Ella Bay Integrated Resort Proposal

Supplementary Environmental Impact Statement

Submission Response: 1.1 Water Resources

1.1 Water Resources

1.1.1 Introduction

The Water Resource response has been developed in consideration of the overall objectives and philosophy of the Ella Bay Integrated Resort Proposal as set out in the EIS Executive Summary.

In further developing our water quality management strategy, the concerns of all the submitters and key stakeholders were taken into consideration, while ensuring that any impact on surface water, groundwater and the natural environment is minimised.

Specific submission concerns have been collated into the following key areas for this section:

- *Hydrological Connectivity of the Wetlands,*
- *Surface Water and Groundwater Management,*
- *Watercourse Setbacks, and*
- *Acid Sulfate Soils.*

In response to a number of submissions regarding water resource management, Golder Associates Pty Ltd—a major international consultant specialising in environmental engineering and hydrological services—prepared *Conceptual Surface Water and Groundwater Hydrology Models* and an associated report for the proposed Ella Bay Integrated Resort (The full report is provided in Volume 4, Appendix A.2.1 and should be read in conjunction with this response).

On completion of the conceptual surface water and groundwater models report, further recommendations for water management within the Site were sought from specialist development consultants THG Resource Strategists (THG) and water consultants EcoWater Solutions, to ensure that any potential water quality or run-off impacts on flora and fauna are mitigated (The full report is provided in Volume 4, Appendix A.2.2 and should be read in conjunction with this response).

Water Resources Objectives

The investigations and subsequent report completed by Golder Associates Pty Ltd was prepared to meet objectives that were to:

- assess any potential impacts upon internal and adjacent water courses,
- assess any potential impacts upon World Heritage Wetlands and beachfront swales,
- assess any potential impacts upon surrounding Wet Tropics of Queensland World Heritage Area (WTQWHA),
- assess any potential impacts upon the Great Barrier Reef World Heritage Area (GBRWHA),

- identify appropriate mitigation measures that could be adopted to address potential changes to surface water flows and groundwater hydrology, and
- identify appropriate mitigation measures that could be adopted to address discharge of chemicals, nutrients and sediment.

The purpose of the *Water Quality Management Strategy* developed by THG was 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 Site.

Key Findings

A summary of the key findings and subsequent recommendations of the Golder *Conceptual Surface Water and Groundwater Hydrology Models* comprises of the following findings. (The full report is available at Volume 4, Appendix A.2.1.)

Surface Water Hydrology

- Approximately 90% of the Development Zone (the Development Zone is predominantly the current cleared areas) is within a catchment that enters an adjacent wetland swale that flows into Ella Bay during the wet season. This area includes all the proposed resort areas, commercial areas, wastewater treatment area, most residences, most of the access roads and most of the golf course.
- Only 10% of the Development Zone is within the catchment of the WTQWHA Wetlands amounting to less than 5 % of the southern portion of the WTQWHA catchment area. This area includes a low proportion of the residences, access roads and golf course. Minor quantities of surface water from the Development Zone flows 500 m through freehold remnant wetlands prior to reaching the WTQWHA Wetlands.

Groundwater Hydrology

- The wetland swale located adjacent to Ella Bay plays an important role in maintaining a natural groundwater divide between seawater and on-shore shallow freshwater aquifers.
- There is **no** mechanism for northwards and southwards migration and/or interaction of groundwater within the coastal plain of Ella Bay from the Development Zone to the WTQWHA Wetlands. The predominant groundwater flow influence within the Ella Bay coastal plain is topography that results in a west to east flow direction.

Hydrology Changes

- Only minor localised changes to existing surface water and groundwater hydrology will occur from the proposed development by maintaining significant areas of open space, minimising below ground disturbances and hardstand areas and using best practice groundwater extraction and Water Sensitive Urban Design (WSUD) techniques.

- The Development Zone primarily comprises existing cleared rainforest and wetland areas. Revegetation of proposed open space areas will reverse some of the existing changes to surface water and groundwater hydrology that would have occurred as a result of previous clearing.
- Harvesting of surface water from sealed surfaces for water supply purposes will not significantly impact upon surface water or groundwater hydrology.
- Groundwater should not be harvested from shallow alluvial groundwater aquifers to protect wetlands and the freshwater interface adjacent to Ella Bay. Well planned and managed harvesting of groundwater from weathered rock aquifers presents a low risk to shallow groundwater and associated wetlands.
- Subject to maintaining and/or mimicking existing hydrology, the proposed development represents a low risk to adjacent wetland swales and ecological systems. Management of the Development Zone to limit changes to surface water and groundwater hydrology within adjacent wetland areas would, by definition, also protect existing surface water and groundwater discharges to Ella Bay and the Reef Lagoon.
- In accordance with standard development practice, detailed investigation, assessment and modelling of surface water and groundwater hydrology and design of required mitigation measures shall be undertaken as part of obtaining approvals and/or operational works permits for each stage of development.
- Changes to surface water and groundwater hydrology identified as potential risks to wetland areas by detailed assessment during each stage of development can be readily mitigated by a range of practical design and/or construction management strategies.

Sediment

- The adoption of a staged construction program over a 10 to 15 year period will limit actual ground disturbance at any time to areas no greater in size than other typical coastal projects undertaken in Far North Queensland.
- Erosion and Sediment Control (ESC) Plans for each stage of construction, down to single lot scale, will be prepared by appropriate personnel and approved by Council as part of Operation Works Permit processes. Auditing of erosion and sediment control implementation and a comprehensive water quality monitoring program are required during construction and operational stages.
- Planned revegetation works within open space areas will reduce existing sediment erosion from cleared areas and also provide additional sediment interception capacity during construction works.
- At the completion of construction works the Development Zone is expected to produce less sediment loading to creeks and wetlands than is currently produced due to farm use.

Nutrients

- Water quality monitoring completed to date has identified that surface water and groundwater within the Development Zone contain elevated nutrient concentrations sourced from surrounding rainforest/wetland areas and farm activities.
- Potential nutrients generated by completed development present a very low risk to surface water and groundwater quality within WTQWHA Wetland areas located to the north.
- In accordance with standard development practice, detailed investigation, assessment and modelling of nutrient generation and uptake shall be undertaken as part of obtaining approvals for each stage of development.
- Potential nutrient impacts identified by detailed assessment during each stage of development can be readily mitigated by a range of practical design and/or construction management strategies to protect creeks and wetland areas that flow directly to Ella Bay.

Contaminants

- Potential contaminants include fuel transport and storage, small scale domestic and commercial chemical use and storage, termite treatments, general litter and road sediment. Mitigation of potential impacts will be primarily achieved by appropriate storage and use, with secondary containment using WSUD techniques. Contaminants will also be minimised by restriction to allowed practices.

Acid Sulfate Soils

- Tests to date show a low probability of acid sulfate soils within the site. However, areas to be disturbed below 5 metres AHD (Australian Height Datum) shall be subject to further acid sulfate soil investigation and, where identified, management in accordance with Queensland State Planning Policy 2/02. Timing for investigations shall be tied to operational works approval of each stage of the development.

A summary of the key findings of the *Water Quality Management Strategy* (the Report) completed by THG are as follows. (The full report is available at Volume 4, Appendix A.2.2.)

The Report sets out a site integrated water cycle management strategy with the objective of a positive -to-no net impact result on the aquatic fauna and flora of the Ella Bay 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 Integrated Resort to minimise the hydrological impacts on the site's ecology and environment generally.

THG 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 proponent taking degraded land and removing cattle and feral animals, rehabilitating degraded ecosystems, providing buffer zones and corridors, establishing new vegetation communities throughout the site and implementing the recommended water management strategies listed in the 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 Ella Bay site, resulting in no interaction from the proposed development into those areas through water movements. As a result, the mitigation activities implemented throughout the Proposal 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 proponent has a comprehensive understanding of the range of issues and challenges involved in achieving water quality management and appreciates that the processes of storm-water pollution need to be analysed in detail. The proponent has embraced the principles and priorities for an implementation plan. In this regard, it is possible to mitigate effectively the likely impacts of the Proposal on the surrounding flora and fauna which exist in, and constitute the existing wetlands, swales and other natural environments of the Site.

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 proposal and, where appropriate, have been adopted.

To implement water quality management 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 and allowing management intervention to isolate, remedy and return to acceptable levels of water quality throughout the proposal at each stage are elements of the principles discussed in the report. Source control, treatment and re-use and continuous improvement approaches have also been set out in detail.

With regard to storm-water the Master Planning phase of the proposal 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 storm-water at or near its source.

The golf course has been designed to produce a positive environmental impact on the site. On balance the impact of the golf course is seen as a positive on the flora and fauna as well as the water courses within the site. As a result, the proposal 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 Integrated Resort, the water quality impacts on flora and fauna throughout the site are considered to be positive.

The full *Water Quality Management Strategy* (THG) and *Conceptual Surface Water and Groundwater Hydrology Models* (Golder) and associated report are available at Volume 4, Appendix A.2.2 and A.2.1 and should be read in conjunction with this section. A detailed discussion and responses to water resource issues that were identified within the submission process now follows.

1.1.2 Submitter Issue: Hydrological Connectivity of Wetlands

1.1.2.1 Hydrological connectivity with the Ella Bay Wetlands

A comprehensive analysis of the current state, hydrological connectivity and a risk assessment of the Wet Tropics Queensland World Heritage Area (WTQWHA) Ella Bay Wetland should be conducted. The relationship of the site to the wetland, and the role of the wetland as a pollution buffer needs to be determined.

EIS reference: Volume 4, Section 4.3

Submitter reference: 25/52

J Dall (6), E Bock (11), B Harvey (C4) (12), R Eastment (13), J Beasley (14), J Rainbird (CAFNEC) (20), Performa Letter (15 submissions) (17,22-35), J Ridd (JES) (36), Department of Primary Industries and Fisheries (43), Environmental Protection Agency (45), Department of the Environment and Water Resources (51)

Proponent Response

Golder was engaged to conduct an extensive groundwater and surface water hydrology model, including a detailed assessment of the hydrological connectivity and risk assessment to the Ella Bay Wetland. The findings indicate that (a) there is no mechanism for northwards and southwards migration and/or interaction of groundwater within the coastal plain of Ella Bay from the Development Zone to the WTQWHA Wetlands and (b) only 10% of the Development Zone is within the catchment of the WTQWHA Wetlands (<5 % of the southern portion of the WTQWHA catchment area) (refer to figure 1.2.2).

The impact of runoff into the WTQWHA has been mitigated with alterations to the Master Plan involving the repositioning of the northern most residences and three holes of the golf course (organic fairways) which will induce minimal hydrological change and more efficient and effective run-off management into the WTQWHA Wetland.

The combination of limited connectivity, minimal change in hydrology and the ongoing management of surface runoff from the organic fairways mitigates any hydrological impact of the Proposal on the WTQWHA Wetland and its potential role as an essential pollution buffer.

Location of the Ella Bay Wetlands

The WTQWHA Ella Bay Wetlands are located beyond the site towards the north. They consist of a large widespread, low-lying (<2 m AHD) wetland that extends the full width of the Ella Bay coastal plain from the base of the Seymour Range to the southern Ella Bay beach ridge. Golder (2007) found that the primary outflow for this section of the WTQWHA Wetlands appears to be the Northern Beach Discharge. There are also three densely vegetated north-south trending wetland swales, located between remnant sand dunes, that commence just inside or adjacent to the northern boundary of the Development Zone. Figure 1.2.1 is a photograph of the wetland behind the beach dune.

Figure 1.2.1: WTQWHA Wetland behind the beach dune (Golder, Volume 4, Appendix A.2.1)

Figure 1.2.2: Inferred surface water way flows (Golder, Volume 4, Appendix A.2.1)

Current hydrological connectivity of Ella Bay Wetland with the site

The *Conceptual Groundwater Model* (Volume 4, Appendix A.2.1—Section 4) and *Preliminary Water Balance* (Volume 4, Appendix A.2.1—Section 5.4) conducted by Golder show that groundwater flows have a minimal influence on the hydrology of the WTQWHA Wetlands.

