Stage 2 Kerosene Vale Ash Repository
Technical Report 1 - Groundwater

April, 2008

Delta Electricity

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1. Introduction

The implementation of Stage 2 of the Kerosene Vale Ash Repository (KVAR) is proposed. The proposed Stage 2 area is adjacent to the current location of the Stage 1 KVAR site. The proposal is to store additional ash on top of the existing capped area that was closed in 1990. Upon completion, the area is to be recapped and revegetated. This assessment of the groundwater system at the site of the existing Stage 1 and proposed Stage 2 ash repository areas was conducted in September 2007.

The proposed Stage 2 area is on top of an area that was previously used for ash storage, beginning in the 1950s, and finally capped in the 1990s (Douglas Partners 2001). The original ash repository area was built in the following three stages:

- Stage 1: A homogeneous embankment, approximately 5 metres high was constructed from mine spoil sourced from nearby open cut mines in the 1960s.
- Stage 2: A homogeneous earth fill embankment, about 3 metres high and built on ash, was constructed in 1972, upstream from the Stage 1 embankment.
- Stage 3: A zoned embankment approximately 8 metres high was built in around 1979 on compacted ash, upstream from the proposed Stage 2 area.

It is anticipated that the existing capping will remain in place and ash will be placed over the existing ash repositories. Approximately 1,500 tonnes per day of dry ash is anticipated to be placed during the operation of the proposed Stage 2 area (approximately 15% moisture content) reaching a maximum height of approximately 20 metres (Australian Height Datum (AHD) 940). The new capping would be placed progressively on the historical ash deposit in layers of between 1 and 1.5 metres thickness (Douglas Partners, 2001).

1.1 Assessment objectives

The primary objective of this assessment is to identify the potential impacts to groundwater during the construction and operational phases of the Stage 2 KVAR. This report details the current subsurface conditions, data from historical studies, the anticipated impacts of the new activity, and outlines a recommended long-term monitoring program. This assessment addresses the requirements for consideration provided by the Director General of the Department of Planning (letter dated 27 February, 2007).

This report assesses the potential for trace minerals and heavy metals to leach out of the ash and migrate within groundwater. The two primary pathways for this to occur are through rainwater infiltration into the ash and groundwater flow through the ash. This assessment looks at the potential for this to occur and any impacts on immediate and/or adjacent areas.

1.2 Methodology

This assessment reviewed the existing data and assessed the potential effects of ash as it is placed.

Data collected through infiltration studies at the nearby Mount Piper facility and through the gathering and analysis of groundwater well monitoring data around the proposed KVAR site was reviewed to assess impacts of exiting operations and potential impacts with proposed changes to operations.

1.3 Ash properties

The ash to be stored in the Stage 2 Repository is generated at the Wallerawang Power Station (WPS) where approximately 80% of the ash produced is fly ash. The focus of this assessment is based on the main constituents of the ash from the Wallerawang Power Station as detailed in Table 1-1 (Hyder, 2001).

Table 1-1 Main constituents of WPS fly ash

Chemical composition	Percentage (%) of ash[1]	Typical NSW ash[2]
Silicon as SiO_2	63.40	57.5–67
Aluminium as Al_2O_3	28.60	22.4–27.6
Iron as Fe_2O_3	1.90	1.1–7.6
Calcium as CaO	0.89	0.35–3.3
Magnesium as MgO	0.39	0.3–1.1
Sodium as Na_2O	0.27	0.2–0.9
Potassium as K_2O	2.84	1.6–3.0
Titanium as TiO_2	1.40	0.9–1.3
Manganese as Mn_3O_4	0.05	NA[3]
Sulfur as SO_3	0.07	0.1–0.3
Phosphorus as P_2O_5	0.18	0.11–0.2
Barium as BaO	0.09	0.0–0.1
Strontium as SrO	0.05	NA
Zinc as ZnO	0.02	NA
Other trace elements (Selenium, etc.)[4]	<0.001	NA
Total[5]	**100**	

Source: ACIRL, Lithgow for Delta Electricity based on samples collected 21/05/01 to 29/05/01.

1. Average of Hopper 1B and Hopper 2B composite.
2. Typical NSW ash: Heidrich 2007.
3. NA Means ‘Not Assessed’.
4. Selenium concentration in ash is in the order of 5mg/kg or 0.0005%.
5. Note that percentages have been rounded to nearest two decimal places, resulting in a total in exceedance of 100%.

2. Site context

2.1 Locality

The KVAR is located to the east of the village of Lidsdale, which is situated approximately 2.5 kilometres to the north-east of WPS. WPS is located approximately 10 kilometres north-west of Lithgow.

