
Volume 1 (2006/07 Wet Season Report)

ACTFR Report 07/22
for the Burdekin Dry Tropics NRM

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Executive Summary

A major rainfall event occurred in January 2007, triggering significant flows across the Burdekin Dry Tropics Region, except for the south-western Belyando and Suttor catchments, where only minor flows occurred. All 30 volunteers monitored a total of 34 sites across the region. The Clare gauging station (Burdekin River mouth) recorded the largest flow event since the commencement of the monitoring project, with 8.3 million ML passing through the Burdekin River during January and February. Due to the significant flows, flood plume monitoring was also conducted along the salinity gradient from the Burdekin River, Haughton River and Barratta Creek mouths.

The total TSS load from the Burdekin River at Inkerman was 6,140,000 tonnes, with a contribution of 1,200,000 tonnes from the Burdekin Falls Dam (with the upper Burdekin major sub-catchment contributing 86% of the sediment load into the dam), 2,240,000 tonnes from the Bowen River (Myuna) and the remainder (2,700,000 tonnes), from the Bowen River below Myuna, the Bogie River and other smaller tributaries that drain directly into the Burdekin River below the Burdekin Falls Dam.

Consistent with the previous three monitored wet seasons, the Bowen River sub-catchment had the highest total suspended sediment (TSS) concentrations of all monitored sub-catchments, with a peak concentration of 10,000 mg/L, and an event mean concentration of 2,380 mg/L for a series of flow events during December 2006-February 2007. Additional volunteer sites were established this wet season within the Bowen catchment to investigate the source of these suspended sediments, with high TSS concentrations (median of 2,380 mg/L and maximum of 11,800 mg/L) measured at the Little Bowen River site.

High TSS concentrations were also measured in the north-western sub-catchments of the upper Burdekin (e.g. Gray Ck, Camel Ck, Clarke River), where median TSS concentrations were >1,150 mg/L. These tributaries were targeted this wet season as they are thought to be significant contributors of sediment to the upper Burdekin River major sub-catchment. High TSS concentrations were also measured at the upper Suttor River site (maximum of 2,410 mg/L and median of 535 mg/L), however TSS concentrations are lower at the downstream Suttor River major sub-catchment site (maximum of 640 mg/L and median of 415 mg/L). Event sampling in the upper Belyando sub-catchment (upper Belyando River and Native Companion Creek) also yielded relatively high median TSS concentrations (1,360 mg/L and 985 mg/L, respectively). Further sampling in both the Suttor and Belyando major sub-catchments during larger flow events is required to increase the confidence in sediment and nutrient data collected to date.

Elevated particulate nitrogen and phosphorus concentrations were measured at sites with high TSS concentrations, where the particulate fraction dominated TN and TP. The highest PN and PP loads were measured at the upper Burdekin sub-catchment, with 3,100 tonnes of TN and 1,150 tonnes of PP. Although nutrients were not measured at the Bowen River major sub-catchment this wet season, a strong relationship between TSS and PN/PP has been measured at this site in previous wet seasons, indicating that PN and PP loads would have been considerable from this sub-catchment.

Consistent with previous wet seasons, the lower Burdekin coastal catchments had considerably lower sediment and particulate nutrient concentrations than the grazed Burdekin sub-catchments. These coastal catchments with more intensive land uses (sugarcane cultivation and horticulture) had disproportionately high nitrate (and nitrite) (NO₃) and phosphate (FRP) event mean concentrations compared to the other larger Burdekin sub-catchments. The highest NO₃ concentrations were recorded at the three Barratta Creek sites (655 µg N/L, 765 µg N/L and 810 µg N/L), with a total NO₃ load of 73 tonnes for the Barratta Creek system. The Haughton River also contributed a NO₃ load of 59 tonnes. FRP loads were highest for the Barratta Creek system (20 tonnes) and Haughton River (30 tonnes), with the exception of the upper Burdekin major sub-catchment (110 tonnes).
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Australian Centre for Tropical Freshwater Research
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1. Introduction

The Burdekin Community Water Quality Event Monitoring Project was established in late 2002 by the Australian Centre for Tropical Freshwater Research (ACTFR), James Cook University for the Burdekin Dry Tropics Natural Resource Management (BDTNRM) regional body to investigate sediment and nutrient concentrations in waterways throughout the Burdekin Dry Tropics Region.

The objectives of the project are as follows:

(i) rank sub-catchments within this region that have the greatest contributions of suspended sediment and nutrients to downstream environments for prioritisation of on-ground investment;

(ii) validate SedNet modelling (CSIRO/NRW/ACTFR) that suggests that the Bowen-Broken, east Burdekin (Goldfields) and upper Burdekin sub-catchments are the greatest contributors to coastal delivery of sediment and nutrient loads;

(iii) build awareness, education and capacity of the Burdekin Dry Tropics community in terms of water quality management through active involvement in a scientific monitoring program;

(iv) ensure the community-assisted monitoring project has robust scientific design and integrity.

This monitoring project has run successfully over the past five wet seasons, with the network of volunteer samplers necessary to capture water quality data from the entire Burdekin Dry Tropics Region growing steadily each year, from 14 volunteers and a similar number of sampling sites in the 2002/03 wet season to 30 volunteers and 54 sites in the latest (2006/07) wet season.

Through this project ACTFR has worked with a team of collaborators to integrate event water quality monitoring projects in the region to reduce duplication of sampling efforts and to improve the communication, data sharing and collaboration amongst the regions stakeholders. Major stakeholders include the scientific community (CSIRO, AIMS, MTSRF), Local, State and Federal Government departments (C2C, NRW-GBR15 Loads Monitoring Program, DPI&F, GBRMPA), industry as well as the broader community. Support to integrate these projects has been received from the State Governments’ Water Quality State Investment Program (WQSIP).

The 2006/07 wet season sampling activities can be classed into five major categories based on sampling scales:

1) property/subcatchment scale: Research (sediment transport processes / relationship between grazing/sugar cane and water quality);

2) sub catchment scale: BDTNRM Community Water Quality Event Monitoring Project and MTSRF Program 3.7.2; (this report)

3) major catchment scale: Natural Resources and Water Great Barrier Reef Catchments Loads Monitoring Program Priority 5 major catchments sites (Belyando, Suttor, Cape, Upper Burdekin); (this report)

4) end of catchment scale: Natural Resources and Water Great Barrier Reef Catchments Loads Monitoring Program; (this report)

5) GBR lagoon flood plume and marine monitoring scale: BDTNRM WQIP Lower Burdekin Pesticide Study, BDTNRM Community Water Quality Event Monitoring Project; (this report), GBRMPA Marine Monitoring Program and the MTSRF Program 3.7.2.

The linkages between each of these projects, the Burdekin Dry Tropics NRM and the Reef Water Quality Protection Plan are shown in Figure 1. For further information about these linkages and on-ground activities, please refer to the 2006/07 wet season work plan (Project Milestone 1; Bainbridge, 2007a). Please note that Figure 1 does not refer to the Townsville Thuringowa Creek to Coral...
WQIP, or the vast range of monitoring (primarily ambient “low flow” conditions) that is being conducted within this region.

More recently BDTNRM has initiated a Water Quality Improvement Plan (WQIP) for the Burdekin Region through the Department of Environment and Heritage Coastal Catchment Initiative (CCI) (www.burdekindrytropics.org.au/cci). The WQIP, to be released in 2008, will detail a strategic approach to the reduction of terrestrial pollutants to the GBR lagoon. Monitoring data collected in the Burdekin Dry Tropics Region by the Regional Water Quality Collaborative will assist in the development of the WQIP.

This report is divided into two sections: Volume 1 provides a review of sediment and nutrient (nitrogen and phosphorus species) concentrations and loads for sub-catchment sites monitored during the 2006/07 wet season, including samples collected from the Burdekin River, Haughton River and Barratta Creek flood plumes. Volume 2 summarises the project findings from the five wet seasons of data collection, and presents a ranking of the major contributing sub-catchments, other key findings from the project, recommendations for on-ground management for reducing sediment and nutrient runoff and future monitoring requirements.
Figure 1. Flow chart of the water quality organisational and program linkages in the Burdekin Dry Tropics Region (from Bainbridge, 2007a).
2. Background (derived from Bainbridge et al., 2006a)

The tropics of northern Australia are renowned for highly variable seasonal and annual rainfall linked to the El Niño Southern Oscillation, tropical lows/cyclones and monsoonal activity (Lough, 2001). This extreme variability is highlighted by the historical daily, annual and event discharge records of the Burdekin River (Figure 3) (Lewis et al., 2006). On average, over 80% of the freshwater discharged from the Burdekin River at the Home Hill (1922-1957) and Clare (1950-current) NRW gauging stations (120001, 120006) occurs during high flow events. This percentage would be similar or even higher within the sub-catchments of the Burdekin Region. The majority of sediments and nutrients are also transported through the Burdekin River waterways during these high flow events (see Lewis et al., 2006). Therefore, an event-focused approach to water quality monitoring is required to quantify the transport of sediments and nutrients in the waterways of the Burdekin River catchment. The Burdekin River is the second largest of the Great Barrier Reef river catchments with an area of 130,035 km² (Figure 2). Due to this large catchment area as well as the ‘flashiness’ of the waterways in the Burdekin Region, a thorough, event-focused water quality monitoring program is not possible without on-ground community volunteer samplers. ACTFR established the community water quality monitoring project in the Burdekin Dry Tropics Region for the BDTNRM body before the start of the 2002/2003 wet season. Since this time, the number of volunteer sites has increased considerably and a substantial proportion of the waterways within the Burdekin Region are now monitored during flow events.

The topography (Figure 4), geology (Figure 5), soil type and hydrology/climate (Figure 6) of the Burdekin sub-catchments are highly variable. The coastal ranges that enclose the eastern margins of the upper Burdekin and Bowen sub-catchments are vegetated with rainforest species and are characterised by considerable slopes, whereas the Belyando, Suttor and Cape Rivers drain low relief floodplain country (Rogers et al., 1999). Large portions of the Suttor, upper Burdekin and Bowen sub-catchments contain igneous rocks (both granites and basalts) while a large area of the Belyando and Cape sub-catchments host rocks of sedimentary origin (Figure 5). The Burdekin catchment, as a whole, is situated in the Dry Tropics Region. Extensive rangeland cattle grazing is by far the dominant land use in the region (Figure 7), however, different management practices such as stocking pressure, spelling and fire regimes would influence pasture cover throughout the catchment (Roth et al., 2003). Small areas of sugarcane, cereal and horticulture cultivation occur in the catchments above Clare Weir, particularly on the Bowen, Suttor and Belyando sub-catchments. Mining can also be an important land use but only occurs in localised areas (Figure 7). Much of the catchment lies upstream of the Burdekin Falls Dam (Lake Dalrymple) including all the major sub-catchments, except the Bowen (Figure 2). The sugar industry is prominent along the coastal catchments (Lower Burdekin and Haughton River catchments) of the Burdekin Region, although large proportions of the upper sections of these coastal catchments are also grazed by cattle (Figure 7 and Figure 8).

Similar event monitoring projects have been established in the neighbouring Wet Tropics and Mackay Whitsunday Regions and are designed to compare sediment and nutrient concentrations from streams draining sub-catchments dominated by different land use types (e.g. comparison of forest, grazing, cropping and urban land uses) (e.g. Bramley & Roth, 2002; Faithful & Finlayson, 2005; Rohde et al., 2006). However, as cattle grazing dominates land use within the Burdekin Region (>95% of the catchment area) this monitoring project has been designed to assess sediment and nutrient levels on a sub-catchment scale by investigating the different environmental parameters (i.e. topography, rainfall, soil type) that may influence water quality in these areas (see Brodie et al., 2004). Sampling sites were established along streams at the end of selected sub-catchments, with site selection based on sub-catchment size, flow contribution, site access, the availability of sampling volunteers and the presence of NRW gauging stations. As the sugar cane production area in the lower Burdekin (Figure 8) is one of the largest and most accessible alternative land use types in the Burdekin Region, a number of sampling sites were established in these sub-catchments (i.e. Barratta Creek, Haughton River) to provide at least one regional comparison of end-of-catchment
water quality influenced by different land use types. These sites were also sampled for a standard suite of pesticides as part of a sub-project (Pesticides in the lower Burdekin) funded through the BDTNRM WQIP. Although the pesticide results are reported in a separate report (Lewis et al., 2007), they form part of the overall events monitoring project identifying sources of pollutants within the Burdekin Dry Tropics Region.

The physical and climatic diversity of the Burdekin sub-catchments as well as the inconsistencies in the length, intensity, location and annual variability of rainfall events in these sub-catchments causes difficulties in the interpretation of water quality datasets. For example, an event in the Burdekin catchment after a prolonged dry period would probably result in significantly higher sediment and nutrient runoff compared to a ‘normal year’. Therefore, data collected over a considerable time period (years) is required to confidently predict catchment pollutant loads and, in turn, to set reasonable targets for the Water Quality Improvement Plan.

For further information about previous wet season monitoring data collected within the Burdekin Region, and other background information about this project see Brodie et al. (2004) and Bainbridge et al. (2006a and b).
Figure 2. Map of the Burdekin Dry Tropics Region including a breakdown of the major sub-catchments.
Figure 3. Annual event discharge records for the Burdekin River with event size classifications. The lower graph is an enlarged version to highlight the recent events within the small to moderate classification. Based on flow data provided by the State of Queensland (Department of Natural Resources and Water), 2007.
Figure 4. Digital Elevation Model of the Burdekin Region.
Figure 5. Geology Map of the Burdekin Region.
Figure 6. Average annual rainfall distribution in the Burdekin Region.
Figure 7. Land use distribution in the Burdekin Region.
Figure 8. Land use distribution in the lower Burdekin Region
3. **Rainfall and Flow Events: 2006/07 Wet Season**

3.1. **2006/07 Rainfall Events**

One major rainfall event occurred during the 2006/07 wet season, where a north-easterly monsoonal event (Figure 9) triggered significant flows across the eastern section of the Burdekin Dry Tropics Region (upper Burdekin, east Burdekin, lower Burdekin and Bowen River catchments), as well as the Cape River in the west (Figure 10). Similar to the previous monitored wet seasons, the south-western Belyando and Suttor catchments received less rainfall and as a result only smaller flows occurred in these catchments.

