THE RISE AND FALL OF THE RICHMOND TWEED ON-SITE REGIONAL SEWAGE & WASTEWATER MANAGEMENT STRATEGY

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Abstract

On-site sewage management and disposal is an important issue in unsewered areas around Australia, but the environmental impacts have not traditionally been considered when designing disposal systems. During 1998 the NSW State Government introduced new guidelines for assessing on-site sewage systems. A major change in design methodology required under the guidelines is to assess the environmental impact of nutrients (phosphorus and nitrogen) as well as hydraulic loading.

Six local government councils in the Richmond-Tweed Region developed a local strategy under the state guidelines to account for regional factors in the design of on-site sewage management systems. Although all councils developed the strategy jointly, the objective of establishing a uniform policy, which crossed Local Government boundaries through the region, did not come to fruition, as a number of Councils did not adopt the strategy. To date Lismore City Council is the only local council in the region to formally adopt the Richmond-Tweed Regional Strategy in its entirety.

The strategy comprised three documents – an 'Assessment Design Guide' document outlining the selection of appropriate treatment and disposal methods, a 'Design' document providing supporting information to ensure sites are adequately assessed and a 'Site Assessment Report Procedures' document, outlining the procedures to be followed.

The strategy document and computer model are currently being redrafted and remodelled as further research is undertaken and results assessed. The latest version, which is yet to be released to stakeholders, attempts to address some of the problematic areas inherent in the current version.

Key Words

On-site effluent management, effluent disposal, regional strategy, nitrogen, phosphorus

1 Introduction

On-site sewage management and disposal is an important issue in unsewered areas in Australia. It has become of increasing importance particularly on the Far North Coast of NSW with the growth of rural residential and multiple occupancy style development. During 1998 the State Government introduced legislative changes aimed at directing NSW towards sustainable on-site management of domestic sewage and wastewater. The changes included amendments to the Local Government (Approvals) Regulation, 1993, which stipulated the responsibilities and powers of Councils to regulate the installation and on-going operation of on-site sewage management systems. The legislative changes were supported with *Environment and Health Protection Guidelines – On-site Management for Single Households* (DLG *et al*, 1998), called "The Silver Book" by many in the on-site effluent management industry.

Traditionally, on-site systems have been designed on the basis of hydraulic load only, and other environmental impacts have not been considered. The "Silver Book" introduced a requirement to assess all environmental constraints of the site, the environmental impact of nutrients (phosphorus and nitrogen) as well as considering hydraulic loading, and provide for a sustainable solution to on-site sewage management when considering both public health risk and environmental pollution.

The "Silver Book" provides guidance on possible ways to meet environmental and health outcomes, and "is not a design and operations manual" (DLG, 1998, p9). The amendment to the Local Government (Approvals) Regulation requires that Councils develop a strategy for on-site sewage management within their area. Six local government authorities within the Far North Coast region Lismore City, Ballina Shire, Richmond Valley Shire (formally Casino and Richmond River Shire Councils), Kyogle Shire and Tweed Shire Councils - decided to develop a joint Richmond -Tweed strategy document to account for regional factors in the design of on-site sewage management systems. The preparation of the regional strategy was coordinated by the Environmental Health section of Lismore City Council.

1.1 Aims and Objectives of Regional On-Site Strategy

The aims of the regional on-site strategy were to:

- Provide a framework for management and regulating the impact of on-site sewage management systems, and to ensure user accountability;
- Provide appropriate information to the general community, plumbers and consultants to improve on-site sewage management; and
- Apply the strategy for assessment of proposed on-site wastewater system designs; and
- Provide a uniform approach to on-site sewage design and management across all local councils within the Richmond/Tweed region.

The objectives of the regional strategy were to:

- ensure the protection of the surrounding environment including groundwater, surface water; land and vegetation through the selection of a system suitable for that particular site;
- aid in the prevention of public health risk from on-site sewage disposal;
- continue maintaining and improving community amenity;
- ensure maximum re-use of resources;
- ensure ecologically sustainable development;
- ensure that the guidelines can be continually updated as new technology is developed;
- recognise the value of wastewater for the possibilities of effective reuse;
- aid in the public recognition of on-site sewage treatment systems;
- ensure on going maintenance and monitoring programs which will involve the land owner/resident and Council; and
- create a framework for improved management of on-site wastewater disposal systems.

