Results of the Laura- Normanby River Water Quality Monitoring Project

An Assessment of Ambient Water Quality and Water Quality Impacts
June 2006- June 2010

South Cape York Catchments

CYMAG Environmental

CARING FOR OUR COUNTRY

CYMAG Environmental Inc.

Cooktown, Queensland

Written by Christina Howley, MSc. Reviewed by Andrew Moss (DERM), Andrew Brooks (Griffith University) and Jason Carroll (SCYC).

June 2010

Copies are available from:

CYMAG Environmental Inc.

P.O. Box 300

Cooktown, Qld, 4895

Phone: (07) 4069 5300

Email: cymag@bigpond.com or chowley@bigpond.com

Data from this project is stored on the DERM Water Quality Database.

Acknowledgements

CYMAG Environmental would like to thank:

- Andrew Moss, Mark Davidson, Sharmane Wickings & the DERM Water Quality Team for their invaluable support with equipment, analysis, and data management
- SCYC for their support for the project, and Jason Carroll for Fieldwork and Map Production (Figure 3)
- FSS EnvWaters for laboratory nutrient analysis & quality control
- Andrew Hartwig and the Lakefield Rangers (Carly & Sarah Jess) and for help with logistics and Kalpowar sampling
- The many volunteers for their enthusiasm and time
- Sue Marsh and Ted Lee for local knowledge & assistance with passive samplers
- Jana Kahabka and the Laura Land and Sea Rangers for field assistance
- Peter Pal for aerial photography
- Beth Ward for access to Broken Dam Station
- Ang-Gnarra for access to the Festival Grounds
- John Spencer (Griffith University) for area calculations

Cover photos: Normanby River estuary at Princess Charlotte Bay and the Winding Normanby River (*Photos by Peter Pal*). Jack Dibella & Christina Howley with passive samplers. Jason Carroll and the CYMAG field sampling vehicle.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1 INTRODUCTION

The Laura-Normanby River in southeast Cape York is the fourth largest river system flowing into the Great Barrier Reef. The Laura-Normanby Catchment Area covers an extensive and relatively undeveloped area consisting of numerous riverine and wetland systems, one of Queensland's largest conservation areas (Lakefield National Park), sacred aboriginal sites, cattle grazing country and rich agricultural land. The East and West Normanby, Kennedy, Jack and Laura River systems all join to form the Laura-Normanby catchment area. These tributaries flow north from dry savannah and sandstone escarpment country in the southwest and wet tropical rainforest in the southeast, discharging into Princess Charlotte Bay- an area known for its rich and healthy marine and coastal ecosystems.

CYMAG Environmental (CYMAG) and South Cape York Catchments (SCYC) commenced monitoring of ambient water quality in the Laura-Normanby River in October 2006 with funding from the Commonwealth Government's Natural Heritage Trust (NHT2) and Caring For Our Country (CFOC). Logistical support has been provided by the Queensland Environmental Protection Agency (EPA) (now DERM). Monthly water quality monitoring was conducted by CYMAG and SCYC scientists at 10 sites across the Laura and Normanby Rivers, from the upper reaches of the catchment to the estuary. The aim of the program was to document water quality in the Laura-Normanby River system under ambient flow conditions and to assess potential anthropogenic impacts upon water quality.

This report provides an overview of the results of this monitoring programme, including water quality in the Laura-Normanby River over the 2006 – 2010 sampling period and impacts from various land-uses within the catchment. The report also highlights data gaps and makes recommendations for future water quality sampling.

Figure 1: Laura-Normanby Catchment Relief Map

2 LAURA-NORMANBY BACKGROUND INFORMATION

2.1 Catchment Area

The Laura and Normanby Rivers flow from the vicinity of Lakeland Downs and the mountains of the Wet Tropics in the southeast, and from King Vale and Fairlight Stations in the southwest, past the town of Laura, through Lakefield National Park and into Princess Charlotte Bay. The Laura-Normanby Catchment Management area as defined by the Queensland Dept of Natural Resources and Mines covers approximately 14,891 km^2 and lies between Latitude 14º 15` to the north and 16º 15` in the south, and Longitude 143º 45` and 145º 20` (**Figure 1**). The greater Normanby catchment area as defined by the Australian Water Resources Council covers an area of 24,228 km^2 and includes the North Kennedy, Hann and Morehead Rivers, which are connected to the Normanby during floods.

2.2 Climate and Rainfall

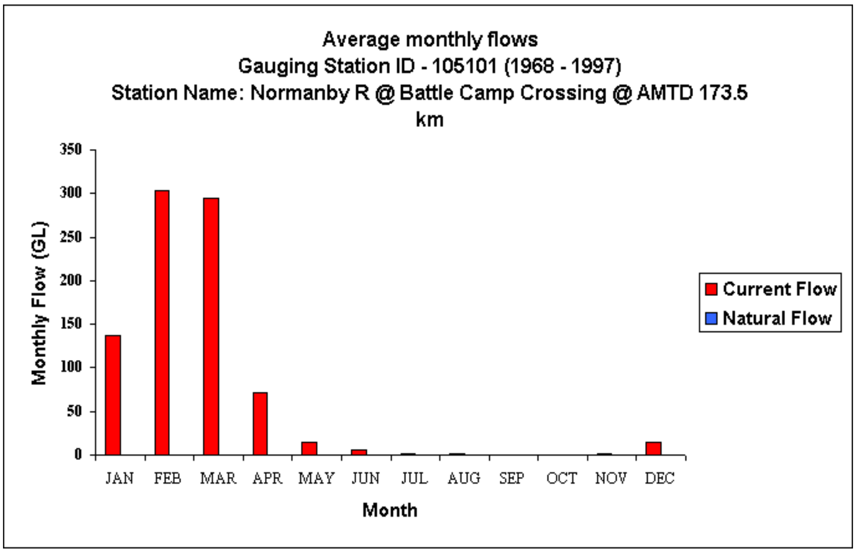
The Catchment is located in the dry tropics where climate is characterised by extreme rainy (summer) and dry (winter) seasons with 95% of its annual rainfall occurring between the months of November and April (80 % between December and March). Mean annual rainfall varies from 800 mm to 1600mm across the Catchment with higher rainfall occurring in the mountains along the eastern and southern borders of the catchment (BOM rainfall statistics: http://www.bom.gov.au).

Mean maximum monthly temperatures in the region range from approximately 29°C in June to 36°C in November. Mean minimum monthly temperatures ranging from approximately 17°C in August to 24°C in February (BOM climate statistics, Musgrave station. http://www.bom.gov.au).

2.3 Topography and Hydrology

The Laura and Normanby Rivers originate in the mountains in the east and south of the Catchment area and flow to the north, discharging into the Coral Sea at Princess Charlotte Bay. Major tributaries include the East and West Normanby Rivers and the Jack River to the southeast and east, and the Mosman, George and Kennedy Rivers in the south and southwest (**Figure 1**). The majority of the Catchment area is of relatively low relief with a gentle slope towards Princess Charlotte Bay. Topography in the upland areas ranges from undulating rises to steep mountain ranges, with deeply dissected sandstone plateaus and intervening plains.

From July to November very little rain falls and many of the river's tributaries run dry during this time. Late in the dry season much of the surface water occurs in isolated waterholes within the river, with only minimal sub-surface flow connecting the waterholes. During the wet season much of the catchment area is flooded. Annual wet season flood waters feed extensive wetland systems in the alluvial and marine plains of the lower Catchment area. Mean Annual Run-off is estimated at 2,500 GL/year (2000-2002 National Land and Water Resources Audit). Average monthly flows in the East Normanby and Laura Rivers are displayed in **Figure 2** below.



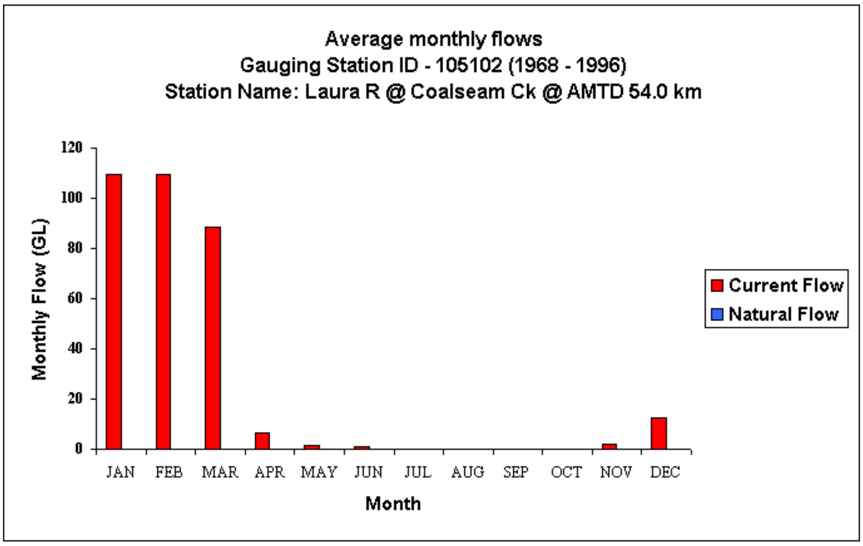


Figure 2: Average Monthly Flows Normanby River and Laura River

2.4 Geology

The central and northern plains of the Catchment area are underlain by a layer up to 70 metres thick of Cainozoic era deposits, including Tertiary period sediments (clayey silty sandstones and claystones, with some rounded quartz gravels) and Quaternary period alluvial deposits (grey silty clay, sand and gravel, and orange and white residual sands). Surface sands and gravels associated with the river systems are usually less than 10 m thick (Horn et al, 1995). The coastal plains at Princess Charlotte Bay are comprised of Quaternary period marine deposits including limestone, salt pans, beach sands and pumice (The 1:250,000 Cape Melville Geological Series, Sheet SD/55-9 (Geological Survey of QLD, Second Edition, 1983) and 1:250,000 Cooktown Geological Series, Sheet SD 55-9 (Geological Survey of QLD, First Edition, 1966).

Underlying these Cainozoic era alluvial and marine deposits are the Mesozoic era sedimentary rocks of the Rolling Downs Group, Gilbert River Formation (formerly named the Battlecamp Formation), and the Dalrymple Sandstone. These primarily sandstone formations are exposed across the hills and mountain ranges in the eastern and southerly regions of the Catchment area. Underlying the Mesozoic sedimentary rocks, and exposed in the mountains of the southern Catchment area, are the Palaeozoic era Hodgkinson Formation metamorphic rocks (greywacke, slate, some conglomerate and metavolcanics), and intrusive Permian period granites. During the Tertiary period, volcanic basalt flowed to the surface from vents in the Hodgkinson Formation rocks. The McLean basalt, located in the Lakeland Downs area, covers approximately 300 km^2 and is composed of olivine basalt and gravels (Horn et al, 1995).

2.5 Hydrogeology

The Laura-Normanby Catchment area overlies two regional groundwater basins: The Laura Basin which underlies the majority of the Catchment area and the Hodgkinson Basin. The Laura Basin is an artesian basin comprised primarily of Mesozoic era sandstone formations. The Basin extends from the southern margin of the Catchment area to the edge of the continental shelf north of Princess Charlotte Bay and has a thickness of up to 1 kilometre (Bain and Draper, 1997). The Laura Basin overlies and is bounded to the south and east by the Palaeozoic era Hodgkinson Basin (Passmore, 1978).

The principal groundwater aquifers in the Laura Basin are the Gilbert River Formation and Dalrymple Sandstone. There are also water resources in the overlying Cainozoic sediments. Groundwater in the Laura Basin flows generally to the north. Recharge by infiltration of rainfall into the outcropping sandstone aquifers occurs mainly along the elevated southern and eastern margins of the Basin (Bain and Draper, 1997). Natural discharge occurs at permanent and semi-permanent springs which abound in the Quinkan region (surrounding Laura) and at Lakefield National Park. Spring flows also maintain perennial or near continuous flow to the little Laura and the Normanby Rivers.

The fractured rock aquifers of the Hodgkinson Basin underlie the southern portion of the Laura-Normanby Catchment area and include the McLean basalt that occurs in the Lakeland region. These aquifers provide an important supply of groundwater for domestic and stock watering purposes, through a number of low yielding bores. The fractured rock aquifers of the Hodgkinson Basin principally recharge vertically and therefore the groundwater supplies are closely dependent on rainfall (Horn et al, 1995).

2.6 Soils

Along the coast and inland from Princess Charlotte Bay, soils are dominated by moderately deep (0.5 m - 1.0 m) and farther inland, very deep (1.5 m - 5.0 m) saline clays. The Laura basin generally consists of shallow (0.25 m - 0.5 m) rocky sandy soils derived from sandstone and red and yellow silty soils and massive sands (1.0 m - 1.5 m deep) in the lower plains. Soils in the Hodgkinson Basin region (southern Catchment area) are comprised primarily of sodic and non-sodic yellow and grey soils, and red and brown structured clay soils derived from volcanic basalt in the Lakeland Downs area. The basaltic soils support a wide range of agricultural enterprises (Horn et al, 1995).

Pockets of sodic yellow or grey Gibson soils occur along the Laura River between Lakeland and Laura and in the vicinity of the Normanby River near Battlecamp. Red Victor soils found in the vicinity of the town of Laura and along the Laura River are generally 1 m to 3 m deep and overlie significant salt depositions. Deep acid to alkaline yellow Greenant soils occur along the alluvial plains of the East and West Normanby Rivers, along the Laura River north of Laura, and along the Normanby River to the north and west of Battlecamp.

Soils in the Catchment area are generally associated with high levels of natural erosion and low nutrient levels. Significantly accelerated rates of erosion have been observed in association with roads constructed through Victor, Greenant, and Gibson soils. A moderate risk of development of secondary salinity is associated with Gibson and Victor soils (Biggs and Philip, 1995).

2.7 Land Use

The major population centres within the Laura-Normanby Catchment area are Lakeland Downs and Laura. Laura is a small aboriginal community located on the Laura River 20 km upstream from its confluence with the Normanby. Lakeland Downs is predominantly an agricultural community, located near the headwaters of the Laura River and the West Normanby River. The resident population for the entire Catchment area is less than 500 (Australian Bureau of Statistics, 2006). Much of the Catchment area outside of the two towns is either grazing land or National Park. Lakefield National Park, which occupies 18% of the Catchment area, is a popular camping destination for both tourists and locals. Jack Lakes National Park and Kalpowar Station occupy much of the north-eastern region of the Catchment.

Horticulture within the Catchment is mainly limited to the upper reaches of the Laura River around Lakeland Downs. The rich basaltic soils in the Lakeland area support a wide range of crops, including bananas, coffee, mangoes, peanuts and sorghum. The water supply to farms comes from the large Honey Dam and numerous small private dams. Groundwater is becoming increasingly relied upon for irrigation as greater areas of land are going into production (Howley & Stephan 2005).

Outside of the conservation areas, grazing is the most extensive land use in the Catchment. Cattle tend to roam freely across land boundaries and into the National Park, which itself was once a cattle station.

Mining is not currently a major industry in the Laura-Normanby Catchment. Most of the mines recorded with the Department of Natural Resources and Mines are abandoned gold mines. Other abandoned mines include arsenic, sapphire, copper and gemstone mines (DNR&M website, 2005). There are several small active gold mines that have been operating in the upper reaches of the Normanby and Laura Rivers for the last 15-20 years.

2.8 Potential Threats to Water Quality

Protection of water quality and quantity was rated as the number one priority in a survey of stakeholders in the Catchment area. The Laura-Normanby Catchment

Management Strategy (Howley & Stephan 2005) identifies the following factors that may impact upon water quality within the catchment:

- accelerated erosion associated with roadworks and other earthworks;
- accelerated erosion resulting from cattle grazing;
- the reduction of riparian zones and aquatic vegetation and disturbance of sediments by cattle and pigs in waterways;
- bacterial contamination from septic system leakage, stock, feral animals, and people camping close to watercourses (shallow groundwater in Laura has been abandoned as a drinking water source due to bacteria levels);
- surface water or groundwater contamination by fertilisers, herbicides and pesticides used for agriculture in the vicinity of Lakeland;
- leachates from unlined rubbish tips adjacent to the Laura River at Laura and Lakeland;
- large-scale groundwater extraction at Lakeland reducing downstream flow levels;
- small-scale mining operations; and
- Fire.

3 CYMAG/SCYC WATER QUALITY MONITORING PROGRAM

3.1 Aims of program

Monitoring of the Laura-Normanby River system was designed to gather ambient water quality data from representative locations across the catchment in order to establish baseline water quality in these systems during the wet and dry seasons. This baseline data is required to assess future changes in water quality resulting from developments within the catchment. Sampling was also conducted to assess for specific impacts upon water quality from current land use.

Objectives:

1) Gather baseline water quality data from the Laura and Normanby Rivers and document the natural variation in water quality through the wet and dry seasons;

2) Compare the data from the Laura & Normanby Rivers with the applicable Qld and ANZECC water quality guidelines and to develop local guidelines if required; AND

3) Assess potential anthropogenic impacts on water quality (e.g. increased turbidity, elevated nutrients or herbicides from agricultural lands, leachates from landfill).

3.2 Sampling design

The monitoring project included both monthly monitoring to document baseline water quality conditions and annual sampling for contaminants. The sampling design and analytical results is thus described in two sections:

- Ambient Monitoring- monthly sampling (where weather permitted)
- Contaminant/ Impact Assessment- annual contaminant sampling at select sites

3.3 Ambient Monitoring Sample Locations and Timing

Ambient monitoring was conducted at 10 primary sites across the catchment (**Figure 3**). These were selected to represent a cross-section of the catchment as much as possible with the resources available. Accessibility determined where the regular monitoring sites were located, and most sites are located where the river crosses a road or track. Sites were also selected to correspond with existing gauging stations and to assess impacts from agricultural land use and town rubbish tips.

Each site was assigned an ID, starting with LN (Laura-Normanby) then LR (Laura River) or NR (Normanby River) and a number starting from 0 at the river mouth to 5 (furthest upstream). The list of monitoring sites, Site ID, corresponding latitude and longitude and rationale behind each location is described in Table 1.

Ambient Water Monitoring was conducted once a month where road access was possible. Sample locations in the northern catchment area– at the estuary and within the National Park- were only accessible by helicopter during the wet. These locations were sampled approximately every 3 months.

Monitoring was conducted between 9am and 3pm. Estuary sites (LN-NR-00 and LN-NR-01) were monitored on an out-going tide, approximately 2 hours after high tide.

Photos of the Laura-Normanby River Monitoring Sites are presented in **Appendix A**.

Figure 3: Laura-Normanby Water Quality Monitoring Locations
(Map Produced by Jason Carroll)

TABLE 1: LAURA - NORMANBY SAMPLING SITES

Primary Sample Locations	**Sample ID***	**Lat/Long**	**Site Characteristics /Sampling Rationale**
Normanby River Mouth	LN-NR-00	14° 24’42.4’’ 144° 08’23.5’’	Final outflow to Princess Charlotte Bay and GBR
Normanby Estuary, 5 km upstream from mouth	LN-NR-01	14° 26’29.3” 144° 08’55.3’’	Normanby estuary conditions
Normanby River -Kalpowar Crossing	LN-NR-02	14°54’42’’ 144°12’42’’	DNR gauging station and monitoring site, downstream from Lakefield camping areas
Normanby River -12 Mile Waterhole	LN-NR-03	15° 12’ 0.7’’ 144° 26’ 06.0’’	Below Laura/Normanby confluence, Campsite No.6
E. Normanby River- Battle Camp Road	LN-NR-04	15° 16’ 50’’ 144° 50’24’’	Road crossing & cattle at site, DNR gauging station 1 km downstream
East Normanby River -Bridge at Peninsula Development Road	LN-NR-05	15° 45’21.7” 145° 00’52.1”	Flowing from undeveloped rainforest, DNR gauging station 1 km upstream
Laura River - Old Laura Crossing	LN-LR-01	15° 20’ 53.7’’ 144° 27’ 22’’	Laura River downstream from Laura township, heavy erosion from road crossing and camping at site, flows underground in dry season
Laura-River - Laura town bridge	LN-LR-02	15° 33’ 18.0” 144° 26’ 20.4”	Below Laura tip
Laura River - Festival Grounds	LN-LR-03	15° 38’32.9” 144° 31’41.7”	Heavy camping use, DNR gauging station (Coalseam Cr.) nearby/ Sample at downstream end of waterhole below campgrounds
Laura River - Carroll’s Crossing	LN-LR-04	15° 44’ 01’’ 144° 40’ 39’’	20 km downstream from Lakeland agricultural area, high cattle use, high algal growth in dry, major road gully erosion
Laura River- Broken Dam Station	LN-LR-05	15° 53’ 9.1’’ 144° 47’ 23.3’’	Laura River at Lakefield, above confluence with Bullhead Creek, adjacent to Lakeland agricultural area
Additional Sample Locations			
Bullhead Creek – above the Laura River confluence	LN-BHC	15° 51’ 23’’ 144° 47’ 21’’	Outflow from Honey Dam and Lakeland tip above Laura River
Honey Dam	LN-HD	15° 51’ 24’’ 144° 47’ 30’’	Catchment for Lakeland agricultural area
Laura R. at Olive Vale Hole	LN-OVH	15° 31’47.1” 144° 26’30.9”	Year-round waterhole, water supply for surrounding stations

3.4 Ambient Monitoring Indicators & Methods

The following indicators were monitored at all (accessible) sites on a monthly basis:

- pH
- Electrical conductivity (µS/cm)
- Salinity (ppt)
- Water temperature (°C),
- Dissolved Oxygen (DO) (mg/L & % saturation),
- Turbidity (NTU),
- Chlorophyll–α (µg/L), and
- Nutrients (mg/L):
  - Total phosphorous
  - Total reactive phosphorous
  - Total nitrogen
  - Ammonia
  - Nitrogen oxides

Appendix B presents information on the use of the above parameters as indicators of water quality.

Water pH, DO, temperature, salinity and conductivity were measured in-situ using the Orion 5 Star Portable Multi-parameter Meter. Turbidity samples were analysed in the field using the HACH 2100P Turbidity Meter. All equipment was calibrated prior to use to ensure accuracy of measurements.

Water Monitoring Equipment Range and Accuracy:

- Thermo Orion 5 Star Multimeter*:*
  - ***pH:*** *range= -2 to 19.99, accuracy = +/-0.002*
  - ***DO:*** *range= 0 to 90.00 mg/L, 0.0 to 600 % saturation, accuracy = 0.2 mg/L (autocorrect for salinity)*
  - ***Conductivity****: range= 0 to 3000 mS/cm*
  - ***Salinity:*** *range= 0.01 to 80.0 ppt NaCl*

- HACH 2100P Turbidity meter
  - *Range: 0-1000 NTU*
  - *Accuracy: ± 2% of reading or ± 1 least significant digit*

Measurements were collected from approximately 10cm below the water surface. A 3m sampling pole was used to extend the probes away from the edge of the river. At each location, three measurements were recorded for each parameter, and averages from the 3 readings were calculated. All measurements, weather, comments on site characteristics, etc. were entered into the Field Data Sheet. The results were then entered into a central database on the CYMAG computer, with data entry quality control checks performed by second person.

