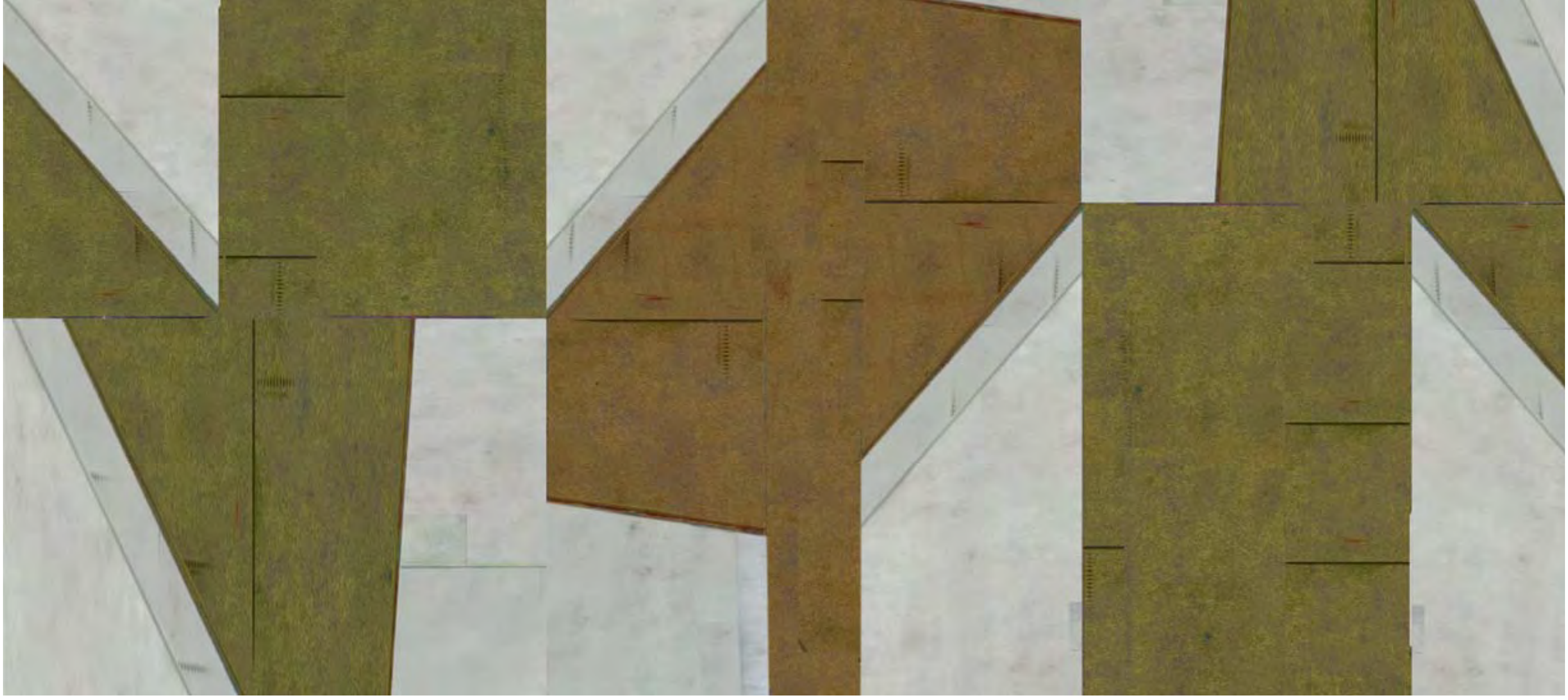
6.4 b Integrated Water Management Plan Bligh Tanner



Ella Bay Draft Integrated Water Management Report

September 2011

BLIGH TANNER
CONSULTING ENGINEERS

SUSTAINABLE LAND DEVELOPMENT

BUILDING STRUCTURES

INTEGRATED WATER MANAGEMENT

INFRASTRUCTURE MASTERPLANNING AND DESIGN

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Version	Author	Reviewed	Approved	Date
Draft 1	Lara Dark / David Hamlyn-Harris	David Hamlyn-Harris	David Hamlyn-Harris	12 November 2008
Draft 2	Lara Dark / David Hamlyn-Harris	David Hamlyn-Harris	David Hamlyn-Harris	15 June 2009
Draft 3	Brendan Tyndall/David Hamlyn-Harris	David Hamlyn-Harris	David Hamlyn-Harris	1 September 2011
Final	David Hamlyn-Harris	David Hamlyn-Harris		30 September 2011

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EXECUTIVE SUMMARY

Introduction
This report addresses the provision of water supply and wastewater infrastructure for the proposed development at Ella Bay. It has been prepared to provide additional technical detail for the water and wastewater strategies and to address issues raised and information requested by the Department of the Environment, Water, Heritage and the Arts (DEWHA). The objective is for the community and the infrastructure to be developed in a way that is ecologically sustainable and has no adverse impacts on the areas of national environmental significance surrounding the site, ie the Ella Bay National Park and wetlands, and the Great Barrier Reef Marine Park.

Site Description and Water Demands
The proposed land uses at Ella Bay include residential, resorts, village precinct including retail and commercial precincts, day spa, public pool facility, community centre, education facilities, sports oval, golf course and driving range. The site will be developed in a number of stages. Stage 1 (Northern) will be that part of the site to the north of Farm Creek, extending from Ella Bay to the western boundary. Population estimates indicate that the maximum population will be up to 3,795 people (1,156 permanent residents, 1,040 visitors and 1,599 resort guests) at peak times, however, on average the numbers will be lower, ie 2,800 people (1,012 permanent residents, 703 visitors and 1085 resort guests). There will also be a significant number of day workers and other visitors to the site.

The estimated total average water demand for Ella Bay at full development is 224 ML/year excluding irrigation demands. Of this, 43 ML/year is attributed to Stage 1 (Northern) of the development. The estimated peak day water demand is 865 kL/d, of which 158 kL/d is attributed to Stage 1 (Northern).

The average demand for water across the different uses is illustrated in the figure below.

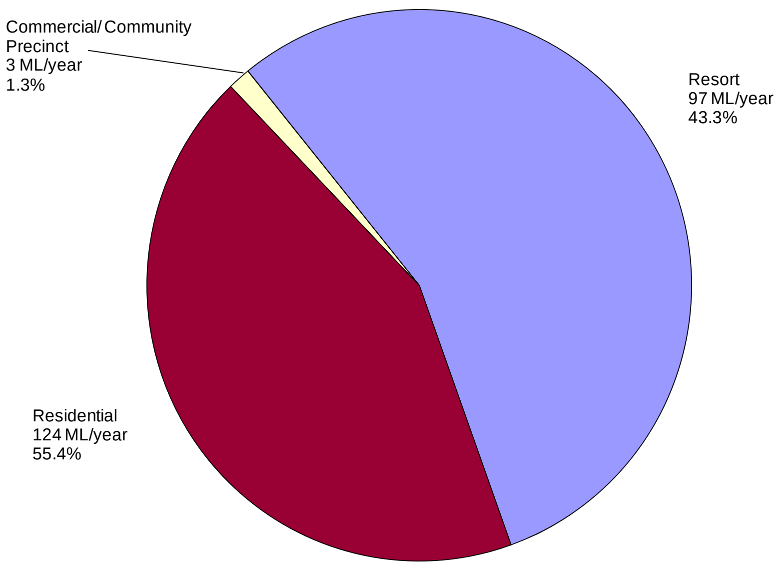

Figure I Demand Distribution

Water Supply Strategy for Ella Bay
The proposed water supply strategy is as follows:

- The primary source of drinking (potable) water will be rainwater harvested from roof catchments. Given the high rainfall in the area this offers a reliable source of water. The water will be treated prior to use to ensure its suitability for consumption;
- Water conservation initiatives will be implemented throughout the design of the development to minimise demands and improve the reliability of the supply;
- Rainwater cannot meet the full potable water demands of the development and a back-up or reserve source of supply will be required. The back-up source will be groundwater from an on-site bore. Investigations (Golder Associates 2009a) have identified a supply of groundwater at the site;
- The primary source of non-potable water will be recycled water. This will be treated on-site to Class A+ standard and used for toilet flushing, cold water laundry and residential garden watering. Class B water

will be supplied for general irrigation. Emergency back-up to essential recycled water uses, ie toilets, will be provided by the groundwater supply; and
- Stormwater harvesting will occur at the site to supplement the supply of water to the resort lagoons as part of the proposed natural swimming pool systems.

The water quality requirements for the development are as follows:
- Drinking water will meet the requirements of the Australian Drinking Water Guidelines (ADWG 2004);
- Class A+ recycled water will be adopted for dual reticulation to households as per the Queensland Public Health Amendment Regulation (No. 1 2008) and the Water Quality Guidelines for Recycled Water Schemes (Natural Resources and Water 2008);
- Minimum Class B recycled water will be supplied for subsurface irrigation and/or restricted access surface irrigation.

Rainwater Harvesting

Rainwater will provide the primary source of potable water supply to the development. A daily water balance model has been developed to assess:
- The potential to capture roofwater to supply internal domestic and non-domestic uses (excluding toilets, and cold water laundry); and
- The shortfall required to be supplied from the backup groundwater supply.

The model calculated roof runoff, demand, storage volume, back-up supply required and overflows etc on a continuous daily basis over the 30 year period. The model considers the relationship between tank volume and supply reliability, where reliability is defined as the percentage of demand that can be satisfied from rainwater on average. Individual models were developed for the different development types such as low density, multi use residential, 3 storey apartments, commercial and resort precincts to allow for the differences in roof area (catchment area) and water demands.

An optimum tank size was determined for each development type. The adopted tank sizes are as follows:
- 13 kL- Detached Dwellings without pool, approximate reliability 99%;
- 20 kL – Detached Dwellings with pool, approximate reliability 98%;
- 20 kL – Neighbourhood facilities, approximate reliability 90%;
- 150 kL - Multiuse Residential Buildings, approximate reliability 96%;
- 50 kL - Residential 3 Storey Apartments building, approximate reliability 97%;
- 3,000 kL- typical Resort development, approximate reliability 93%.

The results of the individual rainwater balance models were compiled to give an overall rainfall capture estimate and level of reliability for the site of 96%, with a total effective storage volume of 30 ML.

Rainwater harvesting will not adversely affect the downstream hydrology, rather it will form an integral part of an overall stormwater management strategy to ensure that post-development site discharges mimic pre-development flow regimes. Rainwater harvesting provides ‘retention’ storage to reduce the overall runoff volume and ‘detention’ storage to reduce peak runoff rates.

Groundwater

Groundwater will provide the back-up supply to the rainwater harvesting system (potable supply) and also to essential elements of the recycled water supply. Groundwater investigations have been undertaken by Golder Associates and at this stage have identified a suitable water supply bore based on yield and water quality known as the Northwest Production Bore. Preliminary water quality monitoring indicates that the groundwater is generally of a high quality and will be suitable for drinking with minor treatment to adjust the water chemistry.

A conservative assessment of the bore capacity has indicated that the Northwest Production Bore can be pumped for at least 35 days at a flow rate of 3 L/s (260 kL/day) without adverse effect. Flow rates of 345 – 432 kL/day may be possible for shorter periods.

The overall groundwater demand was assessed by aggregating the results of the rainwater water balance analyses which provided the daily shortfall in supply for each development type. Analysis of back-up water demands for Ella Bay at ultimate development indicates that:
- The average backup demand is 19 kL/day varying from nil to 100 kL/day depending on season;
- At peak periods the groundwater demand can exceed the 260 kL/day sustainable yield of the groundwater supply for extended periods of time with a peak month demand of up to 529kL/day.

For stage 1, water demands are only approximately 20% of ultimate demand and the shortfall in rainwater supply will not exceed the groundwater supply capacity. During stage 1 development, further investigation will be completed to define more accurately the sustainable bore yield and to identify a second bore supply. In addition, management strategies will be developed to limit demands during very dry weather including:

- Banning pool top-up from the groundwater supply;
- Banning spa use in the resorts;
- Voluntary restrictions on water use generally.

Results of Water Balance Modelling

The overall water supply balance and proportion of water supplied from each source is illustrated in the figure below. This shows the very significant reduction in demand from external sources that is achievable with a full commitment to integrated water management.

The combined results of the water balance modelling from all development types indicate that treated rainwater can potentially supply approximately 96% of the total potable demand if rainwater is used to supply kitchen, bathroom, hot water and residential and community facility swimming pool demands. The approximate total effective rainwater storage volume for the site is 30 ML.

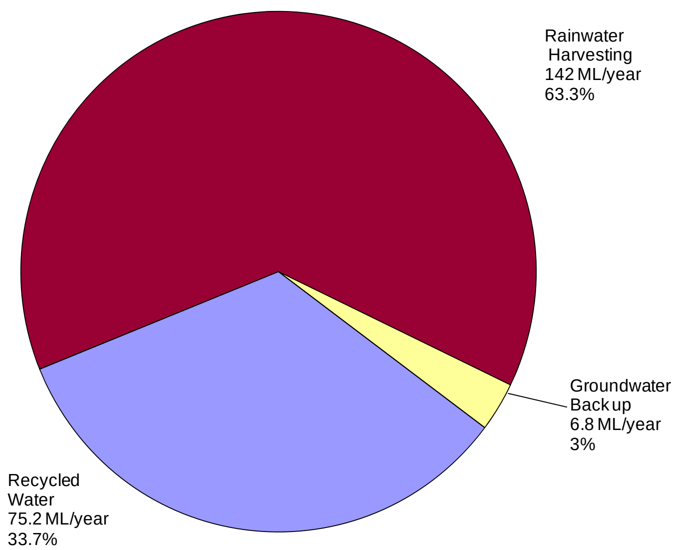

Figure II Water Supply from Each Source

Wastewater Strategy

The proposed wastewater system configuration is as follows:

- Wastewater will be collected in a low infiltration sewerage system (either low infiltration gravity or vacuum sewerage) draining to a number of sewage pumping stations;
- Wastewater will be pumped to a central Sewage Treatment Plant;
- Recycled water will be treated to Class A+ standard in accordance with Guidelines under the Water Supply (Safety and Reliability) Act suitable for residential non-potable reuse;
- Class B recycled water will be used for subsurface irrigation and restricted access surface irrigation;
- Treatment residuals will be thickened on-site and then transported off-site for disposal or reuse; and
- Water that cannot be used immediately will be directed to seasonal storages distributed around the development.

Recycled Water Balance

A recycled water balance model has been developed to assess the potential for recycled water produced on-site to meet the non-potable water requirements for the development (i.e. external uses and toilet flushing) and the storage requirements for full beneficial reuse of recycled water.

The results of the recycled water balance indicate that 98% beneficial reuse can be achieved with an irrigation area of 91 ha and a dedicated storage volume of 11 ML. This would supply toilet flushing, cold water laundry, external uses, commercial laundry demand, garden watering and irrigation. The proportion of recycled water supplied to different uses is shown below. Full reuse is achieved by “over-irrigating” during periods of low demand, ie in wet weather; any additional runoff generated as a result of this will be managed through the site stormwater treatment systems.

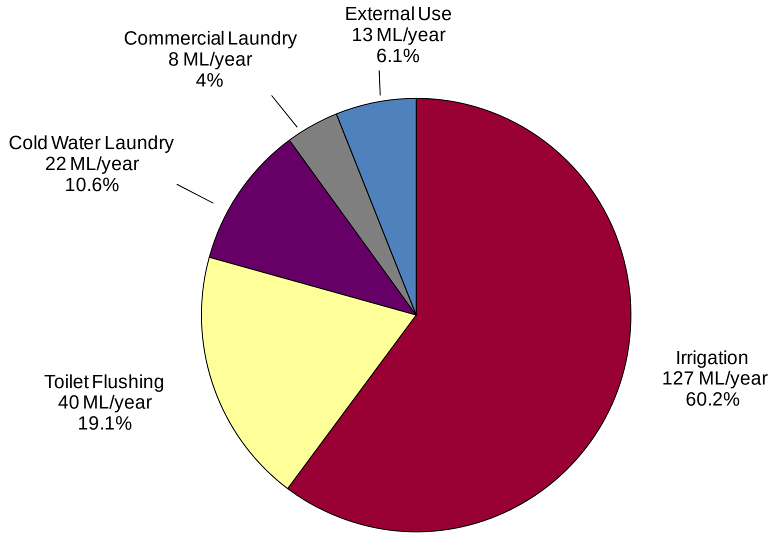

Figure III Recycled Water Usage

How this Report Addresses DEWHA’s Information Request
This report addresses all of DEWHA’s requirements as follows:

Issue	Summary Response
6. Hydrology Impact of groundwater extraction on the beachfront wetland swales	A detailed groundwater investigation has been completed (Golder Associates 2009a and 2009b) and the recommendations of this work have been taken into account in developing the water supply strategy. A safe yield has been recommended that will not affect the beachfront swales.
8. Water Balance Provision of quantitative data on the site water balance	Detailed analysis of population and water demand is provided along with detailed rainwater harvesting and recycled water modelling to confirm the overall site water balance.
What are the downstream hydrological impacts of rainwater collection?	Rainwater harvesting will not adversely affect the downstream hydrology, rather it will form an integral part of an overall stormwater management strategy to ensure that post-development site discharges mimic pre-development flow regimes.
Quantification of environmental water flows in relation to the water availability and water use in the three urban water streams of potable water, wastewater and stormwater, and potentially groundwater.	The report demonstrates that the proposed rainwater harvesting, borewater backup supply and water recycling systems will have no adverse impacts on environmental water flows.
9. Master Plan and Staging (part) Water requirements and water sources for each stage of the development	The detailed analyses identify water supply requirements for Stage 1 (Northern) and Future Stages.
14. Reef Water Quality Protection Plan Water quality issues associated with the project in relation to the Reef Water Quality Protection Plan	The groundwater investigations (Golder Associates 2009a and 2009b) and the wastewater management strategy based on full on-site reuse will ensure that there are no adverse impacts on the reef.

