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St Andrews Way, Coolangatta

Effluent Disposal Assessment and Cost Analysis

Project No. 1530
Date: March 2016

Prepared for: Shoalhaven City Council

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Document and Distribution Status

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Revision No.	Status	Release Date	Document Distribution					
			Alison McVey					
1	DRAFT	09.02.16	PDF					
2	FINAL	21.03.16	PDF					

Distribution Types: F = Fax, H = Hard Copy, P = PDF, E = Other Electronic Document. Digits indicate number of copies.

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1.0 INTRODUCTION

Footprint (NSW) Pty. Ltd. (*Footprint*) has been commissioned by Shoalhaven City Council (*SCC*) to conduct a desktop review of the existing effluent disposal systems at St Andrews Way, Coolangatta (including 99 Edward Wollstonecraft Lane) and prepare a cost analysis of potential upgrade options.

The background to this review are the recorded failures of on-site wastewater management systems in the St Andrews Way subdivision, the closure of the Berrys Bay oyster harvest area due to health risks associated with the presence of pathogens and the results of water quality analysis carried out by the Environmental Water Science Group from the University of Newcastle which link untreated effluent from the subdivision with the Berrys Bay area downslope.

Domestic on-site wastewater management requires property owners to commission and manage mechanical and biological systems to dispose of effluent within their own property in a way that protects human and environmental health. This is not a simple task. In a situation such as this, where space is limited, site conditions and watercourse buffers are not optimal, and areas of high environmental and human health sensitivity are located downstream, the responsibilities of property owners and Council to ensure properly operating systems are great.

Council has commissioned this study to assess three approaches to wastewater management for the subdivision to limit health and environmental risks associated with on-site effluent management to acceptable levels. The four options considered are:

1. Leave the existing systems as is
2. Upgrade of existing on-site disposal systems to provide an improvement in health and environmental risk.
3. Conversion of all on-site disposal systems to pump out
4. Connection of households to Council's sewer system via a low pressure, or similar connection.

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2.0 BACKGROUND

2.1. Subdivision Approval

A development application was approved by Council in 2003 for a twenty three (23) lot residential subdivision. The parcel of land is a Special Rural Lifestyle Area No.4 with allotment sizes ranging from 1,380m^2 - 3,100m^2. The land is zoned rural 1a (SLEP 1985) and RU1 in the Shoalhaven Local Environmental Plan 2014.

One of the objectives contained in SLEP 1985 for Special Rural Lifestyle Area No.4 states: *"All development to be in accordance with the ability of the land to absorb effluent".*

As part of the assessment of the subdivision Council received and considered a report from Environmental Consultants Martens & Associates dealing with the collection and disposal of effluent on each of the sites within the subdivision. Based on the report from the consultants it was determined that effluent generated from a dwelling containing a maximum of four bedrooms could dispose of its effluent on site to a sewage management system designed by Martens & Associates as part of their report. Furthermore, the report did not prohibit other on-site disposal systems from being installed particularly where improvements in technology were implemented. Subdivision Approval was granted and as part of the Development Consent for the subdivision, a Restriction as to User was placed on the title which stated:

> *"No dwelling to be erected on the Lot unless effluent is disposed of in the Area denoted "alpha" Primary Effluent Disposal Field which has been sized to accommodate dwellings consisting of no more than four (4) Bedrooms in accordance with the Martens and Associates report reference 2002G686JRI however this does not limit on site effluent disposal to the Methods outlined in the Martens Report so that changes in technology can be implemented."*

Many of the approved lot sizes are less than the minimum lot size of 2500m^2 now required by Council in Shoalhaven Development Control Plan 2014 for the subdivision of unsewered properties.

Problems have been encountered by the land owners within the estate with their respective sewage management systems not working as efficiently as they were designed to do so.

2.1.1. Subdivision Wastewater Assessment

Investigations carried out as part of the On-site Sewerage Management Study by Martens summarised the site topography and soil characteristics. The report noted the existing dams and drainage run through and are adjacent to the development site.

The Martens report notes that soils over the site as silty loam of variable depth (150-500mm) over light to medium clays to over 1.5m depth, increasing in clay content with depth. A review of individual wastewater reports submitted in support of development applications for building approvals generally supports the soil profile noted by Martens, with a typical profile comprising a topsoil layer (0-200mm) over clay loam and silty clays (200-500mm), over gravelly silty clay to in excess of 1.0m deep.

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A few of the individual reports do note the presence of clayey silt and silty clay at the surface.

The Martens report noted the presence of groundwater in two test pits below the large dam at the northern end of the site and that the water levels in these test pits were an indication of the water gradient from the dam water surface level to the proposed development area below the site.

A review of the individual wastewater report revealed that groundwater seepage was observed on only one allotment and from within the topsoil layer. The lack of groundwater observed in the remaining reports does not preclude groundwater being present, as boreholes were backfilled upon completion of logging and sampling which may not have allowed insufficient time to gauge the presence of groundwater movement through low permeability soils. Additionally, anecdotal evidence would suggest climactic and seasonal conditions can significantly change groundwater levels in this area.

2.2. Current Issues

In 2011 and in response to a number of concerns Shoalhaven City Council conducted a survey of all the developed lots within the 23 lot estate to ascertain the operational effectiveness of on-site effluent disposal systems. Of the 13 lots surveyed a significant number of the systems were found to not be operating in a satisfactory manner.

The problems identified, which include discharge of effluent from systems, appear to be the result of a range of issues related to:

- the size of the lots,
- land gradient and the location of natural flow lines,
- soil types and depth of water table,
- recent high rainfall, and
- potentially high water usage due to the availability of reticulated water within the subdivision.

