Centennial Coal

Angus Place Colliery and Springvale Mine

Angus Place and Springvale Mine Extension Projects

State Significant Developments SSD 5602 & SSD 5594

Response to Response to Submissions

December 2014

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Angus Place and Springvale Mine Extension Projects

Response to Response to Submissions Report

Prepared By:

Centennial Coal Limited

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Prepared By	Reviewed By	Version	Date	Distributed to	When
Iain Hornshaw	Peter Corbett	Final	19/12/2014	DP&E	19/12/2014

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1.0 INTRODUCTION

Angus Place Colliery

Angus Place Colliery is an existing underground coal mine producing high quality thermal coal for domestic markets. It is located 15 kilometres to the northwest of the regional city of Lithgow and 120 kilometres west northwest of Sydney in New South Wales.

The mine's current approval (PA06_0021) was granted in September 2006 under Part 3A of the Environmental Planning and Assessment Act 1979. PA06_0021 and its subsequent modifications remain current and authorises the extraction of up to 4 million tons of run of mine (ROM) coal per annum. The development consent will expire in August 2024. A new Development Consent is required to extract coal in an area to the north-east of the current mine workings.

An Environmental Impact Statement (EIS) was submitted to the Department of Planning and Environment in April 2014 for the Angus Place Mine Extension Project. The exhibition period for the EIS commenced on 12 April 2014 and ended on 26 May 2014. A Response to Submissions (RTS) report was lodged with the Department of Planning and Environment on 1 October 2014.

The Applicant for the Project is Centennial Angus Place Pty Limited (Centennial Angus Place). Angus Place Colliery is owned by Centennial Springvale Pty Limited (as to 50%) and Springvale SK Kores Pty Limited (as to 50%) as participants in the Angus Place/Springvale unincorporated joint venture. Angus Place Colliery is operated by Centennial Angus Place, for and on behalf of, the joint venture participants.

Springvale Mine

Springvale Mine is an existing underground coal mine producing high quality thermal coal for both domestic and international markets. It is located 10 kilometres to the northwest of the regional city of Lithgow and 120 kilometres west-northwest of Sydney in New South Wales.

Underground coal mining commenced at Springvale Mine in 1995 following the granting of Springvale's development consent (DA 11/92) on 27 July 1992, pursuant to Section 101 under Part 4 of the Environmental Planning and Assessment Act 1979. DA 11/92 and its subsequent modifications remain current and authorises the extraction of up to 4.5 million tons of ROM coal per annum at Springvale Mine. The current development consent will expire on 28 September 2015. Development consent is required to ensure Springvale Mine continues to operate beyond this date.

An EIS was submitted to the Department of Planning and Environment in April 2014 for the Springvale Mine Extension Project. The exhibition period for the EIS commenced on 12 April 2014 and ended on 26 May 2014. A RTS report was lodged with the Department of Planning and Environment on 1 October 2014.

The Applicant for the Project is Springvale Coal Pty Limited (Springvale Coal). Springvale Mine is owned by Centennial Springvale Pty Limited (as to 50%) and Springvale SK Kores Pty Limited (as to 50%) as participants in the Springvale unincorporated joint venture. Springvale Mine is operated by Springvale Coal, for and on behalf of, the Springvale joint venture participants.

1.1 Scope

This report considers the matters raised in submissions received by the Department of Planning and Environment following the distribution of the RTS report to various government agencies. This report builds on information presented in the EIS and RTS reports and is to be read in conjunction with those documents.

While there has been no change to either Project from that presented in the EISs and subsequent RTS reports, additional assessment work has been completed and specialist feedback sought to support the Projects. This information is included in this Response to RTS report and is summarised below:

- An update to the Ecotoxicology Assessment on the Coxs River regarding mine water discharge has been completed. The report now includes a second set of sampling results obtained upstream of Springvale Mine's Licenced Discharge Point (LDP) 009 (**Appendix 1**).

- Letter report from GHD Pty Limited containing responses to matters raised by the NSW Environment Protection Authority (EPA) that are not addressed in the Ecotoxicology Assessment (**Appendix 2**);

- Letter report from Jacob's Group (Australia) Pty Limited outlining a technical response to matters raised by the Sydney Catchment Authority (SCA) and the EPA (**Appendix 3**);

2.0 SUBMISSIONS

Following the distribution of the RTS to various government agencies, nine submissions were received in relation to the Angus Place Mine Extension Project and eight submissions were received in relation to the Springvale Mine Extension Project.

Of the nine submissions received in relation to Angus Place:

- Five agencies raised concerns or proposed recommendations/additional consultation for the Angus Place Mine Extension Project.
- Four agencies had no further issues regarding the Angus Place Mine Extension Project.

Of the eight submissions received in relation to Springvale:

- Five agencies raised concerns or proposed recommendations/additional consultation for the Springvale Mine Extension Project.
- Three agencies had no further issues regarding the Springvale Mine Extension Project.

2.1 Summary of Submissions

A summary of the issues raised by the government agencies is provided in **Table 1**. Detailed responses to each of the issues raised are provided in **Section 3.0**.

Table 1 - Summary of Government Agency Submissions

Raised By	Summary of Issue
NSW Health	Nepean Blue Mountains Local Health District Public Health have reviewed the Response to Submissions and have reported that the responses adequately addresses the issues raised by Nepean Blue Mountains Local Health District.
Resources and Energy	The Division of Resources and Energy (DRE) has reviewed the report and is satisfied that the document address a majority of issues identified in the EIS. The inclusion of conditions as recommend in our letter of 6 June 2014 (reference: OUT14/15844) into any development approval, satisfies all issues which were identified by DRE in the review of the EIS. It should be noted that the Mining Operations Plan will be the equivalent of a Rehabilitation Plan. They are not separate documents as indicted in the RTS.
	DRE invites Centennial Angus Place Pty Ltd to contact Will Mitry, Inspector Environment to discuss proposed control sites for the swamps as well as proposed surface water monitoring associated with the Temperate Highland Peat Swamps on Sandstone (THPSS) Monitoring and Management Plan. This will assist in providing clarity in the completion of the management plan.

Department of Primary Industries – Crown Lands	Crown Lands has reviewed the Responses to Submissions (RTS) for the above projects and advises that the RTS adequately addresses the landowners consent requirements that were raised during exhibitions of the EIS.
Heritage Council of NSW	As Delegate of the Heritage Council the above comments by the Proponent are acknowledged.
Lithgow City Council	I refer to the above mentioned project and Angus Place Mine's response to Lithgow City Council's submission dated 16 May 2014 for the development. Council considers that the response to Council's submission adequately addresses the issues raised.
	Council considers that the response to Council's submission adequately addresses the issues raised. However; there was no mention of the following issue: The applicant is to submit a Section 68 Application under the Local Government Act 1993 to Lithgow City Council for the connection to Council's services along with the following documentation: how the development would be connected to Council's services; details in regards to the peak volumes of sewage to be discharged to the Duncan Street pump station. This pump station is currently at capacity and would need an upgrade for any additional loads potentially, so would the Maddocks Lane pump station.
Transport – Roads and Maritime Services	The *Traffic Impact Assessment* submitted in support of the proposed development recommended that the intersection of the mine access road and the Castlereagh Highway (HW18) be upgraded to include a Channelised Right (CHR) turn treatment. The proposed mine extension is the factor that creates the potential for conflict between turning traffic and through traffic at the subject intersection location. Without the mine traffic, the identified road safety risk and impacts on traffic amenity would not arise as a result of the background traffic growth. The recommended conditions of consent provided in Roads and Maritime's submission dated 30 May 2014 are appropriate and should be included as conditions in any consent issued in relation to this project.
	Roads and Maritime accepts the applicant's response and looks forward to contributing to the Construction Traffic Management Plan.
NSW Office of Water	Acknowledgement of the current inability to obtain sufficient entitlement to account for the predicted groundwater take for the Angus Place mine extension and the predicted surface water take for both the Angus Place and Springvale mine extensions.
	The proponent to commit to discussions with NSW Office of Water with regard to the ability to account for the predicted surface water take and groundwater take due to the Springvale and Angus Place mine extension projects.

	A highly adaptive process for monitoring and responding to any evidence of subsidence in the upper aquifers is warranted in view of the continuing risks to sensitive ecological receptors, particularly THPSS. It is recommended this approach be followed rigorously and supplemented with clearly defined and measurable trigger levels for surface water, groundwater and subsidence related impacts. This needs to be supported by clear reporting and management approaches to minimise the potential for unacceptable impacts and the need to consider remediation.
Sydney Catchment Authority	The SCA disagrees with these statements and has significant concerns in relation to the predicted increases in salinity in Lake Burragorang, Coxs River, Kangaroo Creek and Sawyers Creek. Based on predicted increases in salinity, the SCA has assessed that both extension projects do not achieve a neutral or beneficial effect on water quality. The· SCA therefore recommends both applications be refused unless there is a requirement placed upon the applicant to treat mine water discharges to a higher and appropriate level prior to discharge.
	…the Report refers to Tables 4-1 and 4-2 of Annual Water Quality Monitoring Report (SCA 2012-13) for 'health-related', water quality parameters for raw water and site-specific standards specified in raw water supply agreements and states there is no target for salinity. The SCA considers that these two tables are irrelevant for catchment streams and the appropriate water quality objectives for the SCA's storages and catchment waterways are set out in Table 4.3 and 4.4 (SCA 2012-13) which are derived from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 guideline (ANZECC 2000). Unfortunately these tables also do not specify target for salinity…
	The SCA's assessment of the regional water quality and quantity model has identified the following significant deficiencies, as it lacks scientific rigour and has insufficient details to assess the impacts on the receiving water and Lake Burragorang.
	The model lacks goodness-of-fit statistics, has a limited sensitivity analysis, uses unclear inputs to the model setup for the prediction model and its limits, and uses an unconventional presentation of results…
	…the impact of increased low flows has not been assessed, including the increased inundation of aquatic ecosystems that require wetting and drying…
	…the erosion potential of theses flows resulting in increased turbidity and significant impacts on the water quality of the system.
	…no evidence is presented in regards to the assumed input concentrations from various land uses and the assumed 50mg/L concentrations for flows of 0ML/d.
	…there is no evidence to suggest that the use of land-use event mean concentrations for TDS are suitable for modelling salinity in a catchment. More accurate scientific methods related to groundwater and soil modelling or curves fitted to discharges, as demonstrated through the Murray-Darling Basin Modelling, needs to be used.

	…the high salinity levels from LDP001 and LDP009 discharging into Kangaroo Creek and Sawyers Swamp Creek cannot be diluted to below the Site Specific Trigger Value 95% of the time which can deteriorate the health of the aquatic ecosystems in Kangaroo Creek and Sawyers Swamp Creek.
	…loss of aquatic ecosystems upstream of Coxs River can have long-term effects in the ability of the system to assimilate and dilute catchment inputs…
	The SCA recommends that appropriate modelling guidelines and water quality standards be used to compare the impacts.
	…the water quality in Kangaroo Creek and Sawyers Swamp Creek will deteriorate significantly above the guideline limit and the background concentrations for the majority of flow events.
	The SCA recommends that the DTA shall also be shall also be undertaken for Sawyers Swamp Creek and shall address the localised impacts of minewater discharge to the aquatic ecosystem. Long-term exposure of the creeks to high levels of salinity can potentially result in a significantly degraded eco-system in the creeks, which can subsequently impact the water quality in Coxs River and Lake Burragorang.
	The SCA considers the dilution factor analysis is based on predicted median flows for Sawyers Creek (because there is no flow monitoring on Sawyers Creek), monitored median flows in Kangaroo Creek and median discharge volume for both creeks. The SCA recommends that the dilution factor analysis should consider a range of creek flow volumes and discharge volumes including minimum, median and maximum. The analysis should also consider the statistical distributions of the flow volumes and pollution before, at and after the mixing zone.
	Long term impact on ecosystems to deteriorate the health of the aquatic ecosystems in Kangaroo Creek and Sawyers Swamp Creek. A holistic assessment of the long-term water quality effects on the eco-systems and their response should be considered.
NSW Environment Protection Authority	In its responses the proponent's Coxs River Catchment Restoration Program outlines a variety of measures to improve the catchment riparian zone and landscape; however, none relate to a stated goal of improving water quality.
	The EPA recommends, now that Angus Place has been mothballed indefinitely, that the proponent considers implementing a previously proposed option of storing mine water within the old Angus Place workings, but this time with Springvale mine water (thus eliminating the need to discharge the full volume of mine water).

	It is noted that these general conclusions do not appropriately address the areas directly affected by the LDP discharges. One of the simplest comparisons that can be made to verify the statements and conclusions in the RTS is the concordance between model predictions (suggested to have been appropriately calibrated) and the observed flows and quality at the two NOW gauges in the Upper Coxs River catchment (212054 Coxs River upstream Wallerawang and 212055 Neubecks Ck). If this is done, it is clear that the model under-predicts median flow at the NOW gauge 212054 (Node #047 in AWBM model; RPS 2014) and considerably over-predicts conductivity at the NOW gauge 212054 when compared to the observed measurements by NOW (See Table 1). Median flows at 212054 are underestimated by approximately 22% and median conductivities are overestimated by approximately 45%. There is no discussion in the RTS reports of these major discrepancies between prediction and reality.
	There is also no appropriate discussion of the fact that current and historic flows and conductivity levels at gauge 212054 are partially composed of upstream discharge waters…
	It appears that actual daily flows from LDP009, LDP001 and others may not have been utilised in the modelling.
	As identified in earlier comments, extremely limited information was available for the actual LDP009 discharge in both the EIS and RTS. It is clearly the responsibility of the proponent to provide the information upon which major Government decisions need to be made.
	A plot of flows at the NOW 212054 gauge actually identifies a significant increase in flows in the most recent times, potentially as a result of the LDP009 discharge (Figure 1). This has not been acknowledged in the Surface Water Impact Assessment.
	A plot of Conductivity levels at the same Gauge also demonstrates a significantly increasing trend in Conductivity levels (ie an increasing salinization) of Upper Coxs River waters (Figure 2).
	Instead of moving to arrest the decline in water quality (as indicated by conductivity) in this area, the EIS and RTS both advocate increasing this further by increasing the LDP009 discharge to up to 30 to 50ML/day of poorly treated highly saline mine water. This approach to the disposal of unwanted, poorly treated and (for LDP009) toxic mine water is not supported.
	It is also recommended in the EIS that the Angus Place LDP001 discharge is increased from 2 ML/day to 30 ML/day.
	Unclear assumptions, particularly where the coefficients have been assigned a value (and the justification of these values) or whether the coefficients were calculated from the data…no sensitivity analysis allowing for variation in coefficients and their effect on model predictions.
	…RPS (2014) states: “Evaporation in the model was based on average daily evaporation for each month at BOM Station No. 061089 (Scone SCS.”. This is different to the original EIS surface water assessment where evaporation was stated to come from: “Daily Pan A evaporation has been recorded at the Bathurst Agricultural Station (BOM Station No. 63005) from 1966 to current”. It is unclear why the evaporation stations have been changed in the latest iteration of the model and what effect this has had on the model and its predictions…

	The RPS (2014) report still talks about Daily demand at Wallerawang Power Station when it is currently 'mothballed'.
	The Angus Place EIS highlighted that the water balance model was calibrated to discharge in July 2013, which included a period where mine water make was being temporarily held underground (March to July 2013). Discharge at LDP001 has now resumed at a rate of 2ML/d. It is unclear whether the latest 'calibration' has used this information in daily flow calculations and whether the actual flows from LDP009, LDP001 and other discharges have been appropriately used in the modelling.
	The Angus Place EIS Water quality modelling indicates that historical discharge at Angus Place LDP001 accounts for observed increase in salinity in Kangaroo Creek and the Upper Coxs River above Blue Lagoon. As pointed out in comments on the original EIS, the Angus Place LDP001 discharge actually represents the first major impact of mine discharges on the Upper Coxs River…
	Two uncertainty analysis conditions were presented in the RTS (Low Rainfall Condition and High Rainfall Condition), but there has been no assessment of model uncertainty or parameter (ie coefficient) uncertainty.
	Description and presentation of calibration results (eg fitted versus actual) is considered poor. As identified earlier the model under-predicts median flow at the NOW gauge 212054…
	There appears to be no presentation of validation results of the model based on more recent flows (and conductivities) measured at the NSW gauging stations.
	The modelling results and conclusions in RPS (2014) should not be relied upon until the significant issues are addressed. In general, there is a lack of appropriate upstream-downstream comparisons for each LDP discharge in the Upper Coxs River catchment. Little allowance appears to be made for the fact that a proportion of the flows measured in various parts of the Upper Coxs River are actually sourced from upstream LDPs. As a result of this confounding of LDP discharges, flows and water quality in the model and assessment, an inadequate assessment of the true impact of the LDP discharges is achieved (particularly that of LDP009).
	Cardno Ecology Lab Pty Ltd (2010) used species sensitivity distribution (SSD) curves for single-species toxicity information to develop protective concentration (PC) values that protect a large proportion of the aquatic species present in the receiving waters.
	GHD have also not cited or reviewed the extensive literature on salinity impacts on aquatic ecosystems.

	The ANZECC Guidelines recommend that guideline trigger values for slightly-moderately disturbed systems also be applied to highly disturbed ecosystems wherever possible. 1) Where reference sites of high quality are available, lower levels of protection may be negotiated for the site under consideration but this should not result in water of less quality than that already prevailing. 2) Where no high quality reference sites are available, modified water bodies of the best environmental quality in the region serve as reference targets (or intermediate targets for ecosystem recovery). …For some assessments (particularly LDP009) an appropriate reference site has not been chosen for comparison and therefore inappropriate "adopted" trigger values have been used.
	…They do not adequately consider the ionic composition of LDP discharge waters which are very different to the ionic composition of local (reference site) waters.
	…At each point when adopting trigger values the assessment has chosen the highest value of either the ANZECC default guideline levels or local water quality trigger values (based on 80%ile values at a reference site) – this is an inconsistent and inappropriate application of ANZECC Guideline trigger value derivation methods.
	…The assessments do not allow for confounding of LDP sources (ie trigger values calculated for LDP009 ignore upstream influence of LDP001 and other discharges).
	…Both the LDP001 and LDP009 discharges (and adopted trigger values) clearly result in water of lesser quality than that already prevailing.
	…The assessments do not appropriately address the increasing salinization of Upper Coxs River waters (see Figure 2 above) which is likely to be a direct result of the increasing concentration and load of salt from LDP discharges.
	…The assessments advocate no treatment of the highly saline and (for LDP009) toxic discharges which will likely cause further deterioration in water quality and result in adverse ecosystem health effects.
	…The assessments have not undertaken an adequate review of the literature on the effects of salinity and ionic constituents on aquatic ecosystems.
	Based on the reported absence of chronic toxicity in the cladoceran for the sample from Lake Wallace (and further downstream) it would appear that amelioration of the LDP009 discharge occurred at the time of sampling (albeit following significant rainfall events).
	The unusual ionic composition of LDP009 discharge may be a significant contributor to the observed toxic effects. Preliminary re-evaluation of data detailed in Figure 3.3 of the report, showed that normalisation of bicarbonate alkalinity to Ca+Mg+K concentration resulted in the R2 value improving from 0.0099 (Fig 3.3 in report) to R2=0.601.

	A modified Toxicity Identification and Evaluation (TIE) process investigating modifications to the ionic composition of LDP009 on acute Cladoceran toxicity at 100% would be feasible.
	(In)Table 2.3 ammonia and NOx (are) not considered as nutrient pollutants It is noted that the LDP009 discharge has ammonia at 0.44 mg/L (33x the ANZECC/ARMCANZ 2000 nutrient trigger value – see Attachment 2), Mixing zones are not appropriate for the nutrients (Attachment 1)
	Given the large discharge volumes of LDP009 relative to natural flows and the apparent extensive algal growth reported in sections of the Coxs River downstream of the LDP009 and LDP001 discharges, this would seem to be an issue requiring resolution.
	…specifically cautioned against allowing existing freshwater systems that are well below the salinity of 1000 mg/L to be increased up to this level. New information is now available and this is reflected in the ANZECC (2000) guideline trigger values. Note that the Krogh and Miller report on Coxs River Catchment – Water Quality and Macroinvertebrate Communities, referred to in the EPA submission to the EISs, also provides further information on salinity impacts.
	…The RPS reports do not properly account for the overriding principle in the ANZECC (2000) guidelines that should guide management, which is continual improvement (see Section 2.2.1.7). For example, in waters that are of better quality than that set by the water quality objectives, some emphasis should be could still be given to reducing the level of contamination from all sources. Wherever possible, ambient water quality should not be allowed to degrade to the levels prescribed by the water quality objectives. It is also not acceptable to allow poor environmental performance or water pollution, simply because a waterway is degraded. The NWQMS also notes that accepted modern technology, consistent with ongoing economic viability, should be maintained even where this will secure higher water quality outcomes than what the water quality objectives require.
	…The EPA's policy is that the water quality objectives /ANZECC trigger values should be met at the edge of the area where initial (near-field) mixing occurs. Options to meet this policy aim are considered and weighed against the matters to be considered in licensing decisions as set out under Section 45 of the Protection of the Environment Operations Act 1997. The matters that need to be taken into account include the impact of the measures that can be taken to mitigate the impacts of the pollution and maintain or restore the environmental values of the waterway. While the EPA's licensing approach is to consider the effect of a discharge at the edge of a defined initial "near-field" mixing zone, if the discharge volume from the licenced discharge point would dominate flows in system under most conditions then the dilution effects within a near field mixing zone may be relatively minimal. EPA would therefore examine the pollutant concentrations at the point of discharge relative to ANZECC trigger values.
	…Effective discharge controls that consider the level of waste treatment, the concentration and the total mass of pollutants, and the in situ dilution, should ensure that the area of a mixing zone is small and the designated values and uses of the water body as a whole are not prejudiced.

	…Appendix 3 (for both projects) states that "Where dilution is insufficient, the mixing zone criteria are not met in that the mixing zones extend from bank to bank. In this circumstance ANZECC recommends performing a "biological effects assessment" (e.g. Direct Toxicity Assessment)." This is an incorrect interpretation of the ANZECC guidelines.
	…Overall, the dilution assessment in Appendix 3 for both projects does not adequately consider the above guidance and EPA policy on mixing zones. These inadequacies include that: • available initial near-field mixing is not defined in order for EPA to incorporate an appropriate dilution factor into licensing limits • and the extent and configuration of the mixing zone does not allow ANZECC trigger values to be achieved at any near field mixing zone.
	…Taking into account the very low median salinity at the upstream Kangaroo Creek site and low median conductivity levels in the upper parts of the Coxs River catchment (50 - 200µS/cm); the lack of appropriate information on near-field mixing; and the principle of not polluting up to environmental limits, then a value of 350µS/cm (ANZECC 20000 default trigger value), applied at the point of discharge may be an appropriate value to guide management options for slightly to moderately disturbed ecosystems at this stage.
	The RPS report has selectively adopted a site-specific trigger value when it less stringent than the ANZECC default trigger value and has adopted the ANZECC default trigger when the site-specific trigger value is more stringent. This is an unacceptable approach If appropriate data is available to derive site-specific trigger values (as set out in the ANZECC guidelines) and an agreed suitable reference site is available (consistent with the ANZECC guidance on reference sites), then site-specific trigger values are preferred over the default trigger values for physical and chemical stressors such as salinity. Toxicants are usually compared with a single default trigger value, less commonly with a background or reference distribution as the default values are prepared by analysis of a comprehensive set of available ecotoxicological data.
	…The ANZECC guidelines advise that a minimum of two years of contiguous monthly data at a reference site is required before a valid trigger value can be established.
	…The Kangaroo Creek upstream may be an acceptable reference site for the assessment of site specific trigger values, in particular, salinity values appear consistent with values recorded at other upstream sites in the catchment, however, WTAU cannot determine its suitability as a reference site without further information, for example, the metals data are highly elevated compared to the default trigger value and the mix of ions making up salinity may be different.

	Discharge from Sawyer Creek to Coxs River (Springvale) • An inappropriate reference site appears to have been used in the derivation of site specific trigger values for the Discharge from Sawyers Creek to Coxs River. • The derivation of a trigger value of 1539 µS/cm is not consistent with the ANZECC guidelines methodology for defining site specific trigger values and the reference site does not appear consistent with the Section 3.1.4 "Defining a reference condition" in the ANZECC guideline. • Median conductivity levels in the upper parts of the Coxs River catchment are often in the 50 – 200 µS/cm range, indicating that 1539 µS/cm is a significant departure from a suitable reference site and reflects impacts in the catchment. • The reference sites should be selected based on the best available sites representative of the level of protection for the part of the river in question, in this case slightly to moderately disturbed conditions. An appropriate reference site therefore should be at least slightly disturbed. Selection of reference sites and application of trigger values should not result in water of lesser quality than that already prevailing.
	The GHD report (Appendix 9) states that the conductivity of the upstream Kangaroo Creek site was measured at 820 µS/cm. This is not consistent with data presented in Appendix 3 which indicated median EC of 69 µS/cm and the site specific trigger value was calculated to be 89 µS/cm.
	4A Springvale Colliery, Environment Protection Licence No. 3607 and Salinity…The EPA's current position is a continuation of a regulatory effort to reduce the salinity concentrations of the upper Coxs River. The EPA considers the current limits on LDP9 to be interim until a change in management of the mine water (handling, treatment etc) is implemented.
	4C Closure and Mothballing of Angus Place Colliery – Environment Protection Licence (EPL467)…it is apparent to the EPA that Centennial could now again consider this option, including repairing the collapse bore and then direct mine water from Springvale into the mothballed Angus Place workings. There may be scope for a hybrid option of the partial discharge after treatment to reduce salinity of Springvale mine water, with the remaining portion directed into the old Angus Place workings for storage until mining at Springvale ends in 2023 at which time the mine water could be transferred back to Springvale for treatment upon the recommencement of mining at Angus Place.

3.0 RESPONSE TO RTS REPORT

3.1 NSW Health

Nepean Blue Mountains Local Health District Public Health have reviewed the Response to Submissions and have reported that the responses adequately addresses the issues raised by Nepean Blue Mountains Local Health District.

Noted.

3.2 Division of Resources and Energy

DRE has reviewed the report and is satisfied that the document address a majority of issues identified in the EIS. The inclusion of conditions as recommend in our letter of 6 June 2014 (reference: OUT14/15844) into any development approval, satisfies all issues which were identified by ORE in the review of the EIS. It should be noted that the Mining Operations Plan will be the equivalent of a Rehabilitation Plan. They are not separate documents as indicted in the RTS.

Noted.

DRE invites Centennial Angus Place Pty Ltd to contact Will Mitry, Inspector Environment to discuss proposed control sites for the swamps as well as proposed surface water monitoring associated with the THPSS Monitoring and Management Plan. This will assist in providing clarity in the completion of the management plan.

Centennial Angus Place commits to ongoing dialog with DRE regarding the proposed control sites for swamps and surface water monitoring associated with the THPSS Monitoring and Management Plan.

3.3 Department of Primary Industries – Crown Lands

Crown Lands has reviewed the Responses to Submissions (RTS) for the above projects and advises that the RTS adequately addresses the landowners consent requirements that were raised during exhibitions of the EIS.

Noted.

3.4 Heritage Council of NSW

The Heritage Council has previously provided comment on the Angus Place Mine Extension Project, but not for the Springvale Mine Extension Project. Therefore, the following comments will relate solely to the Angus Place Mine Extension Project (SSD 5602) only. As Delegate of the Heritage Council the above comments by the Proponent are acknowledged.

Noted.

3.5 Lithgow City Council (LCC)

I refer to the above mentioned project and Angus Place Mine's response to Lithgow City Council's submission dated 16 May 2014 for the development. Council considers that the response to Council's submission adequately addresses the issues raised.

Noted

Council considers that the response to Council's submission adequately addresses the issues raised. However; there was no mention of the following issue:

Section 68 Application

The applicant is to submit a Section 68 Application under the Local Government Act 1993 to Lithgow City Council for the connection to Council's services along with the following documentation: how the development would be connected to Council's services; details in regards to the peak volumes of sewage to be discharged to the Duncan Street pump station. This pump station is currently at capacity and would need an upgrade for any additional loads potentially, so would the Maddocks Lane pump station.

Consultation with Lithgow City Council has been ongoing throughout 2014 to discuss the proposed sewage upgrade involving the connection of Springvale Mine to Council's services. Whilst it is recognised that works were to be completed by 5 December 2014, an extension request was lodged with the NSW Department of Planning and Environment for the works to be completed by 5 May 2015. This has since been granted by the NSW Department of Planning and Environment in correspondence dated 9 December 2014.

A Section 68 Application for the connection to Council's services along with the following documentation: how the development would be connected to Council's services; details in regards to the peak volumes of sewage to be discharged to the Duncan Street pump station will be submitted to Council.

3.6 Transport – Roads and Maritime Services

The *Traffic Impact Assessment* submitted in support of the proposed development recommended that the intersection of the mine access road and the Castlereagh Highway (HW18) be upgraded to include a Channelised Right (CHR) turn treatment. The proposed mine extension is the factor that creates the potential for conflict between turning traffic and through traffic at the subject intersection location. Without the mine traffic, the identified road safety risk and impacts on traffic amenity would not arise as a result of the background traffic growth. The recommended conditions of consent provided in Roads and Maritime's submission dated 30 May 2014 are appropriate and should be included as conditions in any consent issued in relation to this project.

Centennial Springvale has obtained an intersection design drawing from a suitably qualified traffic specialist. The drawing illustrates the proposed intersection design upgrade as a basis for ongoing discussions between Centennial Springvale and Roads and Maritime Services. On this basis Centennial Springvale commits to ongoing consultation with Roads and Maritime Services to further develop the proposed upgrade.

Roads and Maritime accepts the applicant's response and looks forward to contributing to the Construction Traffic Management Plan.

Centennial Angus Place and Centennial Springvale will develop the Construction Traffic Management Plan in consultation with Lithgow City Council, Forestry Corporation of NSW and Roads and Maritime Services.

3.7 NSW Office of Water

Acknowledgement of the current inability to obtain sufficient entitlement to account for the predicted groundwater take for the Angus Place mine extension and the predicted surface water take for both the Angus Place and Springvale mine extensions.

Centennial Coal commits to ongoing consultation regarding groundwater and surface water licensing arrangements with the NSW Office of Water.

The proponent to commit to discussions with NSW Office of Water with regard to the ability to account for the predicted surface water take and groundwater take due to the Springvale and Angus Place mine extension projects.

Centennial Coal commits to ongoing discussions with NSW Office of Water regarding predicted surface water and groundwater take.

A highly adaptive process for monitoring and responding to any evidence of subsidence in the upper aquifers is warranted in view of the continuing risks to sensitive ecological receptors, particularly THPSS. It is recommended this approach be followed rigorously and supplemented with clearly defined and measurable trigger levels for surface water, groundwater and subsidence related impacts. This needs to be supported by clear reporting and management approaches to minimise the potential for unacceptable impacts and the need to consider remediation.

Chapter 11 of the EIS lists the Statement of Commitments of the Project and details the management plans that will be developed or updated for the Project following the granting of Development Consent. Centennial Angus Place and Centennial Springvale will commit to developing Trigger Action Response Plans as part of the development of these management plans which will detail the response to be taken if mining induced impacts occur. This was included in the revised Statement of Commitments contained in Section 5.0 of the RTS report.

Specifically, as detailed in the Statement of Commitments contained within Section 11.0 of the EIS, Centennial Angus Place and Centennial Springvale will develop a Water Management Plan for the Project within six (6) months of development consent in consultation with the NOW. This was included in the revised Statement of Commitments contained in Section 5.0 of the RTS report.

The Water Management Plan will include a review of the existing monitoring bore data with a commitment to installing real time data loggers in key monitoring bores to enable continuous monitoring

of groundwater levels in response to rainfall events. Additionally, the Water Management Plan will identify critical impact thresholds in groundwater levels, groundwater quality, surface water flows and surface water quality. This will enable an adaptive response and management framework in addition to a mechanism for identifying and reporting variations from predictions, potential geological and hydrological impacts in upstream tributaries that feed into the peat swamps and in areas laterally adjacent to peat swamps, potential downstream geological and hydrological impacts and potential lateral geological and hydrological impacts.

3.8 Sydney Catchment Authority

The SCA disagrees with these statements and has significant concerns in relation to the predicted increases in salinity in Lake Burragorang, Coxs River, Kangaroo Creek and Sawyers Creek. Based on predicted increases in salinity, the SCA has assessed that both extension projects do not achieve a NorBE on water quality. The· SCA therefore recommends both applications be refused unless there is a requirement placed upon the applicant to treat mine water discharges to a higher and appropriate level prior to discharge.

Refer to Section 2.2 of Appendix 3.

…the Report refers to Tables 4-1 and 4-2 of Annual Water Quality Monitoring Report (SCA 2012-13) for 'health-related', water quality parameters for raw water and site-specific standards specified in raw water supply agreements and states there is no target for salinity. The SCA considers that these two tables are irrelevant for catchment streams and the appropriate water quality objectives for the SCA's storages and catchment waterways are set out in Table 4.3 and 4.4 (SCA 2012-13) which are derived from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 guideline (ANZECC 2000). Unfortunately these tables also do not specify target for salinity…

Refer to Section 2.2 of Appendix 3.

The SCA's assessment of the regional water quality and quantity model has identified the following significant deficiencies, as it lacks scientific rigour and has insufficient details to assess the impacts on the receiving water and Lake Burragorang.

Refer to Section 2.2 of Appendix 3.

The model lacks goodness-of-fit statistics, has a limited sensitivity analysis, uses unclear inputs to the model setup for the prediction model and its limits, and uses an unconventional presentation of results…

Refer to Section 2.2 of Appendix 3.

…the impact of increased low flows has not been assessed, including the increased inundation of aquatic ecosystems that require wetting and drying…

Refer to Section 2.2 of Appendix 3.

…the erosion potential of theses flows resulting in increased turbidity and significant impacts on the water quality of the system.

Refer to Section 2.2 of Appendix 3.

…no evidence is presented in regards to the assumed input concentrations from various land uses and the assumed 50mg/L concentrations for flows of 0ML/d.

Refer to Section 2.2 of Appendix 3.

…there is no evidence to suggest that the use of land-use event mean concentrations for TDS are suitable for modelling salinity in a catchment. More accurate scientific methods related to groundwater and soil modelling or curves fitted to discharges, as demonstrated through the Murray-Darling Basin Modelling, needs to be used.

Refer to Section 2.2 of Appendix 3.

…the high salinity levels from LDP001 and LDP009 discharging into Kangaroo Creek and Sawyers Swamp Creek cannot be diluted to below the Site Specific Trigger Value 95% of the time which can deteriorate the health of the aquatic ecosystems in Kangaroo Creek and Sawyers Swamp Creek.

Refer to Section 2.2 of Appendix 3.

…loss of aquatic ecosystems upstream of Coxs River can have long-term effects in the ability of the system to assimilate and dilute catchment inputs…

Refer to Section 2.2 of Appendix 3.

The SCA recommends that appropriate modelling guidelines and water quality standards be used to compare the impacts.

Refer to Section 2.2 of Appendix 3.

…the water quality in Kangaroo Creek and Sawyers Swamp Creek will deteriorate significantly above the guideline limit and the background concentrations for the majority of flow events.

Refer to Section 2.2 of Appendix 3.

The SCA recommends that the DTA shall also be shall also be undertaken for Sawyers Swamp Creek and shall address the localised impacts of minewater discharge to the aquatic ecosystem. Long-term exposure of the creeks to high levels of salinity can potentially result in a

significantly degraded eco-system in the creeks, which can subsequently impact the water quality in Coxs River and Lake Burragorang.

Refer to Section 2.2 of Appendix 3.

The SCA considers the dilution factor analysis is based on predicted median flows for Sawyers Creek (because there is no flow monitoring on Sawyers Creek), monitored median flows in Kangaroo Creek and median discharge volume for both creeks. The SCA recommends that the dilution factor analysis should consider a range of creek flow volumes and discharge volumes including minimum, median and maximum. The analysis should also consider the statistical distributions of the flow volumes and pollution before, at and after the mixing zone.

Refer to Section 2.2 of Appendix 3.

Long term impact on ecosystems to deteriorate the health of the aquatic ecosystems in Kangaroo Creek and Sawyers Swamp Creek. A holistic assessment of the long-term water quality effects on the eco-systems and their response should be considered.

Direct toxicity assessments of the relevant Angus Place Colliery and Springvale Mine water discharge locations have been undertaken. These assessments consider the impacts of Centennial's discharge on the receiving Coxs River catchment. Information on the additional ecotoxicology testing completed since the initial RTS report is included in Appendix 1.

3.9 Environment Protection Authority

In its Responses the proponent's Coxs River Catchment Restoration Program outlines a variety of measures to improve the catchment riparian zone and landscape; however, none relate to a stated goal of improving water quality.

Refer to Section 2.1 of Appendix 2.

The EPA recommends, now that Angus Place has been mothballed indefinitely, that the proponent considers implementing a previously proposed option of storing mine water within the old Angus Place workings, but this time with Springvale mine water (thus eliminating the need to discharge the full volume of mine water).

The status of Angus Place Colliery being in care and maintenance will not be indefinitely. Centennial Coal has made it clear that Angus Place Colliery will be potentially reopened at the completion of mining at Springvale Mine in 2025.

The total water make Angus Place Colliery is required to manage is approximately 160-180L/second or 13.8- 15.5ML/day.

Angus Place Colliery has two primary means of removing mine water from its underground workings:

- Mine water collection system which discharges into Kangaroo Creek (and ultimately Cox's River) via Angus Place LDP001; and
- Bore 940 which inputs water into the Water Transfer Scheme (WTS).

Angus Place Colliery is currently discharging an average of 1.6ML/day through LDP001 and 6.9ML/day through Bore 940 via the WTS. Hence, the total mine water currently being discharged from Angus Place Colliery is approximately 8.5ML/day.

In order to maintain compliance with the existing discharge limits under EPL467, Angus Place Colliery has modified the underground water management infrastructure to transfer water into previous mining areas. The estimated volume of water currently being stored underground is approximately 5-7ML/day. Based upon these estimates, it is predicted that there is approximately 14 months underground storage available.

For safety and serviceability reasons it is important to manage the water levels during the care and maintenance period in the active and future areas of the mine. The implications of overstoring water in these underground areas are:

- Loss of active roadways and future mining areas.
- Flooding in the active roadways may lead to strata stability issues for the future longwall tailgate.
- Emergency contingency to store water underground in the event of a dewatering borehole failure would be lost.

The cumulative mine water make at Angus Place and Springvale is approximately 25ML/day. This is five times as much as the current quantities being stored underground at Angus Place Colliery. If all mine water generated at Angus Place and Springvale was stored underground, the amount of time until the water reached critical levels would be less than three (3) months.

Thus underground storage at Angus Place Colliery does not represent a viable mine water management strategy for the Angus Place and Springvale Mine Extension Projects.

It is noted that these general conclusions do not appropriately address the areas directly affected by the LDP discharges. One of the simplest comparisons that can be made to verify the statements and conclusions in the RTS is the concordance between model predictions (suggested to have been appropriately calibrated) and the observed flows and quality at the two NOW gauges in the Upper Coxs River catchment (212054 Coxs River upstream Wallerawang and 212055 Neubecks Ck). If this is done, it is clear that the model under-predicts median flow at the NOW gauge 212054 (Node #047 in AWBM model; RPS 2014) and considerably over-predicts conductivity at the NOW gauge 212054 when compared to the observed measurements by NOW (See Table 1). Median flows at 212054 are underestimated by approximately 22% and median conductivities are overestimated by approximately 45%. There is no discussion in the RTS reports of these major discrepancies between prediction and reality.

Refer to Section 2.1.1 of Appendix 3.

There is also no appropriate discussion of the fact that current and historic flows and conductivity levels at gauge 212054 are partially composed of upstream discharge waters…

Refer to Section 2.1.1 of Appendix 3.

It appears that actual daily flows from LDP009, LDP001 and others may not have been utilised in the modelling.

Refer to Section 2.1.1 of Appendix 3.

As identified in earlier comments, extremely limited information was available for the actual LDP009 discharge in both the EIS and RTS. It is clearly the responsibility of the proponent to provide the information upon which major Government decisions need to be made.

Refer to Section 2.1.1 of Appendix 3.

A plot of flows at the NOW 212054 gauge actually identifies a significant increase in flows in the most recent times, potentially as a result of the LDP009 discharge (Figure 1). This has not been acknowledged in the Surface Water Impact Assessment.

Refer to Section 2.1.1 of Appendix 3.

A plot of Conductivity levels at the same Gauge also demonstrates a significantly increasing trend in Conductivity levels (ie an increasing salinization) of Upper Coxs River waters (Figure 2).

Refer to Section 2.1.1 of Appendix 3.

Instead of moving to arrest the decline in water quality (as indicated by conductivity) in this area, the EIS and RTS both advocate increasing this further by increasing the LDP009 discharge to up to 30 to 50ML/day of poorly treated highly saline mine water. This approach to the disposal of unwanted, poorly treated and (for LDP009) toxic mine water is not supported.

Refer to Section 2.1.1 of Appendix 3.

It is also recommended in the EIS that the Angus Place LDP001 discharge is increased from 2 ML/day to 30 ML/day.

Refer to Section 2.1.1 of Appendix 3.

Unclear assumptions, particularly where the coefficients have been assigned a value (and the justification of these values) or whether the coefficients were calculated from the data…no sensitivity analysis allowing for variation in coefficients and their effect on model predictions.

Refer to Section 2.1.1 of Appendix 3.

…RPS (2014) states: "Evaporation in the model was based on average daily evaporation for each month at BOM Station No. 061089 (Scone SCS.". This is different to the original EIS surface water assessment where evaporation was stated to come from: "Daily Pan A evaporation has been recorded at the Bathurst Agricultural Station (BOM Station No. 63005) from 1966 to

current". It is unclear why the evaporation stations have been changed in the latest iteration of the model and what effect this has had on the model and its predictions…

Refer to Section 2.1.1 of Appendix 3.

The RPS (2014) report still talks about Daily demand at Wallerawang Power Station when it is currently 'mothballed'.

Refer to Section 2.1.1 of Appendix 3.

The Angus Place EIS highlighted that the water balance model was calibrated to discharge in July 2013, which included a period where mine water make was being temporarily held underground (March to July 2013). Discharge at LDP001 has now resumed at a rate of 2ML/d. It is unclear whether the latest 'calibration' has used this information in daily flow calculations and whether the actual flows from LDP009, LDP001 and other discharges have been appropriately used in the modelling.

Refer to Section 2.1.1 of Appendix 3.

The Angus Place EIS Water quality modelling indicates that historical discharge at Angus Place LDP001 accounts for observed increase in salinity in Kangaroo Creek and the Upper Coxs River above Blue Lagoon. As pointed out in comments on the original EIS, the Angus Place LDP001 discharge actually represents the first major impact of mine discharges on the Upper Coxs River…

Refer to Section 2.1.1 of Appendix 3.

Two uncertainty analysis conditions were presented in the RTS (Low Rainfall Condition and High Rainfall Condition), but there has been no assessment of model uncertainty or parameter (ie coefficient) uncertainty.

Refer to Section 2.1.1 of Appendix 3.

Description and presentation of calibration results (eg fitted versus actual) is considered poor. As identified earlier the model under-predicts median flow at the NOW gauge 212054…

Refer to Section 2.1.1 of Appendix 3.

There appears to be no presentation of validation results of the model based on more recent flows (and conductivities) measured at the NSW gauging stations.

Refer to Section 2.1.1 of Appendix 3.

The modelling results and conclusions in RPS (2014) should not be relied upon until the significant issues are addressed. In general, there is a lack of appropriate upstream-downstream comparisons for each LDP discharge in the Upper Coxs River catchment. Little allowance appears to be made for the fact that a proportion of the flows measured in various parts of the Upper Coxs River are actually sourced from upstream LDPs. As a result of this confounding of LDP discharges, flows and water quality in the model and assessment, an inadequate assessment of the true impact of the LDP discharges is achieved (particularly that of LDP009).

Refer to Section 2.1.1 of Appendix 3.

Cardno Ecology Lab Pty Ltd (2010) used species sensitivity distribution (SSD) curves for single-species toxicity information to develop protective concentration (PC) values that protect a large proportion of the aquatic species present in the receiving waters.

Refer to Section 2.2 of Appendix 2.

GHD have also not cited or reviewed the extensive literature on salinity impacts on aquatic ecosystems.

Refer to Section 2.3 of Appendix 2.

The ANZECC Guidelines recommend that guideline trigger values for slightly-moderately disturbed systems also be applied to highly disturbed ecosystems wherever possible.

1) Where reference sites of high quality are available, lower levels of protection may be negotiated for the site under consideration but this should not result in water of less quality than that already prevailing.

2) Where no high quality reference sites are available, modified water bodies of the best environmental quality in the region serve as reference targets (or intermediate targets for ecosystem recovery).

…For some assessments (particularly LDP009) an appropriate reference site has not been chosen for comparison and therefore inappropriate "adopted" trigger values have been used.

Refer to Section 2.1.2 of Appendix 3.

…They do not adequately consider the ionic composition of LDP discharge waters which are very different to the ionic composition of local (reference site) waters.

Refer to Section 2.1.2 of Appendix 3.

…At each point when adopting trigger values the assessment has chosen the highest value of either the ANZECC default guideline levels or local water quality trigger values (based on 80%ile values at a reference site) – this is an inconsistent and inappropriate application of ANZECC Guideline trigger value derivation methods.

Refer to Section 2.1.2 of Appendix 3.

…The assessments do not allow for confounding of LDP sources (ie trigger values calculated for LDP009 ignore upstream influence of LDP001 and other discharges).

Refer to Section 2.1.2 of Appendix 3.

…Both the LDP001 and LDP009 discharges (and adopted trigger values) clearly result in water of lesser quality than that already prevailing.

Refer to Section 2.1.2 of Appendix 3.

…The assessments do not appropriately address the increasing salinization of Upper Coxs River waters (see Figure 2 above) which is likely to be a direct result of the increasing concentration and load of salt from LDP discharges.

Refer to Section 2.1.2 of Appendix 3.

…The assessments advocate no treatment of the highly saline and (for LDP009) toxic discharges which will likely cause further deterioration in water quality and result in adverse ecosystem health effects.

Refer to Section 2.1.2 of Appendix 3.

…The assessments have not undertaken an adequate review of the literature on the effects of salinity and ionic constituents on aquatic ecosystems.

Refer to Section 2.1.2 of Appendix 3.

Based on the reported absence of chronic toxicity in the cladoceran for the sample from Lake Wallace (and further downstream) it would appear that amelioration of the LDP009 discharge occurred at the time of sampling (albeit following significant rainfall events).

Refer to Section 2.4 of Appendix 2.

The unusual ionic composition of LDP009 discharge may be a significant contributor to the observed toxic effects. Preliminary re-evaluation of data detailed in Figure 3.3 of the report, showed that normalisation of bicarbonate alkalinity to Ca+Mg+K concentration resulted in the R2 value improving from 0.0099 (Fig 3.3 in report) to R2=0.601.

Refer to Section 2.5 of Appendix 2.

A modified Toxicity Identification and Evaluation (TIE) process investigating modifications to the ionic composition of LDP009 on acute Cladoceran toxicity at 100% would be feasible.

Refer to Section 2.6 of Appendix 2.

(In)Table 2.3 ammonia and NOx (are) not considered as nutrient pollutants

It is noted that the LDP009 discharge has ammonia at 0.44 mg/L (33x the ANZECC/ARMCANZ 2000 nutrient trigger value – see Attachment 2), Mixing zones are not appropriate for the nutrients (Attachment 1)

Refer to Section 2.7 of Appendix 2.

Given the large discharge volumes of LDP009 relative to natural flows and the apparent extensive algal growth reported in sections of the Coxs River downstream of the LDP009 and LDP001 discharges, this would seem to be an issue requiring resolution.

Refer to Section 2.7 of Appendix 2.

…specifically cautioned against allowing existing freshwater systems that are well below the salinity of 1000 mg/L to be increased up to this level.

New information is now available and this is reflected in the ANZECC (2000) guideline trigger values. Note that the Krogh and Miller report on Coxs River Catchment – Water Quality and Macroinvertebrate Communities, referred to in the EPA submission to the EISs, also provides further information on salinity impacts.

Refer to Section 2.1.3 of Appendix 3.

…The RPS reports do not properly account for the overriding principle in the ANZECC (2000) guidelines that should guide management, which is continual improvement (see Section 2.2.1.7). For example, in waters that are of better quality than that set by the water quality objectives, some emphasis should be could still be given to reducing the level of contamination from all sources. Wherever possible, ambient water quality should not be allowed to degrade to the levels prescribed by the water quality objectives. It is also not acceptable to allow poor environmental performance or water pollution, simply because a waterway is degraded. The NWQMS also notes that accepted modern technology, consistent with ongoing economic viability, should be maintained even where this will secure higher water quality outcomes than what the water quality objectives require.

Refer to Section 2.1.3 of Appendix 3.

…The EPA's policy is that the water quality objectives /ANZECC trigger values should be met at the edge of the area where initial (near-field) mixing occurs. Options to meet this policy aim are considered and weighed against the matters to be considered in licensing decisions as set out under Section 45 of the Protection of the Environment Operations Act 1997. The matters that need to be taken into account include the impact of the measures that can be taken to mitigate

the impacts of the pollution and maintain or restore the environmental values of the waterway. While the EPA's licensing approach is to consider the effect of a discharge at the edge of a defined initial "near-field" mixing zone, if the discharge volume from the licenced discharge point would dominate flows in system under most conditions then the dilution effects within a near field mixing zone may be relatively minimal. EPA would therefore examine the pollutant concentrations at the point of discharge relative to ANZECC trigger values.

Refer to Section 2.1.3 of Appendix 3.

…Effective discharge controls that consider the level of waste treatment, the concentration and the total mass of pollutants, and the in situ dilution, should ensure that the area of a mixing zone is small and the designated values and uses of the water body as a whole are not prejudiced.

Refer to Section 2.1.3 of Appendix 3.

…Appendix 3 (for both projects) states that "Where dilution is insufficient, the mixing zone criteria are not met in that the mixing zones extend from bank to bank. In this circumstance ANZECC recommends performing a "biological effects assessment" (e.g. Direct Toxicity Assessment)." This is an incorrect interpretation of the ANZECC guidelines.

Refer to Section 2.1.3 of Appendix 3.

…Overall, the dilution assessment in Appendix 3 for both projects does not adequately consider the above guidance and EPA policy on mixing zones. These inadequacies include that:

- **available initial near-field mixing is not defined in order for EPA to incorporate an appropriate dilution factor into licensing limits**
- **and the extent and configuration of the mixing zone does not allow ANZECC trigger values to be achieved at any near field mixing zone.**

Refer to Section 2.1.3 of Appendix 3.

…Taking into account the very low median salinity at the upstream Kangaroo Creek site and low median conductivity levels in the upper parts of the Coxs River catchment (50 - 200µS/cm); the lack of appropriate information on near-field mixing; and the principle of not polluting up to environmental limits, then a value of 350µS/cm (ANZECC 20000 default trigger value), applied at the point of discharge may be an appropriate value to guide management options for slightly to moderately disturbed ecosystems at this stage.

Refer to Section 2.1.3 of Appendix 3.

The RPS report has selectively adopted a site-specific trigger value when it less stringent than the ANZECC default trigger value and has adopted the ANZECC default trigger when the site-specific trigger value is more stringent. This is an unacceptable approach

If appropriate data is available to derive site-specific trigger values (as set out in the ANZECC guidelines) and an agreed suitable reference site is available (consistent with the ANZECC guidance on reference sites), then site-specific trigger values are preferred over the default trigger values for physical and chemical stressors such as salinity. Toxicants are usually compared with a single default trigger value, less commonly with a background or reference distribution as the default values are prepared by analysis of a comprehensive set of available ecotoxicological data.

Refer to Section 2.1.3 of Appendix 3.

…The ANZECC guidelines advise that a minimum of two years of contiguous monthly data at a reference site is required before a valid trigger value can be established.

Refer to Section 2.1.3 of Appendix 3.

…The Kangaroo Creek upstream may be an acceptable reference site for the assessment of site specific trigger values, in particular, salinity values appear consistent with values recorded at other upstream sites in the catchment, however, WTAU cannot determine its suitability as a reference site without further information, for example, the metals data are highly elevated compared to the default trigger value and the mix of ions making up salinity may be different.

Refer to Section 2.1.3 of Appendix 3.

