Mt Piper Power Station
Ash Placement Project

APPENDIX D

HYDROLOGY AND WATER QUALITY

- August 2010

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1. Introduction

1.1. Background

Delta Electricity owns and operates Mt Piper Power Station, a coal fired power station located approximately 17km north-west of Lithgow. As part of the operation of this power station, ash is created and required to be stored on-site, unless otherwise sold for beneficial reuse purposes.

Delta has identified a need to expand its current ash placement facilities, which service the Mt Piper Power Station, to enable the further placement of ash once the existing ash storage area has reached capacity. Previous feasibility and site selection studies have selected four broad sites on which Delta is undertaking planning and assessment activities to obtain relevant approvals for ash placement. The four sites are described as:

- Lamberts North;
- Lambert South;
- Neubecks Creek; and
- Ivanhoe No. 4.

With the ongoing operation of Units 1 and 2 at Mt Piper, the present ash placement area is expected to reach capacity within five to six years. Accordingly, there is a need to obtain development consent for ash placement beyond this time and throughout the power station’s economic life.

As such, Delta is seeking Concept Approval and Project Approval for two of the proposed placement sites Lamberts North and Lamberts South and Concept Approval for the future development of Neubecks Creek and Ivanhoe No.4. Lamberts North and Lamberts South are currently being mined for coal and Project Approval is being sought for these sites to allow for their development for ash storage from around 2015.

The ash storage available at Lamberts North and Lamberts South is sufficient to provide for the existing Mt Piper Power Station Units 1 and 2 until about 2042-2045, which is the effective life of the plant.

A proposal to extend the generation capacity at the power station site by the construction of an additional 2000MW of gas or coal fired generation capacity was considered by the Department of Planning under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Concept approval was issued for the new power station, called Mt Piper Extension, on 12 January 2010.

If the Mt Piper Extension project proceeds as a coal fired plant, the life of Lamberts North and Lamberts South would be less and they would effectively be filled by about 2026.

Concept approval only is being sought for Neubecks Creek and Ivanhoe No 4 as it is necessary to provide additional ash storage should Mt Piper Extension proceed as a coal fired plant. Should Mt Piper Extension proceed as a coal-fired plant project approval for the use of Neubecks Creek and Ivanhoe No 4 as ash storage areas would be required before 2026.

The objectives of the proposal are:

- To provide suitable ash placement areas to ensure the ongoing operation of the existing power station beyond 2015, in order to maintain the existing level of power supply in NSW;
- To provide sufficient storage areas for ash from the proposed Mt Piper Extension power station should it be coal fired; and
- To minimise and manage any environmental or social impacts which may result from the construction and operation of the proposed ash placement areas.

The general location of the Mt Piper Ash Placement areas is shown in **Figure 1-1. Figure 1-2** shows the location of the Lamberts North and Lamberts South ash placement areas.

1.2. Assessment Requirements

The Director-General’s requirements for the Environmental Assessment were issued in February, 2010. The requirements specific to water management are:

- For Neubecks Creek and Ivanhoe No 4 sites (concept plan application only) include an analysis of potential surface water, hydrology, groundwater and water supply constraints to the development of these sites including available mitigation and/or management options that may be applied to achieve acceptable environmental outcomes, with consideration of cumulative impacts from the project and other existing or proposed activities in close proximity to the project site. The assessment must demonstrate sufficient water supply availability to accommodate the requirements of the concept plan as a whole and that these sites can be developed without significant risks to hydrology or groundwater resources, with consideration to cumulative impacts. Key water related risk factors and/or design criteria that would require further detailed investigation prior to the development of these sites must be identified.
- For the Lamberts North and Lamberts South sites the Environmental Assessment must characterise and assess site hydrology and water management including drainage, stormwater, flooding and water supply and provide an assessment of potential risks to surface water and groundwater quality with consideration of relevant State policies and ANZECC water quality guidelines. The water quality investigations must address the cumulative impacts on water of the proposal in conjunction with other activities in the area such as power generation, coal mining and a landfill, in particular the potential impact on the Coxs River system, Huon Creek and Neubecks Creek. The Environmental Assessment must

provide details of proposed water quality monitoring during construction and operation so as to assess changes to the quality of receiving waters and the groundwater table.

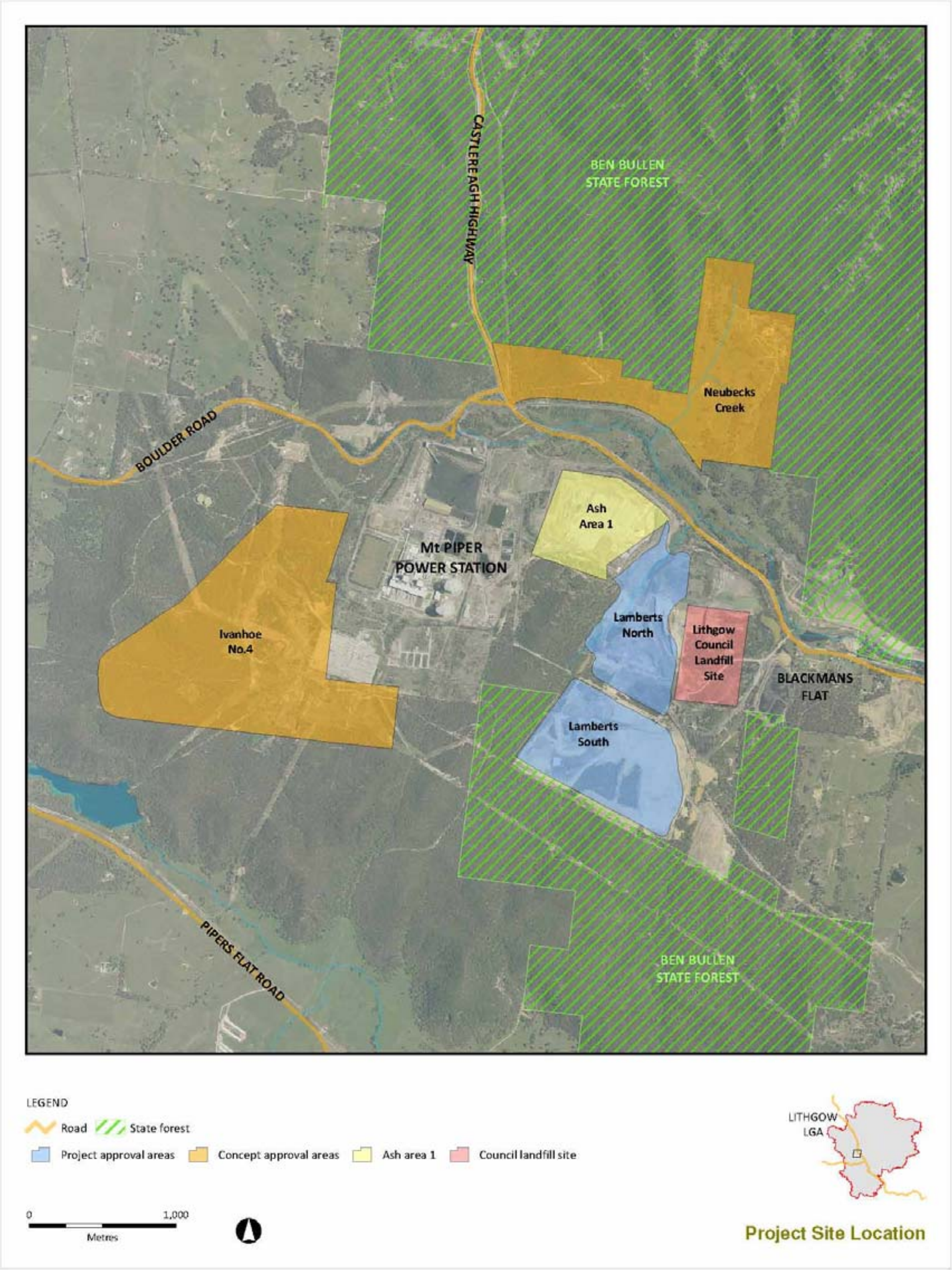
Correspondence was also received from the NSW Office of Water and from the Sydney Catchment Authority. Where relevant the requirements of these agencies are addressed in this study.

1.3. Approach

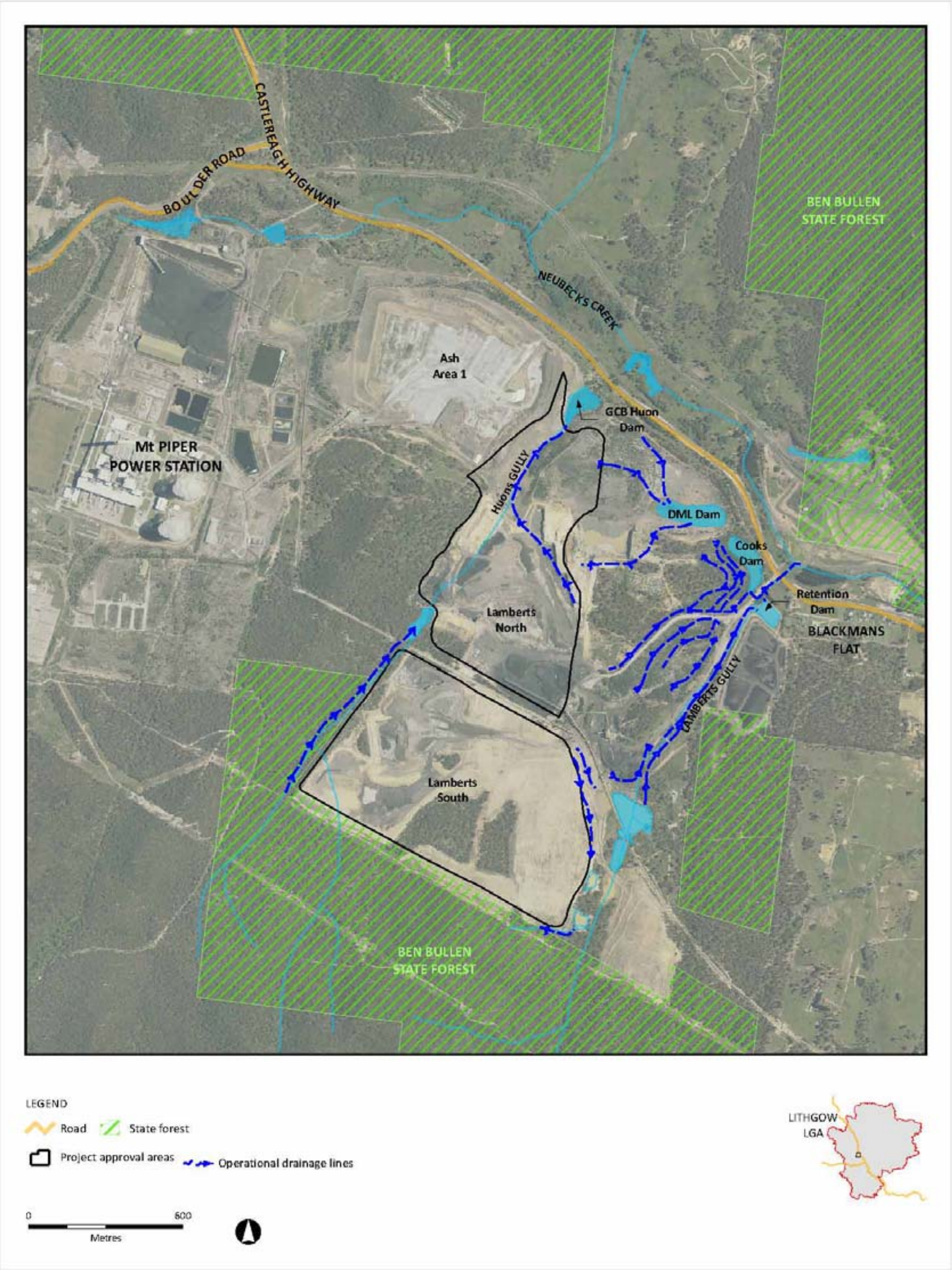
This report addresses the requirements of the Director-General of Planning as follows:

- Chapter 2 provides a review of surface water hydrology and identification of potential for water quality impacts due to surface run-off in Neubecks Creek and Coxs River. A water management system is described for the Lamberts North and Lamberts South sites to demonstrate how water on the sites would be managed to minimise the risk of water pollution in Neubecks Creek. Comments are made on the constraints to development and the need for studies to be done to provide a water management system for Neubecks Creek and Ivanhoe No 4 sites;
- Chapter 3 reviews available information on groundwater quality and movement, using existing bore hole data collected for the on-going monitoring of the existing ash storage area (Area 1) and data from new bore holes drilled in Lamberts North and Lamberts South as part of this study. It looks at the relative contribution to groundwater quality from past mine workings and the existing ash storage area (Area 1), especially the placement of brine treated ash. Based on data collection and modelling undertaken for Area 1 an assessment is made of the potential for groundwater impacts to result from the use of Lamberts North and Lamberts South as new ash storage areas. Comments are made on constraints to development and the need for studies to be done to provide groundwater quality assessments for Neubecks Creek and Ivanhoe No 4 sites;
- Chapter 4 provides a review of available water quality data from Neubecks Creek and an assessment of it against ANZECC/ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. It also provides an assessment of the contribution to the existing water quality from groundwater inflow from mine workings and the existing ash placement Area 1. Cumulative effects from other developments within the Neubecks Creeks catchment are also considered;
- Chapter 5 summarises the impacts on receiving water quality and identifies the measures needed to mitigate any potential impacts on water quality during the life of the facility. It outlines conceptual strategies to mitigate the potential impacts due to construction works and the operation of the ash storage facilities. Monitoring plans are proposed in the context of identifying impacts on water quality in Neubecks Creek from the placement of ash at

Lamberts North and Lamberts South and providing a baseline for assessing potential impacts from Neubecks Creek and Ivanhoe No 4 sites.



- **Figure 1-1 Study Area and Ash placement Sites**



- **Figure 1-2 Lamberts North and Lamberts South – Existing Site layout**

2. Surface Water Hydrology

2.1. Regional Surface Water Hydrology

The project investigation area is located within the Upper Coxs River Catchment. The main drainage from the project area is Neubecks Creek (also known as Wangcol Creek) which drains from the area west and north of Mt Piper Power Station to join the Coxs River north of Lidsdale. The Upper Coxs River Catchment is 382 km^2 in area and forms part of the Coxs River Catchment which flows to Lake Burragorang (Warragamba Dam). The catchments are illustrated in **Figure 2-1**.

The Bureau of Meteorology (BoM) operates rainfall and evaporation gauges for several locations in the vicinity of the project investigation area. The historical rainfall and evaporation records were analysed to determine the climate at the Project investigation areas. A summary of the rainfall and evaporation gauges is presented in **Table 2-1**.

- **Table 2-1 Rainfall and Evaporation Gauge Data**

Gauge Number	063132	063079	063062	063005*
BoM Name	Lidsdale (Maddox Lane	Sunny Corner (Snowline)	Lithgow (Newnes Forest Centre)	Bathurst Agricultural Station
Open – Closed	1959 – present	1903 – present	1938 – 1999	1908 – present
No. of Years of Data	51	107	61	102
Location	3.4 km east of site	14 km west of site	18 km east of site	46 km west of site
Latitude (South)	-33.38	-33.39	-33.37	-33.43
Longitude (West)	150.08	149.90	150.24	149.56
Elevation (m)	890	1,220	1,050	713

Note: * Evaporation Gauge

Monthly rainfall and evaporation averages for the investigation area are presented in **Figure 2-2**. The average annual rainfall for the area of the proposed ash placement facilities is 740 mm and the average annual evaporation is 1350 mm. Rainfall is higher than evaporation for the Mt Piper Area. The proposed ash placement facility will harvest rainfall runoff from the catchments of the site, while the evaporation will be lost from water storages on the site. The water harvested from the catchments of the site will exceed the evaporation lost from the water storages at times through the year and therefore there will be water available on site to be used for dust suppression and rehabilitation.

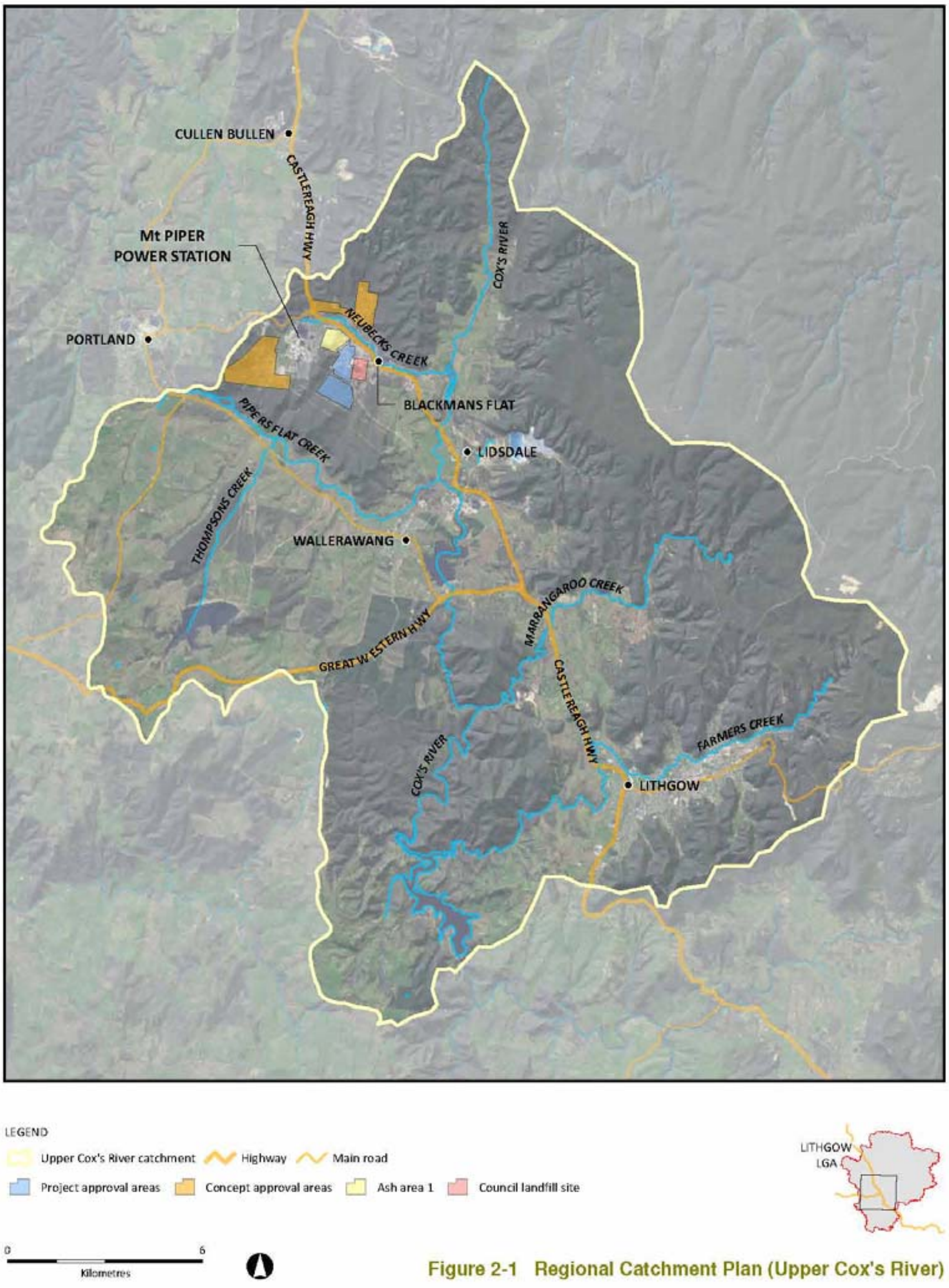
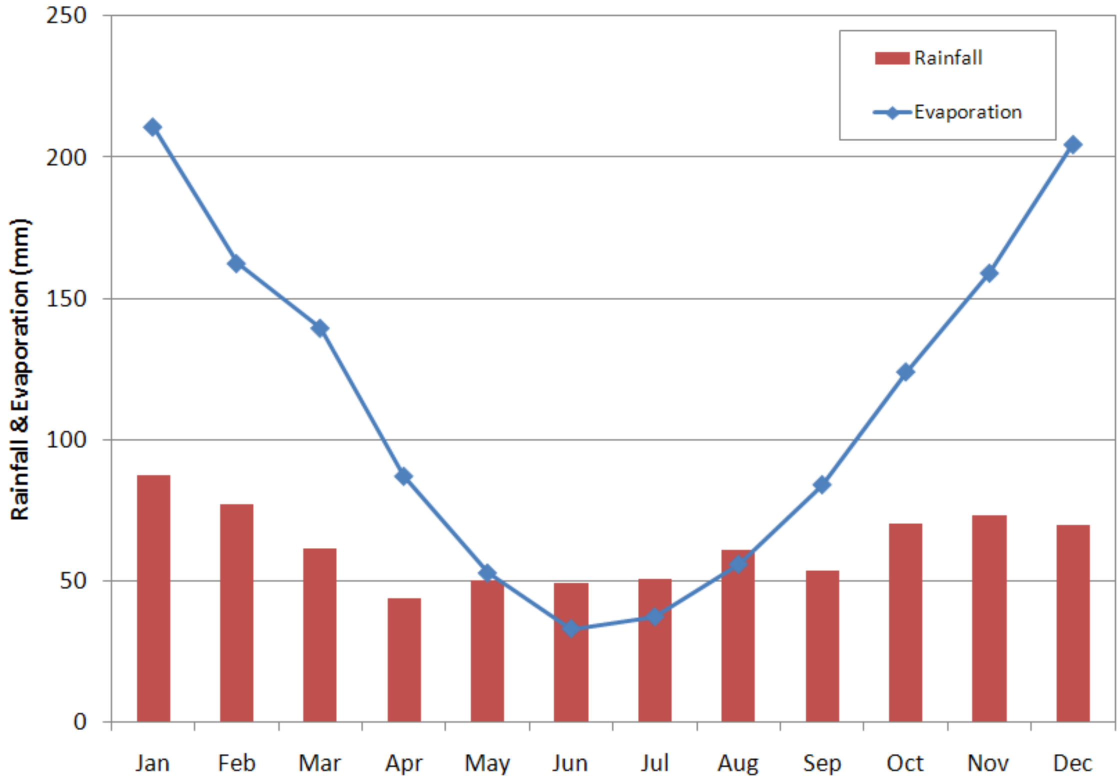


Figure 2-1 Regional Catchment Plan (Upper Cox's River)



- **Figure 2-2 Rainfall and Evaporation Data**

Table 2-2 presents the statistics of the rainfall for the Lisdale (Maddox Lane) gauge. This table shows the percentiles calculated for the historically recorded rainfall spanning the period from 1959 to present. These percentiles are percentages of the years that a certain amount of rainfall has been received in the area.