In 2011 the NSW Food Authority, in conjunction with Shoalhaven City Council, to undertook water quality testing in order to verify pollution sources impacting on the Berry's Bay oyster harvest area downslope of the St Andrews Way development. The results of this study revealed that there was evidence of human faecal contamination downstream of the development and evidence of effluent from the development reaching the outlet of the Berry's Bay catchment to the Shoalhaven River.

In late 2015 Council engaged a contractor to conduct a series of stormwater and effluent disposal audits of consenting properties within the estate with an aim to identify any areas of non-compliance.

Phase 1 of the audit involved an audit of the stormwater and sewer collection system from the dwelling to the point of disposal was undertaken using CCTV and smoke testing to determine whether there were any breaches or cross connections in the two systems.

Phase 2 of the audit involved an audit of the effluent collection and treatment tanks was undertaken in an effort to determine if the ingress of groundwater was occurring into the tanks.

The results of the Phase 1 audit indicated that generally the sewerage and stormwater systems were constructed satisfactorily with no identified cross connections, although some minor issues, including leaks in the stormwater systems, were identified.

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The Phase 2 audit revealed that a significant portion (88%) of the wastewater treatment and/or collection tanks experience surface and/or groundwater ingress when the area around the tanks were flooded with water. Generally these leaks were identified to occur through either; the lids, at the connection between the riser and at tank penetrations (i.e. electrical/inlet out outlet pipes).

2.2.1. Berry's Bay water quality analysis

The Berry's Bay oyster harvest area has experienced closures due to poor microbiological test results. Council has undertaken a range of water quality testing in an attempt to determine the potential source/s of contamination with one potential source being un-sewered development within the Berry's Bay catchment.

The NSW Food Authority, in conjunction with Shoalhaven City Council, engaged the Environmental Water Science Group from the University of Newcastle to undertake water quality analyses to improve the understanding of pollution sources impacting on the Berry's Bay harvest area. Rhodamine WT dye tracing studies and faecal sterol, microbiological and fluorescent whitening agent testing were used. The multifaceted testing was employed to assess the severity and identify the source of elevated microbiological results experienced in the Berry's Bay shellfish harvest area in the Shoalhaven River.

Test results are summarised below with sampling site locations shown in Figure *2.1*. The general theme is that there is a hydraulic link between septic tank/s on the site and the stormwater outlet at the bottom of the site. Faecal contamination is occurring at this location which is likely to be the result of failing on-site wastewater systems.

Dye Testing

Dye test results showed a hydraulic connection between the septic dosing location, the stormwater outlet at the lower end of the St Andrews Way Estate (D2), and the outlet of the Berry's Bay catchment to the Shoalhaven River (D4) suggesting that there is a hydraulic connection between the dosing point and these locations.

Faecal Sterol Analysis

Coprostanol is the key sterol indicator of potential human faecal contamination. Faecal sterol testing showed that for the sample site at lower end of the St Andrews Way Estate (S2) there is evidence of human faecal contamination, and that contamination was likely fresh/recent and unlikely from extensively treated wastewater. Coprostanol was also detected in other samples, but all below the threshold for indication of significant faecal contamination.

Fluorescent Whitening Agent testing

Testing was undertaken for Fluorescent Whitening Agents (FWA) which are contained in detergents and fabric whiteners. Evidence suggests that samples taken below the development site in the perennial stream to the south of the St Andrews Way (S1) estate and at the drainage entry point into the river for this catchment (S5) are likely to contain human sourced wastewater, although concentrations are lower than that likely to be found in raw effluent, septic effluent or secondary treated effluent.

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Figure 2.1: Water Quality Testing Sampling Sites

2.2.2. Constraints to On-Site Effluent Disposal

Several constraints to on-site effluent disposal exist on the subject site as listed in Table 2.1.

When combined with the density of the development they elevate the risk of on-site effluent disposal. The location of the development within the Berry's Bay catchment oyster lease area further exacerbates the health and environmental hazards associated with failure of on-site systems.

Along with limited space are soil, hydrogeological and topographic constraints that further limit the ability to dispose of wastewater on site. When these constraints are combined with the environmental and health consequences associated with oyster farming and recreational water quality downstream, it can be seen that the environmental and health risk is high.

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Table 2.1: Summary of Constraints to On-Site Effluent Disposal

Constraint	Comment
Lot Size	Lot sizes are as low as 1380m^2 and current Section 88B restrictions effectively limit buildings to single storey creating pressure for buildings with large footprints thereby reducing the area of land available for on-site effluent disposal. Based on our site inspections the presence of outbuildings, including large sheds, and swimming pools also further reduces the area available for effluent disposal.
Topography	The development is located on a drainage plain below Mount Coolangatta. Two perennial drainage lines pass through the development site (Figure *2.2*), along with unmarked drainage depressions and therefore effluent disposal is being undertaken in very close proximity to these watercourses.
Groundwater and soil wetness	The subdivision wastewater report noted groundwater in test pits below the existing dam to the north of the site. Anecdotal evidence provided by Council suggests that high groundwater levels are driven by the water level in the dam and when the groundwater is high it can be seen discharging to the kerb and throughout the estate. The road construction may also be limiting groundwater movement downslope. The location of the site at the base of a hillside and the location of watercourses and drainage depressions though the site provide numerous avenues for water to be introduced to the soil profile, either via the surface or through groundwater movement. The nature of soils mean that significant amounts of water can be stored in the soil profile and also mean that water movement is relatively slow, so soils can stay wet for prolonged periods.
Soils and hydraulic loading rates.	The subdivision wastewater report records soils over the site as silty loam between 150-500mm depth above light to medium clays to over 1.5m depth. The report notes the clay layer as the limiting horizon. The subdivision wastewater report recommends a Design Loading Rate (DLR) of 20mm/wk. Individual wastewater reports include a range of soil depths over the site, with some noting clay soils at the surface and others loamy soils to over 0.5m depth. In general DLRs used in individual wastewater reports range from 3-8mm/d (21-56mm/week). Linear loading rates are also important as effluent movement will have a strong horizontal component due to the limiting factors associated with the clay soils of the A and B horizon. A linear loading rate of 25L/m/d would be considered applicable for these soils (SCA, 2012), possibly increasing to up to 40l/m/d for mound systems (AS1547:2012 Appendix N). None of the individual wastewater reports consider the linear loading rate.

