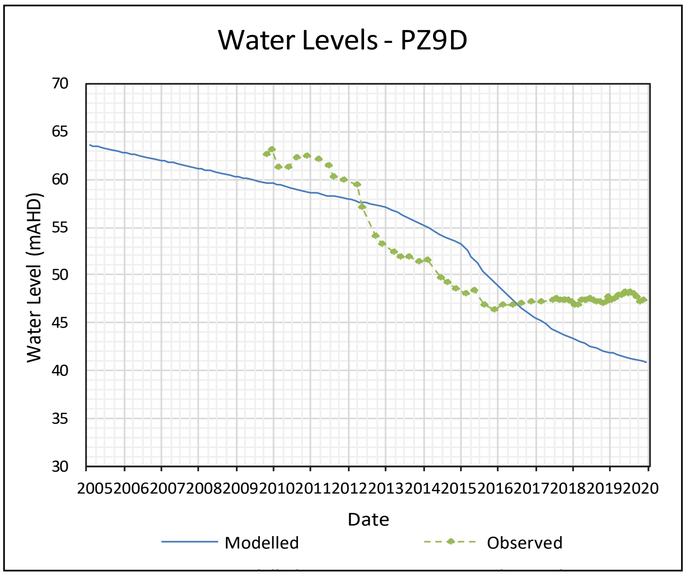

Water Levels - OH944
Water Level (mAHD)
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

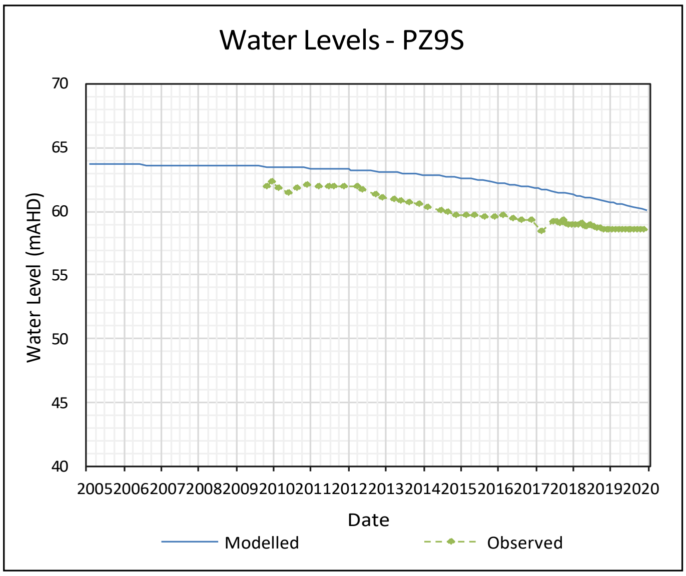

Water Levels - PZ7D
Water Level (mAHD)
60
58
56
54
52
50
48
46
44
42
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

