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Greater Taree City Council On-site Sewage Management Technical Manual

Final Report

R.N2091.001.02_OSSM_Technical_Manual_GTCC

October 2012

Greater Taree City Council On-site Sewage Management Technical Manual

Prepared For:	Greater Taree City Council
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Title :	Greater Taree City Council On-site Sewage Management Technical Manual
Authors :	Ben Asquith, Daniel Williams, Jack Sharples
Synopsis :	This manual presents a technical justification for the revision of Council policy relating to the planning and approval of on-site sewage management systems in the Greater Taree Local Government Area (LGA). This includes the unsewered development of land through rezoning and subdivision. Spatial analysis, hazard mapping and catchment modelling have been used to a) classify unsewered land according to the minimum level of technical investigation required for the approval of a development; b) nominate a minimum lot size based on analysis of local development characteristics; and c) evaluate the long-term sustainability of on-site systems for different existing and greenfield areas within the LGA based on the prevention of localised and broader cumulative impacts. This Technical Manual also contains guiding information and useful resources for fulfilling the obligations of the Development Assessment Framework.

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1 INTRODUCTION

BMT WBM has recently completed a project entitled *Sustainable Development of On-site Sewage Management Systems in Greater Taree* on behalf of Greater Taree City Council (Council). The project involved a broad scale land capability assessment of the Greater Taree Local Government Area (LGA) to establish local benchmarks for safe, effective on-site sewage management incorporating issues such as land capability, cumulative impacts (lot density) and minimum lot size. This technical basis for sustainable on-site sewage management was then used in the formation of a Development Assessment Framework (DAF) for the assessment and approval of on-site sewage management systems and unsewered developments generally. The DAF streamlines the approval process for on-site systems located in lower risk areas. It also provides clear guidance on the supporting information and Minimum Standards required for higher risk locations.

1.1 Aims and Objectives

This *On-site Sewage Management Technical Manual* (the Technical Manual) has been prepared to;

- document the broad scale land capability assessment process as a technical basis for on-site sewage management policy development; and
- provide guidance on scientific and engineering principles and techniques that can be used to demonstrate compliance with the DAF (particularly with regard to High and Very High Hazard allotments).

The main objectives of the Technical Manual are as follows.

- Provide a transparent technical rationale for the On-site Sewage Management Hazard Map, minimum allotment size and cumulative impact determinations.
- Describe and demonstrate the use of specific methods / tools in the assessment of on-site sewage management system applications.
- Describe and demonstrate the use of specific methods / tools to undertake cumulative impact assessments for unsewered developments involving an increase in building entitlements and non-domestic systems.

1.2 Use of the Technical Manual

This Technical Manual is designed primarily for use by environmental / engineering consultants completing wastewater management investigations on behalf of applicants for installation of individual on-site systems and unsewered development applications involving an increase in building entitlements. Specifically it may be used to;

- confirm or assess the basis for On-site Sewage Management Hazard Class for a particular lot;
- confirm or assess the basis for minimum allotment sizes / maximum densities included in the DAF;
- undertake more complex assessment and design procedures required for High and Very High Hazard lots; and
- undertake a site specific cumulative impact assessment to determine maximum lot density / minimum lot size.

2 BACKGROUND

The diversity of bio-physical conditions observed across Greater Taree (and many other LGA's) limits the opportunities for a 'one size fits all' approach to on-site sewage management. Diversity is increased once consideration is given to the variation in the nature and extent of unsewered development. Council have previously investigated ways to standardise approval and regulatory processes for on-site systems in the face of this variation.

Council currently consider the suitability of a proposed on-site system for a site on a case by case basis. Most applications to install or alter an on-site system are required to be supported by a "geotechnical" or site assessment report. These reports (for the purpose of this Study they will be called Wastewater Management Reports) provide a more detailed evaluation of site and soil constraints to on-site sewage management in addition to guidance on selection of an appropriate treatment and land application system. They also typically include calculations to determine the minimum size of land application areas.

There is typically considerable variation in the structure and quality of Wastewater Management Reports (WMR) submitted to Greater Taree City Council. In some cases insufficient supporting information or evidence is provided in the Report to enable Council to approve the proposed system with confidence. NSW legislation (*Local Government Act 1993*) and guidelines (DLG, 2008) effectively apply a performance based approach to preparation of WMRs. The revised *ASNZ1547:2012* does offer more detailed guidance on the key content and assessment requirements for WMRs. However, this document is not an adopted code in NSW and cannot strictly be enforced on its own.

There are limited resources within Council and the community available to complete and assess site and soil assessments and WMRs for on-site systems. As such, opportunities to standardise streamline and justify minimum standards for on-site system approval will offer significant benefits.

This Study presents the outcomes of a detailed broad scale land capability assessment of the Greater Taree LGA that helps define the likely constraints to sustainable on-site sewage management on a lot by lot basis. It also provides technical justification for establishment of a risk based approach to the assessment and approval of on-site systems. Where risks are low Council may adopt reduced assessment and design standards or potentially offer a "deemed to comply" approach. Where risks are higher or uncertain the outcomes of this Study can be used to support requests for more comprehensive levels of assessment and design.

In commissioning this project, Council identified the need for an assessment framework for on-site systems that balances adaptability to the diverse range of circumstances faced by system owners with the provision of a clear set of requirements for the approval of new and upgraded on-site systems and unsewered development. BMT WBM has utilised a range of best practice tools and information relating to on-site sewage management to complete a revised broad scale land capability assessment and make determinations on sustainable lot sizes and densities for unsewered development. The outcomes of this work have been used to establish a Development Assessment Framework for on-site sewage management that is integrated with Council policies and plans.

3 STRUCTURE OF THE DEVELOPMENT ASSESSMENT FRAMEWORK

The Development Assessment Framework (DAF) has been developed to better integrate the design, approval and construction of On-site Sewage Management Systems (OSMS) into broader development planning requirements and provide a standardised and clear process for applicants, designers and installers. The OSMS DAF incorporates Minimum Standards and Acceptable Solutions for each of the four On-site Sewage Management Hazard Classes. It covers applications to install or alter individual on-site systems (domestic and non-domestic) and Development Applications (DA) that increase building entitlements on unsewered allotments. It is designed as a ready reference for system installers and environmental consultants who design on-site systems. This DAF also refers to other council policy and guideline documents in addition to external technical publications that will assist in meeting Councils Minimum Standards and Acceptable Solutions.

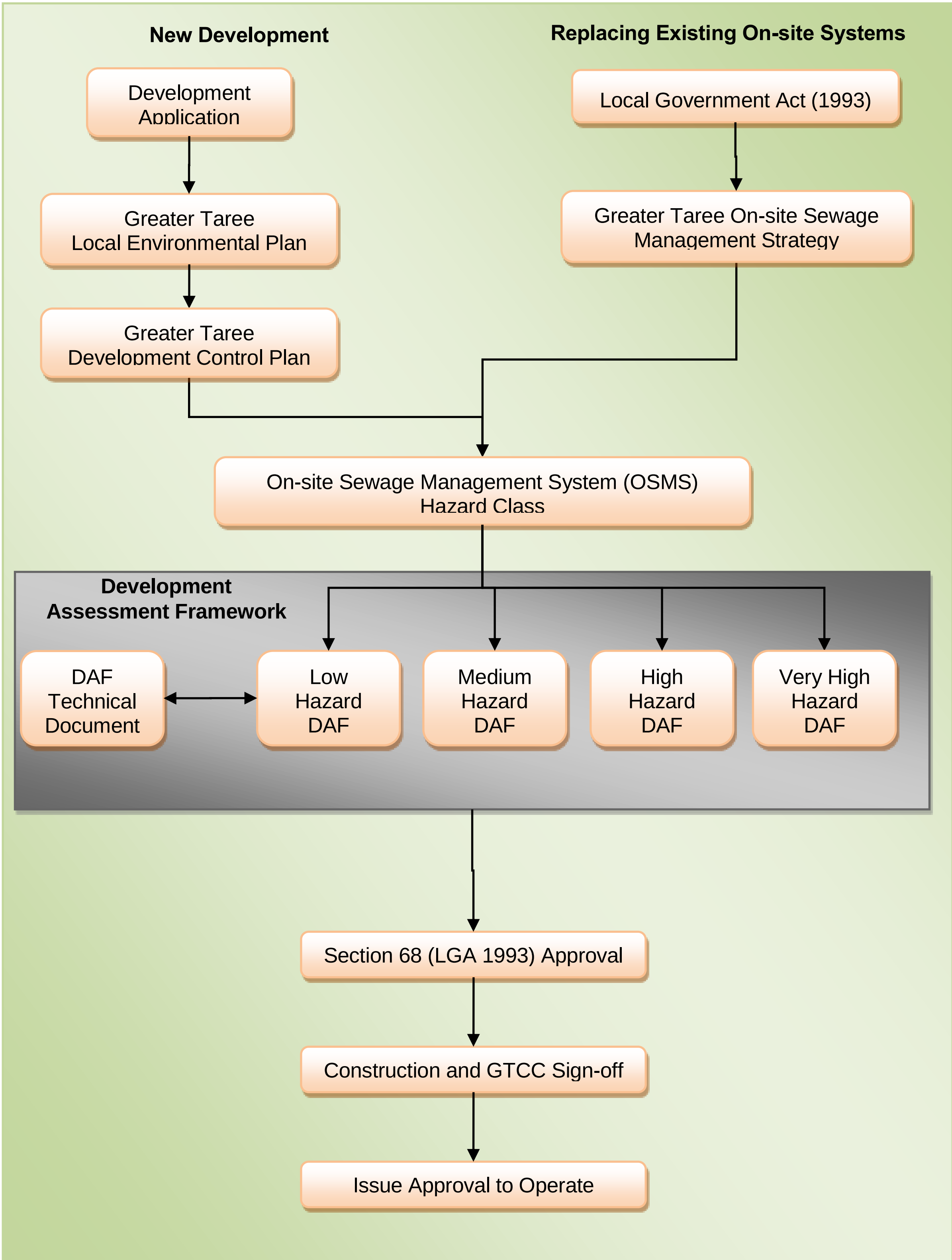
A checklist is provided for each Hazard class that can be used to confirm if the proposed on-site sewage management system or unsewered subdivision meets Councils Minimum Standards and Acceptable Solutions standards. **Where an application meets these standards, approval will be granted promptly. If not, further information will be requested by Council to allow approval.**

Minimum Standards apply to all aspects of the assessment, design and approval process and are divided into the following components.

- Site and Soil Assessment:
- System Selection and Sizing:
- Constructability:
- Increasing Building Entitlements.

The DAF document sets out how applications to install on-site sewage management systems and development applications that increase existing building entitlements can meet Minimum Standards and Acceptable Solutions and recommends resources, tools, standards and guidelines to be used in demonstrating compliance. **An application to install an individual on-site system or unsewered subdivision is unlikely to be approved where an applicant fails to use the recommended resources, tools, standards and guidelines to demonstrate compliance.** Notwithstanding, the DAF does provide flexibility for individual applicants to develop innovative or site specific on-site system designs by allowing for a performance based approach where clear justification is provided and a specific level of assessment and design is undertaken.

In the majority of cases, Councils DAF will reduce the uncertainty associated with how much information is required for approval and streamline / expedite the approval process. However, where specific applications are clearly in contrast to Councils objectives for sustainable and cost appropriate on-site sewage management, the DAF will also make it clear what additional information is required for Council to approve the system / development.


New Development
Replacing Existing On-site Systems
Development Application
Local Government Act (1993)
Greater Taree Local Environmental Plan
Greater Taree On-site Sewage Management Strategy
Greater Taree Development Control Plan
On-site Sewage Management System (OSMS) Hazard Class
Development Assessment Framework
DAF Technical Document
Low Hazard DAF
Medium Hazard DAF
High Hazard DAF
Very High Hazard DAF
Section 68 (LGA 1993) Approval
Construction and GTCC Sign-off
Issue Approval to Operate

4 TECHNICAL BASIS FOR THE FRAMEWORK

The technical basis for the DAF is founded in the following key components.

- Assignment of an On-site Sewage Management Hazard Class to unsewered lots in the LGA based on a range of bio-physical and built characteristics. A separate hazard class was assigned for individual on-site sewage management and increases in building entitlements on unsewered lots. These hazard classifications provide a general guide to the potential for hazards to impair the performance of on-site systems.
- Identification of sustainable minimum allotment size(s) that ensure sustainable, safe and efficient sewage management can take place for the life of a development.
- Determination of maximum sustainable on-site system densities for new unsewered developments designed to provide a high level of protection from cumulative impacts on ecosystems and human health.
- Identification of key existing unsewered villages / areas where the capacity for sustainable on-site sewage management is limited and alternative servicing scenarios should be considered.
- A set of Acceptable Solutions for on-site sewage management on Low and Medium Hazard allotments that allow Council to promptly approve systems/developments with confidence that they will deliver long-term sustainability.

Chapters 5 to 8 of this Technical Manual document the rationale, methodology and outcomes of these four elements of the DAF.

5 ON-SITE SEWAGE MANAGEMENT HAZARD MAPPING

The use of Geographical Information System (GIS) analysis has enabled Council to undertake a revised broad scale land capability assessment of all unsewered lots in the LGA. The process is similar to the site and soil assessment process typically undertaken for single lots and unsewered subdivisions as guided by DLG (1998) and *ASNZS1547:2012*. The availability of a wider range of data sets which, in some cases are of greater accuracy has allowed the GIS analysis and mapping process to be vastly improved on initial approaches. Mapping has incorporated a wide range of built and natural features of the LGA into assignment of On-site Sewage Management Hazard Classes for all unsewered allotments.

Derivation of the final On-site Sewage Management Hazard Class involved comprehensive analysis of a range of individual parameters that typically influence the sustainability of on-site systems. This analysis required a range of hazard classes (e.g. low, medium and high) to be assigned to each parameter based on the degree to which general conditions observed on a site influence the design, construction and operation of systems. Hazard class represents a relative assessment of the likelihood and consequence associated with a particular condition. A simple example is provided by slope. Sites with slopes less than 10% typically do not restrict options for the design, construction and operation of on-site systems and as a result a Hazard Class of 1 (Low) is assigned. Sites with slopes greater than 20% severely restrict options for sustainable on-site sewage management and as such a Hazard Class of 3 (High) is applied.

The method for assessing land capability was undertaken in two stages. Initially, a base hazard level was derived using soil, slope and climate inputs. This process has been limited to consideration of these three fundamental parameters for the following reasons:

- Insufficient data was available for the Study Area to enable more detailed parameters to be evaluated:
- Soil (particularly depth to rock or groundwater), slope and climate constraints are the dominant factors influencing land capability for on-site wastewater management in Greater Taree (and most locations):
- BMT WBM has previously developed a robust, groundtruthed risk assessment matrix using these parameters that has been thoroughly tested in adjacent LGAs.

This base hazard (Stage One) class represents the constraints to design, construction and operation of an effluent land application area (i.e. hazards that influence the relative risk of failure). Stage Two then involved adjustment of this base hazard level based on the proximity to and sensitivity of receiving environments (i.e. the likely consequence of any failure).

Stage one of the process utilised three spatial data layers:

- Soil Landscape Hazard – derived from the soil facet mapping undertaken for this Study and associated soil characteristics. The logic for assignment of soil hazard class is documented in Section 5.1.1 and Appendix A;
- Climate Hazard – derived from the soil parameters and monthly rainfall data. The logic for assignment of climate hazard class is documented in Section 5.1.2; and

- Slope Hazard – derived from the Digital Elevation Model. Areas where slopes are <10% were assigned a low hazard level, 10-15% as a medium hazard, 15-30% as a high hazard and >30% as a very high hazard.

These three layers were combined to assign an initial land capability hazard level using the matrix presented in Table 5-1.

Table 5-1 Stage One Land Capability Assessment Matrix

			Slope Hazard			
			Low (<10%)	Medium (10-15%)	High (15-30%)	Very High (>30%)
Soil Hazard: Low	Climate Hazard	Low	Low	Low	High	Very High
		Medium	Low	Medium	High	Very High
		High	Medium	High	Very High	Very High
Soil Hazard: Medium		Low	Low	Medium	High	Very High
		Medium	Medium	High	Very High	Very High
		High	High	Very High	Very High	Very High
Soil Hazard: High		Low	Medium	High	Very High	Very High
		Medium	High	Very High	Very High	Very High
		High	High	Very High	Very High	Very High

The initial hazard levels from the matrix were then adjusted where an area was within a specified proximity to sensitive receptors. A proximity hazards layer (Stage Two) was derived from the data sources listed in Table 5-2.

Table 5-2 Stage Two Hazard Class Logic

Proximity Hazards	Proximity	Hazard Application
Watercourse	40m	Raise hazard class by 1 for each proximity hazard present. Total hazard capped at 4.
Waterbody	100m	
Floodprone land	Within	
Receiving Environments	**Proximity**	**Hazard Application**
SEPP14 Wetlands	100	Raise hazard class by 2 for each proximity hazard present. Total hazard capped at 4.
SEPP62 Aquaculture Zones	500	

For areas in proximity to the intermittent watercourses permanent waterbodies and flood prone land, the initial land capability hazard was increased by one level. For areas in proximity to SEPP14 Wetlands, SEPP62 Aquaculture Zones and potable water supply catchments, the initial land capability hazard was increased by two levels. Examples of the mapping methodology are presented in Figure 5-1 and Figure 5-2.

The final land capability map provided a hazard level ranging from low to very high for all locations in the Study Area. The land capability map for the Study Area is presented in Figure 5-3. The land capability map (in addition to being a useful output in itself) has been used in the evaluation of available area for effluent management in addition to on-site system performance modelling. The following flow chart summarises the On-site Sewage Hazard Map development process as detailed in the following sections.

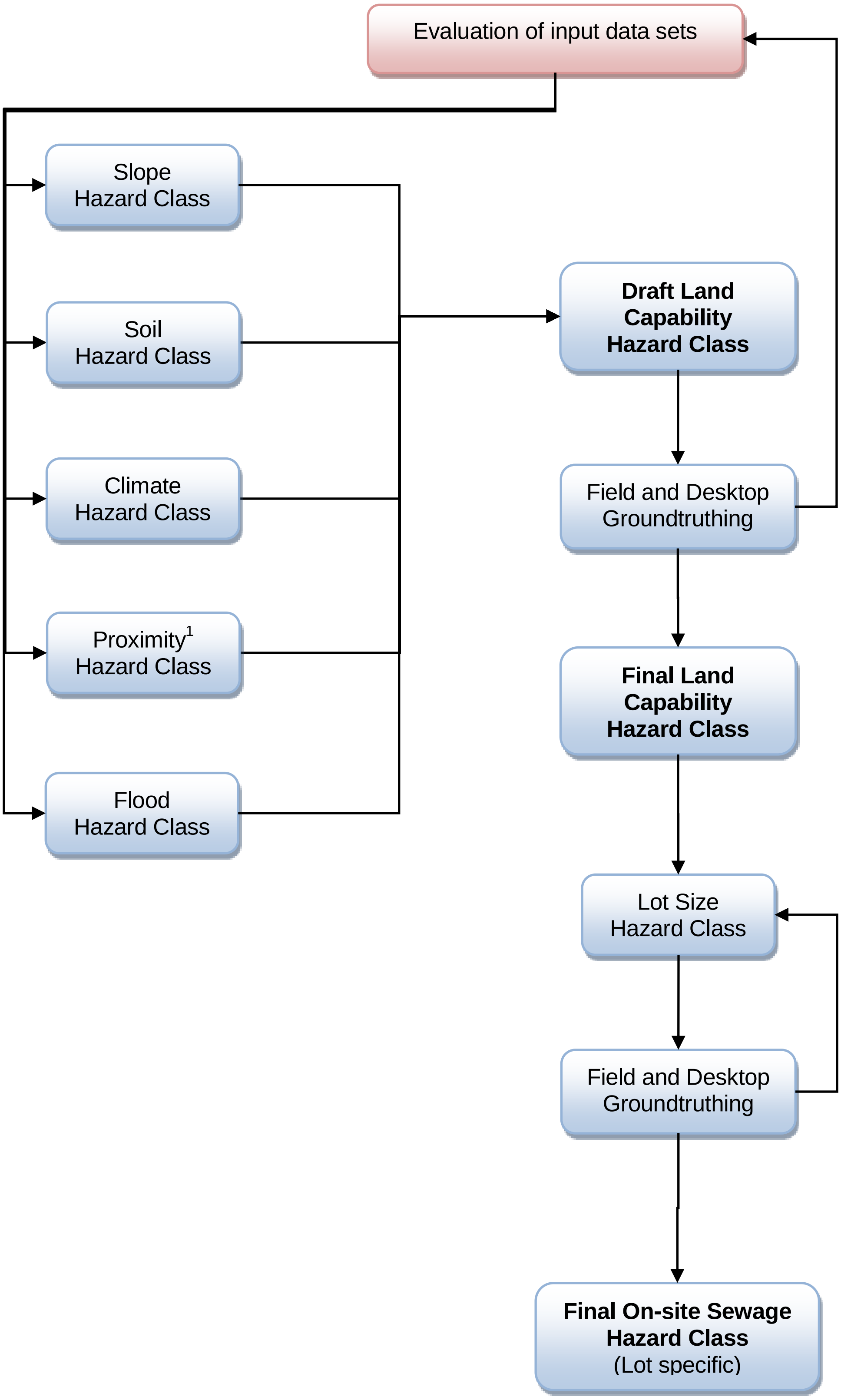
5.1 Input Data for Land Capability Mapping

Eight data sets were used in the creation of the land capability hazard map.

- Digital Elevation Model (DEM) created from LiDAR data (where available) and 10 metre topographical contours (NSW LPMA).
- Soil hazard map created through desktop and groundtruthing of HCCREMS (Banks, 2010) soil landscape mapping and NSW OEH SPADE profiles (refer to Section 5.1.1).
- Climate hazard map created through calculation of gridded monthly water balance for the entire Greater Taree LGA (refer to Section 5.1.2).
- The following data layers were supplied by Greater Taree City Council (or available from state government websites) for use as proximity hazards.
  - Major Waterways.
  - SEPP14 Wetlands.
  - Whole LGA Drainage (GDA).
  - Flood Planning Levels.
  - SEPP62 Priority Aquaculture Zones.

The land capability map was then finalized through the merging of adjacent polygon fragments which shared the same composite hazard class, to create larger continuous polygons of similar hazard class. The final Land Capability Hazard Map is shown in Figure 5-3.

More detailed descriptions of the key input data sets are provided in the following subsections.



Note 1: Includes proximity to watercourses, wetlands, aquaculture and drains.

5.1.1 Soil Hazard Map

Derivation of a single Hazard Class that encapsulates the range of soil characteristics relevant to on-site sewage management requires experienced judgement based on sound soil science principles. A good understanding of soil landscapes and their mapping is also important to ensure the Hazard Class acknowledges the uncertainty associated with broad scale soil landscape mapping. Notwithstanding, this soil Hazard Class is a broad scale parameter that provides a general guide to soil constraints likely to be present. It is accepted that the soil hazard map cannot and should not replace site specific investigations to design effluent land application areas. The DAF simply uses it as a risk based tool to guide the level of detail required for investigation and design of on-site systems.

Published soil landscape mapping from the NSW Government was not available for any areas within the LGA. To address this, unpublished mapping of soil facets was provided by HCCREMS in GIS and spreadsheet format (Banks, 2010). Classification of the mapped soil facets was based on existing NSW government soil survey where possible. Some areas required new field investigations to be undertaken. Unfortunately, most of the data attached to each soil landscape and sub-facet was not useable due to a lack of clarity in classification codes and a lack of any data at all for many of the soil landscapes in the GTCC LGA. Consequently, BMT WBM utilised the mapping layer along with supplied data and soil profiles available on the SPADE website (www.nratlas.nsw.gov.au) to complete a manual desktop assessment of each soil facet in the LGA.

There are 130 soil facets in the LGA and as such, assignment of a soil hazard for on-site sewage management was inevitably based on limited information. Notwithstanding, the project manager is familiar with the soils of the Greater Taree region and is confident that the assigned soil hazard classes are broadly applicable (i.e. at 1:100,000 scale). The basis for the soil hazard class is summarised in Table 5-3. A final soil hazard class was then derived using a weighted average score as summarised in Table 5-4. Weightings were based on the relative influence the various parameters have on the design, construction and operation of on-site systems.

A final soil hazard class was then derived using a weighted average score as summarised in the following table. Weightings were based on the relative influence the various parameters have on the design, construction and operation of on-site systems. Final soil hazard classes for all mapped soil landscapes in the GTCC LGA are presented in Appendix A and will be supplied as a GIS layer.

Table 5-3 Parameters Adopted for Derivation of Soil Hazard Class

Hazard Type	Parameter	Hazard Class	Description	
Depth Hazard	Profile Depth	Low	Greater than 2 metres profile depth	Greater depths of unsaturated soil provide increased treatment of effluent and reduced potential for lateral water movement.
		Medium	1 – 2 metres profile depth	
		High	Less than 1 metre profile depth	
Hydraulic Hazard	Texture	Low	Pedal loam to clay loam soils with mid-range permeability and moderate to free drainage.	
	Structure	Medium	Generally imperfectly drained, weakly structured clay loams and light clays or deep, rapidly drained sands (e.g. sand hills).	
	Indicative Permeability			
	Drainage	High	Generally, shallow, structureless clays and sands in either very rapidly or very poorly drained landscapes.	
Pollution Hazard	Nutrient Retention	Low	Generally soils with high cation exchange (CEC) and / or phosphorus sorption capacity, no sodicity potential and good organic content in topsoil.	
	Sodicity	Medium	Generally soils with moderate CEC, phosphorus sorption capacity, minor sodicity potential and moderate organic content in topsoil.	
	Organic Content	High	Generally soils with low CEC, phosphorus sorption capacity, sodicity potential and/or limited organic content.	

Table 5-4 Weighted Average Logic for Soil Hazard Class

Hazard Type	Hazard Scores (HS)	Weighting (w)	Calculation
Profile Depth	Low Hazard = 1 Medium Hazard = 2 High Hazard = 3	1.5	**Final Hazard Class** = [(Depth HS x w) + (Hydraulic HS x w) + (Pollution HS x w)] / 3 **Weighted average hazard classes** 1 – 1.5 = Low Soil Hazard 1.5 – 2.5 = Medium Soil Hazard 2.5 – 3 = High Soil Hazard
Hydraulic		1	
Pollution		0.5	

5.1.2 Soil Moisture Hazard Map (Climate)

The Soil Moisture Hazard Map (SMHM) was developed to provide a more meaningful assessment of the degree to which climate limits or enhances opportunities for the land application of effluent. It was adopted in preference to an assessment of rainfall and evapo-transpiration alone based on the significant variation in soil hydraulic properties observed across the LGA and the importance of soil water storage capacity and moisture content in effluent management.

The SMHM classifies the Greater Taree LGA based on the number of average climate months where soil moisture is above field capacity. This represents periods where significant deep drainage or surface surcharging of effluent is more likely to occur because evapo-transpiration is providing limited or no assistance in assimilating wastewater. Grid cells with limited or no average months with soil moisture above field capacity represent sites with good evapo-transpiration capacity available for effluent assimilation.

There are two stages in the development of the SMHM. Creation of mean monthly soil moisture grids followed by application of a hazard class to each grid cell based on the number of average months where soil moisture is above field capacity. Soils that are consistently above field capacity will have a higher likelihood of leaching (rapidly draining landscapes) of pollutants or saturation and surcharging of land application areas (slowly draining landscapes).

5.1.2.1 Creation of Mean Monthly Soil Moisture Grids

Mean soil moisture grids represent a continuous 1 year soil water balance

Baseline data layers include;

- 2.5 km^2 grid of mean monthly rainfall (BOM Climate Atlas);
  www.bom.gov.au/climate/averages/climatology/gridded-data-info/metadata/md_ave_rain_1961-90.shtml
- 10 km^2 grid of mean monthly areal Potential Evapo-transpiration grid (BOM Climate Atlas); and
  http://www.bom.gov.au/climate/averages/climatology/gridded-data-info/metadata/md_ave_et_1961-90.shtml
- Soil landscape polygon data file (MapInfo table).

The soil data required pre-processing in the form of insertion of the following data as four separate columns against each soil facet.

- Initial soil moisture (ISM) in mm;
- Field capacity (FC) in mm;
- Permanent wilting point (PWP) in mm; and
- Daily recharge rate (DR) as a decimal.

These data were inferred based on Gardner and Davis (1998) and Hazelton and Murphy (2008) based on soil profile descriptions from the Banks (2010) data or SPADE profiles. The daily recharge rate was adopted from MacLeod (2008) based on indicative hydraulic conductivity and drainage characteristics and represents the proportion of soil water above field capacity that drains following rainfall. The soil landscape vector dataset was converted to a raster format with a cell size of 40m, in order to retain a reasonable level of detail. The rainfall and evapotranspiration data for each month were converted from lat/long co-ordinates to an MGA projection and then interpolated on to the same 40m grid alignment as the soil landscape raster. The soil moisture calculations detailed below were undertaken using these 40m grid inputs.

Firstly, the following calculations were undertaken to produce the mean monthly soil moisture balance (mm).

January Calculation

$SM_{jan} = ISM + Rf_{jan}(1 - [C_v \times 0.8])$

Remaining Months

$SM_{feb.....} = SM_{jan} + Rf_{feb}(1 – [C_v \times 0.8])$ etc...

Where;

SM = Soil moisture for the month (mm);

ISM = Initial Soil Moisture (mm);

Rf = Rainfall (mm/month);

C_v = Runoff Coefficient (obtained from gridded BOM data); and

0.8 = adjustment for baseflow (rainfall that becomes streamflow via subsurface flow).

There are two other conditions / calculations to make depending on the answer to equations 1 and 2.

If SM < PWP then SM = PWP should be applied to each monthly calculation.

If SM > FC then final soil moisture = the greater of (SM x [1-DR]) or FC.

Where;

PWP = Permanent Wilting Point;

FC = Field Capacity; and

DR = Drainage Rate (from MacLeod, 2008).

The final output of this grid analysis was a single soil moisture value (mm) for each month of an average statistical year. The results of these soil moisture calculations were then used to determine an appropriate soil climate hazard level for each soil type.

5.1.2.2 Creation of Final Soil Moisture Hazard Map

The final SMHM (or climate hazard map) was created through classification of grid cells in accordance with the following logic.

Low hazard = 0 months with soil moisture ≥ field capacity.

Medium hazard = 1-3 months with soil moisture ≥ field capacity.

High hazard = 4 or more months with soil moisture ≥ field capacity.

Figure 5-1 to Figure 5-2 show the final climate hazard map and how it integrates with other hazards.

5.2 Derivation of Lot-Based Land Capability

Following the development of the land capability map, it was necessary to determine suitable land capability hazard classes for each lot within the LGA. This was undertaken through the intersection of the land capability map with the Council cadastral boundaries. Average land capability hazard class numbers were then calculated for each lot using an aerial weighted combination of the hazards from the land capability map. Average hazard class numbers were rounded to the nearest integer.

The final mapping output required two hazard maps to be produced – one for a single lot unsewered development and another for unsewered subdivision or rezoning. Critical lot sizes of 4,000 m^2 and 2,000 m^2 were adopted for final hazard class mapping. This is consistent with the outcomes of the *minimum lot* size assessment and maps for Port Stephens and Great Lakes. These hazard triggers are also generally consistent with the outcomes of cumulative impact assessments for existing unsewered allotments.

5.2.1.1 Single Lot

The following logic was applied to cadastral data to produce the single lot hazard class.

Lots >= 4000 m^2 = Average land capability hazard class number (for each lot).

Lots 2000 – 4000 m^2 = Greater of 3 (high hazard) and the average land capability hazard class.

Lots <2000 m^2 = Very high (4) hazard (regardless of land capability).

5.2.1.2 Multiple Lot

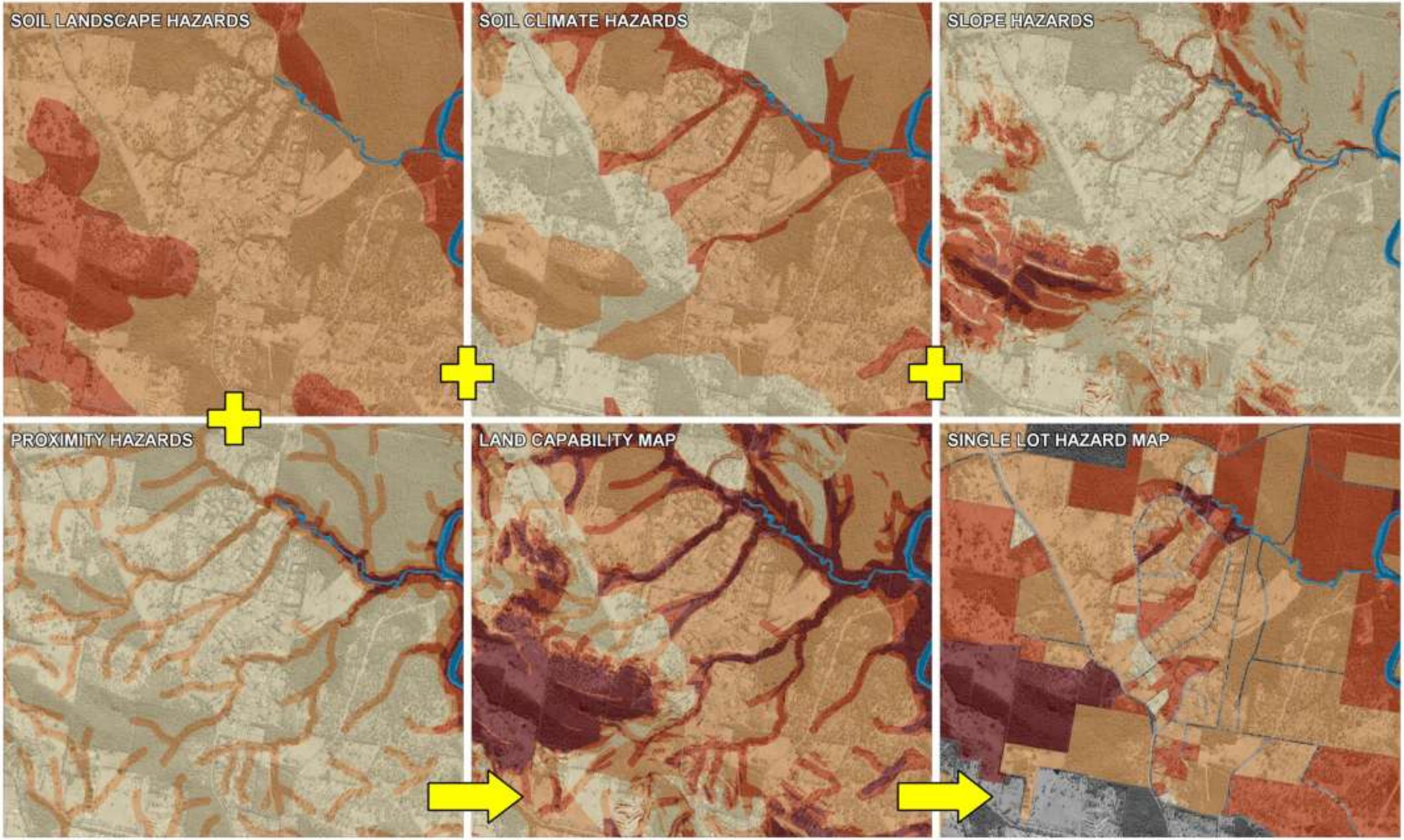
The following logic was applied to cadastral data to produce the multiple lot hazard class.

