Innovative Sewerage Solutions for Small Rural Towns

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Abstract

The development and implementation of alternative wastewater servicing approaches in rural communities in Australia appears more feasible than in larger urban developments as many rural centres rely on septic tanks and surface discharge of greywater. This method of disposal creates many environmental, social and economic issues and is seen to limit potential for growth in many towns. This paper describes a generic methodology for the selection of innovative sewerage options for six regional towns in Victoria, Australia. The method includes consultation with stakeholders, multi criteria assessment and concept design of the most favourable option. Despite the broad range of initial wastewater servicing options presented which included: cluster scale systems, upgrade of existing systems, greywater reuse and alternative collection, the outcome for five of the six towns was a modified centralised collection system as the preferred option. Lack of robust and reliable data on the human health risks and environmental impacts of alternative systems were identified as the primary data gaps in the sustainability assessment. In addition, biases in the assessment method due to stakeholder perceptions were found to be an additional issue.

Keywords

Decentralised systems, sustainability assessment, wastewater

INTRODUCTION

Many small rural communities in Australia are reliant on on-site wastewater systems and rainwater collection to provide their water servicing needs. The level of water and wastewater service provision to these communities is not as high as in large urban centres, and this provides an environment more accepting of innovative and novel servicing options. In urban areas the approach to providing alternative water services is often to recycle wastewater and reduce drinking water usage, but as many rural communities do not have either reticulated sewerage or drinking water supply, the focus of such projects is necessarily different.

Rural towns with priority for upgrade of existing wastewater servicing had been identified by the Department of Sustainability and the Environment (DSE), one of ten Victorian State Government departments with the remit of bringing together the state's responsibilities for sustainability of the natural and built environment. Funding from DSE was provided to local councils for the development and assessment of options for alternative wastewater servicing for each of these towns. Objectives from DSE were that the solutions should:

- Optimise cost efficiency
- Be innovative
- Yield positive social, economic and environmental outcomes
- Integrate all components of the water cycle

CSIRO and GHD Services Pty Ltd. were granted funds from six councils to develop innovative sewerage schemes and provide an assessment of their overall sustainability. A generic methodology was developed which included feedback from stakeholders and considereda comprehensive range of potential options for each town. Following identification of the best three options for each town, detailed economic assessment and a water and mass balance were completed. The results of these analyses were then used to assess the options using a multi-criteria assessment tool (DecisionLab 2000), the outcome of which was an overall ranking of the three most appropriate options. This paper reports the overall outcomes of these collaborative projects between CSIRO Urban Water and GHD Services Pty Ltd, and identifies knowledge gaps, barriers and issues to the final implementation of innovative wastewater servicing schemes.

METHODS

The generic methodology for development and assessment of alternative wastewater servicing options was developed from a number of previous CSIRO studies evaluating alternative water servicing options (Figure 1; Maheepala et al., 2003 and 2004; Diaper et al., 2004; Mitchell et al., 2003). The process was initiated with an inception meeting in which issues of particular concern to each individual town were identified. In conjunction with this initial meeting a toolbox of potential technical options was developed, ranging from upgrade of existing on-site systems, cluster scale options through to centralised treatment.

