An analysis of water, sediment and biological samples from the Clarence River to identify potential causes for poor growth of school prawn during 2009/10

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PFA
PROFESSIONAL FISHERMEN'S ASSOCIATION

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PRINCIPAL INVESTIGATOR John Harrison

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OBJECTIVES:

1. Identify 18 key sites in the lower Clarence river for sediment and water sample testing
2. Engage a certified testing laboratory to sample and test these sites for a range of possible contaminants
3. Report on these test and results and determine a course in conjunction with relevant authorities of action if test results determine this
4. Engage a certified testing laboratory to test fish and prawn samples supplied by the PFA for a range of possible contaminants

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE

The project has provided better information to assist in our understanding of the environmental conditions in the lower reaches of the Clarence River. It has enabled rapid testing of both water and sediment within the lower reaches of the Clarence river to assist in either identifying or eliminating possible causes for the seemingly lack of growth in the school prawns in this current season.

The results of the tests at the 18 sites 2009 and 2010 and on the fish and prawn samples (2009 only) all returned within acceptable parameters. These initial studies suggest that there was no evidence of any excessive contaminants that may impede prawn growth rate.

The presence of elevated concentrations of Aluminium and Iron suggest that run off from upstream land is entering the river in concentrations that may possibly be above acceptable limits, but with no collation of available data on the Clarence River, this may be typical background nutrient and aluminium/iron levels. In response, possible areas for improvement in land management practices to reduce the inflow of high levels of nutrients and other contaminants will be discussed with the Clarence Valley Council, State Government agencies, other key stakeholders such as the Cane Growers Association, the Clarence Estuary Partnership project and others.

Environmental Analysis Laboratory's (EAL) sampling and testing program for the Clarence River shows that, during the summer periods (December 2009 and December 2010), the water quality is within acceptable limits for the region.

Monitoring and analysis effort at the eighteen sites consisted of physicochemical depth profiling (pH, EC, TDS, Turbidity, Salinity and DO), sediment and water sample collection for assessment of specific physicochemical and chemical analyses. Analysis and field monitoring results were compared with appropriate trigger levels.

The sampling and analysis effort is limited to one sampling event per annum at each of the eighteen (18) selected sites. Tidal variations and subsequent changes in water column depth are not accounted for in the sampling and monitoring effort.

Heavy metals or pesticides (in waters, sediment or fish/prawn samples) were not in concentrations considered toxic to fish, crustaceans and other estuarine life (as per the current water quality guidelines).

Within areas of the Clarence with low flushing (i.e. Lake Wooloweyah and Maclean Broadwater) and upstream areas, the testing showed that Acid Sulfate Soils were present in the sediment. Although these sediments are below the water table and not exposed to air, the potential exists for these materials to be disturbed and to produce acidic products, metals and to potentially deoxygenate waters in the case of iron monosulfides (black sludge found in Lake Wooloweyah and Maclean Broadwater).

In areas where waters were turbid (i.e. cloudy), levels of nutrient such as nitrogen and phosphorus typically associated with fertilisers and septic run-off were found to be high. Of all heavy metals EAL analysed, Aluminium and Iron where found to be present in high concentrations upstream, likely due to acid sulfate run off from ASS affected lands around Coldstream River and Shark Creek.

Key points noted during the comparison between the previous data and analysis and monitoring results collected for this period:

- Rainfall totals for the year prior to sampling were lower in 2010 than those recorded for same period at each of the 3 monitoring stations in 2009. Whilst, rainfall for the month prior to sampling was higher in 2010 at all 3 stations than those recorded for the same period in 2009. Rainfall for the 48 hours prior to sampling was greater in 2009 at the Harwood station and similar at the other 2 stations for both sampling years;
- TSS trigger value (20mg/L) was exceeded in the 2010 sampling run only at Lake Wooloweyah;
- pH (2010) values were recorded to be below the normal values for estuaries at SP18 (Main Channel), SP8, SP12, SP11 and SP1 (Tributaries);
- EC was considerably lower at all sites during the 2010 sampling run;

- Total Nitrogen exceeded the trigger value of 0.3 (mg/L N) at all sites in both sampling years. Total Phosphorous trigger value (0.025 mg/L P) was also exceeded in both sampling years at all Main Channel and Tributaries Sites, and Lake Wooloweyah (lagoons sites). At the Lagoons Sites, P was below trigger value in 2009 at SP9 and SP10 (Broadwater), but above trigger value in 2010.
- Nitrate and Ammonia values in 2010 generally exceeded the guidelines at most sites except for some of the sites at Lake Wooloweyah, which were below trigger levels.
- DO at levels of less than 5 mg/L (i.e. below trigger level) were recorded for SP12 and SP11 (South Arm), SP8 (North Arm) and SP18 (Main Channel) consistently in both sampling periods;
- BOD levels for SP3 & SP2 (Lake Wooloweyah) are indicative of lightly to moderately polluted waters. However, DO levels at the same sites (for both years) display concentrations well above 5 mg/L;
- Dissolved Aluminium (Al) and Iron (Fe) concentrations were considerably higher in 2010 than those recorded in 2009. In regard to Aluminium concentrations, only SP16 recoded lower concentrations than 2009; and
- Sulfate levels (in water) were lower in 2010 than those recorded in 2009, whilst Al and Fe are generally higher in 2010 than the concentrations recorded in 2009.

The testing of fish/prawn samples (2009 only) shows that whilst heavy metals were present, the levels at which they were found were not considered toxic to both aquatic species or for human consumption. It is possible that these levels would inhibit growth rates but this inhibition is considered to be fairly minor.

Overall, the concentrations of all contaminants tested were found to be below the acceptable levels, therefore; none of the testing can point to a specific contamination source that may have affected prawn growth. Nutrient inputs and the presence of elevated concentrations of Aluminium and Iron suggest that run off from upstream lands is entering the river in concentrations above the acceptable limits, but with no collation of available data on the Clarence River, this may be typical background nutrient and aluminium/iron levels.

Given the variation of physical factors (such as rainfall received, tidal fluxes, flow conditions etc.) experienced during the two discrete sampling and analysis events, a degree of variation is expected. Nevertheless, the following issues have been identified:

- Concentrations of both TN (and NOx) and TP continue to exceed the adopted trigger values, suggesting significant sources of nutrient enter the estuary;

- Reduction in marine influence was observed at the majority of sites as evidenced by the reduction in Cl and SO_4 recorded, along with greater variation of C:;SO_4 ratios;

- Salinity levels are considerably lower at all sites in the 2010 sampling run despite a relatively lower annual rainfall when compared to last year's records. However, rainfalls for the month prior to the sampling were relatively higher in 2010 than the same period in 2009. Additionally, tidal variations and subsequent changes in water column depth were not accounted for in the sampling and monitoring effort. These factors might explain the difference in salinity levels observed between the two sampling years.

- A net increase in the acid generating potential of benthic sediments was identified between the discrete sampling and analysis periods;

- An increase of heavy metal concentrations (principally Fe and Al) within surface water samples was also identified during the recent sampling effort.

The above summary is intended to provide general information on the findings of the Clarence River study conducted by EAL on behalf of the Professional Fishermans Association Inc.

KEYWORDS:

School prawn, Clarence River, water analysis, sediment analysis

Acknowledgements

The PFA would like to thank the EAL for its quick response to our request for sample collection and analysis. In addition we would like to thank the fishers who collected the fish and prawn samples for testing and who identified the 18 sites for sampling. And importantly we thank the FRDC for supporting this project.

Background/ Need

On 14 December 2009 the Clarence River estuary prawn trawl fishermen closed the River and Lake Wooloweyah to prawn trawling until 4 January 2010. This at a time when harvest rates should be peaking to meet the demand for the school prawns over the Xmas and New Year period. The reason for the decision was based on the small body size of the school prawn in the lake and river. They were not growing despite what seemed to be ideal conditions. Following the major flood in May and a minor fresh in October it was expected that the up coming river trawl season would be a bumper.

For months there has been a problem with the size of the prawns in the river system. Although the reason is unknown, theories include:

- high water temp (29 – 30 degrees) that may not be conducive (too high) to the micro food the prawns eat;
- something left as a residue (e.g., black sludge) after the floods because the prawns are travelling when they should not be (small ones going to sea);
- prawns are not separating into different class sizes as they usually do;
- flood mud on the banks from May that still has no grass growing on it in some places;
- pocket nets catching small travelling prawns when they normally catch a better grade of prawn;
- fish dead (Coldstream River about mid November); bream dead in crab traps and eels dead in traps (South Arm - looked like they have been boiled);

The Clarence estuary prawn trawl is responsible for about 500 tonnes of catch annually; it is a major supplier for the recreational fishing bait market and supplies to numerous markets for human consumption up and down the east coast. Renowned for their high quality, these prawns are strongly sought after. The estuary prawn trawl fishery is significant for local employment and provides many flow-on benefits to the region including processing, transport and other service providers.

Unless the likely problem is identified and possible causes are eliminated, there could be ongoing impacts.

Objectives

1. Identify 18 key sites in the lower Clarence river for sediment and water sample testing
2. Engage a certified testing laboratory to sample and test these sites for a range of possible contaminants
3. Report on these test and results and determine a course in conjunction with relevant authorities of action if test results determine this
4. Engage a certified testing laboratory to test fish and prawn samples supplied by the PFA for a range of possible contaminants

Note: Objective 4 was not included in the second round of sampling in December 2010 because the results in 2009 did not warrant a repeat and in addition there was insufficient funds in the budget to complete this sampling a second time.

Methods

EAL Consulting of Southern Cross University undertook a comprehensive assessment of physical and chemical attributes of water, sediment and biological samples within the Clarence River and a select number of tributaries (Lake Wooloweyah, Coldstream River, Shark Creek, Maclean Broadwater). A total of eighteen (18) sediment and near-surface (i.e. benthic) sediment samples were collected between the River Mouth and the Ulmarra ferry. In addition, eleven (11) locations were netted for biological samples (prawn, mullet, whiting, and bream) for 2009 only. These products were supplied by the PFA..

Sediment, Water and Biological samples were analysed for the following physico-chemical parameters and specific analytes:

SEDIMENTS:

- Physico-chemical: pH1:5, EC1:5, Resistivity, Chloride, Sulfate
- Specific Contaminants: Silver, Arsenic, Lead, Cadmium, Chromium, Copper, Manganese, Nickel, Selenium, Zinc, Mercury, Iron, Aluminium, Tin,
- Organochlorine Pesticides (OCP): including Aldrin, Cis-chlordane, Trans-chlordane, HCB, DDD, DDE, DDT, Alpha-BHC, Beta-BHC, Delta-BHC, Lindane, Dieldrin, Endrin, Heptachlor, Heptachor epoxide, Alphaendosulfan, Beta-endosulfan, Endosulfan sulfate, Methoxychlor)
- Organophosphorus Pesticides (OPP): includes Dichlorvos, Phosdrin, Demeton (total), Ethoprop, Monocrotophos, Phorate, Dimethoate, Diazinon, Disulfoton, Methyl parathion, Chloropyrifos, Ronnel, Parathion, Stirofos, Prothiofos, Azinophos methyl, Coumaphos, Fenitrothion, Fenthion, Malathion)

- Polychlorinated Biphenyls (PCB):
- Acid Sulfate Soils: Oxidisable Sulfur, Titratable Actual Acidity, Acid Neutralising Capability, Acid Volatile Sulfur

WATER:

- Physico-chemical: pH, Electrical Conduc. (EC), Total Dissolved Solids (TDS), Total, Suspended Solids (TSS), Bicarbonate, Chloride, Sulfate, Water Hardness, Biochemical Oxygen Demand (BOD), Total Phosphorus (TP), Orthophosphate, Total Nitrogen, Nitrate, Nitrite, Ammonia
-
- Water Specific Contaminants: Sodium, Potassium, Calcium, Magnesium, SAR, Silver, Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Manganese, Nickel, Lead, Zinc, Mercury, Tin, OCP, OPP, PCB

BIOLOGICAL:

- Specific Contaminants: Silver, Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Manganese, Nickel, Lead, Zinc, Mercury, Tin, OCP, OPP, PCB

In addition to the above, profile data for each specific site will be collected to provide a vertical representation of specific physico-chemical parameters. Pesticide and PCB analyses will be undertaken at trace level detection limits in an attempt to identify trace levels of such contaminants.

In situ water quality testing was undertaken from a small vessel anchored over each site. Following profile logging for pH, EC, salinity, temperature, turbidity, Dissolved Oxygen (DO) and Total Dissolved Solids (TDS), water samples were collected in close proximity to the benthic surface via a pump and transferred immediately to bottles. Sediment samples were collected using a grab sampler and immediately transferred into glass jars. All samples were stored in an esky and immediately frozen upon return to the laboratory.

OCP/OPP/PCB analyses were subcontracted to Labmark laboratories for both sediment and water samples.

Biological samples were delivered to the EAL laboratory (frozen) by PFA EO John Harrison. Samples were ground and digested with NSW Industry & Investment Diagnostics and Analytical Services subcontracted to undertake residue testing (OCP/OPP/PCB).

Based on the results of this work, the PFA will discuss potential management options available with a range of Government agencies and other key stakeholders.

Results/Discussion

This was not an extensive study to show cause and effect relationship. It was a snap shot to see if there were unusual levels of contaminants that could possibly be flagged for further investigation as a contributing factor to low prawn growth rate.

Results and discussion of this research are presented in Appendix C and D of this report.

In brief, the key results are as follows:

The initial round of testing and reporting provided to the Professional Fishermen's Association as part of the 2009 investigation (i.e. summary report dated 10 March 2010) aimed at targeting potential contaminants associated with land uses predominant within the Clarence Catchment (i.e. pesticide use within rural areas, heavy metal contaminant loads potentially associated with urban land uses, acid sulfate inputs etc.). The sampling and analysis effort focused upon assessing concentrations of these particular contaminants in waters, sediments and biota. With the application of appropriate and contemporary trigger levels (relevant to each specific parameter), no parameter was found to represent a significant risk to biotic (e.g. prawn) populations as consistent with the limited scope of the report.

Because of the findings of the 2009 effort, the need for replication of contaminant analysis in biota and sediments was considered redundant and was subsequently not included in the 2010 effort (i.e. the Report). It was considered more appropriate and cost-effective to focus the recent effort upon gathering further (corresponding and comparable) information that would relate directly to habitat health (i.e. pertinent to areas of prawn harvest as identified by PFA). The refinement of the information collected potentially allows for the ready identification of linkages between habitat availability and environmental parameters such as fundamental physico-chemical parameters (such as pH, EC, temperature etc.), physical attributes (such as sedimentation and foraging habitat) and cumulative contaminant loads.

The broad scope (in terms of objectives and area sampled) of the works completed to date have provided snapshots of conditions within the sampling regions of the Clarence Estuary. Further refinement of the scope is recommended as set for Section 6.1 of the Report.

The results of the tests at the 18 sites 2009 and 2010 and on the fish and prawn samples (2009 only) all returned within acceptable parameters. There was no evidence of any excessive contaminants in any results.

This result whilst encouraging in view of the quality of the catch did not assist in identifying the cause of the prawns not growing. Given the anecdotal evidence along the coast that the same scenario (2009) was seen in all but one (Myall Lake) estuary/river system it can possibly be assumed that this was a natural occurring phenomenon.

Benefits and adoption

This study did not identify the cause of a reduced growth rate of school prawn. However, based on the samples collected during 2009 and 2010, contaminants did not appear to be an obvious contributor to the observed growth trend. Although contaminants can not be eliminated as a cause (study was inconclusive), the work suggests that factors other than contaminates should be investigated as the primary driver/s of this observed trend in growth rate.

This information will be conveyed (where appropriate) as a formal scientific report to the relevant authorities including the CMA, Council, Fisheries, Fishers, CRFC, and others.

Potential beneficiaries are the Clarence estuary prawn trawl fishermen, Clarence River Fishermen's Cooperative, suppliers of goods and services, customers, recreational fishers, and the people that enjoy seafood from this region.

Planned outcomes

The project has provided better information to assist in our understanding of the environmental conditions in the lower reaches of the Clarence River. It has enabled rapid testing of both water and sediment within the lower reaches of the Clarence river to assist in either identifying or eliminating possible causes for the seemingly lack of growth in the school prawns in this current season.

The results of the tests at the 18 sites 2009 and 2010 and on the fish and prawn samples (2009 only) all returned within acceptable parameters. These initial studies suggest that there was no evidence of any excessive contaminants that may impede prawn growth rate.

The presence of elevated concentrations of Aluminium and Iron suggest that run off from upstream land is entering the river in concentrations that may possibly be above acceptable limits, but with no collation of available data on the Clarence River, this may be typical background nutrient and aluminium/iron levels. In response, possible areas for improvement in land management practices to reduce the inflow of high levels of nutrients and other contaminants will be discussed with the Clarence Valley

Council, State Government agencies, other key stakeholders such as the Cane Growers Association, the Clarence Estuary Partnership project and others.

Further sampling in the following years will provide a more robust data set however the timing of these samples and the necessary financial support needs to be worked out.

Conclusion

"Looking at metals in fish and prawns was a good option in order to know that both are safe for human consumption. However finding baselines for metals in fish/prawns is difficult, in terms of whether the levels detected affect the health of the fish/shrimp not only from a human health consumption point of view. Finding correlative data which demonstrates that certain tissue levels correspond to deleterious impacts on health is harder still. The role of organic pollutants in aquatic animals is important to examine. However it is tricky to determine the best time for sampling as it is hard to predict when exposure is taking place. Sampling after the prawns have already been affected will tell us little about the causes as the prawn genetics will have probably been affected earlier on. Consequently it is hard to pick an optimal sampling time. In addition the cause of exposure may not directly affect the prawn, but instead the food availability or other parts of the ecosystem. Overall, it is hard to draw any conclusions based on two sampling periods even if they were undertaken in two different years. Sustained monitoring is recommended" *(*Dr Ana Rubio-Zuazo, pers. Comm. 2011).

The reason for the lack of growth in school prawns in the Clarence River still remains unknown. Further sampling in the following years will provide a more robust data set however the timing of these samples and the necessary financial support needs to be worked out.

Attachment A: 2010 Report

EAL Consulting Services

Environmental Analysis Laboratory

EAL Consulting Services

10th March 2010

TO: Professional Fishermen's Association
ATT: John Harrison
51 – 55 River Street
MACLEAN NSW 2463

RE: Sampling and analysis of sediment, water and biological samples collected from the Clarence River in response to recent closure(s) to prawn trawling

SUMMARY

EAL's sampling and testing program for the Clarence River shows that, during the summer period investigated, the water quality is within acceptable limits for the region. Information regarding water quality of the Clarence River itself was not collected and collated as part of this study; therefore our assumptions are based on regional information.

We didn't find any heavy metals or pesticides (in waters, sediment of fish/prawn samples) in concentrations considered toxic to fish, crustaceans and other estuarine life (as per the current water quality guidelines).

Within areas of the Clarence with low flushing (i.e. Lake Wooleweyah and Maclean Broadwater) and upstream areas, the testing showed that Acid Sulfate Soils were present in the sediment. Although these sediments are below the water table and not exposed to air, the potential exists for these materials to be disturbed and to produce acidic products, metals and to potentially deoxygenate waters in the case of iron monosulfides (black sludge found in Lake Woolweyah and Maclean Broadwater).

In areas where waters were turbid (i.e. cloudy), levels of nutrient such as nitrogen and phosphorus typically associated with fertilisers and septic run-off were found to be high.

Of all heavy metals EAL analysed, Aluminium and Iron where found to be present in high concentrations upstream, likely due to acid sulfate run off from ASS affected lands around the Coldstream and Shark Creek.

The testing of fish/prawn samples shows that whilst heavy metals were present, the levels at which they were found were not considered to be toxic to both aquatic species or for human consumption. It is possible that these levels would inhibit growth rates but this inhibition is considered to be fairly minor.

Overall, the concentrations of all contaminants tested were found to be below the acceptable levels, therefore; none of the testing can point to a specific contamination source that may have affected prawn growth. Nutrient inputs and the presence of elevated concentrations of Aluminium and Iron suggest that run off from upstream lands is entering the river in concentrations above the acceptable limits, but with no collation of available data on the Clarence River, this may be typical background nutrient and aluminium/iron levels.

The above summary is intended to provide general information on the findings of the Clarence River study conducted by EAL on behalf of the Professional Fishermans Association. EAL would like to thank John Harrison and the staff at PFA for their assistance provided and for the opportunity to undertake this work.

SAMPLING AND ANALYSES OF SEDIMENTS, WATERS AND BIOTA COLLECTED FROM THE CLARENCE RIVER AND TRIBUTARIES.

In response to a request from the Professional Fishermen’s Association (PFA), EAL has undertaken a comprehensive assessment of physical and chemical attributes within the Clarence River and a select number of tributaries (Lake Woolewayah, coldstream River, Shark Creek, Maclean Broadwater).

Based on information provided by PFA, a total of eighteen (18) sediment and near-surface (i.e. benthic) sediment samples were collected between the River Mouth and the Ulmarra ferry (refer attached Fig. 1). In addition, eleven (11) locations were netted for biological samples (prawn, mullet, whiting, and bream) which were supplied by PFA.

Sediment, Water and Biological samples were analysed for the following physico-chemical parameters and specific analytes:

Sample Media	**Analytes**			
Sediment	Physico-chemical	Texture $pH_{1:5}$ $EC_{1:5}$	Resistivity Chloride Sulfate	
	Specific Contaminants	Silver Arsenic Lead Cadmium Chromium Copper	Manganese Nickel Selenium Zinc Mercury Iron	Aluminium Tin OCP* OPP** PCB***
	Acid Sulfate Soils	Oxidisable Sulfur Titratable Actual Acidity Acid Neutralising Capability Acid Volatile Sulfur		

* Organochlorine Pesticides - including Aldrin, Cis-chlordane, Trans-chlordane, HCB, DDD, DDE, DDT, Alpha-BHC, Beta-BHC, Delta-BHC, Lindane, Dieldrin, Endrin, Heptachlor, Heptachor epoxide, Alpha-endosulfan, Beta-endosulfan, Endosulfan sulfate, Methoxychlor)

** Organophosphorus Pesticides - includes Dichlorvos, Phosdrin, Demeton (total), Ethoprop, Monocrotophos, Phorate, Dimethoate, Diazinon, Disulfoton, Methyl parathion, Chloropyrifos, Ronnel, Parathion, Stirofos, Prothiofos, Azinophos methyl, Coumaphos, Fenitrothion, Fenthion, Malathion)

***Polychlorinated Biphenyls

Sample Media	Analytes		
Water	Physico-chemical	pH Electrical Conduc. (EC) Total Dissolved Solids (TDS) Total Suspended Solids (TSS) Bicarbonate Chloride Sulfate	Water Hardness Biochemical Oxygen Demand (BOD) Total Phosphorus (TP) Orthophosphate Total Nitrogen Nitrate Nitrite Ammonia
	Specific Contaminants	Sodium Potassium Calcium Magnesium SAR Silver Aluminium Arsenic Cadmium Chromium Copper	Iron Manganese Nickel Lead Zinc Mercury Tin OCP OPP PCB
Biological	Specific Contaminants	Silver Aluminium Arsenic Cadmium Chromium Copper Iron Manganese	Nickel Lead Zinc Mercury Tin OCP OPP PCB

Pesticide and PCB analyses were undertaken at trace level detection limits in an attempt to identify trace levels of such contaminants.

In addition to the above, profile data for each specific site was collected to provide a vertical representation of specific physico-chemical parameters. Site Log Sheets 1 – 18 are enclosed.

SAMPLING METHODOLOGY

EAL staff performed sampling and site work over a two day period (22nd & 23rd December 2009), attending all eighteen sites and establishing the vertical profile of each site as shown in Fig. 1.

In situ water quality testing was undertaken from a 14ft vessel anchored over each site. Following profile logging for pH, EC, salinity, temperature, turbidity, Dissolved Oxygen (DO) and Total Dissolved Solids (TDS), water samples were collected in close proximity to the benthic surface. Samples were collected via pumping (12V submersible pump) and transferred immediately to:

1. 1L Plastic bottle (unpreserved);
2. 500mL Glass bottle (unpreserved);
3. Two 43mL glass vials (Sulfuric acid preservation).

Sediment samples were collected using a grab sampler and were immediately transferred into 250mL glass jars (unpreserved).

All samples were stored in an esky and immediately frozen upon return to the laboratory. OCP/OPP/PCB analyses were subcontracted to Labmark laboratories for both sediment and water samples.

Biological samples were delivered to the laboratory (frozen) by PFA staff (John Harrison). Samples were ground and digested with NSW Industry & Investment Diagnostics and Analytical Services subcontracted to undertake residue testing (OCP/OPP/PCB).

A copy of all laboratory certificates is enclosed. The following provides a brief comparison of relevant attributes for each sampling location (i.e. SP1 – 18).

<u>Sediment Sampling Results Discussion</u>

Chemical conditions within the sediment (i.e. specifically pH & Electrical Conductivity (EC)) displayed typical estuarine conditions with both pH and salinity (as derived from EC) decreasing with distance from the river mouth. Fig. 2 below provides a graphical representation of this trend.

It is interesting to note the observed decline in obvious seagrass beds within the downstream reaches of the Clarence River. Given the recent flood event(s) an increased sediment load (as evidenced by the changing sand spits and bars present throughout the river) may have given rise to a decrease in frequency and concentration of such ecological communities.

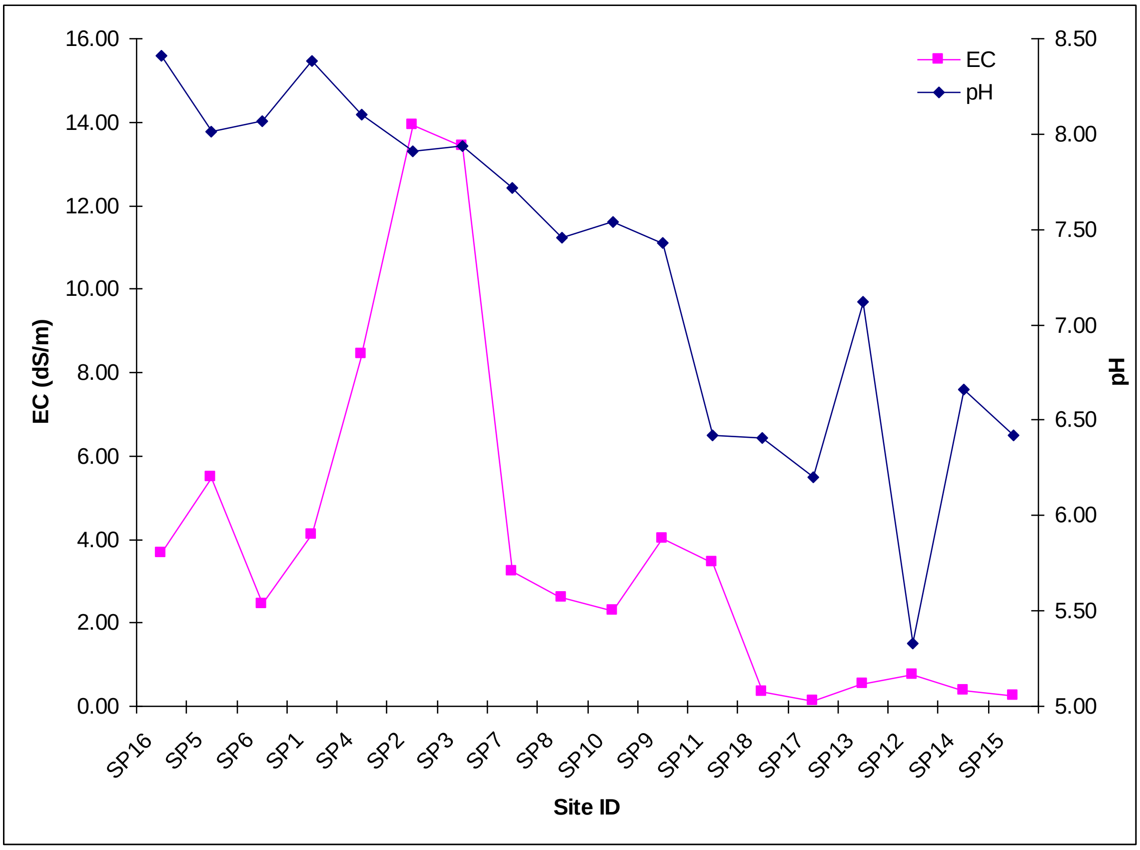

Fig. 2: EC and pH conditions recorded within sediment samples for each site (river mouth to Ulmarra Ferry)

Fig. 3 below shows the concentrations of the heavy metals Arsenic, Lead, Chromium and copper recorded in sediment samples from each site (from river mouth to Ulmarra ferry site).

No metal concentrations were found to exceed the ANZECC/ARMCANZ (2000) guideline values[1].

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[1] ANZECC/ARMCANZ (2000). Australian and New Zealand Guidelines for fresh and marine water quality. Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT.

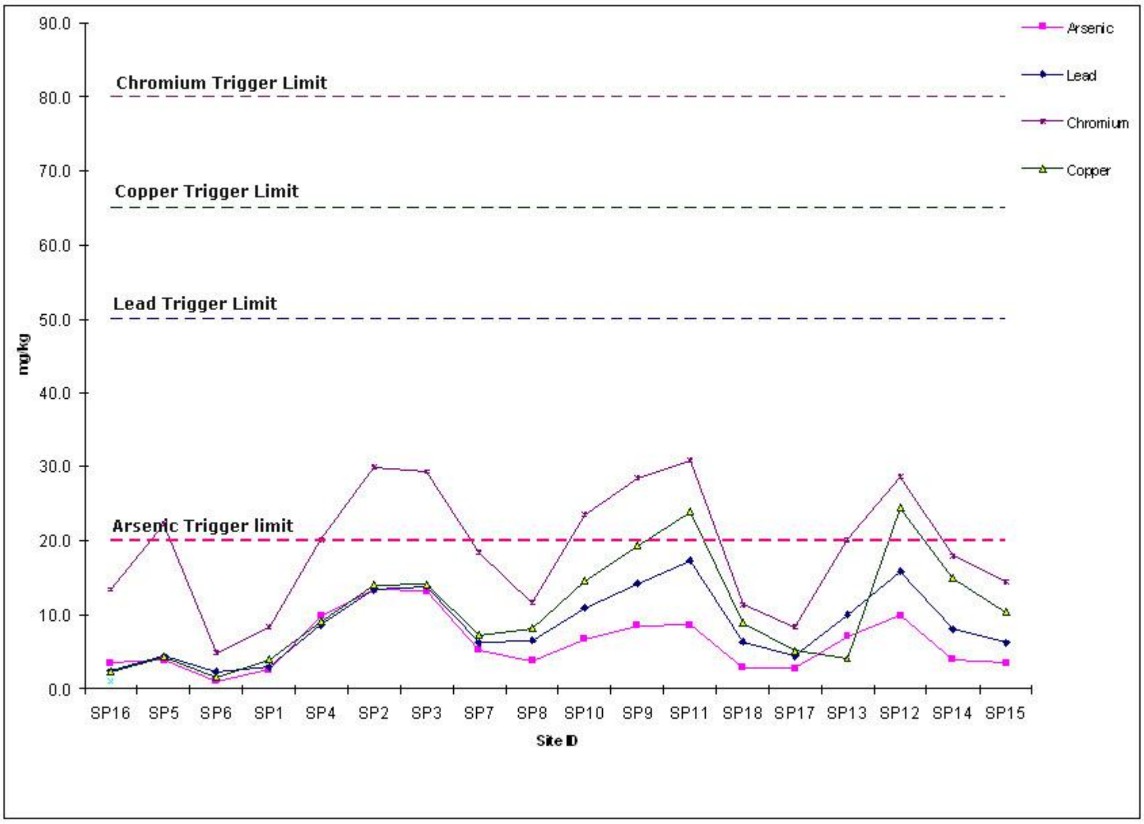

Fig. 3 Concentrations of the heavy metals Arsenic, Lead, Chromium and copper recorded in sediment samples from each site (from river mouth to Ulmarra ferry site).

Analysis of sediment samples to ascertain the presence of naturally occurring Acid Sulfate Soil (ASS) layers indicate the presence of significant quantities of oxidisable sulfur. This is an excellent indicator of the presence of potential sulfidic sediments. The concentration and presence of ASS sediments is seen to increase with distance from the river mouth, as shown below in Fig. 4. Chloride sulfate analyses showed a significant contribution of sulfate to the estuarine system, especially in locations found to contain potential acid sulfate sediments.

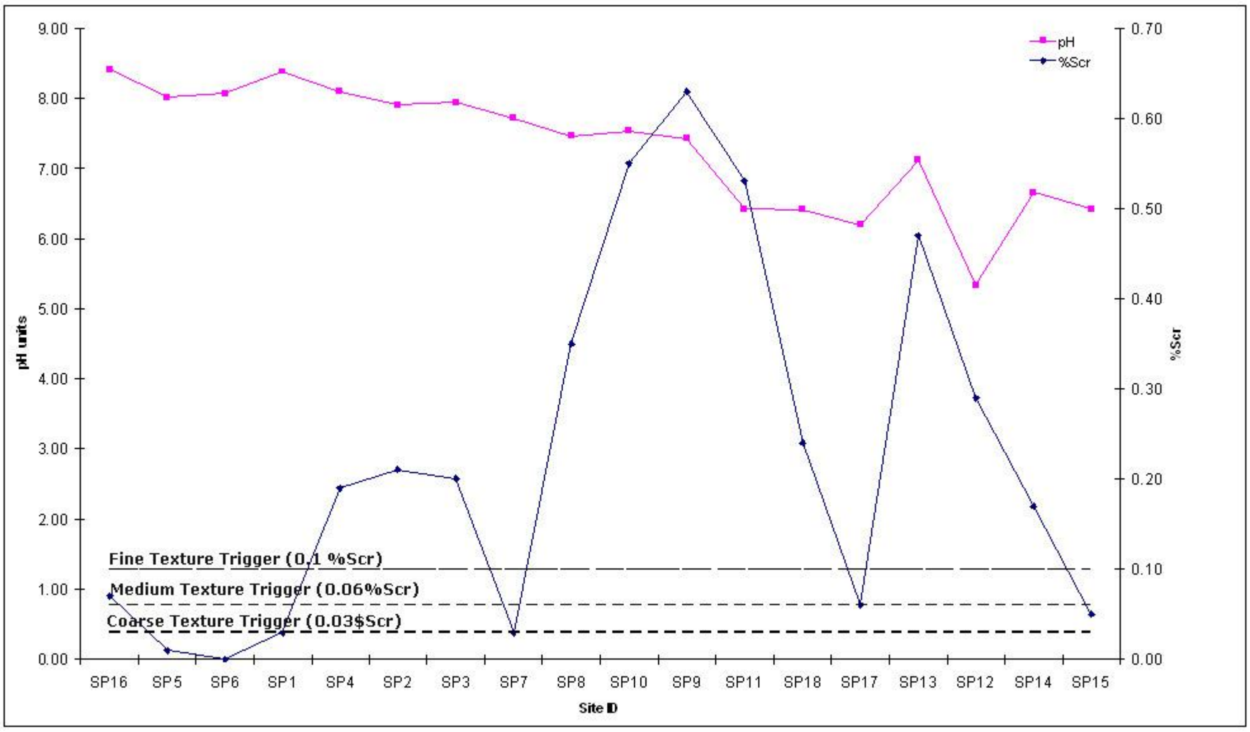

Fig. 4: %Scr concentrations against pH (river mouth to Ulmarra Ferry)

The sediment analysis does not identify any particular contaminant or specific physico-chemical parameter that exceeds the ANZECC/ARMANZ (2000) sediment trigger values. Salinity and pH values are as expected and metal concentrations; although variable do not exceed the high trigger values adopted for this investigation. Samples collected in low energy environments typically displayed characteristics of ASS however; sediments collected in closer proximity to the river mouth demonstrated a high acid neutralising capability, suitably buffering any potential acidity.

Water Sampling Results Discussion

Chemical conditions within the near surface waters (i.e. specifically pH & Electrical Conductivity (EC)) displayed typical estuarine conditions with both pH and salinity (as derived from EC) decreasing with distance from the river mouth. Fig. 5 below provides a graphical representation of this trend.

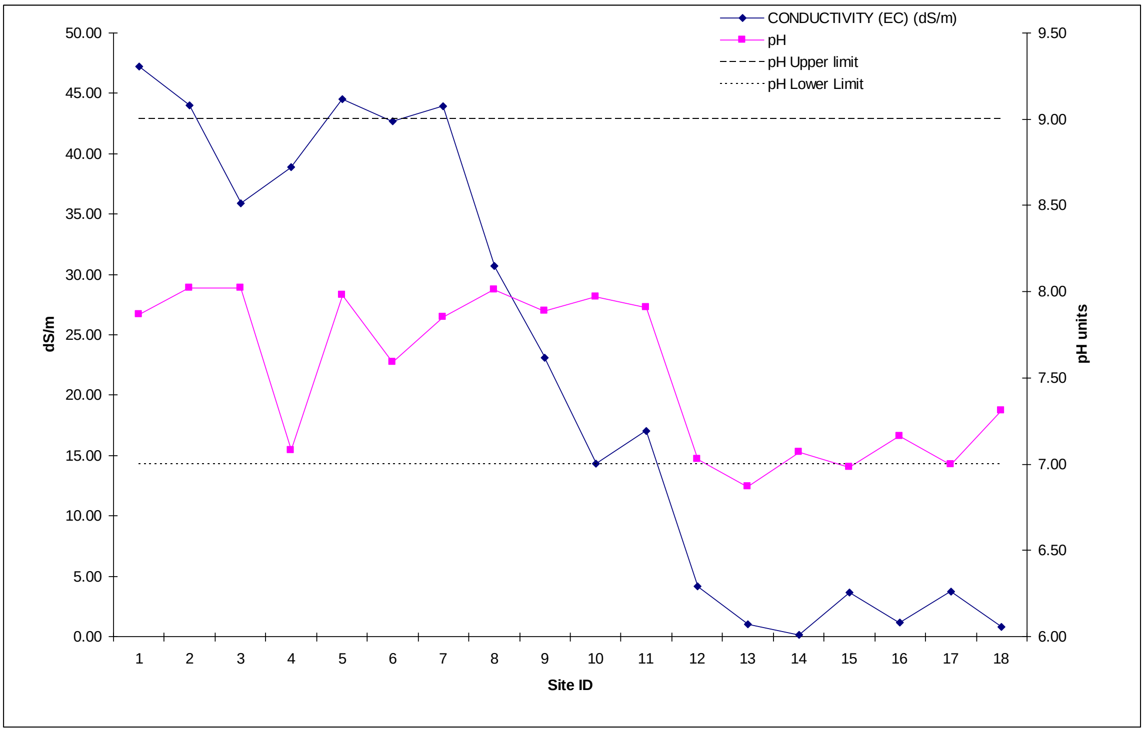

Fig. 5: Water EC and pH characteristics from river mouth to Ulmarra ferry

Figs. 6, 7 and 8 below show the concentrations of the macronutrients (Total Nitrogen, Total Phosphorus, Nitrate, Nitrite and Ammonia) recorded in water samples from each site (from river mouth to Ulmarra ferry site). Values recorded for Total Suspended Solids (TSS) are also shown in Figs. 6 and 7.