The 5th and 10th percentile rainfall represent the dry periods, which received significantly below average rainfall. The 10th percentile rainfall is 500 mm and this is 261 mm less than the average annual rainfall for the area. Conversely, the 90th and 95th percentile represent wet periods when there is significantly higher rainfall than the annual average. The 90th percentile rainfall is 942 mm which is 181 mm higher than the average annual rainfall.

- **Table 2-2 Lidsdale (Maddox Lane) Rainfall Gauge Statistics**

Statistic	Annual Rainfall (mm)
Lowest Recorded	330
5th Percentile	463
10th Percentile	500
Average	761
50th Percentile (Median)	763
90th Percentile	942
95th Percentile	1,167
Highest Recorded	1,260

2.2. Local Surface Water Hydrology

2.2.1. Lamberts Gully

The project investigation area contains two waterways we have termed Huons Gully and Lamberts Gully. These two gullies or waterways appear to have derived from the original Lamberts Creek which was present when the Western Main Colliery holding was active. The waterways have been disturbed by previous mining activities in the catchment. The location of the original Lamberts Creek alignment is unclear but the existing drainage elements comprise Huons Gully (known previously as Eastern Drain and more recently as Huons Creek) and Lamberts Gully which both drain from south to north, with the headwaters of both waterways in the Ben Bullen State Forest (see **Figure 2-3**). Huons Gully drains to a large pond known as Huons Pond or Groundwater Collection basin (GCB), an impoundment which is not connected to Neubecks Creek. The water from the GCB is used for various purposes on the site and is pumped to other dams.

Lamberts Gully drains through the existing Lamberts Gully Coal Mine and then into Neubecks Creek. The Lamberts Gully area lies within the Western Main Colliery and since the 1940s this area has been worked by shallow underground and open cut mining. A summary of these waterways has been presented in **Table 2-3.**

- **Table 2-3 Catchment Summary**

Catchment Areas	Waterway	
	Huons Gully	Lamberts Gully
Total Catchment Area (km^2)	2.11	3.00
Catchment Area Upstream of Proposed Ash Placement Area (km^2)	1.15	2.59
Catchment Previously Disturbed By Mining (km^2)	0.96	0.86

Area of Proposed Ash Placement (km^2)	0.96	0.41

Catchments Delineation

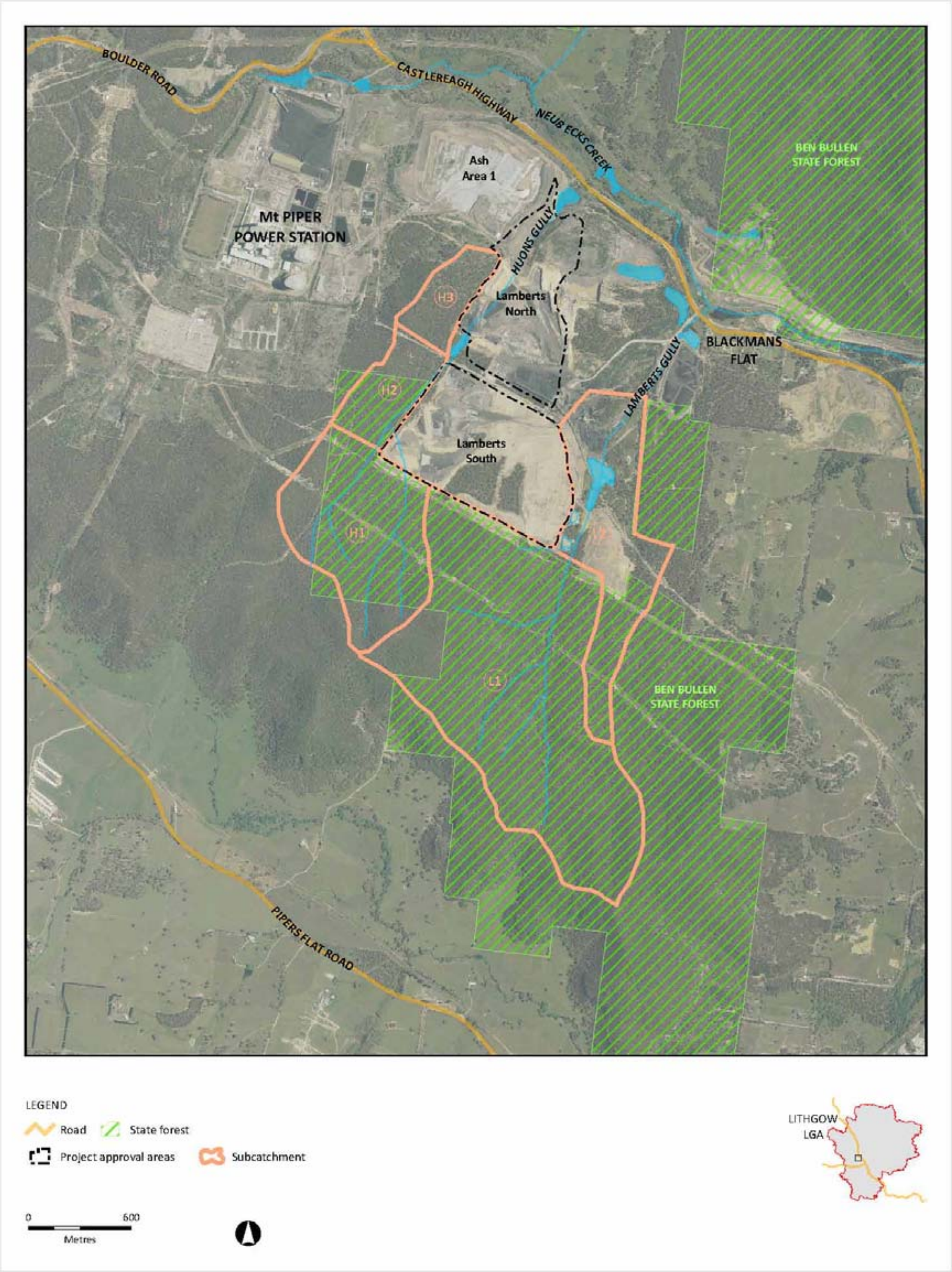
The flows for Huons Gully and Lamberts Gully were determined assuming 100 % of the disturbed areas would be managed on site. The catchments breakdown is shown in **Figure 2-3** and a summary of the catchment areas is presented in **Table 2-4**.

- **Table 2-4 Hydrologic Model Parameters**

Catchment	Area (km^2)
H1	0.74
H2	0.23
H3	0.18
L1	1.92
L2	0.67

Design Rainfall Depths

The design intensity-duration-frequency (IFD) rainfall curve was developed for the proposed ash placement facility at Lamberts North and Lamberts South. The IFD information was developed from *Australian Rainfall and Runoff Volume 1 (Engineers Australia)* and is shown in **Figure 2-4.**



- **Figure 2-3 Lamberts North and Lamberts South Catchment**

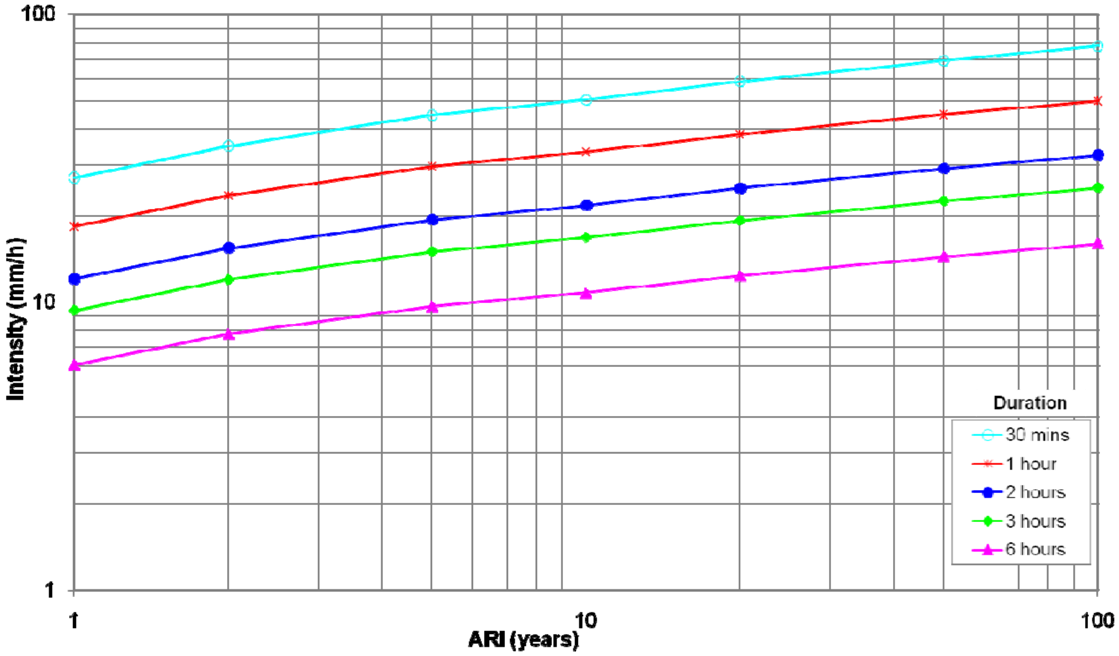


Figure 2-4 IFD Rainfall Information

Design Flow

There was no stream flow gauging information for the waterways in the project investigation area. Therefore, the estimation of the design flows was undertaken using the Rational Method from the *Australian Rainfall and Runoff Volume 1 (Engineers Australia)* for Eastern New South Wales.

The parameters for the Rational Method Calculation is presented in **Table 2-5** and the peak flows for the 2, 10 and 100 year Average Recurrence Interval (ARI) flood events are presented in **Table 2-6**.

- **Table 2-5 Rational Method Catchment Parameters**

Parameter	Huons Gully	Lamberts Gully
Catchment Area (km^2)	1.15	1.92
C_{10}	0.40	0.40
FF_2	0.70	0.70
FF_{10}	1.00	1.00
FF_{100}	1.50	1.50
Time of Concentration (minutes)	50	60
Average Intensity for Time of Concentration (mm/hr) 100 Year ARI	55.0	50.4
Average Intensity for Time of Concentration (mm/hr) 100 Year ARI	35.0	33.5
Average Intensity for Time of Concentration (mm/hr) 100 Year ARI	23.6	25.0

- **Table 2-6 Peak Flows**

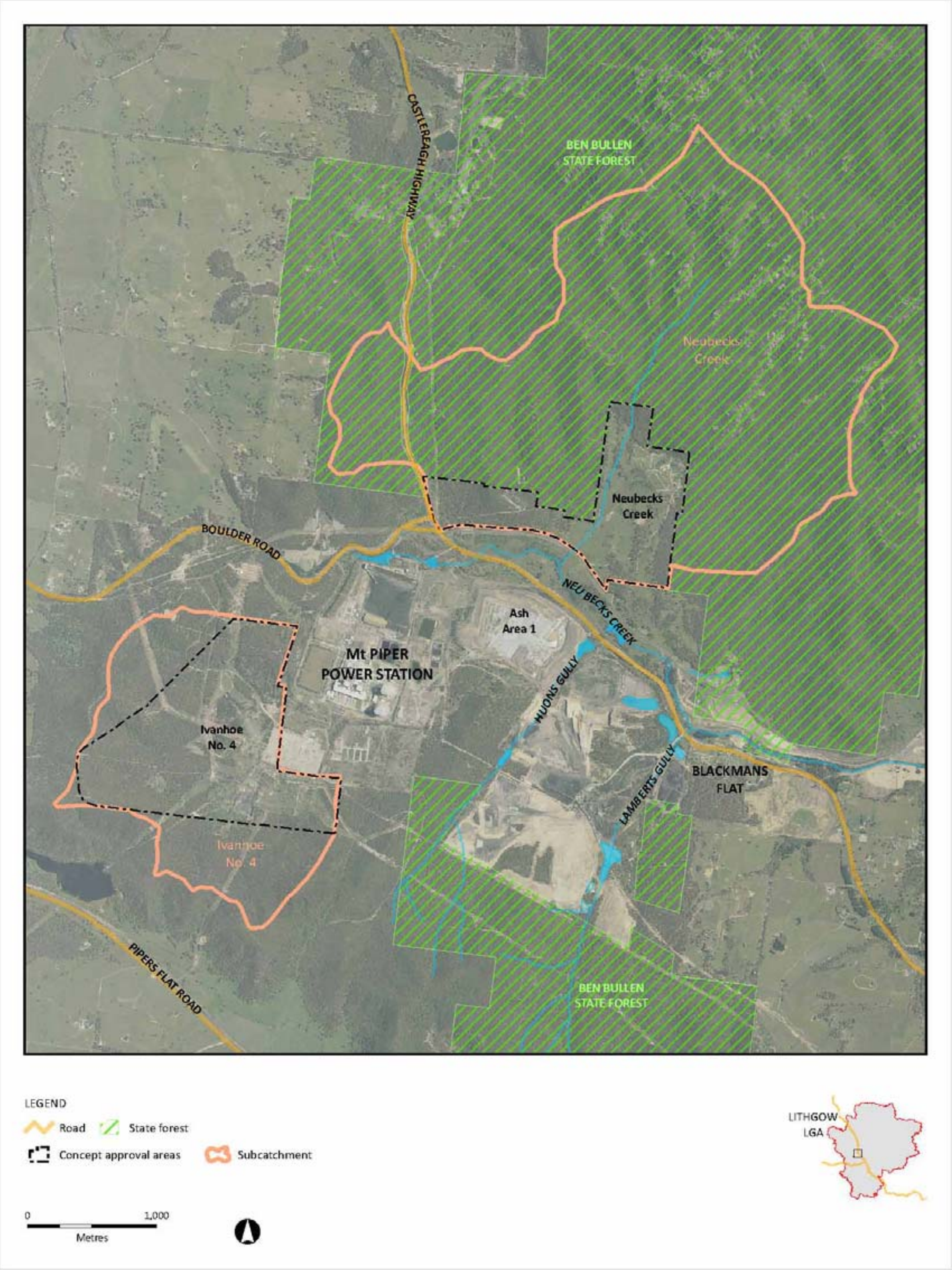
ARI	Huons Gully (m^3/s)	Lamberts Gully (m^3/s)
2	2.2	3.5
10	3.5	7.2
100	10.6	16.1

2.2.2. Neubecks Creek and Ivanhoe No 4

The Ivanhoe No. 4 area includes a number of drainage lines. The catchment for these drainage lines in the drain from the ridge that is on the western and southern sides of the Ivanhoe No. 4 Concept Area. The drainage lines drain from this ridge north and east through the Ivanhoe No. 4 Concept Area. The drainage lines combine and continue to drain north-east to the western arm of Neubecks Creek.

The Neubecks Creek area includes a number of drainage lines and the northern arm of Neubecks Creek. The catchment for these drainage lines and Neubecks Creek drain from North to South. The drainage lines combines with Neubecks Creek, which continues to flow east.

The catchments are illustrated in **Figure 2-5** and a summary of the catchment areas are presented in **Table 2-7**.



- Figure 2-5 Neubecks Creek and Ivanhoe No 4 – Site Catchments

- **Table 2-7 Catchment Summary**

Catchment Areas	Concept Areas	
	Ivanhoe No. 4	Neubecks Creek
Total Catchment Area to Downstream Extent of Concept Area (km^2)	3.2	8.5
Catchment Area Upstream of Concept Area (km^2)	1.9	7.3
Area of Concept Area (km^2)	1.3	1.2

2.3. Potential Impacts on Hydrology

The project has the potential to affect surface water resources in the vicinity of the project sites including:

- Changes to flooding characteristics;
- Changes to regional surface water hydrology in terms of water availability;
- Impacts on water quality; and
- Cumulative impacts.

2.3.1. Impacts on Regional Surface Water Hydrology

The development of the proposed ash placement facility has the potential to affect the water availability of the Upper Coxs River Catchment in two ways, by:

- Reducing the volume of runoff to the Coxs River by reducing the catchment area; and
- Requiring external water sources to supply water demands at the proposed ash placement facility.

The project investigation area for the Lamberts North and Lamberts South ash placement facilities is 1.4 km^2, which is approximately 0.4 % of the Upper Cox River catchment (382 km^2). This is only a very small portion of the Upper Cox River Catchment and development of the ash placement areas would have negligible impact on the catchment in terms of water availability. As the Lamberts Gully project investigation area has been previously disturbed by mining, the runoff from the water has already been removed from the Upper Cox River Catchment.

The Ivanhoe No. 4 area is 1.9 km^2 and the Neubecks Creek area is 1.2 km^2. This equates to approximately 0.4 % and 0.3 % of the Upper Cox River Catchment for Ivanhoe No. 4 and the Neubecks Creek areas respectively. These are only very small portions of the Upper Cox River Catchment and will have negligible impact on the water catchment in terms of water availability.

The development of the ash placement facility requires water to be used for rehabilitation and dust suppression to supply to the operation. The water for the demands of the proposed ash placement would be sourced from water harvested from the disturbed areas of the proposed ash placement facility, as occurs at the existing ash Area 1. This would be achieved by the development of a site water management system, which is outlined for Lamberts North and Lamberts South in **Section 2-4**. A similar system would be required for Neubecks Creek and Ivanhoe No 4 sites, using the same principles of sourcing all water needs from the ash storage area.

2.3.2. Flooding Impacts

The development of the ash disposal facility has the potential to affect the flooding regime of the local creeks by modifying the landform of the area to include the proposed ash placement facility. The potential for flooding impacts is mostly likely due to the upstream catchments of the ash placement facility. The development of the site water management system would include diversion drains to separate clean water from undisturbed catchments upstream of the proposed ash placement facility. The diversion drains would be designed to convey the 100 year ARI flood event. This is outlined in site water management system for Lamberts North and Lamberts South in Section 2-4. Similar arrangements would apply for Neubecks Creek and Ivanhoe No 4 sites.

2.3.3. Water Quality

As the proposed ash placement facility is located in the Upper Coxs River Catchment, releases of water from the site would have the potential to affect the water quality of the Coxs River. The proposed ash placement facility would generate water contaminated by sediment. The site water management system would be designed to manage the contaminated water from the site and minimise the risk of affecting the water quality of the Coxs River by:

- Separating clean water from undisturbed catchments and dirty water on the site;
- Managing the dirty water generated on site, based on the contaminants including sediment dams for runoff containing sediment laden water and a dirty water area for water containing runoff from the exposed ash placement areas;
- Allowing no regular controlled releases from the site;
- Reusing the water generated on site to satisfy the demands for rehabilitation and dust suppression; and
- Allowing water releases from sedimentation dams only in large rainfall events and only after the water has been treated (by settlement) through the dams.

