Stage 2 Kerosene Vale Ash Repository
Technical Report 2 - Surface Water

April, 2008

Delta Electricity

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Contents

Contents (continued)

Page Number

List of tables

List of figures

List of appendices

1. Introduction

1.1 Background

This report details the potential construction and operation phase surface water impacts of the Stage 2 Kerosene Vale ash repository (KVAR) proposal. The assessment details the characterisation of the existing surface water environment, the potential impacts of the Stage 2 activities and proposes measures to manage these impacts. Details of the proposed realignment of Sawyers Swamp Creek are provided in the Stage 2 Kerosene Vale Ash Repository Sawyers Swamp Creek Draft Rehabilitation Plan.

1.2 Assessment objectives

The primary objective of this investigation is to assess the impacts to sub-catchment and catchment surface water resources as a result of the construction and operation of the proposed Stage 2 ash repository area. The assessment includes impacts related to the use of the Stage 2 ash repository area. The assessment addresses the requirements for consideration provided by the Director General of the Department of Planning (letter dated 27 February, 2007).

The assessment addresses the following key areas:

- Catchment hydrology — assessing potential changes in catchment flows as a result of changes to the catchment surfaces.
- Water quality — assessing the potential impacts to water quality resulting from the use of the Stage 2 ash repository area.
- Water management and monitoring — reviewing current management and monitoring activities and identifying any additional requirements.

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 Wallerawang Power Station (WPS). The WPS is located approximately 10 kilometres north west of Lithgow.

2.2 Regional drainage

KVAR is located within the upper catchment of the Coxs River. The Coxs River forms part of the Hawkesbury-Nepean River system and flows to Lake Burragorang, which is part of Sydney's water supply.

Sawyers Swamp Creek flows in a westerly direction past KVAR to join the Coxs River immediately to the north of the town of Lidsdale (approximately 2 kilometres downstream from KVAR). The creek has a catchment area of approximately 12 square kilometres. There are no flow records for the Sawyers Swamp Creek catchment.

Drainage patterns in the middle reaches of the Sawyers Swamp Creek catchment have been significantly altered through mining and ash storage activities, resulting in previous realignments of the creek. The creek now flows, as a concrete channel, around the southern boundary of Sawyers Swamp Creek Ash Dam (SSCAD). From the spillway of SSCAD the creek follows a realigned route around the eastern and then northern boundary of KVAR. The creek in this area is considered degraded and has steep, eroded banks. From here the creek flows through culverts under an internal road and then under the Private Coal Road continuing on to meet its original course before joining the Coxs River (refer Figure 2-1).

2.3 KVAR drainage

The KVAR covers an area of approximately 70 hectares. It is situated immediately to the west of the embankment of the SSCAD. The south east corner of the site (the 'plantation area') has a slope of about 4%, while the remainder of the proposed Stage 2 area is relatively flat. The embankments of the Stage 1 ash placement area and the embankment wall of the historic ash repository are the dominant topographic features of the site. The KVAR currently has an elevation of approximately 920 metres Australian height datum (AHD).

Site drainage is currently controlled in accordance with the *Surface Water Management Plan for the Extension of the Kerosene Vale Ash Placement Area Phase 1, Work Instruction WWE-04* (June 2005) and *Water Management Plan, Work Instruction WWE-05* (June 2005). Details are discussed below and shown in Figure 2-2.

Water management at the site is based on the principle of separation of clean and dirty water as follows:

- Clean water is rainfall runoff from undisturbed areas and includes areas of ash emplacement that have been capped and revegetated.
- Dirty water is any water collected from within disturbed areas and includes the exposed ash face, unvegetated capping, work areas, stockpiles and haul roads.

Clean water is diverted around exposed ash surfaces and disturbed areas in surface drains and discharged to Sawyers Swamp Creek to the east of the site. Runoff from the south-east corner of the site is directed to the return water channel.

Dirty water is collected within open drains around the perimeter of the ash storage area and discharged to a collection pond located within the north east corner of the ash repository area. During operation of the Stage 1 area, this pond was moved as the ash face progressed in a northerly direction. The existing pond has a capacity of 3 megalitres and has been designed to allow storage of dirty water during the 24 hour, 10 year average recurrence interval (ARI) event (Hyder & ERM, 2002). Overflows from the collection pond flow to the return water channel.

Runoff from the exposed ash areas is minimal due to the hydroscopic nature of the ash. Large quantities of moisture can be stored in the upper layers of the ash and evaporated during dry weather. Runoff only occurs during prolonged wet weather. Pilot studies undertaken at a nearby ash repository (Mount Piper Power Station) indicated that only 5% of annual rainfall is discharged as runoff from the ash repository area (Hyder & ERM, 2002).

The collection pond provides primary treatment of water through sediment removal. Water collected in the pond is reused on site for activities such as dust suppression and moisture control of the ash. Excess water collected in the pond is pumped to a 25 megalitre storage dam as an interim measure for reuse on site at a later time. However, while the return water channel is operational, dirty water is released to this channel in favour of the 25 megalitre storage dam.

Delta Electricity currently uses the return water channel to receive water from the SSCAD, which is then directed to a treatment plant at WPS. At the treatment plant, the water is neutralised before being directed into settling ponds and if required, discharged to the Coxs River at a licensed discharge point.

The KVAR Environmental Management Plan requires that capping and revegetation of areas be completed with minimal delay. Erosion and sediment controls are implemented as interim water control measures. Once areas are capped and revegetated runoff can be diverted to the clean water system. Additionally it is a requirement that all work on disturbed areas ceases during heavy rainfall.

2.4 Water quality

2.4.1 Water quality objectives

The Australian and New Zealand Environment and Conservation Council (ANZECC) published the National Water Quality Management Strategy series, which aims to achieve the sustainable use of Australia's water resources by protecting and enhancing their quality, while maintaining their economic and social development. The Australian and New Zealand guidelines for fresh and marine water quality (ANZECC, 2000) form the central technical reference of the National Water Quality Management Strategy, which the federal and all state and territory governments have adopted for managing water quality. These guidelines provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters.

The ANZECC water quality guidelines provided a benchmark for water quality parameters to protect desired environmental values. Environmental values for waterways within Sydney's drinking water catchments are identified in the *Drinking Water Catchments Regional Environmental Plan No. 1* (2007). The following values are identified for the catchment:

- Aquatic Ecosystems
- Recreational Water — primary contact, secondary contact and visual use
- Drinking Water (raw water)
- Primary Industries — irrigation and general water use, livestock drinking water and aquaculture and human consumers of aquatic foods.

2.4.2 Existing water quality

Sawyers Swamp Creek is the primary receiving water for any discharges from the site, which may also influence the quality of the Coxs River. Land uses within the upper Coxs River catchment, including agriculture, coal mining and power generation are known to have detrimental effects on the water quality in the region (The Ecology Lab, 2007).

The primary constituents of the ash produced at the WPS are silicon (as SiO_2 – 63.40%) and aluminium (as Al_2O_3 - 28.6%). Ash may also contain traces of heavy metals and potentially toxic trace elements (e.g. boron, selenium and fluoride). Water quality sampling undertaken during preparation of the review of environmental factors (REF) for the Stage 1 area identified elevated concentrations of boron, fluoride, aluminium, nickel, zinc and cadmium within the water in the SSCAD (Hyder & ERM, 2002).

Delta Electricity currently conducts water quality monitoring at 4 surface water locations in accordance with *Work Instruction WWE-07 (Environmental monitoring plan)*. This monitoring includes water quality within the SSCAD, Dump Creek and 2 sites within Sawyers Swamp Creek.