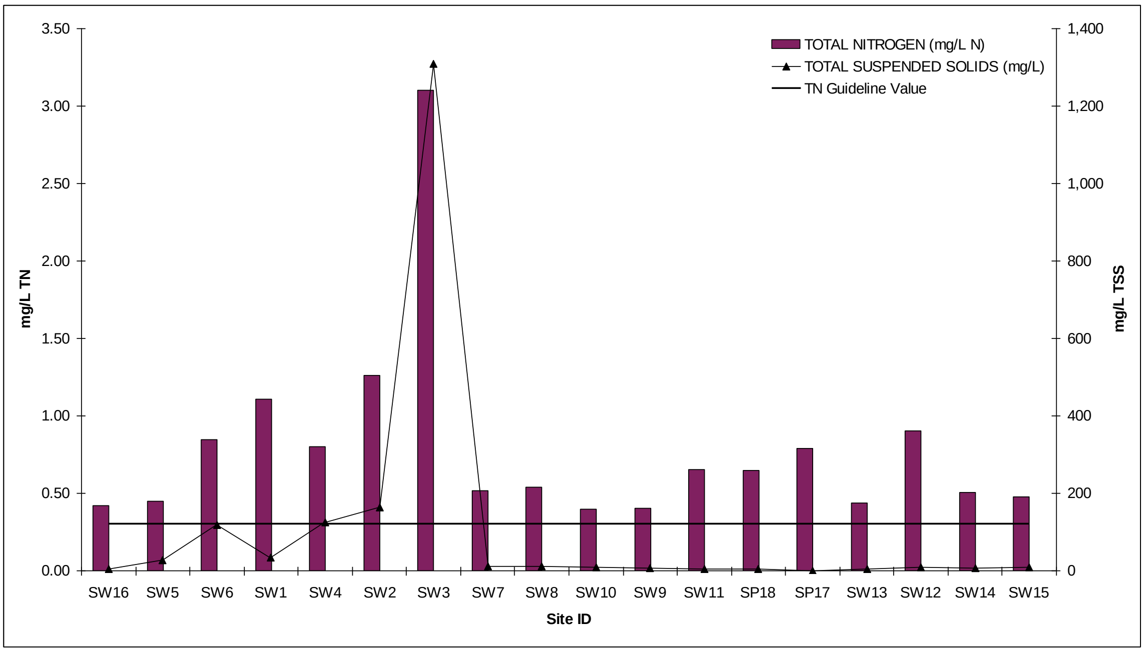

Fig. 6: TN concentrations (including TSS values) in water samples from river mouth to Ulmarra ferry

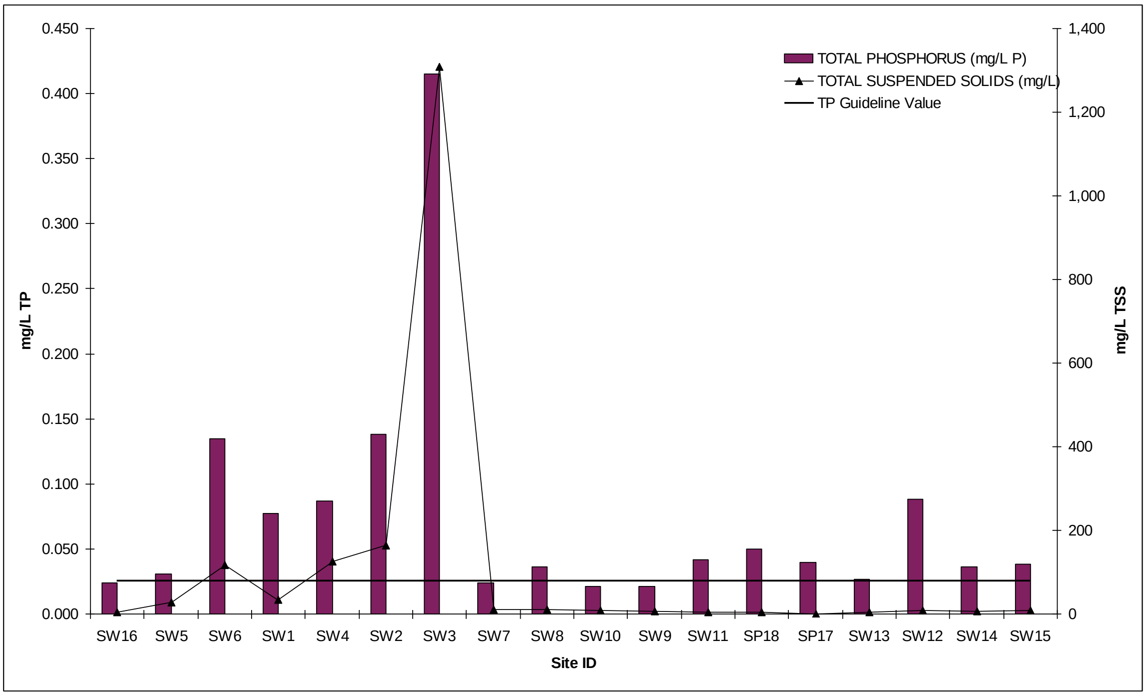

Fig. 7: TP concentrations (including TSS values) in water samples from river mouth to Ulmarra ferry

Nutrient values may have been a function of increased sediment loads encountered during sampling with nutrient analysis not targeting the dissolved phase.

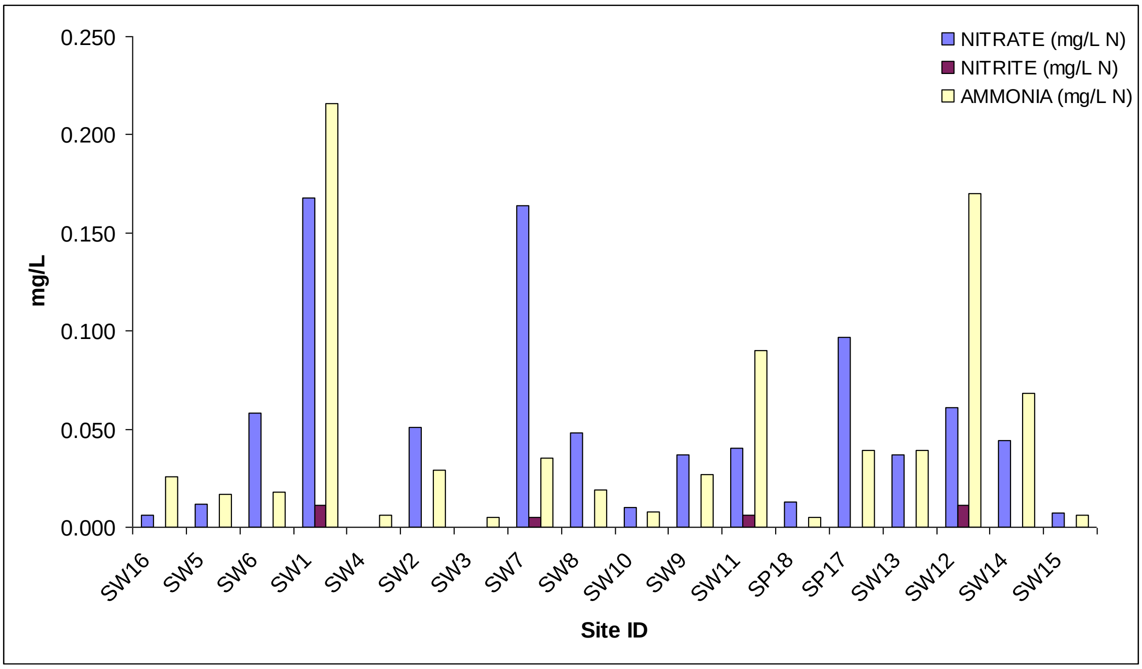

Fig. 8: NO_x/NH_3 concentrations in water samples from river mouth to Ulmarra ferry

Figs. 9, 10 and 11 below shows the concentrations of the heavy metals Arsenic, Lead, Zinc, Copper, Aluminium and Iron recorded in water samples from each site (from river mouth to Ulmarra ferry site).

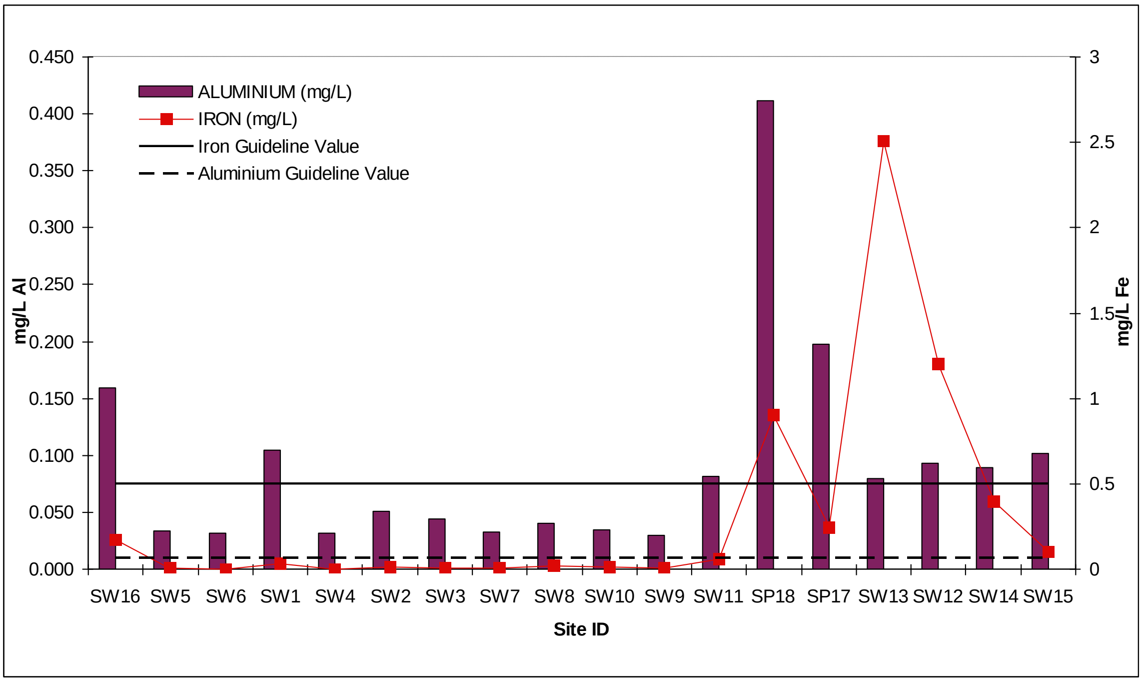

Fig. 9: Aluminium (Al) and Iron (Fe) concentrations in water samples from river mouth to Ulmarra ferry

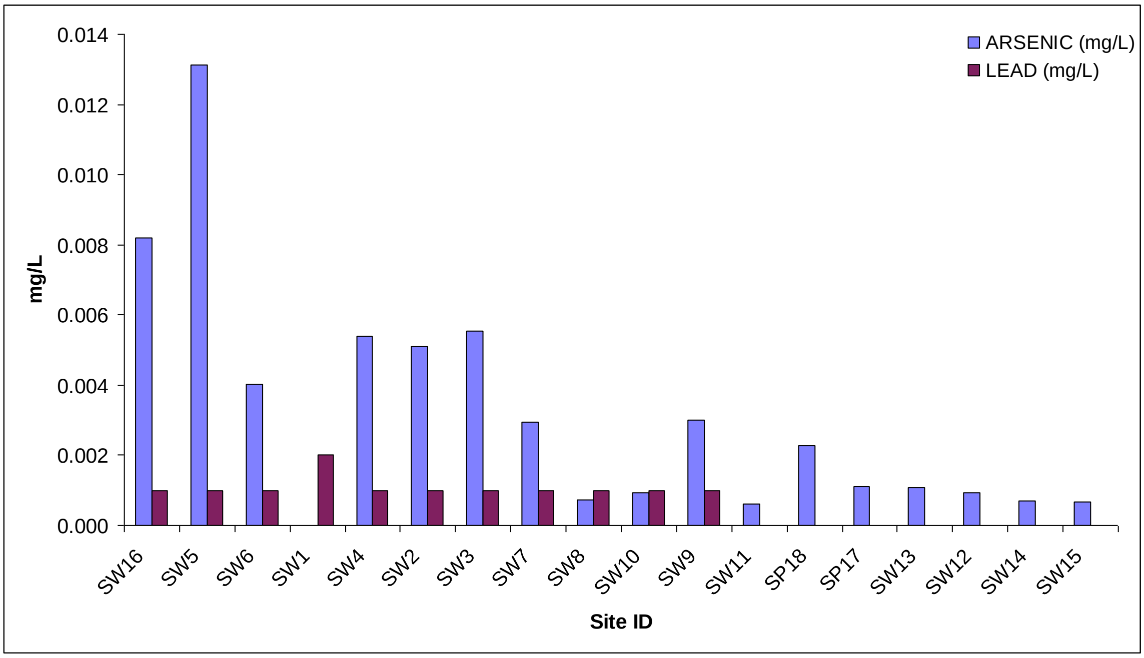

Fig. 10: Arsenic (As) and Lead (Pb) concentrations in water samples from river mouth to Ulmarra ferry

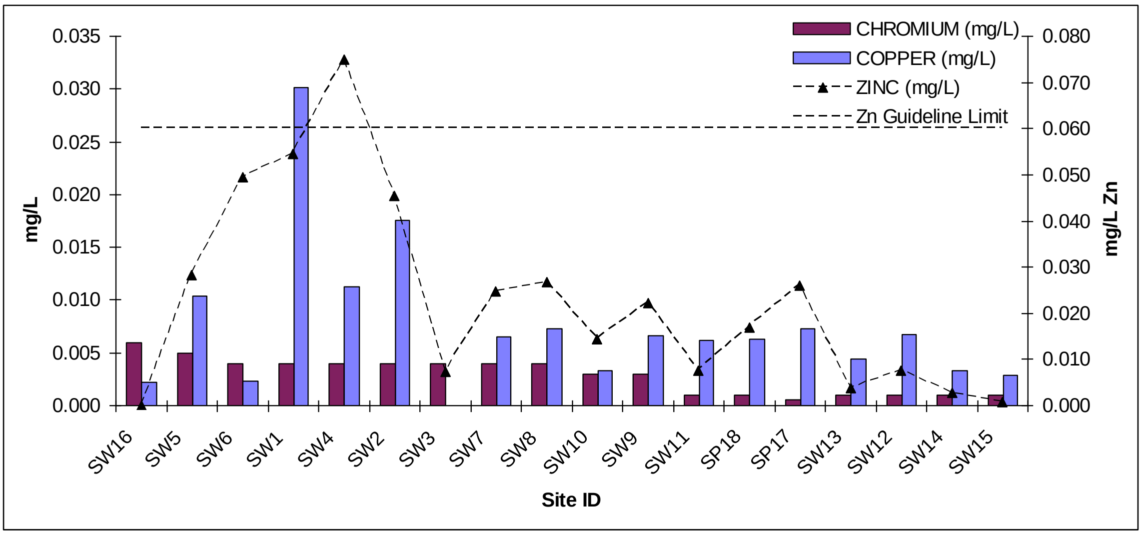

Fig. 11: Chromium (Cr), Copper (Cu) and Zinc (Zn) concentrations in water samples from river mouth to Ulmarra ferry

The water analysis does not identify any particular contaminant or specific physico-chemical parameter that exceeds the ANZECC/ARMANZ (2000) marine water trigger values (with the exception of Zinc). Salinity and pH values are as expected and metal concentrations; although variable do not exceed the trigger values adopted for this investigation.

Nutrient values encountered for this investigation showed total nutrients were in excess of the adopted guideline values; however, as dissolved nutrients were not targeted, these results may be elevated due to high Total Suspended Solids (TSS) values.

Biological Testing Results Discussion

Metal concentrations found in bream, whiting, mullet and prawn specimens collected during this investigation are provided in Fig. 12, 13 and 14. With no reliable trigger values as yet derived for safe levels of metal contaminants in seafood, no reliable assumption can be made at this stage. No OCP/OPP/PCB concentrations were found to exceed the limit of reporting.

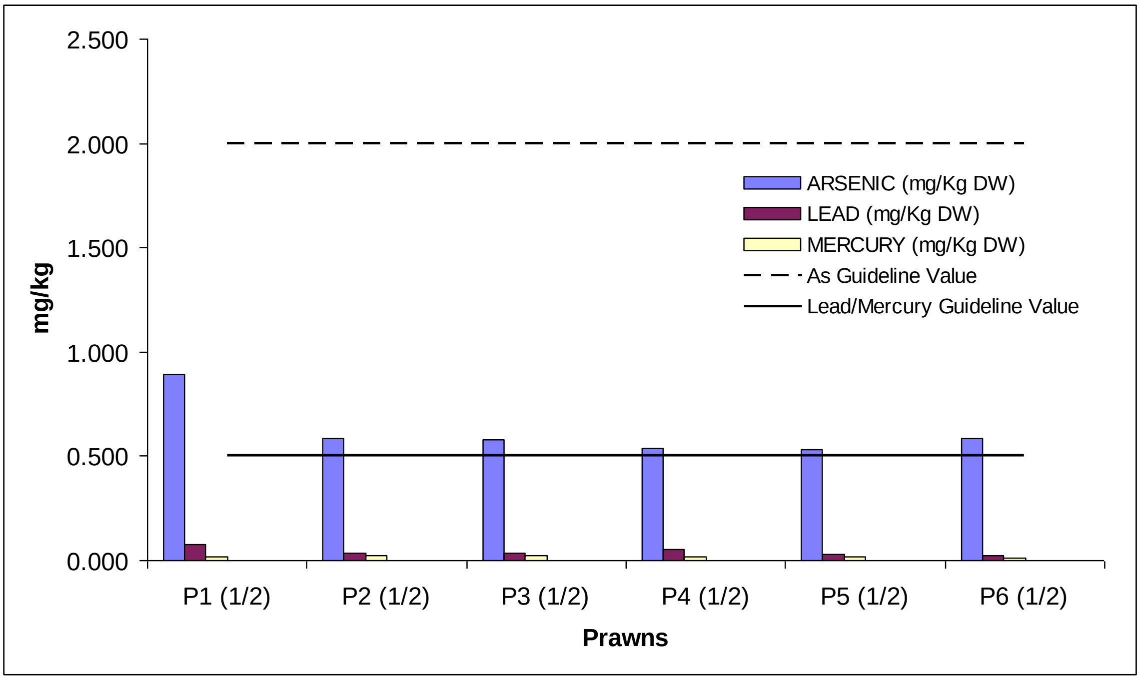

Fig. 12: Metal concentrations in prawn specimens from Clarence River

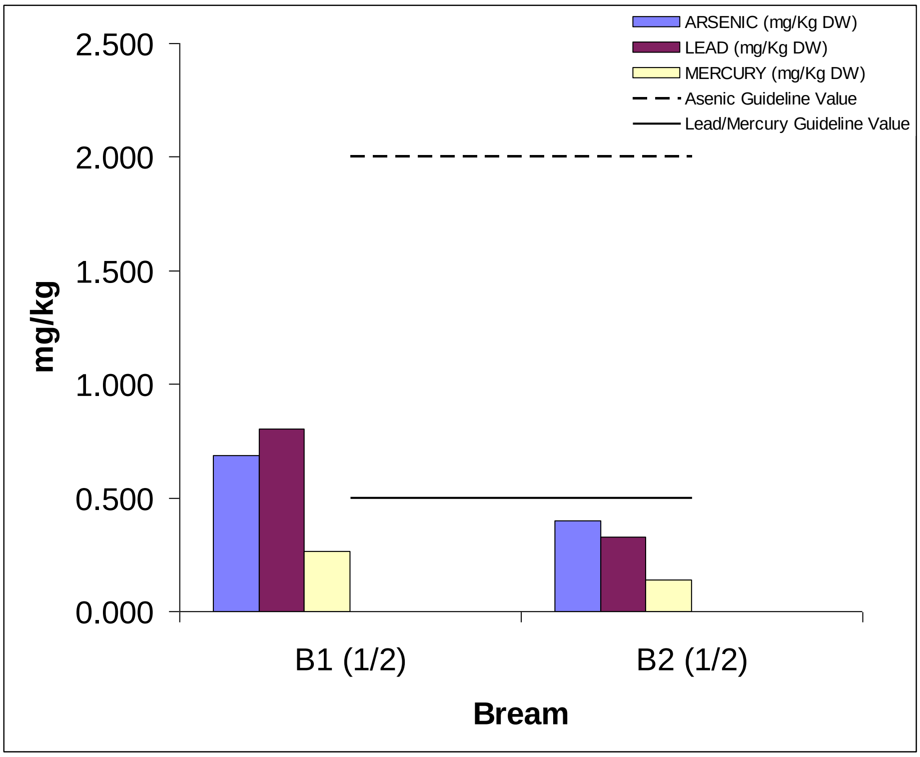

Fig. 13: Metal concentrations in bream specimens from Clarence River

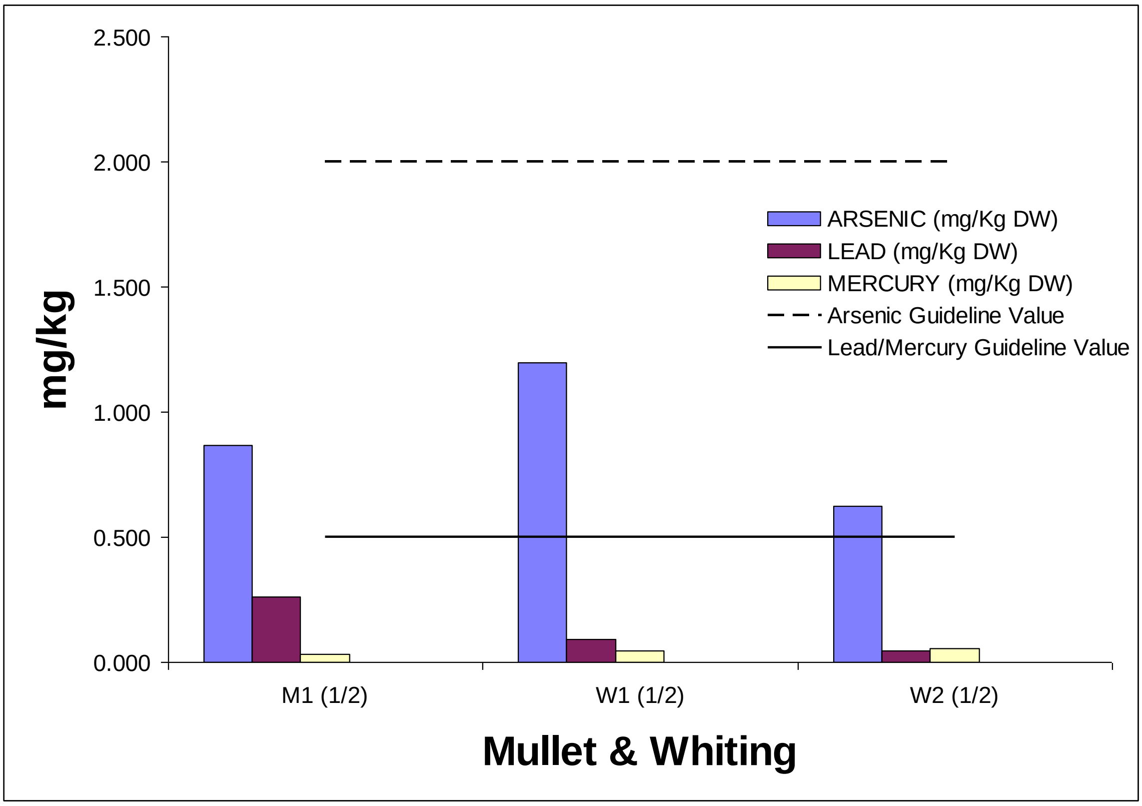

Fig. 14: Metal concentrations in mullet and whiting specimens from Clarence River

Specific Site Characterisation

River Mouth

Samples SP5, SP6, SP7 and SP8 were collected within the downstream reaches of the Clarence River and the North arm and are considered to represent the downstream characteristics (at least geographically) of the River. The direct marine influence is evident with high pH and high salinity (as derived from EC values). Further marine influence is obvious with significant buffering capability is present within river sediment, negating potential acid sulfate impacts.

Lake Wooleweyah

Samples SP1, SP2, SP3, SP4 and SP16 were collected from within Lake Wooleweyah and from channels linked directly to Wooleweyah (Palmers and Romiaka/Oyster). The low energy environment within these locations and elevated nutrients signifies a considerable input of broadscale sediment and nutrient inputs and minimal flushing from environmental flows.

Maclean Broadwater

Samples SP9 and SP10 displayed remarkably dissimilar characteristics to samples collected in Lake Wooleweyah, suggesting higher sediment loads and formation of significant quantities of potential acid sulfate sediments. Nutrient inputs were markedly lower suggesting inputs into the Lake Wooleweyah catchment were elevated as a result of a point source (or a number of point sources).

Lawrence to Southgate/Cowper

Samples SP11, SP12, SP13, SP17 and SP18, especially SP17 show the influence of incoming fresh waters with decreased EC and increased Aluminium and Iron Loads.

Cowper to Ulmarra Ferry

SP14 and SP15 show predominantly neutral pH values with some saline influence still apparent.

Conclusions and Recommendations

With the current information available and with the application of available trigger levels, no specific parameter or contaminant investigated during this assessment was considered to represent a significant risk to water quality or fish/prawn recruitment and/or growth.

The sampling and analysis effort executed have provided representative picture of the individual conditions at each sampling location. Therefore the results obtained represent a snapshot of the sites for the specific tidal and seasonal conditions prevalent at that time.

With no specific contaminant or water quality issues obviously identifiable, it may be prudent to assume that the recent decline in prawn size (observed as part of the commercial catch) is a result of ecological factors (such as a reduction in habitat or fecundity and recruitment rates for the species.

To build upon the information gathered to date, and to gain a more appreciable understanding of the changing conditions within the river (e.g. seasonally), further investigations are considered vital. With the information currently at hand, a much more refined investigation is recommended, focusing primarily upon the major water quality features and minimising sampling effort and costs on specific contaminant investigation (i.e. reduced testing of heavy metals and pesticides). A seasonal effort is seen as the most appropriate investigation frequency, allowing conditions within the Clarence River (associated with the commercial fishing industry interests) to be catalogued and interpreted with a whole picture view.

A further suggestion is a temporal study using Geographic Information Systems (GIS) to map the changing extent of habitat factors (i.e. seagrass communities, sediment movement etc.) in the Clarence.

If you should wish to discuss the results or methods utilised in this investigation further, please feel free to contact either myself or the laboratory manager Graham Lancaster on 02 6620 3678.

Regards,

…………………………………….
Nick Davison
Senior Environmental Consultant
EAL Consulting Services

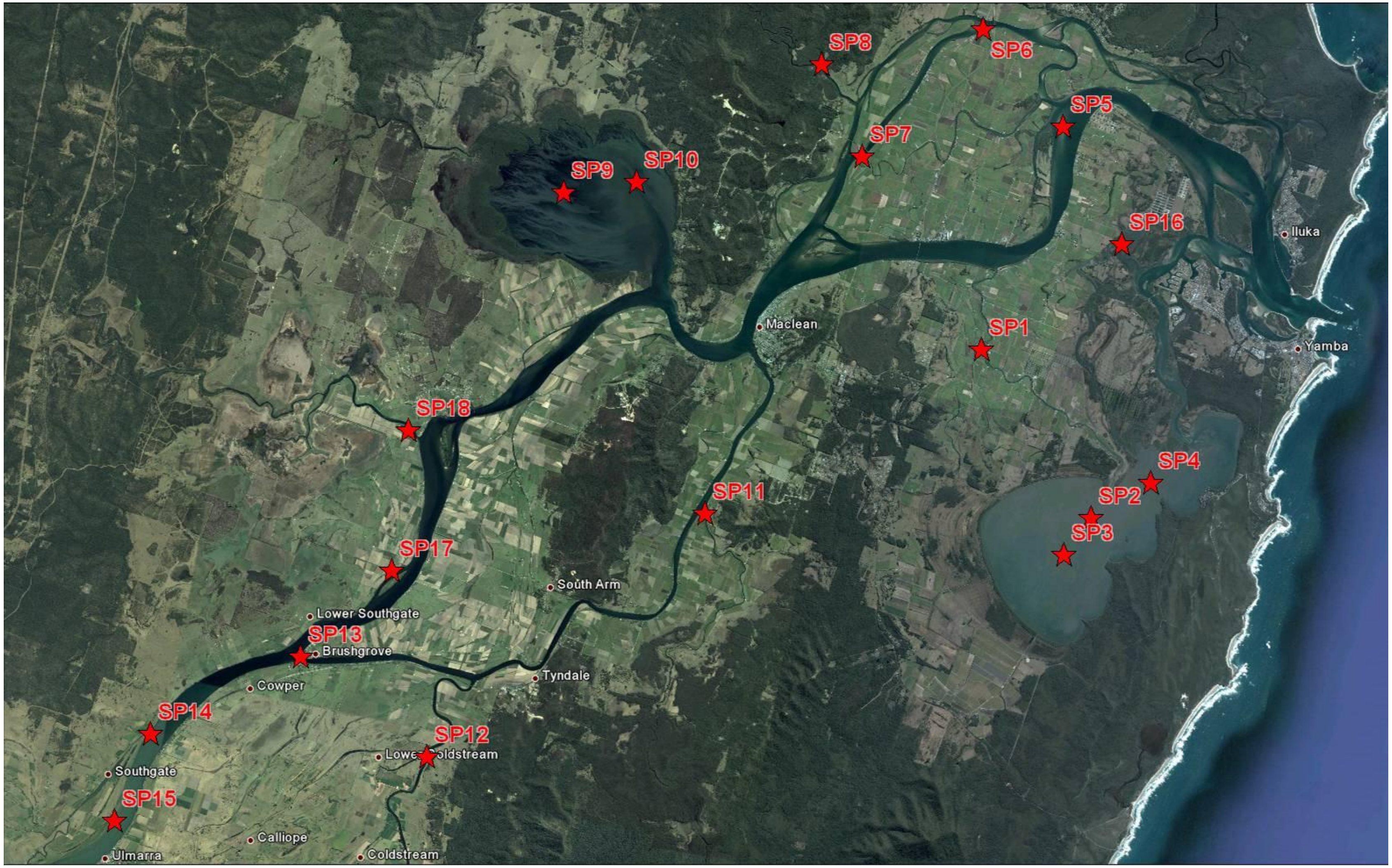

Fig. 1: Sample Locations

Environmental Analysis
Laboratory

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SEDIMENT ANALYSIS RESULT CERTIFICATES

RESULTS OF SEDIMENT ANALYSIS (Page 1 of 1)

18 sediment samples collected by EAL for Professional Fishes Association on 23rd December, 2009 - Lab Job No. A6739
Analysis requested by John Harrison. **Your Job.: 2737**

ANALYTE	METHOD REFERENCE	Sample 1 SP1	Sample 2 SP2	Sample 3 SP3	Sample 4 SP4	Sample 5 SP5	Sample 6 SP6	Sample 7 SP7	Sample 8 SP8
	Job No.	*A6739/1*	*A6739/2*	*A6739/3*	*A6739/4*	*A6739/5*	*A6739/6*	*A6739/7*	*A6739/8*
Texture	*See note 2 below.*	Coarse	Medium	Fine	Fine	Coarse	Coarse	Coarse	Medium
Soil pH (1:5 water)	Rayment and Higgins 4A1	8.38	7.91	7.94	8.10	8.01	8.07	7.72	7.46
Soil Conductivity (1:5 water dS/m)	Rayment and Higgins 4B1	4.110	13.920	13.430	8.430	5.500	2.440	3.230	2.600
Soil Resistivity (ohm.mm)	Calculation	2,433	718	745	1,186	1,818	4,098	3,096	3,846
Chloride (mg/kg)	Vater Extract- Rayment and Higgins	5794	21369	21558	13108	8797	3619	4412	3484
Chloride (as %)	Calculation	0.579	2.137	2.156	1.311	0.880	0.362	0.441	0.348
Sulfate (mg/kg)	Vater Extract- Rayment and Higgins	837	2,982	2,934	1,866	1,170	480	672	756
Sulfate (as % SO3)	Calculation	0.067	0.239	0.235	0.149	0.094	0.038	0.054	0.060
SILVER (mg/Kg DW)	*a*	0.1	0.1	0.1	0.1	<0.1	0.5	0.1	0.1
ARSENIC (mg/Kg DW)	*a*	2.6	13.4	13.2	9.8	3.9	1.0	5.3	3.7
LEAD (mg/Kg DW)	*a*	3.0	13.4	13.9	8.6	4.5	2.3	6.3	6.5
CADMIUM (mg/Kg DW)	*a*	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
CHROMIUM (mg/Kg DW)	*a*	8.3	29.9	29.4	20.1	22.3	4.9	18.4	11.7
COPPER (mg/Kg DW)	*a*	4.0	14.0	14.1	9.1	4.4	1.6	7.3	8.2
MANGANESE (mg/Kg DW)	*a*	138.4	437.6	443.5	320.9	156.5	97.6	214.4	62.0
NICKEL (mg/Kg DW)	*a*	4.3	18.9	21.7	13.3	9.4	2.5	14.8	7.8
SELENIUM (mg/Kg DW)	*a*	0.3	0.8	0.8	0.5	0.3	0.2	0.4	0.4
ZINC (mg/Kg DW)	*a*	57.6	95.8	95.1	81.7	67.2	41.4	74.3	61.5
MERCURY (mg/Kg DW)	*a*	0.01	0.04	0.04	0.02	0.01	0.01	0.02	0.02
IRON (**% DW**)	*a*	0.68	2.86	2.89	2.08	1.14	0.24	1.55	1.04
ALUMINIUM (**% DW**)	*a*	0.31	1.92	1.98	1.21	0.53	0.12	0.91	0.83
TIN (mg/Kg)	a	1.04	2.04	1.92	1.33	0.92	0.32	1.12	0.83
PESTICIDE ANALYSIS SCREEN									
4, 4 DDT (mg/Kg)	*c*	..	<0.05	<0.05	..	<0.05	..	..	<0.05
Methoxychlor (mg/kg)	*c*	..	<0.05	<0.05	..	<0.05	..	..	<0.05
Other Organochlorine Pesticides (mg/Kg)	*c*	..	<0.01	<0.01	..	<0.01	..	..	<0.01
Demeton (total) (mg/kg)	*c*	..	<0.02	<0.02	..	<0.02	..	..	<0.02
Other Organophosphate Pesticides (mg/Kg)	*c*	..	<0.01	<0.01	..	<0.01	..	..	<0.01
PCB's (mg/Kg)	*c*	..	<0.1	<0.1	..	<0.1	..	..	<0.1

METHODS REFERENCE

a. $^{1:3}$Nitric/HCl digest - APHA 3120 ICPMS
b . $^{1:3}$Nitric/HCl digest - APHA 3120 ICPOES
c . Analysis sub-contracted - results attached

NOTES

1. Column 1 ' Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998)
2. Environmental Soil Quality Guidelines, Page 40, ANZECC, 1992.

Additional NOTES

DW = Dry Weight

Organochlorine pesticide (OC's) screen:	(Aldrin, Cis-chlordane, Trans-chlordane, HCB, DDD, DDE, DDT, Alpha-BHC, Beta-BHC, Delta-BHC, Lindane, Dieldrin, Endrin, Heptachlor, Heptachor epoxide, Alpha-endosulfan, Beta-endosulfan, Endosulfan sulfate, Methoxychlor)
Organophosphorus pesticide (OP's) screen:	(Dichlorvos, Phosdrin, Demeton (total), Ethoprop, Monocrotophos, Phorate, Dimethoate, Diazinon, Disulfoton, Methyl parathion, Chloropyrifos, Ronnel, Parathion, Stirofos, Prothiofos, Azinophos methyl, Coumaphos, Fenitrothion, Fenthion, Malathion)
PCB's = Polychloriniated Biphenyls	(Arochlor 1016, 1232, 1242, 1248, 1254, 1260)

RESULTS OF ACID SULFATE SOIL ANALYSIS

16 sediment samples collected by EAL for Professional Fishes Association on 23rd December, 2009 - Lab Job No. A6739

Analysis requested by John Harrison. - **Your Project: 2737**

required if $pH_{KCl} > 6.5$

Sample Site	EAL lab code	Texture (note 6)	MOISTURE CONTENT		ACID VOLATILE SULFUR (AVS)		TITRATABLE ACTUAL ACIDITY (TAA)		REDUCED INORGANIC SULFUR		ACID NEUTRALISING CAPACITY (ANC_{BT})		NET ACIDITY Chromium Suite	LIME CALCULATION Chromium Suite
			(% moisture of total wet weight)	(g moisture / g of oven dry soil)	(% Sav WW) (note 3)	(% Sav DW) (note 3)	pH_{KCl}	(To pH 6.5) (mole H^+/tonne)	(% chromium reducible S) (%Scr)	(mole H^+/tonne)	(% $CaCO_3$)	(mole H^+/tonne)	(mole H^+/tonne) (based on %Scrs)	(kg $CaCO_3$/tonne DW) (includes 1.5 safety Factor when liming rate is $^+$ve)
Method No.							*23A*	*23F*	*22B*	*a- 22B*	*19A2*	*a-19A2*	*note 5*	*note 4 and 6*
SP1	*A6739/1*	Coarse	30.3	0.43	..	..	7.76	0	0.03	19	0.54	108	-53	-2.7
SP2	*A6739/2*	Medium	58.4	1.40	0.00	0.000	8.53	0	0.21	131	3.65	729	-355	-17.8
SP3	*A6739/3*	Fine	57.7	1.36	0.00	0.000	7.46	0	0.20	125	4.21	841	-436	-21.8
SP4	*A6739/4*	Fine	43.3	0.77	0.00	0.000	7.49	0	0.19	119	1.46	292	-76	-3.8
SP5	*A6739/5*	Coarse	33.6	0.51	..	..	7.47	0	0.01	6	..	..	6	0.5
SP6	*A6739/6*	Coarse	21.3	0.27	..	..	7.17	0	<0.01	0	..	..	0	0.0
SP7	*A6739/7*	Coarse	32.1	0.47	0.00	0.000	6.94	0	0.03	19	0.47	94	-44	-2.2
SP8	*A6739/8*	Medium	33.7	0.51	0.00	0.000	6.76	0	0.35	218	0.30	60	178	13.4
SP9	*A6739/9*	Fine	63.3	1.72	0.01	0.027	6.77	0	0.63	393	0.85	170	280	21.0
SP10	*A6739/10*	Fine	49.3	0.97	0.00	0.000	6.75	0	0.55	343	0.55	110	270	20.3
SP11	*A6739/11*	Fine	59.2	1.45	..	..	6.14	13	0.53	331	..	..	343	25.8
SP12	*A6739/12*	Fine	64.0	1.78	..	..	5.02	62	0.29	181	..	..	243	18.3
SP13	*A6739/13*	Coarse	21.2	0.27	..	..	6.62	0	0.47	293	0.37	74	244	18.3
SP14	*A6739/14*	Medium	36.4	0.57	..	..	6.00	9	0.17	106	..	..	115	8.7
SP15	*A6739/15*	Coarse	39.3	0.65	..	..	5.69	24	0.05	31	..	..	55	4.1
SP16	*A6739/16*	Coarse	23.0	0.30	..	..	8.19	0	0.07	44	0.27	54	8	0.6
SP17	*A6894/1*	Medium	26.3	0.36	..	..	6.38	5	0.06	37	0.27	54	7	0.5
SP18	*A6894/2*	Medium	38.4	0.62	..	..	6.19	9	0.24	150	0.27	54	123	9.2

NOTE:

1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)

2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)

3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines*.** QLD DNRME.

4 - Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density rings can be used and dried/ weighed in the laboratory.

5 - **ABA Equation**: **Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)**

6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)

7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays

8 - .. denotes not requested or required

9 - SCREENING, CRS, TAA and ANC are NATA accredited but other SPOCAS segments are currently not NATA accredited

10- Results at or below detection limits are replaced with '0' for calculation purposes.

