



Australian Government

Department of the Environment, Water, Heritage and the Arts

**Marine and Tropical Sciences Research Facility (MTSRF)
June 2007 Milestone Report**

**Project 3.7.2: Connectivity and risk: tracing materials from the upper
catchment to the Reef**

**Project Leader: Jon Brodie, Australian Centre for tropical Freshwater Research,
James Cook University**

Summary

Part 1. ANU and JCU component

Task Leader:

Malcolm McCulloch/Stephen Lewis
Research School of Earth Sciences, Australian National University/ACTFR, JCU.

Task 2: Tracing of materials in the marine environment

Project description

It is planned to undertake a comprehensive sampling of Porites corals in the Townsville-Cairns region in 2006/2007 and again in 2010 to provide quantitative constraints on the effectiveness of the Reef Water Quality Protection Plan. These will complement the AIMS collection made in the mid – 1980's with the new cores covering the last 20 -50 years of river discharge. Coral cores will be analysed using the state-of-the-art laser ablation analyses only possible at ANU, in conjunction with the study at AIMS of the distinctive luminescent lines that are a result of low salinities from flood plumes. In addition to the already well described Ba method (McCulloch et al., 2003) measurements of $^{143}\text{Nd}/^{144}\text{Nd}$ and ^{15}N isotopes in coral cores and luminescent lines will be undertaken at ANU to provide a novel technique to examine changes in sediment and nutrient sources from the major rivers. This will be complemented by sediment cores from Bowling Green Bay, a major sink for sediments from the Burdekin River, as well as other cores taken from the inner and mid-shelf between Townsville and Cairns. The sediment geochemistry of these cores has already been partially characterised by the Australian Institute of Marine Science (G. Brunskill pers comm.) and additional isotopic and where necessary physical and mineralogical properties will complete this dataset. A chronology of these cores is also available from ^{210}Pb ages, but more refined ages may be obtained using OSL dating and distinctive time transgressive terrestrial markers (eg onset of Hg from gold mining). The terrigenous sediment "fingerprints" from these cores will be compared to the terrestrial dataset to examine and quantify the contribution of sediment from each Burdekin sub-catchment. The isotopic composition (Sr-Nd) of suspended actually reaching coral reefs will also be determined and compared the compositions of material from the various river sources as well as sediment cores. This approach will then be applied and other wet tropics catchments in the Townsville-Cairns region.

The possibility of using the oxygen isotopic composition of phosphate to distinguish how the marine versus terrestrial sources of P may have changed over time in the inner and mid-shelf regions of the GBR will also be investigated.

Burdekin, Fitzroy, Herbert, Tully, Johnstone and Russell-Mulgrave river flood plumes will be sampled on an opportunistic basis and suspended sediments and dissolved materials will be recovered along a salinity transects. The isotopic, elemental and mineralogical properties of these materials will be measured according to the methods outlined in Task 1 and linked to a sediment source within the river catchments. In addition, routine collection (weekly) of water samples will be undertaken from both the AIMS and Orpheus Island Research station in order to obtain a long-term 'baseline' record of water quality and trace element composition of the inner Great Barrier Reef waters covering both wet as well as dry seasons. Water samples will be also taken within the flood plume to measure the isotopic, trace element and nutrient compositions of the dissolved components of the flood plume along a salinity transect. This analysis will investigate sediment desorption within the estuarine and flood plume mixing zone.

For reference: Milestone extracted from Project Schedule

Project 3.7.2

Date: September 1, 2007

Description:

Progress report on collection and analysis of coral core samples of Porites coral in Rockhampton – Cairns Region in 2006 [ANU, JCU].

Project Results

Description of the results achieved for this milestone

Task 2: Tracing of materials in the marine environment

Project progress

Due to the considerable widespread flood plumes generated from the large wet season of February-March 2007, collection of additional coral cores in the region will be delayed until November 2007. This delay is required to allow for the incorporation of the latest flood signals into the coral skeletal record. However, a long coral core collected from Magnetic Island (collected 2002) was analysed by laser ablation ICP-MS (Fig 1). Lewis et al. (2007) reported increased Ba/Ca and Mn concentrations since European settlement in the Burdekin River catchment (>1850s) in a long coral core record from Magnetic Island, although this analysis was performed at 2 yearly resolution. This new analysis was able to obtain a much higher resolution (~ two-weekly) made possible by the laser ablation ICP-MS machine. The coral shows historical changes in water quality in freshwater plumes from the Burdekin River and possibly local catchments which reflects changes in bulk sediment and top soil erosion in these catchments. The data support the findings of McCulloch et al. (2003) for the Havannah Island coral Ba/Ca record. In addition, a coral record from Whitsunday Island was also analysed by LA-ICP-MS in March 2007. Results from this analysis are being processed.

In addition, two short coral cores (~1960-2005) and one long core (~1816-1992) from Whitsunday Island were selected for laser ablation ICP-MS analysis at the Australian Institute of Marine Science. The samples were prepared and one short core and the long core (to ~1890) were analysed at ANU, Canberra in March 2007. An annual temperature signature in the coral with Sr/Ca and U/Ca ratios exists in both records (e.g. Fig 2). We have begun to process the results from the short core and the long core, although difficulties have been encountered in the interpretation of the coral's chronology. Assigning a robust chronology is a complex task in coral geochemistry records. While a number of physical (x-rays, density and luminescence) and geochemical (Sr/Ca, U/Ca, Mg/Ca, B/Ca, Ba/Ca) proxies are available, these proxies need to be used collectively and do not always agree. Dr Stacy Jupiter has been particularly helpful and some issues have already been resolved (e.g. anomalous coral luminescence in 1983 was originally interpreted to be the 1981 flood line). However, the assignment of chronology is tedious and time consuming.

Preliminary results suggest that the Ba/Ca ratios have been remarkably stable over both Whitsunday Island coral cores (Fig 3 and 4). This stability indicates that sediment delivery from the O'Connell and Proserpine Rivers has not particularly changed in the last 120 years. The analysis of remaining ~70 years of the long coral core will provide a useful comparison to previous studies which have used coral records influenced by the Pioneer River and found increases in sediment delivery between 1870 and 1890 (Jupiter, 2006). The coral Ba/Ca ratios increased over the last 50-60 mm (equivalent to 4-6 years) in both records; this increase is probably an artefact of the coral tissue layer and does not reflect an increase in sediment loads. In addition, Ba/Ca 'spikes' throughout both coral records could reflect either large floods or be associated with green endolithic algal bands present in the corals. Once a reliable chronology is established these 'spikes' can be properly examined.

A coral coring trip will take place from the 5th to the 12th September 2007 in the Whitsunday Island on the AIMS vessel. It is anticipated that a series of short cores will be collected for analysis at ANU by mid 2008. In addition, further discussions have been held regarding the nitrogen isotope analysis of the coral cores with Dr Hilary Stuart-Williams and Dr Guy Marion.

At this stage a robust methodology is being developed and a suite of standard samples will be analysed by the end of 2007 to determine the optimal sampling design for this analysis.

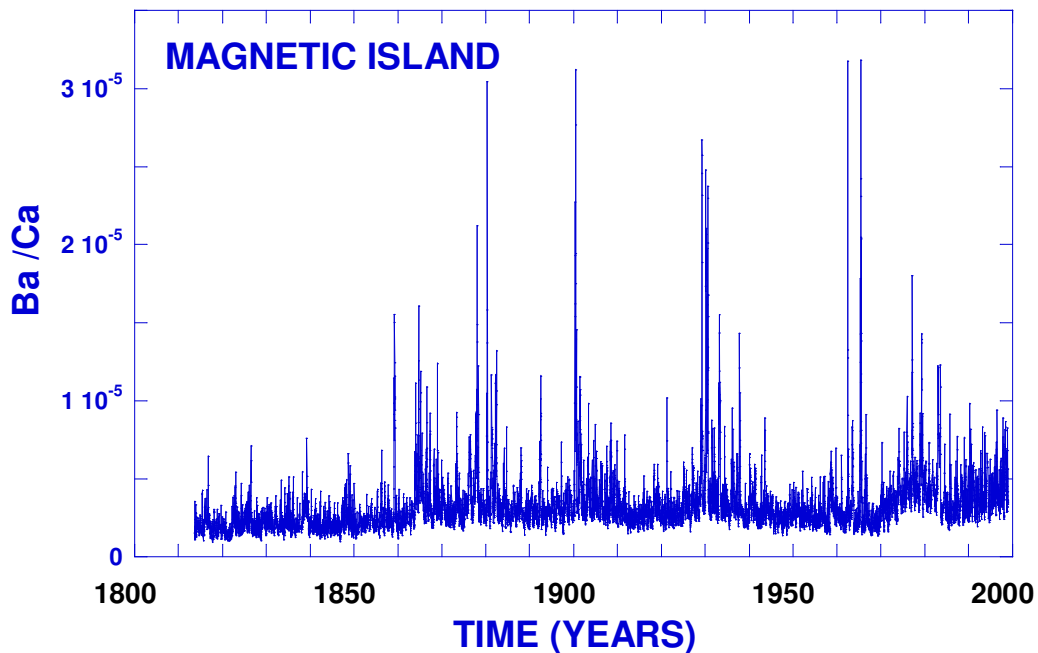


Figure 1: LA-ICP-MS Ba/Ca analysis of a Magnetic Island coral record supports the Havannah Island Ba/Ca (McCulloch et al., 2003) of increased sediment erosion in the Burdekin River catchment since European settlement in the 1850s.

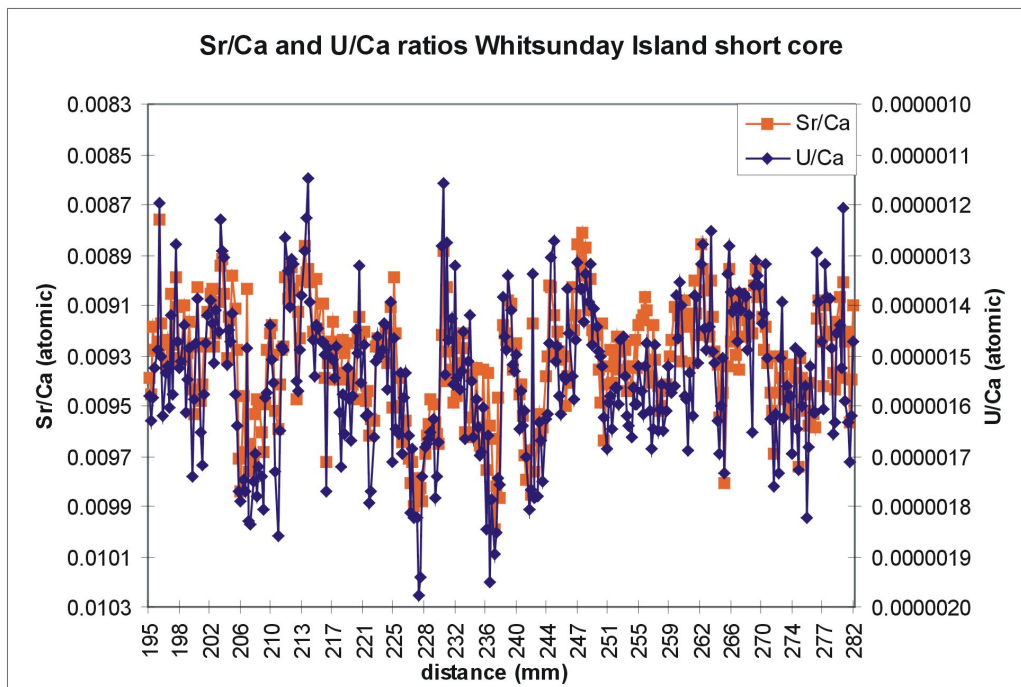


Figure 2: Sr/Ca and U/Ca ratios from the Whitsunday Island short core (W-34) collected by AIMS in 2005. This dataset shows approximately 10 years of growth. The Sr/Ca and U/Ca thermometers display excellent agreement which allows a robust chronology to be developed within the coral core.

