SITE WATER BALANCE AND SURFACE WATER IMPACT ASSESSMENT REVIEW

Abel Upgrade Modification

Environmental Assessment

APPENDIX C

Resource Strategies

DONALDSONCOAL

Part of the Yancoal Australia Group

Donaldson Coal

Abel Upgrade Modification

Surface Water Assessment

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1 Background

1.1 Existing Abel Underground Mine

The Abel Underground Mine is an underground coal mining operation located approximately 23 kilometres (km) north-west of the Port of Newcastle, New South Wales (NSW) in the Newcastle Coalfield. The Abel Underground Mine is owned and operated by Donaldson Coal Pty Ltd, a wholly owned subsidiary of Yancoal Australia Limited.

Project Approval (05_0136) for the Abel Underground Mine was granted on 7 June 2007 by the then NSW Minister for Planning pursuant to section 79J of the NSW *Environmental Planning and Assessment Act*, *1979*. The potential environmental impacts of the existing Abel Underground Mine were assessed in the *Abel Underground Mine Part 3A Environmental Assessment* (Part 3A EA).

Project Approval 05_0136 provided for production of up to 4.5 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal using bord and pillar extraction methods.

Also in accordance with Project Approval 05_0136, the Bloomfield Coal Handling and Preparation Plant (CHPP), which is owned and operated by Bloomfield Collieries Pty Ltd, is approved to process up to 6.5 Mtpa ROM coal from the Abel Underground Mine, Bloomfield Colliery, Tasman Underground Mine and Donaldson Open Cut Mine.

1.2 The Modification

The Abel Upgrade Modification (the Modification) would involve the continuation of underground mining within the existing approved area using a combination of longwall and shortwall mining in addition to continued bord and pillar extraction.

The Modification would lead to an increase in ROM coal production of up to 6.1 Mtpa from the Abel Underground Mine. This, and a proposed increase in ROM coal production from the Tasman Underground Mine associated with the Tasman Extension Project, would lead to an increase in the rate of ROM coal processed at the Bloomfield CHPP, and an associated increase in waste material (e.g. tailings) production.

This Surface Water Assessment examines the following:

- The surface water management system and tailings storage required for the Modification; and
- The potential impacts of the changes in mining method associated with the Modification to the flow regime in the creeks that overlie the underground mining area.

1.3 Previous Surface Water Assessment and other Relevant Information

The Surface Water Assessment prepared for the Part 3A EA (Evans & Peck, 2006) concluded that the water management systems for the Abel Underground Mine, Donaldson Open Cut Mine and Bloomfield Colliery (including the Bloomfield CHPP) could be operated in an integrated manner so as to achieve discharge to Four Mile Creek in accordance with the Environment Protection Licence (EPL) for the Bloomfield Colliery (held at the time).

Following Project Approval for the Abel Underground Mine, the following operational changes have occurred which are relevant to the water management system for the Modification:

- A pipeline has been constructed to allow water to be transferred between the Abel/Donaldson water management system and the Bloomfield water management system.
- Bloomfield no longer discharges tailings to old underground workings located beneath the existing open cut operations. Tailings are now disposed of in a tailings dam from which a large proportion of the water used by the CHPP is recycled. As a consequence the estimated 'loss' of approximately 2,500 ML/year of water to the old underground workings no longer occurs.
- At the time of the Part 3A EA, water supply for the Bloomfield CHPP was drawn from surface water from the Bloomfield Colliery open cut operations, supplemented by groundwater extracted from the old mine workings, as approximately 2,500 ML/year was discharged underground with the tailings. The Part 3A EA anticipated that as the groundwater inflows to the Abel Underground Mine increased, this water would be used as a water supply for the Bloomfield CHPP in place of water taken from the old underground workings. As a result of recycling decant water from the tailings dam, the Bloomfield CHPP requires less water from Abel/Donaldson than was predicted in the Part 3A EA.
- Donaldson Coal obtained a variation to its EPL No. 11080 to allow discharge to Four Mile Creek under specific conditions.

This Surface Water Assessment has considered the changes described above, as well as changes due to the proposed changes mining method (and increased ROM production) associated with the Modification together with an increase in the amount of ROM coal received at the Bloomfield CHPP from the Tasman Extension Project.

This Surface Water Assessment makes reference to a number of water storages, open cut mine areas and operational facilities on the Donaldson Coal and Bloomfield Colliery mine lease areas. For reference, **Figure 1.1** is an aerial photograph that shows the locations of the following features that are referenced throughout this report:

- **Water storages:**
  - 'Big Kahuna' (Donaldson);
  - 'Lake Kennerson' and 'Lake Foster' (Bloomfield);
- **Open cut mine pits:**
  - 'East Pit', 'West Pit' and 'Square Pit' (Donaldson);
  - 'S-Cut (North)' and 'S-Cut (South)' (Bloomfield)
- **Bloomfield CHPP and associated facilities:**
  - Bloomfield CHPP and stockpile area;
  - Existing tailings disposal area – U-Cut (North);
  - Proposed extension of the tailings disposal area – U-Cut (South);
  - Rail loop at which coal is loaded onto trains for transport to the Port of Newcastle.

Figure 1.1: Location of Current Water Storage Dams, Tailings Dam and Future Voids

This report adopts the following structure:

- **Section 2** describes the existing inter-related water management systems of the Donaldson Open Cut Mine, Abel Underground Mine and Bloomfield Colliery (including the Bloomfield CHPP) and the interactions between these systems;
- **Section 3** provides an assessment of the future availability of void space for storage of tailings and water, both of which relate to the proposed strategy for management of water for the Modification;
- **Section 4** provides an analysis of the expected runoff and groundwater contributions to the Abel Underground Mine water management system once open-cut mining is completed in the Donaldson 'Square Pit';
- **Section 5** provides details of the expected water usage associated with the Abel Underground Mine which will have priority for use of water pumped from the mine. This usage will help reduce the volume of excess water that needs to be managed;
- **Section 6** describes the facilities and water management regime that are proposed as part of the Modification in order to allow the mine to manage its water in a manner consistent with Donaldson Coal's existing EPLs. This section also provides a detailed water balance analysis for the Modification;

- **Section 7** provides an assessment of the potential impacts of the changes in mining method associated with the Modification on the flow regime in the various creeks that overlie the underground mining area;
- **Section 8** provides an overall assessment of the surface water impacts associated with the Modification compared to the approved mine plan; and finally
- **Section 9** summarises the monitoring and measures that would be implemented to ensure that Modification has minimal impact on the surface water resources of the creeks in the vicinity of the Abel Underground Mine.

2 Existing Surface Water Management

2.1 System Configuration

Figure 2.1 is a schematic diagram that shows the main elements of the three largely separate, but integrated, water management systems for the:

- Abel and Donaldson Mines;
- Bloomfield Colliery; and
- Bloomfield CHPP.

The figure shows the systems as they existed in the middle of 2012 when the Donaldson Open Cut Mine operations in the 'Square Pit' were nearing completion and rehabilitation of the Donaldson Open Cut Mine 'East Pit' was continuing. The Donaldson Open Cut Mine 'West Pit', located adjacent to the Abel Underground Mine portal, was used as a stockpile area for ROM coal from the Abel Underground Mine awaiting haulage to the Bloomfield CHPP.

Mining at the Bloomfield Colliery was occurring in two open cut pits: the 'S-Cut (North)' and the 'S-Cut (South)'.

The main aspects of the water management systems shown in **Figure 2.1** are:

Abel/Donaldson Mines

- Groundwater inflow to the Abel Underground Mine is directed to the main storage ('Big Kahuna', about 400 ML capacity);
- Surface runoff from the Donaldson Open Cut Mine East Pit, West Pit and Square Pit is pumped to Big Kahuna;
- Runoff from the Abel Underground Mine office and workshop area drains to Big Kahuna;
- Water from Big Kahuna is:
  - used for dust suppression on the haul road between the Abel Underground Mine and the Bloomfield CHPP,
  - available for transfer to 'Lake Kennerson' or 'Lake Foster' within the Bloomfield Colliery (subject to Bloomfield Collieries Pty Ltd accepting this additional water);
  - available for discharge to Four Mile Creek (subject to the water in Big Kahuna meeting the required water quality limits and the required prior rainfall to permit discharge in accordance with EPL No. 11080 – see **Section 2.3.1**);
- Water for underground operations in the Abel Underground Mine is sourced from Hunter Water.

Bloomfield Colliery

- Runoff and groundwater inflow to the active mine pits (S-Cut [North] and S-Cut [South]) is pumped to the main water storage (Lake Kennerson [about 200 ML capacity]);
- Water in Lake Kennerson is:
  - Released as required to Lake Foster (about 45 ML capacity) in order to maintain water supply to the Bloomfield CHPP.
  - Used for dust suppression on the haul roads;
  - Released to Four Mile Creek (subject to the water meeting the required water quality limits and the required prior rainfall to permit discharge in accordance with the EPL for the Bloomfield Colliery – see **Section 2.3.2**);

Bloomfield CHPP

- Lake Foster acts as the supply point for water that is recycled through the Bloomfield CHPP. Lake Foster has minimal catchment area and is a 'closed' storage that is not designed to discharge to the environment;
- Fine tailings from the Bloomfield CHPP are discharged into the tailings dam (U-Cut [South]);
- Decant and seepage water from U-Cut is returned to Lake Foster for re-use in the Bloomfield CHPP;
- As necessary to maintain supply to the Bloomfield CHPP, 'top-up' water is released from Lake Kennerson to Lake Foster.

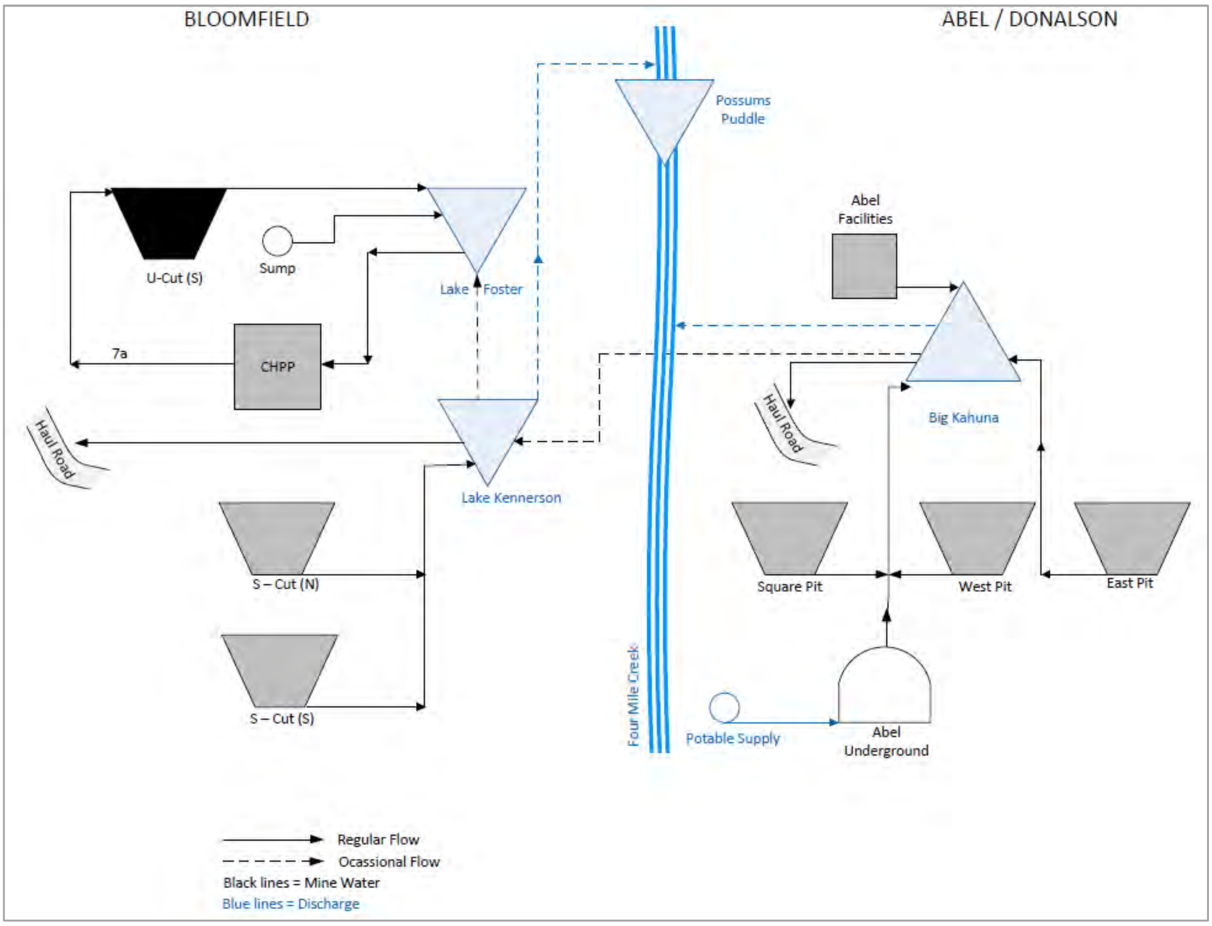

Figure 2.1: Schematic Diagram of the Existing Abel/Donaldson and Bloomfield Water Management Systems

2.2 Water Balance

For the calendar year 2011, **Table 2.1** summaries the estimated water balance of the system depicted in **Figure 2.1**.

Table 2.1: Estimated Water Balance for 2011

Source / Destination	Gains (ML)	Losses (ML)
Big Kahuna		
Groundwater from Abel Underground Mine	420	
Runoff from mine pits and catchments	132	
Runoff from Abel Facilities	15	
Haul road dust suppression		36
Rainfall	56	
Evaporation		72
Transferred to Lake Kennerson		469
Change in Storage over the Year		46
Discharged to Four Mile Creek		0
Balance	**623**	**623**
Lake Kennerson		
Runoff from mine pits and catchments	1,692	
Transferred from Big Kahuna	469	
Haul road dust suppression		108
Rainfall	56	
Evaporation		72
Transferred to Lake Foster		177
Discharged to Four Mile Creek		1,860
Balance	**2,217**	**2,217**
Lake Foster		
Transferred from Lake Kennerson	177	
Rainfall on Lake Foster	17	
Evaporation from Lake Foster		22
Rainfall on U-Cut (South)	320	
Evaporation from U-Cut (South)		412
Retained in Tailings		80
Balance	**514**	**514**

2.3 Environment Protection Licences

Donaldson Coal and the Bloomfield Collieries Pty Ltd each have Environment Protection Licences (EPL) that permit discharge of water to Four Mile Creek under specific water quality and prior rainfall conditions.

2.3.1 Donaldson Coal

Donaldson Coal holds two EPLs:

- #11080 Donaldson Open Cut Mine
- #12856 Abel Underground Mine

For purposes of site water management and discharge, all relevant conditions are contained in EPL 11080 (version 2 December 2011). Discharge to Four Mile Creek is permitted under the following conditions:

- 40 ML over 5 days following 10 mm of rain within 24 hours;
- Maximum salinity 2,000 µS/cm (about 1,250 mg/L);
- pH range 6.0 – 8.0;
- Total suspended solids (TSS) 50 mg/L.

Following the variation to the EPL that allowed licensed discharge, a pipeline was installed from the Big Kahuna to the Bloomfield Colliery with an off-take point where the pipeline crosses Four Mile Creek. The pipeline also allowed water to be discharged to either Lake Kennerson or Lake Foster at Bloomfield. The current pump and pipeline has capacity to discharge about 8 ML/day to Four Mile Creek or transfer at this rate to Bloomfield.

Since the EPL was varied, no discharge has occurred either because the required rainfall conditions had not occurred or the water quality in Big Kahuna was not within the specified limits. **Figure 2.2** shows the results of an analysis to assess the volume of water that could be discharged assuming a maximum daily discharge in line with the limit set by the existing pipeline and pump (8 ML/day for 5 days following 10 mm of rainfall). The analysis, which is based on the long term climate record for Morpeth (adjusted by correlation with the Donaldson record for the period of common record), shows that, in the absence of water quality constraints there would be opportunities to discharge:

- 770 ML in a median year;
- 580 ML in 1 in 10 (10^{th} percentile) dry year;
- 1,040 ML in 1 in 10 (90^{th} percentile) wet year.

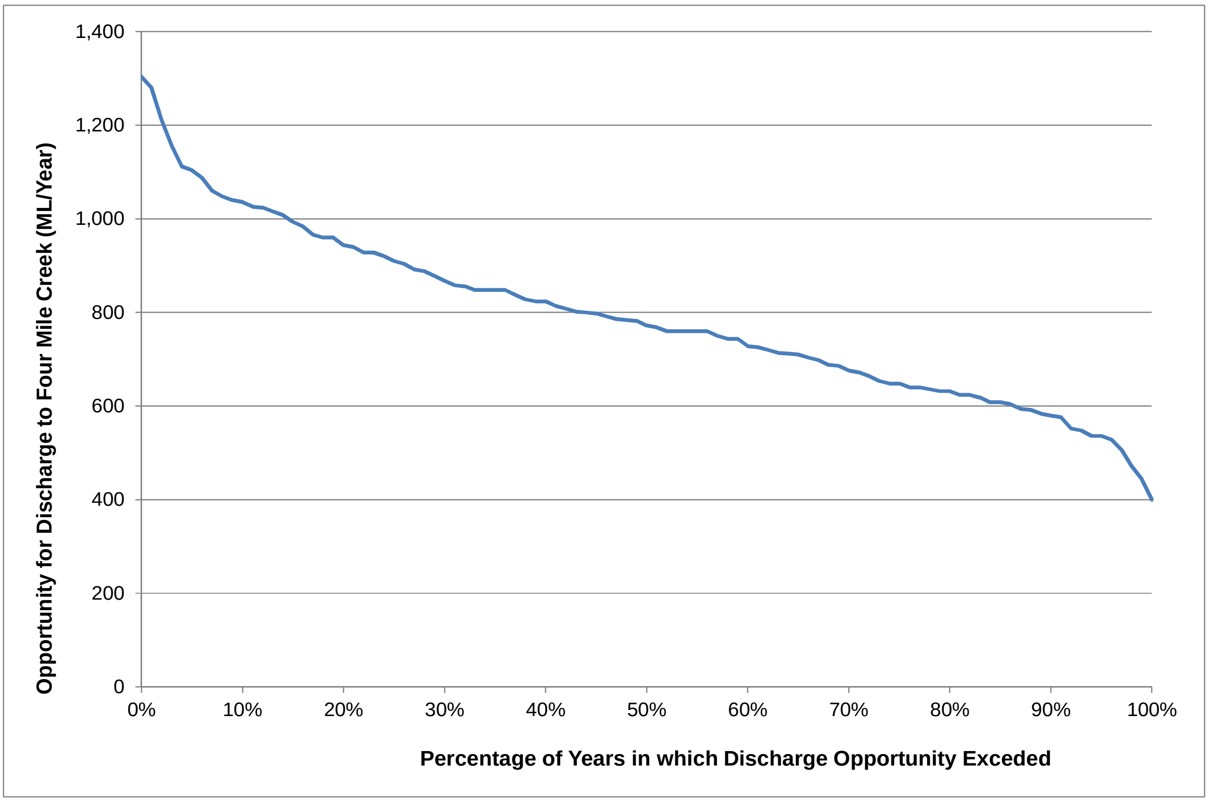

Figure 2.2: Donaldson – Opportunities for Discharge to Four Mile Creek

In practice, it is unlikely that full use would be made of every opportunity to discharge or that the discharge shown in **Figure 2.2** would occur.

2.3.2 Bloomfield Colliery

The EPL for the Bloomfield Colliery (396 – version 2 December 2011) permits discharge of water to Four Mile Creek under the following conditions:

- 40 ML/day under the following wet weather conditions:
  - for 24 hours following 10 mm or more of rainfall in 24 hours in the catchment;
  - for 48 hours following 15 mm or more of rainfall in 24 hours in the catchment; and
  - for 72 hours following 20 mm or more of rainfall in 24 hours in the catchment.
- Maximum salinity 6,000 µS/cm (about 3,750 mg/L);
- pH range 6.5 – 8.5;
- TSS 30 mg/L;
- Filterable iron 1.0 mg/L

Figure 2.3 shows the results of an analysis of Bloomfield's opportunities to discharge - similar to that shown in **Figure 2.2** for Donaldson. The analysis shows that, in the absence of water quality constraints, there would be opportunities to discharge:

- 1,920 ML in a median year;
- 1,350 ML in 1 in 10 (10^{th} percentile) dry year;
- 2,660 ML in 1 in 10 (90^{th} percentile) wet year.

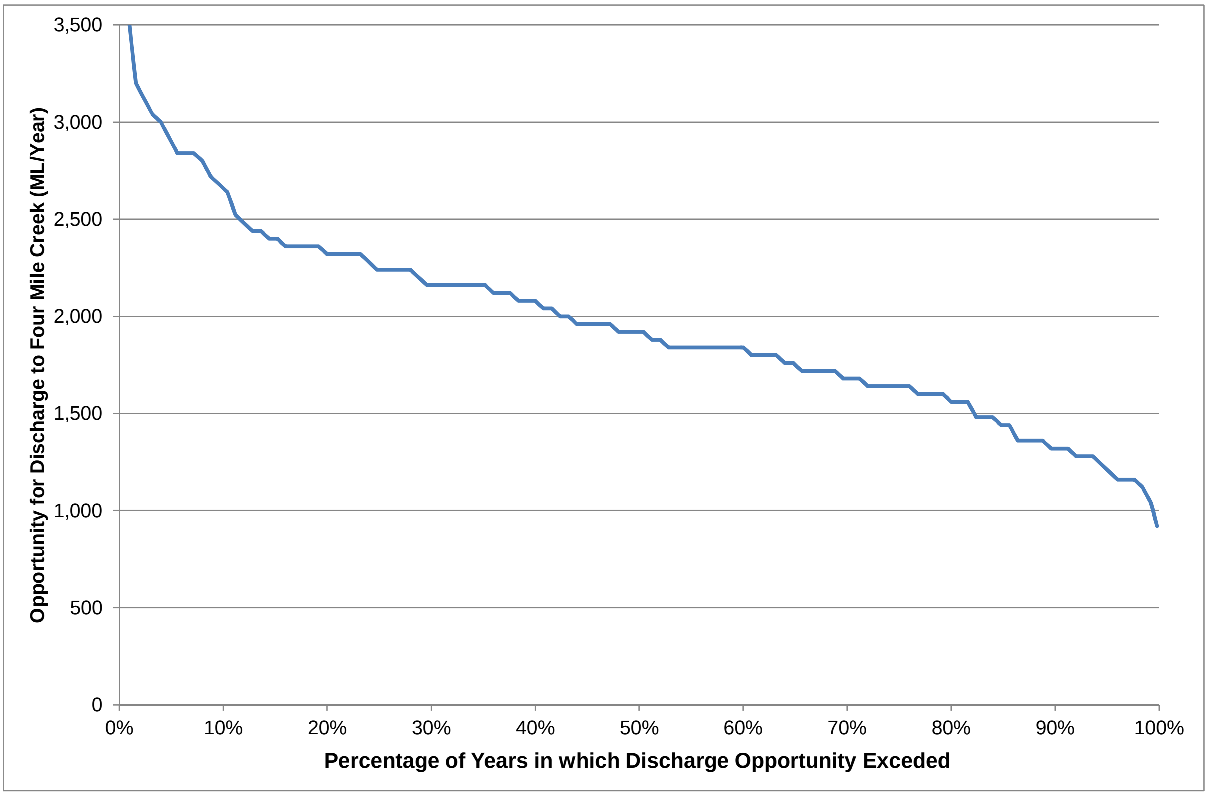

Figure 2.3: Bloomfield – Opportunities for Discharge to Four Mile Creek

Historic records of the actual discharges made by Bloomfield are summarised in **Table 2.2**

Table 2.2: Bloomfield Colliery Discharge to Four Mile Creek

Year	Discharge (ML)	Rainfall (mm)
1999	915	997
2000	2,201	912
2001	1,126	941
2002	680	856
2003	240	701
2004	670	769
2005	229	775
2006	0	663
2007	955	1,150
2008	1,100	1,189
2009	699	943
2010	345	826
2011	1,860	1,181

2.4 Environmental Water Quality and Ecological Monitoring

2.4.1 Monitoring Locations

Since 2000, Donaldson Open Cut Mine has undertaken routine monthly sampling of water in Four Mile Creek at the following locations shown on **Figure 2.4**:

Site EM1: Four Mile Creek at the Donaldson Open Cut Mine upstream boundary (John Renshaw Drive);

Site EM2: Four Mile Creek at the Donaldson Open Cut Mine downstream boundary.

