5.2. Option 1 – Constructed Wetlands and Recycled Water

Refer to Drawing P10 in Appendix B which details the stormwater treatment measures used in this option.

Option 1 included the use of:

- Recycled Water to be made available from the augmented sewage treatment plant to meet BASIX for outdoor uses and toilet flushing on each lot in the development.
- Public open spaces would also be irrigated with recycled water.
- A recycled water trunk main and development of a servicing strategy.
- CDS or similar gross pollutant traps were used upstream of each wetland. The gross pollutant traps were to be used to reduce the inlet zone of the wetland – effectively to zero. That is, CDS units would primarily serve the purpose of capturing coarse sediment with the coincidental benefit that they would also capture gross pollutants.
- Constructed wetlands to treat stormwater at the end of the pipe. We assumed 1m depth of temporary storm flow ponding was possible within the wetlands – this may not be possible in reality due to the flat nature of the site. Where this is not possible larger wetlands would be required to ensure the equivalent total volume was still available.
- Extensive establishment of riparian corridors some of which are adjacent to Duchess Creek would be established with some new creek construction to ensure that flows can be conveyed from Ocean Drive to the existing waterbody. This would also enable future overland flow paths or drainage corridors to tie into Duchess Creek.

5.3. Option 2 – Rainwater Tanks, WSUD and Stormwater Reuse

Refer to Drawing P11 in Appendix B which details the stormwater treatment measures used in this option.

Option 2 comprises:

- Raintanks (for hot water, toilet, laundry and outdoor uses) would be used for BASIX compliance and topped up with potable water. A range of raintanks sizes were explored and the most efficient tank size results were reported.
- Where there is a median in the road system it has been used as either a bioretention treatment device on steeper grades or as a linear sand filter on flatter areas.
- Vegetated buffer strips were used on all perimeter roads which are to have one way cross falls.
- There are CDS units (gross pollutant traps) upstream of each and every secondary stormwater treatment device – that is upstream of each sand filter used to ensure that no coarse sediment enters the sand filters.
- End of line sand filters located around the peripheral roads used to treat the remaining areas.
- A large open water pond located in the public open space area near the regional sports fields. This pond will be used for storage of stormwater following treatment in a grassed swale that runs along the perimeter road adjacent to the sports fields. Water from the pond was extracted to irrigate the sports field. It was assumed that large stormwater pump station would be constructed in the public open space area next to the pond.

- Extensive establishment of riparian corridors some of which are adjacent to Duchess Creek would be established with some new creek construction to ensure that flows can be conveyed from Ocean Drive to the existing waterbody. This would also enable future overland flow paths or drainage corridors to tie into Duchess Creek.

5.4. Option 3 – Combined Approach

Refer to Drawing P12 in Appendix B which details the stormwater treatment measures used in this option.

Generally option 3 comprised a mix of both Options 1 and 2 and includes:

- the use of rainwater tanks on each property. The rainwater tanks would be used for laundry and hot water and a reticulated recycled water supply would be used to supply toilets and outdoor uses. A range of raintanks sizes were explored and the most efficient tank size results were reported.
- The use of reticulated recycled water for toilet flushing and for outdoor uses on each lot.
- The use of recycled water to irrigate public open space especially the regional sports field.
- Where there is a median in the road system it has been used as either a bioretention treatment device on steeper grades or as a linear sand filter on flatter areas.
- Vegetated buffer strips were used on all perimeter roads which are to have one way cross falls.
- There are CDS units (gross pollutant traps) upstream of each and every secondary stormwater treatment device – that is upstream of each sand filter used to ensure that no coarse sediment enters the sand filters.
- End of line sand filters located around the peripheral roads would be used to treat the remaining areas.
- Extensive establishment of riparian corridors some of which are adjacent to Duchess Creek would be established with some new creek construction to ensure that flows can be conveyed from Ocean Drive to the existing waterbody. This would also enable future overland flow paths or drainage corridors to tie into Duchess Creek.

6.0 ASSESSMENT METHODOLOGY

6.1. Peak Flows

An XP-RAFTS computer model of the drainage corridors was constructed. This model was run for the 100 year ARI storm event to derive a flow estimate for the overland flow corridor in question.

Once the peak flow rate was derived for each corridor, the width (and depth) of flow was determined by solving the Manning equation for uniform flow. The actual available flow width measured from each corridor was compared against the estimated flow width to assess if the corridor was wide enough.