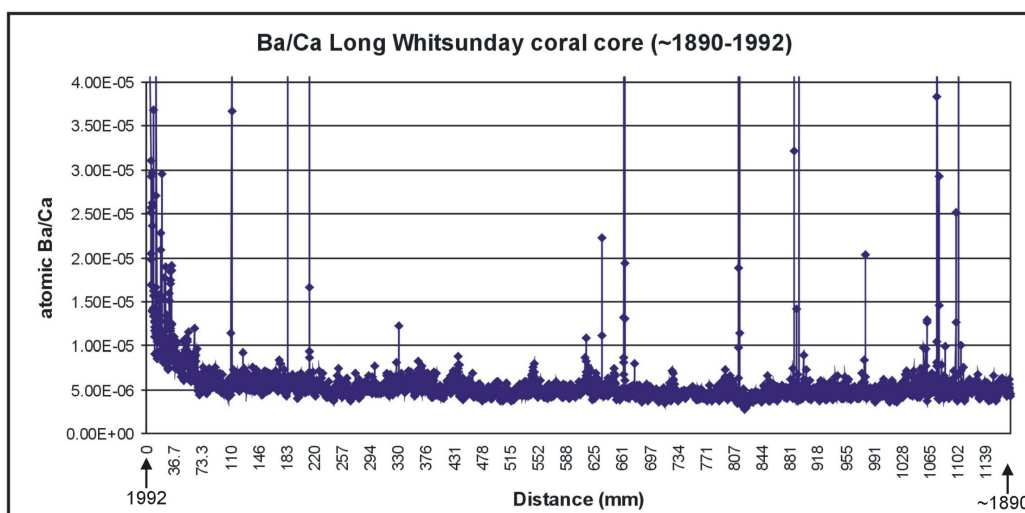


Figure 3: Coral Ba/Ca ratios in the long Whitsunday Island coral core show no apparent upward trend with the exception of the last ~60 mm (~ 5 years) of recent growth. This rise is probably an artefact of the coral tissue layer and does not reflect an increase in sediment delivery. The Ba/Ca 'spikes' in the record need further investigation – it is unknown whether these spikes represent floods or are associated with endolithic green algal bands in the coral. This problem will be resolved when an reliable chronology is established for the corals.

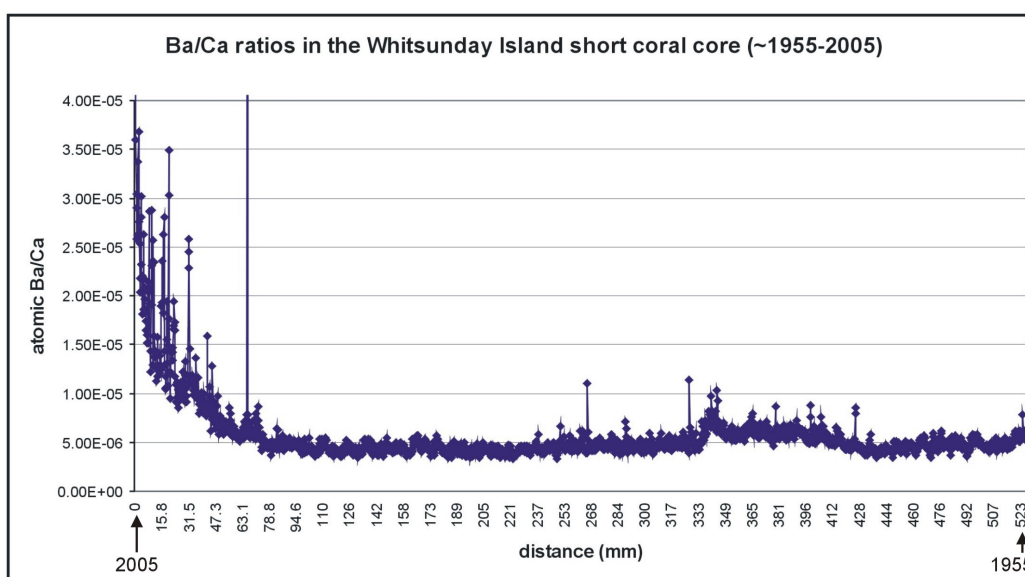


Figure 4: With the exception of the 'recent' ~60 mm of coral growth, the coral Ba/Ca ratios also show no overall upward trend, although an increase is evident between 320 and 400 mm (~1970's). Once a reliable chronology is established this record can be 'patched' with the long coral core record and this increase can be examined.

Problems and opportunities

Assigning a reliable coral chronology has been particularly difficult and time consuming for the Whitsunday Island corals. This difficulty is limiting the interpretations that can be made of these coral records. More time is required to establish an accurate chronology and further discussions will be held with Dr Stacy Jupiter to help establish a robust chronology.

Other issues

None at this stage

Communications, major activities or events

During milestone reporting period

Communications have been held with Stephen Lewis for the trace element analysis of the water samples from the freshwater plume of the Burdekin River to be performed at ANU. Extensive discussions have also been made with Stephen Lewis on the analysis of coral cores from Whitsunday Island. Communications have been held with Dr Hillary Stuart-Williams (ANU) and Dr Guy Marion about the measurement of nitrogen isotopes in coral cores. Currently the necessary equipment for the N isotope analysis is being ordered. Arrangements have been made with Eric Matson (AIMS) for a coring trip to the Whitsunday Islands in September 2007 and another coring trip is scheduled for June 2008. Logistics have been organized for the September 2007 coral coring trip and all necessary permits have been obtained. In addition, Stephen Lewis has completed an advanced resuscitation (oxygen provider) and a marine radio operator course to satisfy the requirements to operate the tenders in the coral coring exercise. Frequent contact has been made with Prof Malcolm McCulloch to arrange additional LA-ICPMS analyses of the Whitsunday coral cores in early 2008. Discussions have been held with Dr Stacy Jupiter to help assign a robust chronology for the corals and Dr Jupiter will be a valuable addition to the coral coring field trip in the Whitsunday Islands in September 2007.

During next milestone reporting period

Coral cores will be collected in November 2007 from inshore reefs off the Tully River. Coral cores will be collected through the Whitsunday Island Group in September 2007.

Forecast variations to planned milestones

None at this stage.

Summary

Part 2. JCU component

Milestone 3: June, 2007

Connectivity and risk: tracing of materials from the upper catchment to the Reef

Project Leader

Jon Brodie

Australian Centre for Tropical Freshwater Research, James Cook University

Task 1: Tracing of materials in the terrestrial environment

Task Leader:

Stephen Lewis

Australian Centre for Tropical Freshwater Research, James Cook University.

Project description:

Sediments will be collected from different soil and rock types as well as from the major stream channels within the Burdekin River catchment and from selected wet tropics rivers between Townsville and Cairns. Suspended sediments will also be recovered from the tributaries of the Burdekin River catchment. The composition of Sr–Nd and other isotopes of tracing potential in the Burdekin River sediments will be measured at the Centre for Microscopy and Microanalysis (CMM: University of Queensland) and Research School of Earth Sciences (RSES: Australian National University) laboratories. The $^{87}\text{Sr}/^{86}\text{Sr}$ isotopic ratio of sediments is mainly controlled by age while the $^{143}\text{Nd}/^{144}\text{Nd}$ and other isotopic ratios are influenced by both the composition of the source rock (e.g. basalt rocks contain a different isotope signature to granites) as well as the age. These isotope tools coupled with the trace element composition and clay mineralogy provide a powerful tool to fingerprint different sediment types and to trace and quantify sediment transport through river catchments. This technique (Nd–Sr) has been applied successfully in the Johnstone River and offshore reefs (McCulloch et al., 2001) and the Murray–Darling fluvial system (Gingele and De Deckker, 2005). The trace element composition of the sediments will also be determined using XRF and ICP–MS at the AAC, CMM and at the RSES. Particular elements (e.g. Ti, Zr, Ca, K) and elemental ratios (Rb/Sr, Zr/Hf, Y/Ho, Th/Ti, Th/W) provide a useful complementary tool to trace sediment through a large river system.

To trace the transport of fine sediments throughout the Burdekin catchment, the sediments will be collected and sieved to recover the mud fraction ($< 63\ \mu\text{m}$) which will be used exclusively. The particle size of this mud fraction (proportion of silt, clay and colloidal particles) will be determined on a Melvin Mastersizer® in the School of Earth Sciences, James Cook University (JCU). X-ray diffraction in conjunction with the Siroquant® program will be employed to determine and quantify the mineralogy of the sediments and, in particular the relative proportion of the major clay minerals (chlorite, smectite, kaolinite and illite) in the sediments. This analysis will be performed at the Advanced Analytical Centre (AAC), JCU. Nitrogen isotope analyses of water samples will be conducted at ANU.

We also plan to conduct preliminary research into tracing the source of nitrate in the Burdekin River catchment. The Burdekin River exports high loads of nitrate and currently the source is unknown. We plan to use nitrogen isotopes to uncover the source of this nitrate.

For reference: Milestone extracted from Project Schedule

Date 8 June 2007

Description

Report on 2006 and 2007 wet season Burdekin high flow sampling with first estimates of the trapping efficiency of the Burdekin Falls Dam [JCU].

Plan of communication outputs and products for year one and summary of any liaison activities to date including minutes of meetings/workshops if applicable [JCU].

Project Results

Description of the results achieved for this milestone

During the 2007 wet season, a suite of water samples (~80 samples) were collected from the tributaries throughout the Burdekin catchment (Fig 5) and from the freshwater plume from Burdekin (and Tully) River (Fig 6). These samples are currently being stored at JCU and the suspended sediments will be recovered and analysed for trace element and isotope composition by the end of 2007. Selected sediment samples were prepared at the University of Queensland in April 2007 for trace element and isotope analyses. It is understood that delays have occurred in the trace element analysis as the ICP-MS machine has broken down (should be repaired by October 2007). Once these results become available, a robust technique can be designed and the next batch of samples can be planned. One hundred and fifty samples were analysed by the School of Earth Sciences for particle size analysis. The results display interesting trends where a finer particulate size fraction (<0.4 µm) have been found in the upper Burdekin River and Bowen River major sub-catchments. The results are presented by dividing the Burdekin Region into six major sub-catchments as well as sampling conducted in the Burdekin Falls Dam overflow and at the end-of-catchment (Burdekin River at Inkerman Bridge) and the Burdekin River plume (see Fig 5).