In addition, since 2003, routine monthly water samples have been collected from Four Mile Creek at the New England Highway.

Routine monthly monitoring has also been carried out by Bloomfield Colliery within and around the Bloomfield Colliery site since 1996, including the following locations on Four Mile Creek and its tributaries (shown on **Figure 2.4**) and listed in approximate order from upstream to downstream:

Site WM10 John Renshaw Drive;

Site WM6 Upstream of "Possums Puddle";

Site WM8 Downstream of "Possums Puddle";

Site WM5 Elwells Creek adjacent to the haul road;

Site WM3 Elwells Creek upstream of the junction with Four Mile Creek;

Site WM12 Shamrock Creek upstream of the junction with Four Mile Creek;

Site WM11 Bloomfield Four Mile Workshops (approximately 500 m upstream of the New England Highway).

Other monitoring locations shown on **Figure 2.4** are:

Site WM7 Lake Forester;

Site WM9 Lake Kennerson.

Water quality samples are analysed for a wide variety of parameters including pH, EC, TSS, TDS, plant nutrients, anions, cations and metals. In addition, event based samples of any discharge from Bloomfield Colliery are collected and analysed for EC, pH, TSS and filterable iron, as required by the EPL conditions. On days when discharge occurs a representative grab sample is also taken for analysis from Site WM11, located downstream of the discharge point. Analysis of the historic EC and pH data for the mine discharge water and the water samples downstream (280 samples since 1999) indicates no identifiable correlation between the discharge and the water quality in the creek ($R^2 < 0.03$). This suggests that the pH and EC in Four Mile Creek are affected more by catchment factors than discharge of mine water.

Stream ecology monitoring has also occurred on two occasions per year since November 2000 at the two designated monitoring sites operated by Donaldson Open Cut Mine (EM1 and EM2 shown on **Figure 2.4**). Additional surveys were also conducted in August 2007 and June 2011 at Site EM2 and at a site downstream of the Bloomfield discharge location (approximately the same location as Bloomfield monitoring site WM3). Data collection involved ecological data sampling (diversity, macroinvertebrate indices - AusRivas and SIGNAL), RCE, probe measurements (DO, pH, conductivity, and turbidity), TDS, TSS and alkalinity. Detailed methods are provided in Robyn Tuft & Associates (2007, 2011).

Water quality monitoring results are provided in **Appendix A**.

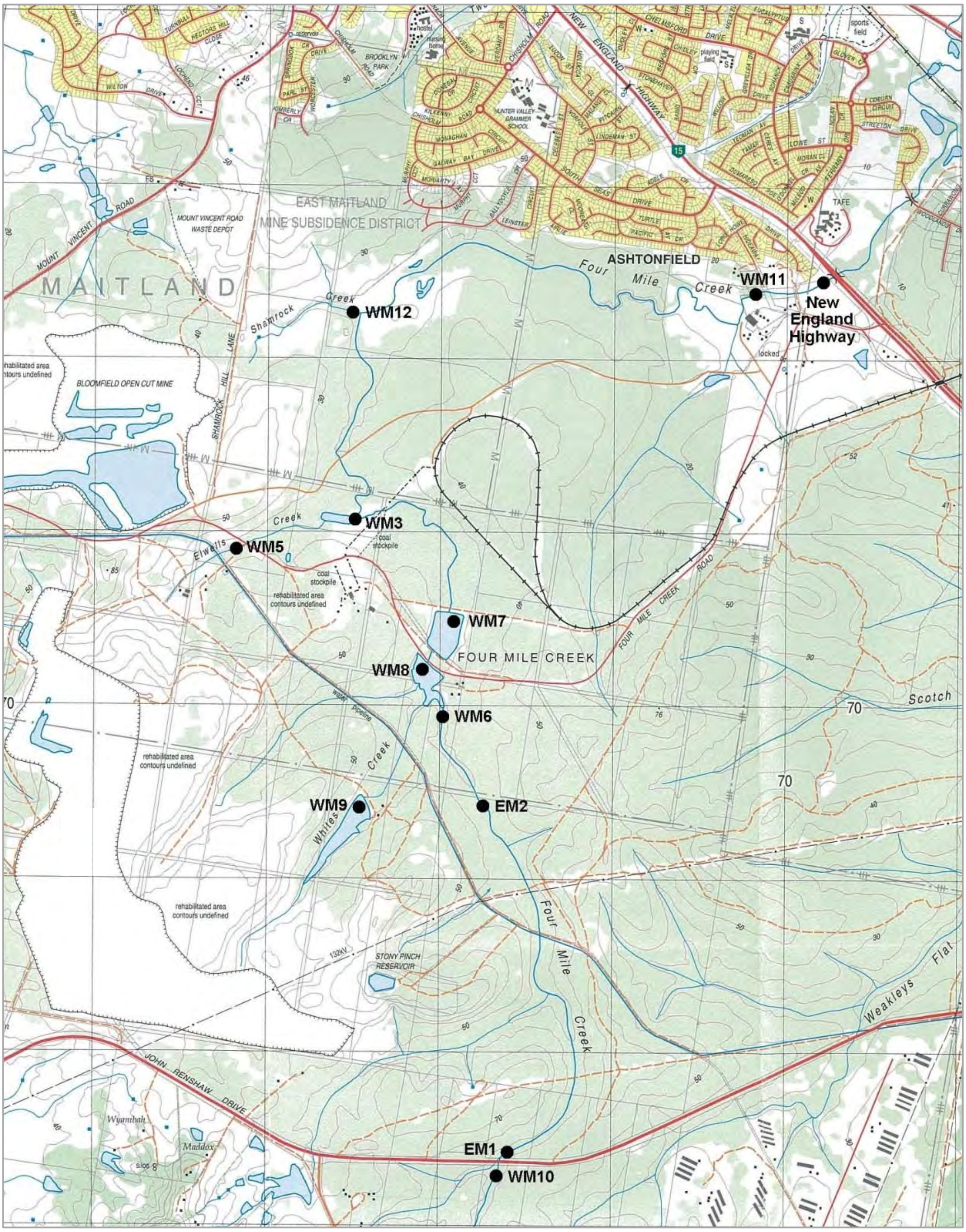

Figure 2.4: Surface Water Monitoring Sites

3 Void Space for Storage of Water and Tailings

Tailings from the Bloomfield CHPP are currently disposed at the existing tailings storage at the Bloomfield U-Cut (North) void. The Bloomfield U-Cut (North) void is nearing capacity, and as such, alternative storages would be required during the Modification.

In addition, groundwater inflows to the Abel Underground Mine are predicted to increase due to the Modification from about 500 ML/year in 2012 to over 2,000 ML/year by the end of 2016 (see **Section 4.3**) before progressively reducing to less than 1,000 ML/year by about 2022. Even if the water quality was suitable for discharge to Four Mile Creek, additional water storage space would be required to retain the groundwater inflow water between opportunities for discharge;

Changes to the existing operations at both the Donaldson Open Cut Mine and Bloomfield Colliery would provide additional storage for tailings from the Bloomfield CHPP and groundwater inflows from the Abel Underground Mine.

In consultation with Bloomfield Collieries Pty Ltd and Donaldson Coal, a number of void spaces have been identified that will become available in the future for storage of tailings or mine water. **Figure** 1.1 shows the location of the existing water storage dams (Big Kahuna, Lake Foster and Lake Kennerson together with the existing tailings storage dam [U-Cut (North)]) and various future void spaces that are listed in **Table 3.1**. The anticipated schedule for various voids space to become available is also set out in **Table 3.1**.

Table 3.1: Anticipated Availability of Void Space

Void	Date Available	Volume (m^3 x 1,000)	Cumulative Volume (m3 x 1,000)
Bloomfield : U-Cut (North)	Current	2,285	2,285
Donaldson Square Pit	Early 2013	2,900	5,185
Bloomfield : U-Cut (South)	2014	1,200	6,385
Bloomfield S-Cut (South)	End 2018	10,000	16,385
Bloomfield S-Cut (North) -	End 2022	10,000+	26,385+
Donaldson Square Pit + 5 m Embankment	Construct if required	Up to 1,000	Optional interim storage options pending availability of S-Cut (South)
Bloomfield S-Cut (South) - Interim	Construct if required	Up to 1,200	

Table 3.1 shows that until the Bloomfield S-Cut (South) becomes available in late 2018, a number of relatively small void spaces will need to be used to meet the requirement for storage of tailings and any excess mine water:

- With the anticipated increase in the rate of coal processing associated with the Modification and the Tasman Extension Project, the existing tailings disposal in U-Cut (North) is expected to be filled by mid-2014;
- The expansion of the tailings disposal area to include the U-Cut (South) area is expected to provide tailings storage (1.2 million cubic metres) which would last an additional 12 months (until mid-2015);
- By the end of 2013 it is anticipated that mining of the Donaldson Square Pit would be completed and active rehabilitation would continue on the Donaldson East Pit with all runoff draining off site

(via sediment basins, as necessary). The Donaldson Square Pit will then become available for storage of water and/or tailings;

- The mine plan for the Bloomfield S-Cut (South) is expected to be able to provide a small area in the south-west corner for storage of tailings or water (1.2 million cubic metres) by 2015. This area is referred to as the 'S-Cut(South) – Interim' storage area;
- By the end of 2018, mining is expected to have completed in the S-Cut (South) which would provide approximately 10 million cubic metres of void space;
- By 2022, mining would be complete in S-Cut (North) which would provide in excess of an additional 10 million cubic metres of void space.

Appendix B contains an assessment of the expected rate of tailings production based on current projections of coal to be processed by the Bloomfield CHPP from the contributing mines (Bloomfield Colliery, Donaldson Open Cut Mine, Tasman Underground Mine [and Tasman Extension Project] and Abel Underground Mine [including the Modification]), the expected timing when various void spaces would become available for storage of tailings and options for providing the required storage volume when required. The preferred strategy in **Appendix B** recognises that the actual volume required for storage of tailings will be dependent on the actual tonnage of ROM processed by the CHPP and the actual proportion of fine tailings. It demonstrates that sufficient storage capacity can be made available when required.

Table 3.2 summarises the expected ROM coal deliveries to the Bloomfield CHPP and the resulting volume of tailings that will require disposal.

Table 3.2: Projected ROM Delivery to Bloomfield CHPP and Required Volume for Tailings Disposal

Year Ending June	ROM Delivery To Bloomfield CHPP (t x 1000)	Fine Tailings Volume	
		Annual (m^3 x 1000)	Cumulative (m^3 x 1000)
2013	5,201	878	878
2014	6,391	1,078	1,956
2015	8,376	1,413	3,370
2016	8,520	1,438	4,807
2017	8,138	1,373	6,181
2018	8,374	1,413	7,594
2019	8,460	1,428	9,021
2020	8,183	1,381	10,402
2021	7,058	1,191	11,593
2022	6,372	1,075	12,669
2023	5,084	858	13,526
2024	3,093	522	14,048
2025	2,920	493	14,541
2026	2,467	416	14,957
2027	2,112	356	15,314
2028	2,406	406	15,720
2029	1,313	222	15,941
2030	241	41	15,982

4 Abel Underground Mine Water Make and Quality

Once active mining of the Donaldson Square Pit is complete in 2013, the major contributions to water make within the Donaldson/Abel Mine site will be:

- Runoff from the Donaldson West Pit coal stockpile area and Abel Underground Mine portal (approximately 28.7 ha) will drain to a sump before being pumped to the Big Kahuna storage;
- Runoff from the Abel Underground Mine workshop and office area (about 2.1 ha) will continue to drain direct to Big Kahuna;
- Groundwater inflow to the Abel Underground Mine underground workings; and
- Runoff within the Donaldson Square Pit may need to be taken into account depending on the way that the pit is used.

In addition to the volume of water generated from these sources, the anticipated salinity is a key factor that will dictate the use way that the water can be used or disposed of. The following sections outline the range of annual flows that can be expected from these various sources and the anticipated water quality.

4.1 West Pit Runoff

Runoff into the West Pit has been estimated using a rainfall:runoff model (AWBM) with parameters that have been selected from published data to represent mine runoff (see **Section 6.4.5** for further details). For this analysis a long term rainfall record has been developed by correlation of the recorded rainfall at the Donaldson office against the long term rainfall record at Morpeth. This record has been utilised to generate a long term daily rainfall record which has then been used to estimate runoff from the Donaldson West Pit which is summarised in **Table 4.1**.

Table 4.1: Statistics for Modelled Annual Runoff from the West Pit

Statistic	ML/year
Average	119
Minimum	27
10^{th} Percentile (Dry)	58
Median	113
90^{th} Percentile (Wet)	188
Maximum	373

Based on monitored water quality in the Donaldson Square Pit (pers. comm. Phil Brown 19/9/2012) the average salinity of runoff into the West Pit is about 2,650 µS/cm (approximately 1,650 mg/L).

4.2 Office and Workshop Runoff

Runoff from the office and workshop area has been estimated using the same climate record as used for runoff estimation for the Donaldson West Pit with parameters in the rainfall:runoff model adjusted to reflect the high proportion of impervious surfaces. **Table 4.2** summarises the annual statistics for runoff from this area.

Table 4.2: Statistics for Modelled Annual Runoff from the Office and Workshop Area

Statistic	ML/year
Average	12
Minimum	4
10th Percentile (Dry)	7
Median	11
90th Percentile (Wet)	18
Maximum	32

Runoff from the office and workshop area is expected to contain sediment and coal dust, but to be low in salinity.

4.3 Abel Underground Mine Groundwater Inflow

As noted in **Section 1**, significant additional groundwater data has been collected since the Part 3A EA was prepared in 2006. These data, together with observations of groundwater inflow have been used to reassess the projected groundwater inflow and to account for the increased rate of mining that will occur with the proposed introduction of longwall and shortwall mining.

Figure 4.1 (after RPS Aquaterra [2012]) shows the predicted groundwater inflow to the Abel Underground Mine (in blue) during the Modification, together with the recent observed inflow (in red). The figure shows predicted groundwater inflow for the 12 months preceding the date at which the flow in plotted. The peak inflow of 2,304 ML is predicted to occur in the year ending 30 June 2016.

Groundwater quality data collected to date indicates that the water extracted from the Abel Underground Mine has averaged about 4,500 µS/cm (2,800 mg/L). This salinity is thought to reflect a significant proportion of relatively fresh inflow associated with two episodes of high inflow (as shown on **Figure 4.1**). Based on available salinity data collected from groundwater bores within the future extraction area, salinity could be as high as 13,000 µS/cm (about 8,100 mg/L). For purposes of this analysis, it has been assumed that the average future groundwater inflow from all sources within the underground mine will be of the order of 8,000 µS/cm (about 5,000 mg/L).

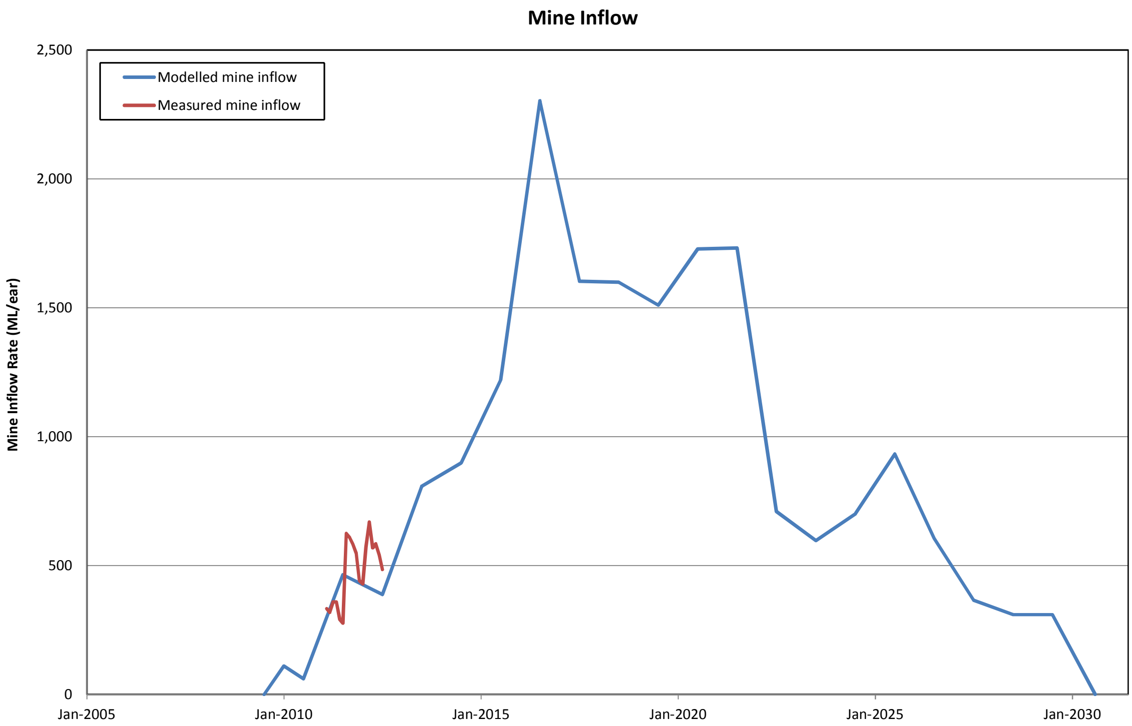

Figure 4.1: 2012 Predicted Groundwater Inflow to the Abel Underground Mine

4.4 Runoff within the Square Pit

There are a number of options for the future use of the Donaldson Square Pit after completion of mining:

- The Donaldson Square Pit could be left as an isolated stand-alone pit which is not utilised for tailings or water storage, in which case a small lake could be expected to develop. The lake would eventually establish a steady state balance between runoff from the catchment area and evaporation from the surface (after accounting for direct rainfall onto the lake);
- The Donaldson Square Pit could be utilised for storage of tailings from the Bloomfield CHPP, in which case all decant water together with rainfall and runoff from within the pit would be returned to the Bloomfield CHPP;
- The Donaldson Square Pit could be utilised for storage of the more saline water from the Abel Underground Mine underground workings, in which case its operation would be linked to the remainder of the Abel Underground Mine water management system and any runoff from the contributing catchment would need to be accounted for.

In order to provide a benchmark for initial assessment purposes, the ‘worst case’ condition would occur if all the runoff from the Donaldson Square Pit contributed to the overall water to be managed within the Abel Underground Mine water management system. **Table 4.3** summarises the annual runoff statistics from the Donaldson Square Pit based on similar rainfall:runoff modelling used to estimate runoff from the Donaldson West Pit.

Based on monitored water quality in the Donaldson Square Pit (pers. comm. Phil Brown 19/9/2012) the average salinity of runoff is assumed to be 2,650 µS/cm (approximately 1,650 mg/L).

Table 4.3: Statistics for Modelled Annual Runoff from the Donaldson Square Pit

Statistic	ML/year
Average	87
Minimum	19
10th Percentile (Dry)	42
Median	83
90th Percentile	138
Maximum	273

4.5 Water Quality in Big Kahuna

Since it commenced operations in March 2008, any excess water from the Abel Underground Mine has been directed to Big Kahuna along with surface runoff and groundwater seepage reporting to the Donaldson Open Cut Mine pits. Because of the higher salinity of the water from underground, salinity levels in the dam have progressively increased since underground operations began (see **Figure 4.2**) and now exceed the salinity limit for discharge to Four Mile Creek (2,000 µS/cm) under Donaldson's EPL No. 11080 (see **Section 2.3.1**). As can also be seen in **Figure 4.2**, since 2010, the pH of water held in Big Kahuna has also exceeded the pH limit for discharge (pH 8.0).

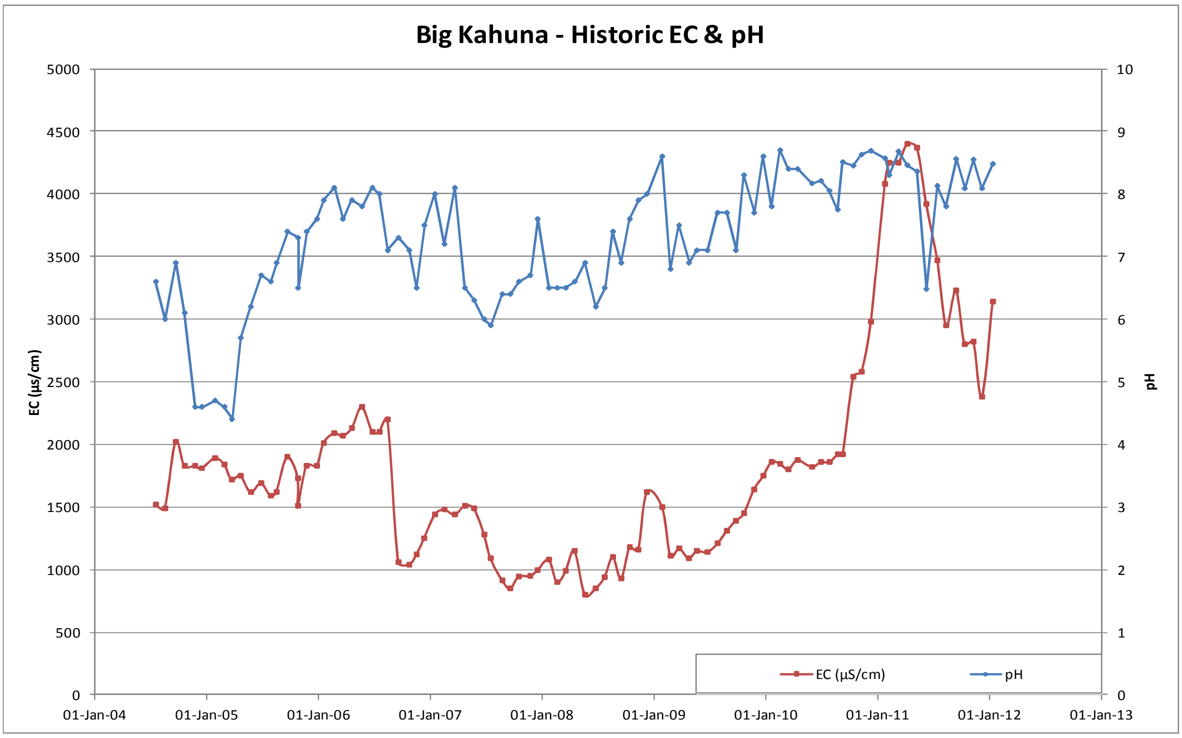

Figure 4.2: Historic Variation of EC and pH in Big Kahuna

Once operations at the Donaldson Open Cut Mine conclude in 2013, water reporting to the Big Kahuna will comprise runoff from the Abel Underground Mine surface facilities and the Donaldson West Pit stockpile area together with groundwater inflows from the Abel Underground Mine. Water from all sources except the surface facilities area is expected to have salinity levels which would preclude direct discharge to Four Mile Creek.

5 Abel/Donaldson Water Use and Discharge

Following completion of mining in the Donaldson Square Pit, the main existing and identified opportunities for water use and discharge associated with the Modification will be:

- Water use within the underground mine operation;
- Water use for dust suppression on the haul road between Abel Underground Mine and the Bloomfield CHPP;
- Discharge to Four Mile Creek in accordance with Donaldson Coal's existing EPL;
- Transfer to the Bloomfield Colliery by mutual agreement.

Key features and considerations in relation to each of these opportunities are set out in the sections below.

5.1 Underground Mine Water Use

Currently water for underground operations is drawn from the Hunter Water potable supply. Records for July and August 2012 indicate that an average of 0.25 ML/day was required to support the current bord and pillar mining operation. On advice from Donaldson Coal, it is assumed that in future:

- Longwall mining will require an average of 1 ML/day;
- Shortwall mining will require an average of 0.5 ML/day; and
- Ongoing bord and pillar operations will require an average of 0.25 ML/day.

