MANAGING THE WATER CYCLE FOR RURAL SUBDIVISIONS

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Abstract

Rural subdivisions are becoming more popular as people who work in the city during the week seek a rural existence for the weekend or simply have made a conscious decision to live in a rural setting and to compute to the city for work. Rural areas are being subdivided into lots of around 0.4 to 10 hectares to accommodate this market niche. The trend appears to be a worldwide phenomenon, particularly for higher income earning professionals who do not necessarily want more than a couple of acres.

The water cycle for any development consists of water, wastewater and stormwater. Wastewater and stormwater in rural subdivisions can contribute to significant degradation of the surrounding catchment and environs if the development has not planned for and utilised best management practices. Developers and Councils alike should be aware of water cycle issues, both practical and regulatory, when a rural development is proposed or being assessed. This becomes particularly acute when the development application incorporates what could be considered "environmental sensitive" areas. These areas are often the most desirable for people to live, for instance near a creek or river or in areas abundant in wildlife.

When writing or considering development applications for environmentally sensitive areas, "Best Management Practices" or BMPs have to, by necessity, be applied to ensure the best possible environmental outcomes. All phases of the water cycle should be considered such as the management of stormwater, potable water, greywater and blackwater, and issues such as erosion, vegetation management, needs for buffer zones, land compatibility, surface and ground water. This paper briefly overviews some issues associated with rural subdivisions.

Keywords

Management, Rural, Stormwater, Treatment, Water, Wastewater,

1. Introduction

A rural residential development is defined herein as any development that is unsewered and is undertaken within a rural or like zone. The most common subdivision applications referred to NSW area Councils for review are rural residential proposals that range from two to over one hundred lots. The minimum size of the lots can depend on the Council and the requirements of their rural Development Control Plan (DCP) if one exists.

Wastewater management for rural lots can be covered by a separate DCP as is the case for the Blue Mountains Council and the Shoalhaven City Council. The use of conventional septic tanks (or CSTs) for new developments in the Blue Mountains is not allowed in the DCP due to the presence of shallow permeable soils and steep gradients. CSTs are allowed in certain areas of Shoalhaven City Council, as the soils there are more suitable. The minimum lot size that can be serviced by an on-site wastewater treatment system is usually 0.4 ha. Developments in more sensitive rural areas require larger lot sizes and more sophisticated wastewater and stormwater management systems.

The challenge in establishing BMPs for rural residential development is to provide guidance to those that propose the developments as well as to those that assess them. BMPs should be applicable to a range of development types and sizes, and to the individual characteristics of the land to which the development proposal relates.

1.1 What Guidelines Are Currently Available?

The process for preparing and assessing rural development proposals should involve extensive consultation throughout the process between the property owner/developer, the relevant Council and other relevant regulatory authorities. For each, responsibility for actions will vary at different stages.

The principal legislation in relation to assessment of development in NSW is the Environmental Planning and Assessment Act, 1979 (EP&A Act). Part 4 of the EP&A Act defines the process and matters for consideration in assessing development applications. In addition to the EP&A Act, a range of NSW and Commonwealth Acts are relevant to the assessment of impacts of development on the water cycle.

Wastewater management is covered under several guidelines (Dept of Local Government, 1998; NSW Health, 2000), standards (AS/NZS 1546.1:1998 and AS/NZS 1547: 2000) and:

- The Council relevant DCP, regional environmental plan, local environmental plan, usually specific for certain areas;
- Council Guidelines related to on-site wastewater treatment (if available); and
- Data and information available from soil landscape maps from Department of Land and Water Conservation and Geographic Information System.

Stormwater management is addressed in several publications (NSW Department of Housing, 1998; NSW Environment Protection Authority, 1997; NSW Environment Protection, 1997; NSW Environment Protection, 1998; and CSIRO, 1999). Storm water impacts on water quality are particularly acute during construction activities through disturbance of soil and spillage of pollutants from construction equipment. The Department of Housing have prepared guidelines for managing construction impacts (Department of Housing, 1998). These are generally accepted in State agencies and Councils as establishing *BMP*s.