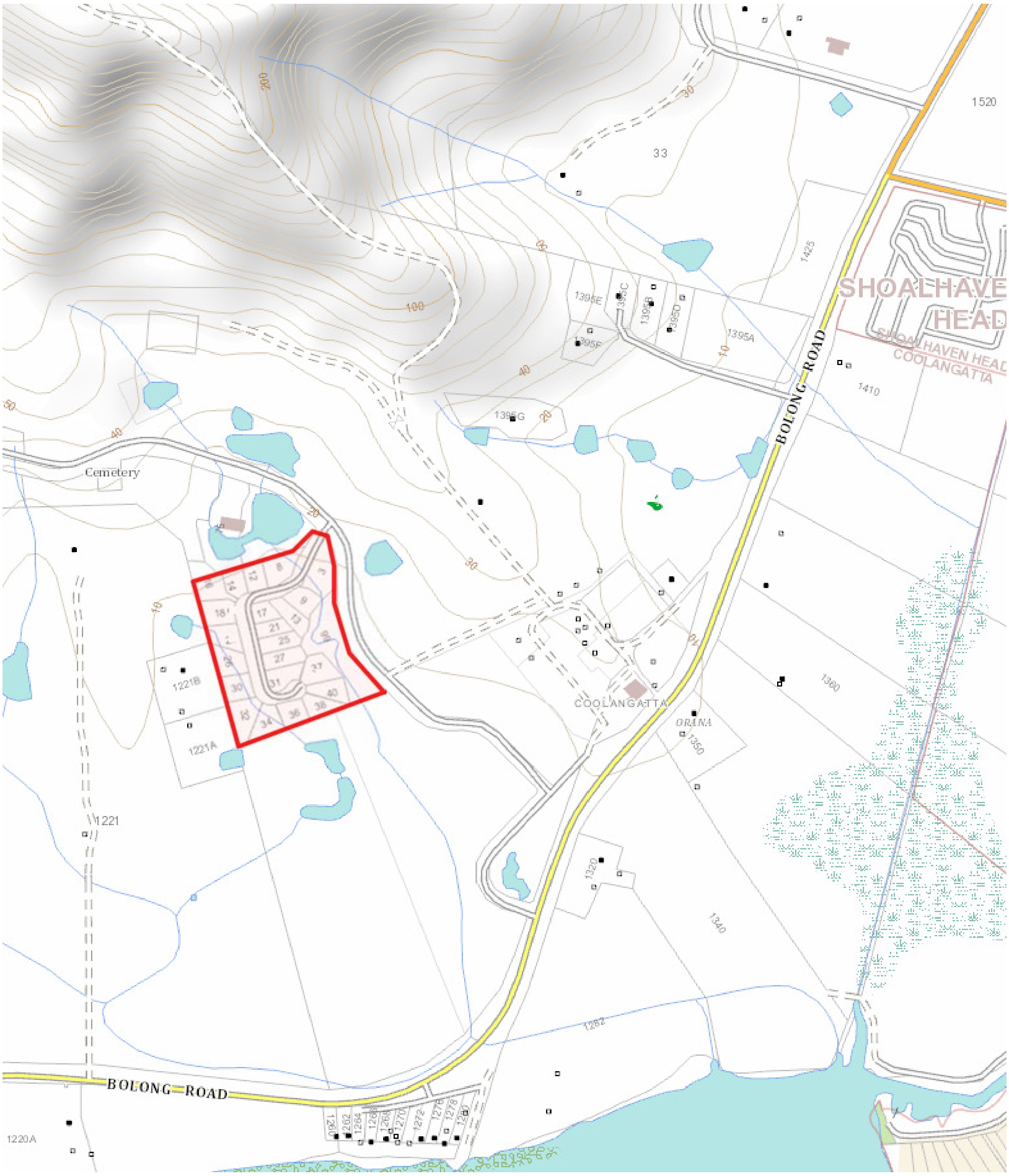

Figure 2.2: Development (red) context in landscape. Note location in low lying drainage plain at base of steep hillside and watercourses mapped through the site.

2.3. Council Guidelines

Council relies on Chapter G8 of the Shoalhaven Development Control Plan 2014 (SDCP 2014) as the primary document for on-site wastewater assessment. SDCP 2014 contains a range of performance criteria including buffers and setbacks to provide health and environmental protection. The DCP outlines a number of acceptable solutions in relation to buffer distances which Council automatically accept as 'acceptable solutions'.

Where acceptable buffer solutions are not used, justification must be provided and Council needs to be satisfied that the performance criteria are met. One justification may be through the use of Appendix R of AS1547:2012 which outlines buffer ranges for a number of site features with variations in buffer distance depending on site constraints. Examples of minimum buffers from Appendix R, include the minimum buffer to a watercourse of 15m horizontally, and the minimum to the seasonally highest groundwater table level of 0.6m vertically.