Lots >= 8000 m^2 = Average land capability hazard class number (for each lot).

Lots 4000 – 8000 m^2 = Greater of 3 (high hazard) and the average land capability hazard class.

Lots <4000 m^2 = Very high (4) hazard (regardless of land capability).

The following figures present the final Land Capability Hazard Map, Final On-site Sewage Management Hazard Maps and two example close ups illustrations of how the individual elements were combined to create the final maps.



LEGEND

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Water Bodies

Title:

Sustainable On-site Sewage Management in Greater Taree
Hazard Map Methodology at Cedar Party

Figure: **4-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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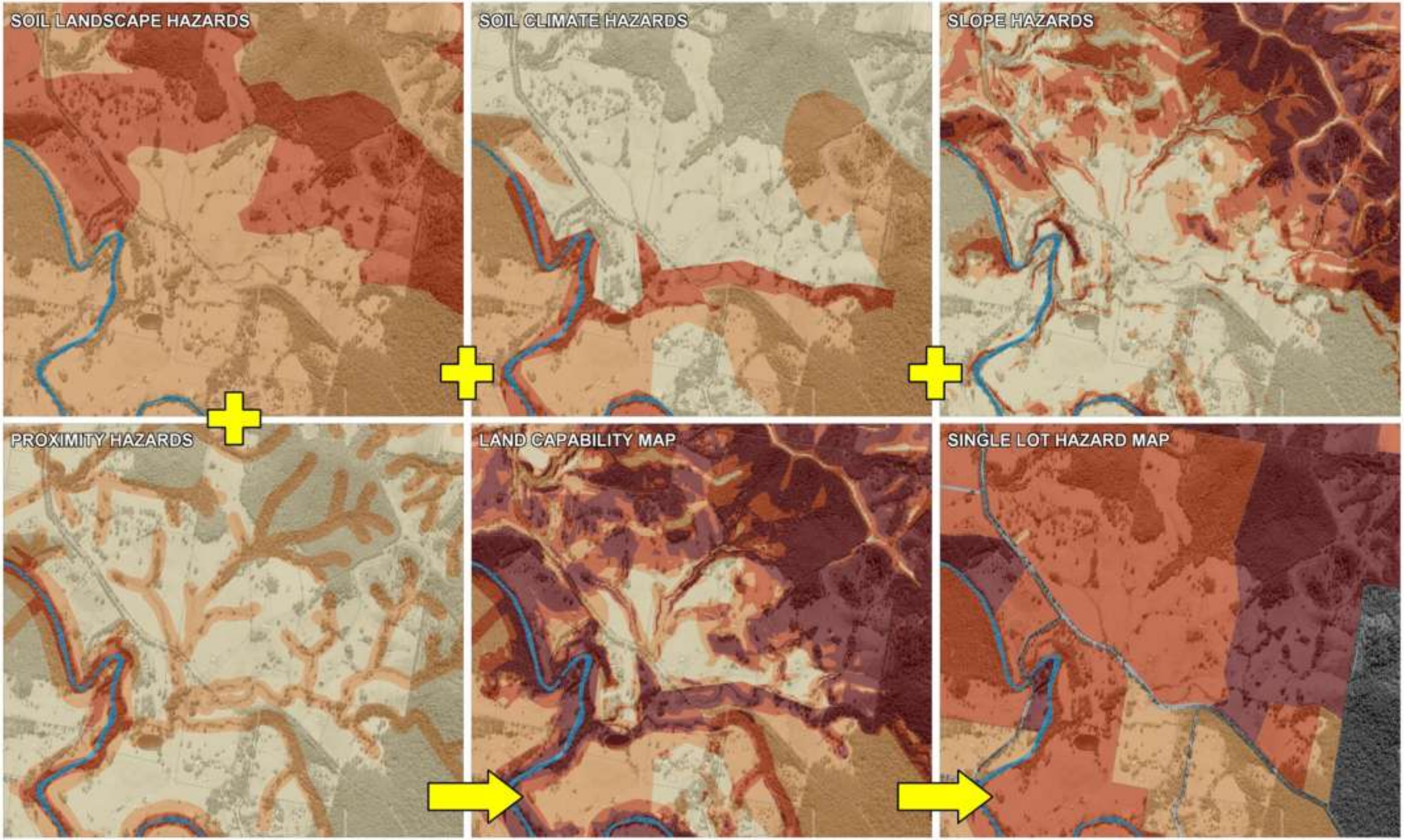

LEGEND

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Water Bodies

Title:

Sustainable On-site Sewage Management in Greater Taree
Hazard Map Methodology at Hillville

Figure: 4-2

Rev: A

N

0 375 750m

Approx. Scale

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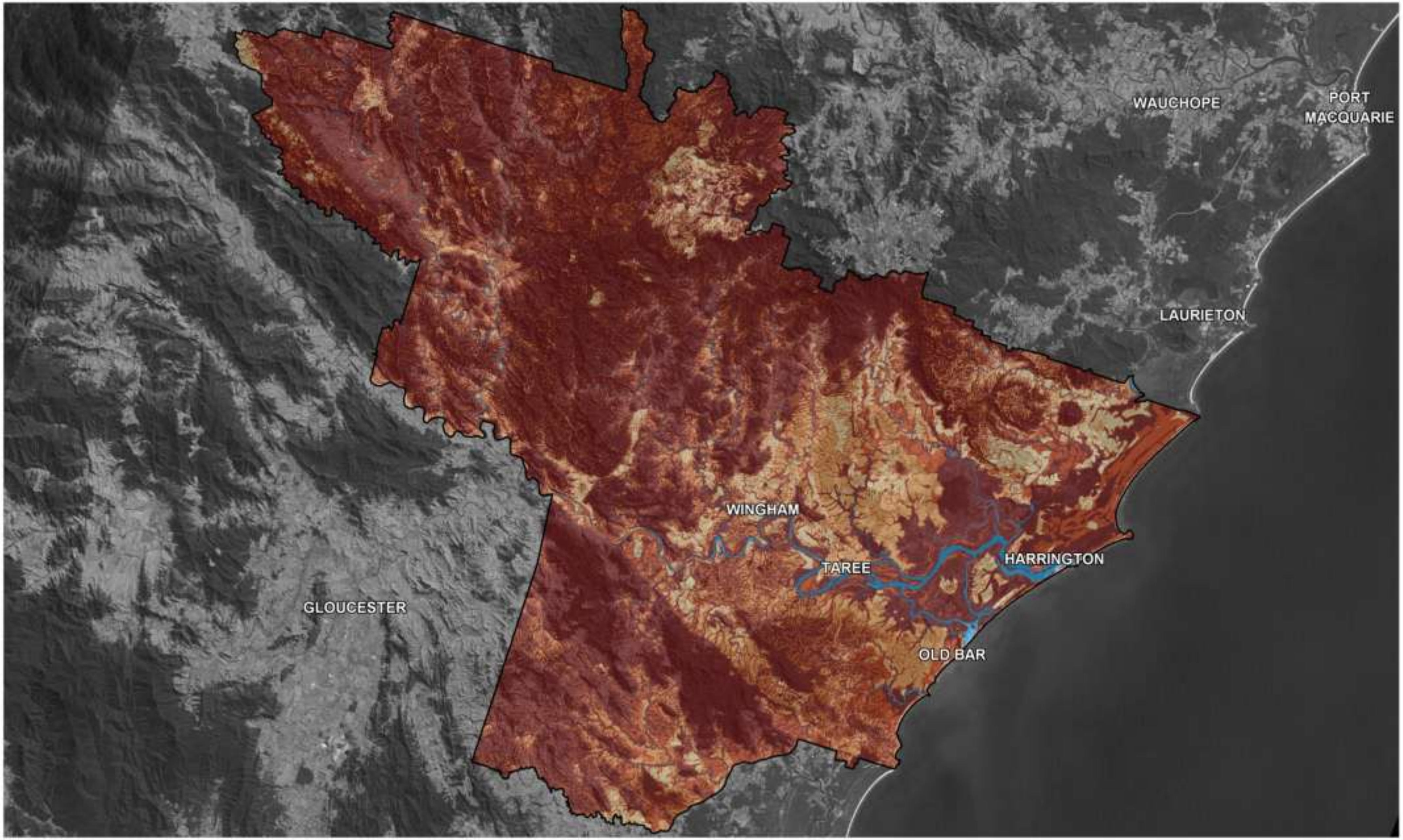

LEGEND

Land Capability Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Water Bodies

Title:

Sustainable On-site Sewage Management in Greater Taree
Final Land Capability Hazard Map

Figure: **4-3**

Rev: **A**

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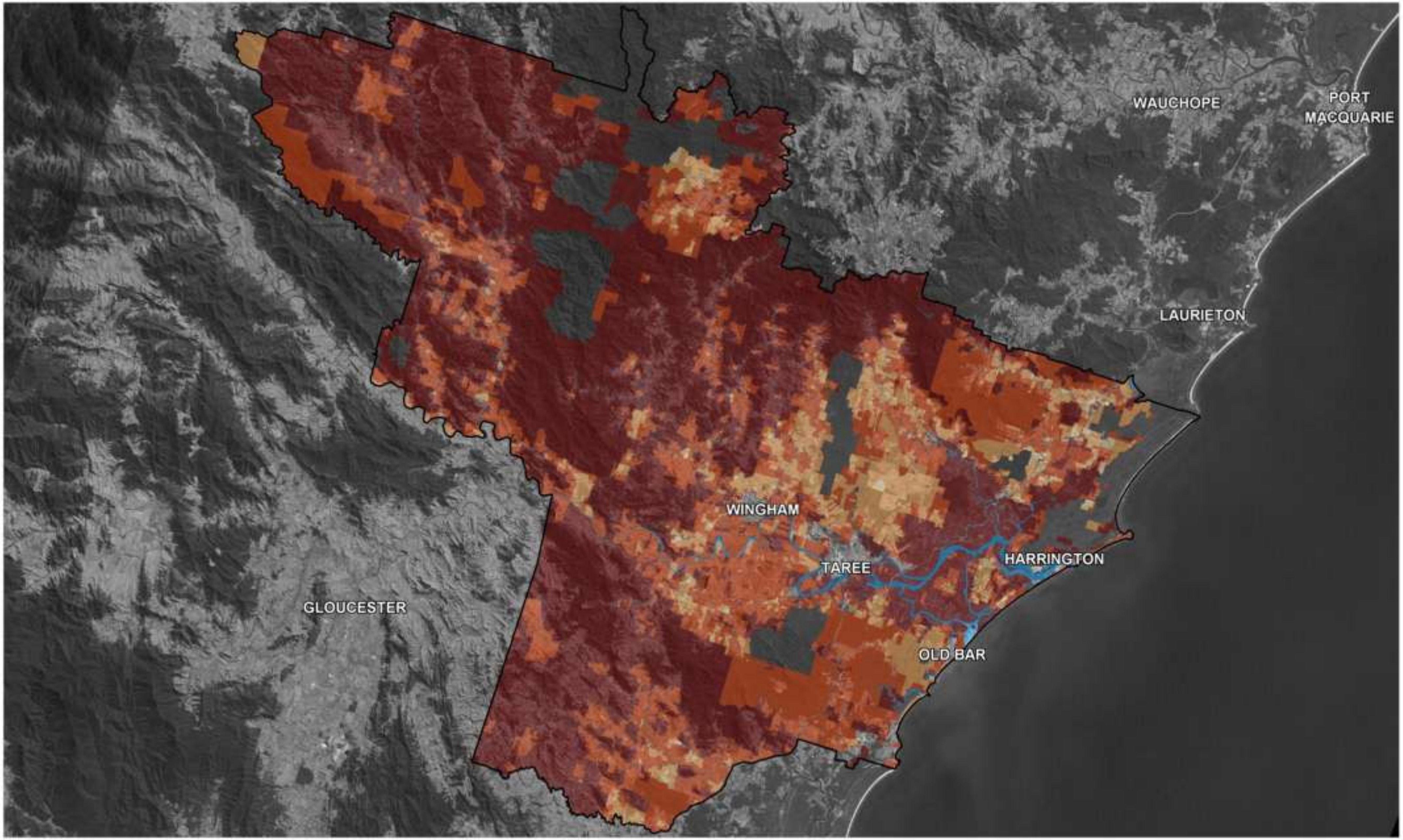

LEGEND

Single Lot On-site Sewage Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Water Bodies

Title:

Sustainable On-site Sewage Managment in Greater Taree
Final On-site Sewage Hazard Map (Single Lots)

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Figure: **4-4**

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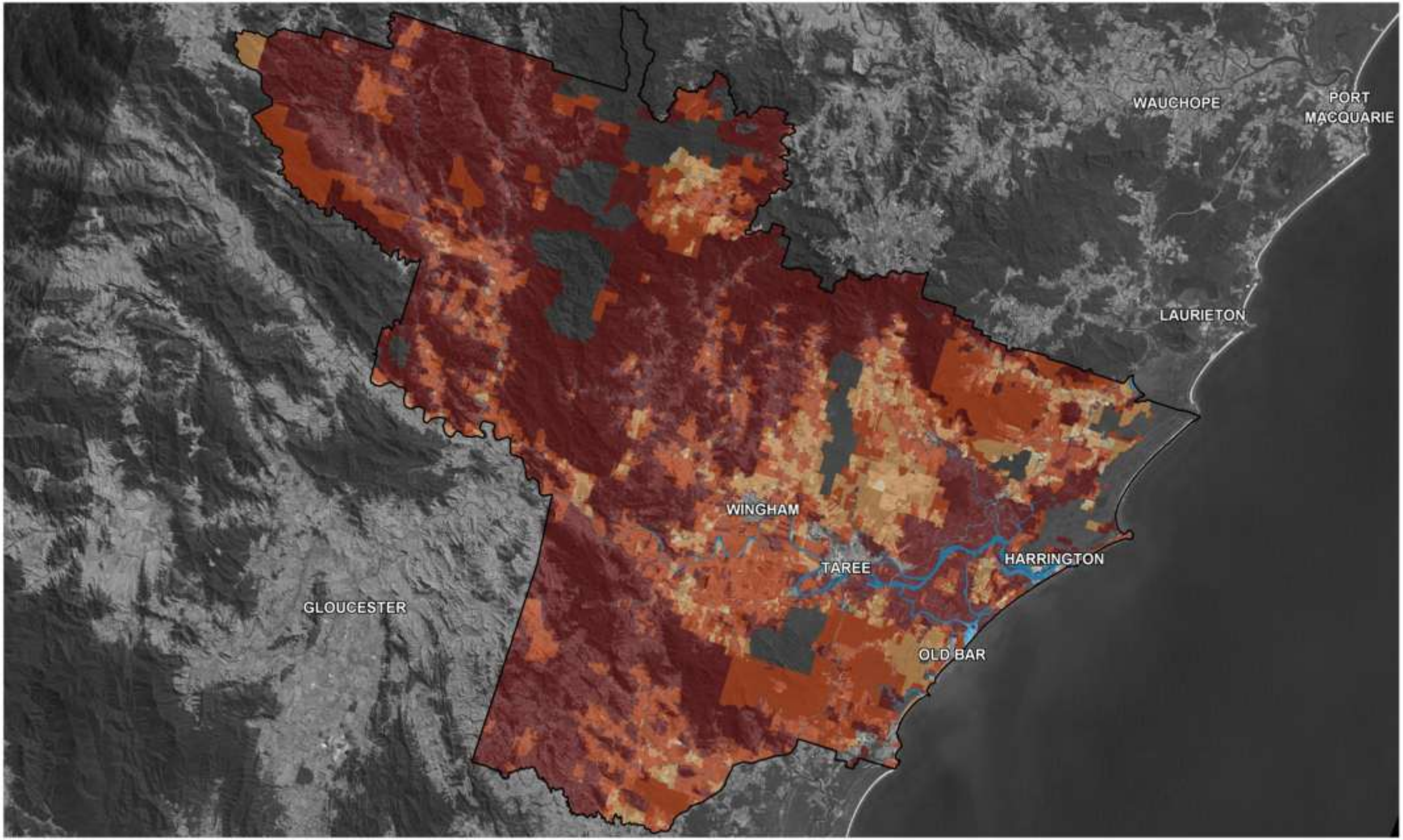

LEGEND

Multiple Lot On-site Sewage Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Water Bodies

Title:

Sustainable On-site Sewage Managment in Greater Taree
Final On-site Sewage Hazard Map (Multiple Lots)

Figure: 4-5

Rev: A

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5.4 Groundtruthing

BMT WBM conducted field groundtruthing of the land capability and on-site sewage management hazard maps in September 2011. Twenty sites were assessed based on the risk matrix and hazard classification protocol detailed in Section 5. Sites were selected to maximise benefits of field checking by;

- concentrating on locations where land capability inputs (i.e. the inputs subject to the most uncertainty) had the potential to influence the final Hazard Class;
- identifying sites where there was observed uncertainty in the individual parameters used to assign a hazard class (e.g. near a soil landscape boundary or area of variable slope); and
- concentrating on areas with higher densities of on-site systems or known performance issues.

Groundtruthing involved visual checking of each site against the matrix in Table 5-1 and Table 5-2. It also involved some checking of soil hazard class against key criteria set out in Section 5.1.1. Hazard maps were then checked via a laptop and GPS at each site with results recorded with supporting photography. The location of groundtruthing sites and results are presented in Appendix B.

The results found no significant discrepancies in the On-site Sewage Management Hazard Class. However, during field investigations it was identified that mapping of dams and other small waterbodies did not extend over the whole LGA. The majority of the northern and western sections of the LGA did not have coverage for dams. As such they were not picked up in the proximity hazard assessment. Efforts were made to determine if this data was available however with no success. It is also worth noting that very little groundtruthing of the HCCREMS soil landscape mapping was undertaken.

Other elements of the land capability map represented the actual situation very well.

5.5 Correction for Cadastral Inaccuracy

During data review and hazard map development a significant spatial error in the location of cadastral boundaries was detected within some areas (predominantly rural). In some cases this error was 30-50 metres and could have the potential to influence the final hazard class calculated for some lots. A GIS and desktop groundtruthing (i.e. via orthophoto inspection and Google Street View) process was developed that enabled the majority of cadastral errors to be rectified. The process undertaken was as follows.

- A 10 metre grid was created of the variability in Land Capability hazard Class within 50 metres of each grid cell. All lots with <2 hazard classes within 50 metres were excluded from the assessment.
- Lots less than 4,000 m^2 and greater than 10 hectares were excluded given the limited potential for land capability / cadastral error to influence final Hazard Class.
- Remaining lots were assessed via GIS and cadastral errors identified where they had potential to influence final Hazard Class.
- A working cadastral file was set up where these lots were adjusted based on orthophoto and LiDAR inspection to better reflect actual conditions.

- Average Land Capability Hazard Class was then recalculated for these erroneous lots only and the final Hazard Class amended accordingly.
- The final On-site Sewage Hazard Class layers were then given an adjusted and original Hazard Class. The adjusted class was adopted for mapping and includes corrections.

5.6 Limitations of Hazard Mapping

The final On-site Sewage Management Maps assign a Hazard Class to individual unsewered allotments in the Greater Taree LGA. It is important to recognise that this site specific Hazard Class was derived using a range of data collected at a range of scales. LiDAR data sourced for creation of slope grids provides a very high level of detail while soil landscape data was mapped at 1:100,000 scale and digitised. Essentially, the Hazard Class assigned to each lot should still be considered a broad scale on-site sewage management hazard. However, this does not preclude the Hazard Maps from being used to at the individual lot scale as long as consideration is given to limitations and uncertainty associated with scale and data source.

There is some uncertainty surrounding the quality and reliability of the soil landscape data supplied by HCCREMS. Where available, SPADE data was used to support the unpublished data set however there were some areas where no supporting soil data were available. It was also identified during the course of the Study that cadastral data for many of the rural areas within the LGA were inaccurate. Some allotments showed property boundaries that were misaligned by 20-40 metres. BMT WBM conducted a review of the On-site Sewage hazard Map to determine the degree to which this impacted on hazard class accuracy (refer to Section 5.5 for detail). The final Hazard Class was adjusted where errors altered the hazard class.

The DAF primarily uses the Hazard maps to guide the level of detail required in supporting information for applications to install on-site systems or unsewered development. They have not been used to prescribe site specific conditions of approval relating to system selection, design and construction. They simply establish a Minimum Standard of supporting information to ensure Council can be satisfied that a proposed unsewered development is sustainable. In fact, where broad scale hazard mapping has identified a higher risk, Council will require site specific investigations to be undertaken to confirm conditions. There will be a minority of occasions where these field investigations will identify lots where data scale and accuracy may have resulted in an inaccurate hazard classification.

A number of elements of the hazard mapping were undertaken to minimise the potential for data scale and accuracy to reduce the benefit of the On-site Sewage Hazard Maps.

- Extensive desktop and field based groundtruthing of the Land Capability and Final On-site Sewage Hazard maps throughout the LGA to confirm that land and allotments have been appropriately classified.
- Iterative testing and refinement of the hazard map development protocol based on the outcomes of groundtruthing.
- Adjustment of the final On-site Sewage Management Hazard Class in areas where cadastral data is highly inaccurate to ensure the mapping is based on best available data.

As a result of this study, all known unsewered lots in the Greater Taree LGA have been assigned an On-site Sewage Management Hazard Class. This Hazard Class provides a technically justifiable basis for setting requirements for supporting information to be submitted with applications for on-site systems and unsewered development.

6 MINIMUM ALLOTMENT SIZE

A review was undertaken of sustainable *minimum* allotment sizes for on-site sewage management within the Greater Taree LGA. Sustainable minimum lot size was considered to allow for typical levels of site development (based on applicable land use zoning) in addition to a conservatively sized land application system (using a mean monthly water balance) and provision of adequate separation distances from sensitive receptors.

Sustainable lot size was then compared with current minimum lot sizes specified in the draft Greater Taree LEP to determine the most appropriate way to integrate land use planning and wastewater management considerations. This included consideration of existing allotments and potential future rezoning and subdivision. Sustainable lot size was also compared to typical unsewered allotment sizes within existing areas to provide insight into the sustainability of existing villages.

The intention of this assessment was to establish a conservative lot size (or some other measure) that was considered adequate to provide Council with a high degree of confidence that an effective, safe and sustainable on-site sewage management service can be accommodated (with factors of safety).

6.1 Methodology

A conservative land area requirement for sustainable on-site sewage management was calculated by the following procedure. The procedure was applied using rainfall data from Forster and pan evaporation data from Taree. A review of the BOM gridded rainfall data indicated annual rainfall varies from ~1,100 – 1,500 mm/year. While it is accepted that some sites may experience higher seasonal rainfall that could influence land application area sizing, it was considered within the bounds of conservatism already factored in to the assessment.

1. A design occupancy of 6 persons for a 4 bedroom house (using reticulated water) was adopted to represent the typical design residential development scenario.

2. A typical system configuration of secondary treatment and subsurface irrigation was assumed. This scenario also allowed for primary dosed trenches and beds (discussed further below).

3. A mean monthly water and annual nutrient balance was undertaken based on the above occupancy assuming a Design Loading Rate (DLR) of 3 mm/day (Category 5 – light clays). This DLR was selected on the basis that it strikes an appropriate balance between conservatism and realism. In practical terms this results in an actual loading rate of 1.3 mm/day which is conservative.

The outcomes of these water and nutrient balance calculations were then used to examine minimum Effluent Management Areas (EMA) required for the majority of sites and dwellings likely to be encountered.

Following this, an assessment was undertaken of a sample of allotments within unsewered zones of the LGA. A total of 171 allotments were assessed to determine the capacity to provide available area for sewage management in addition to area occupied by development and separation distances from objects such as;

- building structures;
- driveways and paths;
- swimming pools and other dedicated recreational areas (e.g. tennis courts);
- land occupied by livestock or horses;
- property boundaries; and
- dams, intermittent and permanent watercourses.

The assessment was undertaken through orthophoto investigations and GIS creation of buffers around the abovementioned objects. Statistics on the area of land and proportion of total lot area occupied by each component (inclusive of buffers) were recorded for analysis. The 171 lots assessed were selected to provide a representative sample of typical development in unsewered areas including Cedar Party, John's River, Bohnock and Mt George.

Statistics obtained from this assessment were analysed to identify any patterns or relationships between lot size, land use zones and area available for effluent LAA's. Multiple scatter plots of lot size and the proportion of the lot unavailable for effluent management were created. This was completed for a number of allotment size ranges to determine relationships for these allotment ranges that could be applied LGA wide.

6.2 Results

Based on the outcomes of the water (checked against annual nutrient balances) balance assessment, an LAA of **650 – 850 m^2** is typically required. The "design" estimate (outlined in points 1 – 3 above) resulted in a minimum land application area of 840 m^2. Allowing for treatment tanks, required zoning of LAAs and other infrastructure required for an on-site system, the typical Effluent Management Area (EMA) was found to be ~1,000 m^2. Primary dosed trenches and beds (which are not always suitable for observed site and soil conditions) occupy approximately half the land area of a secondary dosed irrigation system. However, allowance for a reserve area must be made for primary dosed subsurface systems which results in a comparable land area requirement to that of a secondary dosed irrigation system.

The larger footprint is considered appropriate for planning purposes and allows for situations where issues such as irregular shaped areas and slope limit the proportion of available land that can actually be occupied by a land application system. It is important to note that the outcomes of this minimum allotment size assessment should not be used in a prescriptive or deterministic fashion. Individual applicants should be able to undertake additional site specific investigations to confirm the appropriateness of Council's general minimum lot size for their site.

A moderate relationship between lot size and land area unavailable for effluent management was observed in the total sample data (R^2 = ~0.6). The less than optimal correlation can largely be attributed to the reasonable number of lots (regardless of lot size) observed to be severely constricted by the presence of one or more of the following.

- A dam or intermittent watercourse.
- Open stormwater drains or pits.

- Permanent watercourses.

This sub-component of sampled lots appeared (through further orthophoto investigation and groundtruthing) to be typical of Rural and Rural Small Holdings zones throughout the LGA (refer to Figure 6-2 for examples). Testing of a number of minimum lot sizes ranging from 3,000 – 20,000m^2 found that examples of lots with insufficient area available for effluent management were observed until a minimum lot size of 18,000 m^2 was tested. Given that far too many lots less than 1.8 ha in area are easily capable of sustainable on-site sewage management it is not considered appropriate to adopt a 'most limiting' approach to establishment of minimum lot size.

Figure 6-1 contains the overall results of this analysis (sample size = 171).

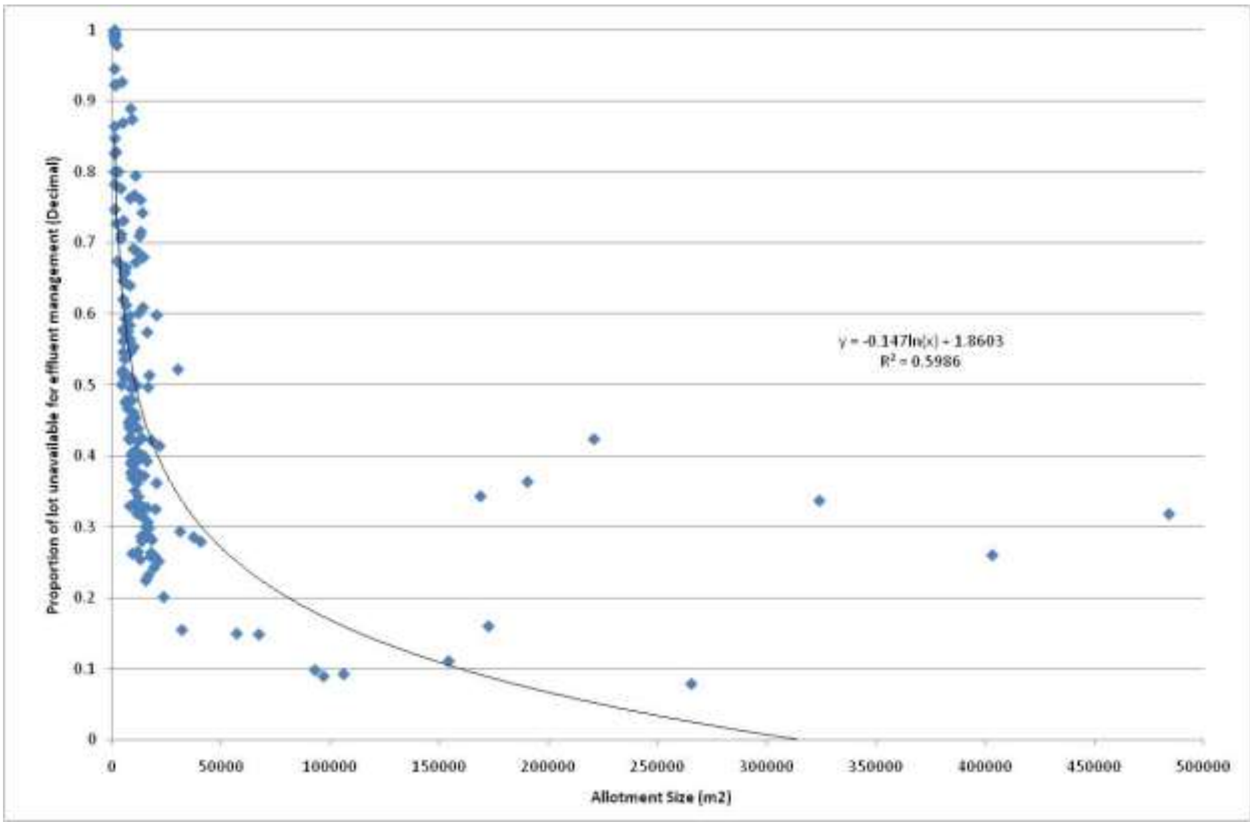


Figure 6-1 Overall Result of Minimum Lot Size Evaluation for Greater Taree LGA

The resulting equation in Figure 6-1 was then used to calculate a "typical" lot size required to provide sufficient land area (Effluent Management Area or EMA) for sustainable on-site sewage management. The size of this EMA was estimated to be 1,000 m^2 (as described above). This assessment was not intended to produce a worst case or most conservative LAA sizing; rather it represented a typical situation experienced within the LGA under design load conditions (i.e. four bedrooms at an occupancy of six people). Cumulative impact modelling of existing systems within the LGA has confirmed that actual occupancy and LAA performance is likely to be significantly underestimated by mean monthly water balances.

The resulting equation from the minimum lot size assessment was then used to estimate the typical lot size required to ensure a minimum of 1,000 m^2 is available for an EMA. This minimum lot size was calculated to be **2,900 m^2**. However, it is important to acknowledge the moderate correlation between lot size and available land for an EMA and the significant influence on available area posed by watercourses, dams and other major natural features.

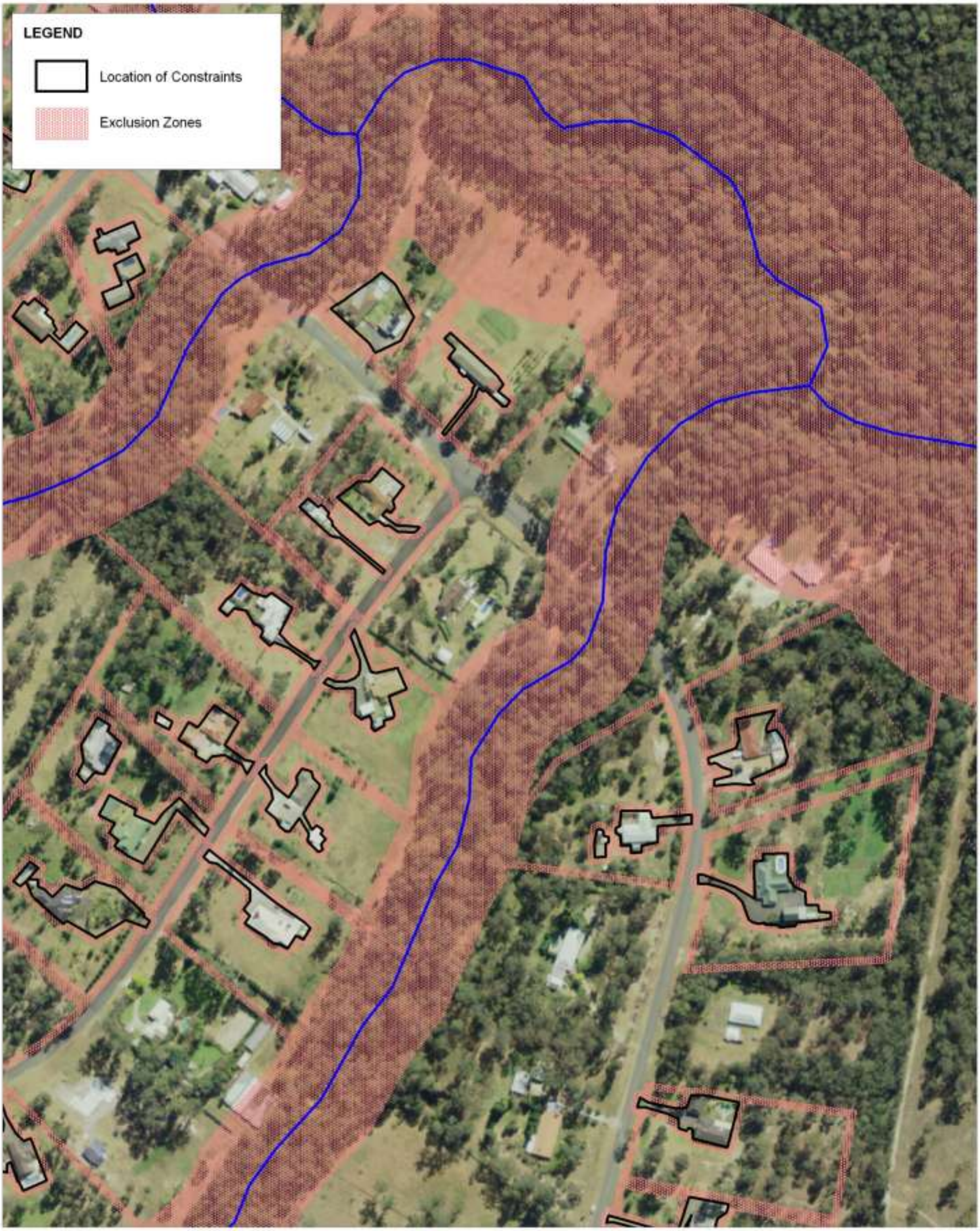
6.3 Outcomes

For the purpose of development planning, lot sizes greater than 2,900 m^2 are likely to be capable of fitting a sustainable on-site sewage management system within the allotment subject to careful site assessment and design purposes. However, based on the relatively small sample size and the major influence of watercourses, dams and other receiving environments, it is recommended that 2,900 m^2 of *useable land should be considered a minimum criterion*. Useable land (for the purpose of on-site sewage management) can be considered to be;

Total allotment area excluding dams, intermittent and permanent watercourses and open stormwater drains and pits in addition to the relevant buffer distances prescribed in the GTCC On-site Sewage Management DAF for those objects.

This number needs to be considered in conjunction with lot sizes for prevention of unacceptable cumulative impacts (see Section 7). In the case of GTCC, the new LEP is likely to prevent lot size becoming a constraint to unsewered development for new subdivisions and rezoning's. However, development within and immediately surrounding existing village zones may have the potential to trigger lot size concerns.