Total and dissolved nutrient samples were collected using the extended sampling pole and sterilised bottles prepared by the laboratory. Nutrient sample collection was per the Qld EPA (now DERM) standard procedures. Total nutrients were filled directly into the sample bottle. Dissolved nutrients were filtered first using a syringe and 0.45 micron filter. Nutrient samples were frozen immediately after collection and sent via freezer truck to the Queensland Health Forensic and Scientific Services Laboratory in Brisbane to be analysed. Nutrient analytical methods are as follows:

Total Phosphorus	Method Number	13800.R3
Ammonia Nitrogen	Method Number	13796.R3
Nitrogen Oxides	Method Number	13798.R3
Filt Reac Phosphorus	Method Number	13799.R3
Total Nitrogen	Method Number	13802.R3

Chlorophyll samples were collected using the extended sampling pole to collect 2 L of water, which was then filtered through a 47 mm diameter *Whatman* brand 1.2µm glass fibre/course "filter paper" using a hand operated vacuum pump connected to a glass Buchner vacuum flask (Millipore side arm flask). The filters were placed in a High Density Polyethylene (HDPE) 15 ml screw top tube with magnesium carbonate preservative, wrapped in aluminium foil, frozen immediately and sent to the Water Quality & Aquatic Ecosystem Health section of DERM for chlorophyll-a analysis. Chlorophyll-a and phaeophytin analysis was conducted by acetone extraction and visible spectrophotometry.

3.5 Contaminant Monitoring

In addition to monthly ambient water quality monitoring, sampling for contaminants was conducted annually at sites where there were potential impacts from agricultural chemicals, rubbish dumps or other land uses. Annual monitoring for contaminants was conducted during the first major rain event of the wet season (first flush), and during subsequent events when possible.

Both water and soil samples were collected and analysed for a range of potential contaminants, depending on the site. Impact assessments included the following analyses.

Laura & Lakeland Rubbish Tips

- Heavy metals (total and dissolved)
- Hydrocarbons
  - -Total Petroleum Hydrocarbons (TPH $C_6 – C_{36}$),
  - -Polyaromatic Hydrocarbons (PAH)
  - -Benzene, Toluene, Ethylene & Xylene (BTEX)
- Solvents
  - -Volatile Organic Compounds (VOCs)
  - -Semi-Volatile Organic Compounds (SVOCs)

Agricultural Land Use

- Pesticides & herbicides
  - -Phenoxyacetic Acid Herbicides
  - -Organochlorine Pesticides & Organophosphorus Pesticides (OC/OP)
  - -Glyphosate (round-up)
  - -Triazines (Atrazine and Simazine)
- Nutrients (as per ambient monitoring)

Mining (*Mining sites not specifically targeted*)

- Heavy metals (total and dissolved)-
  - -baseline metals data across catchment

Septic Systems, Camping (Laura Festival), Feral pigs and Cattle:

- Bacteria
  - -faecal coliform

<u>Grab Samples</u>

Aqueous grab samples for the contaminants listed above were collected in the appropriate sterilised sample bottles, placed directly on ice and sent via JAT refrigerator truck to the NATA accredited ALS Laboratory in Brisbane. Sediment samples were collected using decontaminated soil spoons and sterilised sample jars. Samples were submitted and analysed within laboratory holding times (breaches in holding times are listed in the QA/QC Results (Section 4.5 and **Appendix C**). Latex gloves were worn by samplers in order to ensure that samples were not contaminated.

Bacteria samples were collected in sterilised & preserved sample bottles and submitted to the NATA accredited Cairns Water Laboratory for analysis within 24 hours of collection.

Table 2: LABORATORY ANALYSES & METHODS

Contaminant Type	**Analytes (not all are listed)**	**Lab**	**Method**
Total Metals (soil samples)	Arsenic, Cadmium, Chromium, copper, lead, nickel, zinc	ALS	ICP-AES EG020A-F
Total & Dissolved Metals (water samples)	Arsenic, Cadmium, Chromium, copper, lead, nickel, zinc	ALS	ICP-MS EG020A-F:
Total & Dissolved Mercury (water)		ALS	FIMS EG035F
Organochlorine Pesticides (OC)	Aldrin, Endrin, Dieldrin Heptachlor, 4.4'-DDE, 4.4'-DDD, 4.4'-DDT, Endosulfan sulphate, etc.	ALS	EP131A
Organophosphorus Pesticides (OP)	Diazinon, Malathion, Chlorpyrifos, Parathion, etc.	ALS	EP130
Phenoxyacetic Acid Herbicides	Clopyralid, 2.4-D, Triclopyr, 2.4.5-TP (Silvex), 2.4.5-T, 4-Chlorophenoxy acetic acid	ALS	LCMS EP202-LL

Table 2: LABORATORY ANALYSES & METHODS

Contaminant Type	Analytes (not all are listed)	Lab	Method
Glyphosate		ALS	EP204
Volatile and Semi-Volatile Organics (Solvents, etc.)	Vinyl chloride, 1.1.1-Trichloroethane (TCE), Tetrachloroethene, Pentachloroethane (PCE), 1.1-Dichloroethene (DCE), Chlorobenzene, etc.	ALS	
Poly aromatic Hydrocarbons (contained in oils, diesel, coal, tar, etc.)	Naphthalene, Anthracene, Pyrene, Benzo(a)pyrene, etc.	ALS	EP075
TPH/BTEX	Total Petroleum Hydrocarbons (C_6 – C_{36} Fractions)/ Benzene, Toluene, Ethyltoluene, Xylene	ALS	EP080
Bacteria	Faecal coliform	Cairns Water	TPB070

Passive Samplers

In order to capture contaminant data from a longer period of time, passive samplers developed by ENTOX (Qld University) were deployed at select sampling locations for periods of 30 days and 5 days during the wet season. These devices passively adsorb contaminants from the water column during the period of deployment, and can detect contaminants such as herbicides at much lower concentrations than grab samples. Two types of passive samplers were deployed along with flow monitors:

-Empore Disks (EDS)- herbicide samplers (polar organic compounds)
-Polydimethlysiloxane (PDMS)– PAHs and pesticide/herbicides (non-polar organics)

Passive samplers were deployed over a period of 30 days during the first major rains of the wet season and for 5-day periods during subsequent floods in order to catch contaminants entering the river. After retrieval, the samplers were refrigerated and sent via overnight air courier to the Queensland Health Scientific Services laboratory (QHSS) in Brisbane for analysis. Pesticides and PAHs were analysed by GC-MS. Herbicides were analysed by LC-MS. The complete list of pesticides, herbicides and PAHs screened for are listed in **Appendix E.**

The contaminant concentrations reported by QHSS were calculated using an estimate of flow rates measured by flow monitors deployed with the passive samplers, the solubility of the compounds in water and the uptake rate for the chemicals detected.

Passive samplers were deployed in the Laura River at LN-LR-05 (Broken Dam Station), LN-LR-04 (Crocodile Station near Carroll's Crossing), LN-LR-02 (New Laura) and LN-NR-01 (Normanby River estuary). In 2010 an additional 5-day ED sampler was deployed at Turalba Valley Station (LN-Turalba) between LN-LR-05 and LN-LR-04 to quantify concentrations of herbicides and distances travelled downstream from Lakeland agricultural area. Not all samplers were retrieved- many number were washed away during major flood events.

4 QUALITY ASSURANCE/ QUALITY CONTROL

4.1 Quality Control Methods

The collection of reliable, high quality data has been a priority for the Laura-Normanby Monitoring project, and the project was designed with a high level of quality control.

The field sampling programme included the following quality control checks:

- Documented equipment calibration before each use to ensure meter accuracy
- Three water quality measurements taken at each site to ensure equipment stability, identify outliers and variation
- QC SAMPLES:
  - Sample Duplicates (QC-01) submitted to laboratory for assessment of laboratory precision.
  - Field Method Blanks (QC-02) submitted to assess for sample contamination during transport or analysis. Laboratory supplied blank water for nutrients, metals, and organics was poured into a sample bottle, transported into the field and submitted to the lab with other samples. Equipment Rinsate Blanks (QC-03) submitted for analysis to assess for potential cross-contamination of samples in the field via non-dedicated equipment such as sample collection bottles or filtering syringes. Laboratory supplied blank water for nutrients, metals, and organics was rinsed through the sample bottle or syringe and then into a sample bottle, which was submitted to the laboratory.
  - Certified Reference Material (CRM) samples (QC-04) were submitted for nutrient analysis approximately once every three months. CRM samples were prepared for saltwater and freshwater, total and dissolved nutrients by the Qld Health Laboratory. CRM analysis documents laboratory accuracy and potential loss of nutrients during storage and transportation.
  - Trip blanks (QC-05) were submitted along with samples analysed for volatile organics (petroleum hydrocarbons & PAHs).
  - All QC samples were submitted blind to the laboratory.

Laboratory Quality Control

In addition to the Field Sampling QA/QC procedures listed above, the analytical laboratories were required to conduct their own quality control checks with all analyses. The Laboratory Quality Control Checks are listed in **Appendix C**.
The laboratory supplied a QC report with each group of analytical results, showing that the analytical results met quality control standards. Where Lab QC reports identified breaches, the relevant data has been reviewed and eliminated from this report if necessary.

4.2 QA/QC – Analytical Data Validation

Analytical Data Validation has been conducted to ensure that all data adheres to Quality control standards and falls within the acceptable ranges for accuracy and precision. Analytical data were validated against the following criteria:

- Data Entry Review
- Instrument calibration and performance checks;
- Field Blank analyses;
- Rinsate Blank analyses
- Field duplicates analysis;
- Certified Reference Material (CRM) Analysis (nutrient analyses only);
- Sample Holding Times and Temperature upon receipt by the Lab; and
- Laboratory QC Samples and Reports.

Relative percent differences (RPDs) were calculated between duplicate samples and between the CRM analytical results and certified values. Less than 20% difference was considered to be within the acceptable range. Field blanks and rinsate blanks were reviewed for potential contamination during the field sampling or analytical process. Where QA/QC samples exceeded the acceptable limits, data collected on that day or within the sample batch has been discarded. The data validation criteria are listed in the CYMAG QA/QC Methods (**Appendix C**).

The results of the analytical Data Validation are detailed in the following sections.

4.3 Nutrient Data Quality Results

4.3.1 Duplicate Analysis Results (QC-01)

A total of 38 batches of nutrient samples have been submitted for analysis. A duplicate sample was submitted to the laboratory with 28 of these batches. Of the duplicate samples, all were within the acceptable RPD range with the following exceptions:

- Total Nitrogen duplicate results exceeded the RPD on 2 dates (December 2007 and February 2010). Total Nitrogen results for these batches were discarded.

4.3.2 Field Method Blank Analysis Results (QC-02)

Nutrient field blank samples were submitted for laboratory analysis with 15 Laura-Normanby batches. Field blanks were not submitted with earlier batches as a suitable source of nutrient free re-agent was not available. The field blank samples contained no signs of introduced nutrient contamination with the following exceptions:

- Total Phosphorous (TP) concentrations of 0.006 and 0.008 mg/L were detected in blank samples from September 2009 and February 2010.
- Total Nitrogen (TN) concentrations of 0.08 mg/L, 0.07 mg/L and 0.09 mg/L were detected in blank samples from September 2009 and February 2010.

The TN and TP data collected during the above sample trips has been qualified as having potential low-level contamination. The level of nutrients detected in blank samples relative to the actual sample concentrations is low and not believed to have significantly compromised sample data quality.

4.3.3 Nutrient Equipment Rinsate Analysis Results (QC-03)

Equipment rinsate samples were collected using certified nutrient and contaminant-free water supplied by the relevant labs. The blank water was rinsed through non-disposable sampling equipment such as the extended-pole sampling bottle and syringes used for filtering multiple nutrient samples. The results of rinsate samples were assessed for indications of potential cross-contamination between samples.

A total of 15 nutrient rinsate samples (QC-03) were collected from sampling cups and filtering syringes used during Laura-Normanby sampling events. Rinsate samples contained no detectable nutrient levels with the following exceptions:

- QC-03 syringe rinsate sample collected February 2010 contained 0.004 mg/L filterable reactive phosphorus, 0.002 mg/L ammonia nitrogen and 0.003 mg/L nitrogen oxides. These concentrations barely exceeded the detection limits and are not believed to have compromised sample data quality.
- Concentrations of total nitrogen of 0.005 mg/L and 0.004 mg/L were detected in QC-03 sample cup rinsates collected December 2008 and July 2007. Samples collected on these dates have been qualified as potentially having low level cross-contamination; however these relatively low concentrations are not believed to have significantly impacted the results.
- Syringe rinsate sample QC-03 collected January 2010 contained 0.021 mg/L Nitrogen oxides (NOx). This indicates that there may have been cross-contamination between sites and the NOx results from this date have been deleted.

4.3.4 Certified Reference Material Results (QC-04)

A total of 12 total and dissolved nutrient CRM samples were submitted for analysis with Laura-Normanby samples. The analytical results were compared against the certified values to evaluate the accuracy of laboratory analysis and potential contamination or loss of nutrients during sample transportation. The RPDs between QC-04 CRM samples and the certified values were within the acceptable range for all samples. This indicates that there is a high level of accuracy in the nutrient analysis.

4.3.5 Nutrients Data Quality Summary

The review of the QA/QC analytical results indicates that all but a small fraction of the nutrient data collected between June 2006 and June 2010 is acceptable and of a high data quality. Ammonia nitrate results from one sample batch (out of 38) and total nitrogen results from 2 batches were discarded due to a low level of precision between sample duplicates. Total Nitrogen results from December 2008 and July 2007 have been qualified as potentially having low level (0.0053 mg/L) contamination based on rinsate sample results. Nitrogen oxide results from one sample batch (January 2010) have been deleted due to potential cross contamination identified in rinsate samples. The remaining sample results presented in this report have passed the sample quality validation process.

The results of duplicate samples, field blanks and rinsate blanks indicate that no significant contamination of nutrient samples has occurred during sample collection, transportation or analysis. The results from the analysis of certified reference material indicate that there is a high level of accuracy in the laboratory analytical results.

4.4 Chlorophyll-a Data Quality Results

Only a small number of chlorophyll-a duplicate, blank and rinsate samples have been submitted, due primarily to the time required to collect and filter these samples. There have been no CRM samples submitted for chlorophyll as suitable CRM is not available. Therefore the chlorophyll-a data presented here is largely unvalidated.

Chlorophyll-a QA/QC results are as follows:

- 1 blank sample (QC-02) submitted. No chlorophyll detected in blank.
- 3 sample cup rinsate samples (QC-03) submitted- minor chlorophyll detections (0.0334 µg/L) in 2 rinsates. This could indicate low-level cross-contamination of samples, or rinsate water (which was not certified chlorophyll-free) may have had low levels of chlorophyll
- 1 duplicate chlorophyll sample was analysed- RPD was within acceptable limits

4.5 Contaminant Data Quality Results

4.5.1 Field Duplicate (QC-01) Results

Ten batches of metals samples (including 2 batches of sediment samples) were submitted for analyses. Duplicate water samples were submitted for total metals analysis with 3 of these batches. No duplicate sediment samples were submitted. The RPDs between duplicate and original samples were all within the acceptable range, indicating a high level of precision for aqueous metals analysis. However the total number of duplicate samples collected is low.

Two duplicate samples were submitted for TPH and BTEX analysis. The RPDs were all within the acceptable range. One duplicate sample was submitted for PAH, glyphosate, volatile organics (solvents, etc.), and OC/OP Pesticides. The RPDs were all within the acceptable range. One duplicate bacteria sample was submitted to Cairns Water. The RPD was within the acceptable range.

Due to the high cost of these analyses, the number of duplicate samples is low, however the number of contaminant detections was extremely low (most samples had no contaminant detections) and the low level of duplicate quality control samples is not likely to affect the quality of these results.

4.5.2 Field Blank (QC-02) Contaminant Results

The following field blank samples were submitted for analysis with Laura-Normanby contaminant sample batches:

- 2 dissolved metals and mercury grab samples
- 8 total metals and mercury blank grab samples
- 1 blank grab sample for TPH/ BTEX/ PAHs & VOCs/SVOCs
- 2 blank grab samples for OC/OP Pesticides,
- 1 blank grab samples for Phenoxyacetic acid pesticides and glyphosate

There were no detections of any contaminants in the above blank samples, indicating that there has been no contamination of samples during sample collection, transportation or analysis. However the number of blank samples is low and not representative of every sample batch.

4.5.3 Rinsate Blank (QC-03) Contaminant Results

The following rinsate blank samples were submitted for analysis with Laura-Normanby contaminant sample batches:

- 2 dissolved metals and mercury rinsate samples
- 6 total metals and mercury rinsate samples
- 1 rinsate sample for TPH/ BTEX/ PAHs &
- 2 rinsate samples for OC/OP Pesticides, and
- 1 rinsate sample for Phenoxyacetic acid pesticides and glyphosate.

The majority of contaminant samples were collected directly from the river into the sample bottle; therefore rinsate sampling (checking for contamination from collection cups or filtering syringes) was not required for most contaminant sample batches.

No herbicides, pesticides, TPH, BTEX, or PAHs were detected in rinsate blank samples, indicating that there has been no identified cross-contamination of samples resulting from sample collection methods.

Low levels of total metals were detected in the following rinsate samples:

- 21/2/2007: Cadmium (0.0006 mg/L) and zinc (0.007 mg/L)-
  Samples collected on this date did not contain cadmium or zinc, except for sample LN-LT-TIP collected below the Laura Tip, which had significantly higher concentrations of cadmium (0.014 mg/L) and zinc (0.062 mg/L) than the rinsate sample. Cadmium and Zinc were not detected in the remaining samples, indicating that there has been no cross-contamination.
- 12/3/2007: Chromium concentrations (0.002) mg/L and zinc (0.005)-
  Although these concentrations barely exceed the detection limit, similar concentrations detected in sample LN-BHC from this date were deleted due to the potential contamination identified in the rinsate sample.

4.5.4 Passive Sampler Blank & Duplicate Results

1 Blank and 1 Duplicate Passive sampler was deployed with each batch of passive samplers; however some of these were lost during floods. Blank Passive samplers were transported along with the actual samplers but were not deployed in the rivers.

Blank ED sampler from 2008 and 2009 were non-detect for all herbicides, pesticides and PAHs, indicating that there had been no contamination of the passive samplers during transportation, deployment, retrieval or analysis. The January 2010 blank 30-day PDMS sampler contained concentrations of the PAH anthracene, which was also detected in the PDMS deployed at LN-LR-05. Anthracene, like other PAHs, is produced during combustion, including cigarettes, and may have been introduced to the samples as an airborne contaminant. The anthracene detection at LN-LR-05 has been deleted. No other analytes were detected in blank ED or PDMS samples.

Duplicate samplers were lost during heavy flood events, with the exception of 1 duplicate ED deployed in January 2009. The RPDs for herbicides detected in the duplicate samples were outside of the acceptable RPDs. This is believed to have due to a tear in one of the membranes, which would have affected the rate of flow past the membrane. These concentrations are reported with qualifications. Due to the nature of the passive samplers and the methods of calculating daily rates over a 30-day sampling period, all concentrations reported are only considered to be estimates.

4.5.5 Laboratory QC Sample Results

Fourteen batches of samples were submitted to ALS Laboratory for contaminant and metals analysis. The laboratory conducted quality control tests including laboratory, blank spikes and matrix spikes to assess the accuracy and precision of their analytical methods. ALS provides a quality control report with the sample results identifying any breaches in their quality control sample results. These reports also identify any instances in which samples were not analysed within the accepted holding times, which range from one week to 6 months depending on the analysis and sample preservation.

Table 1 in **Appendix C** lists all breaches in Laboratory Quality Control Sample Results or analytical Holding Times (the acceptable amount of time between sample collection and analysis). Where the quality of the data is considered to have been significantly impacted, results from the relevant batches were deleted and have not been included in this report. Where minor breaches occurred that are not believed to significantly affect the data, the data in question has been qualified as breaching QC limits, and the results are reported with qualifications.

Holding times for various analytes were breached for 10 samples, due primarily to difficulties in transporting samples from remote Cape York sites to laboratories. Mercury, which is analysed with metals, has a shorter holding time than the target metals being analysed and therefore the mercury holding times was breached for a number of samples. Where holding times were exceeded by more than 3 days the results have been deleted and not included in this report, other holding times breaches resulted in the results being qualified but not deleted. Based on the full number of water samples collected it is evident that mercury did not occur above 0.0001 (the

LOR) in the Laura-Normanby water samples and the holding times are unlikely to have any impact on these results.

Laboratory Spike samples showed low mercury recovery in one water sample and low PAH recovery in 4 samples and higher PAH recovery rates in one sample. Most of these were outside of the acceptable limits by only 1 -2 percentage points, and are not likely to have significantly affected the sample results. Based on the body of samples, PAHs are not considered to be present at the Laura Normanby sample sites at concentrations above the (grab sample) detection limits, however; the samples associated with the low recoveries have been qualified and the results cannot be confirmed.

4.5.6 Contaminant Analysis Data Quality Summary

A total of 18 batches of samples were submitted for contaminant analysis. This included 44 metals samples, 16 grab samples and 12 passive samplers submitted for pesticide and herbicide analysis; 12 hydrocarbon and volatile organics samples; 4 passive samplers analysed for hydrocarbons, and 8 sediment samples submitted for a range of the above analyses. Of these, the majority of the contaminant analytical results met the appropriate Field and Laboratory QC standards and are accepted for the purposes of this report. Mercury results were deleted from 3 sample batches due to holding time breaches.

Contaminant and metals duplicate samples indicate a high level of precision for these analyses. Field blank and rinsate results indicate that there has been a very low incidence of contamination of herbicides, pesticides, TPH, BTEX, or PAHs in Laura Normanby grab samples or passive samplers. One instance of low level zinc and chromium detections in a rinsate sample has resulted in the deletion of zinc and chromium analytical results from one water sample collected. Anthracene (a PAH) contamination was identified in one blank passive sampler and the associated passive sampler deployed in the Laura River. These results were deleted and are not reported.

All together a total of 96 samples were analysed for 160 different analytes, with 5 breaches resulting in the deletion of the associated analytical results.

5 WATER QUALITY RESULTS

5.1 Ambient Water Quality Parameters

The assessment of ambient water quality includes the following parameters:

- pH
- Electrical conductivity (mS/cm)
- Salinity (ppt)
- Water temperature (°C),
- Dissolved oxygen (mg/L & % saturation),
- Turbidity (NTU),
- Chlorophyll-a (µg/L), and
- Nutrients (mg/L).

5.2 Statistics

The principal statistic that has been used in this report is the median (50th percentile). Based on between 29 to 112 data points for each river subset, this is a robust statistic. It is not affected by the typically skewed nature of water quality data distributions and, because it covers annual cycles, it avoids the complications of seasonal variation.

In addition to median values, minimum and maximum values have been assessed. Maximum or minimum values (depending on the indicator) represent the worst condition measured and are usually associated with extreme high or low flow events. The likelihood of monthly sampling capturing the true maximum/minimum values that occurred during a particular year is low; however the sampling project has aimed to sample during extreme events in additional to regular monthly monitoring.

The ambient water data has been analysed based on Laura-Normanby River subsets- the Laura River (LR), Normanby River freshwater sites (NR), and Normanby River estuary (NR-EST), and has been characterised based on both annual medians and wet season and dry season variations. Variations between individuals sites (within each subset) have also been assessed and significant differences are discussed.

The data is presented as representative baseline data against which future changes in water quality can be compared. The data has also been compared against the relevant Queensland (Qld EPA 2006) and Australian (ANZECC 2000) Water Quality Guidelines.

The following table shows the range (minimum-maximum values) and median values across each subset of the Laura-Normanby River for all ambient water quality data collected during the four years of sampling. The range and median water quality values for individual sites as well as wet and dry season ranges and median values for each sample location and ambient water quality parameters are listed in **Appendix D.**

The following sections contain a detailed analysis of the ambient water quality results.

