Appendix E

Water Management Plan

(Including Surface Water Management Plan and Groundwater Management Plan)

Donaldson Coal

Abel Area 4 Extraction Plan

Surface Water Management Plan

28 May 2014

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1 Introduction

This surface water management plan has been prepared to accompany the Extraction Plan (EP) application for 'Area 4' within the Abel Mine lease area. Donaldson Coal proposes to extract from Panels 27 to 35 in SMP Area 4 using bord and pillar total extraction methods within the Upper Donaldson Seam.

Evans & Peck has been engaged by Donaldson Coal to prepare a Surface Water Management Plan for the Area 4 Extraction Plan. This Surface Water Management Plan addresses the relevant requirements identified in Schedule 3 of the Conditions of Project Approval 05_0136 (MOD 3) for Area 4, as summarised in **Table 1**.

Table 1: Relevant Conditions of Approval

Schedule 3	Where addressed in Report
Condition 4	
(g) provide revised predictions of the potential subsidence effects, subsidence impacts and environmental consequences of the proposed second workings, incorporating any relevant information obtained since this approval;	Section 3 – Flow and Water Quality Section 4 – Potential Surface Water Impacts
(h) describe the measures that would be implemented to ensure compliance with the performance measures in Tables 2 and 3, and manage or remediate any impacts and/or environmental consequences;	Section 5 – Proposed Monitoring Section 6 – Potential Remediation
(j) include a Water Management Plan, which has been prepared in consultation with EPA and NOW, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on watercourses and aquifers, including:	This Report
• surface and groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality;	Section 3 – Flow and Water Quality
• a program to monitor and report stream flows, assess any changes resulting from subsidence impacts and remediate and improve stream stability;	Section 5 – Proposed Monitoring Section 6 – Potential Remediation
• a program to monitor and report groundwater inflows to underground workings;	Refer to Area 4 Groundwater Management Plan
• a program to predict, manage and monitor impacts to groundwater bores on privately-owned land;	Refer to Area 4 Groundwater Management Plan
(p) include a contingency plan that expressly provides for adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Tables 1 and 2, or where any such exceedance appears likely;	Section 6 – Potential Remediation

Condition 5:	
The Proponent shall ensure that the management plans required under conditions 4(h)-(m) above include: (a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval; and (b) a detailed description of the measures that would be implemented to remediate predicted impacts.	Appendix A – Water Quality Analysis Section 3 – Flow and Water Quality Section 6 – Potential Remediation

The report provides a description of the physical characteristics of the land that overlies Area 4 with particular emphasis on surface water hydrology, creeks and other water related features. Potential impacts as a result of the underground mining include physical alteration to these features as well as changes to water quality. The Risk Assessment undertaken as part of the preparation of the EP identified the following range of potential impacts that are considered in this report:

- Loss of runoff to existing farm dams as a result of:
  - Surface cracking;
  - Cracking in creek bed;
  - Ponding in creek.
- Increased erosion as a result of step/scarp subsidence leading to head-cut erosion in drainage lines and creeks.
- Change in leakage from old workings on Osborn's property (adjacent to dam C04d06) due to depressurisation of aquifers due to mining activities greater than predicted. As this leakage is located in the Subsidence Control Zone, it is considered that there will be no further impact.
- Increased area of ponding or flooding as a result of differential subsidence and a significant rainfall event.

This report provides an assessment of these risks and the controls that will mitigate the potential impacts. These controls include aspects of the mine design and mining method designed to minimise subsidence as well as proven mitigation methods, such as techniques for remediation of surface cracking based on experience gained due to underground mining in Areas 1, 2 and 3.

This report draws upon information presented in the original *Part 3A Environmental Assessment for the Abel Underground Mine* (Donaldson Coal, 2006) (the EA) and the EA for Modification 3 (Donaldson Coal 2012) (Mod 3) with particular reference to the area that will be affected by mining in Area 4; and relevant information gained from the observed impacts associated with mining of Areas 1, 2 and 3 as well as specific studies related to Area 4:

- *Subsidence Predictions and Impact Assessment* (MSEC, 2014);

2 Creeks and Catchments within EP Area 4

2.1 Overview

As shown in **Figure 1**, EP Area 4 is located entirely within the catchment of Four Mile Creek. The creek drains in a northerly direction from the ridgeline associated with Black Hill and, after crossing under John Renshaw Drive, drains through the Donaldson and Bloomfield mine lease areas. Four Mile creek continues under the New England Highway and onto the Hunter River floodplain to the north of Ashtonfield and to the west of Hexham. Land use within the Four Mile Creek includes agricultural land, undisturbed native bush and rural/ residential properties.

The catchment area of Four Mile Creek within EP Area 4 is provided in **Table 2** which also lists the other catchments within the mine lease area that are not affected by the Area 4 EP.

Table 2: Catchment Areas within EP Area 4

Creek	Total Catchment Within Mine Lease (ha)	Catchment Within EP Area 4 (ha)
Four Mile Creek	343	209
Weakleys Flat creek	335	-
Viney Creek	600	-
Buttai Creek	425	-
Bluegum Creek	992	-
Total	**2,695**	**209**

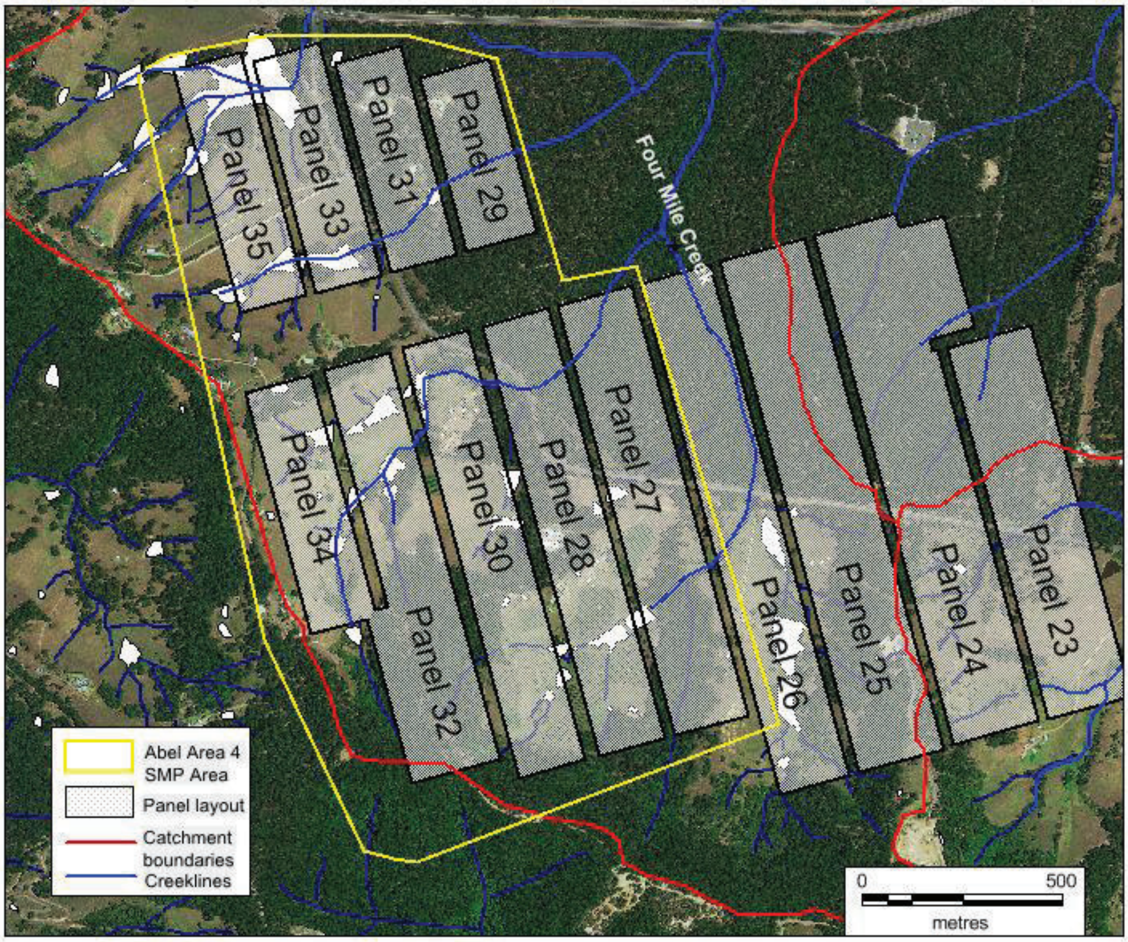

Figure 1: EP Area 4 Locality, Creeks and Catchments

2.2 Stream Order/Schedule

Confusion sometimes arises because two different systems for stream classification have been adopted for different purposes:

- The Strahler stream ordering system (based on defined watercourses on topographic maps) is used in the *Water Management Act 2000* and associated regulations for, amongst other things, regulating ‘Controlled Activities’ in close proximity to watercourses. ‘Controlled Activities’ include preservation of riparian corridors, carrying out of in-stream works and construction of watercourse crossings. Four Mile Creek, the only watercourse within EP Area 4, is a first order stream according to the Strahler system.
- The *Management of Stream/Aquifer Systems in Coal Mining Developments – Hunter Region* (DIPNR Version 1, April 2005) provide guidelines for identifying the significance of watercourses, appropriate mining methods to prevent impacts on watercourses and suitable methods for monitoring and management of the identified watercourses. The guidelines provide differing performance criteria for each of the three categories:
    1) *Schedule 1 Streams* are first and second order watercourses and are usually intermittent. They are categorised as the least significant streams and performance criteria are based on providing stable stream lengths with minimal incision or erosion.

2) *Schedule 2 Streams* are primarily third and higher order streams, which drain into primary catchment river systems. The performance criteria for these watercourses are based on having minimal adverse impact on stream stability or water quality, including the application of buffers.

3) *Schedule 3 Streams* are major rivers and connected alluvial groundwater. The performance criteria are based on a precautionary approach to provide zero mining induced ground movements or fracturing, including the application of buffers. No Schedule 3 streams are located above the Abel Underground Mine area.

The measures for minimising impacts of mining on the creeks proposed in the EA were all referenced to the DIPNR Schedules. Specifically, Donaldson Coal committed to the provision of a minimum barrier of 40 m between the 20 millimetre line of subsidence and the bank of any Schedule 2 Streams unless further studies (to be undertaken prior to any mining occurring which could potentially directly impact on a Schedule 2 Stream) demonstrate that the DIPNR guideline could be met without such a barrier.

Area 4 is wholly within the catchment of Four Mile Creek, which is a Schedule 1 stream.

2.3 Catchment Conditions

EP Area 4 is located to the north of Black Hill Ridge and grades from steeper slopes (up to 100% in isolated places) along the southern boundary to flatter slopes (<5%) along the northern boundary and towards north-eastern corner. Area 4 is entirely within the upper reaches of the catchment of Four Mile Creek, and contains numerous farm dams.

The *Soil Landscapes of the Newcastle 1:100 000 Sheet* (Matthei, 1995) describes the soils in the area as predominantly belonging to the Beresfield soil landscape unit with minor differences on either side of Black Hill Road. Key features of the Beresfield soil landscape unit are:

- Friable brownish-black sandy loam topsoil (50 – 150 mm deep) overlying hard setting yellowish-brown sandy-clay loam (50 – 300 mm deep) and brown clay near the ridge crests. These soils tend to be highly erodible in concentrated flows;
- Similar, but shallower soils on the mid slopes with some areas where the sandy loam topsoil is absent on the mid-slopes. These soils tend to hard setting and have moderate erodibility in concentrated flows.

As can be seen on **Figure 1** there are two distinct patterns of land use within Area 4:

1) Predominantly fully forested land to the north of Black Hill Road, and
2) Cleared land with some remnant forest to the south of Black Hill Road.

2.4 Channel Characteristics

A watercourse survey was undertaken on behalf of Donaldson Coal to collect representative data for the watercourses throughout the Abel Underground Mine area. **Figure 2** shows the locations of the creek survey points in the general vicinity of EP Area 4, while **Table 3** summarises the characteristics of the creek channel at locations within or immediately adjacent to EP Area 4. In **Table 3** the observation points (‘site’ corresponding to the numbering in **Figure 2**) are ordered along each creek from upstream to downstream.

Table 3: Summary of Creek Channel Characteristics in the Vicinity of EP Area 4

Creek	Site	Bed Material	Channel Width (m)	Chanel Depth (m)	Adjoining Vegetation	Notes
Four Mile	77	Sand and gravel	0.5	0.3	Dense forest	
Four Mile	76	Grass	± 2	Indistinct	Grass	Downstream of farm dam. Shallow depression with no defined bed and banks
Four Mile	52	N/A	N/A	N/A	N/A	Field data sheet missing
Four Mile	51	Sand and gravel	1.5	1	Dense forest	Pool approximately 0.5 wide x 0.15 deep
Four Mile	38	Soil and gravel with small boulders	1.5	0.7	Dense forest	
Four Mile	35	Soil	1.25	3	Dense forest	
Four Mile	40	Soil and gravel with small boulders	2 - 3	0.5 - 2.0	Dense forest	Occasional Pools. Steep banks. Occasional sandstone outcrops
Four Mile	42	Soil and sand	3	1	Dense forest	Eroded bank (4 m high) downstream
Four Mile	43	Soil and sand	3	1 - 2	Dense forest	Small pool approx. 2 m x 1 m, 0.2 deep

Some features of Four Mile Creek are:

- Bed and bank material predominantly consisting of soils, with soil and sand, with varying amounts of sand, gravel and boulders. Outcropping of sandstone occurs occasionally.
- The channel dimensions are highly variable with widths generally ranging from 1 to 4 m, and channel depth ranging from about 0.33 to 2 m.
- In some locations where the creek lines cross cleared grass area (e.g. site 76), the creek channel is grassed and does not have well defined bed and banks.
- There was no flow in the creeks during the survey, but a number of small pools (up to 0.4 m deep) were observed.
- As can be seen on **Figure 1**, there are a number of significant farm dams in the headwaters of Four Mile Creek.
- Channel gradients range from 2.5% - 3.5% in the headwaters to about 1% where Four Mile Creek flows out of EP Area 4 (north of Black Hill Road and south of John Renshaw Drive).

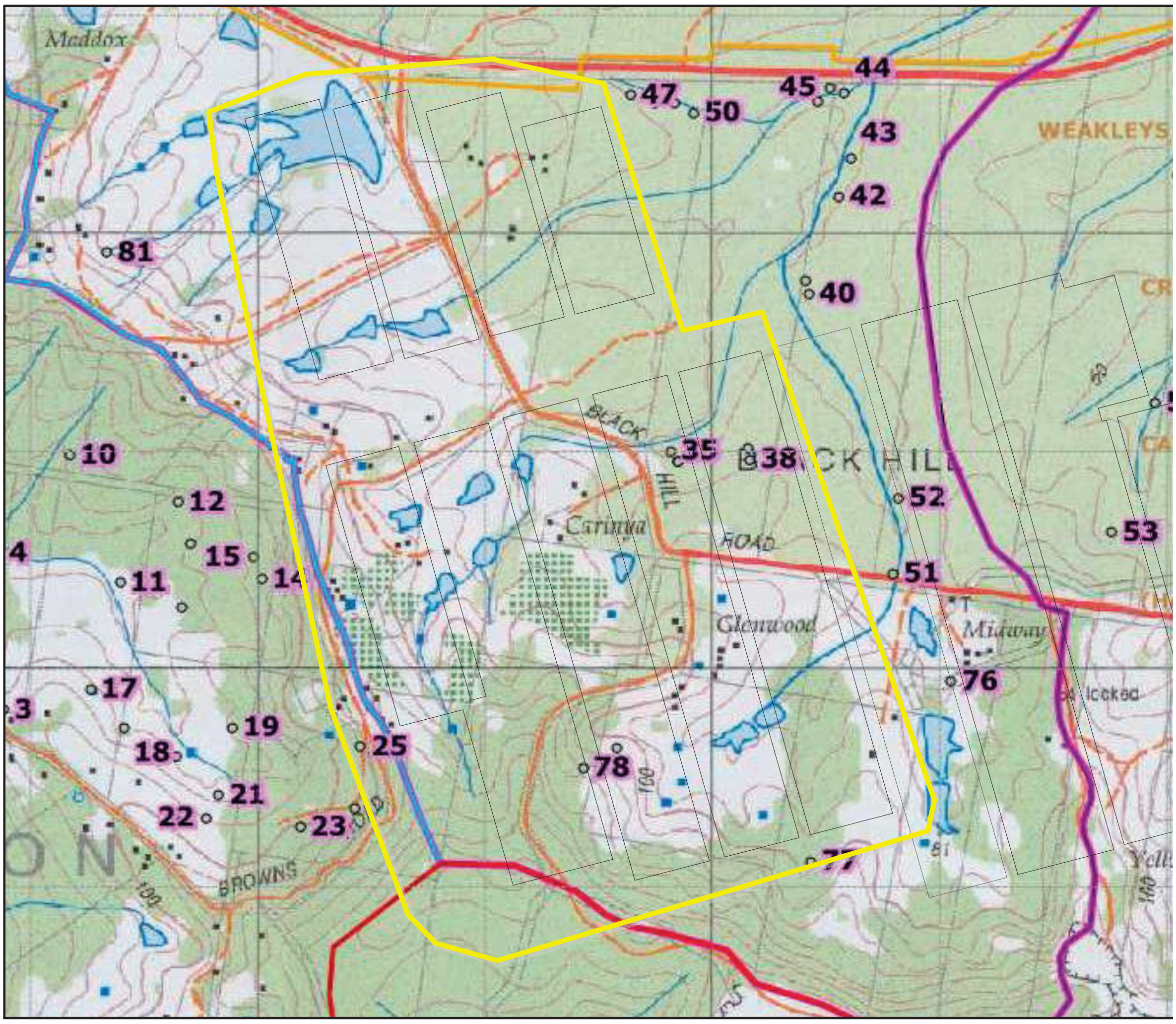

Figure 2: Creek Survey Locations in the Vicinity of EP Area 4 (yellow outline)

3 Flow and Water Quality

3.1 Flow Regime

Four Mile Creek and its tributaries within EP Area 4 are ephemeral and only flow immediately after rainfall. As there are no flow monitoring gauges on any of the creeks within the Abel Mine lease area, runoff characteristics of the creeks have been estimated by means of a rainfall:runoff model which utilises long term rainfall records to characterise the short and long term variability of runoff. For purposes of estimating the runoff characteristics of the catchments with EP Area 4, runoff parameters for the Australian Water Balance Model (AWBM) have been derived from calibration of the model using recorded daily rainfall and runoff for six small catchments in the lower Hunter Valley and Central Coast (Evans & Peck, 2012).

For purposes of estimating the flow regime for EP Area 4, a 126-year rainfall record has been used based on correlation between the rainfall record from the Donaldson Mine meteorological station with the long term rainfall record for Morpeth. Based on the daily flow record generated by the AWBM model, **Figure 3** and **Figure 4** summarise the key characteristics of the flow regime of the catchments draining from EP Area 4:

- **Figure 3** shows the typical runoff (expressed as mm/day) that can be expected during 10th percentile dry, average and 90th percentile wet years. The key aspects of the data shown in **Figure 3** are that runoff from the catchments is highly episodic (negligible runoff on most days) and highly variable from year to year depending on the rainfall.
- **Figure 4** shows the probability of annual runoff (expressed as mm/year) and shows that the median runoff from the EP Area 4 catchment can be expected to be about 1.8 ML/ha. Runoff in a 10th percentile dry year can be expected to be about 0.6 ML/ha, while in a 90th percentile wet year runoff of about 4.2 ML/ha can be expected.

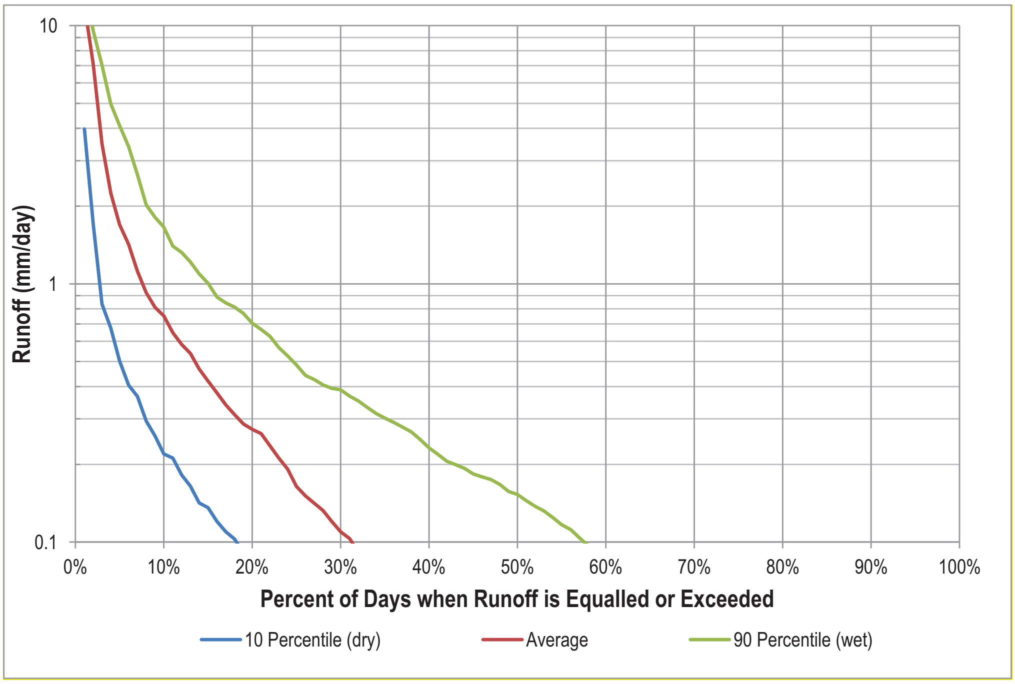

Figure 3: Daily Runoff Probability Graphs for Representative Dry, Average and Wet Years

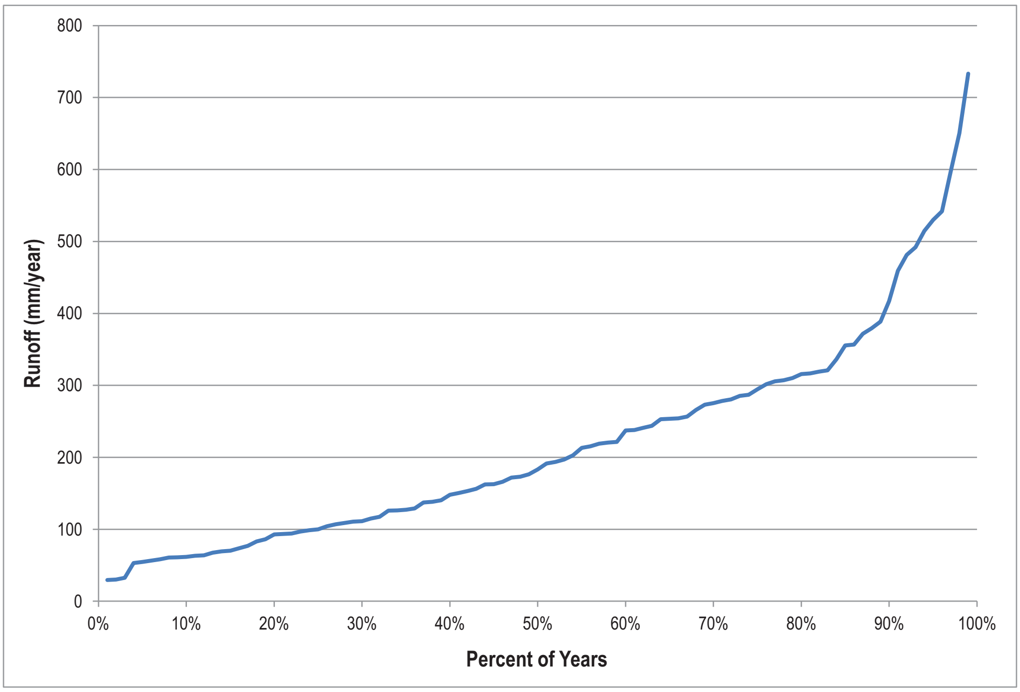

Figure 4: Annual Runoff Probability Graph

Table 4 summarises the annual runoff statistics for the Four Mile Creek catchment and further illustrates the high degree of variability in runoff from year to year.