GLOSSARY

Term	Definition
ADWG	The 2004 edition of the Australian Drinking Water Guidelines, published by the National Health and Medical Research Council (NHMRC) and Natural Resource Management Ministerial Council (NRMMC)
AHMC	Australian Health Ministers' Conference
catchment	Area of land that collects rainfall and contributes to surface water (streams, rivers, wetlands) or to groundwater
chlorination	Use of chlorine as gaseous Cl_2, sodium hypochlorite liquid or granular calcium hypochlorite as a means of disinfection
CW or cw	Cold water
DA	Development Approval
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts
DIP	Department of Infrastructure and Planning
disinfection	A process provided to kill or inactivate pathogenic (disease causing) microorganisms
distribution system	A network of pipes leading from a treatment plant to the customers plumbing systems
DNRW	Department of Natural Resources and Water
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPHC	Environment Protection and Heritage Council
filtration	Process in which particulate matter in water is removed by passage through porous media
groundwater	Water contained in rocks or subsoil
HW or hw	Hot water
IDAS	Integrated Development Assessment System
integrated water management	An approach to water management that considers all aspects of the water cycle as part of an integrated whole rather than as independent systems
irrigation	Provision of sufficient water for the growth of crops, lawns, parks and gardens by flood, furrow, drip, sprinkler or subsurface water application to soil
kL	kilolitre (1,000L)
mg/L	milligrams per litre
ML	megalitre (equivalent to 1,000kL)
nitrogen	An important nutrient found in high concentrations in recycled waters, originating from human and domestic wastes. A useful plant nutrient that can also cause off-site problems of eutrophication in lakes, rivers and estuaries.
NRW	DNRW

Term	Definition
NRMMC	National Resource Management Ministerial Council
phosphorus	An important nutrient found in high concentrations in recycled waters, originating principally from detergents but also from other domestic wastes. A useful plant nutrient that can also cause off-site problems of eutrophication in water bodies
pollutant	Substance that damages the quality of the environment
potable	(Water) of a quality suitable for drinking, cooking and personal bathing
QDC	Queensland Development Code
QWC	Queensland Water Commission
recycled water	Appropriately treated wastewater and urban stormwater suitable for further use
reject	The unusable portion of water in the feed stream of the treatment process
residual	Waste products from the treatment process
risk	The combined likelihood and severity of identified hazards causing harm in exposed populations or receiving environments
runoff	Surface overland flow of water resulting from rainfall or irrigation exceeding the infiltration capacity of the soil
salinity	The presence of soluble salts in soils or waters
STP	Sewage Treatment Plant
stormwater	All surface water runoff from rainfall, predominantly in urban catchments
TDS	Total Dissolved Solids
turbidity	The cloudiness of water caused by the presence of fine suspended matter
UV	Ultraviolet
water balance	The relationship between input, storage and output within a hydrological system
water mining	Process of extracting wastewater directly from a sewer (either before or after a wastewater treatment plant) for reuse as recycled water
water quality	The chemical, physical and biological condition of water
water recycling	Use of appropriately treated wastewater and urban stormwater for beneficial purposes
WWTP	Wastewater treatment plant

1 INTRODUCTION

1.1 Background

Bligh Tanner Pty Ltd was commissioned by Satori Resorts Ella Bay Pty Ltd to prepare an Integrated Water Management Report for the proposed residential and resort development at Ella Bay near Innisfail in North Queensland. Specifically, the report has been prepared to address issues raised by the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) in its letter and Request for Information (RFI) dated 22 May 2008.

Satori Resorts submitted an Environmental Impact Statement (EIS) which was completed in February 2007 and a Supplementary Environmental Impact Statement (SEIS) was completed in March 2008. The DEWHA RFI requested additional, more specific information regarding aspects of the development, including the design of water supply, wastewater and stormwater drainage systems.

This report addresses the water supply and wastewater issues raised.

Reports have also been prepared to address the stormwater management, ground water abstraction and surface water quality. All of these reports are located in Volume 6 Section 6.4 of the Submission Response.

- 6.4 a Coastal Inundation Study WBM
- 6.4 b Architectural Inundation Study
- 6.4 c Integrated Water Management Plan - Bligh Tanner (this report)
- 6.4 d Storm Water Management Plan - Bligh Tanner
- 6.4 e WSUD Stormwater Objectives - Design Flow
- 6.4 f Northern Precinct Stormwater Management Plan- Design Flow
- 6.4 g Groundwater Resource Evaluation Supplemental Report - Golders
- 6.4 h Groundwater Resource Evaluation - Golders
- 6.4 i Water Monitoring Results – Golders

1.2 Site Location

Ella Bay is located in the Cassowary Coast Regional Council (formerly Johnstone Shire Council) area, North Queensland. It is approximately 90 km south of Cairns and 7 km north-east of Innisfail (refer to Figure 1 and Figure 2). The total site area is 469 hectares, of which 241 ha is cleared.

The property is bounded by Ella Bay, part of the Great Barrier Reef Marine Park, to the east and the Ella Bay National Park to the north and west. The wetlands to the north (both within the site and in the National Park) are considered to be of special significance. The Little Cove development area is located at the southern boundary of the site with the Ella Bay National Park extending south beyond that to the community of Flying Fish Point. The Ella Bay National Park is part of the Wet Tropics World Heritage Area.

The site has a 2 km foreshore with Ella Bay. An undeveloped public esplanade runs the length of the foreshore.

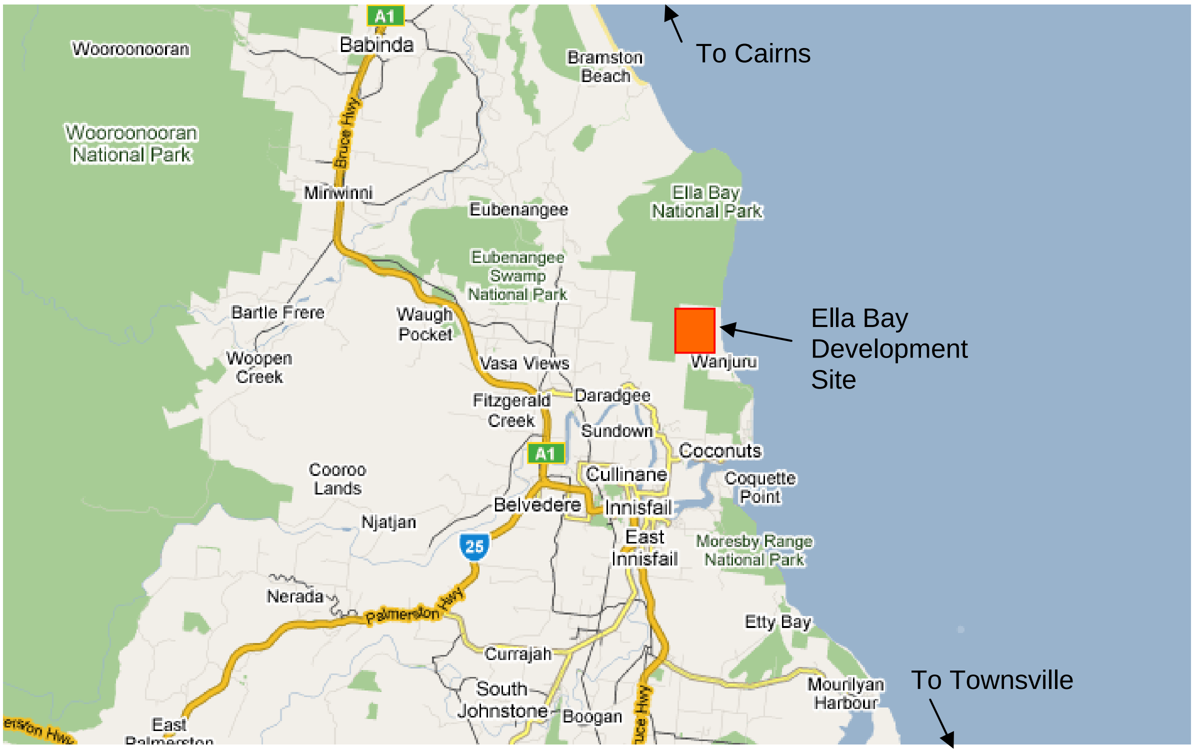

Figure 1 Ella Bay Locality Map

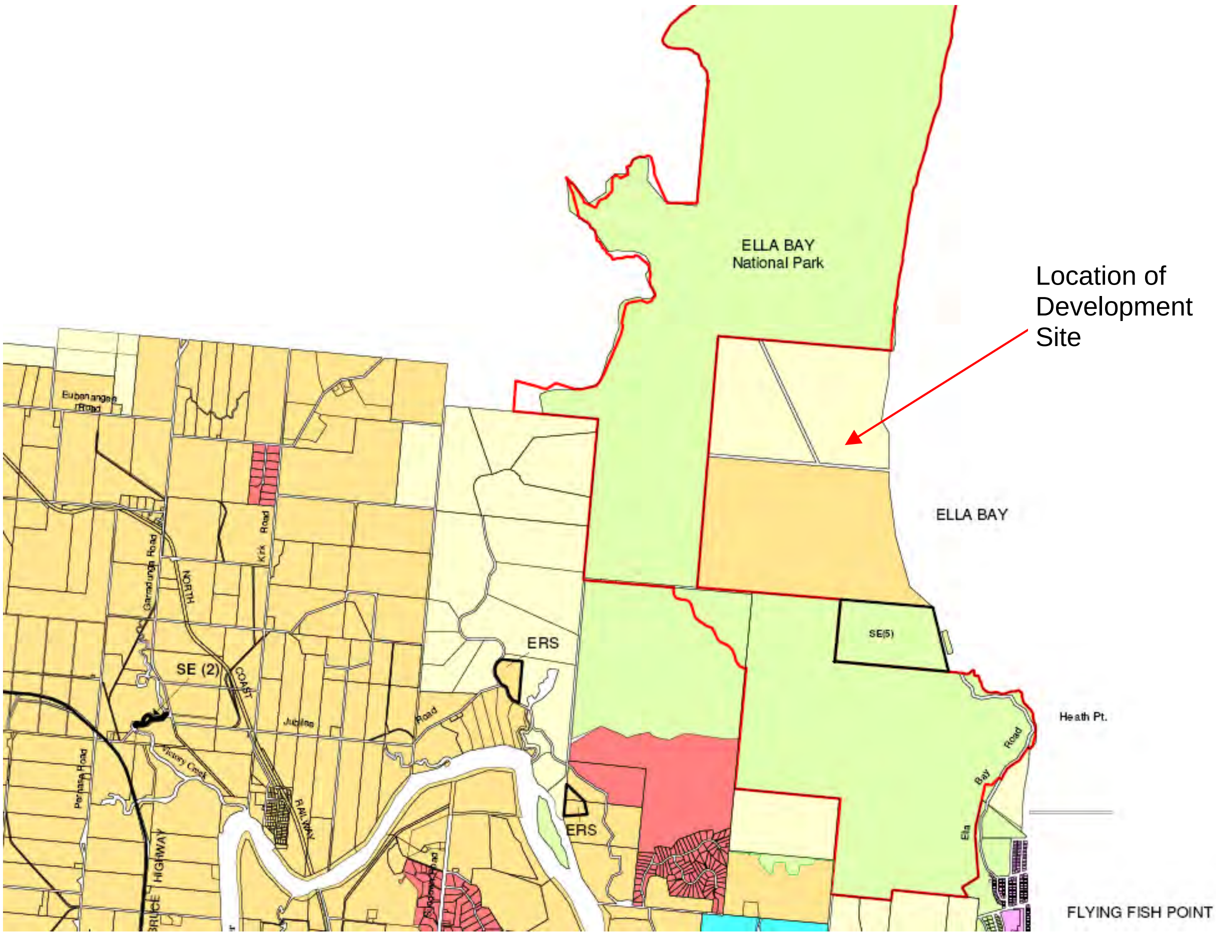

Figure 2 Site Location Plan

1.3 Report Objectives

This report has been prepared to specifically address the issues raised and information requested by DEWHA (refer to Section 1.4). It addresses the provision of water supply and wastewater management infrastructure for the proposed development at Ella Bay. The objective is for the community and the infrastructure to be developed in a way that is ecologically sustainable and has no adverse impacts on the areas of national environmental significance surrounding the site, ie the Ella Bay National Park and wetlands, and the Great Barrier Reef Marine Park.

This report:

- Assesses the land uses and population requiring water and wastewater infrastructure;
- Estimates water demands and wastewater volumes to be managed;
- Identifies and discusses statutory approvals issues for the water and wastewater infrastructure;
- Identifies alternative strategies considered for water supply and wastewater infrastructure;
- Identifies the recommended strategy for adoption;
- Evaluates the capacity of the proposed water sources to meet demands; and
- Provides an outline conceptual description of the proposed water systems.

Water infrastructure concepts have been developed using an Integrated Water Management (IWM) approach, ie recognising the interdependencies between the water supply, wastewater and stormwater drainage systems and the importance of all these services in producing a sustainable development outcome.

1.4 How this Report Responds to the DEWHA RFI

The specific issues raised in the DEWHA letter and RFI dated 22 May 2008 are tabulated below. How each of these issues has been addressed is also provided.

DEWHA issue	How it has been addressed
6. Hydrology	
The water quality monitoring undertaken for the Ella Bay Development site was limited to a single sampling during a dry season (June 2007). The hydrology report recommended that an ongoing surface and groundwater monitoring programme should be undertaken to document background seasonal water quality conditions. However, this has not been undertaken and there is no acceptable background water quality data for the Ella Bay site or the study area for the access road which crosses several creeks.	• Surface and groundwater investigations – Golder Associates (2008a, 2009a and 2009b).
While the SEIS documentation provides a water quality monitoring programme for the Ella Bay site and the access road area, in the absence of background data, compliance with water quality parameters can only be assessed in comparison to target values provided in the EPA water quality guideline standards (2006).	• Surface and groundwater investigations – Golder Associates (2008a, 2009a and 2009b).

DEWHA issue	How it has been addressed
The water quality monitoring report provides details of proposed water quality monitoring locations, water quality parameters and target values, including two figures showing the locations of monitoring stations for the Ella Bay site and the access road area. Monitoring of water quality of streams immediately upstream and downstream of the access road and at the discharge point to the bay is important to ensure that the streams will continue to provide a suitable habitat for the listed frog species, and maintain the water quality that is discharged into the GBRWHA. However, the figures provided do not indicate locations of monitoring points relative to the locations of streams.	• Surface and groundwater investigations – Golder Associates (2008a, 2009a and 2009b).
The beachfront wetland swales are considered to play an important role in maintaining a natural groundwater divide between seawater in Ella Bay and fresh water within on-shore shallow aquifers. These wetlands are dependent upon both rainwater and groundwater flows from the west. Any groundwater abstraction has the potential to impact on these important beachfront wetlands. The SEIS documentation does not completely rule out the potential use of groundwater for the proposed development. Should there be no commitment to completely avoid the abstraction of groundwater either from shallow or deeper aquifers, a detailed groundwater study must be undertaken to assess potential impacts of vegetation from groundwater abstraction.	• Section 9. • Surface and groundwater investigations – Golder Associates (2008a, 2009a and 2009b).
7. Water Quality Control	
To control pollution of stormwater a treatment system including constructed wetlands, and bio-retention ponds has been suggested in consultants reports. The Master Plan provided does not indicate the location of such systems. Given that the majority of the impact mitigation measures proposed for maintaining or enhancing the water quality from the Ella Bay site are linked to staging of the development, it is important that design details of at least one stage of the development (stage to be developed first) incorporating all features be provided to understand the scale and nature of the development.	• WSUD Stormwater Objectives (Design Flow 2010). • Northern Precinct Stormwater Management Plan (Design Flow 2011).

DEWHA issue	How it has been addressed
8. Water Balance	
The report by EnSight on the water balance for the project does not provide quantitative data.	• Section 4 for estimates of water demands; • Section 7 for details of the proposed water supply strategy; • Section 8 for details of rainwater harvesting; • Section 9 for details of groundwater requirements; • Section 10 for details of recycled water supply; • Section 12 for details of the overall proposed water balance.
If all rainwater is to be collected in rainwater tanks, what are the downstream hydrological impacts?	• Section 8.6; • WSUD Stormwater Objectives (Design Flow 2010). • Northern Precinct Stormwater Management Plan (Design Flow 2011).
How are the environmental water flows to the streams, wetland and beach swale areas be maintained?	• WSUD Stormwater Objectives (Design Flow 2010). • Northern Precinct Stormwater Management Plan (Design Flow 2011).
There is no quantitative analysis of environmental water flows in relation to the water availability and water use in the three urban water streams of potable water, wastewater and stormwater, and potentially groundwater.	• Sections 7, 8, 9, 10, 11 and 12; • WSUD Stormwater Objectives (Design Flow 2010). • Northern Precinct Stormwater Management Plan (Design Flow 2011).
9. Master Plan and Staging (part)	
A staging plan should also identify water requirements, water sources, energy requirements and sources for each stage of the development	• Section 4.2 for details of water demands and staging; • Section 7 for details of water sources considered and water supply concept; • Sections 8, 9, 10 and 11 for details of water supply to Ella Bay; • Section 12 for an overview of the water supply from each source.
14. Reef Water Quality Protection Plan	
As you are aware, the Australian and Queensland governments have developed a Reef Water Quality Protection Plan for the long term protection of the water quality in the Great Barrier Reef area. Any discharges into the Great Barrier Reef marine area should meet the objectives of this plan. The water quality monitoring report should address the water quality issues associated with the project in relation to the Reef water quality protection plan.	Wastewater Management: • Section 13. Stormwater Management: • WSUD Stormwater Objectives (Design Flow 2010). • Northern Precinct Stormwater Management Plan (Design Flow 2011). • Water Quality Management: • Surface and groundwater investigations – Golder Associates (2008a and 2009a and 2009b).

2 BACKGROUND DATA

2.1 Climate

Daily rainfall and evaporation data was obtained from the Bureau of Meteorology (Data Drill) from 01/01/1977 to 31/12/2006. The mean rainfall at Ella Bay over this timeframe was 3,411 mm/year and the mean evaporation for the same period was 1,765 mm/yr. It should be noted that the SILO Data Drill interpolates between the nearest rainfall stations and is an estimate of the actual rainfall and evaporation received at the location of the development only.

2.2 Population and Land Use

Land use and population estimates have been based on information received from the developer, Satori Resorts.

2.3 Soils

Soil samples were collected by Golder Associates (2008b) and tested for a range of parameters to provide input data for the MEDLI model. A summary of the soil sample data and the location of sample sites are provided in Attachment A. Soil tests were conducted from 6 bore holes across the site. Samples were collected from each change in natural soil horizon to 1.5m depth. Soil permeability tests were conducted in-situ and further laboratory analysis was completed for nutrients and soil moisture characteristics.

2.4 Groundwater

A background groundwater monitoring program was undertaken by Golder Associates in 2009. In addition, Golders drilled 11 investigation bores to assess the potential for a sustainable potable groundwater supply. The results of these investigations are included in Section 9.

2.5 Surface water

Golder Associates has also investigated surface drainage and surface water quality from the site, however, this is not addressed in this report.

3 LAND USE AND POPULATION

3.1 General

Estimates of population and demand have been prepared as the basis for sizing the required infrastructure. The proposed land uses include residential, resorts, village precinct including retail and commercial precincts, day spa, public pool facility, community centre, education facilities, sports oval, golf course, and driving range.

The site will be developed in a number of stages. Stage 1 (Northern) will be that part of the site to the north of Farm Creek, extending from Ella Bay to the western boundary (refer to the Site Master Plan at Attachment A). Stage 1 excludes wetland areas along the northern boundary that are proposed to be transferred to the state as an extension to the National Park. Development of the balance of the site is also expected to be staged though a specific staging plan is not yet available.

3.2 Assumptions

Given the nature and location of the development, it is expected that the population will vary throughout the year. A mix of permanent, semi-permanent and holiday rental accommodation is anticipated. The assumed occupancy rates for each dwelling type are summarised below:

	Maximum	Average
People per detached dwelling (resident)	2.45	2.9
People per occupied apartment (resident)	2.2	2.65
People per occupied dwelling (visitor)	3.0	2.75
People per occupied resort unit	3.2	2.75
Proportion of detached dwellings occupied	95%	70%
Proportion of apartments occupied	95%	65%
Proportion of resort units occupied	95%	75%

The maximum population is expected to be present during the mid year dry season especially coinciding with the southern states school holidays and the northern hemisphere winter. Typical peak holiday times such as Christmas, New Year and Easter, show higher occupancy than normal for these periods in the middle of the wet season. The occupancy during the wet season is strongly impacted by the severity of cyclone activity. The dry season months of April to September are expected to see higher populations than the wet season.