Many of the existing systems would not be able to meet these recommended minimum buffers, particularly in relation to the groundwater buffer.

3.0 ON-SITE WASTEWATER SYSTEM REVIEW AND UPGRADE APPROACH

3.1. Background

Subsequent to the original subdivision assessment and design of some individual on-site wastewater systems, changes to Council guidelines as well as state and relevant Australian standards have occurred. There are some inconsistencies between system designs and current standards and guidelines.

The purpose of this review is not a detailed audit of specific system design or to check compliance with current Council guidelines or Australian standards, rather the review is an assessment of the current systems risk to health and the environment based on AS1547:2012, Appendix R, specifically Table R2.

Site inspections and audits have been carried out on all on-site wastewater systems as part of Councils standard inspection regimes. Additional inspections were also carried out based on site reports of issues or failures and following periods of heavy rain.

3.2. Existing System Assessment

A comparison of the individual system designs has been carried out against AS1547:2012, *Table R2 – site constraints* as a methodology for assessing the system environmental and health risk of the existing systems, and from there to determine what upgrades are necessary to provide on-site wastewater management that has acceptable environmental and health risks, if this is possible. An overall assessment of site constraints and risks using AS1547:2012, *Table R2 – site constraints* is outlined in Table 3.1 to provide a summary of the constraints found on site. A lot by lot assessment based on the same parameters is contained in Appendix A.

Further risk assessment in Section 5 compares the risk between the four different options for the site.

Figure 3.1 and Figure 3.2 show the breakdown of on-site sewage management systems (OSSM) type and failure type as recorded by Council during inspections in February and March 2015, after a period of heavy rain. A detailed summary of the existing OSSM (including recorded failures) for each lot is included in Appendix B.

All mound systems were inspected in February 2015 and all remaining systems were inspected in March 2015. 70% of system failures were from primary treatment systems, and more than half (55%) of on-site mound systems failed. Neither of the two AWTS systems with subsurface irrigation registered a failure. The recorded wet weather pump out failure was associated with the pump for the grey water system.

Table 3.1 Assessment of site constraints and risk over subdivision

Site/system feature	General comment about the subdivision	Overall site risk level
Proximity to surface water	A large number of sites within 40m of a watercourse, or surface waters and some are less than 1m an intermittent watercourse. Additionally soils present low permeability and the area has relatively high, and intense rainfall, and receiving environment has significant environmental resource value.	High
Proximity to groundwater	Soils are not highly permeable, however localised areas of high water table recorded.	High
Surface slope	Surface slopes are generally not an issue for the site.	Low
The position of the disposal area in the landscape	Small sized lots, and lot configuration means that seepage across property boundaries does occur. In a number of cases effluent disposal is located immediately upslope of surface waters and wet areas.	High
Drainage (surface soils and slope)	Soils are of low permeability. Seepage has been recorded and the area is low lying and at the base of a hillside.	High
Flood potential	A number of sites are located very close to existing watercourses and drainage depressions. Flooding of treatment systems and disposal areas is possible.	High
Geology and soils	Low permeability soils, significant depth to regolith.	Med
Landform	Concave slopes, filled drainage lines and located on the edge of a drainage plain make the site susceptible to waterlogging.	High

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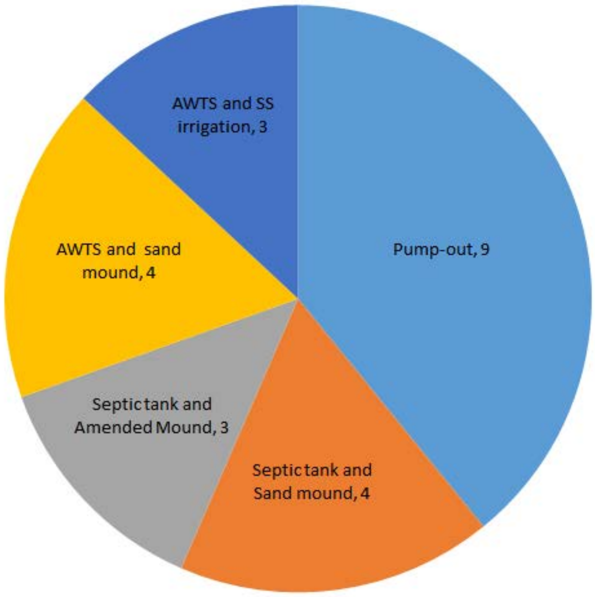

Figure 3.1: Breakdown of main treatment and disposal approach over the subdivision, March 2015.

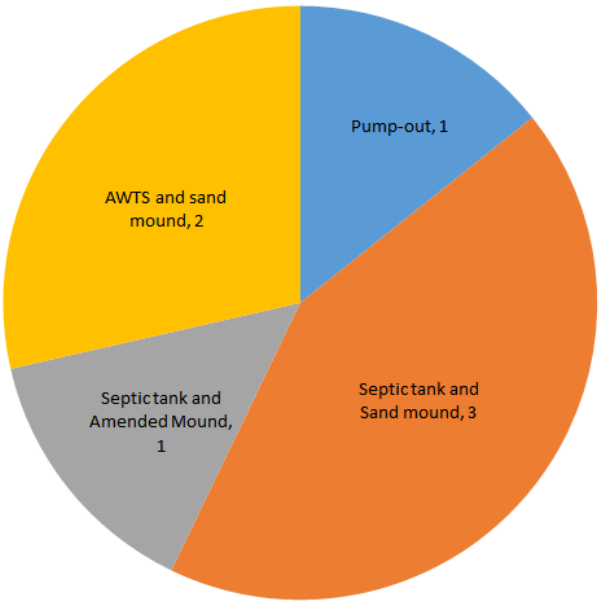

Figure 3.2: Breakdown of systems that recorded failure after heavy rain in February and March 2015

3.2.1. Assessment of treatment approach

Eight of the twenty-one occupied properties are pump out systems, with pump out to be installed on the remaining two properties that were not yet occupied at the time of completing this investigation.

