Assessment of the Ecological Consequences of Gosford City Council's Existing Management for Brisbane Water Estuary

A Report to Cardno Lawson Treloar

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

NEWCASTLE INNOVATION™

Revised Final Report 7 October 2009

Assessment of the Ecological Consequences of Gosford City Council's Existing Management for Brisbane Water Estuary

Preamble

This report assesses the consequences, for Brisbane Water estuary, of Gosford City Council's management of its natural resources. This assessment is part of the development of the Brisbane Water Estuary Management Plan. The assessments relate to reports provided to the University of Newcastle by Cardno Lawson Treloar.

Each report was read and assessed for its potential to impact (positive, negative, neutral) the biodiversity and ecological processes of Brisbane Water estuary. The assessments were based on the following principles:

1. *Boundaries*: management actions were considered relevant to Brisbane Water estuary when they occurred within the Brisbane Water catchment and within the estuary boundaries as defined in the Brisbane Water estuary process study. Management plans that were based outside Brisbane Water's catchment were not included.

2. *Downstream impacts and benefits*: excessive silt entering the estuary is likely to have negative impacts on biodiversity and habitats (e.g. direct smothering, interference with filter-feeding organisms) and ecological processes (e.g. increasing turbidity will reduce primary productivity of algae and seagrasses) (Edgar and Barrett 2000; Cummings et al. 2003; Ralph et al. 2006). Silt may also carry contaminants that may have negative cumulative impacts on biodiversity (e.g. through increased morbidity and mortality) (Ralph et al. 2006). Catchment management that leads to improvements in the quality of riparian vegetation and/or creek water quality is likely to have positive outcomes for the condition of the estuary (Bunn and Arthington 2002; Gillanders and Kingsford 2002; Land & Water Australia 2009).

3. *Cumulative benefits and connectivity*: positive impacts in one area of the estuary are likely to be beneficial to the wider estuary because of the ecological and physical connectivity that results from the movement of water, estuarine food webs, and animal movements. Illustrations of the scale of connectivity that exist in Brisbane Water estuary are provided in the Estuary Processes Study report (Cardno Lawson Treloar 2008). Many of the management actions were assessed to have positive impact on the estuary. These management actions frequently involved small sections of creeks that ultimately drain into Brisbane Water. Taken together, the effect of all these small-scale management actions is likely to be beneficial for the biodiversity and ecological processes of Brisbane Water.

4. *Net effects*: some management plans included a range of actions, some of which are likely to have negative consequences for biodiversity and ecological processes. For example, the construction of seawalls to eliminate shoreline erosion reduces shoreline habitat complexity and a substantial proportion of the estuary's shoreline has already been converted to seawalls (Sainty and Roberts 2007). Seawalls modify shoreline biodiversity and ecological processes compared with natural shorelines (Chapman 2003, Chapman and Roberts 2004). Where a plan included several actions (e.g.

seawall construction, pollution reduction, debris removal, riparian rehabilitation) the potential net effect from all actions was determined.

5. *Implementation and monitoring*: the assessments assume that work is being implemented as outlined in the management plan. Monitoring results that evaluate the effectiveness of the management plans were not reviewed. Therefore, these assessments are an appraisal of the potential effects of the management plans rather than a judgement of their actual outcomes.

Overall Assessment

The overall effect of these plans of management is likely to be beneficial for Brisbane Water estuary. Twenty-one plans of management were assessed. Four plans are likely to have a neutral impact on Brisbane Water estuary, 17 plans are likely to have a positive impact. Only two plans involved management at the scale of the entire estuary: the foreshore parks plan of management, Brisbane Water Plan of Management 1995-2000. However, the net effect of the majority of plans that addressed local issues is likely to be beneficial for the estuary. Benefits are likely to come from rehabilitation of riparian vegetation, community education, creek and drain maintenance that reduces excessive sediment deposition downstream during flood events, maintenance of gross pollutant traps, installation and maintenance of constructed wetlands and detention basins, protection of biodiversity, and pollution control. Neutral impacts were associated with plans with a major focus on routine inspection and maintenance, management of foreshore parks without habitat rehabilitation, and passive recreational activities.