Discharge from Sawyer Creek to Coxs River (Springvale)

- **An inappropriate reference site appears to have been used in the derivation of site specific trigger values for the Discharge from Sawyers Creek to Coxs River.**
- **The derivation of a trigger value of 1539 µS/cm is not consistent with the ANZECC guidelines methodology for defining site specific trigger values and the reference site does not appear consistent with the Section 3.1.4 "Defining a reference condition" in the ANZECC guideline.**
- **Median conductivity levels in the upper parts of the Coxs River catchment are often in the 50 – 200 µS/cm range, indicating that 1539 µS/cm is a significant departure from a suitable reference site and reflects impacts in the catchment.**
- **The reference sites should be selected based on the best available sites representative of the level of protection for the part of the river in question, in this case slightly to moderately disturbed conditions. An appropriate reference site therefore should be at least slightly disturbed. Selection of reference sites and application of trigger values should not result in water of lesser quality than that already prevailing.**

Refer to Section 2.1.3 of Appendix 3.

The GHD report (Appendix 9) states that the conductivity of the upstream Kangaroo Creek site was measured at 820 µS/cm. This is not consistent with data presented in Appendix 3 which indicated median EC of 69 µS/cm and the site specific trigger value was calculated to be 89 µS/cm.

Refer to Section 2.1.3 of Appendix 3.

4A Springvale Colliery, Environment Protection Licence No. 3607 and Salinity…The EPA's current position is a continuation of a regulatory effort to reduce the salinity concentrations of the upper Coxs River. The EPA considers the current limits on LDP9 to be interim until a change in management of the mine water (handling, treatment etc) is implemented.

Refer to Section 2.1.4 of Appendix 3.

4C Closure and Mothballing of Angus Place Colliery – Environment Protection Licence (EPL467)…it is apparent to the EPA that Centennial could now again consider this option, including repairing the collapse bore and then direct mine water from Springvale into the mothballed Angus Place workings. There may be scope for a hybrid option of the partial discharge after treatment to reduce salinity of Springvale mine water, with the remaining portion directed into the old Angus Place workings for storage until mining at Springvale ends in 2023 at which time the mine water could be transferred back to Springvale for treatment upon the recommencement of mining at Angus Place.

Refer to Section 2.1.4 of Appendix 3.

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4.0 APPENDICES

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Appendix 1 : Updated Coxs River Ecotoxicology Assessment

Centennial Coal Company Limited

Coxs River

Ecotoxicology Assessment

November 2014

Executive Summary

GHD Pty Ltd was commissioned by Centennial Angus Place Pty Limited and Springvale Coal Pty Limited to conduct an ecotoxicological study to determine toxicity and chemical constituents of mine water discharge from LDP001 at Angus Place Colliery (AP LDP001) and LDP009 at Springvale Mine (SV LDP009) as well as several locations within the upper Coxs River catchment. This ecotoxicology assessment has been undertaken to assess the impact of mine water discharge from Angus Place Colliery and Springvale Mine on the surrounding receiving environment.

Direct toxicity assessment was undertaken for the mine water discharge samples from AP LDP001 and SV LDP009 using a suite of bioassays. Bioassays at all other locations were conducted using screening tests with the freshwater cladoceran, which has been found to be the most sensitive test species in previous toxicity testing conducted by Centennial Coal Company Limited in the region. Toxicity testing of sampled water was performed using the ANZECC (2000) protocol with species endemic to, or representative of, the receiving environment. Water quality analysis was also undertaken for the samples from each location.

The results of this study show that the discharge at SV LDP009 is having an acute impact on cladoceran species at the Sawyers Swamp Creek site downstream of discharges; however this acute toxicity is ameliorated as the discharge enters the Coxs River. Impacts on cladoceran reproduction show a decreasing trend in the Coxs River with distance downstream of the SV LDP009 discharge point until no adverse impacts are detected on cladoceran reproduction in the upper portion of Lake Wallace.

The results of the toxicity testing were used to determine a concentration of SV LDP009 discharge of 2.7% which will provide protection to 95% of the species in the downstream ecosystem from a 10% reduction in growth or reproduction. An estimate of the runoff contributing to the Coxs River was obtained from the water balance model developed by RPS (2014a). The estimated catchment runoff to the Coxs River at each location was compared to the predicted maximum daily discharge volume from AP LDP001 and SV LDP009 to determine the expected dilution of discharge within the river. The target dilution of SV LDP009 discharge was not found to be met under median rainfall conditions.

Aquatic ecology monitoring results provide supporting evidence that the discharges from AP LDP001 and SV LDP009 are not adversely impacting the aquatic health of the Coxs River. The sites downstream of discharges from AP LDP001 were found to have more pollution sensitive taxa present in the macroinvertebrate assemblages than the upstream Coxs River site.

The water quality results for SV LDP009 do not indicate any parameters that are present in concentrations that could cause the significant toxicity observed in the ecotoxicology results. Furthermore, the chemistry of discharge from AP LDP001, which did not show any toxicity to the cladoceran species, was found to be very similar to that of SV LDP009, with the exception of major ions.

A comparison of toxicity testing results for SV LDP009 discharge upstream and downstream of water quality treatment indicated that the toxicity observed at SV LDP009 is likely to be related to treatment with flocculants prior to discharge and an ionic imbalance. It is recommended to investigate the flocculant agent and dosing rates as management actions to ensure that the toxicity of the SV LDP009 discharge is reduced, thus reducing the impact on the Coxs River.

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Glossary

Acute toxicity	The ability of a substance to cause severe biological harm or death from a single exposure.
Alkalinity	A measure of the ability of an aqueous solution to neutralise acids. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates. It is expressed in units of calcium carbonate (CaCO3).
Analyte	A substance or chemical constituent that is undergoing analysis.
Anion	A negatively charged ion.
Bioassay	An experimental test used to evaluate the relative potency of a chemical by measuring its effect on a living organism relative to a control.
Bioavailability	The fraction of the total of a chemical in the surrounding environment that is available to be taken up by an organism. The environment may include water, sediment, soil, suspended particles and food.
Catchment	The land area draining through the main stream and tributary streams to a particular location.
Cation	A positively charged ion.
Chronic toxicity	The ability of a substance to cause severe biological harm or death from prolonged exposure.
Community	An assemblage of organisms occupying a specified location and time, usually interacting with one another.
Control	The part of an experimental procedure which is like the treated part in every respect except it is not subjected to the test conditions. The control is used as a standard of comparison, to check that the outcome of the experiment is a reflection of the test conditions and not of some unknown factor.
Direct toxicity assessment	The use of toxicity tests to determine the acute and/or chronic toxicity of mixtures of compounds in ambient waters.
Discharge	The quantity of water per unit time, for example cubic metres per second or megalitres per day.
Ecotoxicology	Scientific study of the effects of toxic substances on living organisms.
Effect concentration	The concentration of a substance in water where a certain percent of test organisms exhibit a certain response or effect after a specified exposure period. For example, EC10 is the concentration where 10 percent of the test organisms exhibit a response.

Electrical conductivity	A measure of the concentration of dissolved salts or ions in water.
Guidelines	Numerical concentration or narrative statement that provides appropriate guidance for a designated water use or impact.
Hardness	The concentration of multivalent cations present in water. Generally, hardness is a measure of the concentration of calcium and magnesium ions in water and is expressed in units of calcium carbonate (CaCO3) equivalent. Hardness may influence the toxicity and bioavailability of substances in water.
Ion	An electrically charged atom.
Index	Composite value that can give a quick ranking to an ecosystem feature (e.g. a water body), derived via a formula that combines measurements of important ecosystem characteristics; typically used to rank 'health' or naturalness.
Licensed discharge point	A location where the premises discharge water in accordance with conditions stipulated with the site's Environment Protection Licence.
Longwall mining	Underground coal mining where a block of coal is mined using a longwall shearer, supported by roadway development that is created using a continuous miner unit.
Macroinvertebrate	An animal species that does not develop a vertebral column and is large enough to be seen without the use of a microscope. These animals generally include insects, crustaceans, molluscs, arachnids and annelids.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Meteorology	The science concerned with the processes and phenomena of the atmosphere, especially as a means of forecasting the weather.
No observed effects concentration (NOEC)	The highest tested concentration of a substance in water at which no effect is observable in test organisms in a given population (compared to the control sample).
Percentile	The value of a variable below which a certain per cent of observations fall. For example, the 80th percentile is the value below which 80 per cent of values are found.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Physicochemical	Refers to the physical (e.g. temperature, electrical conductivity) and chemical (e.g. concentrations of nitrate, mercury) characteristics of water.
Riparian	Pertaining to, or situated on, the bank of a river or other water body.

Runoff	Amount of rainfall that ends up as streamflow.
Total dissolved solids	A measure of the inorganic and organic substances dissolved in water.
Total Kjeldahl nitrogen	The sum of the concentrations of organic nitrogen, ammonia (NH4) and ammonium (NH4+) in water.
Total nitrogen	A measure of organic and inorganic nitrogen forms in water. The sum of concentrations of total Kjeldahl nitrogen, nitrite and nitrate.
Total phosphorus	A measure of the organic and inorganic phosphorus in particulate and soluble forms.
Total suspended solids	A measure of the filterable matter suspended in water.
Toxicity	The inherent potential or capacity of a substance to cause adverse effects in a living organism.
Trigger value	The concentration or load of physicochemical characteristic of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. they indicate a risk of impact if exceeded and should 'trigger' action to conduct further investigations or to implement management or remedial processes.
Turbidity	A measure of the clarity of water. Turbidity in excess of 5 NTU is just noticeable to the average person.

Abbreviations

AUSRIVAS	Australian Rivers Assessment System
AWBM	Australian Water Balance Model
BOM	Bureau of Meteorology
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DTA	Direct toxicity assessment
EC	Effect concentration
EPA	Environment Protection Authority
EPL	Environment Protection Licence
ESA	Ecotox Services Australasia
GHD	GHD Pty Ltd
km	Kilometre
km2	Square kilometre
L	Litre
LDP	Licensed discharge point
m	Metre
mg/L	Milligram per litre
ML/day	Megalitre per day
mV	Millivolt
NATA	National Association of Testing Authorities
NOEC	No observable effect concentration
NOW	NSW Office of Water
NTU	Nephelometric turbidity unit
SSTV	Site-specific trigger value
TDS	Total dissolved solids
TSS	Total suspended solids
°C	Degrees Celsius
µS/cm	Microsiemens per centimetre

1. Introduction

1.1 Background

Angus Place Colliery is an underground coal mine located approximately 5 km north of Lidsdale and approximately 15 km north-west of Lithgow. Springvale Mine is also an underground coal mine located approximately 6 km south of Angus Place Colliery. A locality figure is provided in Figure 1-1. Both mines are currently seeking approval to extend mining operations using longwall mining methods as part of the Angus Place Mine Extension Project and Springvale Mine Extension Project respectively.

Groundwater inflows into the underground workings at both Angus Place Colliery and Springvale Mine are transferred to a subterranean pipeline network prior to discharge at licensed discharge point (LDP) LDP009 at Springvale Mine. Mine water from Springvale Mine is taken as a priority, with the remaining capacity supplied by mine water from Angus Place Colliery.

GHD Pty Ltd (GHD) was commissioned by Centennial Angus Place Pty Limited and Springvale Coal Pty Limited to conduct an ecotoxicological study to determine toxicity and chemical constituents of mine water discharge from LDP001 at Angus Place Colliery (AP LDP001) and LDP009 at Springvale Mine (SV LDP009) as well as several locations within the upper Coxs River catchment. This ecotoxicology assessment has been undertaken to assess the impact of mine water discharge from Angus Place Colliery and Springvale Mine on the surrounding receiving environment.

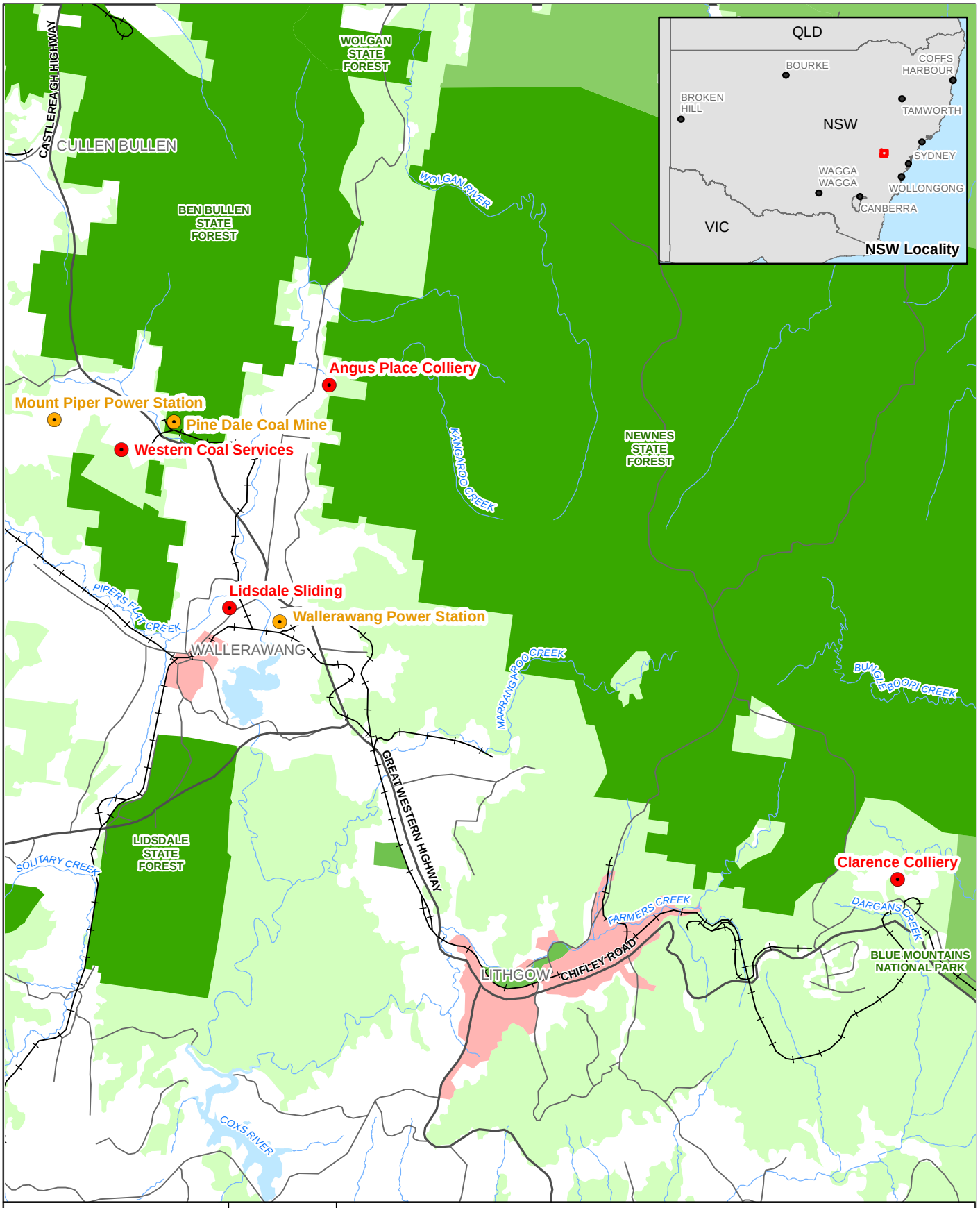
The NSW Environment Protection Authority (EPA) conducted water quality and toxicity testing on discharge from SV LDP009 and the receiving environment on 8 May 2014. GHD was engaged by Springvale Coal Pty Limited to review and interpret the results of the testing provided by the NSW EPA and to determine the impacts on the receiving environment. The outcomes of this assessment are provided in *Springvale EPA Water Quality and Toxicity Assessment: Interpretive Report* (GHD, 2014). The objectives of the work detailed in this report as well as the above mentioned report are to develop a weight of evidence approach to the outcomes of the two mine extension projects.

1.2 Coxs River Catchment

1.2.1 Topography and Land Use

The Western Coalfield lies on the western slopes of the north-south oriented sandstone ridgeline of the Great Dividing Range, to the west of the Wollemi National Park and the Blue Mountains National Park. The area consists primarily of undulating hills and mountain tops, with some low-lying areas.

The region is surrounded by state recognised forests and reserves, including the Turon State Forest and Winburndale Nature Reserve in the west and the Wolgan State Forest, Ben Bullen State Forest and Newnes State Forest to the east. Low-lying areas have been cleared of vegetation for agricultural, commercial and industrial purposes, including coal mining, forestry and power generation. Nearby residential areas include Lithgow and Wallerawang to the south and Portland and Cullen Bullen to the west.



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0 0.4 0.8 1.6 2.4 3.2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Non Centennial Site
- Centennial Site
- Existing Rail
- Dual Carriageway
- Principal Road
- Secondary Road
- Minor Road
- Waterway
- Waterbody
- Built Up Area
- Nature Conservation
- State Forest
- Forest Or Shrub

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	F.M.
APPROVED	S.G.
SCALE	Refer to scalebar

Coxs River Ecotoxicology Assesssment

Locality Plan

Centennial Coal

DATE 14/11/2014

Figure 1-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2217471\2217471_001_Locality_A.mxd

1.2.1 Hydrology

The Coxs River is a perennial river that drains a catchment area of approximately 1,700 km^2 as shown in Figure 1-2 and is part of the greater Hawkesbury/Nepean catchment. The river rises within the Ben Bullen State Forest east of Cullen Bullen and flows generally in a south-east direction into Lake Burragorang (impounded by Warragamba Dam), which is the primary reservoir for drinking water supply to Sydney. The flow in Coxs River is regulated by three reservoirs, Lake Wallace, Thompsons Reservoir and Lake Lyell, which are used to supply power generation activities.

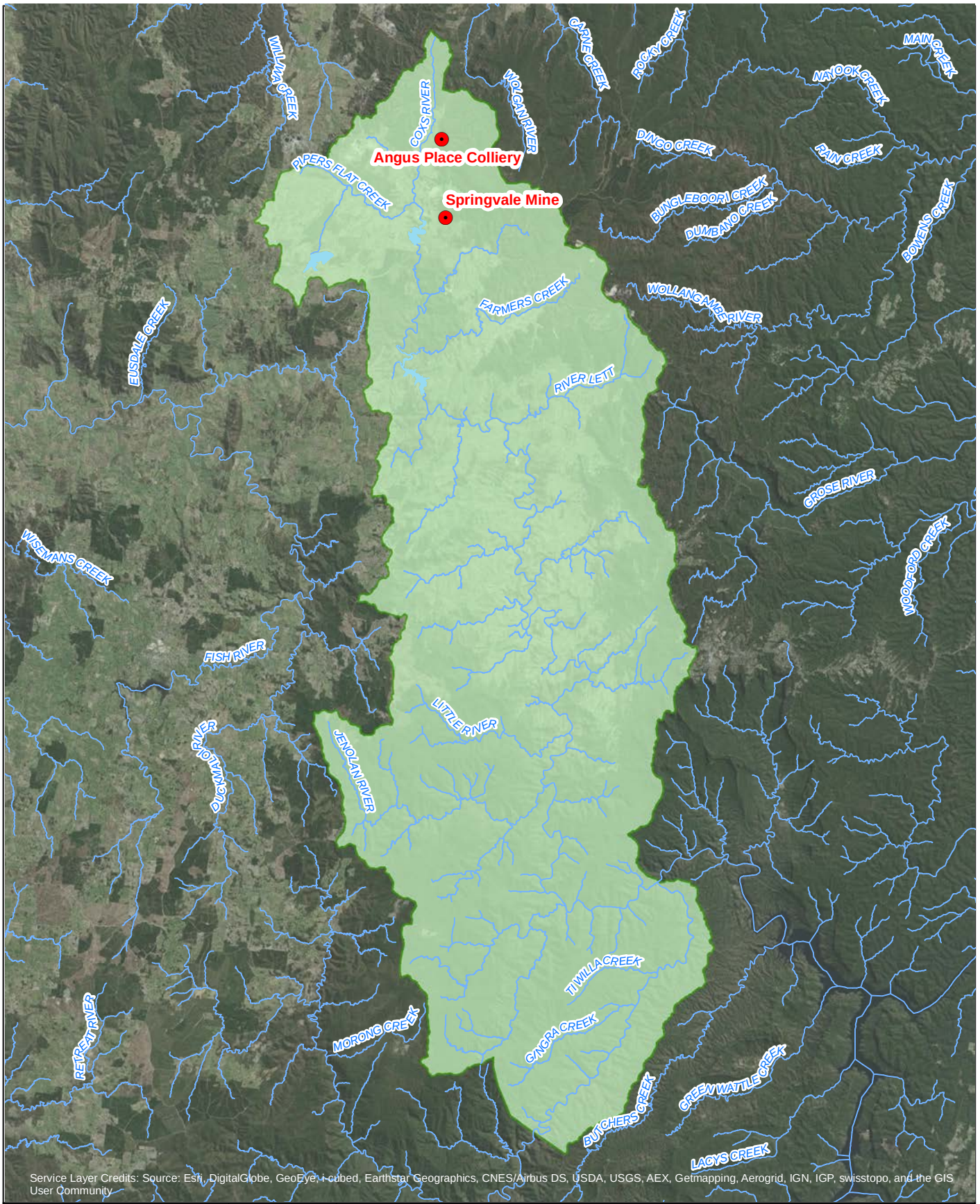
Flows within the Coxs River are monitored at several locations by NSW Office of Water (NOW) gauges. The locations of the four gauges assessed are presented in Figure 1-3 and details are provided in Table 1-1.

A partial series analysis was undertaken on the data available from the NOW gauges on the Coxs River. As the quality of data as provided by the NOW was found to vary, data with a large uncertainty was not included in the analysis. The proportion of the data record used in the analysis is included in Table 1-1 for each flow gauge.

Table 1-1 NSW Office of Water Flow Gauge Details

	Coxs River at Wallerawang Power Station	Coxs River at Bathurst Road	Coxs River at Upstream Lake Lyell	Coxs River at Lithgow	Coxs River at Island Hill
Station number	212054	212008	212058	212011	212045
Record	January 1992 to September 2014	January 1951 to September 2014	December 2000 to September 2014	May 1960 to September 2014	August 1981 to September 2014
Latitude	-33.3971	-33.4277	-33.4757	-33.5343	-33.7573
Longitude	150.0839	150.0825	150.0762	150.0951	150.1970
Elevation	875 m	858 m	857 m	744 m	264
Catchment area	178 km^2	199 km^2	250 km^2	404 km^2	970 km^2
Proportion of record used	97%	97%	95%	97%	99%

Hydrographs and daily percentiles for each flow gauge assessed are presented in Appendix A with selected flow statistics provided in Table 1-2. The median flow within the Coxs River increases from 13.3 ML/day at Wallerawang Power Station downstream to 50 ML/day in the lower Coxs River catchment at Island Hill. The flow statistics presented in Table 1-2 indicate that the average values for the gauges on the Coxs River at Bathurst Road, Lithgow and Island Hill have been skewed by flood events in 1986 and 1990, which were not recorded by the gauges at Wallerawang Power Station or upstream of Lake Lyell.



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0 1.25 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site
- Waterway
- Waterbody
- Coxs River Catchment

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	F.M.
APPROVED	S.G.
SCALE	Refer to scalebar

Coxs River Ecotoxicology Assesssment

Watercourses

Centennial Coal

DATE 14/11/2014

Figure 1-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2217471\2217471_005_Watercourses_A.mxd

LPI: DTDB 2012; ESRI: Aerial Imagery, 2014; RPS: Catchment, 2014

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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0 0.5 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Non Centennial Site
- Centennial Site
- NOW Gauge
- Waterway
- Waterbody

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	F.M.
APPROVED	S.Gray
SCALE	Refer to scalebar

Coxs River Ecotoxicology Assesssment

NSW Office of Water Flow Gauge Locations

Centennial Coal

DATE 14/11/2014

Figure 1-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2217471\2217471_004_NOWGauges_A.mxd

LPI: DTDB 2012; ESRI: Aerial Imagery, 2014

Table 1-2 Coxs River Flow Gauge Statistics

Statistic	Coxs River at Wallerawang Power Station (ML/day)	Coxs River at Bathurst Road (ML/day)	Coxs River at Upstream Lake Lyell (ML/day)	Coxs River at Lithgow (ML/day)	Coxs River at Island Hill (ML/day)
Average	25.5	61.6	29.4	119.7	216.2
Minimum	0.3	0.0	4.9	0.0	0.0
10th percentile	4.5	3.4	12.2	3.3	6.0
50th percentile	13.3	13.9	20.3	30.6	50.0
90th percentile	44.7	94.4	54.1	217.8	425.7
Maximum	4,315	33,729	267	29,319	77,439

1.2.2 Site Overviews

The following coal mining and power generation operations that have been considered in this ecotoxicology assessment, as presented in Figure 1-4:

- Angus Place Colliery – Underground coal mine currently seeking approval to extend mining operations. Mine water is primarily transferred to a pipeline and discharged via SV LDP009.
- Lidsdale Siding – Coal storage and rail loading facility that receives coal from the Western Coal Services Project for transport by rail to Port Kembla or Port of Newcastle for export.
- Mount Piper Power Station – Coal-fired power station owned by Energy Australia.
- Neubeck Coal Project – Proposed open cut coal mine currently seeking approval.
- Pine Dale Coal Mine – Open cut coal mine owned by Energy Australia that is currently under care and maintenance while seeking approval to continue mining operations.
- Springvale Mine – Underground coal mine currently seeking approval to extend mining operations. Mine water is transferred to a pipeline and discharged via SV LDP009.
- Wallerawang Power Station – Coal-fired power station owned by Energy Australia that is currently under care and maintenance.
- Western Coal Services Project – Project approved to provide coal storage, handling and processing functions to source mines Angus Place Colliery and Springvale Mine.

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0 0.2 0.4 0.8 1.2 1.6

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Non Centennial Site
- Centennial Site
- Springvale LDP
- Angus Place LDP
- Waterway

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	F.M.
APPROVED	S.G.
SCALE	Refer to scalebar

Coxs River Ecotoxicology Assesssment

Site Locations

Centennial Coal

DATE 14/11/2014

Figure 1-4

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2217471\2217471_007_SiteLocationandLDPs_A.mxd

LPI: DTDB 2012; ESRI: Aerial Imagery, 2014

1.3 Discharge Locations

Environment Protection Licences (EPLs) are issued by the NSW EPA under the *Protection of the Environment Operations Act 1997*. Licence conditions relate to pollution prevention and monitoring and can control the air, noise, water and waste impacts of an activity. Each site operates under an EPL which specifies conditions under which water is to be discharged via LDPs. Table 1-3 summarises the licence conditions for Centennial Coal Company Limited (Centennial) operations within the Coxs River catchment. Pine Dale Coal Mine and Wallerawang Power Station are both currently under care and maintenance and are understood to have ceased discharging to the Coxs River catchment.

Table 1-3 Licensed Discharge Points

Environment Protection Licence	Discharge point	Discharge limit	Description
Angus Place Colliery			
467	LDP001	2 ML/day	Discharge of mine water and runoff to Kangaroo Creek through wetlands.
	LDP002	No limit	Discharge of surface water from facilities area into the Coxs River through settling ponds.
	LDP003	No limit	Discharge of surface water from the Kerosene Vale stockpile into the Coxs River through a settling pond.
Lidsdale Siding			
5129	LDP004	No limit	Discharge of surface water from facilities area into Pipers Flat Creek through settling ponds.
Springvale Mine			
3607	LDP001	10 ML/day	Discharge of mine water, surface water from facilities area and runoff into Springvale Creek through settling ponds.
	LDP009	30 ML/day	Discharge of mine water from Angus Place Colliery and Springvale Mine into Sawyers Swamp Creek.
Western Coal Services			
3607	LDP006	No limit	Discharge of surface water from facilities area into Wangcol Creek through settling ponds.

1.4 Water Management Strategies

The following three strategies are proposed for the management of mine water as part of the mine extension projects for Angus Place Colliery and Springvale Mine (RPS, 2014a):

- Water strategy WS1 – All mine water from Angus Place Colliery (up to 30.8 ML/day) is discharged via AP LDP001 and all mine water from Springvale Mine (up to 18.8 ML/day) is discharged via SV LDP009.

- Water strategy WS2a – Up to 30 ML/day of mine water from Angus Place Colliery and Springvale Mine is discharged via SV LDP009, consisting of all mine water from Springvale Mine and the remaining volume from Angus Place Colliery. Excess mine water from Angus Place Colliery is discharged via AP LDP001.
- Water strategy WS2b – 2 ML/day of mine water from Angus Place Colliery is discharged via AP LDP001 with the remaining mine water from Angus Place Colliery and Springvale Mine discharged via SV LDP009 (up to 43.4 ML/day).

It should be noted that WS2a is the current water strategy employed by Angus Place Colliery and Springvale Mine at the time of water sampling.

1.5 Scope of Work

This report details the ecotoxicology assessment and provides the results for water quality testing at 12 locations within the Coxs River catchment, including mine water discharge from LDPs at Angus Place Colliery and Springvale Mine. The scope of work included the following:

- Provide details of sample collection at 12 sites in the Coxs River catchment and toxicity and water quality testing conducted.
- Interpret toxicity and water quality testing results for the 12 samples of water collected.
- Compare results with current and historical monitoring conducted by Centennial and with site-specific trigger values and EPL limits specified for licensed discharge points.
- Compare results with modelled catchment runoff within the Coxs River catchment, estimated from water balance modelling provided by RPS (2014a), to determine the dilution of mine water discharge downstream of AP LDP001 and SV LDP009.

2. Methodology

Two rounds of ecotoxicological assessment were conducted in August and October 2014, referred to as round one and round two of testing respectively.

2.1 Sample Collection

2.1.1 Round One of Testing

Samples were collected on the 21 and 22 August 2014 at the following locations, as shown in Figure 2-1:

- Coxs River upstream – Coxs River upstream of Angus Place Colliery and Springvale Mine (at the same location tested by the NSW EPA in May 2014).
- AP LDP001 – Mine water discharge from AP LDP001, which receives underground mine water and catchment runoff. Discharge flows through aeration ponds and pollution control wetlands prior to AP LDP001.
- Wangcol Creek – Wangcol Creek upstream of the confluence with Coxs River.
- SV LDP009 – Mine water discharge from SV LDP009, which receives underground mine water from both Angus Place Colliery and Springvale Mine. Sample was collected downstream of water quality treatment.
- Sawyers Swamp Creek – Sawyers Swamp Creek downstream of discharges from SV LDP009 and upstream of confluence with Coxs River.
- Coxs River confluence – Coxs River downstream of the confluence with Sawyers Swamp Creek and discharges from Angus Place Colliery and Springvale Mine.
- Wallerawang Power Station – Coxs River downstream of discharges from Wallerawang Power Station.
- Lake Wallace – Upper portion of Lake Wallace.
- Lake Lyell upstream – Coxs River downstream of Lake Wallace and upstream of Lake Lyell.
- Lake Lyell – Upper portion of Lake Lyell.
- Lake Lyell downstream – Coxs River downstream of Lake Lyell.

A total of 45 L of water was collected at SV LDP009, 10 L at AP LDP001 and 1 L at all other sites. Samples from each location were also collected for water quality analysis. Samples arrived at the Ecotox Services Australasia (ESA) laboratory for toxicity testing and the ALS Environment Division laboratory for water quality analysis in Sydney on 25 August 2014 and testing commenced immediately upon receipt of the samples.

Approximately 47.5 mm of rainfall was recorded at the Lithgow (Cooerwull) Bureau of Meteorology (BOM) station in the five days prior to sampling, as shown in Figure 2-2. Based on the probabilistic rational method recommended by the Institution of Engineers Australia (1987), the time of concentration for the catchment is expected to be less than 24 hours. As such, rainfall in the days preceding sampling during round one of testing is not expected to affect the results of toxicity testing or water quality analysis.

The LDP discharges recorded at each Centennial site on the 21 and 22 August 2014 are presented in Table 2-1. Approximately 1 ML/day was discharged through AP LDP001 and 23 ML/day was discharged through SV LDP009.

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0 0.4 0.8 1.6 2.4 3.2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Non Centennial Site
- Centennial Site
- Sampling Site
- Waterway
- Waterbody

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	F.M.
APPROVED	S.G.
SCALE	Refer to scalebar

Coxs River Ecotoxicology Assesssment

Sampling Locations

Centennial Coal

DATE 14/11/2014

Figure 2-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2217471\2217471_002_SamplingSites_A.mxd

LPI: DTDB 2012; ESRI, Aerial Imagery, 2014

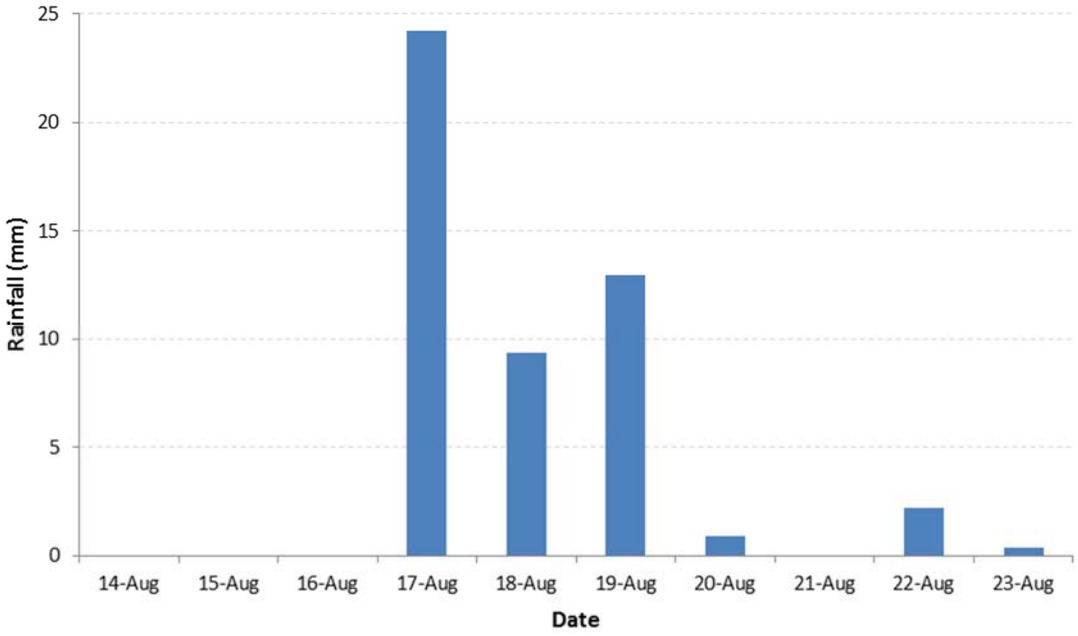


Figure 2-2 Recorded Rainfall Prior to and during Site Visit

Table 2-1 Recorded Discharges during Site Visit

Location	Discharge (ML/day)	
	21 August 2014	22 August 2014
Angus Place Colliery		
LDP001	1.017	1.184
LDP002	0.008	0.009
LDP003	No discharge	No discharge
Lidsdale Siding		
LDP004	No discharge	No discharge
Springvale Mine		
LDP001	1.183	1.232
LDP009	22.507	22.794
Western Coal Services		
LDP006	0.105	0.063

2.1.2 Round Two of Testing

Samples were collected on the 21 October 2014 at the following locations, as shown in Figure 2-1:

- SV LDP009 upstream – Mine water discharge from SV LDP009 upstream of water quality treatment.
- SV LDP009 – Second sample of mine water discharge from SV LDP009 following water quality treatment.
- Kangaroo Creek – Kangaroo Creek downstream of AP LDP001.

A total of 5 L of water was collected at each site with samples put on ice and immediately transferred to the ESA laboratory in Sydney for toxicity testing. Samples from each location were also sent to the ALS Environmental Division laboratory in Sydney for water quality analysis.

2.2 Ecotoxicology Assessment

2.2.1 Direct Toxicity Assessment

Direct toxicity assessment (DTA) is a common method used to determine the toxicity of mixtures of compounds in ambient waters. The method provides an integrated measure of effects and accounts for interactions (synergistic, additive and ameliorative) within a mixture, therefore closely simulating the effects in the receiving waterway. To ensure a close simulation of the toxic effects of the discharge, site-specific testing was undertaken using species indigenous to, or representative of, the receiving ecosystem.

DTA was undertaken for the mine water discharge samples from AP LDP001 and SV LDP009. Toxicity testing at all other locations was conducted using screening tests with the freshwater cladoceran, which has been found to be the most sensitive test species in previous toxicity testing conducted by Centennial in the region.

Toxicity testing involves exposing laboratory test species to a range of concentrations of sampled water for a specified exposure period. At the end of the exposure period, specific end points are assessed, such as species survival, reproduction or growth. Statistical analysis of the results provide the effect concentration (EC) of the sample where 10% (EC_{10}) and 50% (EC_{50}) of test organisms exhibit the specific end point and the no observable effect concentration (NOEC), which represents the highest concentration that has no effect upon the test species.

2.2.2 Species Tested

Toxicity testing of sampled water was performed using the ANZECC and ARMCANZ (2000) protocol with species endemic to, or representative of, the receiving environment. Where possible, chronic bioassays were performed using National Association of Testing Authorities (NATA) accredited tests.

Round One of Testing

The following freshwater species and test protocols were used to test the sample collected from SV LDP009 at Springvale Mine:

- Seven day partial life-cycle (chronic) test using the freshwater cladoceran *Ceriodaphnia cf. dubia*, based on the USEPA (2002) and Bailey *et al*. (2000) protocols.
- 72 hour microalgal growth inhibition (chronic) test using the green alga *Selanastrum capricornutum*, based on the USEPA (2002) protocol.

- 96 hour growth inhibition (chronic) test using the freshwater aquatic duckweed *Lemna disperma*, based on the OECD (2006) protocol.
- 96 hour population growth (acute) test using the freshwater hydra *Hydra viridissima*, based on Riethmuller *et al.* (2003).
- 96 hour imbalance (acute) test using the freshwater eastern rainbowfish *Melanotaenia splendida splendida*, based on USEPA (2002).

For the remaining 10 samples, the seven day partial life-cycle (chronic) toxicity test using the freshwater cladoceran *Ceriodaphnia cf. dubia* based on the protocol specified by USEPA (2002) was conducted. The cladoceran bioassay was selected as it has been found to be the most sensitive test species in previous toxicity testing conducted by Centennial in the region.

Round Two of Testing

Following the results of the DTA conducted in the first round of investigations, presented in Section 3.1, a repeat sample of SV LDP009 discharge and two additional locations were selected for the second round of testing. The seven day partial life-cycle (chronic) toxicity test using the freshwater cladoceran *Ceriodaphnia cf. dubia* based on the protocol specified by USEPA (2002) was conducted for these samples.

2.2.3 Concentrations Tested

ESA recommended the use of laboratory dilution water to provide a more accurate indication of the toxicity of the samples. ESA used in-house diluents for all dilutions and controls to ensure the toxicity observed can be attributed directly to the sample tested. All samples were serially diluted with the appropriate diluent to achieve the test concentration. This is important as toxicity tests conducted by the NSW EPA indicated that upstream samples may have a similar toxicity to the SV LDP009 discharge in some bioassays (NSW EPA, 2014).

Round One of Testing

For the samples of water collected at AP LDP001 at Angus Place Colliery and at SV LDP009 at Springvale Mine, the concentrations used in the toxicity testing were 0%, 6.3%, 12.5%, 25%, 50%, and 100%.

For the remaining nine samples, screening tests with the cladoceran bioassay were conducted at 100% concentration (i.e. no dilution of samples).

Round Two of Testing

For the second round of testing, screening tests with the cladoceran bioassay were conducted at 100% concentration (i.e. no dilution of samples).

2.3 Water Quality Assessment

Water samples from both rounds of testing were tested for the parameters listed in Table 2-2 at the NATA accredited facilities at the ALS Environmental Division Laboratory. This suite of analysis includes the parameters recently specified by the NSW EPA in Springvale Mine's EPL 3607. In addition, the dissolved oxygen (DO), electrical conductivity, pH, redox potential and turbidity were measured in the field prior to sample collection.

Table 2-2 Water Quality Parameters

Category	Parameter
Physicochemical parameters	Electrical conductivity, pH, total dissolved solids (TDS), total suspended solids (TSS).
Nutrients	Ammonia, dissolved organic carbon (DOC), nitrate and nitrite, total Kjeldahl nitrogen, total nitrogen, total phosphorus.
Anions	Alkalinity, chloride, sulfate.
Cations	Calcium, magnesium, potassium, sodium.
Metals (total and dissolved)	Aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium and zinc.
Other	Bromide, cyanide (total and free), fluoride, oil and grease, silica.

In addition to the parameters listed in Table 2-2, SV LDP009 upstream and SV LDP009 were tested for the following semi-volatile organic compounds during the second round of testing:

- Phenolic compounds
- Polynuclear aromatic hydrocarbons
- Phthalate esters
- Nitrosamines
- Nitroaromatics and ketones
- Haloethers
- Chlorinated hydrocarbons
- Anilines and benzidines
- Organochlorine pesticides
- Organophosphorus pesticides

The results were compared to site-specific trigger values (SSTVs) derived for discharge from AP LDP001 and SV LDP009 and limits specified by EPL 467 for AP LDP001 and EPL 3607 for SV LDP009, as shown in Table 2-3. The SSTVs adopted were based on a review of the water quality observed at a monitoring site on Kangaroo Creek upstream of Angus Place Colliery as presented by RPS (2014b; 2014c) and default trigger values recommended by ANZECC (2000). The numbers indicated in bold are those selected as the adopted trigger value for each parameter. SSTVs have been taken as the largest of the default trigger values (which have been hardness corrected where appropriate) and the 80th percentile upstream concentrations, in accordance with the methodology recommended by ANZECC (2000).

Table 2-3 Trigger Values and EPL Limits for Assessment of Water Quality

Parameter	Unit	80th percentile upstream value	Default trigger value	Adopted trigger value	AP LDP001 EPL limits	SV LDP009 EPL limits
Physicochemical parameters						
pH	pH units	**5.9**[a]–6.8	6.5–**8.0**	5.9–8.0	6.5–9.0	6.5–9.0
Electrical conductivity	µS/cm	89	**350**	350	–	1,200
TSS	mg/L	10	**25**	25	30	50
Turbidity	NTU	19.2	**25**	25	–	50
Nutrients						
Ammonia	mg/L	0.03	**0.9**	0.9	–	–
Nitrogen (total)	mg/L	**0.6**	0.25	0.6	–	–
Phosphorus (total)	mg/L	**0.06**	0.02	0.06	–	–
Anions						
Bicarbonate alkalinity	mg/L	20.8	–	225[b]	–	–
Sulfate	mg/L	6	–	644[c]	–	–
Filtered metals						
Aluminium	mg/L	**0.204**	0.055	0.204	–	0.45
Arsenic	mg/L	0.001[d]	**0.024**	0.024	–	0.024
Barium	mg/L	**0.0368**	–	0.0368	–	–
Boron	mg/L	0.05[d]	**0.37**	0.37	–	–
Cadmium	mg/L	0.0001[d]	**0.0005**[e]	0.0005	–	–
Chromium	mg/L	**0.001**[d]	–	0.001	–	–
Cobalt	mg/L	**0.005**	–	0.005	–	–
Copper	mg/L	**0.004**	0.003[e]	0.004	–	0.007
Iron	mg/L	**4.00**	0.3	4.00	–	0.4
Lead	mg/L	0.001[d]	**0.011**[e]	0.011	–	–

Parameter	Unit	80th percentile upstream value	Default trigger value	Adopted trigger value	AP LDP001 EPL limits	SV LDP009 EPL limits
Manganese	mg/L	0.453	**1.9**	1.9	–	1.7
Mercury	mg/L	–	**0.0006**	0.0006	–	–
Nickel	mg/L	0.002	**0.025**[(e)]	0.025	–	0.047
Selenium	mg/L	0.01[(d)]	**0.11**	0.11	–	–
Zinc	mg/L	**0.019**	0.018[(e)]	0.019	–	0.05
Other parameters						
Cyanide (total)	mg/L	0.004[(d)]	**0.007**	0.007	–	–
Oil and grease	mg/L	**5**[(d)]	–	**5**	10	10

(a) 20th percentile value

(b) NSW OEH (2012)

(c) Elphick *et al.* (2011)

(d) Limit of reporting

(e) Hardness correction applied

The NSW OEH (2012) reports that bicarbonate is one of the more potentially toxic major ions to aquatic organisms. Bicarbonate has been found to be about two to 2.5 times more acutely toxic to cladoceran than chloride. There remains uncertainty regarding the most appropriate trigger value for bicarbonate in freshwater. A 95% species protection trigger value for bicarbonate of 225 mg/L was calculated by NSW OEH (2012) based on NOEC data generated from North American species described by Farag and Harper (2012).

A 95% species protection trigger value for sulfate of 644 mg/L was calculated using results from a suite of freshwater species bioassays for temperate freshwater systems with various hardness concentrations (Elphick *et al.* 2011). Elphick *et al.* (2011) used the EC_{10} results from a suite of nine species, many of them used in routine bioassays for DTA by Australian laboratories for temperate freshwater ecosystems. As shown by Elphick *et al.* (2011), increasing hardness reduces the toxicity of sulfate to freshwater temperate organisms similar to those living in the Coxs River and its tributaries.

2.4 Catchment Dilution Assessment

2.4.1 Statistical Analysis of Ecotoxicology Results

The BurrliOZ statistical analytical program (Campbell *et al.*, 2000) used the EC_{10} results from the sample collected at SV LDP009 to calculate the concentration of mine water discharge to protect 99%, 95%, 90% and 90% of species in the receiving environment from a 10% reduction in growth or reproduction. Dilution factors were then calculated for each species protection level, which can be used to assist in deriving site-specific concentrations of contaminants that will not adversely impact organisms within the receiving ecosystem. Concentrations of individual contaminants cannot be extrapolated from toxicity testing results for use as trigger values. However, concentrations can be used for monitoring purposes to ensure that the dilution factors are met at the appropriate monitoring site.

2.4.2 Catchment Runoff

An estimate of the runoff contributing to the Coxs River was obtained from the water balance model developed by RPS (2014a). The model represented all catchments contributing to Lake Burragorang, as shown in Figure 2-3, using the Australian Water Balance Model (AWBM) within the GoldSim Version 10.50 software modelling package. The AWBM is a catchment water balance model that calculates runoff from rainfall after allowing for relevant losses and storage. The AWBM is widely used throughout Australia and has been verified through comparison with large amounts of recorded streamflow data.

The catchments within the water balance model were categorised into the following land use types, each modelled with different AWBM parameters (RPS, 2014a):

- Natural
- Pasture
- Urban
- Disturbed
- Channel

The AWBM parameters for each land use type were calibrated using historical rainfall data from the BOM and flow data from gauges on the Coxs River over the period from 1 January 1979 to 30 June 2014. Further details on the model methodology, calibration, parameters and data used are provided by RPS (2014a).

The daily catchment runoff volume were determined for 16 locations extending downstream of SV LDP009 at Springvale Mine to Lake Burragorang shown in Figure 2-4 using the median rainfall dataset applied within the water balance model by RPS (2014a). Catchment runoff was obtained from the water balance model without the contribution of other operations (Mount Piper Power Station, proposed Neubecks Coal Project and Pine Dale Coal Mine).

2.4.3 Dilution Factor

The estimated catchment runoff to the Coxs River at each location was compared to the predicted maximum daily discharge volume from AP LDP001 and SV LDP009 to determine the expected dilution of discharge within the river. The dilution factor was assessed for the three water management strategies discussed in Section 1.4.

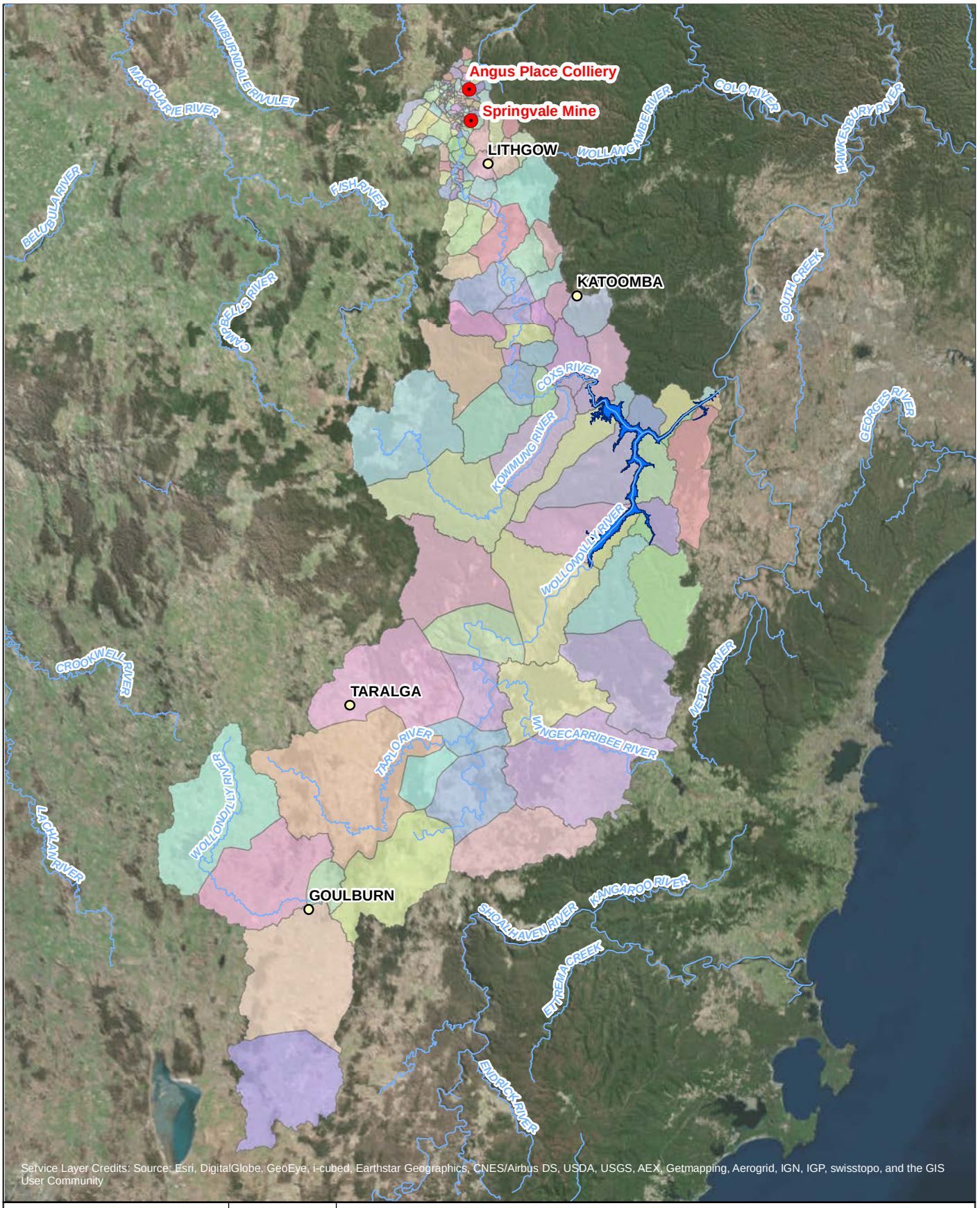
The predicted maximum daily discharge volumes from AP LDP001 and SV LDP009 over the life of each mine for the three water management strategies are presented in Table 2-4. These values were obtained from the water balance model provided by RPS (2014a).

Table 2-4 Predicted Maximum Daily Discharge through AP LDP001 and SV LDP009 (RPS, 2014a)

Water strategy	AP LDP001 discharge (ML/day)	SV LDP009 discharge (ML/day)	Total discharge (ML/day)
WS1	30.8	18.8	45.4*
WS2a	15.4	30	45.4
WS2b	2	43.4	45.4

* Peak daily discharges from AP LDP001 and SV LDP009 occur at different points in time, so the maximum total discharge does not equal the sum of the maximum discharge from the individual LDPs.

The predicted dilution within the Coxs River was compared to the dilution factor determined by the results of toxicity testing using the BurrliOZ statistical analytical program (Campbell *et al.*, 2000).