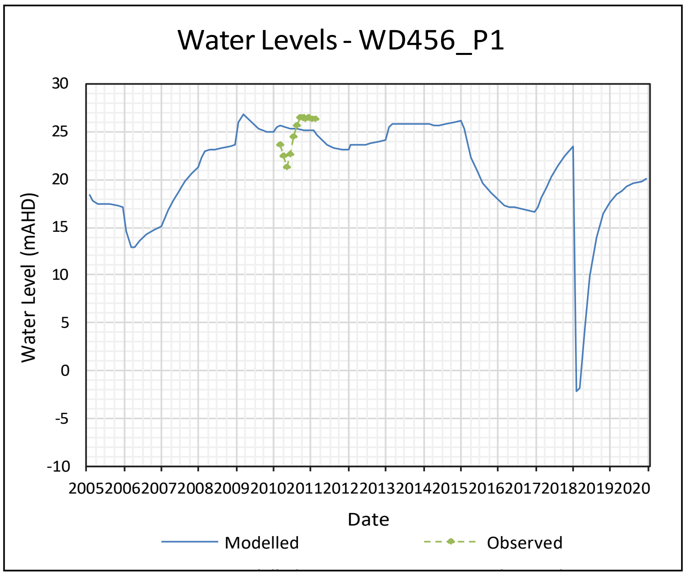

Water Levels - PZ7S
Water Level (mAHD)
Date
Modelled
Observed

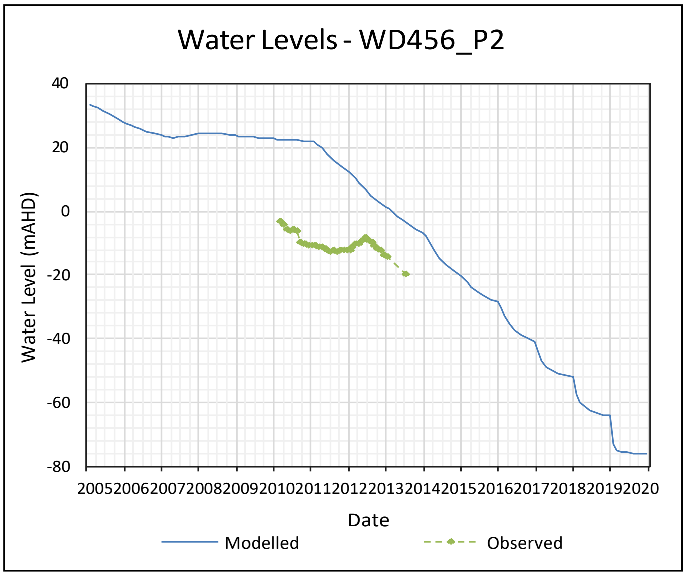

Water Levels - PZ8D
Water Level (mAHD)
Date
Modelled
Observed

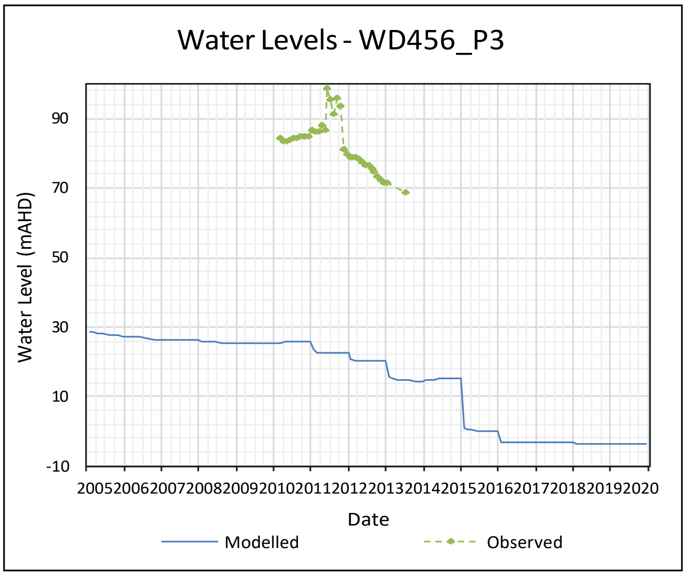

Water Levels - PZ8S
Water Level (mAHD)
Date
Modelled
Observed

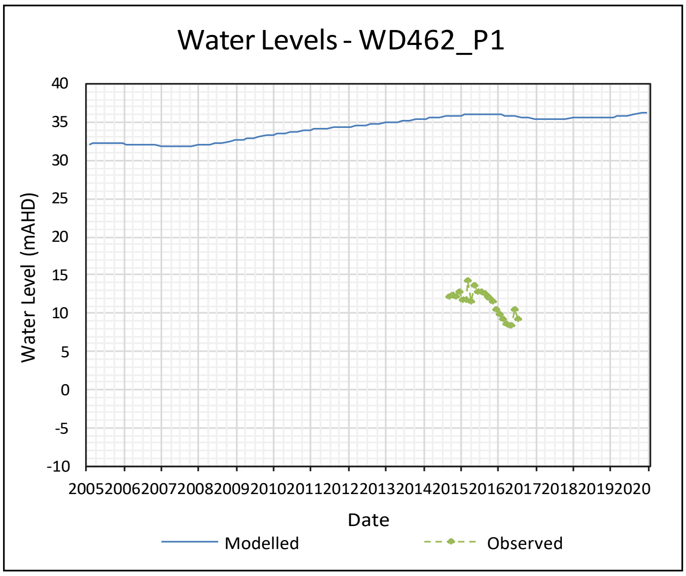

Water Levels - PZ9D
Water Level (mAHD)
Date
Modelled
Observed

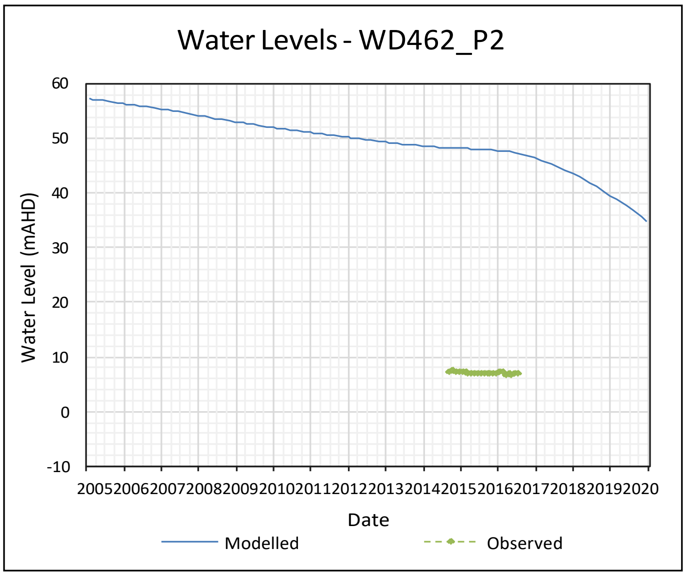

Water Levels - PZ9S
Water Level (mAHD)
Date
Modelled
Observed

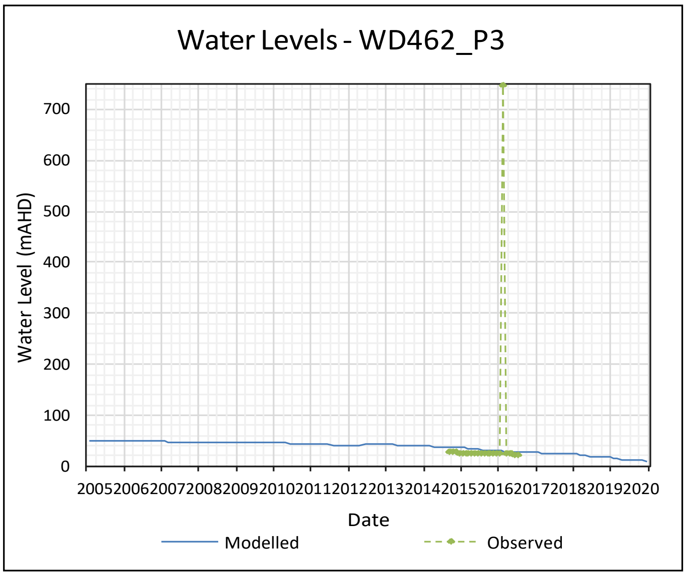

Water Levels - WD456_P1
Water Level (mAHD)