The information contained within the plans (scope of works, rationale, environmental assessment) was sufficient for an assessment of their ecological consequences. A feature missing from many plans (in particular those relating to creek maintenance) was their relationship to an existing Council policy or strategy relating to environmental or natural resource management. It was therefore unclear how the management of these local issues integrates with Council's broad aims and objectives for the management of Brisbane Water estuary.

A/Prof William Gladstone
7 October 2009

Summary of Assessments

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Concrete Pipes under Rail at Brief Street Woy Woy	Brief Street adjoins Phegans Bay	Considers inspection routine only to ensure safety of rail property.	There are no works detailed in plan that could have potential to impact on adjacent waterbody. **Assessment: neutral impact on Brisbane Water estuary biodiversity and ecological processes**
Everglades Main Drain Draft Floodplain Maintenance Plan	The Everglades Main Drain empties into Correa Bay, downstream of the Railway Street boat ramp.	Whilst the plan includes under-scrubbing of some riparian vegetation and removal of aquatic weeds, there is little work proposed near where the creek exists into Correa Bay.	There will only be positive outcomes for Brisbane Water by: (i) identifying opportunities to retain, protect and rehabilitate areas of native riverbank and aquatic vegetation; and (ii) the intention to improve community education and involvement in managing the creek areas to reduce impacts of dumping, nutrient inputs, weed invasion, vandalism and other threats to water quality and remnant vegetation. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**
Initial and Ongoing Maintenance to Erina Levee, Maintenance Plan No 02.02	Erina Creek, which drains into Brisbane Water.	Maintenance of the levee, including removal of trees, mowing, reducing weed growth, repairing erosion, and debris removal.	The area where Erina Creek enters Brisbane Water has a high biomass of macroinvertebrates in seagrass (Gladstone 2006). This area also has a lengthy flushing time of 42 days (Cardno Lawson Treloar 2008) and is therefore vulnerable to excessive sedimentation. Maintenance of the levee could contribute some fine sediment to Erina Creek via removal of trees, mowing and debris removal. It could also reduce sediment inputs from the repair of erosion. It is, on balance, unlikely to lead to increased sedimentation in Brisbane Water estuary. **Assessment: neutral impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Kulara Avenue Creek West Gosford	The creek is located between Pacific Highway and Fagan's Bay, West Gosford. The creek starts midway between Pacific Hwy and Bel Hilton Parade, runs through Kulara Avenue Box Culvert before discharging into Fagan's Bay in Brisbane Water.	It is proposed to undertake initial and regular ongoing maintenance to the creek. The purpose of the work is to remove litter and sediment from the creek bed and remove three selected mangrove trees (*Avicennia marina*) and overgrown vegetation from the creek bed that restrict stormwater flow during flood events. There will also be dredging to a depth of 300 mm and the subsequent removal of *A. marina* mangrove seedlings.	The removal of the mangroves would decrease habitat but would not be significant as there is a very large mangrove habitat in the immediate vicinity of Fagan's Bay. Spraying of the herbicide has the potential to impact on non-target natives through over-spray, however, the potential for any significant impact is low. Positive impacts include the removal of rubbish from the creek and the rehabilitation of riparian vegetation and other bank stabilisation works, likely to have positive outcomes for water quality in the creek water. Fagan's Bay has a relatively high flushing time of 2-3 days (Cardno Lawson Treloar 2008) so any short-term increased in sediment load associated with dredging and mangrove removal is unlikely to have long-term impacts. Fagan's Bay is important for the biodiversity of Brisbane Water seagrass because it contains a distinctive assemblage of macroinvertebrates not found elsewhere in the estuary (Gladstone 2006). Care should therefore be taken to ensure works proceed as proposed. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Ongoing Maintenance to part of Wingello Creek Main Rail line to Pacific Hwy No. 4-02	Wingello Creek drains into Narara Creek, which drains into Fagan's Bay, Brisbane Water.	Debris is to be cleared annually or as required following a flood event. Removal of growing trees is to be undertaken annually. Spraying of typha is to be undertaken twice yearly in spring and autumn.	This section of Wingello Creek is a man-made channel. The only potential impact would be from the spraying of typha with herbicide, however, the potential for any significant downstream negative impacts on the estuary is low. Improvement in riparian vegetation is likely to have positive outcomes for water quality and ultimately for water quality in Narara Creek and downstream areas. Fagan's Bay has a relatively high flushing time of 2-3 days (Cardno Lawson Treloar 2008) so any short-term increased in sediment load caused by removal of debris or bank disturbance is unlikely to have long-term impacts. Fagan's Bay is also important for the biodiversity of Brisbane Water seagrass because it contains a distinctive assemblage of macroinvertebrates not found elsewhere in the estuary (Gladstone 2006). The mouth of Narara Creek is significant for the biodiversity of Brisbane Water estuary because the unvegetated sediments contain a distinct assemblage of macroinvertebrates and the area has the second-highest conservation value (Gladstone and Shokri 2007). Maintenance of the biodiversity and ecological processes of Fagan's Bay and the mouth of Narara Creek are important for the entire estuary. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Ongoing Maintenance to part of Wyoming Creek Landcom Estate Jarrett St Wyoming No. 4-05	Wyoming Creek, which drains into Narara Creek, which drains into Fagan's Bay, Brisbane Water.	Bush regeneration works (including weed removal) and some general clearing of rubbish and organic debris from the creek.	Spraying of the herbicide has the potential to impact on non-target natives through over-spray, however, the potential for any significant negative impact is low. Improvement in riparian vegetation and removal of organic debris is likely to have positive outcomes for water quality in the creek water entering Narara Creek, Fagan's Bay and ultimately Brisbane Water estuary. Fagan's Bay has a relatively high flushing time of 2-3 days (Cardno Lawson Treloar 2008) so any short-term increased in sediment load caused by removal of debris or bank disturbance is unlikely to have long-term impacts. Fagan's Bay is also important for the biodiversity of Brisbane Water seagrass because it contains a distinctive assemblage of macroinvertebrates not found elsewhere in the estuary (Gladstone 2006). The mouth of Narara Creek is significant for the biodiversity of Brisbane Water estuary because the unvegetated sediments contain a distinct assemblage of macroinvertebrates and the area has the second-highest conservation value (Gladstone and Shokri 2007). Maintenance of the biodiversity and ecological processes of Fagan's Bay and the mouth of Narara Creek are important for the entire estuary. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Ongoing Maintenance to part of Wyoming Creek Main Rail line to Pacific Hwy No. 4-03	Wyoming Creek, which drains into Narara Creek, which drains into Fagan's Bay, Brisbane Water.	Channel maintenance to prevent flooding. Debris is to be cleared annually or as required following a flood event. Removal of growing trees to channel and retarding basin is to be undertaken annually. Spraying of typha to the channel is to be undertaken twice yearly in spring and autumn.	The creek in this location is a man made channel. Spraying of herbicide may impact on non-target natives, however, the potential for any significant impact is low. Provided care is taken with silt excavation work to minimise turbidity, the removal of silt will remove associated contaminants and prevent excessive silt being transported and deposited downstream during flood events. This will minimize potential negative effects of siltation on creek and estuary biodiversity and ecological processes. Fagan's Bay has a relatively high flushing time of 2-3 days (Cardno Lawson Treloar 2008) so any short-term increased in sediment load caused by removal of debris or bank disturbance is unlikely to have long-term impacts. Fagan's Bay is also important for the biodiversity of Brisbane Water seagrass because it contains a distinctive assemblage of macroinvertebrates not found elsewhere in the estuary (Gladstone 2006). The mouth of Narara Creek is significant for the biodiversity of Brisbane Water estuary because the unvegetated sediments contain a distinct assemblage of macroinvertebrates and the area has the second-highest conservation value (Gladstone and Shokri 2007). Maintenance of the biodiversity and ecological processes of Fagan's Bay and the mouth of Narara Creek are important for the entire estuary. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Ongoing Maintenance to part of Brady's Gully Creek Wyoming, North Gosford No. 4-01	Brady's Gully Creek, which drains into Narara Creek, which drains into Fagan's Bay, Brisbane Water.	Channel maintenance to prevent flooding. Work includes weed spraying, silt excavation, removal of trees and debris from creek, rubbish removal from creek and surrounds.	Spraying of herbicide has the potential to impact on non-target natives through over-spray, however, the potential for any significant impact is low. Whilst there is some silt excavation work described, provided care is taken to minimise turbidity, the removal of silt will also remove associated contaminants. Removal of dead trees will mobilise some sediments but the resulting impact should be minimal provided care is taken. Removal of silt will also prevent excessive silt being transported and deposited downstream during flood events, thereby minimizing potential negative effects of siltation on creek and estuary biodiversity and ecological processes. Fagan's Bay has a relatively high flushing time of 2-3 days (Cardno Lawson Treloar 2008) so any short-term increased in sediment load caused by removal of debris or bank disturbance is unlikely to have long-term impacts. Fagan's Bay is also important for the biodiversity of Brisbane Water seagrass because it contains a distinctive assemblage of macroinvertebrates not found elsewhere in the estuary (Gladstone 2006). The mouth of Narara Creek is significant for the biodiversity of Brisbane Water estuary because the unvegetated sediments contain a distinct assemblage of macroinvertebrates and the area has the second-highest conservation value (Gladstone and Shokri 2007). Maintenance of the biodiversity and ecological processes of Fagan's Bay and the mouth of Narara Creek are important for the entire estuary. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Open Channel in Melaleuca Park Tascott No. 18-1	The channel runs through Melaleuca Park, Tascott, discharges into a piped system which runs under Glenrock Parade and the main railway line and then discharges into Brisbane Water.	