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FINAL

Wastewater Options Analysis for the ‘Kyeema’ Subdivision at North Gundaroo, NSW

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Synopsis:	A 65-lot rural residential subdivision is proposed to the north of the village of Gundaroo, NSW. This report details the first stage of a wastewater options study, comprising a desktop review and preliminary cost analysis.
Client Details	
Client:	Paul Carmody
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Disclaimer

The information contained in this report is based on independent research undertaken by Mark Saunders and Ben Crawley of Whitehead & Associates Environmental Consultants Pty Ltd (W&A). To my knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an appraisal of the site conditions subject to the limited scope and resources available for this project, and follow relevant industry standards. The work performed by W&A included a desktop review only, and the conclusions made in this report are based on the information gained and the assumptions as outlined.

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EXECUTIVE SUMMARY

Whitehead and Associates Environmental Consultants Pty Ltd were engaged by Paul Carmody to undertake a wastewater options assessment for the proposed 65-lot “Kyeema” subdivision at the northern end of the village of Gundaroo. The property has a total area of 62.7 hectares (ha), comprising Lots 1 and 2 DP 850916. The area subject to the planning proposal (“Site”) is approximately 41ha in area and lies entirely within the Yass Valley Council local government area.

Areas proposed for residential development are to be rezoned as R2 Low Density Residential with a minimum lot size of 2,000m^2 or 5,000m^2. The elevated area in the east of the Site is proposed as E4 Environmental Living, with a minimum lot size of 1ha (10,000m^2). Sensitive areas to the south (McLeod’s Creek corridor) and east of the Site are proposed as E3 Environmental Management. A large (>15ha) remnant parcel will be retained in the north of the Site (RU1).

It is proposed to develop the Site in two stages. Stage 1 will consist of 21 residential lots varying in size from 2,000m^2 to 12,000m^2 whilst Stage two will consist of 44 lots with each lot 2,000m^2 in size.

The Site is subject of a joint planning proposal (PP_2013_YASSV_002_00) along with the proposed Sutton Road development to the south of Gundaroo village. Council has proposed that the Site be rezoned under the YVC 2013 LEP and a ‘Gateway’ determination (dated 3/10/13) has been received from Planning NSW providing support for the proposal to proceed for further investigation and consideration. Items for examination included issues of potable and non-potable water provision, effluent disposal and potential impacts on groundwater.

Gundaroo Village is presently un-sewered with all wastewater being treated on each developed property by individual OWM systems. A number of these systems are old and/or failing, with some susceptible to inundation, particularly during storms. However, recent investigations have found that this approach may be contributing to regional contamination concerns, particularly with regard to (shallow) groundwater vulnerability and associated public and environmental health concerns. The YVC LEP (2013) identifies the Site as suitable for ongoing use of OWM systems for residential development and a land capability assessment (LCA) has been prepared demonstrating conceptual) options for such an approach. However, both Council and state agencies (OEH, Planning NSW and DPI-Office of Water) have highlighted the importance of considering ‘alternative’ wastewater servicing arrangements for the planning proposal.

This Report examined three (3) alternative wastewater servicing solutions for the Site, including (i) on-site wastewater management, (ii) community (or decentralised) wastewater management and (iii) conventional sewerage. The on-site and community approaches are examined in detail with specific regard to collection and reticulation options, treatment technologies and reuse opportunities for treated effluent. The conventional sewerage approach is examined more generally with reference to previous analysis prepared for Gundaroo by YVC.

The key considerations for suitability of a servicing approach for ‘Kyeema’ were: acceptability (Client, regulatory authorities and community); protecting environmental resources; beneficial reuse opportunities; practicality of construction and maintenance; optimising development potential; and economic viability.

The key findings of our analysis show that both on-site servicing and a STEP/STEG based common effluent sewer (CES) scheme with local treatment, storage and effluent irrigation would represent an effective and sustainable servicing solution for the subdivision. Both options provide significant advantages (economic and environmental) over a conventional sewerage approach; however, the community servicing solution presents the greatest opportunity to optimise the social, public and environmental benefits of the subdivision. Adoption of the community approach also provides flexibility in the rollout of servicing to the subdivision, sharing costs between the developer (proponent) and the homeowner, and providing a reliable opportunity for cross-connection with a (potential future) Gundaroo sewerage scheme.

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1 Introduction

Whitehead and Associates ("W&A") were engaged by Paul Carmody ("the Client") to undertake a wastewater options assessment for the proposed "Kyeema" subdivision at the northern end of the village of Gundaroo ("the Site"). The proposed subdivision is bound by Gundaroo Road to the west and Rosamel Street to the south. The Site lies entirely within the Yass Valley Council (hereafter "Council") local government area. The general location of the proposed subdivision is presented in Figure 1.

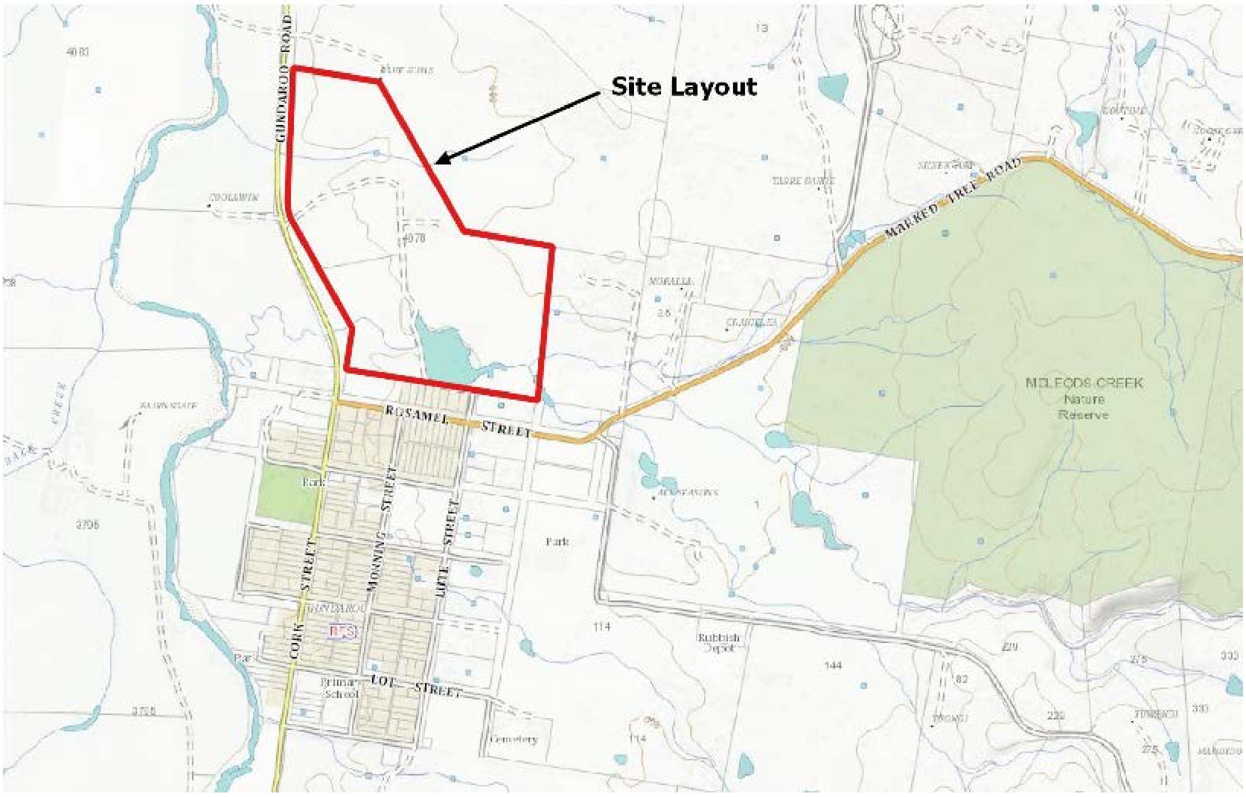


Figure 1: Site Locality Plan

This Wastewater Options Analysis focuses on presenting the range of opportunities for providing (sanitary) wastewater services for the development with a primary aim of determining the most cost effective and environmentally sustainable solution for the Site, whilst taking into consideration a range of driving (and sometimes competing) factors, including:

- acceptability to the Client, regulatory authorities (DPI, OEH and Planning NSW) and Council;
- protecting the environment, including native flora and fauna, surface water and ground water resources;
- providing beneficial reuse of treated wastewater;
- practicality of construction and maintenance;
- optimising development potential of the land; and
- economic viability.

2 Proposed Development

2.1 Background

In September 2013 Council proposed that the Site be rezoned under Council's 2013 LEP. A similar (subdivision) application had also been received by Council for a property (under separate ownership) to the south of Gundaroo village (Sutton Road). Therefore, it was decided to address both planning proposals simultaneously through the submission of a 'joint' planning proposal (PP_2013_YASSV_002_00) to Planning NSW to ensure a timely, effective and consistent approach to the applications.

Council policy (SEP-POL-1) requires that Planning Proposals submitted to Council only be considered if the land has been identified as a 'Future Investigation Area' and "can be connected to a reticulated water supply and sewerage system or **incorporate an alternative water supply and effluent disposal system, which will have no offsite impact on the quality and quantity of surface or ground waters**".

The Gateway Determination (dated 3/10/13) provides support for the proposal to proceed for further investigation and consideration. Notwithstanding planning matters, the determination specifically required consultation with public authorities including NSW Office of Environment and Heritage (OEH), Murrumbidgee CMA, NSW Department of Primary Industries – Office of Water (NOW) and NSW Health. Authorities were requested to respond to 'issues of potable and non-potable water provision, effluent disposal and potential impacts on groundwater'.

2.2 "Kyeema" Planning Proposal

The property has a total area of 62.7 hectares (ha), comprising Lots 1 and 2 DP 850916. The area subject to the planning proposal ("Site") is approximately 41ha in area. There are two (2) existing dwellings on the property, with separate vehicle access from Gundaroo Road.

Under the planning proposal, areas of the Site proposed for residential development are to be rezoned as R2 Low Density Residential with a minimum lot size of 2,000m^2 or 5,000m^2. This includes a rectangular zone in the centre of the Site. Further, the elevated area in the east of the Site is proposed as E4 Environmental Living, with a minimum lot size of 1ha (10,000m^2). Finally, sensitive areas to the south (McLeod's Creek corridor) and east of the Site are proposed as E3 Environmental Management. A large (>15ha) remnant parcel will be retained in the north of the Site (RU1) with no changes to the current LEP proposed.

It is proposed to commence development in two stages, totalling 65 lots, in the R2 and E4 Zones. Stage 1 will consist of 21 residential lots varying in size from 2,000m^2 to 12,000m^2 whilst Stage two will consist of 44 lots with each lot 2,000m^2 in size. A proposed Plan of Subdivision is presented in Figure 2.

Vehicle access to the proposed subdivision would be by an existing (unmade) roadway in the north of Gundaroo Village ('Lute Street') and a direct access from Gundaroo Road.

The Site is identified as a "Future Investigation Area' in the draft Yass Valley Town and Villages Study (2010) where it was stated that the Site:

> *"be considered for the future growth of Gundaroo Village, subject to further investigation – including access to water…..Developing the village in this direction would allow the semi-rural village character to be maintained and the subdivision pattern to reflect that of the existing streets".*

The development has been approved for on-site effluent disposal under Council's 2013 LEP.

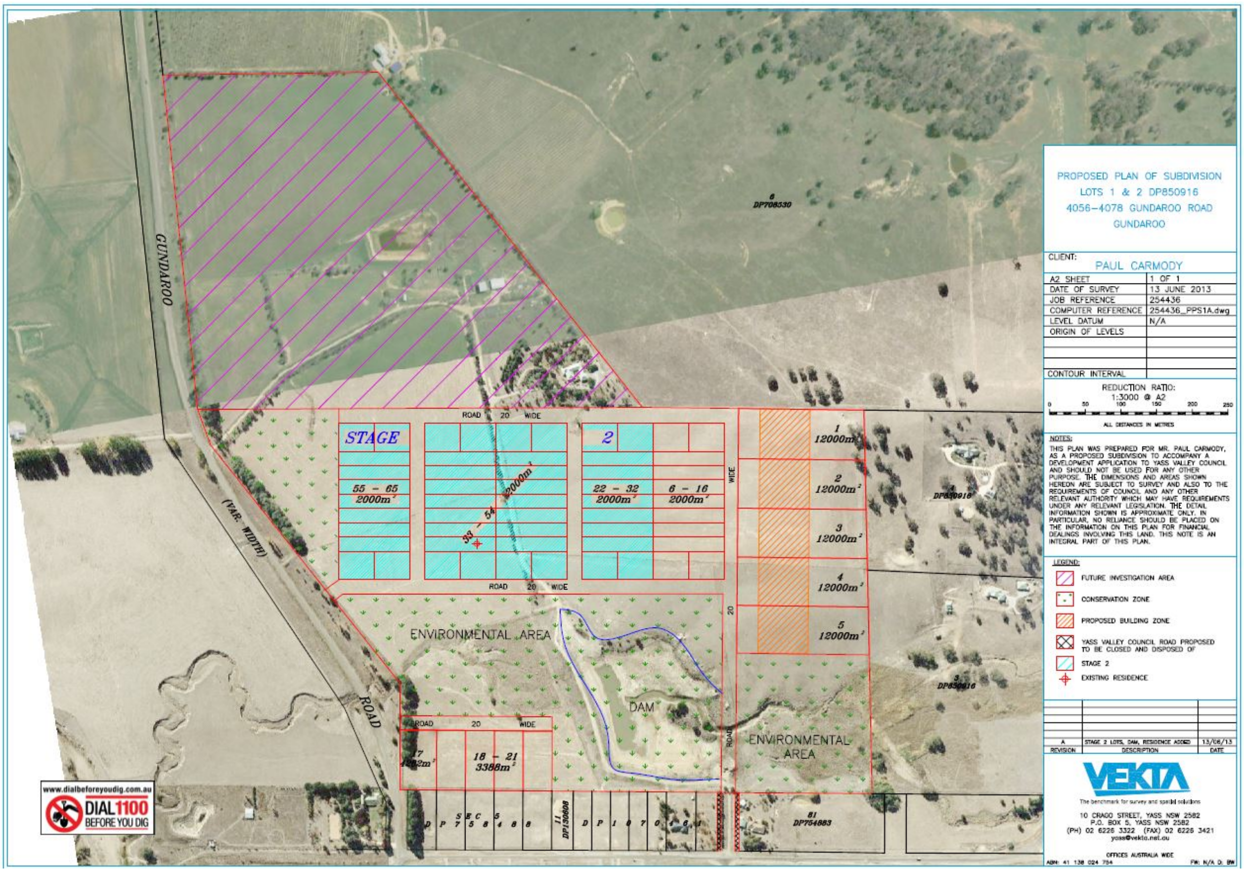


Figure 2: Proposed Kyeema Lot Layout (VETKA, 2013)

3 Site Description

The Site is located on a gently undulating hill which falls towards the south west. Water features on the Site include McLeod's Creek, which runs in an east to west direction along the line of which lies a farm dam. The farm dam has a spillway at the northwest end that allows water to re-join McLeod's Creek. McLeod's Creek continues running west into the Yass River.

It is understood that a current extraction license exists for the property to access 155ML annually from the Yass River for irrigation, stock and domestic purposes. Currently the Site consists of pasture grasses and is used for sheep grazing.

4 Background Information and Investigations

4.1 Groundwater Contamination

Advice provided by the NSW DPI (Office of Water) (NOW), in a letter dated 16 December 2013, identifies that a number of properties in Gundaroo Village currently extract bore water to meet non-potable supply demands. The groundwater is drawn from fractured bedrock aquifers. Data from NOW's database shows groundwater levels range from 7-20m below ground level.

During a subsequent Council meeting about the planning proposal many issues were raised relating to groundwater extraction. From that meeting it became apparent that there are many unregistered bores in the village of Gundaroo. Presently NOW, who issue bore licenses, do not have any bore water monitoring measures in place. The groundwater and fractured rock environment is poorly understood and the groundwater quality is uncertain.

Many properties in Gundaroo Village use on-site wastewater management (OWM) systems with septic tanks and disposal to absorption trenches. These soil absorption systems (SAS) have the potential to contaminate the aquifer and adversely impact on groundwater quality if they perform poorly or fail. The potential impact of on-site wastewater systems on groundwater is exacerbated by the approval of such systems within close proximity to unregistered bores. Typically a 250m buffer (setback) is recommended between OWM systems and groundwater bores to protect against inadvertent or unidentified contamination risk. There are currently two registered groundwater bores at the Site as shown in Figure 3 and Figure 4.

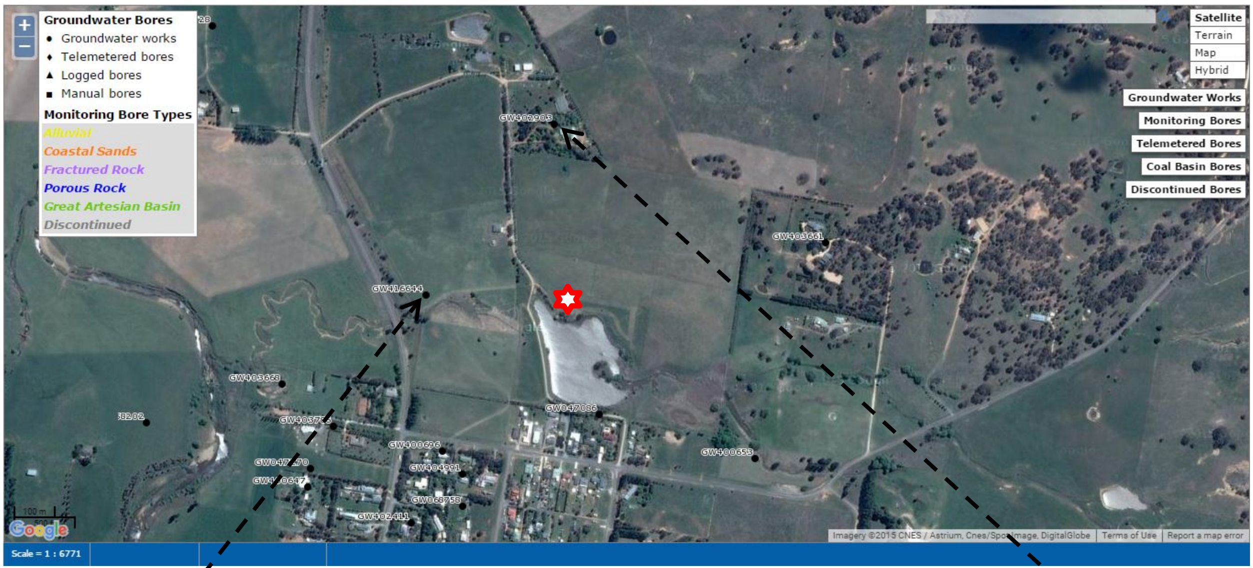
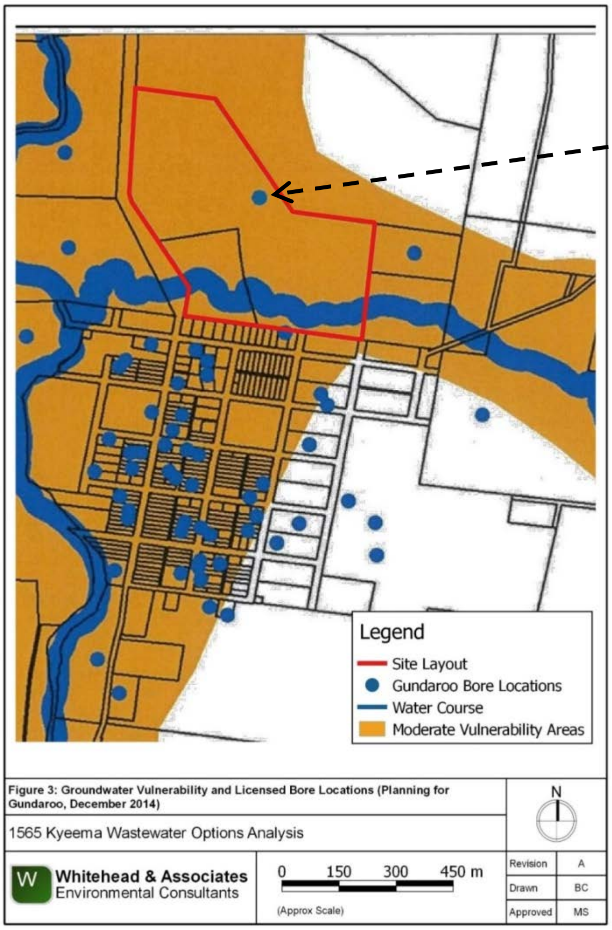


Figure 3: NSW Office of Water Groundwater Map

Registered monitoring bore, (GW 416664), as per NOW recommendation.



Location of GW 402903, as shown on both plans, is incorrect as per Clients advice. Indicative (actual) location shown in Figure 3 (red star).

Figure 4: Groundwater Vulnerability and Licensed Bore Locations (Planning for Gundaroo, December 2014).

4.2 On-Site Wastewater Management System Performance

As mentioned, the Village of Gundaroo is un-sewered with all wastewater being treated on each developed property by individual OWM systems. Records indicate that there are 100 Aerated Wastewater Treatment Systems (AWTS), 69 septic tanks and SAS (trench) systems and 9 alternative systems (wet or dry composting systems) currently operating within Gundaroo.

A number of these systems are old and/or failing. Some systems are susceptible to inundation, particularly during storms, as was evident in December 2014 (see Figure 5). The risks associated with on-site wastewater management (unsewered development) in Gundaroo Village were discussed at an ordinary Council Meeting (25 March 2015) where it was noted that Council should:

- Seek to better understand and quantify the potential contamination risk, and
- Look to developing mitigation measures (i.e. improved selection and management of OWM systems or restrictions on bore water uses).

The Council report notes that "if the village is to continue the reliance upon on-site treatment systems then it is essential they continue to perform as designed. In addition the use of bore water should be restricted to external use only (e.g. garden watering) to further minimise risks".

An audit program was highlighted, with a recommendation to audit each existing system, identify deficiencies and improvements, oversee any remediation works and conduct regular monitoring inspections. The estimated resource/capital cost for this exercise (assuming 200 premises) was found to be equivalent to one (1) full time position (FTE) or $168,000 per annum or $840 per property. It was also noted that this would be an additional cost for landowners on top of any private maintenance agreement in place for their system (i.e. AWTS owners), which are estimated at ~$200-$300 annually.

The Council minutes also report that preliminary investigations into a possible reticulated (assumed traditional gravity sewer) system has been undertaken for Gundaroo, with capital cost estimates of $5.8M (~$24K per connection). The report goes on to note that past studies into the suitability of sewerage were opposed by the local community due to the associated costs of installation and connection, along with the cost of decommissioning existing on-site treatment systems.

Figure 5: Inundated Septic System (Planning for Gundaroo, December 2014)

4.3 Land Capability Assessment

A Land Capability Assessment (LCA) for on-site effluent disposal was undertaken for Stages 1 & 2 of the ‘Kyeema’ planning proposal by Soil and Land Conservation Consulting (SLCC; P. Fogarty), dated May 2011.

No Site investigation was undertaken by W&A as part of this project.