3.2. **2006/07 Flow Events**

In 2007 the Burdekin River at Clare gauging station recorded the largest flow event since the commencement of the monitoring project, with 8.3 million ML passing through the Burdekin River mouth during the January and February period (total event flow) (Figure 11). Based on the classification developed in Lewis et al. (2006), this flow event is ‘large’, and exceeds both the mean event discharge (5.97 million ML) and mean annual discharge (8.35 million ML) which are based on 85 years of continuous records from the Clare (120006B) and Home Hill (120001A) gauging stations.

The significant flows within the catchment generated widespread flooding and road closures in early February, with many volunteers on the smaller tributaries reporting the largest flow events seen in over a decade. As rainfall was very intense over the few days of late January - early February, river water levels rose quickly, with the upper Burdekin River at Sellheim (upstream catchment area of 36, 138 km², ~600 metre-wide channel) rising from <5 metres to 18 metres in <12 hours on the 1st February (Figure 12a). Flows from this catchment and the Cape River (also flooded over the Gregory Developmental Road for the first week of February; see Figure 12b) caused the water level of the Burdekin Falls Dam to rise quickly. As the dam was already close to capacity before this flow event (~80%), the spillway overflowed on the 2nd February, and reached a peak height of ~4.5 metres above the spillway by the 4th February, 2007 (BoM Website, 2007).

Historical gauging data from the NRW Watershed website (www.nrm.qld.gov.au/watershed) suggests that annual river flow for the 2006/07 water year was moderate (equal to the mean annual flow) for the Bowen (940, 000 ML; ranked 12th of 47 records), upper Burdekin (4, 100, 000 ML; ranked 22nd of 60 records) and Cape (740, 000 ML; ranked 16th of 59 records) sub-catchments, with all three catchments experiencing the largest flow events during the monitored period (Figure 11). Smaller flow events were recorded at the south-western Belyando (194, 400 ML; ranked 44th of 58 records) and Suttor (at St Anns: 541, 300 ML; ranked 31st of 40 records) sub-catchments, where flow volumes were similar to those previously monitored (Figure 11). As the discharge from these southern catchments has been below average over the five year monitoring program, the water quality data needs to be interpreted with caution as large flow events may produce different data trends than small flow events.
Figure 9. Satellite imagery from the 28th January (a) and 1st February (b) 2007 illustrating the north-easterly monsoonal effect that triggered the flood event.
Figure 10. Rainfall distribution within the Burdekin Region during the January flood event.
Figure 11. Hydrograph data for the end-of-catchment and major sub-catchments of the Burdekin for the 2006/07 wet season. The previous four monitored wet seasons are shown for comparison.
Figure 11 cont. Hydrograph data for the end-of-catchment and major sub-catchments of the Burdekin for the 2006/07 wet season. The previous four monitored wet seasons are shown for comparison.
Figure 12. The upper Burdekin River at Sellheim in flood at Macrossan Bridge, Flinders Hwy on the 2nd February (a) and the Cape River at the Gregory Developmental Road on the 5th February, where flooding persisted and caused the road to be closed for the first week of February, 2007 (b).
4. Methods

4.1. Sample Sites

To determine the contribution of sediments and nutrients from the sub-catchments of the Burdekin Dry Tropics Region, sampling sites have been established at ‘end-of-catchment’ locations on the five major sub-catchments of the Burdekin River catchment (Belyando, Suttor, Cape, Bowen and upper Burdekin Rivers), which have now been monitored over five wet seasons by ACTFR and other collaborative agency staff. Tributaries within each of these major sub-catchments, the lower Burdekin (Barratta Creek/ Haughton River catchments), the east Burdekin (above and below the dam) and the Don River and Euri Creek catchments (located in the south-east of the region) were sampled through a network of landholder volunteers (predominately graziers) which are critical to the success of this monitoring program. These volunteers collect samples during difficult wet season conditions where road access is restricted for agency staff to sample throughout the flow hydrograph in a timely manner.

In December 2006 additional sampling sites were established in prioritised sub-catchment locations for the 2006/07 wet season, including:

- tributaries within the Bowen River sub-catchment to further investigate the source of elevated suspended sediment and nutrient concentrations being exported by this catchment (Little Bowen, Bowen River at Dartmoor);
- Additional tributaries to the upper Burdekin River sub-catchment including the Clarke River (new sampling volunteer organised as is a major tributary), Burdekin River (Lucky Downs Station) and Grey Creek;
- Carmichael River in the Belyando sub-catchment; and
- Logan Creek in the Suttor sub-catchment.

Sampling sites were positioned at locations accessible during wet season conditions, and as close as possible to the end of the sub-catchment/tributary to represent the greatest catchment area possible. Sites were prioritised to streams where NRW gauging stations have been established to measure stream flow, with sampling sites positioned as near as practical to the gauging station. Locations of the sampling sites for the 2006/07 wet season are illustrated in Figure 13 and details of each site are listed in Table 1.

During the 2006/07 wet season samples were collected from 41 different sub-catchments throughout the Burdekin Region, including 54 sites at upstream/downstream locations within these sub-catchments. Samples were collected during the late January rainfall event by the network of community volunteers, ACTFR, NRW, DPI&F and CSIRO field staff (see Figure 13).
Figure 13. Volunteer and organisation sampling sites during the 2006/07 wet season.
Table 1. 2006/07 wet season Burdekin Region sampling site details.

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### 4.2. Sample Collection and Analysis

Grab samples were collected over the flow hydrograph (i.e. rise, peak and fall) using a bucket and rope, where the sediment and nutrient samples were then sub-sampled into the appropriate containers (Table 2). A stirring rod was provided to each volunteer/staff to ensure the sample water collected in the bucket was well mixed during the sub-sampling. A sampling pole was used in the lower Burdekin and by DPI&F for the Cape River tributary sample sites, where the river water was collected directly into the sample containers. Volunteer samplers were given detailed sampling procedures (with direction pictures) to follow during sample collection as well as the storage of the samples (see Bainbridge, 2007a). Samples were collected from the centre of the channel flow where possible; otherwise samples were collected from the edge of the waterway. Every effort was made to ensure the bucket reached the main river flow, away from the backwash at the riverbank. Nutrient samples were filtered at sampling time using a 0.45µm sterile filter cartridge (Sartorius MiniSart) and stored on ice with the unfiltered nutrient samples (frozen within 24 hours of collection). Sediment samples (Total Suspended Solids) were refrigerated, and all samples were later transported on ice to the laboratory for analysis. Samples were analysed at the ACTFR laboratory by standard ACTFR methods, as summarised by Table 2. Further details are provided in Bainbridge et al. (2006b). An automated ISCO sampler (owned by BDTNRM) collected samples at the Bowen River (Myuna Station) site, with samples sent to the ACTFR laboratory for analysis. Samples were only analysed for TSS and particle size. Samples collected from the other four major sub-catchments (upper Burdekin, Cape, Belyando and Suttor) and the end-of-river (Burdekin River at Inkerman Bridge) by NRW and ACTFR staff, were sent to the NRW laboratory in Brisbane as part of the NRW GBRI5 Loads Monitoring Program. Samples were analysed using standard NRW methods (Table 2).

#### Table 2. Overview of ACTFR and NRW field and laboratory methods.

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Sediment (Total Suspended Solids)</th>
<th>Nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACTFR</strong></td>
<td><strong>Field:</strong> 1L water sample collected in field. Refrigerated and sent to ACTFR.</td>
<td><strong>Field:</strong> TN/TP-60ml tube of sample water; N&amp;P species- 6x 10ml tubes of filtered sample water (using syringe and sterile 0.45µm filters) collected and frozen.</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory:</strong> Known volume of sample is filtered through a Whatman GF/C (~1.2 µm) filter membrane, oven dried and SS weight determined.</td>
<td><strong>Laboratory:</strong> Alkaline persulfate oxidation technique for total and total filterable N&amp;P. Std colourmetric (automated) technique used for dissolved inorganic N&amp;P. PN/PP calculated.</td>
</tr>
<tr>
<td><strong>NR&amp;W</strong></td>
<td><strong>Field:</strong> 1L water sample collected in field. Refrigerated and sent to NRW</td>
<td><strong>Field:</strong> TKN/TKP collected in 250ml bottle then frozen. Species (NH₃ NOₓ PO₄) and DKN DKP collected in 125ml bottle; filtered in the field with 0.45µm filters (Sartorius individually packed and possible pre filter) then frozen and sent to NRW</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory</strong> Determined volume of sample is vacuum filtered through GF/C (~1.2µm) dried at 103-105 °C then weighed and TSS calculated. Ref APHA 21st Ed 2540-D Samples analysed for Particle Size</td>
<td><strong>Laboratory:</strong> Total and dissolved Kjeldahl digestion for N and P determined by FIA. Ref APHA 21st Ed 4500-Norg D 4500-P H. Species (NH₃ NOₓ PO₄) determined by FIA. Ref APHA 21st Ed 4500-NO₃-I, 4500-P G and 4500-NH₃</td>
</tr>
</tbody>
</table>
Particle sizing was also conducted on additional water samples collected at major sub-catchment and smaller sub-catchment sites using a Melvin Mastersizer 2000 at the School of Earth and Environmental Sciences, James Cook University. Samples were analysed for particle sizing at the five major Burdekin sub-catchments (upper Burdekin: 7 samples, Cape: 4, Suttor: 4, Belyando: 6 and Bowen: 42) over the hydrograph as well as 12 samples collected throughout the period of overflow from the Burdekin Falls Dam. Particle sizing was also performed from selected minor sub-catchment sites (35 sites, including 87 samples); however, only one-two samples were collected for analysis which commonly coincided with peak discharge.

4.3. Load Calculations

The continuous time series flow data (hourly cumecs) from the various gauging stations throughout the Burdekin catchment and point source water quality data, were entered into the NR&W Brolga database, and loads were calculated using linear interpolation. In order to calculate loads across the hydrograph, point concentrations were extrapolated to the very start and end of the hydrograph (see Rohde et al., 2006). Linear interpolation is considered the optimal technique to calculate catchment loads where continuous flow (hourly) and sampling (daily) data are employed (Lewis et al., accepted). We have attempted to assess the uncertainty of the load estimates based on the available gauging (flow) and water quality data for each individual sampling site. These uncertainty values and reasoning for the assessment are provided in Appendix B.

The Brolga program is now being used as a database (Microsoft Access®) for the storage of water quality data collected under this project. Brolga has also been used to plot hydrographs showing sediment and nutrient concentrations, and as such flow is shown in cumecs (cubic metres per second) rather than daily discharge (ML).
5. Results and Discussion

5.1. Introduction

The results from the 2006/07 wet season monitoring are presented in this chapter, including sediment and nutrient concentrations and loads, as well as particle size distribution from selected sites. Sites are grouped into each of the five major sub-catchments of the Burdekin, as well as the East Burdekin, Burdekin Falls Dam and Lower Burdekin/Don River regions. Although this section includes some discussion, the results from this wet season are further discussed in volume 2 where they are compared to monitoring data from the previous wet seasons.

Samples from all ACTFR monitoring sites across the Burdekin Dry Tropics Region were analysed for electrical conductivity (EC), with the majority of sample concentrations <250 µS/cm and typical of tropical Australian savannah catchments (ANZECC and ARMCANZ, 2000). Only three samples had elevated EC concentrations, including Basalt River (500 µS/cm), Elphinstone Creek (550 µS/cm) and Euri Creek (500 µS/cm), however these EC concentrations are still relatively low and not necessarily indicative of salinity problems within these catchments. First flush wet season flows can result in these temporarily high values, as was the case for the Basalt River and Euri Creek and the remainder of samples collected at these sites had EC concentrations <250 µS/cm (ANZECC and ARMCANZ, 2000). The only site that may warrant further investigation is Elphinstone Creek as the high salinity value was collected 9 days after the main flow event (during which all EC values were <260 µS/cm), and may be the result of the loss of salts through sub-surface/groundwater flow. Conductivity results are available in Appendix C.

5.2. Upper Burdekin Sub-catchment

During the 2006/07 wet season 13 sub-catchment monitoring sites were sampled in the upper Burdekin major sub-catchment in the late January/early February flow event, including the upper Burdekin River at the Sellheim Crossing (Figure 14). Limited sampling occurred in the Dry River, Basalt River, Maryvale Creek and Lolworth Creek due to the availability of sampling volunteers during the event flows. Additional samples were also collected from the Fanning River, however samples could only be collected after the flow subsided as the Burdekin River flood water had backed up ~300 metres into the Fanning River, where the sampling site was located.

The maximum total suspended solids (TSS) concentration (1210 mg/L) for the upper Burdekin River (Sellheim) coincided with the rising stage of the event, with a median concentration of 530 mg/L (Figure 15). Total nitrogen (TN) and total phosphorus (TP) concentrations also peaked at this time, dominated by the particulate phase, with particulate nitrogen (PN) and particulate phosphorus (PP) making up 81% and 91% of TN and TP, respectively (Appendix C). A strong correlation between TSS and PN/PP has already been established from the Burdekin monitoring data (Bainbridge et al., 2006a and b; Post et al., 2006). As TSS concentrations dropped after the peak of the hydrograph the proportion of PN also decreased (~50-60% of TN), with the contributions of dissolved organic nitrogen (DON), and to a lesser extent the inorganic nitrogen phases (ammonia and oxidised nitrogen) increasing. Similarly to previous wet season data, PP dominated TP throughout the hydrograph.

