Water Quality Management Strategy for Ella Bay Resort -Impacts on Fauna & Flora

Prepared for

Sartori Resorts Ella Bay Pty Ltd

By

THG resource strategists

ecowater SOLUTIONS

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THE PROJECT TEAM

THG Resource Strategists in association with EcoWater Solutions (a subsidiary of the Ecotech Group), provide services in urban design, environmentally sensitive design including water sensitive design, wastewater and stormwater management. We aim to address the challenges of urban growth and increasing pressure on natural resources, particularly air and water, with sustainable management approaches while preserving a high level amenity and quality of community life.

THG Resource Strategists, EcoWater Solutions and their associated partners are dynamic companies evolving provides a team experienced in the delivery of land development, infrastructure and environmental projects. Our team of planners, surveyors, engineers and scientists lead the field in delivery of solutions that combine the best of latest technology, forecast trends, existing regulatory framework, financial viability, practicality and community needs.

The design philosophy and approach of the Team is to maximize natural processes to deliver clean air and water to the environment as cost effectively and practically as possible.

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REPORT VERSION CONTROL

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1 Executive Summary

This Report sets out a site integrated water cycle management strategy with the objective of a positive impact to no net impact result on the aquatic fauna and flora of the Ella Bay development site. In addition the Report summarises findings, sets out conclusions and provides specific recommendations for appropriate water management techniques that could be implemented throughout the Ella Bay Development to minimise the hydrological impacts on the site's ecology and environment generally.

We support the mitigation and management strategies presented in the Golder Associate's Report (2007) in regards to providing appropriate management of surface and groundwater hydrology that mimics existing patterns, in respect of both water quantity and quality.

By the Developer taking degraded land and removing cattle and feral animals, rehabilitating degraded ecosystems, providing buffer zones and greenways, establishing new vegetation communities throughout the site and implementing the recommended water management strategies listed in this report, an overall improvement in water quality and habitat enhancement will occur. This work will allow a greater opportunity for species such as the endangered Common Mist Frog (BAAM, 2007) to increase in abundance throughout the site, based on habitat enhancement and water quality improvements.

The southern and western environments exist topographically above the Development, resulting in no interaction from the Development into those areas through water movements. As a result, the mitigation activities implemented throughout the Development are to focus on minimising or negating any potential impacts on the Great Barrier Reef Marine Park, the Northern Wetland area and the on-site receiving waterways.

The Developer has a comprehensive understanding of the range of issues and challenges involved in achieving water quality management and appreciate that the processes of storm water pollution need to be analysed in detail. It has embraced the principles and priorities for an implementation plan. In this regard, it is possible to mitigate effectively the likely impacts of the Development on the surrounding flora and fauna which exist in, and constitute the existing wetlands, swales and other natural environments of the Development.

An overview of the main suite of measures that could be utilised in order to protect the existing flora and fauna from any significant adverse impacts caused from storm water runoff have been set out covering disruption minimisation of natural corridors, house allotment, street level design issues, golf course and open spaces as well as plantings. These measures have been taken into consideration under the Master Plan for the Development and where appropriate adopted.

To implement water quality management the overarching, recommended design principles to achieve effective management of water quality through extensive and continual monitoring systems have been established. Explanations of why and how such systems should operate providing real time feedback loops allowing management intervention to isolate, remedy and return to acceptable levels of water quality throughout the Development at each stage. Source control, treatment and re-use and continuous improvement approaches have been set out in detail.

With regard to storm water the Master Planning phase of the proposed development has incorporated mitigation and enhancement strategies to alleviate potential impacts on fauna and flora. Incorporation of these strategies into the Master Plan has delivered the non-structural source controls required to minimise the generation of excessive runoff and/or pollution of stormwater at or near its source.

The golf course has been designed to produce a positive environmental impact on the Development. On balance the impact of the golf course is seen as positive on the flora and fauna as well as the water courses in the Development. As a result, the Development has the potential to increase biodiversity from existing levels.

As a result of the above and based on the water quality strategy proposed in more detail throughout this document and taking into account this assessment of the range of impacts and improvements to be carried out under the Master Plan for the Ella Bay Development, the water quality impacts on flora and fauna throughout the site are considered to be positive.

2 Background

2.1 Context

The proposed Ella Bay Integrated Resort Development is located in the Johnstone Shire, 75 to 80km south of Cairns and 10km north east of Innisfail. Sartori Reports Ella Bay Pty Ltd proposes to transform an existing 450ha operating cattle station into a fully master-planned, integrated tourism and residential lifestyle community, proceeding in stages over a ten to fifteen year period.

Sartori Reports Ella Bay Pty Ltd is in the process of finalising a draft Environmental Impact Statement (EIS) for the proposed Ella Bay Integrated Resort Development. Recent submissions from relevant referral agencies on the Draft EIS required further investigations on surface water hydrology and groundwater hydrology, and impacts of water quality on fauna and flora. A report completed by Golder Associates (2007) has been completed addressing these submissions to the Draft EIS. The main report is entitled *Conceptual surface water and groundwater models Ella Bay Integrated Resort*.

The report also provides information on the flora and fauna surveys carried out for the Development.

On completion of the conceptual surface water and groundwater models report Sartori Reports Ella Bay Pty Ltd has requested recommendations for water management within the development from specialist development consultants THG Resource Strategists (THG) and water consultants EcoWater Solutions, to assess water impacts on flora and fauna and provide recommendations on appropriate steps to ensure improvements to the ecology and environment at Ella Bay.

2.2 Scope of Works

The main objective of this report is to provide a site water management strategy that will provide a minimal to no net impact on the aquatic fauna and flora of the Ella Bay development site.

The scope of work for this report comprises the following:

- Review report completed by Golder Associates on surface water hydrology and groundwater hydrology
- In context of hydrology report, also review supporting documentation on fauna and flora
- Identify findings, set out conclusions and provide specific recommendations for the appropriate water management techniques that can be implemented throughout the development to minimise the hydrological impacts on the site's ecology and environment generally

3 Surface and Ground Water

The Ella Bay site is predominantly cleared and level to slightly undulating, with creeks traversing the site and the presence of wetlands in the north and east areas of the property. There are two main creeks on the site that join, forming Farm Creek that flows eastward to the Wetland Swale and Ella Bay, with two minor creeks entering Farm Creek. There are also two other minor creeks that are not associated with Farm Creek, being in the north-western and south-eastern areas of the site (Golder Associates, 2007).

Approximately 90% of the development is within the Wetland Swale catchment, with flows entering the Wetland Swale through Farm Creek or the south-eastern minor creek and wetland. The proposed development in the Northern Catchment is a small area that flows through 500metres of freehold land comprising remnant wetland before reaching the Wet Tropics of Queensland World Heritage Area. This area has been Master Planned to comprise two or three holes of the golf course (Golder Associates, 2007).

The predominant groundwater flow influence is the geology and topography, resulting in the flow from west to east. Groundwater should not be harvested from the shallow groundwater areas, but rather may be possible to harvest from the deeper, weathered-rock regions (Golder Associates, 2007).

The Golder Associates' (2007) report concludes that appropriate mitigation and management strategies will ensure that surface and groundwater hydrology can be managed to mimic existing patterns, in respect of both water quantity and quality. Suggested measures include:

- Harvesting water from 'sealed surfaces' for water supply;
- Adoption of Water Sensitive Urban Design;
- Inherent design which includes vast areas of open space versus relatively minimal hardstand areas;
- Limiting the extent of permanent below ground structures ;
- Limiting the extent of cut and fill;
- staging of construction;
- implementation of erosion and sediment control works during construction;
- Protecting, and rehabilitating existing creeks, gullies and the Wetland Swale; and
- Protecting and rehabilitating most of the existing remnant vegetation surrounding the development zone.

Since the Golder Associates' (2007) report was written and taking into account its view that there was no significant connection of ground water run off to the Northern Wetland area and only minor surface water run off with limited impact, Sartori modified the master plan re-locating the golf course holes along the northern boundary of the Development. This acts as an effective buffer zone between the Northern Wetland area lying outside of the Development and the precinct lots. The precinct lots have also been set back further from the boundary itself. The golf course environment is to be strictly controlled by one authority and at least the northern fairways will operate on organic principles.