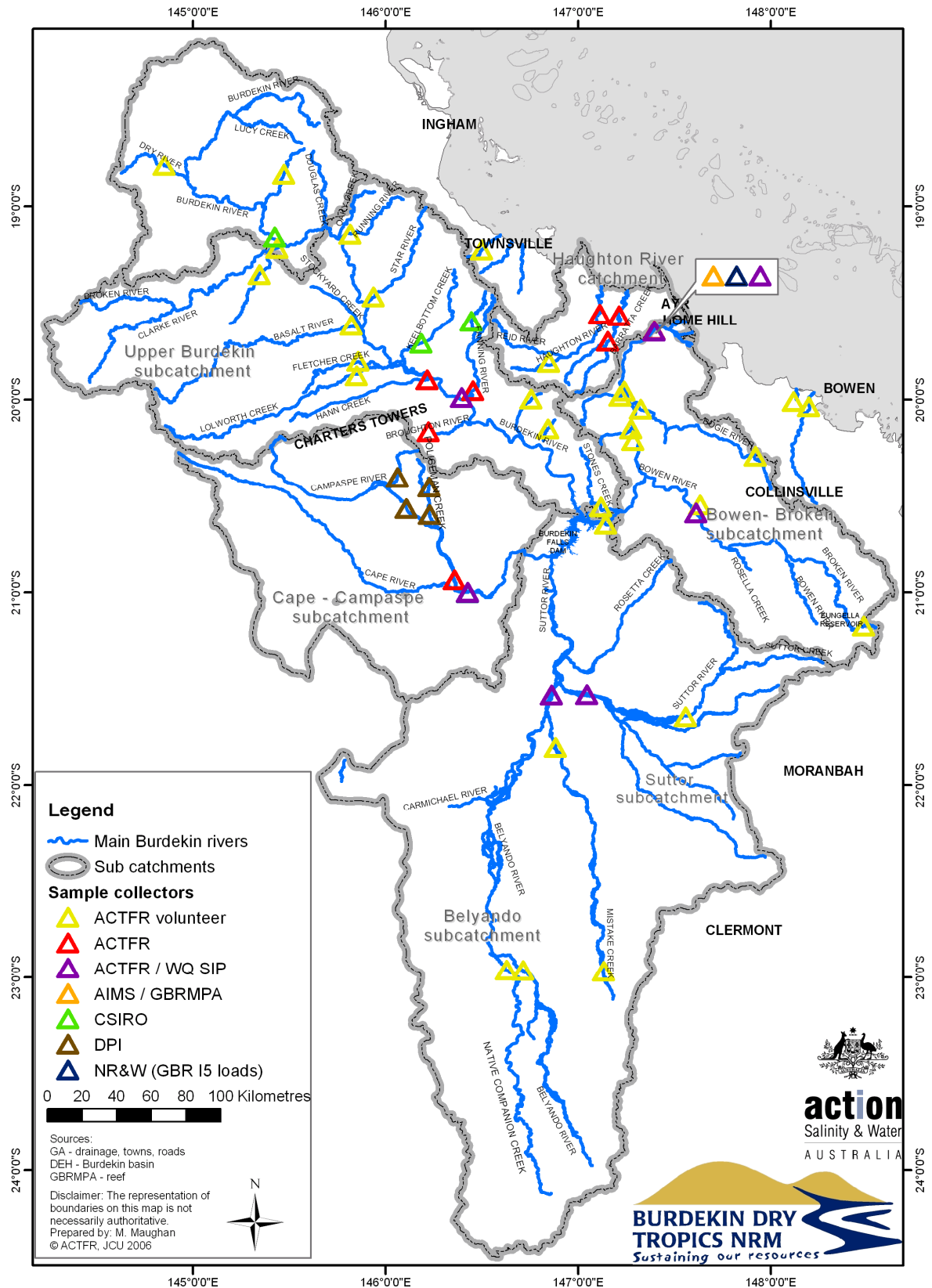
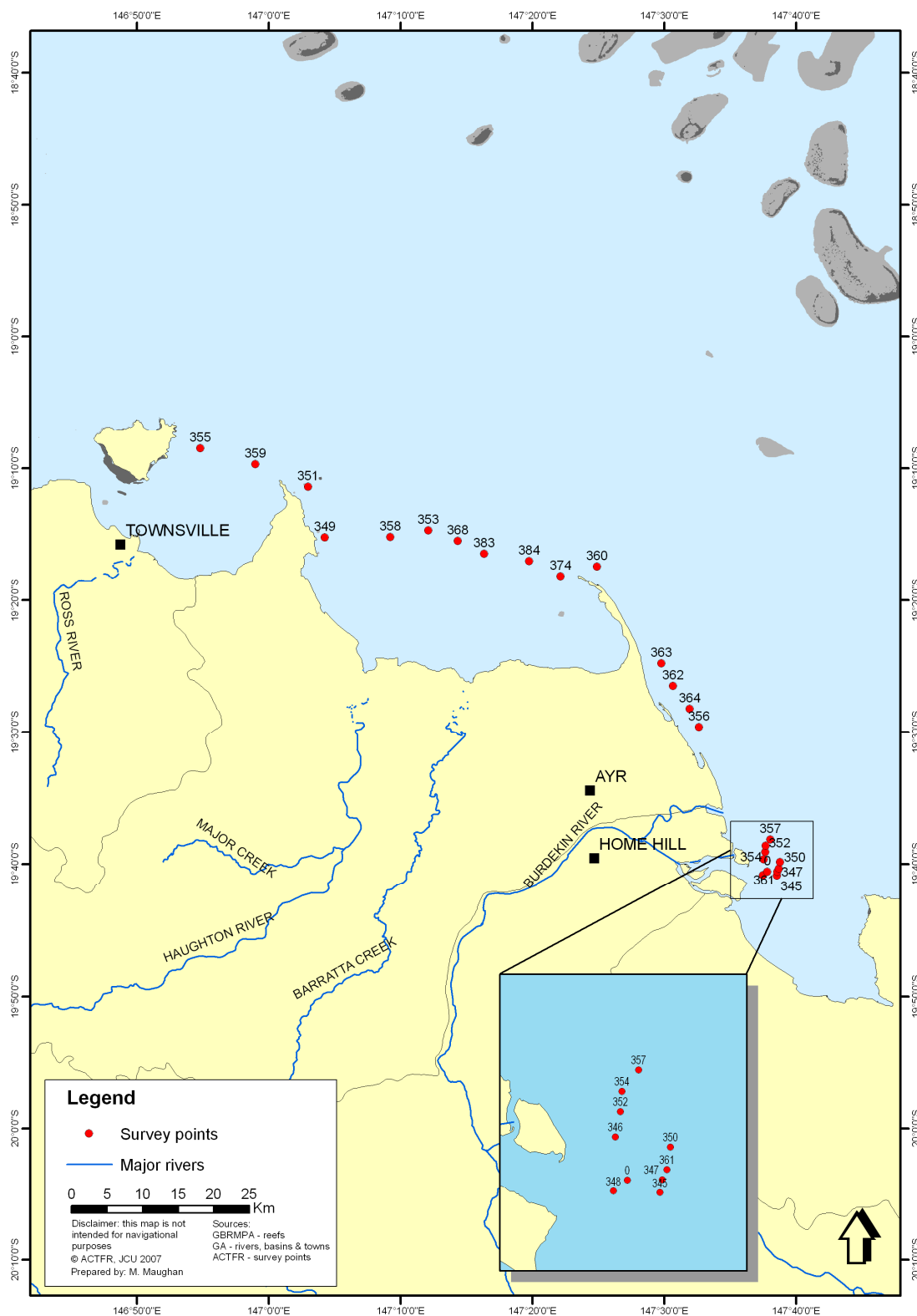


Figure 5. Sampling sites during the 2006/07 wet season.



Particle sizing

a) Upper Burdekin sub-catchment

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 (Fig 7). 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 and may provide the source of the fine grained suspended sediments.

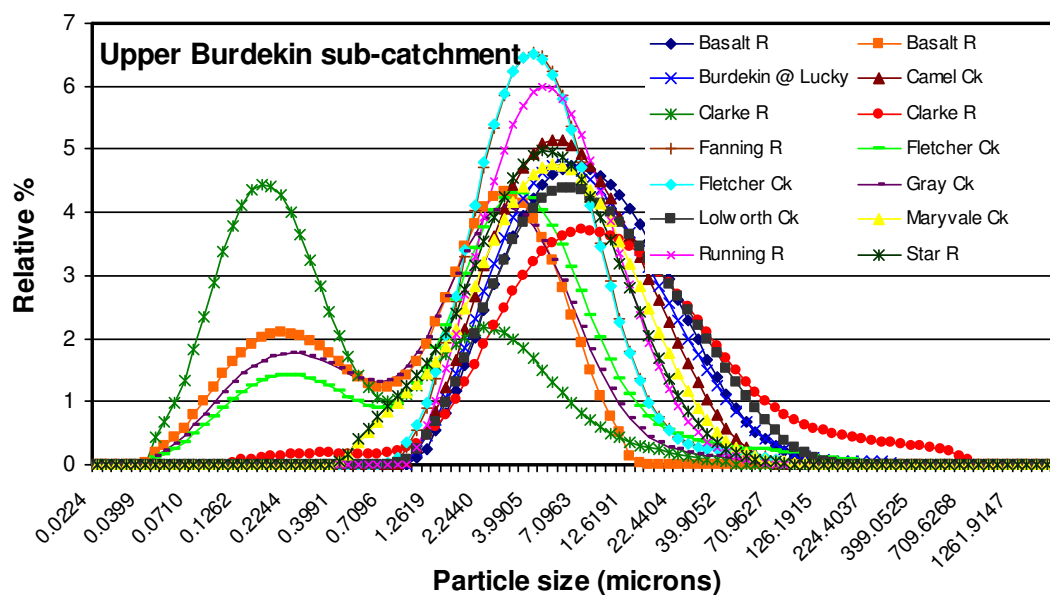


Figure 7: Particle size data for the tributaries of the upper Burdekin sub-catchment.

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 (Fig 8). The considerably finer sediment fraction was not measured in the previous 2005/06 wet season in the upper Burdekin sub-catchment (Bainbridge et al., 2006). 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.

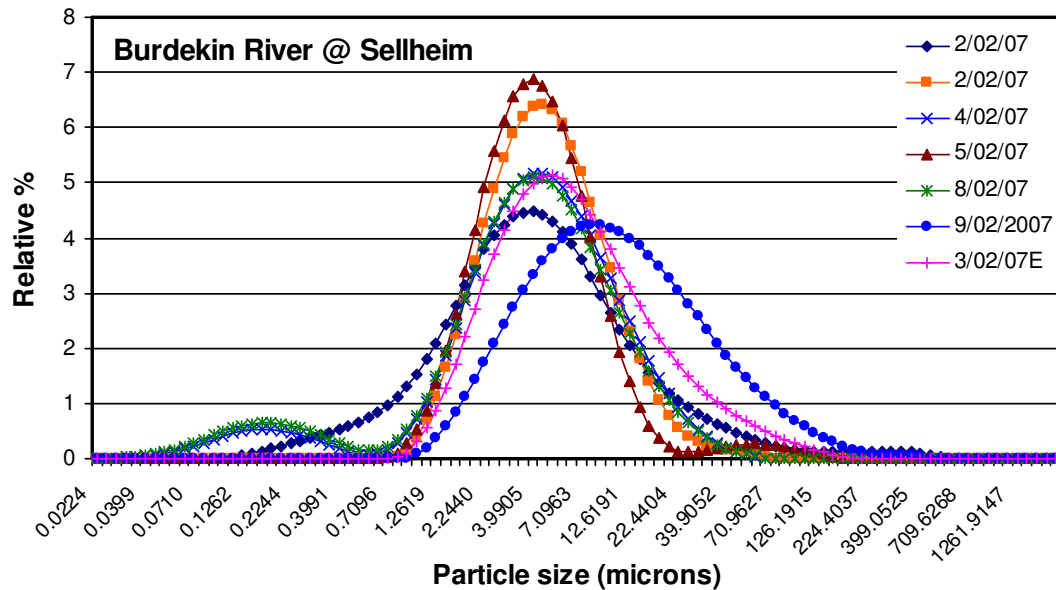


Figure 8: Particle sizing at the Burdekin River at Sellheim major catchment site (upper Burdekin).

b) Cape River sub-catchment

Only two sites were analysed for particle sizing in the Cape River sub-catchment in the 2006/07 wet season including the Campaspe River (Fig 9) and the major sub-catchment site (Fig 10: 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).