Slopes for each corridor were assumed to be at either minimum grade or at steeper grades where appropriate.

RAFTS modelling assumptions are documented in Table 10.

Note that for each of the options the same road and lot layout was used.

When assessing the divided collector road that runs on a north south alignment from the existing Rainbow Beach Estate to Ocean Drive and then across Ocean Drive we assumed that flows up to 4 m3/s can be piped below the road and that flows in excess of 4 m3/s will be conveyed in overland flow paths along the road.

6.2. Water Balance

A water balance using 40 years of local daily rainfall was undertaken using the Aquacycle model.

Aquacycle is a daily urban water balance computer model which has been developed by Dr Grace Mitchell and the Cooperative Research Centre for Catchment Hydrology (CRCCH) to investigate the use of locally generated stormwater and wastewater as a substitute for high quality imported potable water.

Aquacycle is based around the concept of the water balance of the urban water cycle. Its major function is to enable scenario modelling or "gaming" of traditional and integrated water management systems. The model attempts to help us to:

1. Describe the supply of urban stormwater and wastewater in terms of quantity and time and space distribution, i.e. how much water and when and where.
2. Create a system that enables a hierarchy of water that is fit for its purpose to be developed i.e, the models let the user specify how water is to be used in the urban context. For example it enables the user to use rainwater, potable mains water and/or recycled water eg just toilet flushing and garden irrigation, or laundry and toilet flushing
3. Enable a comparison of the different scenarios that are "gamed out".

Aquacycle accounts for the movement of water through the rainfall-drainage system and the supply-wastewater system, as well as cross-links between the two. Thus it is an appropriate model to use for an integrated system.

Local rainfall and soil characteristics need to be entered into the model as do local development and planning conditions. The spatial conceptualisation in Aquacycle is as follows:

1. The smallest spatial unit is one allotment – typically this might be one house lot.
2. A number of allotments grouped together would make up a cluster – typically a cluster could be a subdivision block or a whole suburb or stage of a subdivision.

3. A number of clusters make up a catchment.

Aquacycle operates using a daily time step and as a result it can only provide output in terms of days. This is one of the models' limits – it is not able to provide peak instantaneous demand but can provide peak day demand. The daily time step is both a limit and an advantage. It is an advantage because it means that the model can be run fairly quickly with less data inputs required than a say a 6 minute model.

Aquacycle is limited to running a water balance on 40 years of rainfall data and while this is likely to provide a high level of statistical confidence in the output – it may not be adequate to really capture long term trends.

This means that Aquacycle may not be suitable to test the certainty of supply of a large water supply dam. Aquacycle is however suitable to provide an indication of the performance of say a rainwater tank where dependence on that rain tank is not critical. Aquacycle also, reportedly, provides conservative solutions when compared with a model of a smaller time step such as PURRS.

Aquacycle does not provide water quality analysis or assessment.

One of the other limits of Aquacycle is the accuracy of the outdoor irrigation model. The author of the model has noted that the model is not suited to determining the peak day demand due to the accuracy of the outdoor irrigation model.

To overcome this limitation, the Probabilistic Urban Rainwater and wastewater Reuse Simulator (PURRS) model developed by Urban Water Cycle Solutions was used to assess the peak day demand for reticulated recycled water. See Section 6.3.

Aquacycle models were constructed to simulate Options 1, 2 and 3. Option 0 is essentially the same in terms of the water balance as option 2 and so this option did not need to be replicated again.

The Aquacycle models were based on the proposed road and lot layouts and the proposed land uses and development density described earlier in Section 3.1

Each option reflected the proposed water cycle relevant to that option – for example Option 1 modelled a centralised waste water reuse scenario and Option 2 modelled the use of rainwater tanks, Option 3 a combination of Options 1 and 2.

Aquacycle modelling was based on Port Macquarie rainfall and evaporation data from 1/1/1960 to 21/9/2003. The two pervious soil stores used in the model's runoff generation module were assumed at 50mm each. Calibration parameters assumed are contained in Table 13.

