

Integrated Water and Energy Management at the Newcastle Lighthouse Site

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Abstract:

It is proposed to redevelop the Newcastle “Nobby’s” Lighthouse site as an education site for integrated water cycle and energy management. Nobby’s Lighthouse is located at Newcastle in the Hunter region of NSW. The redevelopment will include a café/convention centre and bed and breakfast accommodation. The site has limited access to electricity and water from reticulated supplies and does not have access to a reticulated sewage disposal scheme. A number of integrated water cycle management strategies are considered that include the use of water efficient appliances, rainwater and highly treated wastewater. Using a multi-criteria matrix an integrated water cycle management strategy is selected that includes use of rainwater for all hot water supplies, on-site treatment and reuse of wastewater for toilet flushing using electroflocculation technology and use of water efficient appliances. This solution is expected to reduce mains water volumetric and peak demands by 29% and 58% respectively.

1.0 INTRODUCTION

Newcastle ‘Nobbys’ Lighthouse is an icon location in the Hunter region of NSW. A consortium led by a leading restaurant owner has proposed to redevelop the site as an education site for integrated water and energy management that will include a café and eight units for bed and breakfast accommodation. The site has limited access to energy and water services. It is proposed to create a redevelopment that will be more sustainable in its energy and water consumption. The Lighthouse site also has a limited capacity to dispose of wastewater. It is envisaged that the sustainable water cycle solution for the site will include the use water efficient appliances and practices, wise use of the limited mains water supply, utilisation of rainwater and reuse of highly treated wastewater.

The proposed integrated water management solution for the site will be combined with a strategy to minimise energy consumption. Solar reflective paint, thermally efficient building fabrics and landscaping will be utilised to balance the impacts of climate extremes on the buildings. Rainwater will be stored in floor slabs to provide a stable temperature environment within the buildings. Solar panels and one kW wind turbines will be used to supplement the mains electricity supply to the site. Solar boosted gas hot water services will also be incorporated into the design. This paper discusses the preliminary investigation and planning for integrated water cycle management at the site.

1.1 The Site

The site has an estimated total area of 2500 m² and currently includes a signal station, the lighthouse, three cottages and a garage. It is proposed to redevelop the cottages and garage as 8 units with a combined roof area of about 600 m² and construct a new building with a roof area of 400 m² to house the café (Figure 1). The café will cater for up to 80 people.

1.2 Existing water supply

Newcastle Ports Corporation has conducted testing to determine the availability of mains water supply at the site. The test results are shown in Table 1. The results in Table 1 reveal that the mains water supply to the Newcastle Lighthouse has a low flow rate and low pressure that is considerably less than the supply to most urban dwellings in the Newcastle region. Development of the café and units at the site will require augmentation of the water supply systems to ensure adequate water supply. Note that, in spite of the low flow rate, a daily mains water volume of about 49,000 litres was available for use.

Table 1: Mains water availability at the Newcastle Lighthouse site

Criteria	Result
Static pressure (kPa)	250
Working pressure (kPa)	50
Flow rate (L/min)	34
Flow rate (L/hr)	2040

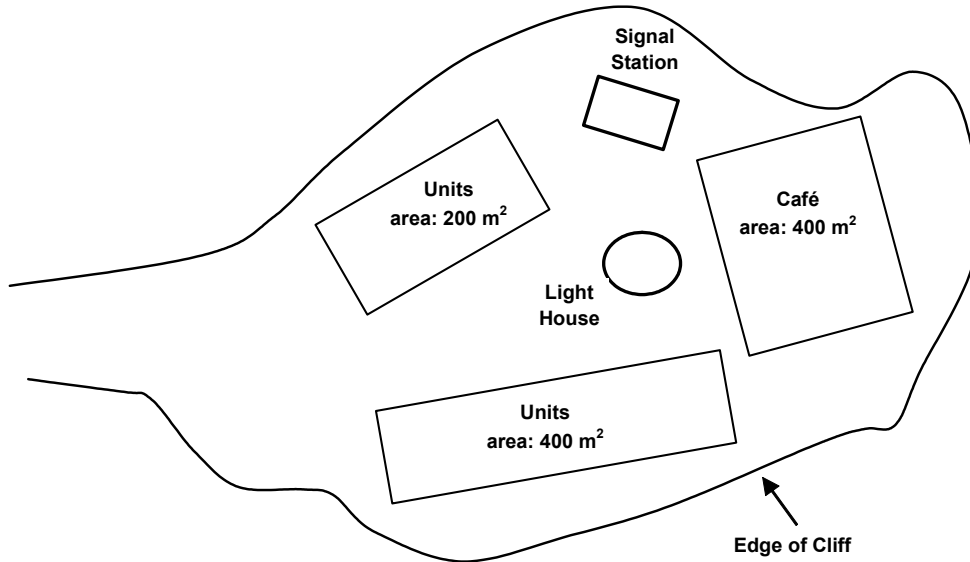


Figure 1: Schematic of the Newcastle Lighthouse site

1.3 Existing sewage disposal system

The existing sewage disposal system consists of 100 mm diameter reticulation main to a septic tank with a capacity of 4500 Litres that overflows to an absorption trench that has a volume of about 5 m³. The absorption system trench is located in the sand dunes at the base of Nobby's headland. The capacity of the sewage system will need to be augmented to be adequate for the proposed development.