2 Strategy Format

The technical strategy (Greg Alderson and Associates 1999) comprised three parts:

- Part A - "Assessment/Design Guide document", which outlined design of wastewater and disposal systems, selection of appropriate wastewater management options and design of generic systems based on-site limitation for specific soil types.
- Part B - "Design Document", which aims to minimise the potential for failure of on-site wastewater systems by stipulating design criteria based on a daily disposal model, treatment systems, disposal systems, installation procedure and requirements and

sample plans of management. This part included the development of an excel based daily effluent disposal model based on the Boughton Model (1984), which uses historic rainfall and evaporation data. The model, which is available as an excel spreadsheet, permits a flexible approach to modelling by adopting appropriate parameters for soil types, design flow, plant evapotranspiration and percolation.

- Part C - "Site Assessment Report Procedures", which aims to inform plumbers, consultants and the like on the reporting requirements associated with the lodgement of an application to Council to install, construct or alter a sewage management system.
- An important part of the strategy is assessing the soil type where effluent disposal is proposed. The strategy classified regional soils into seven broad groups, and suggested appropriate parameters to be adopted for each soil type.

Nutrients (phosphorus and nitrogen) are assessed in the strategy using a per-person mass-balance model rather than the traditional concentrations. This permits assessment of treatment and disposal options such as composting toilets, which reduce nutrient inputs.

2.1 Assessment/Design Guide Document

This Part of the Strategy assists designers to select appropriate types of on-site treatment and disposal systems by evaluating the limitations of various site conditions and constraints. Soils in the region were classified into seven generic soil types, and limitations for each soil type tabulated. An extract from the strategy for Alluvial Soils – Highly Reactive Soils is shown in Table 1. "Soil Landscapes" in Table 1 refers to the NSW Soil Conservation Service classification of soil landscapes in the region outlined in Morand (1994 and 1996).

A selection of generic design drawings for various types of disposal systems currently used on the Far North Coast was also included in this Part of the Strategy. However, the use of a standard design would not negate the need for an individual site assessment.

2.2 Design Document

Part B of the strategy provides background information on issues to be considered when designing on-site sewage management systems, including site assessment, classification of soils, choosing appropriate treatment and disposal methods, and hydraulic modelling.

The strategy developed a daily water balance model on an excel spreadsheet for hydraulic modelling of effluent disposal. The runoff generation features of the model are based on the Boughton Model (Boughton, 1984), and are based on daily historic rainfall and evaporation records. The water balance equation used for modelling effluent disposal is:

$$SM_{i+1} = SM_i + R_e - E_{tp} - DR + DI \qquad \text{Equation 1}$$

Where:

SM_i is either the soil moisture in the plant root zone at the start of time period i, or the depth of storage available in the void spaces of a disposal bed (units)

R_e is the depth of effective rainfall,

E_{tp} is the total evapotranspiration for the time period I,

DI is the depth of effluent applied to the disposal area in time period, I, where appropriate.

DR is the drainage of water below the root zone in time period I, (i.e. the percolation).

It is considered that the relationship between rainfall and evaporation is more important when determining the required effluent disposal area than absolute rainfall and evaporation, and hence rainfall and evaporation records from the same stations were used. Data were available from three evaporation and rainfall stations on the Far North Coast– Alstonville, Tabulam and Tyalgum, which represented three generic climate zones within the region. Tabulam to the west of the region being a dryer area, Alstonville central to the region on a plateau and Tyalgum to the North receiving more rainfall.

Table 1 - Alluvial Soils – Highly Reactive Soils (example Soil Landscapes: Leycester, Tatham, Disputed Plains, North Casino)