An additional advantage of adopting the Useable Land classification is that it eliminates need to alter or interfere with minimum allotment sizes as set out in the LEP. The application of Useable Land is significantly more flexible and will allow site specific opportunities (e.g. a small site with few constraints and limited development) and constraints (e.g. a significant intermittent watercourse running through the middle of a smaller site) to be considered.



Title:

Example of Minimum Allotment Size Assessment Procedure

Figure: 6-2

Rev: A

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7 CUMULATIVE IMPACTS (ON-SITE SYSTEM DENSITY)

The previous chapter summarised the process followed to establish a *minimum allotment size* based on ensuring lots have sufficient usable land to contain a sustainable on-site sewage management service. In addition, consideration should also be given to on-site system density. The range of natural and built environments throughout the LGA display different capacities to receive and safely assimilate effluent loads from on-site systems. A third element of this study involved the application of a methodology for assessing cumulative impacts from on-site systems that strikes a balance between useability, technical rigour and the ability to account for critical factors influencing the impact of multiple systems on a receiving environment.

Local Councils are faced with a great deal of uncertainty when assessing and predicting the long-term performance of existing and proposed decentralised (on-site and cluster) wastewater management systems. Financial resources are rarely available for collection of sufficient field data to isolate and quantify the magnitude and frequency of impacts from existing systems with adequate certainty. In the case of *proposed* decentralised systems, there is no field data to collect. These limitations have led to the development of a range of water cycle modelling tools to assist in decision making by shedding some light on areas of uncertainty. When used in conjunction with realistic amounts of field data, modelling tools can greatly assist in reducing or defining uncertainty in a working environment consistently and indefinitely constrained by available financial resources.

Affordable modelling tools that can practically be applied to on-site and cluster wastewater management system assessment are available that can be drawn from fields such as hydrology, catchment modelling, groundwater assessment and water sensitive urban design in addition to wastewater management. This chapter presents four case studies illustrating how these tools can assist in the assessment of long-term ecosystem and human health impacts and decision making. The case studies have been used to guide policy development regarding on-site system density for both new unsewered development and risks posed by existing unsewered villages.

7.1 Rationale

In developing a procedure for Cumulative Impact Assessment (CIA) from on-site systems the following principles were applied.

- The CIA procedure(s) should utilise models and tools that are economically and practically viable for use in assessing typical unsewered development applications.
- CIA procedure(s) should be adaptable to varying levels of risk.
- Performance targets for CIA's need to be meaningfully measurable and proportionate to targets for non-wastewater pollution sources (e.g. urban stormwater).
- CIA procedure(s) should not be expected to be deterministic tools but rather indicative tools to provide guidance on the potential risk of impacts (i.e. likelihood, consequence and uncertainty).

Two broad aims were identified for CIA assessments for Greater Taree.

- Evaluation of sustainable on-site system densities for new unsewered development.
- Evaluation of the sustainability of existing high risk unsewered villages.

7.1.1 Sustainable Unsewered Development

Council has recently revised their Local Environmental Plan (LEP) in addition to the Development Control Plan (DCP). This has resulted in establishment of new or revised minimum allotment sizes for various land use zones within the LGA. Minimum lot sizes for subdivision of unsewered land are 1.5 ha for rural residential type zones and 40 ha for rural land. Based on previous CIA work undertaken for Port Stephens and Great Lakes Councils, BMT WBM considers 1.5 ha to be a suitably conservative minimum lot size for future unsewered subdivision. Council planning staff also advised BMT WBM that very few unsewered subdivisions or rezoning's were included in long-term strategic plans for Greater Taree.

On this basis it was determined that a single case study would be sufficient to examine critical lot densities for greenfield unsewered rezoning or subdivision within Greater Taree. Potential for such development is localised and based on a minimum lot size of 1.5 ha, considered unlikely to create cumulative impacts due to high on-site system density. The aim of this process was to establish a deemed to comply minimum *Useable Land* (see Section 6.3 for definition) to ensure cumulative impacts are managed. Where a proposed development involves an increase in on-site system density that falls within sustainable limits, no further consideration of cumulative impacts will be required.

The greenfield on-site system density assessment aimed to estimate the relative impact of properly designed, constructed and maintained on-site systems on long-term nutrient and pathogen loads to receiving environments. In completing this assessment, the following assumptions were made.

- Each lot was capable of being serviced by an on-site system designed, sized, constructed and operated in accordance with Councils requirements. This includes land application areas sized to prevent hydraulic surcharging in an average climate year.
- As a result, local impacts arising from poorly performing on-site systems were assumed to be within acceptable levels (e.g. surface hydraulic surcharging and the associated health risks).
- All land application areas comply with relevant separation distances from constructed and natural water bodies and drainage lines.

There may be scenarios within the Greater Taree LGA where the subdivision of unsewered land may be permissible in a form that increases on-site system density above what is considered sustainable. Alternatively, a proposal may be submitted that proposes reduced setback distances to receiving environments. In these cases, a potential DAF will require a site specific CIA to be undertaken.

7.1.2 Sustainability of Existing High Risk Villages

Like many Councils along the NSW coast, GTCC face significant challenges in the management of environmental and health risks associated with on-site systems in existing unsewered villages. Some villages were developed many decades before on-site sewage management was any form of consideration for planning and land development. Allotment sizes and site constraints create severe restrictions on the design, construction and operation of on-site systems. Often there is insufficient land available for the application of full effluent loads under current design standards. These hazards are compounded in a number of villages in the GTCC LGA by the close proximity to sensitive receiving environments such as the Manning River, aquaculture zones and recreational zones.

It can be challenging to determine the most appropriate long-term strategy for improving wastewater servicing for such high risk villages. Ideally, some form of community wastewater management (decentralised or conventional reticulated sewerage) should be adopted where risks warrant investment of this level. However, limited funding is available for provision of a sewerage scheme to most high risk villages in Greater Taree.

Three case studies were undertaken of representative high risk villages within the LGA as part of this Study. The primary aim of these case studies was to examine the potential for on-going wastewater servicing by on-site sewage management as a sustainable strategy for each village. This included examination of general upgrade programs, conversion to effluent pump out and comparison with establishment of a community servicing scheme (i.e. a decentralised system). It is envisaged that the outcomes of the case studies will enable Council and Mid Coast Water to identify the preferred long-term servicing strategy and guide / provide justification for policies on enforced upgrade and management of existing on-site systems that are found to be failing.

7.2 Methodology

Available desktop data was used to build a spatial model to simulate hydrology, catchment pollutant export, on-site system operation, groundwater recharge / pollutant discharge and nutrient / pathogen attenuation in groundwater flow for the selected sites. The models operate on a daily timestep (with the exception of groundwater pollutant attenuation) and have been parameterised using site specific data to provide the best representation of actual conditions in light of limited/no data for calibration.

The models have been used to estimate the long-term hydraulic, nutrient and pathogen loads exported from the study area under existing conditions and the indicative long-term average concentrations of site runoff and groundwater discharge. In the case of greenfield development, that case study has been used to simulate unsewered subdivision of the site at a range of lot densities for quantitative comparison to the existing situation. For the existing high risk villages, the likely performance of existing systems has been compared to a number of potential long-term servicing strategies. Models also provide an estimate of the frequency, magnitude and distribution of the surface failure of OSWMS to assist in estimating local risks to human health and community amenity impacts.

The development of the models involved the integration of two modelling tools as shown in Figure 7-1. In principle, the model shown below is a daily mass balance model that simulates the water / pollutant balance process for the study area for the purpose of estimating long-term hydraulic, nutrient and pathogen loads discharging to receiving surface and groundwater.

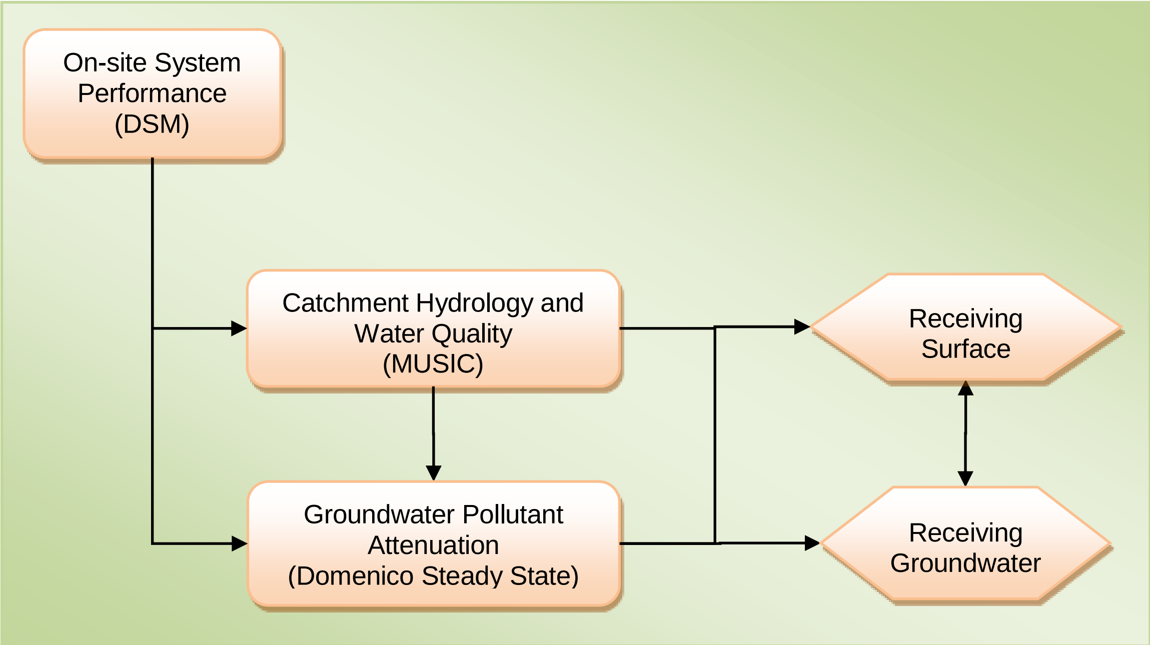


Figure 7-1 Structure of the Lot Density Assessment Models

7.2.1 On-site System Performance: DSM

The Decentralised Sewage Model (DSM) is a GIS based decision support tool designed to assess and compare a range of wastewater servicing options from on-site sewage management to conventional gravity sewerage with central treatment and reuse/disposal. The DSM was developed jointly by BMT WBM and Whitehead & Associates Environmental Consultants. It has the capacity to rapidly assess the long-term environmental/human health performance of wastewater systems in addition to assisting in the concept design and costing of various servicing options. The DSM is comprised of five modules as described in Figure 7-2. Each module of the DSM is able to be used in isolation or collectively depending on the needs of the project.

For this project, the On-lot Performance Model (OLPM) module was used to derive average annual hydraulic and pollutant loads to surface and subsurface export routes. The Node Link module (NLM) was used to simulate the movement of hydraulic, nutrient and pathogen loads from individual on-site systems to Subcatchment discharge points. Additionally, outputs were used in the development of analytical, steady state groundwater models for assessment of subsurface water and contaminant attenuation.

The DSM was selected on the basis that it is the most comprehensive tool available for simulating the long-term operation of multiple on-site systems. A summary of the algorithms used in the DSM can be provided as a separate document for interested parties.

On-lot Performance Model (OLPM); simulates the performance of individual wastewater discharges to land application systems at a daily timestep. Hydraulic, nutrient and pathogen dynamics within the land application system are modelled with daily surplus loads surcharging to the ground surface and discharging below the rootzone recorded as model outputs.

Particle Tracking Model (PTM); tracks the flow path from individual wastewater systems to receiving waters of surplus surface (and shallow subsurface) hydraulic, nutrient and pathogen loads calculated using the OLPM. A user defined pollutant decay rate can be applied to the PTM where suitable data are available. The PTM assists in identifying likely hotspots for sewage pollution and assessing the feasibility of gravity reticulation for community wastewater management.

Node-Link Model (NLM); allows the OLPM outputs for individual wastewater systems to be grouped into Management Units (MU). MU's may be based on physical subcatchments (e.g. for the purpose of input of data into a catchment model) or user defined groups (e.g. for the purpose of scenario testing or concept design of community wastewater systems). Grouped OLPM outputs are linked to a downstream model component such as a pump station, central treatment system, reuse/disposal facility or discharge to a receiving water. The NLM also allows treated effluent from central management components to be linked back to MU's for reuse (e.g. to simulate dual reticulation).

Central Management Components (CMC); simulate the operation of pump stations or central treatment, disposal and/or reuse systems. The CMC uses similar algorithms to the OLPM to simulate hydraulic, nutrient and pathogen processes.

Costing Model (CM); estimates the capital and operating costs of the modelled wastewater servicing scenarios from on-lot to central components. The CM utilises inputs from the NLM to define unit costs for elements of the CMC.

Figure 7-2 Summary of the Structure of the DSM

7.2.2 Catchment Hydrology and Water Quality: MUSIC

Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is an Australian tool developed by the Cooperative Research Centre for Catchment Hydrology (now eWater) as part of their catchment modelling toolkit (see www.toolkit.net.au for more information including a comprehensive user manual). MUSIC is designed to simulate urban and rural residential stormwater systems operating at a range of temporal and spatial scales; catchments from 0.01 km^2 to 100km^2 and modelling time steps ranging from 6 minutes to 24 hours to match the catchment scale.

While primarily an urban stormwater quality modelling tool, users with a sound knowledge of rainfall-runoff processes, soil hydrology and pollutant generation and transport processes can readily adapt MUSIC for use in rural residential applications. BMT WBM has been directly involved in the development of MUSIC and its use in a wide variety of environments including those similar to the two study sites. Importantly, MUSIC is relatively simple to use, allowing models to be developed for small study areas in a relatively short amount of time.

MUSIC was used to simulate rainfall-runoff processes and the ‘background’ nutrient and pathogen loads associated with sources other than wastewater. It also provided an estimate of groundwater recharge and associated nutrient concentrations.

7.2.3 Catchment Pollutant Attenuation and Mass Balance

Model links within the DSM represent the pathway of on-site system hydraulic and pollutant loads out of the management units (subcatchments) to the receiving nodes (stream, estuary or aquifer). A range of chemical and bio-physical processes occur along these pathways that result in the attenuation of nutrients, pathogens and hydraulic loads from the effluent land application area to receiving waterway.

Pollutant attenuation factors were applied to on-site system (DSM) loads as they were transported along the model links prior to inclusion in a catchment mass balance. This enables the pollutant attenuation that occurs between the point of discharge and the receiving environment to be accounted for. Attenuation factors were applied to pollutant loads in both the surface runoff and subsurface deep drainage.

The outcomes of previous modelling for Port Stephens Council and other sites justified the use of previously derived attenuation factors for sites of a similar nature to the Greater Taree case studies. There are three reasons for this.

- Hydrologic and landscape conditions were similar between the Port Stephens, Greater Taree and other study sites previously analysed in detail.
- Sensitivity testing of 2D analytical groundwater modelling indicates that general study area scale attenuation rates are not sensitive to hydraulic gradient or hydraulic conductivity in the majority of contexts.
- The modelling undertaken for this Study is broad scale in nature and not based on site specific data. As such application of broad generalised attenuation rates is sufficient.

It should be noted that under the GTCC DAF, very high hazard sites or sites where setback distances / on-site system density limits are compromised require site specific estimation of attenuation rates.

7.3 Study Site and Scenario Selection

As discussed in Section 7.1, one case study was selected for evaluation of cumulative impacts from new unsewered development and three case studies were developed for evaluation of cumulative impacts from high risk existing unsewered villages. Consideration was then given to the type of modelling scenarios that would enable key “what if” statements to be compared to the existing conditions.

7.3.1 Cumulative Impacts for New Development

Following liaison and advice from Councils Strategic Planning section BMT WBM selected Bohnock as a suitable case study site to identify the potential implications of Greenfield (new) developments within the region. Bohnock is located on the southern side of Manning River in relative close proximity to the Manning River Estuary (Farquhar Inlet) and displays the following common conditions to areas where unsewered development is considered possible.

- Rolling to low hills of residual, erosional and alluvial soils of moderate to shallow depth (0.5 – 1.5 metres).
- Existing unsewered rural residential area surrounded by rural land with some potential for development.
- Sensitive receiving environment (estuary) with aquaculture (oyster production).

A model was initially constructed of the existing subcatchments and on-site systems to represent baseline conditions. Following this two rural sites were nominated for hypothetical rural residential development using on-site systems. A range of lot sizes were then tested to determine the relative impact on nutrient loads discharging to Manning River in addition to residual health risks.

7.3.1.1 On-site System and Lot Density Scenarios

Existing Systems

The Council On-site Sewage Management System database was used to identify known existing systems within the Bohnock study area. Limited system configuration data was available however the broad type of treatment and land application system was available from Approval to Operate records. Typical system configurations for modelling purposes were then developed based on information provided by Council Environmental Health Officers and the experience of BMT WBM.

It should be acknowledged that a number of general assumptions were required to enable model construction. As such, results may not be representative of individual site behaviour. Rather they provide a good indication of cumulative impacts from the broader study area. Where detailed data is available, the DSM is able to better represent site to site variation in on-site system performance.

Approximately 200 existing systems were modelled within the broader Bohnock Study Area as shown in Figure 7-3.

Scenario 1 – New Rural Residential Subdivision

A number of potential areas considered representative of unsewered developed were investigated within Bohnock. All new wastewater management systems were assumed to provide secondary treatment / sub-surface irrigation when modelled within the DSM. Nine DSM scenarios were modelled for the total development area in which the maximum number of systems was modelled for the available area based on the specific lot sizes. Details are outlined in Table 7-1.

It was determined that a wide range of lot density scenarios would be assessed (between 1,000 m^2 / 0.1 ha and 2 ha). In the case of lots less than 3,000 m^2, for the purpose of this exercise it was assumed that an on-site system sized to a mean monthly water balance was able to be constructed and operated in a sustainable fashion. As detailed in Section 6, it is unlikely that lots less than 3,000 m^2 will be capable of containing a sustainable system. However, this theoretical assumption allowed testing of the minimum lot size assessment outcomes in conjunction with lot density. Useable or developable land was determined by establishing exclusions zones based on separation distances (as listed in the DAF). A further 10% reduction was made in useable land to account for road reserves and other public or utility land within a typical rural residential development. It is important to note that in some cases useable land may only constitute part of each allotment (e.g. a subdivision that contains floodprone land).

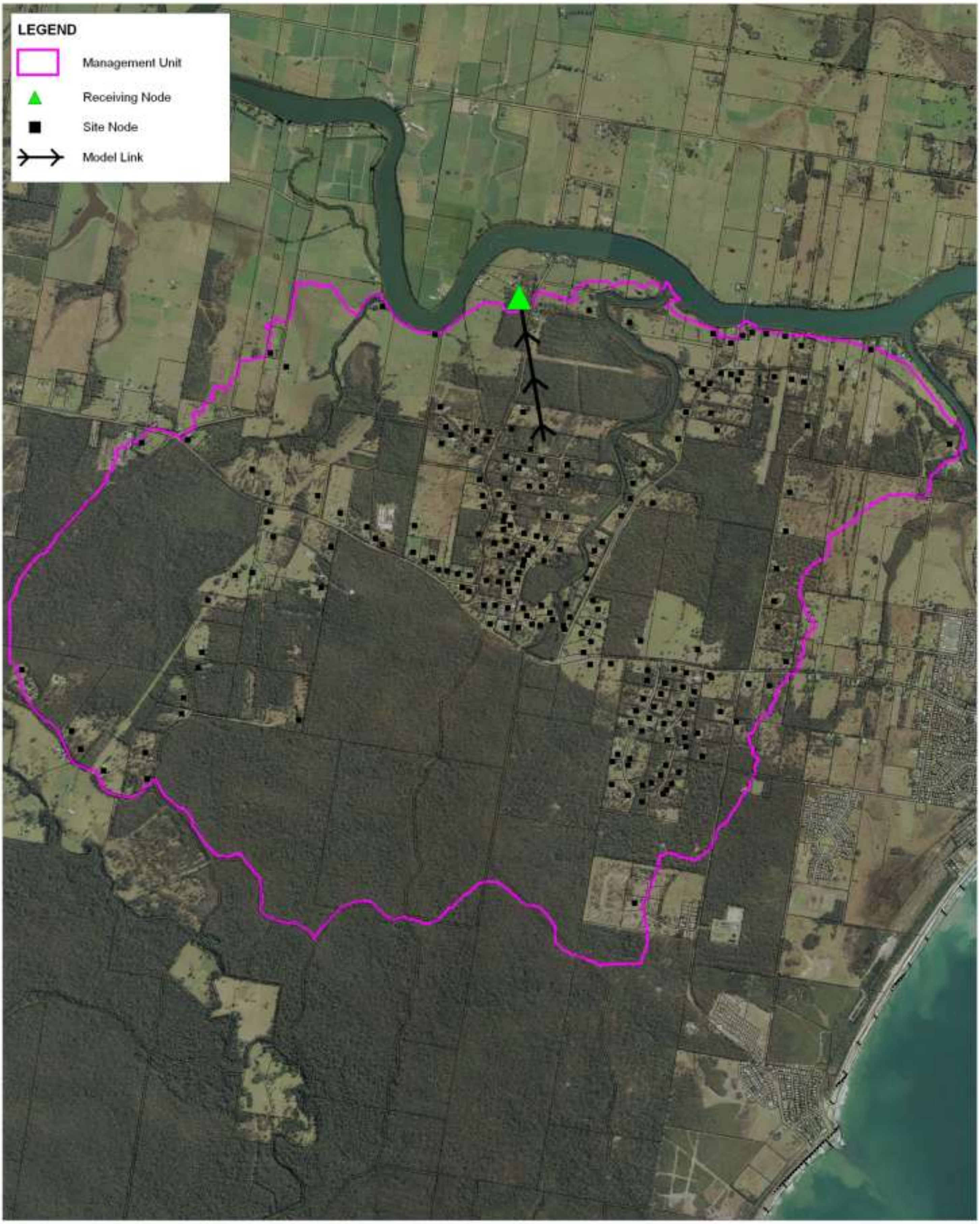
Each lot was assumed to contain a four bedroom house with a reticulated (or unconstrained) water supply. A mean monthly water balance was then conducted to size a generic land application system based on local site and soil characteristics and climate data.

The modelling conducted for this lot density assessment is designed for use as a decision making tool but will not necessarily produce results that accurately reflect measured pollutant loads to receiving waters. Instead it aims to conduct a site mass balance to allow users and decision makers to assess predicted increases in pollutant loads against existing conditions or alternative development concepts.

Table 7-1 Bohnock Development Configurations for Cumulative Impacts Assessment

Lot Size	0.1 ha	0.2 ha	0.3 ha	0.4 ha	0.6 ha	0.8 ha	1 ha	1.5 ha	2 ha
Bohnock Development Area 1									
Total Land	230 ha								
Total Systems	2300	1150	767	757	383	288	230	153	115
Bohnock Development Area 2									
Total Land	218 ha								
Total Systems	2180	1090	727	545	363	273	218	145	109
Configuration	All systems: Secondary Treatment Systems (STS) to Pressure Compensating Subsurface Irrigation								

The layout of the Bohnock DSM models for the existing case and Scenario 1 are depicted in Figure 7-3 and Figure 7-4.



Title:
Bohnock Study Area for Cumulative Impacts Assessment - DSM Layout

Figure: 7-3

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0 0.75 1.5km
Approx. Scale

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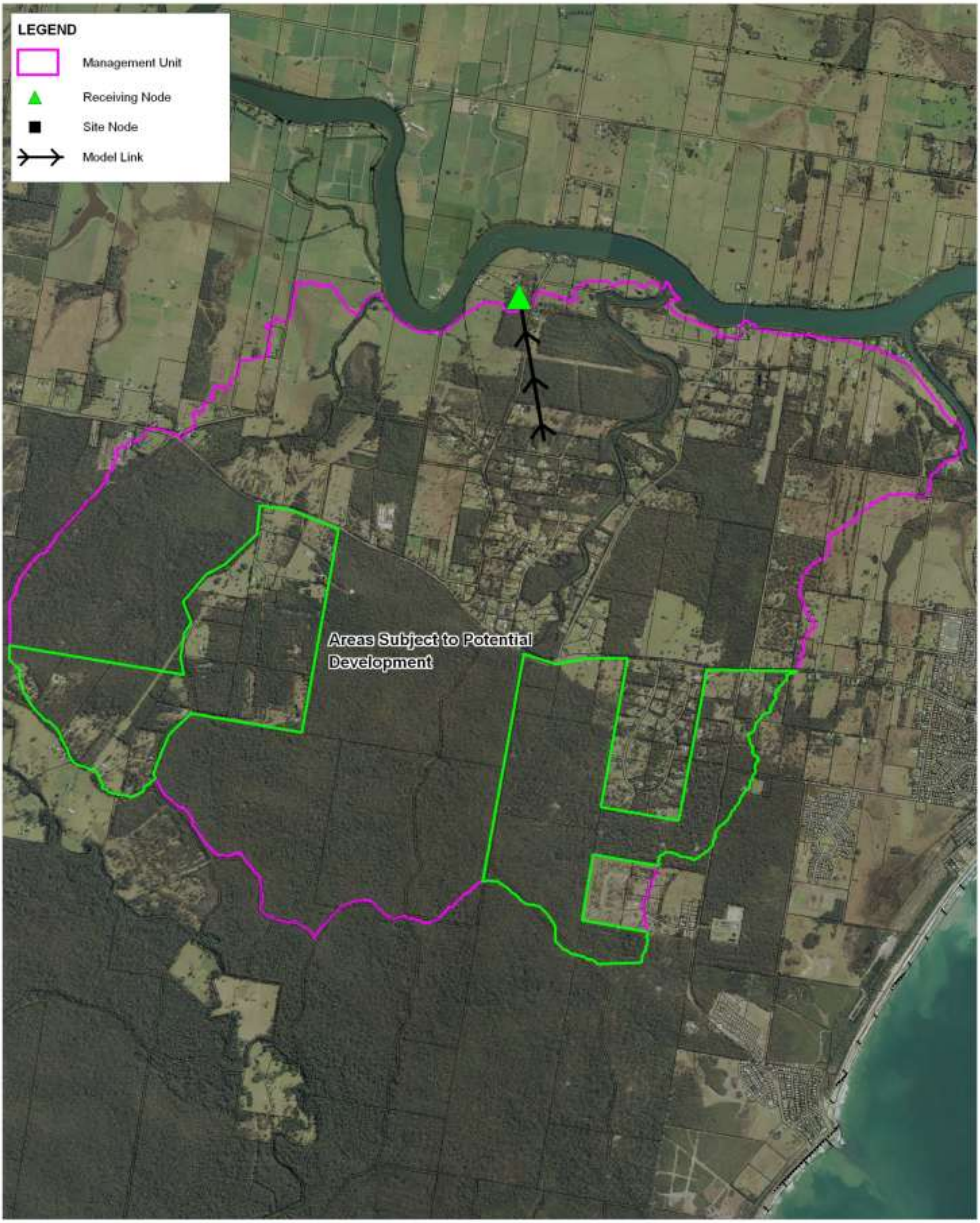

Title:

Bohnock Study Area for Cumulative Impacts Assessment - Scenario 1 DSM Layout

Figure: 7-4

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Approx. Scale

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Filepath : K:\N2091_GTCC_Onsite_Sewage_Planning\MI\Workspaces\DWG_010_DSM_Layout_Bohnock_Scenario1.WOR

7.3.2 Sustainability of Existing High Risk Villages

Cumulative Impact Assessment was undertaken for Johns River, Krambach and Mt George in order to evaluate the long-term sustainability of on-site sewage management as a wastewater servicing option. These sites were selected on the basis of existing small lot sizes, site and soil constraints and observed impacts / failure of systems. In addition to assessing the long-term sustainability of on-site sewage management for these sites, scenarios were developed and tested to examine the benefits of removing on-site land application of effluent on existing small lots through;

a) conversion to effluent pump out; or

b) implementation of a community / decentralised wastewater servicing scheme where treated effluent is managed at a central location via subsurface irrigation.

These three villages were selected in consultation with Council as sites that are generally representative of other locations in the LGA. It is envisaged that outcomes of this element of the Cumulative Impact Assessment (CIA) will provide useful guidance to Council, Mid Coast Water and NSW Office of Environment and Heritage (OEH) on preferred long-term wastewater servicing strategies for high risk villages in Greater Taree.

7.3.2.1 Potential Wastewater Servicing Scenarios

A total of four wastewater servicing scenarios were evaluated in addition to the existing case for each existing site using the DSM;

- the existing case;
- Scenario 1a; Replace Existing Systems with Best Practicable Option;
- Scenario 1b; Replace Existing Systems with Effluent Pump Out;
- Scenario 2; 1a in Addition to New Systems with Best Practicable Option for All Existing Undeveloped Village Lots; and
- Scenario 3; New Community Decentralised Treatment System for Existing Systems.

Scenario 1a CIA Procedure

For Scenario 1a it was assumed that all existing systems would be upgraded to provide secondary treatment for sub-surface irrigation. It was assumed that land application areas would be maximised on the smaller lots up to a size needed based on a monthly water balance. In most cases this land area was not available for land application due to existing development restrictions. Site specific available area calculations were undertaken in accordance with the approach detailed in Section 6 (Scenario 1a).

Scenario 1b CIA Procedure

Results from the Scenario 1a model were analysed to identify sites where there was insufficient available area to prevent excessive hydraulic failure (surcharging) of subsurface irrigation systems. Analysis was undertaken to identify frequency of overflow / surcharge, which is calculated using the following equation:

$$Frequency\ of\ Overflow/Surcharge = \frac{Number\ of\ Years\ Overflow\ or\ Surcharge\ Occurred}{Number\ of\ Years\ Modelled}$$

Systems that were surcharging excessively were consequently changed to effluent pump-out systems within the DSM. Surcharging systems were deemed unacceptable if system run-off was greater than 1% of annual system wastewater flow for more than 50% of total years. This criterion allows some scope for minor, periodic hydraulic failure that is commensurate with the risk posed by on-site systems.

Following review of Council pump out records against metered water use it was identified that Council concern regarding potential illegal discharge of effluent from pump out systems was warranted. Significant discrepancies were identified in a number of site records. The aim of Scenario 1b was to examine which management approach was more effective at managing risks to human health and ecosystems (installation of undersized land application systems versus pump out where risks of direct discharge off-site due to mismanagement are high). As such it was assumed that 10% of the daily (primary) effluent load generated by pump out systems was discharged to the ground surface.

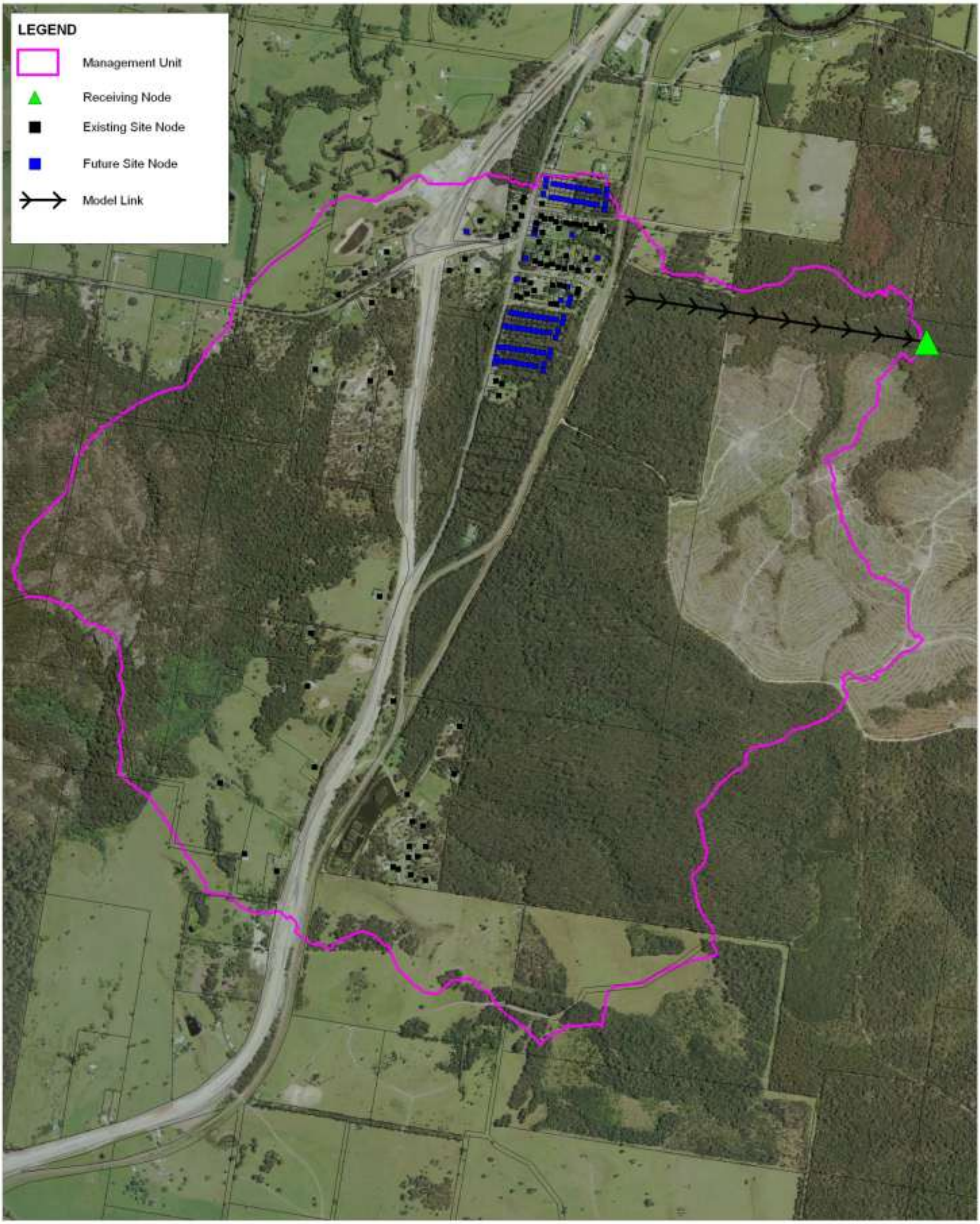
Scenario 2 CIA Procedure

The implications of build out of existing undeveloped village size lots were investigated in combination with the upgraded existing systems of Scenario 1a. This included consolidation of undeveloped lots in north east Krambach based on advice from Councils Planners. All new treatment systems were assumed to provide secondary treatment / sub-surface irrigation with land application maximised based on likely available area.

Scenario 3 CIA Procedure

A community decentralised treatment system was investigated for servicing of sites with existing on-site systems. It was assumed that a collection system conveyed primary effluent (or sewerage) to a central treatment plant location. The treated effluent was land applied to a sufficiently sized area based on a design loading rate that would allow ANZECC water quality guideline targets to be achieved for off-site discharge.

In addition, analysis of system surcharging frequency and volume was undertaken for the three sites for each scenario. DSM model layouts for each site are provided in the following figures.