Maintenance is required to ensure design stormwater flows are maintained within the rock lined channel and that the gross pollutant trap (GPT) is cleaned to prevent downstream pollution and blockage of culverts and that rockwork is repaired in the event of a collapse.	The channel is and rock lined and includes a GPT and trash rack. This means that removal of rubbish and sediment is achieved with minimal if any negative impact on the estuary. The major outcome of the works (assuming they are carried out regularly) will be a reduction in silt outflow, thereby contributing to maintenance of water quality and ecological processes in the estuary. Seagrass beds can trap sediment. However, the area where this channel discharges has no/minimal seagrass (Cardno Lawson Treloar 2008). Therefore, these works are important for preventing additional sediment entering Brisbane Water. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**
Part of Coorumbine Creek, West Gosford, Maintenance Plan No 17.01	Discharges into Fagan's Bay	Maintenance to reduce flooding, including remove any trees growing in the floodway, remove any debris, remove any "excessive" reed or fern growth, remove any foreign items from the whole channel, and excavate silt.	Fagan's Bay has a relatively high flushing time of 2-3 days (Cardno Lawson Treloar 2008) so any short-term increased in sediment load caused by removal of debris, bank disturbance, and silt excavation is unlikely to have long-term impacts. Fagan's Bay is important for estuary biodiversity because it contains a distinctive assemblage of seagrass macroinvertebrates not found elsewhere in the estuary (Gladstone 2006). The plan is likely to be beneficial because it will involve removal of silt, which would otherwise be deposited into Fagan's Bay during a flood. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Worthing Road Creek Constructed Wetlands Operation and Maintenance Manual	Wetlands discharge into Erina Creek	Successful maintenance and management of the constructed wetland system at the confluence of Worthing Road Creek, Karalta Creek and a third unnamed creek located between Terrigal Drive and Karalta Road at Erina.	This will be beneficial to the water quality of Brisbane Water estuary because of its potential to strip nutrients and silt from water entering Erina Creek. The area where Erina Creek enters Brisbane Water has a high biomass of macroinvertebrates in seagrass (Gladstone 2006). This area is therefore ecologically significant for estuarine food webs and likely to be negatively affected by declines in water quality. This area, however, also has a lengthy flushing time of 42 days (Cardno Lawson Treloar 2008) and is therefore vulnerable to short-term declines in water quality. Long-term maintenance of water quality is therefore important for this area. The benefits of these works are conditional, however, on its proper management and maintenance. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**
Maintenance Plan No. 13 – 1, Woy Woy Pool Drain	Alpha Road Woy Woy, which drains into Brisbane Water	Maintenance to reduce flooding, including spraying of typha, silt removal, tree planting, and rubbish removal.	Works may mobilize small amounts of sediment in the short-term. Plant growth in drain will strip nutrients from water. The area where the drain enters the estuary has large areas of seagrass (Cardno Lawson Treloar 2008), which are vulnerable to sedimentation. The area also has a low swell wave height (Cardno Lawson Treloar 2008), which minimizes the opportunity for accumulated sediment to be re-distributed. Maintenance will prevent excessive silt being transported and deposited downstream during flood events, thereby minimizing potential negative effects of siltation on estuary biodiversity and ecological processes. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Wyoming Creek Floodplain Maintenance Plan Final Report	Wyoming Creek, which drains into Narara Creek, which drains into Fagan's Bay and Brisbane Water.	Maintain design flows and levels for a 1% AEP flood event as defined within the Wyoming Creek Floodplain Management Plan, minimise damage to private and public infrastructure, maintain and enhance Wyoming Creek's natural environment wherever possible.	The Maintenance Plan provides a range of actions in five maintenance management areas, the actions including macrophyte management, silt removal, tree and shrub removal from rock walls, and debris removal. If the maintenance work proceeds as planned the effect will be to reduce the amount of silt deposited and therefore transported into Narara Creek during flood events. This is likely to be beneficial for water quality (and therefore biodiversity) in Narara Creek, Fagan's Bay and Brisbane Water estuary. Fagan's Bay has a relatively high flushing time of 2-3 days (Cardno Lawson Treloar 2008) so any short-term increased in sediment load caused by removal of debris or bank disturbance is unlikely to have long-term impacts. Fagan's Bay is also important for the biodiversity of Brisbane Water seagrass because it contains a distinctive assemblage of macroinvertebrates not found elsewhere in the estuary (Gladstone 2006). The mouth of Narara Creek is significant for the biodiversity of Brisbane Water estuary because the unvegetated sediments contain a distinct assemblage of macroinvertebrates and the area has the second-highest conservation value (Gladstone and Shokri 2007). **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Broken Bay Beaches Coastal Management Plan	Putty Beach, Ocean/Umina Beach, Pearl Beach, Patonga Beach, Broken Bay, Brisbane Water Entrance, Headland, Bluff and Rock Shelf Areas	Only management related to Brisbane Water Entrance and Headland, Bluff and Rock Shelf Areas are relevant, all other areas are located outside Brisbane Water estuary and its catchment.	