Also noted by Golder (2007), available observation data indicates that tidal movements within Ella Bay have minimal influence upon wetland areas located 100 m to 200 m away from open water within the swales that are directly connected to the Northern Beach Discharge and Southern Beach Discharge (see figure 1.2.2). This includes wetland areas immediately adjacent to the Southern Ella Bay Beach Dune.

The key influence on surface water flow volumes and levels in the WTQWHA Wetlands located within Catchment B are considered to be direct rainfall within the wetlands and surface water run-off from adjacent up gradient rainforest areas located within the WTQWHA.

Seasonal flows within the WTQWHA are briefly described as follows.

- 'Wet' season: High rainfall volumes resulting in higher wetland levels and flow predominantly towards the Northern Beach Discharge.
- 'Dry' season: Low rainfall volumes resulting in lower wetland levels, with almost no internal flow or discharge to Ella Bay.

A total of approximately 41 hectares of the Development Zone is located within the four southern sub-catchments (B1 to B4) of Catchment B (see figure 1.2.2). This is approximately 5% of the total area of Catchment B that includes the southern portion of the WTQWHA Wetlands. The *Preliminary Water Balance* indicates that surface water run-off from the three wetland based sub-catchments (B2 to B4) are, in total, less than 1% of the total surface water flow volume for Catchment B (Volume 4, Appendix A.2.1—Sections 5.3 and 5.4).

Hydrological connectivity of Ella Bay Wetland with the proposed development

Golder (2007) indicates that there is limited connectivity between the Ella Bay Wetland to the north of the site and the proposed development.

Surface Water

- Approximately 90% of the Development Zone is located within a catchment that enters an adjacent wetland swale that flows into Ella Bay during the wet season. This area includes all the proposed resort areas, commercial areas, wastewater treatment area, most residences, most of the access roads and most of the golf course.
- Only 10% of the Development Zone is within the catchment of the WTQWHA Wetlands (<5% of the southern portion of the WTQWHA catchment area). This area includes a low proportion of the residences (<10%), access roads and golf course.

- Minor quantities of surface water from within Catchment B area of the Development Zone flow 500 m through remnant wetlands located within the Northern Freehold Area prior to reaching the WTQWHA Wetlands.

Groundwater

- There is no mechanism for northwards and southwards migration and/or interaction of groundwater within the coastal plain of Ella Bay north of Farm Creek. The predominant groundwater flow influence within the Ella Bay coastal plain is topography that results in a west to east flow direction (see figure 1.2.3).
- It is considered that there is only minor and localised groundwater interchange between the Development Zone and immediately adjacent sections of the Northern Freehold Area. There would be no groundwater interchange between the Development Area and the WTQWHA.
- Groundwater is considered to form only a minor component of the overall hydrology of the WTQWHA Wetlands.

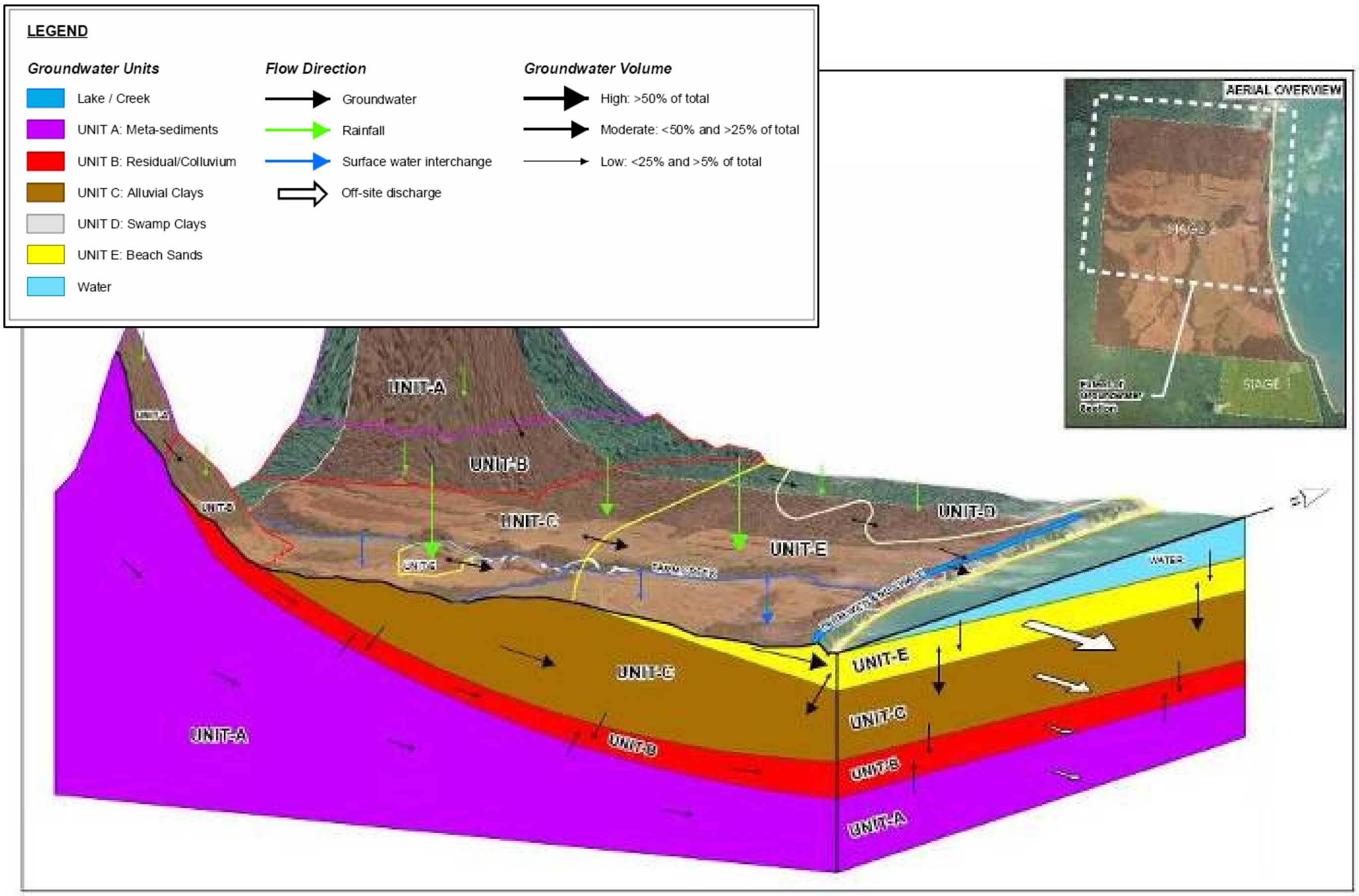

Figure 1.2.3: Internal groundwater section (refer to Golder, Volume 4, Appendix A.2.1)

Risks to WTQWHA Ella Bay Wetlands

Golder (2007) concludes that subject to maintaining and/or mimicking existing hydrology, the development represents minimal risk to adjacent wetland swales and ecological systems. Management of the Development Zone to limit changes to surface water and groundwater hydrology within adjacent wetland areas would, by definition, also protect existing surface water and groundwater discharges to Ella Bay and the Reef Lagoon. In accordance with standard development practice, detailed investigation, assessment and modelling of surface water and groundwater hydrology and design of required mitigation measures shall be undertaken as part of obtaining approvals and/or operations works permits for each stage of development.

Surface water run-off from the Development Zone into the Northern Freehold Area and subsequently into the WTQWHA Wetlands is limited to four relatively small sub-catchments (B1 to B4) (see figure 1.2.2). The relatively small size of these catchments within the Development Zone and the flat topography of the coastal plain in these areas give an opportunity to provide additional sediment and other potential contaminant protection to wetland areas by completely redirecting surface water run-off from one or more of these sub-catchments during and potentially following construction works. As noted in Volume 4, Appendix A.2.1—Section 6.2.2, specialist advice would be required to assess the potential benefits to wetland ecosystems against the reduction in run-off volumes. The Golder report suggested that in practical terms it may only be worth considering the three smallest sub-catchments that directly flow into relatively undisturbed wetland swales.

Minor modifications of the Ella Bay Integrated Resort Master Plan involving the repositioning of the northern most residences and three fairways of the golf course will result in the predominant development area of the four sub-catchments (B1 to B4) as vegetated habitat or organic golf course (see figure 1.2.4). This will provide an additional buffer between the Site and the WTQWHA Wetland. In comparison to the previously proposed residences, the organic fairway will provide for minimal hydrological change and more efficient and effective run-off management. This area makes up the majority of the <5% WTQWHA Wetland southern catchment area that is within the Development Zone.

Figure 1.2.4: North-west residential zone indicating the role of the golf course as a buffer zone (Volume 3, Section 3.1).

It was also concluded in the Golder report (2007) that any changes to surface water and groundwater hydrology identified by detailed assessment during each stage of development as potential risks to wetland areas can be readily mitigated by a range of practical design and/or construction management strategies.

In addition, the Golder report found that potential nutrients generated by completed Development would present a very low risk to surface water and groundwater quality within WTQWHA Wetland areas located to the north of the Development Zone. It was determined that any potential nutrient impacts identified by detailed assessment during each stage of development could be readily mitigated by a range of practical design and/or construction management strategies to protect creeks and wetland areas that flow directly to Ella Bay. For details on wastewater management refer to the *Ecologically Sustainable Development Report* (Ensight) Volume 4, Appendix A.2.9.

Impacts on surface water and groundwater from the use of fertilisers and treated wastewater to maintain parks, gardens and the golf course within the significant open space areas of the site will be at least partially off-set by the removal of cattle grazing and pasture fertilising.

The *Conceptual Surface Water and Groundwater Models* indicates that there is currently only localised minor water interaction between the Development Zone and wetlands located within the Northern Freehold Area and almost no interchange within the WTQWHA Wetland areas.

Potential nutrient impacts that may occur in these areas would be of a minor nature, localised to the immediate area adjacent to the Development Zone and well within the Northern Freehold Area. Other than identification of a potential opportunity to redirect the relatively small surface run-off volumes from the Development Zone into Catchment B, as discussed in Volume 4, Appendix A.2.1—Section 6.2.2, potential nutrient impacts upon the WTQWHA Wetland areas located to the north of the Site are not considered to require further assessment.

The key ecosystem of concern in the event of changes to nutrient concentrations in surface waters and/or groundwater is therefore considered to be the Farm Wetland Swale located behind the beach dune. Surface water discharge from the Development Zone into the Eastern Freehold Area and adjacent beachfront land enters a low-lying (<2 m AHD) continuous wetland swale located behind the Southern Ella Bay Beach Dune that extends along most of the eastern boundary of the Site ('Farm Wetland Swale'). The Farm Wetland Swale intermittently flows out to Ella Bay through the Southern Beach Discharge, however was also found to play an important role in maintaining a natural groundwater divide between seawater in Ella Bay and freshwater within on-shore shallow aquifers.

It is proposed that nutrient modelling (Medli or similar program) will be undertaken during the detailed planning and design stages to provide an accurate assessment of nutrient loadings from existing cattle grazing/fertiliser use, proposed development land and irrigation uses and the impact of potential changes in nutrient concentrations upon this receiving ecosystem. Such nutrient modelling would need to consider and develop a range of appropriate mitigation measures including:

- determining the level of nutrient removal required for wastewater to be used for irrigation purposes, i.e. irrigation using appropriately treated wastewater is likely to be the most sustainable method of fertilising open space areas;
- attenuation of nutrient concentrations from irrigation waters, within the unsaturated soil profile to protect shallow groundwater quality;
- adoption of the most suitable irrigation method, surface or subsurface, for application of treated wastewater for the golf course, residential properties, parkland and resort areas to protect surface water quality.