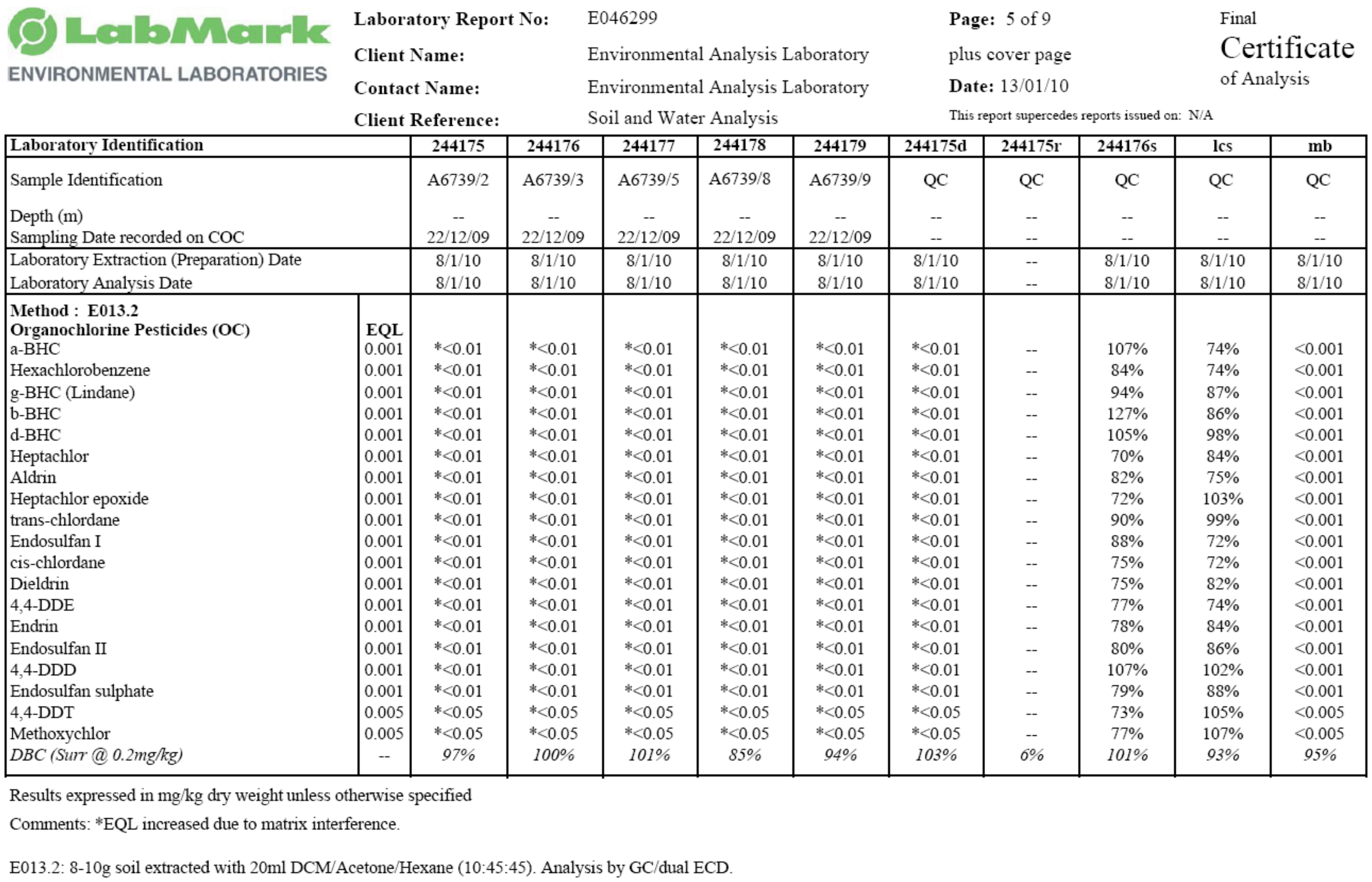
11 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).

NATA

Lab. Accred. No. [illegible]
This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025

(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H+/t; medium Scr≥0.06%S or 37mole H+/t; fine Scr≥0.1%S or 62mole H+/t) - as per QUASSIT Laboratory Methods Guidelines

EAL Consulting Services



LabMark
ENVIRONMENTAL LABORATORIES

Laboratory Report No: E046299
Client Name: Environmental Analysis Laboratory
Contact Name: Environmental Analysis Laboratory
Client Reference: Soil and Water Analysis

Page: 5 of 9
plus cover page
Date: 13/01/10
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**244175**	**244176**	**244177**	**244178**	**244179**	**244175d**	**244175r**	**244176s**	**lcs**	**mb**
Sample Identification		A6739/2	A6739/3	A6739/5	A6739/8	A6739/9	QC	QC	QC	QC	QC
Depth (m)		--	--	--	--	--	--	--	--	--	--
Sampling Date recorded on COC		22/12/09	22/12/09	22/12/09	22/12/09	22/12/09	--	--	--	--	--
Laboratory Extraction (Preparation) Date		8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	--	8/1/10	8/1/10	8/1/10
Laboratory Analysis Date		8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	--	8/1/10	8/1/10	8/1/10
Method : E013.2											
Organochlorine Pesticides (OC)	**EQL**										
a-BHC	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	107%	74%	<0.001
Hexachlorobenzene	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	84%	74%	<0.001
g-BHC (Lindane)	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	94%	87%	<0.001
b-BHC	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	127%	86%	<0.001
d-BHC	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	105%	98%	<0.001
Heptachlor	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	70%	84%	<0.001
Aldrin	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	82%	75%	<0.001
Heptachlor epoxide	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	72%	103%	<0.001
trans-chlordane	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	90%	99%	<0.001
Endosulfan I	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	88%	72%	<0.001
cis-chlordane	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	75%	72%	<0.001
Dieldrin	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	75%	82%	<0.001
4,4-DDE	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	77%	74%	<0.001
Endrin	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	78%	84%	<0.001
Endosulfan II	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	80%	86%	<0.001
4,4-DDD	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	107%	102%	<0.001
Endosulfan sulphate	0.001	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	*<0.01	--	79%	88%	<0.001
4,4-DDT	0.005	*<0.05	*<0.05	*<0.05	*<0.05	*<0.05	*<0.05	--	73%	105%	<0.005
Methoxychlor	0.005	*<0.05	*<0.05	*<0.05	*<0.05	*<0.05	*<0.05	--	77%	107%	<0.005
DBC (Surr @ 0.2mg/kg)	--	*97%*	*100%*	*101%*	*85%*	*94%*	*103%*	*6%*	*101%*	*93%*	*95%*

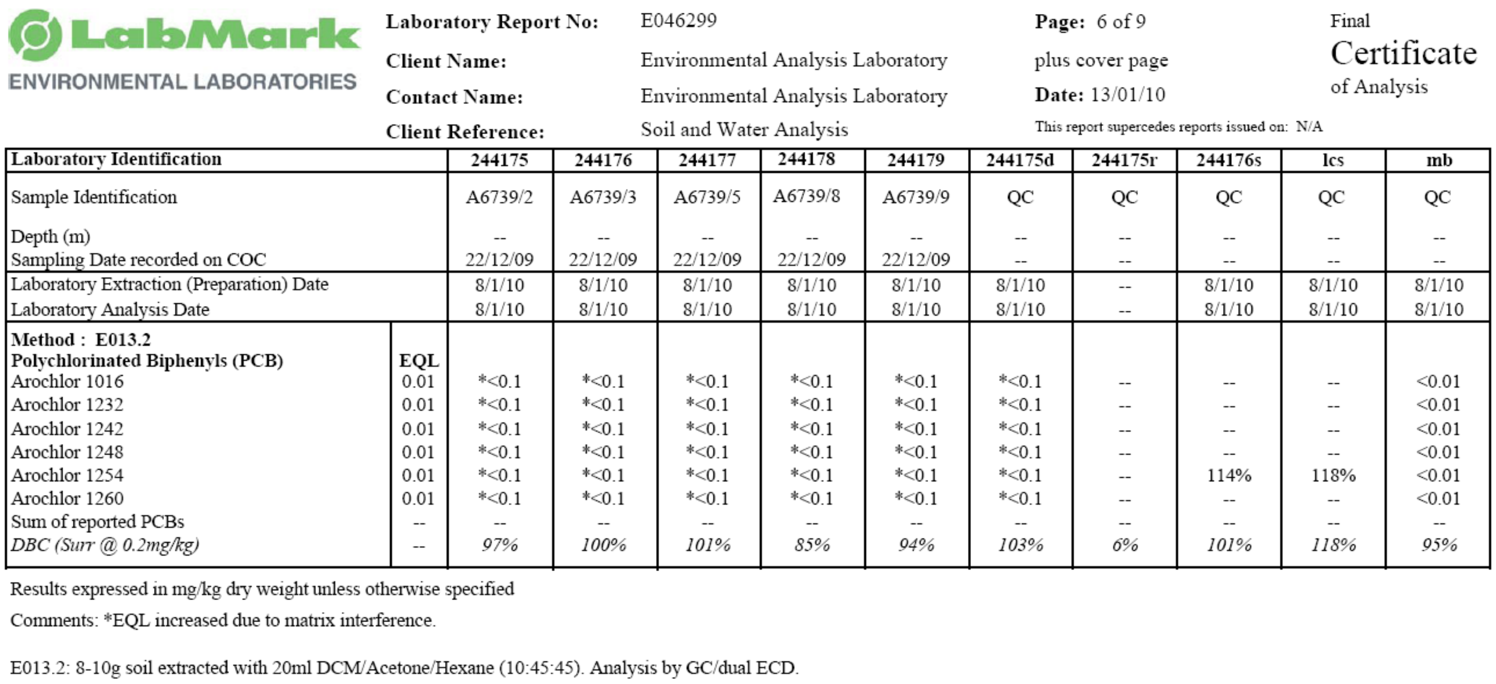
Results expressed in mg/kg dry weight unless otherwise specified

Comments: *EQL increased due to matrix interference.

E013.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45). Analysis by GC/dual ECD.

EAL Consulting Services

Environmental Analysis Laboratory



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of Analysis

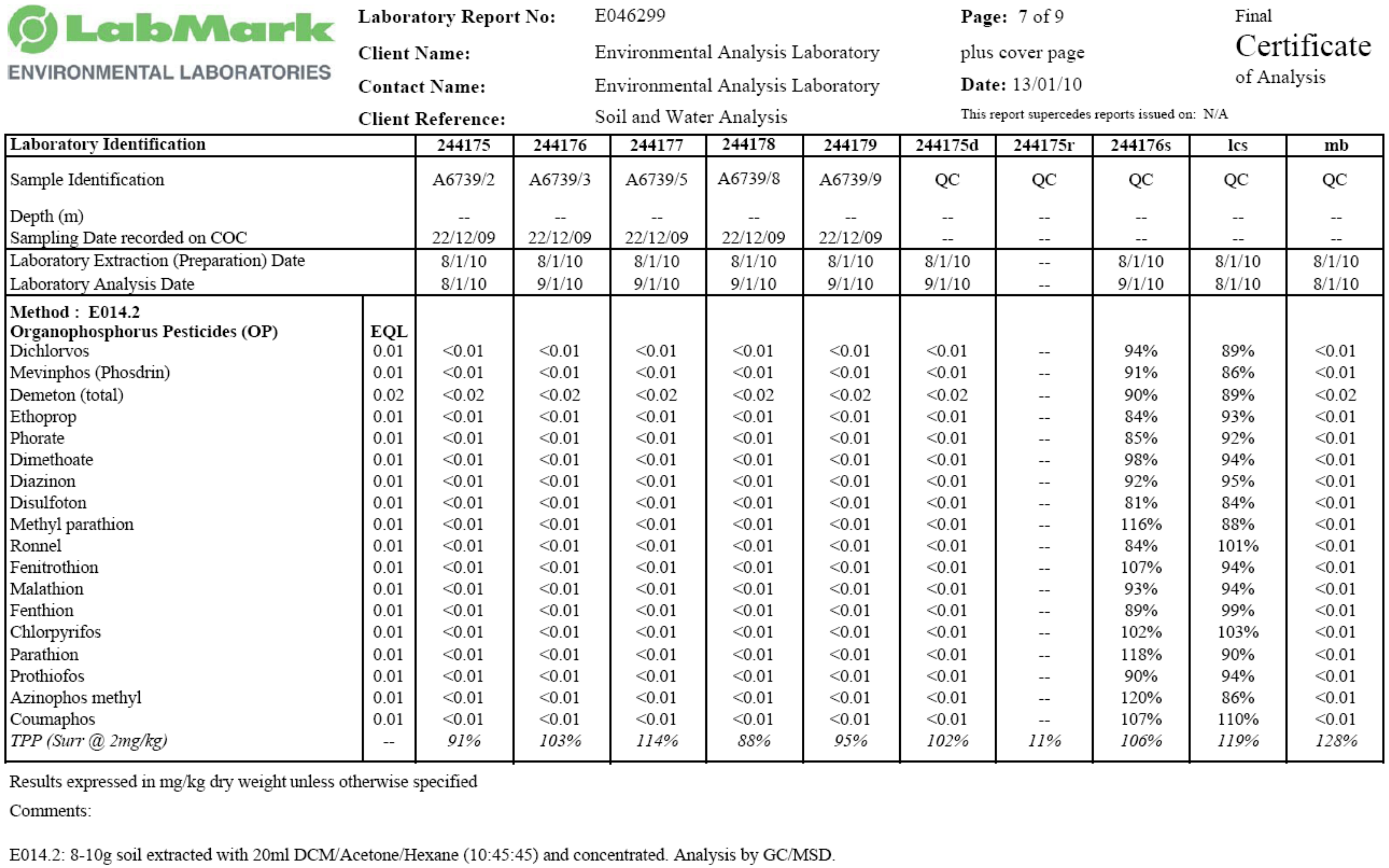
Laboratory Identification		**244175**	**244176**	**244177**	**244178**	**244179**	**244175d**	**244175r**	**244176s**	**lcs**	**mb**
Sample Identification		A6739/2	A6739/3	A6739/5	A6739/8	A6739/9	QC	QC	QC	QC	QC
Depth (m)		--	--	--	--	--	--	--	--	--	--
Sampling Date recorded on COC		22/12/09	22/12/09	22/12/09	22/12/09	22/12/09	--	--	--	--	--
Laboratory Extraction (Preparation) Date		8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	--	8/1/10	8/1/10	8/1/10
Laboratory Analysis Date		8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	--	8/1/10	8/1/10	8/1/10
Method : E013.2											
Polychlorinated Biphenyls (PCB)	**EQL**										
Arochlor 1016	0.01	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	--	--	--	<0.01
Arochlor 1232	0.01	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	--	--	--	<0.01
Arochlor 1242	0.01	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	--	--	--	<0.01
Arochlor 1248	0.01	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	--	--	--	<0.01
Arochlor 1254	0.01	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	--	114%	118%	<0.01
Arochlor 1260	0.01	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	--	--	--	<0.01
Sum of reported PCBs	--	--	--	--	--	--	--	--	--	--	--
DBC (Surr @ 0.2mg/kg)	--	*97%*	*100%*	*101%*	*85%*	*94%*	*103%*	*6%*	*101%*	*118%*	*95%*

Results expressed in mg/kg dry weight unless otherwise specified

Comments: *EQL increased due to matrix interference.

E013.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45). Analysis by GC/dual ECD.

EAL Consulting Services



LabMark ENVIRONMENTAL LABORATORIES

Laboratory Report No: E046299
Client Name: Environmental Analysis Laboratory
Contact Name: Environmental Analysis Laboratory
Client Reference: Soil and Water Analysis

Page: 7 of 9
plus cover page
Date: 13/01/10
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

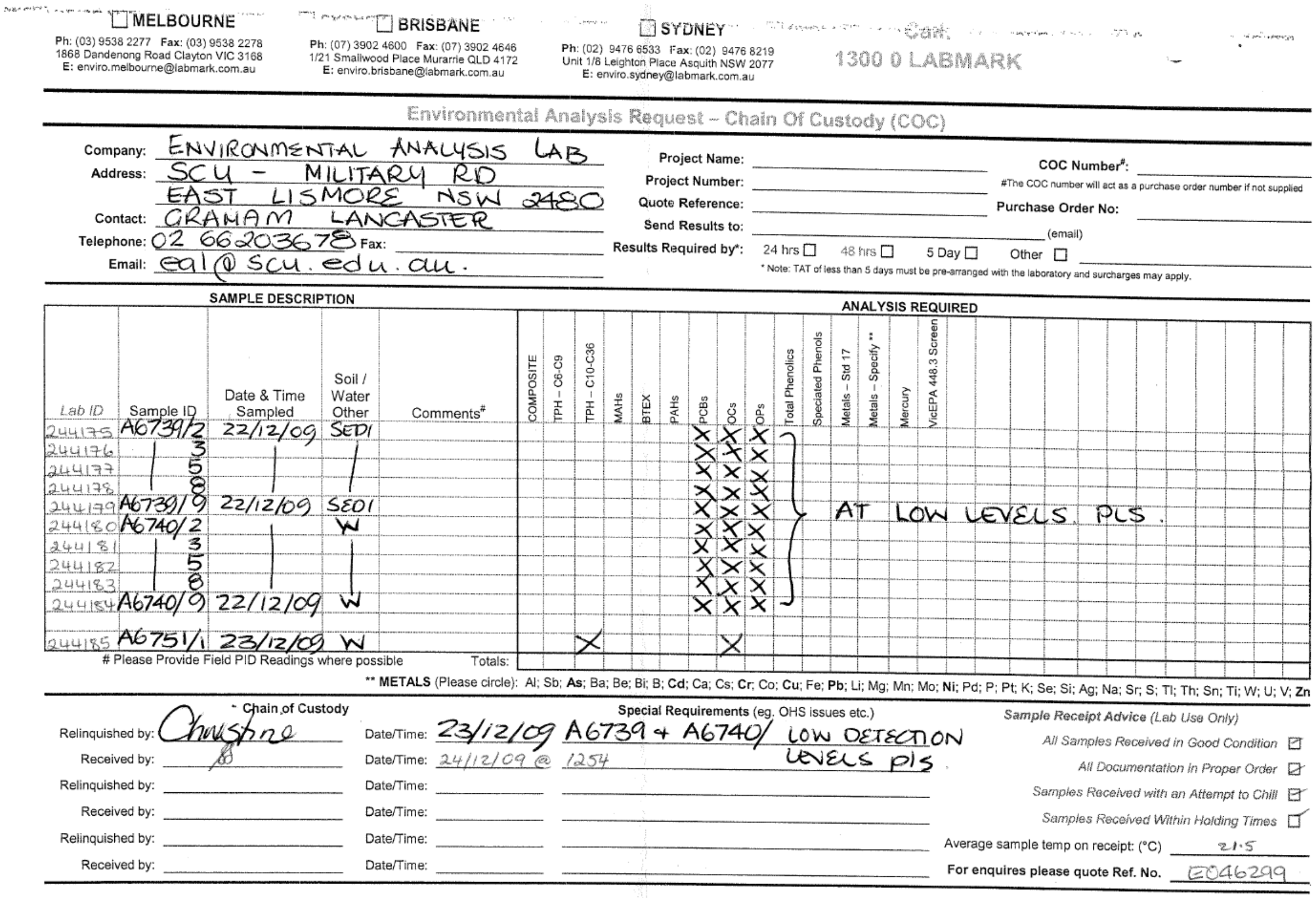
Laboratory Identification		**244175**	**244176**	**244177**	**244178**	**244179**	**244175d**	**244175r**	**244176s**	**lcs**	**mb**
Sample Identification		A6739/2	A6739/3	A6739/5	A6739/8	A6739/9	QC	QC	QC	QC	QC
Depth (m)		--	--	--	--	--	--	--	--	--	--
Sampling Date recorded on COC		22/12/09	22/12/09	22/12/09	22/12/09	22/12/09	--	--	--	--	--
Laboratory Extraction (Preparation) Date		8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	--	8/1/10	8/1/10	8/1/10
Laboratory Analysis Date		8/1/10	9/1/10	9/1/10	9/1/10	9/1/10	9/1/10	--	9/1/10	8/1/10	8/1/10
Method : E014.2											
Organophosphorus Pesticides (OP)	**EQL**										
Dichlorvos	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	94%	89%	<0.01
Mevinphos (Phosdrin)	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	91%	86%	<0.01
Demeton (total)	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	--	90%	89%	<0.02
Ethoprop	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	84%	93%	<0.01
Phorate	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	85%	92%	<0.01
Dimethoate	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	98%	94%	<0.01
Diazinon	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	92%	95%	<0.01
Disulfoton	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	81%	84%	<0.01
Methyl parathion	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	116%	88%	<0.01
Ronnel	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	84%	101%	<0.01
Fenitrothion	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	107%	94%	<0.01
Malathion	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	93%	94%	<0.01
Fenthion	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	89%	99%	<0.01
Chlorpyrifos	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	102%	103%	<0.01
Parathion	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	118%	90%	<0.01
Prothiofos	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	90%	94%	<0.01
Azinophos methyl	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	120%	86%	<0.01
Coumaphos	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	107%	110%	<0.01
TPP (Surr @ 2mg/kg)	--	*91%*	*103%*	*114%*	*88%*	*95%*	*102%*	*11%*	*106%*	*119%*	*128%*

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E014.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45) and concentrated. Analysis by GC/MSD.

EAL Consulting Services



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Unit 1/8 Leighton Place Asquith NSW 2077
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Call:
1300 0 LABMARK

Environmental Analysis Request – Chain Of Custody (COC)

Company: ENVIRONMENTAL ANALYSIS LAB
Address: SCU – MILITARY RD
EAST LISMORE NSW 2480
Contact: GRAHAM LANCASTER
Telephone: 02 66203678 **Fax:**
Email: eal@scu.edu.au.

Project Name:
Project Number:
Quote Reference:
Send Results to: (email)
Results Required by*: 24 hrs ☐ 48 hrs ☐ 5 Day ☐ Other ☐
* Note: TAT of less than 5 days must be pre-arranged with the laboratory and surcharges may apply.

COC Number#:
#The COC number will act as a purchase order number if not supplied
Purchase Order No:

SAMPLE DESCRIPTION / **ANALYSIS REQUIRED**

Lab ID	Sample ID	Date & Time Sampled	Soil / Water Other	Comments#	COMPOSITE	TPH – C6-C9	TPH – C10-C36	MAHs	BTEX	PAHs	PCBs	OCs	OPs	Total Phenolics	Speciated Phenols	Metals – Std 17	Metals – Specify **	Mercury	VicEPA 448.3 Screen
244175	A6739/2	22/12/09	SEDI								X	X	X						
244176	3										X	X	X						
244177	5										X	X	X						
244178	8										X	X	X						
244179	A6739/9	22/12/09	SEDI								X	X	X			AT LOW LEVELS PLS.			
244180	A6740/2		W								X	X	X						
244181	3										X	X	X						
244182	5										X	X	X						
244183	8										X	X	X						
244184	A6740/9	22/12/09	W								X	X	X						
244185	A6751/1	23/12/09	W				X					X							
				Totals:															

Please Provide Field PID Readings where possible

** **METALS** (Please circle): Al; Sb; **As**; Ba; Be; Bi; B; **Cd**; Ca; Cs; **Cr**; Co; **Cu**; Fe; **Pb**; Li; Mg; Mn; Mo; **Ni**; Pd; P; Pt; K; Se; Si; Ag; Na; Sr; S; Tl; Th; Sn; Ti; W; U; V; **Zn**

Chain of Custody

Relinquished by:	Christine	Date/Time:	23/12/09
Received by:		Date/Time:	24/12/09 @ 1254
Relinquished by:		Date/Time:	
Received by:		Date/Time:	
Relinquished by:		Date/Time:	
Received by:		Date/Time:	

Special Requirements (eg. OHS issues etc.)
A6739 + A6740/ LOW DETECTION LEVELS pls.

***Sample Receipt Advice** (Lab Use Only)*
All Samples Received in Good Condition ☑
All Documentation in Proper Order ☑
Samples Received with an Attempt to Chill ☑
Samples Received Within Holding Times ☑
Average sample temp on receipt: (°C) 21·5
For enquires please quote Ref. No. E046299

Environmental Analysis Laboratory

EAL Consulting Services

WATER ANALYSIS RESULT CERTIFICATES

RESULTS OF WATER ANALYSIS

18 samples collected by EAL for Professional Fishes Association on the 23rd December, 2009/14th January, 2010 - Lab. Job No. A6740/A6893
Analysis requested by John Harrison - **EALQ2737**

PARAMETER	METHODS REFERENCE	Water Quality Indicator	Sample 1 SW1	Sample 2 SW2	Sample 3 SW3	Sample 4 SW4	Sample 5 SW5	Sample 6 SW6	Sample 7 SW7	Sample 8 SW8	Sample 9 SW9	Sample 10 SW10	Sample 11 SW11	Sample 12 SW12	Sample 13 SW13	Sample 14 SW14	Sample 15 SW15	Sample 16 SW16	Sample 1 SP17	Sample 2 SP18
	Job No.		*A6740/1*	*A6740/2*	*A6740/3*	*A6740/4*	*A6740/5*	*A6740/6*	*A6740/7*	*A6740/8*	*A6740/9*	*A6740/10*	*A6740/11*	*A6740/12*	*A6740/13*	*A6740/14*	*A6740/15*	*A6740/16*	*A6893/1*	*A6893/2*
pH	APHA 4500-H$^+$-B	6 - 9	7.08	7.59	7.85	7.98	8.02	8.02	8.01	7.89	7.91	7.97	7.03	7.16	6.98	7.00	7.31	7.87	7.07	6.87
CONDUCTIVITY (EC) (dS/m)	APHA 2510-B	..	38.90	42.70	43.90	44.50	44.00	35.90	30.70	23.10	17.00	14.34	4.17	1.16	3.69	3.76	0.79	47.20	0.12	1.06
TOTAL DISSOLVED SALTS (mg/L)	calculation using EC x 680	..	26,452	29,036	29,852	30,260	29,920	24,412	20,876	15,708	11,560	9,751	2,836	788	2,509	2,557	537	32,096	82	718
TOTAL SUSPENDED SOLIDS (mg/L)	GFC equiv. filter - APHA 2540-D	< 75	34	163	1,308	126	27	118	11	11	7	8	4	9	5	7	10	5	<2	5
BICARBONATE (mg/L $CaCO_3$ equivalent)	** Total Alkalinity - APHA 2320	..	100	50	200	200	200	400	150	50	200	150	90	55	30	50	115	200	26	35
WATER HARDNESS (mg/L $CaCO_3$ equivalent)	** using Ca&Mg calculation	150 - 400	4800	5056	5102	5201	5116	4186	3528	2654	1925	1557	431	142	355	383	98	5222	23	106
BIOCHEMICAL OXYGEN DEMAND$_5$ (mg/L O_2)	APHA 5210-B	< 10	<2.0	2.0	5.1	2.6	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
TOTAL PHOSPHORUS (mg/L P)	APHA 4500 P-H	< 0.03	0.077	0.138	0.415	0.087	0.031	0.135	0.024	0.036	0.021	0.021	0.042	0.088	0.027	0.036	0.038	0.024	0.040	0.050
ORTHOPHOSPHATE (mg/L P)	APHA 4500 P-G	< 0.05	0.015	0.005	<0.005	0.005	0.010	0.009	0.010	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	0.012	0.006
TOTAL NITROGEN (mg/L N)	APHA 4500 N-C	<0.3	1.11	1.26	3.10	0.80	0.45	0.85	0.52	0.54	0.40	0.40	0.66	0.90	0.44	0.51	0.48	0.42	0.79	0.65
TOTAL KJELDAHL NITROGEN (mg/L N)	CALCULATION: TN - NOx	..	0.93	1.21	3.10	0.80	0.44	0.79	0.35	0.49	0.37	0.39	0.61	0.83	0.40	0.46	0.47	0.41	0.69	0.64
NITRATE (mg/L N)	APHA 4500 NO_3^--F	< 100	0.168	0.051	<0.005	<0.005	0.012	0.058	0.164	0.048	0.037	0.010	0.040	0.061	0.037	0.044	0.007	0.006	0.097	0.013
NITRITE (mg/L N)	APHA 4500 NO_2^--C	< 0.1	0.011	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	0.006	0.011	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
AMMONIA (mg/L N)	APHA 4500 NH_3-H	< 0.4	0.216	0.029	0.005	0.006	0.017	0.018	0.035	0.019	0.027	0.008	0.090	0.170	0.039	0.068	0.006	0.026	0.039	0.005
SODIUM (mg/L)	** APHA 3120 ICPOES$^{*note 2}$	..	7,281	7,621	7,613	7,751	7,634	6,253	5,316	4,168	3,087	2,536	662	206	541	568	140	7,844	13	165
POTASSIUM (mg/L)	** APHA 3120 ICPOES$^{*note 2}$	..	268	275	276	280	279	232	199	150	109	89	28	10	23	24	6	290	2	8
CALCIUM (mg/L)	** APHA 3120 ICPOES$^{*note 2}$	..	363	376	379	385	381	305	254	192	137	113	35	12	29	30	10	386	4	10
MAGNESIUM (mg/L)	** APHA 3120 ICPOES$^{*note 2}$	..	946	1,000	1,009	1,030	1,012	832	703	528	385	310	84	27	69	75	18	1,034	3	20
SODIUM ABSORPTION RATIO	BY CALCULATION	..	45.7	46.6	46.3	46.7	46.4	42.0	38.9	35.2	30.6	27.9	13.9	7.5	12.5	12.6	6.1	47.2	1.2	7.0
CHLORIDE (mg/L)	** APHA 4500-Cl^-	..	13,677	14,519	14,610	14,966	14,843	11,891	9,922	7,313	5,122	4,143	1,219	343	980	1,039	219	15,164	19	287
SULFATE (mg/L SO_4^{2-})	** APHA 3120 ICPOES$^{*note 2}$	..	2,268	2,402	2,410	2,490	2,464	2,036	1,746	1,332	1,104	925	205	80	170	181	55	2,496	4	37
CHLORIDE/ SULFATE RATIO	Calculation	> 4	6.0	6.0	6.1	6.0	6.0	5.8	5.7	5.5	4.6	4.5	5.9	4.3	5.8	5.7	4.0	6.1	4.3	7.8
SILVER (mg/L)	** APHA 3120 ICPMS$^{*note 1\&2}$	< 0.003	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALUMINIUM (mg/L)	** APHA 3120 ICPMS/OES$^{*note 1\&2}$	< 0.01	0.105	0.051	0.044	0.032	0.034	0.032	0.033	0.040	0.030	0.035	0.082	0.093	0.080	0.089	0.102	0.159	0.198	0.412
ARSENIC (mg/L)	Cl^- Corrected ** APHA 3120 ICPMS$^{*note 1}$	< 0.05	<0.001	0.005	0.006	0.005	0.013	0.004	0.003	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.008	0.001	0.002
CADMIUM (mg/L)	** APHA 3120 ICPMS$^{*note 1\&2}$	< 0.15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CHROMIUM (mg/L)	** APHA 3120 ICPMS$^{*note 1\&2}$	< 0.02	0.004	0.004	0.004	0.004	0.005	0.004	0.004	0.004	0.003	0.003	0.001	0.001	0.001	0.001	0.001	0.006	0.001	0.001
COPPER (mg/L)	Cl^- Corrected ** APHA 3120 ICPMS$^{*note 1}$	< 0.005	0.030	0.018	0.000	0.011	0.010	0.002	0.007	0.007	0.007	0.003	0.006	0.007	0.004	0.003	0.003	0.002	0.007	0.006
IRON (mg/L)	** APHA 3120 ICPMS/OES$^{*note 1\&2}$	< 0.01	0.034	0.013	0.007	0.003	0.007	0.003	0.004	0.019	0.008	0.012	0.058	1.201	2.509	0.398	0.100	0.172	0.246	0.904
MANGANESE (mg/L)	** APHA 3120 ICPMS/OES$^{*note 1\&2}$	< 0.01	0.045	0.007	0.003	0.013	0.025	0.005	0.035	0.083	0.033	0.018	0.151	0.244	0.073	0.072	0.010	0.039	0.003	0.043
NICKEL (mg/L)	Cl^- Corrected ** APHA 3120 ICPMS$^{*note 1}$	< 0.1	<0.001	0.001	0.002	0.003	0.004	0.001	0.001	0.002	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001
LEAD (mg/L)	** APHA 3120 ICPMS$^{*note 1\&2}$	< 0.007	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
ZINC (mg/L)	Cl^- Corrected ** APHA 3120 ICPMS$^{*note 1}$	< 0.05	0.054	0.046	0.007	0.075	0.028	0.050	0.025	0.027	0.022	0.014	0.008	0.008	0.004	0.003	0.001	<0.001	0.026	0.017
MERCURY (mg/L)	** APHA 3120 ICPMS$^{*note 1\&2}$	< 0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
TIN (mg/L)	** APHA 3120 ICPMS$^{*note 1\&2}$	..	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	<0.001	0.001	<0.001	0.001	0.004
PESTICIDE ANALYSIS SCREEN																				
4, 4 DDT (µg/L)	subcontracted: results attached ^{5}	< 0.01	..	<0.05	<0.05	..	<0.05	..	..	<0.05	<0.05	..	..	..	..	..	..	..	..	..
Methoxychlor (µg/L)	subcontracted: results attached ^{5}	..	..	<0.05	<0.05	..	<0.05	..	..	<0.05	<0.05	..	..	..	..	..	..	..	..	..
Other Organochlorine Pesticides (µg/L)	subcontracted: results attached ^{5}	..	..	<0.01	<0.01	..	<0.01	..	..	<0.01	<0.01	..	..	..	..	..	..	..	..	..
Demeton (total) (µg/L)	subcontracted: results attached ^{5}	..	..	<0.2	<0.2	..	<0.2	..	..	<0.2	<0.2	..	..	..	..	..	..	..	..	..
Other Organophosphate Pesticides (µg/L)	subcontracted: results attached ^{5}		..	<0.1	<0.1	..	<0.1	..	..	<0.1	<0.1	..	..	..	..	..	..	..	..	..
Polychlorinated Biphenyls (PCB's) (µg/L)	subcontracted: results attached ^{5}	< 2	..	<0.5	<0.5	..	<0.5	..	..	<0.5	<0.5	..	..	..	..	..	..	..	..	..

Notes:

1a. Total Available metals - samples acidified with nitric acid and then filtered through 0.45µm cellulose acetate

2. Metals/ salts analysed by ICP-MS (Inductively Coupled Plasma - Mass Spectrometry) or ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry)

3. 1 mg/L (milligram per litre) = 1 ppm (part per million) = 1000 µg/L (micrograms per litre)= 1000 ppb (part per billion)

4. For conductivity - 1 dS/m = 1 mS/cm = 1000 µS/cm

5. In Pesticide Analysis Screening, no other pesticides occurred above reportable levels in the attached list

6. For Bacteria - cfu= colony forming unit

7. Analysis performed according to APHA, 2005, “Standard Methods for the Examination of Water & Wastewater”, 21st Edition, except where stated otherwise.