The significance of this is that, while wastewater treatment systems will need to be able to handle the wastewater load from the maximum population, the total volume of treated water that must be managed over the year will be reduced.

The adopted seasonal variation in population is illustrated in Figure 3, Figure 4 and Figure 5.

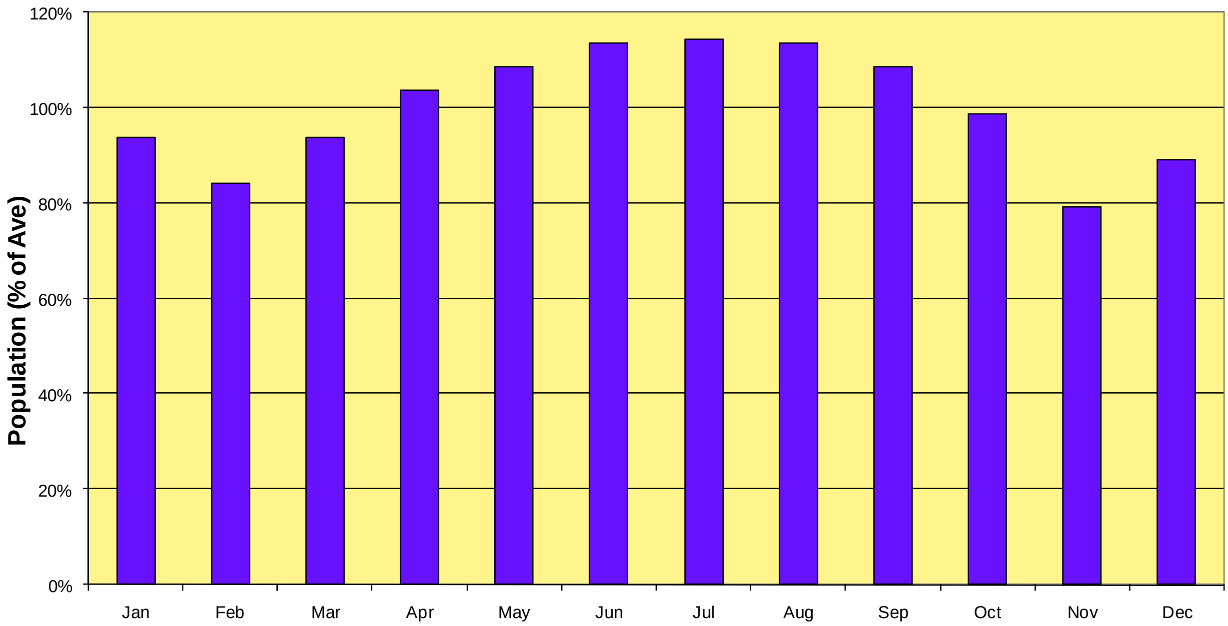

Figure 3 Permanent Residential Population Distribution

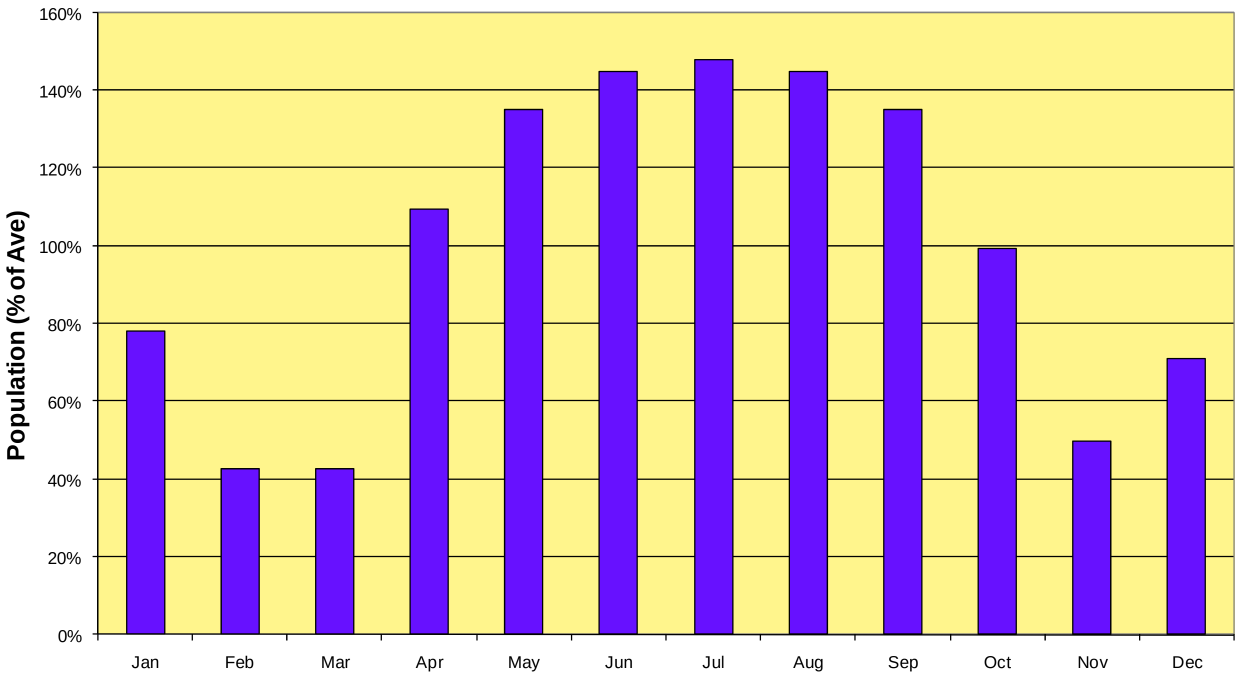

Figure 4 Resort Population Distribution

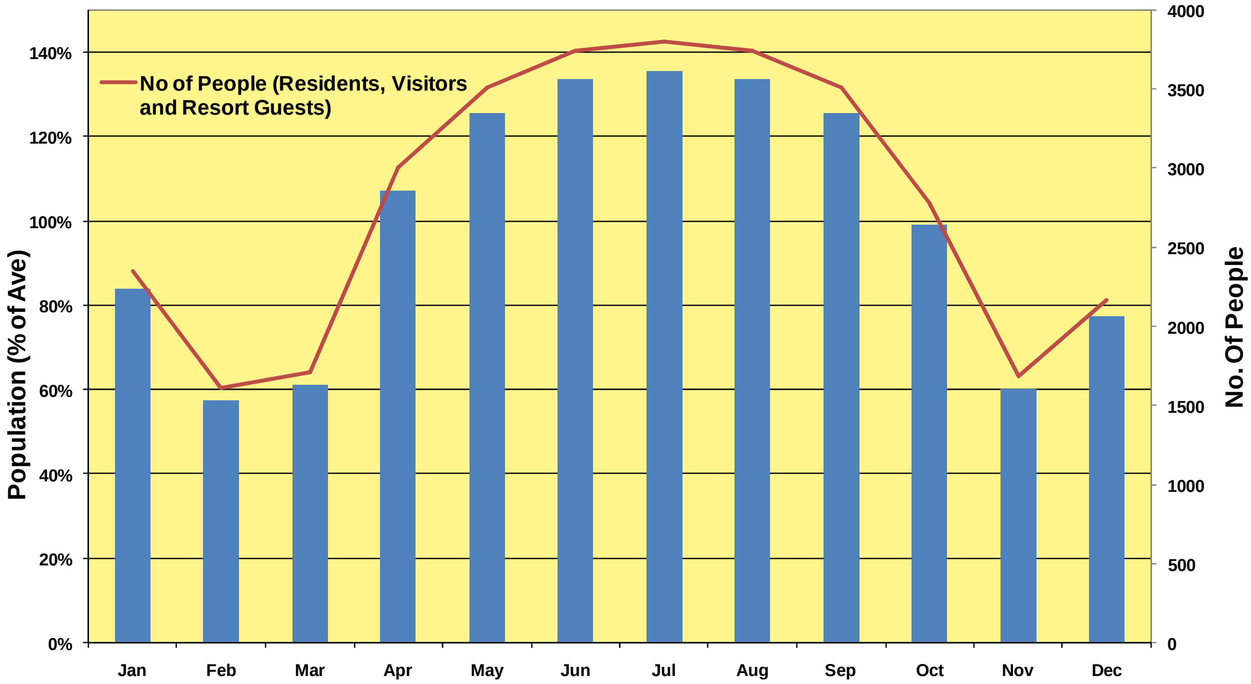

Figure 5 Combined Population Distribution

3.3 Population Estimates

The estimated average and peak populations are summarised in Table 1 and Table 2 below. The data indicate that the maximum population will be up to 3,795 people (1,156 permanent residents, 1,040 visitors and 1,599 resort guests) at peak times, however, on average the numbers will be lower, ie 2,800 people (1,012 permanent residents, 703 visitors and 1085 resort guests). There will also be a significant number of day workers and visitors to the site.

Table 1 Summary of Estimated Average Population

Precinct	No of Dwellings	Average No of People				
		Residents	Visitors	Resort Guests	Employees	Customers
Stage 1 (Northern)						
Detached Residential dwellings	212	345	81	-	-	-
Neighbourhood facility including pool (x2)	-	-	-	-	8	40
Resort	58	-	-	120	83	129
Sub Total	**270**	**345**	**81**	**120**	**91**	**169**
Future Stages						
Detached Residential dwellings	327	467	187	-	-	-
Residential Apartments	334	200	435	-	-	-

Precinct	No of Dwellings	Average No of People				
		Residents	Visitors	Resort Guests	Employees	Customers
Neighbourhood facilities including pools (x4)	-	-	-	-	40	200
Resorts	468	-	-	965	610	497
Commercial and community areas including public pool	-	-	-	-	95	1,196
Sub Total	**1,129**	**667**	**622**	**965**	**744**	**1,893**
TOTAL	**1,399**	**1,012**	**703**	**1,085**	**836**	**2,062**

Table 2 Summary of Estimated Peak Population

Precinct	No of Dwellings	Maximum No of People				
		Residents	Visitors	Resort Guests	Employees	Customers
Stage 1 (Northern)						
Detached Residential dwellings	212	396	120	-	-	-
Neighbourhood facility including pool (x2)	-	-	-	-	10	50
Resort	58	-	-	176	109	209
Sub Total	**270**	**396**	**120**	**176**	**119**	**259**
Future Stages						
Detached Residential dwellings	327	535	276	-	-	-
Residential Apartments	334	225	644	-	-	-
Neighbourhood facilities including pools (x4)	-	-	-	-	50	250
Resorts	468	-	-	1,423	809	776
Commercial and community areas including public pool	-	-	-	-	139	2,320
Sub Total	**1,129**	**760**	**920**	**1,423**	**998**	**3,346**
TOTAL	**1,399**	**1,156**	**1,040**	**1,599**	**1,117**	**3,605**

4 WATER DEMAND AND WASTEWATER FLOW ESTIMATES

4.1 Assumptions

A number of assumptions have been made regarding water demand and wastewater flows and these are outlined below:

- Per capita water demands are detailed in Table 3 below;
- A planning factor of 20% has been added to all demands except the natural swimming pools;
- 25% of private detached dwellings will have a swimming pool;
- Each community facility includes a swimming pool;
- All resort dwellings have a spa;
- Each resort includes a lagoon and “natural” swimming pool system though this demand will be met by stormwater rather than from the potable water supply;
- Cooling towers for air conditioning may use A+ recycled water;
- Wastewater flow taken to be equal to all internal demands;
- Potential non-potable residential uses of A+ recycled water include toilet flushing, laundry (cold water tap), car washing, high pressure cleaning and garden watering;
- A commercial laundry will be developed on site to service the resorts (A+ recycled water will be used for laundry use);
- Other possible uses of recycled water include golf course irrigation, open space irrigation of road verges, vegetated swales, parks, gardens, sporting facilities and community plots, nursery use and fire-fighting;
- Unit demand rates excluding the planning factor are distributed as shown in Table 3.

Table 3 Breakdown of Per Capita Water Uses Excluding Planning Factor [1]

User	Internal Use L/c/day						External Use L/c/day
	Tank/Ground water			Recycled water		Total	
	Kitchen	Bathroom	Laundry Hot Water	Toilet	Laundry Cold Water		
Resident / Visitor	14.0	69.0	8.8	26.0	26.3	144	5
Resort Guest	14.0	103.0	1.8	32.0	5.3	156	0
Employee	4.0	4.8	0.0	11.2	0.0	20	25
Retail/ facilities customer	0.0	0.2	0.0	0.6	0.0	0.8	0
Restaurant customer	2.0	1.2	0.6	5.6	2.4	12	0
Bar customer	0.0	1.2	0.2	3.6	0.8	5.8	0
Pool / Day Spa Customer	0.8	4.0	0.5	1.2	1.5	8.0	0

Swimming pools can be a major user of water for backwashing and top-up. The proposed use of “natural” swimming pools for the resorts will reduce demand on the potable water supply by harvesting rainwater and stormwater runoff. The natural pool system incorporates a large lagoon receiving rainwater and stormwater runoff, and a smaller pool area with discrete water treatment and swimming zones[2].

4.2 Water Demands and Wastewater Flows

The estimated water demands and wastewater flows are tabulated below. The estimated total average water demand for Ella Bay at full development is 224 ML/year excluding irrigation demands. Of this, 43 ML/year is attributed to Stage 1 (Northern) of the development. The estimated peak day water demand is 865 kL/d, of which 158 kL/d is attributed to Stage 1 (Northern).

[1] Based on Draft Stormwater Harvesting Guidelines (HWP, May 2009).
[2] Refer to Attachment C for further detail.

Table 4 Estimated Water Demands and Wastewater Flows (Excluding Irrigation Demands)

Component	Water Demand (excl irrigation)			Wastewater Flow		
	Peak	Average		Peak	Average	
	kL/day	kL/day	ML/yr	kL/day	kL/day	ML/yr
Stage 1 (Northern)						
Detached Residential	114	87	32	92	77	28
Resort (including back-up to natural pool)[5]	44	30	11	41	28	10
Sub Total	**158**	**117**	**43**	**133**	**105**	**38**
Future Stages						
Detached Residential / Apartments	350	252	92	302	228	83
Resort (including back-up to natural pool[3])	339	235	86	315	217	79
Commercial & Community Facilities	18	8	3	9	4	1.5
Sub Total	**707**	**495**	**181**	**626**	**449**	**164**
TOTAL	**865**	**612**	**224**	**759**	**554**	**202**

The average demand for water across the different uses is illustrated in Figure 6.

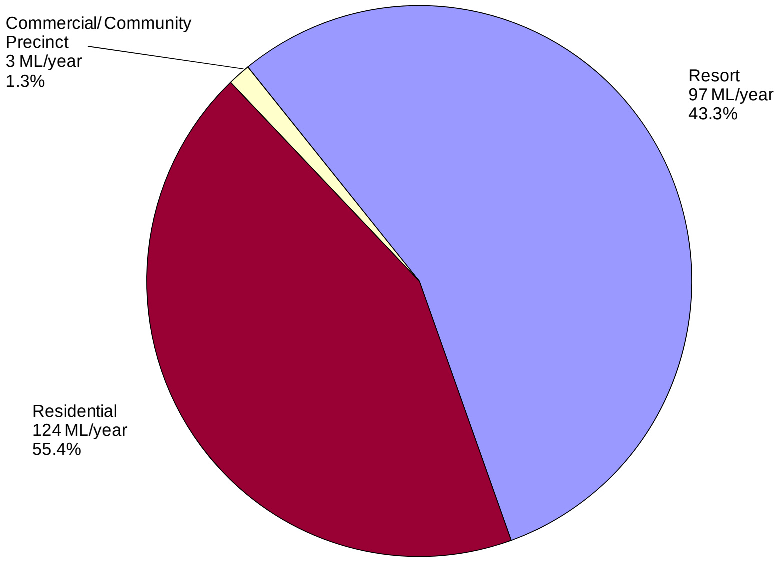

Figure 6 Total Water Demand Distribution (excluding irrigation)

The monthly demand distribution over the year taking into account the annual population variation is shown in Figure 7 below.

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[3] Note: Demand for natural swimming pools during the peak month (July) is nil.

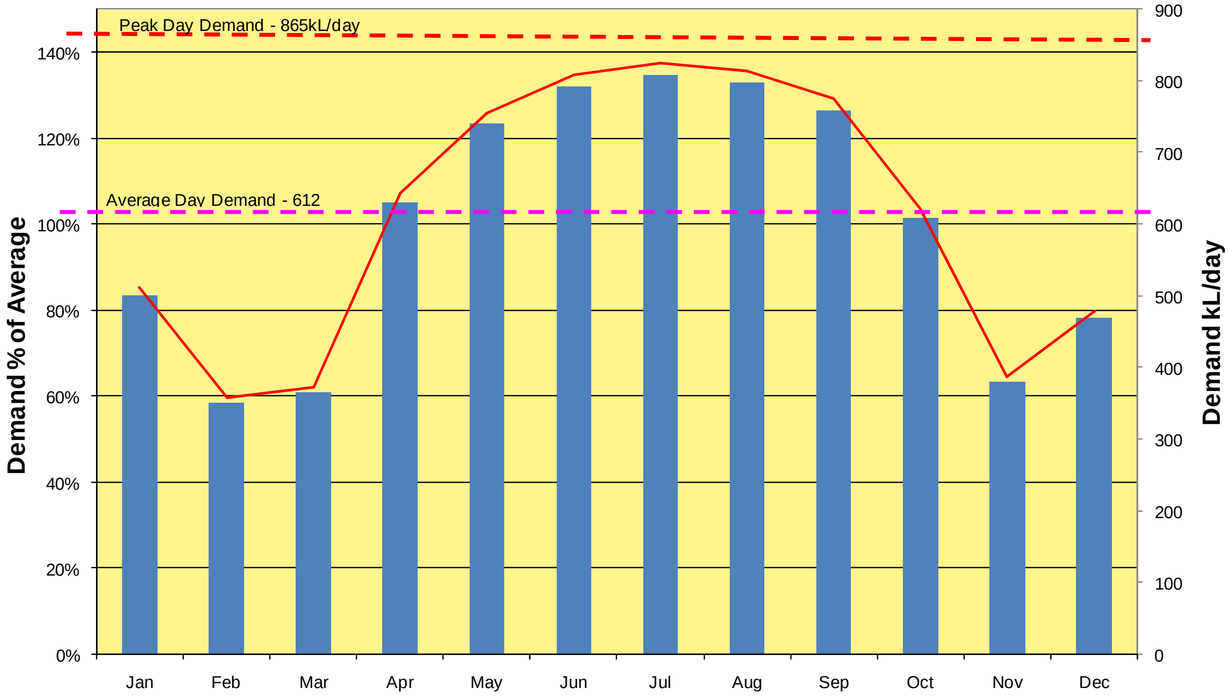

Figure 7 Monthly Water Demand Distribution (excluding irrigation)

5 REGULATORY FRAMEWORK

5.1 General

Development of water infrastructure within Ella Bay will need to meet the requirements of a number of government agencies. The statutory inputs and approvals will include:

- Cassowary Coast Regional Council –plumbing approvals in accordance with AS/NZ3500 Plumbing and Drainage code; stormwater drainage requirements;
- Department of Environment and Resource Management (DERM) – approval under the *Environmental Protection Act* and Regulations for any decentralised wastewater treatment system (as an Environmentally Relevant Activity - ERA) and the environmental impacts of recycled water use;
- Department of Environment and Resource Management (DERM) – requirements under the *Water Supply (Safety and Reliability) Act* 2008 and related parts of the Public Health Act and Regulations; requirements under the *Water Act*; possible implications in relation to the *Vegetation Management Act*; regional groundwater issues (if relevant);
- Queensland Health – potential community health issues arising from the use of rainwater tanks and water recycling under the *Public Health Act*;
- Commonwealth Department of Sustainability, Environment, Water, Population and Communities – *Environmental Protection and Biodiversity Conservation (EPBC) Act*;
- Australian Guidelines for Water Recycling (NRMMC, EPHC & AHMC 2006);
- Department of Infrastructure and Planning – acceptable uses of treated greywater.