2.3.4. Cumulative Impacts

The development of the proposed ash placement facilities represents only a small portion of the Upper Cox River Catchment. However, a number of small areas affected can lead to a significant impact to the catchment if the catchment is not considered as a whole. The development of the proposed ash placement facility has the potential to add to the cumulative impact on the catchment in terms of water quality and water availability.

As discussed above, the sites would have a water management system, which would result in the potential impacts on water quality from the site operations being very low. Other inputs to the cumulative water quality impacts in Neubecks Creek are addressed in more detail in Chapter 4, where contributions to the water quality from the groundwater and from elsewhere within the Neubecks Creek catchment are considered.

The proposed ash placement facility at Lamberts North and Lamberts South has previously been disturbed by mining and therefore the area has already been removed from contributing runoff to the Upper Cox River Catchment. The catchment areas of the Neubecks Creek and Ivanhoe No 4 sites are very small relative to the Upper Coxs River catchment.

The proposed ash placement facilities would not require water allocations or licences to operate, as the facilities would be supplied by the water harvested from the disturbed areas of the sites. Therefore, the development of the proposed ash placement facilities would not affect the water availability of the Upper Coxs River Catchment.

2.4. Surface Water Management

The philosophy of the water management strategy is to provide adequate water to the proposed ash storage facility to operate successfully while minimising environmental impacts by collecting and managing dirty runoff water. A Water Management System will be developed with the following key principles:

- Stormwater runoff from undisturbed areas surrounding the Project site to be diverted away from disturbed areas and released directly into adjacent waterways;
- Design of any drainage systems operating for the life of the project to ensure erosion is minimised;
- Staging ash placement to minimise the operational area exposed at any one time to reduce the potential for erosion;
- Separating sediment-containing stormwater from other sources of polluted water on the site such as the ash placement area;
- Incorporating the reuse of contaminated stormwater into the overall water management strategy for the project to meet the demands for rehabilitation and dust suppression; and

- Minimising the extent and duration of disturbed areas by implementing a progressive rehabilitation strategy including prompt stabilisation of landforms.

The water management system proposed for Lamberts North and Lamberts South is described in the sections following.

2.4.1. Components of the Water Management System

The key elements of the water management system are:

- sediment dams;
- dirty water area storage;
- water storages; and
- diversion drains.

Rainfall runoff on the proposed ash placement facility would be managed by a series of sediment dams, water storages, a Dirty Water Storage Area and diversion drains. Water collected in the Dirty Water Storage Area will be used for rehabilitation and dust suppression. As the ash placement areas are progressively capped and rehabilitated, the runoff from these areas would be directed to sediment dams.

Sediment Dams

Sediment dams would be required to entrap soil and other particles eroded from rehabilitated areas due to rainfall runoff. There would be a number of sediment dams which accept the runoff from capped and rehabilitated areas of both Lamberts North and Lamberts South.

The sediment dams would provide additional storage for water captured on site and water from the sedimentation dams would be used for rehabilitation and dust suppression. There would be no planned releases from the sediment dams to natural waterways off-site.

The sedimentation dams would be designed in accordance with the guidelines from the NSW Department of Environment, Climate Change and Water *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries (2008)*.

Dirty Water Storage Area

The Dirty Water Storage Area would be used to collect and store rainfall runoff from the active ash placement area. The excess runoff stored in this area would be used for rehabilitation and dust suppression as required. The Dirty Water Storage Area would be required to have a storage capacity in excess of 500 ML and would move with the progression of the active ash placement area.

Water Storages

There is a number of existing water storages on project site which would be utilised as part of the Site Water Management System which would apply to Lamberts North. The existing water storages on the site and their characteristics are shown in **Figure 1-2** and presented in **Table 2-8**. These storages were included as they are currently present on site. If they are not available, then alternative dams of similar dimensions would be constructed.

- **Table 2-8 Water Storage Characteristics**

Storage (name as shown in Figure 1-2)	Function in Water Management Strategy	Volume (ML)	Surface Area (m^2)
Huon Dam or GCB	Emergency water storage in large rainfall events	16.8	8,400
DML Dam	Accepts runoff from Lamberts North rehabilitated area	15.9	15,870
Cooks Dam (Sediment Control Dam)	Accepts runoff from existing Area 1 rehabilitated area Accepts overflow from DML Dam	69.9	11,650
Retention Dam	Accepts overflow from sediment dams	4.6	4,600

The water storages are to be used as part of the management system for sediment only contaminated runoff from the capped and rehabilitated areas of the proposed ash placement facility. The Retention Dam is the dam at the bottom of the system and is not designed to have any planned releases to the waterway.

Similar dam structures are shown as existing in the Lamberts South area. Either these dams may be used or similar dams created closer to the time they are required. The assessment undertaken for the site water management system identifies the capacity required for these dams rather than the suitability of those present.

Diversion Drains

There is an external catchment to the proposed ash placement facility, which is undisturbed land in the Ben Bullen State forest. Diversion drains would be included in the proposed ash placement areas to manage clean water runoff from catchment external to the disturbed areas. The diversion drains would be designed to convey the 100 year ARI flood event from the external catchments. The estimates of the designed flows are presented in Section 2.2.1.

2.4.2. Water Balance Modelling

The performance of the water management system for Lamberts North and Lamberts South was assessed for the operation of the existing Mt Piper Power Station (Units 1 and 2) and for the operation of Units 1 and 2 with the operation of Mt Piper Extension should it be coal fired. The modelling software program GoldSim was used. GoldSim is a software package developed by the GoldSim Technology Group to model continuous systems and has the ability to track the movement of water with time based inputs and operating rules.

The water balance model was established at a daily resolution and developed to predict the operation of the proposed water management system. The results of the water balance illustrate the project’s capacity to manage weather extremes over the 30 year project life. The objectives of the water balance are to:

- Control the release of water from the storages so that that releases occur in a manner that minimises impacts upon downstream users and the environment;
- Manage dam storages so as to have enough water to adequately supply the demands for rehabilitation and dust suppression;
- Control and manage the separation and use of clean and dirty water.

The water balance model was developed from a schematisation of the water management system, based on the component descriptions outlined below. The water balance model schematisation is illustrated in **Figure 2-6**.

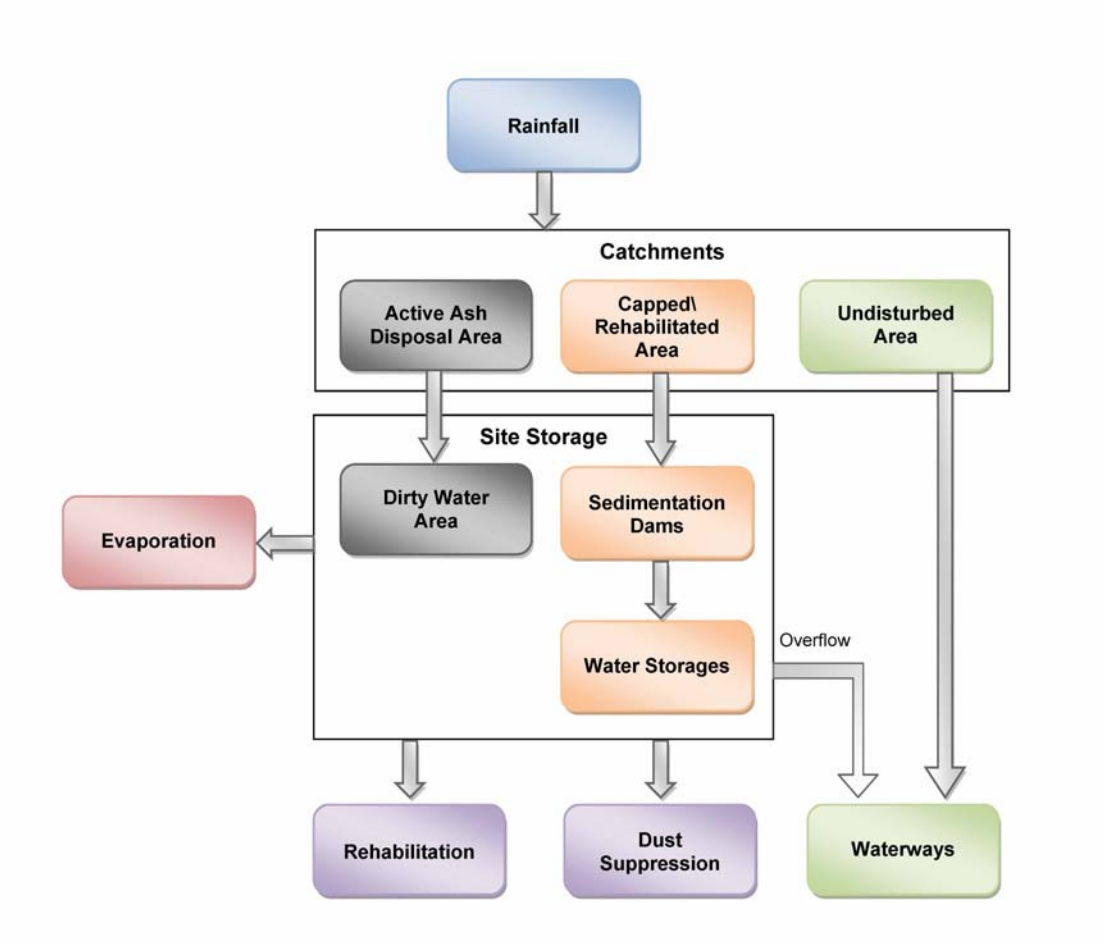
The water balance model was based on stochastic rainfall generation. The purpose of the stochastic rainfall generation is to develop a range of climate sequences for the life of the project based on the recorded historical rainfall data of the Project area. The stochastic rainfall data was generated from recorded historical data using the Stochastic Climate Library for 500 replicates over a 30 year sequences of daily rainfall data. This method allows assessment of a wide range of rainfall sequences which may be experienced over the life of the project and the calculation of a range of exceedance probabilities.

The use of stochastic rainfall in the water balance modelling captures the variability and uncertainty in climatic conditions. The stochastic rainfall developed simulates both ends of the climatic spectrum, including extremely wet and extremely dry conditions as well as above average, below average and average rainfall conditions. The stochastic rainfall data also accounts for the seasonal variability of rainfall for the area. The stochastic rainfall is generated to have the same statistical profile as the historically recorded rainfall.

The stochastic rainfall data for the project site was developed based on the rainfall gauges Lidsdale (Maddox Lane) rainfall gauge (063132) outlined in **Table 2-9**.

- **Table 2-9 Rainfall Gauge for Stochastic Rainfall Generation**

Gauge No.	Gauge Name	Period of Record	Data Application	Comments
063132	Lidsdale (Maddox Lane)	1959-2010	Daily Project Site rainfall	3.4 km south-east of (downstream) of Project Site



- **Figure 2-6 Water Balance Model Schematic**

The water balance model generates runoff based on a conceptual soil storage capacity and base flow index. The soil storage capacity represents the depth of soil storage, which must be filled before runoff occurs. This soil storage capacity was applied based on land use. The base flow index designates the rainfall that becomes surface runoff and a proportion that goes to groundwater. **Table 2-10** outlines the conceptual soil storage capacities and base flow index for project site.

▪ **Table 2-10 Conceptual Soil Storage Capacity Parameters**

Land Use	Soil Storage Capacity (mm)	Baseflow Index (%)
Exposed Ash Area	20	10
Capped\Rehabilitated area	70	10
Disturbed Area	95	10

The conceptual soil storage capacity is an average of the overall soil storage capacity, which is represented as a shallow, medium and deep soil store.

Table 2-11 outlines the water balance model inputs and demands assumed for the project.

▪ **Table 2-11 Water Balance Modelling Inputs and Demands**

	Variable	Description
INPUTS	Rainfall	Lidsdale (Maddox Lane) (0630132)
	Runoff	Rainfall converted to runoff via conceptual soil storages dependant on land uses on the site.
	Groundwater	Groundwater seepage was ignored based on the very low inflows predicted.
DEMANDS	Evaporation	Monthly average total evaporation was developed for the gauge at Bathurst Agricultural Station (063005). This gauge covers the historical period of 1908 to 2010.
	Storage seepage	Ignored for conservatism.
	Rehabilitation and Dust Suppression	Demand of 250 kL/day for Mt Piper 1&2 and 450 kL/day for Mt Piper 1&2 and Mt Piper Extension.

The demand for the proposed ash placement facility is 250 KL/day and 450 kL/day, which is for dust suppression and rehabilitation. The ash is conditioned to approximately 18% moisture content prior to transport using either freshwater or brine. The water demand for the conditioning of the ash has not been considered as part of this assessment as it is reuse water from the power station operations and is applied to ash before it is transported to the placement site.

Catchment areas have been developed for the proposed ash placement facility. These catchments have been based on the proposed staging of the ash placement over the life of the project. A summary of the catchment area is presented in **Table 2-12**. It has been assumed that runoff from successfully rehabilitated areas, after five years of rehabilitation, will be allowed to be diverted away from sediment dams and allowed to drain to the natural waterways.

- **Table 2-12 Catchments Areas**

	Area (ha)	Existing Mt Piper Project	Mt Piper Extension Project
Ash Area 1	50	Rehabilitated at the beginning of the Project Life.	Rehabilitated at the beginning of the Project Life.
Lambert North	50	Active ash placement and progressively rehabilitated between the year 0 and 13. (2015 – 2028)	Active ash placement and progressively rehabilitated between the year 0 and 15. (2015 – 2020)
Lambert South	64	Active ash placement and progressively rehabilitated between the year 13 and 30. (2028 – 2045)	Active ash placement and progressively rehabilitated between the year 6 and 10. (2021 – 2026)
Exposed Ash Area	18	Moving active areas for the 30 year Project life.	Moving active areas for the 10 year Project life.

The storages of the existing Mine Water Management System have been sized either for operational or runoff control depending on their purpose. A summary of the storages and their sizing is shown in **Table 2-13.**

- **Table 2-13 Summary of Water Management System Storages**

Storage	Volume (ML)
Huon Dam	16.8
DML Dam	15.9
Cooks Dam	69.9
Retention Dam	4.6
Sediment Dams (total capacity required for all sediment dams)	400
Dirty Water Area	> 500

2.4.3. Water Balance Results

The water balance model was used to predict the reliability of the demands for the operations including the rehabilitation and dust suppression demands. The model also predicts the adequacy of the site storage to manage extreme rainfall events. The model was run for the 30 year ash placement sequence which equates to 10,958 days. There were 500 climate sequences of 30 year run for the project life, which equals 15,000 years of simulated project life for the proposed ash placement facility.

Water Supply Reliability – Existing Mt Piper Project

Water is required for the rehabilitation and the dust suppression demands for the project site. The rehabilitation and dust suppression water demand varies depending on the amount of rainfall received at the site. More rainfall means less watering required for dust suppression and rehabilitation. The water balance modelling assumes a constant daily water demand of 250 kL/day for Mt Piper Power Station, regardless of ash generated or local rainfall. The modelling results are presented in two ways:

- The overall project reliability – which calculates the total number of days in the 30 year project life in which demand is fully satisfied; and
- The annual reliability – which assesses the number of days per year that the demand is fully supplied. This provides an added level of detail to assess which specific phase of the project may have the potential for water storage.

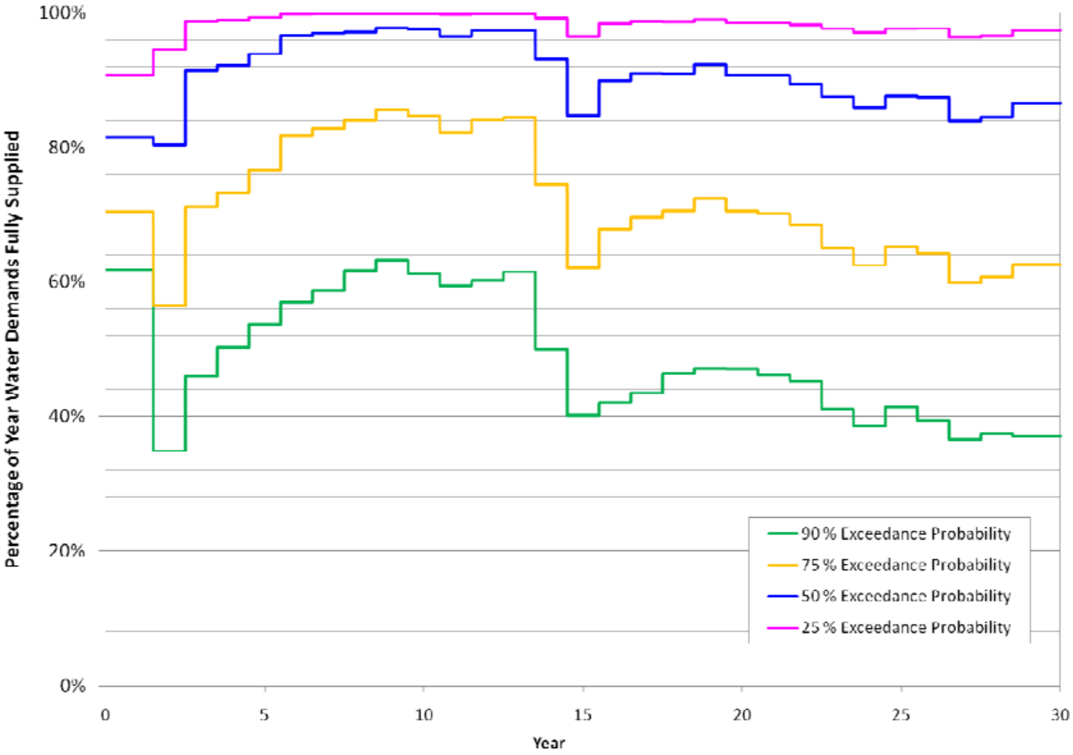
For overall project reliability - The water balance model predicts the average dust suppression and rehabilitation reliability for the project life is 82%. Therefore, on average the daily dust suppression and rehabilitation demand is predicted to be satisfied 82% of the days of the project life, assuming maximum daily water use indicated above. On the other 18% of days the water available would be less than the 250 kL/day.

For annual reliability - The water supply reliability was assessed for a range of different likelihoods i.e. the chance of the risk of water shortage occurring. The aim of this type of assessment is to look at the results with the potential for water shortage and determine how likely that is to occur.

Figure 2-7 shows the exceedance probabilities for the water supply rehabilitation and dust suppression demand. This figure illustrates the likelihood of supplying the water demand, for rehabilitation and dust suppression, in terms of percentage of days in each year the demand is satisfied. This result shows that there is a 50 % chance that the water availability to fully supply the demand for rehabilitation and dust suppression demand between is 300 to 354 days in any given year. Therefore, if the project site were to receive the median rainfall (50th percentile rainfall as outlined in **Table 2-2),** the water demand of 250 kL/day would be fully satisfied for 300-354 days in any given year. This is represented as the blue line in the figure. The site therefore has an ability to supply a high degree of water supply reliability to the proposed ash placement facility. A water supply reliability of 300 to 354 days (81 – 97 % of days) is generally considered medium to high security for water supply reliability.

If the rainfall received at the project site was significantly below average (10th percentile rainfall as outlined in **Table 2-2**), the water balance model predicts there is only a 10 % chance that the proposed ash placement facility will be able to fully supply the water required for 150 to 240 of the days in the year (this is the green line). These numbers are presented as a range because every year is different in terms of how the rainfall occurs and how the site is operated. When rainfall is significantly below average there is only a 1 in 10 chance that in any year the operation will be able to fully supply the demands for fewer than about 180 days (ie when rainfall is significantly below average, for half of the year the full quota of 250 kL/day is able to be supplied; for the other half of the year there is only a 10% chance that the full quota will be provided or a 90% chance that the rainfall will be less than the full quota). Overall, there is a low likelihood that the full water requirement may only be supplied for approximately half the time of the operation.

As discussed below the minimum requirement for dust management on the site is 120 kL/day. There would be a substantially reduced risk of being able to provide 120 kL/day compared with 250 kL/day indicating, when linked to strict management of water storages, a moderate to high likelihood that the 120 kL/day would always be available.