Table 4: Summary Rainfall and Runoff Statistics for Four Mile Creek Catchment within EP Area 4

Statistic	Rainfall (mm/year)	Runoff (mm/year)	Four Mile Creek (ML/year)
Average	928	221	464
Min	422	24	50
10%	632	62	129
50%	910	183	385
90%	1,243	417	876
Max	1,994	976	2,049

Flows in Four Mile Creek are periodically monitored at a flow gauge at the Four Mile Creek Workshops, located approximately 500 m from the New England Highway. The total Four Mile Creek catchment that drains to this gauging location is 2,414 ha, and Area 4 contributes approximately 8% of the total runoff to Four Mile Creek at this point. Therefore, if additional flow monitoring were to be undertaken at the flow gauge, any changes in flow in Four Mile Creek resulting from underground mining in Area 4 would be negligible or unidentifiable due to the high degree of flow variability, and the small proportion of the total catchment that Area 4 represents.

3.2 Water Quality

A review of the pre- and post-mining water quality impacts for Weakley's Flat Creek has been undertaken to establish appropriate water quality triggers for impacts to creeks due to underground mining (see **Appendix A**). The analysis utilises the ANZECC Guidelines recommended approach to identifying trigger levels once sufficient monitoring data is available.

For the Weakleys Flat Creek, monthly water quality monitoring has occurred since July 2000, and underground mining commenced in July 2010. As detailed in **Appendix A**, there has been no impact on the water quality of Weakleys Flat Creek that can be attributed to underground mining activities. Therefore it is expected that there would be minimal impacts on the water quality of Four Mile Creek. Additionally, the analysis outlined in **Appendix A** demonstrates that setting trigger levels using baseline monitoring data as per the ANZECC Guidelines is appropriate.

EP Area 4 is located within the catchment of Four Mile Creek. The water monitoring station, EM1 on Four Mile Creek is located upstream of John Renshaw Drive (about 0.5 km downstream of Area 4) (**Figure 5**). Data collection for this site commenced in July 2000, and mining commenced in the Four Mile Creek catchment in 2013.

Table 5 summarises the key water quality statistics for Four Mile Creek. For comparison purposes, the table also lists the default ANZECC trigger values for lowland creeks with slightly disturbed ecosystems and the calculated trigger values. A calculated trigger level has been derived from the baseline monitoring data (2000 to 2013) and is included in this table (See **Appendix A** for details of the assessment).

Table 5: Summary of Historical Water Quality Statistics for Four Mile Creek (EM1)

Statistic	pH (pH Unit)	EC (µS/cm)	TSS (mg/L)	Al (mg/L)	Mn (mg/L)	Fe (mg/L)
ANZECC default trigger	**6.5 – 8.0 ***	**125 – 2200 ***	**N/A**	**0.055 ^**	**1.9 #**	**N/A**
Calculated Trigger Level	6.5 – 7.1	235 – 580	8 – 34	0.35 – 1.60	0.04 – 0.46	2.32 – 5.56
Number of samples	144	144	141	47	47	47
Minimum	5.9	100	1	0.13	0.0	0.72
20th Percentile	6.5	235	8	0.35	0.0	2.32
Median	6.8	425	16	1.00	0.1	3.6
Average	6.8	414	27	1.18	0.2	4.4
80th percentile	7.1	580	34	1.60	0.5	5.56
Maximum	7.9	985	269	4.50	1.0	20

** ANZECC trigger values for lowland creeks with slightly disturbed ecosystems*

^ 95% Level of protection, slightly - moderately disturbed systems pH >6.5

 # 95% Level of protection, slightly - moderately disturbed systems

Overall, the data indicates that the water quality in Four Mile Creek is consistent with moderately disturbed catchments. Because of the level of existing disturbance on the catchments, it is unlikely that any water quality impacts attributable to mine subsidence would be detectable. Analysis of Weakleys Flat Creek water quality data both before and after the commencement of mining in the region in July 2010 (see **Appendix A**) demonstrates that significant water quality impacts on Four Mile Creek due to underground mining are unlikely.

Although the ANZECC Guidelines published in 2000 provide default 'trigger' values for different indicators of water quality parameters, it is recommended that for slightly or moderately disturbed ecosystems, such as that surrounding the Abel Underground Mine, the 20^{th} and 80^{th} percentile values of data obtained from an appropriate reference system should be used as the basis for revised 'trigger' values. The Guidelines state that two years of monthly sampling is regarded as sufficient to provide an indication of the local ecosystem variability and to provide a basis for derivation of 'trigger' values appropriate to conditions in a particular creek system.

As such, the 20^{th} and 80^{th} percentile values of the historical data at (July 2000 – July 2013) for the key water quality statistics were calculated for use as trigger values. On the basis of the historical monitoring data summarised in **Table 5**, appropriate trigger values for Four Mile Creek are set out in **Table 6**.

Table 6: Proposed Water Quality 'Trigger' Values for Four Mile Creek

Parameter	Proposed 'Trigger' Value Range
pH	6.5 – 7.1
EC (µS/cm)	235 – 580
TSS (mg/L)	8 – 34
Al (mg/L)	0.35 – 1.60
Mn (mg/L)	0.04 – 0.46
Fe (mg/L)	2.32 – 5.56

In line with the way that the ANZECC trigger values are intended to be used, the proposed trigger values in **Table 6** do not represent 'limits'. Rather, they represent ranges in which the majority of observations can be expected, but future observations can be expected outside this range on occasions.

As discussed in **Appendix A**, a key indicator of underground mining-induced water quality impacts is changes in salinity. It is recommended that if the upper bound for salinity (EC) of 580 µS/cm is exceeded for a period of three consecutive months, that this is the trigger to undertake further assessment of the metals (Fe, Al and Mn) to establish whether the change in EC is mining induced. It is recommended that this further assessment considers investigation of the potential pathways for water quality impacts within the Abel Mine underground mining area to identify whether the change in water quality is attributable to underground mining activities, and the nature of activity that has caused the change.

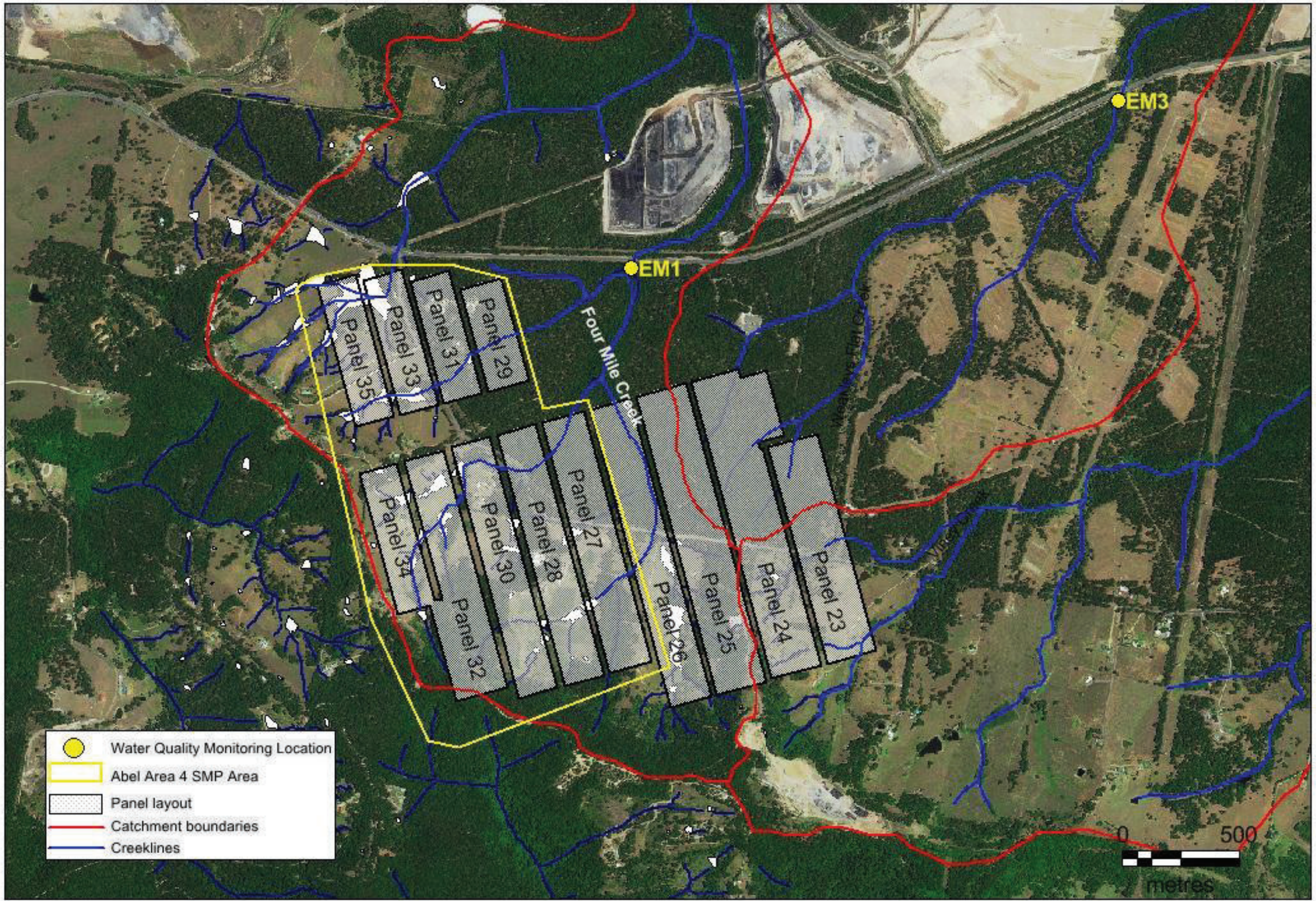

Figure 5: Water Quality Monitoring Locations Downstream of Area 4

4 Potential Surface Water Impacts

4.1 Subsidence Control Zones

Coal extraction will occur using the bord and pillar mining method which allows for subsidence impacts to be managed by increasing or decreasing the amount of coal extracted in particular areas. In order to minimise impacts of subsidence on residences, key infrastructure and creeks overlying the extraction area, Donaldson Coal has adopted a mine plan that includes Subsidence Control Zones (SCZs) to limit subsidence impacts. The SCZs may involve partial extraction of coal or limiting extraction to first workings (i.e. no secondary extraction) in some areas.

There are no Schedule 2 or 3 streams, groundwater dependent endangered ecological communities (EECs) or riparian EECs within EP Area 4. Accordingly, total extraction will be undertaken for Panels 27 to 35, except for areas that will be protected from subsidence through the Subsidence Control Zones, around principal residences and the 4 largest dams at the commercial orchard on Lots 11 and 12 DP877937 and Lots 610 and 611 DP1035588, while this land is used for this purpose.

4.2 Subsidence, Tilts and Strains

The impacts of subsidence are primarily functions of the depth of cover above the coal seam, the depth of the extracted seam and width of the extraction panel. Within EP Area 4, the depth of cover increases from about 50 m at the northern end of Panel 29 to 280 m at the southern end of Panel 32.

Detailed assessment of the likely magnitude and impacts of subsidence on the creeks within EP Area 4 has been undertaken by MSEC (2014). **Figure 6** shows the predicted subsidence resulting from full extraction within EP Area 4 while **Table 7** summarises the maximum subsidence, tilts and curvature on each panel.

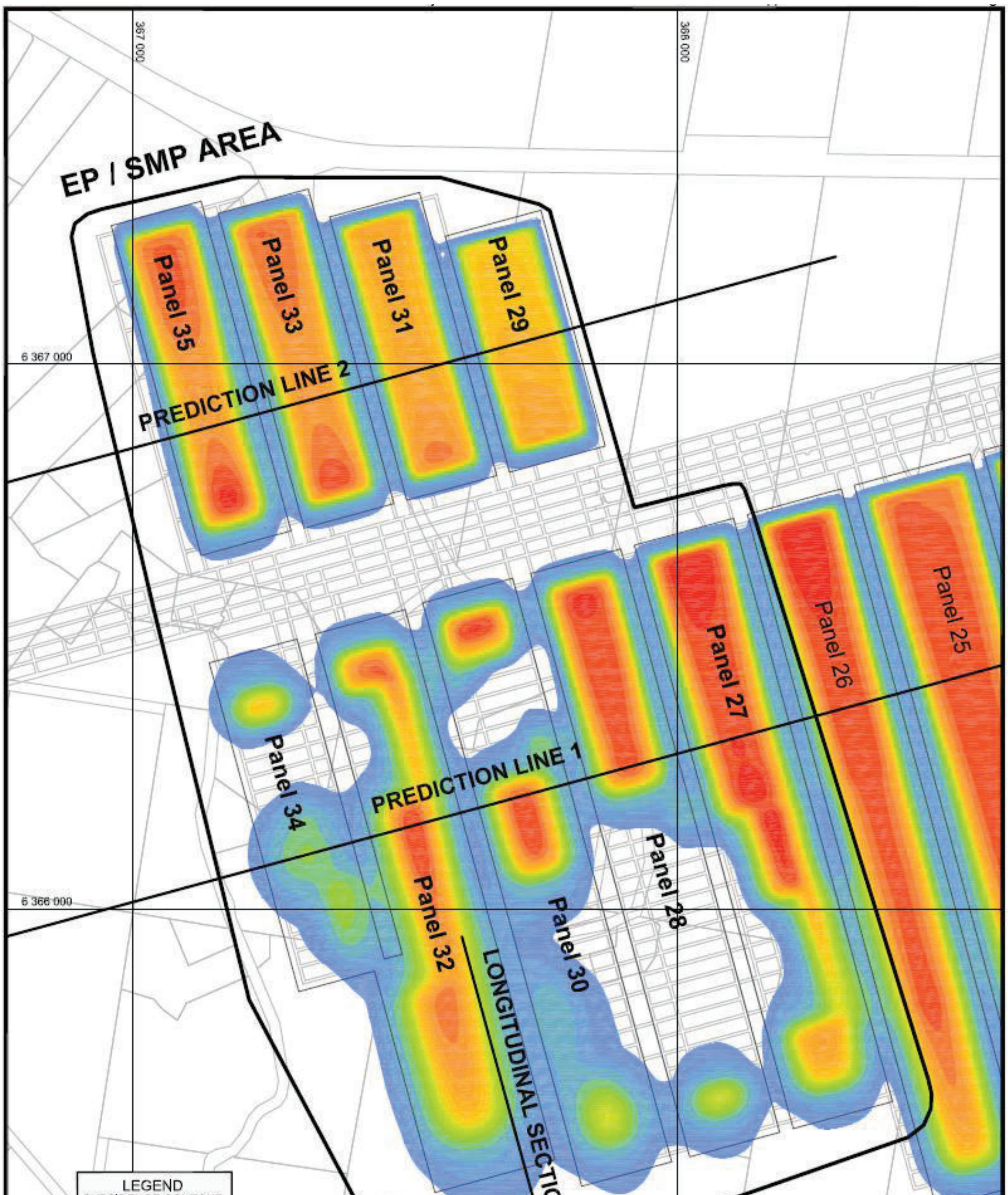

Figure 6: Predicted Subsidence within EP Area 4

(After MSEC, 2014)

Table 7: Maximum Predicted Subsidence Movements
(Extracted from MSEC, 2014)

Panel	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km^{-1})	Maximum Predicted Total Conventional Sagging Curvature (km^{-1})
Panels 27, 28, 30, 32 and 34	1,450	70	>3.0	>3.0
Panels 29, 31, 33 and 35	1,450	70	>3.0	>3.0

4.3 Potential Impacts on Creeks

4.3.1 Potential Ponding and Scour

Depending on the degree of tilt induced by subsidence, mining can potentially result in:

- Increased levels of ponding in locations where the mining induced tilts are in the opposite direction to and are greater than the existing natural creek gradient;
- Increased likelihood of scouring of the stream beds in the locations where the mining induced tilts considerably increase the existing natural creek gradients.

Tilting of the ground surface occurs around the edge of the mine panels. The maximum predicted tilt for Four Mile Creek within EP Area 4 (a reverse grade tilt of 25 mm/m, i.e. 2.5%) is likely to occur along the northern edge of each of the panels where the depth of cover is shallowest. This degree of tilting compares to the natural grade of the creek channel.

The *Subsidence Predictions and Impact Assessment* (MSEC, 2014) includes a detailed assessment of the predicted changes in the longitudinal profile of Four Mile Creek (see **Figure 6**). The figure shows that immediately upstream of the northern edge of Panel 26 (at about 780 m), ponding could occur that may extend for about 100 m with a maximum depth of 0.5 m.

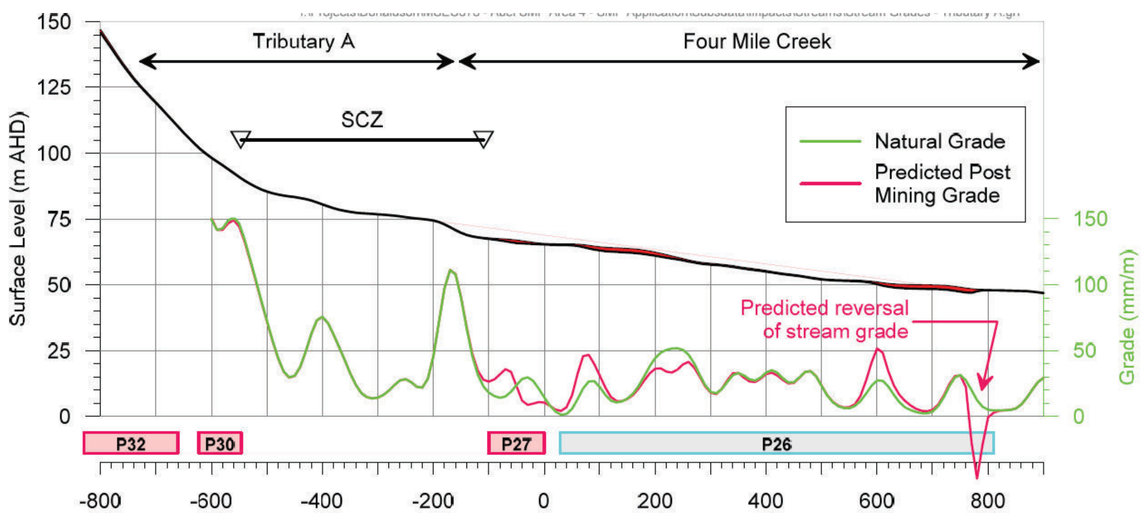

Figure 7: Predicted Subsidence Profile along Four Mile Creek
(After MSEC, 2014)

Figure 7 shows the existing gradient of the creek (green line) and the predicted changes due to subsidence (pink line). Near the northern end of Panel 26 (part of Area 3 mining) the gradient becomes negative as a result of subsidence, and ponding may occur (as discussed previously). However, there are no predicted reversals of grade along the tributaries to Four Mile Creek within the EP Area 4. The graph also indicates that there would be:

- An increase in grade from about 1.6% to about 3.1% at about -80 m; and
- A reduction in grade from about 2.9% to about 1% at about -40m, but no ponding.

The areas of increased gradient give rise to the potential for increased scour in the creek channel. However, because the predicted increase in gradient is within the range of gradients experienced elsewhere along the creek, severe channel erosion and head cutting is not expected. Nevertheless these areas, which are predicted to experience the most significant impacts, would be the focus of monitoring and repair if necessary.

The MSEC report also considers the potential impacts on stream gradient if the actual subsidence exceeded the predicted values by a factor of two. In the case of Four Mile Creek the analysis indicated that, compared to the impacts illustrated in **Figure 7,** the impacts would be:

- Ponding at about -40m could occur to a depth of 0.4 m and extend around 50 m; and
- The bed gradient at about -80m could increase from about 1.6% to about 5.1%;

To aid in assessing the likelihood of ponding along the creeks or on the land surface, MSEC has prepared a contour map of EP Area 4 following subsidence (see **Figure 8**). The locations of predicted mining induced ponding areas are indicated on **Figure 8**.