Date
Modelled
Observed

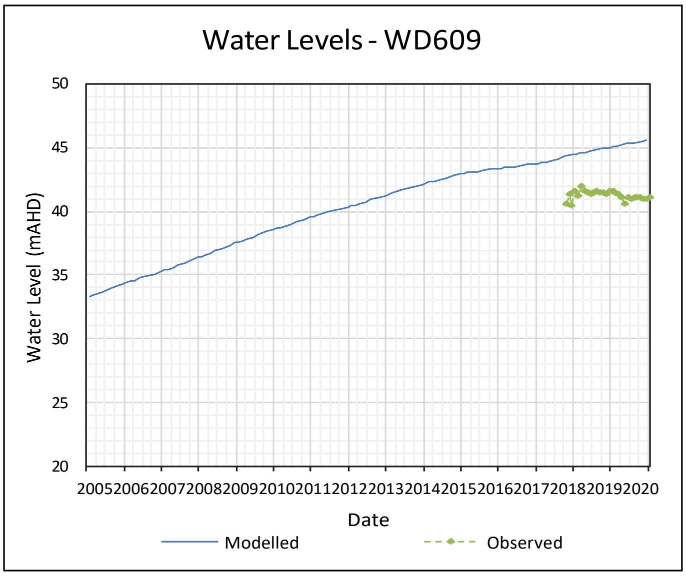

Water Levels - WD456_P2
40
20
0
-20
-40
-60
-80
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

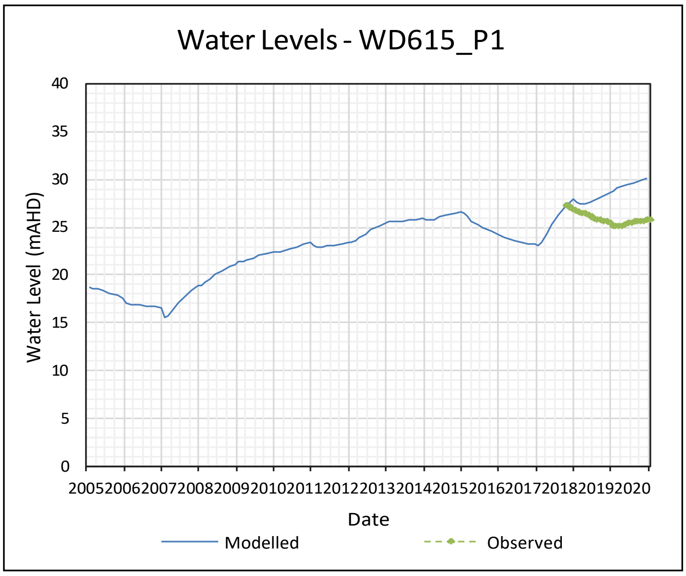

Water Levels - WD456_P3
90
70
50
30
10
-10
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

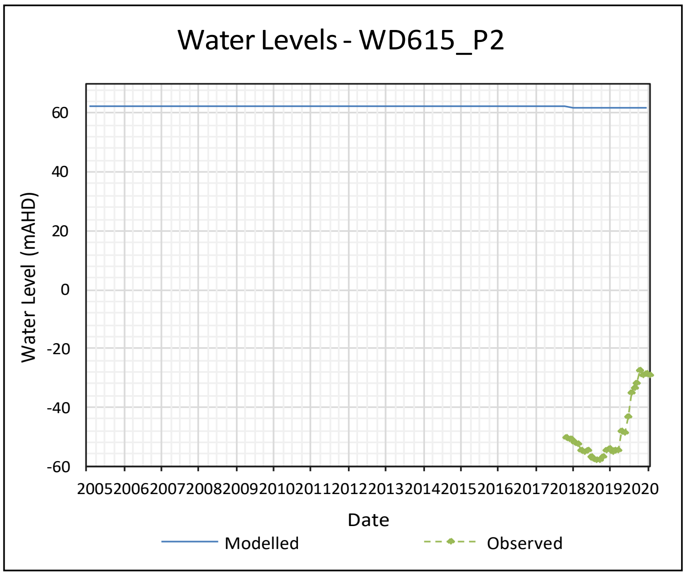

Water Levels - WD462_P1
40
35
30
25
20
15
10
5
0
-5
-10
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

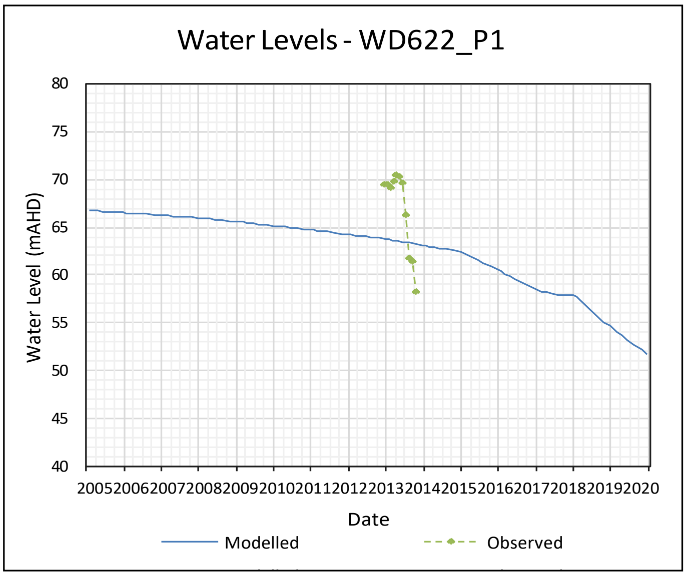

Water Levels - WD462_P2
60
50
40
30
20
10
0
-10
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