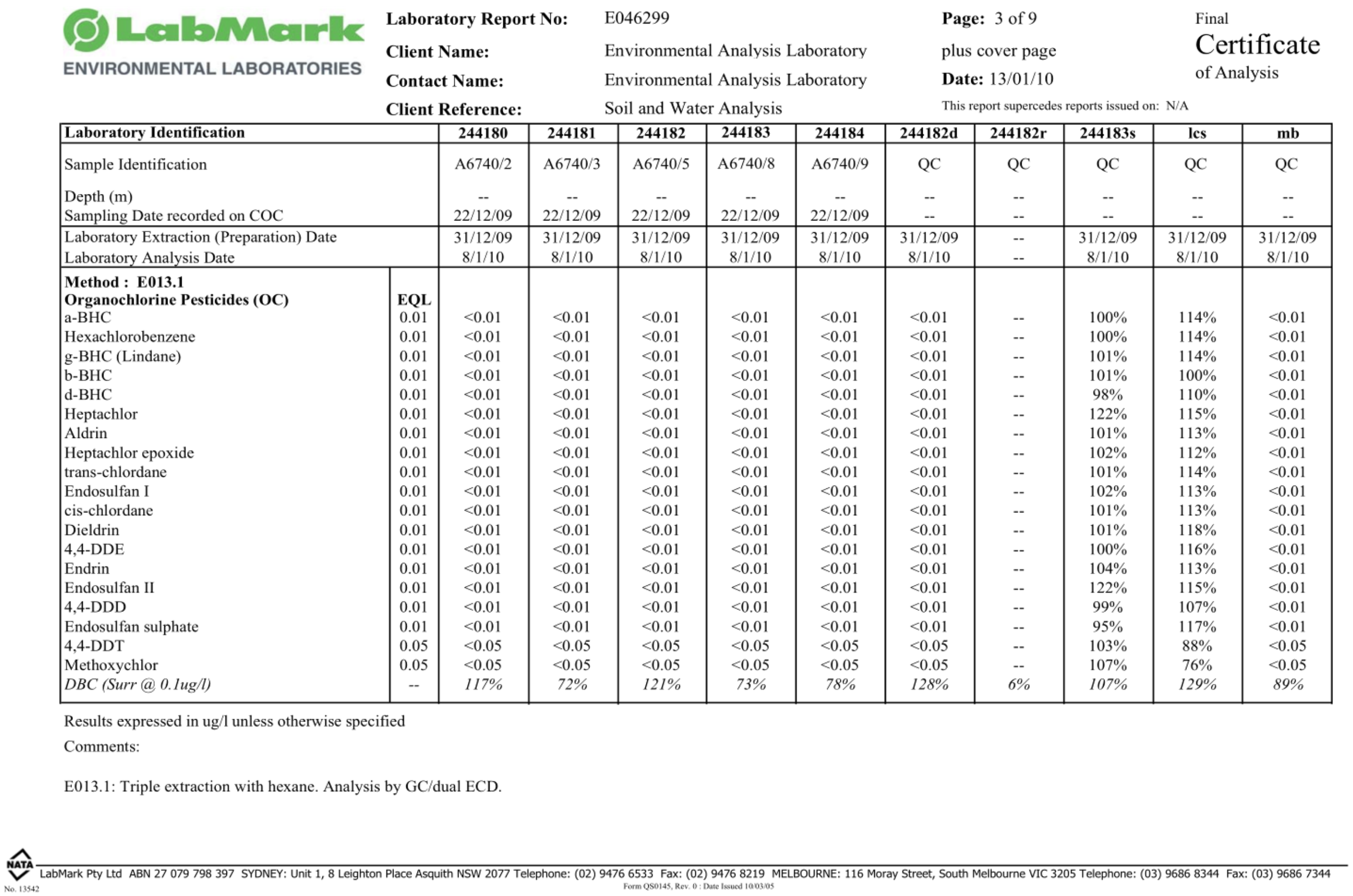
8. Analysis conducted between sample arrival date and Report provision date

9. ** denotes these test procedures are as yet not NATA accredited but quality control data is available

10. .. Denotes not requested

Environmental Analysis Laboratory

EAL Consulting Services



LabMark ENVIRONMENTAL LABORATORIES

Laboratory Report No:	E046299	**Page:** 3 of 9	Final
Client Name:	Environmental Analysis Laboratory	plus cover page	Certificate of Analysis
Contact Name:	Environmental Analysis Laboratory	**Date:** 13/01/10	
Client Reference:	Soil and Water Analysis	This report supercedes reports issued on: N/A	

Laboratory Identification		**244180**	**244181**	**244182**	**244183**	**244184**	**244182d**	**244182r**	**244183s**	**lcs**	**mb**
Sample Identification		A6740/2	A6740/3	A6740/5	A6740/8	A6740/9	QC	QC	QC	QC	QC
Depth (m)		--	--	--	--	--	--	--	--	--	--
Sampling Date recorded on COC		22/12/09	22/12/09	22/12/09	22/12/09	22/12/09	--	--	--	--	--
Laboratory Extraction (Preparation) Date		31/12/09	31/12/09	31/12/09	31/12/09	31/12/09	31/12/09	--	31/12/09	31/12/09	31/12/09
Laboratory Analysis Date		8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	--	8/1/10	8/1/10	8/1/10
Method : E013.1											
Organochlorine Pesticides (OC)	**EQL**										
a-BHC	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	100%	114%	<0.01
Hexachlorobenzene	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	100%	114%	<0.01
g-BHC (Lindane)	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	101%	114%	<0.01
b-BHC	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	101%	100%	<0.01
d-BHC	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	98%	110%	<0.01
Heptachlor	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	122%	115%	<0.01
Aldrin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	101%	113%	<0.01
Heptachlor epoxide	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	102%	112%	<0.01
trans-chlordane	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	101%	114%	<0.01
Endosulfan I	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	102%	113%	<0.01
cis-chlordane	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	101%	113%	<0.01
Dieldrin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	101%	118%	<0.01
4,4-DDE	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	100%	116%	<0.01
Endrin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	104%	113%	<0.01
Endosulfan II	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	122%	115%	<0.01
4,4-DDD	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	99%	107%	<0.01
Endosulfan sulphate	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	95%	117%	<0.01
4,4-DDT	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	--	103%	88%	<0.05
Methoxychlor	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	--	107%	76%	<0.05
DBC (Surr @ 0.1ug/l)	--	*117%*	*72%*	*121%*	*73%*	*78%*	*128%*	*6%*	*107%*	*129%*	*89%*

Results expressed in ug/l unless otherwise specified

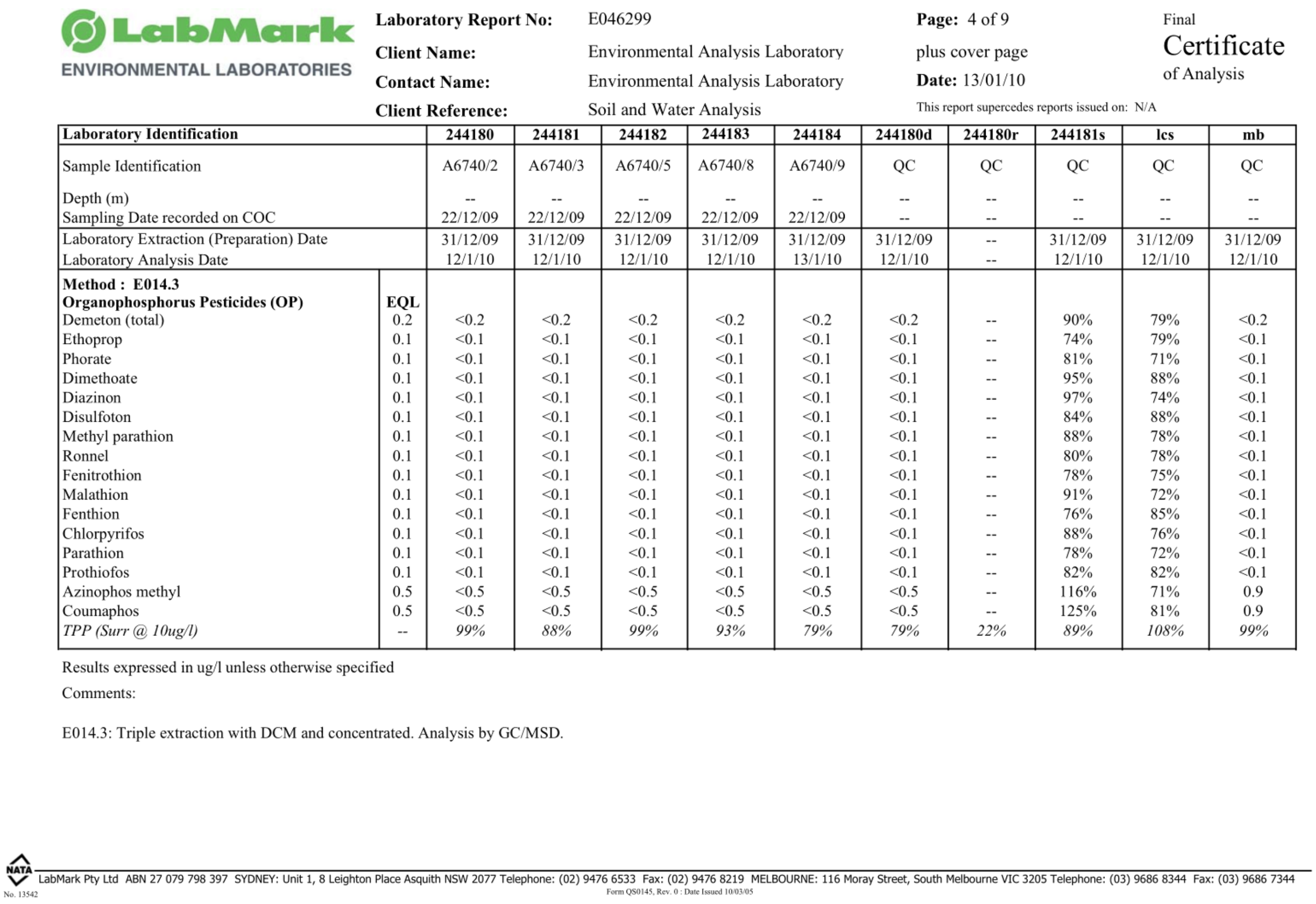
Comments:

E013.1: Triple extraction with hexane. Analysis by GC/dual ECD.

NATA No. 13542 LabMark Pty Ltd ABN 27 079 798 397 SYDNEY: Unit 1, 8 Leighton Place Asquith NSW 2077 Telephone: (02) 9476 6533 Fax: (02) 9476 8219 MELBOURNE: 116 Moray Street, South Melbourne VIC 3205 Telephone: (03) 9686 8344 Fax: (03) 9686 7344

Form QS0145, Rev. 0 : Date Issued 10/03/05

EAL Consulting Services



LabMark
ENVIRONMENTAL LABORATORIES

Laboratory Report No: E046299
Client Name: Environmental Analysis Laboratory
Contact Name: Environmental Analysis Laboratory
Client Reference: Soil and Water Analysis

Page: 4 of 9
plus cover page
Date: 13/01/10
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**244180**	**244181**	**244182**	**244183**	**244184**	**244180d**	**244180r**	**244181s**	**lcs**	**mb**
Sample Identification		A6740/2	A6740/3	A6740/5	A6740/8	A6740/9	QC	QC	QC	QC	QC
Depth (m)		--	--	--	--	--	--	--	--	--	--
Sampling Date recorded on COC		22/12/09	22/12/09	22/12/09	22/12/09	22/12/09	--	--	--	--	--
Laboratory Extraction (Preparation) Date		31/12/09	31/12/09	31/12/09	31/12/09	31/12/09	31/12/09	--	31/12/09	31/12/09	31/12/09
Laboratory Analysis Date		12/1/10	12/1/10	12/1/10	12/1/10	13/1/10	12/1/10	--	12/1/10	12/1/10	12/1/10
Method : E014.3											
Organophosphorus Pesticides (OP)	**EQL**										
Demeton (total)	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--	90%	79%	<0.2
Ethoprop	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	74%	79%	<0.1
Phorate	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	81%	71%	<0.1
Dimethoate	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	95%	88%	<0.1
Diazinon	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	97%	74%	<0.1
Disulfoton	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	84%	88%	<0.1
Methyl parathion	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	88%	78%	<0.1
Ronnel	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	80%	78%	<0.1
Fenitrothion	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	78%	75%	<0.1
Malathion	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	91%	72%	<0.1
Fenthion	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	76%	85%	<0.1
Chlorpyrifos	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	88%	76%	<0.1
Parathion	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	78%	72%	<0.1
Prothiofos	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	82%	82%	<0.1
Azinophos methyl	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	116%	71%	0.9
Coumaphos	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	125%	81%	0.9
TPP (Surr @ 10ug/l)	--	*99%*	*88%*	*99%*	*93%*	*79%*	*79%*	*22%*	*89%*	*108%*	*99%*

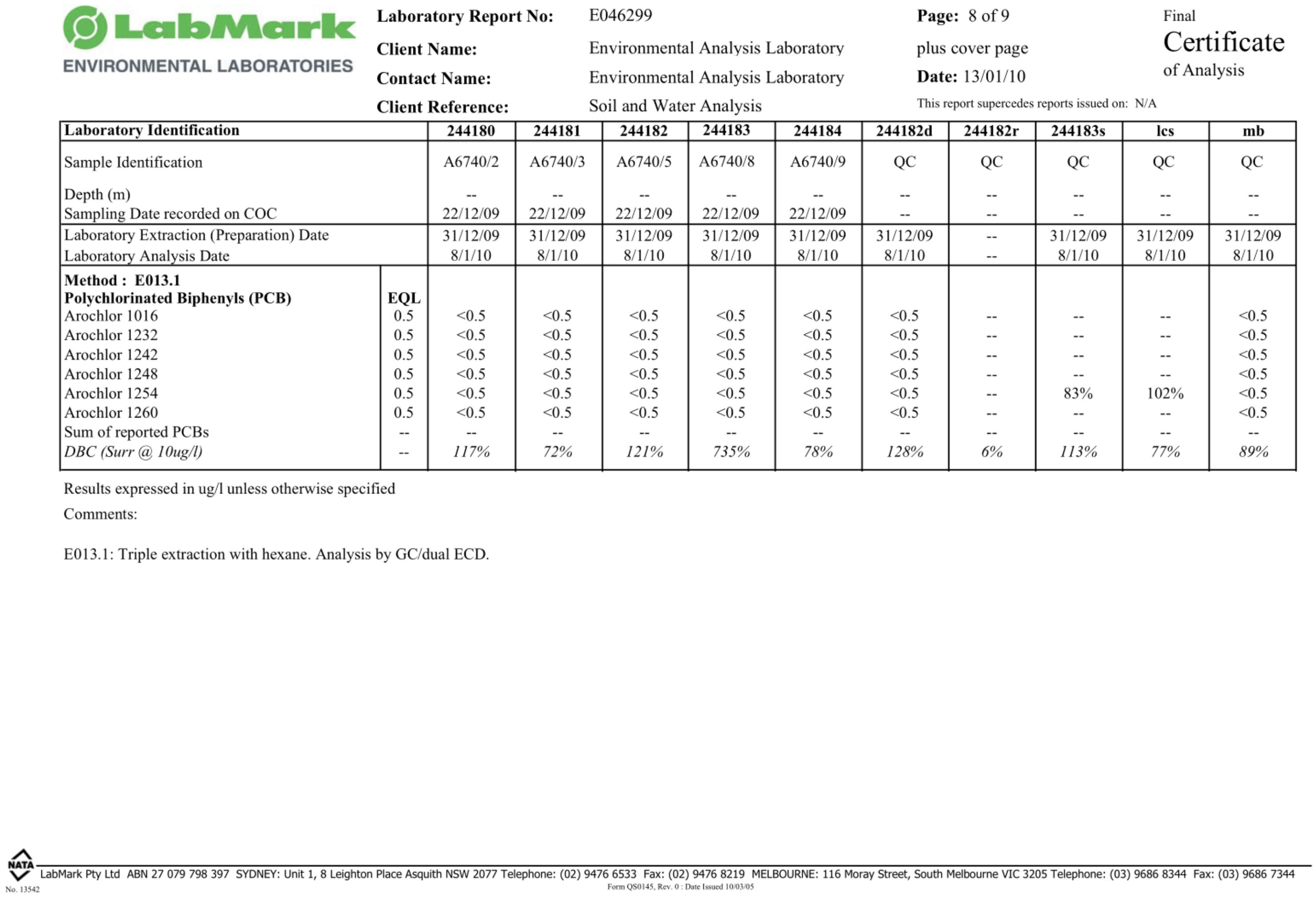
Results expressed in ug/l unless otherwise specified

Comments:

E014.3: Triple extraction with DCM and concentrated. Analysis by GC/MSD.

NATA
No. 13542

EAL Consulting Services



LabMark
ENVIRONMENTAL LABORATORIES

Laboratory Report No: E046299
Client Name: Environmental Analysis Laboratory
Contact Name: Environmental Analysis Laboratory
Client Reference: Soil and Water Analysis

Page: 8 of 9
plus cover page
Date: 13/01/10
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**244180**	**244181**	**244182**	**244183**	**244184**	**244182d**	**244182r**	**244183s**	**lcs**	**mb**
Sample Identification		A6740/2	A6740/3	A6740/5	A6740/8	A6740/9	QC	QC	QC	QC	QC
Depth (m)		--	--	--	--	--	--	--	--	--	--
Sampling Date recorded on COC		22/12/09	22/12/09	22/12/09	22/12/09	22/12/09	--	--	--	--	--
Laboratory Extraction (Preparation) Date		31/12/09	31/12/09	31/12/09	31/12/09	31/12/09	31/12/09	--	31/12/09	31/12/09	31/12/09
Laboratory Analysis Date		8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	8/1/10	--	8/1/10	8/1/10	8/1/10
Method : E013.1											
Polychlorinated Biphenyls (PCB)	**EQL**										
Arochlor 1016	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5
Arochlor 1232	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5
Arochlor 1242	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5
Arochlor 1248	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5
Arochlor 1254	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	83%	102%	<0.5
Arochlor 1260	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5
Sum of reported PCBs	--	--	--	--	--	--	--	--	--	--	--
DBC (Surr @ 10ug/l)	--	*117%*	*72%*	*121%*	*735%*	*78%*	*128%*	*6%*	*113%*	*77%*	*89%*

Results expressed in ug/l unless otherwise specified

Comments:

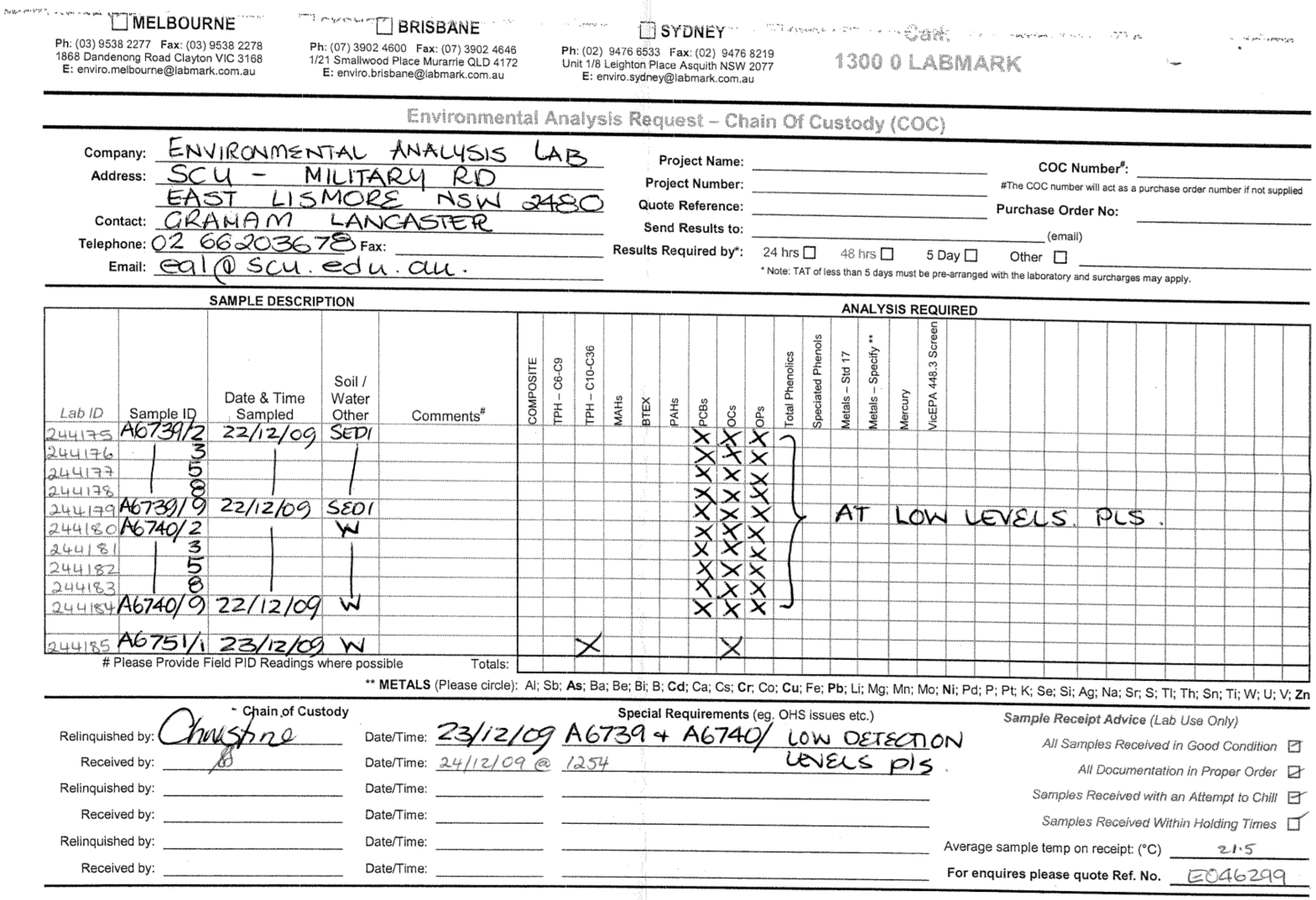
E013.1: Triple extraction with hexane. Analysis by GC/dual ECD.

NATA
No. 13542

LabMark Pty Ltd ABN 27 079 798 397 SYDNEY: Unit 1, 8 Leighton Place Asquith NSW 2077 Telephone: (02) 9476 6533 Fax: (02) 9476 8219 MELBOURNE: 116 Moray Street, South Melbourne VIC 3205 Telephone: (03) 9686 8344 Fax: (03) 9686 7344

Form QS0145, Rev. 0 : Date Issued 10/03/05

EAL Consulting Services



☐ **MELBOURNE**
Ph: (03) 9538 2277 **Fax:** (03) 9538 2278
1868 Dandenong Road Clayton VIC 3168
E: enviro.melbourne@labmark.com.au

☐ **BRISBANE**
Ph: (07) 3902 4600 **Fax:** (07) 3902 4646
1/21 Smallwood Place Murarrie QLD 4172
E: enviro.brisbane@labmark.com.au

☐ **SYDNEY**
Ph: (02) 9476 6533 **Fax:** (02) 9476 8219
Unit 1/8 Leighton Place Asquith NSW 2077
E: enviro.sydney@labmark.com.au

Call:
1300 0 LABMARK

Environmental Analysis Request – Chain Of Custody (COC)

Company: ENVIRONMENTAL ANALYSIS LAB
Address: SCU – MILITARY RD
EAST LISMORE NSW 2480
Contact: GRAHAM LANCASTER
Telephone: 02 66203678 **Fax:**
Email: eal@scu.edu.au.

Project Name:
Project Number:
Quote Reference:
Send Results to: (email)
Results Required by*: 24 hrs ☐ 48 hrs ☐ 5 Day ☐ Other ☐

* Note: TAT of less than 5 days must be pre-arranged with the laboratory and surcharges may apply.

COC Number#:

#The COC number will act as a purchase order number if not supplied

Purchase Order No:

SAMPLE DESCRIPTION / **ANALYSIS REQUIRED**

Lab ID	Sample ID	Date & Time Sampled	Soil / Water Other	Comments#	COMPOSITE	TPH – C6-C9	TPH – C10-C36	MAHs	BTEX	PAHs	PCBs	OCs	OPs	Total Phenolics	Speciated Phenols	Metals – Std 17	Metals – Specify **	Mercury	VicEPA 448.3 Screen
244175	A6739/2	22/12/09	SED1								X	X	X	}					
244176	3	|	|								X	X	X						
244177	5										X	X	X						
244178	8										X	X	X						
244179	A6739/9	22/12/09	SED1								X	X	X			AT LOW LEVELS. PLS.			
244180	A6740/2		W								X	X	X						
244181	3	|	|								X	X	X						
244182	5										X	X	X						
244183	8										X	X	X						
244184	A6740/9	22/12/09	W								X	X	X						
244185	A6751/1	23/12/09	W				X					X							
				Totals:															

Please Provide Field PID Readings where possible

** **METALS** (Please circle): Al; Sb; **As**; Ba; Be; Bi; B; **Cd**; Ca; Cs; **Cr**; Co; **Cu**; Fe; **Pb**; Li; Mg; Mn; Mo; **Ni**; Pd; P; Pt; K; Se; Si; Ag; Na; Sr; S; Tl; Th; Sn; Ti; W; U; V; **Zn**

Chain of Custody

Relinquished by: Christine Date/Time: 23/12/09
Received by: Date/Time: 24/12/09 @ 1254
Relinquished by: Date/Time:
Received by: Date/Time:
Relinquished by: Date/Time:
Received by: Date/Time:

Special Requirements (eg. OHS issues etc.)

A6739 + A6740/ LOW DETECTION LEVELS pls.

Sample Receipt Advice *(Lab Use Only)*

All Samples Received in Good Condition ☑
All Documentation in Proper Order ☑
Samples Received with an Attempt to Chill ☑
Samples Received Within Holding Times ☑

Average sample temp on receipt: (°C) 21.5

For enquires please quote Ref. No. E046299

Environmental Analysis Laboratory

EAL Consulting Services

RESULTS OF SEAFOOD ANALYSIS (Page 1 of 1)

11 soil samples supplied by Professional Fishes Association on 6th January, 2010 - Lab Job No. A6780
Analysis requested by John Harrison. **Your Job.: Q# 2737. Clarence River-Fish/Prawn**

ANALYTE	METHOD REFERENCE	Sample 1 B1 (1/2)	Sample 2 B2 (1/2)	Sample 3 M1 (1/2)	Sample 4 W1 (1/2)	Sample 5 W2 (1/2)	Sample 6 P1 (1/2)	Sample 7 P2 (1/2)	Sample 8 P3 (1/2)
	Job No.	*A6780/1*	*A6780/2*	*A6780/3*	*A6780/4*	*A6780/5*	*A6780/6*	*A6780/7*	*A6780/8*
SILVER (mg/Kg DW)	*a*	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
ARSENIC (mg/Kg DW)	*a*	0.7	0.4	0.9	1.2	0.6	0.9	0.6	0.6
LEAD (mg/Kg DW)	*a*	0.8	0.3	0.3	0.1	0.0	0.1	0.0	0.0
CADMIUM (mg/Kg DW)	*a*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHROMIUM (mg/Kg DW)	*a*	1.4	0.8	1.2	0.6	0.6	0.6	0.4	0.5
COPPER (mg/Kg DW)	*a*	3.0	1.1	2.0	0.5	0.4	16.6	7.8	11.4
MANGANESE (mg/Kg DW)	*a*	8.3	65.7	17.4	3.9	5.7	7.5	3.5	15.2
NICKEL (mg/Kg DW)	*a*	1.1	0.6	0.8	0.4	0.5	0.8	0.4	0.8
SELENIUM (mg/Kg DW)	*a*	0.4	0.2	0.6	0.4	0.4	0.7	0.4	0.6
ZINC (mg/Kg DW)	*a*	18.2	10.5	9.7	14.5	15.7	16.8	11.6	14.1
MERCURY (mg/Kg DW)	*a*	0.26	0.14	0.03	0.05	0.06	0.02	0.03	0.02
IRON (% DW)	*a*	0.026	0.024	0.048	0.007	0.005	0.018	0.008	0.009
ALUMINIUM (% DW)	*a*	0.004	0.008	0.015	0.001	<0.001	0.002	0.001	0.002
TIN (mg/Kg)	a	11.3	6.4	7.4	2.6	1.6	8.0	2.6	1.2
PESTICIDE ANALYSIS SCREEN									
Other Organochlorine Pesticides (mg/Kg)	*c*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Other Organophosphate Pesticides (mg/Kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PCB's (mg/Kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

METHODS REFERENCE

a. $^{1:3}$Nitric/HCl digest - APHA 3120 ICPMS
b. $^{1:3}$Nitric/HCl digest - APHA 3120 ICPOES
c. Analysis sub-contracted - results attached

NOTES

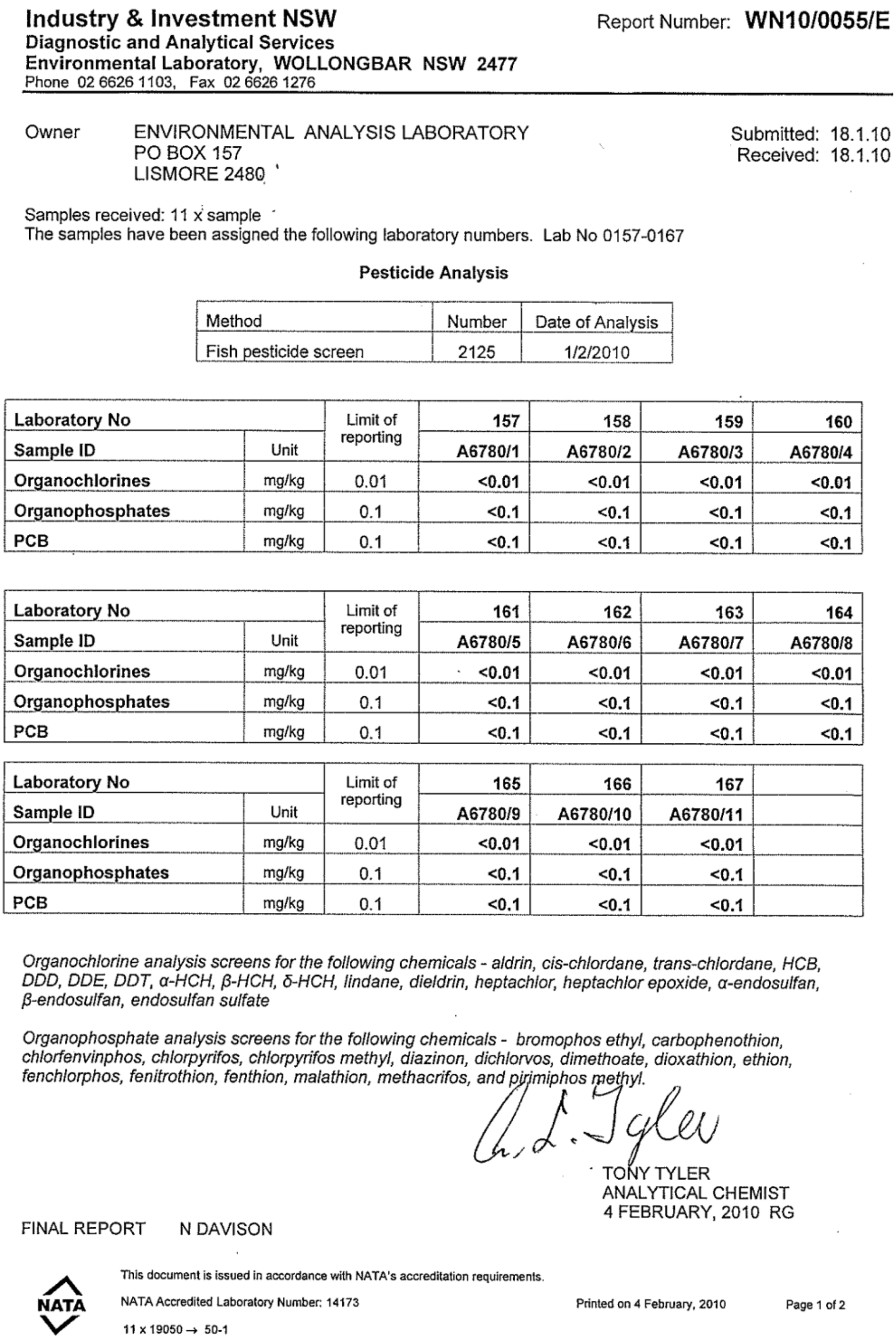
1. Column 1 ' Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998)
2. Environmental Soil Quality Guidelines, Page 40, ANZECC, 1992.

Additional NOTES

DW = Dry Weight

Organochlorine pesticide (OC's) screen:	(Aldrin, Cis-chlordane, Trans-chlordane, HCB, DDD, DDE, DDT, Alpha-BHC, Beta-BHC, Delta-BHC, Lindane, Dieldrin, Endrin, Heptachlor, Heptachor epoxide, Alpha-endosulfan, Beta-endosulfan, Endosulfan sulfate, Methoxychlor)
Organophosphorus pesticide (OP's) screen:	(Dichlorvos, Phosdrin, Demeton (total), Ethoprop, Monocrotophos, Phorate, Dimethoate, Diazinon, Disulfoton, Methyl parathion, Chloropyrifos, Ronnel, Parathion, Stirofos, Prothiofos, Azinophos methyl, Coumaphos, Fenitrothion, Fenthion, Malathion)
PCB's = Polychloriniated Biphenyls	(Arochlor 1016, 1232, 1242, 1248, 1254, 1260)

na = no guidelines available



Industry & Investment NSW
Diagnostic and Analytical Services
Environmental Laboratory, WOLLONGBAR NSW 2477
Phone 02 6626 1103, Fax 02 6626 1276

Report Number: **WN10/0055/E**

Owner ENVIRONMENTAL ANALYSIS LABORATORY
PO BOX 157
LISMORE 2480

Submitted: 18.1.10
Received: 18.1.10

Samples received: 11 x sample
The samples have been assigned the following laboratory numbers. Lab No 0157-0167

Pesticide Analysis

Method	Number	Date of Analysis
Fish pesticide screen	2125	1/2/2010

Laboratory No		Limit of reporting	**157**	**158**	**159**	**160**
Sample ID	Unit		**A6780/1**	**A6780/2**	**A6780/3**	**A6780/4**
Organochlorines	mg/kg	0.01	**<0.01**	**<0.01**	**<0.01**	**<0.01**
Organophosphates	mg/kg	0.1	**<0.1**	**<0.1**	**<0.1**	**<0.1**
PCB	mg/kg	0.1	**<0.1**	**<0.1**	**<0.1**	**<0.1**

Laboratory No		Limit of reporting	**161**	**162**	**163**	**164**
Sample ID	Unit		**A6780/5**	**A6780/6**	**A6780/7**	**A6780/8**
Organochlorines	mg/kg	0.01	**<0.01**	**<0.01**	**<0.01**	**<0.01**
Organophosphates	mg/kg	0.1	**<0.1**	**<0.1**	**<0.1**	**<0.1**
PCB	mg/kg	0.1	**<0.1**	**<0.1**	**<0.1**	**<0.1**

Laboratory No		Limit of reporting	**165**	**166**	**167**	
Sample ID	Unit		**A6780/9**	**A6780/10**	**A6780/11**	
Organochlorines	mg/kg	0.01	**<0.01**	**<0.01**	**<0.01**	
Organophosphates	mg/kg	0.1	**<0.1**	**<0.1**	**<0.1**	
PCB	mg/kg	0.1	**<0.1**	**<0.1**	**<0.1**	

Organochlorine analysis screens for the following chemicals - aldrin, cis-chlordane, trans-chlordane, HCB, DDD, DDE, DDT, α-HCH, β-HCH, δ-HCH, lindane, dieldrin, heptachlor, heptachlor epoxide, α-endosulfan, β-endosulfan, endosulfan sulfate

Organophosphate analysis screens for the following chemicals - bromophos ethyl, carbophenothion, chlorfenvinphos, chlorpyrifos, chlorpyrifos methyl, diazinon, dichlorvos, dimethoate, dioxathion, ethion, fenchlorphos, fenitrothion, fenthion, malathion, methacrifos, and pirimiphos methyl.

A. L. Tyler

TONY TYLER
ANALYTICAL CHEMIST
4 FEBRUARY, 2010 RG

FINAL REPORT N DAVISON

NATA

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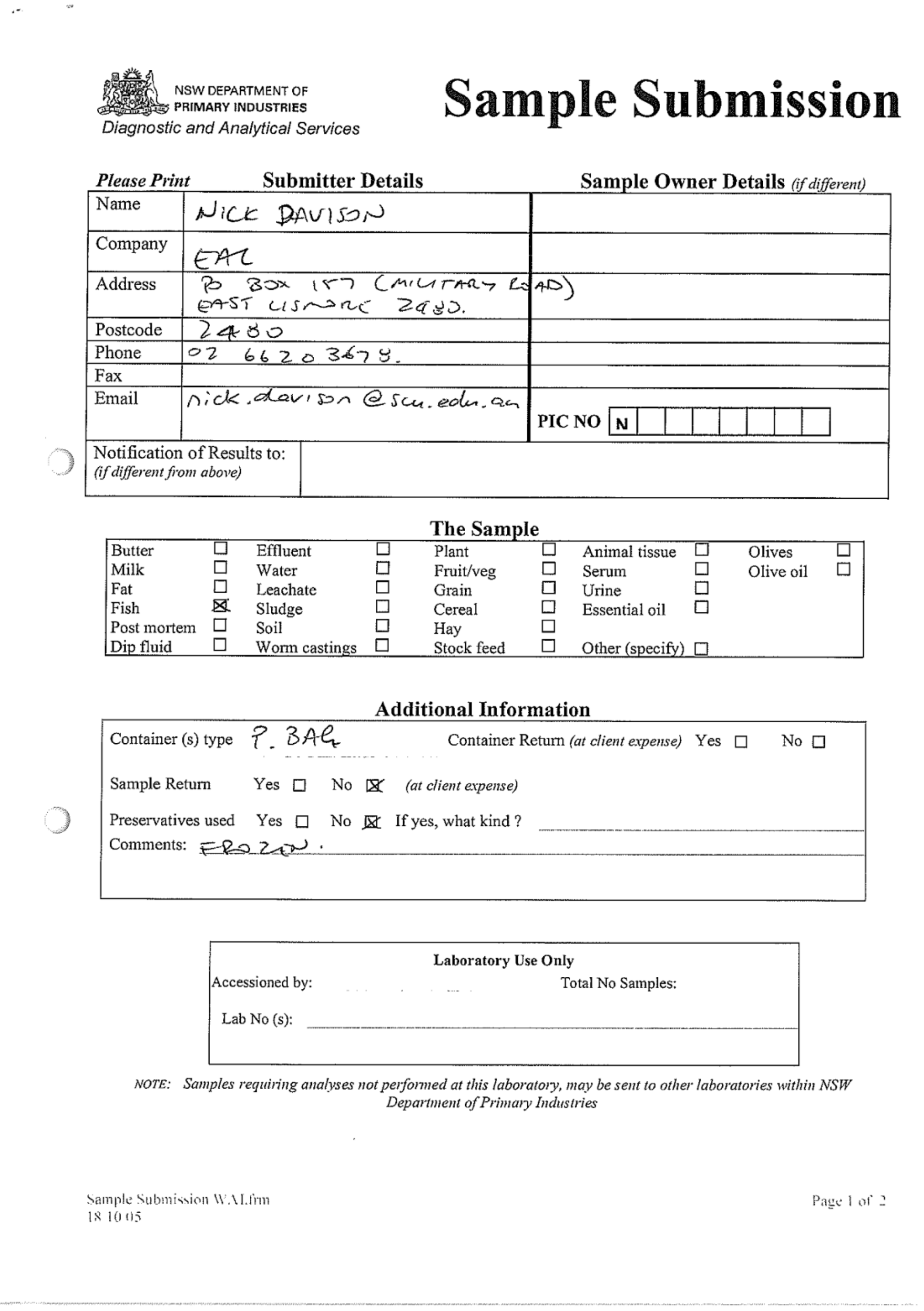

NSW DEPARTMENT OF PRIMARY INDUSTRIES
Diagnostic and Analytical Services

Sample Submission

Please Print	Submitter Details	Sample Owner Details *(if different)*
Name	NICK DAVISON	
Company	EAL	
Address	P BOX 157 (MILITARY ROAD) EAST LISMORE 2480.	
Postcode	2480	
Phone	02 6620 3678.	
Fax		
Email	nick.davison@scu.edu.au	PIC NO N
Notification of Results to: *(if different from above)*		

The Sample

Butter	☐	Effluent	☐	Plant	☐	Animal tissue	☐	Olives	☐
Milk	☐	Water	☐	Fruit/veg	☐	Serum	☐	Olive oil	☐
Fat	☐	Leachate	☐	Grain	☐	Urine	☐		
Fish	☒	Sludge	☐	Cereal	☐	Essential oil	☐		
Post mortem	☐	Soil	☐	Hay	☐				
Dip fluid	☐	Worm castings	☐	Stock feed	☐	Other (specify)	☐		

Additional Information

Container (s) type P. BAG Container Return *(at client expense)* Yes ☐ No ☐

Sample Return Yes ☐ No ☒ *(at client expense)*

Preservatives used Yes ☐ No ☒ If yes, what kind ?

Comments: FROZEN.

Laboratory Use Only

Accessioned by: Total No Samples:

Lab No (s):

NOTE: Samples requiring analyses not performed at this laboratory, may be sent to other laboratories within NSW Department of Primary Industries

Sample Submission WAL.frm
18 10 05

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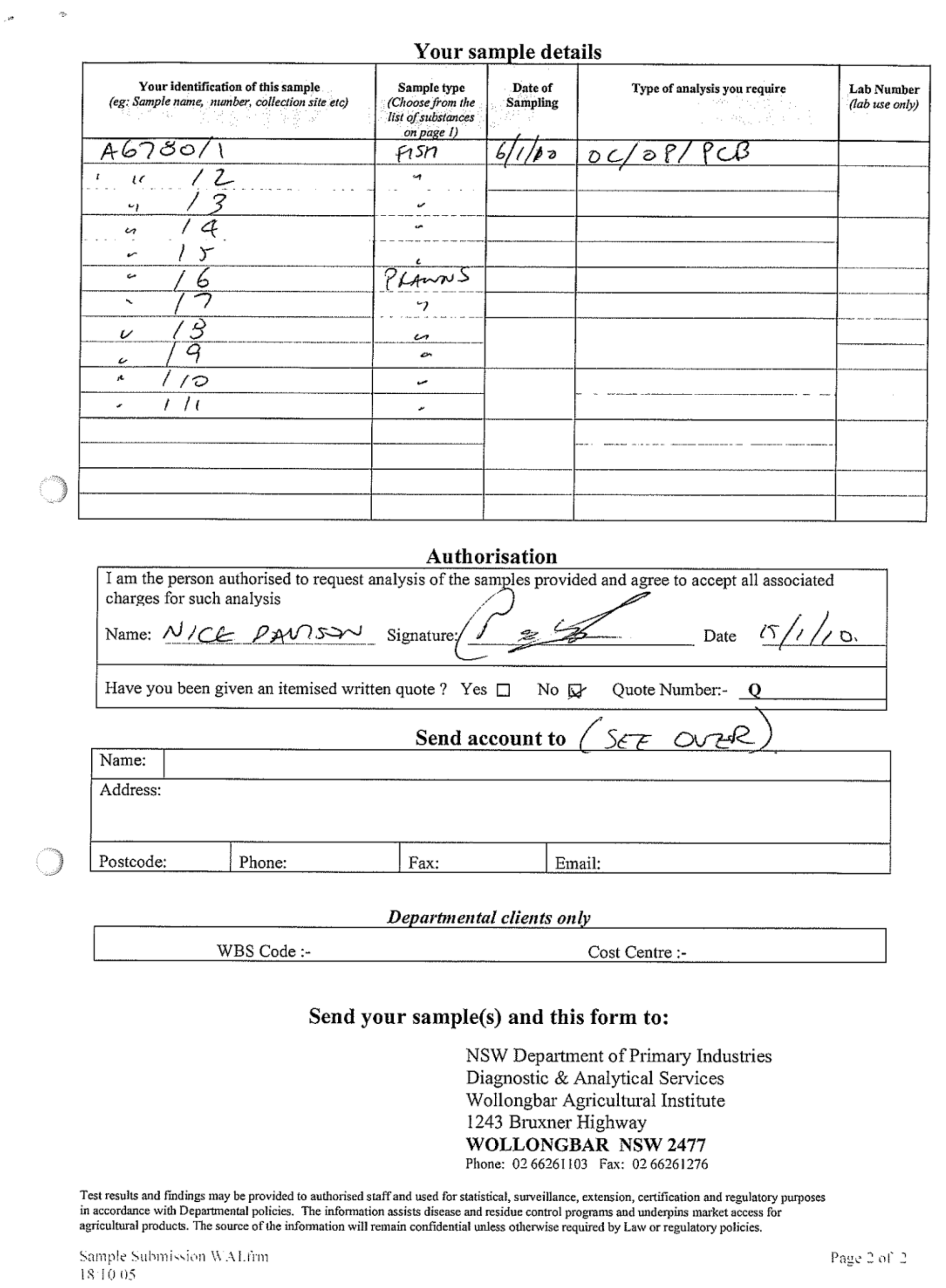

Your sample details

Your identification of this sample (eg: Sample name, number, collection site etc)	Sample type (Choose from the list of substances on page 1)	Date of Sampling	Type of analysis you require	Lab Number (lab use only)
A6780/1	FISH	6/1/10	OC/OP/PCB	
" " /2	"			
" /3	"			
" /4	"			
" /5	"			
" /6	PRAWNS			
" /7	"			
" /8	"			
" /9	"			
" /10	"			
" /11	"			

Authorisation

I am the person authorised to request analysis of the samples provided and agree to accept all associated charges for such analysis

Name: NICK DAWSON Signature: Date 15/1/10.