Water quality data collected by Delta Electricity over the period from 1991 to 2000, was presented in the REF for Stage 1 operations in 2002 (Hyder & ERM, 2002) at sites within Sawyers Swamp Creek and the Coxs River. The key findings of this assessment were:

- Conductivity levels in the Coxs River and Sawyers Swamp Creek were highly variable with elevated levels occasionally recorded at all sites.
- Sulfate, calcium and sodium were the dominant ions.
- Iron concentrations were generally less than 0.2 milligrams per litre (mg/L), complying with ANZECC guidelines for ecosystem protection.
- Manganese concentrations were on average 0.12 mg/L in Coxs River and slightly higher at 0.62 mg/L in Sawyers Swamp Creek (meeting ANZECC ecosystem protection guidelines).
- Lead concentrations were 0.001 mg/L, complying with ANZECC guidelines for ecosystem protection.
- Copper, zinc, and aluminium exceeded ecosystem protection guidelines in both the Coxs River and Sawyers Swamp Creek.

- Of the trace elements, median boron levels for the sampling period exceeded ANZECC guidelines, but median selenium levels were within guideline levels.
- 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.

Delta Electricity has continued monitoring at the same locations throughout the operation of the Stage 1 ash storage area (2002 – 2007). Water quality in Sawyers Swamp Creek (downstream of the junction with Dump Creek) has been similar over this period to that which was presented in the REF, indicating that use of the Stage 1 area has not led to a detrimental effect on water quality. However, the overall quality of the catchment is relatively poor with readings for some parameters exceeding the ANZECC guidelines for ecosystem protection.

During Stage 1 operations, median electrical conductivity was recorded at 1072 microsiemens per centimetre (μS/cm). Median pH was 6.3 (which is below the lower limit ANZECC ecosystem protection guideline). Boron concentrations remained above guideline criteria (median value of 1.4 mg/L was recorded). The medium value for selenium was within the ANZECC guidelines. The heavy metals copper and zinc recorded median values that exceeded the ANZECC guidelines for ecosystem protection, as did cadmium and lead.

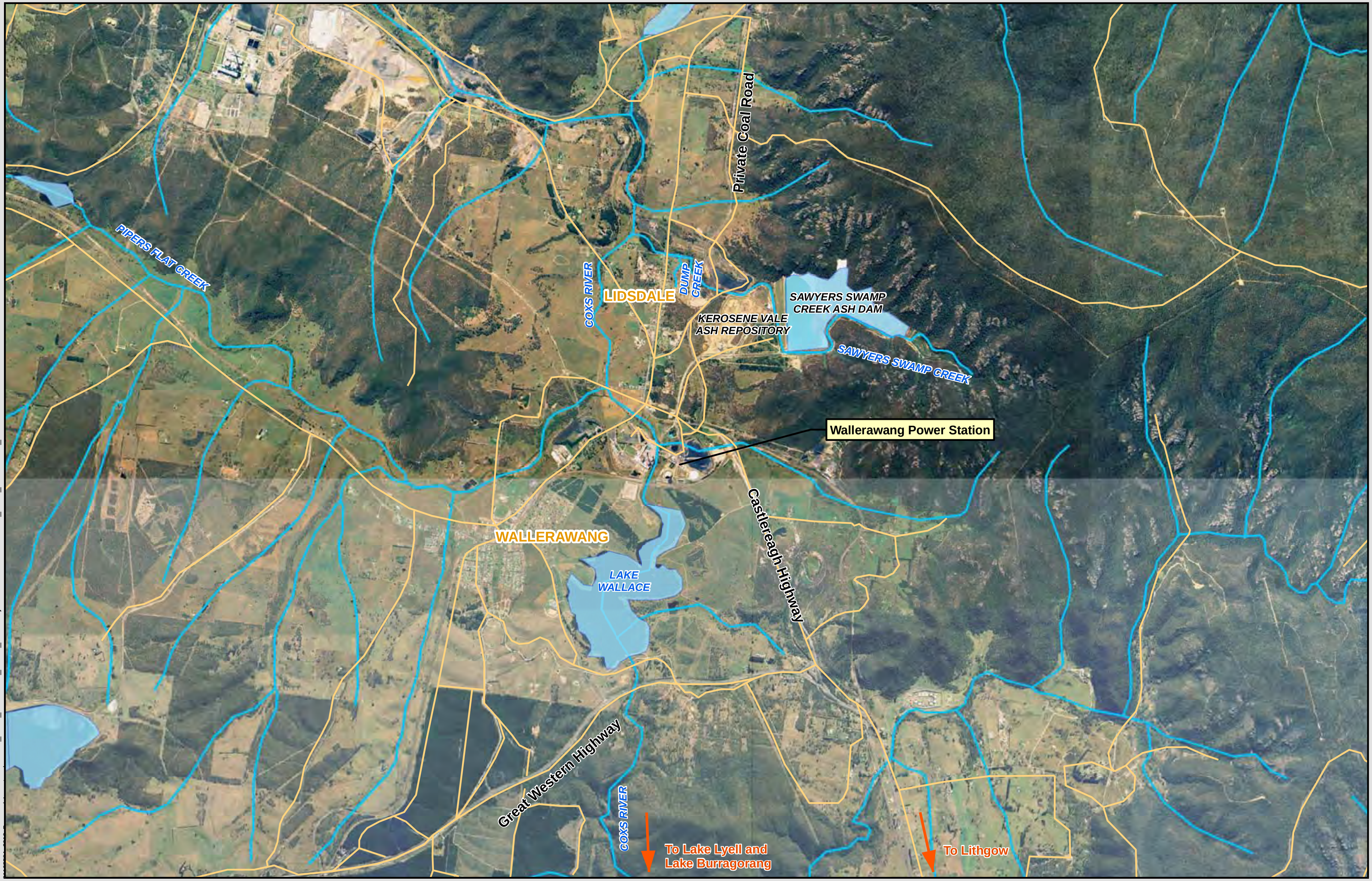

Figure 2-1 Catchment area

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Figure 2-2 Existing site drainage

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3. Potential impacts

3.1 Hydrology

3.1.1 Construction

The construction phase of the proposed Stage 2 area would require the realignment of Sawyers Swamp Creek and construction of a stability berm for the ash area embankments. These activities are not expected to change flows in Sawyers Swamp Creek. Potential impacts during construction of the new creek channel will be further identified in a separate report (PB, 2007a).

3.1.2 Operation

Throughout operation of the proposed Stage 2 area site drainage would vary as ash is placed and surface water is managed to prevent water quality impacts (see below). The Stage 1 water management plan would be adapted to include the ongoing ash placement operations for the proposed Stage 2 activities. This is likely to result in regular changes to the location where clean water is directed into Sawyers Swamp Creek to adapt to changing operations. While this would result in minor changes to flow at certain points along Sawyers Swamp Creek, the net flow to the creek would not change. All flows would reach Sawyers Swamp Creek prior to the creek reaching the culvert crossing under the Private Coal Road.

Following completion of operation of the Stage 2 ash placement area, the final landform would be capped and revegetated and all surface water from the area would enter the catchment as clean water (as previously defined). This would result in a slight increase in the overall flows entering the Sawyers Swamp Creek catchment as water would no longer be captured for reuse on site or for treatment prior to discharge to the Coxs River. Rather than a negative impact, it is considered that this would result in a return of more natural flows to the Sawyers Swamp Creek catchment. It would return catchment flows to pre-Stage 1 condition. Further, the proposed realignment and rehabilitation of Sawyers Swamp Creek would be designed to allow for the final landform flows and hence will ensure that any potential geomorphic impacts resulting from minor increases in flow are prevented. Total flows within the Coxs River would not change.

No flow records are available for Sawyers Swamp Creek to allow assessment of historic flows or flows from the existing catchment. A hydrological model (using XP RAFTS) has been developed to quantify flows from the site under existing conditions and with the proposed final landform. The modelling indicates that flows at the point where Sawyers Swamp Creek passes under Private Coal Road would increase slightly (refer to Table 3-1). Details of this modelling and estimated catchment flows are provided in Appendix A.

Table 3-1 Estimated flows in Sawyers Swamp Creek

	Existing Flow (m^3/s)	Final landform flow (m3/s)
2 year ARI	6.4	6.9
100 year ARI	14.1	15.1

3.2 Water quality

3.2.1 Construction

The construction phase activities, including realignment of Sawyers Swamp Creek, strengthening of the embankment walls, and excavation of the plantation area, have the potential to generate pollutants that could affect surface water quality. The primary impact to water quality during construction would be associated with potential for increased sediment loads as a result of exposed soil being conveyed to Sawyers Swamp Creek during storm events. Increased sedimentation of waterways can smother benthic habitats and organisms, and can increase levels of nutrients, metals and other potential toxicants that attach to the sediment particles.