2.0 EXPECTED WATER DEMAND AT THE PROPOSED DEVELOPMENT

Given that the site has limited mains water supply it was important to reliably determine the expected water demand from the proposed development. Water demand from the proposed café was estimated using water use at a nearby restaurant and water demand from the units is estimated using analysis of the appliances likely to be used.

2.1 Water demand at the Cafe

Water billing records from Hunter Water Corporation have been used to develop a profile of water use at a nearby restaurant as shown in Table 2.

Table 2: Water use at the nearby restaurant

Month	Total Use (L)	Daily Use (L)
July - Oct	746,000	6,110
Nov – Feb	868,000	7,000
Mar - Jun	1,096,000	9,210

Table 2 shows that water use at the restaurant varied from 6,110 L/day in the July to October period to 9,210 L/day in the March to June period. A site inspection revealed that the restaurant has 3 toilet cisterns in woman's toilets. The men's toilet has a single toilet cistern and two waterless urinals. The toilets have 4.5/3 litre dual flush cisterns. Assuming that proportion of restaurant patrons are equally shared between women and men, it is estimated that an average toilet flushing demand is 6

litres/person. Total water use per patron in the restaurant is estimated to be 29 litres. The categorisation of water use per patron at the nearby restaurant is shown in Table 3.

Table 3: Estimated water use per patron at the nearby restaurant

Task	Use (L/person)
Toilet flushing	6
Hand washing	4
Cooking	3
Dish washing	6
Cleaning	10
Total	29

The estimated instantaneous peak water demand at the restaurant is shown in Table 4. Note that estimated peak water demand exceeds the available flow rate (34 L/min) at the lighthouse site.

Table 4: Estimated peak water demand at Scratchleys restaurant

Items	Number	Flow rate (L/min)	Peak Demand (L/min)
Toilets	4	4	16
Taps	5	16	80
Total			96

Using the ratio of the floor area of the nearby restaurant of 690 m² to the floor area of the proposed café of 400 m² and water use results in Table 2, the water demand of the café is estimated in Table 5.

Table 5: Estimated water demand for the cafe

Month	Average water demand (L/day)
Jan	4,058
Feb	4,058
Mar	5,339
Apr	5,339
May	5,339
Jun	5,339
Jul	3,542
Aug	3,542
Sep	3,542
Oct	3,542
Nov	4,058
Dec	4,058

In Table 5 it is shown that the maximum daily water use for the café is expected to be 5339 Litres/day. This is considerably less than the available daily mains water volume of 49,000 Litres. However it is noted earlier in this paper that the estimated peak water demand in the café of 96 Litres/minute exceeds the available mains water supply rate of 34 Litres/minute. It was therefore important to construct a diurnal pattern of expected water use in the café to allow analysis of the required water supply rate at any time during the day. The diurnal pattern, shown in Figure 2, is used in combination with the volumes of average daily water use in Table 5 in the PURRS model by Coombes and Kuczera [2002] to evaluate the effectiveness of various water supply options.

Figure 2 shows that it has been assumed that the busiest period in the café will be the evening period whilst the mid-day and morning periods are expected to produce less water demand.

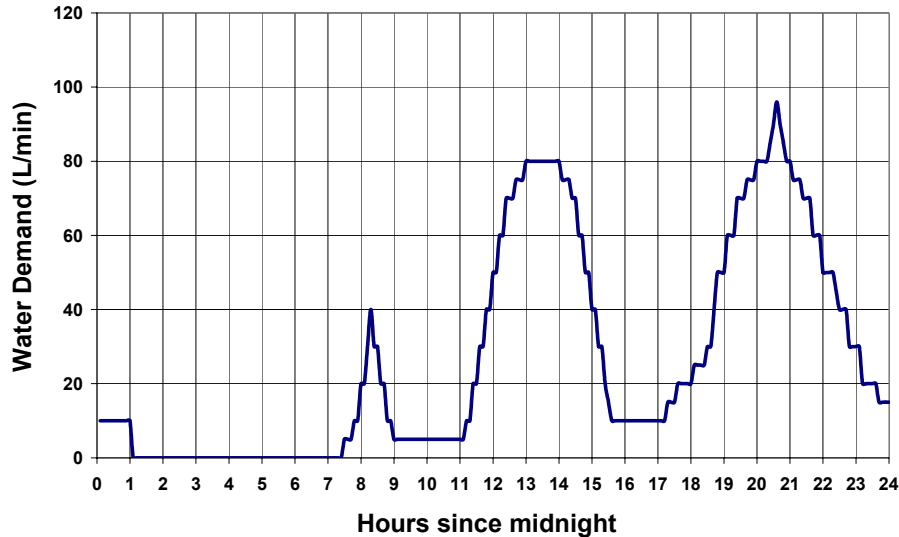


Figure 2: Estimated diurnal water use pattern for the proposed café

2.2 Water demand in the units

It is proposed that each unit will have a spa and 4.5/3 litre dual flush toilets in addition to showers and hand basins. Water use in the units is estimated using knowledge of the water use expected from each appliance. An average of two people is expected to occupy each unit. The expected water use in the units is shown in Table 6.