Management actions related to erosion, amenity, facilities, water quality, marine ecology, bank stability, and navigation. Likely to have local positive impacts around beaches, foreshores and into the southern reaches of Brisbane Water estuary and the intertidal rock shelves at the entrance to Brisbane Water. The area at the entrance to Brisbane Water (including the rock shelf) has the highest conservation value in the estuary for the representation of species diversity (Gladstone and Shokri 2007). Therefore these management actions could make a substantial contribution to biodiversity conservation. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**
Plan of Management, Foreshore Parks	Foreshores of Brisbane Water estuary and waterways in its catchment (exact areas not shown in Plan)	Numbers of actions listed to address issues of Number of Foreshore Parks, Development and Improvement, Maintenance, Management, Impact of Development, Use of Open Space Areas for Events, Fees & Charges, Information on Foreshore Parks, Plan of Management Evaluation, Plan of Management Action Plan, Plan of Management Land Register	Plan requires consideration of environmental effects: “The development of foreshore parks should be incorporated with protection of the natural environment.” Specific actions may lead to localized negative impacts on Brisbane Water estuary e.g. mowing practices, installation/upgrade of facilities such as boat ramps. However, overall impacts likely to be minimal when undertaken within the framework of the Brisbane Water Plan of Management. Potential to use foreshore parks more actively for environmental education. **Assessment: neutral impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Plan of Management for Gosford Foreshore	Gosford foreshore, the Broadwater	To allow the use of the land to provide for water access, passive recreation, cultural experience and entertainment	Potential for short-term and local negative impacts from special events, such as litter entering shallow water, but able to be minimized with appropriate controls. **Assessment: neutral impact on Brisbane Water estuary biodiversity and ecological processes**
Gosford City Council Supplementary Sustainability Report 2008	Gosford LGA	Council intends that this Sustainability Report will support its vision and assist Council and the community to work towards the common goal of sustainable development.	Summary of Gosford's environment under the State-Pressure-Response Framework. A useful resource for raising community awareness and therefore potentially able to increase community engagement. Indirect positive benefits likely for the estuary from increased community awareness and engagement. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**
Worthing Creek Detention Basin and Parkland, Plan of Management	Worthing Creek drains into Erina Creek, which enters Brisbane Water estuary.	To provide two detention basins which will slow stormwater flows up to the 1 in 100 year storm, and thereby greatly reduce the problems of inundation and damage caused to downstream areas. Specific works include detention basins, constructed wetlands, bush regeneration, improved access, and maintenance.	Assuming the system is functioning according to plan and there is regular maintenance, it is likely to reduce downstream impacts of flood, capture silt, and strip nutrients. The area where Erina Creek enters Brisbane Water has a high biomass of macroinvertebrates in seagrass (Gladstone 2006) and is therefore ecologically significant for food webs and likely to be negatively affected by declines in water quality. This area also has a lengthy flushing time of 42 days (Cardno Lawson Treloar 2008) and so is vulnerable to short-term declines in water quality. Long-term maintenance of water quality is important. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Yattalunga Foreshore Reserve, Draft Plan of Management	Yattalunga, Brisbane Water	Overall aim is improvement of the foreshore area for the benefit of the surrounding community. The Plan includes a number of specific actions to address the environmental effects of the reserve on the estuary, including improved drainage and pollution control, regrading to overcome local flooding and control of surface runoff.	The area adjacent to the reserve has a number of important ecological values. Two species of seagrass are represented: *Zostera capricorni* and *Posidonia australis* (Gladstone 2006, Cardno Lawson Treloar 2008). The *Z. capricorni* seagrass in the vicinity of the reserve has the greatest diversity of macroinvertebrates in the estuary (Gladstone 2006, Gladstone and Shokri 2007) and among the highest density of macroinvertebrates (Gladstone 2006). Therefore the outcomes of this plan are likely to have a significant impact on the biodiversity and ecological processes of the estuary. Actions to control pollution to the estuary originating from the reserve and surrounding areas will have a positive impact on the nearby seagrass. However, the proposal to construct a seawall to ameliorate shoreline erosion may have local negative impacts on biodiversity by reducing the amount of ecological niches and expanding the length of estuary foreshore converted to seawalls. Construction of seawalls that provide a range of ecological niches is preferred. The overall impact of all actions is likely to be positive. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