The LCA report details site and soil investigation undertaken at the Site to determine the long-term sustainability of on-site wastewater management servicing of the proposed subdivision and to provide recommendations for suitable OWM systems (including treatment and land application options) to comply with current State and local requirements. The LCA report summarised site and soil conditions as following:

- Climate - cool temperate climate with median annual rainfall of 630mm, pan evaporation 1,200mm; large moisture deficit in summer months, very small surplus in winter; prone to frequent frosts so surface irrigation lines prone to damage by freezing.
- Terrain – site situated on gentle side slope developed on weathered shale of the Ordovician metasediments. Slope form is typically linear divergent, meaning runoff tends to spread out rather than concentrate. The elevated land is flanked to the west by alluvial terraces associated with McLeod’s Creek. A high and low terrace have been identified, both of which would be above flood level.
- Surface hydrology - The main channel of McLeod’s Creek has a large dam, with a spillway directing the overflow to the north side of the old channel. The overflow spills across the low terrace back to the main channel. The creek and dam have a 100m buffer inside which effluent disposal will not be carried out. The buffer does not apply to the short channel section below the dam, which does not now carry flows.
- Subsurface hydrology - Typically around 5-10% of annual rainfall forms surface runoff, although in larger storms, over 50% of rainfall will form runoff. Runoff is directed to the depressions largely as subsurface flows in the upper part of the soil profile and then transmitted through the site due to the significant slope grade of the depressions.
- Slope - Upland terrain has slope grades between 2 and 8%, and is typically around 5-6%. Overall, the land is gently sloping with no steeply sloping areas. The alluvial terraces are flat to gently sloping, with a short section of steeper slope gradients defining the edge of the high terrace.
- Rock and Outcrop – No significant occurrences.
- Soils - Hillslopes have moderately deep gravely red chromosols, comprising loam textured upper layer to around 20cm, grading to a clay loam then light clay subsoil. Total soil depth is typically 60-80cm before grading to weathered parent rock. The strong red colours indicate the soils are well drained and not prone to elevated watertables.

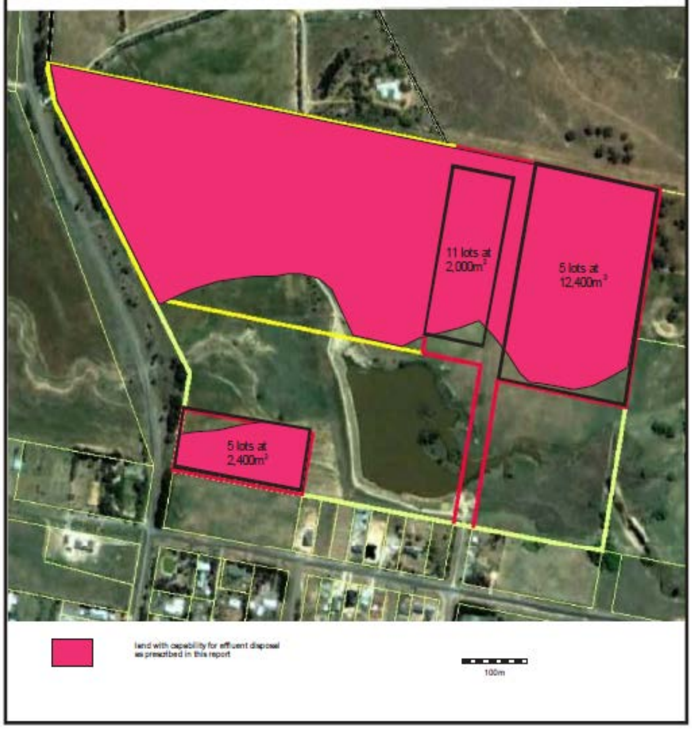
  Soils have a moderate permeability, of 1.5 to 3m/day in the topsoil and .5-1.5m/day in the subsoil. The reddish non-mottled colour of the soils in the depressions indicates that elevated watertables and waterlogging do not occur either on the hillslopes or on the alluvial terrace.
- Erosion - Low erosion hazard due to favourable structure and good coherence. Soil is prone to erosion if groundcover is reduced to <70% by grazing and associated pulverisation by stock. The drainage lines have not been subject to erosion and are in a stable condition. Soils here are non-dispersive and not likely to form erosion gullies.

- Groundwater - There are a number of licensed bores in the village and surrounding areas. Bore records show an aquifer at around 20m and at around 80m. It is likely that these aquifers are in fractures in the unweathered underlying bedrock. Investigations in the Murrumbateman area by the former DLWC have shown that contamination of groundwater typically occurs where plumes from failing absorption trenches come into direct contact with bores, and seep down the bore casing into the aquifer resulting in bacterial and nutrient contamination.

A constraints summary was prepared for the proposed (Stage 1 & 2) subdivision areas showing that:

1) Each lot has adequate land which is suitable for effluent dispersal. However, this land will also be used for a dwelling, sheds, drive way and so on. As such, the assessment recommends that a minimum area of 500sqm (m^2) is dedicated on each lot for effluent dispersal.
2) Soil and site conditions are suitable for both subsurface irrigation of secondary treated effluent and composting toilet with a greywater treatment system. Other advanced treatment systems not covered may also be suited and should be assessed on a case by case basis.
3) Due to the relatively small lot areas of part of the subdivision, the site is not considered suitable for subsoil absorption of primary treated effluent.
4) A lot specific geotechnical investigation will be required for building approval, in order to ensure application of the prescriptions in this report. The investigation must include precise location of the effluent disposal area in relation to buildings, water tanks, driveway etc. It is possible that other options may be available for effluent management, as long as they comply with the basic sizing requirements for the lot, as detailed in this report.

Map 2: land capability for effluent disposal



4.4 Other Relevant Background Studies

4.4.1 Flora and Fauna and Bushfire Review

Flora and Fauna and Bushfire Reviews of the Site were undertaken by Griffin Associates Environmental P/L (GAE, 2011). The study found that the Site is dominated by exotic plants and weeds following agricultural uses for many decades. There was, however, small areas of native flora identified the eastern paddocks of the Site. The study found that the Site provides no suitable habitat for endangered fauna, and the fauna that is present in the Site are common resident or itinerant species of the farmland/peri-urban areas of the Yass Valley. A 'significant' wetland area is located in the south-eastern corner of the Site, this area will be protected by the E3 (Environmental Management) zoning and will not be further developed.

The bushfire study found that the Site is not located in bushfire prone land or part of a buffer zone; therefore the provisions of Planning for Bushfire Protection, 2006, do not apply.

4.4.2 McLeod's Creek Flood Study

A flood study on McLeod's Creek was undertaken by Osgood Civil Resource Engineering (OCRE, 2014) which found that a peak ARI100 food event would have insignificant impacts on the Site. The study found that flood waters would not encroach on any of the (Stage 1 & 2) residential land proposed to be developed at the Site. The study also found that no existing properties would be affected by the ARI100 flood event.

5 Wastewater Servicing Options for Kyeema

As discussed, wastewater servicing for the Gundaroo Village and surrounding areas has traditionally been by way of on-site wastewater management (OWM) systems. However, recent investigations have found that this approach may be contributing to regional contamination concerns, particularly with regard to (shallow) groundwater vulnerability and associated public and environmental health concerns.

The Yass Valley Council LEP (2013) identifies the 'Kyeema' subdivision Site as suitable for ongoing use of OWM systems for residential development and a LCA has been prepared demonstrating preliminary (conceptual) options for such an approach. However, both Council and state agencies (OEH, Planning NSW and DPI-Office of Water) have highlighted the importance of considering 'alternative' wastewater servicing arrangements for the planning proposal.

"The Office of Water supports the provision of reticulated water and sewer to any proposed upzoning of land for industrial, residential or rural residential land uses". [Proposals] "where there is current or future demand for access to groundwater need to be considered for reticulation of sewer to ensure protection of groundwater quality" (NOW, August 2012).

"The NSW Office of Water is supportive of reticulated sewer and water to adequately service the proposed lot sizes for the [Kyeema Planning proposal] site" (NOW, December 2013).

"The Office of Water's concern with AWTS is that their use in concentrated areas may cause potential impacts on groundwater. It was a recommendation from the CSIRO report that Council could investigate decentralised wastewater treatment options….that are either managed by Council, a utility or private operator" (NOW, September 2014).

"Any decision on the Planning Proposal sites will require the same considerations and approach to effluent disposal consistent with the [Gundaroo] village, including possible flood mitigation works, buffer distances, moratorium on new bores or connection to a village reticulated sewerage system" (Council, December 2014).

5.1 Statutory and Regulatory Framework

5.1.1 Environmental Planning and Assessment Act (1979)

The Environmental Planning and Assessment (EP&A) Act 1979 defines and regulates planning and development within NSW, sets out the development approval process and approvals required. Proponents of a recycled water scheme will be required to apply for development approval if the local council specifies in their local environmental plan (LEP) that recycled water schemes require development approval.

The Yass Valley Council LEP (2013) permits the development of 'water treatment facilities' (e.g. recycled water) with consent in all land uses zones with the exception of R1 (general residential). No specific requirements for 'recycled water schemes' are provided in the LEP.

5.1.2 Protection of the Environment Operations Act 1997

The Protection of the Environment Operations Act 1997 (POEO Act) states that it is an offence to pollute waters, or permit waters to be polluted except where that pollution occurs in compliance with an environment protection licence (EPL). Other offences relating to land, air (including odour) and noise pollution are also covered in the POEO Act.

In addition, the POEO Act requires environment protection licences for certain activities listed in Schedule 1 of the Act ('scheduled activities'). The NSW Environment Protection Authority (EPA) issues these licences. Sewage treatment systems are a scheduled activity, defined under the Act as:

Sewage treatment systems (including the treatment works, pumping stations, sewage overflow structures and the reticulation system) that have an intended processing capacity of more than 2,500 persons equivalent capacity or 750 kilolitres per day and that involve the discharge or likely discharge of wastes or by-products to land or waters.

EPA will not generally license non-scheduled recycled water (treatment and reuse) systems, as they can typically be designed and operated to avoid pollution e.g. by using all the recycled water or by discharging surplus recycled water or untreated wastewater to the sewer.

5.1.3 IPART

The Independent Pricing and Regulatory Tribunal (IPART, NSW) regulate the licensing of private water schemes under the *Water Industry Competition Act (WICA) 2006*. Under WICA, private providers must obtain a licence to construct, maintain or operate any water industry infrastructure (network operators' licence), or to supply potable or non-potable water, or provide sewerage services by means of any water industry infrastructure (retail suppliers licence).

WICA is also supported by the *Water Industry Competition (General) Regulation (WICR) 2008*, which sets out the matters a licence application must address, standard licence conditions, information to be contained on the register of licences and the retailer of last resort provisions. The Regulation also provides for the establishment of a marketing code of conduct, a transfer code of conduct and a water industry code of conduct. Under WICR, network operator licensees for sewerage schemes are required to produce a Sewage Management Plan (SMP) and subsequent audit reports on the SMP before commercial operation of the scheme. The sustainability assessment is an audit of relevant components of the SMP, with the aim of helping to determine whether the proposed infrastructure will provide sewerage services which are sustainable and do not present a risk to the environment.

The licensed network operator must submit to IPART an Infrastructure Operating Plan and a Water Quality Plan which is consistent with the AGWR (2006) and addressing the Framework for Management of Recycled Water Quality and Use.

The Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) (AGWR, 2006), were developed to provide guidance on the supply, use and regulation of recycled water schemes. The guidelines use a risk management framework comprising of twelve (12) elements with multiple barriers to control hazards. The framework is summarised by four (4) main categories: commitment to responsible use and management of recycled water; system analysis and management; supporting requirements; and review.

The principles of sustainable use of recycled water are based on three main principles:

- protection of public and environmental health is of paramount importance and should never be compromised;
- protection of public and environmental health depends on implementing a preventative risk management approach; and
- application of preventative measures and requirements for water quality should be commensurate with the source of recycled water and the intended uses.

In regards to public health, relatively few restrictions need to be placed on non-drinking water uses of tertiary treated and disinfected recycled water. End use controls and on-site constraints can also be used to minimise both human exposure to hazards and the impact on receiving environments; such as signage, use of buffer zones, and control of plumbing and distribution systems.

5.1.4 Local Government Act 1993

On-Site Systems

For an on-Site wastewater management system to be installed, an application must be submitted to Council for approval under Section 68 (Part C) of the Local Government Act 1993 (LG Act). The application must also be accompanied with:

- The prescribed application and inspection fees;
- A site plan detailing the location of the proposed OWM system in relation to all buildings, water storage tanks and property boundaries; and
- Manufacturer's details of the proposed OWM system (ALL OWM systems must maintain current accreditation from the NSW Department of Health otherwise Council may not approve of the installation); and
- A Site and Soil Evaluation Report conducted by an appropriately qualified and experienced wastewater consultant using methods as outlined in the New South Wales Department of Local Government 1998; *Environment and Health Protection Guidelines: On-Site Sewage Management for Single Households* and *AS/NZS 1547:2012 On-Site Domestic Wastewater Management*.

Community Systems

Under Section 68 (Part B) of LG Act 1993, approval is required from the local government authority for water supply, sewerage and stormwater drainage work as well as the installation and operation of a sewage management system, including private recycled water schemes that process sewage. Private individuals or companies that wish to produce and or used recycled water in schemes larger than a single lot also require approval under Section 68.

An approval to install or operate is not required under Section 68 of the LG Act if a license under the Protection of Environment Operations Act 1997 is in force for the scheme (Clause 48 of the Local Government (General) Regulation). The local council is the approving authority of a Section 68 approval with the NSW DPI (Office of Water) (NOW) and NSW Health acting as an advisor to the local council.

Section(s) 56-66 of the Local Government Act 1993 set out provisions in relation to flood retarding basins, water supply, sewerage works and facilities. Under these provisions, a non-metropolitan council must obtain Ministerial approval prior to undertaking certain works. This approval has been delegated to the NSW DPI (Office of Water). Under section 60(c) of the LG Act, a council must obtain approval to provide for sewage from its area to be discharged, treated or supplied to any person. DPI (Office of Water) has adopted the framework outlined in the AGWR for assessing s60 applications for approval to treat and supply recycled water under the LG Act.

5.1.5 Local Government (General) Regulation 2005

On-Site Systems

The Local Government (General) Regulation 2005 requires that the owner of an OWM system seek approval by an application form to operate the facility in addition to any other approval required for the installation of an on-site sewage management facility.

Community Systems

The Local Government (General) Regulation 2005 provides detail on the approval to operate as well as the broad performance standards and other criteria for the operation of a recycled water scheme (Clauses 42 to 47). Clause 45 of the Regulation outlines the conditions of approval in relation to the operation of a recycled water scheme including the prohibition of the discharge of recycled water to any watercourse or onto land other than its related effluent application area.

5.1.6 Public Health Act 1991

Under the Public Health Act 1991, the Minister for Health has powers to issue orders and direct public authorities to take action to prevent public health risks. NSW Health has responsibilities under the Public Health Act 1991 for monitoring and managing public health risks and improving public health through regulation, health promotion and other public health measures.

NSW Health plays a key role in setting water quality compliance values for recycled water systems and must be informed of any incident that poses a risk to public health.

5.1.7 Water Management Act 2000

Currently the on-site dam is licensed under the Water Management Act 2000 for irrigation, stock and domestic purposes. The NSW DPI (Office of Water) has recommended that any proposal for the ‘Kyeema’ subdivision to utilise the dam for non-potable water supply will require a license amendment through application to the NSW DPI (Office of Water).

5.1.8 Department of Primary Industries – DPI (Office of Water)

The DPI (Office of Water) is a referral authority under the Gateway planning process. In that role, they have reinforced the importance of protecting groundwater resources in the vicinity of the project Site. In particular, DPI (Office of Water) have highlighted a likely ‘strong’ demand for non-potable water to the proposed ‘Kyeema’ subdivision, with a value of 200kL per annum suggested as a requirement for a typical 1,000m^2 landscaped (lawn/garden etc.) area in the southern highlands. The DPI (Office of Water) has also expressed concern that increases in unsewered development may concentrate potential contamination risk from on-site wastewater management systems in areas of groundwater vulnerability. In a letter dated 16 December 2013, the DPI (Office of Water) made the following recommendations:

- that a minimum buffer of distance of 250m be maintained between all existing and new domestic and stock bores and any effluent irrigation area;
- that a minimum 100m buffer be maintained between McLeod’s Creek and any effluent application areas;
- that a minimum 40m buffer be maintained between the dam and any effluent application areas; and

- that a monitoring bore be constructed (at an appropriate location) to monitor water levels and quality to examine, quantify and, if necessary address, local impacts resulting from future development[1].

The DPI (Office of Water) also recently published a guidance document for "Recycled Water Management Systems" (May, 2015). The document provides guidance on the development and implementation of a RWMS for recycled water suppliers in NSW including local water utilities (under the NSW *Local Government Act,* 1993) and water supply authorities (under the NSW *Water Management Act*, 2000) and should be read in conjunction with AGWR (2006).

6 Identification of Suitable Wastewater Servicing Options

A preliminary options assessment has been undertaken to determine the most cost effective and environmentally sustainable solution to treat and dispose the wastewater produced by the subdivision of the Site.

Options assessed included complete on-site treatment and land application, a decentralised network that utilises complete off-lot treatment or partial off-lot treatment and a conventional sewer solution.

The possibility of the village of Gundaroo (and potentially the Sutton Road development connecting) to the treatment system was taken into consideration for the options assessment. A flow chart outlining the options considered is presented in Figure 6.

[1] Subsequent to this advice, it is understood the proponent has installed the recommended monitoring (sentinel) bore at an appropriate location (as advised by a consultant hydrogeologist). The bore location is registered with the DPI (Office of Water) database (GW416664) and the proponent has committed to a bi-annual (6-monthly) ground water quality monitoring programme to establish baseline conditions and confirm no ongoing contamination risk associated with future development of the Site.

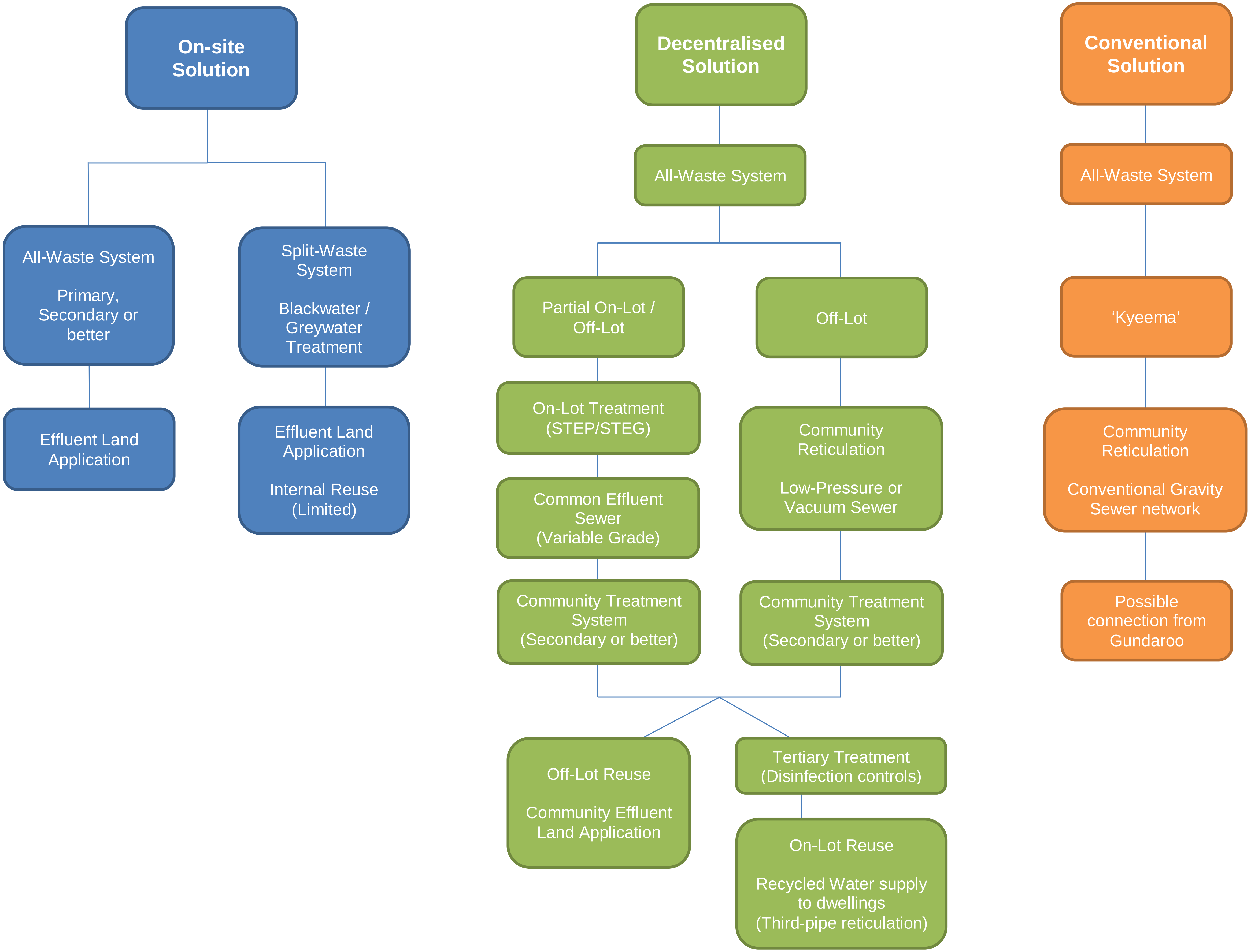


Figure 6: Flow Chart of Options Considered

6.1 Design Conditions

6.1.1 Wastewater Volume

It is noted that the LCA report (SLCC, 2011) assumed a 'typical' 4-bedroom dwelling for each proposed lot, with a design hydraulic load of 575L/day based on a 5EP household with on-site (tank) water supply (from AS/NZS 1547:2000). This value is considered appropriate, although the updated (2012) Australia Standard recommends a marginal increase of the flow allowance to 120 L/person/day (600L/day).

For our assessment, we have assumed that the proposed development will have access to a reliable water supply (equivalent to reticulated water) with access to on-site (tank) water supply and off-site non-potable supply from a community network. Therefore, based on this assumption, a conservative wastewater generation rate (Appendix H of AS/NZS 1547:2012) of 150 L/person/day is considered suitable.

We have considered two broad development scenarios: 3 bedroom and 5 bedroom dwellings on each proposed lot. Assuming a design occupancy rate of 5 person equivalents (EP) for a 3 bedroom dwelling and 8 EP for a 5 bedroom dwelling (Table J1 of AS/NZS 1547:2012) these result in daily wastewater loads of 750 L/lot/day and 1,200 L/lot/day respectively.

Therefore, the estimated (combined load) wastewater generation for the 65-lot 'Kyeema' subdivision is expected to range between 48,750L (rounded to 50kL) and 78,000L (rounded to 80kL) per day[2].

6.1.2 Wastewater Quality

Wastewater generated by the proposed subdivision is expected to be of a typical domestic household nature. As such, untreated wastewater is expected to have characteristics similar to that described in Table 3; which incorporates information taken from DLG (1998) and confirmed from other sources.

Table 1: Characteristics of Typical Untreated Domestic Wastewater

Parameter	Loading	Greywater %	Blackwater %
Biochemical Oxygen Demand (BOD_5)	200-300mg/L	35	65
Suspended solids (TSS)	200-300mg/L	40	60
Total Nitrogen (TN)	20-100mg/L	20-40	60-80
Total Phosphorus (TP)	10-25mg/L	50-70	30-50
Faecal coliforms (FC)	10^3 - 10^{10}cfu/100 mL	medium-high	high

(Source: DLG 1998 p.80)

The contaminants in domestic wastewater have the potential to create undesirable public health concerns and pollute waterways unless managed appropriately. As a result, domestic wastewater must be treated to remove the majority of pollutants to enable attenuation of the remaining pollutants through soil processes and plant uptake.