For planning purposes it is assumed that, in future, all water for underground operations will be recycled from groundwater inflows to the Abel Underground Mine (as is the current practice at the Tasman Underground Mine), however, water may still be sourced externally (as per the current practice at the Abel Underground Mine) if required. In line with the existing practices at the Tasman Underground Mine it is assumed that water treatment prior to re-use would comprise:

- Removal of oil and grease;
- Addition of a flocculent to assist with the removal of suspended sediment;
- Disinfection.

During the Modification, underground mining operations are expected to require up to about 1.75 ML/day. The majority of this water would be recaptured along with the groundwater inflows, however, some 'losses' would occur due to:

- Increased moisture content of the coal;
- Increased relative humidity of the return air.

Data on these two 'losses' is sparse. The 2011 Annual Review for the Metropolitan Colliery indicates that an average of 0.18 ML/day is accounted for by the increase in the humidity of the return air. For purposes of establishing an initial estimate of the future site water balance for the Abel Underground Mine, a 'loss' of 10% (0.175 ML/day) has been assumed.

On the basis of this analysis, the total water supply requirements are estimated to be up to 640 ML/year of which about 585 ML/year would be recycled.

5.2 Dust Suppression

A water-cart is used to reduce dust emissions from the haul road between the Abel Underground Mine and the ROM stockpile at the Bloomfield CHPP. Water requirements for this are estimated to average 25 ML/year with some variation to account for wetter and drier years.

Because any runoff from the haul road drains to Four Mile Creek via sediment basins, future dust suppression would be undertaken using relatively low salinity water (rather than higher salinity water expected from the underground workings).

5.3 Discharge to Four Mile Creek

The Modification would operate within the constraints imposed by Donaldson Coal's existing EPL No. 11080. As noted in **Section 2.3.1**, the EPL:

- Sets the following specific limits on the water quality that can be discharged:
  - Salinity 2,000 µS/cm (about 1,250 mg/L);
  - pH range 6.0 – 8.0;
  - TSS 50 mg/L.
- Permits discharge of 40 ML over 5 days (8 ML/day) following 10 mm of rain within 24 hours. Based on historic rainfall data, it is estimated that the opportunities to discharge would fall within the following range:
  - 580 ML in 1 in 10 (10^{th} percentile) dry year;
  - 770 ML in a median year;
  - 1,040 ML in 1 in 10 (90^{th} percentile) wet year.

5.4 Water Transfer to Bloomfield

As noted in **Section 1**, the current method of tailings disposal involves placement in a tailings dam from which the decant water is recycled to the CHPP. The main losses from this system are:

- Net evaporation loss from the water surface (after accounting for incident rainfall). The net loss by evaporation will vary from year to year depending on the rainfall as shown in **Figure 5.1** with a median of about 170 ML.
- Water retained within the fine tailings which will be dependent upon:
  - the density of the tailings following consolidation,
  - the proportion of fine tailings in the ROM, and
  - the annual throughput of ROM.

The volume of water retained in the fine tailings is estimated to be about 20 ML per million tonnes of ROM (assuming 14% fine tailings).

Notwithstanding some uncertainty about the volume of water retained in the deposited tailings, the total volume of water required to make up for losses in the tailings and by evaporation is reported to be significantly less than the volume of runoff and groundwater seepage into the currently operating pits at Bloomfield. Accordingly, Bloomfield is self-sufficient (i.e. does not require any water to be transferred from the Abel Underground Mine for operational purposes).

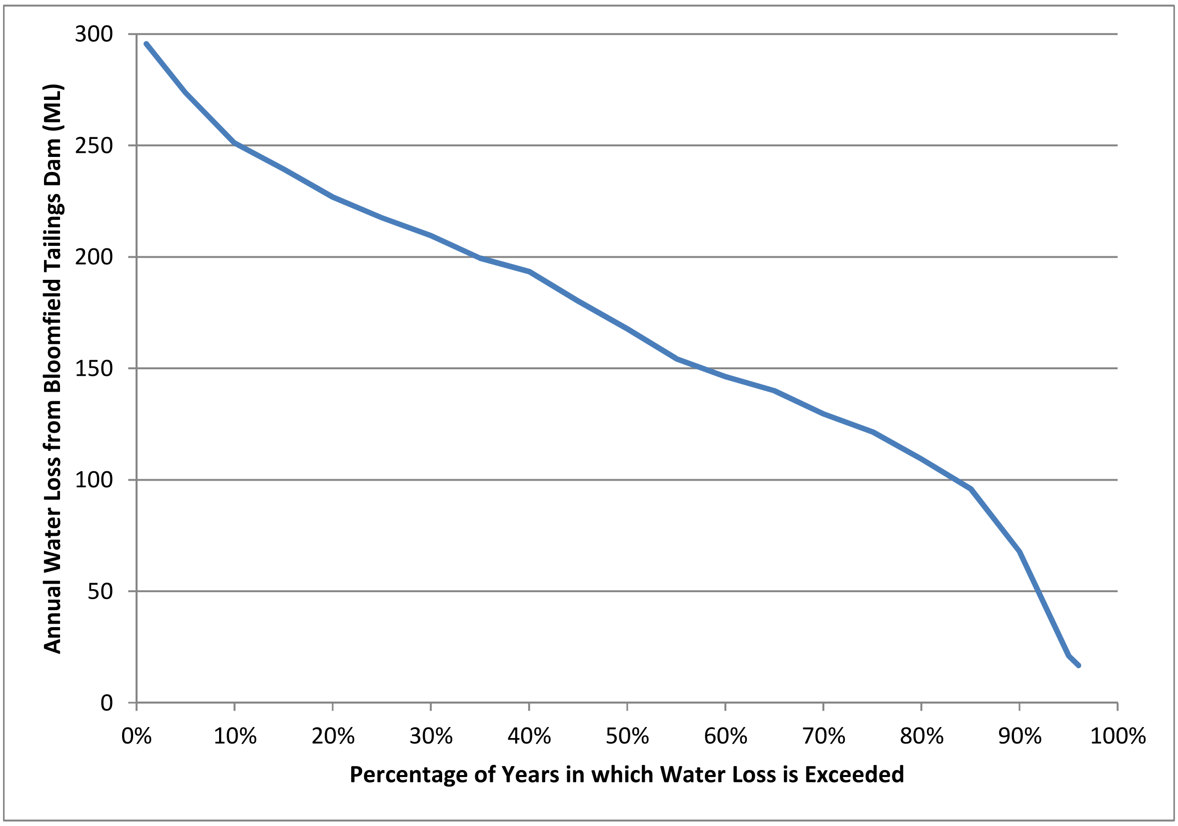

Figure 5.1: Estimated Annual Water Loss from Existing Bloomfield Tailings Dam

Although Bloomfield does not require any water from the Abel Underground Mine for operational purposes, by mutual agreement some water has been transferred:

- either to shandy with water held in Lake Kennerson at Bloomfield in order to lower the pH to within the range permissible for discharge; or
- to assist Donaldson Coal with disposal of excess water.

Table 5.1 summarises the volume of water transferred from Donaldson to Bloomfield since a pipeline was installed in mid-2007.

Table 5.1: Volume of Water Transferred from Big Kahuna to Lake Kennerson

Year	Transfer (ML)
2007 (from 25 June)	472
2008	693
2009	0
2010	70
2011	469
2012 (to 21 October)	637
Total	**2,340**
Average (complete years July - June)	**410**

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6 Proposed Water Management System

6.1 Indicative Water Balance

After allowing for rainfall and evaporation from the surface of Big Kahuna, the data in **Section 4** indicates that the Abel Underground Mine (including the underground operations, Donaldson West Pit and mine facilities area) are likely to generate significantly more water during the Modification than is required to satisfy the water demands and losses set out in **Section 5**. **Table 6.1** provides the results of a simplified water balance analysis based on the predicted groundwater inflow in 2015 and 2016 (from **Figure 4.1**) for a range of climate conditions with and without discharge to Four Mile Creek when conditions permit, assuming an average transfer of 410 ML/year to Bloomfield Colliery (see **Table 5.1**).

Table 6.1: Indicative Water Balance Summary for 2015 and 2016

Year	Discharge to Four Mile Creek	Groundwater Inflow (ML)	Excess Mine Water (ML)		
			1:10 Dry Year	Average Year	1:10 Wet Year
2015	0 ML/day	1,220	717	789	850
	8 ML/day	1,220	282	210	73
2016	0 ML/day	2,304	1,890	1,873	1,804
	8 ML/day	2,304	1,366	1,294	1,157

The data in **Table 6.1** indicates that even if water quality in Big Kahuna was suitable for discharge to Four Mile Creek and there were average opportunities for transfer to Bloomfield Colliery, the Abel Underground Mine would require additional storage capacity to store excess mine water.

On the basis of the analysis in **Table 6.1**, and the staging of void space becoming available (as per **Table 3.1**) surface water management for the Modification would involve two stages:

Stage 1: 2013 - 2018

- Use of the Donaldson Square Pit to store the higher salinity water expected from the Abel Underground Mine as well as tailings from the Bloomfield CHPP when required;
- Use of spare capacity in the Donaldson Square Pit for storage of tailings;
- Treatment of mine water (i.e. using a reverse osmosis [RO] plant) to a standard suitable for discharge to Four Mile Creek.

Stage 2: 2019 - 2030

- Transfer of water from Abel Underground Mine to Lake Foster for use in the Bloomfield CHPP;
- Placement of tailings in one of the major Bloomfield Colliery voids (S-Cut [South] and S-Cut [North]) as they become available;
- Placement of any excess mine water in one of the major Bloomfield Colliery voids as required.

6.2 Proposed Water Management: 2013 - 2018

The proposed water management system for the Modification (integrated with the Bloomfield Colliery and CHPP surface water management systems) for the period 2013 to 2018 is illustrated in **Figure 6.1**.

Prior to about mid-2015, the water management system for the Bloomfield Colliery and CHPP would continue to operate in a similar manner to the current operations, with modest volumes of water transferred from Big Kahuna to Bloomfield when conditions permit. The current surface water management system would be used as long as it can be demonstrated (through regular review of the site water balance) that it is suitable to manage groundwater inflow from the Abel Underground Mine.

Figure 6.1 illustrates indicative surface water management systems for the period after about mid-2015 when tailings from the Bloomfield CHPP would be placed in the Donaldson Square Pit and decant water returned to the Bloomfield CHPP:

- Water from the Abel Underground Mine would be directed to the Donaldson Square Pit;
- Runoff from the Donaldson West Pit and the Abel Underground Mine facilities area would continue to be directed into Big Kahuna;
- Water from the Donaldson Square Pit would be treated in a RO plant at a rate of 4 ML/day. Sufficiently treated water would be directed to the Big Kahuna to achieve the required salinity to allow discharge to Four Mile Creek (2,000 µS/cm) when the necessary rainfall conditions occur. Waste brine would be returned to the Square Pit;
- Water in the Donaldson Square Pit would also be treated to remove oil and sediment and then disinfected for re-cycling for use underground;
- Water from Big Kahuna would be:
  - Used for dust suppression on the haul road;
  - Discharged to Four Mile Creek in accordance with EPL No. 11080 licence conditions;
  - Transferred to Bloomfield when possible;
- Once the tailings storage capacity of U-Cut (North) and U-Cut (South) had been exhausted (expected about mid-2015), tailings would be directed to the Donaldson Square Pit;
- From about mid-2015 onward, sufficient water from the Donaldson Square Pit (decant water and water from Abel Underground Mine) would be pumped back to Lake Foster for re-use in the CHPP.

For purposes of this assessment, the assumed RO plant operating characteristics are:

- Inflow of 4 ML/day with salinity of >8,000 µS/cm (>5,000 mg/L);
- Discharge to Big Kahuna of 3 ML/day with salinity of 240 µS/cm (150 mg/L);
- Waste brine (1 ML/day) returned to the Donaldson Square Pit with salinity of about 30,000 µS/cm.

In order to shandy the runoff from the Donaldson West Pit to a quality suitable for discharge, approximately 0.4 ML of treated water (assumed 240 µS/cm) would be required per ML of runoff. However, the resulting volume of shandied water would be less than the available opportunities for licensed discharge (see **Figure 2.2**). In order to make full use of the expected opportunities for licensed discharge, additional volumes of treated and untreated water could be transferred from the

Donaldson Square Pit to Big Kahuna in the required proportions to maintain the salinity in Big Kahuna below 2,000 µS/cm.

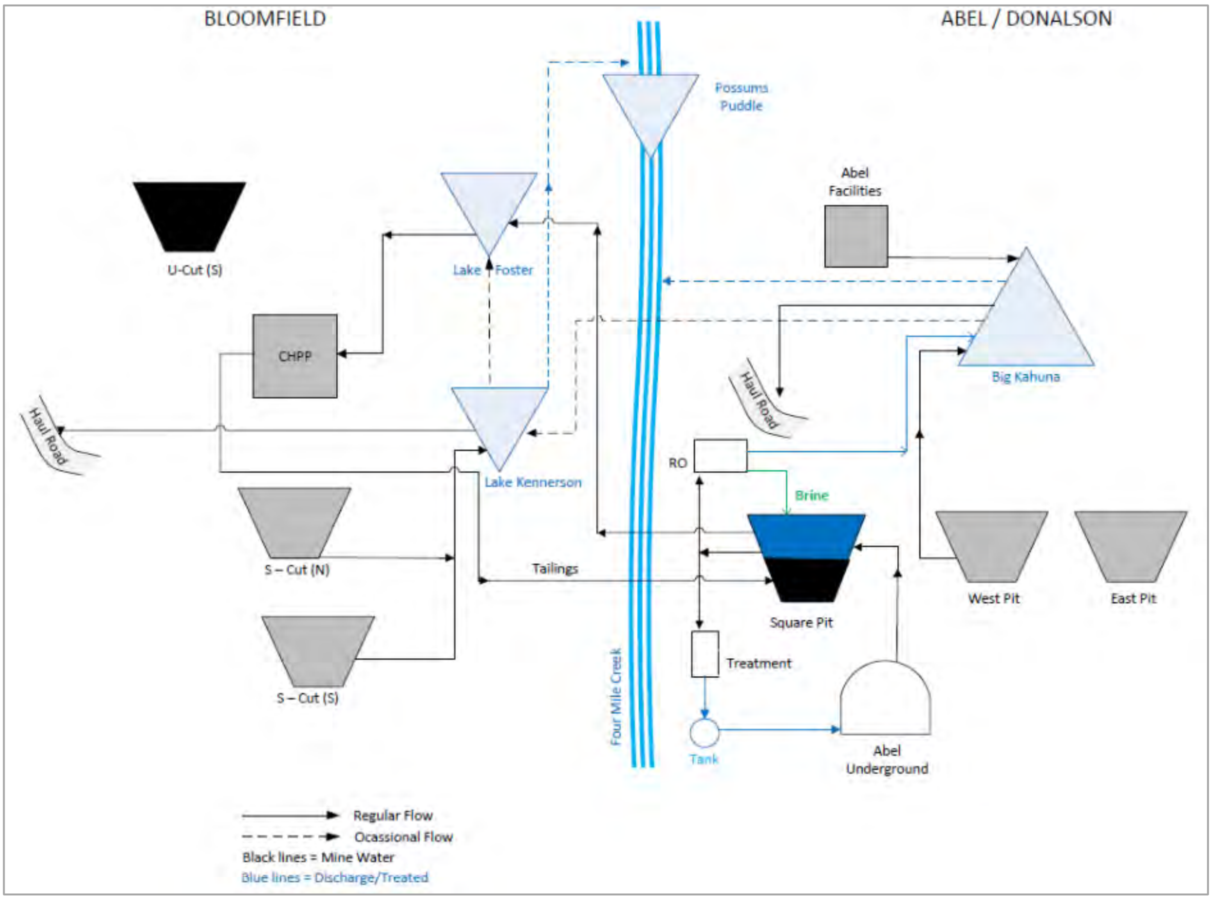

Figure 6.1: Schematic Diagram of Indicative Water Management System in 2015

Table 6.2 provides an indicative water balance for a situation in which sufficient water could be made available in Big Kahuna to take advantage of 75% of the opportunities for licensed discharge. The table shows that such a scheme could enable the licensed discharge of between about 350 to 600 ML/year of water from the Abel Underground Mine, depending on the rainfall regime in a particular year.

Table 6.2: Indicative Water Balance for Scheme Depicted in Figure 6.1

	Annual Rainfall		
	10% Dry	Median	90% Wet
Total runoff to Big Kahuna (@2,650 EC) (ML)	87	144	187
Total RO output (@240 EC) (ML)	279	351	475
Water from Square Pit (@8,000 EC) shandied with RO output (ML)	70	84	114
Total available for discharge (ML)	435	579	777
Waste brine (ML)	70	88	119
Total lost from Square Pit (after accounting for returned brine)	348	435	590

A limitation of the scheme depicted in **Figure 6.1** is that the Donaldson Square Pit has storage capacity of only 2,900 ML and would receive tailings from the Bloomfield CHPP once the U-Cut

(South and North) have been filled to capacity. This issue has been assessed by means of a detailed water balance analysis (see **Section 6.4**) that takes account of tailings deposition.

6.3 Proposed Water Management 2019 - 2030

From the end of 2018 mining is scheduled to be completed in the Bloomfield S-Cut (South) void followed by the S-Cut (North) void in 2022. The capacity of these two voids (over 20,000 ML) will provide more than sufficient void space for storage of tailings from the Bloomfield CHPP covering the period of production from all the currently scheduled mines (**Table 3.2**). From the end of 2018, this void space could be used to store excess water generated by the Modification and remove the need for treatment of water from the Abel Underground Mine.

Figure 6.2 is a schematic diagram showing an indicative water management system from 2019 onwards. Key features of this scheme are:

Abel Underground Mine

- All groundwater inflow to the Abel Underground Mine would be transferred to Lake Foster for use in the CHPP apart from a small 'top-up' to the supply for the recycled supply for underground operations;
- Water for underground operations would be sourced from a separate small storage (nominal capacity 50 ML – approximately one month's supply for the operation);
- Surface runoff from the Donaldson West Pit and Abel Underground Mine facilities area would continue to report to Big Kahuna;
- Water from Big Kahuna would be:
  - used for dust suppression on the haul road between the Abel Underground Mine and the Bloomfield CHPP,;
  - available for transfer to Lake Kennerson or Lake Foster to supplement the Bloomfield CHPP water supply.

Bloomfield Colliery (up to 2022)

- Runoff and groundwater inflow to the active mine pit (S-Cut [North]) would continue to be pumped to Lake Kennerson;
- Water in Lake Kennerson would be:
  - Released as required to Lake Foster in order to maintain water supply to the Bloomfield CHPP;
  - Used for dust suppression on the haul roads;
  - Released to Four Mile Creek, subject to the water meeting the required water quality limits specified in the Bloomfield Colliery EPL and the required prior rainfall to permit discharge.

Bloomfield CHPP

- Lake Foster would continue to act as the supply point for water supply for the Bloomfield CHPP. The priority order for water supply for the operation of the Bloomfield CHPP would be:
  - Water transferred from the Abel Underground Mine underground operations;
  - Water drawn from Lake Kennerson;
  - Any excess water transferred from Big Kahuna;
  - Decant water from tailings disposal in the S-Cut (South) void as necessary to meet the requirements of the Bloomfield CHPP;

- Tailings would be disposed in the S-Cut (South) void.

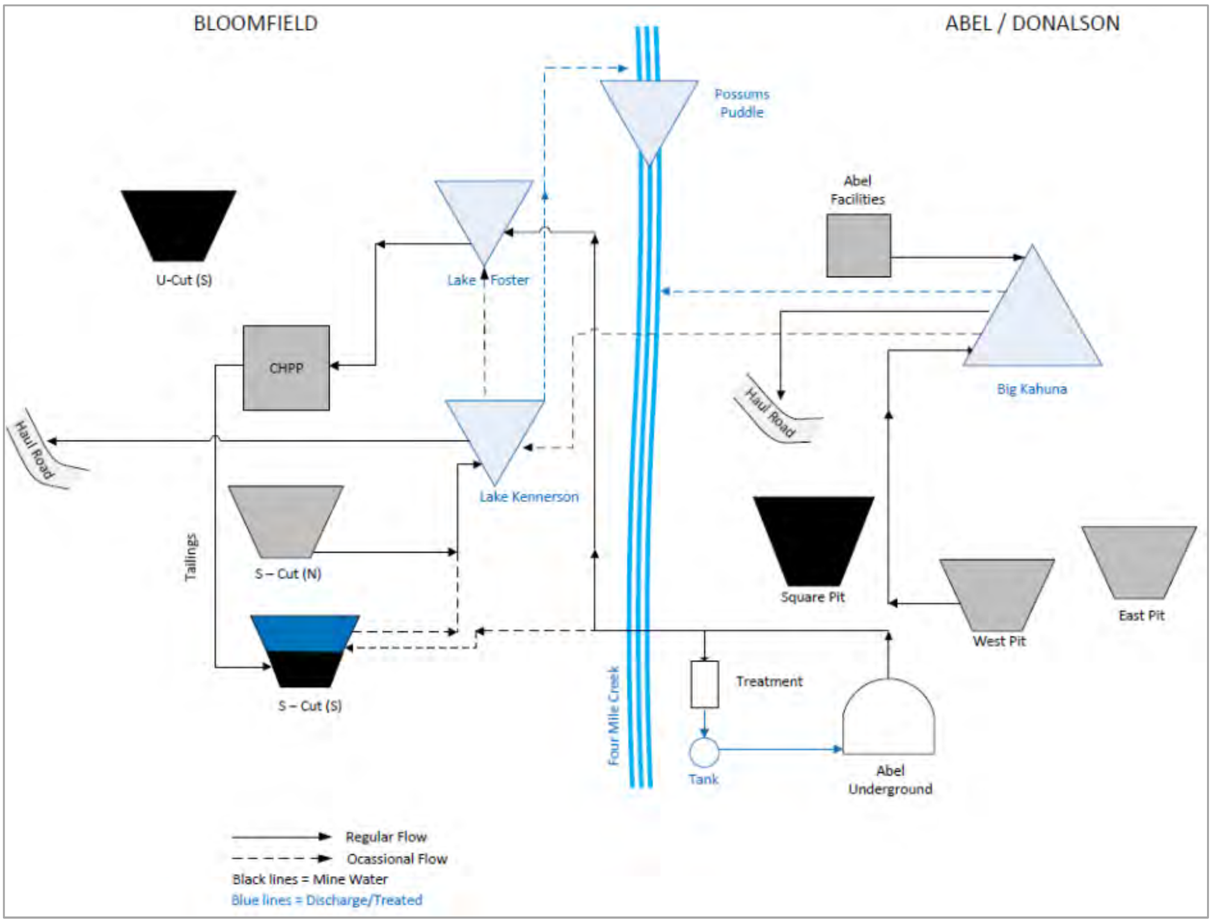

Figure 6.2: Schematic Diagram of Integrated Abel/Bloomfield Water Management System after 2018

6.4 Water Balance and Salinity Accounting Methodology

Separate models have been set up to represent scenarios depicted in **Figure 6.1** (2013 – 2018) and **Figure 6.2** (2019 – 2030).

The models have been set up in a manner that permits an assessment of performance of the water management systems under different climate sequences that represent the full range of wet and dry climate drawn from local historic climate records. The models use 126 years of daily rainfall records from Morpeth which commenced recording in 1885 which has been adjusted by correlation with the record from the Donaldson meteorological station. For the purposes of providing as many rainfall sequences as possible, the rainfall record after 2011 was simulated by repeating the rainfall sequence starting in 1885.

6.4.1 Water Balance Model 2013 - 2018

The water balance model for the period 2013 to 2018 focuses on the Abel/Donaldson water management system and represents daily inflows and outflows and associated salinity from each of the separate elements of the water management system depicted in **Figure 6.1** and accounts for the storage of tailings in the Donaldson Square Pit from mid-2015.