- **Figure 2-7 Water Availability for Rehabilitation and Dust Suppression Demand**

The water balance modelling predicts there will be suitable water availability to supply the rehabilitation and dust suppression demand for the proposed ash placement facility. The consequence of a shortfall of water to supply rehabilitation is minor in that during periods of median rainfall the shortfall would occur on no more than 3-19% of days of the year and during very low rainfall the shortfall would occur on no more than one half of the days of the year. The reliability of water supplied for rehabilitation is calculated on a daily basis and in the event of a shortfall occurring on a given day alternative management processes exist for use on that given day or series of days.

As part of the Water Management System development, a component will be to manage times of low availability of water on site. Water management in very low availability conditions would comprise:

- Controlling dust by minimising work areas and using DUSTEX instead of water. The most distant and least used areas (about 40%) would be capped with a thin layer of overburden. The remaining areas would be capped with sealant such as DUSTEX, thus allowing the sprinklers to be turned off as no water would be required, with labour and time dedicated to keeping the temporary capping intact. The working areas would be minimised and rotated to allow continued placement without affecting production. The method would involve a small area or pad for placement and ash would be progressively placed until the pad reaches optimum height. The pad would then be coated with DUSTEX and the ash placement moved to a different working area. Working areas could be rotated indefinitely by placing temporary capping and placing ash over previously capped areas;
- The use of water only for the management of roads and some working areas. Water carts would be used to supply about 40 kL/hr for 3 hours per day (120 kL/day or less than half of the nominated daily volume of water required). It should be noted that about 20% of the water cart water is sourced from dirty water ponds and surface drains. This will reduce demand on water by minimising usage, while maintaining an effective system for gathering all water from the site.

Water requirements for rehabilitation are minimised by the use of native plants of local provenance, ie species which are hardy and drought tolerant. In the case of extreme conditions, no water would be available but these plants would be no worse off than the surrounding flora.

All of these activities form part of the current water management strategy for ash placement at Mt Piper Power Stations and reflect the local water situation. Should the Mt Piper Power Station and Mt Piper Extension be operating together during very low availability conditions, the water management procedures for ash placement and the minimum water requirements of 120 kL/day would be the same. Work face areas and access roads for the two plants operating would be similar, although the placement rate would be higher.

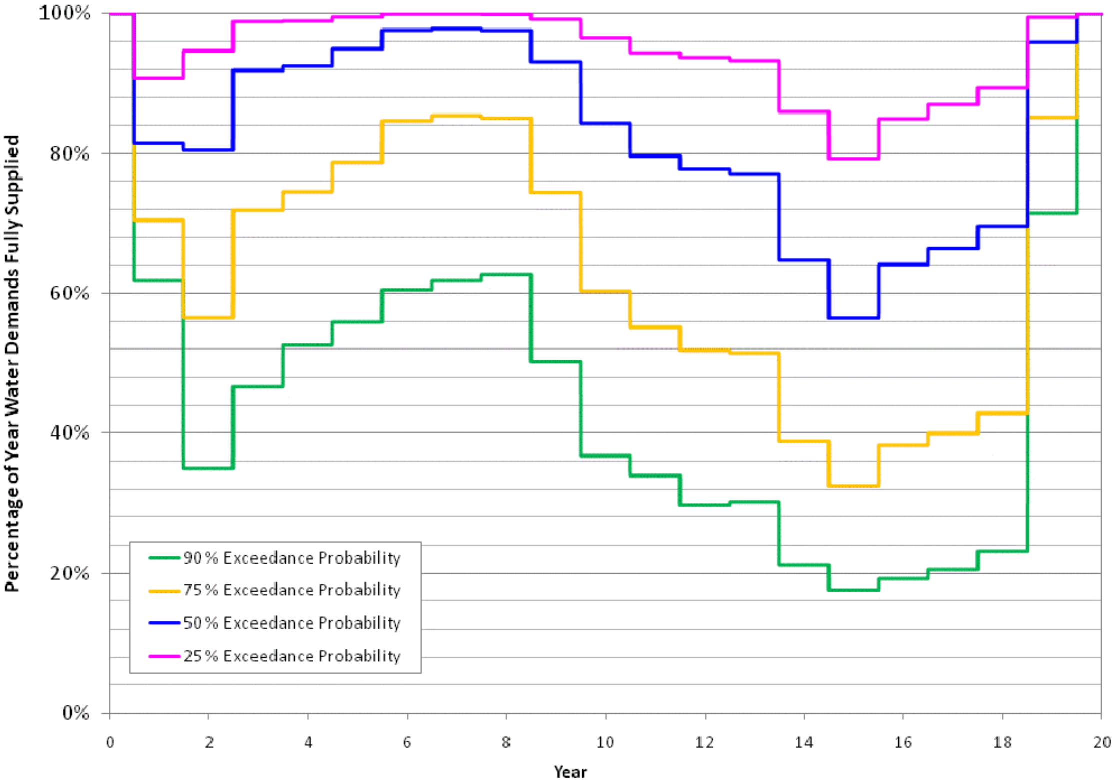
Water Supply Reliability – Mt Piper Extension Project

Water is required for the rehabilitation and the dust suppression demands for the project site. The rehabilitation and dust suppression demand varies depending on the amount of rainfall received at the site. For the overall project reliability the water balance model assumes a constant daily demand of 450 kL/day for Mt Piper and Mt Piper Extension power stations together, regardless of actual need when ash production is low or local rainfall is occurring. The water balance model predicts the average dust suppression and rehabilitation reliability for the project life is 80%. Therefore, on average the dust suppression and rehabilitation demand is predicted to be satisfied 80% of the days of the project life.

For the annual reliability assessment **Figure 2-8** shows the exceedance probabilities for the water supply rehabilitation and dust suppression demand. This figure illustrates the likelihood of supplying the water demand, for rehabilitation and dust suppression, in terms of percentage of days in each year the demand is satisfied.

This result shows that there is a 50 % chance that the water availability to fully supply the demand for rehabilitation and dust suppression demand between 200 to 354 days in any given year. Therefore if the project were to receive the median rainfall (50th percentile rainfall as outlined in **Table 2-2),** the demand would be fully satisfied for 200 – 354 days in any given year. This is represented as the blue line in the figure. The site has an ability to supply a medium to high degree of water supply reliability to the proposed as placement facility.

If the rainfall received at the project site was significantly below average (10th percentile rainfall as outlined in **Table 2-2**), the water balance model predicts there is only a 10 % chance that the proposed ash placement facility will be able to fully supply the water required for 85 to 200 of the days in the year (this is the green line). This is there is only a 1 in 10 chance that in any year the operation will be able to fully supply the demands for less than 180 days (ie a 10% chance there will be a shortfall in water available for one half of the year).

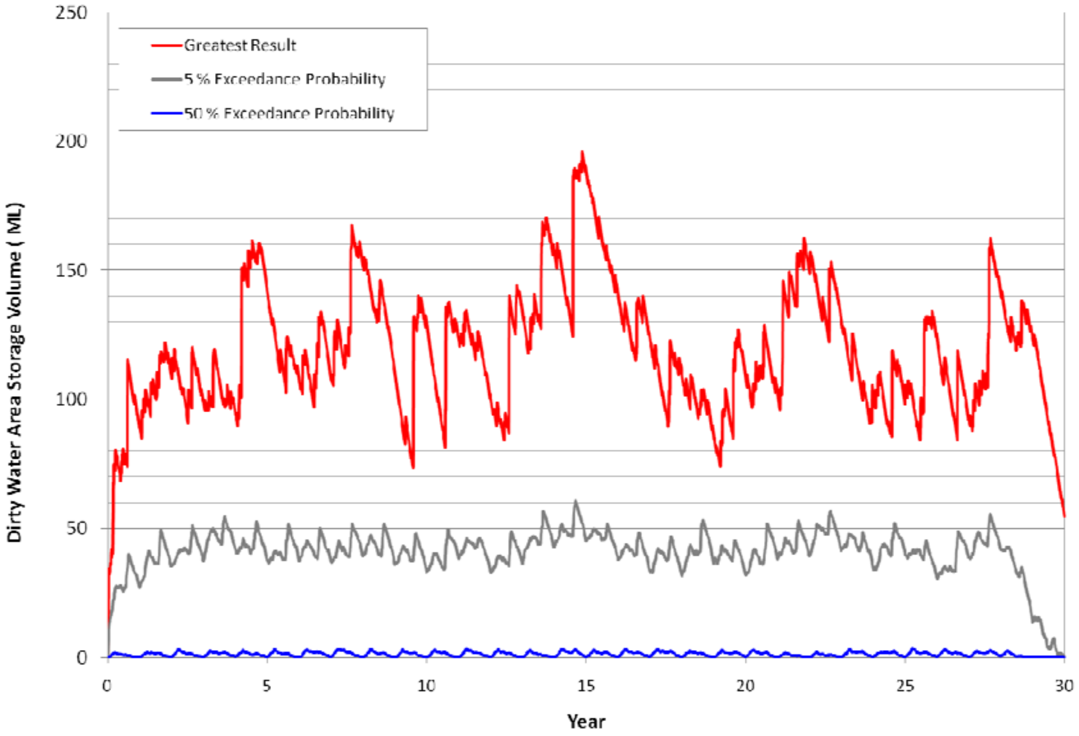


- **Figure 2-8 Water Availability Rehabilitation and Dust Suppression Demand**

The water balance modelling predicts there will be suitable water availability to supply the rehabilitation and dust suppression demand for the proposed ash placement facility. The consequence of a shortfall of water to supply rehabilitation is minor in that during periods of median rainfall the shortfall would occur on no more than 3-23% of days of the year and during very low rainfall the shortfall would occur on no more than one half of the days of the year. This is based on a daily water demand for dust suppression and rehabilitation of 250 kL/day for Mt Piper alone and 450 kL/day for Mt Piper and Mt Piper Extension together, regardless of water availability or water need. The reliability of water supplied for rehabilitation is calculated on a daily basis and in the event of a shortfall occurring on a given day alternative management processes exist for use on that given day or series of days. As part of the Water Management System development, a component will be to manage times of low availability of water on site. Water management in very low availability conditions was discussed above. All of these activities form part of the current water management strategies and reflect the local water situation.

Releases from Site

Figure 2-9 shows the predicted range of storage volume for the Dirty Water Storage, which manages runoff from the active ash placement areas. The figure shows the maximum result and a range of exceedance probabilities over the project life.



- **Figure 2-9 Dirty Water Storage Area**

The water balance model predicts that the maximum volume of water to be stored in the Dirty Water Storage Area, as a result of a major rainfall event, is 200 ML. This maximum volume is less than the volume of the Dirty Water Storage Area. Therefore, the model predicted there would be no releases from Dirty Water Storage Area of the proposed ash placement facility for 15,000 years of simulated project life.

The sediment dams and existing water storages on the site will manage the runoff containing sediment from the capped and rehabilitated areas. There would be no planned releases from this system and the final retention dam would overflow to the waterway after the runoff has been treated appropriately. The frequency of the overflows from the sediment dams system was determined from the water balance model in terms of Average Recurrence Interval. This assessment determined that for the 15,000 years simulated, there were 3,038 years in which water overflowed from the sediment dams. This equates to an ARI of approximately 1 in 5 years and therefore, on average, the site would be predicted to have an overflow from the sedimentation dams in six years of the 30 year project life.

This result represents the maximum likely overflows from the sediment dams over the life of the proposed ash placement facility.

These results are the same for both the existing Mt Piper Project and the Mt Piper Extension Project.

2.4.4. Neubecks Creek and Ivanhoe No 4

To manage the potential impacts of the development of the areas of Ivanhoe No. 4 and Neubecks Creek, a site water management system at each site would need to be developed.

The philosophy of the water management strategy would be to provide adequate water to the proposed ash placement facility to operate successfully while minimising environmental impacts by collecting and managing dirty runoff water. A water management system developed for each area would have the following key principles:

- Stormwater runoff from undisturbed areas surrounding the site would be diverted away from disturbed areas and released directly into adjacent waterways;
- Design of any drainage systems operating for the life of the site to ensure erosion minimised;
- Staging ash placement to minimise the operational area exposed at any one time to reduce the potential for erosion;
- Separating sediment-containing stormwater from other sources of polluted water on the site such as the ash placement area;
- Incorporating the reuse of contaminated stormwater into the overall water management strategy for the Project to meet the demands for rehabilitation and dust suppression; and
- Minimisation of extent and duration of disturbed areas by implementing a progressive rehabilitation strategy including prompt stabilisation of landforms.

In the process of developing the water management system, a number of studies would need to be undertaken for water management and to assess flooding. The development of the water management for the site would require the development of a water balance model. The objectives of the water balance model would be to:

- Control the release of water from the storages so that that releases occur in a manner that minimises impacts upon downstream users and the environment;
- Manage dam storages so as to have enough water to adequately supply to demands for rehabilitation and dust suppression;
- Control and manage the separation and use of clean and dirty water.

2.5. Conclusions

2.5.1. Water Availability

The project investigation area for the Lamberts North and Lamberts South ash placement facilities is only a very small portion of the Upper Cox River Catchment, and development of the ash placement area would have no impact on the Sydney drinking water catchment in terms of water availability.

As the Lamberts Gully project investigation area has been previously disturbed by mining, the runoff from the water has already been removed from the Upper Coxs River Catchment. Similarly, the Neubecks Creek and Ivanhoe No. 4 sites are only very small portions of the Upper Coxs River Catchment and would have no impact on the catchment in terms of water availability.

The development of the ash placement facilities require water to be used for rehabilitation and dust suppression to supply to the operation. The water for the demands of the proposed ash placement would be sourced from water harvested from the areas of the proposed ash placement facility. During periods of low water availability, by implementing water management processes on-site, an alternative water supply would not be required.

There will be no requirement to use water from the Coxs River system for dust management and rehabilitation works for the Mt Piper Ash Placement Project.

2.5.2. Flooding Impacts

The development of the ash disposal facility has the potential to affect the flooding regime of the local creeks by modifying the landform of the area to include the proposed ash placement facility. The potential for flooding impacts would be managed by the use of diversion drains to separate clean water from undisturbed catchments upstream of the proposed ash placement facility. The diversion drains would be designed to convey the 100 year ARI flood event.

2.5.3. Water Quality

As the proposed ash placement facilities would have the potential to affect the water quality of Neubecks Creek and consequently the Coxs River, the system would be designed to manage the runoff water from the site and minimise the risk of affecting the water quality by:

- Separating clean water from undisturbed catchments and dirty water on the site;
- Managing the dirty water generated on site by use of sediment dams for runoff containing sediment laden water and a dirty water area for water containing runoff from the exposed ash placement areas;

- Designing for no regular controlled releases from the site;
- Reusing the water generated on site to satisfy the demands for rehabilitation and dust suppression;
- Designing the sedimentation dams to release water in large rainfall events after the water has been treated through the dams;
- Incorporating the reuse of contaminated stormwater into the overall water management strategy for the project to meet the demands for rehabilitation and dust suppression; and
- Minimising the extent and duration of disturbed areas by implementing a progressive rehabilitation strategy including prompt stabilisation of landforms.

This process has been successfully applied to the existing operation at ash Area 1.

3. Groundwater

3.1. Geological environment

3.1.1. Regional Geology

The Mount Piper area is located at the western edge of the Sydney geological basin, within rocks of the Illawarra Coal Measures (Department of Mineral Resources, 1992). At the power station site the coal measures are believed to be only about 40m thick, overlying sandstones and siltstones of the Shoalhaven Group, and the sequence dips to the east at 1-2^0. The rock layers are relatively undisturbed by folding and faulting, although the 5m-throw Ivanhoe Fault strikes north-south immediately west of the Lamberts Gulley area.

The geological sequence in the vicinity of Mount Piper is as follows, in descending order:

- Lidsdale Seam (1-1.5m): interbedded high ash coal and shale;
- Blackmans Flat Conglomerate (up to 20m, but probably only a few metres here): coarse sandstone and conglomerate;
- Lithgow Seam (2-3m);
- Marrangaroo Conglomerate (about 20m) massive sandstone and conglomerate, with some boulders;
- Shoalhaven Group (>20m): marine sandstone, siltstone and mudstone, sulphide-bearing and acid-generating in places.

3.1.2. Mining Activities

Coal mining commenced in the Wallerawang and Mount Piper district in about 1873 and it is likely that the miners were initially drawn by the presence of the thick Lithgow Seam at shallow depth. Other coalbeds mined in the area included the Irondale and Lidsdale Seams, although the tonnage extracted from these was much smaller. Mining is believed to have commenced close to the power station in about 1900 and has continued intermittently up to the present.

The Lamberts Gully area lies within the Western Main Colliery holding, which occupies the land immediately east of the power station. Since the 1940s the Lithgow Seam here has been worked by shallow underground bord and pillar methods and subsequently by open cut, the latter being generally ‘roof lifting’ exercises to extract pillar remnants. Underground mining ceased in the 1990s and open pit extraction has continued.

The bord-and-pillar method of mining formerly employed at Western Main involves driving a network of tunnels (‘roadways’) in the seam to outline coal pillars, which may later be wholly or partly extracted by splitting or skirting. The initial stage is referred to as First Working and does not result in subsidence, but it does leave large open voids (the access tunnels and bords or ‘rooms’). Pillar extraction (Second Working) on the other hand does cause subsidence and severe surface disturbance over shallow workings at depths less than about 30m. The degree of surface subsidence and the sizes of voids left depend, therefore, on the areal extent of First and Second Workings at the time of underground mine closure.

Superimposed on this are the effects of subsequent open cut mining, where old pillars and un-mined (‘solid’) coal are removed in areas of thin overburden. Although detailed plans of the former Western Main and Lamberts Gully workings are not available, their present condition is most likely to be an extremely irregular pattern of:

- Open voids in old access tunnels and in the shadow of pillar remnants. Some weaker pillar remnants (‘stooks’) have probably crushed since the mine was abandoned, but further failures could continue for decades;
- Collapsed and poorly consolidated roof strata (‘goaf’) filling the larger mined-out underground cavities. Similar, but slightly more compact spoil has been dumped in former open cuts;
- Varying degrees of subsidence and blast-induced fracturing in roof strata, in pillar-supported areas;
- Flooding in lower workings, generally downdip and towards the eastern side of the mine holding. It should be noted that this water level may rise rapidly after heavy rain, such that the area of flooded workings within the Lithgow Seam may vary.

We also understand that free-draining rockfill was placed on the worked-out Lithgow Seam floor in former open cuts, but no details on the distribution, methods of emplacement and compaction standards adopted for the backfill materials were available.

The Ivanhoe No 4 area is known to be extensively underlain by shallow bord and pillar workings of the former Ivanhoe No 4 colliery. The condition of these workings is likely to be similar to those beneath the Lamberts Gully site, except that no open cut “roof lifting” has been carried out there.

The proposed Neubecks Creek ash placement area appears to be partly within the Neubecks Creek mining lease (eastern side) and partly on the Ivanhoe colliery holding (western side). Bord and pillar mining and open cut mining have been carried out in this area (Huon Colliery and Huon Extended Colliery, plus No 3 and 5 open cuts). The mined areas are separated by undisturbed portions of the Lithgow Seam, and workings extend to at least 500m north of the Mudgee Road. The condition of these workings is likely to be similar to that of the Lamberts Gully area.

3.1.3. Soils and Landforms

Few exposures of natural soil profiles are visible in the vicinity of Mount Piper because of the ground disturbance that has resulted from past mining and construction activities. Where the natural soil could be observed it consisted of a duplex residual profile, 1-1.5m deep, resting on weathered sandstone. The horizons are strongly differentiated (ie, a ‘texture contrast’ profile), with the non-erodible A-horizon overhanging dispersive clay subsoil.

However, most of the land surface around Lamberts Gully has been cut or filled, in places more than once. The fill material, to the extent that it could be seen, is made up of fragmented sandstone cobbles and boulders in a silty sand matrix. Where this could be observed the rock fragments and matrix are present in rough proportions >60% to <40%. Most of this material would have been obtained by ripping and blasting overburden from the Lithgow Seam, and would have been somewhat broken down during loading and dumping. Smaller amounts of coal washery reject (mostly black sludge) and excavation spoil were also noted.

The soils in the Ivanhoe No 4 and Neubecks Creek sites were not inspected, although they appear to be similar to but less disturbed than those in the Lamberts Gully area.

3.1.4. Regional hydrogeology

Undisturbed coal measures rocks in the Sydney Basin are generally considered poor groundwater prospects because of low bore yields and water quality that is only fair to poor – that is, of stock quality but non-potable. The seams themselves act as semi-confined aquifers of low hydraulic conductivity and moderate to high salinity. The underlying Shoalhaven Group rocks contain small but significant amounts of fine-grained sulphide minerals. These generate acid where exposed in road cuttings, as along the Great Western Highway at Marrangaroo and Mount Lambie.