Other potential pollutants that could be expected to affect water quality during the construction period include:

- hydrocarbons and chemicals as a result of spills and leakages from construction vehicles or fuel/chemical stores on construction sites
- general litter and gross pollutants from construction materials.

Measures to mitigate these impacts are discussed in Section 4.1.

3.2.2 Operation

The proposed Stage 2 area operations would continue to result in exposed ash areas. There is a potential for pollutants in the ash to be mobilised in runoff from these areas. There is also potential for sediment to be mobilised in runoff from disturbed areas of the site and from capped areas prior to revegetation. However, the potential for pollutants to be discharged from the site would be low given that:

- only 5% of annual rainfall is expected to be discharged as runoff from the ash emplacement
- surface water from disturbed areas would be contained and reused in onsite applications such as dust suppression and moisture control of the ash
- any collected dirty water which is not reused on site would be treated at the WPS prior to discharge via a licensed discharge point to the Coxs River.

These potential impacts are also associated with the existing Stage 1 operations of the KVAR. Comparison of water quality monitoring data collected during operation of the Stage 1 area to data collected prior to use of this area indicate that the water management system is working effectively and that operations are not having a detrimental impact to water quality. It is anticipated that with the continued use of appropriate water quality management measures, the proposed Stage 2 operations would similarly not result in negative surface water quality impacts.

The proposed creek realignment design is discussed in a separate report (PB, 2007a). The design has been developed with a focus on long term geomorphic stability, which aims to ensure an improvement of water quality within the creek through a reduction in sediment load from erosion. Riparian corridors, extending 20 metres from the top of bank on both sides of the creek, would be incorporated into the creek realignment design. These areas would provide natural filters for stormwater runoff, assist in stabilising stream banks, and provide habitat and corridor functions for flora and fauna. As a result of these features of the creek realignment, it is anticipated that water quality within Sawyers Swamp Creek would improve. Further details of the proposed realignment and rehabilitation of Sawyers Swamp Creek are provided in a separate report (PB 2007a).

Changes to groundwater in the area as a result of the operation of the proposed Stage 2 ash repository may also have some impact on water levels or water quality within Sawyers Swamp Creek. The groundwater levels in the area around the Lidsdale Cut and Sawyers Swamp Creek are shallow, and as such these areas have been identified as a potential groundwater discharge area. The groundwater assessment that has been undertaken as part of this Environmental Assessment has noted that there is unlikely to be any additional impacts on groundwater from the continuation of ash storage at the KVAR, as the dry ash placement facility would be located on top of the historical wet ash placement facility. It is important that groundwater management and monitoring measures be incorporated into the construction and operation environmental management plans for the project to ensure that groundwater does not affect surface water quality. Further details are provided in the Stage 2 Kerosene Vale Ash Repository Groundwater Assessment Report (PB, 2007b).

3.2.3 MUSIC software

The Director-General’s Requirements(DGRs) for the project indicate that MUSIC software should be used in the assessment of water quality (see Appendix C of the Environmental Assessment). During the review of the project and associated design it was determined that this software was not appropriate for this application. As a result, MUSIC has not been used in this assessment. The remainder of this section explains this variation from the DGRs and provides further justification of the water quality impact assessment approach used in this report.

MUSIC software capabilities

MUSIC software was developed as an evaluation tool for conceptual design of urban stormwater management systems. The software has been set up as a continuous simulation tool, meaning that it generates flows and pollutant loads based on a continuous rainfall record. This makes calibration an iterative process because real data is event based.

MUSIC is largely limited in its assessment of water quality parameters to consideration of total nitrogen, total phosphorous, total suspended solids and gross pollutants. While MUSIC can be used to model other pollutants, the mean concentrations of the pollutants need to be determined, in addition to deviations from the mean for different samples. The ability to remove the pollutant using different treatment systems would also need to be determined.

Water quality treatment options that can be incorporated into the model include buffer strips, vegetated swales, wetlands, bioretention systems, infiltration systems, ponds, rainwater tanks, sedimentation basins, and gross pollutant traps.

Applicability to KVAR Stage 2 operations

The water quality management system for KVAR during operation of the stage 2 area is proposed to be a continuation of the existing water quality management system at the site. This would involve management measures such as diversion of clean water run-off away from disturbed areas, collection of dirty run-off in sedimentation ponds for treatment prior to reuse, ensuring that a minimal area of the site is disturbed at any one time, and rehabilitation of areas as soon as practical. These management measures would continue to operate without change. Hence, a MUSIC model of existing site water management would replicate that of the proposed site water management during operation and hence produce the same results.

Justification of expected overall improvements to water quality

In relation to the broader Sawyers Swamp Creek catchment and expected benefits to water quality, MUSIC does not provide the user with the tools to assess such improvements that would be achieved through increased geomorphic stability of the creek and rehabilitation of the riparian zone.

Water quality improvements through increased geomorphic stability

MUSIC does not have the capability to assess a reduction in sediment loads as a result of an improved, stabilised creek channel. There is no 'treatment node' that could be applied to represent a stabilised channel, as that is a rehabilitation measure, not a treatment measure.

Instead, an assessment of the stability of the proposed creek realignment was undertaken during development of the Draft Rehabilitation Plan (presented in detail in Appendix B of the Draft Environmental Assessment Report). This assessment included development of a hydraulic model to compare velocity and shear stress within the existing and proposed channels. The assessment found that the proposed channel would be less prone to scour then the existing channel. Further, it is proposed that during detailed design of the channel, realignment additional measures would be incorporated into the channel design to further reduce the potential for scour. This indicates that lower sediment loads would result as channel erosion would be reduced.

Water quality improvements through rehabilitation of the riparian zone

Rehabilitation of the riparian zone would provide additional filtration of stormwater run-off from the catchment as it flows past denser vegetation. The closest representation of the water quality treatment provided by a riparian zone that is within the capability of the MUSIC software is a 'buffer strip' or a 'vegetated swale'.

A vegetated swale is a vegetated open channel structure. These are represented in MUSIC as a defined channel structure with vegetation growth at a specified height. This is not representative of a riparian zone that does not have a defined channel structure; instead it represents a long strip of vegetated area.

A buffer strip is a strip of vegetation adjacent to drainage lines. This provides a much closer representation of a riparian zone then a vegetated swale. However, the use of a buffer strip within the MUSIC model has been developed to represent situations where run-off from impervious surfaces (e.g. roads) flows across a grassed area before it reaches the stormwater treatment system. The buffer strip treatment node is not able to represent denser vegetation that would occur within the riparian zone. Furthermore, the buffer strip treatment is designed to intercept sheet flows and remove pollutants from run-off prior to their entry into a waterway. The treatment is not suitable to model the treatment effects on concentrated channelised flows. Finally, the catchment generating the run-off prior to the riparian zone at Kerosene Vale is not an impervious area.

The capacity of riparian zones to trap sediment, nutrients and other contaminants before they reach a waterway is well documented in publications such as *Principles for Riparian Land Management (*Australian Government, February 2007) and *A Rehabilitation Manual for*

Australian Streams (Cooperative Research Centre for Catchment Hydrology & Land and Water Resources Research and Development Corporation, 2000), among others.

As no negative impact to water quality is predicted as a result of the proposed project, it is not considered appropriate or beneficial to quantify this additional water quality improvement.