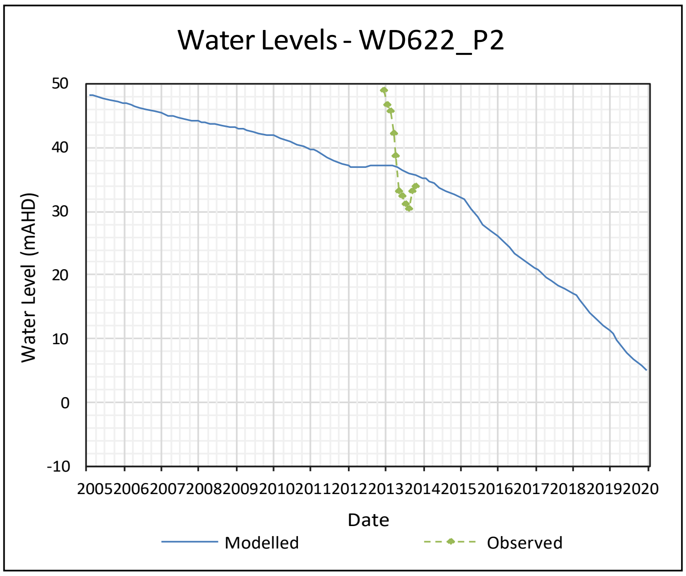

Water Levels - WD462_P3
700
600
500
400
300
200
100
0
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

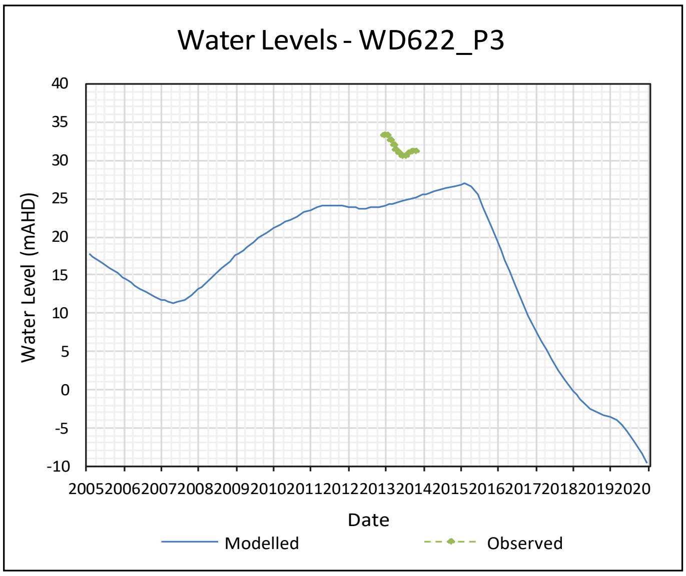

Water Levels - WD609
50
45
40
35
30
25
20
Water Level (mAHD)
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

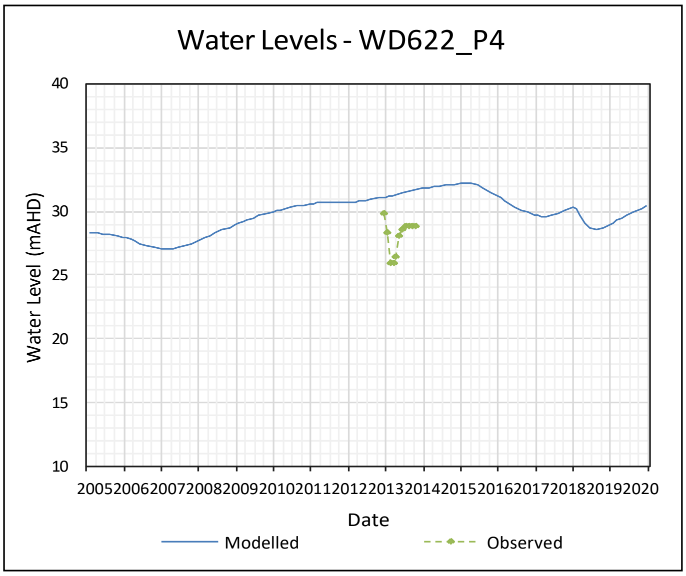

Water Levels - WD615_P1
Water Level (mAHD)
0 5 10 15 20 25 30 35 40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

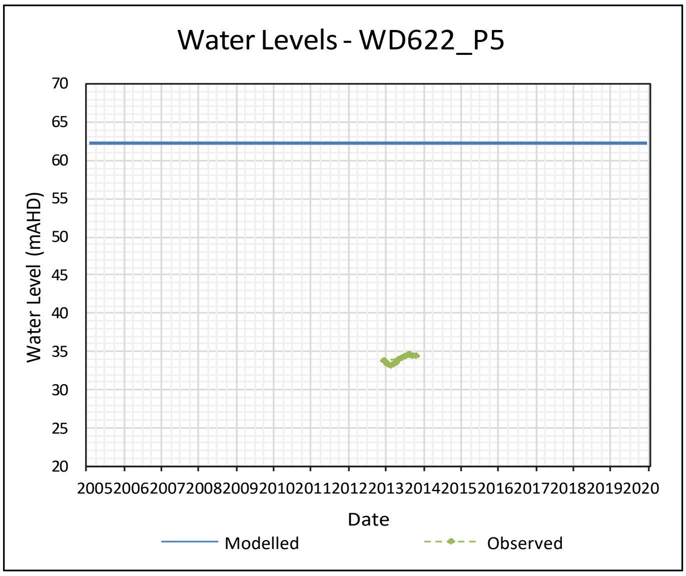

Water Levels - WD615_P2
Water Level (mAHD)
-60 -40 -20 0 20 40 60
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed


Water Levels - WD622_P1
Water Level (mAHD)
40 45 50 55 60 65 70 75 80
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