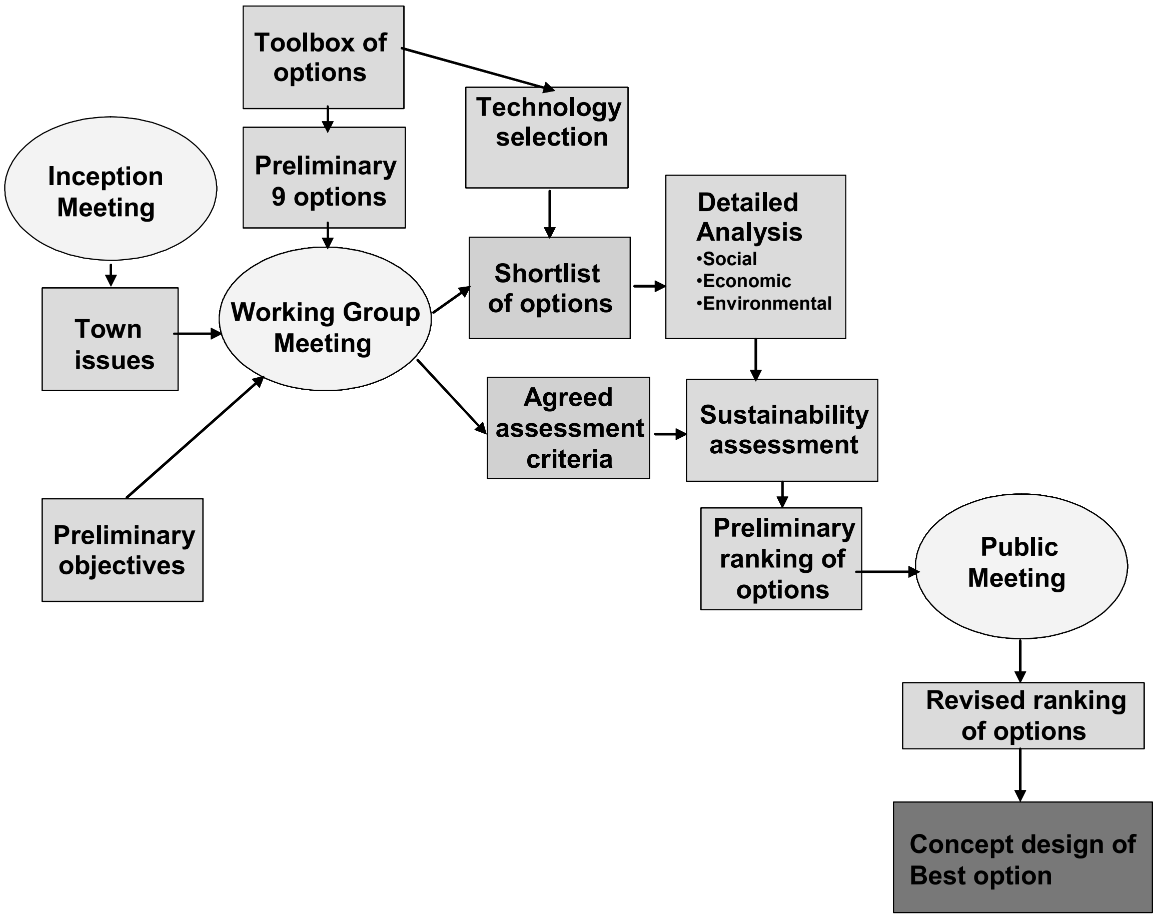

Figure 1: Schematic of generic methodology

The toolbox was summarised into nine fundamentally different and potentially appropriate technical approaches to providing sewerage for all or part of the town (see Figure 2). These options include upgrade of existing on-site treatment systems, tankering of wastewater, modified conventional sewerage and septic tank effluent pumping. The options were assessed and ranked by all stakeholders including representatives from the community, the local water company and council at a working group meeting. The criteria for this preliminary assessment, examples of which are shown in Figure 2, were based on broad study objectives developed from previous work,. In addition to the criteria shown in Figure 2 the following criteria were also included; minimises disruption to the community, provides a robust and reliable service, demonstrates an integrated resource recovery approach and simple management structure. The simple spreadsheet format shown in Figure 2 was used to communicate the options and objectives which allowed transparency in the qualitative ranking of options and facilitated stakeholder involvement during the working group meeting. The selected options were not required to comply with current relevant legislation and strategies, or with any economic assessment, as at this stage such considerations were found to restrict innovation. Compliance and economic issues were addressed later in the detailed conceptual design stage. This working group meeting was also used to obtain feedback on the criteria and to identify additional criteria for inclusion in the full assessment.

		1. Demonstrates innovative (transferrable) alternative methods of sewer/sewerage supply	2. Minimises potential adverse effect of wastewater discharges on the environment	3. Encourages demand management minimising potable water use	4. Mimics predevelopment stormwater flows	5. Demonstrates an integrated water cycle approach	6. Improves, promotes and protects public heath
Objectives Weighting 3 = High, 2 = Medium, 1 = Low		**3**	**2**	**3**	**1**	**2**	**3**
1	Upgraded on-site	3	4	4	3	4	3
2	Demand Management	2	2	3	4	2	2
3	Maximised Grey Water Recycling	3	3	5	4	3	2
4	Tankering to centralised treatment and reuse facility	2	4	1	5	1	3
5	Upgraded on-site treatment for large lots and reticulation to central treatment and reuse for small lots	4	5	1	3	4	4
6	Reticulation and tankering to central treatment and reuse	3	4	1	4	3	4
7	Modified Conventional Sewerage	1	5	1	3	2	5
8	Septic Tank Effluent Collection for small lots (Common Effluent Drainage or Septic Tank Effluent Pumping)	4	4	1	3	3	
9	Septic Tank Effluent Collection for all lots (Common Effluent Drainage or Septic Tank Effluent Pumping)	4	5	3	3	4	

Figure 2: Example of stakeholder ranking of options

Short listed options identified in the preliminary assessment were then developed into detailed conceptual designs with specific collection, treatment and distribution or disposal techniques and technologies, integrating appropriate toolbox techniques for each site. The detailed designs were then assessed using a multi-criteria water sustainability assessment, including both qualitative and quantitative assessment of a broad range of social, environmental and economic measures (Table 1).