4. Management of impacts

4.1 Construction

Mitigation measures would be required to prevent impacts associated with the construction phase of the proposed Stage 2 area. An Erosion and Sediment Control Plan would be prepared (as part of the project Construction Environmental Management Plan) in accordance with *Soils and Construction: Managing Urban Stormwater* (Landcom, 2004) prior to commencement of any construction activities. Mitigation measures that would be required include:

- Installing erosion and sediment controls such as sediment basins, staked straw bales, and sediment fences, in accordance with an Erosion and Sediment Control Plan.
- Ensuring appropriate planning of creek construction works to minimise risk of sediment discharge to the existing waterway through minimising the length of time that soil is exposed.
- Restricting construction traffic to defined internal roads, and where required, operating wheel cleaning areas at locations where vehicles leave the construction site.
- Ensuring that chemicals and fuels are appropriately stored and bunded.
- Training of construction employees to implement spill response procedures and implement, maintain and be aware of sediment and erosion control measures and requirements.

4.2 Operation

The existing water quality management system at the KVAR would be continued throughout the proposed Stage 2 operations and should be detailed within an updated Water Management Plan Work Instruction as part of the operation environmental management plan. This Plan would incorporate both surface water and groundwater management to ensure the catchment is managed on a whole of catchment basis.

A Drainage Plan for ongoing operations is shown in Figure 4-1. Key water quality control measures would include:

- Diversion of clean water around disturbed areas.
- Drainage of all runoff from disturbed areas to a 3 megalitre collection pond which would provide primary treatment of the runoff through settling processes.
- The ‘dirty water catchment’, (the disturbed area), should be limited to an area of approximately 5 hectares at any one time, with an exposed ash area of 1.5 hectares (equivalent to approximately 6 months ash placement). This is the same area that was used for the design of the collection pond during preparation of the REF.
- The 3 megalitre collection pond would be moved to appropriate locations (with dirty water draining to it) as the new ash face progresses.

- Water collected within the pond would be used on site for dust suppression and moisture control of the ash, with any additional water directed to the return water channel for treatment at the WPS prior to discharge to the Coxs River via the existing licensed discharge point.
- The collection pond would be sized with a capacity for the 24-hour, 10 year ARI storm event. Overflows from the pond would be directed to the existing 25 megalitre storage dam. Water collected in this dam would be reused on site or pumped to the return water channel and then to WPS for treatment, and if required, discharge to the Coxs River.
- During extreme storm events, the area adjacent to the 25 megalitre storage dam would act as a retention area and contain overflows from the dirty water catchment. Following a storm event the water would either be used on site or pumped to the return water channel and then to WPS for treatment, and if required, discharge to the Coxs River.

Other general maintenance measures that should be implemented at KVAR to prevent water quality impacts associated with the proposed Stage 2 area include:

- Capping and revegetation of areas with minimal delay, with disturbed areas limited to 5 hectares at any one time.
- Installing erosion and sediment controls to treat runoff from capped areas until vegetative cover is established.
- Restricting work within disturbed areas during heavy rainfall.

4.3 Monitoring

It is recommended that a detailed surface water monitoring program be established as part of the construction and/or operation environmental management plan for the proposed Stage 2 area. The surface water monitoring program should indicate trigger values (based on the ANZECC water quality guidelines), which, if exceeded, would lead to an appropriate management response.

It is recommended that the monitoring program be based on the existing monitoring undertaken at the site. This currently involves quarterly monitoring at 4 surface water locations across the site (2 located within Sawyers Swamp Creek, 1 within Dump Creek and 1 within the SCCAD). The current monitoring provides assessment of the parameters listed in Table 4-1. It is recommended that this list of parameters be reviewed in development of the monitoring plan. A measurement of turbidity (measured as NTU) in addition to total dissolved solids would assist in assessing changes in sedimentation following construction.

It is recommended that monitoring locations be reviewed in conjunction with the development of a groundwater monitoring program and management measures to ensure that potential impacts to Sawyers Swamp Creek associated with groundwater are able to be identified. It is also recommended that additional monitoring be undertaken following wet weather events, with a minimum of 2 events being recorded within the first 12 months of operation, to ensure that the water quality controls identified in Section 4.2 are operating effectively and preventing impacts during wet weather events.

Table 4-1 Water quality monitoring parameters

Category	Parameter
Field Parameters	pH, electrical conductivity, alkalinity ($CaCO_3$), total dissolved solids
Anions	Chloride, fluoride, sulfate
Cations	Sodium, potassium, calcium, magnesium
Metals	Arsenic, silver, barium, boron, cadmium, chromium (III) and (VI), copper, iron, mercury, magnesium, manganese, lead, selenium, zinc

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Figure 4.1 Proposed drainage plan

5. Conclusions

This assessment has identified potential changes and resulting impacts to Sawyers Swamp Creek that could be expected from the construction and operation of the proposed Stage 2 activities at KVAR.

During construction, potential impacts would be mitigated through the implementation of erosion and sediment control measures (to be included in the construction environmental management plan), which should be prepared in accordance with *Soils and Construction: Managing Urban Stormwater* (Landcom, 2004) prior to commencement of any construction activities.

Monitoring data to date has shown that existing water management practices implemented throughout the Stage 1 operations have resulted in an overall neutral impact to water quality within Sawyers Swamp Creek. It is proposed to continue to use existing water management practices across the site, adjusting these procedures appropriately to suit different stages of operation. It is, therefore, expected that site operations would continue to have a neutral impact on water quality.

Continuation of water quality management practices may result in slight changes to the location where clean water is discharged to Sawyers Swamp Creek as operations progress, these changes would not alter the total flow entering the creek prior to it reaching the crossing under the Private Coal Road during operations. Following completion of operation of the Stage 2 activities there would be a slight increase in the overall flows entering the Sawyers Swamp Creek catchment as a result of dirty water no longer being captured for treatment and reuse. It is considered that this would result in a return of more natural flows to the Sawyers Swamp Creek catchment.

The proposed creek realignment would provide for some rehabilitation of Sawyers Swamp Creek. The design would ensure geomorphic stability of the creek, reducing the sediment loads currently generated through bank erosion. The design would also include a functional riparian zone to provide filtration and treatment of runoff entering the creek. These factors would result in an overall beneficial effect on long term water quality within Sawyers Swamp Creek.

It is recommended that the water quality monitoring currently undertaken by Delta Electricity be continued. The existing monitoring program will be reviewed in conjunction with assessing requirements for groundwater monitoring. It is also recommended that wet weather monitoring be incorporated into the program in addition to the quarterly monitoring currently undertaken for the first year following the realignment of the creek section. Documentation of the monitoring program within the operation environmental management plan should identify trigger values (from the ANZECC water quality guidelines) which, if exceeded, would lead to an appropriate management response.

6. References

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Parsons Brinckerhoff (2007b) *Stage 2 Kerosene Vale Ash Repository: Groundwater Impact Assessment,* Report (PB, 2007).

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Appendix A

Hydrological modelling

Overview

A rainfall runoff model was developed using XP-RAFTS to quantify flows from the Sawyers Swamp Creek Catchment, both under existing conditions and following completion of operations at the Stage 2 area. No flow data is available for the catchment to calibrate the model. A sensitivity analysis was undertaken to assess the assumptions used in developing the model.

Description of XP-Rafts

XP-RAFTS was developed as a general purpose rainfall runoff model suitable for a wide range of natural and modified (urbanised) catchments. The model uses a non-linear routing procedure developed by Laurenson to convert rainfall into runoff.

XP-RAFTS can be used to estimate flood discharges for any observed or design (synthetic) storm. Parameters such as slope, catchment area, impervious areas, surface roughness and rainfall losses are used to simulate the catchment response to a specific storm and to generate hydrographs where required. For computational purposes the catchment is sub-divided into a series of sub-catchments, which are differentiated by drainage sub-division, topography, land use or soil type. Discharges are computed at the outlet of each sub-catchment. Sub-catchments may be further sub-divided to provide discharges at points of interest.

Model setup and input parameters

Two models were developed using XP- RAFTS — one to represent the existing catchment and one to represent the catchment following completion of the proposed Stage 2 operations. The layout of the two models is shown in Figure A-1 and Figure A-2 below.