A number of key issues related to regulation of the proposed infrastructure are highlighted below.

5.2 Wastewater/Recycled Water Regulation

5.2.1 Environmental Protection Act 1994

The wastewater treatment plant will cater for a flow greater than 21 equivalent persons and therefore constitutes an Environmentally Relevant Activity under the Environmental Protection Regulation 1998 and would need a Development Permit from the Department of Environment and Resource Management (DERM). The DERM approval will include a range of conditions including minimum water quality and annual reporting. The plant would need to be operated by a registered operator (DERM Registration).

5.2.2 Water Supply (Safety and Reliability) Act 2008

The *Water Supply (Safety and Reliability) Act 2008* commenced on 1 July 2008. It is administered by the Department of Natural Resources and Water (NRW) and the Chief Executive of the NRW is the regulator under the Act. The *Act* also links to the *Public Health Ac*t via the Public Health Amendment Regulation 2008 providing minimum water quality requirements for recycled water.

A number of Guidelines have been prepared that define the detailed requirements under the Act:

- Recycled Water Management Plan and Validation Guidelines – November 2008, NRW;
- Recycled Water Management Plan Exemption Guidelines – November 2008, NRW;
- Water Quality Guidelines for Recycled Water Schemes – November 2008, NRW.

The *Water Supply (Safety and Reliability) Act 2008* requires that certain recycled water schemes prepare and obtain approval for a Recycled Water Management Plan (RWMP). This will be determined in consultation with the Office of the Water Supply Regulator (OWSR) to confirm the application of the Act to this development. Regardless of whether the Act requires this development to prepare a RWMP, the equivalent of an RWMP is considered to be good practice for a development of this scale and a RWMP will be prepared as a requirement of the Department of Emergency Services when using recycled water for fire fighting (refer to Section 5.3).

5.2.3 Public Health Act (2005)

The *Public Health Act 2005* has been amended to incorporate water quality standards for drinking water as well as water recycling for drinking and other non-potable uses. As noted above the Water Quality Guidelines under the *Water Supply (Safety and Reliability) Act 2008* specify the need to meet the requirements of the Health Act. The specific water quality requirements of the Act are discussed further in Section 6.2.

5.2.4 Australian Guidelines for Water Recycling

To the extent that the guidelines are not amended by the requirements of the new *Water Supply (Safety and Reliability) Act* the recycled water supply would be designed to meet the water quality requirements of the Australian Guidelines for Water Recycling (NRMMC, EPHC & AHMC 2006) and the Queensland Water Recycling Guidelines (EPA 2005)[4]. The water recycling guidelines adopt a risk-based approach to the design of water recycling systems, i.e. the minimum treatment processes and water quality to be determined based on an assessment of the risks associated with the water source and use.

5.2.5 Plumbing and Drainage

All plumbing and drainage would need to meet AS/NZS 3500 (Set):2003 – Plumbing and Drainage.

5.3 Fire Fighting

Given the nature and density of the proposed development it will be necessary to provide a secure fire-fighting system for use in the event of both building and bush fires. This will include:

- A reliable water supply that has sufficient flow and pressure characteristics for fire-fighting purposes at all times (minimum pressure and flow is 10 L/s at 200 kPA);
- Sufficient volume to provide a flow of 15 L/s over a period of 2 hours[5]. A minimum 105 kL fire fighting reserve storage will be provided.

Water for fire-fighting could be provided either by recycled water from the reticulated recycled water supply or from the backup borewater supply. If used, recycled water for fire fighting will meet the requirements of the Department of Emergency Services, including:

- Minimum Class A+ recycled water quality; and
- Preparation of a recycled Water Management Plan (RWMP) incorporating Hazard Analysis and Critical Control Point (HACCP) principles.

[4] The NRW Guidelines replace Parts 4, 5 and 6 of the Queensland Water Recycling Guidelines (EPA 2005).
[5] Refer NRM (2005).

6 WATER QUALITY REQUIREMENTS

6.1 Drinking Water Quality

Drinking water must meet the requirements of the Australian Drinking Water Guidelines (ADWG 2004). Table 5 illustrates key water quality parameters and the corresponding ADWG values for aesthetic quality and to protect human health.

Table 5 Potable Water quality and ADWG values

Parameter	Units	Australian Drinking Water Guideline (2004) Values	
		Health	Aesthetic
Chloride as Cl (HPLC)	mg/L		250
Colour: True	HU		15
Iron as Fe ICPMS	mg/L		0.3
Manganese as Mn ICPMS	mg/L	0.5	0.1
Nitrate as N (Cd Reduction)	mg/L as N	10[6]	
Nitrite as N (Seal)	mg/L as N	1[7]	
pH Value @ 25°C	range		6.5 - 8.5
Sulphate as SO_4 (HPLC)	mg/L	500	250
Total Dissolved Solids (calc'd)	mg/L		500
Total Hardness as $CaCO_3$	mg/L		200
Turbidity – Raw	NTU		5
Heterotrophic Plate Count CFU/	CFU/ml		
Total Coliforms MF APHA	CFU/100mL	-	
Faecal Coliforms DW	CFU/100mL	-	
E. coli – MF	CFU/100mL	Not detected	

* Limit of laboratory testing accuracy to be considered zero reading

6.2 Recycled Water Quality

Recycled water must meet certain water quality requirements based on the proposed use of the recycled water. The Water Quality Guidelines for Recycled Water Schemes (Natural Resources and Water 2008) state that water quality criteria for recycled water are to be as set out in the document itself and also the *Public Health Act 2005* and Public Health Regulation 2005.

For Ella Bay, Class A+ recycled water will be adopted for dual reticulation to households. The recommended water quality specifications for Class A+ recycled water as per the Public Health Amendment Regulation (No. 1 2008) and the Water Quality Guidelines for Recycled Water Schemes (NRW 2008) are summarised in Table 6 below.

[6] 50 mg/L as NO_3.
[7] 3 mg/L as NO_2.

Table 6 Class A+ Recycled water quality requirements (Public Health Regulation and Water Quality Guidelines)

ID	Parameter	Minimum	Median	95th percentile[8]	Maximum	Reduction (log)
1	Turbidity (NTU)	-	-	<2	-	-
2	Chlorine residual (mg/L) for dual reticulation	-	-	>0.5	-	-
3	*E. coli* (CFU/100 mL)	-	-	<1	-	5
4	Clostridium perfringens (CFU/100 mL)	-	-	<1	-	5
5	F-RNA bacteriophage (PFU/100mL)	-	-	<1	-	6.5
6	Somatic coliphage (PFU/100mL)	-	-	<1	-	6.5

Due to the sensitivity of the surrounding environment and to promote sustainable irrigation practice the following nutrient reduction limits will also be targeted.

Table 7 Proposed Nutrient Targets in Recycled Water

ID	Parameter	Minimum	Median	95th percentile	Maximum
1	Total Nitrogen (mg/L)	-	10	-	-
2	Total Phosphorus (mg/L)	-	3	-	-

While Class A+ recycled water is required for residential reuse, a lesser quality of recycled water such as Class B could be used for golf course and open space irrigation depending on the controls implemented (e.g. restricted access and spray drift control). It is proposed to supply recycled water of varying quality for the following uses:

- Residential reuse - Class A+
- Public Open Space and Landscaping within residential areas Class A+
- Golf Course Irrigation (sub-surface irrigation) Class B
- Restricted access open space irrigation Class B

6.3 Water Quality Monitoring

Monitoring programs will need to be developed, detailing the strategies and procedures to follow for monitoring the various aspects of the water supply system and water quality.

Groundwater and rainwater for drinking purposes will need to be monitored to ensure compliance with the Australian Drinking Water Guidelines (ADWG).

Recycled water quality monitoring will be required to demonstrate that the treatment process is capable of meeting the stringent Class A+ recycled water guideline values to protect human health. Recycled water quality monitoring will need to be completed as required by the Public Health Regulation.

[8] Performance value for long term samples taken over 12 month period. Samples in the first year of operation have maximum requirements for samples and also requirements for follow-up samples.

7 INTEGRATED WATER MANAGEMENT STRATEGY FOR ELLA BAY

7.1 General

An Integrated Water Management (IWM) approach is proposed for the water supply to Ella Bay to reduce the demands on water resources generally, to help make the water systems as near to self-sufficient as possible, to minimise the environmental impact of the use and disposal of the water and to create a sustainable development. IWM includes:

- Water conservation to reduce water demands overall;
- Source substitution to replace drinking water with water from an alternative source where that water is suitable for the intended purpose, i.e. 'fit for purpose';
- Water recycling;
- Water sensitive urban stormwater design (WSUD);
- Sewerage systems designed to minimise stormwater inflow and groundwater infiltration.

It is also important that any water supply meets certain acceptable minimum delivery standards, including reliability, supply security and cost.

7.2 Water Sources Considered for Ella Bay

The following water sources have been considered for this development:

- Rainwater harvested from roofs;
- Recycled water;
- Stormwater; and
- Borewater.

Town water from Cassowary Coast Regional Council has not been considered because Council has advised that it is not available to this development.

7.3 Source Substitution

The minimum water quality required for uses at Ella Bay depends on the water source and the uses to which it is put. A key consideration is that not all water uses require drinking water quality. For many uses, it may be possible to replace drinking water with water from an alternative source where that water is suitable for that intended purpose, i.e. 'fit for purpose'. The extent to which water from an alternative source may be suitable for source substitution will depend on the source of the water, reliability of supply, the level of treatment provided and any specific regulatory constraints.

Non-potable water demands that can potentially be supplied by an alternative source of water are:

- Toilet flushing;
- Cold water laundry tap;
- Air conditioning cooling towers;
- External household uses such as car washing;
- Household garden watering;
- Irrigation of the golf course including tees, greens, fairways and rough;
- Irrigation of resort landscaping;
- Irrigation of public open space gardens, sporting fields etc;
- Fire-fighting;
- Construction water such as dust suppression.

7.4 Demand Management

In line with the sustainability objectives for the development the water management systems will be designed with a view to achieving a high level of water use efficiency and minimal demands on external water infrastructure. Efficiency measures to be adopted will include:

- Use of dual flush toilets, low flow shower roses and flow restrictors in taps will be mandated;
- Use of water efficient washing machines encouraged and supported where possible;
- Management of system pressures to no more than an acceptable minimum;

- Maximum use of recycled water for uses that do not require potable water including toilet flushing, external uses, household garden watering and irrigation of golf course, open space and buffer areas.

7.5 Water Supply Strategy

7.5.1 Overview

The proposed water supply strategy is as follows:

- The primary source of drinking (potable) water will be rainwater harvested from most roof catchments. Given the high rainfall in the area this offers a reliable source of water. The water will be treated prior to use to ensure its suitability for consumption;
- Water conservation initiatives will be implemented throughout the design of the development to minimise demands and improve the reliability of the supply;
- Rainwater is unlikely to meet the full potable water demands of the development and a back-up or reserve source of supply will be required. The back-up source will be groundwater from an on-site bore. Investigations (Golder Associates 2009a and 2009b) have identified a supply of groundwater at the site. The water will be treated prior to use to ensure its suitability for consumption;
- The primary source of non-potable water will be recycled water. Recycled water will be treated on-site. Class A+ standard will be used for residential uses such as toilet flushing and cold water laundry. Back up to essential recycled water uses, ie toilets will be provided by groundwater supply. Recycled water will also be used for general irrigation and garden watering. Back up to non-essential recycled water uses will be provided by harvested stormwater;
- Stormwater runoff will be harvested and treated to the relevant standards for use in the natural swimming pools.

This approach allows a large degree of beneficial reuse while reducing risks to public health associated with high exposure uses.

7.5.2 Supply Scenarios Considered

Three demand scenarios have been considered and these options are outlined below in Table 8. The proposed water sources for each water use for Scenarios 1-3 are outlined in Table 9.

For the purpose of this report potable water demand has been estimated based on Option 3 demands in order to reduce reliance on potable water systems while minimising high exposure uses of recycled water which could increase risks to human health.

Table 8 Water Supply Options Considered

Rainwater demands	Option 1: Rainwater used for all internal uses and general external uses and commercial laundry, but not garden watering and irrigation; Option 2: Rainwater used for all uses in Option 1 except toilet flushing, general external use, garden watering, commercial laundry and irrigation; Option 3: Rainwater used as per Option 2 except cold water laundry for residential use.
Recycled water demands	Option 1: No internal re-use of recycled water. Recycled water used for residential garden watering, irrigation of golf course and other public areas; Option 2: Recycled water used for toilet flushing, general external use, garden watering, commercial laundry and irrigation of golf course and other public areas; Option 3: Recycled water used for residential laundry cold water supply and uses considered in Option 2.
Estimated annual average potable water demand for the development	Rainwater demands: • Option 1: 612 kL/day (224 ML/year) • Option 2: 503 kL/day (183 ML/year) • Option 3: 406 kL/day (148 ML/year)
Estimated Annual average wastewater discharge for the development	Wastewater Discharge • Option 1, 2 and 3: 554 kL/day (202 ML/year)

Estimated annual average non–potable water demand excluding irrigation and garden watering	Recycled water demands: • Option 1: 0 kL/day (0 ML/year) • Option 2: 134 kL/day (49 ML/year) • Option 3: 206 kL/day (75 ML/year)
Effluent volume available for Irrigation	Irrigation Supply: • Option 1: 554 kL/day (202 ML/year) • Option 2: 420 kL/day (153 ML/year) • Option 3: 347 kL/day (127 ML/year)

Table 9 Water Sources Considered

Water Use	Proposed Water Source		
	Option 1	Option 2	Option 3
Kitchen	PW	PW	PW
Bathroom	PW	PW	PW
Hot water laundry	PW	PW	PW
Cold water laundry	PW	PW	RW
Swimming Pools	PW	PW	PW
Commercial Laundry	PW	RW	RW
Toilet flushing	PW	RW	RW
External Uses	PW	RW	RW
Garden Watering	RW	RW	RW
Irrigation	RW	RW	RW

- PW - Potable water
- RW - Recycled water

7.5.3 Adopted Water Supply Scenario

Based on the preliminary review of the three supply options it was determined that Option 3 was preferred, ie maximum use of recycled water for residential potable uses. This option was preferred because it makes greatest beneficial use of recycled water and minimises the need for groundwater as a backup supply.

The water balance analyses and results are presented in Sections 8, 9, 10 and 12.

7.6 IWM Strategy Schematic

The conceptual arrangement for the integrated water management strategy is illustrated below in Figure 8 Schematic Concept Plan.

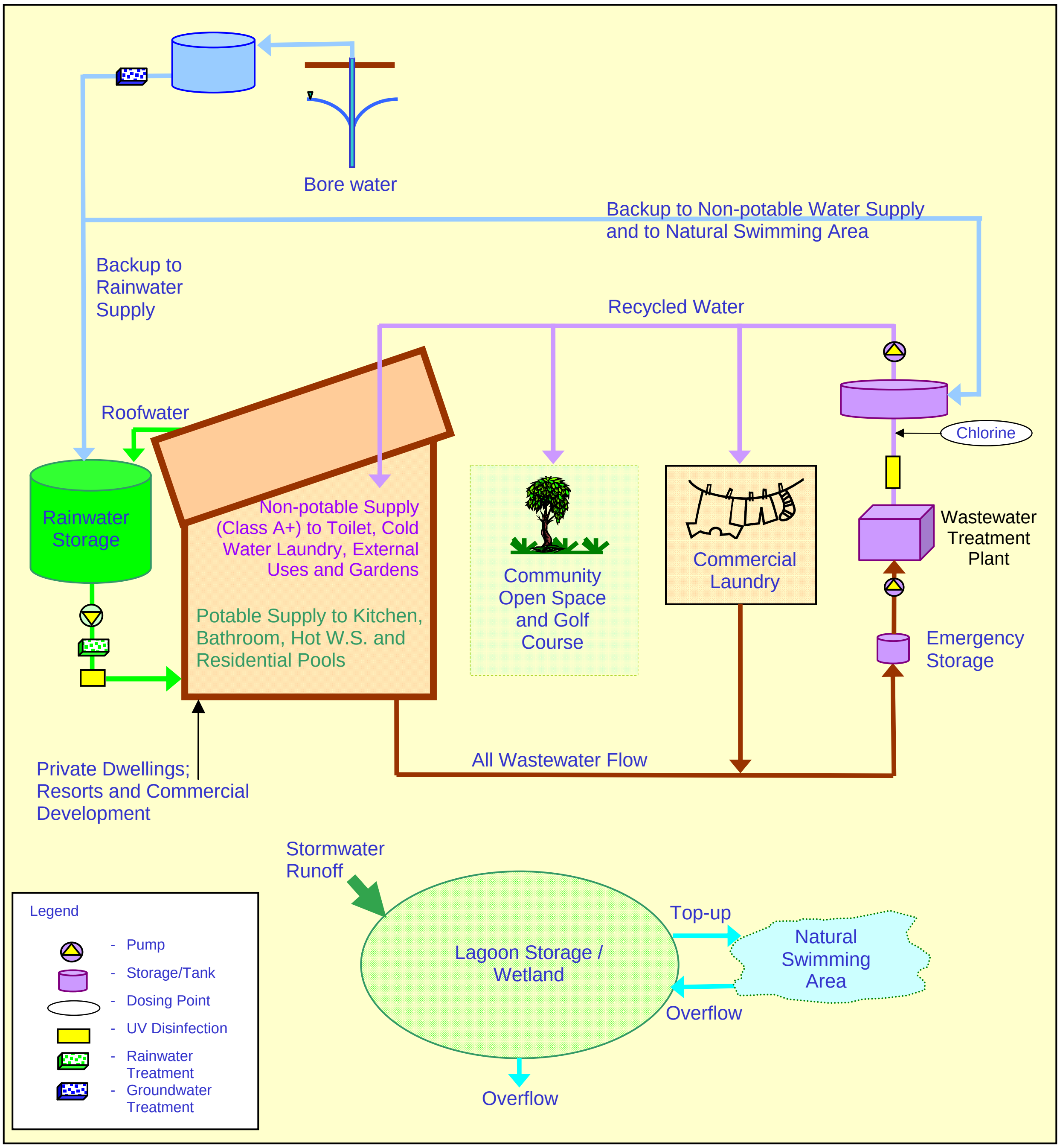

Figure 8 Schematic Concept Plan

8 RAINWATER HARVESTING

8.1 General

Rainwater will provide the primary source of potable water supply to the development.