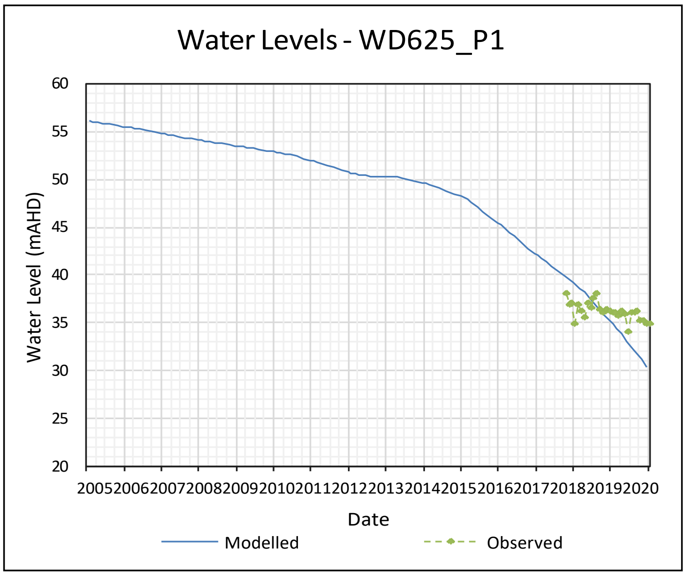

Water Levels - WD622_P2
Water Level (mAHD)
-10 0 10 20 30 40 50
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed


Water Levels - WD622_P3
Water Level (mAHD)
-10 -5 0 5 10 15 20 25 30 35 40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

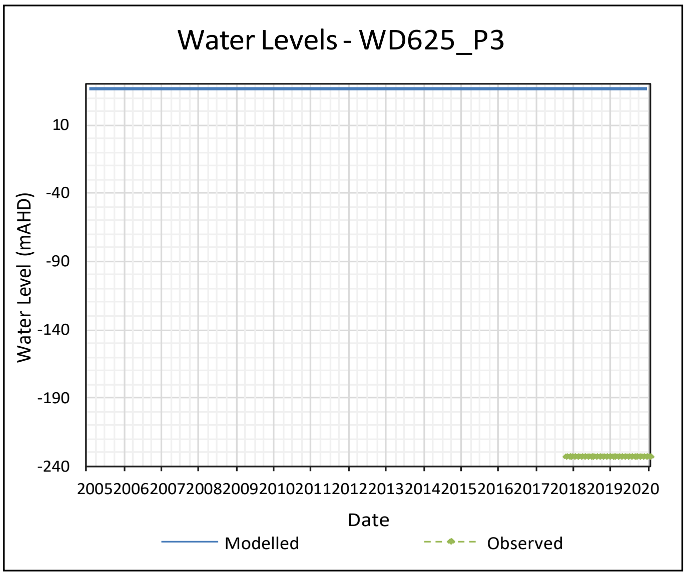

Water Levels - WD622_P4
Water Level (mAHD)
10 15 20 25 30 35 40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed



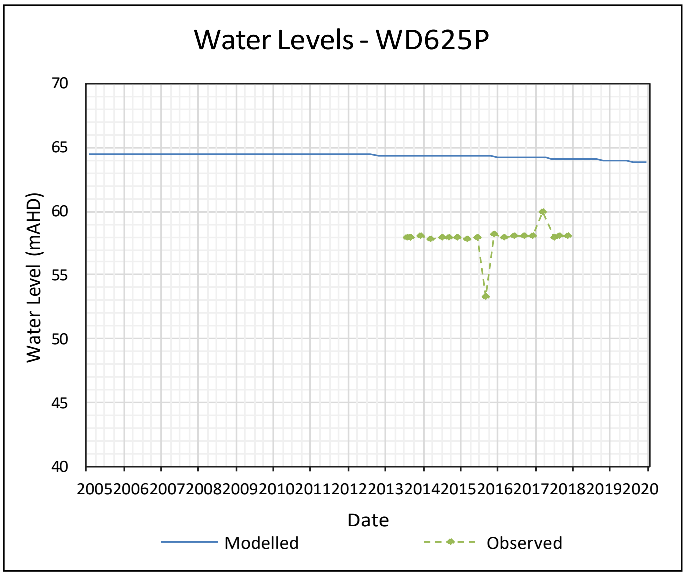
Water Levels - WD622_P5
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed



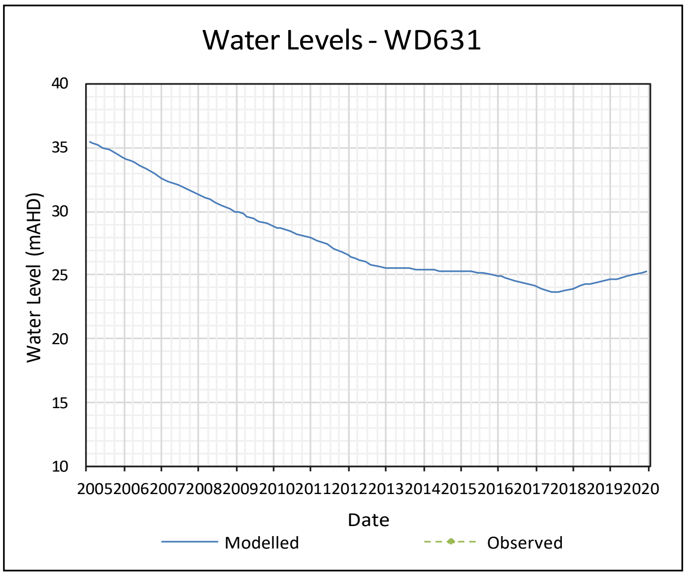
Water Levels - WD625_P1
Water Level (mAHD)
60
55
50
45
40
35
30
25
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed



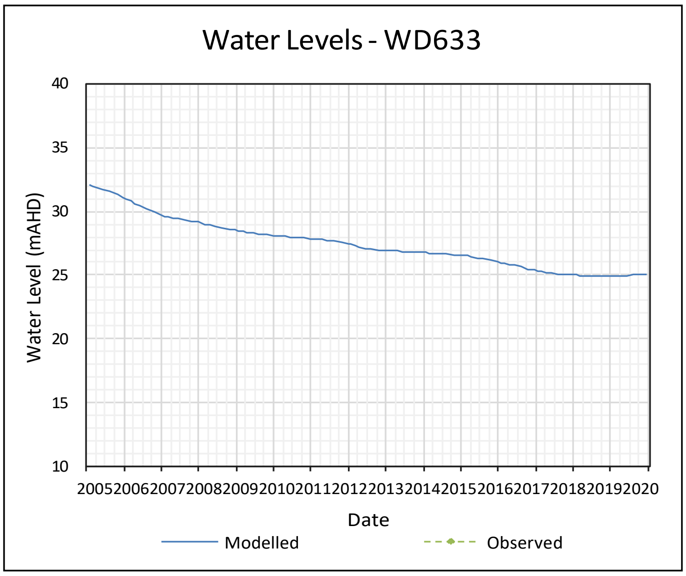
Water Levels - WD625_P3
Water Level (mAHD)
10
-40
-90
-140
-190
-240
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed



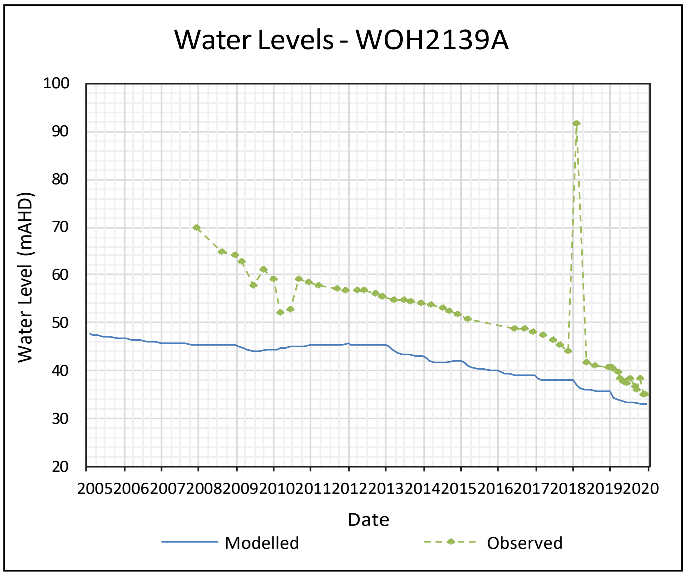
Water Levels - WD625P
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

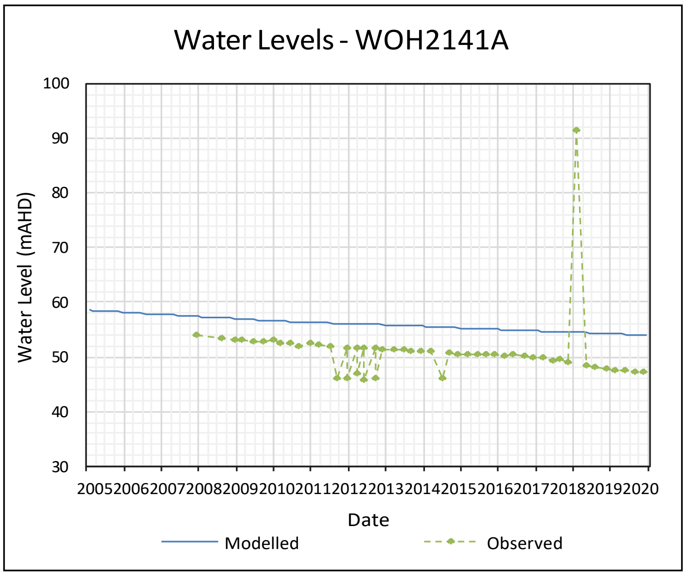


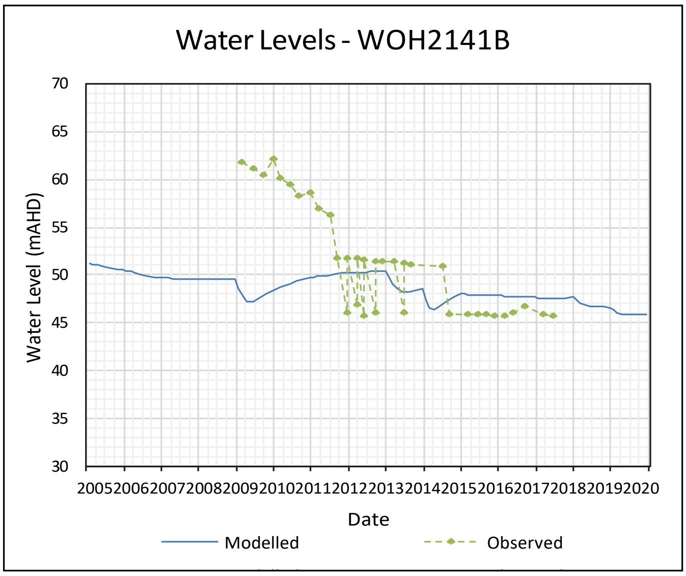
Water Levels - WD631
Water Level (mAHD)
40
35
30
25
20
15
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