The final treatment standard (i.e. primary, secondary or better) will be dependent on the required end use of the treated effluent (or recycled water).

[2] It is acknowledged that this value could be a substantial over-estimate. If the revised SLCC (2011) value of 600L/lot/day is used, the wastewater generation from the 65-lot development would be approximately 40kL/day.

7 Complete (Individual) On-site Solutions

Complete on-site wastewater management involves treating generated wastewater from each lot within each of the individual lot boundaries. Individual treatment and land applications systems would be paid for by property owners and installed at the time the lots are built upon. Responsibility for obtaining approvals and ongoing operation of these systems would reside with individual property owners.

Council regulate the operation of individual on-site wastewater management (OWM) systems through the Section 68 approval process, with an 'Approval to install' issued during development consent and an annual 'Approval to operate' issued for the life of the system.

7.1 Wastewater Contribution

On-site (domestic) wastewater solutions may comprise all-waste and split-waste designs.

All-Waste systems collect, treat and reuse (land apply) all wastewater generated from household fixtures including blackwater (toilet, kitchen and composting leachate) and greywater (bath/shower, basin and laundry). Appropriately treated wastewater from all-waste systems may only be used for landscaping purposes.

Split-Waste systems collect and treat household blackwater and greywater streams separately before reuse via various mechanisms. Treated blackwater may only be used for landscaping purposes. Appropriately treated (and disinfected) greywater may be used as a recycled water resource within the dwelling for cold-water washing machine supply and toilet flushing, as well as external landscaping uses.

7.2 On-site Treatment Options

7.2.1 All-Waste Treatment Systems

All-waste treatment options suitable for (large lot) rural residential subdivision can include primary or secondary treatment systems.

Primary treatment systems traditionally comprise an appropriately sized septic tank for collection and minimum 24-hour retention of wastewater generated from the dwelling (minimum 3,000L). In NSW, septic tanks (and collection wells) must be accredited by NSW Health and in conformance with the Australian Standard (AS1546.1:2008). Modern septic tanks may be of concrete or polymer construction and will include a central baffle and inlet/outlet controls (t-pieces) to prevent solids carryover. Properly functioning septic tanks produce consistent 'primary' effluent quality with the following characteristics (from DLG, 1998):

- BOD – 150 mg/L
- TSS – 50 mg/L
- TN – 50-60 mg/L
- TP – 10-15 mg/L
- FC – 10^5-10^7 cfu/100mL

Primary treatment systems may also include incinerating toilet and pump-out systems. However, for the purposes of this review, we have assumed that these types of systems would not be either appropriate or warranted. Thus, they are not considered further in this document.

Secondary treatment technologies include (but are not limited to) Aerated Wastewater Treatment Systems (AWTS); Sand Filter Systems, Media Filter Systems, Wetland Systems and Mound Systems. Disinfection units are typically installed as a standard component of proprietary secondary treatment systems, or can be installed as an add-on by the system supplier. Disinfection units typically use one or a combination of the following disinfection methods: Ultra Violet (UV) irradiation; Chlorination and Ozone.

Properly functioning secondary treatment systems should be capable of consistently producing effluent quality with the following characteristics (from NSW Health):

- BOD – 20 mg/L
- TSS – 30 mg/L
- TN – <30 mg/L
- TP – <10 mg/L
- FC – <100 cfu/100mL

Investigations carried out by Peter Fogarty of Soil and Land Conservation and Consulting (May, 2011) recommended treatment via an AWTS with subsurface irrigation or a combination of blackwater composting toilets and greywater treatment systems with subsurface irrigation as an appropriate on-site solution for the subdivision.

7.2.1.1 Description of Technology and Costs

Septic Tanks

A septic tank is generally described as a single or multiple chambered tank through which wastewater is allowed to flow slowly to permit suspended matter to settle and be retained, so that organic matter contained therein can be decomposed (digested) by bacterial action in the liquid. Both anaerobic and facultative treatment processes occur within a septic tank and serve to reduce the contaminant load and produce a stable end-product (sludge). Septic tanks require periodic de-sludging (pump out) at intervals between 3-5 years. To improve performance, septic tank may be fitted with an outlet filter to improve solids retention performance and reduce the risk of carryover to land application areas.

Septic tank effluent is <u>NOT</u> disinfected; therefore, strict controls must be placed on end uses. NSW Health requires undisinfected wastewater to be applied to land at depths >0.3m below ground surface to prevent contact.

Current pricing for supply and installation of a 3,500L septic tank in southern Sydney areas is **~$3,200-$5,000** (depending on material and supplier). Ongoing costs would include (5 yearly) pump out costs of approximately **$200-$300** (contractor). Additional maintenance costs may be necessary in event of damage or blockage.

Aerated Wastewater Treatment System (AWTS)

An aerated wastewater treatment system uses both primary and secondary treatment processes to treat wastewater. Wastewater enters the anaerobic chamber (septic tank) where solids settle. The wastewater then enters the aerobic chamber where organic matter is oxidised and consumed by biological processes. The wastewater stream is then passed into a clarifier where it undergoes secondary settling. Finally the wastewater undergoes disinfection via processes such as chlorine dosing or UV exposure (Figure 7).

There are currently 17 AWTS (some with multiple models) accredited by NSW Health for installation within NSW. Each system may use multiple (and differing) treatment processes; however, the final effluent quality would be expected to be equivalent to (or better than) that described in Section 7.2.1 above. Good maintenance of AWTS is essential to ensure a consistently high level of performance. By regulation, AWTS systems are required to be serviced by an appropriately qualified service technician at 3-monthly intervals in NSW.

Current pricing for supply and installation of a domestic (<2,000L/day) AWTS in southern Sydney areas is **~$6,000-$10,000** (depending on supplier). The wider range in capital pricing will also reflect system performance reliability and effluent quality. Ongoing costs would include (quarterly) servicing costs of approximately **$300-$400** per annum and periodic (5 yearly) pump out costs of approximately **$200-$300** (contractor). Additional maintenance costs may be necessary in event of damage or blockage.

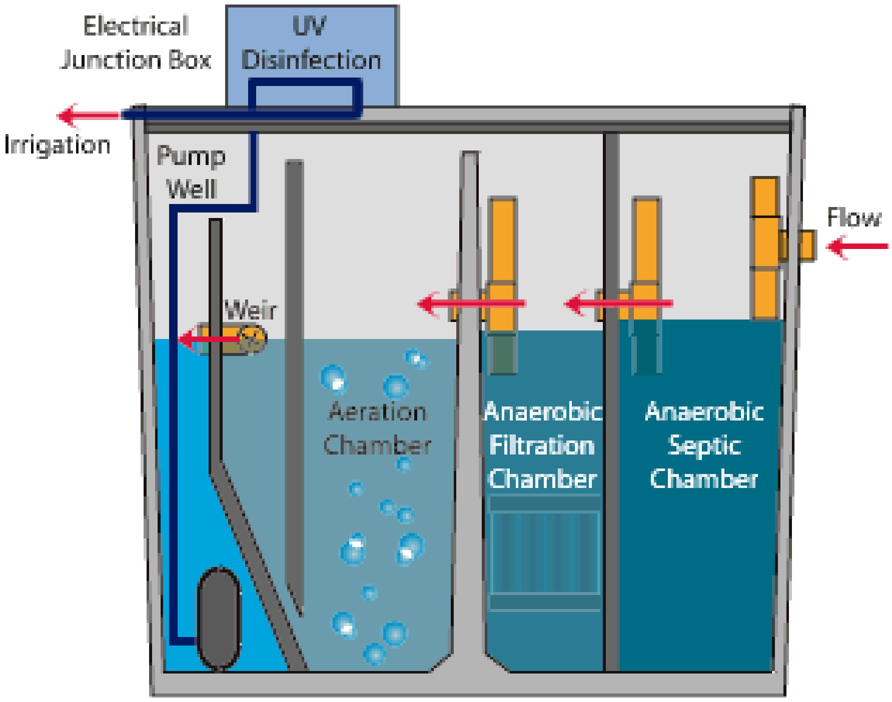


Figure 7: AWTS Process Diagram (Envirocycle 10NR ®)

Sand Filters

Sand filters provide advanced secondary treatment to water that has already undergone primary treatment in a septic tank or similar device. They typically contain approximately 600mm depth of filter media (usually medium to coarse sand, but other media can be incorporated) within a lined excavation containing an underdrain system (Figure 8).

Selection of the filter media is critical and a carefully designed distribution network is necessary to ensure even distribution across the media surface. A dosing well and pump (or flout/siphon) is normally used to allow periodic dosing. Depending on the desired level of treatment, sand filters can be single-pass (SF) or may incorporate a recirculation function (RSF).

Sand filters are proven to be an effective and reliable secondary treatment device, consistently capable of achieving BOD < 10 mg/L and SS < 10 mg/L. Although they are able to remove the majority of pathogenic organisms, subsequent disinfection is required to enable effluent irrigation. Currently there are two (2) aerobic sand filter systems accredited by NSW Health, with detailed sizing and design of these systems is generally undertaken by the chosen supplier/installer.

Indicative pricing for design and installation of a site-specific sand filter system (<2,000L/day) in southern Sydney areas is **~$10,000** (depending on supplier). Ongoing costs would include (6-monthly) servicing costs of approximately **$400** per annum and periodic (5 yearly) primary tank pump out costs of approximately **$200-$300** (contractor). Additional maintenance costs may be necessary in event of damage or blockage.

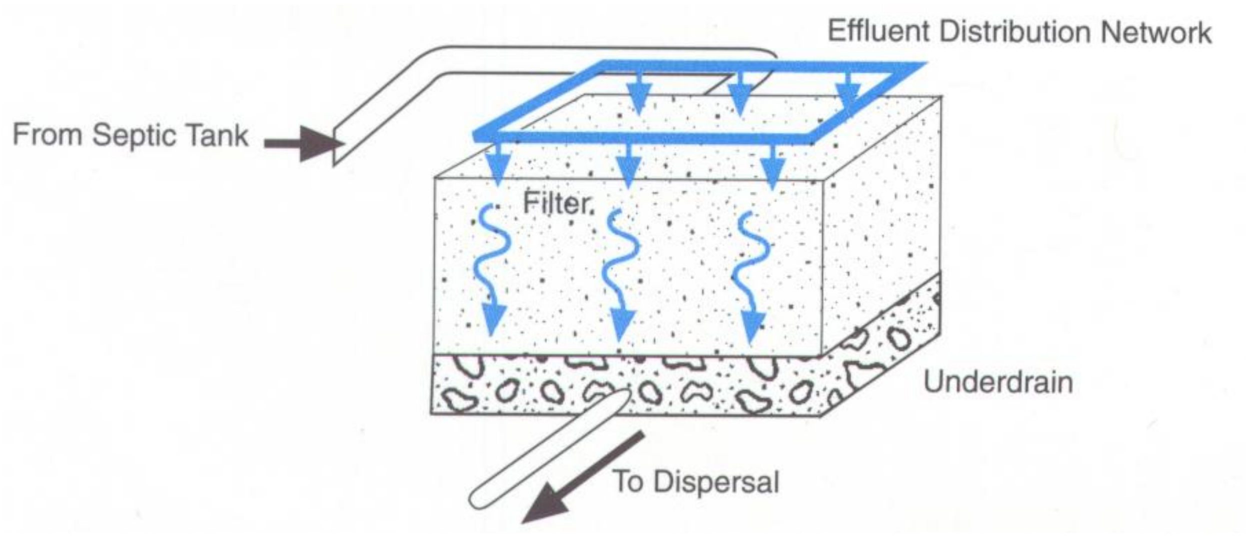


Figure 8: Sand Filter Process Diagram (NSFC)

Media Filter Systems

Media filters operate under the same principles as sand filters but utilise a proprietary textile media in replacement of the sand. This allows higher loading rates and therefore a smaller footprint with a unit approximately 1.2 m x 1 m x 0.8 m required for a typical dwelling. These systems are typically more capable of overcoming a lot of the constraints of AWTS listed above, and have significantly lower operating costs and arguably better performance (Figure 9).

Media (textile) filters generally consist of a watertight fibreglass basin filled with suspended vertical sheets of an engineered textile material. Recirculated wastewater is distributed evenly over the end surface of the hanging sheets by a pressure distribution manifold. The textile material has a complex fibre structure that provides a high water holding capacity, porosity and surface area for biomass attachment. The surface area of the textile media is approximately 4 to 8 times greater than a recirculating sand or gravel filter. The high water holding capacity of the media provides high retention times when coupled with timed, pressure dosing and enables consistently high treatment.

Treatment is facilitated by the aerobic conditions present in the filter unit, which reduce the levels of both BOD (aerobic digestion by micro-organisms) and by the filtering action of the textile material to reduce total suspended solids (TSS). Recirculation of up to 80% of the effluent back over the textile further improves effluent quality, particularly in terms of nitrogen reduction. Long-term monitoring of many domestic and community-scale textile filter systems (in New Zealand, USA and to a lesser extent Australia) indicate that effluent quality can consistently achieve BOD <5 mg/L, TSS <10 mg/L, TN <15 mg/L and TP <10 mg/L. Currently there is one (1) media filter system accredited by NSW Health, with detailed sizing and design of these systems is generally undertaken by the chosen supplier/installer.

Indicative pricing for design and installation of a (domestic AX-20) media filter system (<2,000L/day) in southern Sydney areas is **~$18,000** (including irrigation). Ongoing costs would include (6-monthly) servicing costs of approximately **$500** per annum and periodic (5 yearly) primary tank pump out costs of approximately **$200-$300** (contractor). Additional maintenance costs may be necessary in event of damage or blockage.

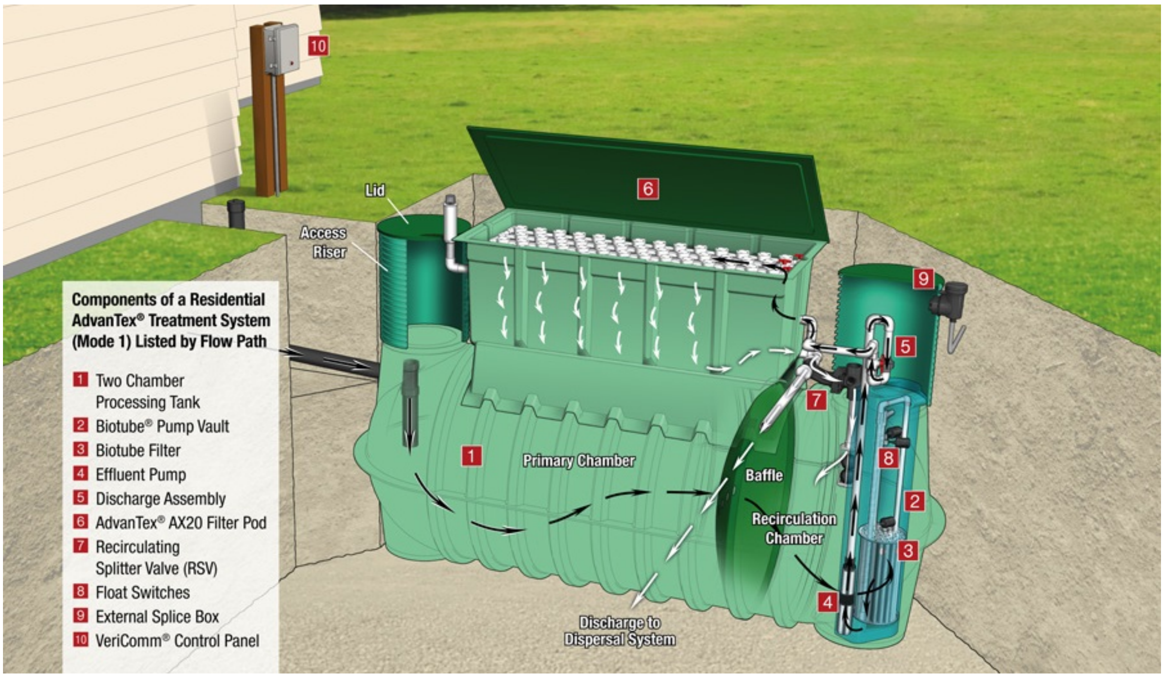


Figure 9: Media Filter system (Innoflow wastewater specialists)

Wetland Systems

Wetland (or Reedbed) treatment systems are designed to ensure that effluent flows beneath a gravel media surface, within the root zone of wetland plants, to ensure there is no standing water in the system. The system is lined with an impermeable membrane and constructed so that effluent flows horizontally through the media, via gravity (Figure 10). The wetland plants (macrophytes) and microbiological biofilms that develop on roots and gravel surfaces remove contaminants and pathogens from the effluent as it passes through. The treated effluent drains to a collection sump, from which it is pumped or discharged by gravity to the land application area system.

Reed beds are generally much more effective at nitrogen removal than phosphorus removal, with phosphorus removal expected to decline over time as the substrate becomes P-saturated. Although they are often touted as 'maintenance-free,' periodic replacement of the filter media assists in ongoing phosphorus removal. Reedbeds are suitable for intermittent use and low-flow scenarios; however very high strength wastes (particularly BOD_5 and nutrients) can overwhelm the system and lead to poor treatment.

Wetland systems are a reliable secondary treatment device, consistently capable of achieving BOD < 10 mg/L and SS < 10 mg/L. Although they are able to remove the majority of pathogenic organisms, subsequent disinfection is required to enable effluent irrigation. Currently there is one (1) constructed wetland treatment system accredited by NSW Health, with detailed sizing and design of these systems is generally undertaken by the chosen supplier/installer.

Indicative pricing for design and installation of a site-specific sand filter system (<2,000L/day) in southern Sydney areas is **~$10,000-$14,000** (depending on site conditions). Ongoing costs would include (3-monthly) servicing costs of approximately **$500** per annum and periodic (5 yearly) primary tank pump out costs of approximately **$200-$300** (contractor). Additional maintenance costs may be necessary in event of damage or blockage.

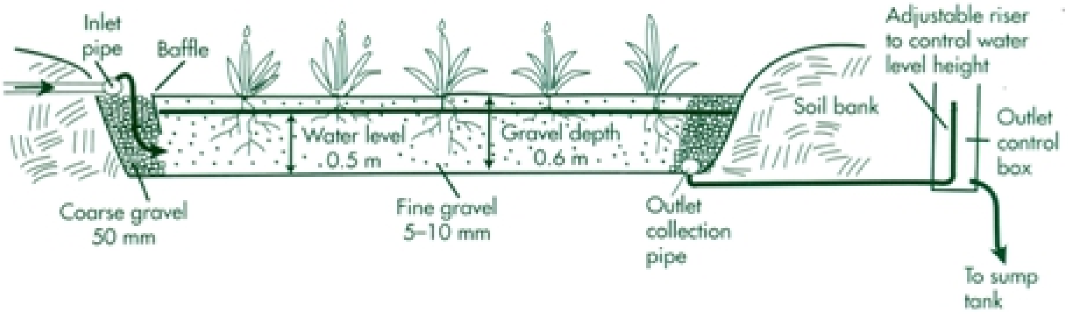


Figure 10: Reed Bed Processes (Queensland Government Wetland Info, 2015)

Mound Systems

Sand mounds, also known as Wisconsin mounds, are often an appropriate on-site solution for lots with limited space, shallow soil profiles, poor drainage or high water tables. Mounds are effectively raised soil absorption systems comprising layered fill, into which effluent is dosed (Figure 11). Effluent receives further treatment as it percolates down through the mound and is then absorbed by the natural soils below the mound. A properly designed mound can have a higher evapotranspiration potential than an ETA bed of equivalent size, further enhancing effluent disposal on constrained lots.

The basal footprint of a domestic mound is typically in the order of 7m wide by at least 20m long, and there are considerable up-front cost in the materials and construction of mounds. Mounds are suitable for primary or secondary treated effluent, and provide further treatment of effluent as it moves through the sand profile.

Mound systems are consistently capable of producing secondary effluent quality (primary systems) and better for secondary systems (10/10/10). Because mounds are both a treatment and land application system, there can be considerable savings in both land area requirements and capital costs. NSW Health does not provide accreditation of Mound treatment systems, with each requiring individual design and installation by a skilled contractor. Currently there is one (1) known installer of proprietary mound systems in NSW.

Indicative pricing for design and installation of a site-specific mound system (<2,000L/day) in southern Sydney areas is **~$12,000-$15,000** (depending on site conditions). Ongoing costs would include (annual) servicing costs of approximately **$300** per annum. If either a primary (septic tank) or secondary (AWTS) system is used for pre-treatment, refer to previous detail in this report for cost information.

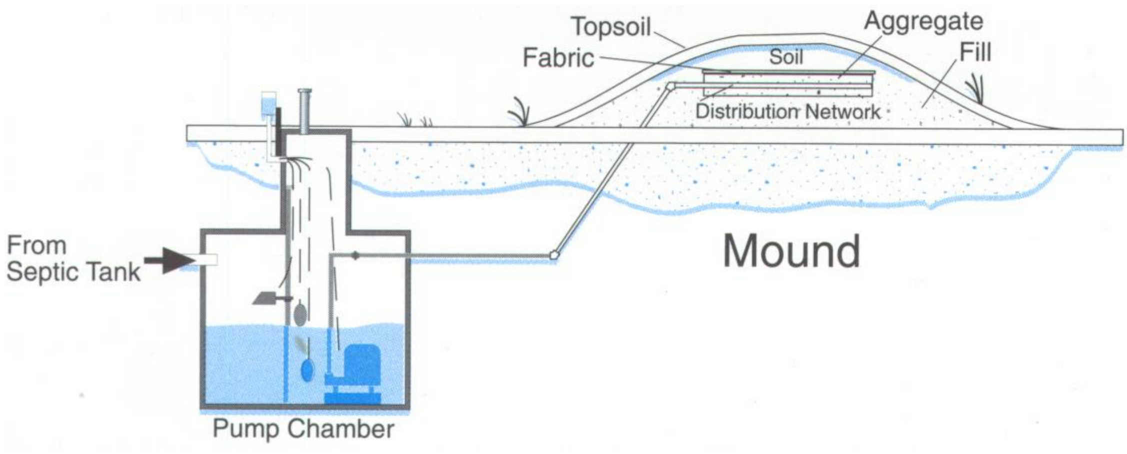


Figure 11: 'Wisconsin' Mound System schematic (NSFC)

7.2.2 Split-Waste Treatment Systems

Split-waste treatment options suitable for (large lot) rural residential subdivision can include primary or secondary treatment systems. As described, blackwater is treated separately using various treatment measures and must be applied to land under controlled conditions to meet compliance objectives. Greywater may be captured and treated to a standard suitable for internal reuse within each individual dwelling.

7.2.2.1 Description of Technology and Costs

Septic Tanks

Blackwater (only) septic tanks may be used for primary treatment of household blackwater wastes. AS/NZS 1547:2012 recommends operational capacities of between 1,500L and 1,800L for 5EP and 8EP household respectively. In NSW, septic tanks (and collection wells) must be accredited by NSW Health and in conformance with the Australian Standard (AS1546.1:2008).

In blackwater only systems, de-sludging is also recommended at 5 year intervals, although typically this tends to be too often and 6-8 years is common.

Refer to previous detail in this report for installation, maintenance and cost information.

