Nerang River Estuary Study – Options for Managing Stormwater and Re-instating Ecosystem Services

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Key Points

- This paper outlines the findings of a study of the ecological health of the Nerang River Estuary and confirmed that urban stormwater runoff has a major impact on ecosystem function.
- Study findings suggest that estuary health improves in locations with remnant riparian and instream vegetation and it is proposed that rehabilitating the riparian zone may be a more cost effective way to improve estuary health than retro fitting stormwater devices into existing urban catchments.

Abstract

This study investigated the function of the Nerang River Estuary, a highly modified waterway on the Gold Coast, in South East QLD. The study's purpose was to assess Estuary condition and understand issues, which may threaten its ecological health. The study also developed management actions to mitigate identified threats to ecological health, which are scheduled for implementation over a 10-year timeframe. Most of the Nerang River Estuary catchment is urbanised, with only limited native vegetation and natural stream banks. Extensive canal networks and constructed lake systems are common across the Estuary catchment, many of which connect directly to the Estuary. Results from the investigations (aquatic fauna, water quality and geomorphic assessments) indicated an extremely strong correlation between overall ecosystem health and the presence of intact riparian zones. The typical means of managing water quality within urban catchments is to retrofit the catchment with stormwater quality improvement devices (SQIDs), generally at significant expense. In contrast, rehabilitation of riparian zones, wetlands and waterways can be comparable in cost while delivering ecosystem services which can increase in value over time. This investigation and other case studies suggest ecological restoration may be a more cost effective long-term solution for improving water quality than retrofitting SQIDs into urban catchments.

Keywords

Estuary and stormwater management, riparian restoration, ecosystem services

Introduction

Waterways including estuaries in urban catchments are subjected to a range of land use pressures, which detract from ecological function, recreation and amenity values (Walsh et al., 2005). Land clearing in combination with urban development alters the hydrological, geomorphic and chemical characteristics of an estuary leading to a number of ecosystem responses, including shifts in species composition, loss of biodiversity and loss of ecosystem services (Lee et al., 2006).

Hydrological change within a urban catchment results in a significant increase in impervious surfaces combined with an efficient drainage network delivering stormwater runoff rapidly to a waterway, largely shortcutting other hydrological pathways, including infiltration to soils and groundwater, evapotranspiration and ponding in wetlands and oxbows (Fryirs and Brierley, 2013). Urban runoff contains a range of pollutants including nitrogen, phosphorous, sediments, heavy metals and hydrocarbons which are discharged into receiving environments, often at loads which exceed the assimilative capacity of an estuary and lead to eutrophication (Eyre and Ferguson, 2002; Waltham et al 2013).

There is a trending increase in nitrogen and phosphorous within estuaries in the east coast of Australia, associated with a rapid increase in land clearing and urbanisation over the past 30 years (Lee et al., 2006; Roy et al., 2001). Eutrophication leads to a variety of impacts within estuaries including oxygen depletion caused by an increase in chemical and biological oxygen demand (Eyre and Ferguson, 2009), an increase in turbidity and smothering of habitats by sediments leading to loss of seagrass beds and benthic organisms, an increase in algal blooms and loss of aquatic vegetation and associated biota (Eyre and Ferguson, 2005). Additionally, accumulation of heavy metals, phosphorous and hydrocarbons within sediments has profound impacts on aquatic biota with respect to species diversity, abundance and health (Roy et al, 2001).

The Study Area

The Nerang River Estuary in South East Queensland is one of the most urbanised and modified waterways in Queensland (Healthy Waterways, 2009) and represents a significant challenge for those wanting to maintain and improve ecological health and associated benefits. The estuarine component of the Nerang River is around 21km in length, the majority of this comprising highly modified and structurally reinforced river banks. The study area is shown below within Figure 1.