The sediment load from the upper Burdekin River (2.8 million tonnes) contributed 88% of the combined load from the four major Burdekin sub-catchments that drain into the Burdekin Falls Dam (Table 3 and Table 4). Load estimates within the upper Burdekin sub-catchment are only available from Running River, however it should be noted that due to limited sample collection, a lower confidence rating has been given to this site (Appendix B). In the 2006/07 wet season Running River contributed 6.4% of the total discharge from the upper Burdekin River, although it only contributed 2% of the total sediment load, with a median TSS concentration of 150 mg/L (Table 3). TSS loads were also calculated for the Star River in the previous wet season, however the 2006/07 flow data are not yet available from NRW (as at August 2007) and as such a load cannot be
calculated. As significant rain fell in the Paluma area (the headwater of the Star) it can be assumed that a considerable proportion of the upper Burdekin River discharge originated from this tributary (Figure 10). Similarly to the previous wet season the Star River median TSS concentrations (107 mg/L) is low compared to other upper Burdekin sub-catchments, and it is likely that this sub-catchment again contributed a disproportionately low sediment load to the upper Burdekin River compared to its flow contribution (Figure 16).

The north and north-western tributaries of the upper Burdekin sub-catchment (Dry River to Maryvale Creek in Figure 16) all had median TSS concentrations >1150 mg/L, except for the Dry River, where only one sample was collected on the fall of a smaller, local event in early January (730 mg/L) (Figure 16). These northern tributaries were targeted this wet season, as they are thought to be significant contributors of sediment to the upper Burdekin River (Sellheim). Maximum TSS concentrations were highest at Grey Creek (5640 mg/L), the Burdekin River at Lucky Downs (near Greenvale; 3745 mg/L), Camel Creek (2745 mg/L), Clarke River (2375 mg/L) and its tributary, Maryvale Creek (2125 mg/L). In comparison, the three western tributaries; Basalt River, Fletcher and Lolworth Creeks had median TSS concentrations (260-515 mg/L) below the upper Burdekin River median TSS (530 mg/L), however limited sampling were conducted at these sites. As mentioned previously, the Star and Running Rivers had the lowest median TSS concentrations of 107 and 150 mg/L, respectively in the tributaries of the upper Burdekin sub-catchment (Figure 16).

Due to the large flow volume discharged from the upper Burdekin River during the 2006/07 wet season (4.1 million ML), it is an important contributor of the total end-of-river nitrogen and phosphorus loads. The upper Burdekin River exported 3,100 and 1,150 tonnes of PN and PP respectively this wet season, which are considerably higher that those exported from other sub-catchments within the region (Table 3). Despite its relatively low event mean concentration (EMC) for DIN (70 µg N/L) and FRP (30 µg P/L), the total load of DIN (280 tonnes) and FRP (110 tonnes) are also considerable for this major sub-catchment (Table 3).

Within the upper Burdekin catchment, nutrient samples were only collected at the larger tributaries. Box plots of the nutrient species are available in Appendix C. The Clarke River had the highest nutrient concentrations, with PN and PP median concentrations of 1370 µg N/L and 1275 µg P/L, respectively. The remaining sites had lower nutrient concentrations, and all had similar median PN (430-685 µg N/L) and PP (105-285 µg P/L) concentrations. For most sites PN dominated TN (>70%), with the remaining dissolved nitrogen fraction dominated by the organic phase (DON) rather than inorganic (NOx and ammonia). Exceptions to this were found in the Running River and Fletcher Creek, where DON consisted of a greater proportion (~45%) of TN than that of the other sites. PP dominated (65-99%) TP for all sites, with DOP and the inorganic phosphorus consisting of minor proportions of TP. The dissolved inorganic and filterable reactive component of phosphorus (FRP) contributed a higher proportion of TP for the Basalt River site. This site drains basalt landscapes where naturally high levels of phosphorus are found.

Particle sizing was conducted at fourteen sub-catchments of the upper Burdekin in the 2007 wet season. Interestingly, some sub-catchments (Basalt River, Clarke River and Fletcher Creek) displayed considerable variability in particle size distribution over the flow hydrograph (Figure 17). This variability indicates erosion from different sources within the catchment areas. While most sub-catchments of the upper Burdekin displayed a uni-modal distribution and were dominated by fine silt (2-15 μm), a much finer fraction (<0.4 μm) was found in some samples from the Clarke River, Basalt River, Gray Creek and Fletcher Creek; these catchments, which drain the north-western area of the Burdekin River, displayed a distinctive bimodal distribution. This catchment area is composed of fine-grained rocks including basalts and sediments (Figure 5) and may provide the source of the fine grained suspended sediments.

The variability in particle size distribution in the sub-catchments of the upper Burdekin is also evident at the major sub-catchment site (Burdekin River at Sellheim). While all samples collected at this site during the 2007 wet season were all dominated by fine silt, some samples contained a much
finer fraction (<0.4 μm). This finer fraction was only detected in 3 of the 7 samples which highlight the different ‘parcels’ of water derived from different terrains in the upper Burdekin (Figure 18). The considerably finer sediment fraction was not measured in the previous 2005/06 wet season in the upper Burdekin sub-catchment (Bainbridge et al., 2006b). This fine fraction may travel large distances in the downstream receiving waters (including the Great Barrier Reef lagoon) and needs to be further studied to determine its composition so the sources of this material can be identified.
Figure 14. The upper Burdekin sub-catchment sample sites.
Figure 15. Hydrograph of the upper Burdekin River (Sellheim Crossing) with TSS concentrations (mg/L).

Figure 16. Box plot of TSS concentrations (mg/L) for the upper Burdekin River sample sites. See Appendix D for description of boxplot features.
Figure 17. Particle size data for the tributaries of the upper Burdekin sub-catchment.

Figure 18. Particle sizing at the Burdekin River at Sellheim major catchment site (upper Burdekin).
Table 3. Sediment and nutrient load calculations for the sub-catchments of the Burdekin Region for the 2006/07 wet season flow event.

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<th>Sub-catchment</th>
<th>Total flow (ML)</th>
<th>Catchment Area km²</th>
<th>TSS (tonnes)</th>
<th>TSS EMC (mg/L)</th>
<th>Ammonia (tonnes)</th>
<th>Nox (tonnes)</th>
<th>DIN (tonnes)</th>
<th>DIN EMC (µg/L)</th>
<th>DON (tonnes)</th>
<th>PN (tonnes)</th>
<th>TN (tonnes)</th>
<th>FRP (tonnes)</th>
<th>FRP EMC (µg/L)</th>
<th>DOP (tonnes)</th>
<th>PP (tonnes)</th>
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<td>Euri Creek @ Koonndah*</td>
<td>256,000</td>
<td>421</td>
<td>15,700</td>
<td>60</td>
<td>1.6</td>
<td>27</td>
<td>29</td>
<td>110</td>
<td>90.0</td>
<td>15</td>
<td>134</td>
<td>15</td>
<td>60</td>
<td>2.6</td>
<td>7.8</td>
<td>25</td>
</tr>
</tbody>
</table>

*Less confidence in load data. **No flow data available but used East Barratta flow data. ***Flow data= (St Anns minus Belyando). total flow calculated using the Brolga program: estimates may vary slightly from NRM gauging data.
Table 4. Summary of major sub-catchment contributions of flow (ML) and sediment load (tonnes) in the 2006/07 wet season.

<table>
<thead>
<tr>
<th>Sub-catchment</th>
<th>Total flow (ML)</th>
<th>Proportion of total flow</th>
<th>Sediment load (tonnes)</th>
<th>Proportion of sediment load</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Above Dam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burdekin River @ Sellheim</td>
<td>4,100,000</td>
<td>75%</td>
<td>2,800,000</td>
<td>88%</td>
</tr>
<tr>
<td>Cape River @ Taemas</td>
<td>740,000</td>
<td>13%</td>
<td>175,000</td>
<td>5%</td>
</tr>
<tr>
<td>Belyando River @ Gregory Dev Rd</td>
<td>194,400</td>
<td>4%</td>
<td>92,300</td>
<td>3%</td>
</tr>
<tr>
<td>Suttor River @ Mt Coolon Rd</td>
<td>360,000</td>
<td>7%</td>
<td>97,500</td>
<td>3%</td>
</tr>
<tr>
<td>Other above dam (e.g. Kirk R. Elphinstone Ck. Sellheim R.) estimate*</td>
<td>105,600</td>
<td>2%</td>
<td>35,200</td>
<td>1%</td>
</tr>
<tr>
<td>Inflow to Dam</td>
<td>5,500,000</td>
<td>100%</td>
<td>3,200,000</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Below Dam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burdekin Falls Dam overflow</td>
<td>5,100,000</td>
<td>60%</td>
<td>1,200,000</td>
<td>20%</td>
</tr>
<tr>
<td>Bowen River @ Myuna</td>
<td>940,000</td>
<td>11%</td>
<td>2,240,000</td>
<td>36%</td>
</tr>
<tr>
<td>Other below dam (East Burdekin, Bogie, Bowen R below Myuna)</td>
<td>2,460,000</td>
<td>29%</td>
<td>2,700,000</td>
<td>44%</td>
</tr>
<tr>
<td>Burdekin River @ Clare</td>
<td>8,500,000</td>
<td>100%</td>
<td>6,140,000</td>
<td>100%</td>
</tr>
</tbody>
</table>

* TSS estimate based on using flow data and median TSS from the Kirk R. and Elphinstone Ck. The red text indicated where estimates have been made to the data or where the result has been calculated using the difference.
5.3. Cape River Sub-catchment

NRW and ACTFR staff sampled the Cape River (Gregory Developmental Road) during the late January flood event, which had two peaks on the 3rd and 5th February, 2007 (Figure 20). Road closures due to flooding prevented sampling efforts to capture the start of this flow event, however the first sample was collected before the first flood peak. Opportunistic sampling was also conducted at Oaky, Policeman and Yarraman Creeks by DPI&F staff, and the Campaspe River by ACTFR staff (Figure 19).

Maximum TSS concentrations for the Cape River occurred at the two flood peaks (345 and 360 mg/L, respectively), with a median of 170 mg/L for the event (Figure 20). The TSS load for the Cape River was 175,000 tonnes (Table 3). This load is only a small fraction (5%) of the total TSS load from the other Burdekin sub-catchments above the Burdekin Falls Dam; the Cape River only contributed a small proportion (13%) of the combined total discharge of these catchments draining into the dam (Table 4).

The Campaspe River had a similar maximum (335 mg/L) and median (130 mg/L) TSS concentration to the Cape River. An opportunistic sample was collected at Yarraman (180 mg/L) and Oaky (197 mg/L) Creeks, however these two samples were collected after the peak of the event (Figure 21). TSS concentrations for Policeman Creek were higher, with a maximum of 500 mg/L.

Total nitrogen concentrations were higher at the Cape River (maximum 945 µg N/L) compared to its Campaspe River tributary (maximum 730 µg N/L), suggesting that the Cape River arm of this catchment contributes higher nitrogen concentrations. TN in the Cape River comprised of PN and DON in equal proportions (~40%), with NO₃ (15%) and ammonia (<1%) in smaller proportions (Appendix C). The Campaspe River had a greater proportion of DON (50%) and NO₃ (35%). TN loads for the Cape River sub-catchment (550 tonnes) were considerable compared to the other sub-catchments, except for the upper Burdekin River.

Maximum TP concentrations were similar for the Cape and Campaspe Rivers (120 and 125 µg P/L, respectively), with samples from both sites dominated by PP (>80%), with the remaining dissolved fraction consisting of DOP and FRP in equal proportions (Appendix C). TP loads for the Cape River (66 tonnes) were consistent with the majority of other sub-catchments.

Only two sites were analysed for particle sizing in the Cape River sub-catchment in the 2006/07 wet season including the Campaspe River (Figure 22) and the major sub-catchment site (Figure 23: Cape River at Gregory Developmental Road). Both sites displayed relatively consistent trends in particle size distribution throughout the flow hydrograph and suspended sediments were largely dominated by the fine silt fraction (2-15 µm). A similar particle size range and distribution were observed in the previous 2006/07 wet season (Bainbridge et al., 2006b).
Figure 19. The Cape sub-catchment sample sites.
Figure 20. Hydrograph of the Cape River with TSS concentrations (mg/L).

Figure 21. Box plot of TSS concentrations (mg/L) for the Cape River sample sites.
Figure 22. Particle sizing data for the tributaries of the Cape River sub-catchment.

Figure 23. Particle sizing at the Cape River at Gregory Developmental Road major catchment site (Cape).
5.4. Belyando Sub-catchment

Although only small flows occurred in the Belyando River catchment during the late January monsoonal influence, samples were collected from all sites including those recently established in the 2005/06 wet season (Figure 24). Opportunistic samples were also collected at the Belyando River (Belyando Crossing) and Carmichael River (majority tributary of the Belyando River) in mid-January during a first flush event, where high TSS concentrations were found at each site (1290 mg/L and 760 mg/L, respectively). TSS concentrations for the Belyando River (Belyando Crossing) were considerably lower throughout the main flow event (median of 325 mg/L), although due to road closures from flooding, samples could not be collected during the peak of the event on the 5th February (Figure 25). The highest TSS concentration (1320 mg/L) measured was collected several days after this main flow event on the 15th February. This increase in concentration may be due to the source of the flow (i.e. another area of the catchment), or dilution of the TSS concentrations in the larger flow event. The total sediment load estimated for the Belyando River for 2006/07 was 92,300 tonnes (Table 3). This load is just under that estimated for the 2005/06 wet season (115,000 tonnes), and reflects the low flow discharged from this catchment (only 4% of the total flow discharged into the Burdekin Falls Dam) (Table 4).

Samples were collected at the upper Belyando River and Native Companion Creek during mid-January with median TSS concentrations of 1360 and 985 mg/L, respectively (Figure 26). Although only small flows occurred in these upper catchments (<2.5 m peak flow height), the higher TSS concentrations are consistent with last wet seasons monitoring data (Bainbridge et al., 2006b). A higher median TSS concentration (710 mg/L) was also measured at upper Mistake Creek in late January, with the concentrations decreasing downstream, where a median TSS concentration of 295 mg/L was measured at the lower Mistake Creek site during early February (Figure 26).