Composting Toilet Systems

NSW Health refers to dry (waterless) composting toilets; however, low-flush models are also available, although they are less common. Composting toilets are generally installed for water saving or lifestyle reasons (e.g. 'eco homes' or remote homes with limited water supply). They are rarely chosen as the preferred solution for new homes on large lots. They require a separate greywater treatment system to treat all greywater streams (including kitchen greywater).

Composting toilet systems receive and treat human excreta, domestic organic matter and bulking agents using natural, aerobic stabilisation processes to produce a product that is suitable for on-site disposal (burial). Large proportions of the solid (TSS), organic material (BOD) and nutrient (N&P) load are removed from the total waste stream with separate blackwater treatment. We expect to reduce the concentration of these parameters by approximately 60-65% for TSS, BOD, total nitrogen (TN) and by 40% for total phosphorous (TP) in the final effluent produced. These values are in agreement with the middle range identified in the DLG guidelines (1998). Any liquid in the system (including urine) forms a concentrated leachate which requires disposal.

There are currently two (2) waterless composting toilet systems (some with multiple models) accredited by NSW Health for installation within NSW. As a primary treatment system, effluent is <u>NOT</u> disinfected; therefore, strict controls must be placed on generated leachate. Further, NSW Health requires composted solids to be buried (at depths >0.1m below ground surface) safely on the property to prevent contact. There are no ongoing maintenance requirements required by the NSW Health accreditation.

Current pricing for supply and installation of a domestic composting toilet system southern Sydney areas is **~$4,500-$6,000** (depending on model/supplier). Additional maintenance costs may be necessary in event of damage or blockage.

Greywater Treatment System (GTS)

Greywater treatment systems are accredited to treat laundry, shower, bath, hand-basin (and in some cases kitchen) greywater only. Blackwater (toilet waste) must never be treated in a greywater treatment system. It is preferable that kitchen water is kept separate from the other greywater streams and treated with the blackwater system, as kitchen greywater can be relatively high in contaminants compared to other streams.

In most cases, greywater treatment systems are essentially AWTS (see below) with modifications to allow for reduced organic loading and elevated fats & oils concentration. In GTS, effluent is typically treated to 'advanced secondary' (tertiary) standard (BOD <10, TSS <10 and FC <10) that can be used for toilet flushing, cold water supply to clothes washing machines, and unrestricted surface and subsurface irrigation. Disinfection is a requirement for treated greywater if it is to be used in the dwelling. The nutrient removal performance can vary considerably between and within greywater treatment system types.

There are currently six (6) GTS and one (1) constructed wetland system accredited by NSW Health for installation within NSW. Each system may use multiple (and differing) treatment processes; however, the final effluent quality would be expected to be equivalent to (or better than) that described above. Good maintenance of GTS is essential to ensure a consistently high level of performance. By regulation, GTS systems are required to be serviced by an appropriately qualified service technician at 3-monthly intervals in NSW.

Current pricing for supply and installation of a domestic (<1,800L/day) GTS in southern Sydney areas is **~$5,000-$8,000** (depending on supplier). The wider range in capital pricing will also reflect system performance reliability and effluent quality. Ongoing costs would include (quarterly) servicing costs of approximately **$200-$300** per annum. Additional maintenance costs may be necessary in event of damage or blockage.

7.3 On-site Effluent Management Options

7.3.1 Effluent Land Application

Depending on the treatment standard (effluent quality), treated wastewater from All-waste and Split-Waste treatment options may be used in a number of ways on each property. The key principle of on-site wastewater management being that:

"all wastewater must be capable of being retained within the lot boundaries and must not present an undue hazard to public/environmental health or off-site receptors".

The previous LCA report (SLCC, 2011) identified irrigation as the most suitable on-site effluent management option for the subdivision. The LCA report recommended 300m^2 and 500m^2 of dedicated irrigation area for a 5EP and 8EP household respectively (assuming all-waste). If a split-waste system is proposed, the required irrigation area reduces to 200m^2 and 320m^2 for each dwelling size. The LCA report also recommends an equivalent (reserve) area be set aside from development as a precautionary measure.

7.3.1.1 Description of Technology and Costs

Subsurface Irrigation (SSI)

The preferred land application option for subdivision lots is pressure-compensating, subsurface drip irrigation. SSI is suitable within lawn and landscaped areas and applies effluent within the root-zone of plants for optimum irrigation efficiency. It is an ideal option for ensuring even, widespread coverage of the proposed irrigation area. SSI installation does not require any bulk materials or heavy machinery and irrigation lines can be simply installed with a small trench digger or "ditch-witch".

Proprietary, pressure-compensating drip irrigation pipe designed for use with treated effluent should be used that will ensure distribution of effluent at uniform, controlled application rates. These products have been specifically designed for use with effluent and allow for the higher

BOD_5, suspended solids, nutrient and biological loads usually present in effluent compared to potable water. They contain specially designed emitters that reduce the risk of blockage, typically incorporating chemicals that provide protection against root intrusion and biofilm development (e.g. Trifluralin). The dripper lines are coloured lilac to clearly identify that they are irrigating treated effluent.

Irrigation pipes (laterals) should be spaced to provide good and even coverage of the area they service. Generally they should be no more than 0.6m apart, roughly parallel and along the contour as close as possible.

An in-line 120µm disc filter may be installed to minimise the amount of solids entering the pipelines and emitters. This must be removed and cleaned regularly (at least at 3-monthly intervals). Alternately, a flush main may be installed to periodically clean-out the irrigation lines to provide effective long term performance. Either manual or automatic flush valves may be installed, with flush water directed back to the treatment system. Air release valves will be installed at the high points in individual irrigation areas to prevent soil particles being sucked into the lines at the end of pump cycles as pipelines depressurise.

Figure 12 provides a schematic representation of a generic subsurface irrigation system, courtesy of Netafim Australia. Specialist advice must be obtained for designing and installing the irrigation system.

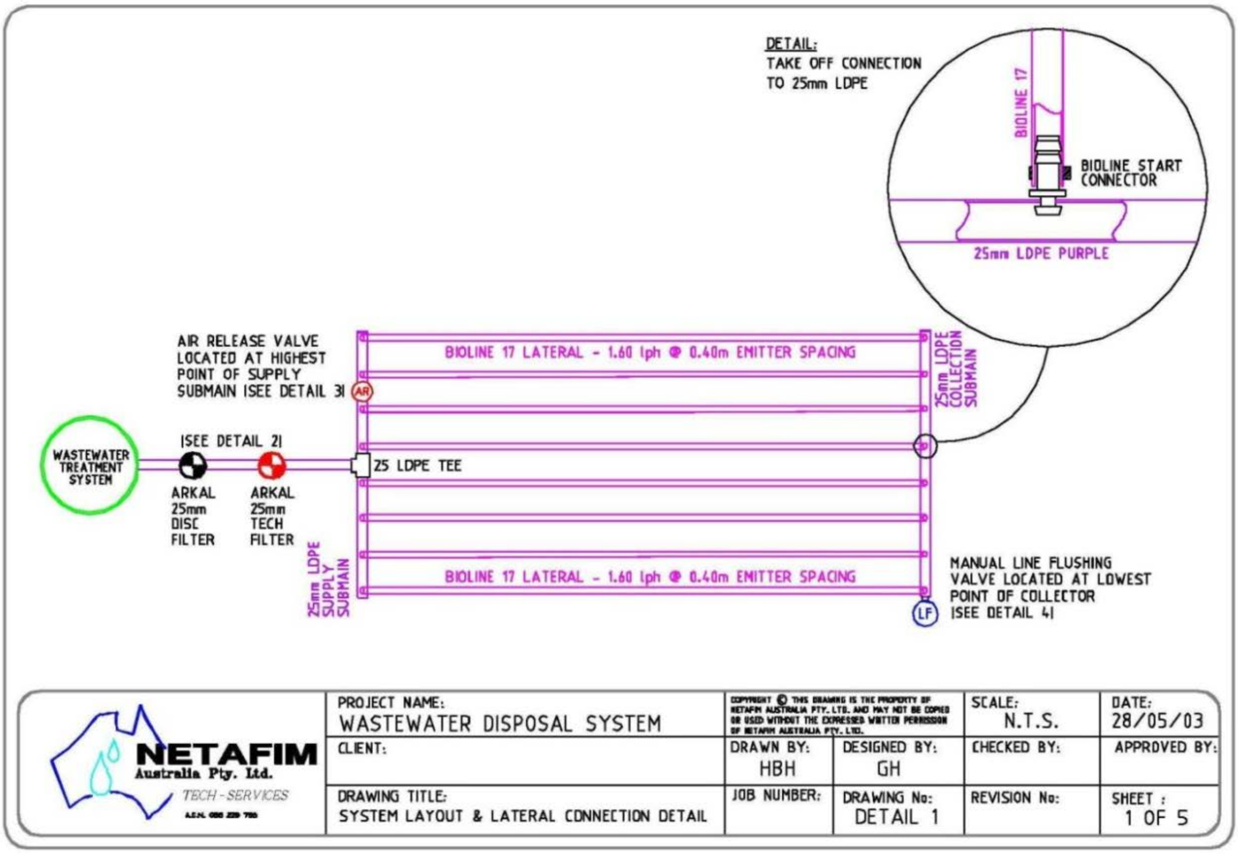


Figure 12: Typical Subsurface Irrigation Detail (courtesy Netafim Australia)

Current pricing for supply and installation of SSI systems up to 800m^2 in southern Sydney areas is **~$1,500-$3,000** (depending on supplier). The wider range in capital pricing will also reflect material quality, system performance reliability and controls. Ongoing costs should be included within (quarterly) servicing costs for accredited treatment systems. Additional maintenance costs may be necessary in event of damage or blockage.

7.4 Limitations/Disadvantages

The prepared LCA report (SLCC, 2011) has identified on-site wastewater management as a suitable and sustainable solution for sanitary waste servicing of the proposed 65-lot rural-residential subdivision. With minimum lot sizes of 2,000m^2, there is considered to be sufficient available area on each proposed lot to accommodate an appropriately sized effluent management area (up to 500m^2) and dedicated reserve area (if required).

Advice from DPI (Office of Water) highlights a likely increase in demand for non-potable water to the proposed 'Kyeema' subdivision, with a value of 200kL per annum (547L/day) suggested as a requirement for a typical 1,000m^2 landscaped (lawn/garden etc.) area in the southern highlands. The availability of treated effluent (600L-1,200L/day) from an on-site solution will likely be sufficient to meet this demand, although, there will be periods of the year when water deficit (or surplus) may require additional management effort (i.e. storage or supplement).

Regardless, as previously described, both Council and State agencies have highlighted a number of concerns relating to an increase in on-site wastewater management systems in Gundaroo. While future OWM systems on the 'Kyeema' subdivision would comply with best-practice design, installation and operation guidelines, there remains an underlying concern that any additional unsewered development could increase the 'cumulative risk' to an already vulnerable groundwater resource.

Under an on-site servicing scenario, a typical residential dwelling in the proposed subdivision would be required to install an individual treatment system (secondary recommended) along with up to 500m^2 of subsurface irrigation area. Depending on the system(s) selected, capital costs for the system could range from ***$6,000-$20,000 for treatment*** with a further ***$3,000 for irrigation*** (if required). Ongoing (maintenance) costs for the system(s) could range from **$300-$500 per annum**. These costs would be borne exclusively by the home owner.

8 Decentralised (Community) Wastewater Solutions

Historically, centralised (conventional) wastewater management has been the only option considered for providing sanitary wastewater (sewage) servicing of developing residential areas. It typically refers to large-scale municipal sewerage systems where individual households are connected to a gravity driven reticulated collection network (sewer) which transfers combined (black and grey) wastewaters to a central treatment facility for processing (or transfer to another network). Disposal or reuse of the treated effluent and other by-products usually occur remote from the point of wastewater origin. Alternately, on-site wastewater management refers to the treatment and disposal of wastewater from single households at the point of generation.

Decentralised, non-conventional wastewater management refers to the collection and treatment of wastewater from individual homes, clusters of homes, isolated communities, industries or institutional facilities and disposal/reuse at or near the point of wastewater generation (Crites and Tchobanoglous, 1998). Apart from the proximity of disposal/reuse, a key point of differentiation between centralised and decentralised wastewater management systems is the frequent use of alternative collection networks and treatment systems. These may include reduced pipe size or grade sewers, pressure or vacuum sewers, waste stream separation and recycled water systems.

The situation in Gundaroo is common to many rural communities throughout Australia and NSW in that they are small, isolated and developed over time with limited consideration given to sustainable wastewater management. Typical responses to dealing with such towns have in the past involved a two-way decision between a conventional centralised approach (i.e. reticulated sewerage, local or offsite treatment and remote disposal/reuse) and traditional on-site wastewater management systems such as septic tanks with absorption trenches. However, over the last fifteen years or more, innovative wastewater service providers have increasingly adopted a more decentralised approach that draws technology from a wide spectrum of options ranging from traditional centralised sewerage through to individual on-site technologies.

Decentralised, non-conventional wastewater management schemes have been implemented by Sydney Water in a number of rural towns in the Sydney southern rural region (e.g. Bargo, Buxton Park and Douglas Park) as part of the Priority Sewerage Program (PSP). Private operators (Permeate Partners and Flow Systems) are also becoming active in the space with a number of greenfield and brownfield developments underway (http://flowsystems.com.au/communities/pitt-town-water/) or in planning with non-conventional sewerage and recycled water solutions. These types of wastewater management systems are well established, with excellent success, in various countries including the United States and New Zealand.

Decentralised wastewater servicing solutions may involve partial (primary) treatment of generated wastewater on each lot, or maceration (slurrying), before conveyance of effluent via a reticulated sewer network to a common treatment facility.

Effluent sewer systems utilise smaller diameter, flexible reticulation pipes that can be laid at shallower depths and without the need for uniform or minimum grades for self-cleansing. This leads to greater ease of installation and substantially reduced construction costs, especially when working with challenging ground conditions (e.g. undulating country, shallow soils, and high watertables). By design, they greatly reduce or even eliminate stormwater inflow and groundwater ingress (I/I) in wet weather. These factors impact heavily on traditional gravity sewer design, resulting in frequent wet weather overflows that pollute the environment, requiring network designers to use much larger pipes and additional storages to manage the increased flows.

8.1 Reticulation (Collection) Options

A wide variety of sewer reticulation options are available for a decentralised servicing approach. These differ in terms of their general mode of operation, infrastructure requirements, construction methods, maintenance procedures and frequency. These factors affect the suitability of the different options for different physical and socioeconomic settings, as well as the life cycle costs of installing, operating and maintaining the sewer network.

Aside from conventional gravity sewers (CGS), a number of alternatives are now available. Alternative collection systems have historically been defined as any system other than conventional gravity reticulation (USEPA, 1991) and can be broadly broken down into three categories: pressure sewers (PS); vacuum sewers (VS); and common effluent systems (CES) or effluent sewers. The categories are based on the primary force behind conveyance. However, each type of collection system can utilise different configurations and technologies.

PS and CES are often used in combination rather than isolation, such as in septic tank effluent pump/septic tank effluent gravity (STEP/STEG) systems. Some common design principles for these systems include:

- additional on-lot storage and in some cases preliminary on-lot treatment infrastructure (e.g. septic tank with outlet filter in STEP/STEG systems);
- the use of lightweight, flexible, small diameter polyvinyl chloride (PVC) or polyethylene (PE) pipe buried at shallower depths with fewer joints than conventional gravity sewers, (socketed and glued or welded joints limit infiltration); and
- remote monitoring. It is common practice in the U.S.A and New Zealand to install remote monitoring systems throughout the collection system that allow the efficient monitoring and manipulation of individual interceptor tank (IT) operation and the reticulation system.

This last principle is an important one when considering alternative collection systems. Just like a conventional sewer, a centralised management program is a vital component of alternative collection systems. Alternative collection systems have demonstrated that they require significantly less maintenance than conventional systems but still require some maintenance and supervision.

The perception of some system designers and operators is that 'scattered' interceptor tanks and/or pump units have the potential to create increased maintenance and supervision requirements. However, any resulting disadvantage is outweighed by having greater control over the system, reduction of dry / wet weather overflows (and their associated environmental impacts), and the reduced need for cleaning of the large, deep pipes associated with conventional systems.

8.1.1 Conventional (Gravity) Reticulation Systems

8.1.1.1 Description of Technology and Costs

Conventional gravity sewers (CGS) are the traditional method of sewer reticulation. Raw sewage is delivered via a (typically 100mm) house drain line to a reticulated sewer network (typically located in the road reserve) that relies on gravity drainage supplemented with lift (pumping) stations where pipes get too deep or need to traverse topographic rises.

Modified gravity sewer (MGS) (may also be referred to as low infiltration gravity sewer) works similarly to CGS but can achieve savings in cost and construction by relaxing traditional design standards, such as by reducing minimum cover requirements and having fewer inspection points. MGS usually require greater maintenance than CGS because of the reduced redundancy in network design (i.e. fewer manholes). MGS are usually only applicable to small rural communities where the costs of CGS are prohibitive and a reduced level of service is acceptable to the community.

Unit rates for installation of CGS and MGS systems are difficult to approximate given the inherent complexity of subsurface construction (e.g. rock) and the need for detailed hydraulic design and network analysis. However, general rule-of-thumb pricing ranges from **$200-$300 per metre** installed (including pipes, fittings, manholes and house connections). Pump station and rising main costs (if required) would be additional.

8.1.1.2 Limitations/Disadvantages

CGS systems can be relatively expensive and difficult to install, particularly in areas of shallow soils, heavy rock, undulating terrain and high groundwater. This is due to the need for deep trenching to maintain the minimum grades required for self-cleansing. Large pipes are required to convey peak wet weather flows as pipes have a tendency to crack and leak, often allowing substantial groundwater and stormwater ingress during wet weather.

Whilst generally, the layout and local landform of the 'Kyeema' subdivision lends itself to a conventional gravity reticulation design, constructed infrastructure would naturally fall towards the dam and McLeod's Creek corridor. This presents an increased risk of significant disturbance to sensitive environmental areas and may present a substantial risk of contamination to the waterways with raw sewage from leaks or overflows should problems occur.

Also, both CGS and MGS will require significant upfront costs that may not be recovered for some time as the subdivision develops over a 10+ year timeframe. Upfront capital costs would include reticulated services (mains, sub-mains, manholes, pump stations etc.) as well as a treatment system capable of managing both current and expected (future) loads from the subdivision. Additionally this type of system would be subject to a much larger hydraulic load due to required design allowances for storm inflows and groundwater infiltration (I/I), adding substantially to upfront capital costs.

8.1.2 Pressure Sewer Systems (Vacuum and Low-Pressure)

8.1.2.1 Description of Technology and Costs

Vacuum sewers (VS) and low-pressure grinder pump (GP) sewers overcome some of the limitations of traditional gravity sewers by providing a driving force to convey wastewater, allowing shallower, smaller diameter pipes. They require more on-lot infrastructure than CGS and MGS systems as both options temporarily store sewage on-lot before transfer to the reticulation system.

In the case of GP systems, each lot contains a small tank (commonly referred to as a 'pot') with grinder pump and level sensors/controls that collect household sewage. The grinder pump breaks up the gross solids and converts sewerage to something more akin to a slurry that possesses different physical and hydraulic properties to raw sewage. The macerated effluent is then pumped through low pressure reticulation lines to a central location for storage and treatment. The on-lot and reticulation pipes are lightweight, flexible and small diameter, constructed of polyvinyl chloride (PVC) or high density polyethylene (HDPE). The pipes are installed at shallower depths than CGS and can closely follow the ground surface profile, removing the need for deep trenching. Furthermore, they have significantly fewer joints than CGS, and the joints are socketed and glued to limit infiltration. Figure 13 (below) presents a schematic of a 'typical' household low-pressure sewer connection. Generally, household ownership and management obligation extends to the property boundary (upstream of the boundary kit).

In the case of vacuum sewers, vacuum pumps provide the conveyance force by sucking sewage through the lines under a negative-pressure (vacuum). A small collection chamber (pot) is placed either on or near the lot to receive wastewater from the household – in some designs small clusters of houses are linked to a single collection chamber. When liquid levels in the collection chamber rise to a pre-determined level a normally closed valve is opened that connects the collection chamber to the vacuum sewer and as a result the liquid (with some air) is sucked into the sewer. When the collection chamber is empty the interface valve closes and the cycle is repeated. Flushing velocities are taken care of by the vacuum applied and pipelines do not have to be laid to achieve minimum grades. VS on-lot infrastructure looks very similar to that presented in Figure 13 (below) for GP applications, with the exception that no pump is fitted within the 'pot'.

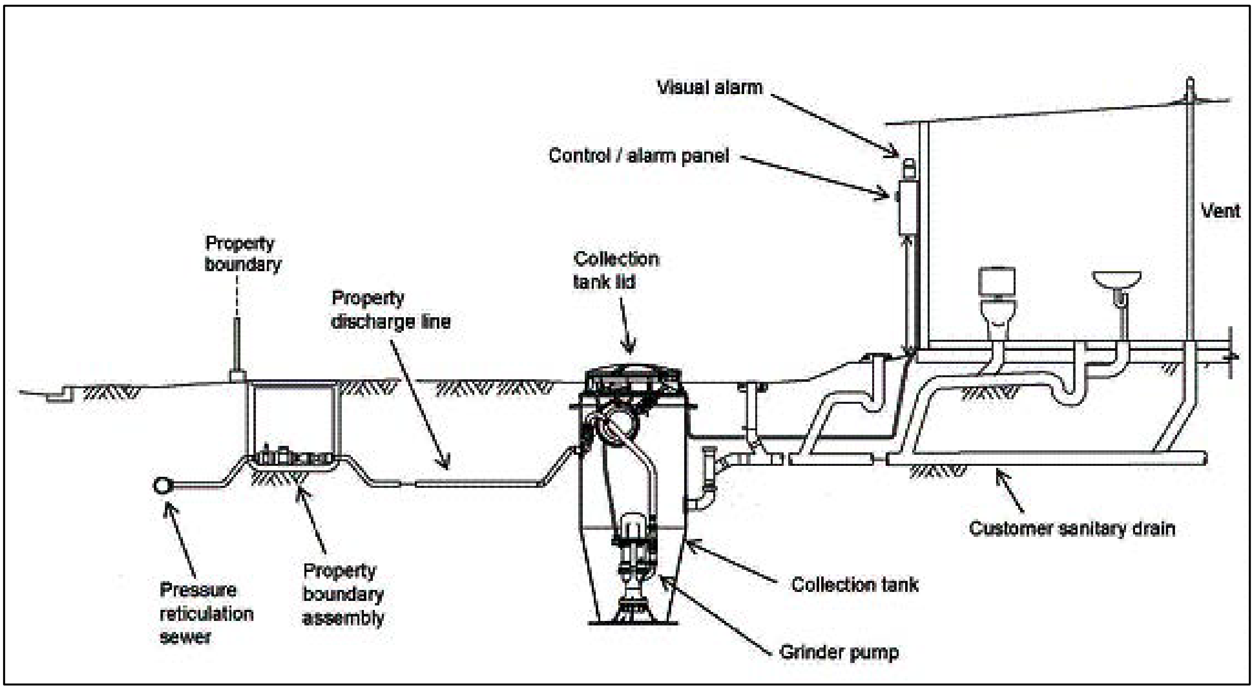


Figure 13: On-Lot components of Low-Pressure sewer (Sydney Water)

Depending on the size of the reticulation scheme, most or all of the pumping pressure is provided by the on-lot grinder pumps (GP) or centralised vacuum facility (VS). However, in larger schemes additional pumping stations may be required. The system is designed so the pressurised pipes are self-cleaning; however, maintenance ports are installed along the system at predetermined locations.