4 Flora and Fauna

Biological Assessment and Management (BAAM) conducted an ecological assessment of the Ella Bay Development site (BAAM, 2007). The following tables detail the important flora and fauna species that were found on the site, as well as those that are likely to be found on the site.

Table 1: Known, Likely or Possible Significant Flora Species on the subject site (R = rare; V = Vulnerable, E = Endangered).

Species Name	EPBC	NCA	Known	Likely	Possible
Aphyllorchis queenslandica	Not Listed	R		X	
Aponogeton cuneatus	Not Listed	R			X
Aponogeton proliferus	E	E			X
Arenga australasica	V	Not listed		X	
Canarium acutifolium var. *acutifolium*	V	Not listed		X	
Carronia pedicellata	E	Not listed			X
Dendrobium mirbelianum	E	Not listed			X
Dendrobium superbiens	V	Not listed			X
Dioclea hexandra	Not listed	V		X	
Elaeocarpus stellaris	Not listed	R			X
Endiandra globosa	**Not Listed**	**R**	**X**		
Fimbristylis adjuncta	E	E			X
Garnotia stricta var. *longiseta*	Not listed	R			X
Ilex sp. (Gadgarra B.P.Hyland RFK2011)	Not listed	R			X
Macaranga polyadenia	**Not listed**	**R**	**X**		
Phaius tancarvilleae	E				X
Piper mestonii	Not listed	R		X	
Polyalthia sp. (Wyvuri B.P.Hyland RFK2632)	Not listed	R		X	
Pseuduvaria villosa	Not listed	R			X

Table 2: Fauna Survey Results: Relevant species listed under the Commonwealth's EPBC Act and NCA recorded in the BAAM survey (2006) or considered likely to occur.

Scientific Name	Common Name	EPBC Status	NCA Status	Occurrence
Birds				
Accipiter novaehollandiae	Grey Goshawk		Rare	Recorded BAAM 2006
Casuarius casuarius	Southern Cassowary	Endangered	Endangered	Recorded BAAM 2006
Collocalia spodiopygius	White-rumped Swiftlet		Rare	Expected
Cyclopsitta diophthalma macleayana	Double-eyed Fig-parrot		Vulnerable	Recorded BAAM 2006
Esacus neglectus	Beach Stone-curlew		Vulnerable	Recorded BAAM 2006
Neochmia phaeton	Crimson Finch		Vulnerable	Expected to occur
Ninox rufa queenslandica	Rufous Owl		Vulnerable	Potential
Amphibians				
Cophixalus infacetus			Rare	Recorded BAAM 2006
Litoria rheocola	Common Mist Frog	Endangered	Endangered	Recorded BAAM 2006
Nyctimystes dayi	Australian Lacelid	Endangered	Endangered	Potential
Mammals				
Pteropus conspicillatus	Spectacled Flying-fox	Vulnerable		Recorded BAAM 2006
Taphozous australis	Coastal Sheathtail Bat		Rare	Potential
Reptiles				
Chelonia mydas	Green Turtle	Vulnerable		Possible but unlikely
Coeranoscincus frontalis			Rare	Potential
Crocodylus porosus	Saltwater Crocodile		Vulnerable	Expected
Eulamprus tigrinus			Rare	Expected
Insects				
Hypochrysops apollo apollo	Apollo Jewel		Vulnerable	Potential

An additional report compiled by 3D Environmental (2007) details the results of a floristic survey conducted throughout the site. The survey found that the vegetation types within the urban footprint of the Ella Bay Development are non-remnant vegetation areas or cleared land. Of Concern vegetation communities exist throughout the property along the Farm Creek and coastal strip, the majority of which were found to be heavily disturbed areas. This disturbance was reported as being the damaging effects of Cyclone Larry as well as the presence of cattle.

Exotic weeds such as Pond Apple (*Annona squamosa*), Hymanachne (*Hymanachne* amplexicaulis) and Sicklepod (*Senna obtusifolia*) are present within some of the disturbed areas. Pond Apple is a highly invasive tree weed, presenting a threat to the biodiversity of the wetland areas it invades. Hymanachne is an exotic, robust perennial grass that has the potential to smother wetland plants and become monoculturic (BAAM, 2007)

The BAAM (2007) report provides recommended mitigation approaches to the individual species identified in Table 1 and 2 (refer to BAMM (2007) for further details). In addition, Sections 5 and 6 of this Water Quality Management Strategy provides further enhancement and mitigation strategies through the proposed integrated water cycle management for the development site that mitigate and enhance the identified fauna and flora species of the site.

Ongoing monitoring of bio-diversity and any adverse impacts can be identified and responded to appropriately. This includes by way of example:

- Water quality and flow
- Eco-system status and stressors
- Habitat (stream side and in stream) and
- Biota (eco-system status)

These follow principles set out in the Queensland Government Water Quality Guidelines, 2006.

5 Potential Development Impacts

Due to the topography of the surrounding land, the receiving environments that the Ella Bay Development has the potential to impact on are limited to the Northern Wetland, the waterbodies on site and the Great Barrier Reef Marine Park within Ella Bay to the east. The southern and western environments exist topographically above the Development, resulting in no interaction from the Development into those areas through water movements. As a result, the mitigation activities implemented throughout the Development are to focus on minimising or negating any potential impacts on the Great Barrier Reef Marine Park, the Northern Wetland area and the on-site receiving waterways.

A range of ecosystem improvements have been set out in the Master Plan including the rehabilitation of degraded areas and providing protected zones. Ecosystems will be created, particularly around sensitive waterways. The Farm Creek will be rehabilitated and revegetated, and cattle and feral animals removed. This work will allow a greater opportunity for species such as the endangered Common Mist Frog (BAAM, 2007) in increasing abundance throughout the site, based on habitat enhancement and water quality improvements.

Research has shown that urban areas produce nutrient, litter and sediment pollution (Walsh, *et. al*, 2004). Typical impacts of urbanising areas around streams are listed in Table 3. Without appropriate management, the development may impact on the receiving environments in these ways. However Ella Bay Development has in its approach to these issues taken a range of steps to avoid the typical impacts of urbanising areas around streams. The Development is an extremely low rate of urbanisation almost to the extent of semi-rural development.

Table 3: Typical impacts of urbanisation on streams (Source: Walsh, 2004)

Affected Feature	Response
Hydrology	▪ Decreased low flow volume ▪ Increased frequency and magnitude of peak flow ▪ Decreased groundwater recharge and lower water table
Geomorphology	▪ Increased channel erosion, incision and sediment transport (depending on the age of the catchment development)
Water Quality	▪ Increased contaminant loads and concentrations
Ecology	▪ Reduced frequency of connection between the stream channel and associated floodplain and wetland systems ▪ Habitat simplification ▪ Less diverse biotic communities ▪ Decreased nutrient retention and altered patterns of nutrient and energy cycling
Biodiversity	▪ Decreased biodiversity values (genetic, species and community levels)

Unmitigated release of contaminants into the surface or groundwater can have detrimental impacts on the receiving environments. The toxicity of the contaminants can have both short- and long-term effects on in-stream biota (Walsh, *et. al,* 2004), including reduction in biodiversity, stunted growth, and bio-accumulation of contaminants in flora and fauna. Frogs are particularly sensitive to contaminants, as are certain invertebrates. The loss of sensitive fauna leads to an increase in more resilient fauna and in certain cases the increase of nuisance species such as mosquitoes and midges. Potential sources and impacts of water quality issues on the receiving environment are listed in Table 4, together with proposed mitigation strategies.