Table 6: Expected water demand in the units

Task	Use (L/pp/day)	Demand (L/min)	Peak demand (L/min)
Toilet flushing	14	4	32
Hand washing	27	16	128
Shower	54	14	112
Spa	500	16	128
Total	595		272

Table 6 shows that the water demand from the units is estimated to be 595 Litres for each guest. If the units are fully occupied the total water demand would be 9,512 Litres/day and the peak water demand is expected to be 272 Litres/minute. The daily water demand in the units of 9,512 Litres is considerably less than the available mains water supply but the expected peak water demand of 272 Litres/minute is significantly greater than the available mains water supply rate of 34 Litres/minute. Using the results in Table 6 and the assumption that during the summer season the units will be fully occupied and in the winter season the occupancy rate will be 60% the water demand of the units is estimated in Table 7.

Table 7: Estimated water demand for the units

Month	Average water demand (L/day)
Jan	9,512
Feb	9,512
Mar	9,512
Apr	5,707
May	5,707
Jun	5,707
Jul	5,707
Aug	5,707
Sep	5,707
Oct	9,512
Nov	9,512
Dec	9,512

A diurnal pattern of the expected variation in water use in the units has been constructed for use in conjunction with the results shown in Table 7 for the purposes of analysing the performance a various water supply options for the site. The diurnal pattern is shown in Figure 3.

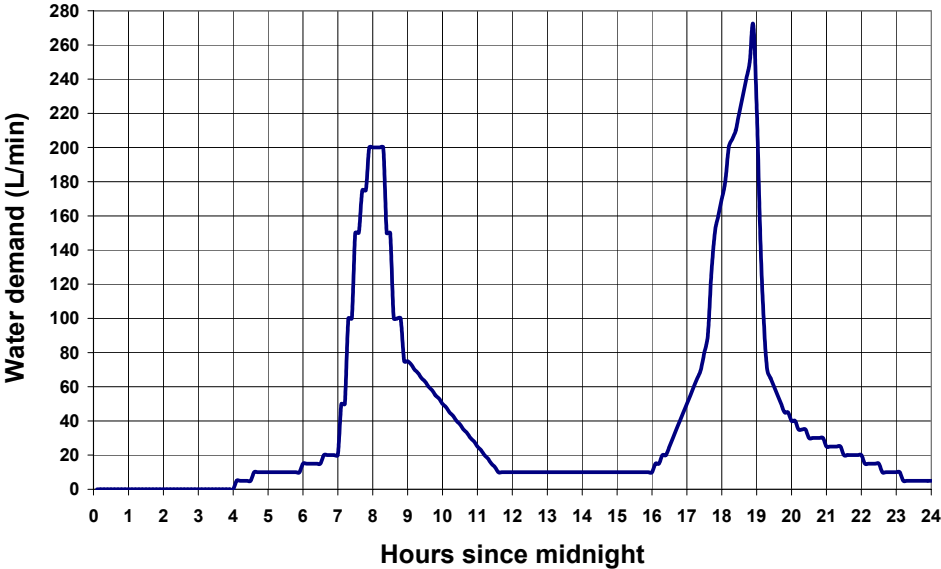


Figure 3: Estimated diurnal water use pattern for the proposed units

Note that in Figure 3, it is assumed that the evening period will be the busiest period for water demand in the units.

2.3 Total water demand at the lighthouse site

The maximum daily water demand at the proposed development will be about 15,850 Litres/day including an irrigation allowance of 1,000 Litres/day. This expected daily water demand is less than the available mains water supply of 49,000 Litres/day. However the peak evening water demand at the site of 368 Litres/minute is considerably greater than the ability of the existing mains water supply rate of 34 Litres/minute. In addition the existing mains water supply is at an unacceptably low pressure for the intended development. Integrated water supply options will need to be considered to enable the mains water supply system to adequately supply the development. The expected total water demand for the redevelopment of the Lighthouse site is shown in Table 8.

Table 8: Estimated water demand for the Lighthouse redevelopment

Month	Average indoor water demand (L/day)	Irrigation water demand (L/day)
Jan	13,570	1,000
Feb	13,570	1,000
Mar	14,851	1,000
Apr	11,046	1,000
May	11,046	1,000
Jun	11,046	1,000
Jul	9,249	1,000
Aug	9,249	1,000
Sep	9,249	1,000
Oct	13,054	1,000
Nov	13,570	1,000
Dec	13,570	1,000

2.4 Sewage disposal at the redevelopment site

The proposed Lighthouse redevelopment will generate about 11,500 Litres/day of wastewater. It is noted that the existing septic tank and absorption trench system discharges into the sand dunes below

the Lighthouse site. Importantly the soil surrounding the absorption trench has the capacity to accept about 3,000 Litres/day of effluent. Additional wastewater treatment capacity will be required at the site. Ideally the proposed wastewater treatment system for the Lighthouse site will reuse some of the treated wastewater and discharge highly (tertiary) treated wastewater to the environment rather than the current practice of discharging wastewater with very little (primary) treatment to the environment via an absorption trench.