Once mined, however, and especially following pillar extraction and subsequent ground subsidence, the coal measures rock mass above and close to the workings may increase in permeability and storage capacity by three orders of magnitudes or more. The most obvious indication of mine water discharge is rust-like iron oxide efflorescence at spring discharge points and along water courses draining from old workings or seam crop lines.

Some details of groundwater conditions in the vicinity of the present ash disposal area are given in Pacific Power report GEO 165 (PPI, 2001). This includes the logs of the latest groundwater monitoring bores in a network of 30 covering the power station and fly ash disposal areas. These indicate that the groundwater here is of low salinity (<300mg/L TDS) but is slightly acidic (pH5-6). Standing water level is in the range RL 908-916 AHD, which is equivalent to depths of 3-8m below ground level. Annual water level fluctuations within these boreholes are generally less than 1m.

A search of the DIPNR (now DECCW) groundwater data base revealed only three registered water bores within approximately 3km from the Mount Piper power station site. It should be noted that even if a bore is registered this does not necessarily mean that it is in use, or has even been equipped with a pump and tank. Conversely, coal exploration boreholes, old water wells, boreholes that were abandoned because of poor yields or high salinity and observation (non-pumping) boreholes may not be registered, and are therefore excluded from the DIPNR data base.

Details of the registered boreholes are given in **Table 3-1** below. Even though the water quality is not given, it can be deduced from the stated use of the well. Domestic and irrigation water would normally be less than 1000mg/L total dissolved salts (TDS) and preferably <500mg/L. Stock water might be a little more saline, say up to 2000-3000mg/L. It is also noteworthy that all three boreholes are in bedrock rather than alluvial sands, indicating that such deposits are sparse in this area.

- **Table 3-1 Registered water bores within 3km from Mount Piper**

DIPNR Borehole No	Depth	Water depth	Yield	Comments
GW101461	45.0m	15.0m	0.33L/s	Stock and domestic, in blue shale. Quality not known.
GW53071	15.2m	No record	4.5L/s	Stock, domestic, irrigation. Quality not known.
GW50996	45.7m	No record	0.38L/s	Domestic, in sandstone. Quality 'good'.

NOTE: According to DECCW records.

3.2. Previous investigations

Connell Wagner (2007) and Aurecon (2009) reported on the use of groundwater bores in the area of the existing ash placement area at Mt Piper Power Station. Some bores were located up-gradient of the existing ash placement area (MPGM4/ D4 and D5). Others were placed inside the ash placement area to monitor the effects of normal ash placement, although some (including B904 at the southern part of the ash placement area) were located to sample underground mine (goaf) workings. With ash placement these boreholes have been progressively covered by ash. The bores have been replaced by 5 new bores in 2001 between the placed ash and the Groundwater Collection Basin. The logs of these boreholes in or close to the Lamberts North area (MPGM4/ D10 to D14) were recorded in a PPI report dated October 2001 (PPI, 2001). Details of these boreholes are given in **Table 3-2** below.

Borehole locations are shown in **Figure 3-1.**

- **Table 3-2 Existing groundwater boreholes in Lamberts North area**

Borehole MPGM4 Series No	Collar RL (mAHD)	BH Depth (m)	Depth to water (m)	Water SWL (mAHD)	Base of Lithgow Seam (mAHD)
D10	924.3	22.2	16.4	908.3	908.3
D11	929.5	27.0	22.0	907.9	905.5
D12	911.7	11.3	2.2	909.9	903.1
D13	911.4	10.6	3.4	908.3	903.4
D14	911.0	8.7	1.3	910.1	902.3

A Statement of Environmental Effects (SEE) for the extension in 2007 of the brine placement area includes a summary of groundwater monitoring results obtained from the borehole sites (D10 – D14) in and around the operating ash emplacement area (Connell Wagner, 2007). Surface monitoring data from the groundwater collection basin (GCB), known as Huons Dam, at the end of Huons Gully are also provided. The GCB is the former Huon Mine No 6 void. Connell Wagner (2007) indicated that groundwater seepage at the ash placement locality is generally to the east to Huons Gully and the GCB due to the gradient of the strata at this location. Any seepage that reaches Huons Gully is contained within the basin and is reused, thus avoiding discharge to Neubecks Creek.

The Protection of the Environment Operations Act requires consideration of the ANZECC (2000) guidelines when assessing effects on ambient water quality in receiving waters. The wider context of the ANZECC (2000) guideline was used to define acceptable ambient water quality. The guidelines used are for protection of freshwater aquatic life. Where appropriate other guidelines used were for protection of livestock, irrigation water or drinking water.

Aurecon (2009) updated these data and provided a comparison with upstream site D5. These data are summarised in **Table 3-3**.

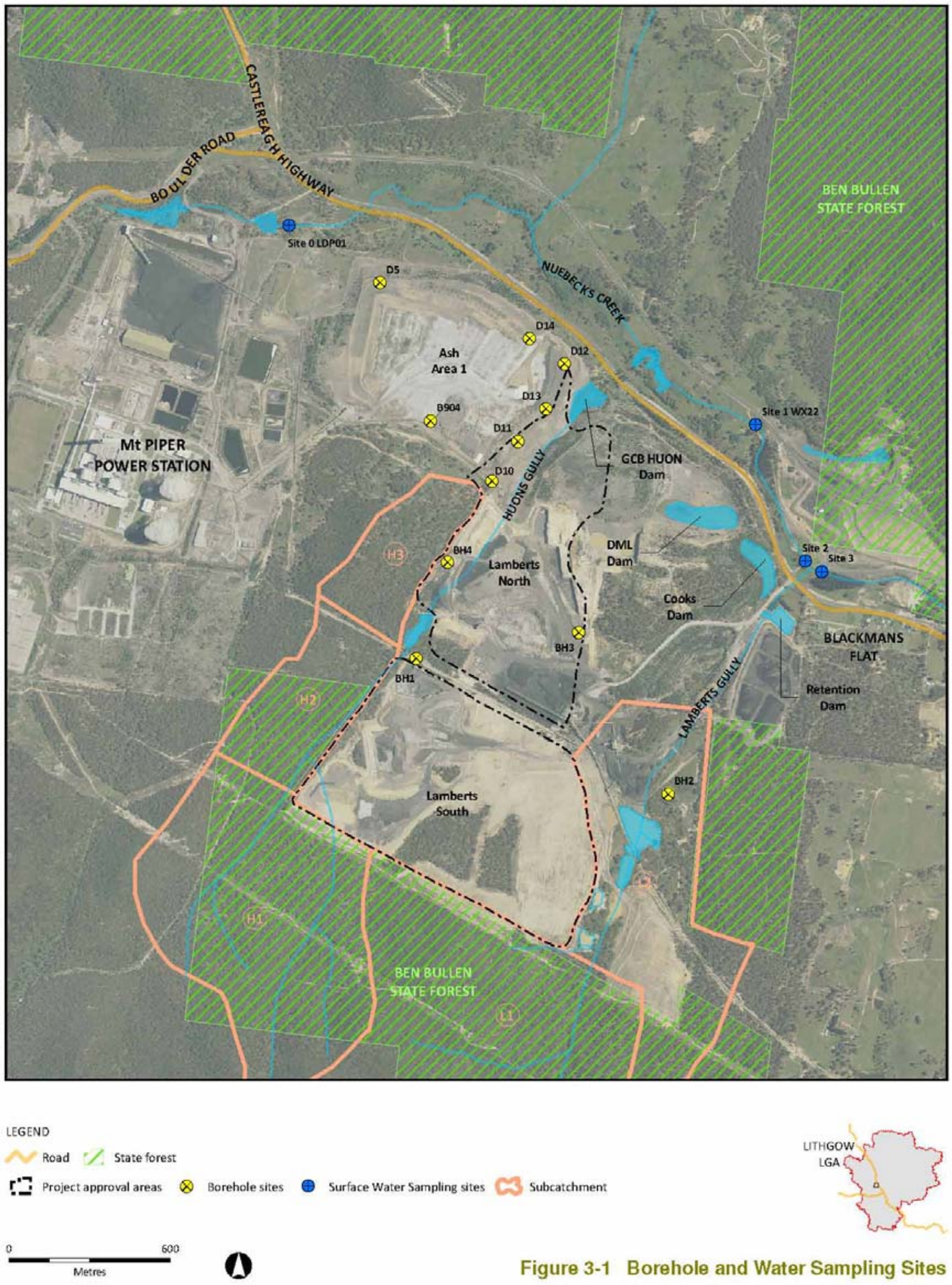


Figure 3-1 Borehole and Water Sampling Sites

The summarised groundwater results show:

- Sulphate, boron, nickel, manganese and iron are naturally elevated in the area due to the local mineralisation associated with groundwater from the coal mining workings;
- Elevated trace elements concentrations are particularly evident at bores B904 and D10 which are adjacent to areas of mine coal pillars (goaf);
- The effect of the underground mine water quality (as indicated from B904 and D10) is reflected in the values for the groundwater collection basin, notably in the higher sulphate and boron compared to the D11 to D14 bores. Trace elements such as nickel and zinc are also elevated in these areas.

Chloride is regarded as an indicator of brine leachates, although no criterion is available for ecosystems. As a guideline an indicator of 350 mg/L is used for moderately tolerant crops. The low chloride concentrations in the groundwater bores (except for D11), indicate no significant effects on the local groundwater from the existing brine conditioned ash. The elevated chloride concentrations at D11 indicate a separate localised source of chlorine in the mine goaf water (Merrick, 2007).

Aurecon (2009) looked at long term trends for chloride since 1993 in the GCB, compared with chloride trends in Neubecks Creek and showed that the goaf chloride has not affected the creek concentrations.

- **Table 3-3 Average Groundwater Concentrations in Monitoring Bores and GCB**

Parameter (mg/L) (sampling time)	MPG M4 / D10 (2001-2009)	B0904 (1997-2000)	MPG M4 /D11 (2001-2009)	MPGM4 /D12 (2001-2006)	MPG M4 /D13 (2001-2005)	MPG M4 /D14 (2001-2003)	MPG M4/D5	GCB (2001-2008)	Guideline (mg/L)
Cond-ivity (uS/cm)	1618	-	2076	1263	1245	1209	1098	1554	30-350
TDS	1374	1384	1390	960	982	865	879	1216	1500**
Mn	3.16	9.2	2.4	6.9	1.46	1.35	8.35	4.26	1.9
Cl	44	22	229	29	68	26	26	41	350 *
SO$_4$	864	892	228	624	418	356	583	791	1000 #
B	1.8	1.5	0.3	0.7	0.04	0.02	0.15	0.893	0.37
Fe	1.26	10.6	6.37	13.63	0.16	3.66	49.9	0.103	0.3 ##
F	0.34	5.3	0.46	0.1	0.2	0.14	0.181	0.089	1.5 ##
Ni	0.372	0.84	0.047	0.672	0.055	0.458	0.066	0.313	0.011
Zn	0.458	2.6	0.104	0.524	0.03	0.02	0.077	0.073	0.008

ANZECC (2000) guidelines for protection of freshwaters, livestock or irrigation waters (# Livestock water; * Irrigation water for moderately tolerant crops; ## drinking water; ** conductivity conversion)

No groundwater investigations are known to have been carried out in the Ivanhoe No 4 area. The potential ash placement area is more elevated than the Lamberts Gully site, but the abandoned mine workings appear to be at least partially saturated. This was deduced from iron stained groundwater discharge in gutters adjacent to the access road to Mt Piper Power Station. Groundwater flow in this area appears to be generally to the east or north east, consistent with the fall of surface topography and the dip of the Lithgow Seam.

No information is available on the groundwater at Neubecks Creek site. It is presumed, however, that the groundwater generally moves towards discharge points along the main watercourse (Neubecks Creek) and the extent of flooding in the abandoned colliery workings will be dependent on topography.

3.3. Groundwater Modelling at Existing Ash Storage Area

Connell Wagner (2007) reported on groundwater modelling undertaken in 1999 and 2006/7 to assess the potential impacts associated with brine co-placement in the ash storage area 1. Groundwater flows were shown to be from west of the ash placement area to the drain which enters the groundwater collection basin (GCB). The model also showed a limited connection between the GCB and Neubecks Creek.

Modelling undertaken in 1999 by Merrick and Tammetta (1999) for brine production and co-placement predicted an insignificant increase in salts and trace elements in the groundwater seeping into the GCB and from there to Neubecks Creek. The modelling showed:

- Water conditioned ash and brine conditioned ash contributed evenly to concentrations of groundwater discharging into Huons Gully and the GCB (Huons Pond);
- The stable background concentrations of major ions throughout the area are not related to the ash deposit. It appeared that the mine goaf zones were bleeding continuously into the spoil material under the attraction of the groundwater sink at the pond;
- There is a low risk that any trace elements generated from ash disposal would increase background levels by more than ANZECC guidelines at Huon Gully or the GCB. There would be no risks at Neubecks Creek, with extremely low concentrations predicted.

The results confirmed that the brine constituents were essentially immobilised in the pores of the water conditioned fly ash and brine conditioned fly ash. Overall the ash had a low rainfall infiltration rate, so the passage of the infiltration through the existing ash deposit was very slow.

Further modelling was undertaken in 2006/7 to predict the potential impacts of the proposed expansion of the brine co-placement area on the GCB and Neubecks Creek (Merrick, 2007). The modelling results showed that the extended area for placement of brine conditioned ash was not expected to cause a significant increase in the concentrations of water quality parameters in the local groundwater or in Neubecks Creek.

The minimal effects of leachates from the ash deposits were due to the slow rate at which leachates from the brine conditioned ash entered the groundwater and the mixing of this with the background groundwater under the ash deposit. The groundwater then flows to the GCB with some possibly reaching Neubecks Creek. The predicted values did not exceed the ANZECC (2000) criteria.

The modelling also noted that the predicted increases in water quality parameters due to inputs from the underground mine areas were also below the ANZECC guidelines, with the exception of boron, nickel and zinc which were naturally elevated. Most of the predicted increases were assessed as being due to poor water quality in the underground mine workings moving toward the GCB and are unrelated to the brine placement area or water conditioned ash placement.

3.4. New Groundwater Drilling Program in Lamberts Gully

A new groundwater drilling program was carried out at Lamberts Gully Colliery on 10-11 December 2009. Four boreholes were drilled (BHs 1-4) and two of these (BH2 and BH4) were completed as groundwater observation wells (piezometers), with details given below and in **Table 3-4** and **Table 3-5**.

The drilling sites shown on **Figure 3-1** were originally chosen so as to cover as much of the Lamberts North and South areas as possible, and to supplement existing observation wells in the north-eastern corner of Lamberts North.

3.4.1. Drilling methods

All four boreholes in the present program were drilled using an airflush blade bit to open the hole down to 1-3m in soil materials, then deepened by means of a 100mm diameter downhole hammer to terminating depth. Details of these boreholes are summarised in **Tables 3-4** and **Table 3-5** below, and their logs are given in Appendix A. Their locations are shown on **Figure 3-1**.

One advantage of the downhole hammer in groundwater drilling is that the depth to the water table is usually demonstrated by aerated water being blown (‘airlifted’) above the borehole collar, and by the cessation of cuttings (rock chips, sand, silt) reaching the surface as a conspicuous dust plume. It should be noted that no such airlift spout was observed in any of the boreholes drilled, indicating either that no water table was intersected or, more likely, that inflows to the boreholes were very small.

Perched water tables and capillary moisture are detectable during drilling in the form of damp chips and by a reduction in the expelled dust at discrete levels. However it is difficult to accurately log the depth and lithology of the rock layers penetrated, other than coal seams, since this has to be largely based on the colour of the dust ejected (+/- 1m is probably the best achievable depth accuracy). Furthermore, chips may gradually accumulate in the base the borehole below the water table, and where water inflows are small a mud ’cake’ can accumulate on the borehole walls and block off further influent seepage.

The boreholes were uncased, although this only presented problems in BH 3, where loose, dry and bouldery open cut spoil was encountered.

- **Table 3-4 Details of SKM 2009 boreholes**

BH No	Approx collar RL (mAHD)	Depth to water	Approx SWL (mAHD)	Hole depth	Comments
BH1	940m	20.7m	920m	33.2m	Left open, no casing
BH2	918m	7.0m	911m	30.0m	Completed as piezometer
BH3	945m	Dry	<933m	11.5m	Hole collapsed, abandoned
BH4	940m	Dry	<915m	25.5m	Completed as piezometer

NOTE: Collar RLs are based on mine contour plans and are not accurate.

- **Table 3-5 GPS locations of SKM 2009 boreholes**

Borehole number	UTM Eastings	UTM Northings	GPS Elevation
BH 1	0224 866	6304 259	947m (+/- 6m)
BH 2	0225 948	6303 880	922m (+/- 11m)
BH 3	0225 577	6204 224	943m (+/- 5m)
BH 4	0225 042	6304 667	933m (+/- 7m)

3.4.2. Piezometer construction

Piezometers were installed in BH 2 and BH 4 to allow water table depths to be accurately measured and for water quality sampling. These were constructed as follows:

- After the borehole had been drilled to full depth the rods and downhole hammer were withdrawn. (The borehole may then be backfilled immediately if unsuccessful; left for some time as an ‘open hole’ to allow the groundwater level stabilise; or ‘completed’ by installing a piezometer tube and screen);

- A 6m section of 50mm ID PVC well screen was placed in the borehole and 3m sections of 50mm ID blank PVC tube were progressively attached to the assembly as it was lowered to the base of the borehole;
- PVC tubing protruding from the top of the borehole was cut off at about 1m above ground level (this is referred to as the 'stick up');
- Clean, fine, uniformly graded 5mm gravel was trickled slowly down the annulus between the PVC tube and the borehole walls;
- This gravel was lightly compacted around the screened interval (the lowermost 6m) by gentle sluicing and vibrating of the PVC column. Its depth was checked by means of a weighted tape;
- When the gravel had fully settled around the well screen, bentonite pellets were trickled down on top of it, until the annulus was fully backfilled up to ground level. This bentonite absorbs water from the borehole walls and swells, creating a continuous seal from the top of the gravel filter zone up to ground level;
- The stick up PVC stub was capped and labelled with the borehole number, and is available for future monitoring. However water level can take a few hours to a few days to stabilise after piezometer completion, hence readings made immediately after installation may not be accurate. (The final water levels for this program were measured one month after drilling).

3.4.3. Borehole BH 1

This borehole was located adjacent to the future ash emplacement area and the existing conveyor track, between an operating open cut and the Springvale - Mount Piper coal conveyor. The borehole collar is at about RL 940m, according to a mine contour plan, and is about 10m above a nearby dry gully and 20m above the adjacent open cut floor. The Lithgow Seam is exposed at the base of this open cut, with overlying minor seams and splits exposed in the pit walls. The seam overburden is composed of closely-jointed siltstone, shale and sandstone, with no visible seeps, ie the present water table is at or below the Lithgow Seam floor level in this pit.

BH 1 was drilled to a depth of 33.2m and terminated at the limit of the available drilling rods. No definite water inflows were recorded during drilling, though damp patches were noted in the airlifted cuttings between 16.7m and 19.6m, immediately above the Lithgow Seam. The seam itself, about 4.5m thick, was dry; this was evident from the black dust plume airlifted to the surface as the downhole hammer advanced through it. The mine operator noted that this was in accord with his own observation that abandoned underground workings in this part of the Lamberts Gully Colliery were dry, though they became flooded down-dip to the east.

On the completion of drilling BH 1 was still dry, so the hole was left open overnight to see if it made any groundwater. The next day water was detected in the borehole – from the splash of a dropped pebble - at a depth greater than 25m, which was the limit of the dipping tape used. However the walls of the borehole were wet below about 18m, which accorded with the observation of wet sand during drilling at around this level. Because the Lithgow Seam – the presumed main aquifer in the area - was not saturated at this location the borehole was not completed as an observation well.

A standing water level of 20.66m below ground level (BGL) was measured on 14 January 2010, one month after drilling. This water level appears to coincide with the working floor level in the adjacent open cut.

3.4.4. Borehole BH 2

This borehole was sited about 400m SE of the washery and 150m SE from the washery tailings dams. The collar RL was about 918m, according to the mine contour plan.

No coal seams were intersected in this borehole, which appears to be below the level of the Lithgow Seam. Again, no definite water inflows were intersected but several damp patches were noted below 15m, down to terminating depth at 30m. Hole advance was halted several times to allow any seeps present to wash the mud cake off the walls and allow accumulated groundwater to be airlifted from the bottom of the hole, but only small volumes of mud were subsequently blown to the surface.

