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Recycled water — case study: Gerringong Gerroa

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Abstract

Gerringong and Gerroa are coastal towns with 3,500 permanent local residents. They are located 120 km from Sydney on the southeast coast of Australia. The region is a popular holiday destination and very well known for its diversified flora and fauna, as well as its beaches. The main local industries are dairy farming and tourism. The Gerringong Gerroa Sewerage Scheme, commissioned in 2002, and designed to meet the local community's needs up to the year 2022 for an estimated population of 11,000, has brought significant benefits to the area. For example, improved housing and commercial development due to sewer reticulation and a sustainable agricultural-based reuse system designed to use greater than 80% of the treated effluent and 100% reuse of the biosolids. The Gerringong Gerroa Sewerage Scheme is the culmination of an intensive environmental impact assessment process and community input to provide the area with a state-of-the-art wastewater treatment system.

Keywords: Recycled water; Sewerage scheme; Reuse

1. Introduction

The vision for the Gerringong Gerroa Sewerage Scheme (GGSS) as set out in the EIS [1] is one that would be ecologically, economically and socially sustainable, thus protecting and enhancing the local environment and quality of life for all inhabitants. Based on the above, a series of desired outcomes were formulated for the project, to guide its development from concept to delivery to operation.

2. Project description

Until the GGSS was commissioned in August 2002, the Gerringong and Gerroa area treated and disposed of sewage using septic tank systems with pump-out and/or absorption trenches. Septic pump-out was discharged to the Gerroa nightsoil depot located south of Gerroa (see Fig. 1).

The design, construction, commissioning and on-going operation of the GGSS has made significant contributions to the sustainable manage-

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Fig. 1. Location of Gerringong Gerroa Sewerage Scheme.

ment of water in an environmentally sensitive region. Benefits to the local community and the surrounding environment include:

- using leading edge technology to treat sewage to an advanced tertiary level;
- reusing at least 80% effluent and 100% biosolids for agricultural purposes;
- protecting the environment from septic contamination and improving water quality in the Crooked River, Blue Angle Creek and Werri Lagoon;
- decommissioning the Gerroa nightsoil depot and eliminating the discharge from this facility into the environment;
- reducing potential health hazards and negative impact on surface water and groundwater associated with inadequate on-site sewage treatment facilities;
- eliminating overflows associated with on-site systems preventing dampness and odour on properties and improving the quality of local waterways by preventing run-off; and
- reducing odours and truck movements associated with septic tank pump-outs.

3. Design basis

The scheme was designed to service an equivalent population of 11,000, catering for the predicted peak tourist season population in the year 2022, and an average dry weather flow of 2.2 ML/d. The sewage predominantly comes from domestic sources and a small number of commercial and industrial contributors. The "peak" holiday population predominantly occurs during the summer months: December, January and February.

4. Collections system

The gravity collection system is comprised of property service connections, reticulated sewers, sewage pumping stations and rising mains. Below-ground pipes range in size from 100 mm to 600 mm with access chambers generally flush with ground surfaces except for some severe flood prone areas. Access lids range from light-duty to heavy-duty concrete to suit loading and flooding.

Rising mains, which have been sized to ensure adequate flow velocities and to minimise retention times, transfer collected sewage from sewage pumping stations to the Gerroa sewage treatment plant (STP). There are 11 submersible wet-well-type sewage pumping stations (SPSs) with storage capacities of 3 h peak dry weather flow (PDWF) plus 2 h pumped dry weather flow upstream to ensure that:

- no sewage overflows occur from sewage pumping stations in dry weather; and
- no more than 20 wet weather overflows occur in a 10-year period from the sewerage reticulation system or sewage treatment plant.

