

What happens when it rains in the Logan-Albert Catchment?

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Introduction

A low pressure system located off the coast of South East Queensland (SEQ) near Fraser Island produced steady rain across the region during the first week of January 2008 (Figure 1a). This steady rainfall saturated soils in the catchments so that the intense rainfall that occurred overnight on Friday 4th January (Figure 1b) in a number of the southern coastal systems, including the upper catchment of the Logan and Albert Rivers, resulted in flash flooding. A full flood report is available on the Bureau of Meteorology website (http://www.bom.gov.au/hydro/flood/qld/fld_reports/DRAFT_South_East_QLD_Floods_January_2008.pdf). A second less intense but more widespread rainfall event occurred on the 5th February in the lower catchments (Figure 1c), again causing localised flooding in the Albert and Logan Rivers.

These floods, which followed an extended period of drought, provided an opportunity to measure the effects of large rain events and their resulting loads of freshwater, nutrients and sediment in the Logan and Albert Estuaries and Southern Moreton Bay (SMB). This was particularly relevant as it provided a rare opportunity to collect data to support improved hydrodynamic and ecological modelling in the region. Furthermore, it has enabled quantification of the loads of diffuse pollutants transported from the catchments, enhanced our understanding of the downstream effects of these loads, and resulted in an improved understanding of the catchment and in-stream processes associated with flooding.

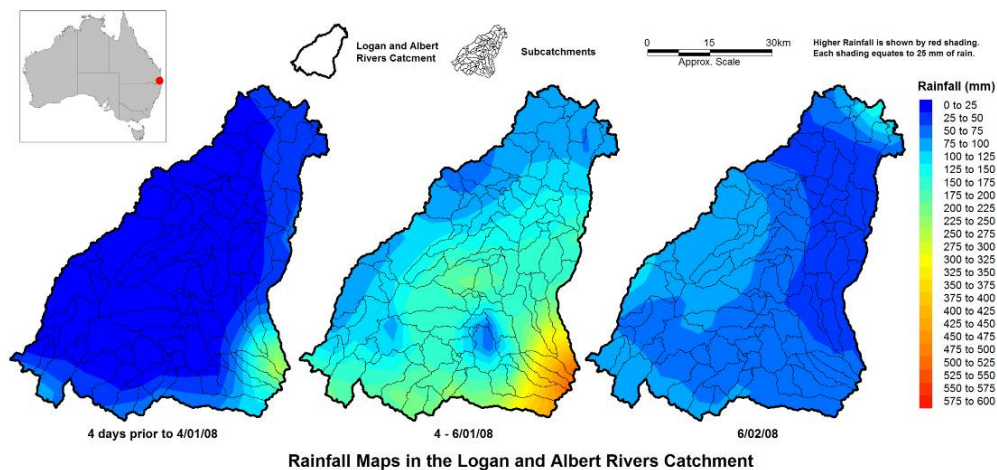


Figure 1. Maps of rainfall in the Logan and Albert Rivers catchment. Higher rainfall is shown by red shading. Each shade equates to 25mm of rain.

Study area and methods

The study was conducted in the Logan and Albert Estuaries and SMB, South East Queensland (Figure 1). Stream flow data was collected at gauging stations located near to the freshwater outflow of the Logan and Albert Rivers (Figure 2). Water quality samples were collected throughout the duration of the flood event at the gauging stations and analysed for sediment and nutrient concentration. Catchment loads of nutrients and sediments were calculated using flow data and water quality sampling results. Soil samples were collected from various locations that were identified as potential sources of sediment eroded from the catchment during the January flood events. These included hillslope soils as well as actively eroding channel banks. Estuarine suspended sediment and deposited sediment samples were also collected along the estuarine reaches of the Logan and Albert Rivers. Samples were analysed to determine a soil signature through the use of “fallout” tracers (^{210}Pb , ^{137}Cs , Pu) and major and minor elements.

Sampling of the Logan and Albert Estuaries and SMB was carried out on seven occasions between January and March 2008 (Figure 3) at 32 sites (Figure 2). Parameters measured were: salinity, temperature, pH, turbidity and dissolved oxygen. In addition, samples were collected for laboratory analysis of total suspended solids (TSS), nutrients (NH_4 , NO_x , DON, TP) and chlorophyll *a*. Refer to EHMP Annual Technical Report 2006-07 (2008) for more detailed methods. Nutrient limitation of phytoplankton was determined for all SMB sites using a PhytoPAM and horizontal tows were undertaken to collect phytoplankton and zooplankton samples (mesh size 100 μm). Seagrass depth range data was collected by field observation.