Unit rates for installation of PS systems range from **$190-$220 per metre** installed (including pipes, fittings, service laterals and project management). On-lot storage vessels (pots) vary in price depending on supplier and number of installations (volume). Typical pricing (per unit) is ~$6,000-$8,000 including boundary kit.

8.1.2.2 Limitations/Disadvantages

Generally speaking, pressure sewerage systems can overcome many of the limitations of traditional (conventional) gravity reticulation systems. However, there are still situations or design considerations that may become limiting for the application of pressure sewer (reticulation) systems, these may include:

- GP systems require higher energy macerating/grinding pumps with typically higher servicing and maintenance requirements.
- On-lot storage vessels (pots) have limited storage capacity (typically <1,000L) to cope with adverse service conditions such as power loss, pump failure or blockage.
- Availability of service/maintenance personnel in regional areas can cause delays in operational support.
- GP and VS systems transport all solids and liquids (slurry) and therefore are limited by minimum velocity requirements and can be more susceptible to crowning solids than effluent sewer systems.
- Due to full-strength organic (BOD) and suspended solid concentrations within the macerated effluent, treatment requirements are generally larger scale and more complex than those required for effluent sewer schemes.

At 'Kyeema', application of a pressure sewer technology would significantly reduce the risk of contamination of sensitive (environmental) features such as the dam and McLeod's Creek. The network can be arranged such that all generated wastewater is directed away from these features (towards the north/west) and all off-lot infrastructure could be installed within the proposed road reserve (reticulation) and adjacent land to the north (treatment works and effluent land application).

Pressure sewer systems are suited to staged implementation assuming sufficient hydraulic design has been completed to include ultimate design flow conditions Pressure sewer reticulation systems can reduce (or delay) some upfront capital costs by staging the installation of on-lot components (i.e. pots) as buildout of the subdivision occurs. This would remain the responsibility of the individual property owner. However, a proportion of the off-lot infrastructure would require construction prior to subdivision release. This would include the variable-grade reticulation network, boundary (connection) kits, pressure (booster) stations and wastewater treatment/land application system(s). Note; these can also be staged to meet growing demand as subdivision buildout proceeds.

Finally, pressure sewer systems require ongoing monitoring, management and control. This is typically undertaken by a central body such as a water authority (i.e. Sydney Water). However, there are instances where a private entity such as a strata body (community title) or private network operator (WICA) can assume management responsibility for such a network. Remote monitoring using telemetry is often used with pressure sewer systems, and local alarms are normally fitted on-lot to alert the resident of problems.

8.1.3 Common Effluent Systems (Effluent Sewers)

8.1.3.1 Description of Technology and Costs

CES utilise partial on-lot treatment and conveyance of (primary) treated effluent only away from the individual connections to a centralised location for further treatment (or in some cases disposal). This type of system has been adopted widely in the USA and New Zealand for servicing isolated villages that cannot practically or economically be connected to a municipal wastewater treatment plant using conventional gravity sewers.

CES systems collect and convey treated effluent (not raw wastewater) loads from individual residences to a central location for further handling. Primary treatment facilities (i.e. septic/interceptor tanks) servicing each allotment provide partial treatment and most solids are retained within the tanks, creating the opportunity for substantial savings in cost and infrastructure of the reticulation and centralised treatment. Many of the harmful and corrosive elements of domestic sewage (i.e. solids, gases) that cause major wear and tear on concrete sewer pipes are eliminated from the reticulation system. CES often combine pressure sewer and small diameter gravity sewer technologies, with STEP/STEG systems identified as the preferred technology for this discussion.

STEP and STEG

Septic Tank Effluent Pump (STEP) and Septic Tank Effluent Gravity (STEG) systems are variable-grade effluent sewer systems. STEG systems may also be referred to as small diameter gravity sewers or effluent drain systems.

STEP systems are used for houses below the hydraulic line of the sewer, while STEG systems are used where a gravity drain is achievable to the sewer. In some cases a single STEP/STEG tank may be installed to treat and convey effluent from multiple lots in localised areas.

STEP/STEG systems offer many advantages over larger diameter, deep, conventional gravity sewers. Installation involves substantially less disturbance due to smaller diameter pipes and shallower depths. They require smaller hydraulic gradients and do not employ manholes. These characteristics result in significant cost savings. Effluent sewer mains are buried at a shallow depth following the contours of the terrain (variable-grade). The vertical and horizontal alignment requirements are not as stringent, removing the need for time consuming and expensive surveying. Typically, effluent sewers can be installed using standard shallow trenching techniques or horizontal directional drilling (HDD). There is no need to consider minimum velocities and gradients. Figure 14 provides a diagrammatic representation of a typical STEP/STEG system arrangement.

STEG collection systems operate like conventional gravity sewers and are employed where gravity drainage is achievable from the property to the effluent sewer. STEP collection systems incorporate a pump vault that is either enclosed within the septic tank itself or outside the tank in a separate pump basin. Liquid level sensors (or float switches) in the pump vault turn the pump on and off as levels rise and fall or signal an alarm if levels become too high. STEP system effluent pumps are typically 0.4kW (0.5 horsepower) and use minimal electricity.

Due to the use of pressurised conveyance of primary treated effluent, STEP systems provide for the greatest flexibility in design, materials (i.e. pipe) and construction when considering alternative collection systems. They are used to service lots below the hydraulic line of gravity mains.

Each house is connected to the effluent main line via a service connection. This service connection protects the house from back-pressure and allows the house to be isolated from the effluent sewer in an emergency. These connections are an important part of the system and it is normal for the service connections to be installed at the same time as the main sewer line, even on vacant lots.

Remote monitoring (using telemetry) can allow a system operator to control pump operation from an office or workshop without having to access the site unless some form of manual repair is required.

A summary of the key features of on-lot components include:

- The wastewater from each house (or clusters of houses where appropriate) is plumbed into an on-lot septic tank (also known as an interceptor tank), with a recommended (minimum) operating capacity of 4,500L.

- Each interceptor tank (IT) is connected by small diameter flexible pipeline to the reticulated effluent sewer pipeline at the property boundary (service connection).
- The IT can be constructed of concrete, fibreglass or plastic, and provides primary treatment, with the solids accumulating at the bottom of the tank and the liquid effluent passing through a screened outlet before being discharged to the effluent sewer.
- The majority of retained solids are degraded (anaerobic digestion) over time, thereby significantly reducing pump-out frequency (typically 7-10 years, depending on occupancy).
- The on-lot interceptor tanks are relatively large (compared to traditional septic tanks in NSW) and thereby provide several days' emergency wastewater storage, if required.

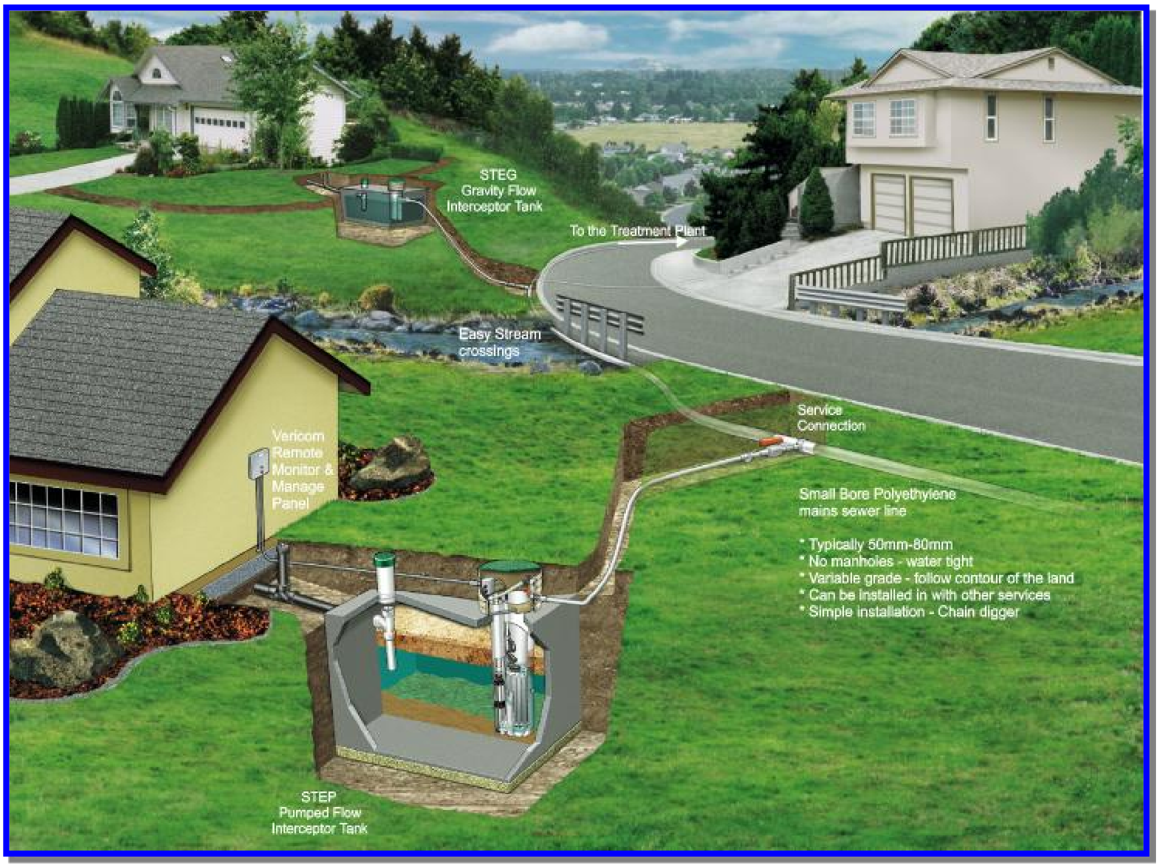


Figure 14: Diagrammatic STEP/STEG arrangement (Orenco Systems Inc.)

Advantages of the STEP/STEG system include:

- Only liquid effluent is being pumped which means the energy required to pump is low, therefore reducing electricity costs.
- Small-bore (50mm - 100mm) pipe sizes for the effluent sewer, using lightweight, flexible polyvinyl chloride (PVC) or high density polyethylene (HDPE).
- It is common practice in New Zealand to install remote monitoring systems throughout the collection system that allow the efficient monitoring and manipulation of individual interceptor tank operation and the broader reticulation system.
- A reduction and, in most cases, elimination of the need for manholes and pump stations within the system.

- Fewer joints than conventional gravity sewers (socketed and glued/welded joints) and provision of a largely watertight collection system thereby reducing (or effectively eliminating) infiltration and inflow (I/I). This means the treatment plant can be considerably smaller since it doesn’t have to cope with large wet weather flows. Similarly, sewers and pump stations do not need to be sized for wet weather flows.
- The cost and maintenance of all on-lot equipment is taken care of by the owner and disposal of chemicals will only affect the individual lot and not the whole system.

Unit rates for installation of CES systems range from **$210-$240 per metre** installed (including pipes, fittings, service laterals and project management).

8.1.3.2 Limitations/Disadvantages

Effluent sewer systems have one minor disadvantage when compared to conventional and pressure/vacuum sewerage systems; that is, the need for on-site treatment (interceptor) tanks on individual lots. With proper design, installation and management, this should not pose a problem for the overall system. Effluent sewer systems almost exclusively include external management of the system by a responsible entity. Remote monitoring technology is often incorporated into on-lot and community components of effluent sewer systems to facilitate third-party management.

An important factor in the efficient operation of a reticulated effluent sewerage system is the need to take large scale management decisions out of the homeowners’ hands. Reducing the responsible management entities from hundreds (property owners) to one (water authority/private operator) has many benefits. The advent of remote monitoring technology for application in decentralised, non-conventional wastewater treatment has ensured a considerable level of risk control exists. In most cases this risk control is far greater than that provided for centralised systems.

At ‘Kyeema’, application of a (STEP/STEG) common effluent system would significantly reduce the risk of contamination of sensitive (environmental) features such as the dam and McLeod’s Creek. As with a pressure solution, the network can be arranged such that all generated wastewater is directed away from these features (towards the north/west) and all off-lot infrastructure could be installed within the proposed road reserve (reticulation) and adjacent land to the north (treatment works and effluent land application).

STEP/STEG effluent sewers are tailor-made for staged implementation in-line with expected community growth (subdivision buildout). Because of their relative freedom from minimum velocity requirements, system hydraulics are not often limiting and the effluent sewer can absorb large fluctuations between initial and ultimate design flow conditions (volume and velocity). Combination STEP/STEG systems provide positive pressure throughout the reticulation network and, combined with modern jointing techniques, substantially reduces the risk of inflow and infiltration. Alternate water supply (town/tank) scenarios will have minimal impact on the design, operation and estimated cost of STEP/STEG, primarily due to the capacity for modulation of daily flows using the balance capability of large on-lot interceptor tanks.

Landowner acceptance of a STEP/STEG effluent sewer option for ‘Kyeema’ (and Gundaroo) may not be troublesome. Existing property owners are familiar with on-site treatment tanks, and day-to-day maintenance responsibilities would be similar to what presently occurs and the knowledge that overall system management responsibility would rest with a new (or established) management entity would greatly improve service confidence.

8.2 Community Treatment System Options

Regardless of the reticulation option selected, collected wastewater (either raw or primary) will require additional treatment to achieve a standard suitable for land application (as a minimum) in line with regulatory standards and community expectations.

This presents a number of considerations when selecting an appropriate treatment technology because the quality and consistency of the wastewater stream can have a significant bearing on the size of the wastewater treatment system required, as well as the reliability and performance of the treatment processes employed. Therefore, not all treatment systems are suitable for the range of reticulation options considered. Common treatment technologies/systems are discussed here along with the applicability for the system with a selected reticulation option.

We have drawn upon existing reports for the study area as well as previous work undertaken by W&A for similar villages and information from technology providers. Detailed designs for any of the systems must be completed following additional detailed investigation (i.e. survey, geotechnical and engineering design etc.).

For comparison, in 2008 the Yass Valley Council – Integrated Water Cycle Management Strategy report (JWP, 2008) identified a requirement for a 350EP (~70,000L/day) treatment system for Gundaroo Village as part of a future service extension. An extended aeration (oxidation pond) system was identified; with an anticipated capital cost of **$488K** (~$7,000 per kL treated) and an annual operating cost of **$83K**. With CPI cost increases, these costs would be approximately $600K (capital) and $93K (operating) in today's value.

8.2.1 Treatment System Positioning

A logical position for a local treatment plant for 'Kyeema' is located in the south-western corner of the remnant parcel. The elevation at this location is largely below the remainder of the Stage 1 and Stage 2 subdivision areas and will allow the reticulation network to utilise gravity design. An indicative network (reticulation/treatment/application) arrangement for a community system is shown in Figure 15.

It is understood the property is owned by the proponent and is zoned primary production (RU1) under the current planning instrument (LEP). The Yass Valley Council LEP (2013) permits the development of 'water treatment facilities' (e.g. recycled water) within the RU1 zoning, with consent. This site has been selected as an appropriate location for treatment and irrigation infrastructure for any system type discussed in this report.

An appropriate treatment option for the identified treatment and reuse site would be a small-scale (package) sewage treatment plant (STP) which may use a combination of physical and biological treatment processes. Many options for wastewater treatment are available and it is beyond the scope of this study to consider them all in detail.

A handful of suitable systems are described here including extended aeration systems, sequencing batch reactors and textile filter systems.

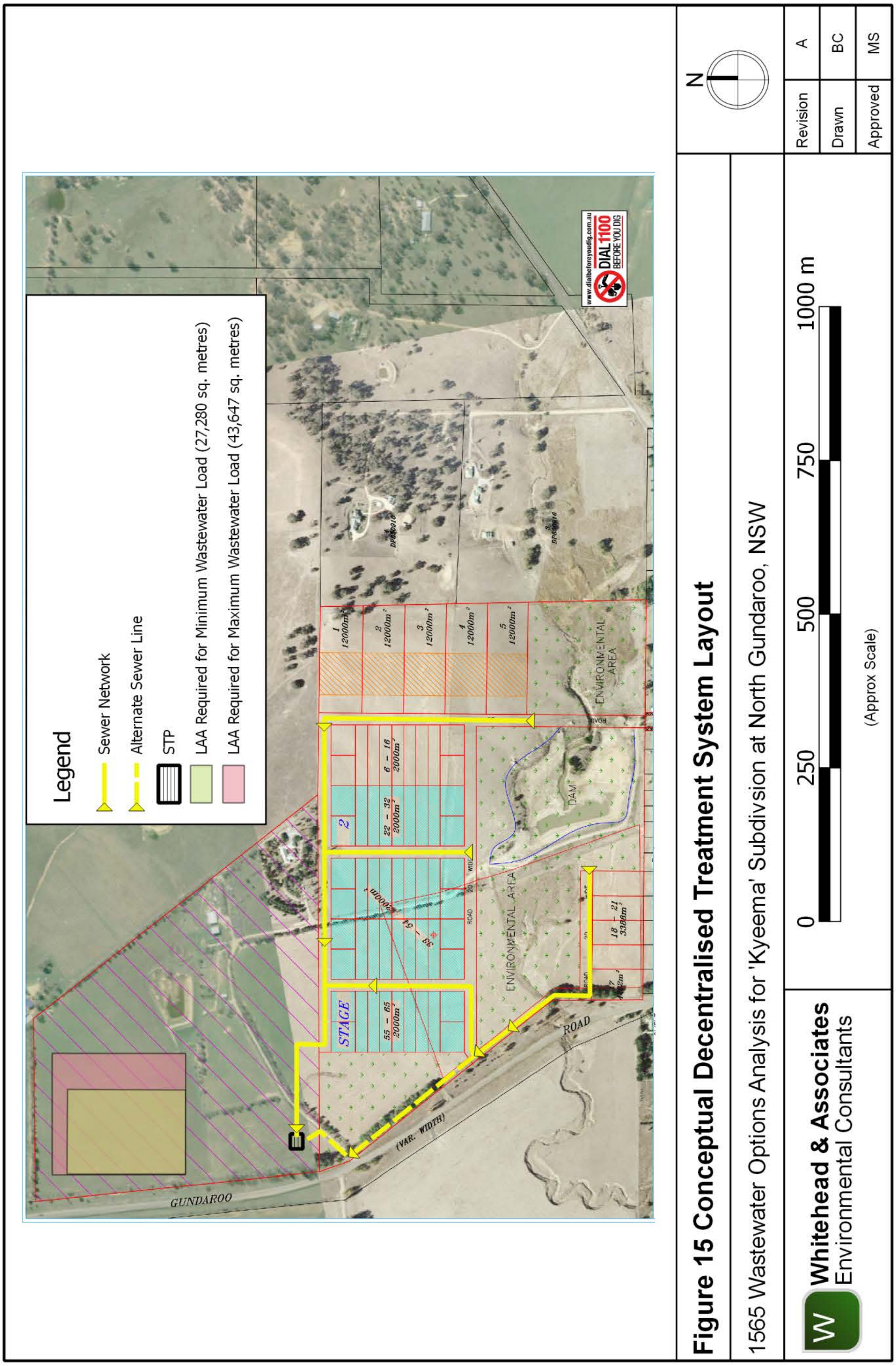


Figure 15: Conceptual Sewer layout

8.2.2 Extended Aeration

Extended aeration, suspended growth (activated sludge) treatment systems are one of the most common types of small-scale wastewater treatment systems installed throughout Australia. They have been shown to achieve high organic load (BOD) and SS reductions of 85-95% and up to 50% phosphorus removal (principally through solids capture). As for most other wastewater treatment systems, nitrogen reduction is more difficult due to the complex chemical reactions in the nitrogen cycle; however, these types of systems can achieve up to 75% nitrification, through the conversion of ammonia to nitrate, which is biologically available for plant uptake in the land application (irrigation) area.

8.2.2.1 Applicability

Extended aeration treatment systems are suitable for receiving raw wastewater loads from community reticulation (CGS, GP and VS) systems, as designs tend to be significantly robust to accommodate the expected fluctuations in wastewater quality (strength) and volume. A typical design for the proposed 'Kyeema' subdivision would comprise:

- large primary treatment capacity (~100kL – 150kL) to provide a minimum 24-hr residence period for the peak (dry-weather) flow from the subdivision, allowing sufficient sludge storage volume;
- an (aerated) treatment reactor (~80kL) to provide reliable treatment to a 'secondary' effluent quality, including >80% nitrification;
- secondary settling (clarification) capacity (~30kL) to provide reliable effluent clarity (TSS <30mg/L) suitable for restricted land application (irrigation) of treated effluent; and
- (if required) disinfection or pathogen control facilities suitable to achieve desired control limits (as determined by consent authority).

With an increased storage requirement (i.e. tanks) the land area (footprint) for this type of treatment system would be **~400-500m^2**. This area would be expected to be accommodated with the identified STP location.

8.2.2.2 Limitations/Disadvantages

A major limitation for this type of system is a reduced opportunity for 'scalability'. In most cases, the majority of the treatment system will need to be designed for ultimate capacity (buildout condition) of the development and yet it is likely that this condition will not be reached for 5-10 years (if not more), resulting in a significant upfront capital outlay with a delayed period for cost recovery. Separately, the setup of a STP under reduced loading conditions can also cause ongoing operational difficulties.

Also, for common effluent sewer (i.e. STEP/STEG) applications, extended aeration treatment systems can struggle because of the decreased organic loading (as solids are retained on-lot). This does not need to be problematic; however, care must be taken to ensure that this has been considered in the design and selection of the preferred treatment system.

8.2.2.3 Costs

Capital cost estimates for extended aeration treatment systems are varied, given the range of technologies, processes and providers available in the Australian market. Based on W&A experience, a preliminary (ballpark) estimate of cost for such a system would be in the range of **$8,000 - $12,000 per kL** treated. Therefore, based on the design loading values presented, the cost of a community (extended aeration) STP for 'Kyeema' would be in the vicinity of $400K-$600K (50kL/day) to $640K-$960K (80kL/day). This cost would be borne exclusively by the developer (proponent).

Expected operational costs are also heavily dependent upon the system selected. Typically, extended aeration treatment systems require operator input (management/maintenance) daily. This may be found to be equivalent to a full-time staff (or contract) position with an annual value of **$50K-$60K**. This cost would be borne by the developer (proponent) and/or management entity.

8.2.3 Sequencing Batch Reactor

Sequencing Batch Reactors (SBRs) also use the activated sludge treatment process, but in a 'fill-and-draw' process (from a balance tank) in order to provide all of the wastewater treatment steps in sequential order within the same reactor vessel. This technology uses a smaller footprint than traditional suspended growth systems. However, SBRs can be more sensitive to shock loads as the microbiological populations within the reactor vessel become conditioned to the background sewage inflows. An SBR variant, known as Intermittently Decanted Extended Aeration (IDEA), which continually feeds raw wastewater to a baffled compartment of the reactor is also available. This system can remove the need for flow equalisation and make the system less susceptible to shock loads.

8.2.3.1 Applicability

SBR (and IDEA) treatment systems are also suitable for receiving raw wastewater loads from community reticulation (CGS, GP and VS) systems for the same reasons as extended aeration systems. However, because treatment occurs as a discrete volume ('batch'), additional flow equalisation (balancing) facilities may also be required.

The land area requirement (footprint) for this type of treatment system would be marginally reduced **~300-400m^2**. This area would be expected to be accommodated with the identified STP location.