Whilst the adopted risk matrix (Appendix A) ranks such systems as having a low environmental and health risk when constructed appropriately and operated correctly, evidence would suggest that this is not the case. Evidence of poor pump out construction and management includes recorded failures of the pump out systems, where overflows have occurred, the lack of warning systems, high probability of effluent being syphoned to avoid pump out costs, and poor pump out scheduling.

Two of the twenty three properties have a combined system consisting of a pump out system which is used during wet weather and a mound disposal system which is used during dry weather. However, only one of these pump-out systems is utilised consistently.

Seven of the twenty three properties have a primary level (septic) of wastewater treatment prior to on-site disposal in a surface mound. Of these seven, four have registered a failure after inspections by Council officers in February and March of 2015. Primary level treated effluent presents a high health risk if not disposed of correctly as the system contains no secondary level of treatment or disinfection component. Additionally, septic tanks have limited ability to reduce the BOD and nutrient loads in effluent.

Primary treatment of effluent can be an acceptable part of an on-site wastewater management approach where the disposal system is appropriately designed, and there are sufficient risk mitigation measures in place such as buffers, setbacks and conservative disposal system sizing to offset the risks associated with effluent that has very limited microbial treatment and therefore presents an environmental and health risk.

In this case a range of factors preclude the use of primary treatment including:

- limited available space,
- proximity to surface waters and groundwater
- landscape features that promote soil wetness, and
- limited infiltration and assimilation of effluent

Primary treatment (septic tank) is very unlikely to be an appropriate treatment approach for the site. The subdivision wastewater management report submitted for the subdivision approval recommended secondary treatment in an AWTS, followed by tertiary treatment in a ‘reactive filter media’ system prior to disposal in sub-surface irrigation.

3.2.2. Assessment of application method and site conditions

Mounds are the most popular disposal approach for the subdivision primarily due to their *potentially* small footprint, with a total of eleven of the twenty three sites using this approach. Of the eleven, six have registered failures associated with seepage from the toe of the mound, or ‘general wetness’ as reported by Council.

Correct mound function relies on even distribution of effluent into the mound, and then sufficient length across the slope to allow effluent that has percolated through the mound to seep into in-situ soils below. The linear loading rate is critical to this. AS1547:2012 recommends a maximum linear loading rate at the toe of 40l/m/d, which is the SCA guidelines for linear loading rates based on surface soil types would suggest a lower level of about 25l/d. Based on a loading rate of 1000l/d for a household, this equates to a mound length along the slope of about 30m using the recommended linear loading rates from the SCA guidelines. Many of the mounds in the subdivision would not achieve this, and some are undersized both in area and toe length. The combination of small footprint and limited length across the slope, often due to space constraints, is a likely cause of mound failure. The combination of primary treatment for many of the mound systems increases health and environmental risk.

Three sites have secondary treatment and disinfection, and use sub surface disposal approaches. These systems have no record of failure, and because of their treatment level and disposal approach are considered top present a lower risk.

3.3. Summary

The location of disposal areas is generally high to very high risk in relation to surface waters, groundwater or general drainage and land form. Prior to development of the site the area contained two distinct drainage lines (Figure *2.2*), one of which has been retained, the other diverted. A number of treatment systems and disposal areas are located in very close proximity to these drainage lines, or in areas that were previous low points. This leads to the very high risk of pollutant transfer to surface waters and shallow ground waters in the case of system failure and increased risk system failure in areas that are characteristically prone to wetness and waterlogging.

The combination of a primary level of treatment in almost half of the on-site disposal systems, along with the majority use of surface mounds as a disposal approach places a reliance on a high level of system performance and assimilation of pollutants by the environment. The limited area available and very limited setback or buffering to surface waters and shallow groundwater and the general wetness of the area means that the majority of current on-site wastewater management systems are not performing satisfactorily.

In total water balance terms, the issue becomes clearer. An additional 17,000 litres per day is added to an area that has low slopes, is not well drained and in parts contains filled drainage lines. In addition to this, just over half of the wastewater treatment is only primary, with no disinfection. The majority of the sites rely on surface mounds for disposal, this leaves limited contingency if the disposal systems do fail, as effluent will discharge at the lower toe of the mound.

4.0 MANAGEMENT OPTIONS AND COST COMPARISON

4.1. Description of Options

4.1.1. Option 1 – Do nothing

The do nothing option is not considered a feasible option from an environmental perspective. It has been included to allow a comparison of the life cycle costs associated with the ongoing operating costs of the existing systems.

4.1.2. Option 2 - Maintain and upgrade existing systems

The aim is to create on-site wastewater management systems for each dwelling that provides an improved level of treatment and disposal management given the site constraints and health risks associated with oyster harvesting and other recreational and environmental values downstream.

Upgrades consist of minor earthworks and repairs for some systems to rectify minor issues such as surface flow diversion or leaking tanks, through to replacement of the treatment and disposal system. In general the upgrades involve the replacement of all septic to mound treatment systems (7 in total) with a high level of secondary treatment and disinfection.