The design of each SPS is customised to suit the individual characteristics of each site, giving consideration to geotechnical conditions, water table, acid sulphate soils, proximity to waterways,

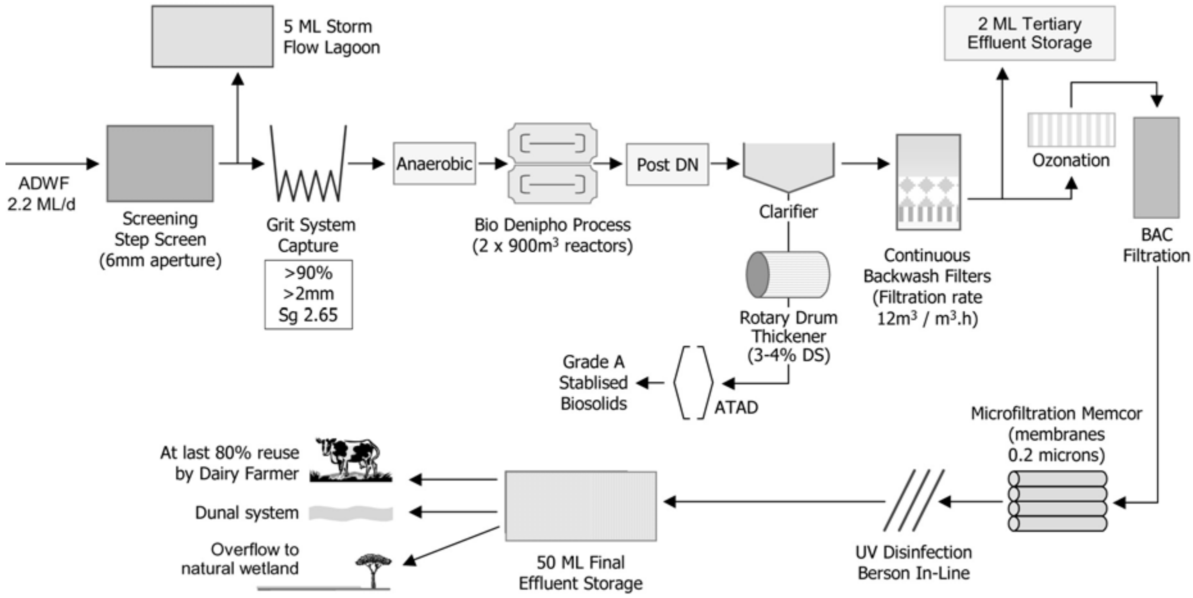

Fig. 2. Gerroa STP process flow diagram.

and land site access. As a result of this customised approach, various concepts have been adopted including: cast *in situ* concrete wells, precast concrete wells and fibreglass wells.

5. Gerroa sewerage treatment plant

The process flow diagram for the Gerroa STP designed to produce advanced tertiary quality effluent is set out in Fig. 2.

5.1. Preliminary treatment

The largest bulk of sewage enters the plant via the inlet pump stations while a small amount enters via the septic receival tank. Both flows are pumped through the mechanically raked screen and into the grit removal system.

Screenings and grit removed during treatment are transported off-site for landfill disposal in accordance with Kiama Municipal Council regulations. Potentially odorous air is withdrawn from the inlet works and treated by a biofilter.

5.2. Biological treatment

Biological treatment consists of a Krüger design BioDenipho process which removes organic matter (BOD), nitrogen, and phosphorus. The BOD is converted into biomass and carbon dioxide by the activated sludge. A large percentage of the nitrogen is converted into gaseous form and is released into the atmosphere. Some nitrogen is also assimilated into the biomass. Most of the phosphorus is assimilated into the biomass.

The biological plant includes two anaerobic selectors, two anaerobic tanks, two bioreactors, post-denitrification tank, clarifier, return sludge pump station, and scum pump station. Degritted wastewater flows to the anaerobic selectors and on through the anaerobic tanks. Effluent from the anaerobic tanks flows alternately into each of the bioreactors.

The bioreactors contain a mass of free-floating microorganisms (activated sludge). The activated sludge is kept in suspension by the action of the mixers and aeration rotors.