8.2.3.2 Limitations/Disadvantages

SBR systems overcome some of the 'scalability' issues associated with extended aeration systems by allowing for multiple treatment reactors, which can be constructed in a staged approach as development progresses. Subsequently, upfront capital expenditure can be minimised, with additional treatment capacity only added as needed until the ultimate condition is reached. This approach would also address the potential under-loading problem identified earlier.

As with extended aeration systems, SBR systems can also struggle when used with common effluent sewer (i.e. STEP/STEG) applications. Again, this issue can be readily addressed with cautious consideration in the design and selection of the preferred treatment system.

8.2.3.3 Costs

The capital cost estimates for a SBR (or IDEA) treatment system for the 'Kyeema' subdivision would be similar to the extended aeration values (**$8,000 - $10,000 per kL** treated). Therefore, based on the design loading values presented, the cost of a community (SBR/IDEA) STP for 'Kyeema' would be in the vicinity of $400K-$500K (50kL/day) to $640K-$800K (80kL/day). This cost would be borne exclusively by the developer (proponent).

Expected operational costs are also heavily dependent upon the system selected. Typically, SBR systems require operator input (management/maintenance) daily. This may be found to be equivalent to a full-time staff (or contract) position with an annual value of **$50K-$60K**. This cost would be borne by the developer (proponent) and/or management entity.

8.2.4 Textile Filters

As described under the On-site treatment options (Section 7.2), media or 'textile' filters use proven packed bed reactor (PBR) technology to treat domestic wastewater to better than secondary effluent standards. In addition to proving highly effective at the single lot scale, this technology has been found to be highly suitable to cluster (community) scale wastewater treatment, particularly on sites with limitations to construction and land availability or staged development.

Figure 16 (below) illustrates several examples of Textile Filter STP's in community situations. Note that compact design and enhanced odour control allow for the STP to be directly integrated into the development setting with minimal impact.

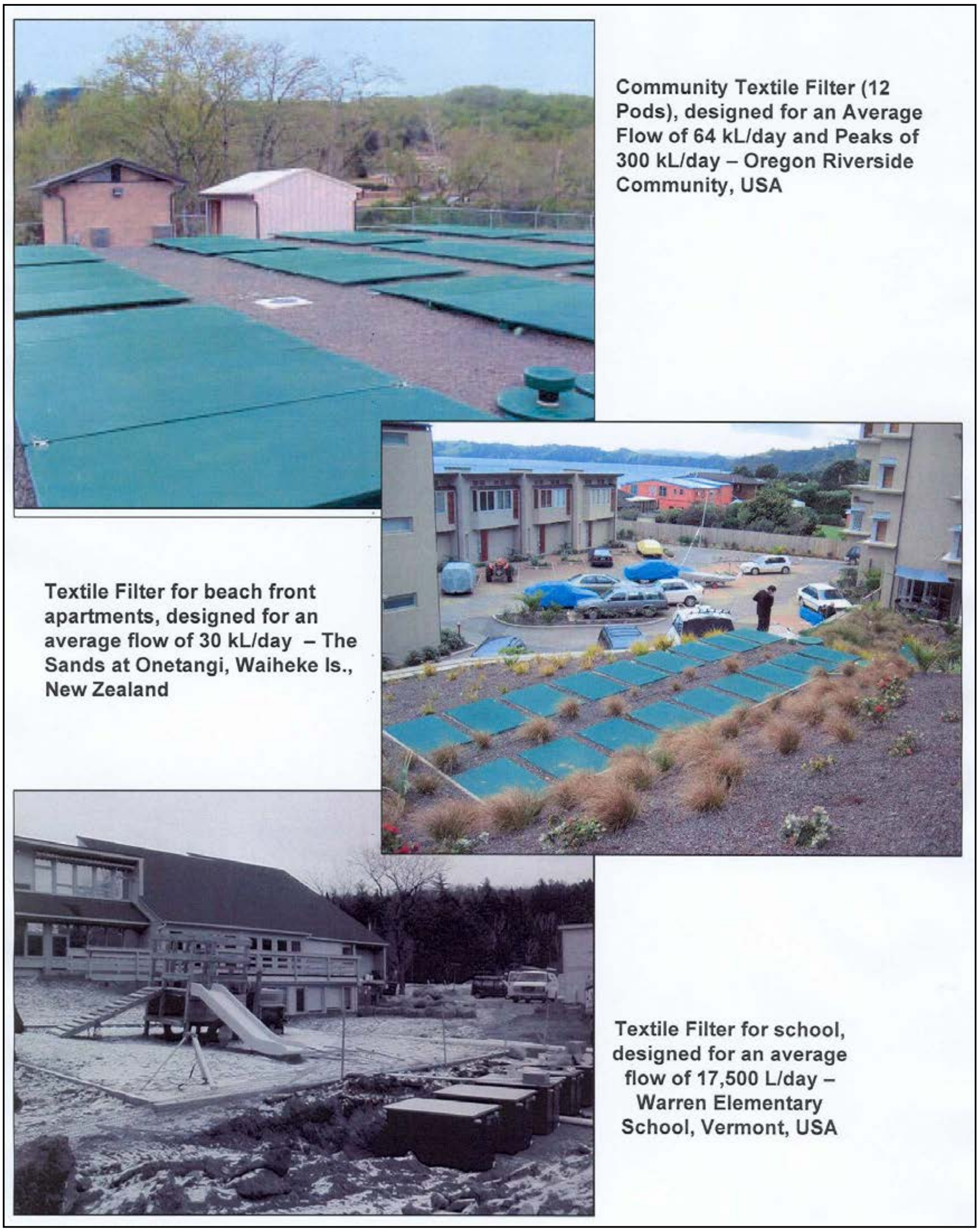


Figure 16: Modular Textile Filter arrangements for a Community System

Recirculating textile filters can be loaded at rates much higher than traditional packed bed reactors (e.g. sand or gravel filters) and do not have the same issues associated with sourcing consistent quality media materials as sand or gravel filters. The loading rate depends on the organic loading and the required effluent quality. The filters are lightweight and modular in form allowing systems to be expanded when required with minimal difficulty. Textile filters have a small footprint when compared to other treatment system options and do not smell or produce potentially harmful aerosols, so buffer requirements from residences and other types of development are minimal.

Recirculating textile filters generally comprise a watertight fibreglass basin filled with suspended vertical sheets of an engineered textile material. Recirculated wastewater is distributed evenly over the end surface of the hanging sheets by a pressure distribution manifold.

The textile material has a complex fibre structure that provides a high water holding capacity, porosity and surface area for biomass attachment. Porosity of the textile media is several times greater than that of sand not only increasing hydraulic conductivity but also allowing the passive input of oxygen into the system and providing more space for solid retention and breakdown by the biomass. Surface area of the various textile media is approximately 4 to 8 times greater than a recirculating sand or gravel filter. The high water holding capacity of the media provides high retention times when coupled with timed, pressure dosing and enables consistently high treatment.

8.2.4.1 Applicability

Whilst Textile Filter treatment systems can be designed for receiving raw wastewater loads from community reticulation (CGS, GP and VS) systems, usually incorporating large primary treatment and flow equalisation (balancing) facilities, they are ideally suited to common effluent sewer (i.e. STEP/STEG) applications.

The use of on-lot primary treatment (interceptor) tanks greatly reduces the need for large primary facilities at the centralised treatment location and utilising a 'recirculating' treatment process results in exceptional treatment performance (high quality effluent) and significant flexibility in nutrient removal. Long term monitoring of many domestic and community-scale textile filter systems indicates that effluent quality as described in Table 2 is consistently achievable. Additional treatment processes can be incorporated to provide enhanced treatment (e.g. further nutrient stripping or active disinfection).

Table 2: Typical 'Textile Filter' Effluent Quality

Parameter	Concentration	% Reduction
Biochemical Oxygen Demand (BOD_5)	< 5 mg/L	90-99
Suspended solids (TSS)	< 5 mg/L	90-99
Total Nitrogen (TN)	10-15 mg/L	65-90
Total Phosphorus (TP)	5-10 mg/L	25-75
Faecal coliforms (FC)	<1,000 cfu/100 mL	99.99

Textile filter systems can overcome most of the scalability issues associated with other 'fixed-capacity' systems. A commercial (AX100) treatment pod can treat average and peak design wastewater flows of 12,000L to 19,000L/day respectively (Orenco Systems ®, 2013), meaning that treatment capacity can be iteratively expanded as development proceeds. For 'Kyeema' this equates to approximately one (AX100) pod per 10 dwellings.

Alternately, the larger (AX-MAX) treatment system (Figure 17) can treat average and peak design wastewater flows of 20,000L to 40,000L/day respectively (Orenco Systems ®, 2013), or approximately one (AX-MAX225) container per 20 dwellings.

The land area requirement (footprint) for this type of treatment system is also significantly reduced **~100-200m^2**. This area would be expected to be accommodated with the identified STP location.

Figure 17: AX-MAX (225) Modular Textile Filter STP

8.2.4.2 Limitations/Disadvantages

On-site pre-treatment still requires individual householders to be educated about the system, particularly to be mindful of preventing harmful substances from entering the system. However, if a contamination event were to occur, the impact would be localised to the subject household, with minimal impact on community treatment system integrity.

Given that all properties in Gundaroo have been exclusively serviced by on-site wastewater management systems (principally septic systems) most residents should be aware of this requirement.

8.2.4.3 Costs

Capital costs for a textile filter (PBR) treatment system for the 'Kyeema' subdivision would be split between on-lot costs (interceptor tanks) and off-lot costs (STP). Depending on hydraulic requirements, on-lot costs would range between **$8,500 and $10,500 per lot**, borne exclusively by the property owner. Off-lot (STP) costs, comprising fixed infrastructure (flow balancing/recirculation tanks, pumping etc.) and treatment units (pods) would be ~**$6,800 per kL** treated. This cost would be borne by the developer (proponent) and/or management entity.

Therefore, based on the design loading values presented, the cost of a community (textile filter) STP for 'Kyeema' would be in the vicinity of $620K for on-lot works and between $340K (50kL/day) and $544K (80kL/day) for the off-lot components.

To aid in system/network management, remote monitoring capability for each new (on-lot) connection is also recommended. The capital cost for this additional item is ~**$1,500 per lot**.

Operational costs for a textile filter treatment system are expected to be substantially lower than both extended aeration and SBR options. This is due in part to shifting part of the maintenance requirement to the home owner, but also due to an increased level of automatic monitoring of system operational conditions (remote monitoring). This allows for the timely identification, reporting and resolution of system problems (both on and off-lot) before they cause serious fault or damage. Also, remote monitoring and management requires less on-site time for a system operator, meaning annual running costs can be significantly reduced.

Textile filter (PBR) technology is very robust and maintenance requirements are substantially reduced. Studies of operational systems in the U.S. and New Zealand have demonstrated combined operational and maintenance costs of <$500 per connection, or **$32.5K** per annum for the 65-lot subdivision. These costs would be borne equally by the homeowner and the developer (proponent) and/or management entity.

8.2.5 Enhanced (Tertiary) Treatment Option

Each of the previously described community treatment system options is capable of producing 'secondary' effluent quality suitable for 'restricted' land application (irrigation) on dedicated land within the property. Disinfection or pathogen controls will be required if surface irrigation techniques are preferred (as determined by consent authority).

Under certain circumstances, it is possible to utilise treated wastewater for internal (household) uses within the subdivision. On single lots this is only possible using treated greywater; however, with large-scale commercial treatment systems, such as that proposed here, it is possible to treat the combined (all-waste) wastewater load to a standard acceptable for reuse (both internally and externally) on each of the new lots.

This could be achieved by providing a dual reticulation (third-pipe) network to distribute 'recycled water' to households and public open space, whilst any unused recycled water would continue to be irrigated in a dedicated land application (irrigation) area on the property.

To achieve 'tertiary' recycled water quality it is typical for providers to utilise advanced membrane bioreactor (MBR) processes. MBR systems effectively combine two proven wastewater treatment processes (i.e. microbial digestion and membrane separation) into a single process where suspended solids and microorganisms responsible for biodegradation are separated from the treated water by an ultra-filtration (UF) system. The process typically also includes advanced disinfection technologies, potentially producing a high quality (Class A) effluent. MBR's are well suited to greenfield development sites where reuse reticulation can be designed into the system rather than brownfield sites where costs of retrofitting are often prohibitively high.

8.2.5.1 Recycled Water Quality

Recent experience has demonstrated that MBR treatment systems are capable of reliably producing 'recycled water' that is expected to meet, or exceed, the following criteria:

- Total Nitrogen: ≤10mg/L;
- Total Phosphorus: 2-5mg/L;
- BOD_5: ≤10mg/L;
- Suspended Solids: ≤10mg/L;
- Faecal Coliforms: ≤10cfu/100mL;
- Total Dissolved Solids: 700mg/L; and

- EC: ~1,000µS/cm.

In this condition, the recycled water would be considered low risk for direct human contact (DWE, 2008) and may be used for internal domestic purposes (toilet flushing and cold-water washing machine supply) to off-set potable water (tank and bore water) demand or for urban irrigation of individual properties and community areas with unrestricted access.

The volume of water recycled available (supply) and required (demand) for a subdivision the size of 'Kyeema' is limited, given it comprises a relatively small 65-lots. However, examination of such a proposal is worthwhile if only to exclude it from additional investigation.

8.2.5.2 Recycled Water Demand

In NSW, the Building & Sustainability Index (BASIX), implemented under the NSW State Environmental Planning Policy Sustainability Index 2004 (BASIX SEPP), mandates water and energy saving targets for all new residential construction. BASIX requires fixtures, fittings and appliances to have minimum ratings in accordance with AS/NZS 6400:2005 (Water Efficient Products) under the Water Efficiency Labelling and Standards (WELS) scheme.

For BASIX approval a new residential development is required to demonstrate up to 40% less potable water usage than the average 'pre BASIX' benchmark home of 90.34kL/person/year or 247L/person/day. The 'pre BASIX' benchmark home was determined from data collated by the then NSW Department of Water and Energy (DWE) and included regional data reflecting both demographic and climate considerations.

The Site is located within the Yass Local Government Area BASIX Water Target Zone which has been prescribed a 40% reduction target. The BASIX reduction targets were determined from data provided by state and federal water and energy utilities as well as long-term climate data obtained from the Bureau of Meteorology. It is noted that the reduction targets are currently under review, with a proposal to increase to 50% reduction in areas prescribed with a 40% reduction target.

BASIX encourages reductions in the consumption of potable water through any of the following strategies: landscape uses, fixtures, alternative water, pools and spas, and central systems. The 'Kyeema' subdivision could utilise an alternative water source through the reticulation of recycled water, for garden and lawns, toilets and laundry (cold water) use, to meet the BASIX reduction targets. Additional listed strategies, i.e. fixtures, may also need to be used in addition to the alternative water source to meet the target.

Using pre-BASIX values, household water (usage) demand has been conservatively estimated for each new residence (ET) as between 1,235L/ET/day (5EP, 3 bedrooms) and 1,976L/ET/day (8EP, 5 bedrooms).

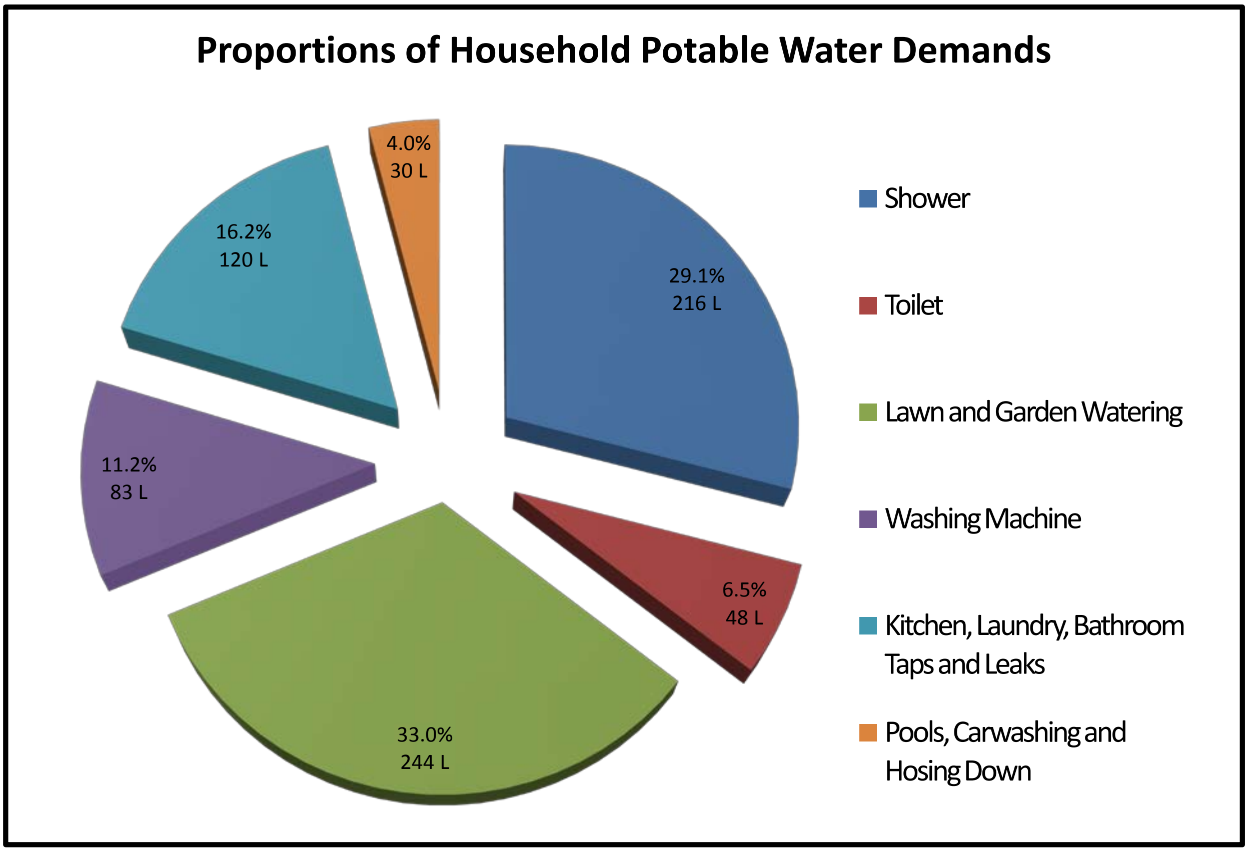
It is noted that these estimates are substantially greater than water consumption values for residential properties in the Yass Valley. JWP (2008) estimated potable water demand for a 'typical' Yass Valley dwelling to be ~195kL per annum (533L/day) in 2004/05.

Additional data for proceeding years (2006-2010) suggest that this estimate may have only marginally increased to ~205kL per annum (560L/day) based on larger dwelling sizes, population increase and permanence.

Assuming a minimum requirement to meet the 40% BASIX target, a reduction of between 224L/ET/day (assuming 205kL/year) and 494L/ET/day (assuming pre-BASIX estimates) would be required from the total household water demand for each new residence.

Figure 18 illustrates proportional breakdown of water use within a 'typical' residential household based on BASIX targets and WELS scheme criteria.

Using this information, it is possible to develop estimates of potential recycled water demand from new dwellings within the 'Kyeema' subdivision. As discussed, permissible internal uses of recycled water include toilet flushing (6.5%) and cold-water washing machine supply (7.4%), while permissible external uses are limited to lawn and garden watering (33%). It is acknowledged that these values are annualised 'averages' and actual demand will change throughout the year (both daily and seasonally).



* Washing machine reuse is for cold water supply only; therefore reuse potential is estimated as 2/3 of total demand for washing machine.

Figure 18: Proportional water usage within a residential household

From this, it is possible to derive estimates of the potential demand for recycled water returned to the dwellings in a dual-reticulation (third pipe) scenario. The total reuse potential (indoor and outdoor) based on an 'average' scenario is between 262L/day and 579L/day, depending on actual water usage.

Therefore, based on our preliminary assessment, each household would have a potential to off-set a minimum 40% of the total potable water demand through the use of an alternative water (recycled water) source, on an annual basis. However, other methods, such as the installation of higher WELS scheme star rated fixtures, may need to be implemented in order to ensure that the BASIX target criteria is met for the entire year.

Assuming the design wastewater generation conditions previously described for the 'Kyeema' subdivision (Section 6.1.1), there would be sufficient 'recycled water' available from an enhanced (tertiary) treatment system to meet the expected non-potable water demand from each new dwelling.

Un-utilised recycled water would continue to be irrigated in a dedicated land application (irrigation) area on the property.

8.2.5.3 Limitations/Disadvantages

The greatest impediment to implementation of a third-pipe (recycled water) reticulation scheme to a relatively small subdivision such as ‘Kyeema’ is cost. To introduce such a system would require a significant investment in ‘enhanced’ treatment capacity (quality) and delivery infrastructure (storage and reticulation) to achieve the desired water quality and reliability of supply to off-set existing potable uses within each dwelling.

Based on other similar projects W&A have been involved in, the breakeven point for such an investment is >200 dwellings, assuming there are no other drivers for implementation (i.e. environmental constraints etc.).

Therefore, if additional housing stock were to be included with the scheme network, the financial viability of such an approach would be greatly enhanced. This could be achieved through connection of the Gundaroo Village (approximately 130 dwellings), increasing the yield from the proposed subdivision or additional development stages.

8.2.5.4 Costs

The estimated capital cost to upgrade a community treatment system to produce ‘tertiary’ recycled water quality suitable for third-pipe reticulation to dwellings (MBR or similar) would be between **$10,000 and $12,000 per kL** treated. This cost would be borne by the developer (proponent) and/or management entity.

Therefore, based on the design loading values presented, the cost of a community (MBR) STP for ‘Kyeema’ would be in the vicinity of $500K-$600K (50kL/day) and $800K-$960K (80kL/day).

However, as noted above, economies of scale apply to this type of advanced treatment system with cost decreasing proportionally with the number of connections. Recent projects have shown capacity to produce high quality ‘recycled’ water for a 2,500-lot subdivision at an estimated cost of $2,000-$3,000 per kL treated.

Other costs associated with this approach would include:

- Recycled Water storage facilities (sufficient to meet peak non-potable water demand and potentially fire-fighting needs).
- Delivery headworks (tanks, pumps etc.).
- Third-pipe (dual) reticulation network[3].
- On-lot infrastructure (metering, cross-flow controls etc.)

[3] For PS and CES reticulation options (see Section 8.1), third-pipe reticulation can often be installed simultaneously, and within the same excavation, providing substantial savings in both time and capital expenditure.

8.3 Community Effluent Management Options

Treated wastewater can pose a threat to human health and the quality of the natural environment. Accordingly, various standards, guidelines and other publications, produced at both state and national levels have been developed to improve our understanding of the risks and to promote a best management approach to design, operation and management of community effluent management systems. Several of the more important guidelines relating to recycled water use at a community scale are listed below:

- NSW Guidelines for Recycled Water Management Systems (NSW Department of Primary Industries – Office of Water, 2015).
- Environmental Guidelines – Use of Effluent by Irrigation (NSW Department of Environment and Conservation, 2004).
- Interim NSW Guidelines for the Management of Private Recycled Water Schemes (NSW Department of Water and Energy, 2008).
- Australian Guidelines for Water Recycling: Managing Health and Environmental Health Risks (Phase 1) (Natural Resource Management Ministerial Council and Environment Protection and Heritage Council, 2006).
- ANZECC Guidelines for Fresh and Marine Water Quality (Australia and New Zealand Environment Conservation Council, 2000).

These guidelines provide important information that would be used in designing and then assessing any proposal to reuse water from a community wastewater treatment system within the development.