The site of the proposed Stage 2 ash repository area is within the Great Dividing Range, approximately 880 metres above sea level. The site slopes gently towards the Coxs River in the south-west, but is generally flat, being part of a large, elevated plateau (Hyder, 2001). The area is moderately dissected by rivers and creeks that drain the plateau to the north, east, west and south.

2.2 Geology

The underlying geology of the Wallerawang region is largely composed of Triassic and Permian aged sediments that form the western edge of the greater Sydney Basin sediments. The Sydney Basin sediments rest unconformably on a folded and intruded underlying basement that dips to the north-east. The folded sediments comprise Lambie Group deposits of the Upper Devonian, and consist largely of quartzite, siltstone, sandstone and claystone. Intruded into the Lambie Group deposits are the younger Lower Carboniferous deposits that typically comprise granite, adamellite, and granodiorite.

The surface geology of much of the Wallerawang area consists of the Shoalhaven Group (Berry Formation), including the Illawarra Coal Measures, with outcroppings of Narrabeen Sandstone (refer to Figure 2-1). The sediments of the Illawarra Coal Measures largely consist of shale and sandstone, while the sediments of the Berry Formation consist of grey siltstone with thin beds of limestone and sandstone. An outcrop of Quaternary sediments consisting of alluvium, gravel sand, silt and clay also occurs in the area.

Bore logs for five bores located on the proposed site were sourced. These logs show that the geology of the site is generally sandy clay to between 5 and 7 metres, underlain by shale and sandstone. Some bores in the proposed Stage 2 ash repository area also show deposits of coal and coaly siltstone of between 0.5 and 1.5 metres thickness interspersed with mudstone, siltstone and claystone at depths between 7 and 15 metres.