Proposed rural developments without sewers within Sydney's catchments require concurrence of the Sydney Catchment Authority and consultation with the EPA and DLWC. A Water Cycle Management Study must also be prepared (DUAP, 2001) to address:

1. Pre-development and post-development run off volumes and pollutant loads from the site of the proposed development;
2. Assessment of the proposed development against the matters for consideration specified in clause 12 of the REP;
3. The impacts of the development on receiving waters;
4. The water cycle management strategies and BMP proposed to be employed to address these impacts; and
5. The arrangements to be made for the ongoing maintenance and monitoring of the water cycle management system.

2 Other Factors that Impact on Water Quality

Land suitability: Similar types of land use can have quite different impacts on water quality, depending on the land management practices employed. While there is a large and evolving body of knowledge about what constitutes a BMP for different land uses and in different geographic locations, these land management practices are not always employed.

Water cycle BMPs for identifying land suitability must include consideration of:

- Soil type, particularly erodability
- Topography & steepness of slopes
- Proximity to watercourses and potential for flooding
- The condition and position of the water table, including potential for salinity to occur
- Site flow patterns/volumes across the site
- Native vegetation and/or fauna numbers
- Cumulative impacts on water quality & hydrology due to other human activity
- Potential for rural residential development to minimise or alleviate existing threats to water quality from the land

Lot Size: Minimum lot sizes for particular areas can be dictated by Council DCPs. In particular, the following issues should be addressed:

- The relationship between development density and changes in hydrology, in particular the likely increase in impervious surfaces;
- The degree to which changes in landform would be required to facilitate development, such as excavation or filling, and the likely impacts on groundwater and surface waters;
- The need for waterway crossings; and
- The potential to create suitable dwelling sites without the need to impact on significant site features (vegetation, riparian zones or drainage lines).

Streetscape Layout: A water sensitive streetscape integrates the road layout and vehicular and pedestrian requirements with stormwater management needs. It uses design measures such as reduced frontages, zero lot-lines, local detention of stormwater in road reserves and managed landscaping.

Road Location and Construction: Roads generally increase the coverage of impermeable surfaces within a site, and can influence surface and groundwater flow patterns, particularly when in cut or fill. Roads can also impact on water quality through the collection of pollutants such as oil and petrol. Road crossings over watercourses have the greatest potential for direct impacts on the stability of beds and banks, and for direct impacts on water quality. Watercourse crossings, primarily for roads but also for other infrastructures such as electricity or gas lines, have the potential to impact both directly and indirectly on aquatic fauna and their habitats. The retention or reinstatement of conditions allowing fish movement along and between waterways (including during flood conditions) must be considered in the design of watercourse crossings (NSW Fisheries, 1999). The design of roads, including their layout, horizontal and vertical alignment, total length and width are all key elements contributing to the sustainability of water management in rural subdivision.

Vegetation Conservation and Buffer Zones: A healthy riparian buffer zone (RBZ) consists of a complex community of plants providing both canopy and understorey for complex communities of insects, birds, fish and mammals. Under certain conditions, retention of buffer zones to watercourses can be an effective means of maintaining water quality and stream hydrology. In addition, buffer zones can contribute significantly to maintenance of terrestrial and aquatic ecological processes. Water sensitive design should incorporate multi-purpose drainage corridors in rural identical developments. These integrate public open space with conservation corridors, stormwater management systems and recreation facilities. This has a water quality as well as social and economic benefits. Applications are also more favourably reviewed if they contain elements of improving existing degraded areas that would positively impact on water quality.

3 Types of Subdivisions

Different types of subdivision provide relative advantages and disadvantages for the management of land and subsequently achievement of water quality objectives. When considering the subdivision of land, developers should evaluate the relative benefits and limitations of the three types of subdivisions in NSW:

- Freehold subdivisions under the Local Government Act, 1993 or EP&A Act, 1979;
- Strata subdivisions under the Strata Titles Act, 1973; and
- Community titles under the Community Land Development Act, 1989 and the Community Land Management Act, 1989.

Freehold Title: In the context of water cycle management and the BMPs discussed in previous sections, freehold title has potential limitations.