Table 4: Potential sources, impacts and recommended mitigation strategies of water quality issues

Potential Sources	Potential Impacts	Recommended Mitigation Strategies
Changes in stormwater surface runoff and groundwater recharge	Decreased low flow volume, Increased frequency and magnitude of peak flow Decreased groundwater recharge and lower water table	▪ Implement the proposed integrated water cycle management strategy ▪ No net impact approach utilising strategies and technologies shown in section 5 and 6.
Erosion and sediment transport	Loss of sediment off the site due to erosion and site disturbance particularly during construction, smothering of fauna and flora in downstream aquatic ecosystems, aesthetically unpleasing	▪ Implement the proposed staged construction ▪ Implement Erosion and Sediment Control Plans with appropriate enforcement to the single lot scale ▪ Provide treatment system to intercept suspended solids (such as constructed wetlands) before discharge to natural waterbodies ▪ Provide vegetated buffer zones to creeks varying between 25 metres to 50 metres on either side of the creek
Litter	Aesthetically unpleasing, destruction of flora through smothering, impact on fauna eating indigestible materials and becoming caught in rubbish	▪ Community education regarding pollutant sources and ways to minimise these (refer to section 6) ▪ Provide treatment system to intercept gross pollutants before discharge to natural waterbodies such as vegetated swales and GPT's if required
Nutrients from fertilisers and stormwater runoff	Eutrophication of the Farm Creek, Wetland Swale and other waterbodies, reduction in biodiversity, growth of algae that smothers plants, reduces food sources and may become a public health risk	▪ Community education regarding pollutant sources and ways to minimise these ▪ Provide treatment system to intercept nutrients (such as constructed wetlands and bioretention systems) before discharge to natural waterbodies
Herbicides, pesticides, and other chemicals	Contamination of waterbodies, reduction in biodiversity, stunted growth, and bio-accumulation of contaminants in flora and fauna	▪ Use organic materials in place of herbicides, pesticides and chemicals where possible (see section 6.3) ▪ Implement correct hazard reduction and management protocols ▪ Implement integrated water cycle management system to intercept pollutants
Termite soil conditioning	Contamination of waterbodies, reduction in biodiversity, stunted growth, and bio-accumulation of contaminants in flora and fauna	▪ Implement non-chemical termite control (such as termite mesh) throughout the development ▪ Implement integrated water cycle management system to intercept pollutants where non-chemical termite control is not feasible

Potential Sources	Potential Impacts	Recommended Mitigation Strategies
Fuel, oils, and road sediment	Contamination of waterbodies, reduction in biodiversity, stunted growth, and bio-accumulation of contaminants in flora and fauna	▪ Implement correct hazard reduction and management protocols ▪ Implement integrated water cycle management system to intercept pollutants ▪ Provide bunded fuel storage to minimize risk ▪ Adopt solar and LPG as back up for the main source of energy supply and fuel as opposed to liquid fuels ▪ Adopt extensive fuel consumption minimisation program through efficiency and alternative technologies such as solar power
Recycled Water discharge	Flooding and/or contamination of waterbodies	▪ Monitor the water quality at strategic locations based on the development of critical limits for selected pollutants ▪ A number of discharge points are available, depending on water quality and quantity of discharge – Government Agencies should be consulted
Geo-exchange for air-conditioning units	Thermal pollution of sensitive groundwater systems, adverse welling / flooding of groundwater systems	▪ Operate geo-exchange in the Unit A groundwater system only, and after appropriate groundwater geo-exchange modelling has been carried out

Adopted measures by the Ella Bay Development to mitigate these potential impacts are detailed in the following section.

6 Water Quality Management Strategy

The impact of stormwater runoff on waterways requires a coordinated management approach with the support of government, technical specialists and the community. The task is twofold: to reduce the present impacts, and formulate long-term runoff management strategies for the Development that will satisfy the needs for economic and community development while ensuring environmental sustainability at Ella Bay.

Stormwater is made up of "critical pollutants" such as phosphorus, nitrogen and pathogens that are carried to waterways at rates and in volumes of runoff water determined by catchment topography, vegetation and rainfall (ARMCANZ and ANZECC, 2000; Lawrence and Breen, 1998).

The most influential factor is usually the degree of urbanisation of the catchment, because the development process clears vegetation, modifies drainage ways from the curves of natural streams to straight lines, and introduces large areas of hard surfaces such as roofs and roadways - leading to increased peak runoff rates. Most urban areas introduce elevated nutrients, hydrocarbons, pesticides and heavy metals to the water stream (Walsh, *et. al,* 2004). The Ella Bay Development lies within already-cleared land, with the urban development areas consisting of only approximately 5% of the site. As a result, the extent of elevated pollutants is not expected to be as high as what would be produced from a larger-developed area, although management procedure are still required to minimise any impact on the receiving waterways.

Intelligent Water Sensitive Urban Design (WSUD) incorporating technologies based on site characteristics can deliver rehabilitation solutions as well as contribute to development that is notionally constrained by water, latent environmental conditions, environmental sensitivity and access to infrastructure. With the increasing sensitivity of waterways and government policies, it is essential to reduce the quantity of nutrients, sediments and other pollutants leaving a site (Connors, Pont and Dawson-Specht, 2005). The Water Quality Strategy below details the WSUD options to be implemented within the Ella Bay Development.

A key area concerns the ability to mitigate the likely impacts of the Development on the surrounding flora and fauna which exist in, and constitute the existing wetlands and other natural environments of the Development. A detailed discussion of the key principles in respect to water cycle management is provided below addressing the individual components of the Development. These principles have been embraced where appropriate under the Master Plan for the Development.

The main objectives for the Ella Bay integrated water cycle management particularly pertaining to stormwater are as follows:

- Maintenance of the current rate and volume of storm water flows across and through the site.
- Maintenance of the current flow paths across the site.
- Harvesting of stormwater flows so as to cause no significant adverse impact on existing water flows requires maintaining the balance of wetlands and interchanging between terrestrial and marine environments.
- No net increase in the discharge of nutrients and sediments from the site to surrounding natural systems.

The key principles which underpin the objectives noted above are:

- The use of integrated catchment management principles.
- The need for protection of the ecological and hydrological integrity of the site.
- The Management of stormwater as close to the source as possible.
- The use of environmental sensitive solutions such as:
  - the use of organic management principles on the proposed golf course;
  - the creation of wetland areas as part of the water treatment solution which will add biodiversity value and amenity as well as satisfy water quality outcomes.
- The sustainable use of stormwater and wastewater to create a self sustainable community in terms of water supply.

Successful achievement of the above is through adoption of environmentally / water sensitive urban design measures. In respect to water, this means adopting a more sustainable approach by focusing on the management of the total water cycle. This is achieved by:

- Minimising disruption to natural drainage pathways (eg. retention of native vegetation, mulched pervious areas, dispersed overland flow paths, vegetated natural waterways, wetlands and floodplains);
- Minimising impervious areas and enhancing the permeability of remaining pervious areas (eg. mulching, protection from vehicle compaction);
- Maintaining existing hydrological connectivity of wetlands by the use of swales, vegetated waterways, and wetlands rather than pipes and lined channels for the stormwater system;
- Offsetting the impacts of development by incorporating retention capacity (eg. infiltration, rainwater tanks, swales, wetlands and retarding basins);
- Minimising water requirements and reducing stormwater runoff by adopting landscaping strategies (eg. mulching, reduce lawn areas, water efficient lawns, ponds and gardens);
- Conserving water by installing water efficient fixtures and appliances;
- Harvesting rainwater for potable purposes;
- Reuse of greywater and treated effluent for non-potable purposes;
- Use of organic management practices in terms of major open space areas such as golf course to minimize the risk of pollutants entering waterways; and
- Use of endemic plants and species in the various landscape elements to increase the local biodiversity and habitat value of the site.

These measures have been taken into consideration under the Master Plan for the Development and where appropriate adopted.

6.1 Minimising Disruption of Natural Corridors

In considering the site in respect to current natural form the following elements are considered to be guiding factors in the primary protection of the site based on the principles espoused above:

1. Protection and rehabilitation into viable open space corridors of major natural flow channels of the site including:
   a. the Farm Creek traversing the site from west to east generally draining catchment A2 on Figure 3 in the Golder Associates report (2007);

   b. the drainage corridor and associated major flow arms connecting to Farm Creek coming from the central southern part of the site and flowing generally in a northerly direction into Farm Creek generally draining catchment A1 on Figure 3 in the Golder Associates report (2007);
   c. the retention of a natural drainage corridor in the south-eastern sector of the site generally draining catchment A3 on Figure 3 in the Golder Associates report (2007); and
   d. retention of the drainage corridor running parallel to the frontal dune and associated wetland generally depicted as catchment A4 in the Golder Associates report (2007).

2. Retention and rehabilitation where necessary of the major remnant vegetation stands on site including :
   a. the south-western corner;
   b. the south-eastern corner; and
   c. the northern sector of the site adjoining the Ella Bay National Park.

3. Establishment of connectivity between these elements noted in 1 and 2 as viable networks through the site.

4. In view of the sensitive nature of the Ella Bay National Park stormwater within the northern section of the future development shall be managed accordingly to ensure existing flows and quality shall be maintained to the north and not impact on the adjoining National Park.