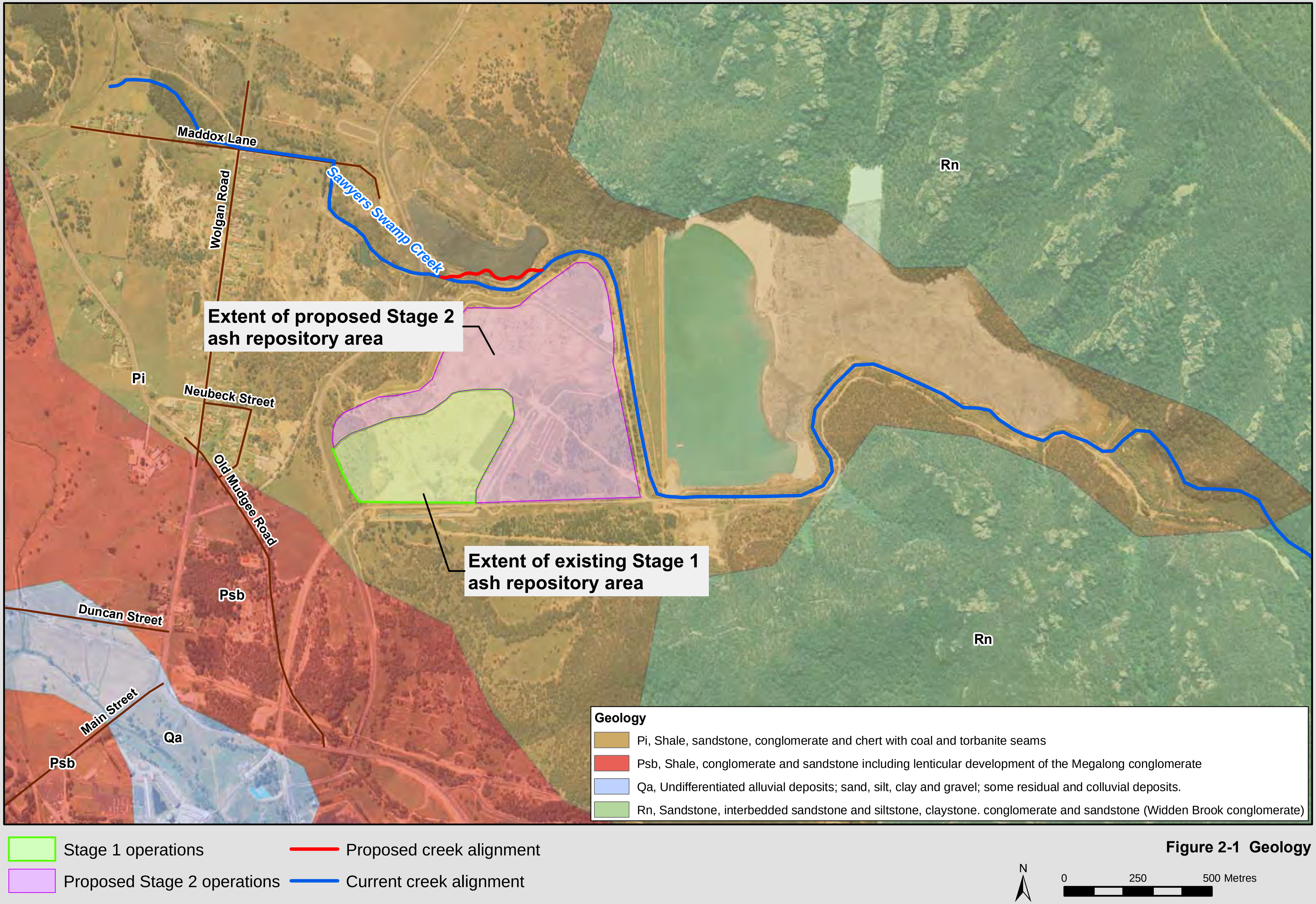

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Figure 2-1 Geology

2.3 Soil characteristics

The main soil landscape unit in the area is the Cullen Bullen soil landscape, which consists of moderately deep (less than 100 centimetre) yellow podsolic soils, soloths and yellow leached earths (Hyder, 2001). This soil group generally has a high water erosion risk, a hard setting surface and moderately acidic to neutral soil.

Soil in the Wallerawang region is generally low to very low in nutrients and has a low nutrient storage capacity, low pH buffering capacity and low water holding capacity.

Potential for acid sulfate soils

Acid sulfate soil (ASS) risk mapping has not yet extended as far inland as the Lithgow region. The likelihood of ASS occurring is thus difficult to determine. Even if ASS were to be identified, they are representative of natural conditions, and can be present without impacting the environment if they are not exposed to the atmosphere. Soils will only be excavated and exposed during the creek realignment phase. Based on the type of soil in the area, and its chemistry, as outlined above, it is unlikely that ASS will be present. As part of the construction environmental management plan, measures for ongoing monitoring of soil during excavation to identify any potential ASS will be undertaken. Should ASS be encountered standard management techniques will be implemented and ASS material segregated from other excavated material.

2.4 Groundwater dependant ecosystems

A search of the Australian Water Resources Register (2005) did not identify any groundwater dependant ecosystems (GDE) in the vicinity of the KVAR site. It is possible that there are some GDEs in the vicinity of Sawyers Swamp Creek and the Lidsdale Cut, where groundwater seeps and springs have been observed, however the vegetation in the area has already been observed to be significantly degraded and it is unlikely that any sensitive GDEs are present. The ecology of these areas is further discussed in Technical Reports 3 in Appendix G and Chapter 9 of the main body of the Environmental Assessment in relation to aquatic ecology.

3. Existing ground water characterisation

3.1 Regional conditions

A search of the Department of Natural Resources (DNR) bore register revealed 89 bores within a 10 kilometre radius of the proposed site. The groundwater bores in the area are registered for private/domestic use (stock or irrigation bores) with some (nine) bores registered for government (other) and local government uses. The standing water level is less than 15 metres below ground level (mbgl).

Groundwater quality in the area is generally fair and is discussed in more detail in sections 3.3 and 3.4.

3.2 Site conditions

Groundwater flows in a north westerly direction (refer to Figure 3-1) from the Stage 1 ash repository area towards the Lidsdale Cut, which collects groundwater flow from up gradient areas. Standing water levels vary between 1 (WGMW4D) and 12 (WGMW6D) metres below ground level. The shallowest groundwater levels were observed in the vicinity of Sawyers Swamp Creek, with small seeps and springs also observed in this area during a site visit in August 2007.

Previous wet-ash disposal dams (pre Stage 1, used between the 1950s and 1990s and then capped) caused elevated groundwater levels in the monitoring bores located on the downstream face of the active ash repository area (ERM, 2002 Appendix C). During this time groundwater inflows to the Lidsdale Cut increased due to the elevated water levels and were sufficient for periodic overflows from the Lidsdale Cut to Sawyers Swamp Creek to occur (ERM, 2002 Appendix C). However, when wet ash disposal activities ceased, water levels in the monitoring bores dropped and no overflow was observed from the Lidsdale Cut. This suggested that there was some seepage into the groundwater from the originally placed wet ash.

Review of data from local borehole logs shows some fluctuation in groundwater levels with time. This appears to be the result of natural variation, with no increase in groundwater levels from bores under or close to the Stage 1 area (WGMD3, WGMD4, WGMD5, and WGMD6) observed. Bores were occasionally observed to be dry, corresponding approximately to extended periods of low rainfall.