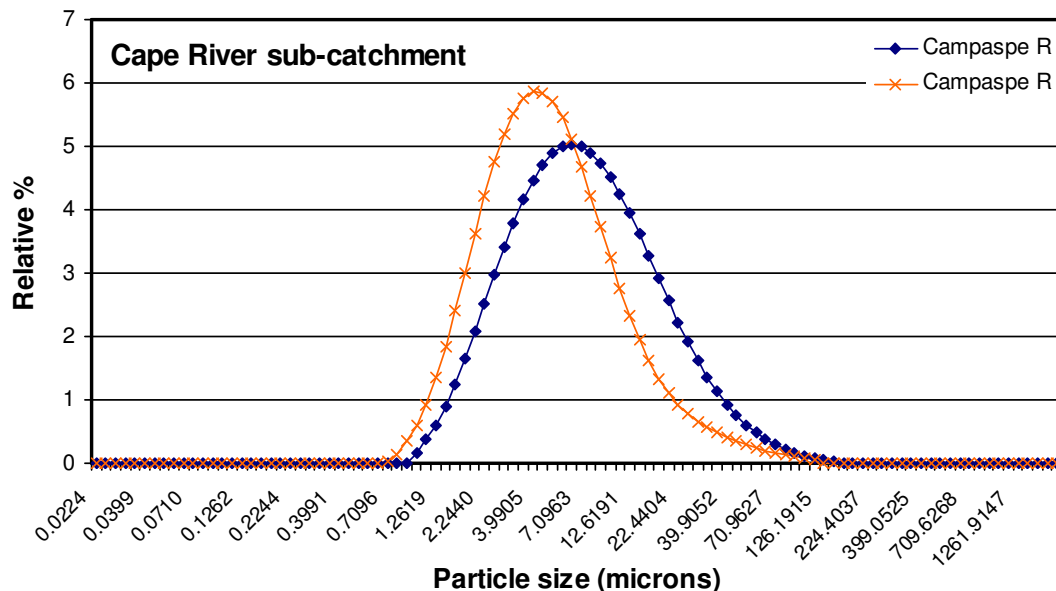


Figure 9: Particle sizing data for the tributaries of the Cape River sub-catchment.

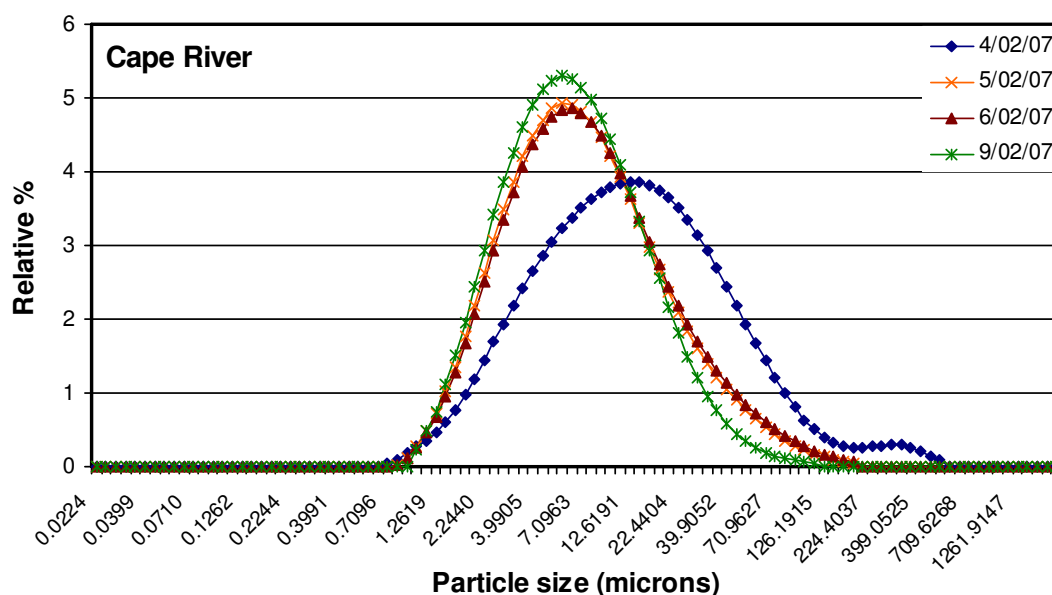


Figure 10: Particle sizing at the Cape River at Gregory Developmental Road major catchment site (Cape).

c) Belyando River sub-catchment

While the finer particle size fraction ($<0.4 \mu\text{m}$) was absent at the sampled sites within the sub-catchments of the Belyando River (Fig 11), this fraction was present at the major sub-catchment site (Fig 12: 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.

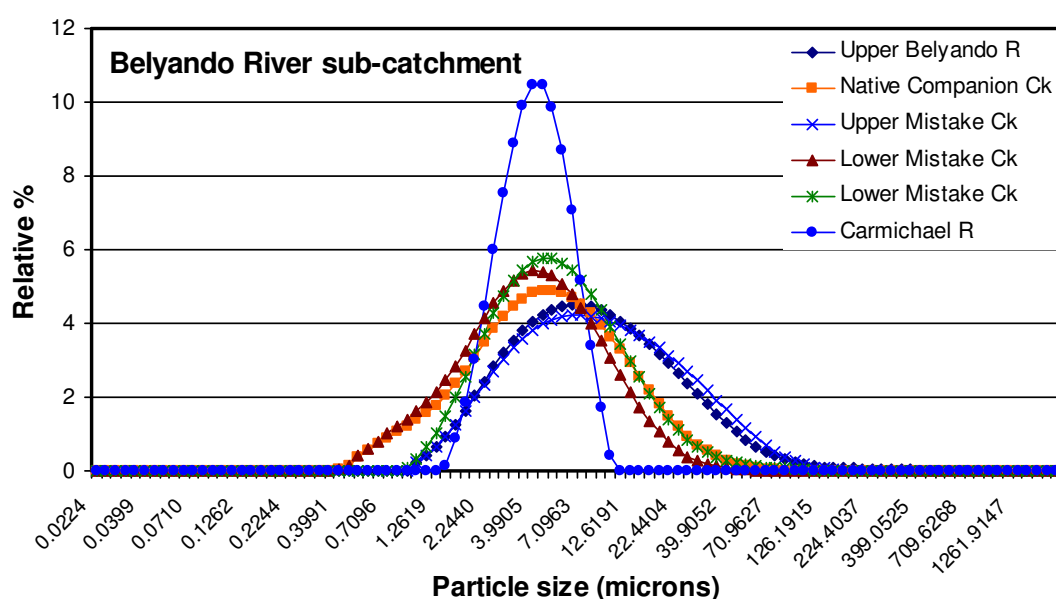


Figure 11: Particle sizing data for the tributaries of the Belyando River sub-catchment.

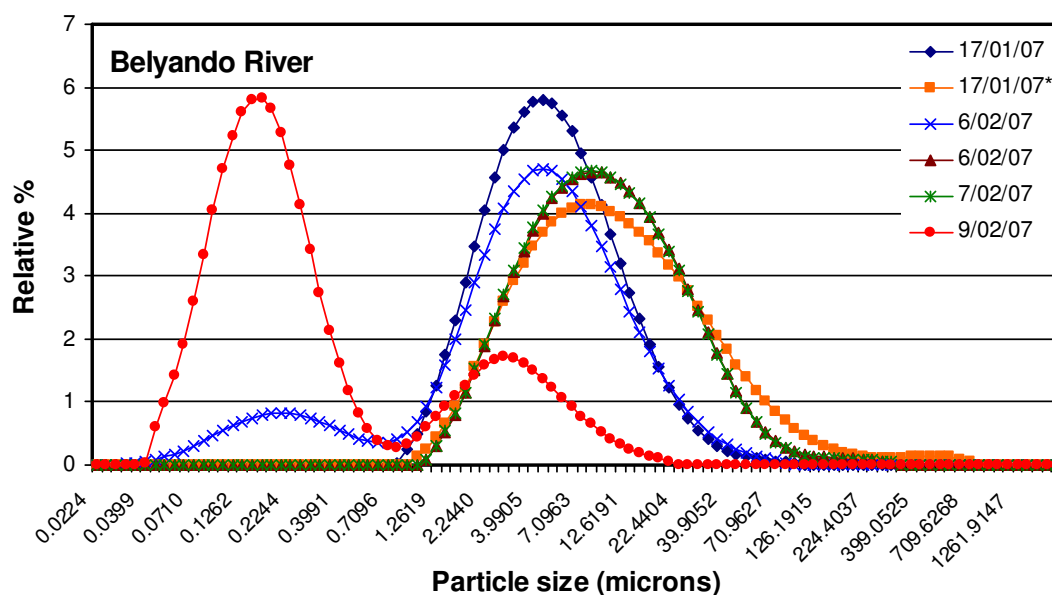


Figure 12: Particle sizing at the Belyando River at Gregory Developmental Road major catchment site (Belyando).

d) Suttor River sub-catchment

A finer sediment fraction was identified in two of the three Suttor River sub-catchments (Fig 13: Eaglefield Creek and Logan Creek), although this fraction was not measured at the major end of sub-catchment site (Fig 14: Suttor River @ Bowen Developmental Road). However, only four samples were analysed for particle size in 2006/07 and the fine fraction ($<0.4 \mu\text{m}$) was evident in Suttor River samples collected in the previous wet season (Bainbridge et al., 2006a). 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.

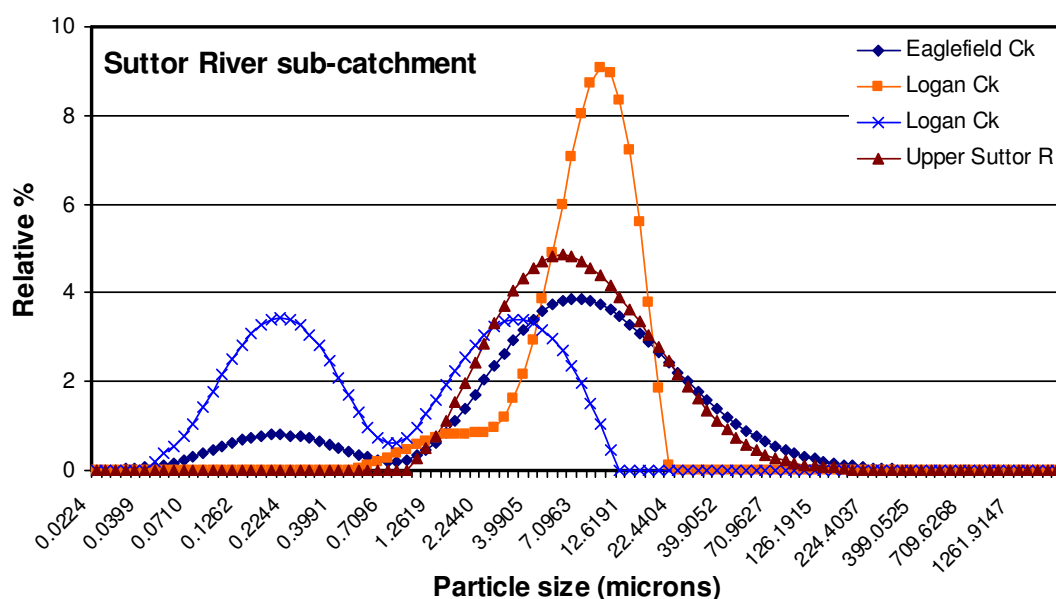


Figure 13: Particle sizing data for the tributaries of the Suttor River sub-catchment.