In the event that fertiliser use and irrigation application within the Development Zone are assessed to present a risk to receiving groundwater and surface water ecosystems there are a range practical mitigation strategies that could be implemented including the:

- adoption a subsurface irrigation method, within key areas of concern;
- preparation of a site specific management plan for the golf course and resort operations that includes a detailed assessment of nutrient requirements, and sources and ongoing soil and water

monitoring to ensure that only the fertiliser required to maintain open space within these properties to a required standard is used;

- design and operation of the wastewater treatment system to remove nutrient concentrations to a standard acceptable for on-site irrigation application or discharge to wetland areas and the Reef Lagoon;
- use of pubic information systems for other environmental issues of concern, such as Cassowary Management, to inform future residents of the Site of the importance of managing garden fertiliser use;
- use of WSUD techniques, such as constructed swales, external bunding and other drainage control systems, to direct surface water generated within the Development Zone into sediment/wetland treatment systems to reduce nutrient concentrations, as required; and
- use of WSUD techniques, such as constructed swales, gross-pollutant traps, wetlands and similar treatment systems, to remove organic matter from surface run-off (generated within both open space areas and remnant/rehabilitated vegetation areas) prior to discharge to gullies, creeks and wetlands.

In *Water Quality Management Strategy* (Volume 4, Appendix A.2.2), THG conclude that due to the topography of the surrounding land and from the results of the Golder modelling, the receiving environments that the proposed Ella Bay development only has the potential to impact on are limited to the Farm Wetland Swale, 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 site, resulting in no interaction from the Proposal into those areas through water movements. The Golder modeling also indicates that there is no groundwater and minimal surface water interaction with the Ella Bay Wetland which will be mitigated through the ongoing management of organic fairways. As a result, the water quality management activities implemented throughout the Integrated Resort are to focus on minimising or negating any potential impacts or potential risks to the Great Barrier Reef Marine Park, the Ella Bay Wetland area and the on-site receiving waterways.

Role of the wetland as a pollution buffer

The combination of limited connectivity, minimal change in hydrology and the ongoing management of surface run-off from the organic fairways mitigates any hydrological impact of the Proposal on the WTQWHA Wetland and its potential role as an essential pollution buffer.

The Golder report found that 10% of the Development Zone is within the catchment of the Ella Bay Wetlands (WTQWHA) which constitutes less than 5% of the wetlands catchment area.

A redesign of the Master Plan to mitigate potential run-off impacts has been undertaken, with the portion of development that occurs within the wetland catchment being occupied by three organic fairways—the residential component being relocated further south. Surface water from the golf course can be monitored and managed to achieve the required water quality and quantity guidelines and hence not impacting upon the WTQWHA Wetland.

1.1.3 Submitter Issue: Surface Water and Groundwater Management

1.1.3.1 Surface Water and Groundwater Monitoring

Further assessment should be made of surface waterways and groundwater, including monitoring to examine freshwater/salt water content. In similar far north Queensland conditions a freshwater veneer supports the near coastal vegetation that needs freshwater to survive. Any draw on the aquifer for water supply, particularly through dry months, could lower the table and cause stress on swamp vegetation. In addition, the foundations of some buildings are expected to penetrate the water table and may impact on natural groundwater pressures (i.e. those that resist salt water penetration).

EIS reference: Volume 4, Section 4.3.1.1 & 4.3.1.2

Submitter reference: 4/52

Department of Natural Resources and Water (42), Department of Primary Industries and Fisheries (43), Wet Tropics Management Authority (50), Department of the Environment and Water Resources (51)

<u>Proponent Response</u>

Golder (2007) has conducted detailed onsite water quality analysis and impact assessment of surface waterways and groundwater including further investigation into salt water content (the full report is available at Volume 4, Appendix A.2.1). Golder's results can be summarised as follows.

- Freshwater conditions dominate surface waterways and groundwater on the Ella Bay site.
- The salt water content results for the wetland swale located behind Southern Ella Bay Beach Dune were within or just above the freshwater aquatic ecosystem guidelines and significantly below seawater concentrations.
- Freshwater conditions could be predominant within the wetland swale during and immediately following 'wet' season periods.
- Draw on deep groundwater aquifers in the case of an emergency pose minimal risk to shallow groundwater and associated wetlands and according to EnSight (Volume 4, Appendix A.2.9) would only occur in a 1 in 100 year dry weather event.
- In the context of the predominant surface water flow volumes to and from the Farm Wetland Swale, minor changes to groundwater flows as a result of buildings, basements, foundations or swimming pools penetrating the water table would not impact upon existing surface water ecological systems or the barrier to saltwater intrusion.
- Ongoing monitoring of both surface water and groundwater quality and quantities will occur throughout construction and operation.

Summary of Surface Water and Groundwater Outcomes and Findings (Golder, 2007)

Hydrology

- Only minor localised changes to existing surface water and groundwater hydrology will occur from the proposed Development by maintaining significant areas of open space, minimising below ground disturbances and hardstand areas and using best practice groundwater extraction and Water Sensitive Urban Design (WSUD) techniques.
- The Development Zone primarily comprises existing cleared rainforest and wetland areas. Revegetation of proposed open space areas will reverse some of the existing changes to surface water and groundwater hydrology that would have occurred as a result of previous clearing.
- Subject to maintaining and/or mimicking existing hydrology, the development represents a low risk to adjacent wetland swales and ecological systems (Farm Wetland Swale and WTQWHA). Management of the Development Zone to limit changes to surface water and groundwater hydrology within adjacent wetland areas would, by definition, also protect existing surface water and groundwater discharges to Ella Bay and the Reef Lagoon.
- In accordance with standard development practice, detailed investigation, assessment and modelling of surface water and groundwater hydrology and design of required mitigation measures shall be undertaken as part obtaining approvals and/or operational works permits for each stage of proposal.
- Changes to surface water and groundwater hydrology identified as potential risks to wetland areas by detailed assessment can be mitigated by a range of practical design and/or construction management strategies.
- Specialist advice on the ecosystems of the wetland areas within the Northern Freehold Area should be sought specifically about how to most appropriately manage surface water flows into this area during construction periods.

Water Harvesting

- Harvesting of surface water from sealed surfaces for water supply purposes will not significantly impact upon surface water or groundwater hydrology.
- Groundwater should not be harvested from shallow alluvial groundwater aquifers (Units C & Unit E in figure 1.2.3) to protect wetlands and the freshwater interface adjacent to Ella Bay.
- Well planned and managed harvesting of groundwater from weathered rock aquifers (Unit A in figure 1.2.3) should present a low risk to shallow groundwater and associated wetlands.
- In the development of the *Ecologically Sustainable Development Report* (Volume 4, Appendix A.2.9) EnSight have found that emergency draw on deep groundwater aquifers may occur in a 1 in 100 year dry weather event.

Surface Water Saltwater Assessment

Basic surface water quality measurements (pH and electrical conductivity) were taken following the 2007 wet season (24 June 2007) at three locations within the wetland swale located behind Southern Ella Bay Beach Dune. The three locations measured are:

- EBSW4 approximately 500 m north of the southern boundary of the Site,
- EBSW5 adjacent to the northern Site boundary within flowing water, and
- EBSW6 approximately 100 north of the Site boundary (WTQWHA).

The results, summarised in Volume 4, Appendix A.2.1—Table 1, indicate higher electrical conductivity within the wetland swale than measured in surface water and groundwater to date within the Site, however, the results were within or just above the freshwater aquatic ecosystem guidelines and significantly below seawater concentrations. This suggests that freshwater conditions could be predominant within the wetland swale located behind Southern Ella Bay Beach Dune during and immediately following 'wet' season periods.

Regional Groundwater Assessment

A search for registered groundwater wells by the Department of Natural Resources and Water (NRW) presented in Volume 4, Appendix C of the Golder report did not identify any location within or adjacent to Ella Bay. The two nearest NRW registered wells (78343 and 92901) are located on the other side of the range from Ella Bay and were constructed with basalt formations that are not present within the geology underlying the Ella Bay area or located within the rainfall catchment for the site.

Golder (1995) identified two existing groundwater harvesting wells in this area which were:

- a 40 m deep well constructed within weathered bedrock at the prawn hatchery located to the south of Ella Bay—this well yielded approximately 4 L/s, and
- a shallow well constructed within alluvial soils used for a residential supply within the Development Zone—this well is no longer in use.

Based upon discussions with the Department of Primary Industries (DPI) at that time, Golder (1995) identified two potential groundwater sources within the proposed Little Cove Development located immediately to the south of the Site:

- an unconfined groundwater system in alluvial deposits in lower areas, and
- fractures within the bedrock on steeper portions and underlying the lower area alluvium.

The DPI at this time (1995) raised concerns with large scale use of the alluvial groundwater system and potential disturbance to the freshwater/saltwater interface. Use of the weathered rock groundwater system was preferred, however 'controlled' pumping would be required to reduce the potential for saltwater intrusion, particularly in lower areas. Within the Ella Bay Development there will be no groundwater extraction from the shallow aquifers.

Experience with similar conditions in the surrounding region indicate that groundwater within the site would generally be intersected within 5 m depth across areas of the site underlain by alluvial soils with surface levels less than 10 m AHD.

Groundwater underlying site areas with topography less than 5 m AHD may correlate to sea levels and be subject to the influence of tidal movements with potentially seasonally high salinity concentrations and minimal beneficial use (i.e. not suitable for irrigation, stock watering, drinking water). As surface levels increase above 5 m AHD groundwater is more likely to be influenced by rainfall recharge with a correlating improvement in water quality that may have some beneficial use.

Groundwater conditions within the metamorphic bedrock formations may vary considerably. In general, the metamorphic rocks are likely to provide localised groundwater storage and extraction capacity in highly fractured zones. Bores within this fractured rock aquifer in the surrounding region are reported to have yields of between 0.5 L/s and 4 L/s. This water is generally considered suitable for most beneficial uses.

Groundwater movement within soils and rock is anticipated to be in a generally eastwards direction in sympathy with site topography, discharging into creeks and the Farm Wetland Swale.

Observations and the shallow groundwater investigations and monitoring carried out within the site (Golder 2006 and Golder 2007) were generally consistent with the above description and are as follows.

- Shallow groundwater inflows were intersected at depths less than 3 m within the alluvium at all lower-lying borehole locations.
- Perched groundwater inflows were also noted at depths less than 3 m within residual soils where surface levels were below 15 m AHD.

Electrical conductivity readings on samples from three groundwater monitoring wells taken prior to and during the 2007 wet season (prior to November 2006 and during May 2007) were all low (refer to Volume 4, Appendix A.2.1—Table 1), indicating freshwater conditions. The well nearest to the ocean was located only approximately 100 m west of the Farm Wetland Swale at the northern end of the Development Zone.

In conjunction with surface water quality test results (refer to Volume 4, Appendix A.2.1—Table 1), the groundwater results indicate that the influence of tidal movements and intrusion of saline water within the Farm Wetland Swale may be limited to severe weather conditions such as king tides and storm surges.

Impact on Groundwater Flow

There is likely to be a relatively high interaction between groundwater within Unit E (Beach Sands, see figure 1.2.3) and surface water that plays an important role in maintaining ecology systems within the Farm Wetland Swale and the natural divide between saline waters from Ella Bay, particularly during the low surface water flow 'dry' season.

In the context of the predominant surface water flow volumes to and from the Farm Wetland Swale, minor changes to groundwater flows as a result of buildings, basements, foundations or swimming pools penetrating the water table would not impact upon existing surface water ecological systems or the barrier to saltwater intrusion.

The proposed resorts located adjacent to the Farm Wetland Swale may include the following elements that have the potential to change the groundwater hydrology of Groundwater Unit E (Beach Sands) at a local level:

- hardstand areas (roofs, roads, cark parks, swimming pools),
- water supply from roofs, and
- excavations for swimming pools, half basements and lift wells to a maximum depth of 2 m that may potentially act as barriers to groundwater flow.