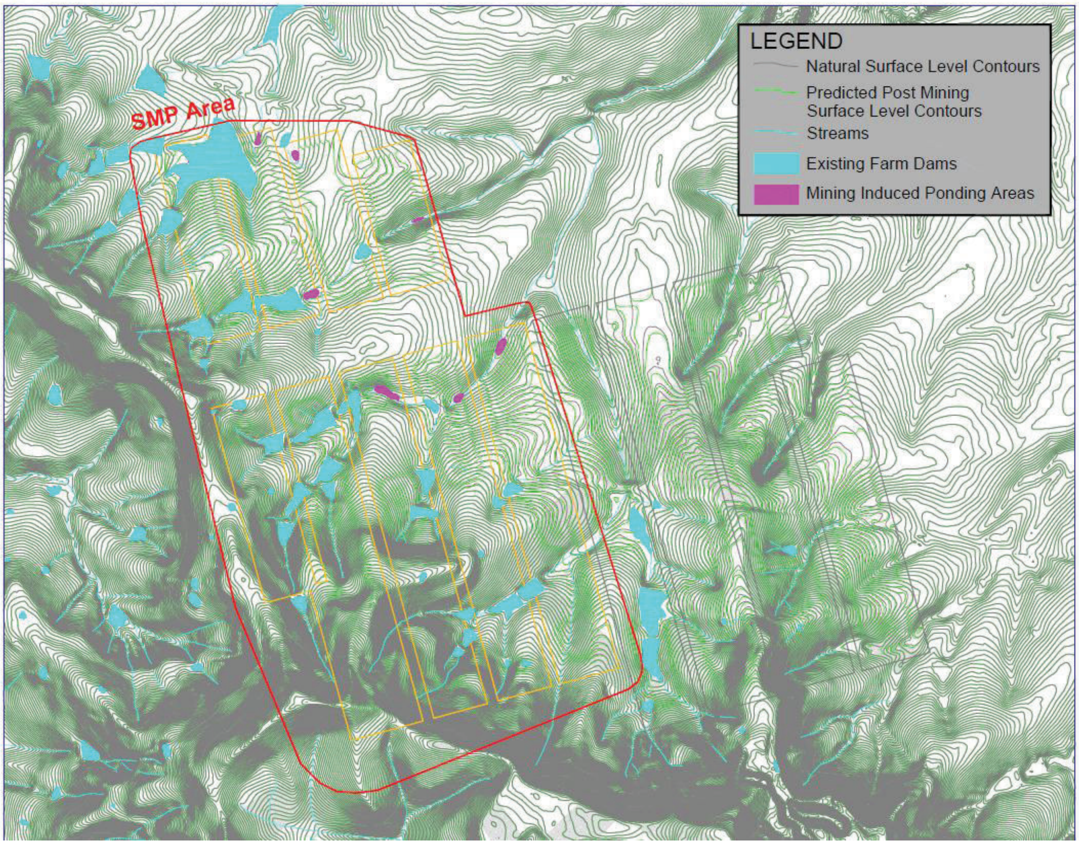

Figure 8: Natural and Predicted Subsided Surface Levels and Ponding Areas
(After MSEC, 2014)

As can be seen on **Figure 8**, the anticipated ponding occurs at six locations within the tributaries of Four Mile Creek. From **Figure 8**, it can be seen that the surface naturally drains along the alignments of the tributaries, and it is therefore not considered that the land is naturally susceptible to flooding or inundation.

As noted in the baseline creek survey (see **Section 2.4**), pools are an existing feature of the creeks and it is unlikely that remedial works would be required. The MSEC report notes that mining induced ponding areas are predicted to have depths of approximately 0.5 metres and lengths up to approximately 100m. This is similar to those assessed in the EA, which states that "*potential ponding depths of 0.1 to 0.5 m estimated for the majority of these* [Schedule 1] *creeks*" with "*ponding depths ranging between 0.4 and 1.0 m*" for two tributaries.

4.3.2 Potential Cracking of Creek Beds

The *Subsidence Predictions and Impact Assessment* (MSEC, 2014) notes that, because of the shallow depth of cover at the northern end of the panels, it is likely that the fractured zone above the proposed panels could extend from the seam up to the surface, leading to some possible loss of the surface water flows into the mine. However, notwithstanding previous bord and pillar mining in Areas 1 and 2 beneath the first and second order ephemeral tributaries to Weakleys Flat and Viney Creeks (total length of streams approximately 2 kilometres), there has been no reported loss of surface water flows into the mine to date.

The MSEC report also quotes the case of longwall mining in the Whybrow Seam at South Bulga and the Beltana No. 1 Underground Mine where coal was extracted from beneath a number of ephemeral drainage lines, with depths of cover that varied between 40 m and 200 m. Although surface cracking was observed across the mining areas, there were no observable surface water flow diversions in the drainage lines after the remediation of the larger surface cracks had been completed.

4.4 Potential Impacts on the Land Surface

The MSEC report notes that the incidence of surface cracking is dependent on the location relative to the extracted panel edges, the depth of cover, the extracted seam thickness and the thickness and inherent plasticity of the soils that overlie the bedrock. The widths and frequencies of the cracks are also dependent upon the pre-existing jointing patterns in the bedrock.

The size and extent of surface cracking above the northern part of the proposed mining area are expected to be similar to those observed above the previously extracted panels in Areas 1 and 2 where the depth of cover ranged from 50 to 100 m. In that case, surface crack widths were typically between 25 mm and 100 mm, with localised surface crack widths greater than 100 mm. The largest surface crack width measured above these panels was around 375 mm.

It has also been found from past mining experience in the NSW Coalfields that the surface crack widths reduce as the depth of cover increases. Crack widths in the order of 30 mm to 50 mm are typically observed where the depths of cover are around 200 m, such as in the case above the southern ends of the proposed panels.

As described previously, **Figure 6** shows the post mining landform contours after accounting for subsidence. Inspection of the contours in **Figure 8** shows that all predicted mining induced ponding areas are within drainage lines. This infers that surface ponding on the landscape is likely to be small and very localised. The most likely area for such depressions is near the northern end of the EP Area.

4.5 Potential Impacts on Farm Dams

The MSEC report identifies a total of 38 farm dams within EP Area 4, of which 32 are located partially or fully above the proposed areas of secondary extraction (see **Figure 9**). All dams are located on the headwaters of Four Mile Creek. The storage capacity of all dams is unknown.

An assessment has been undertaken for all dams within EP Area 4, evaluating the risk of dam volume change or dam wall failure due to subsidence. This risk is a function of the orientation of the predicted maximum differential subsidence with respect to the orientation of the dam. Each dam was assessed and given a risk rating of low, minor or moderate for volume change and dam wall failure (**Table 8**). **Table 9** (which references each dam by the dam numbering shown on **Figure 9**) describes the dams assessed to have a minor or moderate risk of volume change and/or dam wall failure due to subsidence. **Figure 9** displays the predicted subsidence contours due to Area 4 mining with respect to dam locations.

Table 8: Description of Risk Ratings

Rating	Description
Low	Subsidence unlikely to impact dam or dam catchment area.
Minor	Subsidence may have a slight impact on dam (e.g. cracking around dam edges) or dam effective catchment area (e.g. some flow to dam may be reduced, but majority of catchment area likely to remain unaffected).
Moderate	Subsidence may have a moderate impact on dam (e.g. cracking or large amount of subsidence through centre of dam) or dam effective catchment area (e.g. flow to dam may be significantly reduced).

Table 9: Assessment of Subsidence Effects on Dams

Dam Reference	Characteristics and Subsidence effects	Dam Volume Change Risk Assessment	Dam Wall Failure Risk Assessment
C01d01	C01d01, a dam with an area of approximately 0.15ha, lies above panel 27. Sloping to the north-east, it is located directly north-east and downhill of dam C01D02, and has an effective catchment area of approximately 1.1ha. Total subsidence effects due to mining of Able Area 4 range between 100mm at the west side of the dam to 1400mm at the east side of the dam. Convex curvature through the middle to east side of the dam may result in cracking at the east edge of the dam and at the dam wall. Additionally, there is risk of cracking to the south of the dam, which could decrease the amount of flow entering the dam from the catchment. However, the amount of catchment area affected is small. As such, C01d01 is considered to be at a low risk of volume change and a moderate risk of dam wall failure.	Minor risk	Moderate risk
C05d01	C05d01, a dam with an area of approximately 0.24ha, lies above panel 30. Sloping to the north-north-west, it has an effective catchment area of approximately 1.6ha. Total subsidence effects due to mining of Able Area 4 range between 50mm at the south side of the dam to 1400mm at the north side of the dam at the dam wall. Convex curvature through the middle of the dam may result in cracking through the middle of the dam and. Additionally, there is risk of cracking to the north of the dam, which could decrease the amount of flow entering the dam from the catchment. However, the amount of catchment area affected is small. As such, C05d01 is considered to be at a moderate risk of volume change and a minor risk of dam wall failure.	Moderate risk	Minor risk
C07d01	C07d01, a dam with an area of approximately 0.35ha, lies above panel 35. Sloping to the north-east, it is located directly south-west and uphill of dam C07D02, and has an effective catchment area of approximately 5.5ha. Total subsidence effects due to mining of Able Area 4 range between 50mm in the centre of the dam to 400mm at the east side of the dam. Convex curvature through the east side of the dam may result in cracking at the east edge of the dam and at the dam wall. As such, C07d01 is considered to be at a low risk of volume change and a moderate risk of dam wall failure.	Low risk	Moderate risk
C07d02	C07d02, a dam with an area of approximately 0.32ha, lies above panel 35. Sloping to the north-east, it is located directly north-east and downhill of dam C07D01, and directly west and uphill of dam C07d03. It has an effective catchment area of approximately 4ha. Total subsidence effects due to mining of Able Area 4 range between 50mm at the east side of the dam to 1500mm at the west side of the dam. Convex curvature through the centre of the dam may result in cracking through the middle of the dam. Additionally, there is risk of cracking to the north and south of the dam, which could decrease the amount of flow entering the dam from the catchment. As such, C07d02 is considered to be at a moderate risk of volume change and a low risk of dam wall failure.	Moderate risk	Low risk
C07d03	C07d03, a dam with an area of approximately 0.56ha, lies above panels 35 and 33. Sloping to the east, it is located directly east and downhill of dam C07D02, and has an effective catchment area of approximately 4ha.	Moderate risk	Minor risk

Dam Reference	Characteristics and Subsidence effects	Dam Volume Change Risk Assessment	Dam Wall Failure Risk Assessment
	Total subsidence effects due to mining of Able Area 4 range between 50mm at the west side of the dam to 1500mm at the east side of the dam. Convex curvature through the centre of the dam may result in cracking through the middle of the dam and a small portion of the south side of the dam wall. Additionally, there is risk of cracking to the north and south of the dam, which could decrease the amount of flow entering the dam from the catchment. As such, C07d03 is considered to be at a moderate risk of volume change and a minor risk of dam wall failure.		
C09d02	C09d02, a dam with an area of approximately 0.13ha, lies above panel 32. Sloping to the north, it is located directly south and uphill of dam C09d03, and has an effective catchment area of approximately 1.1ha. Total subsidence effects due to mining of Able Area 4 range between 50mm at the north side of the dam to 1500mm at the south side of the dam. Convex curvature through the northern side of the dam may result in cracking through the northern edge of the dam and at the dam wall. Additionally, there is risk of cracking to the south-east and south-west of the dam, which could decrease the amount of flow entering the dam from the catchment. As such, C09d02 is considered to be at a moderate risk of both volume change and dam wall failure.	Moderate risk	Moderate risk
C09d03	C09d03, a dam with an area of approximately 0.31ha, lies above panel 32. Sloping to the north, it is located directly north and downhill of dam C09d03, and has an effective catchment area of approximately 0.91ha. Total subsidence effects due to mining of Able Area 4 range between 100mm at the east and west edges of the dam to 900mm in the middle of the dam. Convex curvature through the centre of the dam may result in cracking through the middle of the dam and at the dam wall. Additionally, there is risk of cracking to the south of the dam, which could decrease the amount of flow entering the dam from the catchment. However, the amount of catchment area affected is small. As such, C09d03 is considered to be at a moderate risk of both volume change and dam wall failure.	Moderate risk	Moderate risk
C09d05	C09d05, a dam with an area of approximately 0.35ha, lies above panel 32. Sloping to the north-east, it is located directly north-east and downhill of dam C09d04, and south-west and uphill of dams C09d06 and C05d01. It has an effective catchment area of approximately 1.6ha. Total subsidence effects due to mining of Able Area 4 range between 100mm at the east and west edges of the dam to 1300mm in the middle of the dam. Convex curvature through the centre of the dam may result in cracking through the middle of the dam. Additionally, there is risk of cracking to the north and south of the dam, which could decrease the amount of flow entering the dam from the catchment. As such, C09d05 is considered to be at a moderate risk of volume change and a low risk of dam wall failure.	Moderate risk	Low risk
C16d01	C16d01, a dam with an area of approximately 0.13ha, lies above panel 31. Sloping to the north-east, it is located north-east and downhill of dam C07d03, and has an effective catchment area of approximately 2.2ha. Total subsidence effects due to mining of Able Area 4 range between 50mm at the east and west side of the dam to 1100mm at the north side of the dam. Convex curvature through the east side of the dam may result in cracking through the east section of the dam. Additionally, there is risk of	Moderate risk	Low risk

Dam Reference	Characteristics and Subsidence effects	Dam Volume Change Risk Assessment	Dam Wall Failure Risk Assessment
	cracking to the north and south of the dam, which could decrease the amount of flow entering the dam from the catchment. As such, C16d01 is considered to be at a moderate risk of volume change and a low risk of dam wall failure.		
C17d01	C17d01, a dam with an area of approximately 0.09ha, lies above panel 31. Sloping to the north-north-east, it is located east and downhill of dam D02d01, and has an effective catchment area of approximately 4ha. The total subsidence effect due to mining of Able Area 4 is approximately 50mm through the south corner of the dam. Convex curvature through the catchment to the south of the dam may result in cracking, which could decrease the amount of flow entering the dam from the catchment. As such, C17d01 is considered to be at a minor risk of volume change and a low risk of dam wall failure.	Minor risk	Low risk
D02d01	D02d01 is the largest dam in the EP area, with an area of approximately 3.14ha, lying above panels 33 and 35. Sloping to the north-east, it is located north-east and downhill of dams D01d02, D01d05 and D03d01, and south-east and uphill of dam C17d01. It has an effective catchment area of approximately 7.5ha. Total subsidence effects due to mining of Able Area 4 range between 50mm at the centre of the dam to 1500mm at the west side of the dam. Convex curvature through the east and west sides of the dam may result in cracking through multiple locations of the dam, including the middle and at the dam wall. Additionally, there is risk of cracking to the south of the dam, which could decrease the amount of flow entering the dam from the catchment. As such, D02d01 is considered to be at a moderate risk of volume change and a moderate risk of dam wall failure.	Moderate risk	Moderate risk
D03d01	C03d01, a dam with an area of approximately 0.35ha, lies above panel 35. Sloping to the north-north-east, it is located south-west and uphill of dam D02d01, and has an effective catchment area of approximately 6ha. Total subsidence effects due to mining of Able Area 4 range between 50mm at the centre of the dam to 600mm at the east side of the dam. Convex curvature through the east side of the dam may result in cracking through the east edge of the dam at the dam wall. As such, D03d01 is considered to be at a low risk of volume change and a moderate risk of dam wall failure.	Low risk	Moderate risk
D04d01	D04d01, a dam with an area of approximately 0.23ha, lies above panel 30. Sloping to the north, it is located north-east and downhill of dam D04d02, and has an effective catchment area of approximately 2.5ha. Total subsidence effects due to mining of Able Area 4 range between 50mm at the centre of the dam to 100mm at the east and west edges of the dam. Convex curvature through the catchment to the south-east and south-west of the dam may result in cracking, which could decrease the amount of flow entering the dam from the catchment. As such, D04d01 is considered to be at a moderate risk of volume change and a low risk of dam wall failure.	Moderate risk	Low risk
D04d02	D04d02, a dam with an area of approximately 0.19, lies above panel 30. Sloping to the north, it is located south and uphill of dam D04d01, and has an effective catchment area of approximately 5ha. Total subsidence effects due to mining of Able Area 4 range between 50mm at the east side of the dam to 1400mm at the west side of the dam.	Moderate risk	Moderate risk

Dam Reference	Characteristics and Subsidence effects	Dam Volume Change Risk Assessment	Dam Wall Failure Risk Assessment
	Convex curvature through the middle of the dam may result in cracking through the middle of the dam and at the dam wall. Additionally, there is risk of cracking to the south of the dam, which could decrease the amount of flow entering the dam from the catchment. As such, D02d01 is considered to be at a moderate risk of volume change and a moderate risk of dam wall failure.		

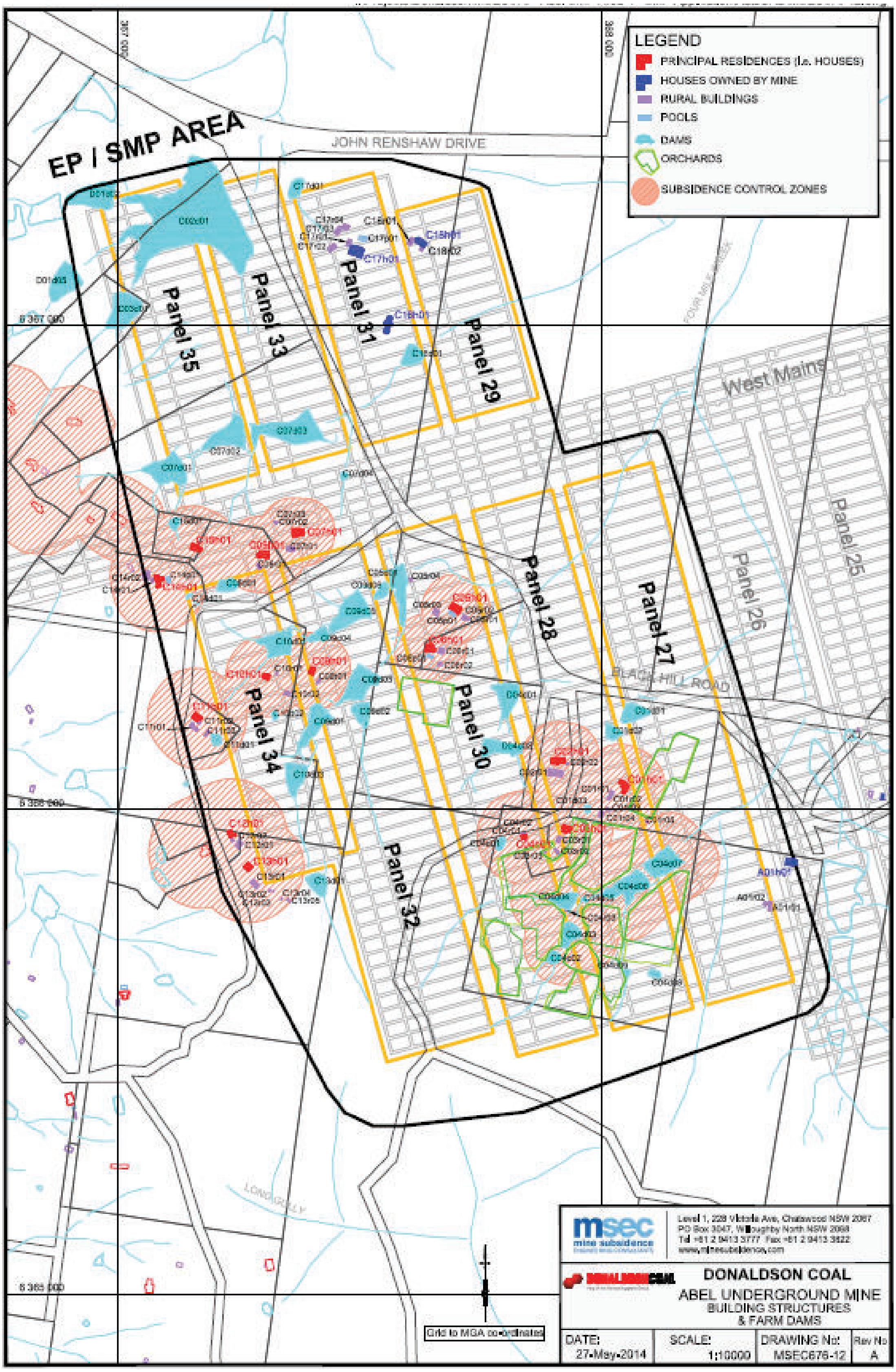

Figure 9: Farm Dams and Buildings within EP Area 4
(After MSEC, 2014)

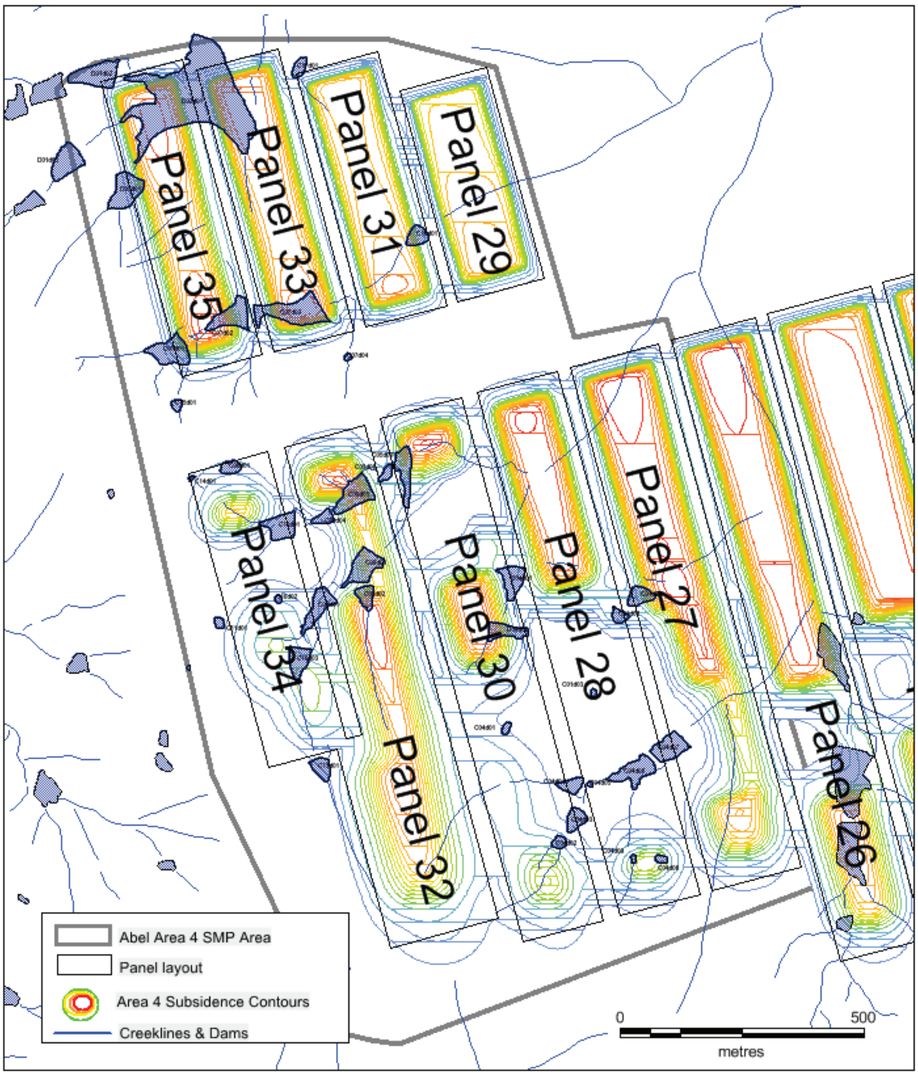

Figure 10: Farm Dams and Subsidence Contours within EP Area 4

The MSEC report also notes that the farm dams located directly above the proposed panels could be subject to strains that could cause cracking, heaving or stepping in the bases or dam walls. In addition there is also a possibility that high concentrations of strain could occur at faults, fissures and other geological features, or points of weaknesses in the strata, leading to a step formation at the surface. If this coincided with a farm dam wall, there is a possibility that cracking in the dam wall or base could occur resulting in loss of the stored water.