5. Buffers 50 metres wide either side of the natural flow corridors noted as 1a, 1b, and 1d shall be retained and revegetated.

Having identified the major elements of the natural drainage system of the site particular measures are now required at the various specific elements of the Development to achieve the main objectives of the integrated water cycle management.

These measures are typified through the development of a strategy for both water quality and quantity management.

Water quality measures are typically shown in the diagram below as they pertain to a site.

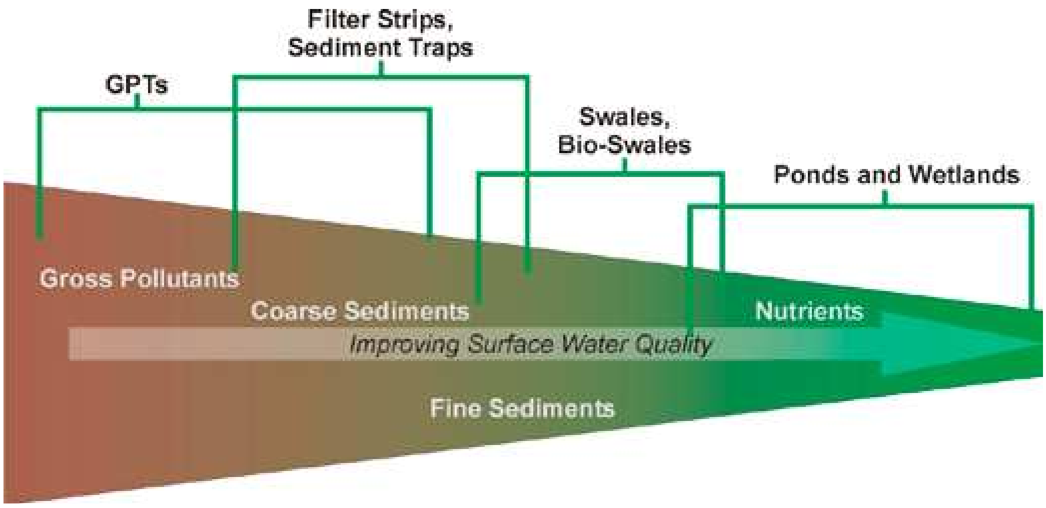

Figure 1: Water quality measures and treatment ranges (Source: ACT Planning and Land Authority, 2006)

Measures in respect to sustainable water supply on site are typified by Figure 2.

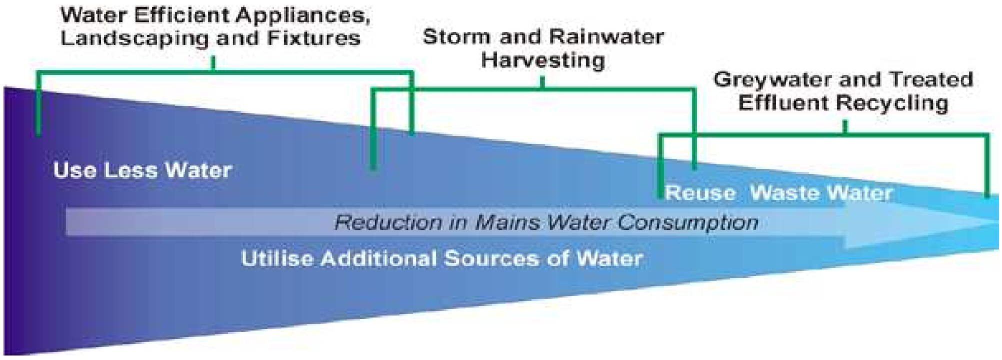

Figure 2: Water reuse measures (Source: ACT Planning and Land Authority, 2006)

These measures are outlined below with appropriate examples starting at the house allotment level. A major approach to treatment will be treating the water as close as possible to its sources thus allowing for a multi faceted approach to water cycle management and also reducing the risk of adverse impacts due to failure of a single sources approach.

6.2 House Allotment

At the house allotment level the measures proposed include:

1. Inclusion of rainwater tanks for harvesting of the roof water.
2. Allowance of tank capacity for runoff retention
3. Excess flows from rainwater tanks directed to vegetated swales incorporating bio-retention and / or natural ground infiltration.
4. Overland flow directed to landscape / garden areas for natural watering / ground infiltration and sheet flowed to roads or to adjoining open space through filter strips.
5. Limit amount of impervious area and use porous pavement where possible and direct to infiltration zones.
6. Runoff from impervious areas to be directed to vegetated bio-retention swales

6.3 Street Level

At street level the treatments proposed include:

1. Pavement will be designed using one way cross-falls and flush kerbs to direct flows across buffer strips and into bio-retention swales or detention units.
2. A series of interconnecting swales and natural creek channels will direct flows to constructed wetlands for future reuse located in major open space / golf course areas.
3. Grates and filter grids will be used to remove major litter from the runoff prior to discharge to offline treatment areas.
4. Gross pollutant will be included in the treatment train if required.
5. Where streets abut natural drainage corridors and / or wetlands runoff shall be directed away from the natural drainage corridors and / or wetlands to the offline treatment system prior to discharge.
6. Where streets abut natural drainage corridors and / or wetlands vegetated buffers / filter strips shall be included between the street and the natural drainage corridors and / or wetlands. Buffers shall be typically of the order of 50 metres in width in respect to wetlands and 25 metres in respect to natural drainage corridors.

6.4 Golf Course / Open space

This area could be utilised for treatment and storage of runoff from the Development Footprint. The measures included in these areas could be typified by:

1. Flows from the development areas surrounding the golf course should be directed through sedimentation basins and / or constructed wetland areas prior to storage or discharge.
2. All treatment measures should be off stream of the natural drainage corridors.
3. Constructed wetlands which hold runoff for future reuse should be offline of natural drainage corridors.
4. All flows falling on the developed area should be captured in a detention system or pass through an off line treatment train before discharge into adjoining natural drainage corridors.
5. Runoff from the golf course area should be directed to a detention system or through a filter / buffer strip prior to discharge of sheet flow into the natural drainage corridors. The strip shall be of the order of 20 metres in width.
6. Retention and / or Detention basins should be included in the treatment system to limit discharge into the surrounding natural drainage corridors and / or wetland areas to predevelopment situations to the greatest extent possible.
7. Preferred use of organic fertilisers and pesticides within close proximity to natural drainage and / or wetland areas around the golf course.

The Master Plan for the Development has embraced these principles to be applied where appropriate.

A typical example of the treatment system is depicted in the diagram below.

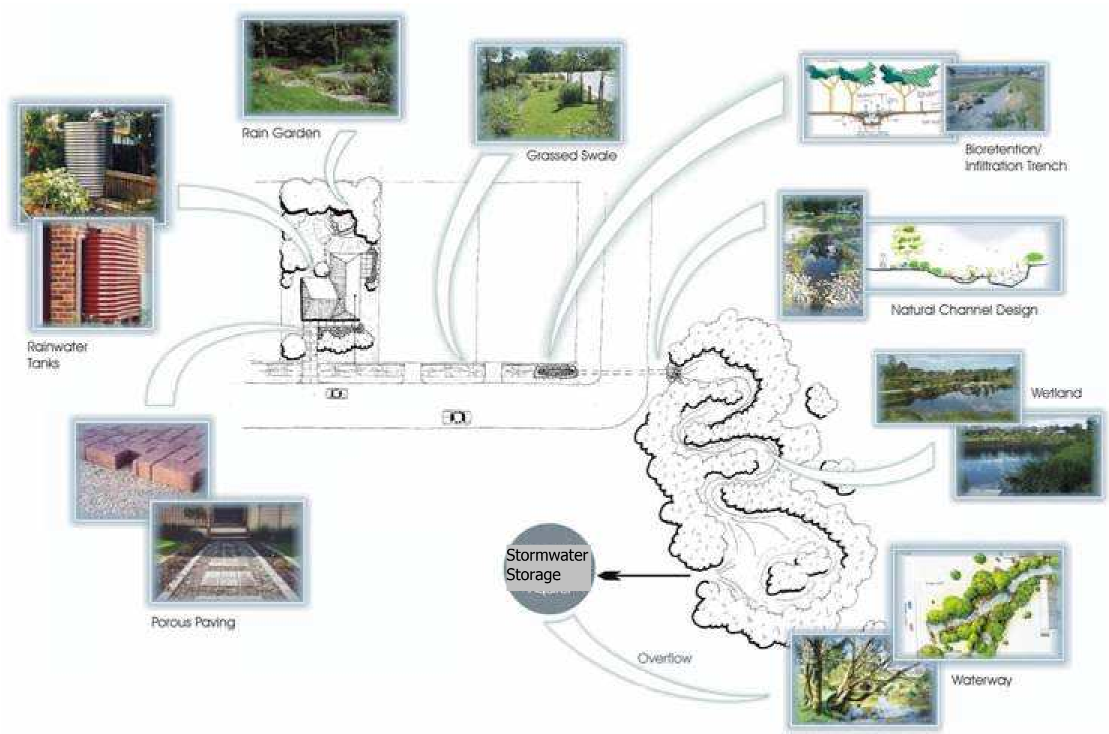

Figure 3: Example of house and street-level treatment measures (Source: BCC, undated)

6.5 Plantings

Landscaping should be considered an integral part of the treatment system from the aspects of functionality; aesthetics, conservation / ecological value and most importantly biodiversity. Plantings shall therefore be based on species endemic to the locality / region and reflect the particular purpose of the area in which they are placed ie. Bioretention area / swale or wetland.