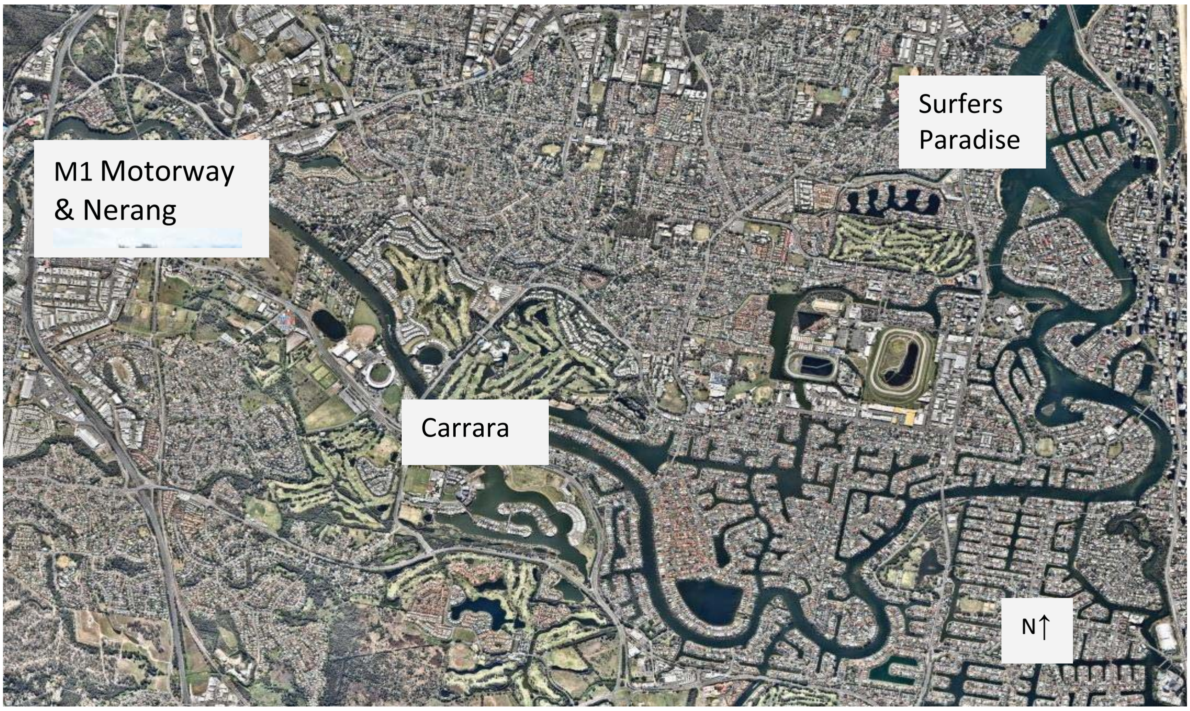

Figure 1. Map of the Nerang River Estuary Study Area. Source: Nearmaps, 2016

Water Quality

An analysis of 10 years of water quality data collected by Gold Coast City Council at 10 locations shows a clear reduction in total phosphorous (TP) and a steady increase in total nitrogen (TN) (see Figure 2). The data suggests that phosphorous has reduced over time in line with the reduction in land development and subsequent export of sediment. Sampling sites within the middle estuary have the worst water quality, while the lower estuary where tidal exchange is higher show water quality to be typically compliant with WQOs.

Higher residence time and poor flushing as freshwater is caught behind the tidal prism is a common explanation for poorer water quality within the tidal prism.

An assessment of TN longitudinally from upstream sites to the Broadwater, shows TN values are highest the middle estuary. In dry weather there is typically an increase in TN with a preference towards NH4 as dissolved oxygen declines and reducing conditions increase. Conversely TP concentration reduces in concentration from the upper reaches of the Estuary towards the lower reaches, most likely the reduction in the delivery of sediment via reduced farming within the catchment (now urban development) and the upgrade of the Hinze Dam in the upper freshwater reaches of the Nerang River. Exceedances of WQOs for TP are typically associated with one to three day rainfall events, which may be a reflection of a first flush from the catchment of accumulated dirt and debris and bound phosphorous.