A water balance model has been developed to assess:

- The potential to capture roofwater to supply internal domestic and non-domestic uses (excluding toilets, and possibly laundry – cold tap only); and
- The shortfall required to be supplied from the backup groundwater supply.

8.2 Assessment of the Reliability of Rainwater Harvesting

The water balance methodology included:

- Development of a daily water balance model to calculate roof runoff, demand, storage volume, back-up supply required and overflows etc on a continuous daily basis over the 30 year period;
- The model considers the relationship between tank volume and supply reliability, where reliability is defined as the percentage of demand that can be satisfied from rainwater on average. A plot is generated of the percentage of demand supplied by rainwater for differing tank storage volumes;
- The tank volume vs reliability curves were used to determine the 'optimum' tank size; this was taken as the point on the curve where the increase in yield per unit of storage volume decreases substantially;
- The demands and available roof catchment for rainwater harvesting vary depending on the type of development. For this reason, individual rainwater balance models were developed for the different development types such as low density, mixed use residential, 3 storey apartments, commercial and resort precincts; and
- The results of the individual rainwater balance models were compiled to give an overall rainfall capture estimate and level of reliability for the site.

8.3 Rainwater Modelling Assumptions

An overview of the parameters used in the roofwater balance modelling is provided in Table 10.

Table 10 Overview of Roofwater Water Balance Parameters

Component	Description
Water uses supplied	All internal household uses excluding toilet flushing and laundry cold water.
Average annual rainfall for Ella Bay	3,410 mm/year[9]
Rainwater losses	20 L/100m^2 roof catchment for first flush 3% additional losses
Connected roof catchment area[10]	210 m^2 per Detached Residential Dwelling (70% of total roof area) 680 m^2 per 3 Storey Residential Apartment Building - 6 dwellings per building (85% of total roof area) 836 m^2 per Multiuse Residential Building - 12 dwellings per building (85% of total roof area) 48,080 m^2 total for resorts and restaurants/bars (85% of total roof area) Commercial and Community facilities
Storages	Estimated storage volumes from the water balance are effective storage volumes and do not include dead storage and trickle top-up
Backup water supply	Water supply supplemented by groundwater to provide reliability

[9] Source: Bureau of Meteorology (Data Drill) - Mean rainfall at Ella Bay between 01/01/1977 and 31/12/2006.
[10] Area of roof that will be connected to the system.

8.4 Results of Rainwater Balance Modelling

8.4.1 Detached Residential Dwellings

The water balance assessed the total tank volume required to meet the demands from the proposed development. Graphs of tank yield (i.e. percentage of demand supplied) vs tank storage volume for an individual tank at a typical residential dwelling with and without a swimming pool is provided in Figure 9 and Figure 10.

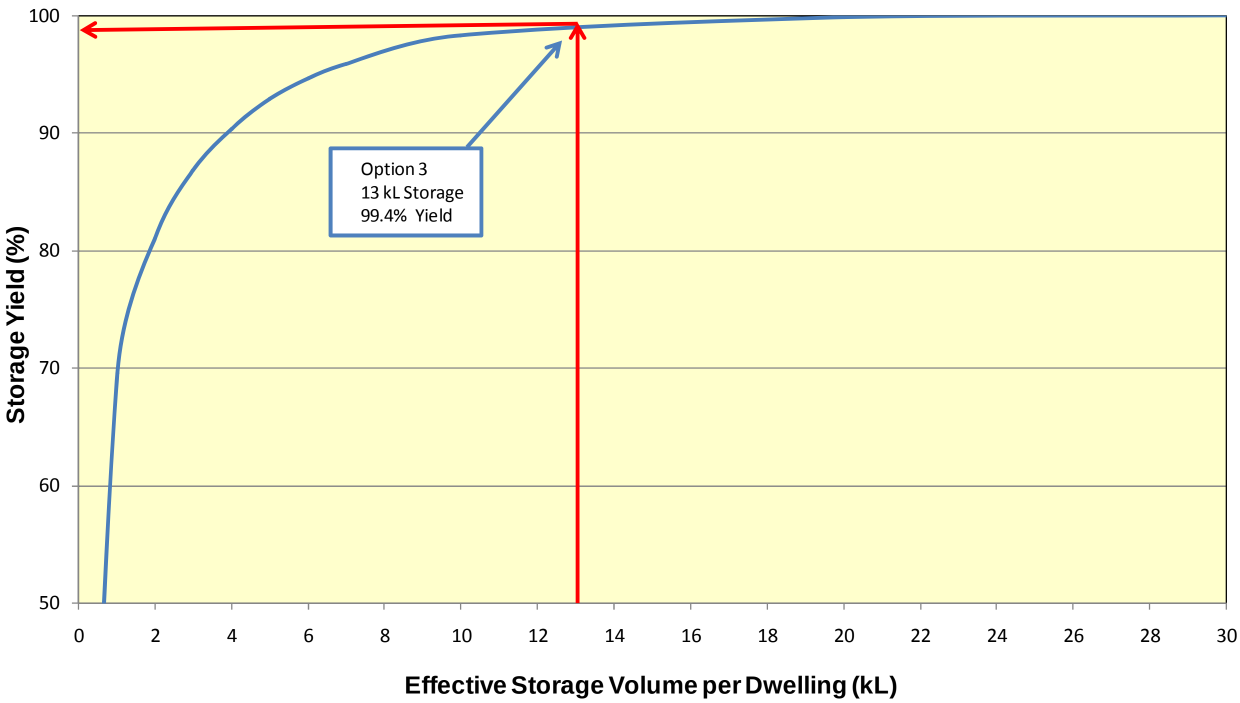

Figure 9 Rainwater Balance – Detached Dwelling- Without Pool

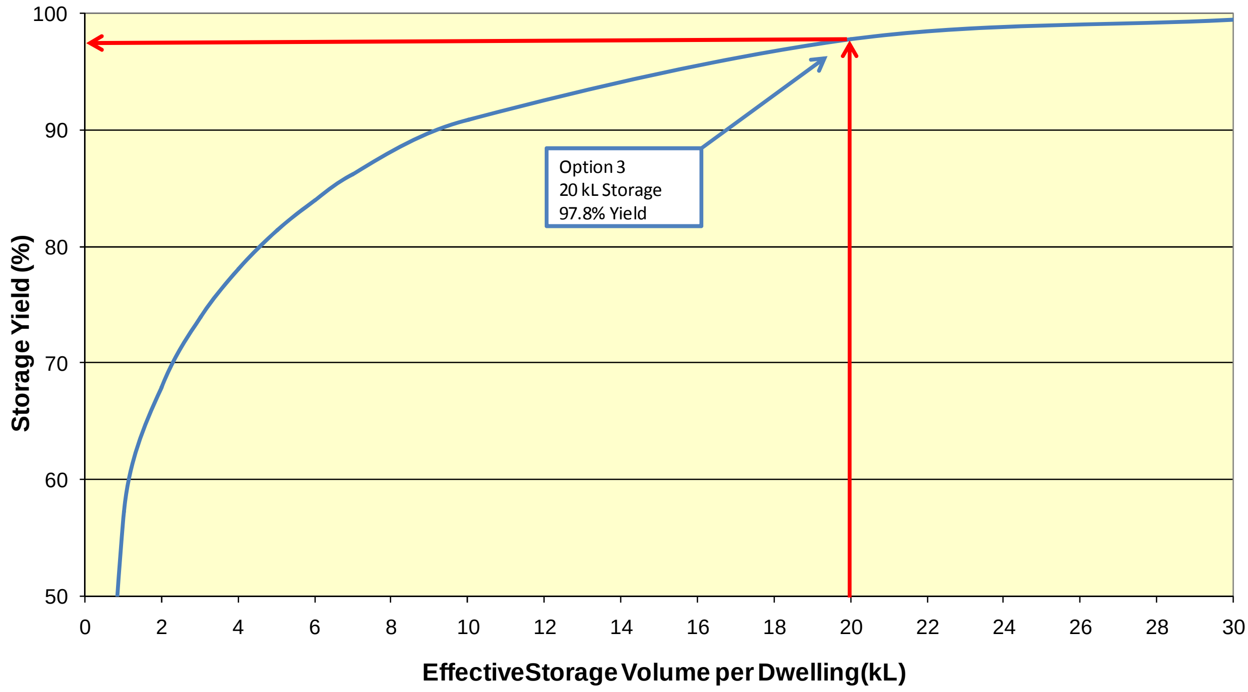

Figure 10 Rainwater Balance – Detached Dwelling- With Pool

Based on this analysis, a minimum 15 kL tank size has been adopted for a standard low density residential dwelling to provide 99% supply reliability. This provides an effective volume of 13 kL taking into account dead storage, and a top up zone. This size represents the point beyond which any increase in tank size gives a relatively small increase in yield. It is noted that the actual tank size provided at each house will depend on the size of the house based on the number of bedrooms and effective roof catchment.

For houses with pools the minimum effective storage volume needs to increase to 20 kL, ie a tank size of approx. 22.5 kL is required.

8.4.2 Apartments

The water balance results for Multi-use Residential blocks and 3 Story Residential Apartments are shown in Figure 11 and Figure 12.

The results indicate the need to provide a minimum 150 kL storage tank for each 12 dwelling multi-use residential development to achieve 96% reliability, and 50 kL for each 6 apartment 3 storey walk up to get 97% reliability.

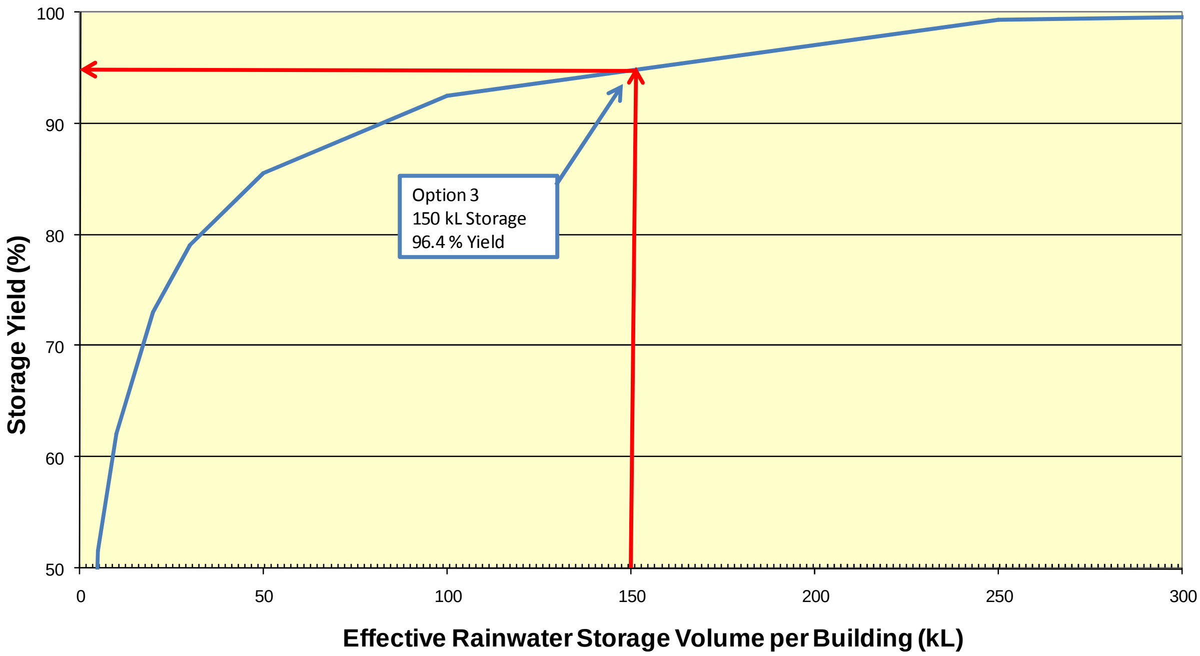

Figure 11 Rainwater Balance – Typical Multi-use Residential Building

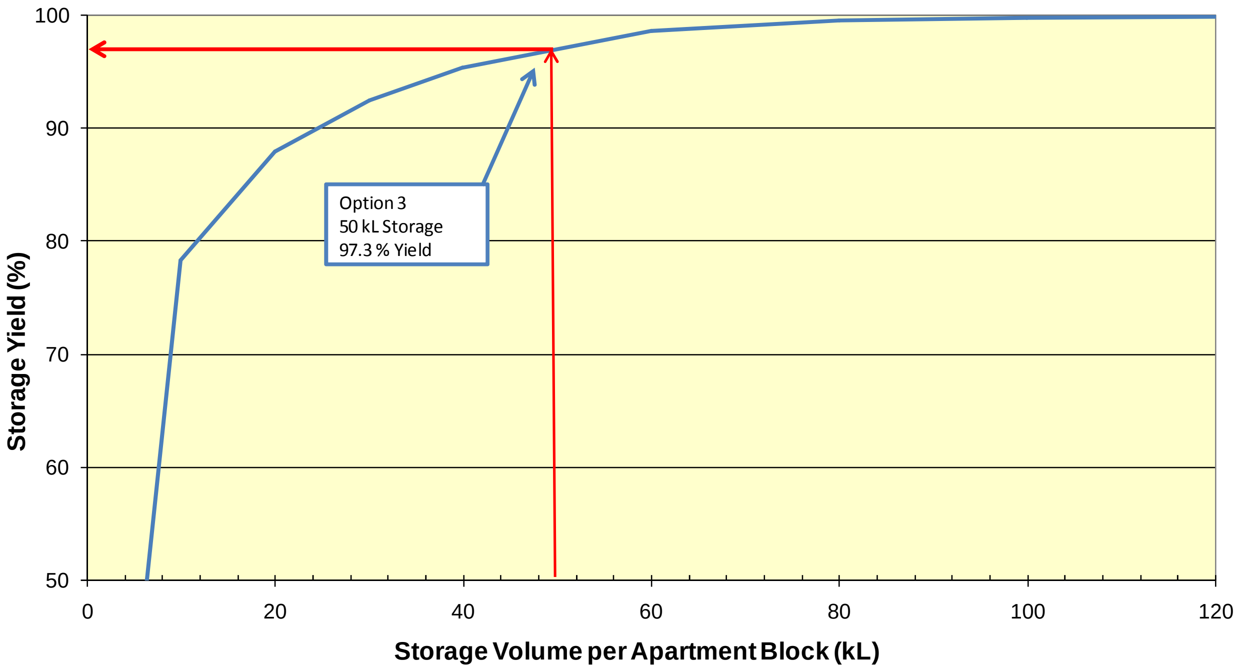

Figure 12 Rainwater Balance – 3 Storey Residential Apartments

8.4.3 Resorts

The water balance results for Resorts are shown in Figure 13. The results indicate the need to provide approximately 3,000 kL of storage for each resort development to achieve 93% reliability. This large volume is a result of having relatively high demand with a relatively small roof area.

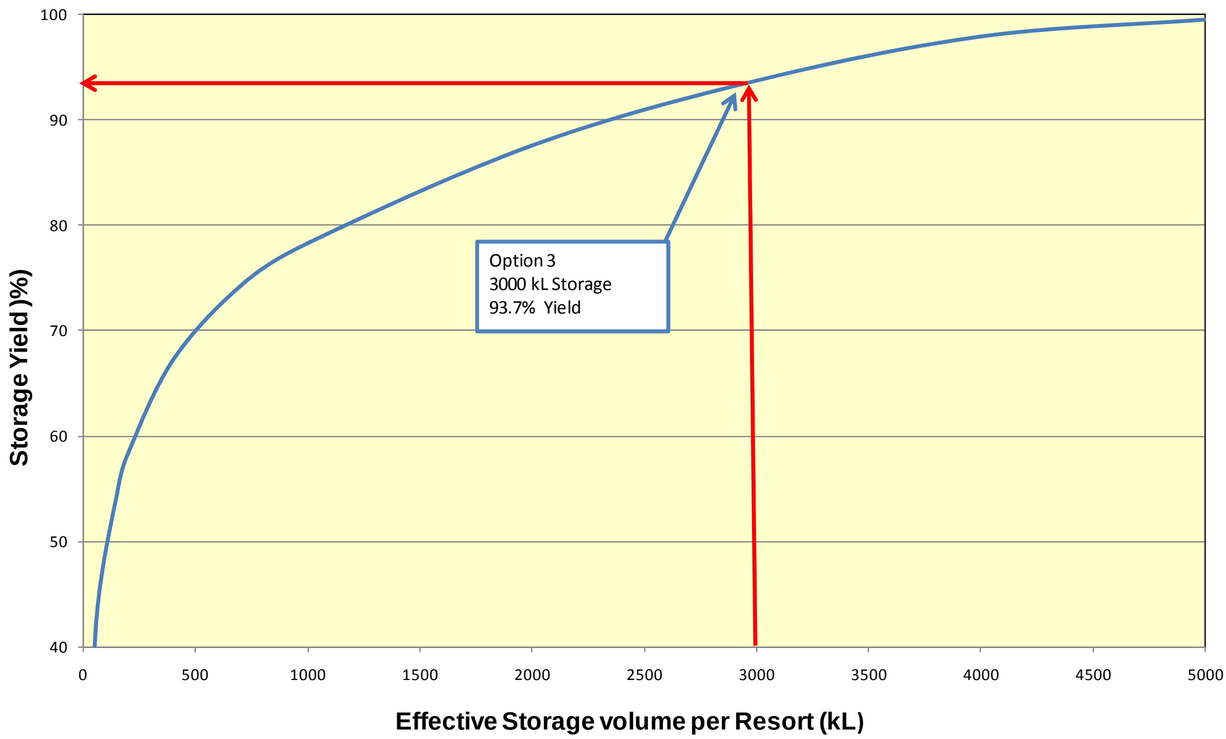

Figure 13 Rainwater Balance – Typical Resort

8.4.4 Neighbourhood Facilities and Commercial / Community Facilities

Water balance models have not been developed for neighbourhood facilities or Commercial/Community facilities due to limited available information on their design and configuration. Nevertheless, all facilities are assumed to use rainwater and the performance of those supplies has been assumed based on the modelling that has been completed.

8.4.5 Overall Water Balance

The combined results of the water balance modelling from all development types are shown in Table 11. The estimates indicate that treated rainwater can potentially supply 96% of the total potable demand, if water is used to supply kitchen, bathroom, hot water service and residential and community facility swimming pool demands. The approximate total effective storage volume for the site is 30 ML. It should be noted that the tank sizing is completed for average reliability for overall development. Specific water balance modelling should be completed to reflect the impact of different dwelling densities and impact of particular commercial facilities when recommending tank sizes to individual resorts/ residential/ mixed use/commercial buildings.