Flows from the catchment of the Sawyers Swamp Creek Ash Dam (SSCAD) have been assumed to be contained within this dam for all storm events up to the 100 year ARI event, based on advice from Delta Electricity (*pers. comm* Delta Electricity, 4/10/07). Water collected within this dam is pumped to the WPS for treatment. There is also a small dam immediately upstream of the SSCAD that collects freshwater from the catchment upstream to minimise the amount of water requiring treatment from the SSCAD. Water from this freshwater dam is released to Sawyers Swamp Creek within the concrete channel that runs along the southern boundary of SSCAD through a 900 millimetre pipe. Additional water is pumped to the creek when required to maintain the dam at a low level. Water from this dam has been included in the model as a constant low flow, at capacity of the 900 millimetre pipe ($0.98m^3/s$, based on the Colebrook-White formula and pipe slope of approximately 0.25%). Water that is pumped from the dam has been excluded from the model, as pumping follows rainfall events rather then occurring during rainfall and hence would not contribute to the design flows being calculated.

Figure A-1 Existing site model layout

Figure A-2 Final landform model layout

Details of the key parameters adopted for each sub-catchment are presented in the Table A-1 below. These parameters have been adopted to represent the land surface of each sub-catchment. Assumed catchment roughness (Manning's n) values have been adopted based on tables of typical values presented in *A Rehabilitation Manual for Australian Streams* (CRC & LWRRDC, 2000). Assumed initial and continuing loss values have been adopted based on guidance within the XP-RAFTS manual (XP Software, 2000) and *Australian Rainfall and Runoff* (Engineers Australia, 2001).

Table A-1 Sub-catchment Parameters

Sub-catchment name	Area (ha)	Vectored slope (%)	Manning's n	Initial loss (mm)	Continuing loss (mm/hr)
Both models					
U/S Catch	385	20	0.15	20	2.5
Dam Catch	225	20	0.15	20	2.5
SSCAD	80	0.001	0.025	0	0
Catch1a	27	24	0.1	20	2.5
Catch1b	30.6	16	0.1	20	2.5
Catch1c	16	24	0.1	20	2.5
Catch2	6	20	0.03	10	2.5
Catch3	10.3	10	0.07	10	2.5
Catch4	4	0.5	0.03	5	2.5
Catch5	6.7	5	0.03	10	2.5
SSC2	22	15	0.07	10	2.5
SSC3	6	30	0.1	20	2.5
SSC4	0.001	0.001	0.025	10	2.5
SSC5	2.1	15	0.03	10	2.5
SSC6	0.001	0.001	0.025	10	2.5
2007 model					
KVAR 1	16.2	0.5	0.04	10	2.5
Final model					
KVAR 1	21.5	0.5	0.04	10	2.5
KVAR 2	19	0.5	0.04	10	2.5

Design rainfall parameters were extracted from Australian Rainfall and Runoff Volume 2 (Engineers Australia, 1987). The adopted Intensity-Frequency-Duration coefficients are shown Table A-2 below.

Table A-2 Intensity frequency duration (IFD) coefficients

${}^{2}I_{1}$	24.0	${}^{50}I_{1}$	44.3	G	0.15
${}^{2}I_{12}$	5.4	${}^{50}I_{12}$	9.4	F_2	4.31
${}^{2}I_{72}$	1.75	${}^{50}I_{72}$	2.8	F_{50}	15.73

Model results

The model was used to calculate peak design flows during the 2, 5, 20 and 100 year ARI events. The 9 hour duration storm was found to be the critical duration for the 2, 5 and 20 year ARI events, while the 2 hour storm was found to be the critical duration for the 100 year ARI event. This was found to be the case for both the existing landform and the final landform models.

The flows calculated for each sub-catchment both under the existing KVAR landform and the final KVAR landform conditions are shown in Table A-3.

The results show that following completion of operation of the Stage 2 ash repository, flows from KVAR would increase. This is a result of the change in landform and additional water being discharged from the KVAR area that would no longer be required to be captured for treatment once the area has been capped and revegetated. Rather then a negative impact, it is considered that this would result in a return to more natural flows to the Sawyers Swamp Creek catchment.

Table A-3 Catchment flows

Sub-catchment	Existing landform 9hr 2Yr ARI (m^3/s)	Final landform 9hr 2Yr ARI (m^3/s)	Existing landform 9hr 5Yr ARI (m^3/s)	Final landform 9hr 5Yr ARI (m^3/s)	Existing landform 9hr 20Yr ARI (m^3/s)	Final landform 9hr 20Yr ARI (m^3/s)	Existing landform 2hr 100Yr ARI (m^3/s)	Final landform 2hr 100Yr ARI (m^3/s)
U/S catch	7.43	7.43	11.29	11.29	16.76	16.76	16.52	16.52
Dam catch	12.23	12.23	18.61	18.61	27.42	27.42	27.28	27.28
SSCAD	12.27	12.27	18.67	18.67	27.52	27.52	27.36	27.36
Catch1a	2.10	2.10	2.46	2.46	2.94	2.94	3.74	3.74
Catch1b	3.29	3.29	4.02	4.02	5.00	5.00	6.43	6.43
Catch1c	3.92	3.92	4.86	4.86	6.13	6.13	7.88	7.88
Catch2	0.32	0.32	0.41	0.41	0.52	0.52	1.73	1.73
Catch3	0.44	0.81	0.58	1.13	0.77	1.53	1.53	2.12
Catch4	0.14	0.14	0.18	0.18	0.25	0.25	0.40	0.40
Catch5	0.33	0.33	0.43	0.43	0.57	0.57	1.44	1.44
SSC2	5.14	4.80	6.54	6.04	8.37	7.69	10.91	10.20
SSC3	5.58	5.25	7.13	6.63	9.14	8.48	11.92	11.23
SSC4	5.83	5.94	7.46	7.60	9.58	9.79	12.50	12.69
SSC5	5.89	5.99	7.56	7.69	9.71	9.92	12.63	12.82
SSC6	6.41	6.91	8.26	9.00	10.65	11.68	14.07	15.06
KVAR1	0.37	0.47	0.53	0.67	0.74	0.95	0.91	1.12
KVAR2	-	0.42	-	0.61	-	0.85	-	1.02

Sensitivity analysis

No flow records are available for Sawyers Swamp Creek to allow for calibration of the XP-RAFTS model. A sensitivity analysis has been undertaken to assess the sensitivity of the model to changes in key parameters that have been assumed. Details of this analysis are shown in Table A-4.

Table A-4 Sensitivity analysis

Change manning n

Catchment	Increase n by 20%				Decrease n by 20%			
	2 year ARI flow	% change	100 year ARI flow	% change	2 year ARI flow	% change	100 year ARI flow	% change
Catch1	2.05	-2%	3.50	-6%	2.18	4%	4.10	10%
SSC1	3.14	-5%	5.83	-9%	3.42	4%	7.10	10%
SSC2	3.72	-5%	7.16	-9%	4.10	5%	8.72	11%
Catch2	0.32	-12%	0.78	-14%	0.42	15%	1.07	18%
SSC3	4.85	-6%	9.92	-9%	5.40	5%	12.18	12%
KVAR1	0.32	0%	1.68	-3%	0.32	0%	1.82	5%
Catch5	5.27	-6%	10.83	-9%	5.87	5%	13.24	11%
SSC4	0.31	-5%	1.28	-11%	0.34	5%	1.62	12%
SSC5	5.50	-6%	11.38	-9%	6.14	5%	13.94	12%
Catch4	5.54	-6%	11.47	-9%	6.21	6%	14.07	11%
KVAR2	0.13	-7%	0.35	-12%	0.15	9%	0.46	15%
Catch3	0.42	-4%	1.33	-13%	0.47	8%	1.84	20%
SSC6	6.02	-6%	12.78	-9%	6.78	6%	15.80	12%