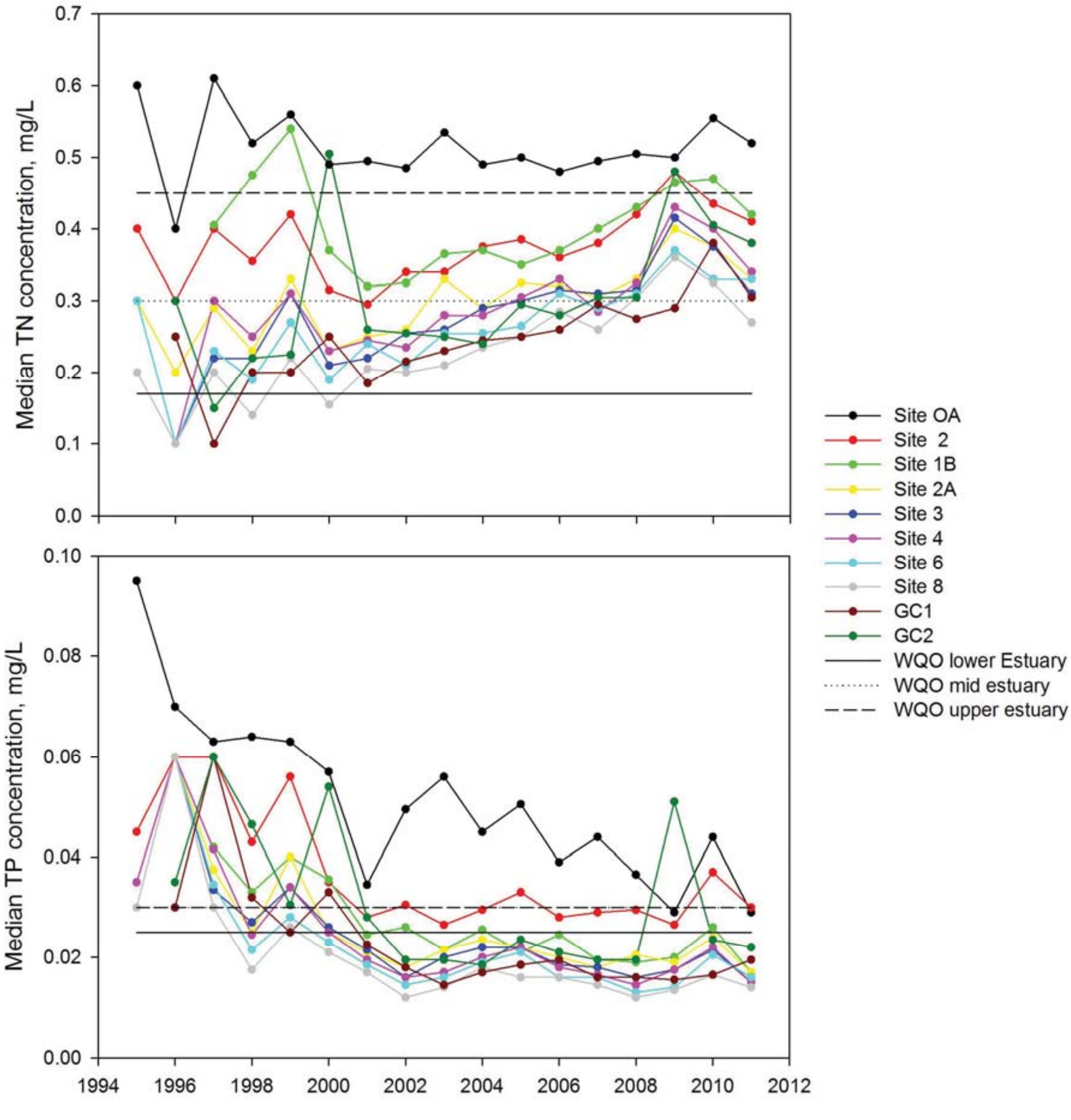

Figure 2. TN and TP values at monitoring locations within the Nerang River estuary. Site OA is at the upper estuary descending to Site 8 at the lower estuary.

Geomorphic findings

Historically the Nerang River was a shallow laterally unconfined sand bed system which at low tide was difficult to navigate (Longhurst, 2002). Gradually the combination of land clearing, dredging and blasting of bedrock in the upstream section at Nerang enlarged and deepened the estuary and substantially extended the tidal extent. Connectivity with the flood plain has been substantially reduced via channelization, bed lowering and construction (and subsequent raising) of the Hinze Dam located in the upper Nerang River. The dam provides protection from the 1 in 100 year flood event for much of the Nerang Catchment but has also substantially reduced environmental flows with consequences for water chemistry, sediment supply and river geomorphology (Lonegran, 2009; Brierley and Fryirs, 2005).

Bank armouring in the form of concrete revetment walls and stone batters has been installed throughout the majority of the estuary, with more than 80% of embankments armoured. Non armoured banks are principally in the upper estuary in the vicinity of Nerang and are associated with public reserves and flood plains. Geomorphic assessments reveal areas of substantial instability in non-armoured sections with bank undercutting, lateral scour and slumping prevalent.

This geomorphic simplification removes numerous habitat types and interrupts geomorphic processes including accretion of sediments and detritus, river meandering and creation of oxbows and connection with the flood plain.

Vegetation

Vegetation within the Nerang River Estuary is highly degraded and is dominated by weeds and discontinuous patches of remnant native vegetation. Key vegetation types include mangrove forest, saltmarsh, seagrass beds, QLD Blue Gum Forest, Swamp Paperbark Forest, freshwater wetlands, Swamp Oak Forest and Notophyll Rainforest. There are numerous parks and reserves containing remnant trees or planted species and then typical urban landscaping within private property.