This model contains the following key elements:

- daily rainfall and evaporation data derived from historic records (see **Section 6.4.3**);
- a rainfall:runoff model which uses the AWBM model with different parameters to represent the runoff characteristics of different surfaces (see **Section 6.4.5**);
- water demands for the Abel Underground Mine operation comprising:
  - supply for underground operations (1.75 ML/day of which 0.15 ML/day is assumed to be 'lost' by way of increased humidity in the exhaust air (see **Section 5.1**);
  - water requirements for dust suppression on the haul road linking the Abel Underground Mine to the Bloomfield CHPP (see **Section 5.2**);
- water storage model which accounts for all inflows, transfers, water demands and losses (evaporation and seepage) from the water storages;
- maintenance of mass balance for water and salt held in all storages, transferred between storages and discharged;
- licensed discharge from Big Kahuna to Four Mile Creek in accordance with the EPL No. 11080 requirements for prior rainfall conditions at a rate of (8 ML/day) and maximum salinity (2,000 µS/cm);
- transfer from Big Kahuna to Lake Kennerson at a rate of 8 ML/day for an average of 51 days per year (average transfer 408 ML/year – see **Table 5.1**);
- the operation of a RO plant at a rate of 4 ML/day with the waste brine (assumed to be 25% of the inflow) returned to the Donaldson Square Pit. The output of the RO plant is assumed to have a salinity of 150 mg/L (250 µS/cm).

6.4.2 Water Balance Model 2019 - 2030

Following completion of mining in the S-Cut (South) by the end of 2018, the void space will be available for storage of any excess water from the Abel Underground Mine as well tailings from the Bloomfield CHPP.

Under this scenario, the timing of opportunities for discharge from Big Kahuna to Four Mile Creek would no longer a critical factor in the operation of the water management system. Accordingly a simplified water balance model has been developed for conditions post-2018. Key features of this model, which reflect the scenario depicted in **Figure 6.2** are:

- the model uses monthly rainfall and evaporation data derived from historic records (see **Section 6.4.3**);
- the model uses monthly runoff from different surfaces which has been derived from the same daily rainfall:runoff model used for modelling the period 2013 - 2018;
- water requirements for the Abel Underground Mine underground operations are assumed to be met from a recycling system which only requires 'top-up' of 0.15 ML/day to make up for water 'lost' by way of increased humidity in the exhaust air. The 'top-up' water is assumed to be supplied

from the water pumped out of the mine. This recycling system is not included as a separate element in the model. However, the requirement for 'top-up' is taken into account;

- water requirements for dust suppression on the haul road linking the Abel Underground Mine to the Bloomfield CHPP are assumed to be provided by runoff from the Donaldson West Pit and Abel Underground Mine facilities area which is collected in Big Kahuna. Any excess water is assumed to be transferred to S-Cut (South);
- the model accounts for all inflows, transfers, water demands and losses (evaporation and seepage) from S-Cut (South) as well as the accumulation of tailings.

6.4.3 Climate Data

The following climate data was used for the water balance analysis:

- Daily rainfall data for Morpeth PO which has a correlation coefficient (R^2) of 0.998 against the rainfall measured at the Donaldson mine site over the period of coincident record (December 1999 – December 2011). For purposes of this analysis the historic record from Morpeth (1885 – 2010) was used in order to provide a full representation of the long term variability of climate conditions.
- Average daily evaporation for each month of the year based on the pan evaporation records from Williamtown Airport (1973 – 2010).
- Monthly potential evapotranspiration for the site from the digital version of the *Climatic Atlas of Australia: Maps of Evapotranspiration* (Version 1.0, Bureau of Meteorology, 2002).

As recommended by Boughton (2010), the monthly potential evapotranspiration data was used to account for evaporation and evapotranspiration losses from the contributing catchments in the rainfall:runoff component of the water balance model (see **Section 6.4.5**).

6.4.4 Catchments and Storages

Where relevant to the particular scenario, the catchments and water storages or voids set out in **Table 6.3** are included in the model.

Table 6.3: Catchment Areas, Storages and Voids

	Area (ha)	Storage Volume (ML)
Catchments		
West Pit	28.7	
Abel Mine Facilities	2.1	
Storages/Voids		
Big Kahuna	4.9	400
Donaldson Square Pit	21	2,900
S-Cut (South) and catchment	55	10,000
S-Cut (North) and catchment	68	10,000

6.4.5 Runoff Modelling

For this study the AWBM model (Boughton, 1984; Boughton & Chiew, 2003; Boughton, 2010) has been used to estimate daily runoff volumes from various catchment surfaces:

- Rehabilitated overburden draining towards mine pits;
- Former mine pits (Square Pit, S-Cut (South) and S-Cut (North));
- The Abel Underground Mine facilities area.

AWBM is a rainfall:runoff model which uses daily rainfall and evapotranspiration to estimate the runoff depth from land surfaces with different runoff generating characteristics. AWBM was developed for Australian catchments and has the advantage of maintaining a relatively simple structure (and relatively few parameters), whilst adequately representing the key runoff processes. The runoff depth calculated by AWBM is converted to a volume of runoff by multiplying by the relevant catchment area.

For purposes of selecting appropriate model parameters to represent the runoff characteristics of the various surfaces, parameters derived from various sources were assessed:

- parameters derived from rainfall and runoff data collected from open-cut mines in the Hunter Valley and Queensland (Australian Coal Association Research Program, 2001);
- published parameters adopted for other surface water assessments for mine projects including Tarrawonga, Maules Creek and Mt Thorley;
- calibrated parameters for AWBM for the local catchments in the lower Hunter Valley and Central Coast based on recorded rainfall and runoff (Evans & Peck 2012);
- published AWBM parameters for ungauged catchments (Boughton & Chiew, 2003)

On the basis of these sources, soil moisture storage characteristics for different land surfaces of relevance to this report (defined by the AWBM parameter 'AveCap') were adopted as set out in **Table 6.4**, which also lists the runoff as a percentage of rainfall from the local full historic climate record.

Table 6.4: Percentage Runoff for AWBM Parameters Representing Different Land Surfaces

Land Surface	Ave Cap	Runoff %
Natural	64	24%
Rehabilitated	87	18%
Open Cut	18	45%
Mine Facilities	4	61%

6.4.6 Water Demands

The water requirements for dust suppression on haul roads and hardstand areas are closely related to the daily weather (since hot windy days can be expected to generate dust). Thompson and Visser (2002) studied the water requirements for dust suppression on mine haul roads and demonstrated a robust relationship between water requirements for dust suppression and the potential evaporation on the day, while taking into account any incident rainfall. An algorithm based on the work of Thompson and Visser (2002) has been benchmarked against estimated mine water use at two mines in the

Hunter Valley and has been adopted for the site water balance model. This element of the water balance model takes account of:

- the area of active haul road;
- daily rainfall; and
- daily evaporation.

Because of the expected higher salinity of water from the Abel Underground Mine, water for dust suppression on the haul road is assumed to be taken only from Big Kahuna.

Water requirements for Abel Underground Mine underground operations have been assumed to be 1.75 ML/day, with 10% loss through an increase in the humidity of the exhaust air (see **Section 5.1**)

6.4.7 Groundwater

For purposes of water balance modelling, the predicted groundwater inflow to the Abel Underground Mine during the Modification (see **Figure 4.1**) has been interpolated on a daily basis using data from RPS Aquaterra (2012).

6.4.8 Assumed Water Transfers and Storage Operating Rules

The relevant water transfer and discharge rules were modelled as follows:

- Subject to maintaining a minimum volume for dust suppression (50 ML) and salinity complying with the EPL (<2,000 µS/cm) discharge from Big Kahuna to Four Mile Creek is modelled to occur at a rate of 8 ML/day for 5 days following any day on which there has been 10 mm or more of rainfall.
- Transfer from Big Kahuna to Lake Kennerson occurs at a rate of 8 ML/day. For modelling purposes, in order to closely mimic the average transfer (410 ML/year see **Table 5.1**) this transfer is assumed to occur for 3-4 days following discharge to Four Mile Creek;
- The RO plant is assumed to have an inflow of 4 ML/day with the waste brine (assumed to be 25% of the inflow) returned to the Donaldson Square Pit. The output of the RO plant is assumed to have a salinity of 150 mg/L (250 µS/cm). The RO plant is assumed to work on all days when the volume of water stored in Big Kahuna is less than 90% of capacity. The maintenance of 'air' space of 10% of the capacity of Big Kahuna was derived by trial and error to a level that ensured that no overflow occurred as a result of inflows from the Donaldson West Pit and the Abel Underground Mine facilities area. In practice, because of the time required for starting and stopping RO plant operations (and the chemical usage for cleaning membranes) the RO plant is likely to be a series of modules which would allow the treatment rate to be varied progressively.
- 'Top-up' supply to account for the assumed 10% loss from water supplied for the underground operations is assumed to be taken from the Donaldson Square Pit.

6.5 Water Balance and Salinity Results 2013 - 2019

6.5.1 Water Balance

The water balance modelling has been undertaken for all climate sequences represented by the historic record. The results of this analysis indicate that, because the overall water balance is dominated by the groundwater inflow to the Abel Underground Mine, the effect of climate on water use for dust suppression and the number of opportunities for discharge to Four Mile Creek are secondary factors in the overall site water balance. This is illustrated by the following graphs which are based on representative rainfall regimes during the first five years of the modified mine operation (assumed to begin in mid-2013) which is the period when the maximum groundwater inflow is predicted (see **Figure 4.1**):

- A median 5 year rainfall sequence starting in 1956 (**Figure 6.3**);
- A 1:10 wet 5 year rainfall sequence starting in 1986 (**Figure 6.4**); and
- A 1:10 dry 5 year rainfall sequence starting in 1939 (**Figure 6.5**).

Although it is anticipated that the S-Cut (South) would be available for storage of tailings and water from the end of 2018, the analysis shown in these figures extends to 2019 in order to illustrate the performance of the system if completion of mining in the S-Cut (South) is delayed. Each figure contains three lines that show:

- The water volume held in Big Kahuna (blue line);
- The water volume required to be stored (in addition to the Big Kahuna) (red line);
- The available capacity in the Donaldson Square Pit (green line) after allowing for the placement of tailings into the Donaldson Square Pit (which is assumed to occur in mid-2015) and the storage of water.

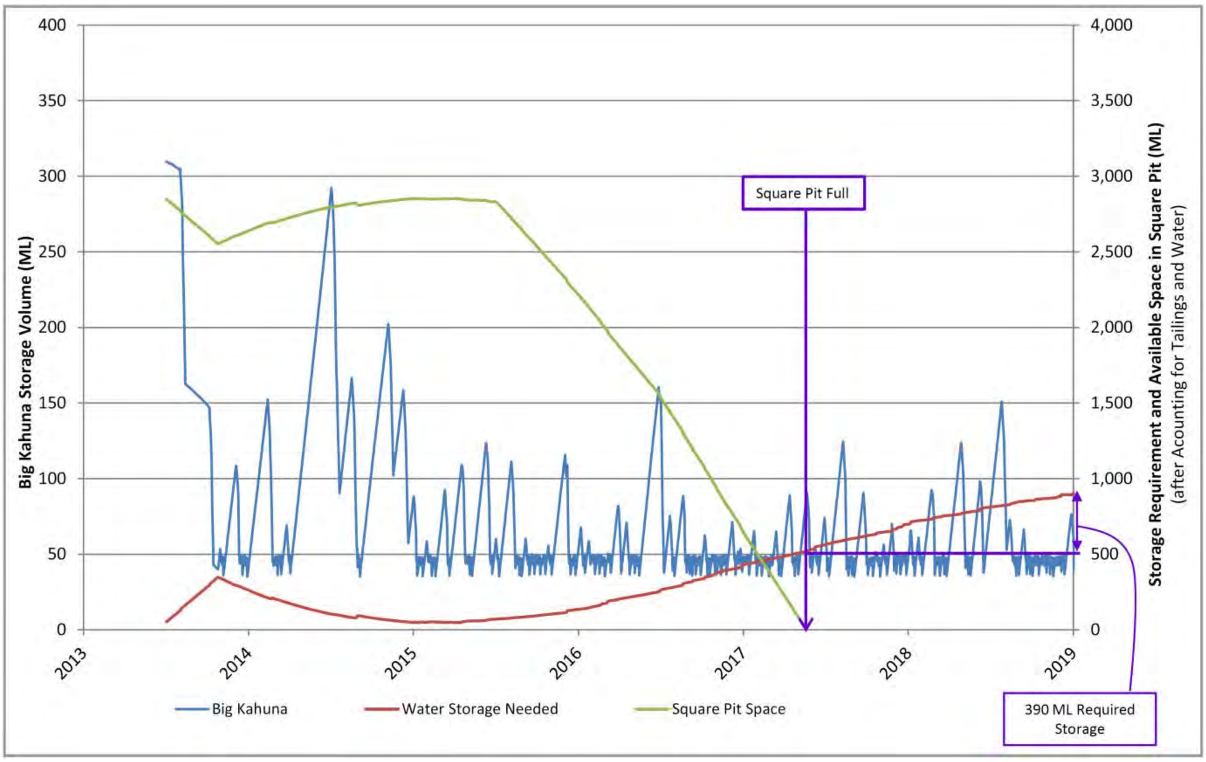

Figure 6.3: Big Kahuna and Square Pit Storage Behaviour for Median 5 Year Climate Sequence

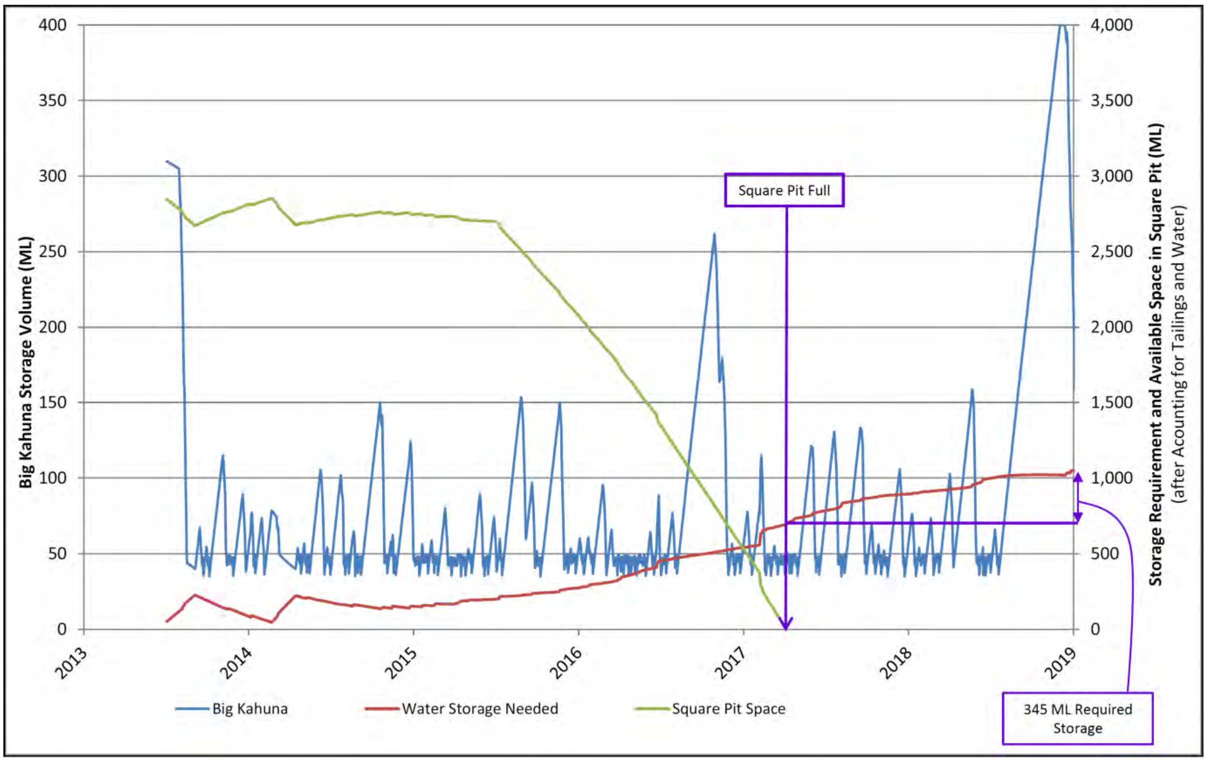

Figure 6.4: Big Kahuna and Square Pit Storage Behaviour for 1:10 Probability Wet 5 Year Climate Sequence

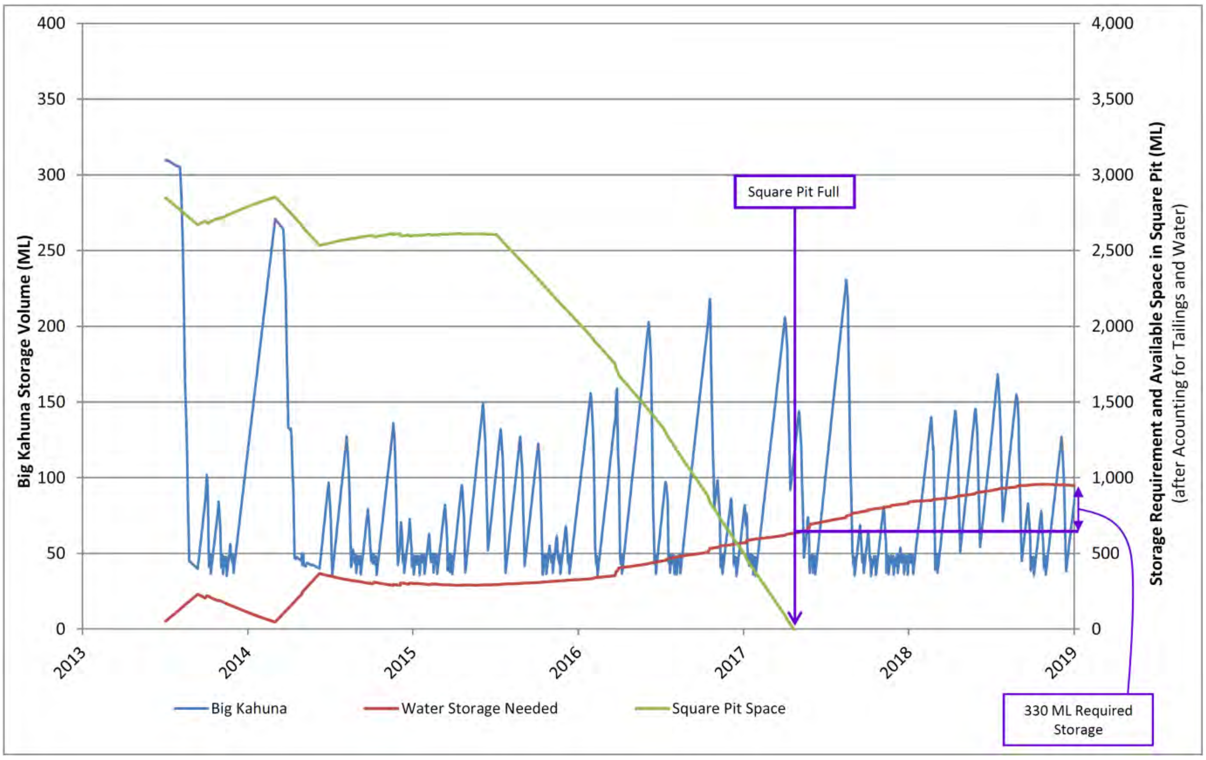

Figure 6.5: Big Kahuna and Square Pit Storage Behaviour for 1 in10 Probability Dry 5 Year Climate Sequence

Notable aspects illustrated in **Figure 6.3** to **Figure 6.5** are:

- For all three climate sequences, the available capacity in the Donaldson Square Pit (green line) would be maintained within the range of 2,500 to 2,900 ML up to mid-2015 when tailings would start to be place in the Donaldson Square Pit. Thereafter the available capacity declines steadily as tailings accumulate. (Note that the analysis assumes that decant water from the tailings is recycled to the Bloomfield CHPP.)
- For all three climate sequences, the available capacity in the Donaldson Square Pit (after accounting for both water and tailings) goes to zero by early to mid-2017 indicating that at that time additional storage space would need to be found for CHPP tailings and water from the Abel Underground Mine.
- The red line (representing the volume of water from Abel Underground Mine that needs to be retained in additional to storage in the Big Kahuna) reaches a peak of between 1,000 and 1,100 ML by mid-2019.
- In the worst case of the three sequences (wet climate sequence shown in **Figure 6.4**), the maximum additional storage required for the period 2015 to 2019 (i.e. in additional to the Big Kahuna and Donaldson Square Pit) is about 400 ML. This is calculated as the difference between the water held in the Donaldson Square Pit when it runs out of space in early to mid-2017 (about 500 to 700 ML) and the maximum required storage (900 to 1,100 ML). The additional storage of 400 ML would only be required until the Bloomfield S-Cut (South) void became available in late 2018.
- If required, this additional storage requirement (about 400 ML) could be made available by either constructing an embankment around the western edge of the Donaldson Square Pit within the existing disturbance area (an embankment about 2.5 m high would be sufficient to hold an additional 500 ML of water) or creating additional storage in the Donaldson West Pit (e.g. by modifying the existing sump within the approved disturbance area).
- While these additional storage options would resolve the water storage issue until the Bloomfield S-Cut (South) void became available, alternative storage would also need to be provided for tailings storage (approximately 2.4 million m³ based on the tailings production schedule in **Table 3.2**). Options for this storage of these tailings include:
  - creating additional storage in the Donaldson Square Pit with the construction of the embankment around the Donaldson Square Pit;
  - storage of tailings in the S-Cut South Interim storage;
  - transferring groundwater inflows from the Abel Underground Mine to the sump in the Donaldson West Pit (creating additional storage capacity for tailings in the Donaldson Square Pit).

The water balance and tailings storage analysis set out above assumes that the all contributing mines will provide ROM coal to the CHPP at the maximum scheduled rates (as set out in **Table 3.2**), that all sources of ROM produce the same proportion of fine tailings as in 2011 and that the projected groundwater inflows to the Abel Mine eventuate as predicted in **Figure 4.1**. If these circumstances occur, Donaldson Coal would ensure that sufficient storage was made available for all tailings and water from the Abel Underground. In addition to the option of using the Donaldson West Pit for storage of excess water (as discussed above) options for storage of tailings include those set out at the bottom of **Table** 3.1.

6.5.2 Salinity

Figures 6.6 to **6.8** show the salinity in Big Kahuna and the Donaldson Square Pit corresponding to the storage behaviour shown in **Figure 6.3** to **Figure 6.5**. All three figures show the same trend:

- Salinity in Big Kahuna would be rapidly drawn down below 2,000 µS/cm by dilution with treated water from the RO plant. This would allow water from Big Kahuna to be discharged to Four Mile Creek whenever rainfall conditions permit in accordance with EPL No. 11080;
- The salinity of water in the Donaldson Square Pit would rapidly rise to about 15,000 µS/cm and remain at about that level for the remainder of the time considered in the analysis. This analysis includes the return of brine from the RO plant to the Donaldson Square Pit.