The original tertiary treatment system as specified by Martens & Associates in the subdivision assessment was considered for costing, however given the limited availability of technical expertise to operate and maintain this type of proprietary system, including checking and replacement of media, it was not considered further.

An AWTS and Membrane BioReactor (MBR) followed by Ultra Violet (UV) disinfection was considered the most appropriate high level treatment system that could best address the environmental constraints on site through a very high level of nutrient, BOD and pathogen removal (Table 4.1). Additionally, there is a network of technicians with the skills and materials to check the operation and maintain these systems.

An MBR system provides for a high level of treatment, that exceeds the NSW department of Health framework for approval of AWTS systems.

It should be noted that properties with existing AWTS systems that had not experienced failure and properties with pump out systems were not upgraded to an AWTS with MBR as it was considered that the upgrade could not be justified based on the small to negligible reduction to environmental and health risk.

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Table 4.1: Comparison of MBR treatment with standard AWTS*.

Parameter	Secondary Treatment	Advanced Treatement	Advanced MBR
Biological oxygen demand	<20mg/l	<10mg/l	<5mg/l
Suspended solids	<30mg/l	<10mg/l	<10mg/l
Thermo Tolerant Coliforms	<30 cfu/100ml	<10 cfu/100ml	<1 cfu/100ml
Total Nitrogen	20 to 50mg/l	<10mg/l	<9mg/l
Phosphourous	10 to 15mg/l	<5mg/l	<2mg/l

*Gardenmaster Advanced MBR Owners Manual.

Disposal system upgrades include the upgrade of existing mound systems to increase their area (where possible), replacement of failing mounds or changing the disposal approach from a mound system to a sub-surface irrigation system. For properties with an existing pump out system the existing system was retained.

In one case, an upgrade to achieve a low environmental and health risk is not considered feasible due to the close proximity of the treatment tanks to a watercourse. Conversion to pump out was considered the only option for this property.

The proposed system upgrades assume Council's continued monitoring and auditing regime administered through the OSSM levy imposed by Council.

In addition to upgrades, a number of systems, including pump out systems are failing due to leakage and water ingress, through faults with the tank structures and seals as well as designs that allow for water ingress at the surface. Upgrades such as sealing tanks, and addition of risers to protect against ponding have been allowed for, where appropriate.

Detailed descriptions of upgrades and cost assumptions can be found in Appendix C.

Although technologies are available to significantly mitigate against environmental and health risks associated with on-site wastewater disposal, there is always a risk of system failure. Property owners are not wastewater management experts, and failure can go unnoticed. The risk of failure due to operational or system failure has *not* been incorporated into the design for appropriate risk level. This is discussed further in section 5.

4.1.3. Option 3 - Convert all sites to pump-out

Nine of the twenty three on-site wastewater management systems are currently (or will be once completed) on pump out systems. This option involves the conversion of twelve of the remaining fourteen systems to pump out (two systems currently have a combined system incorporating pump out). Capital costs include the addition of a septic tank where necessary, and sufficient storage (8000L has been assumed). A number of the existing on site disposal systems have a septic tank and it has been assumed that this can be reused. In these cases only the additional storage has been allowed for in the cost estimates.

As for on-site disposal, failure of pump out systems is possible, particularly during wet periods. As for the upgrade option, allowances have been made to make repairs to existing pump out systems that have previously failed and to install high level alarms and dipsticks on all pump out systems.

4.1.4.Option 4 - Connect to existing reticulated sewer

In late 2015 Shoalhaven Water engaged Pressure System Solutions Pty. Ltd to prepare a pressure sewerage feasibility assessment, titled 'Summary Pressure Sewerage System Feasibility, Design Report, St Andrews Way and Berrys Bay Road'.

The report included preliminary designs for a connection to the existing reticulated sewerage system in Shoalhaven Heads Road for both a scheme involving the St Andrews Way estate only and a scheme involving both the St Andrews Way Development and 11 properties on Berry Bay Road.

Under both schemes it is proposed to install a pressure pump unit on each lot.

4.2. Cost comparison

4.2.1. Overview

Life Cycle Cost (LCC) analysis was conducted over a fifty (50) year period using a discount rate of 5% for each of the above options.

All costing were undertaken exclusive of GST.

4.2.2. Life Cycle Costing Assumptions

A list of assumptions made with respect to the life cycle cost analysis is included in Table D.1 in Appendix D.

Note that with the exception of on-site sewerage management levies for on-site disposal systems and services charges for off-site disposal systems no other Council fees and charges, including compliance costs, legal fees associated with environmental orders and staff time associated with the investigation of complaints etc have been considered in the assessment.

4.2.3. Life Cycle Costing Results

A summary of life cycle costs over the 23 lot development for each option are included in *Table 4.2* and Figure *4.1*, whilst full details are contained within Appendix D.

Table 4.2: Summary of Life Cycle Costs

Option	Real Costs				Discounted Life Cycle Cost ($2016)
	Capital	Annual	Renewal	Total	
1	$0	$1,367,490	$230,100	$1,597,590	$604,080
2	$248,960	$1,594,990	$207,090	$2,051,040	$938,160
3	$127,850	$2,738,250	$84,870	$2,950,970	$1,209,480
4	$851,670	$922,300	$0	$1,773,970	$1,205,260

The results show that Option 1 is estimated to have the lowest overall life cycle cost with Options 3 and 4 having a very similar cost and about $300,000 more than Option 2 and $600,000 more than Option 1.