Plan	Location, relationship to estuary	Main actions/works/objectives	Assessment
Ettalong Beach Reserve Plan of Management	Ettalong Beach, Brisbane Water	Plan was prepared to resolve issues associated with: preservation of the beach, conservation of the foreshore reserves open space, appreciation of the reserve's character, and arrival of the new Fast Ferry.	The area of the estuary adjacent to Ettalong Beach has the highest conservation value in the estuary (for representation of species diversity) because it contains the greatest number of species not found elsewhere in the estuary (Gladstone and Shokri 2007). This plan includes a number of specific actions likely to produce positive impacts on the beach ecosystem (such as retain dunes and vegetation, build appropriate dune vegetation fence, install a bioswale to filter road runoff, rehabilitate dune vegetation, remove weeds). Connectivity of beach and estuarine habitats means that protection of the beach ecosystem will have flow-on benefits to the estuary. Retention of near-natural ecological processes and biodiversity of this beach ecosystem, allowing for its high level of human usage, will contribute to maintenance of estuarine ecological processes and biodiversity. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**
Brisbane Water Plan of Management 1995/2000	Brisbane Water	The plan provides detailed management guidelines for development. The need arose out of strong community concern to preserve the unique character of Brisbane Water whilst enabling people to enjoy its use. Plan provides specific actions relating to: habitat management, water quality, heritage, water use, water depth and sedimentation, channel and foreshore protection, residential structures, tourism, transport, access, commercial development, and planning provisions.	The range of actions, if implemented, would provide a positive impact for biodiversity and ecological processes of Brisbane Water estuary. **Assessment: positive impact on Brisbane Water estuary biodiversity and ecological processes**