Title:
Johns River Study Area for Cumulative Impacts Assessment - DSM Layout

Figure: 7-5

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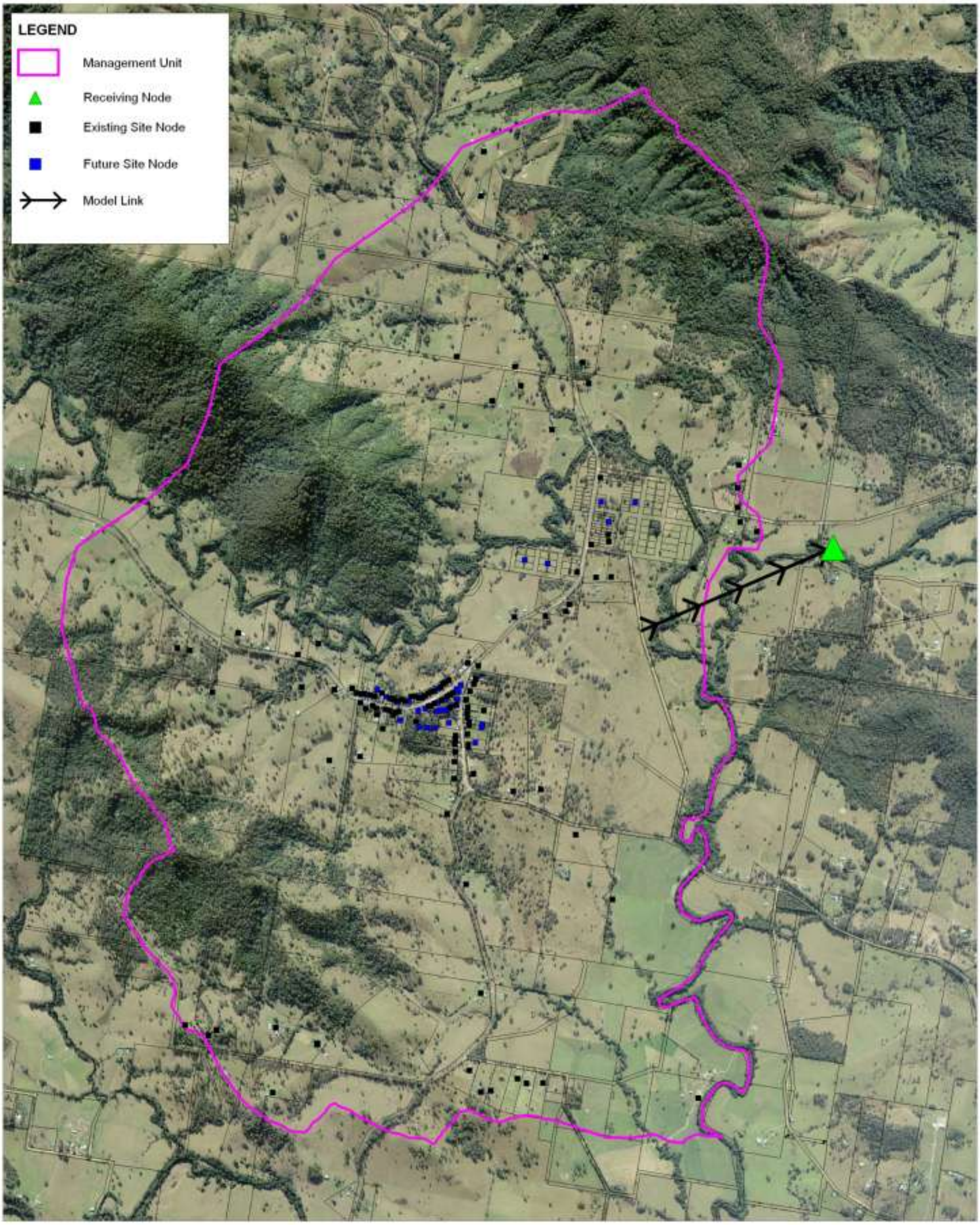

Title:

Krambach Study Area for Cumulative Impacts Assessment - DSM Layout

Figure: 7-6

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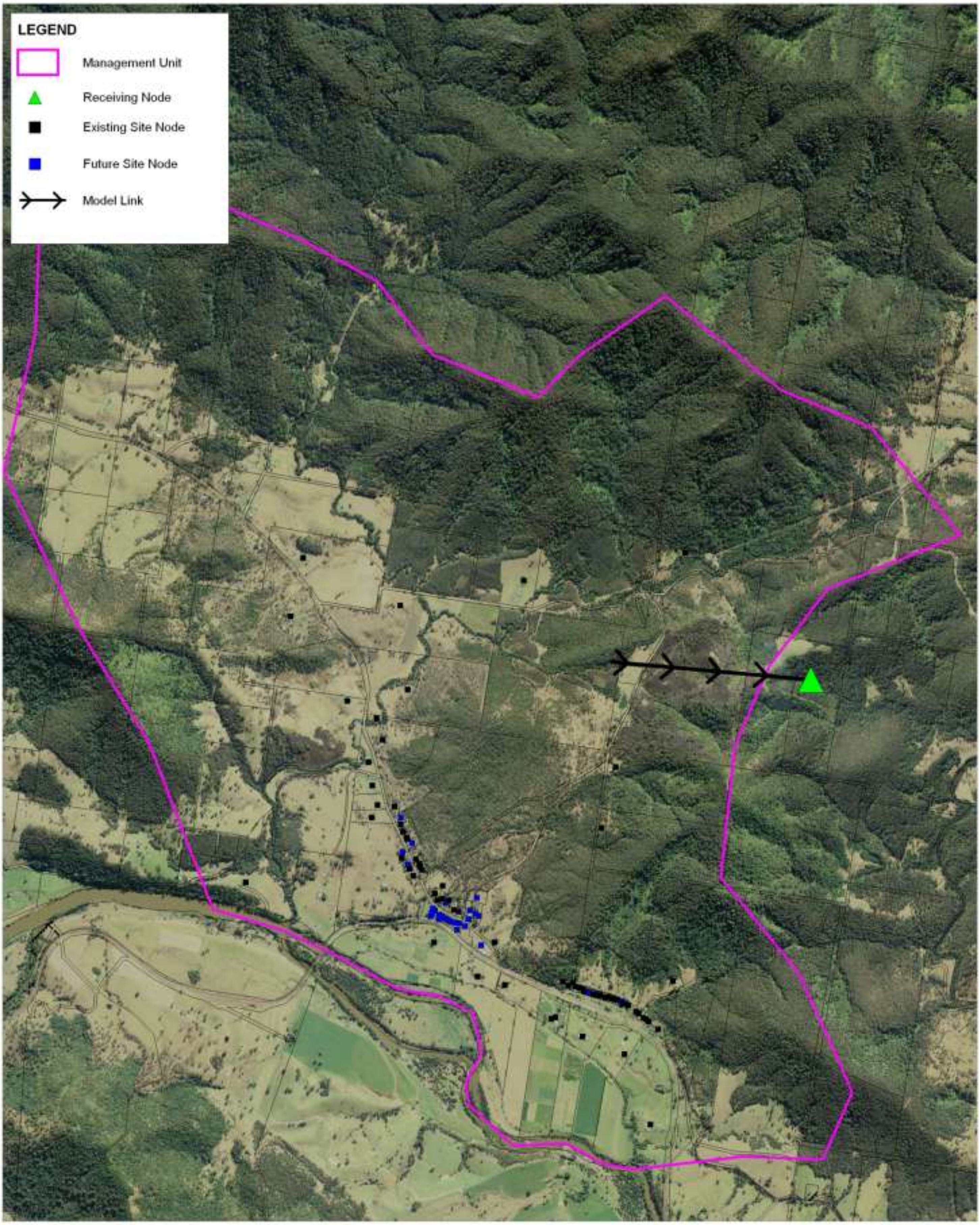

Title:
Mt Geroge Study Area for Cumulative Impacts Assessment - DSM Layout

Figure: 7-7

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Filepath : K:\N2091_GTCC_Onsite_Sewage_Planning\MI\Workspaces\DWG_008_DSM_Layout_MtGeorge.WOR

7.4 Model Construction

As is often the case, there is limited data available to construct fully parameterised, calibrated and validated risk assessment models for the purpose of an on-site system density assessment. However, sufficient data and information has been made available through limited field investigations and GTCC data to ensure a useful decision support tool for wastewater servicing can be established. If considered beneficial, opportunities to collect water quality, quantity and on-site system data can be used to refine accuracy of the modelling.

7.4.1 General Data Inputs

A range of general data were used in development of all components of the lot density models. These datasets were primarily used to construct a spatial model of key bio-physical features of the study area. They are summarised in Table 7-2.

Table 7-2 General Data Used to Construct Spatial Model of Study Sites

Parameter	Source	Purpose
Climate (daily) Rainfall Evaporation Potential Evapo-transpiration Average Temperature	SILO Data Drill Interpolated Data Bohnock: Lat: -31.95, Long: 152.55 Johns River: Lat: -31.75, Long: 152.70 Krambach and Mt George: Lat: -32.05, Long: 152.25 1950 – 2009 (60 years)	Used in water balance calculations for the DSM (on-site systems) and MUSIC (rainfall-runoff model). Air temperature used for DSM pathogen model in lieu of ground temperature.
Digital Elevation Model (DEM) Created in ArcGIS™ through triangulation adopting a 10m grid.	Light Detection and Ranging (LiDAR) data supplied by GTCC. 10m topographic contours where LiDAR not available.	Surface model of the study area used to determine; Hydrologic pathways Groundwater elevation DSM slope interrogation
Soil Landscape Information	Previous local field investigation data. Unpublished soil landscape mapping for HCCREMS (Banks, 2010). NSW SPADE soil profiles.	Development of soil profiles and input parameters for; DSM on-lot performance model MUSIC rainfall-runoff model
Groundwater / Aquifer Data	NSW Office of Water Groundwater Bore Logs Previous local field investigation data.	Recharge properties for MUSIC rainfall-runoff model DSM soil and system properties Hydraulic aquifer properties and dimensions for modelling
Landuse / Cadastre and **Aerial Photography**	Greater Taree City Council	Assessment of current and potential future development configuration in study area. Available area for land application systems (DSM) Effective Impervious Area (EIA) assessment for MUSIC. Drainage configuration.
Hydrology Hydrologic configuration Subcatchment boundaries	GTCC GIS data Previous local field investigation data.	Hydrologic and pollutant pathways Upstream contributions Groundwater discharge points

7.4.2 DSM Inputs

There are three data sets required to run the DSM a shown in Figure 7-8.

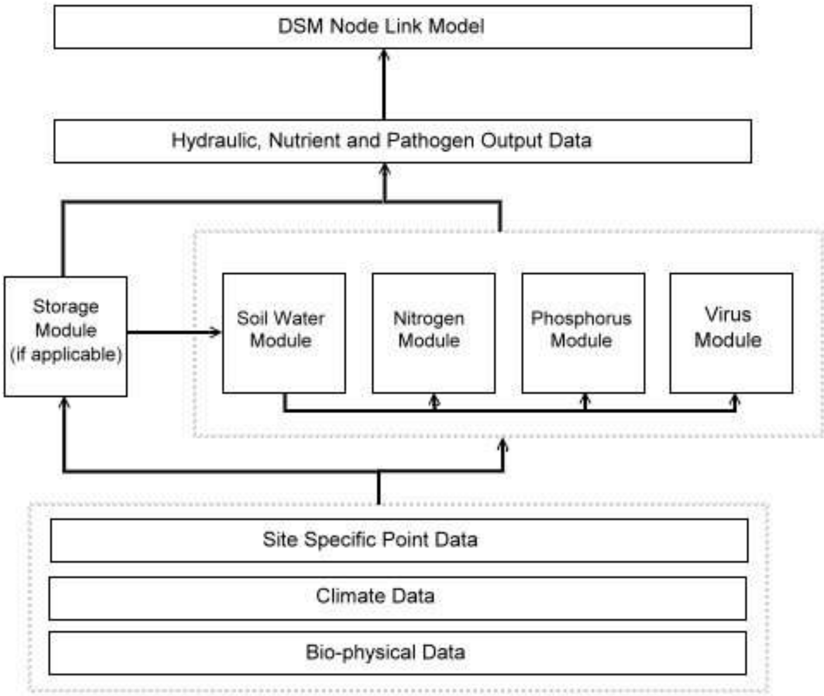


Figure 7-8 Overall Structure of the On-lot Performance Model

7.4.3 Base Model

Desktop and field data were collated and used to build a base (existing case) DSM for each of the sites. Input parameters and model construction is detailed in the following sub-sections.

The DSM requires the following bio-physical data:

- Climate data;
- Elevation / Slope data;
- Soil data; and
- Vegetation data.

These bio-physical data requirements are described in detail below.

7.4.3.1 Climate Data

The DSM requires daily rainfall, evaporation, evapo-transpiration and average temperature for a land application area. For this study interpolated data from SILO (DataDrill) were obtained from Queensland DERM for the closest interpolated grid point for each site. Coordinates were as follows:

- Bohnock; Lat: -31.95, Long: 152.55

- Johns River; Lat: -31.75, Long: 152.70
- Krambach; Lat: -32.05, Long: 152.25

The Krambach data was also utilised for Mt George given the close proximity of the two sites. A DSM modelling period of 60 years (1950-2009) was adopted for all sites.

7.4.3.2 Elevation / Slope Data

The DSM requires a Digital Elevation Model (DEM) in order to assign a percentage slope value for each land application site and enable catchment flowpaths to be mapped. Slope influences the hydraulic performance of land application system in the DSM.

A high resolution (10m) DEM has been derived for the LGA from the LiDAR data provided by GTCC. Where LiDAR was not available, 10 metre topographic contours were used. The DEM is a representation of the ground surface and does not include features such as buildings or vegetation.

7.4.3.3 Soil Data

Modelling of the movement of water, from both effluent land application and rainfall, through the soil is a key component of the DSM, ultimately determining the nutrient movement throughout the land application site.

Necessary soil data were obtained through analysis of the following data.

- Soil profile descriptions and laboratory analysis results for previous soil test sites;
- Field investigations by BMT WBM;
- Published data on typical Australian soils (Gardner and Davis 1998, Hazelton and Murphy 2007, ASNZS1547:2012);
- Unpublished soil data provided by HCCREMS (Banks, 2010);
- Aerial photography;
- Digital Elevation Model (DEM); and
- Cadastre and other spatial datasets.

DSM soil parameters were developed based on published and previously obtained soil profile data. The DSM soil parameters for the soil profiles used in modelling for each of the sites are detailed in Appendix C. Some parameters were inferred based on soil texture, structure, colour and depth using published data on Australian soils (Gardner and Davis 1998, Hazelton and Murphy 2007, ASNZS1547:2012).

7.4.3.4 Vegetation Data

The DSM takes into account the plant utilisation of the nutrient load within the soil by assigning a value for crop uptake of nitrogen and phosphorous from the soil. The crop uptake value represents the load of nitrogen and phosphorous taken up by vegetation within the land application area in kilograms per hectare per day. The crop uptake values adopted for this study are presented in Table 7-3. They have been adopted based on 50% values for kikuyu grass in DECCW (2004).

Table 7-3 DSM Crop Uptake of Nutrients

Parameter	Range
Crop Nitrogen Uptake	200 kg/ha/day
Crop Phosphorus Uptake	20 kg/ha/day

Crop factors are also required to adjust reference crop evapo-transpiration to represent unmanaged mixed grass species. The crop factors for pan evaporation in DECCW (2004) for pasture have been adapted for this study.

7.4.4 MUSIC Inputs

MUSIC requires the input of climate data, soil hydrologic, landuse and pollutant generation characteristics in order to derive runoff volumes, baseflow to groundwater and nutrient and pathogen loads at each study site. Given that MUSIC is a process based mass balance model, adaptation to a rural residential setting is not problematic. A summary of inputs is provided below.

Stormwater quality was modelled with the MUSIC software considering water quality constituents including TN and TP. All sites were modelled in their existing undeveloped condition. At present Council does not specifically require modelling of long-term stormwater pollutant loads as part of rural residential development assessment processes. To retain simplicity, on-site system impacts have been assessed against ***existing undeveloped loads***. This is considered conservative and will allow Council to approve unsewered subdivisions on Low and Medium Hazard lots with confidence that cumulative impacts will be adequately managed. There may be scope in the future to complete modelling of this nature in conjunction with stormwater quality and quantity modelling using MUSIC or similar software.

The MUSIC models for each site are shown in the following figures.

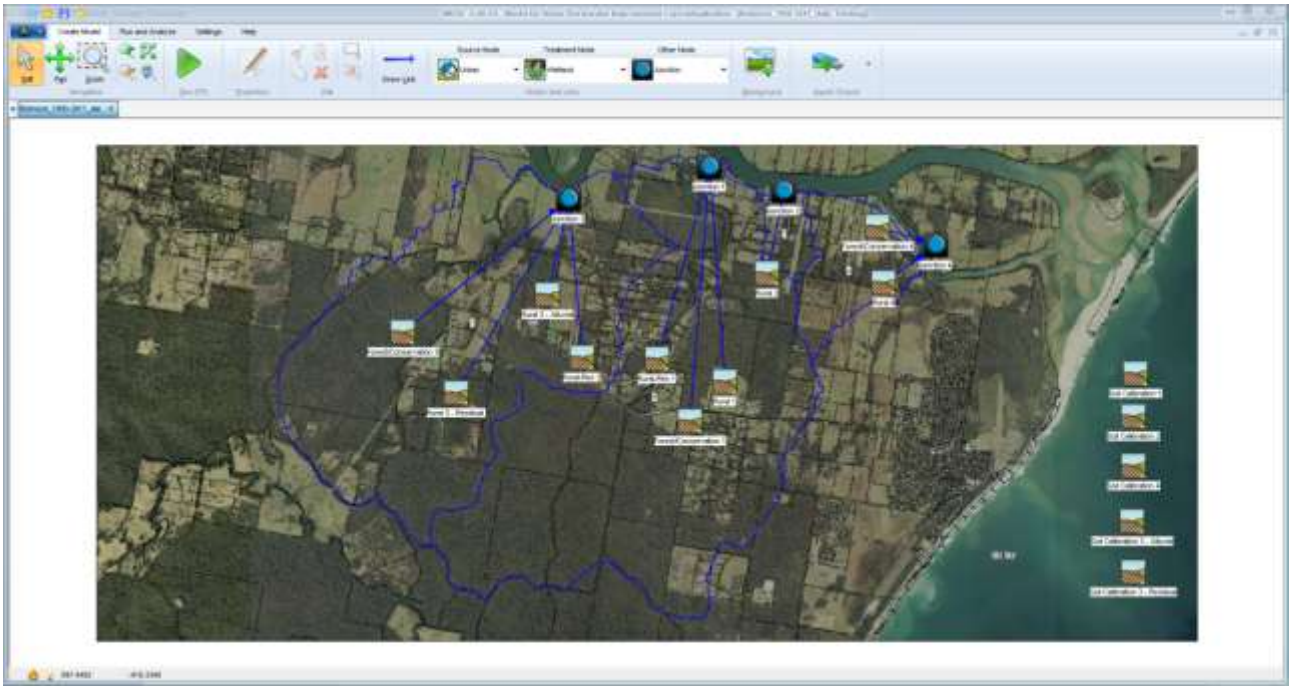


Figure 7-9 Bohnock MUSIC Model

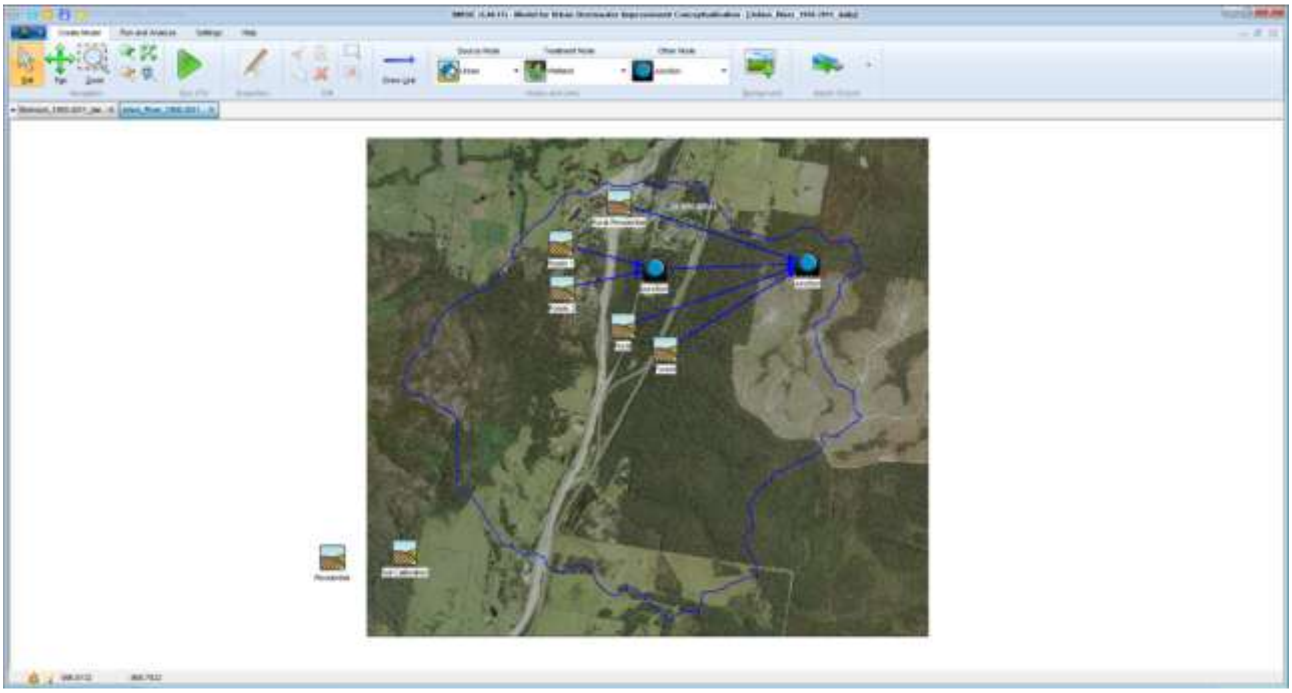


Figure 7-10 Johns River MUSIC Model

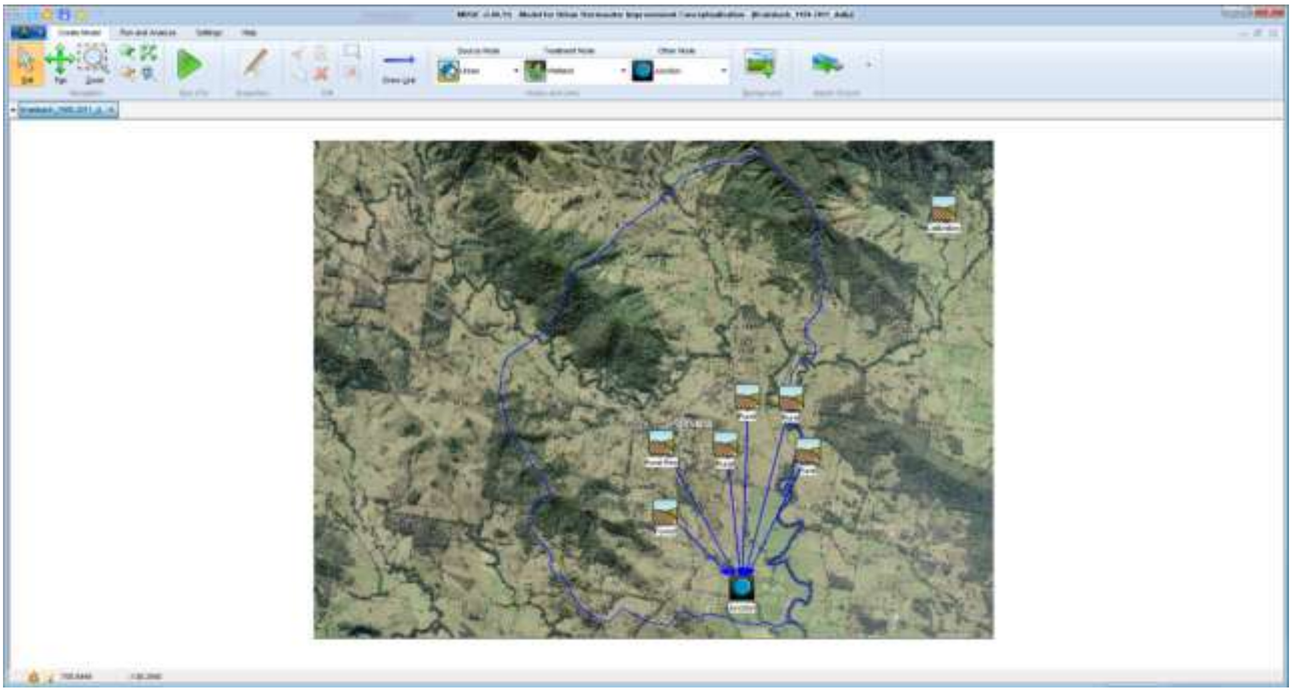


Figure 7-11 Krambach MUSIC Model

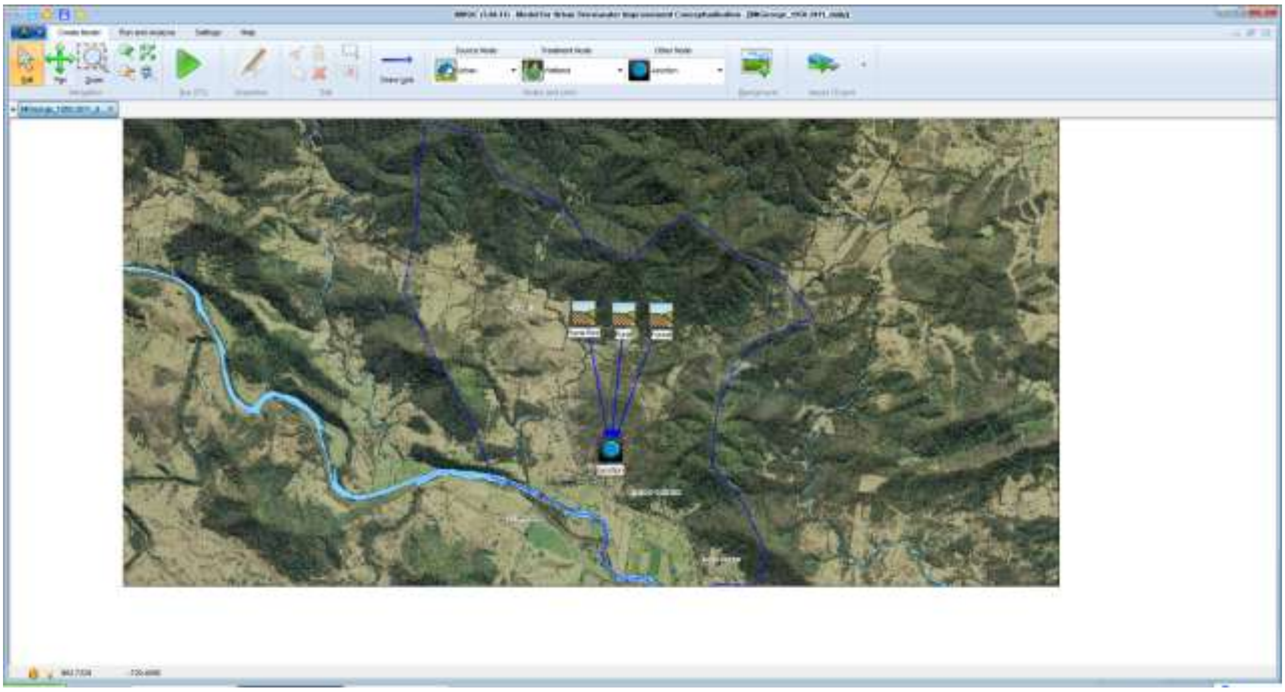


Figure 7-12 Mt George MUSIC Model

7.4.4.1 Meteorological Template

The SILO climate data discussed in Section 7.2.1 was used as the template for the MUSIC model. A daily timestep was adopted which is considered appropriate for a long-term volume based rainfall-runoff model with no routing through stormwater measures. A modelling period from 1950 to 2011 was adopted for all models.

7.4.4.2 Catchments

Catchments for the four study sites were defined considering area topography and natural and artificial (kerb and pipe stormwater drainage) water courses. Based on Geographical Information System (GIS) data (aerial photography, land zoning, etc), the catchments were divided into the following land use types:

- rural-residential;
- rural;
- forest/bushland; and
- roads.

Land use types were used to assign event and dry weather stormwater quality characteristics In addition, the proportion of total impervious area (TIA) directly connected to the constructed drainage system (effective impervious area or EIA) was estimated for each catchment based on the land use types and GIS data.

7.4.4.2.1 Soil Hydrologic Parameters

Default rainfall-runoff parameters within MUSIC are not appropriate for use at these sites. Careful rainfall-runoff parameterisation is crucial to accurate modelling of the existing hydrologic regime. Site specific rainfall-runoff parameters have been developed for each site based on MacLeod (2008) and using the understanding of soil / groundwater characteristics available within the project team following field and desktop investigations. Reference was made to Fletcher *et al* (2004) and *Australian Runoff Quality* (2005) in finalising parameters to ensure site water balance, runoff coefficient and base flow index were reflective of similar sites. Soil parameters for each site have been adjusted to ensure the MUSIC model produces a volumetric coefficient of runoff (C_v) comparable to similar sites.

Soil parameters for Existing Bohnock MUSIC model are presented below. Five different model source nodes were developed to represent the varying soil facets and landscape characteristics observed.

Table 7-4 Rainfall-Runoff Parameters for Bohnock

Parameter	Soil 1	Soil 2	Soil 3 - Alluvial	Soil 3 - Residual	Soil 4
Impervious Area Parameters					
Rainfall threshold (mm/day)	1				
Pervious Area Parameters					
Soil Storage capacity (mm)	137	131	140	131	171
Initial Storage (% of capacity)	30				
Field Capacity (mm)	124	120	115	120	123
Infiltration Capacity Coefficient – a	200	200	200	200	350
Infiltration Capacity Exponent – b	1	1	1	1	2
Groundwater Properties					
Initial depth (mm)	10				
Daily Recharge Rate (%)	45	40	30	40	40
Daily Baseflow Rate (%)	15	20	10	20	20
Daily Deep Seepage Rate (%)	0				

Soil parameters for existing Johns River, Krambach and Mt George MUSIC models are provided below. Testing of model sensitivity indicated a single set of soil parameters for all source nodes within each site was acceptable.

Table 7-5 Rainfall-Runoff Parameters for Johns River

Parameter	Source Nodes
Impervious Area Parameters	
Rainfall threshold (mm/day)	1
Pervious Area Parameters	
Soil Storage capacity (mm)	160
Initial Storage (% of capacity)	30
Field Capacity (mm)	145
Infiltration Capacity Coefficient - a	200
Infiltration Capacity Exponent - b	1
Groundwater Properties	
Initial depth (mm)	10
Daily Recharge Rate (%)	50
Daily Baseflow Rate (%)	30
Daily Deep Seepage Rate (%)	0

Table 7-6 Rainfall-Runoff Parameters for Krambach and Mt George

Parameter	Source Nodes
Impervious Area Parameters	
Rainfall threshold (mm/day)	1
Pervious Area Parameters	
Soil Storage capacity (mm)	135
Initial Storage (% of capacity)	25
Field Capacity (mm)	123
Infiltration Capacity Coefficient - a	200
Infiltration Capacity Exponent - b	1
Groundwater Properties	
Initial depth (mm)	10
Daily Recharge Rate (%)	40
Daily Baseflow Rate (%)	20
Daily Deep Seepage Rate (%)	0

7.4.4.3 Pollutant Generation Rates

Fletcher *et al* (2004) provides a comprehensive set of values obtained from a wide range of catchment studies from Australia and overseas and provides values recommended by NSW DECC (now OEH) for site/catchment modelling within NSW. These concentrations are summarised in Table 7-7 and Table 7-8. It is acknowledged that local data on non-wastewater pollutant loads would be preferable to this approach.

7.4.4.3.1 Receiving Node

A receiving node is used to represent the discharge point for each study area catchment / subcatchment which are shown in Figure 7-9 to Figure 7-12. Given the absence of available data from adjacent up and downstream areas, the models have been established as mass balance tools for the study area only. As a result, MUSIC outputs for the assigned receiving node are not a simulation of actual conditions at that point.

Table 7-7 Base Flow Concentration Parameters (Fletcher et al, 2004)

Concentration (mg/L-log$_{10}$)						
	TSS		TP		TN	
	mean	std. dev	mean	std. dev	Mean	std. dev
Land use/zoning						
Rural-Residential	1.15	0.17	-1.22	0.19	-0.05	0.12
Rural	1.15	0.17	-1.22	0.19	-0.05	0.12
Forest/bushland	0.78	0.13	-1.52	0.13	-0.52	0.13
Roads	1.20	0.17	-0.85	0.19	0.11	0.12

Table 7-8 Storm Flow Concentration Parameters (Fletcher et al, 2004)

Concentration (mg/L-log$_{10}$)						
	TSS		TP		TN	
	mean	std. dev	mean	std. dev	Mean	std. dev
Land use/zoning						
Rural-Residential	1.95	0.32	-0.66	0.25	0.30	0.19
Rural	1.95	0.32	-0.66	0.25	0.30	0.19
Forest/bushland	1.60	0.20	-1.10	0.22	-0.05	0.24
Roads	2.43	0.32	-0.30	0.25	0.34	0.19

7.4.5 Catchment Attenuation Logic

As discussed in Section 7.2.3, the attenuation rates derived for the Port Stephens Cumulative Impact Assessment (BMT WBM, 2011) were adopted without alteration for this study. The following is a brief summary of the approach to creation of attenuation rates.

7.4.5.1 Subsurface Attenuation Rates

Simplistic two dimensional (2D) groundwater modelling has been undertaken to estimate average annual attenuation of total nitrogen, total phosphorus and viruses in groundwater (subsurface deep drainage) flow at specific distances from the point of discharge. Modelling was undertaken for a selection of representative on-site systems and an assumed point of discharge to a drain or stream. Sensitivity testing of groundwater modelling was completed to provide an indication of the level of accuracy of results.

A 2D steady state analytical approach using the Domenico Equation was adopted for the following reasons.

- There is consistently a lack of available data to construct and calibrate a numerical groundwater model for most unsewered development proposals under 100 lots.
- Modelling of average annual pollutant loads in deep drainage indicates that the risk of export through groundwater flow and discharge to drains or a stream is very low in most scenarios.
- Steady state analytical modelling has been undertaken adopting very conservative input parameters and assumes an almost unrealistic worst case scenario for upper bound estimates.

The Domenico equation calculates pollutant concentration at a given point from a finite, planar, continuous source of pollutant under steady state (i.e. equilibrium) conditions. A full description of the equation is provided in Alvarez and Illman (2006). Analytical modelling was applied to average annual leaching concentrations from on-site systems to give an order of magnitude assessment of pollutant loads and risks to use of shallow groundwater. Modelling of unsaturated groundwater flow (i.e. lateral flow along limiting layers) was not specifically undertaken. Instead, attenuation rates obtained for saturated flow were assumed under all flow conditions. This is conservative as unsaturated flow typically results in greater attenuation of pollutants.

The outcome of groundwater modelling was a set of steady state (average annual) pollutant attenuation factors for the two representative environments. These attenuation factors were then applied to average annual on-site system loads estimated from the DSM modelling. A range of potential scenarios were tested to derive a suitably realistic but conservative attenuation rate that could be applied broadly to comparable environments. The limitations of this approach are recognised by the authors however it represents a method that is consistent with other groundwater management fields where risks to groundwater are low (UK Environmental Agency, 2006). It is also important to recognise the limited benefit in adopting more complex methods of estimating subsurface pollutant attenuation for on-site sewage management system assessment. The data required to undertake site specific monitoring programs or build transient numerical groundwater models will almost never be cost effectively collected for developments of this nature.