Option 4 has the lowest recurring costs and highest capital costs, whilst the reverse is the case for the Option 3 which is more clearly demonstrated in Figure 4.1.

It should be noted that the costs in Table 4.2 are total costs for the entire subdivision and that there are significant variations in cost of upgrading individual systems for each option. In particular there are large variations in individual costs for options one and two. In some cases significant upgrades are required, for others, no upgrades are required at all.

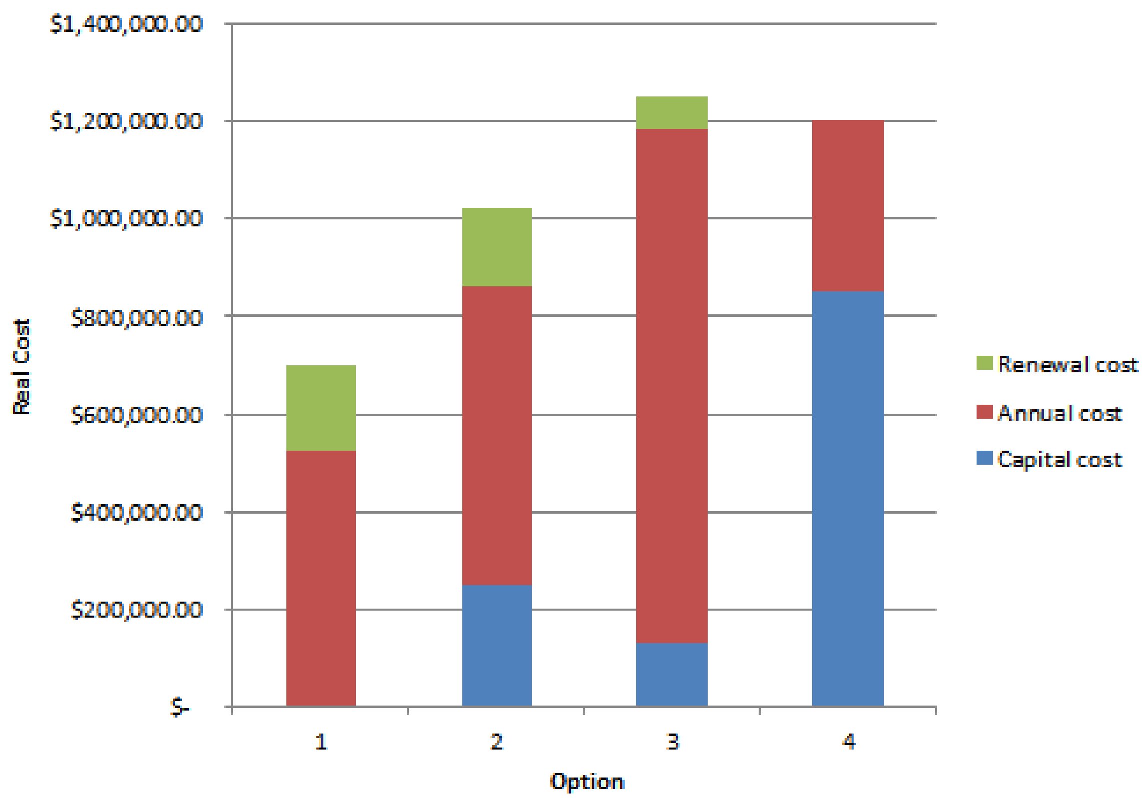


Figure 4.1: Comparison of 50 year life cycle costs forall four options.

5.0 RISK ASSESSMENT BETWEEN OPTIONS

The cost comparison outlined previously relies on the assumption that systems have been upgraded to best practice for each particular option. Nevertheless a risk of failure still remains. Two potential failure types are assessed:

1. Failure as a result of environmental conditions, i.e. failure as a result of flooding, high water table, high rainfall and other environmental conditions.
2. Failure as a result of operational failure, i.e. failure due to a lack of maintenance, mechanical component failure or failure of pipework or storage systems.

We have used these two modes of failure to outline the relative risks of each option. We realise that the failure definitions are broad. However, a more nuanced analysis of a bigger range of potential failure types would likely show a similar difference in risk, in that a system designed and operated by Council's Shoalhaven Water Group is likely to have a lower risk to the environment than a system operated and managed by home owners.

The risk assessment shown Table 5.1 is based on the likelihood and consequence criteria and risk matrix in Tables D.1 and D.2 in Appendix D and show that the higher level of control associated with Option 4 make that option a lower environmental and health risk than Options 2 and 3. Moreover it is noted that options 2 and 3 do not reduce the level of risk for the high category.

Table 5.1 Failure risk for options

Option	Failure due to environmental conditions			Failure due to operational failure		
	Consequence	**Likelihood**	**Risk**	**Consequence**	**Likelihood**	**Risk**
Option 1	Moderate	Likely	High	Moderate	Likely	High
Option 2	Moderate	Occasionally	High	Moderate	Likely	High
Option 3	Moderate	Occasionally	High	Moderate	Occasionally	High
Option 4	Moderate	Unlikely	Moderate	Moderate	Unlikely	Moderate

6.0 DISCUSSION

As discussed in Section 4.1.1 Option 1 (do nothing) is not considered a feasible option from an environmental perspective and was included to allow a comparison of the life cycle costs associated with the ongoing operating costs of the existing systems. Option 1 is therefore not discussed further.

Whilst the results of the life cycle costing show that Option 2 is the most cost effective option there will always remain a higher environmental and associated social and economic risk associated with self-managed on-site wastewater management systems (Options 2 and 3) compared with a sewerage system managed by Council's Shoalhaven Water Group (Option 4), as highlighted in Section5.0 .