Change initial loss

Catchment	Increase initial loss by 20%				Decrease initial loss by 20%			
	2 year ARI flow	% change	100 year ARI flow	% change	2 year ARI flow	% change	100 year ARI flow	% change
Catch1	2.07	-2%	3.45	-8%	2.11	0%	4.07	9%
SSC1	3.19	-3%	5.80	-10%	3.30	0%	7.08	10%
SSC2	3.78	-3%	7.10	-10%	3.94	1%	8.69	10%
Catch2	0.36	-2%	0.87	-5%	0.37	2%	0.94	4%
SSC3	4.97	-3%	9.87	-10%	5.18	1%	11.92	9%
KVAR1	0.32	0%	1.72	0%	0.32	0%	1.73	0%
Catch5	5.39	-3%	10.78	-10%	5.63	1%	13.00	9%

SSC4	0.33	0%	1.36	-5%	0.33	0%	1.49	3%
SSC5	5.63	-4%	11.33	-9%	5.88	1%	13.62	9%
Catch4	5.67	-4%	11.43	-10%	5.94	1%	13.80	9%
KVAR2	0.14	0%	0.39	-2%	0.14	0%	0.40	2%
Catch3	0.44	0%	1.45	-6%	0.44	0%	1.64	7%
SSC6	6.16	-4%	12.75	-9%	6.48	1%	15.37	9%

Change continuing loss

Catchment	Increase initial loss by 20%				Decrease initial loss by 20%			
	2 year ARI flow	% change	100 year ARI flow	% change	2 year ARI flow	% change	100 year ARI flow	% change
Catch1	2.06	-2%	3.71	-1%	2.14	2%	3.77	1%
SSC1	3.20	-3%	6.37	-1%	3.37	3%	6.50	1%
SSC2	3.80	-3%	7.79	-1%	4.03	3%	7.96	1%
Catch2	0.34	-7%	0.89	-2%	0.39	8%	0.93	2%
SSC3	4.97	-3%	10.80	-1%	5.32	3%	11.03	1%
KVAR1	0.31	-3%	1.72	-1%	0.33	3%	1.74	1%
Catch5	5.40	-3%	11.80	-1%	5.78	3%	12.05	1%
SSC4	0.32	-3%	1.43	-1%	0.34	3%	1.45	1%
SSC5	5.64	-3%	12.37	-1%	6.04	3%	12.63	1%
Catch4	5.68	-3%	12.50	-1%	6.10	4%	12.76	1%
KVAR2	0.13	-5%	0.39	-1%	0.14	5%	0.40	1%
Catch3	0.42	-4%	1.52	-1%	0.45	4%	1.55	1%
SSC6	6.18	-4%	13.93	-1%	6.64	4%	14.22	1%