Maximum TN and TP concentrations were 1815 µg N/L and 500 µg P/L, respectively, both coinciding with the high TSS concentration during the first flush event in mid-January. The relative proportions of DON (35-65%) and PN (35-65%) varied throughout the event while the NO₃ contribution was typically low (5-10%). PP dominated (65-95%) the phosphorus speciation, with FRP consisting of ~15%. Maximum TN and TP concentrations (1090 µg N/L and 500 µg P/L, respectively) measured at lower Mistake Creek were similar to those of the Belyando River, and also had a similar breakdown of nitrogen and phosphorus speciation, except for a slightly higher contribution (~15%) of DOP (Appendix C).

While the finer particle size fraction (<0.4 µm) was absent at the sampled sites within the sub-catchments of the Belyando River (Figure 27), this fraction was present at the major sub-catchment site (Figure 28: Belyando River at Gregory Developmental Road). This finding suggests that a pulse of water containing the finer fraction was not sampled at the minor sub-catchment waterways. A finer fraction was measured at Native Companion Creek in the 2005/06 wet season. In addition, the ‘pulse’ of finer material measured in the waning flow of the Belyando River on the 9th February in the 2006/07 wet season was also detected in the waning flow in the 2005/06 season (Bainbridge et al., 2006b). The source of this finer fraction needs to be identified as this sediment may travel large distances in the downstream receiving waters.
Figure 24. The Belyando sub-catchment sample sites.
Figure 25. Hydrograph of the Belyando River with TSS concentrations (mg/L).

Figure 26. Box plot of TSS concentrations (mg/L) for the Belyando sample sites.
Figure 27. Particle sizing data for the tributaries of the Belyando River sub-catchment.

Figure 28. Particle sizing at the Belyando River at Gregory Developmental Road major catchment site (Belyando).
5.5. **Suttor River Sub-catchment**

The Suttor River (Bowen Developmental Rd) was sampled during early February, however due to road closures the beginning of the event could not be sampled (Figure 30). The upper Suttor River site (Figure 29) was also sampled during January (6-9th, 17th, 27th) and early February. An additional site on Logan Creek was also established in the Suttor sub-catchment in December 2006 (Figure 29), and five samples were also collected during early February. One additional TSS sample was also collected during a small flow event in Eaglefield Creek (tributary of the Suttor River) on the 17th January.

TSS concentrations were highest at the upper Suttor River site, with a median and maximum of 535 mg/L and 2,410 mg/L, respectively (Figure 31). These higher TSS concentrations have been consistent for this site over the four years it has been monitored. The sample collected from Eaglefield Creek, which enters the Suttor River downstream of this site also had a high TSS concentration (850 mg/L). Downstream, the Suttor River (Bowen Development Road) had a median TSS concentration of 415 mg/L, with a maximum of 640 mg/L during the rise of the event. Median and maximum TSS concentrations (195 mg/L and 920 mg/L, respectively) were lower again for Logan Creek, which drains the south-western region of this catchment (Figure 31).

The contribution of loads from the Suttor River (Bowen Developmental Road) was 97 500 tonnes of sediment, representing only a minor proportion of the combined load from the Burdekin sub-catchments above the dam (Table 4). This load contribution reflected the minor flow contribution from this sub-catchment (360,000 ML), which was only 7% of the combined flow that discharged into the dam (Table 4).

Nutrient concentrations were also generally highest at the upper Suttor site, with median TN and TP concentrations of 1530 µg N/L (maximum 2,410 µg N/L) and 285 µg P/L (maximum 930 µg P/L), respectively. Whilst TP concentrations at this site were dominated by the particulate form (70-98%), PN dominated TN during the beginning of the flow, with DON and NO₃ proportions equally dominating later in the event. Median TN and TP concentrations (1,075 µg N/L and 210 µg P/L, respectively) were slightly lower at the downstream Suttor River site, with TN consisting of PN (~30%), DON (~50%) and NO₃ (<15%), with NO₃ concentrations increasing towards the end of the event (30% of TN). Similar to the upstream site, PP dominated TP, with FRP consisting of ~15% (Appendix C). The median TN concentration (800 µg N/L) and nitrogen species proportion was similar for Logan Creek, with no strong evidence of elevated inorganic nitrogen resulting from the dry land cropping that consists of 32% of the Logan Creek catchment area (Table 1). However, the TP median (415 µg P/L) was highest at this site, with FRP consisting of up to 25% of TP. These elevated FRP concentrations (maximum 100 µg P/L) may reflect this more intensive land use with the possible addition of phosphate fertilisers.

A finer sediment fraction was identified in two of the three Suttor River sub-catchments (Figure 32: Eaglefield Creek and Logan Creek), although this fraction was not measured at the major end of sub-catchment site (Figure 33: Suttor River @ Bowen Developmental Road). However, only four samples were analysed for particle size in 2006/07 and the fine fraction (<0.4 µm) was evident in Suttor River samples collected in the previous wet season (Bainbridge et al., 2006b). Indeed the suspended sediments measured in the Suttor River in the 2005/06 wet season were considerably finer than in 2006/07. This result suggests that erosion may have occurred in different areas of the Suttor River catchment. For example, the upper Suttor River had reasonable flows in the recent 2006/07 wet season compared to only minor flows in the previous season. The five samples collected from the upper Suttor River in 2006/07 displayed a consistent uni-modal distribution and did not contain a finer sediment fraction.
**Figure 29.** The Suttor sub-catchment sample sites.
Figure 30. Hydrograph of the Suttor River with TSS concentrations (mg/L).

Figure 31. Box plot of TSS concentrations (mg/L) for the Suttor sample sites.
Figure 32. Particle sizing data for the tributaries of the Suttor River sub-catchment.

Figure 33. Particle sizing at the Suttor River at Bowen Developmental Road major catchment site (Suttor).
5.6. **Bowen and Bogie Rivers Sub-catchment**

5.6.1. **Bowen River at Myuna (CSIRO component)**

The Bowen is an important sub-catchment of the Burdekin catchment covering an area approximately 9,500 km². The Bowen catchment has long been considered a ‘hot spot’ area in terms of sediment and nutrient loss in the Great Barrier Reef region (Prosser et al., 2001), and there has been an increased effort in recent years to understand the amounts and sources of sediment and nutrients in this catchment. This section describes the hydrology and sediment loads at the Myuna gauge (NRW gauge 120205) in the Bowen Catchment for the 2006/07 wet season. The Myuna gauge is the second most downstream hydrological gauge in the Burdekin catchment, and receives drainage from ~7,200 km² of the Bowen catchment.

5.6.1.1. **Field Site and Methods**

The automated sampling station is located adjacent to the Queensland NRW’s Myuna Gauge (Latitude 20:35, Longitude 147:35 AMTD). The QNRW gauge has been operating since 1/10/1960 and CSIRO installed the auto-station in 2003.

To calculate discharge, QNRW gauge data was supplied for the 2006/07 wet season at a 10 minute time interval. To determine sediment yield at the Myuna gauge, an automatic gauging station was used. Water depth was measured using a Greenspan ps700 pressure transducer, and this data was related directly back to the QNRW gauge data. Turbidity was recorded at 1 minute intervals when the stream depth was > 30 cm using an Analite NEP180 sensor (which has a range of 0-10,000 NTU) (see Figure 34).

Water samples were collected during events using an ISCO automatic water sampler and samples were returned to the laboratory for analysis of turbidity, total suspended solids (TSS) and particle size distribution. The particle size analysis was undertaken using the Malvern Mastersizer 2000 at the JCU labs. A relationship between suspended sediment and turbidity was derived and used to determine flow weighted suspended sediment concentration (after Gippel, 1995; Grayson et al., 1996). These data, along with the discharge data, were used to calculate the sediment load at the gauge during events. The event based sediment loads were then totalled for each wet season to provide an annual suspended sediment yield at the catchment outlet.

A total of 61 samples were collected over the 2006/07 wet season and 56 samples were suitable for analysis of Total Suspended Sediments (TSS) and Turbidity, however, due to the late negotiation of the contract, nutrients were not analysed.

![Figure 34](image1.png) **Figure 34.** Left, Turbidity, depth transducer and pump cage located within the channel of the Bowen River and Right, the ISCO and sensor box located at the top of the bank adjacent to the QNRW gauging station.
5.6.1.2. Results

The river depth and turbidity recorded at the Myuna gauge for the 2006/07 wet season is shown in Figure 35. Most of the flow occurred between December and April, however, there was an unusual mid-season event in June/July of 2007. At the writing of this report, discharge data for the June/July event was not available from QNRW and therefore this event was not included in the overall 2006/07 wet season analysis. The June/July event was a similar order of magnitude to the late April event (event 6) (Figure 35) which represented <2% of the total load, therefore the exclusion of this event from the wet season analysis is not considered to greatly impact on the final results.

The total discharge for the 2006/07 wet season was 935,000 Ml and comprised of 6 discrete events (Figure 36). The largest event of the season was on the 1st of February 2007 and was the 7th largest daily discharge in the 48 year record at the Myuna gauge (Figure 37). The total sediment load for the 2006/07 wet season was 2,059,000 tonnes which was 3 times higher than the 2004/05 wet season and 17 times higher than the 2005/06 wet season (Table 5). The high loads for the 2006/07 wet season are a direct function of the higher peak discharges and subsequent stream powers experienced in 2006/07.

Figure 38 shows the timing and TSS value of the water quality samples collected by the ISCO system. A total of 56 samples were analysed in the 2006/07 wet season. Nineteen of the samples were collected on the first two events, and the remaining 37 samples were collected during events 3 and 4. No samples were collected during the large event on the 1st of February as sediment blocked the diaphragm of the submersible pump and prevented further sample collection. This was not considered to be a major problem, however, as the turbidity readings were highest in the first two events, and not in the large event on February 1st (Figure 39). There was also a strong relationship between turbidity and TSS for all of the samples collected (Figure 40), across a range of TSS and turbidity values, which ensures that the load predictions for the large event are still likely to be reasonably accurate.

The high TSS and turbidity values shown in early events (e.g. Figure 38) highlight the extreme clockwise hysteresis or ‘first flush’ that occurred during the 2006/07 events (e.g. Figure 42 and Figure 43). Despite the very high sediment concentrations in the first two events, the low discharge meant that the 2 events only represented ~7.1% of the overall load. The majority of the sediment load was carried by events 4 and 5, which represented 88% of the total load, which demonstrates that it is important to have a good understanding of both the water quality and hydrology at a particular site to help determine the total flux from the river system. A breakdown of the sediment load delivered in each of the 6 events is given in Table 6.

It is interesting to note that the TSS values measured over the last 4 wet seasons are not significantly different (p<0.01), however, there is a significant difference between the TSS values collected between 1973-1996 and all other years (Figure 41). This is mainly due to the fact that the 1973-1996 data were collected during low flow conditions, and most of the ISCO samples were collected during event conditions.
Figure 35. Depth and turbidity data as recorded at the CSIRO Myuna autostation between December 2006 and July 2007.

Figure 36. Hydrograph at the Myuna gauge for the 2006/07 wet season showing the 6 discrete events, with the largest event occurring on the 1st of February.
Figure 37. Flow history for the Myuna gauge between 1960-2006.

Figure 38. Hydrograph at the Myuna gauge for the 2006/07 wet season showing the sample collection times and TSS values.
Figure 39. Relationship between discharge and continuous turbidity during the 2006/07 wet season at the Myuna gauge

![Graph showing discharge (cumeecs) and continuous turbidity](image)

\[ y = 4.45x + 142.91 \]

\[ R^2 = 0.95 \]

Figure 40. Relationship between Field Turbidity and TSS for the 2006/07 wet season at the Myuna gauge.

![Graph showing field turbidity and TSS](image)

\[ y = 4.45x + 142.91 \]

\[ R^2 = 0.95 \]
Table 5. Run off and sediment load data for the last 3 wet seasons and nutrient data for 2004/05 and 2005/06.

<table>
<thead>
<tr>
<th>Year</th>
<th>Runoff (Ml)</th>
<th>Sediment load (t)</th>
<th>Nitrogen (kg)</th>
<th>Phosphorus (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-05</td>
<td>204,000</td>
<td>627,000</td>
<td>981,000</td>
<td>318,000</td>
</tr>
<tr>
<td>2005-06</td>
<td>107,000</td>
<td>123,000</td>
<td>208,000</td>
<td>66,000</td>
</tr>
<tr>
<td>2006-07</td>
<td>935,000</td>
<td>2,059,000</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

Table 6. Sediment loads for the 6 events in the 2006/07 wet season

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Sediment load (t)</th>
<th>% total load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28/12/06</td>
<td>66440</td>
<td>3.23</td>
</tr>
<tr>
<td>2</td>
<td>1/1/07</td>
<td>79610</td>
<td>3.87</td>
</tr>
<tr>
<td>3</td>
<td>24/1/07</td>
<td>70600</td>
<td>3.43</td>
</tr>
<tr>
<td>4</td>
<td>27/1/07</td>
<td>287000</td>
<td>13.94</td>
</tr>
<tr>
<td>5</td>
<td>1/2/07</td>
<td>1516350</td>
<td>73.65</td>
</tr>
<tr>
<td>6</td>
<td>15/3/07</td>
<td>32250</td>
<td>1.57</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,052,250</td>
<td>99.68%</td>
</tr>
</tbody>
</table>

Figure 41. Range of TSS values measured at the Myuna gauge over 5 different time periods.
5.6.1.3. Discussion

This section has presented flow and sediment load data for the Myuna gauge for the 2006/07 wet season. The results, and in particular the strong clockwise hysteresis observed during many of the 2006/07 events (Figure 42 and Figure 43), provide some preliminary insights into the potential sources of sediment in the Bowen catchment. Pronounced clockwise hysteresis seems to be related to erosion or early sediment supply just upstream of the measurement location (Asselman, 1999). Therefore, the source of the sediment for the Myuna gauge is likely to be coming from either:

- Remobilised material from the channel bed;
- Sub-catchments not far upstream of the gauge;
- Localised gully systems or channel banks;
- Or a combination of above.
Based on the strong clockwise hysteresis that has been observed in most of the events over the last 3 years, it is unlikely that the major source of sediment is from hillslope erosion. Hillslope erosion dominated environments tend to exhibit anti-clockwise hysteresis. It is likely that some material from hillslope erosion is temporally stored in the gully or channel bed sediments from the previous wet season, and then is remobilised during large events, however, it is unlikely to be a major direct source in most wet seasons. Further research into the sources of sediment in the Bowen catchment is being undertaken using radionuclides by other projects within CSIRO and ACTFR.