The activated sludge leaving the main bioreactors flows through the post-denitrification tank prior to the clarifier. Ethanol may be dosed to this tank to assist in the removal of the remaining nitrate if required. The post-denitrification tank provides an additional volume where denitrifying conditions can be produced to refine the biological nutrient removal process. From the post-denitrification tank the effluent flows to the clarifier.

In the clarifier, the mixed liquor from the bioreactors settles to provide clean water and a more concentrated mixture of activated sludge. The clean water overflows the weirs before being pumped to the sand filters. The sludge settles to the bottom of the clarifier. A rotating bridge scraper pushes the sludge into a sump in the centre of the clarifier from where it is drawn off. The rotating bridge has a scraper on the surface of the clarifier for collecting scum into hoppers.

From the sump in the clarifier, the sludge is returned via the return sludge pump station to the activate sludge process. This stream is called return sludge, or return activated sludge. A small part of the return sludge stream, the excess sludge, is sent to the sludge dewatering system. The amount of return sludge is adjusted according to the influent flow rate, and the sludge settling properties and is controlled by the SCADA system.

5.3. Sand filtration

Secondary effluent from the clarifier is pumped to a bank of sand filters. Alum is added to precipitate out the remaining soluble phos-phorus so it can be removed on the sand filters. The tertiary effluent then flows to storage prior to the advanced tertiary treatment section of the process.

5.4. Ozonation and biological activated carbon filtration (ozone/BAC)

The first stage of advanced tertiary treatment is the ozone/BAC system. In combination, this process breaks down the remaining organic pollutants in the wastewater and removes them biologically.

The ozonation stage involves the introduction of ozone to the tertiary treated wastewater. Ozone is an aggressive oxidant that interacts with and breaks down organic molecules (predominantly COD and organic nitrogen) that remain in the tertiary effluent. The ozone also attacks bacteria and other pathogenic organisms at this stage of the process thereby offering a high degree of chemical disinfection. The chemical oxidation break-down products produced by the ozonation process are generally more biodegradable than their precursors.

The BAC system is a biological filtration plus an absorption process where the effluent passes through a bed of granular activated carbon (GAC) upon which an active biomass is formed. The biomass uses the breakdown products from the ozonation stage as its food source. Excess biomass is removed from the system during backwashing of the GAC filter bed.

Concentrations of pollutants such as pesticides and hormone-like chemicals are significantly reduced over the combined ozone/BAC system.

5.5. Microfiltration

Microfiltration (MF) provides a final polishing step where the remaining suspended solids and microorganisms are physically removed from the effluent. The MF system involves passing the effluent through a membrane with a nominal pore size of 0.2 microns. This provides a very high degree of suspended solids removal along with the removal of bacteria and cysts. Membranes are backwashed approximately every 30 min to remove solids from the membrane surface. A more intensive chemical clean is undertaken approximately every 3 months.

5.6. UV disinfection

The effluent from the MF system is disinfected via an ultraviolet (UV) disinfection system. The UV disinfection unit delivers a lethal dose of radiation to any microorganisms remaining in the effluent. The UV system is designed for a minimum UV dose of 30,000 mWs/cm^2 at the end of lamp life. This UV dose would normally provide a greater than 3 log inactivation of bacteria coupled with a 1 log inactivation of viruses.

5.7. Sludge stabilisation

5.7.1. Thickening

Excess sludge (waste activated sludge) is withdrawn from the clarifier and fed to the rotary drum thickener by a positive displacement pump. Polymer is dosed into the line on the outlet side of the rotary drum thickener feed pump. Polymer improves the de-watering efficiency of the rotary drum thickener and produces thickened sludge of about 5–6% solids. Excess water is returned to the main plant system.