SITE CONDITION	LOW LIMITATION	MEDIUM LIMITATION	HIGH LIMITATION	COMMENTS
SOIL CHARACTERISTICS	P sorption = > 6000	P Sorp = 2000-6000	P Sorp = <2000	Conservative P sorption values is 10,000kg P sorp/ha at 100cm depth but can fall below 7,500kg/ha; if in doubt soil analysis shall be undertaken.
SOIL PERMEABILITY (LTAR)	4 -7.5mm/day	3 - 4mm or 7.5 - 10mm	<3mm or >10mm	Conservative design LTAR use 5mm/day and DIR 11mm/week. Soils are generally poorly drained due to high clay content, but usually have an LTAR of 7mm/day.
DISPERSIVENESS	Class 1	Class 2 or Class 3	Class 4	
SLOPE OF DISPOSAL AREA	0 - 10%	11-15%	16 – 20%	For steeper ground use narrow evapotranspiration/absorption beds or subsurface irrigation; in undisturbed vegetated areas with adequate buffer distances, surface irrigation can be undertaken.
ASPECT	North	North east to north west	South	
EXPOSURE	Full sun and wind	Partly sheltered	Full shelter	
DEPTH TO WATER TABLE OR BEDROCK	>4m	4 to 2m	<2m	
DISTANCE TO INTERMITTENT CREEK OR DRY GULLY — **Ave Slope** **0-10%** **11-15%** **>16%**	>35m	35 to 25m 50 to 40m 85 to 75m	<25m <40m <75m	These distances are determined on-site or from survey maps
DISTANCE PERMANENT WATER WAY — **Ave Slope** **0-10%** **11-15%** **>16%**	>50m	50 to 40m 70 to 60m	<40 m <60m <120m	
SODICITY (exchangeable sodium potential)[5]	0-5	5-10	>10	This soil type generally has ESP within the minor limitation, however the subsoils of soil landscape Distributed Plains have a moderate limitation.
FIELD pH	6 - 8	4.5 - 6	Other	Lime can be added to allow system to fall in moderate or minor limitation category
FLOOD POTENTIAL **DISPOSAL SYSTEM** **TREATMENT SYSTEM**	Rare, above 1 in 20 year contour Above 1 in 100 year contour		Below 1 in 20 year Contour Below 1 in 100 year contour	Locate treatment system above flood way, such that vents, openings and electrical components are not affected by outside water. A lot of these soils may be classed as high.
ELECTRICAL CONDUCTIVITY (dS/m)	<4	4-8	>8	Generally not considered a problem in these soils, if suspected as a problem then soil:water test to be undertaken
BULK DENSITY (g/cm^3)	<1.4		>1.4	Not required for single sites, an indication of bulk density is compaction, these soils can become compacted when wet and have traffic over them
COARSE FRAGMENTS (%)	0-20	20-40	>40	
SITE DRAINAGE	No visible signs of surface dampness		Surface wet, vegetation characteristic of wet area	These soils may be damp due to the high clay content, it is most likely that imported soil will be required
RUN-ON AND UPSLOPE SEEPAGE	Minor	Moderate	High – diversion not practical	Install catch drain above disposal field, if diversion not practical consider alternative location or design system to accommodate for this
CATION EXCHANGE CAPACITY ($cmol^+/kg$)[6]	>15	5-15	<5	Generally moderate to high CEC, on average this soil type has above 25 $cmol^+/kg$ (Morand, 1994)
MINIMUM SYSTEM REQUIRED				
TREATMENT TYPE **MINIMUM REQUIRED**	Any approved system	Any approved system, if septic, use additional filter or improved disposal field	Any approved system, if septic, use additional wetland or sand filter	
DISPOSAL SYSTEM	Any desirable system, e.g. subsurface	Evapotranspiration/ absorption bed	mounded disposal bed or other above enclosures	
GENERAL COMMENTS	Some systems will be of this type	Most sites will be of this category	Some systems will be of this type	

A daily time step in the hydraulic model was considered more appropriate than average monthly modelling used in AS1547 – 1994 (G3.2.2.3) and DLG (1998) because:

- Soil moisture storage accessible to most plants on a daily basis is not necessarily the same as the sum of the likely evapotranspiration and rainfall for the month,
- Average monthly values may incorrectly estimate the periods of near zero evapotranspiration.
- Average monthly figures do not reflect that during high rainfall intensity events, more rainfall may run off the plants and the disposal area simply because it cannot get into the ground, and
- The disposal area may be saturated for some individual days but over a whole month not have been regarded as full when the average is taken.

As well as undertaking hydraulic modelling, the Excel® spreadsheet also calculates the area required for management of phosphorus and nitrogen using a per-person mass-balance model rather than the traditional concentrations. A mass balance calculation is considered the most appropriate method because nutrient concentrations are influenced by flow rates. A mass balance also permits assessment of treatment and disposal options such as composting toilets, which reduce nutrient inputs.