Generally the plant species incorporated in swales / buffer strips / bio-retention swales / and bio-retention basins display the following characteristics:

- Able to tolerate short periods of inundation punctuated by longer dry periods. For bio-retention systems these dry periods may be reasonably severe due to the free draining nature (relatively low water holding capacity) of bio-retention filter media
- Generally have spreading rather than clumped growth forms.
- Are perennial rather than annual.
- Have deep, fibrous root systems.
- Groundcover plants - turf, prostrate or tufted.
- Prostrate species would typically be low mat forming stoloniferous or rhizomatous plants.
- Tufted species would typically be rhizomatous plants with simple vertical leaves.

Generally the plant species incorporated in constructed wetlands and sedimentation basins, display the following characteristics:

- Grow in water as either submerged or emergent macrophytes, or they grow adjacent to water and tolerate periods of inundation (typically sedge, rush or reed species).
- Generally have spreading rather than clumped growth forms.
- Are perennial rather than annual.
- Generally have rhizomatous growth forms.
- Have fibrous root systems.
- Are generally erect species with simple vertical leaves (e.g. *Juncus* spp, *Baumea* spp).

The forgoing provides an overview of the main suite of measures that could be utilised in order to protect the existing flora and fauna from any significant adverse impacts caused from stormwater runoff facilitated by the Development Proposal. These measures have been taken into consideration under the Master Plan for the Development and where appropriate adopted.
Detailed examples and information of these treatment systems based on the proposed conceptual water management layout are set out below.

7 Water Quality Management – Tools and Technologies

Principally, the Ella Bay Development will adhere to the monitoring and management requirements of the Queensland Water Quality Guidelines (2006) and the Queensland Water Recycling Guidelines (2005) in order to maintain a high standard of water quality throughout the site, in both the wastewater and stormwater streams. Details of water quality management techniques, tools and technologies are detailed in the following pages.

7.1 Wastewater

7.1.1 Design Principles

As the Ella Bay Development will be a self-sufficient community in terms of water supply and use, strict controls on the treatment, monitoring, reuse, distribution and overall management will be required. While the specific management, monitoring and control details will be developed during the design stage of the wastewater treatment and reuse, the following aspects are standard.

- Emergency alerting system installed to alert the operator of any breakdowns.
- Operator is on emergency response timing, residing in close proximity to the development, ensuring a quick response
- Back-up systems of equipment are on site, allowing for ease of switch-over from a damaged piece of equipment to a working piece, ensuring little down-time of treatment
- Contaminated (not treated to standard) treated water is to be isolated in storage tank/s until it can be retreated
- Back-up system of reuse water should be made available in the event of contamination/breakdown, to ensure toilets can still be flushed and hot water still provided throughout the development while the problem is identified, isolated and repaired
- Irrigation of recycled water that does not meet the standards is not to occur

In order to manage the potential risks associated with the use of recycled water the Queensland Water Recycling Guidelines (Waterwise Queensland 2005) should be adopted, and a Recycled Water Management Plan should be developed incorporating risk management and Hazard Assessment and Critical Control Point (HACCP) principles.

The primary strategy of a Recycled Water Management Plan is to identify and manage the risks arising from the various aspects of reclaimed water use at Ella Bay. The following management strategies should be developed to ensure the treatment and reuse of recycled water within the Ella Bay Development does not impact on the health of the residents and ecology:

- The critical limits for any proposed critical control points are set at the limit of an accepted variation range for each of the selected parameters. When the critical limit is breached, operational staff are alerted to commence investigative and corrective action.
- Under certain circumstances of deteriorating reclaimed water quality entering the environment through reuse, the nature of the quality failure will be stated and rectified. Under conditions of serious quality failure the manager reserves the right to withhold the supply of reclaimed water to the development until water quality is improved.
- The sewage treatment facility is to be monitored continuously for turbidity and UV function. If these processes are under control, low levels of pathogens can be expected.

The HACCP system for the sewage treatment facility ensures that increases in turbidity or failure in the UV system will create an alarm and initiate corrective action by plant staff.

- The sewage treatment facility is to be monitored continuously for conductivity. If the conductivity of the reclaimed water rises above the set critical level, the source of the salinity is investigated.
- The receiving waterways surrounding reclaimed water irrigation and disposal should be monitored for algal blooms and observations made on a monthly basis. If levels of blue green algae and other algae reach a level of concern adaptive management should be undertaken.
- The sewage treatment facility is to be monitored weekly for the nutrients ammonia, nitrate and phosphate.
- The sewage treatment facility operate an activated sludge process. This process is sensitive to certain toxins and thus, if the WRF biomass is failing to thrive, the effluent may fail to meet HACCP specifications.
- All HACCP plans are audited by qualified staff to ensure that the system retains integrity.

Audit and review at the end of each stage of the development should be carried out by an independent third party assessor. The feedback can then be incorporated in the next stage to achieve a process of iterative development and continuous improvement and monitoring.

7.1.2 Source control

The majority of phosphorus in wastewater comes from human excreta and from household detergents, with the detergent component being the most amenable to reduction and control. Phosphorus is commonly added to detergent to enhance the removal of dirt from clothing. It removes calcium from water hence softening it and preventing the redeposition of dirt. Alternatives do exist and most phosphorus-free detergents contain zeolites and/or polycarboxylic acid to carry out the function of softening the water.

The results from a study undertaken by the CRC for Freshwater Ecology (1997) show considerable reductions in phosphorus in raw wastewater when 64% of the community used phosphorus-free laundry detergent.

Reductions in phosphorus of this magnitude have the potential for significant cost savings in the operation of a wastewater treatment and/or required area for land application of treated wastewater. In addition, this will provide another cost-effective mitigation strategy to protect fauna and flora from the impacts of nutrients generated from the proposed development.

It is recommended that this source control mitigation strategy be part of a community education and management program (refer to section 6.2.1).

7.1.3 Treatment and Reuse

Sewage will be treated to 'Class A' in either a central or decentralised wastewater treatment plant located on-site. Table 5 provides the expected water quality for 'Class A".

Table 5: Recommended water quality specifications for Class A-D recycled water

Class	*E. coli* (median) cfu/100mL[2]	BOD5 mg/L median	Turbidity NTU 95% ile (max.)	SS, mg/L median	TDS, mg/L or EC, µS/cm medians TDS / EC[3]	pH
A	< 10	20	2 (5)[4]	5	1000/1600	6-8.5
B	< 100	20	—	30	1000/1600	6-8.5
C	< 1000	20	—	30	1000/1600	6-8.5
D	< 10,000	—	—	—	1000/1600	6-8.5

(Source: Queensland Recycled Water Guidelines, 2006)

This recycled water will then be further treated through a Reverse Osmosis (RO) plant and reused back in the house / villa (toilet flushing, etc) (refer to ESD report) with any excess water to be used to irrigate the 18 hole golf course (Refer to Section 7.3 – Golf Course for further details on golf course water management). Detailed modelling using appropriate software applications such as Medli can be undertaken during the design stage to quantify land application area and application rates.