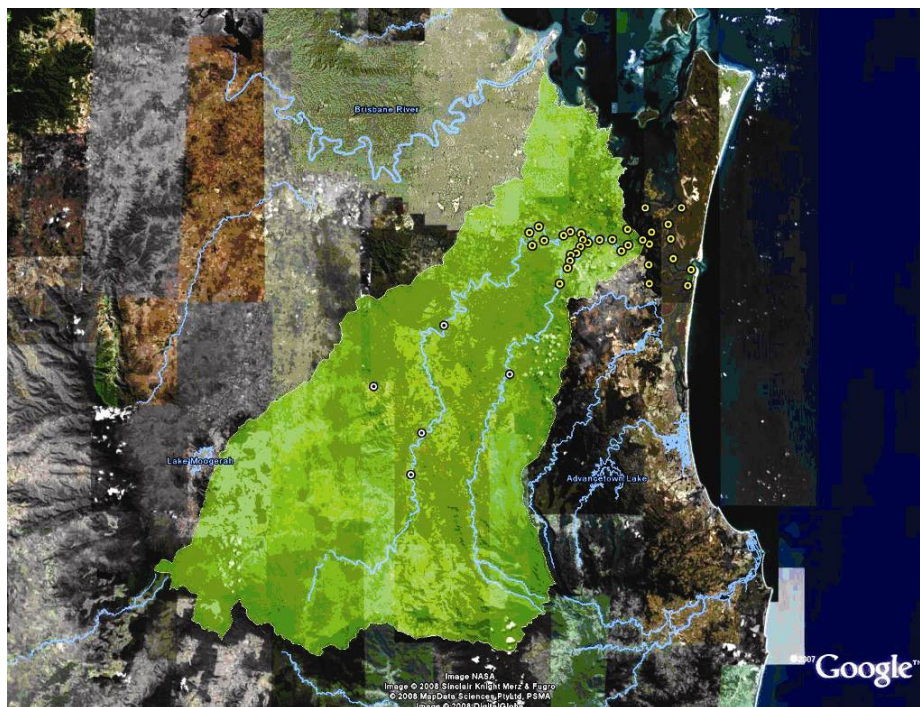


Figure 2. Satellite image of the Logan and Albert Rivers and SMB. Yellow circles show the 32 sampling sites where data were collected during the study. White circles show the locations of sampling stations at which catchment load and flow data were collected.

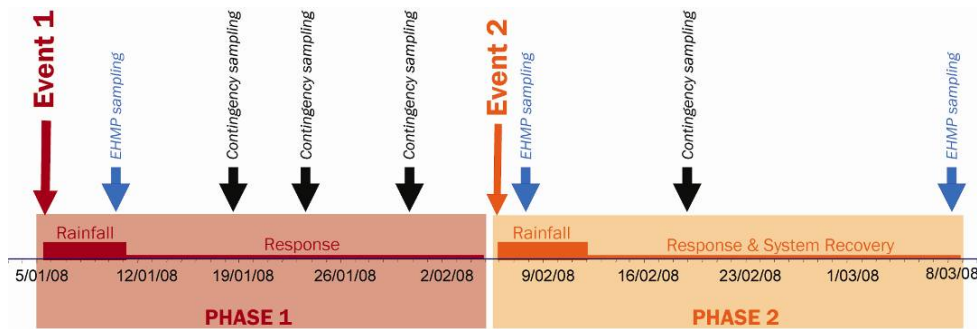


Figure 3. Time line of sampling effort during the event showing sampling dates and rainfall events. These are discussed in detail below. Sampling dates were determined through consultation with experts who were provided with up to date data collected during the study. Blue arrows show dates of regular EHMP sampling, black arrows shows dates of additional contingency sampling.

Results

Two significant rainfall events in the Logan and Albert Rivers catchment were monitored. The first occurred on the 5th of January 2008 and the second on the 7th of February 2008. Results associated with these two rainfall events indicate what occurred during and immediately after each event (rainfall phase) and in response to each event (response phase).

Flows associated with the first rainfall period were determined to be a 1 in 10 yr ARI (Annual Recurrence Interval) with 264 GL of freshwater (equivalent to the volume of 116,000 olympic swimming pools) discharged to SMB. This is 65% of the average annual runoff from the Logan and Albert Rivers catchment and is approximately equivalent to the volume of water in SMB. The Logan and Albert Estuaries were flushed fresh for more than 7 days and salinity of SMB also decreased for that period. Eroding channel banks were identified as the primary source (60-70%) of sediments delivered to the estuaries during the flood event, with topsoil from grazed land contributing about 30%. Other sediment was derived from national park forest. Table 2 highlights the episodic nature of rainfall events this size in the Logan and Albert Rivers catchment.