- No responsibility of individual property owners for communal space;
- Councils pay for the management of open space, roads and other public space;
- Property owners do not have to consult with each other or make collective decisions;
- Fragmentation of property ownership, particularly with small land parcels can create significant challenges with respect to water quality.

However, there are some advantages to freehold, such as the ability for Councils to:

- Own/manage land with special environmental qualities or functions for the public good;
- Ability to use general revenue or specific funding sources for public land management.

Strata subdivision: Strata subdivision provides for tenure to be held by individuals over parts of a subdivision, and for joint ownership, under a body corporate of all owners, of common property within the subdivision. Strata subdivision may be useful where land is identified as required for water quality purposes, such as riparian buffers. Such land under this approach can be retained in the ownership of the body corporate. Councils or the regulatory authorities have limited ability to undertake works directly on the land.

Community Title: This framework allows individual block owners complete autonomy in managing their freehold land, while sharing the benefits of jointly owned access roads, equipment and other services. It is the framework that has been adopted in many recent rural subdivisions, rural developments, eco-villages, vineyard developments, and similar types of development in NSW. The chief advantage with respect to the water cycle is that sustainable management can be encouraged through communal responsibility. The lack of immediate cash flow to the developer and the unfamiliarity of many Councils with the legislation are its chief disadvantages.

4 On-site Management of Water within the Rural Development

The major sources of water pollution in rural developments arise from wastewater and storm runoff. Wastewater from domestic premises, consisting of greywater and blackwater, contains significant amounts of environmental pollutants in the form of carbon (organic matter), the nutrients nitrogen and phosphorus, pathogenic bacteria, viruses and protozoan (oo)cysts and salts. Stormwater can contain grease and oils from paved areas, litter, sewage from overflows, and the products of erosion such as soil and organic matter.

4.1 Wastewater Management Best Practice

Councils have primary responsibility to regulate the installation and operation of on-site sewage management systems used by households under the Local Government Act 1993 and the Local Government (Approvals) Regulation 1999. Polluting waters or permitting waters to be polluted are offences under the Protection of Environmental Operations Act of 1997 (PEO

Act). Breaches under the PEO Act can precipitate a penalty notice, an on-the-spot-fine or a prosecution under the Environmental Offences and Penalties Act 1989 by the EPA or relevant Council.

Untreated or partially treated domestic wastewater from rural developments has the potential to degrade neighbouring streams and groundwater as well as pose a risk to human health. Household flows in Australia are usually in the range of 150 to 300 Lpd for those on reticulated water supply systems (own data) and less than 150 L/person/day (Khalife *et al.*, 2000) for those on point sources such as a bore or tank water. Figures as low as 80 Lpd are not uncommon for point sources. Remote Australian aboriginal communities were recently measured (Khalife *et al.*, 2000) at 103 Lpd with BOD/COD values as high as 674/1370 mg/L.

The ultimate aim of the on-site management of domestic wastewater should be a "zero discharge" scenario in which wastewater is treated and (re)used within the confines of the site. However, centralised sewerage systems are usually the best method of sewage management for rural residential areas where a council water supply is available as there is often insufficient land to sustainably manage the flows of wastewater. The selection of the management system is site specific, but essentially consists of three components:

- Component 1: Waste collection system (eg drains, pipes, etc);
- Component 2: Human waste treatment device; and
- Component 3: Treated wastewater reuse (disposal) system.

There is a multitude of choices when the use of an on-site wastewater treatment system is selected over a centralised sewage scheme. Components 2 and 3 should be paired in such a way as to constitute a BMP suitable for a particular development site.

Human Waste Treatment Devices: Several common systems are listed below.