Have you been given an itemised written quote ? Yes ☐ No ☒ Quote Number:- Q

Send account to (SEE OVER)

Name:
Address:
Postcode: Phone: Fax: Email:

Departmental clients only

WBS Code :- Cost Centre :-

Send your sample(s) and this form to:

NSW Department of Primary Industries
Diagnostic & Analytical Services
Wollongbar Agricultural Institute
1243 Bruxner Highway
WOLLONGBAR NSW 2477
Phone: 02 66261103 Fax: 02 66261276

Test results and findings may be provided to authorised staff and used for statistical, surveillance, extension, certification and regulatory purposes in accordance with Departmental policies. The information assists disease and residue control programs and underpins market access for agricultural products. The source of the information will remain confidential unless otherwise required by Law or regulatory policies.

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18/10/05

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Attachment B: 2011 Report

WATER QUALITY ANALYSIS REPORT

AT EIGHTEEN (18) SELECTED SAMPLING SITES WITHIN

THE CLARENCE RIVER ESTUARY

CLARENCE VALLEY COUNCIL LOCAL GOVERNMENT AREA

A 'Snapshot' Sampling and Analysis Effort of Benthic Sediment and Surface Water Samples Collected from four (4) Hydraulic Regions of the Clarence River Estuary

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For: **Professional Fishermen's Association (Clarence River)**
Report No.: **EAL110017.001 (2998)**
Date: **7th February 2011**

Disclaimer

The Environmental Analysis Laboratory (EAL) as part of Southern Cross University has conducted work concerning the environmental status of the site, which is the subject of this report, and has prepared this report on the basis of that assessment.

The work was conducted, and the report has been prepared, in response to specific instructions from the client or a representative of the client to whom this report is addressed, within the time and budgetary requirements of the client, and in reliance on certain data and information made available to EAL. The analysis, evaluations, opinions and conclusions presented in this report are based on that information, and they could change if the information is in fact inaccurate or incomplete.

While due care was taken during field survey and report preparation, EAL accepts no responsibility for any omissions that may have occurred due to the nature of the survey methodology. EAL has made no allowance to update this report and has not taken into account events occurring after the time its assessment was conducted.

Due consideration has been given to site conditions and to appropriate legislation and documentation available at the time of preparation of the report. As these elements are liable to change over time, the report should be considered current at the time of preparation only.

This report is intended for the sole use of the client and only for the purpose for which it was prepared. Any representation contained in the report is made only to the client unless otherwise noted in the report. Any third party who relies on this report or on any representation contained in it does so at their own risk.

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Executive Summary

The Environmental Analysis Laboratory (EAL) has conducted a water and sediment quality investigation within four (4) regions of the Clarence River Estuary with two discrete sampling efforts undertaken over a two (2) year period. The sampling and analysis effort is limited to one sampling event per annum at each of the eighteen (18) selected sites. Tidal variations and subsequent changes in water column depth are not accounted for in the sampling and monitoring effort.

The sampling effort is focused on the lower reaches of the Clarence River catchment, namely selected hydrological regions within the estuary, which are described based on fluvial geomorphology.

Monitoring and analysis effort at the eighteen sites consisted of physicochemical depth profiling (pH, EC, TDS, Turbidity, Salinity and DO), sediment and water sample collection for assessment of specific physicochemical and chemical analyses. Analysis and field monitoring results were compared with appropriate trigger levels sourced from:

- ANZECC 2000, *Australian Water Quality Guidelines for Fresh and Marine Waters, National Water Quality Management Strategy*;
- QWQG 2009, *Queensland Water Quality Guidelines*;
- Stone et al. (1998) Acid Sulfate Soil Manual ASSMAC, NSW Aust.; and
- SCBD 2006, *Global Biodiversity Outlook 2.*

Sampling of sediment and waters was undertaken on the 23 – 24th December 2009 and 12 – 13th December 2010 with the sampling and analysis effort executed providing a snapshot depiction of the individual conditions at each sampling location at the time of sampling.

Key points noted during the comparison between the previous data and analysis and monitoring results collected for this period:

- Rainfall totals for the year prior to sampling were lower in 2010 than those recorded for same period at each of the three (3) monitoring stations in 2009. Whilst, rainfalls for the month prior to sampling were higher in 2010 at all 3 stations than those recorded for the same period in 2009. Rainfall for the 48 hours prior to sampling was greater in 2009 at the Harwood station and similar at the other 2 stations for both sampling years;
- TSS trigger value (20mg/L) was exceeded in the 2010 sampling run only at Lake Wooloweyah;
- pH (2010) values were recorded to be below the normal values for estuaries at SP18 (Main Channel), SP8, SP12, SP11 & SP1 (Tributaries);
- EC was considerably lower at all sites during the 2010 sampling run;
- Total Nitrogen has exceeded the trigger value of 0.3 (mg/L N) at all sites in both sampling years. Total Phosphorous trigger value (0.025 mg/L P) was also exceeded in both sampling years at all Main Channel and Tributaries Sites, and Lake Wooloweyah (lagoons sites). At the Lagoons Sites, P was below trigger value in 2009 at SP9 & SP10 (Broadwater), but above trigger value in 2010.
- Nitrate & Ammonia values in 2010 generally exceeded the guidelines at most sites except for some of the sites at Lake Wooloweyah, which were below trigger levels.

- DO at levels of less than 5 mg/L (i.e. below trigger level) were recorded for SP12 & SP11 (South Arm), SP8 (North Arm) and SP18 (Main Channel) consistently in both sampling periods;
- BOD levels for SP3 & SP2 (Lake Wooloweyah) are indicative of lightly to moderately polluted waters. However, DO levels at the same sites (for both years) display concentrations well above 5 mg/L;
- Dissolved Aluminium (Al) and Iron (Fe) concentrations were considerably higher in 2010 than those recorded in 2009. In regard to Aluminium concentrations, only SP16 recoded lower concentrations than last year; and
- Sulfate levels (in water) are lower in 2010 than those recorded in 2009, whilst Al & Fe are generally higher in 2010 that the concentrations recorded in 2009.

A reduction in marine influence is evident based on the reduction in chloride and sulfate concentrations observed throughout the estuary and connected hydraulic regions during the recent monitoring phase. When compared to the previous year's data, the Cl:SO_4 ratio displays more variation throughout the (estuarine) system suggesting (with a decrease in marine influence) an increase in the production of sulfate originating from upstream and low energy environments.

Given the variation of physical factors (such as rainfall received, tidal fluxes, flow conditions etc.) experienced during the two discrete sampling and analysis events, a degree of variation is expected. Nevertheless, the following issues have been identified:

- Concentrations of both TN (and NOx) and TP continue to exceed the adopted trigger values, suggesting significant sources of nutrient enter the estuary;

- Reduction in marine influence was observed at majority of sites as evidenced by the reduction in Cl and SO4 recorded, along with greater variation of Cl;SO4 ratios;

- Salinity levels are considerably lower at all sites in the 2010 sampling run despite a relatively lower annual rainfall when compared to last year's records. However, rainfalls for the month prior to the sampling were relatively higher in 2010 than the same period in 2009. Additionally, tidal variations and subsequent changes in water column depth were not accounted for in the sampling and monitoring effort. These factors might explain the difference in salinity levels observed between the two sampling years.

- A net increase in the acid generating potential of benthic sediments was identified between the discrete sampling and analysis periods;

- An increase of heavy metal concentrations (principally Fe and Al) within surface water samples was also identified during the recent sampling effort.

A number of limitations have been identified during the undertaking of these works and the preparations of this report. To provide information that will allow the satisfaction of these identified limitations, EAL recommends the augmentation and alteration of the current investigation efforts. Should the works be required to continue in the future, a systematic and localised approach is proposed, which can be achieved with a similar budget as that allocated for this year.

1. Introduction

1.2 Study Scope

The Environmental Analysis Laboratory (EAL) has been commissioned by the John Harrison of the Professional Fishermen's Association (PFA) to conduct a water quality-sampling program at selected sites within the Clarence River estuary (refer to Figs. 1 & 2).

The water quality sampling has been conducted over two (2) years. The first round of sampling was conducted in December 2009 and the analysis results and basic interpretation was provided on the 10th March 2010.

The second round of samplings was undertaken in December 2010 and the results of analyses are provided in this report.

EAL has undertaken a comprehensive assessment of physical and chemical attributes within the lower reaches of the Clarence River catchment. Sampling has been undertaken at selected hydrological regions within the estuary, with each region identified and selected based on the fluvial geomorphology of each. These are shown on Table 1.

Table 1. Selected Hydrological Regions within the Clarence River Catchment & Sampling Points

Region	Location	Sampling Point Identification(s)
Main Channel	Clarence River	SP15 SP14 SP13 SP17 SP18 SP5
Lagoons	Maclean Broadwater	SP9 SP10
	Lake Wooloweyah	SP3 SP2 SP4
Tributaries	North Arm	SP7 SP8 SP6
	South Arm	SP12 SP11
	Palmers Channel	SP1
	Oyster Channel	SP16

Based on information provided and requests by PFA, a total of eighteen (18) sediment and near-surface (i.e. benthic) water samples were collected between the River mouth (SP5) and the Ulmarra ferry (SP15) (refer to Fig. 2).

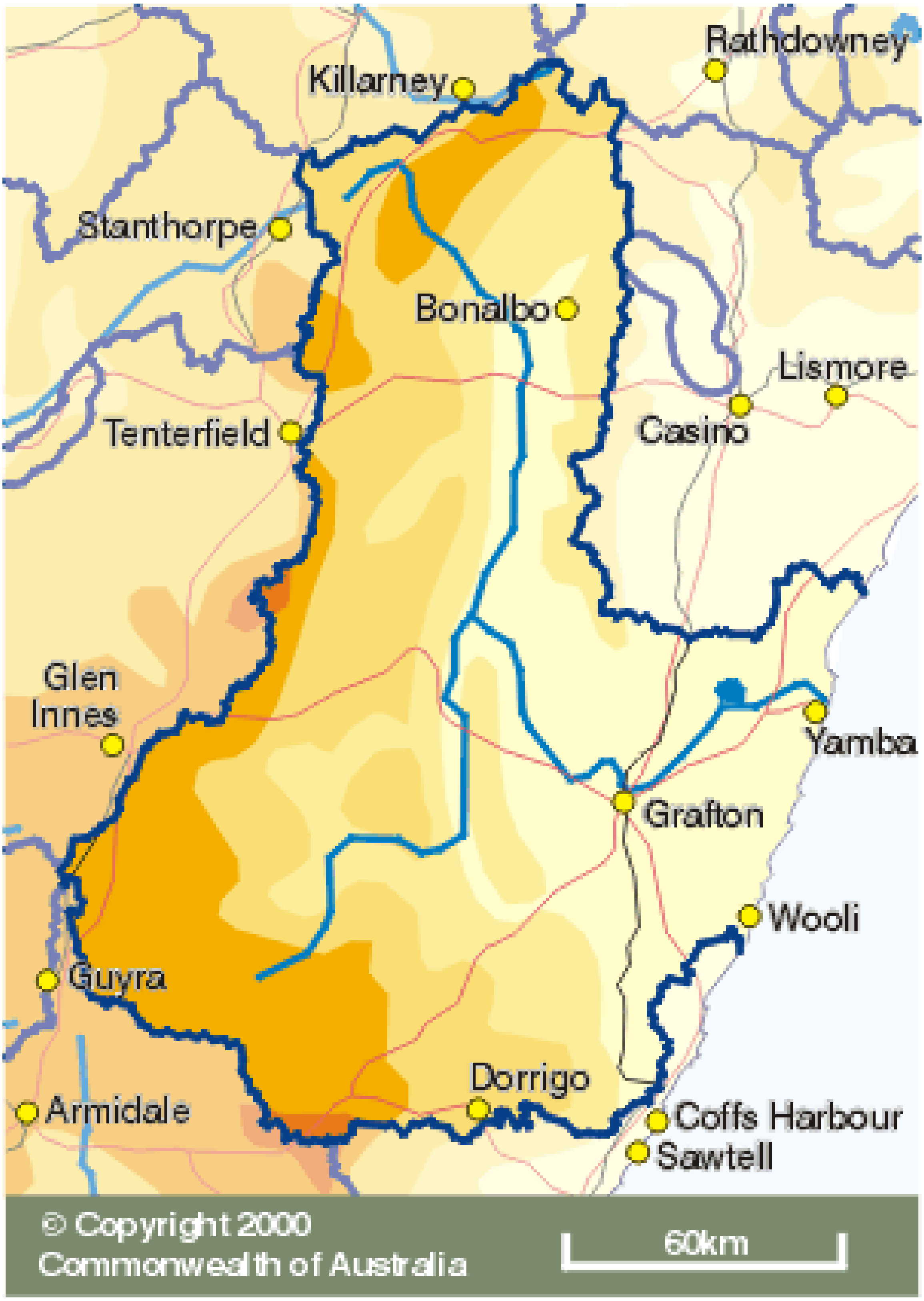


Figure 1. Clarence River Catchment. Source: r2labswiki.com

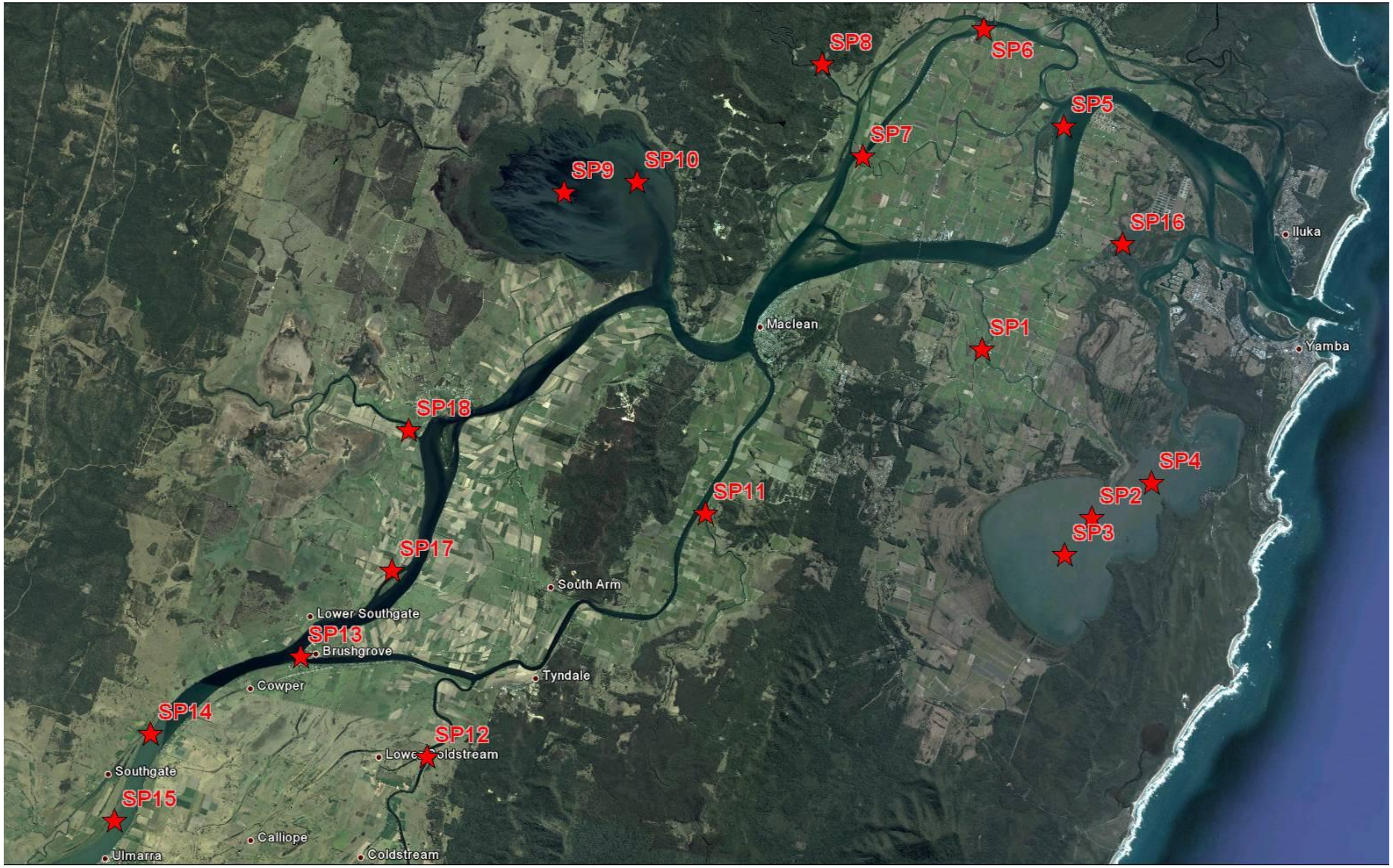


Figure 2. Sampling sites locations (Source: Google maps – http://maps.google.com.au/maps)

1.1 Study Limitation

The water quality sampling is limited to one sampling event per annum at each selected site within the hydrological regions detailed in Table 1. Because of the lack of more frequent sampling per annum at each site, it is not possible to confirm trends that might be associated with seasonal fluctuations, such as significant rainfall events and or lack of rainfall.

The timeframe allocated for each annual sampling event also restricts access to some sites, with an average 100m radius applicable at each sampling location. Tidal variations and subsequent changes in water column depth are also not accounted for in the sampling and monitoring effort.

In contrast to the previous sampling effort (December 2009), no pesticide (Organochlorine, Organophosphorus or PCB) analyses were undertaken in this sampling year. Analysis of biological samples (prawn, mullet, whiting, and bream) was also not conducted this year. These specific analytes and sample media were discarded following results below the limits of reporting recorded last effort.

2. Study Area

2.1 Site Identification and Landuse

The Clarence River lies in the far north coast of New South Wales, with its headwaters in the McPherson Ranges in Queensland (ref to Fig. 1). The river is free flowing with no on stream dams or weirs to inhibit its natural flow (Lockwood 2010). The Clarence River, its estuary and coastal floodplain is the NSW north coast's largest river system with a total catchment of 22,660 square kilometres (Umwelt 2003; Lockwood 2010).

This water quality sampling is focused on the lower reaches of the Clarence River catchment, namely selected hydrological regions within the estuary, which are described based on fluvial geomorphology. Thus, for the purposes on this report, the study area comprises the identified sites within the Clarence River estuary shown on Fig. 2.

The Clarence estuary supports the largest commercial estuary fishery in NSW, production has been estimated to be on average more than twice that of the next most important estuary (Umwelt 2003). Still, the coastal floodplain has been cleared and drained to enhance agricultural productivity since pre-1950. Flood mitigation works have been carried out for over a century on the Clarence, particularly in the 1960s and 1970s. Over the years many extensive drainage systems and hundreds of floodgates and other structures have been constructed. Nowadays, the majority of the floodplain is occupied by sugar cane (particularly in the lower estuary) or cattle grazing (Umwelt 2003).

2.2 Specific Site Characterisation

Main Channel

Samples SP15, SP14, SP13, SP17, SP18 and SP5 were collected within the channel of the Clarence River and are considered to represent the main stream characteristics (at least geographically) of the River. However, it must be noted that SP18 is not actually within the main channel, but it is located at the convergence of a tributary (Sportsmans Creek) with the Clarence River.

Lagoons Sites

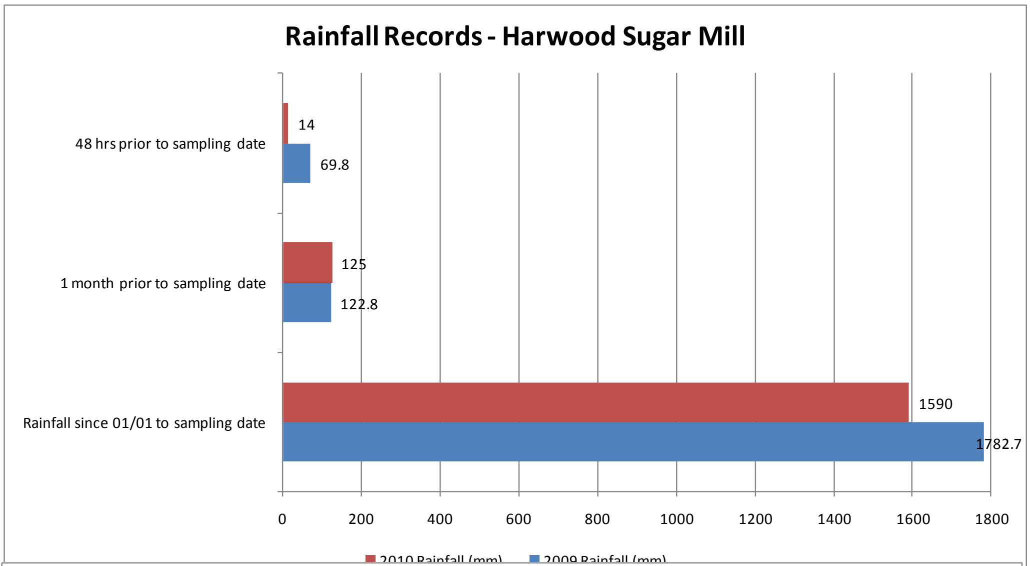
Samples SP3, SP2 & SP4 were collected from within Lake Wooloweyah, whilst, Samples SP 9 & SP10 were collected within the Maclean Broadwater. These are known collectively as the Lagoons Sites.

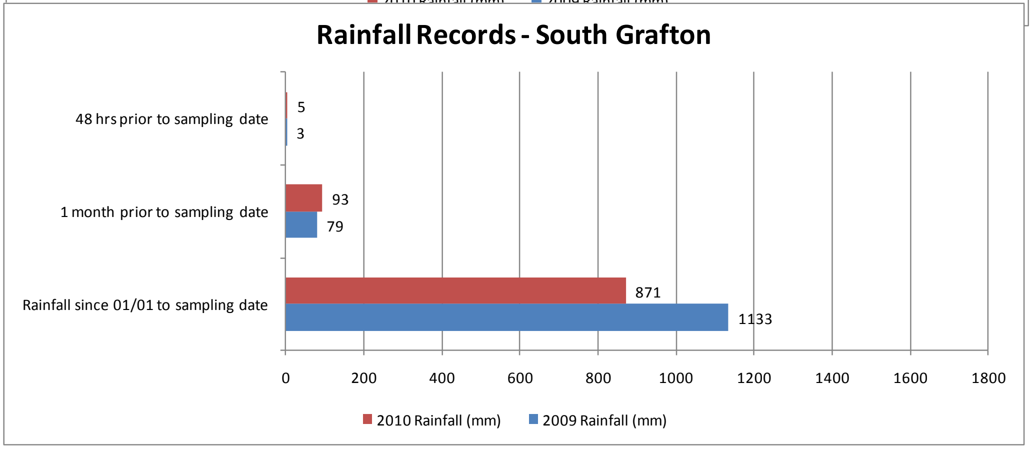
Tributaries Sites

Samples SP7, SP8 & SP5 were collected within the North Arm tributary to the Clarence River. Samples SP12 & SP11 were collected from the South Arm tributary. A single sample was collected from the Palmers Channel (SP1) and the Oyster Channel (SP16). These are known collectively as the Tributaries Sites.

2.3 Rainfall

Rainfall records have been sourced from the Bureau of Meteorology (BoM) website (http://www.bom.gov.au/index.shtml). Records accessed are from the Harwood Island (Harwood Sugar Mill), South Grafton and Copmanhurst (Stockyard Creek) stations. Fig. 3 provides summary of the rainfall records for each of these stations for the year 2009 and 2010.





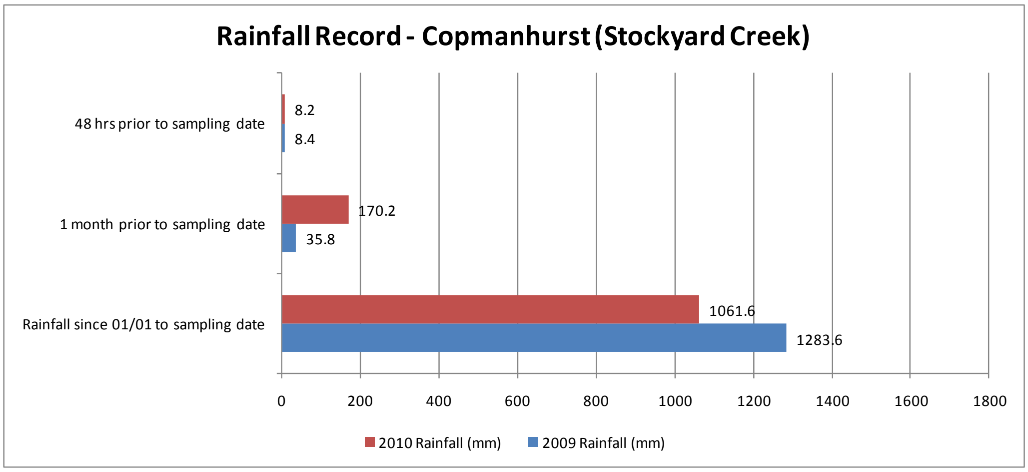


Figure 3. Graphs of rainfall records for the 2009 & 2010 years.
Source: http://www.bom.gov.au/index.shtml

2.4 Local Soils

As described in Morand (2001), the study area is characterised by alluvial plains, tidal plains, abandoned channels and swamps. Islands such as Chatsworth and Palmers have been created by channels migrating across the river delta. Towards the mouth of the Clarence (River), previously formed aeolian and marine sands have been mixed with alluvium. Sand islands such as Freeburn Island have formed as consequences of tidal processes.

Major soil types include Brown and Grey Kandosols overlaying marine clays throughout the (alluvial) plain, Sulfidic Hydrosols within backswamps and tidal areas, Yellow Kurosols and Black Dermosols on headlands, Podosols on sandsheets and marine sands on beaches and tidal deltas and plains.

As stated by Umwelt (2003), the coastal floodplain is underlain by approximately 53,000 ha of high-risk acid sulfate soils (ASS) and these soils are often found at shallow depths across large areas of agricultural land on the coastal floodplain. Fig. 4 shows the potential ASS extent within the study area (as defined by NRAtlas).

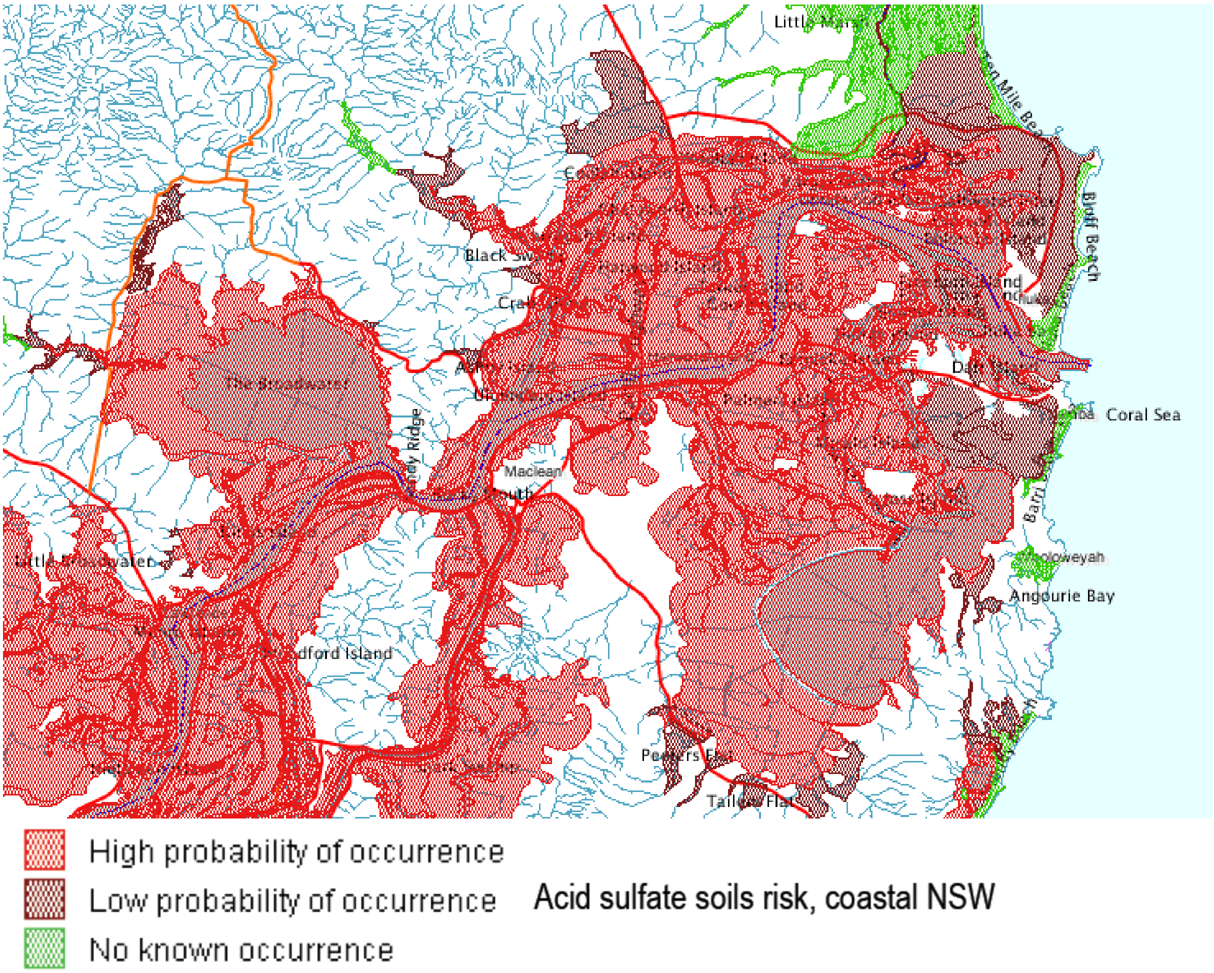


Figure 4. ASS probability of occurrence
Source: Map created with NSW Natural Resource Atlas - http://nratlas.nsw.gov.au/wmc/custom/widgets/printlink/popup/printmap.jsp?

2.5 Significant Aquatic Habitat Features

The estuary contains the second largest area of seagrass in NSW (19 km2), with very large areas in the Broadwater and Lake Wooloweyah providing quality aquatic habitat (Umwelt 2003). Seagrass extent across the estuary is shown in Fig. 5.

The estuary also supports extensive mangrove vegetation and smaller areas of saltmarsh, which provide significant habitat for waterbirds. According to Umwelt (2003), thirty (30) threatened bird species have been recorded in the Clarence, the majority of which (75%) are waders. A large area protected under international conservation agreements has been set aside as roosting and feeding habitat for migratory waders. This area is located around the shores of the lower estuary as shown in Fig. 5.

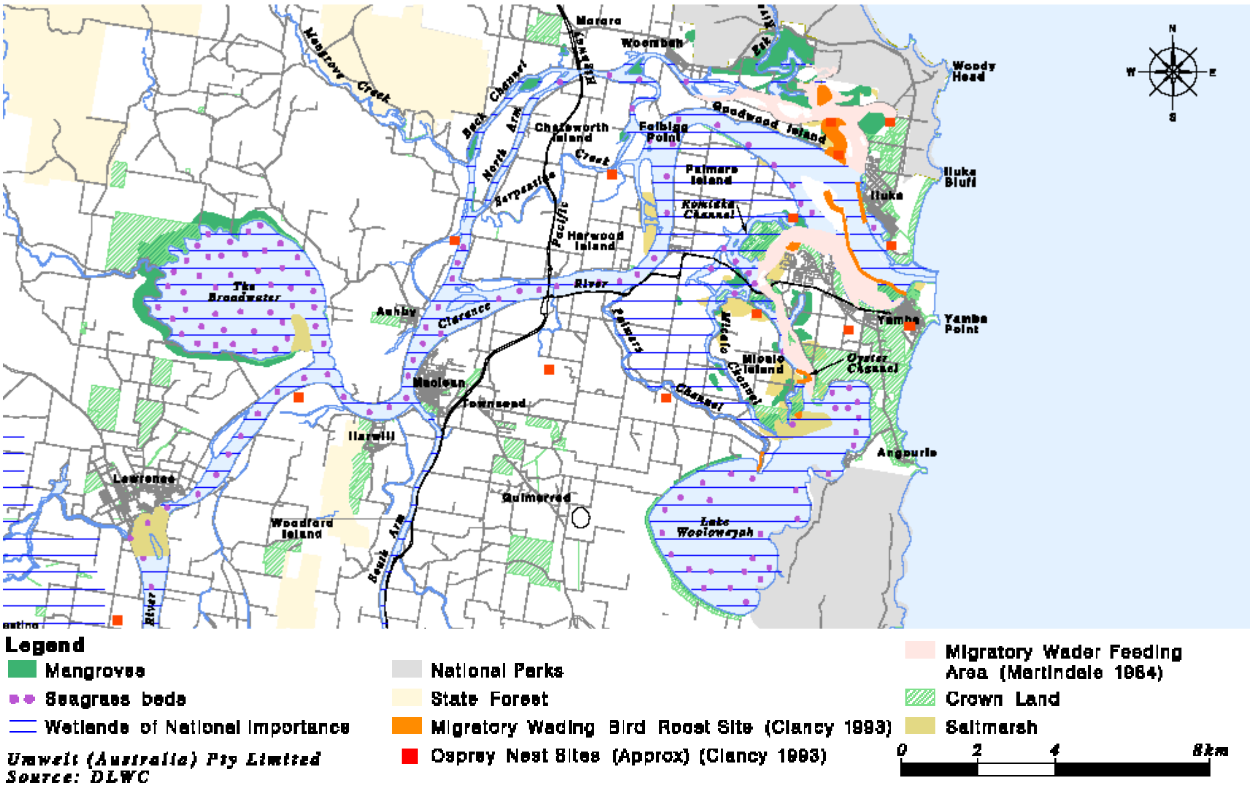


Figure 5. Significant aquatic habitat features found within the study area. Source: Umwelt (2003)

2.6 Water Quality Impacts within the Clarence River

A number of activities conducted within the Clarence River catchment impact upon water quality and subsequently the commercial and recreational qualities of the estuary (both on a broadscale and point source scale).

Below is a brief list and short description of the activities assumed to be impacting upon water quality within the Clarence River (sourced from http://www.dpi.nsw.gov.au/fisheries/habitat/threats/urban):

1. Stormwater and run off – widespread land clearing and development have altered flow regimes;
2. Sedimentation – increased run off and decreased (vegetation) buffering leads to increases in suspended particulate matter within receiving waters;
3. Pesticide pollution – run off from agricultural (and in limited cases residential and commercial lands) containing substances used for pest control has the potential to impact upon aquatic species either directly (via species mortality) or indirectly (habitat impacts);
4. Nutrient pollution – levels of nutrients above the seasonal norm has the potential to impact upon algal and plant growth; and
5. Acid Sulfate Soil – drainage and retention of low-lying lands affected by ASS.

The activities above do not encompass all potential impacting activities within the Clarence River but is considered to describe the major factors affecting the objectives of this study.

3. Sampling Methodology

3.1 General Methodology

SAMPLING AND ANALYSES OF SEDIMENTS AND WATERS COLLECTED FROM THE CLARENCE RIVER ESTUARY, LAGOONS AND TRIBUTARIES

In response to a request from the Professional Fishermen's Association (PFA), EAL has continued a comprehensive assessment of physical and chemical attributes within the Clarence River and at a selected number of tributaries as shown on Fig. 2 and described in Table 1.

Based on information provided by PFA, eighteen (18) sediment and near-surface water samples were collected between the River Mouth and the Ulmarra ferry.

Sediment and Water samples were analysed for the physicochemical parameters and specific analytes listed on Tables 2 & 3.

Table 2. Physicochemical parameters and specific analytes undertaken for each sediment sample

Sample Media	**Analytes**			
Sediment	Physico-chemical	Texture pH$_{1:5}$ EC$_{1:5}$	Chloride Sulfate	
	Specific Contaminants	Silver Arsenic Lead Cadmium Chromium Copper	Manganese Nickel Selenium Zinc Mercury Iron	Aluminium Tin
	Acid Sulfate Soils	Oxidisable Sulfur Titratable Actual Acidity Acid Neutralising Capability		

Table 3. Physicochemical parameters and specific analytes undertaken for each water sample

Sample Media	**Analytes**		
Water	Physico-chemical	pH Electrical Conductivity (EC) Total Dissolved Solids (TDS) Total Suspended Solids (TSS) Bicarbonate Chloride Sulfate	Water Hardness Biochemical Oxygen Demand (BOD) Total Phosphorus (TP) Orthophosphate Total Nitrogen Nitrate Nitrite Ammonia
	Specific Contaminants	Sodium Potassium Calcium Magnesium SAR Silver Aluminium Arsenic Cadmium Chromium Copper	Iron Manganese Nickel Lead Zinc Mercury Tin

In addition to the analysis effort described in Table 3, physicochemical profile data for each specific site was collected to provide a vertical representation of specific parameters present at the time of sampling encountered at each site.

3.2 Sampling Methodology

EAL staff conducted the sampling and monitoring over a two-day period (13th & 14th December 2010), attending all eighteen sites and establishing the vertical profile of each site shown in Fig. 2.

In situ water quality testing was undertaken from a 14ft vessel anchored over each site. Following profile logging for pH, EC, salinity, temperature, turbidity, Dissolved Oxygen (DO) and Total Dissolved Solids (TDS), water samples were collected in close proximity to the benthic surface. Samples were collected via pumping (12V submersible pump) and transferred immediately to the following containers:

1. 1L Plastic bottle (unpreserved);
2. 500mL Glass bottle (unpreserved);
3. Two 43mL glass vials (Sulfuric acid preservation).

Sediment samples were collected using a grab sampler and were immediately transferred into 250mL glass jars (unpreserved).

All samples were stored in an esky and immediately frozen upon return to the laboratory.

3.3 Adopted Water Quality and Sediment Trigger Values

Adopted trigger levels for aquatic ecosystems are listed where applicable with the laboratory results displayed on Appendices A to C.

Guideline values have been adopted based on the most recent applicable information with sources of trigger levels derived from the following publications:

- ANZECC 2000, *Australian Water Quality Guidelines for Fresh and Marine Waters, National Water Quality Management Strategy*;
- QWQG 2009, *Queensland Water Quality Guidelines*;
- Stone et al. (1998) Acid Sulfate Soil Manual ASSMAC, NSW Aust.; and
- SCBD 2006, *Global Biodiversity Outlook 2.*

4. Current Results

4.1 Analysis and Monitoring Results

Laboratory results for Water Quality. Sediments and Acid Sulfate Soils analysis results are provided in Appendices A, B and C respectively.