		Loads discharged into SMB 2008	Annual average loads (past 10 yrs)	Flood	Annual average
Rainfall Phase 1	Sediment	213,259 tonnes	30,000 tonnes	6,100 dump trucks	857 dump trucks
	Nitrogen	610 tonnes	460 tonnes	17.5 dump trucks	13 dump trucks
	Phosphorus	276 tonnes	50 tonnes	8 dump trucks	1.4 dump trucks
Rainfall Phase 2	Sediment	25,253 tonnes	30,000 tonnes	722 dump trucks	857 dump trucks
	Nitrogen	134 tonnes	460 tonnes	3.8 dump trucks	13 dump trucks
	Phosphorus	38 tonnes	50 tonnes	1.1 dump trucks	1.4 dump trucks

Table 2. Comparison between loads discharged into Southern Moreton Bay (SMB) during the two flood events and the modelled average annual loads from this catchment. As an indication of the relative amounts of sediment and nutrients discharged to the estuary and bay, the number of 35 ton dump trucks needed to carry these loads is shown. Note that there is a low reliability of calculating loads because of difficulties with sampling during events.

Rainfall phase 1 (7 days)

There was significant freshwater input and associated catchment loads during the first week of the event. Both estuaries became highly turbid (levels were 7 times greater than normal in the Logan Estuary and 1.5 times greater than normal in the Albert Estuary). The estuaries had increased concentration of organic nitrogen (2 times normal), which is indicative of the catchment origin of the material. Dissolved oxygen decreased in the mid reaches of the estuaries, an indication that organic material was being broken down by bacteria. Dissolved inorganic nitrogen (DIN) decreased following the flood, indicating that sewage derived nutrient was flushed out of the system and that very small amounts of inorganic nitrogen were delivered from the catchment. Chlorophyll *a* was low during the first week, indicating that little primary production took place in the estuary. This probably reflects low residence times of estuarine water as a result of the significant flows of freshwater into the system. Low levels of pesticides associated with agriculture were detected. Concentrations were low because of dilution by the large volume of water associated with the flood.

Water flowing into SMB did not stay resident in the system for long periods, and flow discharged rapidly through Jumpinpin. The freshwater inflow to SMB resulted in salinity being lower than normal. Nitrogen (DIN & DON) concentrations in SMB increased during the first week. Chlorophyll *a* concentrations in the bay were higher than before the flood indicating that a biological response to the nutrient load had occurred at this early stage despite the increased turbidity and reduced residence times associated with runoff of flood waters.

Response Phase 1 (21 days)

In the three weeks following the initial rainfall event salinity in the estuaries began to increase marginally as freshwater flows decreased and were mixed with incoming oceanic water. Total suspended solids varied, ranging from significantly high levels at times to being fairly low at others. This indicates that in addition to the catchment loads, other physical processes within the estuary such as tidal or wind mixing, may be influencing the levels of suspended sediment in the system. Secchi depth, an indicator of light penetration into the water, increased over the three week period as turbid waters were gradually mixed with incoming seawater. Phytoplankton biomass increased along the extent of the Logan and Albert Estuaries (up to four times higher than background levels).

In SMB concentrations of nitrogen and phosphorus did not restrict growth rates of phytoplankton for the first week. As nutrient concentrations decreased in SMB, phytoplankton growth became limited by nitrogen. Phytoplankton biomass increased to 2.5 times background levels over the three week period. The phytoplankton community became less diverse over the three week period and were dominated by individuals of *Skeletonema costatum*, a small rapidly growing, chain forming diatom which is able to tolerate a wide range of salinities. This species was also reported to dominate the phytoplankton community following the floods in 1996 (Heil et al. 1998).

Rainfall Phase 2 (7 days)

The second rainfall event took place on the 7th February. Rainfall took place on a saturated catchment and fell predominantly in the highly urbanised lower catchment. This resulted in rapid flows of freshwater, and associated loads of sediment and nutrients, into the Logan and Albert Estuaries and SMB.

Salinity in the estuaries decreased significantly and the Logan Estuary became fresh to its mouth. Despite the rainfall event being smaller than the event on 5th January (Table 2), nutrient (total nitrogen and phosphorus) concentrations in the estuaries were almost double those following the first event in early January. Chlorophyll *a* concentrations declined significantly immediately after the rainfall, probably as a result of increased flows transporting algae out of the estuary and bay into the ocean. Suspended sediment and turbidity levels

increased significantly and corresponded with a decline in Secchi depth. Dissolved organic nitrogen concentrations were twice those found after the first event. Dissolved oxygen decreased in the Logan and Albert Estuaries, although decreases were more significant in the Logan Estuary than in the Albert. Dissolved oxygen in the lower Logan Estuary declined to about 4.2 mg/l, the lowest levels recorded over the flood monitoring period. This may reflect the influx of organic material discharged into the estuary during the rainfall event.