5.7.2. Stabilisation

The autothermal thermophilic aerobic digestion (ATAD) system provides comprehensive stabilisation of the excess sludge from the biological plant. The process operates in the 50–60 °C temperature range delivering a Grade A stabilised biosolids product in accordance with New South Wales EPA guidelines. The stabilised biosolids are stored on site in liquid form at approximately 4–5% solids before agricultural reuse. No supernatant is returned from the ATAD system or the stabilised sludge storage tank. Any odours produced during the sludge stabilisation process and biosolids storage are withdrawn and treated in the plant's biofilter. The final biosolids product does not produce offensive odours due to the extent of treatment that it has undergone.

In August 2002, the Gerroa STP was brought on-line using septic effluent while the first group of residents was connecting to the sewer. From August 2002 until March 2003 while the process was being optimised, the EPA set interim licence criteria which were met. In April 2003 the final EPA licence took effect, with the exception of phosphorus, which took effect in January 2004. Table 1 sets out the raw sewage quality, EPA licence requirements and the current effluent water quality.

Table 1
Performance criteria

Component	Unit	Raw sewage average	EPA licence, 50%ile	Final effluent (Jul–Nov 04), 50%ile
BOD_5	mg/L	280	5	2
COD	mg/L	644	—	—
SS	mg/L	295	3	2
Ammonia	mg/L	45	—	—
Total Kjeldahl	mg/L	55	—	—
Total Nitrogen	mg/L	55	3	0.79
Total Phosphorus	mg/L	10	0.1	0.015
Alkalinity	mg/L	280	—	—
pH	1–14	7–8	6.5–9 (100%ile)	7.25
Faecal coliforms	FC/100 ml	1×10^6	2	0

6. Beneficial reuse of effluent and biosolids

6.1. Effluent reuse

One of the scheme's objectives is to reuse at least 80% of the treated water on average over the next 20 years. Multi-stage pumps located at the Gerroa STP are used to pump the advanced tertiary treated effluent through a rising main to a local dairy farm where it is used for pasture improvement. As the water demand from the farm is seasonal, a 50 ML storage dam balances the water demand and availability between periods of high demand (spring and summer) and periods of low demand (autumn and winter). Fig. 3 illustrates the use of recycled water over a 12-month period.

The farm is equipped with two linear move irrigators (see Fig. 4) that span 240 m and 320 m and irrigate approximately 70 hectares of the 150-hectare property. The property, which has been acquired by the Sydney Water Corporation and is operated by a local dairy farmer, has the capacity to increase the irrigation area as the GGSS grows.

The irrigators have the flexibility to operate in centre pivot and linear modes, which maximise the irrigation area on an irregularly shaped property. A range of irrigation rates can be applied with maximum flexibility and minimum operator input. The farmer uses a computer program to aid in irrigation scheduling. This ensures that the effluent reuse scheme is operated in accordance with the scheme's environmental management system and the scheme's reuse targets are met or exceeded.

When water is unlikely to be used for irrigation and the storage dam water level is high, water is discharged onto the sand dune systems up to a fixed rate of 0.8 ML/d (for 6 months per year). In extreme periods of extensive wet weather, with the storage dam full, the sand dune system may not be able to accept the entire flow produced by the STP. In this rare event, the surplus of effluent is directed to the natural on-site wetland via a constructed overflow channel, and ultimately to the Crooked River. A small amount of final effluent is also used on-site as process water.

6.2. Biosolids

All biosolids produced by the plant will be beneficially reused on surrounding agricultural areas, subject to compliance with contaminant and stabilisation criteria of the New South Wales EPA Biosolids Guidelines. Excess sludge from the biological process is stored as a liquid in a 1-ML on-site biosolids storage tank after undergoing full stabilisation in the ATAD system. Liquid biosolids are removed from the storage tank via tanker and transported to nearby agricultural properties for beneficial use as a fertiliser. At the application site biosolids are