The MSEC report notes that the farm dams which are at highest risk of cracking are dams C07d03, C16d01, D02d01 and D03d01, which are located in the final tensile zones and depths of cover less than 100m. Other dams which are located within the final tensile zone, at higher depths of cover, could also be affected by a lesser extent of surface cracking.

Any surface cracking or leakages in the farm dams could be identified by visual inspections and remediated by re-instating the bases and walls of the dams with cohesive materials. Any loss of water from the farm dams would flow into the drainage line in which the dam was formed.

4.6 Flooding

With a few minor exceptions noted in **Table 3**, Four Mile Creek and its tributaries within EP Area 4 have well defined channels within a valley setting. There are no defined floodplain areas in the existing landform and the post-mining topography depicted in **Figure 8** indicates that subsidence will not create any new areas that could lead to flooding on a wide scale.

The existing landscape and infrastructure is likely to contain some areas where minor flooding potentially exists on the existing landscape, including:

- Where existing farm access roads cross drainage depressions; and
- Culverts crossing Black Hill Road that may currently be undersized for major storm events.

Based on the landform depicted in **Figure 8**, the predicted subsidence in EP Area 4 is not expected to exacerbate existing localised flooding or create significant new areas of flooding.

4.7 Groundwater Baseflow

Groundwater modelling of the Abel Mine area has been progressively refined since 2000 to take account of ongoing monitoring at the Abel, Donaldson and Bloomfield mines as well as monitoring of inflow to the Abel Mine.

The *Groundwater Assessment* (RPS Aquaterra, 2012, Appendix B of the EA) has assessed the changes in the interactions between the groundwater system and the creeks for the Modification 3 mine layout, including Area 4, compared those for the approved mine layout. **Figure 11** has been prepared based on data from RPS Aquaterra (2012) and shows the expected changes, compared to the approved mine plan, in groundwater baseflow loss to (or gain from) the various creeks that drain from the extraction area.

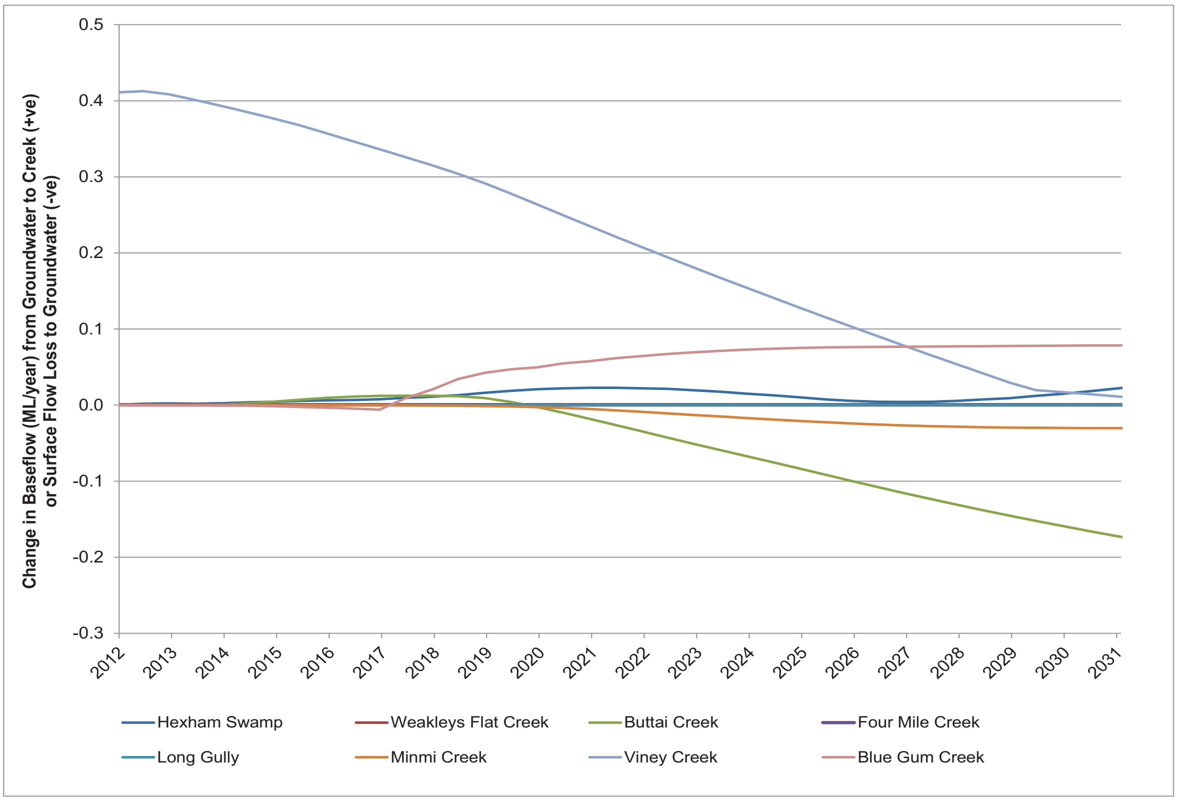

Figure 11: Predicted Baseflow Gains and Losses in Potentially Affected Creeks (Modification 3)

Although the baseflows depicted in **Figure 11** have been inferred from a groundwater model of the whole Abel Mine area, they illustrate the following features:

- All predicted flows are trivial and would be indistinguishable from the surface runoff from the catchments.
- Groundwater baseflow to or from Four Mile Creek is negligible and is not expected to change over time.

5 Proposed Monitoring

The proposed surface water monitoring for EP Area 4 will be based on the monitoring regime that has been refined on the basis of experience in Areas 1, 2and 3.

5.1 Stream Channels

As described in **Section 4.3.1**, the locations of the creeks that are most likely to exhibit the effects of subsidence are:

- Locations at the northern end of the panels where there is likely to be the maximum tilt in the opposite direction to the gradient of the channel which could lead to ponding.
- Any locations where creek channels drain into the subsidence trough. These locations could experience an increase in bed gradient which would make them more prone to scour.

Detailed longitudinal survey of each creek, including a photographic record with location co-ordinates, should be undertaken prior to the commencement of mining and any areas of potential instability noted. Further visual inspections and photographic recording should be carried out immediately following mining and annually for at least two years following completion of mining. Any conditions that warrant remedial action should be repaired in accordance with the principles set out in **Sections 6.2** and **6.3**.

5.2 Dams

As part of its commitments for the Abel Underground Mine, Donaldson Coal will develop a Dam Monitoring and Management Strategy (DMMS) for all significant dams prior to the commencement of any mining which will potentially impact on the dams. The DMMS will provide for the inspection of each dam by a qualified engineer for:

- Current water storage level;
- Current water quality (EC and pH);
- Wall orientation relative to the potential cracking and differential subsidence;
- Wall size (length, width and thickness);
- Construction method and soil / fill materials;
- Wall status (presence of rilling / piping / erosion / vegetation cover);
- Potential for safety risk to people or animals;
- Downstream receptors, such as minor or major streams, roads, tracks or other farm infrastructure; and potential outwash effects.

Photographs of each dam will be taken prior to and after undermining, when the majority of predicted subsidence has occurred.

5.2.1 Large Northern Dam (D02d01)

In addition to the proposed monitoring outlined above, Donaldson Coal will undertake additional management and monitoring for the large northern dam (dam reference D02d01). This should include:

- Developing a site-specific DMMS;
- Installing an extensometer and piezometer at the northern end of the proposed Panel 29 prior to undermining dam to measure the height of fracturing above the seam;
- Conducting a site-specific risk assessment including public safety on John Renshaw Drive and inrush potential;
- Consideration of partial extraction system under dam;
- Consultation with RMS regarding potential flooding of John Renshaw Drive and Black Hill Road;
- Geotechnical investigation and assessment of the existing condition of the dam wall;
- Assessing the capacity of the drainage culverts beneath John Renshaw Drive;
- Reviewing of impacts on previously undermined dams; and
- Developing a Trigger Action Response Plan (TARP) based on the detailed monitoring.

5.3 Water Quality

Routine water quality monitoring will continue at the existing monitoring sites on each of the creeks downstream of Area 4 (**Figure 5**), focusing on the key water quality parameters outlined in **Section 4**. While the water quality at these sites reflect other land use influences, they are considered appropriate for identifying any significant persistent changes in water quality that might be attributed to mine subsidence effects.

Table 10: Water Quality Monitoring for Four Mile Creek at EM1

Parameter	Trigger' Value Range	Frequency of Monitoring
pH	6.5 – 7.1	Monthly
EC (µS/cm)	235 – 580	Monthly
TSS (mg/L)	8 – 34	Monthly
Al (mg/L)	0.35 – 1.60	Quarterly
Mn (mg/L)	0.04 – 0.46	Quarterly
Fe (mg/L)	2.32 – 5.56	Quarterly

6 Potential Remediation

6.1 Surface Cracking

As a result of cracking of soil on the land surface experienced in Areas 1, 2 and 3, Donaldson Coal has well-developed procedures for the identification and rehabilitation of permanent surface cracks which are most likely in areas of maximum curvature along the edges of the panels. The photographs in **Figure 12** illustrate these procedures.

1. Excavator digs down to base of crack

2. Area compacted and re filled

3. Area re-seeded

4. Rehabilitation completed

Figure 12: Typical Process for Rehabilitation of Surface Cracking

In the event of significant cracking of exposed bedrock, cement based grout and crushed rock may be employed.

6.2 Stream Bed Cracking

The *Subsidence Predictions and Impact Assessment* (MSEC, 2014) concludes that it is possible there could be some loss of the surface water flows into the mine through bed-rock cracking in the creek channels where the depths of cover are the shallowest. Any such cracking would be identified through the creek channel monitoring.

Significant bed-rock cracking could warrant grouting of the underlying bedrock. However previous consultation with the NSW Office of Water (formerly DECCW) has suggested that natural healing and regeneration is the favoured management strategy in most instances, due to the likely level of disturbance caused by other strategies such as those employed for surface cracks or backfilling with imported materials from haulage trucks.

6.3 Bed and Bank Stability

No significant change in bed gradient leading to scouring of creek bed and banks is predicted.

If channel scouring does occur, some of the following actions could be undertaken depending on the accessibility of the site.

- Where subsidence monitoring indicates instability in unconsolidated creek banks and where access is possible and safety hazards are manageable, the bank may be graded back to its angle of repose and revegetated.
- Where a ‘head cut’ develops in the creek bed, construction of a drop structure may be required either using imported hard rock (if access permits) or treated timber where access is limited.
- Disturbed areas would be protected from further erosion by use of jute mesh in areas of concentrated flow and grass seeding followed by tree planting in order to establish sustainable riparian zone rehabilitation.
- Revegetation of the creek banks would mimic the current vegetated sections of the creek by using grasses, indigenous trees and shrubs.

6.4 Ponding

Based on the predicted subsidence effects and the ephemeral nature of the creeks over the proposed panels, it is envisaged that some pools may develop within the creek channels near the northern end of the panels. As noted in the baseline creek survey (see **Section 2.4**), pools are an existing feature of the creeks and it is unlikely that remedial works would be required. In addition, any increased ponding along the creeks is likely to be 'in-channel' and therefore the potential effects on existing flora and fauna are likely to be minimal.

However, if subsidence creates a pool that is significantly larger than predicted, remedial actions would include:

- Assessment of the ecological significance of the pool and its impact on the aquatic and riparian habitat by an appropriately qualified ecologist.
- Consultation with regulatory agencies to determine whether action is warranted to reduce or eliminate the pool.
- If required, channels excavation and stabilisation works to re-grade a section of channel in order to eliminate or reduce the length of the pond.

Notwithstanding, the option of undertaking works to re-grade a section of channel, as noted above previous consultation with NSW Office of Water (formerly DECCW) has suggested that extensive in-channel disturbance is not favoured.

6.5 Farm Dams

In the event that subsidence / crack development monitoring of farm dams indicates a significant potential for dam wall failure, dam water will be managed in one of the following ways:

- Pumped to an adjacent dam to lower the water level to a manageable height that reduces the risk of dam wall failure,
- Discharged to a lower dam via existing channels if the water cannot be transferred, or
- Not transferred if the dam water level is sufficiently low to pose a minor risk.

An alternate water supply will be provided to the dam owner until the dam can be reinstated.

In the event of subsidence damage or significant reduction in the storage capacity of a dam due to differential subsidence, Donaldson Coal would remediate the damage and reinstate the dam in consultation with the Mine Subsidence Board.

7 References

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Donaldson Coal

Area 4 Extraction Plan

Surface Water Management Plan
Appendix A: Water Quality Analysis

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1 Introduction

There are 6 watercourse overlying the Abel underground lease area that will potentially be impacted by underground mining associated with the Abel Mine Project:

- Four Mile Creek;
- Weakleys Flat Creek;
- Viney Creek;
- Buttai Creek;
- Blue Gum Creek;
- Long Gully.

Water quality monitoring in these catchment commenced in 2000; underground mining commenced in the Weaklys Flat catchment in 2010, and in the Four Mile Creek Catchment in 2013.

The purpose of this report is to present the pre- and post- mining water quality data for Weakleys Flat Creek, to establish performance indicators applicable for that catchment and to demonstrate that this method of setting performance indicators is appropriate for the Four Mile Creek Catchment that will potentially be impacted by underground extraction in Area 4.

2 Weakleys Flat Creek

2.1 Historical Data (pre-mining)

Water quality data has been collected on a monthly basis at Weakleys Flat Creek upstream of John Renshaw Drive (about 2 km downstream of Area 3). The location of the Weakleys Flat Creek monitoring station (EM3) is shown on **Figure 1**. Data collection for this site commenced in July 2000, sampling was undertaken for the analytes and parameters detailed in **Table 1**.

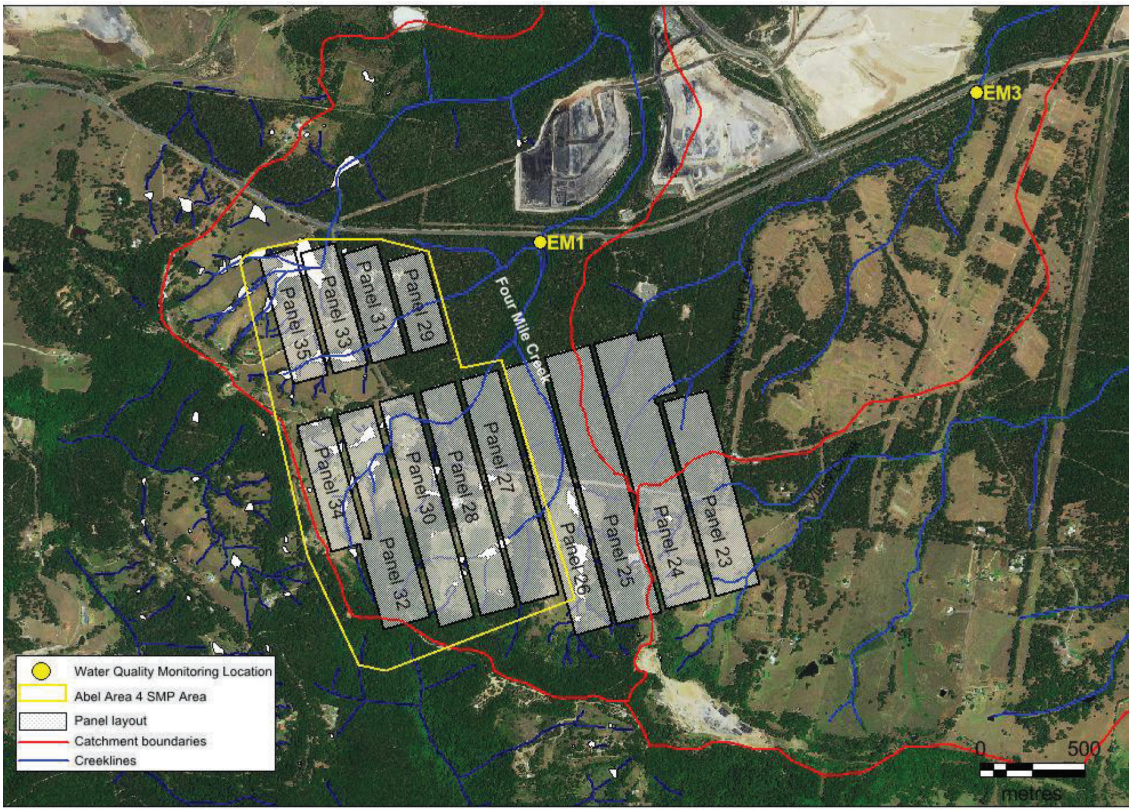

Figure 1: Water Quality Monitoring Locations Downstream of Area 4

Mining commenced within the Weakleys Flat Creek catchment (Abel Area 1, Panels 1 – 13 and East Mains; Abel Area 1, Panels 14 – 25 and Tailgate Headings) in July 2010. Therefore, the pre-mining or baseline data analysis considers the 118 samples collected between July 2000 and July 2010.

Table 1: Analytes and parameters monitored at Weakleys Flat Creek and Four Mile Creek

Analytes monitored on a monthly basis	Analytes monitored 3-4 times a year
Temperature	Alkalinity
pH	Acidity
H+	Chloride
Electrical Conductivity	Calcium
Total Dissolved Solids	Magnesium

Total Suspended Solids	Sodium
Sulphate	Potassium
Turbidity (monthly monitoring July 2002 – February 2010, 3-4 times a year afterwards)	Aluminum
	Arsenic
	Barium
	Cadmium
	Chromium
	Cobalt
	Copper
	Lead
	Manganese
	Selenium
	Zinc
	Iron
	Fluoride
	Nitrate
	Reactive Phosphorus

The potential impact on water quality due to underground mining is due to a contamination of surface water through seepage from underground workings to the surface. Mine water is generally very salty, with electrical conductivity (EC) in the range of 600 to 16,000 µS/cm (2012 EA), as compared with a maximum recommended level of approximately 2,200 µS/cm for fresh water. Therefore the primary trigger for mine induced water quality impacts is EC. Mine water is also likely to be more acidic, and contain higher levels of dissolved metals than fresh water. Monitoring of water quality in areas subject to mining indicates that the effects of subsidence on water quality have been most noticeable in iron, manganese and aluminum (Metropolitan Coal Water Management Plan 2011).

As such, the parameters that have been identified as triggers for mine impacts on nearby waterways for the Abel Underground lease area are: pH, electrical conductivity (EC), total suspended solids (TSS), Aluminium (Al), Manganese (Mn) and Iron (Fe). Therefore, analysis has been undertaken conducted for these six parameters only.

Table 2 provides a statistical summary of pH, EC, TSS, Al, Mn and Fe for the baseline data July 2000 to July 2010. For comparison purposes, the table also lists the default ANZECC trigger values for lowland creeks with slightly disturbed ecosystems as has also been used in the Environmental Assessments to date.

Table 2: Summary of Historical Water Quality Statistics for Weakleys Flat Creek (Pre-mining)

Statistic	pH (pH Unit)	EC (µS/cm)	TSS (mg/L)	Al (mg/L)	Mn (mg/L)	Fe (mg/L)
ANZECC Default trigger	**6.5 - 8.0 ***	**125 - 2200 ***	**N/A**	**0.055 ^**	**1.9 #**	**N/A**
Number of samples	118	117	116	39	39	39
Minimum	5.6	136	1	0.04	0.00	0.26
20th Percentile	6.64	235	3	0.10	0.01	0.91
Median	6.9	550	11	0.21	0.08	1.7
Average	6.9	786	28	1.6	0.27	3.35
80th percentile	7.2	1116	30	1.34	0.47	4.12
Maximum	7.7	4810	920	33	2.60	24

** ANZECC trigger values for lowland creeks with slightly disturbed ecosystems*

^ 95% Level of protection, slightly - moderately disturbed systems pH >6.5

 # 95% Level of protection, slightly - moderately disturbed systems

The results of this analysis of the water quality monitoring data to date for Weakleys Flat Creek (historical and post mining) are provided in **Figure 2 - Figure 7**.

Key aspects of the Weakleys Flat Creek water quality monitoring results and analysis, pre-mining, are:

- Average pH is almost neutral (pH 6.9), with a slightly acidic 20th percentile value of 6.64 and slightly alkaline 80th percentile value of 7.2. The 20th and 80th percentile values are within the default ANZECC trigger levels for further investigation.
- Salinity (as indicated by electrical conductivity – EC) has a very large range, with an average of 786 µS/cm, 20th percentile value of 235 µS/cm and an 80th percentile value of 1116 µS/cm. The 20th and 80th percentile values are within the default ANZECC trigger levels for further investigation.
- Total suspended solids (TSS) has an average value of 28 mg/L, 20th percentile value of 3 mg/L and an 80th percentile value of 30 mg/L. There is no default ANZECC trigger level provided.
- Only 39 samples have been collected for aluminium (Al), with Al data collected three to four times a year. Al has an average value of 1.6 mg/L, 20th percentile value of 0.10 mg/L and an 80th percentile value of 1.34 mg/L. Most values are above the default ANZECC trigger level for further investigation.
- Only 39 samples have been collected for manganese (Mn), with Mn data collected three to four times a year. Mn has an average value of 0.27 mg/L, 20th percentile value of 0.01 mg/L and an 80th percentile value of 0.47 mg/L. Apart from the maximum recording, all Mn values are lower than the default ANZECC trigger level for further investigation.
- Only 39 samples have been collected for iron (Fe), with Fe data collected three to four times a year. Fe has an average value of 3.35 mg/L, 20th percentile value of 0.91 mg/L and an 80th percentile value of 4.12 mg/L. There is no default ANZECC trigger level provided.

