Protecting Moreton Bay:
How can we reduce sediment and nutrients loads by 50%?

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Abstract:

Moreton Bay is under increasing pressure from urbanization and industrial development with more than a million additional people expected to move into the Bay's catchments over the next 25 years. Models of water quality indicate that just to maintain the Bay in its current condition we need to reduce the supply of sediment and associated nutrients by 50%. Are these ambitious targets achievable? How do we go about meeting such targets when resources aimed at improving water quality and habitat are limited? Studies commissioned by the Healthy Waterways Partnership over the last five years provide some answers to these questions. We present a summary of those studies and show how modelled sediment and nutrients budgets (SedNet), sediment tracing, and water quality monitoring data, can be used to identify the primary sources of material entering the Bay. We show that targeted erosion control will provide more than three times the reduction in suspended sediment and associated nutrients exports than would occur if the remedial works were broadly applied. The results show that treating 20% of catchment stream channel length will reduce sediment export by approximately 50%, and that revegetation and control of channel erosion is the highest priority for treating the diffuse sources. The approach can be applied in all large river systems where water quality problems need to be targeted.

Key words: catchment management; erosion; sediment budget; sediment tracing; SedNet.

Introduction

The following provides a summary of points covered in the presentation.

The settlement and development of Southeast Queensland has significantly altered the landscape, riverine, and estuarine environments. Many Australian studies have shown large increases in erosion and sediment delivery as a result of land use changes following European settlement. The effects of European land management practices in the Moreton Bay catchment are no different, and are summarized in Neil (1998) and Capelin et al.. (1998). Before settlement the catchment was in a relatively stable condition with periodic cyclones and aboriginal fire management practices the only substantial disturbance. The impacts of European development and settlement in the catchment led to significant increases in sediment export. This resulted from the extensive clearing in upper parts of the catchment, cultivation on the floodplains, extensive over-grazing, and development of urban centres. Over the entire catchment, only about 25% of the original vegetation remains and sediment loads to the Moreton Bay are now 30 times the pre-European rates (NLWRA, 2001).

The Bay and it catchments are under increasing pressure from urbanisation and industrial development with more than a million additional people expected to move into the region over the next 25 years. Degradation of habitat and water quality has caused widespread concern in the community, and in all levels of government. The Moreton Bay Waterways and Catchments Partnership (MBWCP) is a major initiative to better understand and manage these problems. The MBWCP aims to develop a water management plan to protect and enhance the riverine and marine environments of Southeast Queensland. The initial research which was focused on Moreton Bay identified sediment and nutrients derived from the catchments as a major contributor to the degradation of aquatic habitats within the Bay (WBM Oceanics and Sinclair Knight Merz, 1995). Models of water quality indicate that just to maintain the Bay in its current condition we need to reduce the supply of sediments and nutrients by 50%. To achieve this with the limited resources available means that remedial action must be targeted to the most important sediment source areas in the Bay's catchments.

Sources of sediment delivered to the Bay

Three independent lines of evidence indicate that the Lower Brisbane River catchment, and particularly the Lockyer Creek catchment is the most important sediment source area for the Bay.

- Queensland Department of Primary Industries (1974) Moreton Region Non-Urban Land Sustainability Study noted that 14% of the rural land within the Moreton Bay catchment is subject to severe (hillslope) erosion, with the worst affected areas concentrated in the Bremer and Lockyer tributaries of the Brisbane River. Areas of moderate to slight erosion occur throughout the Moreton Bay catchment, but they are concentrated in the Locker and Upper Brisbane River catchments.
- Douglas et al., 2003 compared the geochemistry of sediments collected in the Bay with 47 soil samples collected from the principle rock-types in the catchment. They showed that over 50% of the sediment delivered to Moreton Bay is derived from soils developed on the Marburg Formation, extensive outcrops of which occur in the Lockyer catchment. The mix of contributing soil types, represented in the Bay sediments, indicates that the Lockyer catchment is the dominant source of sediment to the lower Brisbane River and the central Bay (Figure 1).
- The SedNet model developed for the National Land and Water Resources Audit (Prosser, et al., 2001) is a physically-based process model which constructs sediment and nutrient budgets of a river network and identifies the major sources, stores and loads of material. This model also identified the Lockyer catchment as the major source of sediment delivered to Moreton Bay. The model also indicates that of the 5,240,000 tonnes/year of sediment eroded in the Brisbane River's catchments, 95 % is deposited and stored on hillslopes, floodplains

and reservoirs, only 280,000 tonnes/year or 5% is delivered to the Brisbane River estuary and ultimately to the Bay. Of the sediment delivered to the Bay 80% is derived from less than <20% of the catchment area, mostly in the Lockyer catchment. While significant erosion and sediment sources are present in the upper Brisbane catchment most of the sediment eroded from this area is prevented from reaching the Bay by Wivenhoe Dam.