As part of the study a rapid assessment of all riparian vegetation was completed via a combination of desktop assessment and ground truthing. This assessment and mapping of vegetation enabled an accurate understanding of distribution and health and informed the preparation of a riparian vegetation rehabilitation strategy for the entire estuary.

Key findings from this process included:

- The primary vegetation remnants are in the upper estuary, with the majority of vegetation either remnants of average quality or regrowth typically less than 30 metres wide.
- Remnant vegetation is typically absent from lower reaches, though with some important remnants remain.
- Mangroves (*Avicennia marina*) and Swamp Oak (*Casuarina glauca*) have colonised numerous locations including adjoining armoured river banks.

Stormwater Management

The prevailing stormwater quality management regime in SE QLD, as in most other parts of Australia, is for the adoption of Water Sensitive Urban Design (WSUD) with the GCCC WSUD Guideline in combination with other best practice documents (e.g. the Water by Design Guideline series

Stormwater management typically takes the steps: develop a stormwater or catchment management plan, model pollutant loads within the catchment, run scenarios including stormwater quality improvement devices (SQIDs) iteratively until WQOs are met, prioritise sub-catchment for works and finally, produce a costed action plan.

There is currently no stormwater management plan (SWMP) or catchment management plan (CMP) for the Nerang River Estuary and the majority of urban areas are 20+ years old, pre-dating requirements for inclusion of WSUD within new developments.

Depending on the treatment technology adopted (gross pollutant traps, rain gardens, bioretention filters, constructed wetlands) a typical land requirement in SE QLD is between 1% and 5% of the catchment ($100m^2$ to $500m^2$ per hectare) to be dedicated to SQIDs. At cost of between \$150/m^2 and \$350/m^2 to design, construct and maintain a SQID for two years (ignoring land acquisition costs) \$35,000 to \$175,000 per hectare is the cost of urban retrofit (Healthy Waterways, 2014). The Nerang River estuary catchment is approximately 4300 hectares, with the majority of this area without SQIDs meaning that even if only a portion of this area was to be retro-fitted with SQIDs the cost is comfortably more than \$100M. Note this is the upfront cost only and life cycle costs, which increase the cost of SQIDs further (Water by Design, 2014).

Vegetation, Water Quality and Stream Rehabilitation

Remnant riparian vegetation is very linear and typically there is an absence of lateral connectivity with adjoining floodplains, which have predominantly cleared and filled to enable urban development. Water quality sampling sites are relatively easy to overlay with vegetation remnants to determine what, if any, relationship exists. As stated previously, TN values increased from the upper to the lower estuary, generally in-line with a reduction in the presence of riparian vegetation.

The results suggest that provision of shade, lower water temperatures, and therefore increased dissolved oxygen and presence of organic (labile) carbon could be contributing to water quality trends observed. This observation is consistent with prevailing wisdom around the role of riparian vegetation in maintaining waterway health (e.g. Dosskey et al., 2010; Rutherford et al. 2000), however quantifying the effect of riparian vegetation on water quality in a way that can be compared with other forms of stormwater treatment is difficult (Healthy Waterways, 2014; Dosskey et al., 2010).

From existing research on the stoichiometry of waters within estuaries it is known that the ratios of C:N:P are a significant factor in processing of nutrients and limiting of algal blooms and can equally as important as reducing total nutrient concentrations (Australian Wetlands, 2008; Eyre and Ferguson, 2002). Studies completed within the lakes and waterways of the Nerang River catchment show a trending imbalance in C:N:P and so highlight the importance of instream and aquatic vegetation for maintaining water quality and improving biotic composition (Australian Wetlands, 2008).

The cost of stream rehabilitation varies dependent upon the degree of hard engineering, width of the riparian zone, fencing, ease of access and consulting and approval fees, but most often on a lineal metre or per kilometre (or mile) basis (e.g. Bair, 2005; Rutherfurd et al., 2000), however construction prices are hugely variable on the basis of location and economic conditions. Drawing upon our own construction experience urban stream rehabilitation works range from \$750 to \$2500 per linear metre, assuming no land acquisition costs, or \$750,000 to \$2.5M per kilometre. The Nerang River estuary is approximately 21km in length, meaning the theoretical cost of rehabilitating both banks (42km) is between \$31M and \$105M. Obviously rehabilitation of the entire estuary is impractical, however there is a clear contrast with the cost of stormwater rectification works.

Practical steps to recover ecosystem services

The substantial upfront and life cycle costs associated with retrofitting urban catchments with SQIDs combined with the demonstrated lower cost and environmental benefits associated within rehabilitating the river prompted the preparation of conceptual rehabilitation designs at priority locations within the estuary.