Sensitivity testing was undertaken using a combination of the following;

- a hydraulic gradient ranging from 5% to 50%;
- flow lengths ranging from 2m to 500m;
- concentrations of pollutants in deep drainage ranging from 0.5mg/L-1mg/L (TN), 0.5mg/L-2mg/L (TP) and 1MPN/L-1000MPN/L (viruses).

The results of the sensitivity testing for total nitrogen and total phosphorus loads in groundwater flows showed that adjusting either the hydraulic gradient or pollutant concentration at point of discharge resulted in only minimal changes in the percentage attenuation of pollutant loads. In contrast, adjusting the flowpath length resulted in a major change in the percentage attenuation. Under our assumed scenarios, setback distances were typically 50% of those set out in DLG (1998). The attenuation rates adopted reflect this reduced setback.

7.4.5.2 Surface Attenuation Rates

Surface attenuation was based on the F factors used by Jelliffe in Appendix E of OSRAS. These factors (which are the inverse of an attenuation factor) are based on research from comparable environments by Martens and Warner (1996).

Flow Length > 50m = 70% attenuation

Flow Length < 50m = 50% attenuation

A reduced attenuation factor was applied to any overflow generated by an effluent pump out system due to the more concentrated nature of discharge and typical reduced flow paths to constructed drainage systems.

7.4.5.3 Creation of Catchment Attenuation Rates

Daily time series from the DSM and MUSIC models were inserted into a comprehensive mass balance spreadsheet for application of attenuation in surface and groundwater flow. This then allowed calculation of total hydraulic and pollutant loads for the study area. The procedure for determining indicative groundwater attenuation rates is described in the previous section. It is not appropriate to assume full wastewater loads discharged to the ground surface are conveyed to surface drains and into stormwater runoff. During dryer weather (when soil is not saturated) the capacity for re-infiltration of this water and entrained pollutants will be substantial. In order to address this issue the following logic was developed to apply approximate surface flow attenuation factors from Jelliffe (2000) which in turn were obtained through field investigations for a doctoral thesis undertaken in Sydney by Martens (1996).

Following the outcomes of DSM and MUSIC modelling, a logic for the attenuation of pollutants was developed. This logic was developed using the following procedure.

- Soil water content from the MUSIC model results were used to classify individual days in the 20 year modelling period based on potential for pollutant attenuation / transport.
- Attenuation rates derived through groundwater modelling were used to assign attenuation rates (and subsequent proportions of pollutant loads reaching receiving nodes) to subsurface outputs from DSM results. Rates varied based on soil water content for that day.
- Surface attenuation rates from Jelliffe (2000) were adapted to both sites based on soil water content and applied to surface outputs from the DSM.
- Daily DSM outputs were multiplied by decay rates or inverse values of attenuation rates (i.e. as % of pollutant load discharging to receiving nodes) for the 0.4 ha lot density scenario.
- Average annual attenuation rates for total loads (surface and subsurface loads combined) were then calculated based on the daily attenuation logic and applied to all lot density scenarios.

Final pollutant attenuation rates are summarised in the following table.

Table 7-9 Adopted Attenuation Rates for Catchment Modelling

(Taken from BMT WBM, 2011)

	Hydraulic	Nitrogen	Phosphorus	Pathogen
Rolling hills of residual, colluvial and erosional soils in the western portion of the LGA with bedrock creating relatively shallow episodic perched water tables that discharge to local ephemeral drainage lines and creeks.				
100% Setback Achieved	60%	93%	94%	97%
50-100% Setbacks Not Achieved	40%	85%	70%	94%
Low lying sandy or estuarine environments underlain by shallow unconfined aquifers directly connected to the estuary.				
100% Setback Achieved	40%	99.7%	99.3%	99%
50-100% Setbacks Not Achieved	30%	99%	98.8%	99%[1]
Attenuation factors should be applied to average annual on-site system loads (kg/year) as an inverse (decay) decimal (i.e. 1-AF)				

7.4.6 Final Outputs

Attenuated average annual sewage flows from the DSM were then combined with average annual MUSIC outputs in a mass balance to provide a representation of relative impacts associated with on-site systems. Results have been assessed against baseline existing case MUSIC outputs for all four sites.

7.5 Results

7.5.1 Cumulative Impacts from New Development: Bohnock

Results of cumulative impact modelling for greenfield development are summarised in the following figures. Critical lot density was determined based on achievement of long-term nutrient and pathogen protection targets. A suitable long-term nutrient target for on-site systems was identified as the point where combined on-site system and undeveloped background pollutant loads result in no more than a 10% increase in undeveloped background loads. This target has initially been carried through from the DAF that has been adopted for Port Stephens Council for consistency. At present, GTCC have no policy on targets for stormwater quality. This target was adopted because a) it is unlikely to be possible to develop land without increasing long-term nutrient loads; b) the relatively small contribution to catchment nutrient loads made by on-site systems and c) there is sufficient uncertainty in the modelling process to warrant allowance for a +/-10% error.

It was agreed that new on-site systems should deliver full pathogen removal prior to receiving waters under average long-term conditions. As such the target for cumulative impacts was set at <1 MPN/100ml virus concentration at the receiving water as an annual average. In terms of residual health risks (i.e. risks associated with in-situ surcharging of effluent off-site), all systems were sized to prevent hydraulic failure in an average rainfall year.

Modelled on-site systems were found to have minimal contribution to nitrogen loads produced from the site as the existing background loads were identified as the chief sources. The critical lot size identified at which the combined developed and existing phosphorus loads were equivalent to the existing phosphorus loads (+10% error) was approximately 3,000 m^2. It can also be seen that existing systems in Bohnock are a relatively minor contributor to total catchment loads based on model results. This is consistent with other research into cumulative impacts from contemporary best practice on-site systems where development is located at conservative setback distances to sensitive receiving environments.

No pathogen export was identified for any of the Bohnock lot size model scenarios. Nitrogen export was not identified as an issue for any development density scenario. It should be noted that this hypothetical assessment ignored available area (i.e. the capacity of smaller lots to fit a land application area sized to modern standards). In reality, lots less than 3,200 m^2 would typically not be able to fit such an LAA.

The results of Cumulative Impact Assessment for Bohnock confirm previous research and monitoring of on-site systems that found systems sized to prevent frequent hydraulic failure are unlikely to generate off site impacts. It also confirmed that planned minimum allotment sizes for land use zonings likely to involve unsewered development will be more than adequate to prevent cumulative impacts. Given the limited risk of cumulative impacts occurring as a result of Greenfield development, these results were considered sufficient to support planning policy.

Risks of cumulative impact may occur in cases where setback distances to receiving environments are significantly less than the Minimum Standard in the GTCC DAF. The results of this assessment are based on achievement of the DAF Minimum Standard buffer distances for all new development.

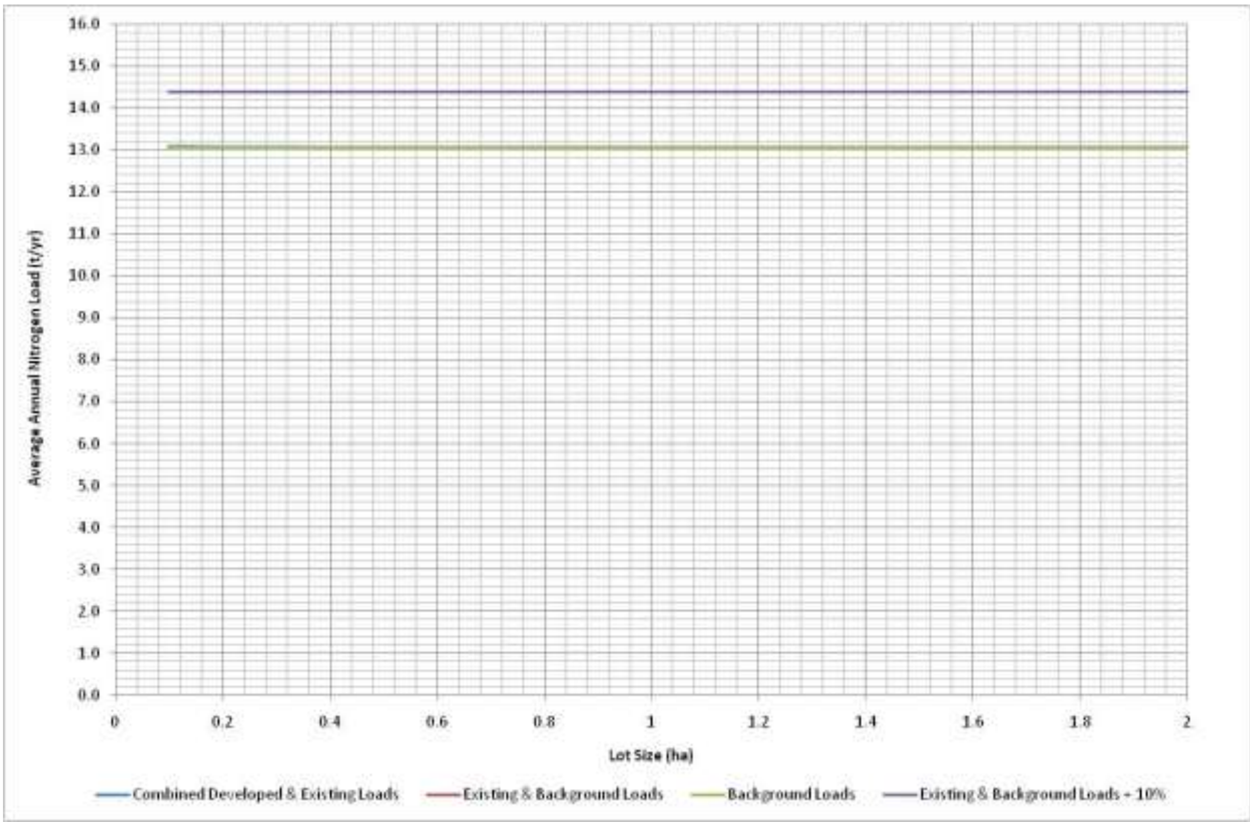


Figure 7-13 Bohnock CIA Results: Nitrogen Loads

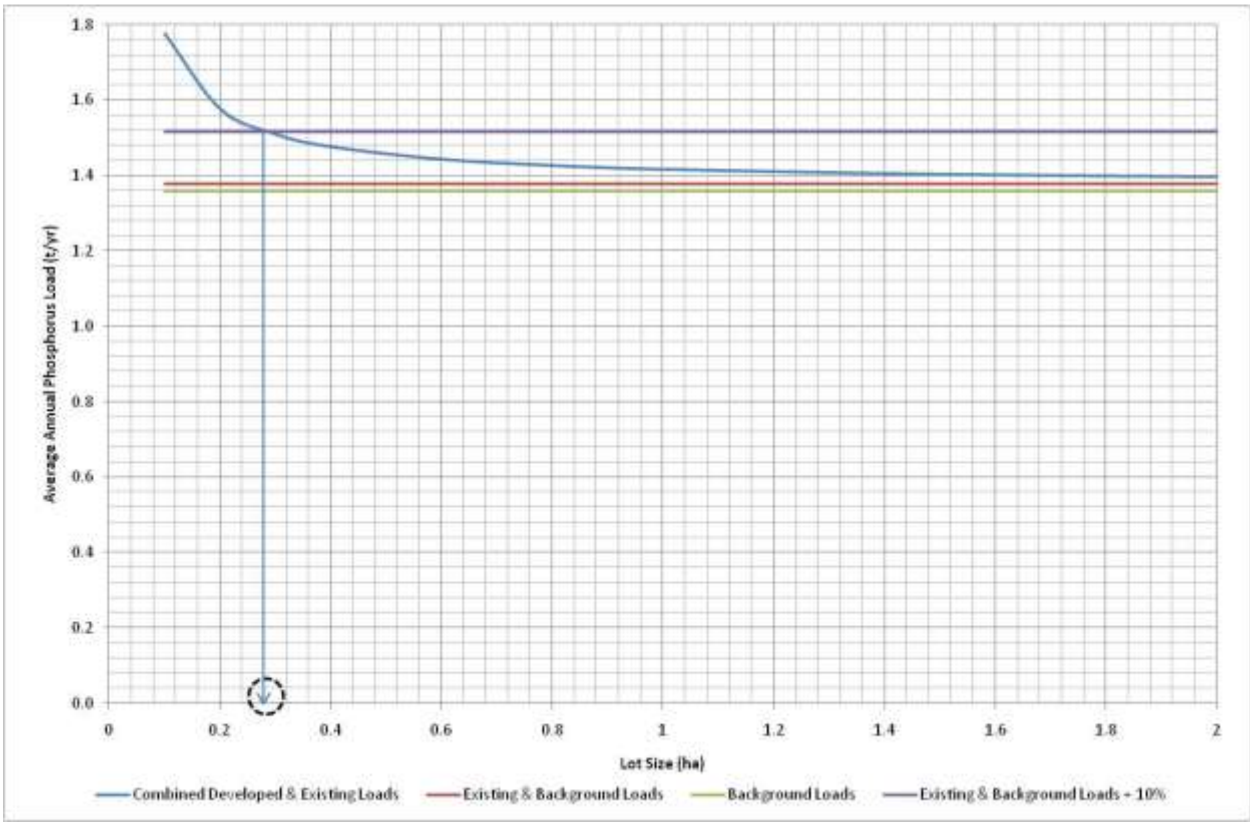


Figure 7-14 Bohnock CIA Results: Phosphorus Loads

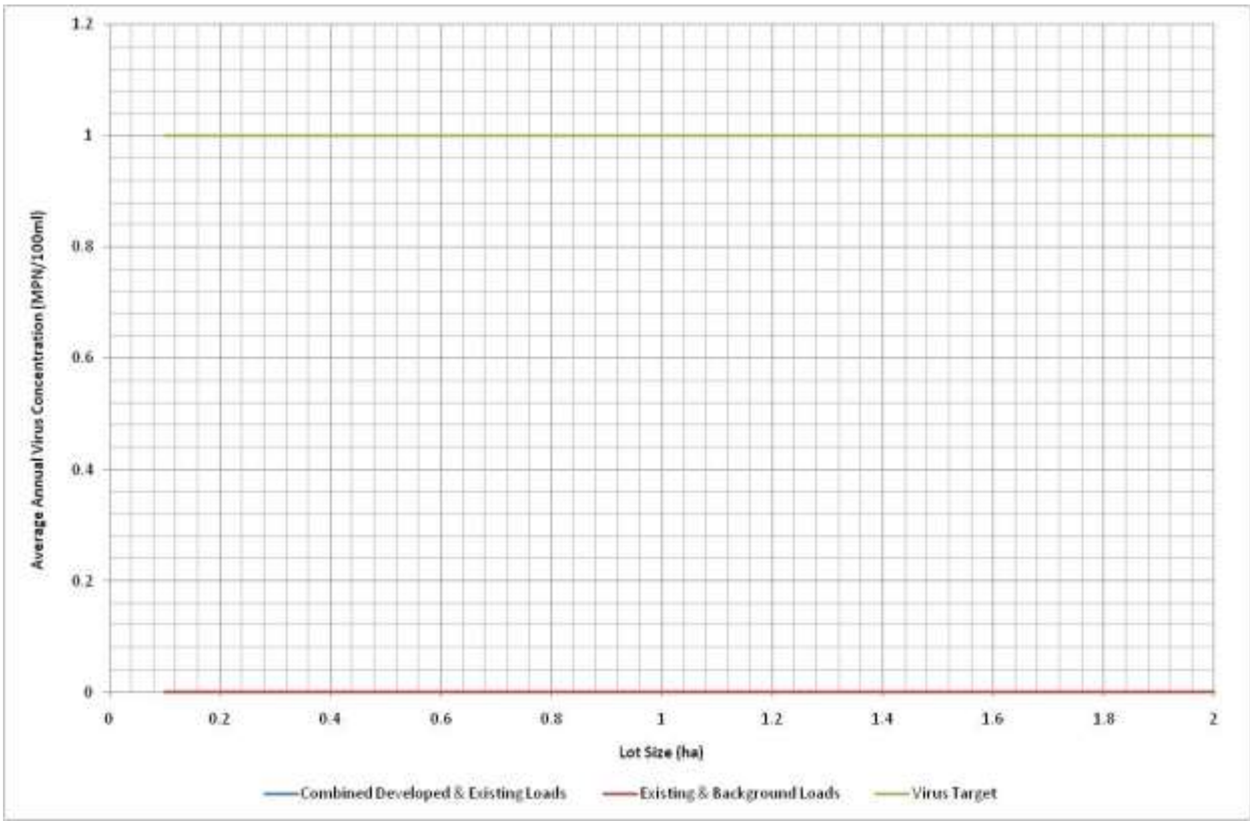


Figure 7-15: Bohnock CIA Results: Pathogen Loads

7.5.2 Sustainability of Existing High Risk Villages

Cumulative Impact Assessment (CIA) modelling for the three existing high risk villages was complete and the results have been evaluated in terms of;

- risks to receiving environments, public health and local (in village) health risks associated with the existing on-site systems;
- relative environmental and health protection benefits likely to be achieved through implementation of some form of improved wastewater servicing strategy; and
- residual risks remaining following implementation of these improved servicing strategies.

Long-term (i.e. average annual) nutrient export provided a guide to the contribution on-site systems may make to total catchment loads. Average annual concentration of viruses provides an indicative estimate of off-site public health risks particularly for aquaculture or recreational water use. Analysis of the frequency of hydraulic failure (surcharging) was undertaken for the three sites for each scenario. This analysis provides indications of the localised health risk within the village as a result of surcharging of land application areas. It also provides some indication of the likelihood of gross system failure which can result in more rapid transport of pathogens to receiving environments during rainfall events. The objective of the Existing High Risk Village assessment was to provide preliminary guidance on the likely benefits or cost effectiveness of broad options for future, improved wastewater servicing. The assessment also provided an indication of the relative risks posed by current on-site systems.

7.5.2.1 Johns River

Results for Johns River are presented in Figure 7-16 to Figure 7-19. Results indicate that in general nutrient export from Johns River is likely to be dominated by non-wastewater sources. As a result, implementation of the potential improvement strategies achieves no real benefit in terms of nutrient loads reduction to receiving waters. Average annual virus concentrations in the effluent portion of study area discharge are <1 MPN/100mls under existing and Scenario 1a conditions which should be considered a minor to low risk situation. Enforced installation of pump out systems (Scenario 1b - based on the assumed 10% overflow rate) greatly increase risks of pathogen export and local health risks.

In looking at the surcharging analysis it can be seen that hydraulic failure is common and frequent (~80% of years) based on the Existing Case model results. However, quantities of surface surcharging effluent are not high. Implementation of Scenario 1a (Best Practicable Option - BPO) reduces the frequency of failure on average but does not reduce the quantity of effluent surcharging. Scenario 1b (effluent pump out for sites with insufficient area for land application) does not reduce the frequency of surcharging beyond that achieved through BPO upgrades (1a). However the quantity of surcharging (in this case overflow from poorly managed pump out systems) is dramatically higher which suggests the potential for elevated pathogen concentrations in receiving waters is much higher.

Scenario 2 assumed existing vacant residential lots within the village were developed in addition to existing systems. Surcharge frequency for the new systems is predicted to be below the target of 50% of years. However, due to the significant number of existing residential lots in Johns River with some potential for development, the quantity of surcharging effluent is high. In other words, “build out” of Johns River in combination with BPO upgrades of existing systems may create elevated risk potential for localised health impacts and risks to recreational water use or aquaculture in receiving waters.

Implementation of a community wastewater management system (with local land application of effluent at a centralised and managed location) would achieve a significantly higher level of ecosystem and health protection than on-going on-site sewage management. Subject to availability of a suitable site it is possible that a community wastewater scheme could deliver comparable benefits to conventional reticulation at lower whole of life costs. As a guide, approximately 4-5 ha of irrigated land would be needed under a land treatment context. Alternatively, reticulated sewerage could be provided however the likelihood of funding for such a scheme is low.

The results of CIA modelling for Johns River suggest that existing systems are a negligible contributor to nutrient loads and pose a moderate to high risk to health within the village. Results also suggest there is currently a low to moderate risks to public health within receiving waters. This off-site risk would be highest during rainfall events. The results of the CIA would suggest that should continued on-site sewage management be determined to be the long-term servicing strategy for Johns River that BPO upgrades to existing systems would be the most effective strategy as opposed to effluent pump out. There will be cases where on-going land application is simply not feasible in which case pump out may be the only option. Notwithstanding, a residual risk is likely to remain with respect to localised health risks and risks to public health within receiving waters. This residual risk is considered moderate. The results suggest that build out of existing undeveloped residential lots should be limited should sewerage or a community wastewater system not be provided for Johns River.

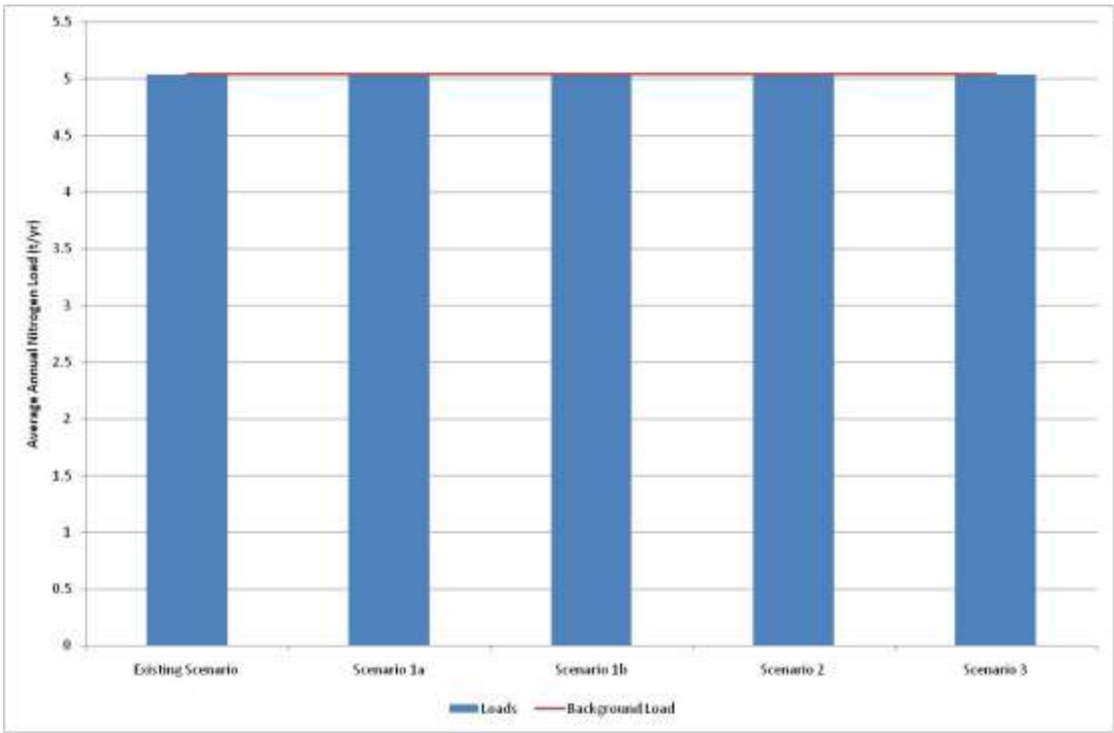


Figure 7-16 Johns River CIA Results: Nitrogen Loads

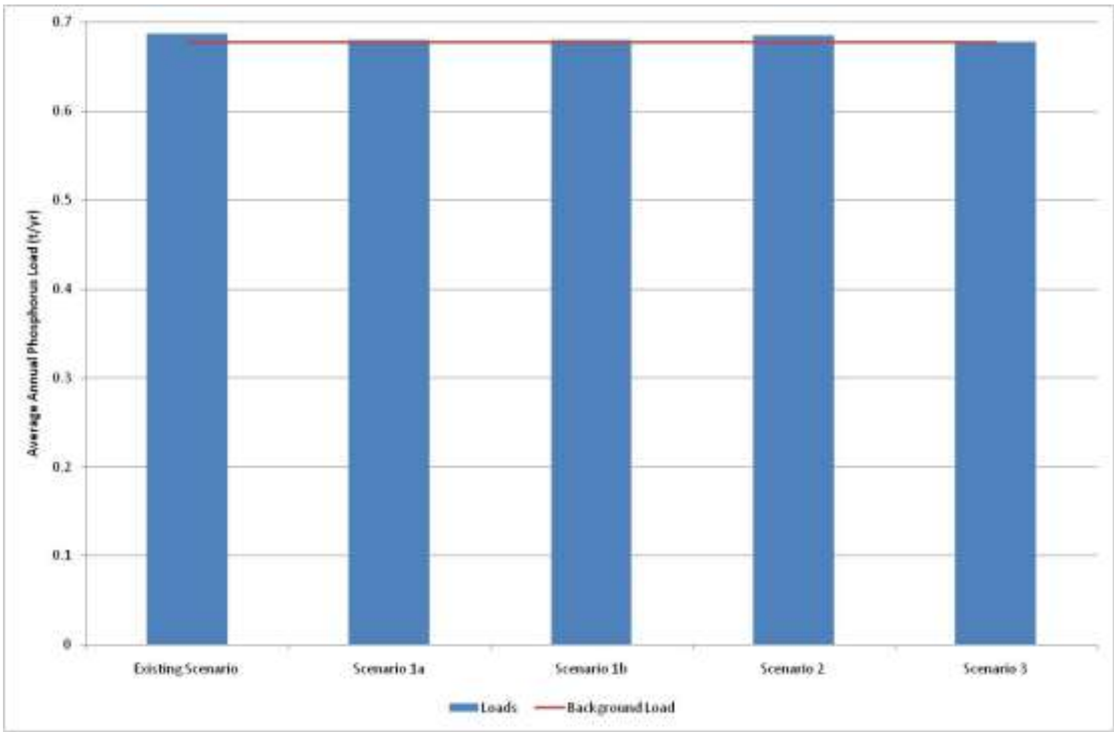


Figure 7-17 Johns River CIA Results: Phosphorus Loads

Key to Scenarios (Refer to Section 7.3.2.1)	
1A – Upgrade to Best Practicable Option (No Pump Out)	1B – Upgrade to Pump Out (where system failing)
2 – Build Out and Upgrade to Best Practicable Option	3 – Community Wastewater Servicing

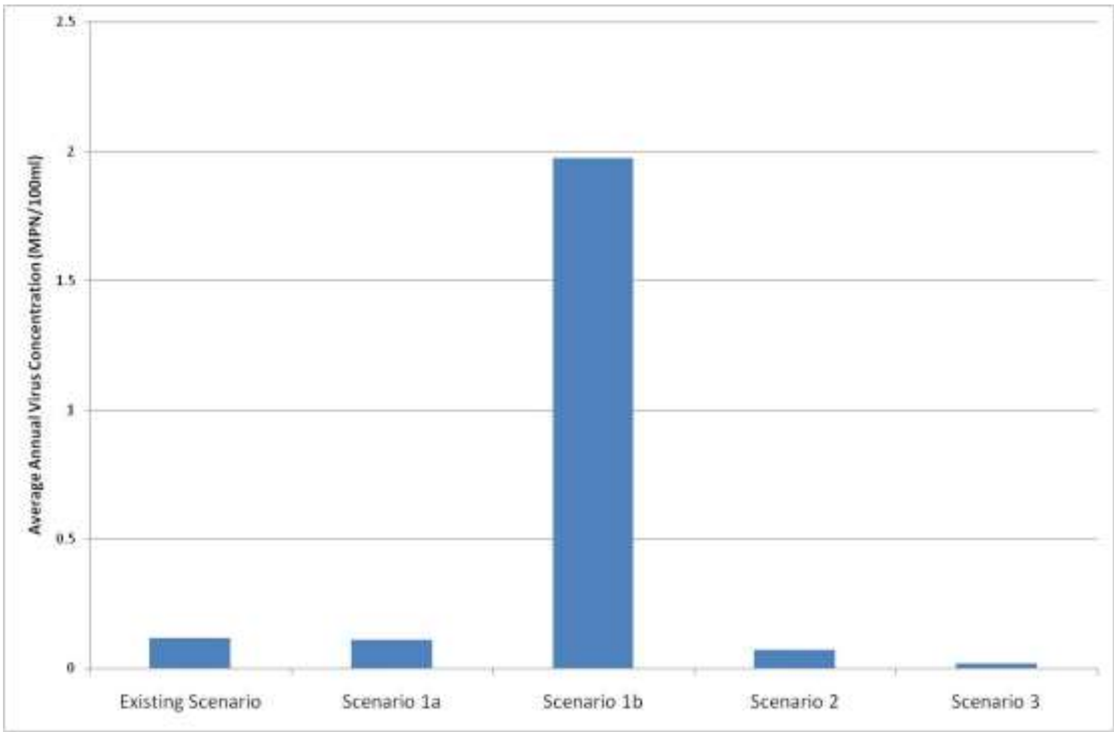


Figure 7-18 Johns River CIA Results: Pathogen Loads

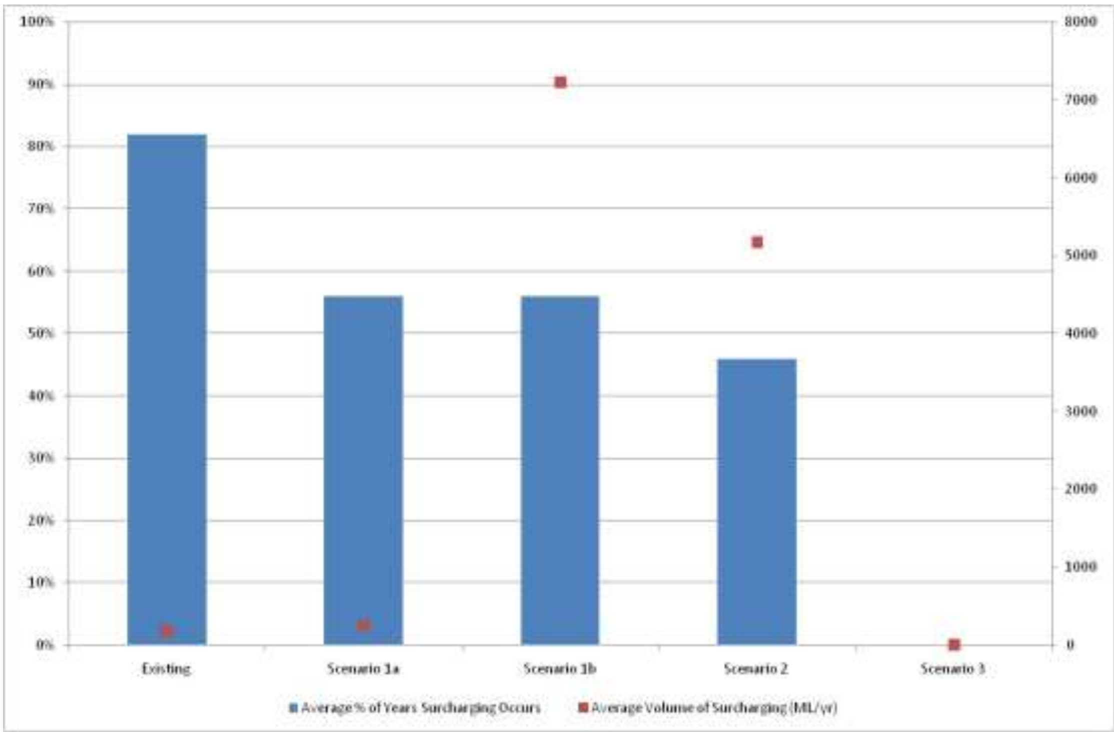


Figure 7-19 Johns River System Surcharging Analysis

Key to Scenarios (Refer to Section 7.3.2.1)	
1A – Upgrade to Best Practicable Option (No Pump Out)	1B – Upgrade to Pump Out (where system failing)
2 – Build Out and Upgrade to Best Practicable Option	3 – Community Wastewater Servicing

7.5.2.2 Krambach

Results indicate that in general nutrient export from Krambach is likely to be dominated by non-wastewater sources. As a result, implementation of the potential improvement strategies achieves no real benefit in terms of nutrient loads reduction to receiving waters.

Average annual virus concentrations in the effluent portion of study area discharge are <1 MPN/100mls under existing and Scenario 1a conditions which should be considered a minor to low risk situation. Enforced installation of pump out systems (Scenario 1b - based on the assumed 10% overflow rate) greatly increase risks of pathogen export and local health risks. Slopes and soil characteristics are likely to increase the risk of rapid pathogen export where failure occurs.

In looking at the surcharging analysis it can be seen that hydraulic failure is common and frequent (~95% of years) based on the Existing Case model results. Quantities of surface surcharging effluent are moderate. It can also be seen that lot size limits the ability to reduce localised health risks and wet weather pathogen export risks in Koribackh Creek and the Wallamba River. Maximising LAA sizes (Scenario 1a) does little to reduce the frequency of surcharge in an average year or volumes. Scenario 1b (effluent pump out for sites with insufficient area for land application) does not reduce the frequency of surcharging beyond that achieved through BPO upgrades (1a). However the quantity of surcharging (in this case overflow from poorly managed pump out systems) is dramatically higher which suggests the potential for elevated pathogen concentrations in receiving waters is much higher.

Scenario 2 assumed existing vacant residential lots within the village were developed in addition to existing systems. Limited future development was assumed for Scenario 2 for Krambach. As a result, surcharge frequency for the new systems is predicted to be comparable to 1a. However, due to the significant number of existing residential lots with high surcharge frequency, residual health risks remain high. In other words, “build out” of Krambach in combination with BPO upgrades of existing systems may create elevated risk potential for localised health impacts and risks to recreational water use or aquaculture in receiving waters.

Implementation of a community wastewater management system (with local land application of effluent at a centralised and managed location) would achieve a significantly higher level of ecosystem and health protection than on-going on-site sewage management. Subject to availability of a suitable site it is possible that a community wastewater scheme could deliver comparable benefits to conventional reticulation at lower whole of life costs.

The results of CIA modelling for Krambach suggest that existing systems are a negligible contributor to nutrient loads but are likely to pose a high risk to health within the village. Results also suggest there is currently a moderate risk to public health within receiving waters. This off-site risk would be highest during rainfall events. The results of the CIA suggest that should continued on-site sewage management be determined to be the long-term servicing strategy for Krambach, BPO upgrades to existing systems would be the most effective strategy as opposed to effluent pump out.

There will be cases where on-going land application is simply not feasible in which case pump out may be the only option. Notwithstanding, a residual risk is likely to remain with respect to localised health risks and risks to public health within receiving waters. This residual risk is considered high. The results suggest that build out of existing undeveloped residential lots should be limited should sewerage or a community wastewater system not be provided for Krambach.