3.3 Regional water quality

A search of the contaminated sites register revealed no known areas of groundwater contamination in the vicinity of the proposed site. Water quality data is thus likely to be representative of naturally occurring conditions.

Figure 3.1 Groundwater hydrology

Water quality data was collected by Delta Electricity over the period from 1991 to 2000, and reviewed by ERM in 2002. The main findings are summarised below:

- Conductivity levels in the Coxs River and Sawyers Swamp Creek are highly variable with elevated levels occasionally recorded at all sites.
- Sulfate, calcium and sodium are the dominant ions.
- Iron concentrations are generally less than 0.2 milligrams per litre (mg/L).
- Manganese concentrations were, on average, 0.12 mg/L in Coxs River and slightly higher at 0.62 mg/L in Sawyers Swamp Creek.
- Lead concentrations were 0.001 mg/L in compliance with ANZECC Ecosystem Protection and Irrigation Guidelines.
- Copper, zinc, and aluminium levels complied with ANZECC Irrigation Guidelines criteria for both Coxs River and Sawyers Swamp Creek, however, exceeded Ecosystem Protection Guidelines (values of 0.0014 mg/L, 0.008 mg/L and 0.0008 mg/L for copper, zinc and aluminium respectively) in both locations.
- Nitrogen concentrations exceeded Ecosystem Protection Guidelines (0.0115 mg/L) at both locations, being 0.031 mg/L at Coxs River and 0.057 mg/L at Sawyers Swamp Creek.

Previous reporting by Pacific Power in 1997 (results stated in ERM, 2002) indicate that the groundwater flows from the ash repository area were relatively free of trace elements. ERM (2002) assessed three groundwater monitoring bores down-gradient of the ash repository area and detected elevated levels of fluoride and boron in the groundwater, with zinc the other major trace element present (see Figure 3-1 for borehole locations). Salinity in the region is generally classified as good (<280 microseimens per centimetre (mS/cm)) to fair (280 – 800 mS/cm) (EPA, 1997) and pH is near neutral.

3.4 Local baseline conditions

An assessment of the groundwater system at the site of the existing Stage 1 and proposed Stage 2 ash repository areas was conducted in September 2007. The assessment was based on existing monitoring data from a network of six wells collected by Delta Electricity between November 2001 and April 2007.

There are five sites located at or close to the Stage 1 area (WGMD2, WGMD3, WGMD4, WGMD5, and WGMD6) and one offsite (WGMD1).

Due to the drought conditions that have prevailed in recent years, several on and off-site groundwater wells have frequently been dry, causing gaps in groundwater chemistry data corresponding to dry conditions since early 2004.

Groundwater quality has been compared to surface water quality at the potential discharge locations — Lidsdale Cut and Sawyers Swamp Creek (ERM, 2002) — as well as against guidelines for the two major beneficial use categories in the area: ANZECC Irrigation and Freshwater Ecosystem Protection Guidelines (ANZECC, 2000).

- The pH values measured in the bores were slightly acidic, and over time, appear to be reasonably consistent, with some small seasonal variation. Low pH spikes were occasionally observed in bores where low water levels have been noted; pH values vary between 6.8 (WGMD3, WGMD4) and 3.1 (WGMD6). There does not appear to be any significant difference in pH between monitoring bores located at the ash repository site and at the up-gradient, off-site location (WGMD1). The pH range is consistent with regional water quality (pH of 3.8 and 6.2 at Lidsdale Cut and Sawyers Swamp Creek respectively), but is slightly lower than the ANZECC Ecosystem Protection and Irrigation Guidelines.
- Conductivity at WGMD4, which has the shallowest groundwater levels, is the most variable, with some seasonal variation evident, and an increasing trend since April 2006. Conductivity data from all other bores did not show any significant change, however, evidence of seasonal variation is present. Conductivity is consistent with regional water quality (ERM, 2002) and is less than the ANZECC (2000) Irrigation and Ecosystem Protection Guidelines.
- Alkalinity (as calcium carbonate) values were consistent over the 6 years of data collection. All monitoring bores showed some seasonal variation, with values between 5 mg/L and 140 mg/L, less than the ANZECC Irrigation and Ecosystem Protection Guidelines.
- Chloride concentrations were between 10 mg/L and 140 mg/L, with some seasonal variation, but no noticeable increasing or decreasing trends. These values were slightly elevated compared to water quality at Lidsdale Cut and Sawyers Swamp Creek; however, were well below the ANZECC Irrigation Guideline.
- Sulfate concentrations in all monitoring bores, with the exception of WGMD4, showed only slight seasonal variation, with no other trends observed over time. Concentrations were between 50 mg/L (WGM2D) and 350 mg/L (WGMD6), consistent with surface water quality (230 mg/L to 300 mg/L). Bore WGMD4, however, showed an increasing trend in sulfate concentration from January 2006, increasing from between 200 mg/L and 550 mg/L to between 650 mg/L and 800 mg/L. The shallow groundwater levels in WGMD4 mean that this bore is most heavily influenced by environmental factors, this trend could be a result of low rainfall in the area, or other natural factors at the surface.
- Total Dissolved Solids (TDS) in all monitoring bores, with the exception of WGMD4 were reasonably consistent over time, with seasonal variation the only observable trend. Concentrations were generally between 100 mg/L and 700 mg/L, consistent with values at Lidsdale Cut (390 mg/L) and Sawyers Swamp Creek (490 mg/L). At WGMD4, concentrations were within this range, until January 2006 when TDS increased from between 270 mg/L and 700 mg/L to values consistently greater than 1,000 mg/L. As for sulfate, it is likely that this change can be attributed to the shallow water levels at WGMD4, which are more easily influenced by surface environmental factors, such as low rainfall.
- Sodium concentrations were reasonably consistent, with seasonal variation the only observable trend. Sodium concentrations were between 10 mg/L (WGMD1) and 90 mg/L (WGM3D), similar to Sawyers Swamp Creek (11 mg/L to 86 mg/L) and less than the ANZECC Irrigation Guideline of 460 mg/L.