Overall, the water quality data indicates that at the Weakleys Flat Creek monitoring point the catchment has water quality that is consistent with a moderately disturbed catchment.

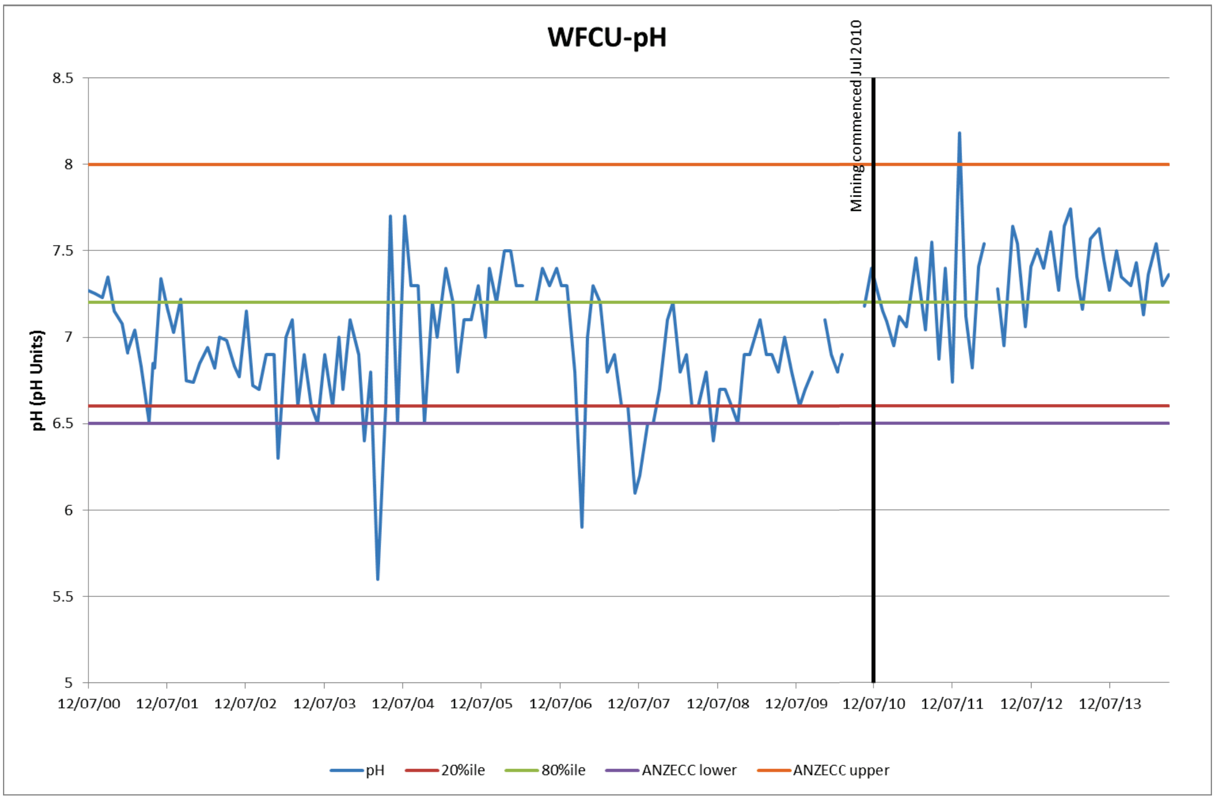

Figure 2: Weakleys Flat Creek Surface Water Quality Monitoring Results – pH

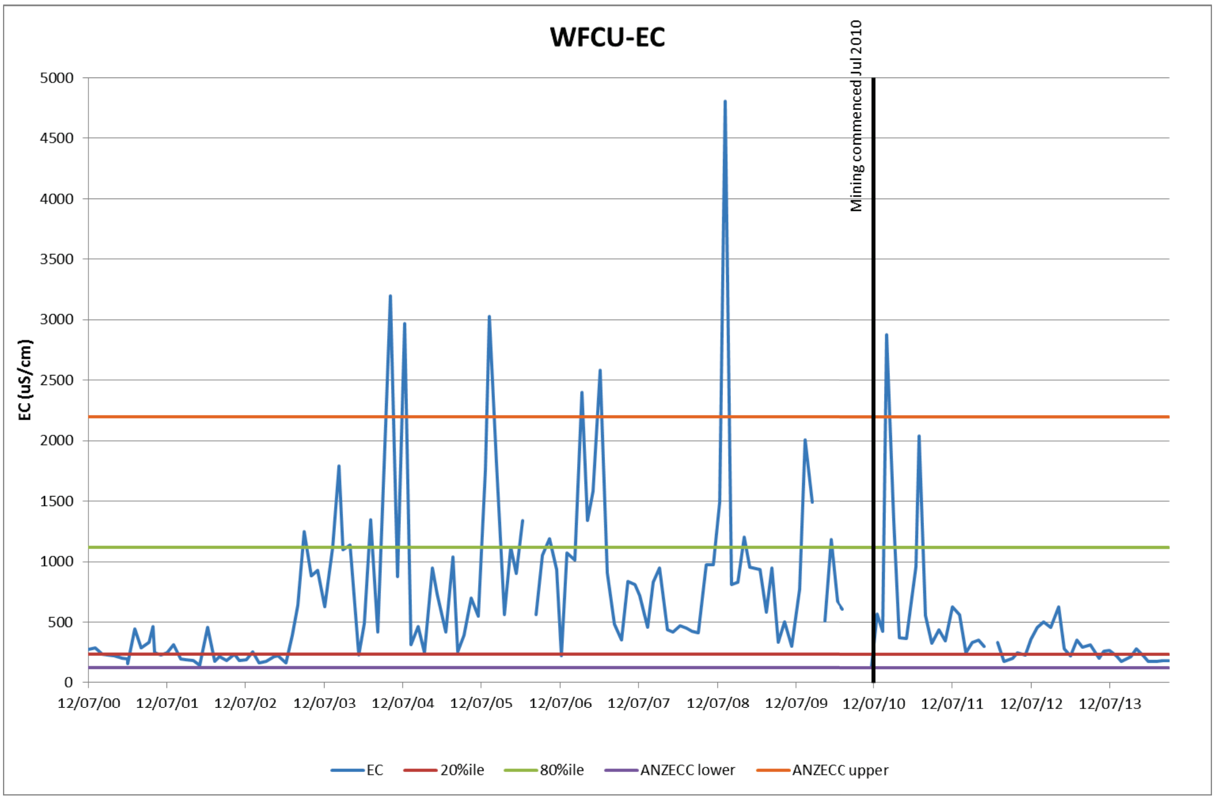

Figure 3: Weakleys Flat Creek Surface Water Quality Monitoring Results – Electrical Conductivity

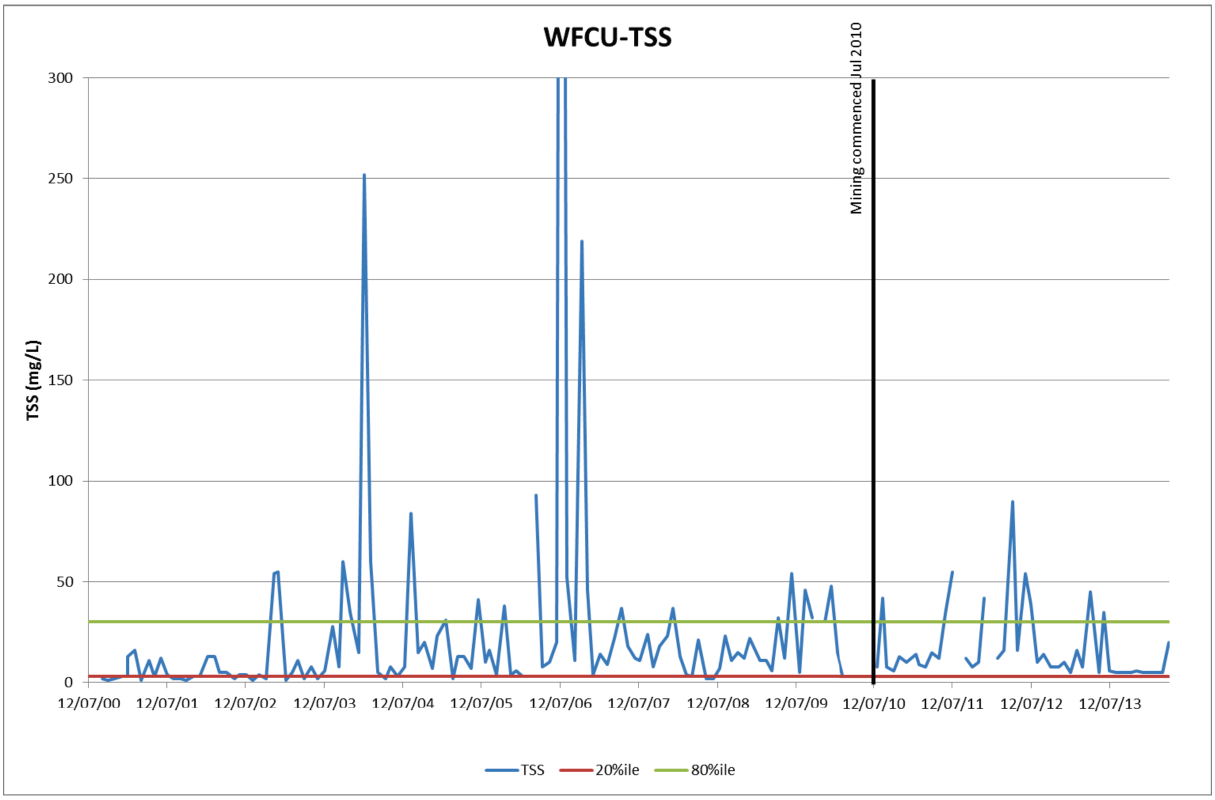

Figure 4: Weakleys Flat Creek Surface Water Quality Monitoring Results – Total Suspended Solids

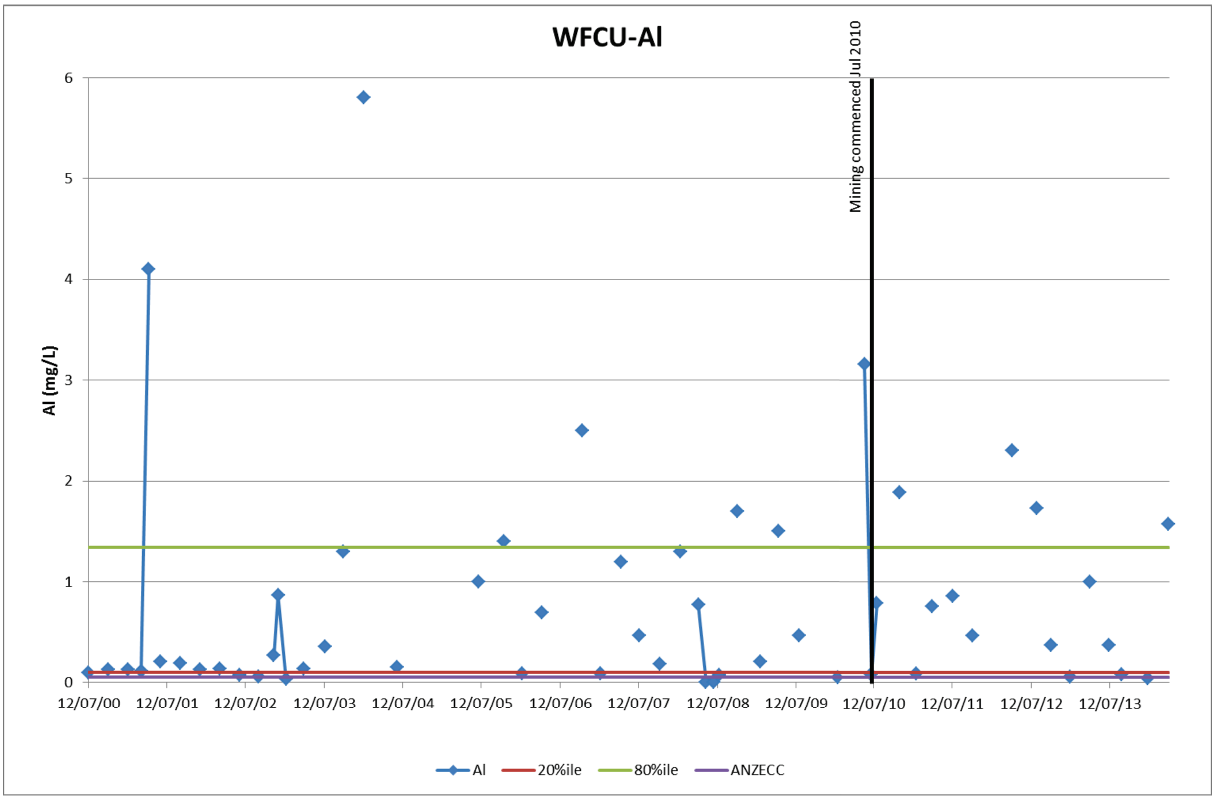

Figure 5: Weakleys Flat Creek Surface Water Quality Monitoring Results – Aluminium

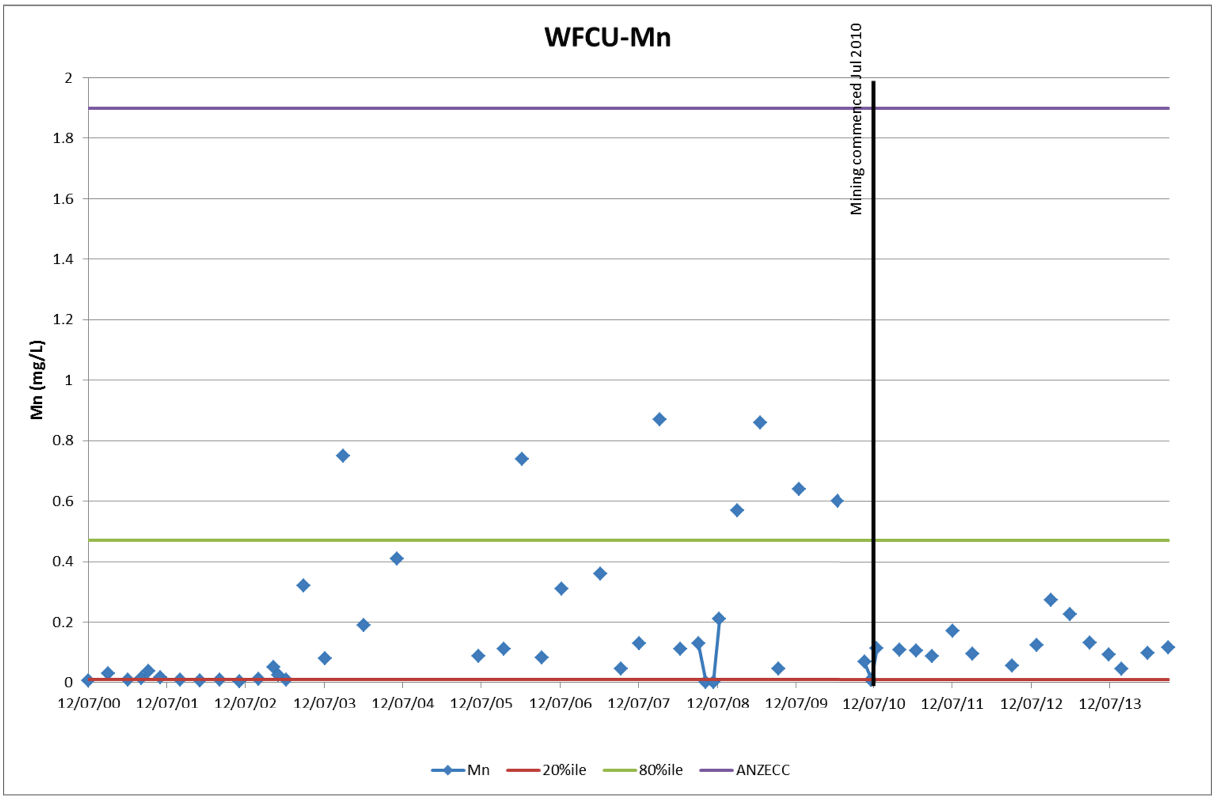

Figure 6: Weakleys Flat Creek Surface Water Quality Monitoring Results – Manganese

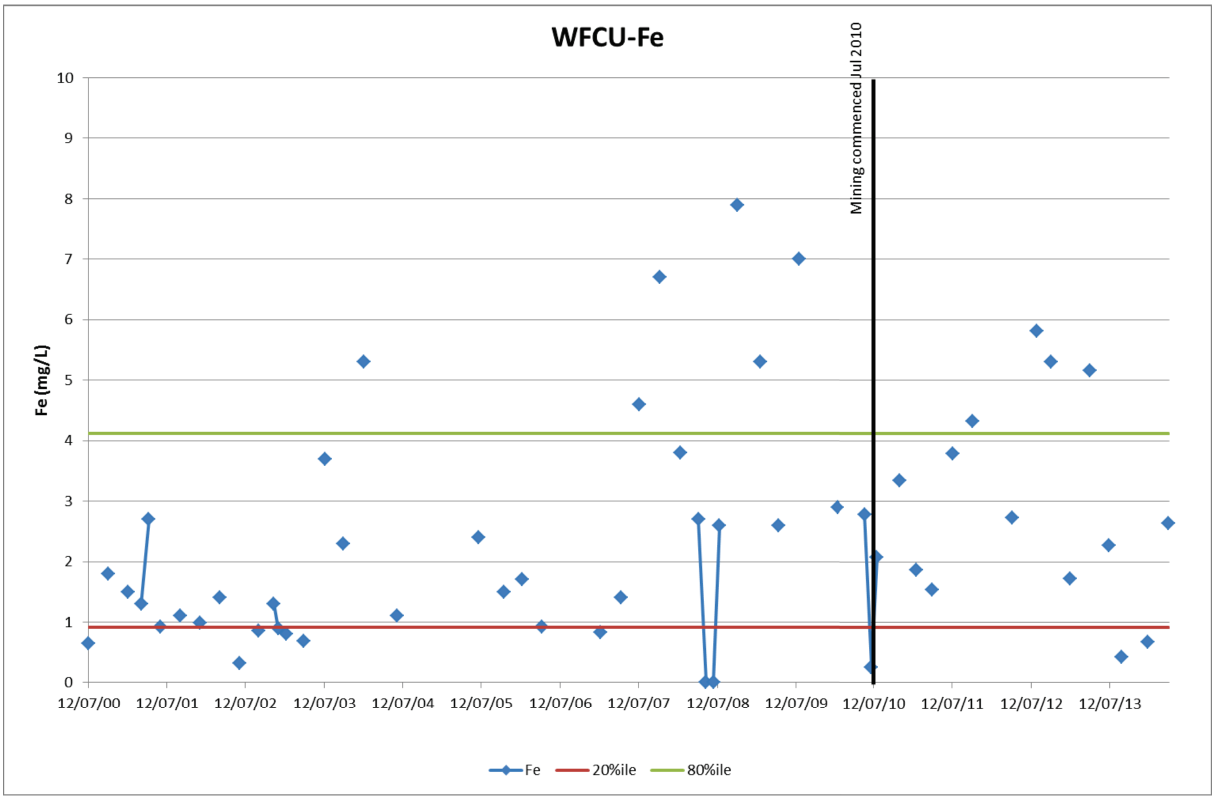

Figure 7: Weakleys Flat Creek Surface Water Quality Monitoring Results – Iron

2.2 Trigger Values

The ANZECC Guidelines published in 2000 ("the Guidelines") provide **default** 'trigger' values for different indicators of water quality parameters as either a '*threshold value*' or as a '*range of desirable values*'. Where an indicator is above a threshold value or outside the range of desirable values "*there may be a risk that the environmental value will not be protected"*. The purpose of these 'trigger' values is to provide a 'trigger' for action or further investigation. They are not prescribed limits.

The Guidelines also state that:

> *"Trigger values are conservative assessment levels, not 'pass/fail' compliance criteria. Local conditions vary naturally between waterways and it may be necessary to tailor trigger values to local conditions or 'local guidelines'."*

The Guidelines also state that two years of monthly sampling is regarded as sufficient to provide an indication of the local ecosystem variability and to provide a basis for derivation of 'trigger' values appropriate to conditions in a particular creek system. For physical and chemical stressors for slightly or moderately disturbed ecosystems, such as that surrounding the Abel Underground Mine, the Guidelines recommend the use of the 20^{th} and 80^{th} percentile values of the data obtained from an appropriate reference system as the basis for revised 'trigger' values. On the basis of the historical monitoring data summarised in **Table 2**, appropriate trigger values for Weakleys Flat Creek are set out in **Table 3**.

Table 3: Proposed Water Quality 'Trigger' Values for Weakleys Flat Creek

Parameter	Proposed 'Trigger' Value Range
pH	6.6 - 7.2
EC (µS/cm)	235 - 1116
TSS (mg/L)	3 - 30
Al (mg/L)	0.10 - 1.34
Mn (mg/L)	0.01 - 0.47
Fe (mg/L)	0.91 - 4.12

In line with the way that the ANZECC trigger values are intended to be used, the proposed trigger values in **Table 3** do not represent 'limits'. Rather, they represent ranges in which most observations can be expected, and therefore a trigger to undertake further assessment if monitoring demonstrates that the upper limit is continuously exceeded.

2.3 Effects of Mining

Mining commenced within the Weakleys Flat Creek tributary in July 2010. Water monitoring data has continued to be collected after the commencement of mining, enabling an analysis of the effects of mining on the tributary.

Table 4 provides a statistical summary of pH, EC, TSS, Al, Mn and Fe from July 2010 to April 2014. For comparison purposes, the table also lists the default ANZECC trigger values for lowland creeks with slightly disturbed ecosystems and the calculated trigger values for each parameter.