The Excel® spreadsheet model permits a flexible approach to modelling by adopting appropriate parameters. An extensive literature summary of appropriate values is included in Part B of the strategy. Parameters, which can be varied in the Excel® spreadsheet model, are:

- Number of persons in the household,
- Daily wastewater flow (L/day)
- Effective rainfall (the percentage of rain which lodges on plants or runs off the disposal area without raising soil moisture)
- Depth to water table, (meters) required buffer to water table
- The percentage depth at which percolation occurs
- The drainage below root zone (or percolation)
- The available water for soil in the disposal area (i.e. the difference between field capacity and permanent wilting point) or void space ratio
- Annual nitrogen volume (kg/person/year)
- Denitrification reduction rate (%)
- Plant uptake of nitrogen (kg/ha/year)
- Plant uptake of phosphorus (kg/ha/year)
- Annual phosphorus volume (kg/person/year)
- Phosphorus sorption capacity of soil in disposal area, (kg/ha/m)
- Time for accumulation of phosphorus
- Crop factor for plants

An important part of the strategy is assessing the soil type where effluent disposal is proposed. The strategy classified regional soils into seven broad groups, based on the soil landscapes in Morand (1994,1996) and suggested appropriate parameters for design of disposal systems in each soil type. Factors which impact on the suitability of soil groups for effluent disposal, such as cation exchange capacity, sodicity, electrical conductivity and acidity were discussed. Preferred system of effluent disposal was identified for each soil type.

2.3 Site Assessment Design Procedures

Part C of the Strategy provided a simplified checklist of the requirements for planning, site evaluation and appropriate wastewater system selection in order to provide a consistent and uniform approach. In undertaking site assessments, field investigation checklists outlining report requirements, including appropriate methodology for various site and soil characteristics, were provided.

Daily Effluent Disposal Model using Boughton Water Balance Model - Alstonville Agricultural Station
Greg Alderson & Associates Pty Ltd
Period of Rainfall & Evaporation Record: 01/07/1970 - 30/06/1992

Client:	Lismore City Council						
Site:	Sample						
Number of Persons	5	equivalent persons					
Daily Flow =	700	l/day					
Nitrogen Volume per year	3.5	kg/year 0.7 kg N /p/year - See Table 7 & table 8					
Denitrification reduce to	2.8	kg/year 20 % reduction rate					
Plant Uptake rate (N) =	200	kg/ha/year - See Table 6					
Phosphorus in Effluent (Ip) =	6.5	kg/year 1.3 kg P /person/year - see Table 11					
P Uptake by plants (Hp) =	20	kg/ha/year - P which is taken up by vegetation, Table 9					
P sorption (Ps) =	10000	kg/ha/m depth - soil sorption capacity, Table 10					
Water Table Depth (Wtd) =	2	m - measured depth to the water table at the disposal site					
Buffer to W table (Bwt) =	0.5	m - adopted buffer to be set above water table					
Time for accumulation of P =	50	years					
Min. planted disposal area =	140	m2 (based on N loading)					
Min. planted disposal area =	203	m2 (based on P loading)					
Trial planted disposal area =	350	m2 (ignored if less than Min. planted disposal area)					
Crop factor =	0.74	See Table 3 and Section B2.8					
% Effective Rainfall =	85%	See Table 2					
Drainage below root zone/ Percolation =	5	mm/day - LTAR					
% of storage depth at which percolation oc	50%	See Section B2.3					
Depth of topsoil/Depth of trench =	0.3	m					
Available water/Void space ratio =	0.183	Available water from Table 1 (m/m)					
Soil Moisture Holding Capacity/ Trench sto	54.9	mm					
Disposal area used for calculation =	350	m2					
Permissible days overflow =	0	days/year					
Minimum effluent application =	2	mm/day/m2					
Max cum stor =	18	mm					
Required permissible storage =	6.3	m3					
Max cum stor =	6.3	m3					
Max cum stor =	9	days		Rainfall Infiltrating (mm)	Required Storage	Effluent Irrigation Rate (mm/day)	Actual Soil Moisture
Storage for permissible overflow =	9	days	Max	59.41	18	10.48	54.9
Storage required =	762	days in total	Mean	2.92	0.4	2	28.49
Storage required =	9.98%	of all days modelle	Median	0	0	2	24.54
			Permiss.		18		
			Min	0	0	0	7.85

Figure 1: Extract from On-Site Effluent Spreadsheet Model

2.4 Further Research Requirements

Further research on the model by Anthony McCardell from Southern Cross University (unpublished) has highlighted many areas that require further investigation and further research. Two fields where further research has become obvious are nutrient production rates (per person) and nutrient dissemination in the nutrient envelope, including plant uptake rates.