It is understood that the four northernmost resorts, located either side of Farm Creek, will be constructed on a relatively small scale, with one to two storey structures that do not require basements. Permanent excavations in these four areas would be predominantly for swimming pool construction within a depth of 2 m from the existing ground surface.

As noted in Volume 4, Appendix A.2.1—Section 6.2.1, the bulk of rainfall in the resort development areas is currently likely to be lost as surface water sheet flow to the Farm Wetland Swale. Existing recharge of Groundwater Unit E in the lower-lying site areas adjacent to the Farm Wetland Swale will be controlled by soil saturation, particularly during the ‘wet’ season. Loss of a limited volume of overall yearly rainfall run-off for water supply harvesting is not considered to have a negative impact upon groundwater recharge on the basis of:

- additional recharge from excess surface water run-off from hardstand areas using WSUD techniques, i.e. constructed swales and sediment/wetland treatment systems, rather than traditional storm-water pipelines; and
- use of recycled water sourced from an on-site wastewater treatment plant for watering of open space areas.

It should also be noted that the existing cattle grazing areas have only been cleared in the past century. Previous natural rainforest and wetland vegetation that would have been present across the entire site would have resulted in significantly higher evapotranspiration rates and resultant lower rate of groundwater recharge than is currently occurring.

The proposed resorts are planned to be set-back from the beachfront by a distance of at least 110 m from the Highest Astronomical Tide (HAT). At this distance, the total thickness of Groundwater Unit E (Beach Sands) is likely to be in the order of at least 5 m to 10 m.

Conservatively allowing for an average depth to groundwater from the existing ground surface of only 1 m, the total saturated thickness of Groundwater Unit E (Beach Sands) is likely to be at least 6 m, providing a total cross-sectional area for groundwater flow along the entire front of the Development Zone in the order of at least 10,000 m^2.

Allowing for excavations to a depth of 2 m below the ground surface and, therefore, 1 m below groundwater levels, across 50% the two southern larger scale resorts, the maximum cross-sectional area reduction to shallow groundwater flows in Unit E (Beach Sands) would be less than 250 m^2 out of a total flow area of 10,000 m^2 (2.5%). The high permeability of Unit E soils would compensate for such shallow, localised, non-continuous barriers and any change in overall groundwater flow volumes would be less than 1%.

Therefore, as stated earlier, in the context of the predominant surface water flow volumes to and from the Farm Wetland Swale, minor changes to groundwater flows within Groundwater Unit E (Beach Sands) would not impact upon existing surface water ecological systems or the barrier to saltwater intrusion.

In the event that subsequent detailed planning and design works result in potential reductions to groundwater flow within Unit E (Beach Sands) of greater than, for example, 5%, there are a number of simple and practical management strategies that could be implemented that include the use of WSUD techniques (i.e. constructed swales and wetlands) to increase groundwater recharge to Unit E (Beach Sands) in the areas between the resorts and the Farm Wetland Swale.

Management of the Development Zone to limit changes to groundwater hydrology adjacent to the Farm Wetland Swale would protect existing groundwater discharges to Ella Bay and the Reef Lagoon.

It is proposed to harvest rainfall from selected sealed surfaces (i.e. building roofs) to provide a significant proportion of potable water supply for the Development Zone. Section 6.3.1 of the Golder report (Volume 4, Appendix A.2.1) indicates that this water harvesting should have minimal impact upon groundwater recharge.

Subject to undertaking appropriate studies and monitoring to demonstrate that there would be no adverse impacts upon wetland ecosystems and groundwater quality, harvesting of groundwater for water supply purposes may also be considered for the following uses:

- construction, and
- emergency operational during extended dry periods—EnSight (2007) indicated this is likely to be limited to a 1 in 100 year dry event.

As identified by Golder (1995), large scale use of the near-surface Groundwater Units [i.e. Unit C (Alluvial Clay), Unit D (Swampland Clay), Unit E (Beach Sands)] for this purpose is not recommended on the basis of the following points.

- The storage capacity of shallow soil aquifer is generally limited and may not provide a suitably reliable water supply.
- Dewatering of the shallow soil-based groundwater systems is likely to impact upon vegetation and interconnected surface water systems (i.e. creeks and wetlands), including potential seawater intrusion.

Only Unit A (Weathered Metasediments) is considered potentially suitable for large scale water supply purposes. Suitable characteristics of this groundwater system include the following characteristics.

- Localised groundwater storage is likely to be relatively large and therefore provide some reliability without resulting in significant drawdown.
- The Conceptual Groundwater Model shows that there are multiple layers of low permeability clay-based groundwater systems (Unit B and Unit C) located between Unit A and sensitive wetland ecosystems that predominantly interact with the higher permeability Unit E (Beach Sands).
- The topography of the site and main recharge source (i.e. elevated hillslopes) may result in sub-artesian groundwater pressure conditions within Unit A.

As noted above, detailed groundwater assessment and modelling is required at the detail design stage to assess the most appropriate locations and extraction volumes that could be sustained with an acceptable factor of safety against impacting upon such systems if extraction is required in the case of a 1 in 100 year dry event (refer to the *Ecologically Sustainable Development Report* (Ensight, Volume 4, Appendix A.2.9). Operation of a large scale groundwater harvesting system within Unit A (Weathered Metasediments) would also require a comprehensive monitoring program to identify and address potential impacts upon shallow groundwater and surface water systems.

1.1.3.2 Impact on Great Barrier Reef World Heritage Area

Flow regime changes and pollutant impacts including the discharge of chemicals, nutrients and sediment from the proposed development Site on the Great Barrier Reef World Heritage Area (GBRWHA) should be assessed.

EIS reference: Volume 4, Section 4.3 & 4.4

Submitter reference: 3/52
E Bock (11), Wet Tropics Management Authority (50), Department of the Environment and Water Resources (51)

Proponent Response

Monitoring Surface Water and Groundwater Quality and Flow Regime Entering the GBRWHA

The Golder report (2007) indicates that a well planned, constructed and operated development at Ella Bay will have minimal impact upon surface water and groundwater hydrology and quality and adjacent wetland areas. Planning for the proposed development is primarily based upon protection of immediate adjacent wetland areas within the Northern Freehold Area and the Farm Wetland Swale. The protection of these potentially more sensitive on-shore wetland ecosystems will in turn provide suitable protection for the adjacent area of the Reef Lagoon. A range of design and mitigation measures have been identified that are proposed to be implemented to maintain and, where possible, enhance water quality.

Mitigation of Contaminant Discharge from the Site on Wetlands and GBRWHA

Potential surface water and groundwater contaminant sources that may be present during the development and subsequent operation of the Development Zone that will require mitigation include the following.

- Fuel, engine oil and lubrication oil storage: Possibly required for construction equipment, golf course maintenance and emergency electricity generators (e.g. resort standby generators). All such storages should be located within appropriately designed, constructed and maintained facilities in accordance with relevant Australian standards and Queensland Government licence conditions.

  It is proposed that Liquid Petroleum Gas (LPG) generators to be used for power generation (refer to Ensight's *Ecologically Sustainable Development Report* at Volume 4, Appendix A.2.9). Such gas fuel supplies present no risk of contamination to groundwater and/or surface water.
- Discarded litter and other domestic and commercial wastes: The Development Zone will be serviced by a domestic and commercial waste collection contractor for disposal to licensed facilities located outside the Site area.

  Potential surface water contaminant sources are likely to be limited to minor domestic waste and general litter. Surface water management systems should include the use Water Sensitive Urban

Design (WSUD) techniques such as gross pollutant traps to intercept this solid waste prior to entering creeks and other surface water systems. The Welcome Centre will also provide community education programs to raise awareness of the roles and responsibilities of visitors and residents and the impact that actions such as littering can have on the surrounding significant and sensitive environment.

- Minor localised domestic and commercial chemical storage and use: Use and/or spillage of chemicals within domestic residences and commercial premises are not considered a significant risk to surface water and/or groundwater in the context of the overall size of the Development Zone its amount of received rainfall.

  Public information systems and community education programs to be developed for other environmental issues will also be used to inform future residents of the Development Zone of the importance of limiting chemical use and correct storage.

  There is likely to be some chemical use and storage associated with the sewage treatment plant. Management of those chemicals that are considered to be potentially hazardous will adhere strict management policies and practices including chemical storage facilities that comply with relevant legislation.

- Herbicide and pesticide storage and use within the golf course and resorts: The likely use and/or spillage of herbicides and pesticides within the golf course and resort areas is generally not considered a significant risk to surface water and/or groundwater in the context of the overall size of the Development Zone its amount of received rainfall.

  A site specific management plan for the golf course and the resort operations will be prepared during operational works phase that includes a detailed assessment of herbicide and pesticide requirements—ensuring that only required amounts of suitable chemicals are used within these properties to maintain the required standard. Furthermore, the three northern most fairways that have been relocated into the Ella Bay Wetland catchment zone are proposed to be organic, therefore not requiring fertilisers.

- Road sediment (i.e. oils, fine ground rubber, etc): The length of the road networks and associated vehicle use within the Development Zone is only a small component of the overall area of the Site.

  To reduce the impact from the limited road sediment on surface water ecosystems, it is proposed that road run-off will be managed using WSUD techniques such as direction into constructed unlined swales and bunds and sediment/wetland treatment areas prior to diffuse discharge to gullies, creeks and wetlands.

- Fuel and chemical transport: Most chemical transport would be in relatively small overall quantities and comprising individual containers with volumes less than 20 litres. The most significant transport volume would likely comprise the delivery of fuel for construction purposes and LPG for power generator supplies. LPG has been proposed as a power generator fuel source. Gas fuel supplies present no risk of contamination to groundwater and/or surface water (for further detail refer to the *Ecologically Sustainable Development Report* at Volume 4, Appendix A.2.9).

Given the relatively narrow access to the Development Zone, the transport of bulk fuel supplies is likely to be limited to smaller volume, non-articulated vehicles.

Within the Development Zone, the transport of bulk liquid fuel will introduce a new potential risk to the Farm Creek and Farm Wetland Swale.

To reduce the potential impacts from spillage or leakage of liquid fuels during internal transport it is proposed that all road run-off should be managed using WSUD techniques such as direction into constructed swales, bunds and sediment/wetland treatment areas that are designed with a capability and sufficient capacity to contain the maximum volume being transported.

- Termite soil treatments for building construction: All buildings within the Development Zone will require the use of termite protection during construction.

  Use and/or spillage of termite treatment chemicals for this purpose is not considered a significant risk to surface water and/or groundwater in the context of the overall size of the Development Zone and receiving rainfall.

  Where possible, however, the use of non-chemical protection methods such as wire meshes will be investigated as an alternative, particularly for the resort buildings located adjacent to the Farm Wetland Swale.

Mitigation of Nutrient Discharge from the Site on Wetlands and GBRWHA

The proposed Ella Bay development incorporates a fully sealed sewerage collection system to all domestic, commercial and resort buildings that will be connected to an on-site wastewater treatment plant. Subject to appropriate design and operation of the wastewater collection and treatment systems, there should be no nutrient impact on surface and/or groundwater quality from the generation and collection of untreated wastewater.

Golder (Volume 4, Appendix A.2.1) recommends that discharge to water should be treated to a tertiary level. Nutrient removal treatment could include the use of engineered artificial wetland systems.

With these recommendations in mind, EnSight have proposed a wastewater treatment process that includes treatment through a Membrane BioReactor (MBR) plant and is discussed in detail in the *Ecologically Sustainable Development Report* (refer to Volume 4, Appendix A.2.9).

Mitigation of Sediment Discharge from Site on Wetlands and GBRWHA

Sediment reduction measures to protect coastal ecosystems and the Reef Lagoon from large-scale sediment sources such as agriculture and smaller-scale sources such as coastal developments have been identified and implemented over the past ten years with reference to the government and industry approach (refer to Volume 4, Appendix A.2.1—Section 8).