This borehole was also left open overnight and a standing water level was detected at 8.5m depth, 17 hours later, prior to piezometer construction. This depth approximately corresponds to that of the nearby gully floor, which is occupied by fine washery tailings. BH 2 was completed later as an observation well with 50mm ID PVC casing and a 6m screened interval.

The SWL could not be measured on completion, since gravel poured round the well screen temporarily displaced water up the casing, but it is expected that this would have stabilised within a few hours. A standing water level of 7.02m BGL was measured on 14 January 2010, one month after drilling.

3.4.5. Borehole BH 3

This borehole was sited about 200m north of the coal washery and 100m west of the mine visitors car park, at approximately RL 945m. Drilling progress was slow in loose, dry, caving backfill (silty sand, with sandstone cobbles and small boulders). The downhole hammer jammed at a depth of 11.5m and atthis point the borehole was abandoned and collapsed, with no groundwater having been encountered. The depth of the backfill is unknown.

3.4.6. Borehole BH 4

The final Lamberts Gully borehole was located at the foot of a natural escarpment and at the western edge of the land disturbed by open cut mining. Groundwater in BH 4 could therefore be expected to be representative of that found up-gradient from the future ash placement sites. The estimated collar level based on mine plans was about RL 940m.

The hole penetrated about 2m of dry spoil, then entered in situ seam overburden. One rider seam was detected at 5-6m depth and mining voids were intersected at 19.6m (0.5m thick) and 25.5m (0.25m thick). Since air circulation was lost in the voids, it was not possible to say at the time if these mine workings were flooded or not at this location. (They were found later to be dry.) BH 4 was terminated at 25.5m and subsequently caved up to 24.6m.

No definite water cuts were identified, but damp cuttings were noted at about 14m. The borehole was completed with 50mm ID PVC tubing and 6m of screen at the base of the hole. No SWL was detectable in BH4 on completion.

No water level was detected again when the borehole was revisited on 14 January 2010, one month after drilling. A bailer was lowered to the base of the hole and returned coated with light grey dust, confirming that this was a dry hole.

3.4.7. Water quality

Full analytical results from testing of groundwater samples drawn from BH 1 and BH 2 in January 2010 are compared with earlier testing from observation wells MPGM4/ D10 to D14) in the NW corner of Lamberts North in **Table 3-6**.

The principal differences arising from this comparison are that:

- The groundwater salt level (TDS) in BH 1 and BH 2 is very low, 120 and 360mg/L respectively; and
- Sulphate, manganese and iron are also much lower.

The existing groundwater in the Lamberts South area falls within ANZECC guidelines in many respects. Note, however, that nickel (Ni) and zinc (Zn) at BH1 are above criteria. As noted above, underground mine water quality is reflected as trace element levels for Ni and Zn.

- **Table 3-6 Groundwater quality**

Parameter (mg/L)	D10	D11	D12	D13	D14	SKM BH1	SKM BH2	Guidelines* ANZECC (2000)
TDS	1295	1423	1000	982	865	120	360	1500
Mn	3.1	2.8	7.0	1.46	1.35	1.30	0.81	1.9
SO_4	813	273	611	418	356	15	140	1000
Fe	1.69	9.04	12.92	0.16	3.66	1.66	0.19	0.3
Ni	0.46	0.06	0.70	0.06	0.46	0.13	0.03	0.011
Zn	0.48	0.12	0.55	0.03	0.02	1.98	0.50	0.008

*Refer Table 3-3 for guideline explanations

3.5. Lamberts Gully Hydrogeology

3.5.1. Nature of the aquifer

In the pre-mining state the coal measures in the areas proposed for ash placement would have constituted a series of stacked, semi-confined and relatively tight sub-aquifers (perched water tables), of which the most permeable members would have been the coal seams themselves. The water table profile probably then followed the surface topography, but was more subdued in relief, and discharged towards low ground such as the gully floor along Lamberts Gully. The striking north east trend of water courses in the vicinity of Mount Piper suggests that these run along weaker and more permeable fault lines – such as the Ivanhoe Fault - or clusters of joints (‘lineaments’).

This hydrogeological system has been greatly altered by mining, which has in effect created a new unconfined and much more pervious aquifer between the floor of the Lithgow Seam, representing the base of the mining-induced disturbance, and the ground surface. Such a disturbed ground aquifer would be made up of:

- Open cut spoil backfill, loose dumped and composed of rock fragments from cobble to boulder size embedded in a silty sand matrix;
- Collapsed and fragmented roof strata (goaf) loosely filling voids in de-pillared underground mine workings;
- Open roadways and ‘rooms’ (hollowed-out pillars) in pillar-supported panels which have not been unroofed by later open cut mining; and
- A small proportion of more or less intact ‘islands’ of coal and roof strata, perhaps 10% of the aquifer area, in previously unworked barrier pillars.

This aquifer is up to 50m thick, but is only saturated in its lower portions, generally below RL 920m. Groundwater levels would have been generally in the range RL 910-920m and discharging eastwards towards Lamberts Gully. At present the water table is artificially lowered in the west due to the presence of the open cut mine, which acts as a groundwater sump.

Other hydraulic characteristics of this disturbed ground aquifer could include that:

- Its hydraulic conductivity is likely to be very high (although variable), say 0.1-10^4 m/d (this is exceptionally pervious for rock masses in the Sydney Basin, comparable with karst limestone or clean river gravel), depending on the degree of mining disturbance;
- Due to the high degree of interconnectivity between the workings and with the surface, response to infiltration from major rainfall events could be very rapid, such that the water table might rise 1-3m in a few hours. Conspicuous springs might appear along the lower parts of the Lithgow Seam crop line;
- The catchment for these workings probably extends updip (westwards) from Lamberts Gully for approximately 3km, into the adjoining Ivanhoe Colliery holding. The extent of groundwater transfer between the Ivanhoe and Western Main workings would depend on the integrity of the barrier pillar between them.

3.5.2. Lamberts North

The following discussion of groundwater in the Lamberts North area is based on information from monitoring bores D10 to D14, a summary of modelling results given in the SEE (Connell Wagner, 2007) and BH 4 from the present program. These indicate that the base of the Lithgow Seam is at about RL 900-905m in the northwestern corner of the proposed ash emplacement, but that it rises southward to about RL 915m in the vicinity of BH 4. The seam is presumed to dip to the east or northeast at 1-2^0.

The groundwater modelling results show the water table in this area discharging towards Huons Gully and Huons Dam (the groundwater collection basin (GCB)) at its lower end, where the surface is at RL 908m. At the site of BH 4 the projected water level is put at about RL 920m some years after completion of the existing emplacement, while the present drilling results suggest that the water table here is at present below RL 915m (the approximate base of this dry borehole).

As the post-mining ground level of Lamberts North is generally in the range RL 920-940m, at least 10m of cover (spoil backfill or in situ seam overburden) would be available between the base of the emplaced ash and the water table.

3.5.3. Lamberts South

The hydrogeological information available on this area indicates that groundwater beneath the higher ground (represented by BH 1) is at about RL 920m and that it discharges eastwards, towards Lamberts Gully at about RL 910m. Given that most of the post-mining topography is likely to lie between RL 940m and 960m, the separation distance between the water table and the base of the brine ash could be generally greater than 20m.

Ash emplacement within the present Lamberts South open cut would require more backfill. The base of this pit is at present about RL 920m and the water table would probably rise on abandonment, possibly to about RP 930-940m (which is the floor level of a nearby dry creek). This suggests that at least 20m of non-saline backfill would be required between the present pit floor and the base of the ash, whereas an emplacement on higher ground (RL 950-960m) would require no backfill at all.

3.5.4. Conclusions

The findings from the 2009 groundwater drilling, and from the review of other sources, show that:

- The main aquifer in the proposed Lamberts North and Lamberts South ash storage areas is the disturbed rock mass up to 50m thick lying between the base of the Lithgow Seam and the ground surface. This is unconfined and probably extremely permeable in places. It is only partly saturated, with standing water levels generally below RL 920m, discharging eastwards towards water courses such as Lamberts Gully;
- Water levels in the vicinity of the operating open cut will probably rise on abandonment and backfilling. The water table may also rise rapidly in response to heavy rainfall events. (Note that elevations given in this report are only approximate, being based on surface contours which are subject to cutting and filling during mine operations);
- Present disposal practices require the brine conditioned ash to be placed 35-40m above the water table (at 946m AHD). Groundwater quality results and modelling discussed above suggest that this practice is sufficient to ensure brine does not leach through to the groundwater. Continuing this practice of placing brine conditioned ash at an appropriate height would allow for groundwater quality to be unaffected by ash placement in Lamberts North (at 946m AHD) and Lamberts South (956m AHD).

3.6. Neubecks Creek and Ivanhoe No 4

To assess the potential impacts of ash placement at these sites a detailed groundwater study would be required for each site. A bore hole monitoring program will be required for each new ash placement site. Given the timeframe and uncertainty of whether these sites would be used for ash placement a limited monitoring program should be established to provide preliminary information on the hydrogeological conditions in the project area and provide a basis for planning a future monitoring network. Further well installation would need to be delayed until planning for the ash storage areas is further advanced.

Information that would assist in designing such a monitoring network would include:

- A plan with topography, with accurate contours, showing the extent of filled ground and other relevant information;
- A plan showing the distribution of abandoned mine workings, distinguishing between open cuts, de-pillared underground workings and pillar supported areas, with Lithgow Seam floor elevations;

The information to be collected from any new bore holes established would include water levels, seasonal fluctuations and water quality test results.

4. Surface water quality

4.1. Assessment approach

This assessment includes a review of existing surface water quality information to understand current conditions in the waterways associated with Mt Piper Power Station – Neubecks Creek - and to assess the potential impacts related to extending the area of ash placement into the sites known as Lamberts North, Lamberts South, Neubecks Creek and Ivanhoe No 4 (see **Figure 1-1**). All sites are located in the Neubecks Creek catchment. As Lamberts North and Lamberts South are subject to project approval, the emphasis will be on those sites. Commentary is also provided on the Neubecks Creek and Ivanhoe No 4 sites.

Based on the processes associated with ash placement the key indicators of concern with respect to water quality include electrical conductivity, total dissolved solids, chloride and trace metals, as follows:

- Conductivity (µS.cm^{-1}) – is a measure of the amount of dissolved salts in the water and its ability to conduct an electrical current. It is important as some plant and animal species are salt sensitive whilst others require higher salt concentrations. Of particular interest is the possibility of the leaching of salts from brine conditioned ash;
- Chloride ions are regarded as an indicator of brine leachates. Although they have no ANZECC (2000) criteria for freshwater aquatic life, it should be noted that concentrations of about 250 mg/L are regarded as suitable for tolerant plant growth;
- pH – is a measure of acidity or alkalinity of water. Most freshwater biota have a range of tolerances between 6.5 and 8;
- Trace elements/metals – can potentially leach from ash storage areas when wet disposal is used, resulting in increased concentrations in surrounding waterways, with potential for putting stress on biota.

4.2. Existing Water Quality Conditions

4.2.1. Assessment of water quality

The assessment of existing water quality conditions within the study area has been made through interpretation of existing water quality data and review of existing reports. Generally water quality information is available for Neubecks Creek at a number of locations, although collection dates vary.

In order to assess existing water quality in a waterway it is necessary to compare water quality data for the relevant indicators against appropriate criteria. The assessment of water quality in this report is made in accordance with default trigger values for chemical and physical stressors for the protection of slightly disturbed upland aquatic ecosystems for south-east Australia as outlined in the National Water Quality Management Strategy (ANZECC/ARMCANZ 2000) and has been shown in **Table 4-1**.

- **Table 4-1 Default trigger values for protection of aquatic ecosystems**

Water quality indicator	**ANZECC/ARMCANZ (2000) trigger value* for protection of upland river aquatic ecosystems**
Turbidity (NTU)	2-25 NTU
Electrical Conductivity (µS.cm^{-1})	30-350 µS.cm^{-1}
pH	6.5 – 8.0
Arsenic	0.0013 mg.L^{-1}
Silver	0.00005 mg.L^{-1}
Barium	-
Beryllium	-
Boron	0.37 mg.L^{-1}
Cadmium	0.0002 mg.L^{-1}
Chromium	0.001 mg.L^{-1}
Copper	0.0014 mg.L^{-1}
Fluoride	-
Iron	0.3 mg.L^{-1}
Mercury	0.00006 mg.L^{-1}
Manganese	1.9 mg.L^{-1}
Molybdenum	-
Nickel	0.011 mg.L^{-1}
Lead	0.0034 mg.L^{-1}
Selenium	0.005 mg.L^{-1}
Zinc	0.008 mg.L^{-1}
Oil and grease	10 mg.L^{-1} ^
Total suspended solids	30 mg.L^{-1} ^

*Trigger values applied are for slightly-moderately disturbed systems

^ As per EPA licence 3607 for Springvale Coal (GHD 2006)

As noted earlier, chloride ions are regarded as an indicator of brine leachates. Although they have no ANZECC (2000) criteria for freshwater aquatic life, it should be noted that concentrations of about 250 mg/L are regarded as suitable for tolerant plant growth.

4.2.2. Surface Water Quality Neubecks Creek

Water quality monitoring of Neubecks Creek has been undertaken at two locations by Delta Electricity and two other locations by Springvale Coal. The sites are shown in **Figure 3-1**, and their location and monitoring record are provided in **Table 4-2**. Sites are reported longitudinally with Site 0 being the most upstream and Site 3 the most downstream.

The first of the two Delta sites is the licensed discharge point (LDP1 called Site 0 in this chapter) which is the power station site runoff holding pond constructed on Neubecks Creek. As the only power station surface water inputs are the uncontaminated drains which enter via the first holding pond and the site is located upstream of the ash disposal area, the site is considered reasonable as a background site for the creek. The second site is downstream of the ash placement area at the stream gauge location shown as WX22. This is called site 1 in this report.

The Springvale Coal sites are located upstream (Site 3) and downstream (Site 4) of the junction of Lamberts Gully with Neubecks Creek.

- **Table 4-2 Water quality monitoring sites Neubecks Creek**

Site Number	Location	Length of record	Source of information
0	Mt Piper PS licensed discharged point – LDP01	2000 – 2009	Delta Electricity (raw data)
1	Neubecks Creek ~400m u/s Blackmans Flat – WX22	2000-2009	Delta Electricity (raw data) Connell Wagner (2007)
2	Neubecks Creek u/sLamberts Gully western main discharge at Blackmans Flat	2000-2007	Springvale Coal (2007) GHD (2006)
3	Neubecks Creek d/s Lamberts Gully western main discharge at Blackmans Flat	2000-2007	Springvale Coal (2007) GHD (2006)

Site 0 – Licensed discharge point

Delta Electricity has provided monthly recordings of water discharged at this site since 2000. The sample site is located in a pond that receives drainage from the power station. It also receives drainage from the upper part of the catchment to the north and west of the power station. A small coal mine is located upstream of this sample point. The data are summarised in **Table 4-3.**

- **Table 4-3 Median concentrations of water quality indicated at the discharge location**

Indicator	LDP01	Guideline
pH	7.39	6.5-8
Conductivity µS.cm^{-1}	404.56	30-350
Alkalinity (as $CaCO_3$ mg/L)	70.71	
Chloride (mg/L)	17.51	
Sulphate (mg/L)	106.40	
TDS (mg/L)	275.31	
Fluoride (mg/L)	0.220	
Sodium (mg/L)	21.30	
Potassium (mg/L)	6.61	
Calcium (mg/L)	30.35	
Magnesium (mg/L)	16.38	
Aluminium (mg/L)	1.46	0.055
Arsenic (mg/L)	0.008	0.0024
Silver (mg/L)	0.002	0.00005
Barium (mg/L)	0.032	
Berillium (mg/L)	0.001	
Boron (mg/L)	0.066	0.37
Cadmium (mg/L)	0.001	0.0002
Chrome (mg/L)	0.003	0.001
Copper (mg/L)	0.008	0.0014
Iron (mg/L)	0.105	
Mercury(mg/L)	0.000	
Manganese (mg/L)	0.102	1.9
Molybdenum (mg/L)	0.004	
Nickel (mg/L)	0.005	0.011
Lead (mg/L)	0.002	0.0034
Selenium (mg/L)	0.001	
Zinc (mg/L)	0.039	0.008

The key findings from Delta Electricity’s monitoring at LDP01 are:

- Median conductivity at the discharge site (LDP01) was higher than further downstream in Neubecks Creek. Conductivity levels fluctuated at this site and at times were recorded as high as 1333µS/cm;
- Chloride concentrations were low, but higher than concentrations downstream of the existing ash placement area;

- Median pH levels complied with the ANZECC/ARMCANZ (2000) guidelines;
- Concentrations of trace elements/metals including arsenic, barium, boron, manganese, nickel and lead were low, complying with relevant guidelines for protection of aquatic ecosystems.
- Median aluminium concentrations of 1.46mg/L at LDP01 were high;
- Silver, cadmium, chrome, copper and zinc were elevated at LDP01. Median concentrations exceeded the ANZECC/ARMCANZ (2000) guidelines for protection of freshwater aquatic ecosystems.

Site 1

Delta Electricity has undertaken monthly monitoring of this site (known as WX22) since 2000, except at times where there was no flow in the creek. This site is located downstream of the existing ash storage area 1 and Huons Gully.

The median results of this monitoring are displayed in **Table 4-4**. Shaded cells denote exceedence of guidelines.

Table 4-4 Median concentrations of water quality indicators in Neubecks Creek at Site 1 (2000-2009)

Indicator	Site 1	ANZECC/ARMCANZ (2000) trigger value
pH	7.26	6.5-8
Conductivity µS.cm^{-1}	333.86	30-350
Alkalinity (as $CaCO_3$ mg/L)	47.55	
Chloride (mg/L)	12.78	
Sulphate (mg/L)	90.02	
Fluoride (mg/L)	0.22	
Sodium (mg/L)	19.37	
Potassium (mg/L)	5.42	
Calcium (mg/L)	24.08	
Magnesium (mg/L)	13.40	
Arsenic (mg/L)	0.006	0.0013
Silver (mg/L)	0.002	0.00005
Barium (mg/L)	0.030	
Boron (mg/L)	0.080	0.37
Cadmium (mg/L)	0.001	0.0002
Chrome (mg/L)	0.007	0.001
Copper (mg/L)	0.004	0.0014
Iron (mg/L)	0.117	
Mercury (mg/L)	0.001	
Manganese (mg/L)	0.513	1.9
Molybdenum (mg/L)	0.001	

Indicator	Site 1	ANZECC/ARMCANZ (2000) trigger value
Nickel (mg/L)	0.004	0.011
Lead (mg/L)	0.002	0.0034
Selenium (mg/L)	0.001	
Zinc (mg/L)	0.042	0.008

The key findings from Delta Electricity's monitoring are:

- The conductivity of Neubecks Creek varied at Site 1 with levels recorded as high as 580µS/cm, although median levels (333µS/cm) complied with the ANZECC/ARMCANZ (2000) guidelines for protection of upland aquatic ecosystems;
- Chloride levels were low, but slightly higher than those at the upstream Site 0:
- Median pH levels complied with the ANZECC/ARMCANZ (2000) guidelines, although pH did fall outside the recommended limits on occasions;
- Concentrations of trace elements/metals including barium, boron, manganese, nickel and lead were low complying with relevant guidelines for protection of aquatic ecosystems;
- Arsenic, silver, cadmium, chrome, copper and zinc were elevated at this site with median concentrations of all indicators exceeding the ANZECC/ARMCANZ (2000) guidelines for protection of freshwater aquatic ecosystems. Silver concentrations showed the greatest magnitude in exceedence with median concentrations of 0.002mg/L;
- Neubecks Creek suffers from prolonged dry periods with no flow recorded between August 2002 and February 2003 and between January 2004 and April 2004. These low flows means the creek is often dominated by groundwater inflows.