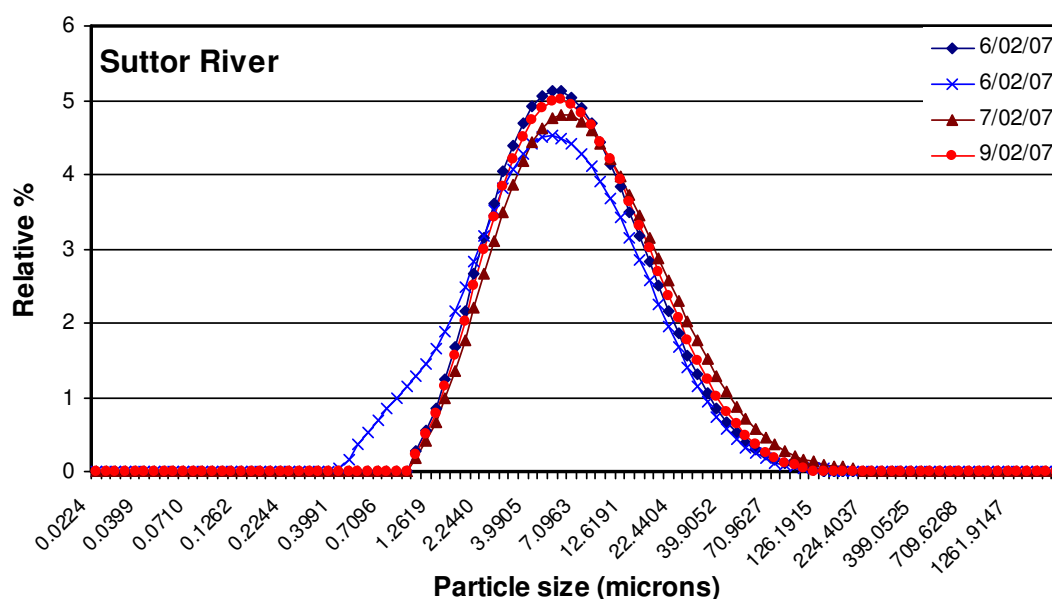


Figure 14: Particle sizing at the Suttor River at Bowen Developmental Road major catchment site (Suttor).

e) Burdekin Falls Dam

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 (Fig 15). 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.

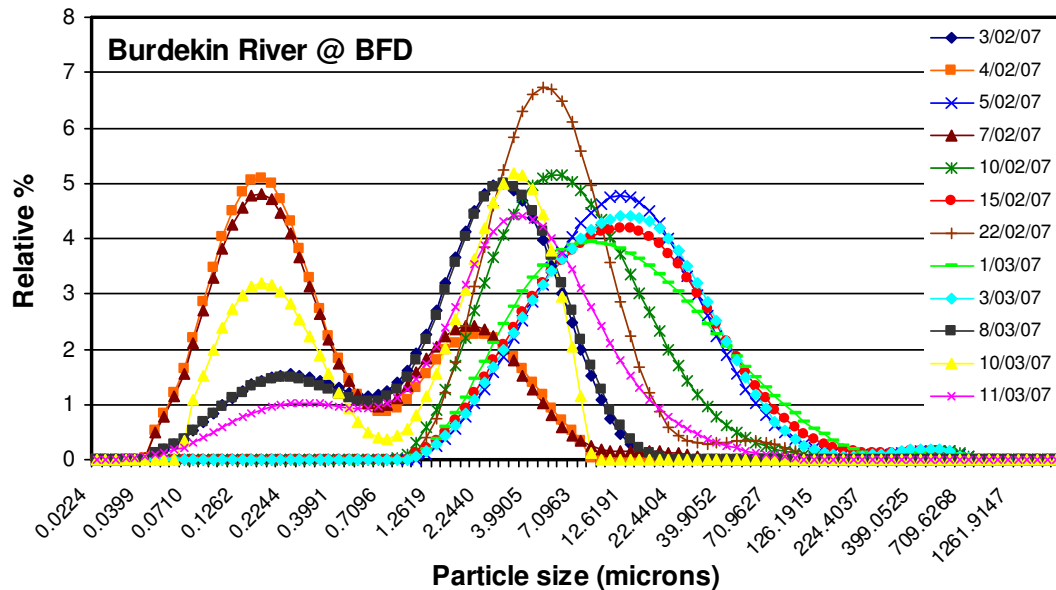


Figure 15: Particle sizing at the Burdekin Falls Dam overflow.

f) Bowen/Bogie River sub-catchment

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 : Fig 16). 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 (Fig 16). The Little Bowen River sub-catchment drains a series of volcanic and sedimentary rocks which may contribute to this finer fraction. Several samples collected from the major sub-catchment site (Bowen River at Myuna: Fig 17) 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).

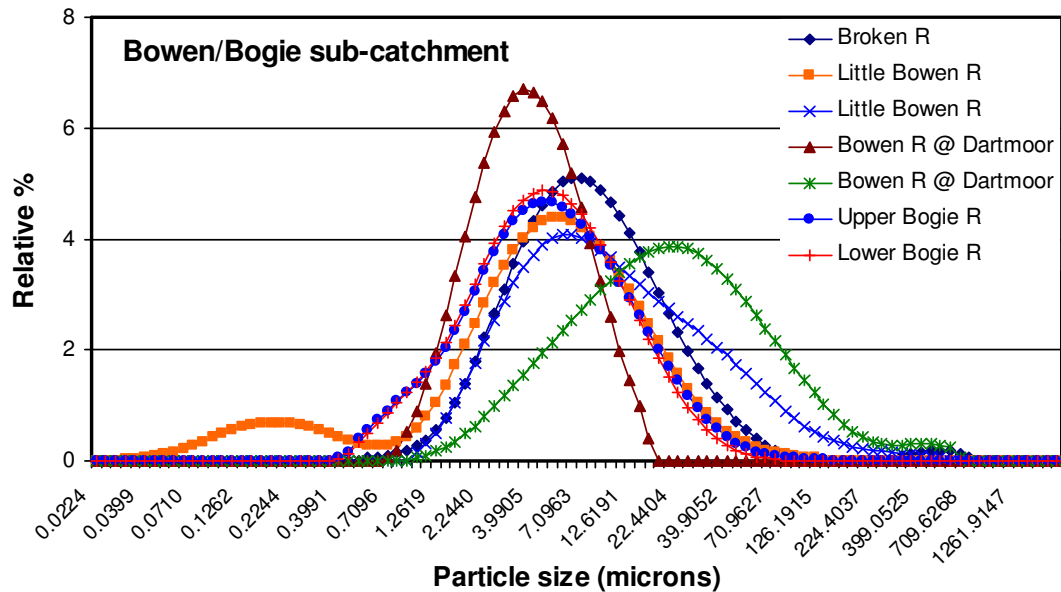


Figure 16: Particle sizing data for the tributaries of the Bowen/Bogie sub-catchment.

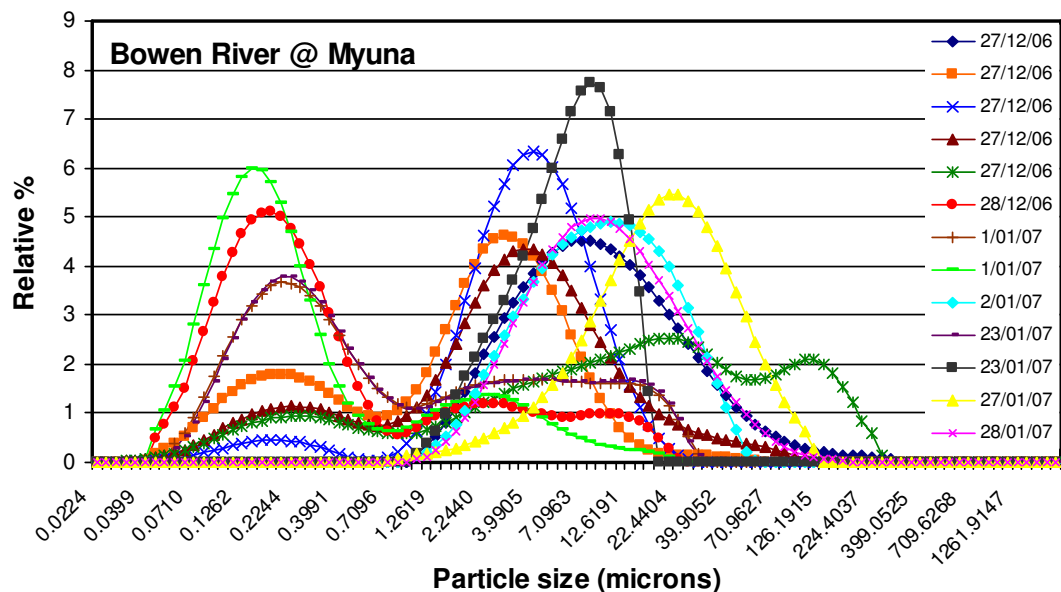


Figure 17: Particle sizing at the Bowen River at Myuna major catchment site (Bowen).

g) East Burdekin sub-catchment

Three of the four sub-catchments sampled for particle size analysis in the East Burdekin contained a finer sediment fraction ($<0.4 \mu\text{m}$). In addition, the Kirk River and Expedition Pass Creek displayed considerable variability in particle size distribution over the flow hydrograph (Fig 18). These catchments contain a mixture of acid volcanic and granitic rocks. 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 $30 \mu\text{m}$ (fine silt).

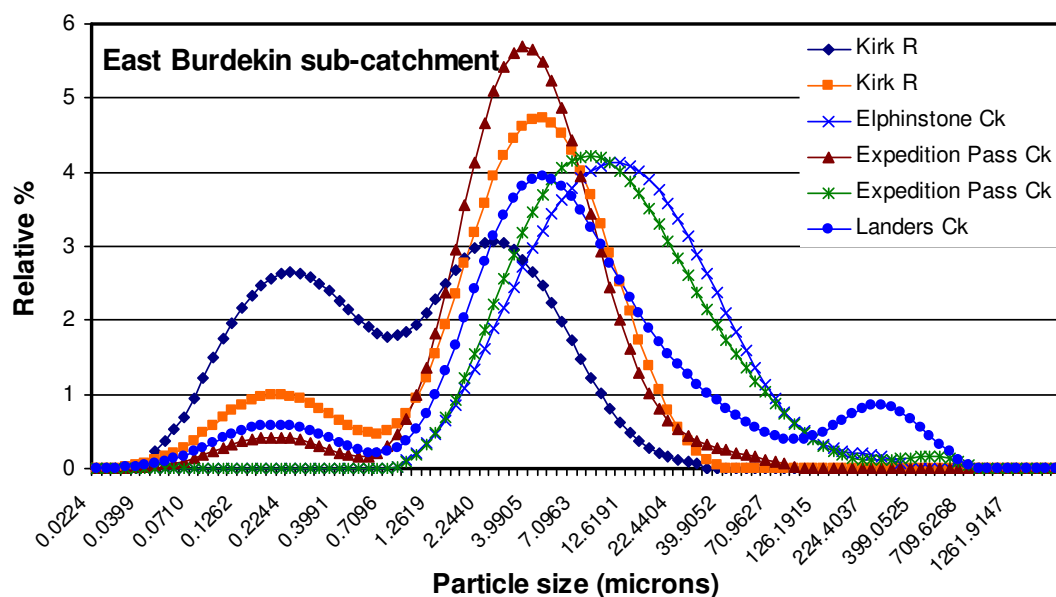


Figure 18: Particle sizing data for the tributaries of the East Burdekin sub-catchment.

h) Burdekin River (end-of-catchment) and Burdekin River plume

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 (Fig 19). A coarser sediment fraction occurred (dominant particle size between 3 and 45 μm ; peak at $\sim 11 \mu\text{m}$) 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 ($< 0.4 \mu\text{m}$). The average particle size distribution is consistent with the 'bulk average' particle size of several sub-catchments of the Burdekin River (Fig 20). 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.