Well designed and maintained roads, resorts, residences and other open space areas within the Development Zone will mitigate most of the existing sediment impact from the Site and provide additional sediment retention capacity through the use of WSUD techniques (i.e. constructed swales and sediment/wetlands treatment areas). Post construction, this should significantly reduce the overall existing sediment load to creeks, adjacent wetland areas and the Reef Lagoon.

Within the Development Zone WSUD techniques are planned to be used as part of sediment control measures during and following construction through:

- using water harvesting and porous paving to reduce run-off from hardstand areas,
- limiting the extent of disturbed areas open at any time,
- managing surface water using WSUD techniques such as constructed swales, sediment/wetlands treatment areas and gross pollutant traps to reduce flow velocities and provide suitable retention times to trap sediment prior to discharge off-site, and
- using WSUD techniques that will also maximise the direction of surface water sheet flow into natural buffers to waterways (provided by vegetation) to be retained and rehabilitated adjacent to gullies, creeks and wetlands.

The primary method of erosion and sediment control during construction will be the preparation and implementation of Erosion and Sediment Control (ESC) Plans for each proposed development area, down to single lot scale, in accordance with the strategies promulgated by the Far North Queensland Regional Organisation of Councils (FNQROC). All ESC Plans will be required to be prepared by appropriately trained and approved personnel in accordance with FNQROC policies as applied by Johnstone Shire Council. This would include review of all ESC Plans as part of each Construction Works Approval to be provided by Council.

Auditing of erosion and sediment control implementation and a comprehensive water quality monitoring program would be required during and following construction.

Subject to implementation of the strategies, sediment discharge to creeks and wetlands is not considered a significant risk to water quality, the adjacent wetlands or Reef Lagoon during or following each stage of construction works.

It should also be noted that the current state of water quality on-site is poor as a result of run-off pollution from on-site cattle and agricultural practices, with waterways found to be containing high levels of nutrients and sediment (refer to figure 1.2.5). With the proposed water quality management techniques the proposed development provides the opportunity to substantially rectify and improve run-off and stream quality and potentially reduce sediment discharge into the Reef Lagoon.

Compatibility with Reef Water Quality Protection Plan

The Commonwealth and Queensland Governments, in conjunction with a broad range of stakeholders, have prepared the Reef Water Quality Protection Plan (Reef Plan, October 2003) that establishes a series of long-term strategies with the following key objectives.

- Objective 1: Reduce the load of pollutants from diffuse sources in water entering the Reef.
- Objective 2: Rehabilitate and conserve areas of the Reef catchment that have a role in removing water borne pollutants.

The Reef Plan identifies that the Johnstone River and Russell/Mulgrave River Systems within the top 10 high risk catchments. Ella Bay is located between these two catchment systems.

Relevant strategies from Reef Plan that have the potential to be influenced by the proposed Ella Bay development are identified below.

Strategy A: Self-management Approaches

Items 3/4: Support and promote industry-lead development of best management practices

The EIS clearly establishes that the proposed development is planned to provide best management practices for a range of potential environmental issues. With respect to water quality this report identifies that minimal changes to existing conditions are anticipated. Where potential risks or changes have been identified a range of best management practices mitigation measures have been identified to protect surface water ecosystems.

Strategy B: Education and Extension

Item 4: Develop and implement a community awareness raising campaign

The EIS identifies that a community education campaign is planned for future Ella Bay residents to support appropriate management of Cassowaries. This report identifies that the education campaign should also include education on the use and storage of domestic fertilisers and chemicals to protect surface water and groundwater quality. For further information on the Welcome Centre and associated community education programs refer to Volume 2, Section 2.2.3.

Strategy D: Planning for Natural Resource Management and Land Use

Item 8: Identify and establish nutrient sensitive zones

THG have assessed the ecological systems present within the Site and adjacent areas (refer to Volume 4, Appendix A.2.2). The Golder report identified two wetland areas (WTQWHA and Farm Wetland Swale) to assess potential interaction and potential impacts upon surface water and groundwater systems. Potential risks and identification of management strategies has been undertaken on the basis of potential nutrient impacts upon these two wetland areas.

Item 9: Acid sulfate soils

Golder indicated that there is a low probability of acid sulfate soils. However, further investigation will be conducted at detailed design and construction phases with the implementation of the State Planning Policy involving acid sulfate soils if required.

Item 10: Net gain of riparian and wetland areas

The EIS identifies that minimal disturbance is planned to existing riparian and wetland areas located within, and adjacent to, the Development Zone. It is intended that as part of the proposed development the creek bank and Cassowary Corridor areas will be rehabilitated.

Strategy I: Monitoring and Evaluation

Item 6: Implement industry-based water quality monitoring programs

A surface water and groundwater monitoring program has commenced within the Development Zone. This program will continue through the planning, design and construction phases of the proposed development to clearly establish base-line water quality conditions and to maintain and enhance these conditions through the use of appropriate design and management.

According to the Golder report, the recommended approach should not only provide adequate protection of water quality, it also actively supports the various strategies for implementation of Reef Plan and its key objectives.

Best Practice Storm-water, Wastewater and Golf Course Design and Management

Additional detailed discussion on storm-water, wastewater and golf course design and management are discussed in Volume 1, Sections 1.1.3.3 and 1.1.3.4, and in Volume 4, Appendix A.2.1 (Golder, 2007) and Volume 4, Appendix A.2.2 (THG, 2007).

1.1.3.3 Run-off and Water Quality Management

Reference to the management of storm-water run-off quality could not be located in the Environmental Management Plan. The subject site is situated in a high rainfall environment and surrounded by sensitive and significant aquatic ecosystems, therefore development of best practice storm-water, golf course and wastewater management and designs are required.

EIS reference: Volume 3, Section 3.5.4, 3.5.5 & Volume 5, Section 5.4.2.4.2

Submitter reference: 6/52

C Head & C Belbin (21), E Bock (11), Department of Natural Resources and Water (42), Department of Primary Industries and Fisheries (43), Wet Tropics Management Authority (50), Department of the Environment and Water Resources (51)**.**

Proponent Response

Storm-water management was referred to in the EIS at Volume 3, Sections 3.5.4 and 3.5.5, and Volume 5, Section 5.4.2.4.2 and has since been further refined. The THG *Water Quality Management Strategy* builds upon the principles of water quality management indicated in the EIS (the full strategy is available at Volume 4, Appendix A.2.9). The strategy provides details on a number of tools and technologies in relation to storm-water quality, golf course run-off and wastewater management that are to be utilised to mitigate any detrimental impacts on the surrounding sensitive and significant natural environment.

The current state of water quality on-site is poor as a result of run-off pollution from on-site cattle and agricultural practices, with waterways found to be containing high levels of nutrients and sediment (refer to figure 1.2.5). With the proposed water quality management techniques the proposed development provides the opportunity to substantially rectify and improve run-off and stream quality.

Figure 1.2.5: Photograph of the Farm Wetland Swales showing poor water quality and high sediment levels

Storm-water Quality Management

The THG *Water Quality Management Strategy* builds on run-off and water quality management measures discussed in the Golder (2007) report and the EIS and indicates a number of water quality tools and technologies that are proposed to be utilised, wherever practicable, for the management of storm-water.

Source Control

Source control involves minimising the generation of excessive run-off and/or pollution of storm-water 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 storm-water systems (pollution prevention); and
- *Structural source control*—techniques that aim to reduce the quantity and improve the quality of storm-water at or near its source by using infrastructure or natural physical resources.

Non-structural Source Controls

Non-structural source controls are concerned with changing behaviour to reduce the amount of pollution that enters the storm-water system. The main advantages of using non-structural source controls are that they:

- are long-term sustainable,
- are cost-effective,
- minimise or prevent issues,
- reduce ongoing operation or maintenance liability ('end of pipe'), and
- are effective use of all resources—including the community's.

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 proposed Ella Bay development. The objective of the community education process is to:

- create awareness of issues,
- enhance knowledge, understanding and skills,
- influence values and attitudes, and
- encourage more responsible behaviour.

The community education program would entail some of the following recommendations/ aspects.

- 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
- storm-water pits stenciled 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 run-off and/or pollution of storm-water at or near its source.These include the following:

- ensuring a small development footprint,
- strategically locating development areas, and
- 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 proposed development. Golder (2007) have incorporated principles of staged construction over a 10–15 year period and the implementation of Erosion and Sediment Control (ESC) Plans during each stage of proposed development at the single lot level.

Structural Source Controls

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

EnSight (Volume 4, Appendix A.2.9) indicated a description of the source control WSUD measures likely to be included in the proposed Ella Bay development (see table 1.2.1).

WSUD Measures	Descriptions
Swales and buffer strips	A swale is a shallow trapezoidal channel lined with vegetation. A buffer strip is a vegetated slope. Storm-water flows along a swale, but across a buffer strip. Treatment is provided by infiltration to the soil and by filtration of shallow flow through the vegetation.
Bioretention swales	Bioretention swales include a vegetated infiltration trench within the invert of a swale. Incorporating the infiltration trench enhances removal of both particles and nutrients.
Sedimentation basins	A sedimentation basin is a small pond, about 1 m deep, designed to capture coarse to medium sediment from urban catchments. Treatment is provided primarily through settling of suspended particles.
Bioretention basins	A bioretention basin is a vegetated bed of filter material, such as sand and gravel. The basin is designed to capture storm-water run-off which then drains through the filter media. Pollutants are removed by filtration and by biological uptake of nutrients.
Constructed wetlands	Constructed wetland systems are shallow, vegetated water bodies that use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from storm-water.
Infiltration measures	Infiltration measures typically consist of a holding pond or tank designed to promote infiltration of appropriately treated to surrounding soils. The primary function of these devices is run-off volume control rather than pollutant removal.
Sand filters	A sand filter is a sand layer designed to filter fine particulates from storm-water before discharging to a downstream drainage system.
Aquifer storage and recovery	Aquifer storage and recovery involves enhancing water recharge to underground aquifers through pumping or gravity feed of treated storm-water.

Table 1.2.1: Structural source control WSUD measures

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

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

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

Proposed Structural Source Control Treatment Measures: Vegetated Swales

Vegetated swales, commonly combined with buffer strips, are used to carry storm-water in lieu of pipes and provide for the removal of coarse and medium sediment. The system uses overland flow and mild slopes (≤4% grade) to slowly carry 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.