3.0 WATER CYCLE MANAGEMENT OPTIONS FOR THE LIGHTHOUSE SITE

The PURRS (Probabilistic Urban Rainwater and wastewater Reuse Simulator) by Coombes and Kuczera [2001] was used to continuously simulate the performance of a conventional and three alternative water management options for the Lighthouse site over a 100 year period. A synthetic pluviograph rainfall record (see Coombes, 2004) based on daily rainfall at Nobbys Lighthouse and pluviograph rainfall at Maryville was used in the PURRS model along with water demand and diurnal information detailed in Section 2.

3.1 The conventional option

The conventional option would require that water supplies are sourced from the Hunter Water Corporation operated water mains and sewage is discharged to the Hunter Water Corporation managed sewage system. An adequate water supply can be achieved by the construction of a new 50 mm diameter water main with a length of about 1,200 metres to establish connection from the existing water main near the Nobby's Surf Club to the Lighthouse site. Construction of this system would require excavation and re-establishment of roads and pathways in a heritage area. In addition the water pipes will require support using concrete blocks in the dune sand environment.

The conventional sewage management option would require the construction of a new 100 mm diameter sewage pipeline from the Lighthouse site to the existing sewage system near the Nobby's Surf Club. Construction of this system will also require excavation and re-establishment of roads and pathways. The use of concrete blocks to support the pipes will also be required. It may be possible to utilise some of the existing sewage disposal system in this pipeline thereby reducing the construction costs by a small amount but it will be necessary to remove the septic tank at additional cost. The low lying nature of the terrain between the Lighthouse site and the Nobby's Surf Club may necessitate the installation of a sewer rising main and booster pumps at considerable additional expense.

The conventional option will incur a number of lifecycle expenses that take the form of charges to the Hunter Water Corporation that include water and sewage headworks charges, tri-annual fixed charges and tri-annual usage charges. Whilst the tri-annual usage and fixed charges can be reliably estimated, the headworks charges for an upgraded connection to the lighthouse site are currently unknown. The estimated construction and lifecycle costs together with the present values of the conventional option are shown in Table 9.

Table 9: Economic evaluation of the conventional option

Costs (\$)		Present values (\$) at a given interest rate	
Construction	Lifecycle	3%	9%
205,100	6,998	-390,555	-288,712

An estimated cost to construct the conventional option is \$205,100 and the annual lifecycle cost is about \$6,998. The present value is calculated in accordance with the methods developed by Coombes and Kuczera [2003] and represents the required level of investment required at the commencement of the project to ensure viable operation of the water and sewage systems over a fifty year period at a given real interest rate. A real interest rate is considered to be the Reserve Bank interest rate less the inflation rate. The present value of -\$390,555 indicates that an investment of \$390,555 at a real interest rate of 3% at the commencement of the project will cover all estimated water and sewage expenses over a fifty year period.

3.2 Alternative option 1

Option 1 includes the use of rainwater for café kitchen hot water uses and on-site treatment, reuse and disposal of wastewater (see Figure 5). The inadequate mains water flow rate to the site can be mitigated by the use of a balance tank and a pressure pump. The mains water solution involves the use of an Aquaplate rainwater tank with a capacity of about 5 kL used as a mains water balance tank that will be topped up at the existing mains water flow rate to a full position whenever the water level is drawn down. Adequate pressure and flow rate will be supplied to the site using a pressure pump (Figure 5).

Rainwater falling on the roofs of café and units will be directed via filtration to three 9,200 L Aquaplate rainwater tanks or to storages within the floor slabs of the buildings. The rainwater storages will be linked using 32 mm diameter pipes and topped up with mains water whenever water levels in the storages are drawn down below a minimum level. Rainwater from the storages will be supplied via a small pump and filter to the hot water systems in the café (Figure 5).

Coombes et al. [2000; 2002] found that the processes of settlement, flocculation and biofilms acted to remove contamination from rainwater stored in tanks. Storage and instantaneous hot water systems set at temperatures greater than 50°C were found to remove microbial contamination from rainwater stored in tanks producing water quality that is compliant with Australian Drinking Water Guidelines. Laboratory experiments by Spinks et al [2003; 2003a] established that a range of waterborne human pathogens were rapidly removed from water heated to temperatures of 60°C and above. Nevertheless it was observed that a high level of microbial contamination in rainwater tanks was unlikely in the inner city regions of Newcastle. Contamination of the rainwater at the Lighthouse site is less likely. Note that the hot water systems at the café will be maintained at temperatures greater than 80°C and are expected to instantly eliminate bacteria from the hot water supply.

The proposed rainwater treatment train will include filtration of roof water using fine mesh prior to discharge into the storages, significant settlement and flocculation due to the large rainwater storage, the action of biofilms, a one micron filter in the delivery system and the temperature in the hot water system. An ongoing monitoring program will be conducted by the School of Environmental and Life Sciences at University of Newcastle in partnership with the proprietors and the Public Health Unit to ensure that high public health standards are maintained. It is envisaged that during the first year of operation an extensive monitoring program will be undertaken that will be scaled back in subsequent years to a routine monitoring program.