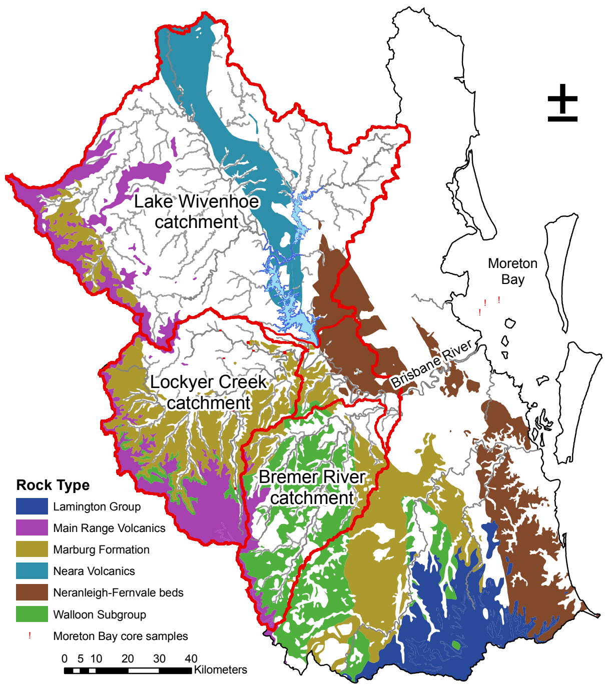

Figure 1. Major rock types underlying soils contributing most of the sediment to Moreton Bay

Erosion processes generating the sediment

Sediment and associated nutrients originate from erosion of hillslopes, and from gully and channel erosion. At the local level, it is common for either hillslope or gully/channel erosion to be the dominant source. The management of these two erosion types differs. For example, channel erosion is best managed by preventing stock access to streams, protecting vegetation cover in areas prone to gully erosion, revegetating bare banks, and reducing sub-surface seepage in areas with erodible sub-soils. Hillslope erosion is best managed by promoting groundcover, maintaining soil structure, and promoting deposition of eroded sediment in riparian zones before it reaches the stream. It is therefore important to be aware of the dominant type of erosion before attempting local or catchment-wide management to control it.

Two lines of evidence indicate that channel erosion dominate the sediment leaving the Lockyer Creek catchment:

- SedNet predicts that channel erosion dominates (60%) the material leaving the catchment. These predictions account for spatial variations in the rate of erosion, and also the probability of sediment being delivered to the catchment outlet given opportunities for deposition in reservoirs and on floodplains.

- Fallout radionuclides (Cs-137 and Pb-210) have been widely used to determine the relative contribution of hillslope and gully/channel erosion to stream sediments (Wallbrink et al., 1993, 1999; Walling and Woodward, 1992). As both fallout radionuclides are concentrated in the surface soil, sediments derived from sheet and rill erosion will have high concentrations of both nuclides, while sediment eroded from gullies or channels have little or no fallout nuclides present. By measuring the concentration in suspended sediments moving down the river and comparing them with concentrations in sediments produced by the different erosion processes, the relative contributions of each process can be determined. The data show that in the upper Laidley Creek catchment gully and channel erosion dominate, in the upper Lockyer Creek catchment hillslope erosion dominates and in the Lower Lockyer the data is consistent with 60% of the sediment being derived from channel erosion, as predicted from by the modelling.