Appendix B

Water quality data

		Date			Water	pH	Conductivity	MO Alk	Chloride	Fluoride	Sulphate	TDS	Sodium	Potassium	Calcium	Magnesium	Arsenic	Silver	Barium	Boron	Cadmium	Chrome	Chrome 6+	Copper	Iron	Mercury	Manganese	Lead	Selenium	Zinc
					Level		Lab.	as CaCO3			Result	Result	Na	K	Ca	Mg	As	Ag	Ba	B	Cd	Cr	Cr 6+	Cu	Fe f	Hg	Mn f	Pb	Se	Zn
					metres		uS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	3720438	9-Nov-01	38	Sawyers S Ck Ash Dam		6.50	157,300	5	13	10.100	811	1280	224	70	91	13	0.023	0.001	0.129	5.47	0.012	0.001		0.004	0.18	0.0002	1.26	0.001	0.275	0.527
	3720439	9-Nov-01	39	Dump Ck		7.40	83,900	16	37	1.100	349	567	80	27	49	30	0.001	0.001	0.046	1.64	0.001	0.001		0.001	1.6	0.0002	0.299	0.001	0.003	0.058
	3720440	9-Nov-01	40	Sawyers Ck WX5		3.60	75,400	5	23	1.000	299	462	65	47	24	19	0.001	0.001	0.03	1.4	0.001	0.001		0.002	0.57	0.0002	1.59	0.002	0.001	0.208
	3729238	5-Feb-02	38	Sawyers S Ck Ash Dam		6.00	184,000	5	15	10.800	806	1330	230	70	93	13	0.039		0.152	6.61	0.01		0.01	0.004	0.1		1.27	0.001	0.305	0.481
	3729239	5-Feb-02	39	Dump Ck		5.60	45,300	13	20	0.700	172	362	39	14	23	14	0.001		0.038	1.04	0.001		0.01	0.002	0.2		0.207	0.001	0.002	0.028
	3729240	5-Feb-02	40	Sawyers Ck WX5		3.40	86,700	5	19	1.100	312	534	69	48	26	20	0.001		0.04	2	0.001		0.01	0.002	1		1.81	0.003	0.001	0.202
	3736938	23-Apr-02	38	Sawyers S Ck Ash Dam		5.90	185,600	5	65	11.000	923	1400	269	85	106	13	0.02	0.001	0.134	6.73	0.011	0.001		0.004	0.1	0.0002	1.36	0.001	0.379	0.387
	3736939	23-Apr-02	39	Dump Ck		3.90	66,700	5	40	0.500	246	394	67	24	22	20	0.001	0.001	0.021	1.1	0.001	0.001		0.002	2.1	0.0002	1.85	0.001	0.001	0.265
	3736940	23-Apr-02	40	Sawyers Ck WX5		3.70	83,600	5	34	1.200	313	500	73	53	26	17	0.001	0.001	0.034	1.55	0.001	0.001		0.002	0.5	0.0002	1.71	0.002	0.001	0.167
	3736941	23-Apr-02	41	Sawyers Ck WX7		6.10	147,800	5	51	1.000	345	594	94	36	43	28	0.001	0.001	0.034	1.62	0.001	0.001		0.003	0.3	0.0002	0.779	0.002	0.003	0.123
	3745438	17-Jul-02	38	Sawyers S Ck Ash Dam		6.40	202,000	5	26	11.400	999	1553	270	81	108	14	0.023		0.122	7.99	0.011		0.001	0.003	0.1		1.54	0.001	0.326	0.395
	3745439	17-Jul-02	39	Dump Ck		3.60	68,500	5	31	0.500	253	474	57	22	21	20	0.001		0.022	1.24	0.001		0.001	0.002	1.9		2.09	0.001	0.001	0.32
	3745440	17-Jul-02	40	Sawyers Ck WX5		3.70	95,200	5	24	1.500	359	636	71	38	30	19	0.001		0.038	2.1	0.001		0.001	0.005	0.33		2.17	0.003	0.001	0.311
	3745441	17-Jul-02	41	Sawyers Ck WX7		6.40	99,500	5	79	0.800	415	738	94	33	51	31	0.001		0.038	2.39	0.001		0.001	0.005	0.15		0.901	0.003	0.006	0.177
	3755238	23-Oct-02	38	Sawyers S Ck Ash Dam		4.80	232,990	5	74	11.100	1100	1722	326	96	107	15	0.023		0.132	7.7	0.015	0.018		0.035	0.3		1.59	0.001	0.3	0.541
	3755239	23-Oct-02	39	Dump Ck		7.10	137,113	5	83	1.200	593	984	156	36	71	42	0.001		0.047	3.3	0.001	0.001		0.002	0.1		0.492	0.001	0.002	0.06
	3755240	23-Oct-02	40	Sawyers Ck WX5		3.20	113,402	1	78	1.900	400	671	84	49	32	21	0.001		0.039	2.1	0.001	0.001		0.005	0.7		2.34	0.004	0.001	0.397
	3755241	23-Oct-02	41	Sawyers Ck WX7		6.20	119,897	5	82	0.900	479	798	111	29	54	35	0.001		0.045	2.6	0.001	0.001		0.005	0.4		1.51	0.001	0.001	0.153
	3763638	15-Jan-03	38	Sawyers S Ck Ash Dam		4.90	238,900	<10	19	14.000	1100	1940	330	100	120	17	<0.05	<0.01	0.12	8.4	0.02	<0.01		0.02	0.03	<0.0001	1.7	<0.01	0.22	0.65
	3763639	15-Jan-03	39	Dump Ck		4.20	70,100	n/a	21	0.510	270	630	71	19	21	23	<0.05	<0.01	0.04	1.4	<0.002	<0.01		<0.01	0.21	<0.0001	2.2	<0.01	<0.006	0.17
	3763640	15-Jan-03	40	Sawyers Ck WX5		6.60	49,800	30	26	1.100	150	420	44	20	31	12	<0.05	<0.01	0.05	0.85	<0.002	<0.01		<0.01	<0.03	<0.0001	0.62	<0.01	<0.006	0.23
	3763641	15-Jan-03	41	Sawyers Ck WX7		6.20	105,600	10	27	0.930	480	720	110	28	47	35	<0.05	<0.01	0.04	2.6	<0.002	<0.01		<0.01	0.33	<0.0001	1.5	<0.01	<0.006	0.06
	3771938	8-Apr-03	38	Sawyers S Ck Ash Dam		5.40	257,800	<10	20	14.000	1390	2170	380	110	140	18	<0.05	<0.01	0.11	8.6	0.02	<0.01		<0.01	0.05	<0.0001	1.7	<0.01	0.2	0.58
	3771939	8-Apr-03	39	Dump Ck		4.30	61,100	0	22	0.440	240	500	61	16	18	20	<0.05	<0.01	0.03	1.2	<0.002	<0.01		<0.01	1.6	<0.0001	1.9	<0.01	<0.006	0.31
	3771940	8-Apr-03	40	Sawyers Ck WX5		6.90	37,800	50	21	0.980	92	400	31	16	26	8.1	<0.05	<0.01	0.06	0.54	<0.002	<0.01		<0.01	<0.03	<0.0001	0.21	<0.01	<0.006	0.12
	3771941	8-Apr-03	41	Sawyers Ck WX7		6.40	115,500	10	27	0.910	540	800	120	28	57	39	<0.05	<0.01	0.03	2.9	<0.002	<0.01		<0.01	0.34	<0.0001	0.64	<0.01	<0.006	0.07
	3781738	15-Jul-03	38	Sawyers S Ck Ash Dam		6.30	260,300	10	20	11.000	1300	2010	360	100	140	17	<0.05	<0.01	0.09	7.9	0.015	<0.01		<0.01	0.03	<0.0001	1.5	<0.01	<0.006	0.47
	3781739	15-Jul-03	39	Dump Ck		3.90	63,600	n/a	22	0.540	240	400	54	13	18	19	<0.05	<0.01	0.02	0.92	<0.002	<0.01		<0.01	1.1	<0.0001	2	<0.01	<0.006	0.4
	3781740	15-Jul-03	40	Sawyers Ck WX5		7.10	42,700	50	16	0.730	130	290	30	17	28	9.2	<0.05	<0.01	0.06	0.6	<0.002	<0.01		<0.01	0.02	<0.0001	0.59	<0.01	<0.006	0.06
	3781741	15-Jul-03	41	Sawyers Ck WX7		6.60	112,500	10	30	1.100	490	820	110	24	58	36	<0.05	<0.01	0.03	2.4	<0.002	<0.01		<0.01	0.05	<0.0001	0.59	<0.01	<0.006	0.12
	3791538	21-Oct-03	38	Sawyers S Ck Ash Dam		6.20	239,000	<10	20	9.000	1200	1790	350	92	120	16	<0.05	<0.01	0.07	7	<0.002	n/a		<0.01	0.02	<0.0001	1.2	<0.01	0.18	0.32
	3791539	21-Oct-03	39	Dump Ck		3.90	63,000	n/a	19	0.500	240	380	59	14	19	20	<0.05	<0.01	0.02	0.96	<0.002	n/a		<0.01	1.6	<0.0001	2	<0.01	<0.006	0.38
	3791540	21-Oct-03	40	Sawyers Ck WX5		6.40	24,800	20	7	0.400	78	170	19	11	15	5.7	<0.05	<0.01	0.06	0.33	<0.002	n/a		<0.01	0.22	<0.0001	0.56	<0.01	<0.006	0.09
	3791541	21-Oct-03	41	Sawyers Ck WX7		6.30	81,100	<10	25	0.800	340	540	86	19	40	28	<0.05	<0.01	0.03	1.5	<0.002	n/a		<0.01	0.05	<0.0001	0.82	<0.01	<0.006	0.16
	3799438	8-Jan-04	38	Sawyers S Ck Ash Dam		5.20	241,800	<10	20	8.000	1200	1830	320	88	130	17	<0.05	<0.01	0.08	7.5	<0.002	<0.01		<0.01	0.2	<0.0001	1.2	<0.01	<0.006	0.27
	3799439	8-Jan-04	39	Dump Ck		3.90	68,600	n/a	19	0.500	260	430	58	16	19	22	<0.05	<0.01	0.03	1.3	<0.002	<0.01		<0.01	1.2	<0.0001	2.1	<0.01	<0.006	0.25
	3799440	8-Jan-04	40	Sawyers Ck WX5		6.50	49,000	30	17	0.700	160	350	43	20	20	12	<0.05	<0.01	0.04	0.1	<0.002	<0.01		<0.01	0.37	<0.0001	0.94	<0.01	<0.006	0.02
	3799441	8-Jan-04	41	Sawyers Ck WX7		5.70	75,800	<10	21	0.700	310	530	73	19	29	26	<0.05	<0.01	0.04	1.7	<0.002	<0.01		<0.01	0.06	<0.0001	2.5	<0.01	<0.006	0.22
	3810038	23-Apr-04	38	Sawyers S Ck Ash Dam		5.20	247,300	<10	22	8.000	1200	1880	370	96	140	17	<0.05	<0.01	0.1	7.9	0.008	<0.01		<0.01	0.35	<0.0001	1.2	<0.01	0.15	0.26
	3810039	23-Apr-04	39	Dump Ck		4.20	66,500	n/a	21	0.500	260	400	64	18	20	22	<0.05	<0.01	0.03	1.3	<0.002	<0.01		<0.01	0.42	<0.0001	2.1	<0.01	<0.006	0.25
	3810040	23-Apr-04	40	Sawyers Ck WX5		6.80	71,200	50	23	1.300	250	480	64	36	32	17	<0.05	<0.01	0.05	1.6	<0.002	<0.01		<0.01	0.2	<0.0001	1.5	<0.01	<0.006	0.03
	3810041	23-Apr-04	41	Sawyers Ck WX7		7.20	122,500	14	26	0.800	560	890	150	33	59	41	<0.05	<0.01	0.03	3	<0.002	<0.01		<0.01	0.21	<0.0001	0.81	<0.01	<0.006	0.1
31-Jul-04	2004-07-38-1	7-Jul-04	38	Sawyers S Ck Ash Dam		5.60	243,100	5	22	9.000	1300	1780	330	81	130	16	0.025	0.005	0.09	7.1	0.007	0.005		0.005	0.005	0.00005	1.1	0.005	0.13	0.24
31-Jul-04	2004-07-39-1	7-Jul-04	39	Dump Ck		4.40	62,000	0	22	0.600	300	360	58	15	19	20	0.025	0.005	0.02	1.1	0.001	0.005		0.005	0.06	0.00005	2	0.005	0.003	0.33
31-Jul-04	2004-07-40-1	7-Jul-04	40	Sawyers Ck WX5		6.40	75,600	40	28	1.500	280	460	60	35	39	18	0.025	0.005	0.06	1.4	0.001	0.005		0.005	0.03	0.00005	1.5	0.005	0.003	0.05
31-Jul-04	2004-07-41-1	7-Jul-04	41	Sawyers Ck WX7		6.10	142,600	20	35	1.000	710	1060	150	30	82	48	0.025	0.005	0.03	3.4	0.001	0.005		0.005	0.04	0.00005	0.45	0.005	0.003	0.08
31-Oct-04	2004-10-38-1	20-Oct-04	38	Sawyers S Ck Ash Dam		5.60	244,900	5	23	10.000	1200	1940	330	84	140	17	0.025	0.005	0.08	7	0.006	0.005		0.005	0.03	0.00005	1.1	0.005	0.11	0.22
31-Oct-04	2004-10-39-1	20-Oct-04	39	Dump Ck		4.00	61,900	0	21	0.500	230	420	55	14	18	20	0.025	0.005	0.02	1	0.001	0.005		0.005	0.83	0.00005	1.8	0.005	0.003	0.34
31-Oct-04	2004-10-40-1	20-Oct-04	40	Sawyers Ck WX5		6.10	28,600	20	11	0.600	84	190	20	12	17	6	0.025	0.005	0.03	0.37	0.001	0.005		0.005	0.33	0.00005	0.53	0.005	0.003	0.08
31-Oct-04	2004-10-41-1	20-Oct-04	41	Sawyers Ck WX7		6.10	130,900	30	32	1.100	590	930	140	27	76	44	0.025	0.005	0.03	2.8	0.001	0.005		0.005	0.05	0.00005	0.41	0.005	0.003	0.07
31-Jan-05	2005-01-38-1	18-Jan-05	38	Sawyers S Ck Ash Dam		5.00	237,700	5	24	6.700	1300	1950	370	93	140	16	0.025	0.005	0.08	7.2	0.007	0.005		0.005	0.04	0.00005	1.2	0.005	0.1	0.27
31-Jan-05	2005-01-39-1	18-Jan-05	39	Dump Ck		4.40	57,600	0	21	0.400	220	430	55	16	16	17	0.025	0.005	0.02	1.1	0.001	0.005		0.005	0.68	0.00005	1.8	0.005	0.003	0.23
31-Jan-05	2005-01-40-1	18-Jan-05	40	Sawyers Ck WX5		6.40	30,200	30	11	0.400	89	250	25	12	16	6.7	0.025	0.005	0.04	0.42	0.001	0.005		0.005	0.09	0.00005	0.67	0.005	0.003	0.07
31-Jan-05	2005-01-41-1	18-Jan-05	41	Sawyers Ck WX7		6.50	108,700	30	27	0.900	480	800	110	22	53	33	0.025	0.005	0.03	2.4	0.001	0.005		0.005	0.16	0.00005	0.82	0.005	0.003	0.08
30-Apr-05	2005-04-38-1	14-Apr-05	38	Sawyers S Ck Ash Dam		4.40	245,300	0	25	7.600	1600	1900	350	87	140	18	0.025	0.005	0.09	7.3	0.007	0.005		0.01	0.09	0.00005	1.4	0.005	0.089	0.33
30-Apr-05	2005-04-39-1	14-Apr-05	39	Dump Ck		4.60	57,800	10	20	0.700	270	420	58	16	17	19	0.025	0.005	0.02	1.2	0.001	0.005		0.005	0.64	0.00005	1.9	0.005	0.003	0.24
30-Apr-05	2005-04-40-1	14-Apr-05	40	Sawyers Ck WX5		6.40	73,700	50	16	1.100	270	480	59	35	38	19	0.025	0.005	0.08	1.5	0.001	0.005		0.005	0.07	0.00005	2.4	0.005	0.003	0.03
30-Apr-05	2005-04-41-1	14-Apr-05	41	Sawyers Ck WX7		6.20	99,200	10	25	0.800	440	740	100	24	46	33	0.025	0.005	0.03	2.2	0.001	0.005		0.005	0.15	0.00005	1	0.005	0.003	0.15
31-Jul-05	2005-07-38-1	19-Jul-05	38	Sawyers S Ck Ash Dam		4.00	218,200	0	24	7.400	1200	1760	340	84	140	18	0.025	0.005	0.09	5.9	0.007	0.01		0.02	0.69	0.00005	1.4	0.005	0.06	0.33
31-Jul-05	2005-07-39-1	19-Jul-05	39	Dump Ck		4.30	55,400	0	21	0.800	220	300	56	14	17	18	0.025	0.005	0.02	0.95	0.001	0.005		0.005	0.83	0.00005	1.7	0.005	0.003	0.33
31-Jul-05	2005-07-40-1	19-Jul-05	40	Sawyers Ck WX5		5.10	91,900	5	18	3.200	490	620	71	50	52	25	0.025	0.005	0.08	1.6	0.001	0.005		0.005	4	0.00005	3.4	0.005	0.003	0.13
31-Jul-05	2005-07-41-1	19-Jul-05	41	Sawyers Ck WX7		6.30	101,600	12	28	0.800	460	650	110	24	52	34	0.025	0.005	0.03	2	0.001	0.005		0.005	0.12	0.00005	0.87	0.005	0.003	0.17