The criteria for option assessment were developed from previous CSIRO sustainability assessment studies and those of others (Hellström et al., 2000; ASCE/UNESCO, 1998). Site specific criteria were also developed in discussion with stakeholders at the working group meeting, in order to ensure particular site requirements were considered when assessing options. The only economic criteria required for the sustainability assessment is the life cycle cost of the total system.

The PROMETHEE MCA method was used (Brans and Vincke, 1985) which is available as a commercial software system (DecisionLab 2000). In order for the analysis methodology to be as transparent as possible and easily communicated to many communities and councils, the analysis methods were kept as simple as possible. Spreadsheets and simple rules were used to rank performance in terms of water and contaminant balances, capital and operating costs and other measures. The options were assessed for stakeholder weighted criteria i.e. economic 40%, environmental 20%, functional 15%, health 15% and social 10%. Following assessment the results were presented to stakeholders and reassessed dependent on feedback from these groups.

Table 1: Sustainability Assessment Criteria

Criteria type	**Criteria description**	**Evaluation method**
Economic	Minimise life cycle costs	Net Present Value method Capex and Opex
Environmental	Reduce nutrient load, suspended solids and bacterial load to surface drains, waterways and groundwater (within predevelopment limits)	Total nitrogen, phosphorous, BOD and suspended solids discharged (kg/year) Simple contaminant balance
Environmental	Reduce nutrient load, suspended solids and bacterial load to soil and land	Total nitrogen, phosphorous, BOD and suspended solids discharged (kg/year) Simple contaminant balance
Environmental	Reduce water flows to surface drains, waterways and groundwater (within predevelopment limits)	Total water discharged (ML/year) Simple water balance
Environmental	Reduce salt load to soil, groundwater and waterways	Total salt discharged (5 point scale) Expert assessment
Environmental	Reduce mains water use	Total water used (ML/year) Simple water balance
Environmental	Increase potable substitution with treated wastewater	Total reuse (% reused) Expected demand
Environmental	Maximise resource recovery locally from sewage/excreta	Potential for biosolids reuse (5 point scale) Expert assessment
Environmental	Minimise use of fossil fuel resources and related greenhouse gas emissions	Energy consumption kWh/year Expected energy consumption
Environmental	Minimise materials usage	Materials use and reuse of existing infrastructure (5 point scale) Expert assessment
Functional	Allow future growth in town	Potential subdivided lots catered for (5

Criteria type	Criteria description	Evaluation method
		point scale) Expert assessment
Functional	Allows combination with other infrastructure requirements for town i.e. improved telecom network	Possible combination with other services (5 point scale) Expert assessment
Functional	Minimises odours, leakage and potential overflows	5 point scale Expert assessment
Health	Reduce health risk from inadequate sanitation	5 point scale Expert assessment
Social	Acceptance of aesthetic aspects of wastewater service (visual)	5 point scale based on community feedback
Social	Acceptance of end uses of treated wastewater	5 point scale based on community feedback
Social	Minimise householder maintenance requirement	5 point scale based on community feedback

RESULTS AND DISCUSSION

All towns studied have existing issues with the wastewater servicing, with system consisting of ageing and failing septic tanks and distribution systems and greywater direct discharge to surface drains, all of which have a detrimental impact on the environment and cause odour and health concerns. The communities range in size, geographic location, topography and each has specific health, economic, social and environmental concerns (Table 2). Most towns are experiencing a restriction in growth on smaller lots, due to the disposal requirements for on-site systems.

Table 2: Summary of rural town characteristics

Town name	Approx Population	Water source	Specific concerns
Birregurra	400	Reticulated reservoir	Two water courses run through town Heavy clay soils
Great Western	250	Reticulated reservoir	Heavy clay soils Groundwater salinity
Lake Bolac	200	Reticulated groundwater and river water	Groundwater salinity Public and private camping/caravan areas Close proximity to lake
Milawa	200	Groundwater	Nitrate contamination of groundwater Localised flooding
Murrabit	100	Reticulated irrigation channel	Monthly market of up to 7000 visitors
Waubra	200	Reticulated groundwater	Town is in drinking water catchment Primary school in town

The options selected for each of the case study towns and the sustainability ranking of these options is given in Table 3. Despite the range of options available to stakeholders during initial option development Figure 2, all except one town ranked modified conventional sewerage as their highest ranked option. The ranking of options was found to change for some towns when the environmental, economic, health and functional criteria weightings were changed compared to the weightings put forward by the stakeholders.