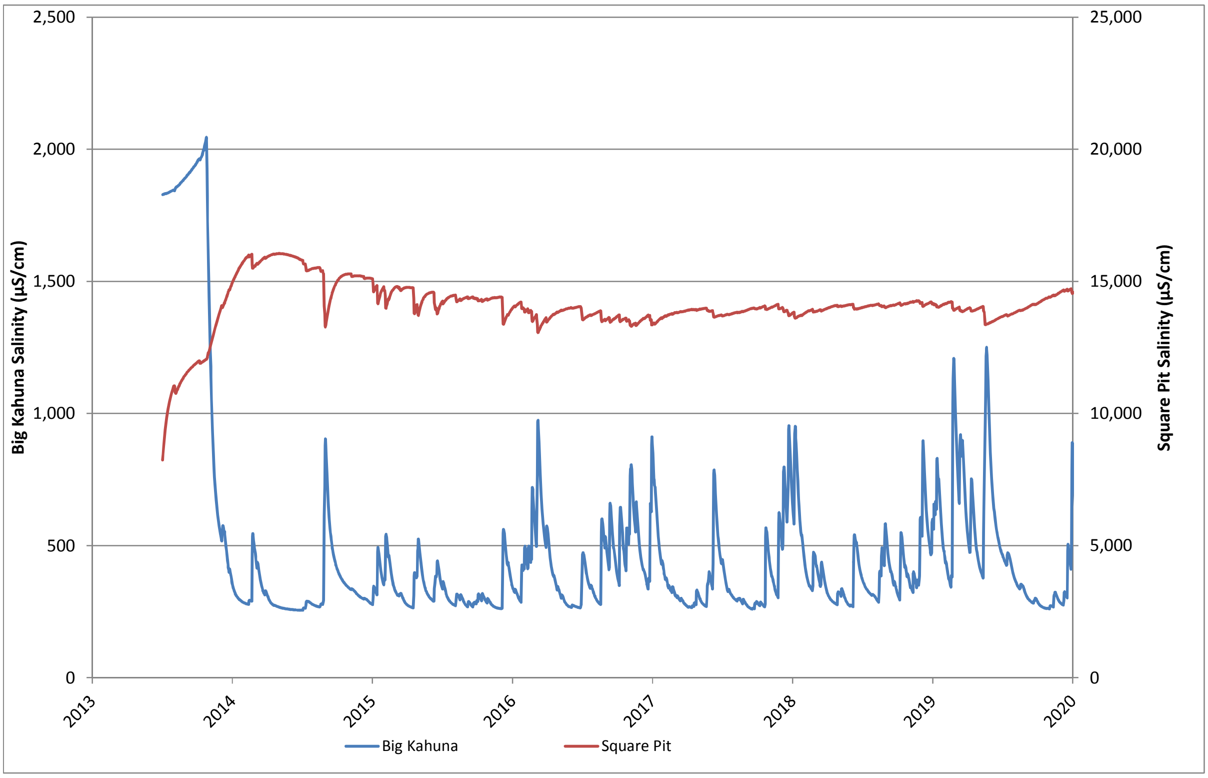

Figure 6.6: Salinity in Big Kahuna and Square Pit for Median Climate Sequence

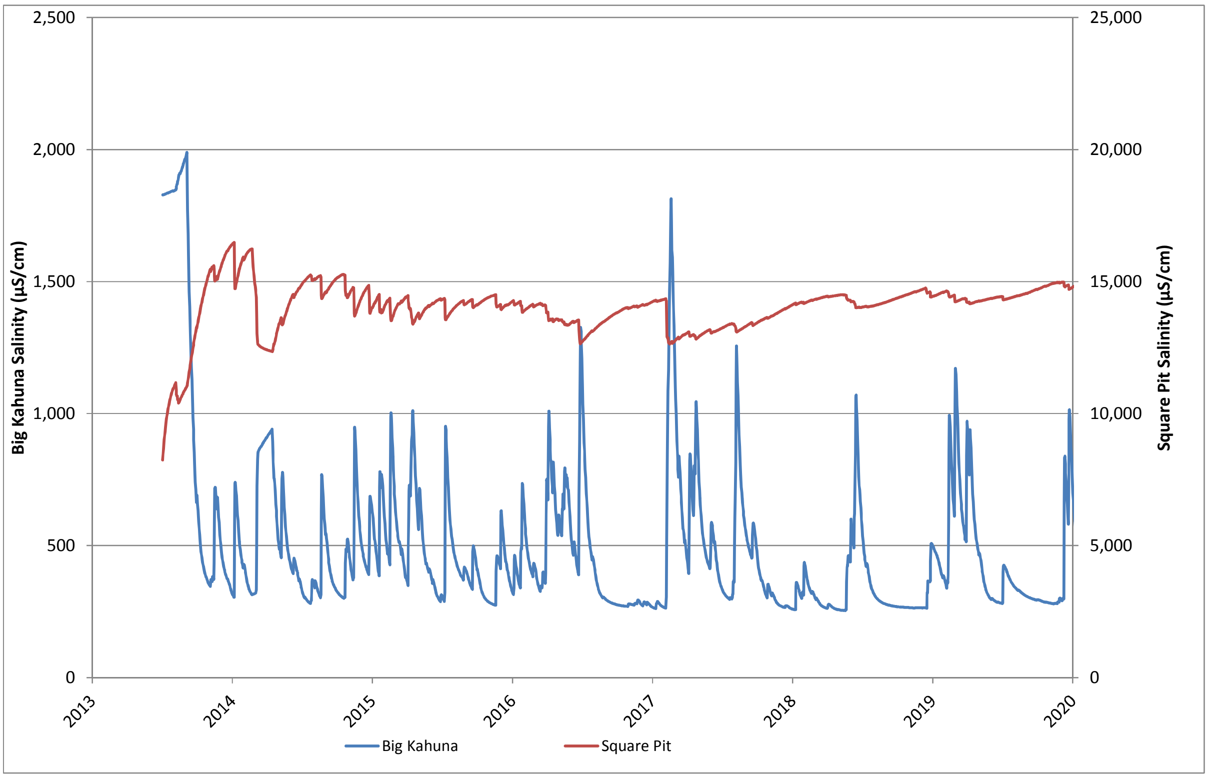

Figure 6.7: Salinity in Big Kahuna and Square Pit for 1 in 10 Probability Wet 5 Year Climate Sequence

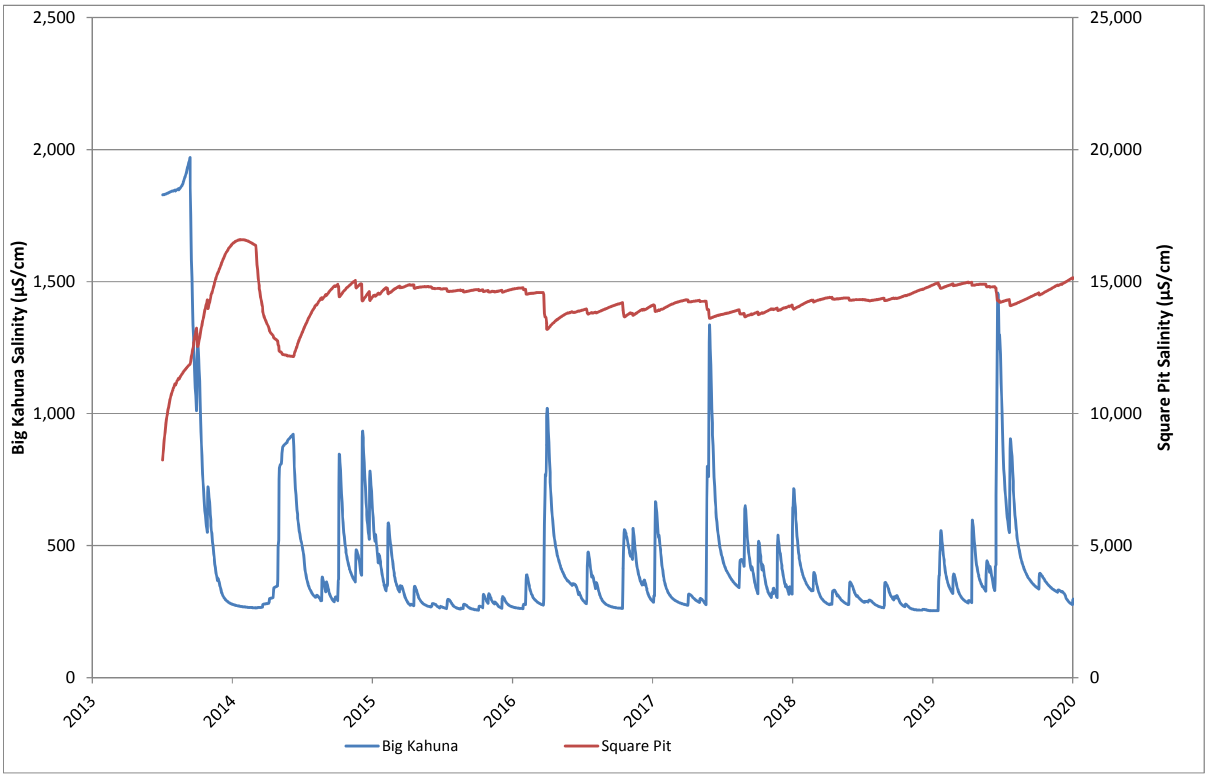

Figure 6.8: Salinity in Big Kahuna and Square Pit for 1 in 10 Probability Dry 5 Year Climate Sequence

6.6 Water Balance Results 2019 - 2030

After the completion of mining in the S-Cut (South), tailings from the Bloomfield CHPP and groundwater inflow to the Abel Underground Mine would be directed to the S-Cut (South) void, as depicted in the system diagram in **Figure 6.2**. If required, the S-Cut (North) void would also be used to store tailings and groundwater inflow to the Abel Underground Mine after S-Cut (South) was filled.

The key water management issue at this stage will be the rate of filling of the S-Cut voids with tailings and excess water. This is illustrated by the following graphs which are based on representative rainfall regimes during the 10 years following commencement of tailings emplacement in S-Cut (South) and assume a 'worst case' situation in which none of the water from the S-Cut (North) or the catchment draining towards S-Cut (South) or S-Cut (North) can be directed to Lake Kennerson for re-use in the Bloomfield operations or discharged to Four Mile Creek in accordance with Bloomfield's existing EPL:

- A median historic 10 year rainfall sequence starting in 1906 (**Figure 6.9**);
- An historic 1 in 10 probability wet 10 year rainfall sequence starting in 1946 (**Figure 6.10**); and
- An historic 1 in 10 probability dry 10 year rainfall sequence starting in 1896 (**Figure 6.11**).

In all three figures the red line represents the available storage capacity in S-Cut (South) and S-Cut (North) combined. This is scheduled to commence with 10,000 ML becoming available when mining is completed in S-Cut South by the end of 2018 and increase by a further 10,000 ML when S-Cut (North) becomes available in 2022.

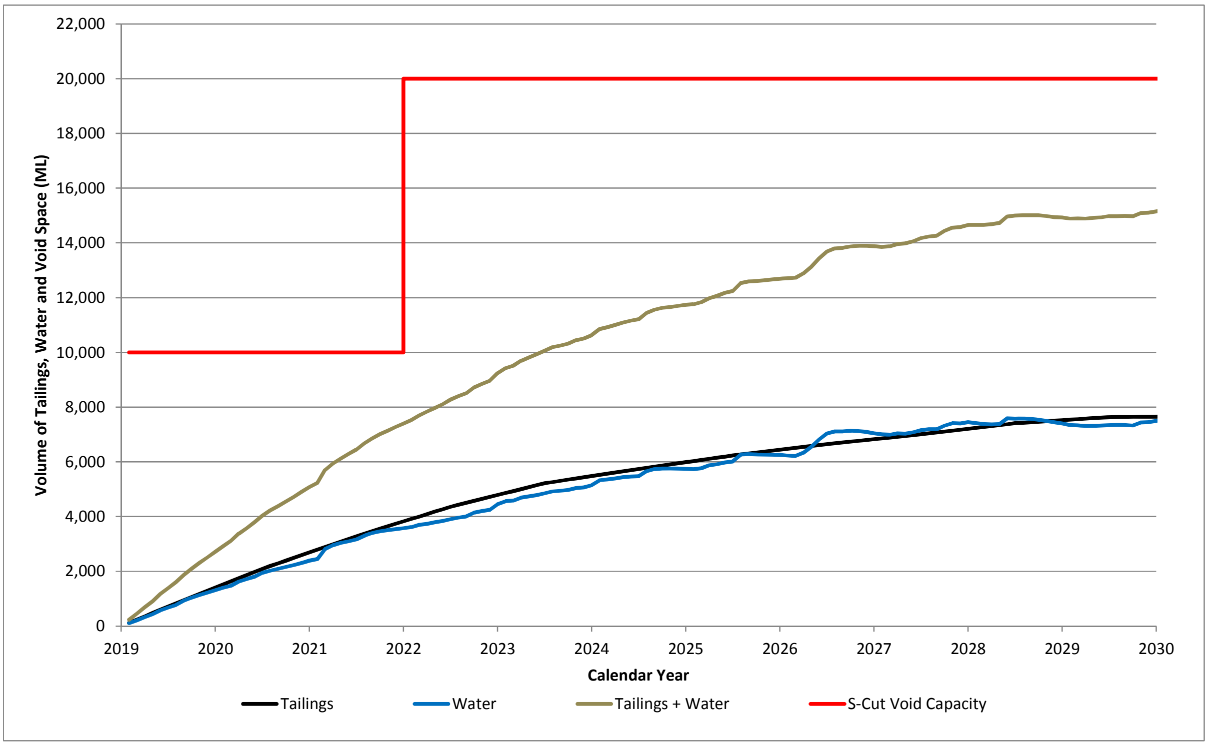

Figure 6.9: Water and Tailings Accumulation for a Median 10 Year Climate Sequence

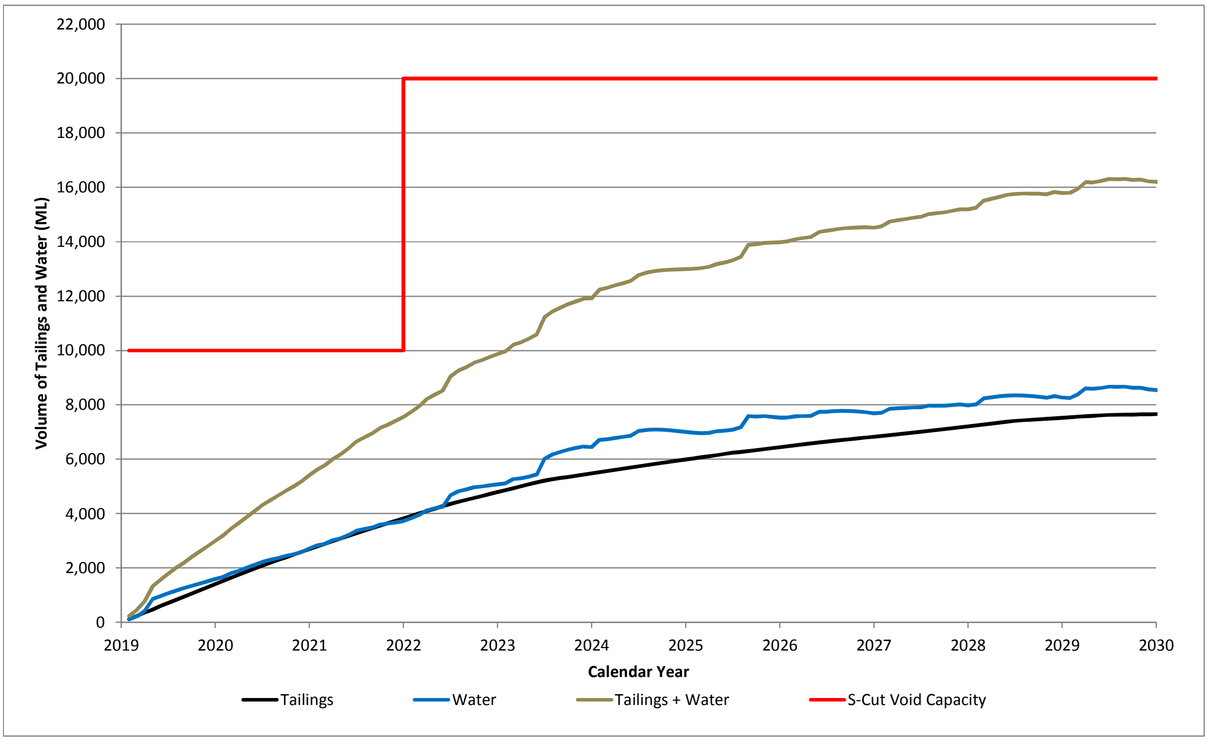

Figure 6.10: Water and Tailings Accumulation for a 1 in 10 Probability Wet 10 year Climate Sequence

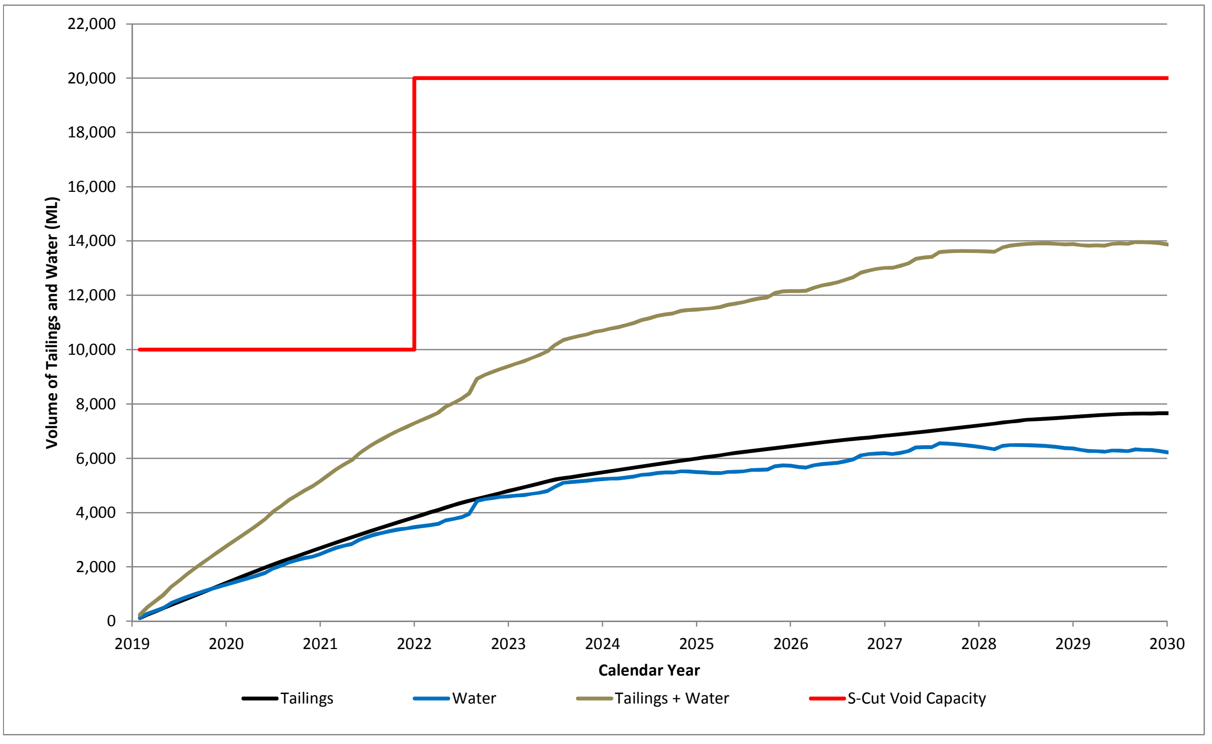

Figure 6.11: Water and Tailings Accumulation for a 1 in 10 Probability Dry 10 year Climate Sequence

These scenarios demonstrate that there is sufficient capacity in the S-Cut (South) and S-Cut (North) to provide storage for excess water and tailings even under 'worst case' conditions in which no use is made of Bloomfield's existing EPL for discharge of water from either of the Bloomfield pits or their contributing catchments.

Key aspects of the performance illustrated in **Figure 6.9** to **Figure 6.11** are:

- For a median climate sequence (**Figure 6.9**) the S-Cut (South) would just fill to its capacity of 10,000 ML (10 million m^3) in the first half of 2023 which would allow for the completion of mining in S-Cut (North) to be completed by 2022, as currently scheduled;
- For a median climate sequence the total volume of water and tailings in the S-Cut (North) at the end of scheduled mining for the Modification would be about 5,000 ML, which is less than half of the estimated capacity of the void;
- For a 1 in 10 probability wet climate sequence (**Figure 6.10**) the S-Cut (South) would just fill to its capacity at the beginning of 2023 which still would allow for the completion of mining in S-Cut (North) to be completed before it was required for storage of tailings and water;
- For a 1 in 10 probability wet climate sequence the total volume of water and tailings in the S-Cut (North) at the end of scheduled mining for the Modification would be about 6,000 ML, which is slightly more than half of the estimated capacity of the void;
- For a 1 in 10 probability dry climate sequence (**Figure 6.11**) the filling of S-Cut (South) would occur slightly later than for the median climate sequence and would also allow for the completion of mining in S-Cut (North) to be completed before it was required for tailings and water;
- For a 1 in 10 probability dry climate sequence the total volume of water and tailings in the S-Cut (North) at the end of scheduled mining for the Modification would only be about 4,000 ML.

Figure 6.12 shows the effect on the rate of filling of the voids in circumstances where 25% of the opportunities to discharge to Four Mile Creek are used to discharge water that would otherwise report to the voids. The figure shows that such a management strategy would delay the filling of S-Cut (South) by 18 months in the case of a wet climate sequence and by about 2 years in the case of median and dry climate sequences. This indicates that, if necessary to delay the filling of S-Cut (North), a strategy could be adopted to direct as much runoff as possible to Lake Kennerson for subsequent discharge to Four Mile Creek in accordance with the requirements of Bloomfield's existing EPL.

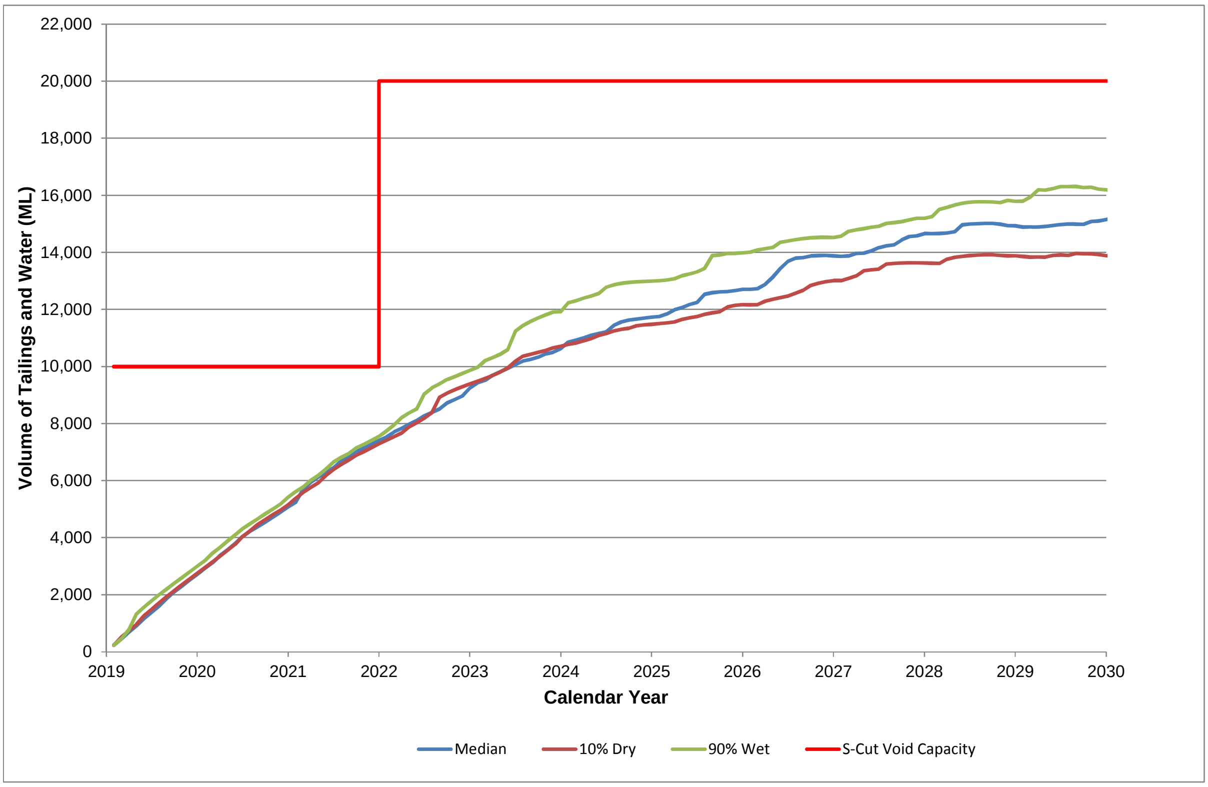

Figure 6.12: Total Water and Tailings Accumulation Different Climate Sequences with Minor Discharge to Four Mile Creek

7 Impacts of Mine Subsidence on Creeks

7.1 Potential Impacts of Mining

The existing approved mine layout for the Abel Underground Mine, and the Modification mine layout, are provided in **Appendix C**.