- Magnesium concentrations were between 5 mg/L (WGMD1) and 75 mg/L (WGMD4). Values were reasonably consistent for all bores and there was some seasonal variation and a slight increasing trend for WGMD4 from January 2006 to April 2007 observed, possibly with the same explanation as for similar changes in other species in WGMD4, as outlined above.
- Fluoride Slightly elevated concentrations were detected at WGMD4 (0.4 mg/L), however, other bores appeared to be below or close to detection limits. This value is less than ANZECC Irrigation Guideline and is lower than regional water quality fluoride concentrations (0.4 mg/L at Lidsdale Cut).
- Calcium concentrations were between 5 mg/L and 30 mg/L for all bores except for WGMD4, which had concentrations between 40 mg/L and 100 mg/L. Again, there is some seasonal variation in all bores. These concentrations are similar to those found in Coxs River and Sawyers Swamp Creek.
- Barium concentrations were less than 0.12 mg/L in all bores, regional water quality information is not available for barium.
- Cadmium concentrations were below or close to detection limits (0.0002 mg/L) for all bores, with the exception of WGMD5, which occasionally had concentrations above detection limits of between 0.03 mg/L and 0.045 mg/L. With the exception of WGMD5, cadmium concentration levels were similar to regional water quality values and less than the ANZECC Ecosystem Protection and Irrigation guidelines.
- Copper concentrations in groundwater were consistent with water quality at Lidsdale Cut and Sawyers Swamp Creek at between 0.005 mg/L to 0.01 mg/L for all bores. These concentrations are higher than the ANZECC Ecosystem Protection limit of 0.0014 mg/L, but less than the Irrigation guideline of 0.2 mg/L.
- Iron concentrations were between 0.02 mg/L and 6.5 mg/L for monitoring bores WGMD1, WGMD2, WGMD3 and WGMD5, similar to concentrations recorded at Lidsdale Cut (2.4 mg/L) and Sawyers Swamp Creek (0.1 mg/L), but above ANZECC guidelines for Irrigation (0.2 mg/L). Concentrations at WGMD6 and WGMD4 were consistently higher at between 30 mg/L and 100 mg/L.
- Lead concentrations were greater than the ANZECC Ecological Protection Guideline. However, the detection limit used for lead analysis in this case was greater than the guideline value. Concentrations of lead detected in all bores ranged between 0.001 mg/L and 0.08 mg/L. The values detected in groundwater were similar to the concentrations at Lidsdale Cut and Sawyers Swamp Creek and less than the ANZECC Irrigation guideline of 2 mg/L.
- Boron concentrations were between 0.01 mg/L (WGMD1) and 1.3 mg/L (WGMD4). The concentration of boron in Sawyers Swamp Creek and Lidsdale Cut is 1.9 mg/L. Concentrations in the groundwater and surface water exceed both the ANZECC Ecosystem Protection Guideline and the ANZECC Irrigation Guideline (0.37 mg/L and 0.5 mg/L respectively).
- Zinc concentrations were slightly elevated, generally less than 0.05 mg/L, with the exception of WGMD5, which occasionally had zinc levels of up to 2.7 mg/L. These concentrations are above the ANZECC Ecosystem Protection guidelines (0.008 mg/L). However, they are consistent with regional water quality, and generally less than ANZECC Irrigation guideline values (2 mg/L).