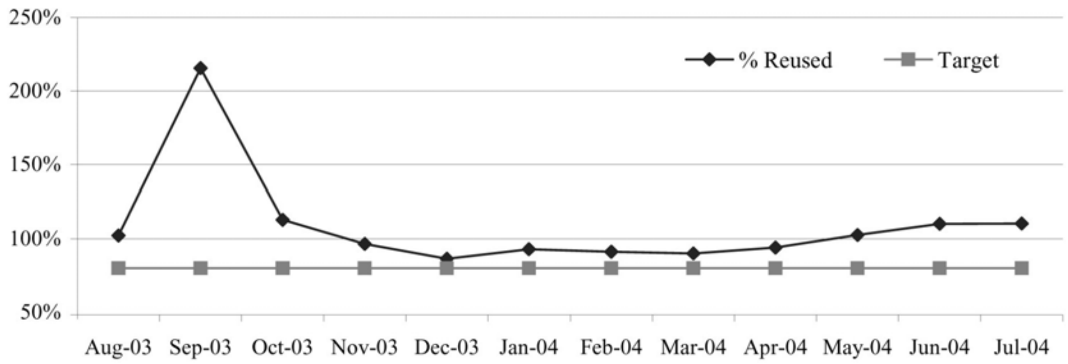

Fig. 3. Annual rolling average of reuse water divided by inflow.

Fig. 4. Dairy farm irrigator.

transferred to a sludge injection vehicle for application below the soil surface.

7. Design criteria for the Gerringong Gerroa Sewerage Scheme

See Tables 2–4.

Table 2
Population EP

Year	Permanent	Peak
2002	3,408	6,405
2022	6,173	10,737

Plant is sized for a maximum population of 11,000 EP.

Table 3
Plant flows

ADWF	2.42 ML/d	28 L/s
PDWF	4.67 ML/d	54 L/s
Max. flow	19.36 ML/d	224 L/s

Table 4
Plant process design

Unit	Number	Description
Screening	1 duty	6-mm aperture
Grit removal	1 duty	Vortex with air lift pumps
BioDenipho:		
Selector/anaerobic	4	2 × 15 m^3, 2 × 45 m^3
Bioreactor	2	2 × 900 m^3
MLSS		4.5 kg. m^3
Aerators	3 per tank	15 kW each
Post-dentrification	1	55 m^3
Clarification	1	24 m diameter, surface loading rate average 0.4 m^3/ m^2/h
Sand filtration	5	Continuous sand bed filters, filtration rate average 12 m^3/ m^2/h
Tertiary storage	2 ML	Buffer storage tank
Ozonation	2 x 50% duty	1,160 g O_3/h
BAC filtration	4	Area per filter 4.9 m^3
Microfiltration	1	Memcor unit with 108 modules
UV disinfection	1	Berson inline 30,000 mWs/cm^2
Sludge processing	2	Rotary drum thickeners
	2	2 ATADs retention time 7.5 days
	1 ML	Storage tank
Chemical dosing:		
Ethanol	5 kL	Extra carbon source, molar ratio ethanol/NO_3–N:1.5
Alum	25 kL	Molar ratio Al/P:1.5
Caustic	17 kL	
Sodium hypochlorite	5 kL	Chlorine residual control for reuse water

8. Conclusions

The $55 million GGSS has proven to date that through innovative design and state-of-the-art wastewater treatment, raw sewage can be processed to produce clean water and advance the management of the urban water cycle. This project was delivered 10 months ahead of time and with minimal variations to the initial agreed project delivery cost. The GGSS is performing well after 2 years of operation and meets all of its contract key performance indicators.

The lesson learnt in delivery of a successful project of this nature can be summarised by the following:

- When delivering a project that serves the local region, the community has to be part of the decision-making. This occurred in Gerringong Gerroa through the community liaison group and by engaging the services of a professional media company.
- Projects are delivered by people who have to work as a coordinated team; they have to move forward as one unit and resolve issues for the benefit of the project. This occurred through partnering and the cooperative attitude of all team members.
- The innovative nature of the project made team members and the community proud to be part of a scheme that would be sustainable and would assist the environment and provide a service to the local community.

References

[1] Manidis Roberts Consultants, Gerringong Gerroa Sewerage Scheme, EIS, November 1999.