For the catchments to be undermined during the Modification there are two potential impacts that might lead to a change in the flow regime as a result of underground mining:

- Subsidence effects leading to cracking (which could provide a pathway for loss of water from the catchment or creek channels) or changes in pools (which could lead to a change in the seepage and evaporation loss);
- Changes in groundwater levels leading to a change in the interactions between the groundwater system and the creeks.

7.2 Potential Subsidence Effects on Catchments and Creeks

Subsidence can potentially impact upon the flow regime in a number of ways. However, the Modification mine layout has been designed to maintain the existing subsidence management commitments for the Abel Underground Mine, including limiting mining to first workings only beneath Schedule 2 streams (i.e. third and higher order according to the Strahler classification system), rainforest areas, the Blue Gum Creek alluvium and cliffs.

Therefore, no longwall or shortwall mining would occur beneath these key natural surface features (**Appendix C**).

Potential additional subsidence impacts to flow regime, such as connective cracking, have been mitigated or eliminated by the Modification mine layout design:

- The *Subsidence Assessment* (Mine Subsidence Engineering Consultants, 2012, Appendix A of the EA) concludes that changes in subsidence (i.e. in comparison to predicted subsidence associated with the approved mine plan) would only occur in the longwall and shortwall mining areas.
- The existing subsidence management commitments for Schedule 2 (i.e. third and higher order) streams would be maintained for the Modification. As such, there would be no longwall or shortwall mining beneath any third and higher order streams (i.e. no change in potential impacts).
- Longwall and shortwall mining would occur beneath first and second order streams. However, the approved mine layout includes mining beneath these steams, and as such, the full range of subsidence effects and associated impacts (e.g. cracking) were predicted for the approved mine layout.
- Predicted tilts and curvatures associated with the Modification mine layout (i.e. in the longwall and shortwall areas) are similar to, or less than, the predicted tilts and curvatures associated with approved mine layout. Therefore, no additional potential consequences from subsidence to first and second order streams due to the Modification are predicted, in comparison to those associated with the approved mine plan.

- Potential consequences from subsidence to first and second order streams would include ponding, flooding, scouring, fracturing, bulking and dilation of bedrock, and diversion of surface water flows. In comparison to those associated with the approved mine plan, no additional potential consequences from subsidence to first and second order streams due to the Modification are predicted.
- Existing subsidence mitigation measures, management and monitoring commitments for the Abel Underground Mine would continue for the Modification, including monitoring and regular inspections of first and second order streams, and the catchment land surface, with mitigation and remediation works undertaken as required (as detailed in the existing Water Management Plan).

7.3 Changes in Groundwater / Creek Interactions

The approved underground mine area lies across the headwaters of a number of creek systems:

- Four Mile Creek and Viney Creek that drain in a northerly direction to the Hunter River floodplain to the west of Hexham;
- Blue Gum Creek and its tributary, Long Gully, that drain to the Hexham Swamp via Pambalong Nature Reserve;
- Buttai Creek that drains in a north-westerly direction to join Wallis Creek that drains to the Hunter River near Maitland.

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 mine layout compared those for the approved mine layout. **Figure 7.1** 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. The figure shows that:

- The predicted change to groundwater interactions with Hexham Swamp, Weakleys Flat Creek, Four Mile Creek, Long Gully, Minmi Creek and Blue Gum Creek associated with the Modification mine layout are all less than ±0.1 ML/year in comparison from the approved mine layout;
- The groundwater contribution to baseflow in Viney Creek is predicted to reduce from about 0.4 ML/year in 2013 to about 0.01 ML/year in 2030;
- The groundwater interaction with Buttai Creek is predicted to increase slightly (+0.01 ML/year in about 2018) and then to lose slightly more than originally predicted (-0.17 ML/year) by the end of mining.

To put these changes in perspective, **Table 7.1** shows the maximum change in baseflow (from **Figure 7.1**) compared to the estimated average annual flow in the various creeks. The estimated average annual and 10^{th} percentile (dry) runoff from each catchment has been derived from modelling of catchment runoff using the AWBM model with parameters calibrated against a number of small catchments in the lower Hunter Valley and Central Coast (see **Section 6.4.5** and Evans & Peck, 2012).

As can be seen from **Table 7.1**, the predicted changes in baseflow as a result of the Modification are negligible. Because the changes in baseflow from, and to, the groundwater system are negligible, they would not lead to any measurable additional change to the flow regime of any of the creeks draining from the Abel Underground Mine area.

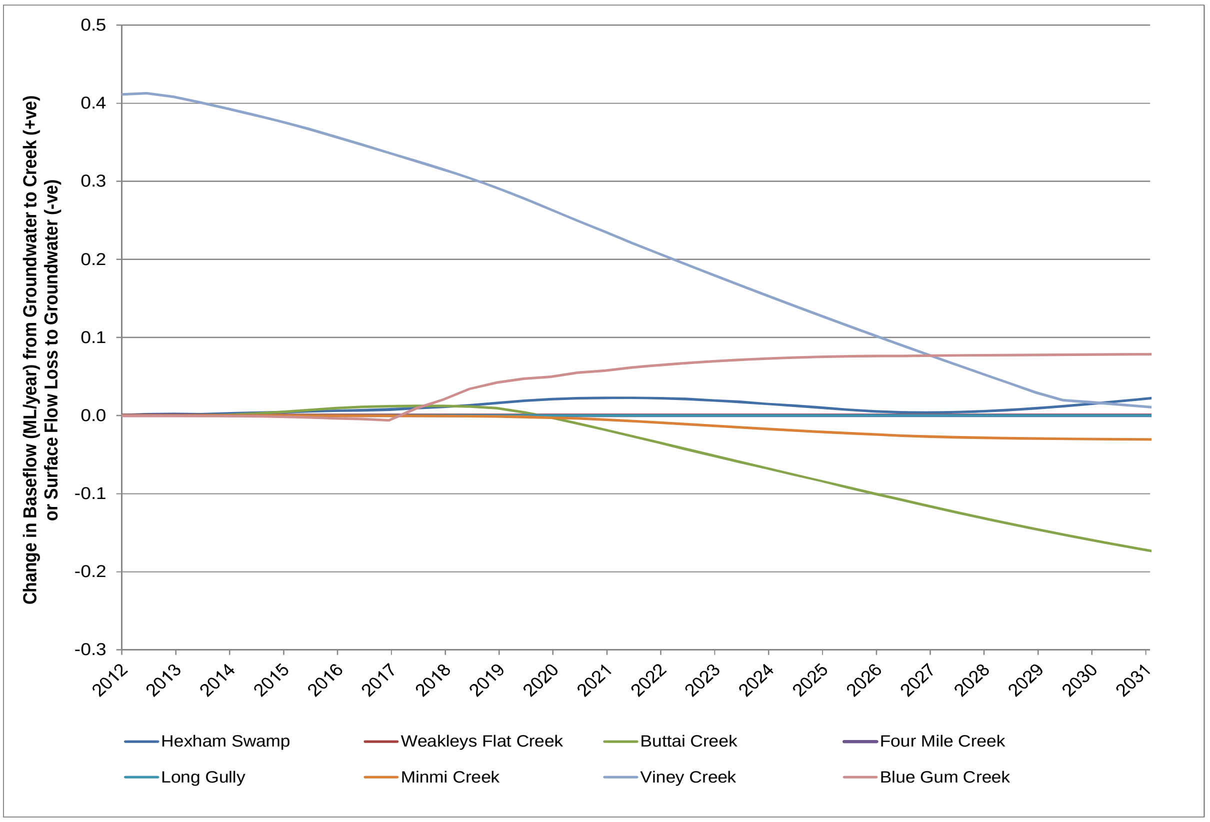

Figure 7.1: Predicted Baseflow Gains and Losses in Potentially Affected Creeks

Table 7.1: Change in Baseflow Attributable to the Modification as a Percentage of Average Annual Runoff

Catchment	Area (ha)	Maximum Groundwater Change (ML/year)	Average Annual Runoff (ML/year)	Change as % of Average Annual Runoff (%)	10th Percentile Annual Runoff (ML/year)	Change as % of 10th Percentile Annual Runoff (%)
Weakleys Flat Creek	839	0.00	1,856	0.00%	517	0.00%
Buttai Creek	2078	-0.24	4,596	-0.01%	1,281	-0.02%
Four Mile Creek	2050	0.00	4,534	0.00%	1,263	0.00%
Long Gully Creek	284	0.00	628	0.00%	175	0.00%
Minmi Creek	647	-0.03	1,431	0.00%	399	-0.01%
Viney Creek	839	0.46	1,856	0.02%	517	0.09%
Blue Gum Creek	1534	0.08	3,393	0.00%	945	0.01%

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8 Surface Water Impacts

8.1 Water Demand and Supply

The analyses in **Section 4** and **Section 5** indicate that at all stages of the life of the Modification:

- Runoff from the Donaldson West Pit (coal stockpile area) and Abel Underground Mine facilities area would be sufficient to meet the needs for dust suppression on the haul road even in a 1 in 10 dry year;
- After allowing for recycling of groundwater inflow to the Abel Underground Mine, the demand for 'top-up' for underground operational purposes would be about 55 ML/year. This requirement can readily be met from the groundwater inflow at all stages of the mine life leaving a significant volume of excess water.

All operational requirements during the Modification are expected to be met from these sources except for potable supply for the offices and bath-house.

8.2 Discharge to Four Mile Creek

To manage the expected volume and salinity of groundwater inflows from the Abel Underground Mine during the Modification, the water management system would involve the construction of an RO plant (inflow capacity 4 ML/day) to provide water of suitable quality for discharge to Four Mile Creek in accordance with the existing EPL No. 11080 held by Donaldson Coal. If required, this system would operate until such time as tailings and excess water could be deposited in the S-Cut (South) void following completion of mining.

The water balance and salinity accounting in **Section 6.5** demonstrates that, with the proposed RO plant and storage of higher salinity water from the Abel Underground Mine in the Donaldson Square Pit, the discharge to Four Mile Creek would only occur in accordance with the existing EPL No. 11080 requirements (i.e. maximum salinity of 2,000 µS/cm and the constraints imposed by prior rainfall).

Following the completion of mining in the Bloomfield S-Cut (South), water from the Abel Underground will be used to service the water requirements for the Bloomfield CHPP and any discharge to Four Mile Creek would revert to existing arrangements for discharge of water from Big Kahuna and Lake Kennerson under the existing EPLs.

8.3 Surface Water Hydrology

Section 7 provides an assessment of the potential impact of the Modification on the hydrology of the creeks that drain from the land above the extraction area. The analysis in those sections indicates that:

- The Modification would not result in additional impacts on drainage patterns, catchment yield or flow regimes in comparison to the approved mine layout.
- The *Groundwater Assessment* predicts that the Modification would result in a negligible change in baseflow from, or to, the creeks in comparison to the approved mine layout.

In view of the above, it is concluded that the Modification will not have any additional impact on environmental flows, basic landholder rights or licensed water users.

8.4 Water Quality

The main potential impact on surface water quality for the Modification relates to discharge to Four Mile Creek. As noted in **Section 8.2**, any discharge to the creek will be in accordance with Donaldson's existing EPL No. 11080. Accordingly, the Modification will not have any additional impact on the water quality in the creek compared to the approved Abel Underground Mine.

The existing water quality and ecological monitoring regime in Four Mile Creek (see **Section 2.4**) will be continued for the Modification.

8.5 Cumulative Impacts

Cumulative impacts from the Modification, West Wallsend, Tasman Underground Mine (and Tasman Extension Project), Donaldson Open Cut Mine and Bloomfield Colliery have been considered in the *Groundwater Assessment* (RPS Aquaterra, 2012), and the effects from these operations are included in the predicted changes in groundwater inflow to the mine and baseflow to creeks used in this surface water assessment.

The *Subsidence Assessment* (Mine Subsidence Engineering Consultants, 2012) considered the cumulative impacts associated with mining of the Borehole seam, and the subsidence predictions have been used to assess potential impacts to surface water in this assessment.

Based on the conclusions presented in **Sections 8.1** to **8.4**, no material additional impacts to surface water flow regime or water quality are predicted due to the Modification.

On this basis, no additional surface water impacts associated with the Modification would be expected when considered cumulatively with other projects in the region.

9 Monitoring, Licensing & Reporting Procedures

9.1 Monitoring

9.1.1 Surface Water Quality Monitoring

Routine water quality monitoring will continue at the existing monitoring sites on Four Mile Creek that are monitored on behalf of Donaldson Coal and Bloomfield Colliery (see **Figure 2.4** for locations):

Site EM1/WM10: Four Mile Creek at John Renshaw Drive;

Site EM2: Four Mile Creek at the Donaldson downstream boundary.

Site WM6 Upstream of "Possums Puddle";

Site WM8 Downstream of "Possums Puddle";

Site WM5 Elwells Creek adjacent to the haul road;

Site WM3 Elwells Creek upstream of the junction with Four Mile Creek;

Site WM12 Shamrock Creek upstream of the junction with Four Mile Creek;

Site WM11 Bloomfield Four Mile Workshops.

Routine water quality monitoring will continue to be conducted as follows:

- Monthly field measurement of temperature, pH, EC, turbidity and DO;
- Monthly collection of water samples for analysis of (pH, EC, TDS, TSS, Sulphate and dissolved iron);
- Quarterly collection of water samples for analysis of turbidity, alkalinity, Chloride, Ca, Mg, Na, K, Al, As, Ba, Cd, Cr, Co, Cu, Pb, Mg, Se, Zn, Fe (dissolved and total), F, N and orthophosphorus.

In addition, as required by Donaldson's EPL No. 11080, daily grab samples will be taken at the discharge point into Four Mile Creek on any days when discharge occurs. These samples will be analysed for

- Conductivity;
- pH; and
- TSS.

Water quality monitoring results will be assessed every six months and reported annually in the relevant Annual Environmental Management Reviews.

9.1.2 Meteorological Monitoring

In compliance with its existing EPL and to provide the required 'trigger' for discharge to Four Mile Creek, meteorological monitoring will continue throughout the life of the Modification.

9.2 Environmental Protection Licensing

The analysis in this Surface Water Assessment indicates that all surface water related aspects of the Modification can be undertaken within the requirements of the existing EPLs held by Donaldson Coal (No. 11080) and Bloomfield Colliery (No. 396). This includes the following aspects related to the Modification:

- Increased rate of extraction from the Abel Underground Mine and the associated increase in groundwater inflow;
- Increased rate of ROM coal processed at the Bloomfield CHPP; and
- The storage of tailings generated by the Bloomfield CHPP.

No changes would be required to either of the EPLs in relation to surface water monitoring and discharge.

10 References

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Appendix A

Water Quality Monitoring Results

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WATER QUALITY MONITORING RESULTS

Table 1 summarises the results of routine monthly water quality monitoring in Four Mile Creek undertaken at the Donaldson Open Cut Mine since 2000 and at the Bloomfield Colliery since 1996.

The monitoring results show a general trend of increasing EC progressively downstream on which a high degree of variability over time is superimposed. Even at monitoring locations in close proximity (e.g. Sites EM1 and WM10, and Sites EM2 and WM6) these are significant differences in the water quality statistics on account of differences in the date of sampling by the two organisations. Other significant aspects of note in the historic water quality data are:

- pH shows some variation over time from slightly acidic to slightly alkaline, but with no significant trend along the creek or in the tributaries (Elwells Creek and Shamrock Creek);
- The average of both salinity and TDS exhibit an increasing trend downstream, but with a noticeable decrease in the vicinity of sites EM2 and WM6 (which are located approximately 700 m apart). The data shows that the two tributaries (Elwells Creek – WM5 and Shamrock Creek – WM12) are significant contributors to the elevated conductivity and TDS at Site WM11 and the New England Highway compared to upstream sites.
- TSS is highly variable over time, with a slight trend towards decreasing TSS downstream (which is consistent with increasing salinity).
- The water quality at site EM2 is significantly influenced by persistent leakage from the Stony Pinch Reservoir belonging to Hunter Water, which drains into Four Mile Creek upstream about 500 m of the site. The effect of this flow is also likely to be reflected at site WM6 (about 500 m downstream of EM2). The flow of good quality water, which is estimated to be of the order of 0.5 ML/day, will cease once Hunter Water are successful in sealing the leak. When this occurs, the water quality at sites EM2 and WM6 can be expected to exhibit an increase in EC that reflects the general downstream trend in increasing EC (e.g. site WM5 on Elwells Creek).

Table 1: Summary of Water Quality Data for Four Mile Creek

	Four Mile Creek Upstream Donaldson	Four Mile Creek@ John Renshaw Dr	Four Mile Creek D/S Donaldson	Four Mile Creek U/S Lake Foster	Elwells Creek Adj Haul Road	Elwells Creel / Four Mile Creek	Shamrock Creek/ Four Mile Creek	Four Mile Creek @ Workshop	Four Mile Creek @ Highway
Site Designation	EM1	WM10	EM2	WM6	WM5	WM3	WM12	WM11	
Collected for[1]	D	B	D	B	B	B	B	B	D
pH									
Mean	6.7	7.2	7.0	6.8	6.7	7.3	7.2	7.4	7.0
10th Percentile	6.4	6.7	6.6	6.4	5.1	6.6	6.8	6.6	6.4
90th Percentile	7.1	7.7	7.4	7.2	7.8	8.0	7.6	8.2	7.6
95th Percentile								8.3	7.6
EC (µS/cm)									
Mean	394	427	180	239	1,969	1,040	1,567	2,394	1,653
10th Percentile	177	200	130	166	450	307	546	455	425
90th Percentile	623	650	257	326	3,970	2,462	2,829	4,816	3,883
95th Percentile								5,228	4,564
Total Dissolved Solids (mg/L)									
Mean	216	296	108	151	1,002	724	902	1,402	518
10th Percentile	78	171	75	73	230	182	310	310	265
90th Percentile	390	426	143	240	2,030	1,048	1,547	3,520	965
Mean	216	296	108	151	1,002	724	902	1,402	518
TSS (mg/L)									
Mean	72	45.4	265	29	39	18.5	41	95	10.5
10th Percentile	6.0	8.0	1.6	1.6	4.0	2.0	1.6	2.9	2.0
90th Percentile	220	107.0	867	67	80	36	99	75	19.5

Note 1: D = Donaldson Mine (2000 – 2011) B = Bloomfield Colliery (1996 – 2011)

STREAM ECOLOGY

Four Mile Creek has been monitored at Sites EM1 and EM2 twice yearly since November 2000 as part of compliance assessment for the mine operation. Additional surveys were also conducted in August 2007 and June 2011 at EM2 and a site in Four Mile Creek downstream of the Bloomfield Colliery discharge location, close to Site WM3. In June 2011 a third site at the New England Highway was also monitored for comparative purposes.

Data collection involved ecological data sampling (diversity, macroinvertebrate index - SIGNAL), RCE, probe measurements (DO, pH, conductivity, turbidity), TDS, TSS and alkalinity. Detailed methods are provided in Robyn Tuft & Associates (2011).

Table 2 summarises the historic ecological assessments for Site EM2 while **Table 3** provides details of the assessments in August 2007 and June 2011.

Table 2: Historical Stream Ecology Monitoring Results: Site EM2

Date	No of Taxa	SIGNAL Index	AusRivas
Baseline	36	5.7	1.04 (Band A)
Autumn, 2001	30	5.3	0.61 (Band B)
Spring, 2001	30	5.8	0.58 (Band B)
Autumn 2002	19	5.4	0.93 (Band A)
Spring 2002	24	5.7	0.57 (Band B)
Autumn 2003	28	5.7	0.73 (Band B)
Spring 2003	27	5.9	0.97 (Band A)
Autumn 2004	31	5.5	
Spring 2004	25	5.5	0.58 (Band B)
Autumn 2005	27	5.6	0.31 (Band C)
Spring 2005	24	5.7	
Autumn 2006	23	4.8	0.68 (Band B)
Spring 2006	20	5.3	0.49 (Band B)
Autumn 2007	20	5.3	0.58 (Band B)
August 2007	22	5.9	0.73 (Band B)
Spring 2007	20	5.4	0.73 (Band B)
Autumn 2008	12	5.9	0.77 (Band B)
Spring 2008	24	5.9	-
Autumn 2009	7	-	0.58 (Band B)
Spring 2009	26	5.7	0.68 (Band B)
Autumn 2010	27	4.9	0.67 (Band B)
Spring 20010	22	5.3	-
Autumn 2011	13	5.4	0.39 (Band C)

Table 3: Four Mile Creek Ecological Monitoring Results August 2007 and June 2011

Site	No. of Taxa	Dominant Taxa	SIGNAL Index	AusRivas O/E (Band)	Ecological Condition Indicated	Vertebrates
August 2007						
Site EM2	22	F. Atyidae (shrimp) F. Leptophlebiidae (mayfly nymphs) F. Baetidae (mayfly nymphs) F. Dytiscidae (beetles) F. Chironomidae (midge fly larvae)	5.9	0.8 Band B	Mildly impaired	F. Gobiidae (gudgeon) (Philypnodon sp)
Site WM3	8	O. Cyclopoida (micro-crustacea) F. Atyidae (shrimp) F. Corixidae (water boatmen) F. Chironomidae (midge fly larvae)	4.1	0.3 Band C	Moderately impaired	F. Gobiidae (gudgeon) (Philypnodon sp) F. Percidae Perca fluviatilis (Redfin Perch)
June 2011						
Site EM2	13	Notonectidae (backswimmer) Atyidae (shrimp) Physidae (freshwater snail) Gyrinidae (beetles) Gerridae (water striders) Hemicordulidae (dragonfly nymphs)	5.4	0.39 Band C	Moderately impaired	-
Site WM3	16	Hydropsychidae (free living caddisfly nymphs) Atyidae (shrimps) Baetidae (mayfly nymphs) Chironimidae (midge larvae) Simulidae (blackfly larvae)	5.4	-	Mildly impaired	F. Gobiidae (gudgeon)
U/S New England Highway	13	Chironimidae (midge larvae) Hemicordulidae (dragonfly nymphs) Simulidae (blackfly larvae) Corixidae (water boatmen bugs) Naididae (worms)	4.3	-	Moderately impaired	-

The results in **Table 3** show that in August 2007 Site EM2 supported a diverse fauna (22 taxa) including sensitive families of macroinvertebrates (mayflies and shrimp) and native gudgeon fish. However, in June 2011 the site only supported a relatively low diversity of fauna (13 taxa) and pollutant sensitive families were restricted to shrimp. These differences in diversity are, however, similar to previously recorded observations such as those in autumn 2008 and 2009 (12 and 7 taxa respectively) (see **Table 2**). In both August 2007 and June 2011, the SIGNAL index at Site EM2 was similar to historic values (**Table 2**) indicating a mildly impaired fauna. However the AusRivas index was lower than historic values in June 2011.

In August 2007, Site WM3 had low diversity of stream fauna (13 taxa) and number of animals collected, which would have limited the accuracy of the SIGNAL index. This may have been due to the residual high flows in the stream as the Bloomfield Colliery had been discharging surplus water for 3 days up until 8 am on the day of sampling. In June 2011 stream fauna diversity had increased compared to June 2007 (16 taxa) and the SIGNAL index, while increased since June 2007, remained in the mildly impaired range. In August 2007, Site WM3 had some sensitive taxa. Native gudgeon and large Redfin Perch (an introduced species) were observed swimming upstream. In June 2011 families included some moderately pollutant sensitive animals as well as more robust fauna and the site also contained native fish species (Cox's gudgeon).

Upstream of the New England Highway, diversity was lower than at WM3 and sensitivity families were restricted to shrimp. The SIGNAL index was also lower, indicating a moderately impaired faunal community. It should be noted that the Highway site would also be influenced by residential runoff from Ashtonfield.