TABLE 3:
Comparison of Ambient Water Quality in the Laura & Normanby Rivers (2006-2010)
Range (Minimum – Maximum) and Median Values

	Temperature: °C	**Salinity: (ppt)**	**Conductivity: (mS/cm)**	**pH: -log [H^+]**	**Dissolved Oxygen: (mg/L)**	**Dissolved Oxygen: (%SAT)**	**Turbidity: NTU**
Laura River min- max	19.6 – 36.3	0.0 – 0.9	0.068 – 1.715	6.80 – 9.01	2.79 – 13.26	36.5 – 166.8*	1.0 – 258.0
Laura River median (n=112)	28.2	0.816	0.4	8.17	6.51	82.3	4.4
Normanby Freshwater min- max	20.6 – 36.0	0.0 – 0.3	0.053 – 0.538	6.51 – 8.73	3.48 - 8.76	42.2 -115.0	2.0 – 168.3
Normanby FW median (n= 84)	27.9	0.1	0.150	7.29	6.11	78.5	7.8
Normanby Estuary min- max	23.5 – 32.1	0.4 – 39.7	0.794 – 58.9	7.06 – 8.17	3.64 - 6.73	50.9 – 97.3	6.7 – 125.7
Normanby Estuary median (n=29)	29.6	27.1	41.9	7.96	4.93	73.5	31.3

n = number of samples in each river subset
* Maximum DO measured at LN-LR-04 when the river was not flowing & clogged with algae

5.2.1 Temperature

Temperature in the Laura-Normanby River ranged from 19.6°C to 36.3°C **(Table 3 above).** The Laura River and Normanby River freshwater sites showed similar ranges and median temperature values. Estuary waters had less extreme minimum and maximum temperatures, however fewer samples were collected from estuary sites and the full range of values is not likely to be reflected.

The minimum temperatures occurred in June and there was a river wide average of 25.4 °C during this month. Temperatures peaked in December, with an average December temperature across all sites of 31.9°C.

5.2.2 Salinity & Conductivity

The climate in this region is characterised by long periods of dry weather interspersed with intermittent and generally short-lived periods of heavy rainfall, mostly in the December to March period. This is reflected in stream flows which are very low or nil during the winter, contrasted with short-lived very high flow events generally occurring between January and March.

Following a high flow event, large quantities of freshwater enter the estuary and for a short period this dominates estuary hydrology. In ensuing dry periods, freshwater is gradually flushed out of the estuary by tidal exchange. **Figure 4** below illustrates the salinity cycle at estuary sites LN-NR-00 (Normanby River mouth) and LN-NR-01 (5 km upstream from the mouth) with low values occurring during flood events and salinity gradually increasing during subsequent dry months.

Salinity within the estuary ranged from 0.4 ppt during freshwater events to a maximum of 39.7 ppt measured at the end of the dry season at LN-NR-01. Corresponding estuary conductivity values ranged from 0.794 mS/cm – 58.9 mS/cm.

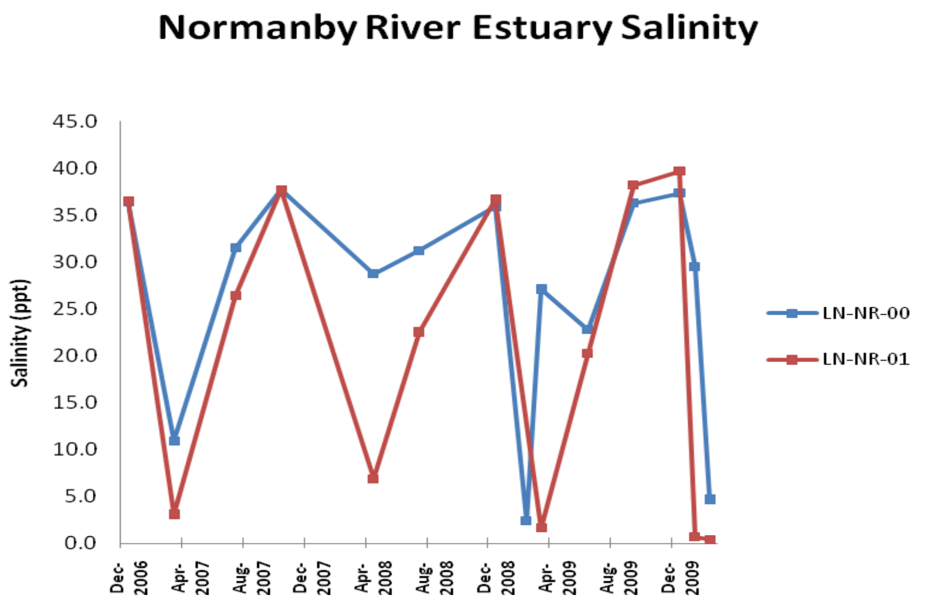


Figure 4: Salinity cycles in the Normanby River estuary

Salinity at freshwater sites in the Normanby River ranged from 0.0 – 0.3 ppt (median 0.1 ppt), while conductivity ranged from 0.053 mS/cm – 0.538 mS/cm (median 0.150 mS/cm). Sampling site LN-NR-05, the furthest upstream site at the East Normanby River Bridge, had the lowest salinity and conductivity. This site springs from mountain rainforests and is upstream from the influence of sodic (saline) soils along the Battlecamp range. However, these statistics could be slightly skewed due to the fact that this site was more accessible than other Normanby sites during the wet season, when conductivity is at its lowest.

Table 4: Minimum, Maximum and Median Conductivity Values (mS/cm) for Laura-Normanby River Subsets

River Subset	Statistic	Annual	Dry Season	Wet season
Laura River	min - max	0.068 – 1.715	0.102- 1.715	0.068 - 0.975
	median	0.4	1.030	0.231
	n	115	74	41
Normanby River	min - max	0.053 – 0.538	0.086 - 0.538	0.053 - 0.137
	median	0.150	0.195	0.077
	n	81	59	22
Normanby River estuary	min - max	0.794 – 58.9	32.4 - 58.9	0.794 - 45.2
	median	41.9	54.8	8.4
	n	29	16	13

*Seasons were determined by rainfall and flow and varied per year
n = number of samples

Laura River sites exhibited higher salinity and conductivity than the Normanby River freshwater sites, most likely due to the saline soils in the region. Salinity in the Laura River ranged from 0.0 – 0.9 ppt, with a median value of 0.4 ppt. Conductivity ranged from 0.068 – 1.715 mS/cm, with a median value of 0.796 mS/cm compared to the Normanby freshwater median of 0.150 mS/cm.

Conductivity values in the Laura River decreased during the wet season during high flow events and increased as flow rates dropped (**Figure 5**). Conductivity values peaked at 1.70 mS/cm at LN-LR-05 (Lakeland, Sept 2009) and 1.72 mS/cm at LN-LR-03 (Festival Grounds, Dec 2007), both corresponding to salinity values of 0.9 ppt.

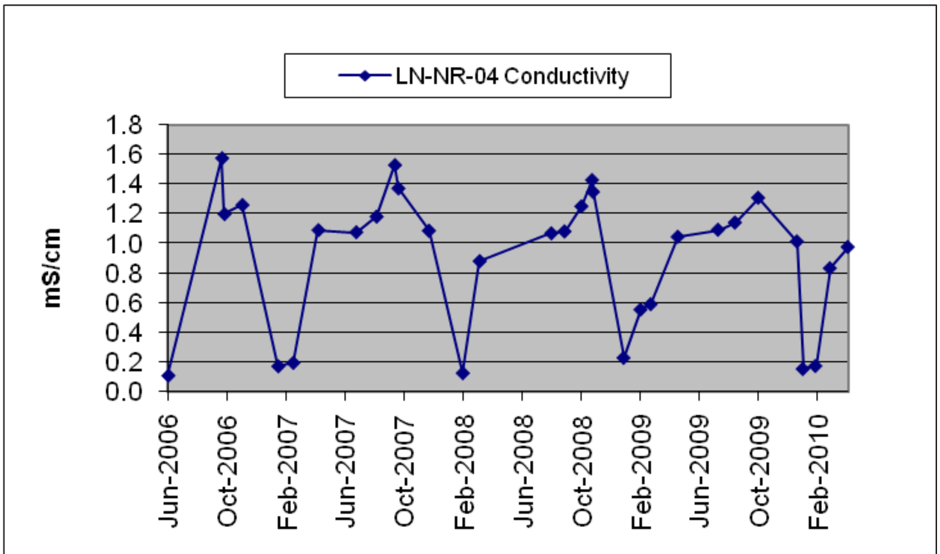


Figure 5: Laura River (Carroll's Crossing) Conductivity Cycle

5.2.3 pH

Table 5: Minimum, Maximum and Median pH Values - Laura-Normanby River Subsets

River Subset	Statistic	Annual	Dry Season[1]	Wet season	Min -Max Guideline[2]
Laura River	min - max	6.80 – 9.01	6.80 – 9.01	6.83 - 8.64	6.0 – 8.0
	median	8.17	8.33	7.76	
	n	115	74	41	
Normanby River	min - max	6.51 – 8.73	6.82 - 8.73	6.51 - 8.06	6.0 – 8.0
	median	7.29	7.35	7.12	
	n	81	59	22	
Normanby River estuary	min - max	7.06 – 8.17	7.67 – 8.17	7.06 – 8.08	7.0 – 8.5
	median	7.96	7.99	7.79	
	n	29	16	13	

1 = Seasons were determined by rainfall and flow rates and varied per year
2 = ANZECC 2000, Tropical Australia
n = number of samples

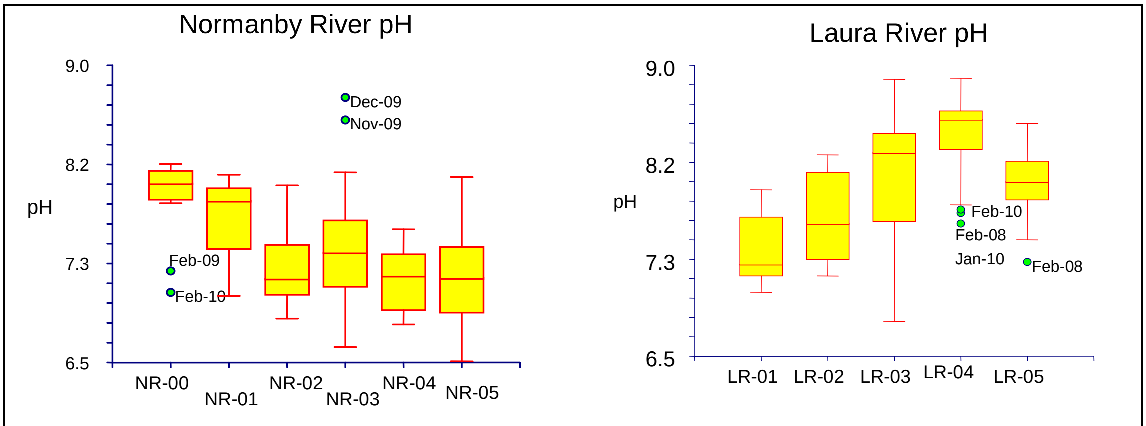
Normanby River estuary pH values ranged from 7.06 to 8.17 (neutral to alkaline) with a slight decrease in pH during wet season freshwater inflows. All estuary measurements were within the expected Guidelines for Enclosed Coastal Waters (Qld 2009) and Australian Tropical Estuaries (ANZECC 2000).

The pH at Normanby River freshwater sites ranged from 6.51 to 8.73, with a median year-round pH value of 7.2 (neutral). The Laura River was more alkaline than the NR freshwater and estuary sites, with a median year round pH value of 8.16. Both the Laura and Normanby freshwater sites exhibited increasing alkalinity during the dry season.

Laura River and Normanby River freshwater sites had pH values during the dry that exceeded the higher Guideline Values for pH (Qld Water Quality Guidelines 2006, Wet Tropics & ANZECC 2000, Tropical Australia). The maximum pH values in the Laura and Normanby Rivers occur during low flow periods, and are associated with elevated salinity (0.5 – 0.9 ppt) and/ or high algal growth. The three furthest upstream sites on the Laura River (LN-LR-03, LN-LR-04 and LN-LR-05) all had year round median pH values that exceeded 8.0.

The high conductivity of these waters is likely to influence the relatively high pH. The high nutrient levels from fertilisers and cattle droppings may also contribute to the alkalinity of these waters. The maximum pH value (9.01) was measured at LN-LR-05 (Broken Dam Station, Lakeland) in December 2009 during a period of very low flow, high algae growth and supersaturated oxygen levels. Maximum pH values in the Normanby River were measured during similar low-flow and high algae conditions.

The Box Plots below (**Figure 6**) show a comparison of pH range and median values at all Laura River (LR) and Normanby River (NR) sites.



The box represents values within the 25th to 75th percentile for each site.
T Lines extending from the box represent the maximum to minimum values.
The line across the box represents the median value.
● = outliers

Figure 6: Laura & Normanby River pH Box Plots
(Median, Minimum & Maximum Values for each Site)

Acid sulphate soils have been identified in wetlands in the Laura Normanby catchment, and may be impacting upon water quality in wetlands that are being heavily dug up by pigs and cattle, such as those at Jack Lakes and Lakeland National Park. Sites along the Normanby River such as LN-NR-03 (12 Mile Waterhole) and LN-NR-02 (Kalpowar Crossing) are downstream from these wetlands and could potentially be influenced by disturbance of acid sulphate soils. These impacts would be most likely to be observed just after the first rains of the year, when the churned up wetlands are first filled with water which would then overflow into the rivers.

Although pH did tend to decrease during the early wet season (**Figure 7**), pH levels at the Laura- Normanby monitoring sites did not drop below a pH of 6.5, therefore it is unlikely that there are significant impacts on aquatic species related to acid-sulphate soils. However, local impacts from disturbance of acid sulphates may exist, and additional sampling would be necessary to detect localised impacts.

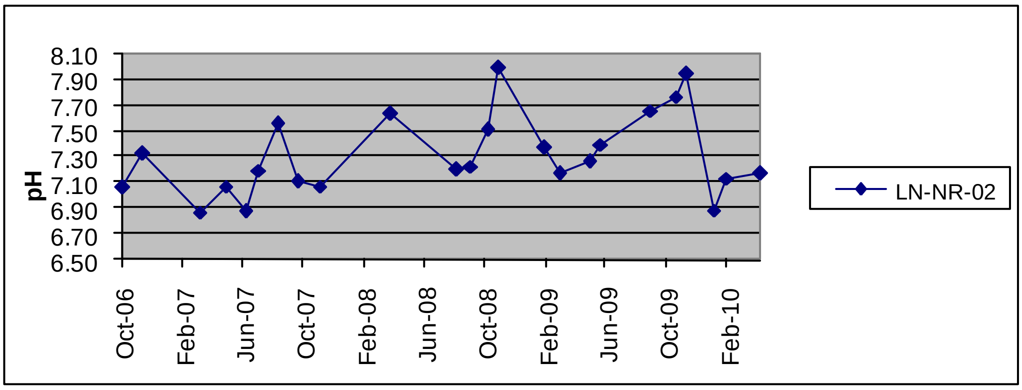


Figure 7: LN-NR-02 (Kalpowar Crossing) pH Cycle

5.2.4 Dissolved Oxygen

Table 6: Dissolved Oxygen Statistics & Guideline Values

Indicator	Statistic	Rationale	Guideline values*
DO (% saturation)	median	This represents a mid range (daytime) value of DO under base flow conditions.	Estuary : 80% – 120% Lowland River: 85% – 120% Upland River : 90% -120%
	minimum	Minimum values are nearly always associated with the introduction of organic matter during large inflows from the catchment. Subsequent bacterial breakdown of this matter causes reduced DO.	Values <50% are of concern (in flowing waters). Values <30% may be lethal to some fish spp.
	maximum	Maximum values are associated with algal blooms. The higher the value the more intense the bloom.	Values >120% saturation are of concern.

*Estuary, Lowland River & Upland River from ANZECC 2000 Tropical Australia Guidelines
Table from A. Moss (DERM)

Stagnant dry season waterholes are often subject to high amounts of algal growth, especially in locations where nutrients are elevated from fertilisers or cattle droppings. Algal blooms results in extremely high oxygen levels during the day while the plants are photosynthesizing, and extreme drops in oxygen at night due to the decomposition (bacterial breakdown) of algae and other organic matter.

Dissolved oxygen concentrations in this report reflect daytime oxygen levels; however it is acknowledged that oxygen levels are extremely variable and are influenced by the time of day, cloud cover, algae, organic matter and flow rates.

Table 7: Minimum, Maximum and Median Dissolved Oxygen Levels (% Saturation) for Laura-Normanby River Subsets

River Subset	Statistic	Annual	Dry Season[1]	Wet season
Laura River	min - max	36.5 – 166.8*	36.5 - 166.8	52.4 - 115.2
	median	82.3	78.9	85.8
	n	115	74	41
Normanby River	min - max	42.2 -115.0	42.2 -115.0	60.1 -90.1
	median	78.5	75.4	80.8
	n	81	59	22
Normanby River estuary	min - max	50.9 – 97.3	56.2- 97.3	50.9 - 80.7
	median	73.5	75.5	64.6
	n	29	16	13

1 = Seasons were determined by rainfall and flow rates and varied per year
n = number of samples

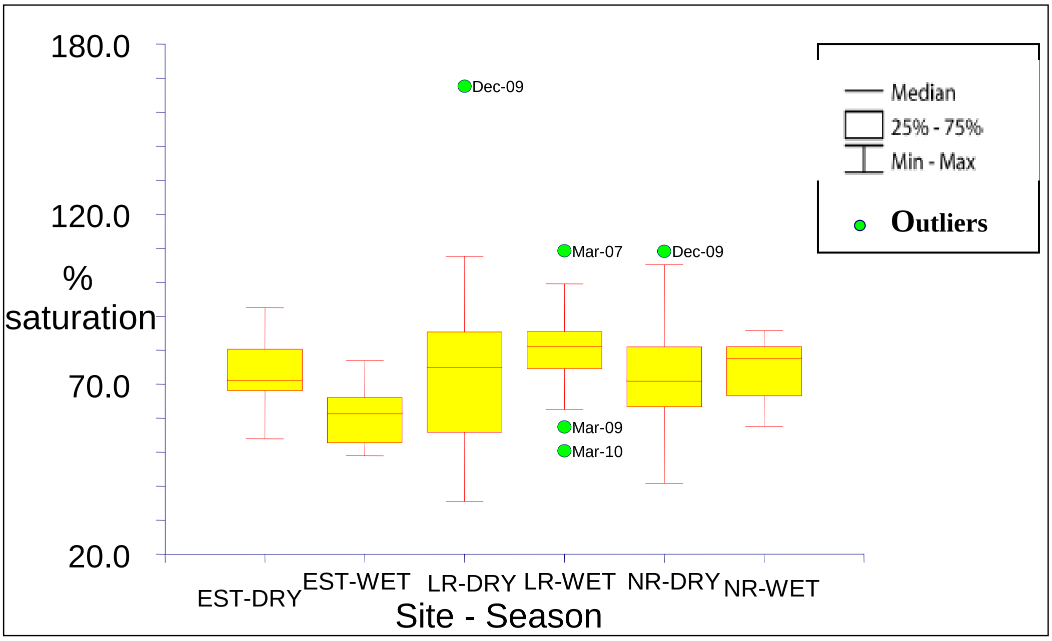


Figure 8: Laura-Normanby Seasonal Dissolved Oxygen BoxPlots: Range and Median Values

Laura-Normanby freshwater dissolved oxygen levels ranged from 36.5% – 166.6%, with median (year-round) values of 82.3% (Laura River) and 77.9 % (Normanby River). Median dissolved oxygen values at Laura- Normanby freshwater sites increased slightly during the wet. However, extreme maximum and minimum values occurred during the dry, when stream flow was greatly reduced and algae growth high.

Estuary dissolved oxygen levels ranged from 50.9% – 97.3%, with a year-round median of 75.3%. Median estuary oxygen levels decreased during the wet season. Although freshwater reaching the estuary during the wet could potentially carry more oxygen than saltwater, warmer water temperatures during the wet season are likely to result in the lower dissolved oxygen concentrations.

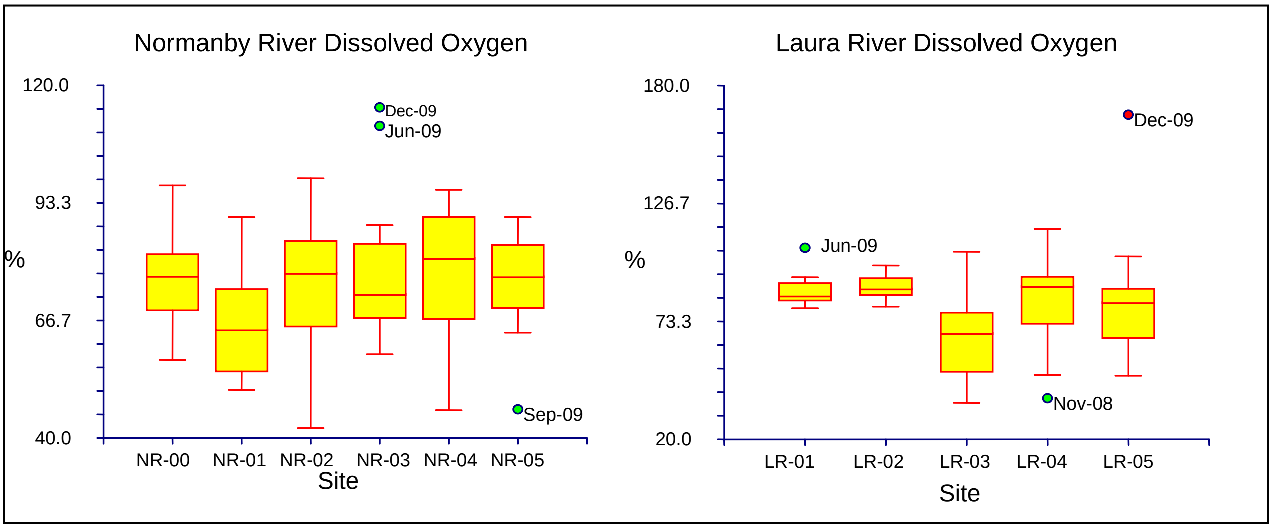


Figure 9: Dissolved Oxygen Box Plots (Year-Round) for Individual Laura-Normanby Sample Sites

Oxygen levels below 50% are relatively common in Laura-Normanby during the dry season periods of low or no flow. Laura-Normanby dissolved oxygen values dropped below 50% at LN-LR-03 on 6 occasions (**Figure 10**).

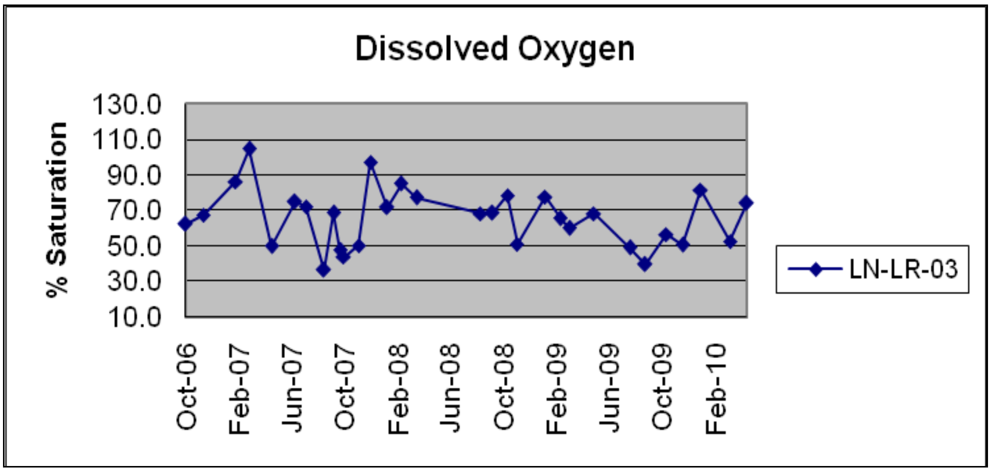


Figure 10: LN-LR-03 (Festival Grounds) Dissolved Oxygen Cycle

Oxygen concentrations were less than 50% at LN-LR-04 (Carroll's Crossing) on 2 occasions (December 07 and October 08), and LN-LR-05 (Broken Dam Station at Lakeland) on 3 occasions (December 07, August 08 and September 2009). Normanby River oxygen levels dropped below 50% at LN-NR-02 (Kalpowar Crossing) in June 09, and at both LN-NR-04 (Battlecamp Crossing) and LN-NR-05 (East Normanby Bridge) in September 2009.