It is also important to point out that there were major differences between the turbidity and TSS relationships between the 2005/06 and 2006/07 data sets (Figure 44). The TSS samples for 2005/06 were analysed at the Queensland Health Scientific Service (QHSS) Lab and the 2006/07 samples were analysed at the Australian Centre for Tropical Freshwater Research (ACTFR) Lab. A comparison of TSS sample analysis has been carried out between these two labs. There was between 1-35% difference between ACTFR and QHSS lab TSS samples, with this difference generally decreasing as the TSS concentration increased (e.g. > 500 mg/L). The difference between the results from the two labs was smaller for sites with larger grain sizes (i.e. the upper Burdekin at Sellheim compared to the Belyando or Suttor sites) (Pers. Comm. Zoe Bainbridge, ACTFR).

To estimate the 2006/07 sediment load for the Bowen catchment, the 2006/07 turbidity/TSS relationship was used. If, however, we used the relationship from the previous year, the total sediment load would have been 827,000 tonnes, which is 2.5 times less than the current estimate. This has major implications for estimating sediment loads and assigning water quality targets for catchments draining to the Great Barrier Reef, and it is recommended that further analysis is undertaken to identify the reason for the discrepancies between TSS results.

With the variation in lab results in mind, it is also possible that there were slightly different sediment sources between the two wet seasons. Different geological units are known to have different turbidity properties and therefore some of the differences in the turbidity/TSS relationships between years may be due to different source areas, particularly if the rainfall distribution was different between the two wet seasons.

Figure 44. Relationship between TSS and Turbidity for the 2005/06 and 2006/07 wet seasons at the Myuna gauge
5.6.2. Bowen and Bogie Rivers

Aside from the intensive sample collection at the Myuna gauge station, two additional sites within the Bowen catchment were also established and monitored during this wet season to investigate the source of high sediment consistently measured at Myuna. These sites include the Little Bowen River (Amberkolly) immediately upstream of the Little Bowen-Broken River junction, and the Bowen River (Dartmoor) located ~8km downstream of this major junction (see Figure 45). Both sites were sampled during the late January and early February major event, with an additional sample collected during late March at the Bowen River (Dartmoor) site. Samples were also collected for the first time at the upper Broken River site (established prior to the 2004/05 wet season), which had its first flows in three years. Volunteers in both the Bowen and Bogie River catchments stated that the late January event was the largest they had seen in over a decade (see Figure 48). The upper and lower Bogie River sites (see Figure 46 for locations) were both sampled in late January/early February, with two flood peaks occurring on the 23rd January (~7m peak height, as measured at the lower site) and 3rd February (~8.5m peak height), both of which were larger than the previous years event (~4m). Two additional samples were also collected during a smaller event in June at the upper Bogie River site.

Within the Bowen catchment, median and maximum TSS concentrations were highest for the Little Bowen (2380 mg/L and 11,795 mg/L, respectively) and Bowen River (Myuna; 4310 mg/L and 10,000 mg/L, respectively) sites (Figure 47). Although we had previously suspected that the Little Bowen arm of the Bowen River was likely to be a major contributor to the elevated TSS concentrations consistently monitored at the Bowen River (Myuna) site, this similarity in TSS concentrations between these sites suggests this is likely. The Little Bowen catchment has large areas of gullying/scalding along the main channel, with sodic soils that are easily dispersible. The Broken River which drains the Eungella Range has a rainforest headwater, and although it has steep slopes in areas, it generally has better ground cover. At the start of the late January event, an opportunistic sample was collected by ACTFR staff at the Little Bowen (Amberkolly) site, whilst establishing this site with the volunteer. This sample yielded a TSS concentration of 11,795 mg/L. A sample was also collected immediately downstream (~50 m) of the Little Bowen-Broken River junction, with a TSS concentration of 3,520 mg/L, with the immediate dilution of the cleaner, more organic water from the Broken River apparent. This mixing is evident in Figure 49, taken on the day of collection of these two samples at the junction of these two rivers. Samples collected a few kilometres downstream on the Bowen River (Dartmoor) had a lower median and maximum TSS concentration (1,160 mg/L and 1,995 mg/L, respectively) (Figure 47). The upper Broken River had a median and maximum TSS concentration of 420 mg/L and 470 mg/L, respectively (Figure 47). This headwater catchment is located above the Eungella Dam, with little connectivity between this upstream site and the other lower catchment sites. However, this site was chosen to investigate the influence of the dairy industry on the water quality in this tributary. Elevated NO₃ concentrations (median 340 µg N/L) were found in the three samples collected from this site, with NO₃ consisting of 45% of TN in two of the samples. Ammonia concentrations were also elevated at this site, with a median ammonia concentration of 50 µg N/L. Most grazed catchments within the Burdekin region have median ammonia concentrations <10 µg N/L. Most grazed catchments within the Burdekin region have median ammonia concentrations <10 µg N/L. PN dominated the proportion of TN for the first sample where TN peaked (3,150 µg N/L), also coinciding with the highest TSS concentration. TP was dominated by PP (~75%) for two of the samples, with FRP dominating (80%) the other sample (Appendix C). These greater proportions of the dissolved inorganic fractions of nitrogen and phosphorus indicate there is a water quality signal from a more intensive land use, and warrants further investigation. It should be noted that a joint project between BDTNRM and Mackay Whitsunday NRM to improve the water quality in the Broken River at Eungella has recently been established.

Although only one nutrient sample was collected for the Little Bowen, the nutrients from this site and the nearby Bowen River (Dartmoor) were similar, with the TN concentration for the Little Bowen (2850 µg N/L) slightly higher than that of the Bowen River (Dartmoor) (maximum of 2400 µg N/L and median of 1575 µg N/L), with PN dominating (>80%) all samples, except for the March
sample collected at Dartmoor, where DON consisted of 50% of TN. TP concentrations were also similar for the Little Bowen (1940 µg P/L) and Bowen River (maximum of 1340 µg P/L and median of 920 µg P/L) sites, with TP dominated by PP (>80%) (Appendix C).

Median TSS concentrations were similar for the upper (375 mg/L) and lower (420 mg/L) Bogie River sites, however the maximum TSS concentration was considerably higher at the downstream site, where 1445 mg/L was measured during the rise of the event (Figure 47). Unfortunately there is no active stream flow gauge to estimate sediment load exports from this catchment, however as it is close to the mouth of the Burdekin River with little opportunity for trapping of the suspended sediments, it is likely to be a considerable contributor of sediment to the end-of-river.

Similarly to the other grazed Burdekin sub-catchments, the proportion of nitrogen speciation was variable (PN ~ 50%, DON ~30% and NO₃ ~20%), and TP was dominated (80%) by the particulate fraction. Maximum concentrations of TN (2050 µg N/L) and TP (853 µg P/L) occurred on the two flood peaks, with median TN and TP concentrations of 1210 µg N/L and 500 µg P/L, respectively (Appendix C).

Four of the five minor sub-catchments within the Bowen/Bogie River displayed a uni-modal distribution and all sites were dominated by fine silt material (1.6 to 20 µm: Figure 50). A sample from the Bowen River at Dartmoor site was the only exception which had a considerably coarser fraction (dominant particle size between 4.5 and 90 µm). Some samples from the Little Bowen River contained a finer sediment fraction (0.04 to 0.70 µm); this was the only minor sub-catchment sampled within the Bowen/Bogie to contain a finer particle size (Figure 50). The Little Bowen River sub-catchment drains a series of volcanic and sedimentary rocks which may contribute to this finer fraction (Figure 5). Several samples collected from the major sub-catchment site (Bowen River at Myuna: Figure 51) displayed a bi-modal particle size distribution and contained a finer sediment fraction (< 0.4 µm). Considerable variability in particle size distribution was recorded at this major sub-catchment site which indicates that the suspended sediments were sourced from a number of different drainage networks. The Bowen River sub-catchment drains a host of rhyolite, basalt, granite and sedimentary landscapes which would explain this variability in particle sizes. In comparison, the Bogie River sub-catchment drains an area of coarser-grained igneous rocks (e.g. granites) and contains only a relatively small area of basalt. The composition of these coarser rocks probably accounts for the consistent uni-modal distribution patterns observed at this site as well as the absence of a finer particle size fraction (range from 0.4 to 90 µm) (Figure 5).

One opportunistic sample was also collected for the general suite of pesticides at the Bowen River (Bowen Developmental Road) at the beginning of the January flow event. Similar to previous preliminary samples collected in the 2005/06 wet season in the Suttor, Belyando and Cape sub-catchments, tebuthiuron was detected (0.04 µg/L). As the State Government GBRI5 Loads Program is taking over the sampling of the major sub-catchment sites next wet season it is recommended that further pesticide samples are collected from the major sub-catchments of the Burdekin.

The upper Broken River, which has forest, dairy and “hobby farms” as land uses has been targeted for improved catchment management through a Sustainable Landscapes Project “Platypus Futures”. “Platypus Futures” is jointly managed by the Mackay Whitsunday NRM and Burdekin Dry Tropics NRM Groups, with support from the QEPA. Pesticide sampling during a late flow event in May detected low concentrations of ametryn and atrazine in this small sub-catchment. MWNRM and QEPA staff from this project are currently working with the catchment landholders and conducting additional monitoring to further investigate the presence of herbicide residues in this upper catchment.
Figure 45. The Bowen sub-catchment sample sites.
Figure 46. The Bogie sub-catchment sample sites.
**Figure 47.** Box plot of TSS concentrations (mg/L) for the Bowen-Bogie sample sites.

**Figure 48.** The Bowen River at the Collinsville Weir on the 24th January 2007.
Figure 49. The Little Bowen River-Broken River junction (Urannah Road) during flood on the 24th January 2007. The muddy light brown water in front from the Little Bowen (coming in from the bottom right) is clearly distinguishable from the organic darker water of the Broken River (coming in from the top right), which is backing up the Little Bowen water at this stage of the flow event.

Figure 50. Particle sizing data for the tributaries of the Bowen/Bogie sub-catchment.
Figure 51. Particle sizing at the Bowen River at Myuna major catchment site (Bowen).
5.7. **East Burdekin Sub-catchments**

The East Burdekin sub-catchment includes the tributaries that drain directly into the Burdekin River above and below the Burdekin Falls Dam (Figure 52). These tributaries have been identified by SedNet modelling as major erosional features, and for those below the Burdekin Falls Dam, important contributors to TSS loads to the Burdekin River at Inkerman (Fentie et al., 2006). Eight sampling sites were established in the 2005/06 wet season to investigate the sediment contribution from these tributaries, with seven sampled during this wet season (Figure 52). Samples were collected from Elphinstone Creek and Kirk River during late January/early February. Two flow peaks were captured for Elphinstone Creek (1st and 2nd February), however significant flows in the Kirk River, including “walls of water” (Pers. Comm. C. Bettridge, volunteer) prevented the collection of samples during peak flow conditions. Samples were collected at Landers Creek (upstream and downstream sites) and Expedition Pass Creek (and cane influenced tributary Eight Mile Creek) during late January/early February. Two opportunistic samples were also collected from the upper (Gregory Developmental Road) and lower (Cardigan Road) Broughton River by DPI&F staff on the 2nd February. No samples were collected at Stones Creek due to the unavailability of the volunteer.

Consistent with last wet season, the highest TSS concentration was measured at Elphinstone Creek, with a peak on the first rise of 2,430 mg/L (Figure 53). As previously mentioned this creek is more disturbed than other grazing sub-catchments as it drains active/inactive mining areas, and generally has highly disturbed soils. The median concentration was also highest for this site (650 mg/L), with median TSS concentrations for all other sites around 100 mg/L (Figure 53). As Kirk River could not be sampled during the rise/peak conditions it is assumed that TSS concentrations during these stages of the hydrograph would have been higher than those measured during the fall conditions. Both Eight Mile (drains Dalbeg sugar area and enters Expedition Pass Creek upstream of the sampling site) and Expedition Pass Creeks had peak TSS concentrations (115 and 485 mg/L, respectively) during the first flush event (28th January) and median concentrations of 60 and 115 mg/L, respectively (Figure 53). Fewer samples were collected from Landers Creek, with one sample collected at the downstream (highway) site on the 1st February (110 mg/L), and a further two samples collected on the 3rd February, one from each site (upstream; 105 mg/L and downstream; 35 mg/L). These low TSS concentrations are similar to those measured in the previous wet season (see Bainbridge et al., 2006b), however a much larger flow occurred this year, with the D/S sample collected on the 3rd February during high flow conditions. As these sub-catchments entering the Burdekin River below the Burdekin Falls Dam are believed to be considerable sources of suspended sediment, further sampling of these sites is recommended. Higher concentrations were measured at the Broughton River (upstream; 400 mg/L and downstream; 675 mg/L) through opportunistic sampling on the 2nd February, however these concentrations are lower than those measured from this river during past wet seasons (Bainbridge et al., 2006a and b) (but may relate to the stage of flow measured during such opportunistic sampling).