The proposed rainwater treatment train will produce acceptable water quality. However additional elements such as UV, ozone or chlorine disinfection can be added to the treatment train to address possible extra institutional requirements. The wastewater disposal strategy will include on-site treatment of wastewater using an electroflocculation wastewater treatment system, reuse of treated wastewater for toilet flushing and irrigation, and disposal of treated sludge to the existing septic system. A schematic of the wastewater treatment system is shown in Figure 4.

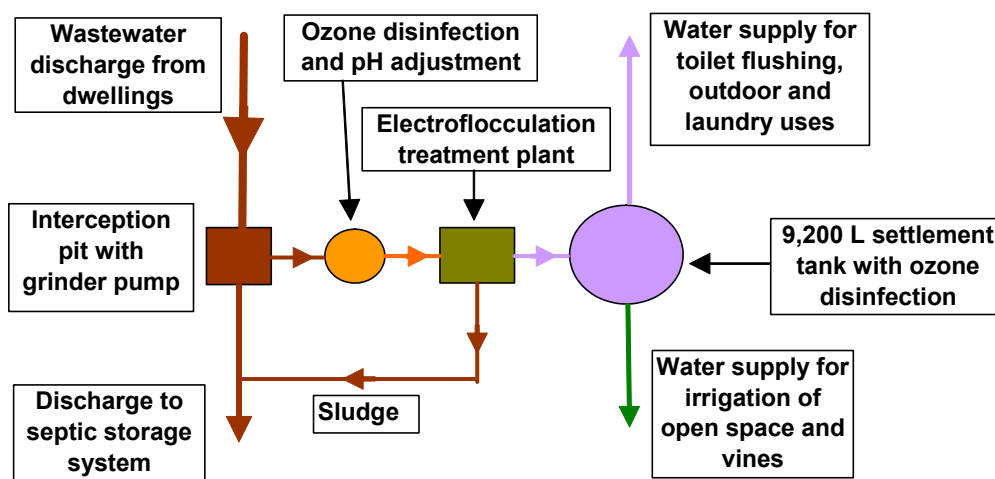


Figure 4: Schematic of the on-site wastewater treatment system

Figure 4 shows that all wastewater from the café and units will be directed to an interception pit with a capacity of 2,000 Litres that contains a grinder pump. The grinder pump will shred solids in the sewage and transfer wastewater to a 1,500 Litre pre-treatment tank. In the pre-treatment tank the pH of the wastewater is adjusted to 6.5 and ozone is added to commence the disinfection process. Upon completion of pre-treatment, the wastewater is directed to the electroflocculation treatment plant in batches of about 1,500 Litres. In the unlikely event that the capacity of the wastewater extraction system is overwhelmed, effluent with all solids removed will be directed to the existing septic tank.

The electroflocculation treatment plant processes wastewater in a reactor tank that contains electrodes. An electrical voltage is applied to the electrodes causing an electric current to pass through the wastewater that liberates a coagulation agent and minute air bubbles. The coagulation agent binds pollutants into flocs that are removed from the wastewater using the air bubbles and discharged to the septic system as sludge. After removal of the pollutants, the wastewater is discharged into a 9,200 Litres settlement tank.

Ozone is used in the settlement tank to remove any remaining microbes and the highly treated wastewater will be disturbed for toilet flushing in the café and units using a pressure pump. Excess treated wastewater will be directed to the environment. This is possible because the proposed wastewater treatment train will remove the majority of pollutants as shown in Table 10. Water quality from conventional and electroflocculation treatment processes are compared to the Australian drinking water guidelines in Table 10.

Table 10: Wastewater quality from conventional and electroflocculation processes

Pollutant	Sewage treatment processes		Drinking Water guidelines
	Conventional	Electro flocculation	
Faecal Coliforms (CFU/100 ml)	≈ 350,000	0	0
Total Coliforms (CFU/100 ml)	≈ 400,000	0	0
Turbidity (NTU)	7	1	< 1
BOD ₅ (mg/L)	8	< 2	< 1
Suspended solids (mg/L)	38	3	500
Dissolved solids (mg/L)	295	250	500
Total oil and grease (mg/L)	< 50	< 2	< 1
Total phosphorus (mg/L)	1.95	< 0.01	-
Total nitrogen (mg/L)	10.6	< 5	-
Iron (mg/L)	0.009	< 0.006	0.3
Lead (mg/L)	-	< 0.005	0.01
Manganese (mg/L)	5.8	3.4	-
Sulphate (mg/L)	70.9	58	250
Zinc (mg/L)	0.021	0.007	3

Table 10 shows that electroflocculation treatment of sewage produces a significant improvement in the quality in comparison to conventional sewage treatment processes. Although the treated wastewater will only be used for toilet flushing it is noted that the electroflocculation treatment produces water quality that is compliant with many of the parameters in the Australian drinking water guidelines. The effective removal of contaminants such as total phosphorus, total nitrogen, BOD₅, oil, grease and microbes will also allow disposal of the highly treated wastewater to the environment. Wastewater quality at the Lighthouse site will also be monitored by the University of Newcastle. The electroflocculation treatment system has been used at many locations including the town of Hill End in NSW, Tulka Beach and Maslin Beach in SA and Lane Cove in NSW.