Although low oxygen levels are to be expected in slow or stagnant waters, it is likely that the naturally low oxygen levels at these sites are compounded by excessive algal growth resulting from fertilisers and cattle droppings.

Dissolved oxygen levels were not recorded below 30% on any occasion. No fish kills were known to occur during the period of sampling, but have been reported in the Laura-Normanby during previous years of drought, and are attributed to low oxygen levels during the dry season.

Oxygen levels exceeded 120% on one occasion at LN-LR-05 (166%) in December 2009, at a time when the river was stagnant and full of algae.

5.2.5 Turbidity

Turbidity is a measure of the amount of particulate matter in the water column and can be used as a surrogate for total suspended sediments or water clarity. The median turbidity value represents the mid-range value under base flow conditions. Maximum turbidity values in the Laura-Normanby are generally associated with the introduction of sediments during or immediately after high rainfall events in the catchment. Increased erosion in catchments due to clearing, grazing, or other intensive land-uses can result in increased turbidity in adjacent streams.

Table 8: Minimum, Maximum and Median Turbidity Levels (NTU) for Laura-Normanby River Subsets

River Subset	Statistic	Annual	Dry Season	Wet season
Laura River	min - max	1.0 - 258	1.0 – 11.6	3.6 - 258
	median	4.4	2.1	35.3
	n	112	71	41
Normanby River	min - max	2.0 - 168	2.0 – 68.0	6.1 -168.3
	median	7.8	6.1	43.5
	n	83	61	22
Normanby River estuary	min - max	6.7 – 125.7	8.7 – 125.7	6.7 – 108.7
	median	31.3	39.8	22.7
	n	29	13	16

n= number of samples

Turbidity in the Laura-Normanby ranged from 1 NTU to 258 NTU. The Laura-Normanby freshwater sites showed turbidity cycles common in tropical rivers with generally short-lasting peaks occurring immediately during or after high rainfall events in the catchment and low turbidity levels (<10 NTU) throughout the dry season (**Figure 11**).

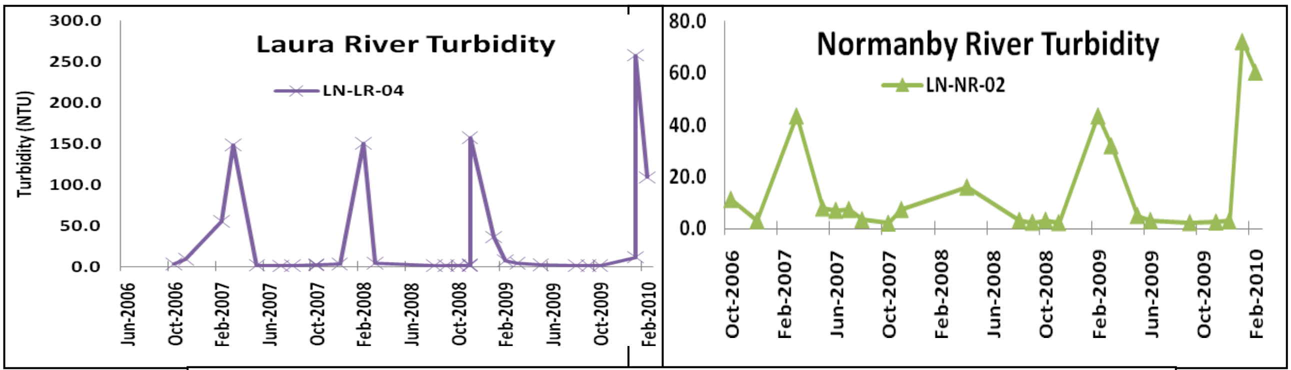


Figure 11: Laura & Normanby River Seasonal Turbidity Cycles

The Normanby River estuary was relatively turbid throughout the year, with a median turbidity value of 31.3 NTU (**Table 8**). The maximum turbidity value of 125.7 NTU was measured during wet season floods, however turbidity values as high as 108.7 NTU were measured during the dry season. Turbidity in the estuary during the dry season is largely controlled by the tidal neap/spring cycle (Moss 2010). Turbidity in the estuary was greatest along the edges, where outgoing tides washed clay sediments from the banks and adjacent mudflats (See Photo 4 in **Appendix A**). This was particularly pronounced at LN-NR-01 (5 km upstream from mouth), where the median turbidity value was 37.2 NTU, compared to LN-NR-00 (Normanby mouth) with a median value of 16.3 NTU (**Table 9**).

The Normanby River freshwater sites had a year-round median turbidity value of 7.9 NTU, compared to the Laura River median of 4.4 NTU. However peaks in turbidity were generally greater at Laura River sites than at Normanby River sites. Maximum turbidity values of 258 NTU at LN-LR-04 (Carroll's Crossing) and 193 NTU at LN-LR-05 (Broken Dam Station Lakeland) were measured after heavy rains in January 2010 and November 2008. Normanby River maximum of 168 NTU was measured at LN-NR-04 (Battlecamp Crossing) in January 2010.

Table 9: Maximum, Median and Average Turbidity Values for Laura-Normanby Sample Sites (NTU)

Sample Site	NR-00	NR-01	NR-02	NR-03	NR-04	NR-05	LR-01	LR-02	LR-03	LR-04	LR-05
Maximum	108.7	125.7	72.3	95.9	168.3	93.7	124.0	62.6	141.3	258.0	193.3
Median	16.3	37.2	7.0	8.7	10.6	6.1	6.9	10.7	2.8	3.5	4.0
Wet Season Median	31.8	58.3	41.3	59.1	86.4	38.3	69.9	28.1	48.5	85.1	46.4
n	15	14	25	19	16	24	10	15	32	32	27

n = number of samples

It is difficult from this data to make any assumptions regarding erosion in the Laura Normanby catchment and the impact of land use on sediment loads in the river. However, the sites with the maximum turbidity values and the highest average wet season turbidity values are LN-LR-04 (Carrolls Crossing) and LN-LR-05 (Broken Dam Station) and LN-NR-04 (Battlecamp Crossing). These sites include the most intensive agricultural land-use and are subjected to extensive gully erosion along the adjacent dirt roads and a high concentration of cattle around the watercourse. These correlations are speculative, yet observations of gully erosion along the Laura River would clearly indicate that this erosion is contributing large quantities of sediment to the river system. The gullies appear to be caused by a combination of road erosion and cattle. A separate and extensive research program is currently underway by Griffith University to characterise erosion within the Laura-Normanby catchment.

5.2.6 Nutrients

Table 10: Laura-Normanby River Minimum, Maximum and Median Nutrient Concentrations

		Total Phosphorus	Filt Reac Phosphorus	Ammonia Nitrogen	Nitrogen Oxides	Total Nitrogen
		mg/L as P	mg/L as P	mg/L as N	mg/L as N	mg/L as N
Laura River N= 126	min	0.006	<0.002	<0.002	<0.002	0.110
	max	0.310	0.095	0.073	1.300	2.000
	median	**0.042**	**0.011**	0.006	**0.124**	**0.469**
Normanby River freshwater N= 87	min	0.004	<0.002	<0.002	<0.002	0.090
	max	0.110	0.019	0.047	0.210	1.400
	median	**0.025**	0.004	0.006	0.019	**0.235**
Normanby River estuary N = 29	min	0.009	<0.002	<0.002	<0.002	0.150
	max	0.071	0.013	0.054	0.130	0.560
	median	**0.032**	0.005	**0.017**	**0.043**	**0.281**
Water Quality Guidelines*						
Estuary		*0.020*	*0.005*	*0.015*	*0.030*	*0.250*
Lowland river		*0.010*	*0.004*	*0.010*	*0.010*	*0.300*
Upland River		*0.010*	*0.005*	*0.006*	*0.030*	*0.150*

N= number of samples

0.042 **BOLD** median values exceed the Water Quality Guidelines

* ANZECC 2000 Water Quality Guidelines, Tropical Australia Upland Rivers & Estuary

Nutrient levels in the Laura River generally exceeded those of the Normanby (**Table 10**). Total Nitrogen concentrations were measured at a maximum concentration of 2.0 mg/L in the Laura River, compared to 1.4 mg/L in the Normanby. The greatest increase was observed in nitrogen oxides (NOx), which were observed at a maximum concentration of 1.300 mg/L and median concentration of 0.124 mg/L in the Laura River, compared to a Normanby River maximum of 0.210 mg/L and median concentration of 0.019 mg/L. Total phosphorous concentrations were also elevated in the Laura River compared to the Normanby.

Nutrient levels were highest at Bullhead Creek and Broken Dam Station in the vicinity of Lakeland, where agricultural run-off is increasing nutrient loads above the natural background concentrations (**Figure 14**). The extent of the agricultural impact on nutrient levels in the Laura River is discussed in more detail in **Section 5.3.3**.

Median concentrations of Total Phosphorous, Dissolved Phosphorous (FRP), Nitrogen Oxides (NOx) and Total Nitrogen in the Laura River exceeded the Queensland (2009) and ANZECC 2000 Water Quality Guidelines for the Protection of Aquatic Ecosystems. Total Nitrogen and Phosphorous concentrations in the Normanby River also exceeded the Guidelines; this may be associated with naturally high sediment loads or cattle impacts. Cattle are frequently observed at Normanby River sites, and during the dry season the water levels drop to a very low flow which exacerbates the impacts from cattle.

Normanby River Total Nitrogen levels generally increased towards the end of the dry season, with peaks occurring between November and February (**Figure 12**). The peaks in TN corresponded with both late dry season low flow periods and wet season high turbidity events. Nitrate and nitrite (NOx) maximum concentrations occurred during the wet season months of January and February, sometimes but not always corresponding with TN peaks. Ammonia peaks also occurred both in November at the end of the dry season, and during wet season high flow periods, however seasonal patterns for ammonia varied for each site and no clear trends were observed (**Figure 13**).

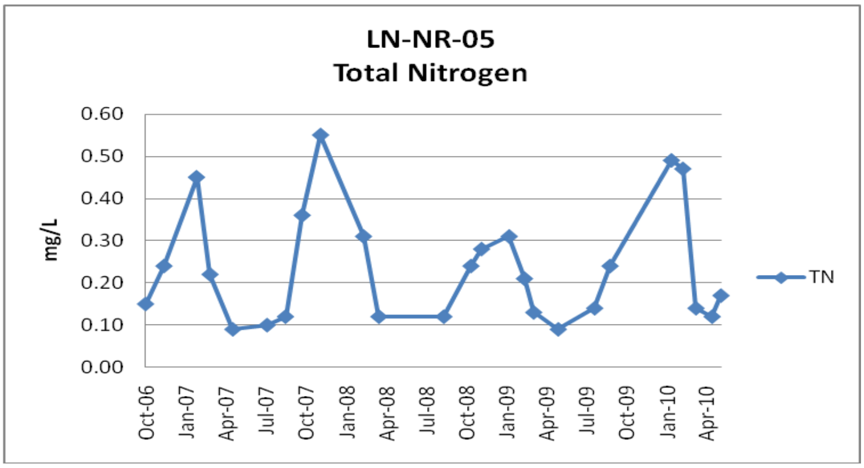


Figure 12: Seasonal TN Cycles at the East Normanby River (LN-NR-05)

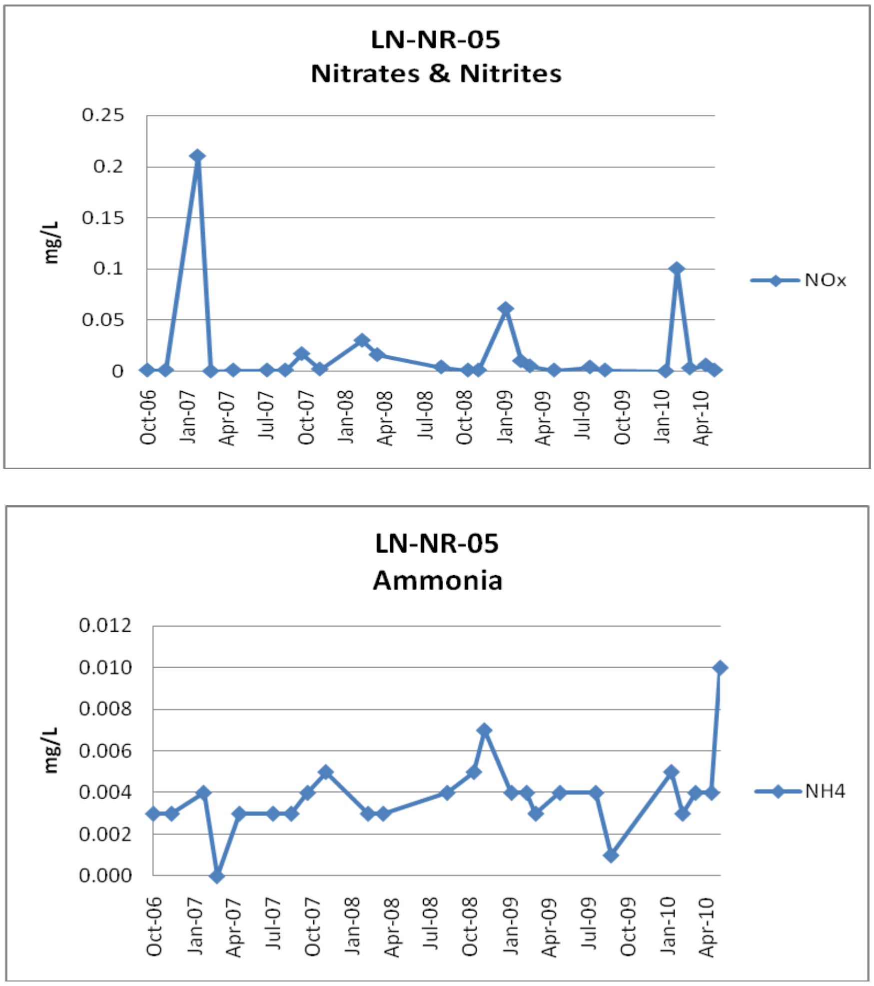


Figure 13: Seasonal Dissolved Nitrogen Cycles at LN-NR-05

Nutrient levels in the estuary were generally higher than at the Normanby River freshwater sites, but less than the concentrations detected in the Laura River. Nutrient levels in the estuary may be correlated with suspended sediments. During the dry season, turbidity levels in the estuary exceeded freshwater site turbidity levels.

Maximum and median nutrient concentrations for each site are listed in **Table 17**.

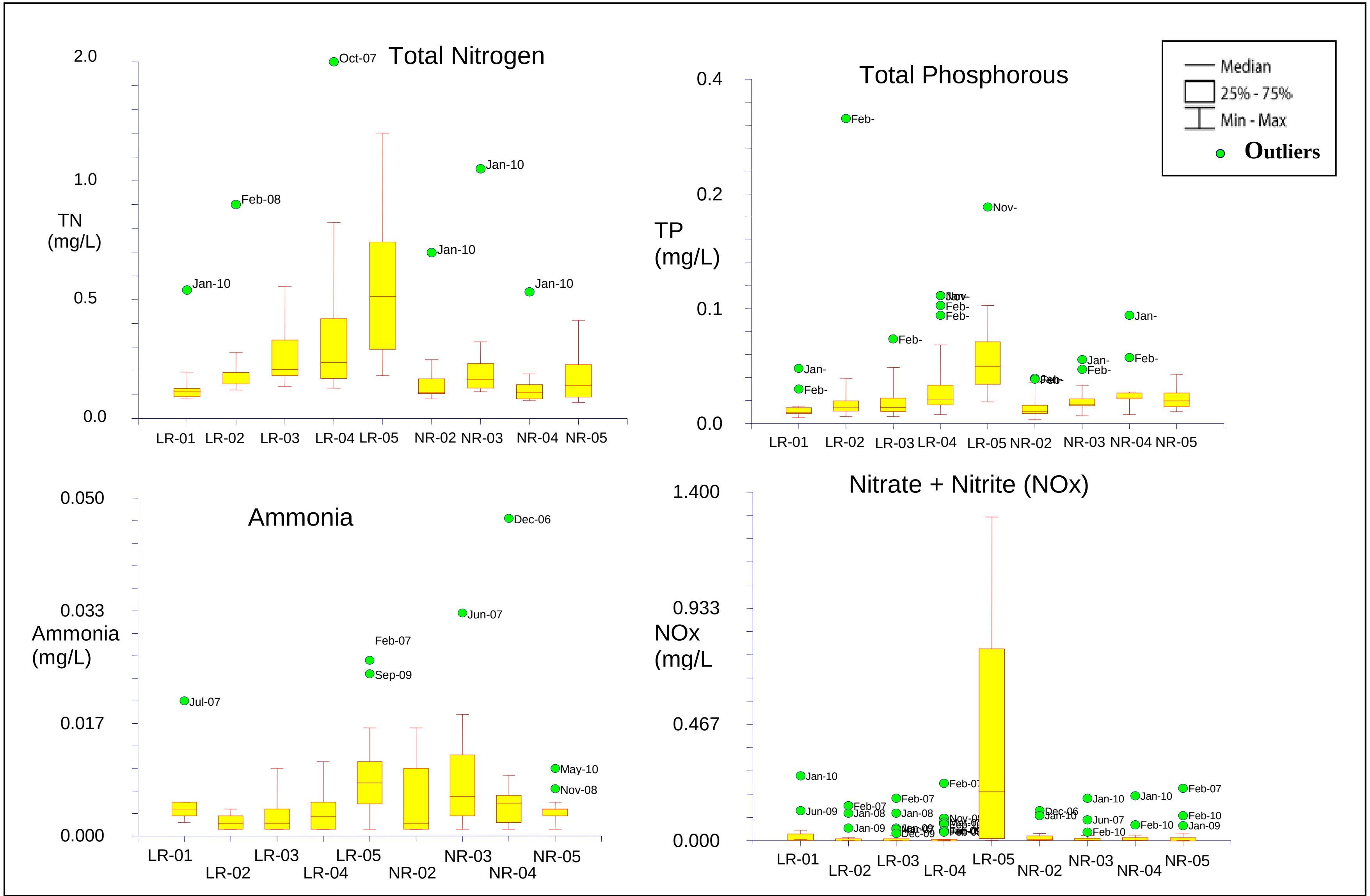


Figure 14: Laura-Normanby Freshwater Sites Nutrient Box Plots

5.2.7 Chlorophyll-a

Table11 : Laura-Normanby Chlorophyll-a
Median and Maximum Concentrations by Site (µg/L)

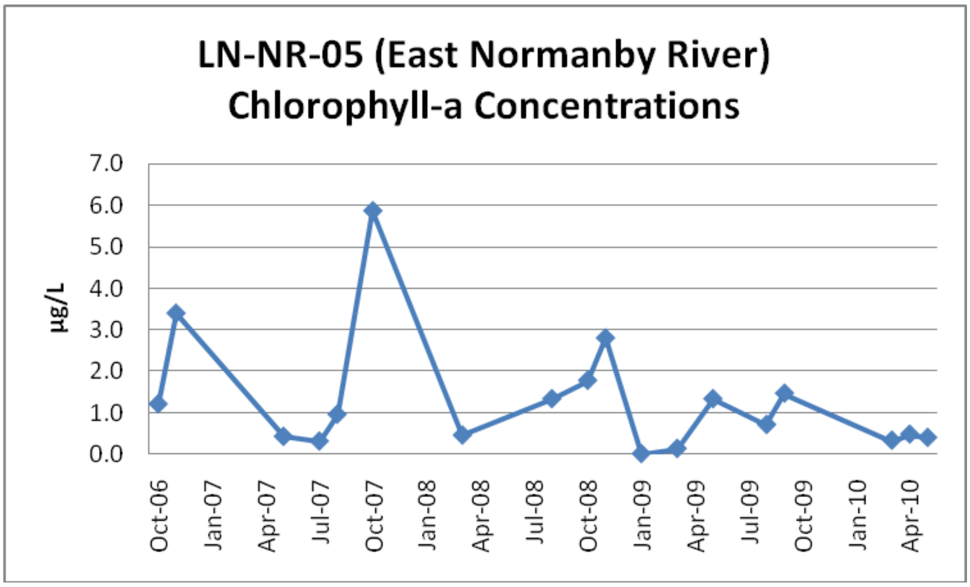
Site ID	Median	Maximum (Date)	n
LN-NR-00-Normanby River (Mouth)	1.193	2.405 (23/03/09)	7
LN-NR-01-Normanby Estuary (5.0km U/S)	1.817	4.542 (14/12/09)	4
LN-NR-02-Normanby River (Kalpowar Crossing GS)	1.403	4.342 (27/08/08)	18
LN-NR-03-Normanby River (12 Mile Waterhole)	3.604	24.803 (01/12/06)	12
LN-NR-04-East Normanby River (Battle Camp Road)	1.392	4.401 (23/09/08)	11
LN-NR-05-East Normanby River (Peninsula Development Road / Mulligan Highway)	0.836	5.878 (15/10/07)	18
LN-LR-01-Laura River (Old Laura Crossing)	2.004	2.832 (27/06/07)	5
LN-LR-02-Laura River (Laura)	1.503	3.696 (24/03/10)	7
LN-LR-03-Laura River (Festival Grounds)	1.526	3.440 (18/11/08)	24
LN-LR-04-Laura River (Carroll's Crossing)	1.692	18.286 (27/11/06)	23
LN-LR-05-Laura River (Broken Dam Stn)	2.872	12.428 (17/12/07)	21
LN-BHC-Bull Head Creek (Lakeland)	10.643	11.273 (17/12/07)	5
Water Quality Guidelines Estuary*	*2.0*		
Water Quality Guidelines Freshwater*	*5 (Lowland Rivers). None established for Upland Rivers (>150 m altitude)*		

n = Number of samples
* ANZECC 2000 Guidelines for Tropical Australia

Chlorophyll Concentrations ranged from 0.534 µg/L to 4.542 µg/L in the Normanby estuary, 0.010 µg/L to 24.802 µg/L in the Normanby River and 0.134 to 18.286 µg/L in the Laura River (**Table 11**). Samples are biased towards lower turbidity periods (non-flood events) as sufficient sample volumes could not be filtered when water turbidity exceeded approximately 20 NTU. Thus sample results do not adequately represent periods of wet season floods.

The maximum chlorophyll-a concentration (24.803 µg/L) was detected in the Normanby River at 12-Mile Waterhole (LN-NR-03) in December 2006 at the end of the dry season when the long and shallow waterhole was fairly stagnant. LN-NR-03 also had the highest median chlorophyll-a value on the Normanby River. On the Laura River, the maximum chlorophyll concentrations occurred at Carroll's Crossing (LN-LR-04), where algal blooms were frequently observed during periods of low flow. High numbers of cattle observed at this site throughout the year are likely to contribute to the regular algal blooms (See Photo 21 in **Appendix A**).

Only 5 chlorophyll samples were collected from Bullhead Creek below Honey Dam in Lakeland, however, chlorophyll-a concentrations were highest at this site, with a median value of 10.64 µg/L. Bullhead Creek receives overflow waters from Honey Dam and run-off from a large agricultural area. Chlorophyll-a concentrations at the adjacent Laura River sample location LN-LR-05 (Broken Dam Station) were also elevated above downstream Laura River locations. Elevated chlorophyll-a concentrations at Bullhead Creek and the Laura River at Broken Dam Station are likely to be associated with nutrient-rich run-off from fertilisers used at Lakeland farms.