In SMB salinity decreased but not to the same levels as following the previous event (30 ppt compared to 20 ppt in January). Similarly nutrient (total nitrogen and phosphorus) concentrations increased in SMB, but not as significantly as following the January event. Secchi depths declined to levels less than those following the January event. Chlorophyll *a* concentrations declined to similar levels to those which were measured in the week after the January event. Phytoplankton were dominated by *Skeletonema costatum* and had low species diversity. Similar to after the first flood episode, phytoplankton growth was not limited by any nutrients. Nutrient limitation studies indicated that following the influx of freshwater, phytoplankton may have become stressed for a short period.

Response Phase 2 and system recovery (30 days)

In the estuaries salinity gradually recovered and was approaching pre-event levels at the culmination of the contingency monitoring program. Suspended solids decreased significantly over the time span but remained variable, probably reflecting that sediment loads from the catchment were not the only driver of suspended solids in the estuaries. Soil and sediment sampling indicated that most of the sediment that reached the estuary was derived from eroding channel banks (60-70%) with topsoil from grazed land contributing about 30%. Other sediment was derived from national park forest. Secchi depth increased each week following the second episode, reaching pre-flood levels after 3 weeks (from 0.15 metres to between 0.4 – 0.7 metres). Nitrogen (DIN and DON) concentrations increased initially two weeks after the second rainfall episode and then decreased rapidly over the following three weeks until they reached pre-event levels. Chlorophyll *a* concentrations reached extremely high levels by the end of the contingency monitoring sampling program, with concentrations in the Upper Logan and the Albert Estuaries reaching higher levels than were recorded after the first rainfall episode. Dissolved oxygen increased substantially over the period following the second rainfall episode. The high levels of dissolved oxygen on the final sampling occasion were probably a reflection of the high algal biomass which was present at the time and which would have produced substantial oxygen through photosynthesis.

In the three weeks after the second rainfall episode, salinity in SMB increased gradually to slightly below pre-event levels of approximately seawater salinity. Nutrient (total nitrogen and phosphorus) concentrations decreased significantly over the period to pre-event levels. Inorganic nitrogen concentrations were very low by the end of the sampling regime, suspended solids remained fairly constant. Secchi depths showed a similar pattern to salinity showing that as saline oceanic water flushed the bay, the water became more transparent and light was able to penetrate deeper into the water. Phytoplankton growth was initially unlimited by any nutrients while the water was saturated following the floods, as inorganic nitrogen concentrations decreased, the phytoplankton became limited by nitrogen. Phytoplankton continued to be dominated by *Skeletonema costatum* although the extent of its dominance decreased over time and plankton diversity increased to pre-event levels. On the final sampling occasion the phytoplankton community was dominated by a species of *Chaetocerus*, a larger chain forming diatom. Chlorophyll *a* concentrations initially increased substantially to well above ambient concentrations and then decreased over a three week period to pre-event levels probably the result of a combination of estuarine flushing, nutrient limitation and zooplankton grazing. Comparison of seagrass depth ranges before and after the event did not detect any differences. This does not necessarily mean that seagrass distribution and seagrass health were not affected by the flood events.

Take home message

The two flood events in the Logan and Albert Rivers catchment discharged approximately 65% of the average annual freshwater runoff into SMB (the larger event was equivalent to a 1 in 10 year event at the end of the catchment). This runoff delivered substantially greater than expected loads of nitrogen, phosphorus and sediment into the Logan and Albert Estuaries and SMB. Despite the massive freshwater runoff into the bay, oceanic flushing resulted in the salinity of the bay and estuaries returning to almost pre-event conditions within 2 months. Sediment and nutrient concentrations in the estuaries and bay initially rose substantially and then declined to pre-event levels within 2 weeks of each event. As a result of nutrient inputs, a non-toxic algal bloom of *Skeletonema costatum* formed in SMB for 5 weeks and then dissipated. The most significant and long lasting effect of the event was high concentrations of chlorophyll *a* in the estuaries that rose constantly after the two events and did not decline for three months. This study has demonstrated the importance of event based monitoring, supplementary to the Ecosystem Health Monitoring Program, to better understand the effects of diffuse pollutants on river and coastal ecosystems.

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