During the wet season, irrigation of recycled water on the golf course may not be suitable, thereby requiring wet-weather storage or other disposal, or a combination of both. Given that the recycled water will be almost sterile (having been removed of nutrients and salts through the RO plant), it is recommended that the water be sent through a reed bed or other wetland system to help naturalise the water, prior to discharge.

Reed-beds comprise a constructed impermeable basin in which the recycled water is kept slightly below the surface of a gravel substrate which supports the growth of wetland plants (usually reeds but can also be shrubs or trees). The recycled water is biologically treated as it moves slowly through the root zone of the wetland plants.

Reed-beds are an increasingly popular type of recycled water treatment device due to their aesthetic appeal, their reliable treatment performance capacities once the reeds are fully established, and their relatively low construction costs and maintenance requirements compared to other options. They are also passive devices not necessarily reliant upon power or pumps, and therefore economical to operate in the long term.

Figure 4: Example of a reed bed system to treat recycled water

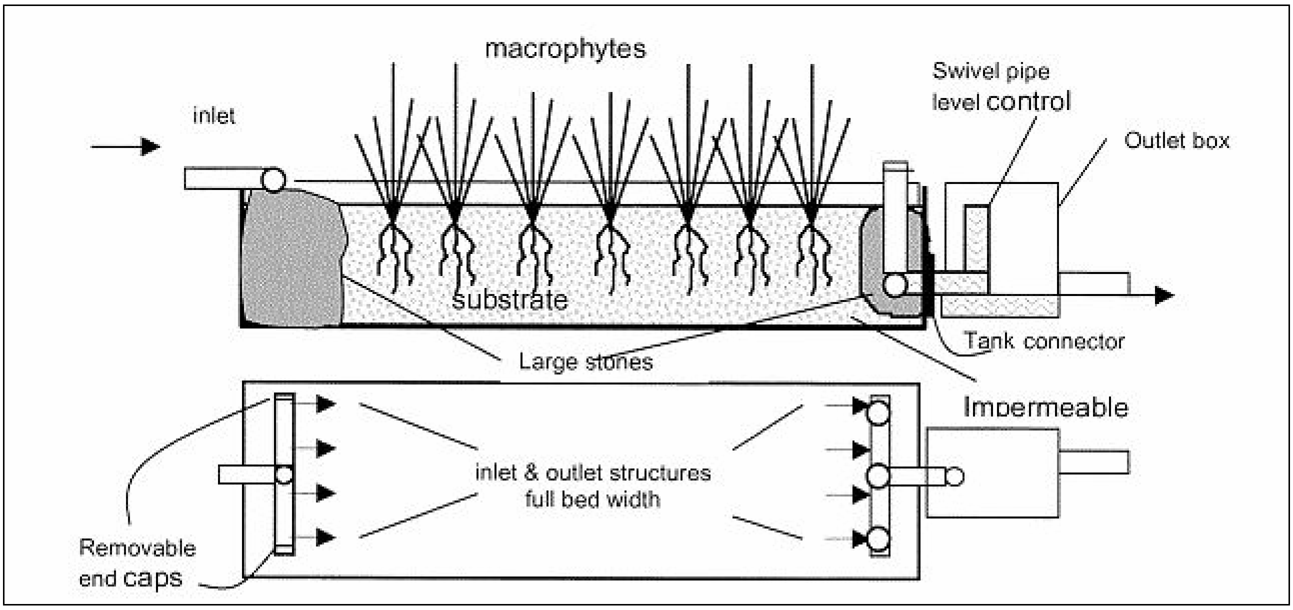

Figure 5: Schematic example of a reed bed system

7.1.4 Modelling

Further water balance and quality modelling for the Ella Bay Integrated Resort Development should be undertaken during the design stages. Such modelling would provide a linkage with strategies and technologies proposed to provide the best combination of water supply, stormwater management and the option of wastewater management applicable to the site.

An analysis of surface water quantity and quality entering the Ella Bay wetland and WTQWHA wetlands could be carried out using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). MUSIC is a widely used decision support program used to run scenarios on particular combinations of stormwater treatment measures using rainfall data from the nearest appropriate rainfall station.

By way of example, the computer modelling package Aquacycle could be utilised during the assessment for water cycle management throughout the proposed development. Aquacycle was created by the Cooperative Research Centre for Catchment Hydrology. Aquacycle modelling informs the optimal sizing of elements of the water cycle such as rainwater tanks, stormwater collection and treatment devices as required.

7.2 Stormwater

7.2.1 Source Control

Source control involves minimising the generation of excessive runoff and/or pollution of stormwater at or near its source. Source Control techniques can be categorised into:

- Non-Structural Source-Control: techniques that aim to change human behaviour to reduce the amount of pollutants that enter stormwater systems (pollution prevention).
- Structural Source-Control: techniques that aim to reduce the quantity and improve the quality of stormwater at or near its source by using infrastructure or natural physical resources.

<u>Non-structural Source Controls</u>
Non-structural source controls are concerned with changing behaviour to reduce the amount of pollution that enters the stormwater system. The main advantages of using non-structural source controls are:

- long term sustainability
- cost-effective
- minimisation or prevention
- reduced ongoing operation or maintenance liability ('end of pipe')
- effective use of all resources – including the community

The non-structural source controls included in the proposed development are community education, appropriate site planning and erosion and sediment control during and after the construction stage.

Community education is recommended for the Ella Bay development. The objective of the community education process is to:

- Create awareness of issues
- Enhance people's knowledge, understanding and skills
- Influence people's values and attitudes
- Encourage more responsible behaviour

The community education program would entail some of the following recommendations:

- Demonstrations and participation in the water quality monitoring program implemented for the proposed development
- Tours, open days and field days of the water management system
- Launches of products such as phosphorus free detergents
- Permanent displays and signs erected adjacent to waterways

- Stormwater pits stencilled with messages such as Drains to Beach
- Distribution of print material, e.g. brochures, posters, booklets, letters, and newsletters

The Master Planning phase of the proposed development has incorporated mitigation and enhancement strategies to alleviate potential impacts on fauna and flora. Incorporation of these strategies into the Master Plan has delivered the non-structural source controls required to minimise the generation of excessive runoff and/or pollution of stormwater at or near its source. These include the following:

- Small development footprint (approximately 5% of the total area)
- Strategically locating development areas
- Rehabilitating degraded areas of the site

A vital element of non-structural source control considerations is sediment management, particularly in the construction stage of the development. Golder Associates (2007) have incorporated principles of staged construction over a 10-15 year period and the implementation of erosion and sediment control plans (ESCP) during each stage of development at the single lot development.

Structural Source Controls

Structural source controls aim to reduce the quantity and/or improve the quality of stormwater at or near its source, commonly through filtration, infiltration and detention. These controls include; swales, buffer strips, bioretention basins, infiltration basins and sand filters for quantity control and stormwater treatment measures such as gross pollutant traps, sedimentation basins and wetlands for quality control.

It is important to note that structural source controls generally focus on managing the impacts of frequent storm events:

- Rainfall events up to the 3 year Annual Recurrence Interval (ARI) event, for environmental flow management.
- Rainfall events up to the 3 month ARI event (approximately 25% of the 1 year ARI event), for water quality management.

Below are further details of the recommended structural source controls for the Ella Bay development.

7.2.2 Proposed Treatment Measures

Vegetated Swales

Vegetated swales are used to convey stormwater in lieu of pipes and to provide for the removal of coarse and medium sediment and are commonly combined with buffer strips. The system uses overland flow and mild slopes (≤4% grade) to slowly convey water downstream. Swales also provide a disconnection of impervious areas from hydraulically efficient pipe drainage systems. The results are slower travel times, thus reducing the impact of increased catchment imperviousness on peak flow rates (Healthy Waterways, 2006).

The interaction between flow and vegetation along swales facilitates pollutant settlement and retention. Swale vegetation acts to spread and slow velocities, which in turn aids sediment deposition. Swales alone can rarely provide sufficient treatment to meet objectives for all pollutants, but can provide an important pre-treatment function.