Table 4: Summary of Post Commencement of Mining Water Quality Statistics for Weakleys Flat Creek

Statistic	pH (pH Unit)	EC (µS/cm)	TSS (mg/L)	Al (mg/L)	Mn (mg/L)	Fe (mg/L)
ANZECC Default trigger	**6.5 - 8.0 ***	**125 - 2200 ***	**N/A**	**0.055 ^**	**1.9 #**	**N/A**
Calculated Trigger	**6.6 - 7.2**	**235 - 1116**	**2 - 30**	**0.10 - 1.34**	**0.01 - 0.47**	**0.91 - 4.12**
Number of samples	45	45	44	15	15	15
Minimum	6.7	173	5	0.04	0.05	0.43
20th Percentile	7.1	218	6	0.09	0.09	1.68
Median	7.4	327	10	0.76	0.11	2.63
Average	7.3	459	17	0.8	0.12	2.91
80th percentile	7.5	513	26	1.60	0.14	4.49
Maximum	8.2	2880	90	2.3	0.27	5.81

** ANZECC trigger values for lowland creeks with slightly disturbed ecosystems*

^ 95% Level of protection, slightly - moderately disturbed systems pH >6.5

 # 95% Level of protection, slightly - moderately disturbed systems

The results of these parameters to date (historical and post mining) in addition to the calculated 20th and 80th percentile trigger values are also displayed in **Figure 2 - Figure 7** for Weakleys Flat Creek.

Key aspects of the Weakleys Flat Creek water quality monitoring sites, after commencement of mining, are:

- Average pH is slightly alkaline (pH 7.3), with a 20th percentile value of 7.1 and slightly alkaline 80th percentile value of 7.5. The 20th percentile value is within the calculated trigger levels for further investigation. However, the 80th percentile value exceeds the calculated trigger levels for further investigation.
- Salinity (as indicated by EC) an average of 459 µS/cm, 20th percentile value of 218 µS/cm and an 80th percentile value of 513 µS/cm. The 20th and 80th percentile values are lower than the upper calculated trigger level for further investigation. After mining commenced, the upper trigger value was only exceeded three times, with a maximum of two exceedences occurring in consecutive months.
- TSS has an average value of 17 mg/L, 20th percentile value of 6 mg/L and an 80th percentile value of 26 mg/L. Apart from the maximum recording, all TSS values are lower than the upper calculated trigger level for further investigation.
- Only 15 samples have been collected for Al, with Al data collected three to four times a year. Al has an average value of 0.8 mg/L, 20th percentile value of 0.09 mg/L and an 80th percentile value of 1.60 mg/L. The 20th percentile value is within the calculated trigger levels for further investigation. However, the 80th percentile value exceeds the calculated trigger levels for further investigation. Upon further inspection of the data, it was found that only four readings exceeded the trigger value, with a maximum of two exceedences occurring during consecutive sample collections.
- Only 15 samples have been collected for Mn, with Mn data collected three to four times a year. Mn has an average value of 0.12 mg/L, 20th percentile value of 0.09 mg/L and an 80th percentile value of 0.14 mg/L. All Mn values are lower than the upper calculated trigger level for further investigation.
- Only 15 samples have been collected for Fe, with Fe data collected three to four times a year. Fe has an average value of 2.91 mg/L, 20th percentile value of 1.68 mg/L and an 80th percentile value of 4.49 mg/L. Apart from the maximum recording, all Fe values are lower than the upper calculated trigger level for further investigation.

Overall, the water quality data indicates that at the Weakleys Flat Creek monitoring point, water quality post commencement of mining was generally within the calculated trigger values for further investigation, and that the 20th and 80th percentile range of the background levels is an appropriate trigger level.

3 Four Mile Creek

3.1 Historical Data (pre-mining)

Water quality data has been collected on a monthly basis at Four Mile Creek upstream of John Renshaw Drive (about 0.5 km downstream of Area 3) since July 2000. The location of the Four Mile Creek monitoring station (EM1) is shown on **Figure 1**. Mining commenced within the Four Mile Creek catchment (Abel Area 3, Panels 23 - 26) in July 2013. Therefore, the historical data analysis considers the 144 samples of water quality data collected between July 2000 and July 2013.

Table 5 provides a statistical summary of pH, EC, TSS, Al, Mn and Fe from July 2000 to July 2013. For comparison purposes, the table also lists the default ANZECC trigger values for lowland creeks with slightly disturbed ecosystems.

Table 5: Summary of Historical Water Quality Statistics for Four Mile Creek

Statistic	pH (pH Unit)	EC (µS/cm)	TSS (mg/L)	Al (mg/L)	Mn (mg/L)	Fe (mg/L)
ANZECC default trigger	**6.5 - 8.0 ***	**125 - 2200 ***	**N/A**	**0.055 ^**	**1.9 #**	**N/A**
Number of samples	144	144	141	47	47	47
Minimum	5.9	100	1	0.13	0.0	0.72
20th Percentile	6.5	235	8	0.35	0.0	2.32
Median	6.8	425	16	1.00	0.1	3.6
Average	6.8	414	27	1.18	0.2	4.4
80th percentile	7.1	580	34	1.60	0.5	5.56
Maximum	7.9	985	269	4.50	1.0	20

** ANZECC trigger values for lowland creeks with slightly disturbed ecosystems*
^ 95% Level of protection, slightly - moderately disturbed systems pH >6.5
 # 95% Level of protection, slightly - moderately disturbed systems

Analysis of these parameters for Four Mile Creek to date (historical and post mining) are provided in **Figure 8 - Figure 13**.

Key aspects of the Four Mile Creek water quality monitoring results, pre-mining (2000 – 2013), are:

- Average pH is slightly acidic (pH 6.8), with a 20th percentile value of 6.5 and slightly alkaline 80th percentile value of 7.1. The 20th and 80th percentile values are within the default ANZECC trigger levels for further investigation.
- Salinity (as indicated by EC) has an average of 414 µS/cm, 20th percentile value of 235 µS/cm and an 80th percentile value of 580 µS/cm. The 20th and 80th percentile values are within the default ANZECC trigger levels for further investigation.
- Total suspended solids (TSS) has an average value of 27 mg/L, 20th percentile value of 8 mg/L and an 80th percentile value of 34 mg/L. There is no default ANZECC trigger level provided.
- Only 47 samples have been collected for aluminium (Al), with Al data collected three to four times a year. Al has an average value of 1.18 mg/L, 20th percentile value of 0.35 mg/L and an

80th percentile value of 1.60 mg/L. All values are above the default ANZECC trigger level for further investigation.

- Only 47 samples have been collected for manganese (Mn), with Mn data collected three to four times a year. Mn has an average value of 0.2 mg/L, 20th percentile value of 0.0 mg/L and an 80th percentile value of 0.5 mg/L. All Mn values are lower than the default ANZECC trigger level for further investigation.
- Only 47 samples have been collected for iron (Fe), with Fe data collected three to four times a year. Fe has an average value of 4.4 mg/L, 20th percentile value of 2.32 mg/L and an 80th percentile value of 5.56 mg/L. There is no default ANZECC trigger level provided.

Overall, the water quality data indicates that at the Four Mile Flat Creek monitoring point, the catchment has water quality that is consistent with a moderately disturbed catchment, with historical results very similar to that of Weakleys Flat Creek.

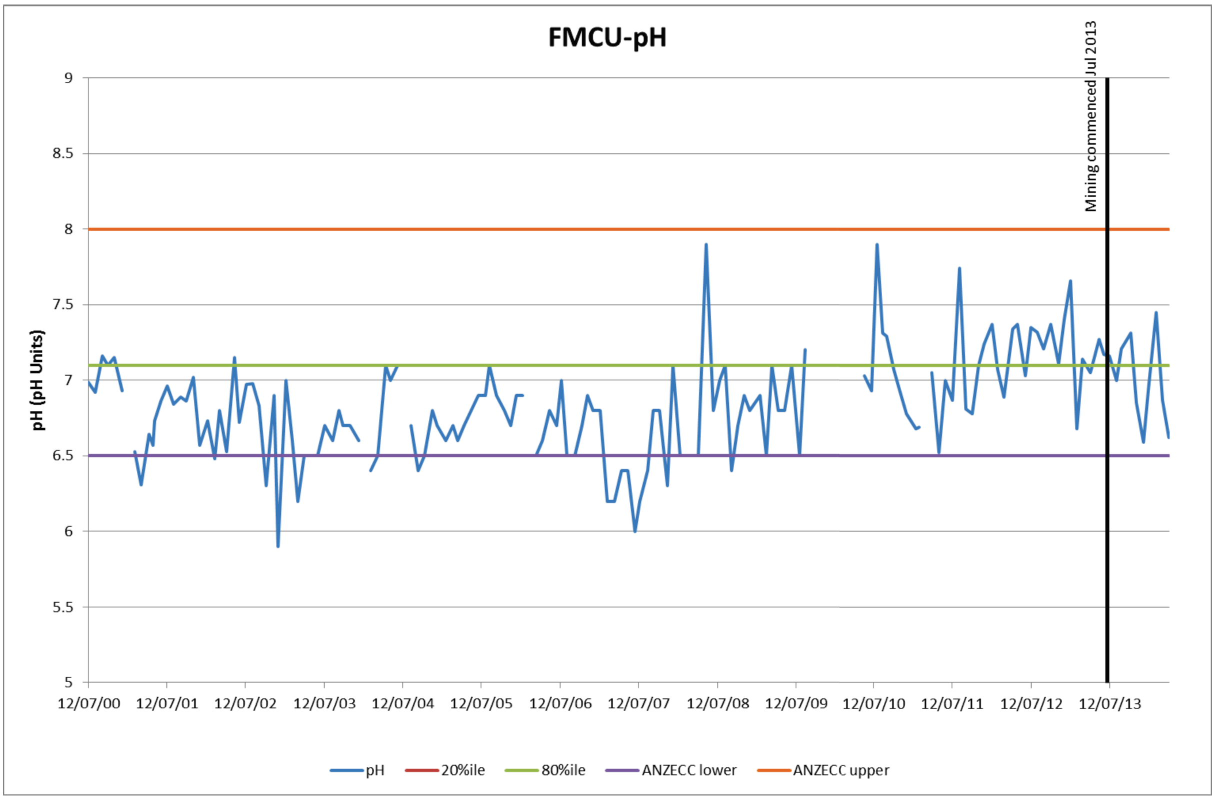

Figure 8: Four Mile Creek Surface Water Quality Monitoring Results – pH

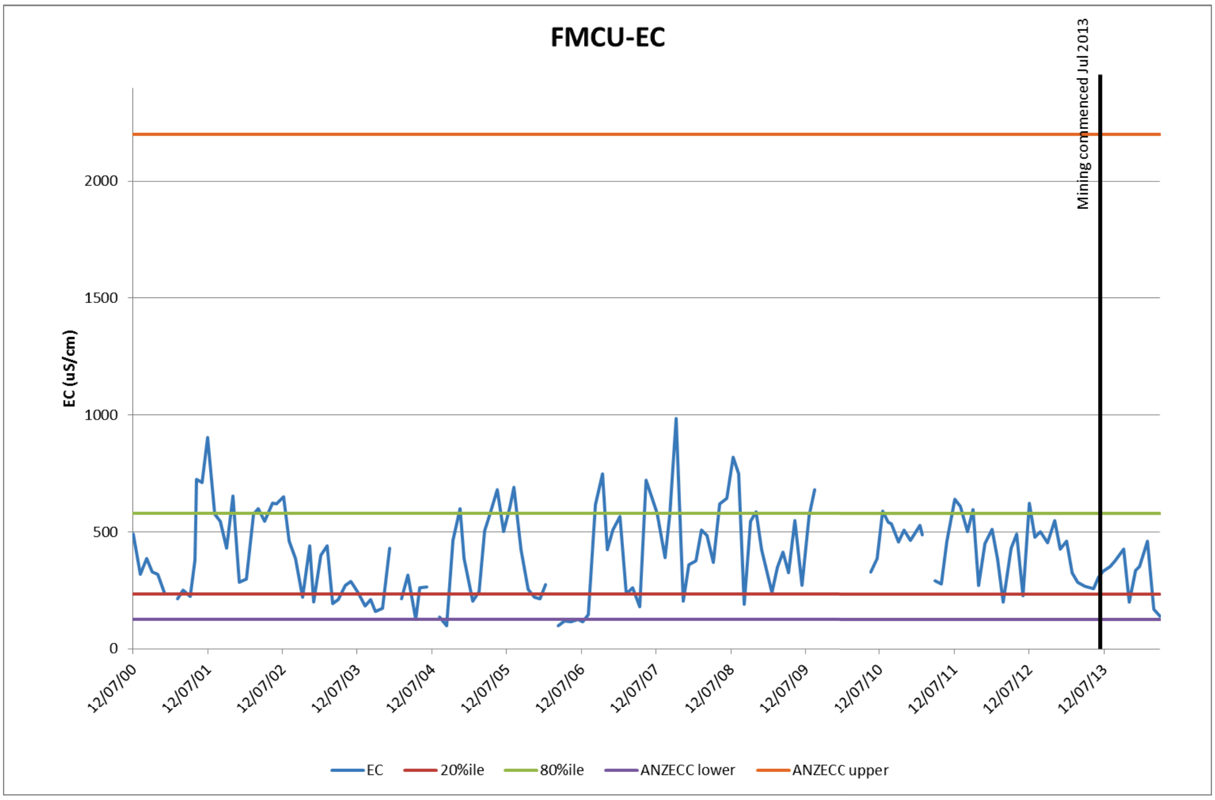

Figure 9: Four Mile Creek Surface Water Quality Monitoring Results – Electrical Conductivity

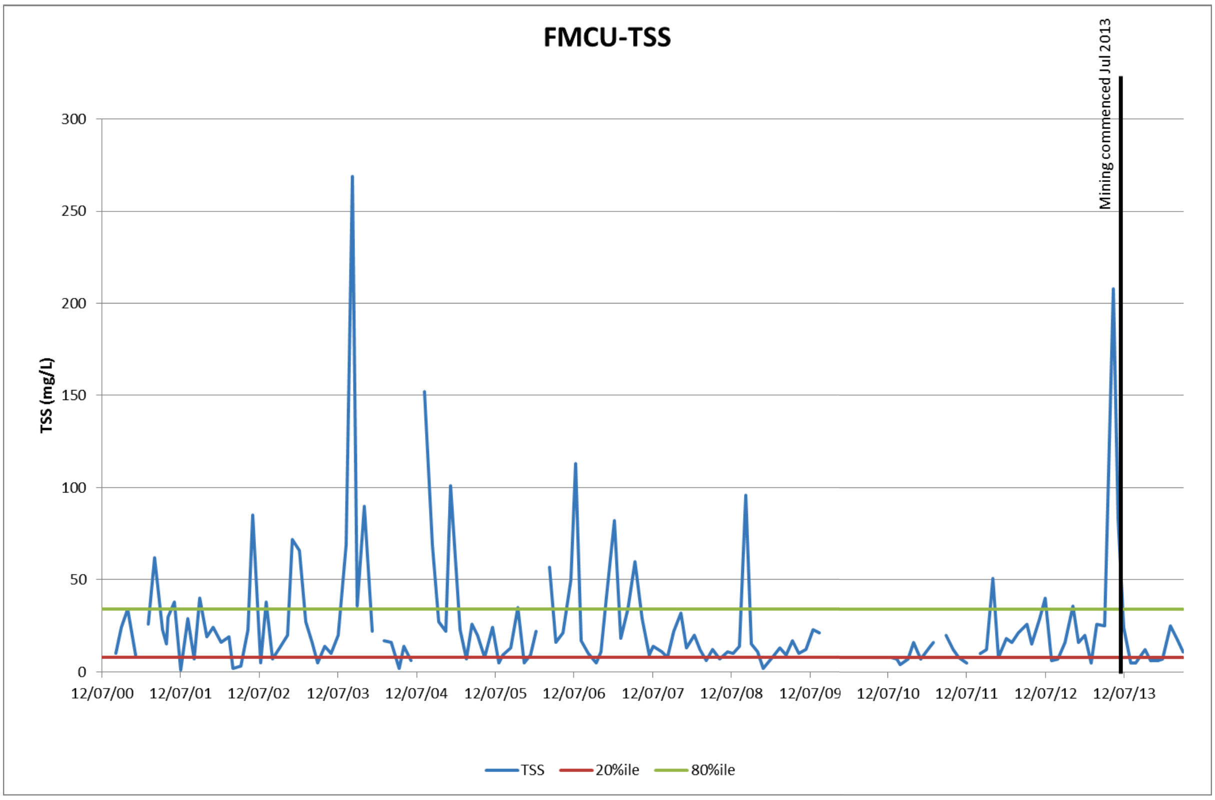

Figure 10: Four Mile Creek Surface Water Quality Monitoring Results – Total Suspended Solids