- The most common is the conventional septic tank (CST). Rural households have extensively employed CSTs over all Council areas and catchments. CSTs partially treat wastewater through solids removal and anaerobic digestion. Their biggest advantage is low cost, whilst their biggest disadvantage is the possible release of nitrates and viruses (pathogens) into the groundwater. Newer designs counter some of the disadvantages with a fully contained disposal system that utilises evapotranspiration, high pH (for pathogen removal) and chemical phosphorus scavenging.
- Aerated wastewater treatment systems (AWTSs) have come to prominence as their reliability has improved. They are essentially a small activated-sludge plant or an aerated filter. Wastewater is processed through several steps (solids settling to disinfection) to achieve a significant degree of treatment. An on-site AWTS requires electricity and has to have a constant wastewater flow to operate at its peak efficiency.
- Waterless or dry composting toilets (DCTs) are designed to accept human waste, organic household waste and kitchen vegetable scraps. There are numerous designs (*eg* multi-chamber, subfloor, and free standing). Treatment employs microorganisms (bacteria, fungi, and moulds to degrade solid wastes into a stable, odourless compost or humus pile. Worms and insects can be added to enhance the degradation process. People who would choose this system would have to be able to live with a non-flushing toilet and be able to manage the generated compost. Greywater requires separate treatment.
- A wet composting toilet (WCT) is much like a dry composting toilet in that it can accept a variety of organic wastes. Conventional flush toilets can be used and the WCT can be located underneath the bathroom area or underground, similar to a septic tank. The composting solids in a WCT act as a filter such that most of solids are retained and the liquid must be further treated.

- In some rural developments it may be feasible and advantageous to "cluster" wastewater management into a common effluent drainage schemes (CEDS). The owner of the rural lot becomes responsible in a CEDS for managing the solids on-site, whilst the effluent is collected and transported to a central treatment plant. Once the wastewater is treated to a high standard, rural lot owners can then be required to reuse a portion of the total flow within the bounds of their rural lot. Biosolids from the central treatment plant would require separate management (NSW EPA, 1997).

Treated Wastewater Reuse Systems: In general, the higher the wastewater quality exiting the wastewater treatment system the greater are the options for its disposal or reuse. NSW Health guidelines (NSW Health, 2000) specify those component 3 systems acceptable from a health perspective.

- Land application systems are the predominant wastewater disposal system, operating mainly by soil absorption, with only limited evapotranspiration. There is no reuse with these systems. The potential for nitrate contamination of groundwater, in particular, is increased with the use of these systems if nitrogen has not been removed. Nitrogen will often dictate the environmentally sustainable density of a development area.
- A licence is generally not required from the NSW EPA to operate an on-site wastewater reuse system for less than 10 persons as long as there is no discharge off site. The treated wastewater reuse system should be designed to suit development site conditions.
- Wetlands have also been used as a component 2 and/or 3 system. The design utilises a sub/surface flow and specific applications of this approach for a particular development would require certification from NSW Health (also see Gopal, 1999). Bolton and Greenway (1999) studied the use of tea tree wetlands as a component 3 system and found *M alternifola* as the most suited species for a "harvestable" constructed wetland.

Narrowing BMP Choices for a Development Site: The procedure culminating in the selection of a site-specific BMP (AS/NZS 1547:2000) should consist of the following steps:

1. Conduct a site assessment of the development site. Determine as a first step whether the site is near contaminated areas, acid sulphate soils, environmentally sensitive areas, watercourses and other potentially restrictive feature(s).
2. Conduct a soil assessment to determine limitations of the site. The subject soils are assessed and placed within the seven broad categories. Each soil type on site will have intrinsic limitations and advantages that will feed into the water balance.
3. Perform a hydraulic (water) balance to determine the volume of effluent that will be generated per lot. This will determine the size of the disposal area. If wastewater is to be treated to a high level and reused to offset potable usage, this area will be smaller in size. The recommended disposal area is to be designed with comparison between the area required to dispose of nitrogen, phosphorus, sodium, pathogens and daily flow.
4. Determine the appropriate on-site wastewater management system by considering the site and soil assessments. This should be based on the parameters: nitrogen, phosphorus, sodium, pathogen, hydraulic load, slope, aspect, soil type, flow rate, human waste treatment device performance, buffers and setback.