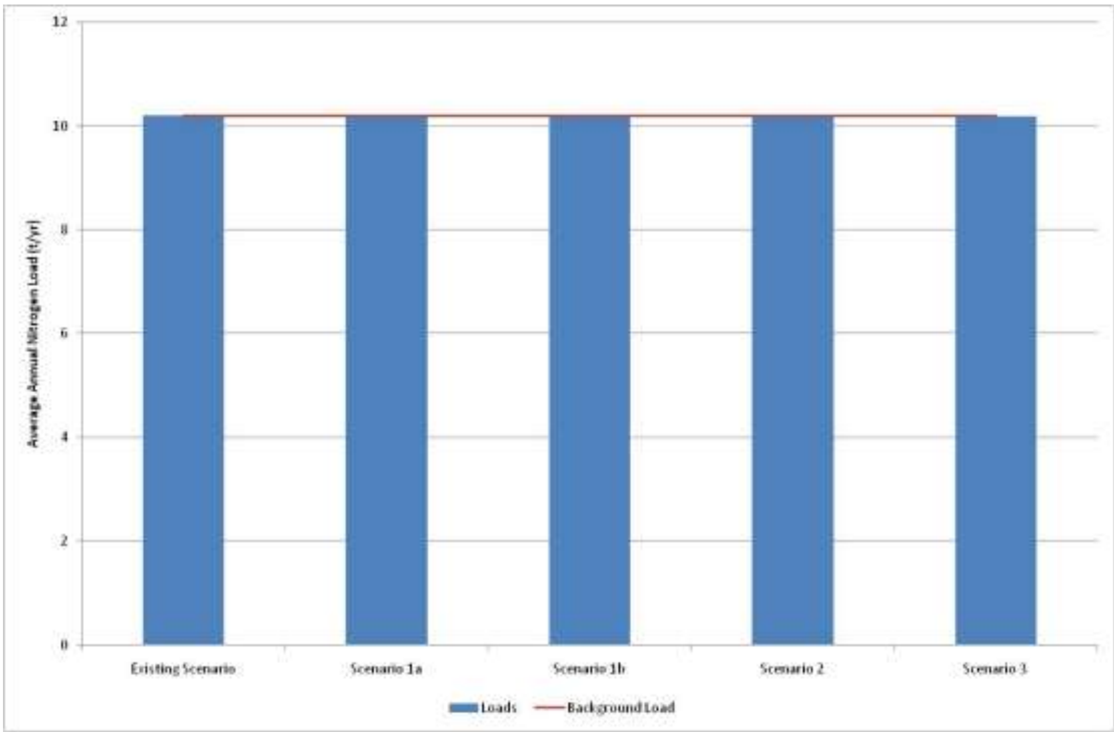


Figure 7-20 Krambach CIA Results: Nitrogen Loads

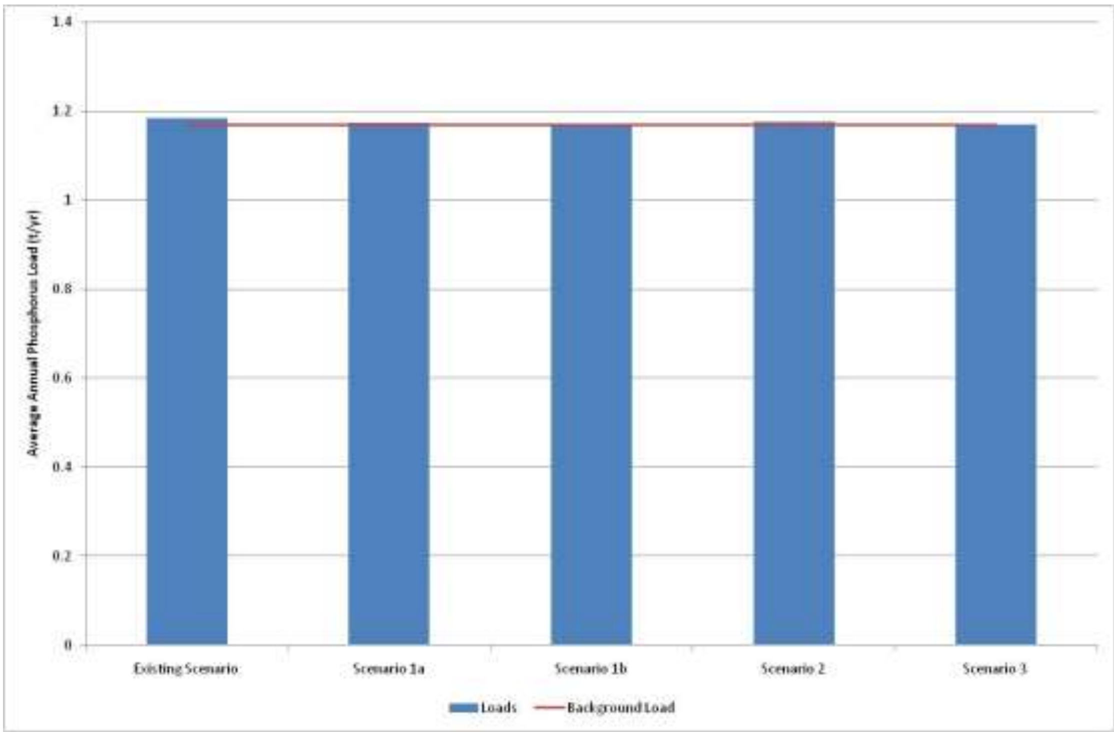


Figure 7-21 Krambach CIA Results: Phosphorus Loads

Key to Scenarios (Refer to Section 7.3.2.1)	
1A – Upgrade to Best Practicable Option (No Pump Out)	1B – Upgrade to Pump Out (where system failing)
2 – Build Out and Upgrade to Best Practicable Option	3 – Community Wastewater Servicing

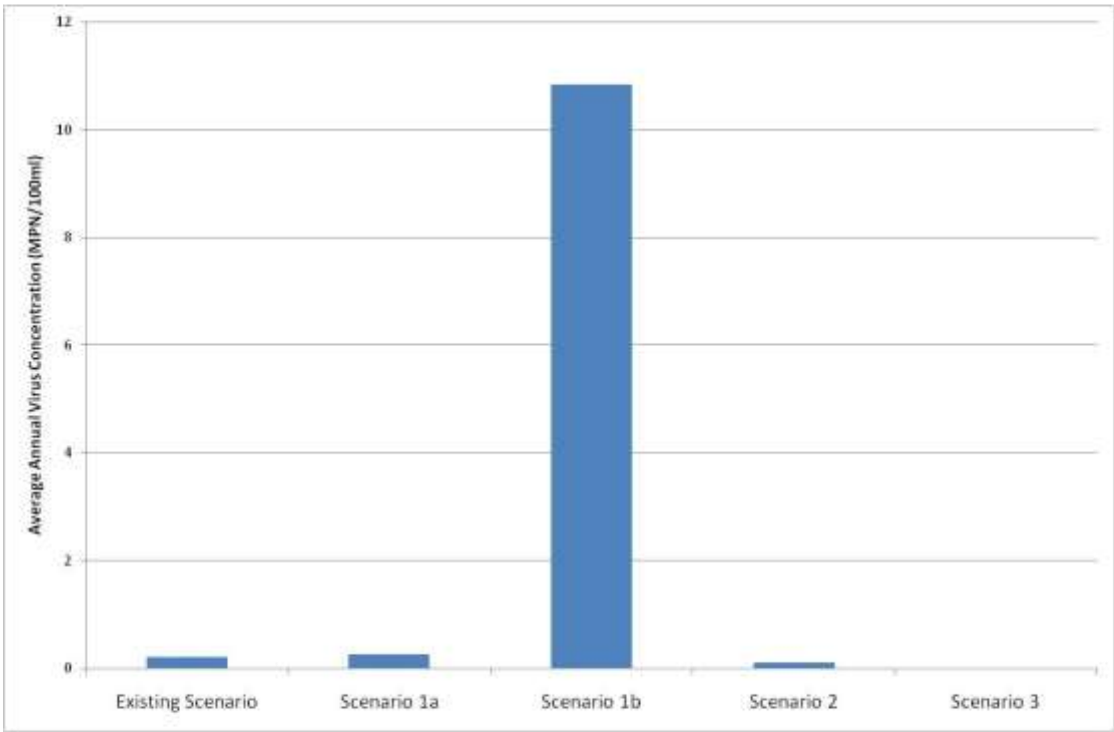


Figure 7-22 Krambach CIA Results: Pathogen Loads

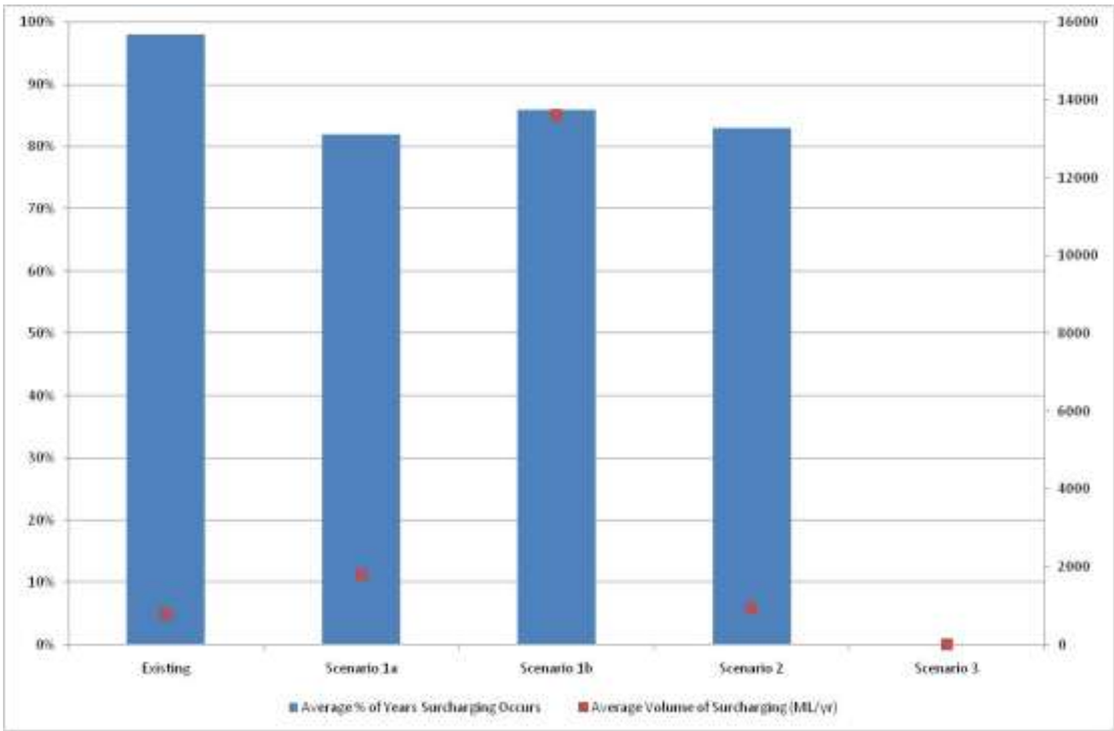


Figure 7-23 Krambach System Surcharging Analysis

Key to Scenarios (Refer to Section 7.3.2.1)

1A – Upgrade to Best Practicable Option (No Pump Out)
1B – Upgrade to Pump Out (where system failing)
2 – Build Out and Upgrade to Best Practicable Option
3 – Community Wastewater Servicing

Build out of existing village lots (subject to best practice) would most likely neither improve nor degrade conditions with respect to health and ecosystem risks. Implementation of a community system with a local land application site (away from the river) is likely to be a more suitable long-term servicing strategy. As a guide, approximately 2-3 ha of irrigated land would be needed under a land treatment context. Alternatively, reticulated sewerage could be provided however the likelihood of funding for such a scheme is low. Results certainly suggest that enforcing higher cost upgrades on existing failing systems may not deliver significant benefits.

7.5.2.3 Mt George

Results indicate that in general nitrogen and phosphorus export from Mt George is likely to be dominated by non-wastewater sources. As a result, implementation of the potential improvement strategies achieves no real benefit in terms of nutrient load reduction to the Manning River. On-site systems are not likely to be a substantial contributor to nitrogen or phosphorus loads based on these results.

Average annual virus concentrations in the effluent portion of study area discharge are <1 MPN/100mls under existing and all potential future servicing scenarios. This suggests off-site health risks can be considered a minor to low risk situation. Enforced installation of pump out systems (based on the assumed 10% overflow rate) only marginally increase risks of pathogen export and subsequent recreational water risks. In looking at the surcharging analysis it can be seen that the more permeable soils enable surcharging frequency and volume to be reduced more significantly through implementation of Scenario 1a when compared to the other three case studies.

In looking at the surcharging analysis it can be seen that hydraulic failure is common and frequent (~92% of years) based on the Existing Case model results. Quantities of surface surcharging effluent are moderate. It can also be seen that there is significant potential to reduce health risks within Mt George through implementation of BPO upgrades (1a) which achieve an acceptable reduction in surcharge frequency and volumes. Enforcement of pump out where land application is not considered sustainable does not significantly increase the frequency of failure but does increase the annual volume of surcharging effluent by 400% or ~1,700 ML/year (based on a 10% illegal discharge rate).

Scenario 2 assumed existing vacant residential lots within the village were developed in addition to existing systems. Limited future development was assumed for Scenario 2 for Mt George. As a result, surcharge frequency for the new systems is predicted to be comparable to 1a. However, the volume of average surcharge does increase sufficiently to suggest "build out" of Mt George may create an unacceptable residual health risk within the village.

Implementation of a community wastewater management system (with local land application of effluent at a centralised and managed location) would achieve a significantly higher level of ecosystem and health protection than on-going on-site sewage management. As a guide, approximately 1-2 ha of irrigated land would be needed under a land treatment context. Alternatively, reticulated sewerage could be provided however the likelihood of funding for such a scheme is low. Subject to availability of a suitable site it is possible that a community wastewater scheme could deliver comparable benefits to conventional reticulation at lower whole of life costs.

The results of CIA modelling for Mt George suggest that existing systems are a negligible contributor to nutrient loads but are likely to pose a moderate to high risk to health within the village. Results also suggest there is currently limited to public health within receiving waters. Although theses off-site risks would be higher during rainfall events. The results of the CIA suggest that should continued on-site sewage management be determined to be the long-term servicing strategy for Mt George, BPO upgrades to existing systems would be the most effective strategy as opposed to effluent pump out. There will be cases where on-going land application is simply not feasible in which case pump out may be the only option.

On-going on-site sewage management is likely to be the most appropriate long-term wastewater servicing option for Mt George. Subject to BPO upgrades of existing systems, an acceptable level of ecosystem and human health protection can be expected (subject to adequate management). The results suggest that build out of existing undeveloped residential lots should be limited unless sewerage or a community wastewater system is to be provided for Mt George.

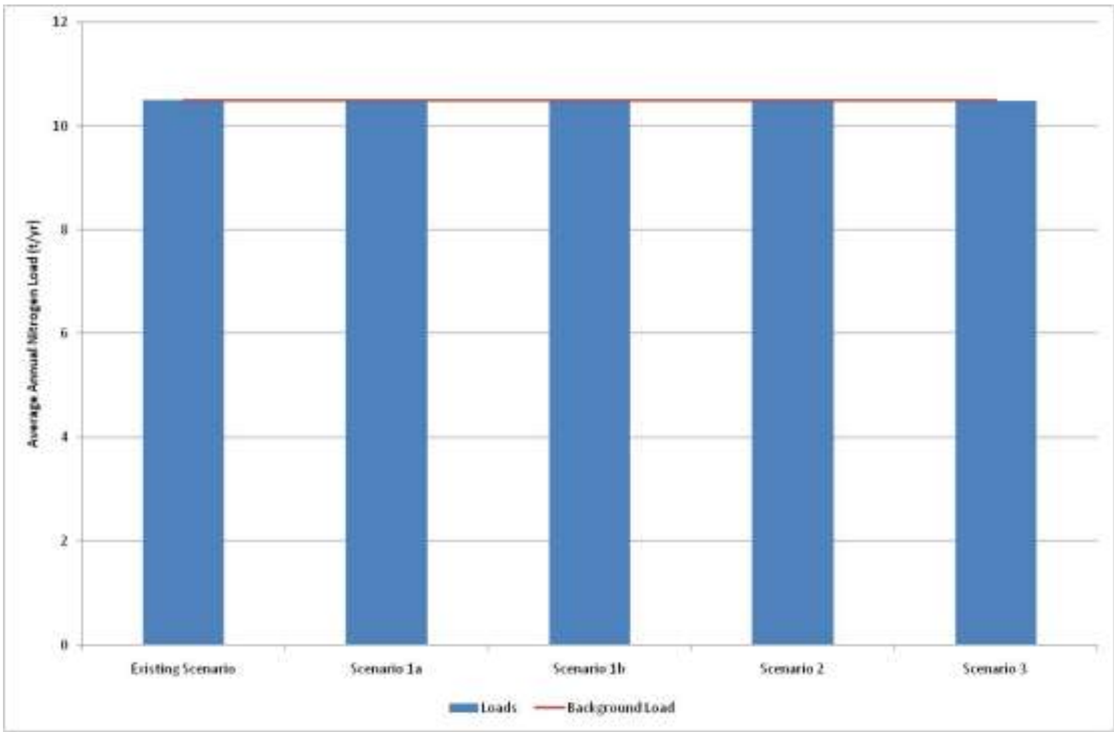


Figure 7-24 Mt George CIA Results: Nitrogen Loads

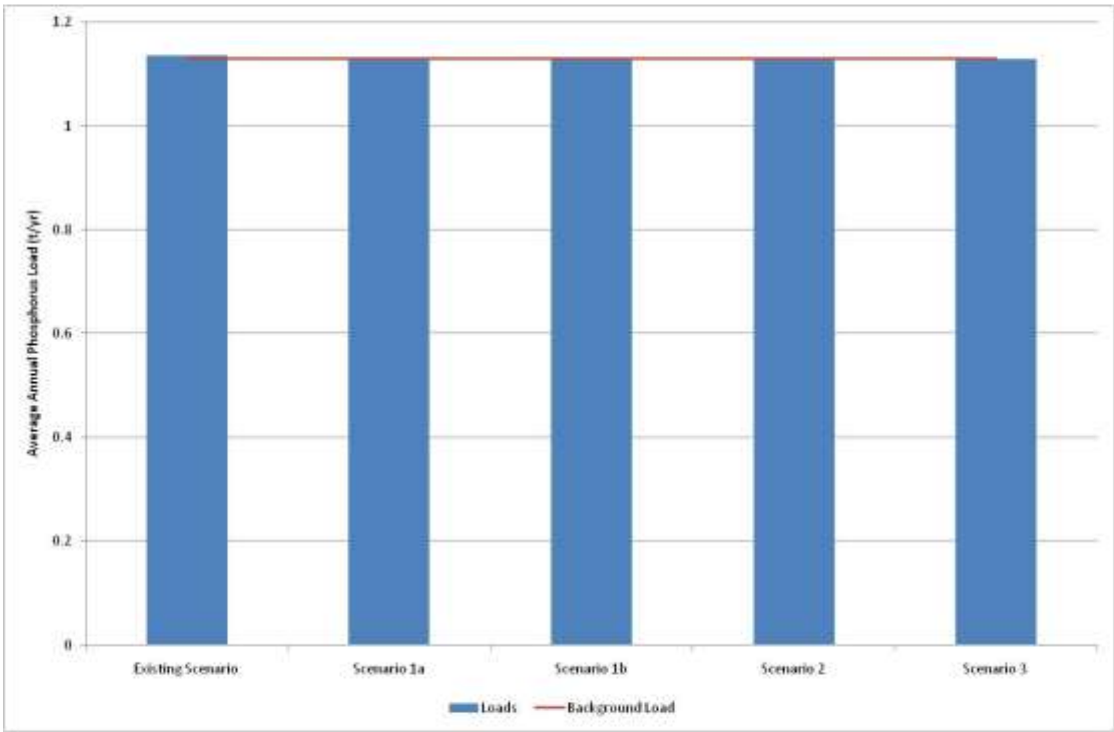


Figure 7-25 Mt George CIA Results: Phosphorus Loads

Key to Scenarios (Refer to Section 7.3.2.1)	
1A – Upgrade to Best Practicable Option (No Pump Out)	1B – Upgrade to Pump Out (where system failing)
2 – Build Out and Upgrade to Best Practicable Option	3 – Community Wastewater Servicing

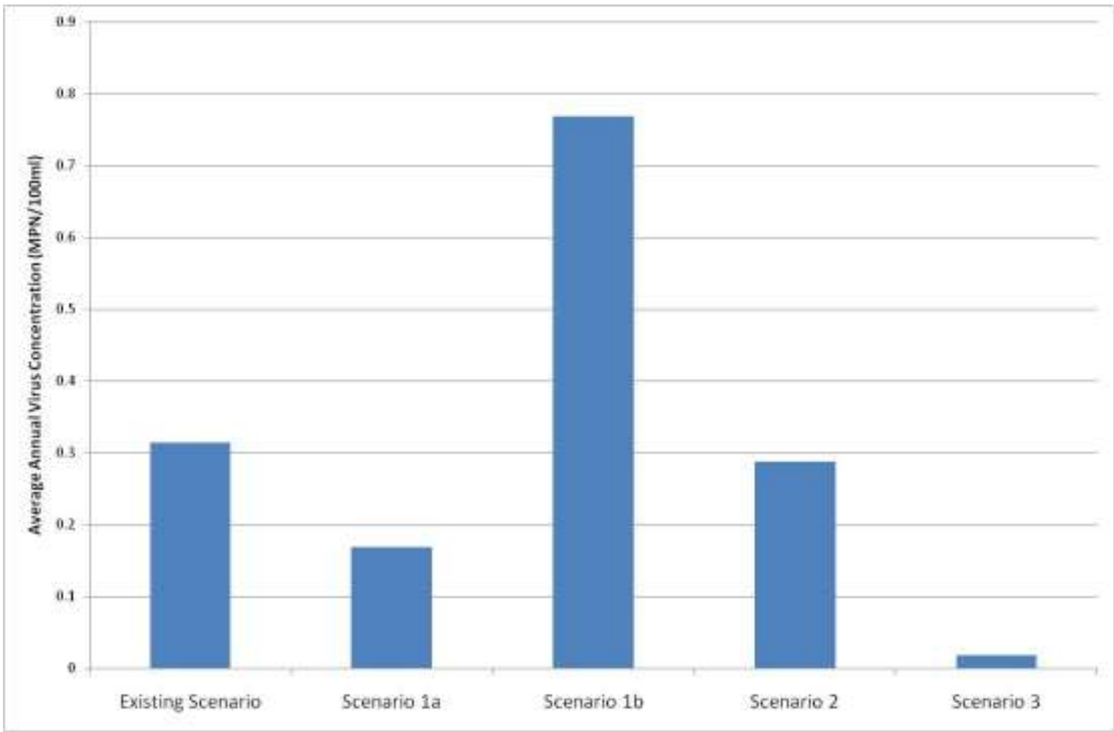


Figure 7-26 Mt George CIA Results: Pathogen Loads

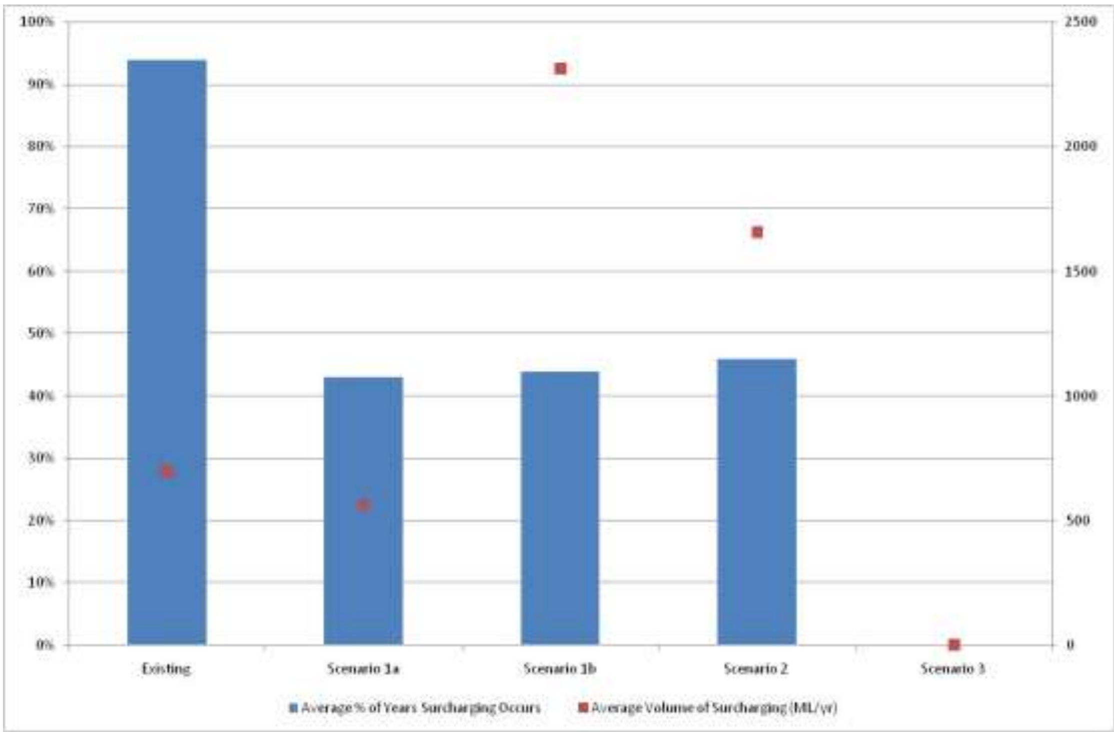


Figure 7-27 Mt George System Surcharging Analysis

Key to Scenarios (Refer to Section 7.3.2.1)	
1A – Upgrade to Best Practicable Option (No Pump Out)	1B – Upgrade to Pump Out (where system failing)
2 – Build Out and Upgrade to Best Practicable Option	3 – Community Wastewater Servicing

7.6 Outcomes

7.6.1 Greenfield Unsewered Development

The results of cumulative impacts modelling were analysed in conjunction with outcomes of the Minimum Lot Size assessment (Section 6) in order to make a final 'most limiting' determination on ***Useable Land*** for unsewered development.

Under *average* conditions a minimum of 3,000 m^2 of Useable Land was estimated based on the Minimum Lot Size assessment. A Useable Land value closer to 2,500 m^2 was identified (due to phosphorus export) with respect to cumulative impacts from new systems approved under contemporary standards. However, as discussed in Section 6.3 and apparent from Figure 6-1, significant variation in available area for on-site sewage management was observed across the LGA. The following conclusions have been drawn.

- Cumulative impacts are unlikely to be significant from new unsewered development where the following are achieved;
  - a Land Application Area (LAA) is sized based on the Design Loading Rates (DLRs) in *ASNZS 1547:2012*;
  - at least 2,500 m^2 of Useable Land is available within each lot; and
  - standard setback distances (presented in Section 6.9 of the GTCC DAF) are achieved for all sites.
- Whilst 3,000 m^2 of Useable Land *typically* enables installation of a sustainable on-site sewage management service, there were a number of notable exceptions identified.
- The Port Stephens Council DAF adopted 4,000 m^2 of Useable Land as the Minimum Standard for low risk (Acceptable Solution) unsewered subdivision to include a factor of safety.

Given the relatively simplistic nature of the cumulative impact assessment approach, the observed variability in minimum lot size / Useable Land and the minimum allotment size of 1.5 ha (GTCC LEP), a conservative approach was adopted here.

It was concluded that the provision of a minimum of 4,000 m^2 of Useable Land (as defined in the DAF) is an appropriate deemed to comply criterion to enable construction and design of a robust on-site sewage management system and provide a high level of protection with respect to cumulative impacts on heath and ecosystems.

This is less than the 1.5 ha minimum lot size included in the current LEP. The Useable Land concept was found to be critical to effective on-site sewage management as the shape of allotments and/or presence of intermittent / permanent water bodies or floodprone land had the ability to prevent construction of a sustainable system on lots up to 2 hectares. Identification of Useable Land has been previously incorporated into DAF procedures for all unsewered developments proposing to increase accessible building entitlements.

Under a DAF, failure to achieve this Useable Land requirement would trigger the need for higher levels of assessment and design. Useable land should be considered in conjunction with setback distances as these two criteria have been identified as critical for preventing cumulative / off-site impacts.

It should also be noted that this Useable Land target has only been assigned to Acceptable Solution development under the DAF. In other words, developments that meet Acceptable Solution criteria of;

- **4,000 m^2 of Useable Land per lot;**
- **achievement of setback distances to sensitive receptors;**
- **classified by Council as Low or Medium On-site Sewage Management Hazard; and/or**
- **being residential development;**

will be considered to adequately manage cumulative impacts without the need for site specific assessment or modelling. Individual applicants are able to complete their own site specific CIA using procedures that would be summarised in a Technical Manual should a DAF be developed for Greater Taree.

7.6.2 Existing Villages

Outcomes of CIA modelling for the three existing villages provides insight into the relative contribution of on-site systems to catchment nutrient loads to receiving waters. It also suggests localised and (in some cases) off-site pathogen contamination risks are likely to be significant. Small lot sizes and undersized Land Application Areas (LAAs) are the primary reason for this. In some cases, limited available area and land capability constraints combine to limit the long-term viability of continued on-site sewage management (Krambach).

In the case of Johns River, there may be potential for adequate management of risks through upgrade of failing systems on an opportunistic basis. However results also suggest some residual health risks will likely remain, particularly during wet weather. The costs to the community to upgrade existing systems needs to be compared to alternative servicing options such as a community wastewater scheme with local land treatment. Modelling indicates a very high level of performance from a community land treatment system scenario.

Modelling suggests that Mt George is a candidate for continued on-site servicing subject to progressive upgrade of on-site systems. This outcome is somewhat dependent on site specific issues relating to the suitability of available area for expansion of land application systems.

It is recommended that GTCC engage with Mid Coast Water to progress long-term wastewater servicing strategies for these three villages, along with other similar locations within the local government area. The assessment undertaken here is an initial high level evaluation of relative risks associated with a number of general servicing scenarios. More detailed analysis and development of more comprehensive servicing concepts and costs would be required to make a more robust judgement.

Table 7-10 Summary of Existing High Risk Village Assessment

Village	Outcomes	Recommendations
Johns River	• On-site systems negligible contributor to nutrient export. • Moderate to high health risks within village (due to surcharging LAAs). • Low to moderate health risks in receiving waters.	**Existing Development** • Best Practicable Option (BPO) upgrades to existing systems with failing LAAs will manage the majority of risk. • Low to moderate health risks would remain, particularly within Johns River. • Provision of a community wastewater scheme would deliver a comparable benefit to conventional sewerage (elimination of residual health risk) at cost. **Future Build Out of Existing Residential Lots** • Health risks within village and receiving waters likely to increase to moderate to high level even with BPO upgrades. • Provision of a community wastewater scheme would be the preferred long-term servicing option.
Krambach	• On-site systems negligible contributor to nutrient export. • **High** health risks within village (due to surcharging LAAs). • Moderate health risks in receiving waters.	**Existing Development** • Provision of a community wastewater scheme or conventional sewerage is the preferred long-term servicing strategy for Krambach. • Best Practicable Option (BPO) upgrades to existing systems with failing LAAs will provide limited improvement in health risks (within Krambach). • Effluent pump out is not considered an effective strategy based on historical practices in tanker removal frequency. **Future Build Out of Existing Residential Lots** • Provision of a community wastewater scheme would be the preferred long-term servicing option.
Mt George	• On-site systems negligible contributor to nutrient export. • Moderate to high health risks within village (due to surcharging LAAs). • Low health risks in receiving waters.	**Existing Development** • Best Practicable Option (BPO) upgrades to existing systems with failing LAAs will most likely effectively manage risk. • Effluent pump out is not considered an effective strategy based on historical practices in tanker removal frequency. • Less likely that provision of a community wastewater scheme would be justifiable based on estimated benefits. • Some uncertainty surrounding suitability of available area for expanded LAAs. **Future Build Out of Existing Residential Lots** • Health risks within village and receiving waters likely to increase to moderate level even with BPO upgrades. • Provision of a community wastewater scheme would be the preferred long-term servicing option. • Alternatively, limitations may need to be placed on future development.

8 RATIONALE FOR ACCEPTABLE SOLUTION TABLES

As part of the Development Assessment Framework (DAF), a series of Acceptable Solution tables were developed comprising minimum sustainable land application areas (LAA) required for five common on-site system types. These Acceptable Solution tables have been provided in Section 5 of the DAF as a system selection and design option for Low and Medium Hazard allotments. The tables present minimum land application area sizes (in m^2 basal area) for a wide range of common residential development scenarios possible throughout the LGA. A total of 900 possible combinations were modelled using an annual water and nutrient balance varying the following broad characteristics:

- Three climate zones;
- Six soil types;
- Two water supply system types;
- Number of bedrooms (1-5);
- Five wastewater system types.

Figure 8-2 illustrates the range of on-site system configurations considered in the Acceptable Solution tables.

8.1 Inputs for Minimum Land Application Areas

The Greater Taree LGA was broken down into three climate zones (northern, central and eastern) as shown in Figure 8-1. The division between climate zones were assigned using gridded average annual rainfall data from the BOM Climate Atlas by identifying the spatial mid-point in average rainfall between stations. Each climate zone was assigned monthly values for rainfall, evaporation and crop factor based on climate data from three BoM stations, with the northern climate zone adopting climate data from the Comboyne gauge, the central climate zone adopting data from the Taree gauge and the eastern zone adopting climate data from the Harrington gauge. The monthly values for the three BoM gauges are shown in Table 8-1 - Table 8-3.