Table 11 Summary of Roofwater Water Balance Results (Ultimate Development)

Precinct	**Nominal Tank Size (effective kL per Dwelling or Facility)**	**Approximate Reliability of Rainwater Supply (%)**	**Total Average**		
			Potable Demand (kL/day)	**Demand Supplied by Rainwater (kL/day)**	**Back-up Demand Required (kL/day)**
Detached dwellings	13	99%	89.4	88.9	0.6
Detached dwellings with pools	20	98%	45.1	44.1	1.0
Neighbourhood facilities including pools	20	90%	19.3	17.4	1.9
Multi-use residential development	150	96%	51.0	49.2	1.8
Apartments	50	97%	15.1	14.7	0.4
Resorts	3,000	93%	184	172	12
Commercial & Community Precinct	Various	-	1.4	0.7	0.7
Total		**96%**	**406**	**387**	**19**

8.5 Rainwater Quality Considerations

The Australian Drinking Water Guidelines (ADWG) adopt a risk-based approach to defining catchment and water quality controls with the aim of taking into account the real potential hazards associated with the water source, likely contamination and proposed uses. At this location, the specific hazards of concern would include:

- Roofing materials affecting water quality;
- Atmospheric fallout;
- Bird droppings;
- Leaves;
- Mosquitoes.

Controls that are recommended to mitigate any risks associated with these potential hazards include:

- 1st flush diversion;
- Leaf guards on all roof gutters to prevent leafs and other contaminants entering the collection system;
- Leaf and debris screening mesh at inlet to tank (recommended screen mesh to be 4 – 6 mm and designed to be self cleaning);
- Mosquito and vermin proof screens not coarser than 1 mm aperture mesh of substantial construction and installed in such a manner as to not cause or accelerate corrosion provided on all openings;
- Flap valves provided at every opening of tanks or other receptacles;
- Rainwater tank lids, covers and inlet downpipes close fitted to exclude mosquitoes and vermin;
- Natural sedimentation within the tank; and
- Water treatment which could include cartridge filters and UV disinfection.

8.6 Downstream Hydrological Impacts of Rainwater Harvesting

Rainwater harvesting will not adversely affect the downstream hydrology, rather it will form an integral part of an overall stormwater management strategy to ensure that post-development site discharges mimic pre-development flow regimes.

Development increases the proportion of impervious areas within a catchment and therefore tends to increase the rate and volume of runoff from the development. The objective of the site stormwater strategy[11] will be to reduce runoff from the site to better mimic pre-development conditions. The stormwater management system will use a range of systems to achieve this, including bioretention filters, wetlands and detention storages. Rainwater harvesting forms part of this overall strategy by providing 'retention' storage to reduce the overall runoff volume and 'detention' storage to reduce peak runoff rates.

[11] Refer to Design Flow 2009.

9 GROUNDWATER

9.1 General

Groundwater will provide the back-up supply to the rainwater harvesting system (potable supply) and also to essential elements of the recycled water supply.

9.2 Groundwater Quality

9.2.1 Shallow wells

A background groundwater monitoring program has been undertaken by Golder Associates (2009a). The program has been reported in Volume 6.4i Water Monitoring Results - Golders. The program includes sampling from a total of 6 shallow monitoring wells. A location map of the monitoring bores and summary of the data obtained to date (October and November 2008) are provided as Attachment B.

The results indicate that the groundwater is slightly acidic (pH 4.5 to 6.0) with total nitrogen generally between 0.25 and 3.5 mgN/L (1 sample @ 83 mgN/L) and total phosphorus between 0.2 and 1.2 mgP/L. Conductivities are low, between 2.2 and 60 μS/cm.

9.2.2 Deep wells

During November and December 2008 Golder Associates (2009a and 2009b) also drilled 11 investigation bores to assess the potential for a sustainable potable groundwater supply.

Two bores were completed for test production bores: Northwest Production Bore and Western Production Bore (PB1B and PB3C) - refer to Attachment B.

Water sampled from the Northwest Production Bore has been analysed and compared with the Australian Drinking Water Guidelines (ADWG) (NHMRC and NRMMC 2004). The results are summarised Table 12. Samples that exceed the drinking water guideline values have been highlighted in yellow. Comments on the water quality data are:
- The water is somewhat turbid, which would not normally be expected from a newly established bore;
- The water is free from faecal contamination;
- The water is slightly acidic (pH <6);
- The water has very low conductivity (50 μS/cm) and dissolved solids (<80 mg/L);
- The water is quite soft (hardness around 15 mg/L as $CaCO_3$);
- There are elevated levels of aluminium and iron, probably due to the acidity and low level of dissolved minerals;
- The water would be expected to be somewhat corrosive to metal fixtures and fittings and may need treatment to stabilise it.

Table 12 Water Quality for Deep Groundwater Well – Northwest Production Bore (Golder Associates 2009a)

Parameter	Unit	Lab Detection Limit	Sample 15/12/2008	Sample 21/12/2008	Drinking Water Guideline Values[12]	
					Health	Aesthetic
E.Coli	CFU/100 ml	1	<1	<1	Not detected	-
Total Coliforms	CFU/100 ml	1	307	220	-	-
Feacal Coliforms	CFU/100 ml	1	<1	<1	-	-
Ammonia	mg/L as N	0.05	<0.05	<0.05	c	0.5 as NH_3 0.35 as N
Total Oxidised Nitrogen	mg/L as N	0.05	0.27	0.25	-	-

[12] Australian Drinking Water Guidelines (NHMRC and NRMMC 2004).

Parameter	Unit	Lab Detection Limit	Sample 15/12/2008	Sample 21/12/2008	Drinking Water Guideline Values[12]	
					Health	Aesthetic
Total Kjedahl Nitrogen	mg/L as N	0.05	1.1	<0.05	-	-
Total N	mg/L	0.05	1.4	0.25	-	-
Total P	mg/L	0.02	<0.02	<0.02	-	-
Nitrite	mg/L as N	0.005	<0.005	<0.005	3 as NO_2 1 as N	-
Nitrate	mg/L	0.05	0.27	0.25	50 as NO_3 10 as N	-
pH (Lab)	Range	0.1	5.6	5.8	c	6-8.5
pH (Field)	Range	-	5.13	5.15	-	-
EC (Lab)	µS/cm	5	52	51	-	-
EC (Field)	µS/cm	-	48.3	53.5	-	-
Bicarbonate Alkalinity	mg/L as $CaCO_3$	5	10	11	-	-
Carbonate Alkalinity	mg/L as $CaCO_3$	5	<5	<5	-	-
Total Alkalinity	mg/L as $CaCO_3$	5	10	11	-	-
Acidity at pH8.3	mg/L as $CaCO_3$	5	<5	<5	-	-
Hardness	mg/L as $CaCO_3$	5	na	15	n	>60 <200
Turbidity	NTU	0.5	11	6.9	c	5
TDS	mg/L	10	82	55	n	500
Chloride	mg/L	2	11	10	c	250
Sulphate	mg/L	2	<2	2	500	250
Fluoride	mg/L	0.05	<0.05	0.05	1.5	-
Calcium	mg/L	0.5	<0.5	<0.5	-	-
Magnesium	mg/L	0.5	3.4	3.7	-	-
Sodium	mg/L	0.5	6.4	6.8	e	180
Potassium	mg/L	0.5	1.4	20	-	-
Silicon	mg/L	1	6	6	-	-
Silica	mg/L	5	16	16	-	-
Aluminium	mg/L	0.05	0.05	0.59	0.5	0.2
Manganese	mg/L	0.05	<0.05	<0.05	0.5	0.1
Iron	mg/L	0.05	0.15	0.39	c	0.3
Lead	mg/L	0.001	<0.001	<0.001	0.01	-
Arsenic	mg/L	0.003	<0.003	<0.003	0.007	-
Cadmium	mg/L	0.0001	<0.0001	<0.0001	0.002	-
Copper	mg/L	0.001	<0.001	<0.001	2	-
Zinc	mg/L	0.005	<0.005	0.009	c	3
Barium	mg/L	0.005	<0.005	<0.005	0.7	-
Mercury	mg/L	0.0002	<0.0002	<0.0002	0.001	-
Molybdenum	mg/L	0.005	<0.005	<0.005	0.05	-
Antimony	mg/L	0.003	0.003	<0.003	0.003	-
Selenium	mg/L	0.003	<0.003	<0.003	0.01	-
Silver	mg/L	0.001	0.003	<0.001	0.1	-
Nickel	mg/L	0.002	<0.002	<0.002	0.02	-
Chromium	mg/L	0.001	<0.001	<0.001	0.05	-

9.3 Bore Yield

Golder Associates (2009a and 2009b) undertook test pumping from the Northwest Production Bore to estimate the sustainable yield of the bore. Monitoring bores were used to determine the impact of pumping at different distances from the production bore to address concerns about the potential impacts of pumping on the Wet Tropic Queensland World Heritage Area (WTQWHA), sensitive wetland areas and the Great Barrier Reef World Heritage Area (GBRWHA) caused by changes in groundwater hydrology. The sensitive wetlands identified at Ella Bay were:

- The dunal swales located near the Eastern Conservation Covenant; and
- The Ella Bay Swamp located north of the proposed resort area.

The results of modelling and extrapolation of test pumping data indicated that there is no direct evidence that the Ella Bay Swamp is hydraulically connected to the silty-gravel aquifer. Monitoring bore levels showed that the shallow aquifer above the groundwater abstraction aquifer exhibited change in level typical of a semi-confined aquifer charged by tidal forcing (Golder Associates (2009a) - Figure 22). The related phenomena of submarine groundwater discharge from the aquifer has been studied by Stieglitz (2005) at Ella Bay.

The groundwater modelling results indicate bore PB1B (Northwest Production Bore) may be pumped continuously for 35 days a rate of 3 L/s (260 kL/day) before potentially producing 0.1 m drawdown at bore A-MW3 (equivalent to the southern extremity of the wetland in the North of Ella Bay Property) and for 80 days before potentially producing 0.1 m drawdown at bore A-MW4 (adjacent to the dunal swale along the eastern boundary of Ella Bay property). This is based on the limitations and assumptions of the simple model, particularly no rainfall recharge and the assumption there is a direct hydraulic connection between the colluvium and the sandy sediments in the wetlands. Flow rates of 4 to 5 L/s (345 – 432 kL/day) may be possible for shorter periods.

A second bore (the western production bore) is recommended as a backup and for use at times of high demand.

It is noted (Golder and Associates 2009a and 2009b) that the analytical model is an estimate of the aquifer behaviour only and the actual operation of the Northwest Bore may need to be modified according to long-term data on the groundwater response in the monitoring bores. This modelling can be considered as a conservative worst case scenario.

9.4 Groundwater Demand

The potential overall groundwater demand was assessed by aggregating the results of the rainwater water balance analyses which provided the daily shortfall in supply for each development type. The daily shortfall data for each development type was multiplied by the number of development units to established an estimate of daily shortfalls.

Analysis of back-up water demands for Ella Bay at ultimate development indicates that:

- The average backup demand is 19 kL/day varying from nil to 100 kL/day depending on season (this is shown in Figure 14);
- Maximum day, maximum week and maximum month demands are shown in Figure 15. The Figure indicates that at peak periods the groundwater demand can exceed 260 kL/day for extended periods of time. In very dry periods demand can reach 529 kL/day, whereas the peak month demand is up to 470 kL/day;
- A percentile plot (Figure 16) of groundwater demand over the 30 year analysis period shows that for 85% of the time the groundwater demand is less than 260 kL/day;
- This results reflect the fact that, despite the high annual average rainfall at Ella Bay, there is still a marked dry season when water demand will exceed harvesting potential.

9.5 Discussion

The yield of the Northwest Production Bore has been conservatively assessed at 260 kL/day for a continuous period of at least 35 days. The analysis of groundwater demand suggests that at full development the bore yield could be exceeded during dry weather for extended periods of time. The majority of this demand is from the resorts which are expected to have relatively high demands compared with available roof catchment and storage volumes.

For stage 1, water demands are only approximately 20% of ultimate demand and the shortfall in rainwater supply will not exceed the groundwater supply capacity. During stage 1 development, further investigation will be completed to define more accurately the sustainable bore yield and to identify a second bore supply. This will also provide a greater level of supply security. In addition, management strategies will be developed to limit demands during very dry weather including:

- Banning pool top-up from the groundwater supply;
- Banning spa use in the resorts;
- Voluntary restrictions on water use generally.

With the confirmed/increased bore capacity and demand management measures the groundwater system will provide a secure back up supply to rainwater harvesting.

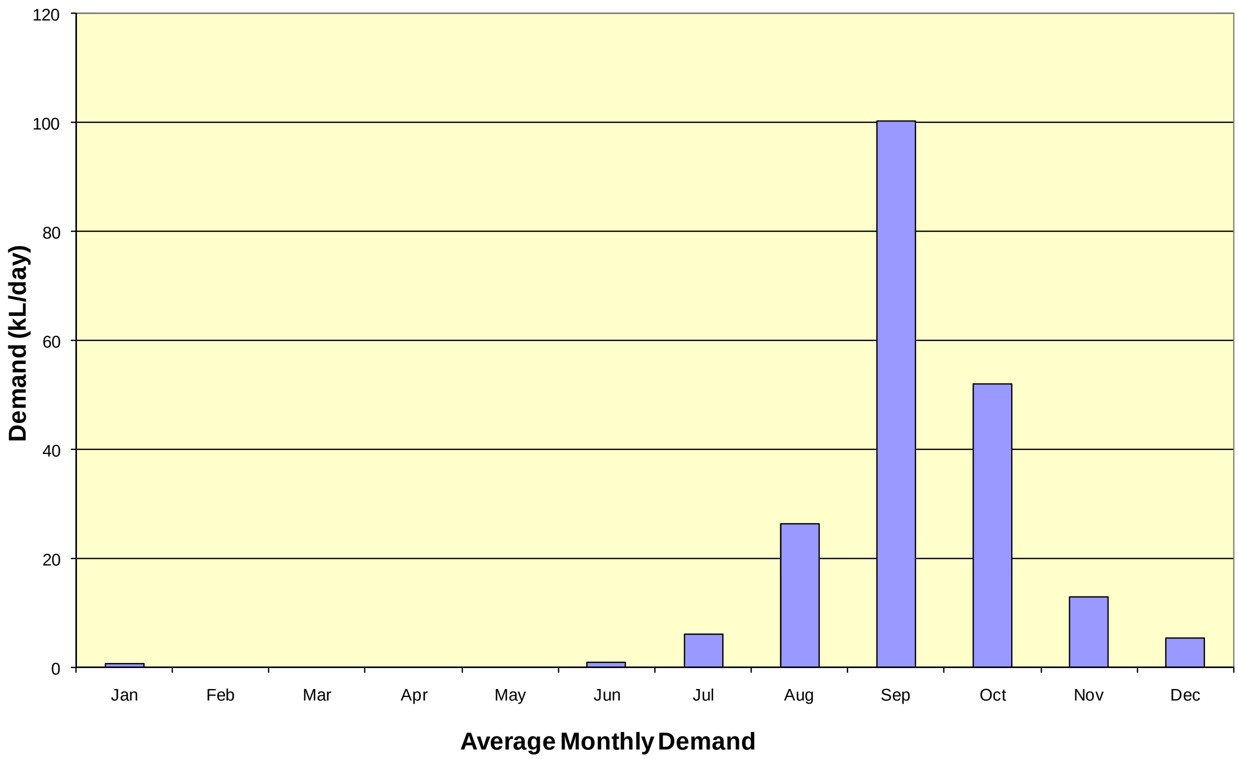

Figure 14 Average Monthly Groundwater Demand

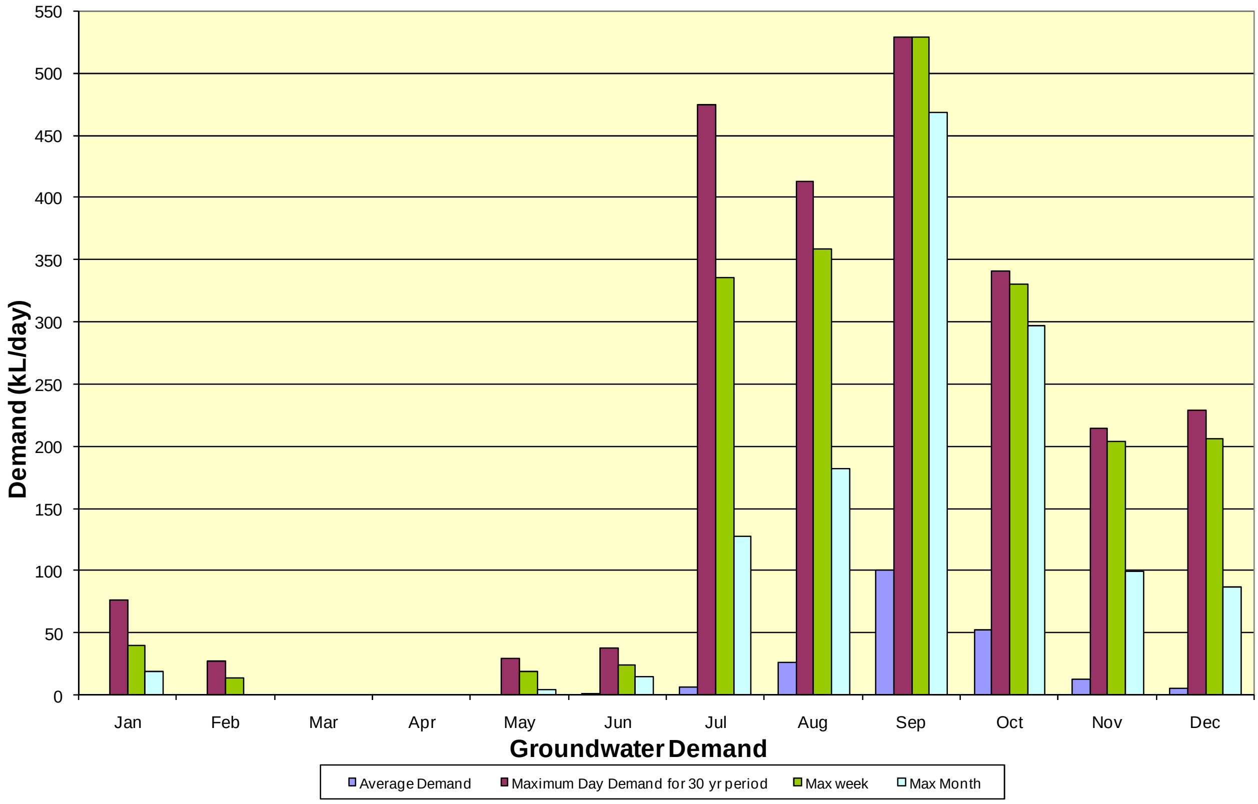

Figure 15 Groundwater Demand Distribution with Maximum Day, Week and Month Demands

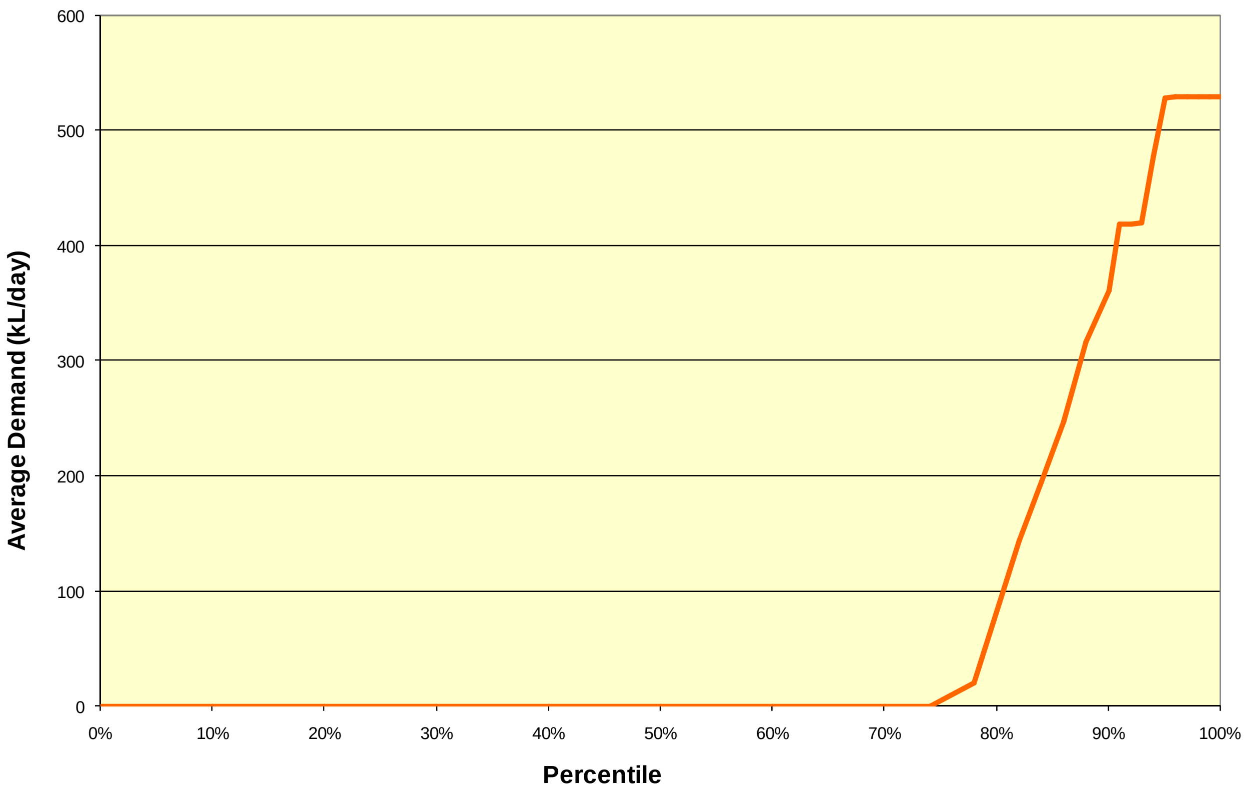

Figure 16 Percentile Plot of Groundwater (Back-up) Demand

10 RECYCLED WATER

10.1 Recycled Water Modelling Assumptions

An overview of the parameters used in the recycled water balance is provided in Table 13.