Protecting the Bay

The weight of evidence from the tracing studies, the catchment scale modelling and field observations is that catchment works aimed at decreasing the supply of sediment to Moreton Bay should be focused on the lower Brisbane River catchment, particularly Lockyer Creek. Here we show the SedNet model predictions of which parts of the Brisbane River catchment make the highest suspended sediment contribution rates to the Brisbane River estuary. Figure 2 shows the areas contributing 50% of the exported suspended sediment, and ranks those areas into high, medium, and low delivery of sediment from gully and channel erosion. The relatively small area of hillslope erosion predicted to contribute at the highest rates is also shown without ranking. The areas of the catchment closest to the Brisbane River estuary are predicted to contribute the most sediment. This is partly because soil eroded in these areas has the greatest likelihood of being transported without being deposited along the way. Middle and upper parts of the catchment may also make significant contributions, particularly areas where the rates of erosion are high. The model predictions provide the best available overview of where to target remedial action that is most likely to reduce sediment delivery to the Brisbane River estuary, and ultimately to Moreton Bay. But, as discussed below, remedial action should not just be confined to these areas. In particular, the sediment tracing data indicates that stripping of sediment from floodplains during floods also contributes to sediment supply.

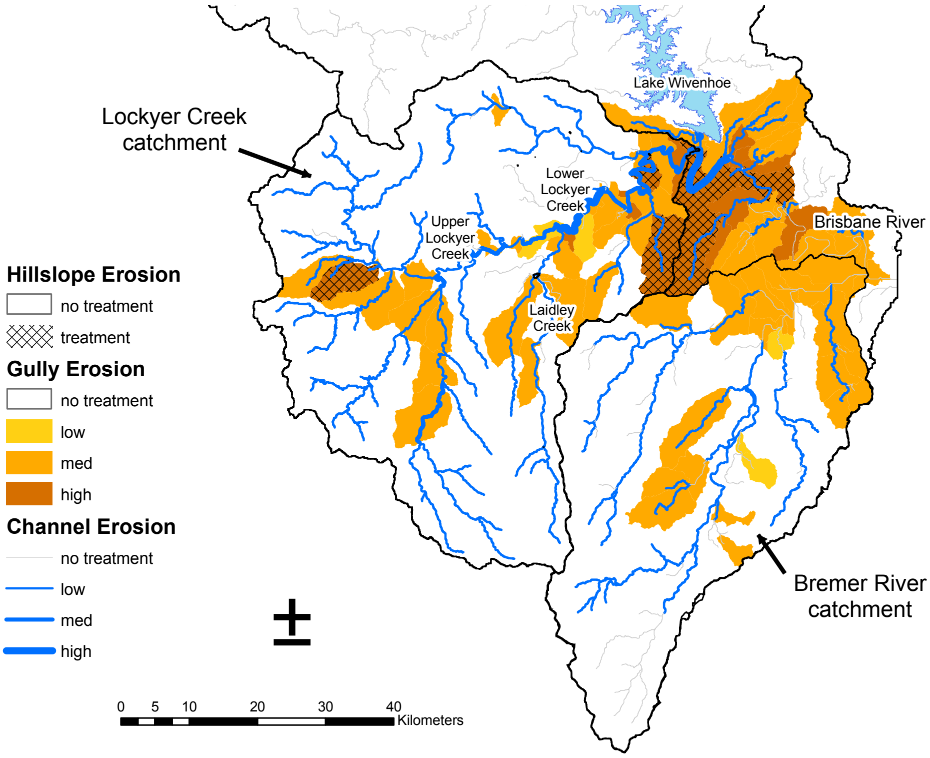

Figure 2. The highest production areas predicted by the SedNet model to contribute 50% of the suspended sediment load to the Brisbane River estuary

Figure 3 shows the reduction in suspended sediment export to the Brisbane River estuary that can be achieved by implementing different amounts of the treatments, targeting areas in descending order of contribution to export. The slope of the curve (reduction in export per km of treatment) is steepest when treating the highest contributing areas and declines as areas with less intense contribution (erosion and delivery) are treated. We estimate that a 50% reduction in sediment export can be achieved through a total 1,270 km treatment, including 610 km of bank revegetation (20% of the total stream channel downstream of Lake Wivenhoe, including all of the large streams identified for treatment in Figure 2), 440 km of gully revegetation and 240 km of hillslope buffer strips. If treatments are only 70% effective at reducing erosion due to difficulties in application the total treatment length increases to 2,900 km. Approximately 70% of the export reduction is predicted to come from reducing bank erosion.