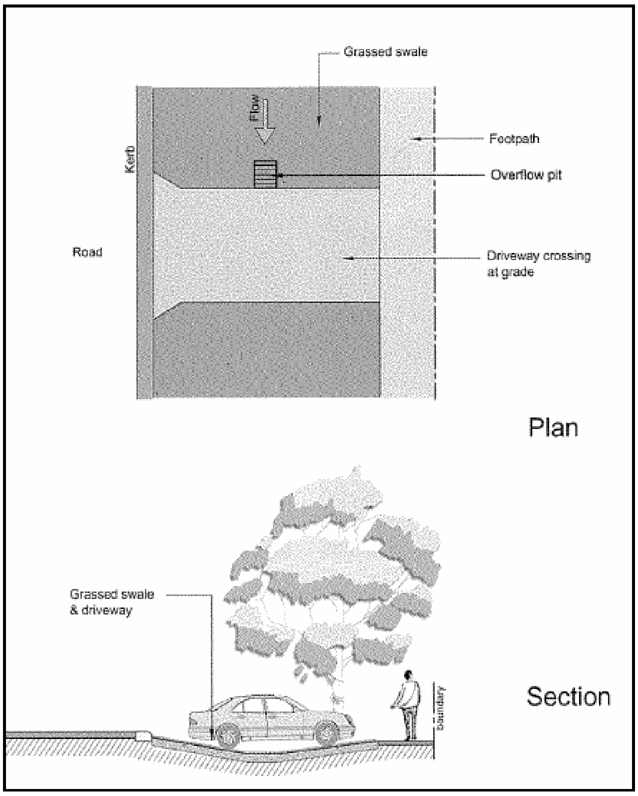

Figure 1.2.6: Vegetated swales (at grade crossing) (Melbourne Water, 2005)

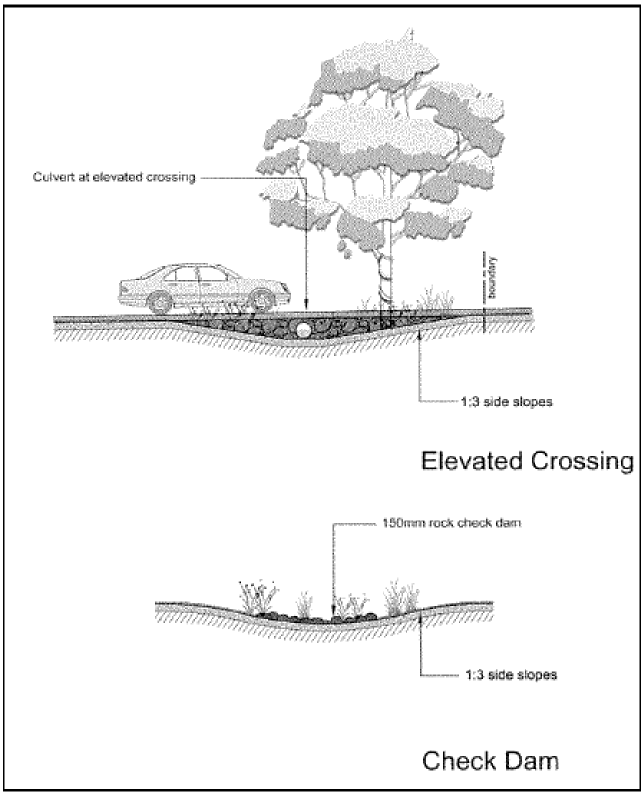

Figure 1.2.7: Vegetated Swales (elevated crossings, check dams) (Melbourne Water, 2005)

Figure 1.2.8: Example of a vegetated swale (Melbourne Water, 2005)

Proposed Structural Source Control Treatment Measures: Bioretention Basins

Bioretention basins (refer to figure 1.2.9) 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. Storm-water moves through a swale into the filter media, or enters via overflow pits, and either percolates into the surrounding soils or is convoyed 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 pre-treatment measures upstream of the basin to reduce the maintenance frequency of the bioretention basin. Bioretention basins are not intended to be infiltration systems; the dominant pathway for water is not via discharge into groundwater. Rather, they convoy collected water to downstream waters (or collection systems for reuse) with any loss in run-off mainly attributed to maintaining soil moisture of the filter media.

Figure 1.2.9: Bioretention basins for a range of urban settings (Melbourne Water, 2005)

The proposed development will investigate the possible the use of underground storage tanks for storm-water 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 1.2.10 and 1.2.11.

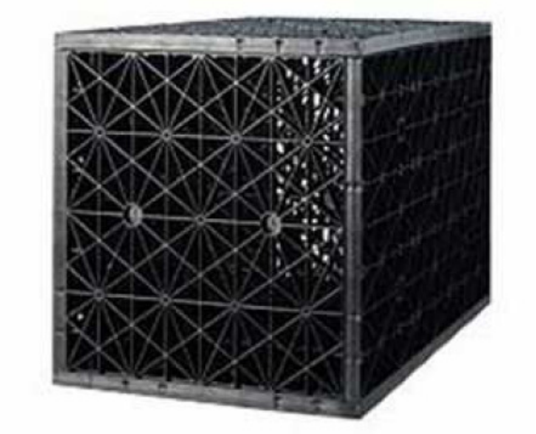

Figure 1.2.10: Example of underground storage tank (Atlantis)

Figure 1.2.11: Example of underground storage tank (Tankmasta)

Proposed Structural Source Control Treatment Measures: Infiltration Systems

Storm-water infiltration systems capture storm-water run-off and encourage infiltration into surrounding in-situ soils and underlying groundwater. They can have a range of benefits including that they:

- protect waterway health and minimise downstream flooding (by reducing storm-water flows and volumes), and
- enhance groundwater recharge or preserve pre-development groundwater recharge.

Infiltration systems are conveyance rather than treatment measures. To protect groundwater quality and avoid clogging, pre-treatment of storm-water 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), which are predominantly below 5 metres RL on the eastern side of the proposed development.

There are four basic types of infiltration systems.

1 A leaky well

2 Infiltration trenches

3 Soak-aways

4 Infiltration Basins

It is proposed that infiltration systems could be included in the development to, above all, preserve pre-development groundwater recharge. This would entail locating groundwater recharge areas on the Site during the design phase and applying this technology to these areas.

Proposed Structural Source Control Treatment Measures: Porous Pavement

Porous pavements are a pavement types that promote 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.

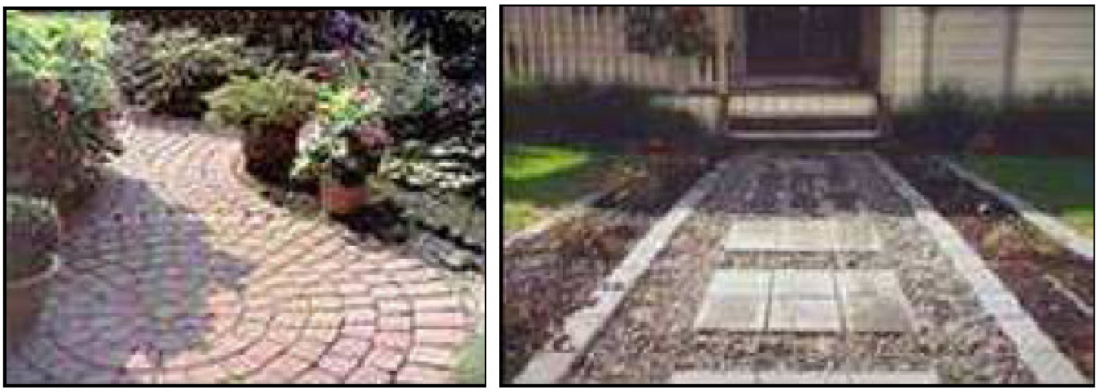

Figure 1.2.12: Examples of porous pavement

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

Proposed Structural Source Control Treatment Measures: 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 storm-water, 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, 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 Biochemical Oxygen Demand (BOD),
- removal of algae,
- 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,
- predation and natural die-off of pathogens.

Figure 1.2.13: Examples of constructed wetlands

Further detailed discussion on storm-water run-off and water quality management including the management of contaminants, nutrients and sediments can be found in Volume 1, Sections 1.1.3.2 and 1.1.3.4, Volume 4, Appendix A.2.1(Golder, 2007) and Volume 4, Appendix A.2.2 (THG, 2007)

Golf Course Run-off Water Quality Management

The golf course is a major component to the proposed development. It has been designed to produce a positive environmental impact on the proposed 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 have a positive impact on the ecology and environment of these areas.

The potential impacts of the golf course could include those set out in table 1.2.2 below.

Positive Impacts	Negative Impacts
Removal of cattle and feral animals from water bodies, thus removal of destructive activities	Changes in watershed dynamics through altered topography and vegetation height/type (short vs long grass)
Creation of 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 further outlined in this section	Potential impact from sodium on soil structure, inhibiting groundcover ability and increasing erosion
	Construction phase of golf course

Table 1.2.2: Potential impacts of the golf course on the receiving environment

To manage potential impacts on flora and fauna from this area the following guiding principles are proposed.

- Reducing chemical application to the golf course
- Incorporating efficient slow release fertilisers based on soil science principles
- No application of organo-phosphates on the golf course
- Utilising microbial methods to increase soil biomass to promote plant nutrient uptake rather than leaching
- Incorporating an Integrated Pest Management strategy for the golf course during the design phase
- Utilising innovative disease management by inoculating the growing media with beneficial bacteria and fungi
- Undertaking an annual soil testing regime to identify soil nutrient amendments required
- Developing a daily irrigation regime based on deficit irrigation using an automatic irrigation system comprising soil moisture monitoring, evapotranspiration and weather station data
- Utilising high quality reclaimed water and storm-water as the primary water supply for the golf course

- Undertaking modelling (using appropriate software applications such as Medli) of the irrigation system using reclaimed water during the design stages of the proposed development
- Including appropriate buffers (rehabilitation of riparian areas) and treatment zones (e.g. constructed wetlands) on the golf course to protect the receiving environment
- Developing 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 on the adjacent environment in comparison to the existing conditions

Wastewater Management

A detailed discussion of wastewater management tools and technologies to ensure the discharge of treated water does not adversely impact on the natural environment are located in Volume 1, Section 1.5, *Energy, Water Supply, Sewerage and Waste Management*; Volume 4, Appendix A.2.2, *Water Quality Management Strategy* (THG, 2007); and Volume 4, Appendix A.2.9, *Ecologically Sustainable Development Report* (EnSight, 2007).

1.1.3.4 Water Quality and Impact on Fauna and Flora

Water quality management and standards should be based on the Queensland Water Quality Guidelines 2006 (EPA, 2006) aimed at protecting native terrestrial and aquatic fauna by regular monitoring of herbicides, fertilizers and sediment entering natural waterways, and planning responses to adverse results.

EIS reference: Volume 3, Section 3.5.4, Volume 4, Section 4.3.1.1

Submitter reference: 4/52
E Bock (11), C Head & C Belbin (21), J Rainbird (CAFNEC) (20), Wet Tropics Management Authority (50)

Proponent Response

Water quality management and standards of the Proposal are to be in accordance with the Queensland Water Quality Guidelines (EPA, 2006) to ensure the protection of terrestrial and aquatic fauna. Through ongoing monitoring of water quality and biodiversity, any adverse impacts can be identified and responded to appropriately. This includes monitoring:

- eco-system status and stressors
- water quality and flow
- habitat (stream side and in stream) and
- biota

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

THG (2007) concluded that the proposed concept for integrated water cycle management, if adopted by the proponent, is sound and consistent with current recommended best practice.

According to THG (2007), based on the water quality strategy proposed and taking into account this assessment of the range of impacts and improvements to be carried out under the Proposal, the water quality impacts on flora and fauna throughout the Site are considered to be minimal. The Proposal provides positive outcomes for the enhancement of flora and fauna habitats and abundances.

THG (2007) also conclude that the package of overall improvements including revegetation, rezoning, 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 Site.

Potential Impacts of the Proposal

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) to increase in abundance throughout the Site, based on habitat enhancement and water quality improvements.

Research has shown that urban areas can produce nutrient, litter and sediment pollution. Typical impacts of urbanisation of areas around streams are listed in the table below. Without appropriate management, the proposed development may impact on the receiving environments in these ways. However the Ella Bay Township has in its approach to these issues taken a range of steps to avoid the typical impacts of urbanisation of areas around streams. The Proposal results is an extremely low rate of urbanisation almost allowing categorisation as semi-rural development.

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)

Table 1.2.3: Typical impacts of urbanisation on streams (Walsh, 2004)

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, 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 1.2.4, together with proposed mitigation strategies.

Potential Sources	Potential Impacts	Recommended Mitigation Strategies
Changes in storm-water surface run-off 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 Volume 4, Appendix A.2.1—Sections 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 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 water bodies • Provide vegetated buffer zones to creeks varying between 25 m to 50 m 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 (Volume 4, Appendix A.2.1—Section 6) • Provide treatment system to intercept gross pollutants before discharge to natural water bodies such as vegetated swales and GPT's if required
Nutrients from fertilisers and storm-water run-off	Eutrophication of the Farm Creek, Wetland Swale and other water bodies, 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 water bodies
Herbicides, pesticides, and other chemicals	Contamination of water bodies, 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 Volume 4, Appendix A.2.1—Section 6.3) • Implement correct hazard reduction and management protocols • Implement integrated water cycle management system to intercept pollutants
Termite soil conditioning	Contamination of water bodies, 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

Fuel, oils, and road sediment	Contamination of water bodies, 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 water bodies	• Monitor the water quality at strategic locations based on the Site 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

Table 1.2.4: Potential sources, impacts and recommended mitigation strategies of water quality issues

Further adopted measures by the proponent to mitigate these potential impacts are detailed in the following Water Quality Management Strategy.