Depth profiling Site Log Sheets 1 – 18 are shown as Appendix D, with each site logged as per the description provided above in Section 3.1.

4.1.1 Surface Water Monitoring Results

Surface water monitoring shows substantial variation between the regions in terms of EC (refer Fig. 6) with pH (although within the upper and lower limits) also displaying a similar trend in variation. Minor variation in water temperature are also observed, however; when compared with DO (Dissolved Oxygen), significant drops in Dissolved Oxygen levels can be seen at sites SW18, SW8 and SW11 (refer Fig. 7).

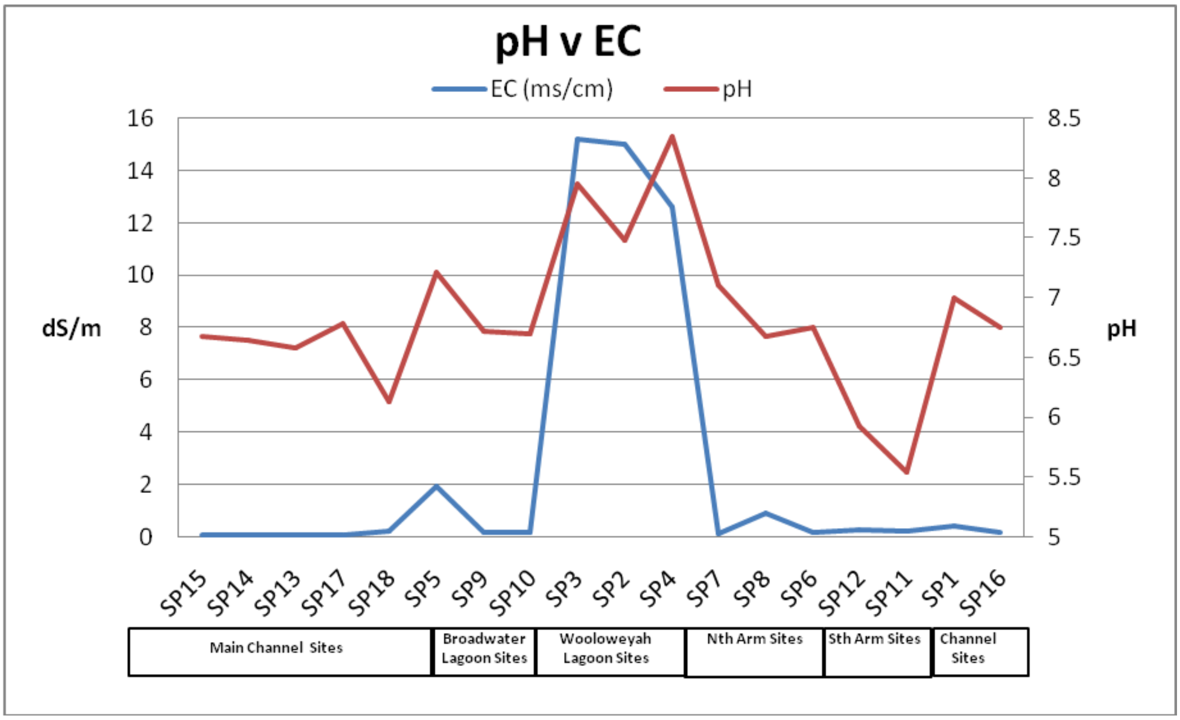


Figure 6. pH and EC (monitoring data 2010)

Levels of Total dissolved Salts (TDS) and Turbidity observed during sampling were found to be elevated in the lagoon sites, principally within Lake Wooleweyah. Turbidity results for SP2, SP3, and SP4 were above the maximum limit of the reporting for the field instrumentation (i.e. values not recorded). Fig. 8 graphically demonstrates the results recorded for Turbidity and TDS during field measurements.

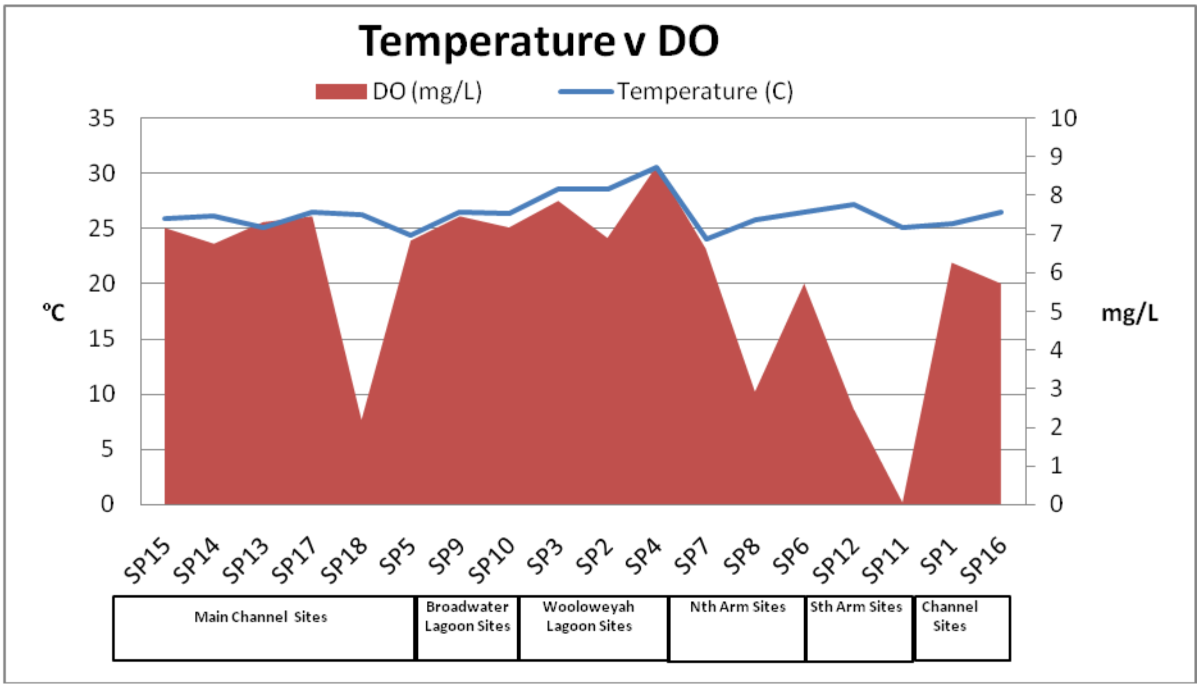


Figure 7. Temperature and Dissolved Oxygen (monitoring data 2010)

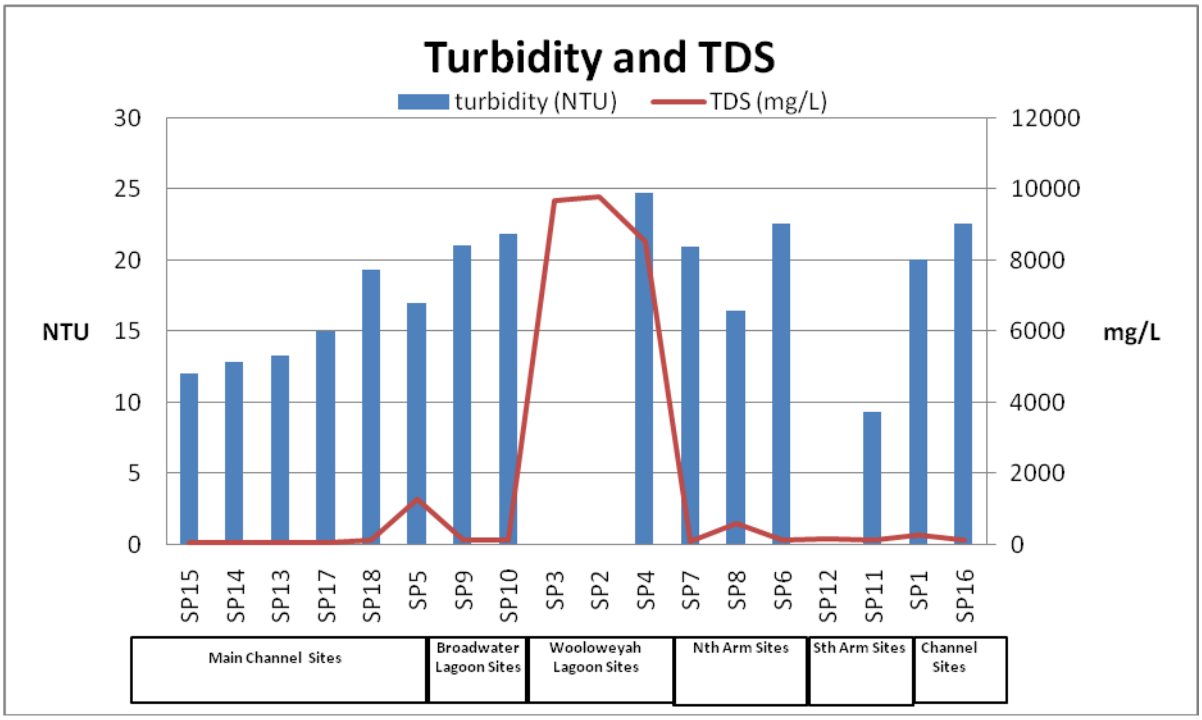


Figure 8. Turbidity and TDS (monitoring data 2010)

4.1.2 Surface Water Analysis Results

Laboratory recorded pH values displayed minor to moderate variation (in most cases) when compared with field measures (0 – 16%) with a typical increase observed. Six (6) of the eighteen sample sites displayed pH values below the adopted lower limit as defined by QWGG (2009).

Nutrient levels for both Total Nitrogen (TN) and Total Phosphorus (TP) were recorded as consistently exceeding the adopted trigger values in all sites. NO_x values (Nitrate, Nitrite and Ammonia) were also found to be elevated in most sites with the notable exception of Lake Wooleweyah). Refer Appendix A for laboratory results for nutrient analyses. With regard to concentrations of metals recorded in surface water samples, the heavy metals Iron (Fe), Aluminium (Al), and Zinc (Zn) periodically occurred in concentrations exceeding the adopted trigger values (please note that Fe does not currently possess a trigger value).

4.1.3 Sediment Analyses

Metals within sediments did not emulate concentrations (of heavy metals) observed within the water column with no correlation between total metals detected in sediment against total metals within waters. Figs. 9 and 10 show the concentrations of metals Fe and Al comparatively between the sample media (i.e. sediment and waters).

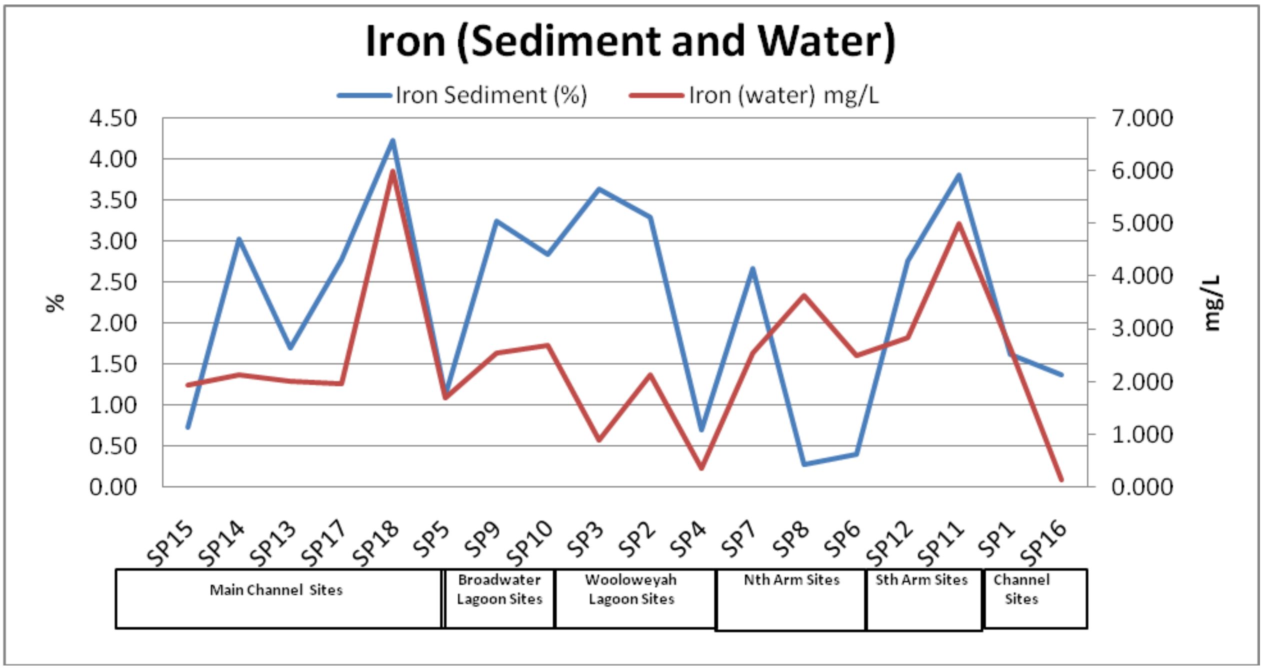


Figure 9. Sediment and Water Fe concentrations 2010

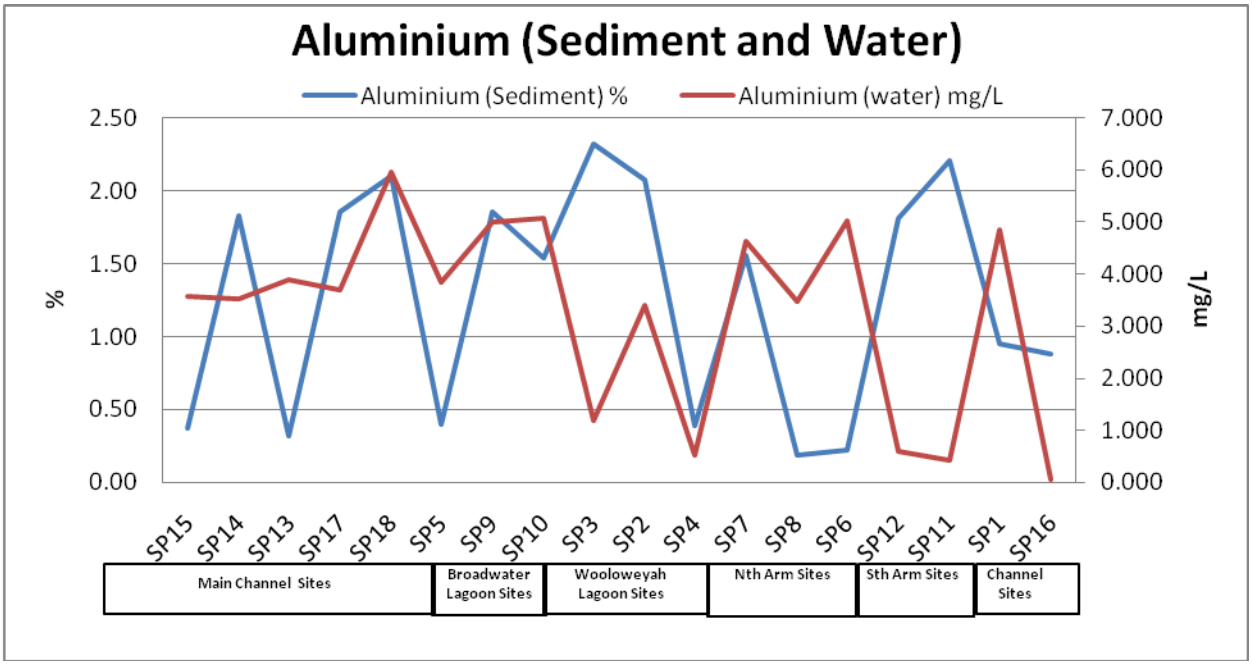


Figure 10. Sediment and Water Al concentrations 2010

Chloride Sulfate ratios were varied across the sampling area, with variation obviously dependent upon the separation between marine and freshwater inputs. The presence and concentration of Fe and Al (in sediment) is directly proportionate, as shown in Fig. 11.

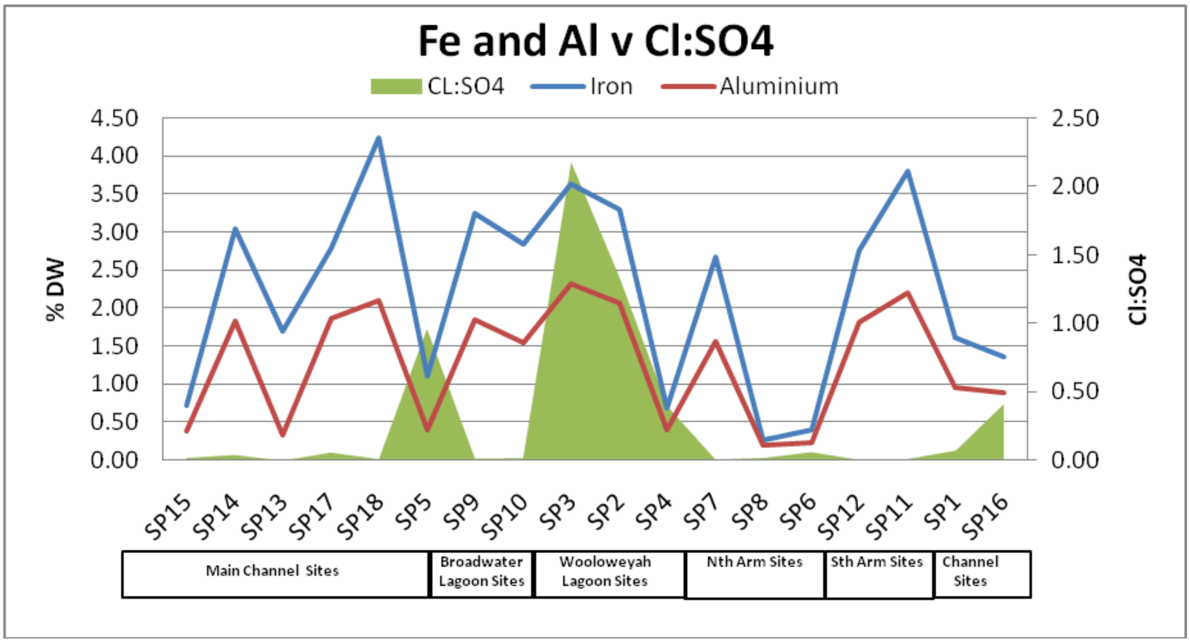


Figure 11. Al and Fe concentrations with Cl:SO$_4$ 2010

4.1.4 Acid Sulfate Analyses

Net Acid Generating Potential within sediments is seen to be positive and above the standard ASS action criteria (refer Fig. 11). Acid Neutralisation Capacity (ANC) was found to be present in SP3, SP2, SP4 and SP16 suggesting a limited acid buffering capacity is present in these specific sites.

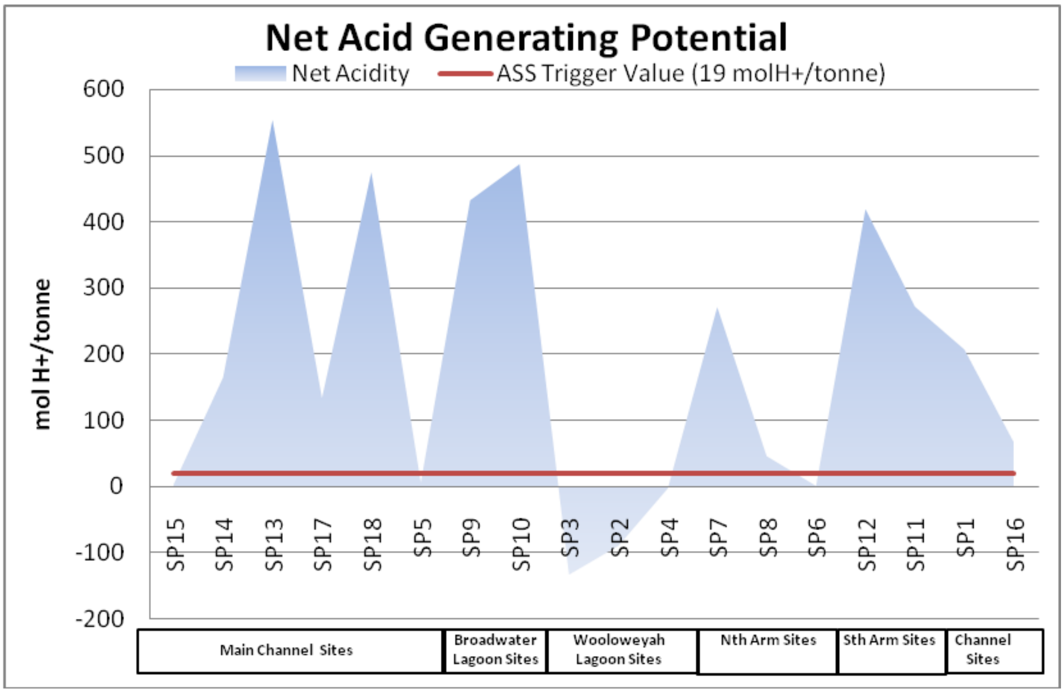


Figure 12. Net Acid Generating Potential 2010

4.2 Comparative Examination

The sampling and analysis effort executed has provided representative depiction of the individual conditions at each sampling location at the time of sampling. Therefore, the results obtained represent a snapshot of the sites for the specific tidal and seasonal conditions prevalent at that time. The comparisons drawn between both sampling periods have not been normalised to minimise and discount naturally occurring variables. The following provides a brief comparison of key parameters for each sampling location for the year 2010 and comparison with corresponding results from the 2009 sampling effort.

4.2.1 Suspended Solids & pH Monitoring Results

Figs. 13, 14 & 15 show the 2009 & 2010 results for Total Suspended Solids (TSS) and pH for each identified Hydrological Region. Generally, TSS trigger value (20mg/L) was exceeded in the 2010 sampling run at Lake Wooloweyah only. Whilst pH (2010) were recorded to be below the normal values for estuaries at SP18 (Main Channel), SP8, SP12, SP11 & SP1 (Tributaries).

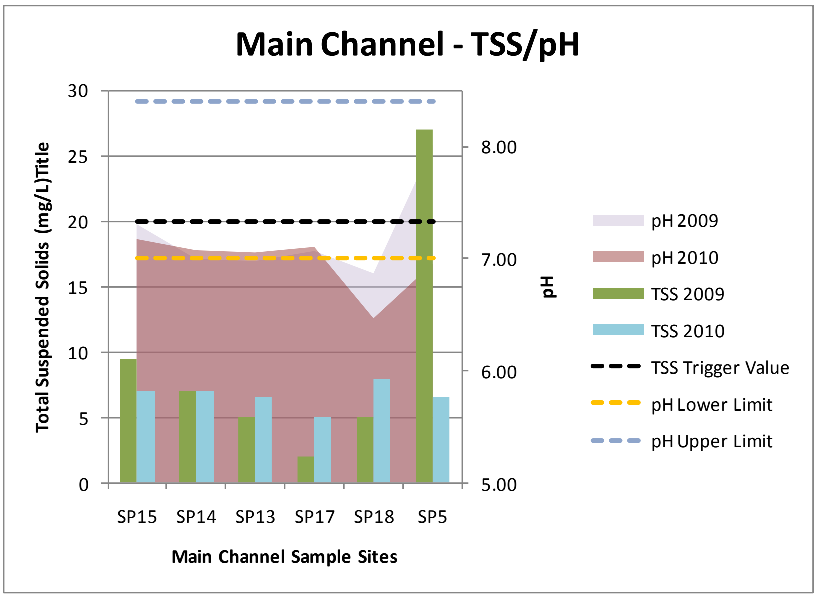


Figure 13. Main Channel TSS & pH results. TSS results for 2010 are all below trigger value, whilst TSS trigger value was exceeded at SP5 in 2009. pH values were below normal values at SP18 in both sampling years.

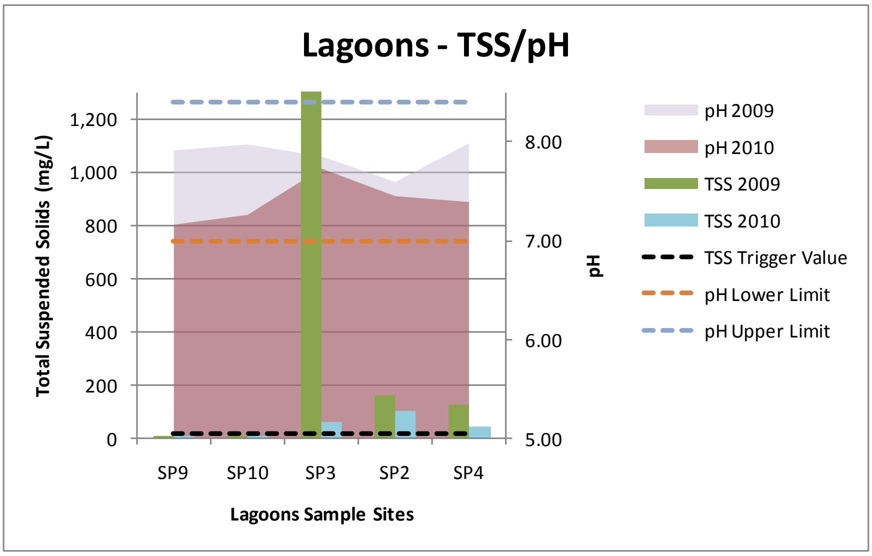


Figure 14. Lagoons TSS & pH results. TSS results for Broadwater (SP9 & SP10) are below trigger value in both sampling years, whilst TSS trigger value for Lake Wooloweyah were exceeded at all 3 sampling sites (SP3, SP2 & SP4) in both sampling years. pH values were within normal values for all lagoons sites in both sampling years.

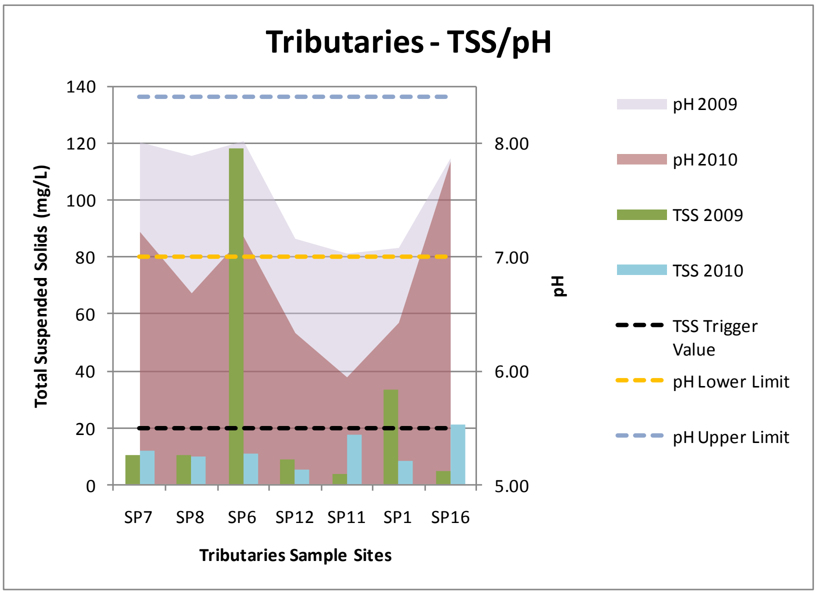


Figure 15. Tributaries TSS & pH results. 2010 TSS results for all sites were below trigger value, whilst 2009 TSS trigger value were exceeded at SP6 & SP1. 2010 pH values were below normal values at SP8, SP12, SP11 & SP1.

4.2.2 Nutrients (N & P) & TSS Sampling Results

Figs. 16, 17 & 18 show the 2009 & 2010 results for Total Nitrogen (N), Total Phosphorous (P) & Total Suspended Solids for each identified Hydrological Region. TSS values are discussed in Section 5.1.2; however, they are also shown in the following graphs to highlight the TSS relationship with nutrients. Notably, Total Nitrogen has exceeded the trigger value of 0.3 (mg/L N) at all sites in both sampling years. Total Phosphorous trigger value (0.025 mg/L P) was also exceeded in both sampling years at all Main Channel and Tributaries Sites, and Lake Wooloweyah (lagoons sites). At the Lagoons Sites, P was below trigger value in 2009 at SP9 & SP10 (Broadwater), but above trigger value in 2010.

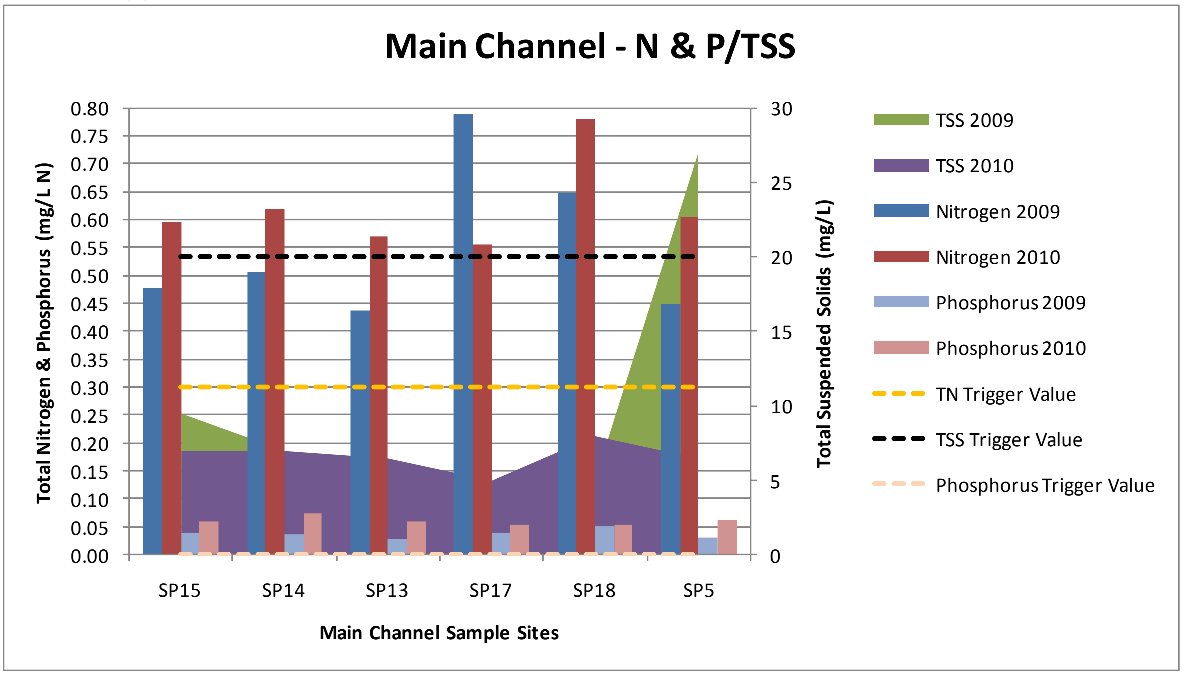


Figure 16. Main Channel N, P & TSS results. N & P results at all sites are above respective trigger values in both sampling years

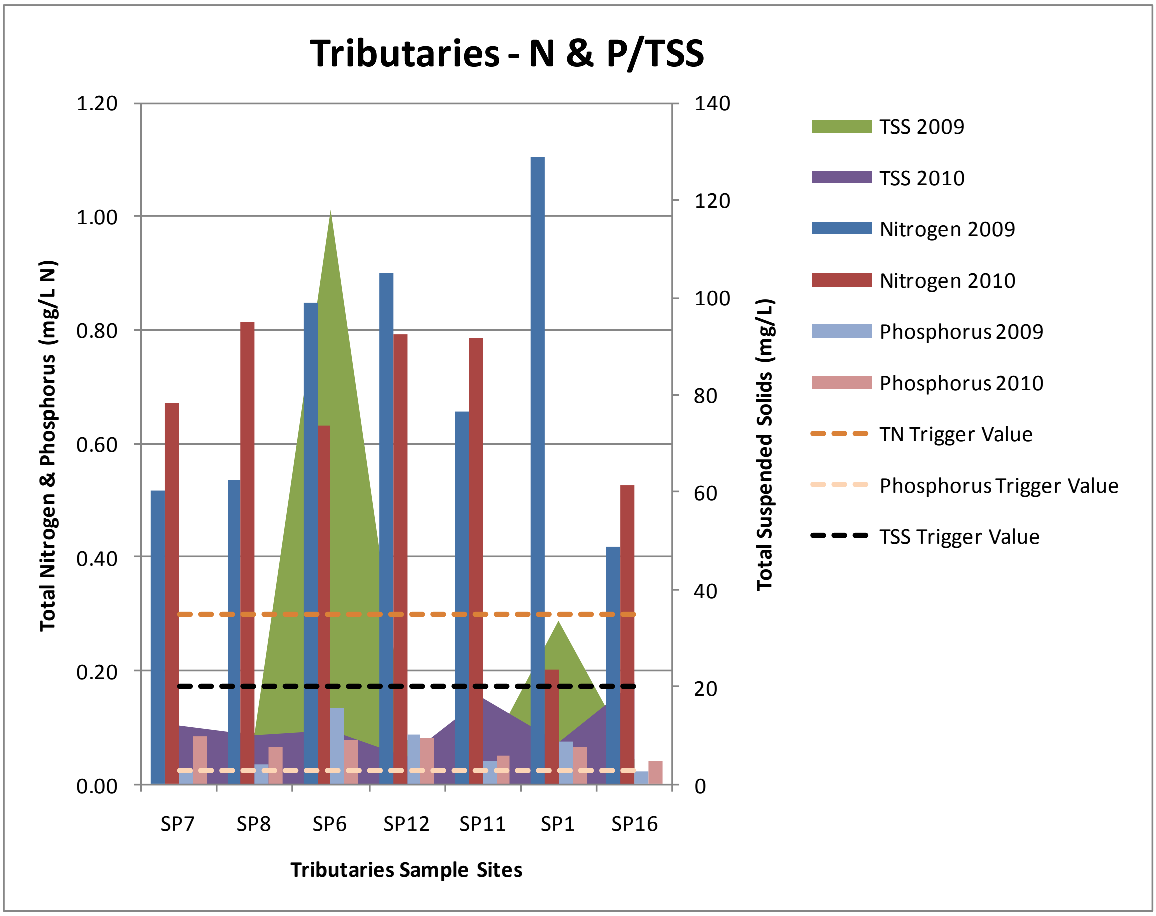


Figure 17. Tributaries N, P & TSS results. N & P results at all sites are at or above respective trigger values in both sampling years.

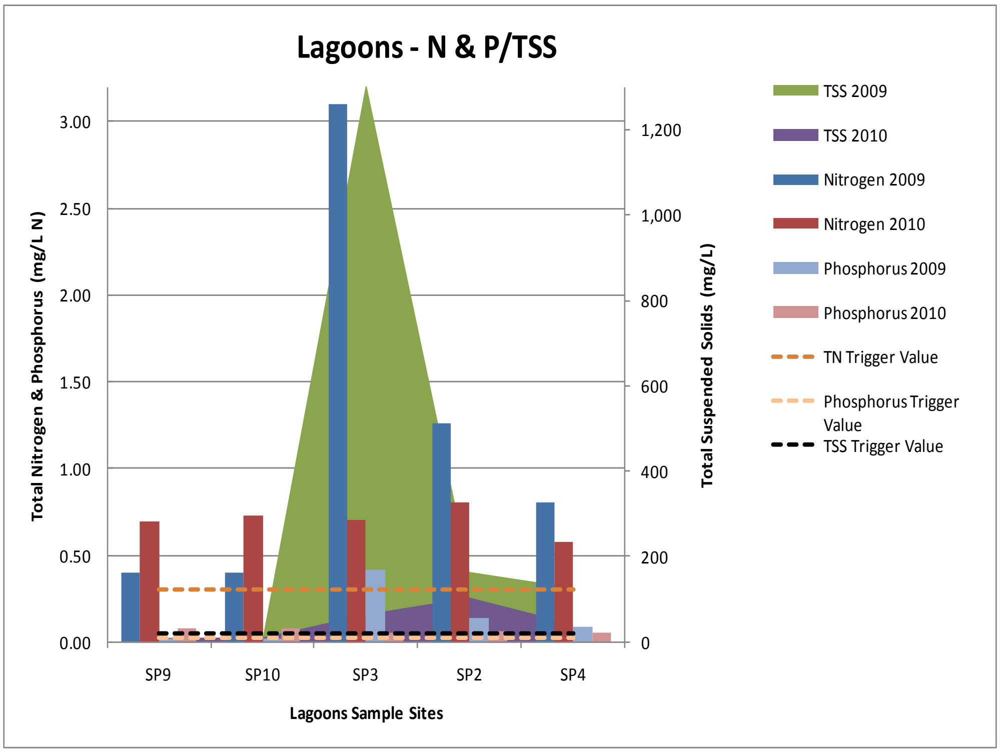


Figure 18. Lagoons N, P & TSS results. N & P results are at or above respective trigger values in both sampling years for most sites. Note the 2009 TSS spike at SP3 coinciding with a spike in N value

4.2.3 Dissolved Inorganic Nitrogen Sampling Results

Dissolved Inorganic Nitrogen (DIN) comprises nitrate-N (NO_3^-), ammonia-N (NH_4^+) and nitrite-N (NO_2^-). Figs. 19, 20 & 21 show the 2009 & 2010 results for DIN for each identified Hydrological Regions. Nitrate & Ammonia values in 2010 generally exceeded the guidelines at most sites except for some of the sites at Lake Wooloweyah, which were below trigger levels.