Elphinstone Creek also had the highest TN (max. 1,800 µg N/L) and TP (max. 1,070 µg P/L) concentrations, with TP dominated by PP (~90%) which is typical of other grazed sub-catchments. TN was made up of relatively equal proportions of PN and DON (each ~40%), with NO₃ to a lesser extent (~20%) (Appendix C). High TN concentrations were also measured at Eight Mile (1,320 µg N/L) and Expedition Pass (1520 µg N/L) Creeks during the first flush event, with median TN concentrations of 545 µg N/L and 780 µg N/L, respectively. The downstream Landers Creek site had a similar median TN concentration of 525 µg N/L, with all four Expedition Pass and Landers Creek sites consisting of similar proportions of nitrogen speciation as Elphinstone Creek. Median TP concentrations for these four sites were between 125-285 µg P/L, with the proportion of PP (35-65%) less than that typical found across the Burdekin sub-catchments. This was most pronounced in the downstream Landers Creek site, where DOP and FRP proportions to TP were ~60% and ~45%, respectively (Appendix C). Further sample collection needs to be undertaken from this catchment before any further conclusions can be drawn.
Four of the East Burdekin sub-catchment sites were analysed for particle size. These sites included Kirk River and Elphinstone, Expedition Pass and Landers Creeks. Three of these sites contained a finer sediment fraction (<0.4 µm) (Figure 54). In addition, the Kirk River and Expedition Pass Creek displayed considerable variability in particle size distribution over the flow hydrograph (Figure 54). These catchments contain a mixture of acid volcanic and granitic rocks (Figure 5). The two catchments situated below the Burdekin Falls Dam (Landers and Expedition Pass Creeks) both contained a finer sediment fraction, although the dominant particle size fraction was between 2 and 30 µm (fine silt).
Figure 52. The East Burdekin sub-catchment sample sites.
Figure 53. Box plot of TSS concentrations (mg/L) for the East Burdekin sample sites.

Figure 54. Particle sizing data for the tributaries of the East Burdekin sub-catchment.
5.8. Burdekin Falls Dam

The overflow from the Burdekin Falls Dam (Figure 55) was sampled daily for TSS from the afternoon of the 02/02/07 (coinciding with the time when water overtopped the spillway) to the 28/03/07 (Figure 56). The sample collected on the first afternoon of overflow was 5 mg/L, and is likely to be dam water being pushed over first. By the following morning the TSS concentration had increased to 220 mg/L, and is likely to be the start of the flood water coming through. TSS concentrations peaked at 405 mg/L on the 4th February coinciding with the peak of the overflow (~4.5m over spillway) (Figure 56). The sediment load calculated from this sample collection indicate that 1,200,000 tonnes of sediment passed through the Burdekin Falls Dam (BFD) during this period, only ~38% of the total sediment load estimated to have entered the dam from the upper Burdekin, Cape, Belyando and Suttor Rivers (Table 4). Therefore, 62% of sediment exported during 2006/07 from these major sub-catchments above the BFD was trapped by the dam, which is lower than the SedNet predictions (Prosser et al., 2001: 90% trapping; Fentie et al., 2006: 77% trapping).

Two distinctive particle size distribution patterns were evident in the suspended sediment samples collected from the Burdekin Falls Dam overflow: a uni-modal distribution and a bi-modal distribution. The uni-modal distribution was measured on the 5th February and then from 10th February to the 3rd March; however, the particle size range within this distribution was variable (Figure 57). The dominant particle size within the uni-modal samples ranged from 2-12 μm to 3-45 μm. Particle size variability was also encountered in the bi-modal distribution patterns, although the minimum particle size measured in all these samples was 0.05 μm. The variation in particle sizes in the Burdekin Falls Dam samples highlights the different parcels of water from different catchment areas passing through the dam. This variability was also observed in the 2005/06 wet season (Bainbridge et al., 2006b). The variability observed in the major sub-catchments above the dam suggests that the determination of specific sediment sources within the catchment will be difficult. However, tracing sediment to a particular soil type should be feasible. The particle size range in the suspended sediments in the Burdekin Falls Dam overflow was similar to the catchments above the dam. In most cases, the peak particle size (between 4.5 and 11 μm) in the Burdekin Falls Dam overflow samples was higher than several of the major sub-catchments (~4 μm) above the dam. This result suggests that the suspended sediments measured in the major catchments all have potential to pass through the dam. A study of the flocculation potential of sediment particles would therefore be valuable to understand the dam trapping capacity.
Figure 55. The Burdekin Falls Dam and end-of-river sample sites.
Figure 56. Hydrograph of the Burdekin Falls Dam overflow with TSS concentrations (mg/L).

Figure 57. Particle sizing at the Burdekin Falls Dam overflow.
5.9. **Lower Burdekin, Haughton and Don River Sub-catchments and Freshwater Plume**

5.9.1. **Lower Burdekin, Haughton and Don River Sub-catchments**

Twelve sampling sites were established prior to the 2005/06 wet season in the Haughton River (Reid River, upper and lower Haughton River), lower Burdekin Region (Barratta Creek system-upper, east and west, Iyah Creek, Plantation Creek, Sheep Station Creek, Yellow Gin Creek) and Euri Creek and Don River catchments near Bowen (Figure 58 and Figure 59). These small sub-catchments (typically <1100 km²) drain the coastal floodplain between Giru and Bowen, and are characterised by a mixture of land uses including sugarcane cultivation, horticulture, grazing and small urban townships (Table 1). All sites were sampled during the January/February rainfall event except for the Iyah Creek catchment which did not receive much rainfall. Intense rainfall and resultant flooding occurred in the upper Haughton River (near Mingela; see Figure 64), resulting in the closure of the Bruce Highway in the lower Haughton for two days (2-3rd Feb). During the 2006/07 wet season 530,000 ML was discharged by this catchment, double that of last years flow (Table 3; Bainbridge et al., 2006b). The road closure restricted access to the other lower Burdekin sampling sites for the two-day period. Due to the size of the flood events, flood plume sampling was also conducted on the 3rd February within the estuaries of the Haughton River and Barratta Creek system, coinciding with the flood peak in the lower Haughton River (Figure 60).

A set of ambient (low flow) samples were also collected in the lower Burdekin and lower Haughton River sites in November 2006 before any major rainfall events occurred. These ambient samples were used as baseline concentrations for Brolga load calculations, but have not been included in the box plot analysis. Pesticide samples were also collected at most sites, as part of a BDTNRM CCI project investigating the presence of pesticides in waterways of the lower Burdekin. The pesticide results from this investigation are provided in Lewis et al. (2007).

TSS results were consistent with the previous years monitoring data for all sites, with the highest median TSS concentrations measured in the larger, predominately grazed catchments including the upper Haughton River (520 mg/L) and Don River (270 mg/L), as well as the smaller (and also grazed) Yellow Gin Creek (280 mg/L) (Figure 62). The lower Burdekin and lower Haughton River sampling sites all had comparatively lower median TSS concentrations (20-55 mg/L), with the Reid River (130 mg/L) and Euri Creek (80 mg/L; Figure 61) also having relatively low median concentrations (Figure 62). TSS concentrations for ambient samples collected in early November were extremely low for all lower Burdekin and lower Haughton River sites (<20 mg/L).

Maximum TSS concentrations were also measured at the upper Haughton (1,460 mg/L) and Don (1,165 mg/L) Rivers during peak flow conditions, however higher concentrations may have occurred in the Don River during a proceeding larger flow event which was not able to be sampled by the volunteer. As a result loads were not calculated for this site. The TSS load for the lower Haughton River (79,000 tonnes) is double that of last year, with 50% of the flow being contributed by the upper part of the catchment (upper Haughton and Reid Rivers) (Table 3). The total load exported from the Barratta Creek system (East and West Barratta Creek sites combined) was 18,400 tonnes, which is very similar to the load in 2005/06 (Table 3). A similar TSS load was produced by Euri Creek (15,700 tonnes), which had a similar discharge and event mean concentration (EMC) as Barratta Creek (Table 3).

Maximum TN and TP concentrations occurred on the rising limb of the hydrograph for all sites, with the highest TN concentrations recorded at the upper Haughton (2,160 µg N/L), upper Barratta (1,660 µg N/L), West Barratta (1,730 µg N/L) and the Don River (2,710 µg N/L) (Appendix C). Particulate nitrogen dominated TN (75-90%) on the rising limb for the two larger grazing catchments, whereas TN consisted of equal proportions of TN, DON and NO₃ for the two Barratta Creek sugarcane influenced sites. Similarly to previous years, peak nutrient concentrations occurred during the smaller first flush at the Barratta Creek sites (Fig 64-66, Bainbridge et al., 2006b).
The median PN concentration (1,150 µg N/L) for the Don River was considerably higher than the median PN concentrations for the other coastal sites (95-450 µg N/L), where PN consisted of only 15-35% of TN (Appendix C). Median DON concentrations were generally higher for all sites (230-560 µg N/L), with DON dominating (45-60%) TN throughout the hydrograph. These median DON concentrations were consistent with the other Burdekin sub-catchment sites. The only exceptions were the Don and upper Haughton Rivers, where DON consisted of only ~20% of TN. Median NO\textsubscript{x} concentrations were similar for most sites (100-150 µg N/L), with NO\textsubscript{x} consisting of 15-25% of TN, except for Yellow Gin Creek (median 21.5 µg N/L) where NO\textsubscript{x} consisted of only 5% of TN. East Barratta, West Barratta and the upper Haughton River all had higher median NO\textsubscript{x} concentrations (195, 250 and 350 µg N/L, respectively). Consistent with last years monitoring data the maximum NO\textsubscript{x} concentrations were recorded at the three Barratta Creek sites during the peak of the first flush (655 µg N/L at upper Barratta; 765 µg N/L at East Barratta; 810 µg N/L at West Barratta) (Appendix C; Fig 73.; Bainbridge et al., 2006b); these maximum NO\textsubscript{x} concentrations were elevated above those found in the other Burdekin sub-catchment sites, and can be attributed to the loss of fertilisers from the more intensive land use (sugarcane and horticulture) within this system. Ammonia concentrations were also slightly elevated for the catchments influenced by more intensive land uses, with median concentrations between 15-35 µg N/L for upper, East and West Barratta, Sheep Station and Plantation Creeks, with maximum concentrations at the East and West Barratta Creek sites of 65 and 70 µg N/L, respectively (Appendix C). In the grazed sub-catchments of the Burdekin, and the other lower Burdekin less intensive land use sites median ammonia concentrations are generally <10 µg N/L (Appendix C).

The highest median (and maximum) TP concentrations were recorded at the three grazed catchments; 270 µg P/L (1,010 µg P/L) in the upper Haughton River, 475 µg P/L (750 µg P/L) in the Don River and 200 µg P/L (450 µg P/L) at Yellow Gin Creek, with the particulate fraction dominating TP (60-75%) throughout the flow event for each of these three sites (Appendix C). Particulate phosphorus consisted of only 35-50% of TP for the remainder of the sites, with lower median PP concentrations (40-115 µg P/L). Consistent with last years monitoring data, these concentrations are reasonably low, reflecting the low TSS concentrations of these sites (as PP is often transported attached to suspended sediment). Median DOP concentrations were low for all sites (5-35 µg P/L), with DOP consisting of <15% of TP. Median FRP concentrations ranged between 35-110 µg P/L for all sites except the two irrigation channel sites: Sheep Station (200 µg P/L) and Plantation (140 µg P/L) Creeks (Appendix C). These FRP concentrations are elevated compared to typical median FRP concentrations in the other Burdekin sub-catchments (generally <20 µg P/L), and may reflect fertiliser usage.

Nutrient results from the ambient sampling conducted in November 2006 found high concentrations of TN at Upper, East and West Barratta Creeks; 1,090, 690 and 2,550 µg N/L, respectively. This concentration measured at West Barratta Creek is higher than TN concentrations measured during the January event, and is dominated by NO\textsubscript{x} (60%). The remaining samples (with TN concentrations between 250-420 µg N/L), were collected at the lower Haughton River, Sheep Station, Plantation and Iyah Creeks. Nitrogen speciation was dominated by DON (~65%) for these samples. TP concentrations were lower, and ranged between 25-100 µg P/L, and were generally dominated by PP (75%).

The dissolved inorganic nitrogen (DIN= NO\textsubscript{x} + ammonia) loads for the coastal sub-catchment sites were lower than the considerably larger inland Burdekin sub-catchments, with the highest loads from the Barratta Creek system (77 tonnes) and the lower Haughton River (67 tonnes) (Table 3). However, the DIN event mean concentrations (EMC) for these coastal sites were considerably higher than most of the other Burdekin sub-catchments, where the higher DIN loads relate to the larger volumes of flow discharged from these large catchments. Similarly to last wet season, FRP loads were highest for the Barratta Creek system (19.8 tonnes) and Haughton River (30 tonnes), with the exception of the upper Burdekin River (Table 3). Given the relatively small size of the Barratta Creek (912 km\textsuperscript{2}) and Euri Creek (421 km\textsuperscript{2}) catchments, these two coastal catchments contribute elevated FRP loads compared to the inland Burdekin sub-catchments.
The coastal sub-catchments of the Burdekin Region also contained variable particle size distributions (Figure 63). The Don River and lower Haughton River sites displayed a bi-modal distribution and contained a finer sediment fraction. The other sites displayed a uni-modal trend and did not contain a finer fraction (Figure 63). In the previous 2005/06 wet season particle sizing at the lower Haughton and Don Rivers sites both displayed a uni-modal trend with a relatively wide particle size range (0.36-632 μm; peak 5 μm: Bainbridge et al., 2006b) compared to a considerably reduced range of 0.45-50 μm and a peak of 2.5 μm in the 2006/07 wet season. Only limited particle sizing has been conducted in these sub-catchments and this variability is similar to that observed in the other Burdekin sub-catchments.
Figure 58. Lower Burdekin and Haughton River sub-catchment sample sites.
Figure 59. Don River sub-catchment sample sites.
Figure 60. Hydrograph of the Haughton River with TSS concentrations (mg/L).