8.3.1 Matching Water Quality to Reuse Application

The guidelines present water quality targets for different reuse applications according to the level of risk associated with reuse. These targets are generally specified in terms of physical, chemical and microbial water quality parameters.

Where the general public is unlikely to come into contact with recycled water (e.g. agricultural irrigation), lower levels of treatment may be used in combination with appropriate controls and safeguards (e.g. controlling access to the reuse area). Conversely, for reuse applications where there is a relatively high risk of contact (e.g. residential garden watering) a higher quality of recycled water is required and similarly, the testing and monitoring required to validate and maintain quality control over the recycled water supply are expected to be more rigorous.

The major risk to human health from contact with treated wastewater, or recycled water is infection from micro-organisms such as viruses, bacteria, protozoa and helminths that may remain in the water. It is not practical to specify water quality targets completely in terms of all micro-organisms and so indicator organisms have been selected that are expected to be representative of the microbial population within a water sample. Thermotolerant coliforms (or faecal coliforms) are most commonly used.

For high risk reuse applications there may be a requirement to also demonstrate compliance with target levels set for viruses and other parasites, for example "<2 virus' per 50L for unrestricted residential use".

Chemical and physical water quality targets are also specified that may vary depending on the proposed reuse application. For example, it may be important to establish minimum criteria for turbidity and colour to ensure a high level of public acceptance where recycled water reuse is proposed for domestic non-potable purposes. Such criteria may be irrelevant for lower level uses like irrigation of parks and playing fields.

Acceptable criteria for other parameters such as suspended solids (SS), biochemical oxygen demand (BOD), nutrients (nitrogen and phosphorus), salinity and pH are important, to manage risks associated with environmental pollution and soil degradation.

8.3.2 Buffers

Buffer zones (setbacks) from irrigation areas are recommended as they provide a form of mitigation against unidentified hazards and minimise risk to public health, maintain public amenity and protect sensitive environments. The AGWR (2006) guideline recommends restricted access and 25-30m (Table 3.5 & 3.8) buffer zones from irrigation areas to the nearest point of public access for spray irrigation of high-quality recycled water suitable for domestic non-drinking water use, as is the case with the Site.

The application of the recommended buffer zones will provide a minimum 1-log (equivalent) reduction in pathogen loads from the irrigation areas. Recommendations to prevent off-lot discharge also include the use of low-throw sprinklers, part-circle (180º inward-throwing) sprinklers and/or tree or shrub screens.

W&A also recommends the following environmental buffers for spray irrigation based on NSW DEC (2004) guidelines;

- 250 metres from domestic groundwater bores;
- 50-100 metres from permanent watercourses; and
- 40 metres from intermittent watercourses and dams.

It should be noted that once development commences, relevant setbacks from dwellings, in accordance with AGWR (2006), will need to be applied.

The recommended buffers will be achievable.

8.3.3 Recycled Water Management

The two (2) recycled water management options identified within this study are:

- Option 1 – Agricultural irrigation, e.g. for fodder crops or grazing pasture. A suitable location for the establishment of an irrigation scheme is identified within the remnant parcel to the north of the Site; and
- Option 2 – Urban residential, e.g. "third pipe" supplying recycled water for either external reuse (i.e. garden watering, landscaping, path and car washing) or internal reuse (i.e. toilet flushing).

Option 1 (agricultural irrigation) would require as a minimum secondary treatment standard. Option 2 (urban residential reuse) would require advanced (preferably tertiary) treatment to allow greater flexibility in design and operation of the reuse system and also provide a higher level of protection to the public.

8.3.3.1 Option 1 – Agricultural Irrigation

This option would comprise the controlled irrigation of (minimum) secondary treated effluent within a dedicated irrigation area located within the remnant parcel to the north of the proposed subdivision.

Preliminary water and nutrient balances prepared for this study indicate that the area required to be set aside for irrigation at ultimate buildout of the (Stage 1 & 2) subdivision ranges from 27,280m^2 (2.7ha) assuming recycled water generation of 50kL per day or 43,647m^2 (4.37ha) assuming recycled water generation of 80kL/day. Phosphorus assimilation (nutrient management) is the limiting balance for sizing the required irrigation area in both instances.

Based on advice provided in the LCA report (SLCC, 2011) surface spray irrigation would likely be a suitable solution for the Site. Whilst the exact details of the most appropriate irrigation system is presently unknown and will likely be determined based on both financial and operational factors, it is considered most likely that large scale surface spray or drip irrigation would be the preferred method. Given the large areas that would be required to be irrigated, fixed (pop-up or impact) or travelling irrigator systems (or similar) would likely be the most suitable options for this Site. Each option is described further here.

Surface irrigation using fixed (pop-up) sprays

A ‘fixed’ (pop-up) irrigation system would comprise the installation of a subsurface (buried) distribution manifold beneath the entire irrigation zone to be serviced. The manifold would be constructed PVC pressure pipe or HDPE, with final pipe sizing determined following detailed hydraulic design. For optimal performance the manifold would be divided into manageable units (zones) to reduce pumping requirements and allow for better control of irrigation rates.

Hydraulically operated ‘pop-up’ sprinklers would be fitted at determined locations throughout each zone (depending on distribution radius and coverage requirements) with the ultimate aim of delivering consistent and complete coverage to the area serviced. There are a large number of sprinkler types available on the market suitable to this type of ‘agricultural’ application.

There are some issues with pop-up sprays that can be potentially problematic, particularly when used in areas with high maintenance needs. Pop-up sprays raise under hydraulic pressure and fall below the ground surface on completion of each irrigation cycle, however, experience notes that the extension tubes often “stick” after they have worn in and can be easily damaged by maintenance machinery (mowers) if not properly re-seated. Also, animal contact with exposed fittings can be troublesome; therefore it is important to ensure that sprinklers are adequately protected from damage.

Surface irrigation using fixed (impact) sprinklers

The use of fixed impact sprinklers on a raised tripod is a much more traditional method of open space irrigation on sites such as golf courses and public parks. Similar to the pop-up arrangement, the system would comprise the installation of a buried (PVC/HDPE) distribution manifold beneath the entire irrigation zone to be serviced. Because impact sprinklers generally operate at ‘relatively’ higher pressures and generate a larger throw-radius, the sprinkler intervals would be larger (less sprays), but would still require detailed hydraulic design.

Impact sprinklers typically comprise a one or two nozzle arrangement allowing for both long and short throw coverage. They typically operate in a 360° configuration, but can easily be limited to other arrangements (e.g. 180° or 90°) for edge or corner operations. Even irrigation application is marginally more difficult with impact sprinkler systems and careful irrigation design is required to ensure optimal performance.

Other than controlling coverage, the main issue associated with impact sprinkler systems is spray-drift. Because of the style of discharge, impact sprinkler are prone to generating fine sprays or aerosols which can be readily captured in wind current. This presents a risk for off-site impacts (including unintended contact risk). These risks can be managed by ensuring adequate buffers are maintained between the irrigation area(s) and receptors, or by increasing the droplet size and reducing the throw radius of the individual sprinklers.

A logical alternative would be the use of a low-profile travelling irrigator (spray or drip) system.

Surface irrigation using ‘travelling’ irrigator

Commercial-scale travelling irrigators are able to reliably irrigate large areas of pasture at controlled soil loading rates to ensure even irrigation distribution and avoid problems with waterlogging or runoff. An electronic control system can be employed and will enable the programing of the irrigator so that correct doses of recycled water are applied. A detailed hydraulic and system design report should be prepared once final approval of the subdivision has been obtained and system selection is being undertaken.

Travelling irrigator systems suitable for large-scale agricultural purposes may include ‘centre-pivot’ or ‘lateral move’ designs.

Centre-pivot irrigation is a form of overhead sprinkler irrigation consisting of several segments of pipe (usually galvanized steel or aluminium) joined together and supported by trusses, mounted on wheeled towers with sprinklers positioned along its length. The machine moves in a circular pattern and is fed with water from the pivot point at the centre of the circle. Agricultural centre-pivots are typically up to 500 metres in length (circle radius) with the most common size being the standard 400m (1/4 mile) machine. This presents an impediment for the Site (cost) because the required irrigation area(s) would require a substantially smaller system (90-100m radius).

To achieve uniform application, centre-pivots require an even emitter flow rate across the radius of the machine. Since the outer-most spans (or towers) travel farther in a given time period than the innermost spans, nozzle sizes are smallest at the inner spans and increase with distance from the pivot point. Most systems now have drops hanging from a u-shaped pipe at the top of the pipe with sprinkler heads positioned ~0.9m (at most) above the crop, thus limiting evaporative losses and wind drift.

As noted, the major drawback of a centre-pivot irrigation system for the Site is expected to be cost. Centre-pivot irrigation systems are highly efficient in delivering water to plant/soil surfaces at appropriate loading rates to prevent soil saturation and enhance vegetative growth. However, they can be expensive to install and operate, with substantial management input required to ensure ongoing operational performance. Given the ‘relatively’ small area(s) requiring irrigation (<5ha max), alternative broad-area irrigation techniques may be more appropriate.

Lateral move irrigation systems are more common for agricultural applications in Australia. The principles are effectively the same as centre-pivot systems; however, the irrigation boom moves in one linear direction making it more suitable for rectangular irrigation areas. A typical ‘run’ would be between 500m-1,000m in length.

Lateral move (travelling) irrigation systems are available in a range of scales and are commonly used in other industries (i.e. turf farming, racetracks etc.). Depending on the level of operator involvement, intended systems can be fixed (one run back and forth continuously) or relocatable. Figure 19 (following page) shows a number a systems available (at variable scales).

Because of the flexibility in sizing and design, this type of system would likely be more suited to operation at the Site with the benefit of lower capital cost compared with fixed and centre-pivot systems and the ability to move the irrigator from site to site.

Figure 19: Lateral move travelling irrigator (examples)

Surface irrigation of treated effluent has the potential to create public health impacts via direct or indirect contact with contaminated surfaces. The NSW DEC (2004) and AGWR (2006) guidelines provide recommendations for irrigation of recycled effluent based on treated effluent quality and the intended end use of the land being irrigated. At present, grazing occurs within the land designated RU1 to the north of the Site (remnant parcel) where the proposed irrigation scheme could be located. This review assumes that this land use will continue.

For agricultural food production (pasture and/or fodder) for grazing animals (excluding pigs and dairy animals), both guidelines recommend:

- Secondary effluent quality (20/30 standard) as a minimum.
- Disinfection using chemical control methods (i.e. chlorine) or detention (i.e. lagoon).
- Helminth (worm) reduction controls comprising >25 days detention (i.e. lagoon) or 'other management controls'[4].

Additional (on-site) preventative measures are also recommended, these include:

- No public access during irrigation.
- 25-30m buffer to nearest point of public access.
- Spray-drift controls (sprinkler selection, wind-speed shut-off etc.).
- Excluding grazing animals for >5 days after last irrigation cycle (withholding period).

[4] If lagoon treatment is not preferred, this may include an 'equivalent filtration process' or veterinary / husbandry controls acceptable to the NSW Department of Primary Industries for the subject species.

Implementation of these recommended controls will be sufficient to manage any residual risk associated with the irrigation practice.

Finally, surface irrigation of treated effluent (recycled water) is not considered appropriate during periods of excessive rainfall; therefore, additional wet-weather storage (nominally >10 days) is required to retain treated effluent during those periods. A secondary dam located on the remnant parcel (north of the dwelling) could be used for this purpose, assuming a 10-day requirement between 500kL and 800kL.

8.3.3.2 Option 2 – Urban Residential reuse

This option would comprise storage and reticulation for dedicated (third-pipe) supply of recycled water to each connected residence with the (Stage 1 & 2) subdivision.

Reticulation (Supply)
Dual reticulation or 'third pipe' schemes deliver highly treated recycled water to residential areas through a separate purple pipe. This pipe supplies recycled water that is suitable for use in toilet flushing, garden irrigation and cold-water supply to washing machines.

The plumbing network consists of two pipelines and two meters at each property; separate pipelines, meters and taps for the recycled water and drinking water supplies. An (external) purple recycled water tap would be available on each property and would require a tap key to access. All plumbing work involving recycled water fixtures needs to be carried out by a licenced plumber in accordance with Plumbing Code of Australia (PCA), Australian Standards AS/NZS3500 Plumbing and Drainage and local (utility) guidelines. Recycled water plumbing requires particular care to ensure that there are no cross connections between potable and recycled water supplies.

All new homes built in suburbs with recycled water supply would have to undergo a series of inspections by NSW Fair Trading at various stages of construction.

If you don't have a purple tap key, you should contact your builder. Alternatively, you can use a compatible ‘anti-vandal’ tap key, available at most hardware stores.

Demand
As part of any Recycled Water Supply scheme a Site water balance will need to be prepared to forecast non-potable water requirements, production and storage necessary (e.g., top-up and non-potable water demand volumes) in the scheme, and key information such as future sewage production, drinking and non-potable water demands, weather conditions and system losses.

From preliminary analysis, it is expected that a proposed community recycled water scheme would be sustainable for ‘Kyeema’, with recycled water generation sufficient to meet non-potable water demands on an annual basis. Of course, due to the fluctuating nature of on-lot recycled water usage (particularly low outdoor usage during winter months) there will likely be a requirement for construction of storages to hold water over to the higher use period.

Whilst this volume is presently unknown, we can assume it would be in the vicinity of 30% the annual requirement (i.e. 65 lots @ 200kL/dwelling), resulting in a required storage volume of ~3.9ML. The secondary dam located on the remnant parcel (north of the dwelling) could be used for this purpose.

Quality
The AGWR (2006) guidelines provide recommendations for urban (non-potable) reuse of recycled water.

For restricted (dual reticulation) on-lot usage for toilet flushing, cold water washing machine supply and controlled external (garden) usage, the guidelines require:

- Tertiary effluent quality (10/10 standard) as a minimum.
- Disinfection using multiple barrier control methods (i.e. chlorine and UV) or membrane filtration.

Additional (on-lot) preventative measures are also recommended, these include:

- Strengthened cross-connection controls.
- Signage.
- Householder and community education.

End User Agreements

Where a third party recipient (property owner) is involved, the success of a recycled water scheme may depend on how arrangements between suppliers and recipients of recycled water schemes are undertaken. The key for both suppliers and customers of recycled water is risk prevention to ensure that harm or damage is avoided in the first place. This requires having an effective management system to identify and control risks to the public and the environment at the point of use of the treated recycled water.

User agreements between the supplier of recycled water and the recipient/s sets out the negotiated terms under which the scheme will operate. The recycled water user agreement may establish:

- the rights and obligations of the parties
- who should perform certain duties, when, and who bears the costs
- who bears the risks associated with supply and use of the recycled water
- who should insure or be indemnified against claims in relation to these risks, and
- the commercial terms under which recycled water is supplied.

9 Preliminary Assessment of Servicing Options

9.1 Assessment Criteria

Details presented in earlier sections of this report have discussed the various strengths and limitations of potential servicing options for the 'Kyeema' subdivision. Particular reference has been made to a number of key assessment criteria for each alternative. These are reproduced here along with additional supporting information.

9.1.1 Relative Cost

Preliminary costs have been derived from recent information for similar sized systems in NSW (where available) or elsewhere. Functional and concept design costings represent +/-30% possibility for variation from standard costs.

9.1.2 Suitability for Staged Servicing

Because of the expected timeframe for build-out of a staged subdivision such as Kyeema, suitability and capability for staged implementation is a major driver for selection of alternative servicing solutions. Factors considered when examining staging capability including:

- Likely upfront capital costs for on-lot, reticulation, treatment, storage and irrigation/reuse;
- Ability to cope with fluctuations between current and ultimate design flows;
- Economies of scale; and
- Relative number of dwellings likely to be serviced (bang for buck).

9.1.3 Integration (Compatibility with Alternate Servicing)

Yass Valley Council and others have (and most likely still are) examined alternatives to provide reticulated services (water and sewerage) to Gundaroo Village and surrounding areas to improve services and address ongoing environmental concerns (failing on-site systems and groundwater vulnerability). Additionally, the proposed subdivision includes 'investigation area' for future expansion of the Kyeema development (remnant parcel) which may include alternate land uses (i.e. commercial) or higher density residential development (increased lot yield).

As part of the assessment, we have examined the potential 'flexibility' of servicing options to integrate with alternative servicing scenarios.

Example: If Kyeema were to proceed with a decentralised servicing option (i.e. STEP/STEG) and Gundaroo Village were to be sewered at some future date, it would be possible for the community treatment system to be re-configured such that excess wastewater or recycled water could be discharged (under license) to the Council sewer. This would free up the remnant parcel for further development and potentially allow for a higher density of development.

9.1.4 Deliverability

Cursory examination was given to the likely capability for delivering each of the identified options within the context of available technology/service provider experience, expertise and project history. Consideration is also given to the difficulty associated with construction and the suitability for options to integrate successfully with existing or proposed management frameworks.

9.1.5 Customer/Stakeholder Acceptance

Finally, there is community sentiment regarding the provision of an "appropriate" wastewater servicing solution for Gundaroo. It is likely that long-term residents will see on-site wastewater management as a preferred alternative, keeping with the 'rural village' feel; however, newer (or potential) residents and other stakeholders may want to see the town develop a comparable level of service to urban areas and feel that a more conventional sewerage approach is warranted or desirable.

The YVC Town and Villages Study (2010) reports that "the Gundaroo community have previously indicated that they are generally unsupportive of a reticulated sewerage system for the village" (p.58).

In examining the identified options, general consideration was given to the likely response from owners and other stakeholders to the various alternatives.

Table 3 presents the results of our preliminary assessment of each of the identified options for wastewater servicing at Kyeema. The information presented is primarily qualitative, or in the case of cost "relative", and is therefore presented as a range of numeric values, with the following emphasis:

-3 strong limiting constraint	+3 strong positive opportunity
-2 moderate limiting constraint	+2 moderate positive opportunity
-1 slight limiting constraint	+1 slight positive opportunity
0 neutral constraint/opportunity	

Table 3: Results of preliminary options assessment

Assessment Criteria		On-Site Wastewater Management	Conventional Gravity Sewer	Pressure Sewer + Community Treatment	Common Effluent Sewer + Community Treatment
Relative Cost	Capital	+2 ($9K-$23K)[5]	-2 ($22K-$30K)[6]	-1 (~$21K)	-1 (~$22.5k)[7]
	Operational	+2 ($300-500 pa)	+1 ($595 pa)[8]	0 (~$800 pa)[9]	+1 (~$600 pa)[9]
Staged Servicing		+2	-2	-1	+2
Integration		0	+1	+2	+2
Deliverability		+2	+2	+1	+1
Acceptance		-2	-1	0	0
Overall		Strong Positive	Slight Negative	Moderate Positive	Moderate-Strong Positive

[5] See section 7.4 discussion; assumes secondary treatment with (irrigation) land application.
[6] Preliminary (per connection) cost from YVC meeting minutes (25/3/15); includes reticulation ($16K-$24K) and dwelling connection (average $6K) for all (existing and future) dwellings in Gundaroo.
[7] Includes on-lot monitoring system (telemetry).
[8] YVC Final Fees and Charges Operational Plan – sewer (2014-2015).
[9] Includes on-lot components, reticulation and community irrigation scheme costs.

9.2 Preferred Servicing Solution

W&A consider that of the four servicing options considered the (i) on-site solution and (ii) community (STEP/STEG) solution present the greatest opportunity for implementation at the 'Kyeema' subdivision.

9.2.1 On-site Servicing Solution

As described, the on-site servicing solution would maintain the 'status quo' within the Gundaroo Village. The preferred solution for a typical residential dwelling in the proposed subdivision would comprise installation of a NSW Health accredited secondary treatment system (AWTS or comparable technology) suitable for treating all wastewater from the dwelling up to a maximum load of 2,000L/day (10EP). Final treatment system selection would come down to owner preference and (most likely) pricing. Secondary treated (and disinfected) effluent would then be applied to the land surface within a dedicated area of each individual lot. Given the minimum lot size of 2,000m^2, dwelling sizes up to 10EP are expected to be able to be accommodated, with sufficient area for reserve (if required).

Cost, deliverability and ability to manage staged servicing are all moderate positive drivers for implementing the on-site servicing approach at Kyeema. However, both community and stakeholder evidence suggests a wavering support for the installation of additional on-site wastewater systems on the periphery of Gundaroo Village. Several studies and reports have indicated past performance of individual on-site systems has been poor in the area and may be contributing to local groundwater impacts and degrading the long-term value of the non-potable water resource. While somewhat anecdotal, this information may impede the implementation of the solution.

All expenditure (capital and operational) for implementation of this solution would be borne by the individual homeowner.

Approvals for this approach would be coordinated (by Council) under the LG Act (1993); Section 68 process, with individual homeowners required to seek approval to install an on-site wastewater system to service their property and also an annual approval to operate the system. The Approval to Operate would be registered to the property owner and would not be transferable.

Performance management of on-site wastewater systems is undertaken by Yass Valley Council under their strategic policy framework, with risk-based inspection and monitoring undertaken of registered systems to ensure ongoing compliance with environment and public health requirements. This approach is well-established within the LGA and would not require any changes to existing regulation or practice.

The individual homeowner would retain responsibility for managing their individual on-site wastewater system and would be required to enter into a contractual agreement with a licensed system maintainer (service agent) for regular (quarterly) maintenance of system components.

9.2.1.1 Summary

Implementation of an on-site servicing solution for the Kyeema subdivision would:

- be consistent with existing consent, planning and policy arrangements for the locality;
- cost-effectively deliver the required level of service to meet homeowner and stakeholder expectations;
- provide flexibility to the homeowner and developer (proponent) in terms of staged implementation; cost allocation; system selection and acceptance;

- provide opportunity for controlled (landscape) reuse of treated water on individual properties, potentially off-setting non-potable water requirements (750L/day – 1,200L/day depending on dwelling size)[10]; and
- integrate with existing management frameworks.

However, the solution does not directly address the underlying (community) concern that continued (and expanded) use of on-site wastewater management systems in Gundaroo presents a potential environment and public health risk. This is particularly relevant where periodic inundation or shallow groundwater conditions occur.

Council has identified a number of possible approaches to addressing the concerns, including system inspections; bore identification and monitoring and delivery of a reticulated sewerage service to the Gundaroo Village.

Implementation of an on-site servicing solution for the Kyeema subdivision would present limited opportunity for (future) integration with a Gundaroo sewerage network.

9.2.2 Community Servicing Solution

9.2.2.1 Collection and Reticulation

CGS (and MGS) is not considered the most appropriate community reticulation option for Kyeema. Conventional reticulation systems, whilst technically feasible, require substantial capital expenditure to design and construct. The significance of the expenditure is often compounded by difficult terrain or hydraulic control requirements (e.g. trenching depths). Much of this expenditure must be completed at the beginning of subdivision development, resulting in a large amount of dedicated infrastructure to be operated (and maintained) during an extended payback period as subdivision buildout occurs.

CGS can also limit available treatment technologies to only those suitable for a combined wastewater stream. Additionally this type of reticulation would be subject to a much larger hydraulic load due to required design allowances for storm inflows and groundwater infiltration (I/I), adding substantially to upfront capital costs. Cost, acceptance and ability to manage staged servicing are all moderate negative drivers for implementing CGS/MGS reticulation at Kyeema. Cursory examination of this option has also been investigated by YVC; however, for various reasons it was not progressed beyond preliminary costing analysis.