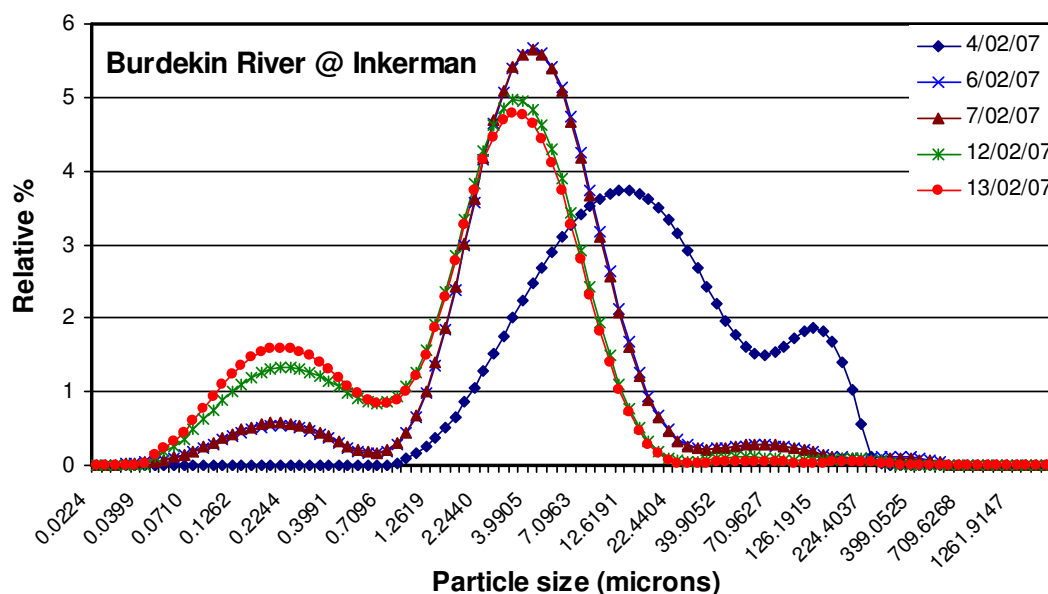


Figure 19: Particle sizing at the Burdekin River at Inkerman end-of-catchment catchment site.

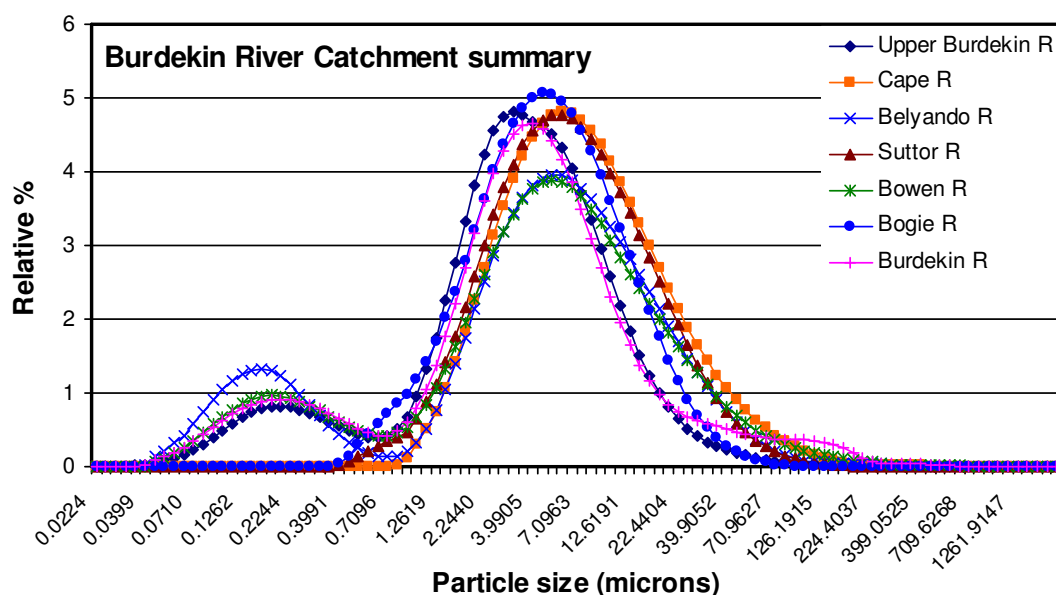


Figure 20: Particle sizing summary at major sub-catchments of the Burdekin River and the Burdekin River at Inkerman end-of-catchment catchment site.

The Burdekin River plume also displays some variability in particle size over the salinity gradient (Fig 21: note that the legend is in practical salinity units or PSU). 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 (see Fig 6). 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.

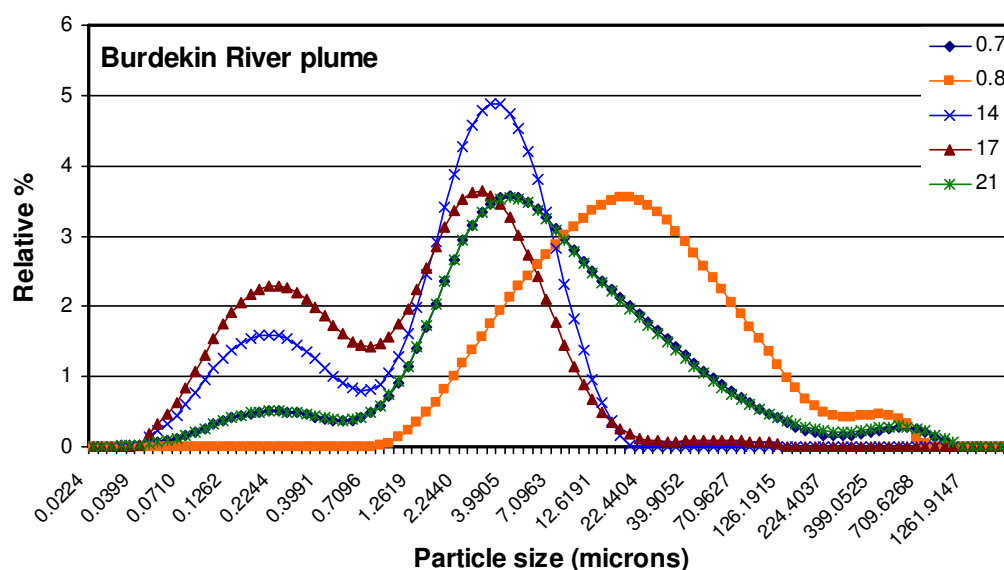


Figure 21: Particle sizing within the Burdekin River plume in the marine environment. Legend indicates the salinity units (in practical salinity units: PSU). 0.7 PSU=No 345; 0.8=No 348; 14=No 364; 17=No 361; 21=No 347 (see Fig 6).

i) Lower Burdekin and Don River sub-catchments

The coastal sub-catchments of the Burdekin Region also contained variable particle size distributions (Fig 22). 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 (Fig 22). 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.

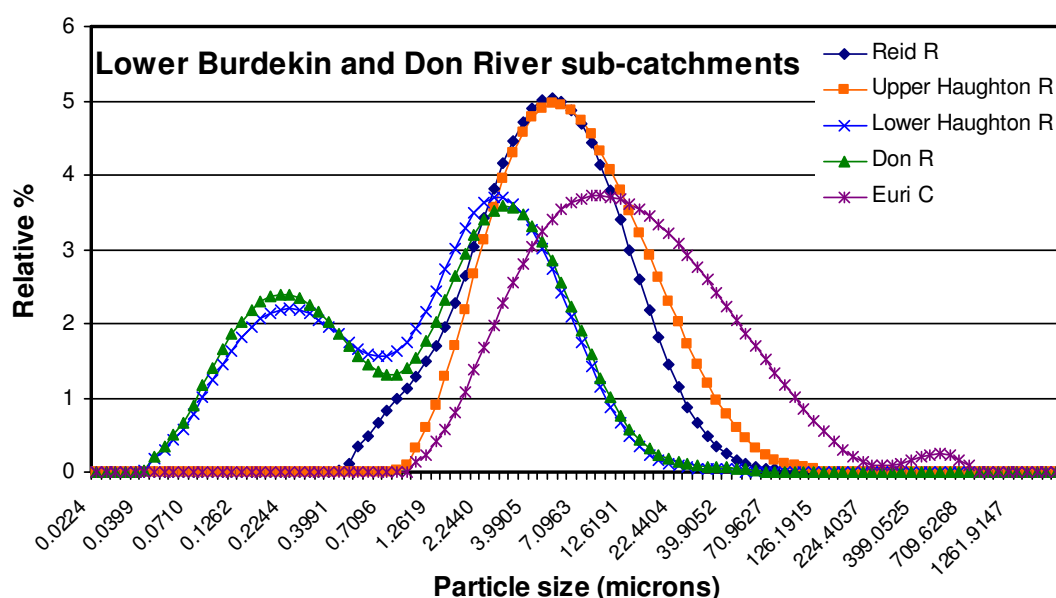


Figure 22: Particle sizing data for the tributaries of the lower Burdekin and Don River sub-catchments.

Water samples taken from the Burdekin River freshwater plume were analysed for trace elements by ICP-MS in March 2007. The ICP-MS analysis of these water samples will be rerun (due to some contamination issues), although preliminary analysis show the initial Ba desorption at very low salinities (~1 ppt) followed by a consistent dilution trend of Ba over the remaining salinity gradient (Fig 23). This trend is consistent with the 2002 flood plume from the Burdekin River (M. McCulloch pers comm.) and supports the interpretation of Ba/Ca ratios in corals as a proxy of sediment delivery to the Great Barrier Reef lagoon.

A comprehensive collection of daily satellite imagery from the 2007 flood plumes along the Great Barrier Reef allow the extent and movement of plumes to be traced over time as well as provide an understanding of biological processes occurring within the plume (Fig 24). Preliminary results suggest that the movements of the Burdekin plume may switch direction by 180 degrees within days. In addition, freshwater plumes throughout the GBR lagoon became a 'green' colour within two-three days of sunlight (Fig 25); this finding provides an insight into the timeframes of biological activity in the flood plume (J. Brodie, unpublished data).

Samples for pesticide analysis were collected from the flood plumes from the Burdekin and Tully Rivers in 2007. These results should become available by August. Data from the Haughton River and Barratta Creek plumes (Fig 26) from February 2007 show the presence of diuron and atrazine in the plume waters (Fig 27). These concentrations were below marine guidelines, although these concentrations would possibly have been higher if this flood event had occurred earlier in the wet season (e.g. November- when pesticides are applied). No pesticide residues were detected in the Burdekin River plume.