Site 2 and Site 3

These data were collected at two sites – upstream Site 2 and downstream Site 3 – where Lamberts Gully joins Neubecks Creek. Data has been collected by Springvale Coal as part of the monitoring program required for the coal mining works. The raw data were not available but summaries were reported in GHD (2006) and Springvale Coal (2007) and show that:

- pH levels in Neubecks Creek were similar between sites with a mean pH of 6.9 recorded at Site 2 and 7.0 at site 3, although pH was low on occasions falling below the lower limit of 6.5 at both sites (GHD 2006). Monitoring results in 2007 continued to show pH levels below 6.5 at both sites, although pH was slightly better at Site 3 (Springvale Coal 2007);
- Electrical conductivity was elevated during this monitoring period with mean concentrations ranging between 810 and 987µS/cm in Neubecks Creek, which is 2 to 3 times the recommended guideline limit of 350µS/cm (GHD 2006). Electrical conductivity results

collected in 2007 show that Site 3 generally has higher conductivity although levels fluctuated considerably. Concentrations in Neubecks Creek were recorded between 250µs.cm^{-1} to 1200µs.cm^{-1} in Neubecks Creek (Springvale Coal 2007);

- Filterable iron concentrations upstream and downstream Neubecks Creek ranged fluctuated and were generally higher downstream (site 3). Monitoring undertaken between 2002 and 2006 reported mean concentrations of 0.2mg/L at both site 2 and 3 (GHD 2007), although at times concentrations were recorded as high as 1.4mg/L at Site 2 and 1mg/L at site 3. Monitoring undertaken in 2007 recorded filterable iron concentrations between ~0.1mg/L and ~ 0.9mg/L (Springvale Coal 2007);
- Filterable manganese was recorded in high concentrations at both site 2 and site 3, with mean levels of 3.3mg/L and 2.59mg/L respectively, both exceeding the recommended ANZECC/ARMCANZ (2000) limit for total manganese of 1.9mg/L (GHD 2006). There was a vast range in concentrations with minimum concentrations of 0.2mg/L and 0.1mg/L recorded at sites 2 and 3 respectively and maximum concentrations of 13.1mg/L and 17mg/L (GHD 2006). Monitoring in 2007 continued to show high filterable manganese concentrations which ranged between ~0.3mg/L to 8mg/L at Site 2 and ~0.6mg/L and ~4.5mg/L at site 3 (Springvale Coal 2007);
- Zinc concentrations were similar between site 2 and site 3 and less than ~0.2mg/L on all sampling occasions in 2007 (Springvale Coal 2007);
- Oil and grease levels varied between the upstream and downstream site throughout 2007, but were notably less than the EPA Licence guideline limit of 10mg/L on all sampling occasions (Springvale Coal 2007);
- Total suspended solids also varied throughout the year but were generally similar between sites. Concentrations generally remained low but did exceed the EPA Licence guideline of 30mg.L^{-1} in March 2007 at both sites (Springvale Coal 2007).

4.2.3. Summary of findings

Neubecks Creek is the primary potential receiving water for any discharges from the existing and proposed ash placement areas, which can in turn influence the quality of water feeding into the Coxs River and Sydney’s drinking water system. Overall, monitoring results indicate that:

- pH levels are within guidelines and generally seem to be lower at downstream sites.
- Electrical conductivity can be elevated at all sites, although at Site 1 immediately downstream of the existing ash Area 1 it falls within guidelines. At Site 0 upstream of any existing ash placement activities the conductivity levels are highest. At Site 1 downstream of the existing ash Area 1 the data generally comply. Further downstream at Sites 2 and 3 the results tend to be higher than at Site 1;
- Chloride ion levels are consistently low where measured;

- Metal concentrations are often below criteria, but are shown to be elevated in Neubecks Creek at Site 1 (particularly silver, arsenic, cadmium, chromium, copper and zinc), at Site 0 (silver and aluminium) and at Sites 2 and 3 (manganese and zinc). Connell Wagner (2007) noted that the lower pH and increased manganese and zinc indicated that the flow in Neubecks Creek was dominated by groundwater inflows during the dry weather rather than catchment runoff. The local groundwater is elevated in these metals due to the acid sulphate conditions in the local underground mine waters.

5. Impacts, Mitigation and Monitoring

5.1. Summary of Impacts

The Director-General’s requirements require the Environmental Assessment to assess the impacts on Neubecks Creek, Coxs River and Huons Creek of the proposal at Lamberts North and Lamberts South and the cumulative impacts from other activities such as the operation of the Mt Piper Power Station, its current ash placement Area 1, coal mining in the area and the proposed Council land fill operation.

The impacts of coal mining and the existing power station operations are included in the assessment. The proposed landfill has yet to begin operation. The EIS prepared for the project (HLA Envirosciences 2005) indicated potential water quality impacts from contaminants associated with leaching of land fill material as well as pollution from leaks and spills. Management measures are proposed within the EIS, including a comprehensive leachate management system.

The impacts on receiving waters will focus on Neubecks Creek. Coxs River is downstream of Neubecks Creek, and any cumulative impact within Coxs River would only be evident if a significant impact due to the proposal was noted in Neubecks Creek.

As indicated in the chapters above, the status of Huons Creek as a waterway is unclear. We have described it as Huons Gully in the area associated with the existing coal mining activities, as it appears for some time to have functioned as a gully or drainage line, receiving groundwater drainage from the existing ash placement area and from the operating open cut coal mine, and is not connected to Neubecks Creek. The drainage above the coal mine activities functions as a dry creek drainage area in catchment without any obvious disturbance. The project proposes to cover Huons Gully with ash to provide the necessary volume for ash and to divert any drainage from the undisturbed areas upstream to Lamberts Gully and thence to Neubecks Creek.

The direct and cumulative impacts of the proposal on Neubecks Creek and Coxs River are summarised below.

5.1.1. Impacts on Surface Water Hydrology

The development of the proposed ash placement facility has the potential to affect the water availability of the Upper Coxs River Catchment in two ways, by:

- Reducing the volume of runoff to the Coxs River by reducing the catchment area; and
- Requiring external water sources to supply water demands at the proposed ash placement facility.

The project investigation area for the Lamberts North and Lamberts South ash placement facilities is approximately 0.4 % of the Upper Cox River catchment. Similarly, the Ivanhoe No. 4 area and the Neubecks Creek area equate to approximately 0.4 % and 0.3 % of the Upper Cox River Catchment respectively. These are only very small portions of the Upper Cox River Catchment and will have negligible impact on the catchment in terms of water availability.

The proposed ash placement facilities would not require water allocations or licences to operate, as the facilities would be supplied by the water harvested from the disturbed areas of the sites. The water would be used for rehabilitation and dust suppression to supply to the operation. The water sourced from the disturbed areas of the proposed ash placement facility would be achieved by the development of a site water management system for each site.

The development of the ash facility has the potential to affect the flooding regime of the local creeks by modifying the landform of the area to include the proposed ash placement facility. The potential for flooding impacts is mostly likely due to the upstream catchments of the facility. The development of the site water management system would include diversion drains to separate clean water from undisturbed catchments upstream of the proposed ash placement facility. The diversion drains would be designed to convey the 100 year ARI flood event.

As the proposed ash placement facility is located in the drinking water catchments of Sydney, releases of water from the site would have the potential to affect the water quality of the receiving waters. The proposed ash placement facility would generate water contaminated by sediment and the site water management system would be designed to manage the contaminated water from the site and minimise the risk of affecting the water quality of the Coxs River by:

- Separating clean water from undisturbed catchments and dirty water on the site;
- Managing the dirty water generated on site, based on the contaminants including sediment dams for runoff containing sediment laden water and a dirty water area for water containing runoff from the exposed ash placement areas;
- Allowing no regular controlled releases from the site;
- Reusing the water generated on site to satisfy the demands for rehabilitation and dust suppression; and
- Allowing water releases from sedimentation dams only in large rainfall events after the water has been treated through the dams.

5.1.2. Impacts on Groundwater

Groundwater monitoring studies undertaken for the existing ash placement area show:

- Sulphate, boron, nickel, manganese and iron are naturally elevated in the existing ash placement area due to the local mineralisation associated with groundwater from the coal mining workings;
- Elevated trace elements concentrations are particularly evident at sites adjacent to areas of mine coal pillars (goaf);
- The effect of the underground mine water quality was reflected in the values for the groundwater collection basin, notably in the higher sulphate and boron levels. Trace elements such as nickel and zinc are also elevated in these areas;
- The low chloride concentrations in the groundwater bores indicate no significant effects on the local groundwater from the existing brine conditioned ash.

Modelling undertaken in 1999 and 2007 for brine production and co-placement predicted an insignificant increase in salts and trace elements in the groundwater seeping into the GCB and from there to Neubecks Creek. The modelling showed:

- The stable background concentrations of major ions throughout the area are not related to the ash deposit, rather that the mine goaf zones were bleeding continuously into the spoil material;
- There is a low risk that any trace elements generated from ash disposal would increase background levels by more than ANZECC guidelines at Huons Gully or the GCB. There would be no risks at Neubecks Creek, with extremely low concentrations predicted.

The results confirmed that the brine constituents were essentially immobilised in the pores of the water conditioned fly ash and brine conditioned fly ash. Overall the ash had a low rainfall infiltration rate, so the passage of the infiltration through the existing ash deposit was very slow.

The minimal effects of leachates from the ash deposits were due to the slow rate at which leachates from the brine conditioned ash entered the groundwater and the mixing of this with the background groundwater under the ash deposit. The groundwater then flows to the GCB, with some possibly reaching Neubecks Creek. The predicted values did not exceed the ANZECC (2000) criteria.

The modelling also noted that the predicted increases in water quality parameters due to inputs from the underground mine areas were also below the ANZECC guidelines, with the exception of boron, nickel and zinc which were naturally elevated. Most of the predicted increases were assessed as being due to poor water quality in the underground mine workings moving toward the GCB and are unrelated to the brine placement area or water conditioned ash placement.

The groundwater assessment concluded that:

- The main aquifer in the proposed Lamberts North and Lamberts South ash storage areas is the disturbed rock mass up to 50m thick lying between the base of the Lithgow Seam and the ground surface. This is unconfined and probably extremely permeable in places. It is only partly saturated, with standing water levels generally below RL 920m, discharging eastwards towards water courses such as Lamberts Gully;
- Present disposal practices require the brine conditioned ash to be placed 35-40m above the water table (at 946m AHD). Groundwater quality results and modelling suggest that this practice is sufficient to ensure brine does not leach through to the groundwater. Continuing this practice of placing brine conditioned ash at an appropriate height would allow for groundwater quality to be unaffected by ash placement in Lamberts North (at 946m AHD) and Lamberts South (956m AHD).

5.1.3. Surface Water Impacts

Based on the processes associated with ash placement the key indicators of concern with respect to water quality include electrical conductivity, total dissolved solids, chloride and trace metals.

Neubecks Creek is the primary potential receiving water for any discharges from the existing and proposed ash placement areas, which can in turn influence the quality of water feeding into the Coxs River. Overall, the Neubecks Creek monitoring results indicate that:

- Electrical conductivity can be elevated at all sites, although immediately downstream of the existing ash Area 1 it falls within guidelines;
- Chloride ion levels are consistently low where measured;
- Metal concentrations are often below criteria, but are shown to be elevated in Neubecks Creek immediately downstream of the existing ash area (particularly silver, arsenic, cadmium, chromium, copper and zinc), at the site upstream of the existing ash area (silver and aluminium) and at downstream sites associated with the existing mine operations (manganese and zinc). The increased manganese and zinc indicated that the flow in Neubecks Creek was dominated by groundwater inflows during the dry weather rather than catchment runoff. The local groundwater is elevated in these metals due to the acid sulphate conditions in the local underground mine waters.

5.1.4. Conclusion

There exists sufficient data from the on-going monitoring and the modelling studies undertaken to suggest that the main contribution to elevated water quality parameters in Neubecks Creek is due to past, underground coal mining activities rather than the existing ash placement works at Area

1 or the operation of Mt Piper Power Station. The Council waste facility site has yet to begin operation so there is no suggestion of any existing cumulative impact from it.

The management of works at the existing Area 1 is appropriate to minimise the risk of a discharge from the construction and operation of the active ash placement areas. A continuation of these practices in the Lamberts North and Lamberts South areas, as well as similar practices at the Neubecks Creek and Ivanhoe No 4 sites would be enough to ensure that ash placement has limited if any effects on the water quality of Neubecks Creek.

The sections below discuss the mitigation measures necessary to minimise the risks.

5.2. Operation

5.2.1. Site Surface Water

Mitigation

As the proposed ash placement facilities would have the potential to affect the water quality of Neubecks Creek and consequently the Coxs River, the system will be designed to manage the ash and sediment contaminated water from the site and minimise the risk of affecting the off-site water quality. This will be done by:

- Separating clean water from undisturbed catchments using catch drains and directing this clean water directly to waterways;
- Managing the dirty water generated in the exposed ash areas to a dirty water area (dams) and designing these dams to provide for no releases from these sites. This water will evaporate and/or be used for dust suppression and rehabilitation sites;
- Reusing the water generated from capped and rehabilitated areas to satisfy the demands for rehabilitation and dust suppression. This will be done on site by use of sediment dams and water storages for runoff containing sediment laden water. The sedimentation dams will be designed to release water in large rainfall events after the water has been treated through the dams. Once the rehabilitation is established, the runoff would be allowed to return to the waterway without the need for any dams.

The management of potential for dirty water runoff during ash placement will involve:

- Placement of ash in layers, with steps to produce a batter slope and bunds at batter extents to prevent discharge of water over the benches and down batter slopes to minimise scour and erosion.
- Drainage of surface water runoff from permanent batters to flow along benches and/or formalised channels. It would be typically directed to the centre of the ash placement area and into dirty water storage areas.

Monitoring

The adequacy of the structures to control water quality runoff would be monitored. This would include:

- Water quality testing of sedimentation dams and water storages to ensure any discharge is appropriate for release to the receiving waterways. The information from this monitoring will also provide advice as to when water from rehabilitated areas will be able to runoff directly to the environment, rather than through a sedimentation dam.

5.2.2. Groundwater

Mitigation

The management of groundwater quality would be achieved by appropriate design and operation of the ash placement facilities. This would include:

- Regrading and profiling of storage areas to provide a base area above groundwater for the placement of ash materials.
- Placement of brine treated ash at defined heights above groundwater levels to minimise risk of seepage into the groundwater table.
- At Huons Gully the placement of a subsurface drainage at the gully invert to provide a discharge area for groundwater seepage from Area 1 as well as ground water movement from upstream in Huons Gully.

Monitoring

The development consent of 1 April 1982 for the Mt Piper Power Station ash placement was modified in April 2000 to allow for brine conditioned ash placement at the site. The 2000 consent requested the preparation of a Water Monitoring Program which would include groundwater quality testing in monitoring bores on or in the vicinity of the Area 1 site. The most recent update to the plan is provided in Aurecon (2008). The results of this testing are reported in an annual Environmental Monitoring Report, the most recent being Aurecon (2009).

A bore hole monitoring program will be required for each new ash placement site. At Lamberts Gully the present two observation wells in Lamberts South, even supplemented by those installed in the NW corner of Lamberts North, are not sufficient for a groundwater monitoring network. They do, however, give preliminary information on the hydrogeological conditions in the project area and provide a basis for planning a future monitoring network. Further well installation would need to be delayed until after the mining activities cease, and until planning for the ash storage areas is further advanced.

Information that would assist in designing such a monitoring network as an extension to the existing monitoring program would include:

- A plan showing topography, with accurate contours, and the extent of filled ground and other relevant information;
- A plan showing the distribution of abandoned mine workings, distinguishing between open cuts, de-pillared underground workings and pillar supported areas, with Lithgow Seam floor elevations;
- Up to date records of the existing groundwater monitoring program, including water levels, seasonal fluctuations and water quality test results. Parameters to be monitored are those that would assist in determining contribution (if any) from ash seepage.

The information to be collected from any new bore holes established would include water levels, seasonal fluctuations and water quality test results. The water quality parameters would include pH, conductivity, ions (especially chloride) and trace metals. As with the previous consent for ash placement, the data from the monitoring sites would be reported in an annual Environmental Monitoring Report.

The annual Environmental Monitoring Report will include all available results and analyses from the borehole monitoring and actions taken or intended to be taken, if any, to mitigate any adverse environmental impacts.

5.2.3. Off-site Surface Water

Management

Neubecks Creek is the primary potential receiving water for any discharges from the existing and proposed ash placement areas, which can in turn influence the quality of water feeding into the Coxs River. Overall, monitoring results from the 4 in-stream sites (at Mt Piper licensed discharge point and 3 sites downstream of the existing ash Area 1) indicate that the identified exceedances of water quality criteria within the receiving waters may be due to varied activities within the catchment, in particular disused mining works. The occasional elevated conductivity and trace metal results cannot be attributed to the existing ash Area 1.

The means of managing water runoff were described above and the maintenance of those processes is important to ensure that ash storage areas do not contribute to any water quality impacts within Neubecks Creek.

Monitoring

A monitoring plan will be developed for the project. The intent will be to identify sufficient sites in Neubecks Creek to:

- Provide background data showing the existing water quality impacts from the Neubecks Creek and Ivanhoe No 4 sites;
- Allow the possibility of separating out potential impacts from the Lamberts North and Lamberts South sites from the existing Area 1 site.

The development consent of 1 April 1982 for the Mt Piper Power Station ash placement was modified in April 2000 to allow for brine conditioned ash placement at the site. The 2000 consent requested the preparation of a Water Monitoring Program which would include water quality testing in receiving waters (Aurecon, 2008). The results of this testing are reported in an annual Environmental Monitoring Report (see Aurecon, 2009).

Water quality monitoring should be based on existing monitoring undertaken in Neubecks Creek so that results between sites are comparable. Currently this involves monthly monitoring by Delta Electricity in Neubecks Creek approximately 400m upstream of Blackmans Flat. Other sites in Neubecks Creek should be selected that are representative of the proposed areas of work and that may identify any proposed impacts from the sites. Monitoring sites should take into consideration groundwater monitoring to ensure the source of any water quality issues can be identified ie groundwater seepage or surface runoff.

Water quality monitoring should consider the ANZECC/ARMCANZ (2000) guidelines and monitoring results should be compared against recommended trigger values for protection of upland river aquatic ecosystems. The recommended water quality monitoring parameters have been devised based on the likely pollutants of concern during the construction and operating stages of Lamberts North and Lamberts South. These parameters include:

- In situ**:** pH, electrical conductivity, total dissolved solids, alkalinity and turbidity;
- Total anions and cations: chloride, fluoride, sulphate, sodium, calcium, magnesium and potassium
- Trace elements/metals: Aluminium, arsenic, silver, barium, boron cadmium, chromium, copper, iron, mercury, manganese, lead, selenium, silica and zinc.

Concentrations should be in accordance with the ANZECC/ARMCANZ (2000) guidelines for protection of aquatic ecosystems.

The results from the monitoring would be reported in the annual Environmental Monitoring Report which will include all available results and analyses from the in-stream monitoring and actions taken or intended to be taken, if any, to mitigate any adverse environmental impacts.

Cumulative Impacts

As noted, mining and power generation have been the dominant land use practices for many years. These practices have contributed to the existing water quality of surrounding creeks, potentially placing stress on aquatic ecosystems.

To assess the relative contributions from various sources to receiving water contribution, sampling design should consider a means by which various inputs can be separately identified. This would require an integrated sampling program to identify contribution from surface drainage from around and on the ash placement facility, ash placement seepage or leachate to groundwater, existing underground coal mine groundwater contribution, contribution from mine sites directly associated with Neubecks Creek and Ivanhoe No 4, contribution from Delta's existing licensed discharge and, should it proceed, from Mt Piper Extension. Cooperation would also benefit from any monitoring program required from Council's waste management site.

It is important that appropriate mitigation measures and a comprehensive monitoring program to identify water quality issues and sources of pollution be continued and expanded to allow the cumulative effects of the proposed ash placement effects on surface water quality to be assessed.

5.3. Construction

5.3.1. Construction Impacts

There are a number of construction phase activities for the preparation of areas for ash storage which include:

- Clearing and grubbing. Areas for ash placement will be cleared of any vegetation and unsuitable founding materials.
- Re-grading/re-profiling of sites to control seepage and maintain uniform drainage.
- Earthworks and fill construction involving the construction of soil banks, filling of areas and spreading and compaction to achieved desired levels.
- Temporary rehabilitation and stockpile remediation of areas previously disturbed by mining activities to control surface flow and erosion. This may involve construction of sedimentation ponds, surface water diversion and revegetation of disturbed areas.
- Construction access and haul roads will be progressively created as ash placement continues.
- Construction of surface drainage works and sub-surface drainage which may include retention basins, sediment and erosion control measures, capping and re-vegetation of areas
- Construction of rock drainage blanket in Huons Gully.

These construction activities have the potential to have an effect on water quality of Neubecks Creek in the following ways:

- the potential to generate sediments and pollutants such as nutrients to local waterways as the soil in cleared areas becomes exposed and the likelihood of erosion is increased;
- Increased vehicle movements in the area in and out of construction sites, increase the likelihood for hydrocarbons and chemicals to enter the surrounding waterways as a result of spills and leakages from construction vehicles;
- General litter and gross pollutants from construction materials;
- Contaminants such as nutrients, metals and other potential toxicants that attach to the sediment particles can be transferred to waterways if appropriate sediment and erosion control measures are not in place or working effectively.