Table 13 Aquacycle Calibration Parameters

base flow index	0.55
base flow recession constant	0.0025
infiltration index	0.1
infiltration recession constant	0.12
surface runoff percentage	3
Trigger to irrigate (garden)	0.42
Trigger to irrigate (public open space)	0.5
Trigger to irrigate (Sports fields)	1

The sewer infiltration calibration parameters were adjusted to obtain a reasonable peaking factor for wet weather wastewater flows. The trigger to irrigate was adjusted to align the model with the water demand data outlined in the options report.

The site was divided into 49 clusters based on catchment characteristics and land use type to allow for model flexibility.

Indoor water demand for residential areas, both medium and low density, was based on the information provided in Section 3.2. Indoor water demand for the schools, commercial areas, community facilities and the caravan park were based on Equivalent Population data obtained from the WSSA manual (1984). Outdoor water demand was adjusted using the irrigation area percentage and the trigger to irrigate parameter (Table 12).

Sub-options were also run for options 2 and 3 to investigate the effectiveness of various rainwater tanks sizes.

Table 14 Rainwater Tank sub-options

IWCM Option and house density	Sub option a Tank sizes (kL)	Sub option b Tank sizes (kL)	Sub Option c Tank sizes (kL)
2 - Low density	8	10	6
2 - Medium density	2	2	3
3 - Low density	10	6	3
3 - Medium density	2	2	2

For Option 2, tank sizes of 8 and 2, 10 and 3 and 6 and 3 kL for low and medium density areas respectively, were modelled.

For Option 3 tanks sizes of 10 and 2, 6 and 2 and 3 and 2 kL tanks for low and medium density areas respectively, were modelled.

The results for each sub-option were analysed and the most efficient tank sizes were selected for costing and reporting in each option. Sub-option c was adopted as the one providing the most efficient tank sizes.

Table 15 documents the number of equivalent tenements (ETs) in Area 14. It also lists the total number of ETs that may be counted for contribution purposes when calculating cost apportionments. This information was used both for the purpose of water balance modelling, for estimating peak day demand and also for apportionment of contribution costs on an ET or area basis.

Table 15 Equivalent Tenements in Area 14

Land Use	No of Lots or Area (Ha^2)	ETs	ETs for contributions
Low density	1229 lots 70.22 Ha	1229	1229
Medium Density	552 lots 17.77 Ha	370	370
Schools	11.34 Ha	106	0
Supermarket	1.742 Ha	Incl below	Included in commercial
Commercial incl Supermarket	4.18 Ha	312	312
Community Facilities	0.9426 Ha	6	0
Caravan Park	7.58 Ha	42	42
Total area for stormwater contributions Sum of low density, medium density, commercial less Supermarket. Schools, Community Facility, Caravan Park and Supermarket are exempt	90.428 Ha	n/a	n/a
Total EPs for water, sewer and recycled water contributions Schools and Community Facility exempt	n/a	2065	1,953

6.3. Peak Day Demand – Recycled Water

The PURRS model uses continuous simulation techniques to simulate the long-term performance of source control measures including rainwater tanks, water efficient appliances, wastewater reuse and other stormwater management devices on urban allotments at short time steps (< 6 minutes), and determines the impact of rainwater tanks and other lot scale water reuse measures on the provision of water supply, sewage and stormwater infrastructure [Coombes, 2004].

This model has undergone extensive process and methodology testing over the past five (5) years and has been widely used throughout Australia. A long synthetic pluviograph rainfall record was created for Port Macquarie by Urban Water Cycle Solutions to allow simulation of a wide range of integrated water cycle management scenarios.

In Options 1 and 3 the peak day demand for recycled water was estimated by constructing and then running a PURRS model for both low density and medium density lots. The model was run to obtain the peak day demand for recycled water. PURRS is a lot scale model and so the results were extrapolated to include the whole proposed Area 14 development. PURRS was not used to provide estimates of peak day demand for the commercial and school uses – estimates based on equivalent tenements were used with the assumptions that both schools and commercial premises would not have a significant peak day.

The peak day demand was also estimated using the Aquacycle results to simply provide a gross error check on the PURRS results.

6.4. Water Quality

The MUSIC model was chosen to model water quality. This model has been released by the CRCCH and is likely to become the industry model of choice.

MUSIC (the Model for Urban Stormwater Improvement Conceptualisation) is suitable for simulating catchment areas of up to 100 km^2 and utilises a continuous simulation approach to model water quality.