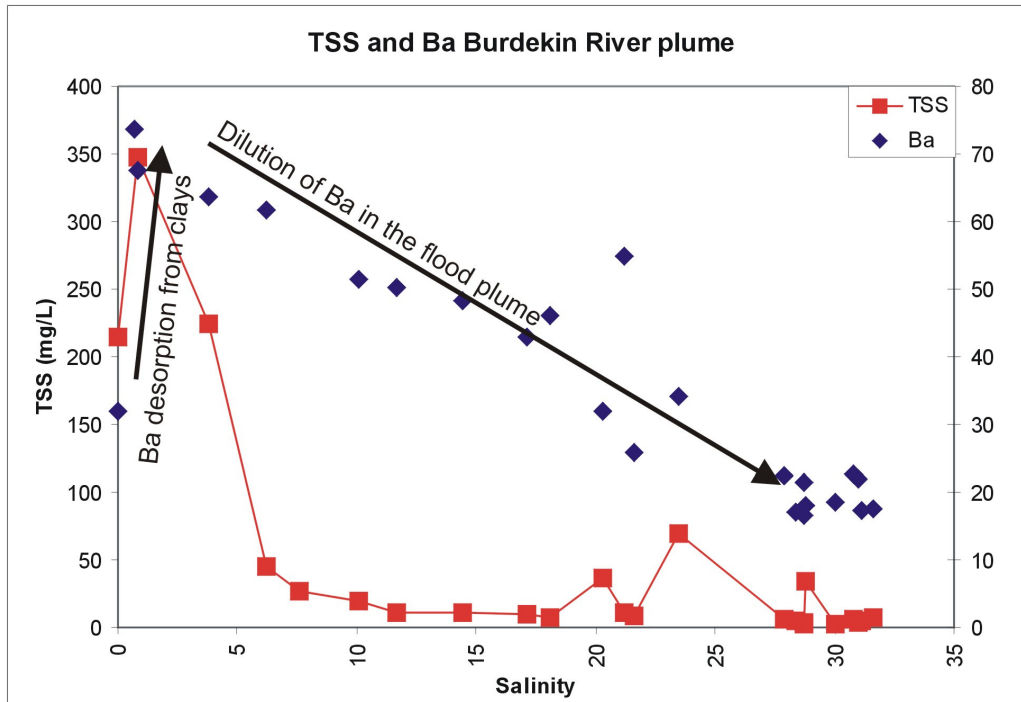


Figure 23. Graph of total suspended solids (TSS) and barium (Ba) concentrations over the salinity gradient in the Burdekin River flood plume. The data show that TSS concentrations decrease rapidly in the flood plume by the 10 ppt salinity zone where the majority of sediments have settled out in the plume. The Ba concentration follows a considerably different trend where Ba becomes desorbed from clays at low salinities and is then slowly diluted as the plume mixes with seawater. This trend supports the coral Ba/Ca proxy of sediment delivery to the GBR lagoon.

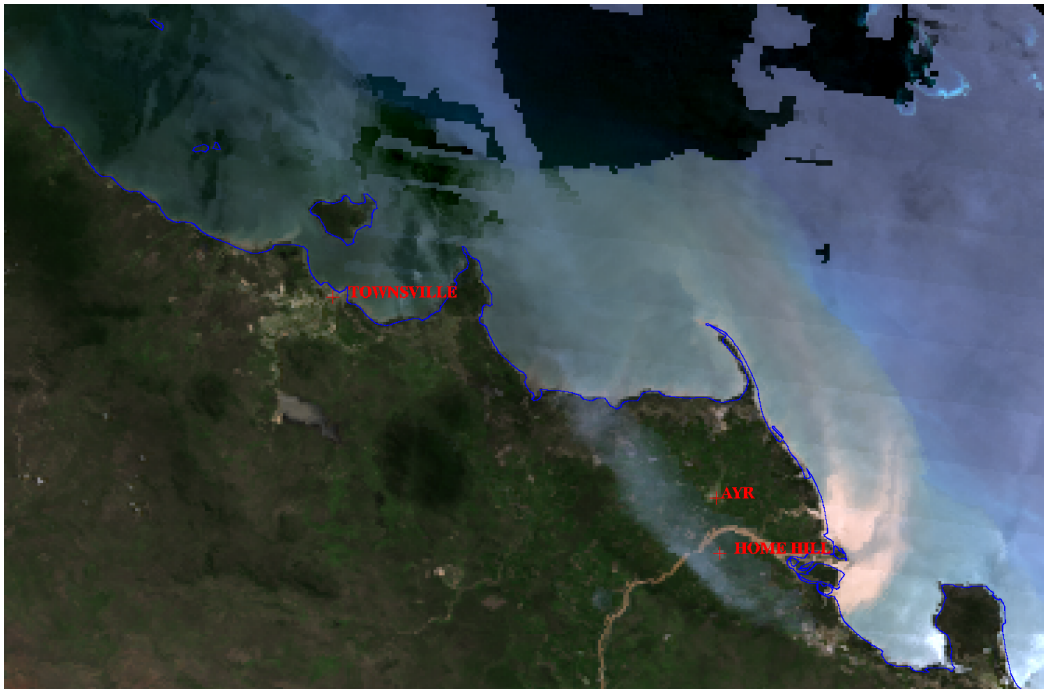


Figure 24. Satellite image of flood plumes from the Burdekin River and the Haughton River and Barratta Creek on the 9th February 2007. The data show the plume to undertake a primarily northward direction, although the Burdekin plume took a southward direction later in the flow event.

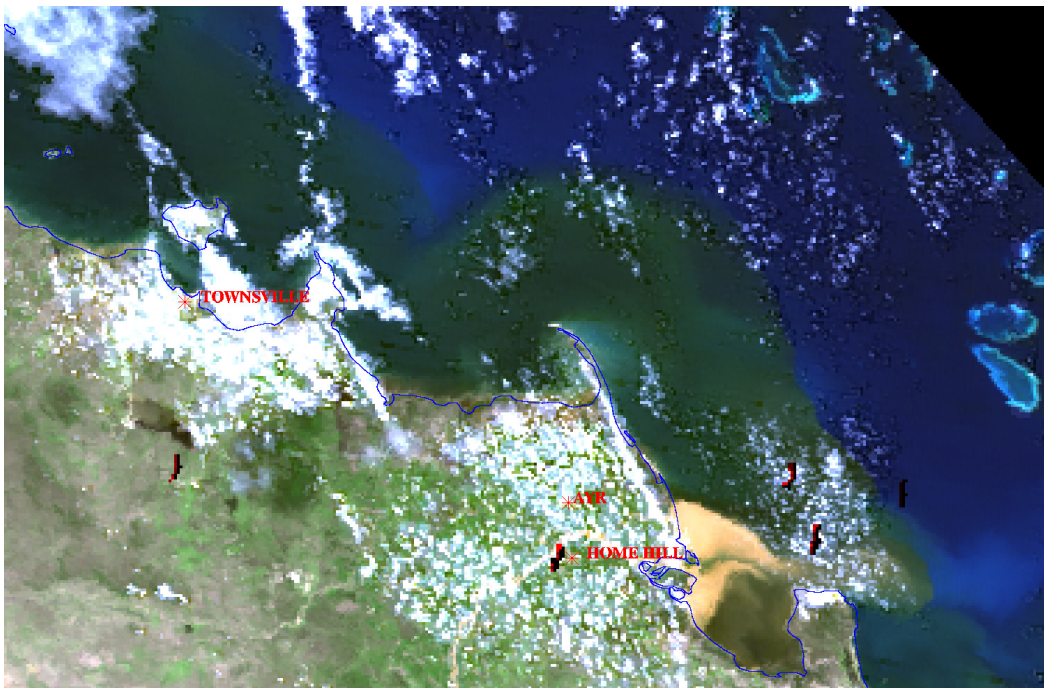


Figure 25. Satellite image of flood plumes from the Burdekin River and the Haughton River and Barratta Creek two days later on the 11th February 2007. The image shows that within a couple of days the flood plume “turns green” which indicates increased biological productivity.

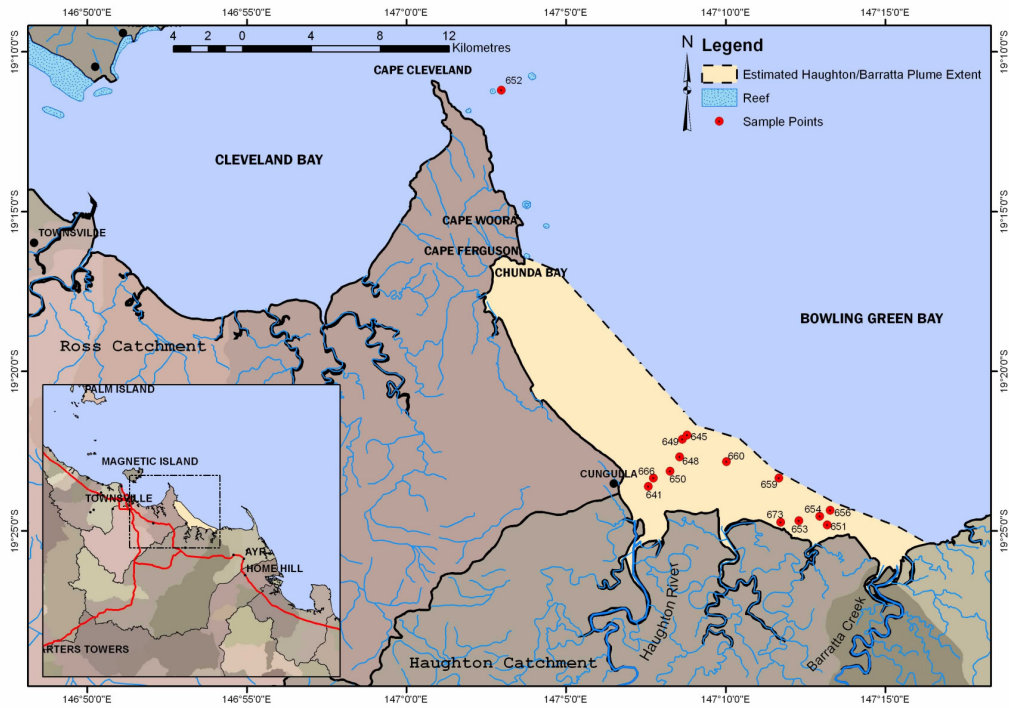


Figure 26. Map of sampling points for the Haughton River and Barratta Creek flood plume. The dotted line represents the estimated extent (by both visual and some GPS points) of the plume on the day (3rd Feb 2007).