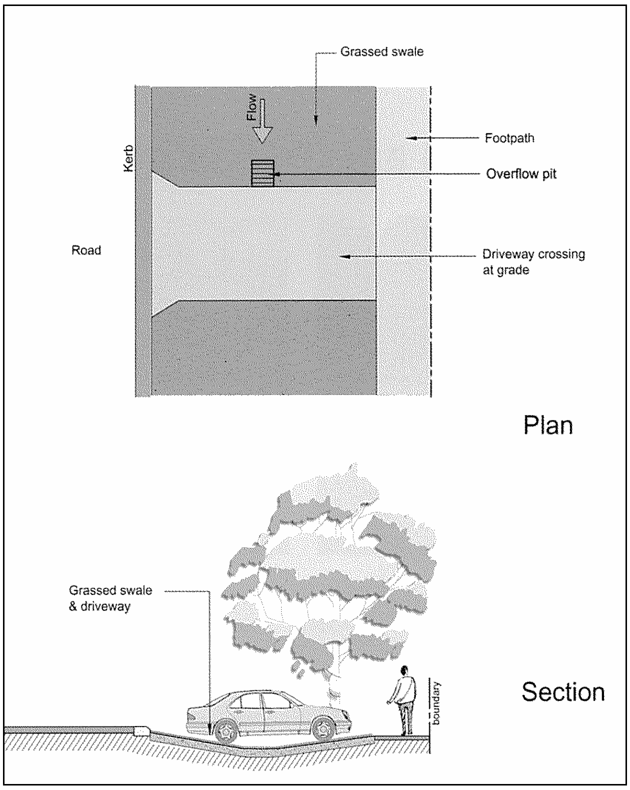

Figure 6: Vegetated swales (At grade crossing) (Melbourne Water, 2005)

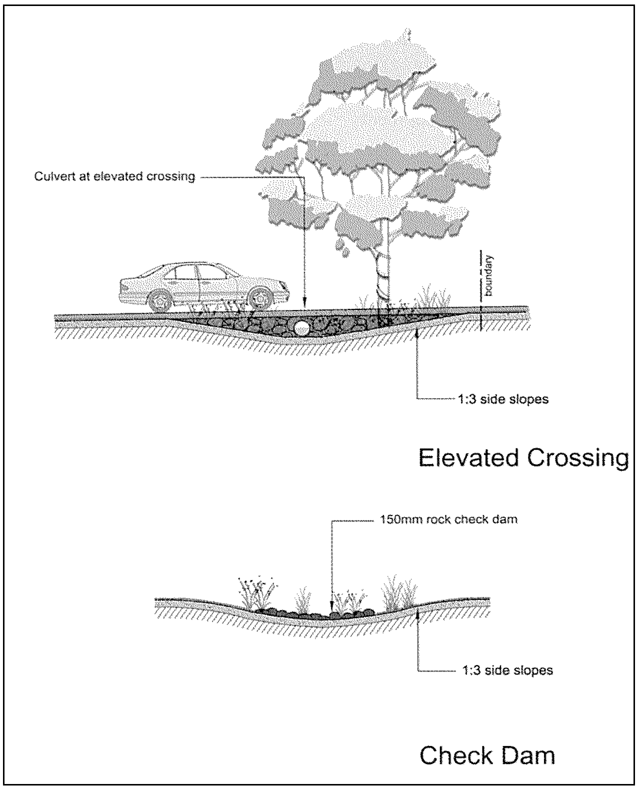

Figure 7: Vegetated swales (Elevated crossings, check dams) (Melbourne Water, 2005)

Figure 8: Example of a vegetated swale.

Figure 9: Example of a vegetated swale

Figure 10: Example of a vegetated swale.

Bioretention Basins
Bioretention basins (refer to Figure 11) add an extra treatment stage to medium and fine sediment removal as well as nutrient removal through a filtration media. Bioretention basins are commonly planted with vegetation, incorporating an extended detention depth and some biological uptake. Stormwater moves through a swale into the filter media, or enters via overflow pits, and either percolates into the surrounding soils or conveyed downstream to another treatment device (Healthy Waterways, 2006).

Bioretention basins can be installed at various scales, for example, in planter boxes, in retarding basins or in streetscapes integrated with traffic claming measures. In larger applications, it is considered good practice to have pretreatment measures upstream of the basin to reduce the maintenance frequency of the bioretention basin. For small systems this is not required.

Bioretention basins are not intended to be infiltration systems; the dominant pathway for water is not via discharge into groundwater. Rather, they convey collected water to downstream waters (or collection systems for reuse) with any loss in runoff mainly attributed to maintaining soil moisture of the filter media.

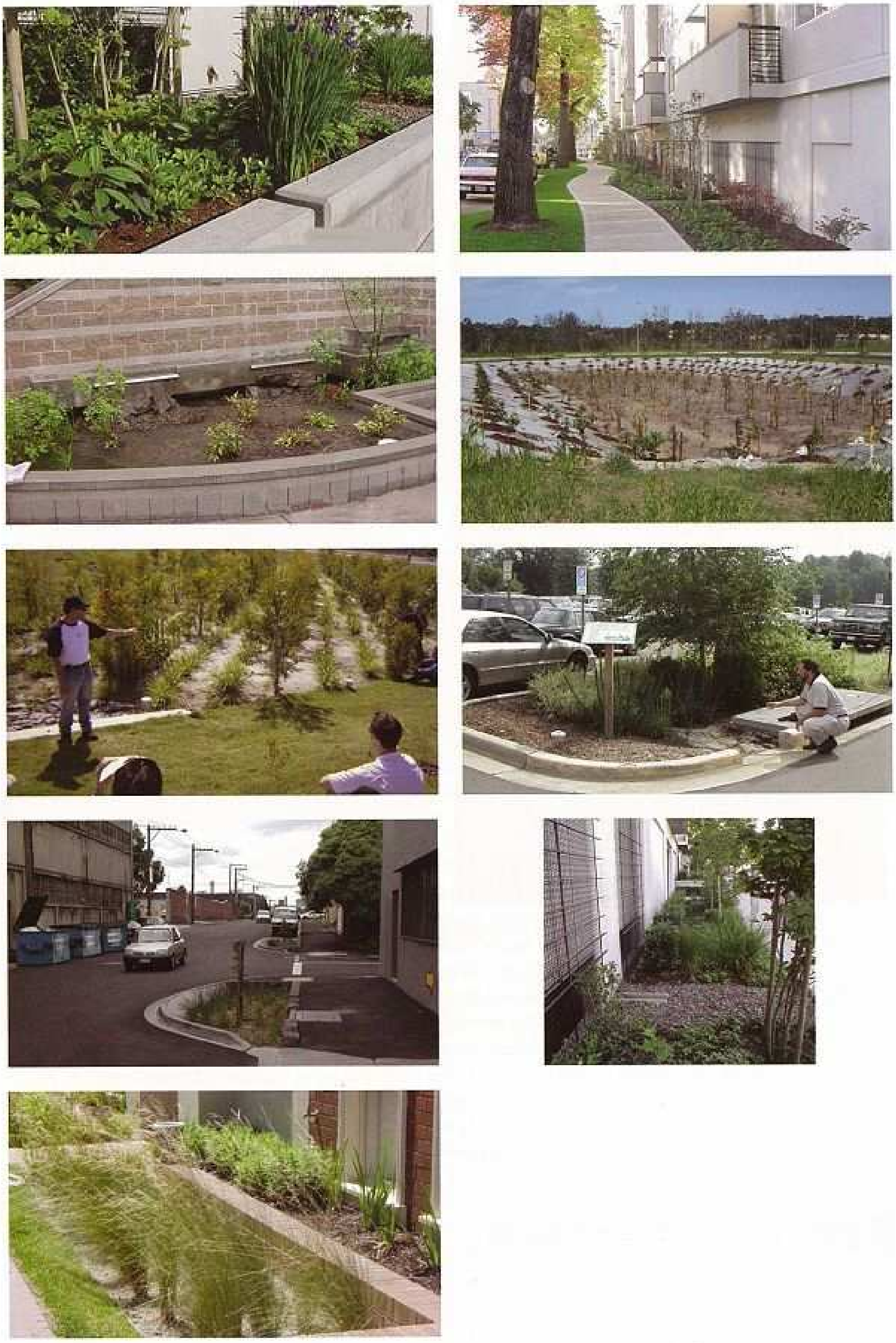

Figure 11: Bioretention basins for a range of development settings (Melbourne Water, 2005).

The proposed development incorporates the use of underground storage tanks for stormwater harvesting and reuse. These underground storage tanks can be connected to the bioretention basins where appropriate. The size requirements and locations will need to be designed using appropriate models such as Aquacycle and MUSIC at a later stage. Examples of underground storage tanks are provided in Figures 12 and 13.