Table 13 Overview of the Recycled Water Balance Parameters

Component	Description
Recycled water demands	Recycled water used for toilet flushing, general external use, residential garden watering, domestic cold water laundry, commercial laundry, air conditioning cooling towers, irrigation of golf course and other public areas
Average non–potable household water demand	Daily residential and business recycled water demands as estimated in Section 4.2.
Irrigation rate	Seasonal irrigation demands were assessed using the MEDLI model and local rainfall data; The maximum potential irrigation demand from MEDLI for this soil type was 580 mm/year.
Soils data used for MEDLI	For CLAY underlain with Clayey SAND (refer to Attachment B for results of soils analysis)
Irrigation Triggers – no irrigation if: Previous days rainfall: Today's rainfall:	 > or = 25 mm > or = 10 mm
Backup water supply	Water supply back-up with groundwater to provide reliability for indoor uses only.

The estimated area available for irrigation is given in Table 14. Irrigated areas have been defined as either Priority 1, 2 or 3. The priorities are defined as follows:

- Priority 1 areas are those which will be supplied with water to meet all of their demands;
- Priority 2 areas will receive water on a regular basis but may not receive all of their demands at all times;
- Priority 3 areas do not require regular irrigation but will be used to ensure full sustainable reuse of the wastewater.

Table 14 Estimated Area Available for Recycled Water Irrigation

Green Areas	Estimated Area	% Assumed Irrigated	Potential Irrigated Area (ha)[13]
Stage 1 (Northern)			
Priority 1			
- Golf Course (Tees and Green)	1	100	1
- Resort Entrance and Nursery	2	100	2
- Communal Vegetable Garden	0.5	100	0.5
Priority 2			
- Golf Course (Fairways)	5	100	5
- Resort General Area	2	100	2
- Residential Gardens	2.1	100	2.1
Priority 3			

[13] Based on information provided by Satori Resorts.

Green Areas	**Estimated Area**	**% Assumed Irrigated**	**Potential Irrigated Area (ha)**[13]
- Golf Course (Rough)	14	10	1.4
- Residential – Off-street Areas/ Community Parks	12	0	0
- Revegetation	13	100	13
Sub Total	51		27
Future Stages			
Priority 1			
- Golf Course (Tees and Green)	4	100	4
- Resort Entrance/Nursery/ Sporting Fields	10	100	10
- Communal Vegetable Garden	1.5	100	1.5
Priority 2			
- Golf Course (Fairways)	15	100	15
- Resort General Area	8	100	8
- Residential Gardens	3.3	100	3.3
Priority 3			
- Golf Course (Rough)	36	10	3.6
- Resort / Village – Off-street Areas/Community Parks	10	100	10
- Residential – Off-street Areas/Community Parks	18	0	0
- Revegetation / Common Areas	9	100	9
Sub Total	115		65
TOTAL PRIORITY 1	**19**		**19**
TOTAL PRIORITY 2	**35**		**35**
TOTAL PRIORITY 3	**112**		**37**
TOTAL (ALL PRIORITIES)	**166**		**91**

10.2 Recycled Water Balance

10.2.1 General

A recycled water balance model has been developed to assess:

- The potential of recycled water produced on-site to meet the non-potable water requirements for the development (i.e. external uses, toilet flushing and cold water laundry);
- The potential for excess recycled water to be used for golf course and open space irrigation; and
- Area and storage requirements for 98% beneficial reuse of recycled water.

10.2.2 Methodology

The recycled water balance model was developed as follows:

- Development of a daily recycled water balance model for the full development to consider the relationship between storage volume, irrigation area and the volume of water that can be beneficially reused;
- A plot is generated of the percentage of recycled water reused for differing tank storage volumes and irrigation areas; and
- The storage volume vs reliability curves generated were used to determine the minimum volume required to achieve 98% beneficial reuse; 98% has been chosen as it provides a practical maximum for sizing of infrastructure.

10.2.3 Results of Recycled Water Balance

The results of the recycled water balance are shown in Figure 17 and Table 15. The curve shows the relationship between storage volume and percentage of water beneficially reused. The data indicate that, with an available irrigation area of 91 ha, the dedicated storage volume required to achieve 98% beneficial reuse is approximately 11 ML. This would supply toilet flushing, cold water laundry, external uses, commercial laundry demand, garden watering and irrigation.

It is noted that:

- Approximately 37% of the available recycled water will be used internally;
- On average, the recycled water supply for irrigation is 0.38 mm/day, well below the estimated average irrigation demand of 1.6 mm/day;
- The MEDLI modelling indicates that irrigation with recycled water at this rate on the site soils will not result in any adverse nutrient impacts with nitrogen application rates below crop demand and phosphorus application 117% of crop demand with the balance adsorbed within the soil;
- Similarly, there will not be any adverse impact due to recycled water salts.

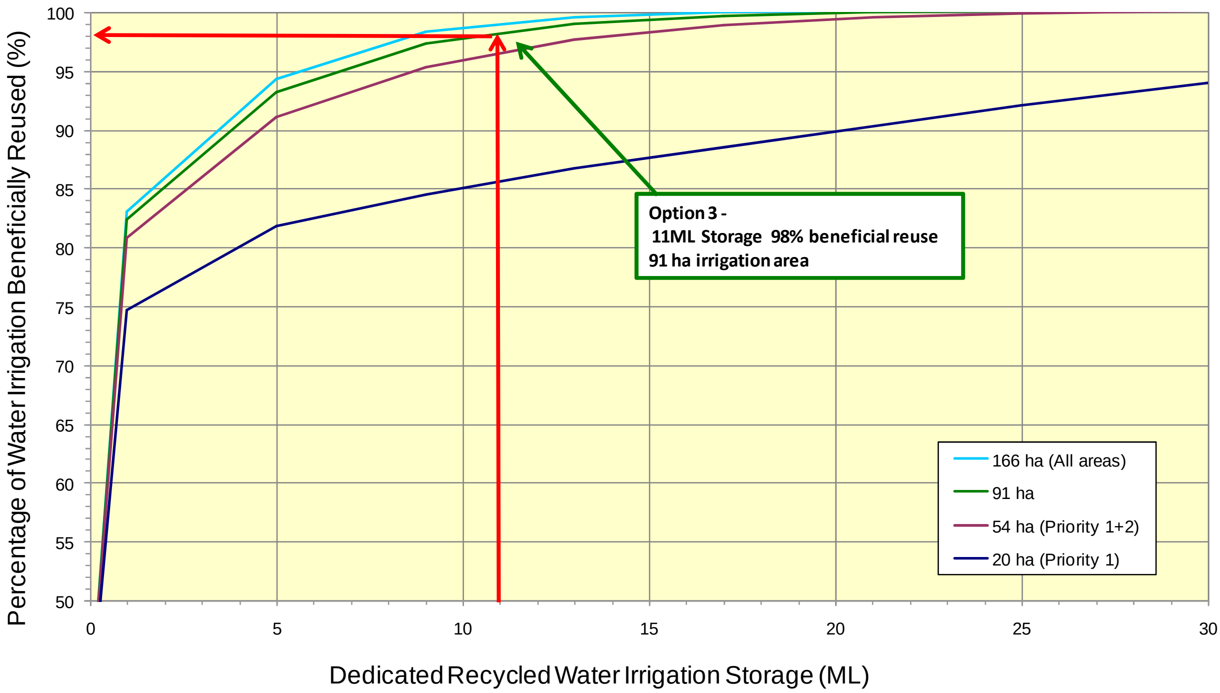

Figure 17 Recycled Water Balance

Table 15 Summary of Recycled Water Balance Results

Parameter	Peak	Average	
	kL/day	kL/day	ML/yr
Total wastewater discharge	759	553	202
Residential and Commercial recycled water demand (excluding irrigation)	286	206	75
Balance available for irrigation	473	347	127
Irrigated area and storage volume	91 ha and 11 ML		
Irrigation rate	0.52 mm/day	0.38 mm/day	
Average irrigation demand		1.6 mm/day	

10.3 Design Considerations

Recycled water is considered suitable for non-potable uses such as toilet flushing, cold water laundry and external uses such as car washing and landscape irrigation. Depending on statutory approvals, it could also be used for fire-fighting, cold water laundry and air-conditioning cooling towers.

Design considerations for a water recycling scheme would include:

- Sources of recycled water and supply volume available;
- The uses for the recycled water;
- The seasonally variable nature of external water demands;
- The storage capacity required to balance seasonal and wet weather supply and demand;
- Practicality of constructing large water storages;
- Water quality and treatment requirements; and
- The need for pumping to distribute the water to the point of use.

Best available technology treatment for Class A+ recycled water would be secondary biological treatment with nutrient removal, membrane micro or ultrafiltration, high rate ultraviolet (UV) irradiation and residual chlorination.

11 STORMWATER

Stormwater harvesting will be used to supplement the supply of water to the resort lagoons as part of the proposed natural swimming pool systems (refer to Attachment C). Further treatment may be required prior to the water being used in the swimming pools.

Australian Guidelines for Water Recycling: Stormwater Harvesting and Reuse (EPHC, NHMRC, & NRMMC-Phase 2) were released in July 2009. These guidelines specifically address risks associated with stormwater reuse and have been included as a valuable source of reference. It should be noted that these guidelines apply to non-potable end uses only. In considering stormwater for higher exposure uses such as swimming pool top-up, water of potable quality will be required. Consequently, Phase 2 (module 1) of the Australian Guidelines for Water Recycling: Augmentation of Drinking Water Supplies (EPHC, NHMRC & NRMMC 2008a) provides guidance on recycled water for drinking which includes treated sewage and stormwater. Also, the Draft Stormwater Harvesting Guidelines (HWP May 2009) provide guidance on water for primary contact including pool top-up.

12 OVERALL WATER BALANCE

The proposed supply strategy including the source of water and demand supplied from each source is shown in Table 16.

Table 16 Proposed Water Sources and Demand Supplied

Proposed Water Supply	Peak kL/day		Average	
	(without backup)	(with backup)	kL/day	ML/yr
Rainwater Harvesting	579	136	387	142
Recycled Water	286	286	206	75
Groundwater (Back-up)	nil	443	19	6.9
Total (excluding irrigation)	886	886	617	225

The overall water supply balance and proportion of water supplied from each source is illustrated in Figure 18 below. The figure shows the very significant reduction in demand from external sources that is achievable with a full commitment to integrated water management.

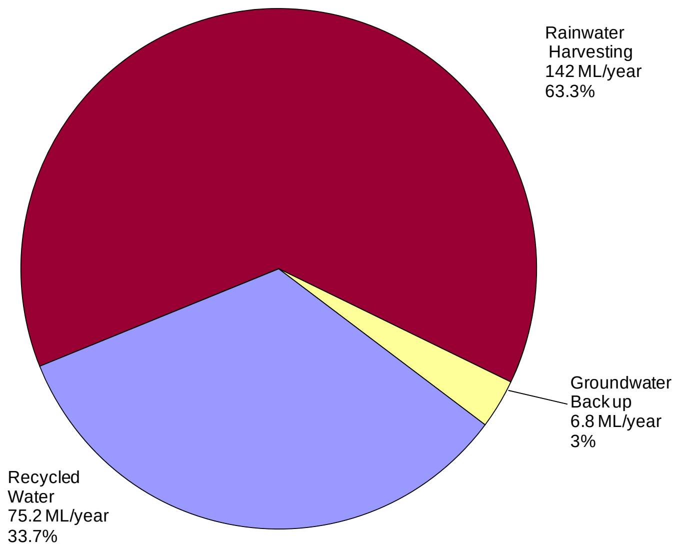

Figure 18 Water Supply from Each Source

13 WASTEWATER MANAGEMENT STRATEGY FOR ELLA BAY

13.1 General

The conventional approach to the design of wastewater collection systems has been to adopt conservative per capita flow allowances and to allow for significant quantities of groundwater infiltration and stormwater inflow (I/I). In Queensland, per capita flows in the range 140 to 270 L/person/day have been used. The allowance for I/I is typically 5 times average dry weather flow, ie sewers are designed to have sufficient capacity to carry 80% stormwater under extreme wet weather conditions. This has been necessary because conventionally designed and constructed sewerage systems are seldom ‘watertight’ with significant leakage through inadequate pipe joints, broken or cracked pipes, poorly sealed manholes and illegal connections.

Integrated water management (IWM) adopts the approach of limiting per capita wastewater flows through water conservation and adopting alternative wastewater collection systems to reduce wet weather flows. Alternative wastewater collection systems reduce the extent of I/I, reducing the capacity and cost of the collection and treatment systems. The other cornerstone of IWM is water recycling, ie providing beneficial reuse of highly treated recycled water to reduce potable water demands and to minimise environmental impacts of wastewater discharge.

It is important for a development such as this in an environmentally sensitive location to manage its wastewater in a sustainable way. In practice, this means treating the water to a suitable standard and reusing it in ways that will protect both the environment and public health. Direct discharge of the wastewater, even if treated to a very high standard, is unlikely to be accepted as a sustainable practice, particularly when viable alternatives exist.

The use of Class A+ recycled water for toilet flushing, cold water laundry and landscape irrigation is an acceptable practice under current Queensland (NRW 2008) and Australian Guidelines for Water Recycling (NRMMC, EPHC, AHMC 2006). The proposed strategy is based on effectively 100% reuse of the recycled water with zero discharge to receiving waters of the Great Barrier Reef Marine Park.

13.2 Proposed Wastewater Strategy

Provision of a local ‘decentralised’ wastewater treatment and water recycling plant within the development is proposed.

Preliminary details of a possible system configuration are as follows:

- Wastewater will be collected in a low infiltration sewerage system;
- The collection system will drain to a number of sewage pumping stations;
- Wastewater will be pumped to a central treatment facility located adjacent to the golf course near the confluence of Farm Creek and the North-South creek;
- Treated water will be pumped from balancing storage tanks directly into the distribution system. Water that cannot be used immediately will be directed to seasonal storages distributed around the development; the seasonal storages could include a combination of covered tanks and covered and uncovered lagoons.
- A service reservoir/s will need to be developed.

13.3 Wastewater Collection System

Possible alternative sewerage systems include:

- A low infiltration ‘smart’ gravity sewerage system using plastic pipes and access chambers rather than conventional pipelines and concrete manholes;
- Vacuum sewerage (particularly well suited to very flat sites with high groundwater levels);
- Low pressure sewerage (well suited to more difficult terrain with higher slopes).

The Ella Bay, either a low infiltration gravity or vacuum sewerage system would be suitable and this will be assessed and determined at the detailed design stage.

13.4 Wastewater Treatment

Recycled water will be treated to Class A+ standard in accordance with Guidelines under the Water Supply (Safety and Reliability Act) suitable for residential non-potable reuse. Plant performance validation and verification will be undertaken in accordance with the guidelines.

The plant will be designed to minimise its footprint, for example, membrane bioreactor (MBR) technology could be used to provide a small plant footprint and high quality treated water for reuse; an MBR plant would include inlet screens, reactor tank with membranes, disinfection using ultraviolet (UV) light and residual chlorination.

Treatment residuals will be thickened on-site and then transported off-site for disposal or reuse depending on existing opportunities in the region. Plant odour will be managed by, at a minimum, covering the inlet works. If necessary, this could extend to covering the bioreactor or housing the entire plant in a building. Any covered areas would be ventilated to odour scrubbers. Plant noise will be managed through the choice of equipment, eg submersible motors rather than surface mounted, the use of acoustic enclosures for particularly noisy equipment such as compressors or, if the plant is in a building, ensuring that the building has appropriate acoustic insulation.

14 CONCLUSIONS & RECOMMENDATIONS

14.1 Conclusions

The water management systems for Ella Bay will be designed to service a resident and visitor population of up to 3,795 people, plus day workers and other visitors. This will require an estimated total of 224 ML/year of water excluding requirements for garden watering and open space irrigation.

The integrated water management strategy for the development is as follows:

- Rainwater will be harvested from all site roofs to provide the main potable (drinking) water supply;
- Supply security will be provided from an on-site bore;
- Wastewater will be treated on-site to a standard suitable for reuse within the development;
- Class A+ recycled water will be reticulated to provide water for toilet flushing, cold water laundry use and garden watering;
- Class B recycled water will be supplied for subsurface irrigation of public open space, including the proposed golf course, or for surface irrigation in areas with restricted access;
- The recycled water system will achieve 98% beneficial reuse of treated water.