A monitoring program will be commissioned to assess water quality, water use, energy use, maintenance issues and the economic performance of the Newcastle Lighthouse development. Manual and automated monitoring protocols are currently being developed. Water level sensors and water quality probes will be placed in the rainwater tanks and the treated wastewater settlement tank that will provide real time information about the performance of the integrated water management system to a central computer. In addition real time information about energy uses, energy generation and room temperatures will also be recorded. Real time and historical information about the operation of the water and energy management schemes will be displayed on a computer screen in the café and

on a website for education purposes. A manual observation process will also be used to measure water quality and quantity.

A schematic of the proposed water cycle management strategy for the alternative option 1 is shown in Figure 5. The rainwater storages will be used to capture the additional rainwater runoff from the roofs for use in the café hot water systems, to reduce stormwater runoff from the site and to provide water for fire fighting. It is proposed to discharges from the rainwater storages to the environment.

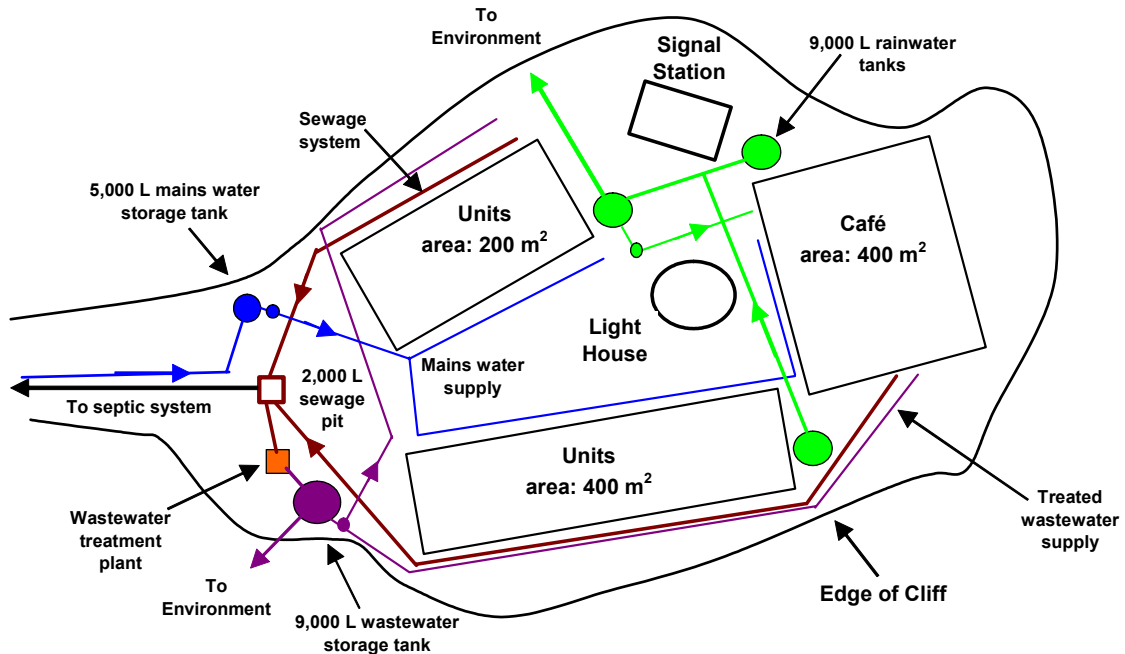


Figure 5: Schematic of the water cycle management strategy for the alternative option 1

The performance of the proposed alternative option 1 was evaluated using the PURRS model, 100 years of rainfall recorded at the Lighthouse and the water use scenarios presented in this report. Toilet flushing and café hot water demand at the site is 7% and 15% of total water demand respectively. The results are shown in Table 11.

Table 11: Water balance results for alternative option 1

Source	Water use (L/annum)	Proportion of total use (%)	Peak demand (L/min)
Mains	3,412,000	78	272
Rainwater	587,000	13	32
Wastewater	391,000	9	48

The use of rainwater for café hot water uses and treated wastewater for toilet flushing and irrigation purposes will result in mains water savings of 978,000 L/annum (22%). Peak demand for mains water will reduce to 272 Litres/minute. Results of the economic analysis of the alternative option 1 are presented in Table 12.

Table 12: Economic evaluation of option 1

Costs (\$)		Present values (\$)	
Construction	Lifecycle	3%	9%
107,700	9,787	-379,948	-231,673

The costs to construct the alternative option 1 are estimated to be \$107,700 with annual lifecycle costs of about \$9,787. The annual lifecycle costs include an allowance for water quality testing of \$6,000 in the initial year of operation and \$1,000 per annum in the ensuing years. In addition it is assumed that all pumps will be replaced every 20 years. Alternative Option 1 has present values of -\$379,948 and -\$231,673 for real interest rates of 3% at 9% respectively. The on-site peak energy demand of the alternative option 1 is expected to be 8.9 kW.