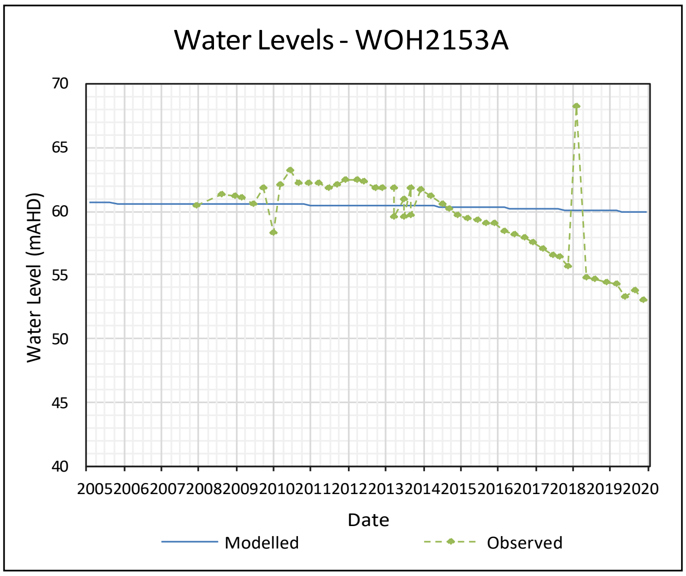


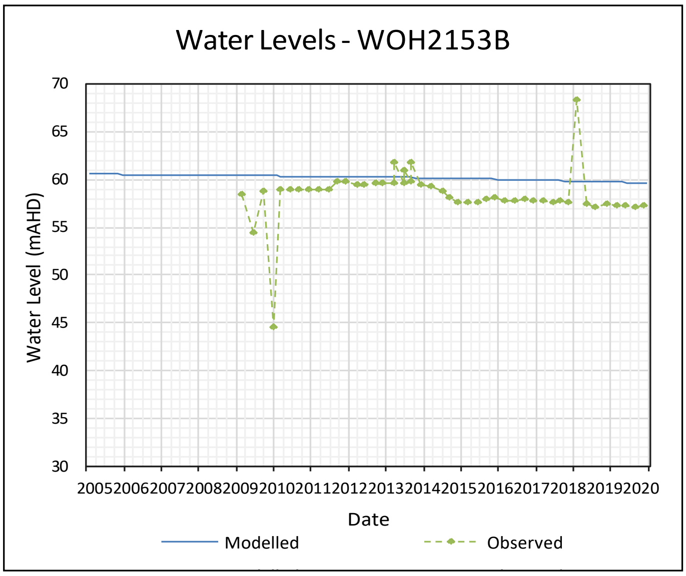
Water Levels - WD633
Water Level (mAHD)
40
35
30
25
20
15
10
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

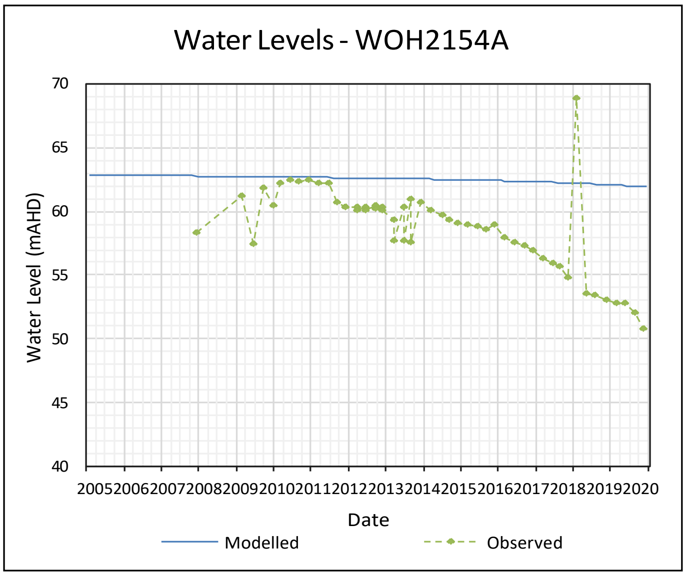

Water Levels - WOH2139A
Water Level (mAHD)
100
90
80
70
60
50
40
30
20
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

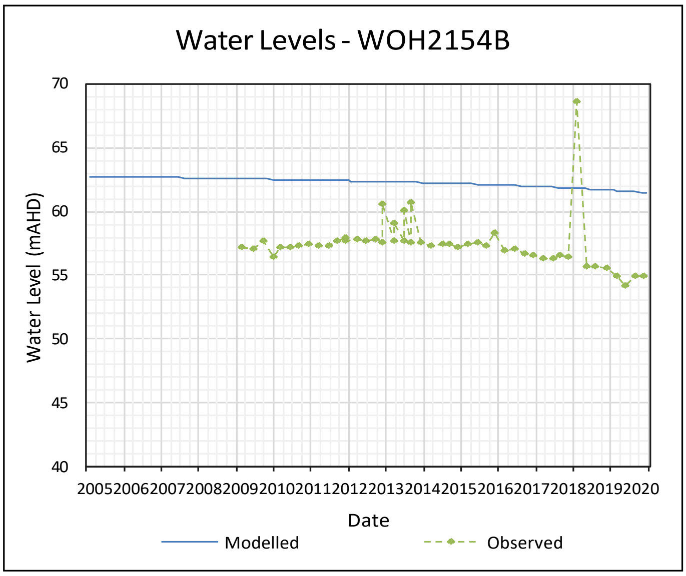

Water Levels - WOH2141A
Water Level (mAHD)
100
90
80
70
60
50
40
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