In August 2007, the RCE scores for Four Mile Creek were higher at Site WM3 than at Site EM2 due to improved bed scores, however this is somewhat artificial as the lower flows at Site EM2 allowed some sedimentation. Water quality also differed between the two sites, with Site EM2 being more turbid but lower in conductivity, total dissolved solids and alkalinity. The conductivity at Site WM3 was high (1,600 µS/cm) and suspended solids were also higher at Site WM3. The survey for Bloomfield Colliery (Marine Pollution Research, 1999) concluded that Four Mile Creek conductivity was variable and the aquatic ecosystem was adapted to elevated conductivity because of the coal bearing geology of the catchment. They also found that many of the freshwater fish present were salinity tolerant.

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Appendix B

Tailings Disposal Strategy

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Donaldson Coal

Abel Modification

Tailings Disposal Options

December 2012

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1 Background

The Abel Underground Mine, along with a number of other mines, provides run-of-mine (ROM) coal to the Bloomfield Coal Handling and Preparation Plant (CHPP) for processing and subsequent loading onto rail for transport to the Port of Newcastle. Project Approval (05_0136) for the Abel Underground Mine was granted on 7 June 2007 and provided for:

- Extraction of up to 4.5 million tonnes per annum (Mtpa) of ROM coal from the Abel Underground Mine.
- Processing of up to 6.5 Mtpa ROM coal by the Bloomfield CHPP.

Tailings from the Bloomfield CHPP are discharged as slurry for disposal within the Bloomfield mining lease area. During the period 2003 to 2007 tailings were disposed of via a shaft to the old historic workings underlying the mine lease. At all other times, tailings have been discharged into mine voids or, more recently, to a tailings dam constructed so as to provide additional storage volume in a previously mined void.

The proposed Modification to the Abel Underground Mine (the Abel Modification) would involve the continuation of underground mining within the approved area using a combination of longwall, shortwall and bord and pillar mining leading to increased annual ROM coal production of up to 6.1 Mtpa and an increased throughput of coal at the Bloomfield CHPP and rail load-out facility to accommodate the increased ROM production from the Abel Underground Mine and the proposed Tasman Extension Project.

This report assesses:

- the estimated cumulative volume of tailings generated by the Bloomfield CHPP;
- the projected void spaces available within the Donaldson and Bloomfield mine areas;
- the projected timeline when each void would become available; and
- options for the sequence for commissioning the void spaces for tailings storage.

In particular, this report provides an assessment of options for tailings storage up to about 2018/19 when Bloomfield anticipates completion of mining in the S-Cut (South) which could provide sufficient capacity for the projected life of the Abel Modification and Tasman Extension Project. The completion of mining in the S-Cut (North) in 2022 would provide additional storage. The availability of this void space provides a high degree of certainty that storage space will not be a limiting factor for the various mines that are currently planned to contribute ROM coal to the Bloomfield CHPP. The key issues are the timing of various voids becoming available between filling of the existing tailings dam and the S-Cut (South) becoming available and whether some void space should be reserved for storage of excess saline mine water from the Abel Underground Mine.

In the course of development of options for future storage of tailings from the Bloomfield CHPP, a range of alternatives were explored. In order to avoid any confusion with strategy scenarios assessed in the earlier reports (numbered Scenarios 1, 2 and 3), scenarios in this report, which represent variations of Scenario 1 in the earlier report, have been numbered Scenarios 1A, 1B and 1C.

2 Existing Tailings Disposal

Tailings from the Bloomfield CHPP are discharged from the thickener as slurry and conveyed by pipeline to the tailings dam known as 'U-Cut North' located about 1.5 kilometres (km) north-east of the Bloomfield CHPP as shown on **Figure 1**.

Figure 1:
Aerial Photograph Showing the Bloomfield CHPP and Tailings Dam

The slurry from the Bloomfield CHPP, which is reported to have a specific gravity of about 1.12, is discharged at a number of different locations into the tailings dam by means of an open pipe laid on the ground or via a channel to convey the slurry to the required discharge point. A pontoon mounted pump system in the south-west corner of the dam returns supernatant water to 'Lake Foster' from which water is drawn for the Bloomfield CHPP. Water is also pumped to 'Lake Foster' from the 'Shamrock Lane Sump' located immediately below the wall of the tailings dam. Typical quality of water from these two sources is set out in **Table 1**.

Table 1: Tailings Dam Water Quality Characteristics

	Tailings Dam	Shamrock Lane Sump
Electrical conductivity (µS/cm)	8,000	5,200
pH	8.0	6.6
Filterable iron (mg/L)	-	2.0

The data in **Table 1** indicates that the water from the tailings dam has salinity above Bloomfield's EPL discharge limit (6,000 µS/cm) and the water from the Shamrock Lane sump exceeds the licence limit for filterable iron (1 mg/L). Accordingly, water from these two sources is maintained in a separate 'closed' system that is then recirculated used to supply the Bloomfield CHPP.

There are no direct measurements of the average density following settlement and consolidation of tailings. However, surveys of the tailings dam at the beginning and end of 2011 indicate an increase in the volume of deposited tailings of 540,000 m^3 from a total of 3.2 million tonnes of ROM washed in the Bloomfield CHPP during the year (0.17 m^3/tonne of ROM).

3 Projected ROM and Tailings Production

Table 2 summarises the projected future delivery of ROM to the Bloomfield CHPP for the life of each contributing mine.

Table 2: Projected ROM Production for Mines Delivering to the Bloomfield CHPP

Year Ending	Bloomfield Open Cut	Donaldson Open Cut	Tasman Underground	Tasman Extension	Abel Underground	Total
June	(t x 1000)	(t x 1000)	(t x 1000)	(t x 1000)	(t x 1000)	(t x 1000)
2013	1,300	900	275	-	2,726	5,201
2014	1,300	-	578	-	4,513	6,391
2015	1,300	-	185	766	6,125	8,376
2016	1,300	-	-	1,155	6,065	8,520
2017	1,300	-	-	1,428	5,410	8,138
2018	1,300	-	-	1,428	5,646	8,374
2019	1,300	-	-	1,428	5,732	8,460
2020	1,300	-	-	1,500	5,383	8,183
2021	1,300	-	-	1,500	4,258	7,058
2022	1,300	-	-	1,500	3,572	6,372
2023	-	-	-	1,500	3,584	5,084
2024	-	-	-	1,428	1,665	3,093
2025	-	-	-	1,428	1,492	2,920
2026	-	-	-	1,428	1,039	2,467
2027	-	-	-	1,017	1,095	2,112
2028	-	-	-	464	1,942	2,406
2029	-	-	-	462	851	1,313
2030	-	-	-	241	-	241

Table 3 summarises estimates of the percentage of ROM delivered to the Bloomfield CHPP which comprises of coarse rejects (disposed of with overburden from the Bloomfield Colliery mining operation) and fine tailings (disposed of to the tailings emplacement). The 2012 estimate of fine tailings from underground sources (last row in **Table 3**) has been derived by calculating the difference between the mass of ROM delivered to the Bloomfield CHPP and the sum of the product coal loaded onto rail and the coarse rejects. Because the 2012 estimate of fine tailings relies on the accuracy of weighing of three relatively large numbers, the analysis can give erroneous values (such as a negative value for the mass of fine tailings) and represent a 'best guess' rather than a measured value.

Table 3: Estimated Percentage of Coarse Rejects and Fine Tailings for Different Sources of ROM

ROM Source	Coarse Rejects	Fine Tailings	Data Source
Open Cut	21%	14%	2006 Abel Environmental Assessment
Underground	12%	8%	2006 Abel Environmental Assessment
Abel Underground	19%	13%	Donaldson Coal

It can be seen that the 2012 estimate of the percentage of fine tailings from underground ROM sources indicate that there is little difference between this and the assumed percentage from open-cut sources. Given this lack of significant difference, it is assumed that future projections of the volume of tailings do not need to take account of the projected change in the proportions of open-cut and underground ROM being fed to the Bloomfield CHPP. Accordingly, the 2011 survey data from Bloomfield provides the best available basis for estimating future requirements for storage of tailings (0.17 m^3/tonne of ROM). **Table 4** summarises the estimated volume and annual volume of fine tailings that would need to be stored based on the ROM production schedule in **Table 2**. **Table 4** also summarises the estimated volumes of coarse rejects.

Coarse rejects from the Bloomfield CHPP would continue to be mixed with overburden material and disposed of under advancing overburden emplacement dumps at the Bloomfield Colliery, and as such, no further consideration of coarse reject disposal is required.

Table 4: Estimated Volume of Fine Tailings

Year Ending June	Fine Tailings Volume		Coarse Reject Volume	
	Annual (m^3 x 1000)	Cumulative (m^3 x 1000)	Annual (m^3 x 1000)	Cumulative (m^3 x 1000)
2013	878	878	779	0
2014	1,078	1,956	699	699
2015	1,413	3,370	737	1,436
2016	1,438	4,807	886	2,322
2017	1,373	6,181	1,155	3,477
2018	1,413	7,594	1,175	4,652
2019	1,428	9,021	1,123	5,775
2020	1,381	10,402	1,155	6,930
2021	1,191	11,593	1,167	8,097
2022	1,075	12,669	1,129	9,226
2023	858	13,526	976	10,202
2024	522	14,048	883	11,086
2025	493	14,541	690	11,776
2026	416	14,957	420	12,195
2027	356	15,314	396	12,592
2028	406	15,720	335	12,926
2029	222	15,941	287	13,213
2030	41	15,982	327	13,540

4 Available Tailings Storage

In addition to the available space in existing tailings dam (U-Cut (North) – estimated to be about 2,285,000 m^3 as at the end of June 2012), there are a number of options for storage of tailings in voids once mining is completed. The location of the Bloomfield CHPP and associated facilities (Lake Foster and the rail loop) together with various storage options are shown on **Figure 2**. The projected void space and timing are summarised in **Table 5**.

Figure 2:
Location of Tailings Storage Options

Table 5: Summary of Tailings Disposal Options

Void	Date Available	Volume (m^3 x 1,000)	Notes
Bloomfield: U-Cut (North) - existing	Current	2,285	Assumes no enhancement
Bloomfield: U-Cut (South)	2014	1,200	Bunds and pipework required
Donaldson: Square Pit	Early 2013	2,900	3.5 km pipeline required
Donaldson: Square Pit + 4 m Embankment	Construct if required	1,000	3.5 km pipeline required
Bloomfield: S-Cut (South) - Interim	Construct if required	1,200	4 km pipeline
Bloomfield: S-Cut (South)	End 2018	10,000	3 km pipeline required
Bloomfield: S-Cut (North)	End 2022	10,000+	2 km pipeline required
Total projected volume		**28,585+**	

In the long term, once mining has been completed in the Bloomfield pits, there will be two large voids available for storage of tailings:

- S-Cut (South) 11,200,000 m^3 – mining scheduled to be completed in late 2018;
- S-Cut (North) 10,000,000 m^3 (est.) - mining scheduled to be completed in late 2022.

In the interim, however there are a number of options for storing smaller volumes of tailings:

1. Providing bunding on the existing filled area to the south of U-Cut North as shown on **Figure 3** in order to provide an estimated 1,200,000 m^3 of storage.
2. Temporary works in the south-west corner of the Bloomfield S-Cut (South) as shown on **Figure 4** to provide interim storage of about 1,200,000 m^3 prior to mining being completed in the remainder of S-Cut (South) which would provide an additional 10,000,000 m^3.
3. Use of the Donaldson Square Pit once mining is completed in early 2013. Without any additional earthworks, a volume of 2,900,000 m^3 would be available (however, the use of this void for tailings might limit the duration for which the void could be used for storage mine water that is too saline for discharge to Four Mile Creek under Donaldson's existing EPL).
4. Additional storage volume could be provided in the Donaldson Square Pit by construction of an embankment (say 5 m high) along the north-western boundary that would allow storage of a further 4 m depth of tailings (about 1,000,000 m^3). **Figure 5** shows an indicative alignment for an embankment.

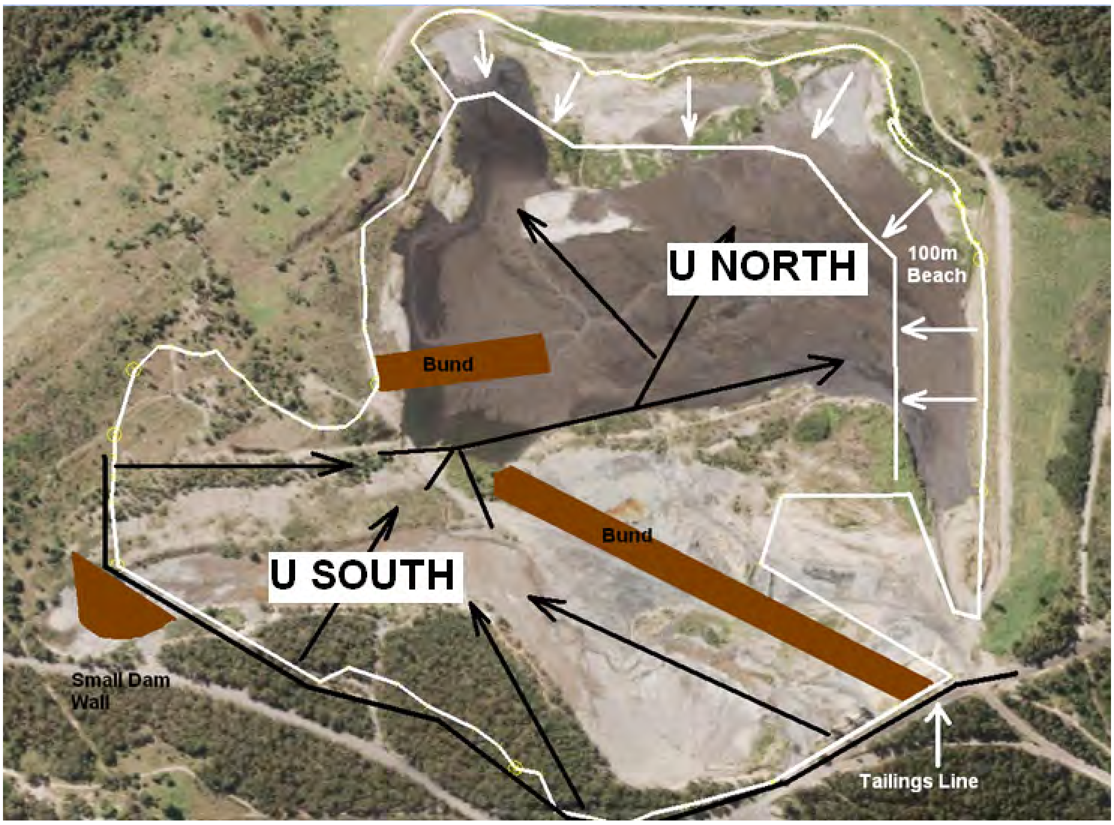

Figure 3:
Concept Development for U-Cut (South)

Figure 4:
Concept Development for S-Cut (South) Interim Storage

Figure 5:
Concept Development for Embankment on Donaldson Square Pit

5 Tailings Disposal

The actual volume occupied by tailings reduces over time as the tailings consolidate from an initial dry density of as low as 0.4 t/m^3. The technical literature indicates that the final settled dry density is a function of:

- The specific gravity of the fine tailings particles (typically in the range of 1.7 – 2.0 for coal);
- The method of discharge (sub-aqueous deposition, which approximates to the current method of disposal typically leads to settled dry density following consolidation of up to 0.6 t/m^3);
- The under drainage arrangements (free underdrainage speeds up consolidation while elevated local groundwater tends to slow the consolidation process).

Assuming 14% fine tailings from both underground and open-cut ROM coal, the observations of the increased volume of tailings in the Bloomfield tailings dam during 2011 imply an average settled density in the dam (including allowing for consolidation of previously deposited tailings) of the order of 0.85 t/m^3. This implied density, is however, highly dependent on the assumed percentage of fine tailings in the ROM coal.

The implied density in the U-Cut (North) is comparable to:

- Antiene Void: measured dry density of tailings after 3 years of consolidation = 0.9 t/m^3 (Lyall & Macoun Consulting Engineers, 1994); and
- Goonyella Riverside Mine: implied dry density of 0.8 – 1.3 t/m^3 for fine tailings percentages of 5% to 8% (URS 2006).

For purposes of assessing future requirements for storage of tailings from the Bloomfield CHPP, the tailings volume per tonne of ROM derived from the 2011 survey has been adopted.

Based on the cumulative volume of tailings listed in **Table 4** and the timing of various voids becoming available (**Table 5**), and following discussion with Abel Underground Mine personnel, three scenarios are presented below. (Note that, in order to avoid confusion with scenarios set out in an earlier version of this report, these scenarios are listed as Scenarios 1A, 1B and 1C).

5.1 Scenario 1A

This scenario is based on the observed increase in volume of tailings per tonne of ROM from the 2011 survey at Bloomfield. This is considered a ‘worst case’ because it does not account for further consolidation of tailings over time. For this scenario the adopted objectives are to:

- Utilise readily available storage voids;
- Utilise S-Cut (South) when necessary.

The following sequence of commissioning of interim storages has been adopted for this scenario:

- Construction of U-Cut South;
- Utilisation of Donaldson Square Pit;
- Utilisation of S-Cut (South) once mining is completed.

Figure 6 shows the results of this analysis which indicates that:

- The existing tailings dam would be full by mid-2014;
- The construction of U-Cut (South) would provide sufficient storage until mid-2015;
- The Donaldson Square Pit would provide sufficient storage until mid-2017 when S-Cut (South) would be required for tailings storage;
- The void space in S-Cut (South) would be sufficient to contain all tailings until the scheduled completion of mining at the Abel Underground Mine and Tasman Extension Project.

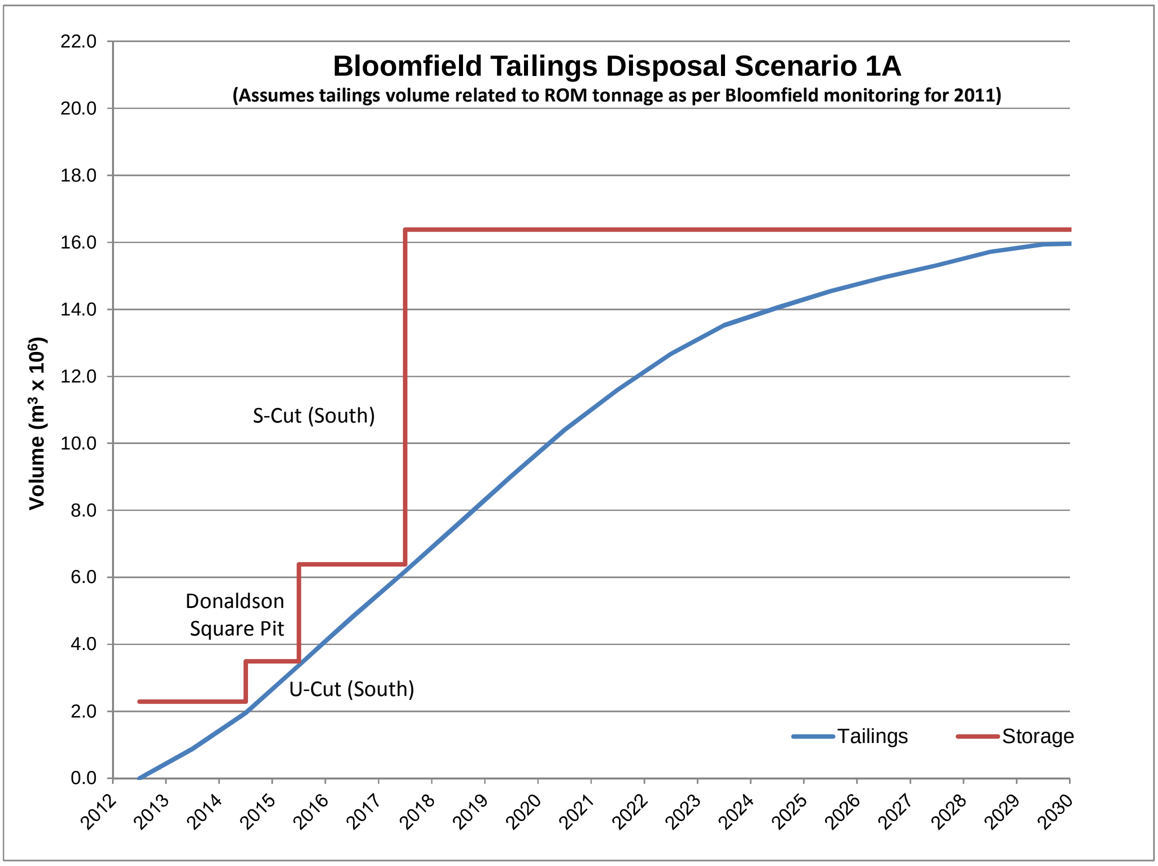

Figure 6:
Cumulative Tailings Volume and Assumed Staging of Storages – Scenario 1A

5.2 Scenario 1B

Scenario 1B adopts the same projected increase in the volume of tailings as Scenario 1A. For this scenario the adopted objectives are to:

- Delay the requirement for use of the Bloomfield S-Cut (South) by utilising the interim storage in S-Cut (South – Interim);

The following sequence of commissioning of interim tailings storages has been adopted:

- Construction of U-Cut South;
- Utilisation of Donaldson Square Pit;
- Construct the interim storage in the south-west corner of S-Cut (South);
- Utilisation of S-Cut (South) when necessary.

Figure 7 shows the results of this analysis which indicates that:

- The existing tailings dam would be full by mid-2014;
- Commissioning of U-Cut (South) would provide storage until mid-2015;
- Tailings would then be placed in the Donaldson Square Pit for about 2 years (to mid-2017);
- Commissioning of S-Cut (South – Interim) would provide storage for about another year (to mid-2018);
- S-Cut (South) would be required by mid-2018, which is slightly ahead of the proposed completion of mining;
- S-Cut (South) would have over 1.5 million m^3 of storage space remaining after the scheduled completion of mining at the Abel Underground Mine and Tasman Extension Project.