1:1,000,000 for A4

0 3 6 12 18 24

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site
- Populated Place
- Lake Burragorang

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	F.M.
APPROVED	S.G.
SCALE	Refer to scalebar

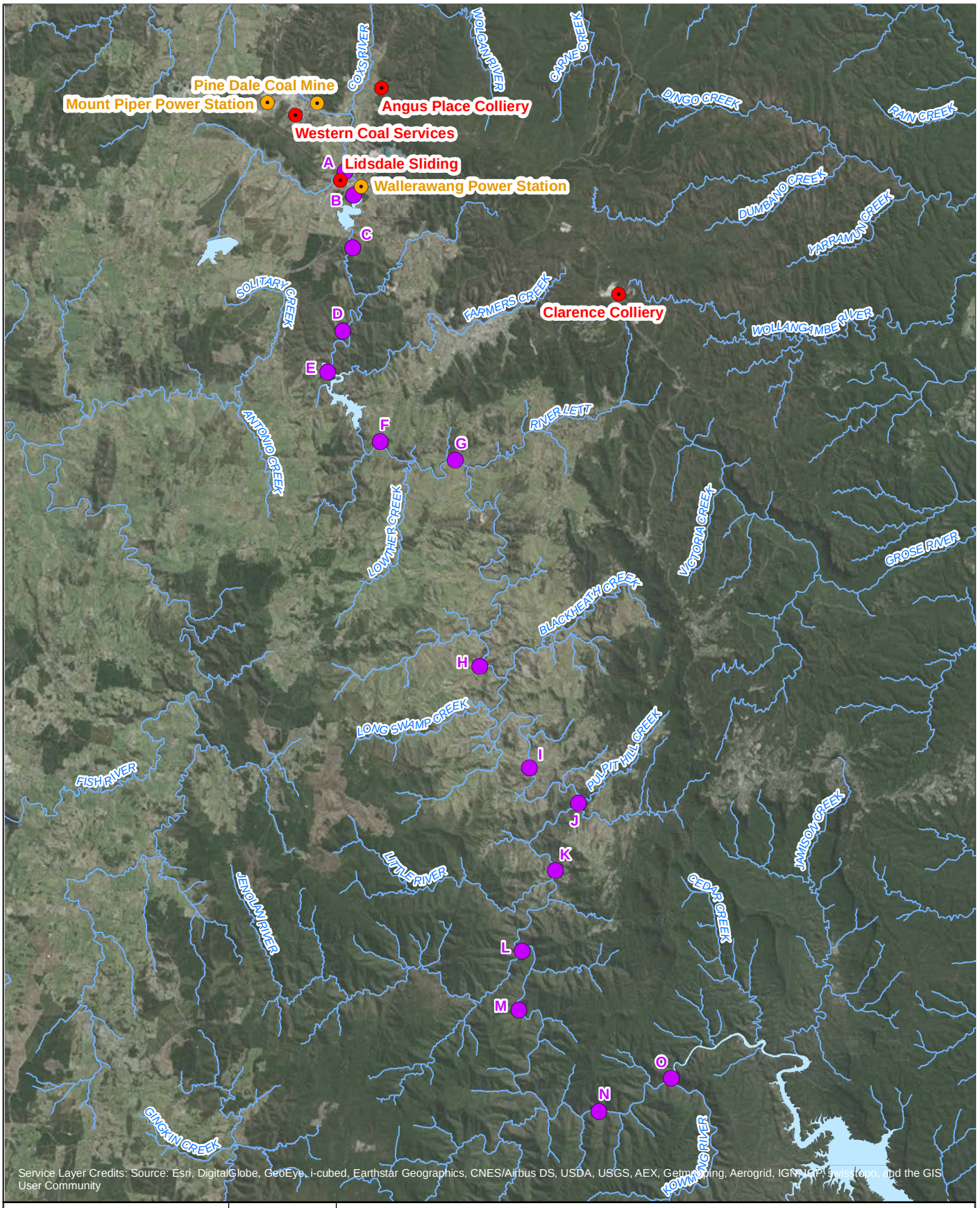
Coxs River Ecotoxicology Assesssment Catchments within Water Balance Model (RPS, 2014a)

Centennial Coal

DATE 14/11/2014

Figure 2-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2217471\2217471_008_ModelCatchments_B.mxd



1:300,000 for A4

0 0.75 1.5 3 4.5 6

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Non Centennial Site
- Centennial Site
- Modelled Catchment Runoff Location
- Waterway
- Waterbody

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	F.M.
APPROVED	S.G.
SCALE	Refer to scalebar

Coxs River Ecotoxicology Assesssment

Catchment Runoff Locations

Centennial Coal

DATE 14/11/2014

Figure 2-4

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2217471\2217471_006_CatchmentRunoff_A.mxd

LPI: DTDB 2012; ESRI: Aerial Imagery, 2014

3. Results and Discussion

3.1 Ecotoxicology Assessment

3.1.1 Round One of Testing

The toxicity testing conducted by ESA fulfilled the criteria for NATA accredited tests with all quality assurance/quality control parameters being met. A copy of the toxicity report is provided in Appendix B and a summary of the results is presented in Table 3-1 for the samples collected at AP LDP001 and SV LDP009. Table 3-2 presents the results of the screening tests with the cladoceran bioassay for the other nine samples. Screening bioassay results are considered to show toxicity if the results are less than 80% of the controls. This is based on the quality control parameter used by the testing laboratory.

As discussed in Section 2.2.1, statistical analysis of the toxicity testing results provide the concentration of the sample where 10% (EC_{10}) and 50% (EC_{50}) of test organisms exhibit the specific end point of the bioassay.

Table 3-1 Summary of Round One AP LDP001 and SV LDP009 Ecotoxicology Results

Bioassay	Concentration (95% confidence limits)	
	EC_{10}	EC_{50}
SV LDP009 discharge		
Eight day cladoceran reproduction	9.3% (5.2%–16.0%)	29.1% (16.3%–50.3%)
72 hour microalgal growth inhibition	3.7% (2.3%–3.8%)	6.0% (5.5%–6.7%)
96 hour duckweed growth inhibition	>100%	>100%
96 hour hydra population growth	5.1% (2.4%–7.3%)	18.0% (13.9%–24.8%)
96 hour eastern rainbowfish imbalance	25% (0.0%–34.2%)	50% (41.7%–59.2%)
AP LDP001 discharge		
Eight day cladoceran reproduction	>100%	>100%

The results of toxicity testing of SV LDP009 discharge presented in Table 3-1 indicate that the discharge is toxic to the test species, with the alga, cladoceran and hydra species showing significant toxicity to the discharge. The alga was observed to have the most sensitivity to the discharge from SV LDP009. The duckweed test showed no toxicity to the discharge and the fish bioassay showed only slight sensitivity.

The results of testing of the sample collected at AP LDP001 indicate that the discharge of mine water from Angus Place Colliery is not toxic to the test species with the reproduction showing no difference to the control organisms at 100% concentration.

Table 3-2 Summary of Round One Screening Ecotoxicology Results

Sample	Reproduction (% of control)	Survival (%)	Electrical conductivity (µS/cm)
Laboratory control	100	90	187
Coxs River upstream	1	40	42
AP LDP001	140	90	1,038
Wangcol Creek	70	100	806
SV LDP009	0	0	1,180
Sawyers Swamp Creek	4	80	1,089
Coxs River confluence	29	100	1,007
Wallerawang Power Station	66	100	949
Lake Wallace	116	100	986
Lake Lyell upstream	106	100	1,049
Lake Lyell	107	90	547
Lake Lyell downstream	113	100	506

3.1.2 Round Two of Testing

The toxicity testing conducted by ESA fulfilled the criteria for NATA accredited tests with all quality assurance/quality control parameters being met. A copy of the toxicity report is provided in Appendix B and a summary of the results is presented in Table 3-3 for the samples collected at AP LDP001 and SV LDP009.

Table 3-3 Summary of Round Two Screening Ecotoxicology Results

Sample	Reproduction (% of control)	Survival (%)	Electrical conductivity (µS/cm)
Laboratory control	100	100	190
SV LDP009 upstream	12	80	1,196
SV LDP009	4	40	1,190
Kangaroo Creek	131	100	833

The results of the second round of screening tests presented in Table 3-3 indicate the water discharged through SV LDP009 upstream of water quality treatment is not acutely toxic however does show chronic toxicity. The discharge through SV LDP009 following water quality treatment was less toxic than the sample from round one of testing.

The results of testing of the sample collected downstream of AP LDP001 at Kangaroo Creek indicate that the discharge of mine water from Angus Place Colliery is not toxic to the test species with the reproduction showing no difference to the control organisms at 100% concentration. This is consistent with the results of the first round of testing of AP LDP001 discharge.

3.2 Water Quality Assessment

3.2.1 Round One of Testing

The water quality testing conducted by ALS fulfilled the criteria for NATA accredited tests with all quality assurance/quality control parameters being met, with the exception of pH and nitrite for the first round due to testing not being conducted within the appropriate holding times. A copy of the full report is provided in Appendix C and a summary of the results is presented in Table 3-4. The results were compared to SSTVs derived for discharge from AP LDP001 and SV LDP009 and limits specified by EPL 467 for AP LDP001 and EPL 3607 for SV LDP009, as shown in Table 2-3. Exceedances of the adopted trigger values have been shown in bold.

Table 3-4 Summary of Round One Water Quality Assessment Results

Parameter	Unit	Coxs River upstream	AP LDP001	Wangcol Creek	SV LDP009	Sawyers Swamp Creek	Coxs River confluence	Wallerawang Power Station	Lake Wallace	Lake Lyell upstream	Lake Lyell	Lake Lyell downstream
Physicochemical parameters												
pH (field)	pH units	**6.47**	7.84	7.82	8.04	9.00	8.50	**9.04**	**9.55**	**9.53**	**9.50**	**9.40**
pH (lab)		**5.69**	8.01	6.98	8.21	8.73	8.47	8.4	8.41	8.65	8.42	8.28
DO (field)	%	72	3.7	85	94.7	88.9	88.4	62.7	76.5	83.7	93.3	96.6
	mg/L	8.22	0.4	9.72	8.1	8.32	8.83	6.64	8.57	9.45	10.62	11.15
Electrical conductivity (field)	µS/cm	45	**1,000**	**554**	**1,148**	**1,055**	**799**	**931**	**1,033**	**1,029**	**534**	**493**
Electrical conductivity (lab)		39	**1,050**	**823**	**1,200**	**1,100**	**1,030**	**973**	**1,010**	**1,080**	**557**	**516**
Redox potential (field)	mV	162	63	49	9.6	-22.8	51.3	-4.4	-11.9	-17.1	-13.7	-19.2
TDS	mg/L	25	682	535	780	715	670	632	656	702	362	335
Temperature (field)	°C	9.4	9.4	9.5	22.9	18.5	15.2	12	10	9.8	9.4	9.3
Total hardness	mg/L	<1	116	244	2	7	76	101	96	82	50	65
TSS	mg/L	22	<5	5	19	10	10	<5	<5	<5	<5	<5

Parameter	Unit	Coxs River upstream	AP LDP001	Wangcol Creek	SV LDP009	Sawyers Swamp Creek	Coxs River confluence	Wallerawang Power Station	Lake Wallace	Lake Lyell upstream	Lake Lyell	Lake Lyell downstream
Turbidity (field)	NTU	0.0	0.0	–	13.5	10.5	–	0.1	0.0	0.0	0.0	0.0
Nutrients												
Ammonia	mg/L	<0.01	<0.01	0.02	0.44	0.09	0.06	0.04	0.03	<0.01	<0.01	<0.01
DOC	mg/L	48	17	7	55	66	6	5	6	42	20	24
Nitrite + nitrate	mg/L	0.24	0.34	<0.01	0.21	0.45	0.42	0.32	0.13	<0.01	0.14	0.04
Total Kjeldahl nitrogen	mg/L	<0.1	<0.1	<0.1	0.6	0.1	0.2	0.2	0.3	0.2	0.3	0.2
Nitrogen (total)	mg/L	0.2	0.3	<0.1	**0.8**	0.6	0.6	0.5	0.4	0.2	0.4	0.2
Phosphorus (total)	mg/L	<0.01	<0.01	<0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.02
Anions												
Bicarbonate alkalinity	mg/L	1	**538**	16	**625**	**512**	**392**	**359**	**336**	**348**	111	128
Total alkalinity	mg/L	1	538	16	625	572	414	375	352	388	113	128
Chloride	mg/L	8	10	34	6	6	15	16	20	18	16	16
Sulfate	mg/L	3	25	341	34	34	142	126	160	164	117	107

Parameter	Unit	Coxs River upstream	AP LDP001	Wangcol Creek	SV LDP009	Sawyers Swamp Creek	Coxs River confluence	Wallerawang Power Station	Lake Wallace	Lake Lyell upstream	Lake Lyell	Lake Lyell downstream
Cations												
Calcium	mg/L	<1	20	45	1	1	14	19	17	13	10	13
Magnesium	mg/L	<1	16	32	<1	1	10	13	13	12	6	8
Potassium	mg/L	<1	32	7	9	10	10	11	12	13	7	8
Sodium	mg/L	4	182	59	291	280	208	202	192	209	75	73
Dissolved metals												
Aluminium	mg/L	0.03	<0.01	0.02	0.01	0.03	0.02	0.02	0.01	<0.01	<0.01	<0.01
Arsenic	mg/L	<0.001	<0.001	<0.001	0.024	0.021	0.014	0.01	0.006	0.004	<0.001	<0.001
Barium	mg/L	0.016	**0.178**	0.014	0.028	0.021	0.02	0.023	0.026	0.025	0.026	0.023
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	<0.05	0.06	0.14	0.07	0.07	0.1	0.08	0.12	0.18	0.09	0.08
Cadmium	mg/L	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	<0.001	<0.001	**0.006**	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	<0.001	0.001	0.003	<0.001	<0.001	<0.001	0.002	0.002	0.002	0.002	0.001
Iron	mg/L	0.09	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Parameter	Unit	Coxs River upstream	AP LDP001	Wangcol Creek	SV LDP009	Sawyers Swamp Creek	Coxs River confluence	Wallerawang Power Station	Lake Wallace	Lake Lyell upstream	Lake Lyell	Lake Lyell downstream
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.057	0.003	0.812	0.008	0.013	0.113	0.077	0.04	0.011	0.002	0.008
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	<0.001	0.012	<0.001	0.038	0.034	0.022	0.018	0.015	0.016	0.005	0.004
Nickel	mg/L	0.004	0.003	0.021	0.004	0.003	0.01	0.007	0.007	0.004	0.002	0.002
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.009	0.117	0.188	0.03	0.028	0.083	0.088	0.117	0.139	0.12	0.109
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.011	0.016	**0.037**	0.007	0.005	0.012	0.016	**0.047**	0.005	<0.005	0.005
Total metals												
Aluminium	mg/L	0.05	0.02	0.11	0.19	0.19	0.14	0.1	0.07	0.06	0.02	0.04
Arsenic	mg/L	<0.001	<0.001	<0.001	0.023	0.022	0.014	0.01	0.006	0.004	<0.001	<0.001
Barium	mg/L	0.016	0.194	0.011	0.027	0.024	0.023	0.022	0.025	0.025	0.023	0.02
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	<0.05	0.07	0.16	0.06	0.08	0.1	0.09	0.12	0.19	0.11	0.09
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Parameter	Unit	Coxs River upstream	AP LDP001	Wangcol Creek	SV LDP009	Sawyers Swamp Creek	Coxs River confluence	Wallerawang Power Station	Lake Wallace	Lake Lyell upstream	Lake Lyell	Lake Lyell downstream
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	<0.001	<0.001	0.005	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.002	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001
Iron	mg/L	0.61	<0.05	0.3	0.3	0.24	0.31	0.2	0.1	0.05	<0.05	0.1
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.058	0.006	0.859	0.014	0.059	0.154	0.09	0.059	0.031	0.006	0.013
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	<0.001	0.014	<0.001	0.036	0.039	0.026	0.021	0.017	0.018	0.005	0.005
Nickel	mg/L	<0.001	0.002	0.02	0.003	0.004	0.011	0.007	0.006	0.004	0.002	0.002
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.007	0.117	0.18	0.015	0.025	0.081	0.087	0.116	0.131	0.106	0.097
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.009	0.01	0.027	0.017	0.009	0.014	0.008	<0.005	<0.005	<0.005	<0.005
Other												
Bromide	mg/L	<0.010	0.067	0.092	0.046	0.057	0.082	0.082	0.074	0.065	0.076	0.063
Cyanide (free)	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004

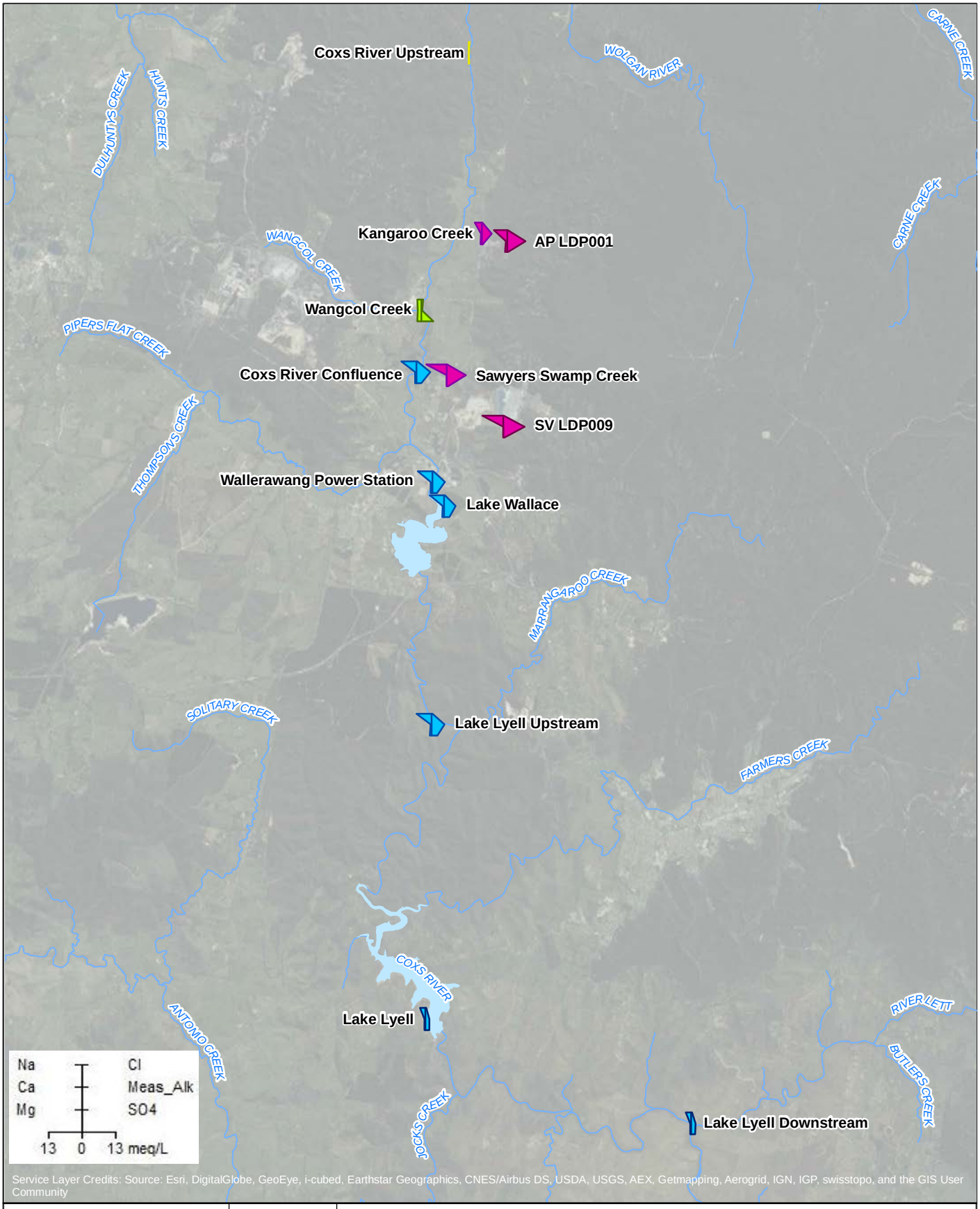
Parameter	Unit	Coxs River upstream	AP LDP001	Wangcol Creek	SV LDP009	Sawyers Swamp Creek	Coxs River confluence	Wallerawang Power Station	Lake Wallace	Lake Lyell upstream	Lake Lyell	Lake Lyell downstream
Cyanide (total)	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Fluoride	mg/L	<0.1	1	0.2	1.5	1.8	1.3	1.1	1.1	1.1	0.6	0.6
Oil and grease	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Silica	mg/L	9.4	8.6	7.5	8.6	8.5	7.8	7.8	3.9	1	0.2	1.8

As seen in Table 3-4, water quality results from the first round of testing show that the majority of sites exceed the adopted trigger values for pH, electrical conductivity and bicarbonate alkalinity. The adopted trigger value for total nitrogen was exceeded at SV LDP009 and AP LDP001 exceeded the adopted trigger value for barium. The trigger for dissolved cobalt was also exceeded at Wangcol Creek and the value for dissolved zinc was exceeded at Lake Wallace and Wangcol Creek.

The underground water discharges from Angus Place Colliery and Springvale Mine via AP LDP001 and SV LDP009 were found to be slightly alkaline and fresh to slightly brackish, with a sodium bicarbonate (Na-HCO_3) type.

The change in water type throughout the catchment is shown by the Stiff diagrams in Figure 3-1. A Stiff diagram is a graphical representation of major ion concentrations in water. The greater the area of the polygon presented in the Stiff diagram, the higher the ionic concentration (or electrical conductivity) of the water.

As shown in Figure 3-1, the upper Coxs River catchment is sodium magnesium chloride (Na-Mg-Cl) type water. Mixing of inputs from Wangcol Creek (Mg-Na-Ca-SO_4 water type) and discharges from Angus Place Colliery and Springvale Mine result in a sodium bicarbonate sulfate (Na-HCO_3-SO_4) water type. This is the dominant water type from the confluence of Sawyers Swamp Creek with Coxs River to downstream of Lake Lyell, with the electrical conductivity reducing with distance downstream.



1:130,000 for A4

0 0.4 0.8 1.6 2.4 3.2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Waterway
- Waterbody
- Mg-Na-Ca-SO_4
- Na-Mg-Cl
- Na-HCO_3-SO_4
- Na-HCO_3

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	T.M.
APPROVED	S.G.
SCALE	Refer to scalebar

Coxs River
Ecotoxicology Assesssment

Stiff Diagrams

Centennial Coal

DATE 14/11/2014

Figure 3-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\221471\2217471_003_StiffDiagrams_A.mxd

LPI: DTDB 2012; ESRI: Aerial Imagery, 2014

3.2.2 Round Two of Testing

The water quality testing conducted by ALS fulfilled the criteria for NATA accredited tests with all quality assurance/quality control parameters being met, with the exception of pH and nitrite for the first round due to testing not being conducted within the appropriate holding times. A copy of the full report is provided in Appendix C and a summary of the results is presented in Table 3-5. The results were compared to SSTVs derived for discharge from AP LDP001 and SV LDP009 and limits specified by EPL 467 for AP LDP001 and EPL 3607 for SV LDP009, as shown in Table 2-3. Exceedances of the adopted trigger values have been shown in bold.

Note all semi-volatile organic compounds tested in the second round of investigations were found to be below the limit of reporting and are not presented in Table 3-5.

Table 3-5 Summary of Round Two Water Quality Assessment Results

Parameter	Unit	SV LDP009 upstream	SV LDP009	Kangaroo Creek
Physicochemical parameters				
pH (field)	pH units	7.32	7.93	7.92
DO (field)	mg/L	6.44	4.74	5.08
Electrical conductivity (field)	µS/cm	**1,192**	**1,127**	**752**
Redox potential (field)	mV	141	116	126
TDS	mg/L	692	652	495
Temperature (field)	°C	19.0	19.0	12.5
TSS	mg/L	13	9	<5
Turbidity	NTU	22	8.5	2.6
Nutrients				
Ammonia	mg/L	0.14	0.43	<0.01
DOC	mg/L	41	5	10
Nitrite + nitrate	mg/L	0.78	0.43	0.11
Total Kjeldahl nitrogen	mg/L	0.2	0.5	<0.1
Nitrogen (total)	mg/L	**1**	**0.9**	0.1
Phosphorus (total)	mg/L	0.02	0.01	**0.12**
Anions				
Bicarbonate alkalinity	mg/L	**506**	**519**	**355**
Total alkalinity	mg/L	516	531	368
Chloride	mg/L	5	6	7
Sulfate	mg/L	34	33	14

Parameter	Unit	SV LDP009 upstream	SV LDP009	Kangaroo Creek
Cations				
Calcium	mg/L	1	1	14
Magnesium	mg/L	1	1	13
Potassium	mg/L	8	9	23
Sodium	mg/L	251	252	130
Dissolved metals				
Aluminium	mg/L	<0.01	0.1	0.01
Arsenic	mg/L	0.023	**0.033**	0.002
Barium	mg/L	0.028	0.025	**0.152**
Beryllium	mg/L	<0.001	<0.001	<0.001
Boron	mg/L	0.07	0.07	0.07
Cadmium	mg/L	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	<0.001
Cobalt	mg/L	<0.001	<0.001	<0.001
Copper	mg/L	<0.001	0.001	<0.001
Iron	mg/L	<0.05	<0.05	<0.05
Lead	mg/L	<0.001	0.001	<0.001
Manganese	mg/L	0.002	0.004	0.002
Mercury	mg/L	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.036	0.035	0.009
Nickel	mg/L	0.002	0.004	0.002
Selenium	mg/L	<0.01	<0.01	<0.01
Strontium	mg/L	0.028	0.018	0.115
Vanadium	mg/L	<0.01	<0.01	<0.01
Zinc	mg/L	0.017	0.012	0.011
Total metals				
Aluminium	mg/L	0.24	0.24	0.07
Arsenic	mg/L	0.03	0.03	<0.001

Parameter	Unit	SV LDP009 upstream	SV LDP009	Kangaroo Creek
Barium	mg/L	0.027	0.026	0.16
Beryllium	mg/L	<0.001	<0.001	<0.001
Boron	mg/L	0.07	0.07	0.06
Cadmium	mg/L	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	0.005	<0.001
Cobalt	mg/L	0.001	<0.001	<0.001
Copper	mg/L	0.003	<0.001	<0.001
Iron	mg/L	0.41	0.14	0.85
Lead	mg/L	0.001	<0.001	<0.001
Manganese	mg/L	0.006	0.008	0.044
Mercury	mg/L	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.048	0.049	0.011
Nickel	mg/L	0.004	0.007	0.002
Selenium	mg/L	<0.01	<0.01	<0.01
Strontium	mg/L	0.02	0.018	0.106
Vanadium	mg/L	<0.01	<0.01	<0.01
Zinc	mg/L	0.006	<0.005	0.016
Other				
Bromide	mg/L	0.034	0.019	0.041
Cyanide (free)	mg/L	<0.004	<0.004	<0.004
Cyanide (total)	mg/L	<0.004	<0.004	<0.004
Fluoride	mg/L	1.3	1.3	0.8
Oil and grease	mg/L	<5	<5	<5
Silica	mg/L	9	9.6	10

As seen in Table 3-5, water quality results from the second round of testing indicate that the adopted trigger values for electrical conductivity and bicarbonate alkalinity were exceeded for all sites, similarly to the results of the first round of testing. The adopted trigger value for total nitrogen was exceeded at both the SV LDP009 sites, upstream and downstream of water quality treatment. Arsenic at the SV LDP009 site (following treatment) was also found to exceed the trigger value. The values for total phosphorus and barium were found to be exceeded at the Kangaroo Creek site.

The discharge from SV LDP009 was found to be slightly alkaline and fresh to slightly brackish, with a sodium bicarbonate (Na-HCO_3) type both upstream and downstream of water quality treatment. These results are consistent with the findings of the first round of testing.

3.3 Catchment Dilution Assessment

3.3.1 Statistical Analysis of Ecotoxicology Results

The EC_{10} values presented in Table 3-1 for SV LDP009 discharge tested during the first round were analysed in the BurrliOZ software package (Campbell *et al*., 2000) and the concentration for varying species protection levels were calculated, as shown in Table 3-6. A concentration of SV LDP009 discharge of 2.7% was determined to provide protection to 95% of species in the downstream ecosystem. To reach a concentration of 2.7%, a dilution factor of 1:37 is required.

Table 3-6 Dilution Factor determined from Ecotoxicology Results

Species protection (%)	Concentration of SV LDP009 (%)	Dilution factor
80	5.1	1:20
90	3.6	1:28
95	2.7	1:37
99	1.7	1:59

3.3.2 Catchment Runoff

The daily catchment runoff determined at locations A to O presented in Figure 2-4 are provided in Table 3-7. Median results are presented along with 10th percentile and 90th percentile values to provide an indication of the possible range of values expected. The median, or 50th percentile, represents the value at which half of the modelled outputs were less than this value. Similarly, the 10th and 90th percentile results represent the values at which 10% and 90% of the modelled outputs were less than these values respectively. The 10th percentile and 90th percentile results have been used (rather than absolute minimum and maximum values) to remove the impact of skewing by infrequent to extreme wet and dry conditions.

Table 3-7 Modelled Catchment Runoff

Location	Catchment runoff volume (ML/day)		
	10th percentile	50th percentile	90th percentile
A	0.63	2.33	23.58
B	1.18	3.19	40.29
C	0.70	0.70	39.76
D	1.54	4.14	67.03
E	1.83	5.07	72.84
F	2.29	7.67	39.68
G	2.32	8.31	67.03

Location	Catchment runoff volume (ML/day)		
	10th percentile	50th percentile	90th percentile
H	2.42	10.36	181.12
I	2.44	11.56	243.86
J	2.46	13.16	310.72
K	3.83	24.33	399.82
L	5.45	30.68	471.66
M	10.84	51.90	594.91
N	15.20	68.74	692.29
O	16.07	71.70	717.06

3.3.3 Dilution Factor

The predicted dilution of SV LDP009 discharges by catchment runoff for each location is presented in Table D-1, Table D-2 and Table D-3 of Appendix D for water strategy WS1, WS2a and WS2b respectively. The predicted dilution of total discharges from AP LDP001 and SV LDP009 is presented in Table D-4 of Appendix D. The results presented in Table D-4 apply to all three water strategies, as the predicted total maximum daily discharge of 45.4 ML/day is the same for each strategy.

3.4 Discussion

3.4.1 Ecotoxicology Assessment

The water quality results for SV LDP009 shown in Table 3-4 and Table 3-5 do not indicate any parameters that are present in significant concentrations that could cause the significant toxicity observed in the ecotoxicology results. The majority of dissolved metals analysed for all sites were found to be below the adopted trigger values, indicating that metals are unlikely to be the cause of observed toxicity. Furthermore, the water quality analysis of AP LDP001 discharge, which did not show any toxicity in the cladoceran bioassay, was found to be very similar to that of SV LDP009, with the exception of major ions.

The treatment of SV LDP009 wastewater was investigated as a potential cause of toxicity in the second round of testing. The results of the second round of testing show that the cause of the acute toxicity of SV LDP009 discharge observed during the first round of testing could be partly related to treatment with flocculants prior to discharge.

The results indicated that the SV LDP009 discharge collected in the second round of testing was less toxic than the sample tested in the first round of investigations. However, the sample did show significant acute and chronic toxicity to the cladoceran. The discharge prior to water quality treatment was within the laboratory quality acceptance criteria, indicating the sample showed no significant acute toxicity. This indicates that the acute toxicity observed in the treated SV LDP009 discharge may be attributed to the treatment with flocculants, which may result in residual flocculants in the receiving environment downstream of the LDP. However, cladoceran reproduction in the SV LDP009 discharge sampled both prior to and following treatment was significantly decreased when compared to the control, indicating chronic toxicity from exposure to the discharge.

As the chronic toxicity observed in SV LDP009 discharge is not readily attributable to metal, flocculant or other toxicant exposure, an ionic imbalance may be the cause of the variability observed. Ionic imbalance may result from the composition and concentration of anions and cations that contribute to salinity. Toxicity associated with ionic imbalance occurs when the concentration and/or ratio of ion exceed or do not meet the physiological tolerance range of test organisms. Generally, chronic toxicity endpoints such as growth and reproduction are more sensitive to the energy expending requirements of osmoregulation associated with ionic imbalances than acute toxicity endpoint of survival.

The screening bioassay results show that the Coxs River upstream site exhibits significant toxicity to cladoceran reproduction and survival tests. This site had low electrical conductivity and the associated ionic imbalance may be responsible for the observed toxicity, as it places the organisms under osmotic stress.

AP LDP001 discharges showed no significant difference in cladoceran survival and an increased reproduction when compared to the control. The results for the sample collected at the Kangaroo Creek site in the second round of testing were consistent with the AP LDP001 results, with no significant difference in cladoceran survival and an increase in reproduction compared to the control.

The Wangcol Creek sample showed that there was a slight toxic impact on the cladoceran with a 37% decrease in reproduction. It is unlikely that the slightly elevated zinc detected at this site would be contributing to all of the observed toxicity.

The sample taken at Sawyers Swamp Creek showed an improvement in cladoceran survival when compared to the SV LDP009 discharge with an 80% survival rate; however reproduction was still significantly decreased. Further downstream in the Coxs River, the cladoceran survival rate improved and was not significantly different from control test at this and all the other downstream sampling locations. The cladoceran reproduction rate was still significantly impacted at the sites on the Coxs River downstream of Sawyers Swamp Creek confluence and downstream of Wallerawang Power Station. The rate of cladoceran reproduction was above the control rate from the upper portion of Lake Wallace and at all other sites downstream of this location.

The electrical conductivity results for each site and the associated cladoceran reproduction toxicity results are shown in Figure 3-2 for both the first and second rounds of testing. A linear regression has been conducted on the results, which shows an R^2 value of 0.0394, indicating that there is no correlation between toxicity and electrical conductivity. It should be noted that the sample size is relatively small (n=15) and outliers have not been removed from the dataset.

Bicarbonate alkalinity has also been suggested by the NSW OEH (2012) as a potential toxicant in coal mine discharge water. The bicarbonate alkalinity results for each site and the associated cladoceran reproduction toxicity results are shown in Figure 3-3 for both the first and second rounds of testing. A linear regression has been conducted on the results, which shows an R^2 value of 0.0467, indicating that there is no correlation between toxicity and bicarbonate alkalinity. It should be noted that the sample size is relatively small (n=15) and outliers have not been removed from the dataset.

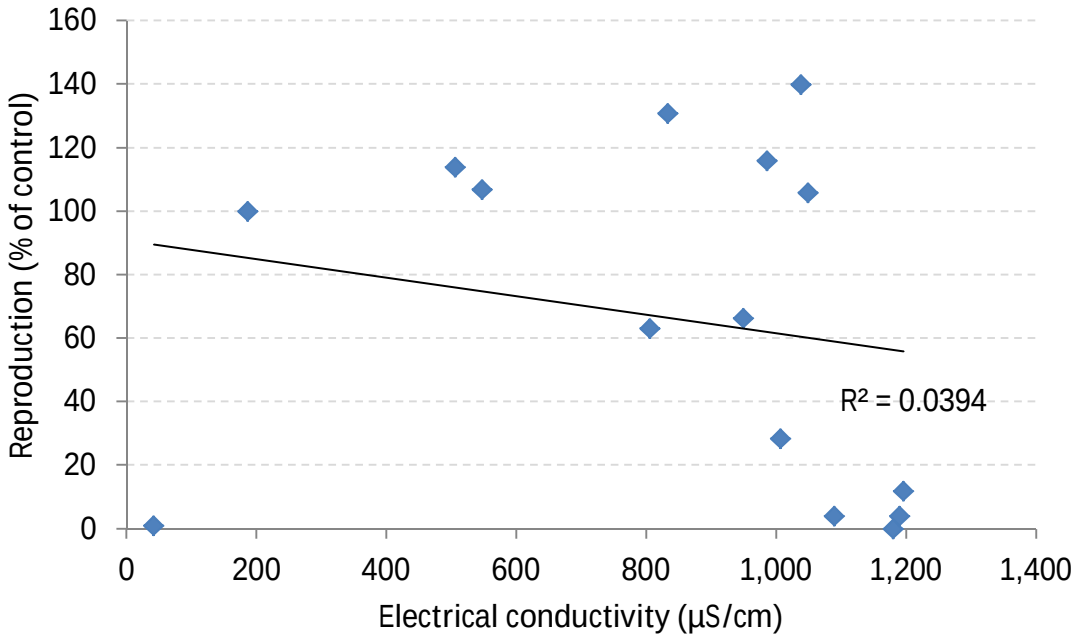


Figure 3-2 Reproduction Toxicity and Electrical Conductivity Results

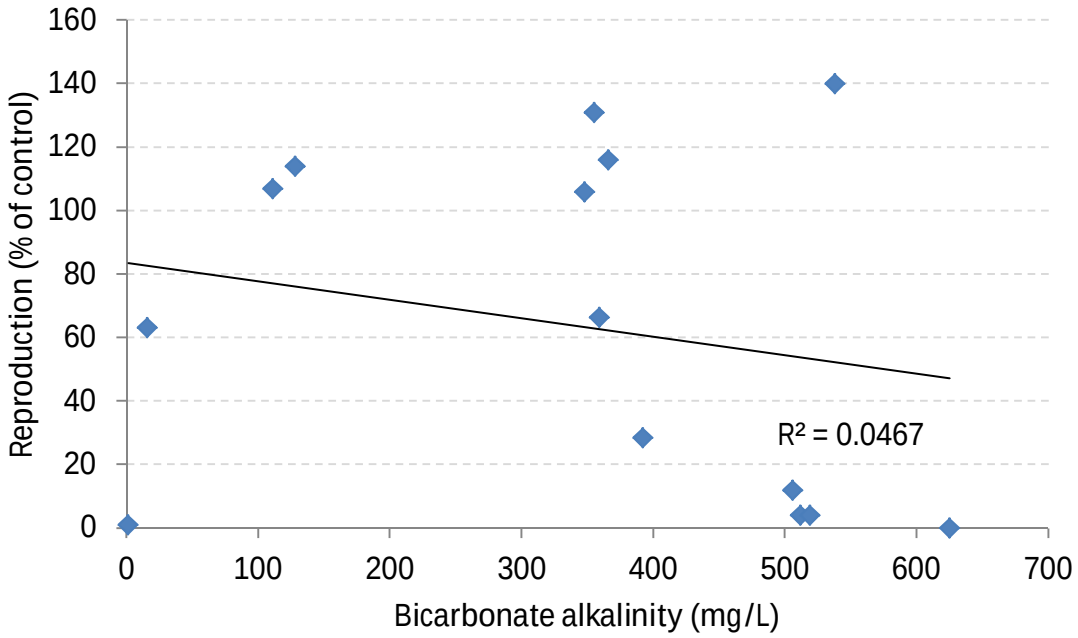


Figure 3-3 Reproduction Toxicity and Bicarbonate Alkalinity Results

3.4.2 Dilution Factor

The target dilution of SV LDP009 discharge to 2.7% (refer Section 3.3.1) is not met under median rainfall conditions. Under 90th percentile rainfall conditions, the target dilution is achieved for water strategy WS1 from Location N, which is situated approximately 5 km upstream of Lake Burragorang. The results indicate that the target dilution of SV LDP009 discharge is not met for water strategies WS2a or WS2b or for the total maximum discharge (AP LDP001 plus SV LDP009 discharges) under any rainfall conditions.

3.4.3 Integrated Catchment Assessment

The aquatic ecological health of the Coxs River has been reported by Cardno (2014a; 2014b), based on monitoring conducted in accordance with the Australian Rivers Assessment System (AUSRIVAS) protocols (Turak *et al.*, 2004). Monitoring of the following four sites on the Coxs River, as shown in Figure 3-4 has been conducted from 2010 to 2012:

- CR1 – Located 700 m upstream of AP LDP001.
- CR2 – Located at the Mount Piper Haul Road crossing, approximately 1 km downstream of AP LDP001.
- CR4 – Located at the Maddox Lane road crossing downstream of AP LDP001, SV LDP009 and discharges from Western Coal Services.
- CR5 – Located at the Main Street road crossing downstream of AP LDP001, SV LDP009 and discharges from Wallerawang Power Station.

Table 3-8 presents the electrical conductivity at each sampling site during aquatic ecology monitoring. Electrical conductivity was found to increase at CR2 downstream of AP LDP001 discharges. However, there were no significant spatial or temporal trends in electrical conductivity during the sampling period between CR2, CR4 and CR5.

Table 3-8 Electrical Conductivity Recorded at Aquatic Ecology Monitoring Points (Cardno, 2014a; 2014b)

Monitoring round	Electrical conductivity (µS/cm)			
	CR1	CR2	CR4	CR5
Autumn 2010	–	944	–	829
Spring 2010	186	560	666	558
Autumn 2011	141	749	930	860
Spring 2011	182	939	853	764
Autumn 2012	92	542	640	704
Spring 2012	99	891	837	817

The assessment of aquatic ecology by Cardno (2014a; 2014b) used a number of indices to assess the condition of each monitoring site, including the following:

- SIGNAL 2 biotic index
- NSW AUSRIVAS model results

The SIGNAL2 score (Stream Invertebrate Grade Number Average Level) is a biotic index based on pollution sensitivity values (grade numbers) assigned to aquatic macroinvertebrate families. Each taxon is assigned a grade from 1 (tolerant) to 10 (sensitive) based on ecotoxicity assessment data. A score of less than 4 indicates severe degradation. The average SIGNAL 2 scores for each of the aquatic ecology monitoring sites is presented in Table 3-9. The results show there is a general trend for macroinvertebrate community assemblage improvement at CR2 and a slight decrease at CR5. However, all sites fit in the moderately degraded category and there are no significant differences between the aquatic ecology community health at all sites.

1:45,000 for A4

0 0.125 0.25 0.5 0.75 1

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Non Centennial Site
- Centennial Site
- Aquatic Ecology Monitoring Location
- Waterway
- Waterbody

LOCATION	-
SEAM	NA
DRAWN	S.M.
CHECKED	F.M.
APPROVED	S.G.
SCALE	Refer to scalebar

Coxs River Ecotoxicology Assesssment

Aquatic Ecology Monitoring Locations (Cardno, 2014a, 2014b)

Centennial Coal

DATE 14/11/2014

Figure 3-4

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2217471\2217471_009_AquaticEcologyMonitoring_A.mxd

LPI: DTDB 2012; Cardno: Aquatic Monitoring Location (2014a, 2014b); Centennial: Aerial Imagery

Table 3-9 Aquatic Ecology SIGNAL 2 Score (Cardno, 2014a; 2014b)

Monitoring round	CR1	CR2	CR4	CR5
Autumn 2010	–	3.6	–	4.0
Spring 2010	4.0	4.0	4.1	4.3
Autumn 2011	4.1	4.7	4.1	4.0
Spring 2011	4.2	4.4	4.6	3.9
Autumn 2012	4.4	4.3	4.6	3.9
Spring 2012	3.9	4.6	3.9	3.7

The NSW AUSRIVAS model provides a river health assessment based on predictive models of macroinvertebrate distribution. Physical and chemical data at each site was used to determine the predicted composition of the macroinvertebrate fauna. The AUSRIVAS morel compares the macroinvertebrate collected at a site (i.e. observed) to those predicted to occur (i.e. expected) at undisturbed reference sites with similar environmental characteristics. An OE50 score was generated, which is a probability score based on predicted occurrence of macroinvertebrate species which ranges from 0 to 1. A score close to 0 indicates an impoverished assemblage and a score close to 1 indicates similarity to the reference site. The following bands are derived from OE50 scores which indicate the level of impact at a site:

- Band A – equivalent to reference condition
- Band B – below reference condition (significantly impaired)
- Band C – well below reference condition (severely impaired)
- Band D – impoverished (i.e. extremely impaired)
- Band X – richer macroinvertebrate assemblage than reference condition

Table 3-10 presents the AUSRIVAS bands for each of the aquatic ecology monitoring sites reported by Cardno (2014a; 2014b). The results indicate that prior to spring 2012, the upstream Coxs River site CR1 was below the reference condition that was expected for an uncontaminated site. The results also show an improvement within macroinvertebrate communities during the sampling periods upstream of CR5.

Table 3-10 Aquatic Ecology AUSRIVAS Bands (Cardno, 2014a; 2014b)

Monitoring round	CR1	CR2	CR4	CR5
Autumn 2011	B	B	B	A
Spring 2011	B	B	B	A
Autumn 2012	B	A	B	B
Spring 2012	A	A	A	B

4. Conclusions

4.1 Ecotoxicology Assessment

The spatial distribution of the sample locations and the toxicity and water quality testing methodologies are considered sufficient to provide information on impacts of mine water discharge from Angus Place Colliery and Springvale Mine on the receiving environment. The results show that the discharge at SV LDP009 is having an acute impact on cladoceran at the Sawyers Swamp Creek site; however this acute toxicity is ameliorated as the discharge enters the Coxs River. Impacts on cladoceran reproduction show a decreasing trend in the Coxs River with distance downstream of the SV LDP009 discharge point until no toxic impacts are detected in the upper portion of Lake Wallace.

The toxicity observed in the SV LDP009 discharge cannot be attributed to any of the water quality parameters tested. The water quality results indicate that the chemistry of the non-toxic AP LDP001 discharge is not significantly different from the toxic SV LDP009 discharge, with the exception of ionic composition.

A comparison of toxicity testing results for SV LDP009 discharge upstream and downstream of water quality treatment indicated that the toxicity observed at SV LDP009 is likely to be related to treatment with flocculants prior to discharge and an ionic imbalance.

It is recommended to investigate the flocculant agent and dosing rates as management actions to ensure that the toxicity of the SV LDP009 discharge is reduced, thus reducing the impact on the Coxs River.

4.2 Integrated Catchment Assessment

The aquatic ecology monitoring results provide supporting evidence that the discharges from AP LDP001 and SV LDP009 are not adversely impacting the aquatic health of the Coxs River. This information supports the findings of the ecotoxicological assessment showing that the electrical conductivity of the Coxs River is not adversely impacting the health of the aquatic ecosystem. Further, the sites downstream of discharges from AP LDP001 were found to have more pollution sensitive taxa present in the macroinvertebrate assemblages (CR2 = 9; CR4 = 6; CR5 = 6) than the upstream CR1 site, which had five pollution sensitive taxa present.

4.3 Coxs River Restoration Program

Centennial has developed the Coxs River Restoration Program as part of a regional biodiversity strategy (RPS, 2014d) that is aimed at further enhancing the biodiversity values of the Coxs River catchment and ameliorating the cumulative impacts associated with Centennial projects and non-Centennial operations in the catchment. Works to improve the terrestrial and aquatic biodiversity value of the Coxs River include the following:

- Watercourse stabilisation activities.
- Removal of grazing pressures.
- Weed removal/control (including blackberry and willow).
- Restoration of riparian areas.
- Revegetation activities with native species.

Further information on the Coxs River Restoration Program is provided by RPS (2014d).

4.4 Assessment Review

It is proposed that Centennial repeat the sampling for this ecotoxicology assessment on a three yearly basis dependent upon water quality results from the assessment locations.