Table 3: Sustainability ranking of options for case study towns

Town	Ranking with stakeholder weighting for all criteria
Birregurra	1.Full reticulation MCS 2. Full reticulation STEP 3.On-site upgrade
Great Western	1. Septic tank effluent collection all lots 2. Cluster scale and on-site upgrade 3. Full reticulation MCS
Lake Bolac	1. Full reticulation MCS 2. Septic tank effluent collection all lots 3. Cluster scale and on-site upgrade
Milawa	1. Full reticulation MCS 2. Cluster scale and on-site upgrade 3. Full reticulation STEP
Murrabit	1. Full reticulation MCS 2. Full reticulation LPS 3. Full reticulation with CED
Waubra	1. Full reticulation MCS 2. Cluster scale and on-site upgrade 3. Full reticulation with CED

MCS - modified conventional sewerage LPS – low pressure sewer
CED – common effluent drainage STEP – septic tank effluent pumping

One of the main reasons for this selection of an ostensibly traditional centralised system, was the early focus and selection by stakeholders of this option. This then precluded some of the more innovative options from the sustainability assessment. Following sustainability assessment, the fully reticulated modified conventional system was found to be the highest ranked option for five of the six towns studied. This may be due to the use of stakeholder criteria weightings which provide a further focus on these traditional systems.

One of the limitations of the methodology used was that during initial development of options, the complex water system was broken down into individual units for simplicity and to facilitate stakeholder understanding. However, this did not readily allow combinations of alternative wastewater servicing approaches to be developed. This step of the methodology needs to be extended to provide stakeholders with a wider array of options. In addition, preliminary sustainability assessment of these options may aid in stakeholder understanding of alternative systems and challenge the perception that traditional systems provide the best option. The ranking system used in this preliminary assessment was based on a qualitative assessment of the impacts of the alternative options, a more quantitative approach at this stage would also aid in stakeholder decision making. Many previous projects haves shown that stakeholder involvement in the development of approaches is vital to the successful implementation of alternative water servicing approaches (Mitchell, 2006). However, the detail of this involvement is not well documented and thorough step-wise processes are not necessarily followed. A detailed description of these processes for option development and quantitative assessment is required. Limited resources in this current project meant that a continued program of stakeholder and community engagement was not possible. In this situation, it may be appropriate to identify key stakeholders and community champions to engage the community and disseminate information.

Analysis of the criteria used for the sustainability assessment, identifies some other reasons why the fully reticulated modified conventional system was ranked highest. Whilst a broad range of criteria were used in the assessment the potential benefits of innovative systems are not necessarily captured. For example in the current listing there is no criterion that improves sustainability due to the beneficial use of nitrogen and phosphorous in wastewater and in the assessment process all nutrients to land were viewed as detrimental to the environment. A criterion was included which allows for the use of biosolids on land but the assessment of land capability for water bourne nitrogen and phosphorous was not undertaken. In addition, qualitative assessment was often used for criteria with a high weighting. For example, the health criterion of 'reduce health risk from inadequate sanitation' was often low for on-site and other alternative sanitation systems. This, coupled with the high weighting assigned to the criteria by stakeholders, reduces the ranking of alternative servicing approaches.

A proposed improvement to the methodology in order to moderate these biases in the selection and assessment, is to assess all preliminary options in terms of quantitative criteria and to involve the stakeholder groups in the generation of this data or to provide them with the results. Lack of data and information on environmental and health risks of alternative wastewater systems was a primary issue throughout this study and is a key area of focus for future work.

The only economic criterion used in the sustainability assessment was life cycle costing. Detail of operating and capital costs will be of importance to all stakeholders involved and allocation of initial infrastructure cost and operating and maintenance responsibilities will need to be discussed with all stakeholders. However, in terms of sustainability, life cycle costing will provide a single measure of the costs associated with wastewater service provision for each of the options. Previous studies have also included externalities in sustainability assessment criteria (Diaper et al., 2003) which incorporate other potential financial factors, such as improved local amenity. However, these factors can be incorporated into other criteria, i.e. improved local amenity may be due to reduced nutrient loads to waterways, and so these criteria were not included in this study.

CONCLUSIONS

The methodology for assessing options for wastewater servicing in rural towns provided a useful tool for exploring alternative approaches. However, there were some limitations to the technique, primarily related to the processes and resources for stakeholder consultation. Limited project funds prevented reassessment of this process but important considerations in future applications of the methodology are:

- Develop initial options generation stage to allow combinations of servicing approaches
- Utilise simple sustainability assessment of broad range of options and use as key learning tool for stakeholders
- Involve stakeholders in collection and generation of data required for quantitative assessment
- Identify key stakeholders and community champions to engage the community and disseminate information where resources are limited
- Ensure positive impact criteria are included in the sustainability assessment i.e. nutrient recycling
- Weighting of criteria should not necessarily be stakeholder driven

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