38 Sawyers S Ck Ash Dam
39 Dump Ck
40 Sawyers Ck WX5
41 Sawyers Ck WX7

Wallerawang Environmental Waters; Surface Water

Yearly Report

WW Env Surface Waters

		Date			Water Level	pH	Conductivity	MO Alk	Chloride	Fluoride	Sulphate	TDS	Sodium	Potassium	Calcium	Magnesium	Arsenic	Silver	Barium	Boron	Cadmium	Chrome	Chrome 6+	Copper	Iron	Mercury	Manganese	Lead	Selenium	Zinc
							Lab.	as CaCO3			Result	Result	Na	K	Ca	Mg	As	Ag	Ba	B	Cd	Cr	Cr 6+	Cu	Fe f	Hg	Mn f	Pb	Se	Zn
					metres		uS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
31-Oct-05	2005-10-38-1	26-Oct-05	38	Sawyers S Ck Ash Dam		4.10	231,700	0	26	7.100	1800	1760	330	85	130	17	0.025	0.005	0.09	6.3	0.007	0.01		0.04	0.34	0.00005	1.4	0.005	0.068	0.4
31-Oct-05	2005-10-39-1	26-Oct-05	39	Dump Ck		4.90	53,400	5	20	0.600	250	320	52	14	16	18	0.025	0.005	0.02	0.99	0.001	0.005		0.005	0.32	0.00005	1.6	0.005	0.003	0.23
31-Oct-05	2005-10-40-1	26-Oct-05	40	Sawyers Ck WX5		6.30	32,600	140	7	0.500	130	250	23	17	22	8.5	0.025	0.005	0.05	0.49	0.001	0.005		0.005	0.23	0.00005	0.67	0.005	0.003	0.07
31-Oct-05	2005-10-41-1	26-Oct-05	41	Sawyers Ck WX7		6.30	84,800	20	25	0.800	370	580	89	22	42	29	0.025	0.005	0.03	1.8	0.001	0.005		0.005	0.03	0.00005	0.68	0.005	0.003	0.18
31-Jan-06	2006-01-38-1	18-Jan-06	38	Sawyers S Ck Ash Dam		4.80	196,600	5	29	5.500	1100	1640	290	71	110	15	0.025	0.005	0.08	4.8	0.001	0.005		0.03	0.03	0.00005	1.2	0.005	0.053	0.31
31-Jan-06	2006-01-39-1	18-Jan-06	39	Dump Ck		5.90	40,700	5	19	0.300	150	310	42	13	13	12	0.025	0.005	0.02	0.63	0.001	0.005		0.005	0.06	0.00005	1	0.005	0.003	0.14
31-Jan-06	2006-01-40-1	18-Jan-06	40	Sawyers Ck WX5		6.50	20,700	30	6	0.300	57	180	13	9	15	4.2	0.025	0.005	0.04	0.24	0.001	0.005		0.005	0.12	0.00005	0.36	0.005	0.003	0.05
31-Jan-06	2006-01-41-1	18-Jan-06	41	Sawyers Ck WX7		6.60	61,400	30	18	0.700	250	440	62	14	29	17	0.025	0.005	0.02	1.1	0.001	0.005		0.005	0.04	0.00005	0.3	0.005	0.003	0.04
30-Apr-06	2006-04-38-1	28-Apr-06	38	Sawyers S Ck Ash Dam		No Data A																								
30-Apr-06	2006-04-39-1	28-Apr-06	39	Dump Ck		No Data A																								
30-Apr-06	2006-04-40-1	28-Apr-06	40	Sawyers Ck WX5		No Data A																								
30-Apr-06	2006-04-41-1	28-Apr-06	41	Sawyers Ck WX7		No Data A																								