5. References

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Appendices

Appendix A – Flow Gauge Figures

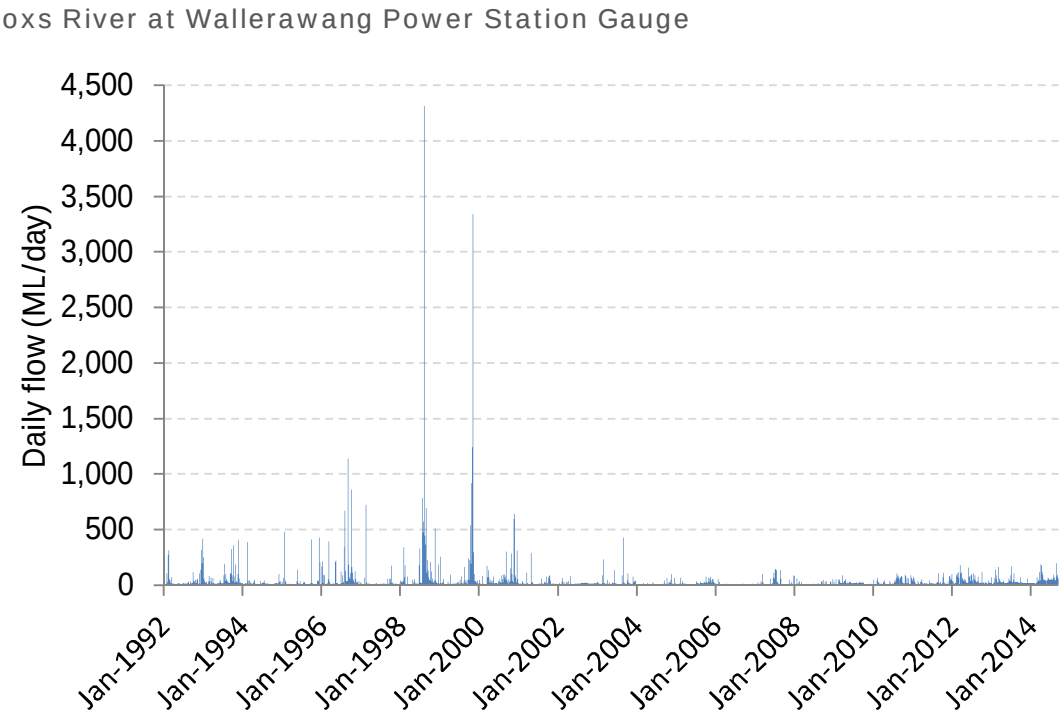


Figure A-1 Observed Flows for Coxs River at Wallerawang Power Station Gauge

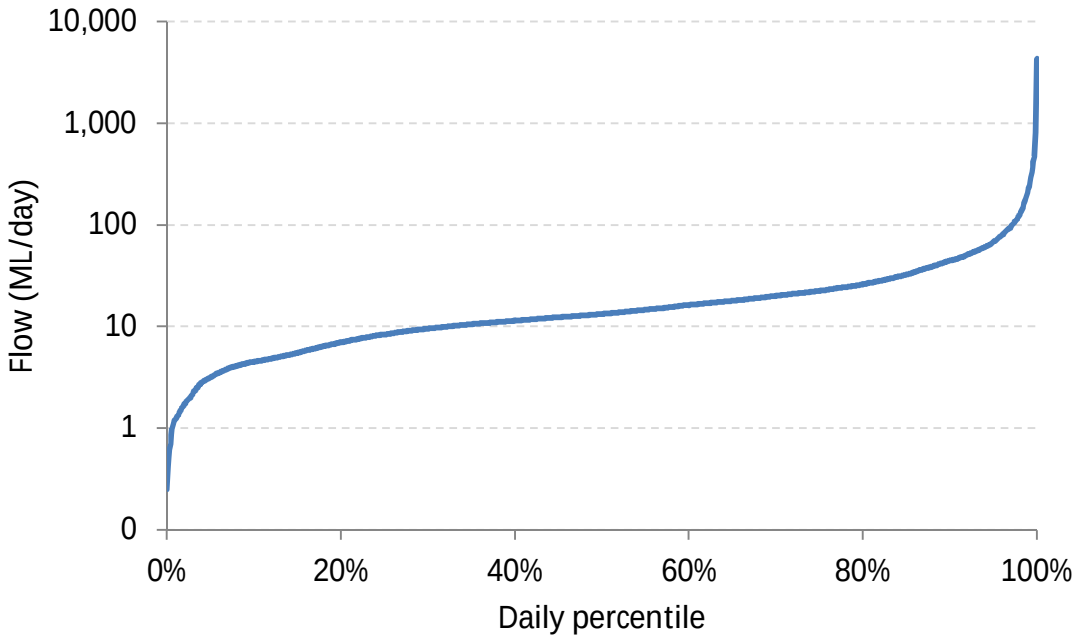


Figure A-2 Daily Flow Percentiles for Coxs River at Wallerawang Power Station Gauge

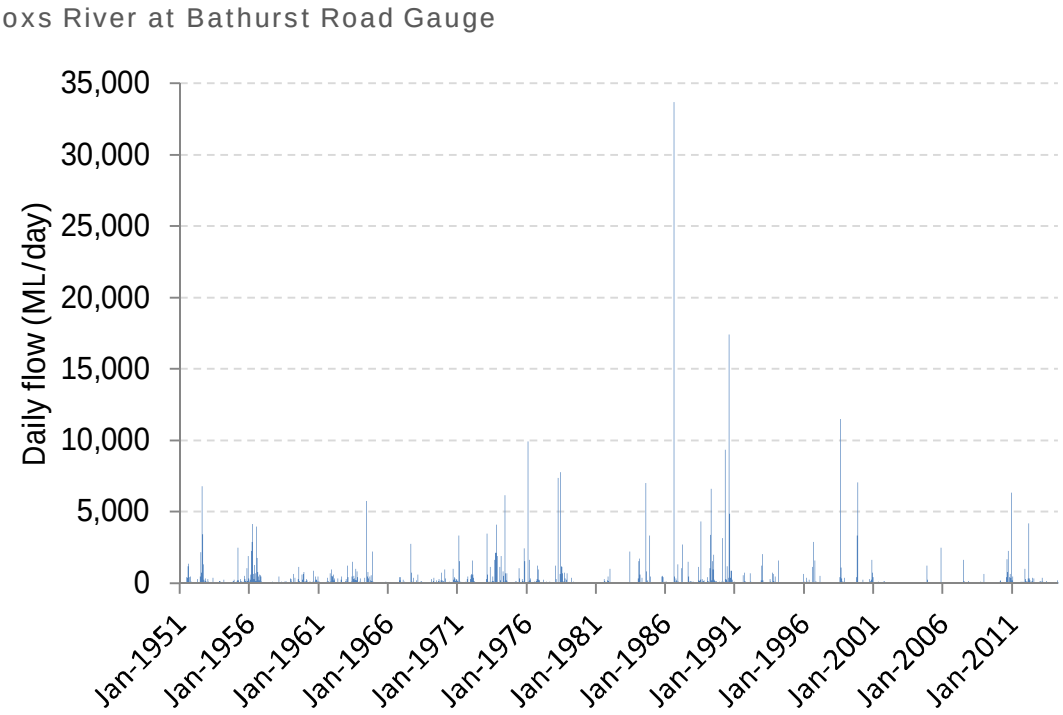


Figure A-3 Observed Flows for Coxs River at Bathurst Road Gauge

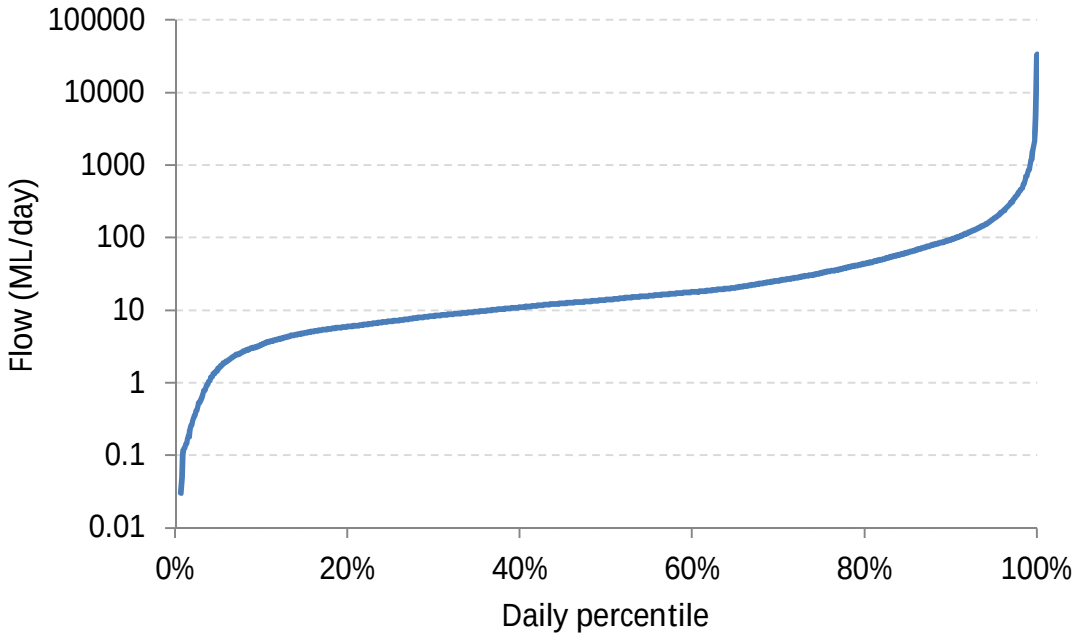


Figure A-4 Daily Flow Percentiles for Coxs River at Bathurst Road Gauge

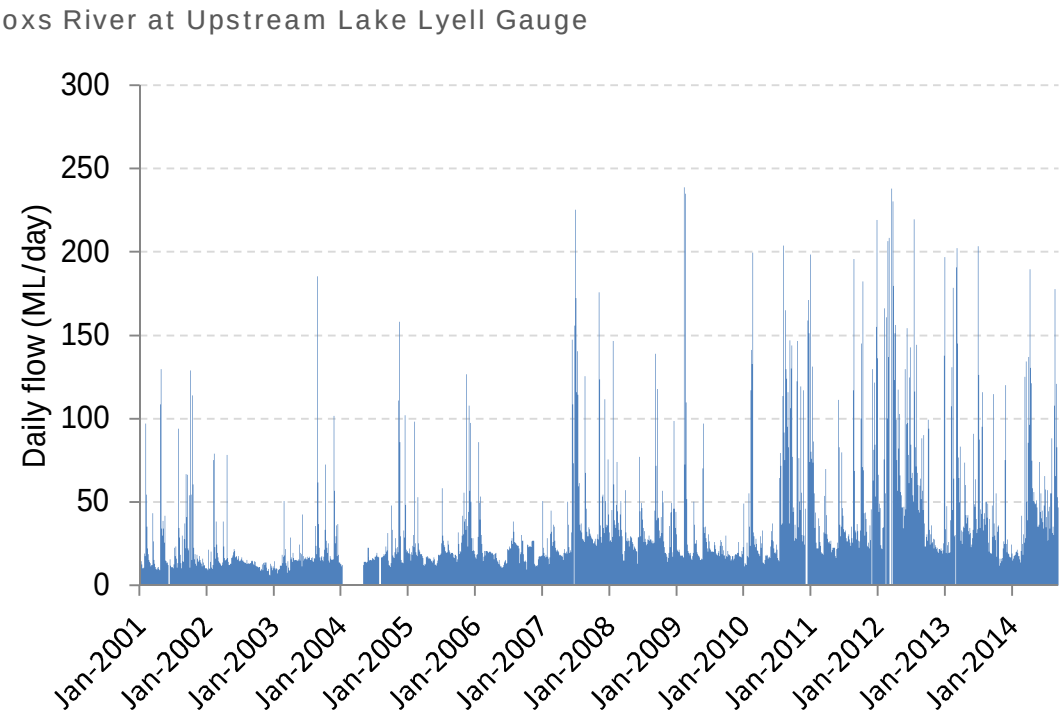


Figure A-5 Observed Flows for Coxs River at Upstream Lake Lyell Gauge

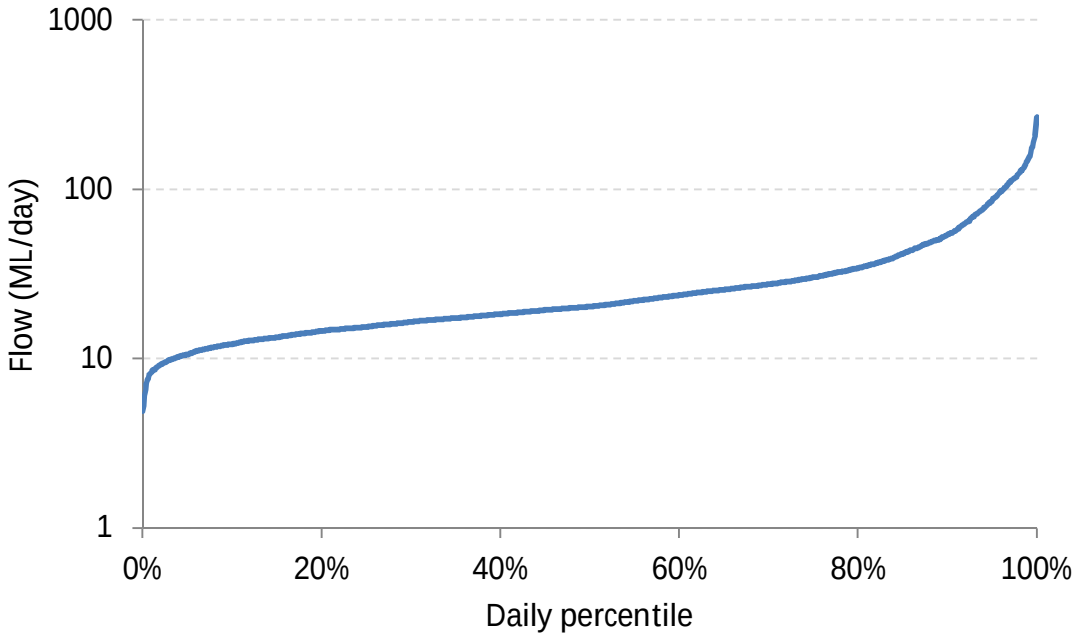


Figure A-6 Daily Flow Percentiles for Coxs River at Upstream Lake Lyell Gauge

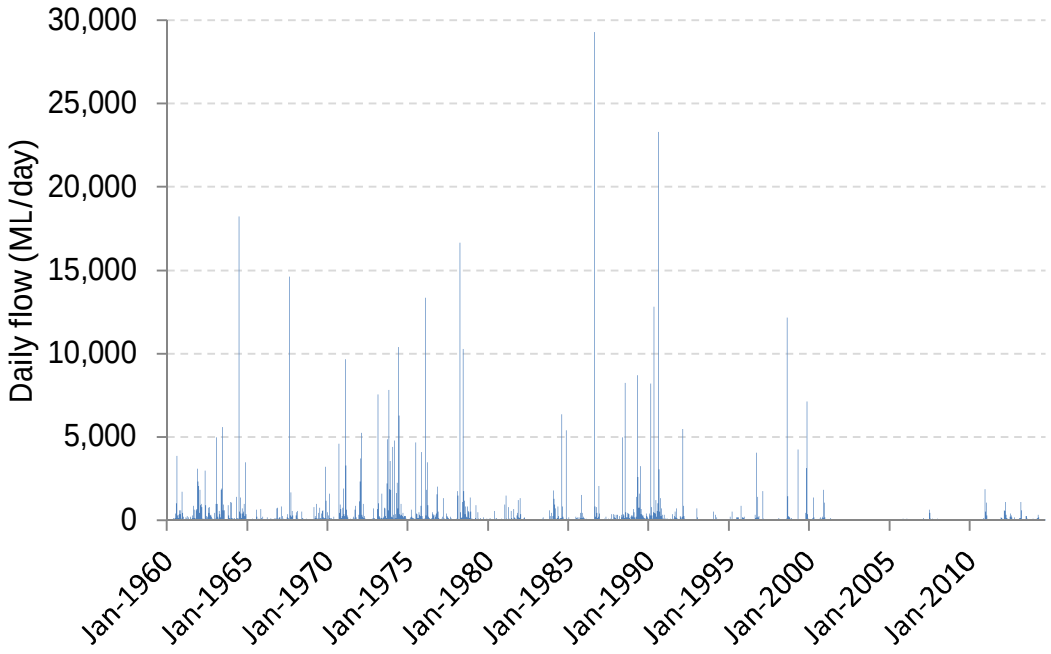


Figure A-7 Observed Flows for Coxs River at Lithgow Gauge

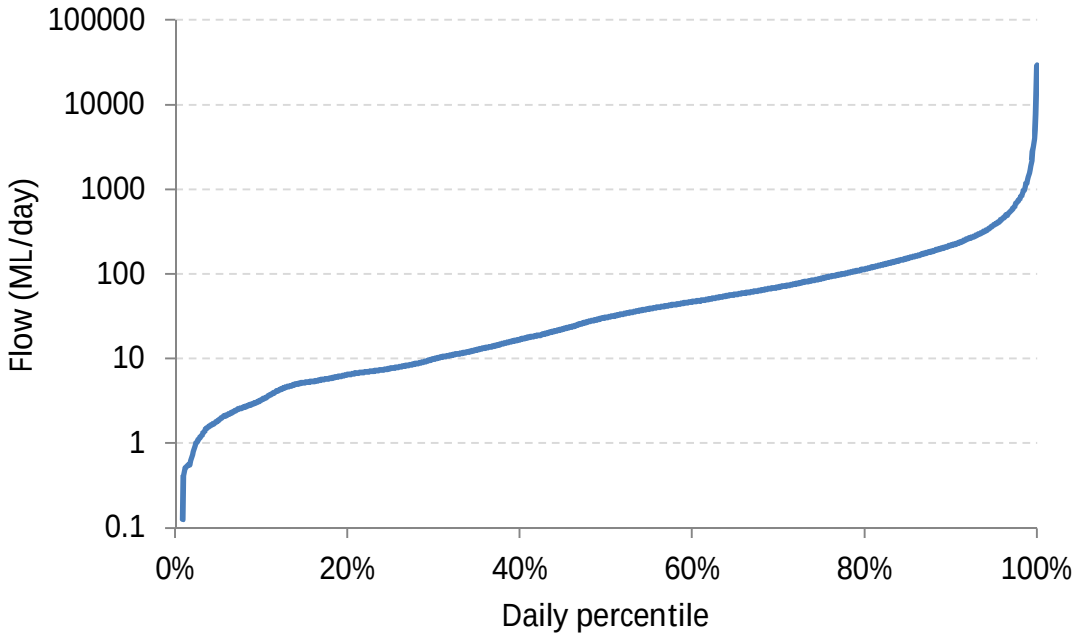


Figure A-8 Daily Flow Percentiles for Coxs River at Lithgow Gauge

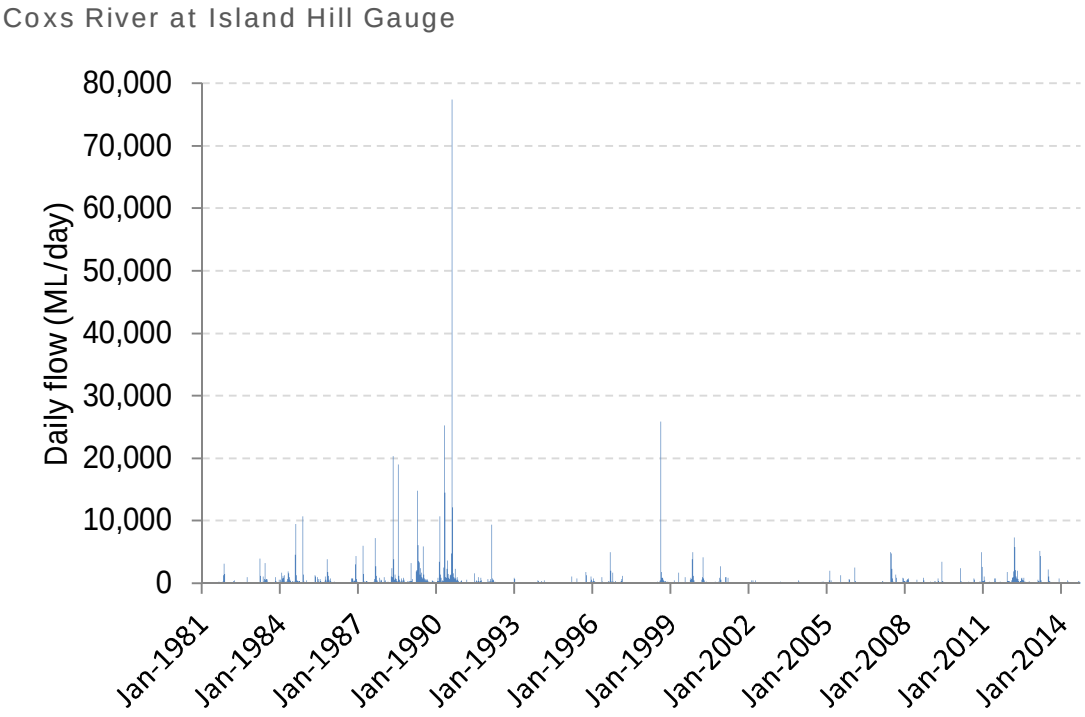


Figure A-9 Observed Flows for Coxs River at Island Hill Gauge

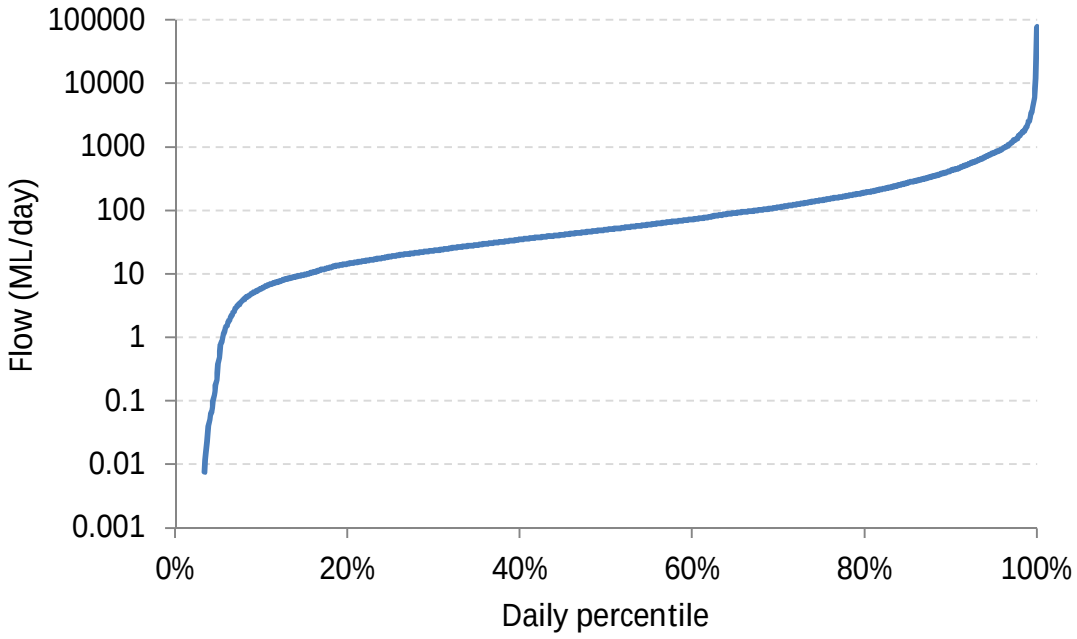


Figure A-10 Daily Flow Percentiles for Coxs River at Island Hill Gauge

Appendix B – Ecotoxicology Report

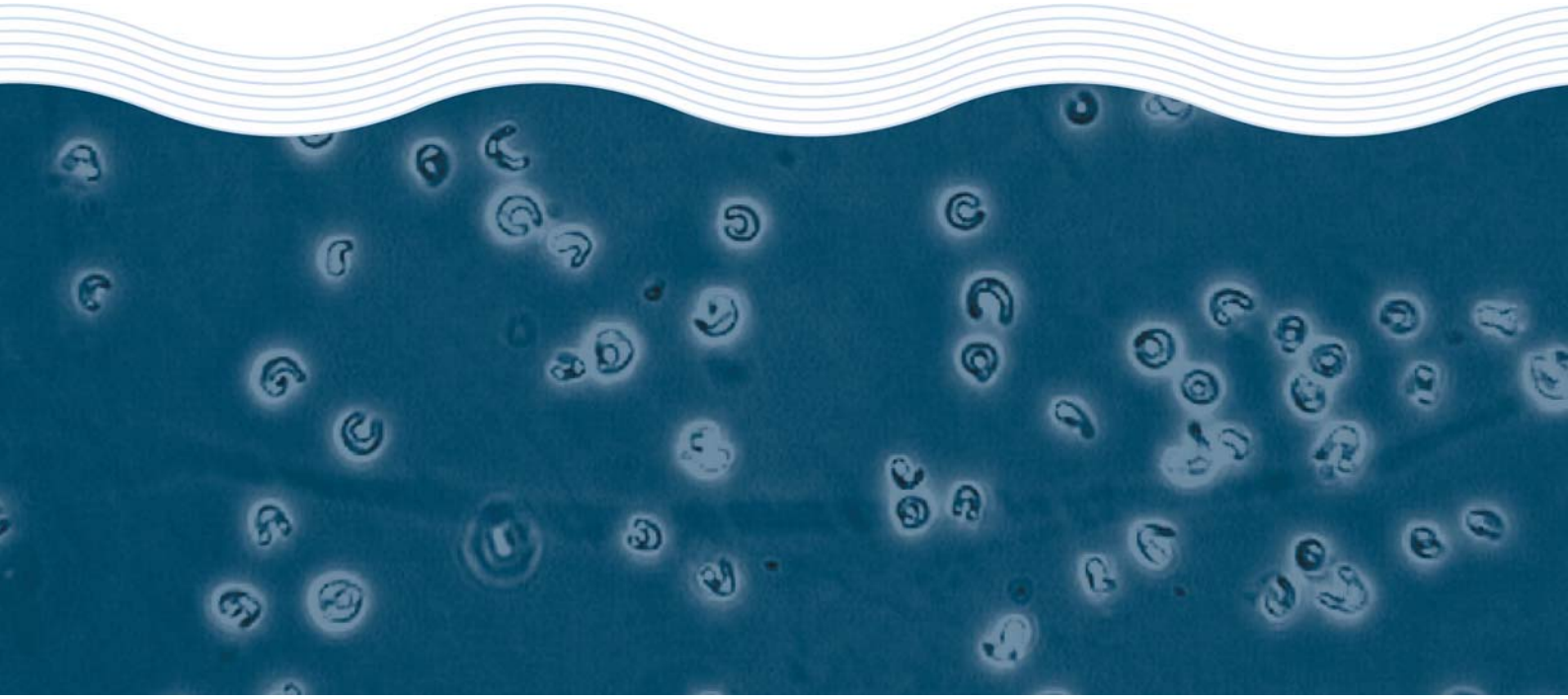
ecotox
SERVICES AUSTRALASIA

Toxicity Assessment of Freshwater Samples

GHD Pty Ltd

Test Report

September 2014



Toxicity Assessment of Freshwater Samples

GHD Pty Ltd

Test Report

September 2014

ECOTOX Services Australasia Pty Ltd ABN>45 094 714 904
unit 27/2 chaplin drive lane cove nsw 2066 T>61 2 9420 9481 F>61 2 9420 9484 W>www.ecotox.com.au

Toxicity Test Report: TR1223/1

Accredited for compliance with ISO/IEC 17025

Client:	GHD Pty Ltd	**ESA Job #:**	PR1223
	GHD Tower, 24 Honeysuckle Drive	**Date Sampled:**	21 August 2014
	Newcastle NSW 2300	**Date Received:**	25 August 2014
Attention:	Stuart Gray	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL1223_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
6808	SVLDP009	Aqueous sample, pH 8.3*, conductivity 1175µS/cm*, total ammonia <2.0mg/L*. Sample received at 16ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	72-hr microalgal growth inhibition test using the green alga *Selenastrum capricornutum*
Test Protocol:	ESA SOP 103 (ESA 2013), based on USEPA (2002)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was filtered to 0.45 µm and then serially diluted with USEPA media. A USEPA control was tested concurrently with the sample.
Source of Test Organisms:	ESA Laboratory culture, originally sourced from CSIRO Microalgal Supply Service, TAS
Test Initiated:	29 August 2014 at 1115h

Sample 6808: *SVLDP009*

Concentration (%)	**Cell Yield x10^4 cells/mL (Mean ± SD)**
USEPA Control	38.2 ± 5.8
3.1	38.8 ± 2.8
6.3	17.5 ± 2.4 *
12.5	9.9 ± 0.7 *
25	7.5 ± 1.3 *
50	7.9 ± 0.4 *
100	3.9 ± 1.6 *

72-hr IC10 = 3.7%**
72-hr IC50 = 6.0 (5.5-6.7)%
NOEC = 3.1%
LOEC = 6.3%

*Significantly lower cell yield compared with the USEPA Control (Wilcoxon Rank Sum Test, 1-tailed, P=0.05)
**95% confidence limits are not reliable

Toxicity Test Report: TR1223/1

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean cell density	≥16.0x10^4 cells/mL	39.2x10^4 cells/mL	Yes
Control coefficient of variation	<20%	15.2%	Yes
Reference Toxicant within cusum chart limits	1.5-6.2g KCl/L	2.4g KCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 September 2014

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

ESA (2013) *ESA SOP 103 – Green Alga, Selenastrum capricornutum, Growth Test*. Issue No 10. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms*. Fourth Edition. EPA-821-R-02-013. United States Environmental Protection Agency, Office of Research and Development, Washington DC, USA,

Toxicity Test Report: TR1223/2

Accredited for compliance with ISO/IEC 17025

Client:	GHD Pty Ltd	**ESA Job #:**	PR1223
	GHD Tower, 24 Honeysuckle Drive	**Date Sampled:**	21 August 2014
	Newcastle NSW 2300	**Date Received:**	25 August 2014
Attention:	Stuart Gray	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL1223_q01

Lab ID No.:	Sample Name:	Sample Description:
6808	SVLDP009	Aqueous sample, pH 8.3*, conductivity 1175µS/cm*, total ammonia <2.0mg/L*. Sample received at 16ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	7-day Growth inhibition of the freshwater aquatic duckweed *Lemna disperma*
Test Protocol:	ESA SOP 112 (ESA 2012), based on OECD method 221 (2006)
Test Temperature:	The test was performed at 25±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was serially diluted with Swedish standard medium (SIS) to achieve the test concentrations. A SIS control was tested concurrently with the sample.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	27 August 2014 at 1100h

Sample 6808: *SVLDP009* **Concentration (%)**	**Specific Growth Rate (Mean ± SD)**	*Vacant*	*Vacant*
SIS Control	0.29 ± 0.04		
3.1	0.21 ± 0.02 *		
6.1	0.24 ± 0.03		
12.1	0.27 ± 0.01		
24.2	0.22 ± 0.04 *		
48.4	0.26 ± 0.01		
96.8	0.29 ± 0.04		
7 day IC10 = <3.1%			
7 day IC50 = >96.8%			
NOEC = 96.8%			
LOEC = >96.8%			

*Significantly lower specific growth rate compared with the SIS Control (Bonferroni t Test, 1-tailed, P=0.05)
**95% confidence limits are not available

Toxicity Test Report: TR1223/2

QA/QC Parameter	Criterion	This Test	Criterion met?
Control specific growth rate	>0.275	0.287	Yes
Reference Toxicant within cusum chart limits	2.3-6.0g KCl/L	3.3g KCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 September 2014

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

ESA (2012) *SOP 112 – Duckweed Growth Inhibition Test.* Issue No. 5. Ecotox Services Australasia, Sydney NSW

OECD (2006) *Lemna sp*. Growth Inhibition Test. Method 221. OECD Guideline for the Testing of Chemicals. Organisation for Economic Cooperation and Development, Paris

Toxicity Test Report: TR1223/3

Accredited for compliance with ISO/IEC 17025

Client:	GHD Pty Ltd	**ESA Job #:**	PR1223
	GHD Tower, 24 Honeysuckle Drive	**Date Sampled:**	21 August 2014
	Newcastle NSW 2300	**Date Received:**	25 August 2014
Attention:	Stuart Gray	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL1223_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
6808	SVLDP009	Aqueous sample, pH 8.3*, conductivity 1175µS/cm*, total ammonia <2.0mg/L*. Sample received at 16ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	96-hr fish imbalance toxicity test using the eastern rainbowfish *Melanotaenia splendida splendida*
Test Protocol:	ESA SOP 117 (ESA 2013), based on USEPA (2002)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was serially diluted with dilute mineral water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the sample.
Source of Test Organisms:	In-house cultures
Test Initiated:	9 September 2014 at 1300h

Sample 6808: *SVLDP009* **Concentration (%)**	**% Unaffected (Mean ± SD)**	*Vacant*	*Vacant*
DMW Control	100 ± 0.0		
3.1	95.0 ± 10.0		
6.3	95.0 ± 10.0		
12.5	95.0 ± 10.0		
25	90.0 ± 11.6		
50	50.0 ± 11.6 *		
100	10.0 ± 11.6 *		
96-hr IC10 = 25.0%**			
96-hr EC50 = 50.0 (40.5-61.7)%			
NOEC = 25%			
LOEC = 50%			

*Significantly lower percentage of unaffected larval fish compared with the DMW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)
**95% confidence limits are not reliable

QA/QC Parameter	**Criterion**	**This Test**	**Criterion met?**
Control mean % unaffected	≥80.0%	100%	Yes
Reference Toxicant within cusum chart limits	5.7-79.3µg Cu/L	47.4µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 September 2014

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

ESA (2013) SOP 117 –*Freshwater and Marine Fish Imbalance Test*. Issue No 10. Ecotox Services Australasia, Sydney, NSW

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth edition EPA-821-R-02-012. United States Environmental Protection Agency, Office of Research and Development, Washington FC, USA

Toxicity Test Report: TR1223/4

Accredited for compliance with ISO/IEC 17025

Client:	GHD Pty Ltd	**ESA Job #:**	PR1223
	GHD Tower, 24 Honeysuckle Drive	**Date Sampled:**	21 August 2014
	Newcastle NSW 2300	**Date Received:**	25 August 2014
Attention:	Stuart Gray	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL1223_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
6808	SVLDP009	Aqueous sample, pH 8.3*, conductivity 1175µS/cm*, total ammonia <2.0mg/L*. Sample received at 16ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	96-hr acute toxicity test using the freshwater hydra *hydra viridissima*
Test Protocol:	ESA SOP 125 (2013), based on Riethmuller et al. (2003)
Test Temperature:	The test was performed at 27±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The sample was serially diluted with Laboratory Water to achieve the test concentrations. A Laboratory Water control was tested concurrently with the sample.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	26 August 2014 at 1330h

Sample 6808: *SVLDP009* **Concentration (%)**	**Population Growth Rate (Mean ± SD)**	*Vacant*	*Vacant*
Lab Control	0.37 ± 0.0		
3.1	0.35 ± 0.02		
6.3	0.33 ± 0.02 *		
12.5	0.25 ± 0.04 *		
25	0.11 ± 0.06 *		
50	0.03 ± 0.03 *		
100	0.00 ± 0.00		
96-hr EC10 = 5.1%**			
96-hr EC50 = 18.0 (14.0-24.8)%			
NOEC = 3.1%			
LOEC = 6.3%			

*Significantly lower population growth rate compared with the Lab Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)
**95% confidence limits are not reliable

Toxicity Test Report: TR1223/4

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean population growth rate	≥0.25	0.374	Yes
Reference Toxicant within cusum chart limits	0.9-12.6µg Cu/L	5.8µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 September 2014

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

ESA (2013) SOP 125 –*Hydra Population Growth Test.* Issue No 3. Ecotox Services Australasia, Sydney, NSW

Riethmuller N, Camilleri C, Franklin N, Hogan A, King A, Koch A, Markich SJ, Turley C and van Dam R (2003). Green Hydra Population Growth Test. In: *Ecotoxicological testing protocols for Australian tropical freshwater ecosystems*. Supervising Scientist Report 173, Supervising Scientist, Darwin NT.

Toxicity Test Report: TR1223/5

Accredited for compliance with ISO/IEC 17025

Client:	GHD Pty Ltd	**ESA Job #:**	PR1223
	GHD Tower, 24 Honeysuckle Drive	**Date Sampled:**	21 August 2014
	Newcastle NSW 2300	**Date Received:**	25 August 2014
Attention:	Stuart Gray	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL1223_q01

Lab ID No.:	Sample Name:	Sample Description:
6808	SVLDP009	Aqueous sample, pH 8.3*, conductivity 1175µS/cm*, total ammonia <2.0mg/L*. Sample received at 16ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia*
Test Protocol:	ESA SOP 102 (ESA 2013), based on USEPA (2002) and Bailey *et al*. (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	The test was extended to 8 days
Comments on Solution Preparation:	The sample was serially diluted with Dilute Mineral Water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the sample.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	28 August 2014 at 1330h

Sample 6808: *SVLDP009*

Concentration (%)	% Survival at 8 days (Mean ± SD)
DMW Control	90.0 ± 31.6
3.1	80.0 ± 42.2
6.3	100 ± 0.0
12.5	100 ± 0.0
25	90.0 ± 31.6
50	70.0 ± 48.3
100	0.0 ± 0.0

8 day IC10 (survival) = 34.0%*
8 day EC50 (survival) = 58.6 (48.0-71.7)%
NOEC = 50%
LOEC = 100%

Sample 6808: *SVLDP009*

Concentration (%)	Number of Young (Mean ± SD)	
DMW Control	15.3 ± 6.2	
3.1	18.1 ± 5.5	
6.3	18.3 ± 4.5	
12.5	13.7 ± 8.3	
25	9.2 ± 5.2	
50	5.6 ± 5.4	**
100	0.0 ± 0.0	

8 day IC10 (reproduction) = 9.3 (5.2-16.0)%
8 day IC50 (reproduction) = 29.1 (16.3-50.3)%
NOEC = 25%
LOEC = 50%

*95% confidence limits are not reliable
**Significantly lower young compared with the DMW Control (Dunnett's Test, 1-tailed, P=0.05)

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % survival	≥80.0%	90.0%	Yes
Control mean number of young	≥15.0	16.6	Yes
Reference Toxicant within cusum chart limits	138.8-478.6KCl/L	219.6mg KCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 September 2014

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2013) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia.* Issue No 9. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR1223/6

Accredited for compliance with ISO/IEC 17025

Client:	GHD Pty Ltd	**ESA Job #:**	PR1223
	GHD Tower, 24 Honeysuckle Drive	**Date Sampled:**	21 August 2014
	Newcastle NSW 2300	**Date Received:**	25 August 2014
Attention:	Stuart Gray	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL1223_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
6807	APLDP001	Aqueous sample, pH8.0*, conductivity 1038µS/cm. Sample received at 16ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia*
Test Protocol:	ESA SOP 102 (ESA 2013), based on USEPA (2002) and Bailey *et al*. (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	The test was extended to 8 days
Comments on Solution Preparation:	The sample was serially diluted with Dilute Mineral Water (DMW) to achieve the test concentrations. A DMW control was tested concurrently with the sample.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	4 September 2014 at 1500h

Sample 6807: *APLDP001*

Concentration (%)	**% Survival at 8 days (Mean ± SD)**
DMW Control	90.0 ± 31.6
3.1	90.0 ± 31.6
6.3	100 ± 0.0
12.5	100 ± 0.0
25	90.0 ± 31.6
50	100 ± 0.0
100	90.0 ± 31.6

8 day EC10 (survival) = >100%
8 day EC50 (survival) = >100%
NOEC = 100%
LOEC = >100%

Sample 6807: *APLDP001*

Concentration (%)	**Number of Young (Mean ± SD)**
DMW Control	13.6 ± 6.0
3.1	16.1 ± 7.3
6.3	15.2 ± 5.3
12.5	20.1 ± 5.8
25	17.4 ± 7.6
50	25.2 ± 4.2
100	19.1 ± 9.1

8 day IC10 (reproduction) = >100%
8 day IC50 (reproduction) = >100%
NOEC = 100%
LOEC = >100%

*95% confidence limits not reliable

QA/QC Parameter	**Criterion**	**This Test**	**Criterion met?**
Control mean % survival	≥80.0%	90.0%	Yes
Control mean number of young	≥15.0	15.1	Yes
Reference Toxicant within cusum chart limits	137.8-480.2mg KCl/L	238.0mg KCl/L	Yes

Test Report Authorised by:  Dr Rick Krassoi, Director on 25 September 2014

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2013) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia.* Issue No 9. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR1223/7

Accredited for compliance with ISO/IEC 17025

Client:	GHD Pty Ltd	**ESA Job #:**	PR1223
	GHD Tower, 24 Honeysuckle Drive	**Date Sampled:**	21 & 22 August 2014
	Newcastle NSW 2300	**Date Received:**	25 August 2014
Attention:	Stuart Gray	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL1223_q01

Lab ID No.:	Sample Name:	Sample Description:
6809	SVLDP009 DS	Aqueous sample, pH 8.8*, conductivity 1089µS/cm*. Sample received at 16ºC* in apparent good condition.
6810	MADDOX	Aqueous sample, pH 8.6*, conductivity 1007µS/cm*. Sample received at 16ºC* in apparent good condition.
6811	LAKE WALLACE	Aqueous sample, pH 8.5*, conductivity 986µS/cm*. Sample received at 16ºC* in apparent good condition.
6812	WANGOL	Aqueous sample, pH 7.7*, conductivity 806µS/cm*. Sample received at 16ºC* in apparent good condition.
6813	COXS DS LYELL	Aqueous sample, pH 8.3*, conductivity 506µS/cm*. Sample received at 16ºC* in apparent good condition.
6814	COXS US LYELL	Aqueous sample, pH 8.7*, conductivity 1049µS/cm*. Sample received at 16ºC* in apparent good condition.
6815	LAKE LYELL	Aqueous sample, pH 8.4*, conductivity 547µS/cm*. Sample received at 16ºC* in apparent good condition.
6816	WPS	Aqueous sample, pH 8.4*, conductivity 949µS/cm*. Sample received at 16ºC* in apparent good condition.
6817	COXS US	Aqueous sample, pH 6.6*, conductivity 41.5µS/cm*. Sample received at 16ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia*
Test Protocol:	ESA SOP 102 (ESA 2013), based on USEPA (2002) and Bailey *et al*. (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	The test was extended to 8 days
Comments on Solution Preparation:	The samples were tested without dilution (i.e. 100% only). A DMW control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	11 September 2014 at 1415h

Toxicity Test Report: TR1223/7

Sample 6809-6817: *Various* **Sample ID**	**% Survival at 8 days (Mean ± SD)**	
DMW Control	90.0 ± 31.6	
SVLDP009 DS	80.0 ± 42.2	
MADDOX	100 ± 0.0	
LAKE WALLACE	100 ± 0.0	
WANGOL	100 ± 0.0	
COXS DS LYELL	100 ± 0.0	
COXS UD LYELL	100 ± 0.0	
LAKE LYELL	90.0 ± 31.6	
WPS	100 ± 0.0	
COXS US	40.0 ± 51.6	*

Sample 6809-6817: *Various* **Sample ID**	**Number of Young (Mean ± SD)**	
DMW Control	19.3 ± 7.2	
SVLDP009 DS	0.8 ± 1.7	**
MADDOX	5.5 ± 5.2	**
LAKE WALLACE	22.3 ± 6.2	
WANGOL	13.6 ± 4.8	
COXS DS LYELL	21.9 ± 4.6	
COXS UD LYELL	20.5 ± 8.2	
LAKE LYELL	20.6 ± 7.7	
WPS	12.8 ± 6.7	
COXS US	0.2 ± 0.6	**

*Significantly lower percentage survival compared with the DMW Control (Bonferroni adjusted t Test, 1-tailed, P=0.05)
**Significantly lower young compared with the DMW Control (Bonferroni adjusted t Test, 1-tailed, P=0.05)

QA/QC Parameter	**Criterion**	**This Test**	**Criterion met?**
Control mean % survival	≥80.0%	90.0%	Yes
Control mean number of young	≥15.0	21.3	Yes
Reference Toxicant within cusum chart limits	137.8-479.6mg KCl/L	274.3mg KCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 25 September 2014

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2013) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia.* Issue No 9. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

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Chain-of-Custody Documentation

Datasheet ID: 601.2
Last Revised: 30 April 2009

Sample Receipt Notification

Attention : Tess Davies

Client : GHD Pty Ltd
GHD Tower, Level 3, 24 Hneysuckle Drive
Newcastle NSW 2300

Email : tess.davies@ghd.com
Telephone : 02 49799993
Facsimile :

Date : 25/08/2014

Re : Receipt of Samples **Pages : 3**

ESA Project : PR1223 ☑ For Review ☐ Additional Documentation Required - Please Respond

Sample Delivery Details

Completed Chain of Custody accompanied samples: **YES**
Samples received in apparent good condition and correctly bottled: **YES**
Security seals on sample bottles and esky intact: **YES**

Date samples received : 25/08/2014
Time samples received : 9:50
No. of samples received : 12
Sample matrix : Aqueous
Sample temperature : 16°C

Comments : Includes 2x5L APLDP001 (ESA ID# 6801, 9x5L SVLDP009 (ESA ID# 6808),
1x1L SV LDP009 DS (ESA ID# 6809), 1x1L MADDOX (ESA ID# 6810)
1x1L LAKE WALLACE (ESA ID# 6811), 1x1L WANGOL (ESA ID# 6812)
1x1L COXS DS LYELL (ESA ID# 6813), 1x1L COXS US LYELL (ESA ID# 6814)
1x1L LAKE LYELL (ESA ID# 6815), 1x1L WPS (ESA ID# 6816)
1x1L COXS US (ESA iD# 6817)

Contact Details

Customer Services Officer : Tina Micevska
Telephone : 61 2 9420 9481
Facsimile : 61 2 9420 9484
Email : tmicevska@ecotox.com.au

Please contact customer services officer for all queries or issues regarding samples

Note that the chain-of-custody provides definitive information on the tests to be performed

Ecotox Services Australia
ABN 45 094 714 904
Unit 27, 2 Chaplin Drive
Lane Cove NSW 2066 Australia

Phone : 61 2 9420 9481
Fax : 61 2 9420 9484
Email : info@ecotox.com.au

Chain-of-Custody / Service Request Form

Datasheet ID: 601.1
Last Revised: 15 July 2014

ecotox SERVICES AUSTRALASIA

Customer: GHD
Contact Name: Stuart Gray
Phone: 0401416936 Email: Stuart.gray@ghd.com (please provide an email address for sample receipt notification)
Sampled by: Stuart Gray

Ship To:
Attention:

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance): Chronic Cerio	Algal growth Sc	Duckweed Ld	Chronic fish	Hydra		Comments / Instructions
21/8		AP LDP001	Grab	2x 5L	x	~~x~~	~~x~~	~~x~~			All dilutions (3.125%) also)
21/8		SV LDP009	|	9x 5L	x	x	x	x	x		All dilutions (3.125% also)
21/8		COXS US	|	1 x 1L	x						100% conc only
21/8		SV LDP009 DS	|	|	|						|
21/8		MADDOX	|	|	|						
22/8		LAKE WALLACE	|	|	|						
21/8		WANGCOL	|	|	|						

Note that testing will be delayed if an incomplete chain of custody is received

- Additional treatment of samples (i.e. spiking)
- Sub-contracted services (i.e. chemical analyses)
- Dilutions required (if different than 100% down to 6.25%)
- Sample holding time restriction (if applicable)
- Sample used for litigation (if applicable)

Note: An MSDS must be attached if Available

ESA Project Number: PR

1) Released By:	Date:	2) Received By: Tina	Date: 25/8/14	3) Released By:	Date:	4) Received By:	Date:
Of:	Time:	Of: ESA	Time: 9:50	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australasia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

Chain-of-Custody / Service Request Form

Datasheet ID: 601.1
Last Revised: 15 July 2014

ecotox SERVICES AUSTRALASIA

Customer: GHD
Contact Name: Stuart Gray
Phone: 0401416936 Email: Stuart.gray@ghd.com (please provide an email address for sample receipt notification)
Sampled by: Stuart Gray

Ship To:
Attention:

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance)						Comments / Instructions
					Chronic cerio						**Note that testing will be delayed if an incomplete chain of custody is received** • Additional treatment of samples (i.e. spiking) • Sub-contracted services (i.e. chemical analyses) • Dilutions required (if different than 100% down to 6.25%) • Sample holding time restriction (if applicable) • Sample used for litigation (if applicable) *Note: An MSDS must be attached if Available* **ESA Project Number: PR_____**
6813 22/8		COXS DS LYELL	Grab	1 x 1L	x						100% Conc only
6814 22/8		COXS US LYELL	|	|	|						|
6815 22/8		LAKE LYELL									
6816 22/8		WPS									
16°											

1) Released By:	Date:	2) Received By:	Date:	3) Released By:	Date:	4) Received By:	Date:
Of:	Time:	Of:	Time:	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australasia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

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Statistical Printouts for the *Selenastrum* Growth Inhibition Tests

Microalgal Growth inhibition Test-Growth-Cell Yield

Start Date:	29/08/2014 11:15	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	1/09/2014 10:30	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 103	Test Species:	SC-Selenastrum capricornutum
Comments:					

Conc-%	1	2	3	4	5	6	7	8
USEPA Control	479157.1	387157.1	349157.1	333157.1	391157.1	377157.1	443157.1	299157.1
3.1	369157.1	403157.1	419157.1	359157.1				
6.3	163157.1	193157.1	195157.1	147157.1				
12.5	105157.1	95157.1	91157.1	105157.1				
25	91157.1	77157.1	69157.1	61157.1				
50	77157.1	73157.1	81157.1	83157.1				
100	25157.1	25157.1	51157.1	53157.1				

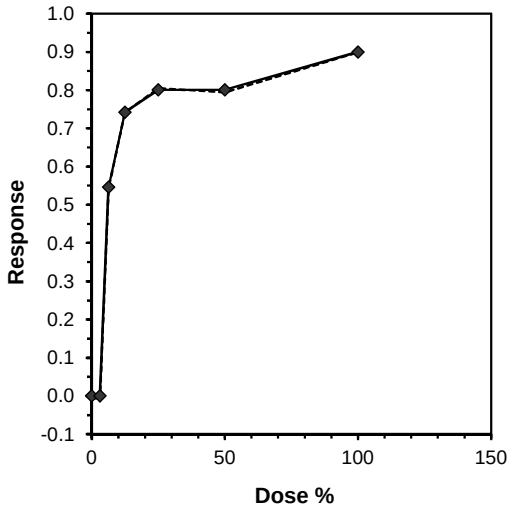
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
USEPA Control	382407.1	1.0000	382407.1	299157.1	479157.1	15.197	8			385032.1	1.0000
3.1	387657.1	1.0137	387657.1	359157.1	419157.1	7.276	4	28.00	12.00	385032.1	1.0000
*6.3	174657.1	0.4567	174657.1	147157.1	195157.1	13.432	4	10.00	12.00	174657.1	0.4536
*12.5	99157.1	0.2593	99157.1	91157.1	105157.1	7.179	4	10.00	12.00	99157.1	0.2575
*25	74657.1	0.1952	74657.1	61157.1	91157.1	17.136	4	10.00	12.00	76657.1	0.1991
*50	78657.1	0.2057	78657.1	73157.1	83157.1	5.638	4	10.00	12.00	76657.1	0.1991
*100	38657.1	0.1011	38657.1	25157.1	53157.1	40.380	4	10.00	12.00	38657.1	0.1004

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.917041	0.93	0.474902	3.761286
Bartlett's Test indicates unequal variances (p = 3.11E-04)	25.21748	16.81189		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Wilcoxon Rank Sum Test	3.1	6.3	4.419276	32.25806
Treatments vs USEPA Control				

Linear Interpolation (200 Resamples)

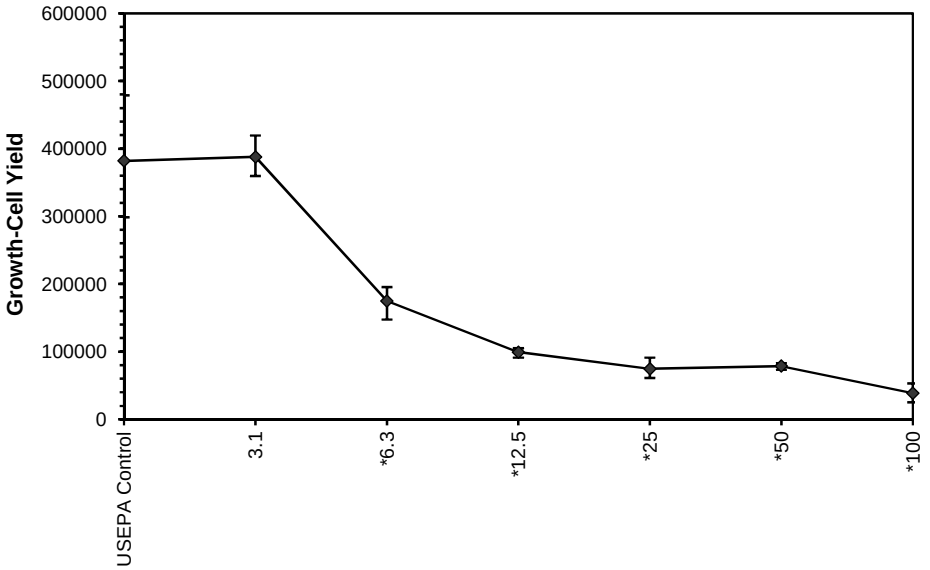
Point	%	SD	95% CL(Exp)		Skew
IC05	3.3928	0.5185	0.2409	3.4425	-2.4593
IC10	3.6857	0.2528	2.3418	3.7851	-3.6327
IC15	3.9785	0.1891	3.0268	4.1276	-2.1668
IC20	4.2713	0.1764	3.4243	4.4702	-1.6081
IC25	4.5642	0.1722	3.7908	4.8127	-1.3398
IC40	5.4427	0.1737	4.8650	5.8404	-0.4644
IC50	6.0283	0.2106	5.4512	6.7251	0.7568



Microalgal Growth inhibition Test-Growth-Cell Yield

Start Date:	29/08/2014 11:15	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	1/09/2014 10:30	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 103	Test Species:	SC-Selenastrum capricornutum
Comments:					

Dose-Response Plot



Microalgal Growth inhibition Test-Growth-Cell Yield

Start Date:	29/08/2014 11:15	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	1/09/2014 10:30	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 103	Test Species:	SC-Selenastrum capricornutum
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
USEPA Control	Cell Yield	38.24	29.92	47.92	5.81	6.30	8
3.1		38.77	35.92	41.92	2.82	4.33	4
6.3		17.47	14.72	19.52	2.35	8.77	4
12.5		9.92	9.12	10.52	0.71	8.51	4
25		7.47	6.12	9.12	1.28	15.15	4
50		7.87	7.32	8.32	0.44	8.47	4
100		3.87	2.52	5.32	1.56	32.32	4
USEPA Control	pH	7.60	7.60	7.60	0.00	0.00	1
3.1		7.70	7.70	7.70	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.20	8.20	8.20	0.00	0.00	1
100		8.20	8.20	8.20	0.00	0.00	1
USEPA Control	Conductivity uS/cm	93.70	93.70	93.70	0.00	0.00	1
3.1		131.50	131.50	131.50	0.00	0.00	1
6.3		167.50	167.50	167.50	0.00	0.00	1
12.5		243.00	243.00	243.00	0.00	0.00	1
25		389.00	389.00	389.00	0.00	0.00	1
50		673.00	673.00	673.00	0.00	0.00	1
100		1231.00	1231.00	1231.00	0.00	0.00	1

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Statistical Printouts for the Duckweed Growth Inhibition Tests

Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	27/08/2014 11:00	Test ID:	PR1223/03	Sample ID:	SV LDP009
End Date:	3/09/2014 10:30	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 112	Test Species:	LD-Lemna disperma
Comments:					

Conc-%	1	2	3	4	5	6	7
SIS Control	0.2728	0.2369	0.2830	0.2780	0.3253	0.3608	0.2499
3	0.1888	0.2299	0.2149	0.2149			
6.1	0.2499	0.2499	0.2560	0.1888			
12.1	0.2780	0.2780	0.2499	0.2560			
24.2	0.2618	0.1684	0.2067	0.2560			
48.4	0.2618	0.2780	0.2435	0.2618			
96.8	0.2925	0.3393	0.2878	0.2299			

			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
SIS Control	0.2867	1.0000	0.2867	0.2369	0.3608	15.007	7				0.2867	1.0000
*3	0.2121	0.7399	0.2121	0.1888	0.2299	8.050	4	3.477	2.574	0.0552	0.2476	0.8637
6.1	0.2361	0.8237	0.2361	0.1888	0.2560	13.414	4	2.356	2.574	0.0552	0.2476	0.8637
12.1	0.2655	0.9260	0.2655	0.2499	0.2780	5.530	4	0.989	2.574	0.0552	0.2476	0.8637
*24.2	0.2232	0.7786	0.2232	0.1684	0.2618	19.768	4	2.959	2.574	0.0552	0.2476	0.8637
48.4	0.2613	0.9114	0.2613	0.2435	0.2780	5.388	4	1.184	2.574	0.0552	0.2476	0.8637
96.8	0.2874	1.0025	0.2874	0.2299	0.3393	15.589	4	-0.034	2.574	0.0552	0.2476	0.8637

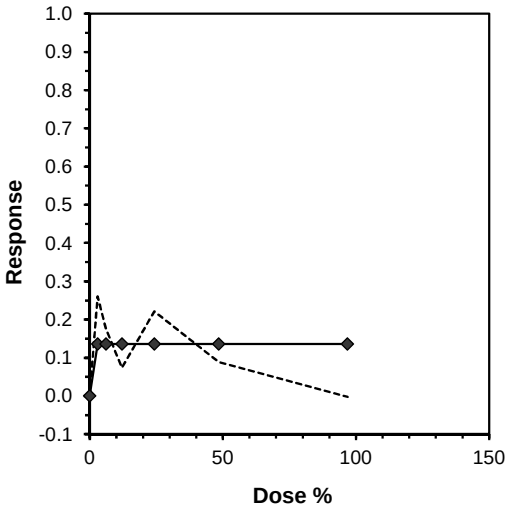
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.972848	0.929	0.075285	0.252535
Bartlett's Test indicates equal variances (p = 0.23)	8.178167	16.81189		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test	96.8	>96.8		1.033058	0.055189	0.192518	0.004095	0.001171	0.012518	6, 24
Treatments vs SIS Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05*	1.1006			
IC10*	2.2011			
IC15	>96.8			
IC20	>96.8			
IC25	>96.8			
IC40	>96.8			
IC50	>96.8			