Re-greening the Nerang River is can commence immediately and incrementally without the need to significant planning, approvals and investment in infrastructure. The substantial inter-tidal zone within the Nerang River Estuary presents extensive opportunities for inclusion of vegetation and habitat. The comparative cost of retro-fitting SQIDs within urban catchments and rehabilitation (and potential purchase) of riparian zones suggests that significant benefits can be achieved at a substantially lower cost.

There are precedents in Queensland for rehabilitation of the riparian zone in lieu of upgrade to sewage treatment plants, with the rationale being that investment in expensive new infrastructure can be delayed or reduced, taking pressure off limited available funding (DEHP, 2014).

Figure 3 shows a typical conceptual arrangement for rehabilitating a section of foreshore adjoining public land in a way which would not impede boat passage, exacerbate flooding or detract from public amenity.

Other recommendations which should be considered as part of rehabilitating the estuary include:

- Insisting on WSUD as part of new developments,
- Facilitating and funding of initiatives on private land (e.g. rainwater tanks) which allow Council to share the burden of stormwater management with the community,
- Adoption of improved urban design which includes riparian zones and buffers for rivers from urban development,
- Leveraging riparian rehabilitation works from environmental offsets against land-use impacts where at source management cannot be achieved.

Conclusions

The Nerang River Estuary is a highly modified system with significant environmental challenges including loss of habitat, deteriorating water quality and decline in native vegetation. This results in the deterioration of ecosystem services and the associated benefits including biodiversity, recreation and amenity values.

Retrofitting a large urban catchment with SQIDs to achieve water quality outcomes is expensive (possibly $100M +) and typically exceeds available budgets. Given that better water quality has been found to be associated with areas of remnant vegetation within the Nerang River estuary, rehabilitation of riparian and intertidal zones should be considered as a means of improving water quality and ecosystem health and at a much lower cost, while also leveraging lasting benefits from ecosystem services.

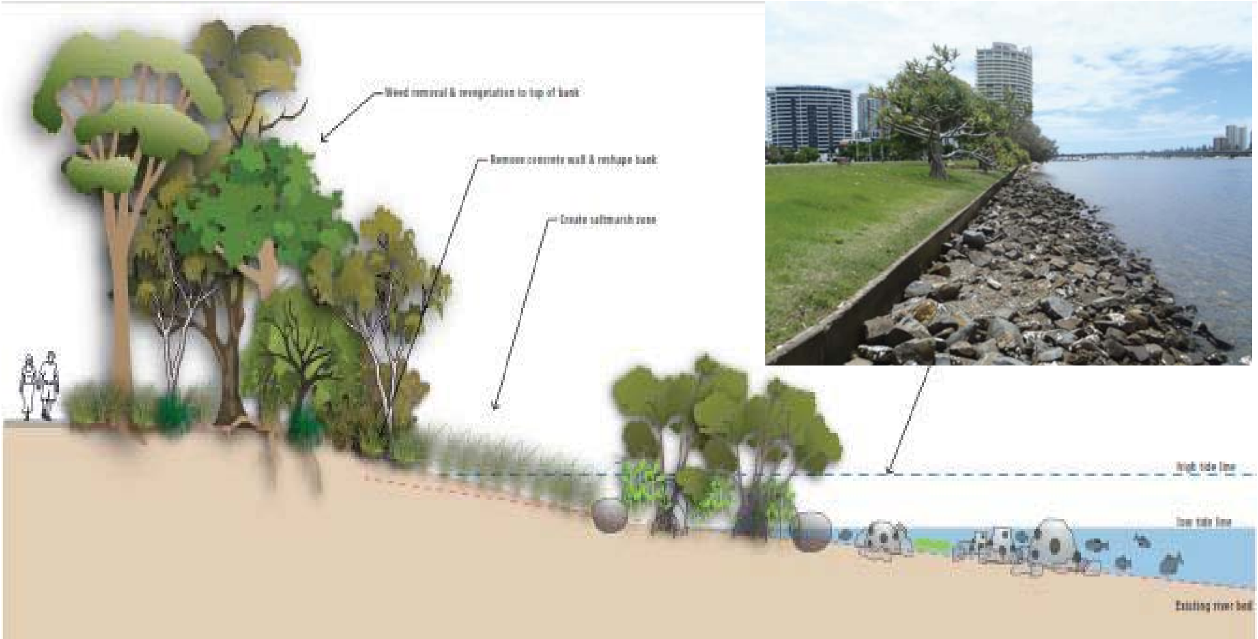

Figure 3. Example of a conceptual arrangement for rehabilitating the Nerang River Estuary riparian zone. Inset shows existing condition.

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