Table 8-1 Comboyne Climate Data

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Rainfall	211.1	249.9	235.7	160.9	133.8	151.5	95.9	82.1	86	115.3	146.8	157.1	**1826.1**
Evaporation	168.3	133.1	120.0	88.9	64.1	55.2	62.1	87.4	113.7	139.7	148.0	175.3	**1361.8**
Crop Factor	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.60	0.65	0.70	0.75	0.80	**0.70**

Table 8-2 Taree Climate Data

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Rainfall	118.9	138.7	149.5	117	96.8	97.7	73.9	61.2	60.2	75.6	86.6	99.9	**1178.8**
Evaporation	176.7	142.8	130.2	96	65.1	57	58.9	80.6	111	142.6	159	186	**1423.5**
Crop Factor	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.60	0.65	0.70	0.75	0.80	**0.70**

Table 8-3 Harrington Climate Data

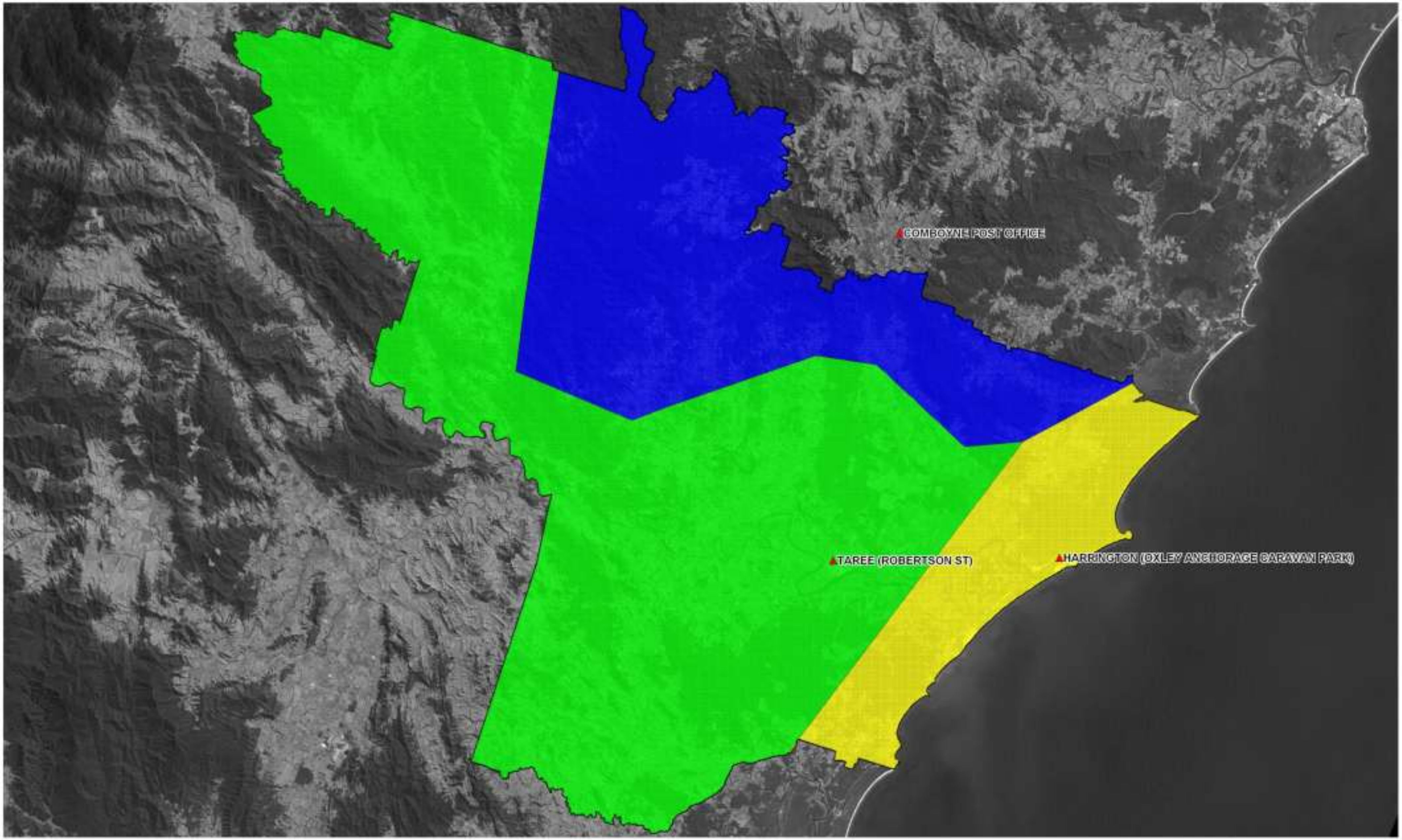
Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Rainfall	117.6	147.8	157.7	138.3	119.1	131.7	90.6	79.1	72.5	85.2	92.2	105.5	**1338.2**
Evaporation	176.7	142.8	130.2	96	65.1	57	58.9	80.6	111	142.6	159	186	**1423.5**
Crop Factor	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.60	0.65	0.70	0.75	0.80	**0.70**

Six general design soil categories were considered ranging from sand to medium/heavy clays. Each soil type was assigned a value for phosphorous sorption (mg/kg) and DLR (mm/day) as shown in Table 8-4. These soils were considered as 'design' soils (i.e. the most limiting soil horizon used to design an on-site system land application area). DLRs were adapted from *ASNZS1547:2012* and phosphorus sorption values were adopted based on local experience conducting site and soil assessments.

Table 8-4 Soil Types and Adopted Parameter Values

Soil Type	Soil P-Sorption (mg/kg)	DLR (mm/day)		
		Primary Trenches/Beds	Secondary Trenches/Beds	Irrigation
Sand	100	20	35	5
Sandy loams	150	15	25	5
Loams	200	10	15	4
Clay loams	300	7	10	3.57
Light clays	350	5	8	2.86
Medium / heavy clays	400	5	5	2.14

The daily design wastewater flow was estimated based upon the number of bedrooms per dwelling (1-5) and type of water supply (reticulated or tank). The design wastewater flow values are shown in Table 8-5. It can be seen that occupancy and per capita wastewater generation were based on *ASNZS1547:2012*.



LEGEND

Climate Zones

- Central
- East
- North

▲ BoM Rainfall Station

Title:

Climate Zones for Acceptable Solution Tables

Figure: 8-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 7.5 15km

Approx. Scale

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Table 8-5 Design Wastewater Flow

Number of Bedrooms	Number of Occupants	Design Wastewater Flow (L/d)	
		Reticulated Supply	Tank Supply
1	2	300	280
2	4	600	560
3	5	750	700
4	6	900	840
5	7	1,050	980

Five wastewater system types were considered including primary and secondary trench systems; primary and secondary Evapo-transpiration / Absorption (ETA) bed systems; and (subsurface) irrigation systems. Given that the Acceptable Solution tables will only be used for proposed systems on Low and Medium Hazard lots, more traditional primary dosed trenches and beds have been included. However, it is acknowledged that opportunities for adoption of primary dosed trenches and beds are limited and in some cases, may not be as cost effective as secondary treatment and subsurface irrigation. A value for void space ratio, Total Nitrogen (TN) and Total Phosphorous (TP) effluent concentrations, maximum depth of storage in trenches/beds, and percentage of nitrogen lost to soil processes were assigned for each system type as shown in Table 8–6.

Table 8-6 Wastewater System Types

System Type	Void Space	Max. Depth (mm)	Effluent TN (mg/L)	Effluent TP (mg/L)	%N Soil
Primary Trench	0.3	450	60	18	0.4
Secondary Trench	0.3	450	30	12	0.2
Primary ET Bed	0.3	300	60	18	0.4
Secondary ET Bed	0.3	300	30	12	0.2
Irrigation	1	0	30	12	0.2

8.2 Assignment of Minimum Land Application Areas

The input parameters summarised above were compiled into a macro enabled water and nutrient balance spreadsheet. The macro enabled an annual water and nutrient balance to be completed for each of the 900 possible combinations of on-site system scenario and the 2700 results output into a table. Results were then assessed and reduced through consideration of a number of practical and design limitations associated with the various land application system types. Values were also rounded up to the nearest practical value (i.e. an installer is unlikely to vary sizes by small increments). This is considered acceptable given the relative accuracy of design procedures. Further justification for not using a monthly water balance is provided in Section 9. .

It is important to recognise that the Acceptable Solutions have been offered as a conservative standard design option for applicants on Low and Medium Hazard lots who wish to fast track their approval whilst providing Council with confidence that their proposal is sustainable. They will not be permitted for adoption on High and Very High Hazard lots, commercial / industrial development or any lot with constraints not identified through the hazard mapping process.

The following points summarise how raw outputs from modelling were reduced and simplified. Further details can be found in the DAF.

- Limitations were placed on maximum allowable slope for trenches and beds to be considered an Acceptable Solution.
- Limitations were placed on allowance of gravity dosing of trenches and beds where even distribution of effluent could prove difficult.
- A minimum of 600mm of soil must be present between the base of any land application system and any limiting layer or water table.
- Limitations were placed on the maximum basal area allowable for trenches and beds considered an Acceptable Solution based on construction challenges associated with achieving level bases across large areas.

8.3 Outcomes

A set of Acceptable Solution tables have been included in the DAF for use as a 'deemed to comply' option for system selection and design on Low and Medium Hazard lots. The minimum land application system sizes are considered conservative for a range of possible development scenarios. Applicants are however free to complete site specific design calculations to derive their own sizing.

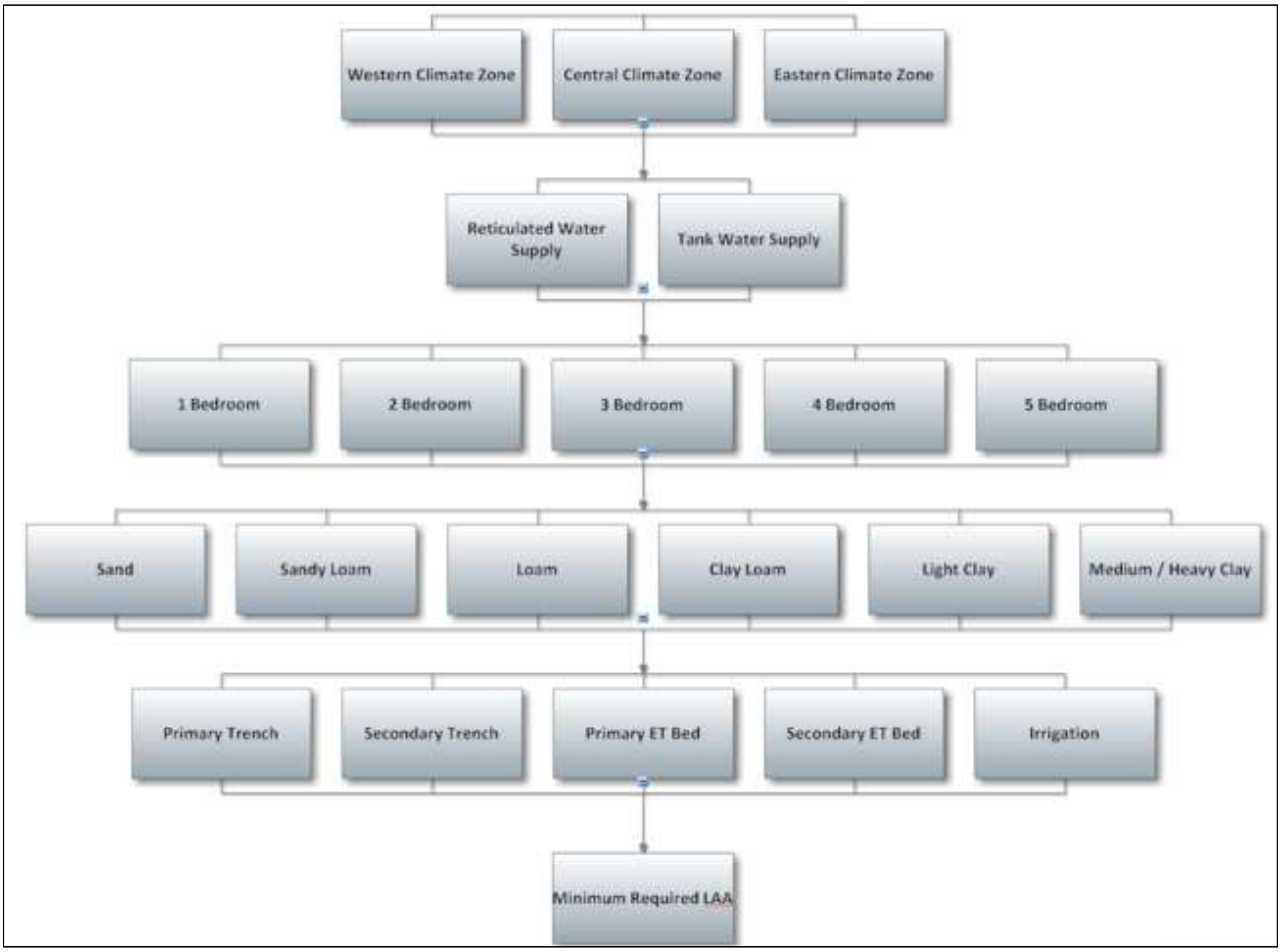

Figure 8-2 Decision Tree for Selection of Acceptable Solutions

9 DAF DESIGN PROCEDURES

The Development Assessment Framework (DAF) sets out a number of design procedures that vary in complexity and information requirements depending on relative risk. Some procedures are already a requirement of on-site sewage management system design. Others are more advanced procedures often limited in use to larger, non-domestic wastewater management systems. Since the implementation of Councils On-site Sewage Management Strategy, it has become apparent that traditional assessment and design procedures associated with domestic on-site systems are not always capable of a) ensuring a system will be capable of managing design loads or b) demonstrating a proposed system will not pose an unacceptable risk to ecosystems and human health. Particular issues have arisen on smaller allotments that feature one or a number of bio-physical constraints to sustainable on-site sewage management. Larger non-residential on-site systems can also require more comprehensive design and assessment procedures.

This leaves Council in a position where they must either request additional information from an applicant or make a determination on an application without confidence. This chapter summarises general guideline information for undertaking key on-site system design procedures required under the DAF. It is not however a design manual and consultants are still expected to use the recommended resources provided below to develop their own procedures and tools to meet Councils Minimum Standards.

9.1 Wastewater Characterisation

When designing domestic on-site sewage management systems, use of standard published guideline values (e.g. *ASNZS1547:2012*) for wastewater flow and constituent loads is normally adequate. However, this is not always the case on highly constrained sites or for non-domestic systems. In some cases the sensitivity of the receiving environment may make the inevitable inaccuracies of typical published values critical to performance. Alternatively, the unique site activities associated with non-domestic facilities may limit the suitability of typical published values. **Guiding information** and recommended data sources are provided in the following chapter. There are two occasions within the DAF where wastewater flow and constituent load generation rates beyond *ASNZS1547:2012, AS1546:2008* and NSW Health (2001 and 2005) are required.

9.1.1 Very High Hazard Domestic On-site Systems

The presence of significant constraints to sustainable on-site sewage management on Very High Hazard lots increases the level of detail and accuracy needed during design procedures to ensure a robust system is installed that is capable of managing these constraints. In the case of new developments, existing water consumption or wastewater generation data are not typically available. In these cases it is important to adopt conservative design wastewater generation rates. Notwithstanding, care should also be taken to not be over conservative resulting in oversizing of treatment and/or land application systems to the point where they do not receive sufficient loads to enable adequate biological activity.

In the case of applications to upgrade or replace an on-site system servicing an existing facility, design wastewater flows and loads should be validated or derived from actual site data wherever possible. The following table provides a summary of guiding information on calculation of design wastewater flows and loads for Very High Hazard domestic on-site systems.

Table 9-1 Calculation of Design Wastewater Flows and Loads: Very High Hazard Domestic

Scenario	Calculation Process	Resources
New Dwelling	**Wastewater Flow** Occupancy calculated at minimum 1.6 persons per bedroom. No allowance for water reduction fixtures/facilities. Seasonal variation to be considered for intermittently occupied / holiday homes (design for peak daily/weekly occupancy).[1] **Constituent Loads** Published domestic loads (e.g. g/day) with conservative allowance made for any non-domestic activities (e.g. hairdressing, cheesemaking).	(Appendix H Table H1of *AS1547*). *AS1646*, NSW Health (2001, 2005).
Existing Dwelling	**Wastewater Flow** Analyse existing water consumption data (or wastewater flow data) and use to validate adopted design flow profile. Consideration should be given to seasonal / monthly variation shown in data.[1] **Constituent Loads** Published domestic loads (e.g. g/day) will normally be sufficient. Existing wastewater quality sampling may be warranted where specific non-domestic activities (e.g. hairdressing, cheesemaking) are occurring.	As above. Consideration should be given to permanently or temporarily installing a Smart Meter to collect detailed water use data where significant variation is likely. As above.

Note 1: Flow balancing / equalisation may be of benefit where uncertainty exists around peak and average wastewater generation rates.

9.1.2 Non-domestic On-site Systems

Non-domestic facilities commonly produce wastewater that varies in quantity and quality over time. They can involve mixed use facilities where domestic wastewater is generated in combination with commercial, industrial or agricultural wastewater. Adoption of domestic wastewater generation rates and constituent loads (e.g. from *AS1547, AS1546*, NSW Health guidelines) should not be undertaken without confirmation that they are applicable to the specific site. As a minimum, typical published wastewater flow and load generation rates should be sourced from industry recognised, applicable sources. It must be recognised however that even these values are generalised average values obtained from sites with a wide range of activities and unique characteristics. Wherever possible, site specific data should be collected for all non-domestic systems and larger flow domestic systems (>10 kL/day).

There is no NSW guideline document available that relates specifically to non-domestic / package wastewater treatment system applications. There are however a small number of nationally and internationally recognised texts and guidelines that should be used for any non-domestic wastewater management system design process. **Applications for non-domestic on-site systems that propose to "scale up" an off the shelf domestic wastewater treatment plant without supporting justification (process design) will not typically be accepted.** The following technical and guidelines documents are recommended for guidance in the design of non-domestic on-site wastewater management systems.

- Crites and Tchobanoglous (1998) *Small and Decentralised Wastewater Management Systems*. McGraw-Hill.

- Asano *et al* (2007) *Water Reuse: Issues, Technologies and Applications*. Metcalf and Eddy.
- Tchobanoglous *et al* (2003) *Wastewater Engineering: Treatment and Reuse*. 4th Edition. Metcalf and Eddy.

Locally, selected components of the following document may be useful.

- EPA Victoria (1997) *Code of Practice for Small Wastewater Treatment Plants*. EPA Victoria Publication 500.

In particular, Crites and Tchobanoglous (1998) and Asano *et al* (2007) are internationally recognised, comprehensively peer reviewed design manuals and planning guidelines that cover a substantial amount of the necessary processes encountered within the Greater Taree LGA. Chapter 4 of Crites and Tchobanoglous (1998) and Chapter 13-3 of Asano *et al* (2007) emphasise the need for a wastewater characterisation process for larger systems rather than simply an adoption of standard values.

Table 9-2 Calculation of Design Wastewater Flows and Loads: High/Very High Non-domestic

Scenario	Calculation Process	Resources
New Facility	**Wastewater Flow**[1] Development of a seasonal/monthly/daily time series (time step applicable to nature of temporal variation) of design wastewater flow. This flow profile should be developed using site specific occupancy / process information e.g. • Anticipated seasonal variation in occupation in a tourist facility. • Anticipated seasonal / monthly / daily variation in production in an industrial facility. • Predicted customer numbers / turnover for a proposed commercial facility. Where site specific information is not available, data should be sourced from similar facilities, preferably local ones. **Constituent Loads**[1] At least the average, minimum and maximum concentrations should be obtained and used to calculate design loads. Local data from similar facilities should be sourced where possible. Published constituent loads (e.g. g/day) may be acceptable where data not available.	**Non-domestic** Section 4: Crites and Tchobanoglous (1998) Section 13-3: Asano *et al* (2007) Lesikar *et al* (2006) EPA Victoria (1997) **Domestic (>10kL/day)** Appendix H of *AS1547* *AS1646*, NSW Health (2001, 2005).
Existing Facility	**Wastewater Flow**[1] Development of a seasonal/monthly/daily time series (time step applicable to nature of temporal variation) of design wastewater flow. This flow profile should be developed using site specific monitoring data from the existing facility. Analyse existing water consumption data (or wastewater flow data) and use to validate adopted design flow profile. **Constituent Loads**[1] At least the average, minimum and maximum concentrations should be obtained through monitoring of existing facility operation and used to calculate design loads. Local data from similar facilities should be sourced where significant deviation from existing conditions expected.	As above. Consideration should be given to permanently or temporarily installing a Smart Meter to collect detailed water use data where significant variation is likely. Composite or grab sampling of raw wastewater is strongly recommended to assist in wastewater characterisation.

Note 1: In the case of Low/Medium Hazard Non-domestic systems (and domestic systems 2-10 kL/day), a single, conservative design value for wastewater flows and constituent loads may be acceptable if it can be demonstrated that there is <10% variation in that parameter over 12 months or sufficient flow equalisation is provided to attenuate peaks.

9.2 Hydraulic Design of Land Application Areas

NSW on-site sewage management guidelines (DLG, 1998) currently recommend the use of monthly water balance (in conjunction with annual nutrient balances) to size land application areas (LAA)). Historically, ASNZS1547:1994 also included a recommended procedure for completion of monthly water balance calculations. However, ASNZS1547:2000 and recently ASNZS1547:2012 do not specify the use of a monthly water balance and rather make more general informative statements. In essence, ASNZS1547:2012 adopts a risk based approach, recommending consideration of water balance where it is possible that climate may play an important role in performance.

The DAF specifies the use of a steady state (essentially annual) water balance calculation for Low, Medium and High Hazard residential system designs. It was concluded that a simplified hydraulic sizing approach would be adopted for on-site systems on Low, Medium and High Hazard allotments. This relates to limitations on the useability and applicability of monthly water balance calculations in moderate to high rainfall areas. It also relates to the limited purpose of monthly water balance calculations for design sizing of subsurface irrigation systems or mounds (the two dominant modern land application options).

Monthly water balance calculations for ***irrigation*** land application areas should not include any cumulative storage allowance in the soil. Daily continuous modelling is required to do this with any accuracy. The DLG (1998) method commonly adopted in NSW only uses the “wettest” month of the year (the month with the smallest difference between retained rainfall and crop evapo-transpiration) to size a Land Application Area (LAA). Monthly water balance calculations do allow an estimate of any wet weather storage tanks proposed. However, these are not advocated for residential systems within the GTCC DAF or amongst other NSW Councils.

It is acknowledged that monthly water balance calculations to enable consideration of storage capacity within a primary dosed trench or bed (i.e. where effluent is draining from a saturated body of gravel controlled by a biomat). However the use of a Climate Adjustment Factor (CAF) as presented below achieves the equivalent outcome through a simpler method of calculation with reduced potential for error or manipulation. Reference should be made to Asquith *et al* (2012) for more justification on this approach.

Hydraulic sizing of land application areas shall be undertaken using Equation 1 below.

$$\boldsymbol{LAA = \frac{Q}{(DLR - CAF)}} \qquad \text{Equation 1}$$

Where;

LAA = Land Application Area (basal area in m^2)

Q = Design Wastewater Generation Rate (L/day)

DLR = Design Loading Rate (mm/day)

CAF = Climate Adjustment Factor (mm/day)

Detailed land application system modelling was used to support design experience in the sizing of land applications within the LGA. The Climate Adjustment Factor (CAF) enables design loading rates to be adjusted to reflect the degree to which climate influences hydraulic performance. They have been determined based on analysis of the frequency and magnitude of hydraulic failure for a range of on-site system types in different climate regions (consistent with the climate zones adopted for the Acceptable Solutions).

In very wet climates the CAF reduces the daily DLR to reflect the limitation placed of hydraulic capacity by consistently high soil moisture. In dry climates the CAF may increase the DLR based on a higher evapo-transpiration output of applied effluent. The result is comparable to a monthly water balance with respect to rigour of design (resulting LAAs are typically <10% larger or smaller). However, it is a simpler approach that requires limited time to calculate. As previously mentioned it also removes significant potential for unnecessary error or artificial manipulation of results.

Climate adjustment factors can be found in Table 9-3 below for trenches/beds or irrigation LAAs in three broad climate zones. The climate zones applicable to these CAFs are presented in Figure 8-1. These CAF values have been tested and are suitable for the variation in site specific climate observed within each of these zones. Design loading rates should be obtained from *ASNZS1547:2012*.

Table 9-3 Climate Adjustment Factors for Hydraulic Design Equation 1

Climate Zones	Climate Adjustment Factor (CAF)
Taree	-0..3 mm/day
Harrington	0.1 mm/day
Comboyne	1.5 mm/day

These CAFs were calculated based on an average annual water balance utilising the inputs summarised in Table 9-4.

Table 9-4 Summary of Input Data for CAF Calculations

Parameter	Central	North	West
Average Annual Rainfall	1179 mm	1338 mm	1817 mm
Volumetric Runoff Coefficient	0.78		
Pan Evaporation	1424 mm		1186 mm
Average Crop Factor	0.7		

In the case of trenches and beds, allowance should ***not*** be made for sidewalls in addition to basal area where Design Loading Rates (DLRs) from *ASNZS1547:2012* are adopted. DLRs are purely a best estimate of the long-term hydraulic capacity of land application systems. It is not a physically measurable parameter like Long Term Acceptance Rate (LTAR) as measured by Laak (1973 and 1986). Work undertaken by Tyler and Converse (1994), Beal *et al* (2006) and others has shown that hydraulic pathways from trenches and beds typically oscillate between equilibrium of sidewall and basal area discharge. The dominant flow path at any point in time depends on a number of factors including biomat thickness, effluent quality, hydraulic head and soil hydraulic conductivity. DLR is not a physical measurement of these processes but a general long-term estimate of ***total*** hydraulic output from a LAA (whether sidewall or basal area discharge).

Given the relative accuracy of any hydraulic design equations, rounding of minimum LAA sizes is acceptable to the nearest $10m^2$.

9.3 Annual Nutrient Balance

DLG (1998) also advocate the use of annual nutrient balance calculations in sizing LAAs for domestic on-site systems. The GTCC DAF requires annual nutrient balance calculations to be completed in some circumstances, depending on relative risk. Outcomes of lot density modelling (Section 7) supported the assumption that nutrients will be adequately assimilated where the following conditions are achieved.

- LAAs are sized to prevent hydraulic failure in average climate conditions.
- LAAs are located in accordance with GTCC buffer distances.
- LAAs are contained within an allotment containing 4,000 m^2 of Useable Land.

As such site specific nutrient balance calculations are not required on Low, Medium and *some* High Hazard allotments that meet the above conditions.

Council recognise the conservatism associated with some elements of the DLG (1998) nutrient balance process and advocate use of a slightly modified method as described and demonstrated in the Municipal Association of Victoria's *Model Land Capability Assessment Report – February 2006* (MAV 2006). The reader is directed to nutrient balance elements contained on pages 18-19, 25 and 35-37 of that document. MAV (2006) can be downloaded from http://www.mav.asn.au/policy-services/environment/water/domestic-wastewater/Pages/default.aspx. DLG (1998) also provides ***nominal*** plant nutrient uptake rates purely to demonstrate use of the nutrient balance procedure. These nominal values are very conservative and underestimate the level of plant uptake occurring in most cases. Council strongly recommend consultants seek more appropriate nutrient uptake values from Table 4.2 of DECCW (2004) *Use of Effluent by Irrigation*. In order to allow for the reduced efficiency in crop production (grass growth) associated with a typical domestic lawn, Council recommend adoption of 50% of published nutrient uptake rates in DECCW (2004). In most cases, use of data for kikuyu will be appropriate and example calculations of nutrient uptake rate are provided below.

Kikuyu Nutrient Uptake

Average dry matter yield (t/ha/year) = 20   TN = 2.6%   TP=0.3% (From Table 4.2 of DECCW 2004)

TN = 0.026 x 20,000 = 520 kg/ha/year x 0.5 (conservative allowance for domestic lawn harvesting)

*TN = **260** kg/ha/year = 71 mg/m^2/day.*

TP = 0.003 x 20,000 = 60 kg/ha/year x 0.5

*TP = **30** kg/ha/year = 16 mg/m^2/day.*

Where a vegetation cover that is clearly different to kikuyu is being adopted, site specific nutrient uptake rates should be calculated following the above procedure. Where harvesting and removal of vegetation is not going to occur, limited nutrient uptake can be assumed.

9.4 Continuous Daily On-site System Modelling

The DAF requires a higher level of on-site system water, nutrient and pathogen modelling in circumstances where risks to ecosystem and human health are elevated. Lots with a Very High On-site Sewage Hazard Class warrant this more comprehensive analysis for two key reasons.

- Availability of suitable land for siting of an effluent land application area is often highly limited. Continuous daily on-site system modelling maximises potential to achieve a sustainable design.
- Continuous daily on-site system modelling provides a higher level of accuracy when assessing potential impacts on what are typically sensitive receiving environments.

Continuous daily soil water, nutrient modelling has been included as an assessment tool to simulate performance of land application systems on Very High Hazard lots and for larger non-domestic systems. One dimensional viral dieoff modelling (Cromer *et* al, 2001) is also required as a method for estimating pathogen export potential. This approach is widely considered current best practice in land application system design, particularly effluent irrigation design. There are two commercially available tools that can be used to complete this modelling or alternatively, consultants may construct their own in spreadsheet form (subject to review and endorsement by Council).

9.4.1 Rationale

Continuous daily on-site system modelling does require more data and a higher level of understanding of soil water, nutrient and pathogen dynamics. As such, it cannot be justified in the context of lower hazard on-site systems. However, on severely constrained sites and in the case of non-domestic facilities, monthly water balance spreadsheets such as that advocated in DLG (1998) are not capable of answering key questions about a systems performance. Prior to the availability of computers with sufficient processing capacity to undertake long-term daily modelling, the monthly spreadsheet approach was an acceptable, practical (albeit conservative) method that allowed climatic influences on crop growth to be incorporated into design. However, daily continuous soil water modelling has been a recognised standard for at least the last 10 years. Some of the limitations of a monthly lumped approach are as follows.

Monthly water balances calculate soil water balance for each month in isolation. While cumulative storage is calculated for the gravel void space in trenches or a wet weather storage tank, this is limited to a twelve month period and the assumption is made that the storage volume returns to zero prior to the next winter. This means the method cannot account for antecedent soil moisture or rainfall conditions over the design life of a system. This occurs on an intra-annual basis and between years. Continuous daily modelling simulates soil/plant water dynamics over decades on a daily basis. This ensures both inter-annual and intra-annual variation in a wide range of conditions (beyond rainfall and cumulative storage volume) is accounted for in the design. Essentially, it simulates wet and dry periods in climate history.

The Monthly method assumes infinite soil water storage with no sound method to quantify water lost to deep drainage prior to evapo-transpiration. As a result, it is assumed that all excess water drains at the end of each month and is not carried over (particularly during winter). Continuous daily models dynamically calculate infiltration, soil water storage, plant uptake, deep drainage and runoff for multiple soil horizons on a daily basis. They then carry water in soil storage over to the next day, month and year to ensure antecedent conditions are accounted for.

As previously stated, the most obvious advantage of a daily model is its ability to identify and quantify dry periods within what may be a 'wet' month. Continuous daily modelling enables opportunities for irrigation within wetter months to be identified and taken where appropriate.

At the time of original publication of DLG (1998), lumped monthly water balances did represent best practice for the time and computing power readily available to stakeholders. However, environmental modelling has progressed dramatically in the proceeding 12 year period. Selected models utilise scientifically validated algorithms that have been extensively tested and peer reviewed. Reference should be made to Gardner and Davis (1998) and Martens (1999b) for further description and justification of continuous daily modelling approach for higher risk sites.

9.4.2 Available Modelling Tools

Two commercially available modelling packages are summarised below that can be used to complete continuous daily modelling in accordance with the DAF.

- Model for Effluent Disposal by Land Irrigation (MEDLI).
- Land Application Mass Balance (LAMB).

MEDLI is a proprietary software package that needs to be purchased from the Queensland Department of Environment and Resource Management (DERM). LAM is a freely available program under subscription arrangement or as an enhanced version for purchase from BMT WBM. A brief summary of each model is provided below with further detail available from the individual software supplier.

Pathogen (vial die-off) modelling can be completed using a spreadsheet application of the method advocated by Cromer *et al*, (2001).

9.4.2.1 MEDLI

MEDLI is a water and nutrient mass balance model developed by the Queensland Department of Natural Resources and Mines (now DERM) and the CRC for Waste Management and Pollution Control (Gardner and Davis, 1998). It is capable of simulating storage pond dynamics, irrigation scheduling, plant growth, transpiration and nutrient uptake, soil water and nutrient dynamics and salinity on a daily time step over long periods (up to 100 years). The structure of MEDLI is shown in Figure 9-1.

MEDLI currently represents the most sophisticated and technically robust modelling tool for designing effluent irrigation schemes available in Australia and has been in the public domain for over ten years. However, it is less suited to on-site sewage management system modelling as a result of its strong reuse / agronomic focus. The MEDLI Technical Manual (Gardner and Davis, 1998) provides a comprehensive description of the algorithms and modules which have been extensively peer reviewed and validated. Importantly, MEDLI is a process based mass balance model that includes dynamic, daily calculation of infiltration (rainfall and effluent), plant growth, transpiration, deep drainage, runoff and soil profile water. There is limited benefit in repeating small elements of the comprehensive Technical Manual (Gardner and Davis, 1998) here. Readers can obtain a copy of the software (or possibly at least the Technical Manual) from the Queensland Department of Environment and Resource Management (http://www2.dpi.qld.gov.au/environment/5721.html).

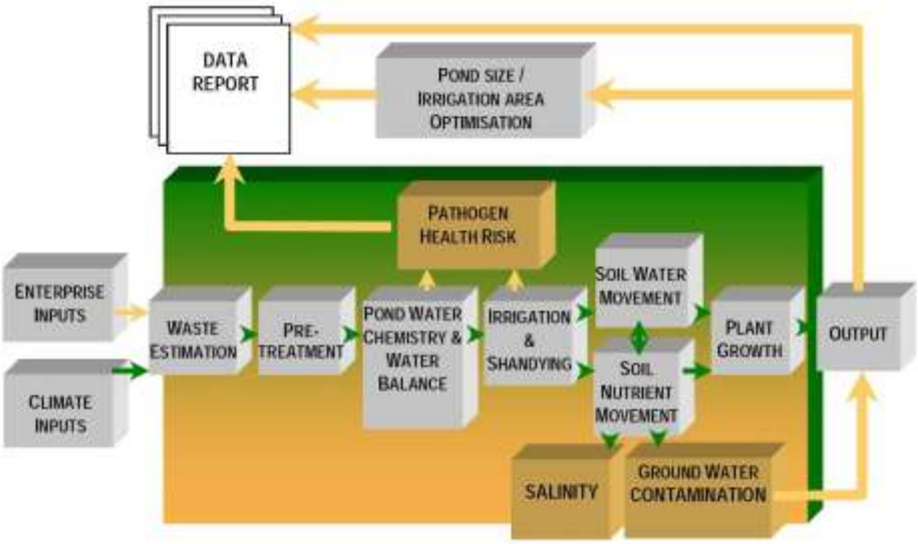

Figure 9-1Structure of MEDLI (Source: MEDLI Technical Description, Queensland DNR)

9.4.2.2 LAM

LAM is a daily soil water, nutrient and pathogen mass balance model developed by BMT WBM specifically for the design and assessment of domestic and non-domestic on-site wastewater land application systems. Algorithms from the Decentralised Sewage Model (See Section 10.3) have been tailored to suit a single site application. In contrast to other tools, LAM focuses on common approaches to effluent land application at domestic and medium scale non-domestic settings such as subsurface irrigation, raised (mound) systems, trenches and beds. A comprehensive description of LAM is available from BMT WBM (newcastle@bmtwbm.com.au). The structure of the model is depicted in the following figure.

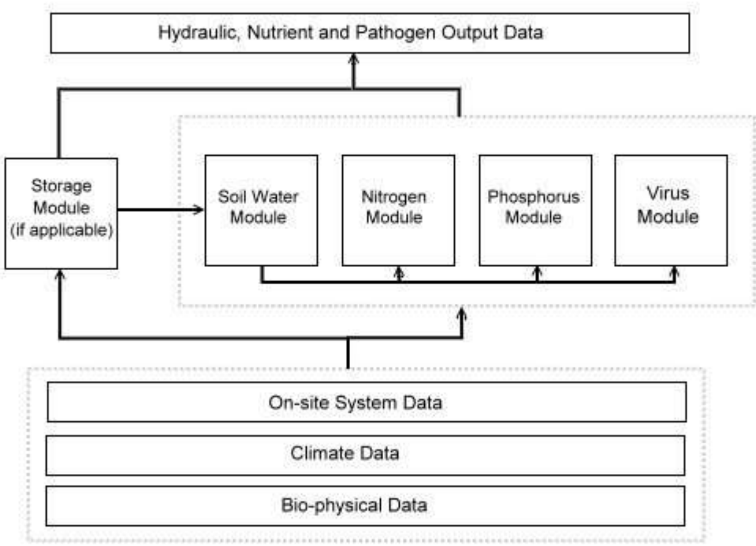

Figure 9-2 Structure of the LAM Model

9.4.2.3 Spreadsheet Based Models

It is possible to construct continuous daily on-site system models in standard spreadsheet software such as MS Excel™. However, both authors and users require significant expertise and experience in soil water, nutrient and pathogen dynamics. Approval from Council will be required should individual consultants wish to build and use their own daily soil water, nutrient and pathogen models. Approval will typically involve some level of peer review of algorithms and testing of the model.

9.4.3 Data Inputs and Outputs

Data requirements and professional resources required for building and running of continuous daily soil water, nutrient and pathogen mass balance models are inevitably greater than current typical practice. However, the experience of many Councils and practitioners supports an increased level of scrutiny in the design and assessment of systems in highly constrained environments. Similarly, poor operational performance can be reduced through the application of a daily modelling approach for non-domestic systems. All of the example modelling tools described in Section 9.4.2 can be operated using readily obtainable field and desktop data whilst producing a meaningful result.