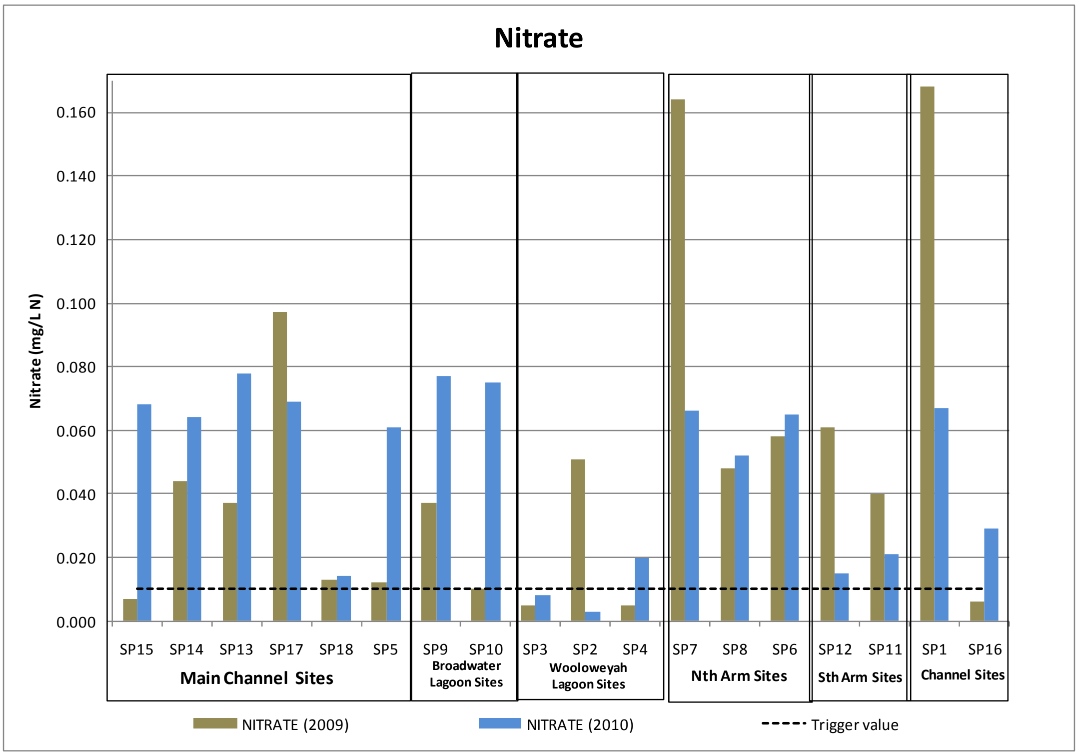


Figure 19. Nitrate trigger level (0.1 Mg/L N) was generally exceeded in 2010 at most sites, except for Sites SP3 & SP2

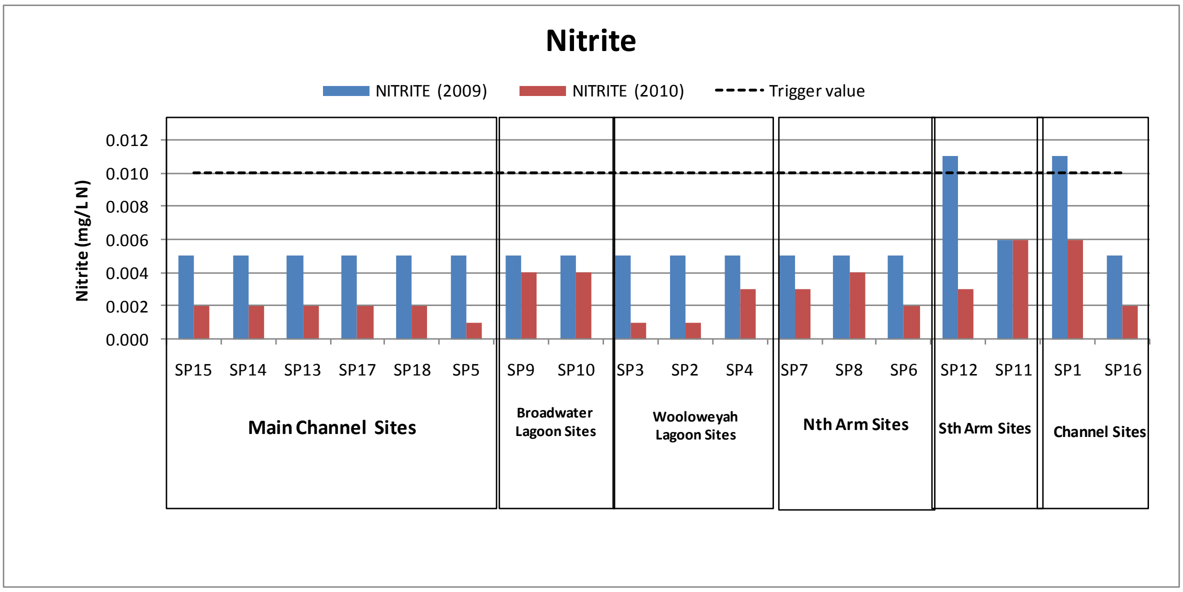


Figure 20. Nitrite trigger level (0.1 Mg/L N) was never exceeded in 2010

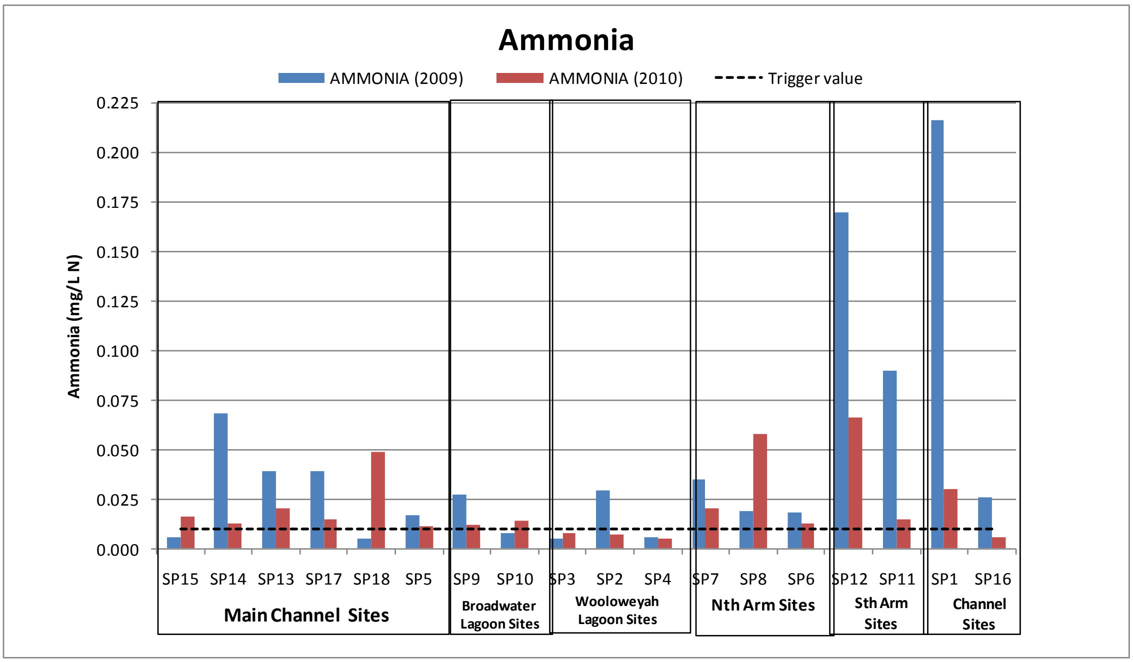


Figure 21. Ammonia trigger level (0.1 Mg/L N) was generally exceeded in 2010 at most sites, except for Sites SP3, SP2 & SP4 (Lake Wooloweyah) and SP16 (Channel Site)

4.2.4 Total N & DIN Sampling Results

The relationship between Dissolved Inorganic Nitrogen (DIN) and Total Nitrogen results for each sampling year are shown on Figs. 22 & 23.

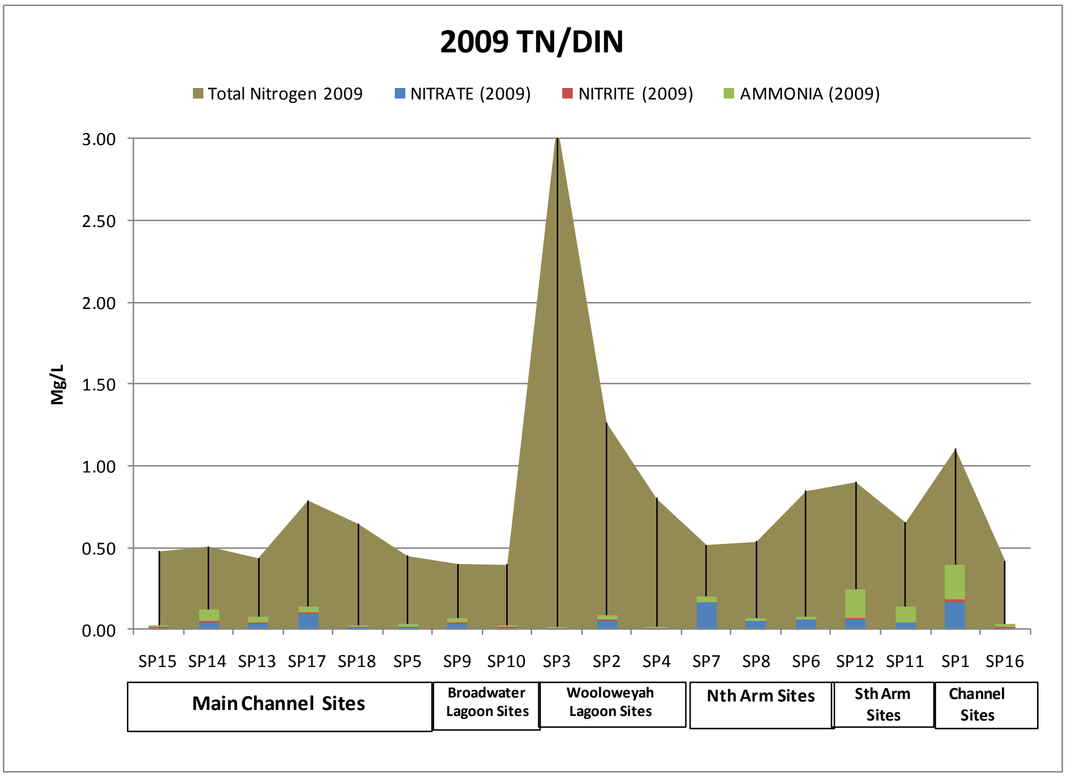


Figure 22. TN & DIN (Nitrate + Nitrite + Ammonia) results for 2009 for each sampling site

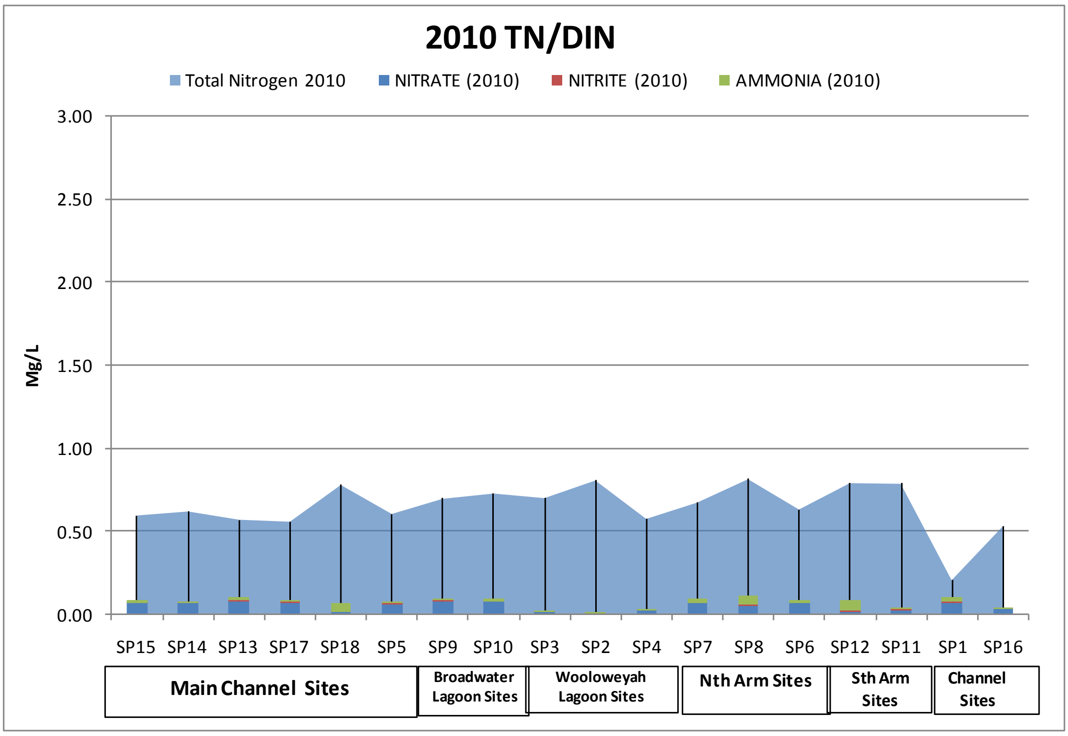


Figure 23. TN & DIN (Nitrate + Nitrite + Ammonia) results for 2010 for each sampling site

4.2.5 Conductivity Results

The 2009 & 2010 results for Electrical Conductivity (a measure of salinity) for each identified Hydrological Regions are shown on Fig. 24. Salinity levels are considerably lower at all sites in the 2010 sampling run despite a relatively lower rainfall when compared to last year's records (see Fig. 5 in Section 3.4).

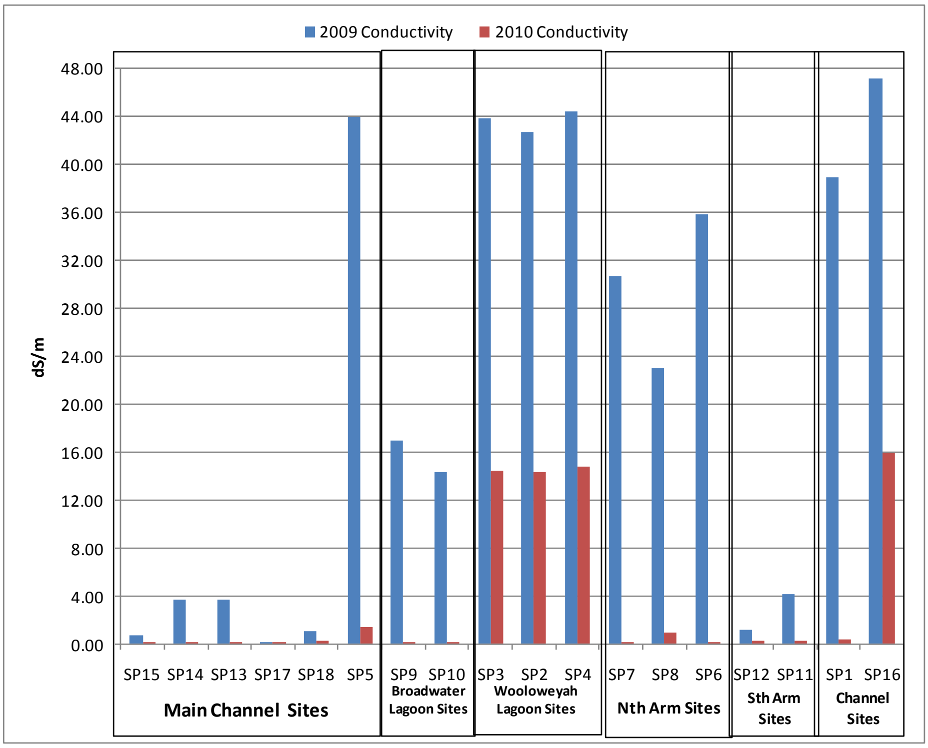


Figure 24. Graph comparing Electrical Conductivity recorded for each site in both sampling years

4.2.6 Dissolved Oxygen & Biochemical Oxygen Demand Results

The 2009 & 2010 results for Dissolved Oxygen (DO) & Biochemical Oxygen Demand (BOD) for each identified Hydrological Regions are shown on Fig. 25. DO trigger level of less than 5 mg/L was recorded for SP12 & SP11 (South Arm), SP8 (North Arm) and SP18 (Main Channel) in both sampling years.

In regard to BOD, results in the order of 3-4 mg/L indicate lightly polluted waters; whilst results in the order of 5-7mg/L are indicative of moderately polluted waters. BOD levels for SP3 & SP2 (Lake Wooloweyah) are indicative of lightly to moderately polluted waters. However, DO levels at the same sites (for both years) display concentrations well above 5 mg/L, which is an indicator of good water quality.

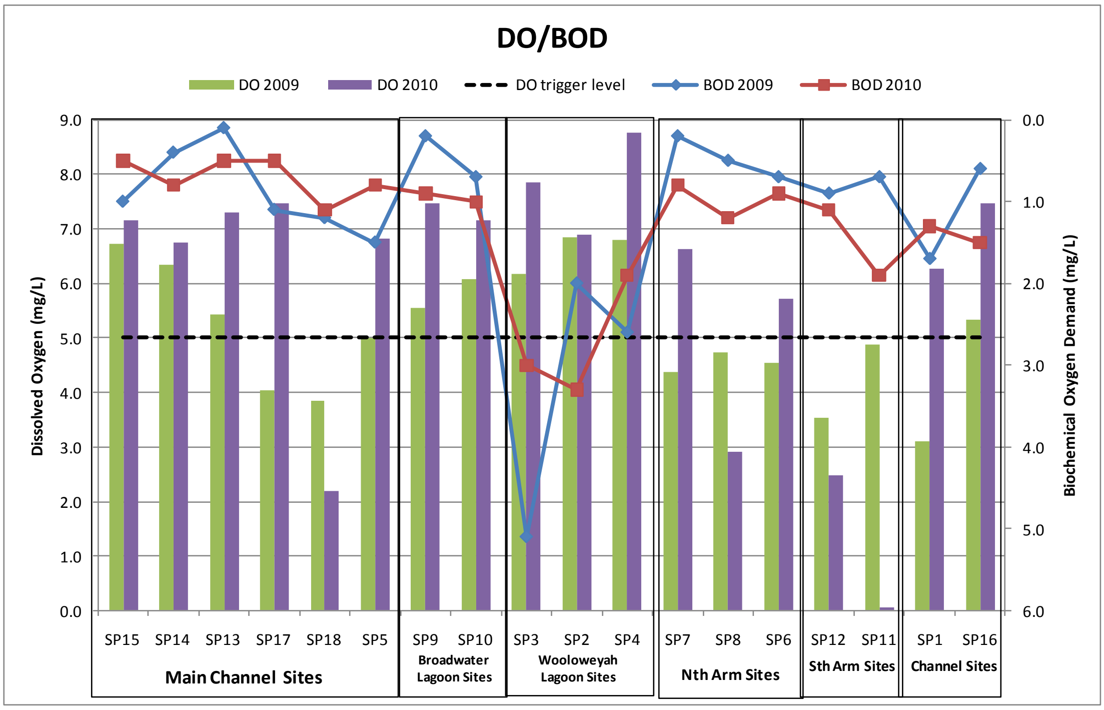


Figure 25. Dissolved Oxygen (DO) & Biochemical Oxygen Demand (BOD) concentrations for each identified Hydrological Region

4.2.7 Sediment Sampling Results

The relationship between pH levels in water and concentrations of Inorganic Sulfur (% chromium reducible S) in sediment for each sampling year is shown on Fig. 26. Whilst Fig. 27 displays the concentrations of Inorganic Sulfur in sediment against the Chloride/Sulfate ratio in water.

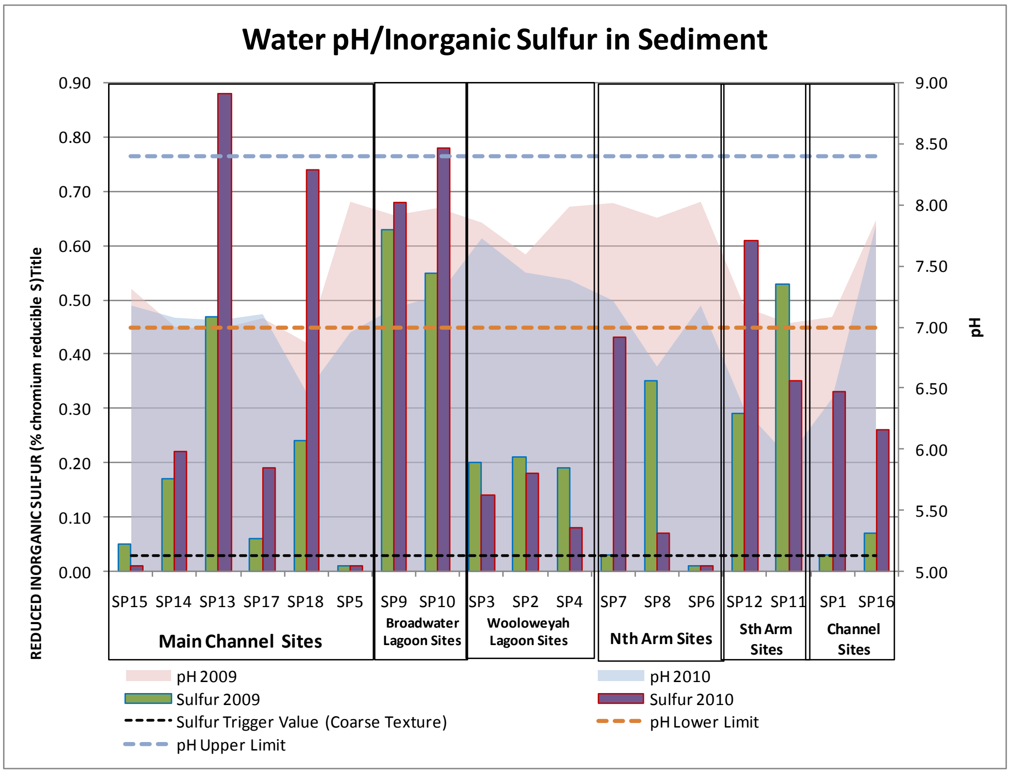


Figure 26. Inorganic Sulfur in sediment for each sampling year compared to pH in water

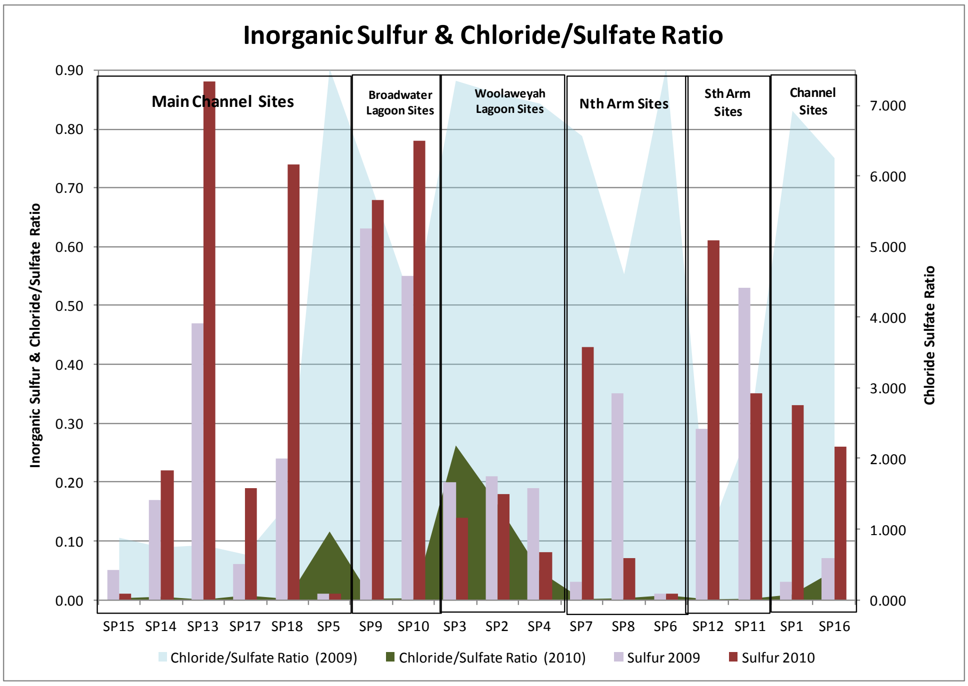


Figure 27. Chloride/Sulfate Ratio is compared with Inorganic Sulfur in sediment for each sampling year

4.2.8 Dissolved Metals Results

Dissolved Aluminium (Al) and Iron (Fe) concentrations were considerably higher in 2010 than those recorded in 2009 as shown on Figs. 28 & 29. In regard to Aluminium concentrations, only SP16 recoded lower concentrations than last year. Notably at pH <6.5, Aluminium concentrations of 0.055 mg/L or greater is of concern. At SP1 & SP18, where ph is less than 6.5, the Aluminium concentrations for 2010 are considerably greater than 0.055 mg/L (refer to Fig. 28).

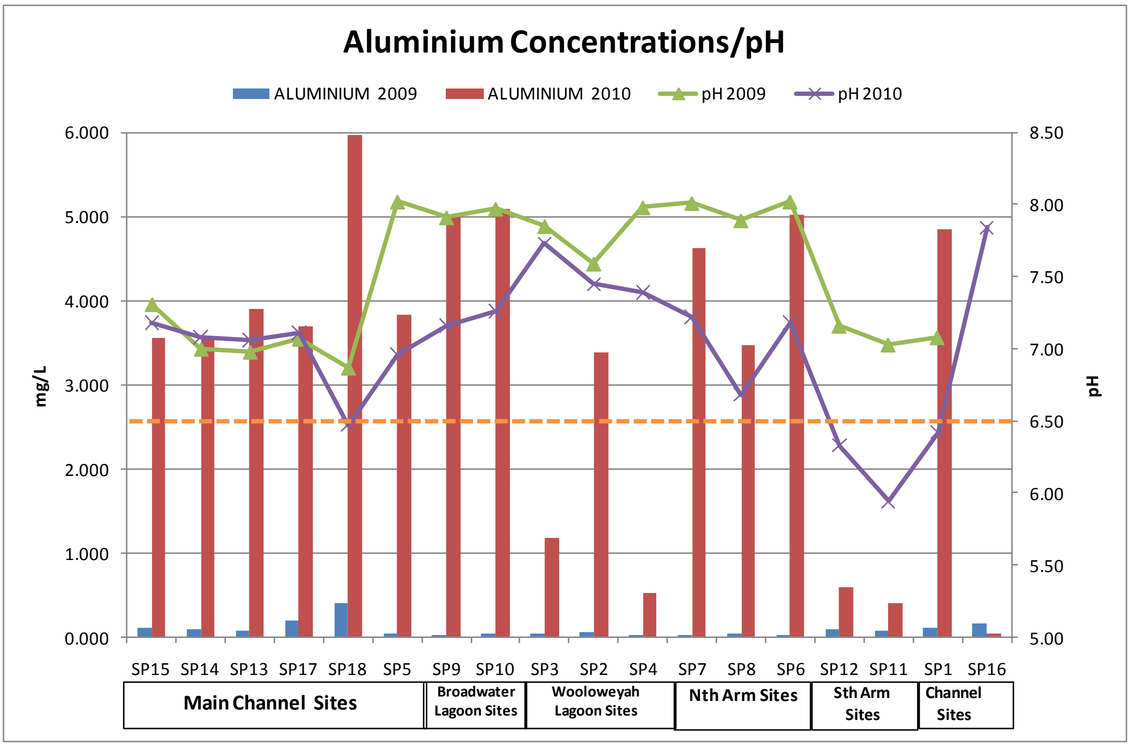


Figure 28. Al concentrations for 2010 are considerably greater at the majority of sites than those recorded in 2009. PH levels are also shown, at pH <6.5, Al concentrations of 0.055 mg/L or greater is of concern

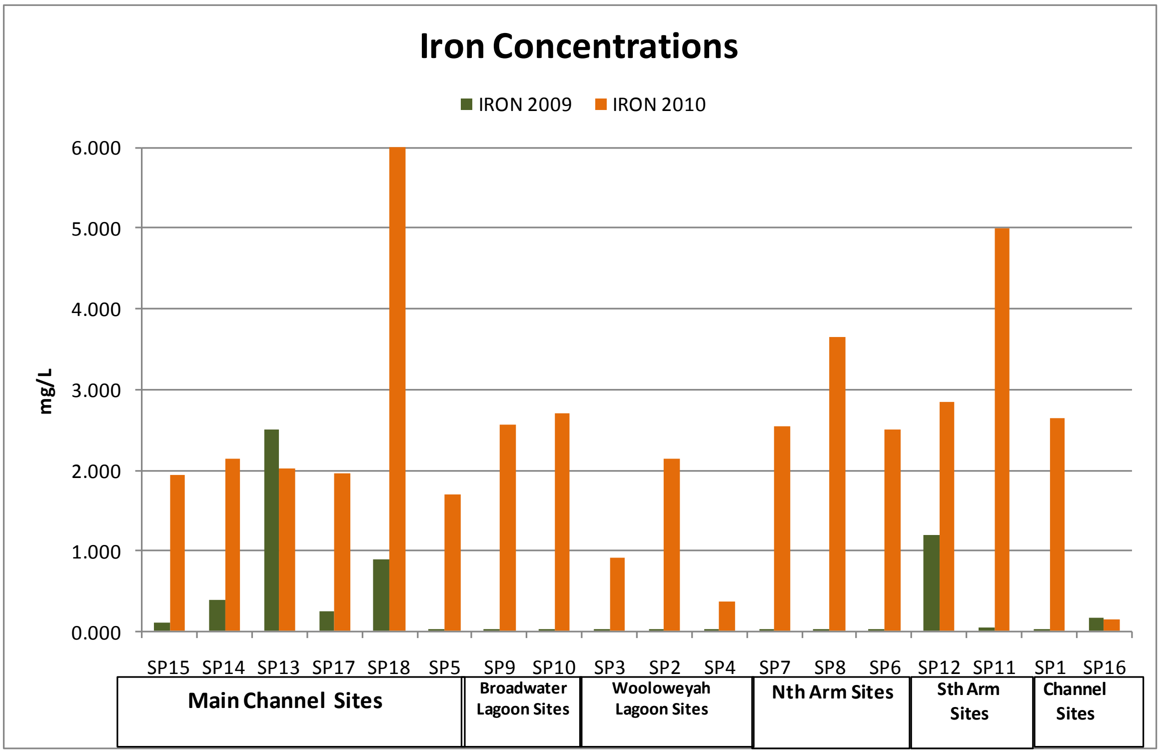


Figure 29. Fe concentrations for 2010 are considerably greater at the majority of sites than those recorded in 2009

Figs. 30 & 31 show the Al and Fe concentrations for each sampling year when compared with Sulfate (in water). Notably, Sulfate levels are lower in 2010 than those recorded in 2009, whilst Al & Fe are generally higher in 2010 that the concentrations recorded in 2009.

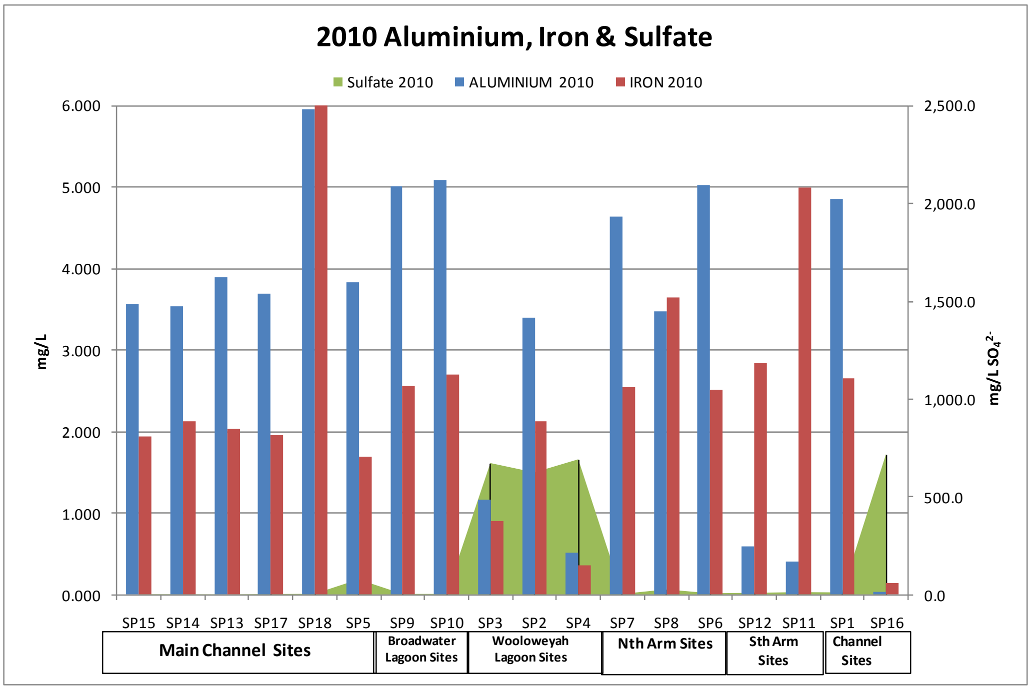


Figure 30. Al & Fe results for 2010 and sulfate

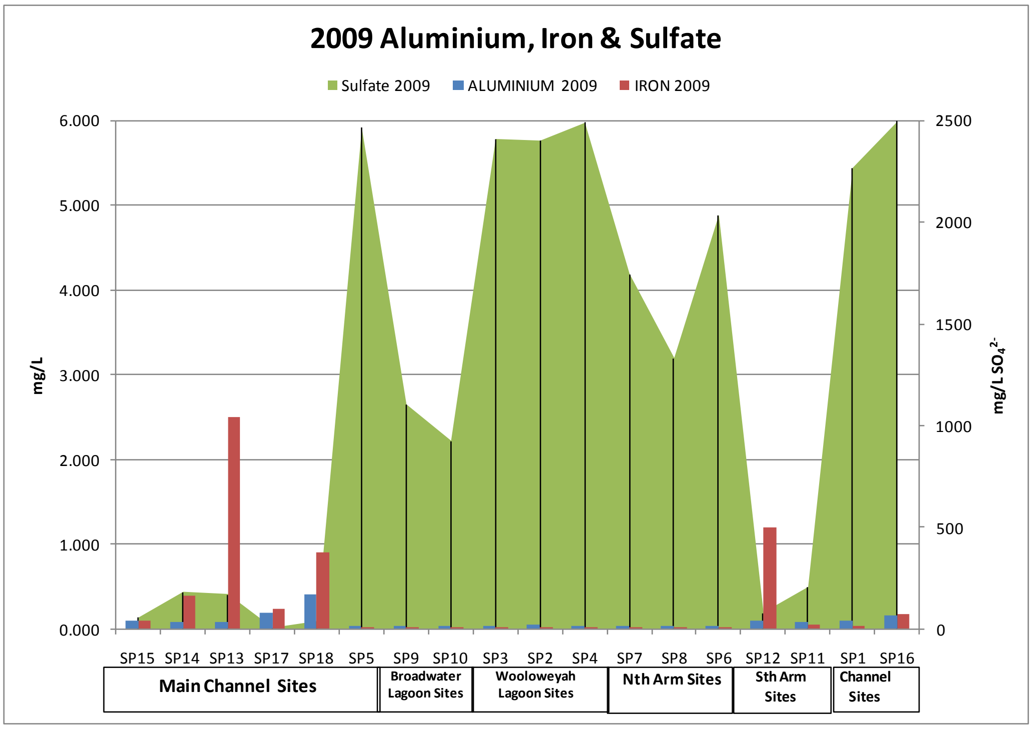


Figure 31. Al & Fe results for 2009 and sulfate

Figs. 32 & 33 show the Al and Fe concentrations for each sampling year when compared with the Chloride/Sulfate Ratio.

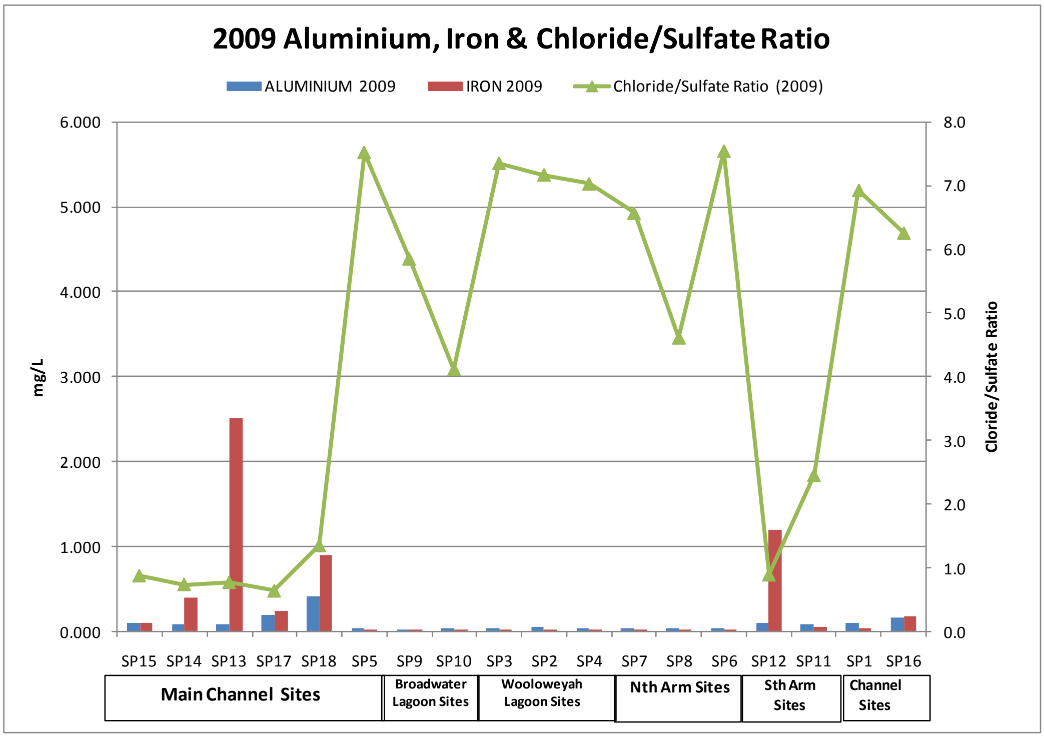


Figure 32. Al & Fe results for 2009 and chloride /sulfate ratio

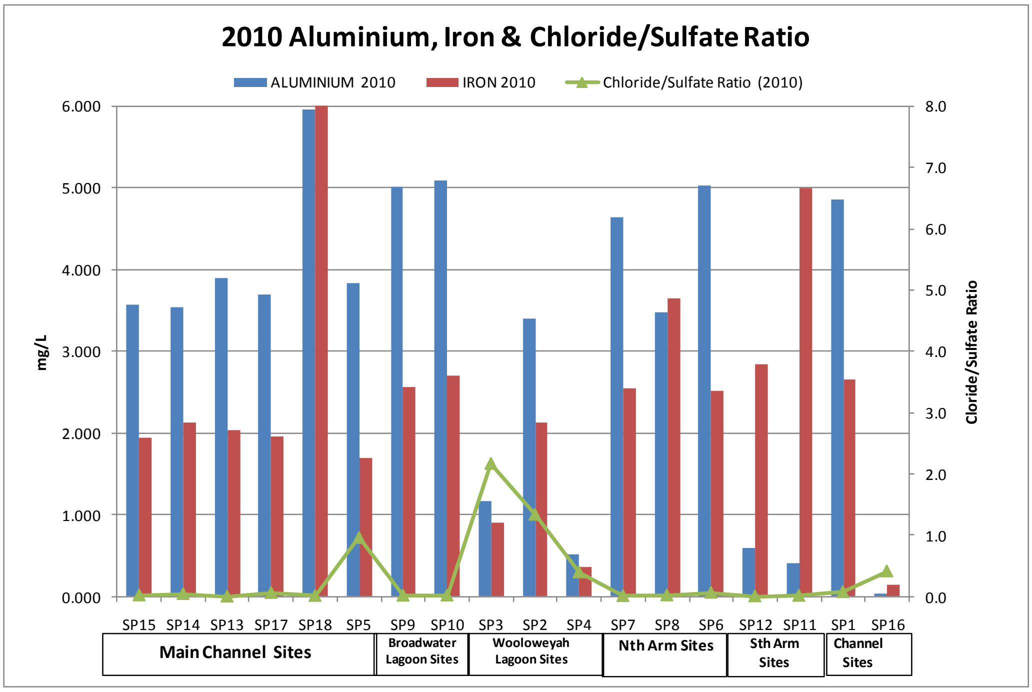


Figure 33. Al & Fe results for 2010 and chloride /sulfate ratio

5. Discussion

Key points noted during the comparison between the previous data and analysis and monitoring results collected for this period:

- 2010 rainfall totals for the year prior to sampling were lower than those recorded for same period at each of the three (3) monitoring stations in 2009, as shown on Fig. 3 - Section 3.4. Whilst, rainfalls for the month prior to sampling were higher in 2010 at all 3 stations than those recorded for the same period in 2009. Rainfall for the 48 hours prior to sampling was greater in 2009 at the Harwood station and similar at the other 2 stations for both sampling years;

- TSS trigger value (20mg/L) was exceeded in the 2010 sampling run only at Lake Wooloweyah;
    - Note that trawling was underway during the time of sampling at this location.

- pH (2010) values were recorded to be below the normal values for estuaries at SP18 (Main Channel), SP8, SP12, SP11 & SP1 (Tributaries);

- EC was considerably lower at all sites during the 2010 sampling run;
    - Denotes a reduction in marine influence upon the estuary (in contrast to values recorded during the 2009/2010 effort).