As such the potential impacts to surface water quality of Neubecks Creek as a result of construction phase activities for the preparation for ash storage include:

- Increased salinity;
- Increased turbidity and sedimentation;
- Increased nutrients and risk of eutrophication;
- Increased metal concentrations which could be toxic to aquatic organisms.

All construction work would be undertaken so as to minimise environmental disturbance and mitigate risks associated with such construction activities.

5.3.2. Construction Environmental Safeguards

To reduce potential water quality impacts of the site during construction, general measures to control erosion of soil and sedimentation would be implemented prior to construction works. Such measures would be documented in a Construction Phase Soil and Water Management Plan (SWMP) prepared in accordance with the principles and practices in *Landcom Soil and Construction, Managing Urban Stormwater Handbook* (Landcom 2004).

More specifically, environmental safeguards would include:

- Vehicles will only travel on designated access roads;
- Management of runoff to waterways and ensure additional impacts on groundwater and surface water quality do not occur;
- Regular site maintenance will be undertaken to ensure frequent dust suppression so that pollution of waterways does not occur;
- Ensuring that chemicals and fuels are appropriately stored and bunded;
- Installing erosion and sediment controls such as sediment basins and sediment fences;

- Ensure construction workers/staff understand and maintain sediment and erosion control measures;
- Preparation and implementation of revegetation and rehabilitation plans for sites once ash is placed and the site capped.

The in-stream monitoring described above would be undertaken during construction to determine if sediment and erosion control measures and surface water diversion techniques are working effectively.

6. References

ANZECC/ARMCANZ (2000). *National Water Quality Management Strategy. Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

AURECON (2008). *Mt Piper Power Station Brine Conditioned Flyash Co-Placement Extension Water Management and Monitoring Plan*. Delta Electricity, May 2008.

AURECON (2009). *Water Quality Monitoring Annual Update Report February 2008 – January 2009.* Mt Piper Power Station Brine Conditioned Flyash Co-Placement Water Management Plan. Delta Electricity, July 2009.

Connell Wagner (2007) *Mt Piper Station – Proposed Extension of Brine in Ash Co-Placement Area Statement of Environmental Effects.* Report for Delta Electricity.

Department of Mineral Resources, NSW (1992) *Western Coalfield 1:100,000 geological map, southern part*. Compiled for DMR by E Yoo.

GHD (2006) *Report for Lamberts Gully Coal Mine: Surface Water Management Plan.* Report for Springvale Coal Pty Ltd. December 2006.

Landcom (2004). *Landcom Soil and Construction, Managing Urban Stormwater Handbook*

Merrick, NP (2007). Groundwater Modelling of Brine-Conditioned Flyash Co-Placement at Mt Piper Power Station. Report by ACCESSUTS for Connell Wagner on behalf of Delta Electricity.

Pacific Power International (PPI) (2001) *Mount Piper PS – installation of groundwater observation wells*. Unpublished report GEO 165 to Delta Electricity, October 2001.

Springvale Coal (2007) *Lamberts Gully Open Cut Coal Mine 2007, Annual Environmental Management Report.*

Appendix A Bore Hole Data

SKM

PROJECT: Mount Piper Ash Emplacement

DETAILS: Lambert Gully observation wells

HOLE No. 1

Sheet 1 of 4

Client Delta Power
Job No: EN2503.200

Start - Finish Date: 10/12/2009-10/12/2009
Bore Dia: 100mm

Driller: Total Drilling
Rig: Edson 3000 Truck

Northings: mN
Eastings: mE
RL:

Logged: GMN
Checked: GMN
Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	Penetration 1 2 3	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
Blade-bit	No definite ground water cuts	Not cased		Not completed as a piezometer			1 2			RESIDUAL SOIL and SILTSTONE (XW), brown	VSt – H	D		
DHH							3 4 5 6 7 8 9			SILTSTONE and SANDSTONE (SW - HW), grey and brown, slightly moist in places but mostly dry		D		

FIELD DATA SYMBOLS	GROUNDWATER SYMBOLS	FIELD DATA ABBREVIATIONS	DENSITY (N-value)	CONSISTENCY (Su)
○ = Environmental Sample ▩ = Undisturbed Tube Sample ● = Disturbed Sample ▯ = Bulk Sample	▼ = Water level (static) ▽ = Water level (during drilling) = Outflow / Inflow MOISTURE CONDITION D - Dry M - Moist W - Wet	Suv = Uncorrected vane shear (kPa) Sup = Pocket penetrometer (kPa) N = SPT blows per 300mm PENETRATION 1 - 4 ranging from no resistance to refusal	VL (very loose) 0 - 4 L (loose) 4 - 10 MD (medium dense) 10 - 30 D (dense) 30 - 50 VD (very dense) 50 - 100 CO (compact) >50/150mm	VS (very soft) < 12kPa S (soft) 12 - 25 F (firm) 25 - 50 St (stiff) 50 - 100 VSt (very stiff) 100 - 200 H (hard) > 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

SKM

PROJECT: Mount Piper Ash Emplacement

DETAILS: Lambert Gully observation wells

HOLE No. 1

Sheet 2 of 4

Client: Delta Power
Job No: EN2503.200

Start - Finish Date: 10/12/2009-10/12/2009
Bore Dia: 100mm

Driller: Total Drilling
Rig: Edson 3000 Truck

Northings: mN
Eastings: mE
RL:

Logged: GMN
Checked: GMN
Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	Penetration 1 2 3	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
DHH	No definite ground water cuts	Not cased					11 12			SILTSTONE and SANDSTONE (SW - HW), grey and brown, slightly moist in places but mostly dry *(continued)*		D		
							13			COAL, black, weak, dry		D		
							14 15 16			SILTSTONE and SHALE, grey		D		
							17 18 19			SANDSTONE, white and grey, very weak, damp (silty sand cuttings)		W		
										COAL, black, dry (Lithgow Seam)				

FIELD DATA SYMBOLS
○ = Environmental Sample
▮ = Undisturbed Tube Sample
● = Disturbed Sample
▯ = Bulk Sample

GROUNDWATER SYMBOLS
▼ = Water level (static)
▽ = Water level (during drilling)
= Outflow / Inflow

MOISTURE CONDITION
D = Dry M = Moist W = Wet

FIELD DATA ABBREVIATIONS
Suv = Uncorrected vane shear (kPa)
Sup = Pocket penetrometer (kPa)
N = SPT Blows per 300mm

PENETRATION
1 - 4 ranging from no resistance to refusal

DENSITY (N-value)		
VL	(very loose)	0 - 4
L	(loose)	4 - 10
MD	(medium dense)	10 - 30
D	(dense)	30 - 50
VD	(very dense)	50 - 100
CO	(compact)	>50/150mm

CONSISTENCY (Su)		
VS	(very soft)	< 12 kPa
S	(soft)	12 - 25
F	(firm)	25 - 50
St	(stiff)	50 - 100
VSt	(very stiff)	100 - 200
H	(hard)	> 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

SKM

PROJECT: Mount Piper Ash Emplacement

DETAILS: Lambert Gully observation wells

HOLE No. 1

Sheet 3 of 4

Client Delta Power
Job No: EN2503.200

Start - Finish Date: 10/12/2009-10/12/2009
Bore Dia: 100mm

Driller: Total Drilling
Rig: Edson 3000 Truck

Northings: mN
Eastings: mE
RL:

Logged: GMN
Checked: GMN
Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	1 2 3 Penetration	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
DHH										COAL, black, dry (Lithgow Seam) *(continued)*		D		
							21							
							22							
							23							
							24			SANDSTONE and SILTSTONE, grey and white, cuttings damp in places		D		
							25							
							26							
							27							
							28							
							29							

FIELD DATA SYMBOLS

○ = Environmental Sample
▮ = Undisturbed Tube Sample
● = Disturbed Sample
▯ = Bulk Sample

GROUNDWATER SYMBOLS

▼ = Water level (static)
▽ = Water level (during drilling)
= Outflow / Inflow

MOISTURE CONDITION

D = Dry M = Moist W = Wet

FIELD DATA ABBREVIATIONS

Sw = Uncorrected vane shear (kPa)
Sup = Pocket penetrometer (kPa)
N = SPT blows per 300mm

PENETRATION

1 - 4 ranging from no resistance to refusal

DENSITY (N-value)		
VL	(very loose)	0 - 4
L	(loose)	4 - 10
MD	(medium dense)	10 - 30
D	(dense)	30 - 50
VD	(very dense)	50 - 100
CO	(compact)	>50/150mm

CONSISTENCY (Su)		
VS	(very soft)	< 12kPa
S	(soft)	12 - 25
F	(firm)	25 - 50
St	(stiff)	50 - 100
VSt	(very stiff)	100 - 200
H	(hard)	> 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

SKM

PROJECT: Mount Piper Ash Emplacement
DETAILS: Lambert Gully observation wells

HOLE No. 1
Sheet 4 of 4

Client	Delta Power	Start - Finish Date:	10/12/2009-10/12/2009	Driller: Total Drilling	Northings: mN	Logged: GMN
Job No:	EN2503.200	Bore Dia:	100mm	Rig: Edson 3000 Truck	Eastings: mE	Checked: GMN
					RL:	Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	Penetration 1 2 3	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
										SANDSTONE and SILTSTONE, grey and white, cuttings damp in places *(continued)*				
DHH							31							
							32			SWL > 25m one day after completion of drilling (11 / 12 / 09) SWL 20.66m BGL on 14 / 01 / 10				
							33							
										33.2 Borehole terminated at limit of drilling rods				
							34							
							35							
							36							
							37							
							38							
							39							

FIELD DATA SYMBOLS
○ = Environmental Sample
▨ = Undisturbed Tube Sample
● = Disturbed Sample
▥ = Bulk Sample

GROUNDWATER SYMBOLS
▼ = Water level (static)
▽ = Water level (during drilling)
= Outflow / Inflow

MOISTURE CONDITION
D = Dry M = Moist W = Wet

FIELD DATA ABBREVIATIONS
Sw = Uncorrected vane shear (kPa)
Sup = Pocket penetrometer (kPa)
N = SPT blows per 300mm

PENETRATION
1 - 4 ranging from no resistance to refusal

DENSITY (N-value)		
VL	(very loose)	0 - 4
L	(loose)	4 - 10
MD	(medium dense)	10 - 30
D	(dense)	30 - 50
VD	(very dense)	50 - 100
CO	(compact)	>50/150mm

CONSISTENCY (Su)		
VS	(very soft)	< 12kPa
S	(soft)	12 - 25
F	(firm)	25 - 50
St	(stiff)	50 - 100
VSt	(very stiff)	100 - 200
H	(hard)	> 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

SKM

PROJECT: Mount Piper Ash Emplacement
DETAILS: Lambert Gully observation wells

HOLE No. 2
Sheet 1 of 3

Client Delta Power
Job No: EN2503.200

Start - Finish Date: 10/12/2009-10/12/2009
Bore Dia: 100mm

Driller: Total Drilling
Rig: Edson 3000 Truck

Northings: mN
Eastings: mE
RL:

Logged: GMN
Checked: GMN
Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	Penetration 1 2 3	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
Blade-bit		Not cased								RESIDUAL SOIL and SLOPEWASH, SILTY SAND, light brown		D		
DHH	11.12.09 ▼8.5m						1 2 3 4 5 6 7 8 9			SANDSTONE, fine grained, brown becoming grey, weak, dry (mostly silty fine sand in cuttings returned)		D		

FIELD DATA SYMBOLS	GROUNDWATER SYMBOLS	FIELD DATA ABBREVATIONS	DENSITY (N-value)	CONSISTENCY (Su)
O = Environmental Sample ▮ = Undisturbed Tube Sample ● = Disturbed Sample ▯ = Bulk Sample	▼ = Water level (static) ▽ = Water level (during drilling) = Outflow / Inflow MOISTURE CONDITION D = Dry M = Moist W = Wet	Suv = Uncorrected vane shear (kPa) Sup = Pocket penetrometer (kPa) N = SPT blows per 300mm PENETRATION 1 - 4 ranging from no resistance to refusal	VL (very loose) 0 - 4 L (loose) 4 - 10 MD (medium dense) 10 - 30 D (dense) 30 - 50 VD (very dense) 50 - 100 CO (compact) >50/150mm	VS (very soft) < 12kPa S (soft) 12 - 25 F (firm) 25 - 50 St (stiff) 50 - 100 VSt (very stiff) 100 - 200 H (hard) > 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

SKM NON CORED BOREHOLE GROUNDWATER.GPJ SKM.GDT 12/1/10

SKM

PROJECT: Mount Piper Ash Emplacement
DETAILS: Lambert Gully observation wells

HOLE No. 2
Sheet 2 of 3

Client	Delta Power	Start - Finish Date: 10/12/2009-10/12/2009	Driller: Total Drilling	Northings: mN	Logged: GMN
Job No:	EN2503.200	Bore Dia: 100mm	Rig: Edson 3000 Truck	Eastings: mE	Checked: GMN
				RL:	Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	Penetration 1 2 3	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
	SWL 11.6m, 10.12.09 @ 1615									SANDSTONE, fine grained, brown becoming grey, weak, dry (mostly silty fine sand in cuttings returned) *(continued)*		D		
							11			SANDSTONE as above, but damp				
							12							
							13					M		
							14							
DHH							15			SANDSTONE, dry to damp (water cut at 15m with minor cuts from 15 - 30m)				
							16							
							17					M		
							18							
							19							

FIELD DATA SYMBOLS	GROUNDWATER SYMBOLS	FIELD DATA ABBREVIATIONS	DENSITY (N-value)	CONSISTENCY (Su)
○ = Environmental Sample	▼ = Water level (static)	Suv = Uncorrected vane shear (kPa)	VL (very loose) 0 - 4	VS (very soft) < 12 kPa
■ = Undisturbed Tube Sample	▽ = Water level (during drilling)	Sup = Pocket penetrometer (kPa)	L (loose) 4 - 10	S (soft) 12 - 25
● = Disturbed Sample	= Outflow / Inflow	N = SPT blows per 300mm	MD (medium dense) 10 - 30	F (firm) 25 - 50
▯ = Bulk Sample	MOISTURE CONDITION	PENETRATION	D (dense) 30 - 50	St (stiff) 50 - 100
	D = Dry M = Moist W = Wet	1 - 4 ranging from no resistance to refusal	VD (very dense) 50 - 100	VSt (very stiff) 100 - 200
			CO (compact) >50/150mm	H (hard) > 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

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SKM

PROJECT: Mount Piper Ash Emplacement
DETAILS: Lambert Gully observation wells

HOLE No. 2
Sheet 3 of 3

Client: Delta Power
Job No: EN2503.200

Start - Finish Date: 10/12/2009-10/12/2009
Bore Dia: 100 mm

Driller: Total Drilling
Rig: Edson 3000 Truck

Northings: mN
Eastings: mE
RL:

Logged: GMN
Checked: GMN
Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	Penetration 1 2 3	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
										SANDSTONE, grey, minor water cuts, mud cuttings return				
							21							
							22							
							23							
							24							
DHH							25					M		
							26							
							27							
							28							
							29			Borehole terminated at 30m No standing water level but walls below approximately 15m Completed as piezometer on 11.12.09 30.0m SWL 7.02m BGL on 14 / 01 / 10				

FIELD DATA SYMBOLS
- ○ = Environmental Sample
- ▮ = Undisturbed Tube Sample
- ● = Disturbed Sample
- ▯ = Bulk Sample

GROUNDWATER SYMBOLS
- ▼ = Water level (static)
- ▽ = Water level (during drilling)
- = Outflow / Inflow

MOISTURE CONDITION
D = Dry M = Moist W = Wet

FIELD DATA ABBREVIATIONS
- Suv = Uncorrected vane shear (kPa)
- Sup = Pocket penetrometer (kPa)
- N = SPT blows per 300mm

PENETRATION
1 - 4 ranging from no resistance to refusal

DENSITY (N-value)

VL	(very loose)	0 - 4
L	(loose)	4 - 10
MD	(medium dense)	10 - 30
D	(dense)	30 - 50
VD	(very dense)	50 - 100
CO	(compact)	>50/150mm

CONSISTENCY (Su)

VS	(very soft)	< 12 kPa
S	(soft)	12 - 25
F	(firm)	25 - 50
St	(stiff)	50 - 100
VSt	(very stiff)	100 - 200
H	(hard)	> 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

SKM

PROJECT: Mount Piper Ash Emplacement

DETAILS: Lambert Gully observation wells

HOLE No. 3

Sheet 1 of 2

Client: Delta Power
Job No: EN2503.200

Start - Finish Date: 11/12/2009-11/12/2009
Bore Dia: 100 mm

Driller: Total Drilling
Rig: Edson 3000 Truck

Northings: mN
Eastings: mE
RL:

Logged: GMN
Checked: GMN
Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	Penetration 1 2 3	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
Blade-bit	No definite ground water cuts	Not cased, frequent caving						▨		FILL, angular SANDSTONE cobbles and small boulders, with dry silty sand matrix, loose to very loose (mine overburden dumped but not compacted)	VL – L	D		
							1	▨						
DHH							2	▨						
							3	▨						
							4	▨						
							5	▨						
							6	▨						
							7	▨						
							8	▨						
							9	▨						

FIELD DATA SYMBOLS

○ = Environmental Sample
▮ = Undisturbed Tube Sample
● = Disturbed Sample
▯ = Bulk Sample

GROUNDWATER SYMBOLS

▼ = Water level (static)
▽ = Water level (during drilling)
= Outflow / Inflow

MOISTURE CONDITION
D = Dry M = Moist W = Wet

FIELD DATA ABBREVIATIONS

Suv = Uncorrected vane shear (kPa)
Sup = Pocket penetrometer (kPa)
N = SPT blows per 300mm

PENETRATION
1 - 4 ranging from no resistance to refusal

DENSITY (N-value)

VL	(very loose)	0 - 4
L	(loose)	4 - 10
MD	(medium dense)	10 - 30
D	(dense)	30 - 50
VD	(very dense)	50 - 100
CO	(compact)	>50/150mm

CONSISTENCY (Su)

VS	(very soft)	< 12kPa
S	(soft)	12 - 25
F	(firm)	25 - 50
St	(stiff)	50 - 100
VSt	(very stiff)	100 - 200
H	(hard)	> 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

SKM

PROJECT: Mount Piper Ash Emplacement

DETAILS: Lambert Gully observation wells

HOLE No. 3

Sheet 2 of 2

Client: Delta Power	Start - Finish Date: 11/12/2009-11/12/2009	Driller: Total Drilling	Northings: mN
Job No: EN2503.200	Bore Dia: 100 mm	Rig: Edson 3000 Truck	Eastings: mE
			RL: --

Logged: GMN
Checked: GMN
Oriented:

DRILLING				FIELD DATA				MATERIAL			SOIL CONDITION		COMMENTS	
Method	Water	Support	1 2 3 Penetration	Piezometer	sample type	Depth RL	Depth	Graphic Log	USC Classification	soil type, unified classification, colour, structure, particle characteristics, minor components	Consistency/ Density	Moisture Condition	Structure and additional observations	Formation
DHH							11	▨		FILL, angular SANDSTONE cobbles and small boulders, with dry silty sand matrix, loose to very loose (mine overburden dumped but not compacted) *(continued)*		D		
							12 13 14 15 16 17 18 19			Rods repeatedly jammed in uncased borehole, took 2 hours to recover hammer and rods. Borehole terminated due to cavings collapsed on removal of rods and hammer Borehole dry on completion of hole at 11.5m		D		

FIELD DATA SYMBOLS

○ = Environmental Sample
▮ = Undisturbed Tube Sample
● = Disturbed Sample
▯ = Bulk Sample

GROUNDWATER SYMBOLS

▼ = Water level (static)
▽ = Water level (during drilling)
= Outflow / Inflow

MOISTURE CONDITION
D = Dry M = Moist W = Wet

FIELD DATA ABBREVIATIONS

Suv = Uncorrected vane shear (kPa)
Sup = Pocket penetrometer (kPa)
N = SPT blows per 300mm

PENETRATION
1 - 4 ranging from no resistance to refusal

DENSITY (N-value)

VL	(very loose)	0 - 4
L	(loose)	4 - 10
MD	(medium dense)	10 - 30
D	(dense)	30 - 50
VD	(very dense)	50 - 100
CO	(compact)	>50/150mm

CONSISTENCY (Su)

VS	(very soft)	< 12kPa
S	(soft)	12 - 25
F	(firm)	25 - 50
St	(stiff)	50 - 100
VSt	(very stiff)	100 - 200
H	(hard)	> 200 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.