The lot density modelling process undertaken as part of this project (see Section 7) included continuous daily soil water, nutrient and pathogen modelling using the Decentralised Sewage Model (DSM) – the parent modelling engine of LAMB. The tables contained in Section 7.4.1 and 7.4.2 of this Technical Manual provide an example of the range of parameters and data required to populate these models. These tables include reference to data sources used for this study to provide an indication of where and how information can be obtained.

Continuous daily modelling enables a more comprehensive design and assessment process for on-site systems and provides Council with a higher level of assurance that a system is sustainable. The following list is a guide to how daily modelling can be used under the DAF for Very High Hazard and non-domestic systems.

- A more accurate calculation of minimum land application area size that ensures the occurrence of hydraulic failure (surface surcharge) is restricted to extreme climate events. This increased accuracy can sometimes allow smaller land application area sizes in comparison to monthly calculations.
- Realistic sizing of any wet weather storage facilities for non-domestic systems. Monthly calculations should never be used to size wet weather storage facilities. Council do not advocate wet weather storage for domestic systems.
- More realistic estimate of hydraulic, nutrient and pathogen loads leaching into subsurface environments as deep drainage to enable a more detailed assessment of potential impacts.
- Derivation of long-term hydraulic, nutrient and pathogen loads leaching via deep drainage and discharging to the ground surface for input into Cumulative Impact Assessment modelling.

9.5 Hydraulic and Process Design

The DAF recognises that there are a number of circumstances in on-site sewage management where "off the shelf" design and technology options cannot provide a sustainable solution. Furthermore, there are circumstances where a more rigorous engineering and design process should be undertaken and provided to Council to enable a decision. Historically, there has been limited input to NSW on-site sewage management guidelines and legislation from hydraulic and process engineering disciplines. This is not the case in other jurisdictions and countries where designs for on-site systems are expected to follow engineering principles of design including the preparation of specifications and design drawings.

In creating the DAF, Council acknowledge that there is limited need for higher level engineering input to proposals for domestic on-site systems on Low and Medium Hazard lots. However, as the nature and extent of constraints increase, so does the need for a sound, engineered system capable of being taken from concept to reality. There have been occurrences of on-site system designs being submitted to Council that "on paper" are capable of meeting performance objectives. However, the ability to convert a conceptual sketch to a final constructed system is either limited or cost prohibitive. This can be prevented through the submission of engineering calculations, specifications and drawings that demonstrate that a system is feasible.

The technical resources listed in Table 9-6 are a sample of key information and guidance available to allow engineering design of on-site systems. "Black Box" technologies put forward without supporting process design information and performance data for non-domestic systems will not be accepted. The references provide a plethora of design procedures, data and guidance to enable sound designs to be developed.

Table 9-5 Different Stages of the Engineering Process

Engineering Stage	Description	DAF Requirement
Feasibility Study	High level identification of potential options. "Rule of thumb" design calculations based on limited, predominantly desktop data. Multi criteria analysis of shortlisted options.	Increase in building entitlements on Low / Medium Hazard lots. First phase of a project involving a non-domestic system >10 kL/day.
Concept Design	Limited field data collected to enable development of conceptual layout (footprint of each major component) and key sizing calculations for critical system elements such as land application / effluent management systems. Typically used to define site performance targets, undertake an initial environmental assessment and prepare a high level cost estimate (e.g. +/-20%). Will usually be sufficient for domestic systems on Low/Medium Hazard lots.	Domestic systems on Low / Medium Hazard lots. Increase in building entitlements on High/Very High Hazard lots.
Preliminary Design	Design stage bridging the gap between concept and detail. Commonly completed to develop specifications for Design and Construct (D&C) contracts intended for technology providers with in-house detailed design capabilities. Preliminary designs contain sufficient detail to prepare a performance specification and confirm that the conceptual design can be taken through to construction with confidence. Usually involve preliminary site surveys, detailed site and soil assessment and hydraulic / process design. Enables cost estimate (+/-15%)	Domestic systems on High / Very High Hazard lots. Non-domestic systems on Low / Medium Hazard lots (<10 kL/day).
Detailed Design	Comprehensive investigation, survey and design calculations/modelling to produce CAD design drawings and specifications sufficient to enable construction. Hydraulic, treatment process, structural/civil engineering design of all components. Enables preparation of a schedule of quantities.	Non-domestic systems on High / Very High Hazard lots or >10 kL/day.

Table 9-6 Recommended Resources for Hydraulic/Process Engineering of On-site Systems

Resource	Drainage / Collection	Pre-treatment / Flow Balancing	Treatment	Disinfection and Storage	Land Application	Water Reuse
Crites and Tchobanoglous (1998) *Small and Decentralised Wastewater Management Systems*. McGraw-Hill	✓	✓	✓	✓	✓	
Tchobanoglous and Burton (2003) *Wastewater Engineering: Treatment and Reuse.* Metcalf and Eddy.		✓	✓	✓		
Asano *et al* (2007) *Water Reuse: Issues, Technologies and Applications.* Metcalf and Eddy.			✓	✓	✓	✓
Crites *et al* (2006) *Natural Wastewater Treatment Systems.* Taylor and Francis.			✓	✓	✓	
Water Environment Federation (2008) *Alternative Sewer Systems: Manual of Practice FD-12.* 2nd Edition. McGraw-Hill.	✓	✓				
USEPA (1991) *Alternative Collection Systems Design Manual*.	✓	✓				
Consortium of Institutes for Decentralized Wastewater Treatment *University and Practitioners Curricula.* www.onsiteconsortium.org	✓	✓	✓	✓	✓	
Converse and Tyler (2000) *Wisconsin Mound Soil Absorption System: Siting, Design and Construction Manual*. http://www.soils.wisc.edu/sswmp/online_publications.htm provides a range of other useful publications.					✓	
DECCW (2004) *Environmental Guidelines: Use of Effluent by Irrigation*.					✓	✓
USEPA (2006) *Process Design Manual: Land Treatment of Municipal Wastewater Effluent.*					✓	
The Water Environment Research Federation provide a range of information. http://www.decentralizedwater.org/	✓	✓	✓	✓	✓	✓
Netafim provide a design manual, hydraulic design software, standard drawings and checklists to assist in design of drip irrigation systems. http://www.netafim.com.au/index.php?sectionid=165					✓	✓
Geoflow provide a range of material (including a hydraulic design spreadsheet) to assist in design of drip irrigation systems http://www.geoflow.com/design_w.html					✓	✓
Orenco Systems Incorporated have a comprehensive engineering library applicable to a range of systems. http://www.orenco.com/corporate/technical_resources/	✓	✓	✓	✓	✓	✓

10 CUMULATIVE IMPACT ASSESSMENT PROCEDURES

There is no 'one size fits all, black box' tool for undertaking this type of assessment. However, effective use of available models and tools is possible through establishment of a Minimum Standard for assessment of risks associated with proposed increases in unsewered building entitlements. The level of detail and complexity can be varied to reflect the potential risk (a function of the likelihood and/or consequence of failure) a specific proposal poses to human and ecosystem health. The DAF has used the outcomes of hazard mapping, minimum lot size and maximum lot density assessments to develop an adaptable Cumulative Impact Assessment (CIA) procedure. Reference should be made to the DAF for guidance on the circumstances in which CIA is required.

In order to maintain simplicity in CIA procedures, the following indicative performance objective has been adopted.

No more than 10% increase in average annual nitrogen and phosphorus loads (kg/year) from existing undeveloped loads

Average virus concentrations in effluent (following attenuation) of <1 MPN/100ml.

No increase in the average number of days where hydraulic failure (surcharging) of Land Application Areas (LAAs) occurs.

It is readily acknowledged that these targets are arbitrary values. It has been adopted after careful consideration of a range of alternatives. Other more conventional targets immediately require significantly more detailed investigations to be undertaken that were disproportionate to potential risk. They also require holistic, integrated assessment of pollutant loads from a development (e.g. stormwater pollutants) which is currently not required for most developments in Greater Taree. Based on the outcomes of lot density modelling (Section 7), the adopted target will strike an effective balance between protection of ecosystems and human health and the need to undertake detailed technical investigations.

Health impacts will be considered to be adequately managed where all land application areas are sized in accordance with Section 9.2 ***and*** the daily water balance modelling indicates no change in surcharge frequency on existing conditions. This assumption is appropriate for environments where subsurface pollutant export is minimal. In other circumstances, the Detailed CIA will be completed which models pathogen export explicitly.

10.1 Standard Cumulative Impact Assessment Procedure

The Standard CIA procedure involves daily water and nutrient balance modelling of the proposed range of on-site systems in addition to use of standard background pollutant loads and pollutant attenuation rates to evaluate the potential for the increase in on-site systems to significantly alter nutrient loads or pathogen export risks within a subcatchment. It draws on standard data for NSW (background loads) and locally applicable parameters derived as part of the *Sustainable On-site Sewage Management* Study (attenuation rates). An example methodology and case study demonstrating how a Standard CIA should be undertaken is provided below. Alternative methodologies will be considered but must meet or exceed the Minimum Standards listed below in order to be approved by Council.

Table 10-1 Minimum Standard for Standard Cumulative Impact Assessments

Risk Assessment Component	Minimum Standard
On-lot Land Application Area (LAA) Assessment	• Daily water and nutrient mass balance modelling for each general on-site system LAA type within the subject site used to derive average annual hydraulic and pollutant loads to surface and subsurface export routes. Also used to estimate frequency of hydraulic failure (surcharge).
Rainfall-Runoff	• Average annual estimate of runoff volume using a volumetric coefficient of rainfall. Recommend use of Figure 2.3 (and subsequent equations) from Fletcher *et al* (2004).[1] See web link below.
Surface and Subsurface Pollutant Export	• Application of catchment attenuation factor (provided in Table 10-8 of the Technical Manual) to combined surface and subsurface on-site loads based on broad characteristics of the receiving environment.[2] • Mass balance combining attenuated on-site system flows and loads with catchment inputs.
Background Pollutant Loads / Concentrations	• Sourced from Tables 2.44 - 2.45 or Figures 2.15 – 2.23 of Fletcher *et al* (2004).[1] • Acceptable export rates / concentrations sourced from published local studies.
Environment and Health Protection Targets[3]	• No more than 10% increase in average annual nitrogen and phosphorus loads (kg/year) based on existing undeveloped background loads. • Average virus concentrations <1 MPN/100ml after application of attenuation rates. • All land application areas sized to prevent an increase in the average number of days/year where hydraulic failure (surcharging) occurs (based on existing conditions.

Note 1: Fletcher et al (2004) available from http://www.catchment.crc.org.au/pdfs/technical200408.pdf.
Note 2: Refer to Section 7.4.5 for explanation of attenuation factor derivation.
Note 3: Site specific targets can be developed and justified on a case by case basis. Outcomes must meet or exceed those achieved by the above targets.

In the case of Standard CIA procedure it is sufficient to complete daily modelling of the anticipated range of general system types, wastewater generation rates (e.g. maximum) and soil characteristics. Results can then be extrapolated based on an assumed breakdown of system types and dwelling sizes / design flows. Development of a site specific daily water, nutrient and pathogen model for every proposed allotment is not necessary.

The Standard CIA is intended to be able to be completed relatively quickly (0.5 to 2 days following field work) for a typical residential subdivision or commercial development. Necessary information for completion is largely provided in this Technical Manual or Fletcher *et al* (2004) with the exception of the daily water, nutrient and pathogen modelling. Refer to Section 9.4 for guidance on daily modelling.

10.1.1 Example Standard Cumulative Impact Assessment

An example Standard CIA is provided below for the following hypothetical unsewered subdivision.

- An existing 5 ha site is proposed to be subdivided into 10 rural living or rural residential lots.
- The hazard class is Medium due to moderate soil constraints and the presence of an intermittent watercourse through the site.
- The proposed subdivision plan indicates a number of the lots would contain between 2,000 – 4,000 m^2 of Useable Land.
- The developer wishes to locate two proposed Effluent Management Areas (EMAs) 30 metres from the intermittent watercourse (i.e. 50-100% achievement of GTCC setback distances in Table 6-8 of the DAF.
- The developer wishes to retain the option to install absorption / evapo-transpiration beds on the higher lots where deeper, structured soils were observed during site and soil investigations.

Reference to Table 2-13 in the GTCC DAF confirms that the proposed subdivision requires a Standard CIA to be completed.

10.1.1.1 On-lot Land Application Area (LAA) Assessment

Daily LAA water, nutrient and pathogen modelling was undertaken using LAMB for two broad system types.

- Four bedroom house (reticulated water supply), secondary treatment system to subsurface irrigation.
- Four bedroom house (reticulated water supply), primary treatment to evapo-transpiration / absorption beds.

One soil type was identified during field investigations and site and soil assessment which was a residual mid-slope profile generally consisting of;

- moderately structured loam topsoil overlying;
- moderately structured clay loam B_1 horizon overlying;
- strongly structured light clay.

Total soil depth of 1.2 metres and a typical root depth of 600mm. Phosphorus sorption was moderate to high. The site is on a mid to lower slope.

Key input parameters are summarised in the following table.

Table 10-2 Summary of Daily LAA Modelling Inputs

Parameter	Unit	System 1	System 2
System Characteristics			
LAA Type		**Conventional Trenches / Beds**	**Sub-surface Irrigation**
Effluent Volume per Working Day	m3	0.9	0.9
Total Phosphorous	mg/L	15	12
Total Nitrogen	mg/L	60	35
Virus	MPN/L	1000	100
Crop Characteristics			
Crop P Uptake	kg/ha/yr	20	20
Crop N Uptake	kg/ha/yr	200	200
Crop Factor		Grass	Grass
Parameter	**Unit**	**Trench / Bed**	**AWTS**
		Light Clay	**Light Clay**
LAA Type		Conventional Trenches / Beds	Sub-surface Irrigation
DLR (from ASNZS1547:2012)	mm/d	8	3.5
LAA	m2	115	260
System Type		**Sub-surface Irrigation**	**Conventional Trenches / Beds**
Soil Type		**Light Clay**	**Light Clay**
Parameter	**Unit**		
Effective Saturation	mm	390	170
Permanent Wilting Point	mm	160	30
Field Capacity	mm	300	65
Saturated Hydraulic Conductivity	mm/day	100	40
Bulk Density	kg/m3	1400	1400
Soil Depth for P Sorption	m	1.25	1.25
INF	mm/day	225	225
Exp 1	-	1.5	1.5
A1	-	240	240
B1	-	0.20	0.20
B2	-	0.10	0.10

LAMB produced the following average annual outputs for surface and subsurface hydraulic, nutrient and pathogen (virus) loads.

Table 10-3 Average Annual Loads from On-site System Types

Average Annual Output (per system)	Secondary Treatment Subsurface Irrigation	Primary Treatment ETA Bed
Mean Annual Overflow (m3) =	0	0
Mean Annual Overflow N (kg) =	0	0
Mean Annual Overflow P (kg) =	0	0
Mean Annual Overflow V (MPN) =	0	0
Mean Annual Surface Runoff (m3) =	0	16
Mean Annual Surface N (kg) =	0	0.05
Mean Annual Surface P (kg) =	0	0.66
Mean Annual Surface V (MPN) =	0	455525
Mean Annual Deep Drainage (m3) =	252	287
Mean Annual Deep Drainage N (kg) =	0.17	1.39
Mean Annual Deep Drainage P (kg) =	2.21	3.24
Mean Annual Deep Drainage V (MPN) =	512975	410518

Under existing conditions hydraulic surcharge is estimated to occur on an average of 1-2 days/year. The proposed 260 m^2 irrigation LAA did not result in any change in the frequency of surcharging and as such met the DAF criteria for health protection. The proposed 115 m^2 trench did result in an increase in surcharge frequency to 14 days in an average year. This does not meet the DAF Minimum Standard. As such, the ETA bed model was re-run with an increased basal area until no increase in surface surcharge was predicted. This LAA area was found to be 190 m^2.

10.1.1.2 Surface and Subsurface Pollutant Export

Reference was then made to Table 10-7 to select the appropriate catchment attenuation rate for the proposed development. This attenuation rate represents the loss and assimilation of *wastewater* loads (discharging as deep drainage or surface surcharge) as it moves from the land application areas to receiving environments. The attenuation rates were then applied to the average annual wastewater system loads for the proposed development as decay factors. Three primary dosed ETA bed systems were assumed with the remaining seven being secondary dosed subsurface irrigation systems.

Table 10-4 Summary of Final On-site System Loads at Receiving Water

Parameter	Attenuation	Average Loads	Average Concentration
Hydraulic	40%	1.6 ML/year	
Total Nitrogen	90%	0.6 kg/year	0.38 mg/L
Total Phosphorus	98%	0.5 kg/year	0.3 mg/L
Virus	99%	61,000 MPN/year	<1 MPN/100ml

10.1.1.3 Rainfall-Runoff

The equation from Fletcher *et al* (page 8) was used to estimate the annual volume of runoff from the proposed development for the existing case. An Effective Impervious Area (EIA) of zero was adopted making the equation;

$C = 0.0013R^{0.8} – 0.095.$

Average annual rainfall for the site was 1247 mm which equates to a volumetric runoff coefficient (C_v) of 0.29.

Average annual runoff therefore equals 362 mm which equates to 18 ML/year.

10.1.1.4 Background Pollutant Loads / Concentrations

Tables 2.4.4 and 2.4.5 in Fletcher *et al* (2004) were then used in conjunction with runoff volume to estimate background pollutant concentrations and loads. A land use of rural was adopted for the semi-cleared, unimproved pasture site. It is reasonable to apply dry weather concentrations for 20% of the runoff volume and wet weather concentrations to the remaining 80%.

Table 10-5 Summary of Background Pollutant Loads / Concentrations

Parameter	Average Loads	Average Concentrations
Total Nitrogen (TN)	32 kg/year	1.8 mg/L
Total Phosphorus (TP)	3.2 kg/year	0.18 mg/L

10.1.1.5 Environment and Health Protection Targets

Average annual on-site system and background flows and loads were combined in a mass balance to provide an estimate of long-term catchment loads from the proposed on-site systems.

Table 10-6 Results of Site Mass Balance for Cumulative Impact Assessment

Parameter	Average Loads	Percent Increase	Average Concentrations
Flow	20 ML	9%	
Total Nitrogen (TN)	32.6 kg/year	2%	1.63 mg/L
Total Phosphorus (TP)	3.7 kg/year	16%	0.19 mg/L
Virus	N/A		<1 MPN/100ml

The results indicate greater than 10% increase in Total Phosphorus loads as a result of the proposed mix of on-site sewage management system. All other targets were met. Options to bring TP loads down to compliance include;

- eliminating the option for primary effluent dosed trenches and beds (this alone doesn't meet the target);
- improving effluent quality at the treatment system;
- increasing the LAA size to reduce the nutrient loading rate;
- reducing the number of lots to nine; or
- undertaking a Detailed CIA including site specific calculation of attenuation rates which may demonstrate compliance.

In this case, the proponent chose to eliminate the option of primary dosed beds and proposed to increase the minimum subsurface irrigation area to 300 m^2 which enabled the development to meet the DAF Minimum Standards.

10.1.2 Minimum Outputs for Standard CIA's

As advised in the relevant Minimum Standards tables in the DAF, it is envisaged that Simple Cumulative Impact Assessments (CIA) will typically be contained in 5-10 pages within the Wastewater Management Report. The following elements should be provided to enable Council to assess the CIA.

- Summary of approach taken and confirmation of compliance with the Minimum Standards documented in Table 10-1.
- Methodology documenting the basis and source of input data including reference to site specific data, published information or the Technical Manual to justify use.
- Results of daily water balance and annual nutrient balances to demonstrate minimum land application system sizing.
- Results demonstrating compliance with local water quality objectives and adequate management of health risk as defined and demonstrated in Section 10.1.1.5.
- Brief discussion of long-term risks to health and environment and recommended management measures to address impacts.

10.2 Catchment Pollutant Attenuation

10.2.1 Standard CIA

In the case of Standard CIAs reference can be made to the following table to select and apply catchment attenuation rates. These rates should be applied to the wastewater flows and loads only (i.e. not the background loads) prior to calculating the site mass balance. They have been derived through a series of modelling processes (using the Domenico steady state equation detailed in Section 7.4.5.1) and on the back of previous experience. As noted in Section 7.4.5, they correlate reasonably well with previous studies. However it should be noted that they are generalised estimates only. More accurate determination requires comprehensive site monitoring and modelling processes that will only be justified for proposed systems in highly sensitive environments where risks are high.

Table 10-7 Catchment Pollutant Attenuation Rates for Standard CIA

<table>
<tr><th></th><th>Hydraulic</th><th>Nitrogen</th><th>Phosphorus</th><th>Pathogen</th></tr>
<tr><td colspan="5">Inland / Rolling Hills
Rolling hills of residual, colluvial and erosional soils predominantly in the western portion of the LGA with bedrock creating relatively shallow episodic perched water tables that discharge to local ephemeral drainage lines and creeks.</td></tr>
<tr><td>GTCC Setbacks[1] Achieved</td><td>60%</td><td>95%</td><td rowspan="3">98%</td><td rowspan="3">99%</td></tr>
<tr><td>50% GTCC Setbacks</td><td>40%</td><td>90%</td></tr>
<tr><td><50% GTCC Setbacks[2]</td><td>20%</td><td>80%</td></tr>
<tr><td colspan="5">Coastal / Estuarine
Lower lying alluvial, sandy or estuarine environments underlain by shallow unconfined aquifers directly connected to the Manning River or Estuary.</td></tr>
<tr><td>GTCC Setbacks[1] Achieved</td><td>40%</td><td colspan="2">90%</td><td rowspan="3">99%</td></tr>
<tr><td>50% GTCC Setbacks</td><td>30%</td><td colspan="2">80%</td></tr>
<tr><td><50% GTCC Setbacks[2]</td><td>20%</td><td colspan="2">60%</td></tr>
<tr><td colspan="5">Attenuation factors should be applied to combined surface/subsurface average annual on-site system loads (kg/year) as an inverse (decay) decimal (i.e. 1-AF)</td></tr>
</table>

Note 1: GTCC Setbacks as follows – open drainage, intermittent and permanent watercourses, groundwater bores and farm dams.

Note 2: Sites where any land application system is proposed within 20 metres of a natural or artificial watercourse will require site specific determination of pollutant attenuation.

10.2.2 Detailed CIA

Site specific modelling using the Domenico steady state approach (discussed in Section 7.4.5) must be undertaken for Detailed CIAs. This approach involves spreadsheet application of the above equations using parameters readily obtained of inferred to a sufficient level of accuracy through site and soil and desktop evaluations. A freely available spreadsheet model that includes this equation can be obtained from the United Kingdom EPA (http://www.environment-agency.gov.uk/research/planning/40373.aspx).

10.3 Detailed Cumulative Impact Assessment Procedure

The Detailed CIA procedure set out below and in the DAF is based on the approach adopted for the on-site system density assessment documented in Section 7. It involves daily simulation of individual on-site systems using mass balance calculations for water, nutrients and (in specific circumstances) pathogens. Wastewater discharge into surface and groundwater is then input into a continuous catchment water quality and runoff model to simulate surface runoff and groundwater recharge. The attenuation of pollutants derived from on-site systems as they move down the catchment is also incorporated based on the outcomes of lot density modelling. The modelling is designed to simulate long-term average conditions but incorporates dynamic conditions on a daily time step to improve accuracy. It also allows assessment of intra-annual variation in results where conditions vary (e.g. areas with holiday homes or highly variably climate).

The models utilised in the Detailed CIA (DSM and MUSIC) do represent current best practice tools for water quantity and quality modelling. However, alternative models do exist and will be considered by Council subject to an initial peer review. As an example, modelling of long-term catchment water quantity and quality can be completed using a number of proprietary models including MUSIC and MIKE NAM. There are no known proprietary models for the simulation of multiple on-site systems on a daily time step other than the DSM. However, it can be done using excel spreadsheet models where the user has expertise in on-site system bio-physical processes and mass balance modelling. It can also be completed using single site models such as MEDLI and LAMB (see Section 9.4.2). The development of a 'Minimum Standard' specification for risk assessment modelling will provide control over the quality of any non-proprietary modelling tools.

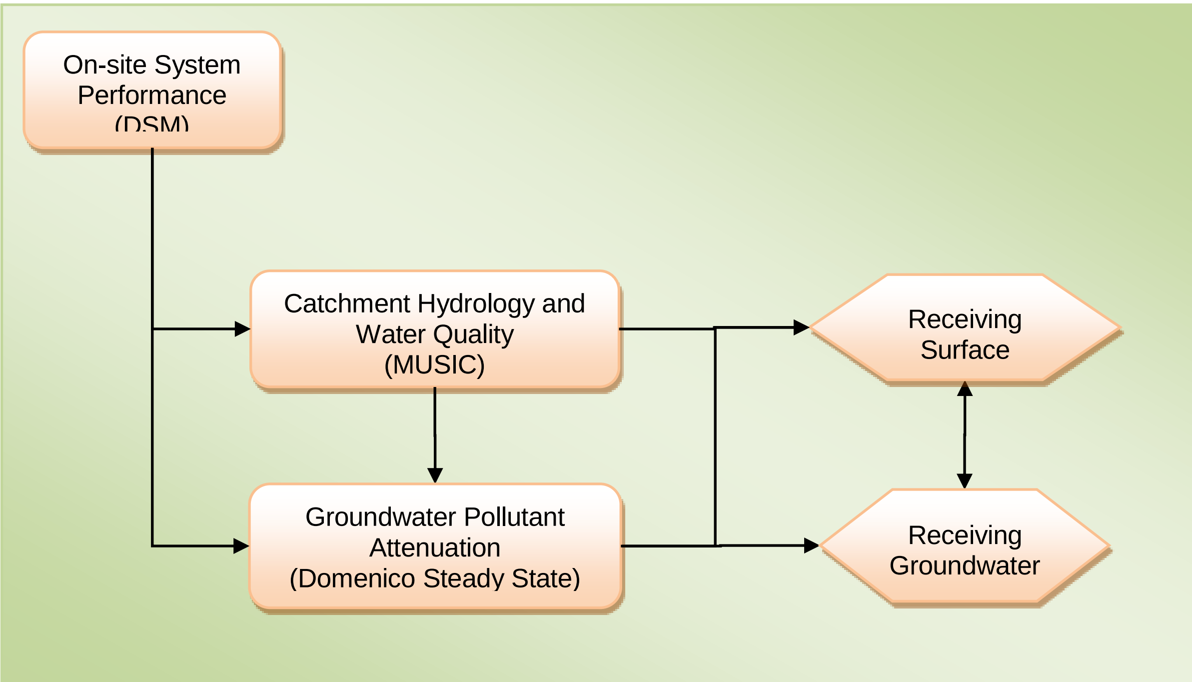

Figure 10-1 Structure of the Detailed CIA Modelling Procedure

The DAF requires a Detailed CIA to be completed in the following circumstances.

- Unsewered increases in building entitlements with any lot containing <2000m^2 Useable Land.
- Unsewered increases in building entitlements on Very High Hazard lots.
- Unsewered increases in building entitlements on High Hazard lots where buffer distances for open drainage, intermittent and permanent watercourses, groundwater bores and farm dams are less than 50% of those documented in the DAF.
- Non-domestic systems that do not meet buffer distances as above.
- Non-domestic systems High and Very High Hazard lots where sufficient Useable Land for the proposed system cannot be demonstrated.

Provided in this section are a set of Minimum Standards for completion of a Detailed CIA and catchment attenuation factors derived through the lot density assessment process. It is acknowledged that the Detailed Risk Assessment Procedure adopted for the lot density assessment represents only one methodology for undertaking this type of work. Alternative methodologies put forward by consultants / developers should meet or exceed these Minimum Standards.

Table 10-8 Minimum Standards for Detailed Cumulative Impact Assessment Procedure

Risk Assessment Component	Minimum Standard
On-lot Land Application Area (LAA) Assessment	• Daily water and nutrient mass balance modelling on a site specific basis used to derive average annual hydraulic and pollutant loads to surface and subsurface export routes. Viral die-off modelling.
Rainfall-Runoff and Groundwater Recharge	• Continuous daily rainfall-runoff, nutrient and pathogen mass balance modelling using MUSIC (or equivalent) used to derive average annual values.
Background Pollutant Loads / Concentrations	• Sourced from Chapter 2 of Fletcher *et al* (2004). • Acceptable export rates / concentrations sourced from published local studies. • Site specific data where available or necessary.
Surface and Subsurface Pollutant Export	• Site specific calculation of catchment attenuation factors for both surface and subsurface on-site loads based on data obtained through desktop and field site and soil investigations and representative of the characteristics of the receiving environment.[2] • Mass balance combining attenuated on-site system flows and loads with catchment inputs.
Environment and Health Protection Targets[3]	• No more than 10% increase in average annual nitrogen and phosphorus loads (kg/year) based on existing undeveloped background loads. • Average virus concentrations <1 MPN/100ml after application of attenuation rates. • All land application areas sized to prevent an increase in the average number of days/year where hydraulic failure (surcharging) occurs (based on existing conditions.

Note 1: Fletcher et al (2004) available from http://www.catchment.crc.org.au/pdfs/technical200408.pdf.
Note 2: Refer to Section 7.4.5 and 10.2.2 for explanation of attenuation factor derivation.
Note 3: Site specific targets can be developed and justified on a case by case basis. Outcomes must meet or exceed those achieved by the above targets.

A comprehensive case study for the application of the Detailed CIA is provided in Section 7 as part of the on-site system density assessment. This assessment will require more comprehensive skills and experience in catchment modelling and the modelling of on-site system performance. As such it is only required for very high risk proposals. Nonetheless it is consistent with assessment and modelling approaches for stormwater impact assessment and other potentially polluting activities.

10.3.1 Minimum CIA Outputs to be Provided

As advised in the relevant Minimum Standards tables in the DAF, it is envisaged that Detailed Cumulative Impact Assessments (CIA) will typically be contained in 10-20 pages within the Wastewater Management Report. The following elements should be provided to enable Council to assess the CIA.

- Summary of approach taken and confirmation of compliance with the Minimum Standards documented in Table 10-8.
- Methodology documenting the basis and source of input data including reference to site specific data, published information or the *Technical Manual* to justify use.
- Summary of results of daily modelling for adopted on-site system types including (as a minimum):
  - Average annual nutrient loads and concentrations:
  - Average annual surface surcharge and deep drainage volumes:
  - Average annual pathogen concentration in deep drainage (where applicable): and
  - Average annual frequency of surface failure (surcharge) of land application systems.
- Summary results of viral dieoff modelling or any other groundwater modelling undertaken.
- Mean annual outputs from the MUSIC (or similar) model.
- Results demonstrating compliance with local water quality objectives and adequate management of health risk as defined and demonstrated in Table 10-6.
- Brief discussion of long-term risks to health and environment and recommended management measures to address impacts.

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APPENDIX A: SOIL HAZARD CLASSES

SL_Code	SL_Name	Process_Gr	GSG	ASCS	Profile depth	Depth Hazard	Texture	Structure	Indicative ksat	Drainage	Hydraulic Hazard	Nutrient retention	Sodicity	Organic	Pollution Hazard	FINAL SOIL HAZARD		BD	PWP	FC	DR
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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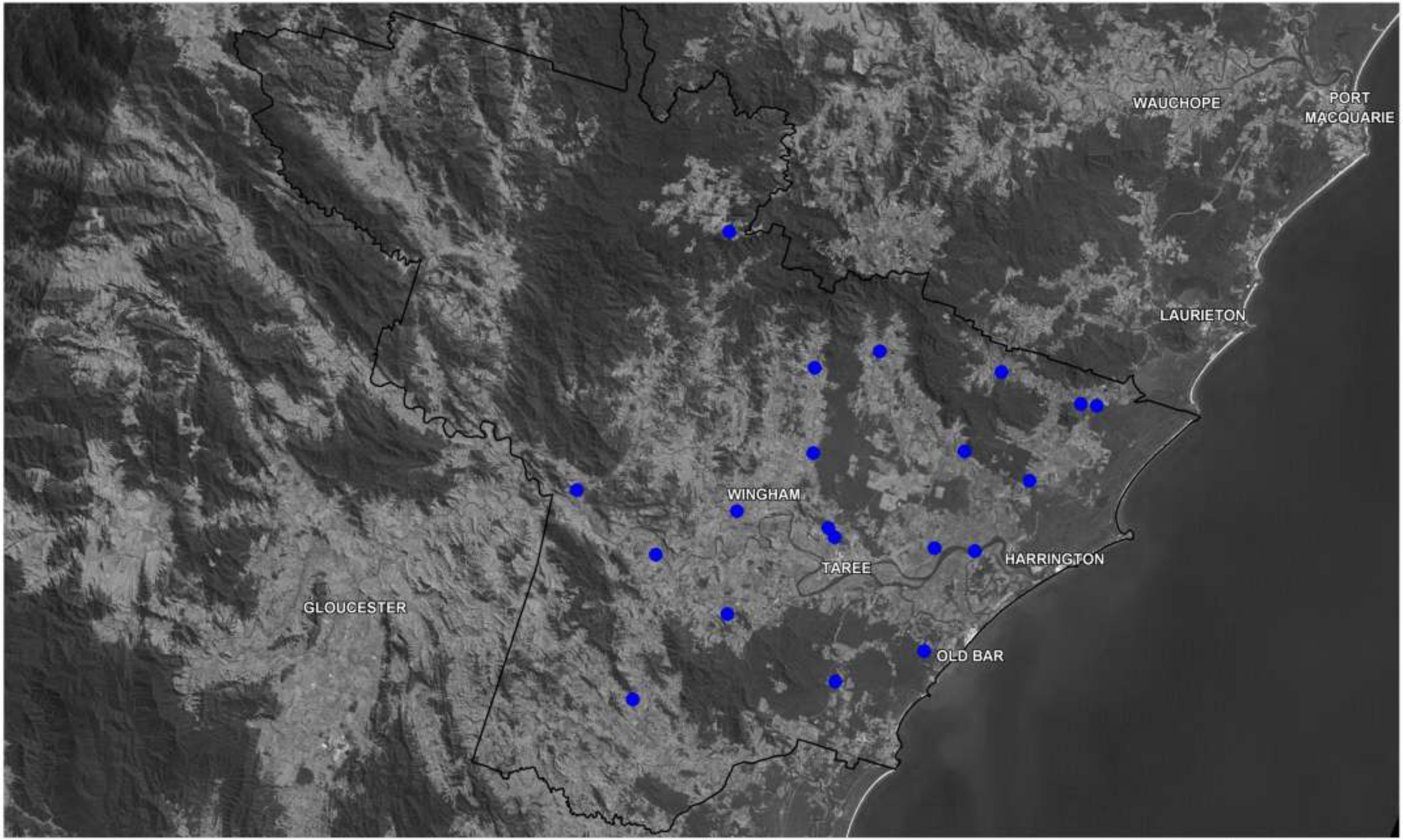
APPENDIX B: GROUNDTRUTHING



LEGEND

- Groundtruthing Site Point

Title:

Greater Taree Land Capability Hazard Map Groundtruthing

Figure: **A-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 7.5 15km

Approx. Scale

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Filepath : K:\N2091_GTCC_Onsite_Sewage_Planning\MI\Workspaces\DWG_011_Groundtruthing.wor

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