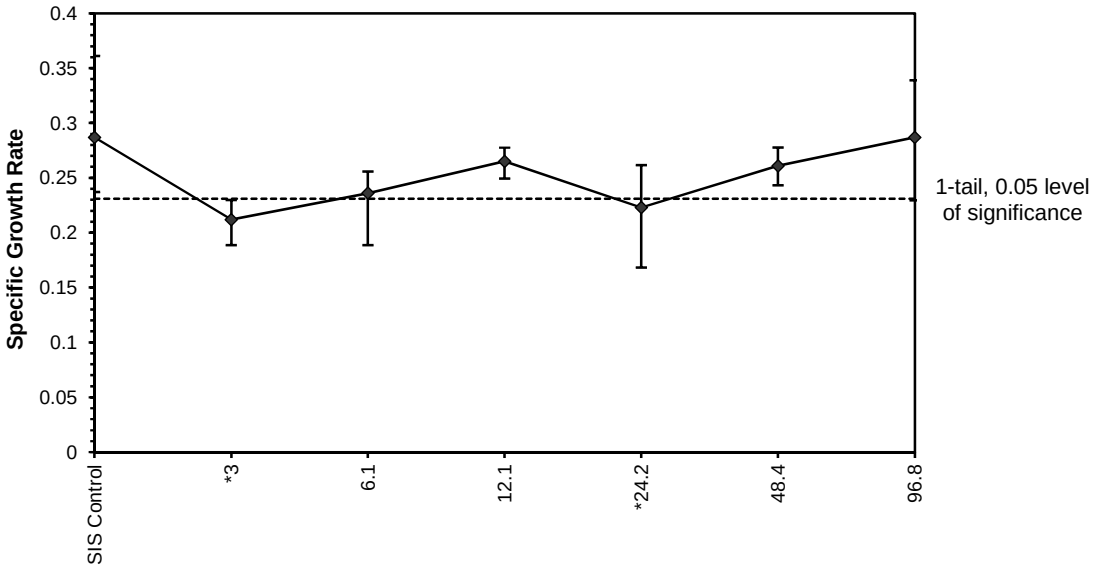
* indicates IC estimate less than the lowest concentration



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	27/08/2014 11:00	Test ID:	PR1223/03	Sample ID:	SV LDP009
End Date:	3/09/2014 10:30	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 112	Test Species:	LD-Lemna disperma
Comments:					

Dose-Response Plot



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	27/08/2014 11:00	Test ID:	PR1223/03	Sample ID:	SV LDP009
End Date:	3/09/2014 10:30	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 112	Test Species:	LD-Lemna disperma
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
SIS Control	Specific growth rate	0.29	0.24	0.36	0.04	72.35	7
3		0.21	0.19	0.23	0.02	61.60	4
6.1		0.24	0.19	0.26	0.03	75.37	4
12.1		0.27	0.25	0.28	0.01	45.64	4
24.2		0.22	0.17	0.26	0.04	94.11	4
48.4		0.26	0.24	0.28	0.01	45.41	4
96.8		0.29	0.23	0.34	0.04	73.65	4
SIS Control	pH	6.40	6.40	6.40	0.00	0.00	1
3		6.70	6.70	6.70	0.00	0.00	1
6.1		6.90	6.90	6.90	0.00	0.00	1
12.1		7.20	7.20	7.20	0.00	0.00	1
24.2		7.60	7.60	7.60	0.00	0.00	1
48.4		7.90	7.90	7.90	0.00	0.00	1
96.8		8.30	8.30	8.30	0.00	0.00	1
SIS Control	Cond uS/cm	309.00	309.00	309.00	0.00	0.00	1
3		331.00	331.00	331.00	0.00	0.00	1
6.1		362.00	362.00	362.00	0.00	0.00	1
12.1		427.00	427.00	427.00	0.00	0.00	1
24.2		563.00	563.00	563.00	0.00	0.00	1
48.4		829.00	829.00	829.00	0.00	0.00	1
96.8		1380.00	1380.00	1380.00	0.00	0.00	1

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Statistical Printouts for the Larval Fish Imbalance Tests

Fish Acute Toxicity Test-96 hr Imbalance

Start Date:	9/09/2014 13:00	Test ID:	PR1223/01	Sample ID:	SV LDP009
End Date:	13/09/2014 17:45	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	MS-Melanotaenia splendida
Comments:					

Conc-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	0.8000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	0.8000
12.5	1.0000	1.0000	1.0000	0.8000
25	0.8000	1.0000	0.8000	1.0000
50	0.4000	0.6000	0.6000	0.4000
100	0.0000	0.2000	0.0000	0.2000

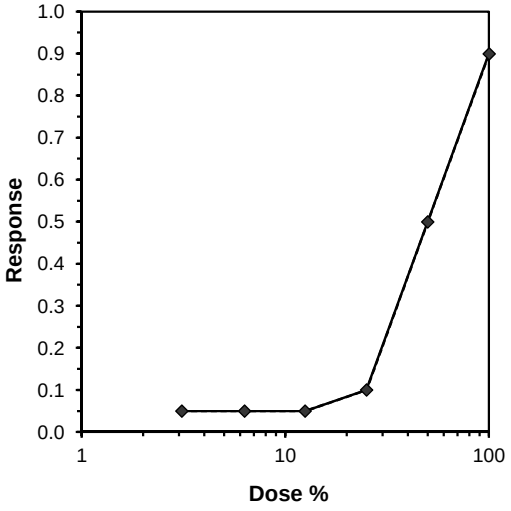
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4			1.0000	1.0000
3.1	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	0.9500	0.9500
6.3	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	0.9500	0.9500
12.5	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	0.9500	0.9500
25	0.9000	0.9000	1.2262	1.1071	1.3453	11.212	4	14.00	10.00	0.9000	0.9000
*50	0.5000	0.5000	0.7854	0.6847	0.8861	14.802	4	10.00	10.00	0.5000	0.5000
*100	0.1000	0.1000	0.3446	0.2255	0.4636	39.900	4	10.00	10.00	0.1000	0.1000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.854934	0.924	-0.56904	-1.15873
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	25	50	35.35534	4
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

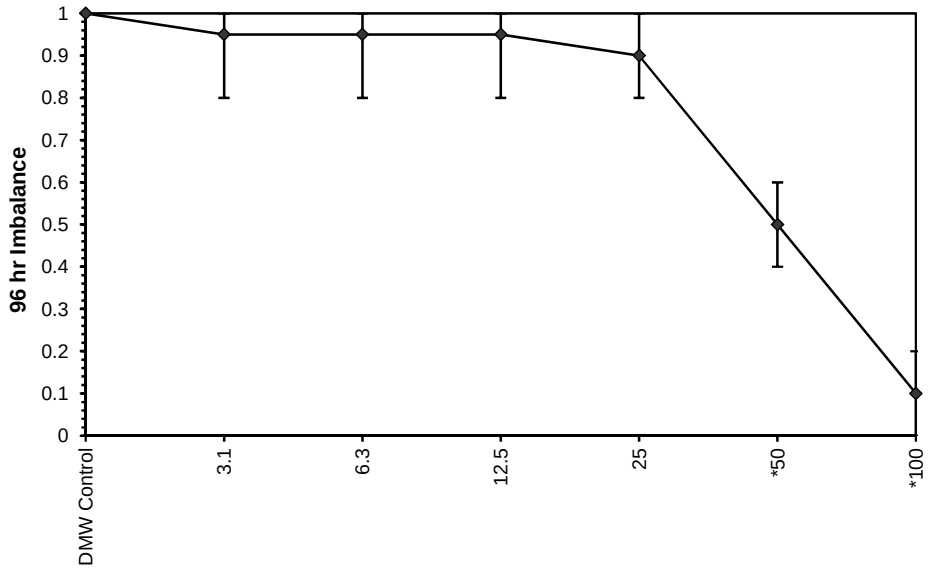
Point	%	SD	95% CL(Exp)		Skew
IC05	12.500	7.862	0.000	34.882	0.6985
IC10	25.000	6.597	0.000	34.148	-0.7220
IC15	28.963	3.832	15.611	37.652	-0.3499
IC20	32.340	3.259	20.596	39.986	0.0255
IC25	35.414	2.902	24.994	42.605	0.0239
IC40	44.038	2.603	37.982	53.577	0.1901
IC50	50.000	2.893	41.870	59.165	0.1542



Fish Acute Toxicity Test-96 hr Imbalance

Start Date:	9/09/2014 13:00	Test ID:	PR1223/01	Sample ID:	SV LDP009
End Date:	13/09/2014 17:45	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	MS-Melanotaenia splendida
Comments:					

Dose-Response Plot



Fish Acute Toxicity Test-96 hr Imbalance

Start Date:	9/09/2014 13:00	Test ID:	PR1223/01	Sample ID:	SV LDP009
End Date:	13/09/2014 17:45	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	MS-Melanotaenia splendida
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Unaffected	100.00	100.00	100.00	0.00	0.00	4
3.1		95.00	80.00	100.00	10.00	3.33	4
6.3		95.00	80.00	100.00	10.00	3.33	4
12.5		95.00	80.00	100.00	10.00	3.33	4
25		90.00	80.00	100.00	11.55	3.78	4
50		50.00	40.00	60.00	11.55	6.80	4
100		10.00	0.00	20.00	11.55	33.98	4
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
3.1		7.80	7.80	7.80	0.00	0.00	1
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.20	8.20	8.20	0.00	0.00	1
100		8.10	8.10	8.10	0.00	0.00	1
DMW Control	DO %	101.20	101.20	101.20	0.00	0.00	1
3.1		100.30	100.30	100.30	0.00	0.00	1
6.3		100.10	100.10	100.10	0.00	0.00	1
12.5		100.50	100.50	100.50	0.00	0.00	1
25		100.90	100.90	100.90	0.00	0.00	1
50		102.50	102.50	102.50	0.00	0.00	1
100		108.10	108.10	108.10	0.00	0.00	1
DMW Control	Conductivity uS/cm	173.60	173.60	173.60	0.00	0.00	1
3.1		213.00	213.00	213.00	0.00	0.00	1
6.3		246.00	246.00	246.00	0.00	0.00	1
12.5		313.00	313.00	313.00	0.00	0.00	1
25		440.00	440.00	440.00	0.00	0.00	1
50		671.00	671.00	671.00	0.00	0.00	1
100		1154.00	1154.00	1154.00	0.00	0.00	1

Fish Acute Toxicity Test-96 hr Imbalance

Start Date:	9/09/2014 13:00	Test ID:	PR1223/01	Sample ID:	SV LDP009
End Date:	13/09/2014 17:45	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	MS-Melanotaenia splendida
Comments:					

Conc-%	1	2	3	4
DMW Control	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	0.8000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	0.8000
12.5	1.0000	1.0000	1.0000	0.8000
25	0.8000	1.0000	0.8000	1.0000
50	0.4000	0.6000	0.6000	0.4000
100	0.0000	0.2000	0.0000	0.2000

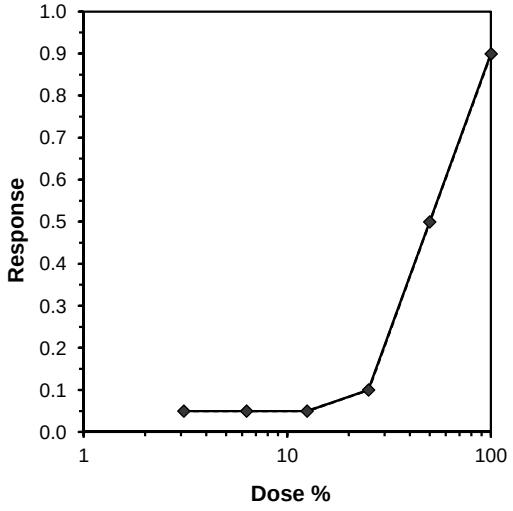
			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
DMW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4			0	20
3.1	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	1	20
6.3	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	1	20
12.5	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	1	20
25	0.9000	0.9000	1.2262	1.1071	1.3453	11.212	4	14.00	10.00	2	20
*50	0.5000	0.5000	0.7854	0.6847	0.8861	14.802	4	10.00	10.00	10	20
*100	0.1000	0.1000	0.3446	0.2255	0.4636	39.900	4	10.00	10.00	18	20

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.854934	0.924	-0.56904	-1.15873
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	25	50	35.35534	4
Treatments vs DMW Control				

Trimmed Spearman-Karber

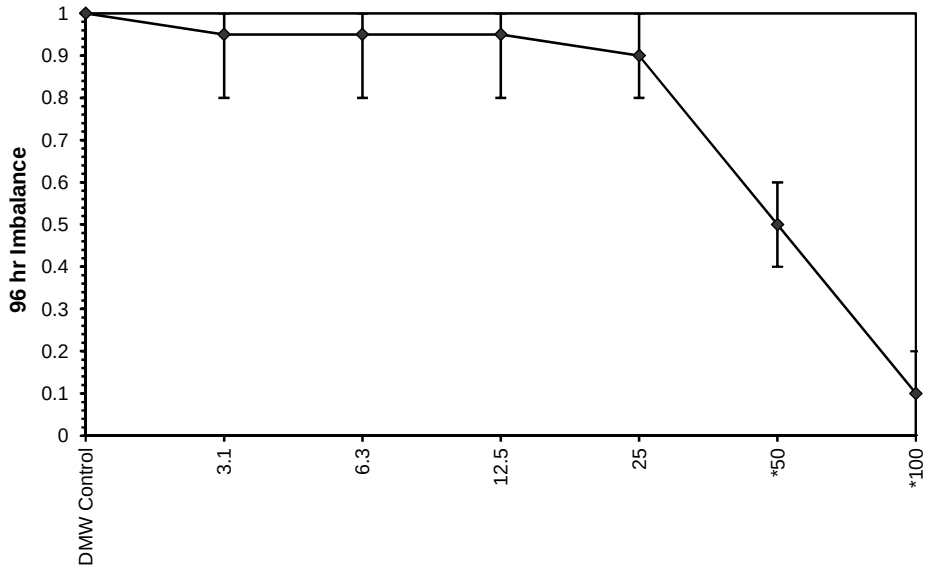
Trim Level	EC50	95% CL	
0.0%			
5.0%			
10.0%	50.000	40.511	61.712
20.0%	50.000	38.338	65.209
Auto-10.0%	50.000	40.511	61.712



Fish Acute Toxicity Test-96 hr Imbalance

Start Date:	9/09/2014 13:00	Test ID:	PR1223/01	Sample ID:	SV LDP009
End Date:	13/09/2014 17:45	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	MS-Melanotaenia splendida
Comments:					

Dose-Response Plot



Fish Acute Toxicity Test-96 hr Imbalance

Start Date:	9/09/2014 13:00	Test ID:	PR1223/01	Sample ID:	SV LDP009
End Date:	13/09/2014 17:45	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	MS-Melanotaenia splendida
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	% Unaffected	100.00	100.00	100.00	0.00	0.00	4
3.1		95.00	80.00	100.00	10.00	3.33	4
6.3		95.00	80.00	100.00	10.00	3.33	4
12.5		95.00	80.00	100.00	10.00	3.33	4
25		90.00	80.00	100.00	11.55	3.78	4
50		50.00	40.00	60.00	11.55	6.80	4
100		10.00	0.00	20.00	11.55	33.98	4
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
3.1		7.80	7.80	7.80	0.00	0.00	1
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.20	8.20	8.20	0.00	0.00	1
50		8.20	8.20	8.20	0.00	0.00	1
100		8.10	8.10	8.10	0.00	0.00	1
DMW Control	DO %	101.20	101.20	101.20	0.00	0.00	1
3.1		100.30	100.30	100.30	0.00	0.00	1
6.3		100.10	100.10	100.10	0.00	0.00	1
12.5		100.50	100.50	100.50	0.00	0.00	1
25		100.90	100.90	100.90	0.00	0.00	1
50		102.50	102.50	102.50	0.00	0.00	1
100		108.10	108.10	108.10	0.00	0.00	1
DMW Control	Conductivity uS/cm	173.60	173.60	173.60	0.00	0.00	1
3.1		213.00	213.00	213.00	0.00	0.00	1
6.3		246.00	246.00	246.00	0.00	0.00	1
12.5		313.00	313.00	313.00	0.00	0.00	1
25		440.00	440.00	440.00	0.00	0.00	1
50		671.00	671.00	671.00	0.00	0.00	1
100		1154.00	1154.00	1154.00	0.00	0.00	1

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Statistical Printouts for *Hydra* Population Growth Tests

Hydra Population Growth Test-Growth Rate

Start Date:	26/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	30/08/2014 15:44	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:					

Conc-%	1	2	3	4
Lab Control	0.3735	0.3735	0.3785	0.3683
3.1	0.3683	0.3408	0.3349	0.3577
6.3	0.3349	0.3033	0.3408	0.3289
12.5	0.2336	0.1950	0.2670	0.2894
25	0.1844	0.1366	0.0603	0.0603
50	0.0603	0.0000	0.0418	0.0218
100	0.0000	0.0000	0.0000	0.0000

			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
Lab Control	0.3735	1.0000	0.3735	0.3683	0.3785	1.116	4			0.3735	1.0000
3.1	0.3504	0.9384	0.3504	0.3349	0.3683	4.374	4	10.50	10.00	0.3504	0.9384
*6.3	0.3270	0.8756	0.3270	0.3033	0.3408	5.061	4	10.00	10.00	0.3270	0.8756
*12.5	0.2462	0.6593	0.2462	0.1950	0.2894	16.697	4	10.00	10.00	0.2462	0.6593
*25	0.1104	0.2956	0.1104	0.0603	0.1844	55.309	4	10.00	10.00	0.1104	0.2956
*50	0.0310	0.0829	0.0310	0.0000	0.0603	83.842	4	10.00	10.00	0.0310	0.0829
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	4			0.0000	0.0000

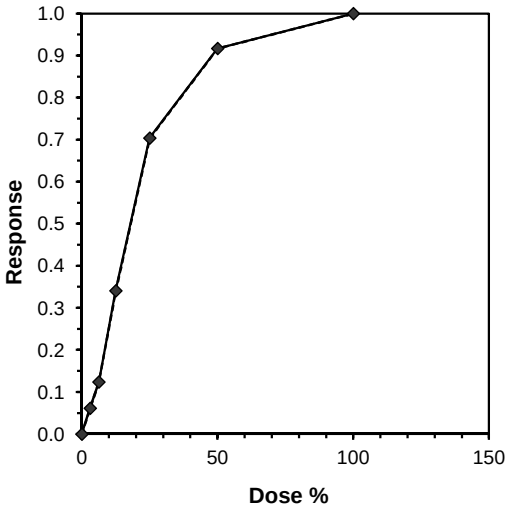
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.962848	0.916	0.208991	0.793682
Bartlett's Test indicates unequal variances (p = 7.52E-03)	15.77501	15.08627		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	3.1	6.3	4.419276	32.25806
Treatments vs Lab Control				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	2.516	0.648	1.094	4.743	0.5183
IC10	5.056	0.810	2.373	7.276	-0.3033
IC15	7.033	0.585	4.993	9.004	-0.1030
IC20	8.467	0.702	6.785	11.378	0.8354
IC25	9.901	0.989	7.936	13.861	0.7298
IC40	14.539	1.485	10.347	18.967	-0.0769
IC50	17.976	1.666	13.979	24.777	0.7715

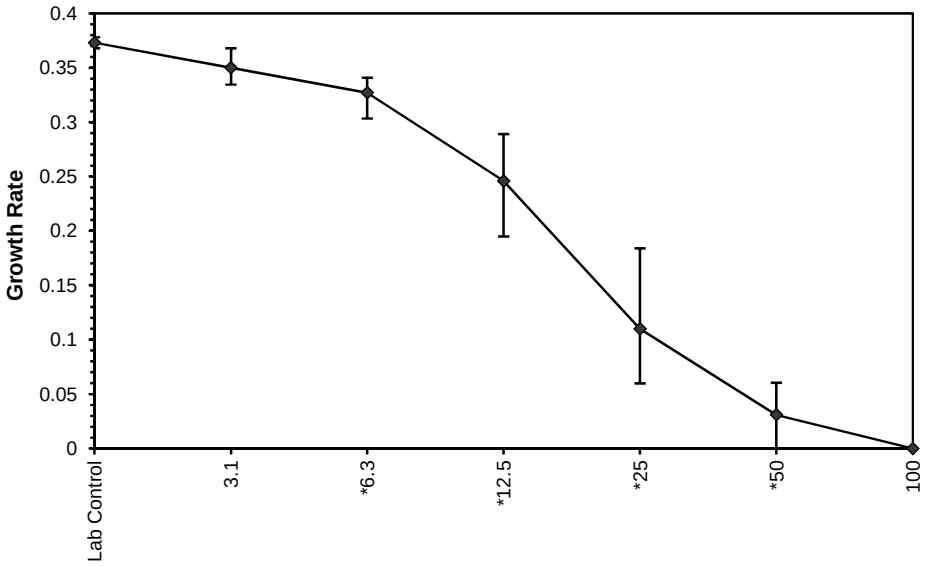
* indicates IC estimate less than the lowest concentration



Hydra Population Growth Test-Growth Rate

Start Date:	26/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	30/08/2014 15:44	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:					

Dose-Response Plot



Hydra Population Growth Test-Growth Rate

Start Date:	26/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	30/08/2014 15:44	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
Lab Control	Growth Rate	0.37	0.37	0.38	0.00	17.28	4
3.1		0.35	0.33	0.37	0.02	35.33	4
6.3		0.33	0.30	0.34	0.02	39.34	4
12.5		0.25	0.20	0.29	0.04	82.35	4
25		0.11	0.06	0.18	0.06	223.82	4
50		0.03	0.00	0.06	0.03	520.46	4
100		0.00	0.00	0.00	0.00		4
Lab Control	Conductivity	26.50	26.50	26.50	0.00	0.00	1
3.1		65.00	65.00	65.00	0.00	0.00	1
6.3		104.80	104.80	104.80	0.00	0.00	1
12.5		181.70	181.70	181.70	0.00	0.00	1
25		332.00	332.00	332.00	0.00	0.00	1
50		619.00	619.00	619.00	0.00	0.00	1
100		1175.00	1175.00	1175.00	0.00	0.00	1
Lab Control	pH	7.00	7.00	7.00	0.00	0.00	1
3.1		7.10	7.10	7.10	0.00	0.00	1
6.3		7.30	7.30	7.30	0.00	0.00	1
12.5		7.50	7.50	7.50	0.00	0.00	1
25		7.90	7.90	7.90	0.00	0.00	1
50		8.20	8.20	8.20	0.00	0.00	1
100		8.30	8.30	8.30	0.00	0.00	1
Lab Control	DO, % sat	96.80	96.80	96.80	0.00	0.00	1
3.1		98.50	98.50	98.50	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		99.10	99.10	99.10	0.00	0.00	1
25		99.70	99.70	99.70	0.00	0.00	1
50		100.70	100.70	100.70	0.00	0.00	1
100		102.60	102.60	102.60	0.00	0.00	1

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Statistical Printouts for the 7-d Chronic Test with *Ceriodaphnia dubia*

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	4/09/2014 15:00	Test ID:	PR1223/02	Sample ID:	AP LDP001
End Date:	12/09/2014 16:00	Lab ID:	6807	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	22.000	17.000	19.000	12.000	15.000	0.000	11.000	12.000	17.000	11.000
3.1	21.000	26.000	17.000	23.000	14.000	10.000	18.000	17.000	0.000	15.000
6.3	13.000	21.000	23.000	13.000	17.000	7.000	20.000	17.000	9.000	12.000
12.5	18.000	22.000	22.000	22.000	32.000	19.000	20.000	22.000	14.000	10.000
25	0.000	23.000	18.000	23.000	21.000	21.000	21.000	10.000	13.000	24.000
50	22.000	26.000	25.000	34.000	25.000	28.000	20.000	28.000	20.000	24.000
100	33.000	24.000	3.000	22.000	21.000	26.000	12.000	11.000	26.000	13.000

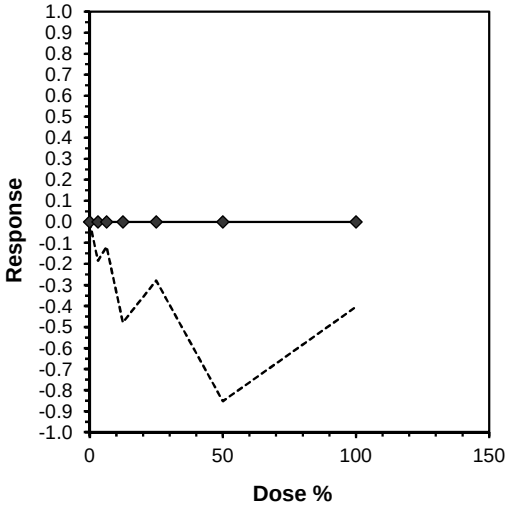
			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
DMW Control	13.600	1.0000	13.600	0.000	22.000	44.416	10				18.100	1.0000
3.1	16.100	1.1838	16.100	0.000	26.000	45.213	10	-0.842	2.347	6.966	18.100	1.0000
6.3	15.200	1.1176	15.200	7.000	23.000	34.646	10	-0.539	2.347	6.966	18.100	1.0000
12.5	20.100	1.4779	20.100	10.000	32.000	28.767	10	-2.190	2.347	6.966	18.100	1.0000
25	17.400	1.2794	17.400	0.000	24.000	43.786	10	-1.280	2.347	6.966	18.100	1.0000
50	25.200	1.8529	25.200	20.000	34.000	16.711	10	-3.908	2.347	6.966	18.100	1.0000
100	19.100	1.4044	19.100	3.000	33.000	47.375	10	-1.853	2.347	6.966	18.100	1.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates normal distribution (p > 0.05)	0.708442	0.895	-0.62529	0.677564
Bartlett's Test indicates equal variances (p = 0.37)	6.518898	16.81189		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	6.966141	0.512216	147.6	44.04286	0.006266	6, 63
Treatments vs DMW Control										

Linear Interpolation (200 Resamples)

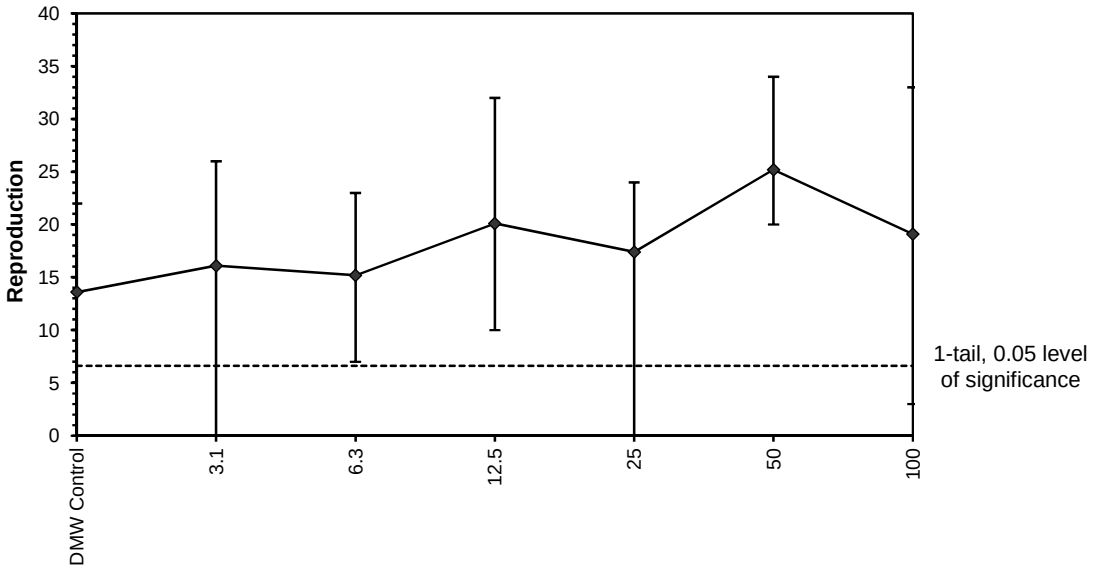
Point	%	SD	95% CL	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	4/09/2014 15:00	Test ID:	PR1223/02	Sample ID:	AP LDP001
End Date:	12/09/2014 16:00	Lab ID:	6807	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	4/09/2014 15:00	Test ID:	PR1223/02	Sample ID:	AP LDP001
End Date:	12/09/2014 16:00	Lab ID:	6807	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	13.60	0.00	22.00	6.04	18.07	10
3.1		16.10	0.00	26.00	7.28	16.76	10
6.3		15.20	7.00	23.00	5.27	15.10	10
12.5		20.10	10.00	32.00	5.78	11.96	10
25		17.40	0.00	24.00	7.62	15.86	10
50		25.20	20.00	34.00	4.21	8.14	10
100		19.10	3.00	33.00	9.05	15.75	10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
3.1		90.00	0.00	100.00	31.62	6.25	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		90.00	0.00	100.00	31.62	6.25	10
50		100.00	100.00	100.00	0.00	0.00	10
100		90.00	0.00	100.00	31.62	6.25	10
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
DMW Control	DO %	101.00	101.00	101.00	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.40	100.40	100.40	0.00	0.00	1
12.5		100.60	100.60	100.60	0.00	0.00	1
25		104.30	104.30	104.30	0.00	0.00	1
50		104.30	104.30	104.30	0.00	0.00	1
100		106.00	106.00	106.00	0.00	0.00	1
DMW Control	Cond uS/cm	185.50	185.50	185.50	0.00	0.00	1
3.1		213.00	213.00	213.00	0.00	0.00	1
6.3		242.00	242.00	242.00	0.00	0.00	1
12.5		298.00	298.00	298.00	0.00	0.00	1
25		409.00	409.00	409.00	0.00	0.00	1
50		625.00	625.00	625.00	0.00	0.00	1
100		1038.00	1038.00	1038.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	4/09/2014 15:00	Test ID:	PR1223/02	Sample ID:	AP LDP001
End Date:	12/09/2014 16:00	Lab ID:	6807	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

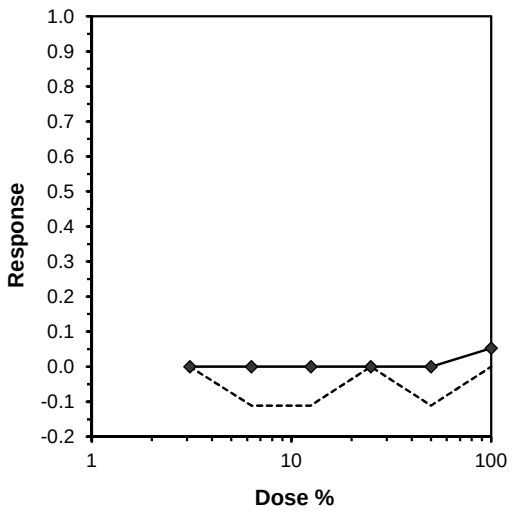
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Isotonic Mean	Isotonic N-Mean
DMW Control	0.9000	1.0000	1	9	10	10			0.9500	1.0000
3.1	0.9000	1.0000	1	9	10	10	0.7632	0.0500	0.9500	1.0000
6.3	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0.9500	1.0000
12.5	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0.9500	1.0000
25	0.9000	1.0000	1	9	10	10	0.7632	0.0500	0.9500	1.0000
50	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0.9500	1.0000
100	0.9000	1.0000	1	9	10	10	0.7632	0.0500	0.9000	0.9474

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	100	>100		1
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

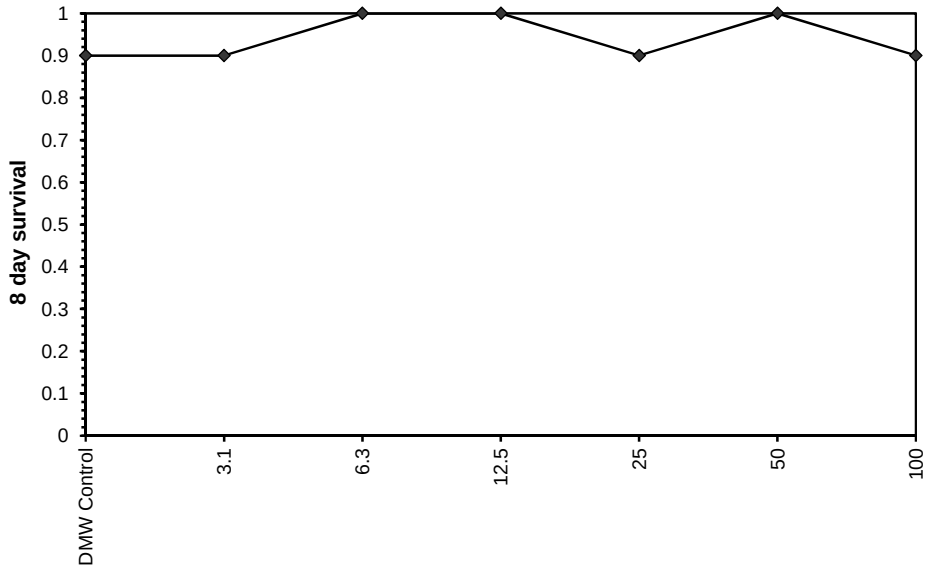
Point	%	SD	95% CL	Skew
IC05	97.438			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	4/09/2014 15:00	Test ID:	PR1223/02	Sample ID:	AP LDP001
End Date:	12/09/2014 16:00	Lab ID:	6807	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	4/09/2014 15:00	Test ID:	PR1223/02	Sample ID:	AP LDP001
End Date:	12/09/2014 16:00	Lab ID:	6807	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	13.60	0.00	22.00	6.04	18.07	10
3.1		16.10	0.00	26.00	7.28	16.76	10
6.3		15.20	7.00	23.00	5.27	15.10	10
12.5		20.10	10.00	32.00	5.78	11.96	10
25		17.40	0.00	24.00	7.62	15.86	10
50		25.20	20.00	34.00	4.21	8.14	10
100		19.10	3.00	33.00	9.05	15.75	10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
3.1		90.00	0.00	100.00	31.62	6.25	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		90.00	0.00	100.00	31.62	6.25	10
50		100.00	100.00	100.00	0.00	0.00	10
100		90.00	0.00	100.00	31.62	6.25	10
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
3.1		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
DMW Control	DO %	101.00	101.00	101.00	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		100.40	100.40	100.40	0.00	0.00	1
12.5		100.60	100.60	100.60	0.00	0.00	1
25		104.30	104.30	104.30	0.00	0.00	1
50		104.30	104.30	104.30	0.00	0.00	1
100		106.00	106.00	106.00	0.00	0.00	1
DMW Control	Cond uS/cm	185.50	185.50	185.50	0.00	0.00	1
3.1		213.00	213.00	213.00	0.00	0.00	1
6.3		242.00	242.00	242.00	0.00	0.00	1
12.5		298.00	298.00	298.00	0.00	0.00	1
25		409.00	409.00	409.00	0.00	0.00	1
50		625.00	625.00	625.00	0.00	0.00	1
100		1038.00	1038.00	1038.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	18.000	22.000	27.000	13.000	13.000	14.000	4.000	12.000	17.000	13.000
3.1	22.000	21.000	8.000	12.000	20.000	22.000	18.000	12.000	24.000	22.000
6.3	17.000	22.000	21.000	22.000	20.000	10.000	16.000	16.000	14.000	25.000
12.5	19.000	21.000	3.000	16.000	11.000	26.000	23.000	5.000	6.000	7.000
25	0.000	12.000	8.000	6.000	10.000	14.000	18.000	8.000	12.000	4.000
50	6.000	0.000	15.000	4.000	11.000	0.000	5.000	3.000	0.000	12.000
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

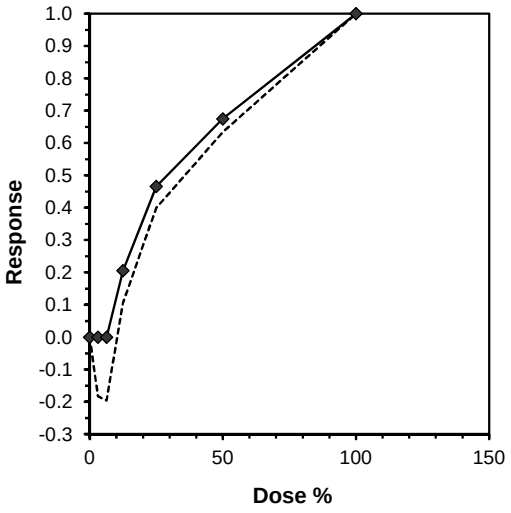
			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
DMW Control	15.300	1.0000	15.300	4.000	27.000	40.648	10				17.233	1.0000
3.1	18.100	1.1830	18.100	8.000	24.000	30.199	10	-1.047	2.287	6.112	17.233	1.0000
6.3	18.300	1.1961	18.300	10.000	25.000	24.580	10	-1.122	2.287	6.112	17.233	1.0000
12.5	13.700	0.8954	13.700	3.000	26.000	60.881	10	0.599	2.287	6.112	13.700	0.7950
25	9.200	0.6013	9.200	0.000	18.000	56.317	10	2.282	2.287	6.112	9.200	0.5338
*50	5.600	0.3660	5.600	0.000	15.000	96.421	10	3.629	2.287	6.112	5.600	0.3250
100	0.000	0.0000	0.000	0.000	0.000	0.000	10				0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates normal distribution (p > 0.05)	0.524712	0.895	0.021178	-0.58724
Bartlett's Test indicates equal variances (p = 0.52)	4.232154	15.08627		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	25	50	35.35534	4	6.112369	0.399501	256.5467	35.72593	3.2E-05	5, 54
Treatments vs DMW Control										

Linear Interpolation (200 Resamples)

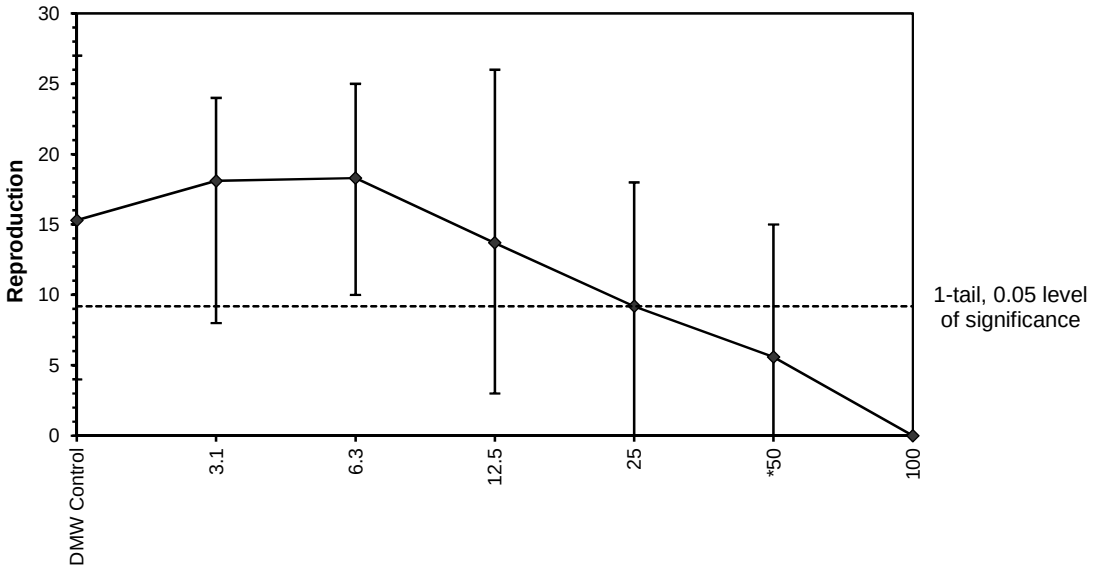
Point	%	SD	95% CL		Skew
IC05	7.812	2.842	2.615	14.253	0.5186
IC10	9.324	2.974	5.246	16.006	0.4828
IC15	10.836	3.134	7.143	17.759	0.5046
IC20	12.348	3.410	7.953	19.842	0.3988
IC25	14.653	3.786	9.147	21.824	0.2875
IC40	21.833	5.661	11.396	32.891	0.2519
IC50	29.051	7.848	16.305	50.346	0.5915



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.30	4.00	27.00	6.22	16.30	10
3.1		18.10	8.00	24.00	5.47	12.92	10
6.3		18.30	10.00	25.00	4.50	11.59	10
12.5		13.70	3.00	26.00	8.34	21.08	10
25		9.20	0.00	18.00	5.18	24.74	10
50		5.60	0.00	15.00	5.40	41.49	10
100		0.00	0.00	0.00	0.00		10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
3.1		80.00	0.00	100.00	42.16	8.12	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		90.00	0.00	100.00	31.62	6.25	10
50		70.00	0.00	100.00	48.30	9.93	10
100		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.30	8.30	8.30	0.00	0.00	1
25		8.30	8.30	8.30	0.00	0.00	1
50		8.40	8.40	8.40	0.00	0.00	1
100		8.40	8.40	8.40	0.00	0.00	1
DMW Control	DO %	100.70	100.70	100.70	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		101.10	101.10	101.10	0.00	0.00	1
12.5		100.70	100.70	100.70	0.00	0.00	1
25		100.80	100.80	100.80	0.00	0.00	1
50		101.70	101.70	101.70	0.00	0.00	1
100		104.70	104.70	104.70	0.00	0.00	1
DMW Control	Cond uS/cm	185.10	185.10	185.10	0.00	0.00	1
3.1		222.00	222.00	222.00	0.00	0.00	1
6.3		252.00	252.00	252.00	0.00	0.00	1
12.5		318.00	318.00	318.00	0.00	0.00	1
25		445.00	445.00	445.00	0.00	0.00	1
50		691.00	691.00	691.00	0.00	0.00	1
100		1180.00	1180.00	1180.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

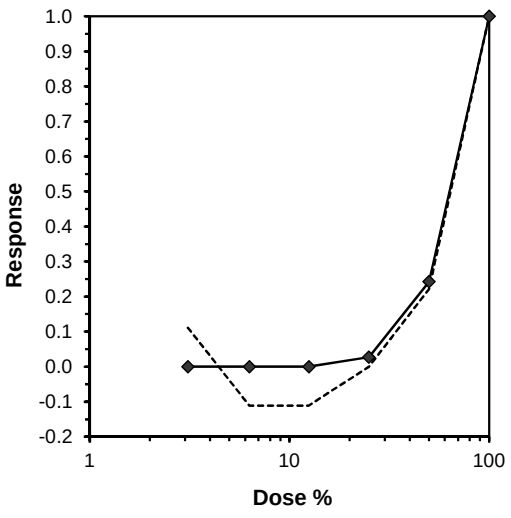
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Isotonic Mean	Isotonic N-Mean
DMW Control	0.9000	1.0000	1	9	10	10			0.9250	1.0000
3.1	0.8000	0.8889	2	8	10	10	0.5000	0.0500	0.9250	1.0000
6.3	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0.9250	1.0000
12.5	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0.9250	1.0000
25	0.9000	1.0000	1	9	10	10	0.7632	0.0500	0.9000	0.9730
50	0.7000	0.7778	3	7	10	10	0.2910	0.0500	0.7000	0.7568
100	0.0000	0.0000	10	0	10	10			0.0000	0.0000

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	50	100	70.71068	2
Treatments vs DMW Control				

Log-Logit Interpolation (200 Resamples)

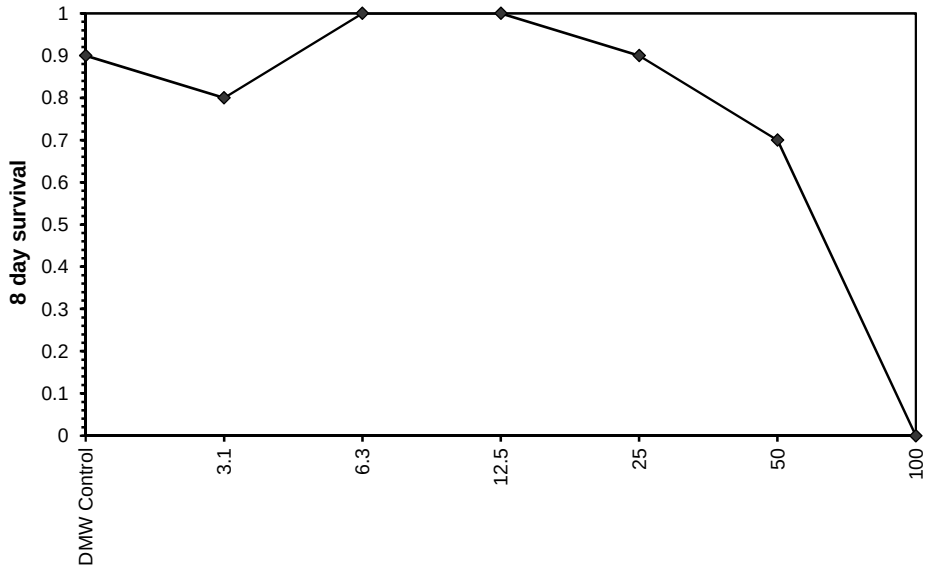
Point	%	SD	95% CL		Skew
IC05	27.968	12.978	2.377	51.172	-0.0598
IC10	33.968	11.803	2.905	52.123	-0.1779
IC15	39.636	10.425	18.668	52.946	-0.3769
IC20	45.186	8.842	23.041	53.715	-0.7060
IC25	50.103	7.084	27.970	54.457	-1.0713
IC40	52.217	3.440	43.267	56.455	-1.5101
IC50	53.576	2.635	47.360	57.739	-0.9084



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.30	4.00	27.00	6.22	16.30	10
3.1		18.10	8.00	24.00	5.47	12.92	10
6.3		18.30	10.00	25.00	4.50	11.59	10
12.5		13.70	3.00	26.00	8.34	21.08	10
25		9.20	0.00	18.00	5.18	24.74	10
50		5.60	0.00	15.00	5.40	41.49	10
100		0.00	0.00	0.00	0.00		10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
3.1		80.00	0.00	100.00	42.16	8.12	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		90.00	0.00	100.00	31.62	6.25	10
50		70.00	0.00	100.00	48.30	9.93	10
100		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.30	8.30	8.30	0.00	0.00	1
25		8.30	8.30	8.30	0.00	0.00	1
50		8.40	8.40	8.40	0.00	0.00	1
100		8.40	8.40	8.40	0.00	0.00	1
DMW Control	DO %	100.70	100.70	100.70	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		101.10	101.10	101.10	0.00	0.00	1
12.5		100.70	100.70	100.70	0.00	0.00	1
25		100.80	100.80	100.80	0.00	0.00	1
50		101.70	101.70	101.70	0.00	0.00	1
100		104.70	104.70	104.70	0.00	0.00	1
DMW Control	Cond uS/cm	185.10	185.10	185.10	0.00	0.00	1
3.1		222.00	222.00	222.00	0.00	0.00	1
6.3		252.00	252.00	252.00	0.00	0.00	1
12.5		318.00	318.00	318.00	0.00	0.00	1
25		445.00	445.00	445.00	0.00	0.00	1
50		691.00	691.00	691.00	0.00	0.00	1
100		1180.00	1180.00	1180.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

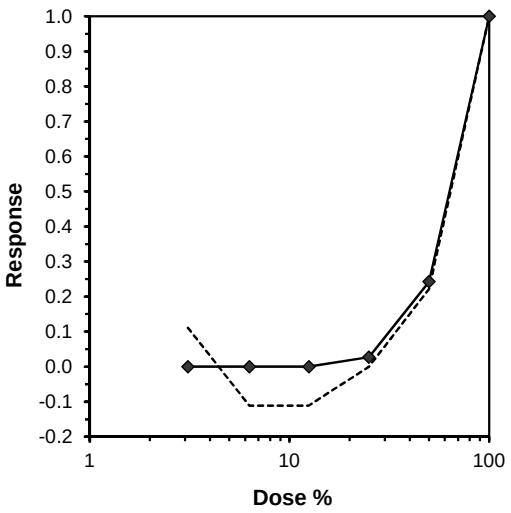
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
3.1	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Number Resp	Total Number
DMW Control	0.9000	1.0000	1	9	10	10			1	10
3.1	0.8000	0.8889	2	8	10	10	0.5000	0.0500	2	10
6.3	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0	10
12.5	1.0000	1.1111	0	10	10	10	0.5000	0.0500	0	10
25	0.9000	1.0000	1	9	10	10	0.7632	0.0500	1	10
50	0.7000	0.7778	3	7	10	10	0.2910	0.0500	3	10
100	0.0000	0.0000	10	0	10	10			10	10

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	50	100	70.71068	2
Treatments vs DMW Control				

Trimmed Spearman-Karber

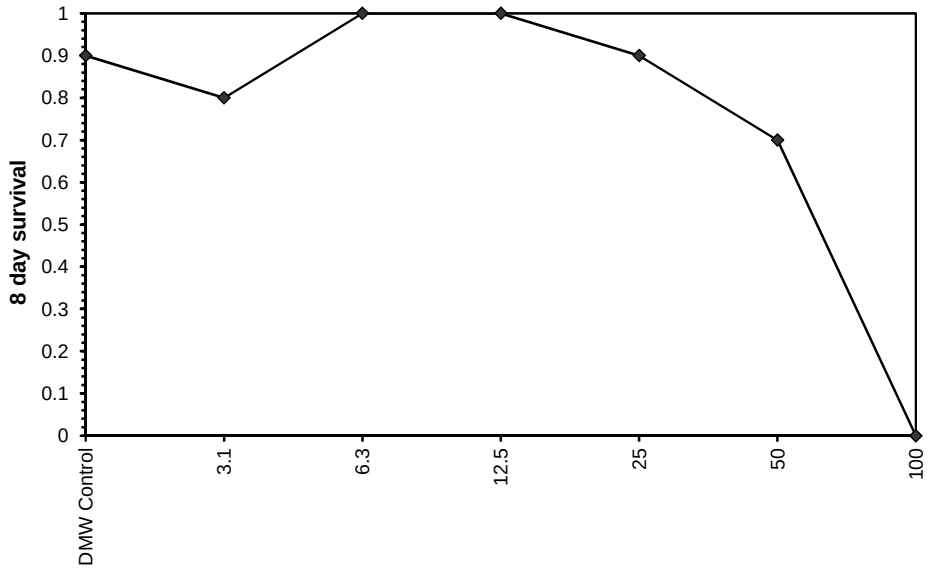
Trim Level	EC50	95% CL	
0.0%	58.631	47.951	71.689
5.0%	60.322	48.795	74.572
10.0%	61.426	47.972	78.653
20.0%	63.031	42.131	94.299
Auto-0.0%	58.631	47.951	71.689



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	28/08/2014 13:30	Test ID:	PR1223/02	Sample ID:	SV LDP009
End Date:	5/09/2014 13:24	Lab ID:	6808	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	15.30	4.00	27.00	6.22	16.30	10
3.1		18.10	8.00	24.00	5.47	12.92	10
6.3		18.30	10.00	25.00	4.50	11.59	10
12.5		13.70	3.00	26.00	8.34	21.08	10
25		9.20	0.00	18.00	5.18	24.74	10
50		5.60	0.00	15.00	5.40	41.49	10
100		0.00	0.00	0.00	0.00		10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
3.1		80.00	0.00	100.00	42.16	8.12	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		90.00	0.00	100.00	31.62	6.25	10
50		70.00	0.00	100.00	48.30	9.93	10
100		0.00	0.00	0.00	0.00		10
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
3.1		8.20	8.20	8.20	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.30	8.30	8.30	0.00	0.00	1
25		8.30	8.30	8.30	0.00	0.00	1
50		8.40	8.40	8.40	0.00	0.00	1
100		8.40	8.40	8.40	0.00	0.00	1
DMW Control	DO %	100.70	100.70	100.70	0.00	0.00	1
3.1		100.60	100.60	100.60	0.00	0.00	1
6.3		101.10	101.10	101.10	0.00	0.00	1
12.5		100.70	100.70	100.70	0.00	0.00	1
25		100.80	100.80	100.80	0.00	0.00	1
50		101.70	101.70	101.70	0.00	0.00	1
100		104.70	104.70	104.70	0.00	0.00	1
DMW Control	Cond uS/cm	185.10	185.10	185.10	0.00	0.00	1
3.1		222.00	222.00	222.00	0.00	0.00	1
6.3		252.00	252.00	252.00	0.00	0.00	1
12.5		318.00	318.00	318.00	0.00	0.00	1
25		445.00	445.00	445.00	0.00	0.00	1
50		691.00	691.00	691.00	0.00	0.00	1
100		1180.00	1180.00	1180.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	11/09/2014 14:15	Test ID:	PR1223/21	Sample ID:	Various
End Date:	19/09/2014 14:00	Lab ID:	Various	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