By simulating the performance of stormwater management systems, MUSIC can be used to determine if these proposed systems and changes to land use are appropriate for their catchments and are capable of meeting specified water quality objectives (CRC 2002). The water quality constituents modelled in MUSIC and of relevance to this report include Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN).

Before discussing any limitation that the MUSIC model has, it is prudent to highlight the limitations of water quality modelling in general. Water quality modelling is based on a multitude of factors such as I:

- rainfall – frequency, volume, dry periods, intensity etc.
- runoff – soil profile, landform, existing land use, starting conditions, loss to groundwater etc.
- pollution export – local human behaviour, land use, economic wealth, state of existing systems and ability to assimilate etc.
- performance of stormwater treatment measures – past performance, lack of performance data, maintenance frequency, model with a process or empirically based.

These are just a few of the factors that affect water quality. To attempt to model these factors, as they interact with each other requires careful use of statistics to manage the huge variability.

The error range is likely to be in the order of 1000 times, i.e. the real concentration at any point in time may vary by up to 1000 times the modelled concentration. In terms of annual average pollution export, this error range is likely to decline significantly as the annual series averages or smoothes out the variability.

The model was run using 6 minute pluviograph data in accordance with the MUSIC Manual which recommends that rainfall with a time step corresponding to the treatment node with the shortest time of concentration should be used. In this case, many of the treatment nodes would have times of concentration of less than 10 minutes and so 6 minute data was used.

The rainfall data was checked for completeness and also for replication of the average rainfall depth across its period. The period included some larger events but was considered to be appropriate for the purposes of water quality modelling.

A model for each option was constructed after first running the Aquacycle models to obtain annual demand estimates for each sub-catchment. Where rainwater tanks were used, the demand for rainwater was entered into each MUSIC model node to ensure that the MUSIC model reflected the proposed water cycle.

Each road, roof and non-roof catchment was modelled separately using the load rates documented in Section 3.4.

The proposed stormwater treatment measures were entered into the model, the models were run and the sizes of treatment devices adjusted iteratively until the water quality objectives of Section 2.1 were achieved.

Where constructed wetlands were proposed in Option 1 the size of the constructed wetlands derived by using the MUSIC model were checked using the method described in the Constructed Wetlands Manual (DLWC, 1998).

6.5. Recycled Water – Reticulation

A pipes model of the proposed development was constructed to model the proposed reticulated recycled water network.

It was assumed that a new pump station would be constructed at the recycled water treatment plant (essentially at the existing STP) and that water would be reticulated in a rising main from the pump station to each dwelling as a direct feed.

The Pipes model included recycled water demands determined by the method documented in Section 3.5. Elevations of each node were determined based on the proposed road and lot layouts.

6.6. Life Cycle Cost Analysis

A life cycle costs analysis (LCA) was undertaken to assist in determining the most cost effective of the four options considered for this study. Life cycle costing includes:

- Acquisition cost – what it costs in today's dollars to create an asset. This included the value of land that could have been developed based on the road and lot layouts prepared by STORM.
- The sum of annual maintenance costs reduced to a present value
- The sum of renewal costs reduced to a present value. For example the use of HydroCon pipes in a sand filter will require replacement of the pipes in 25 years. This means that there is a renewal cost for the sand filter each 25 years of its life.
- Decommissioning costs – what it costs to dispose of the device at the end of its useful life, reduced to a present value.

Because each option has its own complexities and results in the saving of differing amounts of water it is necessary to bring each option back to a common denominator to assess the economic costs.

The MUSIC model has the capacity to produce life cycle costs for each modelled stormwater treatment train. The LCA is based on the predicted pollutant loads and cost estimates entered into the model.

Some elements of the proposed options were not modelled in MUSIC but these were included in the LCA for completeness of the analysis.

Basic assumptions in the LCA are as follows:

- 2% inflation,
- 5.5% real interest rate for discounting
- 50 year life cycle

- Extra over costs only assumed – eg buffer strips – it was considered that no extra over costs are incurred. Swale near sports field – extra over was for subsoil drainage only.
- Cost of domestic plumbing - $2,440/dwelling assumed which would allow for education, cross connection auditing, actual plumbing, non-return valves etc.
- Wetlands – used default cost values which are a function of the wetland surface area and based on a regression analysis of a number of wetlands built in Australia – these rates appeared to be reasonable and close to rates normally adopted by STORM for contribution planning.
- CDS units – sized each unit, used list prices for capital and estimated construction costs – allowed $10K to install each unit – allows for dewatering and is considered conservative. Allowed $1,000 per maintenance event per unit and assumed maintenance required 4 times per year.
- Rainwater tanks were assumed to have a useful life of 25 years and required full renewal at 25 years. This included replacement of pump and associated plumping costs.
- Sand Filters – construction cost is a function of area – maintenance assumed eduction 2 times per year and HydroCon pipe renewal at 25 years.
- Allowed for irrigating sports field with Hunter stainless steel pop ups.
- Water mains priced using Council's water main cost information. Cost includes street mains and trunk mains – given the pipes will be laid in the same trench as the potable water pipe there will be some cost savings on the prices used in this study.
- The recycled water pump station was costed on the basis of an estimate provided by the Department of Commerce. This allowed for noise insulation, a well constructed, low maintenance brick building with stainless steel control boards.
- Extensive refurbishment of the pump station including new pumps was allowed to occur after 25 years together with regular annual maintenance of both the station building and the pumps.
- A new 1 ML clear water storage has been allowed for in the costs and will be located at the STP.

STORM has also calculated the costs for low and medium density lots for contribution purposes.

7.0 OPTIONS ANALYSIS - RESULTS

7.1. Peak Flow Management

An assessment of the conveyance capacity of each drainage and major stormwater overland corridor has been undertaken. The drainage corridors, based on the proposed road and lot layouts, appear to have sufficient width to convey the 1 in 100 year ARI flow.

Some of the XP RAFTS flows – those on the 2 large western catchments draining into Area 14 were checked by also estimating the flow using the Probabilistic Rational Method. The Rational method estimates were found to yield considerably lower flows.

Normal practice would be to then adjust the XP-RAFTS model to yield the same flows as the Rational Method. However, in this instance the corridors were still found to be adequate to convey the flows and so refinement of the XP-RAFTS model was unnecessary.

This aspect of the design will need to be checked carefully during concept and detailed design stages of the development. If necessary it may be required to convey a greater proportion of flow within the piped system to reduce overland flows to acceptable levels.

7.2. Water Quality

Each option was able to comply with the stormwater treatment objectives. The sizes, types and locations of each stormwater treatment device are shown on the drawings in Appendix B.

7.3. Recycled Water Reticulation

The proposed location of the recycled water main is shown on the drawings in Appendix B.

The proposed system can be described as follows:

- 3 off Goulds, 45kW pumps fitted with Hydrovar variable speed drives. The pumps would alternate service with two duty and one stand by pump to deliver recycled water from the STP to each dwelling in Area 14. The system would be a direct feed system with a 1 ML clear water tank located at the STP. The pumps and mains have been sized to ensure that a minimum of 12m head delivers recycled water to the highest property.
- There was some difficulty with the use of the existing Bonnyview reservoir due to its low elevation. This is the reason that the reservoir will not be used to provide a potable service Area 14.
- The peak day demand for recycled water in Area 14 was found to be approximately 2.17 ML estimated using PURRS, with Aquacycle results giving a very comparable value of 2.19ML. This meant that the Bonnyview reservoir with a volume of 0.76 ML could not be used as a peak day reservoir in any event.
- It was resolved to assume the system would be a direct feed system pumping from the STP. A reservoir at the STP of 1 ML has been allowed for in the cost planning.
- This approach resulted in the minimum extent of new mains required and will save 3 km of rising main if the Bonnyview reservoir is not used.

7.4. Water Balance

The Aquacycle model was run for each option and the results for both the catchment and allotment scale are presented below in Tables 15 and 16.

Table 16 Catchment Scale Water Balance Results

Catchment Scale	Option 0	Option 1	Option 2	Option 3
PROPOSED WATER CYCLE MEASURES n/a = not applicable in this option R'ntnks = rainwater tanks Recyc = reticulated recycled water supply WSUD = water sensitive urban design comprising sand filters, vegetative buffers, bioretention etc	R'ntnks, wetlands	Recyc, wetlands	R'ntnks, WSUD	R'tnks, Recyc, WSUD
Average Total Mains Supply (kL/annum)	269,093	158,382	269,093	82,448
Average Total recycled water supplied (kL/annum)	n/a	351,544	n/a	286,950
Average Total stormwater supplied (kL/annum)	22,652	n/a	22,652	n/a
Average Total rainwater supplied (kL/annum)	211,452	n/a	211,452	133,240
TOTAL	**503,197**	**509,926**	**503,197**	**502,638**
% Reduction on Potable Mains Supply	47%	69%	47%	84%