Figure 61. Hydrograph of Euri Creek with TSS concentrations (mg/L).
Figure 62. Box plot of TSS concentrations (mg/L) for the lower Burdekin, Haughton and Don River sample sites.

Figure 63. Particle sizing data for the tributaries of the lower Burdekin, Haughton and Don River sub-catchments.
Figure 64. Debris remaining on the Cardington Rd bridge on the 2nd February after significant flows occurred overnight in the upper Haughton River. The flooded resulted from intense rainfall in the upper Haughton and Reid River catchments.

5.9.2. Lower Burdekin and Haughton River Freshwater Plume

The freshwater plume from the Haughton River and Barratta Creek was sampled on the 3rd February 2007 from the mouth of these waterways to Cape Cleveland (Figure 65). Fourteen samples were collected throughout the plume for TSS, nutrients and pesticide analyses. The results for the pesticide analysis will be reported in the “pesticides in the lower Burdekin and Don River catchments” report (Lewis et al., 2007). Similarly to the freshwater plume from the Burdekin River, TSS concentrations rapidly decreased from 200 mg/L at the mouth of the Haughton River to ~20 mg/L by the 15 PSU salinity zone (Figure 66). TSS concentrations increased above 30 mg/L in some samples within the 30-35 PSU salinity zone, although these elevated TSS samples were collected near the mouth of Barratta Creek in shallow waters (<1.5 m) and may have been influenced by the creek waters or from sediment resuspension. Within a few kilometres from the mouths of the Haughton River and Barratta Creek, TSS concentrations were generally below 20 mg/L. PN (Figure 66) and PP (Figure 67) displayed similar trends over the salinity gradient to TSS concentrations. Both PN and PP generally decreased from 26 μM and 8.7 μM to <5 μM and <1 μM, respectively, by the 15 PSU salinity zone. The samples collected in the higher salinities near the mouth of Barratta Creek were exceptions where PN and PP concentrations were elevated and coincided with elevated TSS concentrations. Ammonia (Figure 68) and NOx (Figure 69) concentrations in the freshwater plumes from the Haughton River and Barratta Creek displayed conservative mixing behaviour throughout the salinity gradient and were not affected by the increased TSS concentrations in the samples collected in close proximity to the mouth of Barratta Creek (Figure 65). This result suggests that the sampled area near Barratta Creek may have been influenced by sediment resuspension rather than from freshwater discharged from the creek. The concentrations of ammonia and NOx decreased from 3.36 μM and 6.03 μM near the mouth of the Haughton River to 0.61 and 0.90 μM, respectively, at the outer reaches of the plume. Interestingly, these concentrations were lower than the Burdekin River plume. FRP concentrations also displayed a general decrease over the salinity gradient in the Haughton River and Barratta Creek freshwater plumes from 1.33 to 0.37 μM (Figure 70). DON (Figure 71) and DOP (Figure 72) concentrations were variable throughout the salinity gradient and displayed no discernable trend.
Figure 65. The freshwater plumes from the Haughton River and Barratta Creek were sampled on the 3rd of February 2007. The plume edge was mapped using a combination of GPS readings and visual estimations.

Figure 66. TSS and PN concentrations taken over the salinity gradient from the freshwater plumes in Bowling Green Bay from the Haughton River and Barratta Creek. Both TSS and PN decrease considerably throughout the salinity gradient with the exception of a few samples in the 30-35 PSU salinity zone. These samples were collected near the mouth of Barratta Creek.
Figure 67. TSS and PP concentrations taken over the salinity gradient from the freshwater plumes in Bowling Green Bay from the Haughton River and Barratta Creek. Similarly to TSS and PN, PP concentrations decrease considerably throughout the salinity gradient with the exception of a few samples in the 30-35 PSU salinity zone. These samples were collected near the mouth of Barratta Creek.

Figure 68. TSS and ammonia concentrations taken over the salinity gradient from the freshwater plumes in Bowling Green Bay from the Haughton River and Barratta Creek. Ammonia concentrations display a linear decrease over the salinity gradient which is indicative of conservative mixing.
Figure 69. TSS and NO\textsubscript{x} concentrations taken over the salinity gradient from the freshwater plumes in Bowling Green Bay from the Haughton River and Barratta Creek. Similarly to ammonia concentrations, NO\textsubscript{x} displays a linear decrease over the salinity gradient which is indicative of conservative mixing.

Figure 70. TSS and FRP concentrations taken over the salinity gradient from the freshwater plumes in Bowling Green Bay from the Haughton River and Barratta Creek. Similarly to dissolved inorganic nitrogen species, FRP concentrations display a general linear decrease over the salinity gradient.
Figure 71. TSS and DON concentrations taken over the salinity gradient from the freshwater plumes in Bowling Green Bay from the Haughton River and Barratta Creek. DON concentrations were variable throughout the salinity gradient and displayed no apparent trend.

Figure 72. TSS and DOP concentrations taken over the salinity gradient from the freshwater plumes in Bowling Green Bay from the Haughton River and Barratta Creek. Similarly to DON, DOP concentrations were variable throughout the salinity gradient and displayed no apparent trend.
5.10. **Burdekin River Mouth and Flood Plume**

5.10.1. **Burdekin River Mouth (Inkerman)**

The Burdekin River at Inkerman peaked on the 2\textsuperscript{nd} February, coinciding with the peak of the major event in the Bowen catchment, as well as the BFD overflowing. The Department of Natural Resources and Water sampled the flood event throughout the hydrograph from the 23/01-13/02/07 (Figure 73). Given the high TSS concentrations measured during the first major peak (2,500-3,000 mg/L), this water is likely to be sourced from the Bowen River (median: 4,310 mg/L and maximum: 10,000 mg/L) and other minor, ungauged tributaries within close proximity of the Burdekin River mouth (e.g. Bogie River, Landers Creek etc) (Figure 74). The following, smaller flow peaks on the 5\textsuperscript{th} and 7\textsuperscript{th} are more likely to be a result of dam overflow water (median: 65 mg/L and maximum: 405 mg/L) reaching Inkerman, where TSS concentrations had fallen to <500 mg/L (see Figure 56).

Two minor peak events occurred at Inkerman on the 25\textsuperscript{th} and 29\textsuperscript{th} January before the major flood event, which also coincide with two minor flow events that occurred in the Bowen River on the 24\textsuperscript{th} and 28\textsuperscript{th} January, respectively (Figure 36).

The total discharge from the Burdekin River during the 2006/07 wet season was 8.5 million ML, equivalent to the mean annual average discharge, and is the largest event to occur during the monitoring program timeframe. The median (470 mg/L) and maximum (3,060 mg/L) TSS concentrations for the Burdekin River (Inkerman) are considerably higher than that measured during the previous wet season, with a total sediment load of 6.14 million tonnes exported during this wet season (Table 3). This total sediment load is 12 times that estimated for the previous wet season, and this variability between years relating to flow volume, catchment condition and rainfall distribution and intensity highlights the difficulties in setting end of river targets for management purposes that can be applied to any given wet season.

Using sediment and flow data available, a best estimate of sediment contributions from the major sub-catchments above and below the BFD has been developed for the 2006/07 wet season (see Table 4). It is estimated that of the total sediment load exported from the Burdekin River at Inkerman (6.14 million tonnes), 1.2 million tonnes (20%) was contributed from the BFD overflow, with the upper Burdekin sub-catchment being the major source (~88%) of this sediment inflow into the BFD. Using the high frequency TSS/turbidity data collected at the Bowen River (Myuna), a load of 2.24 million tonnes (35%) is estimated to have been contributed from this catchment (at Myuna), with the remainder; 2.7 million tonnes (45%) attributed to ‘other’ that includes contributions from the Bowen River catchment below Myuna (ungauged), the Bogie River and other smaller tributaries draining directly into the Burdekin River below the dam. Given the relatively small size of this ‘other’ catchment area (8,225 km\textsuperscript{2}), it is unlikely that such a high proportion of the total sediment load was contributed from this area, and this estimation is still course. A possible explanation may be that the sediment load from the BFD overflow is currently being underestimated as the overflow sampling for TSS concentrations can only be conducted at the edge of the flow, where TSS concentrations are likely to be lower than that of the middle for a river this wide. Another possible explanation is that sediment sampling at the major sub-catchments, and/or gauging station flow estimates may be inaccurate.

During this wet season it is estimated that 8,600 tonnes of nitrogen and 3,000 tonnes of phosphorus were also exported from the Burdekin River at Inkerman (Table 3). The particulate fraction dominated TN (66%) and TP (93%) with 5,650 tonnes (PN) and 2,800 tonnes (PP), respectively. TN load contributions from the upper Burdekin (4,340 tonnes), Cape (550 tonnes) and Suttor (340 tonnes) major sub-catchments were all substantial, with the dissolved fractions (DIN, DON) likely to be transported over the BFD. This is particularly so for the dissolved organic fraction (DON), where the DON load contributions from the upper Burdekin, Cape and Suttor sub-catchments is substantial, and if only limited trapping occurs during transport to the end-of-river, could make up to ~80% of this end-of-river DON load (1650 tonnes) (Table 3). The upper Burdekin River also had a considerable TP load contribution, of 1270 tonnes. Unfortunately nutrient budgeting for the
Burdekin River major sub-catchments and end-of-river cannot be estimated as nutrient samples were not collected at the BFD overflow or the Bowen River major sub-catchment site.

Similarly to the majority of major sub-catchments, the Burdekin River at the Inkerman end-of-catchment site displayed some variability in particle size over the flow hydrograph (Figure 75). A coarser sediment fraction occurred (dominant particle size between 3 and 45 μm; peak at ~11 μm) in this catchment which coincided shortly after peak discharge was achieved. Two days after this sample was collected, the dominant particle size reduced considerably to 1.3-10.0 μm with a peak of 3-4 μm. In addition, the subsequent samples taken following peak discharge also contained a finer particle size fraction (<0.4 μm). The average particle size distribution is consistent with the ‘bulk average’ particle size of several sub-catchments of the Burdekin River (Figure 76). In particular, the particle size distribution pattern of the finer fraction for the Burdekin River at Inkerman closely matches the averages for the upper Burdekin and the Bowen sub-catchments; these sub-catchments contribute a sizable proportion of the sediment load.

![Figure 73. Hydrograph of the Burdekin River (Inkerman) with TSS concentrations (mg/L).](image)

![Figure 74. Box plot of TSS concentrations (mg/L) for the major Burdekin sub-catchments and end-of-river (Inkerman).](image)
Figure 75. Particle sizing at the Burdekin River at Inkerman end-of-catchment catchment site.

Figure 76. Particle sizing summary at major sub-catchments of the Burdekin River and the Burdekin River at Inkerman end-of-catchment catchment site.
5.10.2. Burdekin River Freshwater Plume

The freshwater plume from the Burdekin River was sampled throughout the salinity gradient on the 6-7th February 2007. Twenty-four samples were collected in the Burdekin plume for sediment, nutrient and chlorophyll a analyses, while additional samples were collected for pesticide and trace metal analyses (Figure 77). The Great Barrier Reef Marine Park Authority mapped the extent of the Burdekin River freshwater plume from a light aircraft on the 8th February and discovered that the plume extended about as far north as Hinchinbrook Island (D. Haynes, pers comm. 2007). Satellite images from the 9th, 11th, 13th and 25th of February trace the plume movements over several days (Figure 78 to Figure 82). On the 9th of February, the Burdekin plume tracked in a northerly direction and extended as far north as Hinchinbrook/Palm Island (Figure 78), while on the 11th of February (Figure 79) the plume turned a ‘dark green colour’ and began to take a more southerly course (see the turbid zone off mouth of the river). The dark green colour is thought to represent increased biological activity within the freshwater plume. On the 13th February two separate images show the plume to take a southerly and offshore course and impact as far east as Old Reef (Figure 80 and Figure 81). On the 25th February, on the waning flow of the Burdekin River, the plume is more constricted to the coastline and moves in a northerly direction (Figure 82).

TSS concentrations in the Burdekin freshwater plume fell rapidly from 348 mg/L to <20 mg/L by the 10 PSU salinity zone (Figure 83). This behaviour is similar to that observed in the Burdekin River plume in previous years (Devlin et al., 2001; Brodie et al., 2004). The barium (Ba) concentrations decrease linearly over the salinity gradient which indicates conservative mixing (Figure 83). This behaviour is consistent to that measured in the 2002 Burdekin River plume (M. McCulloch, pers comm.). However, the behaviour of Ba would have been interesting once biological activity had increased in the plume (see Figure 79). Chlorophyll a concentrations were typically quite low in the Burdekin plume (range from <0.2 µg/L to 1.96 µg/L: Figure 84) and these concentrations would probably have increased once conditions cleared and full sunlight became available as shown in the satellite images (Figure 78 to Figure 81). The chlorophyll a concentrations displayed a slight increase after the 23 PSU salinity zone, which indicates lowered turbidity in the plume and improved conditions for increased biological activity (Figure 84).

Similarly to TSS concentrations, PN (Figure 85) and PP (Figure 86) fall rapidly by the 10 PSU salinity zone; PN fell from 13.4 µM to 3.4 µM by the 6 PSU zone while PP fell from 7.4 µM to < 0.5 µM by the 10 PSU zone. This behaviour is consistent with the measurements taken from previous monitored Burdekin flood plumes (Devlin et al., 2001; Brodie et al., 2004). Following this transition, PN and PP concentrations remain consistently low throughout the plume.

Ammonia (Figure 87) and oxidised nitrogen (NOx= nitrate + nitrite: Figure 88) concentrations decreased linearly throughout the salinity gradient of the Burdekin River plume. NOx concentrations, in particular displayed strong conservative mixing in the flood plume from a concentration of 14.8 µM near the Burdekin River mouth to < 4 µM at the outer reaches of the plume (Figure 88). Once conditions cleared and full sunlight became available, increased biological activity would have resulted in non-conservative mixing where ammonia and NOx would have been uptaken by phytoplankton at around the 25-30 PSU salinity zone. FRP concentrations in the Burdekin River plume were variable over the salinity gradient, although concentrations generally decreased from 0.69 µM near the river mouth to 0.32 µM toward the outer reaches of the plume (Figure 89). Concentrations of ammonia, NOx and FRP were several times the ambient concentrations reported for the Townsville region of 0.15, 0.05 and 0.15 µM, respectively (Furnas and Brodie, 1996).