The rainwater supply will meet approximately 96% of potable water demands. Groundwater will be required to supply the other 4%. The conservative estimate of groundwater supply capacity is 260 kL per day. At full development, groundwater demand could be up to 530 kL/day, however, for Stage 1 demands will be substantially less and within the capacity of the bore. During Stage 1, investigations will be undertaken to confirm the sustainable yield of the bore and to develop a second borewater supply. In addition, a demand management strategy will be developed to restrict water usage, in particular for pool top-up and for spas, in very dry periods.

The recycled water supply will meet 100% of all residential water uses, ie toilet flushing and cold water laundry. Recycled water not used for residential purposes will be used for garden watering and open space irrigation. To achieve 98% beneficial reuse (ie effectively full reuse) a total irrigation area of 91 ha and a wet weather storage volume of 11 ha is required. The recycled water supply will only be able to satisfy approximately 37% of the potential irrigation water demand.

Wastewater will be collected to an on-site treatment plant for treatment and recycling.

14.2 Recommendations

It is recommended that the water management system should be developed as proposed in this report.

It is further recommended that additional groundwater investigations should be undertaken to confirm the available supply and to develop a back-up source. Allied to this is the need for a water restrictions policy to manage demand in periods of very dry weather.

15 References

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Attachment A – Results of Soil Tests

Ella Bay
11/11/2008
2008.125.1
Adjusted soils data and MEDLI irrigation rate results

Sample ID and Range	Layer Thickness	Layer Thickness	Soil Description	Lower Storage Limit	Lower Storage Limit	Upper Storage Limit	Upper Storage Limit	Saturat-ion Moisture Content	Saturat-ion Moisture Content	Air Dry Moisture Content[1]	Air Dry Moisture Content[1]	Saturated Hydraulic Conduct-ivity	Saturated Hydraulic Conduct-ivity	Bulk Density	Bulk Density	Porocity	Porocity
	mm	mm		(%v/v)	(%v/v)	(%v/v)	(%v/v)	(%v/v)	(%v/v)	(%v/v)	(%v/v)	(mm/hr)	(mm/hr)	g/cc	g/cc	v/v %	v/v %
SS1 0-0.6	600	100	Silty SAND	5	5	23.8	23.8	27.4	27.4	4	4	79.58	79.58	1.65	1.65	37.7	37.7
		500			5		23.8		27.4				79.58		1.65		37.7
SS1 0.6-0.9	300	300		5	5	15	15	17.5	17.5	4			79.58	1.7	1.7	35.8	35.8
SS1 0.9-1.2	300	300	Clayey SAND	5	5	15	15	16.7	16.7	4			79.58		1.7		35.8
SS1 1.2-1.5	300			5		15		17.2		4							
SS2 0-0.2	200	100	CLAY	28.7	28.7	41.3	41.3	56.4	56.4	23	20	34.4	34.4	1.65	1.15	37.7	56.6
		100			28.7		41.3		56.4				34.4		1.15		56.6
SS2 0.2-0.8	600	600		28.7	28.7	41.3	41.3	47.4	47.4	23			34.4	1.75	1.35	34	47.9
SS2 0.8-1.25	450		Clayey SAND	5		23.8		29.5		4							
SS2 1.25-1.5	250			5		15		20		4							
SS3 0.1-0.25	250	100	Silty SAND	5	5	23.8	23.8	32	32	4	4	73.3	73.3	1.7	1.7	35.8	35.8
		150			5		23.8		32				73.3		1.7		35.8
SS3 0.25-0.60	350	350		5	5	15	15	23.3	23.3	4			73.3		1.75		34
SS3 0.6-1.10	500			4		12		15.7		3				1.75		34	
SS3 1.10-1.50	400		Clayey SAND	5		15		16.8		4							
SS4 0-0.35	350	100	CLAY	34	34	45	45	69	69	27	20	29.75	29.75	1.7	0.8	35.8	69.8
		250			34		45		69				29.75		0.8		69.8
SS4 0.35-0.65	300	300		34	34	45	45	66.6	66.5	27			29.75	1.8	0.85	32.1	67.9
SS4 0.65-0.8	150			33.8		45.5		74		27							
SS4 0.80-1.50	700			33.8		45.5		69.7		27							
SS5 0-0.3	300	100	CLAY	33.8	33.8	45.5	45.5	49.3	49.3	27	20	24.58	24.58	1.7	1.3	35.8	50.9
		200			33.8		45.5		49.3				24.58		1.3		50.9
SS5 0.3-1.0	700	700		12	12	24	24	35	35	10			24.58	1.8	1.7	32.1	35.8
SS5 1.0-1.3	300		Clayey SAND	80		18		21.8		64							
SS5 1.30-1.50	200			80		18		21.7		64							
SS6 0-0.3	300	100	CLAY	18	18	30	30	36.8	36.8	14	14	50.8	50.8	1.7	1.65	35.8	36.8
		200			18		30		36.8				50.8		1.65		36.8
SS6 0.3-0.6	300	300		13	13	23	23	25.6	25.6	10			50.8	1.8	1.8	32.1	25.6
SS6 0.6-0.8	200			60		16		28.2		48							
SS6 0.8-1.5	700			19		28		30.6		15							
MEDLI Default	100		Grey CLAY	26.7		42		47		4.2		10		1.39		47.5	
	500			27.5		43.6		48.6		-		1		1.35		49.1	
	600			30.7		42.4		47.4		-		0.5		1.38		47.9	
	300			32.8		42.7		48.2		-		0.1		1.36		48.2	
MEDLI Default	100		SAND	4		10.9		50.1		4		50		1.31		50.6	
	500			6.4		13.6		42.3		-		50		1.52		42.7	
	600			7.5		13.8		43.6		-		20		1.48		44	
	300			6		9.1		43.1		-		10		1.5		43.5	

RED Values used in MEDLI.
BLACK Values given as test results.
Air dry moisture content assumed to be
approximately 80% of wilting point/lower storage

Ella Bay
11/11/2008
2008.125.1
Adjusted soils data and MEDLI irrigation rate results

Sample ID and Range	Layer Thickness	Layer Thickness	Soil Description	Adsorp. Coeff.	Adsorp. Expo.	Desorp. Expo	Nitrate N	Organic N	Total Irrigation
	mm	mm					mg/kg	mg/kg	mm/yr
SS1 0-0.6	600	100	Silty SAND	88.62	0.1925	0.1733	1	407	589
		500		88.62	0.1925	0.1733			
SS1 0.6-0.9	300	300		88.62	0.1925	0.1733			
SS1 0.9-1.2	300	300	Clayey SAND	88.62	0.1925	0.1733			
SS1 1.2-1.5	300								
SS2 0-0.2	200	100	CLAY	246.2	0.2699	0.2429	1	1345	586
		100		246.2	0.2699	0.2429			
SS2 0.2-0.8	600	600		246.2	0.2699	0.2429			
SS2 0.8-1.25	450		Clayey SAND						
SS2 1.25-1.5	250								
SS3 0.1-0.25	250	100	Silty SAND	215.08	0.2435	0.2192	1	1143	607
		150		215.08	0.2435	0.2192			
SS3 0.25-0.60	350	350		215.08	0.2435	0.2192			
SS3 0.6-1.10	500								
SS3 1.10-1.50	400		Clayey SAND						
SS4 0-0.35	350	100	CLAY	494.68	0.3674	0.3307	1	1457	596
		250		494.68	0.3674	0.3307			
SS4 0.35-0.65	300	300		494.68	0.3674	0.3307			
SS4 0.65-0.8	150								
SS4 0.80-1.50	700								
SS5 0-0.3	300	100	CLAY	194.97	0.1924	0.1734	1	844	544
		200		194.97	0.1924	0.1734			
SS5 0.3-1.0	700	700		194.97	0.1924	0.1734			
SS5 1.0-1.3	300		Clayey SAND						
SS5 1.30-1.50	200								
SS6 0-0.3	300	100	CLAY	478.81	0.5208	0.4687	1	1099	590
		200		478.81	0.5208	0.4687			
SS6 0.3-0.6	300	300		478.81	0.5208	0.4687			
SS6 0.6-0.8	200								
SS6 0.8-1.5	700								
MEDLI Default	100		Grey CLAY	73	0.39	0.25	2.5	800	486
	500			73	0.39	0.25			
	600			73	0.39	0.25			
	300			73	0.39	0.25			
MEDLI Default	100		SAND	75	0.33	0.15	7	350	617
	500			75	0.33	0.15			
	600			75	0.33	0.15			
	300			75	0.33	0.15			

RED Values used in MEDLI.
BLACK Values given as test results.
Air dry moisture content assumed to be
approximately 80% of wilting point/lower storage

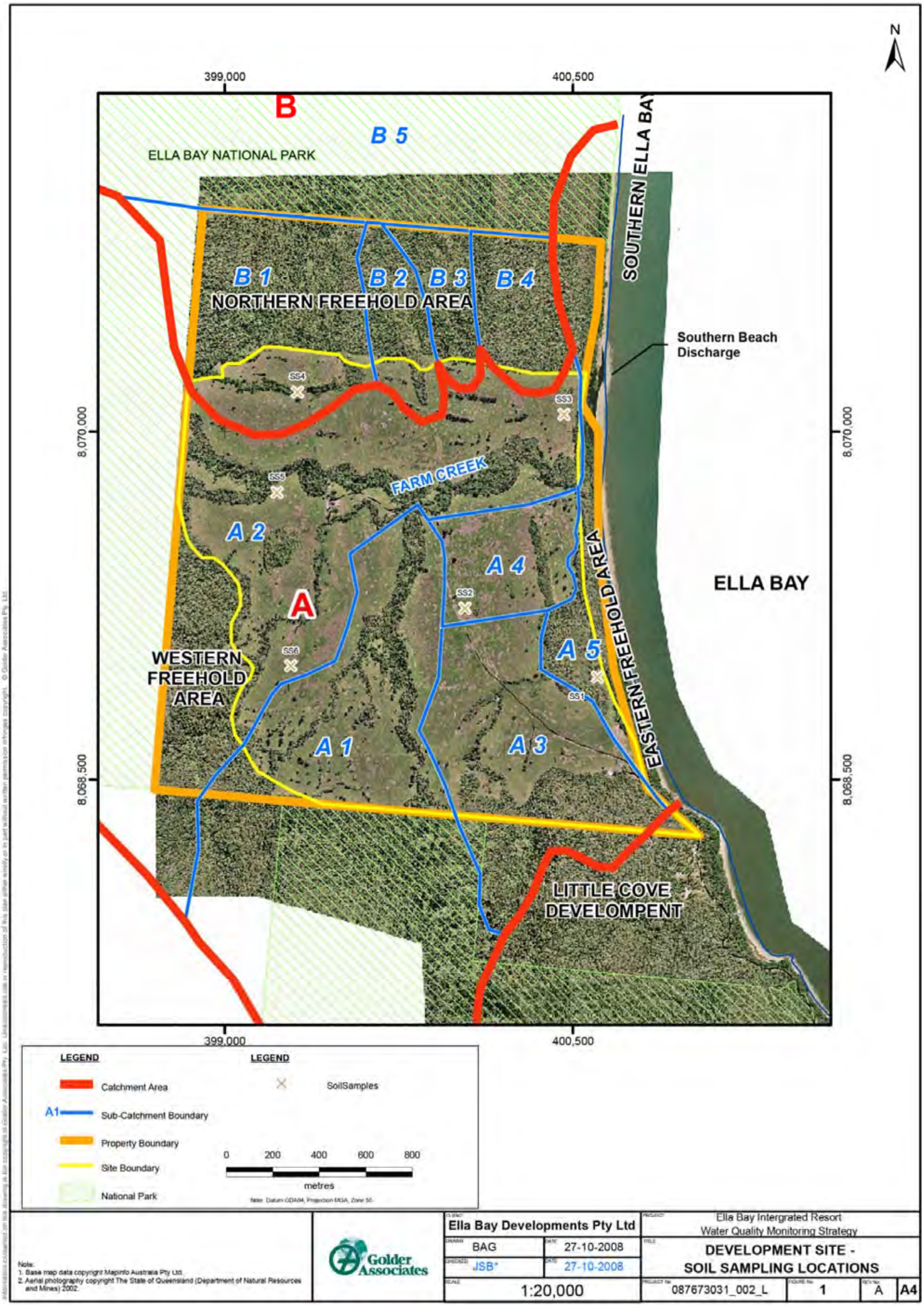

Figure A-1 Soil Sampling Locations

Attachment B –Groundwater Sampling Results

Table B- 1 Shallow Groundwater Monitoring Results (October 2008)[14]

ID	Location	Total N mg/L	Total P mg/L	Turbidity NTU	Temp °C	pH (field)	Conductivity µS/cm	Redox mV	Diss. O_2 mg/L
A MW1	Farmlands Catchment (A1)	2.4	0.23	600	23.5	5.5	51	268	2.4
A MW2	Farmlands Catchment (B1)	3.5	0.24	600	23.8	5.2	56	415	2.7
A MW3	Farmlands Catchment (A4)	1.4	0.19	600	25.5	4.9	41	438	3.4
A MW4	Farmlands Catchment (A2)	83.2	0.29	600	26.3	4.7	2.2	478	4.1
A MW5	Farmlands Catchment (A4)	2.6	1.24	600	27.3	5.5	46	313	4.2
A MW6	Beachfront Swale (A5)	2.4	0.06	600	28.5	5.8	51	323	4.0

Table B- 2 Shallow Groundwater Monitoring Results (November 2008)

ID	Location	Total N mg/L	Total P mg/L	Turbidity NTU	pH (field)	Conductivity µS/cm
A MW1	Farmlands Catchment (A1)	0.51	0.54	600	5.71	43
A MW2	Farmlands Catchment (B1)	0.41	0.14	600	5.16	42
A MW3	Farmlands Catchment (A4)	0.29	0.33	600	4.85	24
A MW4	Farmlands Catchment (A2)	0.25	0.33	600	4.37	13
A MW5	Farmlands Catchment (A4)	0.37	0.33	600	5.15	30
A MW6	Beachfront Swale (A5)	0.57	0.3	600	6.09	52

[14] Some samples (i.e. A MW1, MW2 and A MW3) are average values of purging records.

Figure B-1 Groundwater Sample Locations at Ella Bay Development

Attachment C – Natural Swimming Pools

Natural Swimming Pools
Introduction
Ella Bay will use natural swimming pools at the resorts. Natural swimming pools are in ground pools that are cleaned biologically through the use of the aquatic plants and microorganisms and do not use chemicals such as chlorine (refer to Figure C1).

The natural swimming pools at Ella Bay will consist of two distinct areas as follows:
- Storage lagoon and wetland containing plants;
- Swimming zone.

Figure C-1 Photos of Natural Swimming Pools (Source 2009 Hearst Communications)

Water Demands
A water balance for the natural swimming pools and storage lagoon/wetland was completed to determine whether an external water supply would be needed.

The water balance for these pools is based on the following assumptions:

- Total water surface area of pool and lagoon is 5.4 ha;
- Pool zone to lagoon zone ratio 1:4, therefore 1.08 ha pool area and 4.32 ha lagoon area;
- Average depth of the swimming pool is 1.2 m;
- Average depth of the lagoon is 0.8 m;
- Effective impervious catchment of 10 ha;
- The pool will be lined and waterproof with an assumed seepage loss of 0.5 mm/day and the lagoon will be engineered to minimise leakage with an assumed seepage loss of 1.0 mm/day;
- Pool top-up from the lagoon will cease if the lagoon has been drawn down more than 0.4 m from full;
- Pool and lagoon balance analysed over 30 years from 1/11977 to 31/12/2006.

The results of the natural swimming pool balance showed that the lagoon and pool would need a back-up supply or effective external catchment[15] to maintain the swimming zone at a full level and prevent the wetland water level dropping too low. The amount of water required depends to a large extent on the contributing external catchment. The relationship between shortfall and contributing external catchment is depicted graphically in Figure C-2 for the total pool and lagoon area.

It is recommended that topping up of the storage lagoon/wetland pool zone should stop if the water level in the lagoon drops by 0.4 m leaving 0.4m for aesthetic purposes and also to ensure the plants have enough water.

The pool external demand could vary from 64 kL/year to 2,290 kL/year depending on the contributing effective impervious catchment. It has been assumed that at least 10 ha effective catchment will be used and therefore a demand of approximately 226 kL/year will need to be supplied from groundwater or stormwater harvesting. The monthly distribution for the shortfall is shown in Figure C-3. It can be seen that the shortfall occurs in the summer when there is more loss to evaporation.

If an external catchment is utilised, it should be noted that the runoff entering the pond is from an urban catchment and therefore the system will be classed as stormwater harvesting and will need to meet the requirements of the relevant water quality guidelines prior to use in the natural swimming pools.

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[15] The effective catchment is the area that equates to 100% runoff based or the effective impervious area.

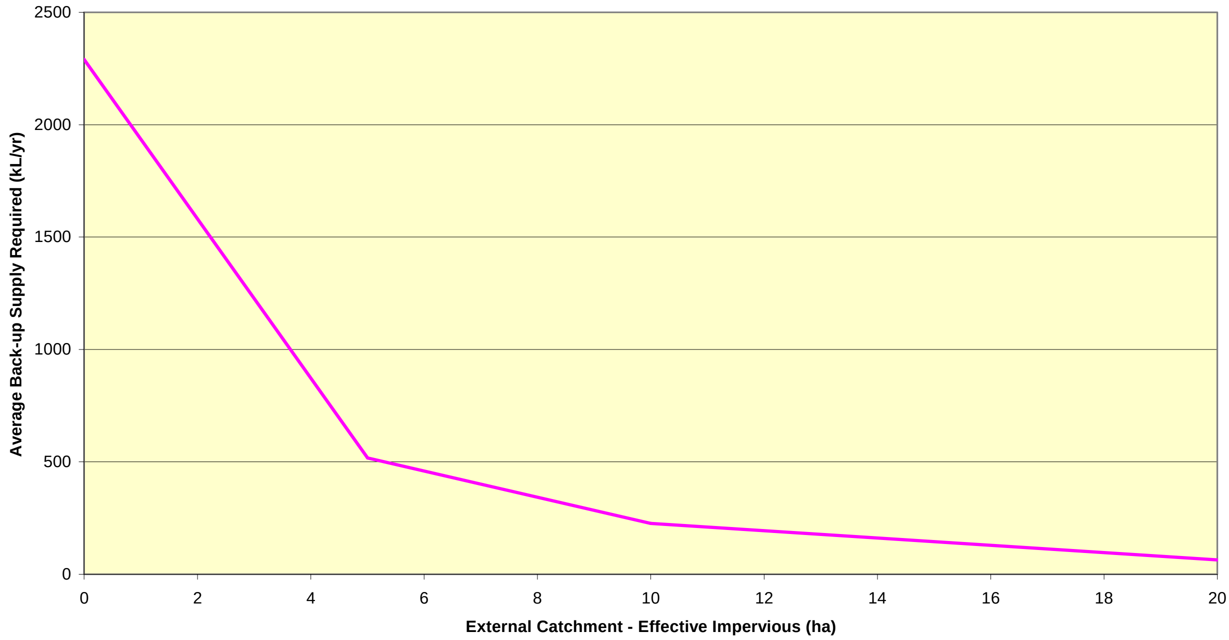

Figure C-2 Overall Reliability of Storage Lagoon/Wetland

Figure C-3 Monthly Demand Distribution for Natural Swimming Pools