Table 17 Allotment Scale water balance results

Allotment Scale	Option 0	Option 1	Option 2	Option 3
PROPOSED WATER CYCLE MEASURES R'ntnks = rainwater tanks, recyc = reticulated recycled water supply, WSUD = design comprising sand filters, vegetative buffers, bioretention etc	R'ntnks, wetlands	recyc, wetlands	R'ntnks, WSUD	Rn'tnks, Recyc, WSUD
Average Mains water supply (kL/annum)	134	63	134	33
Average Recycled Water supplied (kL/annum)	n/a	204	n/a	153
Average Stormwater supplied (kL/annum)	n/a	n/a	n/a	n/a
Average Rainwater supplied (kL/annum)	133	n/a	133	81
Total Water Consumed (kL/annum)	**267**	**267**	**267**	**267**
% reduction on Potable Mains Supply	50%	76%	50%	87.6%
Typical Medium Density Lot- 2 people				
Average Mains water supply (kL/annum)	60	37	60	21
Average Recycled Water supplied (kL/annum)	n/a	105	n/a	68
Average Stormwater supplied (kL/annum)	n/a	n/a	n/a	n/a
Average Rainwater supplied (kL/annum)	82	n/a	82	53
Total Water Consumed (kL/annum)	**142**	**142**	**142**	**142**
% reduction on Potable Mains Supply	58%	74%	58%	85%

7.5. Life cycle costs

Life cycle costs for each of the four options have been presented in Table 18.

Table 18 Life cycle costs for Area 14

	Option 0	Option 1	Option 2	Option 3
PROPOSED WATER CYCLE MEASURES R'ntnks = rainwater tanks, recyc = reticulated recycled water supply, WSUD = design comprising sand filters, vegetative buffers, bioretention etc	R'ntnks, wetlands	recyc, wetlands	R'ntnks, WSUD	Rn'tnks, Recyc, WSUD
Uses of rainwater or recycled water	toilet, laundry, hotwater, outdoor	toilet, laundry, outdoor	toilet, laundry, hotwater, outdoor	tanks for hot wtr & laundry. recyc for toilet & outdoor
Stormwater Treatment (not including rain tanks)				
Capital cost - Treatment Devices	$5,239,308	$8,778,117	$2,839,152	$3,237,275
Capital Cost - Riparian Buffer Zones	$2,336,000	$2,336,000	$2,336,000	$2,336,000
Design of stormwater treatment devices and preparation of vegetation management plans for riparian buffers at 5%	$378,765	$555,706	$258,758	$278,664
Contingency at 20%	$1,590,815	$2,333,965	$1,086,782	$1,170,388
Value of land that would otherwise be developed	$810,000	$1,456,980		
Total Capital Cost	**$10,354,888**	**$15,460,767**	**$6,520,692**	**$7,022,327**
Sum of Annual Maintenance Costs	$2,559,021	$4,672,758	$2,829,759	$2,818,978
Sum of Renewal Costs	$ 481,867	$801,583	$232,697	$46,260
Decommissioning Cost	$161,083	$273,696	$68,233	$91,826
Sub-total: Operating life cycle costs ($2006)	$3,201,971	$5,748,037	$3,130,689	$2,957,064
Total Stormwater life cycle costs	**$13,556,859**	**$21,208,804**	**$9,651,381**	**$9,979,391**
Rainwater Tanks for Lots				
Capital Costs including additional plumbing and pump	$5,153,900		$5,153,900	$4,079,900
Operating Costs (PV - $2006)	$4,168,797		$4,168,797	$3,932,510
Total Rainwater Tanks life cycle costs	**$9,322,697**		**$9,322,697**	**$8,012,410**
Potable water and sewerage - head works**	$23,031,729	$23,031,729	$23,031,729	$23,031,729
Potable water – reticulation only	$3,906,000	$3,906,000	$3,906,000	$3,906,000
Sewer – reticulation only	$2,929,500	$2,929,500	$2,929,500	$2,929,500
Total Potable Water and Sewerage Costs	**$29,867,229**	**$29,867,229**	**$29,867,229**	**$29,867,229**