3.3 Alternative option 2

Alternative option 2, similar to alternative option 1, includes the use of rainwater for café kitchen hot water uses and on-site treatment, reuse and disposal of wastewater (see Figure 6). The inadequate mains water flow rate to the site will be mitigated by the use of a balance tank and a pressure pump. In the alternative option 2, rainwater will also be used to supply hot water uses in the units. The quality of rainwater used for hot water supply will be maintained by using instantaneous hot water systems that are set at temperatures greater than 60°C. Mixing values will be used to ensure that hot water is delivered to taps at non-scalding temperatures.

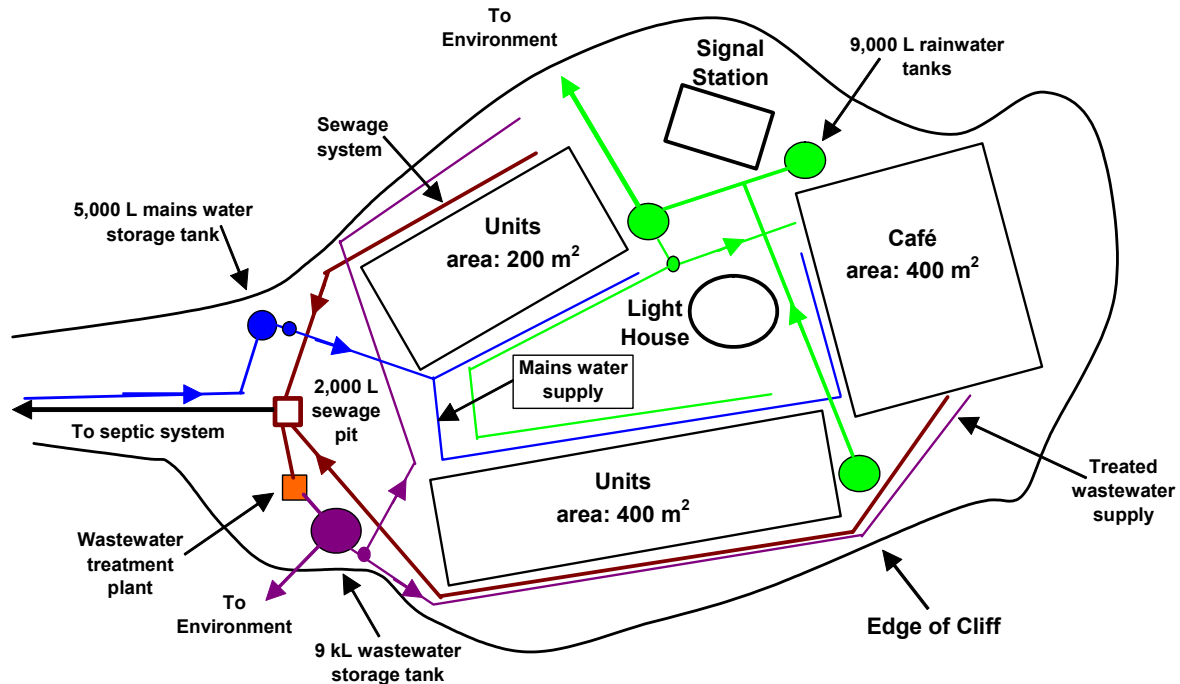


Figure 6: Schematic of the water cycle management strategy for the alternative option 2

The performance of the proposed alternative option 2 was evaluated using the PURRS model and the results are shown in Table 13.

Table 13: Water balance results for alternative option 2

Source	Water use (L/annum)	Proportion of total use (%)	Peak demand (L/min)
Mains	3,118,000	71	152
Rainwater	881,000	20	152
Wastewater	391,000	9	48

The use of rainwater for café hot water uses and treated wastewater for toilet flushing and irrigation purposes will result in mains water savings of 1,272,000 L/annum (29%). Peak demand for mains water will reduce to 152 Litres/minute. Results of the economic analysis of the alternative option 2 are presented in Table 14.

Table 14: Economic evaluation of option 2

Costs (\$)		Present values (\$)	
Construction	Lifecycle	3%	9%
105,800	9,516	-368,842	-226,014

The costs to construct the alternative option 2 are estimated to be \$105,800 with annual lifecycle costs of about \$9,516. The annual lifecycle costs include an allowance for water quality testing of \$6,000 in the initial year of operation and \$1,000 per annum in the ensuing years. In addition it is assumed that all pumps will be replaced every 20 years. Alternative Option 2 has present values of -\$368,842 and -\$226,014 for real interest rates of 3% at 9% respectively. The on-site peak energy demand of the alternative option 2 is expected to be 8.15 kW.

3.4 Alternative option 3

Alternative option 3 includes the use of mains water for all water uses, and on-site treatment and disposal of wastewater (see Figure 7). Highly treated wastewater will be discharged to the environment. The inadequate mains water flow rate to the site will be mitigated by the use of a balance tank and a pressure pump.