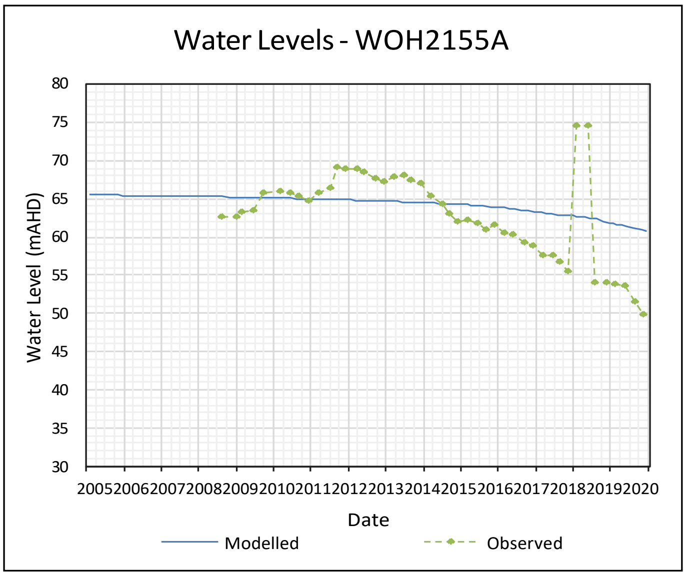

Water Levels - WOH2141B
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

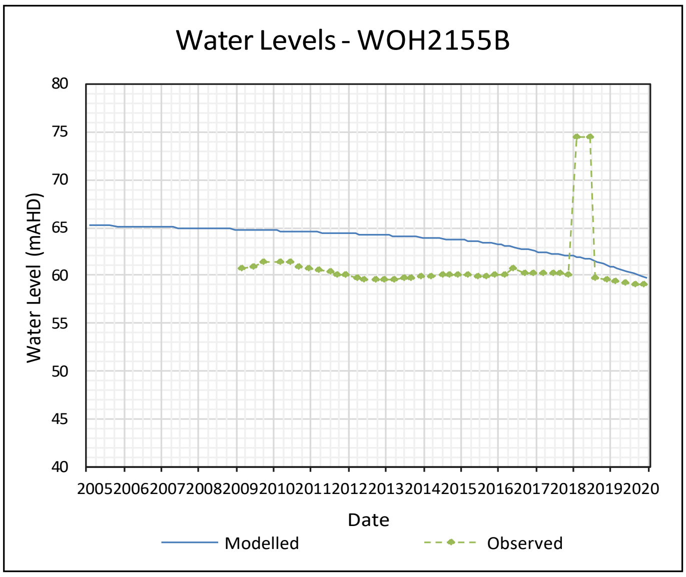

Water Levels - WOH2153A
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

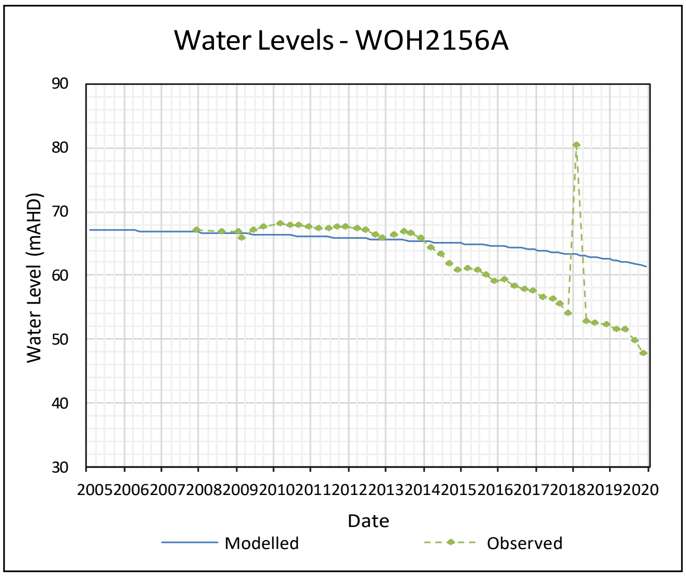

Water Levels - WOH2153B
Water Level (mAHD)
70
65
60
55
50
45
40
35
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

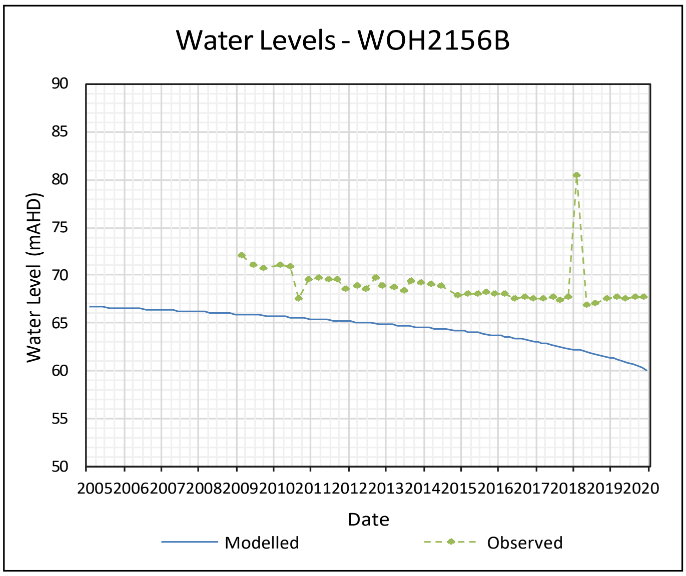

Water Levels - WOH2154A
Water Level (mAHD)
70
65
60
55
50
45
40
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed


Water Levels - WOH2154B
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 2020
Date
Modelled
Observed


Water Levels - WOH2155A
Water Level (mAHD)
80
75
70
65
60
55
50
45
40
35
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed


Water Levels - WOH2155B
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 2020
Date
Modelled
Observed


Water Levels - WOH2156A
Water Level (mAHD)
90
80
70
60
50
40
30
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed


Water Levels - WOH2156B
Water Level (mAHD)
90
85
80
75
70
65
60
55
50
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Modelled
Observed

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