- Arsenic, silver, selenium, chromium (III) and mercury concentrations were all low, and thought to be close to or at the detection limits (ALS Laboratories, 2007) of most standard laboratory analytical methods (the analytical laboratory and detection limits were not stated in the data provided).

3.5 Summary

Concentrations of trace elements (magnesium, iron, cadmium, fluoride, zinc, manganese and boron) have been detected at levels greater than ANZECC guidelines in regional groundwater and surface water, indicating groundwater and surface water in the area has naturally elevated concentrations of these compounds.

Concentrations of many trace elements are higher at monitoring bores down-gradient of the Stage 1 ash repository area (WGMD4 and WGMD5) than at up-gradient locations (WGMD1 and WGMD2). Groundwater is known to infiltrate surface water and detection of trace elements in the surface water suggests the source of contamination may be the existing Stage 1 ash. However, with the exception of boron, all concentrations were below ANZECC Irrigation guideline values.

Given the low water infiltration rates as discussed in Section 4, and subsequent long water retention times, it is likely that the concentrations of trace elements described above are representative of saturated concentrations within the ash and are unlikely to be affected by the proposed Stage 2 activities.

4. Infiltration impact study

4.1 Ash properties

At WPS approximately 80% of the ash produced is fly ash. Fly ash is generally the fine-grained material collected from the flue gasses by electrostatic precipitators or a fabric filter. The remaining 20% of ash produced is bottom ash, which is heavier, coarser and is collected in a wet hopper at the bottom of the boiler. The main constituents of ash from the WPS, as measured in May 2001, are detailed in Table 1-1 (Hyder, 2001). Geotechnical assessments were undertaken assuming a compacted dry ash density of 1.2 tonnes per cubic metre (t/m^3) and moisture content of 20% (Douglas Partners, 2001).

Only a small proportion of the minerals present in the ash, are in soluble form (e.g. sodium oxide, potassium oxide, calcium oxide, magnesium oxide). Typical leaching behaviour would comprise a larger initial release followed by a rapid decrease in the rate of leaching towards a steady state concentration. Given the long historic use of this area for ash placement, equilibrium conditions are likely to have been reached.

4.2 Water infiltration to the ash heap

Beginning in 1996, extensive field trials at Mount Piper Power Station were undertaken by Pacific Power to determine infiltration rates to fly ash pads, and the potential for mobilisation of trace elements in the ash to the groundwater system (Hyder, 2002). The ash tested in the Mount Piper trial is considered to have similar properties to the ash generated from WPS (Hyder, 2002). Therefore, the results of the Mount Piper field trials have been used to assess the likely infiltration of water to the proposed ash repository, and any potential impacts to the groundwater system. The trials have replicated actual conditions, and therefore, it was considered that desktop hydrogeological modelling would not provide any further information.

The Mount Piper field trials were undertaken over two years, during which periods of above and below average rainfall conditions were experienced. Moisture probes were embedded in the ash and samples were collected over the duration of the trial. The objective of the tests was to determine the quantity of runoff versus infiltration and evaporation rates for both capped and uncapped fly ash.

Fly ash consists almost entirely of spherical shaped particles, and can therefore be densely packed during compaction, resulting in comparatively low permeability values and thus minimising infiltration of water. The permeability of well-compacted fly ash generally ranges from 10^{-6} to 10^{-8} metres per second (m/s) (http://www.tfhrc.gov/hnr20/recycle/waste/cfa54.htm), which is similar to a silty clay soil.

The results of the trials indicated that infiltration rates for uncapped ash were very low, with an average rate of 0.59%, and evaporation rates of around 95%. The capped area of the ash pad indicated an infiltration rate over the trial period of less than 0.07% (or 1 millimetre). With around 5% of annual rainfall discharged as runoff from the ash surface and less than 1% of annual runoff infiltrating the ash (ERM, 2002 Appendix C), the data implies that water leaching into the ash to mobilise potential contaminants is not likely to be significant.

It is expected that following revegetation, infiltration rates would potentially decrease further. Additional mitigation measures for the ash repository will include the presence of naturally occurring, low permeability in situ clayey soils (1.5 to 2 metres), which will form the base of the proposed ash repository, and minimisation of areas of uncapped ash though staged ash placement.

Rainwater infiltration provides the pathway for the trace elements contained within the ash to the groundwater. Based on the above mentioned studies, it is considered that the rates of infiltration are extremely low. As a result, the impacts to groundwater of the proposed Stage 2 placement of ash should have a negligible additional impact on groundwater.