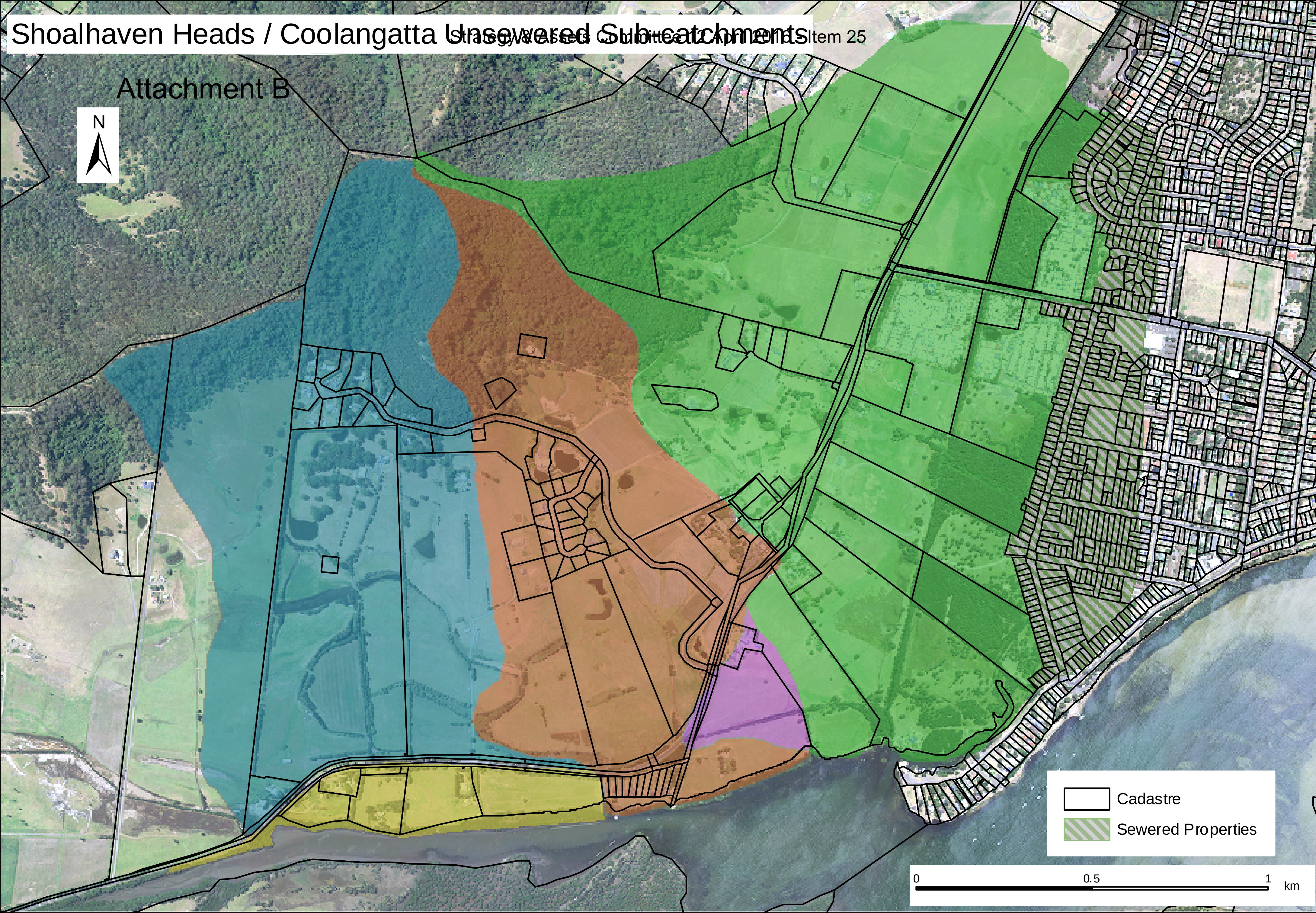
The complexity of on-site systems, (Option 2) combined with their number and lack of operator experience presents numerous opportunities for failure. The consequences of failure are exacerbated by the site constraints such as high water tables, proximity to watercourses and waterlogging. The risk of system failure is reduced by the upgrades outlined for Option 2, but nevertheless continues to exist.

Option 3 has a slightly lower likelihood of operational failure than compared to Option 2 given the lower complexity of the system, and the lack of an on-site disposal system. However, these systems are still operated by property owners, and as such are at risk of overflow and leakage without the owners, or Council's knowledge.

Option 4 has the lowest risk of the three options as it less likely to fail due to environmental issues, primarily due to its fully sealed fibreglass or plastic tank. Operational failure is also less likely as Council's Shoalhaven Water Group will have Environmental Management and Quality systems in place to ensure systems are operating effectively, and that any failures are addressed quickly.

The cost difference between Option 2, the cheapest option (discounting Option 1 as discussed above) and Option 4, the lowest risk option, is about $270,000 over 50 years (or $5,400/year). Whilst not quantified, the economic costs associated with the closure of the estuary, or the health impacts of consumption of contaminated shellfish, or the environmental costs of estuary pollution, the dollar value of a single occurrence of one of these impacts would likely exceed the difference between Option 2 and Option 4 ($270,000).

The prevention of one additional contamination occurrence over 50 years by implementing the lower risk Option 4 would make it the cheaper option. Given the previous failure rate of on-site and pump out systems, the prevention of at least one contamination occurrence over the next 50 years is likely if a reticulated system is installed. In the long term Option 4 would be the most cost effective approach from an economic, environmental and community health perspective.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