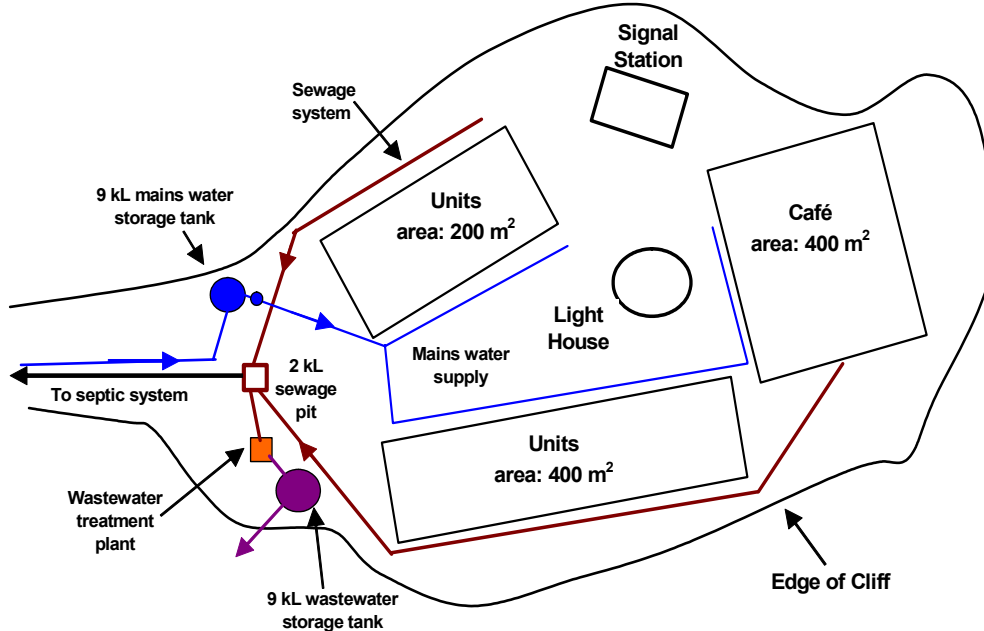


Figure 7: Schematic of the water cycle management strategy for the alternative option 3

The performance of the proposed alternative option 3 was evaluated using the PURRS model and the results are shown in Table 15.

Table 15: Water balance results for alternative option 3

Source	Water use (L/annum)	Proportion of total use (%)	Peak demand (L/min)
Mains	4,390,000	100	368

Table 15 shows that the mains water demand of the alternative option 3 is 4,390,000 L/annum. The peak demand for mains water will be 368 Litres/minute. Results of the economic analysis of the alternative option 3 are presented in Table 16.

Table 16: Economic evaluation of option 3

Costs (\$)		Present values (\$)	
Construction	Lifecycle	3%	9%
100,100	10,186	-382,942	-228,849

The costs to construct the alternative option 3 are estimated to be \$100,100 with annual lifecycle costs of about \$10,186. The annual lifecycle costs include an allowance for water quality testing of \$6,000 in the initial year of operation and \$1,000 per annum in the ensuing years. In addition it is assumed that all pumps will be replaced every 20 years. Alternative Option 3 has present values of -\$382,942 and -\$228,849 for real interest rates of 3% at 9% respectively. The on-site peak energy demand of the alternative option 3 is expected to be 12.65 kW.

4.0 DISCUSSION

The performance of the various water cycle management options is ranked using a multi-criteria process as shown in Table 17. It shows that the alternative option 2 has been ranked as the best performed option. This option included the use of rainwater for all hot water uses, reuse of treated wastewater for toilet flushing and disposal of highly treated wastewater to the environment. Considerable savings in mains water supplies will be experienced. The use of rainwater for hot water supplies and reuse of treated wastewater for toilet flushing will require approval from the NSW

Department of Health and a subsequent monitoring program to ensure that acceptable water quality is maintained. After an initial period of intense monitoring to establish water quality performance it is envisaged that a routine monitoring schedule can be maintained.

Table 17: Summary of water cycle management options

Criteria	Option			
	Conventional	1	2	3
Water savings (kL/annum)	0	978	1,272	0
Construction costs (\$)	205,100	107,700	105,800	100,100
Lifecycle costs (\$/annum)	6,998	9,787	9,516	10,186
On-site Peak energy demand (kW)	0	8.9	8.15	12.65
Present value at 3% (\$)	-390,555	-379,948	-368,842	-382,942
Present value at 9% (\$)	-288,712	-231,673	-226,014	-228,849
Rank	4	2	1	3

The discharge of treated wastewater to the environment will require approval from the NSW Environment Protection Authority and a monitoring program to show that an acceptable quality of treated wastewater is maintained. Further design investigation, negotiation with suppliers and discussions with government agencies will produce a more precise knowledge the expected project costs. Indeed it is possible that the costs of alternative options may be significantly reduced.

5.0 OBSERVATIONS

This paper has presented some of the preliminary investigations required in the redevelopment of the Newcastle "Nobby's" Lighthouse site as an education site for integrated energy and water management. Even at the early states of the redevelopment, the multi-disciplinary focus of integrated water cycle management has been paramount. This focus has been essential in the project development and design. It has, so far, included restaurateurs, councillors, state government representatives, engineers, microbiologists, architects, electricians and the local aboriginal land council. Considerable knowledge will be gained by the development and operation of this site. Importantly the use of integrated water cycle and energy management techniques will allow the sustainable redevelopment of the lighthouse site.

5.0 REFERENCES

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