There is the potential for a slight increase in groundwater levels in the vicinity of the ash repository as a result of the increased pressure of the ash as it is placed, leading to a reduction in pore volume. These effects, as in the past, are expected to be short-term and to dissipate over time.

As the proposed dry ash placement will occur on top of existing capping material, there is unlikely to be an increase in groundwater levels related to infiltration of stormwater or dust suppression water through the exposed ash prior to capping.

Routine monitoring and analysis of the groundwater quality and levels at the site for the life of the operation is recommended, and is further discussed in Section 6.

5. Potential groundwater impacts

5.1 Construction versus operation

The impacts of the construction and operation of the proposed Stage 2 area, due to the nature of the operation, should be very similar to the Stage 1 activities currently underway. The risks (with regard to groundwater) involved with the proposed activity, as with Stage 1, are the opportunity for surface runoff to come into contact with new ash, and for water to infiltrate the ash pack (see Section 4).

The proposed Stage 2 ash repository would be located on top of the historical wet ash repository area. The presence of the historical capping material under the ash will form a relatively impermeable barrier. The presence of such an impermeable zone will limit infiltration of stormwater and dust suppression water. Therefore, changes in groundwater levels via this mechanism are not anticipated. However, this will also mean that water infiltrating into the placed ash will be discharged to surface water at the interface of the ash and the historical capping material.

There is a possibility that groundwater levels may temporarily rise during construction due to compaction of the material causing increased pore pressures. However, the impact of this is expected to be minor, as there are naturally occurring seasonal variations. Historical data supports that the increase in groundwater level, if any, should be temporary and the naturally occurring conditions will return upon cessation of work. Any increased water levels due to reduced pore space would be controlled by staging the stacking rates and ongoing monitoring as outlined in Section 6.

The Stage 2 dry ash would be capped once the design height is reached. With capping in place the groundwater infiltration rates would be low and the risk of potential impacts reduced.

5.2 Salinity

Water level changes due to ash placement in the area have been observed in the past, and were not noted to have led to increased salinity. Potential salinity issues can be addressed by controlling groundwater level changes. Since no salinity issues have been observed in the past and any potential changes in water level would be temporary, no long-term salinity problems are foreseen as a result of the proposed Stage 2 activities. The proposed groundwater monitoring program should include monitoring of key salinity indicators to confirm no changes in groundwater salinity are occurring during Stage 2 activities.

5.3 Groundwater recharge and discharge areas

The immediate area within which the proposed Stage 2 area would be located has fairly consistent geology, with no outcrops or other formations that would be likely recharge areas. Infiltration of water in the immediate area is expected to be low due to the presence of capped ash limiting recharge to the local groundwater system. Placing additional dry ash on top of this area is unlikely to cause additional impact(s) on recharge to the underlying groundwater system.

Discharge areas are located to the north of the proposed Stage 2 ash repository area, close to the Swayers Swamp Creek and Lidsdale Cut areas. Increases in groundwater levels that may result from ash placement may increase discharge to these areas.

The discharge area that could be affected by the proposed Stage 2 activities would be a section of Sawyers Swamp Creek to the north of the site, which is to be realigned. This creek has naturally low surface flows, and is likely to gain flow from groundwater, seepage from Sawyers Swamp Creek Ash Dam and surface water runoff. However, there is insufficient data to establish the contribution to flow from groundwater discharge and thus quantifying the potential impacts from any change in groundwater conditions is not possible. The design of the realigned creek is such that base flow would be maintained in the new section of creek. Potential impacts resulting from the proposed creek realignment would be minimal in relation to creek flow and are further discussed in the main body of the Environmental Assessment in relation to the design of the creek realignment.

Given the current level of degradation of the waterway and current regional surface water quality, it is unlikely that any groundwater discharged to these areas would have a significant impact on baseline water quality.

5.4 Water quality

An assessment of current groundwater quality based on monitoring undertaken by Delta Electricity over the period from November 2001 to April 2007 indicates that concentrations of trace elements including zinc, copper, lead, cadmium, barium, fluoride and boron are present in the groundwater down gradient of the existing and proposed ash repository areas. However, concentrations in the groundwater, while higher in some cases than the ANZECC Ecosystem Protection Guidelines, are generally lower than the ANZECC Irrigation Guidelines. Trace element concentrations are consistent with current regional water quality at groundwater discharge locations.

Water quality during the proposed operation of the Stage 2 ash repository area is likely to be similar to that currently observed in the area. The historical capping material will remain in place, isolating the groundwater from the newly placed ash, and maintaining historical groundwater water conditions.