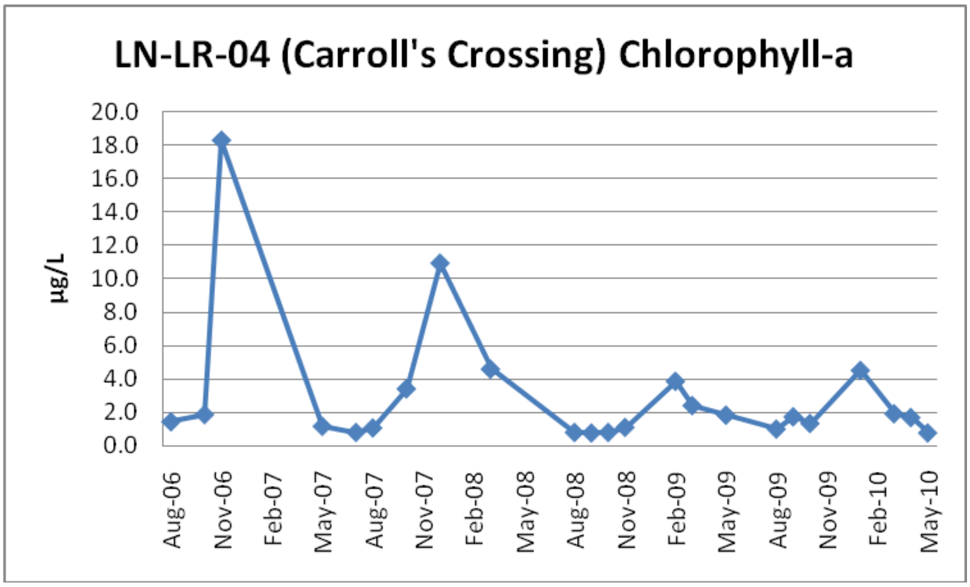


Figure 15: Laura-Normanby River Chlorophyll-a Seasonal Cycles

Discussion:
Major peaks in chlorophyll-a occurred at the end of the dry season when waterholes were subject to low flows and algal blooms (**Figure 15**). Minor peaks in chlorophyll-a occurred during the wet season after flushes of nutrient-rich run-off had entered the waterways. Both the Laura and Normanby Rivers experienced dry season algal blooms and chlorophyll-a peaks. Bullhead Creek and the Laura River at Lakeland showed some evidence of elevated chlorophyll-a concentrations from nutrient-rich run-off. High numbers of cattle around the drying waterholes in the dry season are likely to contribute to the chlorophyll peaks at these sites (12 Mile Waterhole, Carroll’s Crossing and Broken Dam Station).

5.3 Contaminant Analysis/ Impact Assessment Results

In addition to ambient water quality monitoring, assessments of potential impacts from rubbish tips at Lakeland and Laura, and agricultural chemical use in the Lakeland area were conducted annually. The following sections detail the analytical results from these impact assessments.

5.3.1 Lakeland Rubbish Tip

The Lakeland Rubbish Tip is an un-lined dump located on top of a small hill, adjacent to a creek that runs into Bullhead Creek approximately 1.5 km downstream (See Photo 23, **Appendix A**). Bullhead Creek flows into the Laura River 2 km west at Broken Dam Station. Honey Dam, which receives much of the run-off from the town of Lakeland Downs and surrounding horticultural areas, also runs into Bullhead Creek (**Figure 16**).

Anecdotal reports suggest that various hazardous wastes have been dumped at the Lakeland Rubbish Tip, including waste oil and agricultural chemicals. During a visit to the tip in 2007, numerous vehicles and batteries were observed abandoned at the tip and small oil stains on the ground. Lakeland residents reported that a range of contaminants have previously been detected in surface water below the tip; however no analytical results were available (pers. comm. Vicki Brown, 2006). Two properties downstream from the Rubbish Tip are utilising water from Bullhead Creek and for drinking water and other household purposes.

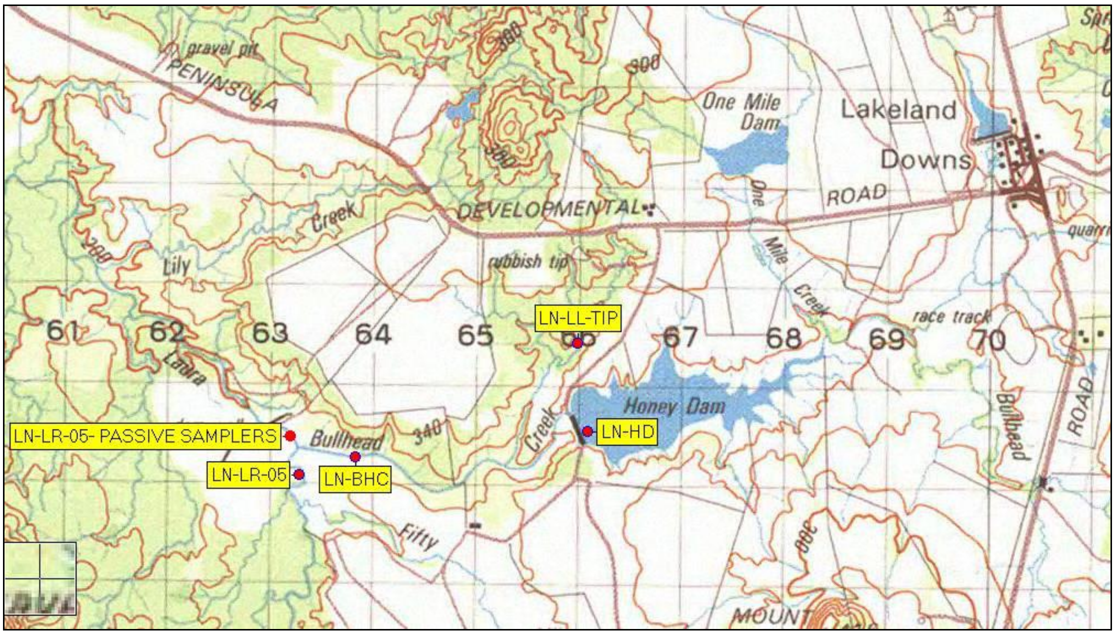


Figure 16: Lakeland Tip and Honey Dam Downstream Sample Locations

In order to test for potential contamination leaching from the Lakeland Tip, a range of grab samples were collected from a property immediately below the tip (LN-LL-Tip) and from Bullhead Creek (LN-BHC) near it's confluence with the Laura River. Contaminant grab samples were collected after the first rains of each wet season, and opportunistically during the dry season.

Water and sediment grab samples collected from LN-LL-Tip and LN-BHC were analysed for Pesticides and Herbicides, Poly-aromatic Hydrocarbons (PAHs), Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethylene & Xylene (BTEX), and Solvents. None of the above contaminants were detected in water or sediment grab samples collected below the tip (**Table 12**).

Passive samplers capable of detecting ultra-low (ng/L) concentrations of PAHs and pesticides were deployed in the Laura River below Bullhead Creek during the 2008, 2009 and 2010 wet seasons. The PAH phenanthrene was detected at an estimated concentration of 7 ng/L in a 5-day passive sampler deployed in Jan 2009 at the Laura River below the confluence with Bullhead Creek. The low level detection could have originated from a number of sources, including the rubbish tip, pesticide use or local machinery. Although PAHs can be carcinogenic to humans and toxic to aquatic life, the low level detection of phenanthrene is not likely to threaten Laura-Normanby aquatic ecosystems. No other PAHs were detected in Laura-Normanby water samples.

Metals concentrations in water and sediment samples collected below the Lakeland Tip (LN-LL-Tip) in February 2007 did not indicate that metals were leaching from the Tip into surface water, although chromium and zinc in sediments were elevated above downstream Bullhead Creek and Laura River sites (**Table 13**). In August 2008, zinc concentrations in Bullhead Creek water samples (0.009 mg/L) were elevated above concentrations in Laura River samples (<0.005 mg/L) and exceeded the Water Quality Guidelines for the Protection of Aquatic Ecosystems (ANZECC 2000). Copper concentrations in water samples collected from Bullhead Creek exceeded the water quality guidelines in February 2008, November 2008 and January 2009; however the concentrations are likely to be natural levels associated with suspended sediments.

Elevated metals at Bullhead Creek could be associated with tip leachates, run-off from local properties (zinc is commonly elevated in urban areas), or natural variation in sediments and high levels of suspended sediments in water. Metals concentrations in the Laura-Normanby are discussed in more detail in **Section 5.2.5**.

Table 12: Lakeland Tip Water and Sediment Sample Results

Date	**Samples**	**Analyte**	**Result (LOR*)**
09/02/07	LN-LLTIP (water)	OC/OP Pesticides	Not-detected (<0.5 μg/L)
		Polynuclear Aromatic Hydrocarbons (PAHs)	Not-detected (<1.0 μg/L)
		BTEX	Not detected (<1 to 2 μg/L)
		Total Petroleum Hydrocarbons (TPH)	Not detected (<20 to 100 μg/L)
		VOCs (Solvents, Fumigants, etc)	Not detected (<5.0 μg/L)
		Total Metals	Not detected above LOR (varied)
09/02/07	LN-LLTIP (sediment)	OC/OP Pesticides	Not-detected (<0.05 mg/kg)
		PAHs	Not-detected (<0.5 mg/kg)
		BTEX	Not-detected (<0.2 – 0.5 mg/kg)
		Total Petroleum Hydrocarbons	Not-detected (<10 - 100 mg/kg)
		VOCs (Solvents, Fumigants,etc)	Not-detected (<0.5 mg/kg)
		PhenylUrea Herbicides	Not detected (<0.02 mg/kg)

Table 12: Lakeland Tip Water and Sediment Sample Results

Date	Samples	Analyte	Result (LOR*)
		Triazines (Atrazine & Simazine)	Not detected (<0.05 mg/kg)
12/3/07	**LN-BHC**	Total Metals	Not elevated above guidelines*
25/2/08	**LN-BHC**	Total Metals	Cu (0.002) mg/L exceeds guidelines*
31/03/08	**LN-BHC**	BTEX	Not detected (<1 to 2 μg/L)
		Total & Dissolved Metals	Not elevated above guidelines
26/08/08	**LN-BHC**	PAHs	Not-detected (<1.0 μg/L)
	LN-BHC **LN-LR-05**	Total Metals	Zn (0.009 mg/L) at BHC exceeds guidelines
26/08/08	**LN-BHC**	PAHs	Not-detected (<0.5 mg/kg)
29/11/08	**LN-BHC**	PAHs	Not-detected (<1.0 μg/L)
		Total Metals	Cu (0.002) mg/L and Al (0.36 mg/L) exceed ANZECC guidelines.
22/01/09	**LN-BHC**	Total Petroleum Hydrocarbons	Not detected (<10 to 100 μg/L)
		PAHs	Not-detected (<1.0 μg/L)
		Total & Dissolved Metals	Cu (0.002) mg/L exceeds guidelines. (Not significantly elevated above background)
January 2009 (5 day)	**LN-LR-05 Passive Sampler**	PAHs	All non-detect (<0.2 ng/L) except: **Phenanthrene detected at 0.7 ng/L** (estimated daily concentration)
January 2009 (30 day)	**LN-LR-05 Passive Sampler**	PAHs	All non-detect (<0.2 ng/L)
January 2010 (30 day)	**LN-LR-05 Passive Sampler**	PAHs	All non-detect (<0.2 ng/L)

*LOR = Limit of Reporting: Concentrations cannot be detected below this Limit.

* ANZECC (2000) Water Quality Guidelines for the Protection of Aquatic Ecosystems (95%)

Table 13: Metals Concentrations in Laura River & Kalpowar Crossing Sediments (mg/kg)

Date:	09/02/2007	09/02/2007	26/08/2008	26/08/2008	21/02/2007	26/08/2008	26/03/2007
Site ID:	LN-LLTIP Lakeland Tip	LN-HD Honey Dam	LN-BHC Bullhead Creek	LN-LR-05 Laura River Broken Dam Stn	LN-LT-TIP Laura Tip	LN-LR-02 Laura R.- Laura	LN-NR-02 Kalpowar Crossing
Total Metals							
Arsenic	<5	<5	<5	<5	9	**9**	6
Barium			140	90		70	
Cadmium	<1	<1	<1	<1	<1	<1	<1
Chromium	101	77	80	48	20	32	21
Copper	31	35	26	10	20	17	<5
Iron			40000	16500		31600	
Lead	6	<5	5	8	32	13	<5
Nickel	80	97	102	22	13	8	7
Zinc	63	56	44	23	77	35	16
Mercury	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

5.3.2 Laura Rubbish Tip

The Laura Town rubbish tip is also located adjacent to the Laura River, and during the wet season a gully runs directly through the tip area and into the Laura River at LN-LR-02 (the Laura River Bridge). When the gully is dry, small springs can be observed flowing from the direction of the tip into the Laura River at LN-LR-02. Rubbish including household waste and abandoned vehicles is disposed of at the Laura tip. Properties downstream use water from the Laura River for drinking and other uses.

In order to determine if leachates from the Laura Tip were reaching the Laura River, a number of samples were collected during the 2007, 2008 and 2009 wet season from the gully or springs adjacent to the tip (LN-LT-Tip), and from LN-LR-02 located approximately 0.3 km downstream from the tip. Samples were also collected from the Laura River approximately 0.5 km upstream from the tip (LN-LTTIP-US) to test for background metals concentrations (**Figure 17**).

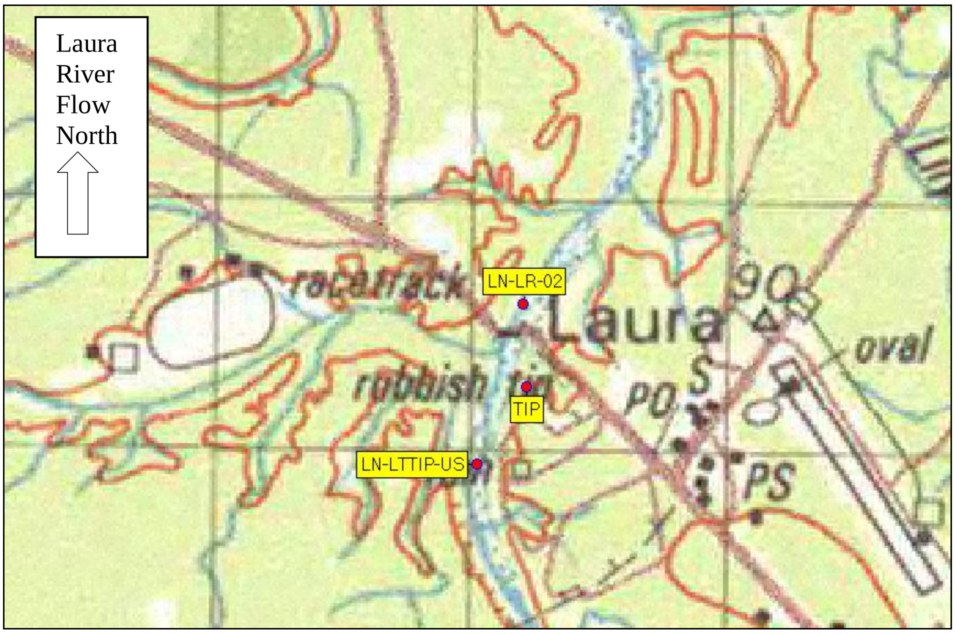


Figure 17: Laura Tip Sample Locations

Water samples were analysed for total and dissolved metals, Total Petroleum Hydrocarbons, Polyaromatic Hydrocarbons, BTEX and Volatile Organic Compounds (Solvents, paints, Cleaning products, etc.). Sediments from the gully flowing through the tip were analysed for Hydrocarbons and Metals.

The results indicated that there is no significant contamination from hydrocarbons (PAHs, TPH, BTEX) or solvents (VOCs) leaching from the Laura Tip into the Laura River. Sediment samples from the gully running past the tip contained 200 mg/kg of Total Petroleum Hydrocarbons (C10- C28 Fractions) but no hydrocarbons were detected in the Laura River. The results of water and sediment contaminant samples are detailed in **Table 14**.

Total Metals (lead, chromium, copper, nickel and zinc) were elevated in surface water and sediment samples collected from a gully running through the Tip. Concentrations of copper, lead and zinc exceeded the Water Quality Guidelines for the Protection of

Aquatic Ecosystems. However, the metals did not appear to be impacting on water quality in the Laura River. Metals concentrations in the Laura River below the Tip (LN-LR-02) did not exceed the Guidelines, and were similar to concentrations in samples collected from the Laura River upstream from the Tip (LN-LTTIP-US). Elevated metals concentrations in Laura Tip surface water appear to be primarily associated with suspended sediments as dissolved metals were not elevated in water samples collected from the Tip. Metals concentrations are listed in **Table 13 (sediments) and Table 15 (water)**.

Table 14: Laura Tip Water and Sediment Sample Results

Date	Sample ID	Analyte	Result (LOR*)
21/02/2007	LN-LR-02 LN-LT-TIP LN-LTTIP-US	Total Metals Dissolved Metals	Total Metals (Cr, Cu, Pb, Ni, & Zn) elevated at Laura Tip. Dissolved metals not elevated. Laura River metals not elevated above background.
21/02/2007	LN-LT-TIP LN-LR-02	Polynuclear Aromatic Hydrocarbons	Not-detected (<1.0 μg/L)
		Total Petroleum Hydrocarbons (TPH)	Not detected (<10 to 100 μg/L)
	LN-LT-TIP	BTEX	Not detected (<1 to 2 μg/L)
		VOCs (Solvents, Paints, etc)	Not detected (<5.0 μg/L)
21/02/2007	LN-LT-TIP (sediment)	Polynuclear Aromatic Hydrocarbons	Not detected (<0.5 mg/kg)
		Total Petroleum Hydrocarbons	C10 - C14 Fraction Detected: **80 mg/kg** C15 - C28 Fraction Detected: **120 mg/kg**
		Total Metals	Lead & Zinc exceeds background levels
31/03/2008	LN-LT-TIP LN-LR-02	Polynuclear Aromatic Hydrocarbons	Not-detected <1.0 μg/L
		Total Petroleum Hydrocarbons (TPH)	Not detected (<20 to 100 μg/L)
		BTEX	Not detected (<1 to 2 μg/L)
		Total & Dissolved Metals	Not significantly elevated
	LN-LR-02 (sediment)	Polynuclear Aromatic Hydrocarbons	Not-detected <0.5 mg/kg
19-3-2009	**LN- LT-TIP**	Total & Dissolved Metals	Zinc exceeds Guidelines (**0.082 mg/L)**

*LOR = Limit of Reporting: Concentrations cannot be detected below this Limit.

Table 15: Laura Tip Water Quality Samples- Total & Dissolved Metals (concentrations in mg/L)

	Sample ID:	**LN-LT-TIP**	**LN-LTTIP-US**	**LN-LR-02**	**LN-LT-TIP**	**LN-LR-02**	**LN-LR-02**	**LN- LT-TIP**
	Location:	Gully at Tip	Laura River upstream	Laura River downstream	small spring below Tip	Laura River downstream	Laura River downstream	small spring below Tip
	Sample Date:	21/02/2007	21/02/2007	21/02/2007	31/03/2008	31/03/2008	26/08/2008	19/03/2009
	TURBIDITY:	447.7	NA	16.7	23	62.6	7.0	11
Total Metals	**Water Quality Guideline***							
Aluminium	0.055							**0.02**
Arsenic	0.013/0.024	**0.002**	**0.001**	**0.001**	**0.001**	**0.001**	**0.002**	**0.001**
Cadmium	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium		**0.014**	<0.001	<0.001	<0.001	**0.002**	<0.001	<0.001
Copper	0.0014	**0.013**	**0.002**	**0.002**	**0.001**	**0.002**	<0.001	**0.002**
Lead	0.0034	**0.029**	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001
Nickel	0.011	**0.011**	**0.001**	**0.001**	**0.003**	**0.002**	<0.001	**0.002**
Zinc	0.008	**0.055**	<0.005	<0.005	<0.005	<0.005	<0.005	**0.082**
Dissolved Metals								
Arsenic	0.013/0.024	<0.001		**0.001**	**0.001**	<0.001		**0.001**
Cadmium	0.0002	<0.0001		<0.0001	<0.0001			<0.0001
Chromium		<0.001		<0.001	<0.001	<0.001		<0.001
Copper	0.0014	0.001		**0.001**	<0.001	**0.001**		**0.001**
Lead	0.0034	<0.001		<0.001	<0.001	<0.001		<0.001
Nickel	0.011	<0.001		<0.001	**0.002**	<0.001		**0.003**
Zinc	0.008	DEL*		<0.005				**0.008**

* ANZECC 2000 Guideline for the Protection of Aquatic Ecosystems (95% Level of Protection)
DEL* Sample result deleted due to low level contamination indicated in rinsate blank sample.
BOLD = All concentrations above the Limit of Reporting (LOR) are written in Bold. Non-detect concentrations are written as Less than (<) the LOR.
Grey Shading = Concentrations exceed the Water Quality Guidelines

5.3.3 Agricultural Impacts- Nutrients, Herbicides & Pesticides

The ambient monitoring programme was designed to monitor nutrient levels across the Laura-Normanby River system, and specifically to assess the impact of horticultural land-use on nutrient levels downstream from the Lakeland agricultural area. In addition, pesticides and herbicides samples were collected a minimum of one time per annum, after the first major rains of the wet season.

Nutrients

Nutrient levels in the Laura River were significantly higher than those in the Normanby River, particularly in the Lakeland agricultural region at Bullhead Creek and the Laura River at Broken Dam Station (**Table 17**). Concentrations of nitrogen oxides, commonly associated with fertilisers, were approximately 10 times higher at Lakeland (LN-LR-05) than at other freshwater sites. Nutrient concentrations remained elevated 20 km downstream at Carroll's Crossing (LN-LR-04), but generally decreased with distance from Lakeland (**Figure 18**). Concentrations of nutrients appeared to have dropped back to background levels between the Laura Festival Ground (LN-LR-03) and Old Laura Crossing (LN-LR-01), although concentrations varied at each site due to varying levels of flow and access to LN-LR-02 and LN-LR-01. The smaller sample numbers from these sites make it difficult to compare results.