Water Quality Management Strategy for Ella Bay Resort

The impact of storm-water run-off 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 run-off management strategies for the Proposal that will satisfy the needs for economic and community development while ensuring environmental sustainability and mitigating impacts on flora and fauna at Ella Bay.

Storm-water is made up of ‘critical pollutants’ such as phosphorus, nitrogen and pathogens that are carried to waterways at rates and in volumes of run-off water determined by catchment topography, vegetation and rainfall (Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and Australian and New Zealand Environment Conservation Council (ANZECC), 2000; Lawrence and Breen, 1998).

The most influential factor is usually the degree of urbanisation of the catchment. As the proposed 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 this will lead to increased peak run-off rates. Most urban areas introduce elevated nutrients, hydrocarbons, pesticides and heavy metals to the water stream (Walsh, 2004). The Proposal lies within already-cleared land, with the urban development areas consisting of only a minor area of the total 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). This Water Quality Strategy details the WSUD options to be implemented within the proposed development.

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

The main *objectives* for the Ella Bay integrated water cycle management particularly pertaining to storm-water 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 storm-water 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,
- need for protection of the ecological and hydrological integrity of the Site,
- management of storm-water as close to the source as possible,
- use of environmental sensitive solutions such as:
  - organic management principles on the proposed golf course,
  - creating possible wetland areas as part of the water treatment solution which will add biodiversity value and amenity as well as satisfy water quality outcomes, and

- sustainable use of storm-water 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 (e.g. 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 (e.g. 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 storm-water system;
- offsetting the impacts of development by incorporating retention capacity (e.g. infiltration, rainwater tanks, swales, wetlands and retarding basins);
- minimising water requirements and reducing storm-water run-off by adopting landscaping strategies (e.g. mulching, reduce lawn areas, water efficient lawns, ponds and gardens);
- conserving water by installing water efficient fixtures and appliances;
- harvesting rainwater for potable purposes;
- reusing greywater and treated effluent for non-potable purposes;
- using organic management practices in terms of major open space areas such as the golf course to minimise the risk of pollutants entering waterways; and
- using 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 and where appropriate adopted in the Proposal.

Minimising Disruption of Natural Corridors

When 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 1.2.2 in Section 1.1.2.;
    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 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 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 report (2007).
2. Retention and rehabilitation where necessary of the major remnant vegetation stands on the 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 points 1 and 2 as viable networks through the Site.
4. In view of the sensitive nature of the Ella Bay National Park, storm-water within the northern section of the proposed development shall be managed accordingly to ensure existing flows and quality are maintained to the north and do not impact on the adjoining National Park.
5. An average 100 m vegetation strip along the main east-west and north-south natural flow corridors 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 Proposal 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 following figure (figure 1.2.14) as they pertain to a site.

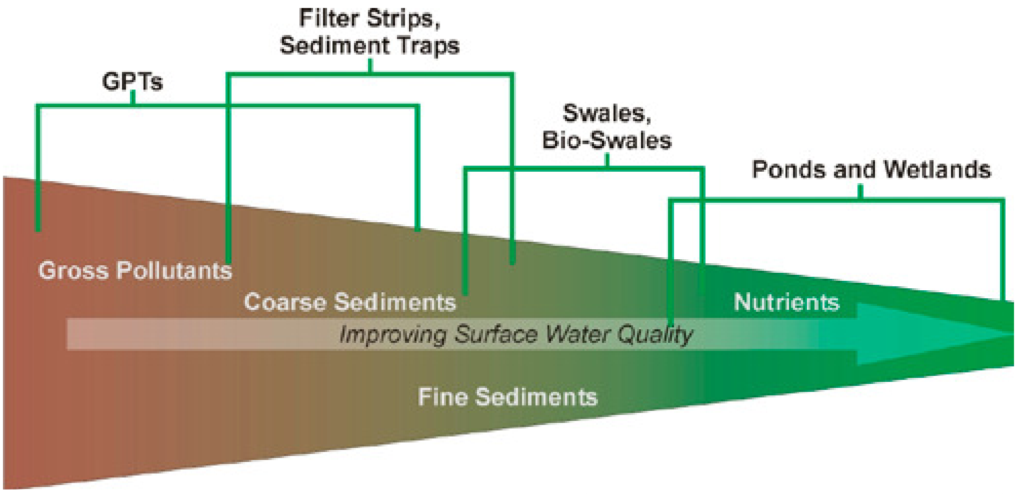

Figure 1.2.14: Water quality measures and treatment ranges (ACT Planning and Land Authority, 2006)

Measures in respect to sustainable water supply on site are typified in figure 1.2.15.

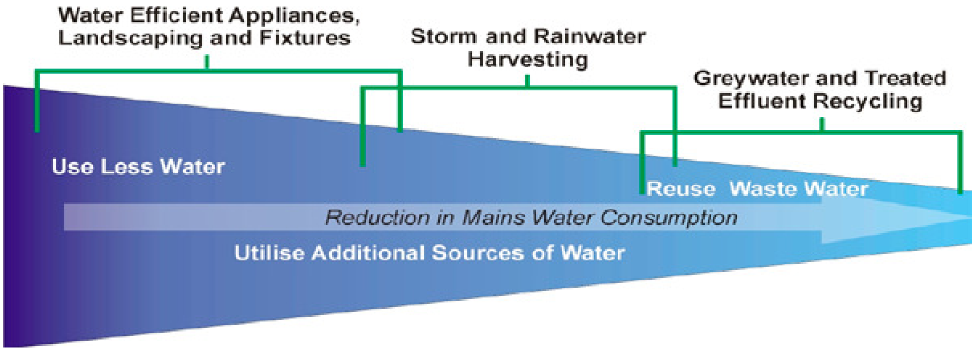

Figure 1.2.15: Water reuse measures (ACT Planning and Land Authority, 2006)

Water reuse 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.

House Allotment

At the house allotment level the measures proposed include:

- including rainwater tanks for harvesting of the roof water,
- allowing tank capacity for run-off retention,
- directing excess flows from rainwater tanks to vegetated swales incorporating bio-retention and/or natural ground infiltration,
- directing overland flow to landscape/garden areas for natural watering/ground infiltration and sheet flowed to roads or to adjoining open space through filter strips,
- limiting the amount of impervious area and using porous pavement where possible, and
- directing run-off from impervious areas to vegetated bio-retention swales.

Street Level
At street level the treatments proposed include that:

- 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,
- 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,
- grates and filter grids will be used to remove major litter from the runoff prior to discharge to offline treatment areas,
- gross pollutant will be included in the treatment train if required,
- where streets abut natural drainage corridors and/or wetlands, run-off shall be directed away from the natural drainage corridors and/or wetlands to the offline treatment system prior to discharge, and
- 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 m in width in respect to wetlands and 25 m in respect to natural drainage corridors.

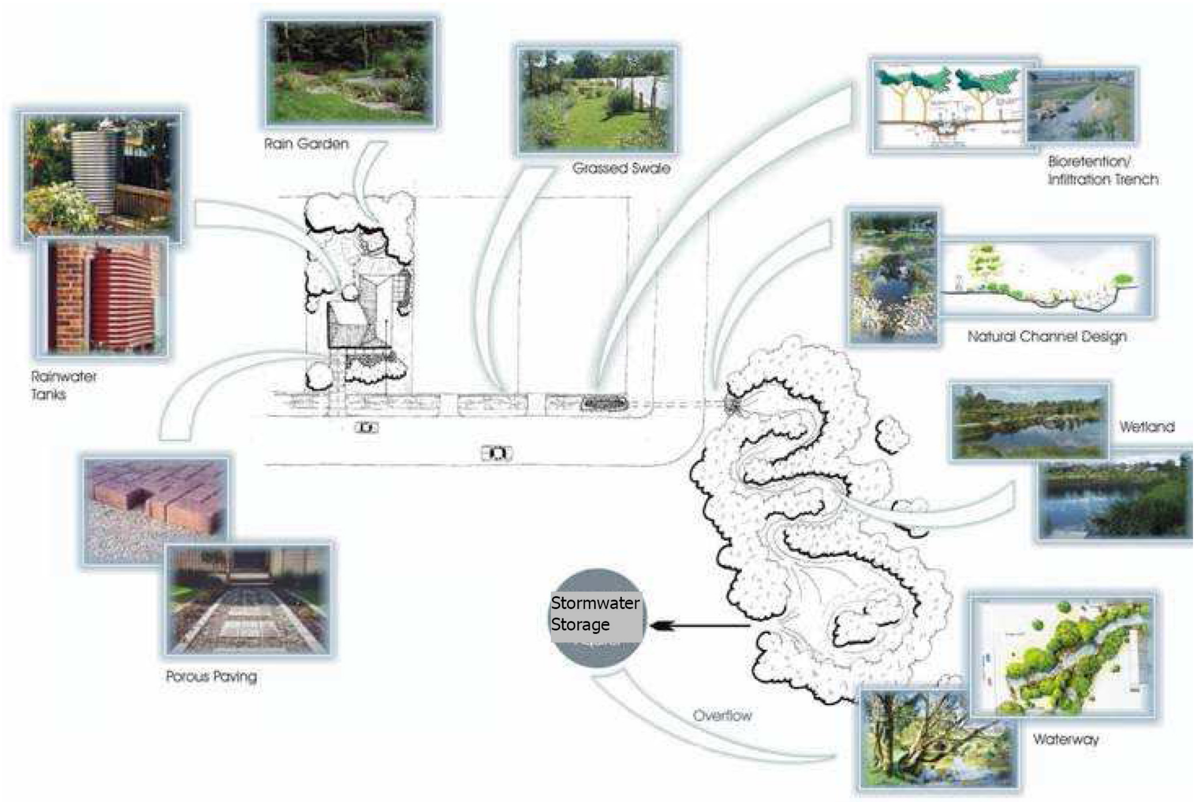

Figure 1.2.16: Example of house and street-level treatment measures (BCC)

Golf Course/Open Space

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

- flows from the development areas surrounding the golf course being directed through sedimentation basins and/or constructed wetland areas prior to storage or discharge,
- all treatment measures being off-stream of the natural drainage corridors,
- constructed wetlands which hold run-off for future reuse being offline of natural drainage corridors,
- all flows falling on the developed area being captured in a detention system or pass through an off line treatment train before discharge into adjoining natural drainage corridors,
- run-off from the golf course area being 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 m in width,
- retention and/or detention basins being included in the treatment system to limit discharge into the surrounding natural drainage corridors and/or wetland areas to pre-development situations to the greatest extent possible, and
- 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 Proposal has embraced these principles to be applied where appropriate.

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 of species endemic to the locality/region and reflect the particular purpose of the area in which they are placed (i.e. 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

- They are 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 they have spreading rather than clumped growth forms.
- They are perennial rather than annual.
- They have deep, fibrous root systems.

- They are often groundcover plants—turf, prostrate or tufted. Prostrate species would typically be low mat forming stoloniferous or rhizomatous plants whilst 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.

- They 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 they have spreading rather than clumped growth forms.
- They are perennial rather than annual.
- Generally they have rhizomatous growth forms.
- They have fibrous root systems.
- They 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 storm-water run-off facilitated by the Proposal. These measures have been taken into consideration under the Master Plan for the Proposal and, where appropriate, adopted.

1.1.4 Submitter Issue: Watercourse Setbacks

1.1.4.1 Riparian Strips

Setbacks should be maintained from any watercourse, consistent with distances set in *Regional Vegetation Management Codes*, with retention or planting of native vegetation to aid infiltration and filtering of overland flow to the streams. Linear riparian strips are best provided for by dedication to park or separate title vested in Council, community title or similar.