	Option 0	Option 1	Option 2	Option 3
PROPOSED WATER CYCLE MEASURES R'ntnks = rainwater tanks, recyc = reticulated recycled water supply, WSUD = design comprising sand filters, vegetative buffers, bioretention etc	R'ntnks, wetlands	recyc, wetlands	R'ntnks, WSUD	Rn'tnks, Recyc, WSUD
Uses of rainwater or recycled water	toilet, laundry, hotwater, outdoor	toilet, laundry, outdoor	toilet, laundry, hotwater, outdoor	tanks for hot wtr & laundry. recyc for toilet & outdoor
Continued from previous page				
Recycled Water – Distribution				
Total Acquisition Cost excl domestic plumbing		$5,205,440		$5,205,440
Domestic Plumbing		$4,345,640		$4,345,640
Sum of Annual Maintenance Costs		$2,767,639		$2,767,639
Sum of Renewal Costs		$33,199		$33,199
Decommissioning Cost		$1,311		$1,311
Recycled Water Life Cycle Cost		**$12,353,229**		**$12,353,229**
Cost to produce recycled water (PV $2006) $0.25/kL		$1,488,043		$1,214,625
Sub-total costs ($2006)	**$52,746,785**	**$64,917,306**	**$48,841,307**	**$61,426,883**
Less: PV of potable water saved ($1.40/kL)	-$5,549,230	-$8,333,043	-$5,549,230	-$9,960,236
Total Life cycle cost $2006	**$47,197,555**	**$56,584,263**	**$43,292,076**	**$51,466,647**

** The actual contribution charge for a low density dwelling is based on the charge for 1 ET of $11,793.

7.5.1. Lot Scale Costs and Contributions

Approximate lot scale contributions for both low and medium density lot types have been calculated for the purpose of assessing the economic cost burden of each IWCM option.

Stormwater treatment costs have been apportioned based on the areas shown in Table 15.

Potable water, sewer and recycled water contributions have been estimated based on an Equivalent Tenement (ET) basis with the number of ETs for contributions also shown in Table 15.

Note that the proposed Supermarket is to construct its own stormwater treatment measures – achieving 45% retention of nutrients on its lot. The Supermarket will therefore be exempt from stormwater Section 94 contributions and the area of land contributing has been removed from the calculation for this purpose.

Contributions for commercial developments have not been calculated but could be estimated on an ET basis using the contribution for a low density lot which is 1 ET.

Table 19 Contributions and Capital costs for a low density lot

Option	O	1	2	3
Stormwater apportioned on area basis	$6,031	$8,848	$4,120	$4,437
Potable water and sewer head works contributions	$11,793	$11,793	$11,793	$11,793
recycled water contribution - apportioned on ETs	$0	$2,665	$0	$2,665
Total water cycle contributions per low density lot	**$17,824**	**$23,306**	**$15,913**	**$18,895**
Provision of reticulation of sewer and water	$3,500	$3,500	$3,500	$3,500
Tank Costs - per low density lot	$3,100	$0	$3,100	$2,500
Domestic recycled water plumbing includes audits & education	$0	$2,440	$0	$2,440
Total water cycle capital costs - per lot	**$24,424**	**$29,246**	**$22,513**	**$27,335**
Cost over and above Option 0 - Current Practice	$0	$6,142	-$1,911	$2,912
PV of Operational costs of rainwater tanks	$2,406	$0	$2,406	$2,249
PV of water saved	-$3,153	-$2,419	-$3,153	-$3,733
Total Life cycle cost per low density lot	**$23,677**	**$26,827**	**$21,766**	**$25,851**
Cost over and above Option 0 - Current Practice	$0	$3,150	-$1,911	$2,174