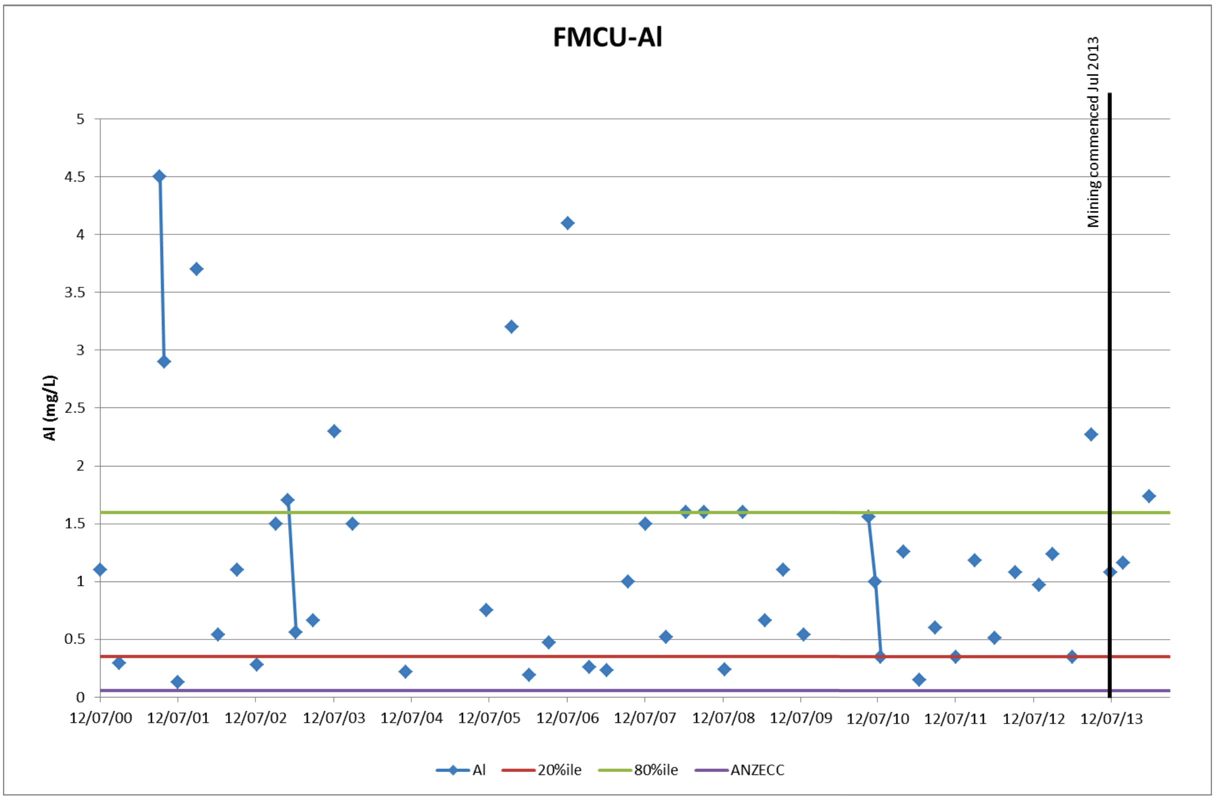

Figure 11: Four Mile Creek Surface Water Quality Monitoring Results – Aluminium

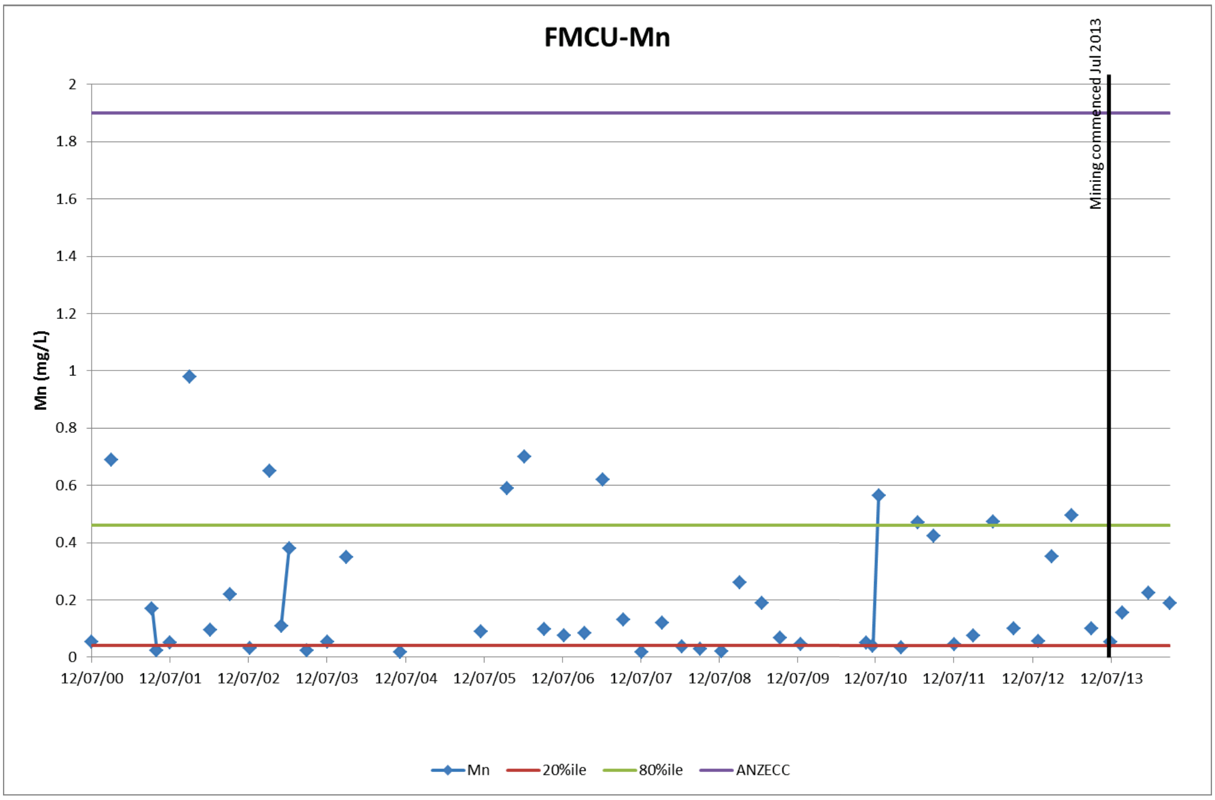

Figure 12: Four Mile Creek Surface Water Quality Monitoring Results – Manganese

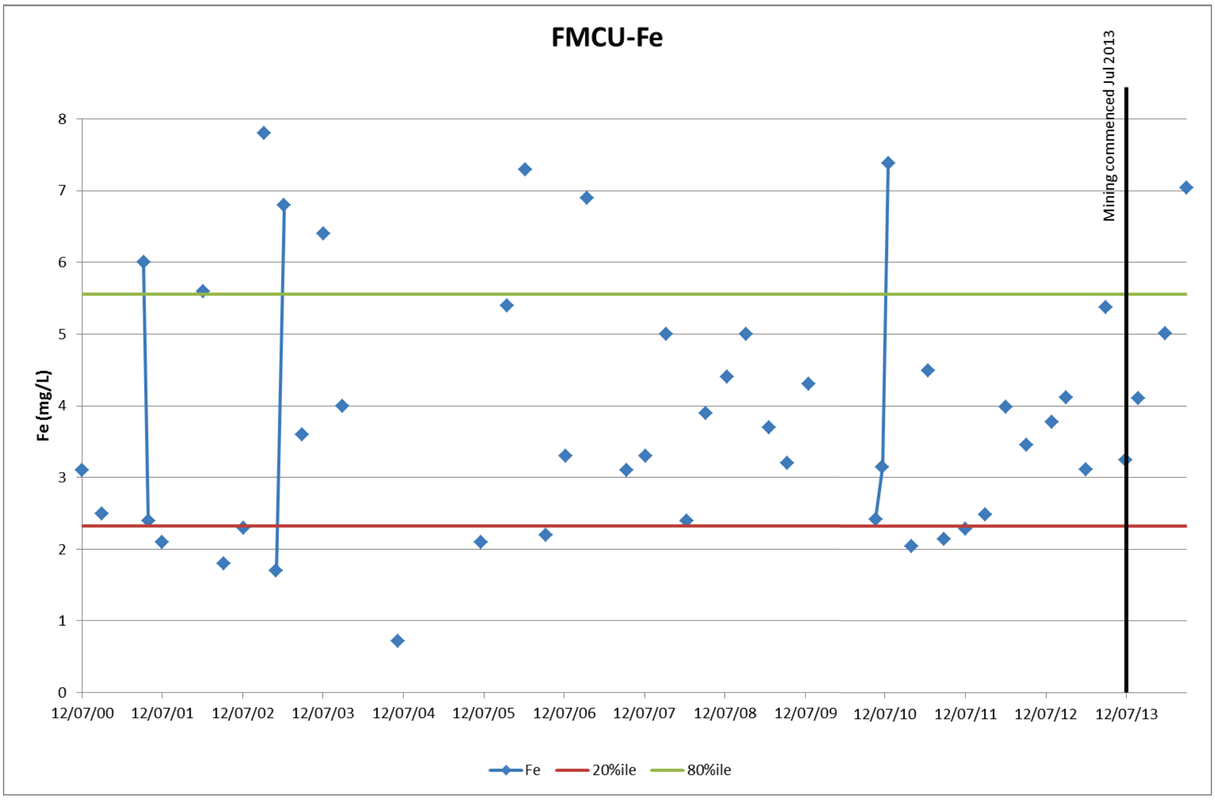

Figure 13: Four Mile Creek Surface Water Quality Monitoring Results – Iron

3.2 Trigger Values

As discussed in **Section 2.2**, the Guidelines recommend the use of the 20th and 80th percentile values of the data obtained from an appropriate reference system as the basis for revised 'trigger' values. On the basis of the historical monitoring data summarised in **Table 5**, appropriate trigger values for Four Mile Creek are set out in **Table 6**.

Table 6: Proposed Water Quality 'Trigger' Values for Four Mile Creek

Parameter	Proposed 'Trigger' Value Range
pH	6.5 – 7.1
EC (µS/cm)	235 – 580
TSS (mg/L)	8 – 34
Al (mg/L)	0.35 – 1.60
Mn (mg/L)	0.04 – 0.46
Fe (mg/L)	2.32 – 5.56

4 Future Monitoring and Further Analysis for Abel Area 4

The post commencement of mining water quality data at Weakleys Flat Creek monitoring point was generally in the range of the 20th and 80th percentile calculated trigger values. This demonstrates that the use of these 20th and 80th percentile values were appropriate for use as trigger values. Where values exceeded the upper trigger value, exceedences did not occur for more than two consecutive months or sample collections.

Insufficient data is available at the Four Mile Creek monitoring location post commencement of mining to undertake an analysis similar to Weakleys Flat Creek. However, as Four Mile Creek and Weakleys Flat Creek are located within the same broader catchment, it is appropriate also that the trigger levels for Four Mile Creek water quality impacts are set at the 80th and 20th percentile bounds as calculated from the baseline data (**Table 6**). Monitoring should continue at the Four Mile Creek monitoring location (EM1) for pH, EC, and TSS, on a monthly basis, and Al, Mn and Fe on a quarterly basis.

As discussed in **Section 2.3** a key indicator of mining induced water quality impacts is changes in salinity. It is recommended that if the upper bound for salinity (EC) is exceeded for a period of three consecutive months, that this is the trigger to undertake further assessment of the metals (Fe, Al and Mn) to establish whether the change in EC is mining induced. It is recommended that this further assessment considers investigation of the potential pathways for water quality impacts within the Abel Mine underground mining area to identify whether the change in water quality is attributable to underground mining activities, and the nature of activity that has caused the change.

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ABEL AREA 4 EXTRACTION PLAN

Groundwater Management Plan

FOR

DONALDSON COAL LIMITED

By

Groundwater Exploration Services Pty Ltd

May 2014

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TABLES

FIGURES

1 INTRODUCTION

This Groundwater Management Plan (GMP) has been prepared to support existing groundwater assessments accompanying the Extraction Plan (EP) / Subsidence Management Plan (SMP) application for 'Area 4' within the Abel Mine lease area. Area 4 comprises nine panels (Nos. 27 – 35) and the further development of the West Mains Headings covering an area of 209 ha located South of John Renshaw Drive.

A Risk Assessment undertaken as part of the preparation of the EP / SMP Area 4 identified a range of potential impacts that are considered. These include:

- Loss of a the groundwater resource as a result of:
    - Connective cracking;
    - Additional flow to underground workings from the intersection with structures;
- Depressurisation of aquifers due to mining activities greater than predicted;
- Elevated salinity in groundwater inflows through mine workings;

The identified risks have been considered along with conditions which have been placed on the modification approval identified within Schedule 3 of the Conditions of Project Approval 05_0136 (MOD 3) for Area 4.

The controls that will mitigate the potential impacts of the greater project have been included within the overarching Water Management Plan. These controls include aspects of the mine design and mining method designed to minimise subsidence impacts as well as proven mitigation methods, such as techniques for remediation of surface cracking based on experience gained in SMP Areas 1, Area 2 and Area 3.

This review of potential risks draws upon a number of documents which provide details of the groundwater environment at Abel Underground Mine which include:

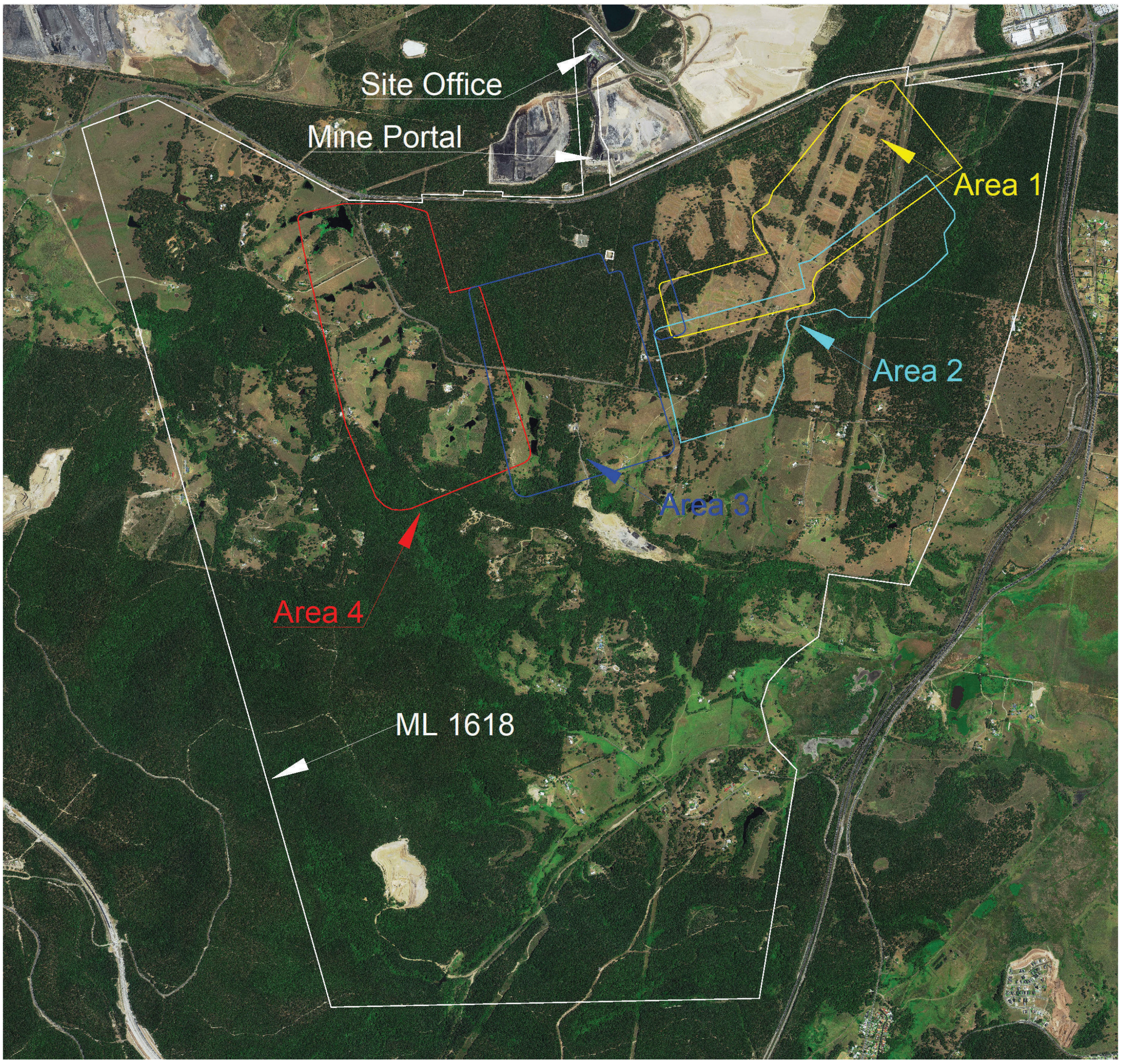
- Information presented in the original Part 3A Environmental Assessment for the Abel Underground Mine (Donaldson Coal, 2006);
- Abel Upgrade Modification Groundwater Assessment (RPS, 2013);
- Relevant information gained from the observed impacts associated with mining of SMP Areas 1, 2 and 3:
- Annual Environment Management Report (Abel Underground Coal Mine 1 June 2012 to 31 May 2013), and;
- Subsidence Predictions and Impact Assessment (MSEC676, 2014);

The GMP is specifically required as a component of the Site Water Management Plan (SWMP). The specific sections of the Consent Conditions that are to be taken into account in preparing the GMP include Schedule 3 of the Modification Approval (Specific Environmental Conditions – Underground Mining).

The conditions which have been placed on the modification include:

- a program to monitor and report groundwater inflows to underground workings;
- a program to predict, manage and monitor impacts to groundwater bores on privately-owned land.

Figure 1: EP / SMP Area 4 Location Diagram



2 HYDROGEOLOGY

2.1 OVERVIEW OF THE MAIN HYDROGEOLOGICAL UNITS

Two distinct aquifer systems occur within or near the project area:

- A fractured rock aquifer system in the coal measures, with groundwater flow mainly in the coal seams; and
- A shallow granular aquifer system in the unconsolidated alluvium.

In the Abel Underground Mine area, permeability is generally highest in the coal seams and in areas where there is significant fracturing or faulting. However, overall the coal measures have a low inherent permeability. The interbedded sandstones and siltstones are of lower permeability and offer very limited inter-granular porosity and little secondary permeability and storage in joints.

Groundwater is also found to occur in the alluvial overburden across the footprint of the Abel underground mine. However, this is limited to thin cover within ephemeral streams such as:

- Four Mile Creek, plus tributaries of
- Weakleys Flat Creek
- Viney Creek
- Buttai Creek
- Bluegum Creek

In Area 4, only Four Mile Creek is of significance.

Groundwater flow within the coal measures is controlled to a large degree by regional topography, with recharge occurring in areas of elevated terrain and then slow movement down-dip or along strike to areas of lower topography. There is considered to be limited hydraulic connectivity between the alluvium associated with these creeks and the coal measures.

There is considered to be a component of lateral flow in the coal measures out of the project area over the Southern and Eastern boundaries.

Groundwater levels in the near surface material, which includes alluvium/colluvium and weathered bedrock, show a much closer relationship to the local topography. While groundwater levels in the deeper coal measures are not influenced by local topography, the surficial groundwater levels are locally influenced.

Groundwater level contours for the Donaldson Seam show an overall pattern of flow to the East, South and West from a central ridge which extends southwards from the Donaldson Open Cut Mine. The flow pattern is largely independent of the local topography. The contours are also influenced from dewatering in the Donaldson Open Cut Mine area and more recently with the mining activities within the underground mine in SMP Areas 1, 2 and 3.

Groundwater flow within the deeper coal measures is therefore believed to be more regionally controlled, whereas flow within the near-surface material is subject to local topographic influences. However, groundwater within geological structures such as joint and thrust fault structures have been encountered, specifically within SMP Area 1 with elevated groundwater inflows occurring to underground workings on intersection.

2.2 RECHARGE AND DISCHARGE

Rainfall recharge occurs to the coal seams where they outcrop or sub crop at shallow depths immediately to the north of Abel Underground Mine and to the limited alluvial aquifers which are associated with the main drainage pathways of the creeks.
The coal seams, where covered by overburden, are recharged mainly by flow along the bedding from elevated areas where the beds are exposed in outcrop, with minimal downward percolation through the overburden. After reaching the water table, flow is predominantly down-gradient along the more permeable horizons, but also with a component of continuing downward flow to recharge underlying coal seam aquifers.

Groundwater discharge occurs through evaporation, flow and through baseflow contributions to creeks where the water table intersects the land surface. Groundwater seepage to the underground mine also accounts for groundwater from coal seam aquifers and overlying strata. There is almost no existing groundwater abstraction in the Abel Underground Mine area other than for coal mine dewatering.

2.3 GROUNDWATER QUALITY

The quality of groundwater sampled from within the Abel Underground Mine area is highly variable. Historically, total dissolved solids (TDS) measured within the groundwater monitoring network has ranged from less than 518 mg/L to 16,000 mg/L. The highest salinities reported from the surficial groundwater (i.e. the weathered Permian/alluvium-colluvium). The lowest reported salinity of 518 mg/L was from the Donaldson Seam near sub crop. The monitoring network at Abel Underground Mine has shown measured salinity to be variable within the Permian Coal measures. Recent monitoring of groundwater inflow from within Area 1 and 2 indicated that groundwater entering the underground mine ranges from 2225 – 11000 µS/cm.

2.4 GROUNDWATER AND SURFACE WATER INTERACTION

There is believed to be limited interaction between the surface drainage system (i.e. creeks) and the deeper groundwater within the coal measures. The shallow groundwater found within unconsolidated alluvium associated with the creeks is limited in nature due to the unconsolidated soils being confined to the narrow alignments of the various creeks. There is expected to be some interchange of water between the creek-beds and the shallow weathered bedrock beneath. These localised occurrences of surficial groundwater do not represent a significant or regionally extensive aquifer system.

2.5 GROUNDWATER DEPENDENT ECOSYSTEMS

No Groundwater Dependent Ecosystems have been identified in the EP / SMP Area 4.

3 POTENTIAL IMPACTS DURING EP / SMP AREA 4

3.1 LOSS OF A THE GROUNDWATER RESOURCE

Groundwater inflows to the mine during operations will be managed using the existing processing and mine water management system. Because of the shallow depths of cover over the Area 4 workings, there is a risk that connective cracking could provide a direct link between the underground mine and surface.

Subsidence may also cause a connection with sub-surface geological structures which contain stored groundwater in volumes which could cause short term elevated inflow rates. This has previously occurred in a number of locations.

In Panel 3 and Panel 7 of Area 1, elevated inflows occurred due to intersection of fracture networks and these elevated flow rates lasted for a short period until storage was depleted. The structure intersected in Panel 3 was interpreted as a thrust fault which did not propagate into the Donaldson Seam. The Panel 7 inflow event being more persistent and assessed to be the result of interconnection of storage associated with an inferred thrust fault to the East of Panel 7.

A similar event occurred in Panel 19 in Area 2 and more recently in the West Mains development in Area 3. In each case the elevated inflow rate peaks were short and inflow water quality having elevated salinity levels indicating that the groundwater entering the mine were not sourced from surface water features.

3.2 DEPRESSURISATION OF AQUIFERS DUE TO MINING ACTIVITIES GREATER THAN PREDICTED

Groundwater levels have been predicted to be lowered to extraction levels during mining activities. To date, mining activities within Area, 1 Area 2 and Area 3 have caused a drawdown cone in line with expectations provided by predictive modelling results and confirming that the low permeabilities of coal measure stratigraphy limits the lateral propagation of drawdown impacts.

Mining activities in Area 1, Area 2 and more recently Area 3 have partially caused depressurisation in Area 4 and the progression of mine development and extraction within Area 4 will extend to drawdown further to the west and reduce groundwater pressures within the Donaldson Seam to mining levels across the footprint of EP / SMP Area 4.

Given the experience of mining activities to date and results of ongoing monitoring, it is unlikely that lateral propagation of depressurisation, greater than that predicted will occur.

3.3 ELEVATED SALINITY IN GROUNDWATER INFLOWS THROUGH MINE WORKINGS

The cover depth, mining levels and overburden stratigraphy encountered in Area 4 are very similar to that which has occurred in Areas 1, 2 and 3. Therefore, groundwater salinities in Area 4 are anticipated to be similar in nature.

3.4 MINE INFLOW

A mine inflow rate substantially higher than predicted by the modelling may indicate greater impacts on near-surface groundwater and / or the wetland environments. The inflow rate has been predicted to increase progressively from 0.3 ML/d in Year 1 to a maximum rate of 1.9 ML/d in 2019 as shown in Table 1.

No significant increases to inflows which have been predicted are anticipated with mining in EP / SMP Area 4 due to experience gained in similar geological conditions as currently being undertaken in SMP Area2 and SMP Area 3.

Table 1: Predicted Mine Inflows

Mine Year	ML/d	ML/Year
2010	0	0
2011	0.3	100
2012	1.0	350
2013	1.6	600
2014	2.2	800
2015	3.3	1200
2016	4.8	1750
2017	6.6	2400
2018	4.4	1600
2019	3.8	1400
2020	5.2	1900
2021	3.7	1350
2022	2.2	800
2023	2.7	1000
2024	2.1	750
2025	2.2	800
2026	1.9	700
2027	1.5	550
2028	1.0	350
2029	0.8	300
2030	0.0	0

3.5 IMPACTS TO GROUNDWATER BORES ON PRIVATELY-OWNED LAND

The majority of the bores located within 5km of the Abel Underground Mine footprint are monitoring or test bores, predominantly associated with monitoring the current and future impacts of mining activities within the area. Stock/domestic bore GW051353 is associated with the Abel Underground Mine.

Of the bores not associated with Donaldson mining operations, two bores (GW058760 and GW0061307) are located to the North of Donaldson Open Cut Mine and to the North of the Newcastle Coal Measures sub-crop. This location is stratigraphically higher than the Modification and outside the sub-crop of the Donaldson Seam. Irrigation bores GW053411 and GW053412 are located within the down gradient section.

Hence no privately owned bores are predicted to be impacted upon so long as drawdowns resulting from mining operations are within the predicted range.

4 PROPOSED MONITORING

The groundwater monitoring programs in place have been operating on the Abel project site since September 2005 and at the Donaldson mine since June 2000. It is proposed that the monitoring network be continuously upgraded with additional bores as the project footprint expands.

Initially, all available piezometers available have been monitored since the networks evolution in 2000. However review of monitoring requirements has been undertaken routinely following AERM requirements. A number of older monitoring sites have been removed over time as the open cut has been exhausted and additional bores added to the network as mining within the underground environment develops.

The groundwater monitoring program includes:

- Monthly measurement of water levels in a representative network of piezometers.
- Quarterly sampling of all standpipe piezometers, for laboratory analysis of electrical conductivity (EC), total dissolved solids (TDS) and pH.
- Annual collection of water samples from all standpipe piezometers for laboratory analysis of a broader suite of parameters
    - Physical properties (EC, TDS and pH)
    - Major cations and anions (Ca, Mg, Na, K, Cl, SO_4, HCO_3 and CO_3)
    - Nutrients
    - Dissolved metals.
- Weekly measurement of the volume of mine water pumped from the underground workings. Separate inflow rates should be monitored if two or more separate mining areas are active at any time.
- Weekly measurement on site of the EC, TDS and pH of the mine water pumped from the underground workings.
- Periodic / opportunistic measurement underground of the EC, TDS and pH of the mine water during any short term elevated inflow events encountered.

The monitoring frequency and parameters for monitoring are listed in Table 1. The monitoring bore network for the Abel Underground Mine is detailed in Table 2.

Key bores monitoring impacts of EP / SMP Area 4 extraction include:

- C078 – Donaldson Seam / Weathered Permian Overburden
- C080 – Donaldson Seam
- DPZ6 – Upper and Lower Donaldson Seams
- DPZ12 – Upper Donaldson Seam Overburden

C078 and C080 are vibrating wire piezometers with transducers within the upper Donaldson Seam. Both show depressurisation resulting from earlier mining activities. C078 (Figure 2) shows lower of water pressures in line with prediction occurring as a result of mining in SMP Areas 1, 2 and 3. C080 (figure 3) shows mining related depressurisation in line with predictions resulting from mining activities in SMP Area 3 within the Donaldson Seam with no observed impact seen at shallower levels at this location.