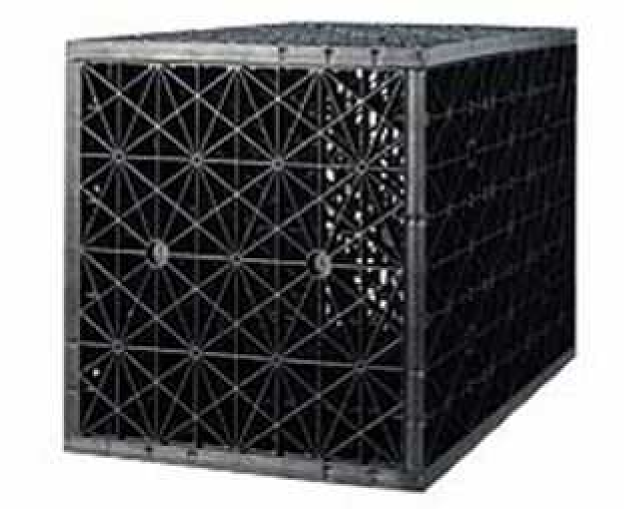

Figure 12: Example of underground storage tank (Source: Atlantis – www.atlantiscorp.com.au)

Figure 13: Example of underground storage tank (Source: Tankmasta - www.dempseype.com.au)

<u>Infiltration Systems</u>
Stormwater infiltration systems capture stormwater runoff and encourage infiltration into surrounding in-situ soils and underlying groundwater. They can have a range of benefits including:

- protecting waterway health and minimising downstream flooding (by reducing stormwater flows and volumes)
- enhancing groundwater recharge or preserving pre-development groundwater recharge

Infiltration systems are conveyance rather than treatment measures. To protect groundwater quality and avoid clogging, pre-treatment of stormwater entering infiltration systems is required.

The application of infiltration systems is best suited to moderate to highly permeable in-situ soils (i.e. sandy loam to sandy soils); however, infiltration systems can still be applied in locations with less permeable soils by providing larger detention volumes and infiltration areas.

There are four basic types of infiltration systems:

- A leaky well
- Infiltration trenches
- Soak-aways
- Infiltration Basins

It is recommended that infiltration systems are included in the proposed development to above all preserve pre-development groundwater recharge. This would entail locating groundwater recharge areas on the development site during the design phase and application of this technology to these areas.

Porous Pavement

Porous pavements are a pavement type that promotes infiltration, either to the soil below or to a dedicated water storage reservoir below it. Porous pavements should generally be located in areas without heavy traffic loads.

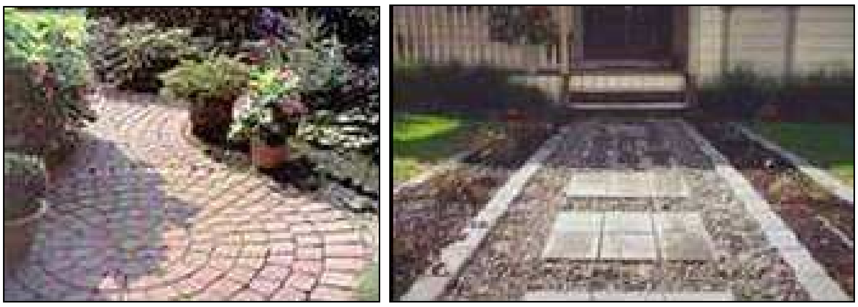

Figure 14: Examples of porous pavement

It is recommended that porous pavements be used throughout the development where appropriate. These appropriate locations should be determined during the design phases of the proposed development.

Wetlands

Constructed wetland systems are shallow, extensively vegetated water bodies that have the ability to remove and reduce contaminants such as pesticides, metals, oils, nutrients, and sediments from water through naturally occurring biological, chemical and physical mechanisms. Constructed wetlands are constructed ecosystems designed to provide a mechanism for the removal of contaminants prior to release of water into natural water bodies.

Water levels within the wetland rise during rainfall events and outlets are configured to release flows over two to three days, back to dry weather water levels. In addition to treating stormwater, constructed wetlands can also provide habitat, passive recreation, improved landscape amenity and temporary storage of treated water for reuse schemes (Healthy Waterways, 2006).

The advantages of constructed wetlands include the ability to operate on solar energy, self-organise and self-maintain to a large degree, increase treatment capacity over time, produce root-zone oxygen and consume carbon dioxide, and achieve high levels of treatment with minimal maintenance when well designed and managed.

Constructed wetlands are based on ecological principles of function and structure to maintain healthy aquatic systems and environments by:

- trapping suspended solids, heavy metals, and pesticides,
- lowering BOD,
- algal removal,
- settling and retention of suspended particulate matter,
- filtration and chemical precipitation through contact of the water with the substrate and litter,
- chemical transformations,
- the uptake and assimilation of nutrients,
- adsorption and ion exchange on the surfaces of plants, substrate, sediment and litter,

- breakdown, transformation and uptake of pollutants and nutrients by micro-organisms and plants, and
- predation and natural die-off of pathogens.

Figure 15: Examples of constructed wetlands.

7.3 Golf Course

The golf course is a major component to the proposed Development. It has been designed to produce a positive environmental impact on the Development. It is carefully integrated into the various settings amongst precinct lots and alongside greenways and creeks. Two or three holes along the Northern Boundary have been established to increase the extent of a buffer zone from the Northern Wetland area. Organic management of these holes is an objective which will be a positive impact on the ecology and environment of those areas.

The potential impacts of the golf course would include those set out in Table 6.

Table 6: Potential impacts of the Golf Course of the receiving environment

Positive	Negative
Removal of cattle and feral animals from waterbodies, thus removal of destructive activities	Changes in watershed dynamics through altered topography and vegetation height / type (short vs long grass)
Buffer zones between golf course and surrounding environment	Potential for pollutants entering surface water bodies via sheet flow in the event of poor irrigation management
Water sensitive design technologies implemented throughout part of the golf course, such as constructed wetlands	Groundwater contamination from the use of reclaimed water (including nitrate and phosphate)
Golf course implements management strategies as detailed below	Potential impact from sodium on soil structure, inhibiting groundcover ability and increasing erosion
	Construction phase of golf course

To manage potential impacts on flora and fauna from this area the Development should take account of the following guiding principles:

- Reduction in chemical application to the golf course
- Incorporate efficient slow release fertilisers based on soil science principles
- No application of organo-phosphates on the golf course
- Utilise microbial methods to increase soil biomass to promote plant nutrient uptake rather than leaching
- Incorporate an Integrated Pest Management strategy for the golf course during the design phase
- Utilise innovative disease management by inoculating the growing media with beneficial bacteria and fungi
- Undertake an annual soil testing regime to identify soil nutrient amendments required
- Develop a daily irrigation regime based on deficit irrigation using an automatic irrigation system comprising soil moisture monitoring, evapotranspiration and weather station data
- Utilise Class A reclaimed water and stormwater as the primary water supply for the golf course
- Undertake modelling (using appropriate software applications such as Medli) of the irrigation system using reclaimed water during the design stages of the proposed development
- Include appropriate buffers (rehabilitation of riparian areas) and treatment zones (e.g. constructed wetlands) on the golf course to protect the receiving environment
- Develop a water quality monitoring program that includes 'critical limits' for selected water quality parameters

These principles should also be read in conjunction with Queensland Government Water Management Guidelines, 2006. By implementing the above guiding principles, the golf course is expected to have a more positive impact of the adjacent environment in comparison to the existing conditions

The Master Plan has embraced these principles for adoption where appropriate.

8 Conclusions

It is concluded that the proposed concept for integrated water cycle management if adopted by the Developer is sound and consistent with current recommended best practice.

Based on the water quality strategy proposed in this document and taking into account this assessment of the range of impacts and improvements to be carried out under the Master Plan for the Ella Bay Development, the water quality impacts on flora and fauna throughout the site are considered to be minimal, with the Development providing positive outcomes for the enhancement of flora and fauna habitats and abundances.

We also conclude that the package of overall improvements including re-vegetation, re-zoning, removal of cattle and feral animals from the site together with the introduction of comprehensive management information and reporting systems on the condition of the environment including that of water will enhance the abundance and biodiversity of fauna and flora within the Development site.

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