Table 20 Contributions and Capital costs for a med density lot

Option	O	1	2	3
Stormwater apportioned on area basis	$3,398	$4,985	$2,321	$2,500
Potable water and sewer contributions (2 bedroom unit)	$7,961	$7,961	$7,961	$7,961
Recycled water contribution - apportioned on ETs	$0	$1,786	$0	$1,786
Total water cycle contributions per medium density lot	**$11,359**	**$14,732**	**$10,282**	**$12,247**
Provision of reticulation of sewer and water	$2,345	$2,345	$2,345	$2,345
Tank Costs - per low density lot	$2,500	$0	$2,500	$2,200
Domestic recycled water plumbing includes audits & education	$0	$2,440	$0	$2,440
Total capital costs - per lot	**$16,204**	**$19,517**	**$15,127**	**$19,232**
Cost over and above Option 0 - Current Practice	$0	$3,313	-$1,077	$3,028
PV of Operational costs of rainwater tanks	$2,249	$0	$2,249	$2,170
PV of water saved	-$1,944	-$1,243	-$1,944	-$2,062
Total Life cycle cost per low density lot	**$16,509**	**$18,274**	**$15,433**	**$19,339**
Cost over and above Option 0 - Current Practice	$0	$1,765	-$1,077	$2,830

It can be observed that for Option 3, the extra cost to the lot owner will be about $2,900 for a low density development and approximately $3,000 for a medium density lot. However when the reduction in water bills is factored in over the next 50 years the cost difference reduces to $2,100 per low density lot and $2,800 per medium density lot.

7.6. Intangible Benefits

7.6.1. Ecological Benefits in General

Options 1 and 3 provide the opportunity to recycle approximately 300 ML of effluent each year. This effluent would otherwise be infiltrated into the sand dunes adjacent to Area 14. Given the low level of performance of the infiltration trench to date recycling will certainly significantly reduce the load on the infiltration system.

It may be possible to recycle the treated effluent in other locations however the relatively constant year round demand for recycled water in Area 14 will reduce the loading on the infiltration trench all year round whereas if the water was sold say to a golf course the demand would be seasonal and so the reduction in the loading on the infiltration trench would also be seasonal with the greater risk of spills of effluent to Duchess Creek at certain times of the year.

Recycling in Area 14 will reduce the nutrient load on the groundwater in the catchment by virtue of the fact that there is less infiltration of effluent into the groundwater. During wet weather overflows the partially treated effluent will be disinfected and then discharged directly Duchess Creek. Recycling of the effluent may reduce the risk of overflows by reducing the loading rate on the infiltration trenches. Recycling of the effluent will certainly result in an increase in the ecological sustainability of Area 14.

Each option from a stormwater perspective will achieve the same water quality outcomes. However it is worth noting that Options 2 and 3 which use sand filters to filter the stormwater are more likely to reduce the spread of weeds in the catchment.

Option 1 is likely to be the least sustainable even though it achieves the water quality objectives. This is based on the fact that there would be no rainwater tanks to reduce the flows leaving the developed estate.

Option 3 is likely to be the most sustainable option given the large reduction in both roofwater flows and wastewater into the catchment. Certainly Option 3 would provide the largest retention of nutrients within the catchment.

Constructed wetlands in this catchment may provide some additional habitat values, however, given the Lake Cathie SEPP14 listed Wetland is located adjacent to the site the artificial habitat is considered to be of low ecological value – almost negligible, when compared with what is naturally available.

7.6.2. Social Benefits/Opportunities

When designed and constructed competently, wetlands arguably provide better aesthetic amenity than sand filters. If, however, sandfilters, are grassed, they do not result in the sterilisation of any land. By way of example, the Kiama – Hindmarsh Park sand filter often has people picnicking within the sand filter area. The well drained area ensures the surface remains dry most of the time.

Wetlands may also provide an opportunity for boardwalks, passive recreation tracks and community education.

Sand filters are likely to be safer with no permanently ponded water – wetlands by contrast create permanent pools with some increased risk of drowning.

7.7. Preferred Option

Following a workshop with Council, Option 3 was selected as the preferred option for the following reasons:

- Option 1 is more economically expensive than any other option and so is excluded on that basis.
- Option 2 would be preferential to Option 0 – current practice – and so Option 0 is excluded on that basis.
- The local community has expressed significant opposition to an ocean outfall at Bonny Hills and as a result the treatment plant currently disposes of its effluent into coastal sand dunes. There are significant issues associated with infiltration including clogging of the infiltration trenches that makes the long term viability of this approach questionable. The predicted increases in waste water flows due to the increase in population will exacerbate this problem.
- In planning for the new development in Area 14, Council considered that the new development, by recycling the treated effluent, would enable a significant reduction of the volume of treated effluent that needs to be disposed of via infiltration. This then favours Option 3 over Option 2 because Option 3 would result in the recycling of nearly 300 ML per annum while option 2 would not recycle any effluent locally.