Any water that does pass through the ash would be discharged at the interface of the newly placed ash and historical capping material. This could enable a pathway for the transport of trace elements leached from the ash into the surface water. Surface water at the site will be captured and reused at the site. Surface water management is further discussed in Chapter 8 of the main body of the Environmental Assessment and in Technical Report 2: Surface Water in Appendix F.

The quality of groundwater discharged to the surface at the Lidsdale Cut is currently consistent with surface water quality and it is likely that this trend would continue. However, it is worth noting that increasing the thickness of the ash layer could increase residence times. By increasing residence times there is potential to increase trace element concentrations in groundwater. To ensure mitigation measures are successful, existing monitoring programs should be continued during the proposed Stage 2 activities, this is discussed in Section 6.

6. Groundwater monitoring program

6.1 Management of impacts

It is recommended that a detailed groundwater monitoring program is established as part of the operational environmental management plan prior to the commencement of Stage 2 activities; this should be a continuation of Stage 1 monitoring, with minor amendments as outlined below based on data collected to date. To allow for comparison and analysis, the program should include analyses of similar parameters as undertaken for Stage 1 activities.

During the first 12 months of Stage 2 activities, groundwater monitoring should be undertaken on a monthly basis. If impacts are not observed during this time, monitoring could then continue on a quarterly basis. The analytical suite currently undertaken by Delta Electricity should be maintained with a few additional analytes, as described in Table 6-1. These additional analytes are suggested, based on observation of data collected during Stage 1 activities. It is possible that additional trace elements, which are common in other ash leachates, but which have not been analysed here, may be detected under such an expanded monitoring regime.

A review of the analytical program should be undertaken if certain elements are consistently below detection limits. A minor amendment to monitoring of low detection limit trace metals should also be undertaken to ensure that the ANZEEC guideline values are higher than the detection limit of analysis. Key salinity indicators should also be included in the analytical suite to confirm that changes in groundwater salinity do not occur.

WGMD1, WGMD5 and WGMD6 from which data have not been available in recent times should be included in the monitoring program. If it is determined that these bores have been lost or damaged, then they should be re-drilled and constructed in a similar location.

It is recommended that two new down-gradient wells to the north of the site be installed in order to properly capture and define down-gradient groundwater conditions and assess any potential changes as a result of the slight relocation of placement activities. These new wells should be located to the north-east of WGMD5 and to the south-west of WGMD6 if reinstallation is required.

Table 6-1 Delta Electricity groundwater monitoring analytical suite

Category	Analyte	Category	Analyte
Field parameters	pH	Metals	Arsenic
	Conductivity		Silver
	Alkalinity (calcium carbonate)		Barium
	TDS		Boron
Anions	Chloride		Cadmium
	Fluoride		Chromium (III)
	Sulfate		Chromium (VI)
Cations	Sodium		Copper
	Potassium		Iron
	Calcium		Mercury
	Magnesium		
	Manganese		
	Lead		
	Selenium		
	Zinc		

7. Conclusions and recommendations

As the proposed Stage 2 ash repository would be located on top of the historical wet ash repository area, additional impacts to groundwater are considered unlikely. Some temporary, small changes in groundwater levels may occur as a result of changed pore pressure during construction activities. Any increase in groundwater levels may increase groundwater recharge to the Lidsdale Cut and Sawyers Swamp Creek areas. This can be reduced through the implementation of management controls. The proposed Stage 2 repository area would be located on a historical ash repository area that already limits infiltration of water to the groundwater system.

Historical water quality monitoring has not indicated significant leaching of minerals and/or trace metals into the groundwater system. Placement of dry ash of the same composition with minimal water infiltration over the existing ash layer is unlikely to result in any additional impacts on groundwater quality. Any additional leaching of trace elements from the Stage 2 ash is anticipated to be small. However with the location of an impermeable historical capping layer under the newly placed ash, it is likely that there will be some discharge of leachate water containing trace elements at the surface interface of these two zones. This discharge will be captured as part of surface water management activities.

Runoff from the proposed Stage 2 area ash surface would be collected and stored in lined ponds and recycled for use at WPS. These measures are further discussed in the Technical Report 2 and Chapter 10 of the Environmental Assessment. It is believed that these measures would be sufficient to prevent runoff from detrimentally impacting the environment.

It is recommended that a detailed Groundwater Monitoring Plan be prepared for the proposed Stage 2 activities, based on the current (Stage 1) water quality monitoring regime. Trigger values for management responses should also be established. At a minimum, the analytical suite currently in use should be maintained with the monitoring frequency increased to monthly monitoring for the first 12 months of Stage 2 operations.

8. References

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