DON concentrations in the Burdekin River freshwater plume gradually decreased through the salinity gradient, although concentrations remained relatively high in the outer reaches of the plume (>6 µM: Figure 90). DOP concentrations remained consistently low (< 0.3 µM), but variable, throughout the salinity gradient of the Burdekin plume (Figure 91). DON and DOP concentrations are considered natural in the freshwater and marine environment (Brodie and Mitchell, 2005) and...
DON commonly makes up the highest proportion of TN in ambient marine waters (Furnas and Brodie, 1996).

A standard QHSS suite of pesticides were also analysed in selected samples in the Burdekin River plume. No pesticide residues or their associated breakdown products were detected in the plume.

The Burdekin River plume also displays some variability in particle size over the salinity gradient (Figure 92: note that the legend is in practical salinity units). The variability in particle size over the salinity gradient may be explained by ‘different parcels’ of water being sampled within the plume, dynamic processes within the plume such as flocculation, biological productivity (e.g. phytoplankton production) or sediment resuspension. Interestingly, the particle size range in the samples collected at 14 and 17 PSU is greatly reduced (0.05 to 30 μm) compared to the samples collected near the mouth of the Burdekin River (range from 0.05 to 710 μm). However, the sample from the 21 PSU salinity zone contained a particle size distribution identical to the sample collected at the 0.7 PSU zone. These samples were collected in close proximity to each other and would explain their identical particle size distribution (Figure 77). Therefore the reduced range for the 14 and 17 PSU salinity samples is most representative of the particle size fraction which travels the largest distances in the marine environment.
Figure 77. The Burdekin freshwater plume was sampled on the 6-7\textsuperscript{th} February 2007. At this time, the plume was influenced by relatively strong (>20 knots) south-easterly winds which drove the plume along the coast in the northerly direction. The plume was sampled through the salinity gradient (0-32 PSU).
Figure 78. Terra satellite image of the Burdekin River plume on the 9th February 2007. At this time strong south-easterly winds drove the plume in a northward direction.

Figure 79. Terra satellite image of the Burdekin River plume on the 11th February 2007. The direction of the wind has now changed and the Burdekin plume is starting to turn to a southerly course. Note that the freshwater plume waters have turned a dark green colour which may indicate increased biological productivity.
Figure 80. Terra satellite image of the Burdekin River plume on the 13th February 2007. Northerly winds have now driven the plume to a more southerly direction with the plume also reaching further offshore onto Old Reef.

Figure 81. Aqua satellite image of the Burdekin River plume on the 13th February 2007.
Figure 82. Terra satellite image of the Burdekin River plume on the 25th February 2007. The waning flow of the Burdekin River coupled with a return to south-easterly winds has constricted the plume to the coastline where it is following a northerly direction up to Magnetic Island.

Figure 83. TSS (red line) and barium (Ba: blue dots) concentrations through the salinity gradient of the Burdekin River plume. The TSS concentrations fall rapidly from 348 mg/L to <20 mg/L by the 10 PSU salinity zone. Ba concentrations decrease linearly through the salinity gradient which indicates conservative mixing.
Figure 84. Chlorophyll \( a \) concentrations across the salinity gradient in the Burdekin River plume were generally low and slightly increased after the 23 PSU zone. These concentrations would have likely been higher once biological activity had increased.

Figure 85. PN concentrations in the Burdekin River plume followed a similar pattern to TSS concentrations in which concentrations fell rapidly by the 10 PSU salinity zone.
Figure 86. PP concentrations in the Burdekin River plume also followed a similar trend to PN and TSS. Concentrations of PP fell rapidly by the 10 PSU salinity zone and remained low in the plume over the mixing gradient.

Figure 87. Ammonia concentrations decreased linearly in the Burdekin River plume indicating conservative mixing. The chlorophyll $a$ concentrations in the Burdekin plume (Fig P4) confirm that biological activity in the Burdekin plume at the time of sampling was relatively low.
Figure 88. NO\textsubscript{x} concentrations displayed a strong linear trend decreasing over the salinity gradient. This linear decrease indicates that at the time of sampling NO\textsubscript{x} was behaving conservatively in the freshwater plume.

Figure 89. FRP concentrations were variable over the salinity gradient in the Burdekin plume, although concentrations generally decreased towards the outer reaches of the plume.
Figure 90. DON concentrations remained relatively high in the Burdekin freshwater plume, although concentrations decreased gradually towards the outer reaches of the plume.

Figure 91. DOP concentrations were consistently low, but variable in the Burdekin River freshwater plume.
Figure 92. Particle sizing within the Burdekin River plume in the marine environment. Legend indicates the salinity units (in practical salinity units: PSU).
6. References


7. Appendices
Appendix A

List of Acronyms and Units of Measurement
### Appendix A: List of Acronyms and Units of Measurement

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIMS</td>
<td>Australian Institute of Marine Science</td>
</tr>
<tr>
<td>ACTFR</td>
<td>Australian Centre for Tropical Freshwater Research</td>
</tr>
<tr>
<td>BDTNRM</td>
<td>Burdekin Dry Tropics Natural Resource Management</td>
</tr>
<tr>
<td>BFD</td>
<td>Burdekin Falls Dam (Lake Dalrymple)</td>
</tr>
<tr>
<td>BOM</td>
<td>Bureau of Meteorology</td>
</tr>
<tr>
<td>CCI</td>
<td>Coastal Catchment Initiative</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
</tr>
<tr>
<td>Cumecs</td>
<td>Cubic metres per second (m³/s)</td>
</tr>
<tr>
<td>DIN</td>
<td>Dissolved Inorganic Nitrogen</td>
</tr>
<tr>
<td>DIP</td>
<td>Dissolved Inorganic Phosphorus</td>
</tr>
<tr>
<td>DON</td>
<td>Dissolved Organic Nitrogen</td>
</tr>
<tr>
<td>DOP</td>
<td>Dissolved Organic Phosphorus</td>
</tr>
<tr>
<td>DPI&amp;F</td>
<td>Department of Primary Industries and Fisheries (QLD Government)</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency (QLD Government)</td>
</tr>
<tr>
<td>GBR</td>
<td>Great Barrier Reef</td>
</tr>
<tr>
<td>GBRCA</td>
<td>Great Barrier Reef Catchment Area</td>
</tr>
<tr>
<td>mg/L</td>
<td>Milligrams per litre</td>
</tr>
<tr>
<td>ML</td>
<td>Megalitres</td>
</tr>
<tr>
<td>ML/day</td>
<td>Megalitres per day</td>
</tr>
<tr>
<td>m³/s</td>
<td>Cubic metres per second (Cumecs)</td>
</tr>
<tr>
<td>N</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>NRW</td>
<td>Department of Natural Resources and Water (QLD Government)</td>
</tr>
<tr>
<td>P</td>
<td>Phosphorus</td>
</tr>
<tr>
<td>PN</td>
<td>Particulate Nitrogen</td>
</tr>
<tr>
<td>PSU</td>
<td>Practical salinity units</td>
</tr>
<tr>
<td>PP</td>
<td>Particulate Phosphorus</td>
</tr>
<tr>
<td>QHSS</td>
<td>Queensland Health Scientific Services</td>
</tr>
<tr>
<td>RWQPP</td>
<td>Reef Water Quality Protection Plan</td>
</tr>
<tr>
<td>SS</td>
<td>Suspended Sediments</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>TN</td>
<td>Total Nitrogen</td>
</tr>
<tr>
<td>TP</td>
<td>Total Phosphorus</td>
</tr>
<tr>
<td>WQ</td>
<td>Water Quality</td>
</tr>
<tr>
<td>WQIP</td>
<td>Water Quality Improvement Plan</td>
</tr>
<tr>
<td>WQSIP</td>
<td>Water Quality State Level Investment Program</td>
</tr>
<tr>
<td>µg N/L</td>
<td>Micromgrams of nitrogen per litre</td>
</tr>
<tr>
<td>µg P/L</td>
<td>Micromgrams of phosphorus per litre</td>
</tr>
<tr>
<td>µM</td>
<td>Micromol</td>
</tr>
</tbody>
</table>
Appendix B

Load Calculation Uncertainty Estimates
**Appendix B: Load Calculation Uncertainty Estimates**

<table>
<thead>
<tr>
<th>Sub-catchment</th>
<th>Confidence Level</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burdekin River @ Inkerman</td>
<td>High</td>
<td>Limited sample numbers (although one on rise, peak and fall).</td>
</tr>
<tr>
<td>Burdekin River @ Sellheim</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Running River @ Mt Bradley*</td>
<td>Low</td>
<td>Gauging Stn upstream of sample site. Rise/peak of flashy main event not sampled.</td>
</tr>
<tr>
<td>Cape River @ Taemas</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Belyando River @ Gregory Dev Rd</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Upper Sutter River @ Eaglefield*</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Sutter River*** @ Mt Coolon Rd*</td>
<td>Med</td>
<td></td>
</tr>
<tr>
<td>Burdekin Dam overflow</td>
<td>Med</td>
<td></td>
</tr>
<tr>
<td>Bowen River @ Myuna</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Haughton River @ Bruce Hwy</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Barratta Creek @ Northcote</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>West Barratta Creek @ Bruce Hwy**</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>East Barratta Creek @ Bruce Hwy</td>
<td>Med</td>
<td></td>
</tr>
<tr>
<td>Euri Creek @ Koonandah*</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

*Less confidence in load data. **No flow data available but used East Barratta flow data. ***Flow data= (St Anns minus Belyando). ^total flow calculated using the Brolga program: estimates may vary slightly from NRM gauging data.
Appendix C

Conductivity and Nutrient Box Plots for the Major Sub-catchments of the Burdekin (2006/07 Wet Season)
Appendix C: Nutrient Box Plots

Upper Burdekin Sub-catchment Conductivity and Nutrient Species for the 2006/07 Wet Season

Conductivity (µs/cm)

- Dry River
- Bur R (Lucky D)
- Gray
- Camel
- Redbank
- Maryvale
- Running
- Star
- Basalt
- Fletcher

Nutrient Box Plots

Particulate Nitrogen (µg N/L)

- Clarke
- Running
- Basalt
- Fletcher
- Lolworth
- Upp Burdekin

Dissolved Organic Nitrogen (µg N/L)

- Clarke
- Running
- Basalt
- Fletcher
- Lolworth
- Upp Burdekin
Cape Sub-catchment Conductivity and Nutrient Species for the 2006/07 Wet Season
Campa spe Cape Site

Particulate Nitrogen (µg N/L) n=3 n=8

Dissolved Organic Nitrogen (µg N/L) n=3 n=8

NOx (µg N/L) n=3 n=8
Belyando Sub-catchment Conductivity and Nutrient Species for the 2006/07 Wet Season

**Filterable Reactive Phosphorus (µg P/L)**

- **Campapa**
  - n=3
- **Cape**
  - n=8

**Conductivity (µS/cm)**

- **Upper Belyando**
  - n=3
- **Native Companion**
  - n=3
- **Upper Mistake**
  - n=5
- **Lower Mistake**
  - n=5
- **Carrmichael**
  - n=1

**Particulate Nitrogen (µg N/L)**

- **Lower Mistake**
  - n=5
- **Belyando**
  - n=8
Suttor Sub-catchment Conductivity and Nutrient Species for the 2006/07 Wet Season

- Conductivity (µS/cm)
  - Upper Suttor: n=6
  - Logan: n=5
  - Eaglefield: n=1

- Particulate Nitrogen (µg N/L)
  - Upper Suttor: n=7
  - Logan: n=5
  - Suttor: n=7

- Dissolved Organic Nitrogen (µg N/L)
  - Upper Suttor: n=7
  - Logan: n=5
  - Suttor: n=7
Bowen Sub-catchment Conductivity and Nutrient Species for the 2006/07 Wet Season
Event-based Community Water Quality Monitoring in the BDTR: 2006-2007 (VOL 1)

East Burdekin Sub-catchment Conductivity and Nutrient Species for the 2006/07 Wet Season

Upper Broken
Little Bowen
Bowen (Dartmoor)
Lower Bogie

Filterable Reactive Phosphorus (µg P/L)
n = 4
n = 1
n = 7
n = 3

Kirk
Elphinstone
Landers (U/S)
Landers (D/S)
8 Mile
Expedition

Conductivity (µS/cm)
n = 6
n = 7
n = 1
n = 2
n = 4
n = 4

Elphinstone
Landers (U/S)
Landers (D/S)
8 Mile
Expedition

Particulate Nitrogen (µg N/L)
n = 7
n = 1
n = 2
n = 4
n = 4

Australian Centre for Tropical Freshwater Research
Lower Burdekin Sub-catchment Conductivity and Nutrient Species for the 2006/07 Wet Season
Major Sub-catchments Nutrient Species for the 2006/07 Wet Season

Particulate Nitrogen (µg N/L)

- Burdekin (Seithem) n=11
- Cape n=8
- Belyando n=8
- Suttor n=7
- Lower Bogie n=7
- Bur R Inerman n=23

Dissolved Organic Nitrogen (µg N/L)

- Burdekin (Seithem) n=11
- Cape n=8
- Belyando n=8
- Suttor n=7
- Lower Bogie n=7
- Bur R Inerman n=23

NOx (µg N/L)

- Burdekin (Seithem) n=11
- Cape n=8
- Belyando n=8
- Suttor n=7
- Lower Bogie n=7
- Bur R Inerman n=23
Appendix D

Features of Box Plot Graph
Appendix D: Box plot diagram showing major features of the plot

Box Plots: Summary plot based on the median, quartiles, and extreme values. The box represents the inter-quartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median.