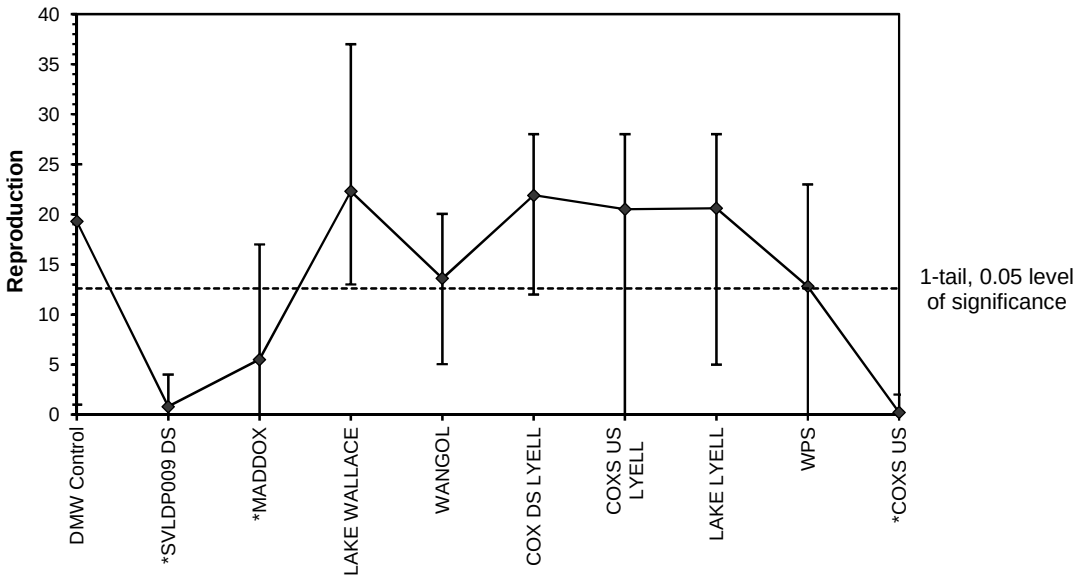
Conc-	1	2	3	4	5	6	7	8	9	10
DMW Control	24.000	23.000	18.000	24.000	20.000	19.000	1.000	24.000	15.000	25.000
SVLDP009 DS	0.000	4.000	0.000	0.000	0.000	0.000	0.000	0.000	4.000	0.000
MADDOX	4.000	7.000	17.000	0.000	4.000	2.000	4.000	2.000	12.000	3.000
AKE WALLACE	22.000	21.000	13.000	24.000	20.000	22.000	23.000	24.000	37.000	17.000
WANGOL	13.000	18.000	13.000	10.000	15.000	10.000	20.000	18.000	5.000	
COX DS LYELL	19.000	28.000	26.000	22.000	22.000	18.000	25.000	24.000	23.000	12.000
COXS US LYELL	25.000	28.000	24.000	20.000	23.000	27.000	22.000	14.000	0.000	22.000
LAKE LYELL	28.000	17.000	5.000	18.000	26.000	26.000	28.000	27.000	17.000	14.000
WPS	17.000	23.000	18.000	11.000	0.000	12.000	16.000	10.000	16.000	5.000
COXS US	0.000	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

			Transform: Untransformed					1-Tailed		
Conc-	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
DMW Control	19.300	1.0000	19.300	1.000	25.000	37.367	10			
*SVLDP009 DS	0.800	0.0415	0.800	0.000	4.000	210.819	10	7.128	2.593	6.731
*MADDOX	5.500	0.2850	5.500	0.000	17.000	94.767	10	5.317	2.593	6.731
AKE WALLACE	22.300	1.1554	22.300	13.000	37.000	27.728	10	-1.156	2.593	6.731
WANGOL	13.556	0.7024	13.556	5.000	20.000	35.208	9	2.154	2.593	6.915
COX DS LYELL	21.900	1.1347	21.900	12.000	28.000	21.030	10	-1.002	2.593	6.731
COXS US LYELL	20.500	1.0622	20.500	0.000	28.000	39.978	10	-0.462	2.593	6.731
LAKE LYELL	20.600	1.0674	20.600	5.000	28.000	37.196	10	-0.501	2.593	6.731
WPS	12.800	0.6632	12.800	0.000	23.000	52.447	10	2.504	2.593	6.731
*COXS US	0.200	0.0104	0.200	0.000	2.000	316.228	10	7.359	2.593	6.731

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates non-normal distribution (p <= 0.05)	1.308145	0.895	-0.92016	2.801025
Bartlett's Test indicates unequal variances (p = 9.06E-08)	50.40083	21.66599		

Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test indicates significant differences Treatments vs DMW Control	6.730781	0.348745	759.0183	33.68002	1.9E-19	9, 89

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	11/09/2014 14:15	Test ID:	PR1223/21	Sample ID:	Various
End Date:	19/09/2014 14:00	Lab ID:	Various	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	19.30	1.00	25.00	7.21	13.91	10
SVLDP009 DS		0.80	0.00	4.00	1.69	162.33	10
MADDOX		5.50	0.00	17.00	5.21	41.51	10
AKE WALLACE		22.30	13.00	37.00	6.18	11.15	10
WANGOL		13.56	5.00	20.00	4.77	16.12	9
COX DS LYELL		21.90	12.00	28.00	4.61	9.80	10
OXS US LYELL		20.50	0.00	28.00	8.20	13.96	10
LAKE LYELL		20.60	5.00	28.00	7.66	13.44	10
WPS		12.80	0.00	23.00	6.71	20.24	10
COXS US		0.20	0.00	2.00	0.63	397.64	10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
SVLDP009 DS		80.00	0.00	100.00	42.16	8.12	10
MADDOX		100.00	100.00	100.00	0.00	0.00	10
AKE WALLACE		100.00	100.00	100.00	0.00	0.00	10
WANGOL		100.00	100.00	100.00	0.00	0.00	9
COX DS LYELL		100.00	100.00	100.00	0.00	0.00	10
OXS US LYELL		100.00	100.00	100.00	0.00	0.00	10
LAKE LYELL		90.00	0.00	100.00	31.62	6.25	10
WPS		100.00	100.00	100.00	0.00	0.00	10
COXS US		40.00	0.00	100.00	51.64	17.97	10
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
SVLDP009 DS		8.80	8.80	8.80	0.00	0.00	1
MADDOX		8.60	8.60	8.60	0.00	0.00	1
AKE WALLACE		8.50	8.50	8.50	0.00	0.00	1
WANGOL		8.70	8.70	8.70	0.00	0.00	1
COX DS LYELL		8.30	8.30	8.30	0.00	0.00	1
OXS US LYELL		8.70	8.70	8.70	0.00	0.00	1
LAKE LYELL		8.40	8.40	8.40	0.00	0.00	1
WPS		8.40	8.40	8.40	0.00	0.00	1
COXS US		6.60	6.60	6.60	0.00	0.00	1
DMW Control	DO %	100.90	100.90	100.90	0.00	0.00	1
SVLDP009 DS		89.00	89.00	89.00	0.00	0.00	1
MADDOX		94.80	94.80	94.80	0.00	0.00	1
AKE WALLACE		99.10	99.10	99.10	0.00	0.00	1
WANGOL		109.00	109.00	109.00	0.00	0.00	1
COX DS LYELL		109.10	109.10	109.10	0.00	0.00	1
OXS US LYELL		104.50	104.50	104.50	0.00	0.00	1
LAKE LYELL		106.40	106.40	106.40	0.00	0.00	1
WPS		90.30	90.30	90.30	0.00	0.00	1
COXS US		102.80	102.80	102.80	0.00	0.00	1
DMW Control	Cond uS/cm	187.20	187.20	187.20	0.00	0.00	1
SVLDP009 DS		1089.00	1089.00	1089.00	0.00	0.00	1
MADDOX		1007.00	1007.00	1007.00	0.00	0.00	1
AKE WALLACE		986.00	986.00	986.00	0.00	0.00	1
WANGOL		806.00	806.00	806.00	0.00	0.00	1
COX DS LYELL		506.00	506.00	506.00	0.00	0.00	1
OXS US LYELL		1049.00	1049.00	1049.00	0.00	0.00	1
LAKE LYELL		547.00	547.00	547.00	0.00	0.00	1
WPS		949.00	949.00	949.00	0.00	0.00	1
COXS US		41.50	41.50	41.50	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	11/09/2014 14:15	Test ID:	PR1223/21	Sample ID:	Various
End Date:	19/09/2014 14:00	Lab ID:	Various	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

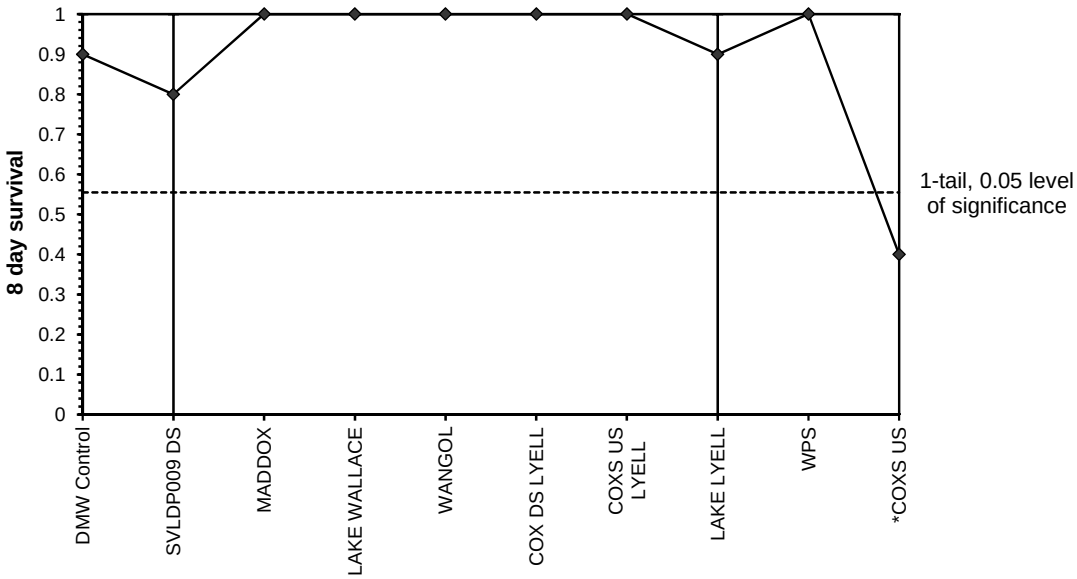
Conc-	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
SVLDP009 DS	0.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
MADDOX	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
AKE WALLACE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
WANGOL	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
COX DS LYELL	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
COXS US LYELL	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
LAKE LYELL	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
WPS	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
COXS US	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000

			Transform: Arcsin Square Root					1-Tailed		
Conc-	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
DMW Control	0.9000	1.0000	0.9948	0.5236	1.0472	16.644	10			
SVLDP009 DS	0.8000	0.8889	0.9425	0.5236	1.0472	23.424	10	0.881	2.593	0.1541
MADDOX	1.0000	1.1111	1.0472	1.0472	1.0472	0.000	10	-0.881	2.593	0.1541
AKE WALLACE	1.0000	1.1111	1.0472	1.0472	1.0472	0.000	10	-0.881	2.593	0.1541
WANGOL	1.0000	1.1111	1.0472	1.0472	1.0472	0.000	10	-0.881	2.593	0.1541
COX DS LYELL	1.0000	1.1111	1.0472	1.0472	1.0472	0.000	10	-0.881	2.593	0.1541
COXS US LYELL	1.0000	1.1111	1.0472	1.0472	1.0472	0.000	10	-0.881	2.593	0.1541
LAKE LYELL	0.9000	1.0000	0.9948	0.5236	1.0472	16.644	10	0.000	2.593	0.1541
WPS	1.0000	1.1111	1.0472	1.0472	1.0472	0.000	10	-0.881	2.593	0.1541
*COXS US	0.4000	0.4444	0.7330	0.5236	1.0472	36.886	10	4.404	2.593	0.1541

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates non-normal distribution (p <= 0.05)	4.03	0.895	-1.39557	5.718277
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test indicates significant differences	0.148165	0.21065	0.097478	0.017668	5.0E-06	9, 90
Treatments vs DMW Control						

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-8 day survival

Start Date:	11/09/2014 14:15	Test ID:	PR1223/21	Sample ID:	Various
End Date:	19/09/2014 14:00	Lab ID:	Various	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

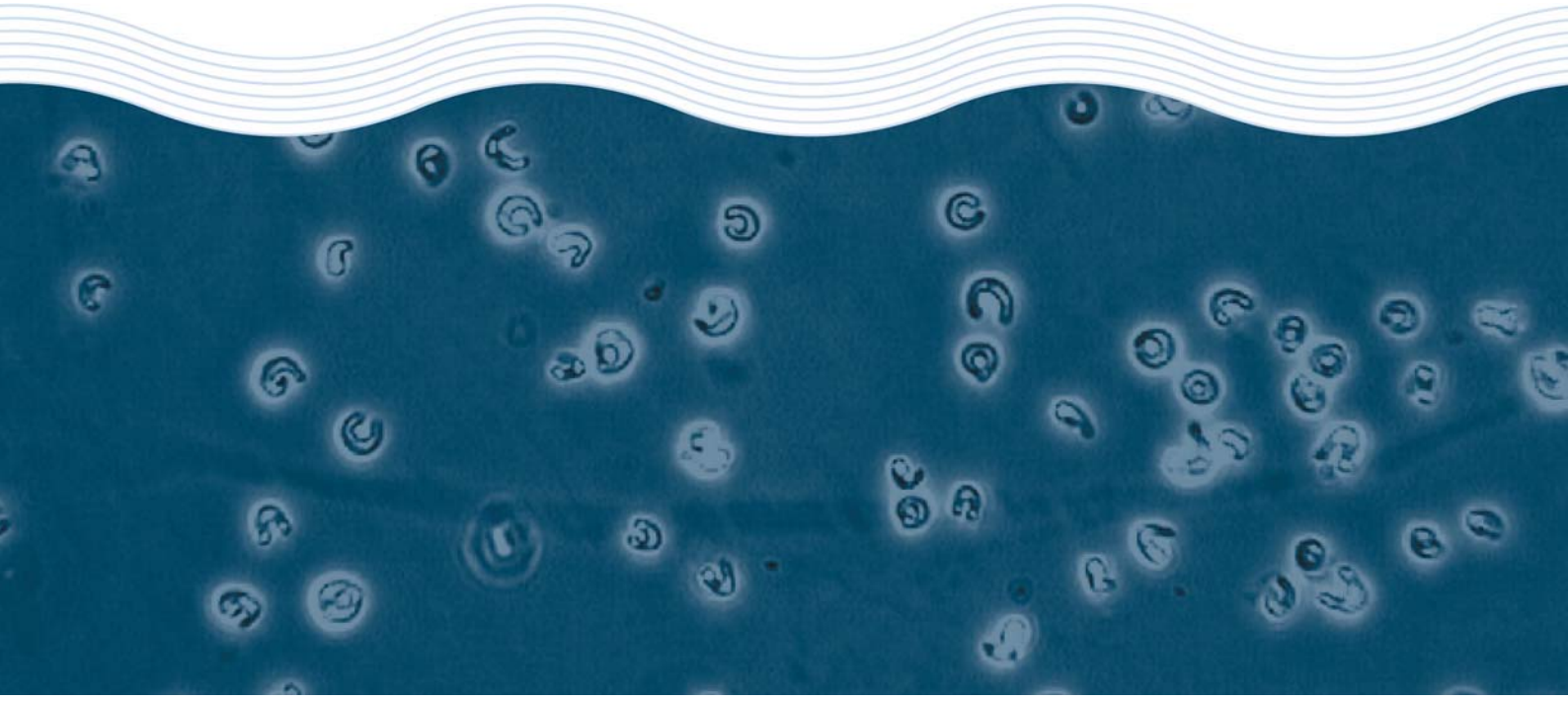
		Auxiliary Data Summary					
Conc-	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
DMW Control	No of Young	19.30	1.00	25.00	7.21	13.91	10
SVLDP009 DS		0.80	0.00	4.00	1.69	162.33	10
MADDOX		5.50	0.00	17.00	5.21	41.51	10
AKE WALLACE		22.30	13.00	37.00	6.18	11.15	10
WANGOL		12.20	0.00	20.00	6.21	20.43	10
COX DS LYELL		21.90	12.00	28.00	4.61	9.80	10
OXS US LYELL		20.50	0.00	28.00	8.20	13.96	10
LAKE LYELL		20.60	5.00	28.00	7.66	13.44	10
WPS		12.80	0.00	23.00	6.71	20.24	10
COXS US		0.20	0.00	2.00	0.63	397.64	10
DMW Control	% survival	90.00	0.00	100.00	31.62	6.25	10
SVLDP009 DS		80.00	0.00	100.00	42.16	8.12	10
MADDOX		100.00	100.00	100.00	0.00	0.00	10
AKE WALLACE		100.00	100.00	100.00	0.00	0.00	10
WANGOL		100.00	100.00	100.00	0.00	0.00	10
COX DS LYELL		100.00	100.00	100.00	0.00	0.00	10
OXS US LYELL		100.00	100.00	100.00	0.00	0.00	10
LAKE LYELL		90.00	0.00	100.00	31.62	6.25	10
WPS		100.00	100.00	100.00	0.00	0.00	10
COXS US		40.00	0.00	100.00	51.64	17.97	10
DMW Control	pH	8.10	8.10	8.10	0.00	0.00	1
SVLDP009 DS		8.80	8.80	8.80	0.00	0.00	1
MADDOX		8.60	8.60	8.60	0.00	0.00	1
AKE WALLACE		8.50	8.50	8.50	0.00	0.00	1
WANGOL		8.70	8.70	8.70	0.00	0.00	1
COX DS LYELL		8.30	8.30	8.30	0.00	0.00	1
OXS US LYELL		8.70	8.70	8.70	0.00	0.00	1
LAKE LYELL		8.40	8.40	8.40	0.00	0.00	1
WPS		8.40	8.40	8.40	0.00	0.00	1
COXS US		6.60	6.60	6.60	0.00	0.00	1
DMW Control	DO %	100.90	100.90	100.90	0.00	0.00	1
SVLDP009 DS		89.00	89.00	89.00	0.00	0.00	1
MADDOX		94.80	94.80	94.80	0.00	0.00	1
AKE WALLACE		99.10	99.10	99.10	0.00	0.00	1
WANGOL		109.00	109.00	109.00	0.00	0.00	1
COX DS LYELL		109.10	109.10	109.10	0.00	0.00	1
OXS US LYELL		104.50	104.50	104.50	0.00	0.00	1
LAKE LYELL		106.40	106.40	106.40	0.00	0.00	1
WPS		90.30	90.30	90.30	0.00	0.00	1
COXS US		102.80	102.80	102.80	0.00	0.00	1
DMW Control	Cond uS/cm	187.20	187.20	187.20	0.00	0.00	1
SVLDP009 DS		1089.00	1089.00	1089.00	0.00	0.00	1
MADDOX		1007.00	1007.00	1007.00	0.00	0.00	1
AKE WALLACE		986.00	986.00	986.00	0.00	0.00	1
WANGOL		806.00	806.00	806.00	0.00	0.00	1
COX DS LYELL		506.00	506.00	506.00	0.00	0.00	1
OXS US LYELL		1049.00	1049.00	1049.00	0.00	0.00	1
LAKE LYELL		547.00	547.00	547.00	0.00	0.00	1
WPS		949.00	949.00	949.00	0.00	0.00	1
COXS US		41.50	41.50	41.50	0.00	0.00	1

Toxicity Screening of Freshwater Samples

GHD Pty Ltd

Test Report

October 2014



Toxicity Screening of Freshwater Samples

GHD Pty Ltd

Test Report

October 2014

ECOTOX Services Australasia Pty Ltd ABN>45 094 714 904
unit 27/2 chaplin drive lane cove nsw 2066 T>61 2 9420 9481 F>61 2 9420 9484 W>www.ecotox.com.au

Toxicity Test Report: TR1238/1

Accredited for compliance with ISO/IEC 17025

Client:	GHD	**ESA Job #:**	PR1238
	Level 3, 24 Honeysuckle drive	**Date Sampled:**	21 October 2014
	Newcastle NSW 2300	**Date Received:**	23 October 2014
Attention:	Stuart Gray	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL1238_q01

Lab ID No.:	Sample Name:	Sample Description:
6908	U/S LDP009	Aqueous sample, pH 8.3*, conductivity 1196µS/cm*. Sample received at 23ºC* in apparent good condition.
6909	LDP009	Aqueous sample, pH 8.4*, conductivity 1190µS/cm*. Sample received at 23ºC* in apparent good condition.
6910	Kangaroo	Aqueous sample, pH 8.5*, conductivity 833µS/cm*. Sample received at 23ºC* in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia*
Test Protocol:	ESA SOP 102 (ESA 2013), based on USEPA (2002) and Bailey *et al*. (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were tested without dilution (100%). A DMW control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	24 October 2014 at 1500h

Sample 6908, 6909, 6910: *U/S LDP009, LDP009, Kangaroo*

Concentration (%)	% Survival at 7 days (Mean ± SD)	
DMW Control	100 ± 0.0	
U/S LDP009	80.0 ± 42.2	
LDP009	40.0 ± 51.6	*
Kangaroo	100 ± 0.0	

Sample 6908, 6909, 6910: *U/S LDP009, LDP009, Kangaroo*

Concentration (%)	Number of Young (Mean ± SD)	
DMW Control	16.4 ± 6.8	
U/S LDP009	1.9 ± 2.1	**
LDP009	0.7 ± 1.5	**
Kangaroo	21.5 ± 4.8	

*Significantly lower percentage survival compared with the DMW Control (Bonferroni adjusted t Test, 1-tailed, P=0.05)
*Significantly lower young compared with the DMW Control (Heteroscedastic t Test, 1-tailed, P=0.05)

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % survival	≥80.0%	100%	Yes
Control mean number of young	≥15.0	16.4	Yes
Reference Toxicant within cusum chart limits	141.7-427.3mg KCl/L	244.0mg KCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 7 November 2014

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2013) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia.* Issue No 9. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

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SERVICES AUSTRALASIA

Chain-of-Custody Documentation

Datasheet ID: 601.2
Last Revised: 30 April 2009

Sample Receipt Notification

Attention : Stuart Gray

Client : GHD Pty Ltd
Level 3, 24 Honeysuckle Drive
Newcastle NSW 2300

Email : stuart.gray@ghd.com
Telephone : (02) 4979 9017
Facsimile :

Date : 23/10/2014

Re : Receipt of Samples **Pages : 2**

ESA Project : PR1238 ☑ For Review ☐ Additional Documentation Required - Please Respond

Sample Delivery Details

Completed Chain of Custody accompanied samples: **YES**
Samples received in apparent good condition and correctly bottled: **YES**
Security seals on sample bottles and esky intact: **YES**

Date samples received : 23/10/2014
Time samples received : 10:00
No. of samples received : 3
Sample matrix : Aqueous
Sample temperature : 23°C

Comments : Includes 1x5L U/S LDP009 (ESA ID# 6908), 1x5L LDP009 (ESA ID# 6909) and 1x5L KANGAROO (ESA ID# 6910)

Contact Details

Customer Services Officer : Tina Micevska
Telephone : 61 2 9420 9481
Facsimile : 61 2 9420 9484
Email : tmicevska@ecotox.com.au

Please contact customer services officer for all queries or issues regarding samples

Note that the chain-of-custody provides definitive information on the tests to be performed

Ecotox Services Australia
ABN 45 094 714 904
Unit 27, 2 Chaplin Drive
Lane Cove NSW 2066 Australia

Phone : 61 2 9420 9481
Fax : 61 2 9420 9484
Email : info@ecotox.com.au

Chain-of-Custody / Service Request Form

ecotox SERVICES AUSTRALASIA

Datasheet ID: 601.1
Last Revised: 15 July 2014

Customer: GHD
Contact Name: STUART GRAY
Phone: 0401416936 Email: stuart.gray@ghd.com (please provide an email address for sample receipt notification)
Sampled by: SG/TD

Ship To:
Attention:

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance)	Comments / Instructions
					Chronic Cerio	**Note that testing will be delayed if an incomplete chain of custody is received** • Additional treatment of samples (i.e. spiking) • Sub-contracted services (i.e. chemical analyses) • Dilutions required (if different than 100% down to 6.25%) • Sample holding time restriction (if applicable) • Sample used for litigation (if applicable) *Note: An MSDS must be attached if Available* **ESA Project Number: PR 1238**
21/10/14	10:30 am	U/S LDP009	Grab	1 x 5L	X	Screening test only
21/10/14	11:00 am	LDP009	Grab	1 x 5L	X	Screening test only
21/10/14	11:30 am	KANGAROO	Grab	1 x 5L	X	Screening test only

6908
6909
6910
4.23°C

1) Released By:	Date:	2) Received By:	Date:	3) Released By:	Date:	4) Received By:	Date:
SGray		TM	23/10/14				
Of: GHD	Time:	Of: ESA	Time: 1000	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australasia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

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Statistical Printouts for the 7-d Chronic Test with *Ceriodaphnia dubia*

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	24/10/2014 15:00	Test ID:	PR1238/02	Sample ID:	Various
End Date:	31/10/2014 12:15	Lab ID:	6908, 6909, 6910	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

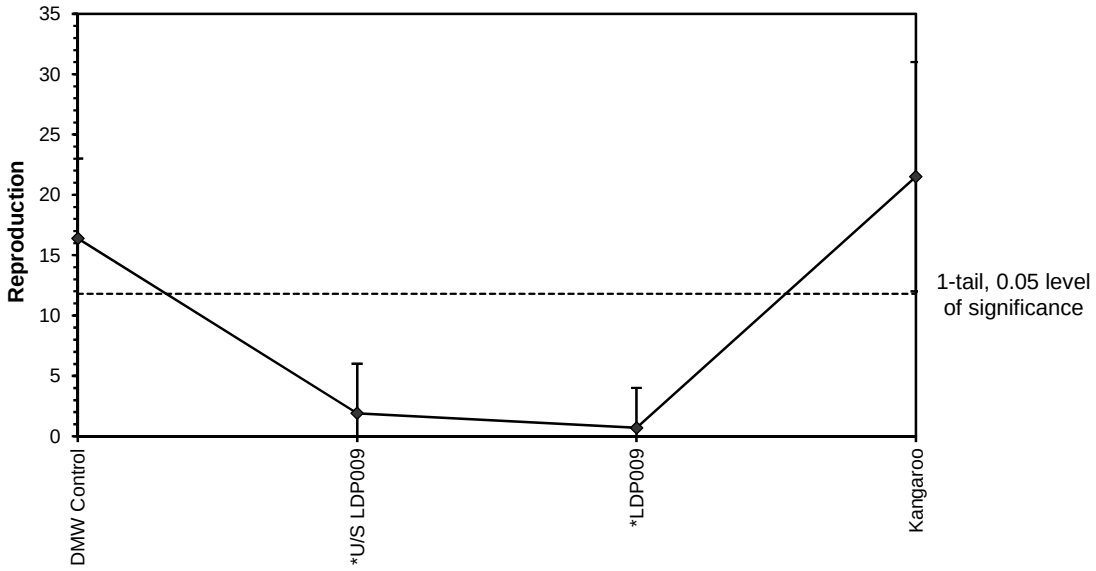
Conc-	1	2	3	4	5	6	7	8	9	10
DMW Control	0.000	14.000	23.000	20.000	22.000	20.000	18.000	20.000	15.000	12.000
U/S LDP009	4.000	2.000	0.000	0.000	6.000	0.000	1.000	2.000	4.000	0.000
LDP009	0.000	3.000	0.000	0.000	0.000	0.000	0.000	4.000	0.000	0.000
Kangaroo	20.000	12.000	21.000	21.000	23.000	31.000	22.000	19.000	21.000	25.000

			Transform: Untransformed					1-Tailed		
Conc-	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
DMW Control	16.400	1.0000	16.400	0.000	23.000	41.276	10			
*U/S LDP009	1.900	0.1159	1.900	0.000	6.000	112.198	10	6.461	1.812	4.068
*LDP009	0.700	0.0427	0.700	0.000	4.000	213.491	10	7.162	1.833	4.018
Kangaroo	21.500	1.3110	21.500	12.000	31.000	22.171	10	-1.948	1.746	4.571

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.863234	0.94	-1.40556	5.976053
Bartlett's Test indicates unequal variances (p = 9.11E-05)	21.30151	11.34487		

Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Heteroscedastic t Test indicates significant differences	4.570897	0.278713	1084.158	18.83056	8.2E-14	3, 36
Treatments vs DMW Control						

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	24/10/2014 15:00	Test ID:	PR1238/02	Sample ID:	Various
End Date:	31/10/2014 12:15	Lab ID:	6908, 6909, 6910	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	16.40	0.00	23.00	6.77	15.86	10
U/S LDP009		1.90	0.00	6.00	2.13	76.85	10
LDP009		0.70	0.00	4.00	1.49	174.64	10
Kangaroo		21.50	12.00	31.00	4.77	10.15	10
DMW Control	% survival	100.00	100.00	100.00	0.00	0.00	10
U/S LDP009		80.00	0.00	100.00	42.16	8.12	10
LDP009		40.00	0.00	100.00	51.64	17.97	10
Kangaroo		100.00	100.00	100.00	0.00	0.00	10
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
U/S LDP009		8.30	8.30	8.30	0.00	0.00	1
LDP009		8.40	8.40	8.40	0.00	0.00	1
Kangaroo		8.50	8.50	8.50	0.00	0.00	1
DMW Control	DO %	109.30	109.30	109.30	0.00	0.00	1
U/S LDP009		110.10	110.10	110.10	0.00	0.00	1
LDP009		108.40	108.40	108.40	0.00	0.00	1
Kangaroo		109.30	109.30	109.30	0.00	0.00	1
DMW Control	Cond uS/cm	189.50	189.50	189.50	0.00	0.00	1
U/S LDP009		1196.00	1196.00	1196.00	0.00	0.00	1
LDP009		1190.00	1190.00	1190.00	0.00	0.00	1
Kangaroo		833.00	833.00	833.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-7 Day Unaffected

Start Date:	24/10/2014 15:00	Test ID:	PR1238/02	Sample ID:	Various
End Date:	31/10/2014 12:15	Lab ID:	6908, 6909, 6910	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

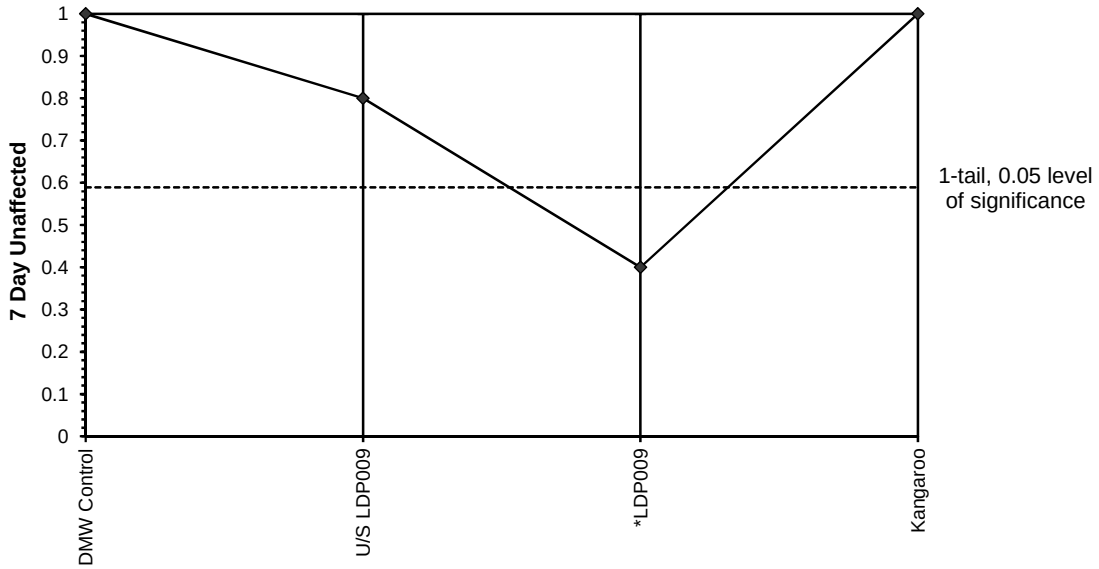
Conc-	1	2	3	4	5	6	7	8	9	10
DMW Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
U/S LDP009	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000
LDP009	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	1.0000	0.0000	0.0000
Kangaroo	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

			Transform: Arcsin Square Root					1-Tailed		
Conc-	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
DMW Control	1.0000	1.0000	1.0472	1.0472	1.0472	0.000	10			
U/S LDP009	0.8000	0.8000	0.9425	0.5236	1.0472	23.424	10	1.342	2.213	0.1727
*LDP009	0.4000	0.4000	0.7330	0.5236	1.0472	36.886	10	4.025	2.213	0.1727
Kangaroo	1.0000	1.0000	1.0472	1.0472	1.0472	0.000	10	0.000	2.213	0.1727

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.862131	0.94	-0.39442	1.030754
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Bonferroni t Test indicates no significant differences	0.161394	0.215192	0.219325	0.030462	6.6E-04	3, 36
Treatments vs DMW Control						

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-7 Day Unaffected

Start Date:	24/10/2014 15:00	Test ID:	PR1238/02	Sample ID:	Various
End Date:	31/10/2014 12:15	Lab ID:	6908, 6909, 6910	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Auxiliary Data Summary

Conc-	Parameter	Mean	Min	Max	SD	CV%	N
DMW Control	No of Young	16.40	0.00	23.00	6.77	15.86	10
U/S LDP009		1.90	0.00	6.00	2.13	76.85	10
LDP009		0.70	0.00	4.00	1.49	174.64	10
Kangaroo		21.50	12.00	31.00	4.77	10.15	10
DMW Control	% survival	100.00	100.00	100.00	0.00	0.00	10
U/S LDP009		80.00	0.00	100.00	42.16	8.12	10
LDP009		40.00	0.00	100.00	51.64	17.97	10
Kangaroo		100.00	100.00	100.00	0.00	0.00	10
DMW Control	pH	8.20	8.20	8.20	0.00	0.00	1
U/S LDP009		8.30	8.30	8.30	0.00	0.00	1
LDP009		8.40	8.40	8.40	0.00	0.00	1
Kangaroo		8.50	8.50	8.50	0.00	0.00	1
DMW Control	DO %	109.30	109.30	109.30	0.00	0.00	1
U/S LDP009		110.10	110.10	110.10	0.00	0.00	1
LDP009		108.40	108.40	108.40	0.00	0.00	1
Kangaroo		109.30	109.30	109.30	0.00	0.00	1
DMW Control	Cond uS/cm	189.50	189.50	189.50	0.00	0.00	1
U/S LDP009		1196.00	1196.00	1196.00	0.00	0.00	1
LDP009		1190.00	1190.00	1190.00	0.00	0.00	1
Kangaroo		833.00	833.00	833.00	0.00	0.00	1

Appendix C – Water Quality Report

CERTIFICATE OF ANALYSIS

Work Order	: **ES1418822**	Page	: 1 of 11
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR STUART GRAY	Contact	: Barbara Hanna
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: stuart.c.gray@ghd.com	E-mail	: Barbara.Hanna@alsglobal.com
Telephone	: ----	Telephone	: +61 2 8784 8555
Facsimile	: ----	Facsimile	: +61 2 8784 8555
Project	: 2217471	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: 161034	Date Samples Received	: 25-AUG-2014
Sampler	: LH	Issue Date	: 01-SEP-2014
Site	: ----		
		No. of samples received	: 12
Quote number	: EN/005/14	No. of samples analysed	: 12

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics
Dian Dao		Sydney Inorganics
Shobhna Chandra	Metals Coordinator	Sydney Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **ED093F: Sodium Adsorption ratio could not be calculated as Calcium and Magnesium results are below the detection limit for sample ES1418822 #006.**
- **EG020: It has been confirmed by re-digestion and re-analysis that total Strontium concentration is less than dissolved for sample ES1418822 # 001. For all other samples and analytes where dissolved is greater than total, the difference is within experimental variation of the methods.**
- **Ionic Balance out of acceptable limits due to analytes not quantified in this report.**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SV LDP009	MADOOX	AP DS LDP001	AP LDP001	SV LDP009 DS
				Client sampling date / time	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00
Compound	CAS Number	LOR	Unit		ES1418822-001	ES1418822-002	ES1418822-003	ES1418822-004	ES1418822-005
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		8.21	8.47	8.28	8.01	8.73
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Adsorption Ratio	----	0.01	-		80.1	10.4	5.31	7.36	47.4
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		1200	1030	591	1050	1100
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	1	mg/L		780	670	384	682	715
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		19	10	13	<5	10
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		2	76	64	116	7
ED009: Anions									
Bromide	24959-67-9	0.010	mg/L		0.046	0.082	0.035	0.067	0.057
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	22	<1	<1	60
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		625	392	291	538	512
Total Alkalinity as CaCO3	----	1	mg/L		625	414	291	538	572
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		34	142	17	25	34
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		6	15	10	10	6
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		1	14	11	20	1
Magnesium	7439-95-4	1	mg/L		<1	10	9	16	1
Sodium	7440-23-5	1	mg/L		291	208	98	182	280
Potassium	7440-09-7	1	mg/L		9	10	19	32	10
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		0.01	0.02	0.02	<0.01	0.03
Arsenic	7440-38-2	0.001	mg/L		0.024	0.014	<0.001	<0.001	0.021
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		0.028	0.020	0.092	0.178	0.021
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	SV LDP009	MADOOX	AP DS LDP001	AP LDP001	SV LDP009 DS
				Client sampling date / time	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00
					ES1418822-001	ES1418822-002	ES1418822-003	ES1418822-004	ES1418822-005
EG020F: Dissolved Metals by ICP-MS - Continued									
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L		<0.001	**0.001**	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	**0.002**	**0.001**	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		**0.008**	**0.113**	**0.010**	**0.003**	**0.013**
Molybdenum	7439-98-7	0.001	mg/L		**0.038**	**0.022**	**0.006**	**0.012**	**0.034**
Nickel	7440-02-0	0.001	mg/L		**0.004**	**0.010**	**0.002**	**0.003**	**0.003**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L		**0.030**	**0.083**	**0.079**	**0.117**	**0.028**
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.007**	**0.012**	**0.012**	**0.016**	**0.005**
Boron	7440-42-8	0.05	mg/L		**0.07**	**0.10**	<0.05	**0.06**	**0.07**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	**0.06**	<0.05	<0.05
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.19**	**0.14**	**0.05**	**0.02**	**0.19**
Arsenic	7440-38-2	0.001	mg/L		**0.023**	**0.014**	<0.001	<0.001	**0.022**
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		**0.027**	**0.023**	**0.089**	**0.194**	**0.024**
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L		<0.001	**0.002**	<0.001	<0.001	**0.002**
Copper	7440-50-8	0.001	mg/L		**0.003**	<0.001	**0.002**	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		**0.014**	**0.154**	**0.012**	**0.006**	**0.059**
Molybdenum	7439-98-7	0.001	mg/L		**0.036**	**0.026**	**0.005**	**0.014**	**0.039**
Nickel	7440-02-0	0.001	mg/L		**0.003**	**0.011**	**0.001**	**0.002**	**0.004**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L		**0.015**	**0.081**	**0.066**	**0.117**	**0.025**
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.017**	**0.014**	**0.014**	**0.010**	**0.009**
Boron	7440-42-8	0.05	mg/L		**0.06**	**0.10**	<0.05	**0.07**	**0.08**
Iron	7439-89-6	0.05	mg/L		**0.30**	**0.31**	**0.23**	<0.05	**0.24**
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SV LDP009	MADOOX	AP DS LDP001	AP LDP001	SV LDP009 DS
				Client sampling date / time	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00	21-AUG-2014 15:00
Compound	CAS Number	LOR	Unit		ES1418822-001	ES1418822-002	ES1418822-003	ES1418822-004	ES1418822-005
EG035F: Dissolved Mercury by FIMS - Continued									
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES									
Silicon as SiO2	14464-46-1	0.1	mg/L		**8.6**	**7.8**	**9.7**	**8.6**	**8.5**
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**1.5**	**1.3**	**0.7**	**1.0**	**1.8**
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.44**	**0.06**	<0.01	<0.01	**0.09**
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	**0.01**
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.21**	**0.42**	**0.02**	**0.34**	**0.44**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.21**	**0.42**	**0.02**	**0.34**	**0.45**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.6**	**0.2**	<0.1	<0.1	**0.1**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ **Total Nitrogen as N**	----	0.1	mg/L		**0.8**	**0.6**	<0.1	**0.3**	**0.6**
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.02**	**0.01**	<0.01	<0.01	**0.01**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**13.4**	**11.6**	**6.45**	**11.6**	**12.3**
Total Cations	----	0.01	meq/L		**12.9**	**10.8**	**6.04**	**11.0**	**12.6**
Ionic Balance	----	0.01	%		**1.69**	**3.73**	**3.34**	**2.27**	**0.98**
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**55**	**6**	**14**	**17**	**66**
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	COXS US	WANGCOL	WALLACE	US LYELL	LYELL
				Client sampling date / time	21-AUG-2014 15:00	21-AUG-2014 15:00	22-AUG-2014 15:00	22-AUG-2014 15:00	22-AUG-2014 15:00
					ES1418822-006	ES1418822-007	ES1418822-008	ES1418822-009	ES1418822-010
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**5.69**	**6.98**	**8.41**	**8.65**	**8.42**
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Adsorption Ratio	----	0.01	-		----	**1.64**	**8.52**	**10.0**	**4.63**
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**39**	**823**	**1010**	**1080**	**557**
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	1	mg/L		**25**	**535**	**656**	**702**	**362**
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		**22**	**5**	<5	<5	<5
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		<1	**244**	**96**	**82**	**50**
ED009: Anions									
Bromide	24959-67-9	0.010	mg/L		<0.010	**0.092**	**0.074**	**0.065**	**0.076**
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	**16**	**40**	**2**
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**1**	**16**	**336**	**348**	**111**
Total Alkalinity as CaCO3	----	1	mg/L		**1**	**16**	**352**	**388**	**113**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**3**	**341**	**160**	**164**	**117**
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**8**	**34**	**20**	**18**	**16**
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	**45**	**17**	**13**	**10**
Magnesium	7439-95-4	1	mg/L		<1	**32**	**13**	**12**	**6**
Sodium	7440-23-5	1	mg/L		**4**	**59**	**192**	**209**	**75**
Potassium	7440-09-7	1	mg/L		<1	**7**	**12**	**13**	**7**
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.03**	**0.02**	**0.01**	<0.01	<0.01
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	**0.006**	**0.004**	<0.001
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		**0.016**	**0.014**	**0.026**	**0.025**	**0.026**
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	**0.0001**	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	COXS US	WANGCOL	WALLACE	US LYELL	LYELL
				Client sampling date / time	21-AUG-2014 15:00	21-AUG-2014 15:00	22-AUG-2014 15:00	22-AUG-2014 15:00	22-AUG-2014 15:00
					ES1418822-006	ES1418822-007	ES1418822-008	ES1418822-009	ES1418822-010
EG020F: Dissolved Metals by ICP-MS - Continued									
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L		<0.001	**0.006**	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		<0.001	**0.003**	**0.002**	**0.002**	**0.002**
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		**0.057**	**0.812**	**0.040**	**0.011**	**0.002**
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	**0.015**	**0.016**	**0.005**
Nickel	7440-02-0	0.001	mg/L		**0.004**	**0.021**	**0.007**	**0.004**	**0.002**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L		**0.009**	**0.188**	**0.117**	**0.139**	**0.120**
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.011**	**0.037**	**0.047**	**0.005**	<0.005
Boron	7440-42-8	0.05	mg/L		<0.05	**0.14**	**0.12**	**0.18**	**0.09**
Iron	7439-89-6	0.05	mg/L		**0.09**	**0.05**	<0.05	<0.05	<0.05
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.05**	**0.11**	**0.07**	**0.06**	**0.02**
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	**0.006**	**0.004**	<0.001
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		**0.016**	**0.011**	**0.025**	**0.025**	**0.023**
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L		<0.001	**0.005**	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		**0.002**	<0.001	<0.001	**0.001**	**0.001**
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		**0.058**	**0.859**	**0.059**	**0.031**	**0.006**
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	**0.017**	**0.018**	**0.005**
Nickel	7440-02-0	0.001	mg/L		<0.001	**0.020**	**0.006**	**0.004**	**0.002**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.001	mg/L		**0.007**	**0.180**	**0.116**	**0.131**	**0.106**
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.009**	**0.027**	<0.005	<0.005	<0.005
Boron	7440-42-8	0.05	mg/L		<0.05	**0.16**	**0.12**	**0.19**	**0.11**
Iron	7439-89-6	0.05	mg/L		**0.61**	**0.30**	**0.10**	**0.05**	<0.05
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	COXS US	WANGCOL	WALLACE	US LYELL	LYELL
				Client sampling date / time	21-AUG-2014 15:00	21-AUG-2014 15:00	22-AUG-2014 15:00	22-AUG-2014 15:00	22-AUG-2014 15:00
					ES1418822-006	ES1418822-007	ES1418822-008	ES1418822-009	ES1418822-010
EG035F: Dissolved Mercury by FIMS - Continued									
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG052F: Dissolved Silica by ICPAES									
Silicon as SiO2	14464-46-1	0.1	mg/L		**9.4**	**7.5**	**3.9**	**1.0**	**0.2**
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	**0.2**	**1.1**	**1.1**	**0.6**
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	**0.02**	**0.03**	<0.01	<0.01
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.24**	<0.01	**0.13**	<0.01	**0.14**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.24**	<0.01	**0.13**	<0.01	**0.14**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<0.1	<0.1	**0.3**	**0.2**	**0.3**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ **Total Nitrogen as N**	----	0.1	mg/L		**0.2**	<0.1	**0.4**	**0.2**	**0.4**
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	<0.01	**0.01**	**0.02**	**0.01**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**0.31**	**8.38**	**10.9**	**11.7**	**5.15**
Total Cations	----	0.01	meq/L		**0.17**	**7.62**	**10.6**	**11.1**	**4.43**
Ionic Balance	----	0.01	%		----	**4.71**	**1.68**	**2.75**	**7.46**
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**48**	**7**	**6**	**42**	**20**
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DS LYELL	WPS	----	----	----
				Client sampling date / time	22-AUG-2014 15:00	22-AUG-2014 15:00	----	----	----
Compound	CAS Number	LOR	Unit		ES1418822-011	ES1418822-012	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		8.28	8.40	----	----	----
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Adsorption Ratio	----	0.01	-		3.93	8.74	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		516	973	----	----	----
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	1	mg/L		335	632	----	----	----
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		<5	<5	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		65	101	----	----	----
ED009: Anions									
Bromide	24959-67-9	0.010	mg/L		0.063	0.082	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	16	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		128	359	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		128	375	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		107	126	----	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		16	16	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		13	19	----	----	----
Magnesium	7439-95-4	1	mg/L		8	13	----	----	----
Sodium	7440-23-5	1	mg/L		73	202	----	----	----
Potassium	7440-09-7	1	mg/L		8	11	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	0.02	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	0.010	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L		0.023	0.023	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DS LYELL	WPS	----	----	----
				Client sampling date / time	22-AUG-2014 15:00	22-AUG-2014 15:00	----	----	----
Compound	CAS Number	LOR	Unit		ES1418822-011	ES1418822-012	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.001**	**0.002**	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.008**	**0.077**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.004**	**0.018**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.002**	**0.007**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.001	mg/L		**0.109**	**0.088**	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.005**	**0.016**	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.08**	**0.08**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.04**	**0.10**	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	**0.010**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.020**	**0.022**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.013**	**0.090**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.005**	**0.021**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.002**	**0.007**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.001	mg/L		**0.097**	**0.087**	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		<0.005	**0.008**	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.09**	**0.09**	----	----	----
Iron	7439-89-6	0.05	mg/L		**0.10**	**0.20**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DS LYELL	WPS	----	----	----
				Client sampling date / time	22-AUG-2014 15:00	22-AUG-2014 15:00	----	----	----
Compound	CAS Number	LOR	Unit		ES1418822-011	ES1418822-012	----	----	----
EG035F: Dissolved Mercury by FIMS - Continued									
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG052F: Dissolved Silica by ICPAES									
Silicon as SiO2	14464-46-1	0.1	mg/L		**1.8**	**7.8**	----	----	----
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	----	----	----
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.6**	**1.1**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	**0.04**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.04**	**0.32**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.04**	**0.32**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.2**	**0.2**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ **Total Nitrogen as N**	----	0.1	mg/L		**0.2**	**0.5**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.02**	**0.02**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**5.24**	**10.6**	----	----	----
Total Cations	----	0.01	meq/L		**4.69**	**11.1**	----	----	----
Ionic Balance	----	0.01	%		**5.57**	**2.35**	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**24**	**5**	----	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1423116**	Page	: 1 of 10
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR STUART GRAY	Contact	: Barbara Hanna
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: stuart.gray@ghd.com	E-mail	: Barbara.Hanna@alsglobal.com
Telephone	: +61 4979 9999	Telephone	: +61 2 8784 8555
Facsimile	: ----	Facsimile	: +61 2 8784 8555
Project	: 17471 COXS RIVER ECOTOX	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 22-OCT-2014
Sampler	: ----	Issue Date	: 29-OCT-2014
Site	: ----		
		No. of samples received	: 3
Quote number	: EN/005/14	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.**
- **EG020: It has been confirmed by re-digestion and re-analysis that total Strontium concentration is less than dissolved for sample ES1423116 - #001. For all other samples and analytes where AF is greater than total, the difference is within experimental variation of the methods.**
- **EP075: 'Sum of PAH' is the sum of the USEPA 16 priority PAHs**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	U/S LDP009	LDP009	KANGAROO	----	----
				Client sampling date / time	21-OCT-2014 10:30	21-OCT-2014 11:00	21-OCT-2014 11:30	----	----
					ES1423116-001	ES1423116-002	ES1423116-003	----	----
EA015: Total Dissolved Solids									
Total Dissolved Solids @180°C	----	10	mg/L		**692**	**652**	**495**	----	----
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		**13**	**9**	<5	----	----
EA045: Turbidity									
Turbidity	----	0.1	NTU		**22.0**	**8.5**	**2.6**	----	----
ED009: Anions									
Bromide	24959-67-9	0.010	mg/L		**0.034**	**0.019**	**0.041**	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		**10**	**12**	**13**	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**506**	**519**	**355**	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**516**	**531**	**368**	----	----
ED040F: Dissolved Major Anions									
Silicon as SiO2	14464-46-1	0.1	mg/L		**9.0**	**9.6**	**10.0**	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**34**	**33**	**14**	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**5**	**6**	**7**	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**1**	**1**	**14**	----	----
Magnesium	7439-95-4	1	mg/L		**1**	**1**	**13**	----	----
Sodium	7440-23-5	1	mg/L		**251**	**252**	**130**	----	----
Potassium	7440-09-7	1	mg/L		**8**	**9**	**23**	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	**0.10**	**0.01**	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.023**	**0.033**	**0.002**	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Barium	7440-39-3	0.001	mg/L		**0.028**	**0.025**	**0.152**	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	**0.001**	<0.001	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	U/S LDP009	LDP009	KANGAROO	----	----
				Client sampling date / time	21-OCT-2014 10:30	21-OCT-2014 11:00	21-OCT-2014 11:30	----	----
Compound	CAS Number	LOR	Unit		ES1423116-001	ES1423116-002	ES1423116-003	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Manganese	7439-96-5	0.001	mg/L		**0.002**	**0.006**	**0.037**	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.036**	**0.035**	**0.009**	----	----
Nickel	7440-02-0	0.001	mg/L		**0.002**	**0.004**	**0.002**	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Strontium	7440-24-6	0.001	mg/L		**0.028**	**0.018**	**0.115**	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L		**0.017**	**0.012**	**0.011**	----	----
Boron	7440-42-8	0.05	mg/L		**0.07**	**0.07**	**0.07**	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.24**	**0.24**	**0.07**	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.030**	**0.030**	<0.001	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Barium	7440-39-3	0.001	mg/L		**0.027**	**0.026**	**0.160**	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L		**0.001**	**0.005**	<0.001	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L		**0.003**	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L		**0.001**	<0.001	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L		**0.006**	**0.008**	**0.044**	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.048**	**0.049**	**0.011**	----	----
Nickel	7440-02-0	0.001	mg/L		**0.004**	**0.007**	**0.002**	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Strontium	7440-24-6	0.001	mg/L		**0.020**	**0.018**	**0.106**	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L		**0.006**	<0.005	**0.016**	----	----
Boron	7440-42-8	0.05	mg/L		**0.07**	**0.07**	**0.06**	----	----
Iron	7439-89-6	0.05	mg/L		**0.41**	**0.14**	**0.85**	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
EK025SF: Free CN by Segmented Flow Analyser									