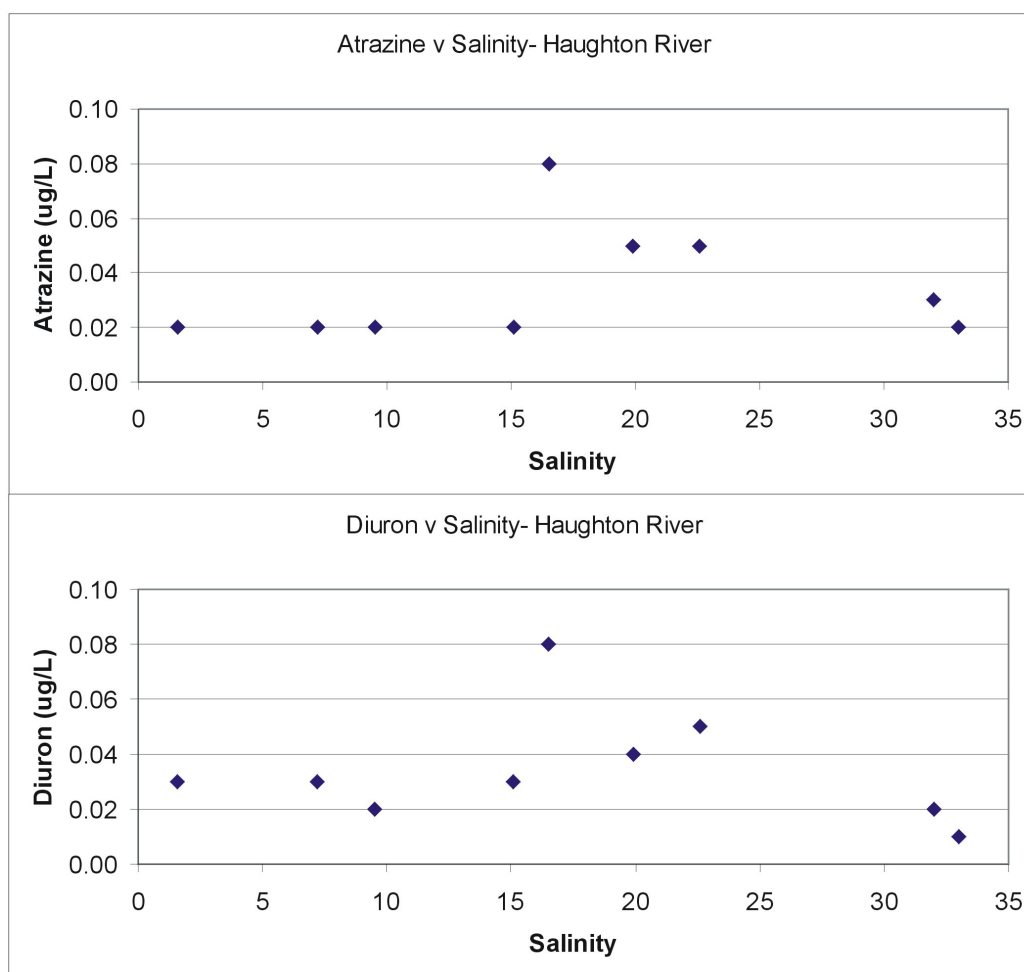


Figure 27. Diuron and atrazine residues were detected in the Haughton River and Barratta Creek flood plumes (example from the Haughton River transect). These concentrations were below the marine guidelines.

The estimates of relative sediment contribution to the Burdekin end-of-river catchment have been considerably improved by the knowledge of sediment trapping by the Burdekin Falls Dam. The sampling of the overflow from the dam over the last two wet seasons along with the flow gauge data have allowed sediment loads to be calculated and so the contribution of sediment from the catchments above the dam to the end-of-catchment export can be determined (Tables 1 and 2). Moreover, sediment loads from the major contributing sub-catchments above the dam allow for an estimation of sediment trapping to be made (Tables 1 and 2). However, we note that this process involved some assumptions which may considerably alter our estimates. The main assumption is that the suspended sediment samples collected from the left edge of the Burdekin River below the dam are representative (homogenous) of the entire river. Cross river sampling of the upper Burdekin River during large flows have shown that, in some cases, the TSS samples collected from the edge of the river may be up to half the concentration of the sample taken from the middle. In addition, sediment loads from the major sub-catchments above the dam are predominately based on samples collected from the middle of the river. If this relationship holds true for the Burdekin River at the dam, then sediment loads for the Burdekin Dam overflow will be underestimated and thus sediment trapping estimates would be overestimated. While we believe that sediment concentrations would probably be well-mixed at the dam wall, further research is required to validate this key assumption. The second assumption we have made is an estimation of sediment and flow contribution of the East Burdekin catchments above the dam. These estimates have been made based on the data available.

Flow data have been estimated based on the difference of the dam overflow and the flows from the other gauged major sub-catchments as well as considering dam capacity prior to the wet season. TSS concentration data are based on sampling from the Kirk River and Elphinstone Creek. The third assumption is that all suspended sediments measured in the major sub-catchments above the dam have equal potential to pass through the dam. Particle size data from these sub-catchments support this assumption as the range in particle size in the dam overflow is consistent with the other major sub-catchments above the dam (Fig 15). However, more complex relationships such as the settling/flocculation potential of these sediments is unknown. While measurements in the 2007 wet season showed that the upper Burdekin major sub-catchment may also produce a finer particle size fraction, the fact that lagoons in the upper Burdekin become clear in the dry season and that lagoons in the Belyando-Suttor catchment remain turbid suggests that settling/flocculation potential of sediments may play an important role in the Burdekin catchment.

Based on our above (best available) assumptions, we estimate that the Burdekin Falls Dam trapped 88% of sediment in the small 2006 flow event and 62% in the larger 2007 wet season. Because of our assumption based on samples collected from the edge of the Burdekin Dam overflow, we note that these estimates are probably at the higher range. These trapping estimates are considerably higher than the 2005 estimate (15%) which was based on limited sampling data and a number of assumptions (Bainbridge et al., 2006a). The 2005 estimate has now been superseded by the subsequent wet season data. The range of sediment trapping estimates of the 2006 and 2007 wet season are within the average predicted by the SedNet model (77%). We consider that the sediment trapping in the 2007 wet season is more representative of an average wet season and that the SedNet estimate may need to be adjusted to 60%, although more data is required before this recommendation can be made.

Table 1: A summary of the flow and sediment loads from the Burdekin sub-catchments above the dam in the 2006/07 wet season.

	Sub-catchment	Total flow (ML)	Proportion of total flow	Sediment load (tonnes)	Proportion of sediment load	TSS EMC (mg/L)
Above Dam	Burdekin River @ Sellheim	4,100,000	75%	2,800,000	88%	683
	Cape River @ Taemas	740,000	13%	175,000	5%	236
	Belyando River @ Gregory Dev Rd	194,400	4%	92,300	3%	475
	Suttor River @ Mt Coolon Rd	360,000	7%	97,500	3%	271
	Other above dam (e.g. Kirk R. Elphinstone C. Sellheim R.) estimate*	105,600	2%	35,200	1%	333
	Inflow to Dam	5,500,000	100%	3,200,000	100%	582
Below Dam	Burdekin Falls Dam overflow	5,100,000		1,200,000		235

* TSS estimate based on using flow data and median TSS from the Kirk R. and Elphinstone C. The red text indicates where estimates have been made to the data or where the result has been calculated using the difference.

Table 2: A summary of the flow and sediment loads from the Burdekin sub-catchments above the Burdekin Falls Dam in the 2005/06 wet season.

	Sub-catchment	Total flow (ML)	Proportion of total flow	Sediment load (tonnes)	Proportion of sediment load	TSS EMC (mg/L)
Above Dam	Burdekin River @ Sellheim	2,400,000	79%	1,760,000	86%	733
	Cape River @ Taemas	90,000	3%	31,200	2%	347
	Belyando River @ Gregory Dev Rd	243,700	8%	115,000	6%	472
	Suttor River @ Mt Coolon Rd	273,000	9%	135,000	7%	495
	Other above dam (e.g. Kirk R. Elphinstone C. Sellheim R.) estimate*	30,300	1%	10,800	1%	356
	Inflow to Dam	3,037,000	100%	2,052,000	100%	676
Below Dam	Burdekin Falls Dam overflow	1,400,000	70%	242,000	48%	173

* TSS estimate based on using flow data and median TSS from the Kirk R. and Elphinstone C. The red text indicates where estimates have been made to the data or where the result has been calculated using the difference.

Several communication outputs have occurred in this project mainly in the form of seminar presentations. These include:

1. *European meeting of the ISRS, Bremen, Sept, 2006.*

“Massive phytoplankton bloom in Great Barrier Reef lagoon follows river discharge in central Queensland, Australia”

Jon Brodie, Ken Rohde, John Faithful, Bronwyn Masters, Arnold Dekker

2. *ACRS, MISSION BEACH*

“Herbicide residues in the Great Barrier Reef: sources and risk”

Jon Brodie

3. *AMSA, Cairns, 2006*

“Massive phytoplankton bloom in Great Barrier Reef lagoon follows river discharge in Mackay Whitsunday region, central Queensland”

Jon Brodie, Ken Rohde, John Faithful, Bronwyn Masters, Arnold Dekker

4. *Lower Burdekin*

Water Quality Forum

Tuesday 29th. AUGUST 2006

“Water quality issues in the lower Burdekin: featuring herbicides”

Presentation by Jon Brodie.

5. *PESTICIDE WORKSHOP*

Bioscience Precinct (QUT)

306 Carmody Road

St Lucia QLD

Monday 23rd October 2006

“Pesticide residues in flood plume waters off the Mackay Whitsunday Region and risk to marine ecosystems”

Jon Brodie, Ken Rohde, John Faithful, Bronwyn Masters, Bob Noble

6. *APVMA BOARD VISIT to NORTH QUEENSLAND, Cairns, 3 May, 2007*

“Herbicide residues in the Great Barrier Reef Region: Sources and risk”

Jon Brodie

7. *Pesticides and the Sugar Industry: A way forward in the Burdekin.*

Wednesday 6th June Seagulls Resort, Townsville

“Herbicide residues in the Great Barrier Reef Region: Sources and risk”

Jon Brodie

8. *Pesticides and the Sugar Industry: A way forward in the Burdekin.*

Wednesday 6th June Seagulls Resort, Townsville

“Pesticide residues in the lower Burdekin and Don River catchments”

Stephen Lewis, Aaron Davis, Jon Brodie, Zoë Bainbridge, Vivian McConnell, Mirjam Maughan

9. *Presentation to CSIRO staff (and project collaborators)*

“MTSRF sediment tracing in the Burdekin River catchment”

Stephen Lewis, Zoë Bainbridge, Jon Brodie

10. *AMSA, Cairns, 2006*

“Water quality monitoring of sediments and nutrients in the Burdekin Region”

Zoë Bainbridge, Jon Brodie

Explanation of Activity changes

There are no foreseen changes to the planned activities for the next milestone period.

Problems and opportunities

The ICP-MS machine at UQ has broken down and this has delayed the ICP-MS trace element results.

Communications, major activities or events

During milestone reporting period

The water quality day of the MTSRF workshop (18th April) was attended by Jon Brodie, Stephen Lewis and Zoë Bainbridge. Communications have been held with the UQ laboratory on the trace element and isotopic analysis of sediment samples for tracing purposes. In addition, communications have been held with Prof. Malcolm McCulloch for the trace element analysis of the water samples from the Burdekin River freshwater plume. Jon Brodie, Zoë Bainbridge and Stephen Lewis attended an ARC (linkage) water quality workshop ("Long term changes to Mackay Whitsunday water quality and connectivity between terrestrial, mangrove and coral reef ecosystems: clues from coral proxies and remote sensing records") in Mackay. Jon Brodie presented a seminar on the 2007 satellite imagery of the freshwater plumes in the GBR lagoon at this workshop.

This project has formed valuable collaboration ties with MTSRF program 3.7.2 (sampling of Tully flood plume), the Burdekin Dry Tropics NRM (BDTNRM) water quality monitoring program of the Burdekin sub-catchments and flood plume (samples collected also for suspended solid and nutrient concentrations) and BDTNRM CCI pesticide investigation in the lower Burdekin (pesticide measurements in the lower Burdekin sub-catchments and in freshwater plumes). In addition, collaborative arrangements have been made with the Mackay Whitsunday NRM to sample flood plumes from the Mackay region and also with the Great Barrier Reef Marine Park Authority through their pesticide Marine Monitoring Program. The extension project of 3.7.2 has also formed collaborative links with the Australian Institute of Marine Science (Dr Janice Lough and Eric Matson) to collect coral cores throughout the Whitsunday Island Group to investigate and quantify historical changes in sediment and nutrient delivery.

During next milestone reporting period

By the next milestone period, preliminary analysis of sediment samples taken from the Burdekin River catchment and freshwater plume should be available.

Forecast variations to planned milestones

None.