On preliminary assessment, a PS community reticulation system is considered suitable for further examination as an alternative wastewater servicing solution for Kyeema. Implementation of a PS reticulation network allows for some delay in capital expenditure as individual (on-lot) components can be added to the network incrementally as the subdivision develops. However, a PS would require a higher level of treatment at the treatment plant site to accommodate the substantial macerated solids load from the individual on-lot storage vessels. Integration, deliverability and ability to manage staged servicing are all moderate positive drivers for implementing PS reticulation at Kyeema. Sydney Water and ACTEW (and SCA to a lesser extent) all have positive experience in the construction and operation of pressure sewer systems, with the technology readily available and well understood.

A CES (STEP/STEG) community reticulation system is considered the preferred collection and reticulation option for Kyeema. The STEP/STEG option provides the added benefit of primary treatment of effluent on-lot, reducing the hydraulic requirements (solids control and minimum velocities) of the effluent sewer, and overall treatment requirements at the community treatment plant. Although this option is relatively more expensive than the CGS and PS options it provides

[10] This benefit could be further enhanced by the implementation of a split-waste system design (i.e. GTS) as described in Section 7.2.2.

a great deal more flexibility in design, construction and operation, making it well suited for Kyeema.

Maintenance costs, integration, deliverability and ability to manage staged servicing are all strong positive drivers for implementing CES (STEP/STEG) reticulation at Kyeema. Whilst we are not able to comment specifically on the acceptability of this approach, given that there are no comparable examples in the locality, existing property owners are familiar with on-site treatment tanks, and day-to-day maintenance responsibilities would be similar to what presently occurs and the knowledge that overall system management responsibility would rest with a new (or established) management entity would greatly improve service confidence.

9.2.2.2 Treatment

The preferred treatment technology for a (STEP/STEG) common effluent sewer system at Kyeema is a commercial media or 'textile' filter. Because of their modular nature, textile filters can be expanded progressively as the needs of the community increase. This presents an attractive option for Kyeema which is likely to experience progressive growth for a number of years. This also provides the flexibility that if a significant increase in demand were to occur (i.e. connection of Gundaroo Village) the system would be readily expandable to meet the demand.

The use of on-lot primary treatment (interceptor) tanks greatly reduces the need for large primary facilities at the centralised treatment location and utilising a 'recirculating' treatment process results in exceptional treatment performance (high quality effluent) and significant flexibility in nutrient removal. The system would be capable of reliably producing secondary effluent quality suitable for controlled land application within a dedicated irrigation area.

Figure 20 (below) presents a schematic of an 'example' commercial textile filter STP layout.

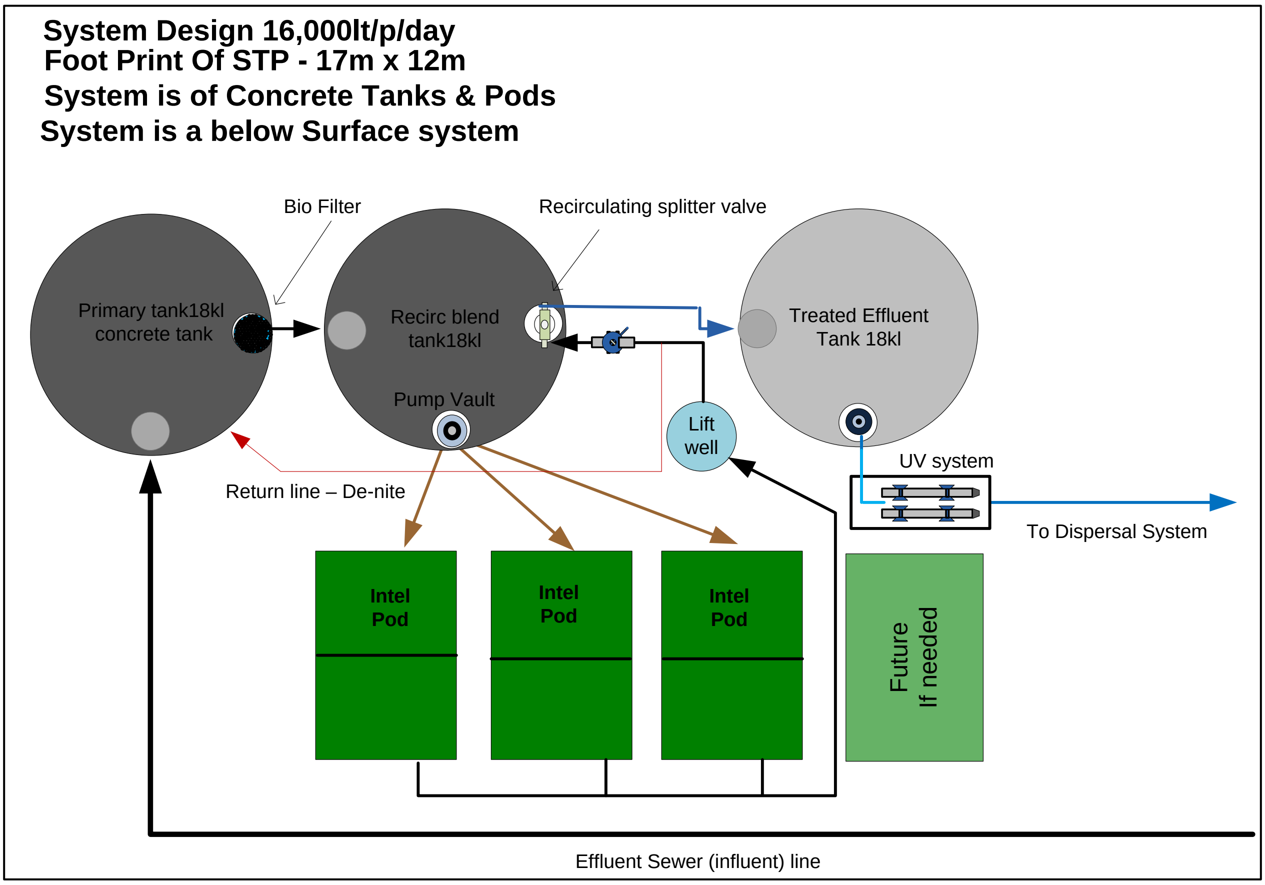


Figure 20: Sample STP arrangement (16kL/day)

9.2.2.3 Effluent Management

We consider that local treatment, storage and effluent irrigation would be the most suitable effluent management approach for a staged development scenario. The construction of a local treatment, storage and irrigation option provides an important opportunity for the sustainable reuse of resources at, or near, the point of generation, in keeping with the principles of ecologically sustainable development (ESD) and integrated water cycle management (ICWM). The local availability of high quality effluent would provide a reliable and sustainable resource for property managers and reduce the reliance on local groundwater or surface water supplies for irrigating managed (grazing) pasture.

For Kyeema, the preferred solution would comprise the installation of a surface irrigation system within a dedicated area of the remnant parcel to the north of the subdivision. Preliminary analysis suggests an area ~4ha would be required to service the entire subdivision (at build-out). Using a fixed impact sprinkler system or lateral-move travelling irrigators, the irrigation area could be progressively installed as additional capacity becomes necessary. This option would also require construction of a wet-weather storage facility (500kL-800kL) within vicinity of the irrigated land.

Development and implementation of an Irrigation Management Plan (IMP) for the proposal in accordance with AGWR (2006) would ensure safe and sustainable operation of the system, whilst also allowing for the continued use of the area for animal grazing. Assuming the availability of disinfected secondary quality effluent for irrigation purposes, risk management protocols would only require withholding of stock from the managed grazing pasture for 5 days following the last irrigation cycle.

9.2.2.4 Costs

Off-lot capital expenditure for construction of the community servicing solution, up to and including the boundary kit on each subdivision lot (CES reticulation, STP, storage and irrigation scheme) would be borne by the developer (proponent) and/or management entity.

Off-lot operational expenditure for ongoing maintenance/management of the community servicing solution, up to and including the boundary kit on each subdivision lot would be borne by the developer (proponent) and/or management entity.

All on-lot expenditure (capital and operational) for implementation of this community servicing solution would be borne by the individual homeowner.

9.2.2.5 Consent

Consent for the implementation of a community servicing solution at Kyeema will require approval from Yass Valley Council under the zoning and community title provisions of the local environmental plan (LEP).

Operating approvals for this approach would be coordinated (by Council) under Section 68 (Part B) of LG Act 1993 for the installation and operation of a sewage management system, including private recycled water schemes, that produce and/or use recycled water. The NSW DPI (Office of Water) and NSW Health would act in a referral capacity to Council for any application.

9.2.2.6 Management Responsibility

Ongoing operation of a community servicing solution would require establishment of an authorised management entity (i.e. body corporate, strata committee etc.) who would assume responsibility for the day-to-day operation of the scheme.

Whilst this approach has become more common in NSW in recent years through the WICA (2006) licensing process, it is much less standard at the smaller subdivision scale. Commonly these smaller systems are regulated under the local planning scheme (LEP) and DA process through the application of consent conditions.

As guidance, the US EPA (2003) has developed a system of management models for on-site and decentralised sewage management systems with the aim of maximising the management and performance of these systems. Each of the models represents an increasing removal of householder responsibility for system maintenance and management, as well as increasing sensitivity of the environment in which the systems are located.

The preferred model is discussed here as an example of the type of management approach the developer (proponent) could consider for Kyeema.

*The **Responsible Management Entity (RME) – Operation and Maintenance** Model is useful where the servicing solution must meet specific water quality requirements (environmental sensitivity) or public health is a priority. Frequent and highly reliable operation and maintenance is required to ensure optimal operating conditions are maintained. Issuing the operating permit (Approval to Operate) to an RME instead of the property owner provides greater assurance of control over performance compliance.*

For a service fee, an RME takes responsibility for the operation and maintenance of key system components. In the case of Kyeema, this may include the CES reticulation, STP, storage and irrigation scheme. This approach can reduce the number of permits and the administration functions performed by the regulatory authority. System failures are also reduced as a result of routine and preventive maintenance.

Under the preferred servicing scenario, the homeowner would remain responsible for all on-lot components (individual interceptor tanks and house drains).

9.2.2.7 Summary

Implementation of a community servicing solution for the Kyeema subdivision would:

- be consistent with existing consent, planning and policy arrangements for the locality;
- cost-effectively deliver the required level of service to meet homeowner and stakeholder expectations;
- provide additional flexibility to the developer (proponent) in terms of staged implementation; cost allocation; system selection and acceptance;
- provide opportunity for controlled (agricultural) reuse of treated water at a dedicated location on the property;
- address the underlying (community) concern that continued (and expanded) use of on-site wastewater management systems in Gundaroo presents a potential environment and public health risk;
- provide support for reducing minimum lot sizes for subdivision lots[11] (presently 2,000m^2);
- integrate with existing management frameworks; and
- present a strong opportunity for (future) integration with a Gundaroo sewerage network.

[11] Provision of reticulated sewerage is only one consideration for increased development density. Other planning matters may take precedence.

10 Conclusions and Recommendations

One (1) on-site solution and three (3) community sewerage solutions were investigated during this desktop analysis. Each option was examined for its suitability as a long-term and sustainable wastewater servicing solution for the proposed ‘Kyeema’ subdivision with specific reference to likely rollout timeframes, practicality for installation and maintenance, limitations and preliminary cost estimates.

Of the options investigated W&A suggest that on preliminary consideration either the on-site servicing approach or a STEP/STEG based common effluent sewer (CES) scheme with local treatment, storage and effluent irrigation would be the servicing solutions most likely to meet the specific project objectives. However, other systems identified for potential further consideration include vacuum and pressure sewer reticulation with local treatment, storage and effluent irrigation.

A comparison of the two (2) preferred options along with the conventional (sewerage) approach is summarised in Table 4.

Table 4: Comparison of options

	On-Site Servicing Solution	Community Servicing Solution	Conventional Servicing Solution
Number of Lots	65		
Per Lot Capital Cost (mid-range)	$16,000	$22,500	$24,000
Capital Cost Borne by	Home Owner	Developer (off-lot) Home Owner (on-lot)	Developer
Maintenance Cost Borne by	Home Owner	Developer (off-lot) Home Owner (on-lot)	Developer
Suitability for Staged Servicing	High	Medium	Medium
Deliverability	High	High	Low-Medium
Customer Acceptance	Medium	Medium	High
Ultimate Responsibility	Home Owner Council	Management Entity Council	Council

The final decision for the approach taken will rest with the developer (proponent) and will reflect the advice provided here, along with a range of other considerations.

While the on-site servicing solution represents the least-cost option for the Kyeema subdivision, it does present some challenges in terms of reliability of service, community acceptance and environmental protection. YVC report that “a high number of AWTS systems in Gundaroo do not appear to be serviced regularly”…and “there is anecdotal evidence of issues with the operation of septic tanks and absorption trenches"[12]. These concerns are not insurmountable and can be readily addressed through appropriate system selection and design, homeowner education, planning (density) controls and Council management.

Whilst marginally higher cost; the community servicing approach is supported by Agency stakeholders (DPI, OEH and Planning NSW) and Council, and represents industry best-practice for small-scale (decentralised) wastewater servicing. Indications are that a (STEP/STEG) community servicing solution would address many environmental and public health concerns raised by the Gundaroo community about the proposal. Further, adoption of this approach provides significant flexibility in the rollout of servicing to the subdivision, sharing costs between the developer (proponent) and the homeowner, and providing a reliable opportunity for cross-connection with a (potential future) Gundaroo sewerage scheme.

Lastly, we highlight that the cost estimates provided here are preliminary only, and suitable for initial consideration of options. The estimates should be revised and tightened as more information comes to hand and the subdivision design proceeds.

[12] Planning for Gundaroo, Attachment A, December 2014 Council Report.

11 References (Cited and Used)

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Appendix A:
Preliminary Water & Nutrient Balances

Nominated Area Water Balance & Storage Calculations

Site Address: **Kyeema' - Stage 1 & 2 (Minimum scenario)**

INPUT DATA

Design Wastewater Flow	Q	50,000	L/day	Expected (minimum) daily load from subdivision
Design Percolation Rate	DIPR	28	mm/week	Weekly Design Infiltration Percolation Rate (DIPR)
Daily DPR		4.0	mm/day	Assumed from Soil and Land Consulting's Capability Assessment for On-Site Effluent Disposal Report (P. Fogarty, 2011)
Nominated Land Application Area	L	15,000	m sq	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Crop Factor	C	0.4-0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Runoff Coefficient		0.8	untiless	Proportion of rainfall that percolates into soil profile (remainder runs off)
Rainfall Data	Canberra airport (070014)			Mean Monthly Data (1939-2008)
Evaporation Data	Canberra airport (070014)			Mean Monthly Data (1939-2008)

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days in month	D	\	days	31	28	31	30	31	30	31	31	30	31	30	31	**365**
Rainfall	R	\	mm/month	59.3	56.1	50.8	46.4	45.1	41.1	41.3	46.6	52.3	62.7	64.2	52.5	**618.4**
Evaporation	E	\	mm/month	257.3	210	173.6	111	68.2	48	52.7	80.6	111	161.2	195	248	**1716.6**
Daily Evaporation				8.3	7.5	5.6	3.7	2.2	1.6	1.7	2.6	3.7	5.2	6.5	8.0	
Crop Factor	C			0.80	0.80	0.80	0.40	0.40	0.40	0.70	0.70	0.70	0.80	0.80	0.80	
OUTPUTS																
Evapotranspiration	ET	ExC	mm/month	206	168	139	44	27	19	37	56	78	129	156	198	**1257.97**
Percolation	B	(DPR/7)xD	mm/month	124.0	112	124.0	120.0	124.0	120.0	124.0	124.0	120.0	124.0	120.0	124.0	**1460.0**
Outputs		ET+B	mm/month	329.8	280	262.9	164.4	151.3	139.2	160.9	180.4	197.7	253.0	276.0	322.4	**2718.0**
INPUTS																
Retained Rainfall	RR	R*runoff coef	mm/month	47.44	44.88	40.64	37.12	36.08	32.88	33.04	37.28	41.84	50.16	51.36	42	**494.72**
Effluent Irrigation	W	(QxD)/L	mm/month	103.3	93.3	103.3	100.0	103.3	100.0	103.3	103.3	100.0	103.3	100.0	103.3	**1216.7**
Inputs		RR+W	mm/month	150.8	138.2	144.0	137.1	139.4	132.9	136.4	140.6	141.8	153.5	151.4	145.3	**1711.4**
STORAGE CALCULATION																
Storage remaining from previous month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the month	S	(RR+W)-(ET+B)	mm/month	-179.1	-141.8	-118.9	-27.3	-11.9	-6.3	-24.5	-39.8	-55.9	-99.5	-124.6	-177.1	**-370.5**
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Maximum Storage for Nominated Area	N		mm	**0.00**												
	V	NxL	L	**0**												
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	5489	5954	6974	11785	13455	14108	12124	10829	9624	7643	6677	5528	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: **14,108** m^2

Nutrient Balance

Site Address: Kyeema' - Stage 1 & 2 (Minimum scenario)

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 27,280 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake				
Hydraulic Load	50,000	L/Day	Crop N Uptake	260	kg/ha/yr	which equals	71 $mg/m^2/day$
Effluent N Concentration	20	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8 $mg/m^2/day$
% Lost to Soil Processes (Geary & Gardner 1996)	0.15	Decimal	**Phosphorus Sorption**				
Total N Loss to Soil	150,000	mg/day	P-sorption result	210	mg/kg	which equals	2,352 kg/ha
Remaining N Load after soil loss	850,000	mg/day	Bulk Density	1.4	g/cm^3		or
Effluent P Concentration	8	mg/L	Depth of Soil	0.8	m		15600 kg/ha
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal	which equals	1392.857143 mg/kg

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			**Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)**		
Nitrogen	11,933	m^2	Nominated LAA Size	170,000	m^2
Phosphorus	27,280	m^2	Predicted N Export from LAA	-4,109.75	kg/year
			Predicted P Export from LAA	-763.84	kg/year
			Phosphorus Longevity for LAA	-55	Years
			Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**170000**	m^2			
Daily P Load	0.4	kg/day	→ Phosphorus generated over life of system	7300	kg
Daily Uptake	1.3972603	kg/day	→ Phosphorus vegetative uptake for life of system	0.150	kg/m^2
Measured p-sorption capacity	0.2352	kg/m^2			
Assumed p-sorption capacity	0.118	kg/m^2	→ Phosphorus adsorbed in 50 years	0.118	kg/m^2
Site P-sorption capacity	19992.00	kg	→ Desired Annual P Application Rate	909.840	kg/year
			which equals	2.49271	kg/day
P-load to be sorbed	-364.00	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. Conservative estimate based on work by Geary & Gardner (1996) and Patterson (2002).

[3]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Nominated Area Water Balance & Storage Calculations

Site Address: **Kyeema' - Stage 1 & 2 (Maximum scenario)**

INPUT DATA

Design Wastewater Flow	Q	80,000	L/day	Expected (maximum) daily load from subdivision
Design Percolation Rate	DIPR	28	mm/week	Weekly Design Infiltration Percolation Rate (DIPR)
Daily DPR		4.0	mm/day	Assumed from Soil and Land Consulting's Capability Assessment for On-Site Effluent Disposal Report (P. Fogarty, 2011)
Nominated Land Application Area	L	23,000	m sq	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Crop Factor	C	0.4-0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Runoff Coefficient		0.8	untiless	Proportion of rainfall that percolates into soil profile (remainder runs off)
Rainfall Data	Canberra airport (070014)			Monthly Data (1939-2008)
Evaporation Data	Canberra airport (070014)			Monthly Data (1939-2008)

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days in month	D	\	days	31	28	31	30	31	30	31	31	30	31	30	31	**365**
Rainfall	R	\	mm/month	59.3	56.1	50.8	46.4	45.1	41.1	41.3	46.6	52.3	62.7	64.2	52.5	**618.4**
Evaporation	E	\	mm/month	257.3	210	173.6	111	68.2	48	52.7	80.6	111	161.2	195	248	**1716.6**
Daily Evaporation				8.3	7.5	5.6	3.7	2.2	1.6	1.7	2.6	3.7	5.2	6.5	8.0	
Crop Factor	C			0.80	0.80	0.80	0.40	0.40	0.40	0.70	0.70	0.70	0.80	0.80	0.80	
OUTPUTS																
Evapotranspiration	ET	ExC	mm/month	206	168	139	44	27	19	37	56	78	129	156	198	**1257.97**
Percolation	B	(DPR/7)xD	mm/month	124.0	112	124.0	120.0	124.0	120.0	124.0	124.0	120.0	124.0	120.0	124.0	**1460.0**
Outputs		ET+B	mm/month	329.8	280	262.9	164.4	151.3	139.2	160.9	180.4	197.7	253.0	276.0	322.4	**2718.0**
INPUTS																
Retained Rainfall	RR	R*runoff coef	mm/month	47.44	44.88	40.64	37.12	36.08	32.88	33.04	37.28	41.84	50.16	51.36	42	**494.72**
Effluent Irrigation	W	(QxD)/L	mm/month	107.8	97.4	107.8	104.3	107.8	104.3	107.8	107.8	104.3	107.8	104.3	107.8	**1269.6**
Inputs		RR+W	mm/month	155.3	142.3	148.5	141.5	143.9	137.2	140.9	145.1	146.2	158.0	155.7	149.8	**1764.3**
STORAGE CALCULATION																
Storage remaining from previous month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the month	S	(RR+W)-(ET+B)	mm/month	-174.6	-137.7	-114.4	-22.9	-7.4	-2.0	-20.0	-35.3	-51.5	-95.0	-120.3	-172.6	**-339.8**
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Maximum Storage for Nominated Area	N		mm	**0.00**												
	V	NxL	L	**0**												
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	8782	9527	11159	18856	21528	22573	19398	17326	15398	12229	10684	8845	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: **22,573** m^2

Nutrient Balance

Site Address: **Kyeema' - Stage 1 & 2 (Maximum scenario)**

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 43,647 m^2

INPUT DATA [1]

Wastewater Loading				Nutrient Crop Uptake					
Hydraulic Load		80,000	L/Day	Crop N Uptake	260	kg/ha/yr	which equals	71	mg/m^2/day
Effluent N Concentration		20	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8	mg/m^2/day
% Lost to Soil Processes (Geary & Gardner 1996)		0.15	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil		240,000	mg/day	P-sorption result	210	mg/kg	which equals	2,352	kg/ha
Remaining N Load after soil loss		1,360,000	mg/day	Bulk Density	1.4	g/cm^3		or	
Effluent P Concentration		8	mg/L	Depth of Soil	0.8	m		15600	kg/ha
Design Life of System		50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal	which equals	1392.857143	mg/kg

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nitrogen	19,092	m^2	Nominated LAA Size	170,000	m^2
Phosphorus	43,647	m^2	Predicted N Export from LAA	-3,923.60	kg/year
			Predicted P Export from LAA	-676.24	kg/year
			Phosphorus Longevity for LAA	-72	Years
			Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE
STEP 1: Using the nominated LAA Size

Nominated LAA Size	170000	m^2				
Daily P Load	0.64	kg/day	→ Phosphorus generated over life of system		11680	kg
Daily Uptake	1.3972603	kg/day	→ Phosphorus vegetative uptake for life of system		0.150	kg/m^2
Measured p-sorption capacity	0.2352	kg/m^2				
Assumed p-sorption capacity	0.118	kg/m^2	→ Phosphorus adsorbed in 50 years		0.118	kg/m^2
Site P-sorption capacity	19992.00	kg	→ Desired Annual P Application Rate		909.840	kg/year
				which equals	2.49271	kg/day
P-load to be sorbed	-276.40	kg/year				

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. Conservative estimate based on work by Geary & Gardner (1996) and Patterson (2002).

[3]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.