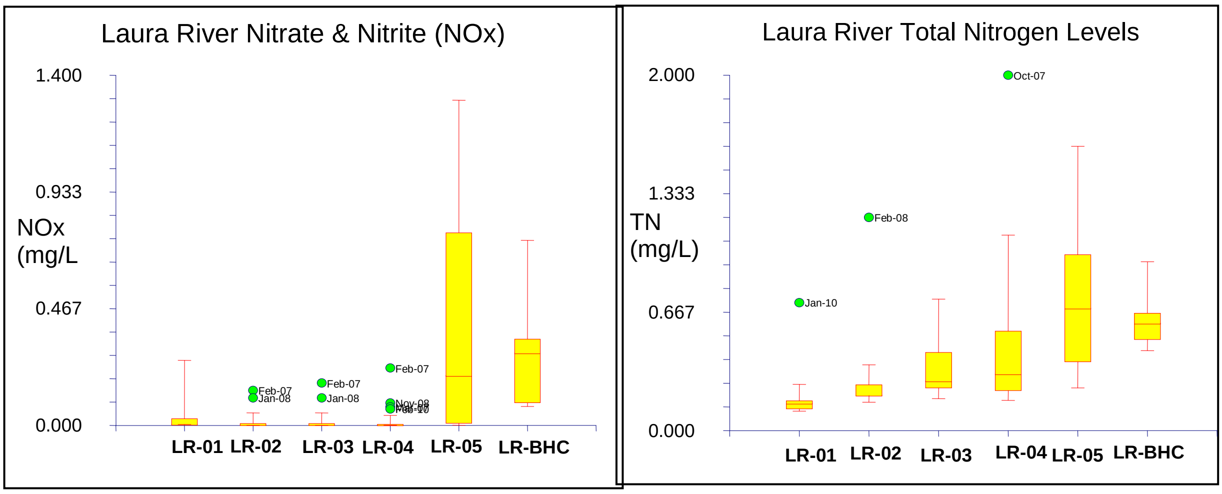


Figure 18: Laura River Total & Dissolved Nitrogen Box Plots (by Site)

Table 16: Laura River Sample Location Downstream Distance from Lakeland

Site ID	Site Name	Distance downstream from Lakeland
LN-LR-05 & LN-BHC	Lakeland agricultural region- Bullhead Creek and Broken Dam Station	0
LN-LR-04	Carroll's Crossing	20 km
LN-LR-03	Festival Grounds	40 km
LN-LR-02	Laura Town Bridge	55 km
LN-LR-01	Old Laura Crossing	70 km
LN-NR-03	Normanby R. 12-Mile Waterhole	85 km
LN-NR-02	Normanby River Kalpowar Crossing	125 km
LN-NR-00	Normanby estuary- mouth	180 km

Table 17: Maximum and Median Nutrient Concentrations (mg/L) at Laura Normanby Sample Sites

Site ID – Location & Number of Samples (N)		Total Phosphorus	Filt Reac Phosphorus	Ammonia Nitrogen	Nitrogen Oxides	Total Nitrogen
LN-NR-00-Normanby Estuary (Mouth) N=15	max	0.071	0.008	0.042	0.110	0.350
	median	**0.029**	0.004	**0.016**	0.026	0.243
LN-NR-01-Normanby Estuary (5.0km U/S) N=14	max	0.066	0.013	0.054	0.130	0.560
	median	**0.035**	**0.006**	**0.018**	**0.061**	**0.322**
LN-NR-02-Normanby River (Kalpowar Crossing) N=26	max	0.046	0.009	0.016	0.120	0.930
	median	**0.017**	0.003	0.005	0.017	**0.207**
LN-NR-03-Normanby River (12 Mile Waterhole) N=20	max	0.065	0.013	0.033	0.170	1.400
	median	**0.025**	0.004	**0.008**	0.019	**0.306**
LN-NR-04-East Normanby River (Battlecamp Rd) N=16	max	0.110	0.019	0.047	0.180	0.710
	median	**0.034**	**0.006**	**0.007**	0.021	**0.193**
LN-NR-05-East Normanby River (Peninsula Development Rd) N=25	max	0.050	0.008	0.010	0.210	0.550
	median	**0.027**	0.005	0.004	0.021	**0.234**
LN-LR-01-Laura River (Old Laura Crossing) N=10	max	0.056	0.006	0.020	0.260	0.720
	median	**0.019**	0.003	0.006	**0.046**	**0.220**
LN-LR-02-Laura River (Laura Town Bridge) N=15	max	0.310	0.005	0.004	0.140	1.200
	median	**0.038**	0.003	0.002	0.024	**0.297**
LN-LR-03-Laura River (Festival Grounds) N=30	max	0.086	0.012	0.010	0.170	0.740
	median	**0.023**	0.004	0.003	0.016	**0.351**
LN-LR-04-Laura River (Carroll's Crossing) N=32	max	0.130	0.044	0.011	0.230	**2.000**
	median	**0.039**	**0.009**	0.004	0.020	**0.455**
LN-LR-05-Laura River (Broken Dam Stn- Lakeland) N=27	max	0.220	0.095	0.026	1.300	1.600
	median	**0.069**	**0.024**	**0.009**	**0.391**	**0.735**
LN-BHC-Bull Head Creek (Lakeland) N = 10	max	0.130	0.070	0.073	0.740	0.950
	median	**0.054**	**0.018**	**0.022**	**0.311**	**0.650**
Water Quality Guidelines (Freshwater)		0.01	*0.005*	*0.006*	*0.03*	*0.15*
Water Quality Guidelines (Estuary)		*0.020*	*0.005*	*0.015*	*0.030*	*0.250*

0.042 **BOLD** median values exceed the Water Quality Guidelines

*Qld Water Quality Guidelines (2009) Wet Tropics Region & ANZECC 2000, Tropical Australia

Although there may be some pulses of elevated nutrients after heavy rains, ambient nutrient concentrations in the Normanby River below the confluence with the Laura do not appear to be elevated as a result of agricultural land use in the Lakeland region. Median concentrations of nitrogen oxides at Twelve Mile Waterhole (LN-NR-03) (located below the confluence with the Laura River) were below those detected upstream in the East Normanby River, where there is no major agricultural land use. Elevated nutrient concentrations in the Normanby River are more likely to be associated with suspended sediments during high turbidity events and impacts from cattle in the watercourse during periods of low flow.

Median nutrient concentrations in the Normanby estuary were elevated above the estuary water quality guidelines. However, the results of this sample program do not indicate that there is likely to be a significant impact on nutrient levels in the Normanby estuary or Great Barrier Reef from agricultural land use in Lakeland, due to the distance from Lakeland to the estuary and the decreasing nutrient levels downstream from LN-NR-05. Nutrient concentrations in the estuary are likely to be associated with high levels of suspended sediments.

Herbicides & Pesticides
Due to the lack of knowledge regarding specific agricultural chemicals used historically or more recently in the Lakeland area, a wide range of pesticides and herbicides were screened. Samples were collected from Honey Dam (LN-HD), which receives much of the Lakeland run-off, Bullhead Creek (LN-BHC) approximately 1.5 km downstream from Honey Dam, the Laura River at Broken Dam Station (LN-LR-05) adjacent to large banana plantations and Carroll's Crossing or Crocodile Station (LN-LR-04), 20 km downstream from Lakeland. Pesticide and herbicide samples were also collected from the Normanby River at Kalpowar Crossing and the estuary to confirm that contaminants were not reaching the estuary or Great Barrier Reef.

Grab samples were collected in 2007 and 2008. Passive Samplers were deployed in the Laura and Normanby Rivers during the 2008, 2009 and 2010 wet seasons.

Table 18 lists the results from all pesticide and herbicide grab samples and sediment samples that were collected. Most grab samples did not contain any detectable level of contaminants.

Passive sampler results are listed in **Table 19**. Because of the extended sampling period (5 days and 30 days), passive samplers were capable of detecting herbicides and pesticides at much lower concentrations (ng/L) that the grab samplers. The actual daily concentrations in the water are estimates based on the amount present in the sampler and the flow rate measured by passive flow monitoring devices deployed with the passive samplers. Listed concentrations should be considered to be only indicative of daily concentrations.

Table 18: Pesticide and Herbicide Grab Sample Analytical Results

Date	Sample IDs	Pesticide Group	Result (LOR*)
09/2/07	LN-LR-04 LN-LR-05 LN-HD	Organochlorine & Organophosphorus (OC/OP) Pesticides Phenoxyacetic Acid Herbicides Glyphosate	Not-detected (< 0.010 - 0.10 μg/L) Not-detected (<0.5 μg/L) Not-detected (<10 μg/L)
09/2/07	LN-LR-05 LN-HD **(sediment)**	OC/OP Pesticides Phenoxyacetic Acid Herbicides Simazine & Atrazine	Not Detected (<<0.05 mg/kg) Not Detected (<0.02 mg/kg) Not Detected (<0.05 mg/kg)
25/2/08	LN-BHC & LN-LR-05	OC/OP Pesticides	Not-detected (< 0.010 - 0.10 μg/L)
		Glyphosate (round-up)	Not detected (<10 μg/L)
		Phenoxyacetic Acid Herbicides	Not detected (<0.01 μg/L)
31/3/08	LN-BHC & LN-LR-05	OC/OP Pesticides	Not-detected (< 0.010 - 0.10 μg/L)
		Glyphosate (round-up)	Not detected (<10 μg/L)
	LN-BHC	Phenoxyacetic Acid Herbicides	Not detected (<0.01 μg/L)
	LN-LR-05	**Phenoxyacetic Acid Herbicides**	**2,4 D Detected: 0.05 ug/L** (Guideline = 140 μg/L) **2,4,6-T Detected: 0.09 μg/L** (NO guideline value)
26/8/08	LN-BHC	Atrazine Simazine	Not detected (<0.5 μg/L)
		Phenylurea Herbicides (Diuron)	Not detected (<5 μg/L)
		Glyphosate (round-up)	Not detected (<10 μg/L)
26/8/08	LN-BHC LN-LR-05 **(sediment)**	Atrazine Simazine	Not detected (<0.05 mg/kg)
29/11/08	LN-BHC	OC/OP Pesticides	Not-detected (< 0.010 - 0.10 μg/L)
		Phenoxyacetic Acid Herbicides	Not detected (<0.01 μg/L)
22/2/09	LN-BHC	OC/OP Pesticides	Not-detected (< 0.010 - 0.10 μg/L)
		Glyphosate (round-up)	Not detected (<10 μg/L)
		Phenoxyacetic Acid Herbicides	Not detected (<0.01 μg/L)
22/2/10	LN-BHC	OC/OP Pesticides	Not-detected (< 0.010 - 0.10 μg/L)
		Glyphosate (round-up)	Not detected (<10 μg/L)
		Phenoxyacetic Acid Herbicides	Not detected (<0.01 μg/L)

*LOR= Limit of Reporting: the lowest detectable concentration based on the analytical method. Non-detect concentrations are written as Less than (<) the LOR.
ANZECC 2000 Guideline for the Protection of Aquatic Species (99% Level of Protection)

Table 19: Pesticides, Herbicides and PAHs detected in PDMS and ED Passive Samplers Deployed in the Laura-Normanby 2008, 2009 & 2010 Wet Seasons - Estimated Daily Concentrations[1] (ng/L)

Sample Site:	Broken Dam Stn (Lakeland)	Broken Dam Stn (Lakeland)	Broken Dam Stn (Lakeland)	Broken Dam Stn (Lakeland)	Broken Dam Stn (Lakeland)	Turalba Stn (10 km downstream)	Crocodile Stn (22 km downstream)	Normanby estuary	ANZECC 2000 Guidelines[2]
Sample Period:	Feb 2008	Jan 2009	Jan 2009	Jan 2010	Apr 2010	Apr 2010	Apr 2010	Feb 2010	
Sample Duration:	5days	5days	30days	30days	5days	5days	5days	30days	
ED Passive Samplers									
Herbicides									
Diuron	**1**	**19***	**1.2**	<0.3	**0.38**	**0.20**	**0.07**	<0.3	ID
Simazine	<0.3	<0.3	<0.3	<0.3	**0.99**	**0.71**	**0.68**	<0.3	**200**
Atrazine	**81**	**99**	**5.9**	<0.3	<0.3	<0.3	<0.3	<0.3	**700**
Desethyl Atrz.	**8.8**	**6.3**	**1.2**	<0.3	<0.3	<0.3	<0.3	<0.3	ID
Hexazinone	<0.3	<0.3	**1**	<0.3	<0.3	<0.3	<0.3	<0.3	ID
Tebuthiuron	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	**20**
Metolachlor	<0.3	<0.3	<0.3	**3.3**	<0.3	<0.3	<0.3	<0.3	ID
PDMS Passive Samplers									
Pesticides/Herbicides									
Diuron breakdown product	NA	**10**	<0.05	<0.05	NA	NA	NA	NA	ID
Galaxolide	NA	<3	**1**	**0.048**	NA	NA	NA	NA	ID
Pendimethalin ___H2209	NA	**40**	**38**	<0.05	NA	NA	NA	NA	ID
Metolachlor	NA	<0.05	<0.05	**0.369**	NA	NA	NA	NA	ID
PAHs									
Phenanthrene 178	NA	**0.7**	<0.1	<0.1	NA	NA	NA	NA	ID
(no other PAHs were detected)									

1 Concentration estimated using passive samplers with an assumed sampling rate of 0.08 L.day-1 30 days) or 0.59 L.day-1 (5 day)
2 ANZECC 2000 Guidelines for the Protection of Aquatic Ecosystems (99% Level of Protection)
19* **C**oncentrations in red varied by up to 50% between original and duplicate samples.
1.2 Bold values are detections that were confirmed by GC-MS; Concentrations represent estimated daily averages calculated from measured flow rates
<0.3 Values marked with a '<' sign were not detected and are based on the blanket LOR value for a 5 or 30 days deployment period.
ID Insufficient data exists – no guideline values have been established
NA Not analysed

Low concentrations of herbicides and other contaminants were detected in passive samplers deployed at the Laura River near Lakeland during the 2008, 2009 and 2010 wet seasons. The herbicides diuron, atrazine, disethyl-atrazine (a break-down product of atrazine) and hexazinone were detected in ED passive samplers. Contaminants detected in PDMS samplers included diuron breakdown product, galaxolide, pendimethalin, metolachlor and phenanthrene. Phenoxy-acetic acid herbicides 2,4-D and 2,4,6-T were detected in grab samples from Broken Dam Station in March 2008.

Concentrations were highest at Broken Dam Station (LN-LR-05) which receives run-off from much of the agricultural land in the Lakeland vicinity. The herbicides diuron, atrazine and simazine were the most common contaminants detected at Broken Dam Station. Reduced concentrations of these herbicides were detected 22 km downstream at Crocodile Station.

Other contaminants detected in the Laura River at Lakeland include galaxolide (Hexahydrohexamethyl Cyclopentabenzopyran), a synthetic musk-like chemical commonly used in detergents, shampoos and fabric softener. Galaxolide is considered to be very harmful to the aquatic environment, although no toxicity guidelines are available. It is likely that this is reaching the Laura River from residential or commercial use of cleaning products.

The herbicides detected did not exceed the Water Quality Guidelines for the Protection of Aquatic Ecosystems (ANZECC 2000) although guidelines have not been established for some of these chemicals. Based on the detected concentrations these herbicides are not considered likely to significantly impact on the health of aquatic ecosystems in the Laura Normanby River. However the concentrations reported for passive samplers are only estimates, and pulses of higher, potentially toxic concentrations may occur. Some of the contaminants detected can be accumulated in fish to higher concentrations than that occurring in the water.

5.3.4 Estuary and Potential GBR Impacts (Hydrocarbons & Herbicides)

Low concentrations of petroleum hydrocarbons and herbicides were detected in the Laura River between Lakeland and Laura. In order to confirm that these contaminants were not reaching the estuary or potentially impacting on Great Barrier Reef ecosystems, both grab samples and passive samplers were analysed from lower Normanby River sites, including Kalpowar Crossing (LN-LR-02) and the Normanby estuary (LN-NR-00). Samples were analysed for Total Petroleum Hydrocarbons, Polyaromatic Hydrocarbons, and a range of Pesticide and Herbicides.

No contaminants were detected in any samples collected from Kalpowar Crossing or the estuary. Sample dates and analytical results are listed in **Table 20**.

Based on the analytical results, and the low concentrations detected in the Laura, it is unlikely that herbicides, pesticides or hydrocarbons from the Lakeland region or Laura are reaching the Normanby estuary or the Great Barrier Reef at detectable concentrations or levels that would impact on aquatic ecosystem health.

Table 20: Lower Normanby Grab Sample Results-
Hydrocarbons, Pesticides & Herbicides

Date	Sample IDs	Pesticide Group	Result (LOR*)
26/03/2007	LN-NR-02	Polynuclear Aromatic Hydrocarbons	Not-detected <1.0 µg/L
		Total Petroleum Hydrocarbons (TPH)	Not detected (<10 to 100 µg/L)
		Glyphosate (round-up)	Not detected (<10 µg/L)
		Phenoxyacetic Acid Herbicides	Not detected (<0.01 µg/L)
26/03/2007	LN-NR-00	Polynuclear Aromatic Hydrocarbons	Not-detected <1.0 µg/L
		Total Petroleum Hydrocarbons (TPH)	Not detected (<10 to 100 µg/L)
		BTEX	Not detected (<1 to 2 µg/L)
15-4-2008	LN-NR-00 & LN-NR-02	Organochlorine & Organophosphorus Pesticides	Not-detected (< 0.010 - 0.10 µg/L)
		Phenoxyacetic Acid Herbicides	Not detected (<0.01 µg/L)
		Glyphosate (round-up)	Not detected (<10 µg/L)
20/2/2009 & 22/2/2009	LN-NR-00 LN-NR-02	Organochlorine & Organophosphorus Pesticides	Not-detected (< 0.010 - 0.10 µg/L)
		Glyphosate (round-up)	Not detected (<10 µg/L)
		Phenoxyacetic Acid Herbicides	Not detected (<0.01 µg/L)
Feb 2010 (30 days)	LN-NR-01 Passive Sampler	Herbicides (See Table 17)	Not detected (<0.3 ng/L)

*LOR= Limit of Reporting: the lowest detectable concentration based on the analytical method. Non-detect concentrations are written as Less than (<) the LOR.

5.3.5 Total and Dissolved Metals

Total and Dissolved Metals samples were collected from Laura-Normanby sample locations during the wet and dry seasons in order to document baseline metals concentrations in water and potential impacts. Impacts from rubbish tips are discussed in the above sections. Small scale mining occurs or has historically occurred in some parts of the catchment, particularly the southwest corner. This area is outside the scope of the CYMAG Monitoring Project and localised impacts from mining have not been specifically assessed.

During base flow, the Laura-Normanby River had relatively low metals concentrations, often below the detection limits (LOR). Metals were generally associated with suspended solids and increased during periods of high turbidity. The metals most commonly occurring under ambient conditions were (in order of magnitude): iron (Fe), aluminium (Al), manganese (Mn), and barium (Ba). Arsenic, chromium, copper, lead and nickel were also detected in estuary waters in low concentrations.

Aluminium and iron concentrations were among the highest metal concentrations detected in Laura-Normanby water samples. Aluminium ranged from 0.13 mg/L to 5.67 mg/L, with the higher range occurring in the Laura River and Normanby estuary, while the Normanby freshwater samples all exhibited Al concentrations between 0.1 and 1 mg/L. Very few samples were analysed for aluminium and it is unlikely that the full range is represented. Iron concentrations were correlated with turbidity, with concentrations ranging from non-detect (<0.05 mg/L) during the dry season to 7.25 mg/L in the Laura River during a flood. The majority of aluminium and iron was associated with suspended sediments. Although only 3 samples were analysed for dissolved iron and aluminium, dissolved aluminium accounted for 5% to 8% of total aluminium in these Normanby freshwater samples. Dissolved iron comprised between 20% to 36% of total iron in freshwater samples, and less than 1% in the estuary sample.

Arsenic was detected in all sections of the river, at concentrations ranging from <0.001 mg/L to 0.01 mg/L. Dissolved concentrations comprised between 44% to 60% of the total arsenic in the estuary, and up to 100% of the total arsenic concentrations in some Laura and Normanby freshwater samples. Arsenic is naturally occurring in soils and groundwater in the Laura-Normanby catchment.

Trace metals chromium, copper, lead, nickel and zinc were generally below the detection limits in Normanby freshwater samples. However elevated zinc concentrations at LN-NR-05 in August 2008 exceeded the water quality guidelines for the Protection of Aquatic Ecosystems. It is possible that the zinc may have originated from bridge construction materials or other anthropogenic sources from upstream properties.

Copper, chromium, lead, nickel and zinc concentrations were below the detection limits in the Laura River during the dry season; however they were significantly elevated during periods of high turbidity. Copper exceeded the water quality guidelines at Laura River sites in February 2007, February 2008 and November 2008. Lead concentrations exceeded the water quality guidelines at LN-LR-03 and LN-LR-04 in February 2008. Nickel and zinc concentrations also exceeded the Guidelines in February 2008 and November 2008. The increase in metals during wet season floods indicates that these are natural background concentrations associated with sediments. However, it is possible that historic mining, grazing and horticultural land-use in the catchment has lead to increased erosion, thus elevating the metals concentrations associated with sediments. Both turbidity levels and correlated metals concentrations were higher in the Laura River than in the Normanby, possibly due to the greater level of disturbance in this sub-catchment.

Mercury was not detected in any Laura-Normanby water samples above the detection limit (<0.0001 mg/L).

Laura-Normanby Metals Concentrations are presented in **Tables 21 - 23**.

Table 21: Normanby Estuary Total & Dissolved Metals Concentrations (mg/L)

	Sample ID:	LN-NR-00	LN-NR-01	LN-NR-00	LN-NR-01	LN-NR-00	LN-NR-01
	Date:	26/03/2007	26/03/2007	24/10/2007	24/10/2007	15/04/2008	15/04/2008
	TURBIDITY:	16.3 NTU	32.6 NTU	108.7 NTU	83.3 NTU	30.1 NTU	34.7 NTU
Total Metals & Hg	**Water Quality Guidelines***						
Aluminium						**0.57**	**1.29**
Arsenic		**0.0014**	**0.0016**	**0.0043**	**0.003**	**0.010**	**0.001**
Barium						**0.011**	**0.028**
Cadmium	0.0055	<0.0002	<0.0002	<0.0002	<0.0002	<0.0001	<0.0001
Chromium		**0.0012**	**0.0018**	**0.0064**	**0.0039**	**0.006**	**0.003**
Copper	0.0013	<0.001	<0.001	**0.001**	**0.001**	**0.006**	**0.002**
Lead	0.0044	**0.0003**	**0.0003**	**0.0024**	**0.0014**	<0.001	<0.001
Manganese						**0.072**	**0.045**
Nickel	0.07	**0.0011**	**0.0012**	**0.0028**	**0.002**	**0.001**	**0.001**
Vanadium	0.1					<0.01	<0.01
Zinc	0.015	<0.005	<0.005	**0.007**	<0.005	<0.005	<0.005
Iron						4.06	2.06
Mercury	0.0004	<0.0001	<0.0001	<0.0001*	<0.0001*	<0.0001	<0.0001
Dissolved Metals & Hg							
Aluminium						<0.01	
Arsenic		<0.005	**0.0007**			**0.006**	
Barium						**0.002**	
Cadmium	0.0055	<0.002	<0.002			<0.0001	
Chromium		**DEL**	<0.005			**0.005**	
Copper	0.0013	<0.001	<0.001			<0.001	
Lead	0.0044	<0.002	<0.002			<0.001	
Manganese						**0.003**	
Nickel	0.07	**0.0012**	**0.0007**			<0.001	
Vanadium	0.1					<0.01	
Zinc	0.015	**DEL**	**DEL**			<0.005	
Iron						<0.05	
Mercury	0.0004	<0.0001	<0.0001			<0.0001	

*ANZECC 2000: Guidelines for the Protection of Aquatic Ecosystems (Saltwater), 95% Level of Protection

<0.0001*: Sample Holding times breached, results qualified. **DEL =** Samples contaminated by filter materials, results not accepted.

BOLD "0.0014" = All concentrations above the Limit of Reporting (LOR) are written in Bold. Non-detect concentrations are written as Less than (<) the LOR.