- Total Nitrogen has exceeded the trigger value of 0.3 (mg/L N) at all sites in both sampling years. Total Phosphorous trigger value (0.025 mg/L P) was also exceeded in both sampling years at all Main Channel and Tributaries Sites, and Lake Wooloweyah (lagoons sites). At the Lagoons Sites, P was below trigger value in 2009 at SP9 & SP10 (Broadwater), but above trigger value in 2010.

- Nitrate & Ammonia values in 2010 generally exceeded the guidelines at most sites except for some of the sites at Lake Wooloweyah, which were below trigger levels.

- DO at levels of less than 5 mg/L (i.e. below trigger level) were recorded for SP12 & SP11 (South Arm), SP8 (North Arm) and SP18 (Main Channel) consistently in both sampling periods;

- BOD levels for SP3 & SP2 (Lake Wooloweyah) are indicative of lightly to moderately polluted waters. However, DO levels at the same sites (for both years) display concentrations well above 5 mg/L;
    - DO level is typically governed by water temperature. Note the significant decrease in sites SP 18, SP8, SP6 and SP12 which is largely unconnected to water temperature variations.

- Dissolved Aluminium (Al) and Iron (Fe) concentrations were considerably higher in 2010 than those recorded in 2009. In regard to Aluminium concentrations, only SP16 recoded lower concentrations than last year; and

- Sulfate levels (in water) are lower in 2010 than those recorded in 2009, whilst Al & Fe are generally higher in 2010 that the concentrations recorded in 2009.

Nutrient values encountered for this investigation showed total nutrients were in excess of the adopted guideline values. The deficit difference between TN and DIN values demonstrates that a significant quantity of Nitrogen within the estuary may be in organic forms (refer to Figs 22 & 23). A significant increase in dissolved phase metal Al and Fe was also encountered when compared with the previous year's data.

The sediment analysis does not identify any particular contaminant or specific physicochemical parameter that exceeds the ANZECC/ARMANZ (2000) sediment trigger values. Typically, all samples displayed characteristics of ASS with high Reduced Inorganic Sulfur levels common. Net Acid Generating potential was moderated by endemic Acid Neutralising Capacity being present in some low energy environments; however, the effective neutralising potential of the assumed neutralising agent ($CaCO_3$ in shell) is considered to be largely unavailable. A net increase in Acid Generating potential was observed between the two individual monitoring periods as illustrated in Fig. 34.

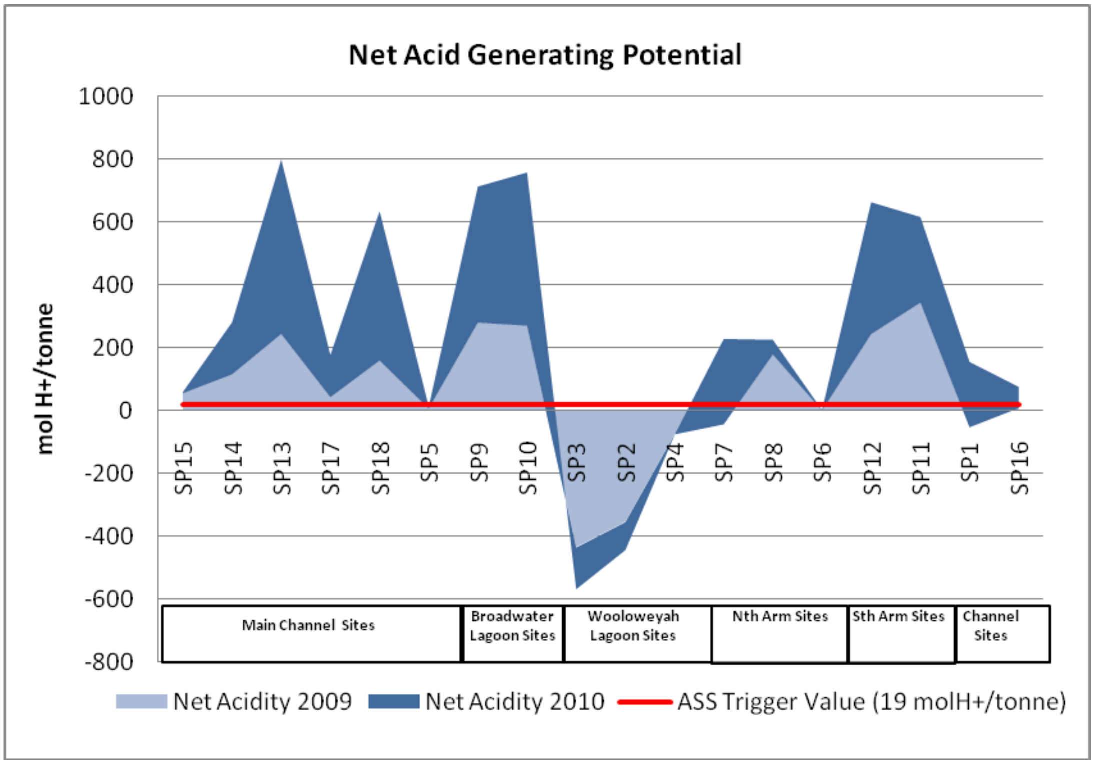


Figure 34. Net Acid Generating Potential (2009 and 2010)

A reduction in marine influence is evident based on the reduction in chloride and sulfate concentrations observed throughout the estuary and connected hydraulic regions during the recent monitoring phase. When compared to the previous year's data, the $Cl:SO_4$ ratio displays more variation throughout the (estuarine) system suggesting (with a decrease in marine influence) an increase in the production of sulfate originating from upstream and low energy environments (see Figs. 35, 36 and 37).

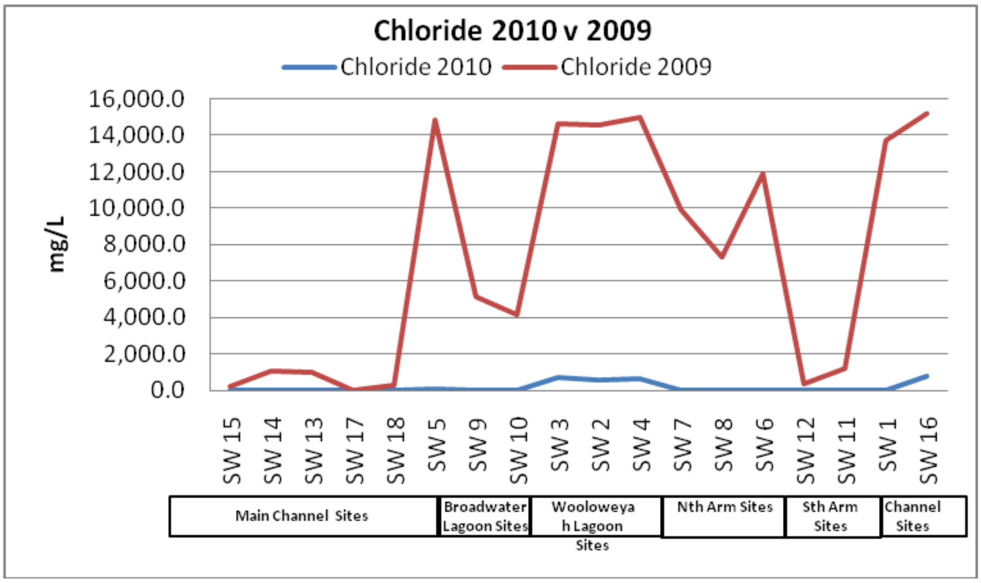


Figure 35. Chloride concentration (2009 and 2010)

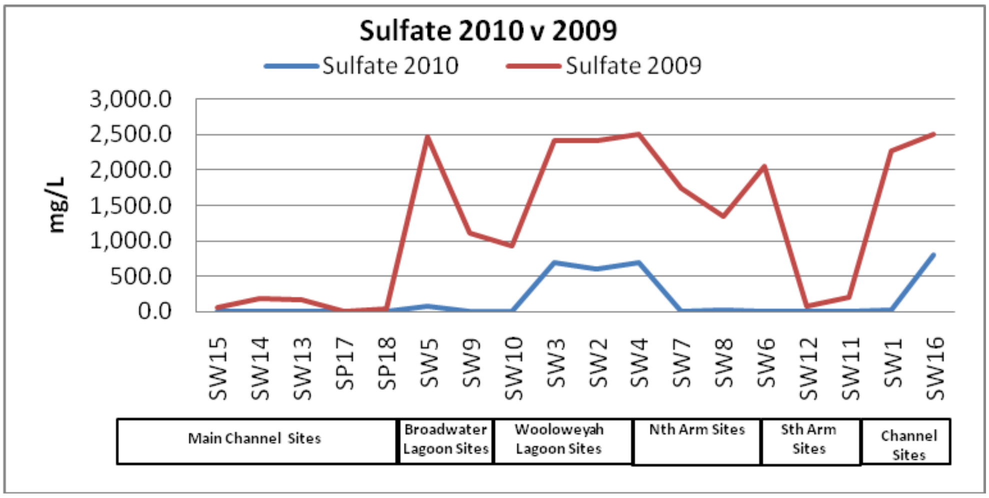


Figure 36. Sulfate Concentration (2009 and 2010)

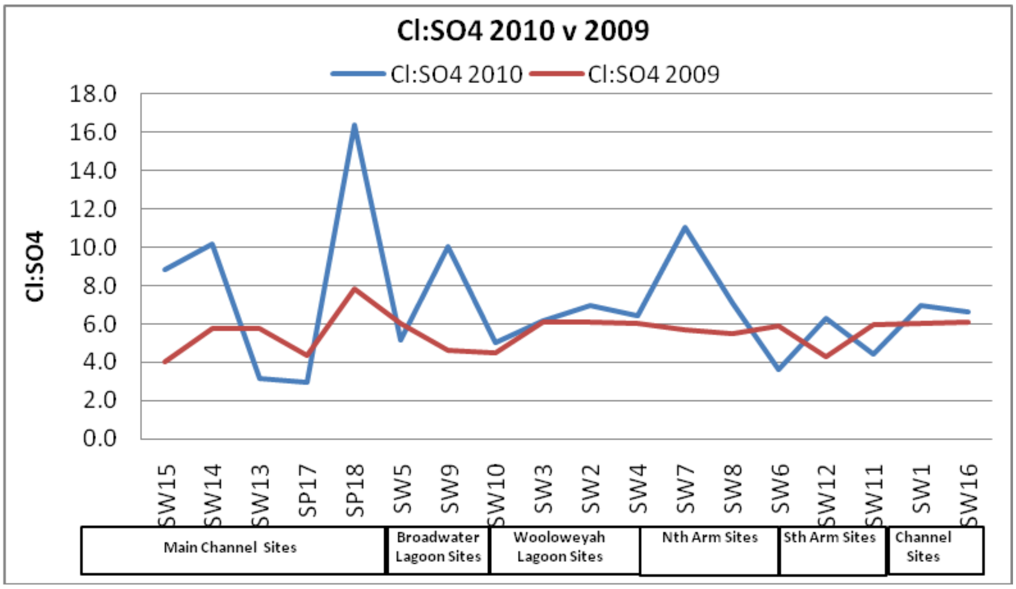


Figure 37. Cl:SO4 ratio (2009 and 2010)

6. Conclusions and Recommendations

Given the variation of physical factors (such as rainfall received, flow conditions, tidal fluxes etc.) experienced during the two discrete sampling and analysis events, a degree of variation is expected. Nevertheless, with the data obtained and via comparisons with the 2009 results the following issues have been identified:

- Concentrations of both TN (and NOx) and TP continue to exceed the adopted trigger values, suggesting significant sources of nutrient enter the estuary;

- Reduction in marine influence was observed at majority of sites as evidenced by the reduction in Cl and SO4 recorded, along with greater variation of Cl;SO4 ratios;

- Salinity levels are considerably lower at all sites in the 2010 sampling run despite a relatively lower annual rainfall when compared to last year's records. However, rainfalls for the month prior to the sampling were relatively higher in 2010 than the same period in 2009. Additionally, tidal variations and subsequent changes in water column depth were not accounted for in the sampling and monitoring effort. These factors might explain the difference in salinity levels observed between the two sampling years.

- A net increase in the acid generating potential of benthic sediments was identified between the discrete sampling and analysis periods;

- An increase of heavy metal concentrations (principally Fe and Al) within surface water samples was also identified during the recent sampling effort.

6.1 Recommendations

As outlined in the previous report prepared to accompany the results of the 2009 sampling effort, one of the outcomes of this study is to provide recommendations aimed at refining the sampling effort so that a more focused approach is implemented for future works. For instance, as recommended in last year's report, persistent contaminants of concern (such as pesticides and polychlorinated biphenyls) and biological samples were excluded from the 2010 sampling program.

With regard to 2010 results (and their interpretation), EAL has identified specific limitation inherent to the sampling and analysis programme and identified a recommended refinement of works should the continuation of the project be approved. These aspects are further discussed in the following sections.

The following limitations have been identified during the undertaking of these works and the preparations of this report:

1. The refinement of the ultimate project objective is required in order to tailor the sampling and analysis effort to the specific needs of PFA. At present, EAL has undertaken two investigation efforts with the following defined objectives:

    a. 2009 – Identify potential contributing factors that may be affecting prawn stocks and fecundity/growth rates within the investigation area; and
    b. 2010 – Undertake a similar refined sampling and analysis effort to assess water quality within the Clarence River estuary (on a broadscale setting) and to establish possible trends.

2. The number of points and the sheer size of the investigation area preclude the establishment of regional trends with in situ variations (i.e. providing an ineffective representative characterisation of the site(s)). The lack of suitable periodic data set(s), along with the absence of physical input data such as rainfall intensity and location, minimises the potential for trends to become apparent. Seasonal factors that affect the conditions within a specific hydraulic region at any given time may 'skew' data to either provide no significant correlation at all, or indicate false positive scenarios; and

3. The analytical suite currently covers the parameters and analytes described in Section 3.1. EAL recommends further refinement of the analyte suite for each of the sampling media to minimise costs and refine the focus of the investigation.

6.1.2 Amended Scope of Works

Should the works be required to continue in the future, a systematic and localised approach is recommended, which can be achieved with a similar budget as that allocated for this year. The following sets forth an alternate effort in an attempt to satisfy the limitations of the investigation as established over the past two years:

- Based on the initial concept of establishing potential causes and/or contributing factors that resulted in the reduction in catch sizes and yields (of prawns) in the Clarence in the 2009/2010 season, and the continuation of the investigation effort, EAL recommend the following objective be used for future and further investigations:

    a. Identify and compare periodical conditions within selected working areas of the Clarence River Estuary in order to establish trends affecting the recruitment, growth and stability of aquatic resources and species (i.e. prawn crops); and
    b. Establish appropriate monitoring methods and trigger levels to apply to Water and/or Sediment parameters likely to result in impacts upon prawn stocks.

- Reduce the current number of sampling and monitoring locations by targeting more points within the appropriate working areas. A total of ten (10) sample sites within the main channel between Ulmarra and Maclean as well as continuing the effort within Lake Wooloweyah;

- Increase sampling frequency to at least two efforts per annum;

- Identify available meteorological and catchment monitoring stations, suitably located to define local inputs that have the potential to significantly alter chemical conditions within the estuary;

- Based on the results of the previous monitoring and analytical efforts, the suite of parameters may be further refined and amended, as follows:

Sample Media	**Analytical Suite**			
	Field Monitored		**Lab Analyses**	
Sediment	pH	EC	pH EC TN TP NO_x	Ortho-Phosphate Chloride Sulfate Aluminium Iron CRS Sulfur TAA ANC Retained Acidity
Water	pH EC Salinity DO	Temperature Turbidity TDS	pH EC TN TP NO_x	Ortho-Phosphate Chloride Sulfate Total /Dissolved Aluminium Total /Dissolved Iron

Based on the current costing for the 2010 sampling, monitoring, analysis and reporting effort, the following table sets out the costing as per the alternate effort as stated above. The following costing is calculated on one (1) sampling effort that may be utilised at a desired frequency over the preferred sampling period. EAL recommend the adoption of the below (or an amended version) for a twice per year sampling effort that is expected to deliver a more representative depiction of water and sediment quality within the specific areas of investigation.

ACTION	**ACTIVITY**	**RATE**	**EST. UNIT**	**EST. COST**
Sampling and Monitoring Effort	Sampling and monitoring (including travel, site time and sample handling)	$960 + GST per day	1	960
	Vehicle Costs - Boat - Vehicle	- $200 + GST per day - $1.20 per km	1 120	200 144
Sediment Analysis	Pack 01 (CRS, TAA, ANC Ret. Acid.,	$80 + GST per sample	10	800
	Pack 15 (pH, EC, Cl, SO_4)	$60 + GST per sample	10	600
	Pack 19 (TN, TP, NO_x, OPh	$50 + GST per sample	10	500
	Sing 08 (Fe, Al)	$40 + GST per sample	10	400
	Bulk Sample Discount	- 15%	1	-$345
Water Analysis	Pack 16 (pH, EC, TDS, Fe, Al, Cl, SO_4)	$60 + GST per sample	10	600
	Sing 06 (BOD)	$35 + GST per sample	10	$350
	TSS, NO_xTN. TP, OPh	$80 + GST per sample	10	$800
	Bulk Sample Discount	- 15%	1	-$262.50
Total Est. Cost per sampling effort				$4,746.50 + GST
Water Quality Analysis Report				$1,800 + GST
Total Sampling (based on two efforts) and Reporting				$11,293 + GST

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Appendices

Appendix A - Laboratory Results for Water Quality Analysis

RESULTS OF WATER ANALYSIS (Page 1 of 1)

18 samples supplied by Environmental Analysis Laboratory on the 15th December, 2010 - Lab. Job No. B2059

Analysis requested by Nick Davison - **Your Project: EAL2998 - PFA Clarence Water testing 2010**

PARAMETER	METHODS REFERENCE	Adopted Trigger Values	*Detection Limits* *Routine*	Sample 1 SW 1	Sample 2 SW 2	Sample 3 SW 3	Sample 4 SW 4	Sample 5 SW 5	Sample 6 SW 6	Sample 7 SW 7	Sample 8 SW 8	Sample 9 SW 9	Sample 10 SW 10	Sample 11 SW 11	Sample 12 SW 12	Sample 13 SW 13	Sample 14 SW 14	Sample 15 SW 15	Sample 16 SW 16	Sample 17 SW 17	Sample 18 SW 18
	Job No.		..	*B2059/1*	*B2059/2*	*B2059/3*	*B2059/4*	*B2059/5*	*B2059/6*	*B2059/7*	*B2059/8*	*B2059/9*	*B2059/10*	*B2059/11*	*B2059/12*	*B2059/13*	*B2059/14*	*B2059/15*	*B2059/16*	*B2059/17*	*B2059/18*
pH	APHA 4500-H$^+$-B	7 - 8.4 ^{11a}	*na*	6.42	7.45	7.73	7.39	6.96	7.18	7.22	6.68	7.16	7.26	5.94	6.33	7.06	7.08	7.18	7.84	7.11	6.47
CONDUCTIVITY (EC) (dS/m)	APHA 2510-B	0.125-2.200 ^{11e}	*<0.01*	0.36	14.39	14.52	14.78	1.47	0.19	0.13	0.91	0.18	0.19	0.24	0.25	0.10	0.13	0.10	15.92	0.11	0.22
TOTAL DISSOLVED SALTS (mg/L)	calculation using EC x 680	..	*<7*	247	9,785	9,874	10,050	996	130	89	617	125	130	160	170	69	88	68	10,826	73	152
TOTAL SUSPENDED SOLIDS (mg/L)	GFC equiv. filter - APHA 2540-D	< 20 ^{11a}	*<1*	9	104	64	42	7	11	12	10	10	9	18	6	7	7	7	21	5	8
BIOCHEMICAL OXYGEN DEMAND$_5$ (mg/L O$_2$)	APHA 5210-B	Lightly polluted waters = 3-4 mg/L; Moderately polluted = 5-7mg/L ^{11c}	*<0.5*	1.3	3.3	3.0	1.9	0.8	0.9	0.8	1.2	0.9	1.0	1.9	1.1	0.5	0.8	0.5	1.5	0.5	1.1
DISSOLVED OXYGEN (mg/L)	field measured	> 5 ^{11b}	*na*	6.3	6.9	7.9	8.8	6.8	5.7	6.6	2.9	7.5	7.2	0.1	2.5	7.3	6.8	7.2	7.5	7.5	2.2
TOTAL PHOSPHORUS (mg/L P)	APHA 4500 P-H	< 0.025 ^{11a}	*<0.01*	0.07	0.06	0.06	0.05	0.06	0.08	0.09	0.07	0.08	0.08	0.05	0.08	0.06	0.08	0.06	0.04	0.06	0.06
ORTHOPHOSPHATE (mg/L P)	APHA 4500 P-G	< 0.006 ^{11a}	*<0.005*	0.025	0.005	0.002	0.002	0.009	0.019	0.019	0.008	0.013	0.012	0.004	0.009	0.015	0.015	0.013	0.009	0.011	0.004
TOTAL NITROGEN (mg/L N)	APHA 4500 N-C	< 0.3 ^{11a}	*<0.01*	0.20	0.81	0.70	0.57	0.60	0.63	0.67	0.82	0.70	0.73	0.79	0.79	0.57	0.62	0.60	0.53	0.56	0.78
TOTAL KJELDAHL NITROGEN (mg/L N)	CALCULATION: TN - NOx	..	*<0.01*	0.13	0.80	0.69	0.55	0.54	0.56	0.60	0.76	0.62	0.65	0.76	0.77	0.49	0.55	0.53	0.50	0.49	0.76
NOx	*HIDE*		*<0.005*	*0.073*	*0.004*	*0.009*	*0.023*	*0.062*	*0.067*	*0.069*	*0.056*	*0.081*	*0.079*	*0.027*	*0.018*	*0.080*	*0.066*	*0.070*	*0.031*	*0.071*	*0.016*
NITRATE (mg/L N)	APHA 4500 NO$_3^-$-F	< 0.01 ^{11a}	*<0.005*	0.067	0.003	0.008	0.020	0.061	0.065	0.066	0.052	0.077	0.075	0.021	0.015	0.078	0.064	0.068	0.029	0.069	0.014
NITRITE (mg/L N)	APHA 4500 NO$_2^-$-C	< 0.01 ^{11a}	*<0.001*	0.006	0.001	0.001	0.003	0.001	0.002	0.003	0.004	0.004	0.004	0.006	0.003	0.002	0.002	0.002	0.002	0.002	0.002
AMMONIA (mg/L N)	APHA 4500 NH$_3$-H	< 0.01 ^{11a}	*<0.005*	0.030	0.007	0.008	0.005	0.011	0.013	0.020	0.058	0.012	0.014	0.015	0.066	0.020	0.013	0.016	0.006	0.015	0.049
DISSOLVED METALS																					
SILVER (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.0014 ^{11d}	*<0.001*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALUMINIUM (mg/L)	** APHA 3120 ICPMS/OES$^{\text{*note 1\&2}}$	pH <6.5 = 0.055 ^{11d}	*<0.005*	2.192	<0.005	<0.005	<0.005	0.807	2.326	2.962	1.309	1.508	2.362	0.484	0.216	2.198	1.435	1.912	<0.005	1.954	2.719
ARSENIC (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	As (III) = 0.024 As (V) = 0.013 ^{11d}	*<0.001*	0.002	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.002	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.028	0.001	<0.001
CADMIUM (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.0002 ^{11d}	*<0.001*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CHROMIUM (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.027 ^{11d}	*<0.001*	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.002	<0.001	<0.001	0.002	0.002	0.001	0.003	0.002	0.002
COPPER (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.013^{11d}	*<0.001*	0.002	0.002	0.002	0.002	0.001	0.004	0.003	0.003	0.002	0.004	0.001	0.002	0.004	0.002	0.002	0.002	0.003	0.002
IRON (mg/L)	** APHA 3120 ICPMS/OES$^{\text{*note 1\&2}}$	..	*<0.005*	1.358	<0.005	<0.005	<0.005	0.531	1.251	1.520	1.833	0.981	1.365	1.180	1.716	1.212	0.990	1.121	<0.005	1.146	2.700
MANGANESE (mg/L)	** APHA 3120 ICPMS/OES$^{\text{*note 1\&2}}$	< 1.9 ^{11d}	*<0.001*	0.010	0.002	<0.001	<0.001	0.011	0.008	0.009	0.039	0.007	0.010	0.068	0.100	0.009	0.006	0.009	0.002	0.007	0.042
NICKEL (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.011 ^{11d}	*<0.001*	0.001	0.004	0.004	0.004	<0.001	0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	0.001	0.001	0.005	0.001	0.001
LEAD (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.0044 ^{11d}	*<0.001*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SELENIUM (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	..	*<0.001*	0.002	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ZINC (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.015 ^{11d}	*<0.001*	0.016	0.001	0.001	0.001	0.003	0.170	0.029	0.019	0.001	0.156	0.045	0.014	0.167	0.027	0.009	0.001	0.116	0.047
MERCURY (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.0001 ^{11d}	*<0.005*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CHLORIDE (mg/L)	** APHA 4500-Cl-	..	*<1*	74.5	4,189.8	4,296.6	4,395.9	395.0	33.5	19.9	199.1	30.8	31.4	44.6	47.5	12.5	17.1	12.9	5,267.4	16.0	42.9
sulfur	raw data	..	*<0.3*	3.6	201.3	231.8	229.1	25.4	3.1	0.6	9.3	1.0	2.1	3.4	2.5	1.3	0.6	0.5	265.6	1.8	0.9
SULFATE (mg/L SO42-)	** APHA 3120 ICPOES*note 2	..	*<1*	10.7	603.9	695.5	687.4	76.2	9.3	1.8	28.0	3.1	6.3	10.1	7.5	4.0	1.7	1.5	796.9	5.4	2.6
CHLORIDE/ SULFATE RATIO	Calculation	..	*..*	6.9	6.9	6.2	6.4	5.2	3.6	11.1	7.1	10.1	5.0	4.4	6.3	3.1	10.1	8.8	6.6	2.9	16.4
TOTAL METALS																					
SILVER (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.0014 ^{11d}	*<0.001*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ALUMINIUM (mg/L)	** APHA 3120 ICPMS/OES$^{\text{*note 1\&2}}$	pH <6.5 = 0.055 ^{11d}	*<0.005*	4.851	3.392	1.175	0.521	3.833	5.023	4.633	3.473	5.005	5.084	0.408	0.594	3.897	3.532	3.565	0.042	3.687	5.965
ARSENIC (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	As (III) = 0.024 As (V) = 0.013 ^{11d}	*<0.001*	0.002	<0.001	<0.001	0.003	0.003	0.002	0.002	0.002	0.002	0.002	<0.001	<0.001	0.001	0.001	0.001	<0.001	0.001	<0.001
CADMIUM (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.0002 ^{11d}	*<0.001*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CHROMIUM (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.027 ^{11d}	*<0.001*	0.003	0.005	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003	<0.001	0.001	0.002	0.002	0.002	0.003	0.002	0.003
COPPER (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.013^{11d}	*<0.001*	0.004	0.003	0.002	0.002	0.003	0.003	0.004	0.003	0.003	0.003	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.002
IRON (mg/L)	** APHA 3120 ICPMS/OES$^{\text{*note 1\&2}}$	..	*<0.005*	2.653	2.131	0.904	0.363	1.696	2.509	2.541	3.654	2.556	2.697	5.001	2.847	2.030	2.134	1.948	0.151	1.962	5.997
MANGANESE (mg/L)	** APHA 3120 ICPMS/OES$^{\text{*note 1\&2}}$	< 1.9 ^{11d}	*<0.001*	0.049	0.128	0.057	0.034	0.027	0.061	0.079	0.073	0.083	0.093	0.080	0.160	0.080	0.108	0.099	0.018	0.053	0.226
NICKEL (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.011 ^{11d}	*<0.001*	0.002	0.005	0.004	0.004	0.001	0.002	0.002	0.001	0.002	0.002	0.001	0.001	0.002	0.001	0.002	0.004	0.001	0.001
LEAD (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.0044 ^{11d}	*<0.001*	0.001	0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SELENIUM (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	..	*<0.001*	0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	0.003	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ZINC (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.015 ^{11d}	*<0.001*	0.038	0.010	0.001	0.001	0.005	0.020	0.025	0.025	0.014	0.018	0.021	0.021	0.020	0.017	0.015	<0.001	0.012	0.019
MERCURY (mg/L)	** APHA 3120 ICPMS$^{\text{*note 1\&2}}$	< 0.0001 ^{11d}	*<0.005*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
CHLORIDE (mg/L)	** APHA 4500-Cl-	..	*<1*	70.7	4,154.5	4,195.8	4,236.2	395.4	33.4	18.9	188.6	30.0	30.1	43.2	46.8	11.4	17.4	11.0	4,694.6	15.3	42.2
sulfur	raw data	..	*<0.3*	3.5	208.0	223.9	230.3	25.8	2.1	1.0	8.6	0.9	1.0	4.0	2.8	0.2	0.4	0.5	239.1	0.7	1.1
SULFATE (mg/L SO4^{2-})	** APHA 3120 ICPOES*note 2	..	*<1*	10.5	624.1	671.8	691.0	77.4	6.2	3.1	25.9	2.7	2.9	12.0	8.5	0.7	1.3	1.4	717.4	2.1	3.4
CHLORIDE/ SULFATE RATIO	Calculation	..	*..*	6.7	6.7	6.2	6.1	5.1	5.4	6.0	7.3	10.9	10.3	3.6	5.5	16.4	13.7	8.1	6.5	7.1	12.3

Notes:

1a. Total Available metals - samples acidified with nitric acid and then filtered through 0.45µm cellulose acetate

1b. Dissolved metals - samples filtered through 0.45µm cellulose acetate and then acidified with nitric acid prior to analysed

2. Metals/ salts analysed by ICP-MS (Inductively Coupled Plasma - Mass Spectrometry) or ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry)

3. 1 mg/L (milligram per litre) = 1 ppm (part per million) = 1000 µg/L (micrograms per litre)= 1000 ppb (part per billion)

4. For conductivity - 1 dS/m = 1 mS/cm = 1000 µS/cm

5. In Pesticide Analysis Screening, no other pesticides occurred above reportable levels in the attached list

6. For Bacteria - cfu= colony forming unit

7. Analysis performed according to APHA, 2005, “Standard Methods for the Examination of Water & Wastewater”, 21st Edition, except where stated otherwise.

8. Analysis conducted between sample arrival date and Report provision date

9. ** denotes these test procedures are as yet not NATA accredited but quality control data is available

10. .. Denotes not requested

11^{a}. Table 3.1.1 QWQG 2009

11^{b}. P.3. 3-25 ANZECC/ARMCANZ 2000

11^{c}. SCBD 2006

11^{d}. Table 3.4.1 ANZECC/ARMCANZ 2000

11^{e}. Table 3.3.3 ANZECC/ARMCANZ 2000

Appendix B - Laboratory Results for Acid Sulfate Soils Analysis

RESULTS OF ACID SULFATE SOIL ANALYSIS

18 samples supplied by Environmental Analysis Laboratory on the 15th December, 2010 - Lab. Job No. B2058

Analysis requested by Nick Davison - Your Project: EAL2998 - PFA Clarence Sediment Testing 2010

Sample Site	EAL lab code	TEXTURE (note 6)	MOISTURE CONTENT		TITRATABLE ACTUAL ACIDITY (TAA)		REDUCED INORGANIC SULFUR		ACID NEUTRALISING CAPACITY (ANC_{BT}) required if pH_{KCl} > 6.5		NET ACIDITY Chromium Suite	LIME CALCULATION Chromium Suite
						(To pH 6.5)	(% chromium reducible S)				mole H^+/tonne	kg $CaCO_3$/tonne DW
			(% moisture of total wet weight)	(g moisture / g of oven dry soil)	pH_{KCl}	(mole H^+/tonne)	(%Scr)	(mole H^+/tonne)	(% $CaCO_3$)	(mole H^+/tonne)	(based on %Scrs)	(includes 1.5 safety Factor when liming rate is $^+$ve)
Method No.											*note 5*	*note 4 and 6*
SP1	*B2058/1*	Medium	35.4	0.55	6.37	2	0.33	206	..	0	208	15.6
SP2	*B2058/2*	Fine	57.9	1.38	7.59	0	0.18	112	1.51	302	-89	-4.4
SP3	*B2058/3*	Fine	65.6	1.90	7.45	0	0.14	87	1.65	330	-132	-6.6
SP4	*B2058/4*	Medium	27.6	0.38	7.30	0	0.08	50	0.39	78	-2	-0.1
SP5	*B2058/5*	Coarse	22.7	0.29	6.90	0	0.01	6	..	0	6	0.5
SP6	*B2058/6*	Coarse	21.5	0.27	6.25	2	<0.01	0	..	0	2	0.1
SP7	*B2058/7*	Fine	38.7	0.63	6.33	3	0.43	268	..	0	272	20.4
SP8	*B2058/8*	Coarse	18.5	0.23	5.98	3	0.07	44	..	0	47	3.5
SP9	*B2058/9*	Fine	60.9	1.56	6.15	9	0.68	424	..	0	433	32.5
SP10	*B2058/10*	Fine	46.4	0.86	6.45	1	0.78	486	..	0	487	36.6
SP11	*B2058/11*	Fine	65.9	1.93	5.15	54	0.35	218	..	0	272	20.4
SP12	*B2058/12*	Fine	56.8	1.31	5.03	39	0.61	380	..	0	419	31.5
SP13	*B2058/13*	Coarse	20.8	0.26	6.04	5	0.88	549	..	0	554	41.6
SP14	*B2058/14*	Fine	61.6	1.60	5.85	28	0.22	137	..	0	165	12.4
SP15	*B2058/15*	Coarse	24.5	0.33	6.05	4	<0.01	0	..	0	4	0.3
SP16	*B2058/16*	Fine	32.8	0.49	6.82	0	0.26	162	0.71	142	68	5.1
SP17	*B2058/17*	Fine	60.3	1.52	6.10	16	0.19	119	..	0	134	10.1
SP18	*B2058/18*	Fine	57.3	1.34	6.02	14	0.74	462	..	0	475	35.6

NOTE:

1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)

2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)

3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines .*** QLD DNRME.

4 - Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density rings can be used and dried/ weighed in the labor

5 - **ABA Equation**: **Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)**

6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)

7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays

8 - .. denotes not requested or required. '0' is used for ANC and Snag calcs if TAA pH <6.5 or >4.5

9 - SCREENING, CRS, TAA and ANC are NATA accredited but other SPOCAS segments are currently not NATA accredited

10- Results at or below detection limits are replaced with '0' for calculation purposes.

11 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).

12 - Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.

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(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H^+/t; medium Scr≥0.06%S or 37mole H^+/t; fine Scr≥0.1%S or 62mole H^+/t) - as per QUASSIT Guidelines

Appendix C - Laboratory Results for Sediments Analysis

RESULTS OF SOIL ANALYSIS

18 samples supplied by Environmental Analysis Laboratory on the 15th December, 2010 - Lab. Job No. B2058
Analysis requested by Nick Davison - Your Project: EAL2998 - PFA Clarence Sediment Testing 2010

ANALYTE	METHOD REFERENCE	Sample 1 SP1	Sample 2 SP2	Sample 3 SP3	Sample 4 SP4	Sample 5 SP5	Sample 6 SP6	Sample 7 SP7	Sample 8 SP8	Sample 9 SP9	Sample 10 SP10	Sample 11 SP11	Sample 12 SP12	Sample 13 SP13	Sample 14 SP14	Sample 15 SP15	Sample 16 SP16	Sample 17 SP17	Sample 18 SP18	Detection Limits (routine)	Composite Acceptable Limit Column 1	Individual Acceptable Limit Column 1	Background Range
	Job No.	B2058/1	B2058/2	B2058/3	B2058/4	B2058/5	B2058/6	B2058/7	B2058/8	B2058/9	B2058/10	B2058/11	B2058/12	B2058/13	B2058/14	B2058/15	B2058/16	B2058/17	B2058/18	..	See note 1	See note 1	See note 2
SILVER (mg/Kg DW)	a	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	**na**	na	**na**
ARSENIC (mg/Kg DW)	a	5	12	14	4	3	1	9	<1	8	7	9	8	6	8	2	6	5	8	<1	**<25**	<100	**0.2-30**
LEAD (mg/Kg DW)	a	7	15	17	3	4	2	14	2	14	12	17	15	7	15	3	7	15	16	<1	**<75**	<300	**<2-200**
CADMIUM (mg/Kg DW)	a	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	**<5**	<20	**0.04-2.0**
CHROMIUM (mg/Kg DW)	a	14	26	29	6	10	3	23	2	23	21	24	23	9	23	7	12	22	24	<1	**<25**	<100	**0.5-110**
COPPER (mg/Kg DW)	a	9	14	16	2	3	2	18	2	17	14	19	22	3	19	3	6	17	20	<1	**<250**	<1000	**1-190**
MANGANESE (mg/Kg DW)	a	154	587	860	75	93	85	247	23	545	303	1009	319	219	980	102	113	560	223	<1	**<375**	<1500	**4 - 12,600**
NICKEL (mg/Kg DW)	a	9	17	19	3	5	2	17	1	16	14	19	19	3	17	4	7	16	20	<1	**<150**	<600	**2-400**
SELENIUM (mg/Kg DW)	a	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	**na**	na	**na**
ZINC (mg/Kg DW)	a	49	86	76	15	26	11	75	6	72	67	100	93	14	73	19	34	69	105	<1	**<1750**	<7000	**2-180**
MERCURY (mg/Kg DW)	a	0.06	0.06	0.06	<0.05	<0.05	<0.05	0.05	<0.05	0.09	0.06	0.06	0.07	<0.05	0.06	<0.05	<0.05	0.05	0.07	<0.05	**<3.75**	<15	**0.001-0.1**
IRON (% DW)	a	1.62	3.29	3.64	0.70	1.11	0.40	2.67	0.27	3.25	2.84	3.81	2.76	1.70	3.04	0.72	1.37	2.78	4.24	<0.01	**na**	na	**na**
ALUMINIUM (% DW)	a	0.95	2.07	2.32	0.39	0.40	0.23	1.56	0.19	1.85	1.54	2.20	1.81	0.32	1.83	0.38	0.88	1.86	2.10	<0.01	**na**	na	**na**
CHLORIDE (mg/Kg)	a	705	9,274	12,605	1,716	438	22	113	36	282	335	131	69	5	336	6	3,450	258	219				
sulfur	raw data	*3218.80*	*2306.30*	*1931.30*	*1443.80*	*151.90*	*118.80*	*4800.00*	*625.00*	*6437.50*	*6343.80*	*3556.30*	*5281.30*	*11375.00*	*2731.30*	*105.60*	*2787.50*	*1462.50*	*6812.50*	<0.3			
SULFATE (mg/L SO42-)	a	9,656	6,919	5,794	4,331	456	356	14,400	1,875	19,313	19,031	10,669	15,844	34,125	8,194	317	8,363	4,388	20,438	<1			
Chloride/Sulfate Ratio		0.07	1.34	2.18	0.40	0.96	0.06	0.01	0.02	0.01	0.02	0.01	0.00	0.00	0.04	0.02	0.41	0.06	0.01				
TIN (mg/Kg DW)	a	4	7	7	2	3	1	7	1	5	5	8	7	2	6	2	3	5	6	<1			

METHODS REFERENCE

a. $^{1:3}$Nitric/HCl digest - APHA 3120 ICPMS
b . $^{1:3}$Nitric/HCl digest - APHA 3120 ICPOES
c . Analysis sub-contracted - results attached

NOTES

1. Column 1 ' Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998)
2. Environmental Soil Quality Guidelines, Page 40, ANZECC, 1992.

Appendix D - Depth Profiling Site Log Sheets