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	U/S LDP009	LDP009	KANGAROO	----	----
				Client sampling date / time	21-OCT-2014 10:30	21-OCT-2014 11:00	21-OCT-2014 11:30	----	----
Compound	CAS Number	LOR	Unit		ES1423116-001	ES1423116-002	ES1423116-003	----	----
EK025SF: Free CN by Segmented Flow Analyser - Continued									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	----	----
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	<0.004	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**1.3**	**1.3**	**0.8**	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.14**	**0.43**	<0.01	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.78**	**0.43**	**0.11**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.78**	**0.43**	**0.11**	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.2**	**0.5**	<0.1	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**1.0**	**0.9**	**0.1**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.02**	**0.01**	**0.12**	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**11.2**	**11.5**	**7.84**	----	----
Total Cations	----	0.01	meq/L		**11.2**	**11.3**	**8.01**	----	----
Ionic Balance	----	0.01	%		**0.36**	**0.69**	**1.03**	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**41**	**5**	**10**	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	----	<5	----	----
Oil & Grease	----	5	mg/L		----	<5	----	----	----
EP075A: Phenolic Compounds									
Phenol	108-95-2	2	µg/L		<2	<2	----	----	----
2-Chlorophenol	95-57-8	2	µg/L		<2	<2	----	----	----
2-Methylphenol	95-48-7	2	µg/L		<2	<2	----	----	----
3- & 4-Methylphenol	1319-77-3	4	µg/L		<4	<4	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	U/S LDP009	LDP009	KANGAROO	----	----
				Client sampling date / time	21-OCT-2014 10:30	21-OCT-2014 11:00	21-OCT-2014 11:30	----	----
Compound	CAS Number	LOR	Unit		ES1423116-001	ES1423116-002	ES1423116-003	----	----
EP075A: Phenolic Compounds - Continued									
2-Nitrophenol	88-75-5	2	µg/L		<2	<2	----	----	----
2.4-Dimethylphenol	105-67-9	2	µg/L		<2	<2	----	----	----
2.4-Dichlorophenol	120-83-2	2	µg/L		<2	<2	----	----	----
2.6-Dichlorophenol	87-65-0	2	µg/L		<2	<2	----	----	----
4-Chloro-3-methylphenol	59-50-7	2	µg/L		<2	<2	----	----	----
2.4.6-Trichlorophenol	88-06-2	2	µg/L		<2	<2	----	----	----
2.4.5-Trichlorophenol	95-95-4	2	µg/L		<2	<2	----	----	----
Pentachlorophenol	87-86-5	4	µg/L		<4	<4	----	----	----
EP075B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	2	µg/L		<2	<2	----	----	----
2-Methylnaphthalene	91-57-6	2	µg/L		<2	<2	----	----	----
2-Chloronaphthalene	91-58-7	2	µg/L		<2	<2	----	----	----
Acenaphthylene	208-96-8	2	µg/L		<2	<2	----	----	----
Acenaphthene	83-32-9	2	µg/L		<2	<2	----	----	----
Fluorene	86-73-7	2	µg/L		<2	<2	----	----	----
Phenanthrene	85-01-8	2	µg/L		<2	<2	----	----	----
Anthracene	120-12-7	2	µg/L		<2	<2	----	----	----
Fluoranthene	206-44-0	2	µg/L		<2	<2	----	----	----
Pyrene	129-00-0	2	µg/L		<2	<2	----	----	----
N-2-Fluorenyl Acetamide	53-96-3	2	µg/L		<2	<2	----	----	----
Benz(a)anthracene	56-55-3	2	µg/L		<2	<2	----	----	----
Chrysene	218-01-9	2	µg/L		<2	<2	----	----	----
Benzo(b+j) & Benzo(k)fluoranthene	205-99-2 207-08-9	4	µg/L		<4	<4	----	----	----
7.12-Dimethylbenz(a)anthracene	57-97-6	2	µg/L		<2	<2	----	----	----
Benzo(a)pyrene	50-32-8	2	µg/L		<2	<2	----	----	----
3-Methylcholanthrene	56-49-5	2	µg/L		<2	<2	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	2	µg/L		<2	<2	----	----	----
Dibenz(a.h)anthracene	53-70-3	2	µg/L		<2	<2	----	----	----
Benzo(g.h.i)perylene	191-24-2	2	µg/L		<2	<2	----	----	----
^ Sum of PAHs	----	2	µg/L		<2	<2	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	2	µg/L		<2	<2	----	----	----
EP075C: Phthalate Esters									
Dimethyl phthalate	131-11-3	2	µg/L		<2	<2	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	U/S LDP009	LDP009	KANGAROO	----	----
				Client sampling date / time	21-OCT-2014 10:30	21-OCT-2014 11:00	21-OCT-2014 11:30	----	----
Compound	CAS Number	LOR	Unit		ES1423116-001	ES1423116-002	ES1423116-003	----	----
EP075C: Phthalate Esters - Continued									
Diethyl phthalate	84-66-2	2	µg/L		<2	<2	----	----	----
Di-n-butyl phthalate	84-74-2	2	µg/L		<2	<2	----	----	----
Butyl benzyl phthalate	85-68-7	2	µg/L		<2	<2	----	----	----
bis(2-ethylhexyl) phthalate	117-81-7	10	µg/L		<10	<10	----	----	----
Di-n-octylphthalate	117-84-0	2	µg/L		<2	<2	----	----	----
EP075D: Nitrosamines									
N-Nitrosomethylethylamine	10595-95-6	2	µg/L		<2	<2	----	----	----
N-Nitrosodiethylamine	55-18-5	2	µg/L		<2	<2	----	----	----
N-Nitrosopyrrolidine	930-55-2	4	µg/L		<4	<4	----	----	----
N-Nitrosomorpholine	59-89-2	2	µg/L		<2	<2	----	----	----
N-Nitrosodi-n-propylamine	621-64-7	2	µg/L		<2	<2	----	----	----
N-Nitrosopiperidine	100-75-4	2	µg/L		<2	<2	----	----	----
N-Nitrosodibutylamine	924-16-3	2	µg/L		<2	<2	----	----	----
N-Nitrosodiphenyl & Diphenylamine	86-30-6 122-39-4	4	µg/L		<4	<4	----	----	----
Methapyrilene	91-80-5	2	µg/L		<2	<2	----	----	----
EP075E: Nitroaromatics and Ketones									
2-Picoline	109-06-8	2	µg/L		<2	<2	----	----	----
Acetophenone	98-86-2	2	µg/L		<2	<2	----	----	----
Nitrobenzene	98-95-3	2	µg/L		<2	<2	----	----	----
Isophorone	78-59-1	2	µg/L		<2	<2	----	----	----
2.6-Dinitrotoluene	606-20-2	4	µg/L		<4	<4	----	----	----
2.4-Dinitrotoluene	121-14-2	4	µg/L		<4	<4	----	----	----
1-Naphthylamine	134-32-7	2	µg/L		<2	<2	----	----	----
4-Nitroquinoline-N-oxide	56-57-5	2	µg/L		<2	<2	----	----	----
5-Nitro-o-toluidine	99-55-8	2	µg/L		<2	<2	----	----	----
Azobenzene	103-33-3	2	µg/L		<2	<2	----	----	----
1.3.5-Trinitrobenzene	99-35-4	2	µg/L		<2	<2	----	----	----
Phenacetin	62-44-2	2	µg/L		<2	<2	----	----	----
4-Aminobiphenyl	92-67-1	2	µg/L		<2	<2	----	----	----
Pentachloronitrobenzene	82-68-8	2	µg/L		<2	<2	----	----	----
Pronamide	23950-58-5	2	µg/L		<2	<2	----	----	----
Dimethylaminoazobenzene	60-11-7	2	µg/L		<2	<2	----	----	----
Chlorobenzilate	510-15-6	2	µg/L		<2	<2	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	U/S LDP009	LDP009	KANGAROO	----	----
				Client sampling date / time	21-OCT-2014 10:30	21-OCT-2014 11:00	21-OCT-2014 11:30	----	----
Compound	CAS Number	LOR	Unit		ES1423116-001	ES1423116-002	ES1423116-003	----	----
EP075F: Haloethers									
Bis(2-chloroethyl) ether	111-44-4	2	µg/L		<2	<2	----	----	----
Bis(2-chloroethoxy) methane	111-91-1	2	µg/L		<2	<2	----	----	----
4-Chlorophenyl phenyl ether	7005-72-3	2	µg/L		<2	<2	----	----	----
4-Bromophenyl phenyl ether	101-55-3	2	µg/L		<2	<2	----	----	----
EP075G: Chlorinated Hydrocarbons									
1.3-Dichlorobenzene	541-73-1	2	µg/L		<2	<2	----	----	----
1.4-Dichlorobenzene	106-46-7	2	µg/L		<2	<2	----	----	----
1.2-Dichlorobenzene	95-50-1	2	µg/L		<2	<2	----	----	----
Hexachloroethane	67-72-1	2	µg/L		<2	<2	----	----	----
1.2.4-Trichlorobenzene	120-82-1	2	µg/L		<2	<2	----	----	----
Hexachloropropylene	1888-71-7	2	µg/L		<2	<2	----	----	----
Hexachlorobutadiene	87-68-3	2	µg/L		<2	<2	----	----	----
Hexachlorocyclopentadiene	77-47-4	10	µg/L		<10	<10	----	----	----
Pentachlorobenzene	608-93-5	2	µg/L		<2	<2	----	----	----
Hexachlorobenzene (HCB)	118-74-1	4	µg/L		<4	<4	----	----	----
EP075H: Anilines and Benzidines									
Aniline	62-53-3	2	µg/L		<2	<2	----	----	----
4-Chloroaniline	106-47-8	2	µg/L		<2	<2	----	----	----
2-Nitroaniline	88-74-4	4	µg/L		<4	<4	----	----	----
3-Nitroaniline	99-09-2	4	µg/L		<4	<4	----	----	----
Dibenzofuran	132-64-9	2	µg/L		<2	<2	----	----	----
4-Nitroaniline	100-01-6	2	µg/L		<2	<2	----	----	----
Carbazole	86-74-8	2	µg/L		<2	<2	----	----	----
3.3`-Dichlorobenzidine	91-94-1	2	µg/L		<2	<2	----	----	----
EP075I: Organochlorine Pesticides									
alpha-BHC	319-84-6	2	µg/L		<2	<2	----	----	----
beta-BHC	319-85-7	2	µg/L		<2	<2	----	----	----
gamma-BHC	58-89-9	2	µg/L		<2	<2	----	----	----
delta-BHC	319-86-8	2	µg/L		<2	<2	----	----	----
Heptachlor	76-44-8	2	µg/L		<2	<2	----	----	----
Aldrin	309-00-2	2	µg/L		<2	<2	----	----	----
Heptachlor epoxide	1024-57-3	2	µg/L		<2	<2	----	----	----
alpha-Endosulfan	959-98-8	2	µg/L		<2	<2	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	U/S LDP009	LDP009	KANGAROO	----	----
				Client sampling date / time	21-OCT-2014 10:30	21-OCT-2014 11:00	21-OCT-2014 11:30	----	----
Compound	CAS Number	LOR	Unit		ES1423116-001	ES1423116-002	ES1423116-003	----	----
EP075I: Organochlorine Pesticides - Continued									
4.4`-DDE	72-55-9	2	µg/L		<2	<2	----	----	----
Dieldrin	60-57-1	2	µg/L		<2	<2	----	----	----
Endrin	72-20-8	2	µg/L		<2	<2	----	----	----
beta-Endosulfan	33213-65-9	2	µg/L		<2	<2	----	----	----
4.4`-DDD	72-54-8	2	µg/L		<2	<2	----	----	----
Endosulfan sulfate	1031-07-8	2	µg/L		<2	<2	----	----	----
4.4`-DDT	50-29-3	4	µg/L		<4	<4	----	----	----
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	4	µg/L		<4	<4	----	----	----
^ Sum of DDD + DDE + DDT	----	4	µg/L		<4	<4	----	----	----
EP075J: Organophosphorus Pesticides									
Dichlorvos	62-73-7	2	µg/L		<2	<2	----	----	----
Dimethoate	60-51-5	2	µg/L		<2	<2	----	----	----
Diazinon	333-41-5	2	µg/L		<2	<2	----	----	----
Chlorpyrifos-methyl	5598-13-0	2	µg/L		<2	<2	----	----	----
Malathion	121-75-5	2	µg/L		<2	<2	----	----	----
Fenthion	55-38-9	2	µg/L		<2	<2	----	----	----
Chlorpyrifos	2921-88-2	2	µg/L		<2	<2	----	----	----
Pirimphos-ethyl	23505-41-1	2	µg/L		<2	<2	----	----	----
Chlorfenvinphos	470-90-6	2	µg/L		<2	<2	----	----	----
Prothiofos	34643-46-4	2	µg/L		<2	<2	----	----	----
Ethion	563-12-2	2	µg/L		<2	<2	----	----	----
EP075S: Acid Extractable Surrogates									
2-Fluorophenol	367-12-4	0.1	%		**32.7**	**28.2**	----	----	----
Phenol-d6	13127-88-3	0.1	%		**23.3**	**20.2**	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%		**52.3**	**45.6**	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%		**62.9**	**50.8**	----	----	----
EP075T: Base/Neutral Extractable Surrogates									
Nitrobenzene-D5	4165-60-0	0.1	%		**58.7**	**50.8**	----	----	----
1.2-Dichlorobenzene-D4	2199-69-1	0.1	%		**51.4**	**45.7**	----	----	----
2-Fluorobiphenyl	321-60-8	0.1	%		**64.8**	**54.1**	----	----	----
Anthracene-d10	1719-06-8	0.1	%		**71.0**	**62.3**	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%		**77.2**	**66.8**	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075S: Acid Extractable Surrogates			
2-Fluorophenol	367-12-4	10.0	116.6
Phenol-d6	13127-88-3	10.0	69.0
2-Chlorophenol-D4	93951-73-6	20.9	129.7
2.4.6-Tribromophenol	118-79-6	10.0	150.7
EP075T: Base/Neutral Extractable Surrogates			
Nitrobenzene-D5	4165-60-0	29.4	141.7
1.2-Dichlorobenzene-D4	2199-69-1	23.6	120.7
2-Fluorobiphenyl	321-60-8	27.2	134.9
Anthracene-d10	1719-06-8	26.6	113
4-Terphenyl-d14	1718-51-0	21.4	123

Appendix D – Catchment Runoff Results

Table D-1 Dilution of SV LDP009 Discharges for Water Strategy WS1

Location	Dilution (% of daily flow)		
	10th percentile	50th percentile	90th percentile
A	96.78	88.96	44.36
B	94.11	85.49	31.82
C	96.41	96.40	32.11
D	92.43	81.97	21.90
E	91.15	78.75	20.51
F	89.15	71.02	32.15
G	89.01	69.35	21.90
H	88.61	64.48	9.40
I	88.52	61.92	7.16
J	88.43	58.82	5.71
K	83.06	43.59	4.49
L	77.52	37.99	3.83
M	63.43	26.59	3.06
N	55.30	21.48	2.64
O	53.91	20.77	2.55

Table D-2 Dilution of SV LDP009 Discharges for Water Strategy WS2a

Location	Dilution (% of daily flow)		
	10th percentile	50th percentile	90th percentile
A	97.96	92.78	55.99
B	96.23	90.39	42.68
C	97.72	97.72	43.01
D	95.12	87.88	30.92
E	94.26	85.53	29.17
F	92.91	79.63	43.06
G	92.82	78.31	30.92
H	92.54	74.34	14.21
I	92.49	72.18	10.95
J	92.42	69.51	8.80
K	88.67	55.22	6.98
L	84.63	49.44	5.98
M	73.46	36.63	4.80
N	66.37	30.38	4.15
O	65.11	29.50	4.02

Table D-3 Dilution of SV LDP009 Discharges for Water Strategy WS2b

Location	Dilution (% of daily flow)		
	10th percentile	50th percentile	90th percentile
A	98.58	94.90	64.79
B	97.36	93.15	51.86
C	98.41	98.41	52.19
D	96.58	91.30	39.30
E	95.96	89.53	37.34
F	94.99	84.98	52.24
G	94.92	83.93	39.30
H	94.72	80.73	19.33
I	94.68	78.97	15.11
J	94.64	76.73	12.26
K	91.88	64.08	9.79
L	88.84	58.58	8.43
M	80.02	45.54	6.80
N	74.06	38.70	5.90
O	72.97	37.71	5.71

Table D 4 Dilution of Total Discharges (AP LDP001 and SV LDP009) for All Water Strategies

Location	Dilution (% of daily flow)		
	10th percentile	50th percentile	90th percentile
A	98.64	95.11	65.81
B	97.48	93.43	52.98
C	98.48	98.48	53.31
D	96.72	91.65	40.38
E	96.13	89.95	38.40
F	95.20	85.54	53.36
G	95.13	84.53	40.38
H	94.95	81.42	20.04
I	94.90	79.70	15.70
J	94.86	77.53	12.75
K	92.21	65.11	10.20
L	89.28	59.67	8.78
M	80.73	46.66	7.09
N	74.92	39.78	6.15
O	73.85	38.77	5.95

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The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

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GHD

Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310
T: (02) 4979 9999 F: (02) 4979 9988 E: ntlmail@ghd.com

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
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0	J Woodworth / T Davies	S Gray	*S Gray*	S Gray	*S Gray*	29/09/14
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2	J Woodworth / T Davies	S Gray		S Gray		25/11/14

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Appendix 2 : Letter Report from GHD Pty Ltd

18 December 2014

Centennial Coal
Environmental Projects Coordinator – West
1384 Castlereagh Highway
LIDSDALE NSW 2790

Our ref: 22/17471
108185
Your ref:

Dear Nagindar

Coxs River Ecotoxicology Assessment
Response to EPA Submissions

In response to the NSW Environment Protection Authority (EPA) letters of the 4 November 2014 and 24 November 2014 from Richard Whyte, GHD Pty Ltd (GHD) has prepared this document containing information to be forwarded to the EPA to address the issues raised in the letters.

1 Toxicity of LDP009 Discharge

The EPA's position stated on the 3 June 2014 is that "*The EPA is unable to support the Springvale and Angus Place expansions in their current form given the absence of any commitment in the EIS to address the handling/treatment of the mine water, in either the short or long term*." "*…The EPA recommends treatment to significantly reduce the salt and contaminant level of the mine water, or achieve beneficial reuse (or a combination of both)…"*

Subsequent to this statement, ecotoxicity tests were conducted on the LDP009 discharge at Springvale Mine by the EPA and by Centennial to determine the potential toxicity of the discharge to the receiving environment. Bioassays were conducted in May 2014 by the EPA using a Microtox 15 minute (marine bacteria) test, a 48 hour cladoceran immobilisation test and a 48 hour rainbowfish larval imbalance test. The cladoceran test was shown to be the most sensitive to the LDP009 discharge and this bioassay has been used in subsequent studies to enable comparisons of results.

Cladoceran bioassays were conducted on the LDP009 discharge (post-treatment) by the EPA (48 hour immobilisation) and Centennial (seven day reproduction and immobilisation) in May 2014 and August 2014, respectively. The Centennial bioassay (refer GHD (2014a)) showed that chronic toxicity (0% reproduction in 100% LDP009) was evident in the LDP009 discharge and confirmed the EPA findings that the discharge showed acute toxicity (EPA: 60–80% immobilisation in 100% LDP009 and Centennial: 60–100% immobilisation in 100% LDP009). Centennial's *Coxs River Ecotoxicology Assessment* (2014a) report was presented as Appendix 10 to Response to Submissions (RTS) on Springvale and Angus Place Mine Extension Projects.

The toxicity of the discharge from LDP001 at Angus Place Colliery was also assessed in August 2014 by Centennial and no acute or chronic toxicity was detected. The similarity of the contaminant concentrations in both the LDP001 and LDP009 discharges tend to indicate that the existing LDP009 treatment system may in some way be contributing to the toxicity observed in both the EPA and Centennial studies from the comparison of upstream and downstream results. Centennial subsequently

GHD Pty Ltd ABN 39 008 488 373
Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300 PO Box 5403 Hunter Region Mail Centre NSW 2310 Australia
T 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com

investigated further the source of the observed acute toxicity of LDP009 discharges. Samples prior to flocculant treatment and following treatment were collected on 21 October 2014 by GHD and subjected to toxicity testing at the ESA Laboratory (Sydney, NSW). The results of this second round of testing along with the first round of testing undertaken August 2014 are attached as Appendix 1 to the Response to Submissions on Springvale and Angus Place RTSs. The updated *Coxs River Ecotoxicology Assessment* (GHD (2014b)) was provided to the EPA on 1 December 2014. Centennial has committed to an investigation of the source of acute toxicity of LDP009 and a subsequent options study to reduce the toxicity once the source has been determined. Prior to Centennial's investigation into the toxicity of LDP009 flocculant pre-treatment, the EPA collected two samples of mine water prior to treatment from a pipe rupture (part of the Springvale Delta Water Transfer Scheme) in September 2014. These samples collected by the EPA had not been pre-treated with a flocculant. Unfortunately, one of the samples was not representative of discharge water and only the results from the sample collected from the flow from the rupture site have been considered by GHD (2014c). The result from the EPA sample of the discharge pre-treatment showed that 0% cladoceran immobilisation in 100% sample was observed, i.e. no acute toxicity was observed for the discharge sample not treated with a flocculant. The EPA only tested for acute toxicity using cladoceran and Microtox and hence chronic toxicity could not be determined. The EPA result has been confirmed by Centennial's testing in October 2014 (GHD 2014b) which showed that the mine water pre-treatment met the accepted criteria of ≤20% immobilisation for no significant acute toxicity in 100% sample. However, chronic toxicity was detected in the pre-treatment sample collected in October 2014 (refer to GHD 2014b).

As no acute toxicity was observed in the pre-treatment sample, an acute cladoceran bioassay toxicity identification evaluation (TIE) to determine the source of the toxicity is not required.

2 Review of Provided Submission

At the request of Centennial, GHD have provided feedback on relevant sections of the EPA submission to the Angus Place and Springvale Mine Extension Project, RTS reports (4 November 2014) We have prepared this document detailing our response to a few key items that have not been already addressed as part of other reports.

2.1 Coxs River Catchment Restoration Program

In its Responses the proponent's Coxs River Catchment Restoration Program outlines a variety of measures to improve the catchment riparian zone and landscape; however, none relate to a state a goal of improving water quality.

The aquatic ecology monitoring over the last three to four years across the Centennial's western operation sites have found that aquatic ecology health is more dependent upon riparian vegetation and habitat condition than water quality concentrations. This is evident in Wangcol Creek where mining has modified sections of creek with poor riparian vegetation. Monitoring in these sections indicated poor AUSRIVAS scores. However, when compared with downstream sections of the creek, near Springvale Coal Services site (Western Coal Services Project) where the vegetation is of a better quality however salinity and metal concentrations are higher, AUSRIVAS scores improved.

Water quality is managed at each existing Centennial site with on-site capture of dirty water preventing discharge to the environment. Mine water has historically been used by industry with the overflow discharging to Coxs River. The characterisation of the quality of this discharge water has been provided as part of the surface and groundwater quality assessments in the Angus Place and Springvale Mine Extension Project EIS's. The water quality varies across Angus Place Colliery and Springvale Mine and varies depending upon geological conditions.

As part of the Regional Biodiversity Strategy (RPS (2014)) Centennial has committed to the rehabilitation and management of a number of sites along Coxs River (Commonwealth Colliery Rehabilitation Site, Wolgan Road Southern Management Site, Brays Lane Lidsdale Management Site, Coxs River Angus Place Management Site) and Wangcol Creek (Wangcol Creek Rehabilitation and Lamberts Gully Rehabilitation Areas). The physical parameters of this Coxs River Catchment Restoration Program are within Centennial owned and/or operated lands. The proposed rehabilitation within these lands will further enhance the biodiversity values that exist within the Coxs River Catchment and ameliorate the cumulative impacts associated with Centennial projects and the many other projects that influences the physical and chemical nature of the Coxs River.

The comment made in regards to the above proposed restoration program that vegetation and water quality are not directly connected is not correct. There has been a number of studies to suggest that the quality of the riparian vegetation is a fundamental component of maintaining good water quality. For example:

Vegetation within a riparian zone can slow the overland movement of water, and cause sediment and attached nutrients to be deposited on the land before they can reach the stream channel. Riparian vegetation can also take up and remove some of the nutrients being transported. Trees and deep-rooted shrubs and grasses use significant quantities of sub-surface waters. (Source: *Improving Water Quality*; Land and Water Australia, 2002).

2.2 Protective Concentrations

Cardno Ecology Lab Pty Ltd (2010) used species sensitivity distribution (SSD) curves for single-species toxicity information to develop protective concentration (PC) values that protect a large proportion of the aquatic species present in the receiving waters.

Cardno Ecology Lab Pty Ltd (Cardno) as part of their ecotoxicology studies undertaken in ACARP study (Cardno (2010)), found that the mayfly species *Atalophlebia* was the most sensitive species to mine water discharges from selected mine sites in the Hunter Valley and Illawarra regions. The suggestion of the EPA reviewer is that Centennial should test water against this species. However, Centennial has used the cladoceran species *Ceriodaphnia dubia* as a standard bioassay species using the NATA accredited chronic reproduction bioassay throughout all of Centennial's sites. The consistent use of a single test allows for comparisons across the company's mine water discharges of varying water quality. The species tested is considered to be appropriate as the cladoceran is likely to be present within the environment. While the mayfly species have also been identified as part of aquatic ecology monitoring within Wangcol Creek and Coxs River. cladoceran species is the preferred bioassay for toxicity studies for the following reasons.

Toxicity testing using mayfly species is typically an acute bioassay only and as a tropical species, it is sometimes used for tropical ecosystem assessment. Testing using a freshwater mayfly species is not common practice and is not a recommended NATA bioassay. As such:

- The ESA Laboratory does not use the mayfly species in NATA accredited bioassays, and this test was not undertaken for Angus Place Colliery and Springvale Mine (GHD (2014a and 2014b) for this reason.
- The tests undertaken in Cardno (2010) were either undertaken by Cardno or done in-house or undertaken through Macquarie University. It is noted that neither are NATA accredited laboratories. Further, routine testing using the mayfly species would be impractical as these organisms were collected from a natural system and are only available seasonally.

The aim of the Cardno (2010) study was the derivation of protective concentration values using species sensitivity distribution curves incorporating both field and laboratory data. However, a major flaw of this methodology is that the field data also is impacted by other unknown constituents in the stream water, which is stated in the report: "*…varying toxicities for the different mine waters over a broad range of conductivities were identified, suggesting that constituents of the mine waters other than EC are contributing to toxicity (e.g. pH, ionic composition or metals), but to an, as yet, unknown extent*." Nevertheless, protective concentrations above the ANZECC (2000) guidelines were derived for all waterways in the study with electrical conductivity values ranging from 323 µS/cm to greater than 2,245 µS/cm.

2.3 Literature Review

GHD have also not cited or reviewed the extensive literature on salinity impacts on aquatic ecosystems.

Noted, GHD has not cited this information. As part of this response we have included relevant discussions from papers cited in the EPA submission of 4 November 2014.

2.3.1 Studies Reviewed

Cardno (2010) ACARP Paper – Effects of Mine Water Salinity on Freshwater Biota Investigations of Coal Mine Water Discharge in NSW

The paper aims to establish a framework for setting environmental protection trigger values for existing mines with a requirement to discharge water. It is understood that the treatment of water has the potential to become an ecological issue in itself and that appropriate investigation and tailored site-specific conditions need to be identified in order to achieve the catchment objectives.

Cardno (2010) acknowledges that impacts from salinity are varied and complex. Changes in a waterway's salinity have the potential to influence the direct survival of aquatic organisms but also indirectly through the modification of habitat and food sources.

The study considered the effects of salinity on macroinvertebrates and diatoms. Cardno (2010) found in the literature review that diatoms are more likely to be salt-sensitive than macroinvertebrates, with studies indicating depleted assemblages at electrical conductivity levels above 233 µS/cm. The

assessment of diatoms as part of the Cardno (2010) study allowed for the consideration of indirect impacts.

Considering that macroinvertebrates can survive in areas of elevated electrical conductivity, a study undertaken by Rutherford and Kefford (2005) found that a majority of macroinvertebrates appear to be tolerant of salinity between 3,125 µS/cm and 12,500 µS/cm with the orders of Plecoptera, Ephemeroptera and Isopoda the least tolerant.

The Cardno (2010) study acknowledges the progression of studies on ecotoxicology and specifically studies into the response of macroinvertebrates to electrical conductivity. Cardno (2010) reference the ANZECC (2000) tolerance threshold for adverse effects on fauna of 2,345 µS/cm (Goetsch and Palmer, 1997; Hart *et al.*, 1991; Rutherford and Kefford, 2005). However, Cardno (2010) use the results of more recent studies on the mayfly to challenge this electrical conductivity level. Chronic tests conducted using mayfly species have indicated that impacts to species can occur from electrical conductivity levels below 1,000 µS/cm (Hassell *et al.*, 2006). Similarly, sensitivity has been observed in chironomids considering electrical conductivity levels from 650 µS/cm to 5,000 µs/cm.

Cardno (2010) indicate that the testing of species such as the mayfly and chironomids are more likely to detect an adverse result than the typical crustacean test species (such as cladoceran) when considering salinity alone. Chronic effects on plants and algae as a result of increased electrical conductivity have previously been found to occur in conductivities above 1,562 µS/cm. Further, a major conclusion of the Cardno (2010) was that "*The relationships between conductivity and abundance of aquatic biota are generally weak and vary between streams, suggesting that that the default guidelines may be overly conservative and/or that other environmental factors play equal or more important roles in determining the abundance and distribution of stream biota*."

OEH (2012) Chemical and Ecotoxicology Assessment of Discharge Waters from West Cliff Mine Paper – Effects of Mine Water Salinity on Freshwater Biota Investigations of Coal Mine Water Discharge in NSW

Mine water discharge was required to occur as part of operations at the West Cliff Mine. OEH undertook an ecotox assessment in parallel to a Pollution Reduction Program undertaken on the site. The OEH (2012) ecotoxicology study used a comprehensive suite of test species similar to those undertaken by Centennial with the inclusion of glass shrimp and bacteria (bacteria specifically associated to marine environment and only representative of response characteristics of the water).

The results of the assessment indicated sensitivity in the fish and cladoceran species. The testing indicated chronic toxicity of fish and cladoceran may be associated with the bicarbonate alkalinity. However, trace metals (aluminium, nickel, zinc, copper and cobalt) may have also contributed to the observed toxicity and definitive interpretation of the source of toxicity was unable to be determined in this study.

Toxicity of bicarbonate alkalinity was suggested to occur at concentrations greater than 500 mg/L consistent with findings by Farag and Harper (2012). Trigger values were calculated for bicarbonate alkalinity using ANZECC (2000) methodology with North American species ecotoxicology data.

Kefford et al. *(2013) Salinity and stream macroinvertebrate community structure – the case of the Hunter River Catchment, eastern Australia*

Kefford *et al* (2013) specifically looks at the correlation of statistical models from monitoring results and field assessments to determine conclusions on conductivity versus in-stream habitat conditions and other selected environmental characteristics. The study considers the nature of discharge into three categories: pulse (e.g. Angus Place Colliery LDP001), press (e.g. Springvale Mine LDP009 after Wallerawang Power Station closure) or ramp (e.g. proposed discharge as part of Angus Place Colliery and Springvale Mine extension projects).

The study points out a clear gap in Australian guidelines which assume that discharges of high electrical conductivity have an ionic proportion similar to sea water. Given that saline effluent composition is highly variable and dissimilar to sea water; the current ANZECC (2000) guidelines are unable to protect aquatic life against the concentrations of individual major ions.

As a result of pulse type discharges, electrical conductivity was determined to be an important factor in the impact on macroinvertebrate populations in the Hunter River catchment, based on the assessment of a number of index-based characteristics. However, the study concluded that it is difficult to draw a causal relationship between electrical conductivity and the composition of macroinvertebrate communities.

OEH (2011) Coxs River Catchment – Water Quality and Macroinvertebrate Communities

The historical and current water quality in the Coxs River and a 'snap shot' of macroinvertebrate assemblages were assessed. The study found that electrical conductivity and metals were elevated in the Coxs River catchment due to discharges from Wallerawang Power Station and mine water discharges. The study concluded that *"…it is highly probable that the impacts to aquatic biota in these areas reflect the synergistic effects of multiple stressors in the environment…"* The report concluded with a recommendation for an electrical conductivity target of 500 µS/cm for the environmental protection of Coxs River based on recommendations from other studies, particularly the Cardno (2010) study discussed above, which recommended an electrical conductivity for 95% species protection of 585 µS/cm for Brennans Creek based on field and laboratory data.

2.3.2 Conclusions

The reports discussed above provide a wide range of methodologies to assess the impacts of electrical conductivity on ecosystem health. All studies suggest that electrical conductivity plays an important role in ecosystem health, but state that additional factors also need to be taken into account. In particular, the OEH (2012) and the Hunter River Catchment study (Kefford *et al.*, 2013) suggest that ionic composition is also a factor in the potential of mine water discharges to cause adverse impacts on the receiving ecosystem.

2.4 Effect of Rainfall at the Time of Sampling

Based on the reported absence of chronic toxicity in the cladoceran for the sample from Lake Wallace (and further downstream) it would appear that amelioration of the LDP009 discharge occurred at the time of sampling (albeit following significant rainfall events).

Approximately 47.5 mm of rainfall was recorded at the Lithgow (Cooerwull) Bureau of Meteorology (BOM) station in the five days prior to sampling, as shown in Figure 2-1. Based on the probabilistic rational method calculations recommended by the Institution of Engineers Australia (1987), the time of concentration for the catchment is expected to be less than 24 hours. As such, rainfall in the days preceding sampling during round one of testing is not expected to affect the results of toxicity testing or water quality analysis. Rainfall on the 21 August was less than 1 mm and on the 22 August rainfall was less than 5 mm.

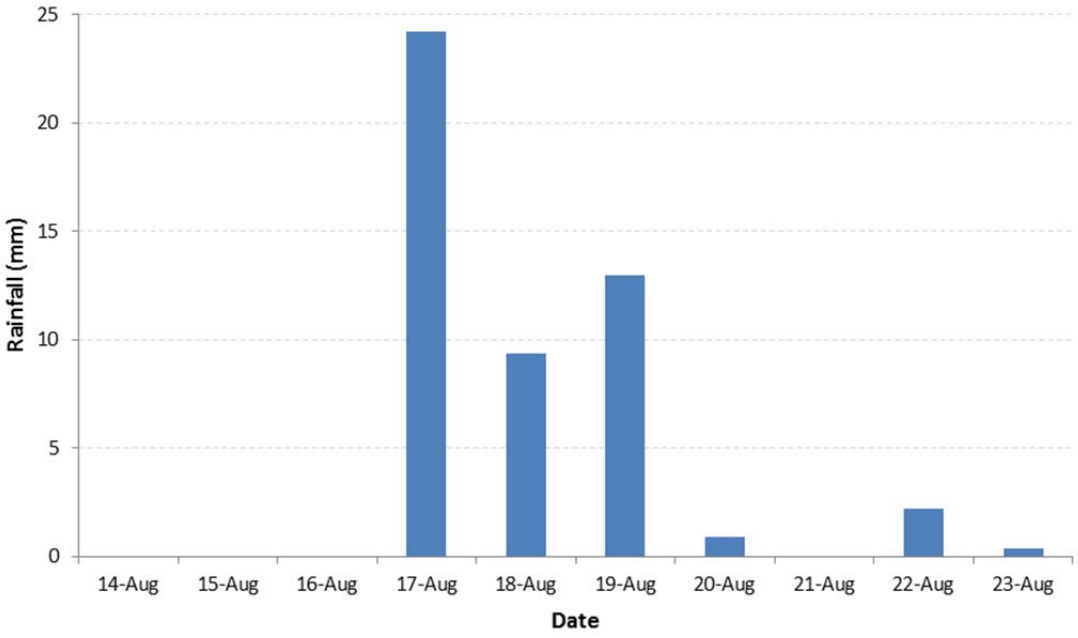

Figure 2-1 Recorded Rainfall Prior to and during Site Visit

2.5 Ionic Composition of LDP009 Discharge

The unusual ionic composition of LDP009 discharge may be a significant contributor to the observed toxic effects. Preliminary re-evaluation of data detailed in Figure 3.3 of the (Ecotoxicology Assessment (GHD; 2014) report, showed that normalisation of bicarbonate alkalinity to Ca+Mg+K concentration resulted in the R^2 value improving from 0.0099 (Fig 3.3 in report) to R^2=0.601.

GHD attempted to reproduce the results suggested by the reviewer but were unable to achieve the R^2 value of 0.601. See Figure 2-2 and Figure 2-3 below.

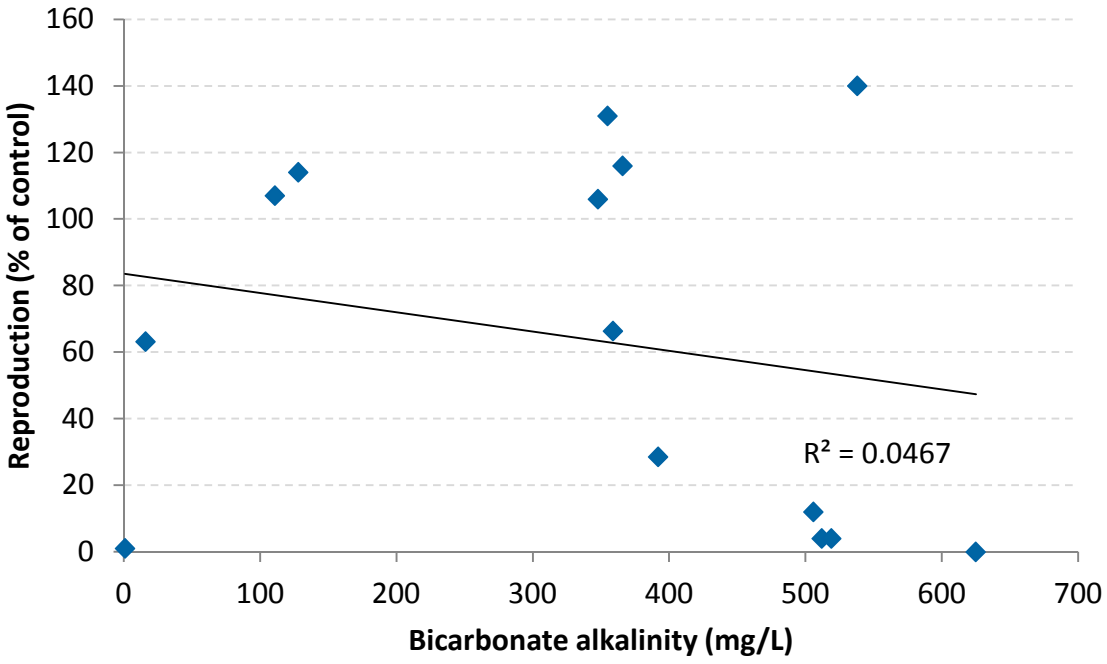

Figure 2-2 Reproduction rates of Cladoceran Compared with Bicarbonate Alkalinity Concentration

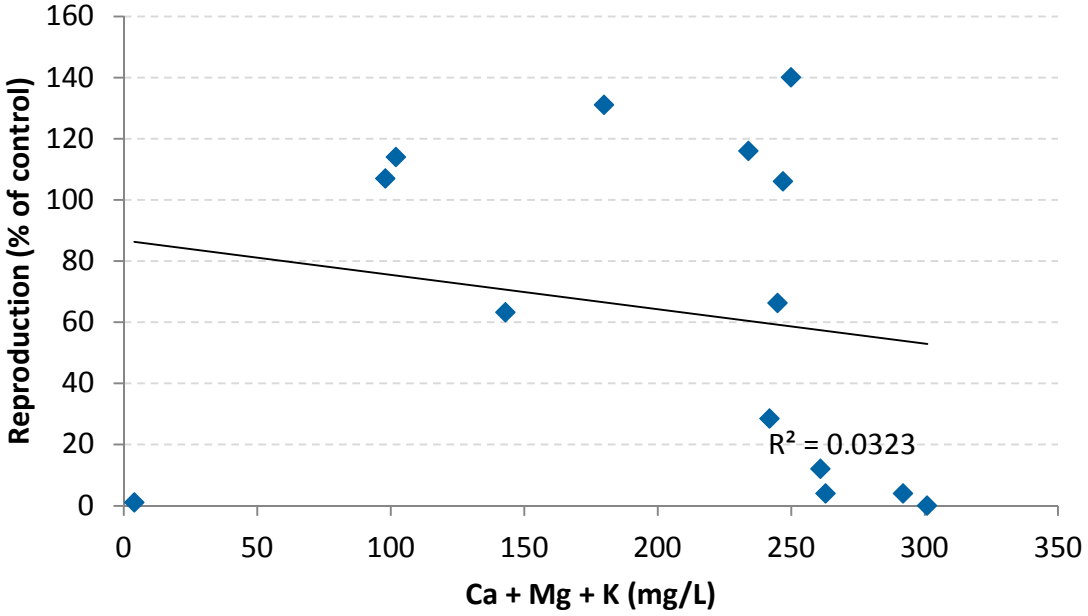

Figure 2-3 Reproduction rates of Cladoceran Compared with Ca+Mg+K Concentration

Given the results of Figure 2-3, an R^2 value of less than the suggested 0.601 was achieved and indicated a lower correlation in the results. We were not provided the plot of the data developed by OEH as part of the review. Regardless, GHD acknowledge issues with ionic composition. These are currently being investigated further in the context of acute toxicity at LDP009..

2.6 Toxicity Identification and Evaluation Investigations

A modified Toxicity Identification and Evaluation (TIE) process investigating modifications to the ionic composition of LDP009 on acute Cladoceran toxicity at 100% would be feasible.

The TIE tests could be undertaken at this location however it is the opinion of GHD that the toxicity of LDP009 is not significant enough such that the TIE would indicate the responsible component. GHD has indicated to Centennial that the expected risk of the TIE being inconclusive is very high.

As acute toxicity was not present in pre-treatment results, investigation into the treatment process would be viewed as more beneficial than a TIE investigation.

2.7 Nutrient Toxicity

(In)Table 2.3 ammonia and NOx (are) not considered as nutrient pollutants

It is noted that the LDP009 discharge has ammonia at 0.44 mg/L (33x the ANZECC/ARMCANZ 2000 nutrient trigger value – see Attachment 2), Mixing zones are not appropriate for the nutrients (Attachment 1)

The ANZECC/ARMCANZ (2000) trigger value referred to by the reviewer is for NH_4^+ (ammonium) where as we have assessed total ammonia (the sum of NH_3 and NH_4^+). The corresponding default trigger value for ammonia is 0.9 mg/L for freshwater 95% species protection (Table 3.4.1, ANZECC/ARMCANZ, 2000).

Given the large discharge volumes of LDP009 relative to natural flows and the apparent extensive algal growth reported in sections of the Coxs River downstream of the LDP009 and LDP001 discharges, this would seem to be an issue requiring resolution.

The correlation between the discharges and algal growth is speculative, given the catchment's other land uses. As discussed within the CSIRO Land and Water report on assessments of river condition under the current flow regime and proposed flow regimes in the lower Coxs River, "*high nutrient concentrations, warm water, and low flow velocities in river pools are conducive to algal growth… Very low and constant flows are the most likely to promote pool stratification and resultant water quality degradation*". This indicates that factors other than just nutrients can encourage algal growth.

Toxicity testing on LDP009 discharges indicated that algal growth was inhibited from the control and duckweed showed no inhibition or growth from the control. This suggests there are other factors influencing the suggested algal growth.

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Sincerely

Lachlan Hammersley
Environmental Engineer
(02) 4979 9999

Jill Woodworth
Principal Environmental Scientist
(02) 4979 9999

Stuart Gray
Senior Hydrogeologist
(02) 4979 9999

Appendix 3: Letter Report from Jacobs Group (Australia) Pty Ltd

Jacobs Group (Australia) Pty Limited
100 Christie Street
St Leonards NSW 2065 Australia
PO Box 164 St Leonards NSW 2065 Australia
T +61 2 9928 2100
F +61 2 9928 2500
www.jacobs.com

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Peter Corbett
Centennial Angus Place Pty Ltd
Locked Bag 1002
WALLERAWANG
NSW 2845

19 December 2014 IA060400/003c

Dear Peter,

Hydrological Advice to Response to Submissions

1. Introduction

We have prepared this letter in accordance with our proposal (002294/007a, dated 5 December 2014) seeking advice on comments received from the NSW Environment Protection Agency (NSW EPA) and Sydney Catchment Authority (SCA) on Centennial's Response to Submissions on their Angus Place and Springvale Mine Extension Projects (NSW EPA, 2014 and SCA, 2014).

This letter has been prepared to address comments relevant to both Angus Place and Springvale and is based on the assumption that both Mine Extension Projects are proceeding as per the EIS.

2. Proposed Response

2.1 Response to NSW EPA

2.1.1 Water Balance Model (referred to in Attachment One)

Issue EPA01) It is noted that these general conclusions do not appropriately address the areas directly affected by the LDP discharges. One of the simplest comparisons that can be made to verify the statements and conclusions in the RTS is the concordance between model predictions (suggested to have been appropriately calibrated) and the observed flows and quality at the two NOW gauges in the Upper Coxs River catchment (212054 Coxs River upstream Wallerawang and 212055 Neubecks Ck). If this is done, it is clear that the model under-predicts median flow at the NOW gauge 212054 (Node #047 in AWBM model; RPS 2014) and considerably over-predicts conductivity at the NOW gauge 212054 when compared to the observed measurements by NOW (See Table 1). Median flows at 212054 are underestimated by approximately 22% and median conductivities are overestimated by approximately 45%. There is no discussion in the RTS reports of these major discrepancies between prediction and reality.

The EPA's comment on median flows at NSW Office of Water Station No. 212054 is noted, however, as will be presented below, did not invalidate the capability of the model to reasonably match observed salinity.

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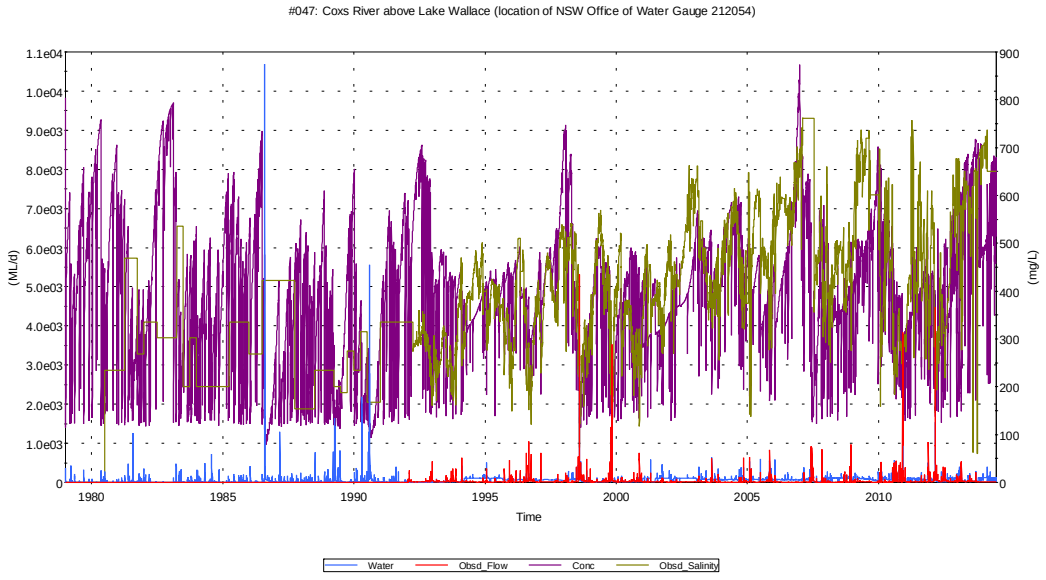
The cause of the disparity in median flows identified by the EPA has been resolved and is discussed in the response to query EPA010, further below. It is highlighted that this issue was active in both the prediction simulation and the prediction null case simulation presented in RPS (2014e) and therefore does not invalidate the predicted impacts since it was active in both simulations

Node #047 resides immediately upstream of Lake Wallace and is coincident with water quality monitoring station Springvale COXS UPSTREAM, Delta Electricity / EnergyAustralia WX9 and historical monitoring reported by the Australian Water Technology study (AWT, 1992), E013 (refer to Table 3.3 in RPS 2014e).

Figure 3.5 of Regional Water Quality Impact Assessment (RWQIAM) (RPS, 2014e) presents the modelled versus observed salinity at Node #047. Whilst not a precise match, the magnitude of fluctuation in modelled concentration and trends (both decreasing and increasing) are well represented. As stated in RPS (2014e), the level of calibration achieved is considered appropriate for the purpose of impact assessment because it is demonstrated that the key processes that explain historical change in salinity are encapsulated. This is particularly the case given the scale and detail of the model that was constructed.



Issue EPA02) There is also no appropriate discussion of the fact that current and historic flows and conductivity levels at gauge 212054 are partially composed of upstream discharge waters…

As per the Director General Requirements (DGRs) for the EIS, modelling is required to account for cumulative impact assessment. The water management strategies represented in the model for Angus Place and Springvale are specified in Section 3.3.2 of RPS (2014e). Detail of other activities within the catchment is specified in Section 3.3.1 of RPS (2014e).

Issue EPA03) It appears that actual daily flows from LDP009, LDP001 and others may not have been utilised in the modelling.

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Detail of mine water discharge used in model predictions is presented in Section 3.1.2 of RPS (2014e).

For the calibration simulation, site discharge data at Angus Place LDP001 was used between 14 September 2010 to 30 June 2014, with an assumption of historical discharge commencing 1 January 1979 at 2ML/d, increasing linearly to 5ML/d on 30 June 2006 and then 2ML/d on 1 July 2006, increasingly linearly to 3ML/d on 13 September 2010.

For the calibration at Springvale, there is a discussion of treatment of the Springvale Delta Water Transfer Scheme (SDWTS) in Section 2.5.3 of RPS (2014e). Historical discharge through Delta Electricity LDP020 / Springvale LDP009 was reconstructed based on underground pumping data as well as historical records received from EnergyAustralia and applied directly to the model.

Issue EPA04) As identified in earlier comments, extremely limited information was available for the actual LDP009 discharge in both the EIS and RTS. It is clearly the responsibility of the proponent to provide the information upon which major Government decisions need to be made.

The lack of flow and quality monitoring at Springvale LDP009 and in Sawyers Swamp Creek was acknowledged in the EIS and is noted. An extensive monitoring network has now been installed.

As presented in the RWQIAM (RPS, 2014e), responsibility for discharge from the SDWTS to Sawyers Swamp Creek, when mine water was not required by Wallerawang Power Station, resided with Delta Electricity, a state-owned corporation, from time of commissioning of the SDWTS in 2006 to 2012 (referred to as Delta Electricity LDP020). It is understood that detailed water quality monitoring of Delta Electricity LDP020 was not required. Responsibility for discharge from the SDWTS transferred to Centennial in August 2012. As operators of the Sawyers Swamp Creek Ash Dam and the Dry Ash Placement Facility within Sawyers Swamp Creek, Delta Electricity / EnergyAustralia there may be historical data from monitoring stations within Sawyers Swamp Creek that Centennial does not presently have access to.

Issue EPA05) A plot of flows at the NOW 212054 gauge actually identifies a significant increase in flows in the most recent times, potentially as a result of the LDP009 discharge (Figure 1). This has not been acknowledged in the Surface Water Impact Assessment.

As discussed in RPS (2014e), there has been discharge to the Coxs River via Kangaroo Creek for a considerable period and to Sawyers Swamp Creek, incidentally, from 2006, when mine water was not required at Wallerawang Power Station.