Grey Shading = Concentrations exceed the Water Quality Guidelines

Table 22: Normanby River Freshwater Sites- Total Metals Concentrations (mg/L)

	Sample ID:	**NR-02**	**NR-02**	**NR-03**	**NR-04**	**NR-05**	**NR-05**	**NR-05**	**NR-03**	**NR-02**	**NR-04**	**NR-05**	**NR-02**	**NR-02**	**NR-02**	**NR-03**
	Date:	26/03/07	10/10/07	10/10/07	10/10/07	8/10/207	9/02/07	31/03/08	27/08/08	27/08/08	27/08/08	26/08/08	15/04/08	20/02/09	23/03/09	23/03/09
	Turbidity:	43.5	2.0	8.3	16.7	4.5	56.4	12.4	8.7	3.1	5.7	2.9	16.0	43.5	32.0	30.9
Total Metals	**Guidelines**															
Aluminium	--												**0.13**		**0.26**	**0.41**
Arsenic	0.013/0.024	**0.001**	<0.001	**0.002**	**0.003**	**0.003**	<0.001	<0.001	**0.002**	**0.001**	**0.002**	**0.001**	**0.001**	**0.001**	**0.001**	**0.002**
Barium	--								**0.018**	**0.028**	**0.017**	**0.005**			**0.019**	**0.024**
Cadmium	0.0002	<0.0001	**0.0004**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	**0.0002**	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	--	<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
Copper	0.0014	**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**
Lead	0.0034	<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
Manganese	1.9								**0.046**	**0.009**	**0.263**	**0.056**			**0.206**	**0.030**
Nickel	0.011	**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**
Vanadium	--								<0.01	<0.01	<0.01	<0.01			<0.01	<0.01
Zinc	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	**0.011**	<0.005	<0.005	**0.006**	**0.008**
Iron	--								**0.63**	**0.21**	**1.66**	**1.15**	**1.09**		**1.41**	**1.88**
Total Hg																
Mercury	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001*	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	--	--

*ANZECC 2000 Guidelines for the Protection of Aquatic Ecosystems (Freshwater), 95% Level of Protection

Grey Shading = Concentrations exceed the Water Quality Guidelines

<0.0001* Sample Holding times breached, results qualified

BOLD "0.0014" = All concentrations above the Limit of Reporting (LOR) are written in Bold. Non-detect concentrations are written as Less than (<) the LOR.

Table 23: Laura River Total Metals Concentrations (mg/L)

	Sample ID:	21/02/07	08/10/07	08/10/07	25/02/08	25/02/08	25/02/08	31/03/08	31/03/08	26/08/08	26/08/08	26/08/08	26/08/08	29/11/08	29/11/08
	Date:	**LR-02**	**LR-03**	**LR-04**	**LR-05**	**LR-04**	**LR-03**	**LR-02**	**LR-05**	**LR-02**	**LR-03**	**LR-04**	**LR-05**	**LR-05**	**LR-04**
	Turbidity:	16.7	2.0	2.0	76.6	150.7	133.7	62.6	6.6	7.0	2.1	1.6	1.1	193.3	157.3
Total Metals	**Guidelines***														
Aluminium														**5.67**	**3.58**
Arsenic	0.013/0.024	**0.001**	**0.001**	**0.007**	<0.001	**0.001**	**0.002**	**0.001**	**0.001**	**0.002**	**0.004**	**0.003**	**0.001**	<0.001	<0.001
Barium										**0.080**	**0.068**	**0.062**	**0.055**		
Cadmium	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	**0.0002**	<0.0001	<0.0001	<0.0001	<0.0001	**0.0002**	**0.0003**	<0.0001	<0.0001	<0.0001
Chromium		<0.001	<0.001	<0.001	**0.005**	**0.011**	**0.014**	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	**0.02**	**0.01**
Copper	0.0014	0.002	<0.001	<0.001	**0.004**	**0.007**	**0.009**	**0.002**	**0.001**	<0.001	<0.001	<0.001	<0.001	**0.009**	**0.006**
Lead	0.0034	<0.001	<0.001	<0.001	**0.002**	**0.004**	**0.006**	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Manganese	1.9									**0.078**	**0.024**	**0.018**	**0.011**	**0.162**	**0.105**
Nickel	0.011	**0.001**	<0.001	**0.001**	**0.007**	**0.012**	**0.016**	**0.002**	**0.002**	<0.001	<0.001	<0.001	<0.001	**0.023**	**0.011**
Vanadium										<0.01	<0.01	<0.01	<0.01		
Zinc	0.008	<0.005	<0.005	<0.005	**0.006**	**0.009**	**0.018**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	**0.017**	**0.007**
Iron										**0.88**	<0.05	<0.05	<0.05	**7.25**	**4.77**
Total Hg															
Mercury	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

*ANZECC 2000 Guidelines for the Protection of Aquatic Ecosystems (Freshwater), 95% Level of Protection

Grey Shading = Concentrations exceed the Water Quality Guidelines

<0.0001* Sample Holding times breached, results qualified

BOLD "0.0014" = All concentrations above the Limit of Reporting (LOR) are written in Bold. Non-detect concentrations are written as Less than (<) the LOR.

5.3.6 Bacteria

Contamination of water with faecal contamination can render the water unfit for drinking, and at high concentrations can be harmful to aquatic species. Bacterial contamination of the Laura-Normanby River is of concern due to the high numbers of cattle and feral pigs in the catchment, often concentrating around the water. Laura and Lakeland septic systems are also of concern; contamination of shallow groundwater in the Laura Town region has forced drinking water wells to be re-located (Howley and Stephan, 2005). Bacteria samples were collected opportunistically from Laura-Normanby sample locations, however the number of samples collected was limited by the difficulty of transporting samples to a laboratory for analysis within 24 hours of collection. The Analytical results from bacteria samples collected from the Laura-Normanby Catchment Area are listed in **Table 24.**

Table 24: Laura-Normanby Bacteria Sample Results

Site	Date	Faecal Coliform	Comments
LN - LR – 03 Festival Grounds	21/06/2007	14 CFU/100mL	Samples collected before and after Dance Festival
LN - LR - 03	25/06/2007	18 CFU/100mL	
LN-LR-03 (dup.)	25/06/2007	15 CFU/100mL	
LN - LR – 03 Festival Grounds	19/11/2007	10 CFU/100mL	
LN- LR- 05 Broken Dam Stn	19/11/2007	67 CFU/100mL	
LN- NR- 05 East Norm. Bridge	19/11/2007	130 CFU/100mL	
LN - NR – 01 NR estuary	15/04/2008	250 CFU/100mL	
LN - NR – 02 Kalpowar Cross.	15/04/2008	10 CFU/100mL	
JL – 01 (Jack Lakes wetland)	15/04/2008	190 CFU/100mL	The Jack Lakes wetlands are located along the Jack River tributary to the Normanby River and have high numbers of pigs and cattle.
JL - 3C (Jack Lakes wetland)	15/04/2008	60 CFU/100mL	

ANZECC 2000 Guidelines for Recreational Use	**NHMRC 2004 Drinking Water Guidelines**
150 CFU/100mL	0 CFU/100 mL

Australian water quality guidelines (ANZECC 2000) state that faecal coliforms in waters used for swimming or bathing should not exceed 150 CFU/100 mL. The samples collected from the Laura-Normanby freshwater sites did not exceed this level. One sample collected from the Normanby estuary had a bacteria count of 250 cfu; however it is unlikely that this area would be used for recreational use involving contact with the water.

Concentrations of bacteria at the East Normanby Bridge (130 cfu) and Broken Dam Station (67 cfu) measured in November 2007 were elevated above background concentrations and are likely to be attributed to cattle manure which is frequently observed in and around the waterways at these sites.

At the request of the Ang-Gnarra (Laura) rangers, bacteria samples were collected from LN_LR-03 (Festival Grounds) before and after the Laura Dance Festival at that site in 2007. The Dance Festival hosts up to 5000 people camping along and bathing in the river every two years. Samples were collected before and after the festival immediately downstream of the festival grounds at the end of a long waterhole where numerous people were bathing. The analytical results indicated that the bacteria count in the river did not change significantly before and after the festival. On the 21st of June bacteria levels were at 14 CFU/100mL. After the festival, on the 25th of June, bacteria levels ranged from 15 CFU/100mL to 18 CFU/100mL. At these levels the water is safe for swimming.

The drinking water guidelines (NHMRC 2004) state that drinking water should not contain any faecal coliform bacteria. It is therefore recommended that water from the Laura or Normanby Rivers be boiled or otherwise treated before drinking.

6 SUMMARY OF RESULTS

Temperatures in the Laura-Normanby River ranged from 19.6°C to 36.3°C; minimum temperatures occurred in June (average 25.4 °C) and maximum temperatures in December (average 31.9°C). Salinity within the estuary ranged from 0.4 ppt during freshwater events to a maximum of 39.7 ppt measured at the end of the dry season. Salinity at freshwater sites in the Laura- Normanby River ranged from 0.0 – 0.9 ppt, while conductivity ranged from 0.053 mS/cm – 1.715 mS/cm mS/cm. Laura River sites exhibited higher conductivity than Normanby River freshwater sites, most likely due to the saline soils in the region. Estuary pH values ranged 7.06 to 8.17 and freshwater pH values ranged from 6.51 to 9.01. Although acid-sulphate soils have been disturbed in wetlands across the catchment, there was no indication of increased acidity (lower pH) in Laura-Normanby waters.

Laura-Normanby freshwater dissolved oxygen levels ranged from 36.5% – 166.6%, with median (year-round) values of 82.3% (Laura River) and 77.9 % (Normanby River). Dissolved oxygen levels below 50% were relatively common during the dry season periods of low flow and high algal growth. It is likely that the naturally low oxygen levels in slow or stagnant waters were compounded by excessive algal growth resulting from fertilisers in the Lakeland region and cattle droppings.

The Normanby River estuary was relatively turbid throughout the year, with a median turbidity value of 31.3 NTU. Dry season sediment loads appear to be derived from natural bank erosion from within the estuary. Maximum turbidity values of 258 NTU at Carroll’s Crossing, 193 NTU at Broken Dam Station (Lakeland) and 168 NTU at Battlecamp Crossing were measured after heavy wet season rains in January 2010 and November 2008. It is difficult from the turbidity data to make any assumptions regarding erosion in the Laura Normanby catchment and the impact of land use on sediment loads in the river. However, the sites with the maximum turbidity values and the highest average wet season turbidity values include the most intensive agricultural land-use and are subjected to extensive gully erosion and a high number of cattle around the watercourse. Observations of gully erosion along the Laura-Normanby River indicate that this erosion is contributing large quantities of sediment to the river system. The gullies appear to be caused by a combination of road erosion and cattle grazing.

Nutrient levels in the Laura River generally exceeded those of the Normanby and were clearly elevated in the vicinity of the Lakeland agricultural area. Concentrations of nitrogen oxides, commonly associated with fertilisers, were up to 10 times higher at Lakeland (LN-LR-05) than at other freshwater sites, and exceeded the Water Quality Guidelines for the Protection of Aquatic Ecosystems (ANZECC 2000). Nutrient concentrations appeared to have dropped back to natural background levels between the Laura Festival Ground (LN-LR-03) and Old Laura Crossing (LN-LR-01).

Minor increases in chlorophyll-a levels at Bullhead Creek (and the Laura River at Broken Dam Station during the wet season were also likely to be associated with nutrient-rich run-off from fertilisers used at Lakeland farms. More significant increases in chlorophyll-a levels occurred at 12 Mile Waterhole, Carroll's Crossing and Broken Dam Station at the end of the dry season when waterholes were subject to low flows and algal blooms. High numbers of cattle around the remaining waters in the dry season are likely to contribute to the chlorophyll peaks at these sites. Elevated bacteria concentrations measured in November 2007 at the East Normanby Bridge (130 CFU/100mL) and Broken Dam Station (67 CFU/100mL) are also likely to be attributed to the high number of cattle at these sites.

Very low levels of herbicides and other contaminants were detected in the Laura River downstream from Lakeland. The herbicides diuron, atrazine and simazine were the most common contaminants detected. Concentrations were highest in the Laura River below Broken Dam Station & Bullhead Creek, which receives run-off from much of the agricultural land in the Lakeland vicinity. Reduced concentrations of these herbicides were detected approximately 25 km downstream at Crocodile Station. The concentrations of all herbicides were well below the Guidelines for the Protection of Aquatic Ecosystems (ANZECC 2000) and are not likely to have a significant impact on aquatic ecosystems in the Laura Normanby River.

Sampling below the Lakeland and Laura Rubbish Tips did not indicate that there was any significant contamination from either rubbish tip making its way into the Laura River. One PAH detection (phenanthrene) and slightly elevated metals in Bullhead Creek may have come from the Lakeland tip or from adjacent properties. Sediment and water samples from the gully running past the Laura tip contained petroleum hydrocarbons and elevated metals (lead, chromium, copper, nickel and zinc); however these were not detected downstream in the Laura River. No contaminants from the tips were detected at levels that would threaten Laura River aquatic ecosystems.

No contaminants were detected in any samples collected downstream at Kalpowar Crossing or the estuary. Based on these analytical results, and the low concentrations detected in the Laura River, it is unlikely that herbicides, pesticides or hydrocarbons from the Lakeland region or Laura are reaching the Normanby estuary or the Great Barrier Reef at detectable concentrations or levels that would impact on aquatic ecosystem health. Although there may be some pulses of nutrients after heavy rains, the results of this program do not indicate that there is likely to be a significant impact on nutrient levels in the Normanby estuary or Great Barrier Reef from agricultural land use in Lakeland. Erosion throughout the catchment and increased sediment loads in flood waters may have an impact on reefs and other marine ecosystems (seagrass, etc.) in Princess Charlotte Bay.

In conclusion, the Laura-Normanby River is in generally good condition with ambient conditions relatively unchanged by human land use. However, clear impacts on water quality are observed in the Lakeland region, where nutrient levels are elevated to levels that threaten aquatic ecosystems by causing algal blooms and reducing oxygen levels. Cattle trampling and defecating in streams across the catchment is also likely to be responsible for increased erosion, algal blooms and high bacteria levels. The nature of the river, with low flow rates and isolated waterholes during the dry season, makes it particularly susceptible to the increased nutrient and bacteria loads contributed by horticulture and cattle (and to a lesser extent by feral horses and pigs). These impacts are observed both within and outside of National Park land.

7 RECOMMENDATIONS

ACTION	RESPONSIBILITY*	PRIORITY
Assessment of Nutrient Use in Laura-Normanby Catchment,- o Property Scale Nutrient & Pesticide Run-off Monitoring, o Identify specific properties where nutrient management could be improved, o Provide support for landowners to implement improved nutrient management	Landholders, Landcare, CFOC	HIGH
Provide assistance to Landholders along the Laura & Normanby Rivers to improve fencing and alternate water sources to keep cattle out of waterway o Specific sites of concern, inc.: East Normanby Bridge, Battlecamp Crossing, Broken Dam Station, Carroll’s Crossing	Landholders, Landcare, Catchment Group, CFOC	HIGH
Prioritise Lakeland National Park for removal of cattle and other feral animals	DERM (QPW)	HIGH
Research into Erosion Mitigation along roads and river banks of the Laura-Normanby	Reef Rescue/ CFOC Research Orgs.	HIGH
Investigate and implement improved road construction to minimise erosion- particularly along Battlecamp Road	Main Roads, Cook Shire Council	HIGH
Monitoring of bacteria levels where river is utilised for drinking water: o inc. Lakefield ranger station	Landowners	MED
Assess localised mining impacts; i.e. abandoned mines. Monitor water quality (turbidity, metals) downstream from current or future mines	DERM, Mine Operators	LOW
Develop Water Quality Guidelines for the Laura-Normanby River (freshwater & estuary)	DERM	MED
Property Owners to Register Records of Pesticide & Herbicide Use for future monitoring of water quality	DEEDI (Dept of Primary Industries) & Landholders	MED

*Responsible organisations as recommended by CYMAG. Other organisations may share responsibility for implementing these actions.

8 REFERENCES

1:250,000 Cooktown Geological Series, Sheet SD 55-9 (Geological Survey of Qld, First Edition, 1966).

1:250,000 Cape Melville Geological Series, Sheet SD/55-9 (Geological Survey of Qld, Second Edition, 1983).

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

Australian Bureau of Statistics (2006). Population data for the Lakeland & Laura Townships (combined).

Bain, J.H.C. and Draper, J.J., (Eds). (1997) *North Queensland Geology.* Australian Geological Survey Organisation and Geological Survey of Queensland.

Biggs, A.J.W. and Philip, S.R. (1995). *Soil Survey and Agricultural Suitability of Cape York Peninsula.* (Cape York Peninsula Land Use Strategy, Office of the Coordinator General of Queensland, Brisbane, Department of the Environment, Sport and Territories, Canberra, and Queensland Department of Primary Industries, Brisbane).

Horn, A.M., Derrington, E.A., Herbert, G.C., Lait, R.W., Hillier, J.R. (1995). *Groundwater Resources of Cape York Peninsula.* (Cape York Peninsula Land Use Strategy, Office of the Coordinator General of Queensland, Brisbane, Department of the Environment, Sport and Territories, Canberra, and Queensland Department of Primary Industries, Brisbane).

Howley & Stephan (2005). *Laura Normanby Catchment Management Strategy.* (Laura-Normanby Catchment Management Group. Lakeland)

NHMRC (2004). *Australian Drinking Water Guidelines*. (National Health and Medical Research Council, Canberra)

Moss, Andrew (in preparation). *Report on the long-term monitoring of estuaries and coastal waters in Central Queensland, 1993 to 2006.* (Qld Dept of Environment & Resource Management, Brisbane)

Passmore, V.L. (1978). *Laura Basin Explanatory Notes and Stratigraphic Correlations*. (Bureau of Mineral Resources, Geology and Geophysics, Dept of National Resources, Record 1978/38).

Personal Communication. Vicki Brown (July, 2005). Laura-Normanby Catchment Management Group & Lakeland Resident.

Personal Communication, Andrew Moss (July 2010). Qld Dept of Env. & Resource Management, Water Quality & Aquatic Ecosystem Health, Principal Scientist.

APPENDIX A
LAURA-NORMANBY SAMPLE LOCATION PHOTOS

Photo 1: LN-NR-00 Normanby River Mouth (P. Pal Photo)

Photo 2 : Normanby Estuary in Flood

Photo 3 : Collecting Water Samples At LN-NR-01 (Photo by Peter Pal)

Photo 4: LN-NR-00 Sediment From Mangroves (January 2010) (Christina Howley)

Photo 5: LN-NR-01, Normanby Estuary 5 km Upstream From Mouth

Photo 6: LN-NR-01 in Flood (28-1-10)

Photo 7: Normanby Saltmarsh in Flood, 30-3-09

Photo 8: Passive Sampler attached to Float at LN-NR-01 (30-3-09)

Photo 9: Normanby River Upstream from LN-NR-01 (P. Pal Photo)

Photo 10: LN-NR-02 Kalpowar Crossing in Flood

Photo 11: LN-NR-02 Kalpowar Crossing

Photo 12: LN-NR-03, 12-Mile Waterhole (20-8-04)

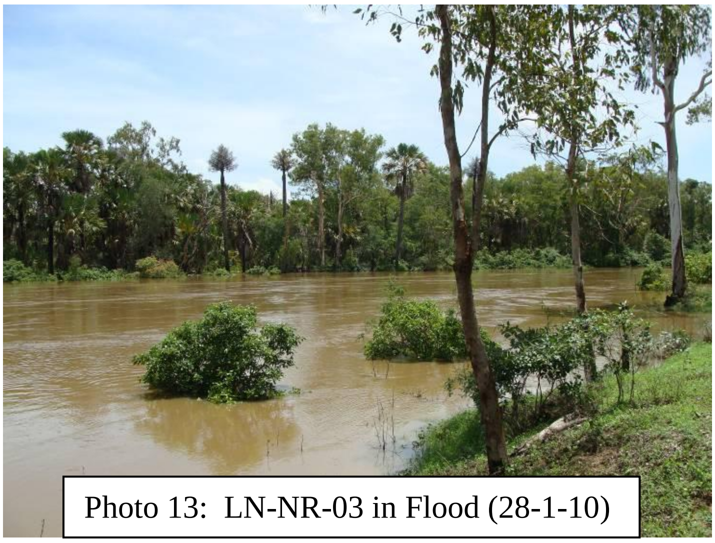


Photo 13: LN-NR-03 in Flood (28-1-10)

Photos 14 & 15: LN-NR-04, Battlecamp Crossing

Photos 16 & 17: LN-NR-05, East Normanby River

Photo 18: LN-LR-01, Laura River at Laura

Photo 19: Passive Sampler deployed at LN-LR-02, Festival Grounds (14-5-09)

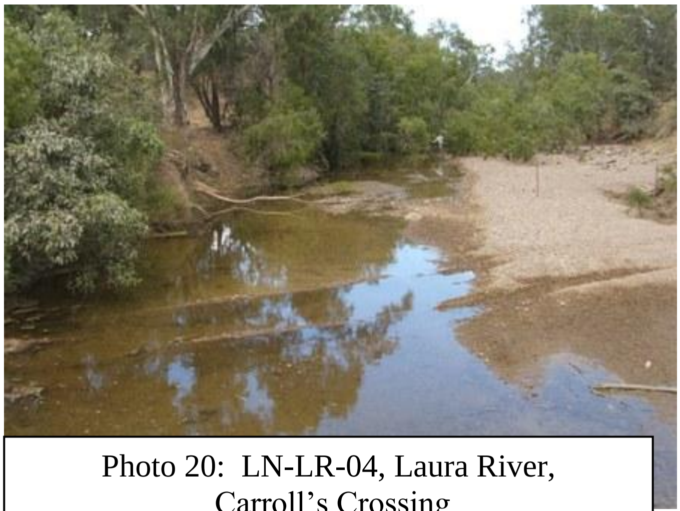


Photo 20: LN-LR-04, Laura River, Carroll's Crossing

Photo 21: Algae at LN-LR-04 (5-8-09)

Photo 22: LN-LR-05, Broken Dam Station, Lakeland

Photo 23: Lakeland Rubbish Tip above Bullhead Creek

Photo 24: Sampling at Laura Rubbish Tip

Photo 25: Normanby Estuary Helicopter Sampling

APPENDIX B –
DESCRIPTION OF INDICATORS (A. Moss, DERM*)

Category	Indicator	How measured	What does it mean?	What causes it?
Nutrients	Nitrogen Organic Nitrate plus nitrite Ammonia Phosphorus Filterable reactive Total	Total nutrients are made up of a dissolved component (e.g. nitrate plus nitrite, ammonia and filterable reactive phosphorus) and an organic component, which is bound to carbon (e.g. organic nitrogen). Nutrients in the dissolved state can be readily used by plants.	High nutrient concentrations in a waterbody (eutrophication) may lead to excessive weed and algal growth.	Excess nutrients enter a waterbody through several means, including discharge of treated sewage, stormwater, and in run-off from land, for example as fertiliser, animal waste, or decaying plant matter.
Chlorophyll a	Chlorophyll a	Chlorophyll a is a pigment found in green plants, including aquatic plant. Measuring the amount of chlorophyll a in the water therefore indicates the amount of green algae present in the water.	High concentrations of algae (algal blooms) may harm other aquatic organisms, either through the production of toxins, reduction of available light through covering the water surface, or by using all available oxygen during respiration at night.	Algal growth is stimulated by high concentrations of nutrients. Low levels of light (e.g. in a stream shaded by riparian vegetation, or a turbid estuary) may limit algal growth even if nutrient concentrations are high.
Salinity	Conductivity	A measure of the amount of dissolved salts in the water, and therefore an indicator of salinity.	In freshwater, low conductivity indicates suitability for agricultural use. In salt waters low conductivity indicates freshwater inflows such as stormwater run-off.	Excess salinity in freshwater streams occurs as a result of excess soil salinity, which may be caused by excess land clearing and changes to the groundwater table.

Category	Indicator	How measured	What does it mean?	What causes it?
Water clarity	Turbidity	Turbidity is a measure of how cloudy or murky the water is, and is measured by determining the scattering of light by suspended particles in the water column.	Water clarity (the degree of light penetration) is important as aquatic plants depend on light to photosynthesise and produce oxygen. Large amounts of sediment in a waterbody can also smother benthic organisms.	Sediment enters the water through erosion and run-off from the surrounding land; clearing of land, particularly the riparian zone, may result in increased sediment loads to a waterway.
Oxygen	Dissolved oxygen	Oxygen is measured as the amount of oxygen dissolved in the water at that temperature.	Oxygen is essential for life processes of most aquatic organisms. Many aquatic organisms will suffocate if there is insufficient oxygen in the water.	Typically, oxygen levels may decrease as a result of excess algal and bacterial respiration. If a large amount of algae is present in a waterbody, oxygen production (photosynthesis) during the day may result in supersaturated oxygen levels (above 100%), while respiration during the night when there is no photosynthesis will deplete the oxygen concentrations. Large amounts of organic matter in a waterway result in increases in populations of bacteria that break down the matter, and an increase in the rate of break down. Oxygen is consumed during the decomposition process, and results in little oxygen being available for other organisms.