Estimating treatment costs at $8,000 per km gives a total cost of achieving a 50% reduction in sediment supply to the Bay of between $10-23M, or less than $15 per head of population in Brisbane city. In contrast, if treatment is spatially randomly implemented the total treatment length required to reduce export by 50% is more than three times (9,000 km) that required if treatment is targeted. The benefit of targeting treatment here is typical of catchments where erosion and sediment delivery are strongly variable (Lu *et al.*, 2004, Wilkinson *et al.*, 2005)

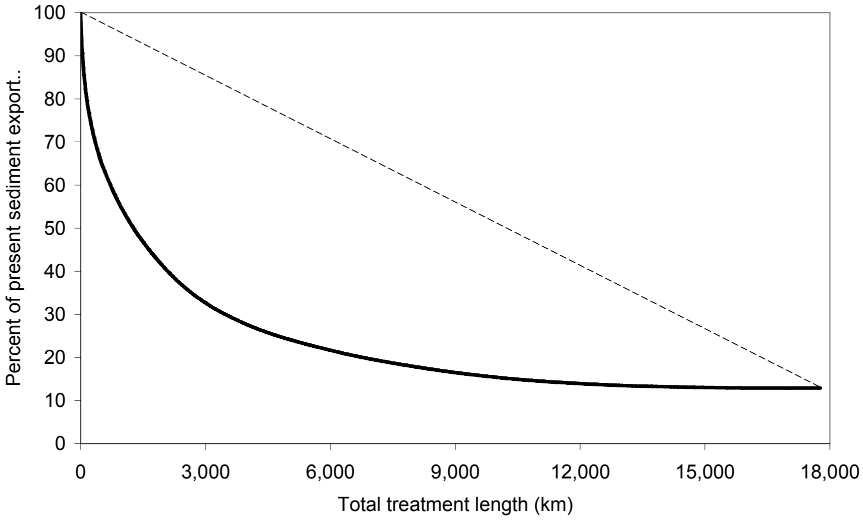

Figure 3: Reductions in suspended sediment export to Moreton Bay that can be achieved with different amounts of treatments. The solid line shows the response to treatment that is targeted in descending order of contribtion to export. The dashed line shows the approximately linear response that can be expected from spatially random treatment (Lu *et al.*, 2004)

Design principles

Many of the high priority treatment areas, particularly those for channel erosion are located in the lower catchment. Controlling channel erosion in these lower parts of the river system will be difficult because of the high erosion forces associated with peak flood flows in these reaches (Figure 2). Most of the annual runoff occurs in a few large events. Therefore, treatment should involve a combination of direct measures in these reaches and also measures in headwater reaches designed to slow the movement of runoff through the catchment.

Control measures need to take every opportunity to increase the infiltration and to slow water movement throughout the catchment. This is directly opposite to much of the *river improvement work* which has been carried out over the last 100 years. These works aimed to increase drainage and maximise channel efficiency by removing vegetation, straightening and confining channels, and removing any barriers to flow. In redesigning the catchment drainage network to protect the bay we need to decrease the efficiency of flow, install barriers, encourage vegetation and spread the flow both spatially and temporally. As well as providing protection for the Bay catchment works should be designed utilising ecological principles (eg Lake et al., 2006) to provide aquatic habitat, improve connectivity, and provide refugia (many forms of which may have been lost with degradation). This would improve the health of the river network as well as providing protection for the Bay.

While increasing infiltration and slowing the movement of water may slightly increase flooding and delay drainage, having a short-term negative impact on agricultural production, it will also increase the recharge of the groundwater aquifers providing more water for production during droughts. Given the current climate change scenarios this should make agricultural production in the Lockyer more sustainable.

Recovery times

Wallbrink et al., 2002 showed fine-grained sediment entering the estuary has been stored within the channel system for between 1 and 20 years. This indicates that mobilisation of long-term sediment stores in the channel is not a major source of sediment delivered to the Bay. This suggests that the response of this system to erosion control measures could be rapid and we should see improvement in the Bay within decades.

Strategies for implementation

Significantly decreasing the supply of sediment from the Lockyer catchment to Moreton Bay will involve redesigning the landuse patterns throughout the catchment. Strategies aimed at slowing water movement and decreasing erosion will involve taking land out of production. To make this viable we need to consider incentives which reward and make it economic to manage the catchment to protect the Bay. Catchment stewardship is something we should consider paying for.

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