As presented in the RWQIAM, predicted median flow will be increased in the Upper Coxs River in Water Strategy 1 (WS1), and is consistent with historical flows in WS2a and WS2b. As noted, predicted median flows in Sawyers Swamp Creek are dominated by proposed discharge at Springvale LDP009.

Below Lake Wallace, predicted median flows are not significantly above historical observation, however, low flows (5%ile) are higher in WS1, WS2a and WS2b.

Issue EPA06) A plot of Conductivity levels at the same Gauge also demonstrates a significantly increasing trend in Conductivity levels (ie an increasing salinization) of Upper Coxs River waters (Figure 2).

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Figure 3.5 of the RWQIAM (RPS, 2014e) presents the modelled versus observed salinity at NSW Office of Water Station No. 212054 from January 1979 to June 2014.

As discussed above, there has been discharge to the Coxs River via Kangaroo Creek for a considerable period and to Sawyers Swamp Creek, incidentally, from 2006, when mine water was not required at Wallerawang Power Station.

As presented in the RWQIAM, salinity in the Coxs River and between Lake Wallace and Lake Lyell will be elevated compared to the null case, however, will be within the range of historical observation.

The increasing trend in salinity at Gauge 212054 is emulated in Figure 3.5, of RPS (2014e), reproduced in query EPA01 above, and has been increasing since 1993.

Issue EPA07) Instead of moving to arrest the decline in water quality (as indicated by conductivity) in this area, the EIS and RTS both advocate increasing this further by increasing the LDP009 discharge to up to 30 to 50ML/day of poorly treated highly saline mine water. This approach to the disposal of unwanted, poorly treated and (for LDP009) toxic mine water is not supported.

As presented in the Response to Submissions, the description of proposed groundwater discharge as highly saline is not accurate. Groundwater with a TDS of ~800mg/L is not of high salinity and is classified as fresh and within the acceptable range for drinking water.

As established in the RWQIAM (RPS, 2014e), predicted salinity will lie within the range of historical observation, except for immediately above Lake Burragorang where an increase compared to observation is within the ANZECC default trigger values for the protection of aquatic ecosystems. Modelling predicts an increase in salinity in Lake Burragorang, however, from a modelled median of 85mg/L to a modelled median salinity of 97mg/L.

The EPA's comment on the identified toxicity of discharge from Springvale LDP009 is addressed in the response to ecotoxicological comments presented elsewhere.

Issue EPA08) …[9] It is also recommended in the EIS that the Angus Place LDP001 discharge is increased from 2 ML/day to 30 ML/day.

As noted in the SWIA (RPS, 2014a), the discharge limit at Angus Place LDP001 was originally 30ML/d and the statement in the SWIA and EIS refers to restoration of the discharge limit to its previous value.

Issue EPA09) Unclear assumptions, particularly where the coefficients have been assigned a value (and the justification of these values) or whether the coefficients were calculated from the data…no sensitivity analysis allowing for variation in coefficients and their effect on model predictions.

The EPA's comment on sensitivity analysis is noted and will be incorporated into a future revision of the model.

A discussion of the basis of the input concentrations is presented in response to query SCA07.

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As presented in the response to query EPA14, below, the parameters adopted for the rainfall runoff model were based on literature values published by the model author, including in regard to the Coxs River catchment.

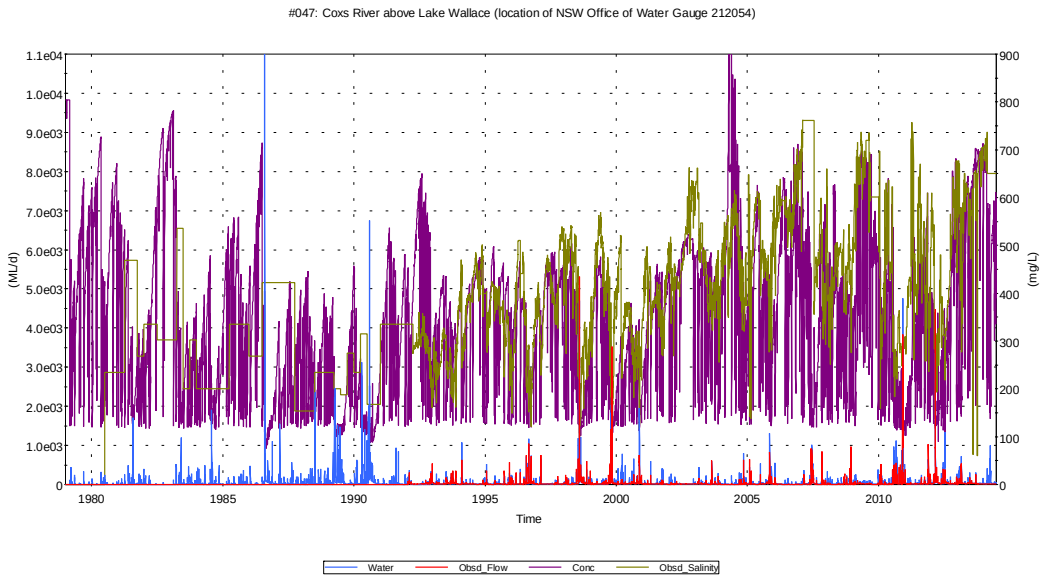
Two uncertainty analysis conditions, a Low Rainfall and a High Rainfall condition, were presented in RPS (2014e).

Issue EPA10) …RPS (2014) states: "Evaporation in the model was based on average daily evaporation for each month at BOM Station No. 061089 (Scone SCS.". This is different to the original EIS surface water assessment where evaporation was stated to come from: "Daily Pan A evaporation has been recorded at the Bathurst Agricultural Station (BOM Station No. 63005) from 1966 to current". It is unclear why the evaporation stations have been changed in the latest iteration of the model and what effect this has had on the model and its predictions…

The evaporation station used in the RWQIAM should have been Bathurst Agricultural Station and was set to Scone in error. The impact of this issue is discussed below.

Output from an interim update of the RWQIAM is presented below, at Node #047, which is the location of the NSW Office of Water Station No. 212054. This updated model (run ID: 002a_CAL-Jun14_04b.gsm) incorporates a resolution to the disparity in median flow identified by the EPA in their query, EPA01, which was caused by an unintended activation of release from and recirculation to Thompsons Creek Reservoir, an update to the evaporation dataset to reflect spatially distributed and daily evaporation derived from the SILO climatic dataset as opposed to monthly average, an update to the historical daily rainfall dataset to a more sophisticated infilling and disaggregation method than the manual patch method previously used as well as a few other minor changes.

Overall, these changes demonstrate no significant difference to the modelled salinity profile as compared to Figure 3.5 of RPS (2014e), although the minimum salinity needs further refinement.



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For reference, the median flow at 212054 in this interim calibration simulation is now 14.1ML/d compared to 13.0ML/d from the observation record, over an equivalent period.

Issue EPA11) The RPS (2014) report still talks about Daily demand at Wallerawang Power Station when it is currently 'mothballed'.

As presented in Section 2.3 of RPS (2014e), Unit 7 at Wallerawang Power Station closed in January 2013 and Unit 8 closed in April 2014. The historical record of use of mine water as 'make-up' at Wallerawang Power Station was implemented directly into the model. In addition, records of discharge at Delta Electricity / EnergyAustralia LDP004, downstream of dam wall at Lake Wallace were also incorporated into the model.

As noted in Section 3.3.1 of RPS (2014e), closure of Wallerawang Power Station was incorporated into the prediction simulation.

Issue EPA12) The Angus Place EIS highlighted that the water balance model was calibrated to discharge in July 2013, which included a period where mine water make was being temporarily held underground (March to July 2013). Discharge at LDP001 has now resumed at a rate of 2ML/d. It is unclear whether the latest 'calibration' has used this information in daily flow calculations and whether the actual flows from LDP009, LDP001 and other discharges have been appropriately used in the modelling.

The water balance model referred to in the EIS is the site water balance model, rather than the regional water quality impact assessment model (RWQIAM). The RWQIAM was constructed to respond to request for additional detail on the day-to-day variation in predicted water quality to that presented in the EIS.

Detail on the mine water discharges adopted in the model is provided within the response to query EPA03.

Issue EPA13) The Angus Place EIS Water quality modelling indicates that historical discharge at Angus Place LDP001 accounts for observed increase in salinity in Kangaroo Creek and the Upper Coxs River above Blue Lagoon. As pointed out in comments on the original EIS, the Angus Place LDP001 discharge actually represents the first major impact of mine discharges on the Upper Coxs River…

The discharge to Kangaroo Creek via Angus Place LDP001 is located at the top of the Coxs River catchment and therefore we concur with the EPA's comment.

Issue EPA14) Two uncertainty analysis conditions were presented in the RTS (Low Rainfall Condition and High Rainfall Condition), but there has been no assessment of model uncertainty or parameter (ie coefficient) uncertainty.

The EPA's comments are noted and are discussed in detail below.

The assumed concentration for each land use was selected based on observed data and the appropriateness of those coefficients assessed in model calibration. Further detail on the basis of input concentrations is presented in the response to query SCA07.

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The parameters adopted for the rainfall runoff model were based on literature values published by the model author, including in regard to the Coxs River.

As noted in Section 3.3.1 of RPS (2014e), proposed changes to land use within the Coxs River catchment were incorporated into the prediction model, however, it was not considered that this was uncertain, therefore was not incorporated into uncertainty analysis.

Issue EPA15) Description and presentation of calibration results (eg fitted versus actual) is considered poor. As identified earlier the model under-predicts median flow at the NOW gauge 212054…

Figure 3.5 of the RWQIAM (RPS, 2014e) presents the modelled versus observed salinity at NSW Office of Water Station No. 212054 from 1979 to June 2014, and is reproduced in the response to query EPA01 above.

The EPA's comment on additional calibration statistics and comment on median flows are acknowledged. A detailed response to the query on median flows and the appropriate of model calibration are presented in the response to EPA01.

From the figure reproduced in response to query EPA01, modelled salinity compares well to observed salinity insofar the magnitude of fluctuation in daily salinity is reasonably represented and decreasing and increasing trends are also reasonably replicated.

Issue EPA16) There appears to be no presentation of validation results of the model based on more recent flows (and conductivities) measured at the NSW gauging stations.

The calibration period of the model is 1 January 1979 through to 30 June 2014.

As indicated in Section 2.5.3 of RPS (2014e), when mine water make was not required at Wallerawang Power Station as make up water, flow within the SDWTS was discharged to Sawyers Swamp Creek initially via Delta Electricity LDP020 and then, post August 2012 (following transfer of responsibility to Centennial), via Springvale LDP009.

Historical discharge to Sawyers Swamp Creek was incorporated into the calibration model and has essentially been continuous since January 2013.

Issue EPA17) The modelling results and conclusions in RPS (2014) should not be relied upon until the significant issues are addressed. In general, there is a lack of appropriate upstream-downstream comparisons for each LDP discharge in the Upper Coxs River catchment. Little allowance appears to be made for the fact that a proportion of the flows measured in various parts of the Upper Coxs River are actually sourced from upstream LDPs. As a result of this confounding of LDP discharges, flows and water quality in the model and assessment, an inadequate assessment of the true impact of the LDP discharges is achieved (particularly that of LDP009).

The RWQIAM (RPS, 2014e) presents tabulated model output with respect to flow and salinity through each watercourse and in each reservoir within the Coxs River catchment. For Angus Place LDP001, in regard to Kangaroo Creek, it is stated in the text that upstream modelled water quality is 50mg/L since is a natural land use type. For Springvale LDP009, with respect to Sawyers Swamp Creek, it is also stated in the text that modelled water quality upstream of point

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of discharge is 50mg/L. As a general response, a null case is presented at every reporting location for prediction simulations, which allows direct assessment of the impact of the proposal. In addition, time-series results at each location are presented graphically.

The EPA's comment on cumulative impact assessment is addressed in the response to query EPA02.

2.1.2 ANZECC/ARMCANZ Assessment (referred to in Attachment One)

Issue EPA18) The ANZECC Guidelines recommend that guideline trigger values for slightly-moderately disturbed systems also be applied to highly disturbed ecosystems wherever possible.

1) Where reference sites of high quality are available, lower levels of protection may be negotiated for the site under consideration but this should not result in water of less quality than that already prevailing.

2) Where no high quality reference sites are available, modified water bodies of the best environmental quality in the region serve as reference targets (or intermediate targets for ecosystem recovery).

…For some assessments (particularly LDP009) an appropriate reference site has not been chosen for comparison and therefore inappropriate "adopted" trigger values have been used.

This query is addressed in the response to query EPA33 provided below.

Issue EPA19) …They do not adequately consider the ionic composition of LDP discharge waters which are very different to the ionic composition of local (reference site) waters.

The EPA's comment is acknowledged and additional analytes will be included in the next revision of the SSTV assessment, if it is not superseded by the local biological effects data (Direct Toxicity Assessment (DTA)).

Discussion of the SSTV assessment is presented in response to query EPA33 with respect to update to proposed reference sites.

Issue EPA20) …At each point when adopting trigger values the assessment has chosen the highest value of either the ANZECC default guideline levels or local water quality trigger values (based on 80%ile values at a reference site) – this is an inconsistent and inappropriate application of ANZECC Guideline trigger value derivation methods.

The EPA's comment is acknowledged and is agreed.

A response to this query is provided in the response presented to query EPA33.

Issue EPA 21) …The assessments do not allow for confounding of LDP sources (ie trigger values calculated for LDP009 ignore upstream influence of LDP001 and other discharges).

This query is addressed in the response to query EPA33. Specifically, the issue of Angus Place LDP001 being used, in part, as a reference site in the Springvale LDP009 assessment with respect to the Coxs River upstream of Lake Wallace, will be corrected in a revision to the SSTV.

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Issue EPA22) …Both the LDP001 and LDP009 discharges (and adopted trigger values) clearly result in water of lesser quality than that already prevailing.

This query is addressed in the response to query EPA33, presented below.

Issue EPA23) …The assessments do not appropriately address the increasing salinization of Upper Coxs River waters (see Figure 2 above) which is likely to be a direct result of the increasing concentration and load of salt from LDP discharges.

This query is addressed in the response to query EPA06.

Issue EPA24) …The assessments advocate no treatment of the highly saline and (for LDP009) toxic discharges which will likely cause further deterioration in water quality and result in adverse ecosystem health effects.

The proposed water management strategies are presented in the EIS. As we understand it, the SSTV assessment, as part of the hierarchy of preferences for deriving trigger values, as specified in ANZECC (2000), presents proposed values based on local reference data. The DTA, which is of a higher preference than local reference data, presents proposed trigger values based on local biological data. As such, the SSTV assessment and DTA are assessments of what is proposed.

As presented in the Response to Submissions, the description of groundwater as highly saline is not accurate. Water of this quality is classified as fresh and within the acceptable range for drinking water. The Australian Drinking Water Guidelines (ADWG) (NHMRC, 2011) classifies a TDS of <600mg/L (equivalent to 895µS/cm), based on aesthetics not health, to be good quality drinking water and a range between 600 and 900mg/L (equivalent to 1343µS/cm) to be fair quality.

The toxicity of Springvale LDP009 identified during the DTA is acknowledged and it is understood this is being investigated and is reported elsewhere.

Issue EPA25) …The assessments have not undertaken an adequate review of the literature on the effects of salinity and ionic constituents on aquatic ecosystems.

The list of additional references is noted.

As we understand it, the reference to the work by Hart et. al. (1990, 1991) was noted because it was quoted in Section 8.2.3.3 of ANZECC (2000).

It is understood that detailed response to the EPA's comments on the DTA, in particular with regard to salinity, will be provided by the ecotoxicological consultant and is presented elsewhere.

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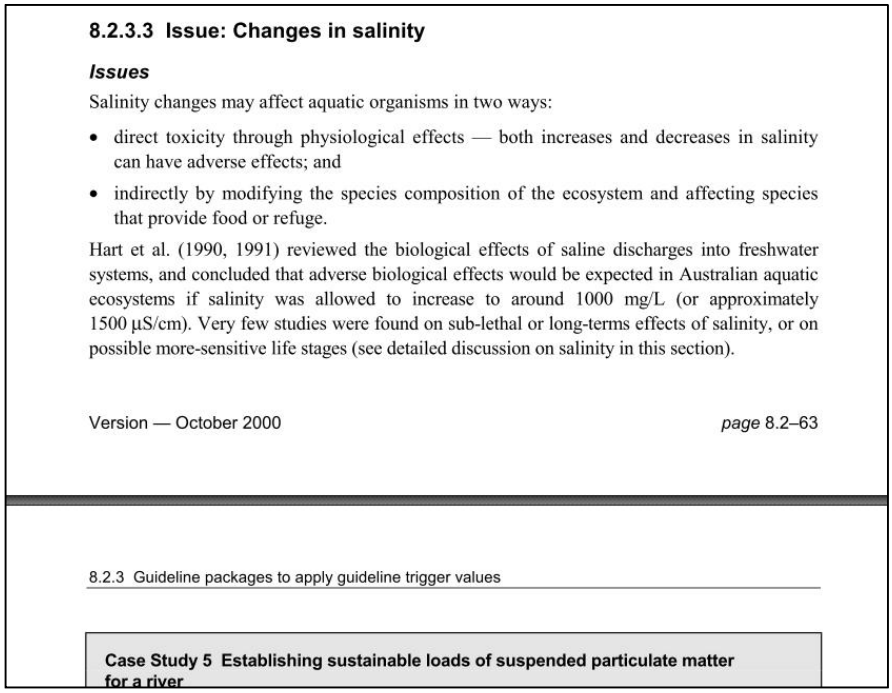

8.2.3.3 Issue: Changes in salinity

Issues

Salinity changes may affect aquatic organisms in two ways:

- direct toxicity through physiological effects — both increases and decreases in salinity can have adverse effects; and
- indirectly by modifying the species composition of the ecosystem and affecting species that provide food or refuge.

Hart et al. (1990, 1991) reviewed the biological effects of saline discharges into freshwater systems, and concluded that adverse biological effects would be expected in Australian aquatic ecosystems if salinity was allowed to increase to around 1000 mg/L (or approximately 1500 µS/cm). Very few studies were found on sub-lethal or long-terms effects of salinity, or on possible more-sensitive life stages (see detailed discussion on salinity in this section).

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8.2.3 Guideline packages to apply guideline trigger values

Case Study 5 Establishing sustainable loads of suspended particulate matter for a river

2.1.3 ANZECC/ARMCANZ Assessment (referred to in Attachment Three)

Issue EPA26) …specifically cautioned against allowing existing freshwater systems that are well below the salinity of 1000 mg/L to be increased up to this level.

New information is now available and this is reflected in the ANZECC (2000) guideline trigger values. Note that the Krogh and Miller report on Coxs River Catchment – Water Quality and Macroinvertebrate Communities, referred to in the EPA submission to the EISs, also provides further information on salinity impacts.

As presented in the RWQIAM, the proposal will result in surface water quality that is within historical ranges due to past activity in the catchment including open cut mining, underground mining, power generation and ash disposal.

For Kangaroo Creek, it is acknowledged in the EIS, SWIA and RWQIAM that discharge at Angus Place LD001 is the first major change to water quality as the site resides at the top of the Coxs River catchment. As noted in the EIS, there has been discharge at Angus Place LDP001 for a considerable period, albeit the magnitude of this discharge is proposed to be increased.

As per the response to query EPA25, the additional references are noted. Detailed response to the EPA's comments on the DTA is presented elsewhere.

Issue EPA27) …The RPS reports do not properly account for the overriding principle in the ANZECC (2000) guidelines that should guide management, which is continual improvement (see Section 2.2.1.7). For example, in waters that are of better quality than that set by the water quality objectives, some emphasis should be could still be given to reducing the level of contamination from all sources. Wherever possible, ambient water quality should not be allowed to degrade to the levels prescribed by the water quality objectives. It is also not acceptable to

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allow poor environmental performance or water pollution, simply because a waterway is degraded. The NWQMS also notes that accepted modern technology, consistent with ongoing economic viability, should be maintained even where this will secure higher water quality outcomes than what the water quality objectives require.

An update to the SSTV assessment will be undertaken and a discussion is presented in response to query EPA33.

As presented in the EIS and in Centennial's response to the Pollution Reduction Program (PRP) on its Environmental Protection Licence (EPL), treatment of 30-50ML/d via Reverse Osmosis is not economically feasible.

Issue EPA28) …The EPA's policy is that the water quality objectives /ANZECC trigger values should be met at the edge of the area where initial (near-field) mixing occurs. Options to meet this policy aim are considered and weighed against the matters to be considered in licensing decisions as set out under Section 45 of the Protection of the Environment Operations Act 1997. The matters that need to be taken into account include the impact of the measures that can be taken to mitigate the impacts of the pollution and maintain or restore the environmental values of the waterway. While the EPA's licensing approach is to consider the effect of a discharge at the edge of a defined initial "near-field" mixing zone, if the discharge volume from the licenced discharge point would dominate flows in system under most conditions then the dilution effects within a near field mixing zone may be relatively minimal. EPA would therefore examine the pollutant concentrations at the point of discharge relative to ANZECC trigger values.

This issue is addressed in the response to query EPA29 provided below.

Issue EPA29) …Effective discharge controls that consider the level of waste treatment, the concentration and the total mass of pollutants, and the in situ dilution, should ensure that the area of a mixing zone is small and the designated values and uses of the water body as a whole are not prejudiced.

The EPA's comment is acknowledged. As stated in the SWIA (RPS, 2014ab), Lake Wallace is a water supply reservoir that was constructed in 1978 for use by Wallerawang Power Station. Other components of the Coxs River Water Supply Scheme include Lake Lyell and Thompsons Creek Reservoir. With the decommissioning of Wallerawang, there is no longer direct extraction from Lake Wallace; however, the lake still constitutes a component of the Coxs River Water Supply Scheme for EnergyAustralia's other power station, Mount Piper Power Station.

The Sawyers Swamp Creek catchment is in a highly disturbed state, with historical and current land uses comprising wet ash deposition, dry ash placement and a rehabilitated open cut mine. Discharge has been occurring to Sawyers Swamp Creek since 2006 and as presented in the Ecological Impact Assessment, there is no expected change to aquatic ecosystems downstream of Springvale LDP009 due to the proposal. A SSTV assessment, as applied to immediately upstream of Lake Wallace is not considered unreasonable.

Issue EPA30) …Appendix 3 (for both projects) states that "Where dilution is insufficient, the mixing zone criteria are not met in that the mixing zones extend from bank to bank. In this circumstance ANZECC recommends performing a "biological effects assessment" (e.g. Direct Toxicity Assessment)." This is an incorrect interpretation of the ANZECC guidelines.

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The EPA's comment is acknowledged and the quoted statement is not correct.

The hierarchy of preference for deriving trigger values is local biological effects data, then local reference data, then the default approach, as presented in Figure 3.1.2 of ANZECC (2000). There is not a recommendation in ANZECC (2000) following the outcome of the SSTV assessment.

Issue EPA31) …Overall, the dilution assessment in Appendix 3 for both projects does not adequately consider the above guidance and EPA policy on mixing zones. These inadequacies include that:

- *available initial near-field mixing is not defined in order for EPA to incorporate an appropriate dilution factor into licensing limits*
- *and the extent and configuration of the mixing zone does not allow ANZECC trigger values to be achieved at any near field mixing zone.*

This query is addressed in the response to query EPA32.

Issue EPA32) …Taking into account the very low median salinity at the upstream Kangaroo Creek site and low median conductivity levels in the upper parts of the Coxs River catchment (50 - 200µS/cm); the lack of appropriate information on near-field mixing; and the principle of not polluting up to environmental limits, then a value of 350µS/cm (ANZECC 20000 default trigger value), applied at the point of discharge may be an appropriate value to guide management options for slightly to moderately disturbed ecosystems at this stage.

The EPA's comment on near-field mixing is acknowledged. As indicated in the SWIA, SSTV and RWQIAM (RPS, 2014abcde), proposed flows do dominate in Kangaroo Creek and Sawyers Swamp Creek when compared to natural runoff.

Issue EPA33) The RPS report has selectively adopted a site-specific trigger value when it less stringent than the ANZECC default trigger value and has adopted the ANZECC default trigger when the site-specific trigger value is more stringent. This is an unacceptable approach

If appropriate data is available to derive site-specific trigger values (as set out in the ANZECC guidelines) and an agreed suitable reference site is available (consistent with the ANZECC guidance on reference sites), then site-specific trigger values are preferred over the default trigger values for physical and chemical stressors such as salinity. Toxicants are usually compared with a single default trigger value, less commonly with a background or reference distribution as the default values are prepared by analysis of a comprehensive set of available ecotoxicological data.

The EPA's comments on the SSTV (RPS, 2014cd) are acknowledged and are addressed below.

The site specific trigger values, from a suitable reference site, should be the 80th percentile parameter values, whether or not they are more stringent than the default trigger value.

Reference sites and 80th percentile values will be updated in a subsequent revision of the SSTV assessment.

With respect Springvale LDP009, there were two SSTV assessment scenarios presented in RPS (2014d). The first examined Sawyers Swamp Creek as a separate watercourse. There is

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currently no surface water sampling location upstream of Springvale LDP009 and as a substitute the adopted reference site was Kangaroo Creek Upstream. The 80th percentile value for Kangaroo Creek will be updated in a subsequent revision of the SSTV assessment.

The second scenario examined Sawyers Swamp Creek as a tributary of the Upper Coxs River. As noted by the EPA, in accordance with Section 3.1.4 of ANZECC (2000), the reference site/s should reflect local conditions. There are five current land uses in the Coxs River catchment above Lake Wallace. These include natural, pasture, disturbed, urban and channel. Accordingly, adoption of a single reference site, for example, natural, would not reflect current water quality within the catchment, a large majority of which is outside of the extent of the Proposal.

To account for combination of catchment uses, and to address the 'confounding' issues noted by the EPA, an approach to an update to the SSTV assessment for Springvale LDP009 may consider multiple reference sites.

Issue EPA34) …The ANZECC guidelines advise that a minimum of two years of contiguous monthly data at a reference site is required before a valid trigger value can be established.

The monitoring frequency is not explicitly stated in the SSTV assessment (RPS, 2014cd). The analysis was conducted on contiguous monthly data. A summary of the surface water monitoring network, including frequency, is presented in Table 3.4 of the SWIA for Angus Place (RPS, 2014a) and Table 3.4 of the SWIA for Springvale (RPS, 2014b).

Issue EPA35) …*The Kangaroo Creek upstream may be an acceptable reference site for the assessment of site specific trigger values, in particular, salinity values appear consistent with values recorded at other upstream sites in the catchment, however, WTAU cannot determine its suitability as a reference site without further information, for example, the metals data are highly elevated compared to the default trigger value and the mix of ions making up salinity may be different.*

The Kangaroo Creek Upstream site resides on Kangaroo Creek upstream of the contribution from Angus Place LDP001. Figure 1 in the SSTV assessment (RPS, 2014cd) presents the location of relevant monitoring stations, including high resolution aerial photograph. As presented in Figure 1, the Kangaroo Creek catchment upstream of the monitoring station is in a natural state.

For Sawyers Swamp Creek, there is no surface water monitoring location upstream of Springvale LDP009. As noted in the RWQIAM (RPS, 2014e), there is a concrete channel that diverts catchment runoff around the Sawyers Swamp Creek Ash Dam, which is a wet ash dam that was used by Wallerawang Power Station prior to its conversion to a dry ash system in about 2002. From Figure 1 of RPS (2014cd), the Kangaroo Creek catchment lies immediately to the north of the Sawyers Swamp Creek catchment.

With respect to the mix of ions, the EPA's comment is acknowledged and will be incorporated into a future update of the SSTV assessment. It is highlighted that the Proposal consists of discharge of groundwater, ultimately recharged by the Coxs River, to Kangaroo Creek and Sawyers Swamp Creek, and this is expected to account for the ionic composition.

Issue EPA36) Discharge from Sawyer Creek to Coxs River (Springvale)

- *An inappropriate reference site appears to have been used in the derivation of site specific trigger values for the Discharge from Sawyers Creek to Coxs River.*

- *The derivation of a trigger value of 1539 µS/cm is not consistent with the ANZECC guidelines methodology for defining site specific trigger values and the reference site does not appear consistent with the Section 3.1.4 "Defining a reference condition" in the ANZECC guideline.*
- *Median conductivity levels in the upper parts of the Coxs River catchment are often in the 50 – 200 µS/cm range, indicating that 1539 µS/cm is a significant departure from a suitable reference site and reflects impacts in the catchment.*
- *The reference sites should be selected based on the best available sites representative of the level of protection for the part of the river in question, in this case slightly to moderately disturbed conditions. An appropriate reference site therefore should be at least slightly disturbed. Selection of reference sites and application of trigger values should not result in water of lesser quality than that already prevailing.*

This query has been addressed in the response to query EPA33.

Issue EPA38) The GHD report (Appendix 9) states that the conductivity of the upstream Kangaroo Creek site was measured at 820 µS/cm. This is not consistent with data presented in Appendix 3 which indicated median EC of 69 µS/cm and the site specific trigger value was calculated to be 89 µS/cm.

There are three monitoring stations in Kangaroo Creek: Kangaroo Creek Downstream of National Park; Kangaroo Creek Upstream and Kangaroo Creek Downstream. Within the Coxs River, there are also three monitoring stations: Coxs River Far Upstream, which lies above the confluence with Kangaroo Creek; Coxs River Confluence with Kangaroo Creek and Coxs River Downstream, which lies above the confluence of Coxs River and Wangcol Creek. It is understood that the Kangaroo Creek site referred to in the GHD report is the Kangaroo Creek Downstream site, which is located downstream of the point of discharge from Angus Place LDP001, whereas the SSTV assessment (RPS, 2014cd) is based on the Kangaroo Creek Upstream site.

2.1.4 Water Management Strategy (referred to in Attachment Four)

Issue EPA39) 4A Springvale Colliery, Environment Protection Licence No. 3607 and Salinity…The EPA's current position is a continuation of a regulatory effort to reduce the salinity concentrations of the upper Coxs River. The EPA considers the current limits on LDP9 to be interim until a change in management of the mine water (handling, treatment etc) is implemented.

It is understood that Centennial has responded to the NSW EPA in regard to this matter.

As we understand it, Centennial has requested evaluation of the proposed mine water strategy within the current approvals process.

Issue EPA40) 4C Closure and Mothballing of Angus Place Colliery – Environment Protection Licence (EPL467)…it is apparent to the EPA that Centennial could now again consider this option, including repairing the collapse bore and then direct mine water from Springvale into the mothballed Angus Place workings. There may be scope for a hybrid option of the partial discharge after treatment to reduce salinity of Springvale mine water, with the remaining portion directed into the old Angus Place workings for storage until mining at Springvale ends in 2023 at which time the mine water could be transferred back to Springvale for treatment upon the recommencement of mining at Angus Place.

Discussion of use of the Northern Panels for underground storage is included in licence variation documentation with respect to EPL467. It was noted that, at the time, there was 470 days of storage at ~2ML/d.

An assessment of potential available storage will be undertaken and provided, however, it is anticipated that this will not significantly impact the discharge requirement as the storage space is low. This storage space will also be affected by groundwater inflow to the underground void as a result of rebounding groundwater pressures. This is expected to 'fill' the void before it could be utilised.

The above advice will be updated when the results of assessment and, potentially, additional groundwater modelling, are received, if not already addressed.

In regard to future mining at Angus Place and storage at Springvale, as presented in the EIS and the GWIA, Springvale is hydrogeologically up-gradient of Angus Place. It is not conceptually feasible to store water 'uphill' of Angus Place.

2.2 Response to SCA

Issues SCA01) The SCA disagrees with these statements and has significant concerns in relation to predicted increases in salinity in Lake Burragorang, Coxs River, Kangaroo Creek and Sawyers Creek. Based on predicted increases in salinity, the SCA has assessed that both extension projects do not achieve a NorBE on water quality. The SCA therefore recommends that both applications be refused unless there is a requirement placed upon the applicant to treat minewater discharges to a higher and appropriate level prior to discharge.

As presented in the RWQIAM (RPS, 2014e), the Proposal will lead to salinity in the Coxs River that is within historical ranges aside from Kangaroo Creek, where discharge from the Angus Place Colliery resides at the top of the Coxs River catchment and historical increase in salinity in Kangaroo Creek is due to the discharge of mine water make at this location. It is proposed that discharge to Kangaroo Creek continues. As noted in the RWQIAM (RPS, 2014e), Sawyers Swamp Creek is a highly disturbed catchment and historical and current land uses includes wet ash deposition, dry ash placement facility, underground mining access portal and Kerosene Vale open cut mine, now rehabilitated. It is acknowledged in the EIS, SWIA, and RWQIAM that the proposed discharges do dominate flows in both Kangaroo Creek and Sawyers Swamp Creek. It is highlighted that discharge at Kangaroo Creek has been on-going for a considerable period and discharge to Sawyers Swamp Creek has occurred since 2006, whenever mine water make from the SDWTS was not required by Wallerawang Power Station.

The proposed increase in salinity in Lake Burragorang due to the Proposal is acknowledged, however, as stated in the RWQIAM, this is considered to have a neutral effect.

Issue SCA02) …the Report refers to Tables 4-1 and 4-2 of Annual Water Quality Monitoring Report (SCA 2012-13) for 'health-related', water quality parameters for raw water and site-specific standards specified in raw water supply agreements and states there is no target for salinity. The SCA considers that these two tables are irrelevant for catchment streams and the appropriate water quality objectives for the SCA's storages and catchment waterways are set out in Table 4.3 and 4.4 (SCA 2012-13) which are derived from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 guideline (ANZECC 2000). Unfortunately these tables also do not specify target for salinity…

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As specified in the Sydney Water Catchment Management Act 1998 No. 171, Clause (13):

"13 Role

The role of the SCA is, subject to and in accordance with this Act:

(a) to manage and protect the catchment areas and catchment infrastructure works, and

(b) to be a supplier of raw water, and

(c) to regulate certain activities within or affecting the outer catchment area as well as the inner catchment area."

and Clause (14):

"14 Objectives

(1) The principal objectives of the SCA are as follows:

(a) to ensure that the catchment areas and the catchment infrastructure works are managed and protected so as to promote water quality, the protection of public health and public safety, and the protection of the environment,

(b) to ensure that water supplied by it complies with appropriate standards of quality,

(c) where its activities affect the environment, to conduct its operations in compliance with the principles of ecologically sustainable development contained in section 6 (2) of the Protection of the Environment Administration Act 1991,

(d) to manage the SCA's catchment infrastructure works efficiently and economically and in accordance with sound commercial principles.

(2) In implementing its principal objectives, the SCA has the following special objectives:

(a) to minimise risks to human health,

(b) to prevent the degradation of the environment.

(3) Nothing in this section gives rise to, or can be taken into account in, any civil cause of action."

Accordingly, for Lake Burragorang, it was put that the Proposal constitutes a neutral effect on water quality since the predicted increase in salinity is minor in nature and does not lead to an impact in regard to its use as bulk raw water supply.

With respect to the catchment, the water quality criteria specified in Table 4.4 are the ANZECC (2000) default trigger values. As presented in ANZECC (2000), in order of preference, trigger values should be derived from local biological data (obtained from DTA) and then local reference data (derived using the SSTV approach) and lastly the default approach.

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Detailed discussion of the EPA's comments on the DTA, particularly in regard to salinity, is understood to have been prepared by the ecotoxicological consultant and is presented elsewhere.

Issue SCA03) The SCA's assessment of the regional water quality and quantity model has identified the following significant deficiencies, as it lacks scientific rigour and has insufficient details to assess the impacts on the receiving water and Lake Burragorang.

The Australian Water Balance Model (AWBM) is widely used in Australia for rainfall runoff modelling and was written by Professor Walter Boughton, Fellow of the Institute of Engineers, and as of recently Honorary Professor of Griffith University. The initial version of the AWBM was written in 1993 by Boughton and its predecessors, the SFB model in 1984 and his original model in 1964. Whilst attached to the Cooperative Research Centre for Catchment Hydrology at Monash University, in 2003, Boughton and Chiew refined the AWBM using a land use coefficient. This has been superseded by Boughton's later work, documented in Boughton (2010).

GoldSIM is the preeminent software platform for mine water balance work in Australia and is used worldwide in the consulting industry. The other commonly used software for mine water balance in the consulting industry is OpSIM.

For the RWQIAM, as stated in RPS (2014e), a GoldSIM module incorporating the AWBM was adapted and deployed over 281 sub-catchments, inclusive of 42 different rainfall definitions.

Relevant details and assumptions used in the model are presented in RPS (2014e) and calibration sufficient for the purpose of impact assessment is demonstrated at multiple watercourses and reservoirs, despite only having access to publically available information.

Issue SCA04) The model lacks goodness-of-fit statistics, has limited sensitivity analysis, uses unclear inputs to the model setup for the prediction model and its limits, and uses an unconventional presentation of results...

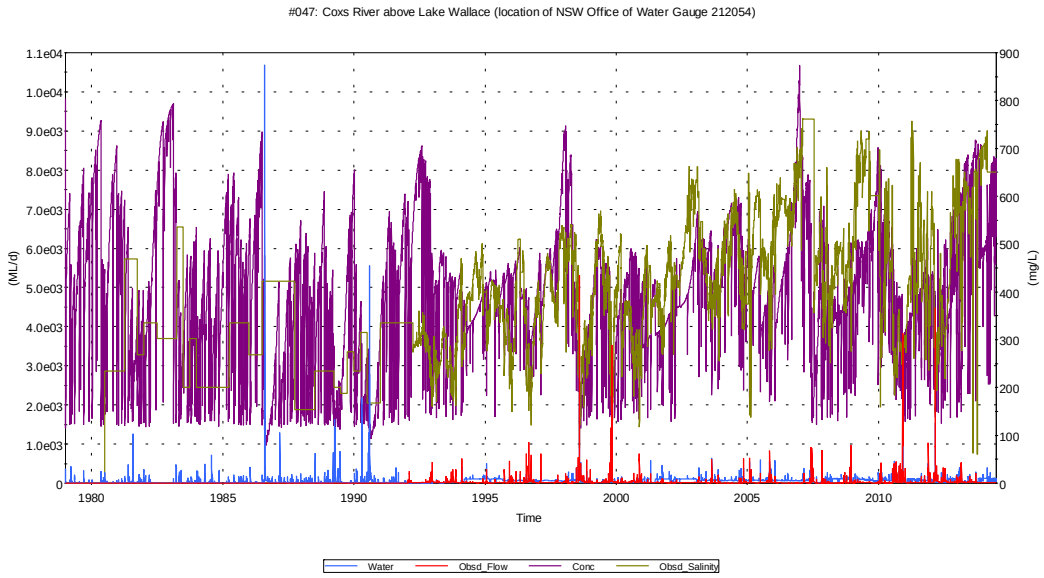
The SCA's comment on tabulation of calibration statistics is noted. Calibration of the model was presented graphically in RPS (2014e). An example, Figure 3.5 from RPS (2014e) is reproduced below, which is the same figure as provided in the response to query EPA01 above. This location corresponds with NSW Office of Water Station No. 212054.

Whilst not a precise match, the magnitude of fluctuation in modelled concentration and trends (decreasing and increasing) are well represented.

The SCA's comment on sensitivity analysis is noted and will be implemented into the next revision of the RWQIAM.

Water use within the catchment is described in Section 2.3 of RPS (2014e) and details of storages and environmental release rules are presented in Section 2.4. Detail of water supply in the model is presented in Section 2.5. A summary of historical water quality in the Coxs River catchment is presented in Section 2.6.

Details of the setup and assumptions used in the model is presented in Section 3.1 of RPS (2014e) including the assumed mine water discharge and seasonally variable daily demand at Mount Piper Power Station and Wallerawang Power Station.



As noted in RPS (2014e), coefficients used in the AWBM were taken from literature values for the Coxs River catchment presented in Boughton (2010), whom is the author of the AWBM. The AWBM coefficients were amended to represent urban and channel runoff.

Issue SCA05) …the impact of increased low flows has not been assessed, including the increased inundation of aquatic ecosystems that require wetting and drying…

The RWQIAM (RPS, 2014e) presents tabulated predicted daily flow and salinity statistics within each watercourse and reservoir. Table 3.14 and Table 3.15 from RPS (2014e) are replicated here by way of example.

Table 2.1 : Predicted Daily Flow Statistics (ML/d) at #047 (Coxs River upstream of Lake Wallace) (from Table 3.14 of RPS (2014e))

Percentile	CAL	NUL	WS1	WS2a	WS2b
Minimum	2.0	4.4	13.3	13.3	13.3
5%	3.4	6.2	33.0	33.0	33.0
10%	4.5	6.7	35.1	35.1	35.1
20%	6.6	7.5	36.8	36.8	36.8
50%	41.8	10.3	47.9	47.9	47.9
80%	105.4	30.4	60.9	60.9	60.9
90%	112.2	51.5	81.9	81.9	81.9
95%	131.2	95.3	126.1	126.1	126.1
Maximum	10694.0	5576.5	5607.4	5607.5	5607.5

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Table 2.2 : Predicted Daily Salinity Statistics (mg/L) at #047 (Coxs River upstream of Lake Wallace) (from Table 3.14 of RPS (2014e))

Percentile	CAL	NUL	WS1	WS2a	WS2b
Minimum	79	107	111	111	111
5%	156	191	358	358	358
10%	195	254	484	484	484
20%	284	397	639	639	639
50%	402	599	755	755	755
80%	514	681	780	780	780
90%	599	713	787	787	787
95%	665	731	791	791	791
Maximum	874	771	797	797	797

Discussion of the impact of the Proposal against catchment-based river flow objectives is presented in Section 10.2 of the EIS.

Issue SCA06) …the erosion potential of theses flows resulting in increased turbidity and significant impacts on the water quality of the system.

An analysis of the erosion potential of discharge to Kangaroo Creek and Sawyers Swamp Creek under the various water management strategies is presented in Section 6.3 of the SWIA for Angus Place and Springvale respectively (RPS, 2014ab).

The estimated velocity, at normal depth, in Kangaroo Creek, below Angus Place LDP001, was 0.78m/s assuming discharge at 28.6ML/d. As indicated in RPS (2014a), this is compared to the critical velocity, inclusive of vegetation, nominated in the Blue Book (Landcom, 2004 and DECCW, 2008) of 1.8m/s and is also small compared to the estimated velocity experienced during a typical large rainfall event of 2.0m/s (1 year Average Recurrence Interval). Similarly, at Springvale LDP009, considering a discharge at LDP009 of 43.8ML/d, the estimated velocity was 0.94m/s, as compared to the critical velocity, inclusive of vegetation, being 1.8m/s. The estimated velocity during a typical large rainfall event in Sawyers Swamp Creek downstream of LDP009 is 2.1m/s (1 year Average Recurrence Interval).

Issue SCA07) …no evidence is presented in regards to the assumed input concentrations from various land uses and the assumed 50mg/L concentrations for flows of 0ML/d.

The SCA's comment on discussion of input concentrations is acknowledged and is addressed below.

The natural land use class nominated an input concentration of 50mg/L based on surface water quality monitoring presented in the SWIA (RPS, 2014ab). In Table 3.9 of RPS (2014a), median salinity at station Kangaroo Creek Upstream, whose catchment is in an undisturbed state, is 67mg/L. Other sites presented in Table 3.9 included Wolgan River Upstream and Wolgan River Downstream with median salinity, as TDS, of 50 and 40mg/L.

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The pasture land use class nominated a concentration of 100mg/L. This was based on surface water quality monitoring at station Angus Place Coxs River Upstream in Table 3.9 of RPS (2014a). The median salinity, as TDS, was 100mg/L.

The disturbed land use was guided by surface water quality monitoring at Western Coal Services Wangcol NOW, which is a monitoring station upstream of point of discharge to Wangcol Creek from the Western Coal Services site. The median salinity, as TDS, is 328mg/L and the mean was 384mg/L.

The urban land use class was set as an intermediate between pasture and disturbed and the concentration was set at 250mg/L. Only 14 of 281 sub-catchments (or 5%) in the RWQIAM were set to urban class.

The last land use class was channel and was set to be equivalent to pasture, namely 100mg/L, since the 7 sub-catchments of 281 (2.5%) were channels, some engineered, through pasture land use class.

As stated in RPS (2014e), *"It is noted that the model approach adopted assumed concentration was 50mg/L when water flow was 0ML/d, so as to avoid a division-by-zero error."*. The stated assumption is not relevant to modelled salinity within reservoirs and only refers to handling of the concentration calculation of sub-catchments where baseflow store reduces to zero. The purpose of the statement was for documentation of an internal assumption for a future user of the model and was not intended to hold particular significance. As indicated in RPS (2014e), the model is based on salt flux in parallel to flow. When flow reduces to zero, there is no mechanism for salt to move in the model. The SCA's comment on the potential ambiguity of this assumption is, however, acknowledged and this issue will be resolved in the next revision of the RWQIAM.

Issue SCA08) …there is no evidence to suggest that the use of land-use event mean concentrations for TDS are suitable for modelling salinity in a catchment. More accurate scientific methods related to groundwater and soil modelling or curves fitted to discharges, as demonstrated through the Murray-Darling Basin Modelling, needs to be used.

As presented in RPS (2014e), the AWBM is a rainfall runoff model based on saturated excess. The structure of the model was presented in Section 3.1 of RPS (2014e) after Boughton (2010) and is reproduced below as Figure 2.1.

The model incorporates surface storage capacity, "soil", segregated into three different capacities. As illustrated in Figure 2.1, rainfall excess is partitioned to surface runoff and baseflow recharge, "groundwater", and these stores are depleted according to calibrated parameter values.

The mean concentration approach is relatively simplistic, however, when coupled with a non-linear rainfall runoff model based on rainfall excess which incorporates surface runoff and baseflow storage, performs well. A more sophisticated approach, which inevitably leads to more uncertainty due to more parameters, could be considered based on surface store of salt in each sub-catchment but is not considered warranted at this stage given the capability of the current model, as demonstrated by the calibration plot replicated in the response to query SCA01, or output from an interim update to the RWQIAM presented in the response to query EPA10.

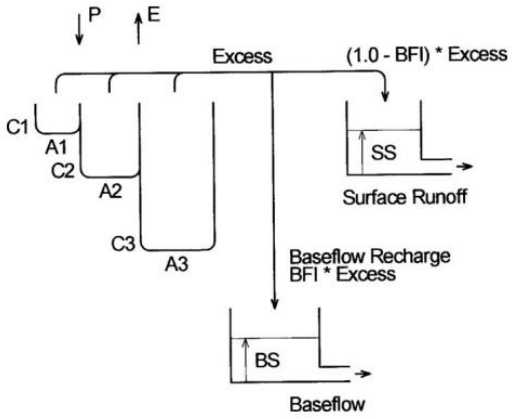

Figure 2.1 : Structure of the AWBM rainfall-runoff model

Issue SCA09) …the high salinity levels from LDP001 and LDP009 discharging into Kangaroo Creek and Sawyers Swamp Creek cannot be diluted to below the Site Specific Trigger Value 95% of the time which can deteriorate the health of the aquatic ecosystems in Kangaroo Creek and Sawyers Swamp Creek.

As noted in the Response to Submissions, the quality of groundwater, which ultimately was recharged from the Coxs River, meets the ADWG (NHMRC, 2011) and the description as being high salinity is not accurate.

It is acknowledged in the SWIA, RWQIAM and SSTV assessment (RPS, 2014abcde) that the proposed discharges do dominate flows in Kangaroo Creek and Sawyers Swamp Creek respectively.

As per the response to query EPA06, there has been discharge to Kangaroo Creek and Sawyers Swamp Creek for a considerable period and as presented in the Ecological Impact Assessment, these systems are already in an adapted state and there is no expected change to the status of these systems due to the Proposal.

Issue SCA10) …loss of aquatic ecosystems upstream of Coxs River can have long-term effects in the ability of the system to assimilate and dilute catchment inputs…

The proposed mine extensions at Angus Place and Springvale do not include plans to clear riparian vegetation from within Kangaroo Creek or Sawyers Swamp Creek.

At Kangaroo Creek, there has been discharge through LDP001 over a considerable period and it is proposed that this continues. The Ecological Impact Assessment indicates the aquatic ecosystems in the Coxs River are already in an adapted state. The Proposal does incorporate an increase to discharge to LDP001, however, as presented in response to query SCA06, the potential for increased erosion is not considered significant.

At Sawyers Swamp Creek, there has been discharge from LDP009 since ~2006, on commissioning of the SDWTS. When mine water supplied to the transfer scheme was not required, this water was discharged to Sawyers Swamp Creek via Delta Electricity LDP020.

Responsibility for discharge from the SDWTS was transferred from Delta Electricity (now EnergyAustralia) to Centennial in August 2012. Accordingly, there has been discharge to Sawyers Swamp Creek historically and it is proposed this continues. As noted in the EIA, this water management strategy is an alternative to discharge to the Newnes Plateau / Wolgan River. The Proposal does incorporate an increase to discharge at Springvale LDP009; however, as noted above, analysis implies the potential for increased erosion is not considered significant.

Issue SCA11) The SCA recommends that appropriate modelling guidelines and water quality standards be used to compare the impacts.

The RWQIAM was prepared using an industry standard rainfall runoff code and executed within an industry standard software platform. The model was calibrated appropriately for the purpose of impact assessment and included sufficient detail to account for the processes important to predicting salinity, as demonstrated by the calibration, despite being limited to only publically available information.

The SCA's comment on sensitivity analysis is noted and will be incorporated into the next revision of the RWQIAM.

Discussion of relevant water quality standards is presented in the response to query SCA01.

Issue SCA12) …the water quality in Kangaroo Creek and Sawyers Swamp Creek will deteriorate significantly above the guideline limit and the background concentrations for the majority of flow events.

As per the response to query SCA06, there has been historical discharge to Kangaroo Creek for a considerable period. As presented in the EIS, the aquatic ecosystems downstream of Kangaroo Creek are already in an adapted state and the status of these systems is not expected to change due to the Proposal. As presented in Figure 1 of the SSTV assessment (RPS, 2014c) the catchment of Kangaroo Creek upstream of point of discharge from Angus Place LDP001 is in a natural state.

For Sawyers Swamp Creek, historical catchment use includes a wet ash dam, Sawyers Swamp Creek Ash Dam, constructed in about 1979, a Dry Ash Placement Facility, underground mining portal access and the Kerosene Vale open cut mine, now rehabilitated. As presented in the response to query SCA06, there has been historical discharge to Sawyers Swamp Creek from the SDWTS since 2006 when mine water was not required at Wallerawang Power Station. The Proposal does consist of an increase in volume and frequency of discharge (continuous). As established in the EIS, the Ecological Impact Assessment indicates there is no expected change to the condition of these systems as they are already in an adapted state.

Issue SCA13) The SCA recommends that the DTA shall also be shall also be undertaken for Sawyers Swamp Creek and shall address the localised impacts of minewater discharge to the aquatic ecosystem. Long-term exposure of the creeks to high levels of salinity can potentially result in a significantly degraded eco-system in the creeks, which can subsequently impact the water quality in Coxs River and Lake Burragorang.

Direct Toxicity Assessment has been undertaken and it is understood that response to comments received from the NSW EPA have been prepared by the ecotoxicological consultant and is presented elsewhere.

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As noted in the response to query SCA06, there has been historical discharge to Kangaroo Creek and Sawyers Swamp Creek and as indicated in the Ecological Impact Assessment, aquatic ecosystems are already in an adapted state. Accordingly, as presented in the EIS, it is not expected that there will be a change in the status of these systems due to the Proposal.

Issue SCA14) The SCA considers the dilution factor analysis is based on predicted median flows for Sawyers Creek (because there is no flow monitoring on Sawyers Creek), monitored median flows in Kangaroo Creek and median discharge volume for both creeks. The SCA recommends that the dilution factor analysis should consider a range of creek flow volumes and discharge volumes including minimum, median and maximum. The analysis should also consider the statistical distributions of the flow volumes and pollution before, at and after the mixing zone.

It is acknowledged in the SSTV (RPS, 2014cd) and RWQIAM (RPS, 2014e) that historical and proposed discharges do dominate flows in Kangaroo Creek and Sawyers Swamp Creek respectively.

The SCA's suggestion for extending the dilution factor analysis is noted. The suggestion by the SCA to also include a flow monitoring station upstream and downstream of Springvale LDP009 in Sawyers Swamp Creek is noted.

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4. Closing

Should you require additional information then please do not hesitate to contact our office.

Yours sincerely

Dr Justin Bell
Environmental Engineer (Groundwater) / Hydrogeologist / Surface Water Engineer
+61 2 9032 1685
Justin.Bell@jacobs.com

Centennial Coal

Centennial Coal Company Limited
P O Box 1000
Toronto NSW 2283
www.centennialcoal.com.au