Making the Final Selection: Once the rural development site is characterised, a decision can be made as to the most appropriate BMP. BMPs that effectively manage all the wastewater are the most acceptable to councils and regulatory authorities as they (1) conserve water, (2) separate/divert and pre-treat effluent at the source; and (3) recycle and reuse effluent. The overall risk of the potential development site will need to be ascertained as certain BMPs can only cope with limited degrees of risk. The most limiting feature therefore determines the site capability for a land application system or on-site sewage management system. In some cases the problems posed by a limiting feature or features can be overcome by using special designs or by modifying the site (see Table I).

Table I. Risk Capabilities of Selected On-Site Wastewater Management BMPs.

BMP	Risk Capability	Notes
CST & Absorption Trench (subsoil irrigation)	Low	Widely used but can be polluting to surface and ground waters. **Potential Gaps as a BMP**: • Australian designs have a detention time of 24 hrs, whereas European standards & US are from 3 to 5 days. A longer required detention could improve performance. • Little data are available on septic tank performance from rural applications (other than remote Aboriginal communities).
CST & Alternative Leachate Fields	Medium to High	Alternative leachate fields are well known in WA and are being trialed in NSW with high risk allotments. **Potential Gaps as a BMP**: • The absorption field employs "red mud" from aluminium smelting because of the presence of iron and aluminium for precipitation of phosphorus. It is unknown what other metals/inorganics might also be in the leachate. • Some councils have questioned ammonia levels in the effluent.
AWTS & Subsurface Irrigation	High	System has to receive a constant wastewater flow. Not all systems produce a consistently high quality effluent. **Potential Gaps as a BMP**: • There are different makes that employ activated sludge or an aerated (or upflow) tricking filter. More data gathering is needed to identify the most effective designs. Most councils only see one or two models.
DCT & Absorption Trench	Low to Medium	This BMP reduces the pollutant load to the absorption trench and recycles the biosolids. **Potential Gaps as a BMP**: • There are no data on the effluent that results from this BMP.
WCT & Absorption Trench	Low to Medium	The pollutant load to the absorption trench and biosolids are recycled. **Potential Gaps as a BMP**: • There are no data on the effluent that results from this BMP.
WCT & AWTS	High to Extra High	This system allows the recycling of biosolids (as compost). Treated wastewater could potentially offset potable water usage.
CEDS & Activated Sludge	High to Extra High	BMP is most suited to larger rural developments.

4.2 Stormwater Management Best Practice

Stormwater management during construction is a critical element of reducing water quality impacts of new development. Significant disturbance of land through removal of vegetation, excavation and filling creates potential for erosion and sediment transport to streams, impacting on water quality and ecological health. Effective management of land disturbance, including minimisation of disturbance, mitigation of impacts and rehabilitation upon completion, is critical. Councils have the power through the development and subdivision approval processes under the EP&A Act to direct that certain measures be undertaken to manage erosion and sedimentation.

The Department of Housing (NSW DOH, 1998) has prepared guidelines for managing construction impacts. These are generally accepted in State agencies and Councils as establishing *BMP*s. Councils, the EPA and DLWC generally require preparation of an Integrated Soils and Water Management Plan to manage and mitigate erosion and water quality impacts during construction. This may form part of a broader construction Environmental Management Plan. The DLWC has prepared soil landscape maps for many areas of NSW. These include descriptions of structure and erodibility.

Storm events also negatively impact the treated wastewater reuse system, particularly if that system involves surface/subsurface irrigation. This factor is usually taken into account when conducting the water balance and may require a storage facility for treated effluent during wet weather.

5 Conclusions

Rural subdivisions will continue to be proposed in NSW and elsewhere to meet a development market niche. These developments are mostly non-sewered with lot sizes ranging from 0.4 to 10 hectares. Each lot will require some form of on-site wastewater management system and possibly their own water supply.

The challenge in establishing BMPs for rural residential development is to provide guidance that is applicable to a range of development types and sizes, and the individual characteristics of the land to which the development proposal relates. This guidance on water quality issues is needed by developers, Councils, and regulatory authorities to allow the effective implementation of BMPs to protect the water quality and general environment within rural catchments. Rural residential development can make a positive contribution to achieving sustainability, providing BMPs are applied. This paper only briefly touches on the detail, selection and application of these BMPs and original source material should be consulted for additional information.

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