DP76 and DPZ12 are standpipe piezometers with DPZ 6 screened at shallow depths within the Donaldson Seam near sub crop and DPZ 12 in Upper Donaldson Seam Overburden east of EP / SMP Area 4. Historically, these two piezometers have shown erratic water levels. However within the past 12 months, water levels have remained relatively stable in these two monitoring bores. Figure 4 shows a selection of hydrographs from Abel Underground and Donaldson Open Cut monitoring areas.

Figure 2: Hydrograph for C078

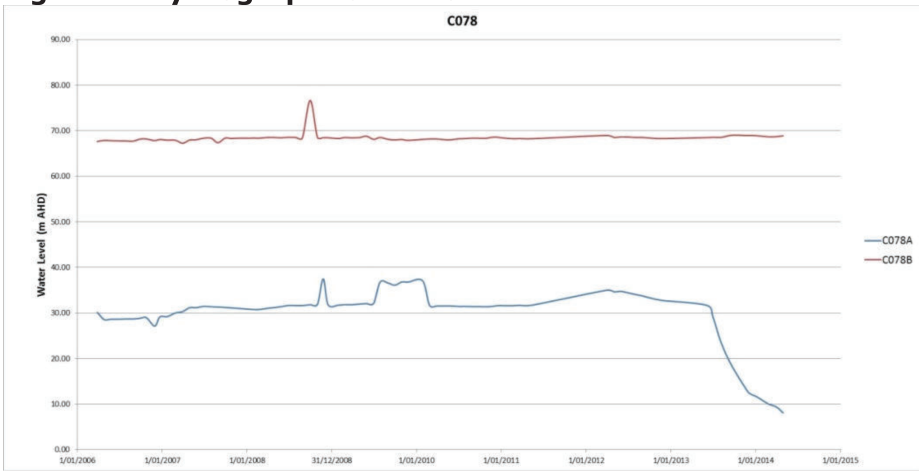


Figure 3: Hydrograph for C080

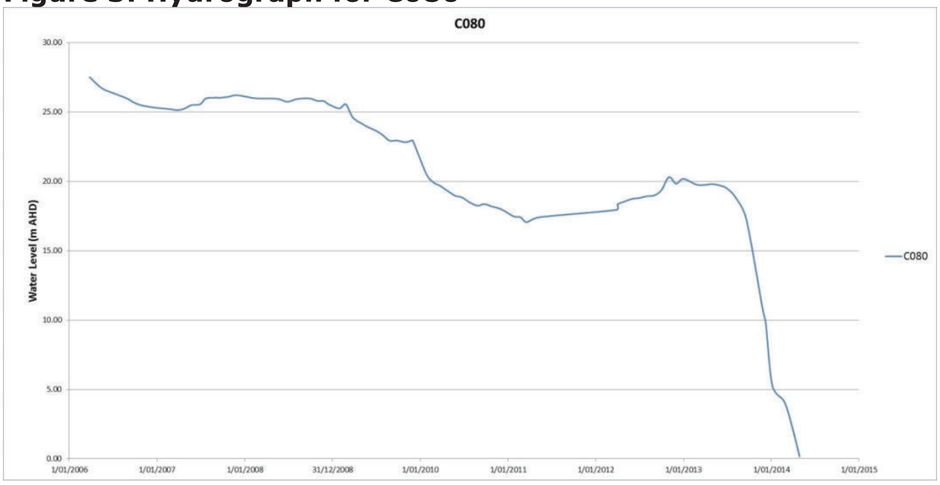


Figure 4: Selected Donaldson and Abel Standpipe Hydrographs

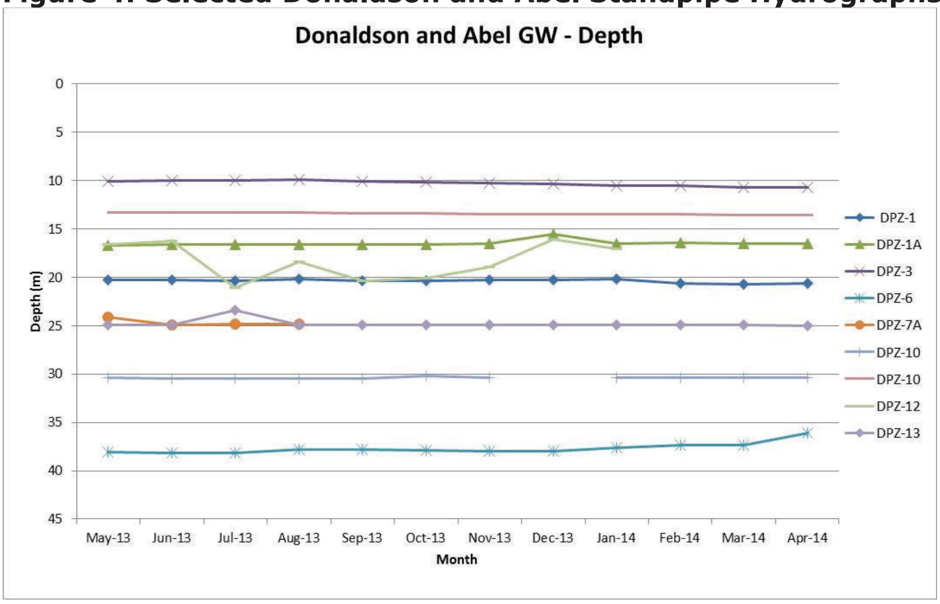


Table 2: Monitoring Frequency

Monitoring	Frequency	Analysis Suite	Location
Groundwater Quality	Monthly	Field (GW Level, pH, EC, Temp, Odour, Colour), Lab (pH, EC, TSS, TDS, Sulphate)	Reg DPZ-1, DPZ-1A, DPZ-3, DPZ-6, DPZ-8, DPZ-10, DPZ-13, DPZ-14A, DPZ-16A, FMCPZ-2, DPZ-17, DPZ-20, JRD1, JRD2.
	Quarterly (January, April, July, October)	Field (GW Level, pH, EC, Temp, Odour, Colour), Lab (pH, EC, TDS, TSS, Alkalinity, Sulphate, Chloride, Major Cations [Ca, Mg, Na, K], Total Metals [Al, As, Ba, Cd, Cr, Co, Cu, Pb, Mn, Se, Zn, Fe]	
Groundwater Levels	Monthly	Standpipe Piezometers	DPZ-1, DPZ-1A, DPZ-3, DPZ-6, DPZ-8, DPZ-10, DPZ-13, DPZ-14A, DPZ-16A, FMCPZ-2, DPZ-17, DPZ-20, JRD1, JRD2C284, TA24, TA32, TA41, TA28,
		Vibrating Wire Piezometers	B005, B002A, B029, B017, B031, B030, C140, C133, C138, C093, C078, C080, C092, C063, C148, C223, C072, C123, C082, C081, C095.
Mine Inflows	Weekly	Rate	Portal Meters
	Weekly	Field (pH, EC, Temp, Odour, Colour)	Portal Meters
	Quarterly (January, April, July, October)	Lab (pH, EC, TDS, TSS, Alkalinity, Sulphate, Chloride, Major Cations [Ca, Mg, Na, K], Total Metals [Al, As, Ba, Cd, Cr, Co, Cu, Pb, Mn, Se, Zn, Fe]	Portal Meters

Table 3: Groundwater Monitoring Network

Piezometer	MGA Coordinates		Surface RL (mAHD)	Depth	Screen / Vibrating Wire Piezometer	Water Level			Aquifer Formation	Status
	E	N		(m)	(m)	Date	m BGL	m AHD		
CO62A	370143	6366248	36	157	124-118	27/03/2006	11.4	24.6	Donaldson Seam	Active
CO62B	370143	6366248	36	157	87-81	27/03/2006	4.2	31.8	Overburden	Active
CO63A	372109	6366193	19	255	197	27/03/2006	27	-8	Donaldson Seam	Active
CO63B	372109	6366193	19	255	130	27/03/2006	24.9	-5.9	Overburden	Active
CO72	369927	6362562	63	318	264	27/03/2006	44.3	18.7	Donaldson Seam	Active
CO72A	369919	6362569	63		168	23/03/2006	41.3	21.7	Overburden	Active
CO72B	369911	6362570	63		45-42	27/03/2006	13	50	Alluvium/weathered Permian	Active
CO78A	367140	6367054	77	101	99-96 and	26/04/2006	48.6	28.4	Donaldson Seam	Active
CO78B	367140	6367054	77	24	24-18	28/03/2006	9.5	67.5	Alluvium/weathered Permian	Active
CO80	368040	6365176	177	300	280	27/03/2006	148.4	28.6	Donaldson Seam	Active
CO81A	369992	6364001	2.3	225	149.7	27/03/2006	-23.9	26	Donaldson Seam	Active
CO81B	369992	6364001	2.3	20	20-14	27/03/2006	0.3	2	Alluvium/weathered Permian	Active
CO82	370319	6364647	34	20	20-14	27/03/2006	15.3	18.7	Alluvium/weathered Permian	Active
C087	367187	6367079	74	18.3	18.3-12.3	26/04/2006	10.5	63.5	Alluvium/weathered Permian	Active
C123A	366288	6364703	56.1	267.4	229	28/04/2008		-8.1	Lower Donaldson Seam	Active
C123B	366288	6364703	56.1	267.4	207	28/04/2008		-2.5	Upper Donaldson Seam	Active
C123C	366288	6364703	56.1	267.4	162	28/04/2008		31.4	Beresfield Seam	Active
C123D	366288	6364703	56.1	267.4	148	28/04/2008		21.9	Upper Buttai Seam	Active

Piezometer	MGA Coordinates		Surface RL (mAHD)	Depth	Screen / Vibrating Wire Piezometer	Water Level			Aquifer Formation	Status
	E	N		(m)	(m)	Date	m BGL	m AHD		
C123E	366288	6364703	56.1	267.4	78	26/05/2008		36	Sandgate-Donaldson Interburden	Active
C123F	366288	6364703	56.1	267.4	29	28/04/2008		47.4	Fassifern-West Borehole	Active
C138A	364964	6367034	29.2	332	136	30/10/2008		-10.3	Ashtonfield Seam	Active
C138B	364964	6367034	29.2	332	142	30/10/2008		-12.5	Big Ben-Ashtonfield	Active
C138C	364964	6367034	29.2	332	163	30/10/2008		-11.5	Big Ben Seam	Active
C138D	364964	6367034	29.2	332	113	30/10/2008		-7.7	Donaldson Seam	Active
C138E	364964	6367034	29.2	332	75	30/10/2008		7.8	Sandgate-Donaldson Interburden	Active
C141A	363873	6364370	30.3	303	282	24/11/2008		9.9	Ashtonfield Seam	Active
C141B	363873	6364370	30.3	303	267	29/10/2008		9.9	Big Ben Seam	Active
C141C	363873	6364370	30.3	303	150	29/10/2008		13.5	Donaldson Seam	Active
C141D	363873	6364370	30.3	303	100	29/10/2008		19.7	Sandgate-Donaldson Interburden	Active
C141E	363873	6364370	30.3	303	30	29/10/2008		19.7	Sandgate Seam	Active
C148A	362443	6364501	22.2	243.3	237	25/02/2009		18.5	Big Ben-Ashtonfield	Active
C148B	362443	6364501	22.2	243.3	200	25/02/2009		19.1	Big Ben Seam	Active
C148C	362443	6364501	22.2	243.3	125	25/02/2009		19.6	Sandgate-Donaldson Interburden	Active
C148D	362443	6364501	22.2	243.3	50	25/02/2009		20.5	West Borehole Seam	Active
C223A	365530	6364594	164.8	294.81	350	26/02/2010		9.2	Lower Donaldson Seam	Active
C223B	365530	6364594	164.8	294.81	325	26/02/2010		5.2	Upper Donaldson Seam	Active
C223C	365530	6364594	164.8	394.81	242	26/02/2010		16.2	Buttai Seam	Active
C223D	365530	6364594	164.8	394.81	160	26/02/2010		30.4	Sandgate Seam	Active
C223E	365530	6364594	164.8	394.81	125	26/02/2010		40.7	West Bore hole	Active

Piezometer	MGA Coordinates		Surface RL (mAHD)	Depth	Screen / Vibrating Wire Piezometer	Water Level			Aquifer Formation	Status
	E	N		(m)	(m)	Date	m BGL	m AHD		
C257(75m)	370030	6366642	41.6	122	75	17/08/2010		12	Sandgate-Interburden	Active
C257(55m)	370030	6366642	41.6	122	55	17/08/2010		19.1	Sandgate-Interburden	Active
C257(35m)	370030	6366642	41.6	122	35	17/08/2010		22	Donaldson Seam	Active
C262A	370208	6367201	33.4	100	70	17/08/2010		-1	Donaldson Seam	Active
C262B	370208	6367201	33.4	100	50	17/08/2010		12.5	Sandgate-Interburden	Active
C262C	370208	6367201	33.4	100	30	17/08/2010		24.1	Sandgate-Interburden	Active
DPZ2	371847	6370120	22.3	30	15.8-27.8	16/12/2004	15.1	7.2	Beresfield Seam	Active
DPZ3	368774	6368609	49.1	30	6.8-18.8	17/08/2005	12.4	36.7	Undifferentiated coal measures below Lower	Active
DPZ5	371367	6368780	12.8	24	43252	17/08/2005	6.83	5.97	Undifferentiated coal measures above Donaldson	Active
DPZ6			57.7	43	26.7-42.5	14/08/2002	13.64	31.02	Upper and Lower Donaldson Seams	Not read - unreliable
DPZ7A	368848	6367641	55.4	18	12.9-16.9	11/07/2001	16.9	38.5	Overburden above Upper Donaldson	Not read since 2001
DPZ7B	368848	6367641	55.4	41	22.9-34.9	17/08/2005	23.5	31.9	Lower Donaldson	Active
DPZ8	369375	6368074	51.8	33	22.2-32.2	17/08/2005	25.3	26.5	Lower Donaldson and Big Ben Seams	Active
DPZ9	369848	6368017	36.4	40	12.5-36.5	17/08/2005	32.1	4.2	Upper and Lower Donaldson and Big Ben Seams	Active
DPZ10	371002	6368464	19.8	30	11.8-29.8	17/08/2005	13.8	6	Beresfield Seam	Active
DPZ12	369115	6366415	59.5	24	43252	17/08/2005	16.8	42.7	Overburden above Upper Donaldson	Active – erratic readings
DPZ13	371221	6367558	21.5	30	18-30	17/08/2005	7.3	14.2	Overburden above Upper Donaldson	Active
DPZ17-24m						13/06/2002	15.9	-0.6		Not read since 2002
DPZ17-38m						13/06/2002	15.9	-0.6		Not read since 2002
DPZ17-62m						17/08/2005	18.3	-3		Active
DPZ20A	370541	6368439	20.1	51	11.5-17.5	23/05/2006	11.1	9	Surficial aquifer – creek bed level	Active

Piezometer	MGA Coordinates		Surface RL (mAHD)	Depth	Screen / Vibrating Wire Piezometer	Water Level			Aquifer Formation	Status
	E	N		(m)	(m)	Date	m BGL	m AHD		
DPZ20B	370540	6368439	20.1	51	44	23/05/2006	32.2	-12	Big Ben Seam	Active

5 TRIGGER ACTION RESPONSE PLAN (TARP)

The Trigger Action Response Plan (TARP) has been developed to focus upon appropriate trigger and response actions for mitigation of impacts to natural environment as a result of the coal extraction.

Monitoring serves to provide advice of changes to groundwater levels or quality and also of subsidence impacts that occur as predicted or to raise alert that an abnormal condition relating to coal extraction has developed. Each program has established triggers used to indicate levels of impact and an appropriate response. The fundamental means of determining the magnitude of any impact and the need for further monitoring and/or remedial actions is based upon the Trigger Action Response Plan documented in Table 4.

The TARP has been designed to allow quick reference to risks of impact from mining to environmental aspects identified within the mining area and surrounds.

The contingent measures are proposed to ensure the timely and adequate management of impacts outside of predicted levels. Appropriately qualified hydrogeologist / hydrologist would be engaged to undertake investigations. The following issues are to be addressed within response reporting:

- Scope of the study.
- Aims and objectives.
- Analysis of trends.
- Assessment of any impacts against prediction.
- Cause analysis of any change or impact.
- Options for management and mitigation.
- Assessment for the need for contingent measures.
- Any recommended changes to this plan.
- Appropriate consultation.

A Site specific mitigation/action plans following a review will include:

- A description of the impact to be managed.
- Results of the Hydrogeologist / hydrologist investigations.
- Specific actions required to mitigate/manage.
- Timeframes for implementation.
- Roles and responsibilities.
- Identification of and gaining appropriate approvals from landholders and government agencies.
- Consultation and communication plan.

Table 4: Trigger Action Response Plan

Aspect	Parameter	Frequency	Purpose	Trigger	Action	Responsibility	Timing	Purpose
Groundwater monitoring	Groundwater level	Overburden: Monthly (manual) Permian: Monthly (manual)	To provide baseline water level data and to identify any water level impacts	Overburden: An additional drawdown of 5m relative to the predicted drawdown in the near surface groundwater levels, which is not attributed to climatic conditions Coal Measures: Groundwater drawdown outside of predicted drawdown predictions	Repeat water level monitoring to confirm. Refer the matter to an independent hydrogeologist for review	Environmental Officer	Inform relevant agencies within 30 days. Investigation initiated within 7 days.	Inform agencies of baseline assessment and monitoring. Identify, investigate and report on impacts to groundwater levels.
	Groundwater quality	Quarterly: pH, EC, TDS Biannual: Cations, Anions, Nutrients & Dissolved metals	To provide baseline water quality data and to identify any water quality impacts	An observed increase in salinity by more than 25% outside the max baseline range or other parameter in excess of operational mining conditions, sustained over a consecutive 6 month period	Repeat groundwater sampling to confirm. Refer the matter to an independent hydrogeologist for review	Environmental Officer	Inform relevant agencies within 30 days. Investigation initiated within 7 days	Inform agencies of baseline assessment and monitoring. Identify, investigate and report on impacts to groundwater quality.
Hydraulic connection with near surface groundwaters and baseflow impacts	Groundwater level	Overburden:), Monthly (manual)	To identify any base flow impacts to 4 Mile Creek or connected Overburden	Overburden: An additional drawdown of 5m relative to the predicted drawdown in the near surface groundwater levels , which is not attributed to climatic conditions Consistent trend toward water level trigger as measured over time (using at least 3 months data. Coal Measures: Nil	Repeat water level monitoring to confirm. Refer the matter to an independent hydrogeologist for review	Environmental Officer	Inform relevant agencies within 30 days. Investigation initiated within 7 days	Ensure adequate baseflow are maintained to 4 Mile Creek Creek
	Groundwater quality	Quarterly: pH, EC, TDS	Identify any water quality impacts to Overburden due to	An observed increase in salinity by more than 25% outside the max baseline	Repeat groundwater sampling to confirm. Refer	Environmental Officer	Inform relevant agencies within 30 days.	Identify, investigate and report on water quality impacts to

Aspect	Parameter	Frequency	Purpose	Trigger	Action	Responsibility	Timing	Purpose
		Yearly: Cations, Anions, Nutrients & Dissolved metals	mining (including post mining)	range or other parameter in excess of pre mining conditions sustained over a consecutive 6 month period	the matter to an independent hydrogeologist for review		Investigation initiated within 7 days	near surface groundwater associated with 4 Mile Creek
Mine inflows	Flow rate	Daily (when pumping)	Identify unexpected high mine inflows and determine whether this will impact on near-surface groundwater	An observed inflow rate 100% in excess of the predicted inflow rate at any stage during the mine life sustained for 3 consecutive months	Refer the matter to an independent hydrogeologist for review	Environmental Officer	Inform relevant agencies within 30 days. Investigation initiated within 7 days	Identify, investigate and report on drawdown impacts to existing users and creeks
	Water quality	Weekly: pH, EC, TDS Quarterly: Cations, Anions, Nutrients & Dissolved metals	Determine whether a new source of surface water or near surface groundwater may have been induced to inflow into the mine	An observed increase or decrease in salinity by more than 25 percent outside normal operating values sustained over a consecutive 6 month period	Repeat water quality sampling to confirm. Refer the matter to an independent hydrogeologist for review	Environmental Officer	Inform relevant agencies within 30 days. Investigation initiated within 7 days	Identify, investigate and report on water quality impacts and determine whether a new source of inflows has occurred

Aspect	Parameter	Frequency	Purpose	Trigger	Action	Responsibility	Timing	Purpose
Licenced users	Groundwater level	Quarterly	Monitoring potential water level impacts to existing registered bores	An additional drawdown of 2m relative to the predicted drawdown	Repeat water level sampling to confirm. Refer the matter to an independent hydrogeologist for review Where impacts are determined to be the result of Abel Underground mine operations. Inform landholders with adjacent bores and DPI/NoW of preliminary Investigation outcomes. Undertake a detailed investigation and assess possible mitigation measures in consultation with the landowner and DPI/NoW If deemed necessary prepare and implement a site mitigation/action plan to the satisfaction of DPI, in consultation with the landowner DPI and NoW.	Environmental Officer	Inform relevant agencies within 30 days. Investigation initiated within 7 days.	Ensure water supply is maintained
	Groundwater quality	Quarterly: pH, EC, TDS	Monitoring potential water quality impacts to existing registered bores	An observed decrease in water quality by more than 25 percent outside baseline values over a consecutive 6month period	Repeat water quality sampling to confirm. Refer the matter to an independent hydrogeologist for review	Environmental Officer	Inform relevant agencies within 7 days. Investigation initiated within 1 week	Ensure water quality is maintained

6 REPORTING AND REVIEW

6.1 ANNUAL ENVIRONMENTAL MANAGEMENT REPORT (AEMR)

The AEMR will incorporate a groundwater review prepared by an independent expert to the satisfaction of the New South Wales Office of Water (NOW), which will contain the following;

- A basic statistical analysis (mean, range, variance, standard deviation) of the results for the parameters measured in individual bores and as a subset of the aquifer;
- an interpretation of the water quality results and changes in time for water quality and water levels (supported with graphs and contour plots showing changes in aquifer pressure levels);
- Reporting on the differentiation between shallow and deep aquifers, with interpretation of results;
- (an interpretation and review of the results in relation to cut-off criteria and predictions made in the Modification EA; and
- an interpretation of the water balance identifying the volume and make up of mine pit inflows as compared to Part V licence (required under Part V of the Water Act 1912), and predictions made in the EA or previous AEMR;