References

Bunn SE, Arthington AH (2002) Basic principles and consequences of altered hydrological regimes for aquatic biodiversity. *Environmental Management* 30: 492-507.

Cardno Lawson Treloar (2008) Brisbane Water Estuary Processes Study. Report prepared for Gosford City Council and Department of Environment and Climate Change (Cardno Lawson Treloar, Gordon).

Chapman MG (2003) Paucity of mobile species on constructed seawalls: effects of urbanization on biodiversity. *Marine Ecology Progress Series* 264: 21-29.

Chapman MG, Roberts DE (2004) The use of seagrass wrack in restoring disturbed Australian saltmarshes. *Ecological Management and Restoration* 5: 183-190.

Cummings VJ, Thrush SF, Hewitt J, Norkko A, Pickmere S (2003) Terrestrial deposits on intertidal sandflats: sediment characteristics as indicators of habitat suitability for recolonising macrofauna. *Marine Ecology Progress Series* 253: 39-54.

Edgar GJ, Barrett NS (2000) Effects of catchment activities on macrofaunal assemblages in Tasmanian estuaries. *Estuarine, Coastal and Shelf Science* 50:639-654.

Gillanders BM, Kingsford MJ (2002) Impacts of changes in flow of freshwater on estuarine and open coastal habitats and the associated organisms. *Oceanography and Marine Biology: an Annual Review* 40: 233-309.

Gladstone W (2006) Spatial and Temporal Variation in the Biodiversity of Macroinvertebrates in Brisbane Water Estuary and its Relationship to Environmental Variation. Final report of the Brisbane Water Estuary Biodiversity Study. Report to Gosford City Council (University of Newcastle, Ourimbah).

Gladstone W, Shokri M (2007) Spatial and Habitat-related Patterns in the Biodiversity of Brisbane Water Estuary: a Tool for Sustainable Estuary Management. Report to Gosford City Council (University of Newcastle, Ourimbah).

Land & Water Australia. 2009. Water use across a catchment and effects on estuarine health. [Online] (Updated June 16th, 2009). Available at: http://lwa.gov.au/node/3218. Accessed 7 October 2009.

Ralph PJ, Tomasko D, Moore K, Seddon S, Macinnis-Ng CMO (2006) Human impacts on seagrasses: eutrophication, sedimentation, and contamination pp 567-593 IN AWD Larkum, RJ Orth, CM Duarte (eds) Seagrasses: Biology, Ecology and Conservation (Springer, Dordrecht).

Sainty GR, Roberts DE (2007) Ecological Assessment of the Shoreline around the Brisbane Water Estuary. Report prepared for Cardno Lawson Treloar Pty Ltd (Sainty & Associates Pty Ltd, Potts Point and Bio-Analysis Pty Ltd, Narara).