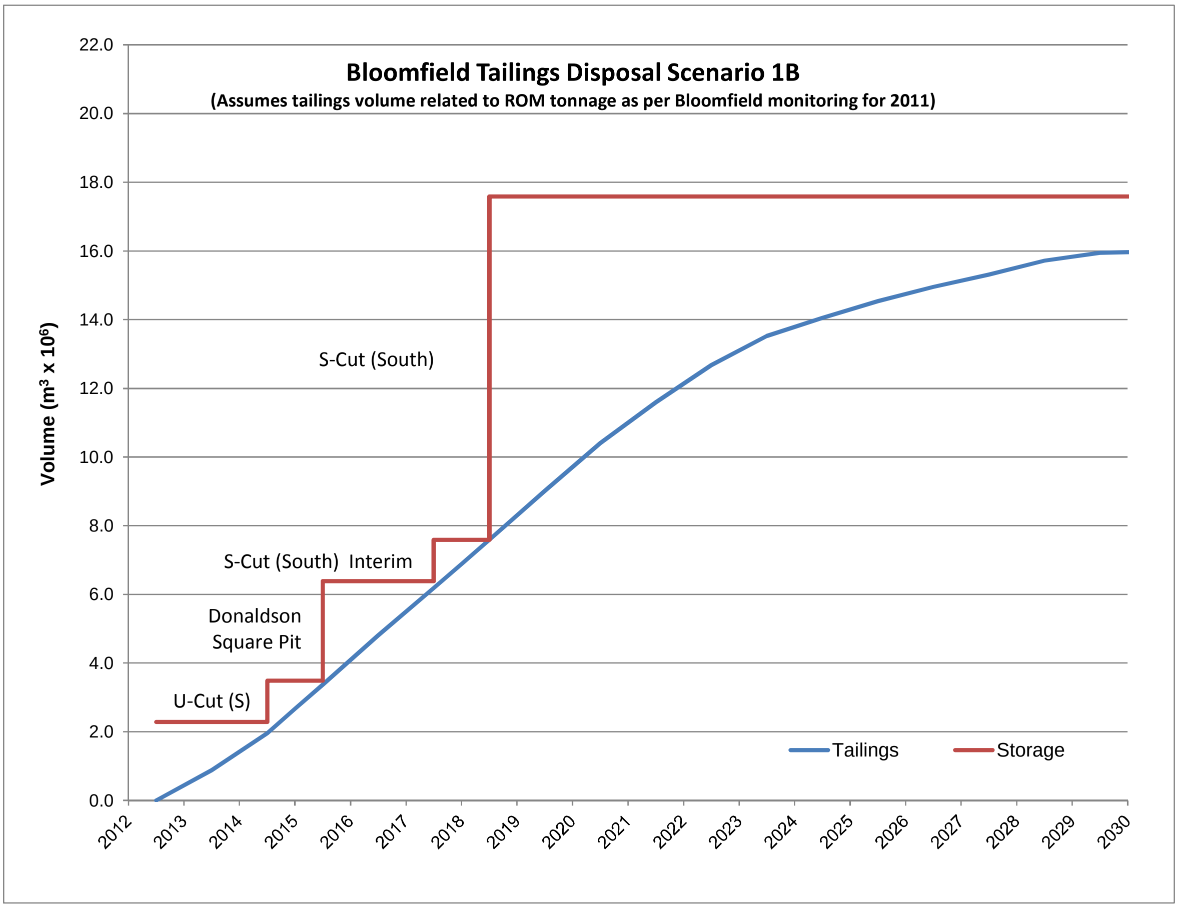

Figure 7:
Cumulative Tailings Volume and Assumed Staging of Storages – Scenario 1B

5.3 Scenario 1C

Scenario 1C adopts the same projected increase in the volume of tailings as Scenario 1A. For this scenario the adopted objective is to:

- Delay the requirement for use of the Bloomfield S-Cut (South) until after the scheduled completion of mining in late 2018;

The following sequence of commissioning of interim tailings storages has been adopted:

- Construction of U-Cut South;
- Utilisation of Donaldson Square Pit;
- Construction of an embankment to increase the capacity of the Donaldson Square Pit;
- Construct the interim storage in the south-west corner of S-Cut (South);
- Utilisation of S-Cut (South) once mining is completed.

Figure 8 shows the results of this analysis which indicates that:

- The existing tailings dam would be full by mid-2014;
- By the use of all the interim storage options, the requirement for tailings storage in S-Cut (South) could be delayed until the beginning of 2019. This would allow completing of mining in accordance with the current schedule. (Note that the sequence of commissioning the various smaller interim storages would not alter this outcome);
- S-Cut (South) would have over 2 million m^3 of storage space remaining after the scheduled completion of mining at the Abel Underground Mine and Tasman Extension Project.

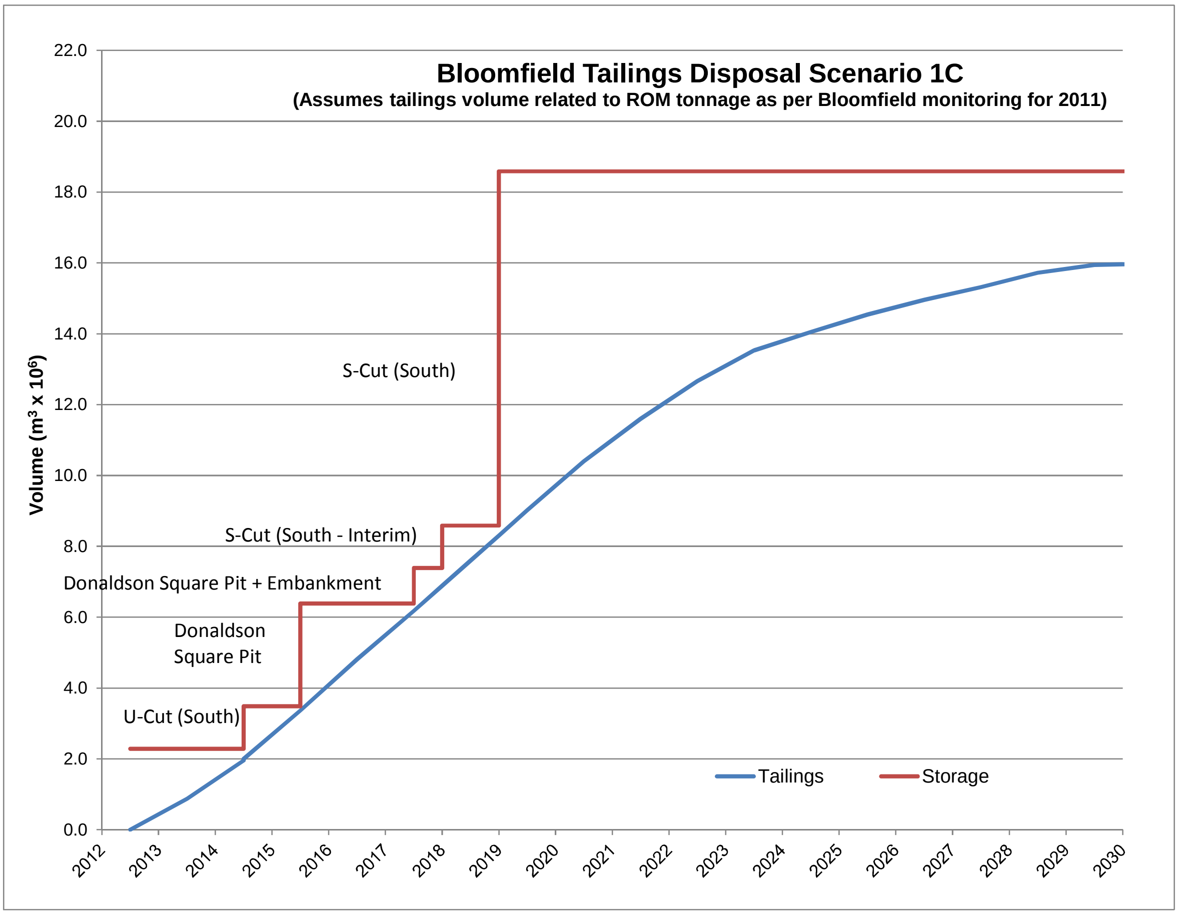

Figure 8:
Cumulative Tailings Volume and Assumed Staging of Storages – Scenario 1C

6 Conclusions and Recommendations

The tailings disposal strategy options assessed in this report are based on the observed volume of tailings per tonne of ROM accumulated in the Bloomfield U-Cut (North) during 2011.

Key features of the scenarios assessed in this report are:

- Scenario 1A would allow storage of the total anticipated volume of tailings in the U-Cut, Donaldson Square Pit and the S-Cut (South). However, it would be likely to require the placement of tailings into the S-Cut (South) prior to the scheduled completion of mining and would, therefore, result in some sterilisation of coal resource.
- Scenario 1B is would involve the commissioning of the S-Cut (South-Interim) storage once the Donaldson Square Pit was full. This would delay the need for placement of tailings in S-Cut (South) until mid-2018, which would be slightly before the scheduled completion of mining in late 2018.
- Scenario 1C would involve the construction of an embankment to increase the capacity of the Donaldson Square Pit and temporary works in the south-west corner of the S-Cut (South). These interim works would delay the need for placement of tailings in S-Cut (South) until after the scheduled completion of mining.

Because there is some uncertainty about the actual rate of ROM delivery to the Bloomfield CHPP and the volume of tailings following consolidation, the proposed strategy involves:

- Placing the maximum volume of tailings into the U-Cut (North and South) while progressively monitoring the rate of increase in the volume of tailings and ROM throughput in the Bloomfield CHPP;
- Transferring tailings disposal to the Donaldson Square Pit while continuing to monitor the increase in volume and regularly update the estimated date when the Donaldson Square Pit will be full;
- Delaying any decision for as long as possible to determine whether the S-Cut (South-Interim) would provide sufficient capacity to allow the scheduled completion of mining in S-Cut (South)
- If necessary, constructing an embankment along the western side of the Donaldson Square Pit to provide additional storage. If consolidated tailings density is found to be greater than inferred from the observations in the U-Cut (North) in 2011, or ROM production does to reach the scheduled rates, construction of an embankment to increase the capacity of the Donaldson Square Pit may not be required.

Currently tailings disposal is carried out using the ‘sub-aqueous’ method which discharges tailings at or under the level of the water. The tailings literature (e.g. Swarbrick, 2008) quote consolidated density for this method in the range of 0.4 to 0.6 t/m^3. However, by utilising ‘sub-arterial’ discharge and active management of surface drainage, the literature quotes consolidated density of 1.0 to 1.5 t/m^3. Whilst the <u>inferred</u> density achieved in the U-Cut (South) in 2011 (0.85 t/m^3) is greater than the literature values, the quoted higher density achieved by ‘sub-arterial’ discharge suggests that modification of tailings management could help extend the life of the existing dam and other interim storages and thereby reduce the requirement for use of the small the interim storages identified in Scenario 1C.

7 References

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Appendix C

Mine Layout Plans

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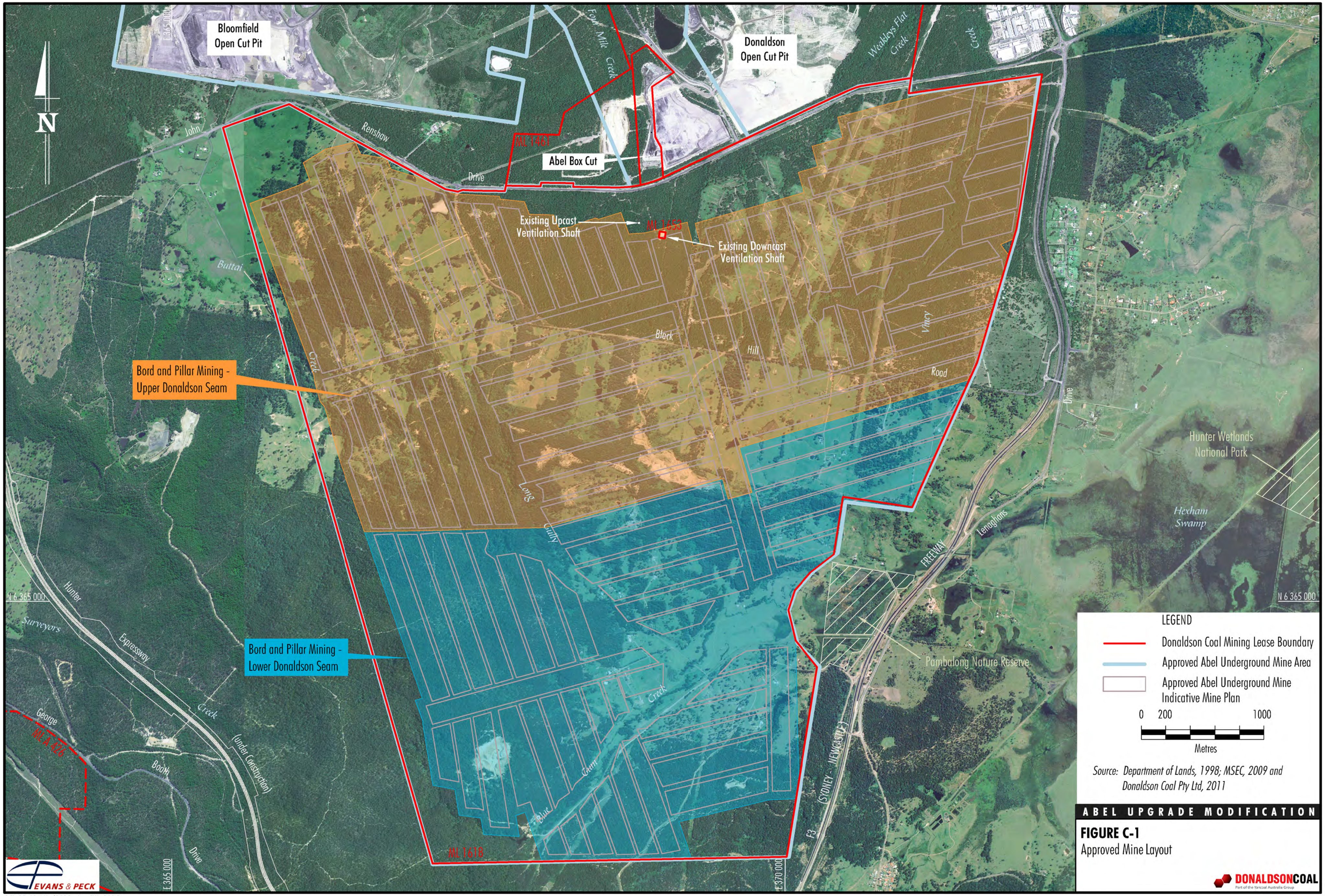

FIGURE C-1
Approved Mine Layout

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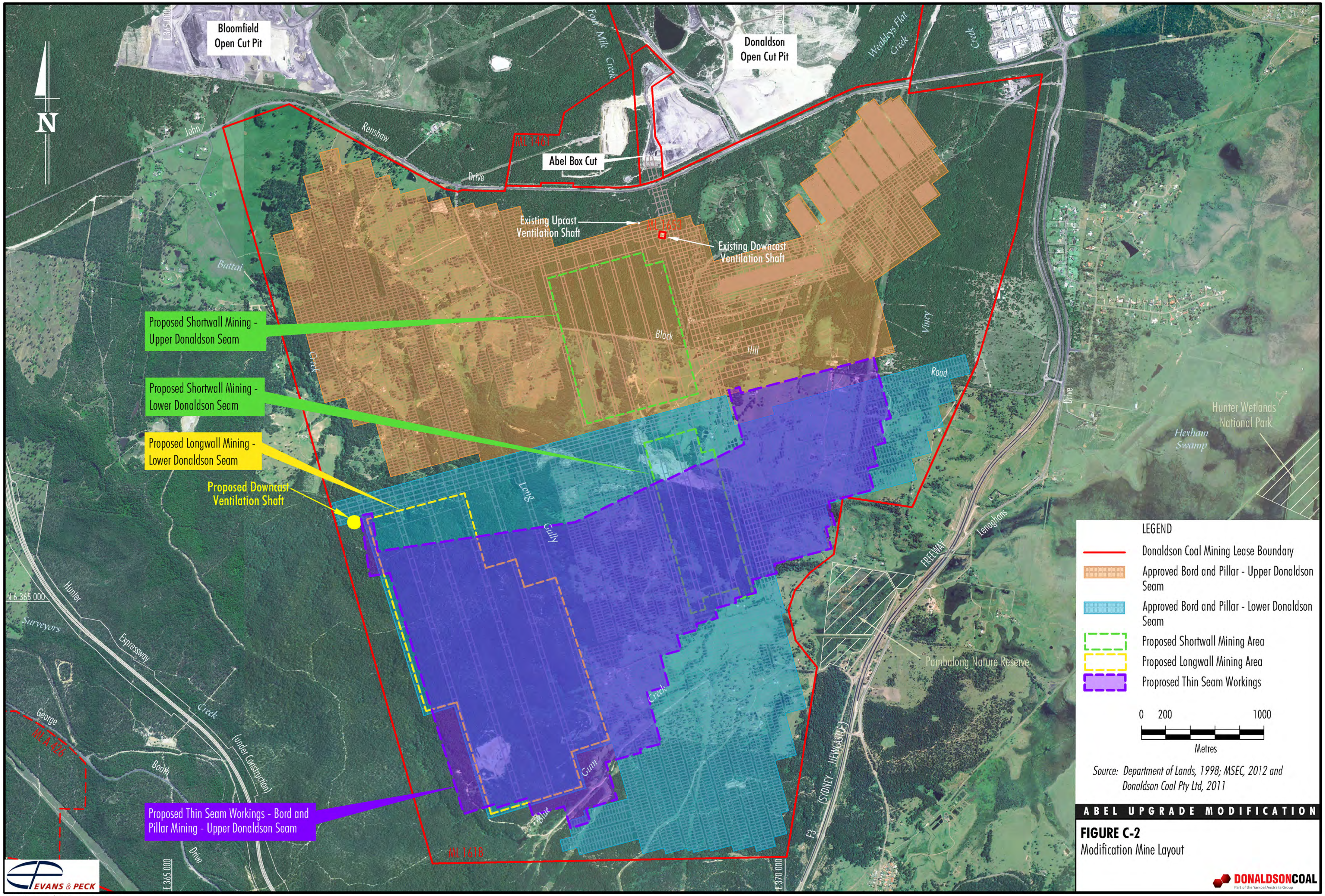

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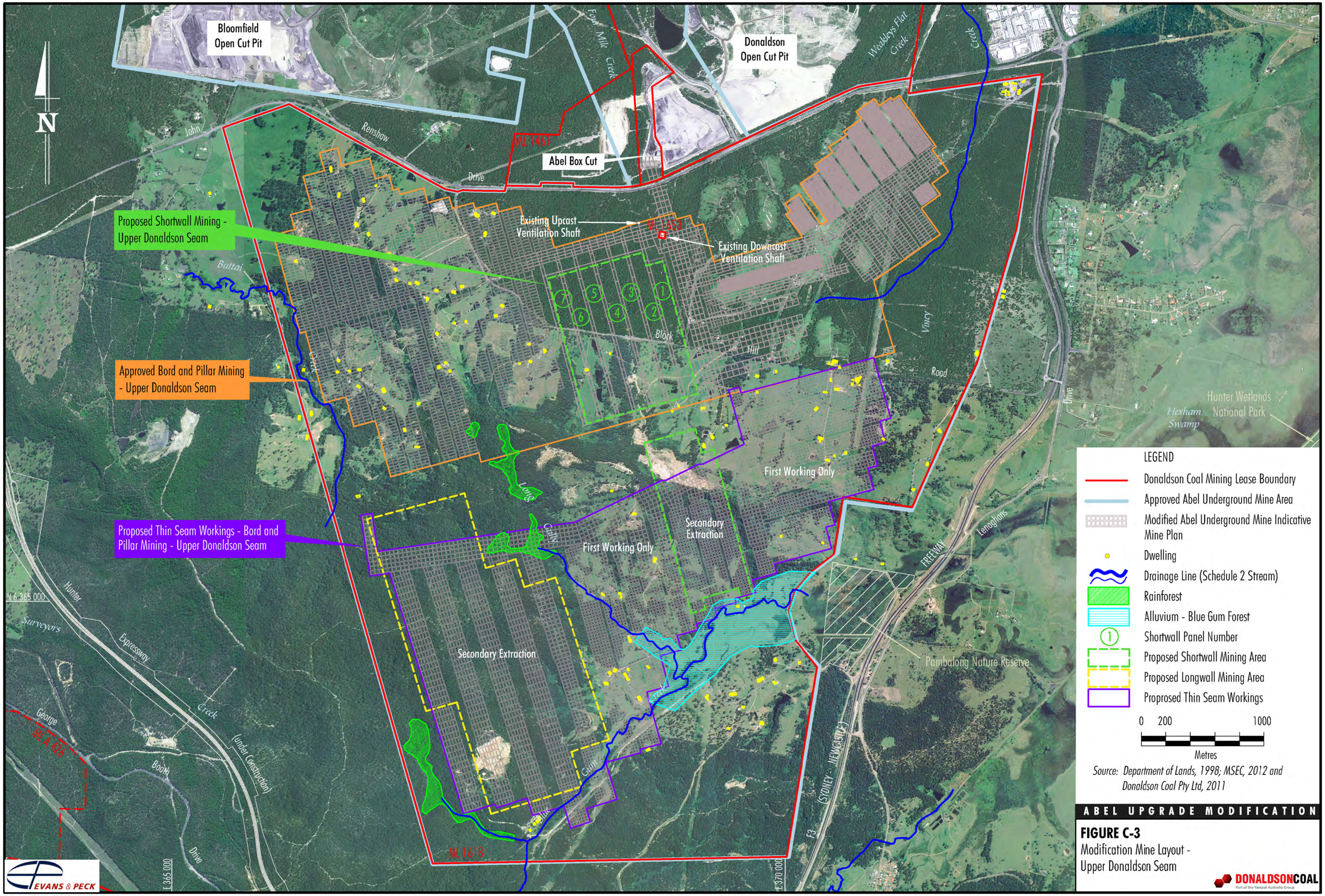

ABEL UPGRADE MODIFICATION

FIGURE C-3
Modification Mine Layout - Upper Donaldson Seam

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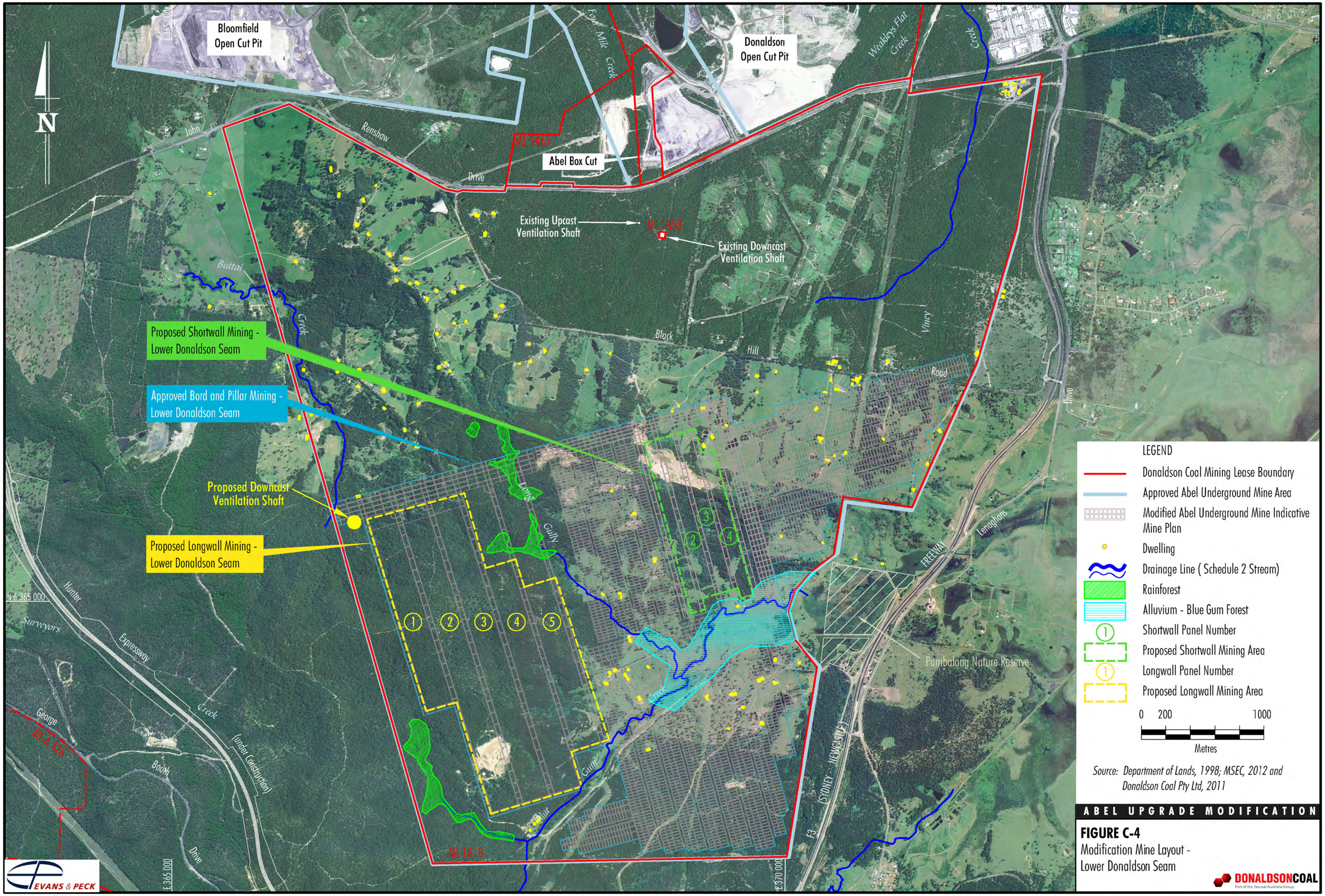

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