EIS reference: Volume 4, Section 4.3.1.1

Submitter reference: 2/52

Department of Natural Resources and Water (42), Department of Primary Industries and Fisheries (43)

Proponent Response

The *Regional Vegetation Management Code for Coastal Bioregions* requires that clearing does not occur within 25 metres from each high bank of a stream. Watercourse setbacks for all minor tributaries within the Site will be maintained in accordance with the vegetation management code, consisting of a 25 metre vegetation strip on each bank (tributaries indicated in blue). The two major east-west and north-south riparian strips are to be included in a vegetation and habitat corridor with a width averaging approximately 100 metres (tributaries indicated in red). This is depicted in figure 1.2.17.

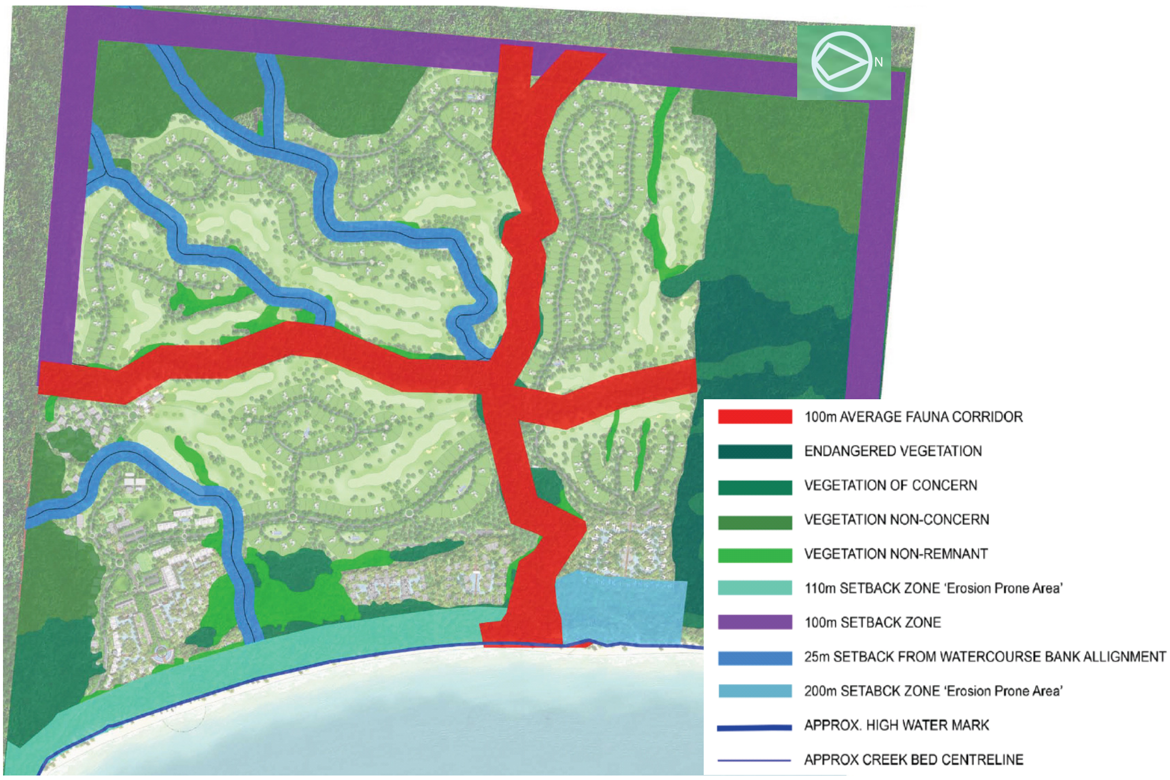

Figure 1.2.17: Master Plan indicating watercourse setbacks (refer to Volume 3, Section 3.1)

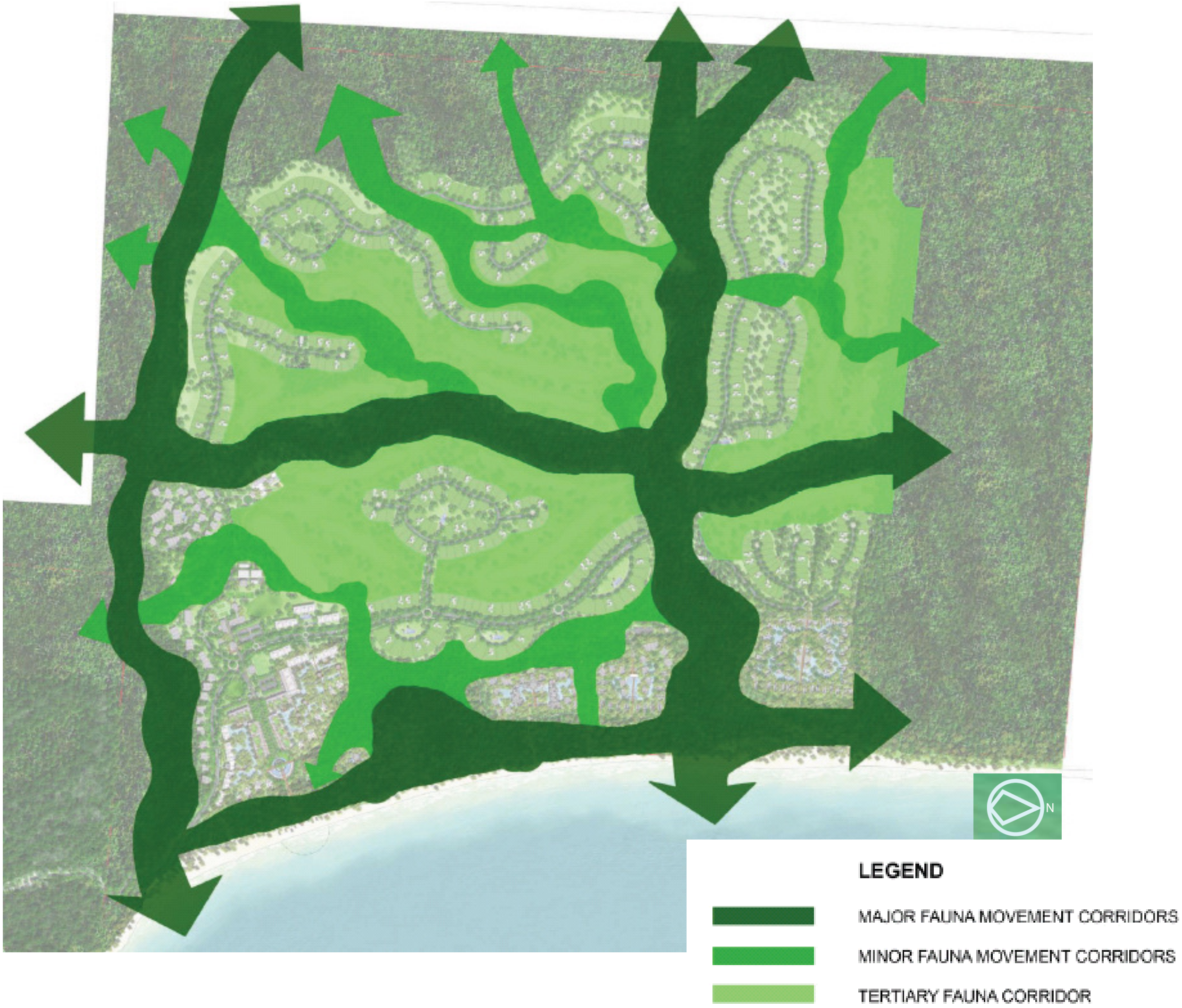

Figure 1.2.18: Fauna Corridor Plan (for the full plan refer to Volume 3, Section 3.1)

Revegetation and rehabilitation of watercourses is to be conducted in partnership with Terrain Natural Resource Management (the regional conservation body) and Degree Celcius (specialists in offset brokerage). For further information refer to the *Regulated Offsets and Additional Environmental Investments* report at Volume 4, Appendix A.2.11.

These watercourse setbacks help to ensure clearing does not cause land degradation by maintaining bank stability, protecting against erosion, maintaining water quality by filtering sediments, nutrients and other pollutants, and maintaining aquatic and wildlife habitat. The EIS identifies that minimal disturbance is planned to existing riparian and wetland areas located within and adjacent to the Development Zone. The proposed development intends to rehabilitate creek banks and fauna corridors and to designate and protect these areas under Conservation Covenants and the Local Area Plan.

The proposed resorts are planned to be setback from the beachfront and Farm Wetland Swale by a distance of approximately 110 m from the Highest Astronomical Tide (HAT). There will also be a 500 m distance between the Development Zone and the Wet Tropics of Queensland World Heritage Area (WTQWHA) boundary, which, according to the Golder report (2007), will provide a more than adequate buffer to prevent groundwater interchange between these areas and also ensure that the existing groundwater hydrology within the WTQWHA Wetland is not impacted.

Specific Development Zone elements that will enhance watercourses and significantly reduce the risk of potential changes to existing surface water and groundwater hydrology conditions within and adjacent to the Site include:

- maintaining a high percentage open space (i.e. golf course, residential gardens, public parks and gardens, resort gardens, existing and rehabilitated habitat),
- protecting and rehabilitating existing creeks, gullies and the Farm Wetland Swale,
- protecting and rehabilitating most existing remnant vegetation within the Development Zone,
- protecting areas of remnant rainforest and wetland vegetation surrounding the Development Zone within the Site (Northern Freehold Area, Western Freehold Area and Eastern Freehold Area), and
- providing a buffer of approximately 500 m between the Development Zone and wetland areas within the WTQWHA.

This approach, in conjunction with appropriate detailed design and construction supervision will inherently:

- maintain existing surface water flow detention periods, velocities and volumes for:
  - sheet flow over cleared land to gullies, creeks and wetlands that will contain and be surrounded by remnant and rehabilitated vegetation within the Development Zone,
  - all Gullies and creeks discharging to the Farm Wetland Swale,
  - the Farm Wetland Swale and flow to Ella Bay through the Southern Beach Discharge, and
  - creeks and swales entering the Northern Freehold Area of the Site that subsequently discharges to the WTQWHA Wetlands.
- maintain groundwater recharge and discharge rates to and from each of the groundwater units and surface water features (gullies, creeks and wetlands),
- limit disturbance to or restriction of groundwater flow within the shallow groundwater units (Unit C, and Unit E) that are present within the Development Zone.

1.1.5 Submitter Issue: Acid Sulfate Soils

1.1.5.1 Acid Sulfate Soils

The EIS suggests that the risk of potential acid sulfate soils is low, however does not discuss the excavation of areas for basements, which will be directly behind the foredune. Acid sulfate soils have the potential to adversely affect the values of the Great Barrier Reef World Heritage Areas and must be adequately tested for, monitored and managed. The development of an Acid Sulfate Soil Management Plan is recommended.

EIS reference: Volume 5, Section 5.4.1

Submitter reference: 3/52
Department of Natural Resources and Water (42), Department of Primary Industries and Fisheries (43), Department of Environment and Water Resources (51)

Proponent Response

According to the Johnstone Shire Planning Scheme the Site does not fall within an area of potential acid sulfate soil. Investigations completed to date by Golder Associates Pty Ltd (Golder 2006) appear to verify that acid sulfate soils are not widespread within the Site. As such it is unlikely that acid sulfate soils will be of concern, as acknowledged in the submission received from the Department of Natural Resources and Water.

To protect water quality and ecosystems, all areas of the proposed development requiring ground disturbances located below 5 metres AHD shall be subject to an acid sulfate soil investigation and management where identified, in accordance with the *Queensland State Planning Policy 2/02*. If required, site specific Acid Sulfate Soil Management Plans will be developed. Timing for such investigations shall be tied to approval of each stage of development.