Category	Indicator	How measured	What does it mean?	What causes it?
pH	pH	A measure of the acidity or alkalinity of the water.	Extremes of pH (less than 6.5 or greater than 9) can be toxic to aquatic organisms.	Changes to pH can be caused by a range of potential water quality problems (eg low values due to acid sulphate run-off). pH values are also related to soil geology and may be naturally low (eg in melaluka swamps) or high (in limestone areas). High pH values can also be caused temporarily when high rates of photosynthesis by aquatic plants (including algae) lead to a decrease in carbon dioxide, and therefore a decrease in carbonic acid in the water.

*Moss, Andrew (in preparation). *Report on the long-term monitoring of estuaries and coastal waters in Central Queensland, 1993 to 2006.* (Qld Dept of Environment & Resource Management, Brisbane)

APPENDIX C
CYMAG QAQC SAMPLES & DATA VALIDATION

Quality Control Checks

QC checks of both field sampling and laboratory sample analysis are used to assess and document data quality and to identify discrepancies in the measurement process that need correction. QC samples are used to determine the representativeness of the environmental samples, the precision of sample collection and handling procedures, the thoroughness of the field equipment decontamination procedures, and the accuracy of laboratory analysis. The number and type of QC samples collected are determined by the type of data to be collected.

QC samples collected to assess field sample collection procedures are as follows.

Field Duplicates

Field Duplicates, submitted to the laboratory "blind", are used to evaluate variation in analyte concentration between samples collected from the same point and/or the laboratory precision in a given matrix. The RPD (Relative % Difference) of the duplicates is used as the accept/reject criteria. The following guide should be used when assessing the RPD of any given pair of duplicates.

- If the results are < 10 X Level of Reporting (LOR) then no RPD limit is applied.
- If the results are 10 – 20 X LOR then the RPD should be within 50%.
- If the results are > 20 X LOR then the RPD should be within 20%.

Sample non-homogeneity can lead to RPD's greater than detailed above. It should be the aim of field personnel to endeavour to obtain a pair of samples as homogenous as possible.Duplicate samples are collected simultaneously from the sample matrix.

At least one duplicate sample will be collected for each group of 20 samples of a similar matrix type and concentration. The field replicates will be handled and analyzed in the same manner as all environmental samples. The duplicate samples will be submitted blind to the laboratory.

Frequency: 1 per 20 samples
Analytes: ALL
Sample ID: QC-01

Field Blanks/ Method Blanks

Field blanks will be used to indicate the presence of external contaminants that may have been introduced into the samples during collection. Field blanks will be prepared on site during the sampling event by pouring organic-free or inorganic-free water, as appropriate, into sample containers.

Frequency: One blank sample per sample batch (or 1 per 20 samples)
Analytes: ALL
Sample ID: QC-02

<u>Rinsate Blanks</u>

Rinsate Blanks are blanks prepared in the field from reagent-grade water that is poured over or passed through the sample collection device after the device has been decontaminated, then collected in a sample container and returned to the laboratory for analysis. Rinsate blanks document the thoroughness of decontamination procedures and will be used to assess the adequacy of practices to prevent cross-contamination between sampling equipment and samples.

Rinsate samples will be collected during every sample trip where sampling equipment is used to collect more than one sample. Organic-free or inorganic-free water, as appropriate, will be collected following the final decontamination rinse of sampling equipment (such as a dissolved nutrients syringe or extendable sampling cup) and then dispensed into sample containers.

Frequency: One per sample trip where non-dedicated equipment is used (syringe for dissolved nutrients, sampling cup)
Analytes: ALL
Sample ID: QC-03

<u>Trip Blanks</u>
Trip blanks are prepared by the field sampling team with reagent grade water at a designated clean location prior to sampling activities. Trip blanks are not opened in the field and act as a check for sample contamination originating from sample transport and site conditions.

Trip blanks will be used to document potential contamination that may be introduced into the sample containers by volatile organic compounds (VOCs) through diffusion during sample transport and storage. One trip blank will be prepared off-site and included with each batch of samples scheduled for analysis of VOCs regardless of environmental medium.

Frequency: One per sample batch sent to laboratory
Analytes: volatile organics only
Sample ID: QC-04

Laboratory Quality Control Checks

In addition to field QC samples, the analytical laboratory uses a series of QC samples specified in each standard analytical method to assess laboratory performance. The types of laboratory QC samples are method blank, laboratory control standard, duplicate, matrix spike, and matrix spike duplicate. Analyses of laboratory QC samples are performed for samples of similar matrix type and concentration and for each sample batch.

Method Blank (MB): A method blank is a sample of deionized (DI) water, sea sand, or analyte-free substance that mimics the field matrix and is prepared identically to an actual sample. Contamination in the method blank is indicative of a high bias caused by the accidental addition of target analytes through the preparation or extraction, or contributed by the instrument.

LCS or Blank Spike: This is a blank that has been spiked with the compounds of interest. Since it is prepared identically to an actual sample, an LCS failure in the recovery of a spike compound could be indicative of bias introduced in the preparation or extraction process.

Matrix Spike/Matrix Spike Duplicate (MS/MSD): An actual field sample that is spiked with the compounds of interest. Failures in the MS/MSD, especially those that are duplicated well, could be indicative of matrix effect. Matrix effect is a bias caused by interference in the recovery of an analyte due to the sample matrix.

TABLE 1: Laboratory Analysis Quality Control Breaches						
Batch	**Sample Date**	**River**	**Sample**	**Analyte**	**Breach**	**Comments/ Actions**
EB0702159	14-3-07	Laura	LN-LT-Tip (water)	PAHs	Low Recovery on Lab Spike samples	Results were non-detect, unlikely to have higher concentrations based on other sample results. Accept results.
EB0703550	26/03/2007	LN	LN-NR-02 LN-NR-00	PAHs & phenols	Recovery above data quality objective	The results were non-detect, not likely to be affected by high recoveries
EB0713142	Oct/nov 2007	LN	NR-02, 03,04, 05 LR-03& 04	Total Mercury	Holding time exceeded (8 days)	Non-detect results accepted with qualification
EB0802790	Feb 2008	LN	LN-BHC, LR-05	OP/OC Pesticides	Holding time exceeded (2 days)	Results accepted with qualification, minor holding time breach
EB0802790	Feb 2008	LN	LN-BHC, LR-05	Phenoxyacetic acid Herbicides	Holding time exceeded (3 days)	Results accepted with qualification
EB0804454	31/03/2008	LN	LN-LR-TIP LN-LR-02	PAHs	Low recovery rate for Lab Spike samples	PAH non-detect results accepted with qualifications
EB0804454	31/03/2008	LN	LN-LR-TIP LN-LR-02	PAHs & TPH	Holding time exceeded (1 day)	Results accepted, minor breach
EB0804454	31/03/2008	LN	LN-BHC	OC/OP Pesticides	Holding time exceeded (1 day)	Results accepted, minor breach
EB0804454	31/03/2008	LN	LN-BHC LN-LR-05	Phenoxyacetic acid Herbicides	Holding time exceeded (3 days)	Results accepted with qualification
EB0808697	15/04/2008	NR	LN-NR-02	Total Mercury	Holding time exceeded (55 days)	**Mercury results deleted**
EB0811705	26/08/2008	LN soil	LN-BHC LN-LR-02 LN-LR-05	Total Metals & PAHs	Laboratory Duplicate exceeds RPD limits	Most likely due to sample non-homogeneity, results accepted
EB0811705	26/08/2008	LN	LN-BHC	Triazines & PAHs	Recovery greater than	All results non-detect, therefore not

TABLE 1: Laboratory Analysis Quality Control Breaches						
Batch	**Sample Date**	**River**	**Sample**	**Analyte**	**Breach**	**Comments/ Actions**
		soil	LN-LR-05		data quality objectives	affected by high recoveries
EB0811705	26/08/2008	LN soil	LN-BHC LN-LR-02 LN-LR-05	Manganese	Recovery greater than data quality objectives	**Manganese results deleted**- significant breach
EB0811705	26/08/2008	LN water	LN-BHC LN-LR-05	Phenoxyacetic acid Herbicides	Holding time exceeded (2 days)	Non-detect results accepted with qualification
EB0902931	20/02/2009	LN water	LN-NR-02	Total Mercury	Low recovery for Lab QC samples	Mercury not-detected in sample. Results accepted with qualification
EB0908148	23/03/2009	LN water	LN-NR-02 LN-NR-03	Total and Dissolved Mercury	Holding time exceeded (30+days)	**Mercury Results deleted**
EB1003574	22/02/2010	LN water	LN-BHC	Phenoxyacetic acid Herbicides	Holding time exceeded (2 days)	Potential loss of contaminants, non-detect results accepted with qualification

APPENDIX D
AMBIENT WATER QUALITY PARAMETERS –
Minimum. Maximum and Median Measurements For Each Sample Location

Sample ID:		pH: -log [H^+]	Temperature: °C	Conductivity: (mS/cm)	Salinity: ppt	Disolved Oxygen: (mg/L)	Disolved Oxygen: (%SAT)	Turbidity: NTU
LN-BHC	min	7.67	18.5	0.594	0.0	5.49	65.1	1.3
n=7	max	8.46	28.9	1.088	0.5	12.87	171.0	21.2
	median	8.07	26.7	1.022	0.5	9.55	122.0	4.1
LN-LR-01	min	7.05	21.3	0.068	0.0	6.55	79.3	4.3
n=10	max	7.93	31.2	0.344	0.2	8.25	106.6	124.0
	median	7.37	26.8	0.164	0.1	6.95	85.0	6.9
LN-LR-02	min	7.19	24.4	0.098	0.1	5.45	67.5	2.0
n=15	max	8.23	32.7	0.938	0.5	7.69	98.6	62.6
	median	7.82	29.3	0.385	0.2	6.68	87.8	10.7
LN-LR-03	min	6.80	21.4	0.071	0.0	3.02	36.5	1.5
n=32	max	8.88	33.0	1.715	0.9	8.27	104.8	141.3
	median	8.29	28.3	1.040	0.5	5.12	67.8	2.8
LN-LR-04	min	7.64	21.4	0.111	0.0	2.79	38.6	1.0
n=32	max	8.77	32.1	1.570	0.8	9.31	115.2	258.0
	median	8.54	28.2	1.070	0.5	6.85	89.6	3.5
LN-LR-05	min	7.31	19.6	0.180	0.1	3.67	48.8	1.1
n=27	max	9.01	36.3	1.704	0.9	13.27	166.8	193.3
	median	8.00	26.9	0.816	0.4	6.60	82.4	4.0

Sample ID:		pH: -log [H+]	Temperature: °C	Conductivity: (mS/cm)	Salinity: ppt	Disolved Oxygen: (mg/L)	Disolved Oxygen: (%SAT)	Turbidity: NTU
LN-NR-00	min	7.09	24.1	4.520	2.4	4.19	57.7	7.3
n=15	max	8.17	31.8	56.5	37.7	6.73	97.3	108.7
	median	8.02	29.9	45.2	29.5	5.18	79.4	16.3
	stdev	0.32	2.6	18.2	12.4	0.86	11.9	28.2
LN-NR-01	min	7.06	23.5	0.794	0.4	3.64	50.9	6.7
n=14	max	8.08	32.1	58.9	39.7	6.45	90.1	125.7
	median	7.87	29.4	34.1	21.4	4.66	65.0	37.2
	stdev	0.34	2.8	24.5	16.5	0.82	11.1	31.2
LN-NR-02	min	6.87	23.3	0.053	0.0	3.49	42.2	2.0
n=25	max	7.99	33.7	0.443	0.2	8.02	98.9	72.3
	median	7.21	28.3	0.145	0.1	6.00	79.1	7.0
	stdev	0.32	2.4	0.079	0.0	1.03	12.9	20.5
LN-NR-03	min	6.63	24.6	0.060	0.0	4.17	59.0	4.5
n=19	max	8.73	36.0	0.514	0.2	8.76	115.0	95.9
	median	7.45	29.3	0.216	0.1	5.93	73.2	8.7
	stdev	0.53	3.1	0.101	0.0	1.19	15.4	29.1
LN-NR-04	min	6.82	22.5	0.055	0.0	3.77	46.3	5.7
n=16	max	7.62	33.0	0.538	0.3	7.98	96.3	168.3
	median	7.28	28.0	0.199	0.1	6.64	82.2	10.6
	stdev	0.26	3.5	0.107	0.1	1.35	15.6	42.2
LN-NR-05	min	6.51	20.6	0.058	0.0	3.76	46.5	2.8
n=24	max	8.00	32.0	0.251	0.1	7.91	95.7	93.7
	median	7.24	27.1	0.087	0.0	6.32	79.1	6.1
	stdev	0.37	2.3	0.044	0.1	0.90	10.9	26.5

Table 2: Range and Median Ambient Water Quality Parameters for Laura-Normanby SubSets by Season

Sample ID:		pH -log [H+]	Temperature °C	Conductivity (mS/cm)	Salinity ppt	Disolved Oxygen (mg/L)	Disolved Oxygen (%SAT)	Turbidity NTU
LR dry	min	6.80	19.6	0.102	0.0	2.79	36.5	1.0
N=74	max	9.01	36.3	1.715	0.9	13.27	166.8	11.6
	median	8.33	27.6	1.030	0.5	6.23	78.9	2.1
	stdev	0.41	3.3	0.387	0.2	1.89	23.8	2.3
LR wet	min	6.83	26.6	0.068	0.0	4.02	52.4	3.6
N=41	max	8.64	32.7	0.975	0.5	9.05	115.2	258.0
	median	7.76	29.0	0.231	0.1	6.58	85.8	35.3
	stdev	0.43	1.5	0.258	0.1	0.94	11.3	60.6
NR dry	min	6.82	20.6	0.086	0.0	3.49	42.2	2.0
N=59	max	8.73	36.0	0.538	0.3	8.76	115.0	68.0
	median	7.35	27.2	0.195	0.1	6.00	75.4	6.1
	stdev	0.38	3.2	0.090	0.0	1.21	14.9	8.8
NR wet	min	6.51	25.7	0.053	0.0	4.65	60.1	6.1
N=22	max	8.06	30.9	0.137	0.1	7.26	90.1	168.3
	median	7.12	28.7	0.077	0.0	6.33	80.8	43.5
	stdev	0.34	1.4	0.024	0.0	0.73	8.8	38.4
NR EST wet	min	7.06	26.9	0.794	0.4	3.96	50.9	8.7
N=13	max	8.08	31.8	45.200	29.5	5.75	80.7	125.7
	median	7.79	30.6	8.440	4.7	4.88	64.6	39.8
	stdev	0.40	1.5	16.973	11.2	0.59	9.8	30.5
NR EST dry	min	7.67	23.5	32.400	20.2	3.64	56.2	6.7
N = 16	max	8.17	32.1	58.900	39.7	6.73	97.3	108.7
	median	7.99	26.9	54.800	36.4	5.13	75.5	22.7
	stdev	0.13	2.9	8.743	6.4	1.04	11.8	29.4

APPENDIX E
Passive Sampler PAH and Pesticide/ Herbicide Results & Analyte List

Table 1 –
Concentration of Pesticides and PAHs detected in PDMS samplers 2009 & 2010*

Sample Reference	**Blank 5day 2009**	**Blank* 30days 2009**	**Blank* 30days 2010**	**LN LR.05 5days Jan 2009**	**LN LR.05 30days Jan 2009**	**LN LR.05 30days 2010**
	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
Pesticides/Herbicides						
Diuron breakdown product	<45	<45	<0.05	**10**	<0.05	<0.05
GALAXOLIDE	<0.05	<0.05	<0.05	<3	**1**	**0.048**
PENDIMETHALIN ________h2209	<0.54	<0.54	<0.05	**40**	**38**	<0.05
METOLACHLOR	<0.05	<0.05	<0.05	<0.05	<0.05	**0.369**
PAHs						
ACENAPHTHYLENE 152	<0.2	<0.2	<0.2	<1.5	<0.2	<0.2
spk4 ACENAPHTHENE 154	<0.2	<0.2	<0.2	<0.9	<0.2	<0.2
FLUORENE 166	<0.1	<0.1	<0.1	<1.2	<0.1	<0.1
PHENANTHRENE 178	<0.1	<0.1	<0.1	**0.7**	<0.1	<0.1
ANTHRACENE 178	<0.1	<0.1	0.123	<0.6	<0.1	0.062**
FLUORANTHENE 202	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1
spb6 PYRENE 202	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1
BENZ[a]ANTHRACENE 228	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1
CHRYSENE 228	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1
BENZO[b+k]FLUORANTHENE 252	<0.1	<0.1	<0.1	<0.6	<0.1	<0.1
BENZ[e]PYRENE 252	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1
BENZ[a]PYRENE 252	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1
PERYLENE 252	<0.1	<0.1	<0.1	<0.9	<0.1	<0.1
INDENO[123cd]PYRENE 276	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1
BENZO[ghi]PERYLENE 276	<0.2	<0.2	<0.2	<0.9	<0.2	<0.2
DIBENZ[ah]ANTHRACENE 278	<0.2	<0.2	<0.2	<0.7	<0.2	<0.2
Recovery	**89-125%**	**81-131%**		**90-115%**	**91-124%**	

*2008 PDMS Samplers were lost in floods

0.062** = Contamination detected in Blank sample. Sample result not accepted.

- Bold values are detections greater or lower than the LOR and were confirmed on a full ion scan when GC-MS is used
- Values marked with a '<' sign were not detected and are based on the blanket LOR value for a 5 or 30 days deployment period
- Concentrations represent daily averages calculated from the flow rates measured with plaster flow monitors (PFMs)

Table 2 – Concentration of Herbicides in water (ngL^{-1}) calculated from the mass accumulated in ED samplers January & February 2008 AND 2009.

Sample Name	Flumeturon	Diuron	Simazine	Atrazine	Desethyl Atrz.	Desisopropyl Atrz.	Hexazinone	Tebuthiuron	Ametryn	Prometryn
Blank	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LN-LR-05 (5 day) Jan 2008	<0.3	**1.0**	<0.3	**81**	**8.8**	<0.3	<0.3	<0.3	<0.3	<0.3
Jan- Feb 2009										
Blank 5 Day	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LN-LR-05 5 Day	<0.3	**19**	<0.3	**99**	**6.3**	<0.3	<0.3	<0.3	<0.3	<0.3
LN-LR-05 5 Day duplicate	<0.3	**8.6**	<0.3	**41**	**3.0**	<0.3	<0.3	<0.3	<0.3	<0.3
Blank 30 Day	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
LN-LR-05 30 Day	<0.3	**1.2**	<0.3	**5.9**	**1.2**	<0.3	**1.0**	<0.3	<0.3	<0.3

A sampling rate of 0.59 $Lday^{-1}$ was used for the 5 day no membrane samplers, and 0.08 $Lday^{-1}$ for the 30 day samplers

Table 3- Concentrations of Herbicides in water (ngL^{-1}) calculated from the mass accumulated in ED samplers Dec 2009 – Apr 2010

Deployment Site	deployment	Length(days)	Diuron	Simazine	Metolachlor
Broken Dam 5 day	2/4 – 4/4/2010	5	0.38	0.99	-
Broken Dam 30 day	28/12/09-27/1/10	30	-	-	3.3
Normanby 30 day	28/1 – 23/12/2010	26	-	-	-
Turallba 5 day	2/4 – 4/4/2010	5	0.20	0.71	-
Crocodile St 5 day	2/4 – 4/4/2010	5	0.07	0.68	-

Concentration in Water (ng/L) estimated using passive samplers with an assumed sampling rate of 0.08 L.day-1 (+membrane; 30 days) or 0.59 L.day-1 (-membrane; 5 day)

TABLE 4: 10/05/2009 PESTICIDES & PAH ANALYTES LIST - GCMS - PDMS SAMPLERS			
Acephate	Dieldrin	Metribuzin	Tetradifon
Aldrin	Dimethoate	Mevinphos Z+E	Tetramethrin
Ametryn	Dimethomorph	Molinate	Thiabendazole
Amitraz	Dioxathion	Monocrotophos	Tonalid
Atrazine	Disulfoton	Musk Ketone	Transfluthrin
Azinphos Ethyl	Diuron Breakdown Product	Musk Xylene	Triadimefon
Azinphos Methyl	Endosulfan Alpha	Nicotine	Triadimenol
Benalaxyl	Endosulfan Beta	Nonachlor Cis	Triallate
Bendiocarb	Endosulfan Ether	Nonachlor Trans	Trifluralin
Bifenthrin	Endosulfan Lactone	Omethoate	Vinclozalin
Bioresmethrin	Endosulfan Sulphate	Oxadiazon	
Bitertanol	Endrin	Oxychlor	
Bromacil	Endrin Aldehyde	Oxydemeton Methyl	**Pahs**
Bromophos Ethyl	Ethion	Oxyfluorfen	Naphthalene
Cadusaphos	Ethoprop	Parathion Ethyl	Acenaphthylene
Captan	Etrimiphos	Parathion Methyl	Acenaphthene
Carbaryl	Famphur	Pendimethalin	Fluorene
Carbophenothion	Fenamiphos	Permethrin	Phenanthrene
Chlordane Cis	Fenchlorphos	Phenothrin	Anthracene
Chlordane Trans	Fenitrothion	Phorate	Fluoranthene
Chlordene	Fenthion Ethyl	Phosmet	Pyrene
Chlordene Epoxide	Fenthion Methyl	Phosphamidon	Benz[A]Anthracene
Chlorfenvinphos E+Z	Fenvalerate	Phosphate Tri-N-Butyl	Chrysene
Chlorothalonil	Fipronil	Piperonyl Butoxide	Benzo[B+K]Fluoranthene
Chlorpyrifos	Fluazifop Butyl	Pirimicarb	Benz[E]Pyrene
Chlorpyrifos Me	Fluometuron	Pirimiphos Methyl	Benz[A]Pyrene
Chlorpyrifos Oxon	Fluvalinate	Procymidone	Perylene
Coumaphos	Furalaxyl	Profenophos	Indeno[123cd]Pyrene
Cyfluthrin	Galaxolide	Prometryn	Benzo[Ghi]Perylene
Cyhalothrin	Haloxyfop 2-Etoet	Propagite	Dibenz[Ah]Anthracene
Cypermethrin	Haloxyfop Methyl	Propanil	
Dcpp	Hcb	Propazine	
Ddd O,P	Hch-A	Propiconazole	
Ddd P,P	Hch-B	Propoxur	
Dde O,P	Hch-D	Prothiophos	
Dde Pp	Heptachlor	Pyrazaphos	
Ddt O,P	Heptachlor Epoxide	Rotenone	
Ddt P,P	Hexazinone	Simazine	
Deet	Iprodione	Sulprofos	
Deltamethrin	Isophenophos	Tcep	
Demeton-S-Methyl	Lindane	Tcpp	
Desethylatrazine	Malathion	Tebuconazole	
Desisopropylatrazine	Metalaxyl	Tebuthiuron	
Diazinon	Methamidophos	Temephos	
Dichloroaniline	Methidathion	Terbuphos	
Dichlorvos	Methoprene	Terbuthylazine	
Diclofop Methyl	Methoxychlor	Terbutryn	
Dicofol P,P	Metolachlor	Tetrachlorvinphos	