The literature search in Part B of the Strategy identified no recent studies of nitrogen and phosphorus production rates, and figures from Witt *et al* (1974) were recommended as an interim. The applicability of the Witt research, which was undertaken in rural America in the early 1970s, to current Australian systems is debatable as nutrient production is diet related. It is considered that nutrient production rates would be a valuable area for further Australian research. The latest research on nutrient production from the Septic Safe programme in Dunoon Northern NSW (Kaarac *et al.*, 2001) indicates that nitrogen production is 4.5kg/p/y as compared with 3.8kg/p/yr Whelan and Titammis (1982) and 2.2kg/p/yr Witt *et al.* (1974) used in the Regional Strategy.

While extensive research into plant nutrient uptake rates is available, existing research relates mainly to commercial horticultural or plantation production. For example, most available data relates to agricultural crops or commercial tree plantations. As an interim, the Strategy recommends nutrient uptake rates from the available literature; however, the applicability of existing studies to typical rural on-site effluent disposal areas is also debatable. It is considered that study of plant nutrient uptake rates in "typical" on-site effluent disposal would also be a valuable area for further Australian research.

Nutrient loss through percolation of effluent from the disposal beds into the subsoil is also a very relevant factor that has not been considered to date. However, in the latest version of the model a nutrient percolation rate from subsurface irrigation (SSI) areas is allocated a value of 10mg/L. It is widely assumed that a concentration of up to 10mg/L N (in the form of nitrate) poses no threat to groundwater (Reed *et al*., 1995). ANZECC Guidelines (1992) allow 50mg/L nitrate. This is equivalent to about 11 mg/L N, the amount adopted for concentration of N at the boundary of a SSI disposal bed. This is a very conservative estimate of N concentration in the receiving groundwater beneath, as mixing and dilution with other water will occur in the unsaturated zone before the effluent reaches the water table.

For ETA beds we assume that there will be a limited lateral movement of N sideways from the trenches, available for plant roots. In this case the TN loading area will be the same as the hydraulic area plus a continuous strip, of specified width, around each trench. It is acknowledged that some N will percolate into the soul below, in concentrations relative to the volume of effluent percolated and reduced by plant uptake.

2.5 The Regional Approach

Lismore City Council formally adopted the Regional Strategy document on 2nd November 1999 as the *Lismore City Council On-Site Sewage and Wastewater Management Strategy*. The concept of the six local councils within the Region adopting a uniform strategy for on-site effluent disposal has not come to fruition. Other councils that participated in the preparation of the Richmond-Tweed Strategy are either in the process of drafting their individual strategies, have produced an alternate document based on the principles of the Regional Strategy approach or chosen to do nothing.

This has resulted in the status quo remaining, whereby six different on-site effluent disposal standards are in place for the six councils in the region. This creates differing standards for assessment, design and installation of on-site systems for each council. The implications of the differing standards mean that some systems approved in one council are not necessarily approved in another. Some council assessments are more thorough, for example, some utilise nutrient management as part of the assessment criteria resulting in the approval of more sustainable systems. Some councils chose to ignore this aspect. The overall impact of the six different standards has the effect of creating confusion for industry, consultants and clients.

The reasons for the non-adoption of the strategy by councils range from:

- individual staff within some councils choosing not to adopt the strategy, and
- the interference of councillor politics into the process by some councils.

Conclusion

In principal the concept of a Richmond-Tweed Regional On-Site Sewage Management Strategy, gained widespread support from the six regional councils as indicated by their input. However, the influence of individual staff within councils and councillor politics has ensured that the regional concept has not come to fruition. To date the strategy was adopted by Lismore Council in November 1999 as the "*Lismore City Council On-Site Sewage and Wastewater Management Strategy*". The strategy is considered to have resulted in a greater understanding of the processes involved in the installation of more sustainable on-site effluent disposal systems by all stakeholders in the Lismore City Council area.

It is considered that stakeholders in the region have largely accepted the strategy, with consultants utilising the document and indicating that they find the background information in the strategy a very useful resource. The major benefit of the strategy is considered to be that all stakeholders now have a greater understanding of the processes involved in on-site effluent disposal and the objectives of sustainable on-site sewage management and the prevention of public health risks is closer to fruition.

The technical strategy documents and computer model are being continually updated as research and investigation into on-site effluent disposal continues to evolve.

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